Himes Creek Habitat Survey and Inventory Report

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Introduction

In December of 2015, the Colorado Water Conservation Board (CWCB) and Colorado Parks and Wildlife (CPW) initiated discussions with the San Juan National Forest (SJNF) staff regarding a collaborative effort to study and quantify instream flow (ISF) requirements on several streams of interest to the SJNF. The SJNF was interested in investigating the applicability of the Colorado ISF Program (administered by the CWCB) to meet SJNF stream protection and fishery management goals. Four streams on the SJNF were selected for "a pilot study" to test the overall ability of the CWCB program to satisfy the Forest Service's (USFS) stream protection goals and objectives. During the spring and summer of 2016, SJNF, CWCB, and CPW personnel collaborated on the collection of ISF quantification data on the four stream segments pre-selected for the pilot study. Himes Creek in Mineral County was one of the four pilot streams. Himes Creek is a small, first and second order tributary to the West Fork of the San Juan River near the base of Wolf Creek Pass, approximately 12 miles north of Pagosa Springs, CO.

The initial analyses that came to the State from the SJNF for Himes Creek indicated that the USFS thought R2CROSS was not appropriate for this stream type. The rationale for this opinion was based on the general lack of riffle or run habitat in Himes Creek. The stream is a very steep, plunge-pool stream, Rosgen stream type A or Aa+ (Rosgen, 1996 at 4-30) where the limiting low flow fish habitat are the small pools associated with plunges and waterfalls, rather than riffle habitat in a typical R2CROSS generated ISF recommendation. While riffles are not totally absent from Himes Creek (two riffles were located in the reach of interest to the FS), they are atypical for this stream and this stream type and do not represent conditions characteristic of the reach.

The natural environment in Himes Creek was originally thought to be a pure, self-sustaining population of Colorado River cutthroat trout. Later, genetic investigations on the Himes Creek cutthroats revealed that these fish are genetically rare and unique and are therefore of great importance to both the USFS and the State of Colorado. The precise genetic nature of this fish population is documented by CPW (Rogers et al, 2018) and this written report has been made available to the CWCB to support the Himes Creek ISF recommendation. SJNF personnel have expressed a preference for an "all unappropriated water" ISF recommendation for Himes Creek based on this fish species, the plunge-pool nature of the stream, and land status of the Himes Creek watershed.

Due to the opinions of the USFS described above and the USFS's somewhat unique approach to the Himes Creek ISF recommendation, CWCB staff requested an evaluation of Himes Creek by CPW. Specifically, CPW was asked to look at the recommended Himes Creek ISF reach in detail and assess the habitat and the USFS claims regarding the lack of riffle habitat, document the size and nature of the pool habitat, assess limiting habitat types, and photo document the reach for the benefit of the CWCB's ISF appropriation process. Such an assessment is largely qualitative in nature but there are quantitative comparative methods whereby an investigator is able to measure and report stream habitat characteristics. CPW and CWCB personnel determined that the R1/R4 methodology described in the USFS publication, *Fish and Fish Habitat Standard Inventory Procedures Handbook (INT-GTR-346),* could be modified to quantify, to some degree, the habitat in Himes Creek.

Background and Methods

In September of 2017, staff from CPW and CWCB conducted a modified R1/R4 habitat survey of Himes Creek; a first and second order stream located on the SJNF, Pagosa Ranger District, in southwest Colorado. The survey began at the point of diversion for Himes Creek Ditch, near the USFS boundary and ended at a point just upstream of the confluence with the Rod and Gun Club Lake tributary (Figure 1). Overall, 279 feet of stream was physically measured, distributed along 0.65 miles of Himes Creek using the sub-sampling protocol described below.

The R1/R4 survey protocol was developed to provide a tool for fisheries managers to describe the structure and dimension of fish habitat in wadeable streams using quantitative and repeatable metrics. This survey was specifically designed to detect changes or impacts to fish habitat from land-use practices. Surveyors identify specific Habitat Units (HU) delineated by fast or slow water types (i.e. a pool HU is defined by the head crest and tail crest of the pool). Within each HU, surveyors measure the dimensions of the pool, riffle, run, or cascade and quantify habitat attributes such as large wood, substrate size, and bank stability.

