2019 Madison River Drainage 2188 Project Monitoring Report

to

Northwestern Energy

Environmental Division

Butte, MT

By

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Montana Fish, Wildlife & Parks

INTERNET WEB PAGES CITED IN THIS REPORT, OR OF LOCAL INTEREST
(In alphabetical order)

Aquatic Nuisance Species Task Force	www.anstaskforce.gov
Madison River Foundation	www.madisonriverfoundation.org
Lower Madison River Monitoring page	www.madisondss.com/madison.php
Montana Fish, Wildlife, & Parks	www.fwp.mt.gov
Northwestern Energy	northwesternenergy.com
Stop Aquatic Hitchhikers	http://stopaquatichitchhikers.org
Quake Lake bathymetric map	http://fwp.mt.gov

FWP personnel took all photos in this report unless otherwise credited.

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Executive Summary

There were ten monitoring activities or projects completed in the Madison river basin pursuant to the 2188 project FERC license articles in 2019. Long-term abundance monitoring for rainbow and brown trout in the two established sections of the upper Madison River was conducted. Estimated abundances of brown and rainbow trout declined below 20-year averages in the upper Madison River. Water temperature was monitored at 12 sites and air temperature at 6 sites; results are displayed in Appendix A1-A3. The average length of rainbow trout captured during annual Hebgen Reservoir fisheries assessment remained above long-term averages at 16.3 inches. Additionally, the proportion of rainbow trout over 14 inches has increased noticeably since 2005. Zooplankton density in Hebgen Reservoir was monitored and temporal trends are displayed in this report. Ennis Reservoir gillnet catch trends showed a decrease in Utah chub and an increase in rainbow trout. A stream restoration project to improve fish habitat and ranch operations was initiated on South Meadow Creek, a tributary to Ennis Reservoir. 65,000 Arctic grayling eggs were introduced into Madison River tributaries as part of the Madison Artic grayling re-introduction plan. A migration barrier was constructed in Tepee Creek for possible reintroduction of westslope cutthroat trout. Redd counts and core sampling were conducted at established monitoring sites in the Madison River.

Introduction

Montana Fish, Wildlife & Parks (FWP) has conducted studies in the Madison River Drainage to assess the effects of hydropower operations at Hebgen and Ennis dams on fisheries since 1990 (Byorth and Shepard 1990, Clancey 1995, Clancey 1996, Clancey 1997, Clancey 1998a, Clancey 1999, Clancey 2000, Clancey and Downing 2001, Clancey 2002, Clancey 2003, Clancey 2004, Clancey and Lohrenz 2005, Clancey 2006, Clancey 2007, Clancey 2008, Clancey and Lohrenz 2009, Clancey and Lohrenz 2010, Clancey and Lohrenz 2011, Clancey and Lohrenz 2012, Clancey and Lohrenz 2013, Clancey and Lohrenz 2014, Clancey and Lohrenz 2015, Moser and Lohrenz 2016, Moser and Lohrenz 2017). This work has been funded through an agreement with the owner and operator of the dams. The dams were owned by Montana Power Company (MPC) until 1999 and then PPL Montana until November 18, 2014, when they were purchased by Northwestern Energy (NWE). The original agreement between FWP and MPC to fund this work was designed to anticipate Federal Energy Regulatory Commission (FERC) relicensing requirements for MPC's hydropower system on the Madison and Missouri rivers. This includes Hebgen and Ennis dams, as well as seven dams on the Missouri River collectively referred to by FERC as the 2188 Project (Figure 1). In 2000 the FERC issued NWE a license to operate the 2188 Project for 40 years (FERC 2000). The license details the terms and conditions NWE must meet, including fish, wildlife, recreation protection, mitigation, and enhancement measures. NWE has convened committees with annual budgets and authority to spend mitigation funds to address fisheries, wildlife, water quality, and recreation issues pursuant to license requirements. The Madison Fisheries Technical Advisory Committee (MadTAC) is composed of representatives from NWE, FWP, the U.S. Fish & Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the U.S. Bureau of Land Management (BLM).

This report summarizes work FWP completed in 2019 with funding provided by the MadTAC to address license requirements of FERC project 2188. Work included 1) fish abundance assessments in the Madison River, 2) assessment of fish populations in Hebgen and Ennis reservoirs, 3) conservation and restoration of Arctic grayling populations, 4) conservation and restoration of westslope cutthroat trout populations, and 5) enhancement and restoration of tributary streams.

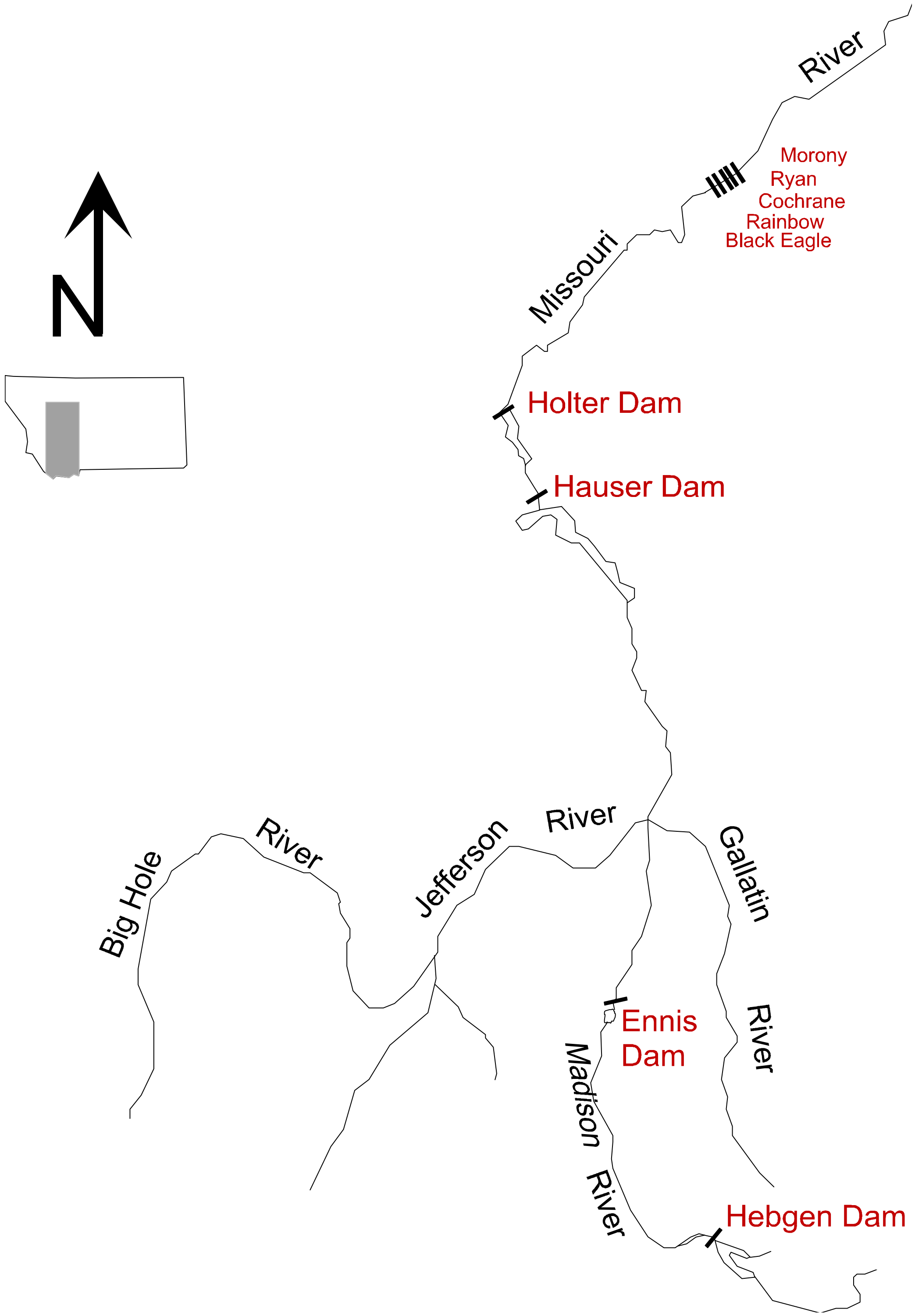

Figure 1. - Locations of NWE dams on the Madison and Missouri rivers (FERC Project 2188)

Article 403 – River Discharge

Minimum and maximum instream flows in various sections of the Madison River are mandated in Article 403 and in Condition No. 6 of the FERC license to NWE. Specifically, Condition 6 in its entirety states: "*During the operation of the facilities authorized by this license, the Licensee shall maintain each year a continuous minimum flow of at least 150 cfs in the Madison River below Hebgen Dam (gage no. 6-385), 600 cfs on the Madison River at Kirby Ranch (USGS gage no. 6-388), and 1,110 cfs on the Madison River at gage no. 6-410 below the Madison development. Flows at USGS gage no. 6-388 (Kirby Ranch) are limited to a maximum of 3,500 cfs under normal conditions excepting catastrophic conditions to minimize erosion of the Quake Lake spillway. License requirements also require the :Establish[ment] a permanent flow gauge on the Madison River at Kirby Ranch (USGS Gauge No. 6-388).* FWP and NWE continue to jointly monitor river flows to avoid deviations from operational conditions. NWE conducted a leakage test of the Madison Dam September 11-13 per FERC requirements. FWP was notified of the test and granted consent. Minimum flow requirements at USGS gage no 6-410 were maintained during the test and flow was maintained in the bybass reach directly below the dam at 104cfs, 24cfs more than the 80cfs instantaneous minimum maintenance flow requirement for the time period July1-March 31. No deviation from the conditions for flow requirements in article 403 occurred.

Article 408- 1) Effects of project operations on Hebgen Reservoir fish populations; 3) Reservoir draw down effects on fish; 4) Monitor the effects of modified project operations on upper Madison River fish populations 7) Monitor species of special concern.

Hebgen Reservoir Fisheries Assessment

FWP conducts annual gillnetting in Hebgen Reservoir using 125-foot variable mesh experimental gillnets to monitor trends in reservoir fish assemblages for the purpose of assessing the effects of project operations. Gross changes in reservoir fish assemblage trends would warrant a review of and potential change to project operations to address identified issues. Sampling yielded 1,277 fish (Table 1). Utah chub comprised 65.7% of the sample, brown trout 17.5%, rainbow trout 10.9%, and mountain whitefish 5.9%, respectively. Utah chub are the most abundant fish species in Hebgen Reservoir and have comprised the majority of fish sampled during annual gillnetting since its inception (Figure 2). Brown trout relative abundance and mean length have trended slightly upward since 2014. The mean number per net of brown trout sampled in gill nets has ranged from 2.3/net in 2001, to 12.5/net in 1999 (Figure 3). The number/net of mountain whitefish decreased to 2.8/net from 4.4/net observed in 2018 (Figure 4). Average length of rainbow trout sampled has remained fairly stable since 2010, ≥16.0. This is an approximate 1.5- inch increase in average length from those observed in the mid 90's through the early 2000's, ≥ 14.5 inches. Rainbow trout per/net was the highest observed since hatchery supplementation of the Hebgen rainbow trout fishery was halted by FWP with a mean 5.5/net (Figure 5). Based upon current trend data no recommendations to NWE for a change in project operations is warranted.

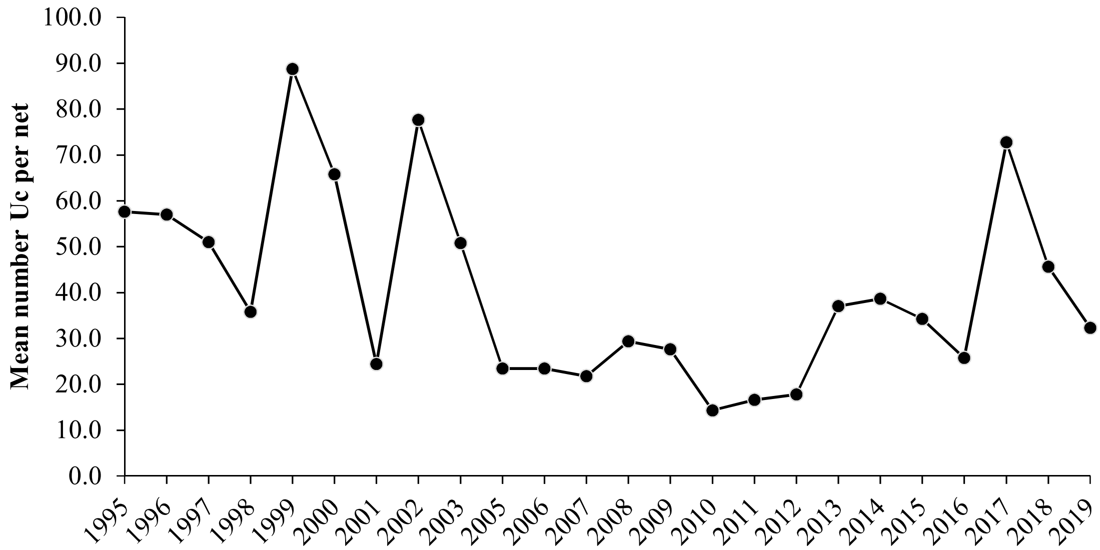

Figure 2 . Mean number of Utah chub (Uc) per net 1995-2019.

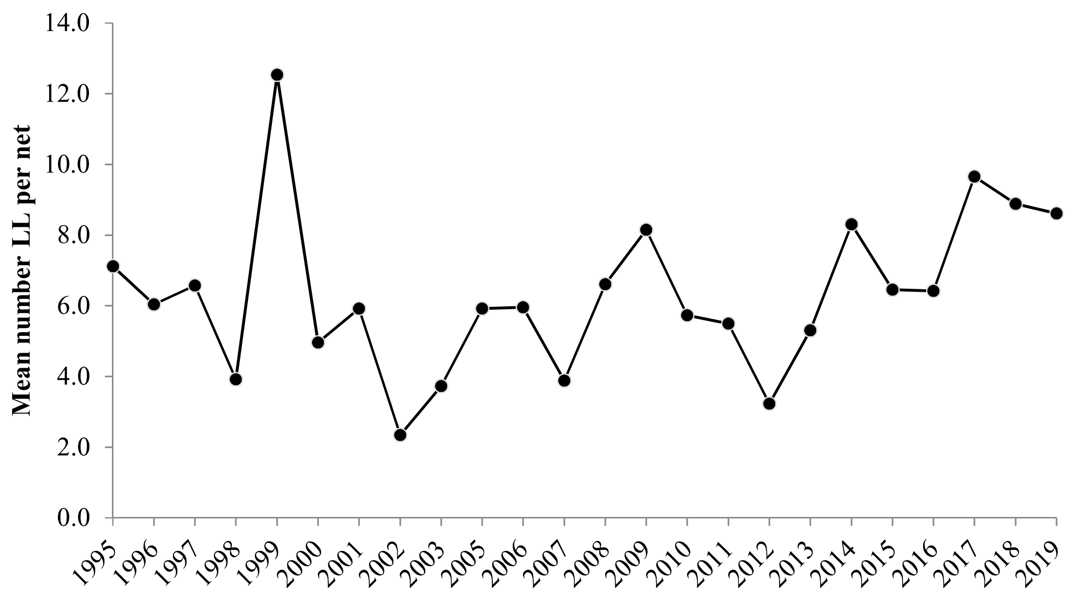

Figure 3 . Mean number of brown trout (LL) per net 1995-2019.

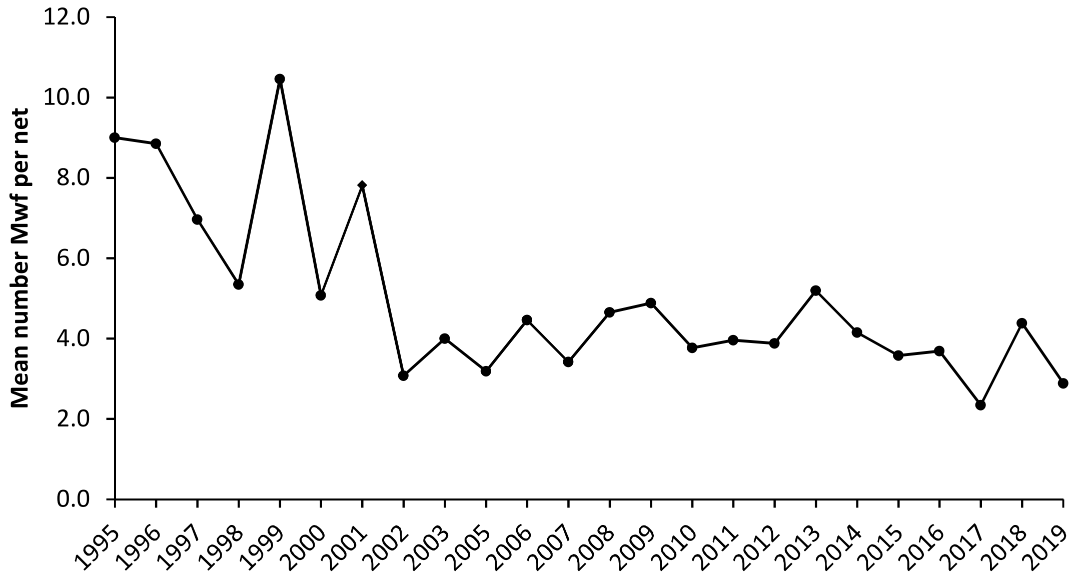

Figure 4 . Mean number of mountain whitefish (Mwf) per net 1995-2019.

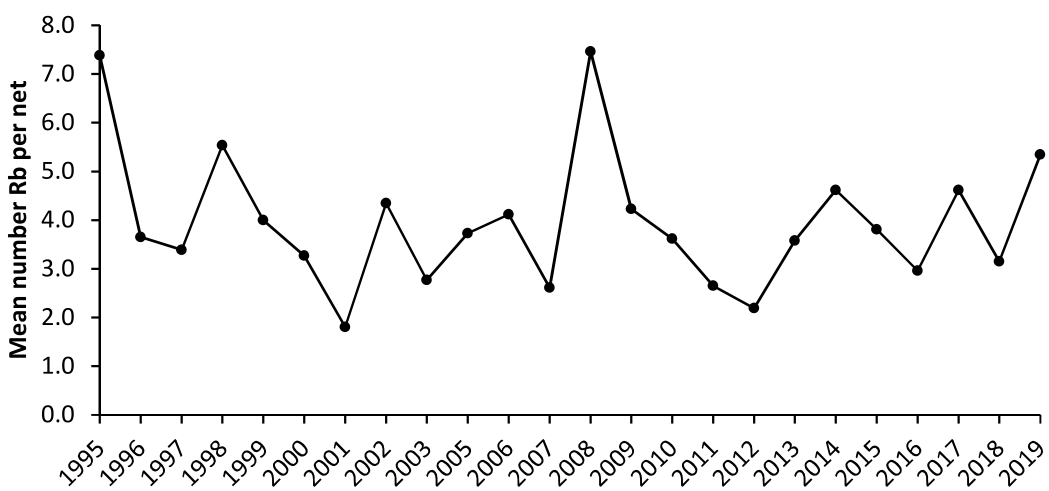

Figure 5 . Mean number of rainbow trout (Rb) per net 1995-2019.

Table 1.- Hebgen Reservoir rainbow trout, brown trout, mountain whitefish, Utah chub catch per unit effort (C/*f*) ± SE, mean length, mean length tested at 95% confidence (CI), mean weight, mean weight tested at 95% confidence.

Species	C/*f* number per net	Mean length	Upper 95% CI	Lower 95% CI	Mean weight	Upper 95% CI	Lower 95% CI
Rainbow trout	5.5±1.4	16.3	16.4	16.3	1.54	1.55	1.53
Brown trout	8.6±2.3	17.6	17.6	17.5	1.91	1.92	1.90
M.whitefish	2.8±0.83	16.0	16.1	15.9	1.67	1.83	1.50
Utah chub	32.3±7.6	10.3	10.4	10.2	0.45	0.45	0.45

Hebgen Reservoir Trophic Status

FWP began monitoring the trophic status of Hebgen Reservoir in 2006 while investigating potential limiting factors to wild rainbow trout recruitment to the Hebgen Reservoir fishery and if any potential change to operational guidelines, such as reservoir draw down, could affect reservoir productivity. Monitoring of Hebgen Reservoir trophic status consists of taking secchi disk measurements in conjunction with zooplankton tows to establish a Trophic State Index number (TSI) (Carlson 1977).

A Secchi disk is used to measure light penetration (in meters) into the Hebgen Reservoir water column. Secchi depths are recorded as the distance from the water surface to the point in the water column where the disk colors became indiscernible.

Monthly zooplankton tows are conducted at nine established sites on Hebgen Reservoir to evaluate plankton community densities and composition. Plankton samples are collected with a Wisconsin® plankton net with 153-micron mesh (1 micron = 1/1,000th millimeter) towed vertically through the entire water column at one meter per second. Tows are taken preferably at locations with a minimum depth of 10 meters. Samples are rinsed and preserved in a 95% ethyl alcohol solution for enumeration. Zooplankton are identified to groups, cladocera or copepoda, and densities from each sample are calculated.

Applying the Trophic State Index (TSI) (Figure 6) developed by Carlson (1977), Hebgen Reservoir has been classified as oligotrophic-mesotrophic for all years monitoring has occurred. The highest mean TSI score and zooplankton abundances for years data are available occurs in the month of June (Figure 7).

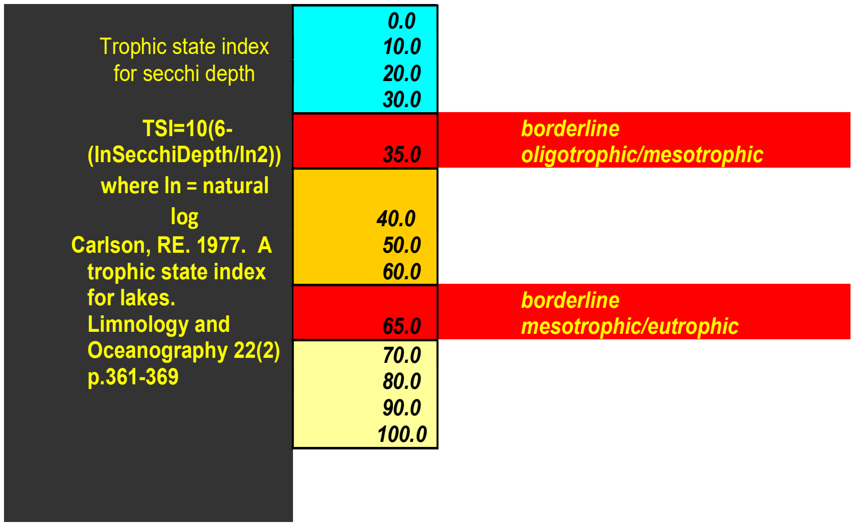

Figure 6. - Trophic State Index (TSI) developed by Carlson (1977).

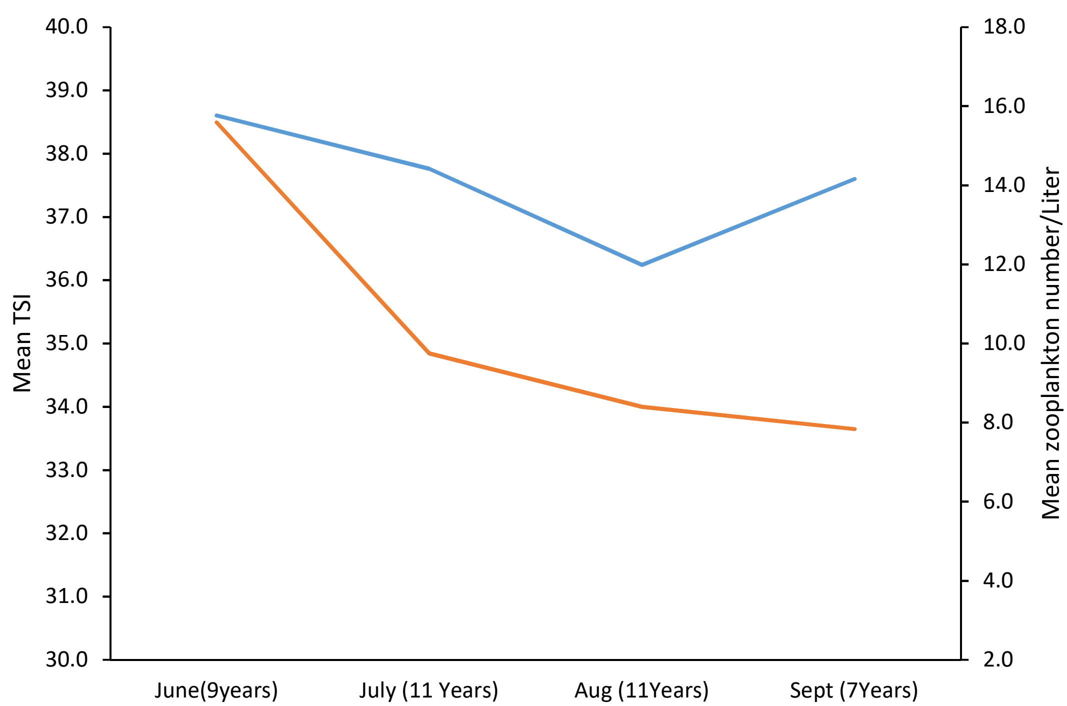

Figure 7. Mean TSI scores and zooplankton abundance by month for years data exists. The blue line is TSI and red line is zooplankton abundance.

Zooplankton group abundance varied by month and trends in total abundance show peak densities occurring in late spring and early summer (Figure 8). Mean abundance in June samples was 17.4 individuals/L, the highest density observed during the year with copepoda constituting 57% and cladocera 43% of the sample. Copepoda was the dominant zooplankton group observed in samples throughout the sampling period; July (64%), August (65%), respectively.

