Madison River Drainage Fisheries

and

Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program

2008
Annual Report
to
PPL Montana
Environmental Division
Butte
www.pplmontana.com

and

Turner Enterprises, Inc.
Bozeman

by

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Montana Fish, Wildlife, & Parks
Ennis
August 2009

Montana Fish, Wildlife & Parks
www.fwp.mt.gov

INTERNET WEB PAGES CITED IN THIS REPORT
(in alphabetical order)

Aquatic Nuisance Species Task Force................www.anstaskforce.gov
Blue Ribbon Flies ....www.blueribbonflies.com
Ennis on the Madison Flyfishing Festival/Madison River Foundation...
www.ennisflyfishing.com
Lower Madison River Monitoring page....
www.madisondss.com/ppl-river.cfg/ppl-madison.php
Montana Fish, Wildlife, & Parks......................www.fwp.mt.gov
New Zealand Mudsnail in the Western USA........
www.esg.montana.edu/aim/mollusca/nzms
PPL Montana..www.pplmontana.com
Protect Your Waters...................................www.protectyourwaters.net
Whirling Disease Foundation.........................www.whirling-disease.org

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

FERC Articles addressed in this report

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EXECUTIVE SUMMARY

Beach seining for young-of-the-year Arctic grayling and mountain whitefish was conducted in late September. Juvenile rainbow trout, brown trout, Utah chub and white sucker were captured, but no Arctic grayling. Rainbow trout over six inches were estimated at 1500 – 2000/mile in the Pine Butte and Norris sections, while brown trout were estimated at 1000 – 1500/mile. Estimates were not conducted in the Varney section due to high river flows. Water temperature was monitored at 14 sites and air temperature at 7 sites within the Madison Drainage. New Zealand mudsnails were found to be persistent throughout the river, but at the lowest densities since initial detection. Sentinel fish from captive rainbow trout stock are still severely infected by whirling disease in the river, but wild rainbows appear to be developing a resistance to the disease. The Sun Ranch hatchery was used to incubate eggs for the southwest Montana westslope cutthroat trout conservation and restoration program. The Cherry Creek Native Fish Introduction Project continued in 2008 with the second treatment of Phase 3. Westslope cutthroat trout eyed egg introductions were continued in Phase 1 and initiated in Phase 2 in 2008. The West Madison Canal was monitored via electrofishing to assess characteristics of fish entrainment. Concerned anglers and citizens conducted fish salvage in the West Madison Canal after the headgate was closed in the Fall. The response of fish populations to stream restoration in O'Dell Creek was monitored. The number of rainbow trout captured during annual Hebgen Reservoir gillnetting increased markedly from 2007. The proportion of rainbow trout over 14 inches in the Hebgen gillnet catch has increased noticeably since 2005. Whirling disease, salmincola, and blackspot disease were monitored in reservoir fish. Trapping of rainbow trout immigrating into Hebgen tributaries to spawn continued. Zooplankton density in Hebgen Reservoir peaked in July.

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INTRODUCTION

Montana Fish, Wildlife, & Parks (MFWP) 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, MFWP 1995, MFWP 1996, MFWP 1997, MFWP 1998a, MFWP 1999a, MFWP 2000, MFWP 2001, MFWP 2002, MFWP 2003, MFWP 2004a, MFWP 2005, MFWP 2006, MFWP 2007). This work has been funded through an agreement with the owner and operator of the dams, initially Montana Power Company (MPC), now PPL Montana. The original agreement between MFWP 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). PPL Montana 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 PPL Montana and several agencies. Each committee has an annual budget and authority to spend money that is provided to them by PPL Montana to address the requirements of PPL Montana's FERC license for operating the Madison & Missouri dams. The Madison Fisheries Technical Advisory Committee (MadTAC) is composed of personnel of PPL Montana, MFWP, the U.S. Fish & Wildlife Service (USFWS), the U.S. Forest Service (USFS), and the U.S. Bureau of Land Management (BLM). Each entity has equal authority in decision making within the TAC. Collectively, the nine dams on the Madison and Missouri rivers are called the 2188 Project, which refers to the Federal Energy Regulatory Commission (FERC) license number that authorizes their operation. The Federal Energy Regulatory Commission issued PPL Montana a license to operate the 2188 Project for 40 years (Federal Energy Regulatory Commission 2000). The license details the terms and conditions PPL Montana 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 (MUCAWCTM). The MUCAWCTM, which was formalized in 1999 (MFWP 1999b), 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

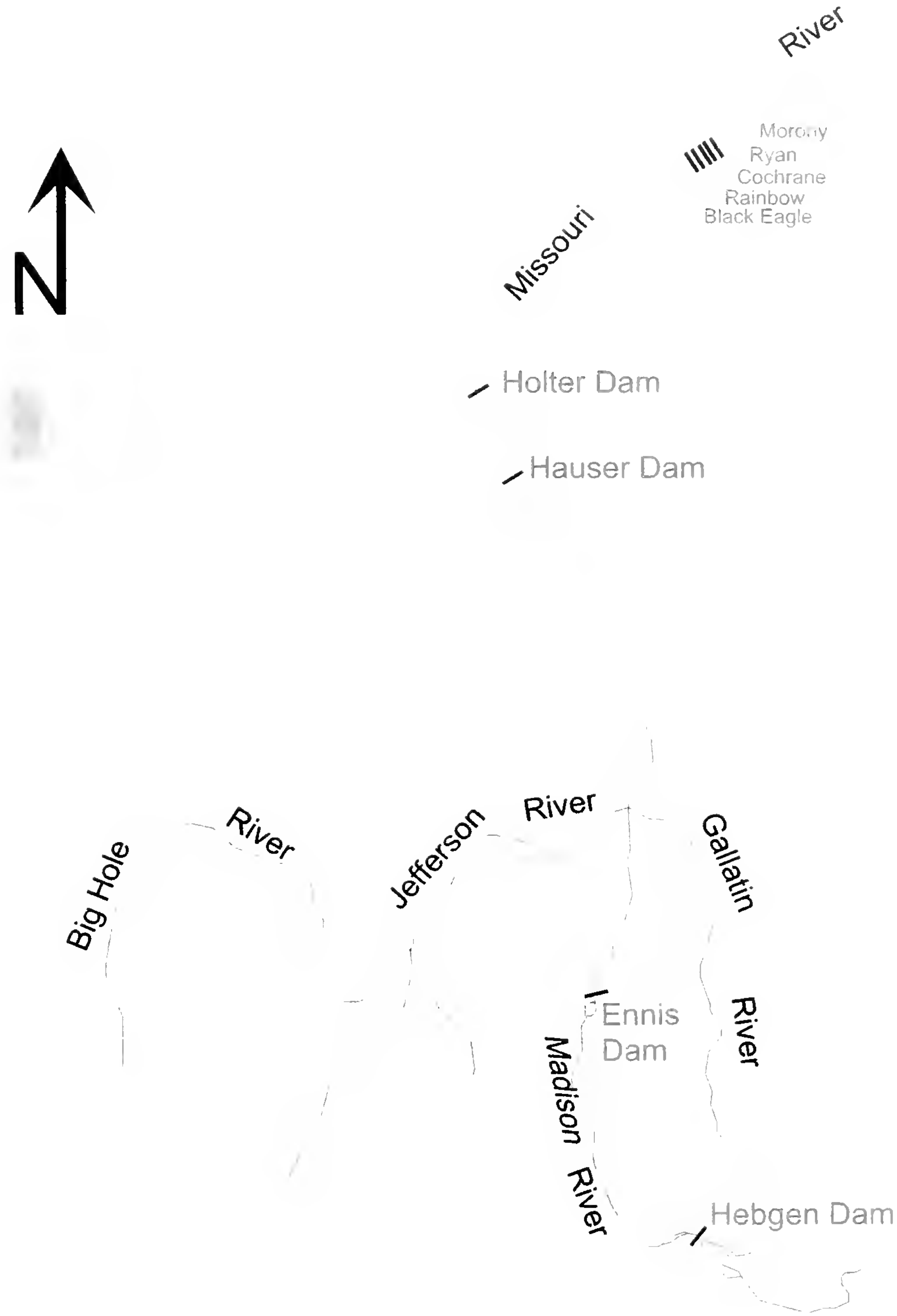


Figure 1. Locations of PPL Montana dams on the Madison and Missouri rivers (FERC Project 2188).

5. Design and implement an effective monitoring program by the year 2002 to document persistence and demonstrate progress towards goal

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.

Entities participating in the development of the MUCAWCTM were American Wildlands, Montana Chapter of the American Fisheries Society, Montana Department of Natural Resources and Conservation (MDNRC), Montana Farm Bureau, MFWP, Montana Stockgrowers Association, Montana Trout Unlimited, Montana Wildlife Federation, Natural Resource Conservation Service, BLM, USFS, USFWS, and private landowners.

In 2006, the MUCAWCTM was updated and combined with a similar document for Yellowstone Cutthroat Trout *Oncorhynchus clarki bouvieri*.

Late in 1996, MFWP initiated a program entitled "The Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program". The goal of this 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 MFWP and PPL Montana includes provisions to address issues regarding species of special concern.

In recognition of the severity of the situation faced by the westslope cutthroat trout, and in keeping with the philosophy of promoting native species on their properties, Turner Enterprises, Incorporated (TEI) offered access to the Cherry Creek drainage on the Flying D Ranch to assess its suitability for introducing westslope cutthroat. Cherry Creek, a tributary to the Madison River, was identified as an opportune location to introduce genetically pure WCT, and it will provide an opportunity to meet or fulfill MUCAWCTM objectives 3, 4, & 5. MFWP determined in 1997 that introducing westslope cutthroat to Cherry Creek is feasible, but would require the removal of all non-native trout presently in that portion of the drainage (Bramblett 1998, MFWP 1998b). MFWP, TEI, and the Gallatin National Forest (GNF) subsequently entered into an agreement to pursue this effort. The agreement outlines the roles and responsibilities of each party, including the GNF, which manages the public land at the upper end of the Cherry Creek drainage. Administrative and legal challenges to the Cherry Creek Project delayed its implementation from 1999 - 2002. The project was successfully implemented in 2003.

In 2001, the Sun Ranch entered into an agreement to assist MFWP with westslope cutthroat trout conservation and recovery. The ranch built a small hatchery facility and a rearing pond to facilitate development of a westslope cutthroat trout broodstock for the Madison and Missouri river drainages, and provided personnel to assist with fieldwork and conduct hatchery operations.

METHODS

Madison Grayling

A beach seine (Figure 2) is used to monitor index sites in Ennis Reservoir (Figure 3) for young-of-the-year grayling and other fish species. Seining is conducted by pulling a 125 x 5 foot fine-mesh net along shallow areas in the reservoir.

Figure 2. Beach seining in Ennis Reservoir.

Population Estimates

Electrofishing from a driftboat mounted mobile anode system (Figure 4) is the principle method used to capture Madison River trout for population estimates in several sections of the Madison River (Figure 5). Fish captured for population estimates are weighed and measured, marked with a fin clip, and released. A log-likelihood statistical analysis (MFWP 2004b) is used to estimate trout populations.

In recent years estimates for all sections and all years have been converted from age-based estimates to length-based estimates due partially to the major time requirement necessary to age fish, and to maximize the statistical probability that the estimates are accurate.

Figure 3. Locations of Ennis Reservoir 2008 seining sites.

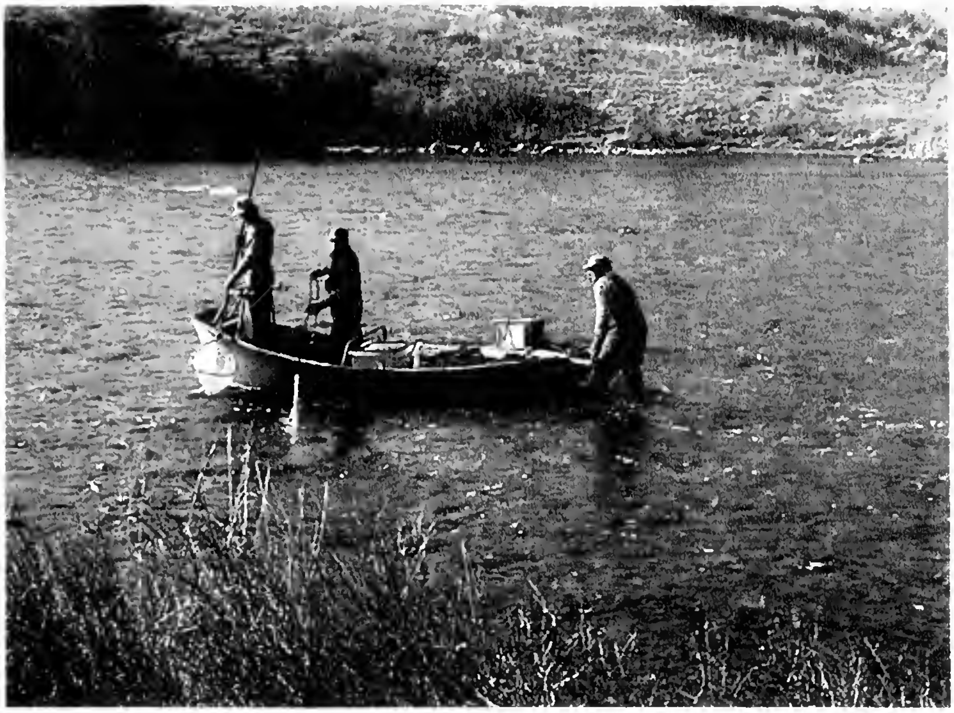


Figure 4. Electrofishing (shocking) in the Norris section of the Madison River.

River Discharge

Article 413 of the FERC license mandates PPL Montana 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 accomplish this. 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. Pulsed flows are triggered when water temperature at the Madison (Ennis) Powerhouse is 68° F or higher and forecast air temperature at Three Forks for the following day is 80° F or higher. The volume of water released in the pulse is determined by how much the water and/or air temperature exceeds the minimum thresholds (Table 1). The increase in water volume in the lower river reduces the peak water temperature that would occur at the 1100 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/ppl-river.cfg/ppl-madison.php.

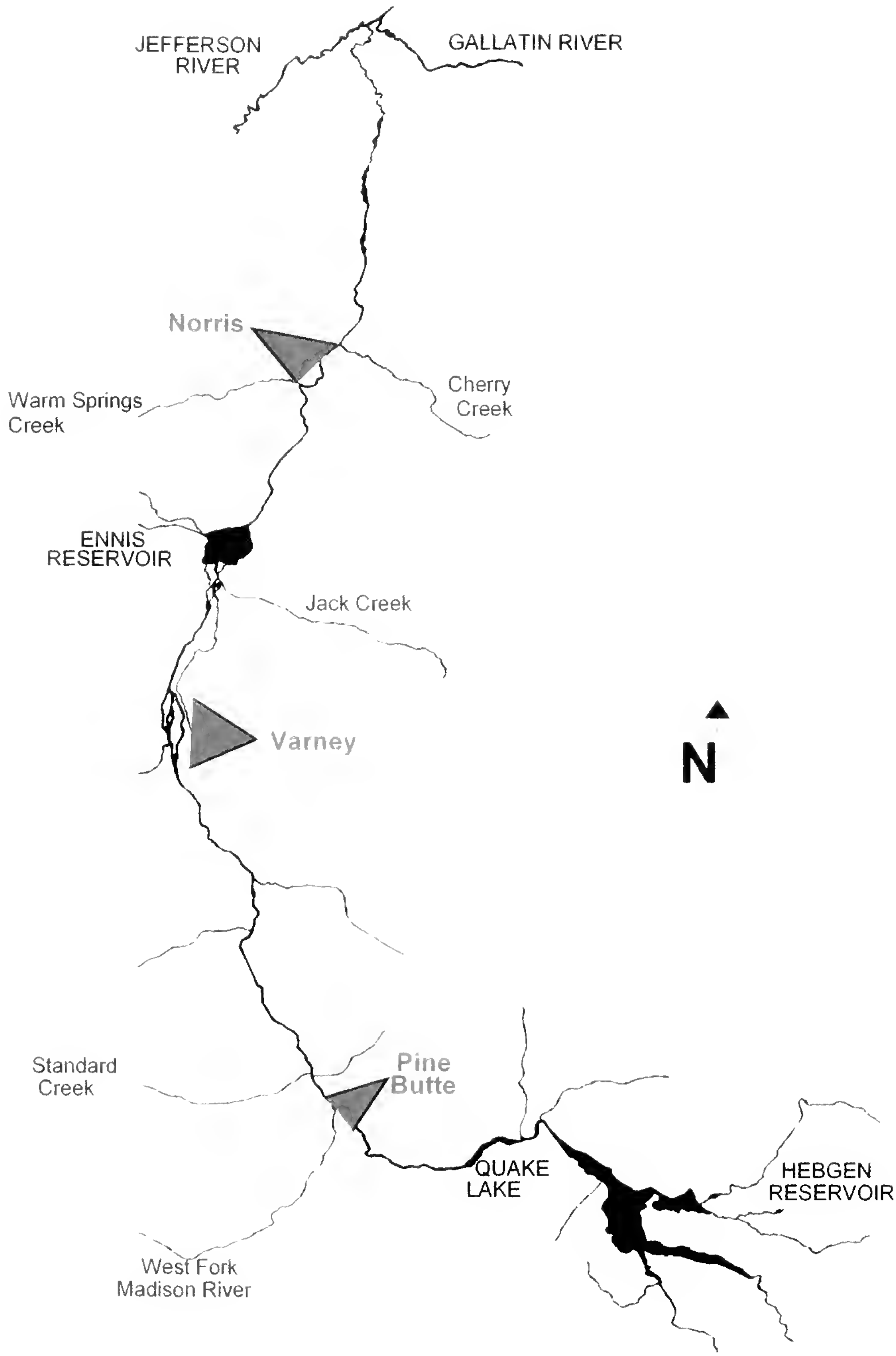


Figure 5. Locations of Montana Fish, Wildlife, & Parks 2008 Madison River population estimate sections. Estimates were not conducted in the Varney section in 2008 due to high Fall river discharge.

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	≥ 68°, < 70°	< 80° No action	≥ 80° 1400 cfs	
Pulsing Required, Volume Contingent of Weather Forecast > 90°F	≥ 70°, < 72°	< 90° 1400 cfs	≥ 90°, < 95° 1600 cfs	≥ 95° 2100 cfs
Pulsing Required, Volume Contingent of Weather Forecast > 85°F	≥ 72°, < 73°	< 85° 1400 cfs	≥ 85°, < 90° 1600 cfs	≥ 90° 2100 cfs
Pulsing Required, Volume Contingent of Weather Forecast > 85°F	≥ 73°	< 85° 1800 cfs	≥ 85° 2400 cfs	

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 soil for terrestrial vegetation and other wildlife needs.

On August 31, stop logs in the Hebgen Dam intake structure in the reservoir catastrophically failed, increasing river flow immediately below the dam from 850 cfs to 3300 cfs in 2 hours. The intake structure is in the reservoir near Hebgen Dam, but the event did not affect the stability of the dam. River discharge remained over 3000 cfs for 28 days until flow through the intake structure was controlled. During the event Hebgen Reservoir elevation decreased approximately 10 feet to normal winter operational elevation.

Temperature Monitoring

Water temperature was recorded at 14 sites and air temperature at seven sites throughout the course of the Madison River from above Hebgen Reservoir to the mouth of the Madison River at Headwaters State Park (Figure 6). Optic StowAway temperature loggers recorded temperature in Fahrenheit every 30 minutes. Air temperature recorders were placed in areas that were shaded 24 hours per day.

Aquatic Nuisance Species

Highway signs announce FWP's West Yellowstone Traveler Information System (TIS) (Figure 7). 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 ANS to other waters. 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.

The State of Montana hired an Aquatic Nuisance Species Coordinator in 2004. The position is responsible for developing and coordinating ANS control & management activities among state agencies as well as between state and non-state entities. The ANS 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 ANS during work activities. The ANS Coordinator is an employee of FWP.

<u>New Zealand Mudsnails</u>

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

<u>Whirling Disease</u>

Whirling disease monitoring has been conducted in the Madison River since 1996 by using sentinel cage techniques. Each cage holds 50 young-of-the-year rainbow trout for 10 days. At the end of the 10 day period, fish are transferred to whirling disease free water in a laboratory where they are held until they are 90 days old, at which time they are euthanized and sent to the Washington Animal Disease Diagnostic Lab (WADDL) for analyses. Juvenile rainbow trout used in the studies are not offspring of Madison River fish,

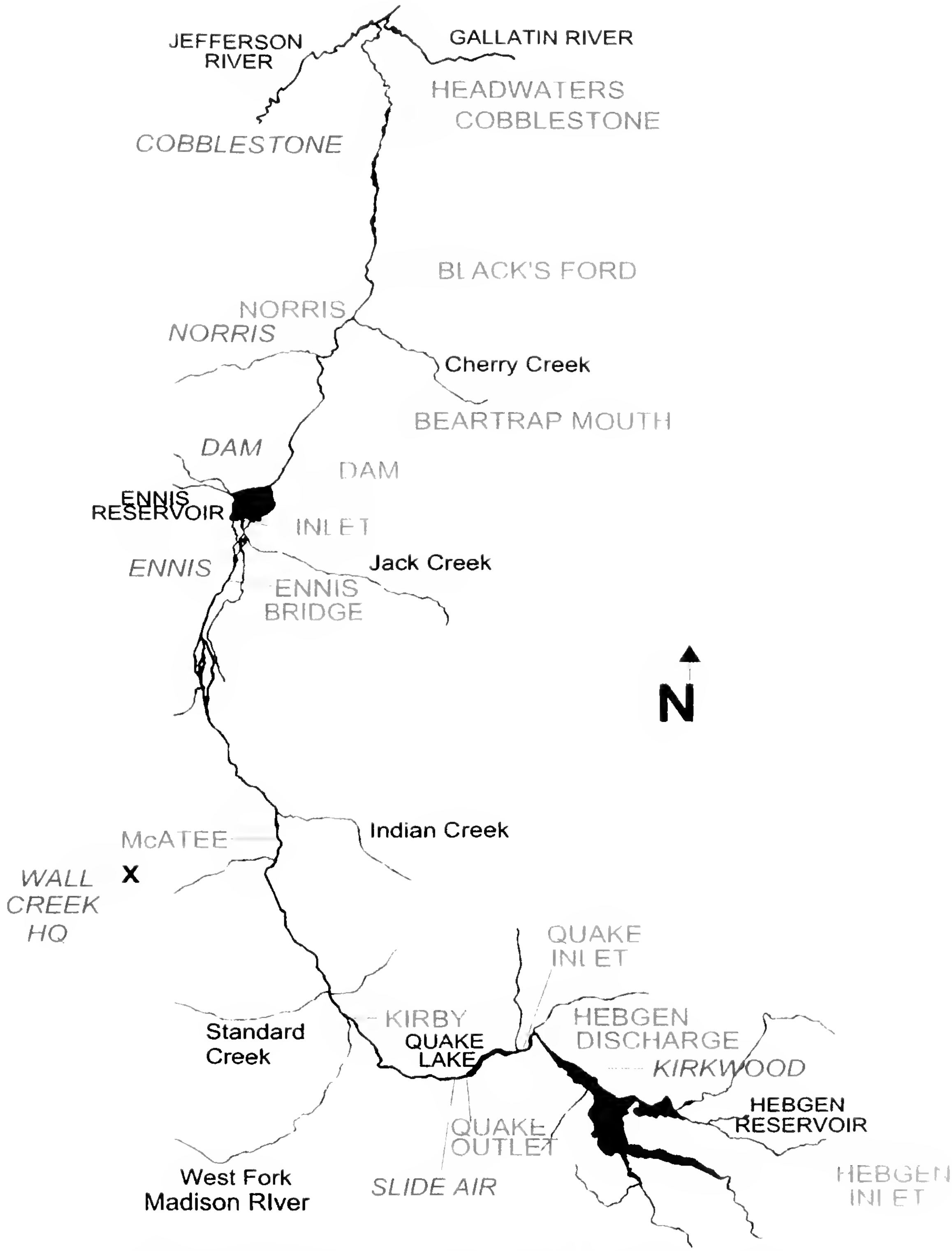


Figure 6. Locations of Montana Fish, Wildlife, & Parks annual temperature monitoring sites. Air temperature sites are blue, water temperature sites are in red.

Figure 7. Roadside sign announcing the Traveler Information System at West Yellowstone.

but are from the same captive stock used since studies began in 1996. This stock has been used continuously over the years to allow comparison over time and between various rivers.

Dave Kumlien, Executive Director of the Whirling Disease Foundation, presents two articles regarding whirling disease on the Blue Ribbon Flies webpage. These articles summarize some of the advances that have been made by whirling disease researchers and additional information that is needed. To view these and other articles, go to www.blueribbonflies.com, click on Journal, then on Articles and Essays.

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 (MFWP 1998a, Sloat et al. 2000). Backpack electrofishing was used to survey fish species. Removal of non-native species will require use of the EPA registered piscicides (fish-pesticides) rotenone or antimycin.

The Madison District of the U.S. Forest Service conducts projects to benefit westslope cutthroat trout and to restore stream habitat in tributaries to the Madison River. Grant money from the PPL Montana relicensing agreement paid for materials and operations, and members of the Madison River Foundation, the Madison-Gallatin Chapter of Trout Unlimited, and the Montana Conservation Corps provided labor.

Sun Ranch Westslope Cutthroat Trout Brood

Gametes (eggs & sperm) for the Sun Ranch Westslope Cutthroat Trout program were collected from four streams and from the Sun Ranch Pond in 2008. All fertilized eggs were transported to the Sun Ranch Hatchery for incubation and hatching (Figure 8). A portion of the resulting fry from two of the streams and the Sun brood were introduced to

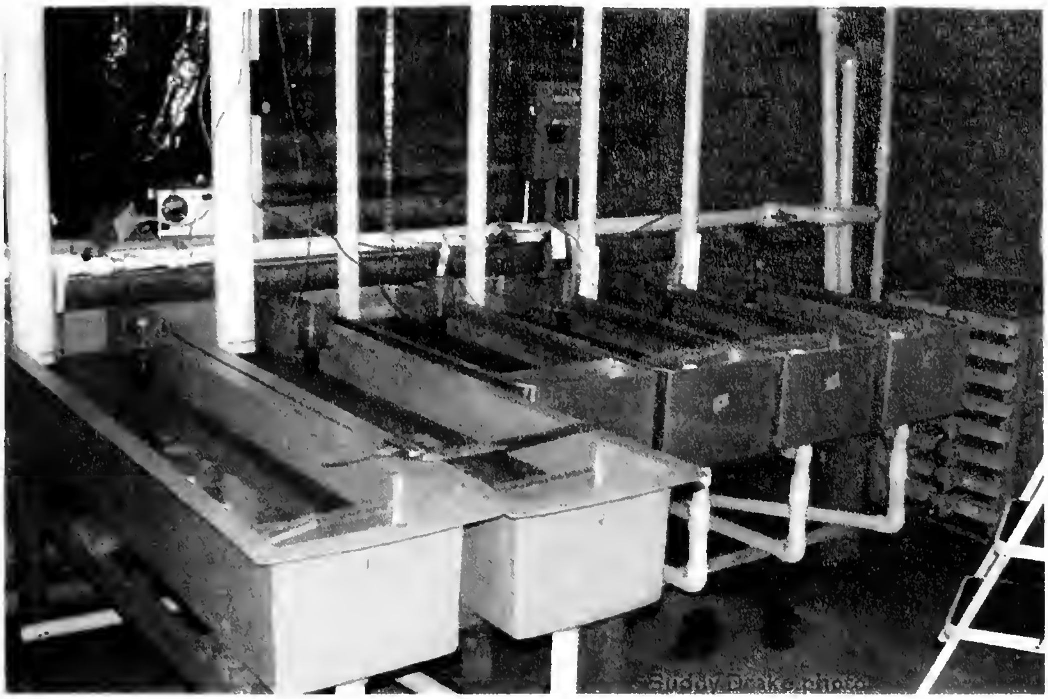


Figure 8. Sun Ranch Hatchery rearing troughs.

the Sun Ranch Brood Pond (Figure 9) to contribute to the Sun Ranch brood development. One of the two contributing streams was a new population not previously represented in the brood. Two of the wild populations did not contribute to the Sun brood in 2008 because they contributed in previous years. Fry from the Sun Ranch Pond broodstock were used for introductions in Cherry Creek and stocked into the pond to facilitate development of the Sun Ranch brood.

Occasionally, when project personnel are unavailable to do so, USFWS personnel from the Ennis National Fish Hatchery caretake the eggs or fry at the Sun Ranch Hatchery. Generally, this requires few days each year, but is an important contribution to the program.

Cherry Creek Native Fish Introduction Project

The Cherry Creek Native Fish Introduction Project was initiated in 2003. The project area is comprised of over 60 miles of stream habitat and the 7-acre, 105 acre-foot Cherry Lake, and includes all of the Cherry Creek Drainage upstream of a 25-foot waterfall (Figure 10) approximately 8 miles upstream of the Madison River confluence. The only fish species present in the project area in 2003 were brook trout, rainbow trout, and Yellowstone cutthroat trout (YCT) (Figure 11). The large size of the project area requires that the project be completed in phases. Each phase will be treated for at least two consecutive years. In 2008 all of the Phase 3 mainstem and tributaries received their second treatment.

Figure 9. Sun Ranch Brood Pond.

Figure 10. Cherry Creek waterfall at stream mile 8.0. This falls is the downstream extent of the project area.

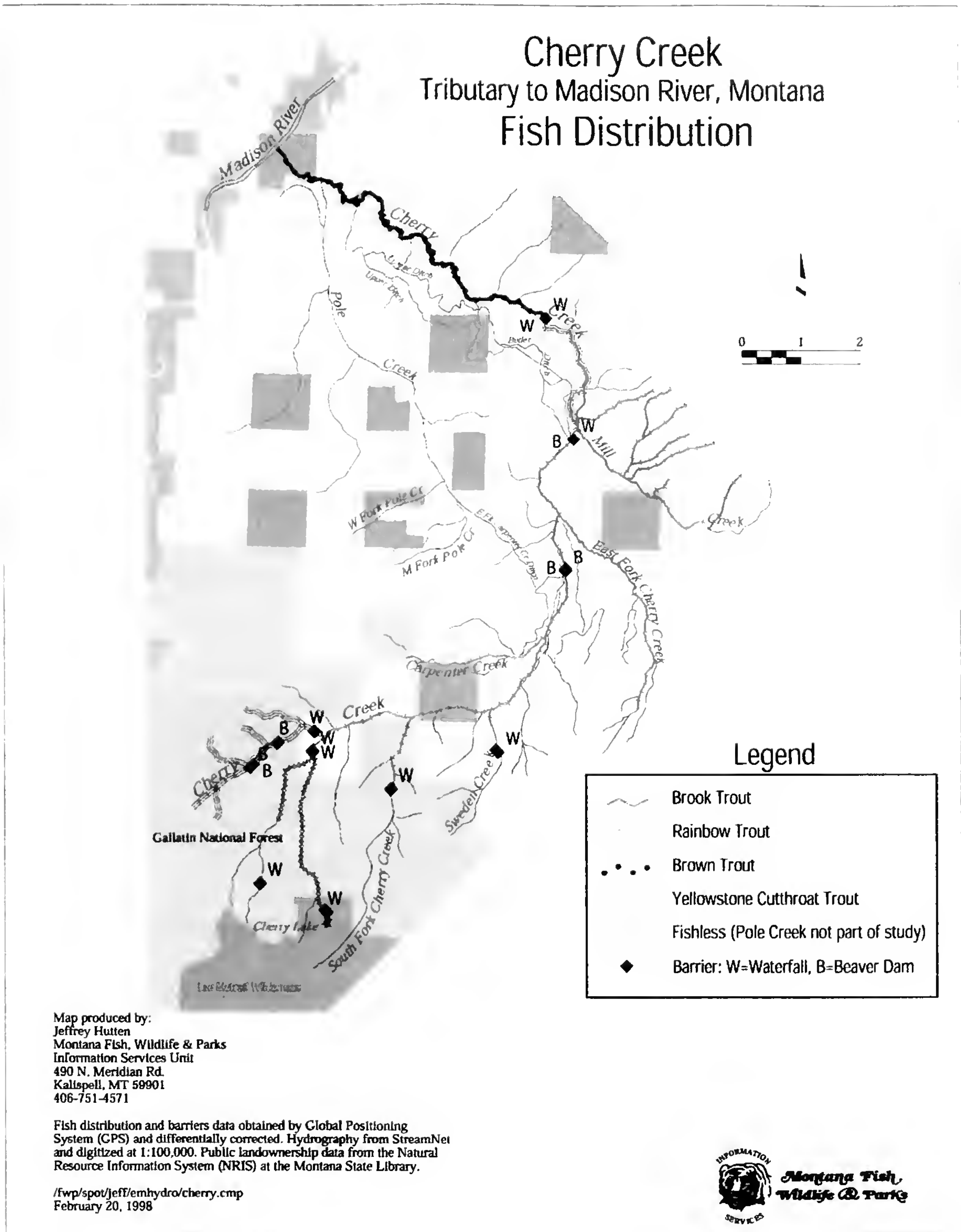


Figure 11. Cherry Creek Drainage. Landownership patterns have changed since this map was produced.

Preparatory fieldwork consisted of determining stream flow time, placing application station markers, posting sentinel fish, setting up the detoxification station, and some electrofishing to assess thoroughness of previous years treatments.

Fintrol was unavailable for use at Cherry Creek in 2007 and 2008 due to a production problem, so a rotenone product called CFT Legumine was used. Bioassays were conducted in the East Fork Cherry Creek in July 2007 to determine the effective exposure time of the CFT (Table 2). Based on bioassay results, CFT label instructions, and results of the 2007 treatment, CFT was applied to the stream during the 2008 treatment at no more than 1.0 part-per-million (ppm) for four hours. Treatments were initiated on August 4. Stream discharge was measured following standard USGS protocols, and a staff gauge was temporarily placed to determine if discharge changed appreciably during or prior to treating a given section of stream. Discharge was measured in a stream section the evening prior to treatment of that section, which allowed calculation and preparation of the piscicide that night or the next morning.

Table 2. Results of CFT Legumine rotenone bioassays in the East Fork of Cherry Creek to determine effective exposure time, July 2007. Run time of the application station was 7 hours 52 minutes. CFT application was initiated at 09:33.

Sentinel fish station[1/]	Time of initial exposure	Time of 100% mortality	Hours of exposure til 100% mortality
30	10:03	10:50	0:47
60	10:33	12:55	2:22
90	11:03	12:55	1:52
120	11:33	14:00	2:27
150	12:03	14:55	2:52
180	12:33	16:15	3:42[2/]
210	13:03	16:15	2:48
240	13:33	NA[3/]	

[1/] Minutes of stream flow time downstream of CFT application station
[2/] 2 fish dead, 1 gravely ill at 1455 hrs (2:22 hours of exposure)
[3/] 100% mortality of sentinel fish was confirmed the following morning at 11:45

Stream treatments were made using trickle application systems (Figure 12). The system consists of a 3½ gallon plastic bucket & lid, garden hose, a gate valve, and a commercially available automatic dog watering bowl. A plastic elbow is fixed to a hole drilled in the bottom of the bucket, a short section of garden hose and the gate valve are clamped to the elbow (Figure 13), and a longer section of garden hose attach the assembly to the dog waterer. The bucket is partially filled with filtered stream water, the CFT is added, then the bucket is topped off with filtered stream water and stirred with a wooden dowel. At a predetermined time, the gate valve is opened, allowing the mixture to flow into the bowl, where it then trickles into the stream through a small hole drilled in the bottom of the bowl (Figure 14). Typically, one bucket empties in 3½ - 4 hours. Applications of CFT are designed using a 4-hour application period. In previous years, Antimycin

Figure 12. Trickle system and sentinel fish bag on Cherry Lake Creek. The sentinel fish bag is upstream of the CFT application point to monitor the effectiveness of the station above the one shown here.

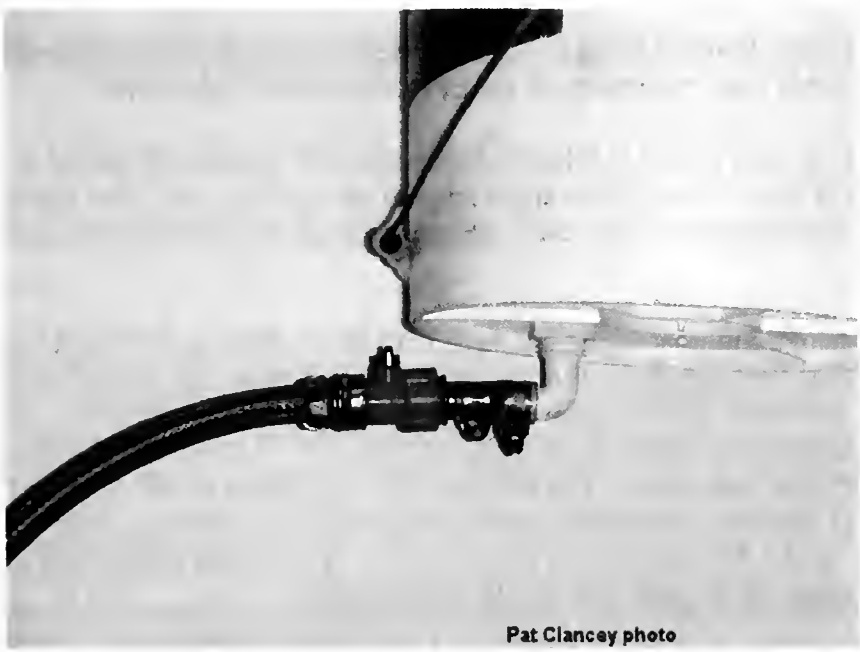


Figure 13. Elbow & gate valve assembly.

Figure 14. Close-up view of the dog waterer trickling CFT/streamwater mixture into the stream during the Cherry Creek Project.

applications were designed using a 7-hour application period, but rotenone acts on the fish more quickly than Antimycin, so the treatment period is shortened.

Stations were placed at selected points along the stream and started at predetermined times to coordinate application of the mixture with other stations along the stream. Backpack sprayers were used each day to treat off-channel water and larger pools.

Westslope cutthroat eggs from three wild donor streams, the Sun Ranch brood, and the Washoe Park Hatchery were reared to the eyed stage then placed in remote streamside incubators (RSI) (Figure 15) in the Cherry Lake fork of Phase 1 and in Phase 2. Eggs completed incubation in the RSI, hatched, and fry departed the RSI into the stream under their own power. The RSI is plumbed to allow stream water to flow into the bottom of the bucket, percolate up through an artificial substrate where the eggs are placed, and out the RSI near the top of the bucket. When ready to enter the stream, fry follow the water out the hole near the top of the bucket.

A capture bucket was placed on the outflow of the RSI to capture and enumerate departing fry to allow estimation of survival in the RSI.

Figure 15. Remote streamside incubator (round bucket) and capture bucket (square bucket) in Cherry Creek

Fish Entrainment

Efforts have been initiated to evaluate fish entrainment into irrigation ditches along the Madison River. Ditches are observed from public roads or where they traverse across public land, or with permission of the water right holders. Surveys are conducted in the fall to determine if significant numbers of fish enter into ditches and become stranded after the headgate is closed, thus lost to the river population. Surveys are conducted annually for at least several years, and will also be conducted as drought diminishes and normal and high water years occur.

In 2007 and 2008, the West Madison Canal (WMC) was monitored by electrofishing to determine characteristics of fish entrainment. Three 500-foot sections were established. The sections were called Eight-mile, Willow Ranch, and Range View Road (Figure 16), which are approximately one, four, and six miles respectively below the headgate on the Madison River (Figure 17). Monitoring was conducted eight times in 2007, from May 16 – October 17, and four times in 2008, from June 26 – September 17. The WMC was closed earlier than usual in 2008 to facilitate headgate and diversion sill reconstruction. Fish captured in the ditch during electrofishing were speciated, enumerated, measured for length & weight, examined for disease symptoms, and fin clipped. Fish larger than 6 inches were also tagged with a colored stringer tag. Each of the 3 sections was assigned a specific tag color to determine movement between sections and to determine distribution throughout the ditch during salvage efforts.

Figure 16. Photos of three sections of the West Madison Canal monitored for fish entrainment. Clockwise from top left – Eight-mile, Willow Ranch, and Range View Road.

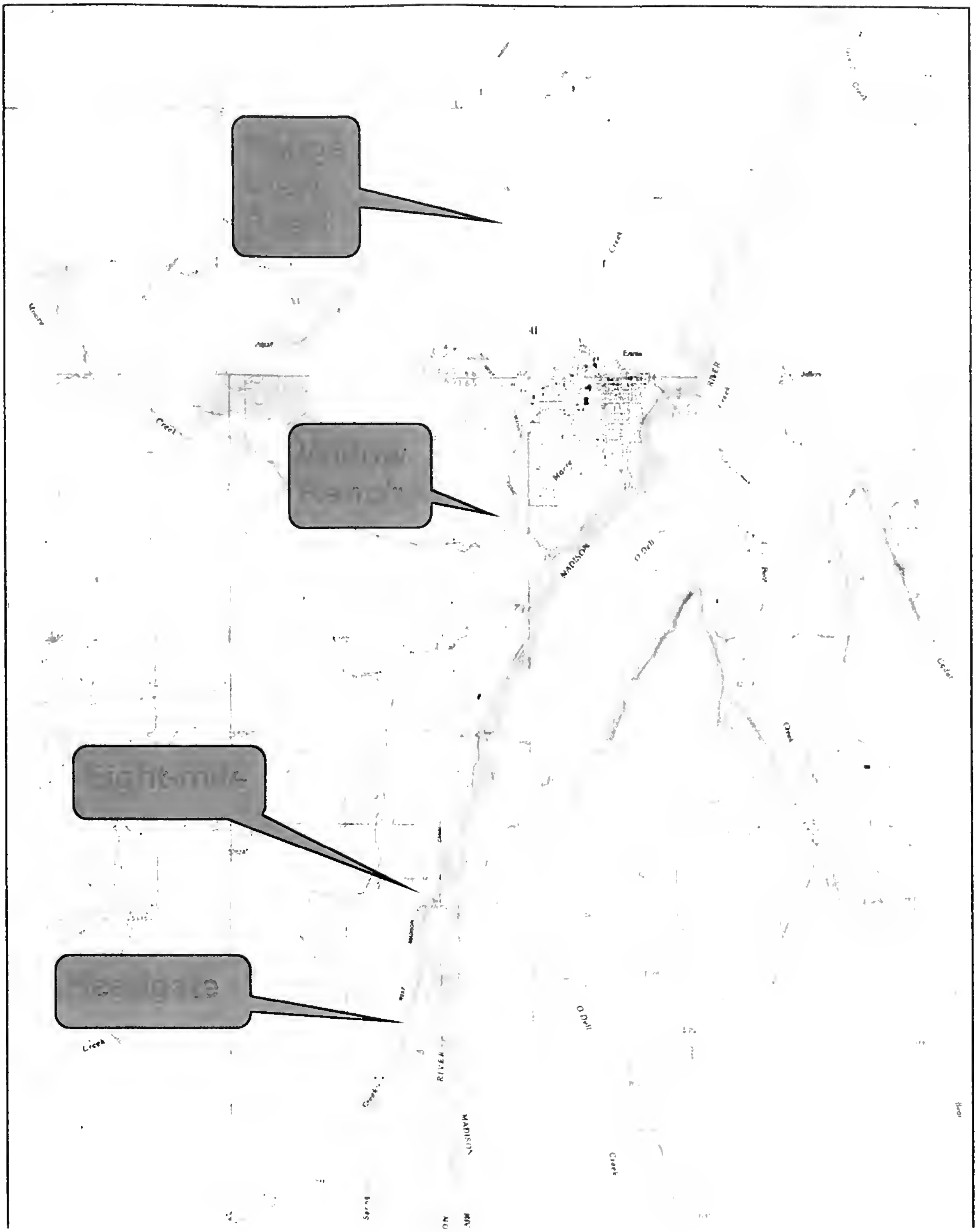


Figure 17. Locations of West Madison Canal fish entrainment monitoring sections.

Fish Habitat Enhancement

Smith Lake

Smith Lake Dam on Lake Creek, a tributary to the West Fork of the Madison River, is a four foot high cobble and earthen dam believed to have been constructed in the 1920s to funnel water for operation of a sluice box and water wheel pump (Figure 18) to deliver water 500 vertical feet to an offsite water trough for livestock. Brown trout migrate up Lake Creek for spawning, but in some years fish passage around the dam is blocked by tarps used to reduce leakage through the dam and the bypass channel. Several alternative methods were explored to provide stockwater and reduce or eliminate the need for the water wheel pump.

Figure 18. Old water wheel on Lake Creek below Smith Lake compound used to deliver water to cattle during summer months. MFWP photo by Travis Lohrenz.

O'Dell Creek

O'Dell Creek is a spring creek that originates south of Ennis and flows north approximately 12 miles to its confluence with the mainstem Madison River. In 1955 a ditch was excavated to intercept groundwater flow and portions of O'Dell Creek were channelized to dewater a wetland complex, maximize available rangeland for cattle, and simplify irrigation. In 2005, DJP Consulting and the Granger Ranches received funding from PPL Montana Madison Fisheries and PPL Montana Wildlife technical advisory committees and other sources to restore form and function to portions of O'Dell Creek and associated wetlands on Granger Ranch property (Table 3, Figure 19). Backfilling of the East Ditch resulted in groundwater resuming its original flow pattern into the wetland and also resulted in increased streamflow in other stream channels. Fisheries monitoring is conducted at six sites in the project area (Figure 20). Future plans include channel narrowing and vegetation development in the Above Falls and Below Falls sections.

Table 3. Summary of stream restoration actions on fish monitoring sites at O'Dell Creek, 2005 - 2008.

Fish Monitoring Site	Result of Stream Channel Modification
O'Dell Ditch	Backfilled
O'Dell Spring North	Increase in stream discharge, no physical modifications
Old Middle	Historic channel reconnected and reconstructed
O'Dell West	Channel narrowed & deepened, increase in stream discharge
Above Falls	Increase in stream discharge, no physical modifications
Below Falls	Increase in stream discharge, no physical modifications

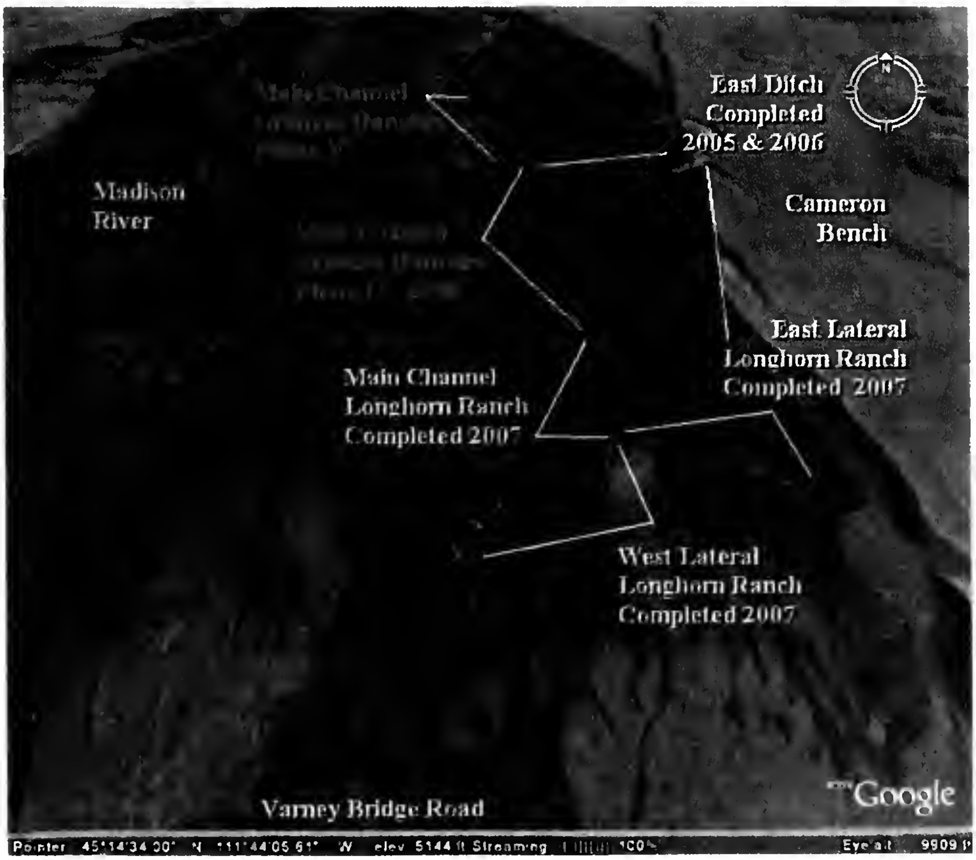


Figure 19. Schedule of stream improvement activities on O'Dell Creek, Granger and Longhorn ranches, from Peters 2009.

