Madison River Drainage Fisheries

and

Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program

2015
Annual Report
to
Northwestern Energy
Environmental Division
Butte
www.northwesternenergy.com

by

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Ennis
December 2015

Montana Fish, Wildlife & Parks

www.fwp.mt.gov

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/ppl-madison.php
Montana Fish, Wildlife, & Parks……………………..……..……..www.fwp.mt.gov
Northwestern Energy…………………………………..…northwesternenergy.com
Protect Your Waters………………..…………www.protectyourwaters.net or .com
Quake Lake bathymetric map……. ttp://fwp.mt.gov/fishing/guide/waterbodyDetail.html?llid=1113877448522

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FERC Articles addressed in this report

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EXECUTIVE SUMMARY

Beach seining for juvenile Arctic grayling and mountain whitefish was conducted in Ennis Reservoir in 2015, no juvenile grayling and 19 juvenile whitefish were captured. Arctic grayling eyed egg introductions were conducted with remote site incubators at five locations, three juvenile grayling were captured in Fall surveys. Long-term population trends for rainbow and brown trout in three river sections of the Madison River are displayed. Water temperature was monitored at 15 sites and air temperature at 7 sites within the Madison Drainage. Darlinton Ditch spring creek, Hebgen and Ennis reservoirs, numerous Madison River Fishing Access Sites and other waters were sampled for aquatic invasive species by FWP AIS staff in 2015. No New Zealand mudsnails, Eurasian Watermilfoil or juvenile or adult Zebra or Quagga mussels were detected in the river or reservoirs, and NZMS abundance in Darlinton Ditch was moderate. The Sun Ranch hatchery was used to incubate wild westslope cutthroat trout eggs from three streams, a pond and the Sun Ranch Brood pond. Environmental DNA samples were collected in Ruby Creek on two separate occasions in 2015 prior to transferring mature aboriginal Madison drainage wild westslope cutthroat trout from their natal stream. The number and average length of rainbow trout captured during annual Hebgen Reservoir gillnetting remained high. The proportion of rainbow trout over 14 inches in the Hebgen gillnet catch has increased noticeably since 2005. Analyses of Hebgen Reservoir rainbow trout otoliths was conducted and is being finalized to determine the contribution of wild and hatchery sources to the fishery. Zooplankton density in Hebgen Reservoir was monitored.

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INTRODUCTION

Montana Fish, Wildlife, & Parks (FWP) has conducted fisheries studies in the Madison River Drainage since 1990 to address effects of hydropower operations at Hebgen and Ennis dams on fisheries, and to assess the status of the Arctic grayling *Thymallus arcticus* population of Ennis Reservoir (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). This work has been funded since 1990 through an agreement with the owner and operator of the dams, initially Montana Power Company (MPC) until 1999, and then PPL Montana until November 18, 2014, when PPL Montana's hydropower facilities were purchased by Northwestern Energy (NWE).

The original agreement between FWP and MPC was designed to anticipate relicensing requirements for MPC's hydropower system on the Madison and Missouri rivers, which includes Hebgen and Ennis dams, as well as seven dams on the Missouri River (Figure 1). NWE has maintained the direction set by MPC, and convened several committees to address fisheries, wildlife, water quality, and recreation issues related to the operation of the hydropower facilities on the Madison and Missouri rivers. These committees are composed of representatives of NWE and several agencies. Each committee has an annual budget and authority to spend NWE mitigation funds to address the requirements of NWE's Federal Energy Regulatory Commission (FERC) license for operating the Madison & Missouri dams. The Madison Fisheries Technical Advisory Committee (MadTAC) is composed of personnel of NWE, FWP, the U.S. Fish & Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the U.S. Bureau of Land Management (BLM). Collectively, the nine dams on the Madison and Missouri rivers are called the 2188 Project, which refers to the FERC license number that authorizes their operation. 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 during the license term, including fish, wildlife, and recreation protection, mitigation, and enhancement measures.

During the late 1990's, numerous entities developed the Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana (WCTA). This agreement, which was formalized in 1999 (Montana FWP 1999), identifies Conservation & Restoration Goals and Objectives for westslope cutthroat trout (WCT) *Oncorhynchus clarki lewisi* in Montana. The Plan states "The management goal for westslope cutthroat trout in Montana is to ensure the long-term, self-sustaining persistence of the subspecies within each of the five major river drainages they historically inhabited in Montana (Clark Fork, Kootenai, Flathead, upper Missouri, and Saskatchewan), and to maintain the genetic diversity and life history strategies represented by the remaining populations." Objectives are:

1. Protect all genetically pure WCT populations
2. Protect introgressed (less than 10% introgressed) populations
3. Ensure the long-term persistence of WCT within their native range
4. Providing technical information, administrative assistance, and financial resources to assure compliance with listed objectives and encourage conservation of WCT
5. Design and implement an effective monitoring program by the year 2002 to document persistence and demonstrate progress towards goal

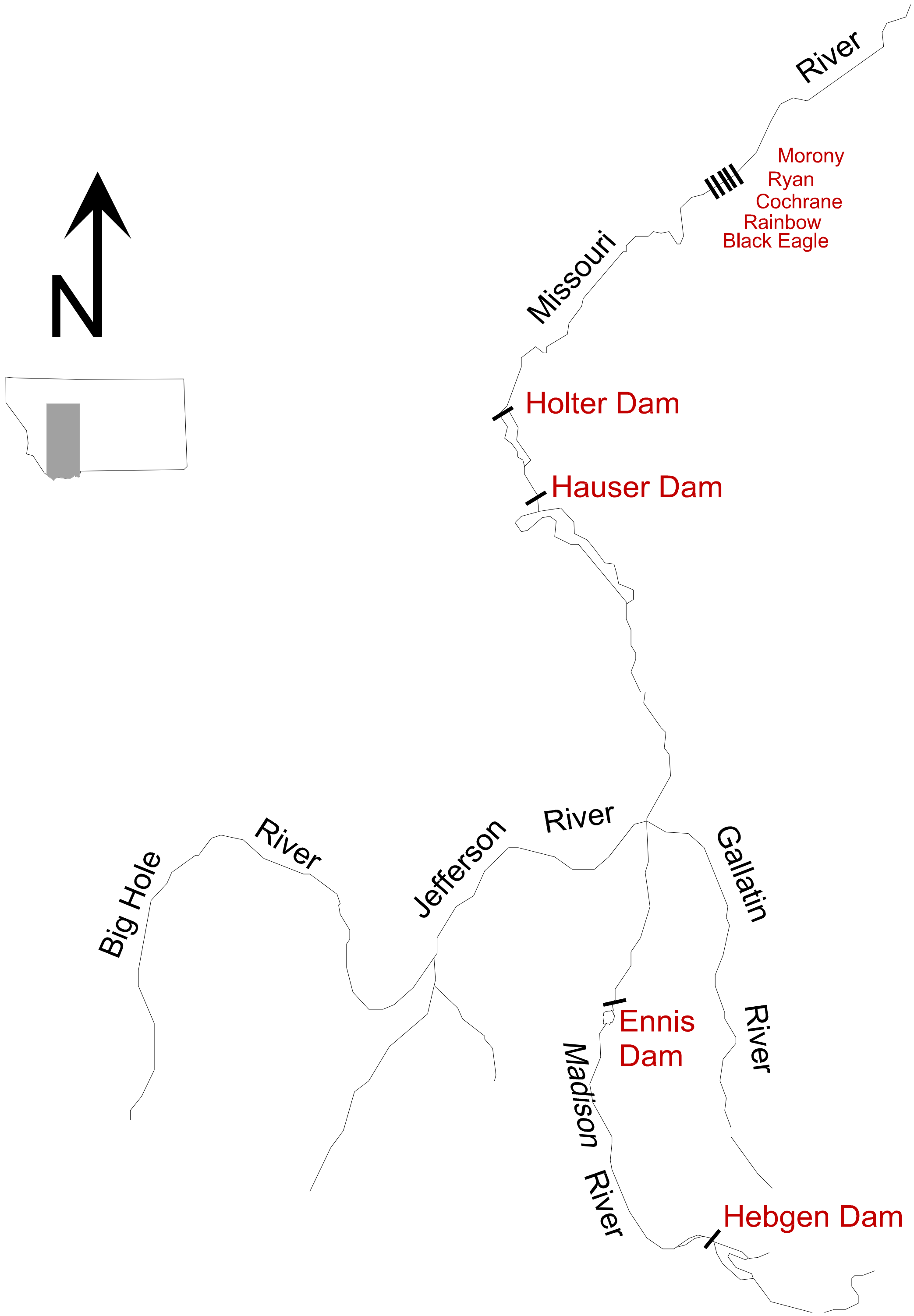


Figure 1. Map showing locations of NWE dams on the Madison and Missouri rivers (FERC Project 2188).

Objective 3 further states "The long-term persistence of westslope cutthroat trout within their native range will be ensured by maintaining at least ten population aggregates throughout the five major river drainages in which they occur, each occupying at least 50 miles of connected habitat…". Within the Missouri River Drainage, four geographic areas are identified, including the upper Missouri, which consists of the Big Hole, Gallatin, and Madison subdrainages.

In 2007, the WCTA was updated and combined with a similar document for Yellowstone Cutthroat Trout *Oncorhynchus clarki bouvieri* (Montana FWP 2007).

Signatories to the 2007 Montana Cutthroat Trout Agreement are American Wildlands, the Blackfeet Tribal Business Council, the Confederated Salish and Kootenai Tribes, the Federation of Fly Fishers, the Greater Yellowstone Coalition (GYC), the Montana Chapter of the American Fisheries Society, the Montana Cutthroat Trout Technical Committee, the Montana Department of Environmental Quality, the Montana Department of Natural Resources and Conservation, the Montana Farm Bureau, Montana Fish, Wildlife & Parks, the Montana Stockgrowers Association, Montana Trout Unlimited, the Montana Wildlife Federation, the USDA Natural Resources Conservation Service, the Bureau of Land Management, the U.S. Fish & Wildlife Service, the Forest Service, and Yellowstone National Park. Additionally, Plum Creek Timber Company provided a letter of support for the 2007 Cutthroat Agreement, citing their 30 year agreement with the U.S. Fish & Wildlife Service to the Native Fish Habitat Conservation Plan for Plum Creek properties.

Late in 1996, FWP initiated an effort is to conserve and restore the native westslope cutthroat trout in the Madison River drainage. Fieldwork for this effort began in 1997 in tributaries of the Madison River. The agreement between FWP and NWE includes provisions to address issues regarding species of special concern.

In 2001, the Sun Ranch entered into an agreement to assist FWP with westslope cutthroat trout conservation and recovery. The ranch built a small hatchery facility to rear eggs for introductions and a rearing pond to facilitate development of a westslope cutthroat trout broodstock for the Madison and Missouri river drainages.

METHODS

Madison Grayling

In January, 2014, FWP released an environmental assessment entitled 'Southwest Montana Arctic Grayling Reintroductions' in which FWP proposed to reintroduce Big Hole River and Red Rock Lake grayling into waters of the Madison and Big Hole drainages using eyed eggs in remote site incubators (Clancey 2014). After a 38-day public comment period and a public meeting in Ennis, comments were received from seven parties. Five supported the proposal, one opposed, and one supported some aspects but opposed other aspects. The Decision Notice responding to the comments and approving the proposal was issued on April 1, 2014.

The Arctic grayling introduction program was initiated in the Madison Drainage and in other waters across southwest Montana in May, 2014 (Clancey and Lohrenz, 2015). The program is an effort to re-establish viable Arctic grayling populations in formerly occupied waters or at sites where their populations are diminished. In May, 2015, gametes were collected (Figure 2) from the Arctic grayling brood populations in Upper Twin Lake in the Axolotl Lakes area and from Green Hollow Pond on the Flying D Ranch for the second year of introductions. The Arctic grayling populations in both ponds were started from the Big Hole River Arctic grayling population. The fertilized eggs were transported to FWP's Yellowstone River Hatchery in Big Timber for incubation. Once the eggs incubated to the eyed

Figure 2. A female Arctic grayling from the wild brood being stripped of eggs.

stage of development they were distributed into remote site incubators (RSIs) at introduction sites where incubation was completed, hatching occurred, and fry emerged (Figure 3).

Electrofishing was conducted near introduction sites in October to survey for the introduced Arctic grayling.

A beach seine (Figures 4 & 5) is used to monitor index sites in Ennis Reservoir (Figure 6) for young-of-the-year Arctic grayling and other fish species. Seining is conducted by pulling a 125 x 5 foot fine-mesh net along shallow areas in the reservoir. Standard index sites were seined in 2015 (Appendix A).

Population Estimates

Electrofishing from a driftboat mounted mobile anode system (Figure 7) is the principle method used to capture Madison River trout for population estimates in several sections of the Madison River (Figure 8).

Fish captured for population estimates are weighed and measured, marked with a fin clip, and released. A log-likelihood statistical analysis (Montana FWP 2004) is used to estimate trout populations.

Figure 3. Arctic grayling remote site incubators at a site in the West Fork Madison.

Figure 4. Beach seining in Ennis Reservoir.

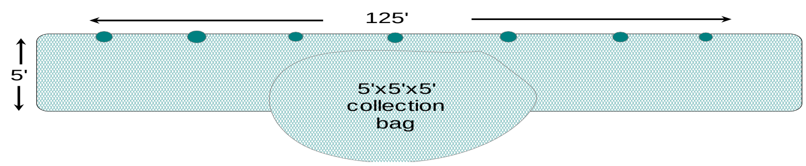


Figure 5. Depiction of a beach seine.

Ennis Reservoir Gillnetting

Gillnetting was conducted in Ennis Reservoir in early October, 2015. Experimental nets, composed of five 25-foot panels of progressively larger mesh (¾", 1", 1 ¼", 1 ¾" 2") were set at four locations and left to fish overnight (Figure 6). Floating nets were used at the shallow south end of the reservoir, and one floating and one sinking net was used at the deeper north end. Because the south end of the reservoir is so shallow, floating nets are capable of sampling nearly the entire water column. At the deeper north end, a floating net and a sinking net were required to sample pelagic and benthic areas, respectively. Captured fish were removed from the nets, separated by species, measured, weighed, enumerated, and released if alive.

River Discharge

Pulse Flows

Article 413 of the FERC license mandates NWE to 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 will occur for thermal mitigation. Pulsed flows are triggered when water temperature at the Madison (Ennis) Powerhouse is 68^{o} F or higher and forecast air temperature at Three Forks for the following day is 80^{o} 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 1). 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 or eliminating 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.

The meteorological and temperature data monitored in the lower river may be viewed in real-time or near-real time at http://www.madisondss.com/madison.php.

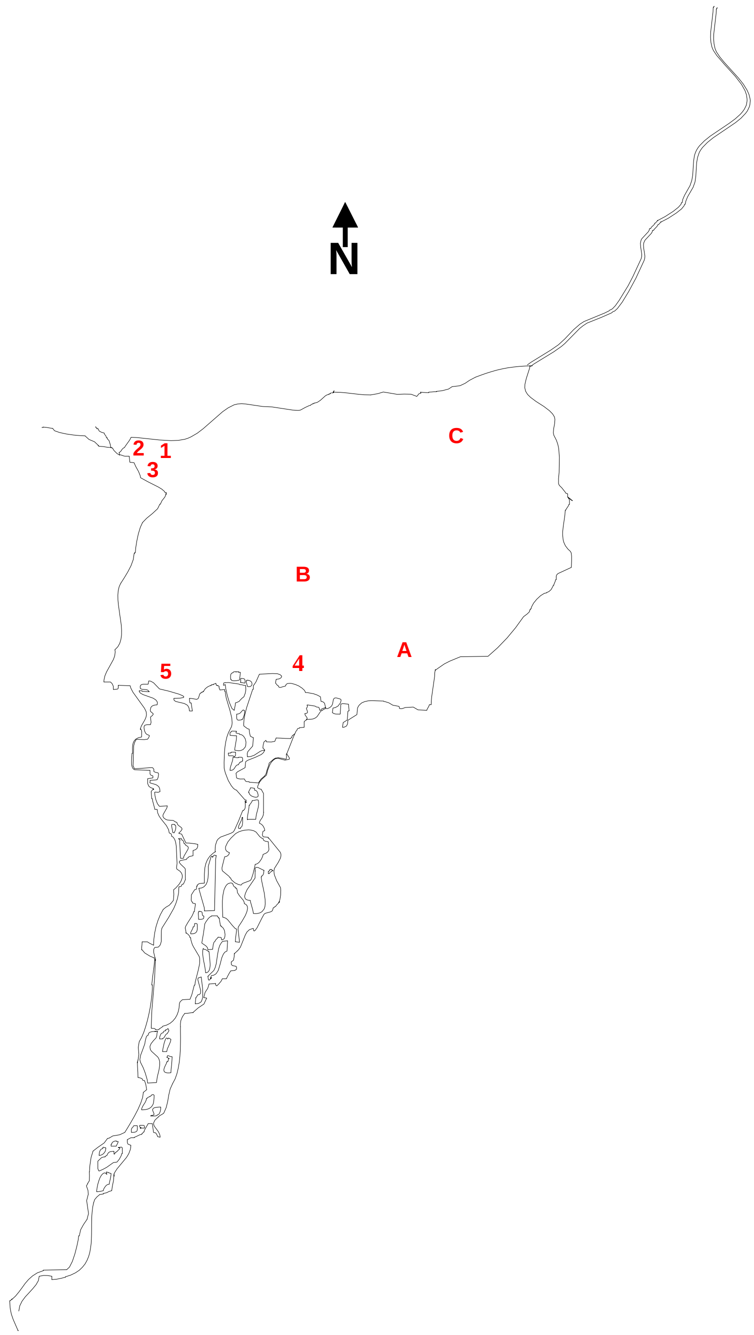


Figure 6. Locations of Ennis Reservoir 2015 gill netting (letters) and beach seining (numbers) sites. The beach seining site numbers correspond to locations described in Appendix A.

Figure 7. Mobile anode electrofishing (shocking) in the Norris section of the Madison River.

Flushing Flows

Article 419 of the FERC license requires the company to develop and implement a plan to coordinate and monitor flushing flows in the Madison River downstream of Hebgen Dam. A flushing flow is a flood stage of runoff that mobilizes streambed materials, resulting in 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.

Minimum Flows

Fish, Wildlife & Parks and NWE (and NWE's predecessors Montana Power Company and PPL Montana) have an agreement established in 1968 to maintain minimum instantaneous river flows at the USGS Kirby and McAllister gauges in the upper and lower river of 600 and 1,100 cfs, respectively. These instream flow levels were determined by FWP to provide favorable overwinter habitat for yearling trout, and also protect against summer and fall drought in low water years. These minimum flows were incorporated into Article 403 of the FERC license for the 2188 Project and are required elements of operating Hebgen and Ennis dams.

Temperature Monitoring

Water temperature was recorded at 15 sites and air temperature at seven sites throughout the Madison River Basin from upstream of Hebgen Reservoir to the mouth of the Madison River at Headwaters State Park (Figure 9). Beginning in 2010, a water temperature recorder was deployed in the river between the Kirby and McAtee sites at a station named 'Wall Creek Bridge' to provide data related to the on-going surface discharge out of Hebgen Reservoir during reconstruction of the control structure. Each of the Tidbit™ temperature loggers recorded over 43,000 temperature points in Fahrenheit from late April through early October. Air temperature recorders were placed in areas that were shaded 24 hours per day.

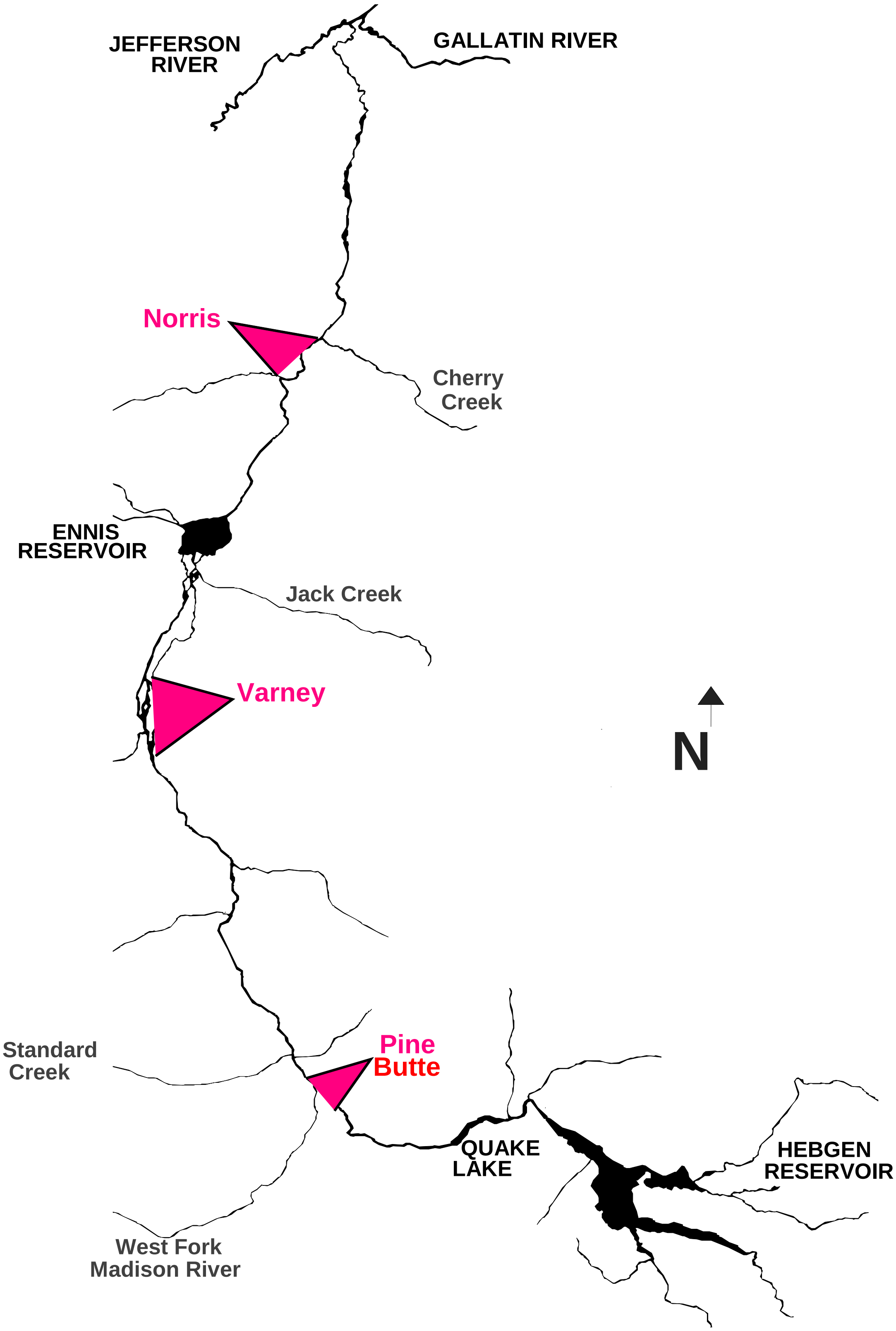


Figure 8. Locations of Montana Fish, Wildlife, & Parks 2015 Madison River population estimate sections.

Table 1. Pulse flow trigger criteria.

	Water temperature at Madison (Ennis) Powerhouse	Tomorrow's Maximum Forecast Air Temperature at Three Forks / Pulse Flow Rate (McAllister Discharge)		
No Pulsing Required	Less than 68°F	No action		
Pulsing Contingent on Weather Forecast	$\geq$ 68°, < 70°	< 80°	$\geq$ 80°	
		No action	1400 cfs	
Pulsing Required, Volume Contingent of Weather Forecast > 90°F	$\geq$ 70°, < 72°	< 90°	$\geq$ 90°, < 95°	$\geq$ 95°
		1400 cfs	1600 cfs	2100 cfs
Pulsing Required, Volume Contingent of Weather Forecast > 85°F	$\geq$ 72°, < 73°	< 85°	$\geq$ 85°, < 90°	$\geq$ 90°
		1400 cfs	1600 cfs	2100 cfs
Pulsing Required, Volume Contingent of Weather Forecast > 85°F	$\geq$ 73°	< 85°	$\geq$ 85°	
		1800 cfs	2400 cfs	

Discharge from Hebgen Reservoir typically occurs from a depth of about 40 feet, but for several years during construction of the new intake structure since 2009 has been from the reservoir surface. Specific dates of surface releases are:

- 5/10/12 – 1/10/13
- 5/28/13 – 12/30/13
- 6/9/14 – 1/26/15
- 4/14/15 – 11/24/15

Aquatic Invasive Species

Highway signs announce FWP's West Yellowstone Traveler Information System (TIS) (Figure 10). The five signs are located near major highway intersections in the West Yellowstone area, notifying drivers entering and leaving the area of the TIS system. The TIS notifies anglers and water recreationists of the presence of New Zealand mudsnails in the Madison River and Hebgen Reservoir, and instructs them on methods of reducing the likelihood of transporting New Zealand mudsnails and other AIS to other waters.

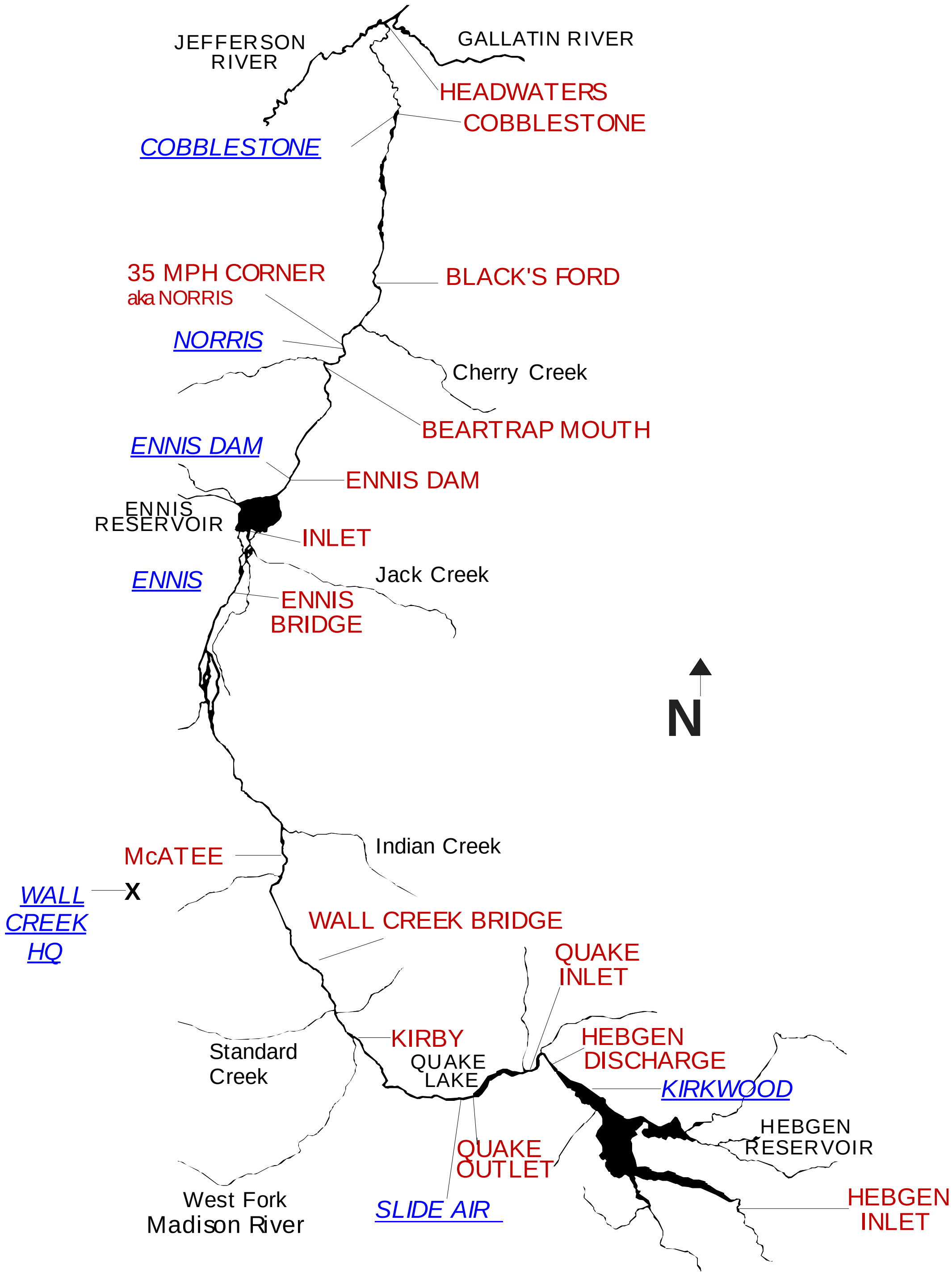


Figure 9. Locations of Montana Fish, Wildlife & Parks temperature monitoring sites. Air temperature monitoring sites are blue and underlined; water temperature monitoring sites are red. A river site near Wall Creek was added in 2010.

Figure 10. Roadside sign announcing the Traveler Information System near West Yellowstone, Montana.

Additional messages broadcast by the system include messages on whirling disease, zebra mussels, weed control, and TIPMont, the FWP hotline to report hunting & fishing violations. The system broadcasts at the AM frequency of 1600 KHz. Funding for the purchase, installation and signage of the system was provided by a $9,800 grant from the Pacific States Marine Fisheries Commission as part of an effort to prevent the westward spread of zebra mussels.

Fish, Wildlife & Parks hired an Aquatic Invasive Species Coordinator in 2004. The position is responsible for developing and coordinating AIS control & management activities among state agencies as well as between state and non-state entities. The AIS Coordinator is responsible for developing and coordinating Hazard Analysis and Critical Control Point (HACCP) Training to State employees and other groups. The HACCP Program is a method to proactively plan and implement measures to prevent the inadvertent spread of AIS during work activities.

In 2010, FWP initiated a public education campaign called "Inspect/Clean/Dry". This campaign uses highway billboards (Figure 11) and vehicle tailgate wraps and posters (Appendix B) to create public awareness of aquatic invasive species issues.

In 2015, the FWP AIS field crews surveyed the Madison River (multiple sites), Quake Lake, Hebgen and Ennis reservoirs, Cliff and Wade lakes, the Ennis National Fish Hatchery, the Sun Ranch Hatchery and Darlinton Ditch Spring Creek. AIS personnel also conducted follow-up surveys in seven private ponds on the Smiling Moose Ranch where illegal fish introductions had occurred and were addressed by FWP in 2014 (Clancey and Lohrenz 2015). Water temperature, GPS coordinates, pH, weather conditions, horizontal plankton tow, notes on substrate, and invertebrate and macrophyte surveys were collected. A minimum of 400 feet is surveyed at each site. In addition to visual surveys for AIS, horizontal plankton tows were conducted to sample for Zebra and Quagga mussel veligers and invasive zooplankton.

In addition to regular biological monitoring, angler/boater surveys were conducted throughout the drainage to inspect watercraft and angling gear for AIS and to educate the public on AIS issues. At Hebgen Reservoir 34 vessels were inspected, 359 on the Madison River and 100 at Ennis Reservoir. The majority of boaters had clean watercraft and was aware of AIS issues and none of the angling boats were using live bait.

In 2009 the FWP AIS program conducted monitoring of dissolved calcium concentration in state waters to evaluate risk of zebra and quagga mussel establishment. The calcium level of a water body is a

Figure 11. Inspect/Clean/Dry billboard.

critical characteristic for zebra and quagga mussel establishment. These mussel species do not survive when there is a low calcium concentration in the water, since calcium is an essential element in the composition of the bivalve shell. Calcium concentrations of 15 mg/liter or less are thought to limit the distribution of zebra and quagga mussels. Survival of the larvae and size of an established adult population are both thought to increase with increasing levels of calcium.

New Zealand Mudsnails

New Zealand Mudsnails have spread throughout the Madison River since first detected in 1994. NWE and FWP each maintain monitoring sites at various locations within the Madison Drainage.

Westslope Cutthroat Trout Conservation and Restoration

Efforts to conserve and restore genetically pure westslope cutthroat trout in the Madison Drainage center on maintaining genetically pure populations, high quality stream habitat, adequate instream flow, and, where necessary, removal of competing or hybridizing non-native trout. Stream habitat surveys were conducted throughout much of the Madison Drainage from 1997 – 1999 (Clancey 1998a, Sloat et al. 2000). Backpack electrofishing was used to survey fish species. Removal of non-native species will typically require use of the EPA registered piscicides (fish-pesticides) rotenone or antimycin.

The Beaverhead-Deerlodge and Custer Gallatin national forests and Yellowstone National Park are conducting projects to benefit westslope cutthroat trout and/or to restore stream habitat in tributaries to the Madison River. MadTAC has provided grants to each of these federal agencies to assist their efforts.

Sun Ranch Westslope Cutthroat Trout Brood

Gametes (eggs & milt) for the Sun Ranch Westslope Cutthroat Trout program were collected from three streams, one pond and the Sun Ranch brood stock in 2015. All fertilized eggs were transported to the Sun Ranch Hatchery for incubation and hatching (Figure 12). The MadTAC has provided funding for the Sun Ranch Program annually since 2004 (Appendix C).

Ruby Creek Westslope Cutthroat Trout Project

Ruby Creek (Figure 13) is a tributary to the Madison River south of the town of Ennis. A 15-foot waterfall (Figure 14) at stream mile 0.7 isolates most of the drainage from Madison River fish. Rainbow trout and Rocky Mountain (mottled) sculpin *Cottus bairdi* were the only fish species found above the waterfall, while rainbow and brown trout and sculpin are common below the waterfall. Brown trout are known to use the lower 0.7 miles of the stream for spawning.

In 2012 FWP produced an Environmental Assessment (EA) entitled "Reintroduction of Native Westslope Cutthroat Trout in Ruby Creek by Removal of Non-native Rainbow Trout with Electrofishing and Rotenone" (Clancey 2012). Written comments were received from five parties and verbal comment from one party during the 30 day EA review period that ended June 16, 2012. All commenting parties supported the proposed project or felt it to be a workable project as proposed. Letters were received from the Madison River Foundation (MRF) and GYC; emails were received from three individuals and verbal comment from the adjacent landowner. The MRF and the GYC offered volunteer help for the pre-treatment fish salvage and stream monitoring during the rotenone treatment.

Figure 12. Sun Ranch Hatchery rearing troughs.

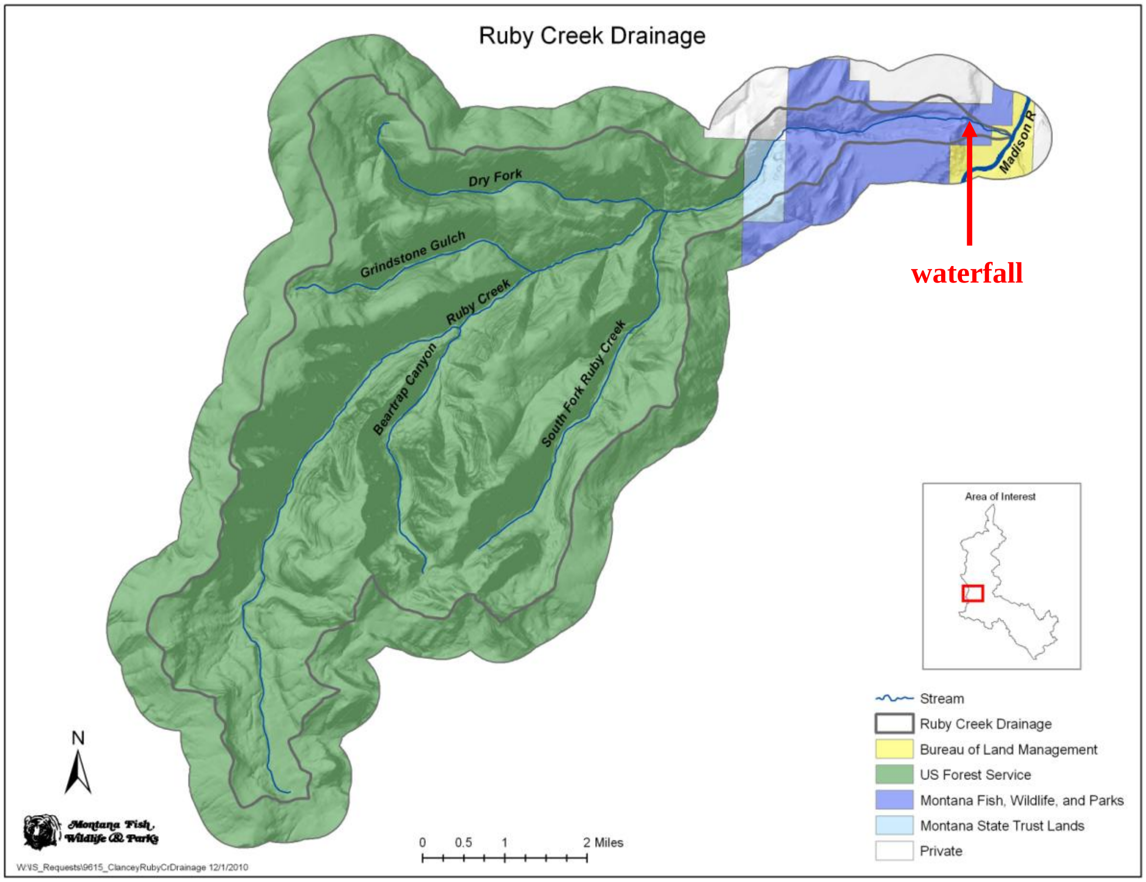


Figure 13. Ruby Creek Drainage, tributary to the Madison River.

Figure 14. Ruby Creek waterfall at stream mile 0.7. This waterfall is a barrier to upstream fish movement and will serve to isolate the reintroduced WCT population from non-native fish.

Fish distribution was determined by electrofishing on several occasions in 2010- 2012. On all sample dates fish were found only in mainstem Ruby Creek up to approximately stream mile 7 ½ and in the lower ¾ mile of the South Fork of Ruby Creek. The named tributaries of Beartrap Creek, Grindstone Gulch and Dry Gulch were dry on all sample dates, and the mainstem was dry from approximately mile 7 ½ to mile 10. Though streamflow is perennial upstream of mile 10, no fish were ever sampled there. Sunk Creek, a tributary of the South Fork of Ruby Creek, was sampled by electrofishing in 2010, but was dry during chemical treatments in subsequent years.

Fish were captured on-site for use as sentinels during the initial treatment and during neutralization of all treatments. During the initial treatment in December 2012, five rainbow trout and five sculpins were placed in flow-through buckets every ½ hour of stream flow time throughout the treatment area. Dye testing showed flow-through time of the treatment area to be 5 ¾ hours. Rainbow and brown trout were used as sentinel fish through the neutralization zone, where flow-through time was 34 minutes.

Dry rotenone powder was mixed with sand and gelatin for application during the bioassay, and the dry mix as well as a liquid formulation of rotenone was used during treatments.

In 2015, a procedure known as environmental DNA (eDNA) was used to sample for surviving rainbow trout. Through this procedure, a specific amount of stream water is pumped through a filter and the filter is preserved in a desiccant. The filter is then analyzed for the presence of a specific organisms DNA to determine if that organism is present in the stream.

Fish Habitat Enhancement

South Fork of Meadow Creek

A project to replace an aged irrigation and livestock watering system in a section of the South Fork of Meadow Creek was initiated in 2011 by the Madison Watershed Coordinator with significant funding provided by MadTAC for fencing and an off -channel livestock watering system. The project also reconstructed the instream irrigation weirs and headgates. Approximately 3,000 feet of stream was fenced to develop a riparian pasture, controlling livestock access to the stream. Additional funding for the project was from the Montana Department of Natural Resources and Conservation, Montana Department of Environmental Quality, Madison Conservation District and the landowners.

Moore's Creek

Similar to the project on the South Fork of Meadow Creek, a section of Moore's Creek immediately north of the town of Ennis was fenced to create a riparian pasture that will have limited grazing, and off-channel livestock water sources were developed in 2015. This project was developed and managed by the Madison Watershed Coordinator. Approximately 2,200 feet of stream was fenced to develop a riparian pasture, controlling livestock access to the stream. Funding for the project was from the Natural Resource Conservation Service, Montana Fish, Wildlife & Parks Future Fisheries Program, Madison Conservation District, the MRF, Madison-Gallatin Trout Unlimited (MGTU), the landowners and MadTAC.

Smith Lake Dam Fish Ladder

Smith Lake is a decades old impoundment on Lake Creek, a tributary to the West Fork of the Madison River. It is constructed of large cobble and sealed to some extent with tarps, but has a fish bypass channel on the north bank. The dam was constructed to provide both a water source and a power source to provide water to livestock on a public pasture on an elevated bench. Water in the small reservoir was funneled into a water wheel that powered a diaphragm pump that lifted water up to the pasture, a vertical lift of about 500 feet. To provide as much head as possible, the by-pass channel was permitted to be blocked until October 1 each year, at which time the tarps sealing the channel were to be removed to allow spawning brown trout to pass upstream of the dam. Despite that requirement, the channel often was not opened, and is some years when it was opened was filled with large cobbles by unknown persons.

In 2008, FWP secured funding and developed a well and water line to provide water to livestock on the elevated bench, eliminating the need for the Smith Lake Dam pump. Despite this, those unknown persons continued to block the by-pass with cobbles. FWP partnered with MadTAC, MRF, MGTU and GYC to construct and install a fish ladder in the location of the by-pass channel.

<u>Ruby Creek Stream Channel</u>

A short section of the Ruby Creek stream channel was undercutting an historic homestead cabin, threatening to collapse the cabin into the stream, likely over a period of several years, causing obstruction of the stream channel, lateral scour and destruction of riparian habitat. Because the cabin is on land owned by Montana FWP, a state agency, it could not be demolished per 22-3-4 MCA. An alternative plan was developed to re-route the stream channel so it no longer undercut the cabin.

Hebgen Basin

Hebgen Reservoir and its tributaries are shown in Figure 15.

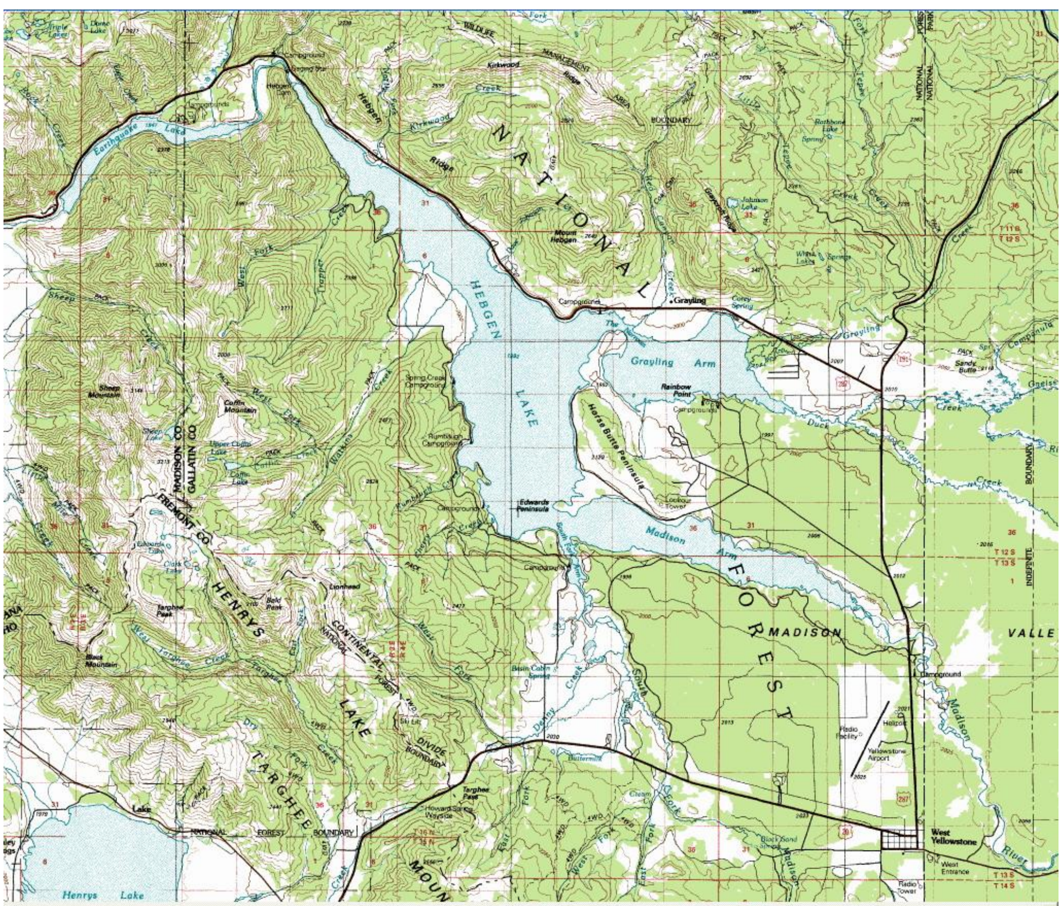


Figure 15. Map of Hebgen Reservoir and surrounding area.

Hebgen Reservoir Gillnetting

FWP has conducted annual gillnetting on Hebgen Reservoir for over forty years to monitor trends in reservoir fish populations, including species assemblage, age structure, and the contribution of hatchery reared rainbow trout to the Hebgen fishery.

Variable mesh 125 foot long experimental gillnets were deployed overnight at index sites on Hebgen Reservoir (Figure 16) over a three-day period during the new moon phase in late May or early June. Twenty-five nets (14 floating and 11 sinking nets) were fished during this period, with a maximum of nine nets fished per night.

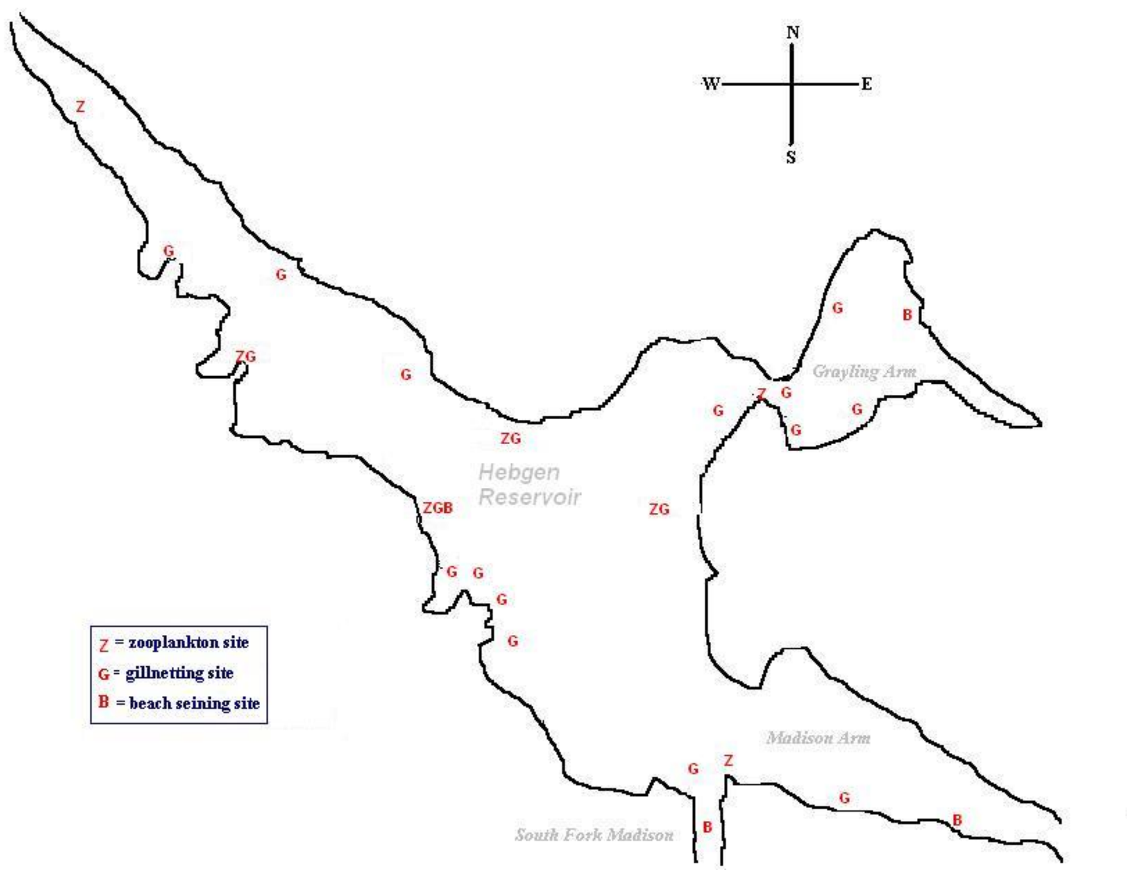


Figure 16. Map showing monitoring site locations of Hebgen Reservoir zooplankton, gillnetting, and beach seining.

Samples were sorted by net and processed systematically by species with total length and weight recorded. Rainbow trout were also visually examined for physical anomalies commonly seen in hatchery-reared stocks (fin erosion, fin anomalies, etc). Vertebrae were extracted from rainbow trout specimens and examined for the presence of tetracycline marks, a biological stain that appears in ossified structures. Tetracycline can be added to hatchery pellets to put a mark in the vertebrae, theoretically creating a positive identification feature for hatchery raised fish.

Hebgen Reservoir Juvenile Fish Sampling

Beach seining (Figure 4) was conducted at several sites on Hebgen Reservoir to monitor overlap of juvenile habitat use among young-of-the-year rainbow trout, brown trout, mountain whitefish, and Utah chub *Gila atraria*. Samples were collected using a 125'x 5' x ¼" inch mesh seine with a 5'x 5' x 5' collection bag (Figure 5). The float and lead lines of the seine are tied to long dowels and pulled through the water by two people, then pulled onto shore where fish are separated from debris and enumerated. At each site all young-of-the-year trout, whitefish, and up to 30 Utah chub are measured. All remaining chubs are enumerated.

Hebgen Reservoir Zooplankton Monitoring

Monthly zooplankton tows were conducted at seven established sites on Hebgen Reservoir (Figure 16) to evaluate plankton community densities and composition. Plankton were collected with a Wisconsin plankton net (Figure 17) with 153 micron mesh (1 micron = 1/1,000,000th meter) towed vertically through the entire water column at one meter per second. Tows were taken at locations with a minimum depth of 10 meters. Samples were rinsed and preserved in a 95% ethyl alcohol solution for enumeration. Zooplankton were identified to order Cladocera (daphnia) or Eucopepoda (copepods), and densities from each sample were calculated.

Figure 17. A Wisconsin plankton net (left) and Secchi disk (right) used to collect zooplankton and measure light penetration, respectively, in Hebgen Reservoir.

A Secchi disk (Figure 17) was used to measure light penetration (in meters) into the Hebgen Reservoir water column. Depths were taken in conjunction with zooplankton tows to establish a Trophic State Index number (TSI) to determine reservoir productivity (Carlson 1977). Secchi depths were recorded as the distance from the water surface to the point in the water column where the disk colors became indiscernible.

Wind and other environmental influences on Hebgen Reservoir are monitored at a small weather station along the reservoir shoreline on Horse Butte. These data are collected to aid in efforts to develop predictive tools for Hebgen Reservoir events, such as development of blue-green algae blooms and zooplankton distribution relative to trout stocking.

RESULTS AND DISCUSSION

Madison Grayling

Introduction of Arctic grayling in the Madison Drainage through RSIs was conducted from May 15 – 30, 2015. Eyed eggs incubated in the RSIs at six sites. Water temperature strongly influenced the duration of incubation and emergence (Table 2, Figure 18). Three young-of-the-year grayling were captured in Fall monitoring, one in the West Fork Madison spring and two in Moore's Creek (Figure 19).

Table 2. Water temperature characteristics and approximate date of last emergence at Madison Drainage Arctic grayling RSI introduction sites, 2015. Eggs were placed into the RSIs on May 15, and O'Dell Creek and Lake Creek received a second batch of eggs on May 22.

RSI site	Average water temperature (range) (F)	Approximate date of last emergence
O'Dell Creek	53.9 (45.8 – 66.9)	May 28
Blaine Spring Creek	54.1 (48.7 – 67.1)	May 26
Moore's Creek	53.4 (42.2 – 70.7)	May 26
Moore's Creek spring	47.9 (39.0 – 58.5)	May 28
West Fork spring	46.9 (42.2 – 53.8)	May 30

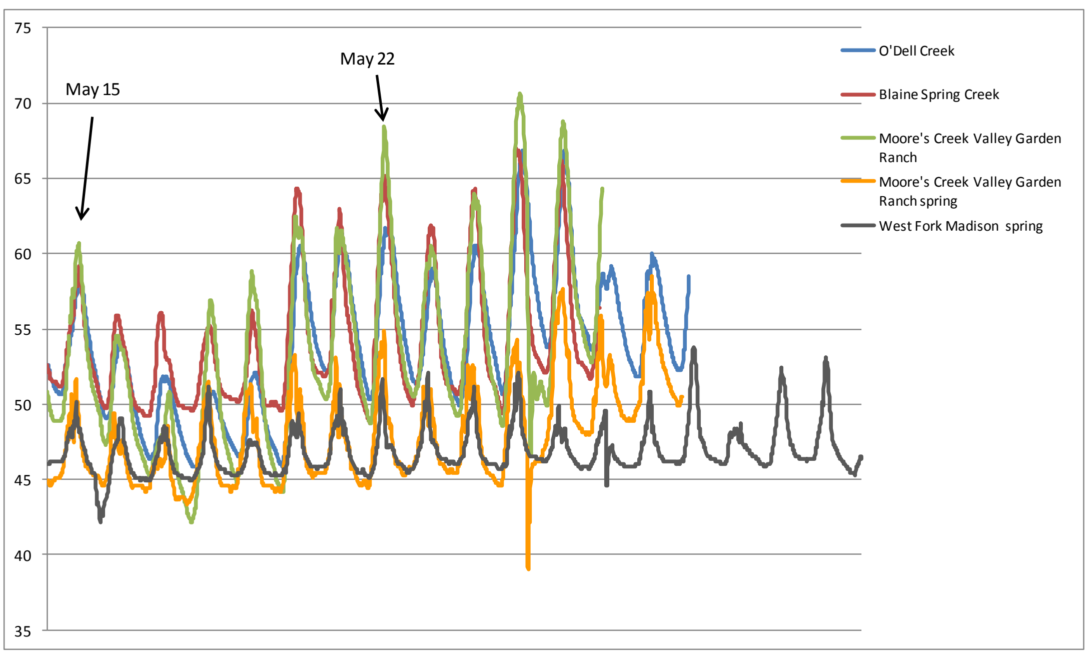


Figure 18. Water temperature profiles at Arctic grayling introduction sites, 2015. See Table 2 for incubation period. The temperature logger at Lake Creek was lost, so no data are available for that site.

