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Final Report
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1.0 Introduction

TerraPower plans to build a 345-megawatt sodium-cooled Natrium™ reactor and energy storage system (the Project) at a site located in southwest Wyoming. Tetra Tech is preparing an Environmental Report as part of the Construction Permit Application to the Nuclear Regulatory Commission (NRC). A description of the principal aquatic ecological features of the site and vicinity is needed in the Environmental Report to evaluate potential impacts to the aquatic environment that may result from Project construction or operation. In July of 2022, Tetra Tech contracted BIO-WEST, Inc. (BIO-WEST) to conduct surveys of fish and benthic macroinvertebrates in a total of six segments within two stream systems (North Fork Little Muddy Creek and Hams Fork) that could be impacted. Due to seasonal variation in aquatic communities and imperfect capture efficiencies, multiple sampling events are typically necessary to detect rare species and appropriately characterize aquatic communities. Therefore, surveys were replicated across fall (October 2022), spring (June 2023), and summer (August 2023) seasons. Winter sampling was not conducted due to ice coverage on both streams and potentially hazardous conditions for biologists. This comprehensive final report delineates the segments selected, describes the habitat conditions encountered, details the sampling methods employed, and summarizes results of all surveys in context with existing information.

1.1 Study Area

The proposed Kemmerer Unit 1 generating facility would be located between U.S. Highway 189 and North Fork Little Muddy Creek approximately 3 miles south of the city limit of Kemmerer, Lincoln County, Wyoming, and a short distance southeast of the existing coal-fired Naughton Power Plant (**Figure 1**). The Project would include two approximately 6-mile-long transmission lines and a water supply pipeline that would connect the new Kemmerer Unit 1 facility to the existing Naughton Plant infrastructure. Since Project construction and operation activities could affect North Fork Little Muddy Creek, baseline information on the aquatic communities of the creek was collected for inclusion in the Environmental Report. Additionally, to take advantage of existing infrastructure, the Project will use the Naughton Power Plant's existing Cooling Water Intake Structure (CWIS) on Hams Fork approximately seven miles north of the power plant (**Figure 1**). Therefore, baseline information on the aquatic communities of Hams Fork in the vicinity of the CWIS was also collected. Both Hams Fork and North Fork Little Muddy Creek are tributaries of Blacks Fork within the Green River subbasin of the Colorado River drainage.

Six survey segments within the two stream systems were chosen for seasonal sampling based on discussions with Tetra Tech, locations of project infrastructure, aquatic habitat conditions, and available access points. Each segment was a minimum of 100 meters in length, with exact segment locations selected during an August 2022 reconnaissance trip conducted by BIO-WEST biologists. They included three survey segments on the Hams Fork – one segment at the existing dam/intake structure and two segments upstream (**Figure 2**). Three survey segments were also selected within the North Fork Little Muddy Creek drainage – one upstream of the Kemmerer Unit 1 site near the planned water pipeline and transmission lines on an unnamed tributary that carries effluent from the Naughton Power Plant, one on North Fork Little Muddy Creek near the mid-point of the Kemmerer Unit 1 site, and one downstream of the site (**Figure 3**). Brief

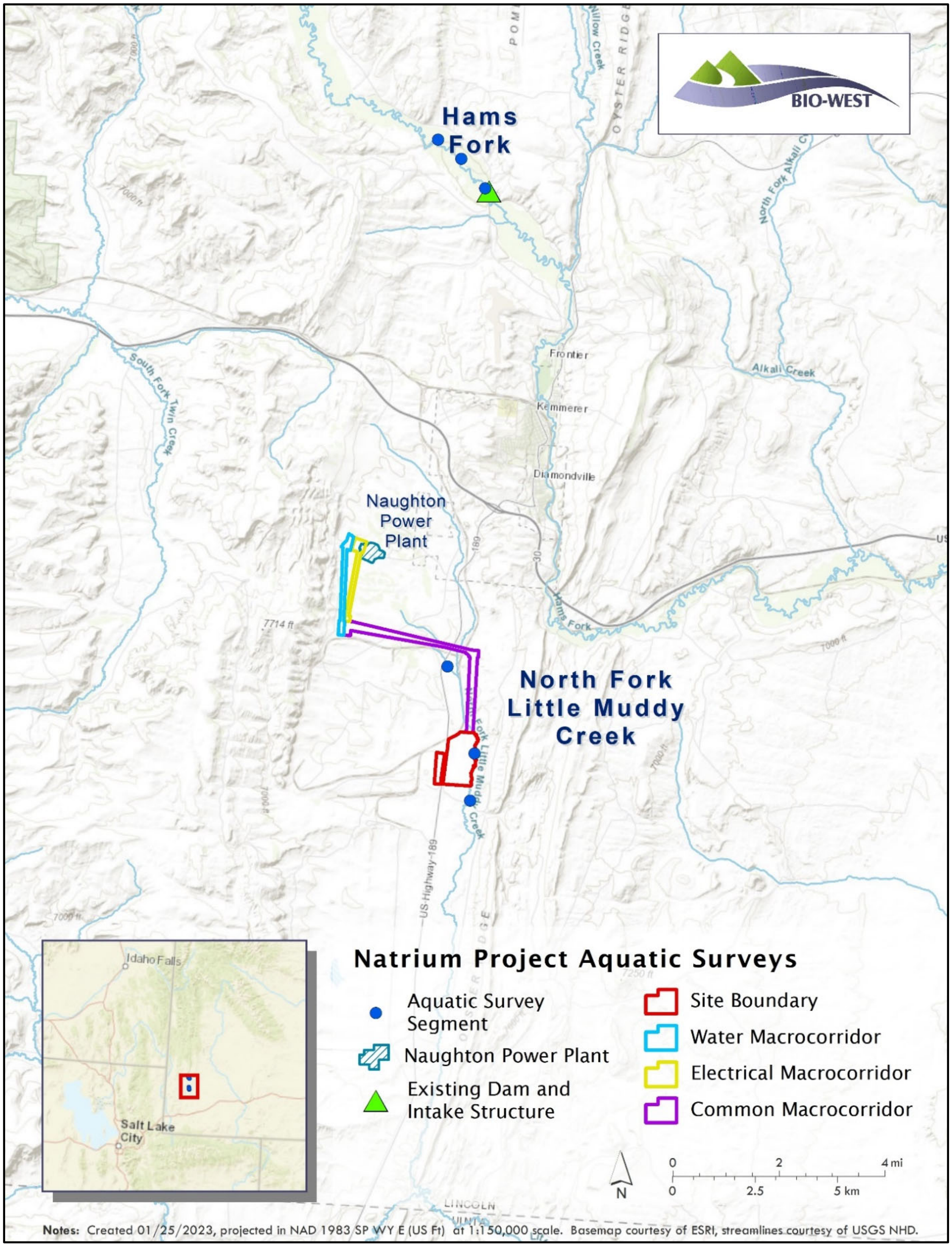

Figure 1. Map of aquatic survey segments in relation to the Kemmerer Unit 1 site and associated infrastructure in Lincoln County, Wyoming.

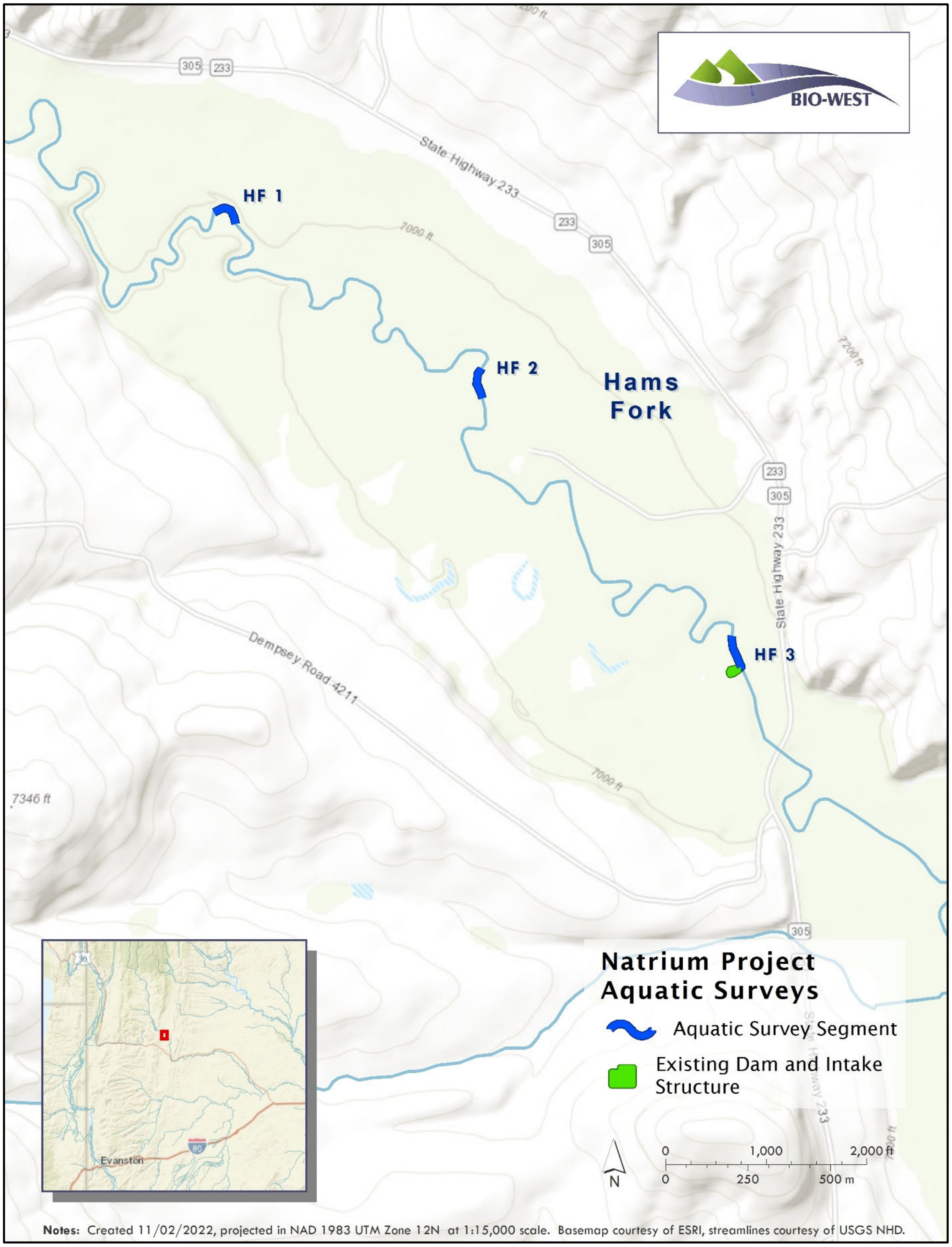

Figure 2. Map of aquatic survey segments on Hams Fork in relation to the existing dam and intake structure.

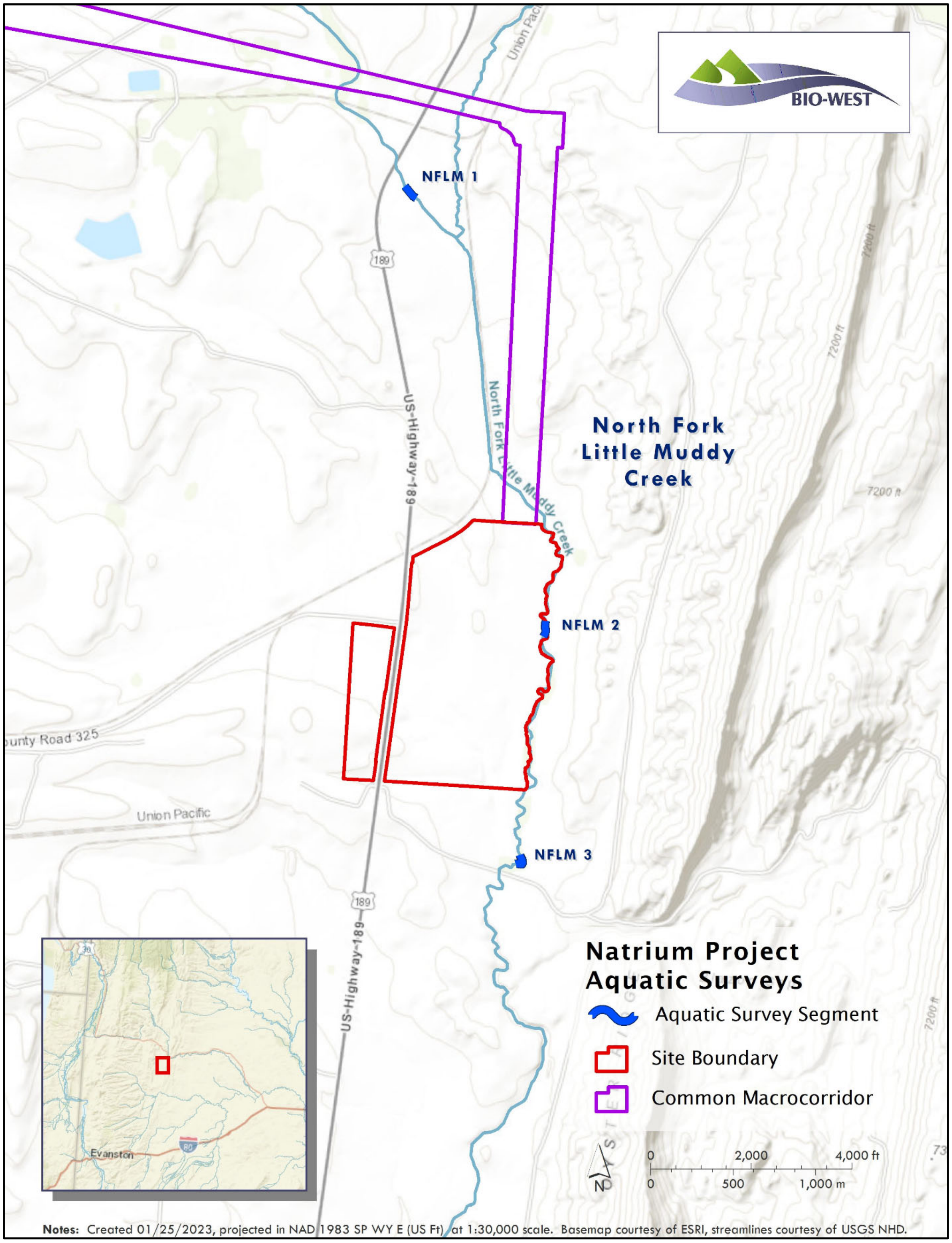

Figure 3. Map of aquatic survey segments in the North Fork Little Muddy Creek drainage in relation to the Kemmerer Unit 1 site and associated infrastructure.

descriptions of the habitat conditions observed at each segment are provided in Section 3.2, with representative photos of each segment taken during the August reconnaissance trip provided in Appendix A.