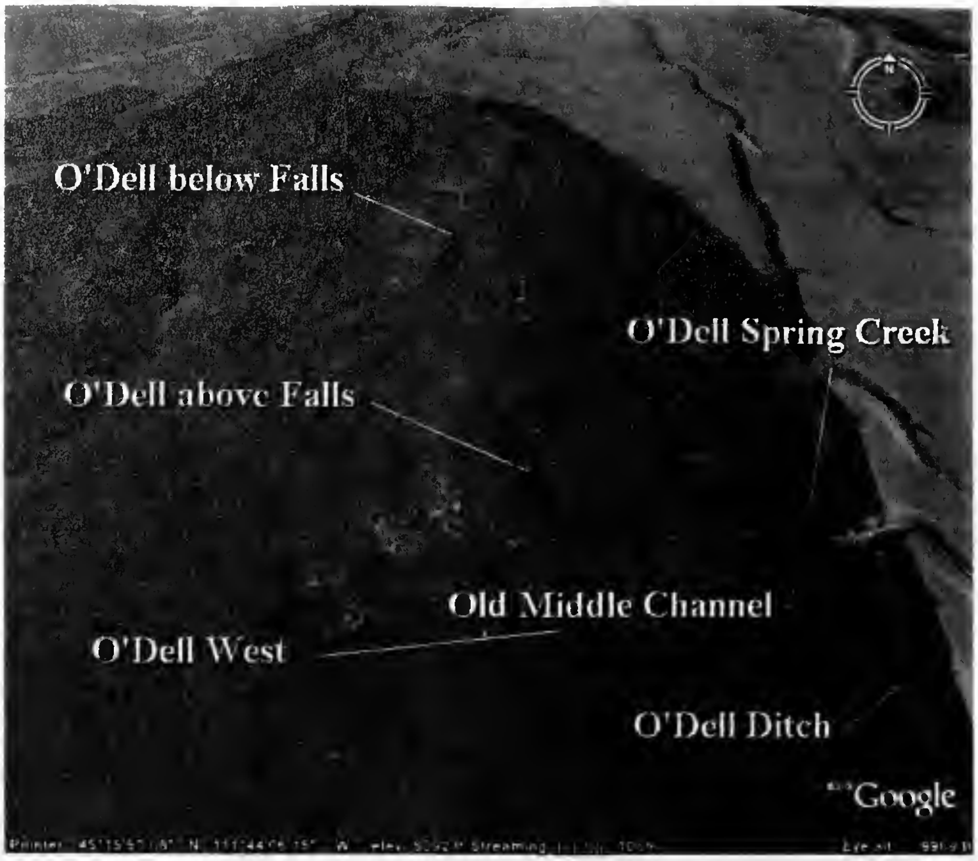


Figure 20. Map depicting approximate locations of fish sampling sites on O'Dell Creek, from Peters 2009.

Hebgen Reservoir

Hebgen Reservoir and its tributaries are shown in Figure 21.

Hebgen Reservoir Gillnetting

Gillnetting has been conducted annually on Hebgen Reservoir by MFWP for over thirty 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 experimental gillnets, 125 foot long, were deployed overnight at index sites on Hebgen Reservoir (Figure 22) over a three-day period during New Moon in early June. A total of 25 gill nets (14 surface and 11 bottom nets) were fished during this period, with a maximum of nine nets fished per night.

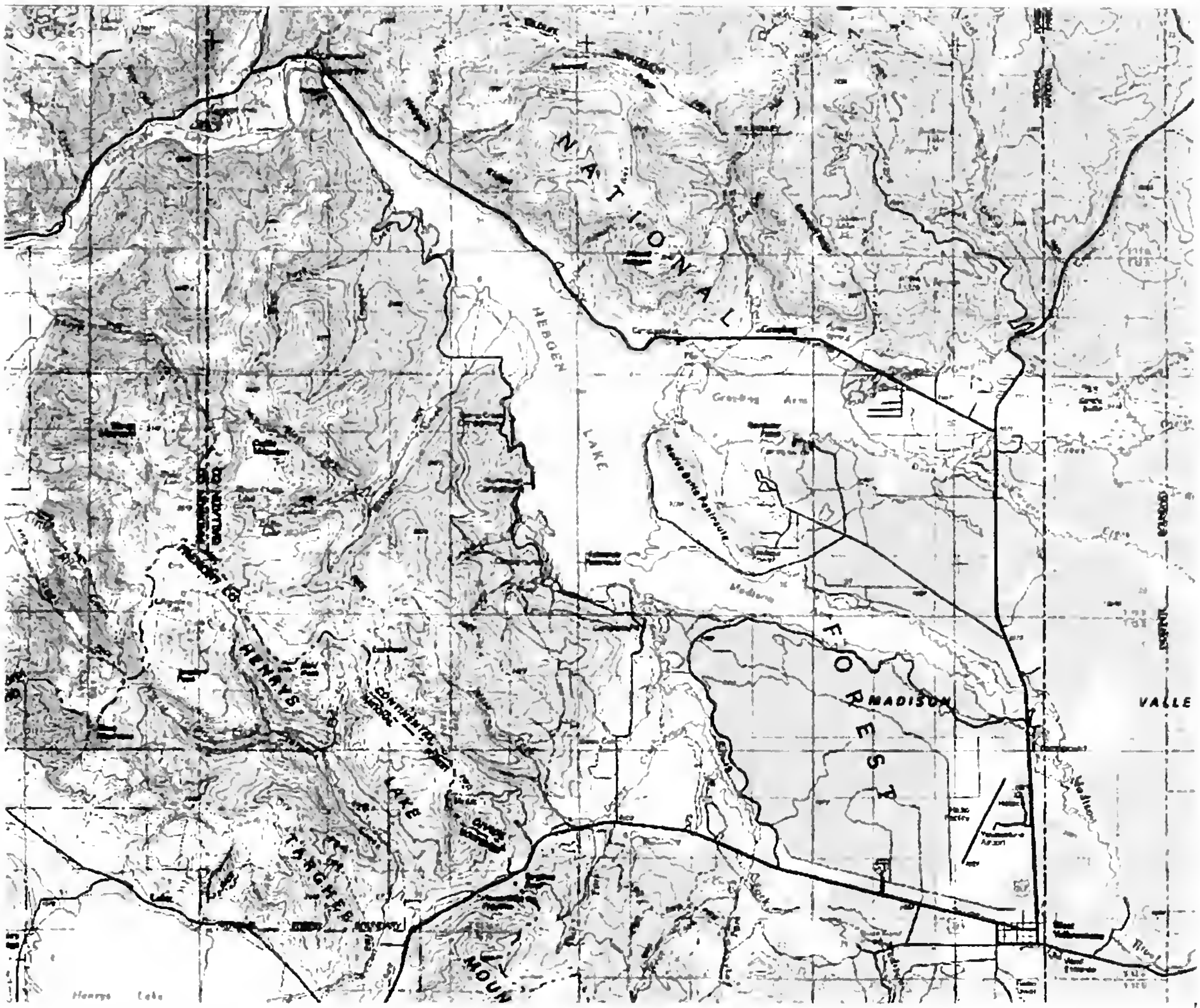


Figure 21. Hebgen Reservoir and surrounding area.

Samples were sorted by net and processed systematically by species. Total length and weight were recorded and scales removed from rainbow trout, brown trout and mountain whitefish for age determination. Rainbow trout were also visually examined for physical anomalies seen in hatchery-reared stocks, and for external and internal tags applied to wild juvenile and adult rainbow trout at tributary traps in previous years. Additionally, vertebrate were extracted from all rainbow trout specimens and examined for the presence of oxy-tetracycline marks, a biological stain that appears in ossified structures. Oxy-tetracycline is typically administered to hatchery-reared fish through feeding prior to stocking. Finally, brown trout stomachs were dissected and contents examined to document their utilization of Utah chub as forage.

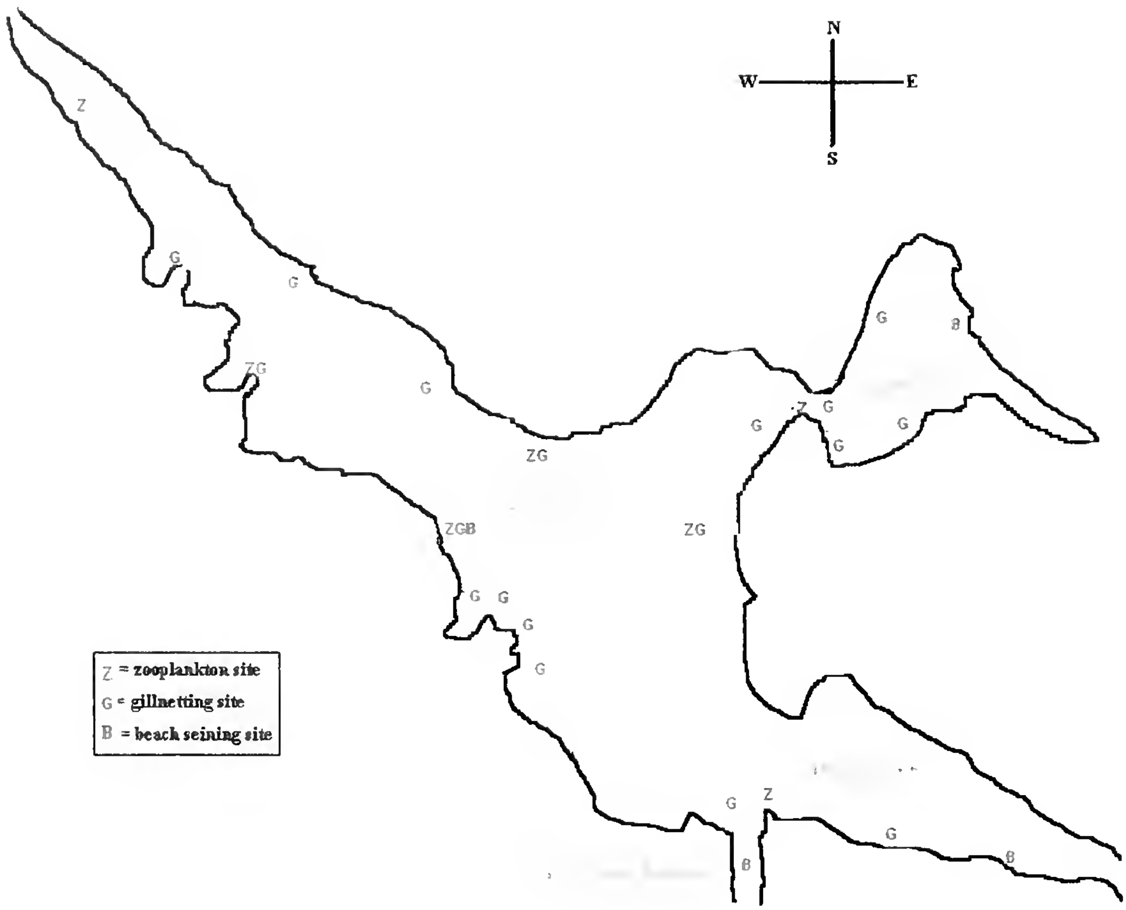


Figure 22. Locations of Hebgen Reservoir zooplankton, gillnetting, and beach seining sites.

Hebgen Reservoir Disease Monitoring

Whirling Disease

Sentinel fish cages containing young-of-the-year Eagle Lake rainbow trout were deployed in two 10-day exposures, June 18 – 28 and June 28 – July 8, in three Hebgen tributaries (Duck Creek, Black Sands Springs, and South Fork Madison) to test for the presence of whirling disease. Sentinel fish were reared in isolation tanks for another 80 days at the MFWP Whirling Disease Laboratory in Pony, Montana. At the conclusion of the 90-day period fish were sacrificed and sent to the Washington Animal Disease Diagnostic Lab (WADDL) at Washington State University where they underwent histological examination for whirling disease infection and were rated on MacConnell-Baldwin scale (Appendix A), which grades infection from 0-5 with 0 being no infection and 5 being severe infection.

Salmincola

Fish species were examined for the presence of the parasitic copepod *Salmincola sp.* during tributary trapping and annual reservoir gillnetting from 2005 through 2007. Examinations for parasites were limited to preferred attachment sites, which include the gills, mouth and the base of fins (Figure 23). Examinations were conducted on live specimens while anesthetized to reduce handling time and stress on the fish. While fish were sedated, the mouth and opercles were manipulated to expose the tongue and gills so parasites could be enumerated. After examination of the gills and mouth, the fins were examined for parasites by gently forcing them forward towards the head. The number of parasites per attachment site was enumerated and recorded (Table 4). A paired T-test and Analysis of variance were run to test for difference in Fulton's K (Condition factor) between infected and non-infected individuals.

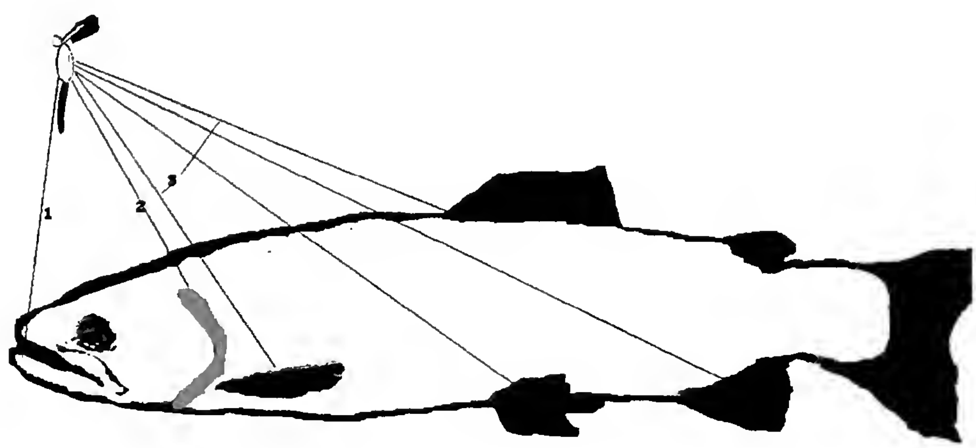


Figure 23. Common attachment sites of Salmincola parasites: 1. mouth; 2. gills; 3. base of fins.

Table 4. Salmincola infection severity classifications.

Number of parasites	Infection Class
0	0
1-5	1
6-10	2
10+	3

Black Spot Disease

Fish collected from the Madison River above Hebgen Reservoir were examined for black spot disease trematode. Examinations consisted of visual observation for the presence of black spots along the body and eyes of fish (Figure 24). Small dark brown or black slightly raised cysts on the body, fins, gills and eyes are present in infected fish.

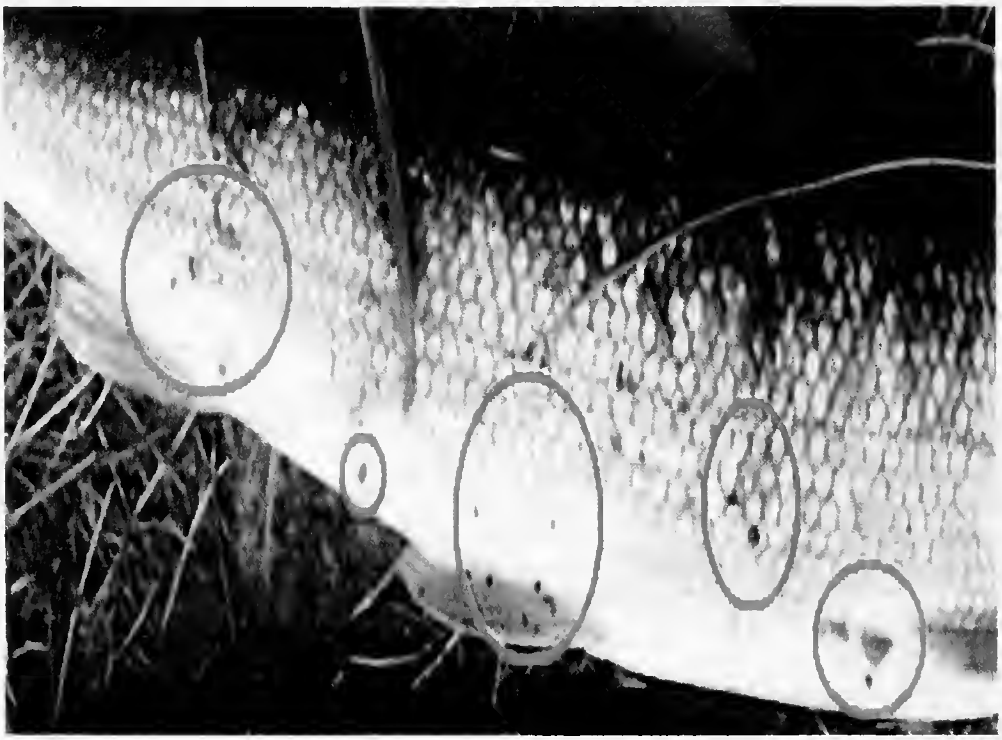


Figure 24. Black cysts on the body of a mountain whitefish caused by infection from a trematode. MFWP photo by Travis Lohrenz.

Tributary Trapping

Rigid panel weirs (Figure 25) were constructed and operated on Duck Creek and the South Fork Madison River and a floating panel weir (Figure 26) was constructed and operated on the mainstem Madison River above Hebgen Reservoir to monitor rainbow trout spawning escapement and recruitment to the adult population in 2008. Weirs were placed in a shallow glide with uniform streambed elevation and water depth between two and three feet at base flow. The trap box was positioned to capture rainbow trout ascending tributaries to spawn. When numbers of fish captured fell below five fish/day for a one-week duration, the trap was removed.

Figure 25. Rigid weir assembly used to trap immigrating rainbow trout on Duck Creek and the South Fork Madison. MFWP photo by Travis Lohrenz.

Figure 26. Rigid panel weir used on the Madison River in 2008. MFWP photo by Travis Lohrenz.

All fish captured were anesthetized prior to being worked to reduce handling time and stress. Data collection for individual fish included total length and weight, scale collection for age determination, external examination for whirling disease characteristics, salmincola and blackspot disease, and hatchery characteristics. Additionally, individuals were inspected for coded-wire-tags, administered to young-of-the-year and yearling rainbow trout at the Duck Creek and South Fork Madison rotary screw traps from 2004-2006, and a uniquely numbered floy-tag which were attached to adult rainbow trout during weir operations from 2005-2007 (Figure 27). If no floy-tag was observed, one was administered to the fish for future identification .

Figure 27. Hebgen Reservoir rainbow trout tagged with a floy tag.

Annual interval mortality was calculated from the number of fish tagged in previous years at the Duck Creek adult trap and number of recaptures recovered in each successive year using the Jolly-Seber method described in Analysis and Interpretation of Freshwater Fisheries Data (Guy and Brown 2007).

Scales collected from rainbow trout were sent to MFWP scale processing lab in Bozeman MT where scales were mounted on acetate paper. Scales were aged using microfiche reader at 24x magnification.

Juvenile Fish Sampling

Beach seining 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. Samples were collected using a 125'x 5' x ¼" inch mesh seine with a 5'x 5' x 5' collection bag (Figure 28). The float and lead lines of the seine are tied to long dowels and pulled through the water by two people (Figure 2) for approximately 100 yards, 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

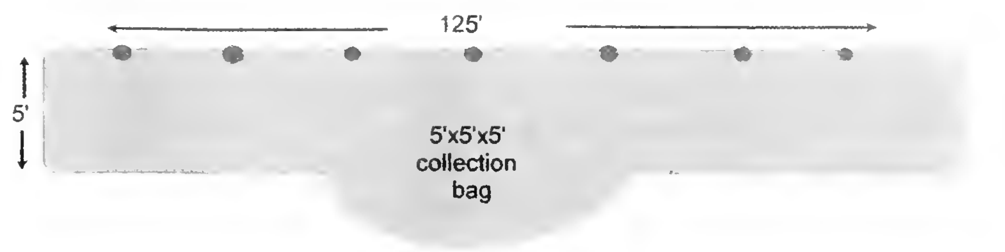


Figure 28. Depiction of seine used during beach seining.

are measured and preserved in Davidson's solution for stomach content analysis. All remaining chubs are enumerated.

Hebgen Reservoir Zooplankton Monitoring

Monthly zooplankton tows were conducted at seven established sites on Hebgen Reservoir to evaluate plankton community densities and composition (Figure 22). Plankton were collected with a Wisconsin plankton net 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) and Eucopepoda (copepods) and densities from each sample were calculated (citation of method). Carapace length was measured on six individuals of each Cladocera and Eucopopoda from each aliquot. Length adjustments were made to convert from micrometers to millimeters, and individual lengths were recorded in millimeters. Mean length was calculated for each sample and each site to determine if spatial and temporal variation existed.

RESULTS AND DISCUSSION

Madison Grayling

No young-of-the-year Arctic grayling were captured during beach seining in Ennis Reservoir 2008 (Appendix B).

Arctic grayling require loose, recently scoured gravels and cobbles to broadcast their eggs over during spawning each spring (Byorth and Shepard 1990). Generally, normal spring runoff creates these conditions, but it is possible that winter and spring ice scour also make such conditions available. The duration and severity of the Madison River ice gorge (Figure 29) may affect the spawning success of the Ennis Reservoir grayling.

The USFWS re-evaluated the petition to list fluvial Arctic grayling as a Threatened species in light of a lawsuit filed in 2003 by the Center for Biological Diversity (CDB), concluding in 2007 that listing Arctic grayling under the Threatened and Endangered Species Act was not warranted. A listing would have likely include all grayling populations regardless of behavioral traits or genetic similarity to Big Hole River fluvial grayling.

Madison grayling are genetically very similar to Big Hole fish, but exhibit adfluvial behavior. They reside in Ennis Reservoir all year except when they enter the Channels area of the Madison River in April to spawn, though periodically FWP receives reports of grayling in the Madison River as far as 30 miles upstream of Ennis Reservoir into the Fall.

MFWP has developed 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 ruling that listing grayling is not warranted, landowners and irrigators continue to enroll in the program. Currently 32 landowners have enrolled 155,301 acres, with an additional 7,650 acres of State land enrolled.

Population Estimates

Population estimates were conducted in the Norris section in March and in the Pine Butte section in September (Figure 5). Estimates were unable to be conducted in Varney due to high flows caused by the Hebgen Dam intake structure failure August 31 – September 28. These exceedingly high flows also likely confounded the 2008 Pine Butte estimates.

Figures 30-31 illustrate population levels of six inch and larger rainbow trout per mile from for the Pine Butte and Norris estimate sections, and Figures 32-33 illustrate numbers of six inch and larger brown trout. Estimates could not be conducted in Varney in 2008 due to the catastrophic failure of stop-logs in the Hebgen Reservoir intake tower on August 31. The populations of six-inch and larger rainbow trout in the Pine Butte and Norris monitoring sections remained high despite apparent decreases from levels observed in recent years. Brown trout populations continue to decline in the Madison as well as other waters across the western U.S.

In 2005, FWP Regional Management personnel began reporting population numbers greater than six inches rather than using fish length to assign fish as yearling or two year old & older. Appendix C1 contains charts illustrating fish numbers as yearling and two year old & older fish per mile as reported in previous years of this report (MFWP 1995 – 2008). Appendix C2 contains historic total population levels of two year old & older rainbow and brown trout (+ 80% C.I.) for each section.

Figure 29. The Madison River at the U.S. Highway 287 Bridge at Ennis, illustrating ice-gorged and ice-free conditions.

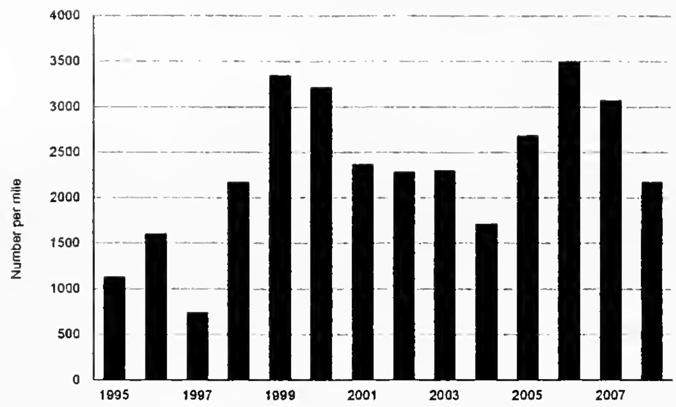


Figure 30. Rainbow trout (≥ 6”) estimates in the Pine Butte section of the Madison River, 1995–2008, fall estimates.

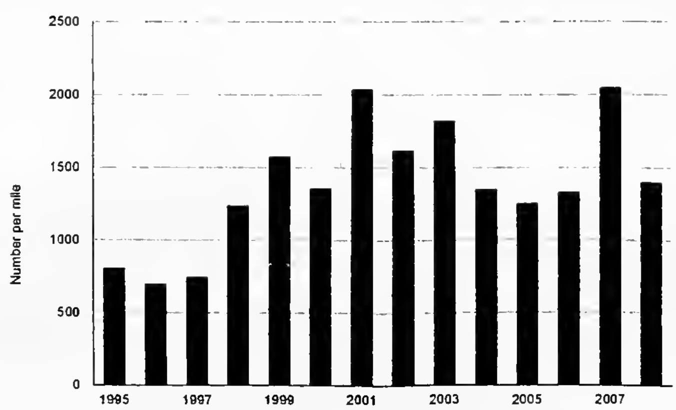


Figure 31. Rainbow trout (≥ 6”) estimates in the Norris section of the Madison River, 1995–2008, spring estimates.

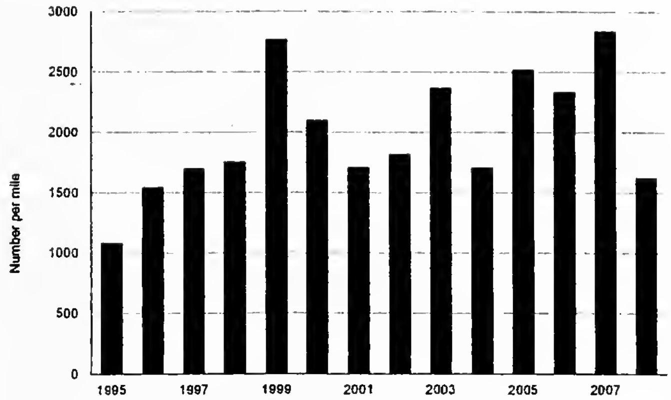


Figure 32. Brown trout (≥ 6”) estimates in the Pine Butte section of the Madison River, 1995–2008, fall estimates.

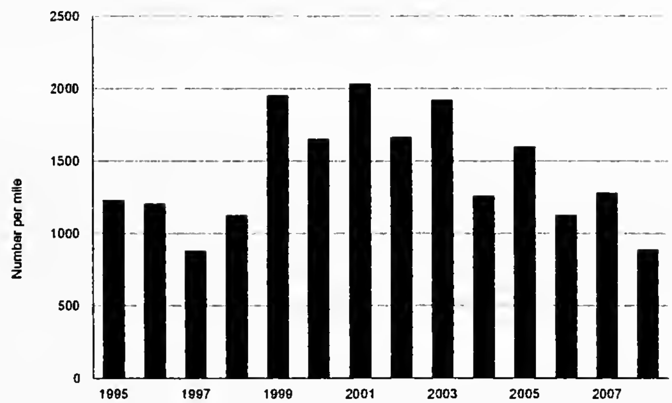


Figure 33. Brown trout (≥ 6”) estimates in the Norris section of the Madison River, 1995–2008, spring estimates.

River Discharge

Fish, Wildlife & Parks and PPL Montana (and PPL Montana's predecessor Montana Power Company) have a long established agreement to maintain minimum instantaneous river flows at the USGS Kirby and McAllister gauges in the upper and lower river of 600 and 1100 cfs, respectively. These minimum flows were incorporated into the FERC license for the 2188 Project and are required elements of operating Hebgen and Ennis dams.

In 1994 PPL Montana 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 were necessary every year from 2000 – 2007. Pulse flows were not necessary in 2008. Table 5, adapted from PPL Montana data, summarizes statistics regarding pulse flows in the Madison in years pulsing was conducted.

Flushing flows were conducted in the Madison River June 2 – 6, 2008. The combination of Hebgen Reservoir storage volume and runoff forecast exceeded trigger volumes by 57,780 acre-feet. Data collection to assess the effects of the flushing flow were scheduled for September 3 – 4, but were not able to be conducted due to the August 31 failure of the Hebgen Dam intake structure. Elements of the in-reservoir structure failed catastrophically, increasing river discharge immediately below the dam from 851 cfs to 3300 cfs in 2 hours. Flushing flow data collection was completed in October, but will not be a true measure of the flushing flows because the river discharge exceeded normal operational levels from August 31 until approximately September 28.

Temperature Monitoring

Optic StowAway temperature recorders were deployed throughout the Madison River to document air and water temperatures (Figure 6). Table 6 summarizes the data collected at each location in 2008. Appendix D1 contains thermographs for each location, Appendix D2 contains thermographs at selected locations showing the 24-hour diurnal temperature fluctuation of each site around the warmest date of the year.

Aquatic Nuisance 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). It is estimated that about 42% of the species on the Threatened or Endangered species lists are at risk primarily because of alien-invasive species.

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 ANS program coordinated through FWP (Appendix E).

Table 5. Summary statistics for years in which pulse flows were conducted on the Madison River.

Year	Hebgen October 1 pool elevation[1/]	Feet below full pool	Feet of Hebgen draft due to pulsing	Number of days pulsing occurred
2000	6531.21	3.66	0.61	29
2001	6530.53	4.34	0.05	13
2002	6530.46	4.41	0.70	18
2003	6528.59	6.28	2.68	39
2004	6532.07	2.8	0.28	12
2005	6531.52	3.35	0.30	17
2006	6530.86	4.01	1.74	15
2007	6526.05	8.82	2.12	43

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

New Zealand Mudsnails

Sampling for NZMS was not conducted in 2008 due to the high river flows caused by the Hebgen Dam intake structure failure. In previous years sampling was conducted at numerous sites on the Madison River between Varney and Greycliff FASs. All sites were positive, but densities were at their lowest level since initial detection.

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

1) Listing New Zealand mudsnails as a Prohibited species in Montana.
2) Assisting in development of a regional management plan for New Zealand mudsnails, an important portion of which will describe actions to be undertaken when New Zealand mudsnails 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 New Zealand mudsnails or other ANS.
5) Purchasing portable power washing systems for cleaning boats and trailers at fishing access sites.

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

Table 6. Maximum and minimum temperatures (°F) at selected locations in the Madison River Drainage, 2008. Air and water temperature data were recorded every 30 minutes from April 24 –October 6 (7944 readings). Thermographs for each location are in Appendix D1.

	Site	Max	Min
Water	Hebgen inlet	75.65	40.71
	Hebgen discharge[1/]	70.09 (63.08)	36.36
	Quake Lake inlet[1/]	70.12 (63.70)	35.32
	Quake Lake outlet	62.75	35.80
	Kirby Bridge[2/]	63.64	32.42
	McAtee Bridge	67.21	33.03
	Ennis Bridge	71.01	35.87
	Ennis Reservoir Inlet	69.62	37.14
	Ennis Dam	71.61	37.33
	Bear Trap Mouth	75.96	35.08
	Norris	75.90	35.35
	Blacks Ford	77.79	35.00
	Cobblestone	78.73	35.61
	Headwaters S.P. (Madison mouth)	77.55	36.79
Air	Kirkwood Store	94.23	23.55
	Slide	98.39	23.52
	Wall Creek HQ	91.72	23.51
	Ennis	94.45	23.24
	Ennis Dam	91.58	27.27
	Norris	100.79	29.55
	Cobblestone	91.01	26.26

[1/]Water temperature at Hebgen discharge & Quake inlet were elevated due to surface releases from Hebgen Reservoir during engineering inspections in late July. Maximum temperatures during 'normal' operations are listed in parentheses.
[2/] The Kirby temperature recorder ceased operating on July 21

NZMS have been detected in one private hatchery, but have not been found in any state or federal hatcheries. Strategies have been implemented to prevent the spread of NZMS from the private hatchery. The spread of New Zealand mudsnails has slowed and appears to be confined to east of the Continental Divide.

Additional information on Aquatic Nuisance Species is on the web at www.anstaskforce.gov and www.protectyourwaters.net, and for New Zealand mudsnails specifically, is available at www.esg.montana.edu/aim/mollusca/nzms.

Whirling Disease

Caged young-of-the-year rainbow trout in the Madison River continue to exhibit high infection rates & severity, with Spring and early Summer histology scores lower than those in 2007, but still exceeding the level that results in population level effects according to the MacConnell- Baldwin Scale (Appendix A). However, the juvenile rainbow trout used in the sentinel cage studies are not offspring of Madison River rainbow trout, but are from the captive stock that has been used in sentinel cages since studies began in 1996. The high infection rate exhibited by this captive stock shows that whirling disease is still at high levels in the Madison River, but offspring of Madison River rainbow trout appear to be developing a resistance to whirling disease as evidenced by rainbow trout population estimates in the upper river (Figures 30-31). In 1998, and again in 2004, eggs were collected from spawning rainbow trout near the Slide Inn below Quake Lake and the resulting fry exposed to a controlled number of TAMs in the Wild Trout Laboratory in Bozeman. Fry from the 2004 spawners exhibited a lower proportion of fish in the highly infective categories compared to those from 1998 (Figure 34). For rainbow trout, average histology scores above 2.5 are associated with high mortality of young-of-the-year and significant decreases in population. In Figure 34, the average histology score of the 1998 test fish is 4.13, while that of the 2004 test fish is 2.42.

Vincent (2007) speculated that high levels of whirling disease spores persist in the Madison River because some rainbow trout produced in the late 90's through early 2000's still survive in the river, and their offspring are not resistant. He further speculated that as those older fish fall out of the spawning population, only fish that have developed resistance to whirling disease will remain, and the number of whirling disease spores in the river will diminish.

Information on whirling disease, including numerous links, is available online at www.whirling-disease.org.

Westslope Cutthroat Trout Conservation and Restoration

Habitat projects conducted by the Madison Ranger District of the Beaverhead-Deerlodge National Forest are summarized in Appendix F.

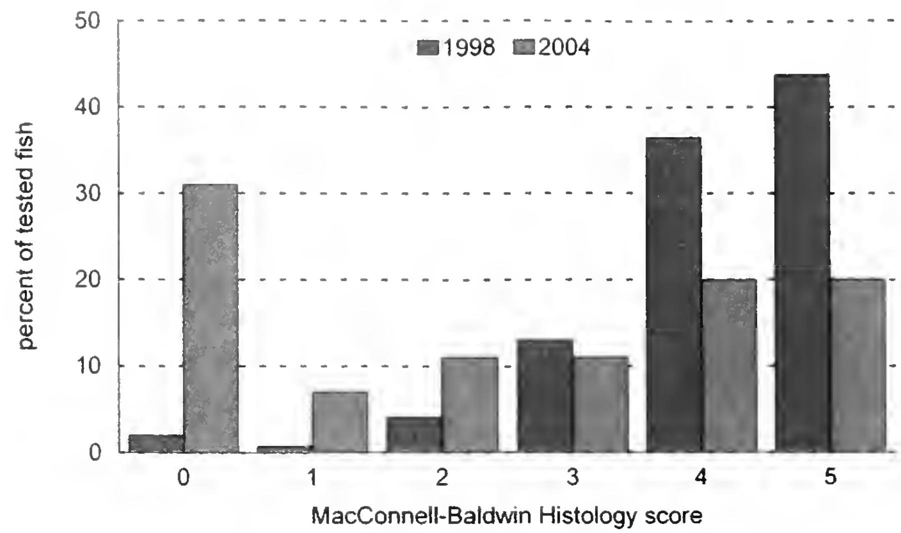


Figure 34. Percentage of young-of-the-year Madison River rainbow trout within MacConnell-Baldwin histology ratings in 1998 and 2004. See Appendix A for MacConnell-Baldwin definitions.

<u>Sun Ranch Westslope Cutthroat Trout Program</u>

Ten female and 28 male Sun Ranch brood fish were spawned in 2008, producing 3,277 eyed eggs for introduction into Cherry Creek and 571 fry for introduction into the Sun Pond. Additionally, approximately 187 fry produced from eggs taken at two streams in 2008 were introduced into the Sun Pond.

Between donor stream wild populations and the Sun Ranch Brood Pond, 13,529 eyed eggs were incubated at the Sun Hatchery in 2008. In addition to FWP, Yellowstone National Park used the hatchery in 2008 to eye eggs from a newly discovered WCT population in YNP for introduction in a WCT project they are conducting in Specimen Creek, and also contributed fry to the Sun Brood, helping diversify the genetic composition of the brood.

<u>Cherry Creek Native Fish Introduction Program</u>

In 2008, 5,868 eyed WCT eggs were placed into RSIs in Phase 1 and 5,978 eyed eggs into Phase 2 (Figure 35), resulting in 4,356 fry and 4,731 fry, respectively, released into each Phase. Egg sources were from three wild donor streams, the Sun Ranch brood, and the Washoe Park Hatchery. Wild and Sun Brood eggs were reared to the eyed stage at the Sun Ranch Hatchery then placed in RSI's (Figure 15). A total of 5,924 eggs were from the three wild streams, 3,277 from the Sun Ranch brood (which is comprised of donors from two of the wild streams used in 2008 as well as five additional wild streams since 2002) and

2,645 from the Washoe Park Hatchery. Genetic samples will be collected annually to ascertain the proportion of the population from each donor source as the WCT population establishes and stabilizes.

Personnel from MFWP, Montana State University, Gallatin National Forest, and Turner Enterprises spent approximately 158 worker-days completing the project in 2008, including all preparatory and support activities and chemical treatments. A total of 14.6 gallons of CFT and two pounds of powdered rotenone were required to complete treatments in 2008, all in Cherry Creek and tributaries (Table 7).

Fish Entrainment

The WMC draws water from the river on the west bank of the western river channel approximately one mile upstream of the Eight-mile Fishing Access Site, and has been observed for fish entrainment since 2001. Surveys were limited in 2002 & 2003 as ice-up occurred prior to the ditch being shut down for the year, so ice cover concealed stranded fish. In years when the WMC headgate was closed prior to ice-up, several hundred or more fish, primarily trout, were observed stranded in the ditch and were lost to the population. It is unlikely that preventing those trout from becoming entrained in the ditch would increase the river population by that same number of fish due to competition, predation, and angling harvest that would occur in the river. The trout population below Varney is dominated by brown trout, and most fish observed in the ditch are brown trout (Figure 36). Other species entrained include rainbow trout, mottled sculpin, longnose dace, and juvenile whitefish and white suckers. In recent years local anglers, interested citizens, and the Madison River Foundation (ennisflyfishing.com) were granted permission by the WMC water users and FWP to conduct a fish salvage effort.

In 2007 and 2008, WMC water right holders allowed FWP access to the ditch to actively monitor fish entrainment. Each of three 500-foot sections was surveyed with electrofishing during the irrigation season.

In 2008, few fish were observed in the ditch during electrofishing (Figure 37), and the fish salvage effort saw far fewer fish than previous years. In 2007, a significant increase in entrainment occurred between mid-July and mid-August in each of the two upstream sections, 8-Mile and Willow Ranch, and to a lesser degree in the downstream Range View Road section between mid-August and early September. The 8-mile section showed increasing numbers of fish throughout the season, the number of fish in the Willow Ranch section peaked in August and then decreased through mid October, and the number of fish in the Range View Road section remained low and steady after early September. A similar trend appeared in 2008, but with far fewer fish entrained.

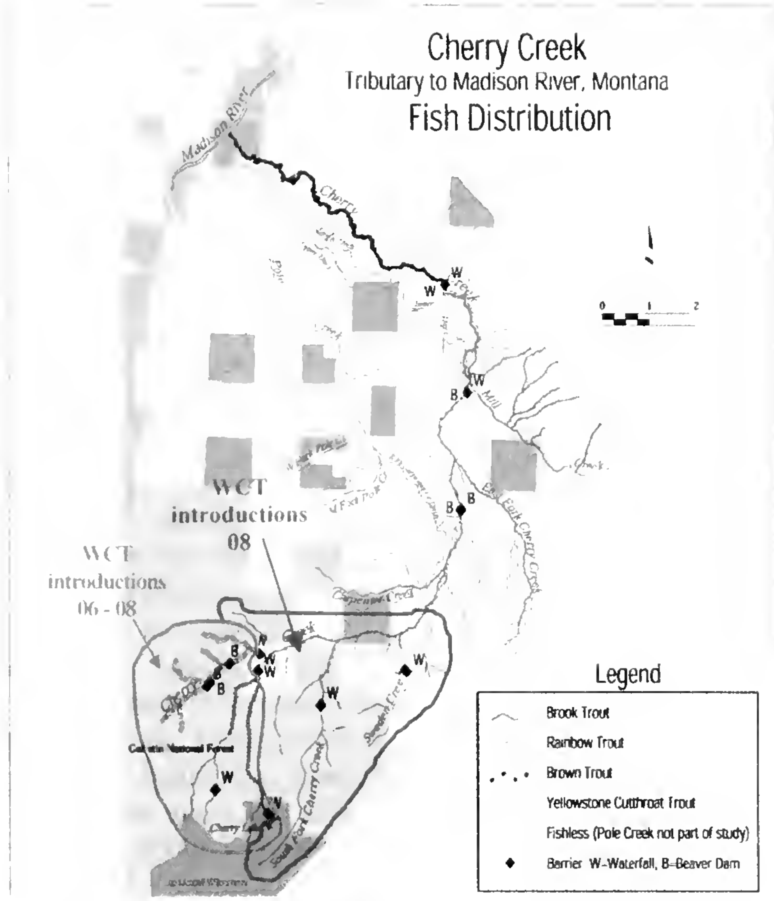


Figure 35. Phases 1 and 2 of Cherry Creek Native Fish Introduction Project where westslope cutthroat trout were introduced in 2006 - '08 following eradication of non-native Yellowstone cutthroat, rainbow, and brook trout in 2003 – '07.

Table 7. Schedule of piscicide treatments at the Cherry Creek Native Fish Project, number of stream miles treated, number of worker-days, and quantity of piscicide used.

Year	Phase	miles treated	# worker-days	piscicide quantity
2003	1	11	284	4.9 gallons Antimycin
2004	1	11	240	6.4 gallons Antimycin; 1.0 gallon rotenone
2005	2	8	220	7.0 gallons antimycin 1.0 gallons rotenone lqd 1 lb rotenone pwdr
2006	2	8	256	5.9 gallons Antimycin
2007	2, 3	4, 23	264	9.0 gallons rotenone
2008	3	23	158	14.6 gallons rotenone 2 lbs rotenone pwdr

Figure 36. A sample of fish salvaged from the West Madison Canal and released into the Madison River.

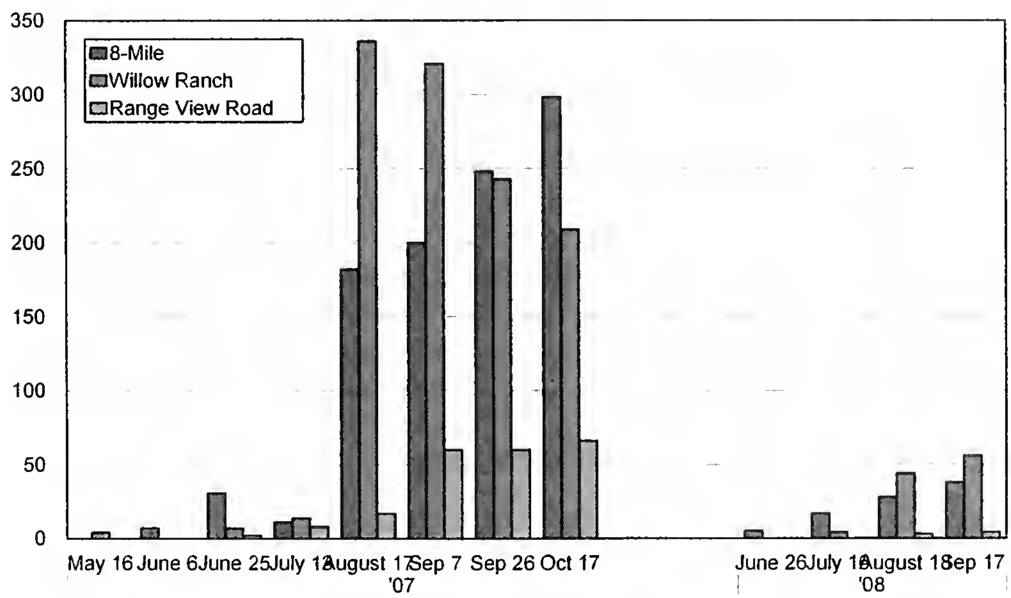


Figure 37. Number of fish captured (all species combined) by sample date in three sections of the West Madison Canal in 2007 & 2008.

Figures in Appendix G show species composition and rate of entrainment by date for each of the three sections. Figure 38 illustrates the proportion of brown trout, rainbow trout, and whitefish by size class on the final sample date in October.

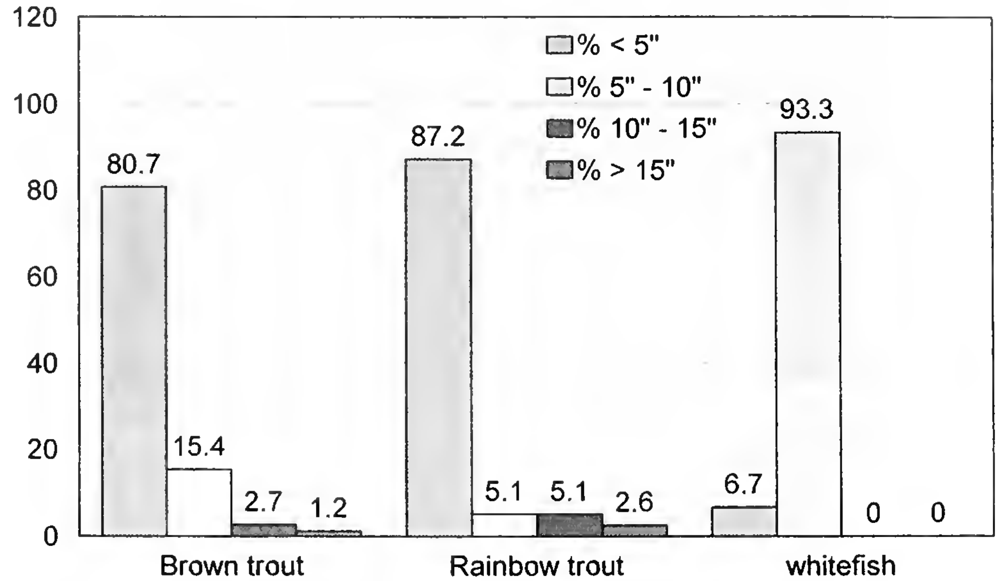


Figure 38. Proportion of brown trout, rainbow trout, and mountain whitefish by size class in three sections of the West Madison Canal in October, 2007.

Methods to reduce or eliminate stranding are being explored. Screening is one option, but it is very expensive and in some locations has not worked as well as anticipated. Another method is to incrementally close the headgate over several days, which slowly reduces the volume of water in the ditch, prompting many fish to move upstream, exiting the ditch and returning to the river prior to complete closure of the headgate. This method has been used successfully on the Granger (Storey) Ditch for several years (Mel McKittrick, 2004, pers.comm.). The incremental shutdown method is also employed in effect on the WMC because as the irrigation season is completed, water flow into the ditch is reduced to a volume that will satisfy stockwater rights, which is less than the volume necessary for irrigation. However, a steep drop in the canal near the head of the Willow Ranch section is impassable to all but a few very large fish, so nearly all of the fish below that point have no chance of returning to the river as ditch flows decrease.

Fish Habitat Enhancement

Smith Lake

The aged stock water delivery system on Lake Creek is being deactivated in favor of a more efficient system that will eliminate the need to manipulate streamflow at Smith Lake Dam. Plans were developed and grants applied for to drill a well and develop a delivery system that will deliver water to the stock tanks, eliminating the need to seal the dam and bypass with tarps, allowing brown trout and other fish to freely pass the dam for spawning and other needs.

O'Dell Creek

Physical channel modifications and habitat complexity were conducted at O'Dell Creek in 2005 - 2008. These modifications are summarized in Table 3. Additional stream channel improvements are scheduled for 2009 and 2010.

Mottled sculpin were frequently observed during fish population monitoring in the O'Dell sections, but are not reported here.

