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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
Pat Clancey
Montana Fish, Wildlife, & Parks
Ennis
April 1999

Montana Fish, Wildlife & Parks

EXECUTIVE SUMMARY

No young-of-the-year Arctic grayling were captured in Ennis Reservoir in 1998. Populations of two year old & older rainbow trout in the Pine Butte and Varney monitoring sections remained at levels similar to recent years, while numbers increased in the Norris section. Two year old & older brown trout numbers remained similar to recent years in all monitoring sections. Results of whirling disease tests conducted in the Madison River in 1998 indicate that water temperature plays a crucial role in the production of triactinomyxons and infection of young-of-the-year rainbow trout, however, the infection rate of young-of-the-year rainbow trout is not uniform throughout the river. Timing of rainbow trout spawning and fry emergence was monitored in 1998. Water temperature was monitored at 14 sites throughout the Madison River, and air temperature at 7 sites. The Cherry Creek Native Fish Introduction Project was delayed for one year. The Federal Energy Regulatory Commission is expected to release the Final Environmental Impact Statement for the Madison-Missouri 2188 Project in 1999.

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INTRODUCTION

Montana Fish, Wildlife, & Parks (MFWP) has conducted fisheries studies in the Madison River Drainage since 1990 to assess and improve the status of the Arctic grayling (*Thymallus arcticus*) population of Ennis Reservoir, and to address effects on fisheries of hydropower operations at Hebgen and Ennis dams (Byorth and Shepard 1990, MFWP 1995, MFWP 1996, MFWP 1997a, MFWP 1998a). This work has been funded through an agreement with the Montana Power Company (MPC), owner and operator of the dams. The 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). Collectively, the nine dams are called the 2188 Project, which refers to the Federal Energy Regulatory Commission (FERC) license number that authorizes their operation. In December 1997, MPC announced its intention to sell its electrical generation system, including the 2188 Project. At that time, they committed to continue the agreement with MFWP through 1998, and later agreed to provide half the payment in 1998, and half in 1999.

Late in 1996, MFWP initiated a ten-year 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 (*Oncorhynchus clarki lewisi*) in the Madison River drainage. Fieldwork for this effort began in 1997 in tributaries of the Madison River. The agreement between MFWP and MPC includes a provision to address issues related to species of special concern. In June, 1997, the U.S. Fish & Wildlife Service (USFWS) received a petition to list the westslope cutthroat trout as a Threatened species throughout its entire range, which includes parts of Montana, Idaho, Oregon, Washington, and Wyoming. Six conservation/environmental organizations and one individual filed the petition.

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 lands, Turner Enterprises, Incorporated (TEI) offered access to the Cherry Creek drainage on the Flying D Ranch to assess its suitability for introducing westslope cutthroat. 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 the drainage. MFWP and TEI subsequently entered into an agreement to pursue this effort. The agreement outlines the roles and responsibilities of each party, including the Gallatin National Forest, which manages the land at the upper end of the Cherry Creek drainage (Figure 2). TEI is providing half the annual budget for the Madison Drainage Special Projects Program for 1998 and 1999.