2.0 Methods

2.1 Habitat and Water Quality

Habitat conditions were described by visually estimating the percent cover of mesohabitat types (e.g., riffle, run, pool, backwater) within each segment using predefined categories similar to those proposed by Hawkins et al. (1993) (**Table 1**). Additionally, areal coverage of individual fish habitat parameters such as undercut bank, submerged aquatic vegetation, woody debris, and overhanging/inundated vegetation was visually estimated as percent coverage of the total wetted area/bank area using similar categories. Water depth (feet) and mean current velocity (feet/second) were quantified at a minimum of six representative points within each segment using a flowmeter and incremental wading rod. At each of these points, dominant and subdominant substrates were also visually classified based on definitions in **Table 1**. Lastly, standard water quality parameters (water temperature [°C], dissolved oxygen [mg/L and percent saturation], pH, and specific conductance [µS/cm]) were measured at each segment using a handheld water quality sonde. Habitat data collected at each segment are summarized in Section 3.2, and water quality data are summarized in Section 3.3.

2.2 Fishes

Depending on stream size and access conditions at time of sampling, electrofishing was conducted with one of two electrofishing units. Where feasible, electrofishing was conducted with a Smith-Root 5.0 GPP boat/barge-electrofisher mounted on a 15 ft aluminum jon boat. This unit allowed for boat-electrofishing in deeper areas, and barge-electrofishing in wadeable areas. In situations where boat access was infeasible and flow conditions were unsafe for boating (Hams Fork segments in spring 2023), or stream size was too small for the boat (North Fork Little Muddy Creek), a backpack electrofisher (Smith Root LR-24) was used. Electrofishing was not conducted at Hams Fork Segment 3 (HF 3) in spring 2023 as flow conditions were unsafe for boat operation and this segment was too deep for backpack electrofishing. In all other cases, a minimum of 900 seconds/15 minutes of pulsed DC electrofishing “pedal time” (when electric current is actually applied) was conducted at each segment. Survey crews consisting of two netters started at the downstream end of the segment and moved upstream to minimize the influence of surveyor-generated turbidity on sampling efficiency. Lastly, to help ensure capture of all species present, three Gee-style minnow traps were baited with dry dog food, deployed overnight at each segment, and retrieved the following day. All fishes collected were identified to species and enumerated by gear type, except some young-of-year suckers (*Catostomus* sp. < 25 mm total length) were identified only to genus because their small size limited the ability to identify them to species in the field without harming them. No fish were killed during the study. Up to 50 individuals of each species were measured (total length, inches) and weighed (grams), with voucher photographs taken of each species. Following data collection, all fishes were released near the point of capture. Data were analyzed to provide raw abundance, percent relative abundance, and catch-per-unit-effort (CPUE) by species and survey segment for electrofishing (fish/minute) and minnow trap sampling (fish/trap-night). Species richness was also recorded for each segment overall and by sampling method. Length frequency histograms were generated for species with sufficient sample size. Results of all sampling events are provided in Section 3.4.

Table 1. Habitat, substrate, and cover codes used to describe habitat conditions at each segment.

Code	Habitat / Substrate / Cover Type	Definition
Habitat		
BW	Backwater	An off channel but connected body of water in an abandoned secondary mouth, behind a bar, or in a bank indention, with no perceptible flow, and typically a sand or silt substrate.
PO	Pool	Area within a channel where flow is not visually perceptible or barely so, deeper depths, and typically a surface substrate of silt or sand.
ED	Eddy	Similar to pool except water flow is evident (but slow) and typically circular or opposite that of the channel.
SH	Shoal	Generally shallow areas with laminar flow and slow to moderate velocity over any substrate.
RN	Run	Moderate or rapid velocity water with little or no surface disturbance, moderate depths.
RF	Riffle	Area within a channel where gradient is moderate to high, depth is shallow, velocity is moderate to rapid, and water surface is disturbed by turbulence.
SW	Slackwater	Low-velocity habitats usually along inside margin of river bends or shoreline indentations, or immediately downstream of debris piles, bars, or other instream features.
IP	Isolated Pool	Small body of water in a depression, old backwater, or side channel that is not connected to the channel due to receding flows.
Substrate		
SI	Silt	Fine sediments with no visual grain size, tactilely smooth.
SA	Sand	Visually coarse fine sediments, tactilely gritty.
FG	Fine Gravel	<2.5 cm
CG	Coarse Gravel	2.5 - 7.6 cm
SC	Small Cobble	7.6 - 15.2 cm
LC	Large Cobble	15.2 - 25.0 cm
BLD	Boulder	>25.0 cm
BR	Bedrock	Rock with no definable grain size.
Cover		
IV	Inundated Vegetation	Inundated emergent or terrestrial vegetation near stream edges, islands, or point bars.
RT	Roots	Inundated roots of riparian trees along stream edges, islands, or point bars.
SWD	Small Woody Debris	Small diameter (twig-like) woody debris.
LWD	Large Woody Debris	Larger diameter woody debris such as limbs, trunks, and large root wads.
OV	Overhanging Vegetation	Emergent or terrestrial vegetation hanging over the stream surface along stream edges, islands, or point bars.
BRS	Bedrock Shelves	Sharp transitions or undercuts in bedrock.

2.3 Benthic Macroinvertebrates

Benthic macroinvertebrates were collected with a D-frame kick net (500-micron mesh) in wadeable areas and supplemented with additional sampling using a Ponar grab sampler in non-wadeable habitats (>3.8 ft deep). Kick net sampling was conducted in swift-flowing riffle habitats (where present) and was also supplemented with jab-style sampling in undercut banks, backwaters, and littoral areas, generally following methods described in Barbour et al. (1999). Due to non-wadeable depths at HF 3, a petite Ponar grab sampler was used to collect benthic organisms from mid-channel areas at this survey segment. Three grabs were conducted, and all associated sediment and detritus were combined into a sieve bucket to rinse out fine sediments. Ponar collections at HF 3 were supplemented with jab-style sampling using the D-frame kick net along the stream margins and littoral zones. All macroinvertebrates and associated detritus were preserved in 95% ethanol in clearly labeled containers for later laboratory analysis.

In the laboratory, an experienced taxonomist sorted and identified all organisms within the sample, or until a minimum of approximately 500 organisms was reached, identifying benthic invertebrates to the lowest practical taxonomic level.

Assessments of ecological condition based on macroinvertebrate communities were conducted at each segment and season using the Wyoming Stream Integrity Index (WSII) developed by the Wyoming Department of Environmental Quality (Hargett and ZumBerge 2006). This index incorporates multiple metrics that were developed for specific bioregions in the state, integrating compositional, structural, and functional components of macroinvertebrate assemblages to quantify the status of aquatic life use. For each survey segment per season, WSII was calculated using ten metrics and scoring criteria provided for the Wyoming Basin (**Table 2**). Scoring was based on taxa richness (Ephemeroptera, Trichoptera, and Plecoptera taxa richness), assemblage composition (percent non-insect, Plecoptera, and Trichoptera), functional feeding groups (percent collector-gatherer and scraper), tolerance (Hilsenhoff Biotic Index [HBI]; Hilsenhoff 1987), and life history (semivoltine taxa richness) metrics (Hargett and ZumBerge 2006). Functional feeding groups and tolerance values (Northwest designations) used to calculate HBI were assigned based on Barbour et al. (1999). Taxa were classified as semivoltine (i.e., > 1 year to complete life cycle) based on unpublished data provided by R.W. Wisseman (2001).

Each metric quantified was standardized through integration as described in Hargett and ZumBerge (2006), resulting in unitless scores that ranged from 0 to 100. Segment-level WSII scores were quantified by calculating means of the ten metrics assessed, which were then assigned a criterion for the status of aquatic life use based on numeric thresholds assigned for the Wyoming Basin. Status of aquatic life use criteria included full support (> 51.9%), indeterminate (34.6–51.9%), and partial/non-support (< 34.6%) (Hargett and ZumBerge 2006). Lastly, 95% confidence intervals were also calculated based on scores from all metrics for each segment/season to account for uncertainty in WSII scores and status of aquatic life use assignments. Values and standardized scores for each metric along with overall WSII aquatic life use assignments are summarized in Section 3.5.

Table 2. Metrics used to calculate the Wyoming Stream Integrity Index.

Metric	Definition	Predicted Response to Increased Perturbation
No. Ephemeroptera Taxa	Number of taxa in the insect order Ephemeroptera (mayflies)	Decrease
No. Trichoptera Taxa	Number of taxa in the insect order Trichoptera (caddisflies)	Decrease
No. Plecoptera Taxa	Number of taxa in the insect order Plecoptera (stoneflies)	Decrease
% Non-Insects	Percent of individuals which are not insects (e.g., amphipods, oligochaetes, snails)	Increase
% Plecoptera	Percent of individuals that are Plecoptera (stoneflies)	Decrease
% within Trichoptera (less Hydropsychidae)	Percent of trichopterans that are not Hydropsychidae	Decrease
% Collector-gatherer	Percent of all individuals that are in the Collector-Gatherer Functional Feeding Group and feed on fine particulate organic matter	Increase
% Scraper	Percent of all individuals that are in the Scraper Functional Feeding Group and feed by scraping biofilms	Decrease
Hilsenhoff Biotic Index (HBI)	The HBI is calculated by multiplying the number of individuals of each taxa by its assigned tolerance value, summing these products, and dividing by the total number of individuals	Increase
No. Semivoltine Taxa (less semivoltine Coleoptera)	The number of semivoltine taxa (taxa requiring more than one year to complete their life cycle), excluding semivoltine Coleoptera which are often semi-aquatic	Decrease

3.0 Results

3.1 Sampling Conditions

The initial fall 2022 sampling event was conducted October 18–19, 2022, under mostly sunny skies and light winds. Air temperatures at a nearby weather station at Kemmerer Municipal Airport ranged from 32–68°F (0–20°C). Mean daily discharge taken from USGS gage #09223000 (Hams Fork Below Pole Creek, Near Frontier, WY) was 13.3 and 13.4 cubic feet per second (cfs), which is slightly lower than the long-term median of approximately 20 cfs during this time period (USGS 2023). No streamflow gage was present on North Fork Little Muddy Creek, but flows seemed rather typical based on visual assessment (stream within banks, emergent littoral vegetation wetted).

Although spring sampling was initially planned for May 2023, high flows on Hams Fork in May resulted in unsafe sampling conditions. Spring sampling was ultimately conducted June 13-14, 2023. Weather conditions during sampling were relatively cool for June, with air temperatures ranging between 46-65°F (8-18°C). Intermittent rain and episodic thunderstorms (at times heavy) occurred on the days of sampling. Due to above-average snowfall in the area the previous winter, as well as localized rain during sampling, both Hams Fork and North Fork Little Muddy Creek experienced relatively high flows during the spring 2023 sampling event. Mean daily discharge on the Hams Fork was 354 cfs and 348 cfs, slightly higher than the median for this date of 334 cfs (USGS 2023). Although no gage data is available for North Fork Little Muddy Creek, flows were elevated during the sampling period (out of bank at times) due to localized runoff from recent rains.

Summer sampling took place August 22-24, 2023, under seasonally typical weather conditions with air temperatures ranging between 48–78°F on the days of sampling. Intermittent rain and thunderstorms occurred on the days of sampling but did not substantially influence flow conditions. Mean daily discharge on the Hams Fork ranged from 27-32 cfs during the time of sampling, slightly higher than the median of approximately 20 cfs during this time period (USGS 2023). On the afternoon of August 22nd, the project team noted zero flow and isolated pools at North Fork Little Muddy Creek. Communication with Naughton Power Plant staff confirmed that plant discharge had been diverted into a reservoir while a pump was being replaced. The following day, on August 23rd, typical flow conditions were noted in North Fork Little Muddy Creek.

3.2 Habitat

3.2.1 Hams Fork 1 (HF 1)

HF 1 was the most upstream segment, located about 2.4 stream miles above the existing dam and intake structure (**Figure 2**). Stream width was approximately 45–70 feet (ft). Measured water depths ranged from 0.7–4.1 ft, and current velocities ranged from 0.2–2.5 feet per second (ft/s). Habitat was mainly run, with lesser amounts of riffle, slackwater, backwater, and eddies. Substrate was dominantly cobble, with interspersed gravel, sand, and silt. Water was generally clear and submerged aquatic vegetation (*Myriophylum* sp.) covered approximately 60% of the survey segment in all seasons. Woody debris was consistently present but not abundant, and undercut banks provided additional cover. Surrounding terrestrial areas were used for livestock grazing and irrigated hay production. Although riparian vegetation was limited, livestock access to the stream resulted in trampling of streamside vegetation in places.