O'Dell Ditch

Sampling of the O'Dell Ditch has not occurred since the completion of phase one of the project in the summer of 2005 when the ditch was back-filled. In 2005 sampling yielded 24 rainbow trout and 137 brown trout in 29.7 min of shocking (CPUE 325 trout/hour). Rainbow trout in the section ranged from 2.9 to 11.7 inches in total length, brown trout ranged from 2.0 to 10.0 inches. Seven of the 24 rainbow trout sampled (29%) were sexually mature males, and several rainbow trout redds were observed during sampling

Old Middle Channel

The abundance of brown trout, the predominant species in the Old Middle Channel, has increased every year since monitoring was initiated (Table 8). In addition to the brown trout, 18 rainbow were sampled in 2008 in 34 minutes of shocking. CPUE for the reach was 384 trout/hr. Rainbow trout ranged in length from 4.0 to 11.0 inches, and brown trout ranged from 3.0 to 15.0 inches.

Enhancement of habitat complexity from pre-restoration conditions with the addition of large woody debris, large pools and under cut banks in the restored Old Middle Channel Section has likely contributed to the notable increase in the number of fish in the 8.0 to 11.0 inch length range. However, stream current velocity in portions of the section is high and may currently be limiting the number of fish inhabiting the reach.

Table 8. Number of brown trout sampled by length group and year in O'Dell Old Middle Channel section.

Length Group	2005	2006	2007	2008
3.0- 3.9	1	4	0	1
4.0- 4.9	0	25	9	14
5.0- 5.9	1	35	41	57
6.0- 6.9	0	20	49	38
7.0- 7.9	0	6	19	11
8.0- 8.9	0	13	10	20
9.0- 9.9	0	4	10	25
10.0-10.9	0	4	2	23
11.0-11.9	0	1	2	5
12.0-12.9	0	0	3	3
13.0-13.9	0	2	0	1
14.0-14.9	0	0	0	1
15.0-15.9	0	0	0	1
16.0-16.9	0	1	0	0
17.0-17.9	0	0	0	0
18.0-18.9	0	1	0	0
19.0-19.9	0	0	0	0
20.0-20.9	0	0	0	0
Total Captured	2	116	145	200

O'Dell Spring Creek North

One hundred and four brown trout and 12 rainbow trout were sampled in 30.9 minutes of shocking time in the O'Dell Spring North (CPUE 229 trout/hr). Rainbow trout ranged from 3.7 to 5.2 inches total length, and brown trout from 2.0 to 7.4 inches total length.

The O'Dell Spring North Section fish assemblage and size structure has shown no detectable change since monitoring began in 2005. The section is still dominated by 3.0 to 5.0 inch brown trout (Table 9). However, flow has increased in this section since restoration activities in phase 1 were completed (Peters 2008, pers. comm.). The increase in flow may have made the section more accessible to larger fish for spawning. Three redds were observed in the reach in 2008 when none had been observed in previous years.

O'Dell Above Falls

Because mark recapture estimates conducted in previous years in the O'Dell Above Falls section have been largely unsuccessful, a CPUE sampling effort was conducted in 2008. In total, 160 salmonids were collected in 42 minutes of shocking (CPUE 229 trout/hr). In addition to the 153 brown trout captured (Table 10), six rainbow trout and one mountain whitefish were caught. Rainbow trout lengths ranged from 4.0 to

Table 9. Number of brown trout sampled by length group and year in the O'Dell Spring North section.

Length Group	2005	2006	2007	2008
3.0- 3.9	31	22	12	11
4.0- 4.9	67	97	48	42
5.0- 5.9	20	42	22	38
6.0- 6.9	10	12	4	9
7.0- 7.9	2	6	1	2
8.0- 8.9	2	4	0	1
9.0- 9.9	1	0	0	0
10.0-10.9	1	1	1	0
11.0-11.9	1	0	0	0
12.0-12.9	0	0	0	0
13.0-13.9	0	0	0	0
14.0-14.9	1	0	0	0
15.0-15.9	0	0	0	0
16.0-16.9	0	0	0	0
17.0-17.9	0	0	0	0
18.0-18.9	0	0	0	0
19.0-19.9	0	0	0	0
20.0-20.9	0	0	0	0
Total Captured	136	184	88	103

9.0 inches, brown trout from 4.0 to 20.0 inches, and the sole mountain whitefish was 5.0 inches.

The number of trout handled in the Above Falls section has declined in recent years compared to 2005 and 2006. This may be due to redistribution of fish due to restoration activities, or due to factors that have caused a general decline of brown trout observed in southwestern Montana. A similar trend is occurring in the Madison River (Figures 32 and 33). Brown trout length groups from 15.0 through 18.0 inches that were absent in 2007 in the Above Falls Section were present in 2008, but brown trout less than nine inches declined significantly from earlier years.

O'Dell Below Falls

As with the Above Falls section, a CPUE rather than a mark-recapture estimate was conducted in the Below Falls section in 2008. A total of 46 trout were sampled (4 rainbow trout, 42 brown trout) in 30 minutes of shocking (CPUE 92 trout/hr). Rainbow trout in the section ranged from 3.0 to 5.9 inches in length and brown trout from 4.0 to 19.0 inches. Numbers of brown trout by length group and year are summarized in Table 11.

Table 10. Number of brown trout sampled by length group and year in the O'Dell Above Falls section.

Length Group	2005	2006	2007	2008
3.0- 3.9	4	2	0	0
4.0- 4.9	4	11	0	7
5.0- 5.9	63	60	31	23
6.0- 6.9	84	112	35	22
7.0- 7.9	43	58	25	6
8.0- 8.9	12	14	9	3
9.0- 9.9	23	53	6	9
10.0-10.9	31	33	14	18
11.0-11.9	14	32	3	21
12.0-12.9	12	23	2	12
13.0-13.9	11	20	4	13
14.0-14.9	7	18	2	6
15.0-15.9	8	7	0	8
16.0-16.9	7	5	0	2
17.0-17.9	5	4	0	2
18.0-18.9	3	5	0	0
19.0-19.9	2	0	0	0
20.0-20.9	0	1	0	1
Total Captured	333	458	131	153

The abundance of brown trout in the Below Falls section decreased significantly in 2008 compared to previous years due primarily to a decrease in the number of fish less than 13 inches.

Electrofishing effort for the Above Falls and Below Falls sections has declined on average by 26.5 minutes since project implementation. This is potentially a result of a reduction in the numbers of smaller length groups and a shift to a more balanced population in the reaches.

Fish monitoring will not occur in the O'Dell Creek restoration project in 2009, but will resume in 2010 and be conducted biannually. As in previous years, fish will be monitored to document any change in species assemblage, number, and size.

Hebgen Reservoir

The intake structure at Hebgen Reservoir suffered a catastrophic failure of a 17-foot section of stop logs on August 31, resulting in an uncontrolled reservoir discharge (Figure 39). During this event the reservoir elevation dropped an average of six inches/day, with an average loss of 3,665 acre-feet/day. River flows immediately below the dam increased from 850 cfs to 3300 cfs in 2 hours, and remained above 850 cfs until September 26.

Table 11. Number of brown trout sampled by length group and year in the O'Dell Below Falls section.

Length Group	2005	2006	2007	2008
3.0- 3.9	0	0	1	0
4.0- 4.9	3	3	2	1
5.0- 5.9	16	11	13	3
6.0- 6.9	43	24	32	3
7.0- 7.9	14	17	32	0
8.0- 8.9	7	14	10	0
9.0- 9.9	7	13	7	0
10.0-10.9	9	21	12	3
11.0-11.9	13	18	13	10
12.0-12.9	9	7	4	2
13.0-13.9	0	4	6	5
14.0-14.9	4	5	4	7
15.0-15.9	7	7	2	3
16.0-16.9	5	3	2	0
17.0-17.9	7	14	1	1
18.0-18.9	1	2	3	3
19.0-19.9	2	0	1	1
20.0-20.9	1	3	0	0
Total Captured	148	166	145	42

Gillnetting

Table 12 summarizes characteristics of fish captured during the 2008 Hebgen gillnetting. The number of rainbow trout captured in 2008 by gillnetting increased markedly from previous years (Figure 40). The number of rainbows captured per year has varied from 47 in 2001 to 194 in 2008. The proportion of the rainbow trout gillnet catch under 14 inches has decreased noticeably since 2003 (Figure 41).

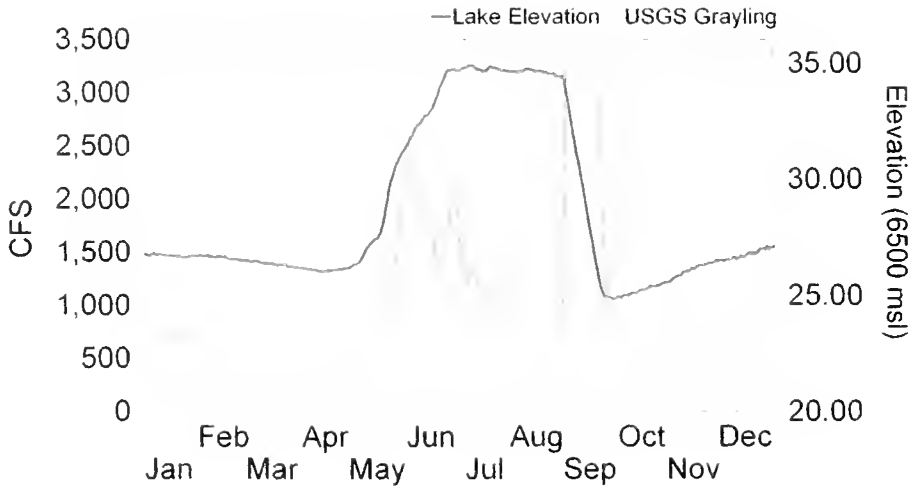


Figure 39. Hebgen Reservoir elevation and river discharge at USGS Grayling gauge 0.3 miles below Hebgen Dam. 2008.

Table 12. Summary of 2008 Hebgen Reservoir gillnet catch.

Species	Number caught	Average Length (range)	Average weight (range)
Rainbow trout	194	15.9	1.53
Brown trout	172	17.3	1.84
Whitefish	126	16.4	1.75
Utah Chub	764	9.3	0.58

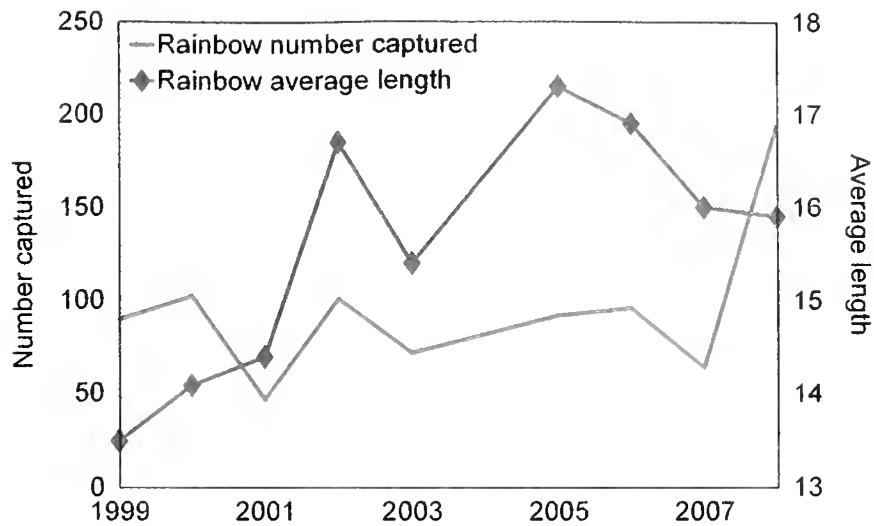


Figure 40. Rainbow trout average length (inches) vs. number captured during annual Hebgen gillnetting, 1999-2008. 2004 data set not shown because of sampling error.

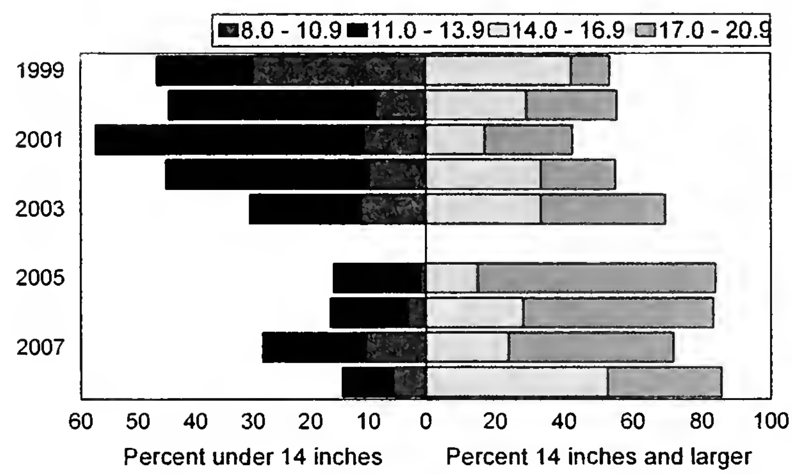


Figure 41. Percent of Hebgen Reservoir rainbow trout gillnet catch under and over 14 inches, 1999-2008. 2004 data set not shown because of sampling error.

Brown trout and whitefish have shown similar trends since 1999 as rainbows, with fewer fish captured by gillnetting, yet a larger average size (Figures 42 and 43).

Rainbow trout of hatchery origin are estimated to have comprised 6.7 % of the rainbow trout sample in 2008, as evidenced by the presence of hatchery fin characteristics coupled with a clipped adipose fin and/or oxy-tetracycline marks in vertebrae. Of the 194 rainbow trout handled, the adipose fin was absent on one, and vertebrae from 7 of 112 (6.3%) rainbow trout examined were positive for oxy-tetracycline marks. Three of these seven exhibited both oxy- tetracycline marks and hatchery dorsal fin erosion. In total, 13 rainbows exhibited known hatchery characteristics either by direct observation or by extrapolating the oxytetracycline ratio (6.3%) to the entire catch. Ten fish exhibited hatchery dorsal fin erosion characteristics only, but were not assigned as hatchery fish due to the uncertainty of what caused the dorsal fin malformation. If these fish are considered, then 11.9% of the 2008 gillnet catch can be attributed to hatchery origin.

Two (1.0%) coded-wire-tagged rainbow trout from tributary traps were recovered during gillnetting. One fish was snout tagged, which indicates its tributary of origin was the South Fork Madison. The location of the tag on the other fish failed to be recorded during processing.

Relative weight is often used as an index of fish condition. It can be evaluated on a scale of 0-105 (Guy and Brown 2007). A higher value indicates better condition of the fish. Typically, relative weight tends to increase with fish length. Figure 44 illustrates the relative weight of rainbow trout, a planktivore, and brown trout, a piscivore, captured during Hebgen Reservoir gillnetting. Rainbow trout body condition decreases with increasing length, while brown trout condition increases with increasing body length. This might suggest forage availability is limited to rainbow trout due to reduced plankton production during the over wintering period. Light penetration is likely limited due to snow and ice cover, potentially affecting primary productivity in the reservoir and consequently zooplankton abundance. Conversely, the piscivorous nature of brown trout could feasibly make it easier to maintain body condition during over wintering, with Utah chub and other fish species available for forage.

Of 103 brown trout stomachs analyzed eight contained fish. One contained mountain whitefish, 4 contained Utah chubs, and 3 contained unidentifiable fish remnants. Nineteen of the stomachs examined were empty and 76 contained macroinvertebrates. Stomach content data in 2008 was not comparable to previous years analyses because in previous years stomach contents were not identified to species.

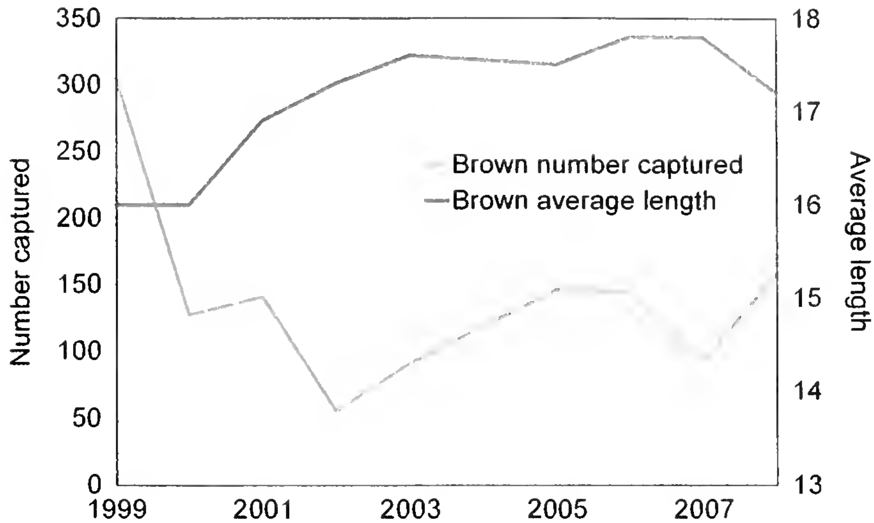


Figure 42. Brown trout average length (inches) vs. number captured during annual Hebgen gillnetting, 1999-2008. 2004 data set not shown because of sampling

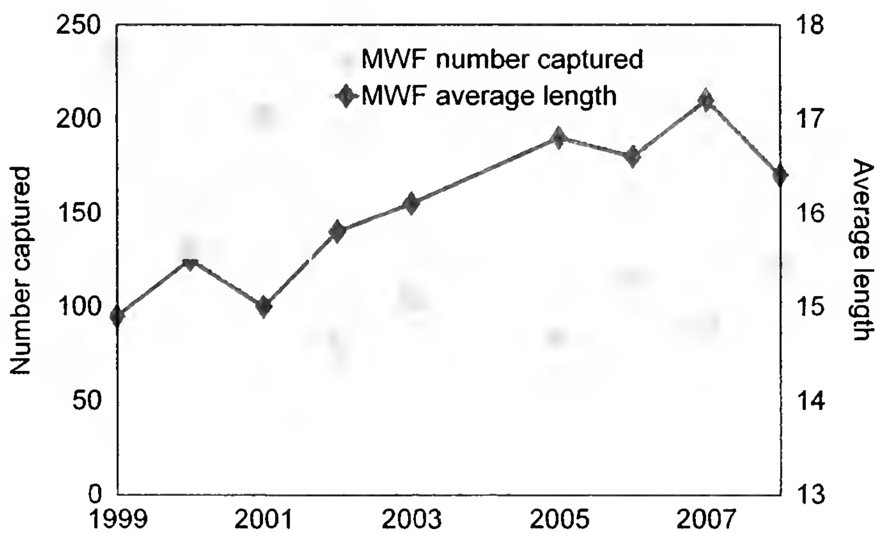


Figure 43. Mountain whitefish average length (inches) vs. number captured during annual Hebgen gillnetting, 1999-2008. 2004 data set not shown because of sampling error.

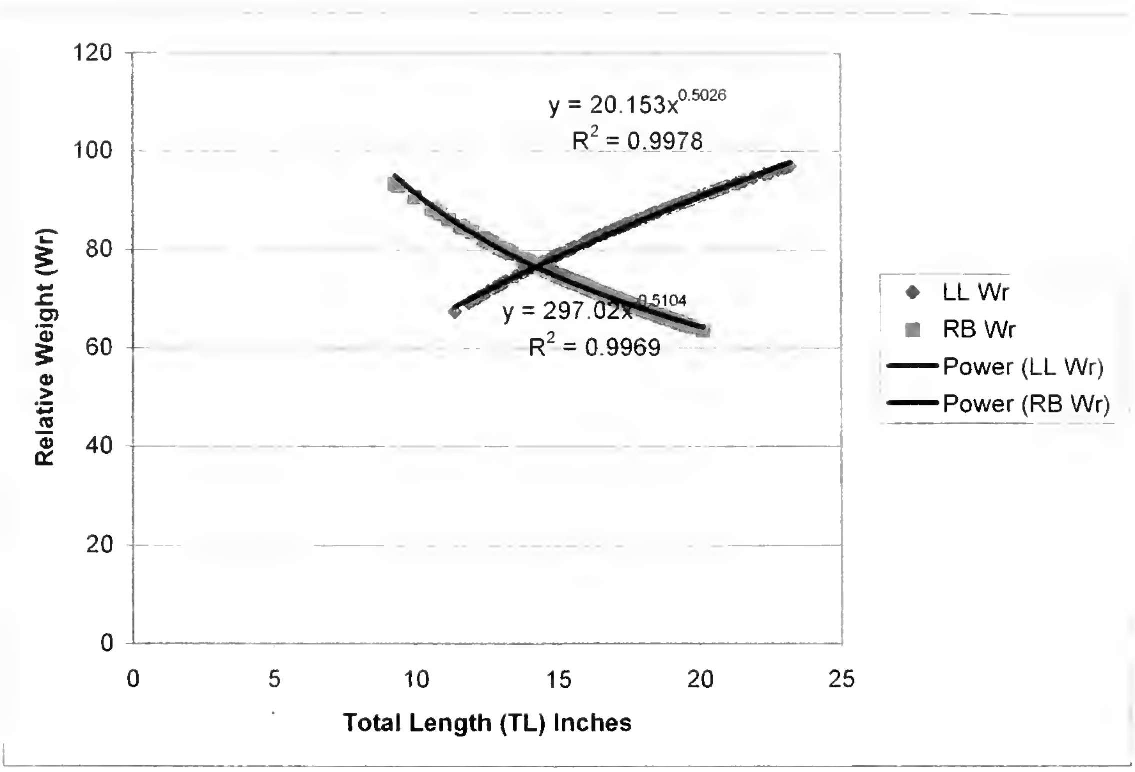


Figure 44. Rainbow and brown trout relative weights (Wr) versus total length (TL) from 2008 Hebgen Reservoir Spring gillnetting.

Whirling Disease

Results of 2008 whirling disease sentinel fish exposures are in Table 13. Examination of sentinel cage fish from the South Fork Madison River showed a moderately high occurrence of whirling disease infection, with a mean infection rate of 2.9 on the MacConnell-Baldwin scale (Appendix A). The highest rate of infection, 3.3, occurred in fish that were exposed from June 18, 2008 – June 28, 2008. Infection severity declined in sentinel fish in subsequent exposures. Sentinel fish deployed in Duck Creek, Cougar Creek, Grayling Creek and Black Sands Springs revealed no presence of infection in first exposures. Analysis from the second round of exposures have not been completed. Rainbow trout exhibiting external characteristics of whirling disease have been observed at the adult immigrant trap on Duck Creek in 2005 through 2008.

Sentinel cage results revealed a high severity of whirling disease infection (4.7) in the South Fork Madison in 2006 and moderately high infection (3.8) in 2007 (Vincent pers.comm. 2007). Laboratory and field investigations have shown survival of young-of-the-year rainbow trout to be greatly reduced when infection grade is 3.0 or greater, with 99% mortality observed within 30 days in laboratory trials and 97% mortality observed within one year in the field (Vincent 2004; Sipher and Bergersen 2001). Contribution

Table 13. Whirling disease sentinel cage histology results for Hebgen tributaries, 2008.

Cage Location	Test Dates	Number of Fish per Infection Score[1/]						Number of Fish Tested	Batch Histology Score
		0	1	2	3	4	5		
Duck Ck	6/18–28/08	50	0	0	0	0	0	50	0
South Fork Madison	6/18-28/08	4	4	8	5	15	14	50	3.30
South Fork Madison	6/28/08-7/8/08	5	8	6	5	9	4	37	2.46
Cougar Ck	6/18–28/08	42	0	0	0	0	0	42	0
Grayling Ck	6/18-28/08	38	0	0	0	0	0	38	0

[1/] See Appendix A for Infection Score definitions

from the South Fork Madison to the Hebgen rainbow fishery could be adversely affected considering the dominant life history strategy expressed is to emigrate to the reservoir as young-of-the-year (MFWP 2004; Sestrich and Lohrenz 2005), increasing the potential for exposure to whirling disease at the lower end of the drainage.

Redd count data collected by Watschke (2006) suggested that ninety-two percent of the documented wild rainbow trout production (excluding the main stem Madison River) in the Hebgen Basin occurs in Duck Creek and the South Fork Madison, with Duck Creek contributing 56% and the South Fork Madison 36%, respectively. Presently, whirling disease presence has been documented in the South Fork Madison, Cougar Creek, Duck Creek (although results have not been able to be reproduced in Duck Creek) and the Madison River above Hebgen.

Cranial deformities characteristic of whirling disease were observed in 3 rainbow trout handled at the Madison weir in 2008. Yellowstone National Park personnel collected rainbow trout for whirling disease analysis while conducting mark recapture population estimates in the Madison River in 2008 (Koel pers comm. 2008).

Planned monitoring includes continued time series exposures of sentinel fish in Hebgen tributaries to determine when infection rates are highest and to locate the upper range of whirling disease distribution in the South Fork Madison drainage. In addition, juvenile whitefish will be exposed to different concentrations of whirling disease parasites in a laboratory setting to better understand its effects on them.

Salmincola

Salmincola infection data was collected only during Hebgen Reservoir gillnetting in 2008, not at traps operated in spawning tributaries. Salmincola currently is prevalent only in Duck Creek, not in other tributaries or in Hebgen Reservoir.

Fish examined during 2008 Hebgen Reservoir gillnetting showed a low occurrence of Salmincola infection (Figure 45), with infection occurring only in rainbow

Figure 45. Adult salmincola parasites (circled in yellow) infecting the gills of a rainbow trout. MFWP photo by Travis Lohrenz.

trout and mountain whitefish. Three of 32 (9.3%) mountain whitefish and 9 of 40 rainbow trout (22.5%) examined were Salmincola positive, brown trout and Utah chub exhibited no infection. Infection severity of fish positive for Salmincola did not exceed Class 1 and no gill damage, such as necrosis at parasite attachment sites, was observed. Salmincola parasites were removed and sent to MFWP fish health personnel for identification.

During Hebgen Reservoir gillnetting in 2006 and 2007, a total of 639 Utah chub, 105 mountain whitefish, 101 brown trout, and 75 rainbow trout were examined for Salmincola. Salmincola did not occur in Utah chub or brown trout. Four of 105 mountain whitefish (3.8%) and 16 of 75 rainbow trout (21.3%) were infected, but none exceeded Class 1 infection.

Salmincola infection has been most prevalent in rainbow trout; 71% of them examined at the Duck Creek weir between 2005-2007 exhibited infection. In addition, the Class 3 infection rate has increased from May to June during each year of operation (Table 14)

Water temperature has been shown to affect the rate of Salmincola infection (McGladdery and Johnson 1988). Mean daily water temperatures for Duck Creek during peak emigration were 48.3°F, 52.5°F, and 50.3°F in 2005 – 2007, respectively. In each

Table 14. Percent of rainbow trout captured in Duck Creek weir exhibiting Salmincola infection, 2005 – 2007.

		Infection Class[1/]				Avg monthly water temp
		0	1	2	3	
2005	May	16	60	15	9	46.4
	June	18	9	44	29	53.2
	change	2	-51	29	20	6.8
2006	May	36	47	10	7	50.3
	June	14	51	19	16	56.6
	change	-22	4	9	9	6.3
2007	May	50	38	8	4	52.5
	June	24	41	29	6	58.6
	change	-26	3	21	2	6.1

[1/] Infection Class definitions:
0 = No parasites
1 = 1 – 5 parasites
2 = 6 – 10 parasites
3 = 10 or more parasites

year infection prevalence increased with increasing water temperature, with the largest change in infection occurring between May and June (Table 13).

Conley and Curtis (1993) found that the life cycle of *Salmincola edwardsii* is influenced by temperature, and seasonal variation in parasite infection might be expected in natural populations. This may explain the low occurrence of Salmincola observed in fish examined during annual gillnetting, and in fish examined during the operation of the Madison weir in the fall of 2007. Gill damage caused by Salmincola can limit gas exchange across the gill lamellae and may cause additional stress during summer months when water temperatures are higher and dissolved oxygen levels are lower (Sutherland and Wittrock 1985).

Of the 614 rainbow trout examined at the Madison weir in 2007, 33 (5.3%) exhibited infection. Two of 653 brown trout (0.3%) and 30 of 290 mountain whitefish (2.7%) examined exhibited infection. Infection severity for all fish examined at the Madison weir in 2007 did not exceed an infection classification of 1, with 4 parasites being the maximum number observed on a single fish during trap operation.

No Salmincola infection of rainbow trout less than 7 inches has been observed. This was also seen in other research. Studies conducted by Poulin (1991) point to host size, behavior, and initial parasite load as the factors that influence infection intensity. Salmincola infection increased in arctic char (*Salvelinus alpinus*) with age and size (Amundsen et. al 1997). Similarly, in a study of juvenile sockeye salmon (*Oncorhynchus nerka*) Chigbu (2001) detected no Salmincola infection in fish less than 75 mm (3 inches).

Salmincola parasitism had no apparent affect on body condition, as all rainbows recaptured after spawning exhibited poorer condition regardless of infection severity (Figure 46). Reduced condition is likely attributed to loss of gametes and energy expenditure during spawning. However, the mean numbers of parasites/fish captured at the Duck Creek weir increased from 0.86 during immigration (pre-spawning) to 9.0 during emigration (post-spawning).

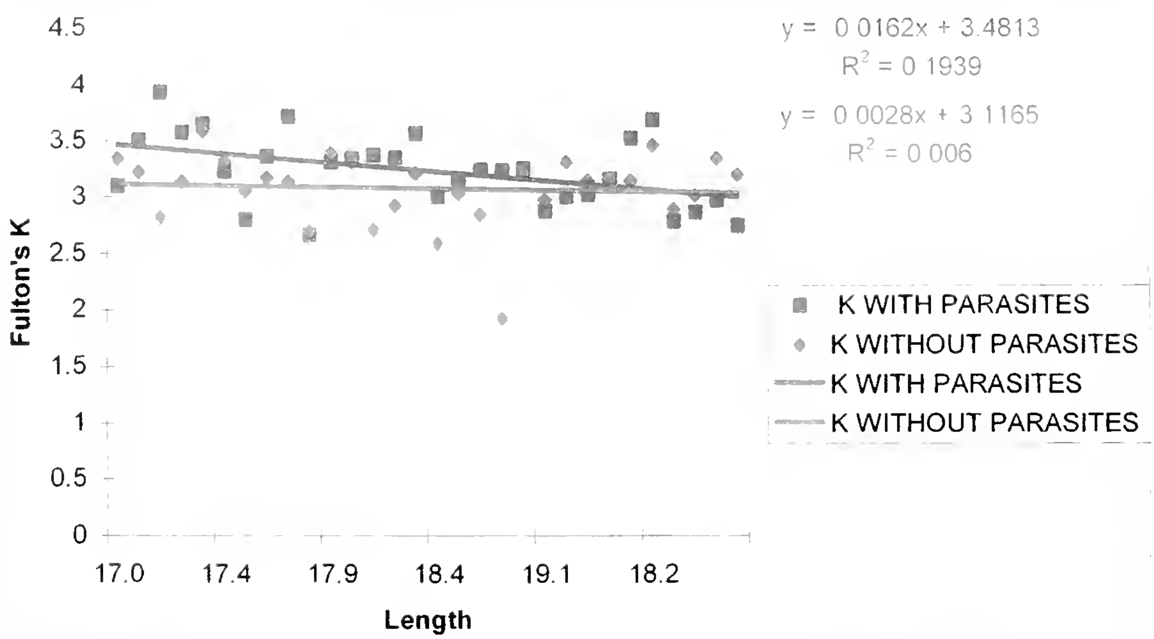


Figure 46. Condition (K) of pre- and post-spawn rainbow trout captured in the Duck Creek weir.

Blackspot Disease

Blackspot was first observed in the Madison River Drainage and Hebgen Basin during evaluation of fish at the Madison River weir in the fall of 2007 and was observed in all fish species handled at that location. Brown trout exhibited the highest rate of infection. Black spot disease was only observed in one brown trout and one rainbow in 2008, substantially less than in 2007. Fish become more susceptible to infection when stressed by environmental factors such as high water temperatures and decreased habitat availability. Decreased observance of black spot in fish handled at the weir could be attributed to the increase in reservoir pool volume and associated habitat availability in 2008 from 2007.

Hebgen Tributary Trapping

Table 15 summarizes characteristics of Spring spawning rainbow trout in Duck Creek and the South Fork Madison River, and Fall spawning rainbows in the mainstem Madison River.

Table 15. Summary of length (inches) and weight (pounds) for Spring spawning rainbow trout in Duck Creek and the South Fork Madison River, and Fall spawning rainbow trout in the mainstem Madison River. Rb = rainbow trout, LL = brown trout, MWF = whitefish.

			Madison River		
	Duck Creek	SF Madison	Rb	LL	MWF
Average Length	17.2	18.3	18.3	18.8	17.0
Length range	11.6 – 21.0	14.1 - 21.0	3.8 – 21.2	3.7-23.5	8.5-19.9
Average Weight	1.66	1.98	2.08	2.45	1.95
Weight range	0.52 – 2.49	1.10 – 2.94	0.14- 3.52	0.37- 5.00	0.20-2.61

Duck Creek

In 2008, adult trapping efforts on Duck Creek captured 215 rainbow trout (175 ♀, 40 ♂). Peak 2008 spawning immigration occurred from June 3 - June 6 with 191 rainbow trout passing through the trap over those 4 days.

Three of the 215 rainbow trout sampled (1.4%) were positive for the presence of a coded-wire-tag, and 11 individuals (5.1%) with floy-tags from previous years were recaptured.

Scale analysis of rainbow trout captured at the Duck Creek trap showed that the majority of fish (98%) comprising the spawning run were four years of age or older. Forty-three (73%) of 59 rainbow trout scale samples taken at the Duck Creek weir were aged to 6 years old or older (Figure 47) when initially floy tagged. Annual interval mortality calculations (assuming 100% tag retention) suggest that 26 % of the fish in the population die within one year after tagging, and up to 63% die within two years. These results are consistent with life-span estimates of Holton and Howard (2003), who conclude that, in general, the life span of rainbow trout in lentic environments in Montana averages around 7 to 8 years old.

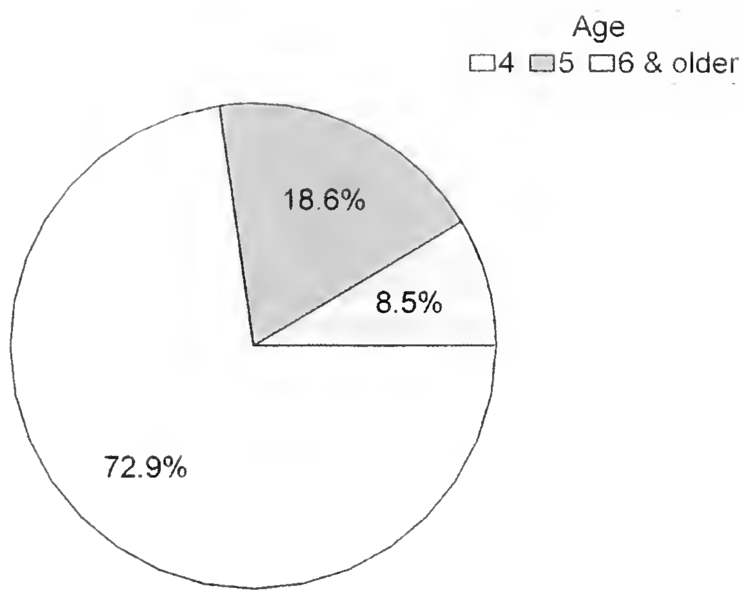


Figure 47. Age composition of rainbow trout captured in the Duck Creek adult spawning trap in 2008.

Trap operation in 2008 was difficult. Spring runoff crested the top of the weir panels on several occasions, and large woody debris and other materials carried in the high flows broke panel stringers and individual rails. Trap maintenance became a safety concern, as flows were swift. To avoid a similar situation the Duck Creek adult trap will be moved to a more secure site in 2009.

None of the rainbow trout captured in 2008 exhibited hatchery dorsal fin characteristics and none were missing adipose fins. Adipose fins were removed from a portion of hatchery reared fish planted in the reservoir in an effort to determine hatchery contribution to the fishery.

South Fork of the Madison

The South Fork Madison immigrant adult trap was operated from April 10 - 30. Peak immigration of spawning adults occurred in mid April when mean daily water temperatures were approximately 45°F. In 2008, 57 rainbow trout (24 ♀, 33 ♂) were sampled in the adult trap on the South Fork Madison. Mean length and weight of fish handled were 18.3 inches and 1.98 pounds (Table 15). No coded wire tagged fish were recovered during trap operation and none of the fish examined exhibited hatchery dorsal fin characteristics or the absence of an adipose fin. However, three (5%) rainbows that were floy tagged in 2007 were recaptured in 2008. Scale analysis of samples collected in 2007 showed that 87% of rainbow trout comprising the run were 6 years old or older (Figure 48).

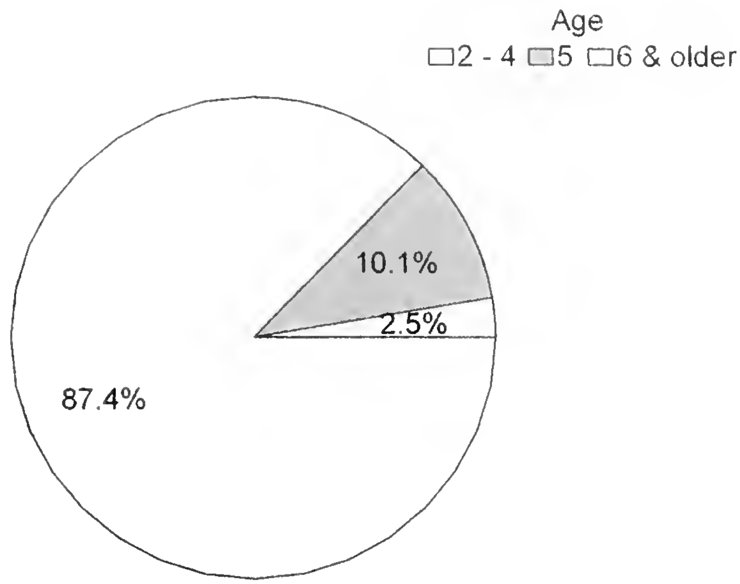


Figure 48. Age composition of rainbow trout captured in the South Fork Madison adult spawning trap in 2008.

Capture efficiency was low in 2008 due to high run off that began in mid April. There were several instances where large woody debris pushed panels below the waters surface. Additionally, the trap was vandalized on one occasion when panels were broken, the trap box disturbed and fish working gear thrown into the water. Modifications to trap design similar to the style of trap used on the Madison River will be employed on the South Fork Madison in 2009 to facilitate debris passage over the trap and downstream fish movement while increasing trapping efficiency. Modifications will include the construction of 10-foot resistance weir panels that will be anchored to the streambed with a base rail constructed of 4-inch angle iron.

Backcalculation of scale data suggests that South Fork Madison rainbow trout attain a larger size at age than Duck Creek rainbows (Figure 49), likely a function of life-history strategy. South Fork Madison rainbows predominately emigrate to the reservoir as young-of-the-year while Duck Creek fish predominately emigrate after rearing in the stream until age 2 or 3, resulting in a longer reservoir residence time for South Fork fish, and longer access to reservoir food sources. However, 7 of 2,628 (0.27%) Duck Creek rainbows coded-wire tagged during emigration to the reservoir have been recovered in adult spawning traps, while 0 of 29,951 South Fork rainbows have been recovered.

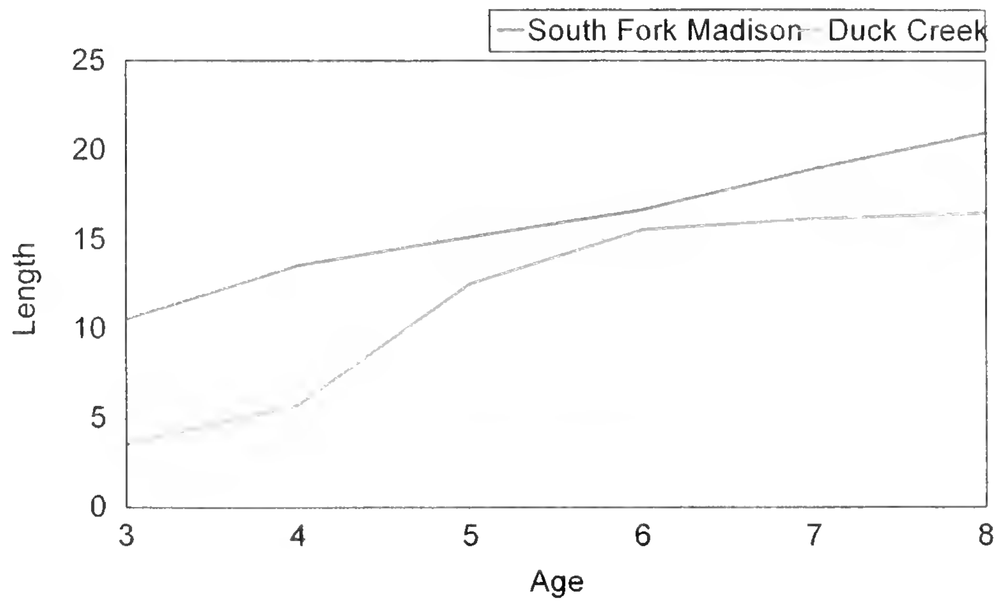


Figure 49. Length at age of South Fork Madison and Duck Creek rainbow trout.

In studies of lake versus tributary rearing of Bonneville Cutthroat trout in Strawberry Reservoir (Knight et al 1999), and rainbow trout in Lake Alexandria, New Zealand (Hayes 1995) the contribution of early migrants to lakes or reservoirs is significantly less than that of those fish that rear in natal streams before emigrating.

Factors that may be limiting the contribution of early migrant rainbow trout are susceptibility to predation, habitat and forage availability due to reservoir storage conditions, and competition with other fishes. Availability of littoral cover can greatly increase juvenile fish survival by reducing the probability of an encounter with a predator. Additionally, both intra and interspecific competition for forage and other resources is amplified when habitat availability is condensed (Walls et al. 1990). A study of brown trout on Lake Eucumbene, New South Wales, showed higher lake levels to be linked to year class survival (Tilzey 1999). Contrastingly, by rearing in the natal stream for 2-3 years, Duck Creek juveniles likely experience less forage and habitat competition and posses greater predator avoidance and forage capabilities when they enter the reservoir than do the South Fork emigrants.

Madison River mainstem

The Madison River resistance panel weir was operated for 35 days between September 3 and October 31, 2008. A total of 583 fish were handled (Table 16), with four rainbow and six brown trout recaptures from 2007. The greatest number of brown trout and rainbow trout to pass through the weir occurred on October 18, when the mean daily water temperature was 52° F and daily discharge was 406.0 cubic feet per second (cfs). The number of mountain whitefish peaked on October 31. None of the rainbow trout captured exhibited hatchery dorsal fin characteristics or the absence of an adipose fin, either of which indicate a fish of hatchery origin. Gender composition of fish captured at the weir is shown in Figure 50.

Table 16. Summary of fish handled at the Madison weir in 2008.

Month	Rainbow Trout	Brown Trout	Mountain Whitefish	Total All Species Handled
September	8	4	0	12
October	188	229	154	571
Total	196	233	154	583
Percent of Total	34.0%	41%	25%	100.0%

No mortality was observed in 2008 in the modified trap box. In 2007, mortality of several whitefish was observed in the trap box on days when 30 or more fish occupied the box.

The addition of the elongated raceway may have been effective in reducing the number of fish stacked directly below the weir, though this cannot be confirmed as far fewer fish ascended the river in 2008 than in 2007. Seven percent of the fish captured in the trapbox in 2008 exhibited hook scars, a four percent increase in observance from 2007. This is possibly due to fewer fish ascending the river, resulting in a greater probability of each fish being hooked by an angler.

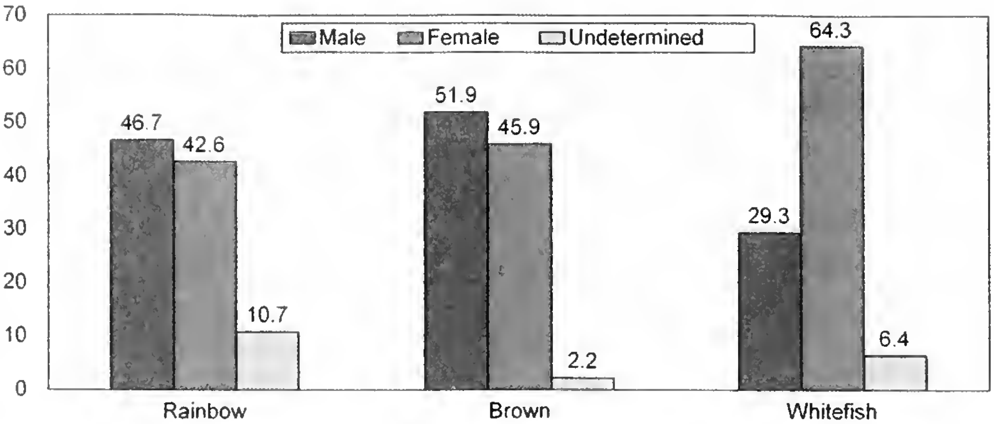


Figure 50. Percent gender composition of fish handled at the Madison weir in 2008.

Five of 23 (22 whitefish, 1 brown trout) fish caught on the weir panels in 2008 exhibited hook scars (22%) and 6 fish (26%) exhibited marks administered by YNP personnel conducting population estimates within approximately ½ mile upstream from the trap. The remaining 11 fish were counted as weir mortalities from impingement and one mountain whitefish was classified as a handling mortality.

Table 17 compares Madison weir operation in 2007 and 2008.

Reservoir elevation may have influenced the timing and strength of the Fall rainbow trout run into the river in 2008. In 2007, reservoir volume during trap operation decreased an average of 497 acre-feet per day. In 2008, due to the catastrophic failure of stoplogs in the Hebgen intake structure on August 31st, reservoir volume decreased an average 3,665 a-f per day through September 28th (Figure 51). Fish were not sampled at the Madison weir in any significant numbers until after September 28th when issues at the dam were resolved and reservoir elevation began to stabilize (Figure 52). Two other factors that could have influenced trap efficiency in 2008 were the disconnection of one of the weir panels from the base rail, and significantly fewer fish ascending the river than in 2007. The disconnection of the panel created a crease within the panel assembly that forced a 12 foot section below the waters for two days. Field repairs were made to the section, but proper lift of the panels was still somewhat compromised. No fish were observed jumping the weir, and gaps along the base rail were sealed, limiting the potential for fish to bypass the trap through gaps in pickets. Fewer fish ascending the river would also compress the duration of the run.

Table 17. Summary of Madison weir operation, 2007 vs. 2008. Handling mortality is defined as mortality caused directly by handling, or mortality of handled fish found within 24 hours after handling. Weir mortality is defined as mortality caused by fish becoming impinged in the weir panels or mortality caused by stress/crowding in the trap box. Handled fish exhibited unique marks or tags that did not occur on unhandled fish, allowing their differentiation.

	2007	2008	
Begin operation	Sept 15	Sept 3	
End operation	Nov 7	Oct 31	
Begin& end reservoir elevations			
Total # days operated	36	35	Trap not operated some weekends or if adequate number of crew unavailable
Total rainbows captured (# morts)	733 (4 handling; 4 weir)	197 (0)	
Total brown captured (# morts)	772 (2 handling; 5 weir)	233 (0 handling; 1 weir)	
Total whitefish captured (# morts)	491 (4 handling; 158 weir[1/])	154 (1 handling; 22 weir)	[1/] 49 whitefish weir morts on 10/24/07 when 143 whitefish caught in trapbox. 47 whitefish morts on 11/6&7/07 when panels were raised to maximize capture for whitefish egg-take for whirling disease research
Total Captured – all species (# morts)	1996 [10 handling (0.5%), 167 weir (8.4%)]	584 [1 handling (0.2%), 22 weir (3.8%)]	Weir morts may not be handled fish

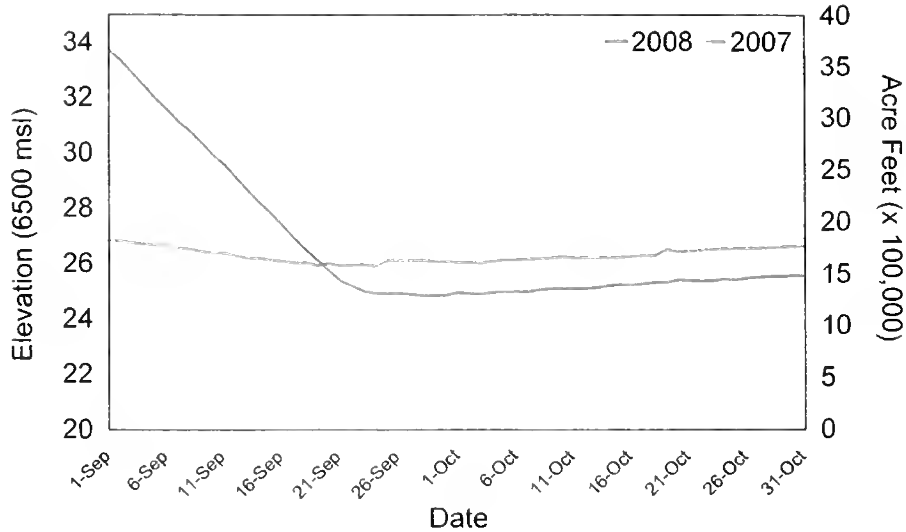


Figure 51. Hebgen Reservoir pool volume vs elevation, September and October 2007 and 2008.