Figure 19. Young-of-the-year Arctic grayling (top) and mountain whitefish (bottom) captured in November, 2015, in Moore's Creek.

No juvenile Arctic grayling were captured by beach seining in Ennis Reservoir in 2015. Only six young-of-the-year Arctic grayling have been captured since 1996 (Appendix A).

In April 2007, the USFWS determined that fluvial Arctic grayling in the Big Hole River did not qualify as a Distinct Population Segment (DPS), and therefore were not warranted for listing as a Threatened species under the Endangered Species Act (ESA). This decision was challenged in court. As part of a settlement agreement the USFWS agreed to re-evaluate the status of Arctic grayling in the Missouri River Basin.

In May 2009, the USFWS concluded that all Arctic grayling in the upper Missouri River Basin were genetically and geographically distinct from other Arctic grayling populations, therefore qualified for designation as a DPS and warranted for listing; however, listing of the Upper Missouri River Arctic grayling DPS under the ESA was precluded due to higher priority species. The Madison River population of Arctic grayling is included in the 2009 DPS designation. As part of settlement for a lawsuit associated with many species tenure on the Candidate Species List, the USFWS agreed to reevaluate the status of Arctic grayling in the Upper Missouri DPS, beginning in October 2013. In August 2014, the USFWS determined that listing Arctic grayling under ESA was 'not warranted'. Earthjustice filed suit in February 2015 challenging the USFWS's not warranted determination.

MadTAC funds are used to assist with Arctic grayling recovery efforts in the Madison, Big Hole, Ruby, and Elk Lake drainages as mitigation for the impacts of hydropower facilities on the Madison and Missouri rivers. These funds have helped FWP develop a Candidate Conservation Agreement with

Assurance (CCAA) for fluvial Arctic grayling in the Big Hole Drainage. Landowners who sign onto the CCAA must develop and implement pro-active site-specific land management conservation measures in cooperation with agencies that will reduce or eliminate detrimental habitat conditions for the grayling. Despite the USFWS determination of 'not warranted' in September, 2014, landowners and irrigators continue to enroll in the CCAA program. Currently 33 landowners have enrolled 160,000 acres, with an additional 7,030 acres of State land enrolled, and 68 habitat restoration projects have been completed to date. Additionally, MadTAC funds have previously been used to assist with monitoring the development of a self-sustaining Arctic grayling population in the upper Ruby River and developing and implementing stream-flow restoration plan for Narrows Creek, a grayling spawning tributary to Elk Lake. In 2013, MadTAC cost-share funds were granted to MFWP for a project to reconnect portions of Swamp Creek to the Big Hole River, a project that was completed in 2014.

Population Estimates

Population estimates were conducted in the Norris section of the Madison River in March and in the Pine Butte and Varney sections in September (Figure 8). Figures 20-22 illustrate the number of rainbow trout per mile for several size classes in each of the three sections, and Figures 23-25 illustrate numbers of six inch and larger brown trout per mile in each section. The population for each of the size groups displayed includes all larger size groups as well. For instance, the line representing the estimated number of Pine Butte rainbow trout 12 inches and larger (Figure 20) includes all rainbow trout larger than 12 inches, not just those 12 – 14 inches.

In recent years rainbow trout 12 inches and larger exhibited an upward trend in all three river sections. That trend continued in the Varney and Norris sections in 2015. There was a decrease in 2015 in the number of rainbows in those size classes in the Pine Butte section, but they still remain at the high end of their historic abundance. Brown trout in the Pine Butte section remain at historically high levels, while in the Norris section their numbers continue to decrease.

It is plausible that the surface releases since 2012 during reconstruction of the Hebgen Reservoir outlet structure have contributed to faster trout growth, especially in the Pine Butte section. Water temperature monitoring sites from Hebgen Dam (Hebgen discharge) to McAtee have been monitored since 1995, and have shown their highest maximum temperatures in 2012 – 2015. It is also plausible that trout growth will slow once Hebgen Dam repairs are completed and operations return to normal, which includes reservoir releases from 40 feet deep where water is cooler than surface water.

Ennis Reservoir Gillnetting

Table 3 summarizes the 2015 Ennis Reservoir gillnet data.

Charts illustrating the number captured, average length and species composition from 1995 – 2015 are in Appendix D.

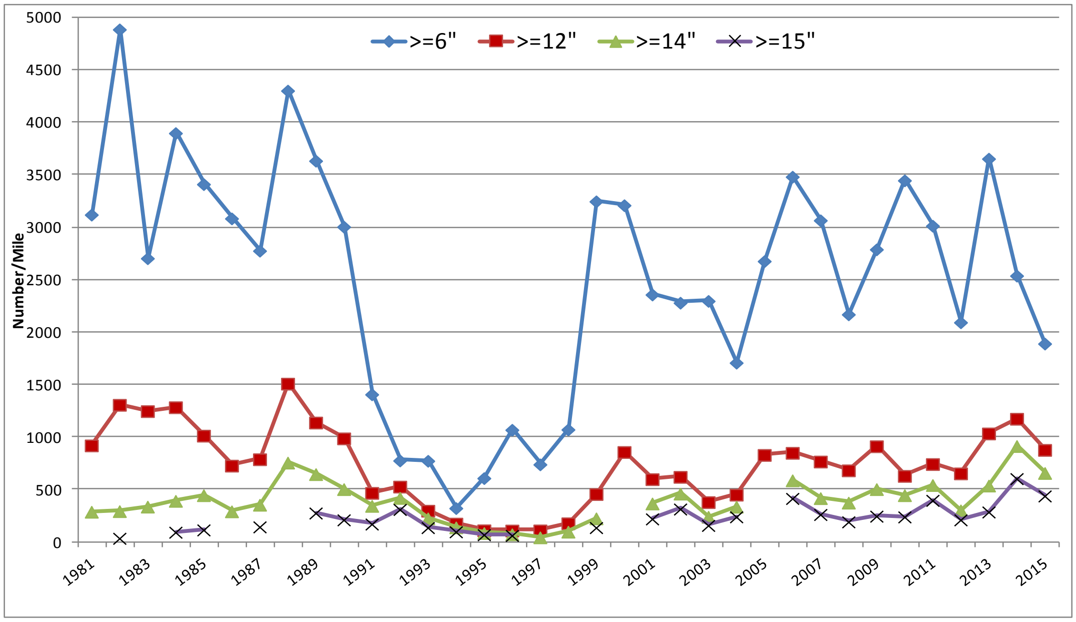


Figure 20. Figure showing the long-term trend of the rainbow trout population by size group in the Pine Butte section of the Madison River during fall, 1981–2015.

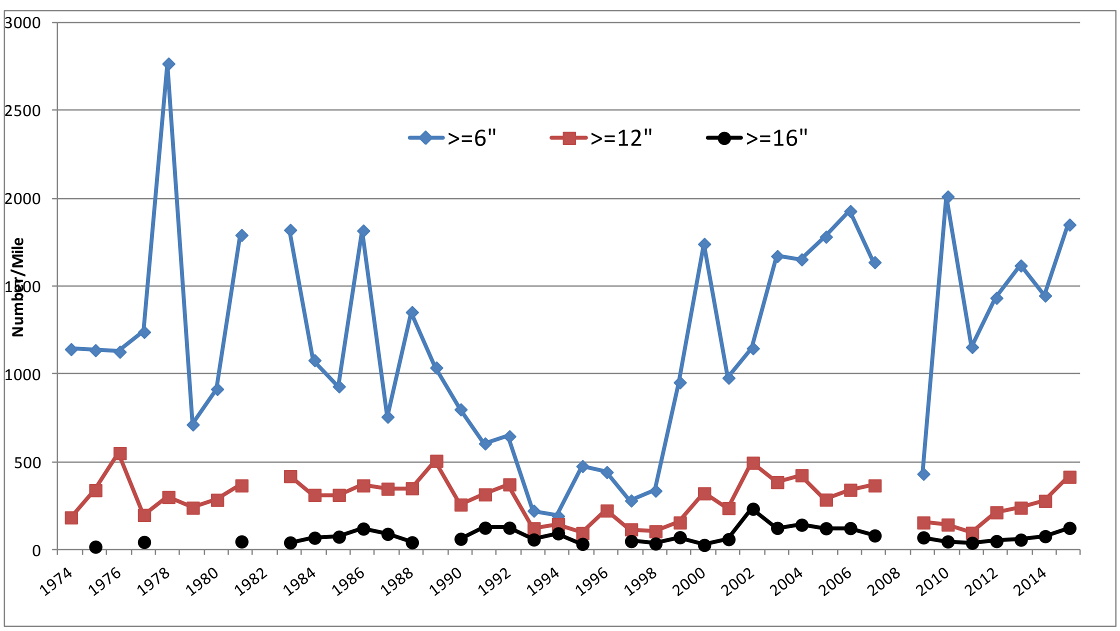


Figure 21. Figure showing the long-term trend of the rainbow trout population by size group in the Varney section of the Madison River during fall, 1974–2015.

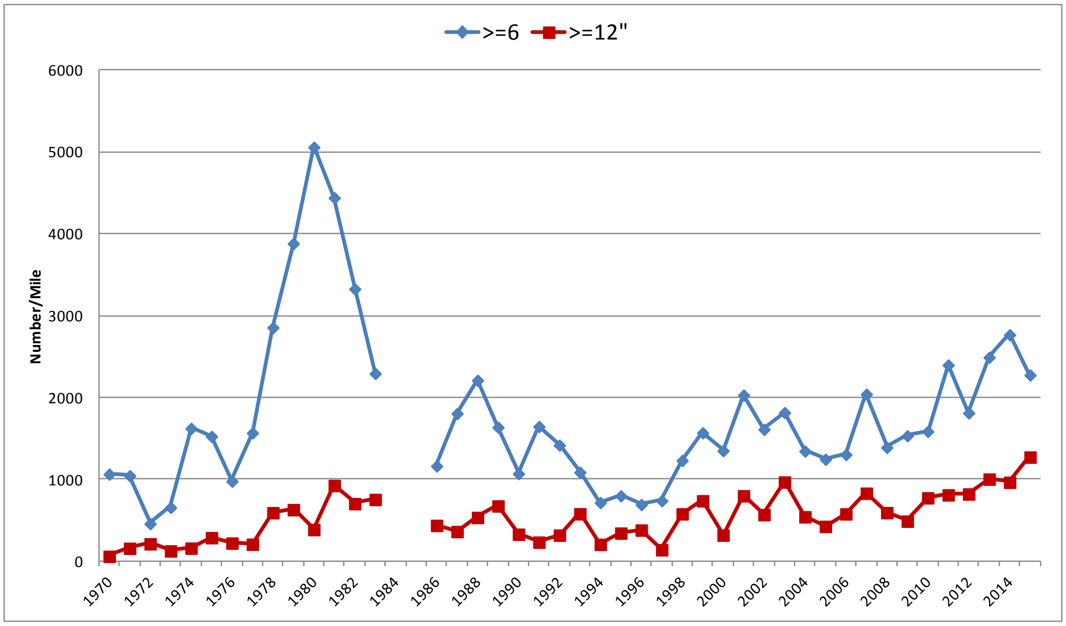


Figure 22. Figure showing the long-term trend of the rainbow trout population by size group in the Norris section of the Madison River during spring, 1970–2015.

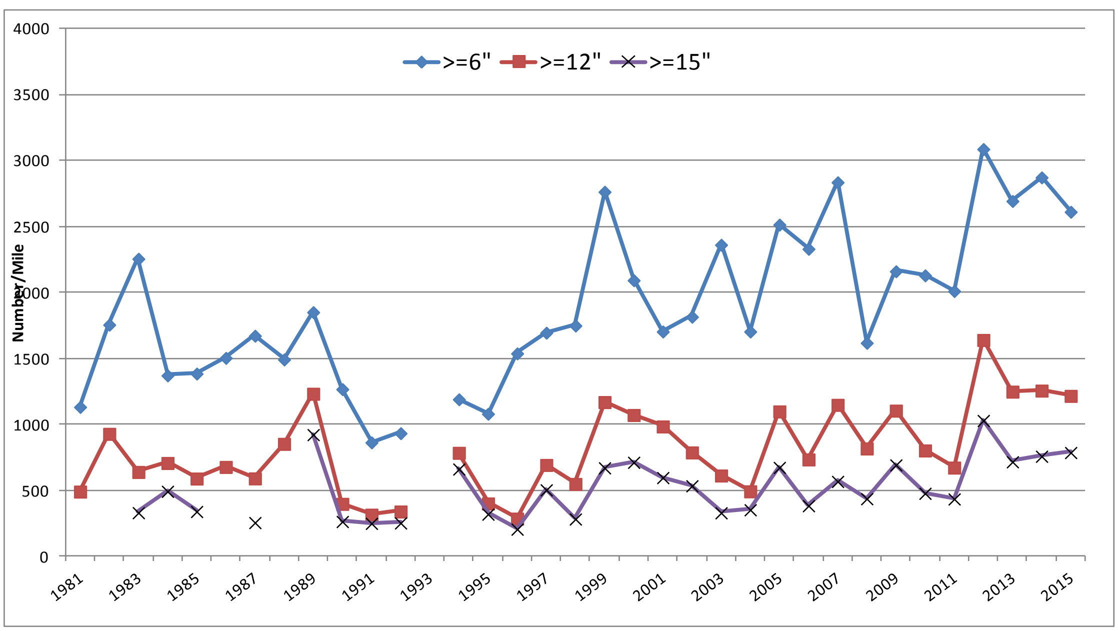


Figure 23. Figure showing the long-term trend of the brown trout population by size group in the Pine Butte section of the Madison River during fall, 1981–2015.

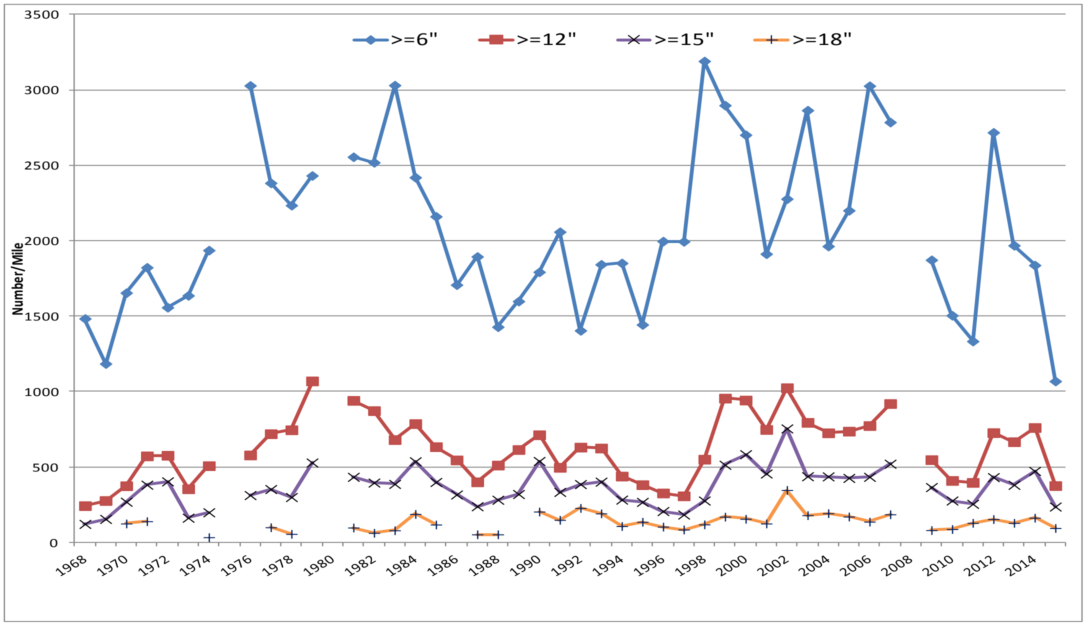


Figure 24. Figure showing the long-term trend of the brown trout population by size group in the Varney section of the Madison River during fall, 1968–2015.

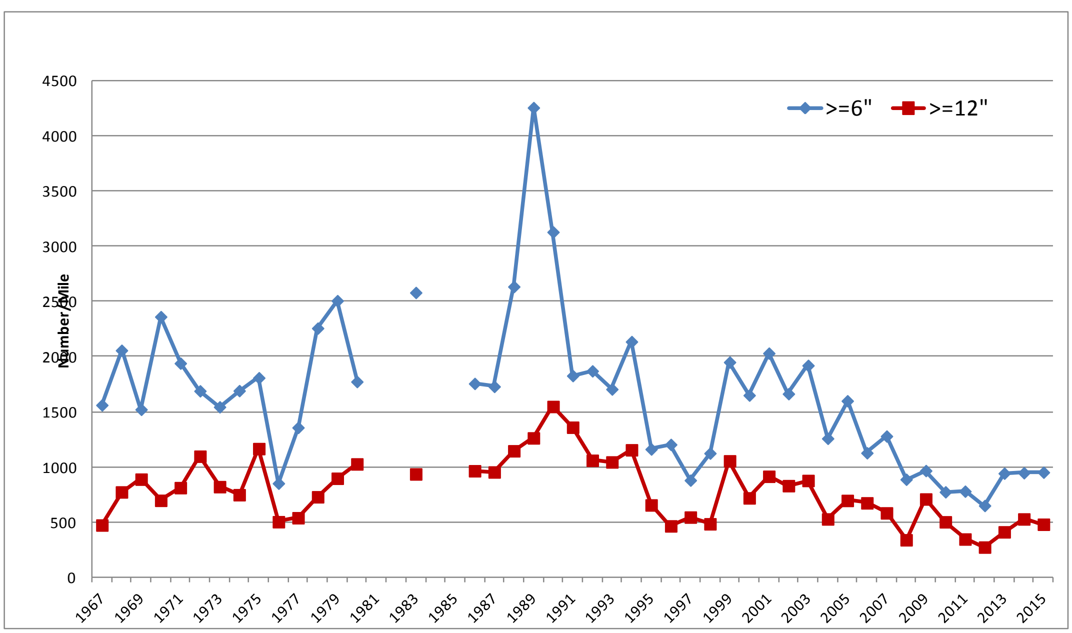


Figure 25. Figure showing long-term trend of the brown trout population by size group in the Norris section of the Madison River during spring, 1967–2015.

Table 3. Summary of October 6 – 7, 2015, gillnet catch in Ennis Reservoir. Length is in inches, weight is in pounds.

	UC[1]	Wsu	Rb	LL	MWF	LnSu
Avg.length	8.2	11.6	13.7	16.3	11.7	13.1
Avg.weight	0.37	0.85	1.10	1.76	0.62	0.93
Number sampled	138	210	55	23	1	2

[1] UC = Utah Chub; Wsu = White Sucker; Rb = rainbow trout; LL = brown trout; MWF = mountain whitefish; LnSu = longnose sucker

Rainbow and brown trout population levels in the Bypass section between Ennis Dam and Powerhouse (Figure 26) compare favorably with population levels in other sections of the Madison River. The preponderance of holding sites among the boulder and cobble substrate allows for a greater density of fish than in other river sections.

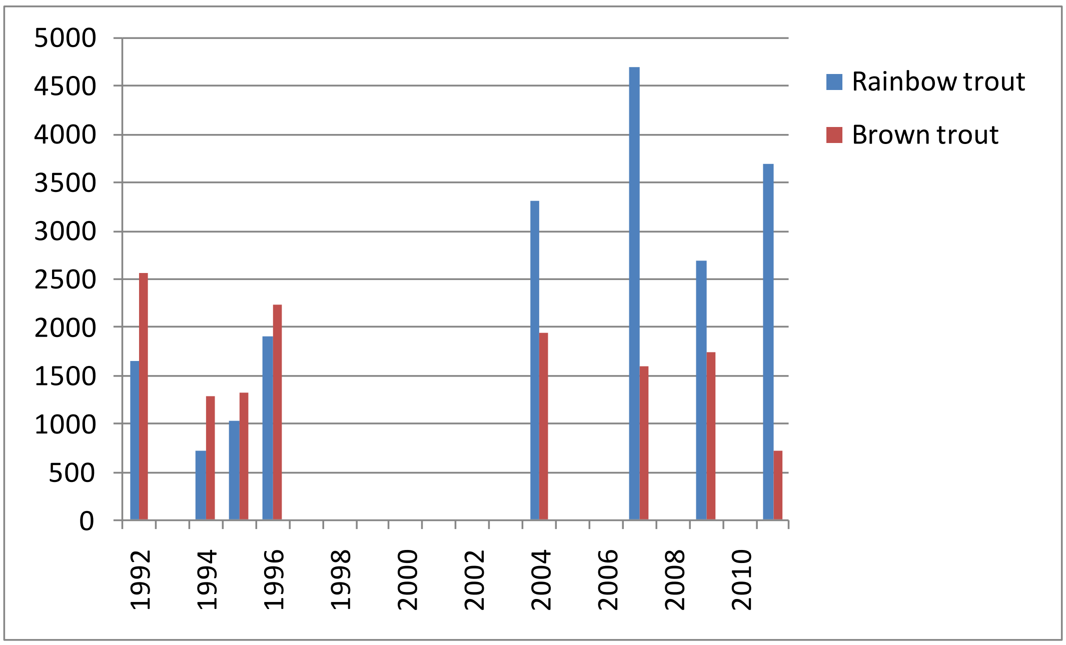


Figure 26. Population estimates (number/mile) of rainbow and brown trout in the Bypass section of the Madison River, spring estimates. NWE personnel conducted the 1992 estimate.

River Discharge

Pulse Flows

In 1994 NWE implemented a pulse flow system on the Madison River downstream of Ennis Reservoir in years of high water temperature to prevent thermally induced fish kills. Despite being developed as a stop-gap measure for extremely warm and dry years, pulse flows have been necessary every year from 2000 – 2007, 2009 and 2013 - 2015. Table 4, adapted from NWE data, summarizes statistics regarding pulse flows in the Madison in years pulsing was conducted.

Flushing Flows

Flushing flow releases from Hebgen Reservoir were not conducted in the Madison River in 2015 as the triggering criteria were not met.

Scour chain monitoring of bedload movement at four long-term sites showed little or no scour in 2014 when peak daily discharge ranged from approximately 3,000 cfs at Kirby to 5,000 cfs at McAllister for several days in late May. During years when flushing flows are conducted, maximum discharge at Kirby is typically 3,500 cfs to adhere to license conditions (see *Minimum Flows* section below), and at McAllister has been as high as 7,600 cfs. When flushing flows are conducted they are typically maintained for at least 3 days.

Table 4. Summary statistics[1/] for years in which pulse flows were conducted on the Madison River .

Year	Hebgen pool elevation[2/]	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
2009	6533.02	1.85	0.03	2	1.82
2013	6531.07	3.80	1.70	42	2.10
2014	6532.73	2.14	0.06	4	2.08
2015	6531.97	2.90	0.06	16	2.42

[1/] As of October 1st each year

[2/] Hebgen full pool is 6534.87 msl. The FERC license requires NEW to maintain Hebgen pool elevation between 6530.26 and 6534.87 from June 20 through October 1.

Minimum Flows

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 NEW. 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.*

Establish a permanent flow gauge on the Madison River at Kirby Ranch (USGS Gauge No. 6-388). Include a telephone signal at the gauge for link to Hebgen Dam operators and the Butte-based System Operation Control Center."

Temperature Monitoring

Onset Tidbit™ temperature recorders were deployed throughout the Madison River to document air and water temperatures (Figure 9). Table 5 summarizes the data collected at each location in 2015, and Appendix E1 contains thermographs for each location. Appendix E2 contains comparisons of annual maximum temperatures at selected adjacent monitoring sites and Appendix E3 contains annual 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 been attained on more than just one day in a year. Some water temperature recorders were not recovered in some years, or the data recorder malfunctioned and the data were not recoverable, but for years where the data are available there are notable patterns:

- For all 16 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 17 of 18 years where data are available, maximum water temperature at the Quake Inlet site is higher than maximum water temperature at the Quake outlet site
- In 2015, maximum water temperature was recorded at the Kirby and McAtee sites since monitoring was initiated at those sites in 1995. In both instances, the maximum temperature occurred in early July, before summer time air temperatures moderated.
- The Ennis Reservoir Inlet site annually exhibits the highest maximum water temperature of the 7 sites between Hebgen Dam and Ennis Reservoir
- In 18 of the 21 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 5^{o} F warmer than at Ennis Dam
- Maximum water temperature at Blacks Ford has been suppressed by pulse flows conducted to prevent thermal stress related fish kills; the last fish kill occurred in 1988.
- During construction of the new intake structure, discharge from Hebgen Reservoir has been from the reservoir surface since 2012. Specific dates of surface releases are:
    - 5/10/12 – 1/10/13
    - 5/28/13 – 12/30/13
    - 6/9/14 – 1/26/15
    - 4/14/15 – 11/24/15
- In 2015, all-time high water temperature since monitoring was initiated in 1994 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 80^{o} F at every site except Ennis Dam. In every instance, the maximum temperature occurred in early July, before summer time air temperatures moderated.

Aquatic Invasive Species

The annual economic cost of invasive species management and control in the United States is estimated to be nearly $120 billion (Pimentel et al 2005). The Aquatic Invasive Species Task Force estimates that 42% of the species on the Threatened or Endangered species lists are significantly affected by alien-invasive species (www.anstaskforce.gov/impacts.php).

In 1994, two invasive species were detected in the Madison Drainage – New Zealand mudsnails *Potamopyrgus antipodarum* and whirling disease *Myxobolus cerebralis*. Montana has an active multi-agency AIS program coordinated through FWP (Appendix B).

Within FWP Region 3 dissolved calcium levels measured in 2009 varied from 11mg/l at the Big Hole River Fish Trap FAS to 62 mg/l at Clark Canyon Reservoir. The sole site sampled in the Madison Drainage was Ennis Reservoir, which showed a calcium concentration between 20 – 24 mg/l. Calcium concentrations of 15 mg/liter or less are thought to limit the distribution of Zebra and Quagga mussels.

In the Madison Drainage six watercraft failed inspections, two for having attached vegetation four for having standing water in the live-well or bilge.

FWP AIS field crews found no Zebra or Quagga mussel veligers or adults, or Eurasian Watermilfoil in samples collected at Madison Drainage sites in 2015.

<u>New Zealand Mudsnails</u>

AIS crews sampled numerous sits throughout southwestern Montana in the Yellowstone and throughout the Upper Missouri system, including the Madison Drainage. All were positive for the presence of NZMS. The highest density sampled was $488/m^2$ in Darlinton Ditch at the Cobblestone Fishing Access Site.

The Montana Aquatic Species Coordinator has developed a plan to address New Zealand mudsnails. Specifically, these actions include:

1. Listing NZMS as a Prohibited Species in Montana.
2. Assisting in development of a regional management plan for NZMS, an important portion of which will describe actions to be taken when NZMS are found in or near a hatchery.
3. Establishing statewide monitoring efforts.
4. Conducting boat inspections at popular FAS, many of which are on the Madison River. This effort assists with public education/outreach and also ensures boats are not spreading NZMS or other AIS.
5. Purchasing portable power washing systems for cleaning boats and trailers at fishing access sites.

The FWP Fisheries office in Ennis uses a power washer to clean project equipment to reduce the chance of spreading AIS through work activities.

With one exception AIS have not been found in any private, state or federal hatchery in Montana, though there are AIS in or near the supply waters of some hatcheries. Strategies have been implemented to prevent the spread of NZMS from the sole private hatchery in which they were discovered, and to prevent AIS from entering hatcheries in their supply water. The spread of NZMS has slowed and appears to be confined in Montana to east of the Continental Divide.

Additional information on Aquatic Invasive Species is on the web at www.anstaskforce.gov and www.protectyourwaters.net.

Westslope Cutthroat Trout Conservation and Restoration

Habitat projects and investigations conducted by the Beaverhead-Deerlodge and Custer Gallatin national forests using MadTAC money are summarized in Appendix F.

Table 5. Table showing maximum and minimum temperatures (^{o}F) recorded at locations in the Madison River Drainage, 2015. Air and water temperature data were recorded from April 24 –October 6 (43,456 data points each recorder). Thermographs for each location are in Appendix E1.

	Site	Max	Min
Water	Hebgen inlet	80.2	46.9
	Hebgen discharge	69.9	38.8
	Quake Lake inlet	71.0	37.6
	Quake Lake outlet	68.1	38.4
	Kirby Bridge	73.6 [a/]	37.4
	Wall Ck Bridge	74.9 [a/]	36.3
	McAtee Bridge	74.5 [a/]	36.5
	Ennis Bridge	74.7	39.8
	Ennis Reservoir Inlet	79.4	39.5
	Ennis Dam	76.9 [a/]	49.2
	Bear Trap Mouth	80.0 [a/]	47.9
	35-mph corner (aka Norris)	80.4 [a/]	47.7
	Blacks Ford	81.8 [a/]	43.9
	Cobblestone	82.8 [a/]	45.4
	Headwaters S.P. (Madison mouth)	81.9	44.7
Air	Kirkwood	87.3	27.1
	Slide	90.3	28.3
	Wall Creek HQ	93.6	27.0
	Ennis	97.2	25.1
	Ennis Dam	94.6	33.2
	Norris	91.5	34.8
	Cobblestone	87.8	32.1

[a/] Highest temperature recorded at site since monitoring was initiated in 1994 or 1995.

Sun Ranch Westslope Cutthroat Trout Program

Egg take from three streams, one pond and the Sun Ranch brood stock in 2015 provided 27,410 eyed eggs and 6,500 fry. Eyed eggs or fry from wild sources were introduced into York Gulch in the Big Hole Drainage, Elkhorn Creek and Camus Lake in FWP Region 4, Grayling Creek and Goose Lakes in Yellowstone National Park and the Sun Ranch Brood pond.

Appendix C lists the contributions to and production of the Sun Hatchery since 2001 as well as an annual summary for 2015 activities, and Appendix G provides a list of streams for which NWE funding has been used for genetic analyses.

Ruby Creek Westslope Cutthroat Trout Project

The Ruby Creek rotenone treatment was initially conducted on December 5, 2012, with additional treatments on April 9 and October 16, 2013 (Clancey and Lohrenz 2013, Clancey and Lohrenz 2014). Liquid rotenone and rotenone powder dough were applied to the stream and its fish bearing tributaries.

In 2014, nine rainbow trout were captured in 47.6 hours of electrofishing time, and found to be primarily located in the higher reaches of the South Fork, or in Ruby Creek's mainstem near the South Fork. Three of the rainbow trout found in the South Fork were upstream of the chemically treated section, in an area where they had not been found during pre-treatment electrofishing in 2010 through 2012. This section of the South Fork was treated with rotenone dough to 50 parts-per-billion active ingredient in October 2014. Neutralization was conducted in the Ruby Creek mainstem 2 ½ hours streamflow time above the waterfall. Sentinel brook trout placed downstream of the barrier waterfall showed no indication of distress within 24 hours after the estimated passage time of the rotenone, so were released.

Because rainbow trout were captured by electrofishing after rotenone treatments, twenty-five locations within the Ruby Creek treatment area were sampled for environmental DNA (eDNA) prior to introducing westslope cutthroat trout (WCT). One of those samples indicted a positive result for rainbow trout DNA, so electrofishing was conducted throughout that approximately 1 ½ mile section on three different occasions, but no rainbow trout were found in more than 5 hours of electrofishing. The source of the rainbow DNA is unknown, but may have been in fecal matter from a predator that carried it to that site. Nine additional eDNA samples within that 1 ½ miles were negative for rainbow trout DNA.

Introductions of genetically pure aboriginal Madison WCT occurred in late September when fish were transferred from their native stream near Hebgen Reservoir to Ruby Creek (Figure 27). Transferred WCT ranged from 3.7 – 5.9 inches. WCT as small as 3 inches were spawning in their native stream in Spring 2015. Similar transfers are anticipated annually for up to seven years, and are expected to include transfers of WCT from the only other known genetically pure aboriginal Madison population.

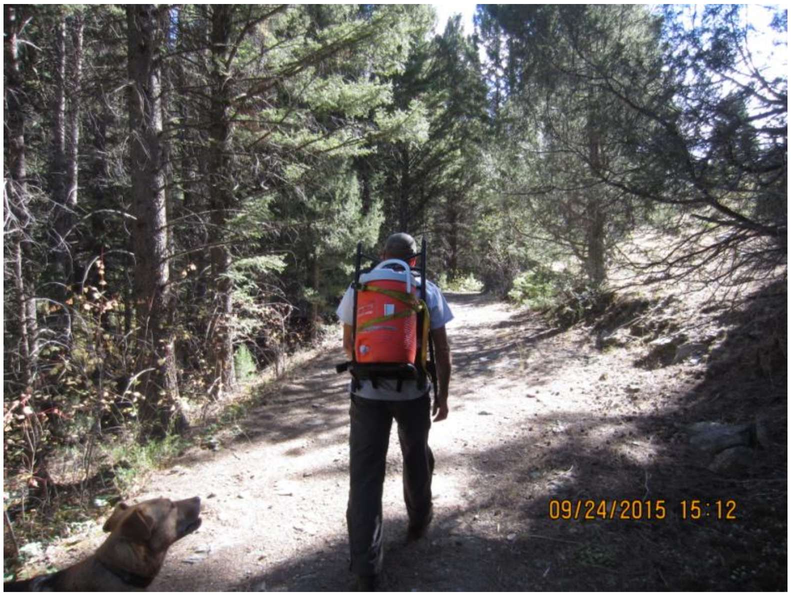


Figure 27. Transporting and releasing genetically pure aboriginal Madison westslope cutthroat trout into Ruby Creek, September, 2015.

Fish Habitat Enhancement

South Fork of Meadow Creek

A project to rebuild irrigation infrastructure on a section of the South Fork of Meadow Creek, including in-stream weirs and headgates, was completed in 2012. The original design of the instream weir structures was modified out of concern that they would not pool adequate water to feed the irrigation ditches. There were no stream channel modifications as part of this project, but the stream corridor was fenced in October 2012 creating a 30-foot zone on each side of the stream where livestock grazing and access to the stream banks are controlled. A well and two circular off-channel watering troughs were developed. A hardened stream crossing was developed to facilitate equipment and livestock movement through the riparian corridor.

The Madison Watershed Coordinator is monitoring and photographing stream channel morphology in the project area (Figure 28). With the removal of the constant stress of livestock access along the stream banks, the channel is notably narrowing due to sediment deposition in over-widened areas, with establishment of grasses and willows that stabilize the riparian soil, development of in-channel pools, and in some areas, conversion of a sediment laden stream bottom to courser gravels and cobbles that are conducive to trout populations.

The property owners/livestock operators state that the development of the riparian pasture and off-channel watering troughs (outside of the riparian pasture) have provided unanticipated benefits to their operation, even during severely cold and windy weather. Livestock are grazed for only a few days each year in the riparian pasture, but the quality of the vegetation is higher than prior to the fencing. Livestock are also drinking more water from the troughs than they did when they had unrestricted access to the stream, even when the trough spigots are covered with thick ice. The velocity of the water exiting the spigots maintains flow of water and prevents the water in the troughs from freezing over. Additionally, existing and developing willows along the stream corridor provide a windbreak to the livestock, even outside the fenced corridor. Other noted benefits include elimination of icing on livestock because they are able to obtain water from the troughs rather than entering the stream to drink, elimination of livestock loss from literally sinking into a swampy area where they used to drink when the stream was ice-covered or too dewatered, reduced labor for the operators by not having to chip ice from the stream, less time spent moving and managing livestock, and ease of moving livestock between pastures due to a fence construction layout that directs livestock rather than allowing them to wander in multiple directions when moving.

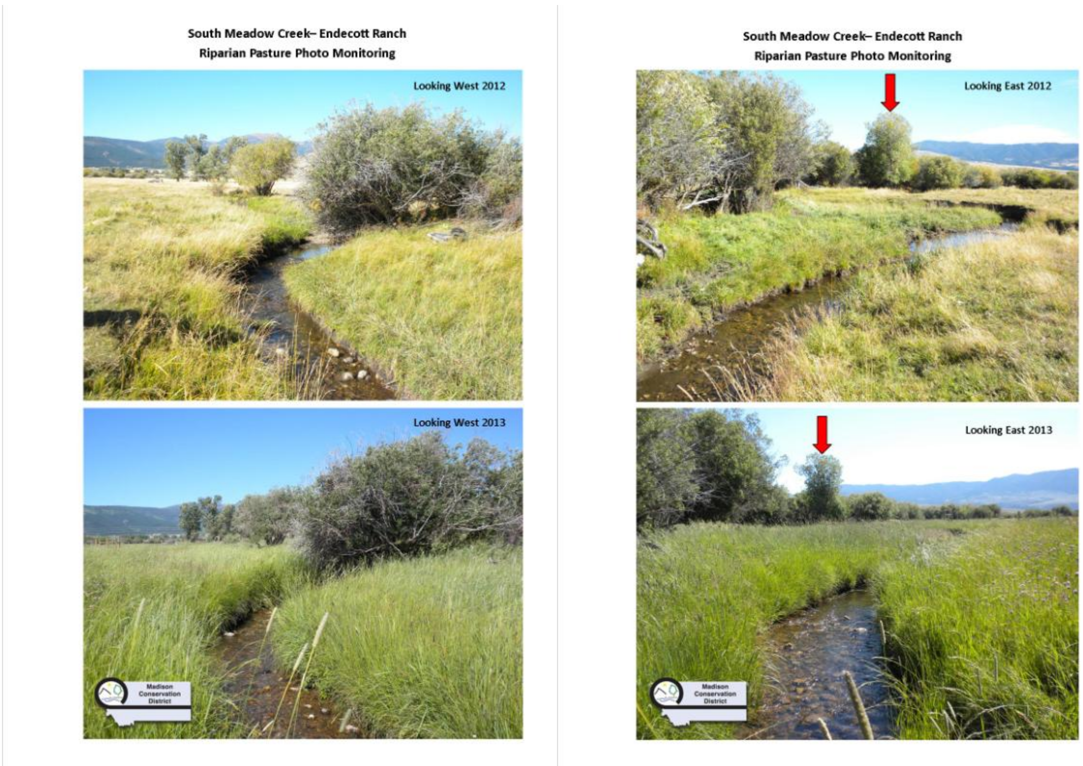


Figure 28. Photos of the Endecott section of the South Fork Meadow Creek, illustrating grass conditions before (top photos) and after (bottom photos) construction of riparian fence that controls livestock access. Photos courtesy of the Madison Conservation District.

Fish populations have been sampled in two sections of the project area since Fall 2011 (Table 6). Generally, few fish are captured due to dewatering of the stream for irrigation, but 2011 was a high water year that provided adequate stream flow for trout into the Fall. Data for brown trout and brook trout in the two sections are combined to display catch-per-hour of electrofishing and average length (Figure 29).

Moore’s Creek

A restoration project was conducted on a section of Moore’s Creek directly north of the town of Ennis. The intent of this project is to improve water quality and fish habitat, improve the health and vigor of the riparian area and stream channel, address the health of Moore’s Creek water quality and enhance livestock operations through increased management efficiency through construction of fencing and watering facilities. This project will allow the stream channel to adjust to a more natural state and provide habitat for wild fish through in-stream improvements and a robust riparian plant community.

A well and two circular off-channel watering troughs were developed. A hardened stream crossing was developed to facilitate equipment and livestock movement through the riparian corridor.

Table 6. Summary statistics of electrofishing in two sections of the South Fork of Meadow Creek, 2011 – 2015.

	Brown trout			Brook trout		
Section and Date	Number captured	CPUE[1/] (hour)	Average length (range)	Number captured	CPUE[1/] (hour)	Average length (range)
Section 1						
9/20/11	128	127.3	4.7 (2.3 – 13.3)	21	20.9	3.7 (2.4 – 10.0)
4/13/12	11	25.0	4.8 (3.1 – 7.1)	10	22.7	5.6 (3.2 – 7.5)
9/27/12	37	82.6	4.5 (2.6 – 7.7)	9	20.1	4.6 (3.0 – 7.2)
4/29/13	4	9.4	4.9 (3.5 – 6.2)	23	54.2	6.3 (5.4 – 8.0)
4/6/14	8	14.9	5.4 (4.2 – 8.0)	36	67.1	6.1 (3.5 – 8.2)
10/10/14	18	22.9	9.2 (7.0 – 12.9)	22	28.0	6.3 (3.7 – 9.1)
4/20/15	1	1.7	9.2	24	40.3	6.2 (3.6 – 8.5)
Section 2						
9/20/11	86	108.1	3.8 (2.8 – 9.5)	102	128.3	3.8 (2.3 – 10.1)
4/13/12	31	76.9	5.1 (2.4 – 11.2)	10	24.8	6.0 (3.3 – 7.6)
9/27/12	Not Sampled					
4/29/13	1	2.9	3.3	6	17.7	5.8 (4.8 – 6.5)
4/6/14	5	15.4	4.1 (3.2 – 5.9)	9	27.8	5,6 (4.1 – 6.5)
10/10/14	none	0.0	--	24	46.8	5.5 (3.2 – 8.3)
4/20/15	3	12.1	6.3 (3.8 -9.0)	11	44.2	5.8 (4.0-7.3)

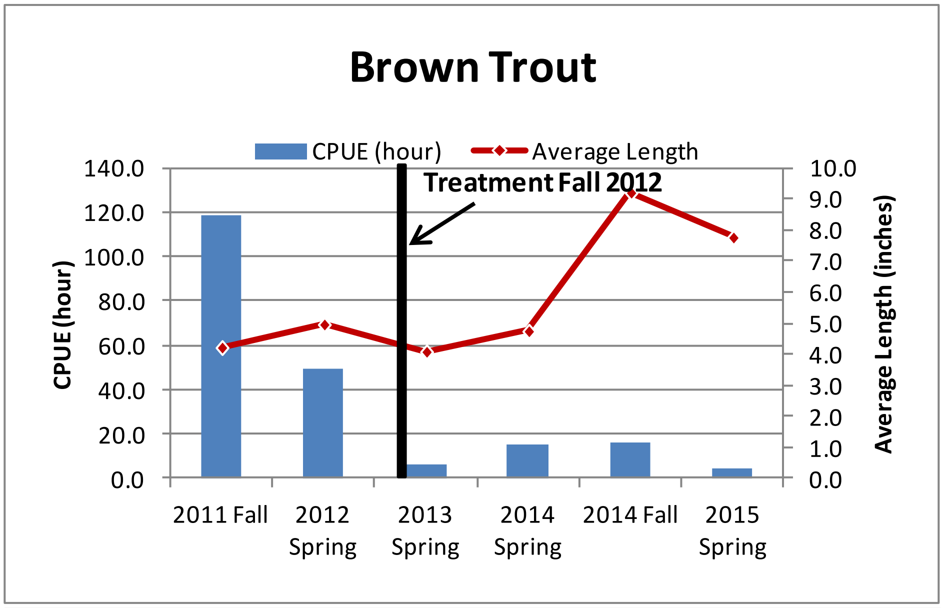
[1/] Catch per unit effort (hour) of electrofishing

A report from the Madison Watershed Coordinator to Montana Future Fisheries Program is in Appendix H.

The fish population was sampled within a section of the project area (Table 7) and water temperature (Figure 30) was monitored at four sites in Moore's Creek within and downstream from the project area.

Smith Lake Dam Fish Ladder

A small fish ladder was installed in Smith Lake Dam in August, 2015 (Figure 31). Recreationists report seeing numerous brown trout upstream of the ladder in October.



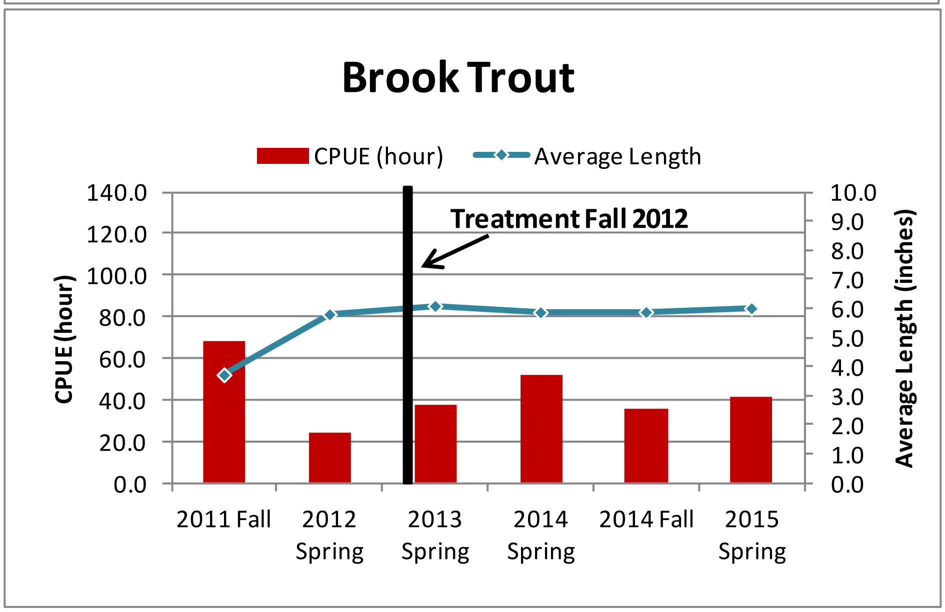
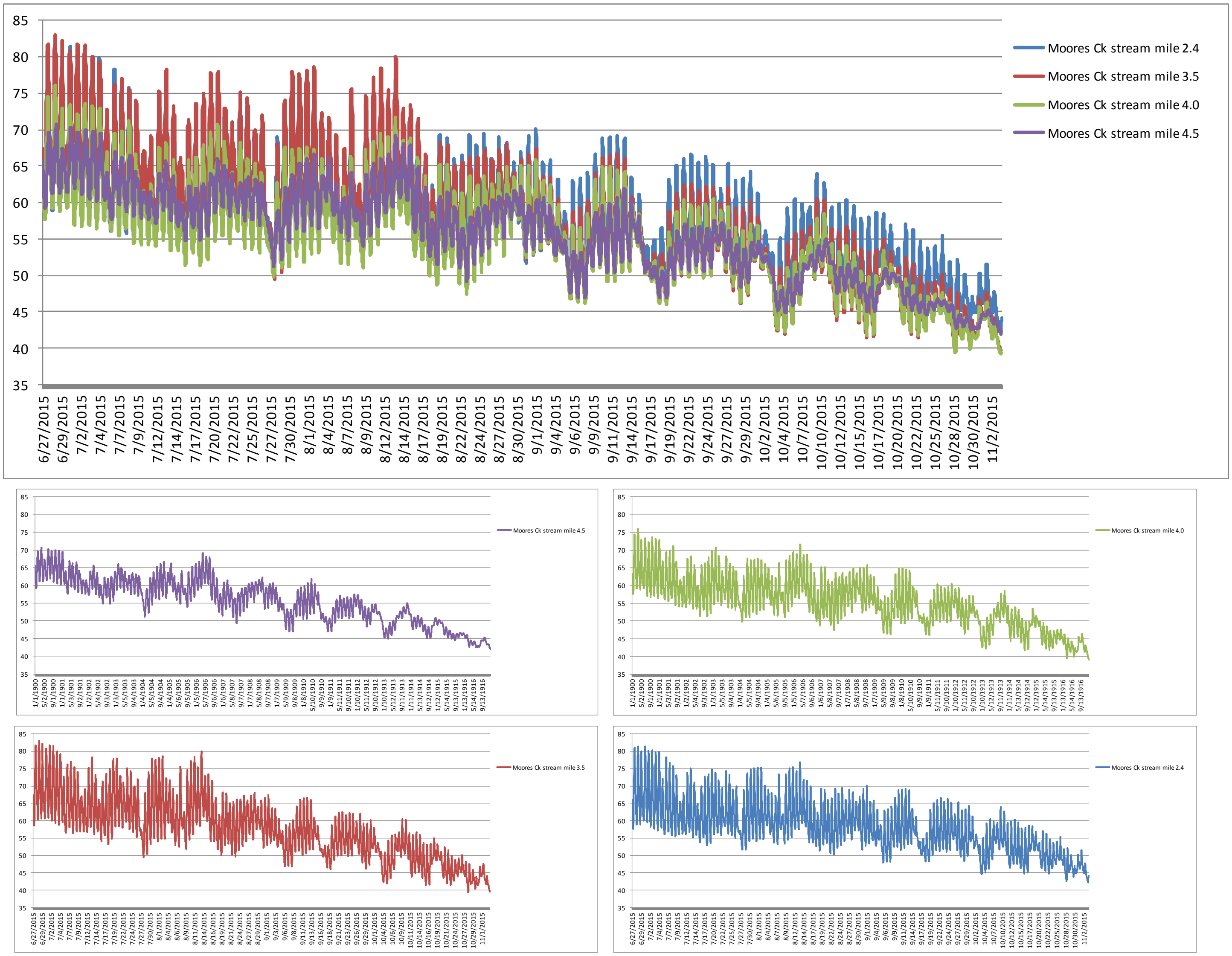


Figure 29. Catch-per-unit-effort and average length of brown trout and brook trout in the Endecott section of the South Fork of Meadow Creek, 2011 – 2015.

Table 7. Summary statistics of electrofishing in a section of Moore's Creek, June 26, 2015.

Species	Number captured	CPUE[1/] (hour)	Average length (range)
Brown trout	16	47.1	7.2 (5.8-11.4)
White sucker	6	17.6	5.5 (2.8 – 7.1)
Sculpin	4	11.8	5.0 (4.4 – 5.6)
Longnose dace	1	2.9	4.9

[1/] Catch per unit effort (hour) of electrofishing



		# data points	start	end	max	min	avg
stream mile 2.4	Valley Garden Ranch	6226	6/27/2015 0:00	11/3/2015 16:30	81.4	42.2	58.1
stream mile 3.5	Ennis RV Village culvert	6216	6/27/2015 0:00	11/3/2015 11:30	83.0	39.4	57.6
stream mile 4.0	Goggins bridge behind barn	6219	6/27/2015 0:00	11/3/2015 13:00	76.0	39.2	55.1
stream mile 4.5	Goggins weir south property	6219	6/27/2015 0:00	11/3/2015 13:00	70.7	42.0	55.6

Figure 30. Water temperature data from four sites in Moore's Creek, 2015.

Ruby Creek Stream Channel

Survey and design were completed for re-routing the Ruby Creek stream channel to eliminate the undercutting of an historical homestead cabin that was threatening to collapse into the active Ruby Creek stream channel. In October, the new channel was excavated, the excavated willows were placed in the existing channel to facilitate stabilization near the homestead cabin. Soil was used to fill and taper the streambank in front of the cabin (Figure 32), and native grass seed was scattered over the soil. Locally harvested sod was used to line the banks of the newly constructed stream channel.

Figure 31. Photos of Smith Lake Dam, before (left) and after (right) a fish ladder was installed.

Hebgen Basin

<u>Hebgen Reservoir Gillnetting</u>

A total of 780 fish were captured during Hebgen Reservoir gillnetting in 2015 (Table 8), almost 54 percent of them were Utah chub.

The number of rainbow trout captured per year has varied from 40 in 2001 to 194 in 2008 (Figure 33). Average length of rainbow trout captured has been higher over the last decade than in the mid-late 1990's. Additionally, the proportion of the rainbow trout gillnet catch under 14 inches has decreased noticeably since 2002 (Figure 34), except in 2012 when it was in a similar proportion to 1999-2002. From 1995 to 2003, rainbow trout averaged 14.3 inches, while from 2004 through 2015, they average 16.3 inches.

Beginning in 2013, otolith (ear bone) micro-chemistry technique was used to identify origin of Hebgen Reservoir rainbow trout. Analysis of water samples from Hebgen Reservoir spawning tributaries and hatcheries used to produce stocked rainbow trout indicated that each potential natal water exhibits a unique elemental chemical signature. This same elemental chemical signature can be detected in the focus of each otolith which will indicate which natal water produced that fish. Otolith samples were collected from rainbow trout captured by electrofishing, gillnetting and angler creel. Analysis of otolith microchemistry was completed in 2015 (Appendix I). Results show that 37 of the 288 analyzed otoliths indicate fish of hatchery origin.

Brown trout numbers have fluctuated widely with no consistent trend evident for more than a few consecutive years (Figure 35). The number of fish captured annually has ranged from 40 in 2001 to 326 in 1999.

Figure 32. Before (top) and after (bottom) photos of the Ruby Creek stream channel at the McAtee Homestead site.

The number of mountain whitefish captured decreased significantly in 2002, but has remained relatively stable in recent years (Figure 36). The number captured per year has varied from 80 in 2002 to 235 in 1999.

The number of Utah chub captured decreased significantly in 2005 and has remained low until 2013. Average length has shown no consistent trend since 1995 (Figure 37). The number of Utah chub captured annually has ranged from 268 in 2008 to 2,245 in 1999.

Utah chub comprised 77 percent of the total Hebgen gillnet catch in 1995-2003 but have averaged 61 percent since (Figure 38).

Table 8. Summary of 2015 Hebgen Reservoir gillnet catch.