3.2.2 Hams Fork 2 (HF 2)

HF 2 was located approximately 1.2 stream miles downstream of HF 1 in a free-flowing section above the hydraulic influence of the downstream dam/intake structure at HF 3 (**Figure 2**). Stream width was approximately 30–50 ft. Measured water depths ranged from 1.0–3.0 ft, and current velocities ranged from 0.6–3.1 ft/s. Habitat was mostly run and riffle, with scattered slackwaters, eddies, and pools. Substrate was predominantly cobble with lesser amounts of gravel, sand, and silt. Water was generally clear, and submerged aquatic vegetation (*Myriophylum* sp.) covered approximately 60% of the segment in all seasons. Woody debris was consistently present but not abundant. Undercut banks and overhanging terrestrial vegetation provided additional cover. Surrounding terrestrial areas were used for livestock grazing and irrigated hay production. Although riparian vegetation was limited, livestock access to the stream resulted in trampling of streamside vegetation in places.

3.2.3 Hams Fork 3 (HF 3)

This segment was located at the existing CWIS, which includes a small diversion dam and associated intake structure (**Figure 2**). Stream width was approximately 75 ft. Due to the pooling effects of the dam, this was the deepest and slowest segment, with measured water depths ranging from 2.3–8.0 ft, and current velocity ranging from 0.1–1.4 ft/s. Habitats were classified mainly as pool and run with scattered backwaters, slackwaters, and eddies. Substrates were predominantly silt with lesser amounts of cobble, gravel, and sand. The water was generally clear, but submerged aquatic vegetation was less common than in other segments due to the increased depths at this segment. Woody debris was present along banks and undercut banks and overhanging vegetation provided additional cover.

3.2.4 North Fork Little Muddy Creek 1 (NFLM 1)

NFLM 1 was located approximately 1.5 stream miles upstream of the Kemmerer Unit 1 site on an unnamed tributary carrying Naughton Power Plant effluent (**Figure 3**). The channel of North Fork Little Muddy Creek above the confluence of this tributary was generally dry. Wetted stream width was 3–9 ft. Habitat diversity was rather low with at least 90% of the segment being run habitat across seasons. Measured water depths ranged from 0.7–3.1 ft, and current velocities ranged from 0.1–1.4 ft/s. Substrate was 100% silt. Water was noted to be clear during base flow conditions but was extremely turbid following runoff from rainstorms. Submerged aquatic vegetation (*Potamogeton foliosus*) was prevalent in fall 2022, with reduced coverage in other seasons. No undercut banks or woody debris were noted. Surrounding terrestrial areas were used for livestock grazing (sheep and cattle were noted in the area).

3.2.5 North Fork Little Muddy Creek 2 (NFLM 2)

NFLM 2 was located on North Fork Little Muddy Creek near the midpoint of the Kemmerer Unit 1 site (**Figure 3**). Wetted stream width was 3–8 ft. Habitat diversity was rather low with 95% of the segment being run habitat across seasons. Measured water depths ranged from 0.5–2.3 ft, and current velocities ranged from 0.1–1.1 ft/s. Substrate was 100% silt and water was typically turbid. Submerged aquatic vegetation was present, but limited, and portions of the channel were bordered in cattails (*Typha* sp.) resulting in overhanging and inundated vegetation covering much of the banks. No undercut banks or woody debris were noted. Surrounding terrestrial areas were used for livestock grazing (sheep and cattle were noted in the area).

3.2.6 North Fork Little Muddy Creek 3 (NFLM 3)

NFLM 3 was located approximately 0.4 stream mile downstream of the Kemmerer Unit 1 site on North Fork Little Muddy Creek (**Figure 3**). Stream width was 2-7 ft. Habitat diversity was rather low with at least 90% of the segment being classified as run habitat across seasons. Measured water depths ranged from 0.9–3.1 ft, and current velocities ranged from 0.3–1.4 ft/s. Substrate was 100% silt and water was generally turbid. Submerged aquatic vegetation was limited and the entire channel was bordered in cattails resulting in overhanging and inundated vegetation covering much of the banks. No undercut banks or woody debris were noted. Surrounding terrestrial areas were used for livestock grazing (sheep and cattle were noted in the area).

3.3 Water Quality

Water quality showed both diel and seasonal variation (**Table 3**). At Hams Fork, observed water temperatures were lowest in fall 2022, ranging from 44.8 to 51.6 °F (7.1-10.9°C), intermediate in spring 2023, ranging from 54.9 to 56.8 °F (12.7-13.8°C), and highest in summer 2023, ranging from 64.2 to 67.3 °F (17.9-19.6°C). Water temperature differences between survey segments within a particular sampling event were likely influenced more by survey time of day than location, with measurements taken at segments sampled earlier in the day consistently being cooler than those taken later in the afternoon. Seasonal patterns in dissolved oxygen (DO) were also evident due to the inverse relationship between DO and water temperature, as expected. Hams Fork DO was lowest in summer 2023 (7.35-7.90 mg/L), intermediate in spring 2023 (8.25-8.53 mg/L), and highest in fall 2022 (9.21-10.05 mg/L). Specific conductance at Hams Fork was lowest in spring 2023 (329-330 µS/cm), intermediate in summer 2023 (353-388 µS/cm), and highest in fall 2022 (441-455 µS/cm). This was likely influenced by flow conditions, as spring 2023 had the highest flows (thus more dilution) and fall 2022 had the lowest flows (potentially more concentration of soluble minerals, etc.). Lastly, pH ranged between 8.38 and 8.76 and no clear diel or seasonal patterns were evident based on the available data.

Seasonal patterns in water temperature and dissolved oxygen were less consistent at North Fork Little Muddy Creek (**Table 3**). Fall 2022 exhibited the warmest water temperature measured (23.3°C) during the coolest ambient air temperatures observed among seasons. However, similar to Hams Fork, DO levels were typically higher in fall 2022 (9.12-9.84 mg/L) compared to spring 2023 and summer 2023 (6.89-9.17 mg/L). No distinct diel or seasonal patterns in pH were noted, with values ranging from 8.01-9.29. Similarly, specific conductance ranged from 1498-4169 µS/cm and no clear patterns were evident based on the available data.

Table 3. Water quality measurements at three survey segments on Hams Fork (HF) and three survey segments in the North Fork Little Muddy Creek drainage (NFLM) during fall 2022, spring 2023, and summer 2023.

Segment	Date	Time	Water Temperature (°C)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% Saturation)	pH	Specific Conductance (µS/cm)
HF 1	10/18/2022	10:54	7.1	9.21	76	8.47	444
HF 2	10/18/2022	12:36	8.6	10.05	86	8.60	441
HF 3	10/18/2022	14:40	10.9	9.23	82	8.73	455
NFLM 1	10/18/2022	15:26	23.3	9.84	114	8.99	1498
NFLM 2	10/18/2022	16:33	20.1	9.42	103	9.29	1525
NFLM 3	10/18/2022	15:58	17.7	9.12	95	8.40	1604
HF 1	06/13/2023	12:36	13.2	8.53	81	8.66	329
HF 2	06/13/2023	11:28	12.7	8.25	78	8.67	330
HF 3	06/13/2023	14:38	13.8	8.53	82	8.76	329
NFLM 1	06/13/2023	17:15	14.6	7.51	75	9.13	4169
NFLM 2	06/13/2023	16:35	17.4	7.42	78	8.51	2744
NFLM 3	06/13/2023	16:00	11.3	6.89	75	8.82	1580
HF 1	08/22/2023	12:15	18.6	7.35	79	8.51	354
HF 2	08/22/2023	10:56	17.9	7.44	78	8.38	353
HF 3	08/22/2023	14:20	19.6	7.90	86	8.50	388
NFLM 1	08/23/2023	9:00	16.8	7.86	82	8.01	2507
NFLM 2	08/23/2023	9:17	15.8	7.89	80	8.05	2513
NFLM 3	08/22/2023	15:25	23.2	9.17	109	8.37	2618

3.4 Fishes

3.4.1 Hams Fork

Across all segments and seasons, over 127 minutes of electrofishing time and 27 minnow trap-nights resulted in capture of 2,034 fishes representing three families, eight genera, and ten species (**Table 4**). Species captured most frequently were Redside Shiner *Richardsonius balteatus* (71% relative abundance), White Sucker *Catostomus commersonii* (14%), and Longnose Dace *Rhinichthys cataractae* (6%). Less common species included Rainbow Trout *Oncorhynchus mykiss* and Utah Chub *Gila atraria*, with only two and seven individuals collected, respectively.

Species richness was lowest at HF 3 (8 species), intermediate at HF 1 (9), and highest at HF 2 (10). In general, species composition was relatively similar between HF 1 and HF 2, with Redside Shiner, White Sucker, and Longnose Dace being the three most abundant species at each. Although Redside Shiner and White Sucker were similarly dominant at HF 3, Speckled Dace *Rhinichthys osculus*, Longnose Dace, and Mountain Sucker *Catostomus platyrhynchus* were absent or rare. In contrast, abundance of Fathead Minnows *Pimephales promelas* increased at HF 3, becoming the third most abundant species at this segment.

When analyzed by gear type, electrofishing accounted for approximately 90% of fishes collected (1,822 individuals) from Hams Fork whereas minnow traps accounted for 10% (212 individuals). All species observed were captured via electrofishing, whereas minnow traps captured seven of ten species. Minnow traps did not capture any of the salmonids (Rainbow Trout, Mountain Whitefish *Prosopium williamsoni*, Brown Trout *Salmo trutta*). Overall electrofishing catch-per-unit-effort (CPUE) was 14.26 fish/minute (min) and decreased from upstream (20.88 fish/min at HF 1) to downstream (7.83 fish/min at HF 3) (**Table 5**). Minnow trap CPUE showed the opposite trend, increasing from upstream (5.22 fish/trap-night at HF 1) to downstream (12.44 fish/trap-night at HF 3), with the overall CPUE being 7.85 fish/trap-night (**Table 6**).

Among seasons, species richness, total fish abundance, electrofishing CPUE, and minnow trap CPUE all showed consistent trends, being highest in fall 2022, and lowest in spring 2023 (**Table 7**, **Table 8**).

Fish collected at Hams Fork ranged in size from a 12 mm (0.5 inch) young-of-year sucker (*Catostomus* sp.) to a 536 mm (21.1 inch) Brown Trout weighing 1,264 grams (2.8 lbs.). Length-frequency histograms for Brown Trout, Mountain Whitefish, and White Sucker provide evidence for multiple size/age classes within the population (**Figure 4**). Length-frequency histograms for other species with sufficient data can be found in Appendix B.

3.4.2 North Fork Little Muddy Creek

Across all segments and seasons, over 145 minutes of electrofishing time and 27 trap-nights with minnow traps resulted in capture of 189 fishes representing two families, five genera, and seven species (**Table 9**). Species captured most frequently included Redside Shiner (41% relative abundance), Speckled Dace (28%), and Longnose Dace (13%). The least common species was Utah Chub, with only one individual collected at NFLM 2.

Table 4. Abundance (#) and percent relative abundance (%) of fishes collected from three segments on the Hams Fork (HF) via electrofishing and minnow trapping in 2022-2023.

Species	Status	HF 1		HF 2		HF 3		Overall	
		#	%	#	%	#	%	#	%
Fathead Minnow (*Pimephales promelas*)	non-native	10	1.00	4	0.59	15	4.32	29	1.43
Longnose Dace (*Rhinichthys cataractae*)	non-native	36	3.59	93	13.62	1	0.29	130	6.39
Speckled Dace (*Rhinichthys osculus*)	native	20	1.99	28	4.10	-	-	48	2.36
Redside Shiner (*Richardsonius balteatus*)	non-native	733	73.01	489	71.60	224	64.55	1446	71.09
Utah Chub (*Gila atraria*)	non-native	1	0.10	3	0.44	3	0.86	7	0.34
White Sucker (*Catostomus commersonii*)	non-native	158	15.74	34	4.98	93	26.80	285	14.01
Mountain Sucker (*Catostomus platyrhynchus*)	native	11	1.10	2	0.29	-	-	13	0.64
Young-of-Year Sucker (*Catostomus* sp.)	---	14	1.39	-	-	3	0.86	17	0.84
Rainbow Trout (*Oncorhynchus mykiss*)	non-native	-	-	1	0.15	1	0.29	2	0.10
Mountain Whitefish (*Prosopium williamsoni*)	native	11	1.10	7	1.02	1	0.29	19	0.93
Brown Trout (*Salmo trutta*)	non-native	10	1.00	22	3.22	6	1.73	38	1.87
Species Richness		**9**		**10**		**8**		**10**	
Total Abundance		**1004**		**683**		**347**		**2034**	

Table 5. Abundance (#) and catch-per-unit-effort (CPUE; fish/min) of fishes collected by electrofishing from three segments on the Hams Fork (HF) in 2022-2023.

Species	Status	HF 1		HF 2		HF 3		Overall	
		#	CPUE	#	CPUE	#	CPUE	#	CPUE
Fathead Minnow (*Pimephales promelas*)	non-native	10	0.22	1	0.02	10	0.33	21	0.16
Longnose Dace (*Rhinichthys cataractae*)	non-native	20	0.44	81	1.56	1	0.03	102	0.80
Speckled Dace (*Rhinichthys osculus*)	native	17	0.37	14	0.27	-	-	31	0.24
Redside Shiner (*Richardsonius balteatus*)	non-native	705	15.38	477	9.18	122	4.07	1304	10.21
Utah Chub (*Gila atraria*)	non-native	1	0.02	-	-	3	0.10	4	0.03
White Sucker (*Catostomus commersonii*)	non-native	158	3.45	26	0.50	88	2.93	272	2.13
Mountain Sucker (*Catostomus platyrhynchus*)	native	11	0.24	1	0.02	-	-	12	0.09
Young-of-Year Sucker *(Catostomus sp.)*	---	14	0.31	-	-	3	0.10	17	0.13
Rainbow Trout (*Oncorhynchus mykiss*)	non-native	-	-	1	0.02	1	0.03	2	0.02
Mountain Whitefish (*Prosopium williamsoni*)	native	11	0.24	7	0.13	1	0.03	19	0.15
Brown Trout (*Salmo trutta*)	non-native	10	0.22	22	0.42	6	0.20	38	0.30
Overall		**957**	**20.88**	**630**	**12.13**	**235**	**7.83**	**1822**	**14.26**
Electrofishing Time (min)		**45.83**		**51.95**		**30**		**127.78**	

Table 6. Abundance (#) and catch-per-unit-effort (CPUE; fish/trap-night) of fishes collected in minnow traps from three segments on the Hams Fork (HF) in 2022-2023.