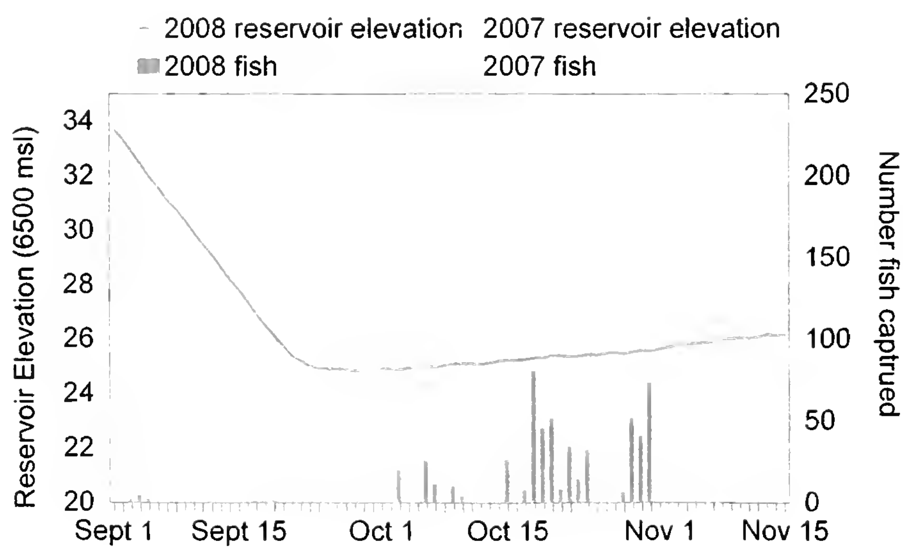


Figure 52. Number of fish/day versus reservoir elevation during Madison weir trap operation, 2007 and 2008.

The contribution of the Madison River rainbow trout spawning run to the Hebgen Reservoir fishery is presently unquantified. In May 2006, a rotary screw trap was installed on the Madison River below Baker's Hole Campground to identify peak emigration of young-of-the-year rainbow trout from the Madison. A total of 361 young-of-the-year rainbow trout were sampled in May 2006, one month before emigration of young-of-the-year began on the South Fork Madison and approximately two months ahead of the Duck Creek emigration. In 2007, rotary screw trap operation began on March 15, and 218 young-of-the-year rainbow trout were captured the first night of operation. High flows during Spring runoff make operation of the screw trap difficult, and decrease capture efficiency of the trap.

Information regarding the Fall rainbow spawning run initially came from limited young-of-year emigration and temperature data collected in 1990 (Fredenberg 1991), which indicated that rainbows may be spawning as early as January. Water temperature directly affects the rate of egg development and hatching. For example, rainbow trout eggs incubated at a constant water temperature of 40° F require 640 temperature units to hatch (Piper et al. 1982), where a temperature unit is defined as 1° above 32° F for a 24-hour period. A constant water temperature of 40° F would provide 8 temperature-units per day, requiring 80 days for eggs to hatch. Another 1,080 temperature-units are required by sac fry for yolk absorption before swim up (Fredenburg 1991). Back calculation to time of emergence, based upon first observance of young-of-the-year rainbow trout in the Madison screw trap and water temperature, suggests that rainbow trout are spawning as early as mid September in the Madison River. This is four months earlier than Fredenburg (1991) suggested, but coincides with local angler reports of catching sexually mature or "ripe" rainbow trout during the months of September and October. The Madison weir was installed to investigate the Fall rainbow trout spawning run.

It is uncertain why rainbow trout are spawning in the Madison River in the Fall. The Fall spawning run may be linked to the warm thermal regime of the Gibbon and Firehole rivers in Yellowstone National Park. In a study of the reproductive biology of rainbow trout and brown trout in the Firehole River above the Firehole Falls, rainbow trout were observed spawning in the Fall of the year. It was hypothesized that the Fall spawning was likely an adaptation to the thermal regime of the river (Kaya 1977). Another possible explanation is that the run developed out of past stocking practices. Since 1954, several strains of rainbow trout have been used to augment the Hebgen Reservoir fishery. MFWP began stocking wild strains of Eagle Lake and DeSmet rainbow trout in 1987. Prior to that domesticated Arlee and Shasta strains were used. In some instances, domesticated hatchery strains have been observed to spawn at times uncharacteristic of rainbow trout as a result of selective breeding in hatchery systems. In order to maximize productivity and increase the size of fish being stocked, hatcheries developed Fall spawning individuals to maximize the size of fish to be planted (Leitritz 1959). Fish samples collected at the Madison weir were sent in for strain analysis and should help determine if the fall run of rainbows is a result of hatchery stocks into Hebgen, or the result of downstream movement of rainbow trout above Firehole Falls.

Rotary screw traps (Figure 53) were not operated on any of the Hebgen tributaries in 2008. High water from spring run off prevented installation of the traps. It is anticipated that screw traps will be set in Duck Creek and the SF Madison in 2009.

Figure 53. Rotary screw trap typically used to sample young-of-the-year and yearling fish on Hebgen tributaries.

<u>Juvenile fish sampling</u>

The number of young-of-year Utah chub captured from June through August 2008 increased significantly over the number captured during the same period the previous two years, while the number of young-of-the-year salmonids declined from 2007, but were greater than in 2006 (Figure 54).

Of the 75 young-of-the-year rainbow trout in 2008, 73 were collected at the Madison Arm index site: 18 in June, 52 in July, and 3 in August. The only other young-of-the-year rainbow trout sampled in 2008 was captured at the South Fork Madison Index site.

Utah chub spawning has been observed in May through late August in Hebgen Reservoir. Typically, spawning takes place in shallow near-shore zones often with submergent or emergent vegetation and inundated terrestrial vegetation. Vegetation has been suggested to be key to the success of spawning for Utah chub (Teuscher and Lueke 1996). The low number of young-of-the-year Utah chub observed in 2007 and conversely the relatively high number observed in 2008 potentially was a result of increased reservoir elevation and the amount of inundated vegetation available for Utah chub spawning in 2008. Reservoir elevation from June through September 2008 was significantly higher than the same period in 2007 (Figure 55).

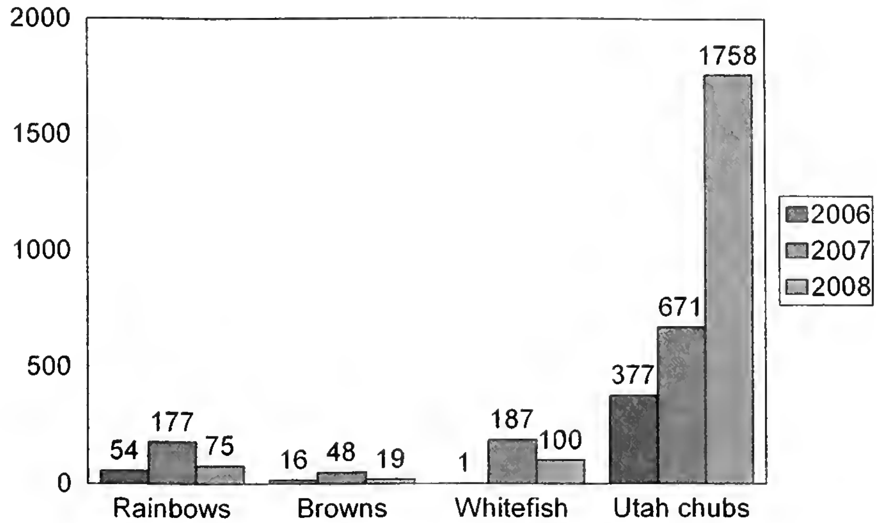


Figure 54. Number of young-of-the-year captured during Hebgen Reservoir beach seining, 2006 – 2008.

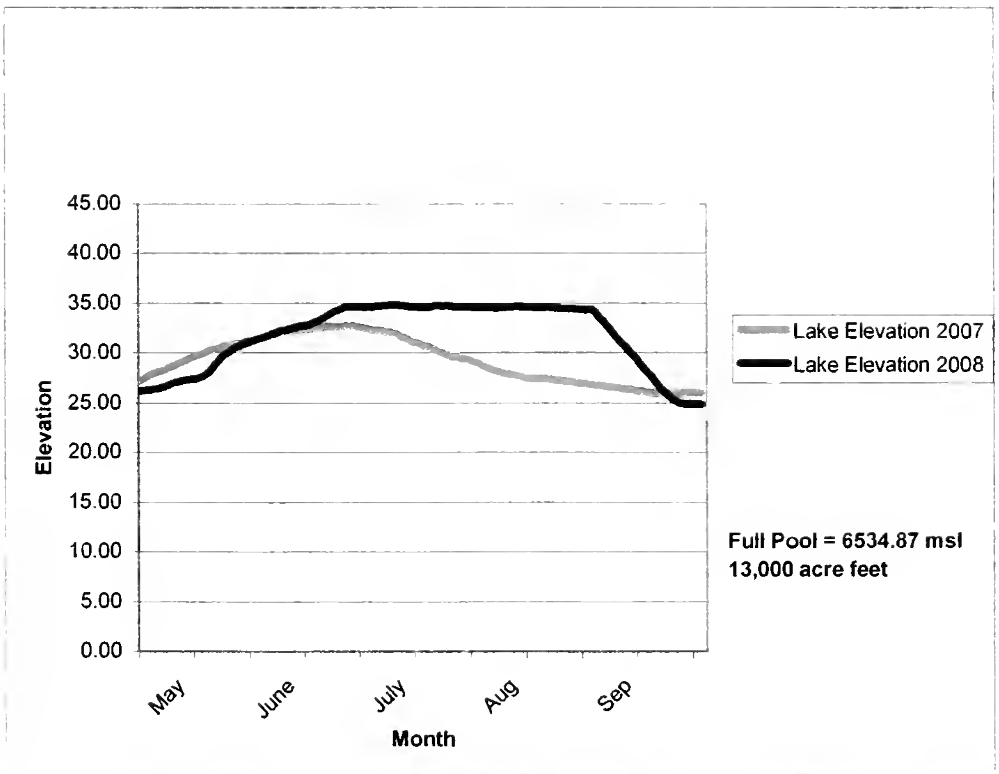


Figure 55. Difference in Hebgen Reservoir pool elevation, in feet, May – September, 2007 and 2008.

Similarly, studies have shown that shoreline vegetation is important for the rearing of young-of-the-year adfluvial salmonids that emigrate to lakes and reservoirs. However, given the fecund nature of the Utah chub, with mature females from Hebgen averaging 40,750 eggs (Graham, 1955), a quick hatch rate, typically 6 to 9 days at 65.0°F to 67.0°F, and territorial behavior of young chubs, emigrating young-of-the-year rainbow trout may be precluded from rearing habitat within the vegetated near-shore portion of the reservoir.

Hebgen Reservoir Zooplankton Monitoring

Densities (individuals/liter) of cladoceran and copepod zooplankton peaked in July with mean densities for all sites at 4.95 individuals/liter for cladocerans (Figure 56) and 5.65 individuals/liter for copepods (Figure 57). Overall, abundance of cladocerans was down from the previous year by 3.32/liter, while copepod densities were higher by 2.95/liter. Temporal trends in abundance were similar to those observed in previous years with peak densities occurring in late spring and early summer and a declining thereafter.

Body size of both cladoceran and copepods increased as densities declined (Figures 58 and 59). This has been observed in zooplankton populations in several temperate lakes. The warming of the reservoir in early spring typically triggers a phytoplankton bloom promoting quick growth of the zooplankton community. However, size selective predation on larger cladocerans by fish reduces their abundance and predation shifts to copepods. Reduced predation on the remaining cladoceran community could account for the increase in body size seen in the cladoceran community through summer until densities are such that another predation shift occurs (Hall and Threlkeld 1976).

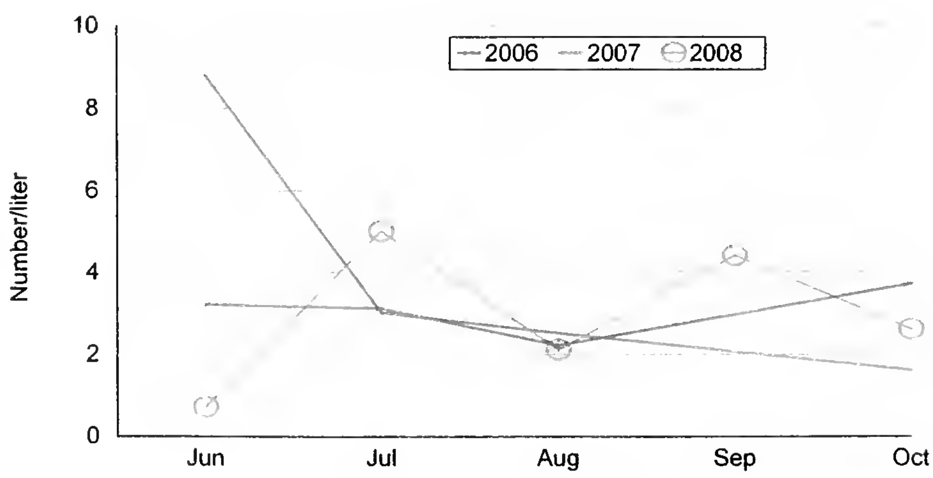


Figure 56. Cladoceran densities (individuals/liter) by month for 2006, 2007, and 2008.

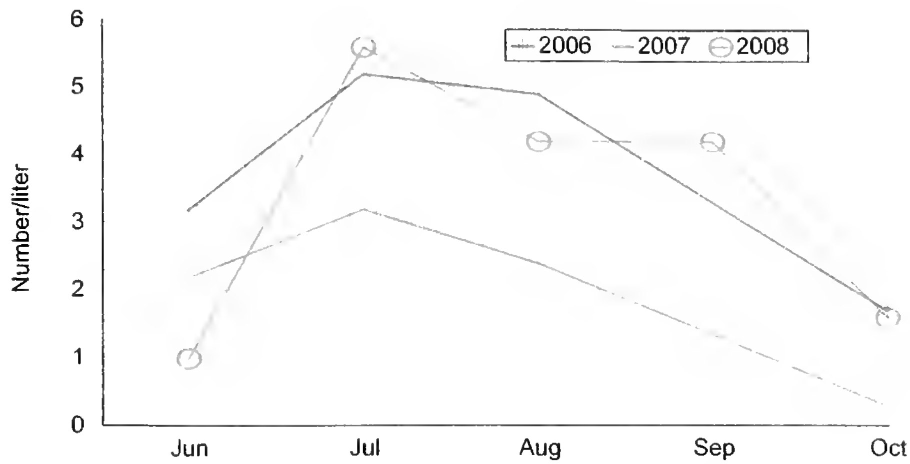


Figure 57. Copepod densities (individuals/liter) by month for 2006, 2007, and 2008.

Utah chub comprise the majority of the fish biomass in Hebgen Reservoir and may be influencing zooplankton densities through grazing. There appears to be a threshold level at which numbers of juvenile Utah chubs suppress cladoceran density (Figure 60).

Cladoceran densities in Hebgen also seem inversely related to the ratio of adult Utah chub/brown trout (Figure 61).

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

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. Shortened season duration is often associated with an increase in elevation, reducing the total number of days of primary production. 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. Mean surface water temperatures for Hebgen over the last four years were at or exceeded 50° F an average of 130 days. In 2007, surface temperatures were at or exceeded 50° F for 152 days, extending the growing season by almost a month, which may have contributed to the increase in cladoceran densities observed.

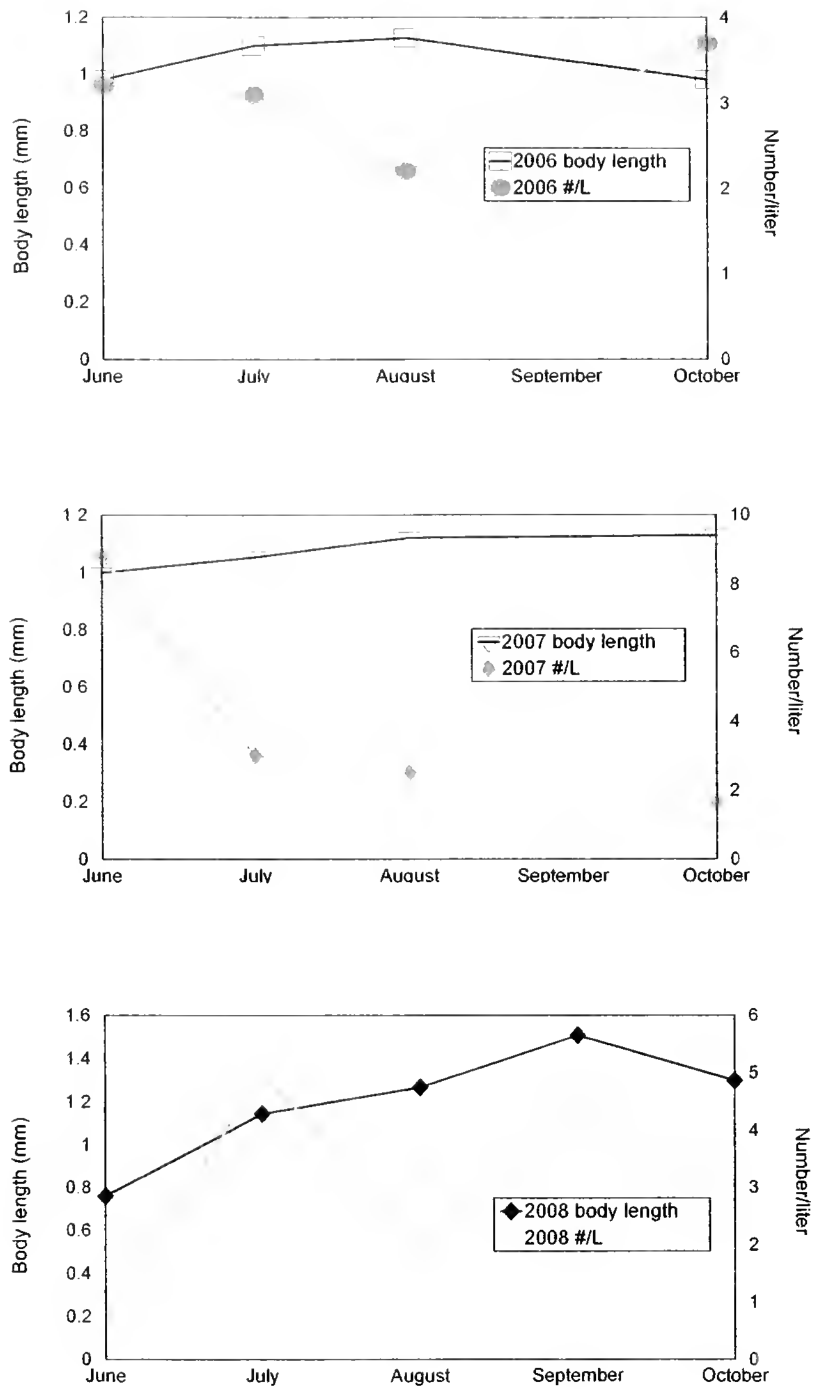


Figure 58. Hebgen cladoceran density vs. mean body length (mm), 2006 – 08.

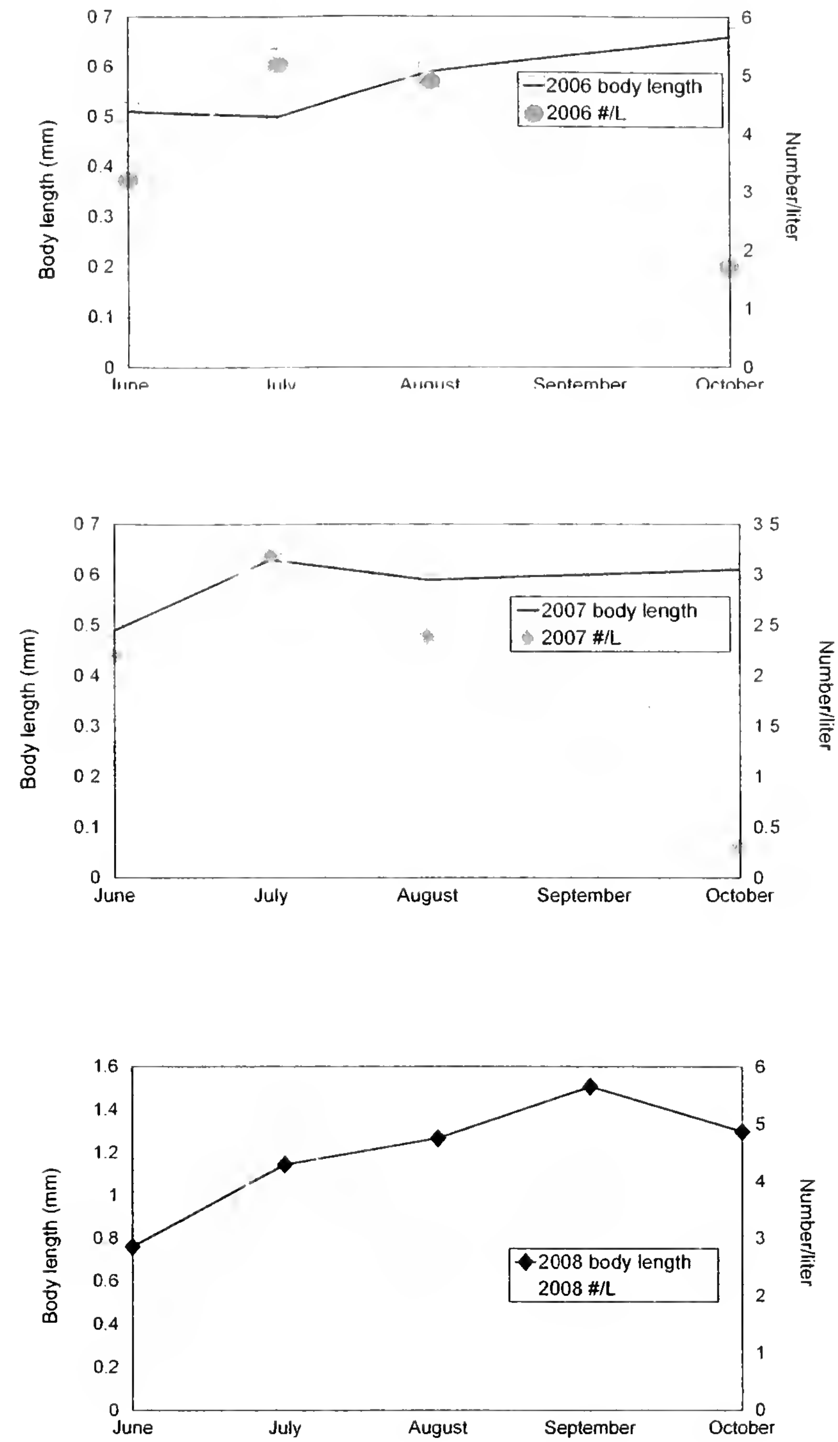


Figure 59. Hebgen copepod density vs. mean body length (mm), 2006 – 08.

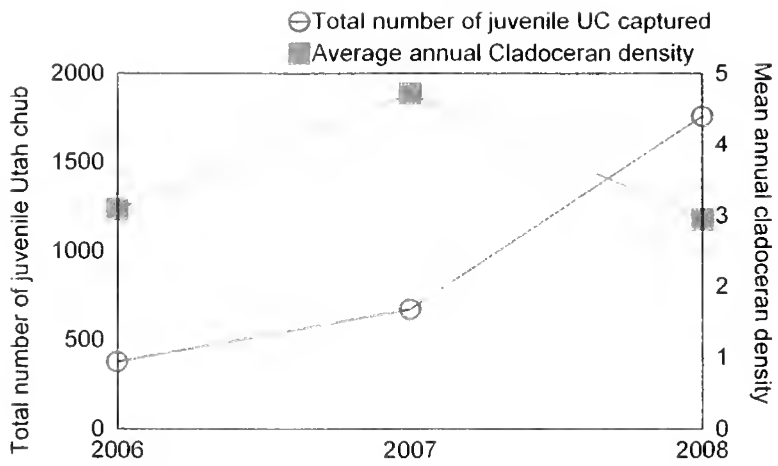


Figure 60. Number of juvenile Utah chub collected in annual beach seining versus annual mean cladoceran density, 2006-2008.

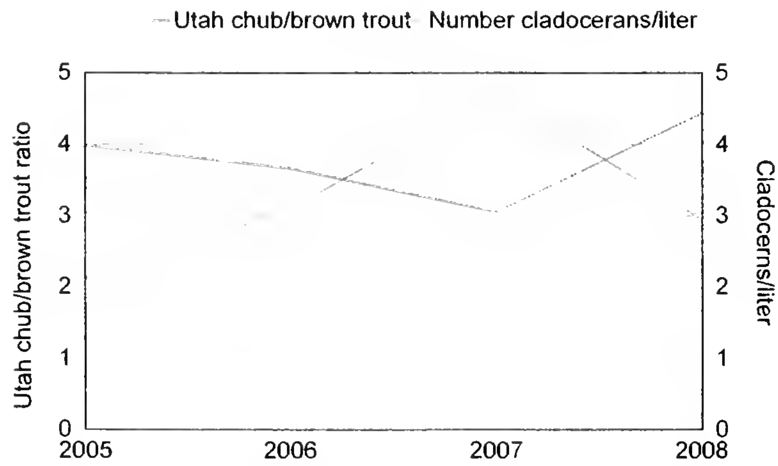


Figure 61. Number of Utah chub per brown trout (calculated from annual spring gillnetting) and annual mean cladoceran density, 2005 - 2008.

CONCLUSIONS AND FUTURE PLANS

The Madison (Ennis) Reservoir grayling population continues to persist at low levels. While the Madison population is very similar genetically to the Big Hole population, it exhibits an adfluvial life history pattern versus the fluvial behavior of the Big Hole River population.

Population estimates will continue to be conducted annually in the Madison River. These data are necessary for setting angling regulations, and to monitor environmental and biological impacts on the populations.

New Zealand Mudsnail populations will continue to be monitored through the 2188 Biological and Biocontaminant monitoring program and through the FWP Aquatic Nuisance Species Program.

Rainbow trout captive stock used in sentinel cage studies in the Madison River have continued to show high infection rates and severity. In laboratory studies, progeny of Madison River rainbow trout are exhibiting resistance to whirling disease.

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

In 2008, adult WCT from the Sun Pond were spawned and resulting fry stocked back into the pond. Wild donor populations will continue to be tapped for the next several years as well for replicating existing wild, genetically pure WCT populations into fishless streams to expand the range and numbers of WCT, thereby diminishing their extinction risk.

The Cherry Creek Native Fish Introduction Project will continue in 2009. Introductions will be conducted in Phase 2 of the project area, and are anticipated to be initiated in Phase 3.

In 2009 effort will be directed toward designing and potentially implementing a barrier system that will reduce or eliminated fish entrainment in the West Madison canal.

In 2009, a well will be drilled and a delivery system implemented to deliver water to stock tanks near Lake Creek, eliminating the need to use tarps to pool water behind Smith Lake Dam. This will allow year-round passage for spawning brown and other aquatic species.

Monitoring of the fisheries response to the O'Dell Creek wetland restoration project continued in 2008. Brown trout are the predominant species in the project area, and have shown increased numbers in some monitoring sections and decreased numbers in other monitoring sections.

The number of rainbow trout captured during Hebgen Reservoir gillnetting in 2008 increased markedly from previous years. The proportion of the catch over 14 inches has increased noticeably since 2003.

The South Fork of the Madison, where juvenile rainbow trout emigrate to the reservoir as young-of-the-year, is the only tributary of Hebgen Reservoir to show high whirling disease infection of sentinel fish.

In 2008, rainbow trout six year old and older comprised 73 percent and 87 percent of the fish ascending Duck Creek and the South Fork of the Madison, respectively, to spawn. The remainder of the fish were four and five year olds.

The 2008 spawning run into the Madison River upstream of Hebgen was significantly reduced compared to 2007, confirmed by capture at the Madison weir and angler reports. Anecdotal reports from anglers indicate that the Fall spawning run of rainbow trout has been diminishing for over 10 years.

The number of young-of-the-year Utah chub captured during beach seining in Hebgen Reservoir increased nearly three-fold in 2008 compared to 2007, while the number of rainbow trout, brown trout and whitefish all diminished.

Hebgen zooplankton densities peaked in July. Body size of individual plankters increased as densities declined.

LITERATURE CITED

Amundsen, P. A., R. Kritoffersen, R. Knudsen, and A. Klemetsen. 1997. Infection of *Salmincola edwardsii* (Copepoda: Lernaeopodidae) in an age-structured population of Artic charr-a long-term study. Norwegien College of Fishery Science, 1996. University of Tromso, Tromso, Norway.

Bramblett, R.G. 1998. Environmental Assessment. Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program: Cherry Creek Native Fish Introduction. Prepared for Montana Fish, Wildlife, & Parks, April 15, 1998. 70 pages.

Byorth, P. and B. Shepard. 1990. Ennis Reservoir/Madison River Fisheries Investigations. Montana Fish, Wildlife, & Parks Final Report to Montana Power Company. 90 pages.

Chigbu, P. 2001. Occurrence and distribution of Salmincola *californiensis* (Copepoda: Lernaeopodidae) on juvenile sockeye salmon (Oncorhynchus nerka) in Lake Washington. Journal of Freshwater Ecology, Vol 16, number 4. 2001.

Conley, D.C. and M.A. Curtis. 1993. Effects of temperature and photoperiod on the duration of hatching, swimming, and copepodid survival of the parasitic copepod *Salmincola edwarsdsii*. Canadian Journal of Zoology. 71: 972-976.

Federal Energy Regulatory Commission. 2000. Order Issuing New License, Project No. 2188-030. Issued September 27, 2000.

Fredenberg, W. 1991. Hebgen Lake fry recruitment study, final report. Montana Fish, Wildlife and Parks. Bozeman MT.

Graham, R.J. 1955. Biology of the Utah chub in Hebgen Lake, Montana. Master's thesis. Montana State University, Bozeman Montana.

Guy, C.S. and M.L. Brown, editors. 2007. Analysis and interpretation of freshwater fisheries data. American Fisheries Society, Bethesda, Maryland.

Hall, D.J. and S.T. Threlkeld. 1976. The size –efficiency hypothesis and the size structure of zooplankton communities. Annual Review of Ecological Systems. 7:177-208. www.annualreviews.org/aronline.

Hayes, J.W. 1995. Importance of stream versus early lake rearing for rainbow trout fry in Lake Alexandria, South Island, New Zealand, determined from otolith daily growth patterns. New Zealand Journal of Marine and Freshwater Research, 29:409-420.

Holton, G.D. and H.E. Johnson. 2003. A field guide to Montana fishes. Third edition. Montana Fish Wildlife and Parks, Helena Montana.

Johnson, B. and P. Martinez. 2000. Trophic economics of lake trout management in reservoirs of differing productivity. North American Journal of Fisheries Management. 20: 127.

Johnson, J. 1988. Environmental assessment of plans to restore Strawberry Reservoir fishery. Utah Division of Wildlife Resources No 87-14. Salt Lake City, Utah.

Kaya, C. M. 1977. Reproductive biology of rainbow and brown trout in a geothermally heated stream: The Firehole river of Yellowstone National Park. Transactions of the American Fisheries Society. 106:354-361.

Knight, C.A., R.W. Orme and D.A. Beauchamp. 1999. Growth, survival, and migration patterns of juvenile adfluvial Bonneville cutthroat trout in tributaries of Strawberry Reservoir. Transactions of the American Fisheries Society. 128:553-563.

Koel, Todd. 2008. Personal Communication

Leitritz, E. 1959. Trout and Salmon Culture (hatchery methods). California Dept. of Fish and Game.

McGladdery S.E. and C.E. Johnston. 1988. Egg development and control of the gill parasite, *Salmincola salmoneus*, on atlantic salmon kelts (*Salmo salar*) exposed to four different regimes of temperature and photoperiod. Aquaculture 68:193-202.

McKittrick, M. 2004. Personal communication.

Montana Fish, Wildlife, & Parks. 1995. Madison River/Ennis Reservoir Fisheries. 1994 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. May 1995.

Montana Fish, Wildlife, & Parks. 1996. Madison River/Ennis Reservoir Fisheries. 1995 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. February 1996.

Montana Fish, Wildlife, & Parks. 1997. Madison River/Ennis Reservoir Fisheries. 1996 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. March 1997.

Montana Fish, Wildlife, & Parks. 1998a. Madison River/Ennis Reservoir Fisheries. 1997 Annual Report to Montana Power Company, Environmental Division, Butte, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 1998.

Montana Fish, Wildlife, & Parks. 1998b. Decision Notice: Cherry Creek Native Fish Introduction Project. Region 3, July 6, 1998. Pat Clancey. 30 pages.

Montana Fish, Wildlife, & Parks. 1999a. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 1998 Annual Report to Montana Power Company, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. April 1999.

Montana Fish, Wildlife, & Parks. 1999b. Memorandum of Understanding and Conservation Agreement for Westslope Cutthroat Trout in Montana. May 1999.

Montana Fish, Wildlife, & Parks. 2000. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 1999 Annual Report to PPL Montana (formerly Montana Power Company), Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. April 2000.

Montana Fish, Wildlife, & Parks. 2001. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2000 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey and Dan Downing, Ennis. April 2001.

Montana Fish, Wildlife, & Parks. 2002. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2001 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 2002.

Montana Fish, Wildlife, & Parks. 2003. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2002 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. March 2003.

Montana Fish, Wildlife, & Parks. 2004a. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2003 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. May 2004.

Montana Fish, Wildlife, & Parks. 2004b. FA+. Montana Fish, Wildlife, & Parks, Information Services Unit, Bozeman.

Montana Fish, Wildlife, & Parks. 2005. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2004 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey & Travis Lohrenz, Ennis. April 2005.

Montana Fish, Wildlife, & Parks. 2006. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2005 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 2006.

Montana Fish, Wildlife, & Parks. 2007. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2006 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. June 2007.

Montana Fish, Wildlife, & Parks. 2008. Madison River/Ennis Reservoir Fisheries and Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. 2007 Annual Report to PPL Montana, Environmental Division, Butte, and Turner Enterprises, Inc., Gallatin Gateway, from Montana Fish, Wildlife, & Parks, Pat Clancey, Ennis. July 2008.

Pimentel, D., R. Zuniga, and D. Morrison. 2005. Update on the environmental and economic costs associated with alien-species in the United States. Ecological Economics, 2005 (Vol. 52) (No. 3) 273-288.

Piper, R.G., I.B. McElwain, L.E. Orme, J.P. McCraren, L.G. Fowler and J.R. Fowler. 1983. Fish hatchery management. Second Printing, American Fisheries Society and United States Department of Interior. Fish and Wildlife Service. Washington, D.C.

Poulin, R., E.R. Manfred, M.A. Curtis. 1991. Infection of brook trout fry, *Salvelinus fontinalis*, by ectoparasitic copepods: the role of host behaviour and initial parasite load. The Association for the Study of Animal Behaviour. 41:467-476.

Sestrich, C. and T. Lohrenz. 2005. Hebgen Basin interagency fisheries working group 2005 accomplishment report to PPL Montana.

Sipher, C. R. and E. P. Bergersen. 2001. The effects of whirling disease on growth and survival of snake river cutthroat and Colorado River rainbow trout fingerlings. 7th Annual Whirling Diseases Symposium abstracts. Whirling Disease Foundation, Bozeman MT, and Utah Division of Wildlife Resources, Logan, UT.

Sloat, M.R., B.B. Shepard, and P. Clancey. 2000. Survey of tributaries to the Madison River from Hebgen Dam to Ennis, Montana with an emphasis on distribution and status of westslope cutthroat trout. Report to Montana Fish, Wildlife, & Parks, Helena, Montana. 165 pages.

Sutherland, D.R. and D.D. Wittrock. 1985. The effects of *Salmicola californiensis* (Copepoda: Lernaeopodidae) on the gills of farm-raised rainbow trout, *Salmo gairdneri*. Canadian Journal of Zoology 63:2893-2901.

Tilzey, R.D.J. 1999. Environmental cues in the reproductive migrations of brown trout (Salmo trutta) in Lake Eucumbene, New South Wales. Australian Society for Fish Biology. Kingston ACT.

Teuscher D. and C. Luecke. 1996. Competition between kokanees and Utah chub in Flaming Gorge Reservoir, Utah-Wyoming. Transactions of the American Fisheries Society. 125:505-511.

Vincent, Dick. 2004. Personal Communication.

Vincent, Dick. 2007. Personal Communication.

Walls, M., I. Kortelainen and J. Sarvala. 1990. Prey responses to fish predation in freshwater communities. Ann. Zool. 27:183-199.

Watschke, Darin. 2006. Assessment of Tributary Potential for Wild Rainbow Trout Recruitment in Hebgen Reservoir, Montana. Master of Science Thesis, Montana State University, Bozeman, MT. 139 pages.

Appendix A

The MacConnell-Baldwin whirling disease grade-of-severity scale and definitions.

Grade 0: No abnormalities noted. *Myxobolus cerebralis* is not seen.

Grade 1: Small, discrete focus or foci of cartilage degeneration. No or few associated leukocytes.

Grade 2: Single, locally extensive focus or several smaller foci of cartilage degeneration and necrosis. Inflammation is localized, few to moderate numbers of leukocytes infiltrate or border lytic cartilage.

Grade 3: Multiple foci (usually 3 –4[1/]) of cartilage degeneration and necrosis. Moderate number of leukocytes are associated with lytic cartilage. Inflammatory cells extend minimally into surrounding tissue.

Grade 4: Multifocal (usually 4 or more sites[1/]) to coalescing areas of cartilage necrosis. Moderate to large numbers of leukocytes border and/or infiltrate lytic cartilage. Locally extensive leukocyte infiltrates extend into surrounding tissue.

Grade 5: Multifocal (usually 6 or more[1/]) to coalescing areas of cartilage necrosis. Moderate to large numbers of leukocytes border and/or infiltrate necrotic cartilage. The inflammatory response is extensive and leukocytes infiltrate deeply into surrounding tissue. This classification is characterized by loss of normal architecture and is reserved for the most severely infected fish.

[1/] lesion numbers typical for head, not whole body sections.

Appendix B1

Summary of Ennis Reservoir beach seining 1995 - 2007

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

Appendix B2

Description of young-of-the-year Arctic grayling beach seining locations in Ennis Reservoir, and catch at each site. See Figure 3 for site locations.

Species abbreviations:

AG	Arctic grayling
MWF	mountain whitefish
Rb	rainbow trout
LL	brown trout
WSu	white sucker
UC	Utah chub
LND	long-nose dace

September 29, 2008

Site and time seined	AG	MWF	Note
Meadow Ck FAS North shore willows 1315 hrs Fig 3 site 1	0	0	Dense macrophytes; 1 Rb (3.0") 2 LL (3.0", 3.0") 45 juvenile UC, 48 juvenile WSu
Meadow Ck FAS West shore willows 1420 Fig 3 site	0	0	Dense macrophytes 3 juvenile WSu
South shore ¾ mile east of Moores Ck 1510 hrs Fig 3 site 2	0	4 (5.0", 4.8", 4.8", 4.7")	Abundant macrophytes; 7 juvenile UC 31 juvenile WSu 1 LND
1000 yards east of Clutes Landing 1215 Fig 3 site 3	0	2 (4.5", 4.0")	No macrophytes; 1 LL (3.9") dozens juvenile UC dozens juvenile WSu

Appendix C1

Historic population estimates of aged rainbow and brown trout per mile in the Pine Butte, Varney, and Norris sections of the Madison River

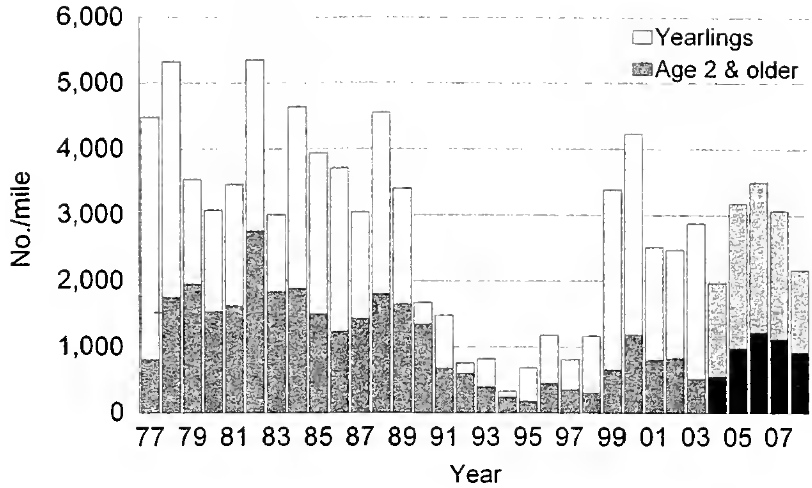


Figure C1 - 1. Rainbow trout populations in the Pine Butte section of the Madison River, 1977-2008, fall estimates. Estimates for 2004 - 2008 are not aged.

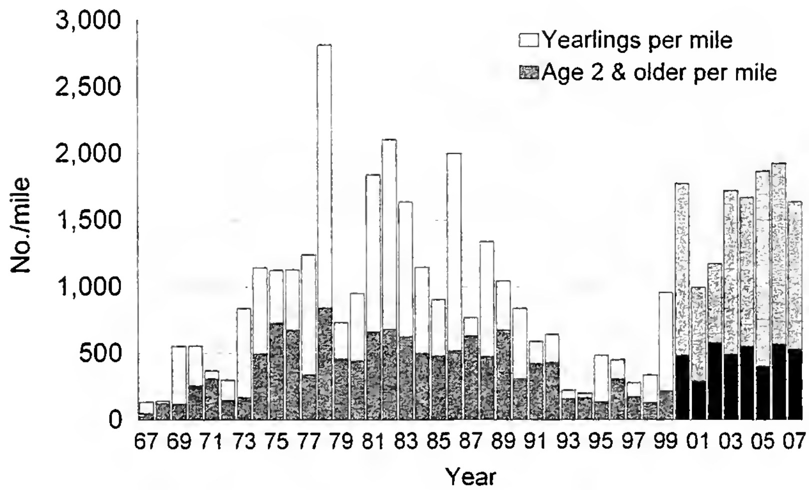


Figure C1 – 2. Rainbow trout populations in the Varney section of the Madison River, 1967-2007, fall estimates. Estimates for 2000 - 2007 are not aged. Estimates were not conducted in Varney in 2008.

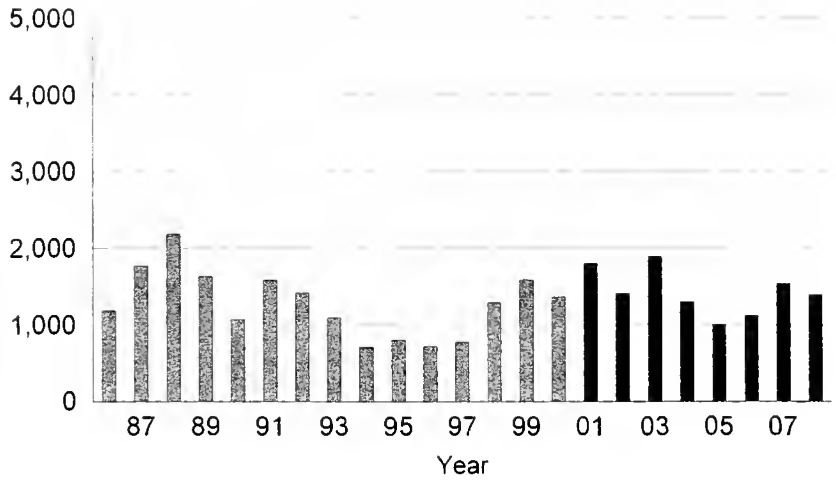


Figure C1 – 3. Rainbow trout populations in the Norris section of the Madison River, 1986-2008, spring estimates. Estimates for 2001 - 2008 are not aged.

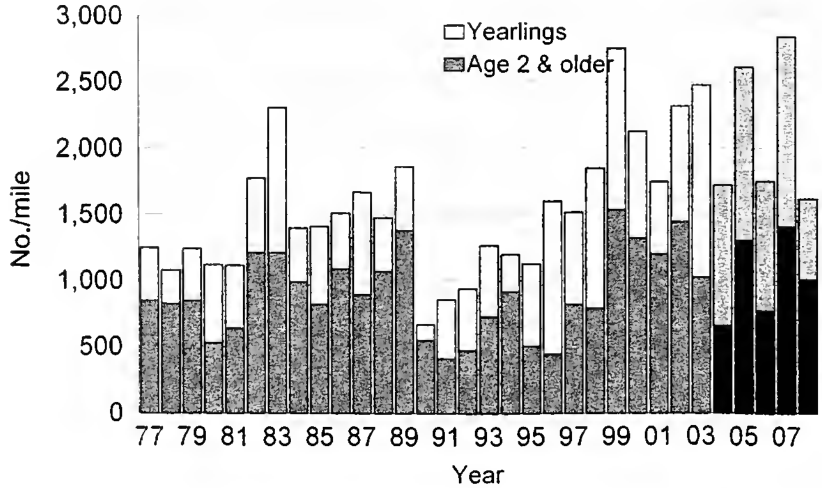


Figure C1 - 4. Brown trout populations in the Pine Butte section of the Madison River, 1977-2008, fall estimates. Estimates for 2004 - 2008 are not aged.

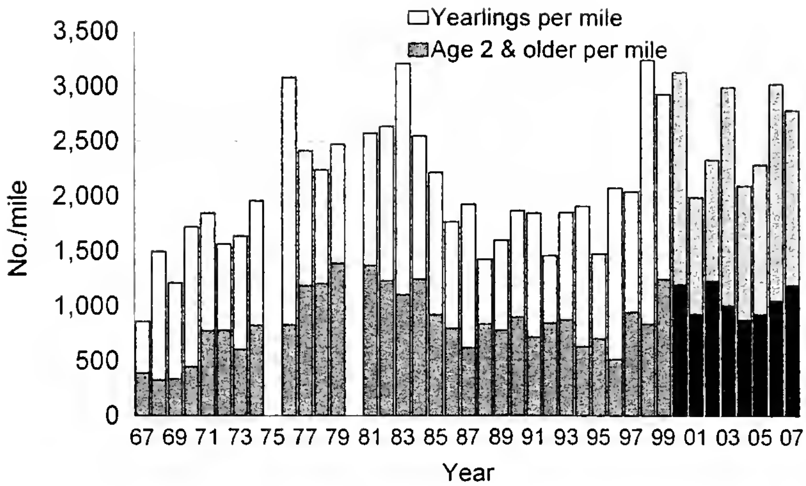


Figure C1 - 5. Brown trout populations in the Varney section of the Madison River, 1967-2008, fall estimates. Estimates for 2000 - 2008 are not aged. Estimates were not conducted in Varney in 2008.