The R1/R4 survey protocol has numerous classifications for pool type or riffle type depending on the formative feature. Fast-water habitat types in Himes Creek were often steep cascades or high gradient riffles between step-pool channel types (Figure 4). A High Gradient Riffle (HGR) is a habitat type with a steep slope and fast, turbulent water, with large boulder and cobble substrate. This is distinct from a Low Gradient Riffle (LGR) that more closely resembles the traditional riffle habitat used in ISF quantification techniques such as R2CROSS. The distinction between a cascade, high gradient riffle, and low gradient riffle is primarily channel slope and substrate size. For slow-water habitat types, the survey uses a hierarchy structure to identify the type of pool (dammed or scour), the position in the channel, and the formative feature. For example, a common slow-water habitat type in Himes Creek is a scour plunge pool formed by boulders, or SPB. See Figures 4 - 8 for examples of high gradient riffles, scour pools, and runs in Himes Creek. For a more detailed description of habitat units and survey metrics see Overton, et al (1997).

Within each HU, the habitat type was classified using the above referenced manual; surveyors then measured the channel dimensions (length, width, and depth) within the HU. Several habitat attributes were quantified in addition to channel morphology, including bank stability as a percentage of the total bank length and large woody debris within the bankfull channel (single pieces and aggregates). Substrate size was quantified using a Wolman Pebble Count at two cross-sections. Each habitat unit was documented with photos and GPS coordinates, and detailed field notes regarding unique habitat features such as waterfalls or large cascades.

Sub-sampling

Surveyors used a sub-sampling protocol in order to survey a longer section of stream than would otherwise be possible with time constraints and the steep terrain of Himes Creek. The R1/R4 manual describes methods for determining a sub-sampling interval based on survey objectives. For the Himes Creek survey, staff sampled every tenth habitat unit, walking the entire stream channel and counting the number of Habitat Units between physical measurement locations.

Reference Streams

The R1/R4 survey produces several metrics that are suitable for comparison to other survey protocols, such as the Environmental Protection Agency's Wadeable Streams Assessment (WSA). Reference streams were selected from the WSA database based on the North American Level 3 Ecoregion Code, stream order, and reference condition noted in the database (see Table 4). Two streams that were classified as 'Slightly disturbed' (Red Mountain Creek and Adams Fork Conejos River) were added to the comparison due to their close proximity to Himes Creek (Figure 2).

Habitat inventory methods, such as R1/R4, use reference streams to provide context for habitat survey data by providing a benchmark to evaluate change over time (for repeated surveys) or for evaluating current stream condition. The reference streams identified in Table 5 can give insight to typical conditions in undisturbed landscapes subjected to similar habitat forming processes (ie: bank stability, large wood abundance). The reference stream comparison can also be used to identify areas where habitat types differ significantly (ie: channel slope, substrate size). However, the objectives of each habitat survey will influence the type and location of data collected; therefore, interpretations derived from comparisons of reference stream data should be used cautiously.

Results

Himes Creek is characterized by a steep, confined channel dominated by step-pools and cascades. The average channel slope is 18-20% with a width to depth ratio of 12. The average wetted width for all habitat types was 4.8 feet and the average depth was 0.4 feet. Approximately 52% of the habitat in Himes Creek is pool habitat, reflecting the series of step-pool type features that dominate this system (Table 1 and 2). Numerous small step-pools were measured in the survey of which the average pool depth was 0.4 feet. Large, deep pools were rarely encountered during the survey; the maximum pool depth was only 2.0 feet. Among all pools, the average residual pool depth was 0.8 feet (Table 1).

Approximately half (52%) of the habitat-units measured in Himes Creek were classified as slow-water habitat, reflecting the steep, step-pool environment of this system. The predominant slow-water habitat type observed was scour pools formed by a plunge over boulders (habitat type = SPB). The most abundant fast-water habitat types were Runs and High Gradient Riffles (HGR). Surveyors also measured two cascades with lengths of 17 and 44.5 feet that are representative of the abundance and size of cascades in this reach. Often times, the distinction between a cascade, HGR, or LGR was difficult to discern as the channel transitioned from cascades to HGR with subtle breaks in channel slope and braided channels.

The substrate of Himes Creek is comprised of large boulders and cobbles with a median size (D50) of 86.3 mm and D84 of 237.5 mm (Table 1). Large wood is abundant in this system and is a formative feature in many habitat units (Figure 11 and 12). Surveyors measured 946 pieces of "large wood" per mile (wood > 0.1 ft diameter and 3 ft long) primarily existing in one or two logs per Habitat Unit rather than as aggregates or debris jams. The stream banks are armored by large boulders or bedrock in most locations, resulting in greater than 95% of the banks classified as stable (Table 1 and 3). Several locations did show evidence of mass wasting adjacent to the stream with steep, bare soil banks approximately 30 feet long and 50 feet high; these adjacent landforms are a major source of sediment to this system (Figure 9). The

riparian forest is primarily late successional fir and spruce, interspersed with large stands of aspen. Several areas had numerous wind-felled trees within the bankfull channel.