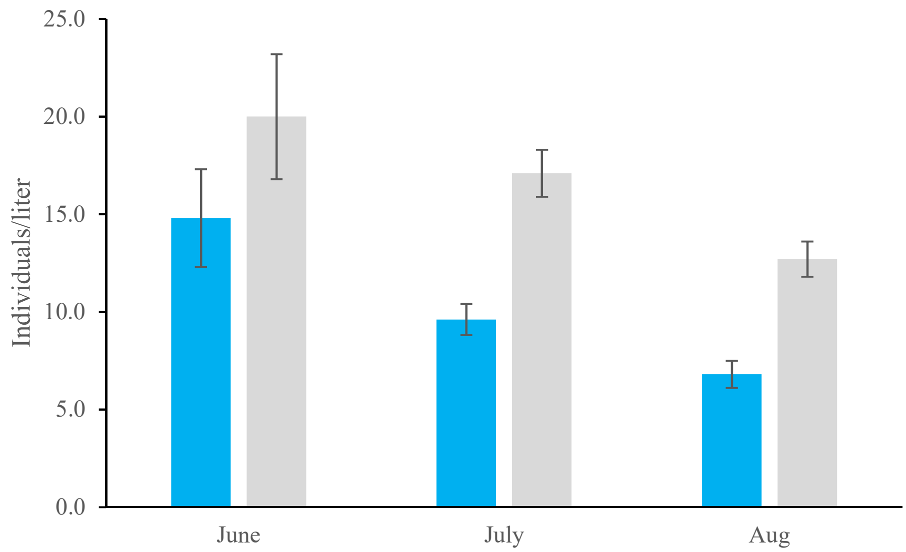

Figure 8. - Mean Cladocera and copepoda abundance (zooplankton/liter) reservoir wide June-Aug 2019. Cladocera are represented by blue column and copepoda gray column. Error bars are 95% confidence interval.

Primary productivity in Hebgen Reservoir may be limited by elevation and residence time Johnson and Martinez (2000). With a full pool elevation of 6,534.87 feet, Hebgen Reservoir may be more characteristic of a high elevation lake with a short growing season allowing for relatively few days of primary production. Additionally, increases in discharge from Hebgen could affect the duration nutrients required for primary production stay in the reservoir. No changes to project operations have been considered at this time but monitoring will continue.

Madison River Fisheries Assessment

FWP conducts abundance estimates annually in two established monitoring sections in the upper Madison River to evaluate fish abundance and the influence of project operations and mitigation and enhancement measures (PM&E) on them.

Electrofishing from a drift boat mounted mobile anode system (Figure 9) is the principle method used to monitor trout abundances in the Madison River.

Figure 9. - Mobile anode electrofishing (shocking) in the Norris section of the Madison River.

Fish captured for abundance estimates are weighed and measured, observed for hooking scars, marked with a fin clip, released, and allowed to redistribute for at least ten days. A recapture run is conducted after the ten days. During the recapture run, fish are observed for marks administered during the marking run, lengths are taken on marked fish, and length and weights are recorded on fish that do not exhibit a mark.

Estimated abundances of brown and rainbow trout ≥ 152 mm (≈ 6”) declined below the 20-year averages in the upper Madison River in 2019 (Figure 10). In the Pine Butte Section, estimated brown and rainbow trout abundances declined by about 40% from 2018 to 2019. The estimated abundance of brown trout was 1,600 trout/mile in 2019, which is 80% of the 20-year average.

The estimated abundance of rainbow trout decreased to 2,201 trout/mile in that same reach, which is 93% of the 20-year average for that section. Estimated abundances of brown trout in the Varney Section remained relatively stable at 1,325 fish/mile, which is 81% of the 20-year average for that reach. Estimated abundances of rainbow trout declined by 55% to 805 fish/mile, which is 72% of the 20-year average. The Norris Section, which is downstream of Ennis Lake, was not sampled in 2019.

Estimated abundances of small brown (Figure 11a) and rainbow (Figure 11b) trout have generally increased in the Pine Butte Section since 2014. However, the estimated abundances of brown (Figure 11c) and rainbow (Figure 8d) trout > 277 mm (> 11") have declined during that same time period. These trends indicate that recruitment of age-0 fish appears to remain high, but mortality of age-2 and older fish has increased for unknown reasons. Estimated abundances of small rainbow trout varied from year-to-year in the Varney Section (Figure 12b) whereas small brown trout illustrated a similar trend to those observed in the Pine Butte Section with increasing abundances since 2014 (Figure 12a). Low estimated abundances of large fish were observed for both species the last several years in the Varney Section (Figure 12c, d), which suggests increasing mortality of large brown and rainbow trout in the Varney Section since 2014. A shift in the size structure of those populations is also evinced by the length frequency histograms from the Pine Butte and Varney sections (Figures 13 and 14). Despite relatively high estimated abundances of age-1 brown and rainbow trout in both sections compared to the 10-year mean, estimated abundances of age-2 and older fish, which are typically fish ≥ 277 mm, remained low in 2019. Although brown and rainbow trout ≥ 500 mm have historically composed a small percentage of the catch in the Pine Butte and Varney sections, those fish became increasingly rare during 2018 and 2019 sampling efforts. FWP will assess whether changes in abundances are associated with 2188 project operations and if operational changes should be considered in the future.

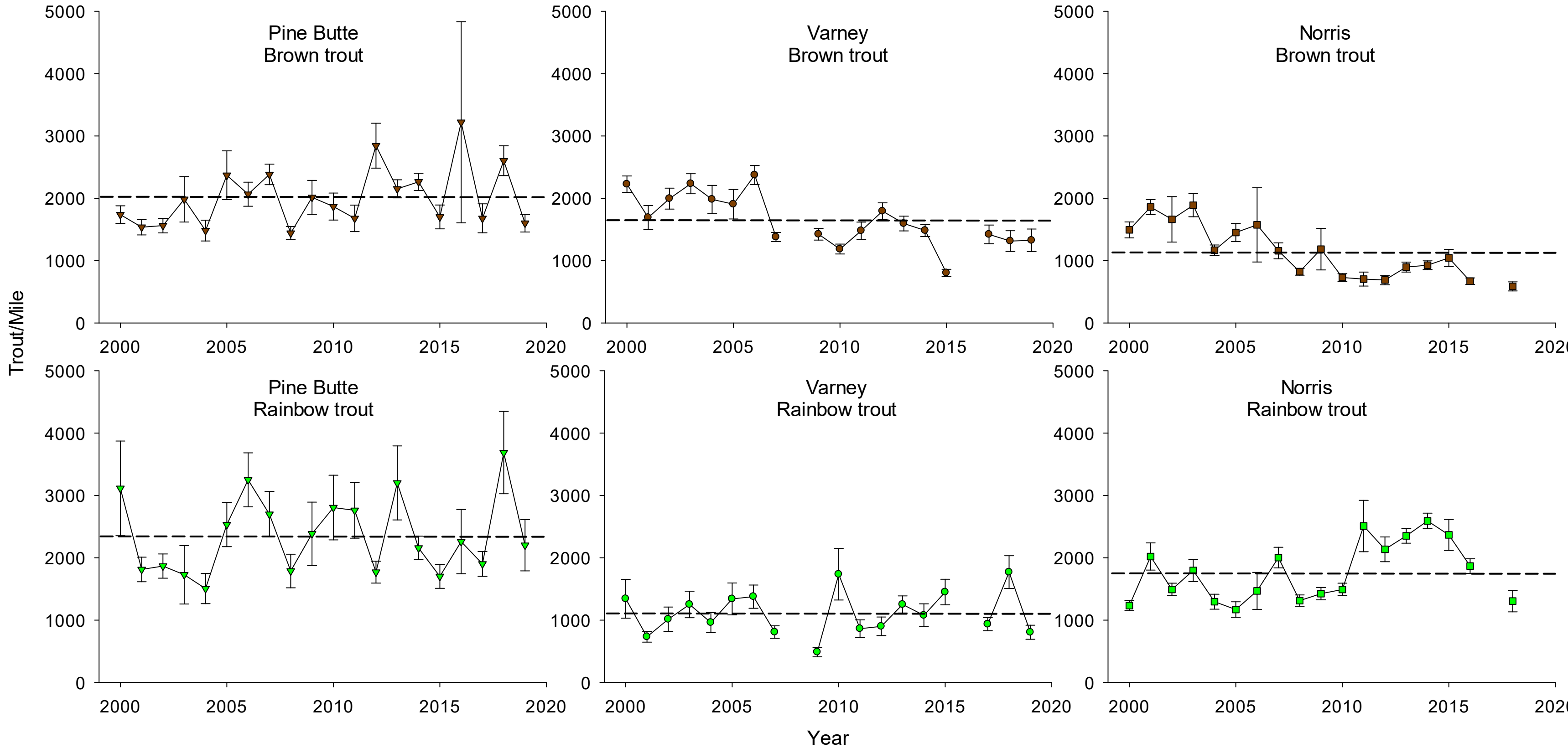

Figure 10. -Estimated abundances of brown (brown squares) and rainbow (green circles) trout ≥ 152 mm (≈ 6") captured in the three long-term sampling sections of the Madison River. Dashed lines are the 20-year averages of estimated abundances and error bars are the 95% confidence intervals for each sampling event.

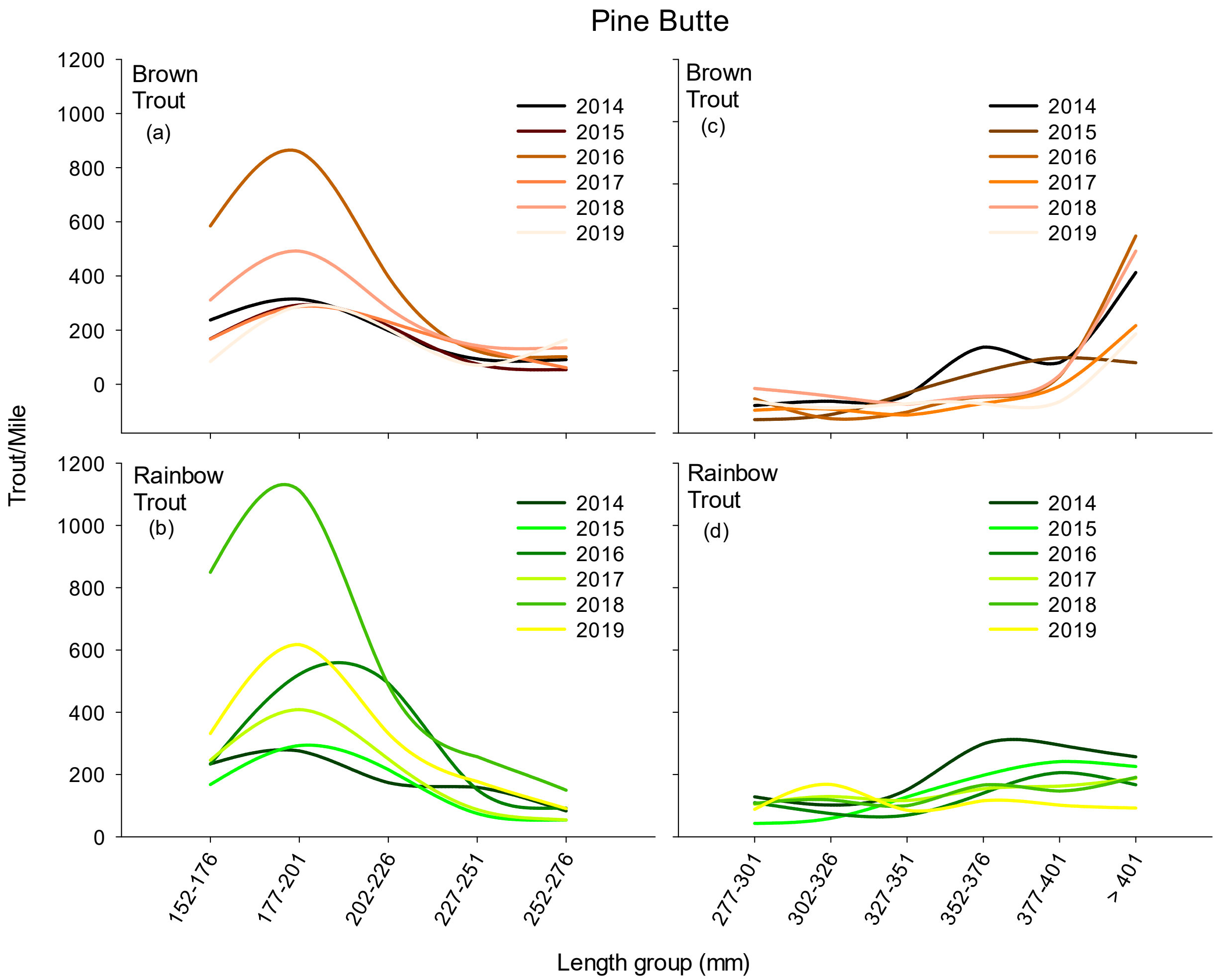

Figure 11. - Estimated abundances of brown and rainbow trout in the Pine Butte Section of the Madison River. A nearest neighbor function was used to smooth the line between years.

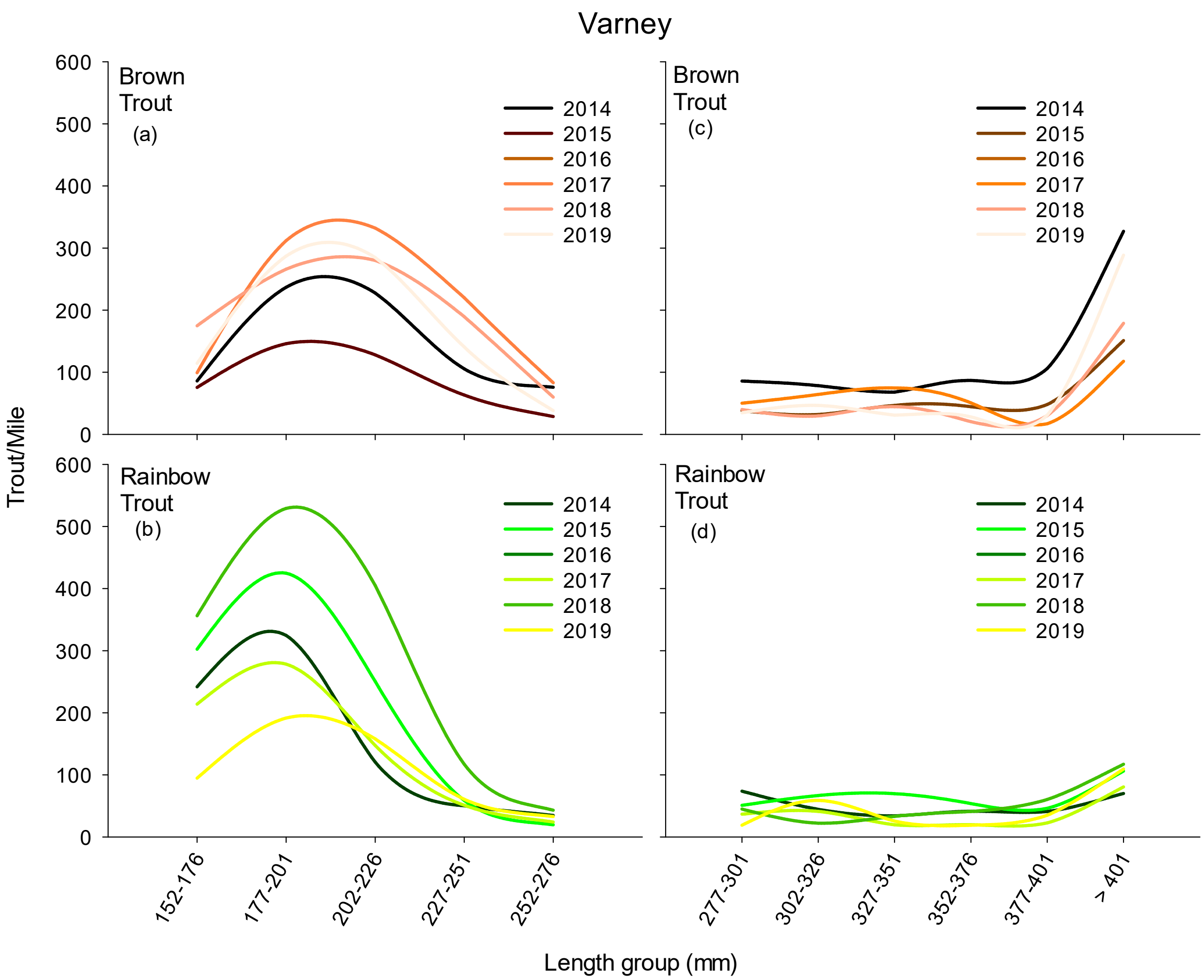

Figure 12.- Estimated abundances of brown and rainbow trout in the Pine Butte Section of the Madison River. A nearest neighbor function was used to smooth the line between years.

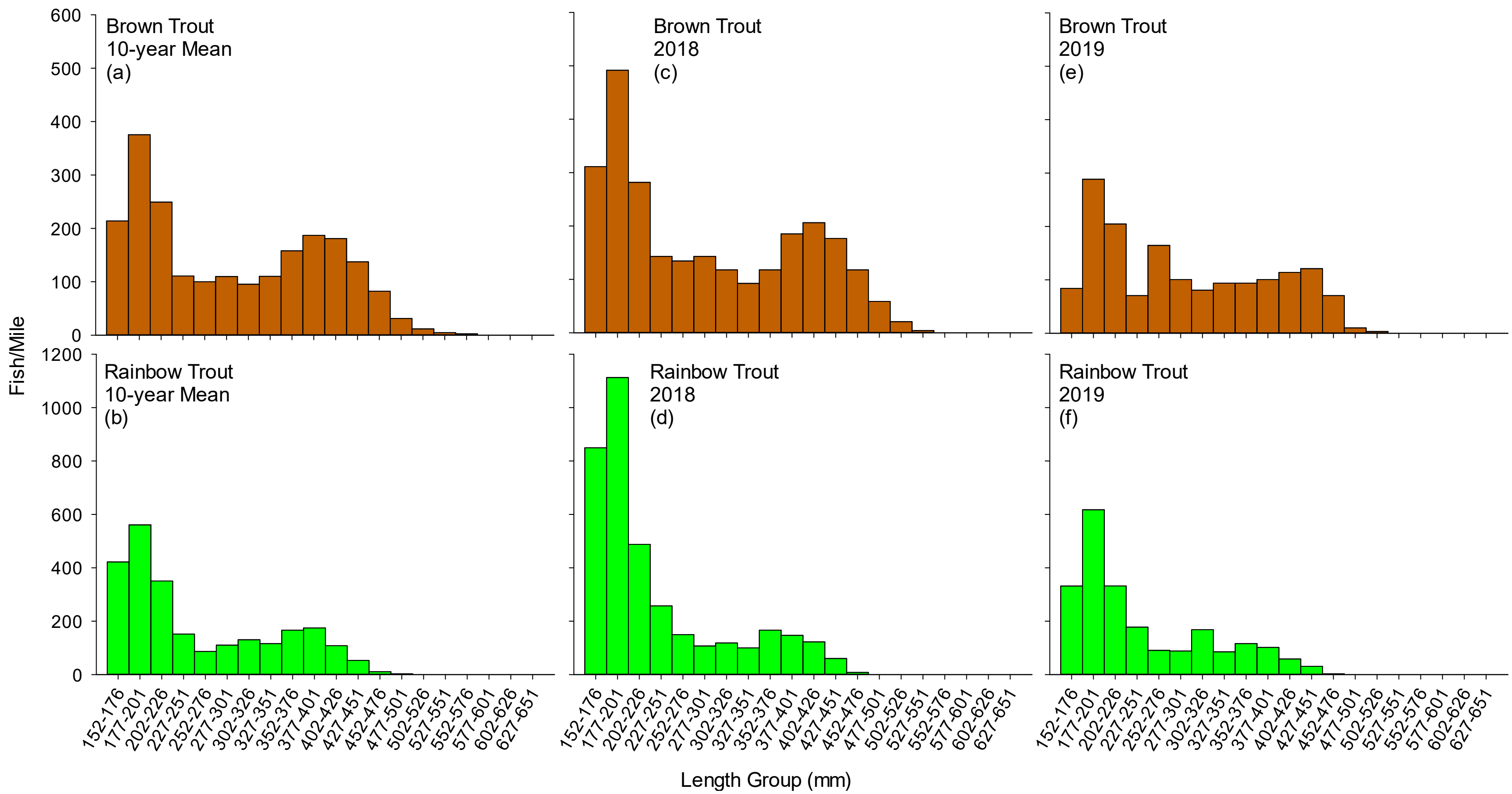

Figure 13. Length frequency histograms of brown and rainbow trout ≥ 152 mm (≈ 6”) captured in the Pine Butte Section of the Madison River.

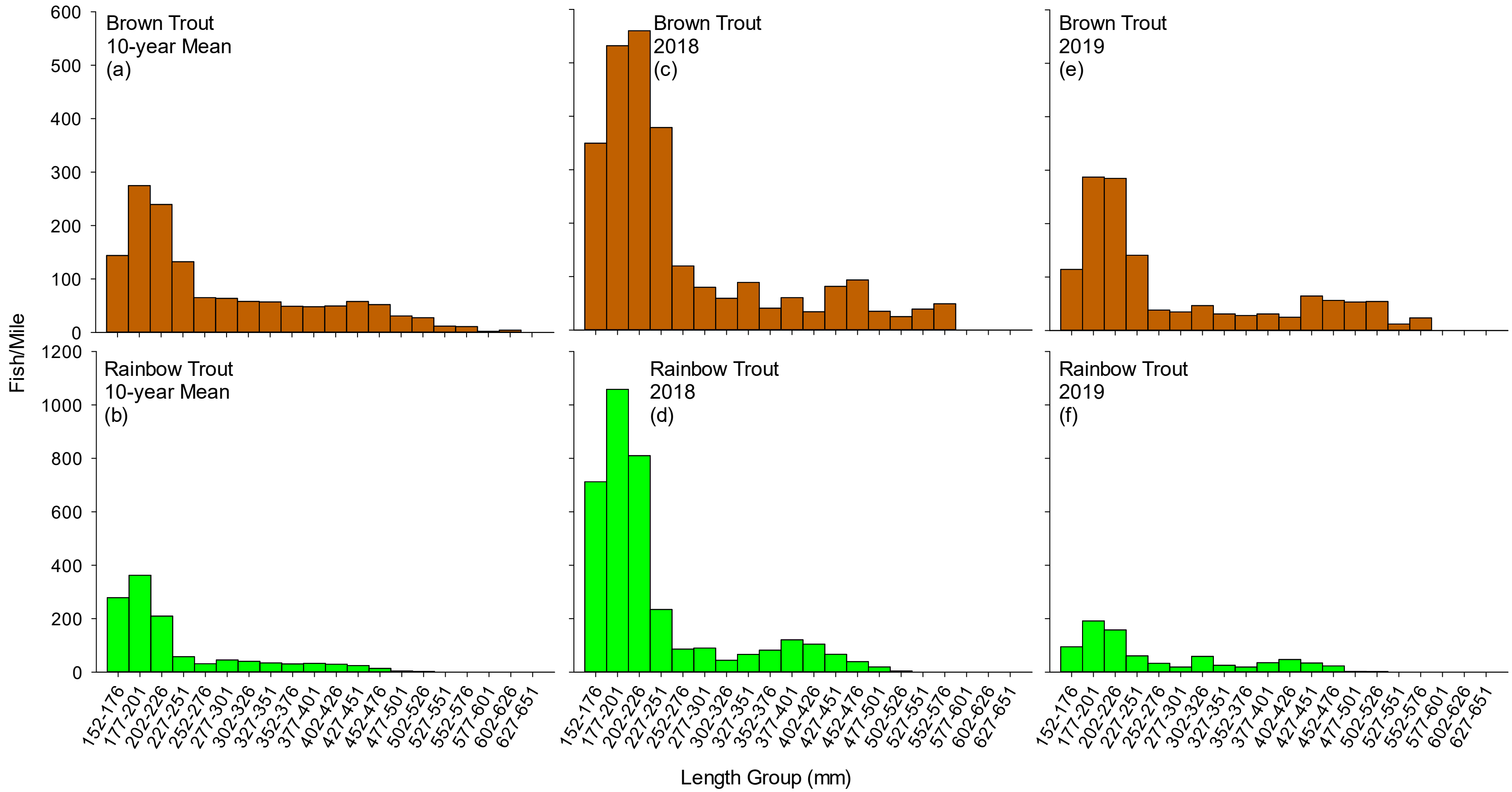

Figure 14. Length frequency histograms of brown and rainbow trout ≥ 152 mm (≈ 6”) captured in the Varney Section of the Madison River.

Monitor Species of Special Concern; Madison Artic Grayling; Westslope Cutthroat Trout

Opportunities to recover, conserve, and expand native fish species distribution are continually being pursued by FWP and partner agencies. Due to habitat loss and impacts to native fish species, such as Artic grayling and westslope cutthroat trout, associated with the operations of the Madison Project NWE is committed to providing funding for PM&E measures under Articles 408, 409, 412 the 2188 FERC agreement form Hebgen Reservoir to Three Forks Montana (FERC 2000) .

Arctic grayling introductions in the Madison Drainage began in May 2014 (Clancey and Lohrenz, 2015) to re-establish viable Arctic grayling populations in formerly occupied waters or at sites where their populations are diminished. Sixty-five thousand Arctic grayling eggs, from the Green Hollow pond located on the Flying D Ranch (Gallatin drainage), were introduced at three sites in the Madison Drainage through Remote Site Incubators (RSIs) (Figure 15). Introduction sites were Odell Spring Creek- Granger Ranch (15,000), Odell Spring Creek- Longhorn Ranch (45,000) and Blaine Spring Creek (10,000) (Figure16). Water temperature data for the duration of incubation and emergence is displayed in Table 2.