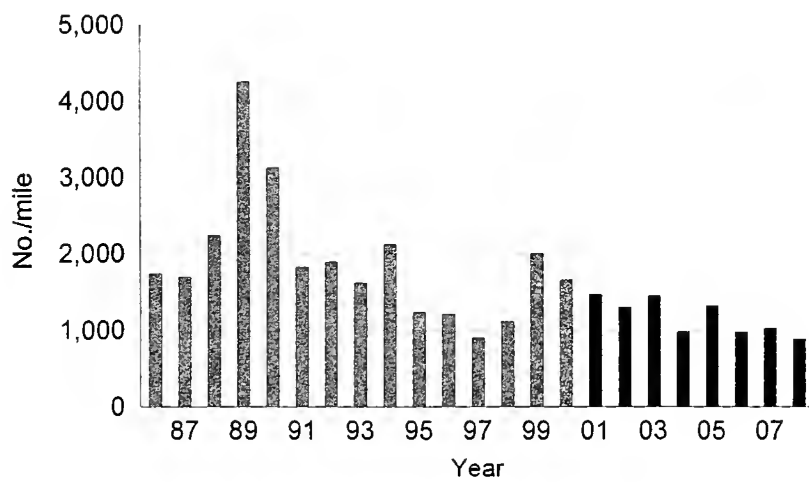


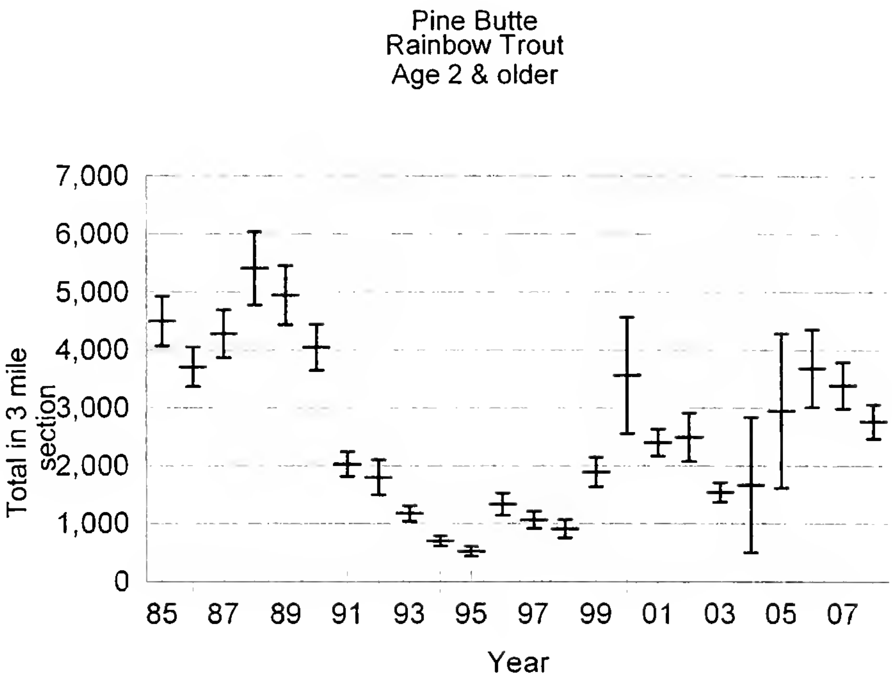
Figure C1 – 6. Brown trout populations in the Norris section of the Madison River, 1986-2008, spring estimates. Estimates for 2001 - 2008 are not aged.

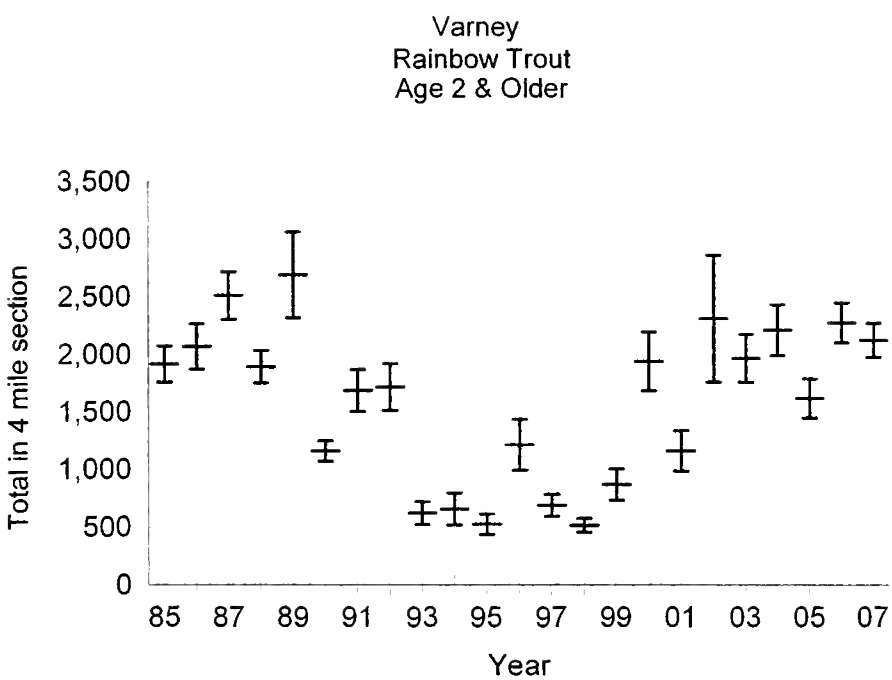
Appendix C2

Population estimates (total number in section± 80 percent Confidence Intervals)
of age 2 & older rainbow and brown trout in the Madison River
See Figure 5 for section locations

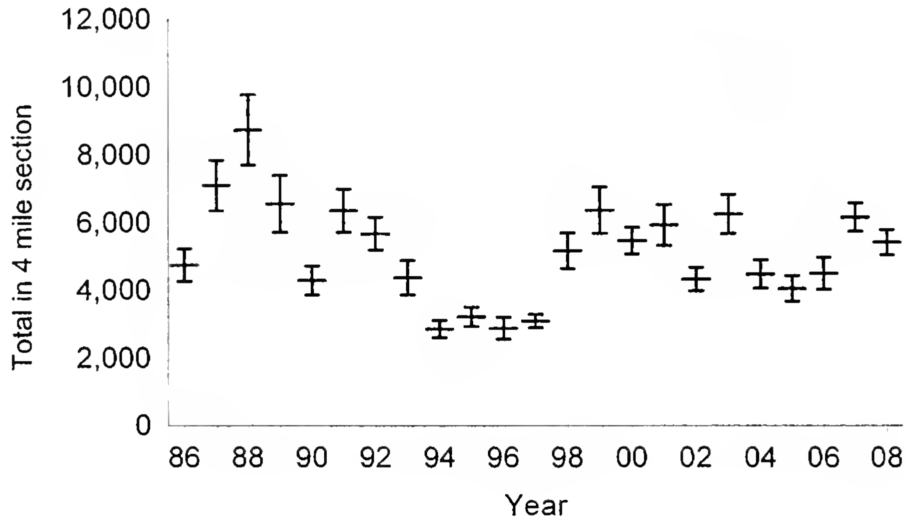
section lengths

Pine Butte – 3 miles
Varney – 4 miles
Norris – 4 miles

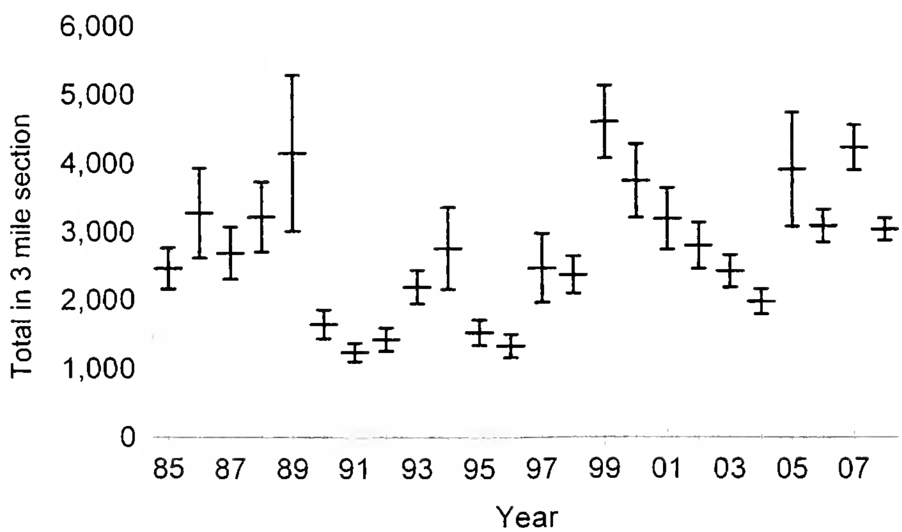

Pine Butte
Rainbow Trout
Age 2 & older
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
Total in 3 mile section
85
87
89
91
93
95
97
99
01
03
05
07
Year


Varney
Rainbow Trout
Age 2 & Older
3,500
3,000
2,500
2,000
1,500
1,000
500
0
Total in 4 mile section
85
87
89
91
93
95
97
99
01
03
05
07
Year

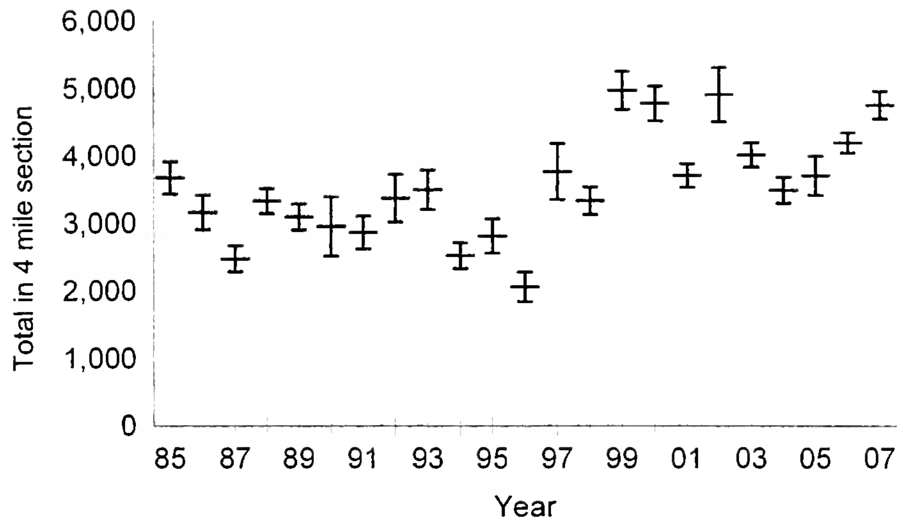
Norris
Rainbow Trout
Age 2 & Older



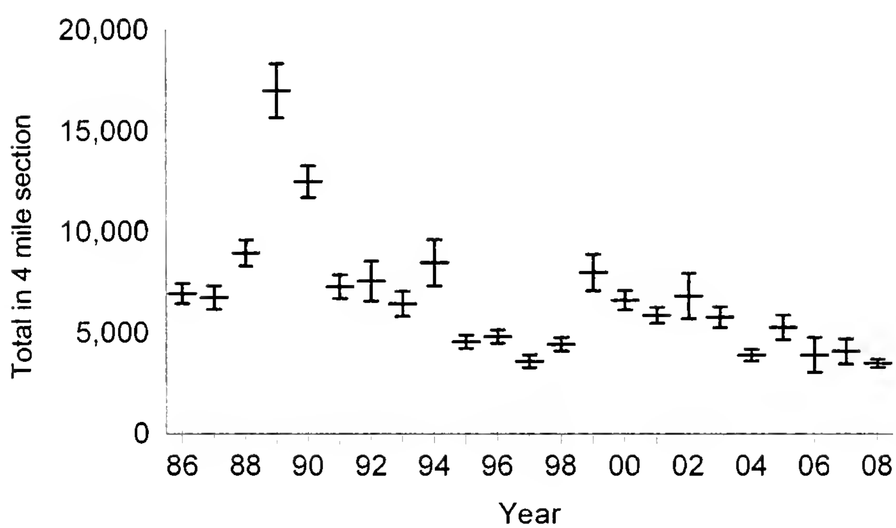
Pine Butte
Brown Trout
Age 2 & older



Varney
Brown Trout
Age 2 & Older



Norris
Brown Trout
Age 2 & Older

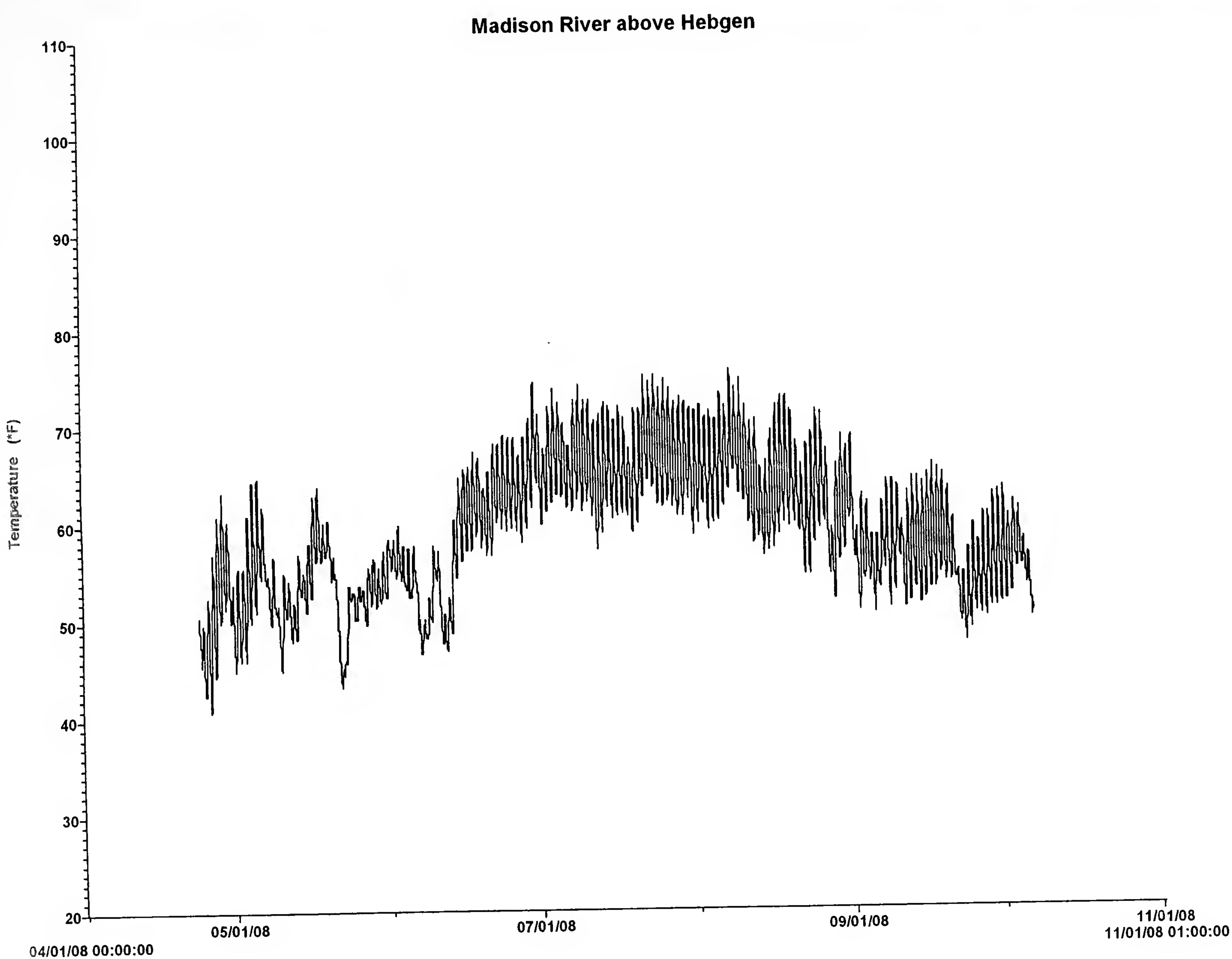


Appendix D1

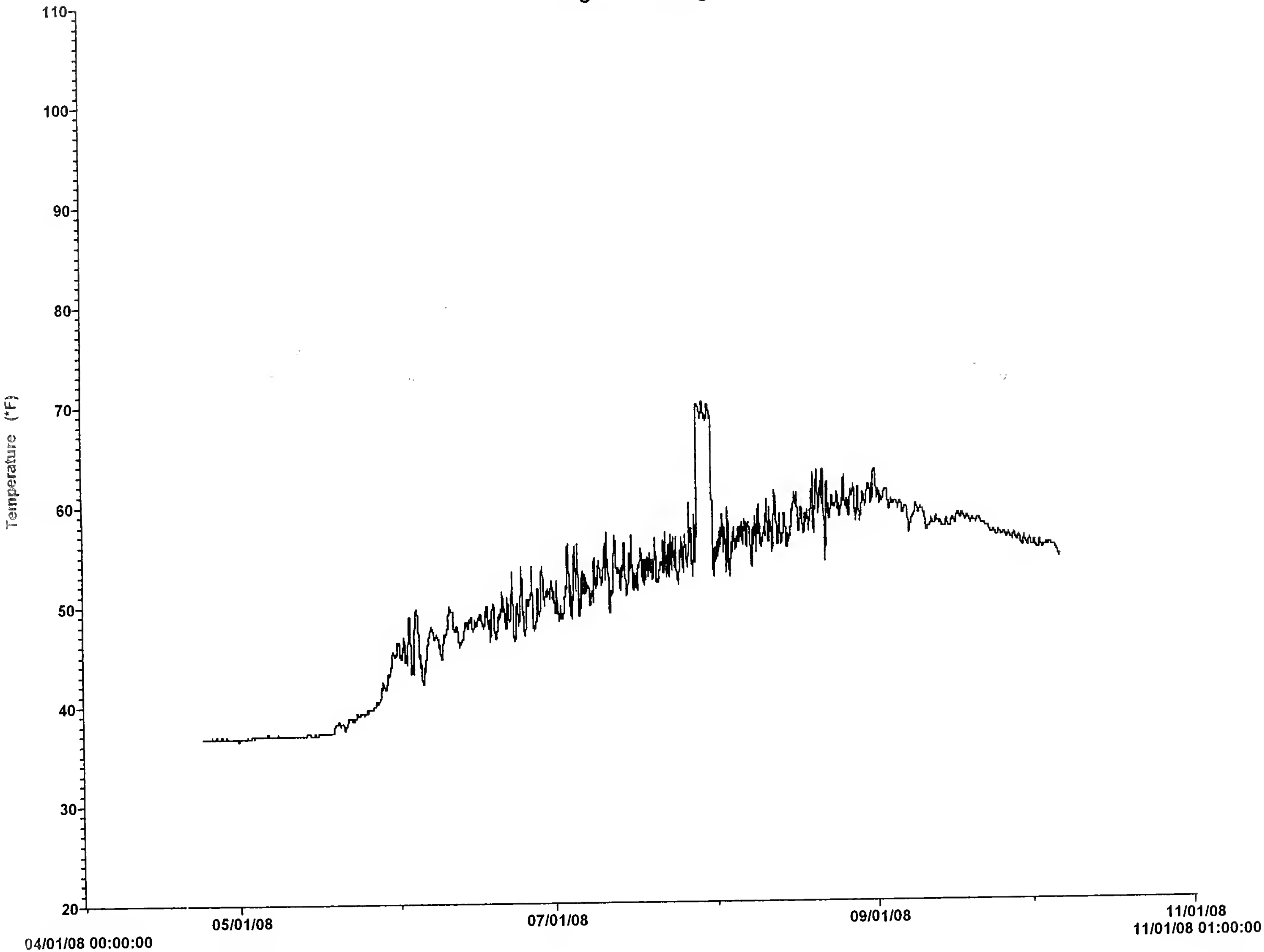
Temperature recordings from monitoring sites on the Madison River
See Figure 6 for locations

NOTES:

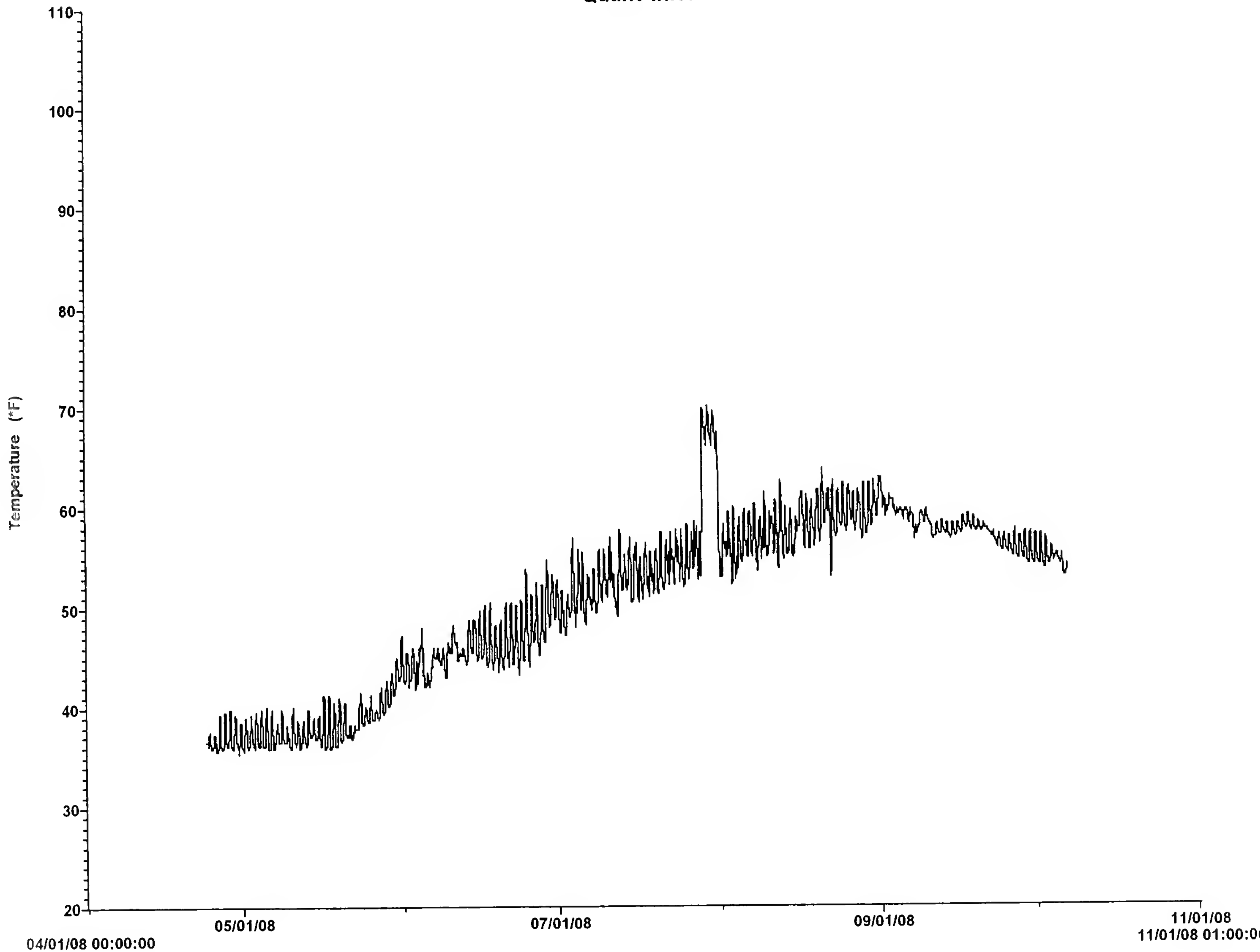
- Water temperature at Hebgen discharge & Quake inlet were elevated due to surface releases from Hebgen Reservoir during engineering inspections in late July
- The Kirby temperature recorder ceased operating on July 21


Madison River above Hebgen
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

Hebgen discharge

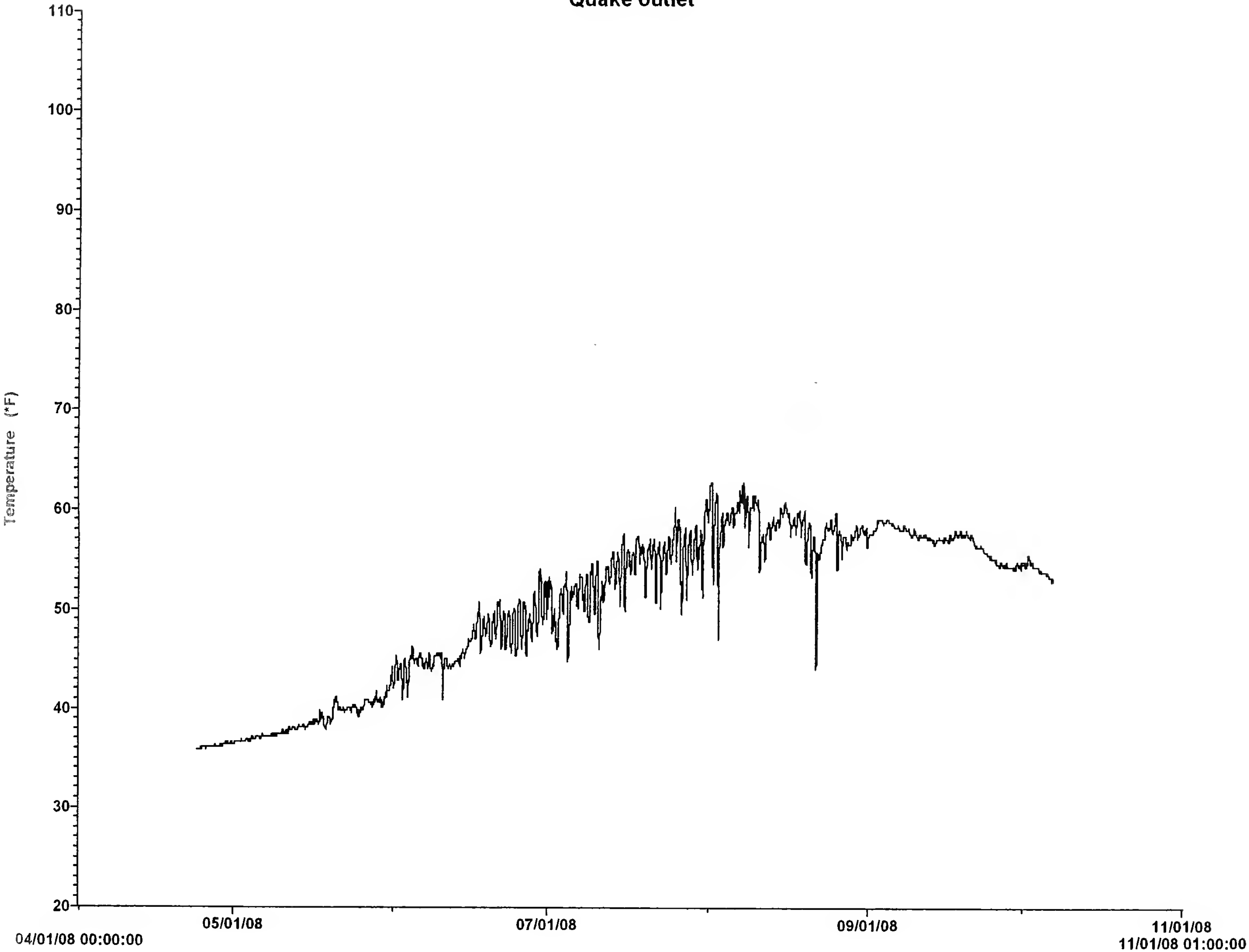


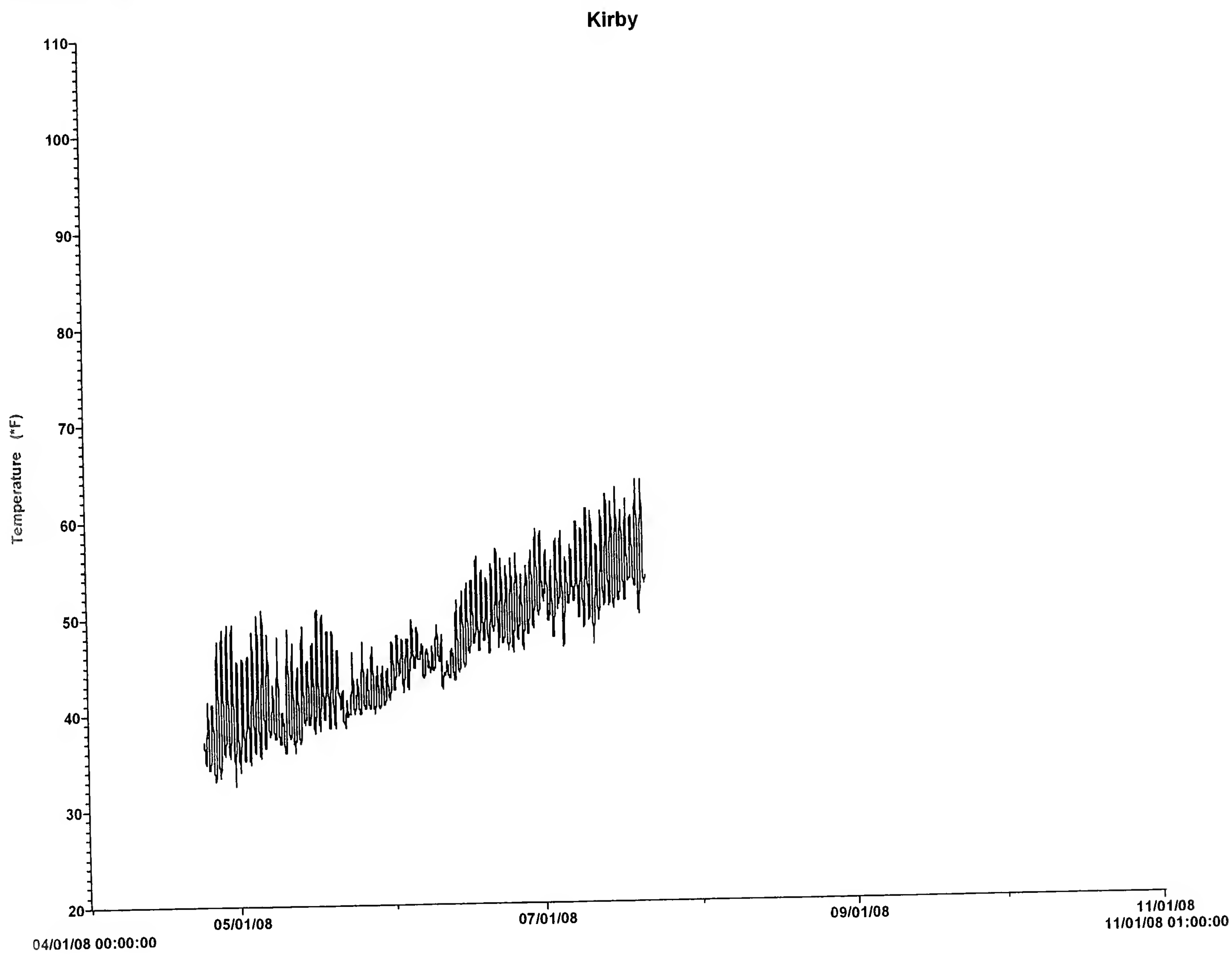
Quake Inlet

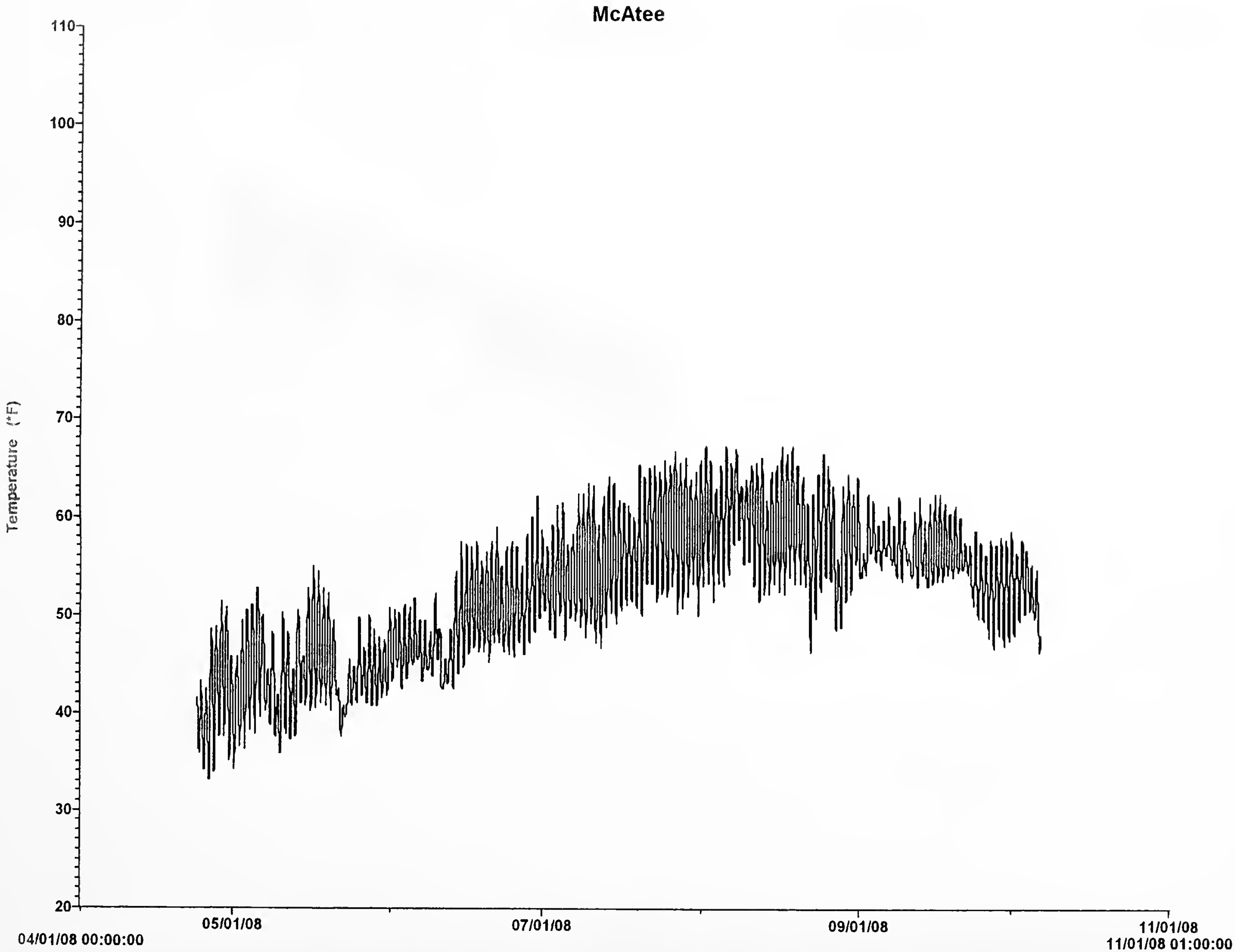


110
100
90
80
70
60
50
40
30
20
Temperature (*F)
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