Himes Creek has a similar width to depth ratio to the nine reference streams that were selected (Table 5). This can be attributed primarily to the stable banks and lack of landscape disturbances that would induce over-widening or incising of the channel (Table 3). The average residual pool depth is also similar among Himes Creek and the reference streams. However, the stream metric for pool habitat (percent pool = 52%) in Himes Creek differs significantly when compared to the reference sites; this is primarily due to the steep channel gradient (18%) and large substrate size (D50 = 86.3mm). In comparison, the reference streams have a pool percentage of 4-27%, an average channel slope of 7%, and an average D50 of 16mm. In summary, the surveyed reach of Himes Creek has a much higher percentage of pools than the reference streams due to the step-pool nature of the stream. Figure 3 illustrates the unique habitat types found in Himes Creek when compared to reference streams with similar land-use patterns and basin size.

Discussion

Himes Creek and its watershed are largely free of anthropogenic disturbances that would disrupt the natural processes forming and maintaining fish habitat. There is no obvious evidence of present or historic livestock grazing, roads, timber harvest, or mining in the watershed and the entire basin, except for a small portion below the Himes Creek Ditch diversion structure, which is located on USFS system lands. The stream banks are primarily stable and armored by large boulders or bedrock; this limits excessive sediment source areas along the stream. As noted above, there are several points within the valley where landslide deposits or mass wasting deposits are adjacent to the stream; these areas are characterized by high, nearly vertical banks of bare soil. These features are natural but are a significant source of sediment to the stream. Himes Creek also has abundant riparian vegetation and large woody debris that provide cover and habitat features that are critical for fish.

Despite the undisturbed condition of Himes Creek, fish habitat availability is limited due to the high channel gradient and numerous cascades and plunge pools. Surveyors noted numerous small waterfalls that were 4-5.5 feet high, as well as long cascades, that may be a barrier to some life stages of fish, or a complete barrier during certain periods of the year. Habitat types that are important to specific fish life stages and seasons are also limited in this type of system. Suitable spawning gravels occur infrequently as the substrate is dominated by large boulders and cobbles. Sufficient pool depth for over-wintering habitat may also be limited as the average pool depth observed was only 0.4 feet. There were virtually no riffles in the segment, only a few short (less than 8 feet) higher gradient runs, and a few “rock garden” habitat units that were dominated by small basketball-size “pocket water pools.”

Comparing the R1/R4 survey data of Himes Creek to the reference streams highlights the unique habitat conditions found in this stream. There were few habitat types on Himes Creek that resemble the habitat conditions typically surveyed in other habitat inventories that would allow a more direct comparison (ie: gradient = 3-7%, D50 = 2-3mm). Although Himes Creek is characteristic of headwater mountain streams, this system is unique from a fish population perspective because water diversions downstream and waterfalls upstream impede fish movement. Steep channel gradient, numerous waterfalls and cascades, and large substrate size presents challenges for fish attempting to access over-wintering, spawning, or rearing habitat and the lack of habitat connectivity with downstream tributaries

eliminates access to refugia during periods of drought, severe winters, excessively high flows, or other forms of disturbance.

Conclusions

The Himes Creek site visit and R1/R4 survey and analysis support the USFS's position on the following:

- Himes Creek is a very steep stream that is not conducive to standard R2CROSS or hydraulic modeling for ISF recommendation development. We observed very few habitat units where R2CROSS data could be collected. Furthermore, the few sites where such data could be collected and analyzed are not representative of the reach (they are more accurately categorized as outliers), and they do not fall under any definition of the "critical low flow habitat" that is the underlying assumption of the R2CROSS methodology.
- The Himes Creek survey was conclusive and confirmative of observations made previously by USFS and CPW Fishery Biologists and SJNF Hydrologists, namely that:
    - No true critical riffles exist in Himes Creek above the FS boundary.
    - While fish passage from pool to pool during low flow is a significant challenge to the fish population, the passage challenges are small cascades and waterfalls, not riffles. These are not appropriate sites for R2CROSS analysis.
    - The critical low flow habitats are pools and the available pool habitat consists of very small, relatively shallow pools. We know, from fish sampling events (including those before, during and following drought), that the Himes Creek fish survived in these small pools.
    - Spawning habitat, specifically spawning gravel substrate, seems to be rare in Himes Creek. To optimize spawning habitat availability and protection throughout the spawning and incubation seasons for the Himes Creek fish population, CPW believes that an ISF water right for all of the available flow is necessary to preserve the natural environment.
    - Professional judgment leads to the conclusion that the Himes Creek fish over-winter in these same small pools.
    - There is not a commonly accepted ISF methodology that can efficiently and accurately model pool dynamics (hydraulics) that will result in an accurate ISF recommendation.
    - Given the nature of the rare and unique natural environment in Himes Creek (the rare lineage Colorado River cutthroat trout – see Rogers et al, 2018) and the critical nature of the pool habitat upon which these fish depend, it is important that any ISF protection strategy ensure the perpetual existence and maintenance of the pools – they must be maintained in their current volume and quality, free from sediment accumulation over time. CPW is in agreement with the USFS that, in the case of Himes Creek, the full range of available flows are needed to ensure the protection this critical low flow habitat into the future.