Figure 15. - Arctic grayling remote site incubators at Odell Spring Creek-Granger Ranch

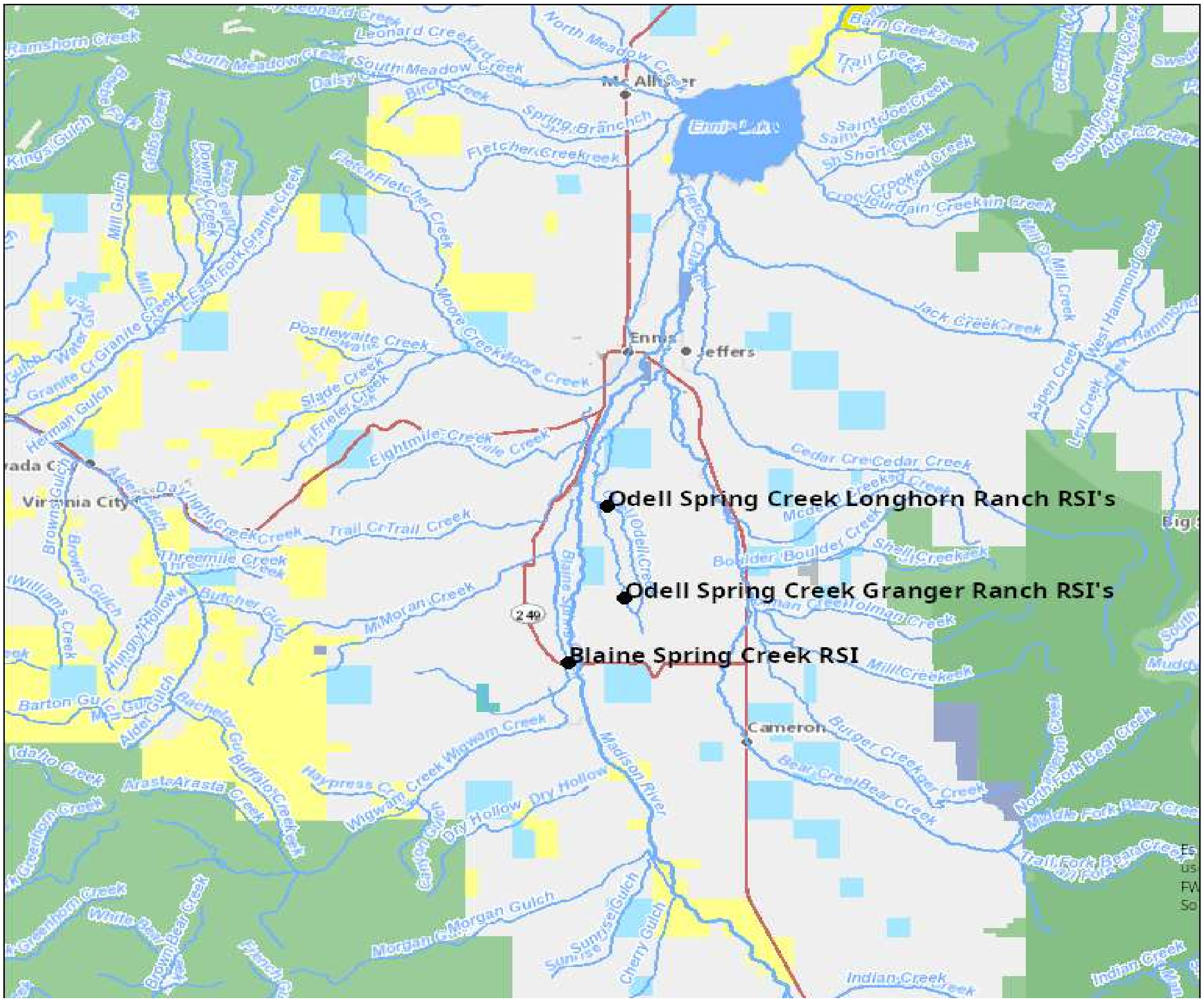

Figure 16.- Location of Artic grayling introductions 2019.

Table 2. - Water temperature characteristics and approximate date of last emergence at Madison Drainage Arctic grayling RSI introduction sites, 2019. Eggs were placed into the RSIs at Odell Spring Creek -Granger Ranch, Odell Spring Creek- Longhorn Ranch, and Blaine Spring Creek on May 22.

RSI site	Mean water temperature ◦F	Temperature range ◦F	Approximate date of last emergence
Odell Spring Creek-Granger Ranch	51.5	48.7-54.1	June 2
Odell Spring Creek-Longhorn Ranch	50.3	49.0-52.1	June 9
Blaine Spring Creek	-	-	June 2

Limited success of Arctic grayling introductions in the Madison drainage to date effected a review of the current introduction approach. Introduction sites were revisited and a list of habitat features, potentially beneficial and limiting to introduction success, was developed (Appendix A- Table 8). Additionally, angler reports of grayling capture locations were cross referenced with proximity of introduction sites and sites where juvenile grayling have been sampled(Appendix A-Table 8). Given the relatively small numbers of eggs introduced at sites where grayling have been recovered and after considering habitat, FWP will focus introduction efforts at those sites and increase the quantity of eggs introduced.

The state of Montana's Fisheries Management Plan calls for the protection and reintroduction of WCT trout with less than 10% non-native fish hybridization (i.e., conservation populations) to 20% of historically occupied waters (Montana Statewide Fisheries Management Program and Guide). The MadTAC has granted funding to FWP to pursue these conservation efforts under Articles 408, 409, and 412 of the 2188 project FERC license.

Funds granted by MadTAC to FWP and CGF were used to construct a migration barrier with explosives above a natural falls in Tepee Creek, a tributary to Grayling Creek near Hebgen reservoir. The CGF explosives crew blasted and removed a bedrock formation immediately below an existing waterfall and associated plunge pool (Figures 17-18). The channel modification has decreased the depth of the downstream plunge pool and increased the height of the waterfall by the corresponding height. FWP and CGF crews will revisit and evaluate the barrier in 2020, at that time a decision will be made as to whether or not to remove non-natives from the seven miles of the main stem and unnamed tributaries above the barrier and reintroduce genetically pure WCT.

Figure 17.- Custer-Gallatin National Forest explosives crew preparing to blast bedrock to enhance fall on Tepee creek for a migration barrier. Photo courtesy of Allison Stringer Custer-Gallatin National Forest Service.

Figure 18.- Tepee creek enhanced waterfall after blasting of bedrock and removal of plunge pool. Photo courtesy of Allison Stringer Custer-Gallatin National Forest Service.

Wall Creek is occupied by a WCT conservation population of >95% genetic purity. Currently, non-native rainbow trout are able to ascend Wall Creek and hybridize with individuals in the WCT population. To prevent further introgression of the Wall Creek WCT population, FWP in partnership with the Beaverhead-Deerlodge National Forest, requested and was granted funding from the MadTAC for the survey and design of a migration barrier that would secure 7.5 to 8.0 miles of WCT occupied waters in the Wall Creek drainage (Figure 19). During the 2019 and 2020 funding cycles MadTAC granted $120,000 in cost share funding for the construction of the barrier. Other funding sources include Montana Future Fisheries ($40,000), USFS ($10,000), and the Western Native Trout Initiative WNTI ($9,488). An additional funding source has shown interest and construction of the barrier is anticipated for August 2020.

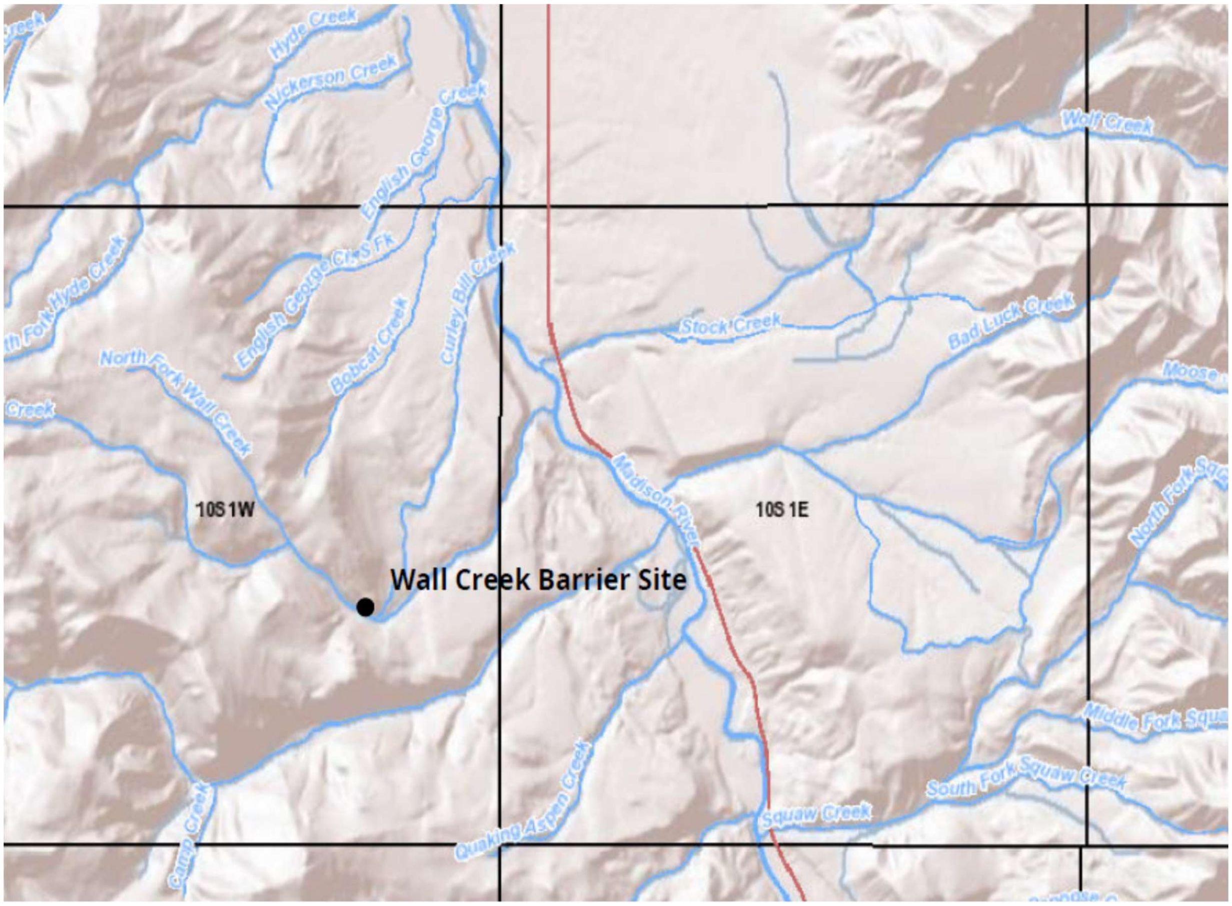

Figure 19. -Location of Wall Creek barrier.

Article 409- 3) Fish habitat enhancement both in main stem and tributary streams

South Meadow Creek

Flow augmentation and habitat degradation in tributary streams can have adverse effects on Madison River water quality and fish populations. Article 409 sub-article 3 stipulates that PM&E measures will be taken to address these issues as they are identified.

In 2012 the Madison Watershed Coordinator identified and initiated a project to rebuild irrigation infrastructure and re-establish the riparian corridor along a reach of South Fork Meadow Creek, a tributary to Ennis Reservoir (Figure 20). Stream corridor rehabilitation was promoted by fencing a 30-foot zone on each side of the stream to eliminate livestock access to the stream banks. The removal of the constant stress of livestock access along the stream banks, stimulated the growth and recovery of grasses and willows that stabilize the riparian soil and reduce sediment input from raw stream banks.

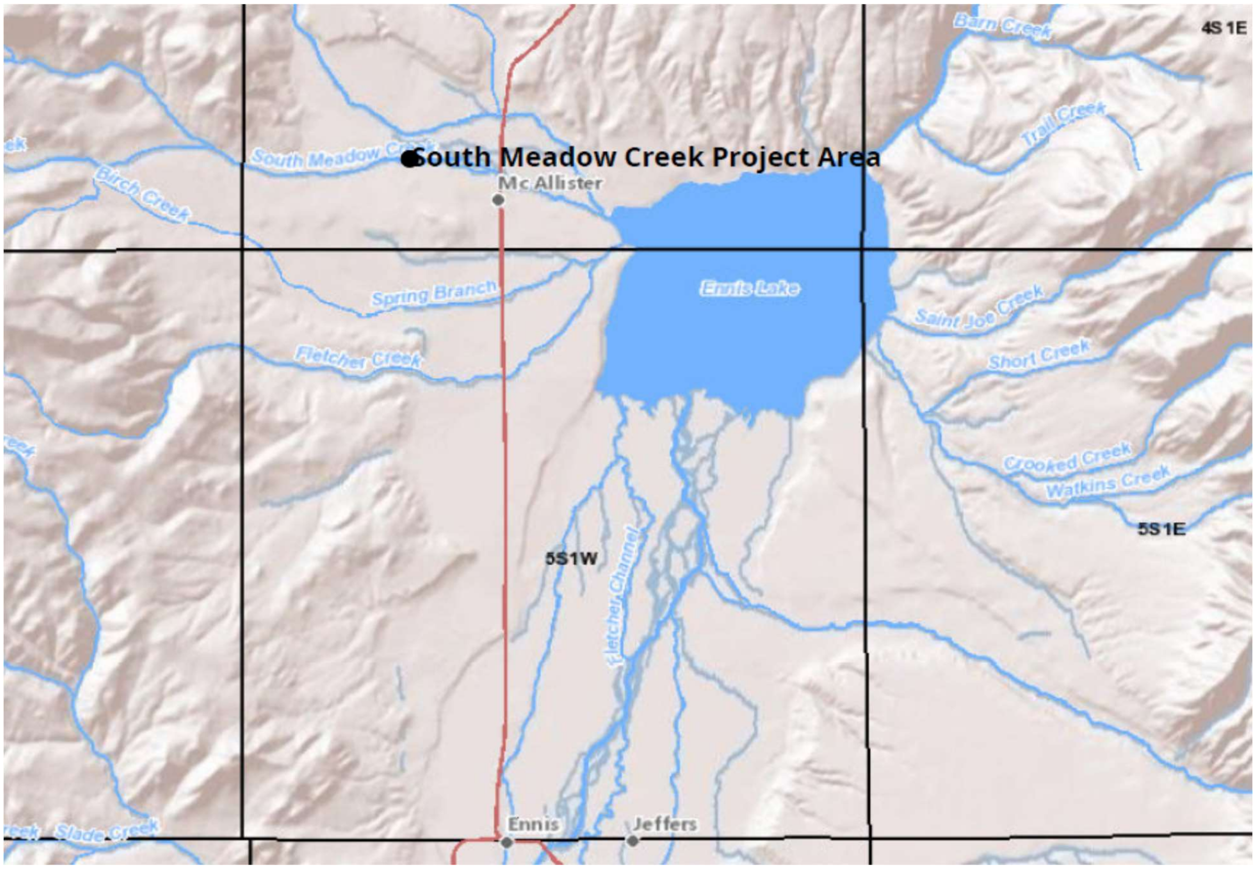

Figure 20.- Location of South Meadow Creek Project.

McNeil Resources of Townsend, MT was commissioned by FWP in 2018, with funds granted by the Mad TAC, to evaluate and develop a design to enhance fish habitat in a 1000' reach of South Meadow Creek that is within the 2012 project area. A previous landowner straightened this reach of stream, likely for water conveyance. The channel straightening resulted in loss of instream habitat such as pools and spawning gravels. Additionally, the section of stream was disconnected with the historic flood plain. Material removed from the stream was deposited in a berm along the stream bank, preventing water during high flows access to the flood plain which is needed to irrigate riparian vegetation (Figures 21-22).

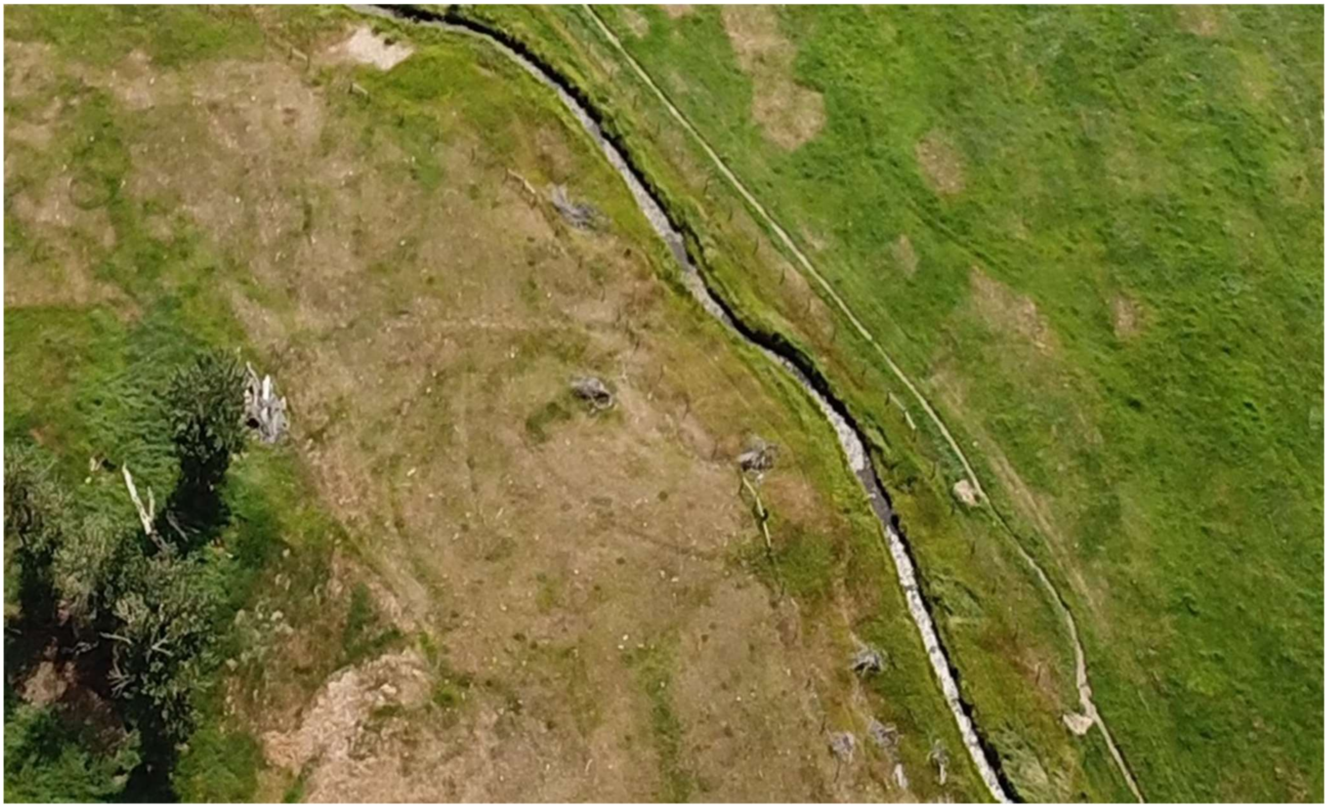

Figure 21.- Aerial view of project reach showing channel straightening-Photo courtesy of Madison Conservation District.

Figure 22. -Berm material removed to reconnect flood plain.

Design objectives for the reach were : 1) provide adequate pool habitat in times of low water, 2) Develop and retain adequate spawning gravels at pool tail outs, 3) Add sinuosity to the reach to dissipate stream energy during high flow events, 4) reconnect the flood plain bench on the North side of the stream to promote riparian recovery, 5) bring the stream width back to appropriate dimensions, 6) improve cattle operations.

Rehabilitation of the reach began in November. Flood plain elevation was re-established, which will ensure irrigation of riparian plant species and prevent flooding of the landowners calving pasture. After re-establishment of the flood plain elevation, structures were incorporated into the stream to provide pool habitat in low water conditions and promote deposition of spawning gravels at pool tail outs. Additionally, stream channel size was brought back to appropriate dimensions by extending the bank toe and revegetating with sod mats (Figures 23-24). Construction continued until freezing conditions forced operations to halt. The project will resume and be completed in April 2020.

Of note neighboring landowners upstream have expressed interest in pursuing similar measures to improve stream conditions.

Figure 23.- Placement of instream structure for pool development.


Figure 24. -Portion of stream below a pool structure that was narrowed.

Article 412 – 1) Monitor the effects of project operations (including pulsed flows) on Ennis Reservoir and the lower Madison River fish populations

Ennis Reservoir Fisheries Assessment

Ennis Reservoir was gillnetted in October to assess trends in reservoir fish populations pursuant to article 412-1. A total of 240 fish were sampled in 2019; Utah chub comprised 39% of the sample, white sucker 41%, brown trout 13%, and rainbow trout 7%, respectively.

Mean length and weight of rainbow trout sampled has trended downward over the last decade; however, the number per net increased from 4/net in 2017 to 12/net in 2019. (Table 3). Brown trout mean length and weight was the lowest observed since 2013 (Table 4).

Supplementation of the Ennis Reservoir rainbow trout fishery ended in 1994 and has been managed by FWP as a wild trout fishery since that time.

Table 3 -.Ennis Reservoir rainbow trout catch per unit effort (C/*f*) ± SE, mean length, mean length tested at 95% confidence (CI), mean weight, mean weight tested at 95% confidence.

Year	C/*f* number per net	Mean Length	Upper 95% CI	Lower 95% CI	Mean weight	Upper 95% CI	Lower 95% CI
2003	3.0 ± 0.9	17.2	17.6	16.7	1.79	1.91	1.67
2005	4.0 ± 2.8	15.3	16.1	14.4	1.59	1.75	1.43
2007	3.3 ± 1.6	17.6	17.9	17.2	1.62	1.68	1.56
2009	2.3 ± 1.9	16.3	17.1	15.5	1.74	1.93	1.55
2011	2.7 ± 1.8	14.4	15.0	13.9	1.32	1.43	1.21
2013	21.0 ± 7.5	12.3	12.6	12.0	0.87	0.89	0.85
2015	13.3 ± 5.4	12.6	12.9	12.3	0.93	0.96	0.90
2017	4.0 ± 2.2	11.8	12.5	11.2	0.75	0.83	0.67
2019	12.0 ± 5.2	12.4	12.7	12.0	0.84	0.87	0.81

Table 4.- Ennis Reservoir brown trout. catch per unit effort (C/*f*) ± SE, mean length, mean length tested at 95% confidence (CI), mean weight, mean weight tested at 95% confidence.

			95% CI for mean length			95% CI for mean weight	
Year	C/*f* number per net	Mean Length	Upper bounds	Lower bounds	Mean weight	Upper bounds	Lower bounds
2003	3.6 ± 0.5	17.4	18.1	16.7	2.13	2.34	1.92
2005	9.0 ± 4.5	15.2	15.7	14.6	1.50	1.57	1.43
2007	5.0 ± 1.2	17.3	18.2	16.5	2.45	2.65	2.25
2009	5.3 ± 2.9	17.1	17.5	16.6	1.77	1.87	1.67
2011	7.0 ± 1.7	15.4	16.0	14.8	1.73	1.85	1.61
2013	9.7 ± 2.2	12.7	13.2	12.2	0.94	1.00	0.88
2015	5.6 ± 2.7	15.9	16.4	15.4	1.71	1.81	1.61
2017	6.3 ± 2.8	16.4	16.9	16.0	1.60	1.68	1.52
2019	4.3 ± 1.2	11.7	12.2	11.2	0.70	0.78	0.62

Pulse Flows

Article 413 of the FERC license mandates NWE monitor and mitigate thermal effects in the lower river (downstream of Ennis Reservoir). In coordination with agencies, the company has developed and implemented a remote temperature monitoring system and a 'pulsed' flow system to mitigate high water temperatures. Real-time or near real-time meteorological and temperature monitoring is conducted to predict water temperature the following day, which determines the volume of discharge that is necessary for thermal mitigation. Pulsed flows are triggered when water temperature at the Madison (Ennis) Powerhouse is 68° F or higher and the predicted air temperature at the Sloan Station (River Mile 17) near Three Forks, MT for the following day is 80° F or higher. The volume of water released in the pulse is determined by how much the water and/or air temperature exceeds the minimum thresholds (Table 5). The increase in water volume in the lower river reduces the peak water temperature that would occur at the 1,100 cubic-feet-per-second (cfs) base flow. Discharge from Ennis Dam is increased in the early morning so that the greatest volume of water is in the area of Black's Ford and downstream during the late afternoon when daily solar radiation is greatest. The increased volume of water reduces the peak water temperature in the lower river reducing the potential for thermally induced fish kills. Discharge from Hebgen Dam typically does not fluctuate on a daily basis during pulse flows but is occasionally adjusted to increase or decrease the volume of water going into Ennis Reservoir, where daily fluctuations in the lower river are controlled. In total there were 32 calls for a pulse flow releases in 2019, however only 10 actual pulse releases were needed as natural discharge was more than the predict pulse (NorthWestern Energy 2020). Table 6 gives summary statistics for years when pulse flows were conducted on the Madison River.

Table 5.- Criteria for Pulse Flow (Northwestern Energy 2020)

Today's maximum power- house release temperature at the Madison DSS website or USGS McAllister gage on or after 8:30 p.m.	Tomorrow's predicted maximum air temperature (◦F) and corresponding pulse flows (cfs). Look up predicted high air temperature for the next day at Sloan Station near Three Forks, MT.		
	>=75 and < 85	>=85 and < 95	>=95 and < 105
Greater than or equal 68 to and less than 69	1150	1150	1400
Greater than or equal to 69 and less than 70	1150	1400	1600
Greater than or equal to 70 and less than 71	1150	1600	2000
Greater than or equal to 71 and less than 72	1400	1600	2100
Greater than or equal to 72 and less than 73	1450	1800	2400
Greater than or equal to 73 and less than 74	1600	2100	2800
Greater than or equal to 74 and less than 75	1800	2600	3000
Greater than 75	2600	3200	3200

Table 6 . Summary statistics for years in which pulse flows were conducted on the Madison River. 1/ As of October 1st each year **2/** Hebgen full pool is 6534.87 msl. The FERC license requires NWE to maintain. Hebgen pool elevation between 6530.26 and 6534.87 from June 20 through October 1.