Species	Number caught	Average Length (range)	Average weight (range)
Rainbow trout	99	16.7 (9.7 - 20.2)	1.92 (0.32 – 3.43)
Brown trout	168	17.9 (6.2 – 23.3)	2.20 (0.09 – 5.50)
Whitefish	93	15.8 (7.0 – 22.2)	1.80 (0.10 – 3.71)
Utah Chub	420	8.6 (5.5 – 14.3)	0.40 (0.05 – 1.57)

Hebgen Basin Juvenile Fish Sampling

Beach Seining

Beach seining has been conducted intermittently to monitor juvenile fish numbers in Hebgen Reservoir. Figure 39 illustrates total catch at three index sites for 2007, 2008 and 2011 - 2015.

Numbers of juvenile chubs have consistently been low in June and shown dramatic increases in July, which may be a function of their size. Graham (1955) found peak spawning of Utah chub in Hebgen occurred mid June to early July in shallow near-shore zones often with submergent or emergent vegetation and inundated terrestrial vegetation. The number of young-of-the-year Utah chub captured by beach seining appears to be closely related to reservoir elevation, which affects the availability of spawning habitat utilized by Utah chub (Figure 40). Teuscher and Lueke (1996) suggest vegetation as a key component to successful Utah chub spawning. Differences observed in the number of young-of-the-year Utah chub throughout the years may be a function of reservoir elevation on Utah chub access to inundated shoreline vegetation.

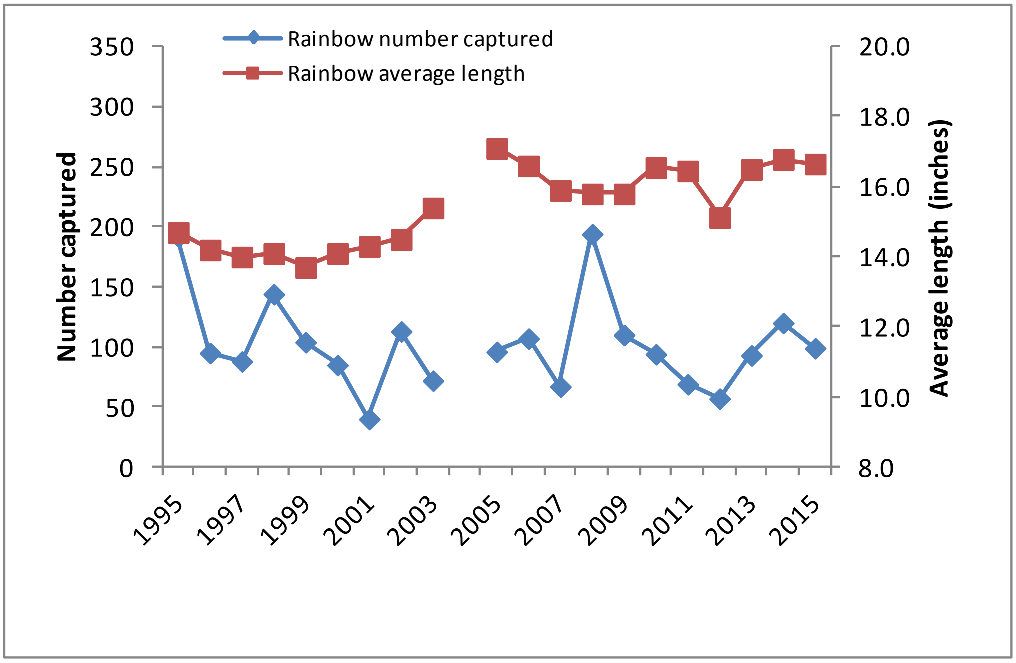


Figure 33. Figure showing rainbow trout average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2015. Data from 2004 are not shown because of sampling error.

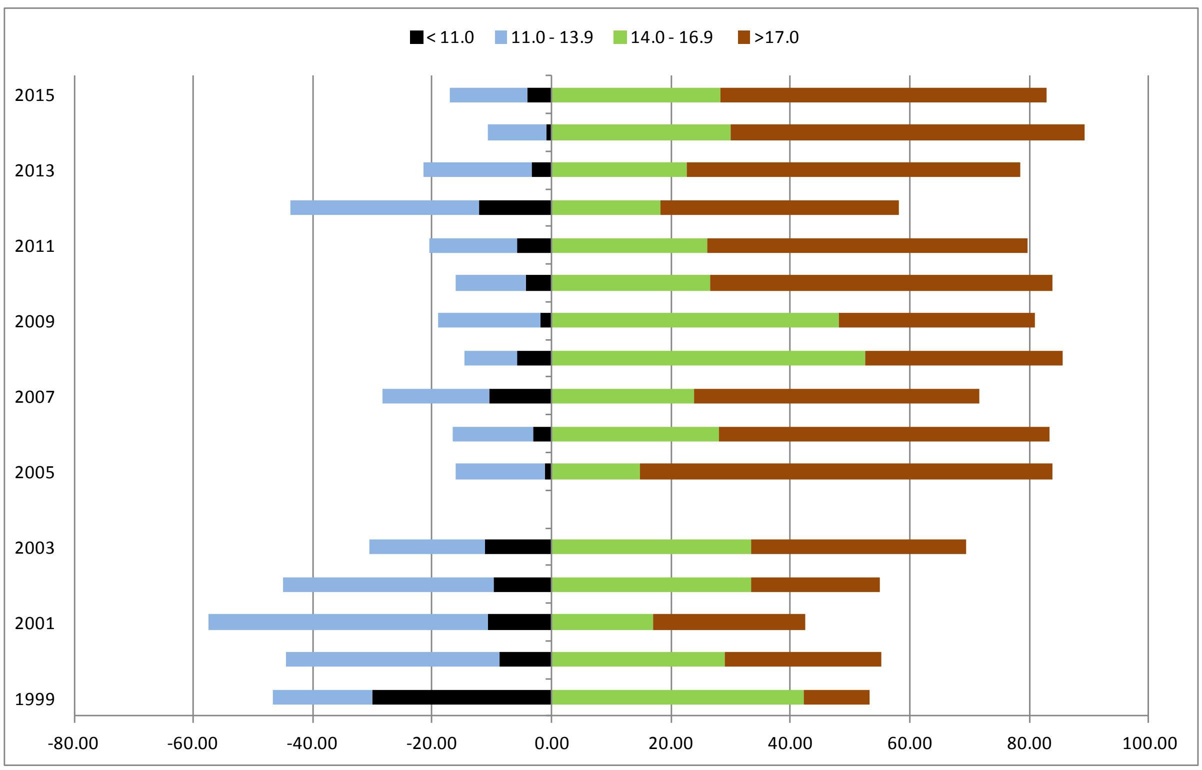


Figure 34. Figure showing percentage of Hebgen Reservoir rainbow trout gillnet catch under and over 14 inches, 1999-2015. Data from 2004 are not shown because of sampling error.

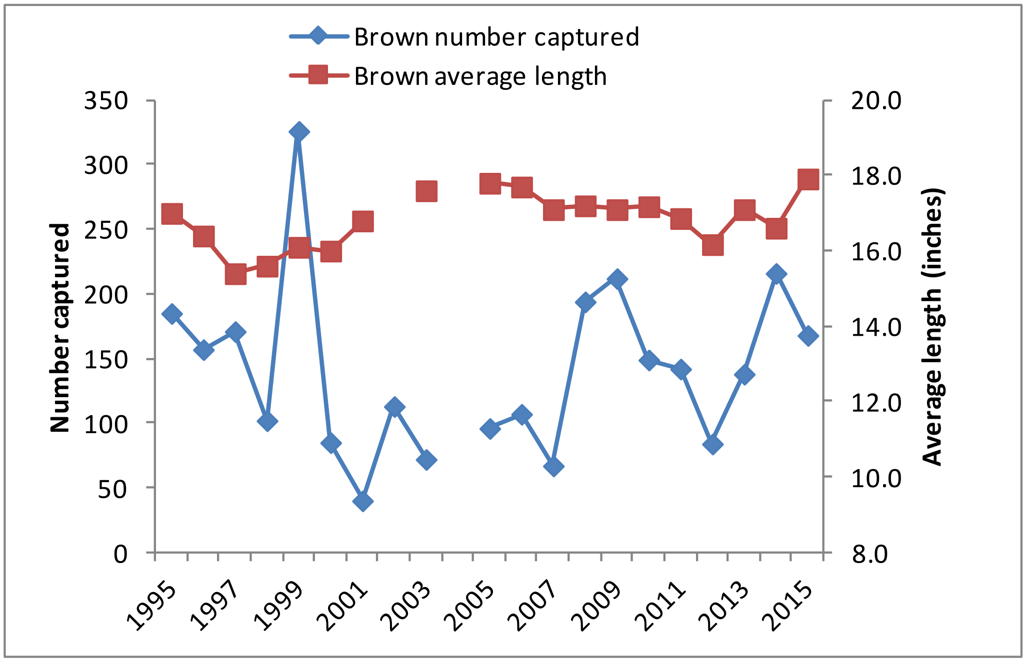


Figure 35. Figure showing brown trout average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2015. Data from 2004 are not shown because of sampling error.

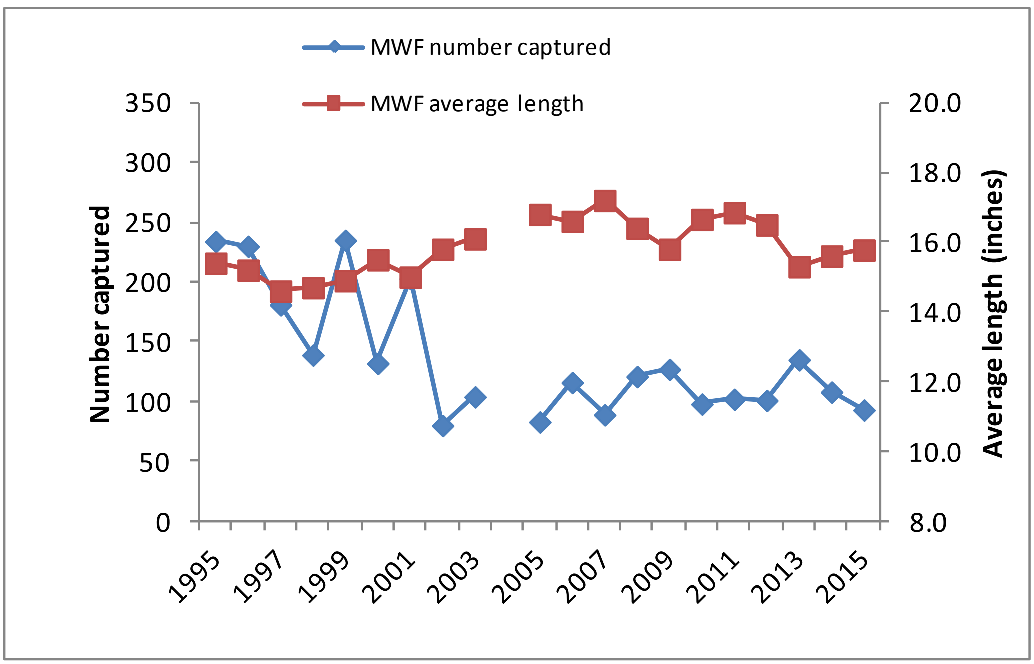


Figure 36. Figure showing mountain whitefish average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2015. Data from 2004 are not shown because of sampling error.

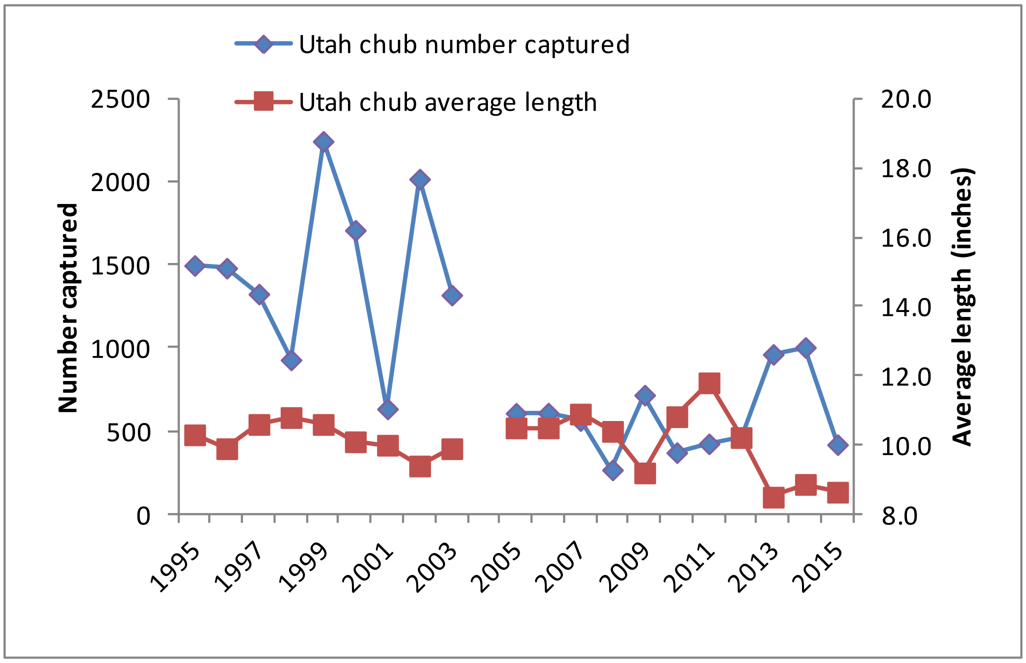


Figure 37. Figure showing Utah chub average length in inches (right axis) vs. number captured (left axis) during annual Hebgen gillnetting, 1995-2015. Data from 2004 are not shown because of sampling error.

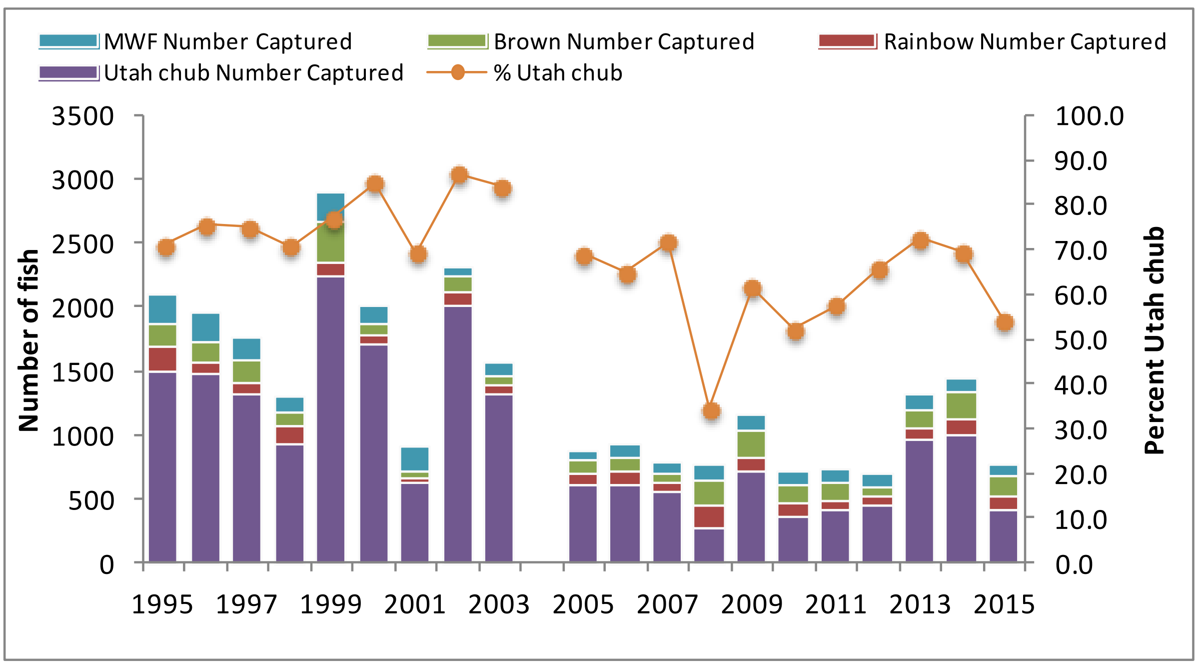


Figure 38. Figure showing species composition of Hebgen Reservoir gillnet catch, 1995 – 2015. Data from 2004 are not shown because of sampling error.

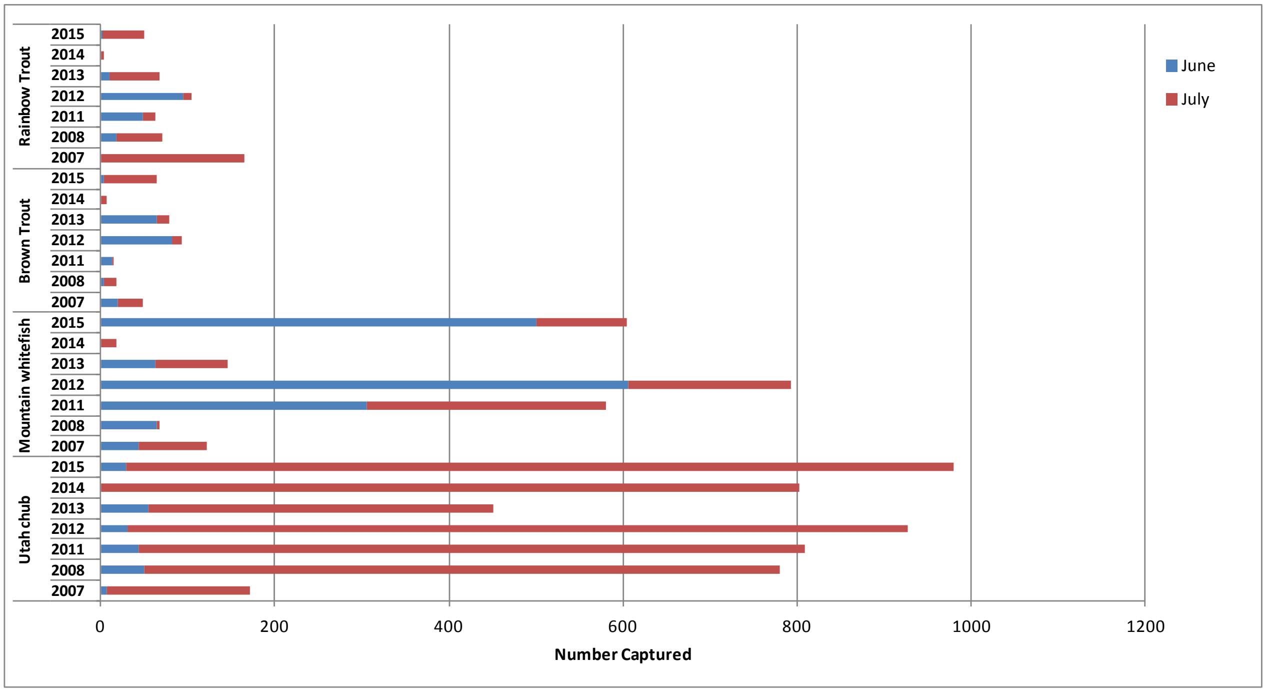


Figure 39. Beach seining catch of juvenile Hebgen Reservoir fish, June and July, 2007, 2008, 2011 - 2015.

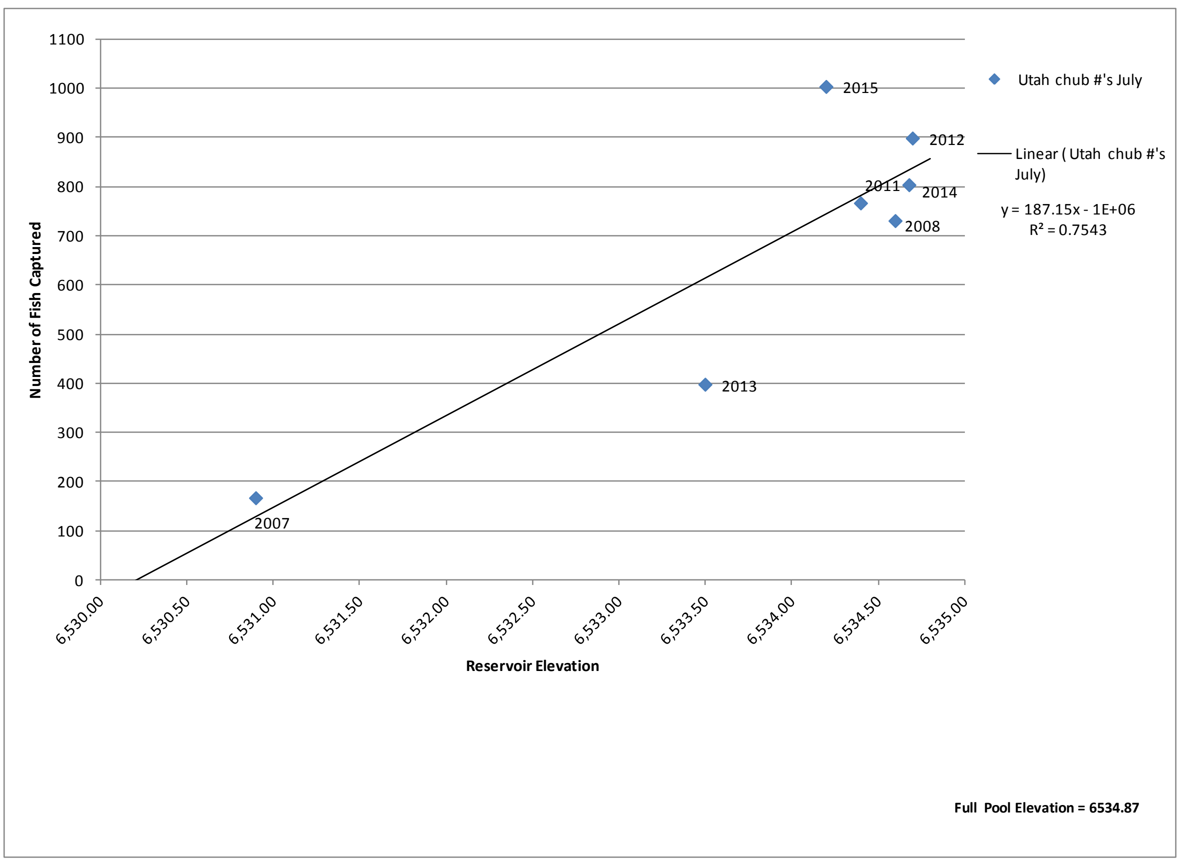


Figure 40. Number of young-of-the-year Utah chub collected during July seining of index sites versus reservoir elevation 2007, 2008, 2011 - 2015.

Hebgen Reservoir Zooplankton Monitoring

Densities (individuals/liter) of cladoceran and copepod zooplankton in Hebgen Reservoir have been monitored since 2006 (Appendix J). Annual temporal trends in abundance show peak densities occurring in late spring and early summer (Figure 41), immediately after reservoir ice-off.

Studies of Utah chub diet in several western reservoirs have shown zooplankton to be their principle food item. In Strawberry Reservoir, Utah, Johnson (1988) reported that Utah chub shoreline feeding on zooplankton was detrimental to the survival of young-of-the-year cutthroat and rainbow trout. Similarly, enclosure experiments with Utah chub and kokanee *Oncorhynchus nerka* showed that increased densities of Utah chub reduced zooplankton densities and negatively affected kokanee growth (Teuscher and Lueke 1996).

Applying the Trophic State Index (TSI) (Figure 42) developed by Carlson (1977), Hebgen Reservoir is classified as oligotrophic-mesotrophic with 2009 – 2014 mean TSI scores ranging between 35.6 – 40.3. The 2015 score was 37.1. This may partially explain the low plankton densities observed in Hebgen. Figure 43 illustrates mean cladoceran and mean copepod densities versus mean TSI score for each of the seven monitoring sites for 2009-2015.

Primary productivity in Hebgen Reservoir may be limited by climate conditions. A high elevation short-duration growing season allows for relatively few days of primary production. Hebgen Reservoir, with a full pool elevation of 6,534.87 feet, may be more characteristic of an alpine lake than of lakes at lower elevations. Johnson and Martinez (2000) found lake elevation and a shortened growing season (the number of days water surface temperature is at or exceeds 50°F) to be inversely related to lake productivity.

Additionally, wind patterns may be affecting the mixing of nutrients from tributaries entering the main body of Hebgen Reservoir. For the months of June through October, 2007-2009, at the West Yellowstone airport, wind direction was predominately out of the northwest (Figure 44). Given Hebgen Reservoirs northwest-southeast orientation this data would suggest that nutrients may be confined to the arms of the reservoir for much of the growing season. FWP and NWE incorporated an anemometer into the weather station in 2011 to measure wind direction on the reservoir rather than at nearby areas such as the West Yellowstone airport. Wind direction data (Appendix K) shows that wind patterns predominately occurred out of the southwest in 2011 and 2013, out of the northwest in 2008 – 2009, 2012 and 2015, and from the east-southeast in 2014. This raises some interesting questions concerning nutrient cycling through the reservoir as the productive Madison and Grayling arms of Hebgen are oriented east - west along with the less productive main body of the reservoir. Also, the narrow connection of the Grayling and Madison arms to the main body of the reservoir may be functioning as bottlenecks to limit the amount of nutrient exchange between the arms and the main reservoir.

Zooplankton densities at monitoring sites in the main body of the reservoir (Dam, Watkins, Johnson and Horse Butte sites) were examined to assess the influence of wind on them (Figure 45). It appears that wind direction may have the greatest affect on zooplankton densities. Typically, in years with predominantly northwesterly winds (2008, 2009, 2012), poor nutrient mixing occurs throughout the main body of the reservoir resulting in relatively low zooplankton densities. However, in 2015, a year with predominantly northwesterly winds, plankton densities were noticeably higher than is similar years. We speculate that this is due to significantly warmer water in the Spring, creating favorable conditions for plankton development. Predominantly easterly or southeasterly winds improve nutrient mixing and result in higher zooplankton densities. The affect of wind frequency of occurrence and mean wind speed are unclear.

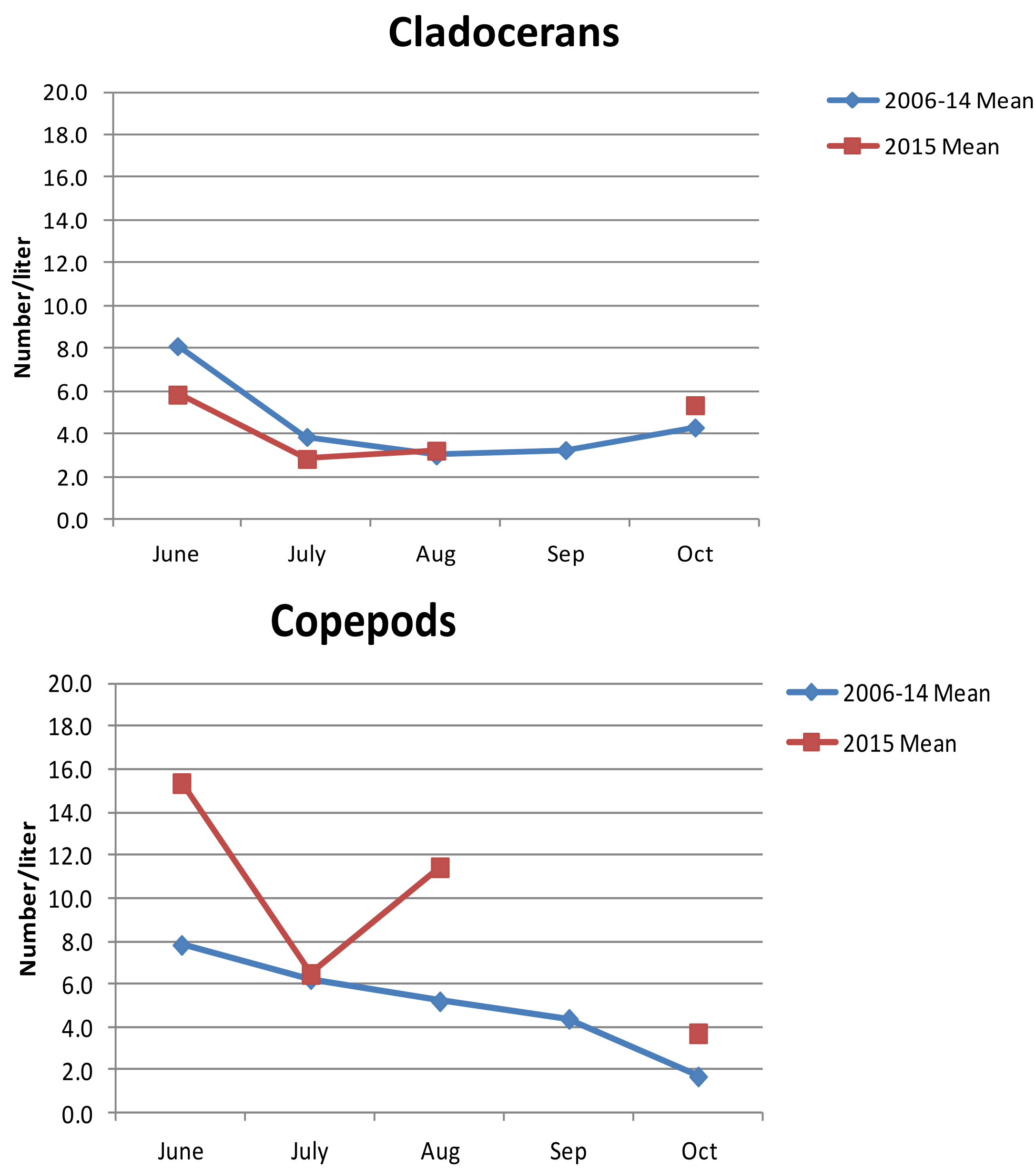


Figure 41. Figure comparing 2015 Hebgen Reservoir monthly cladoceran and copepod densities (individuals/liter) to the 2006 -14 monthly averages.

CONCLUSIONS AND FUTURE PLANS

The Madison River/Ennis Reservoir grayling population is very similar genetically to the Big Hole River population. The Arctic grayling introduction and monitoring effort initiated in 2014 is anticipated to continue through 2023, and is using fertilized eggs from captive descendents of the Big Hole population. Introductions will be conducted for 4-5 consecutive years at selected sites, with monitoring occurring to determine the success at each site. In 2015, introductions were conducted in the West Fork of the Madison River, O'Dell Creek, Blaine Spring Creek and Moore's Creek. Additional sites will be considered as they are identified.

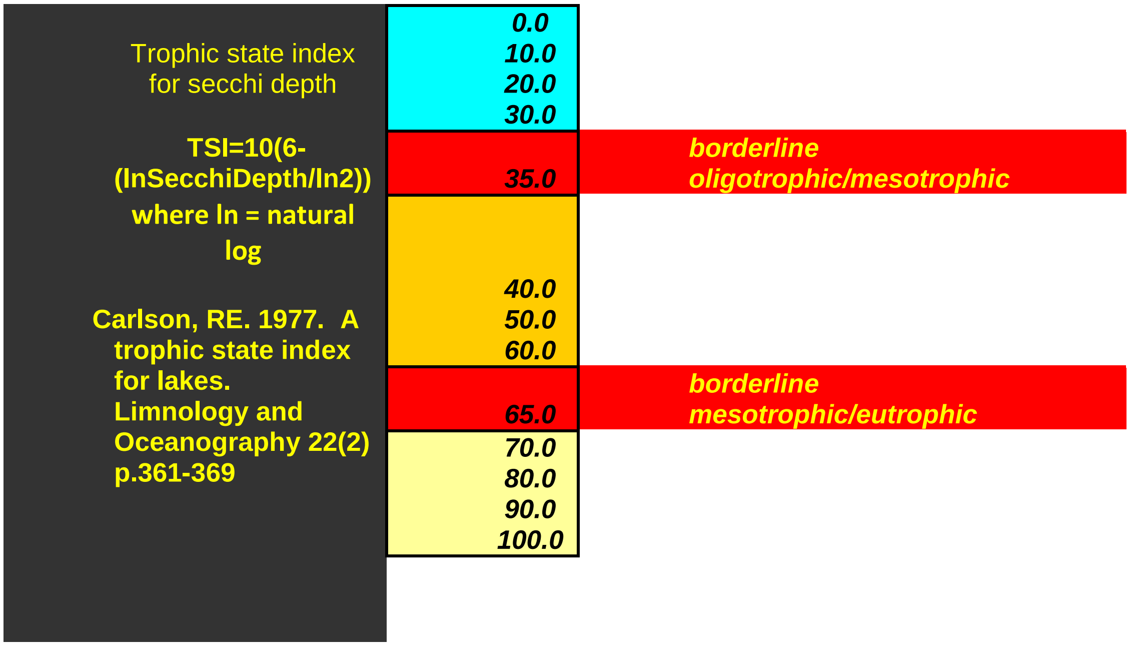


Figure 42. Figure depicting the trophic state index formula and classification for lake productivity using secchi depth measurements.

Fish population monitoring will continue annually in the Madison River. These data are necessary for setting and reviewing angling regulations, for monitoring environmental and biological impacts on the populations, and for assessing the long-term effects of fish population and water management decisions.

Monitoring of fish population response to habitat improvement projects in the Madison Basin will continue into the future. Projects conducted in 2015 include construction of riparian fencing, hardened stream crossings, water gaps, and off-channel watering a section of Moore's Creek on the Goggins Ranch, installation of a fish ladder to facilitate fish passage at Smith Lake Dam, evaluation of several sites on Jack Creek needing habitat improvement and measures to prevent an historic homestead cabin from collapsing into Ruby Creek on the Wall Creek Wildlife Management Area.

Aquatic Invasive Species monitoring will continue through the 2188 Biological and Biocontaminant monitoring program and through the FWP Aquatic Invasive Species Program.

FWP has implemented a program and provided equipment to clean sampling gear to reduce the chance of moving AIS between waters.

The proportion of the Hebgen Reservoir rainbow trout gillnet catch larger than 14 inches has increased since 2005. The Hebgen Reservoir rainbow trout micro-chemistry study will continue, and is expected to be completed in 2015.

Zooplankton densities in Hebgen Reservoir will continue to be monitored. Cladoceran density tends to be at its highest in June while copepod density peaks in July, though in 2014 and 2015 both were highest in June. Predominant wind direction appears to affect zooplankton density in the main body of Hebgen Reservoir, likely due to its affect on nutrient mixing.

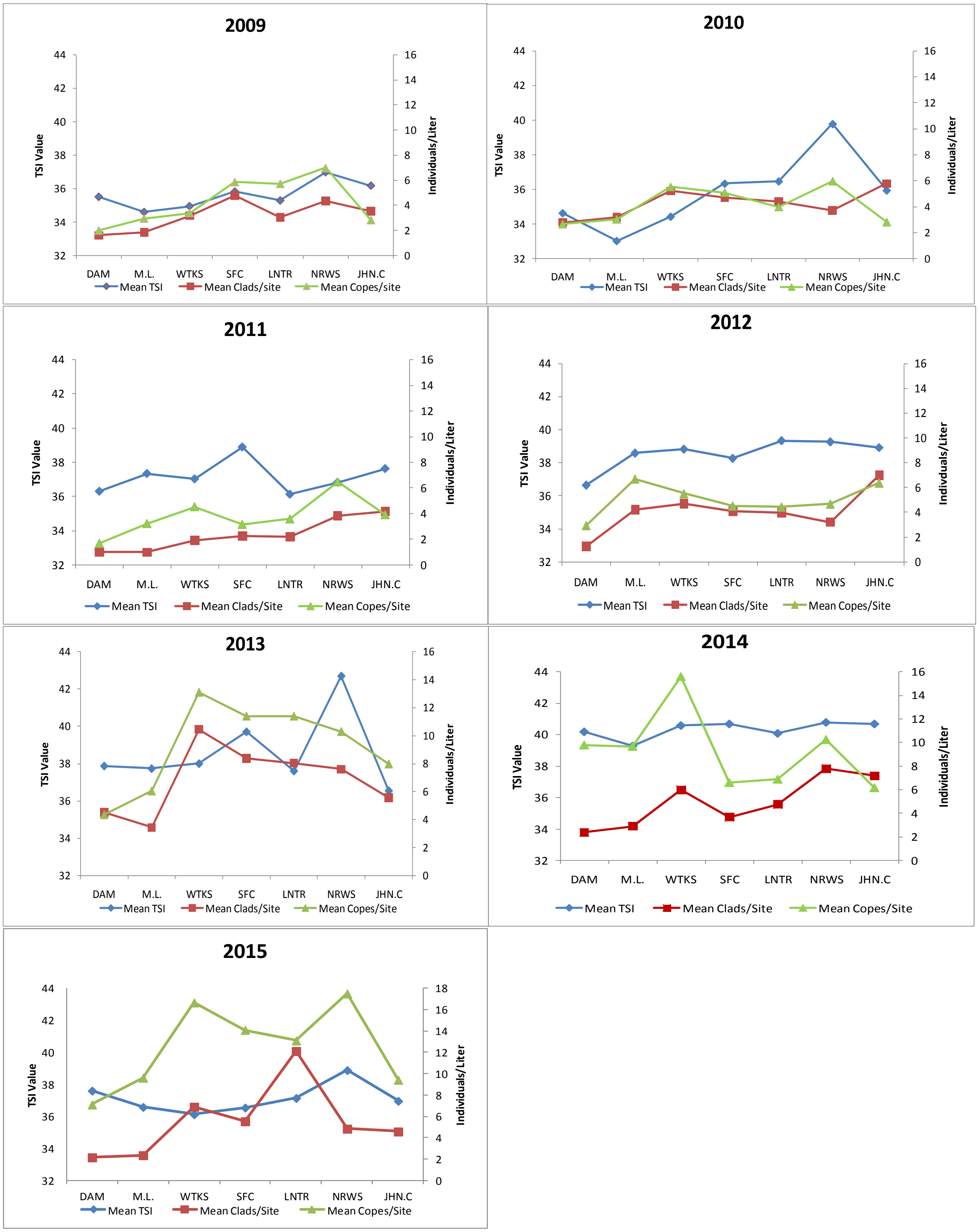
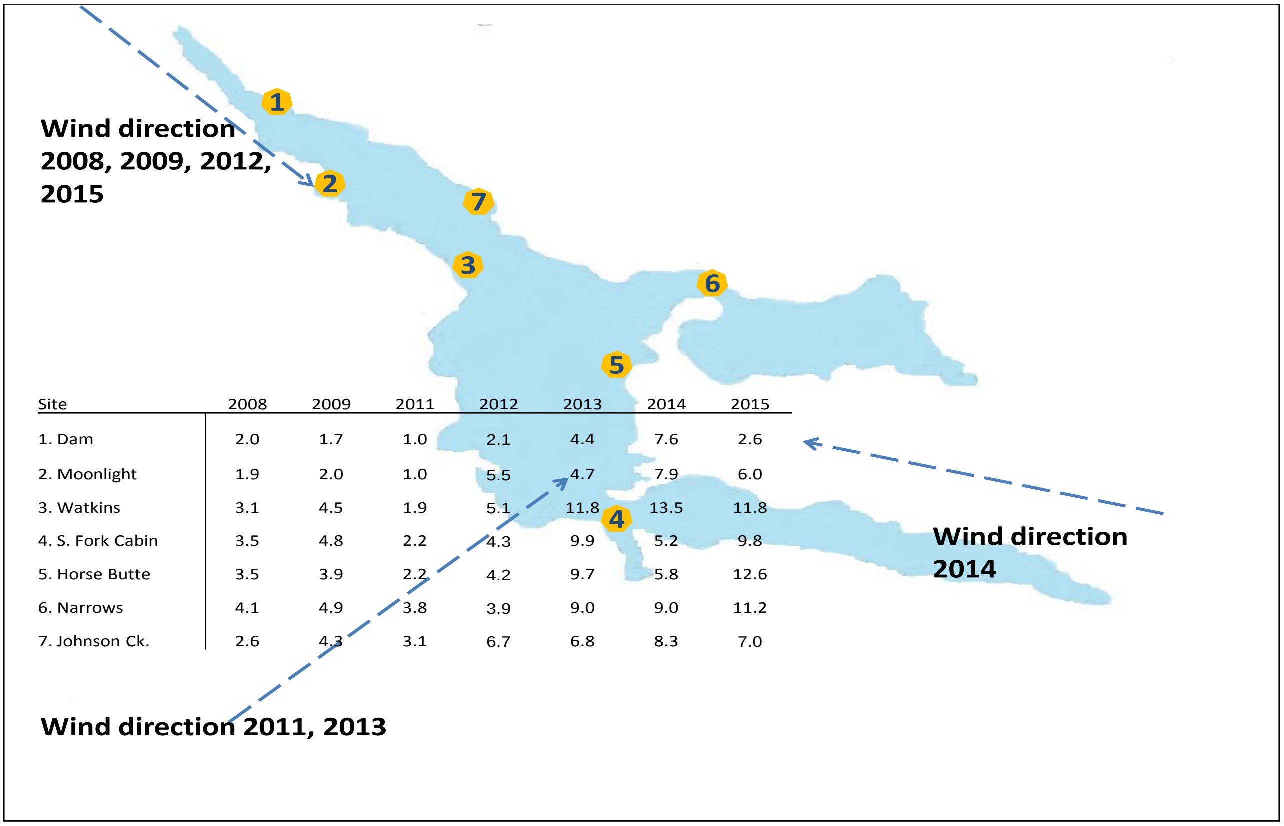


Figure 43. Hebgen Reservoir mean TSI score and mean densities of zooplankton by site, 2009 - 2015. Site names are Dam, Moonlight Bay, Watkins Creek, South Fork Cabin, Lone Tree (Horse Butte), Narrows, and Johnson Creek. Sites are listed in a counterclockwise fashion from the dam (Figure 16).



Site	2008	2009	2011	2012	2013	2014	2015
1. Dam	2.0	1.7	1.0	2.1	4.4	7.6	2.6
2. Moonlight	1.9	2.0	1.0	5.5	4.7	7.9	6.0
3. Watkins	3.1	4.5	1.9	5.1	11.8	13.5	11.8
4. S. Fork Cabin	3.5	4.8	2.2	4.3	9.9	5.2	9.8
5. Horse Butte	3.5	3.9	2.2	4.2	9.7	5.8	12.6
6. Narrows	4.1	4.9	3.8	3.9	9.0	9.0	11.2
7. Johnson Ck.	2.6	4.3	3.1	6.7	6.8	8.3	7.0

Figure 44. Prevailing wind direction and mean zooplankton densities per site for 2008, 2009, and 2011 - 2015.

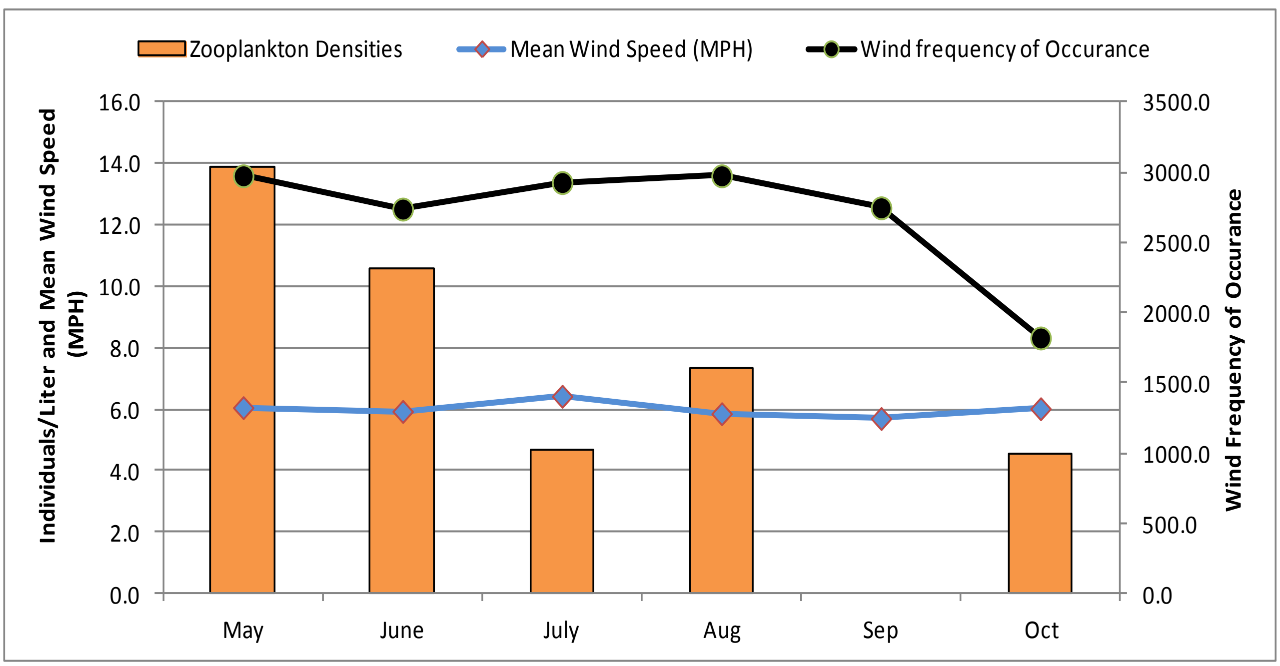


Figure 45. Chart showing mean wind speed in miles per hour (MPH), wind frequency of occurrence (number of occurrences/month) and mean zooplankton densities (number/liter) by month, 2015, at the Dam, Watkins, Johnson and Horse Butte monitoring sites in the main body of Hebgen Reservoir.

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Appendix A1

Summary of Ennis Reservoir beach seining 1995 - 2014

Species abbreviations:

AG Arctic grayling
MWF mountain whitefish
LL brown trout
Rb rainbow trout

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

Appendix A2

Description of young-of-the-year Arctic grayling beach seining locations in Ennis Reservoir, and catch at each site. See Figure 6 for site locations.

<u>Species abbreviations</u>:

AG	Arctic grayling
MWF	mountain whitefish
Rb	rainbow trout
LL	brown trout
WSu	white sucker
UC	Utah chub

Site	AG	MWF	Note
Meadow Ck FAS rental house 9/30/15 Fig 6 site 1	0	5	Macrophytes sparse 64°F MWF – 4.6, 4.8, 5.0, 5.1, 5.3 inches 1 UC
Meadow Ck FAS north shore willows 9/30/15 Fig 6 site 2	0	9	Macrophytes moderate 62°F MWF – 3.7, 3.9, 4.1, 4.3, 4.7, 4.7, 4.7, 4.8, 4.9 inches 1 LL – 3.7 inches 1 UC 1 sculpin
Meadow Ck FAS South shore near creek mouth 9/30/15 Fig 6 site 3	0	0	Macrophytes absent 64°F No fish captured
Madison River mouth 9/30/15 Fig 6 site 4	0		Macrophytes sparse 56° 1 Rb – 1 inch 1 WSu 3 UC
Southwest shore east of Fletcher's mouth 9/30/15 Fig 6 site 5	0	5	Macrophytes sparse 58° MWF – 4.3, 4.3, 4.4, 5.2, 5.4 14 UC

Appendix B

The Montana Aquatic Nuisance Species Management Plan was finalized in October of 2002 and a full time Aquatic Nuisance Species (ANS) Program Coordinator was hired by Montana Fish, Wildlife and Parks in February of 2004. The emphasis of the Montana ANS Program is on coordination, education, control and prevention of spread, monitoring and detection, and rapid response. The species of emphasis are New Zealand mudsnails, whirling disease, and Eurasian milfoil (all of which are established in Montana), and zebra mussels (which is yet to be documented in the state). Strategies to prevent the further spread and introduction of these species are outlined below.

1. Statewide distribution survey for New Zealand Mudsnails has been completed. All state, federal and private hatcheries have been inspected for New Zealand mudsnails. One private hatchery contains New Zealand mudsnails, strategies have been implemented to prevent the spread of this invasive through hatchery operations. The spread of New Zealand mudsnails has slowed and appears to be confined to east of the divide.

2. Zebra Mussel veliger sampling has been completed for all major reservoirs on the Missouri River, and on other high priority lakes and reservoirs. To date no zebra mussels have been found within the state.

3. Legislation and Rule making: In 2005 a rule making system was developed to classify exotic wildlife (terrestrial and aquatic) as either non controlled, controlled or prohibited. The following ANS have been since added to the prohibited list: snakehead fish (29 species), grass carp, silver carp, black carp, bighead carp, zebra mussels, rusty crayfish, nutria, African clawed frogs, North American bullfrogs, and New Zealand mudsnails. Legislation was also passed during the 2005 session to provide exceptions for the possession of prohibited species, primarily for the purposes of research, in addition to providing for tougher enforcement authority including the ability to confiscate illegally possessed exotic wildlife.

4. Montana continues to actively participate in the 100th Meridian angler survey program and during 2005 submitted more than 1,700 entries to the angler survey database. The angler surveys are conducted as part of the Montana boat inspection program, which was greatly expanded in 2005. Boat inspections have occurred on all major lakes, reservoirs and popular cold-water trout rivers. The first boat with zebra mussels was found in Montana in March 2005.

5. Training: a one day workshop was provided during the Annual Meeting of the Montana Chapter of the American Fisheries Society on ANS identification, 2 day HACCP workshops have been provided for Montana hatchery personnel and field workers, a half day training was provided for Montana Firefighters on the prevention of spread of ANS, and a half day training was provided on ANS identification and prevention of spread as part of fish health training for fisheries and hatchery personnel within FWS Region 6.

6. Public outreach: presentations on ANS have been made to several special interest groups including Walleyes Unlimited, Fishing Outfitters Association of Montana and Lake Associations. ANS informational booths were present at five Montana outdoor shows: Billings, Bozeman, Great Falls, Missoula and Kalispell. Informational packets have been developed and are being distributed for private pond owners to encourage responsible pond ownership.

7. Illegal introductions: to date over 500 illegal fish introductions have been recorded in Montana. Illegal introductions have been identified as a major source of ANS introductions into Montana

waters. An aggressive public outreach campaign was launched during summer of 2005 with an increase in law enforcement to discourage the activity of “bucket biology”.

With just **three easy steps**, you can do your part to help stop the spread of aquatic invasive species like plants, mussels and whirling disease:

INSPECT.
CLEAN.
DRY.

1. INSPECT.

After leaving a lake or stream, inspect your boat, engine, trailer, anchor, waders, and other fishing and boating gear for mud, water, and vegetation that could carry aquatic invasive species.

2. CLEAN.

Completely remove all mud, water, and vegetation you find. Boaters should use a pressurized power sprayer, found at most do-it-yourself car washes. The hot water helps kill organisms and the pressure removes mud and vegetation. No need to use soap or chemicals.

3. DRY.

Aquatic invaders can survive only in water and wet areas. By draining and drying your boat and fishing equipment thoroughly, you will kill most invasive species. The longer you keep your boat, trailer, waders, and other equipment outside in the hot sun between fishing trips, the better.

A message brought to you in partnership by
Montana Fish, Wildlife & Parks and the Montana Department of Agriculture

MONTANA AGRICULTURE

Montana Fish, Wildlife & Parks

STOP AQUATIC HITCHHIKERS!