- Due to the nature of the Himes Creek ISF reach – its natural environment characteristics, the aquatic habitat, and its hydraulics, CPW believes that the SJNF's approach to an ISF recommendation for Himes Creek is both reasonable and appropriate.

Tables

Table 1: Himes Creek R1/R4 habitat survey data summary

All habitat types				
Average depth (ft)	**Average length (ft)**	**Average width (ft)**	**Average slope**	**W/D ratio**
0.4	13.3	4.8	18-20%	12

Slow Water Habitat Type					
% of survey = pool	**# of pools per mile**	**Average pool depth (ft)**	**Average residual pool depth (ft)**	**Maximum pool depth (ft)**	**# of deep pools (>1ft)**
52%	208	0.4	0.8	2	5

Fast Water Habitat Type			
% of survey = Fast Water	**Average depth (ft)**	**Average length (ft)**	**Average width (ft)**
48%	0.34	15.9	3.7

Substrate size	
D50 (mm)	**D84 (mm)**
8630%	237.50

Bank stability	
Bank stability (% of total length)	**Undercut banks (% of total length)**
>95%	7

Large woody debris (LWD)		
LWD singles/mile (>0.1ft dia, >3ft length)	**Root wads/mile**	**LWD aggregates/mile**
946	19	340

Table 2: Dimensions for all habitat units measured during the Himes Creek R1/R4 habitat inventory. HGR: High Gradient Riffle, SPB: Scour Plunge Boulder, STP: Step-pool, DMW: Dammed Main LWD, RUN: Run, SMB: Scour Mid-scour Boulder, CAS: Cascade, LGR: Low Gradient Riffle

							Fast-water	Slow-water habitat type					
Habitat Unit #	Channel code	Habitat description	Habitat type**	Length (ft)	Width (ft)	Avg depth (ft)	Avg max depth (fast type) (ft)	Max depth (ft)	Crest depth (ft)	Step pool #	STP # pools >1m	STP avg max depth (ft)	Residual pool depth
1	Main	Fast	HGR	16	4	0.18	0.3						
2	Main	Slow	SPB	6.8	5	0.28		0.85	0.4				0.45
3	Main	Slow	SPB	7.5	6.6	0.2		0.6	0.2				0.4
4	Main	Slow	STP	10	4.5	1.05				3		1.05	
5	Main	Slow	DMW	8	6.6	0.31		1.1	0.2				0.9
6	Main	Fast	RUN	6.5	1.8	0.4	0.7						
7	Main	Fast	RUN	13	4.7	0.5	0.8						
8	Main	Slow	SMB	9.5	4.1	0.5		1.1	0.3				0.8
9	Main	Fast	HGR	9.2	2.6	0.25	0.6						
10	Main	Slow	SMB	8.2	7.5	0.4		0.9	0.3				0.6
11	Main	Slow	DMW	13.6	6.2	0.4		1.5	0.2				1.3
12	Main	Fast	HGR	9.5	2.2	0.2	0.7						
13	Main	Slow	SPB	9.4	4.5	0.25		1.3	0.2				1.1
14	Main	Fast	RUN	11.7	2.3	0.3	1						
15	Main	Fast	CAS	44.5	5.5	0.5	0.6						
16	Main	Fast	LGR	16.5	3.9	0.2	0.7						
17	Main	Slow	STP	27.3		0.7				6		0.7	
18	Main	Slow	SPB	7.5	7.1	0.4		1.3	0.2				1.1
19	Main	Fast	CAS	17	6.5	0.5	0.5						
20	Main	Slow	SPB	12.5	6.5	0.4		0.6	0.2				0.4
21	Main	Fast	RUN	15	3.7	0.4	1						

Table 3: Bank stability and large woody debris (LWD) for all habitat units measured during the Himes Creek R1/R4 habitat inventory.