Year	Hebgen Oct1 pool elevation[1/]	Feet below full pool	Feet of Hebgen draft due to pulsing	Number of days pulsing occurred	Feet of Hebgen draft to meet 1,100 cfs minimum McAllister gauge
2000	6531.21	3.66	0.61	29	3.05
2001	6530.53	4.34	0.05	13	4.29
2002	6530.46	4.41	0.70	18	3.71
2003	6528.59	6.28	2.68	39	3.60
2004	6532.07	2.80	0.28	12	2.52
2005	6531.52	3.35	0.30	17	3.05
2006	6530.86	4.01	1.74	15	2.27
2007	6526.05	8.82	2.12	43	6.70
2008	6524.84	10.03	0.00	0	10.03
2009	6533.02	1.85	0.03	8	1.82
2010	6531.50	3.37	0.00	3	3.37
2011	6534.04	0.83	0.00	0	0.83
2012	6532.00	2.87	0.00	0	2.87
2013	6531.07	3.80	1.70	35	2.10
2014	6532.73	2.14	0.06	42	2.08
2015	6531.97	2.90	0.48	11	2.42
2016	6530.41	4.46	1.00	26	3.46
2017	6532.62	2.25	1.66	36	0.59
2018	6531.54	3.33	0.67	36	2.66
2019	6531.18	3.69	0.08	10	3.61

Temperature Monitoring

Temperature affects all living organisms and fish species have specific thermal ranges that are optimal for their persistence. While FWP initiated temperature monitoring to aid with the development of the pulse flow program, water temperature monitoring is relevant to all of the 2188 articles and is affected by PM&E activities enacted under those Articles.

Water temperature was recorded at 12 sites and air temperature at six sites throughout the Madison River basin from upstream of Hebgen Reservoir to the mouth of the Madison River at Headwaters State Park (Figure 25). Each of the Tidbit™ temperature loggers recorded over 40,000 temperature points in Fahrenheit from late April through early September. Air temperature recorders were placed in areas that were shaded from solar radiation 24 hours per day.

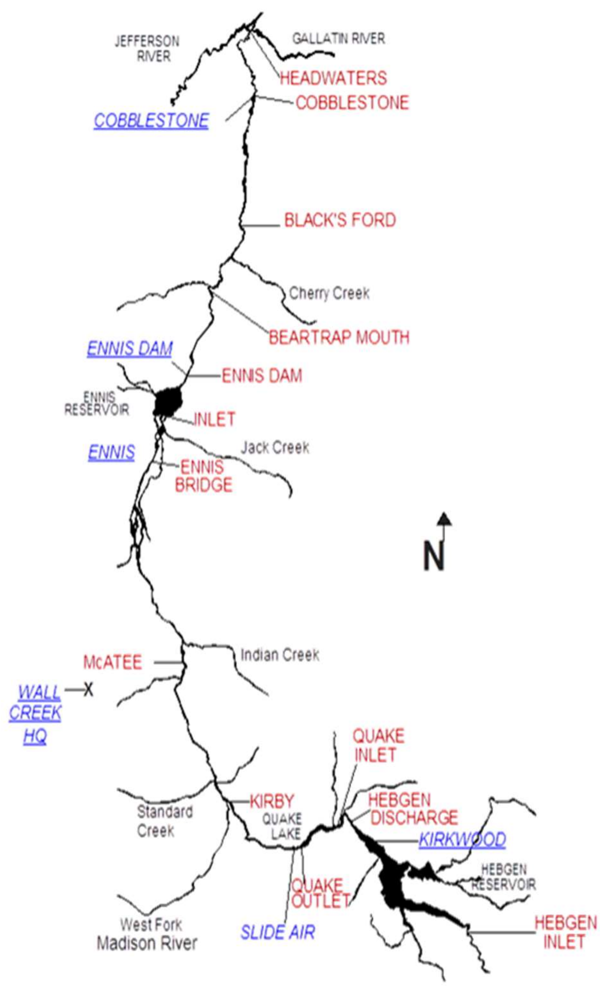

Figure 25. - Locations FWP temperature monitoring sites. Air temperature monitoring sites are blue and underlined; water temperature monitoring sites are red.

Table 7 summarizes the data collected at each location. Appendix A2 contains comparisons of annual maximum temperatures at selected adjacent monitoring sites and Appendix A3 contains annual maximum temperature longitudinal profiles illustrating the maximum water temperature recorded at each river monitoring site since 1997. It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have occurred on more than just one day in a year. Water temperature recorders were not recovered at every site in some years, or the data was not recoverable because of recorder failure, but for years where data are available notable patterns occur:

- For all 17 years where data are available, maximum water temperature at the Hebgen Inlet site is higher than maximum water temperature at the Hebgen discharge site
- For 20 of 21 years where data are available, maximum water temperature at the Quake Inlet site is higher than maximum water temperature at the Quake outlet site
- Since 1995 maximum water temperatures were recorded in July at the Kirby and McAtee sites. In both instances, the maximum temperature occurred in early July, before daylength shortened and summertime air temperatures were moderated.
- The Ennis Reservoir Inlet site annually exhibits the highest maximum water temperature of the seven sites between Hebgen Dam and Ennis Reservoir
- In 20 of the 24 years where data are available, maximum water temperature at the Ennis Dam site is lower than at the Ennis Reservoir Inlet site
- Maximum water temperatures at all sites downstream of Ennis Dam typically are about 5º F warmer than at Ennis Dam
- Maximum water temperature at Blacks Ford has been successfully attenuated by pulse flows conducted to prevent thermal related fish kills; the last fish kill occurred in 1988.
- In 2015, thermal maxima for the recorded period (1994 to present) was recorded at the Kirby, Wall Creek Bridge and McAtee sites and at every monitoring site from Ennis Dam to Cobblestone. Below Ennis Dam, maximum temperatures equaled or exceeded 80º F at every site except Ennis Dam. In every instance, the maximum temperature occurred in early July, before summer air temperatures moderated.

Table 7.- Table showing maximum, minimum and mean temperatures (ºF) recorded at locations in the Madison River Drainage, 2019. Air and water temperature data were recorded from April 22 –September 22. Temperature graphs for each location are in Appendix A-1.

Deployment	Site	Max	Min	Mean
Water	Hebgen inlet	75.4	42.8	60.1
	Hebgen discharge	65.1	37.7	53.8
	Quake Lake inlet	64.9	37.3	53.1
	Quake Lake outlet	63.8	37.6	52.7
	Kirby Bridge	69.5	35.9	53.2
	McAtee Bridge	69.9	34.0	53.9
	Ennis Bridge	71.2	35.0	55.9
	Ennis Reservoir Inlet	74.7	42.9 (late deployment	57.1
	Ennis Dam	72.4	39.5	60.1
	Bear Trap Mouth	76.4	39.0	60.3
	Blacks Ford	77.9	38.0	59.3
	Cobblestone	79.1	39.1	60.8
	Headwaters S.P. (Madison mouth)	NA	NA	NA
Air	Kirkwood	89.8	14.3	53.3
	Slide	NA	NA	NA
	Wall Creek HQ	93.2	14.3	56.7
	Ennis	92.2	17.0	57.6
	Ennis Dam	100.0	28.8	63.9
	35 MPH Corner	84.6	24.4	60.0
	Cobblestone	97.1	13.5	59.8

419-Coordinate and monitor flushing flows

Article 419 of the FERC license requires that NWE develop and implement a plan to coordinate and monitor flushing flows in the Madison River downstream of Hebgen Dam. A flushing flow must be large enough to mobilize streambed materials and produce scour in some locations and deposition in other locations. This is a natural occurrence in unregulated streams and rivers, and renews spawning, rearing, and food producing areas for fish, as well as providing fresh mineral and organic soil for terrestrial vegetation and other wildlife needs.

Core Sampling and Redd Counts

FWP assists NWE annually with core sampling to evaluate the composition of substrates from the riverbed at known salmonid spawning areas (Figure 26). Core samples provide information about fines that can be tied to channel changing flows and whether a flushing flow should be initiated to reduce the amount of fine sediments in spawning gravel.

Core samples are collected with a 12" McNeil core sampler (Figure 27). The core sampler is drilled into the substrate to a depth of 8." Substrate from within the 12"x 8" area is collected, dried, and sorted using a sieve method. Percent composition of the substrate sample according to size is then calculated.

Figure 26.- Redd at the Norris redd counting and core sampling site.

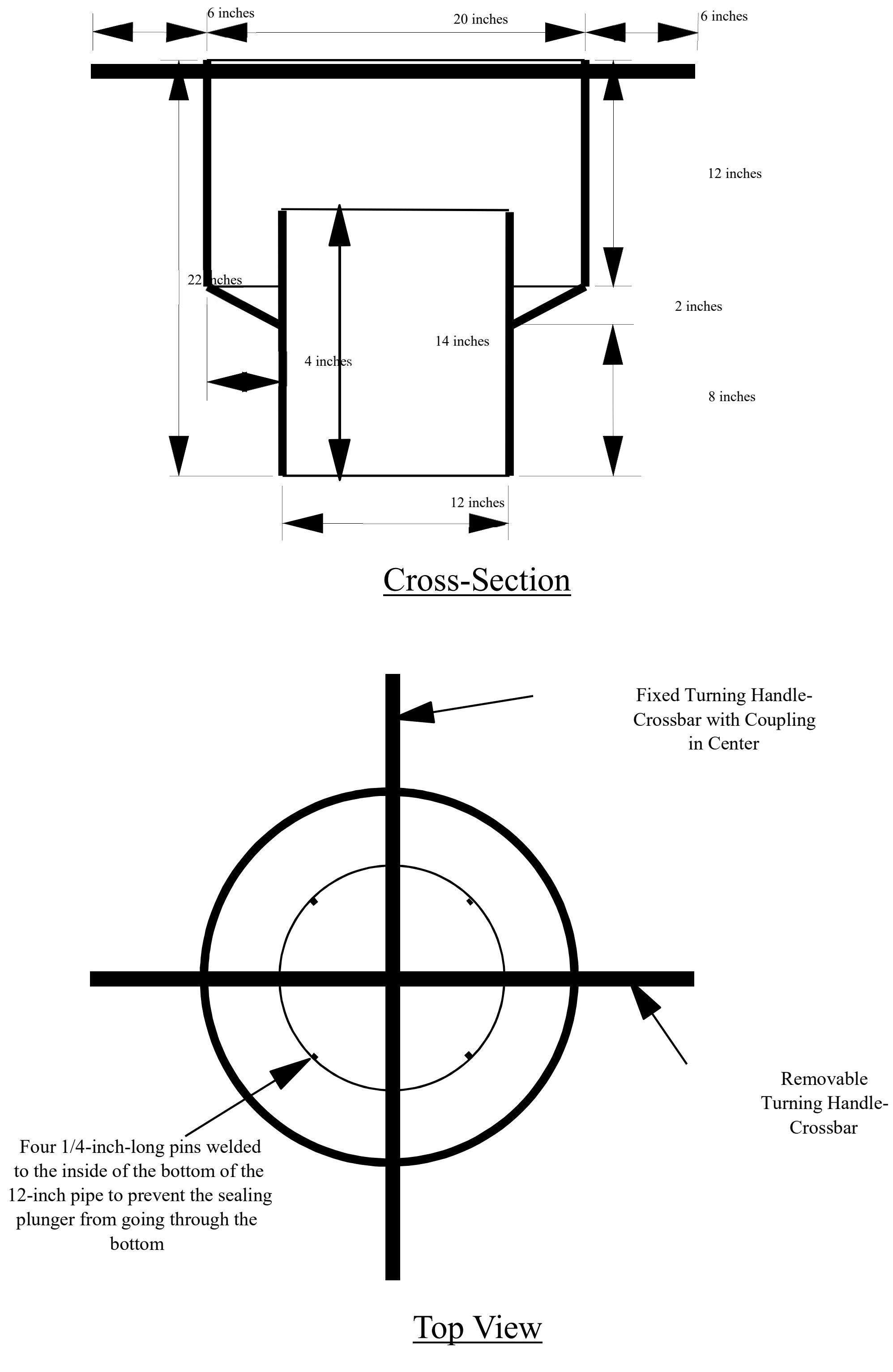

Figure 27-. Schematic of 12-inch diameter substrate sampler, modeled after the original 6-inch diameter sampler developed by McNeil and Ahnell (1964).

Results from core sampling have shown flushing flows when they are initiated to be fairly ineffective. The last flushing flow occurred in 2018. Conditions in upper Madison River are relatively stable with little change in sediment deposition. Fredle index numbers – a measure of embeddedness of substrate - remain above five for all but one site on the upper Madison. The number of fines <0.84 mm in the lower river are continuously higher than those values observed in the upper river. Fredle index numbers have trended noticeably downward in the lower Madison over the last ten years (Figure 28) (R2 Resource Consultants 2018). Samples taken in 2018 and 2019 are still being analyzed by a contractor hired by NWE. Data collected through 2017 is in Table 8 and trends for median % fines are in Figure 29 (R2 Resource Consultants 2018).

Table 8. Upper Madison River % fines <.84mm median value ± standard deviation (SD), lower Madison River % fines <.84mm median value ± SD, NWE flushing flow event, peak flow in cubic feet per second (CFS) at USGS gage 06041000.

Year	Upper Madison River % fines <.84 mm median ±SD	Lower Madison River % fines <.84mm median ± SD	NWE flushing flow	Peak Flow CFS USGS gage 0604100
1995	6.6 ±4.4	15.9 ±5.4		7360
1996	5.8 ±1.2	8.3 ±4.5		7980
1997	7.4 ±3.9	9.8 ±4.5		7910
1998				6820
1999				5500
2000				4450
2001				2460
2002	3.7 ±1.5	9.6 ±4.1	No	5180
2003	8.6 ±3.2	10.0 ±5.7	No	4670
2004	7.6 ±2.7	10.7 ±5.2	No	3440
2005	6.9 ±4.1	13.5 ±8.0	No	4470
2006	9.7 ±3.7	13.5 ±5.0	Yes	5390
2007	5.1 ±2.5	8.5 ±4.0	No	3400
2008	5.4 ±2.9	9.7 ±4.8	Yes	5390
2009	9.3 ±3.2	12.4 ±11.7	No	4050
2010	7.0 ±5.3	11.9 ±5.7	No	5540
2011	10.1±3.4	13.8 ±8.2	Yes	7100
2012	6.8 ±7.2	15.9 ±5.4	No	4810
2013	5.8 ±2.1	18.8 ±18.7	No	2850
2014	8.4 ±3.4	22.9 ±13.7	No	5560
2015	8.3 ±6.1	12.6 ±8.3	No	4490
2016	7.1 ±4.0	14.7 ±10.2	No	3180
2017	7.9 ±2.4	11.7 ±5.7	No	4520

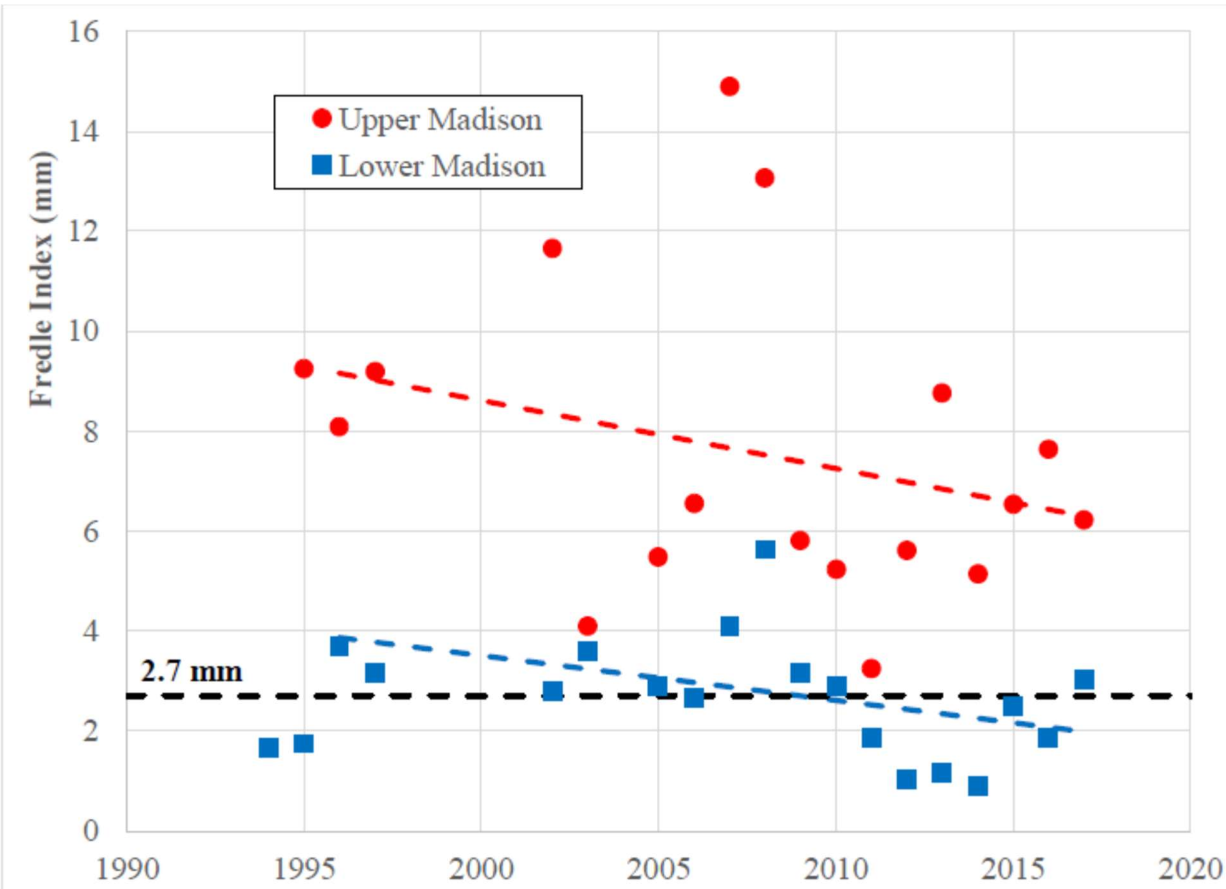

Figure 28. Median annual Fredle Index, trend lines developed for the Madison River from data available since 1996 (R2 Resource Consultants).

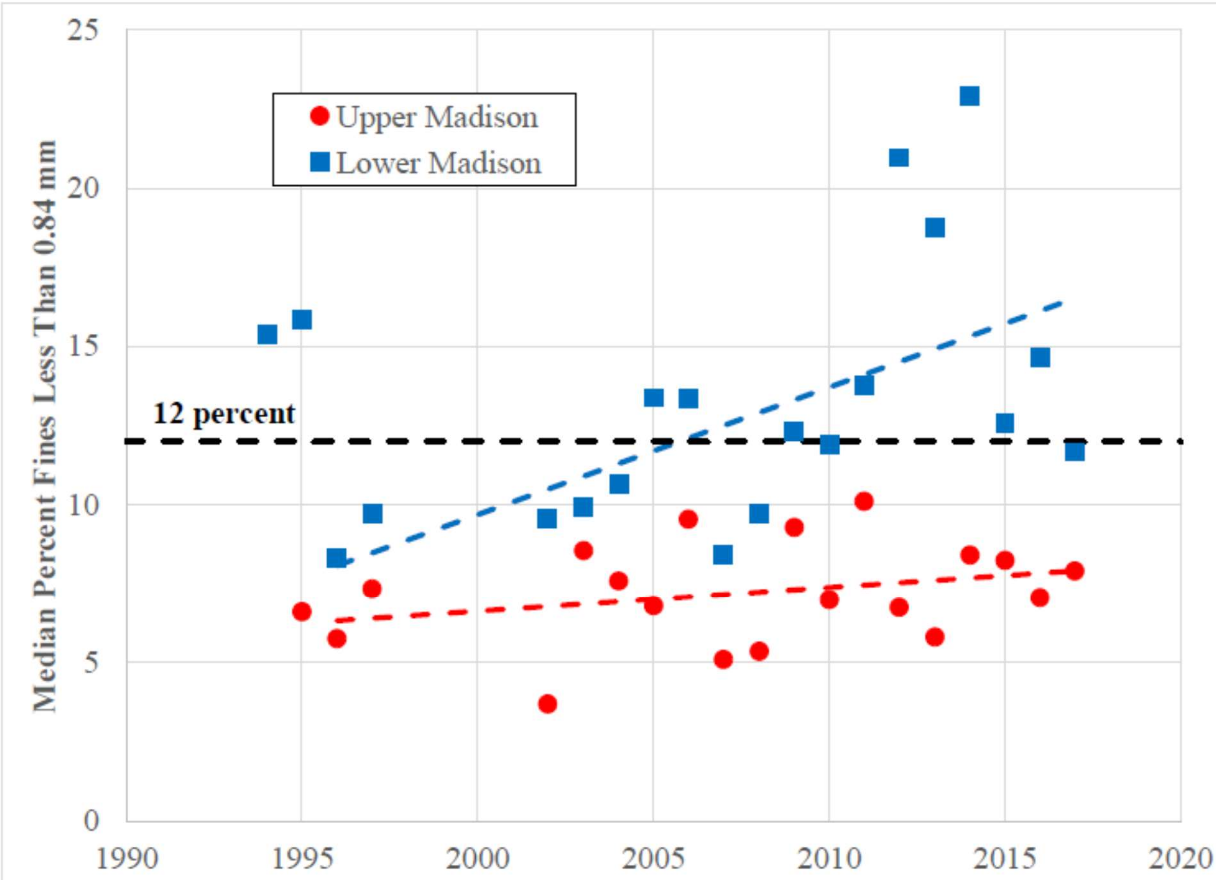

Figure 29. Median annual percent fines less than 0.84 mm, trend lines developed for the Madison River from data available since 1996 (R2 Resource Consultants).

MadTAC funding has been granted to other agencies or groups to initiate and conduct projects that adhere to the FERC license articles. Their accomplishment reports are in Appendix A4.

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Appendix A

Summary of Ennis Reservoir sampling 1995 - 2018 Habitat Evaluation of Introduction Sites and Egg Numbers Introduced at Sites since 2014

Table 9.-Ennis Reservoir Arctic grayling sampling, date and species sampled

Date	AG	MWF	LL	Rb
7/27/95	12	177	4	0
9/1/95	23	89	4	0
6/18/96	0	6	1	2
7/22/96	0	0	0	0
8/22/96	0	0	1	0
8/20/97	1	0	3	0
10/27/97	0	5	0	0
9/4/98	0	0	0	0
9/22/99	2	34	0	0
11/2/00	0	14	3	0
8/29/01	0	0	0	0
10/2/02	1	2	4	0
10/6/03	0	2	3	1
9/28/04	1	9	96	0
9/27/05	0	11	19	5
11/5/07	0	0	0	0
9/29/08	0	0	3	1
10/1/09	0	0	139	30
10/22/09	1	5	0	0
10/6/10	0	0	1	0
10/3/11	0	4	9	5
10/9/13	0	3	1	3
10/29/14	0	1	0	0
9/30/15	0	19	1	1
10/5/2016	0	2	2	6
10/3/2017	0	0	2	2
10/9/18	0	26	27	9
2019	No sampling occurred			

Species abbreviation AG-Arctic grayling ,MWF-mountain whitefish, LL-brown trout, and Rb-rainbow trout.

Table 10. Grayling introduction site habitat evaluation. Habitat features of introduction sites beneficial or potentially limiting to recruitment.