MAKE THE CALL: Report violations anonymously to **1-800-TIP-MONT**

Appendix C

Sun Ranch Hatchery Contributions and Production
2001 – 2015

Drake & Associates 2015 Summary Report

Year	Donor Stream	M:F spawned	# eggs produced	Recipient Water	# eggs/fry out
2001	Papoose Ck - Madison	NA	NA	Sun Brood Pond	356 fry
	MF Cabin Ck - Madison	23:12	NA		
2002	WF Wilson Ck – Gallatin	?:6	NA	Sun Brood Pond	483 fry
	MF Cabin Ck – Madison	?:3	NA		104 fry
2003	Ray Ck – Big Belt Mtns	25:9	2,420	Sun Brood Pond Bar None Pond	566 fry 560 fry
	Prickly Pear Ck – Missouri	4:1	NA	Prickly Pear Ck Eureka Ck Little Tizer Ck	28 120 52
	Hall Ck – Elkhorn Mtns	4:1	NA	Hall Ck Little Tizer Ck	20 91
2004	Cottonwood Ck – Blacktail	12:6	1,652	Sun Brood Pond	820 fry
	Muskrat Ck – Elkhorn Mtns	15:7	2,028	Bar None Pond	814 fry
	Ray Ck F x McClure Ck M (Madison)	4:8	1,410		
	Ray F x Hall M	2:1	362		
2005	Cottonwood Ck – Blacktail Ck	13:6	2,849	Sun Brood Pond Disease testing	528 fry 11 fry
	Brown's Ck – Beaverhead	10:5	772	Sun Brood Pond	646 fry
	Sun Brood Pond	37:16	13,851	Sun Brood Pond	800 fry
				Sun Pond disease sentinels	120 fry

2005, continued	Sun Brood Pond	37:16	13,851	Euthanized to reduce hatchery load	750 fry
				Disease testing	100 fry
				Moret Pond	700 fry
				Calibration of CWT injector	5 fry
	Muskrat Ck – Elkhorn Mtns	18:9	NA	SF Crow Ck	2,262 eyed eggs

2006	Browns Ck – Beaverhead	1:1	301	Sun Brood Pond	284 fry
	Muskrat Ck – Elkhorn Mtns	16:8	2,027	Sun Brood Pond Cherry Ck - Madison	184 fry 1,750 eyed eggs
	Whites Gulch – Big Belt Mtns	3:3	982	Cherry Ck - Madison	726 eyed eggs

2007	Muskrat Ck – Elkhorn Mtns	11:22	6,533	Cherry Ck - Madison Sun Brood Pond	5,445 eyed eggs 291 fry
	Ray Ck – Big Belt Mtns	13:25	4,371	Cherry Ck - Madison Sun Brood Pond	3,467 eyed eggs 194 fry
	Whites Gulch – Big Belt Mtns	4:8	1,688	Cherry Ck – Madison Sun Brood Pond	1,015 eyed eggs 59 fry
	Sun Brood Pond	37:17	NA	Cherry Ck – Madison	2,994 eyed eggs
				Sun Brood Pond	326 fry
				High Lk – Gallatin (YNP)	1,611 eyed eggs
	Last Chance Ck – Madison (YNP)	12:8	NA	High Lk – Gallatin (YNP)	177 eyed eggs

Year	Donor Stream	M:F spawned	# eggs produced	Recipient water	# eggs/fry out
2008	Muskrat Ck – Elkhorn Mtns	28:14	NA	Cherry Ck – Madison	3,199 eyed eggs
	Ray Ck – Big Belt Mtns	23:12	NA	Cherry Ck – Madison	1,700 eyed eggs
	Whites Gulch – Big Belt Mtns	11:6	NA	Cherry Ck – Madison Sun Brood Pond	1,015 eyed eggs 117 fry
	Sun Brood Pond	28:10	NA	Cherry Ck – Madison	3,218 eyed eggs
				Sun Brood Pond	571 fry
				High Lk – Gallatin (YNP)	2,844 eyed eggs
	Last Chance Ck – Madison (YNP)	13:8	NA	High Lk – Gallatin (YNP) Sun Brood Pond	286 eyed eggs 70 fry

Year	Donor Stream	M:F spawned	# eggs produced	Recipient water	# eggs/fry out
2009	Muskrat Ck – Elkhorn Mtns	24:12	NA	Cherry Ck – Madison Sun Brood Pond	4,134 eyed eggs 311 fry
	Whites Gulch – Big Belt Mtns	8:5	NA	Cherry Ck – Madison	630 eyed eggs
				Cherry Lk – Madison	500 fry
				Sun Brood Pond	283 fry
				Cottonwood Ck (FWP Region 4)	1,350 eyed eggs
	Ray Ck – Big Belt Mtns	20:10	NA	Cherry Ck – Madison Sun Brood Pond	1,911 eyed eggs 15 fry
	Geode Ck (YNP)	17:16	NA	High Lk - Gallatin (YNP)	838 eyed eggs
	WF Wilson Ck – Gallatin	NA	NA	Eggs destroyed - hybridized	

Year	Donor Stream	M:F spawned	# eggs produced	Recipient water	# eggs/fry out
2010	Last Chance Ck – Madison (YNP)	5:5	NA	Little Tepee Ck – Madison	443 eyed eggs
	Wally McClure Ck - Madison	10:0			
	Brays Canyon – Beaverhead	7:7	NA	Cherry Ck – Madison Sun Brood Pond	1,066 eyed eggs 123 fry
	Prickly Pear Ck – Elkhorn Mtns	8:4	NA	Eureka Ck	641 eyed eggs
	Wild Horse Ck	5:3	NA	Elkhorn Ck – Gallatin Wild Horse Ck	678 eyed eggs 76 eyed eggs
	Geode Ck (YNP)	24:18	NA	EF Specimen Ck – Gallatin	4,156 eyed eggs
	Sun Brood Pond	10:5	NA	Cherry Ck – Madison	398 eyed eggs 3,400 fry
				Sun Brood Pond	496 fry
	WF Wilson – Gallatin	1:1	NA	Eggs destroyed – male was hybrid	

2011	Sun Brood Pond	16:7	6,488	Cherry Ck – Madison Sun Brood Pond	848 fry 818 fry
	Whites Gulch – Big Belt Mtns	7:7	1,296	Cherry Lk – Madison Cottonwood Ck (FWP Region 4)	458 fry 498 eyed eggs
	Muskrat Ck – Elkhorn Mtns	12:6	1,204	EF Specimen Ck - Gallatin Sun Brood pond	1,046 eyed eggs 87 fry
	Geode Ck (YNP)	16:8	1,628	EF Specimen Ck – Gallatin	1,200 eyed eggs

Year	Donor Stream	M:F spawned	# eggs produced	Recipient water	# eggs/fry out
2012	Sun Brood Pond	31:9	8,787	Cherry Ck – Madison Sun Brood Pond	3,900 fry 1,500 fry
	Sappington Ck – Big Hole	20:10	1,977	Cherry Ck – Big Hole	1,556 eyed eggs
	Bryant Ck – Big Hole	22:11	2,963		2,398 eyed eggs
	Plimpton Ck – Big Hole	16:8	840		518 eyed eggs
	Geode Ck (YNP)	39:18	4,370	EF Specimen Ck – Gallatin	3,550 eyed eggs

2013	Sun Brood Pond	38:9	15,145	Sun Brood Pond	3,000 swim-up fry
	Squaw Lake -Big Hole	20:10	9,587	Sun Brood Pond	50 swim-up fry
				Cherry Ck – Big Hole	5,280 eyed eggs
	Papoose Creek – Big Hole	3:1	365		337 eyed eggs
	Divide Creek– Big Hole	2:1	39		29 eyed eggs
	Last Chance Ck (YNP)	13:11	1,217	Goose Lakes (YNP)	702 fry
	Skelly x White creeks	16:5	1,463		700 fry
	Muskrat x Little Boulder	10:7	521		357 eyed eggs
	Muskrat - Big Hole	4:4	413	Sun Brood Pond	50 fry 311 fry destroyed
	Divide x Papoose creeks - Big Hole	2:1	1,013		50 fry 364 fry destroyed

Year	Donor Stream	M:F spawned	# eggs produced	Recipient water	# eggs/fry out
2014	Sun Brood Pond	56:22	19,339	Sun Brood Pond	1,260 swim-up fry
				Elkhorn Creek - FWP R4	15,000 eyed eggs
	Threemile – Missouri River, FWP R4	20:10	5,826	Cottonwood Creek – R4	1,500 eggs
				Goose Lakes – YNP	2,000
				destroyed	2,000
	Jerry – Big Hole	18:9	764	Jerry Creek	Donor fish were slightly hybridized, so all 726 eyed eggs were re-introduced into Jerry Creek
	Bender – Big Hole	6:6	683	Cherry Creek – Big Hole	501 eggs
	Last Chance – YNP	5:3	177	NA (intended for Ruby Creek – Madison)	Only 1 viable egg, destroyed
	Whites Gulch – Big Belt Mtns	48:12	3,660	Cherry Lake – Madison	2,000 swim-up fry
2015	Sun Brood Pond	58:29	24,649	Sun Brood Pond	800 swim-up fry
				Elkhorn Creek - FWP R4	11,000 eyed eggs
				Grayling Creek- YNP	5,000 eyed eggs
				Goose Lakes – YNP	5,100 swim-up fry
	Lone Willow	16:8	4,306	Camus Lake – Big Belt Mtns	3,651 eyed eggs
				Sun Brood Pond	400 swim-up fry
	York Pond – Big Hole	12:6	4,825	York Gulch	2,782 eyed eggs
				Sun Brood Pond	200 swim-up fry
	Geode - YNP	50:25	4,977	Grayling Creek – YNP	4,977eyed eggs
	American – Big Hole	6:12	1,500	No viable eggs	

2015 Sun Ranch WCT Recovery Program Summary

The following is a summation of the 2015 Sun Ranch hatchery operations, the number of eggs incubated, and the distribution of those eggs. Also included is the dissemination of eggs raised to fry stage in the hatchery.

Drake & Associates personnel began opening the Sun Ranch hatchery on May 11, 2015, by flushing the well and hatchery piping. The hatchery was completely cleaned and readied to accept WCT eggs by May 13. We placed our initial trap sets in the brood pond that same day, and spawned the first fish on May 25. Nineteen females from the first trap set contained overly ripened eggs. Those females along with 41 other adult fish were used for disease testing, conducted by MT Fish, Wildlife and Parks' Fish Health Lab.

Alternating our trapping to no more than three days a week, we captured and spawned 29 females and 58 males between May 25 and June 10. These pairings resulted in 29 lots for a total of 24,649 eggs.

We received our first eggs from Yellowstone National Park on May 14, and the first contributions from MT Fish, Wildlife & Parks on May, 22.

YNP's contributions totaled 25 lots from Geode Creek, for the sum of 5,526 eggs from 25 females and 50 males.

FWP contributed 9 lots from York Pond, 3 of which were not viable, for a total of 4,825 eggs from 6 females and 12 males. Additionally, Lone Willow Creek provided 8 lots for a total of 4,306 eggs from 8 females and 16 males. Three lots from America Creek were all bad, and were disposed of at the hatchery.

Water temperature determines how long eggs incubate before hatching. This season's eggs were incubated at the hatchery well's water temperature of 44 - 48 degrees Fahrenheit until they developed eyes, which typically occurs 10 to 15 days before the eggs hatch.

Once eyed, the eggs are transported to recipient streams where they are placed in remote site incubators (RSI's).

From the Sun Ranch's 21,933 viable eggs, 5,000 were placed in RSI's in Grayling Creek in YNP, and 5,100 more were raised as fry for Goose Lakes, also in YNP. Dave Moser, FWP, used over 11,000 for a genetic swamping project on Elkhorn Creek in the Big Belt Mountains. And, an additional 800 were raised as fry for release into the Sun Ranch brood pond for future spawning efforts.

Dave Moser, FWP, also placed 3,651 Lone Willow eggs into Camus Lake, Big Belt Mountains. Four hundred Lone Willow eggs were withheld and raised to fry stage for release into the Sun Ranch brood pond.

Jim Olsen, FWP, released 2,782 York Pond eggs into York Gulch, Big Hole drainage. Two hundred York Pond eggs were also withheld as a contribution to the Sun Ranch brood.

Drake & Associates personnel, with the assistance of YNP biologists, stocked slightly over 5,000 fry into Goose Lake on August 31, 2015. That same day approximately 1,400 fry were stocked into the Sun Ranch brood pond.

The hatchery was cleaned, disinfected, and the water turned off for the season on September 2, 2015.

2015 Sun Ranch WCT Recovery Summary

	Total Eggs	Eyed	Ave. Percent
Sun Rn. Pond 29 Lots, 29F 58M	24,649	21,933	89
Lone Willow Crk., FWP 8 Lots, 8F 16M	4,306	4,051	94
York Pond, FWP 6 Lots, 6F 12M	4,825	2,982	62
Geode Crk., YNP 25 Lots, 25F 50M	5,526	4,977	89
American Crk., FWP	1,500	0	0

Drake & Associates 2015 Expenditures:

Income:

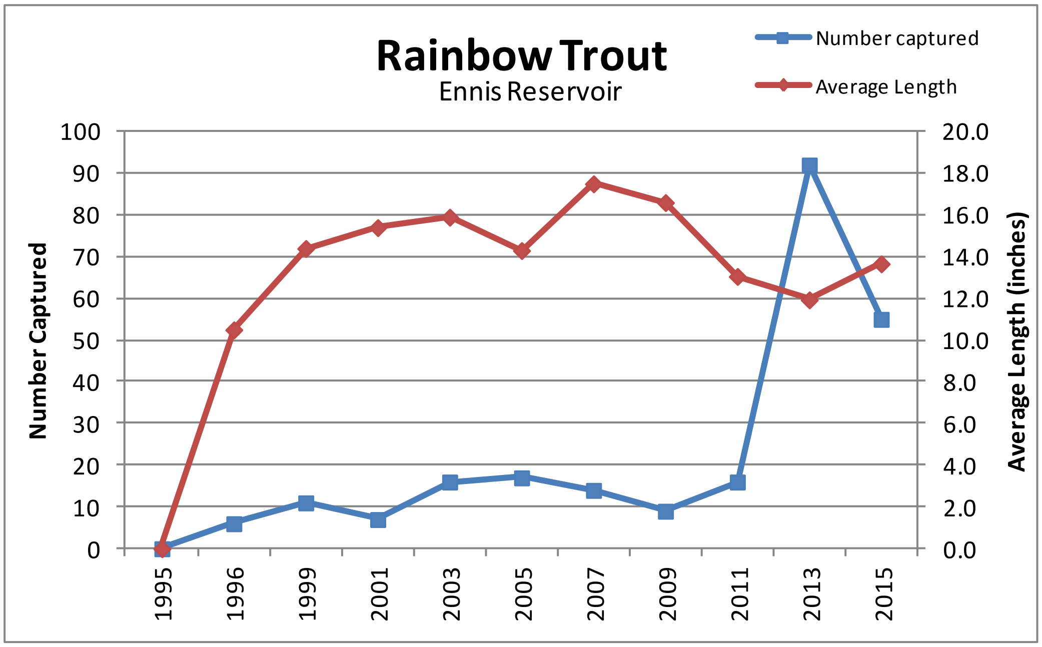
Madison River Foundation		$ 5,000.00
PPL		$ 10,000.00
Fish, Wildlife & Parks		$ 10,000.00
Yellowstone National Park		$ 10,000.00
	Total	$ 35,000.00

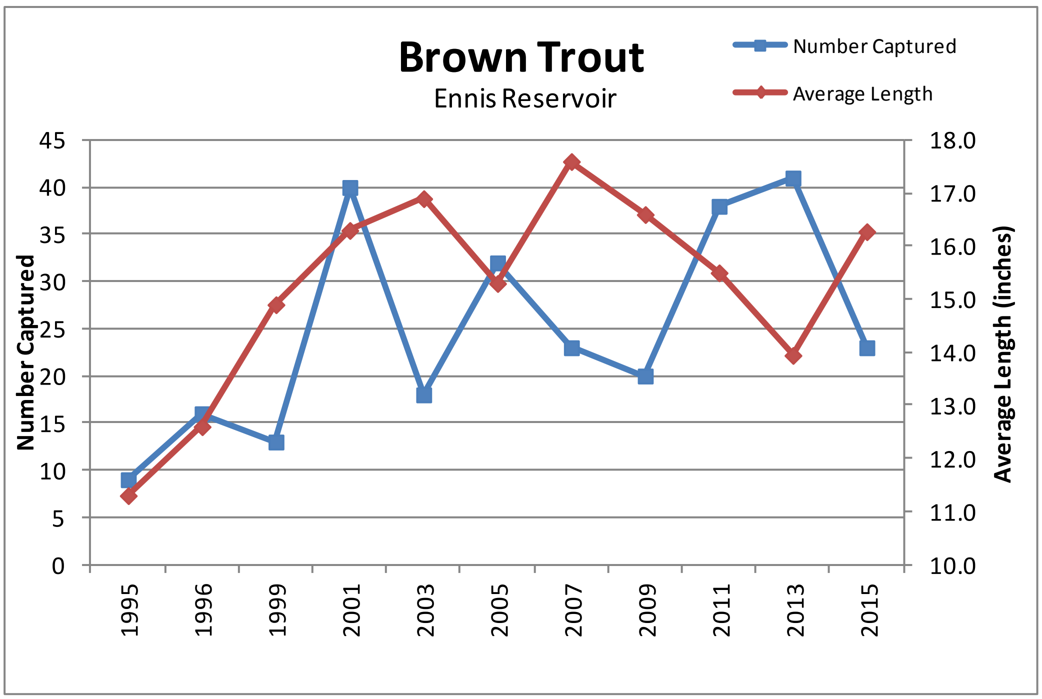
Expenses:

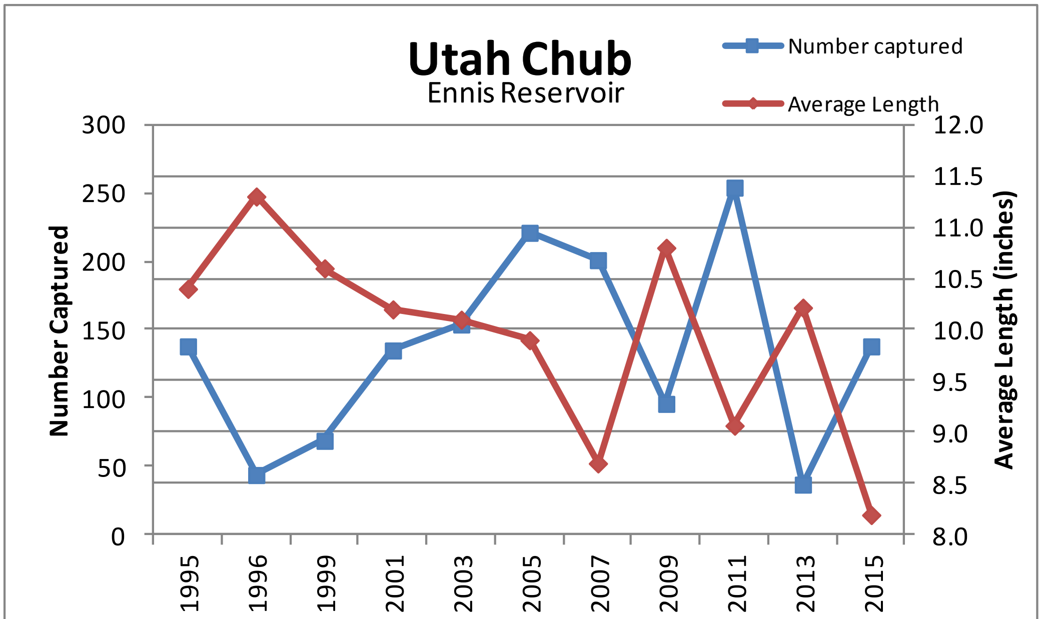
Personnel		$ 29,386.25
Mileage		$ 5,940.50
Misc. supplies		$ 99.65
Electrician		$ 639.00
	Total	$ 36,065.40

Appendix D

Ennis Reservoir Gillnet Trend
1995 – 2015






Utah Chub
Ennis Reservoir
Number captured
Average Length
Number Captured
Average Length (inches)
300
250
200
150
100
50
0
12.0
11.5
11.0
10.5
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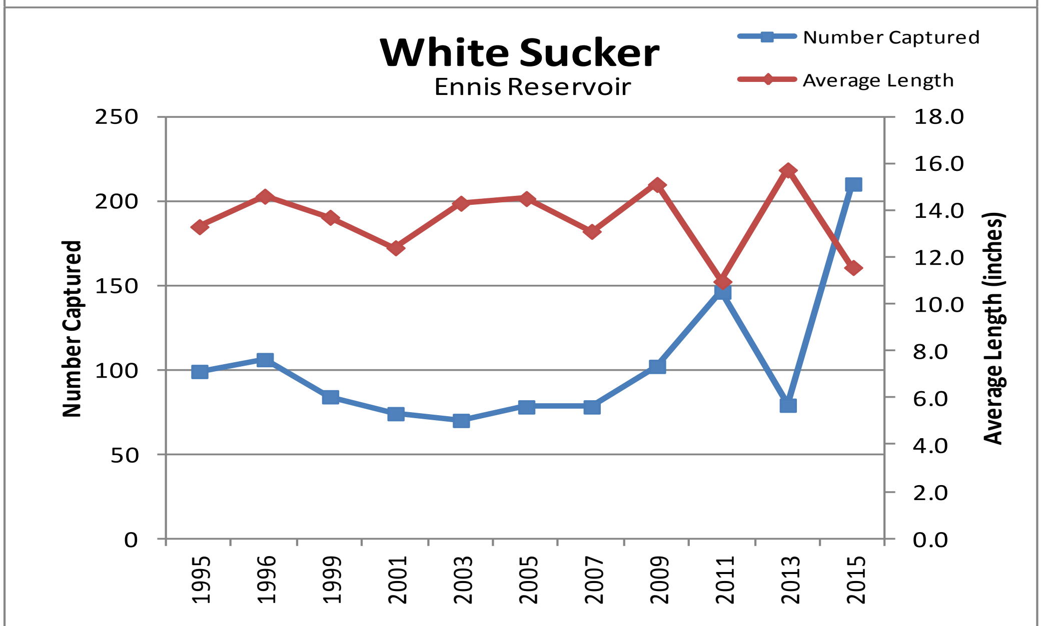
2007
2009
2011
2013
2015


White Sucker
Ennis Reservoir
Number Captured
Average Length
Number Captured
Average Length (inches)
250
200
150
100
50
0
18.0
16.0
14.0
12.0
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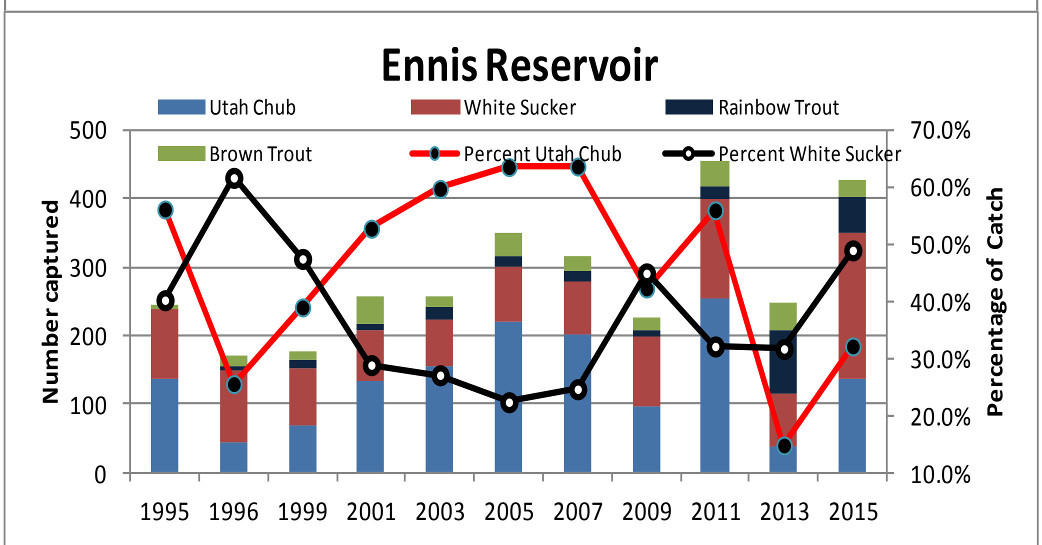
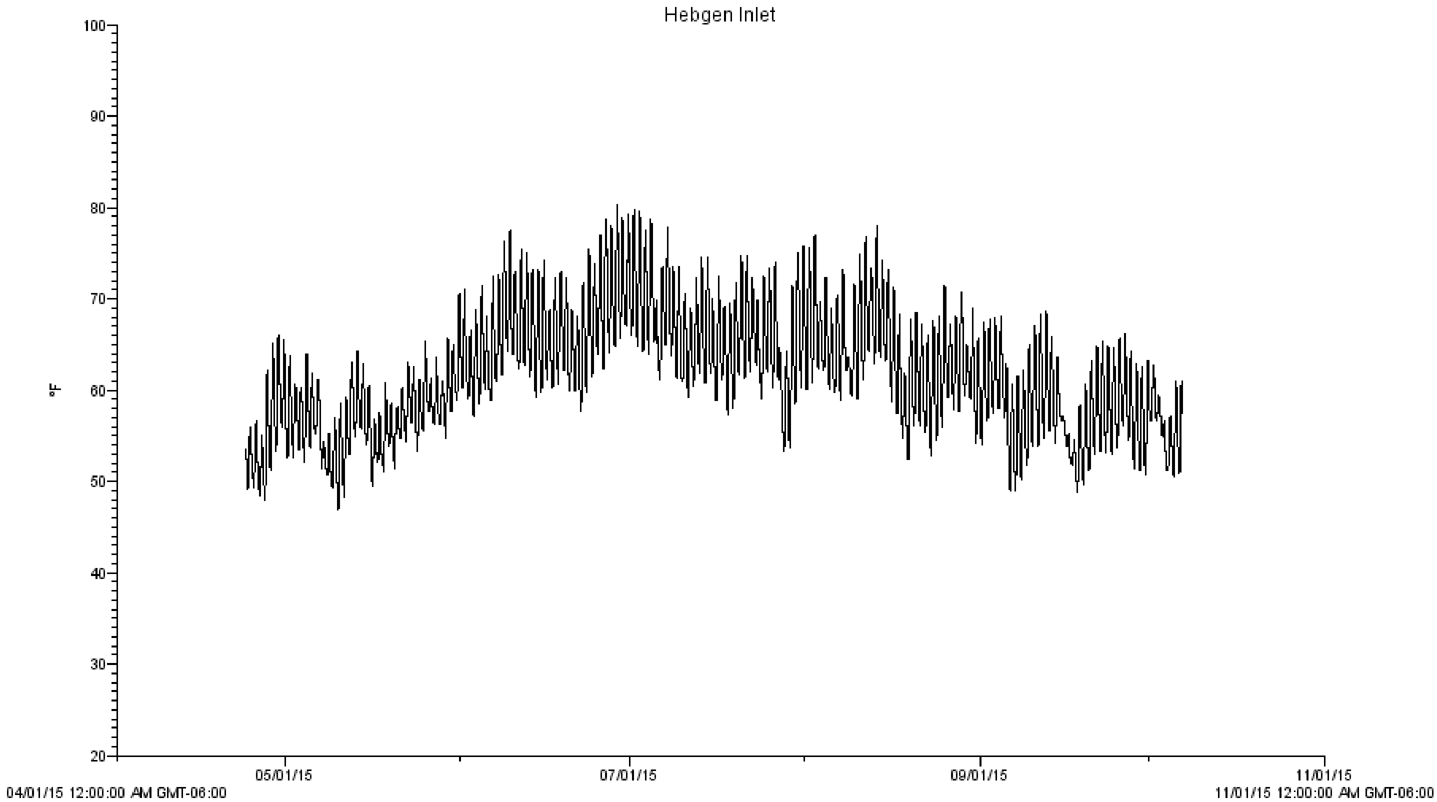
2007
2009
2011
2013
2015


Ennis Reservoir
Utah Chub
White Sucker
Rainbow Trout
Brown Trout
Percent Utah Chub
Percent White Sucker
Number captured
Percentage of Catch
500
400
300
200
100
0
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
1995
1996
1999
2001
2003
2005
2007
2009
2011
2013
2015

Appendix E1

Temperature recordings from Madison River monitoring sites
2015
See Figure 9 for locations


Hebgen Inlet
°F
100
90
80
70
60
50
40
30
20
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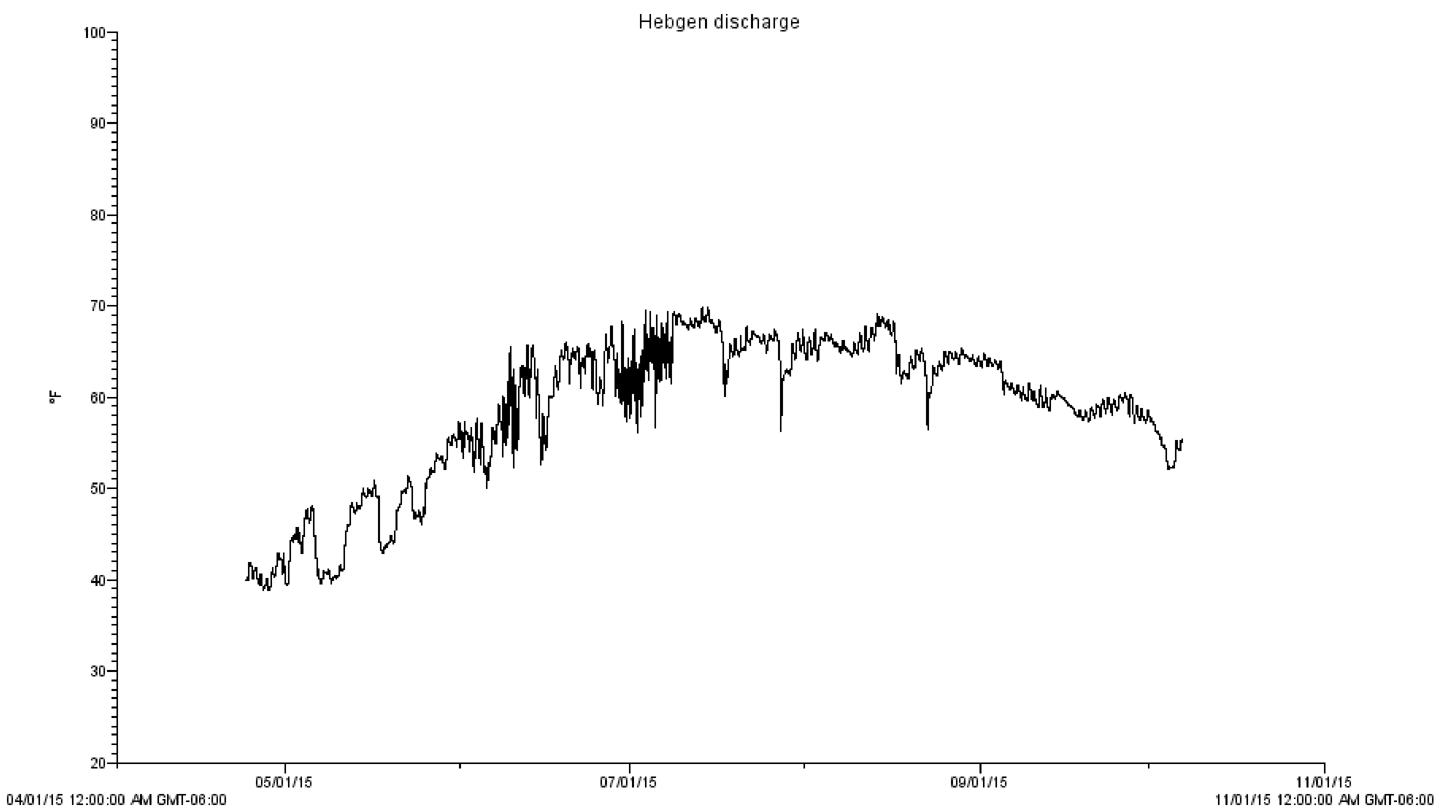
Hebgen discharge
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80
70
60
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40
30
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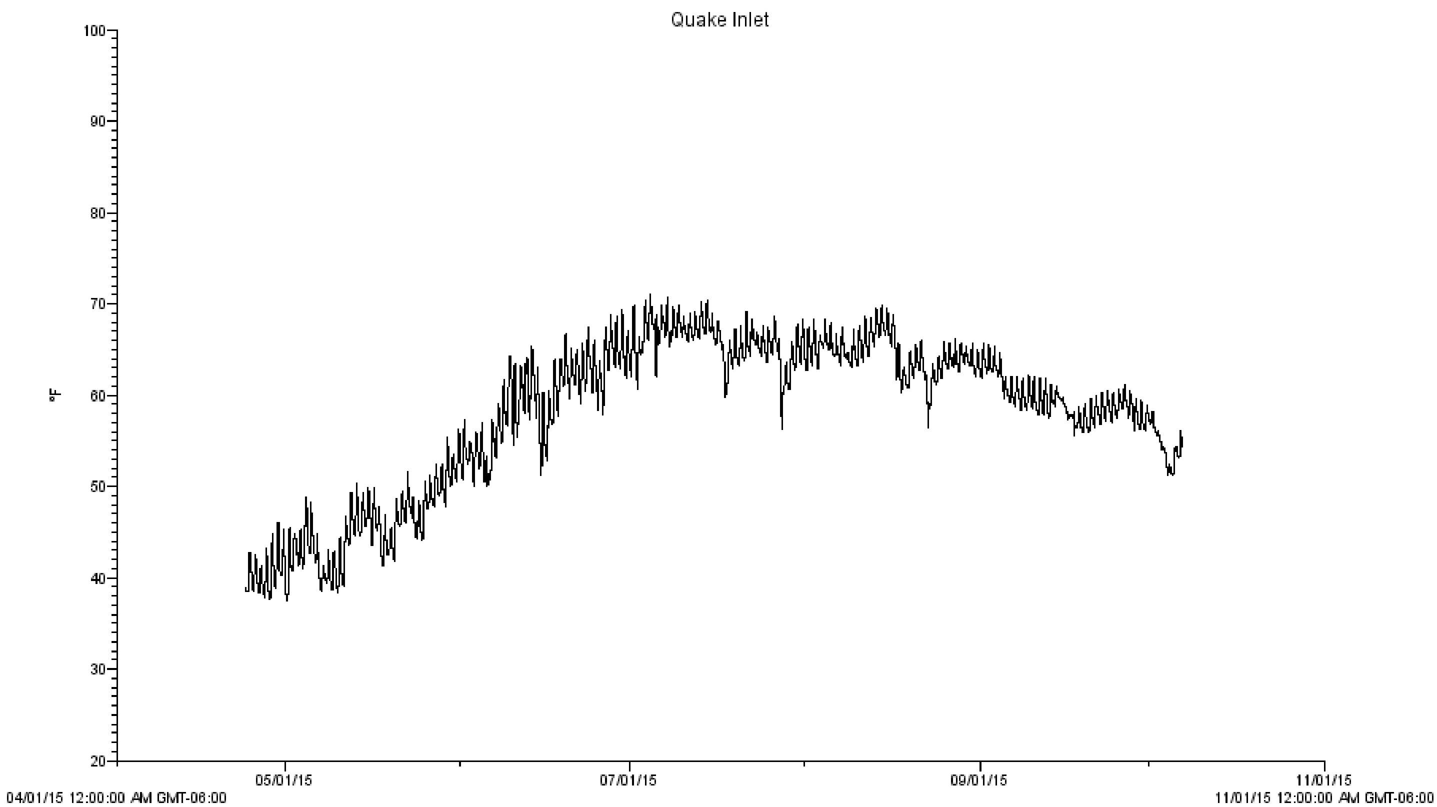
Quake Inlet
100
90
80
70
60
50
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30
20
°F
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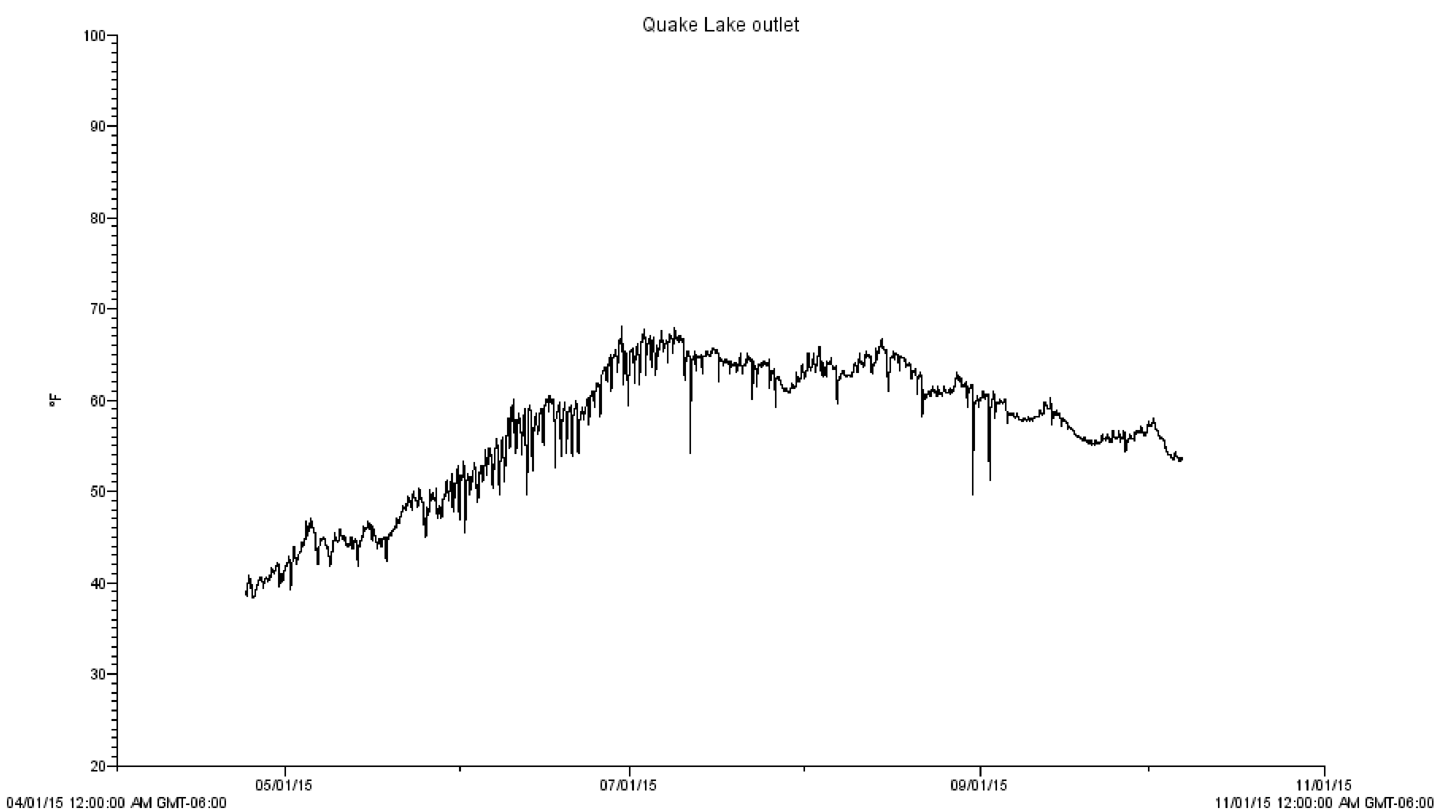
Quake Lake outlet
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°F
04/01/15 12:00:00 AM GMT-06:00
05/01/15
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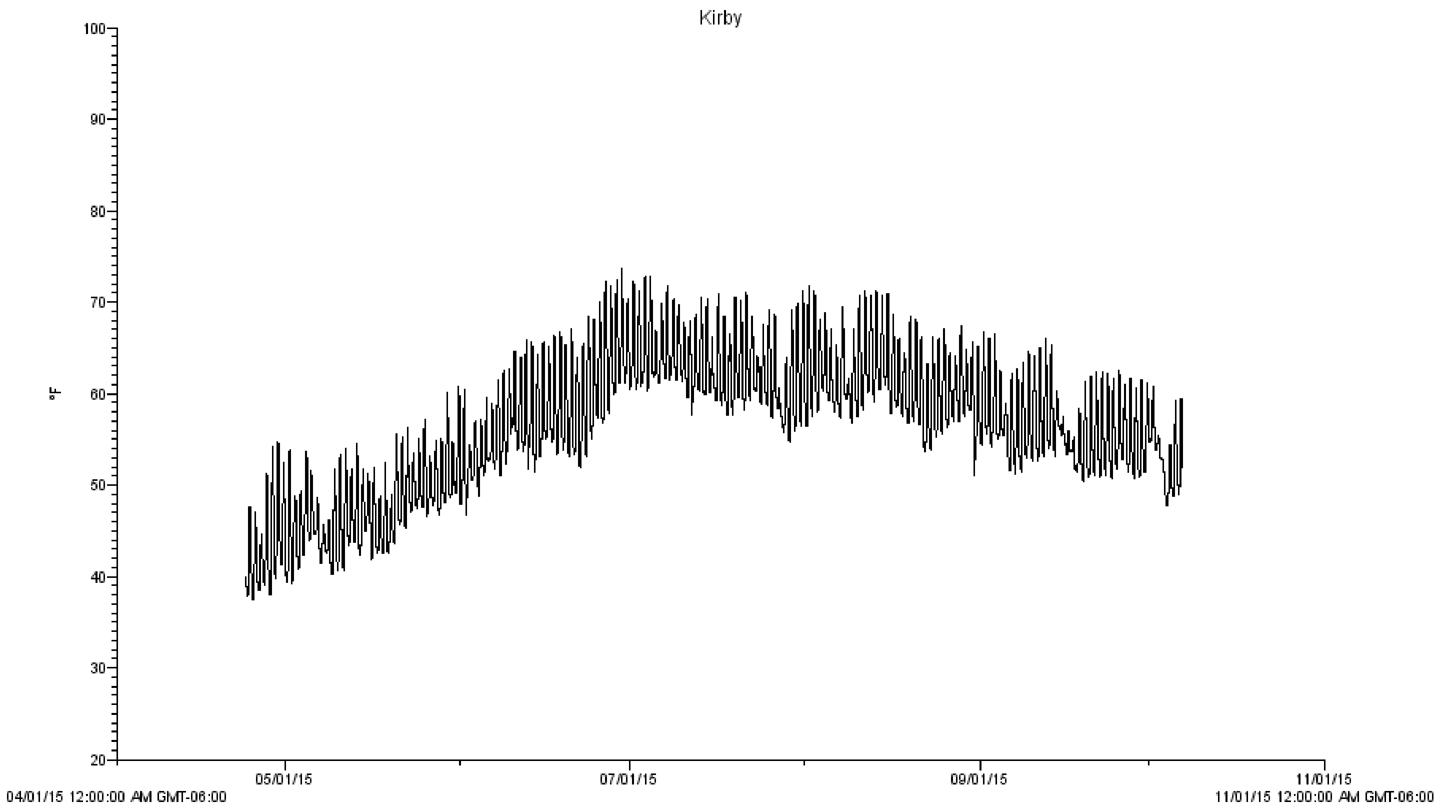
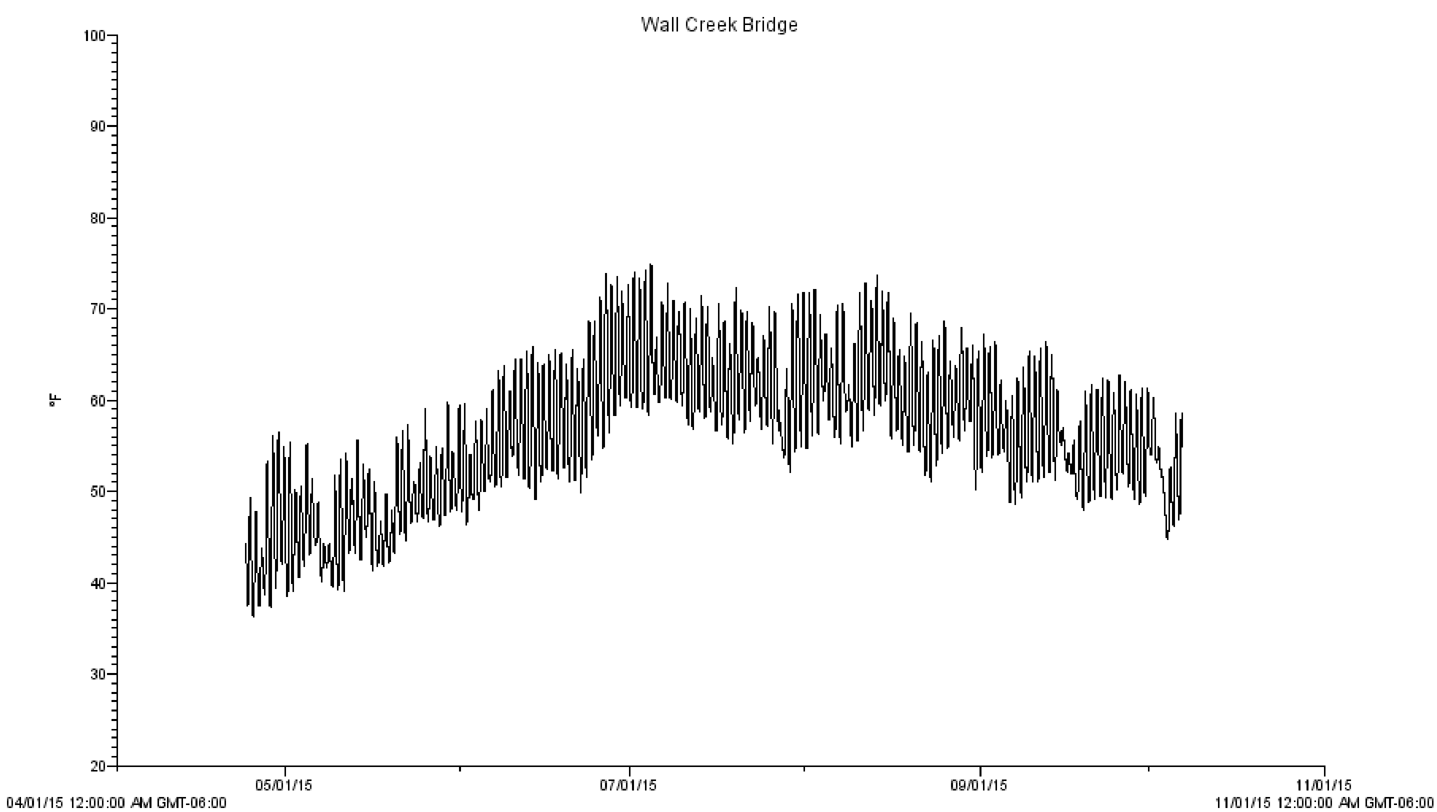

Kirby
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00


Wall Creek Bridge
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
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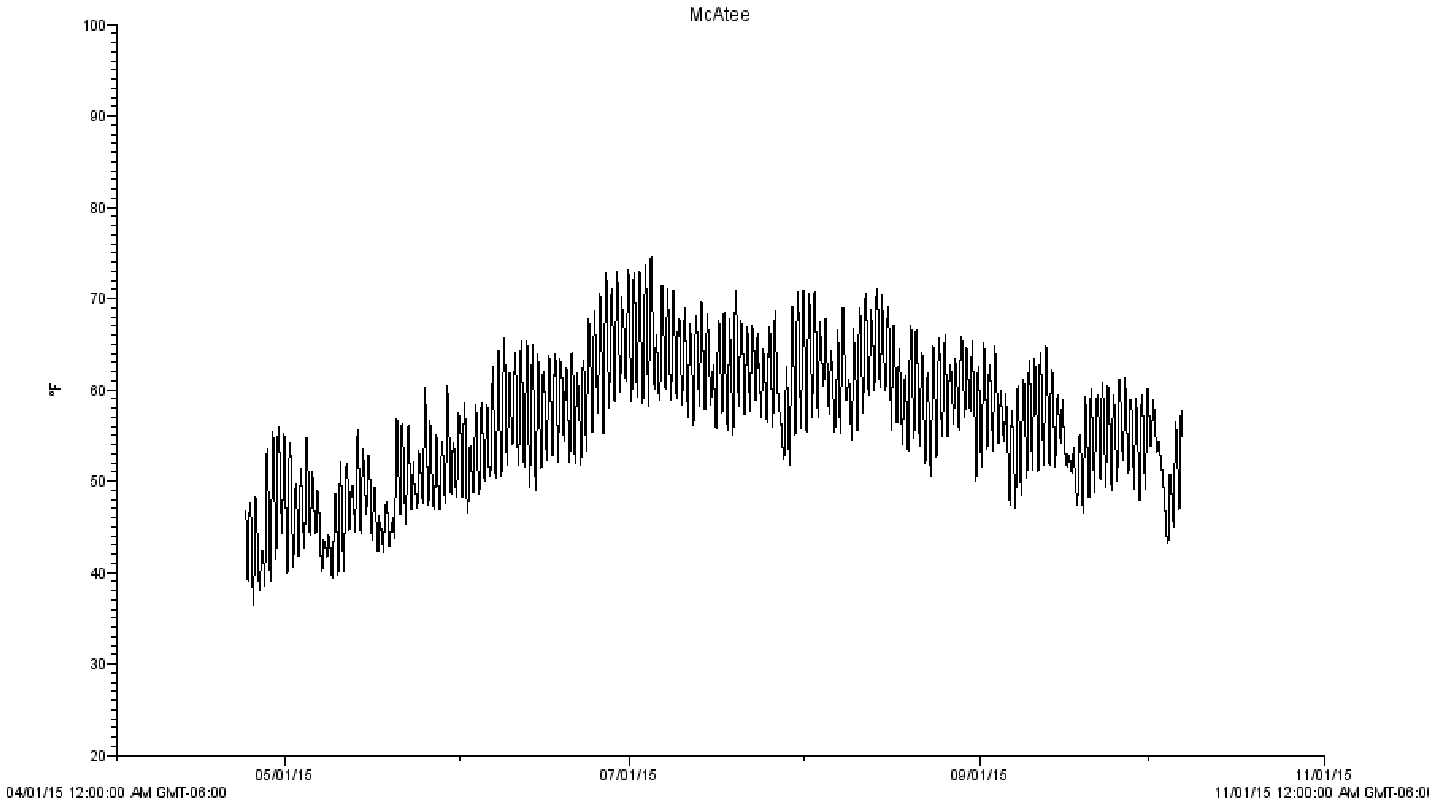
McAtee
100
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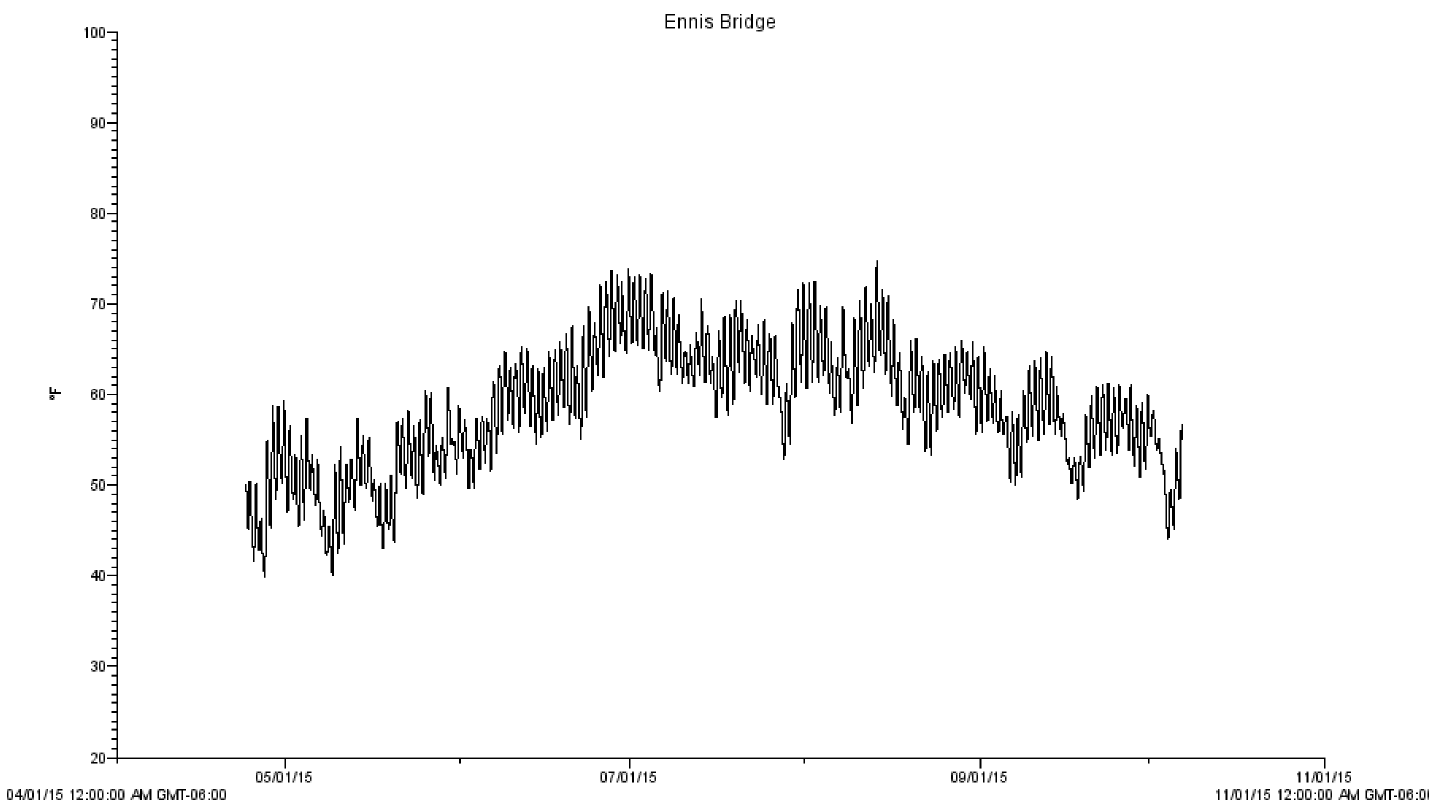
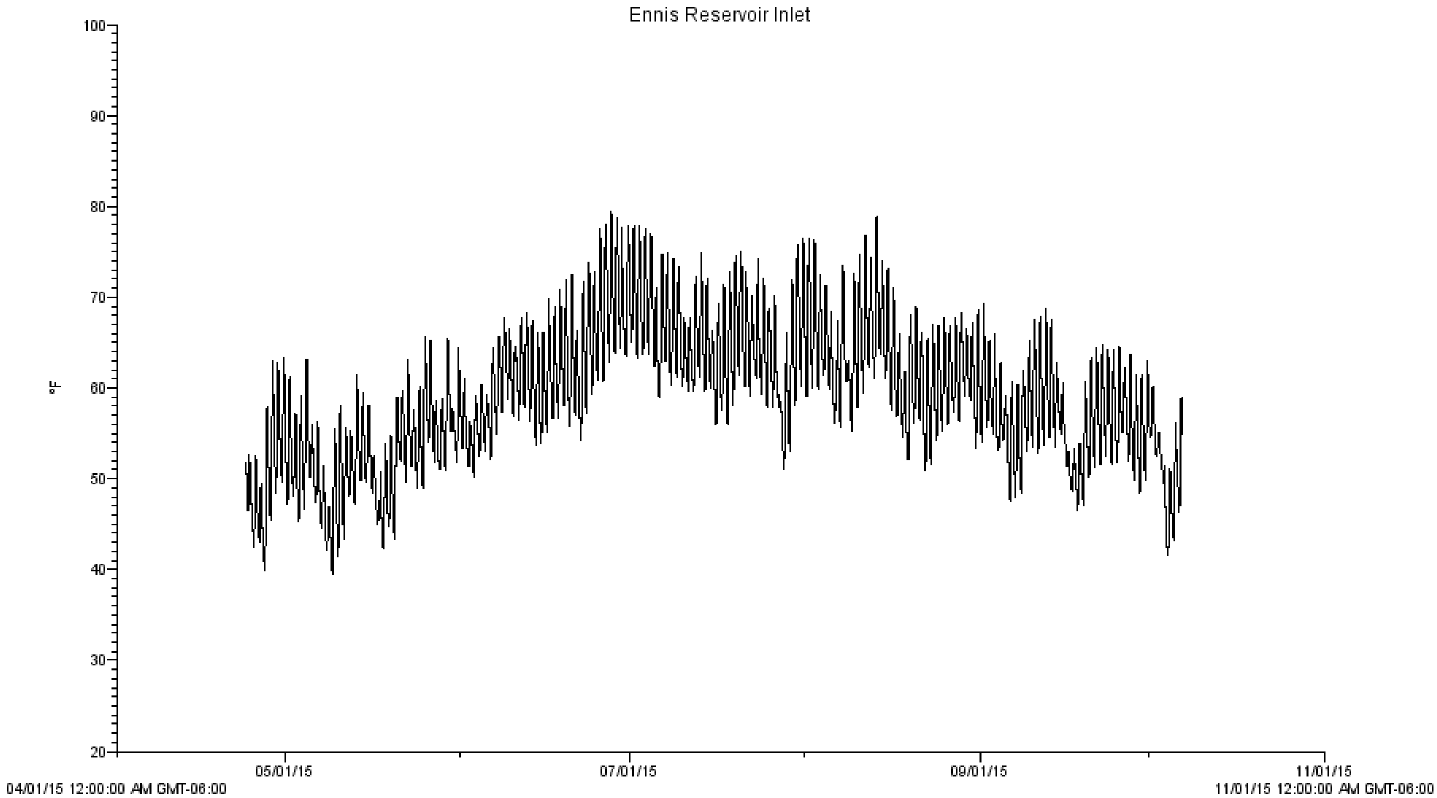
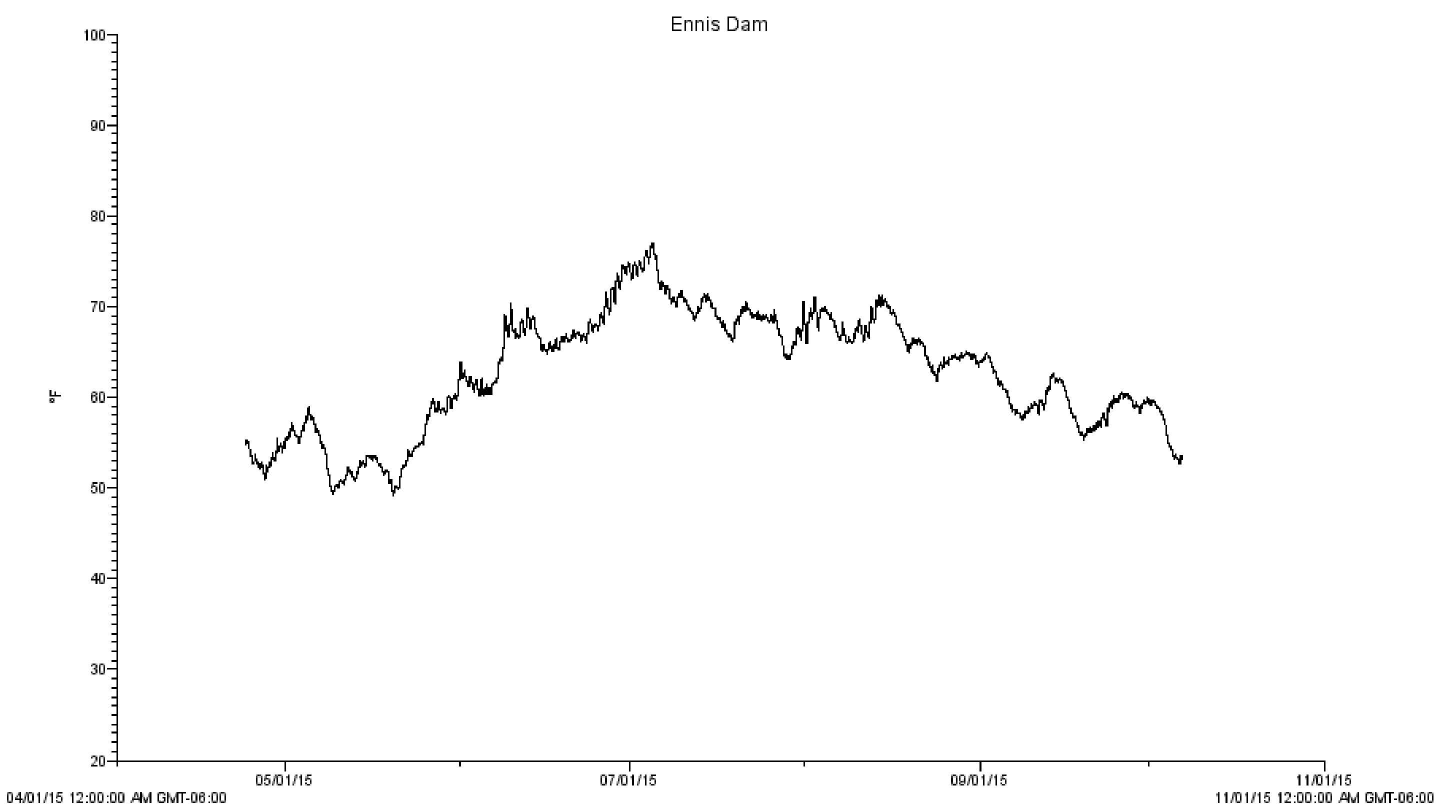
°F
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00