	Bank stability						LWD		
Habitat Unit #	Bank length L (ft)	Bank length R (ft)	Stable L (ft)	Undercut L (ft)	Stable R (ft)	Undercut R (ft)	LWD singles	LWD aggregates	LWD root wads
1	16	18	16	0	18	0	0	0	0
2	6.8	6.8	6.8	0	6.8	0	1	0	0
3	7.5	8	7.5	0	8	4.5	0	0	0
4	10	10	10	0	10	0	0	0	0
5	8	8	8	0	8	4	1	1	0
6	6.5	6.5	6.5	0	6.5	0	0	0	0
7	13	13	13	0	13	0	2	0	0
8	9.5	9.5	9.5	3	9.5	0	4	0	0
9	9.7	9.7	9.7	0	9.7	7	3	10	0
10	8.2	8.2	8.2	0	8.2	0	0	0	0
11	7	13	7	0	13	0	5	1	1
12	9.5	9.5	9.5	0	9.5	0	1	0	0
13	9.4	9.4	9.4	7	9.4	4.5	4	0	0
14	11.7	11.7	11.7	0	11.7	0	1	0	0
15	44.5	44.5	44.5	0	44.5	0	0	0	0
16	16.5	16.5	16.5	0	16.5	0	5	4	0
17	27.3	27.3	27.3	0	27.3	0	10	0	0
18	7.5	7.5	7.5	4	7.5	0	4	0	0
19	17	17	17	0	17	0	1	1	0
20	15	15	15	0	15	0	4	0	0
21	15	15	15	5	15	0	4	1	0

Table 4: Selection criteria used to identify reference streams for comparison with the Himes Creek R1/R4 data.

Reference stream selection criteria		
Stream order	**Eco Region**	**Reference condition***
1st or 2nd	6.2.14 (Western Cordillera, Southern Rockies)	Reference

*two streams were included that are classified as 'slightly disturbed'

Table 5: Habitat data from nine reference streams and Himes Creek used for comparison of the Himes Creek R1/R4 habitat inventory results. Reference streams were surveyed by the Environmental Protection Agency's Wadeable Streams Assessment (WSA) program.

Site Name	State	LWD in bankfull (#/100ft)	D50 (mm)	% pool (% of reach)	Mean residual pool depth (ft)	Thalweg mean depth (ft)	Channel slope (%)	W/D ratio	Mean wetted width (ft)	Reach length (ft)	Reference condition (R = reference, S = slightly disturbed)
Saladon Creek	NM	0	2.10	4.3	0.48	0.43	3.05	47	12.57	463	R
Lost Man Creek	CO	0	3.00	19.3	0.44	0.64	18.74	6	3.28	492	R
Ouzel Creek	CO	19	1.51	12.9	0.77	1.66	6.19	18	28.28	912	R
Crystal Creek	CO	1	1.51	6.0	0.74	1.69	2.91	20	30.40	1230	R
Rock Creek	CO	8	3.00	5.0	0.53	1.57	10.42	16	26.89	787	R
No Name Creek	CO	4	3.00	16.0	0.84	1.64	6.45	13	18.16	656	R
Red Mountain Creek	CO	0	2.10	8.7	0.30	0.90	3.60	16	13.93	512	S
Adams Fork Conejos River	CO	0	2.10	14.0	0.42	0.50	6.57	13	6.59	492	S
Jack Creek	WY		130	27.0			5.50	16		413	
Himes Creek	CO	18	86.30	43.1	0.80	0.40	18.00	15	4.80	279	