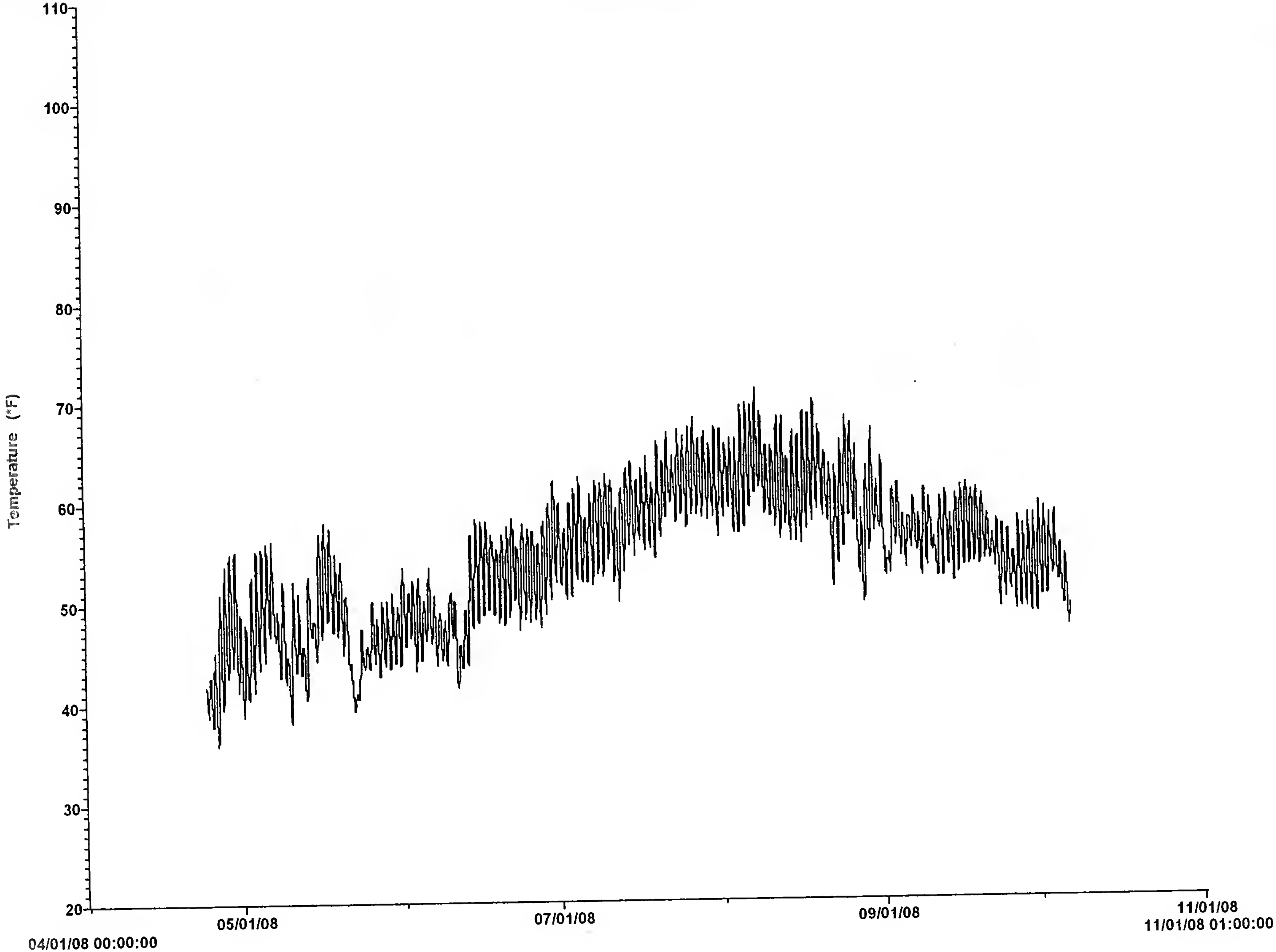
Quake outlet



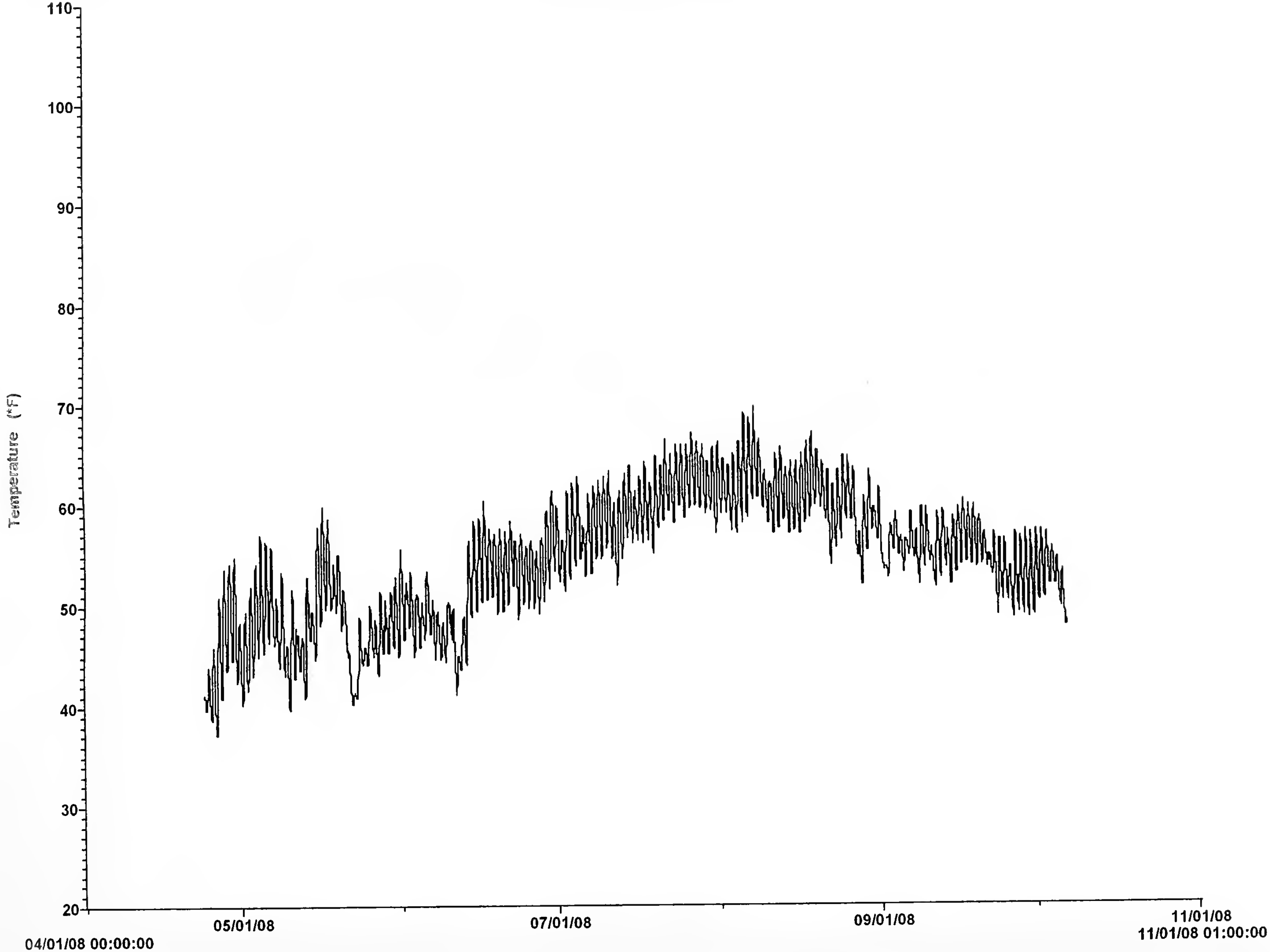

Kirby
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

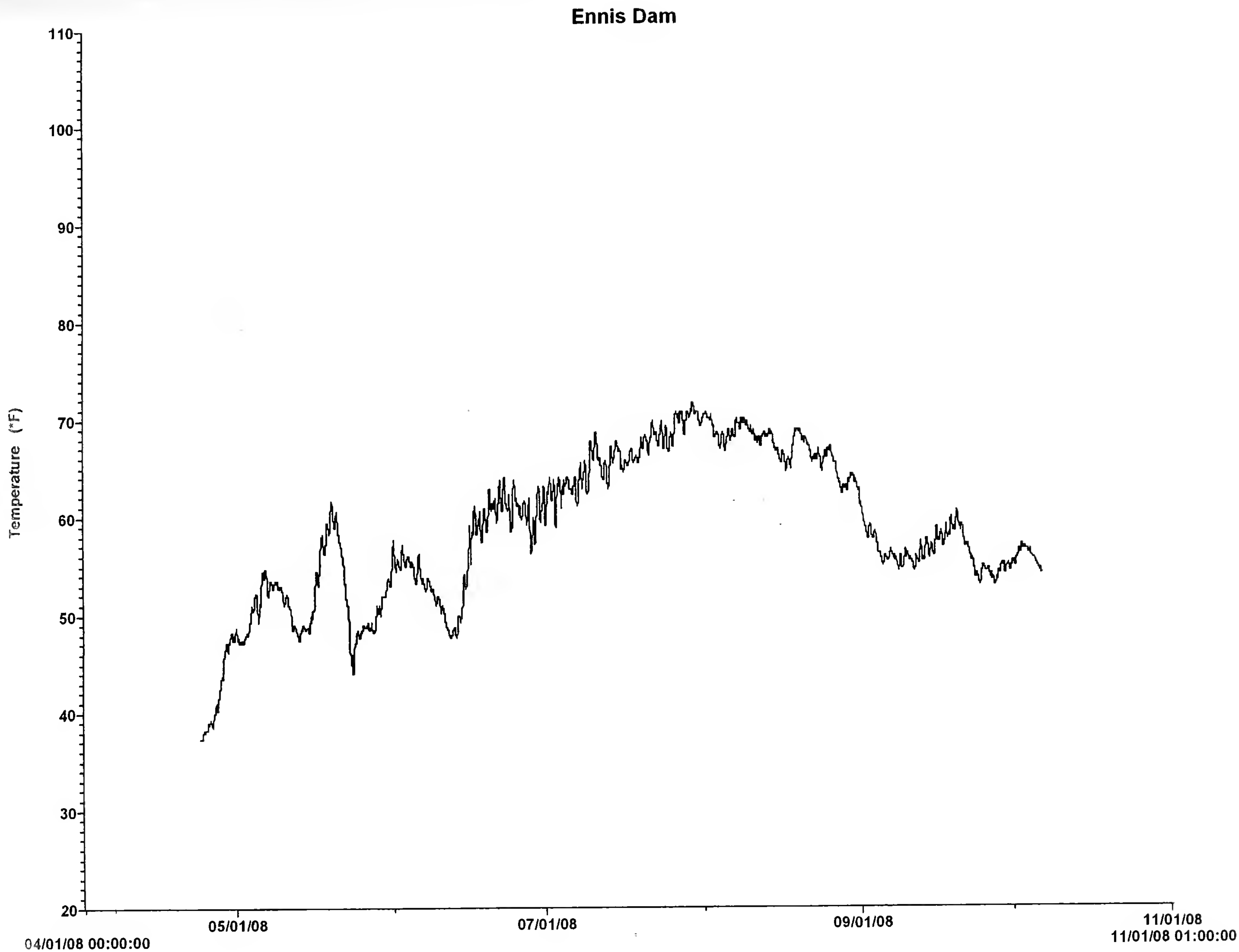

McAtee
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

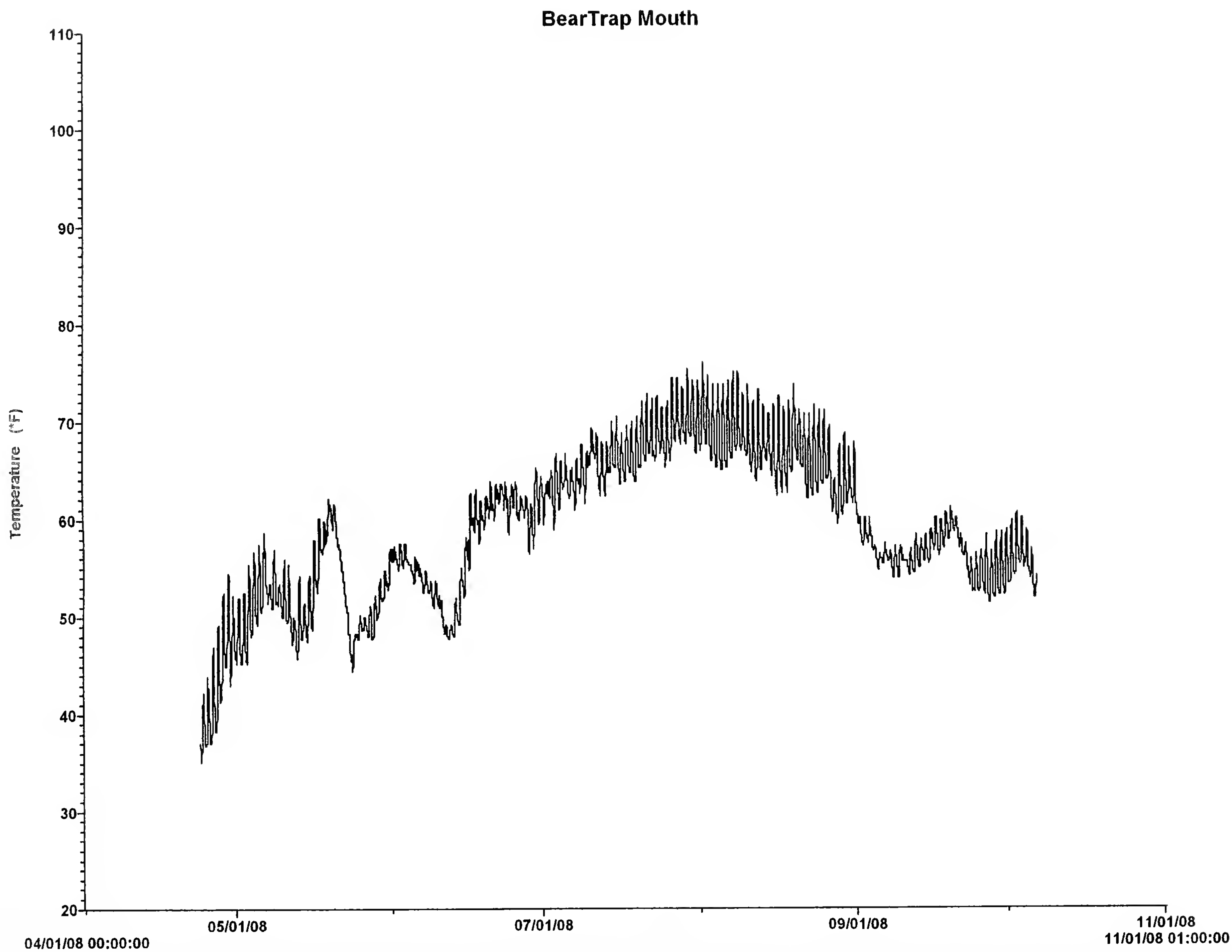
Ennis Bridge

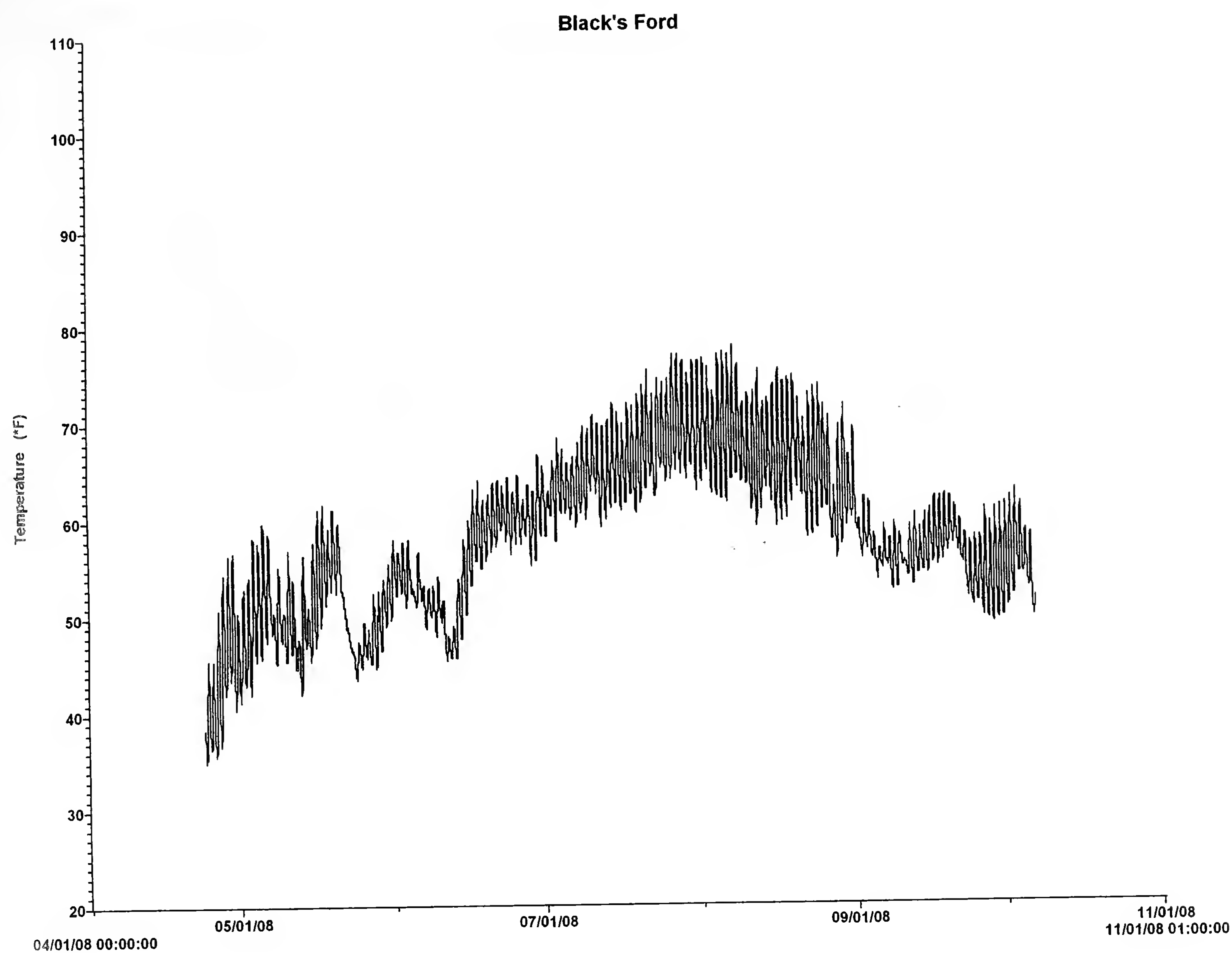


Ennis Reservoir Inlet

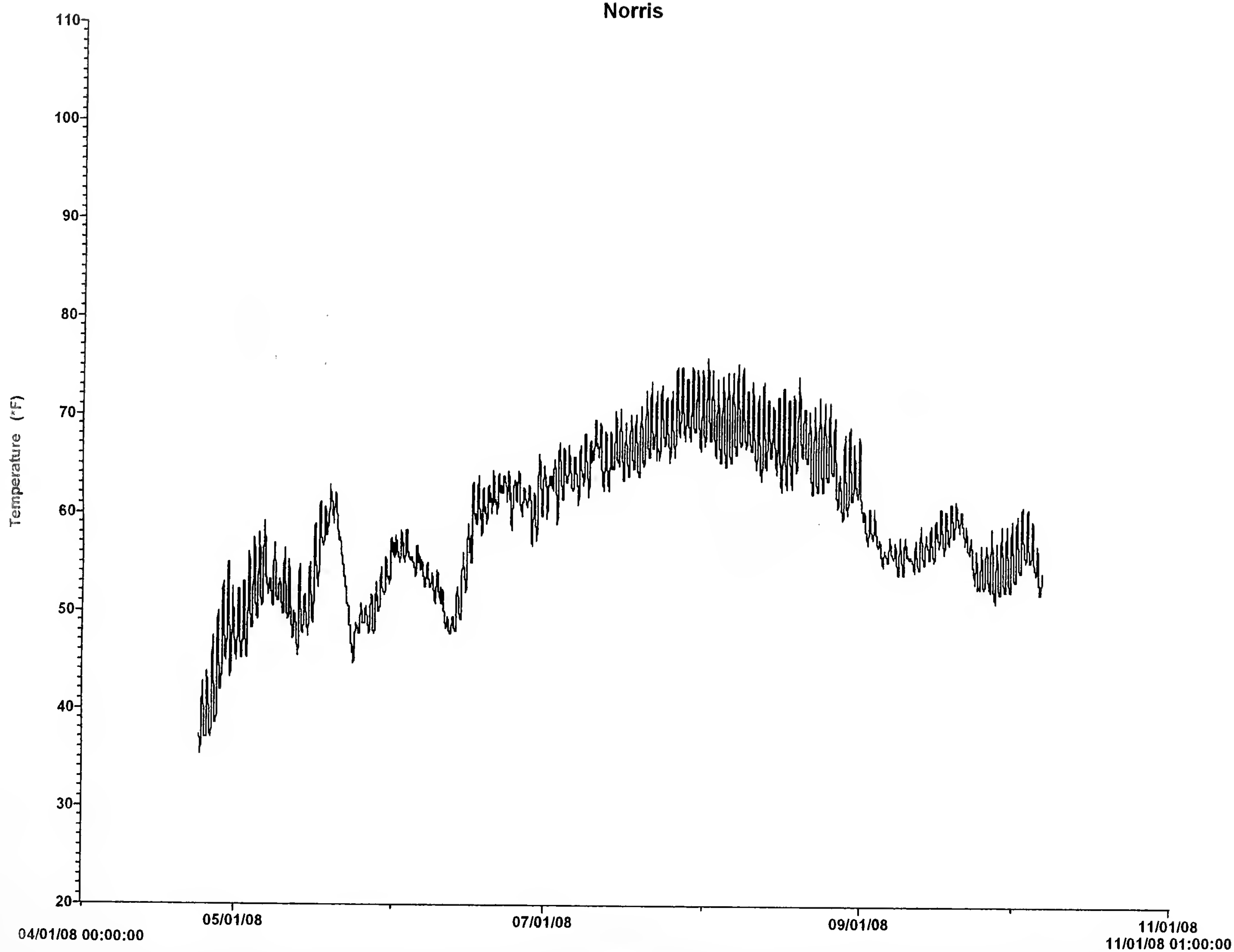



Ennis Dam
110
100
90
80
70
60
50
40
30
20
Temperature (*F)
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

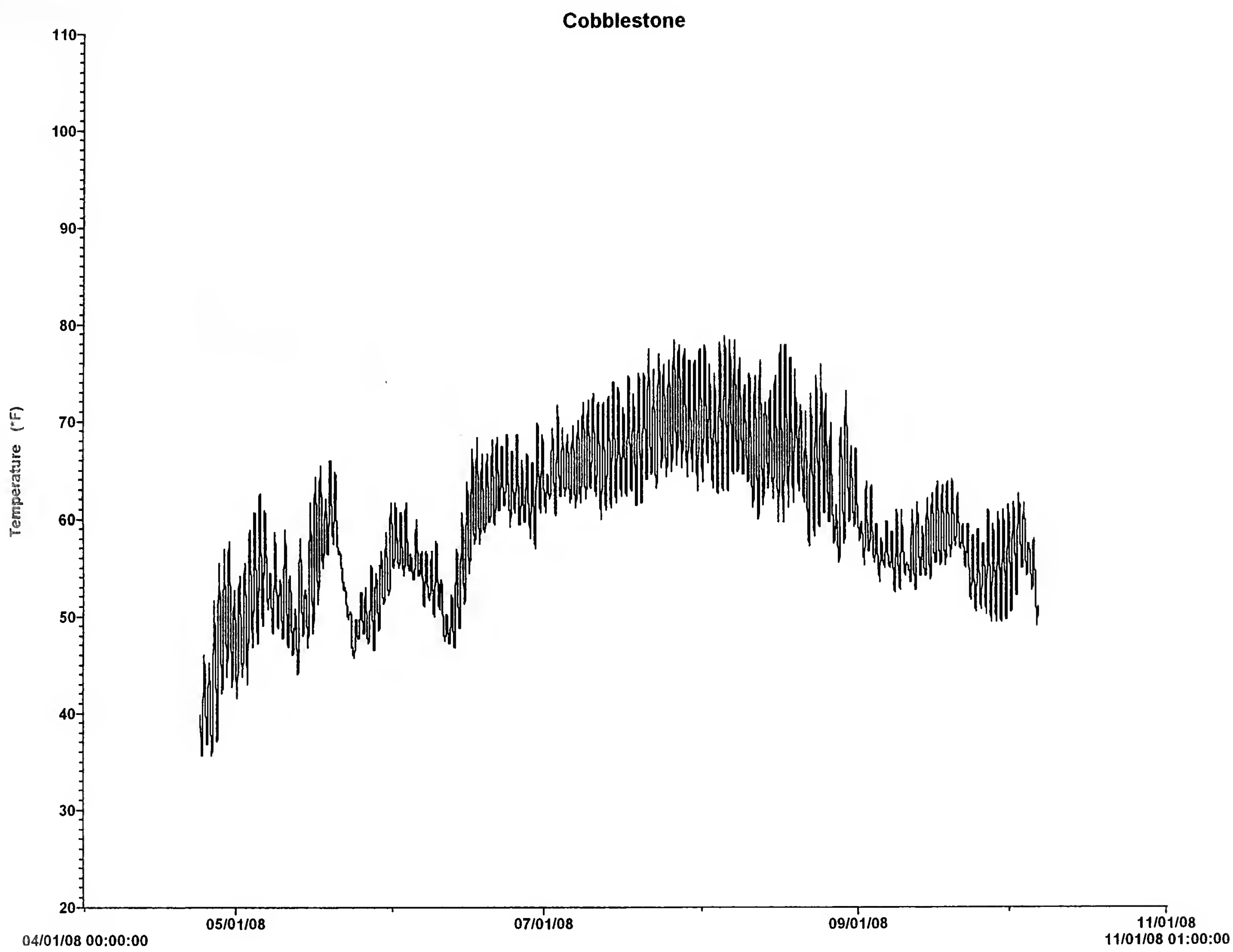

BearTrap Mouth
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

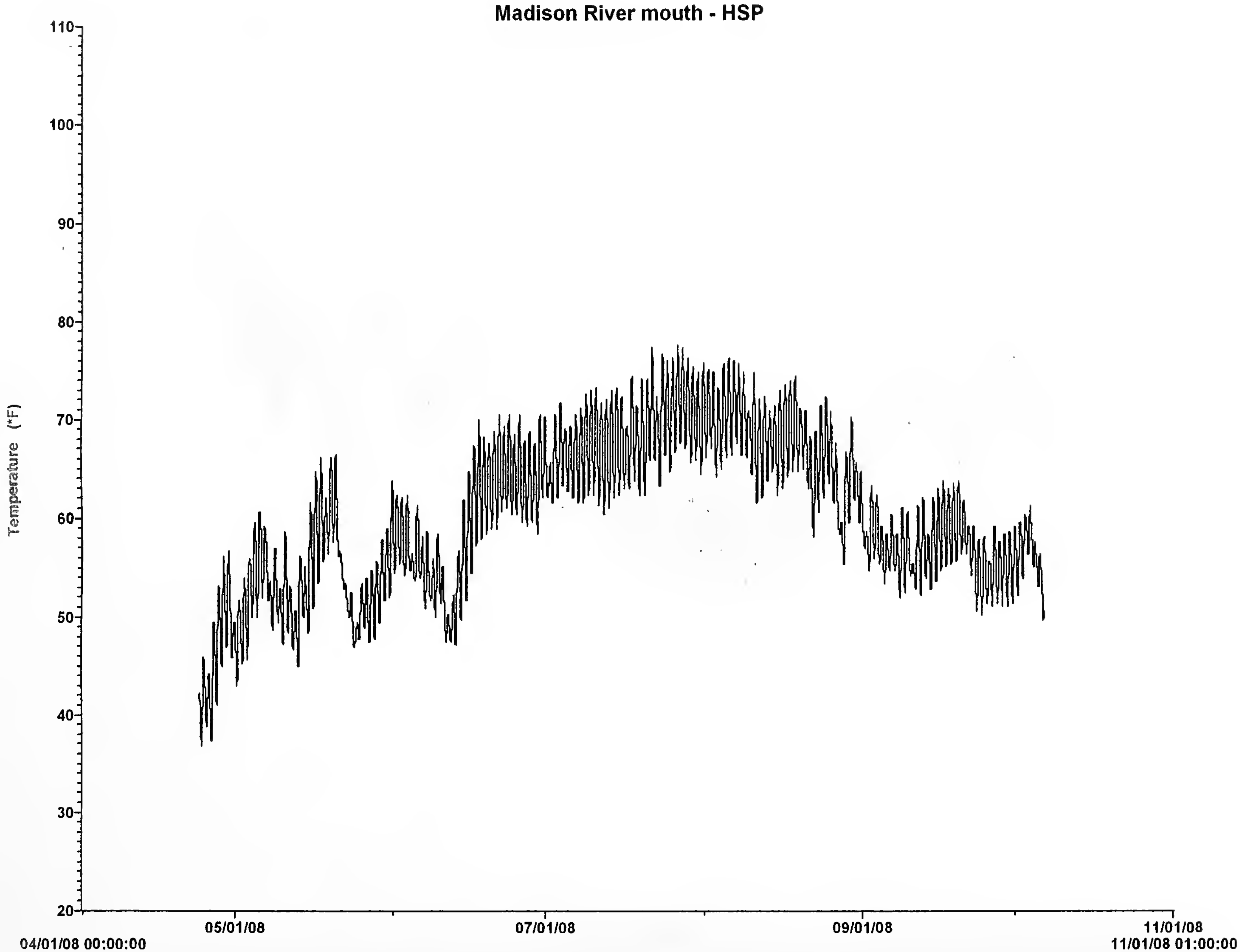

Black's Ford
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

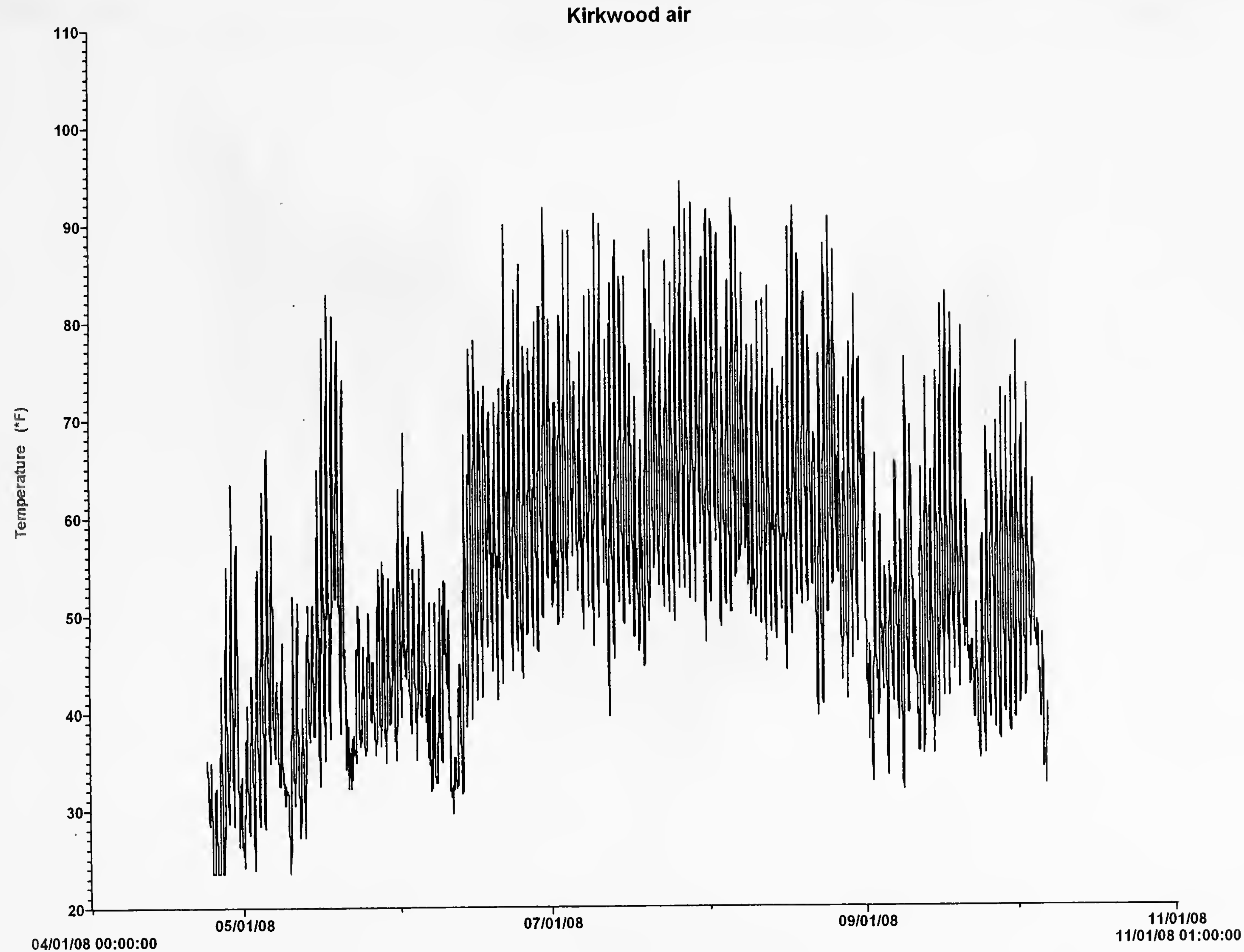
Norris



Temperature (°F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

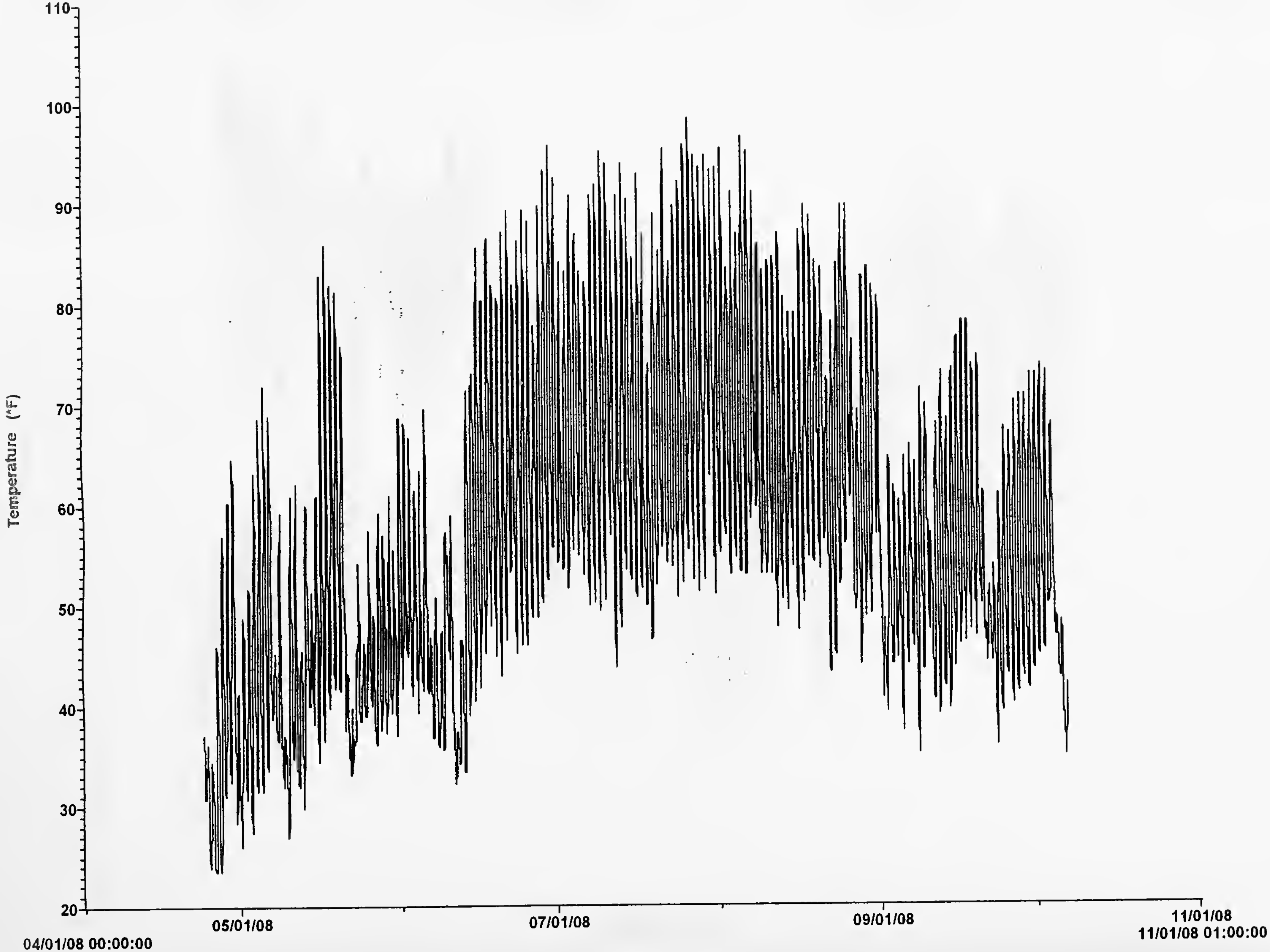

Cobblestone
Temperature (°F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00


Madison River mouth - HSP
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00



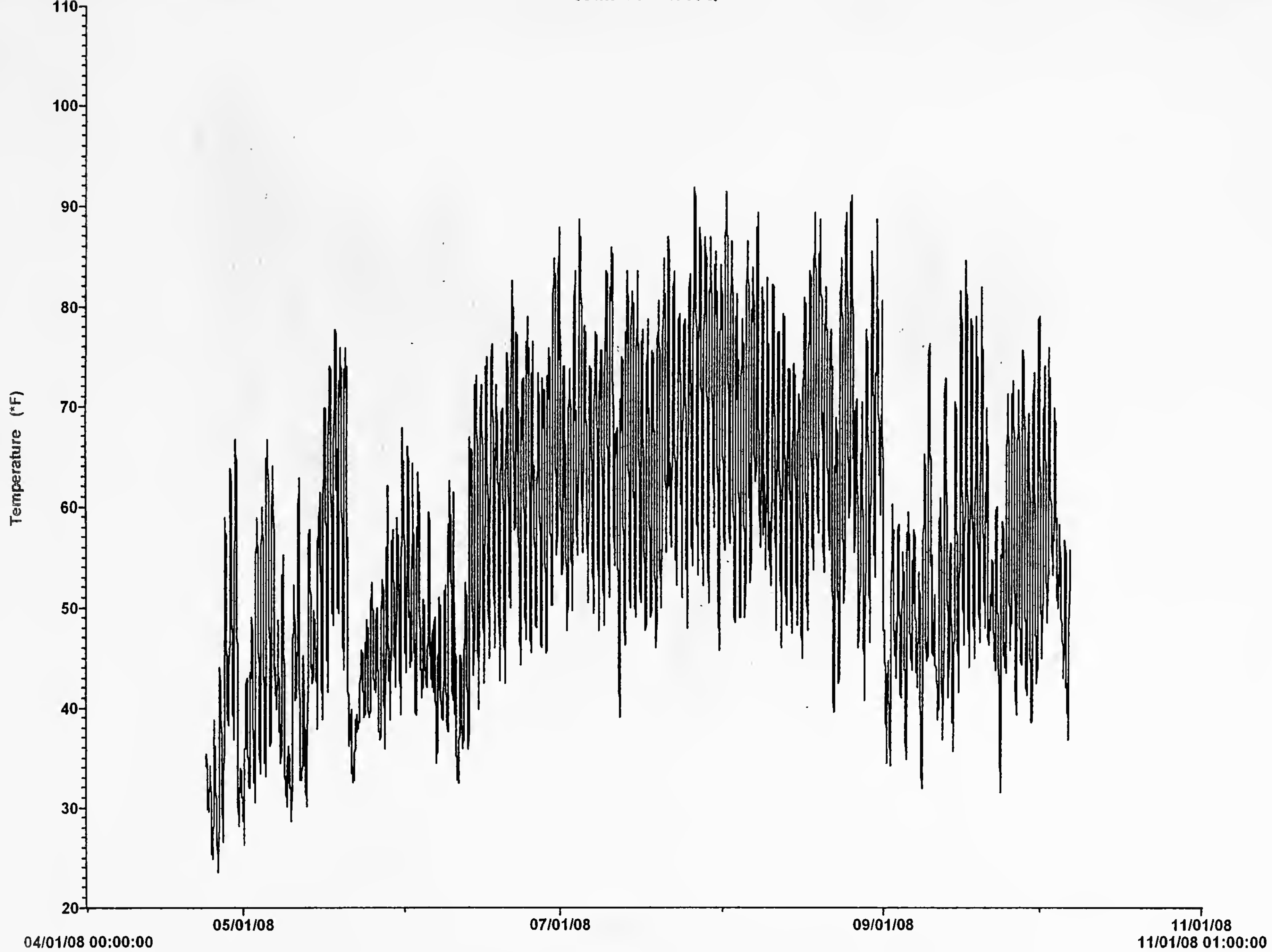
Kirkwood air
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

Slide air

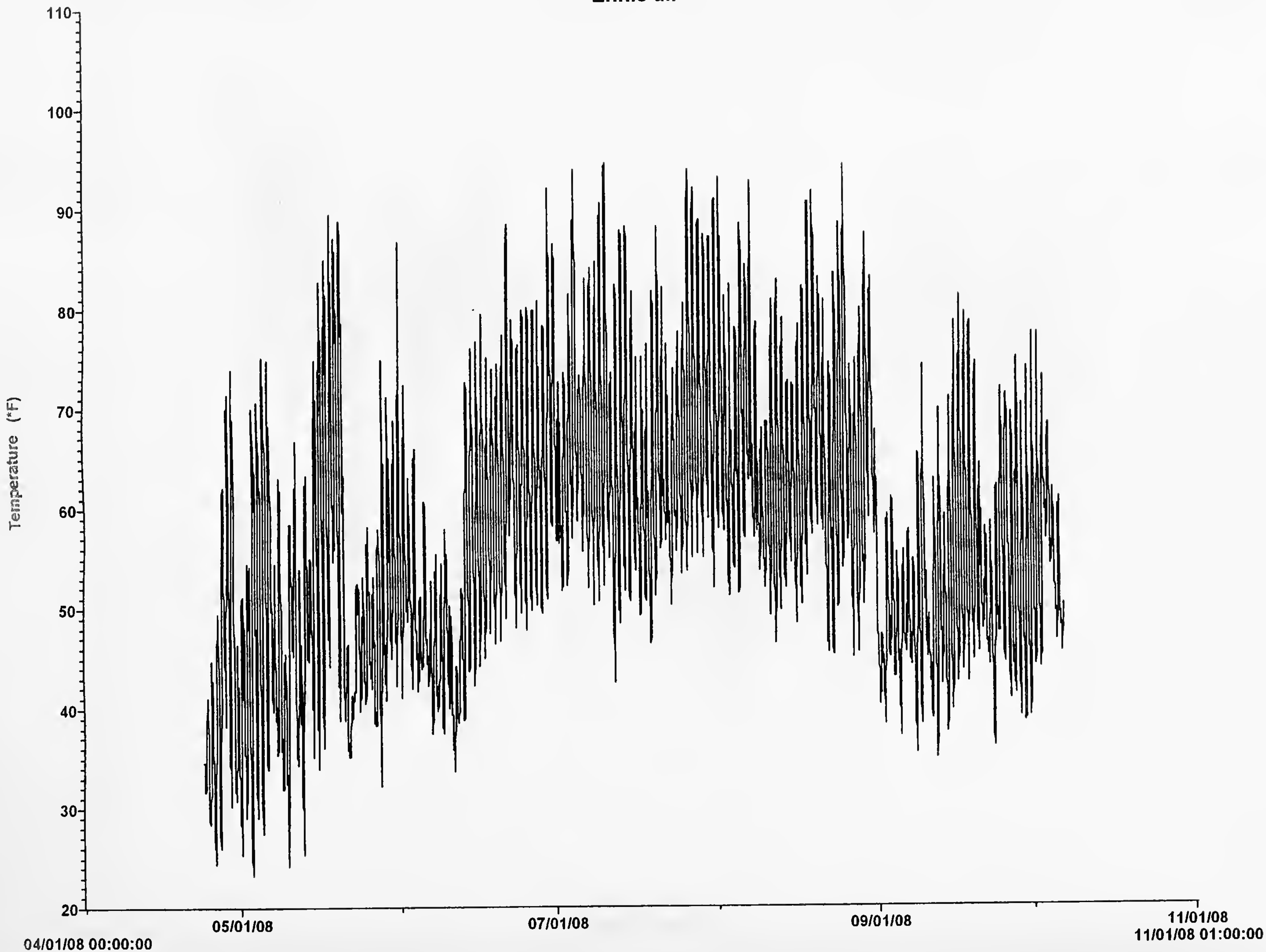


Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

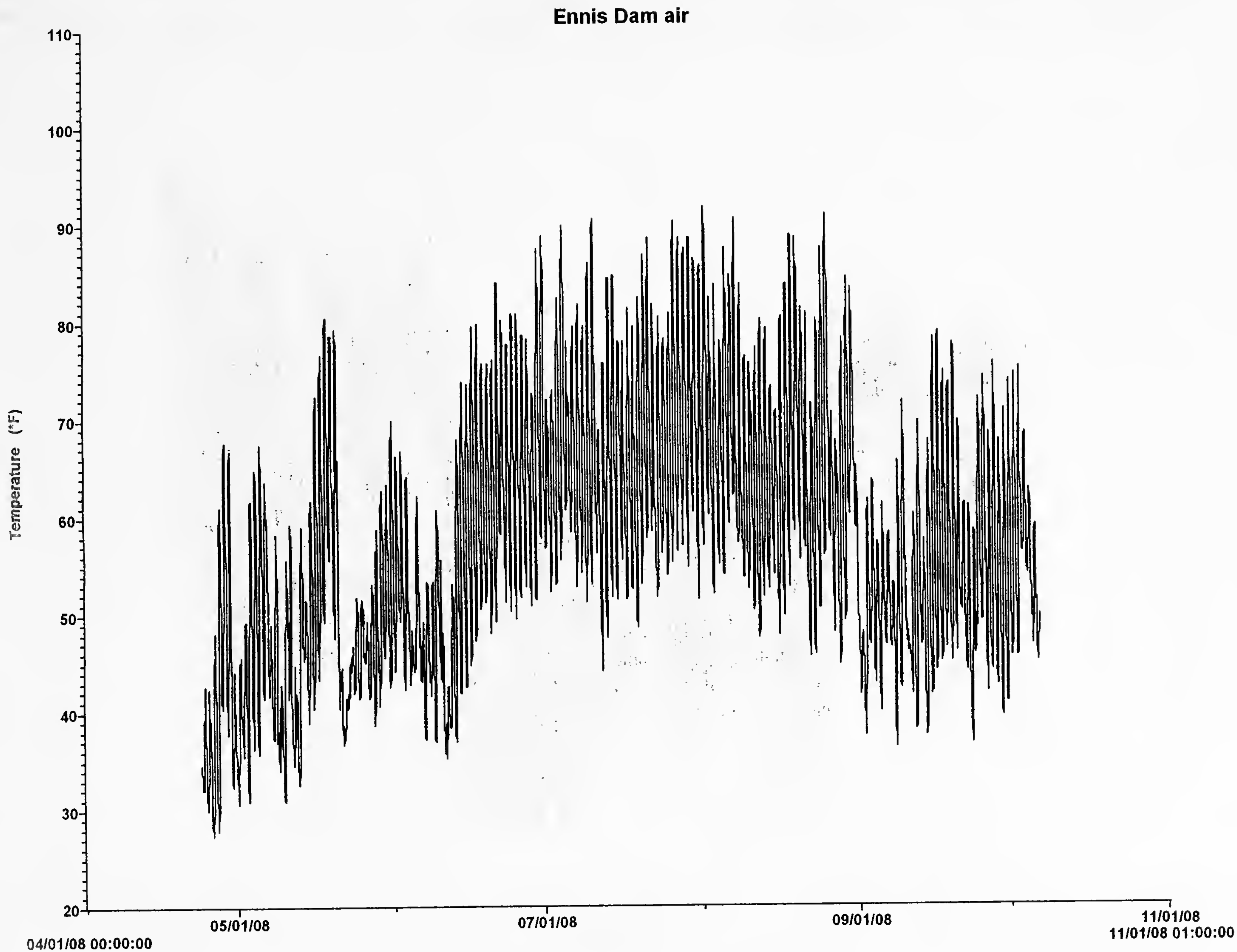
Wall Creek HQ



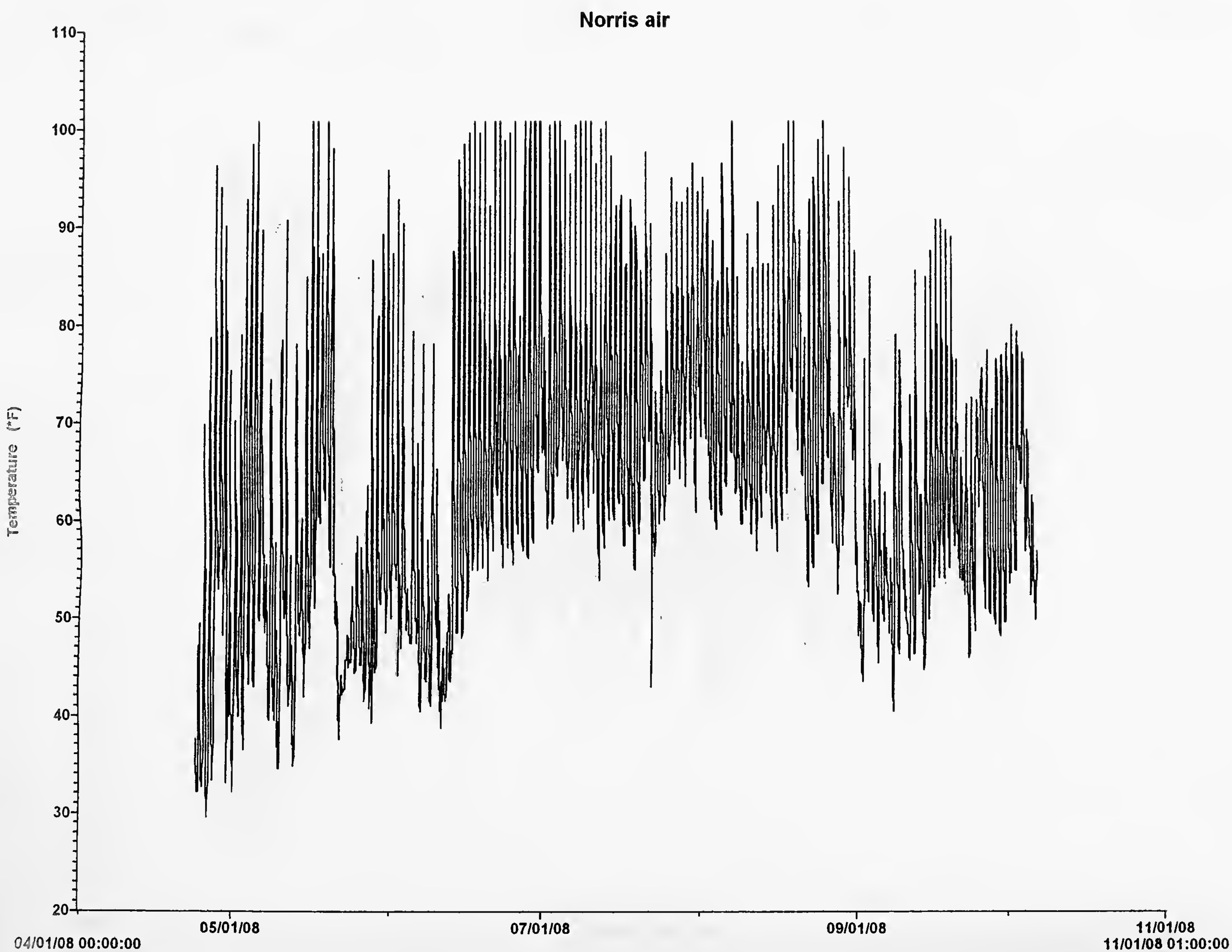
Ennis air

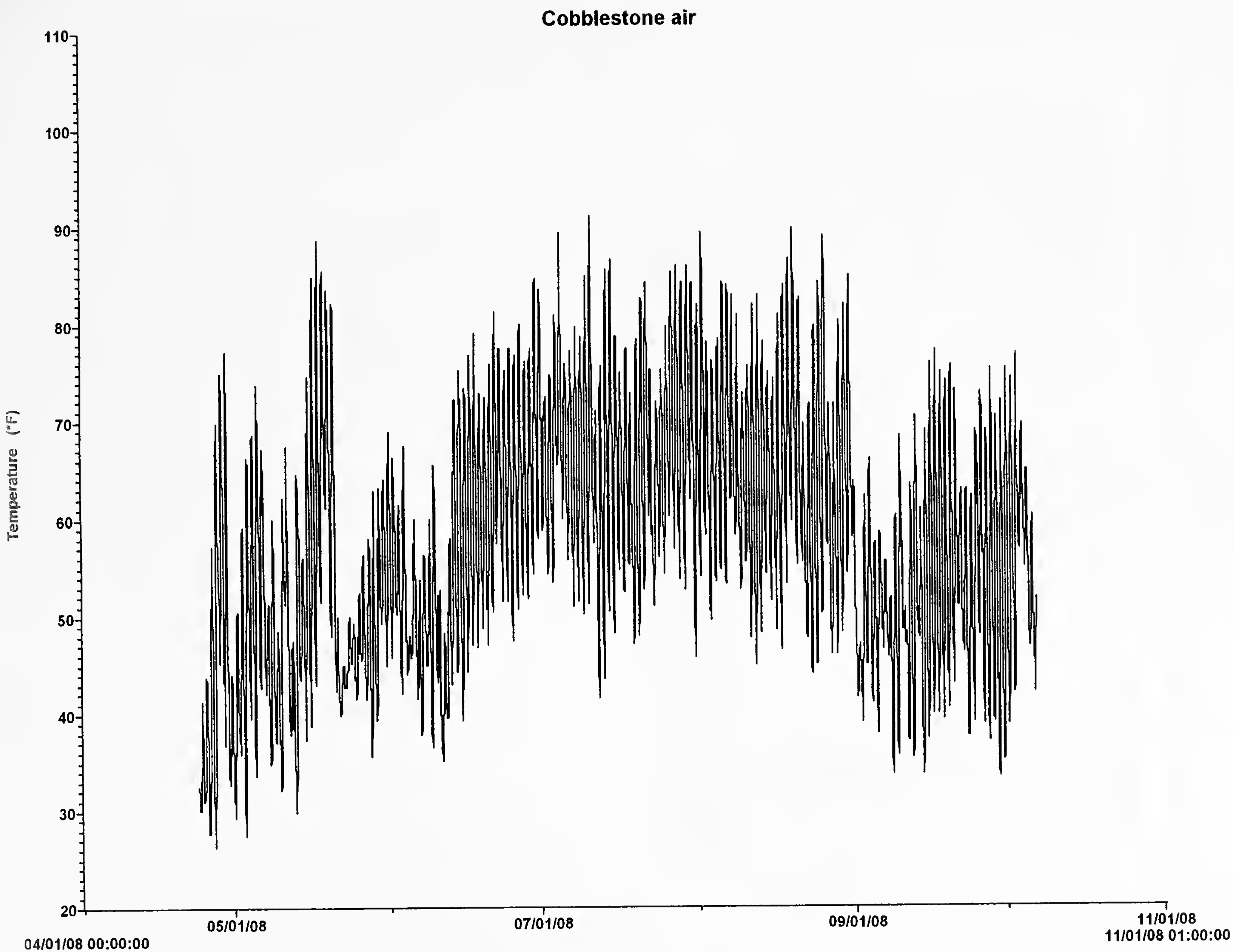


Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00



Ennis Dam air
Temperature (*F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00


Norris air
Temperature (°F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00



Cobblestone air
Temperature (°F)
110
100
90
80
70
60
50
40
30
20
04/01/08 00:00:00
05/01/08
07/01/08
09/01/08
11/01/08
11/01/08 01:00:00

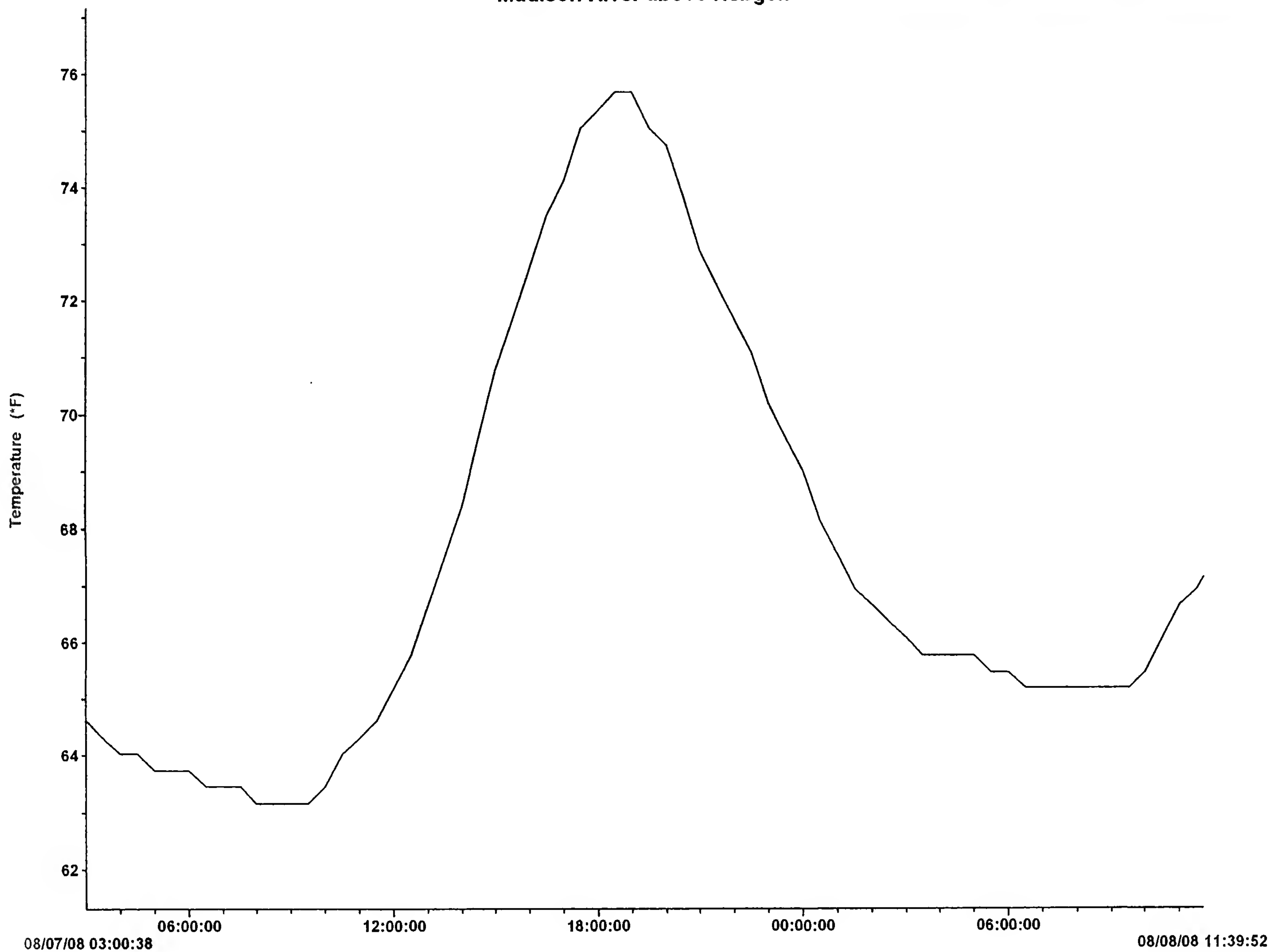
Appendix D2

Diel water temperature fluctuations during the warmest 24 hours at river monitoring sites

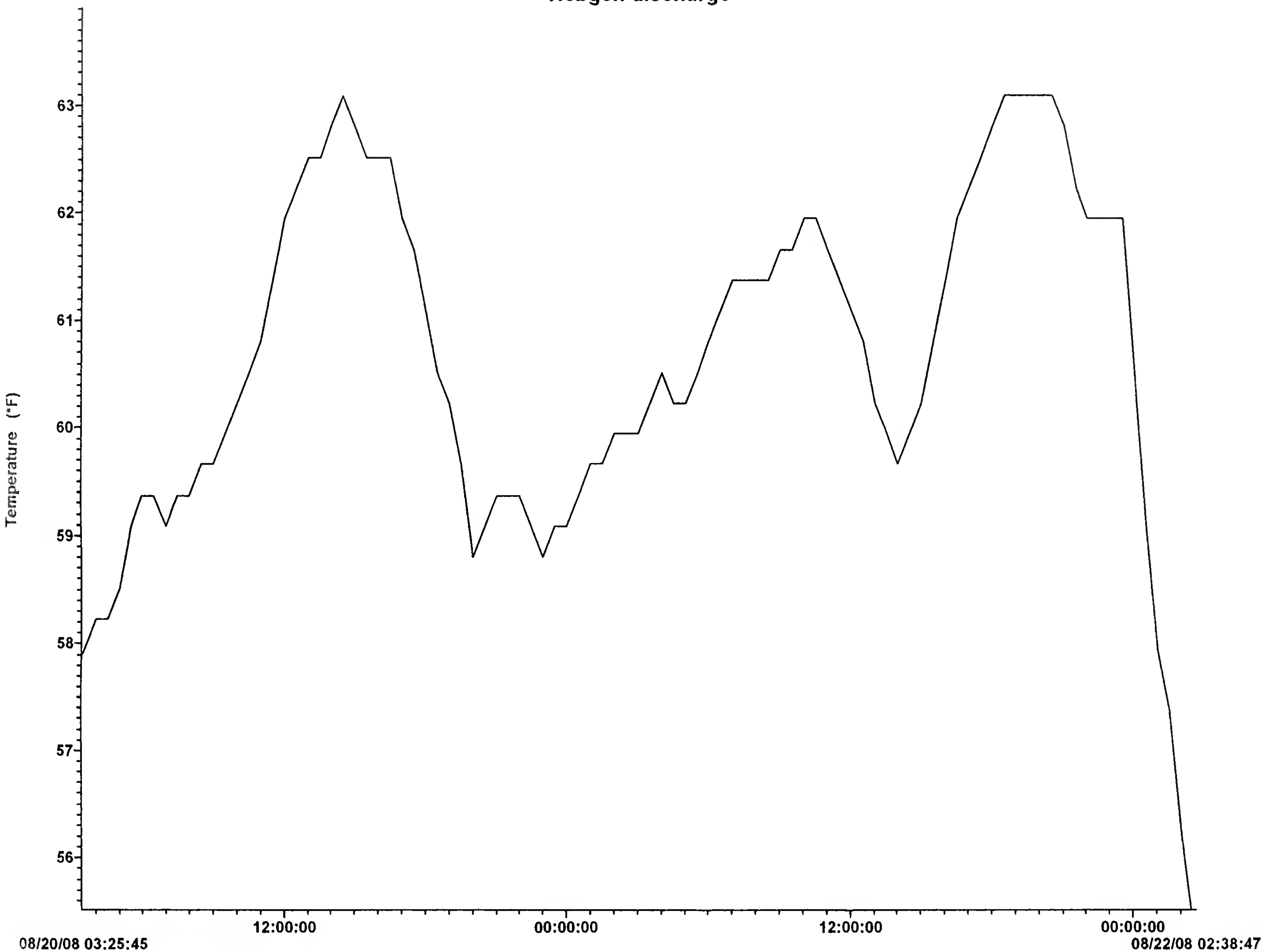
Site	Date	Maximum temperature
Hebgen inlet	8/7	75.65
Hebgen discharge	7/29 (8/20, 21, 31)	70.09 (63.08)
Quake inlet	7/28 (8/20)	70.12 (63.70)
Quake outlet	8/1, 7	62.75
Kirby	7/19, 20	63.64
McAtee	8/1, 5, 16, 18	67.21
Ennis Bridge	8/7	71.01
Ennis Reservoir Inlet	8/7	69.62
Ennis Dam	7/29, 30	71.61
Beartrap mouth	8/1	75.96
Norris	8/1	75.90
Black's Ford	8/7	77.79
Cobblestone	8/5	78.73
Headwaters State Park	7/26	77.55