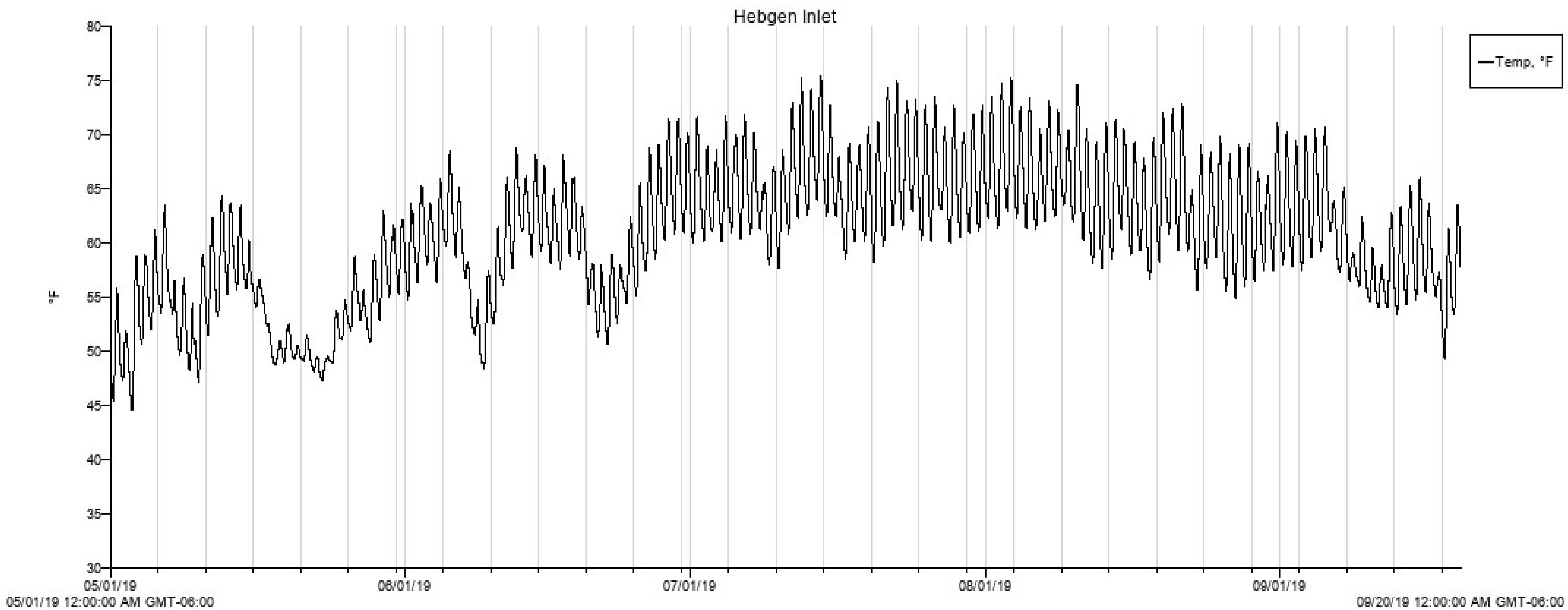
Introduction Site	Habitat Features Beneficial	 Potentially limiting
Odell Spring Creek-Granger Ranches	Back waters for rearing Stream margins with appropriate velocity for rearing Deep pools	Water velocity Spawning substrate size Brown Trout abundance Area of spawning substrate available Length of pools Sediment Lack of macrophytes
Odell Spring Creek-Longhorn Ranch	Pool length and depth Spawning substrate more abundant Deep pools	Water velocity Spawning substrate size Brown Trout abundance Area of spawning substrate available Sediment Lack of macrophytes
Blaine Spring Creek	Rearing habitat Spawning substrate size and quantity Macrophytes	Pools with depth Brown Trout abundance
Moore Creek	Well-developed pools with length and depth Spawning substrate of appropriate size and area Velocity Stream margins with appropriate velocity for rearing	Proximity to reservoir Sediment Few back waters for rearing

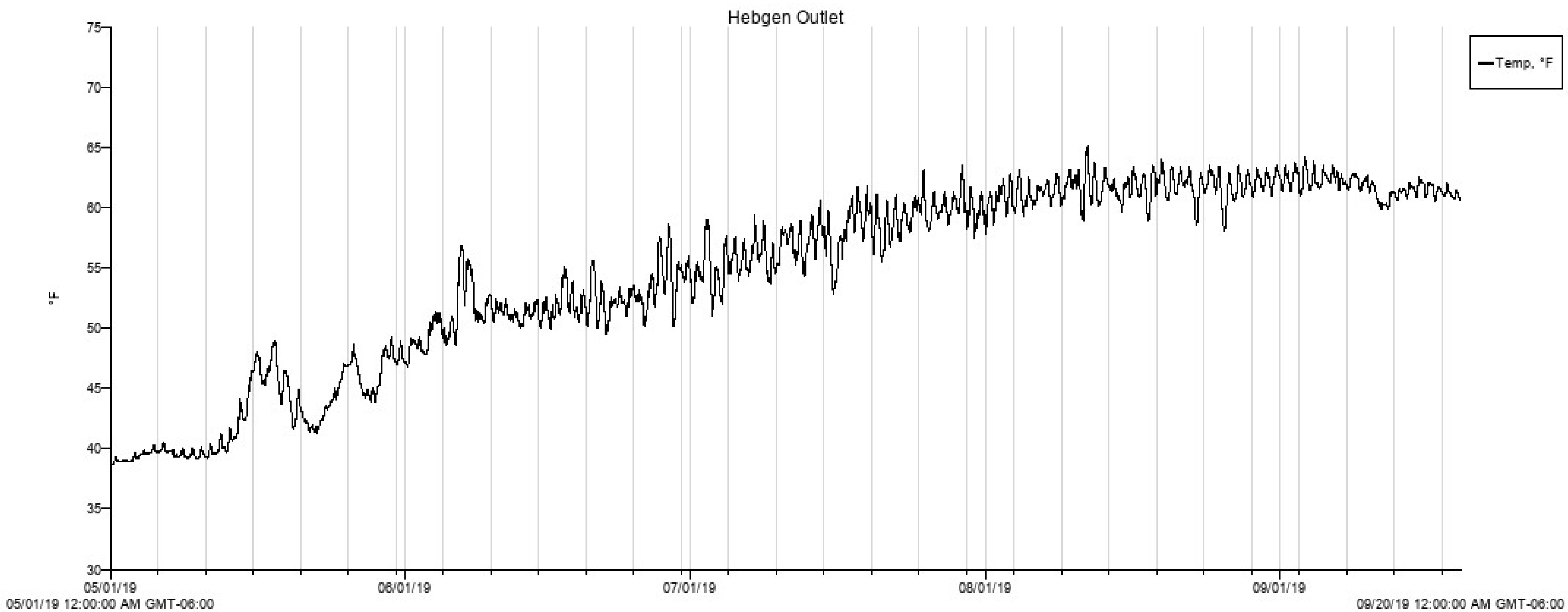
Table 11.-Arctic grayling introductions number of eggs at each introduction site and year, and if any were recovered or reported.

Introduction site	Year 2014	2015	2016	2017	2018	2019	Sub total	Grayling recovered/reported
Odell Spring Creek Granger Ranches		36,000		32,000	60,000	15,000	143,000	None
Odell Spring Creek Longhorn Ranch						45,000	45,000	None
Blaine Spring Creek Granger Ranches		15,000	5,000	1,000	42,000	10,000	73,000	Angler report 2 AG at 8-mile FA 2017, Angler report 1 AG at Burnt Tree Hole FA 2019
Moore Creek Valley Garden Ranch		5,000	5,000	20,000			30,000	Two juvenile AG recovered in 2015 angler report AG in Fletcher Channel 2016
West Fork Madison Upper	1,200							None
West Fork Madison Middle	10,000	30,000	5,000				45,000	One young of the year recovered 2015 sampling
Lake Creek		13,000	27,000	5,000			45,000	None
Denny Creek				5,000	2,000		7,000	None

Appendix A1

Temperature recordings from Madison River monitoring sites
2019
See Figure 11 for locations




Hebgen Outlet
75
70
65
60
55
50
45
40
35
30
°F
Temp, °F
05/01/19
06/01/19
07/01/19
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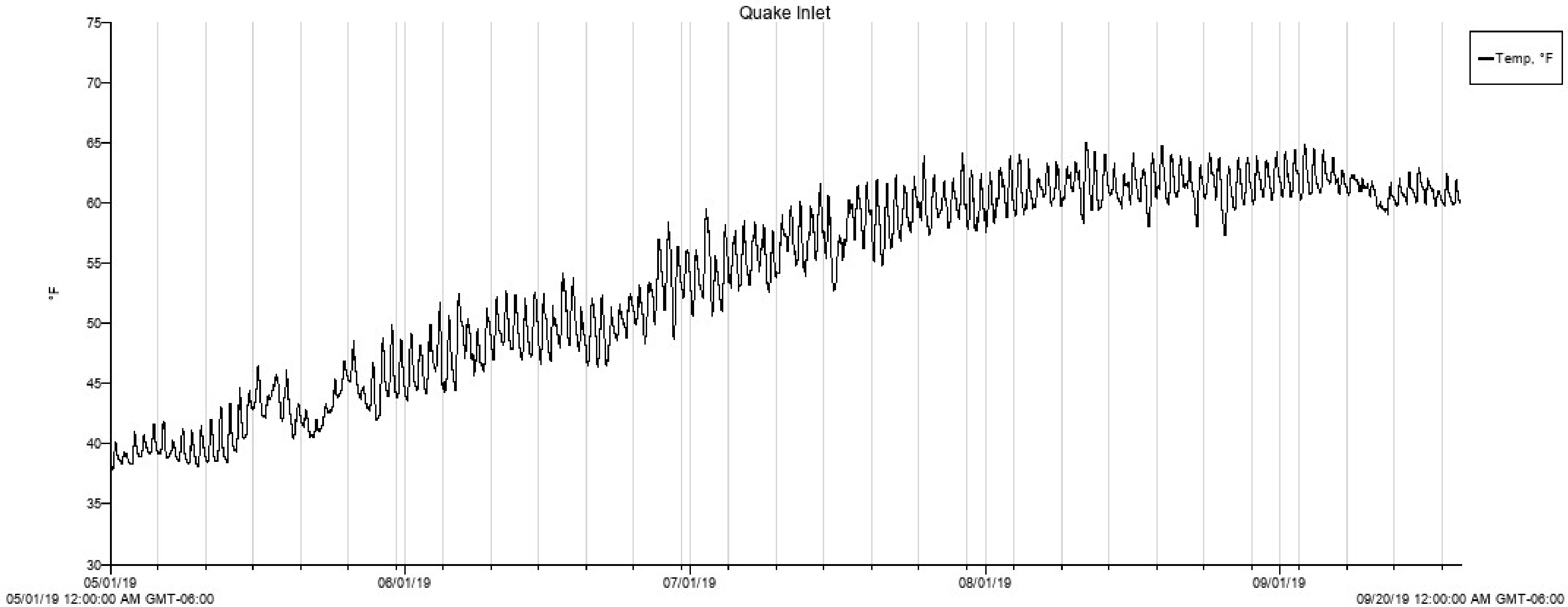

Quake Inlet
Temp, °F
°F
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
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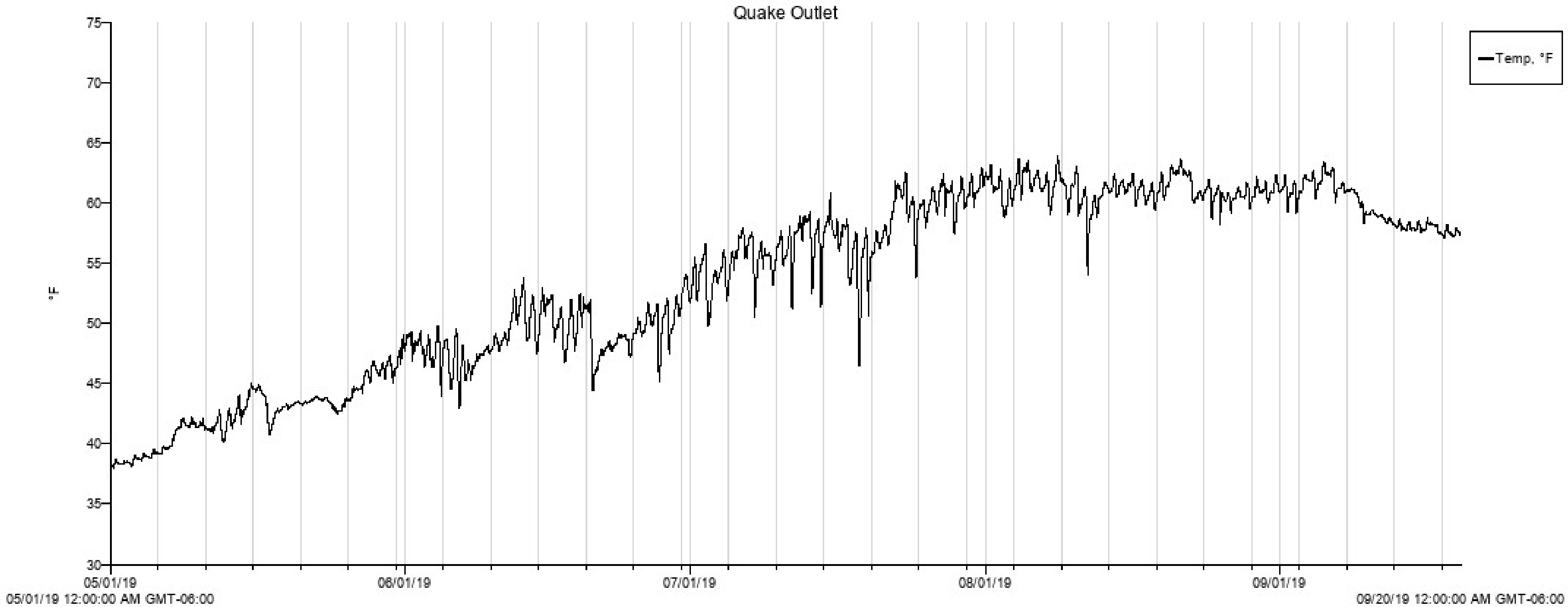
09/20/19 12:00:00 AM GMT-06:00


Quake Outlet
Temp, °F
°F
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
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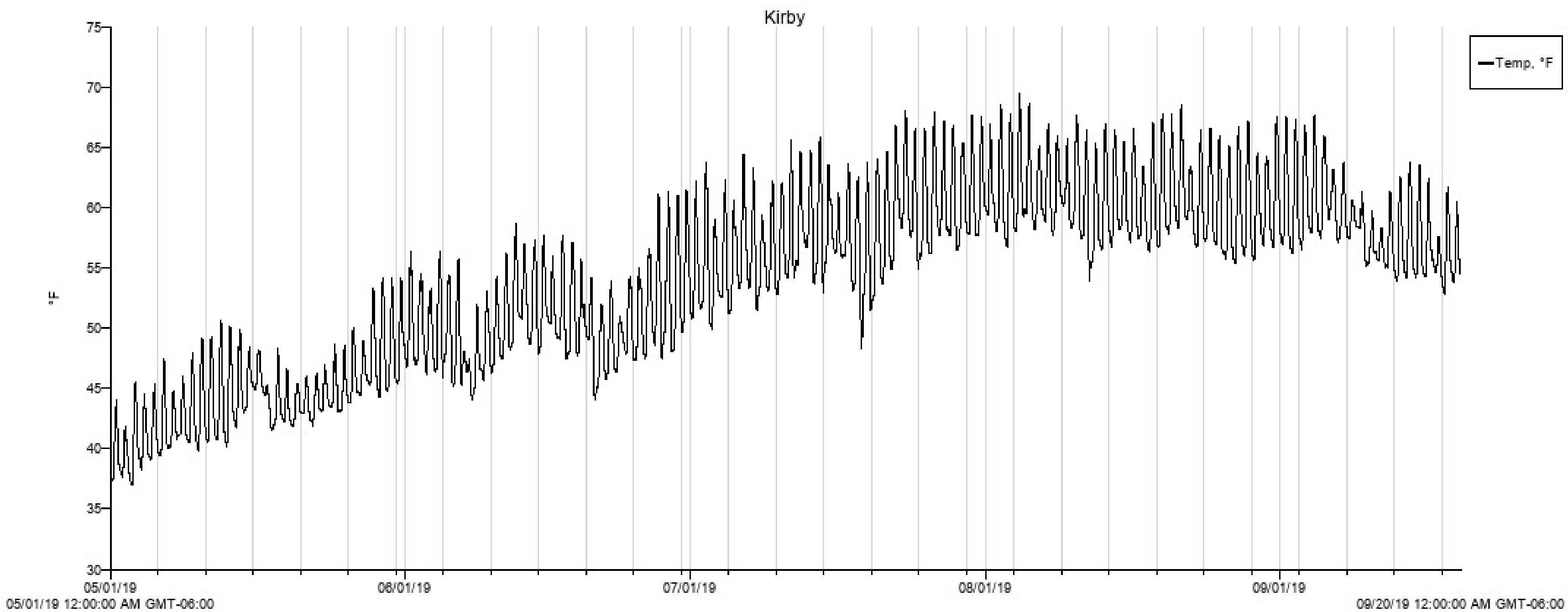
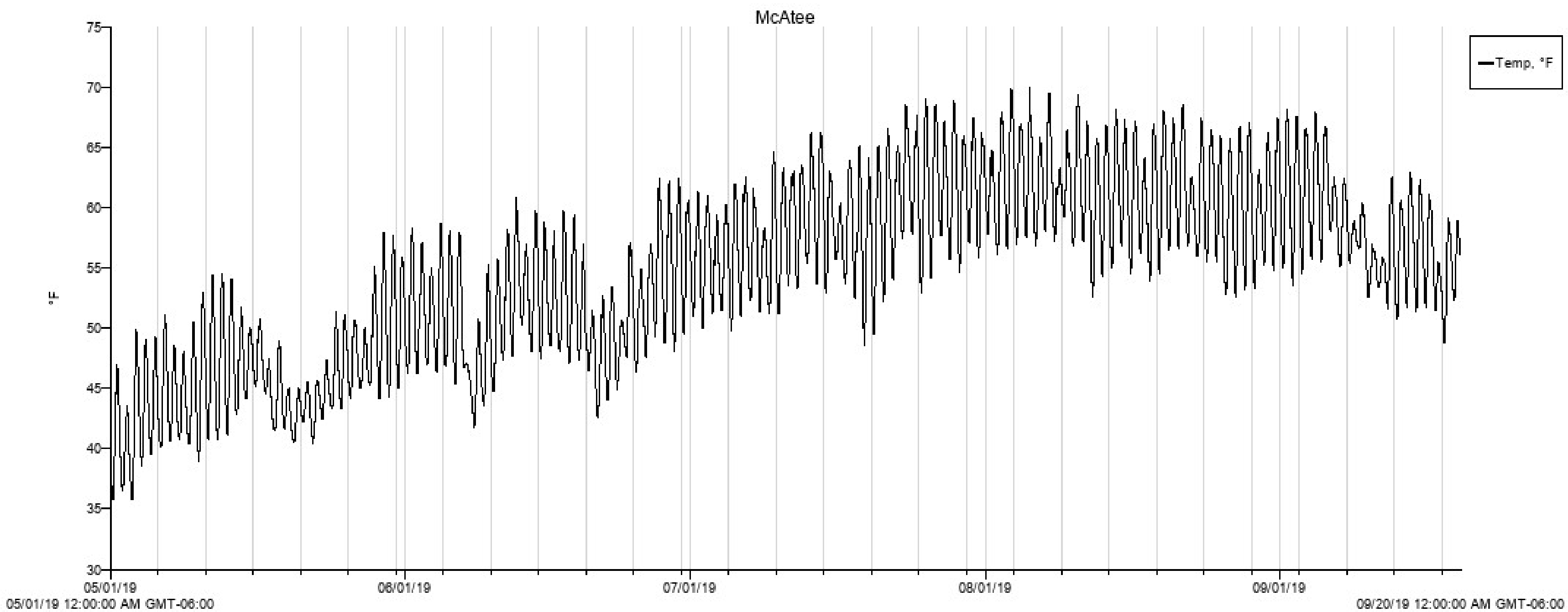


Kirby
Temp, °F
°F
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
05/01/19 12:00:00 AM GMT-06:00
09/20/19 12:00:00 AM GMT-06:00


McAtee
Temp, °F
°F
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
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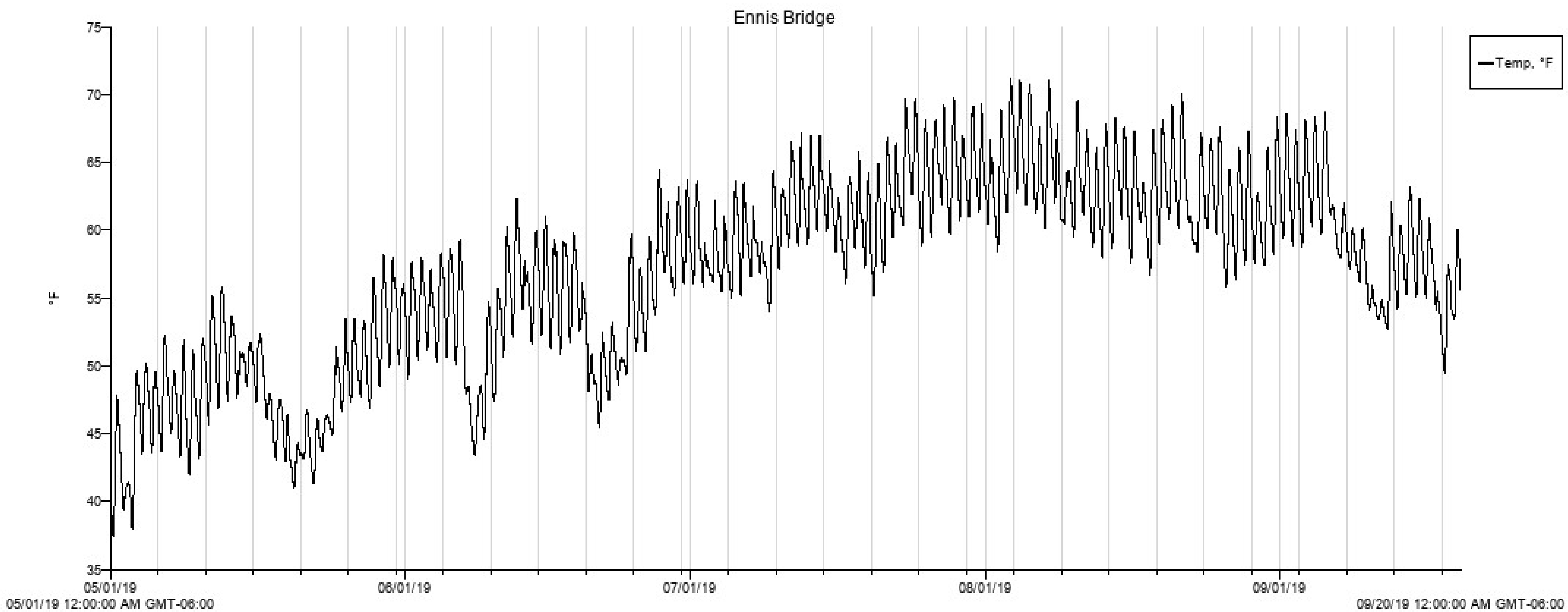
Ennis Bridge
Temp, °F
°F
75
70
65
60
55
50
45
40
35
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
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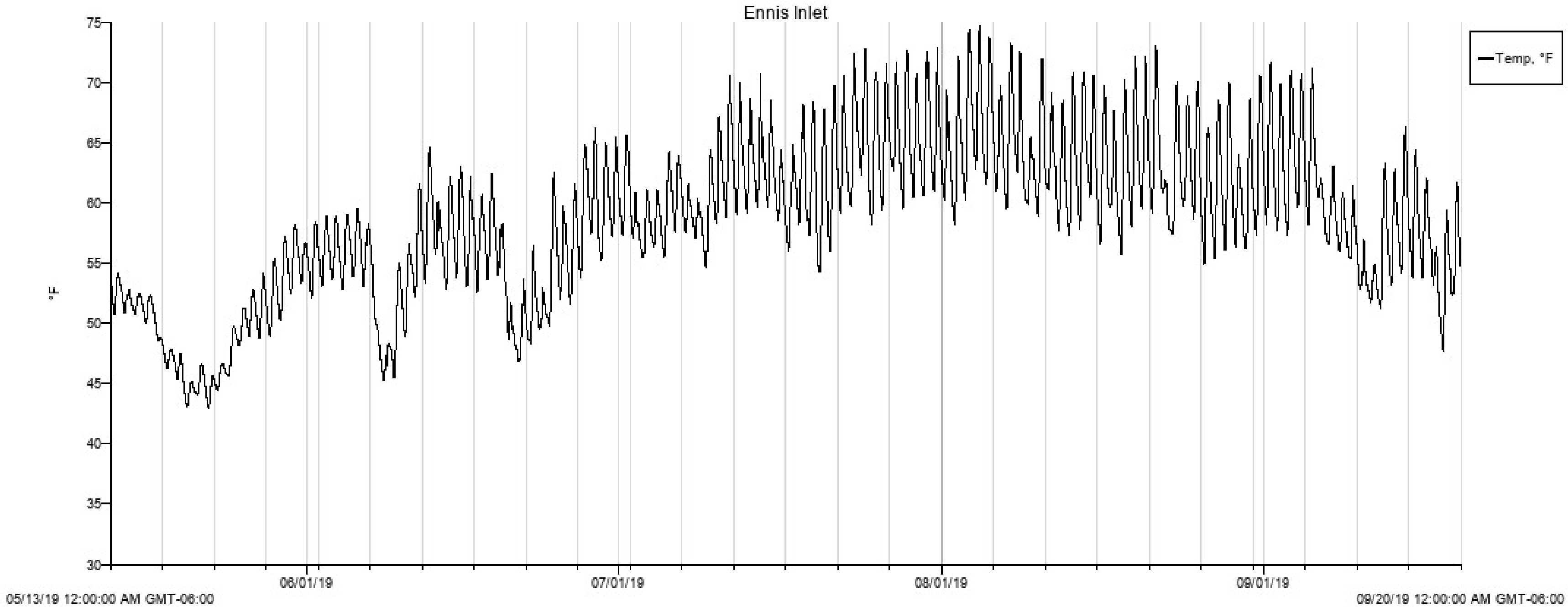
Ennis Inlet
75
70
65
60
55
50
45
40
35
30
°F
Temp, °F
06/01/19
07/01/19
08/01/19
09/01/19
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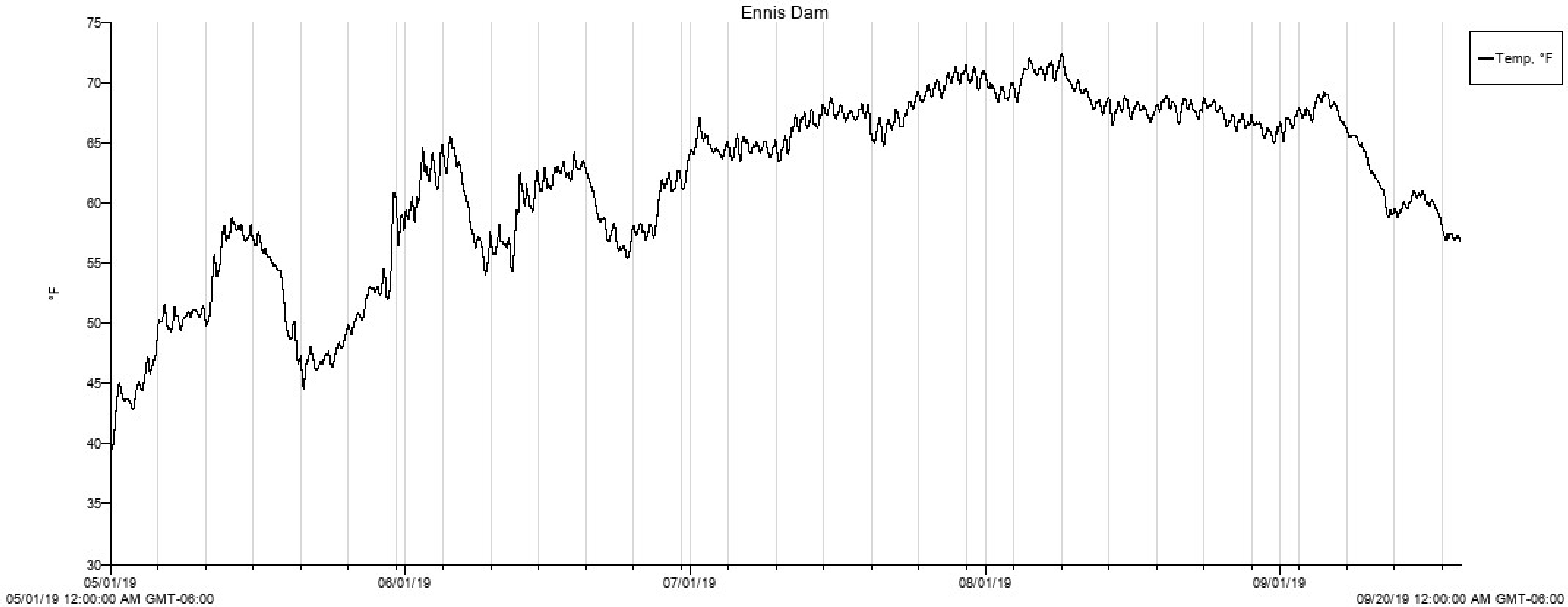
Ennis Dam
75
70
65
60
55
50
45
40
35
30
°F
Temp, °F
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
05/01/19 12:00:00 AM GMT-06:00
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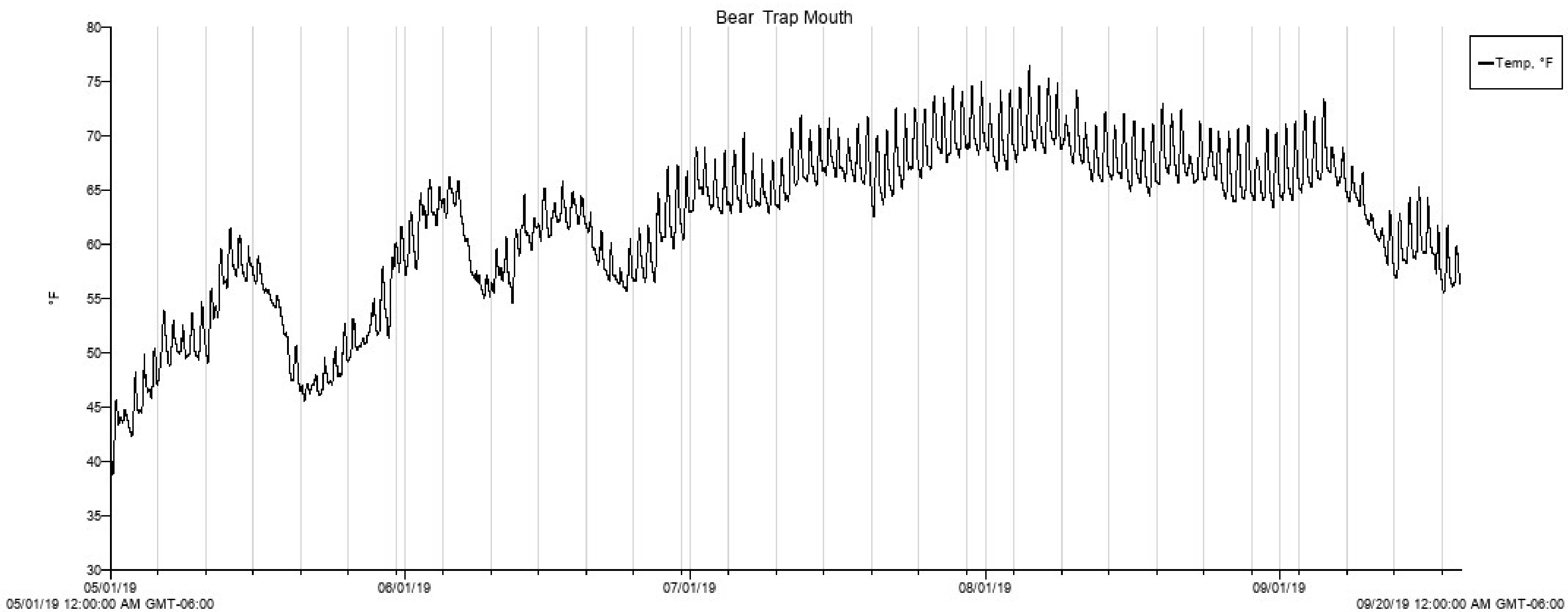
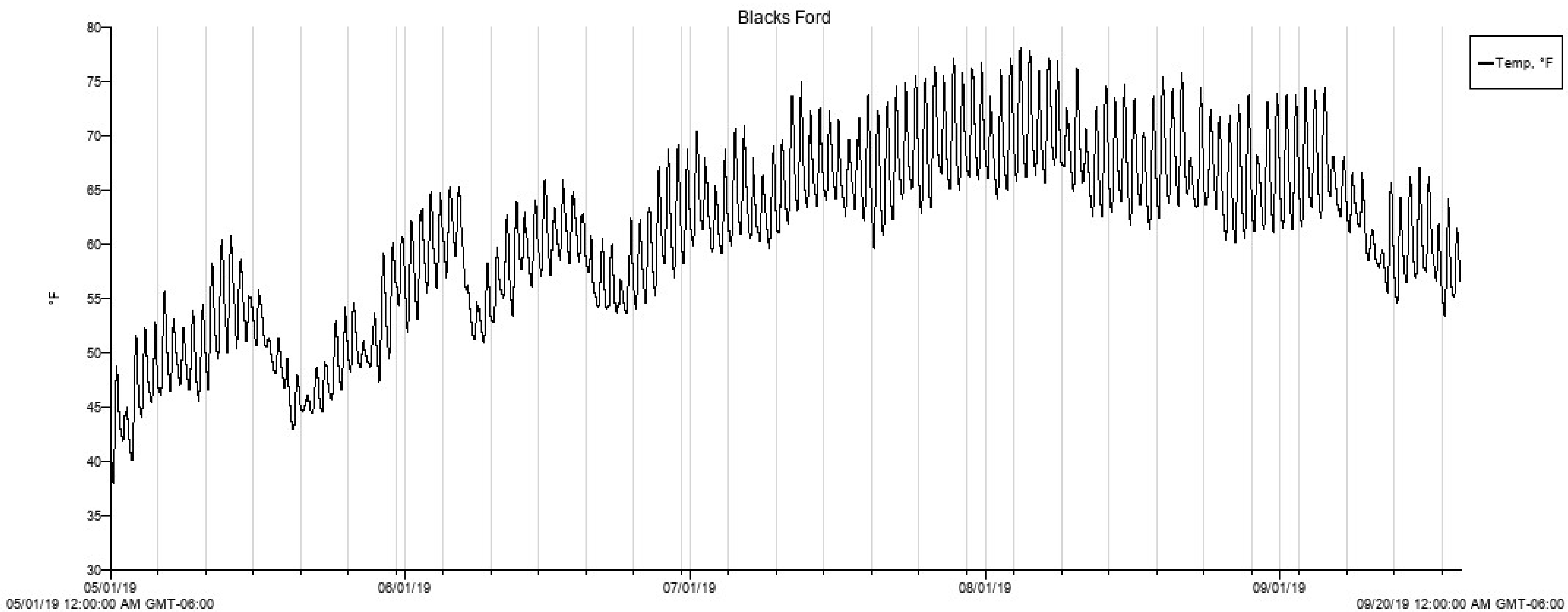