Species	Status	HF 1		HF 2		HF 3		Overall	
		#	CPUE	#	CPUE	#	CPUE	#	CPUE
Fathead Minnow (*Pimephales promelas*)	non-native	-	-	3	0.33	5	0.56	8	0.30
Longnose Dace (*Rhinichthys cataractae*)	non-native	16	1.78	12	1.33	-	-	28	1.04
Speckled Dace (*Rhinichthys osculus*)	native	3	0.33	14	1.56	-	-	17	0.63
Redside Shiner (*Richardsonius balteatus*)	non-native	28	3.11	12	1.33	102	11.33	142	5.26
Utah Chub (*Gila atraria*)	non-native	-	-	3	0.33	-	-	3	0.11
White Sucker (*Catostomus commersonii*)	non-native	-	-	8	0.89	5	0.56	13	0.48
Mountain Sucker (*Catostomus platyrhynchus*)	native	-	-	1	0.11	-	-	1	0.04
Overall		**47**	**5.22**	**53**	**5.89**	**112**	**12.44**	**212**	**7.85**
Trap-nights		**9**		**9**		**9**		**27**	

Table 7. Number (#) and percent relative abundance (%) of fishes captured from three survey segments on Hams Fork during fall (October 2022), spring (June 2023), and summer (August 2023).

Species	Status	Fall		Spring		Summer	
		#	%	#	%	#	%
Hams Fork 1							
Fathead Minnow *(Pimephales promelas)*	non-native	10	1.5	-	-	-	-
Longnose Dace *(Rhinichthys cataractae)*	non-native	5	0.7	1	5.3	30	9.8
Speckled Dace *(Rhinichthys osculus)*	native	10	1.5	1	5.3	9	2.9
Redside Shiner *(Richardsonius balteatus)*	non-native	526	77.6	15	78.9	192	62.5
Utah Chub *(Gila atraria)*	non-native	-	-	1	5.3	-	-
White Sucker *(Catostomus commersonii)*	non-native	119	17.6	1	5.3	38	12.4
Mountain Sucker *(Catostomus platyrhynchus)*	native	-	-	-	-	11	3.6
Young-of-Year Sucker *(Catostomus sp.)*	---	-	-	-	-	14	4.6
Mountain Whitefish *(Prosopium williamsoni)*	native	-	-	-	-	11	3.6
Brown Trout *(Salmo trutta)*	non-native	8	1.2	-	-	2	0.7
Species Richness		**6**		**5**		**7**	
Total Abundance		**678**		**19**		**307**	
Hams Fork 2							
Fathead Minnow *(Pimephales promelas)*	non-native	1	0.3	3	4.3	-	-
Longnose Dace *(Rhinichthys cataractae)*	non-native	27	7.9	19	27.1	47	17.2
Speckled Dace *(Rhinichthys osculus)*	native	4	1.2	20	28.6	4	1.5
Redside Shiner *(Richardsonius balteatus)*	non-native	278	81.8	16	22.9	195	71.4
Utah Chub *(Gila atraria)*	non-native	-	-	2	2.9	1	0.4
White Sucker *(Catostomus commersonii)*	non-native	10	2.9	9	12.9	15	5.5
Mountain Sucker *(Catostomus platyrhynchus)*	native	-	-	1	1.4	1	0.4
Rainbow Trout *(Oncorhynchus mykiss)*	non-native	-	-	-	-	1	0.4
Mountain Whitefish *(Prosopium williamsoni)*	native	4	1.2	-	-	3	1.1
Brown Trout *(Salmo trutta)*	non-native	16	4.7	-	-	6	2.2
Species Richness		**7**		**7**		**9**	
Total Abundance		**340**		**70**		**273**	
Hams Fork 3							
Fathead Minnow *(Pimephales promelas)*	non-native	15	6.6	-	-	-	-
Longnose Dace *(Rhinichthys cataractae)*	non-native	-	-	-	-	1	0.8
Redside Shiner *(Richardsonius balteatus)*	non-native	141	61.8	1	100.0	82	69.5
Utah Chub *(Gila atraria)*	non-native	-	-	-	-	3	2.5
White Sucker *(Catostomus commersonii)*	non-native	65	28.5	-	-	28	23.7
Young-of-Year Sucker *(Catostomus sp.)*	---	-	-	-	-	3	2.5
Rainbow Trout *(Oncorhynchus mykiss)*	non-native	1	0.4	-	-	-	-
Mountain Whitefish *(Prosopium williamsoni)*	native	1	0.4	-	-	-	-
Brown Trout *(Salmo trutta)*	non-native	5	2.2	-	-	1	0.8
Species Richness		**6**		**1**		**5**	
Total Abundance		**228**		**1**		**118**	

Table 8. Species richness, total fish abundance, electrofishing CPUE (fish/min), and minnow trap CPUE (fish/trap-night) by season at Hams Fork.

Season/Date	Species Richness	Total Abundance	Electrofishing CPUE	Minnow Trap CPUE
Fall (October 2022)	9	1246	24.0	13.4
Spring (June 2023)	7	90	1.6	3.6
Summer (August 2023)	8	698	14.2	6.6

Table 9. Abundance (#) and percent relative abundance (%) of fishes collected from three segments on the North Fork Little Muddy Creek drainage (NFLM) via electrofishing and minnow trapping in 2022-2023.

Species	Status	NFLM 1		NFLM 2		NFLM 3		Overall	
		#	%	#	%	#	%	#	%
Fathead Minnow (*Pimephales promelas*)	non-native	-	-	5	5.4	2	2.8	7	3.7
Longnose Dace (*Rhinichthys cataractae*)	non-native	-	-	-	-	24	33.8	24	12.7
Speckled Dace (*Rhinichthys osculus*)	native	21	84.0	29	31.2	3	4.2	53	28.0
Redside Shiner (*Richardsonius balteatus*)	non-native	3	12.0	49	52.7	25	35.2	77	40.7
Utah Chub (*Gila atraria*)	non-native	-	-	1	1.1	-	-	1	0.5
White Sucker (*Catostomus commersonii*)	non-native	1	4.0	-	-	14	19.7	15	7.9
Mountain Sucker (*Catostomus platyrhynchus*)	native	-	-	9	9.7	3	4.2	12	6.3
Species Richness		**3**		**5**		**6**		**7**	
Total Abundance		**25**		**93**		**71**		**189**	

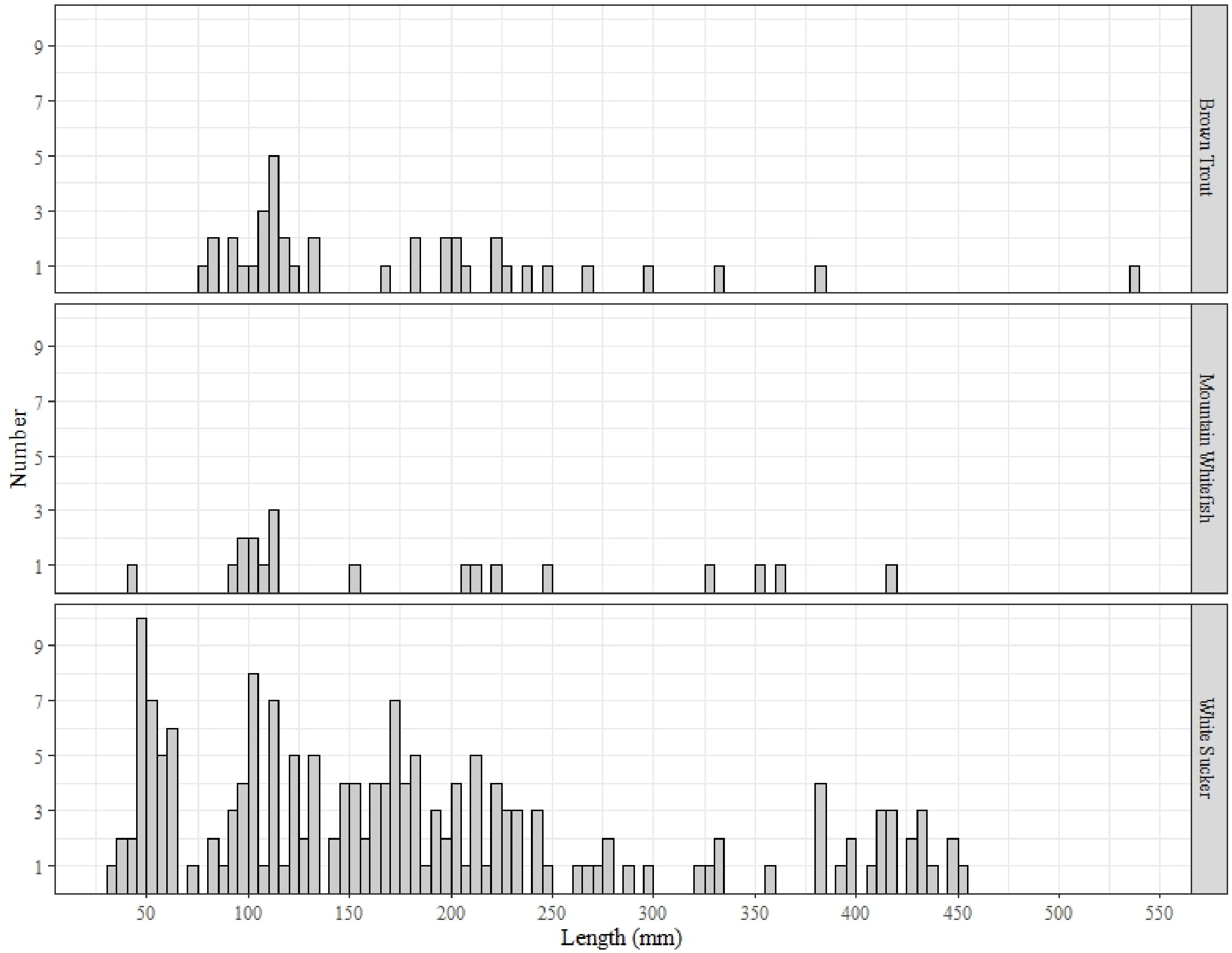

Figure 4. Length-frequency histograms for Brown Trout (top), Mountain Whitefish (middle), and White Sucker (bottom) captured from Hams Fork during all sampling events.

Species richness increased from upstream to downstream, being lowest at NFLM 1 (3 species) and highest at NFLM 3 (6 species). Similarly, abundance was lowest at NFLM 1 (25 individuals) and increased at the downstream segments (71-93 individuals) (**Table 9**).

When analyzed by gear type, minnow traps caught more fish (113 individuals, 60% of all fish captured) in North Fork Little Muddy Creek than backpack electrofishing (76 individuals, 40%), but electrofishing caught more species (7 species) than minnow traps (5 species) (**Table 10**, **Table 11**). White Sucker and Utah Chub were not captured by minnow traps. Overall electrofishing CPUE was low (0.52 fish/min) and increased from upstream (0.07 fish/min at NFLM 1) to downstream (0.87 fish/min at NFLM 3). Overall minnow trap CPUE was 4.19 fish/trap-night and was lowest at NFLM 1 (2.44 fish/trap-night) and highest at NFLM 2 (7.11 fish/trap-night).

Among seasons, species richness and total fish abundance were highest in fall 2022 and lowest in spring 2023 (**Table 12**, **Table 13**). Electrofishing CPUE was highest in fall 2022 (1.2 fish/min) and similar in spring 2023 and summer 2023 (0.2 fish/min). Lastly, minnow trap CPUE was highest in summer 2023 (10.6 fish/trap-night) and lowest in spring 2023 (0.1 fish/trap-night).

Fish collected at North Fork Little Muddy Creek ranged in size from a 40 mm (1.6 inch) Fathead Minnow to a 275 mm (10.8 inch) White Sucker. Length-frequency histograms for species with sufficient data can be found in Appendix B.

3.5 Benthic Macroinvertebrates

3.5.1 Hams Fork

In aggregate, a total of 4,972 individual macroinvertebrates from 70 unique taxa were identified from seasonal sampling (**Table 14**). Segment abundance and taxa richness overall were noticeably higher at HF 1 (1,779 individuals, 45 taxa) and HF 2 (2,474 individuals, 48 taxa) than HF 3 (719 individuals, 38 taxa). Dominant taxa across segments (relative abundance > 10%) included mayflies of the *Baetis* genus (16.2%), caddisflies of the genus *Hydropsyche* (15.3%), and midges of the family Chironomidae (10.9%). Abundant taxa at HF 1 included pea clams of the family Sphaeriidae (15.1%) and midges of the genus *Simulium* (13.9%). At HF 2, the two most abundant taxa were *Baetis* sp. (23.1%) and *Hydropsyche* sp. (21.3%). The top two taxa at HF 3 were annelids in the subclass Oligochaeta (31.0%) and chironomid midges (16.6%) (**Table 14**).

WSII metric values among segments showed number of Ephemeroptera, Trichoptera, and Plecoptera taxa were higher at HF 1 and HF 2 than HF 3 (**Table 15**). In contrast, HF 3 yielded higher percentages of non-insect and collector-gatherer taxa. Calculations of HBI showed similar results across segments and seasons. Variation in metric values between seasons was highest at HF 1 and HF 2, due to larger changes in percent Trichoptera and percent collector-gatherer taxa, respectively (**Table 15**).