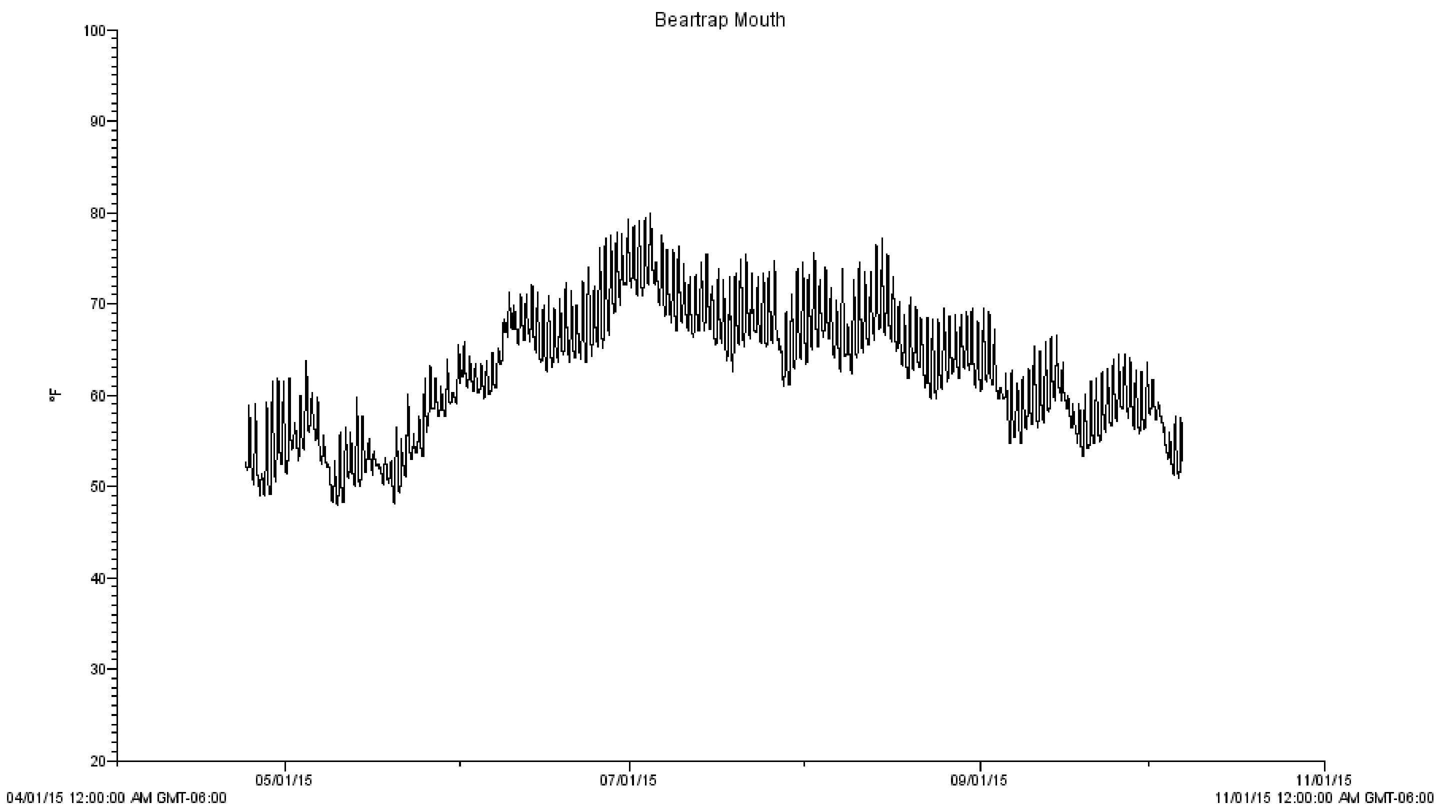

Ennis Bridge
100
90
80
70
60
50
40
30
20
°F
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00

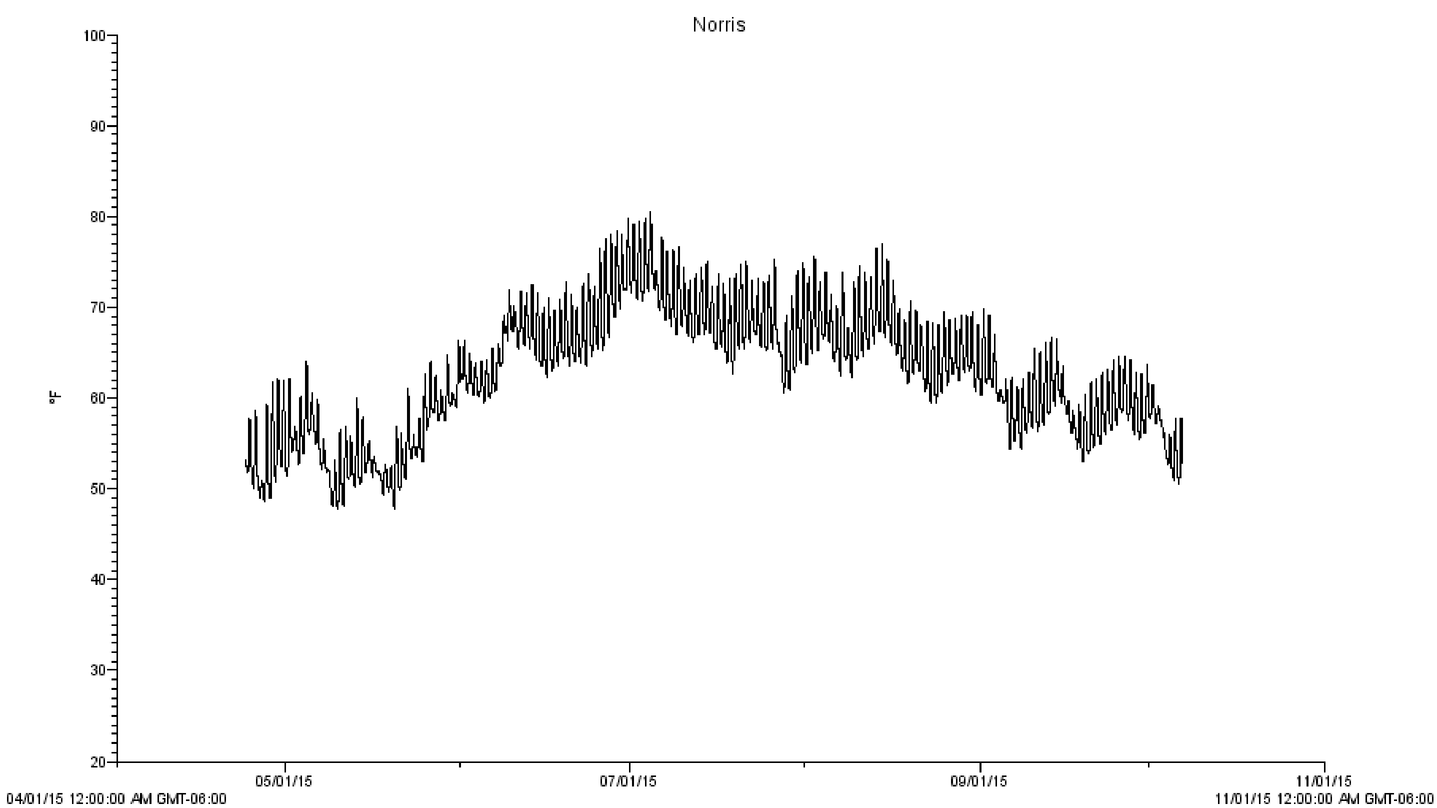
Ennis Reservoir Inlet



Ennis Dam




Beartrap Mouth
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00


Norris
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
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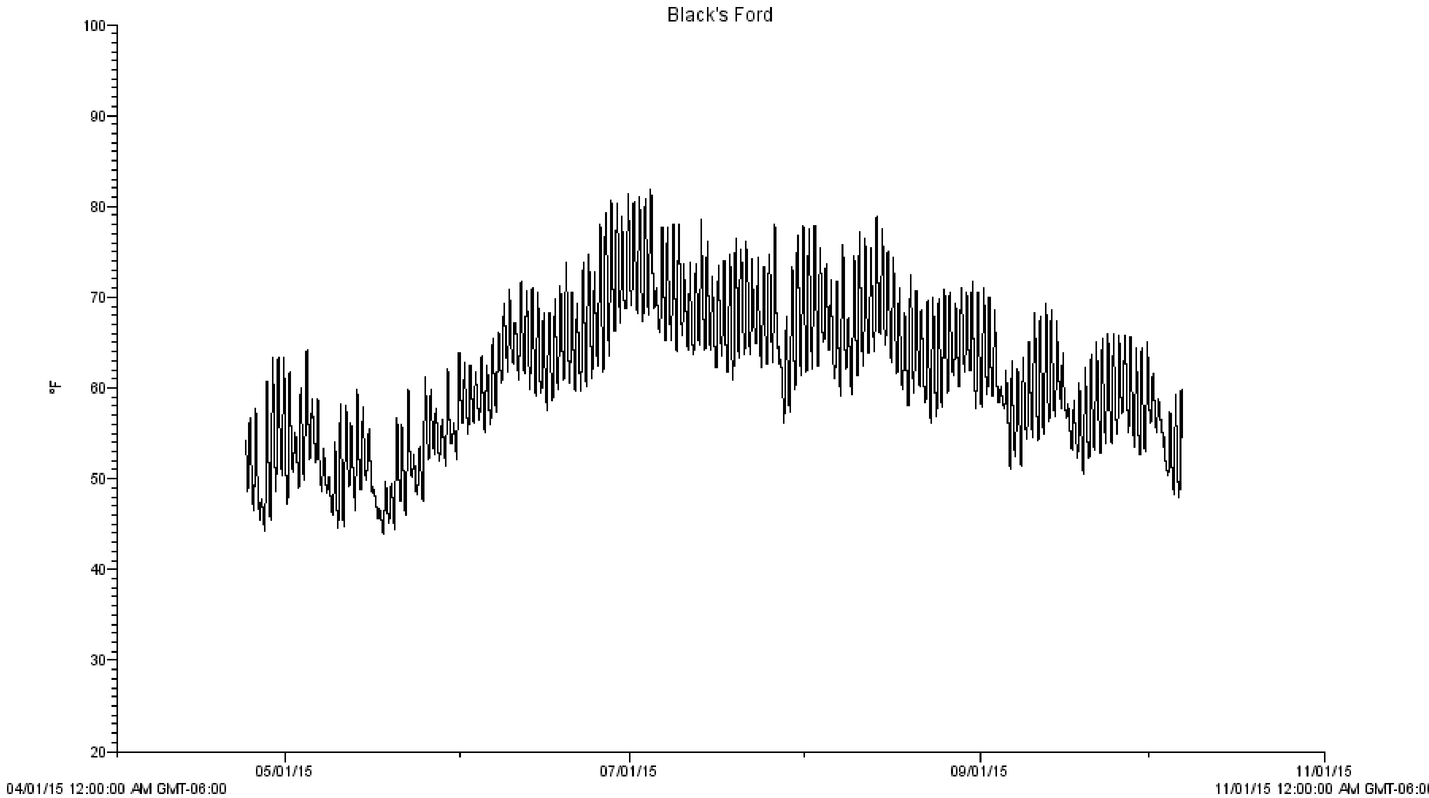
Black's Ford
100
90
80
70
60
50
40
30
20
°F
05/01/15
07/01/15
09/01/15
11/01/15
04/01/15 12:00:00 AM GMT-06:00
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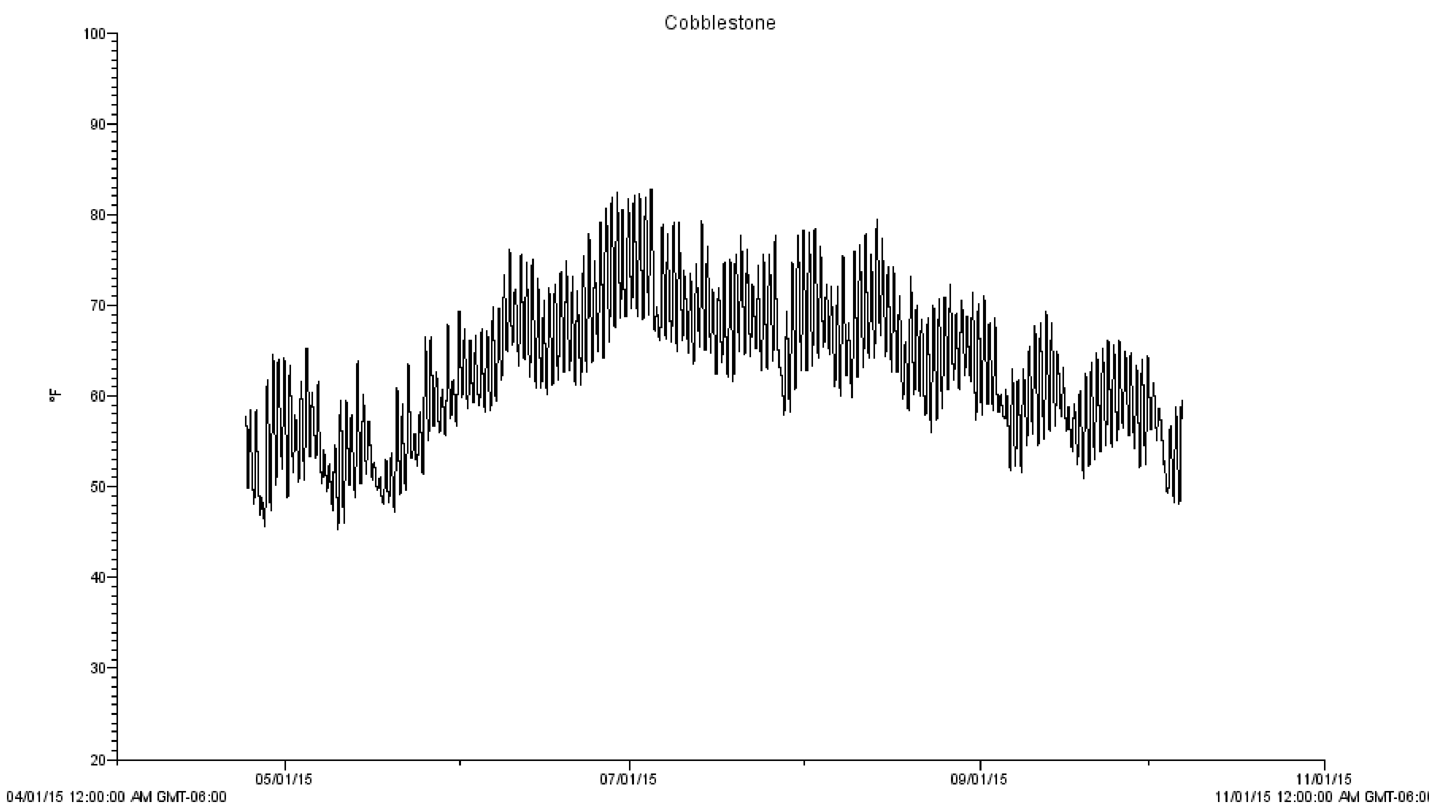
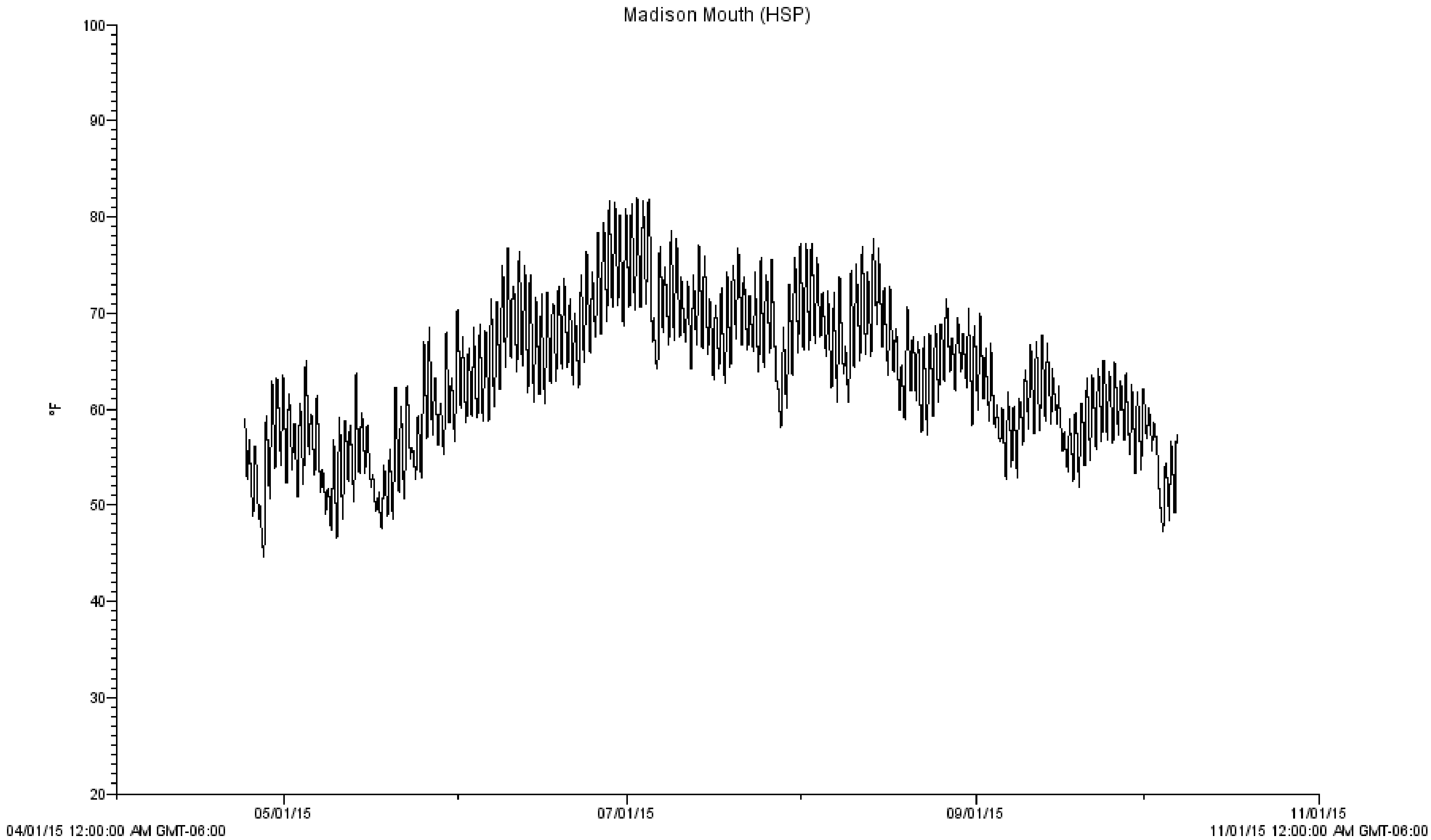
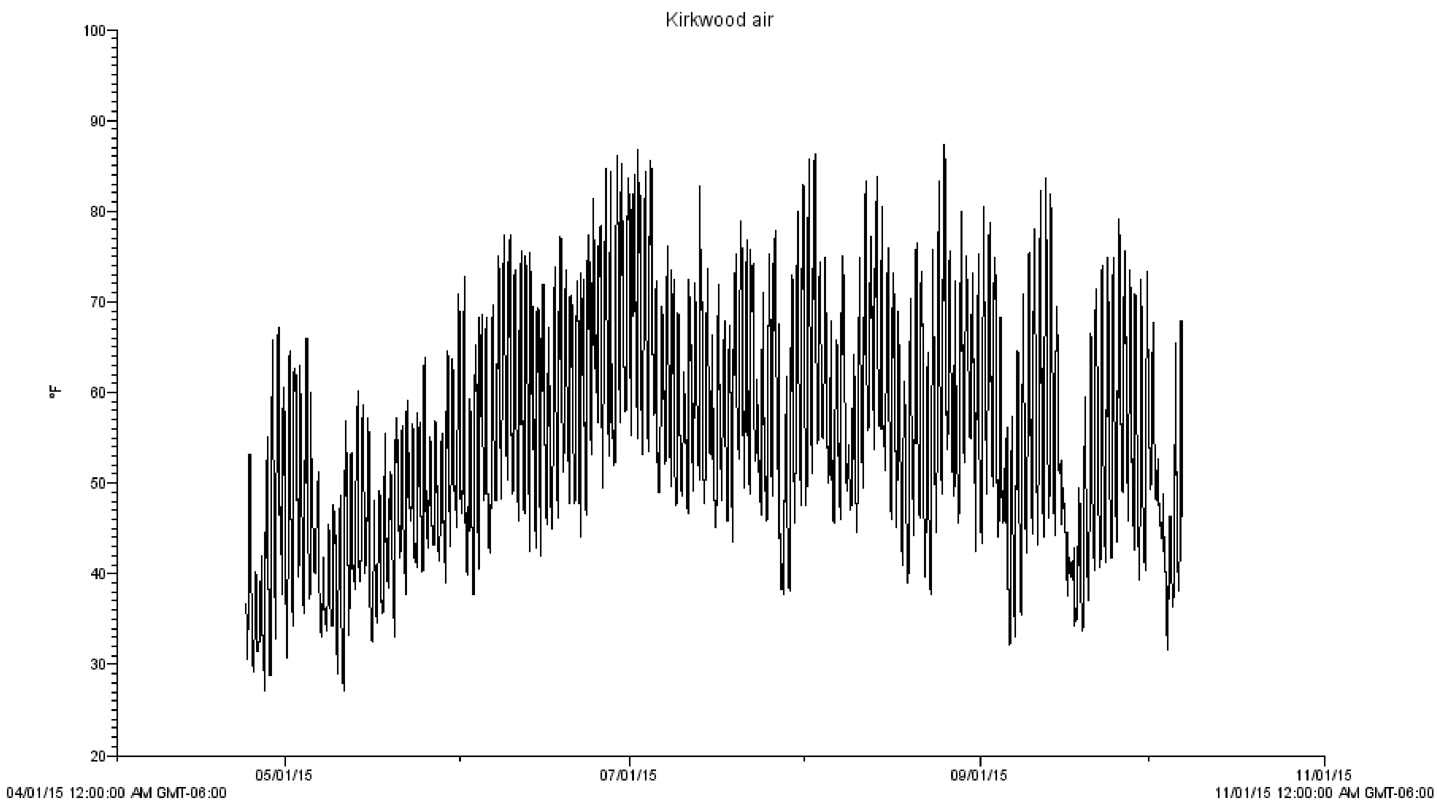
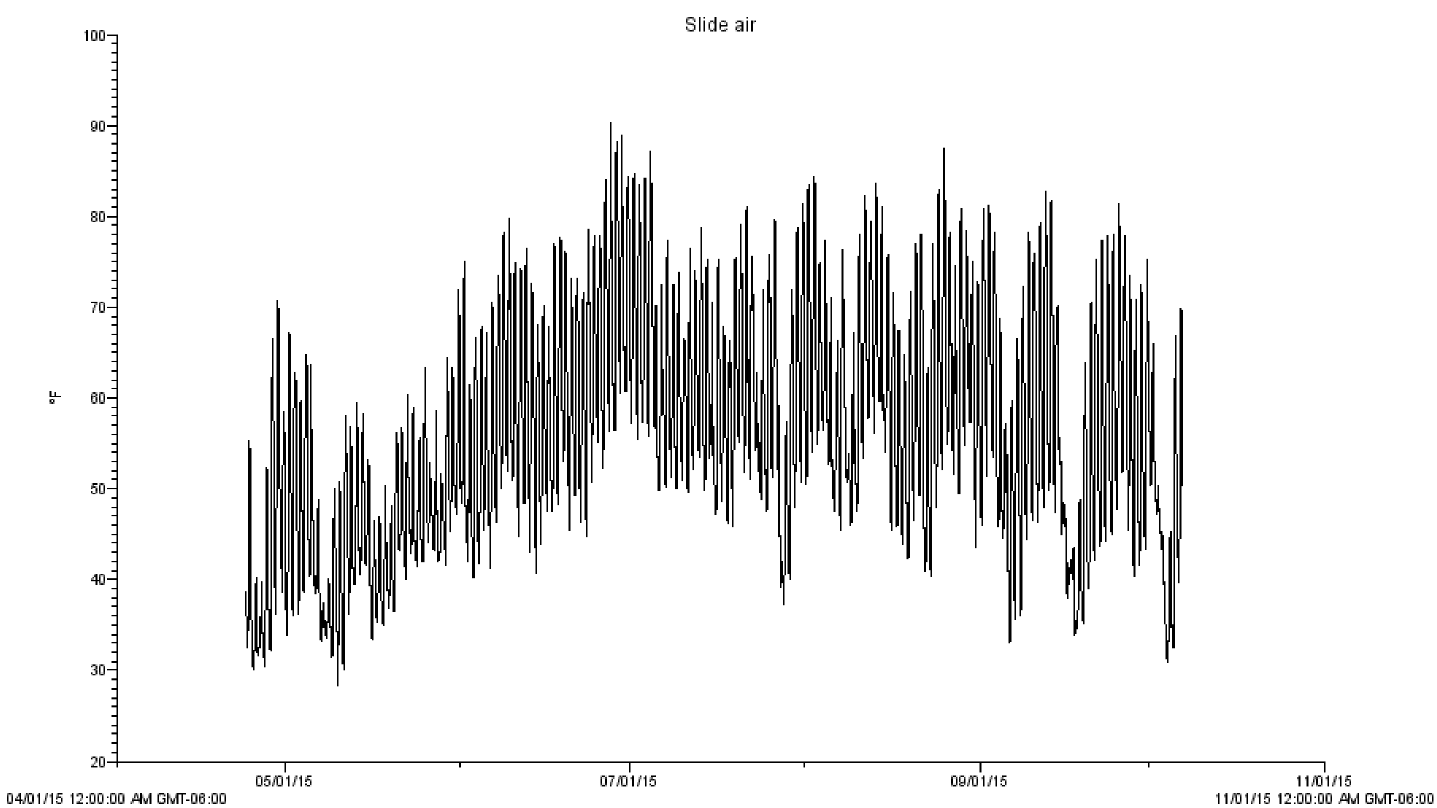
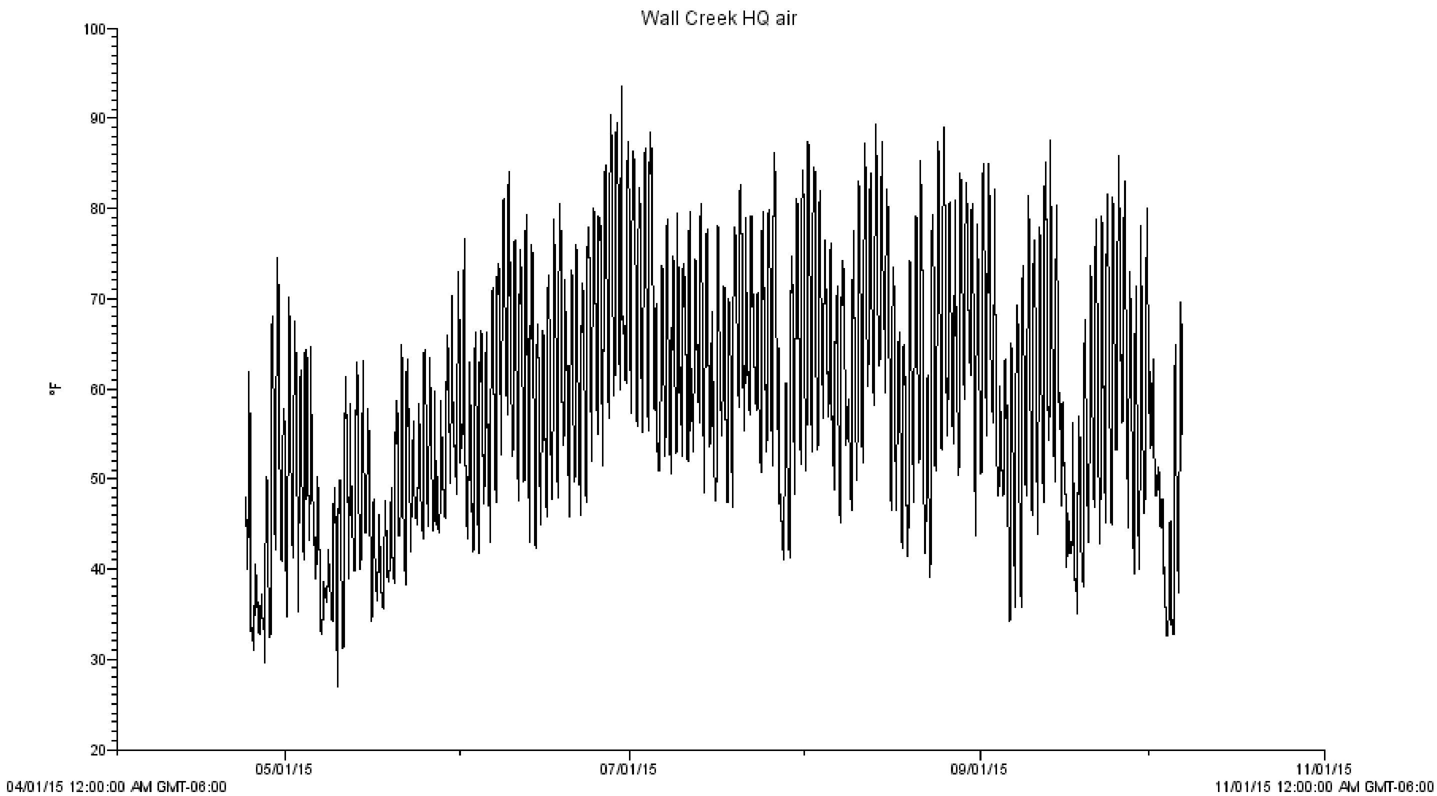

Cobblestone
100
90
80
70
60
50
40
30
20
°F
05/01/15
07/01/15
09/01/15
11/01/15
04/01/15 12:00:00 AM GMT-06:00
11/01/15 12:00:00 AM GMT-06:00

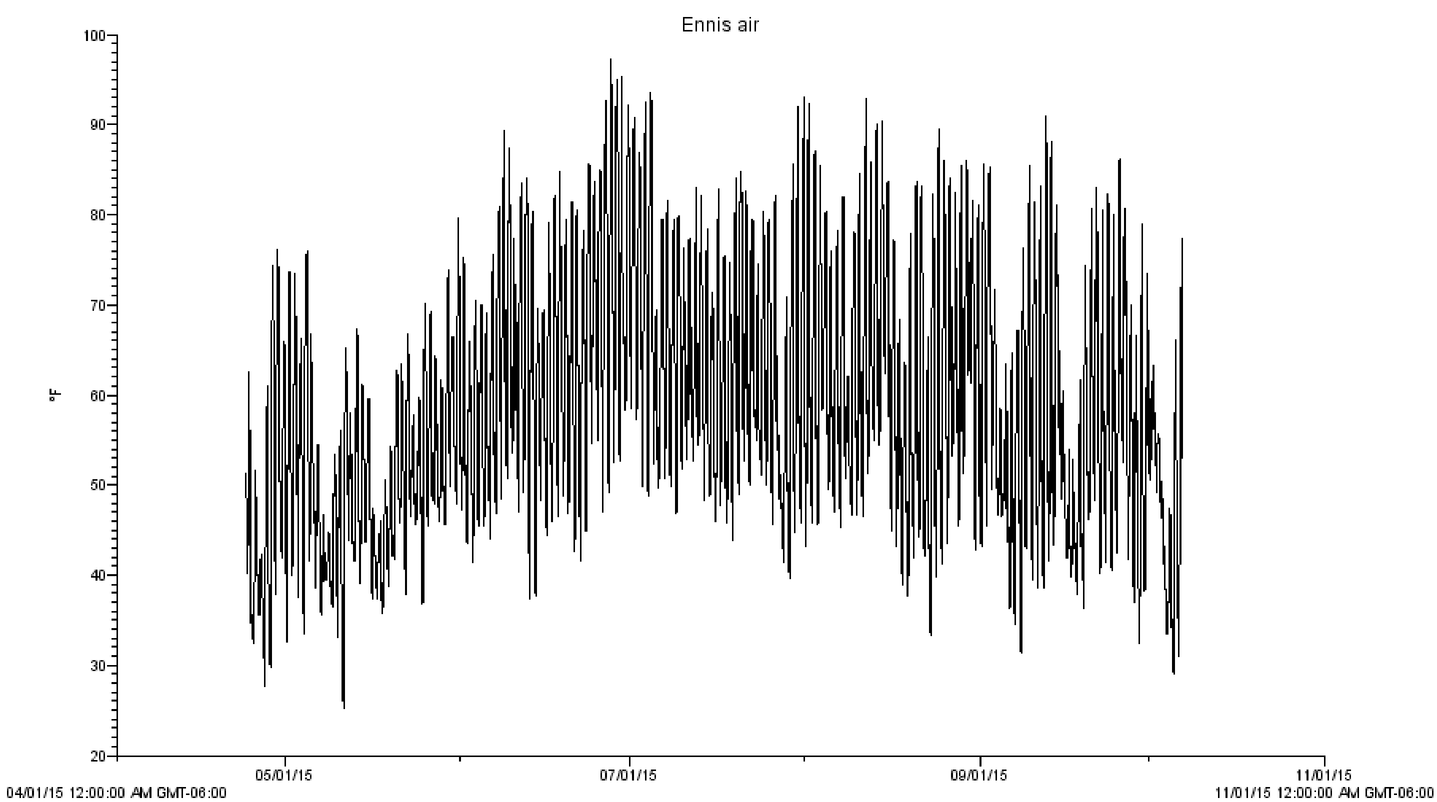


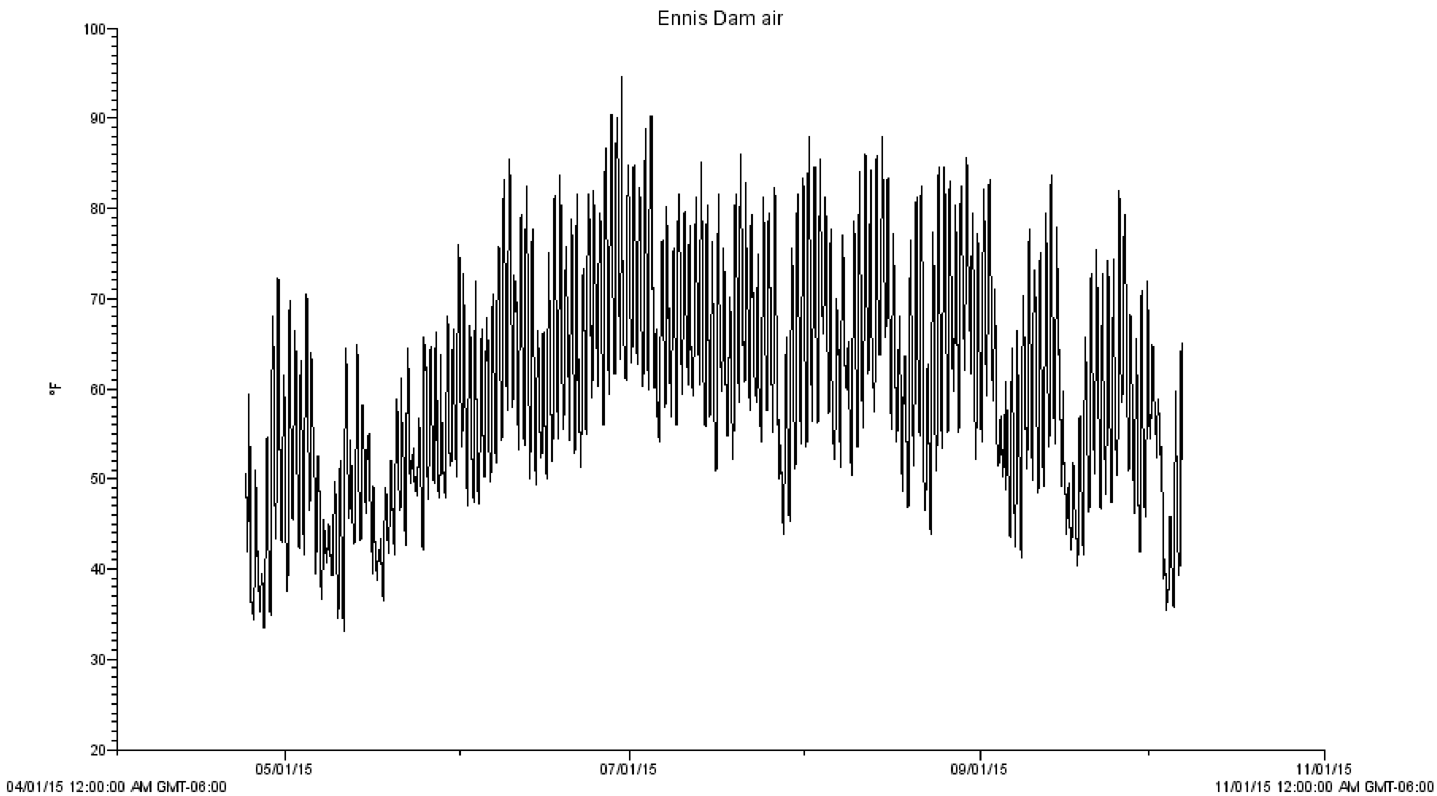
Madison Mouth (HSP)
100
90
80
70
60
50
40
30
20
°F
05/01/15
07/01/15
09/01/15
11/01/15
04/01/15 12:00:00 AM GMT-06:00
11/01/15 12:00:00 AM GMT-06:00


Kirkwood air
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00

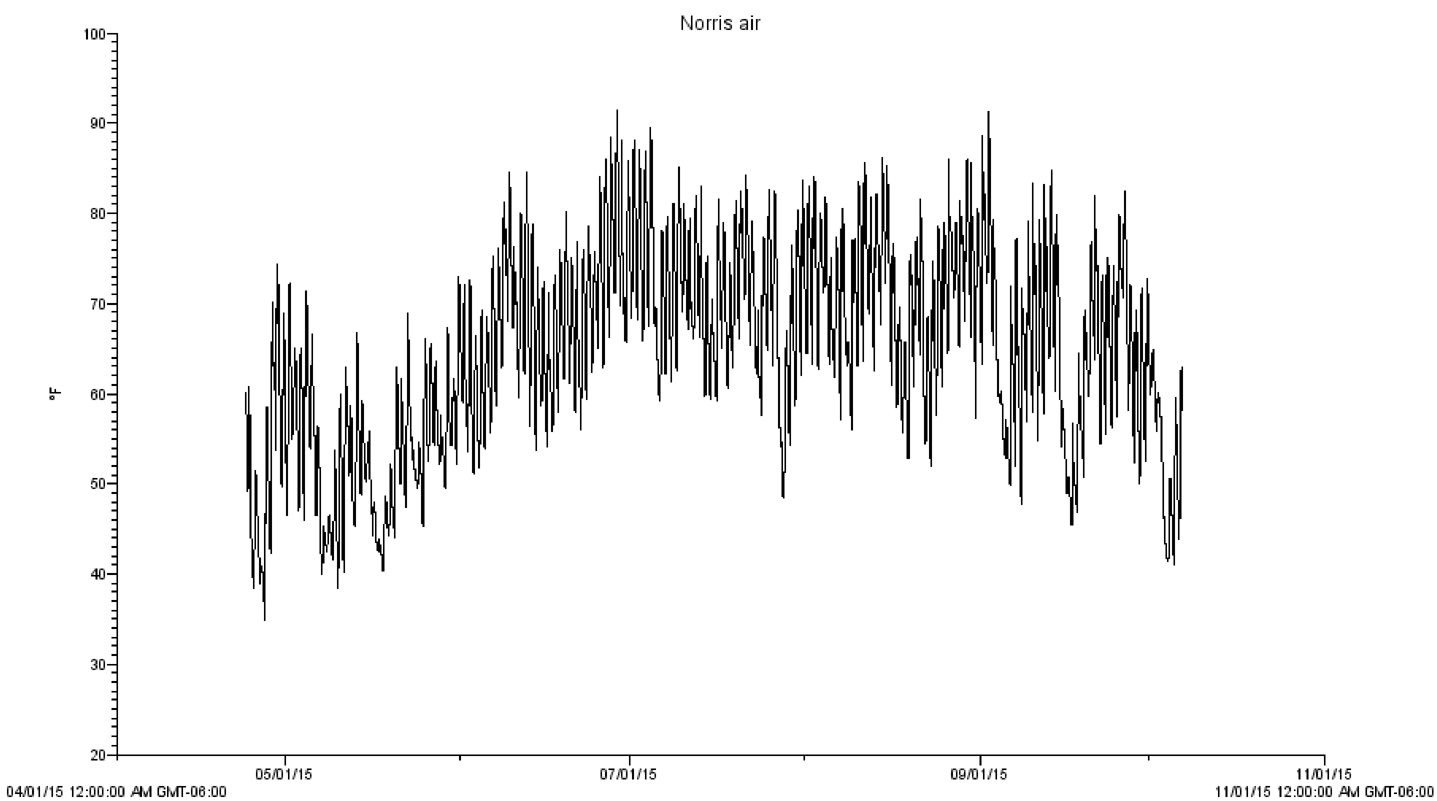

Slide air
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00


Wall Creek HQ air
100
90
80
70
60
50
40
30
20
°F
05/01/15
07/01/15
09/01/15
11/01/15
04/01/15 12:00:00 AM GMT-06:00
11/01/15 12:00:00 AM GMT-06:00

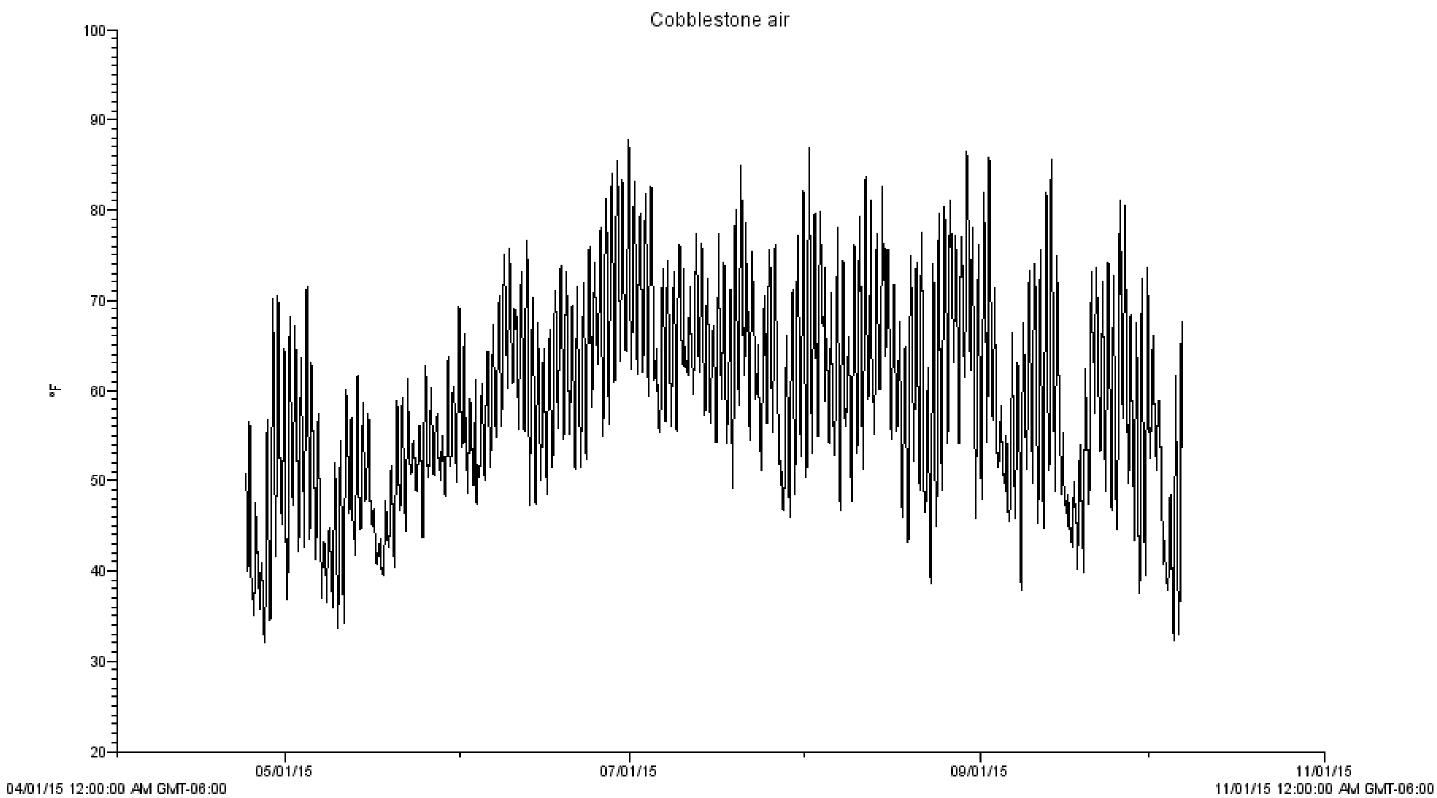

Ennis air
100
90
80
70
60
50
40
30
20
°F
05/01/15
07/01/15
09/01/15
11/01/15
04/01/15 12:00:00 AM GMT-06:00
11/01/15 12:00:00 AM GMT-06:00



Ennis Dam air
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00



Norris air
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00


Cobblestone air
°F
100
90
80
70
60
50
40
30
20
04/01/15 12:00:00 AM GMT-06:00
05/01/15
07/01/15
09/01/15
11/01/15
11/01/15 12:00:00 AM GMT-06:00

Appendix E2

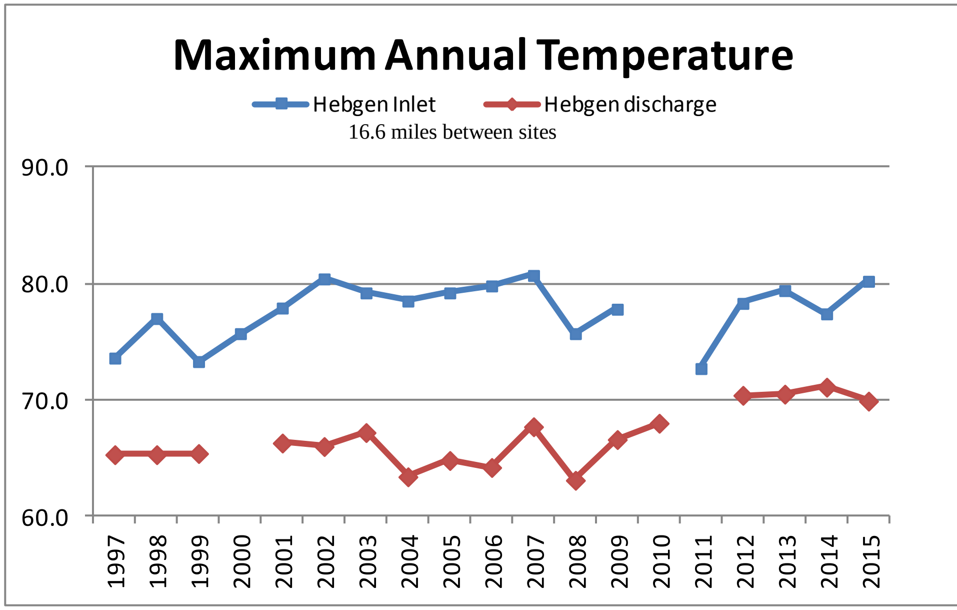
Comparison of maximum annual water temperatures at selected Madison River monitoring sites
1994/1995/1996 - 2015
See Figure 9 for locations

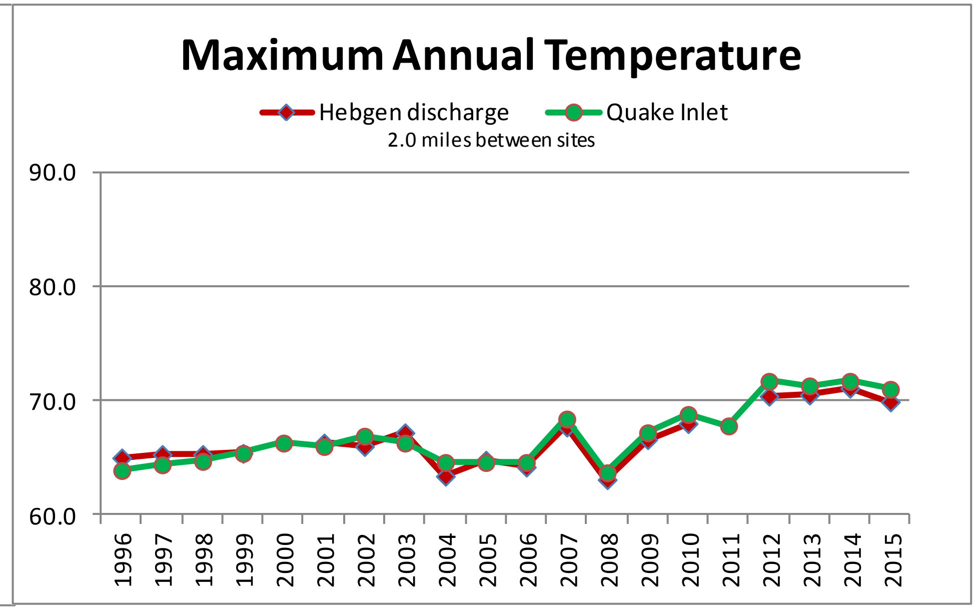
NOTES:

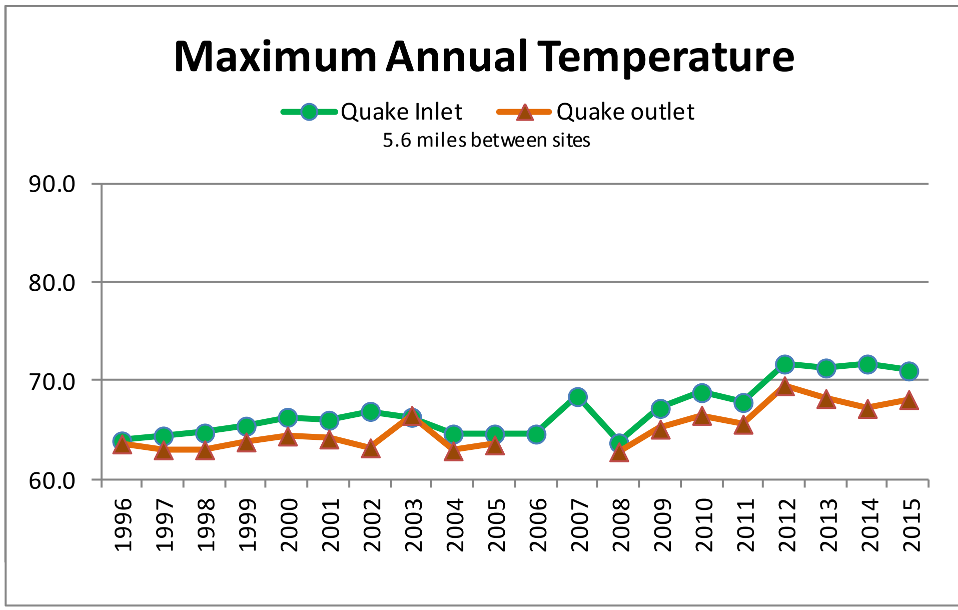
- Recorders at some locations were not recovered some years

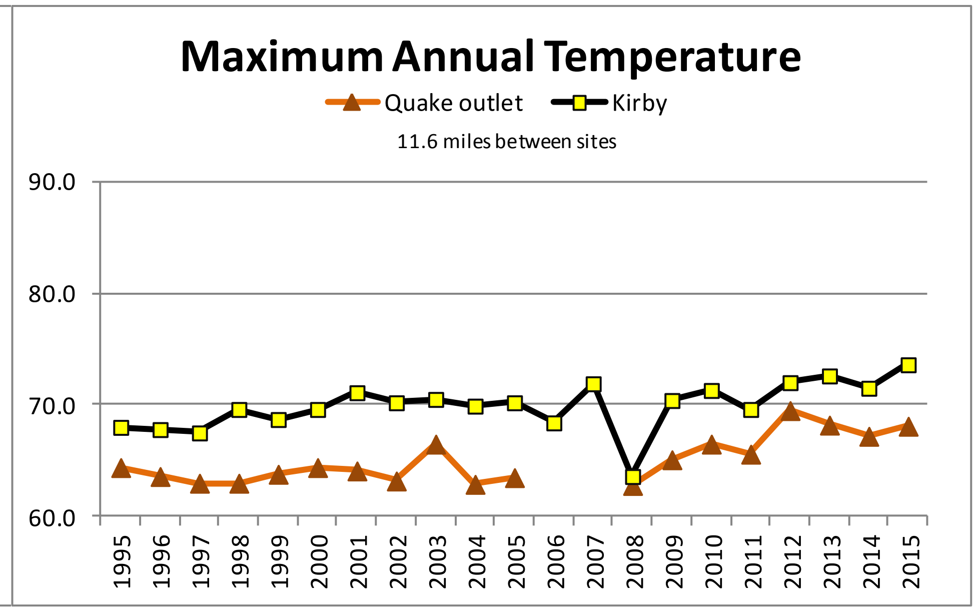
- It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year

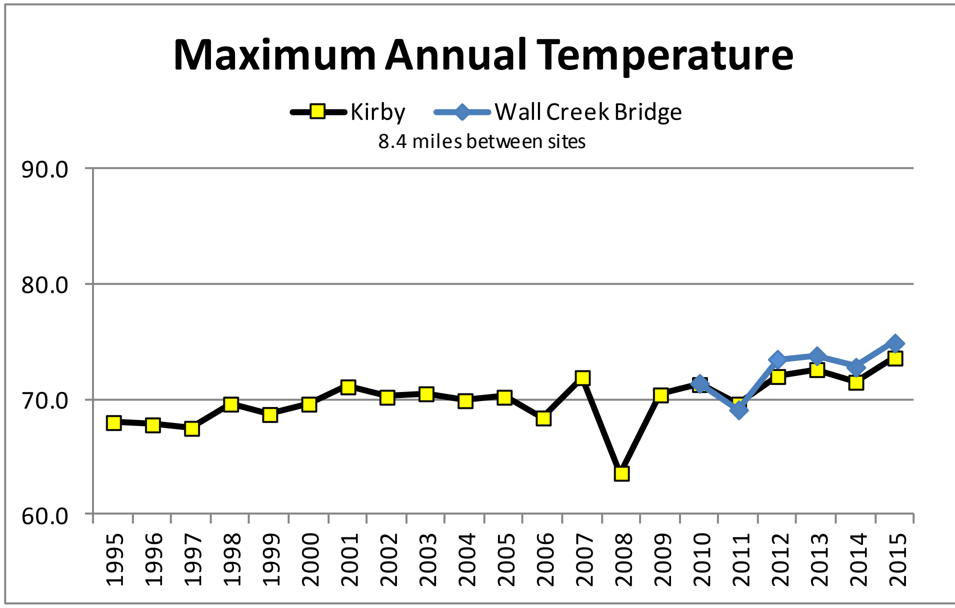
- Pulse flows were conducted out of Ennis Reservoir annually from 2000 – 2007, in 2009, and 2013 - 2015. See report pages 6 and 26

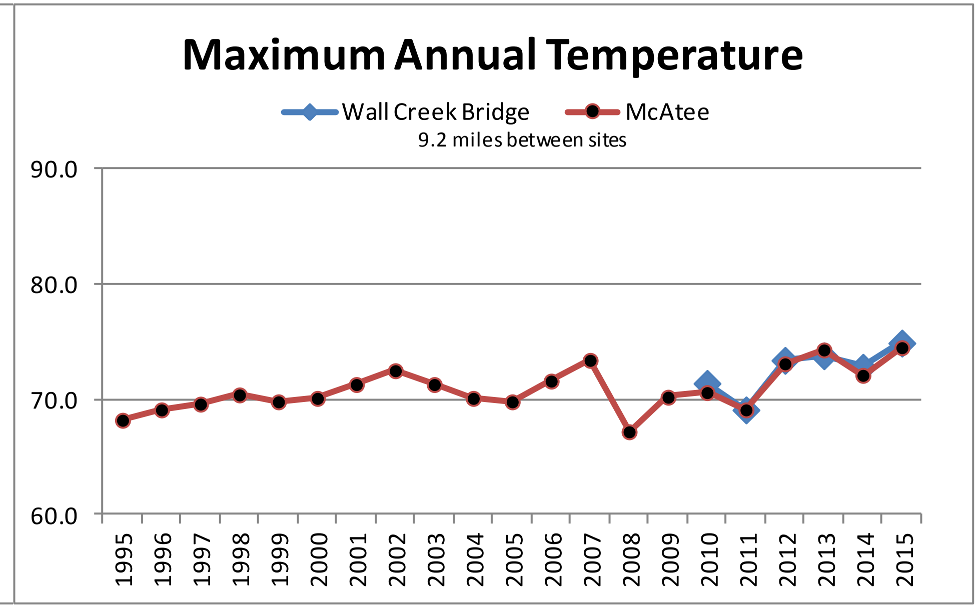

Maximum Annual Temperature
Hebgen Inlet
Hebgen discharge
16.6 miles between sites
90.0
80.0
70.0
60.0
1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

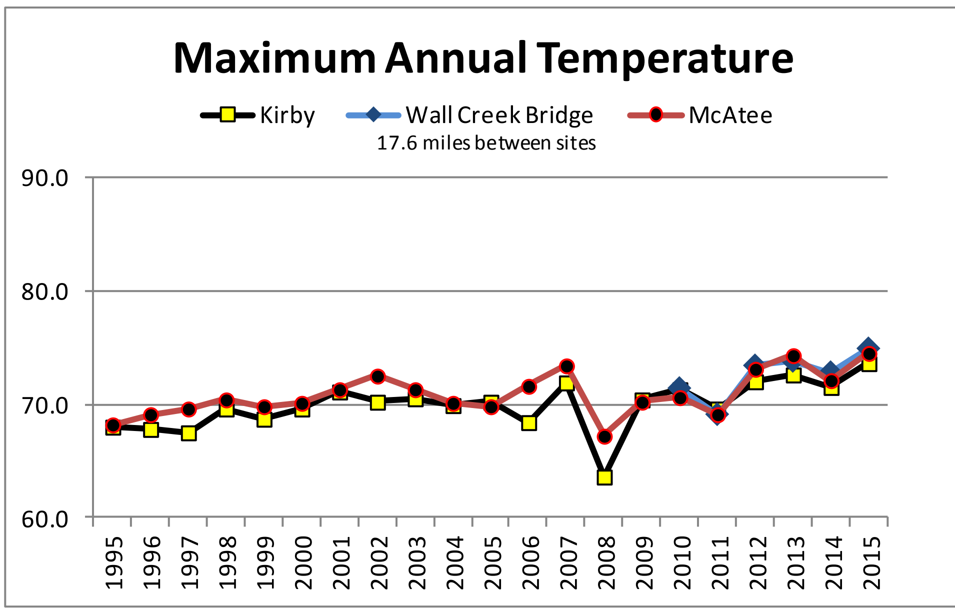

Maximum Annual Temperature
Hebgen discharge
Quake Inlet
2.0 miles between sites
90.0
80.0
70.0
60.0
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

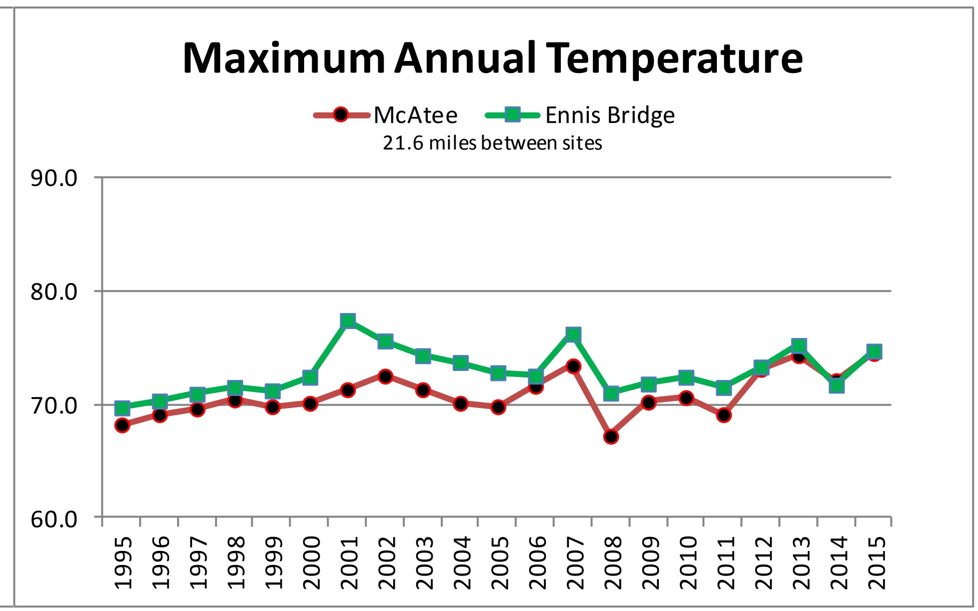

Maximum Annual Temperature
Quake Inlet
Quake outlet
5.6 miles between sites
90.0
80.0
70.0
60.0
1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

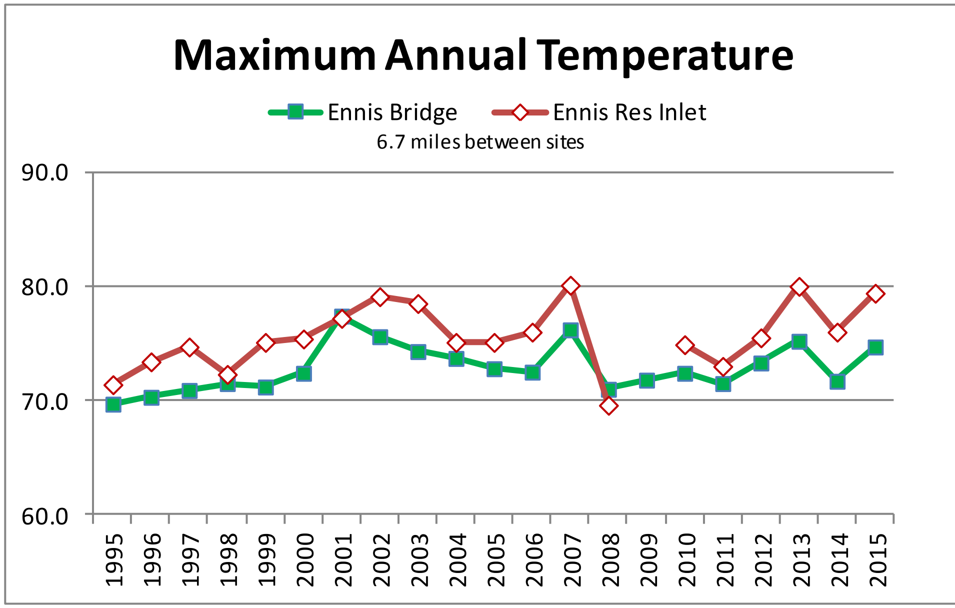

Maximum Annual Temperature
Quake outlet
Kirby
11.6 miles between sites
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

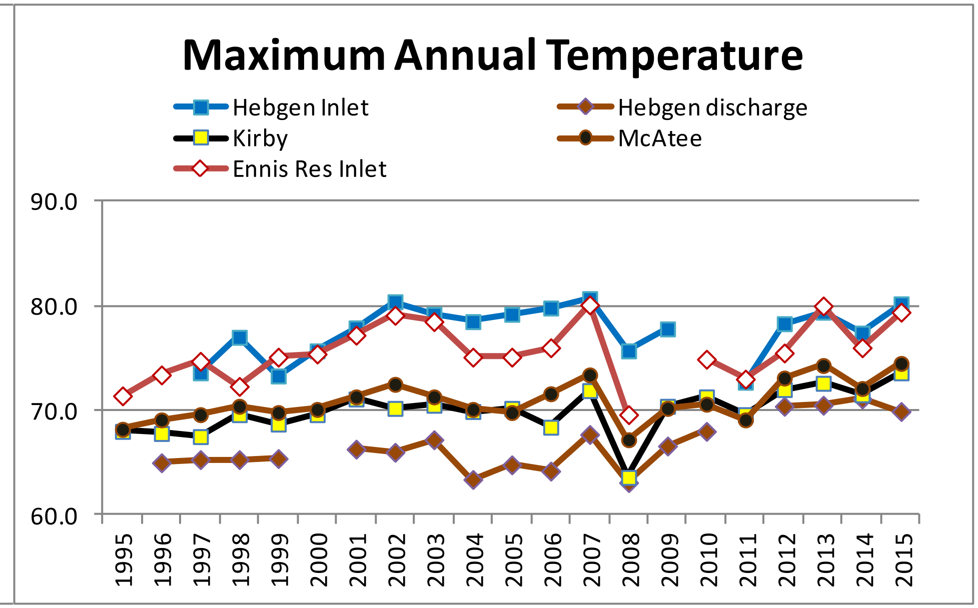

Maximum Annual Temperature
Kirby
Wall Creek Bridge
8.4 miles between sites
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

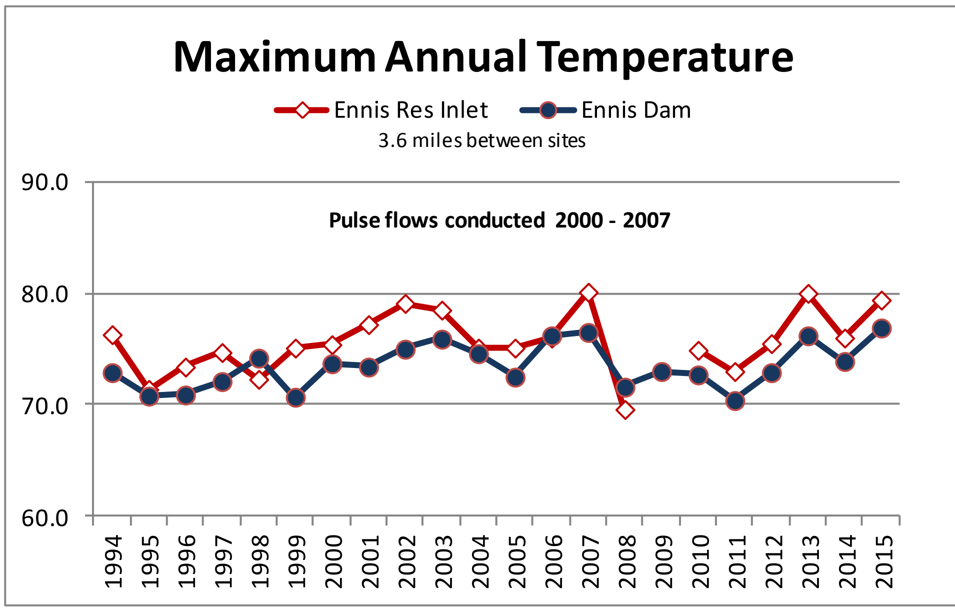

Maximum Annual Temperature
Wall Creek Bridge
McAtee
9.2 miles between sites
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

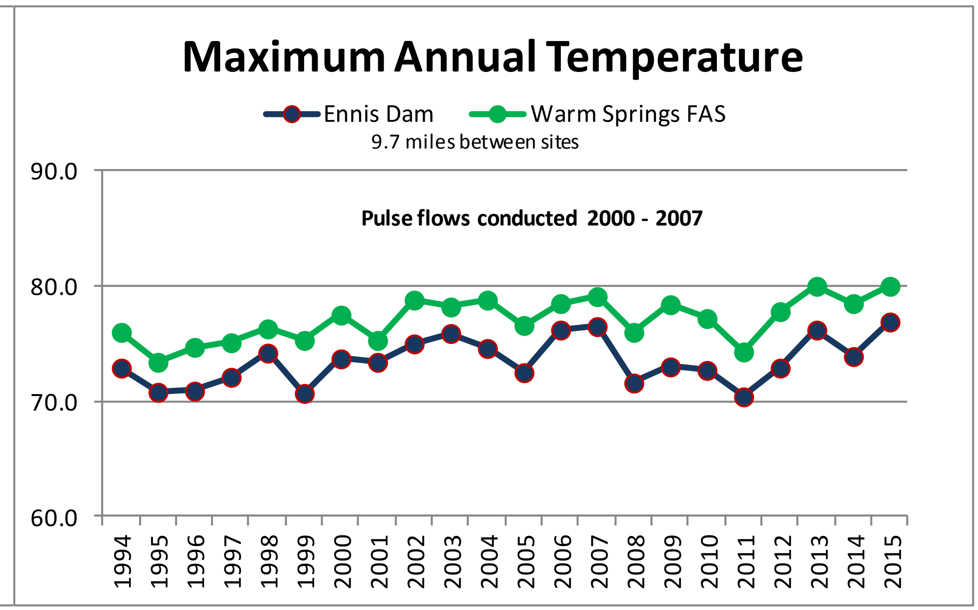

Maximum Annual Temperature
Kirby
Wall Creek Bridge
McAtee
17.6 miles between sites
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

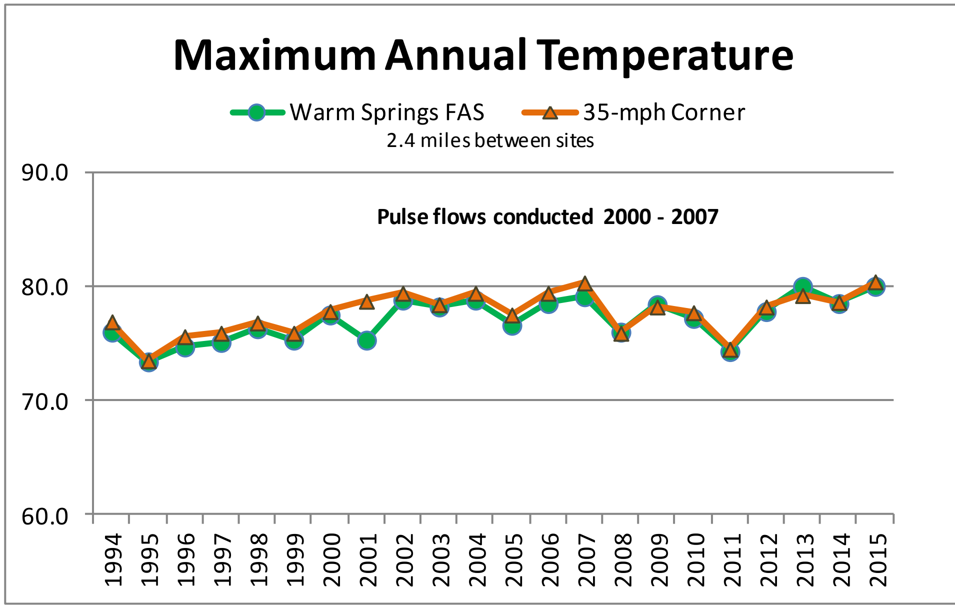

Maximum Annual Temperature
McAtee
Ennis Bridge
21.6 miles between sites
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

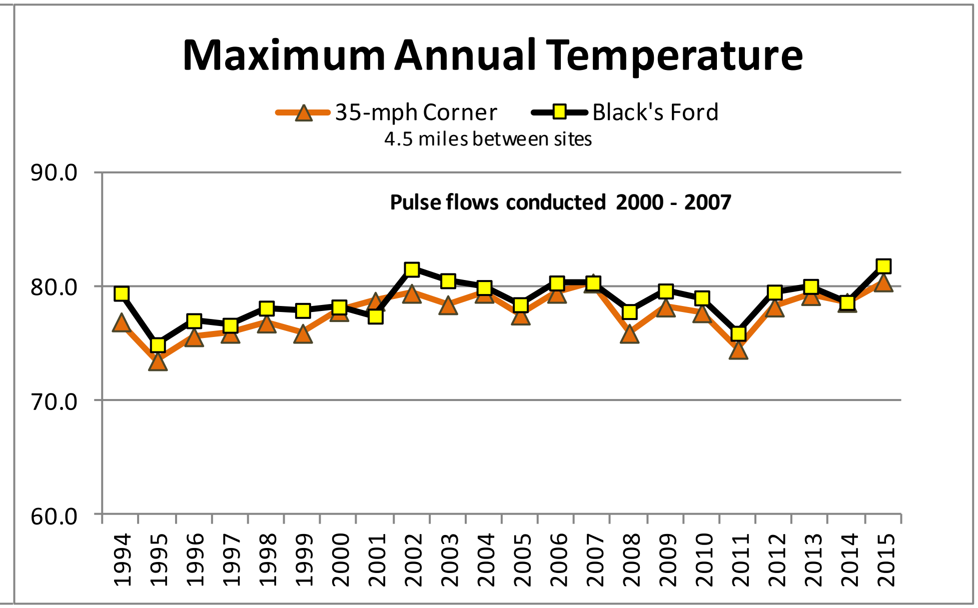

Maximum Annual Temperature
Ennis Bridge
Ennis Res Inlet
6.7 miles between sites
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

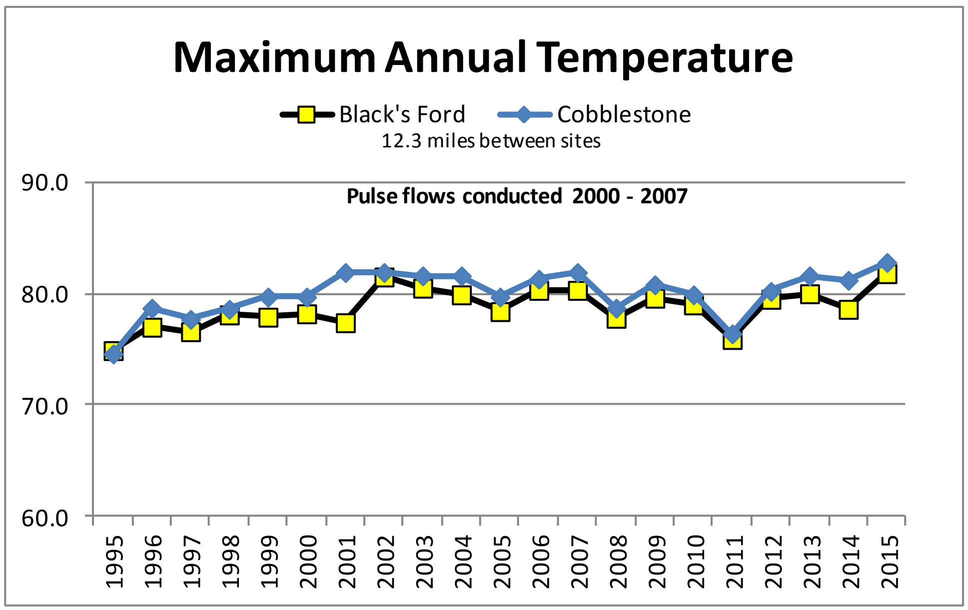

Maximum Annual Temperature
Hebgen Inlet
Hebgen discharge
Kirby
McAtee
Ennis Res Inlet
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

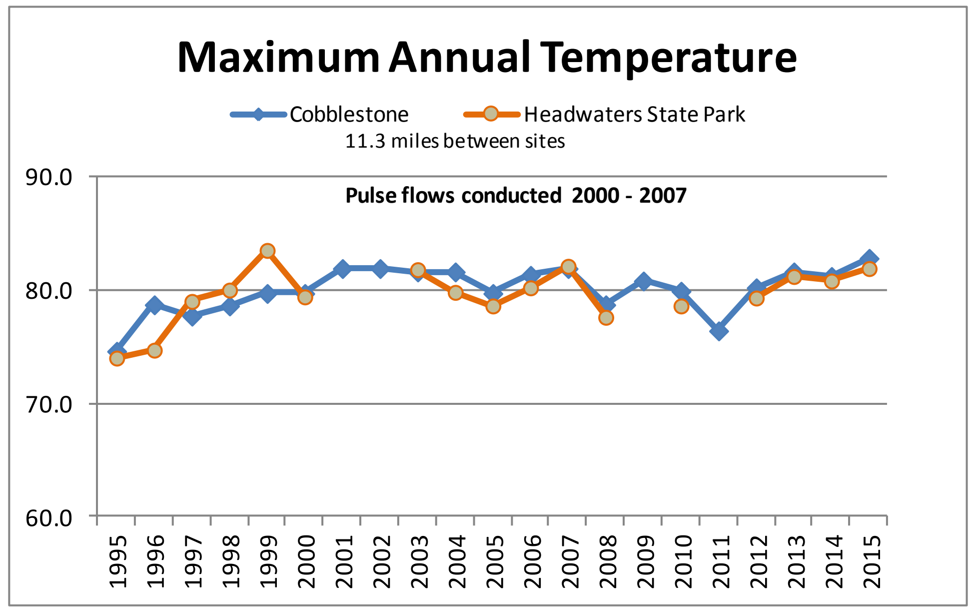

Maximum Annual Temperature
Ennis Res Inlet
Ennis Dam
3.6 miles between sites
Pulse flows conducted 2000 - 2007
90.0
80.0
70.0
60.0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

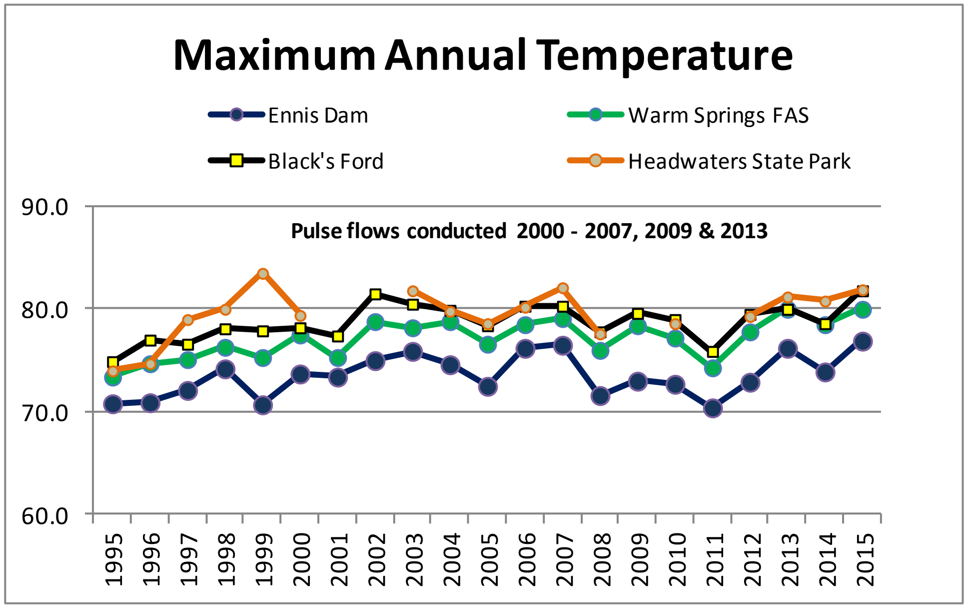

Maximum Annual Temperature
Ennis Dam
Warm Springs FAS
9.7 miles between sites
Pulse flows conducted 2000 - 2007
90.0
80.0
70.0
60.0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


Maximum Annual Temperature
Warm Springs FAS
35-mph Corner
2.4 miles between sites
Pulse flows conducted 2000 - 2007
90.0
80.0
70.0
60.0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


Maximum Annual Temperature
35-mph Corner
Black's Ford
4.5 miles between sites
Pulse flows conducted 2000 - 2007
90.0
80.0
70.0
60.0
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


Maximum Annual Temperature
Black's Ford
Cobblestone
12.3 miles between sites
Pulse flows conducted 2000 - 2007
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015


Maximum Annual Temperature
Cobblestone
Headwaters State Park
11.3 miles between sites
Pulse flows conducted 2000 - 2007
90.0
80.0
70.0
60.0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015

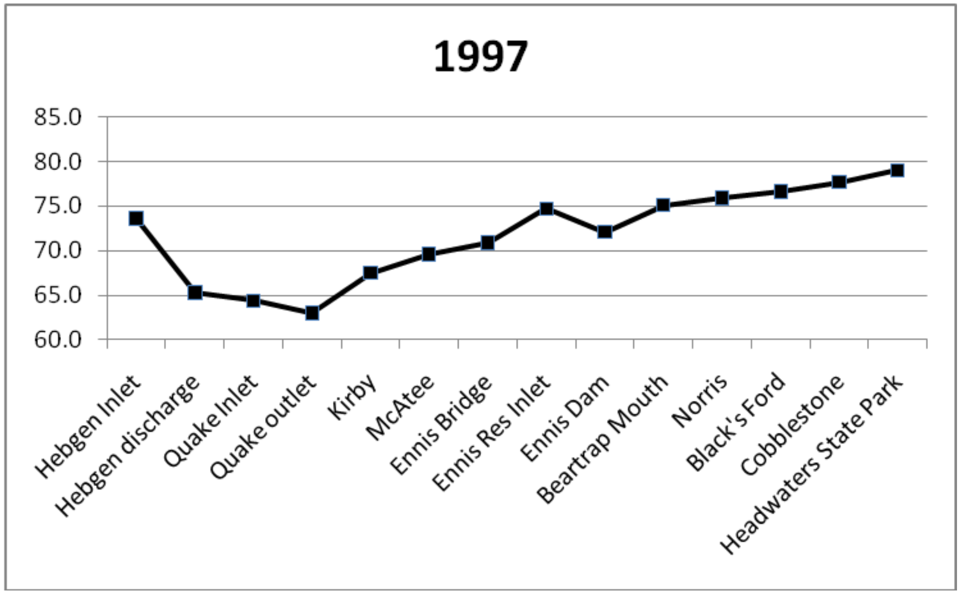

Maximum Annual Temperature
Ennis Dam
Warm Springs FAS
Black's Ford
Headwaters State Park
Pulse flows conducted 2000 - 2007, 2009 & 2013
90.0
80.0
70.0
60.0
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

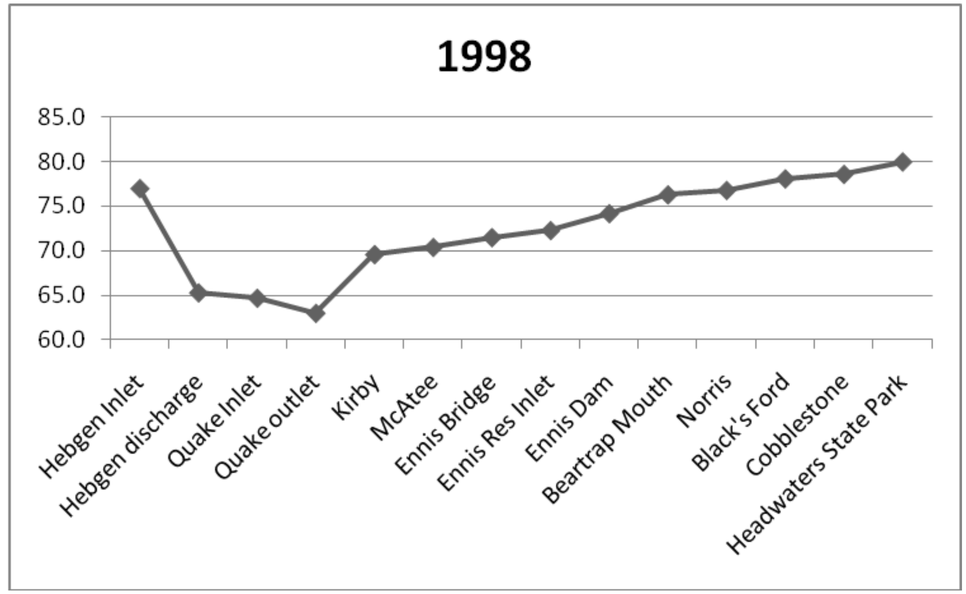
Appendix E3

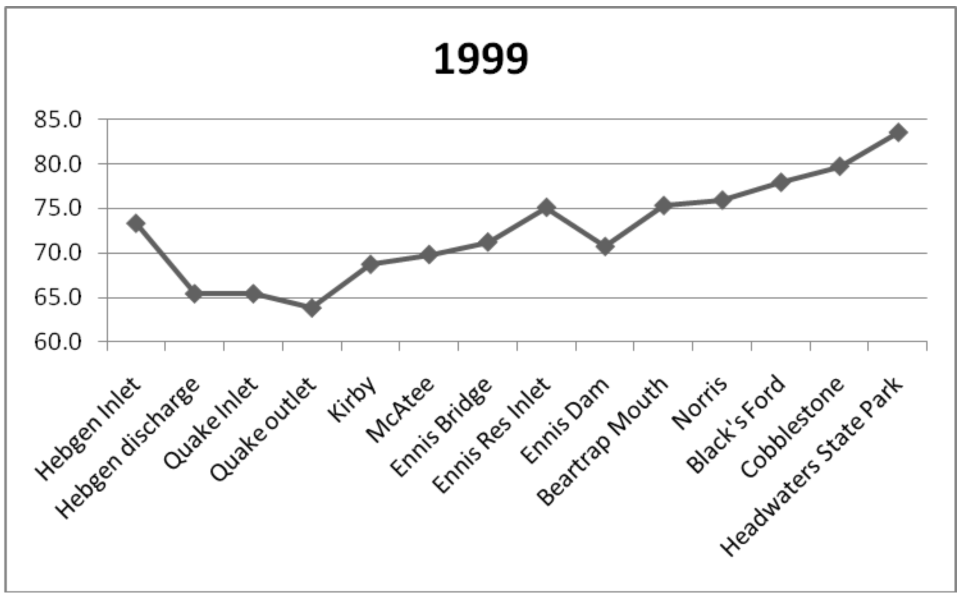
Maximum annual water temperatures recorded at Madison River monitoring sites
1997 - 2015
See Figure 9 for locations

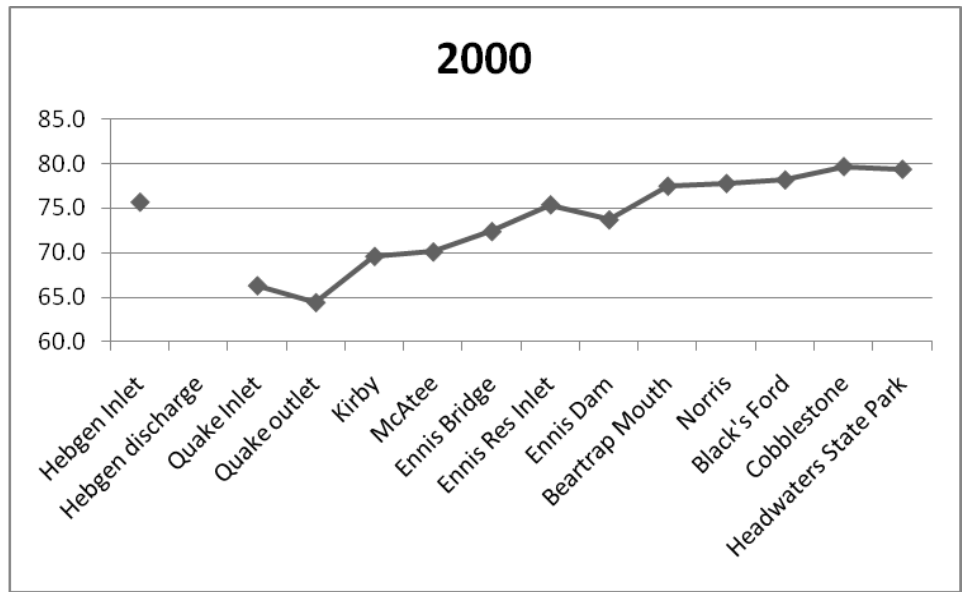
NOTES:
- Recorders at some locations were not recovered some years

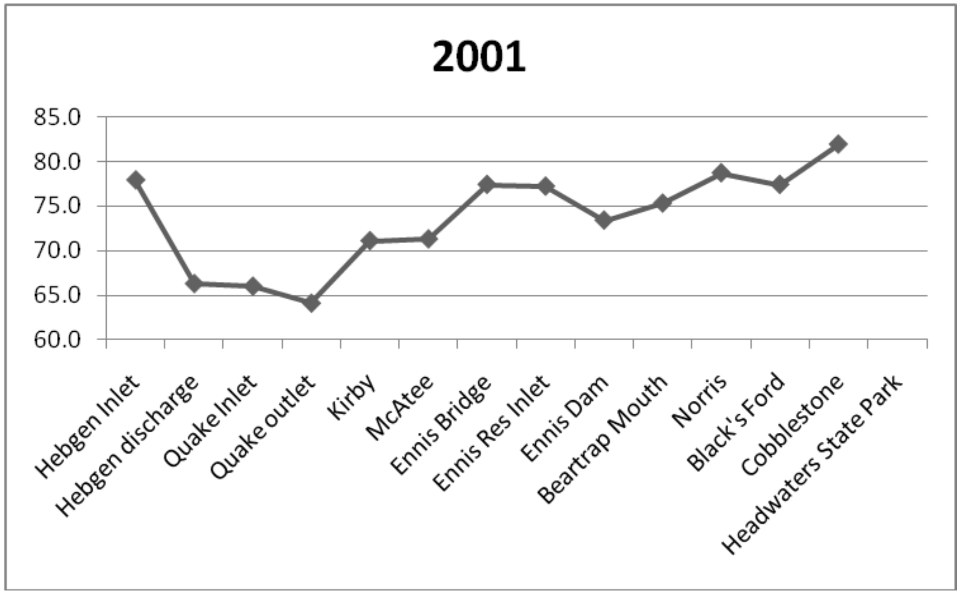
- It is important to note that the maximum temperatures at each site throughout the river did not all occur on the same day in any year, and that the maximum temperature at any given site may have been attained on more than just one day in a year

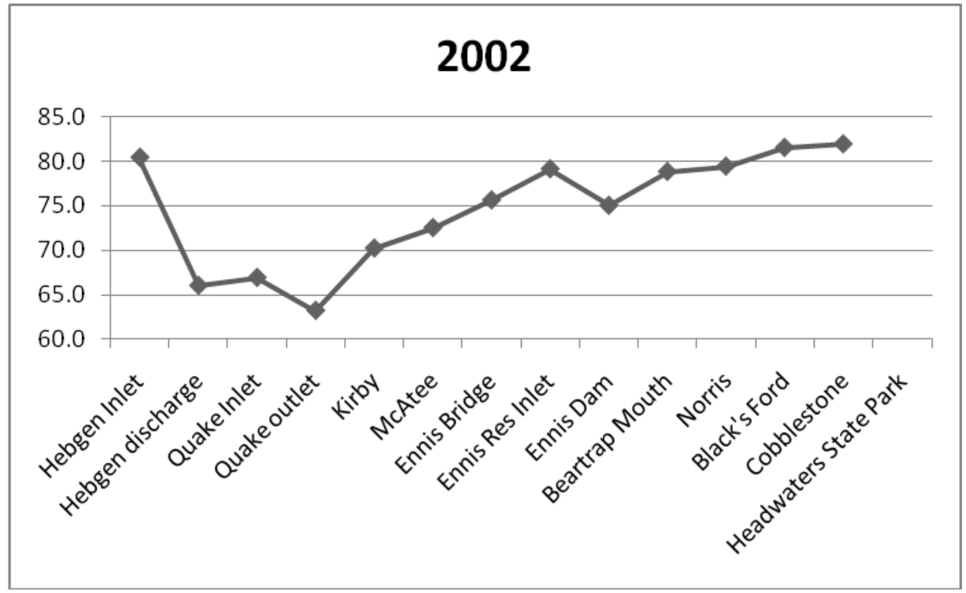

1997
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park

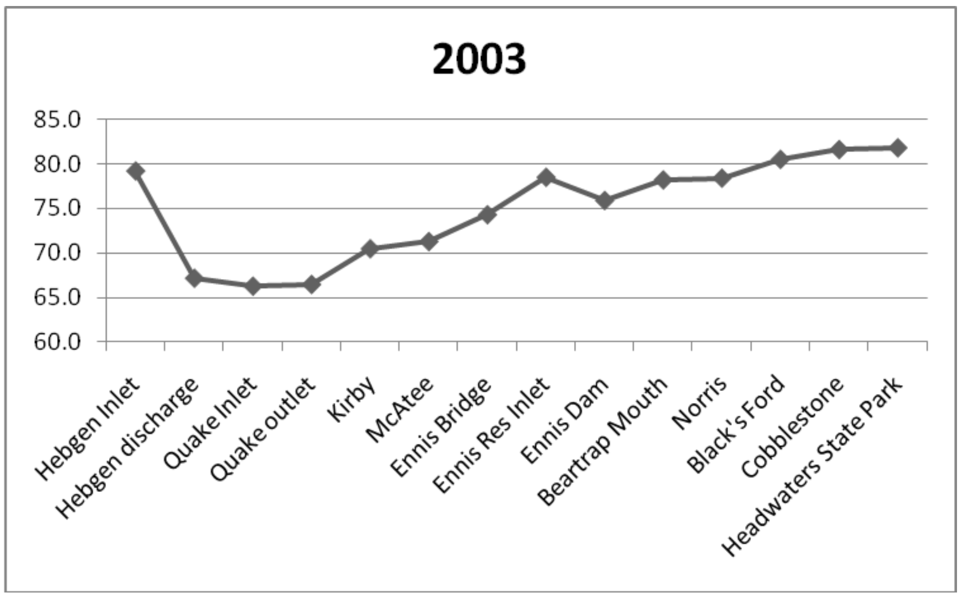

1998
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park

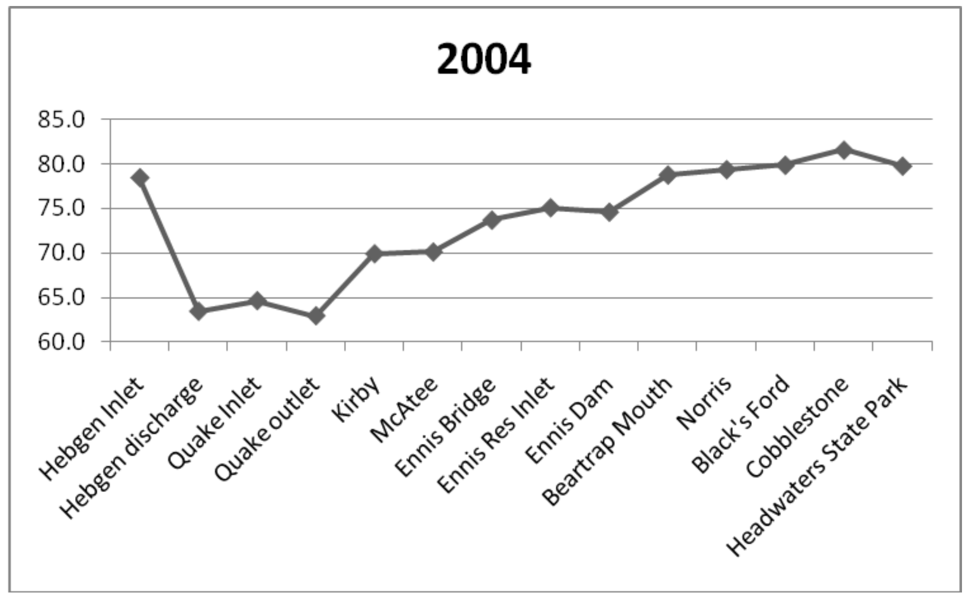

1999
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park

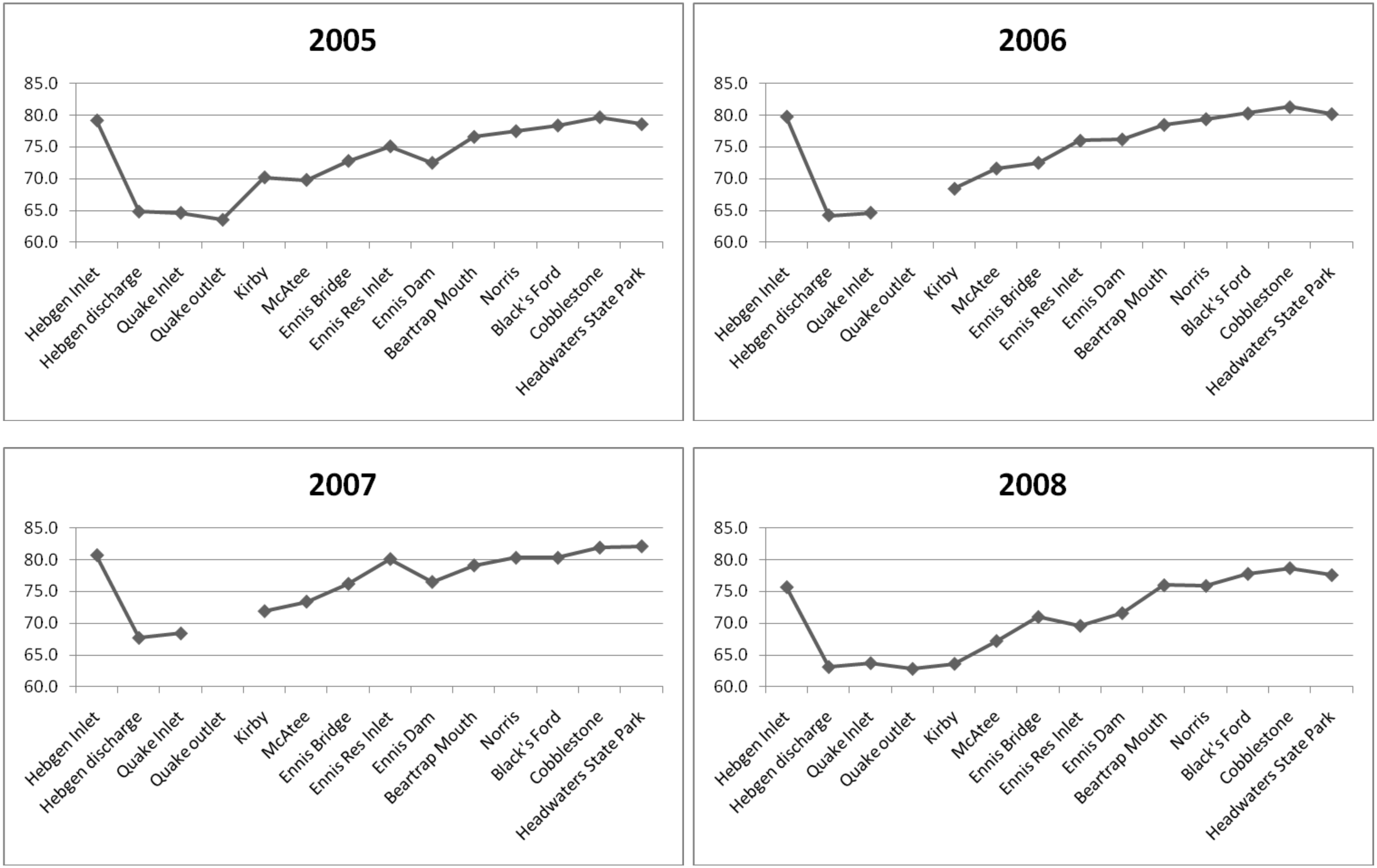

2000
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park

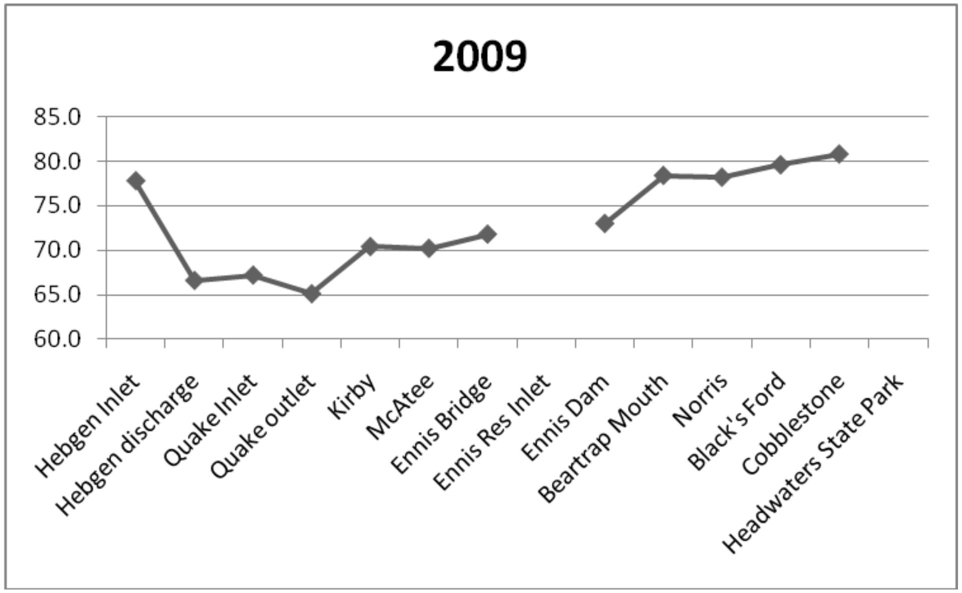

2001
85.0
80.0
75.0
70.0
65.0
60.0
Hebgen Inlet
Hebgen discharge
Quake Inlet
Quake outlet
Kirby
McAtee
Ennis Bridge
Ennis Res Inlet
Ennis Dam
Beartrap Mouth
Norris
Black's Ford
Cobblestone
Headwaters State Park


2002
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
Norris
Black's Ford
Cobblestone
Headwaters State Park


2003
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
Norris
Black's Ford
Cobblestone
Headwaters State Park


2004
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
Norris
Black's Ford
Cobblestone
Headwaters State Park