Bear Trap Mouth
Temp, °F
°F
80
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
05/01/19 12:00:00 AM GMT-06:00
09/20/19 12:00:00 AM GMT-06:00


Blacks Ford
Temp, °F
°F
80
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
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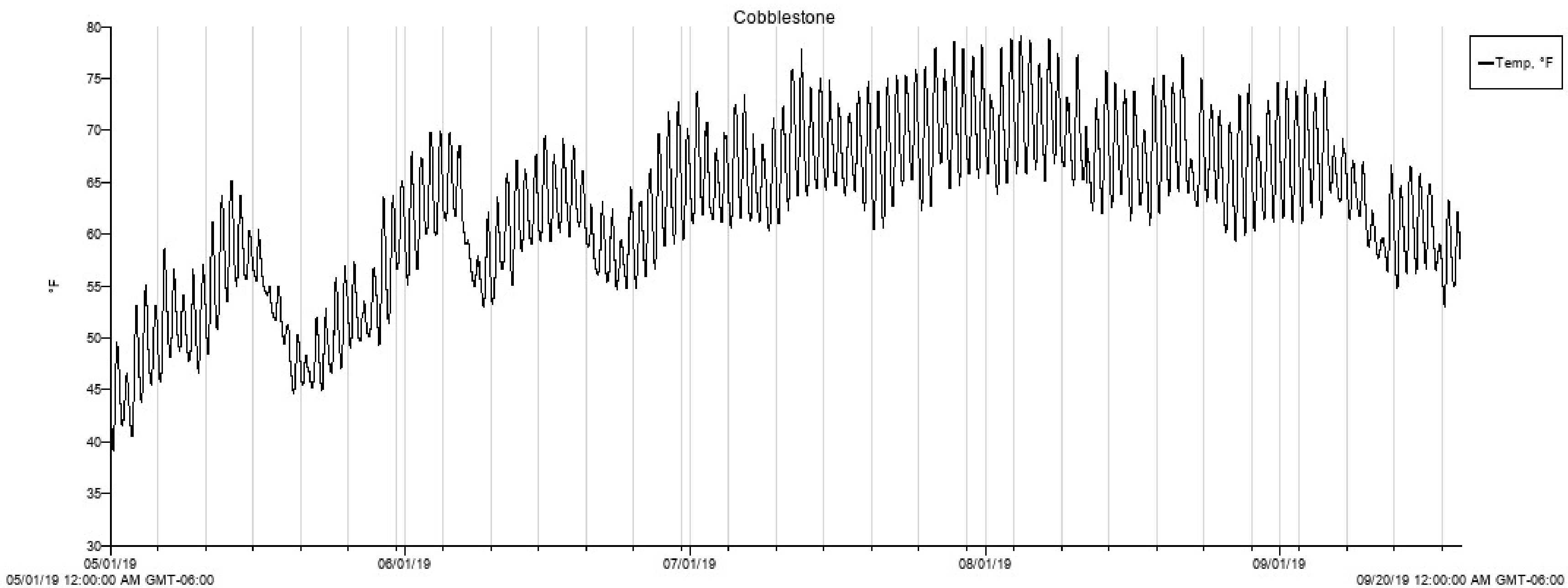
09/20/19 12:00:00 AM GMT-06:00


Cobblestone
Temp, °F
°F
80
75
70
65
60
55
50
45
40
35
30
05/01/19
06/01/19
07/01/19
08/01/19
09/01/19
05/01/19 12:00:00 AM GMT-06:00
09/20/19 12:00:00 AM GMT-06:00

Appendix A2

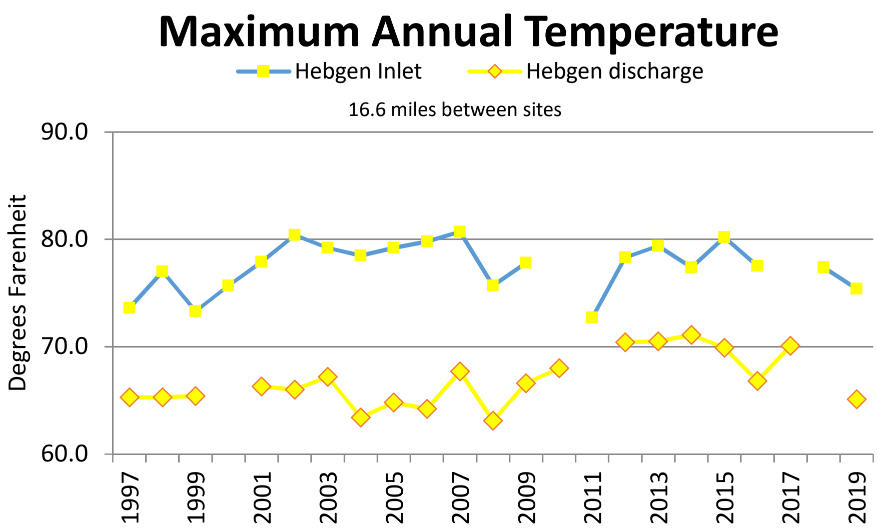
Comparison of maximum annual water temperatures at selected Madison River monitoring sites
1997 - 2019
See Figure 11 for locations

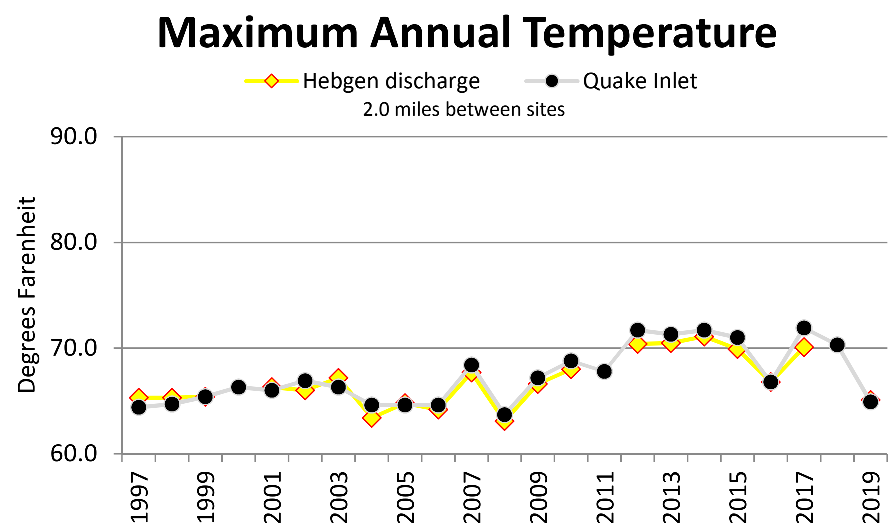
NOTES:

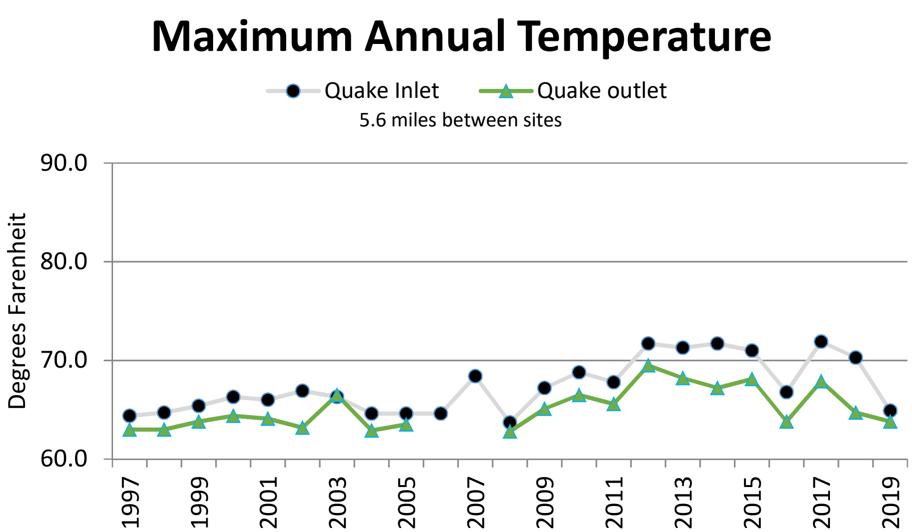
- Recorders at some locations were not recovered some years

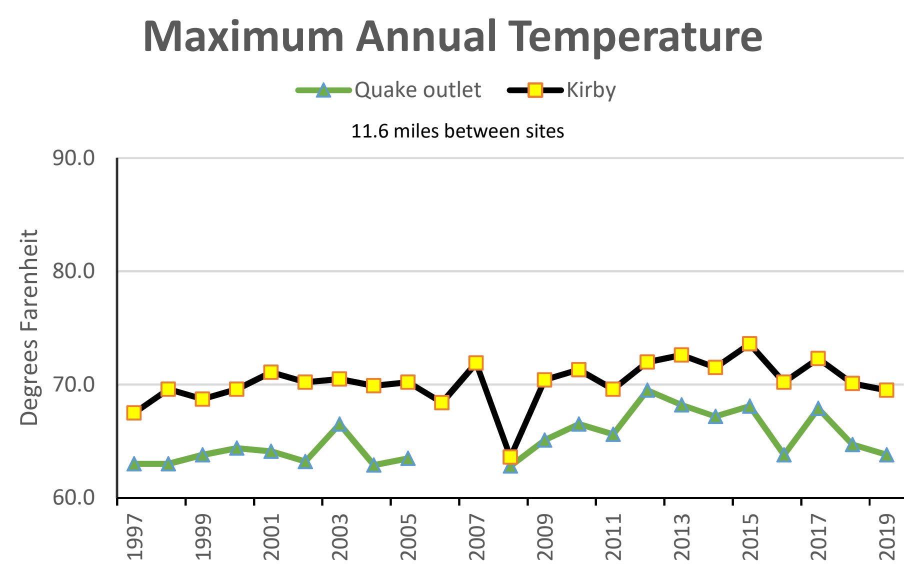
- It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year

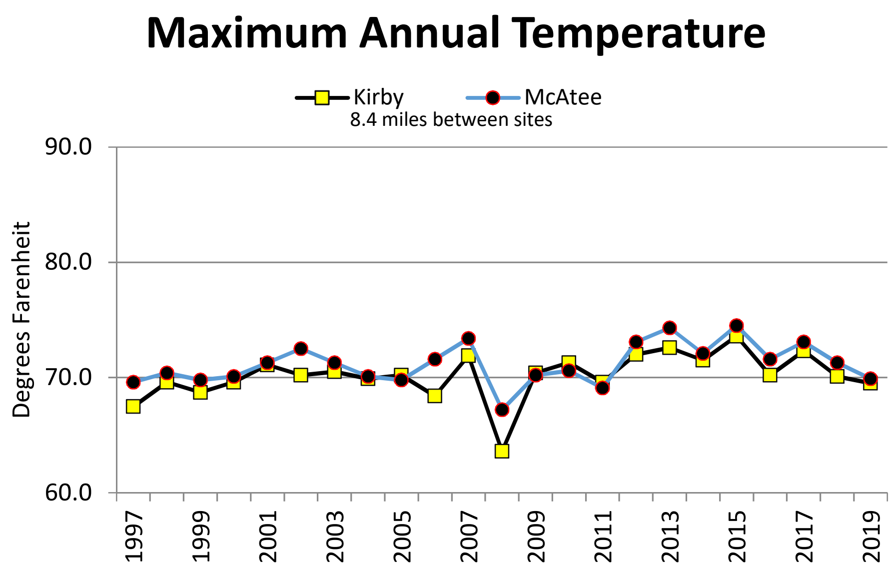
- Pulse flows were conducted out of Ennis Reservoir annually from 2000 – 2007, in 2009, and 2013 - 2019.

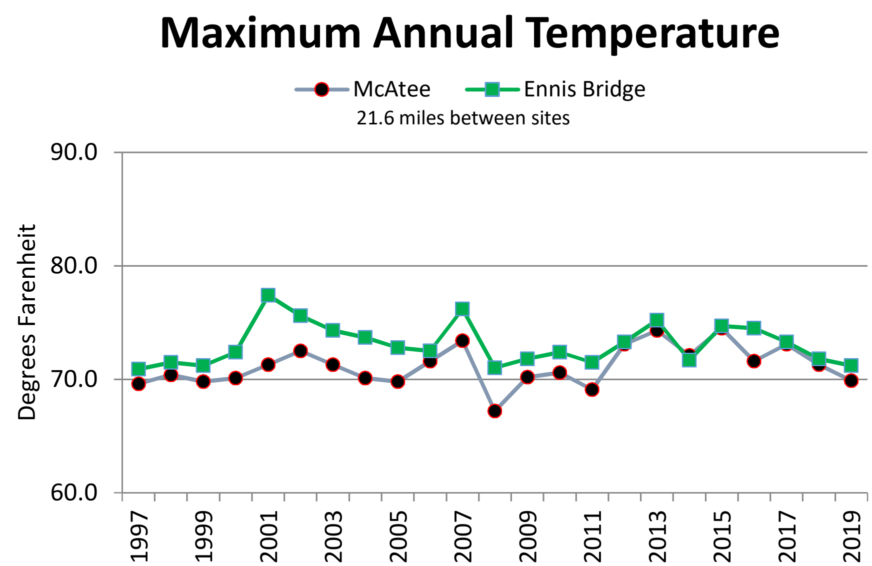

Maximum Annual Temperature
Hebgen Inlet
Hebgen discharge
16.6 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

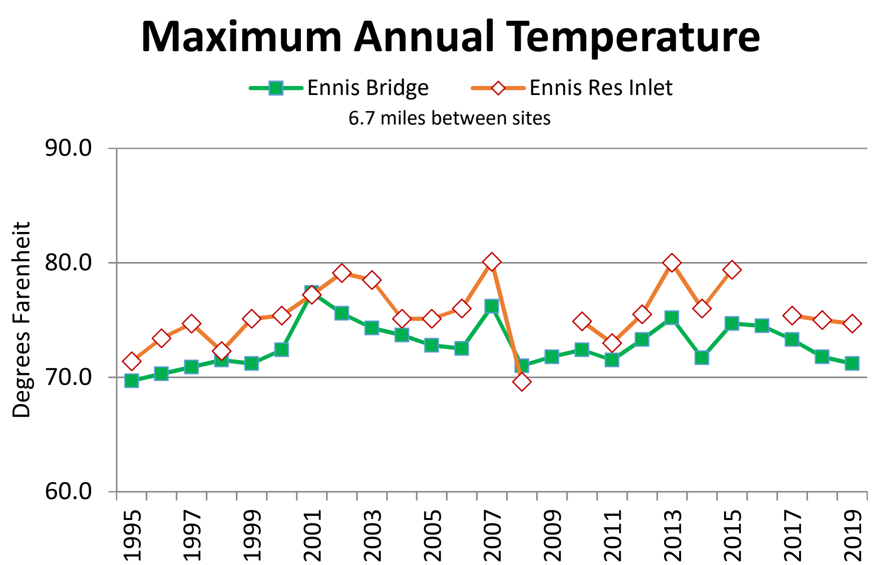

Maximum Annual Temperature
Hebgen discharge
Quake Inlet
2.0 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

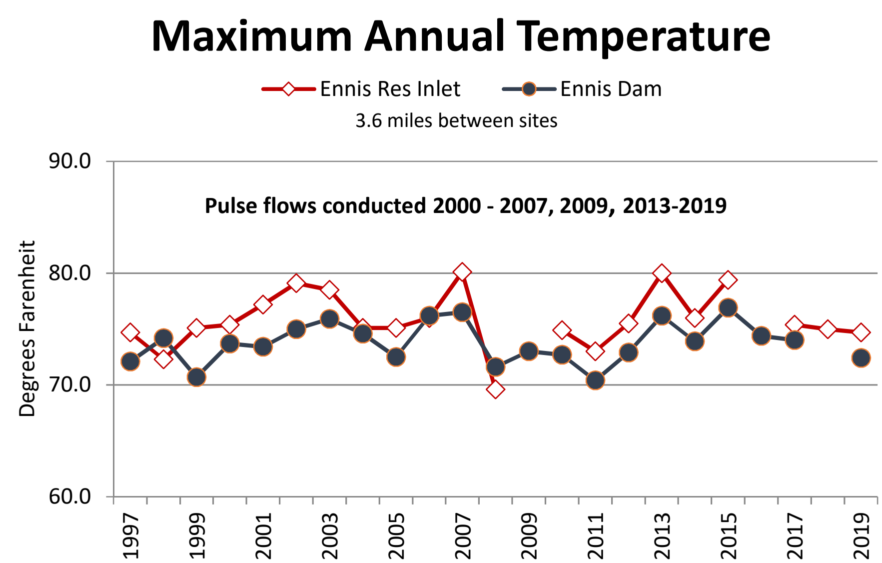

Maximum Annual Temperature
Quake Inlet
Quake outlet
5.6 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

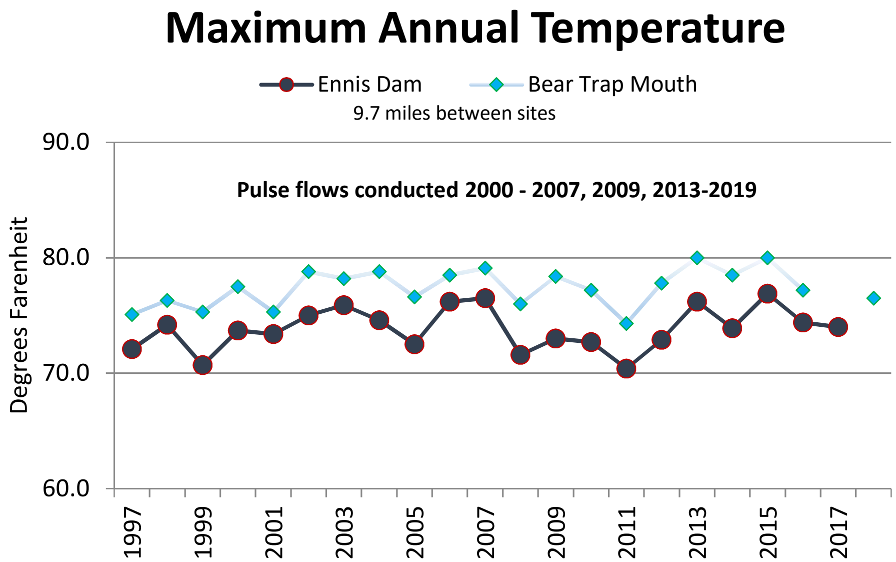

Maximum Annual Temperature
Quake outlet
Kirby
11.6 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