Composite WSII scores reflect these differences in metric values, both seasonally and among segments. WSII scores were similar in the fall and summer for HF 1 (35.5-44.4) and HF 2 (35.3-44.3) (**Figure 5**). In spring, WSII was higher at HF 1 (41.7) than HF 2 (28.9), due mostly to large differences in percent Trichoptera score and percent Collector-gatherer score (**Table 15**). This

Table 10. Abundance (#) and catch-per-unit-effort (CPUE; fish/minute) of fishes captured by electrofishing at three segments on the North Fork Little Muddy Creek drainage (NFLM) in 2022-2023.

Species	Status	NFLM 1		NFLM 2		NFLM 3		Overall	
		#	CPUE	#	CPUE	#	CPUE	#	CPUE
Fathead Minnow (*Pimephales promelas*)	non-native	-	-	4	0.08	2	0.04	6	0.04
Longnose Dace (*Rhinichthys cataractae*)	non-native	-	-	-	-	10	0.20	10	0.07
Speckled Dace (*Rhinichthys osculus*)	native	2	0.04	14	0.28	-	-	16	0.11
Redside Shiner (*Richardsonius balteatus*)	non-native	-	-	8	0.16	15	0.30	23	0.16
Utah Chub (*Gila atraria*)	non-native	-	-	1	0.02	-	-	1	0.01
White Sucker (*Catostomus commersonii*)	non-native	1	0.02	-	-	14	0.28	15	0.10
Mountain Sucker (*Catostomus platyrhynchus*)	native	-	-	2	0.04	3	0.06	5	0.03
Overall		**3**	**0.07**	**29**	**0.59**	**44**	**0.87**	**76**	**0.52**
Electrofishing Time (min)		**45.18**		**49.45**		**50.48**		**145.11**	

Table 11. Abundance (#) and catch-per-unit-effort (CPUE; fish/trap-night) of fishes captured in minnow traps at three segments on the North Fork Little Muddy Creek drainage (NFLM) in 2022-2023.

Species	Status	NFLM 1		NFLM 2		NFLM 3		Overall	
		#	CPUE	#	CPUE	#	CPUE	#	CPUE
Fathead Minnow (*Pimephales promelas*)	non-native	-	-	1	0.02	-	-	1	0.01
Longnose Dace (*Rhinichthys cataractae*)	non-native	-	-	-	-	14	0.52	14	0.12
Speckled Dace (*Rhinichthys osculus*)	native	19	0.86	15	0.23	3	0.11	37	0.33
Redside Shiner (*Richardsonius balteatus*)	non-native	3	0.14	41	0.64	10	0.37	54	0.48
Mountain Sucker (*Catostomus platyrhynchus*)	native	-	-	7	0.11	-	-	7	0.06
Overall		**22**	**2.44**	**64**	**7.11**	**27**	**3.00**	**113**	**4.19**
Trap-nights		**9**		**9**		**9**		**27**	

Table 12. Number (#) and percent relative abundance (%) of fishes captured from North Fork Little Muddy Creek during fall (October 2022), spring (June 2023), and summer (August 2023).

Species	Status	Fall		Spring		Summer	
		#	%	#	%	#	%
North Fork Little Muddy Creek 1							
Speckled Dace *(Rhinichthys osculus)*	native	18	94.7	-	-	3	60.0
Redside Shiner *(Richardsonius balteatus)*	non-native	1	5.3	-	-	2	40.0
White Sucker *(Catostomus commersonii)*	non-native	-	-	1	100.0	-	-
Species Richness		**2**		**1**		**2**	
Total Abundance		**19**		**1**		**5**	
North Fork Little Muddy Creek 2							
Fathead Minnow *(Pimephales promelas)*	non-native	1	1.2	1	100.0	3	27.3
Speckled Dace *(Rhinichthys osculus)*	native	29	35.8	-	-	-	-
Redside Shiner *(Richardsonius balteatus)*	non-native	42	51.9	-	-	7	63.6
Mountain Sucker *(Catostomus platyrhynchus)*	native	9	11.1	-	-	-	-
Utah Chub *(Gila atraria)*	non-native	-	-	-	-	1	9.1
Species Richness		**4**		**1**		**3**	
Total Abundance		**81**		**1**		**11**	
North Fork Little Muddy Creek 3							
Fathead Minnow *(Pimephales promelas)*	non-native	2	3.8	-	-	-	-
Longnose Dace *(Rhinichthys cataractae)*	non-native	15	28.3	-	-	9	81.8
Speckled Dace *(Rhinichthys osculus)*	native	2	3.8	1	14.3	-	-
Redside Shiner *(Richardsonius balteatus)*	non-native	23	43.4	-	-	2	18.2
White Sucker *(Catostomus commersonii)*	non-native	8	15.1	6	85.7	-	-
Mountain Sucker *(Catostomus platyrhynchus)*	native	3	5.7	-	-	-	-
Species Richness		**6**		**2**		**2**	
Total Abundance		**53**		**7**		**11**	

Table 13. Species richness, total fish abundance, electrofishing CPUE (fish/min), and minnow trap CPUE (fish/trap-night) by season at North Fork Little Muddy Creek.

Season/Date	Species Richness	Total Abundance	Electrofishing CPUE	Minnow Trap CPUE
Fall (October 2022)	6	153	1.2	1.9
Spring (June 2023)	3	9	0.2	0.1
Summer (August 2023)	5	27	0.2	10.6

Table 14. Number of benthic macroinvertebrates by lowest taxonomic unit (LTU) collected from each survey segment in Hams Fork during fall 2022, spring 2023, and summer 2023 sampling events.

Phylum	Order	Family	Genus/Species/LTU	HF 1	HF 2	HF 3	Overall #	Overall %
Annelida			Oligochaeta	17	44	223	284	5.7
			Hirudinea	0	0	1	1	<0.1
Arthropoda	Coleoptera	Dytiscidae	*Acilius abbreviatus*	0	1	2	3	0.1
			Agabus sp.	0	1	1	2	<0.1
			Colymbetes incognitus	0	0	2	2	<0.1
			Laccophilus maculosus	0	1	1	2	<0.1
			Liodessus obscurellus	1	2	0	3	0.1
			Rhantus binotatus	1	1	1	3	0.1
			Rhantus sericans	1	0	0	1	<0.1
		Elmidae	*Dubiraphia sp.*	7	20	5	32	0.6
			Optioservus sp.	197	274	0	471	9.5
		Gyrinidae	*Gyrinus bifarius*	1	1	0	2	<0.1
			Gyrinus sp. 2	7	5	13	25	0.5
			Gyrinus sp. 3	1	2	22	25	0.5
		Haliplidae	*Haliplus sp.*	1	0	0	1	<0.1
		Hydraenidae	*Ochthebius lineatus*	0	1	0	1	<0.1
		Hydrophilidae	*Enochrus sp.*	0	1	0	1	<0.1
			Hydrobius fuscipes	1	0	0	1	<0.1
			Tropisternus lateralis	1	0	0	1	<0.1
			Copepoda	2	0	1	3	0.1
	Diptera	Athericidae	*Atherix sp.*	35	10	0	45	0.9
		Ceratopogonidae	*Bezzia* complex	0	1	1	2	<0.1
		Chironomidae	Chironomidae	175	249	119	543	10.9
		Limoniidae	*Hexatoma sp.*	0	2	0	2	<0.1
			Symplecta sp.	0	1	0	1	<0.1
		Simuliidae	*Simulium sp.*	247	110	0	357	7.2
		Tabanidae	*Tabanus sp.*	0	0	2	2	<0.1
		Tipulidae	*Tipula sp.*	3	0	0	3	0.1
	Ephemeroptera	Baetidae	*Baetis sp.*	231	571	5	807	16.2
			Callibaetis sp.	34	0	68	102	2.1
		Caenidae	Caenidae	0	1	0	1	<0.1
		Ephemerellidae	*Ephemerella sp.*	0	39	0	39	0.8
		Ephemeridae	*Ephemera sp.*	6	11	0	17	0.3
		Heptageniidae	*Stenonema sp.*	23	22	1	46	0.9
		Leptohyphidae	*Tricorythodes sp.*	52	60	0	112	2.3
		Leptophlebiidae	*Leptophlebia sp.*	6	7	1	14	0.3
			Neoleptophlebia sp.	1	0	0	1	<0.1
			Paraleptophlebia sp.	22	46	1	69	1.4

Table 14 continued.

Phylum	Order	Family	Genus/Species/LTU	HF 1	HF 2	HF 3	Overall #	Overall %
	Hemiptera	Corixidae	*Callicorixa sp.*	0	1	4	5	0.1
			Cenocorixa bifida	0	0	14	14	0.3
			Corixini	0	0	17	17	0.3
			Hesperocorixa laevigata	0	0	4	4	0.1
			Sigara sp.	4	6	22	32	0.6
		Notonectidae	*Notonecta spinosa*	0	0	9	9	0.2
	Lepidoptera	Crambidae	*Petrophila sp.*	1	17	0	18	0.4
			Lepidoptera sp.	2	3	0	5	0.1
			Noctuoidea	0	0	1	1	<0.1
	Megaloptera	Sialidae	*Sialis sp.*	1	2	2	5	0.1
	Odonata	Aeshnidae	*Anax junius*	0	0	13	13	0.3
		Calopterygidae	*Calopteryx sp.*	0	1	0	1	<0.1
		Coenagrionidae	*Enallagma sp.*	14	11	10	35	0.7
		Gomphidae	*Ophiogomphus sp.*	2	0	0	2	<0.1
	Plecoptera	Perlodidae	*Cultus sp.*	4	11	0	15	0.3
			Perlodidae	15	17	0	32	0.6
	Trichoptera	Brachycentridae	*Brachycentrus occidentalis*	91	39	0	130	2.6
		Helicopsychidae	*Helicopsyche sp.*	1	0	0	1	<0.1
		Hydropsychidae	*Cheumatopshyche sp.*	0	19	0	19	0.4
			Hydropsyche sp.	231	528	1	760	15.3
		Leptoceridae	*Oecetis disjunctus*	7	2	0	9	0.2
		Limnephilidae	Limnephilidae	1	3	0	4	0.1
	Amphipoda	Hyalellidae	*Hyallela sp.*	33	104	28	165	3.3
	Decapoda	Cambaridae	*Faxonius sp.*	15	90	99	204	4.1
Mollusca	Sphaeriida	Sphaeriidae	Sphaeriidae	268	79	6	353	7.1
	Basommatophora	Ancylidae	*Ferrissia sp.*	2	33	2	37	0.7
		Lymnaeidae	*Lymnaea sp.*	0	0	2	2	<0.1
			Stagnicola sp.	0	0	2	2	<0.1
		Physidae	*Physella sp.*	9	19	12	40	0.8
		Planorbidae	Planorbidae	2	0	1	3	0.1
Nematoda			Nematoda	0	1	0	1	<0.1
Platyhelminthes	Tricladida	Dugesiidae	*Dugesia sp.*	3	4	0	7	0.1
			Taxa Richness	**45**	**48**	**38**	**70**	
			Total Abundance	**1779**	**2474**	**719**	**4972**	

Table 15. Metric values and scores for calculating the Wyoming Stream Integrity Index (Wyoming Basin) at three segments in the Hams Fork during fall 2022, spring 2023, and summer 2023 sampling events. Composite WSII scores for each segment/season are in bold text.

	Fall		Spring		Summer	
Metric	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
Hams Fork 1						
No. Ephemeroptera Taxa	7	77.8	2	22.2	4	44.4
No. Trichoptera Taxa	3	33.3	3	33.3	3	33.3
No. Plecoptera Taxa	1	16.7	1	16.7	0	0.0
% Non-insect	10.2	86.5	17.1	73.7	23.6	63.5
% Plecoptera	2.2	9.8	5.7	25.6	0.0	0.0
% Trichoptera (less Hydropsychidae) (% within Trichoptera)	15.2	15.2	90.9	90.9	33.3	33.3
% Collector-gatherer	49.7	61.2	58.6	49.4	25.6	93.0
% Scraper	20.8	53.9	2.9	7.4	7.9	20.5
HBI	5.1	49.8	4.6	57.5	5.3	47.0
No. Semivoltine Taxa (less semivoltine Coleoptera)	2	40.0	2	40.0	1	20.0
Composite WSII Score		**44.4**		**41.7**		**35.5**
Hams Fork 2						
No. Ephemeroptera Taxa	6	66.7	5	55.6	4	44.4
No. Trichoptera Taxa	5	55.6	2	22.2	3	33.3
No. Plecoptera Taxa	0	0.0	1	16.7	1	16.7
% Non-insect	6.3	91.9	8.2	87.8	19.7	69.6
% Plecoptera	0.0	0.0	2.3	10.3	0.3	1.2
% Trichoptera (less Hydropsychidae) (% within Trichoptera)	12.1	12.1	3.6	3.6	6.3	6.3
% Collector-gatherer	39.9	74.1	86.2	13.0	43.8	69.0
% Scraper	22.6	58.4	0.6	1.6	15.0	38.8
HBI	4.2	64.1	4.6	58.0	4.9	53.6
No. Semivoltine Taxa (less semivoltine Coleoptera)	1	20.0	1	20.0	1	20.0
Composite WSII Score		**44.3**		**28.9**		**35.3**
Hams Fork 3						
No. Ephemeroptera Taxa	2	22.2	3	33.3	0	0.0
No. Trichoptera Taxa	0	0.0	1	11.1	0	0.0
No. Plecoptera Taxa	0	0.0	0	0.0	0	0.0
% Non-insect	26.6	64.3	65.0	0.0	64.4	0.0
% Plecoptera	0.0	0.0	0.0	0.0	0.0	0.0
% Trichoptera (less Hydropsychidae) (% within Trichoptera)	0.0	0.0	0.0	0.0	0.0	0.0
% Collector-gatherer	79.9	21.2	95.0	1.3	72.3	31.3
% Scraper	2.1	5.4	0.0	0.0	3.6	9.3
HBI	6.8	23.8	5.1	50.3	5.9	38.3
No. Semivoltine Taxa (less semivoltine Coleoptera)	0	0.0	0	0.0	1	20.0
Composite WSII Score		**13.7**		**9.6**		**9.9**

resulted in a partial/non-support aquatic life use status at HF 2 in spring, whereas all other events at HF 1 and HF 2 had an Indeterminate aquatic life use. WSII scores were much lower at HF 3 (9.6-13.7) and all seasons yielded aquatic life use statuses of partial/non-support (**Figure 5**). In addition to having high percentages of non-insect and collector gatherer taxa, HF 3 also had more frequent metric scores of zero, particularly in spring and summer seasons (**Table 15**).