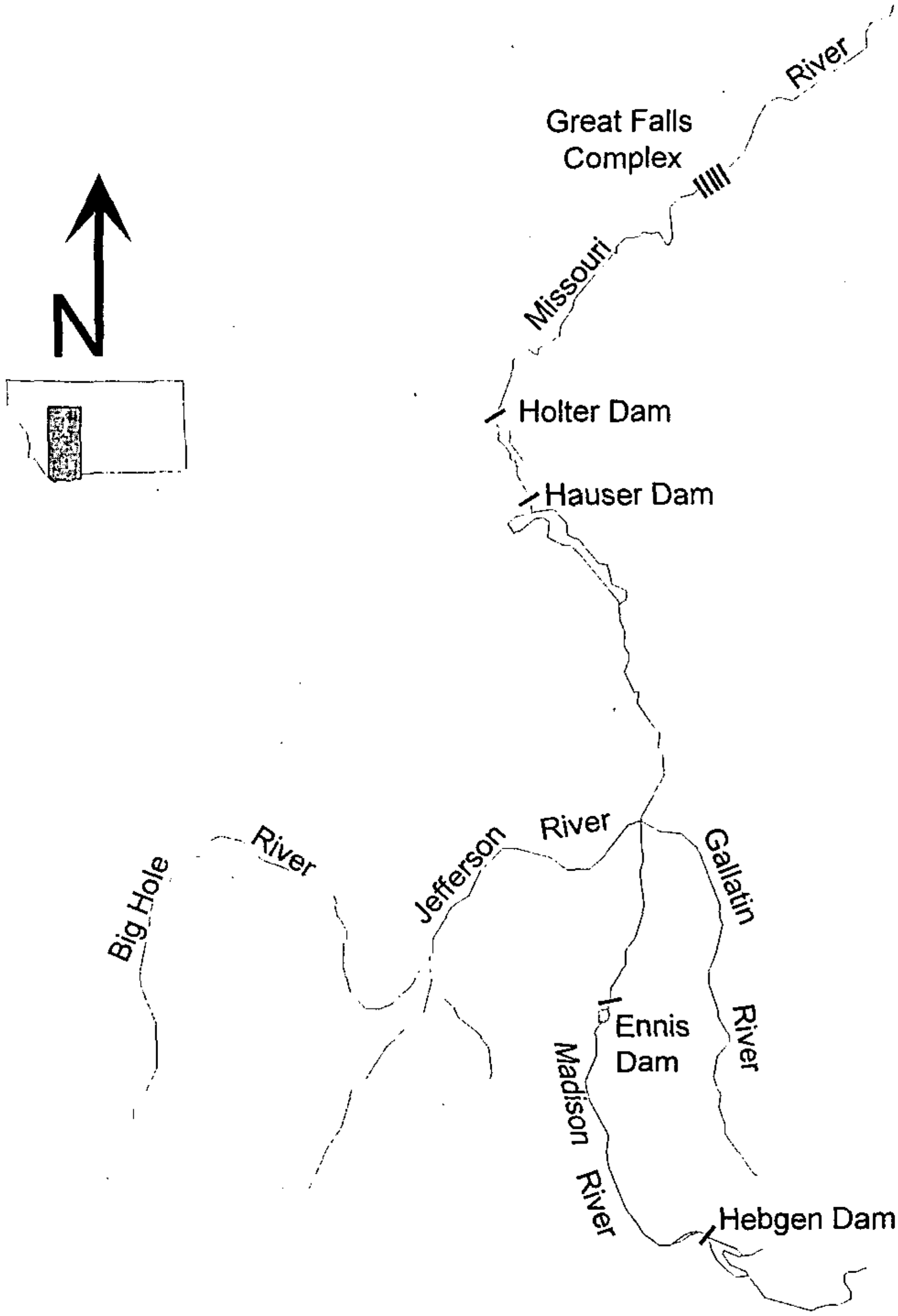

Figure 1. Locations of Montana Power Company dams on the Madison and Missouri rivers.