- Water temperature at Hebgen discharge & Quake inlet were elevated due to surface releases from Hebgen Reservoir during engineering inspections in late July. Maximum temperatures during 'normal' operations are listed in parentheses and are shown in the following charts.
- The Kirby temperature recorder ceased operating on July 21

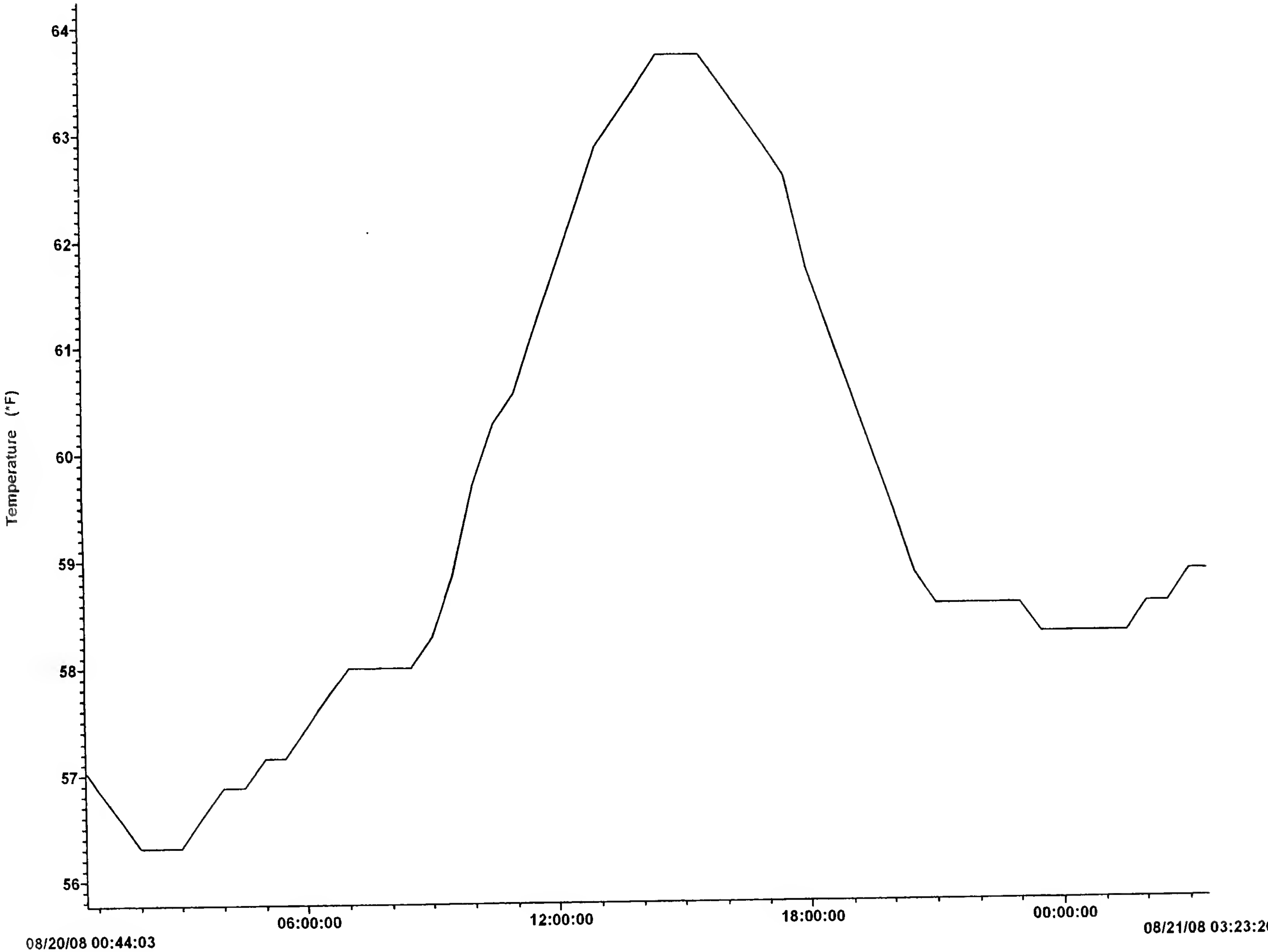
Madison River above Hebgen



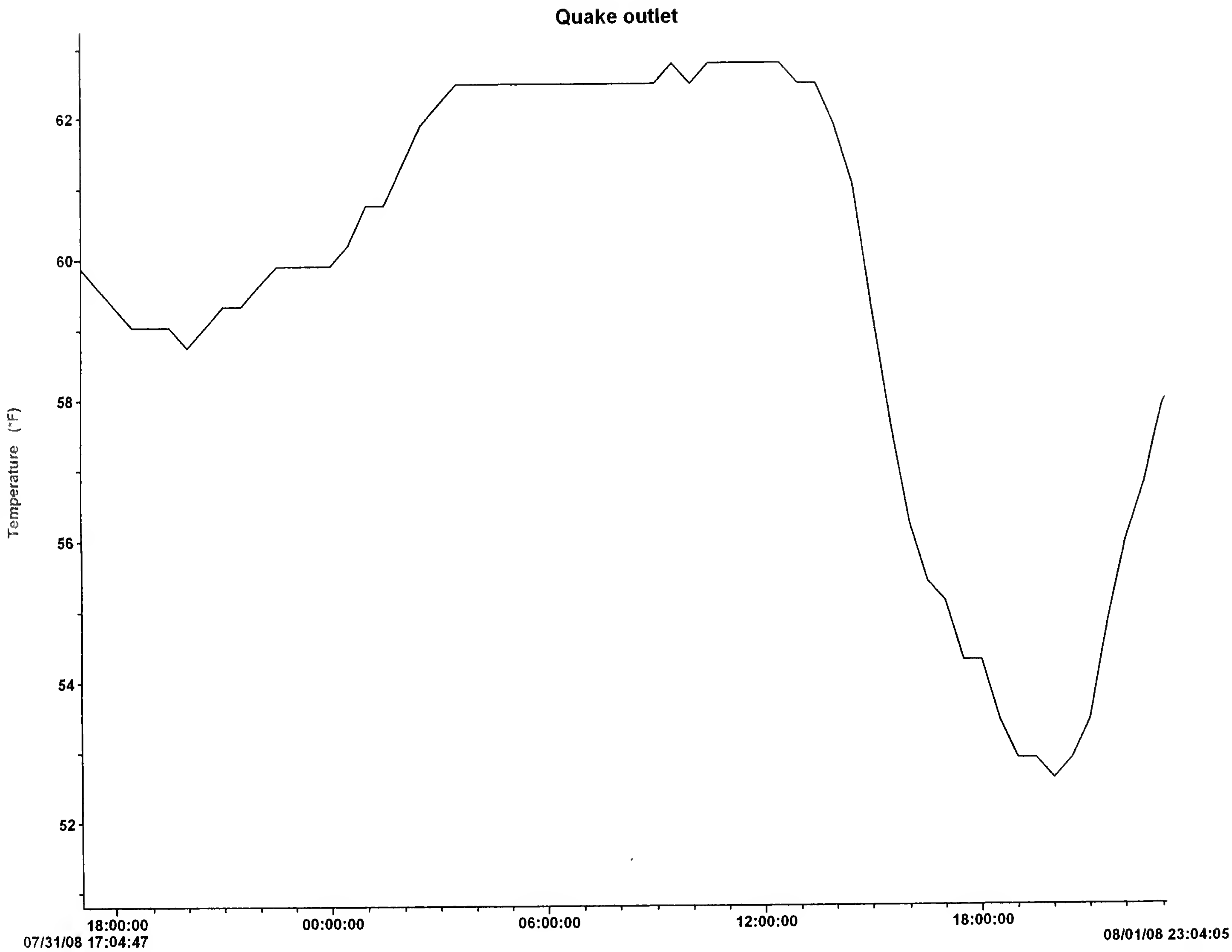
Hebgen discharge



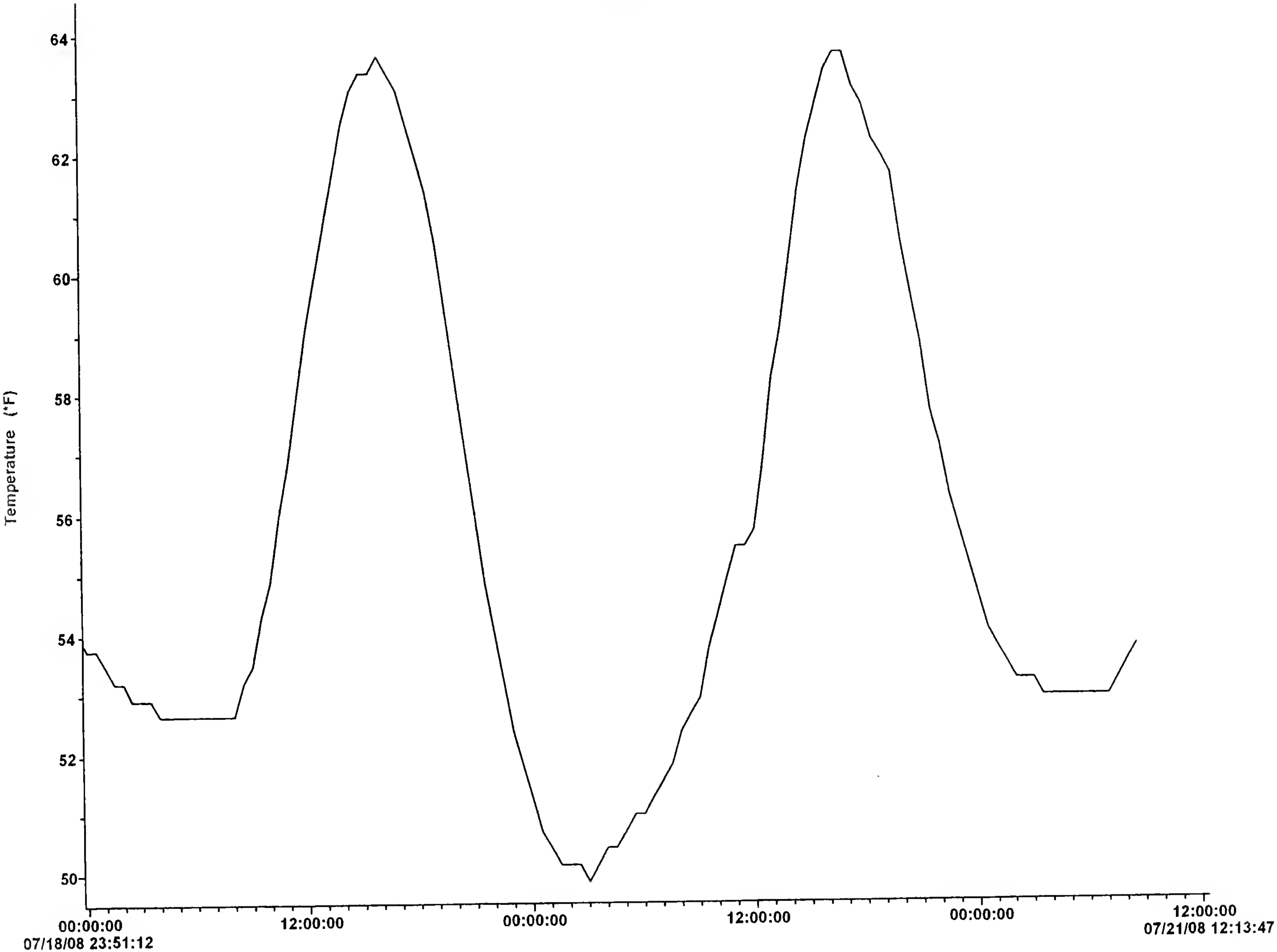
Quake Inlet



Temperature (*F)
64
63
62
61
60
59
58
57
56
08/20/08 00:44:03
06:00:00
12:00:00
18:00:00
00:00:00
08/21/08 03:23:26


Quake outlet
Temperature (°F)
62
60
58
56
54
52
18:00:00
07/31/08 17:04:47
00:00:00
06:00:00
12:00:00
18:00:00
08/01/08 23:04:05

Kirby



Temperature (*F)
64
62
60
58
56
54
52
50
00:00:00
07/18/08 23:51:12
12:00:00
00:00:00
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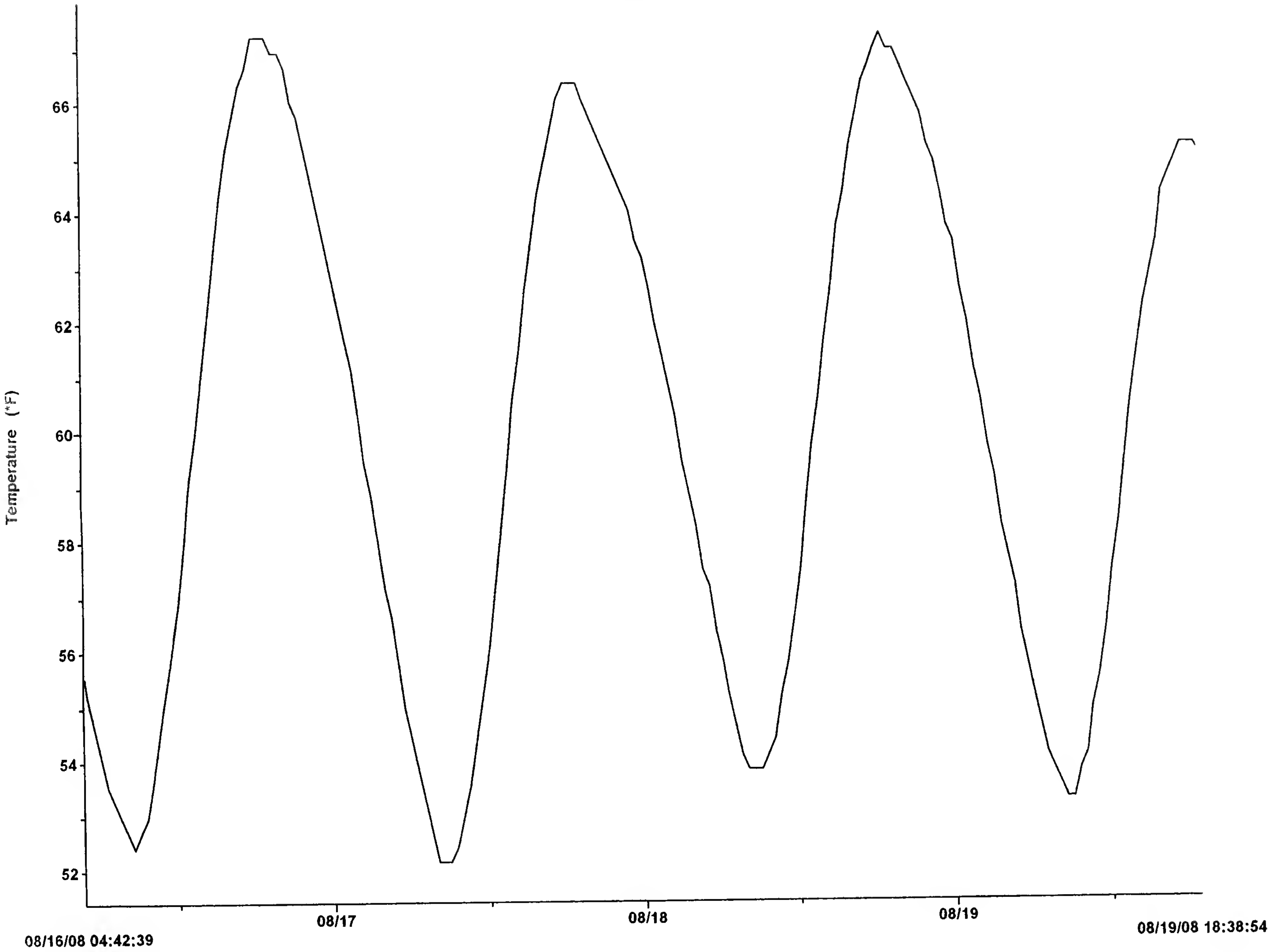
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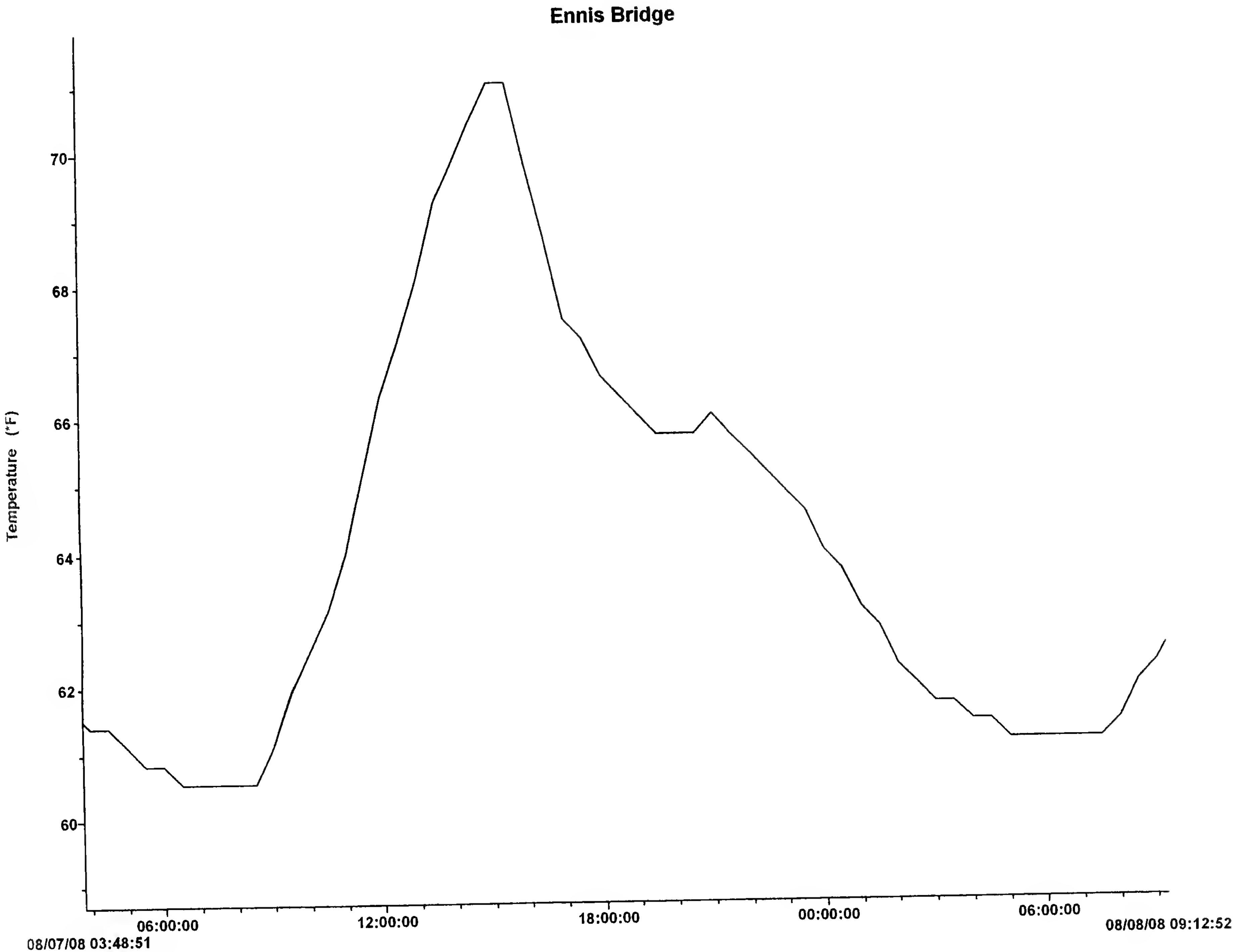

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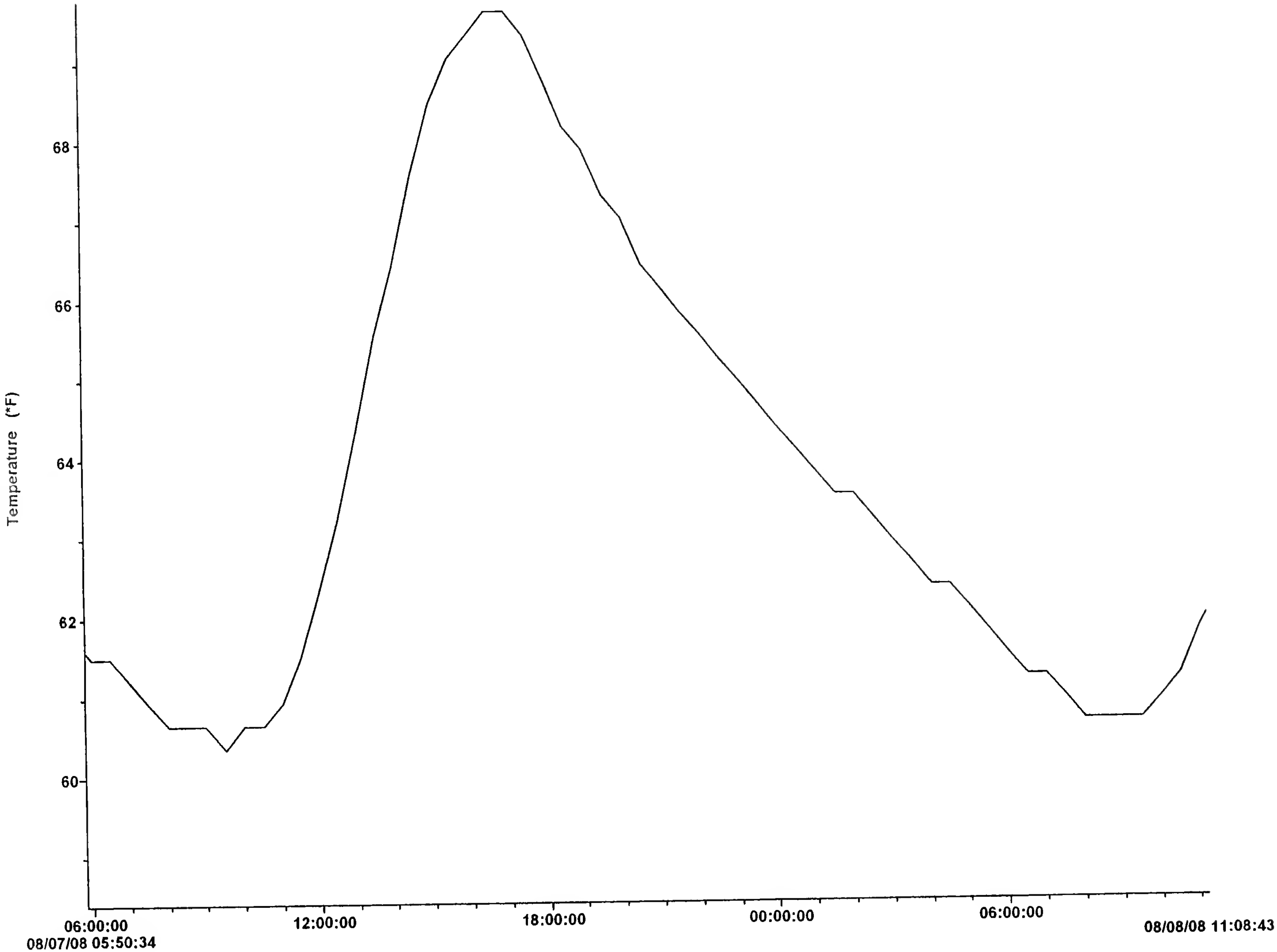

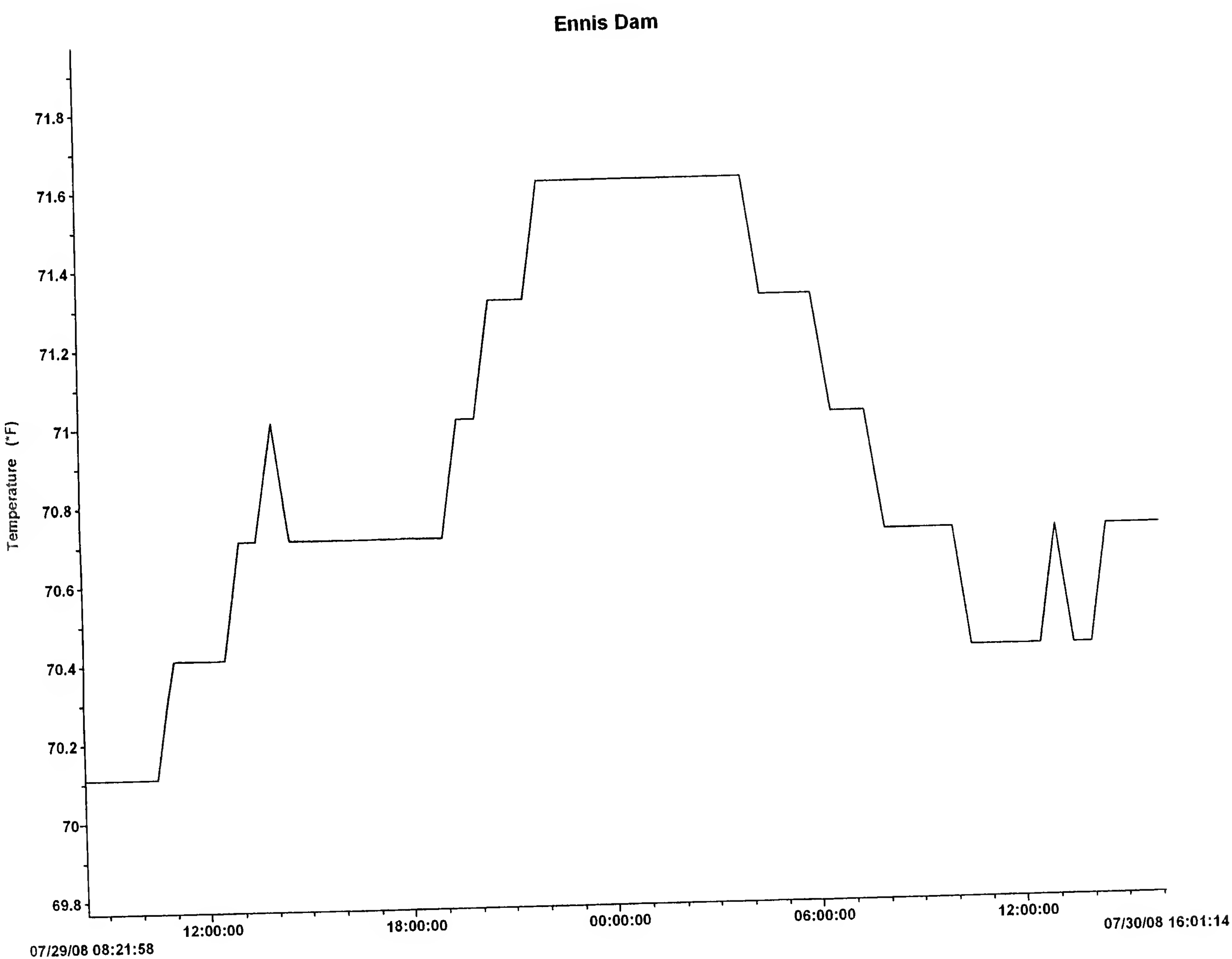
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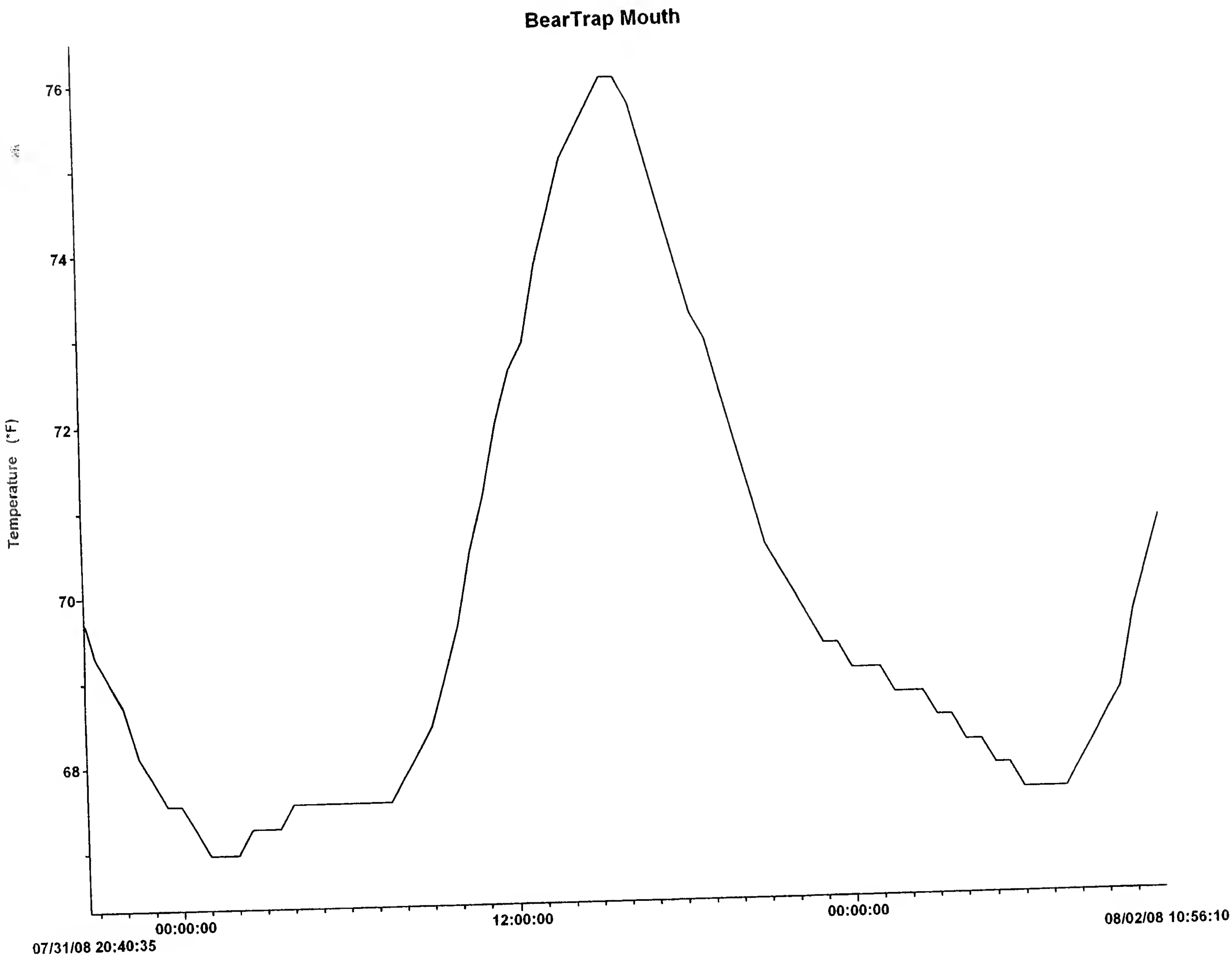
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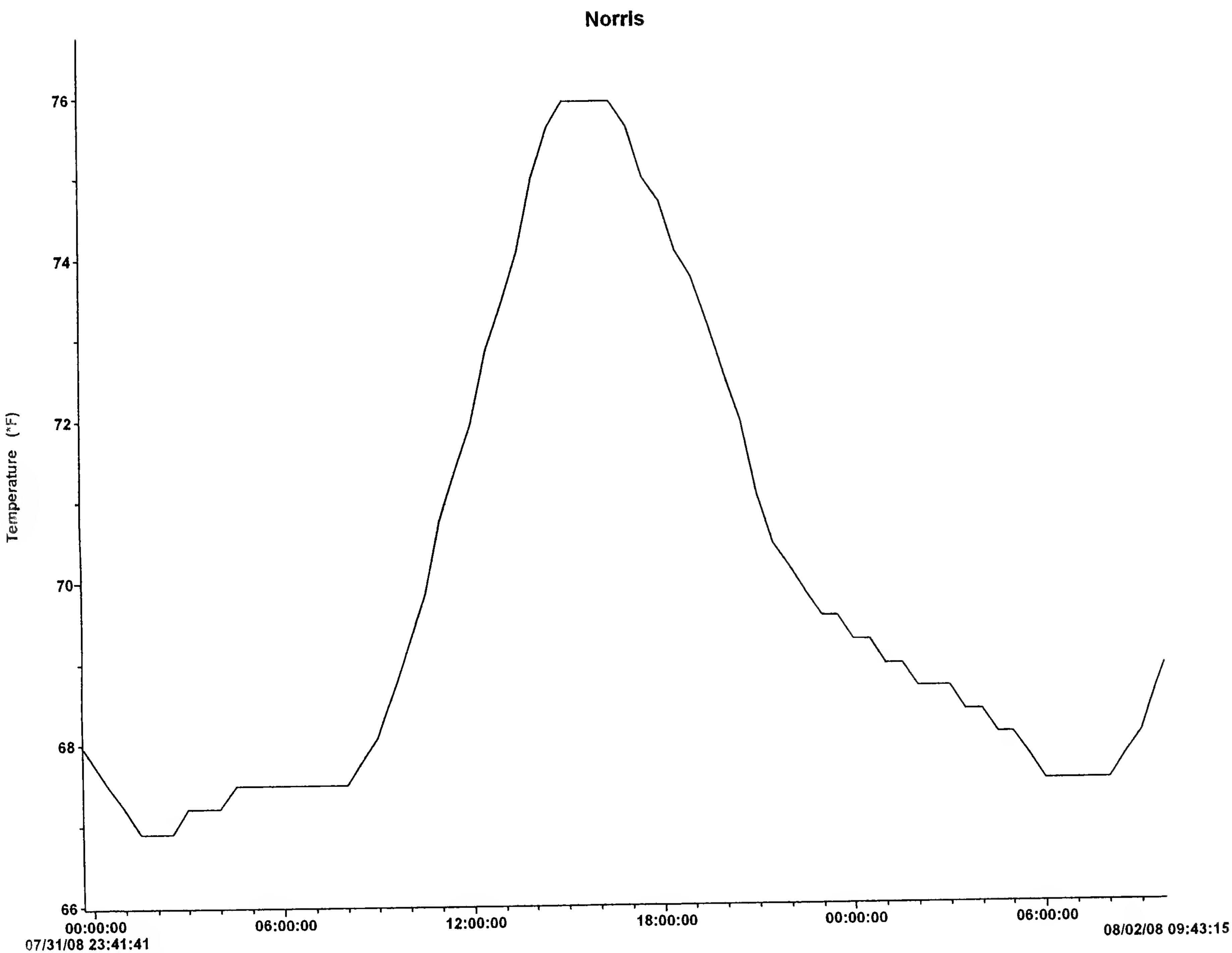
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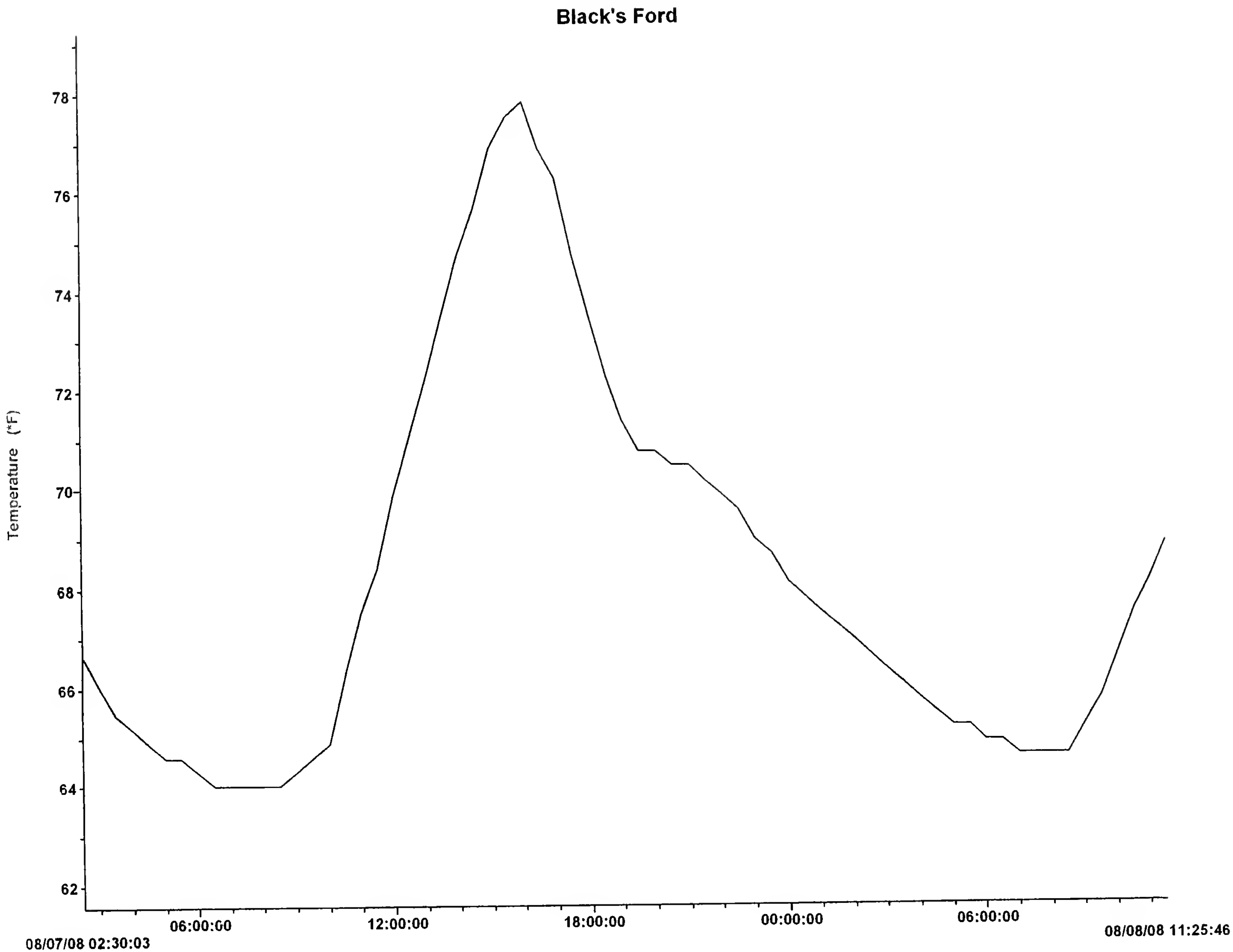
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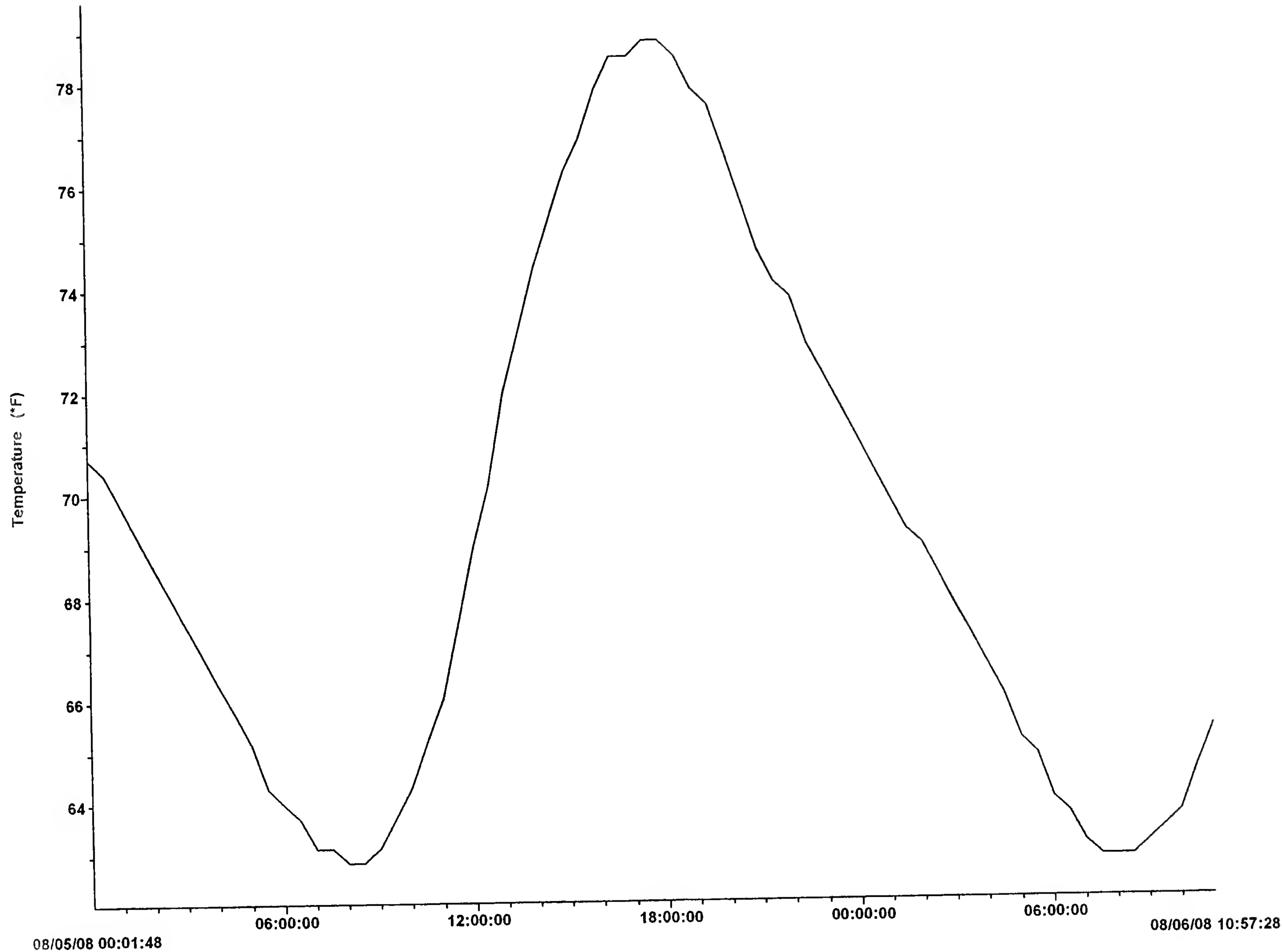

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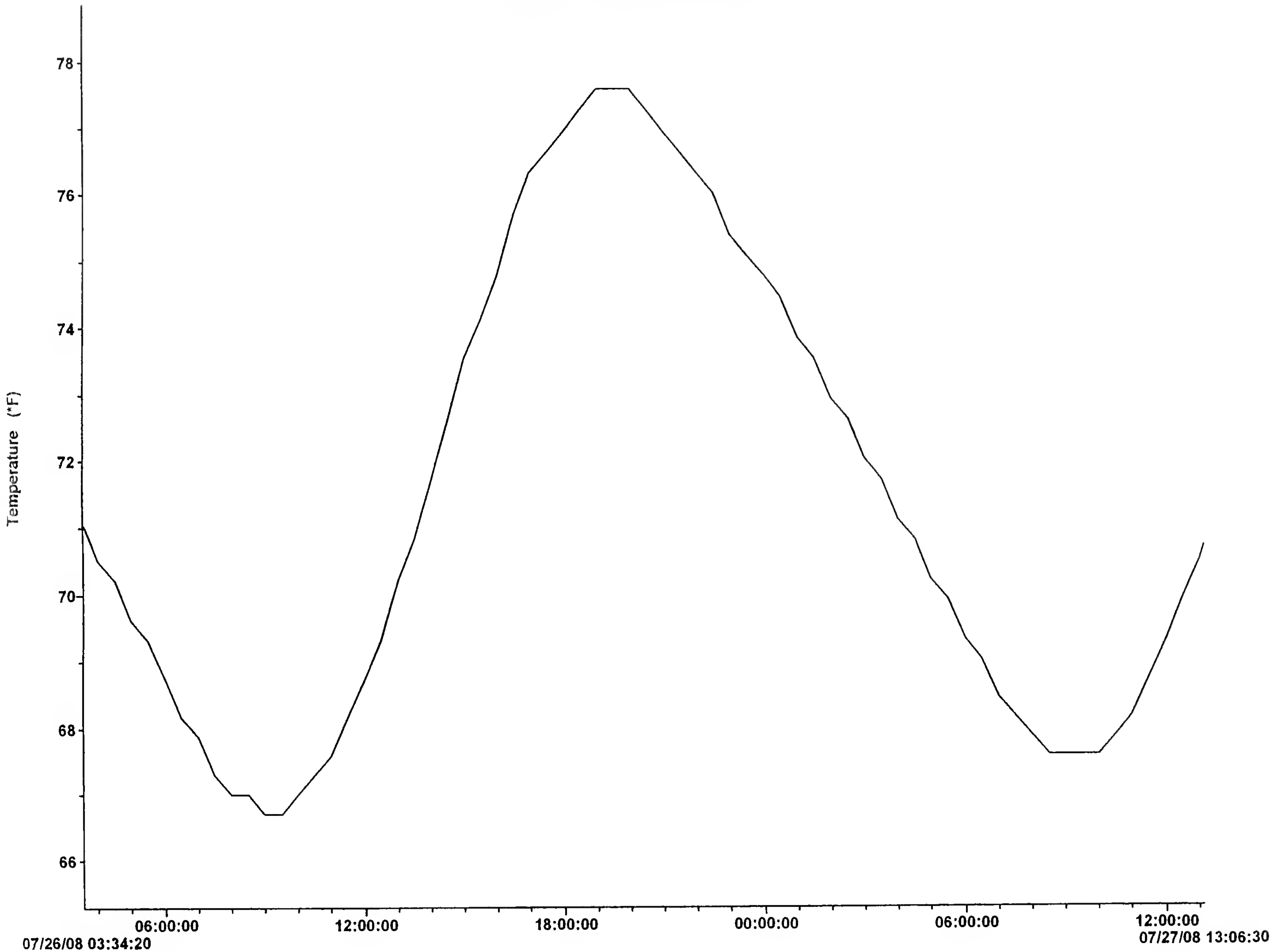


Appendix E

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".

Appendix F

Madison Ranger District – Aquatic Restoration Partnerships
2008 Monitoring Reports

Westslope Cutthroat Trout Habitat Restoration Monitoring
Arasta Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2008

Background

Arasta Creek originates on the east flank of the Gravelly Mountains and flows into the Madison River near Cameron, Montana. The removal of beaver from this drainage, combined with historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of the stream channel, along with an elevated fine sediment load. The pasture which Arasta Creek flows through includes both FS (treated) and BLM (untreated) landownership. This pasture is currently being rested from livestock grazing and riparian vegetation, particularly sedges, appear to be responding well. Arasta Creek supports a population of WCT upstream of a cascade barrier. Molecular analysis of this population indicates genetic integrity varies from 95-82%.

The goal of channel restoration in Arasta Creek is to reverse patterns of over-widened and/or downcut channel geometry. The means to accomplishing this objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved pool habitat and watershed function with reduced fine sediment load being exported downstream into the Madison River system, an impaired water body on the Montana Department of Environmental Quality's 303d list.