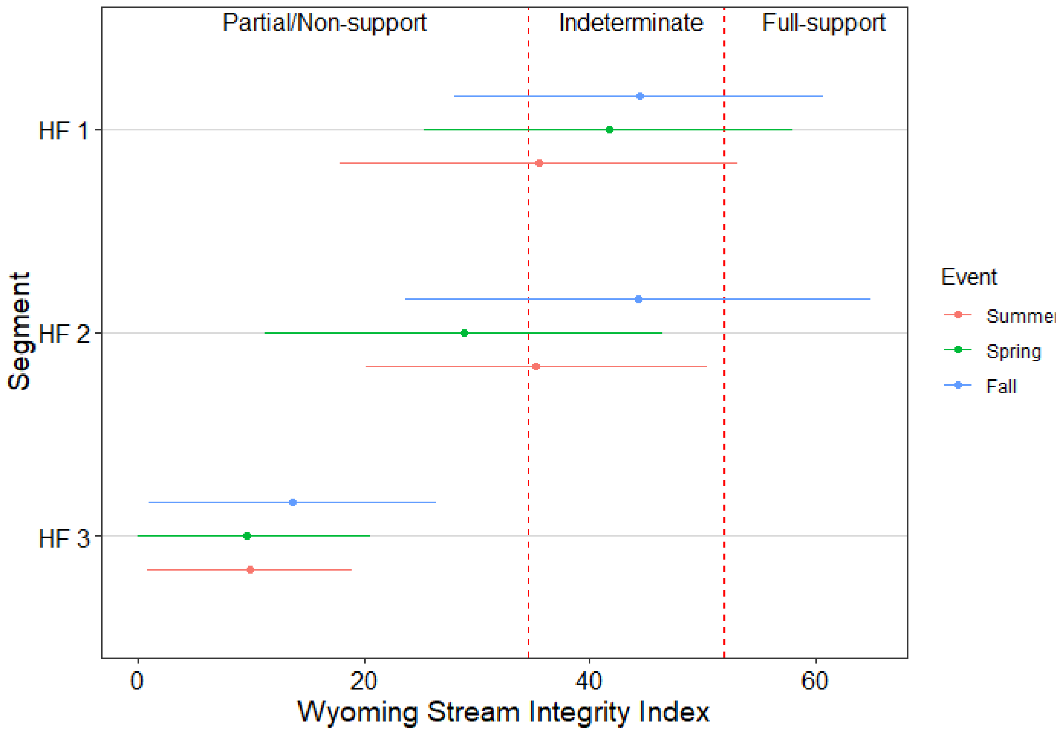

Figure 5. Composite Wyoming Stream Integrity Index scores (Wyoming basin; mean ± 95% confidence intervals) and associated aquatic life use status thresholds at three segments on Hams Fork during fall 2022, spring 2023, and summer 2023 sampling events.

3.5.2 North Fork Little Muddy Creek

In aggregate, a total of 1,651 individual macroinvertebrates from 36 unique taxa were identified from seasonal sampling (**Table 16**). Segment abundance and taxa richness overall were higher at NFLM 1 (629 individuals, 22 taxa) and NFLM 2 (680 individuals, 25 taxa) than NFLM 3 (342 individuals, 15 taxa). Dominant taxa across segments included midges of the family Chironomidae (23.1%), mayflies of the *Callibaetis* genus (15.5%), amphipods of the genus *Hyallela* (12.4%), crayfish of the genus *Faxonius* (11.2%), and snails of the genus *Physella* (10.3%). Insects mostly dominated assemblages at NFLM 1 and NFLM 2, which included chironomids (22.3-32.1%) and *Callibaetis* (17.2-20.3%). In contrast, NFLM 3 assemblages had higher abundances of non-insect taxa that included *Hyallela* (36.5%) and *Faxonius* (23.7%), though *Physella* (20.7%) was also relatively abundant at NFLM 1 (**Table 16**).

Table 16. Number of benthic macroinvertebrates by lowest taxonomic unit (LTU) collected from each survey segment in the North Fork Little Muddy Creek drainage during fall 2022, spring 2023, and summer 2023 sampling events.

Phylum	Order	Family	Genus/Species/LTU	NFLM 1	NFLM 2	NFLM 3	Overall #	Overall %
Annelida	Oligochaeta		Oligochaeta	15	28	68	111	6.7
Arthropoda	Anisoptera	Libellulidae	*Sympetrum sp.*	1	0	0	1	0.1
	Coleoptera	Dytiscidae	*Dytiscus marginicollis*	0	1	0	1	0.1
			Hydroporinae sp.	1	0	0	1	0.1
			Laccophilus maculosus	4	28	11	43	2.6
			Liodessus obscurellus	2	1	1	4	0.2
		Elmidae	*Dubiraphia sp.*	0	0	1	1	0.1
		Gyrinidae	*Gyrinus bifarius*	2	0	0	2	0.1
			Gyrinus sp. 2	1	0	0	1	0.1
		Haliplidae	*Haliplus sp.*	1	0	0	1	0.1
		Helophoridae	*Helophorus sp.*	2	1	0	3	0.2
		Hydraenidae	*Ochthebius sp.*	0	1	0	1	0.1
			Copepoda	0	1	0	1	0.1
	Diptera	Ceratopogonidae	*Bezzia* complex	0	1	4	5	0.3
			Culicoides sp.	0	0	1	1	0.1
		Chironomidae	Chironomidae	140	218	24	382	23.1
		Limoniidae	*Symplecta sp.*	0	1	0	1	0.1
		Muscidae	*Limnophora sp.*	0	1	0	1	0.1
		Simuliidae	*Simulium sp.*	0	42	0	42	2.5
		Stratiomyidae	*Nemotelus sp.*	1	0	0	1	0.1
		Tabanidae	*Tabanus sp.*	1	0	0	1	0.1
			Brachycera	0	1	0	1	0.1
	Ephemeroptera	Baetidae	*Callibaetis sp.*	108	138	10	256	15.5
		Caenidae	*Caenis sp.*	19	1	0	20	1.2
	Hemiptera	Corixidae	*Corisella decolor*	0	10	0	10	0.6
			Hesperocorixa laevigata	0	1	0	1	0.1
			Sigara sp.	2	34	3	39	2.4
		Notonectidae	*Notonecta kirbyi*	0	1	0	1	0.1
			Notonecta spinosa	0	0	1	1	0.1
	Odonata	Aeshnidae	*Anax junius*	6	0	0	6	0.4
		Coenagrionidae	*Enallagma sp.*	64	21	3	88	5.3
	Trichoptera	Hydroptilidae	*Hydroptila sp.*	32	2	0	34	2.1
	Amphipoda	Hyalellidae	*Hyallela sp.*	58	21	125	204	12.4
	Decapoda	Cambaridae	*Faxonius sp.*	29	75	81	185	11.2
			Ostracoda	10	16	4	30	1.8
Mollusca	Basommatophora	Physidae	*Physella sp.*	130	35	5	170	10.3
			Taxa Richness	**22**	**25**	**15**	**36**	
			Total Abundance	**629**	**680**	**342**	**1651**	

WSII composite scores were mostly similar across segments, excepting NFLM 1 and NFLM 2 which had relatively high scores in fall (**Table 17**, **Figure 6**). Percent non-insect taxa were substantially higher at NFLM 3, which also yielded no Trichoptera taxa during any event. Variation in metric values between seasons at NFLM 1 and NFLM 2 was mostly due to seasonal changes in the trichopteran community (**Table 17**). Most events yielded aquatic life use statuses of partial/non-support, with composite WSII scores ranging from 4.8 to 28.0. NFLM 1 in fall was the only sampling event that produced an aquatic life use status higher than partial/non-support (35.6, indeterminate), as shown in **Table 17** and **Figure 6**.

4.0 Discussion and Conclusions

Data presented in previous sections characterize fish and benthic macroinvertebrate communities in two streams potentially impacted by construction and operation of Kemmerer Unit 1 and associated infrastructure. The information in this report is based on seasonal surveys conducted in October 2022 (fall), June 2023 (spring), and August 2023 (summer). Within Hams Fork, these surveys documented 10 fish species ranging from native cold-water salmonids such as Mountain Whitefish to non-native generalist species such as Fathead Minnow. Of the 10 species collected, only the Speckled Dace, Mountain Sucker, and Mountain Whitefish are originally native to the upper Green River basin (Baxter and Stone 1995; WGFD 2017). Data provided by Wyoming Game and Fish Department (WGFD) show five fish collections within the mainstem Hams Fork in this general area (Kemmerer City Reservoir downstream to Kemmerer, Wyoming) from 2002 to 2004 (J. Lockwood, WGFD, e-mail to P.R. Moore, May 12, 2022). Collectively, these surveys documented the same 10 species (disregarding rare sucker hybrids and unknowns).

Both fish and benthic macroinvertebrate community composition were relatively similar between the two upstream segments (HF 1 and HF 2) which were comprised mainly of run and riffle habitats with cobble and gravel substrates. In these segments, Redside Shiner, White Sucker, and Longnose Dace were the numerically dominant fish species, and mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera), indicators of good water quality, were common in the macroinvertebrate community. In contrast, HF 3 was deeper, with slower velocities and siltier substrates due to impoundment by a small dam/intake structure. Here, certain small-bodied cyprinids adapted to shallow swift waters (i.e., Longnose Dace and Speckled Dace) were less abundant or absent whereas non-native Fathead Minnows increased in abundance. Fathead Minnow are typically found in quiet ponds, pools, and backwaters within their native range east of the Rocky Mountains (Minckley 1959; Deacon 1961). Similarly, benthic macroinvertebrate sampling documented decreased abundance or absence of mayflies, stoneflies, and caddisflies at HF 3 and increased dominance of worms (Oligochaeta) and midges (Chironomidae).

Both total fish abundance and electrofishing CPUE at Hams Fork decreased from upstream (HF 1) to downstream (HF 3). Reduced abundance and catch rates at HF 3 were likely due to habitat differences which limited the abundance of certain small-bodied cyprinids, as noted above. Interestingly, minnow trap CPUE exhibited an opposite trend of electrofishing CPUE, being highest at HF 3 and lower at upstream segments. This suggests that baited minnow traps may be

Table 17. Metric values and scores for calculating the Wyoming Stream Integrity Index (Wyoming Basin) at three segments in the North Fork Little Muddy Creek drainage during fall 2022, spring 2023, and summer 2023 sampling events. Composite WSII scores for each segment/season are in bold text.

	Fall		**Spring**		**Summer**	
Metric	**Value**	**Score**	**Value**	**Score**	**Value**	**Score**
North Fork Little Muddy Creek 1						
No. Ephemeroptera Taxa	2	22.2	1	11.1	0	0.0
No. Trichoptera Taxa	1	11.1	0	0.0	0	0.0
No. Plecoptera Taxa	0	0.0	0	0.0	0	0.0
% Non-insect	28.3	62.0	44.8	30.1	75.0	0.0
% Plecoptera	0.0	0.0	0.0	0.0	0.0	0.0
% Trichoptera (less Hydropsychidae) (% within Trichoptera)	100.0	100.0	0.0	0.0	0.0	0.0
% Collector-gatherer	55.8	53.1	82.8	17.5	75.0	27.7
% Scraper	29.6	76.6	0.0	0.0	0.0	0.0
HBI	7.6	11.5	6.0	35.9	6.6	27.0
No. Semivoltine Taxa (less semivoltine Coleoptera)	1	20.0	0	0.0	1	20.0
Composite WSII Score		**35.6**		**9.5**		**7.5**
North Fork Little Muddy Creek 2						
No. Ephemeroptera Taxa	2	22.2	0	0.0	0	0.0
No. Trichoptera Taxa	1	11.1	0	0.0	0	0.0
No. Plecoptera Taxa	0	0.0	0	0.0	0	0.0
% Non-insect	15.0	80.0	63.2	1.3	58.5	8.7
% Plecoptera	0.0	0.0	0.0	0.0	0.0	0.0
% Trichoptera (less Hydropsychidae) (% within Trichoptera)	100.0	100.0	0.0	0.0	0.0	0.0
% Collector-gatherer	74.2	28.8	68.4	36.4	58.5	49.6
% Scraper	7.3	19.0	0.0	0.0	0.0	0.0
HBI	7.1	18.9	5.3	46.4	5.3	47.1
No. Semivoltine Taxa (less semivoltine Coleoptera)	0	0.0	0	0.0	0	0.0
Composite WSII Score		**28.0**		**8.4**		**10.5**
North Fork Little Muddy Creek 3						
No. Ephemeroptera Taxa	1	11.1	0	0.0	1	11.1
No. Trichoptera Taxa	0	0.0	0	0.0	0	0.0
No. Plecoptera Taxa	0	0.0	0	0.0	0	0.0
% Non-insect	58.9	20.5	100.0	0.0	89.8	0.0
% Plecoptera	0.0	0.0	0.0	0.0	0.0	0.0
% Trichoptera (less Hydropsychidae) (% within Trichoptera)	0.0	0.0	0.0	0.0	0.0	0.0
% Collector-gatherer	88.4	10.1	87.5	11.2	91.7	5.7
% Scraper	2.3	6.0	12.5	32.4	0.5	1.3
HBI	5.7	40.0	8.0	4.7	6.2	33.3
No. Semivoltine Taxa (less semivoltine Coleoptera)	0	0.0	0	0.0	0	0.0
Composite WSII Score		**8.8**		**4.8**		**5.1**

more effective in the slower moving waters at HF 3 compared to the generally swifter upstream segments.