Figures

Figure 1: Map of Himes Creek and survey reach

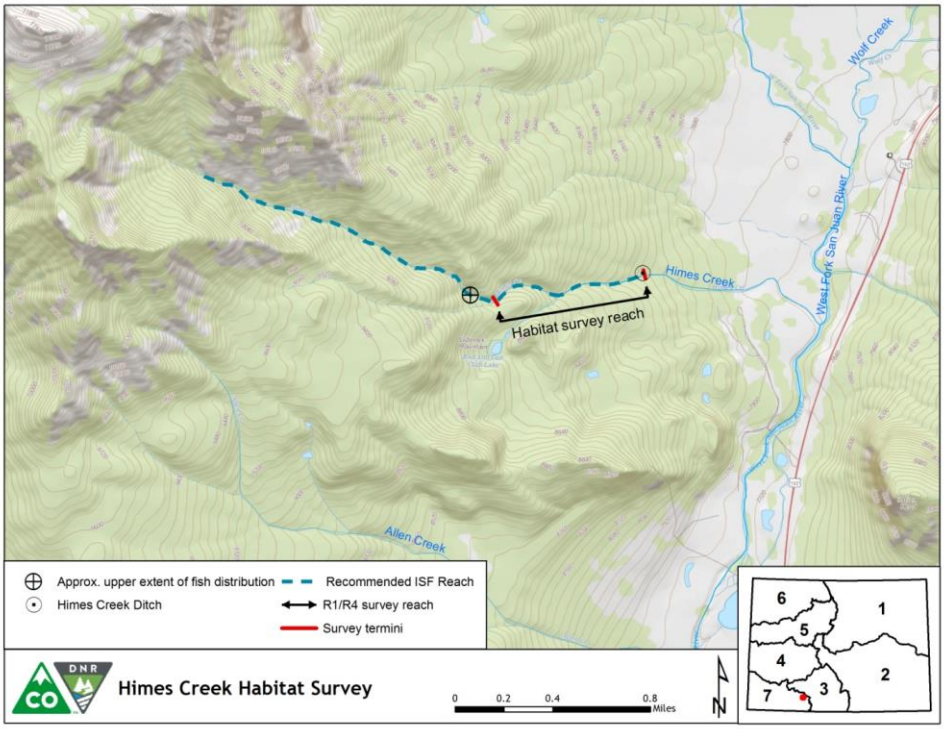

Figure 2: Reference streams location

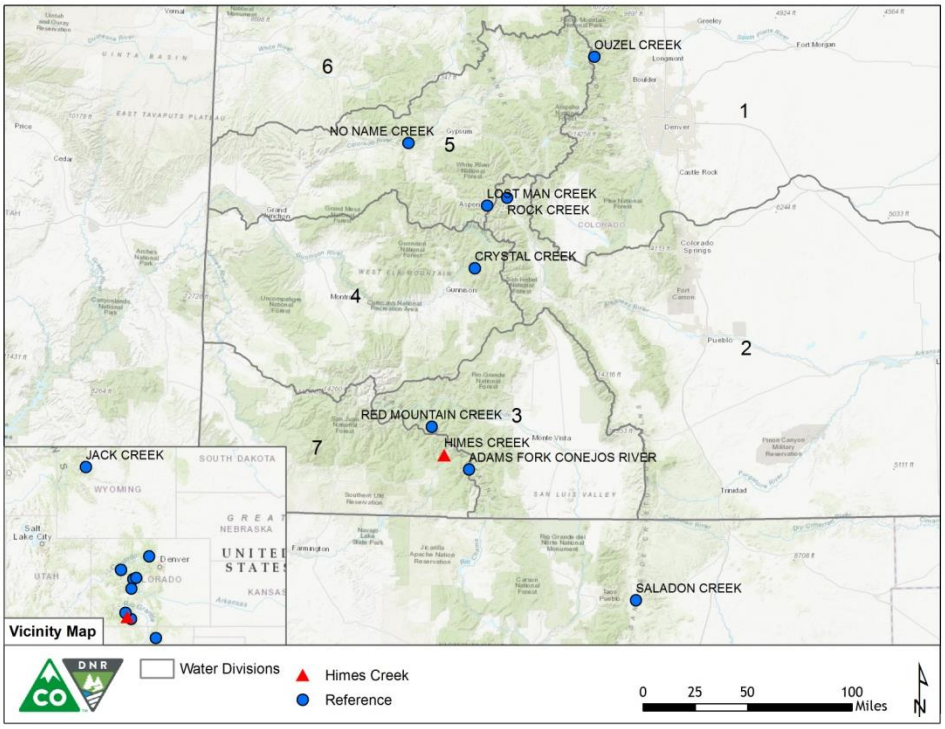

Figure 3: Boxplot of habitat survey data from Himes Creek (R1/R4 protocol) and reference streams (WSA protocol)