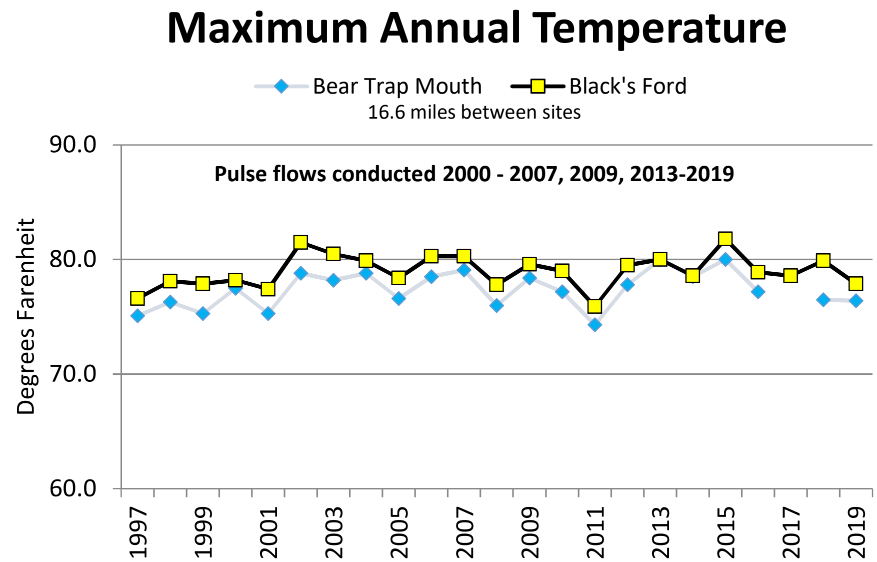

Maximum Annual Temperature
Kirby
McAtee
8.4 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

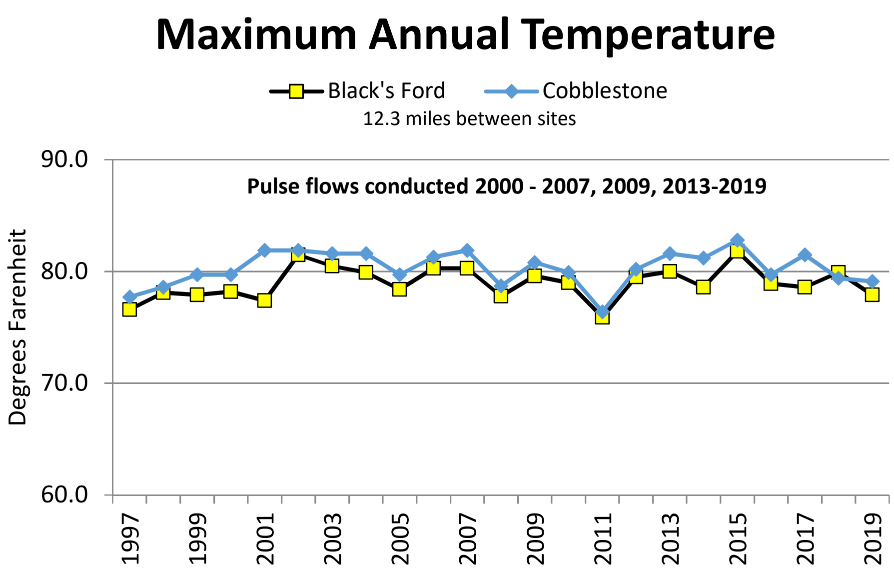

Maximum Annual Temperature
McAtee
Ennis Bridge
21.6 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

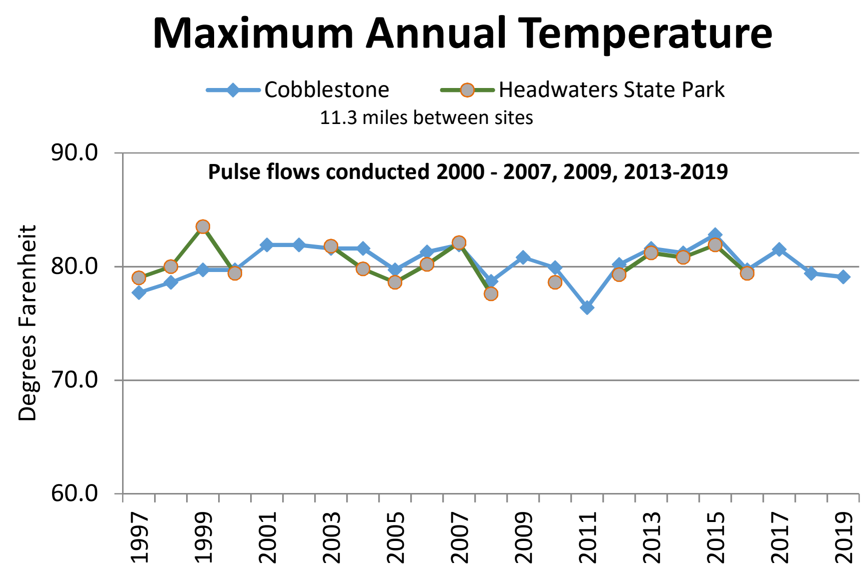

Maximum Annual Temperature
Ennis Bridge
Ennis Res Inlet
6.7 miles between sites
Degrees Farenheit
90.0
80.0
70.0
60.0
1995
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

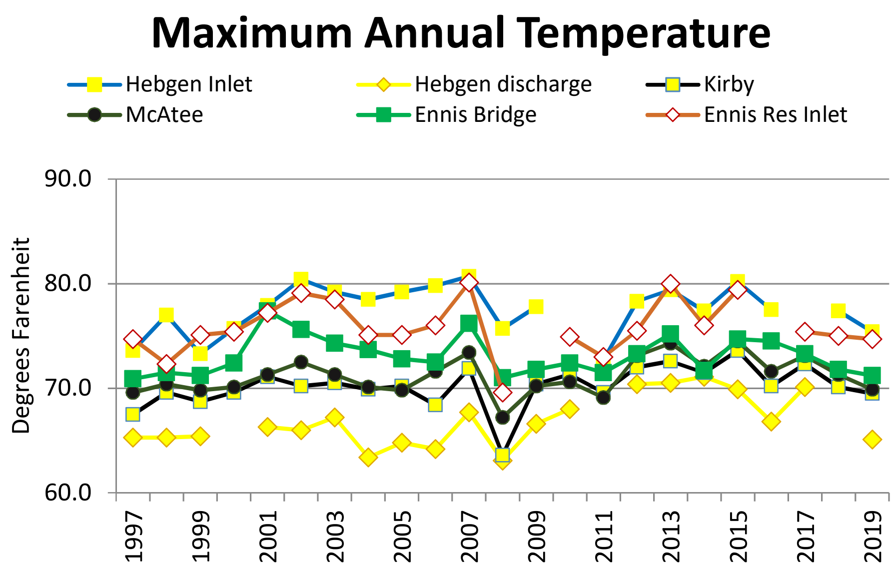

Maximum Annual Temperature
Ennis Res Inlet
Ennis Dam
3.6 miles between sites
Pulse flows conducted 2000 - 2007, 2009, 2013-2019
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

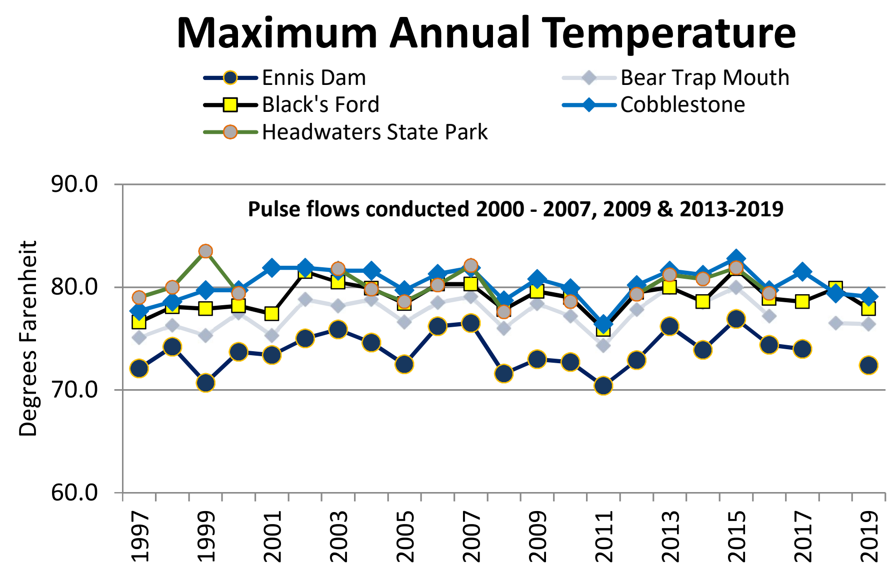

Maximum Annual Temperature
Ennis Dam
Bear Trap Mouth
9.7 miles between sites
Pulse flows conducted 2000 - 2007, 2009, 2013-2019
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017


Maximum Annual Temperature
Bear Trap Mouth
Black's Ford
16.6 miles between sites
Pulse flows conducted 2000 - 2007, 2009, 2013-2019
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019


Maximum Annual Temperature
Black's Ford
Cobblestone
12.3 miles between sites
Pulse flows conducted 2000 - 2007, 2009, 2013-2019
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019


Maximum Annual Temperature
Cobblestone
Headwaters State Park
11.3 miles between sites
Pulse flows conducted 2000 - 2007, 2009, 2013-2019
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019


Maximum Annual Temperature
Hebgen Inlet
Hebgen discharge
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019


Maximum Annual Temperature
Ennis Dam
Bear Trap Mouth
Black's Ford
Cobblestone
Headwaters State Park
Pulse flows conducted 2000 - 2007, 2009 & 2013-2019
Degrees Farenheit
90.0
80.0
70.0
60.0
1997
1999
2001
2003
2005
2007
2009
2011
2013
2015
2017
2019

Appendix A3

Maximum annual water temperatures recorded at Madison River monitoring sites

1997 - 2019

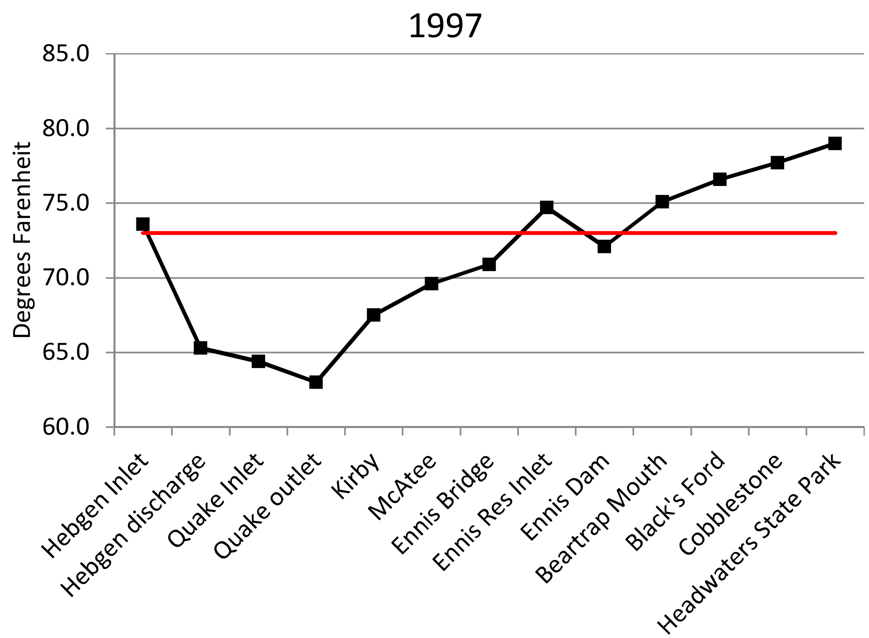
See Figure 11 for locations

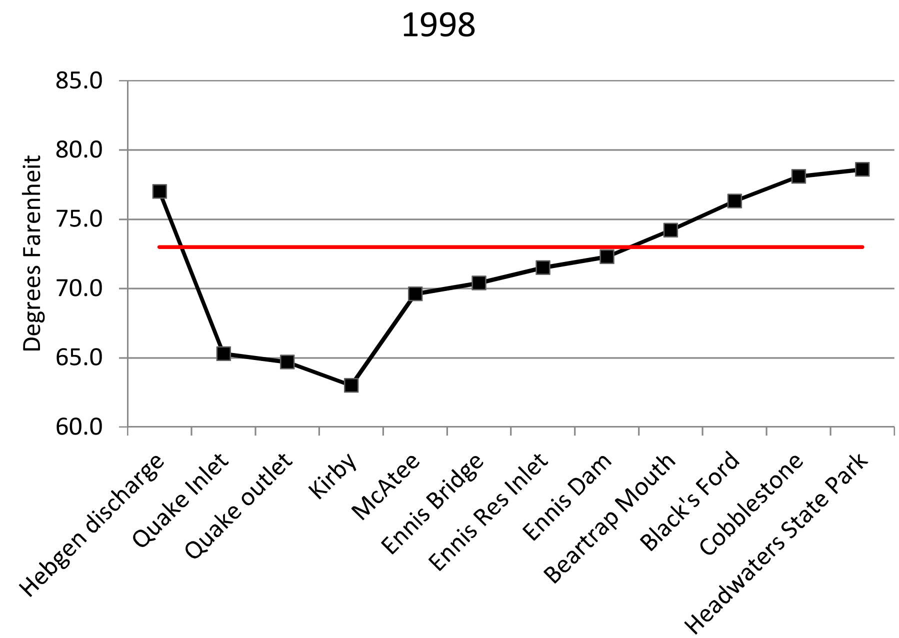
NOTES:

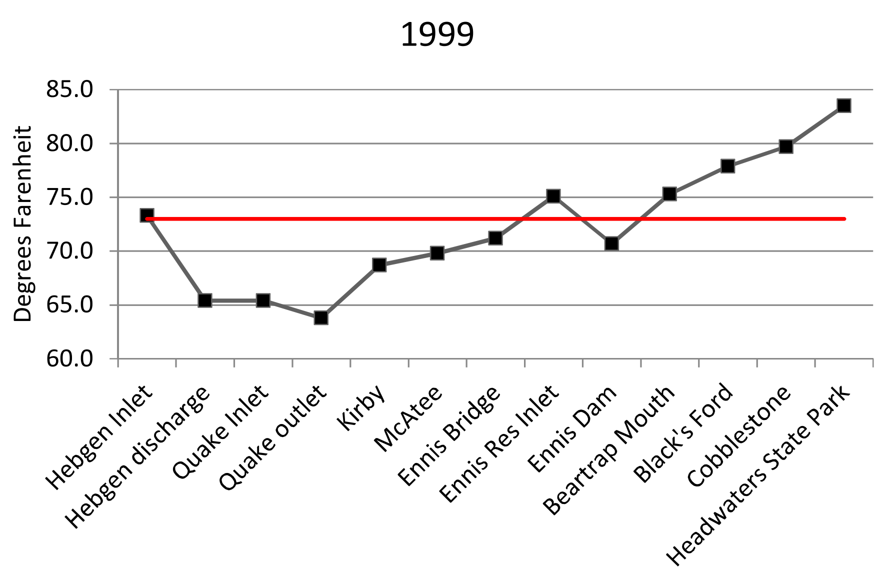
- Recorders at some locations were not recovered some years

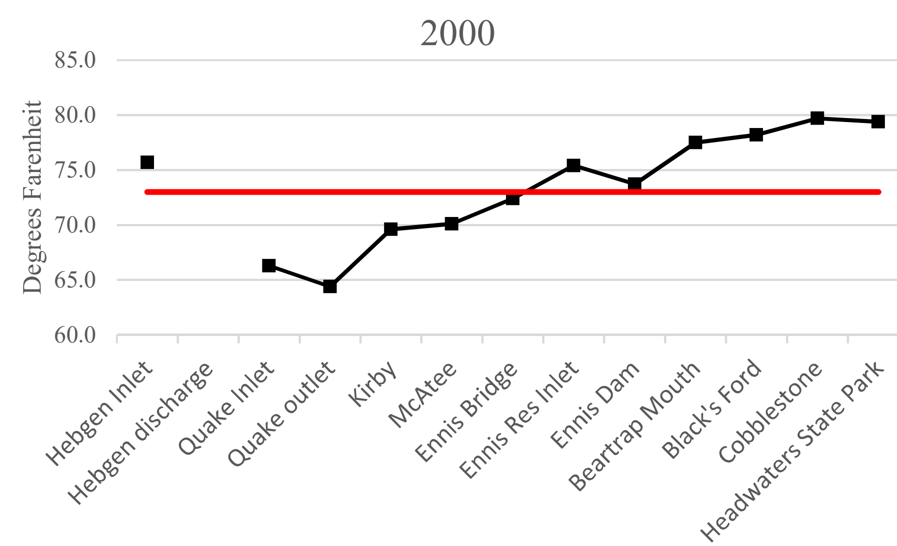
- It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year.