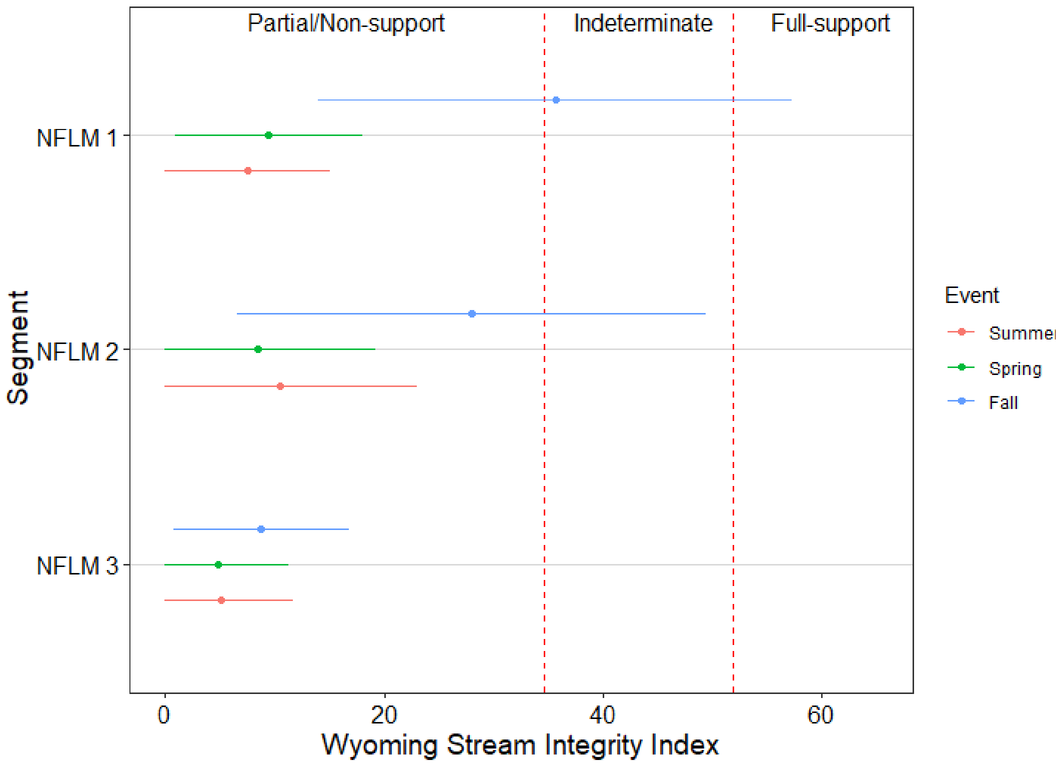

Figure 6. Composite Wyoming Stream Integrity Index scores (Wyoming basin; mean ± 95% confidence intervals) and associated aquatic life use status thresholds at three segments in the North Fork Little Muddy Creek drainage during fall 2022, spring 2023, and summer 2023 sampling events.

Among seasons, species richness, abundance, and CPUE of both fish sampling methods at Hams Fork were lowest in spring 2023, due to high flow conditions which limited sampling efficiency. The same metrics were all highest in fall 2022, perhaps because many young-of-year fishes grow to catchable size by October. Alternatively, differences observed between fall 2022 and summer 2023 could have been influenced by inter-annual variability in recruitment or a variety of other factors. Similarly, composite WSII scores were generally highest in fall 2022 and lower in spring 2023 and summer 2023. Differences in macroinvertebrate community composition between seasons may be influenced by intra-annual ontogenetic patterns in life cycles of resident insect taxa (Johnson et al. 2012), among other factors.

Within the North Fork Little Muddy Creek drainage, seasonal surveys at the three survey segments documented seven fish species, of which only the Speckled Dace and Mountain Sucker are originally native to the drainage (Baxter and Stone 1995; WGFD 2017). Data provided by

WGFD show five fish collections within this general reach of North Fork Little Muddy Creek (from Naughton Power Plant to confluence with Little Muddy Creek) from 2004 to 2018 (J. Lockwood, WGFD, e-mail to P.R. Moore, May 12, 2022). Collectively, these surveys also document seven species, but two of the collections document Roundtail Chub *Gila robusta*, which was not observed in this study. On the other hand, none of the WGFD collections list Longnose Dace, which was observed in this study. Roundtail Chub was rare in WGFD collections (0.4% relative abundance; 2,844 fishes collected), and the species' absence in this study (189 fishes collected) may just reflect inherent sampling variability associated with a lower sample size. Longnose Dace have become established in the Hams Fork drainage, presumably introduced by bait fishermen (Baxter and Stone 1995) and were documented in the mainstem Hams Fork during this study. The reason for its absence from previous North Fork Little Muddy Creek collections is unclear. It should be noted that Longnose Dace and Speckled Dace are closely related species that are known to hybridize in areas where Longnose Dace have been introduced (Sigler and Miller 1963).

Total abundance and richness of fishes was lowest at NFLM 1 and higher at downstream segments, but an opposite trend was observed in macroinvertebrate richness and abundance, being lowest at the downstream segment (NFLM 3). This may reflect the influence of fish predation on macroinvertebrate communities in a small stream environment. However, a variety of other potential mechanisms may be influencing fish and macroinvertebrate communities within this effluent-dominated system and additional data are needed under varying hydrologic conditions to better understand exact mechanisms behind the spatial and temporal patterns observed.

Overall electrofishing CPUE was low in the North Fork Little Muddy Creek drainage, and in contrast to Hams Fork, minnow traps collected more fish here than electrofishing. This demonstrates the effectiveness of baited minnow traps in such small stream environments. Additionally, it should be noted that backpack electrofishing efficiency was often limited due to turbidity.

Among seasons in North Fork Little Muddy Creek, species richness, total fish abundance, and catch rates from both fish sampling methods were low in spring 2023. Although flow in North Fork Little Muddy Creek did not fluctuate as drastically as in Hams Fork, rainstorms during spring 2023 sampling did result in high muddy water at some survey segments, which may have influenced catch rates. As observed at Hams Fork, macroinvertebrate composite WSII scores were generally highest in fall 2022 and lower in spring 2023 and summer 2023. Seasonal differences in macroinvertebrate communities may be influenced by life cycle timing of resident insect fauna and potential interactions with abiotic disturbances (Johnson et al. 2012, Ofogh et al. 2023). For example, zero flow conditions observed on August 22, 2023 may have influenced macroinvertebrate community composition, as most invertebrates observed in summer 2023 can burrow into the substrate or have adult life stages that can fly (Coleoptera, Hemiptera). It's unknown how often zero flow conditions occur in this portion of North Fork Little Muddy Creek.

Results of this study in context with previously available information from WGFD provide useful baseline data on aquatic habitat, fish communities, and benthic macroinvertebrate communities that will aid in assessing potential impacts from Project construction and operation. Continued monitoring of the established survey segments is recommended to allow evaluation of potential temporal changes in aquatic communities as Kemmerer Unit 1 construction and operation progress. Based on results from this study, and to allow comparisons to existing data, monitoring is recommended annually in August and/or October, as annual peaks in discharge associated with spring snow melt in this region result in decreased fish capture efficiencies in spring and early summer months. Additionally, when seasonal variation in macroinvertebrate communities exist, indices generated during base flow periods of summer and fall have shown the best bioassessment performance (Ofogh et al. 2023).

5.0 References

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Appendix A. Photos

Figure A1. Segment HF 1 during August 2022 reconnaissance.

Figure A2. Segment HF 2 during August 2022 reconnaissance.

Figure A3. Segment HF 3 during August 2022 reconnaissance event showing dam (lower photo) and upstream pool (upper photo).

Figure A4. Segment NFLM 1 during August 2022 reconnaissance.

Figure A5. Segment NFLM 2 during August 2022 reconnaissance.

Figure A6. Segment NFLM 3 during August 2022 reconnaissance.

Figure A7. BIO-WEST and Tetra Tech personnel barge electrofishing at segment HF 2 in fall 2022.

Figure A8. Backpack electrofishing at NFLM 2 during spring 2023.

Figure A9. Minnow trap set at HF 2 in fall 2022.

Figure A10. Macroinvertebrate sampling with D-net at HF 1 in fall 2022.

Figure A11. Longnose Dace (*Rhinichthys cataractae*) captured from Hams Fork.

Figure A12. Mountain Sucker (*Catostomus platyrhynchus*) captured from North Fork Little Muddy Creek.

Figure A13. Redside Shiner (*Richardsonius balteatus*) captured from North Fork Little Muddy Creek.

Figure A14. Speckled Dace (*Rhinichthys osculus*) captured from Hams Fork.

Figure A15. Brown Trout (*Salmo trutta*) captured from Hams Fork.

Figure A16. Mountain Whitefish (*Prosopium williamsoni*) captured from Hams Fork.

Figure A17. Rainbow Trout (*Oncorhynchus mykiss*) captured from Hams Fork.

Figure A18. White Sucker (*Catostomus commersonii*) captured from Hams Fork.

Figure A19. Fathead Minnow (*Pimephales promelas*) captured from North Fork Little Muddy Creek.


Figure A20. Mountain Sucker (*Catostomus platyrhynchus*) captured from Hams Fork.

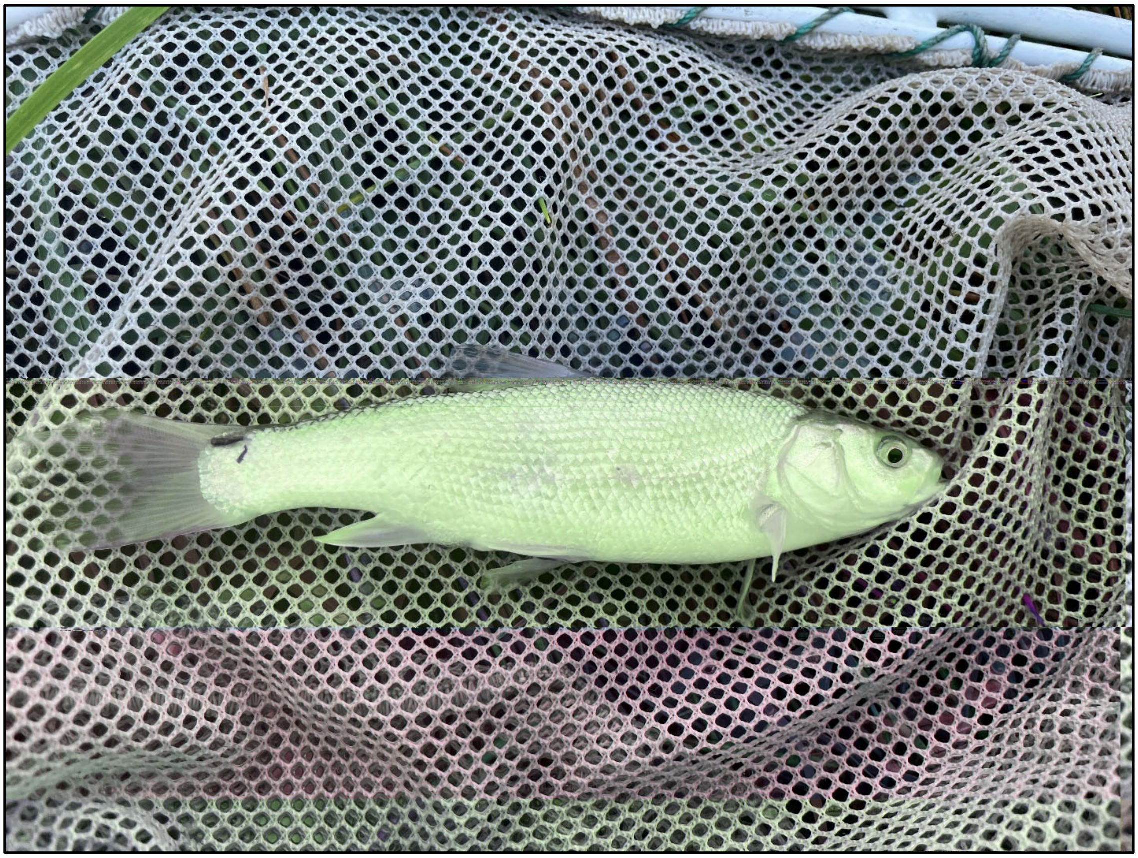

Figure A21. Utah Chub (*Gila atraria*) captured from North Fork Little Muddy Creek.