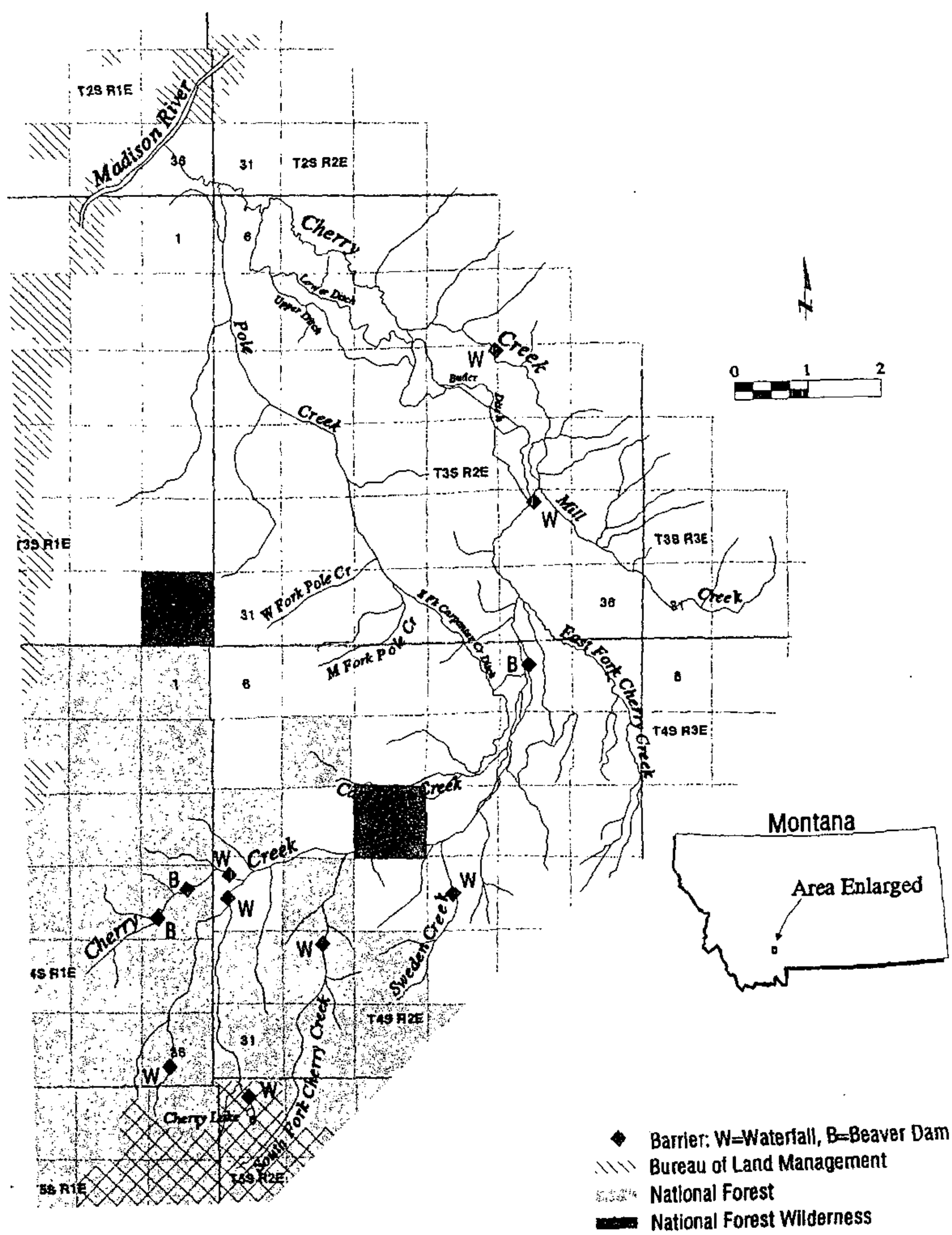

Figure 2. Cherry Creek land ownership. Map produced by MFWP Information Services Unit.

METHODS

Madison Grayling

Index sites in Ennis Reservoir (Figure 3) are sampled for young-of-the-year (YOY) grayling and other fish species using a beach seine. A 125'x 5'x ¼" mesh seine with a 5'x 5'x 5' bag is fed off a moving boat in water up to five feet deep, with a worker in the water at each end of the seine. The workers proceed to walk perpendicularly into the shoreline pulling the seine into a large arch behind them. The seine is pulled onto the shoreline and captured fish are enumerated by species. This is a modification of standard beach seining methodology, in which the seine is pulled parallel to the shoreline. This modification is used due to the large proportion of Ennis Reservoir that is shallow, and is therefore effectively a littoral zone, and because YOY grayling are not routinely found near shore.

Population Estimates

Electrofishing from a driftboat mounted mobile anode system is the principle method used to capture Madison River trout for population estimates. Fish captured for population estimates are weighed and measured, marked with a fin clip, and released. A log-likelihood statistical analysis (Montana Fish, Wildlife, & Parks 1997b) is used to estimate trout populations in several sections of the Madison River (Figure 4). Yearling fish are distinguished from two year old & older fish. Generally, the number of two year old & older fish is a better indicator of year class strength and subsequent reproductive potential.

Gillnetting

Gill netting of Ennis Reservoir was not conducted in 1998 due to higher priority tasks associated with westslope cutthroat trout conservation and restoration activities. Gill netting of Ennis Reservoir will be conducted in 1999, probably in September.