2005
2006
2007
2008
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
Norris
Black's Ford
Cobblestone
Headwaters State Park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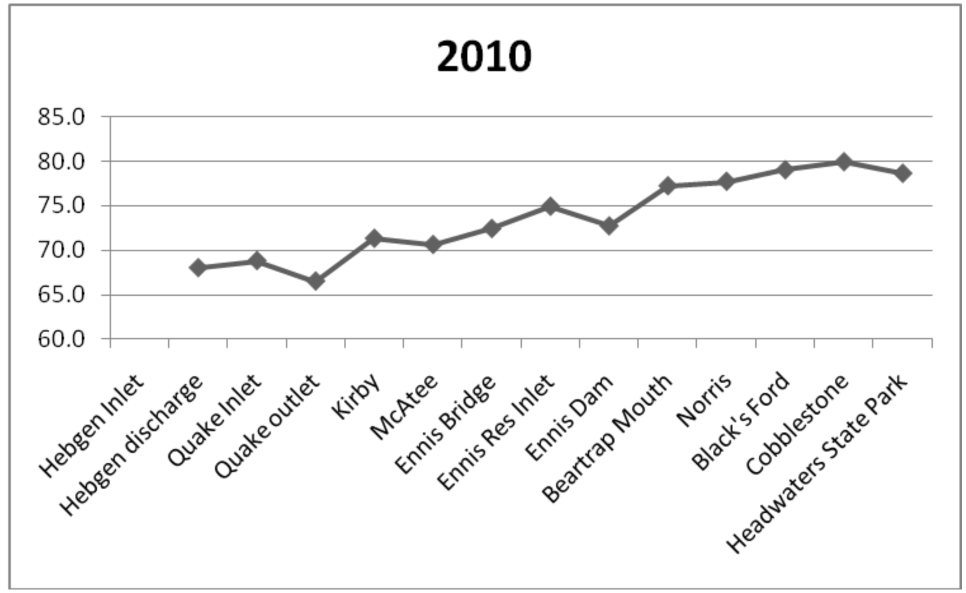
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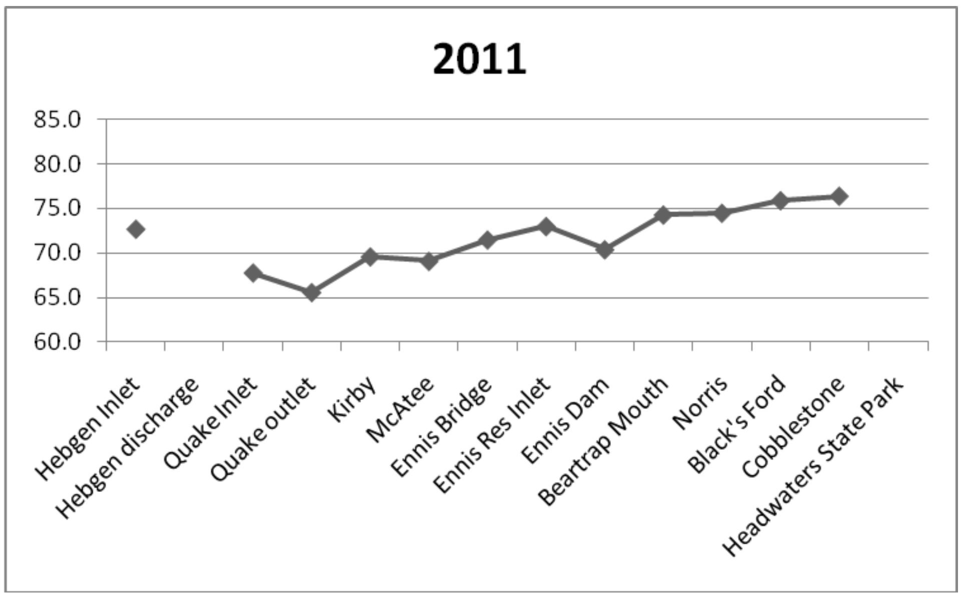
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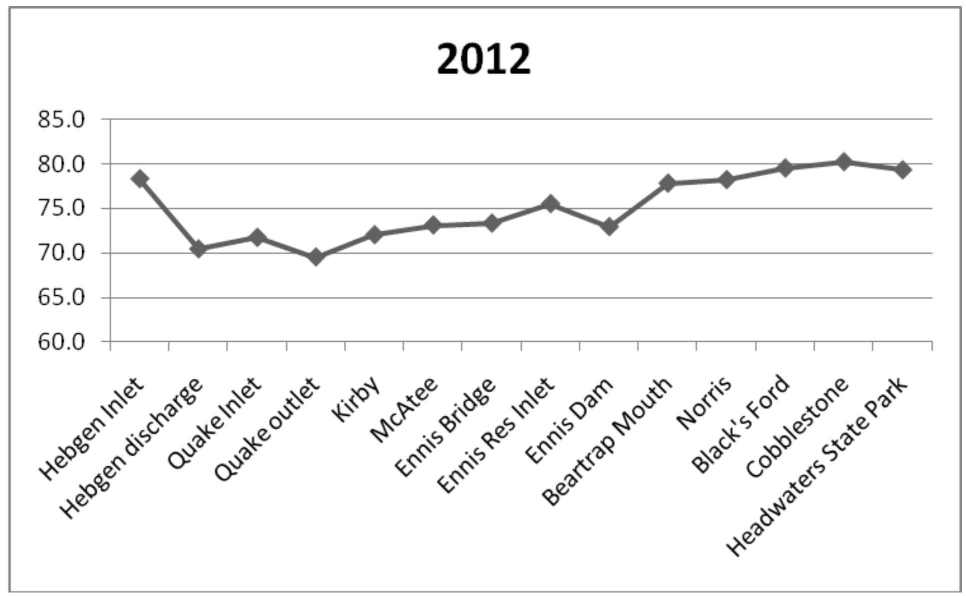
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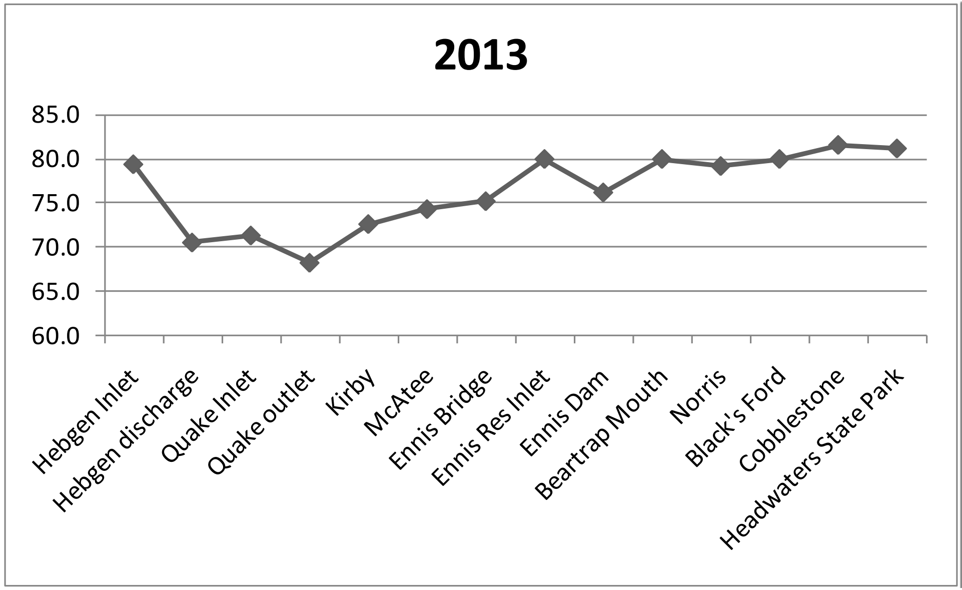
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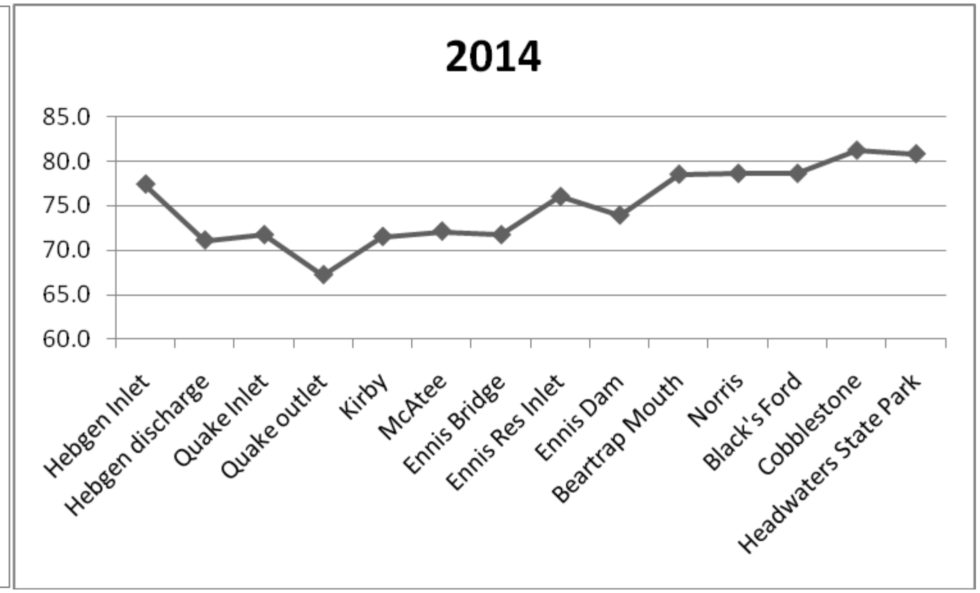
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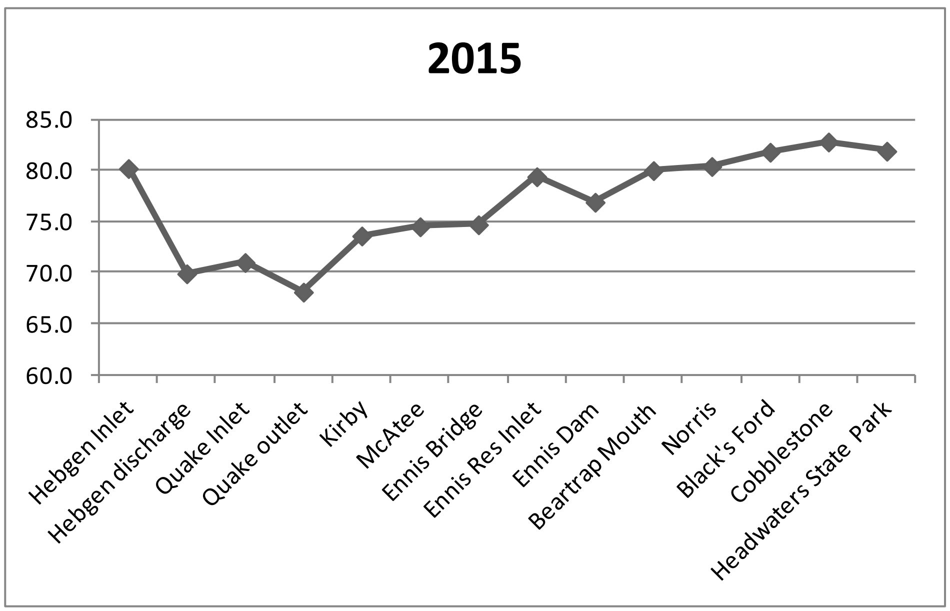
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Appendix F

Beaverhead-Deerlodge and Custer Gallatin national forest Monitoring Reports

Project Title: **Beaverhead-Deerlodge National Forest, Madison Ranger District Seasonal Technician Funding Report 2015**

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 $6,499 to the Madison Ranger District, Beaverhead-Deerlodge National Forest to assist with hiring fisheries technicians for field season 2015. Two fisheries technicians were hired to conduct field work across all 7 Districts of the B-D NF. The technicians worked a total of 160 ten-hour days with 118 days funded by the USFS at a cost of $15,635. Mad TAC dollars were used to fund 42 days ($5,565) of work on Madison River drainage projects and one Ruby River project (all listed below). Additionally, about $1,000 of Mad TAC funding was utilized to purchase field gear for the technicians. All of the listed projects support one or more of the above PM&E measures.

- Ruby Creek: 2 days
  The fisheries technicians conducted electrofishing surveys to follow up on suspect rainbow trout eDNA detections within the Ruby Creek westslope cutthroat trout (WCT) restoration project area. No rainbow trout were captured or observed.

- Horse Creek: 2 days
  The Horse Creek drainage was inventoried from headwaters downstream to the Forest boundary to determine WCT distribution, obtain 50 WCT fin clips for genetic analysis, and evaluate a historically documented fish passage barrier upstream of the confluence of Camp Creek. WCT fin clips were sent into the Wild Trout and Salmon Genetics Lab in Missoula by FWP. WCT upstream of the cascade were determined to be 98% unaltered WCT.

- Cabin Creek: 1 day
  Cabin Creek was electrofished between the historic natural barrier and the partially constructed, new fish passage barrier in an effort to move nonnative fishes downstream of the new barrier site and to collect WCT genetics. Over 150 nonnative fish were captured and moved downstream of the project area and fin clips were collected from all WCT captured (n = 5).

- Wall Creek: 1 day

  The crew conducted a site review for a proposed fish passage barrier construction project on Wall Creek in the Madison River drainage. They also reviewed a newly constructed headgate structure that was constructed on Wall Creek under special use permit by the Kelly Ranch on B-D NF lands.

- West Fork Madison River: 1 day

  The Madison Ranger District and Greater Yellowstone Coalition partnered to construct a riparian exclosure fence on the West Fork of the Madison River in summer 2014. The intent of the project was to improve water quality by excluding livestock, dispersed campers, ATV's, and passenger vehicles from a highly impacted riparian area about ½ acre in size. The area is improving rapidly, but annual fence maintenance/repair is required. The techs spent one day repairing the fence, taking photos of vegetation response, and identified willow planting opportunities within the exclosure.

- Sureshot Lakes: 4 days

  The fisheries technicians conducted Western toad breeding site inventories at Upper Sureshot Lake in the North Meadow Creek drainage on two occasions and worked with FS range and fire crew staff to repair an historic irrigation ditch that controls flow into the upper lake.

- Wigwam Creek: 2 days

  In 2010 Wigwam Creek, in the northern part of the Gravelly Mountains, was the focus of a multifaceted WCT habitat enhancement project. This project included the installation of fences, construction of an off-stream livestock watering facility, and active restoration of aquatic habitat using bioengineered techniques. The goal of the fence exclosure and in-stream habitat restoration/enhancement was to address several areas of Wigwam Creek that have been impacted by historic and recent livestock grazing. In late summer 2015, B-D fisheries technicians spent one day repairing the exclosure fence and returned for to a second day to conduct WCT population estimates within and outside of the exclosure area. WCT numbers were comparable in both reaches electrofished (inside and outside exclosure); however, larger fish were captured within the exclosure reach. Riparian and stream habitat condition within the exclosure have markedly improved since 2010.

- McClure Creek: 1 day

  B-D fisheries technicians assisted MT FWP biologists with electrofishing in McClure Creek, tributary to Hebgen Lake, to assess population strength of this genetically unaltered WCT population for potential to translocate a portion of population to Ruby Creek.

- Wade Lake: AIS survey: 1 day

  The fisheries technicians boated the perimeter of Wade Lake to conduct a lentic Aquatic Invasive Plant Survey. Target invasives included curly leaf pond weed and Eurasian water milfoil. No target AIS plant species were observed.

- Smith Lake Fish Ladder: 1 day

  A denil fish ladder was installed at the inlet/dam at Smith Lake in the Lake Creek drainage (tributary to the West Fork Madison River) to provide upstream passage, to pristine spawning habitat, for fluvial Arctic grayling and brown and rainbow trout from the mainstem Madison River. The ladder was necessary to allow spawning fish passage of the dam, notably for a significant brown trout spawning run. Ladder construction and installation was contracted through Montana Fish, Wildlife and Parks in summer 2015. The seasonal technicians conducted a site visit to document brown trout movement through ladder in October 2015. Numerous brown trout were documented in Smith Lake, upstream of the fish ladder.

- Greenhorn Creek WCT Conservation Project: 5 days

  The primary purpose of this project was to help achieve the goal of ensuring the long-term, self-sustaining presence of WCT in the upper Missouri River drainage by protecting and expanding a genetically unaltered WCT population in the Greenhorn Creek, in the Ruby River drainage. In 2015, piscicide treatment effectiveness was evaluated with basin scale electrofishing surveys and eDNA sampling. Brook trout were detected in two 200m reaches with eDNA and simultaneous electrofishing surveys captured individual brook trout within the same reaches. The Greenhorn drainage will be refounded by Dark Hollow WCT and genetically unaltered WCT brood stock in 2016. Madison Ranger District fisheries technicians spent 5 days on the Greenhorn project in August 2015 collecting eDNA water samples, electrofishing and setting gill nets.

South Fork Sixteenmile Creek
Fish Barrier

Purpose and Need

Westslope cutthroat trout (WCT) once occupied 17,465miles of stream habitat within the entire Missouri River drainage above Great Falls, MT at the time of the Lewis and Clark Expedition (Shepard et al. 2003). Presently, genetically pure and slightly pure populations currently occupy approximately 5.5% of the historically occupied habitat. Within the smaller Upper Missouri sub-basin, WCT once occupied 1,859 stream miles. Presently, genetically pure and slightly pure populations currently occupy approximately 3.5% (or 65 miles) of the historically occupied habitat.

The greatest threat to native inland cutthroat trout is hybridization, competition and predation by non-native introduced trout. Isolation in some drainages is considered the only viable tool to maintain both the upstream native population and the downstream non-native recreational fishery.

Only one remaining population of native westslope cutthroat trout still exists within the Sixteenmile Creek watershed. The Sixteenmile Creek drainage flows westerly from the northern Crazy Mountains near Ringling, MT to Toston, MT where it joins the Missouri River. This slightly hybridized population occupies five headwater tributaries along the northern Bridger Mountains which join to form the headwaters of the South Fork Sixteenmile Creek.

Proposed Action

Montana Fish, Wildlife and Parks (MFWP) and the Custer Gallatin National Forest (CGNF) jointly proposed to restore native westslope cutthroat trout in the headwaters of the South Fork Sixteenmile Creek drainage. The overall proposal consists of three parts: 1) construction of a concrete fish passage barrier to prevent non-native trout from re-invading upstream habitat; 2) treating selected stream reaches within upper South Fork Sixteenmile Creek drainage including five tributaries with a registered fish toxicant to remove non-native trout; and, 3) restoring using existing, slightly hybridized westslope cutthroat trout previously collect from along the extreme headwater reaches. The Forest Service was the responsible agency for approving that portion of the project requiring ground disturbance on National Forest System Lands, such as the construction of the fish passage barrier.

The fish barrier structure consists of a 15-foot wide spillway with two vertical drops separated by a gently sloping concrete slab designed to pass a 100-year flood. In essence, the design emulates two natural waterfalls at either end of a bedrock chute. This barrier will prevent further expansion of rainbow trout and preserve the slightly hybridized population of westslope cutthroat trout.

Accomplishments

The CGNF completed environmental planning and permitting in the spring of 2013. MFWP solicited bids for the fish barrier in 2013, but didn’t receive any qualified bids. MFWP re-solicited bids again in 2014 awarding the contract Battle Ridge Builders from Belgrade, Montana in the amount of $175,189. Construction was started in mid-July 2015 and finished up in late-September 2015.

Associated Work

MFWP and the CGNF fisheries personnel retested the WCT genetics throughout the upper drainage above the barrier in October 2015. Genetics results are pending. If pure enough fish still exist, both agencies will collect, re-test and set aside a couple hundred of the purest of the purest WCT in September/October 2016 and treat the upper drainage to remove all remaining hybrids. The set aside fish will later be reintroduced back into the headwaters and further monitored.

Partnership

Funding was pieced together from several partners including Montana Fish, Wildlife and Parks (Future Fisheries), Custer Gallatin National Forest, NorthWestern Energy, Montana Fish, Wildlife and Parks, and Madison Gallatin Trout Unlimited Chapter. Madison River Fisheries TAC provided $30,660 towards this project in December 2012, Project # 009-13.

Outreach

Public scoping during project planning.

Required Permits

- Montana Fish, Wildlife and Parks (Stream Preservation Act 124 Permit) – USFS-SFSixteenMileCreek-Barrier-2014 (dated 5/29/2013).

- Montana Department of Environmental Quality (Short-term Water quality standard for turbidity related construction activity – 318 authorization) – SFSixteenMileCreek-Barrier-2014 (dated 5/29/2013).

- Department of the Army Corps of Engineers (Section 404 of the Clean Water Act permit –Wetlands) – NWO-2013-00129-MTH (dated 6/18/2015).

Future Work

- Finish constructing an electric fence to prevent cattle disturbance around the barrier.

- Finish spreading slash along access routes.

- Continue planting sedge plugs and willow cuttings around the newly created pond.

- Collect, re-test and hold headwater WCT's to be used for restocking.

- Treat headwater tributaries to remove all unwanted hybridized trout before restocking with purest of the purest tested WCT.

Lessons Learned

Expand the size of your initial working group before moving forward with a project proposals.

Acknowledgments

Besides all of the funding partners, administrative personnel, and permitting personnel, there were many outstanding folks that worked together to see that the South Fork Sixteenmile Creek fish barrier was constructed:

Ron Spoon, Montana Fish, Wildlife and Parks, Fish Biologist
Dale White, Custer Gallatin National Forest, Hydrologist, Design Engineer, and Contracting Officer Rep.
Kevin McDonnell, Montana Fish, Wildlife and Parks, Design & Construction Section
Paul Valle, Montana Fish, Wildlife and Parks, Design & Construction Section
Mark McNearney, Montana Fish, Wildlife and Parks, Design & Construction Section
Charlie Boucher, Custer Gallatin National Forest, Grants and Agreement Specialist
Mike Jensen, DJ & A, Structural Engineers
Scott Spaulding, Northern Region, Regional Fisheries Biologist
Lee Nelson, Montana Fish, Wildlife and Parks, Fish Biologist
Dave Moser, Montana Fish, Wildlife and Parks, Fish Biologist
Travis Horton, Montana Fish, Wildlife and Parks, Regional Fish Manager
Gary Senger, Montana Fish, Wildlife and Parks, Fish Technician
Jody Hupka, Montana Fish, Wildlife and Parks, Fish Technician
Dan Frazer, Montana Fish, Wildlife and Parks, Fish Technician
Jedediah Hinkle, Custer Gallatin National Forest, Fish Technician
Bonnie Griffis, Custer Gallatin National Forest, Fish Technician
Andy Godtel, Custer Gallatin National Forest, Fish Technician
Lisa Stoeffler, Custer Gallatin National Forest, District Ranger
John Kattell, Northern Region, Regional Structural Engineer
Jonathan Kempff, Custer Gallatin National Forest, Forest Engineer
Reggie Clark, Custer Gallatin National Forest, District Range Conservationist
Bill Landis, Grazing Permittee, Alexandra Grazing Allotment
Tip Zupan, Landowner, King of Hearts Ranch

Cabin Creek Fish Barrier

Montana Fish, Wildlife & Parks

MADISON RIVER -FOUNDATION-

FOREST SERVICE U S DEPARTMENT OF AGRICULTURE

NorthWestern Energy

Delivering a Bright Future

NATIONAL FISH AND WILDLIFE FOUNDATION NFWF

BAIRCO CONSTRUCTION, INC.

Purpose and Need

Westslope cutthroat trout once occupied 17,466 miles of stream habitat within the upper Missouri River drainage at the time Lewis and Clark Expedition (Shepard et al. 2003). Presently, genetically pure and slightly pure populations currently occupy approximately 5.5% of the historically occupied habitat. Within the smaller Madison River sub-basin, WCT once occupied 1,222 miles. Presently, genetically pure and slightly pure populations currently occupy approximately 4.2% (or 51 miles) of the historically occupied habitat. The Cabin Creek population makes up approximately 35% of the remaining native WCT habitat within the Madison River sub-basin. Westslope cutthroat trout distribution improved substantially within the Madison River sub-basin upon the completion of the Cherry Creek westslope cutthroat trout restoration project.

The Quake Lake Earthquake of 1959 ripped through the area leaving massive scarps and uplifting throughout. Shifting along lower Cabin Creek resulted in a short high gradient canyon stream reach that isolated a population of native westslope cutthroat trout in the headwaters. Through the years, this reach has slowly eroded allowing a few rainbow trout to invade the headwaters resulting in a slightly hybridized upstream population. Westslope cutthroat trout just above the scarp are slightly hybridized becoming purer as you move upstream toward the headwaters.

Proposed Action

Area fish biologist proposed to build a fish barrier consisting of a 25-foot wide spillway with two vertical drops separated by a gently sloping concrete slab designed to pass a 100-year flood. In essence, the design emulates two natural waterfalls at either end of a bedrock chute. This project would prevent further expansion of rainbow trout and preserve the existing genetic status of the westslope cutthroat trout population.

Accomplishments

The CGNF completed environmental planning and permitting in the spring of 2014. Later that same year, CGNF awarded a contract to Bairco Construction, Inc. from Lovell, Wyoming in the amount of $307,573 to construct the Cabin Creek fish barrier.

The project was originally scheduled to be completed between August and October 2014. Because of two unusually back-to-back wet weather events in mid-August and early-September, streams flows nearly tripled exceeding the contractor's capacity to dewater the stream during construction. In the best interest of all parties, it was mutually agreed to give the contractor an extra year to complete the project.

Bairco Construction, Inc. started construction on the Cabin Creek barrier in late-August 2015 taking just over three weeks to complete. Bairco Construction, Inc. provided the following two drone and one time-lapse YouTube video links that best describes the construction process:

www.youtube.com/watch?v=Dq5O3589v5U

www.youtube.com/watch?v=LHgFhYoIZFE

www.youtube.com/watch?v=95F_auIp0OM

Associated Work

The fish barrier was located approximately 1/8 stream miles downstream the 1959 earthquake scarp. The primary fishery between the scarp and the downstream barrier was rainbow trout, brown trout and mountain whitefish, suckers and mottled sculpin. MFWP, Beaverhead-Deerlodge National Forest and CGNF fisheries personal removed a large portion of the non-native fish located in between the scarp and the new barrier and placed them downstream of the barrier.

Partnership

Funding was pieced together from several partners including NorthWestern Energy, Montana Fish, Wildlife and Parks (Future Fisheries), National Fish and Wildlife Foundation (Bring Back the Natives), U.S. Forest Service, Montana Fish, Wildlife and Parks, and the Madison River Foundation. The Madison River Fisheries TAC provided $173,810 for this project over three years ($75,000 in December 2012, Project # 008-13, $75,000 in December 2013, Project # 006-14, and $23,810 in August 2014, mid-year proposal).

Bairco Construction, Inc. was an incredible company to work with during all phases of this project. Many felt that Bairco was a full partner having an invested interest in the outcome.

Outreach

A newspaper article was published in the local West Yellowstone newspaper which acknowledged are the funding partners and contractor. There has been very wide distribution of three YouTube videos clips attached.

Required Permits

- Montana Fish, Wildlife and Parks (Stream Preservation Act 124 Permit) – GALCO-14-03 (dated 6/10/2014).

- Montana Department of Environmental Quality (Short-term Water quality standard for turbidity related construction activity – 318 authorization) – GALCO-14-03 (dated 6/10/2014).

- Department of the Army Corps of Engineers (Section 404 of the Clean Water Act permit –Wetlands) – NOW-2014-1053-MTH (dated 6/23/2014).

Future Work

- Design and construct an interpretative sign to be located along FS Trail # 207 overlooking the Cabin Creek fish barrier.

- Continue to monitor westslope cutthroat trout genetics and population size upstream from the barrier to determine project success.

- Annually monitor the soundness of the Cabin Creek fish barrier and provide maintenance if necessary.

Lessons Learned

When working in remote and logistically difficult areas, invest up front by working with folks from the construction side of the contracting equation. Their knowledge went a long way in improving the overall end product.

Acknowledgments

Besides all of the funding partners, administrative personnel, and permitting personnel, there were many other outstanding folks that worked together to make this project a total success:

Dale White, Custer Gallatin National Forest, Hydrologist, Design Engineer, and Contracting Officer Rep.
Gary Stephens, Custer Gallatin National Forest, Contracting Officer
Charlie Boucher, Custer Gallatin National Forest, Grants and Agreement Specialist
Brent Mabbott, NorthWestern Energy, Fish Biologist
Mike Jensen, DJ & A, Structural Engineers
Scott Spaulding, Northern Region, Regional Fisheries Biologist
Pat Clancey, Montana Fish, Wildlife and Parks, Fish Biologist
Mike Vaughn, Montana Fish, Wildlife and Parks, Fish Biologist
Lee Nelson, Montana Fish, Wildlife and Parks, Fish Biologist
Darin Watschke, Beaverlodge-Deerlodge National Forest, Fish Biologist
Travis Lohrenz, Montana Fish, Wildlife and Parks, Fish Technician
Jedediah Hinkle, Custer Gallatin National Forest, Fish Technician
Cavan Fitzsimmons, Custer Gallatin National Forest, District Ranger
Todd Stiles, Custer Gallatin National Forest, District Resource Assistant
Joel Krause, Northern Region, Regional Engineer
Jonathan Kempff, Custer Gallatin National Forest, Forest Engineer

Beaver Creek Fish Barrier

FOREST SERVICE
U S
DEPARTMENT OF AGRICULTURE

Montana Fish, Wildlife & Parks

NorthWestern Energy
Delivering a Bright Future

Purpose and Need

Westslope cutthroat trout (WCT) once occupied 17,466 miles of stream habitat within the upper Missouri River drainage at the time Lewis and Clark Expedition (Shepard et al. 2003). Presently, genetically pure and slightly pure populations currently occupy approximately 5.5% of the historically occupied habitat. Within the smaller Madison River sub-basin, WCT once occupied 1,222 miles. Presently, genetically pure and slightly pure populations currently occupy approximately 4.2% (or 51 miles) of the historically occupied habitat. Westslope cutthroat trout distribution improved substantially within the Madison River sub-basin upon the completion of the Cherry Creek westslope cutthroat trout restoration project.

The greatest threat to native inland cutthroat trout is hybridization, competition and predation by non-native introduced trout. Isolation in certain drainages is considered the only viable management tool to maintain both the upstream native fishery and a non-native downstream recreational fishery.

The headwaters of Beaver Creek and Rose Creek are occupied by an isolated slightly hybridized population of westslope cutthroat trout. This population currently occupies approximately 3.5 miles of stream habitat. Just above the Lee Metcalf Wilderness Boundary lies a smooth bedrock chute or slab with fairly laminar flow that is thought to be responsible for keeping non-native trout from reaching the headwaters.

Sometime within the last one to two decades, the upper Beaver Creek drainage experienced an extreme flow event that resulted in a deposit of boulders and LWD immediately downstream from this bedrock slab. As a result, the length of the slab was shortened (a portion became buried by the deposit), plus a plunge pool formed near the bottom. It is not known if this event and debris were as a result of the 2000 Beaver Creek Fire or some other upstream event such as a landslide. It is believed that non-natives made their way into the headwaters during or shortly after this major event. The genetics in the headwaters have remained stable between 2005 and 2011.

Proposed Action

Fish biologists from MFWP and CGNF discussed several options to create a barrier including different locations. One option included blasting a vertical face with a 4’ + hydrologic jump. The option that was settled on was to blast the deposit of boulders and LWD in an attempt to lengthen the bedrock slab and remove the downstream plunge pool. The adjacent Lee Metcalf Wilderness Boundary played a major role in selecting the final option and location. The bedrock slab is located approximately 100 meters outside of the Lee Metcalf Wilderness Boundary.

This project will be phased over three years due to the remoteness and to also take advantage of the high energy of spring flows to move materials rather than relying on the brute strength of crew members.

Accomplishments

In October 2015, the CGNF trail crew implemented as much as they could during a five-day work week. The main goal was to increase the length of the exposed slab as much as possible and remove the downstream plunge pool. The crew drilled 16 holes, set off seven shots of explosives using approximately 300 lbs. of waterproof ANFO and fire line explosives (cord). The plan is to let Mother Nature move as much debris downstream as possible this spring before crews return next fall. The majority of deposit was removed 2015.

Associated Work
Continue to work with the local outfitter and guide and sign the trailhead to avoid conflicts with trail and back country users.

Partnership

Implementation funding was provided exclusively by the Madison River Fisheries TAC. CGNF and MFWP provided in-kind funding to cover planning, permitting and oversight costs. Phase 1 of the Beaver Creek was initially funded in December 2014, Project # 015-15, in the amount of $10,198. The CGNF re-submitted a modified proposal in September 2014 which was approved by a quorum vote of TAC members via email. This modified proposal called for returning the initial $10,198 back to the TAC account and using leftover funds from the Cabin Creek fish barrier project fund all three phases ($23,810) of the Beaver Creek fish barrier project over the next three years: 2015, 2016 and 2017. No further proposals will be submitted to complete this project in either 2016 and 2017.

Outreach

None

Required Permits

- Montana Fish, Wildlife and Parks (Stream Preservation Act 124 Permit) – GALCO-14-03 (dated 6/10/2014).

- Montana Department of Environmental Quality (Short-term Water quality standard for turbidity related construction activity – 318 authorization) – GALCO-14-03 (dated 6/10/2014).

Future Work

- Continue blasting in 2016 and 2017 to finish removing the downstream deposit and upstream LWD jam to extend the length of the laminar flowing bedrock slab.

- Continue to monitor westslope cutthroat trout genetics and population size upstream from the barrier to monitor project success.

Lessons Learned

None

Acknowledgments

Besides all of the funding partners, administrative personnel, and permitting personnel, there many outstanding folks that worked together to get this project off to a successful start:

Charlie Boucher, Custer Gallatin National Forest, Grants and Agreement Specialist
Dale White, Custer Gallatin National Forest, Hydrologist
Pat Clancey, Montana Fish, Wildlife and Parks, Fish Biologist
Bonnie Griffis, Custer Gallatin National Forest, Fish Technician
Jedediah Hinkle, Custer Gallatin National Forest, Fish Technician
Cavan Fitzsimmons, Custer Gallatin National Forest, District Ranger
Lauren Oswald, Custer Gallatin National Forest, Acting District Ranger
Kimberly Schlenker, Custer Gallatin National Forest, Recreation-Wilderness Program Manager
Todd Stiles, Custer Gallatin National Forest, District Resource Assistant
Will Shoutis, Custer Gallatin National Forest, District Trails Supervisory
Brian Wilson, Custer Gallatin National Forest, West Yellowstone Smokejumper
Mike Feibig, American Rivers
Scott Bosse, American Rivers

Custer Gallatin National Forest Seasonal Technicians

The Madison River Fisheries TAC provided the CGNF with $3,977 (Project # 013-15) in December 2014 to pay for seasonal employee salaries which equates to 30 eight hour days or 24 ten hours day to help with project implementation and monitoring within the Madison River drainage supervised by MFWP, CGNF and NorthWestern Energy employees.

Annual Water and Air Temperature Monitoring

The CGNF Watershed program has five long-term water and air temperature monitoring sites (Red Canyon Creek, Cabin Creek, Watkins Creek, Little Tepee, and South Fork Madison River) within Hebgen Basin is addition to those locations currently monitored by NorthWestern Energy and MFWP. These data sets are stored at the CGNF Forest Supervisor's Office in Bozeman, Montana and are available upon request. It takes approximately two person days to download, re-launch continuous recording temperature recorders, and analyze data for these five sites.

Tepee Creek Surveys

The same land formation that resulted in the formation of an unnamed waterfall along upper Grayling Creek bisects the entire watershed including Tepee Creek and Little Tepee Creek. Yellowstone National took advantage of their unnamed waterfall to restore westslope cutthroat trout into the headwaters of Grayling Creek in 2013 and 2014.

Montana Fish Wildlife and Parks took advantage of a similar formation along Little Tepee Creek to introduce westslope cutthroat trout within a naturally fishless stream reach.

The CGNF, MFWP, and Yellowstone National Park have been discussing the possibility of modifying a third unnamed waterfalls along middle Tepee Creek and restoring westslope cutthroat trout above. CGNF approved their portion of the project in June 2015 which would include the modification of Tepee Creek Falls using explosives to prevent the future expansion of rainbow trout into the headwaters. MFWP has not yet approved their portion of the overall project which would include removing non-natives and re-stocking with westslope cutthroat trout.

CGNF seasonal employees spent four days collecting macroinvertebrate samples, learning access routes to and from the various stream reaches, and looking into project logistics for when the time comes the overall project is fully approved by all parties.

Ruby Creek Westslope Cutthroat Trout Restoration

CGNF seasonal employees worked jointly with MFWP and Beaverhead-Deerlodge National Forest crews for two days to finish removing rainbow trout from Ruby Creek before re-introducing genetically pure westslope cutthroat trout from Wally McClure Creek and other native sources.

Cabin Creek Fish Barrier Project

CGNF seasonal crews spent 10 days working along lower Cabin Creek removing non-native trout between the newly constructed fish barrier and the upstream scarp and reclaiming the construction site, staging area and access routes associated with the construction of the Cabin Creek fish barrier.

Beaver Creek Fish Barrier

CGNF seasonal crews spent five days organizing and working in association with the trail crew to implement Phase 1 of this fish barrier project.

Wally McClure Creek Population Monitoring

CGNF seasonal crews spent three days working in association with MFWP employees to conduct a full inventory of Wally McClure Creek.

Which PM&E measure(s) in the Project 2188 License will this proposal enhance or support:

FERC Article	Item	Report Topic	Project	Page Number
409	**(3)**	**Fish habitat Enhancement**	**Annual Water & Air Temperature Monitoring**	**?**
412	**(5)**	**Species of Special Concern – Westslope Cutthroat Trout**	**South Fork Sixteenmile Cr fish barrier project**	**?**
			Cabin Creek fish barrier project	**?**
			Beaver Creek fish barrier project	**?**
			Seasonal Employees	**?**

Report by: **Bruce Roberts**

Appendix G
NWE funded Westslope Cutthroat Trout genetic testing results

Westslope cutthroat trout populations tested for genetic status under NWE 2188 Program			
W = westslope cutthroat trout; Y = Yellowstone cutthroat trout; R = rainbow trout			
Stream	Collection Date	Number of fish	Lab analysis
Horse Creek above cascade	7/29/15	30	98.0W x 2.0(R+Y) (23 of 30 100W)
Horse Creek below cascade	7/29/15	29	94.2W x 2.7R x 3.1Y
Hyde Creek	7/8/15	25	88.3Wx9.4Y x 2.3R
Wall Creek	6/4/15	25	95% W x 5% R & Y
English George Creek	6/3/15	25	94% W x 6% R & Y
SF Madison River	10/7/2014	188	133 fish≥92.3%W 55 fish<92.3%W (xR) culled
Whites Gulch	6/11-16/2014	60	100% W
Sun Ranch Brood Pond	May 2014	100	Pedigree analysis, 100% W
SF Madison River	9/17-18/13	63	47 fish>85%W 16 fish<85%W (xR) culled
Cherry Lake, Madison	Various dates 2013	53	Pedigree analysis, 100% W
Cherry Creek, Madison	various dates 2012	100	100% W
Pine Butte Creek	11/1/2012	22	97.8% W x 2.2% Y
Deadman Creek	11/1/2012	8	98.4% W x 1.6% Y
McClure Creek	10/7/2012	16	100% W
SF Madison River	8/29/2012	113	89 fish ≥ 85% W, 24 < 85% (x R) culled
Wall Creek	10/24/2011	32	95.0% W x 0.4% R x 4.6% Y
SF Madison	9/21-23/2011	242	216 @ 97.1%W x 2.9% R 26 @ various levels of intermediate; culled
SF Madison	8/3/2011	55	51 @ 97.1%W x 2.9% R 1 @ 0.8%W x 99.2%R, culled 3 @ various levels of intermediate, culled
Soap Ck	?	51	98% W x 2% R
McClure	6/26/2010	19	100% W
Wild Horse	6/26/2010	8	100% W
Last Chance	6/25/2010	16	100% W
WF Wilson	6/25/2010	2	1 100% W; 1 WxR

Brays Canyon	6/21/2010	26	100% W
Prickly Pear	6/1/2010	19	18@100% W 1@>99%W - 1R? allele
Cherry Lake	numerous dates 2009	50	100% W
McClure	10/7/2009	49	100% W
Brays Canyon	10/1/2009	50	100% W
Prickly Pear	10/1/2009	50	100% W
Little Tepee of Tepee of Grayling	10/1/2009	10	92.3%W x 1.9%Y x 5.8%R
Hyde	8/5/2009	25	88.5%W x 7.3%Y x 4.2%R
English George	8/4/2009	25	93.4%W x 4.3%Y x 2.3%R
SF Madison	7/16/2009	25	15 @ 97.7%W x 2.3%R 5 @ 0.8%Wx99.2%R 5 various levels of intermediate
Upper Fox	9/18/2008	18	97% W x 3% R
Tepee Ck of Grayling Ck	8/25/2008	8	51.5%W x 26.6%Y x 21.9%R
Wild Horse	7/17/2008	30	100% W
Last Chance	7/2/2008	21	100% W
Ray	6/19/2008	60	100% w
Muskrat	6/18/2008	52	100% W
Whites Gulch	6/11/2008	54	100% W
Halfway	9/26/2007	50	99.9% W x 0.1% R
Hall	9/20/2007	50	100% W
Ray	6/21/2007	45	100% W
Muskrat	6/20/2007	38	100% W
Last Chance	6/18/2007	20	100% W
Whites Gulch	6/12/2007	24	100% W
Bear Ck	9/19/2006	25	100% W
Bean Ck	9/18/2006	25	100% W
Browns	6/22/2006	25	100% W
Muskrat	6/21/2006	24	100% W
Ray	6/20/2006	35	100% W
Whites Gulch	6/12/2006	31	100% W
Last Chance	6/5/2006	30	100% W
Cabin Ck - mainstem	10/17/2005	15	97% Wx 3% R swarm
Cabin Ck - Middle Fork	10/11/2005	8	mixture of pure W & hybrid WxR
Cabin Ck - Middle Fork	10/11/2005	17	mixture of pure W & hybrid WxR
Whites Gulch	9/8/2005	50	100% W
Hellroaring Ck	7/26/2005	10	27%Wx17%Yx56%R swarm

Little Elk River	7/19/2005	10	100% Y
Arasta	7/14/2005	25	87%Wx8%Rx5%Y
Browns	6/28/2005	15	100% W
Soap Ck	6/8/2005	10	94% Wx3% R swarm
Cottonwood Ck - Blacktail	6/1/2005	19	swarm - 1 fish had 3 Rb alleles; 18 fish no R alleles detected
Stone	2005	30	100% W
Stone	2004	50	100% W
Hall	7/9/2004	2	100% W
McClure	7/1/2004	8	100% W
Ray	7/1/2004	5	100% W
Muskrat	6/30/2004	22	100% W
Cottonwood Ck - Blacktail	6/1/2004	33	100% W
Jones Ck	10/30/2001	25	WxYxR; some individuals exhibited Y alleles, one exhibited R alleles
Bean Ck	10/29/2001	54	98% W x 2% R; only 1 fish displayed R alleles
Bear Ck	10/29/2001	53	100% W
Wall Ck	10/19/2001	25	99% W x 1% R
NF English George	10/18/2001	9	WxRxY, too few fish to discern percentages
SF English George Ck	10/18/2001	23	80.4%Wx19.6%Y swarm
WF Wilson	10/1/2001	48	100% W

Appendix H

Madison Conservation District

Local Common Sense Conservation

222 E. Main Street Suite 2B | PO Box 606 | Ennis, MT 59729
406.682.7289

WWW.MADISONCD.ORG

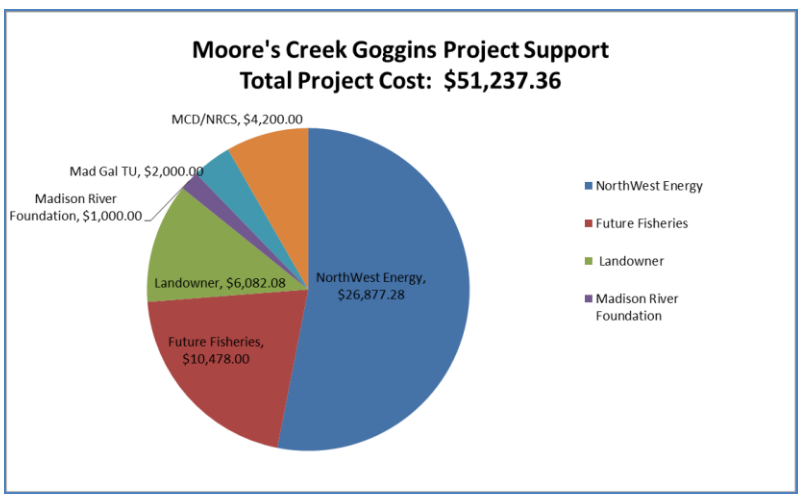
November 12, 2015

Michelle McGree
Montana Fish Wildlife and Parks
1420 E Sixth Ave
Helena, MT 59620

Dear Ms. McGree,

This communication serves as project update and final invoicing for the Moore's Creek Enhancement at the Goggins Ranch in Ennis, MT. Attached are invoices for fencing materials and labor, photos from the construction, and a final invoice for the awarded grant amount of $10,478. The project is now fully complete, with all construction components installed for the fencing, well, pipeline, tanks, water gaps, and hardened crossing.

Additional support has been provided by Northwestern Energy, the Landowner, MCD and NRCS, Madison Gallatin Trout Unlimited, and the Madison River Foundation. The below graphic illustrates the partner commitments to date. The most significant additional project expense was the installation of the new watering system, with a total cost of $26,918.00, which has been invoiced to NorthWestern Energy.



Please contact me directly with any questions or concerns on this submission (406.682.3181). The generous assistance of Montana Fish, Wildlife & Parks in making this project successful is greatly appreciated, and we look forward to continuing with similar projects in the future.

Sunni Heikes-Knapton
Madison Watershed Coordinator

Feeds-N-Needs

10 Goggins Dr
Ennis, MT 59729
406/682-4122

11/10/2015

Moores Creek Fencing Supplies

40	twist sticks	$0.80	$32.00
2	cable	$118.00	$236.00
154	5x8 post	$13.90	$2,140.60
116	bullnose	$1.10	$127.60
93	tightener	$2.95	$274.35
6	wire	$105.00	$630.00
98	SR603 post	$5.95	$583.10
2	4.5 x 6.5 post	$7.00	$14.00
116	3.5 x 10.5 rail	$9.30	$1,078.80
2	704 clip	$15.00	$30.00
22	gate handle	$5.95	$130.90
22	gate anchor	$1.50	$33.00
22	gate activator	$5.50	$121.00
125	681 insulator	$0.50	$62.50
152	joint clamp	$1.20	$182.40
1	partial box nails	$38.00	$38.00
1	partial box staples	$49.00	$49.00
64	3.5 x 16.5 rail	$14.95	$956.80
1	partial box nails	$68.00	$68.00
14	6x10 post	$25.50	$357.00
8	6x8 post	$19.95	$159.60
1	partial box screws	$69.00	$69.00
	Total		$7,373.65
	less 15%		$6,267.60

R-H FENCE CONSTRUCTION
ROBERT HOERAUF
217 EDWARDS
WHITEHALL, MONTANA 59759
CELL: 490-9392
HOME: 287-5299
boysddm@aol.com

November 9, 2015

Moores Creek Goggins
sunni@madisoncd.org

INVOICE#20151054

R-H Fence built **3900'** of three (3) wire electric fence for the price of **$.75** per foot and a total cost of **$2925.00**.

R-H Fence built sixty (60) braces for a price of **$35.00** per brace and a total cost of **$2100.00**

R-H Fence built **310'** of four (4) rail fence for the price of **$3.50** per foot and a total cost of **$1085.00**.

R-H Fence built **255'** of pipe panel fence for a price of **$3.50** per foot and a total cost of **$892.50**.

TOTAL COST $ 7002.50

TOTAL DUE $ 7000.00

Thank you for using R-H Fence Construction to build your fence and we hope you will allow us to provide you with a bid in any future projects that you may have. If you have any questions or concerns, please contact us at any time.

Sincerely,

Robert Hoerauf
R-H Fence Construction


Figure 1: Pre Construction Conditions

Figure 2: Fence Installation Underway

Figure 3: Installed Fence on south pasture

Figure 4: Installed Fence above Corral

Figure 5: Installed Fence above Corral Bridge

Figure 6: Well and Pipeline Installation

Figure 7: Hardened Crossing

Figure 8: Tire Tank Initial Install

Figure 9: Tire Tank Install Complete

Appendix I

Contribution of Stocked Rainbow Trout to the Hebgen Reservoir Fishery

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Introduction

Understanding the contribution of different sources to recruitment of fish into a fishery is important for proper management of recreational species, especially when stocking hatchery-reared juveniles is used to sustain the fishery. However, tracking fish throughout their lives is difficult, if not impossible, using traditional methods such as mark-recapture or radio telemetry studies. Otolith microchemistry analysis has repeatedly proven to be a reliable technique for identifying natal origin (e.g., Thorrold et al. 1998; Bickford and Hannigan 2005; Warner et al. 2005; Coghlan et al. 2007; Gibson-Reinemer et al. 2009), nursery areas (e.g., Brazner et al. 2004), spawning migrations (e.g., Brenkman et al. 2007), and general movements (e.g., Kafemann et al. 2000; Zlokovitz et al. 2003; Muhlfeld et al. 2012) of fishes. Trace elemental and isotopic concentrations of otoliths reflect the surrounding environment and remain unchanged following deposition on the otolith (Campana and Thorrold 2001). Commonly-used isotopic and elemental ratios include $^{87}Sr:^{86}Sr$, Sr:Ca, Ba:Ca, Mg:Ca, and Mn:Ca (e.g., Humston et al. 2010; Pangle et al. 2010; Clarke et al. 2007). The similarity between water and otolith chemistry enables researchers to understand fish movements among habitat patches if distinct chemical variation exists and individuals remain in locations long enough to incorporate the signatures of those environments into otoliths (Kennedy et al. 2002).

Biologists with Montana Fish, Wildlife & Parks (FWP) annually stock thousands of rainbow trout fingerlings into Hebgen Reservoir (FWP 2013a; FWP 2013b). However, the contribution of those stocked fish to the fishery remains poorly understood. Although rainbow trout spawning behaviors have been studied in many tributaries of Hebgen Reservoir (Watschke 2006), recruitment of wild fish in the reservoir and its tributaries remain poorly understood. Given sufficient variability in water chemistry among areas of interest (i.e., Hebgen Reservoir's tributaries and the hatcheries), otolith microchemistry analysis could provide the information needed to quantify the proportion of stocked and wild rainbow trout in the fishery.
The objectives of this study were to:

1) Characterize the spatial distribution of ^{87}Sr:^{86}Sr, and Sr:Ca ratios in the waters of selected tributaries to Hebgen Reservoir, as well as Bluewater Hatchery and Ennis National Fish Hatchery.
2) Identify the contribution of hatcheries and Hebgen Lake tributaries to the stock of rainbow trout in Hebgen Reservoir.

Methods

Study area.—Hebgen Reservoir and its tributaries are located in the Middle Rockies ecoregion of southwest Montana and northwest Wyoming. The reservoir has a drainage area of about 2,343 km^2 (Figure 1). The Hebgen Basin is primarily composed of Quaternary rhyolite flows and intrusive igneous rocks with undivided surficial deposits in areas immediately adjacent to the Madison, Gibbon, and Firehole rivers and several of their tributaries (Love and Christiansen 1985). The areas north of the reservoir are composed of Mississippian limestones and Lower Mesozoic deposits (Taylor et al. 1988).

Water chemistry.— Montana Fish, Wildlife & Parks biologists collected water samples from 13 locations including Hebgen Reservoir, several of its tributaries, the Bluewater Hatchery and the Ennis National Fish Hatchery (sampling locations are shown in Figure 1). All water samples were collected using ultra-clean vials during runoff (May 16) and baseflow (July 18) conditions in 2013, with the exception of the Ennis National Fish Hatchery, which was collected using the same methods in January 2015 (Table 1; Figure 1). Samples were filtered with 0.45-μm sterile filters and preserved with 20 μL of HNO_3 after returning to the laboratory.

Strontium was separated from other elements by loading water samples onto 50μL ion chromatographic columns packed with Sr-Spec resin (EICHROM). After purification, the isotopic analysis of Sr was performed on a Nu-Plasma Multi-Collector Inductively Coupled Plasma Mass Spectrometer (MC-ICP-MS). Isotopic data were normalized to National Bureau of Standards standard NBS 987, with a reported ^{87}Sr:^{86}Sr value of 0.710245. A mean value of 0.710264 ± 0.000010 (N = 6) was obtained for repeated measurements of the NBS 987 standard. Elemental concentrations of Ca, Sr, Ba, Mg, and Mn were measured using a Thermo Scientific VG PQ ExCell ICP-MS.

Otolith Microchemistry— Montana Fish, Wildlife & Parks biologists collected rainbow trout otoliths from Hebgen Reservoir. All otoliths were removed using non-metallic instruments, cleaned, and stored in polyethylene vials or coin envelopes prior to preparation.

One sagittal otolith from each fish was randomly selected for laser ablation. Otoliths were prepared using methods similar to those described by Muhlfeld et al. (2012). Each otolith selected for laser ablation was first rinsed and scrubbed with a nylon brush to remove any foreign material or tissue, then dried under a laminar flow hood for twenty-four hours. The otoliths were then mounted on petrographic slides, sulcus side up, using cyanoacrylate glue. Once the glue hardened the otoliths were sanded to approximately 40-50 microns above the plane of the nucleus, similar to Garcez et al. (2014). Otoliths were sanded first using 600- and 1500-grit sandpaper then polished using 0.5- and 0.1-μm diamond lapping film. Once the sanding and polishing process is complete, the otoliths were rinsed and scrubbed again with Milli-Q water, soaked in Milli-Q water overnight to dissolve the glue, and lastly remounted on a new petrographic slide using the same cyanoacrylate glue.

The facilities at WHOI were used to conduct microchemical analysis of all rainbow trout otoliths. Samples were analyzed using laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) with a 213 nm laser ablation system (e.g. Walther et al. 2008). The analysis was used to quantify otolith ^{87}Sr:^{86}Sr ratios as well as element:Ca ratios (Sr:Ca, Ba:Ca). All otoliths collected from Hebgen Reservoir were ablated along a 200 x 140 μm raster transect centered on the otolith core. Laser parameters for the raster patterns were as follows: diameter 100 μm, repetition rate 20 Hz, scan speed 5 μm·s–1. The raster transects centered on the core provided the microchemical signature incorporated into the otolith that is attributed to the timing in which fish occupy their natal stream or hatchery. The ablated otolith material was carried by He gas to the ICP-MS where it mixes with an Ar carrier gas and wet aerosol (2% HNO_3) from a 20-μL/min perfluoroalkoxy self-aspirating nebulizer. For quality assurance, a certified reference material was run every 10 samples (e.g. Muhlfeld et al. 2012) to assess instrument drift and changes in mass bias (Jackson and Hart 2006). All results were normalized using a standardized reference material described by Jackson and Hart (2006).

Otolith Aging .— All otoliths analyzed with LA-ICP-MS were aged by counting annual growth rings (annuli). Otoliths were aged to examine the contribution of stocked hatchery fish to each year class within Hebgen Reservoir. Two fisheries professionals with otolith aging experience independently verified all aging results.