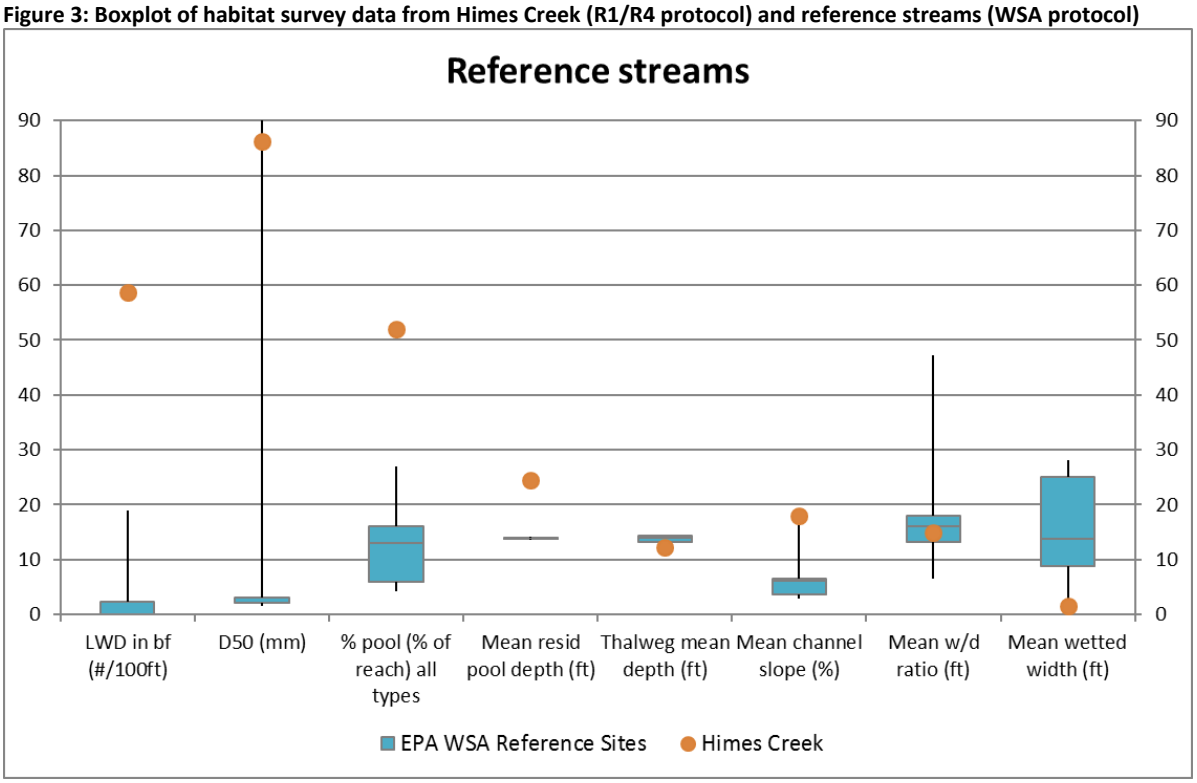

Figure 4: High Gradient Riffle (background) and Scour Plunge Boulder pool (foreground) at HU1 and HU2.

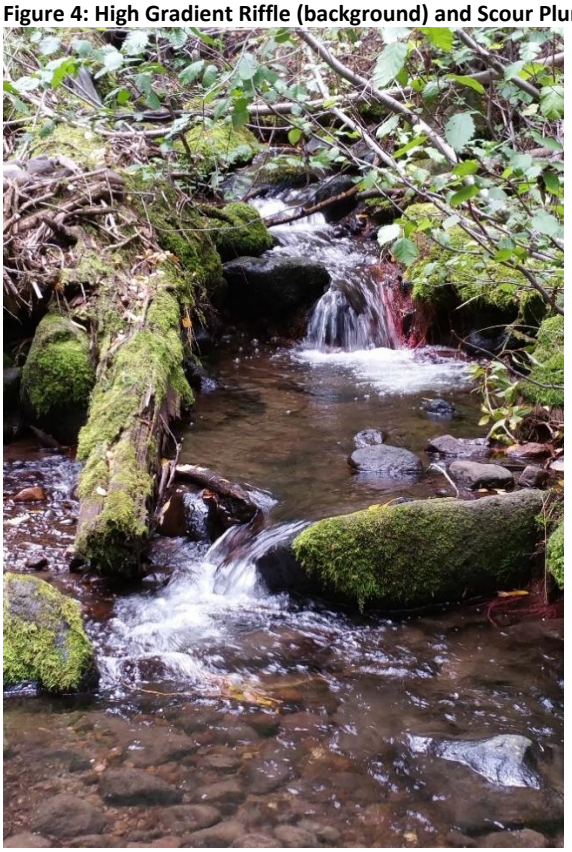

Figure 5: Run habitat type at HU7

Figure 6: Dammed pool formed by large wood (DMW) and High Gradient Riffle (HGR) at HU11 and HU12