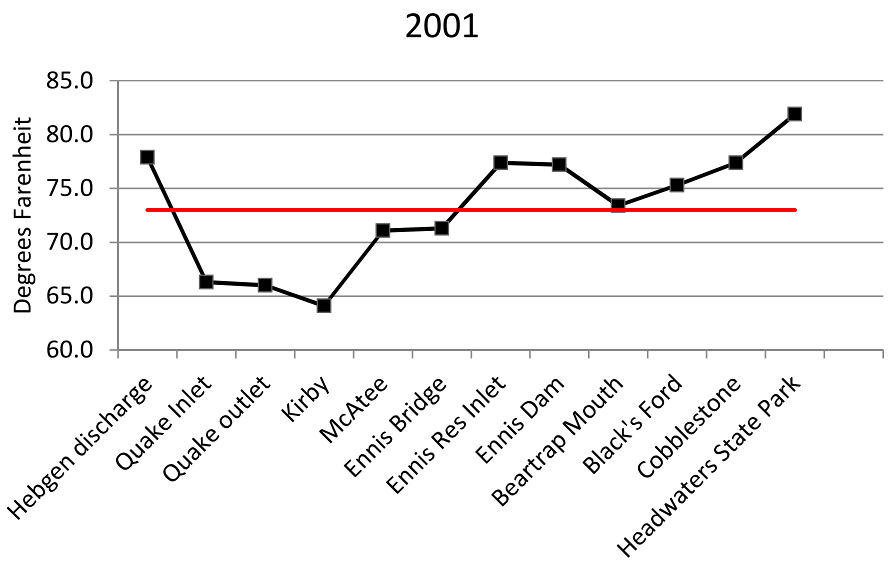
- Red lines show 73◦

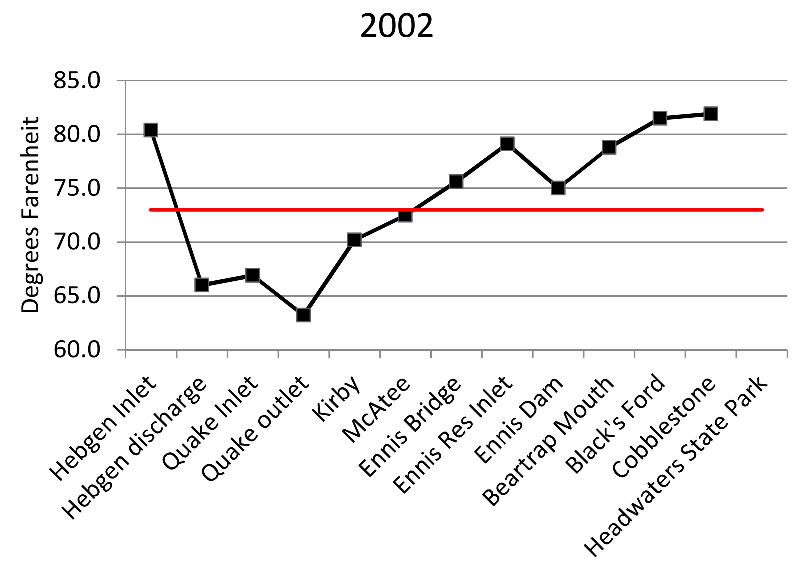

1997
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

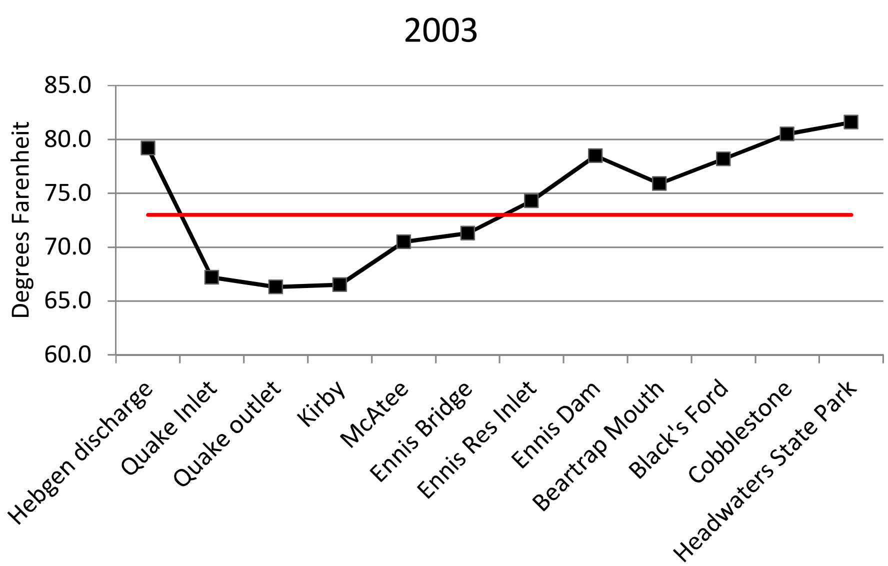

1998
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

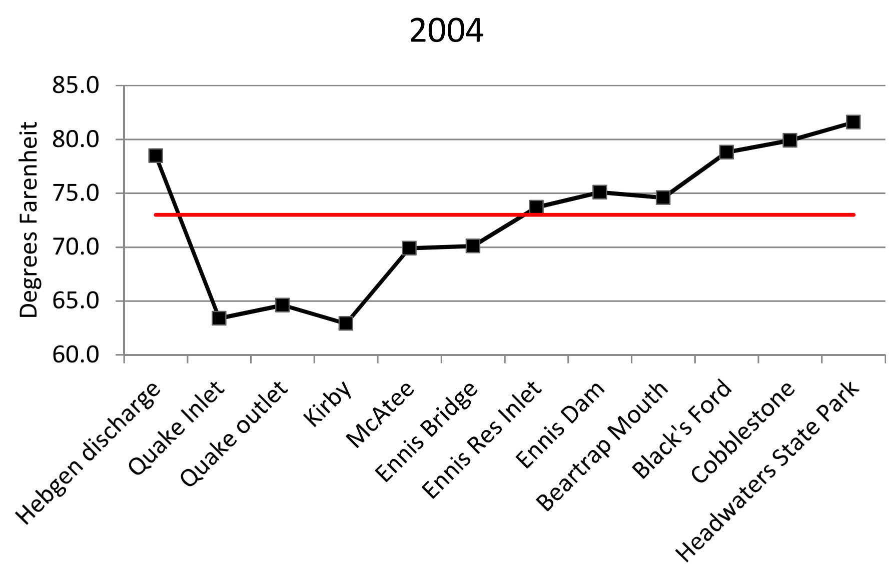

1999
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

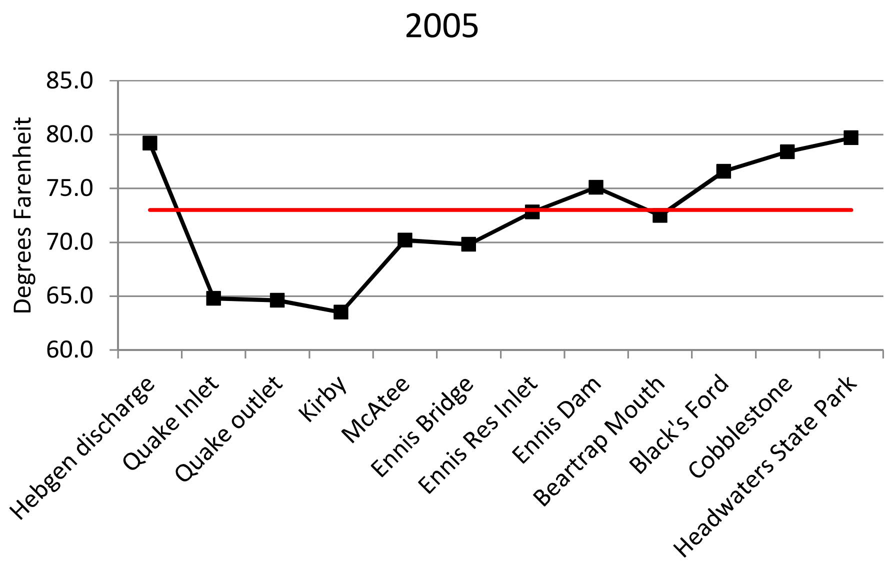

2000
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

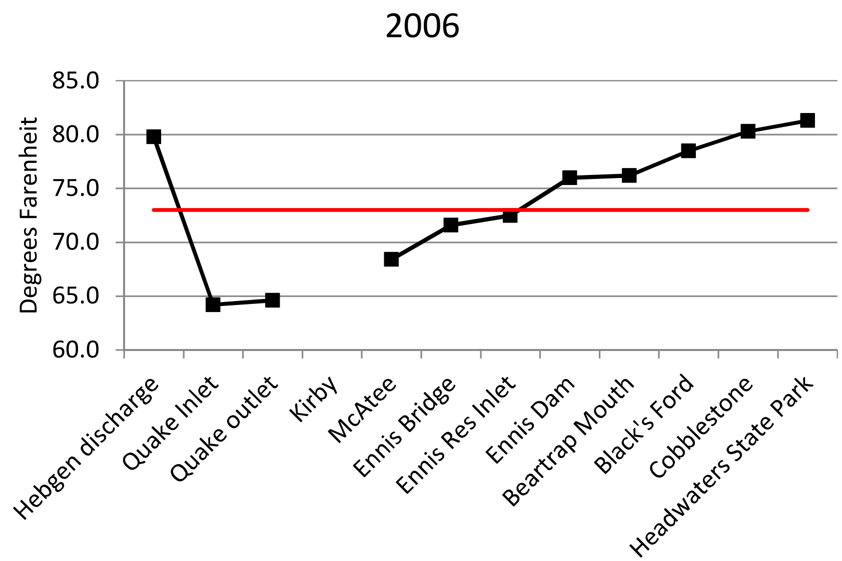

2001
Degrees Farenheit
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

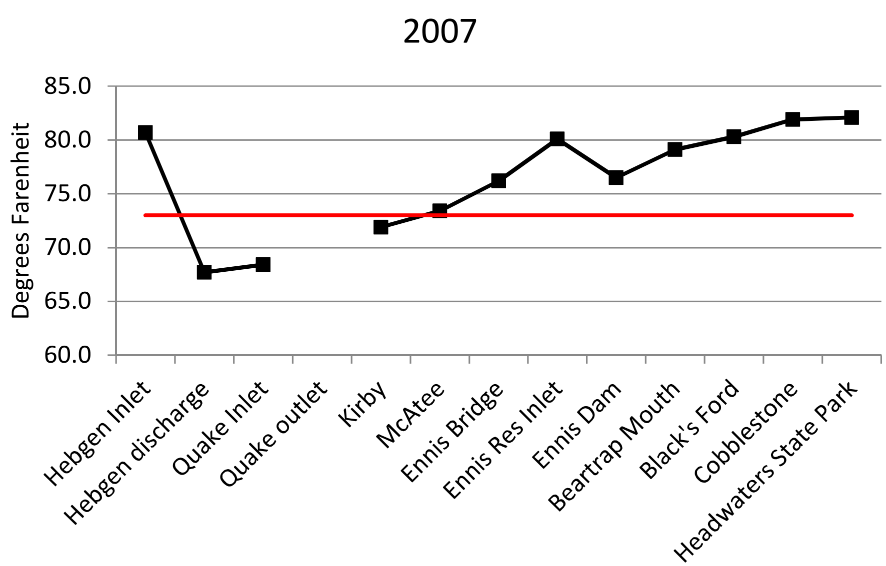

2002
Degrees Farenheit
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

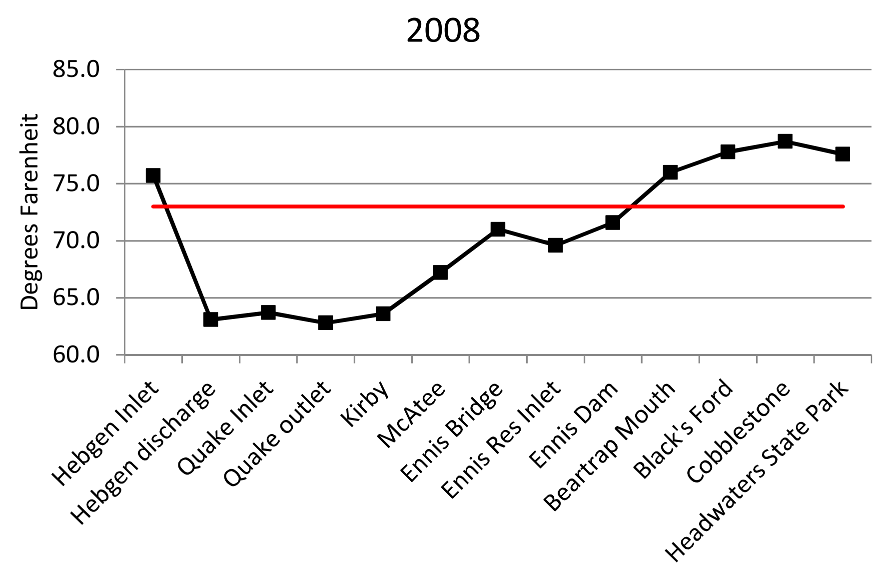

2003
Degrees Farenheit
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

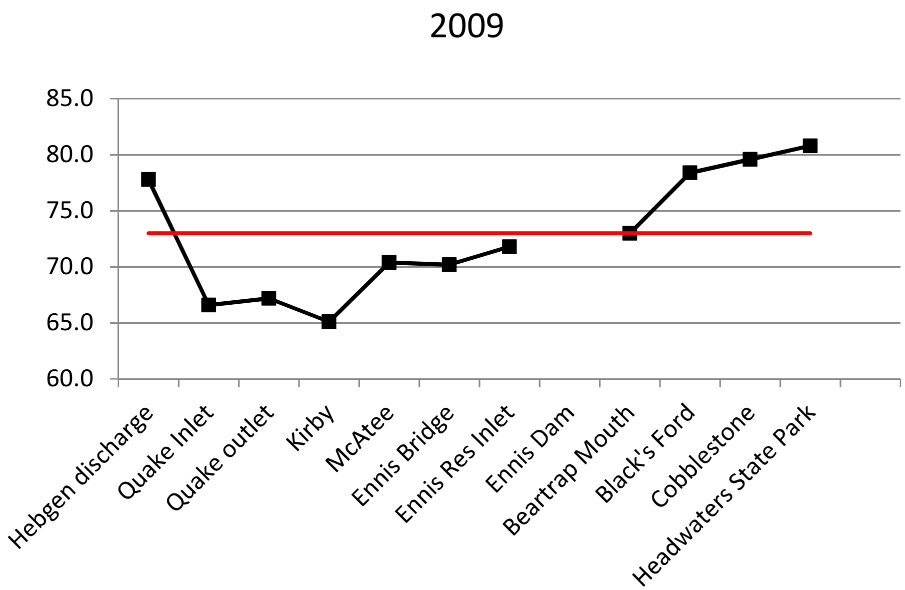

2004
Degrees Farenheit
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

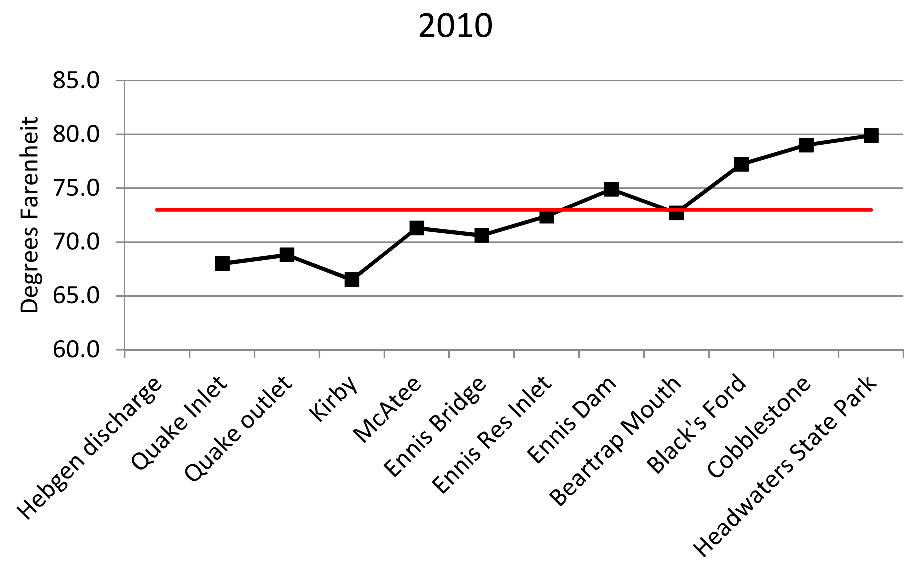

2005
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park

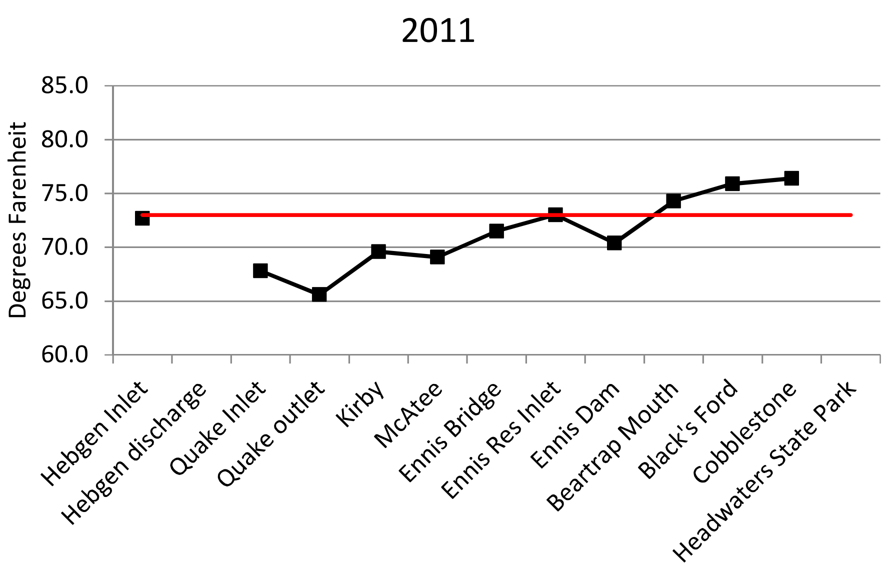

2006
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park


2007
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park


2008
85.0
80.0
75.0
70.0
65.0
60.0
Degrees Farenheit
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park


2009
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park


2010
Degrees Farenheit
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Black's Ford
Cobblestone
Headwaters State Park


2011
Degrees Farenheit
85.0
80.0
75.0
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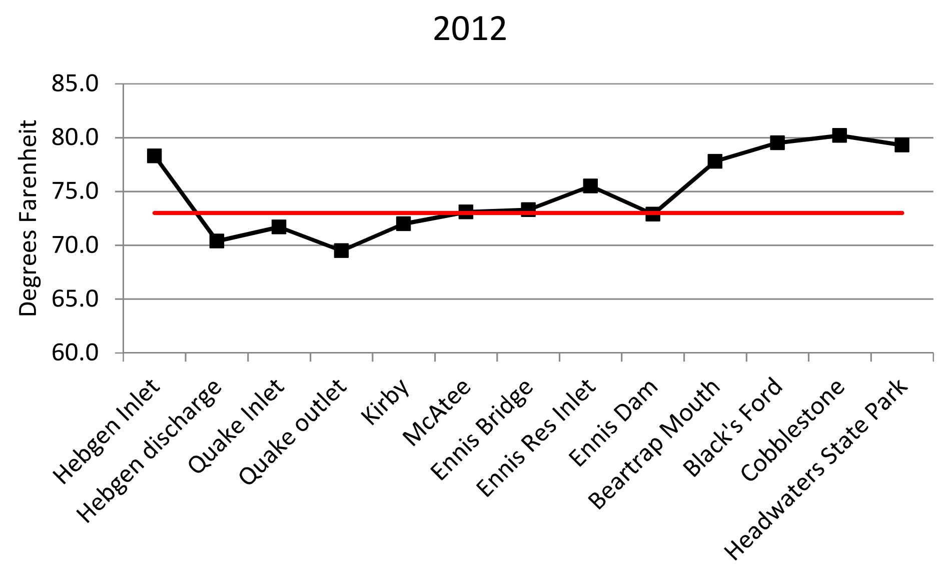
Black's Ford
Cobblestone
Headwaters State Park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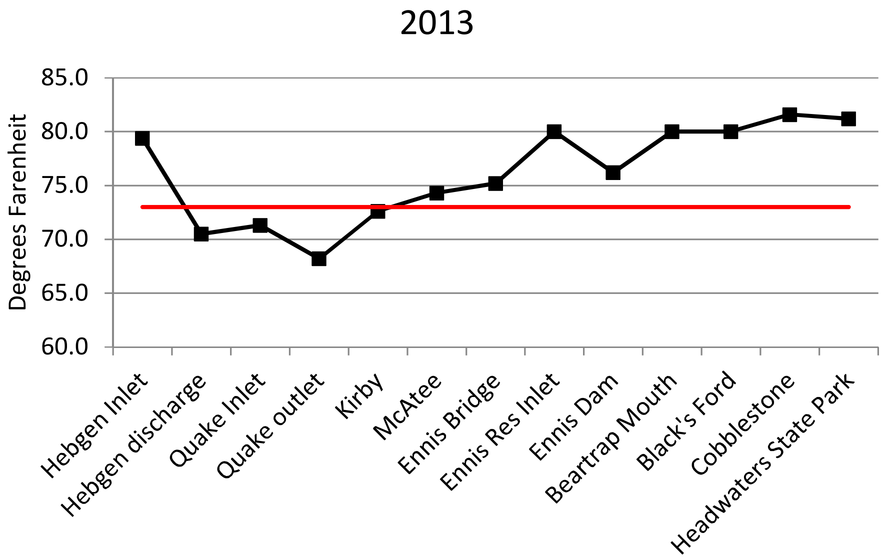
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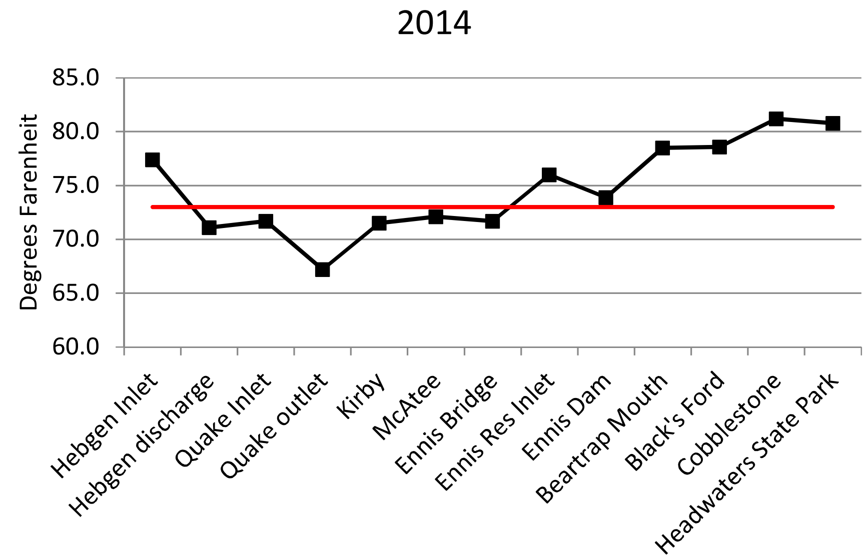
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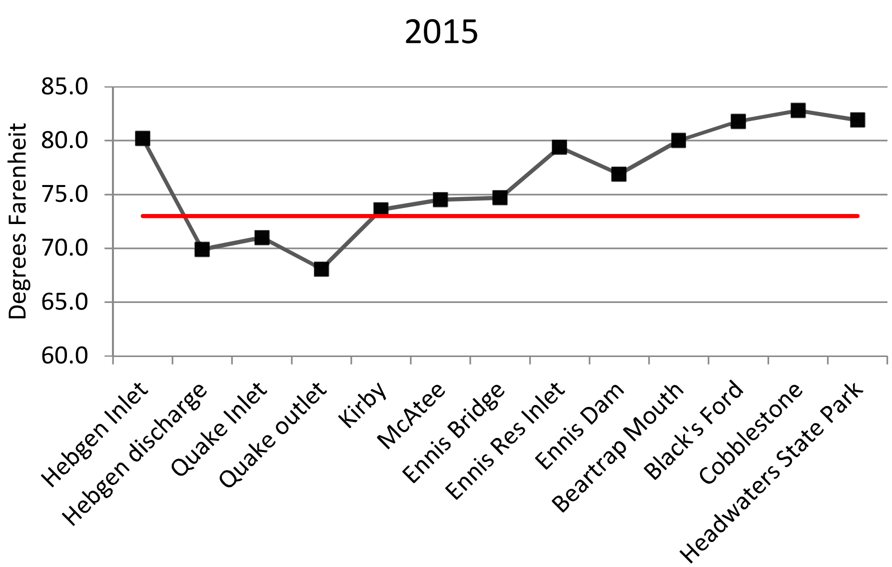
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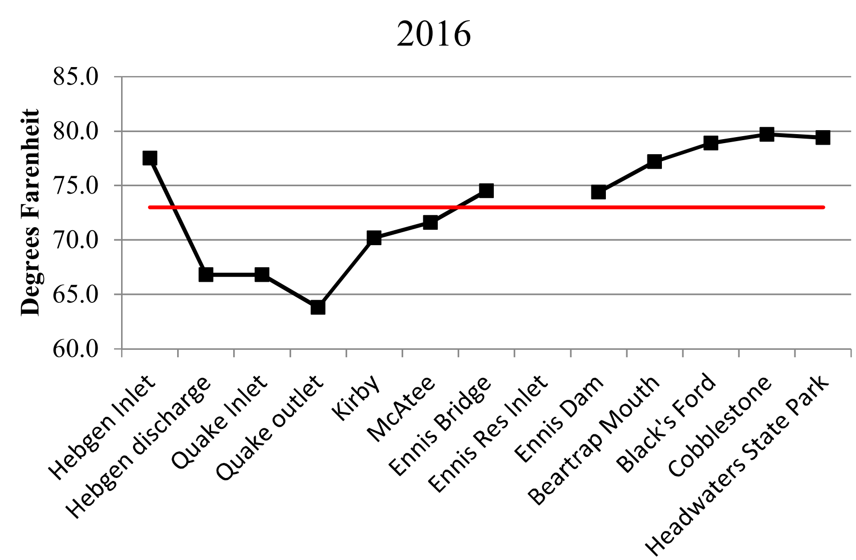
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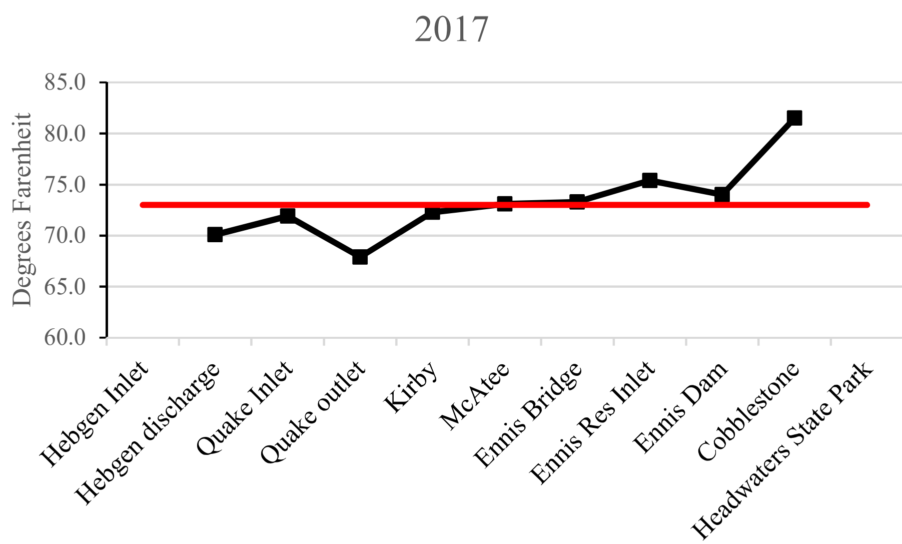

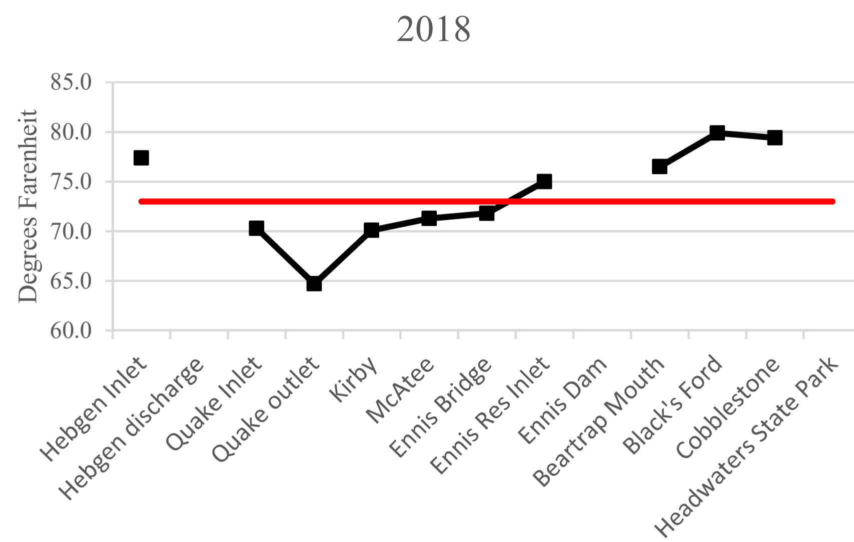

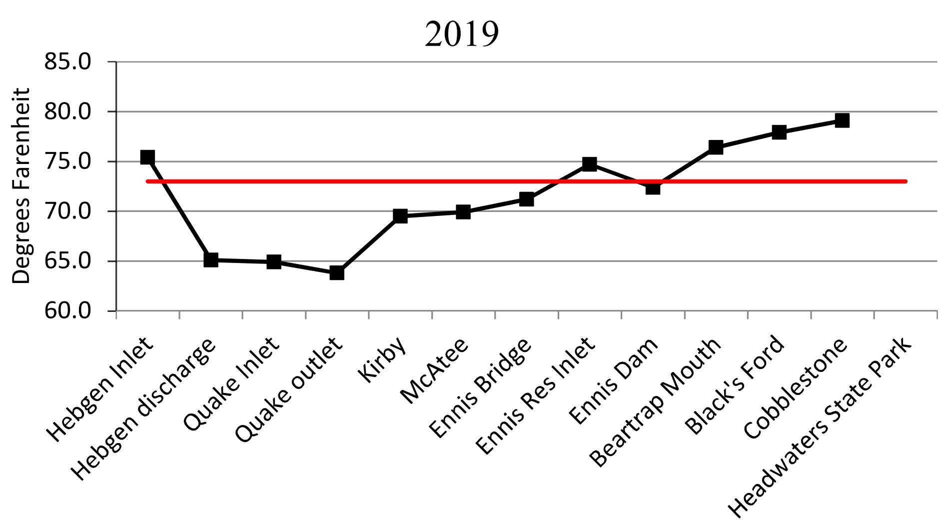

Appendix A3- Figures-Maximum water temperatures at Madison River monitoring sites 1997-2019.

Appendix A4

Project Title: **Beaverhead-Deerlodge National Forest, Madison Ranger District Seasonal Technicians and WF Madison Stream Restoration Project Report 2019**
Report by: **Darin Watschke**

The following work enhanced/supported PM&E measure(s) 408, 409, and 412 in the Project 2188 License.

Location of Projects: **Madison and Ruby River drainages**
The Madison River Fisheries Technical Advisory Committee provided $9,000 to the Madison Ranger District, Beaverhead-Deerlodge National Forest to help fund a fisheries technician during field season 2019. The technician worked a total of 128 days with 71 days funded by the USFS at a cost of about $10,000. Mad TAC dollars were used to fund 57 days ($7,800) of work on Madison River drainage projects and one Ruby River and one Gallatin River project (all listed below). Additionally, about $1,200 of Mad TAC funding was utilized to purchase supplies and field gear for the technicians. The following listed activities summarize the work performed by the technician in 2019.

- Bear Creek Days: Education Outreach and Fish Dissection: *2 days*
  Over 50 students were engaged with native species conservation, salmonid identification, and general fish biology and physiology.

- Upper and Lower Sureshot Lakes: *5 days*
  Conducted a thorough inventory of sensitive amphibians breeding sites at Upper and Lower Sureshot Lakes and connected ponds in the North Meadow Creek drainage over two days. The remaining 2 days were dedicated to brushing and clearing sections of the Sureshot Ditch (ditch repair was in 2016) and ongoing monitoring and headboard adjustments to maintain water levels in the lakes.

- West Fork Madison Stream Habitat Restoration: *16 days*
  Worked with biologist and Madison River foundation employees to plant over 200 willow slips in overburdened area in upper WF Madison River riparian enclosure on National Forest.

  Surveyed aquatic habitat and fish distribution in the headwaters of the WF Madison River drainage prior to large wood placement for pool habitat restoration. Part of this evaluation included a day of electrofishing in a one mile section downstream of the USFS Cabin, and a small section upstream to assess population size and distribution. The technician also identified pool construction locations and standing large wood that could later be incorporated into pool habitats. Over 10 pool habitats and other beneficial channel alterations were the successfully constructed with excavator and hand tools in ½ reach of the upper WF Madison River. (Please see restoration photos included on pages 3 – 6

- Crockett Lake/Doubtful Reservoir: 3 *days*
  On four separate occasions, surveys were conducted for Western Toad, Columbia Spotted Frog, and Tiger Salamander presence/absence, as well as in identified breeding sites. Habitat data was also collected on these visits to identify preferred breeding habitat and timing of breeding.

- Madison River: 3 days
  The technician assisted NW Energy, MT FWP and USFS to conduct annual sampling on the mainstem Madison River. Field work included sediment core, macroinvertebrate, and periphyton sampling. The technician also accompanied NW Energy staff to provide field assistance if needed during the Ennis Dam Leakage Test. In addition the technician participated in the Mad TAC biologist meeting.

- Hellroaring Creek: 2 day
  Conducted electrofishing presence/absence and population distribution surveys within the Hellroaring Creek drainage as part of the Strawberry-Cascade Sheep Allotment NEPA analysis data collection effort.

- Wigwam Creek BAER-Roads: 4 days
  Assisted with Burned Area Emergency Response activities in the Wigwam Creek drainage following the Wigwam Fire. Specific duties included riparian fence repair, culvert replacement and road repairs with the Madison County roads crew, and electrofishing presence/absence and population distribution surveys within the riparian enclosure area.

- Spanish Creek/Big Brother Lake Poisoning w/GNF: 3 days
  Assisted the Gallatin NF, MT FWP, and Turner Enterprise with a piscicide treatment in Spanish Creek and Big Brother Lake for Westslope cutthroat restoration.

- Wall Creek Barrier Grant Application Writing: 6 days
  Completed grant applications for SW RAC and the MT Trout Foundation to secure funding for the Wall Creek Fish Barrier and WCT Conservation project.

- Ramshorn Creek WCT Restoration Project: 6 days
  Assisted the Beaverhead-Deerlodge NF and MT FWP with a piscicide treatment in The Ramshorn Creek drainage for Westslope cutthroat restoration.

- Ruby Creek Drainage Assessment: 2 days
  Inventoried channel conditions and total number of landslides in the Ruby Creek drainage, from headwaters to mouth, to assess post Monument Fire effects.

Total Madison Days: 57 days

WF Madison River Stream Restoration Paired Before and After Photos