Appendix B. Length-frequency Histograms

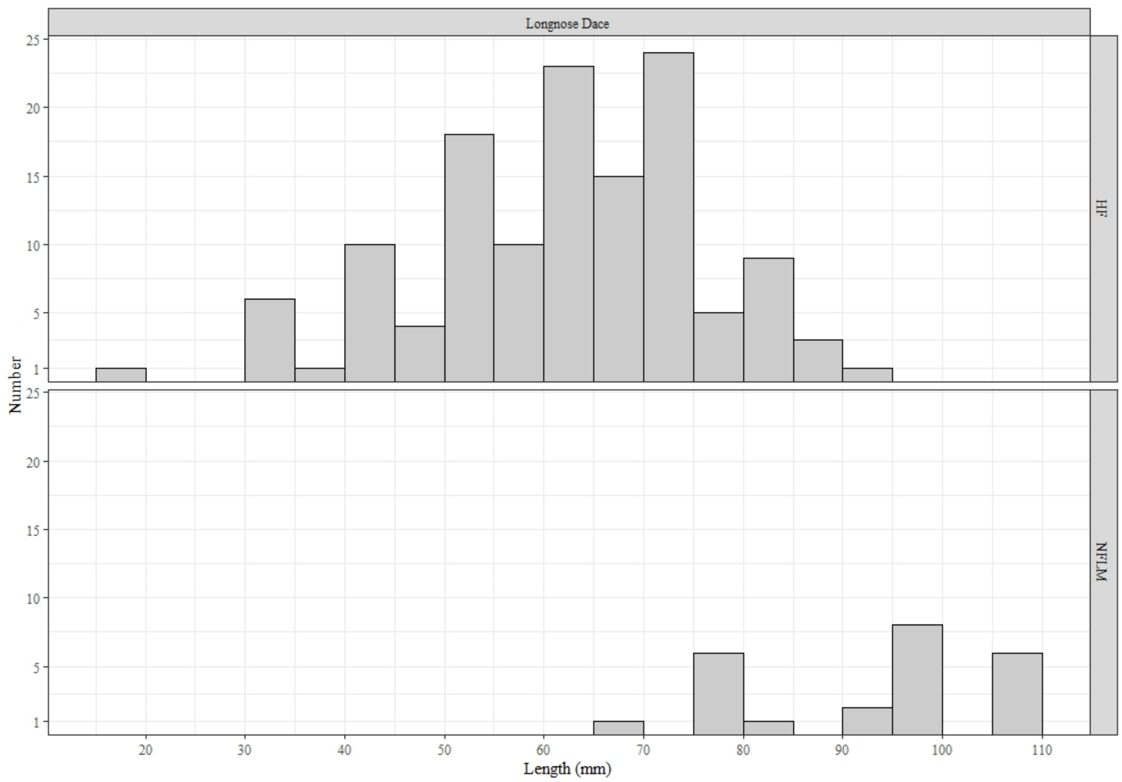

Figure B1. Length-frequency histogram for Longnose Dace captured from Hams Fork (top) and North Fork Little Muddy Creek (bottom).

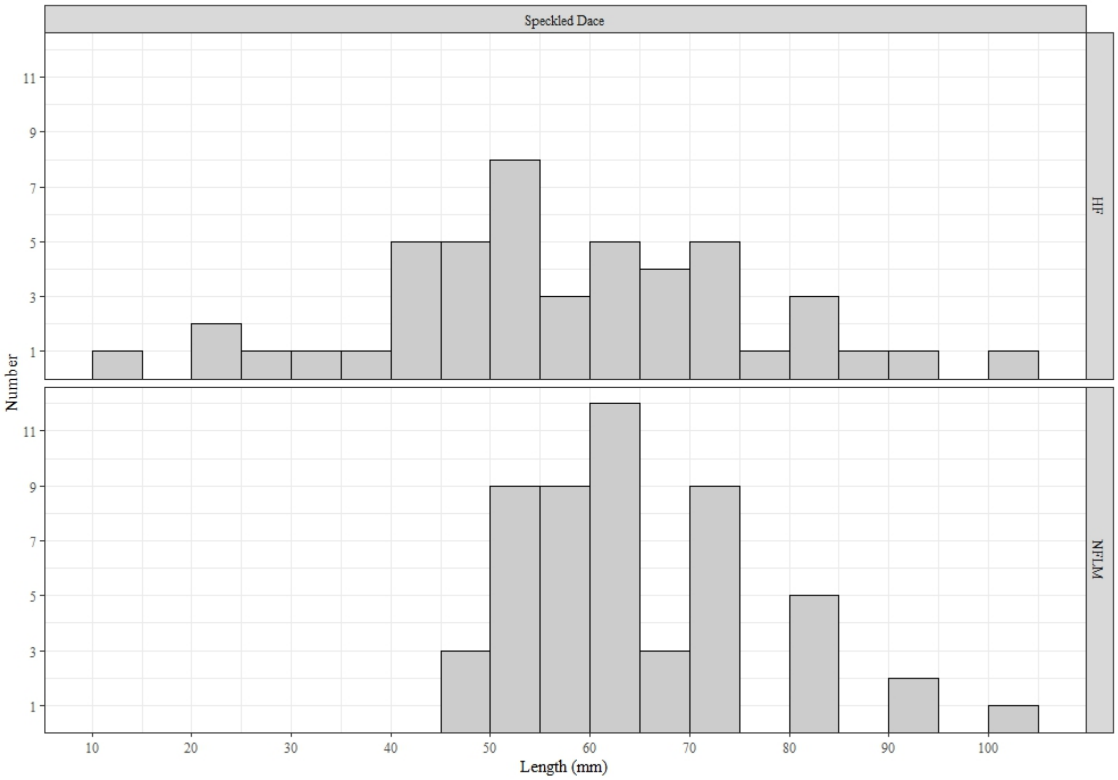

Figure B2. Length-frequency histograms for Speckled Dace captured from Hams Fork (top) and North Fork Little Muddy Creek (bottom).

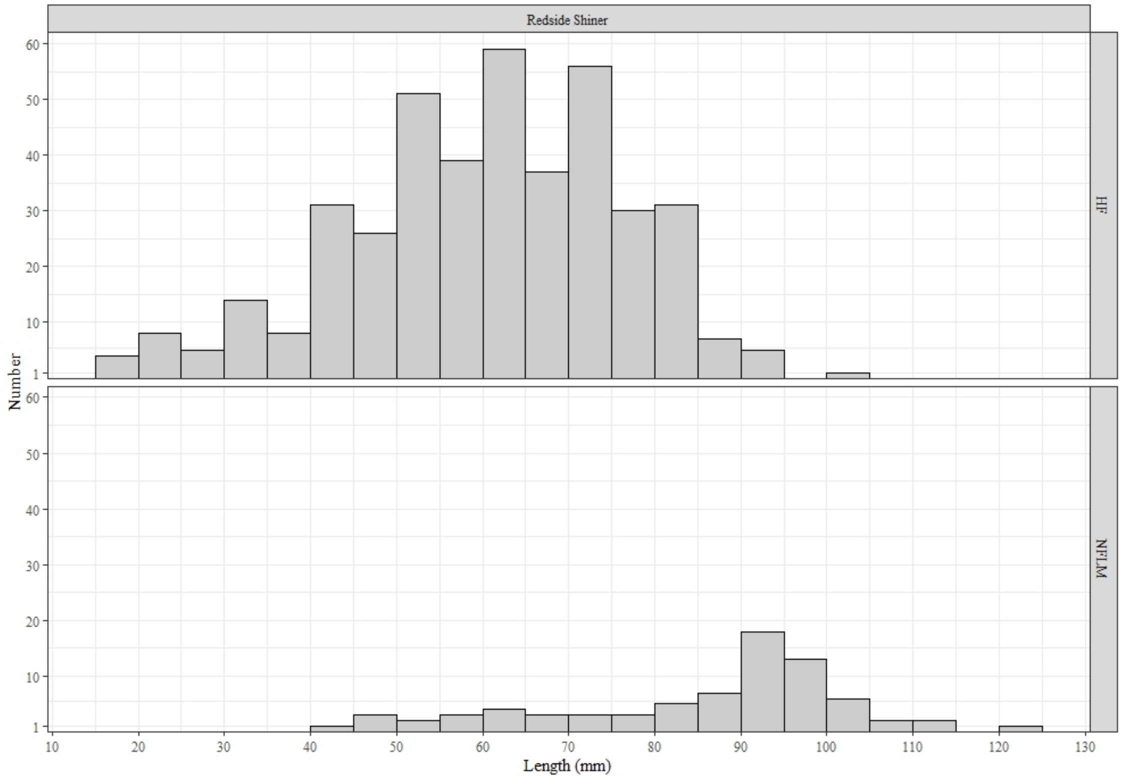

Figure B3. Length-frequency histograms for Redside Shiner captured from Hams Fork (top) and North Fork Little Muddy Creek (bottom).

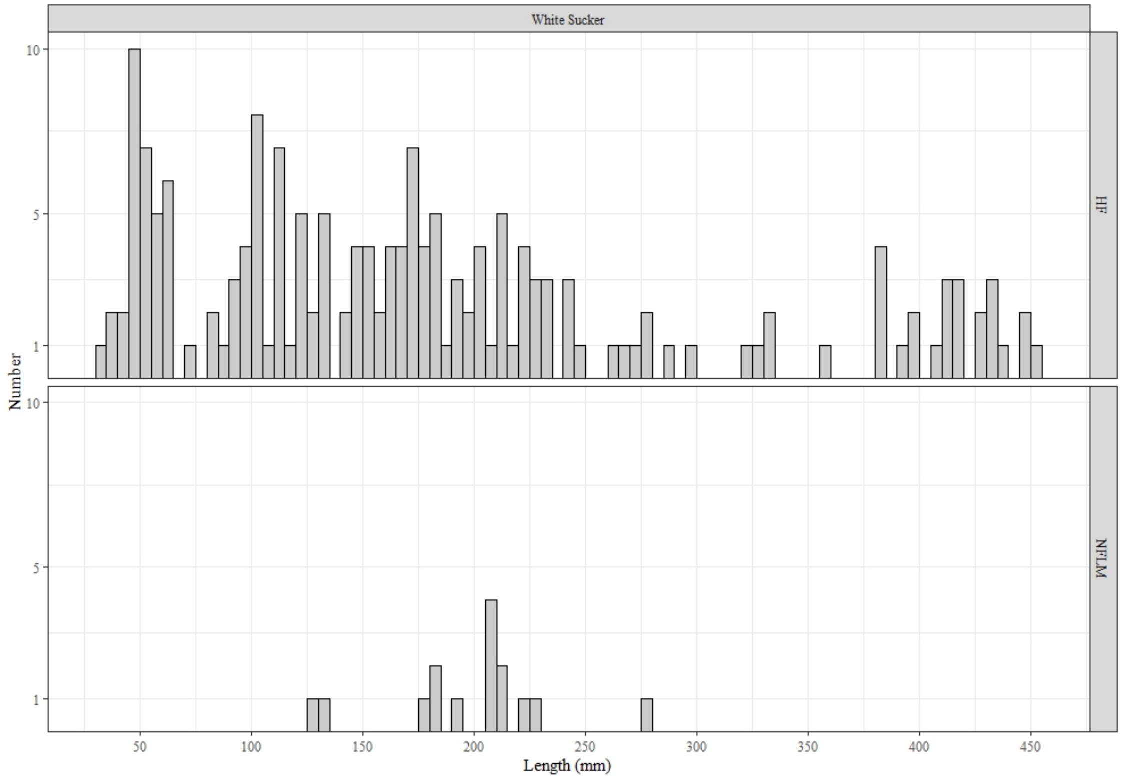

Figure B4. Length-frequency histograms for White Sucker captured from Hams Fork (top) and North Fork Little Muddy Creek (bottom).

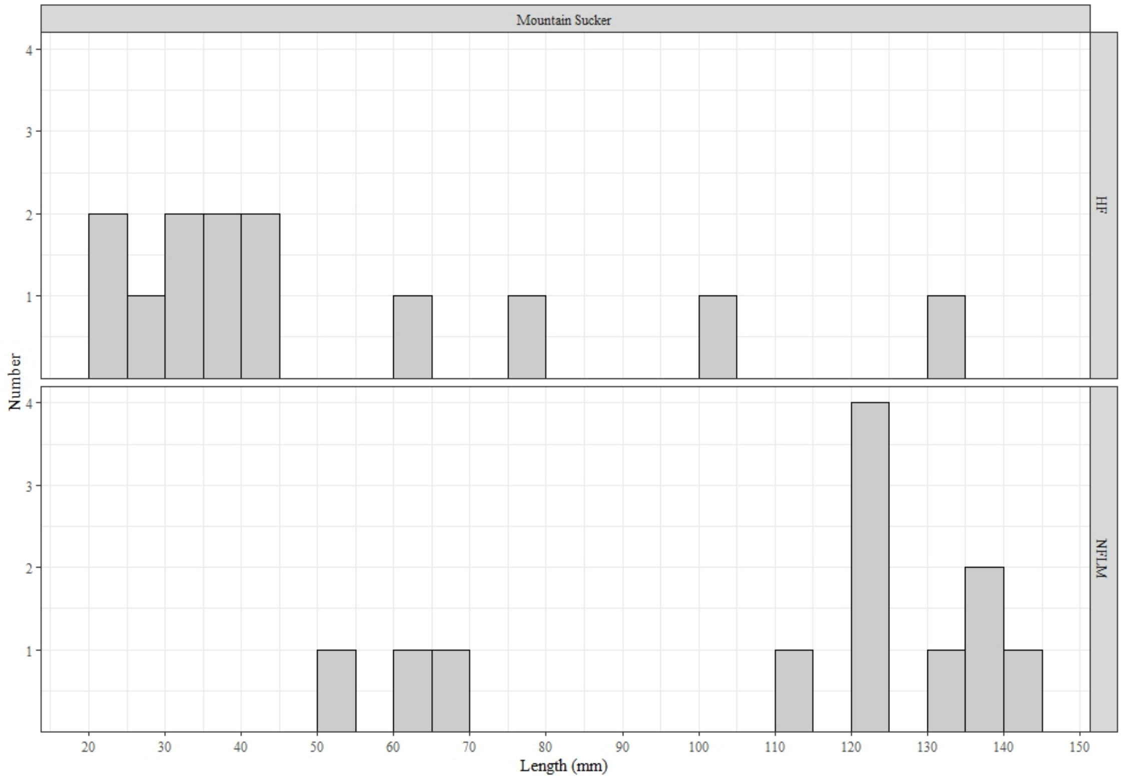

Figure B5. Length-frequency histograms for Mountain Sucker captured from Hams Fork (top) and North Fork Little Muddy Creek (bottom).