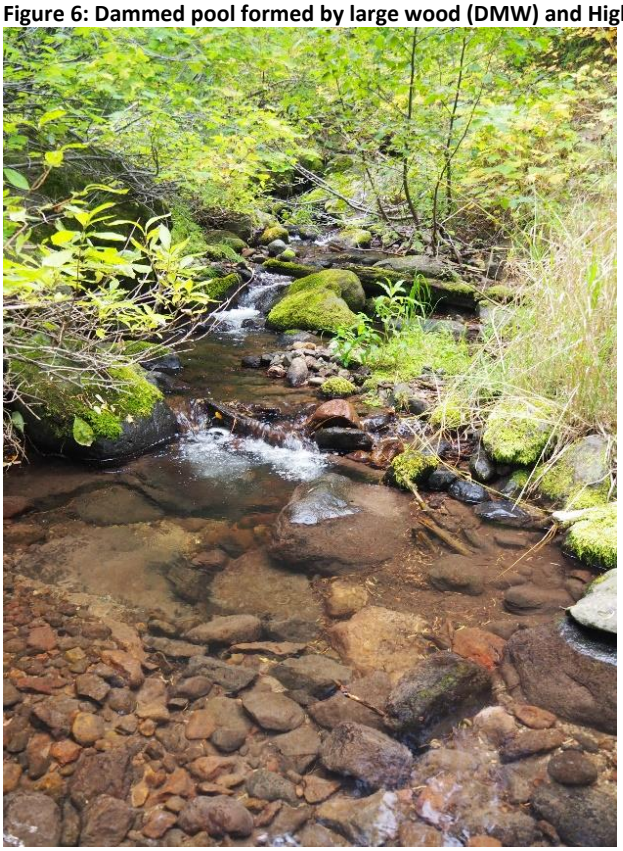

Figure 7: Cascade upstream of HU18

Figure 8: Step-pools and large substrate in HU15 classified (Habitat type = cascade)

Figure 9: Large eroding bank in the vicinity of HU15. Stream is at the foot of this slope.

Figure 10: Waterfall at the upper extent of the survey

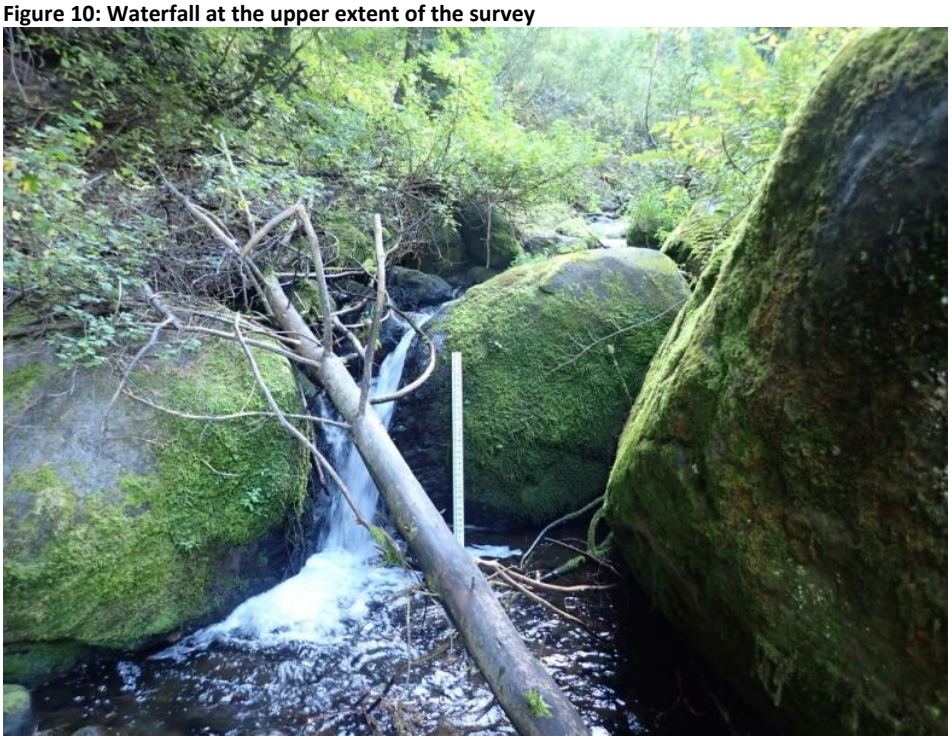

Figure 11: Braided channels and LWD in channel

Figure 12: Large pool at HU20

Acknowledgments
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