Attainment of this goal and objectives entails the installation of low-head riffles and baffles using native rock and wooden stakes to influence deposition of fine sediments during springtime high flows. The elevated load of fine sediment in Arasta Creek, normally interpreted as a negative, actually provides the natural material to rebuild point bars and stream banks. These structures employ wooden stakes – anywhere from 50-100 cm long – that are pounded into the streambed in a dot-grid matrix, leaving roughly 10-50 cm of the stake protruding above the streambed surface in tributary-scale channels. The interstices formed by the spaces between stakes are then filled with native cobbles and smaller materials to form the riffle or baffle. Stakes provide the integrity to the structure to persist high flows and influence sediment deposition. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition, and are aligned to allow for upstream fish passage. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

Riffle and baffles were initially installed in September 2005, with work continuing during the summer of 2008. This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". The Madison-Beaverhead Counties RAC has also provided funds toward the purchase of supplies in 2005-7; funding and volunteer labor have been provided by the Madison River Foundation and the Madison-Gallatin chapter of TU . Restoration efforts in this treatment reach are close to complete; additional restoration opportunities upstream could be addressed in future years.

Results

Monitoring of morphological parameters indicate that this restoration technique has been successful in narrowing bankfull width in the treated channel (FS), while the untreated reach (BLM) has actually increased in bankfull width (Table 1). Both reaches have been rested from grazing since 2006 (three seasons). Pool frequency has increased in the treated reach, but actually decreased in the untreated reach, whereas residual depth has increased very slightly in both reaches. The expectation is that pools should scour deeper in future years as structures continue to mature and additional high flow events influence scouring.

Table 1. Channel characteristics, Arasta Creek, 2004-2008

Channel characteristic	2004	2008
Arasta meadow reach (BLM & FS)		
Total channel length (km)	1.24	1.38
Mean bankfull width (m)	1.33	1.21
Pool frequency (pools / km)	33.9	34.1
Pool spacing	22.2	24.3
Mean residual pool depth (m)	0.29	0.31
BLM reach (untreated)		
Total channel length (km)	0.500	0.516
Mean bankfull width (m)	1.25	1.39
Pool frequency (pools / km)	28.0	21.3
Pool spacing	28.6	33.8
Mean residual pool depth (m)	0.22	0.24
FS reach (treated)		
Total channel length (km)	0.740	0.864
Mean bankfull width (m)	1.39	1.11
Pool frequency (pools / km)	37.8	41.7
Pool spacing	19.0	21.6
Mean residual pool depth (m)	0.33	0.34

From 2005 to 2008, the treated reach increased in length by a considerable amount (17%), indicating that stream narrowing has been accompanied by increased sinuosity. Channel length increased in the untreated reach over this same period, however this change was relatively small compared to the overall reach length (3%).

Structures installed in Arasta Creek have been very successful influencing sediment deposition, particularly in the downstream eddy areas of baffles, and upstream of riffles (Figure 1). In 2006 and 2007, we purchased sedge plugs and planted them in these areas of deposition to help stabilize these unconsolidated sediments. Sedges appear to thrive in these environments, and continued monitoring will be needed to determine how effective they are in sediment stabilization.

All of the structures in Arasta Creek survived the high duration spring runoff of 2008 without need of any maintenance, and additional sediments were deposited (Figure 3).

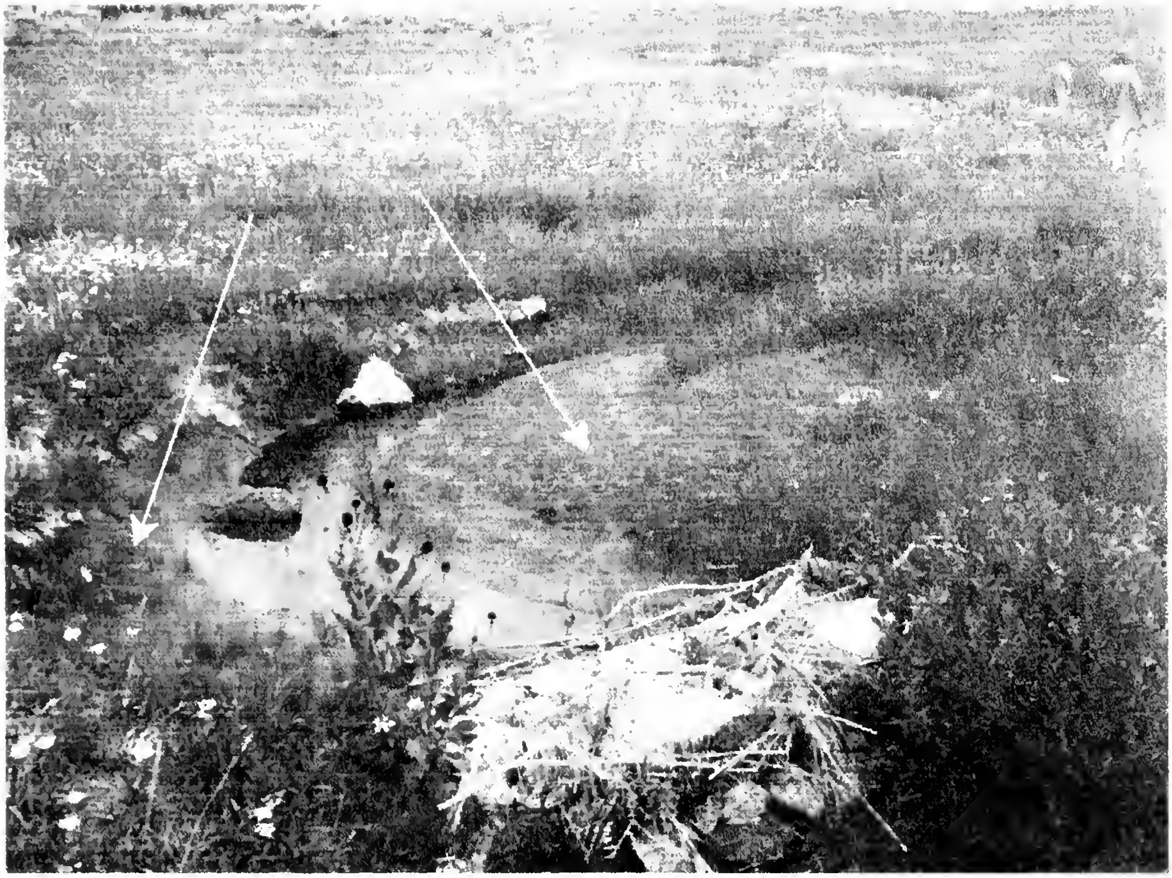


Figure 1. Riffle structure trapping fine sediments upstream (arrows), 2007.


Figure 2. Same structure adapted for fish passage, 2007


Figure 3. Same structure following long duration spring runoff, July 2008.


Figure 4. Riffle with fish passage at left, raising water surface elevation about 2 feet, 2007.

Westslope Cutthroat Trout Restoration Monitoring
Buford Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2008

Background

Buford Creek flows out of the far southern end of the Gravelly Mountains to its confluence with the West Fork of the Madison River about 30 miles south of Cameron, Montana. The early removal of beaver from the headwater tributaries of this drainage by trappers in the first half of the 19th century, combined with historic overgrazing by livestock, had resulted in considerable channel degradation with sediment being exported downstream (Lisle, 1972). More recent grazing management has protected the channel in its lower reaches with the installation of a large riparian exclosure. The channel is an "E" type as it flows through a meadow in its lower reaches, with highly erodible soils common to the southern Gravelly range in its headwaters, similar to Fox Creek. The entire drainage is currently grazed by livestock under Amendment 7 riparian standards; light trampling and heavy willow browse occurs from elk and moose.

The goal for Buford Creek in 2008 was to determine if any channel restoration opportunities exist, and whether the distribution of willow could be improved/restored. The means to accomplishing any needed channel restoration would employ techniques that influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream.

The installation of low-head riffles and baffles using native rock and wooden stakes is designed to influence deposition of fine sediments during springtime high flows. The elevated load of fine sediment in the West Fork originates primarily from eroding stream banks. Such erosion is normally interpreted as a negative impact, however in this case it actually provides the material to rebuild point bars and stream banks. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

This project has received funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration".

Habitat

No inventory of habitat was conducted in Buford Creek in 2008. Streambanks inside the large exclosure at the lower end of this drainage are well vegetated, and the channel, and "E" type, appears to be fairly narrow with good depth. A habitat inventory in 2009 would be useful to helping confirm the condition of the channel and to determine whether future restoration activities would be useful.

Fish

A 200 meter reach of lower Buford Creek inside the exclosure was electro-shocked to determine the densities of native fish and collect tissue samples for genetic analysis (PINES). Results from electro-fishing (Table 1) indicate that Buford Creek supports a population of WCT missing its smaller size classes, indicating poor reproduction in the last year or two. Larger fish are relatively abundant, the largest being 310 mm, and suggests that over-wintering habitat is not limiting. Results from molecular analysis of tissue samples (n=11) collected from this reach indicate this population is 85% pure, with hybridization occurring primarily from rainbow trout (13%) and Yellowstone cutthroat trout (2%). Sculpin were very abundant in this in this reach.

Table 2. Densities (fish/100m) of WCT shocked by size class, West Fork Madison River, 2008.

	Date	Length (m)	≤ 76 mm	77-152 mm	>152 mm	Sculpin
Reach 1	29 Sept 2008	200	0.0	4.0	5.5	86.5

Amphibians

No amphibians were observed during visits to this drainage, however more extensive survey is needed to confirm this. Past surveys in the headwater area of the watershed (Lobo Mesa) have identified breeding populations of western (boreal) toads in the landscape, so the presence of this species in the Buford drainage would not be surprising.

Figure 1. Buford Creek, looking upstream from the vicinity of its confluence with the West Fork Madison River, September 2009.

References Cited

Lisle, Thomas, E. 1972. Sediment yield and hydrodynamic implications, West Fork of the Madison River, Montana. Master's Thesis, University of Montana, Missoula, MT. 81 pp.

Westslope Cutthroat Trout Habitat Restoration Monitoring
Fox Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2008

Background

Fox Creek originates on the far southern end of the Gravelly Mountains and flows into the upper West Fork of the Madison River about 30 miles south of Cameron, Montana. The early removal of beaver from this drainage by trappers in the first half of the 19th century, combined with historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of the stream channel, along with an elevated fine sediment load. From its confluence with the West Fork, Fox Creek exhibits primarily "B" channel characteristics for about 1.5 miles with numerous head cuts. The upper mile is an over widened "E" channel with various sub-reaches being downcut. This upper segment flows through a meadow composed of highly erodible soils common to the southern Gravelly range, and has high potential given its low gradient and sinuous morphology. The entire drainage is currently grazed by livestock under Amendment 7 riparian standards; light trampling and heavy willow browse occurs from elk and moose. Fox Creek supports a population of WCT with a genetic purity of 97%.

The goal of channel restoration in Fox Creek is to reverse its degraded channel geometry, and hopefully one day restore the distribution of willows to its riparian community. The means to accomplishing this first objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream into the Madison River system.

The installation of low-head riffles and baffles using native rock and wooden stakes is designed to influence the deposition of fine sediments during springtime high flows. The elevated load of fine sediment in Fox Creek originates primarily from its eroding headwater stream banks. Such erosion is normally interpreted as a negative impact, however in this case it actually provides the material to rebuild point bars and stream banks. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

This project has received funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration".

Habitat

In 2008, spring runoff appeared to be above average in its magnitude and its duration. Large head cuts (4-6 feet tall) were observed in the existing channel in the lower reach, and likely function as a barrier to upstream movement of fish, although they are less permanent than a more desirable bedrock formation.

The inventory of morphologic parameters in 2008 indicate that the channel actually contains frequent and moderately deep pool habitat (Table 1). The depth of Reach 1 pools are skewed by the presence of deep plunge pools associated with the tall head cuts (Figure 1) in this reach; removal of these pools from the dataset reduces the mean residual pool depth of this reach to 0.34 meters, which still represents good pool depth and morphology in this landscape. Bankfull width was considerable lower in Reach 2 than Reach, likely due to relatively better bank stability, although sub-reaches are still in poor condition in Reach 2.

A small number of baffles were installed at various location of the channel from July through September 2008. After observations of livestock grazing patterns both in this drainage and in other drainages being treated with similar structures, it was determined that until the channel could be protected from livestock impacts, the investment of restoration activities in this channel would not be as productive as desired.

Table 1. Channel characteristics, Fox Creek, 2008.

	2008	
Channel characteristic	Reach 1	Reach 2
Channel length (km)	1.28	2.26
Stream bed gradient (%)	2 – 4	< 2
Mean bankfull width (m)	2.23	1.79
Pool frequency (pools / km)	37.5	47.1
Pool spacing	12.0	26.3
Mean residual pool depth (m)	0.39	0.38

Figure 1. Large head cut, lower Fox Creek, July 2008.

Water temperature was monitored in Fox Creek just upstream of its confluence with the West Fork of the Madison River from late July through mid-September, and is graphed as the mean daily water temperature in Figure 2. We missed the early half of the summer, but it appears that Fox Creek does not suffer from high water temperatures in late summer, and in fact dropped considerably beginning in early September. It is recommended that future monitoring of water temperature should begin in mid-June if at all possible to better understand when WCT spawning may begin in this system.

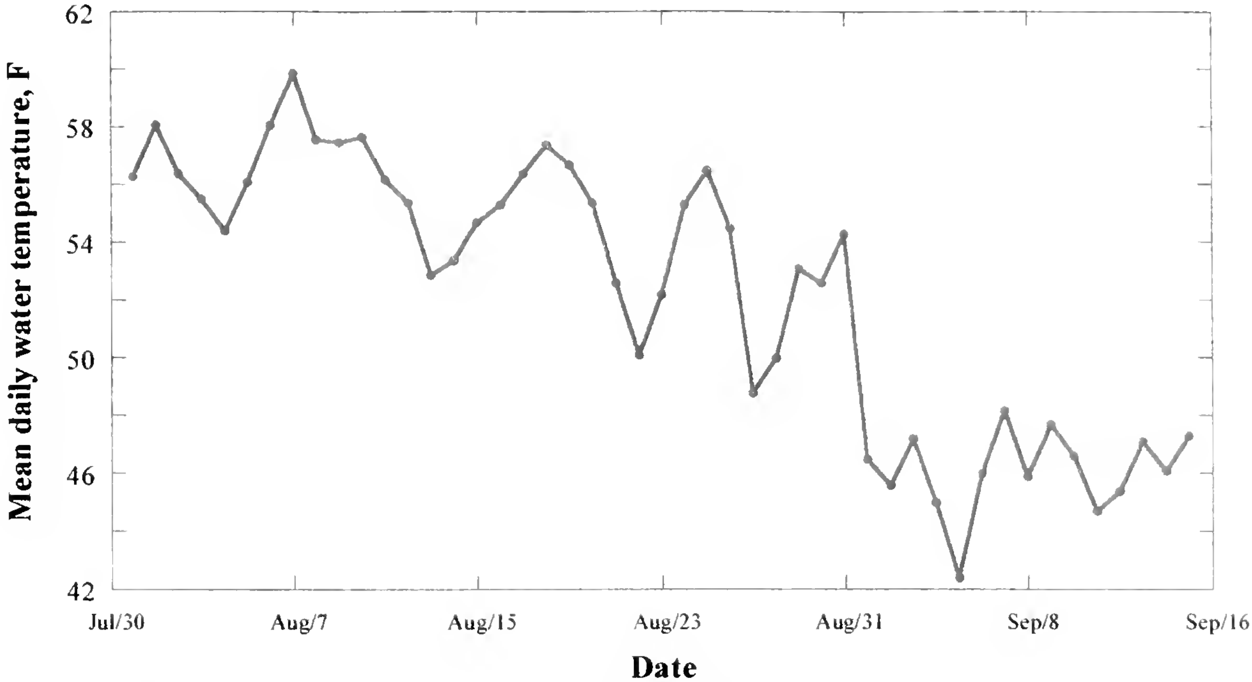


Figure 2. Mean daily water temperature (° F) in lower Fox Creek, summer 2008.

Fish

Two reaches, one just upstream of the West Fork confluence and another about a mile upstream in the meadow, were electro-shocked to determine densities of native fish and to collect tissue samples for genetic analysis (PINES). Results from molecular analysis of tissue samples (n=18) collected from the upper reach indicate that WCT in upper Fox Creek are slightly hybridized (3%) with rainbow trout alleles, forming a hybrid swarm. It is likely that the tall head cuts in the lower reach provide a form of physical barrier that has reduced the rate of introgression of this headwater population of WCT in Fox Creek.

Densities of WCT in Fox Creek are generally low, although the upper reach supports a density almost twice that of the lower reach. The population in Reach 2 is strongly composed of larger WCT, which is generally uncommon in this landscape. Sculpin were numerous in both reaches, but their density was particularly high in Reach 2.

Table 2. Densities (fish/100m) of WCT shocked in Reach 1 and Reach 2, by size class, Fox Creek, 2008.

	Date	Length (m)	≤ 76 mm	77-152 mm	>152 mm	Sculpin
Reach 1	23 July 2008	100	0.0	2.0	3.0	9.0
Reach 2	18 Sept 2008	400	2.2	2.5	4.2	43.0

Amphibians

Amphibians, particularly western (boreal) toads, were relatively well distributed and numerous throughout the drainage in all age classes. Larvae were also observed in the stream channel in the meadow reach. Columbia spotted frog adults were observed in lower numbers throughout the drainage, with a dense cohort of juveniles observed in the headwater channel/springs in late summer.

Stream Habitat Restoration Monitoring
Tepee Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2008

Background

Tepee Creek originates on the east flank of the Gravelly Mountains as a tributary to Horse Creek, flowing into the Madison River near Cameron, Montana. Historic trapping of beaver and over grazing have caused the stream channel to down cut and over-widen; this system currently experiences a high fine sediment load. Although livestock grazing ceased 25 years ago, the channel had yet to restore itself. Tepee Creek still experiences light to moderate trampling and heavy browsing by ungulates associated with the nearby Wall Creek Wildlife Management Area. Tepee Creek in the project area is fishless due to a natural cascade barrier located just downstream of the treatment area. Molecular analysis of westslope cutthroat trout (WCT) downstream in Horse Creek indicates that this population is greater than 90% pure. Once habitat has been restored to acceptable levels in Tepee Creek, there is an opportunity to introduce pure WCT into this headwater tributary.

The goal of restoration in Tepee Creek is to influence natural stream processes, particularly fine sediment deposition, to restore channel morphology. A secondary objective is improved watershed function by reducing fine sediment loads transported to the Madison River, an impaired water body on the MT Dept. of Environmental Quality's 303d list.

Installation of willow weirs - channel spanning dams constructed of wooden stakes, woven willow, and sedge clumps - has have trapped fine sediments and built point bars and stream banks, particularly where sedges have expanded as they respond to increased water storage and soil moisture. Weirs are particularly effective as they mimic beaver dams, trapping fine sediment and increasing stream bed elevation (Fig. 1). Baffles, where wooden stakes are pounded into the stream bed in a triangle dot-grid and the interstices are filled with cobble, willow, and sedge plugs to direct flow against the opposite bank and induce stream meandering (Figure 2). Sediment also deposits on top of and in the back eddy created by these baffles, but not as effectively as the weirs. By creating a series of baffles and weirs, the stream bed elevation is raised and a meander-pool-point bar morphology is created.

Figure 1. Channel spanning weirs composed of wood stakes, willow, rock, and sedge plugs, September 2006.

Figure 2. View looking downstream at a series of baffles built in 2006 that induced meandering, July 2007.

Results

Riffle and baffles were initially installed in September 2004, with monitoring and further construction continuing through 2008. In 2005 all structures survived winter ice jams and spring flows intact while trapping fine sediment. Channel cross sections were established in order to monitor channel morphology (Figures 3-6), supplemented with photographs. The cross sections in 2005 showed an increase in stream bed elevation, indicating successful sediment deposition. While the structures did survive the 2006 season, little increase in stream bed elevation occurred, indicating no further sediment deposition. It appeared that the structures had reached their capacity to trap sediment in the first year. In 2006 weir structures were installed in an effort to increase the amount of sediment deposition; monitoring results from subsequent years indicate that these structures have been quite effective in this regard.

In 2008, some weirs incurred small water breaches as a result of the long duration of spring runoff. This resulted in lowered water surface elevations upstream of the structures. Breached weirs were sealed with bio-degradable sandbags and sedge chunks that blocked upstream flow. The cross sections from 2008 indicate another year of sediment deposition, in addition to evidence of channel narrowing (Figures 3-6). Photographs indicate that large quantities of sediment deposited upstream of weirs, creating bars, recruiting sedges, and narrowing the channel (Figure 7).

While large amounts of sediment have been deposited, it is generally fine and highly mobile. In order to stabilize this sediment sedge plugs were planted in 2007 and 2008. As these plugs mature, their root masses will stabilize the point bars. Also, baffle and weir construction continued upstream, expanding the restoration reach. Further monitoring, construction, and maintenance will continue into the near future. However, someday, through sediment deposition and vegetation recruitment Tepee Creek should return to historic conditions and support a native population of WCT.

Funding

This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". The Madison-Beaverhead Counties RAC also provided funds toward the purchase of supplies in 2005-6.

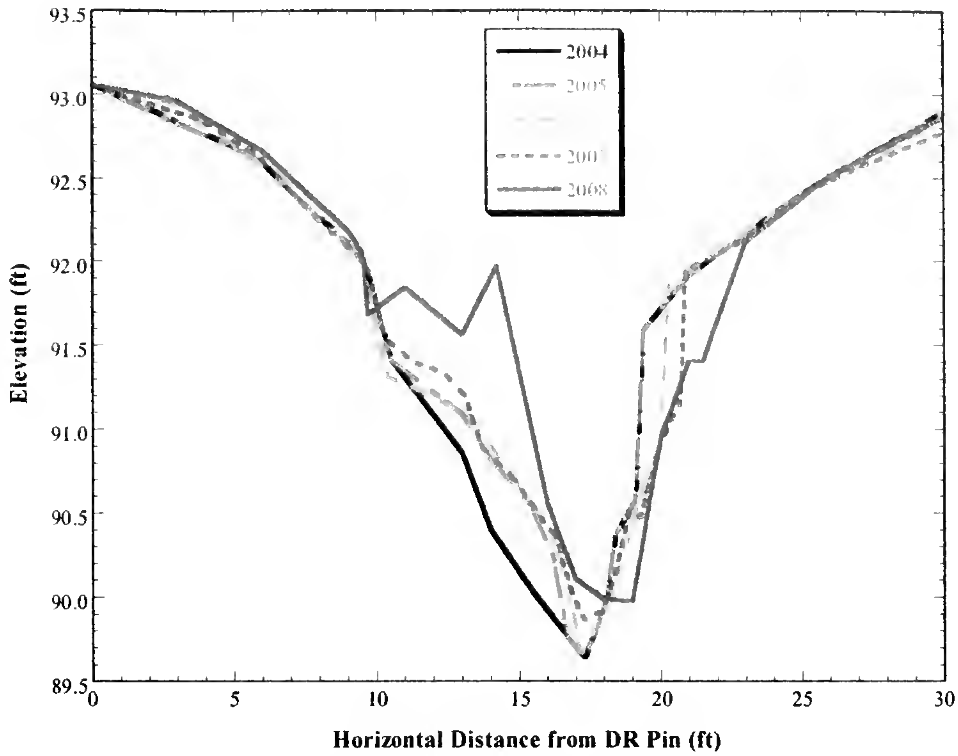


Figure 3. Transect #1; note in 2008 the large sediment deposition at left.

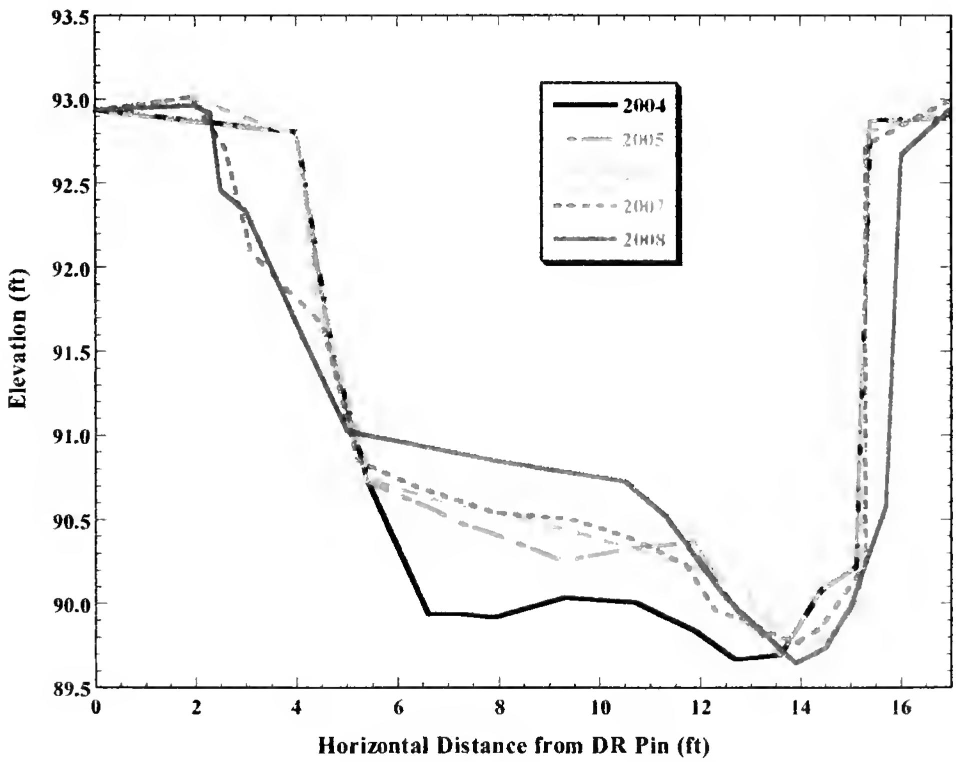


Figure 4. Transect #2, relates annual increases in sediment deposition and streambed elevation.

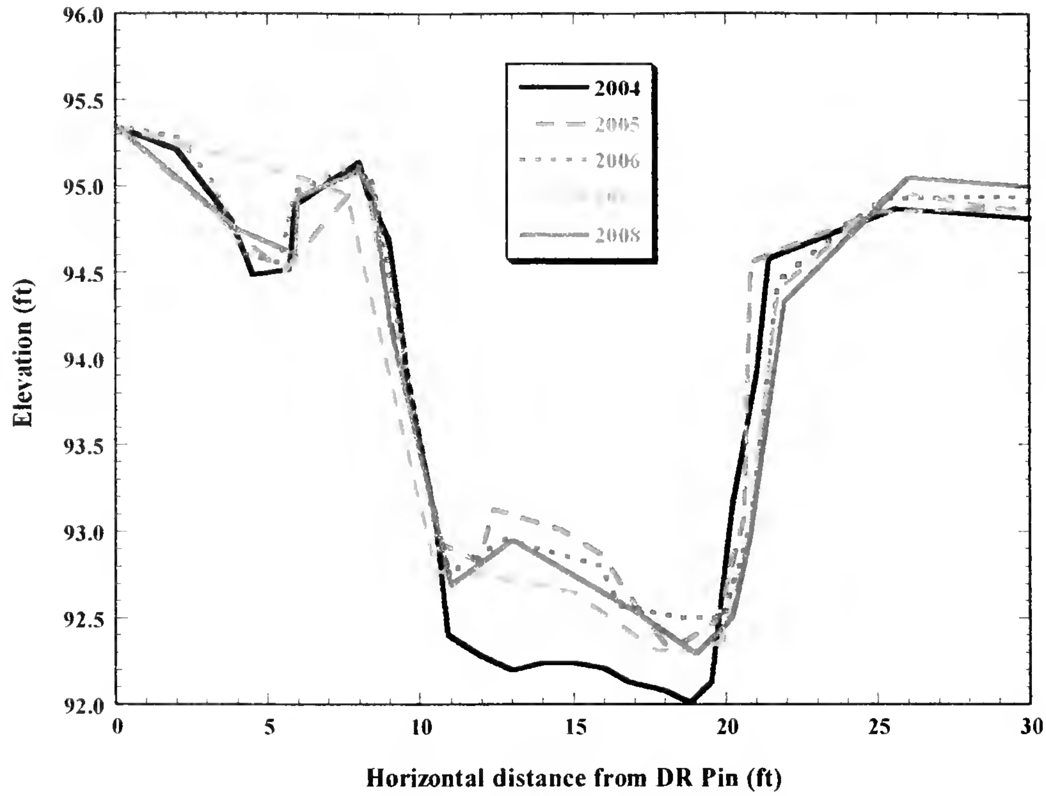


Figure 5. Transect #3, showing annually variable deposition immediately over Riffle #6.

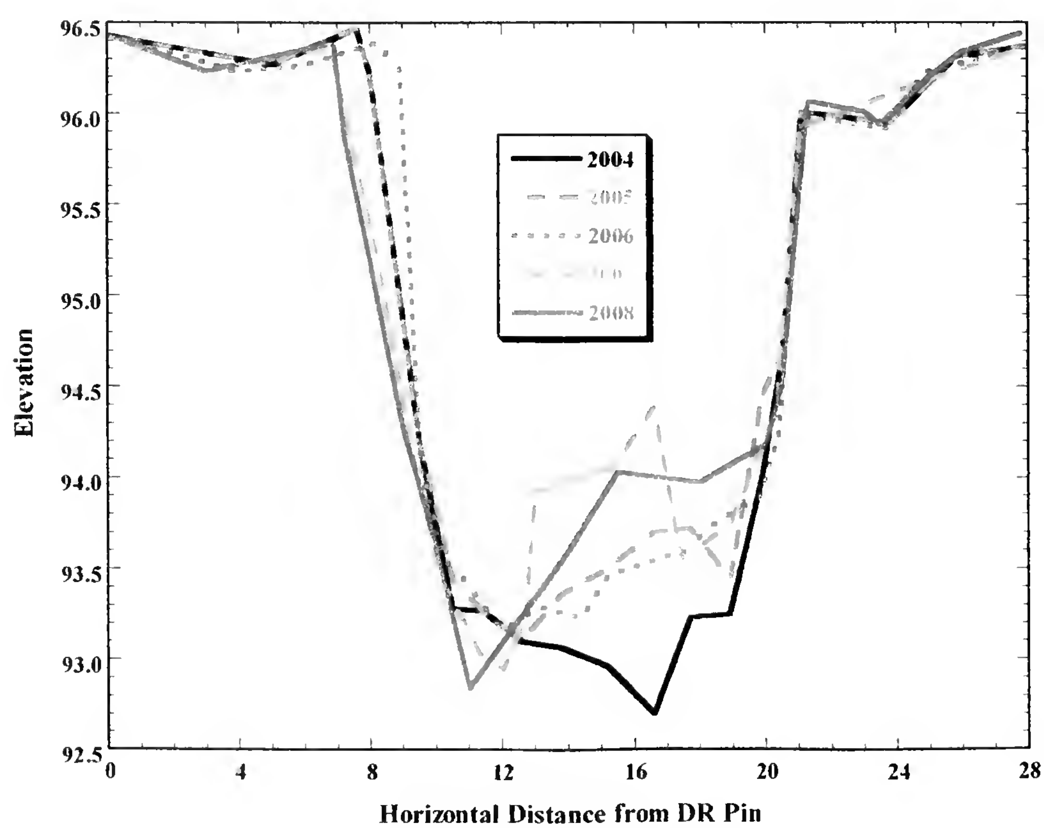


Figure 6. Transect #4, showing annually variable sediment deposition just upstream of Riffle #6.

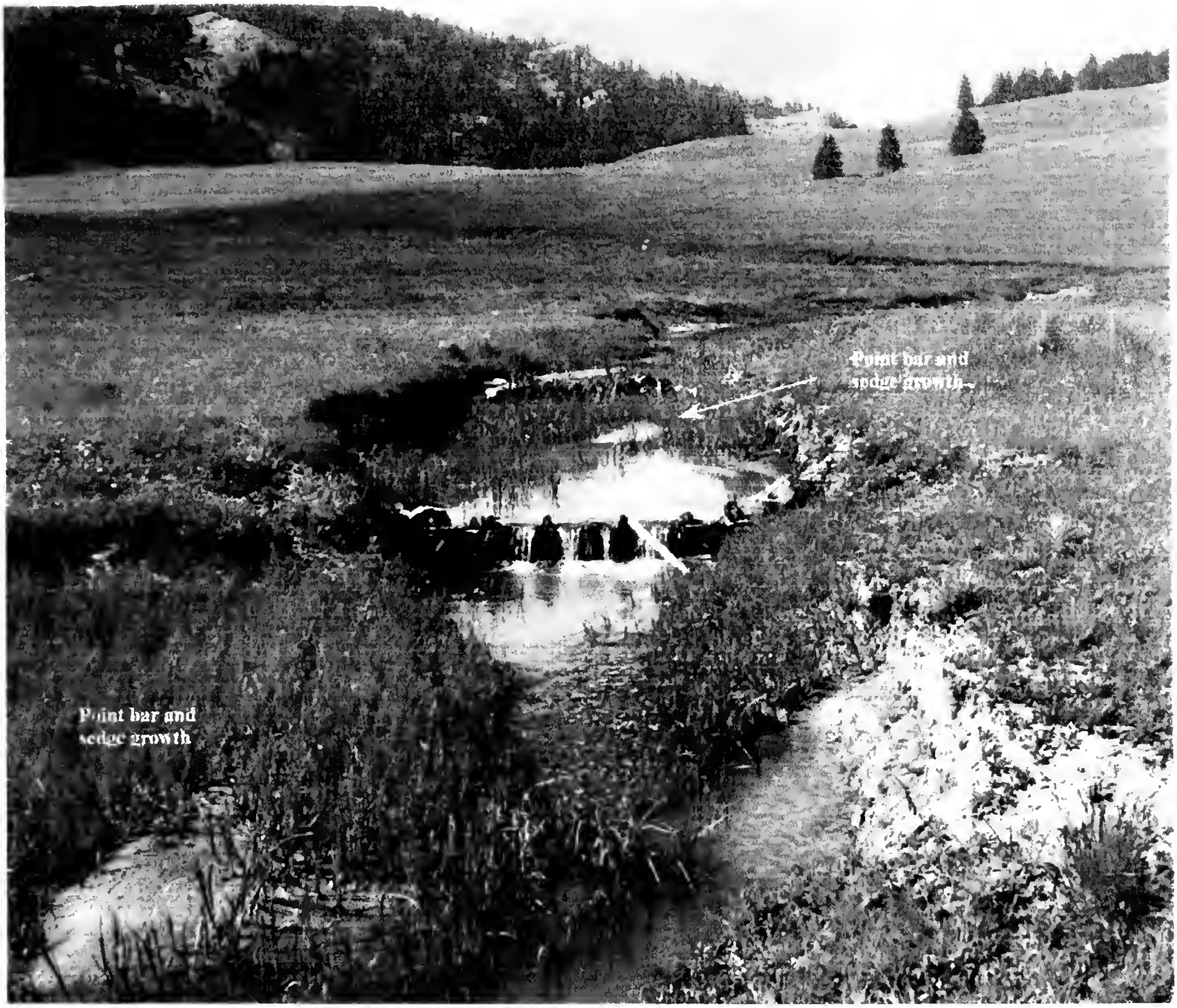


Figure 7. A weir trapping large amounts of sediment and raising the surface water level, July 2008. Sedge recruitment is already occurring on the point bars, and spawning gravel has been sorted in the thalweg below the weir.

Westslope Cutthroat Trout Restoration Monitoring
West Fork Madison River, Madison Ranger District
Beaverhead-Deerlodge National Forest
2008

Background

The West Fork of the Madison River originates on the far southern end of the Gravelly Mountains, flowing generally in an easterly direct to its confluence with the Madison River about 30 miles south of Cameron, Montana. The early removal of beaver from the headwater tributaries of this drainage by trappers in the first half of the 19th century, combined with historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of the stream channel, along with an elevated fine sediment load. In the vicinity of the West Fork Cabin, the channel is a degraded "Ea" type for about 1.5 miles and flows through a meadow composed of highly erodible soils common to the southern Gravelly range. Evidence of past beaver dams exists with down-cutting and eroding of banks. The entire drainage is currently grazed by livestock under Amendment 7 riparian standards; light trampling and heavy willow browse occurs from elk and moose.

The goal of channel restoration in the West Fork of the Madison is to reverse its degraded channel geometry, and hopefully one day restore the distribution of willows to its riparian community. The means to accomplishing this first objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream.

The installation of low-head riffles and baffles using native rock and wooden stakes is designed to influence deposition of fine sediments during springtime high flows. The elevated load of fine sediment in the West Fork originates primarily from eroding stream banks. Such erosion is normally interpreted as a negative impact, however in this case it actually provides the material to rebuild point bars and stream banks. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

This project has received funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration".

Habitat

In 2008, three reaches of the upper West Fork were inventoried after an extended spring runoff. Reach 3 was located upstream of FR9628, the other two reach reaches were adjacent to each other farther downstream. Each reach exhibited morphology of a large "Ea" channel with cobble and discontinuous down-cutting of the channel. Reach 2 had lower gradient and less down-cutting than Reach 1 or 3. Results indicate that the all three reaches contain moderately frequent pools with varying residual depth (Table 1). Bankfull width was considerable lower in Reach 2 than the other two reaches, with considerable braiding.

Table 1. Channel characteristics, West Fork Madison River, 2008.

	2008		
Channel characteristic	Reach 1	Reach 2	Reach 3
Channel length (m)	260	600	280
Mean bankfull width (m)	2.10	1.63	2.06
Pool frequency (pools / km)	34.6	20.0	42.9
Pool spacing	13.8	30.7	11.3
Mean residual pool depth (m)	0.31	0.24	0.18

After observations of livestock grazing patterns both in this drainage and in other drainages being treated with similar structures, it was determined that channel restoration would not be effective without some form of protection from livestock trampling.

Fish

The West Fork supports a population of WCT with a genetic purity of 94%, based on allozyme analysis of three fin clips in 1991. One reach **upstream** of the barrier culvert on FR9628 near the West Fork Cabin (Figure 1) were electro-shocked to determine the densities of native fish and collect tissue samples for genetic analysis (PINES). Results from molecular analysis of tissue samples (n=8) collected from this reach have yet to be analyzed. Densities of WCT in this reach of the West Fork are low, but indicate reproduction and recruitment is occurring given the variety of size classes. No sculpin were caught or observed in this reach.

Table 2. Densities (fish/100m) of WCT shocked by size class, West Fork Madison River, 2008.

	Date	Length (m)	≤ 76 mm	77-152 mm	>152 mm	Sculpin
Reach 1	23 July 2008	100	4.0	2.0	2.0	0.0

Amphibians

A vernal pond west of the West Fork cabin was observed to support a breeding population of western (boreal) toads. Adult boreal chorus frogs were also observed in this same pond.

Figure 1. Barrier culvert on FR 9628, upper West Fork Madison River, July 2009.

Westslope Cutthroat Trout Habitat Restoration Monitoring
Wigwam Creek, Madison Ranger District
Beaverhead-Deerlodge National Forest
2008

Background

Wigwam Creek originates on the east flank of the Gravelly Mountains and flows into the Madison River near Cameron, Montana. The removal of beaver from this drainage, combined with failed water diversions and historic overgrazing by livestock, has resulted in considerable down cutting and over-widening of the stream channel, along with an elevated fine sediment load. Wigwam Creek is currently grazed by livestock under Amendment 7 riparian standards; light trampling and willow browse occurs from elk and moose. The treatment segment of Wigwam Creek supports a population of WCT; molecular analysis indicates that the genetic integrity of this population varies from 95-82%.

The goal of channel restoration in Wigwam Creek is to reverse its over-widened channel geometry. The means to accomplishing this objective is to influence natural processes such as sinuosity, fine sediment deposition, stream bank formation, and floodplain connectivity to accelerate the rate of channel recovery. Secondary objectives include improved watershed function with reduced fine sediment load being exported downstream into the Madison River system.

The installation of low-head riffles and baffles using native rock and wooden stakes is designed to influence deposition of fine sediments during springtime high flows. The elevated load of fine sediment in Wigwam Creek, normally interpreted as a negative, actually provides the natural material to rebuild point bars and stream banks. Riffles are constructed as channel-spanning features, generally installed to influence upstream sediment deposition. Baffles are not intended to span the channel, instead acting to form point bars and increase sinuosity in the channel. Riffles and baffles typically exhibit an elevation gradient across the channel, influencing flow against one bank and deposition against the other bank, particularly in the downstream backwater area.

Riffle and baffles were initially installed in September 2004, with work continuing during the summer of 2007. This project has received considerable funding support from PPL-Montana in each year under the authority of Article 409 of the PPL FERC license on the Madison River, specifically part (3) "fish habitat enhancement both in the main stem and tributary streams, including enhancement for all life stages of fishes" and part (9) "riparian habitat restoration". In the past, the Madison-Beaverhead Counties RAC have provided funds for supplies and funding and volunteer labor have been provided by the Madison River Foundation and the Madison-Gallatin chapter of TU. Restoration efforts in this treatment reach are close to complete; in 2008 only limited maintenance was performed.

Results

In 2008, spring runoff was about average to above average, but its duration was relatively extended. This resulted in greater scouring of the channel. Early season review of the channels and structures indicated that relatively little new sediment deposition had occurred and that in some instances, fine sediments had been lost from structures during the extended high flow. Early season trailing on livestock through the allotment resulted in heavy trampling of a 50 meter long reach of the restored channel about 100 meters upstream of the bridge, with some limited impact to about five structures. More importantly, late season grazing in the restored channel reach was considerably above past levels observed, resulting in further loss of sediment associated with structures and in some cases, impact to the structures themselves. This was documented in a late season field review by Forest Service hydrologists from the Greater Yellowstone area (Regions 1 and 4), who recommended that these structures appear to have benefit as a restoration tool, but cautioned their use in grazed systems. Wigwam Creek is scheduled to be excluded from livestock grazing by the implementation of exclosures and improved water facilities in 2009.

Quantitative monitoring of morphological parameters in 2008 indicate that the channel continues to adjust and improve, with some interesting changes. Bankfull width actually increased slightly, likely due to grazing impacts, but possibly also confounded by the extended spring runoff. Sinuosity and length of channel did not change (Table 1), which may be a clue that the channel has reached its potential under its current alignment and valley morphology.

Most interesting is how pool habitat improved after remaining static the last three years. Pool frequency and residual depth both increased considerably, with a concurrent reduction in pool spacing, all likely a function of the extended spring runoff (Table 1). However, 2006 experienced an above average extended spring runoff, but without improvement in pool habitat characteristics. This result suggests that this restoration technique is successful in initially influencing the narrowing and sinuosity of a degraded channel, after which channel geometry and scouring flows allow pool development.

This conclusion also points out the importance of long term monitoring in following the various changes in channel response, and in making useful management decisions adaptively.

Table 1. Channel characteristics, Wigwam Creek, 2004-2007

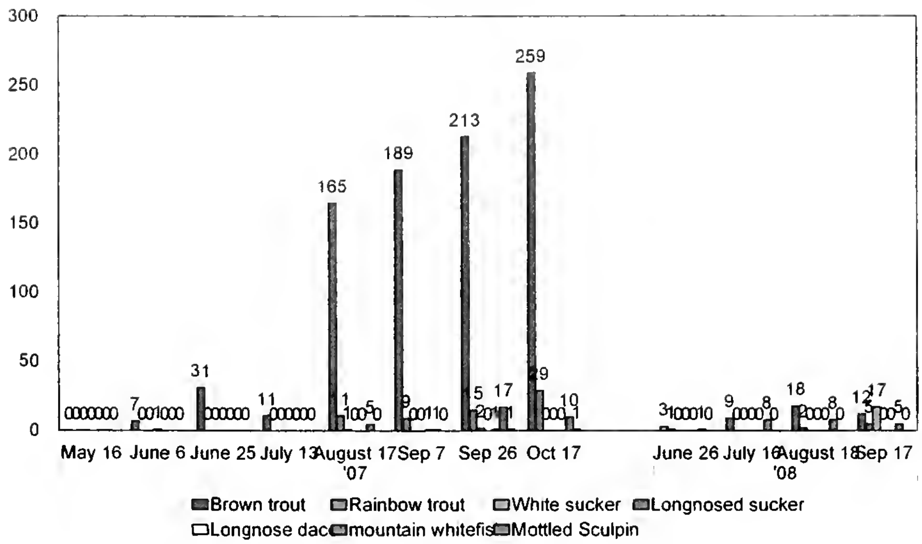
Channel characteristic	2004	2005	2006	2007	2008
Channel length (m)	405	440	437	489	490
Stream bed gradient (%)	2.45	2.25	2.28	2.03	2.03
Sinuosity	1.02	1.11	1.10	1.23	1.23
Mean bankfull width (m)	2.65	2.51	2.29	2.04	2.18
Pool frequency (pools / km)	24.7	34.1	34.3	49.1	59.2
Pool spacing	15.3	11.7	12.7	10.0	7.8
Mean residual pool depth (m)	0.23	0.21	0.22	0.21	0.26

Livestock use, September 2009, Wigwam Creek in the restoration reach.

Appendix G

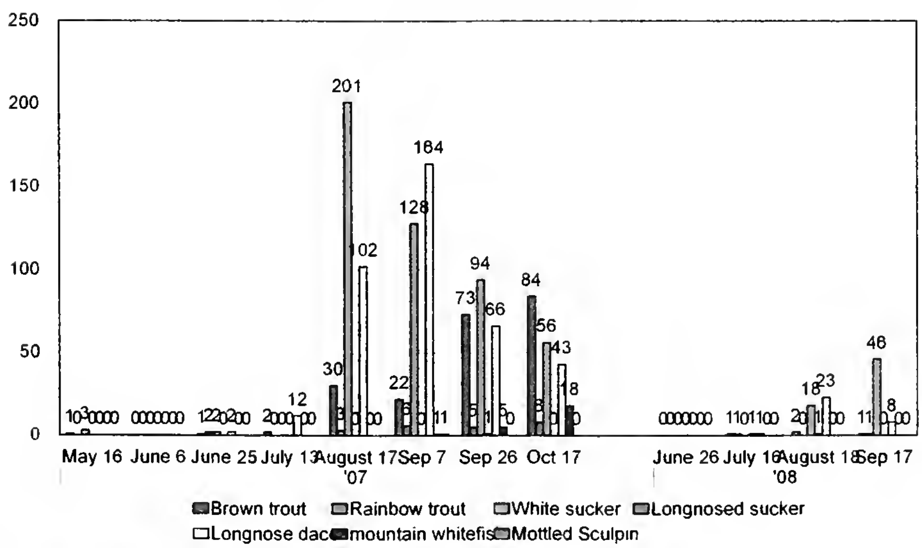
West Madison Canal Fish Surveys 2007 & 2008
500 ft sections

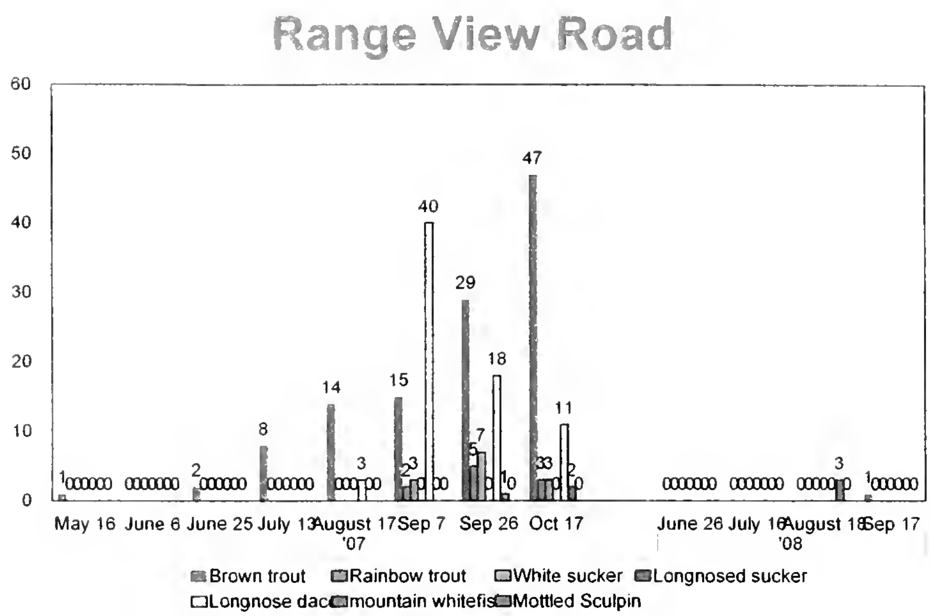
8 Mile



approx 1 mile below headgate

Willow Ranch





approx 6miles below headgate