Data Analysis.—Since the primary objective of this study was to examine hatchery vs. natural spawning stream contributions to the Hebgen Reservoir rainbow trout population, only baseflow stream samples and hatchery water samples were used in this analysis. The baseflow stream water samples were used exclusively due to baseflow stream conditions coinciding with the timing in which rainbow trout fry would be emerging from their eggs and occupying their natal stream prior to their outmigration to the reservoir. Only $^{87}Sr:^{86}Sr$ and Sr:Ca ratios were retained for further analysis given the presence of sufficient variability to distinguish between hatchery and naturally spawned fish. The variability in water sample $^{87}Sr:^{86}Sr$ and Sr:Ca ratios was assessed using simple bivariate plots.

Strontium:Ca ratios measured in otoliths have been found to be lower than those measured in the ambient water a fish occupies (e.g. Muhlfeld et al. 2012; Munro et al. 2004). To facilitate a comparison between water and otolith Sr:Ca ratios a rainbow trout specific partition coefficient (0.24) calculated by Munro et al. (2004) was applied to the water samples using the following equation:

$$Sr:Ca_{water} * 0.24 = Sr:Ca_{otolith}$$

In order to identify which streams or hatcheries fish likely originated from, a range of expected values fish would be likely to exhibit was generated for both $^{87}Sr:^{86}Sr$ and Sr:Ca ratios for each stream and hatchery (these values were required due to a lack of reference data, specifically fish with known origin). Generating a range of expected values required quantifying the variation found in otolith results. Fifty fish were randomly selected and the standard deviation of the otolith results was calculated for each fish, a mean standard deviation value was then calculated for both $^{87}Sr:^{86}Sr$ and Sr:Ca ratios. The calculated standard deviations were multiplied by 3 in order to simulate the full range of values that could be expected in fish otoliths and reduce misclassifications. Streams that had overlapping ranges of expected values were then grouped together as a single classification group. While the hatcheries had non-overlapping ranges of expected values they were grouped together to satisfy the primary objective of this study (hatchery vs. naturally reproduced fish). A bivariate plot of Sr:Ca (X axis) and $^{87}Sr:^{86}Sr$ (Y axis) was then used to classify fish based on their similarities to the stream and hatchery groups. Many of the otolith results that did not fall within the ranges of expected values were assigned to groups based on their $^{87}Sr:^{86}Sr$ values, and the unlikelihood of their inclusion in other groups.

Results

Water Chemistry.—Of the water samples that were analyzed, ratios of $^{87}Sr:^{86}Sr$ ranged from 0.70872 to 0.71942 among sampling locations (Table 1). The Bluewater Hatchery had the lowest $^{87}Sr:^{86}Sr$ ratio. The highest $^{87}Sr:^{86}Sr$ ratio was observed in Grayling Creek during baseflow conditions. Although the range of $^{87}Sr:^{86}Sr$ ratios was high, several locations exhibited similar ratios (e.g., Firehole and Gibbon rivers).

Ratios of Sr:Ca ranged from 0.47 to 4.89 mmol:mol (Table 1). The Gibbon River had the lowest Sr:Ca ratio and the Bluewater Hatchery samples had the highest.. The bivariate plot of Sr:Ca and $^{87}Sr:^{86}Sr$ illustrates the variability of microchemical ratios among sample locations (Figure 2). The bivariate plot of Sr:Ca and $^{87}Sr:^{86}Sr$ ratios of the Bluewater and Ennis National

Hatchery samples clearly indicate they are different than all other locations. According to the bivariate plot Grayling and Duck Creeks are also distinguishable from other stream samples and the hatcheries.

Adjusted water sample results after multiplying the partition coefficient by stream and hatchery Sr:Ca values can be found in Table 2. The three standard deviations applied to water sample results to create a range of expected values fish may exhibit were +/- 0.0924168, and +/- 0.0019312 for Sr:Ca and ^{87}Sr:^{86}Sr respectively; Figure 3 shows each stream with expected values for Sr:Ca and ^{87}Sr:^{86}Sr ratios.

Fish were assigned to three groups: Hatchery, Wild Group 1, and Wild Group 2 (Figure 4). The Hatchery group consisted of both the Bluewater Hatchery and the Ennis National Fish Hatchery and contained all fish with otolith Sr:Ca results between 0.55 and 1.26 mmol:mol and otolith ^{87}Sr:^{86}Sr results between 0.70679 and 0.71143. Wild Group 1 consisted of Grayling and Duck creeks and contained all fish with otolith Sr:Ca results between 0.23 and 0.63 mmol:mol and otolith ^{87}Sr:^{86}Sr results between 0.71547 and 0.72135. Wild Group 2 consisted of Madison, S.F. Madison, Firehole, and Gibbon rivers as well as Cougar Creek and contained all fish with otolith Sr:Ca results between 0.02 and 0.45 mmol:mol and otolith ^{87}Sr:^{86}Sr results between 0.70720 and 0.71345. Stream and hatchery groupings are illustrated in Figure 4. The majority of fish that did not fall within these groups (n=49) were assigned to groups based on their ^{87}Sr:^{86}Sr values (Figure 5). Eleven fish were not assigned to a groups due to the similarities between Wild Group 1 and Wild Group 2 ^{87}Sr:^{86}Sr expected values (refer to the discussion for more information). The number, age, and percentage of fish assigned to each group can be found in Table 3 and graphically in Figure 6. Table 4 contains a break-down of the initial fish groupings and the final fish groupings after assigning fish to likely origins based on ^{87}Sr:^{86}Sr ratios.

Discussion

The variability of Sr:Ca and ^{87}Sr:^{86}Sr ratios in this study is similar to or greater than the ratios used to identify natal origins of other freshwater fishes (e.g., Muhlfeld et al. 2012). In other studies, reference otoliths (from fry collected from known tributaries) have been used to increase the certainty of classifying the natal origins fish with unknown origins because the otolith microchemical variance as well as the partition coefficient can be calculated for the specific system being examined (Munro et al. 2004; Muhlfeld et al. 2012). While reference data was not available for this study, the bivariate plots (Figure 2) clearly indicate that there is sufficient variability among water sampling locations to identify whether fish originated from the hatcheries or Hebgen Reservoir tributaries as a result of natural reproduction. The fish were classified with a high degree of confidence by assignment to groups based on their ^{87}Sr:^{86}Sr values as well as in a more conservative method by only attributing fish to the range of expected values based on the variance of the water Sr:Ca and ^{87}Sr:^{86}Sr ratios (Table 3). The large majority of fish sampled were assigned to Hebgen Reservoir tributaries (84%) opposed to the 13% assigned to the hatcheries. The numbers and percentages of fish assigned to each group can be found in Table 4 with a breakdown of the initial grouping and final groupings with most unknown fish assigned.

There was sufficient variability among the Hebgen Reservoir tributaries themselves to partition the fish natal origins into 2 distinguishable groups. These groupings make sense geographically, with one exception. Grayling Creek and Duck Creek flow into the northern portion of the Hebgen Reservoir, while Firehole River, Gibbon River, Madison River, and the South Fork of the Madison River all flow into the southern portion of Hebgen Reservoir. The Cougar Creek classification with the southern tributaries seems to be the only spatial classification anomaly. It might be possible to parse out enough variation to assign unknown fish to Cougar Creek (and potentially more individual tributaries) with the addition of 1) reference otolith data collected from all tributaries and/or 2) incorporation of other element:Ca ratios (Ba:Ca, Mg:Ca, Mn: Ca) into the study. This additional data would also be valuable in order to validate the classification groups identified here.

The baseflow water samples were used for analysis, because it coincides with fry emergence and tributary rearing. Paired spring runoff water samples were also collected for Grayling Creek, Madison River, Duck Creek, and S.F. Madison. Unlike the other tributaries, water collected from Grayling Creek during spring runoff had a very different ^{87}Sr:^{86}Sr ratio as the same creek sampled during baseflow. In the case of Grayling Creek if fry emergence occurs at some point during spring runoff, their ^{87}Sr:^{86}Sr otolith signature would be more similar to the runoff water chemical signatures. Water samples from Grayling Creek collected during baseflow (0.71942) were classified as Wild Group 1, where water sampled during spring runoff (0.71139) would have been classified within Wild Group 2. It is therefore possible that some of the fish classified as Unknown or as Wild Group 2 actually came from Grayling Creek at some point during runoff.

The main study objective of determining the proportion of fish collected in Hebgen Reservoir originating from native tributaries vs. hatcheries was clearly accomplished with a high degree of confidence. The attempt to assess the contribution of specific tributaries to juvenile rearing was also successful, however with less specificity as desired. This study has provided a better understanding of production of wild rainbow trout in the reservoir’s tributaries and the contribution of hatchery-reared rainbow trout. In order to have a higher degree of certainty with the current classifications as well as to potentially further classify the contributions of individual tributaries, the addition of 1) reference otolith data to calculate system-specific partition coefficients, 2) multiple water samples collected for each tributary to directly calculate the microchemical variances, and/or 3) analysis of additional element:Ca ratios in both water and otoliths, would be necessary. This project should have immediate and direct management implications by informing managers about the efficacy of on-going stocking of Hebgen Lake with hatchery-reared rainbow trout.

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Table 1. Locations of water samples collected in 2012. Elemental ratios are mmol:mol for strontium. Locations colored red were not used in the data analysis since the primary objective of this study was to assess natal origins.

Location	$^{87}Sr:^{86}Sr$	Sr:Ca
Gibbon River (baseflow)	0.70966	1.21310
Firehole River (baseflow)	0.71006	0.46638
Madison River (runoff)	0.71052	0.85136
Madison River (baseflow)	0.70969	0.73612
Grayling Creek (runoff)	0.71139	1.34915
Grayling Creek (baseflow)	0.71942	1.36141
Cougar Creek (baseflow)	0.71152	1.49770
Duck Creek (runoff)		2.83496
Duck Creek (baseflow)	0.71740	2.24332
S.F. Madison (runoff)	0.70935	1.11989
S.F. Madison (baseflow)	0.70913	0.77126
Madison Arm (baseflow)	0.71140	1.13973
Grayling Arm (baseflow)	0.71418	1.87451
Middle Reservoir (baseflow)		1.39332
Dam (runoff)	0.71268	1.47873
Dam (baseflow)	0.71254	1.42655
Bluewater Hatchery (fry	0.70872	4.87669

tanks)		
Bluewater Hatchery (fingerling ponds)	0.70872	4.89044
Ennis National Fish Hatchery	0.709496	2.68006

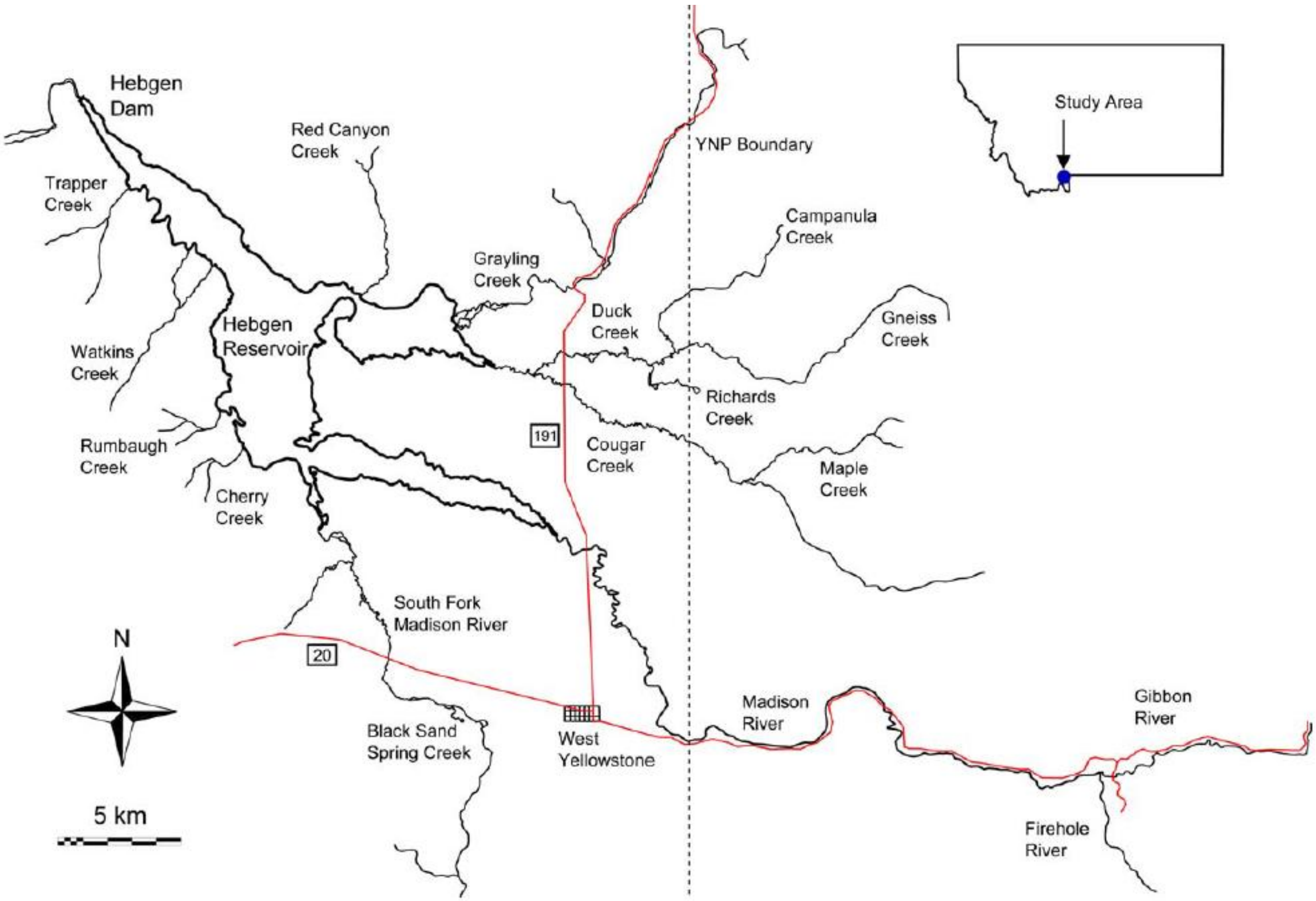


Figure 10. Map of Hebgen Reservoir and its tributaries (Watschke 2006). The Bluewater hatchery (not pictured) is located about 160 km northeast of Hebgen Reservoir near Bridger, Montana, and the Ennis National Fish Hatchery (not pictured is located about 77 km northwest of Hebgen Reservoir.

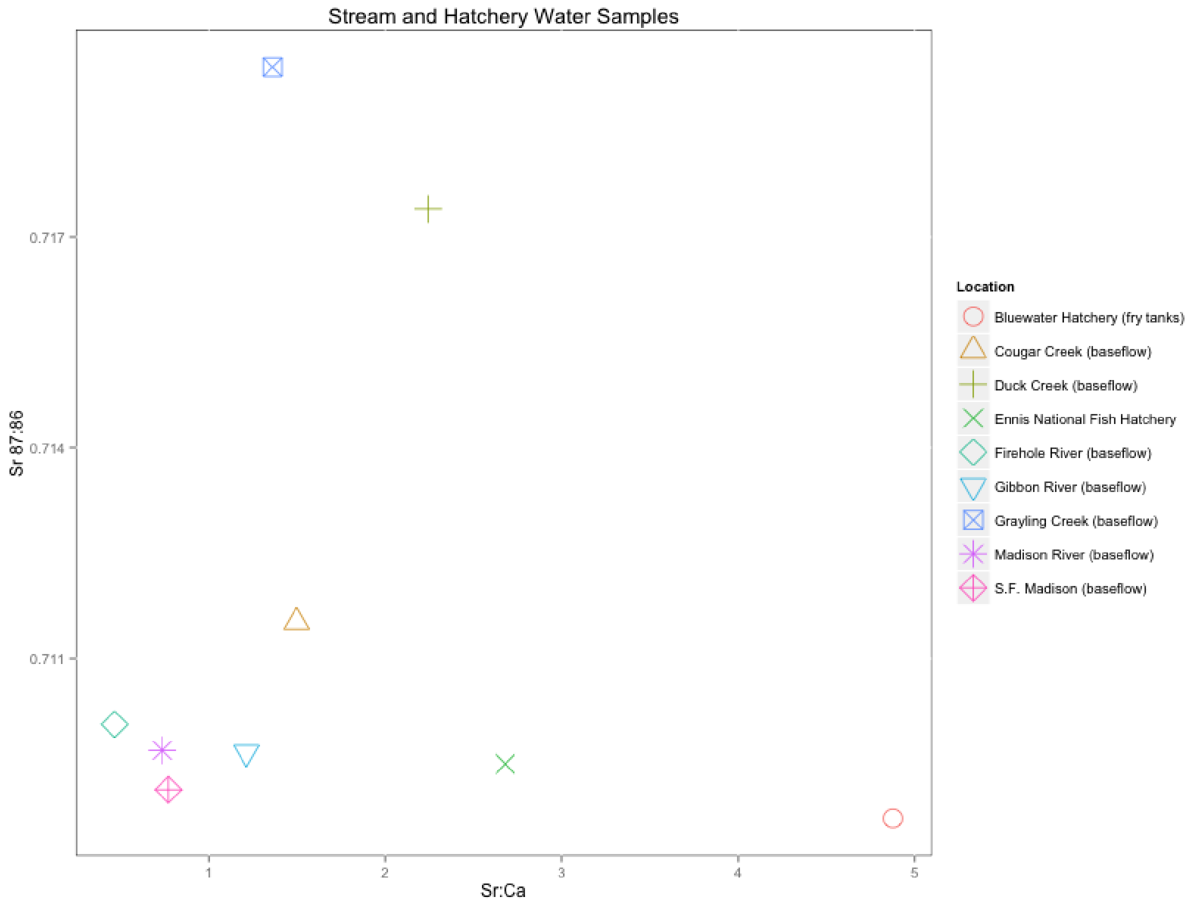


Figure 2. Sr:Ca and ^{87}Sr:^{86}Sr ratios of water samples collected from selected tributaries (2013), the Bluewater Hatchery (2013), and Ennis National Fish Hatchery (2015).

Table 2. Water Sr:Ca ratios before and after partition coefficient adjustment (Sr:Ca*.24)

Location	Sr:Ca	Adjusted Sr:Ca
Gibbon River (baseflow)	1.21	0.29
Firehole River (baseflow)	0.47	0.11
Madison River (baseflow)	0.74	0.18
Grayling Creek (baseflow)	1.36	0.33
Cougar Creek (baseflow)	1.50	0.36
Duck Creek (baseflow)	2.24	0.54
S.F. Madison (baseflow)	0.77	0.19
Bluewater Hatchery (fry tanks)	4.88	1.17
Ennis National Fish Hatchery	2.68	0.64

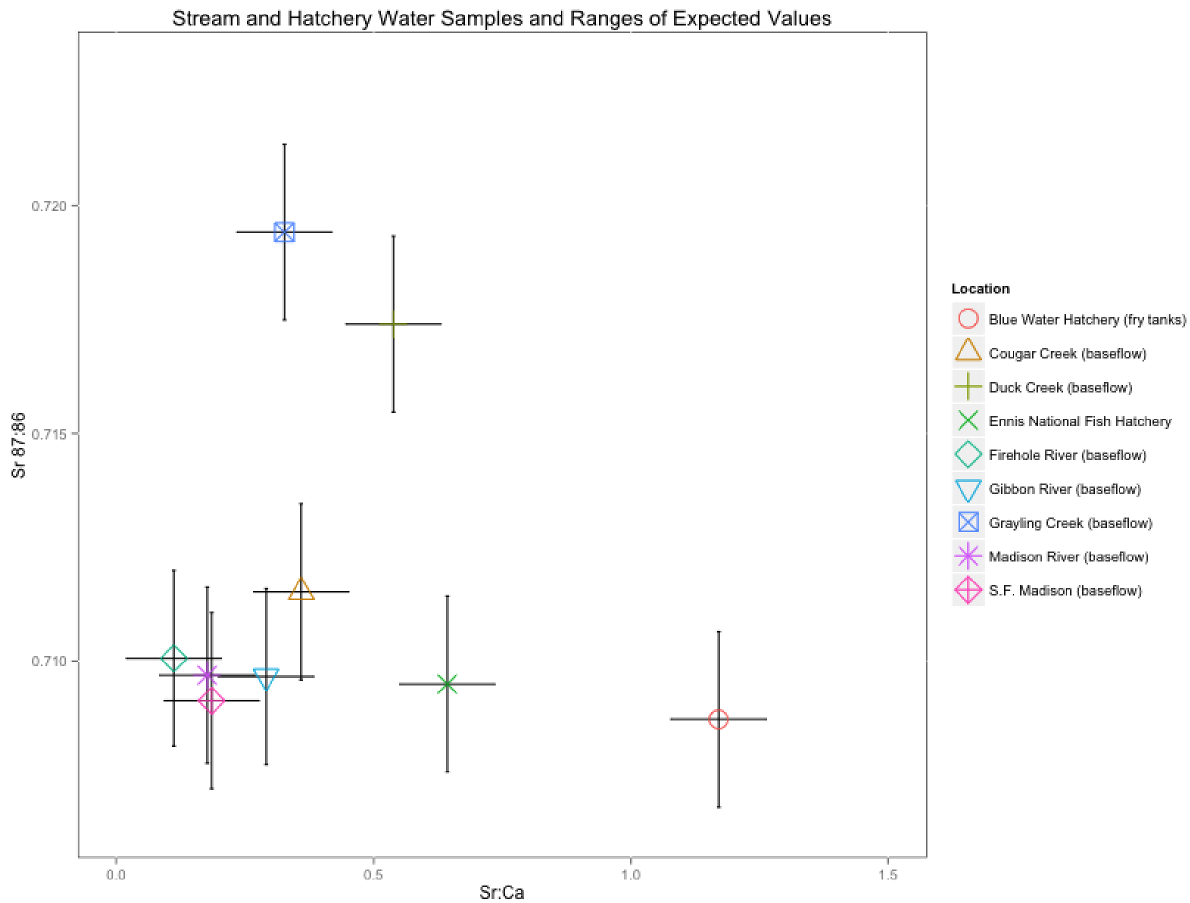


Figure 3. Bivariate plot of water sample Sr:Ca (after applying partition coefficient) and $^{87}Sr{:}^{86}Sr$ ratios; black bars represent ranges of expected values fish would be likely to exhibit if they originated from each stream or hatchery.

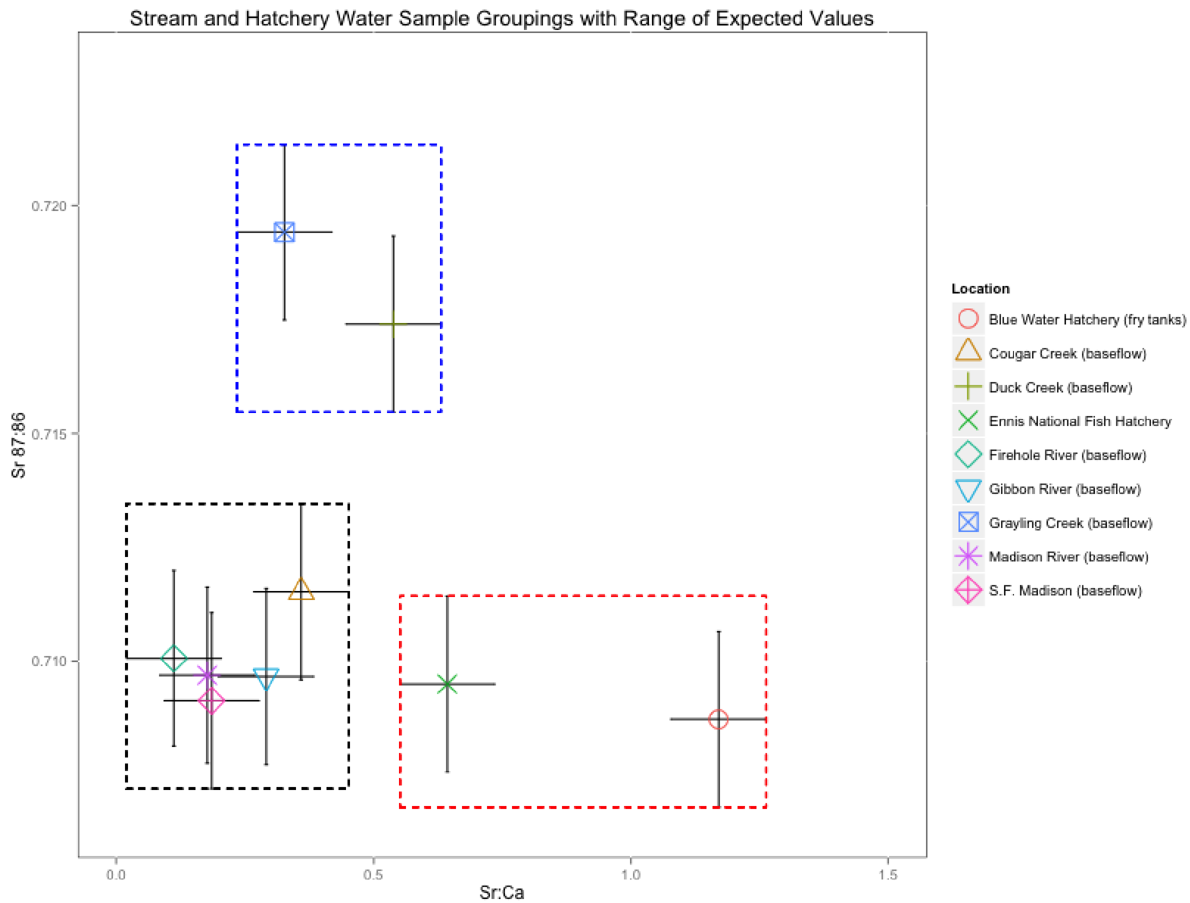


Figure 4. Stream and hatchery groups based on ranges of expected values; hatcheries were grouped together. The squares represent each group, the blue square represents Wild Group 1, the black square represents Wild Group 2, and the red square represents the Hatchery group.

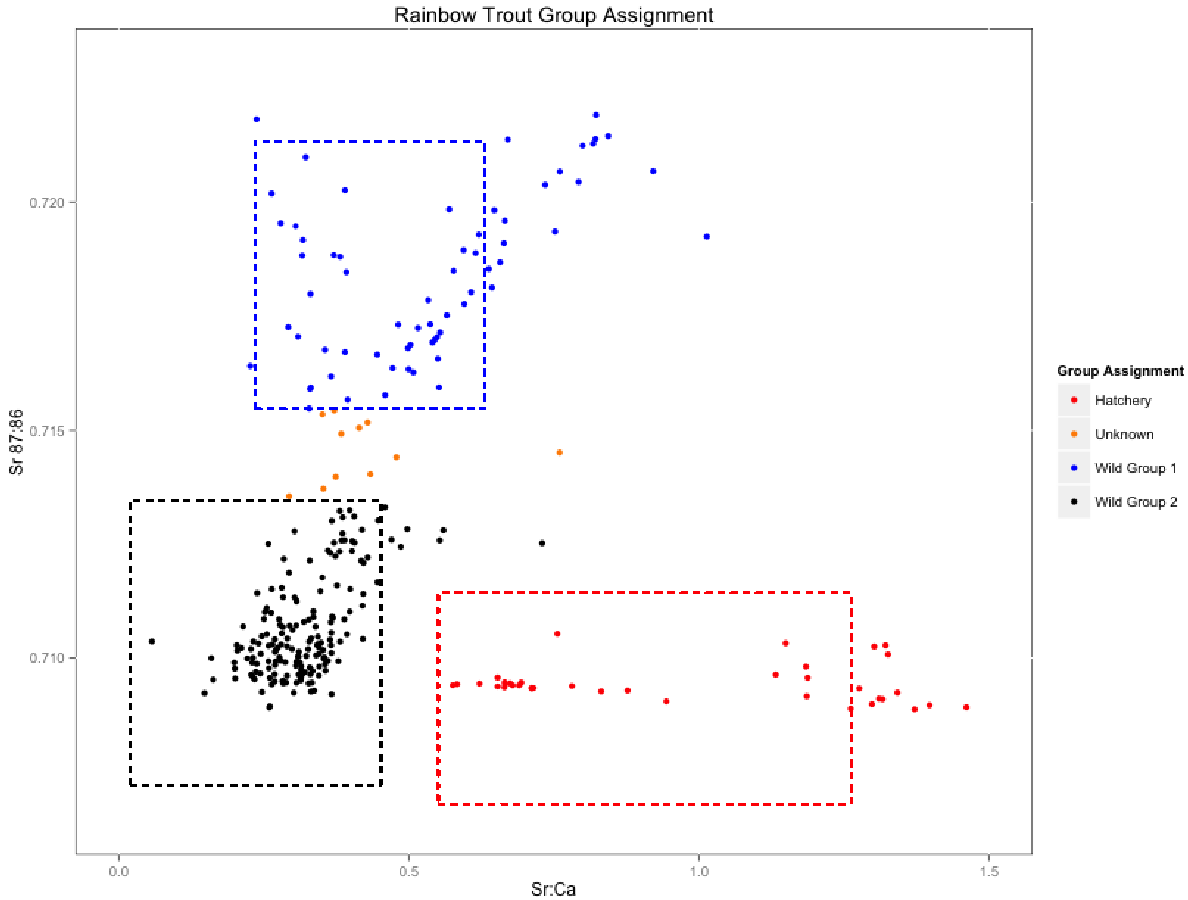


Figure 5. Rainbow trout group assignments. Fish otolith results outside of the boxes were assigned using otolith ^{87}Sr:^{86}Sr results.

Table 3.

Fish Age	Wild Group 1 *n*	Wild Group 2 *n*	Hatchery *n*	Unknown *n*
1	4	20	9	2
2	20	42	14	3
3	16	48	9	3
4	19	37	3	0
5	4	17	1	3
6	1	7	0	0
7	0	3	0	0
8	1	1	0	0
9	0	0	1	0
Total (*n*)	65	175	37	11
Percent (%)	0.23	0.61	0.13	0.04

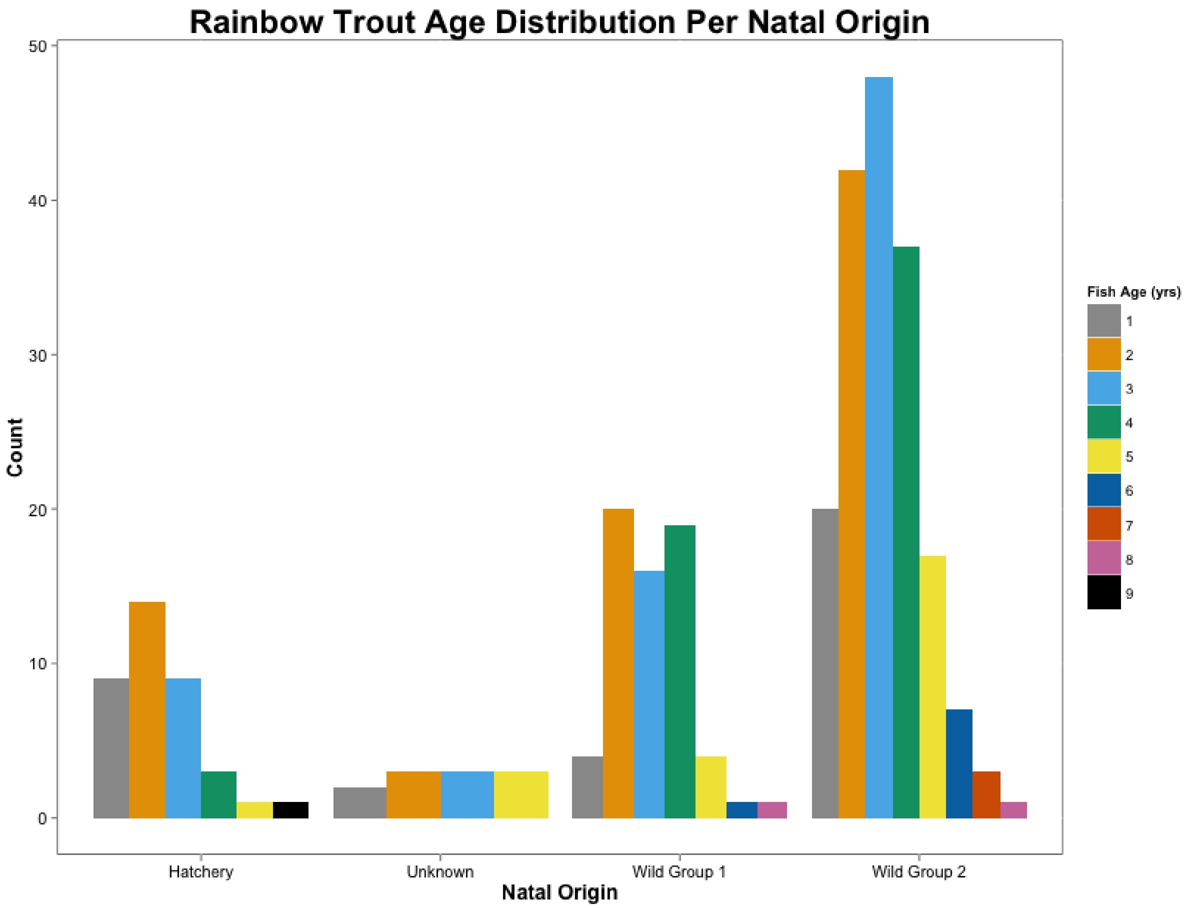
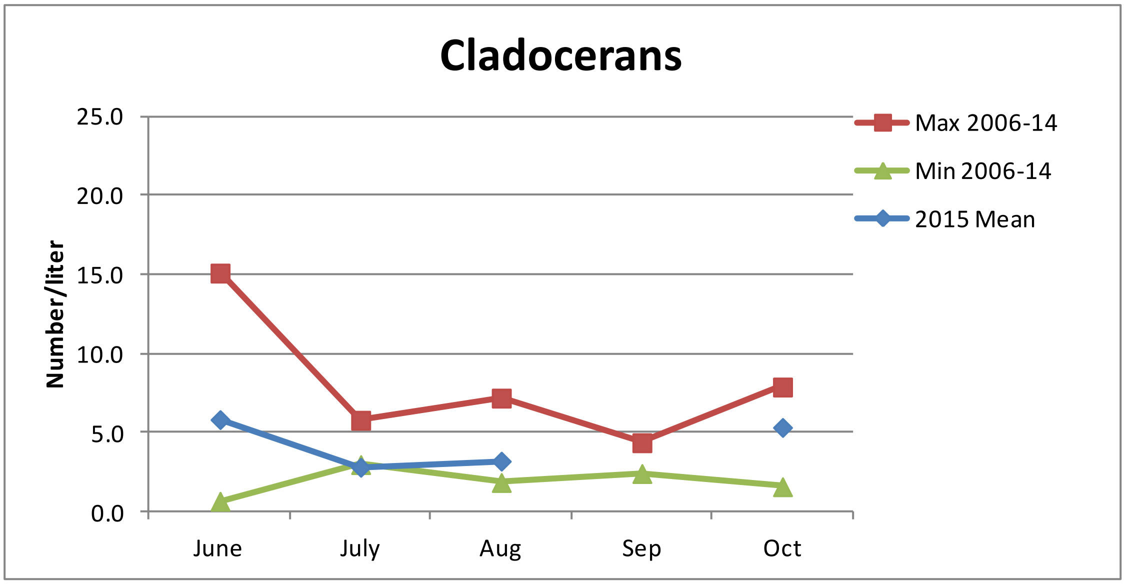


Figure 6. Age and number of fish assigned to each group.

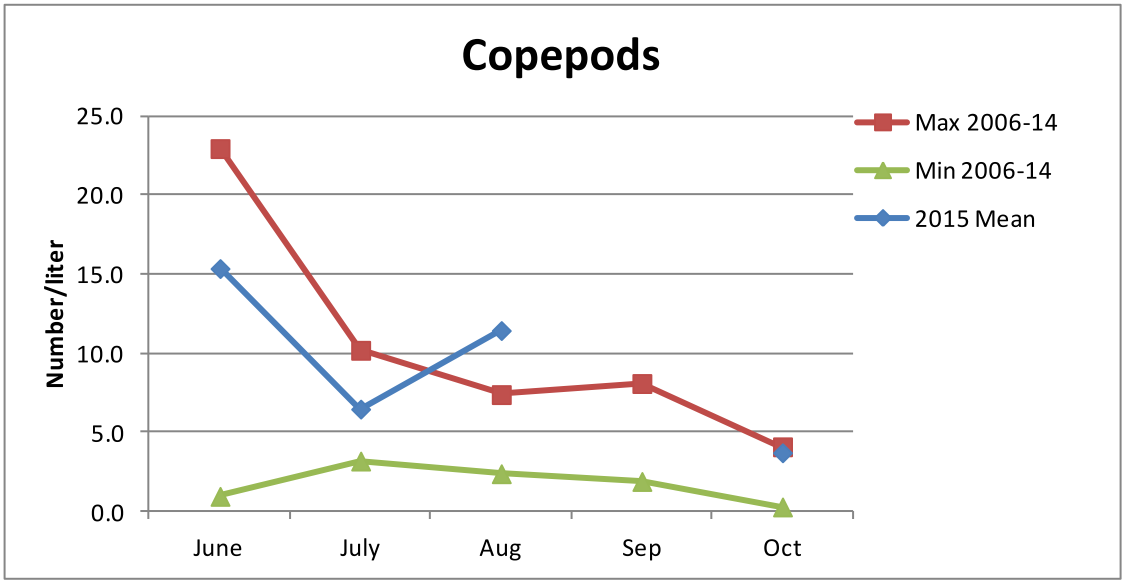
Table 4.

Assigned Group	Grouping (unknowns included) *n* (%)	Grouping (unknowns not included) *n* (%)
Wild Group 1	65 (23)	45(16)
Wild Group 2	175 (0.61)	168(58)
Hatchery	37 (0.13)	26(9)
Unknown	11 (0.04)	49(17)

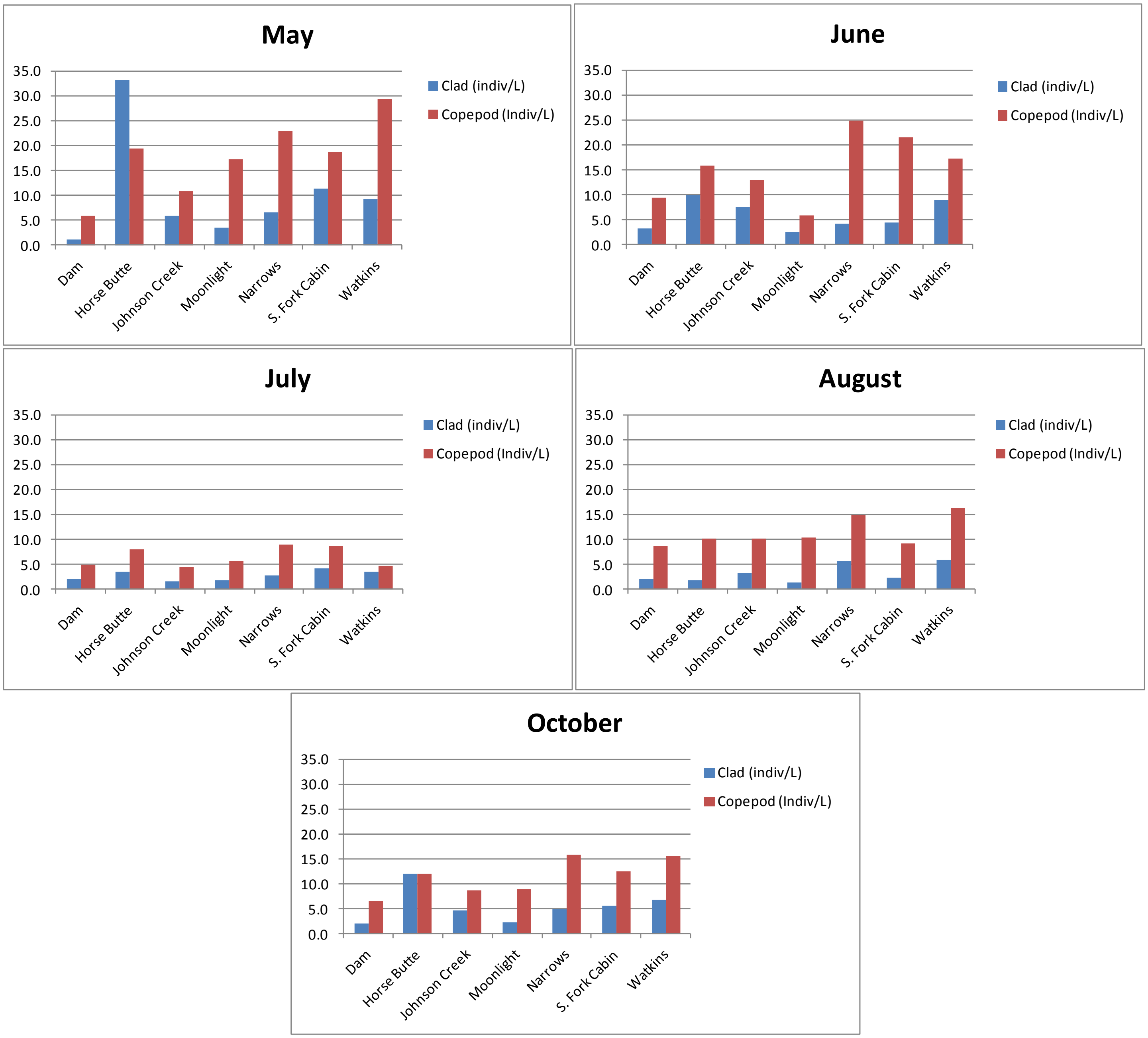
Appendix J
Hebgen Reservoir zooplankton charts



Appendix Figure J -1. Monthly average maximum and minimum cladoceran densities (#/liter) vs 2015 monthly average densities of seven sample sites.



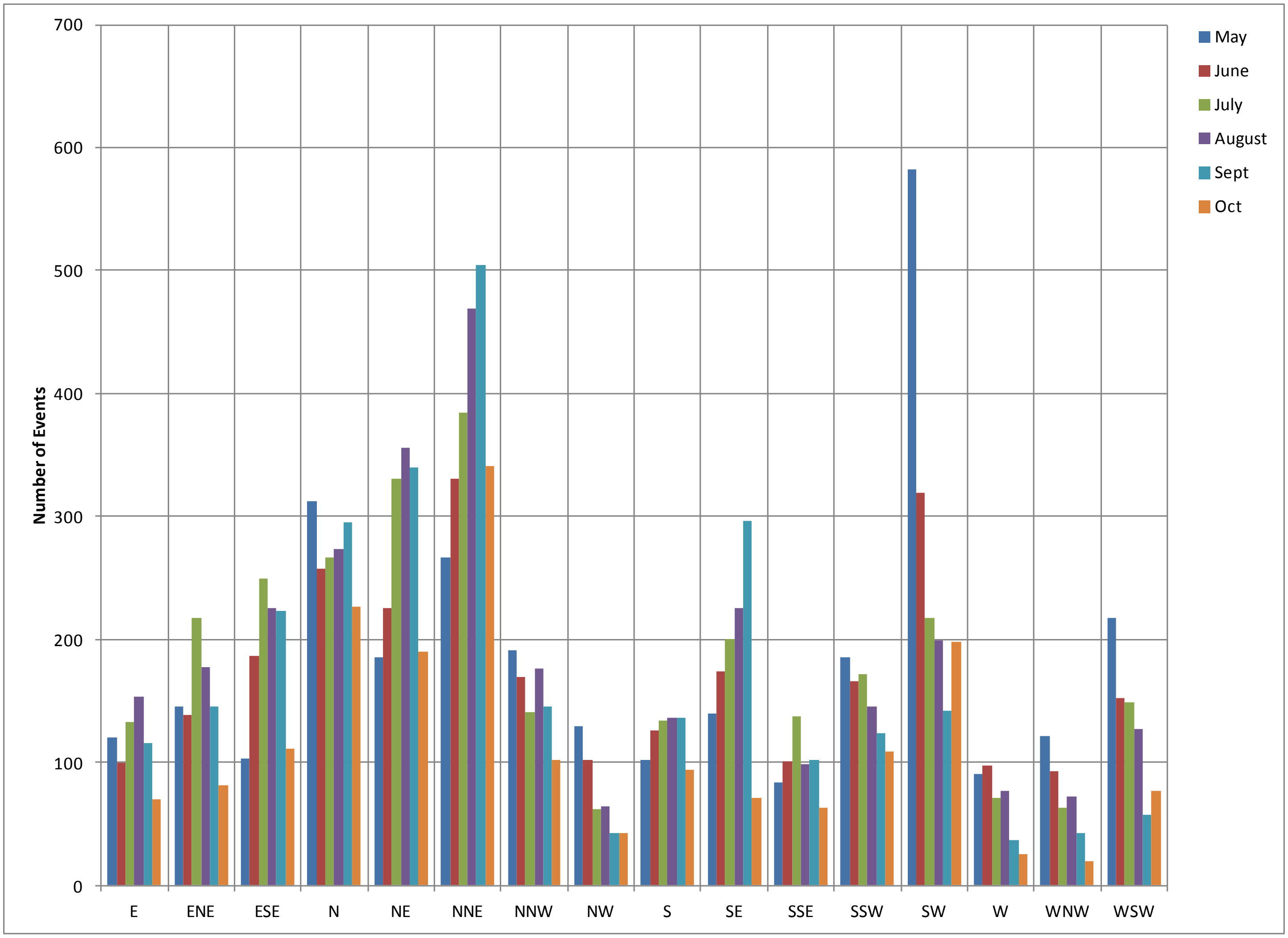
Appendix Figure J -2. Monthly average maximum and minimum copepod densities (#/liter) vs 2015 monthly average densities of seven sample sites.



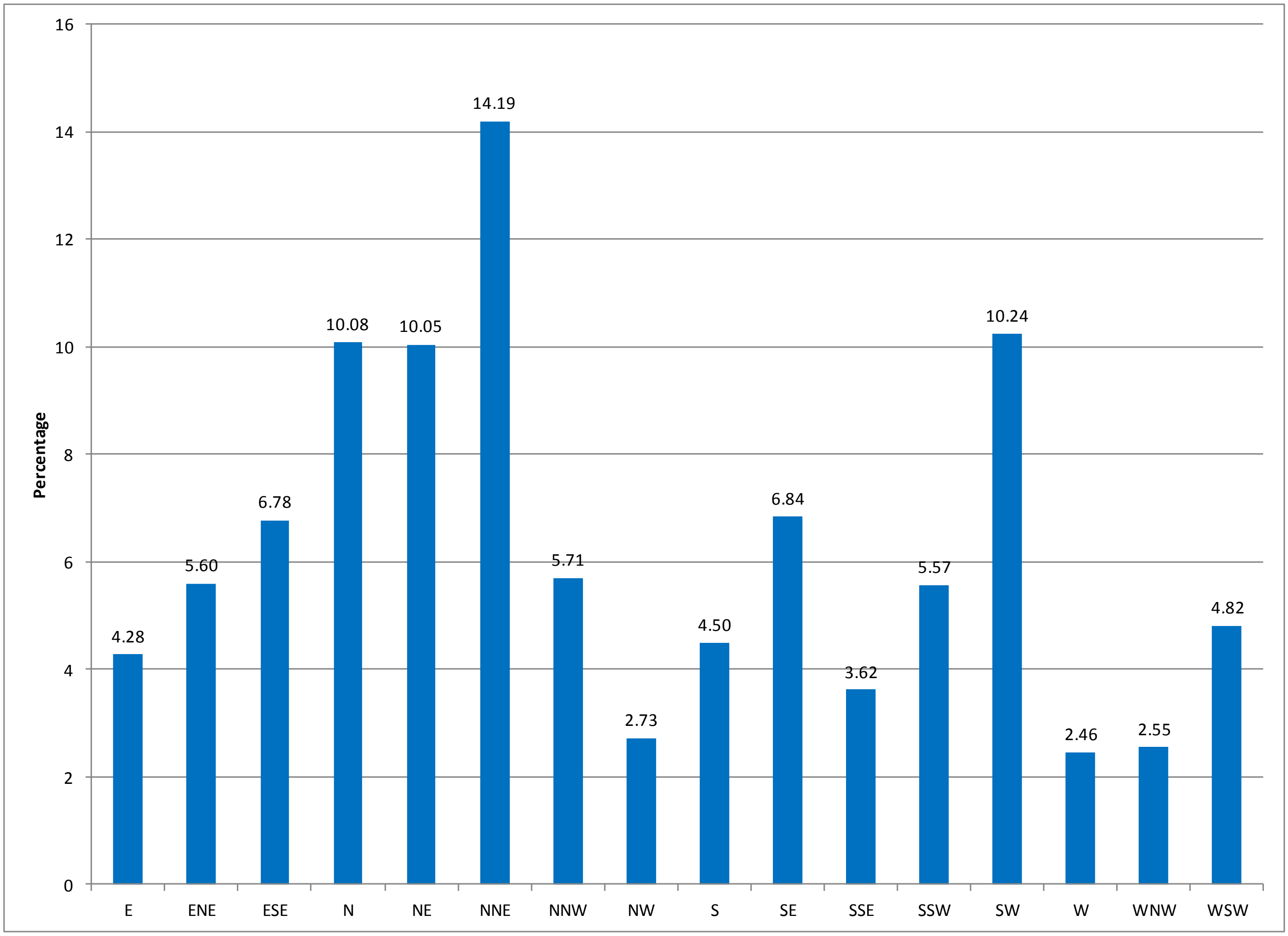
Appendix Figure J -3. Monthly cladoceran and copepod densities (#/liter) at seven sample sites, 2015.

Appendix K

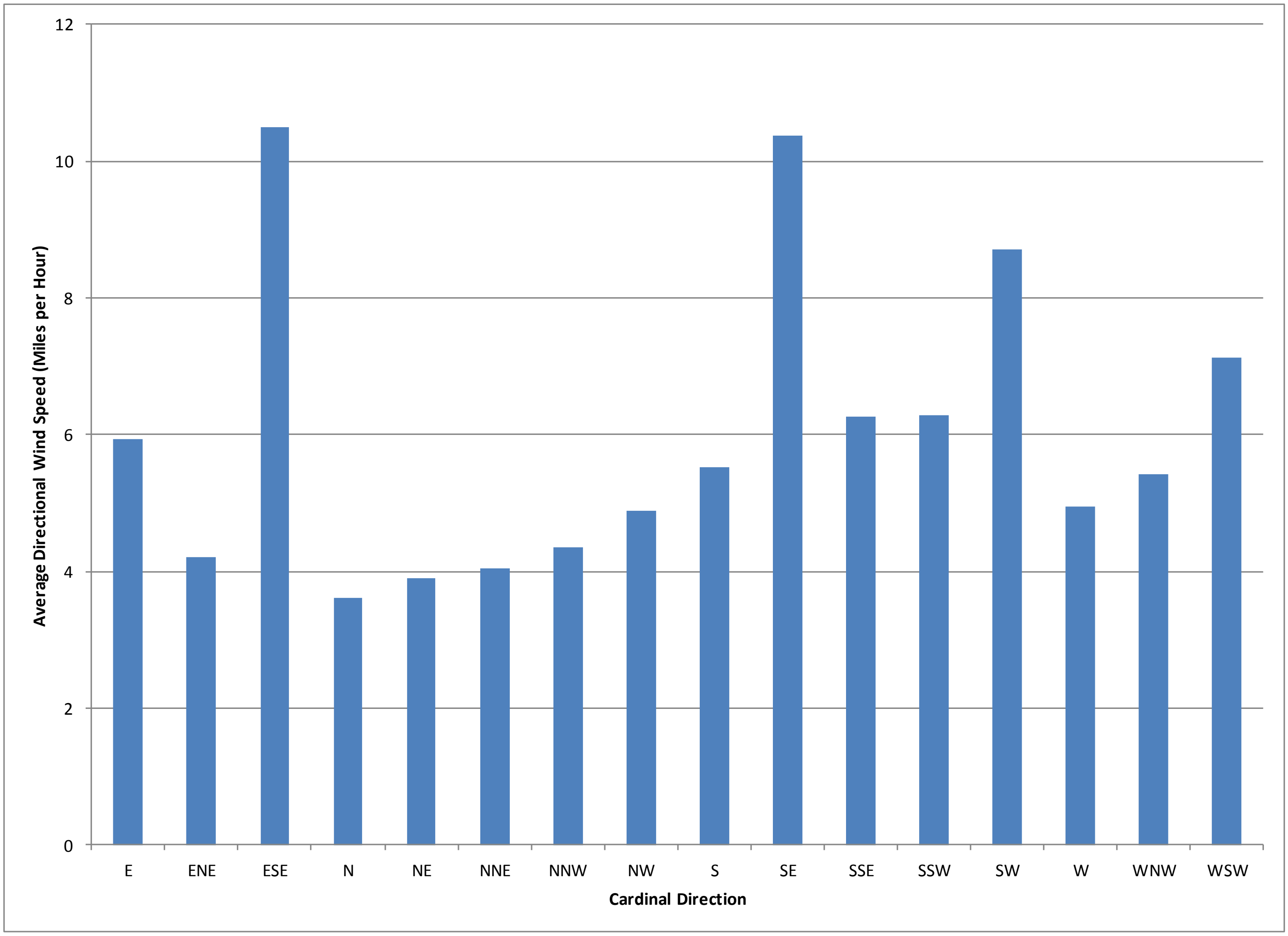
Hebgen Reservoir wind data, 2015



Appendix Figure K-1. Number of wind events by direction for Hebgen Reservoir, May - September, 2015.



Appendix Figure K-2. Distribution of wind direction by percent occurrence for Hebgen Reservoir, May – September, 2015.



Appendix Figure K-3. Directional average wind speed (miles per hour) at Hebgen Reservoir, May – September, 2015.