Whirling Disease

Whirling disease (*Myxobolus cerebralis*) monitoring and research were continued in the Madison River in 1998 (Vincent pers.comm.). Two types of live cage experiments were conducted in the Madison River in 1998: 1) one time-series study and 2) five spatial-series studies. In the time-series study, conducted near Kirby Bridge in the Pine Butte section (Figure 4), eight lots of 50 YOY rainbow trout were placed in a live-cage for consecutive ten-day periods from May 5 to October 28.

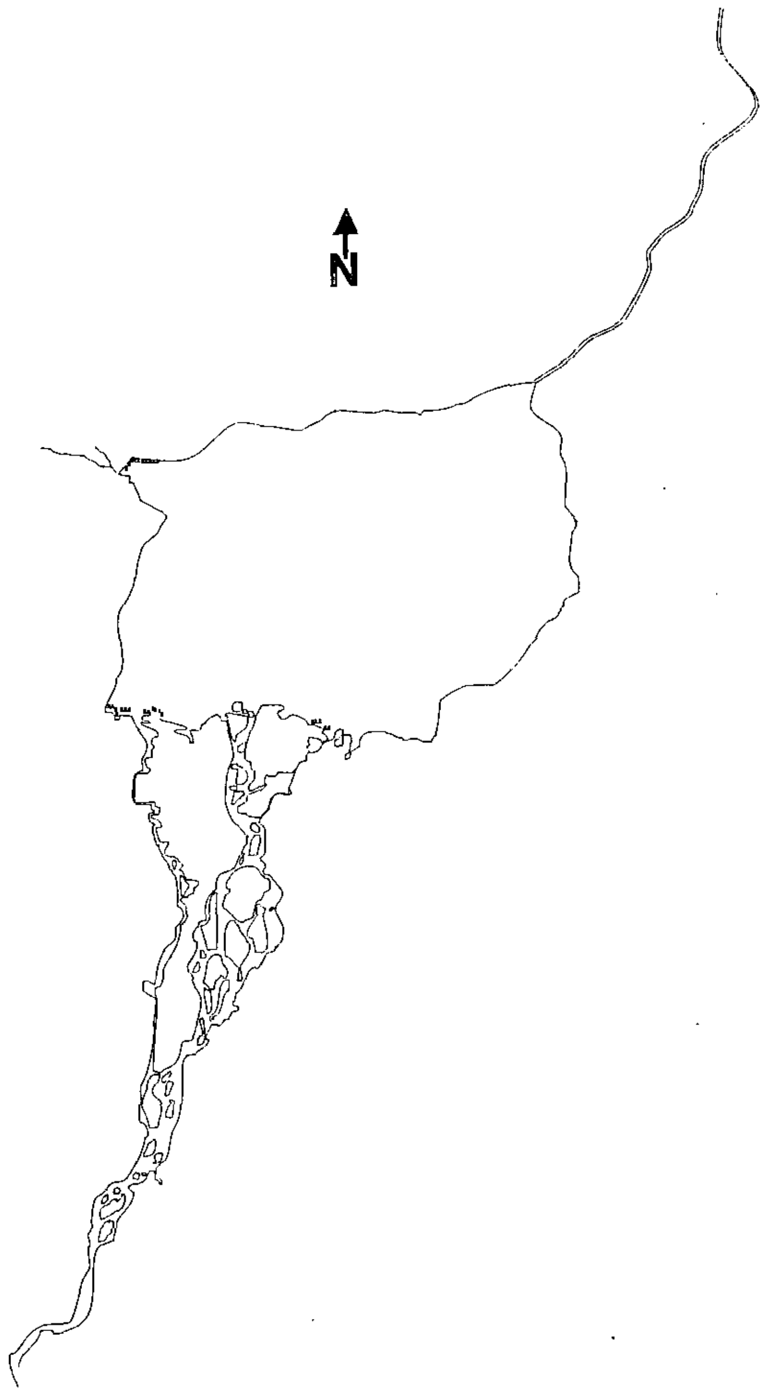

Figure 3. Locations of Ennis Reservoir seining sites.

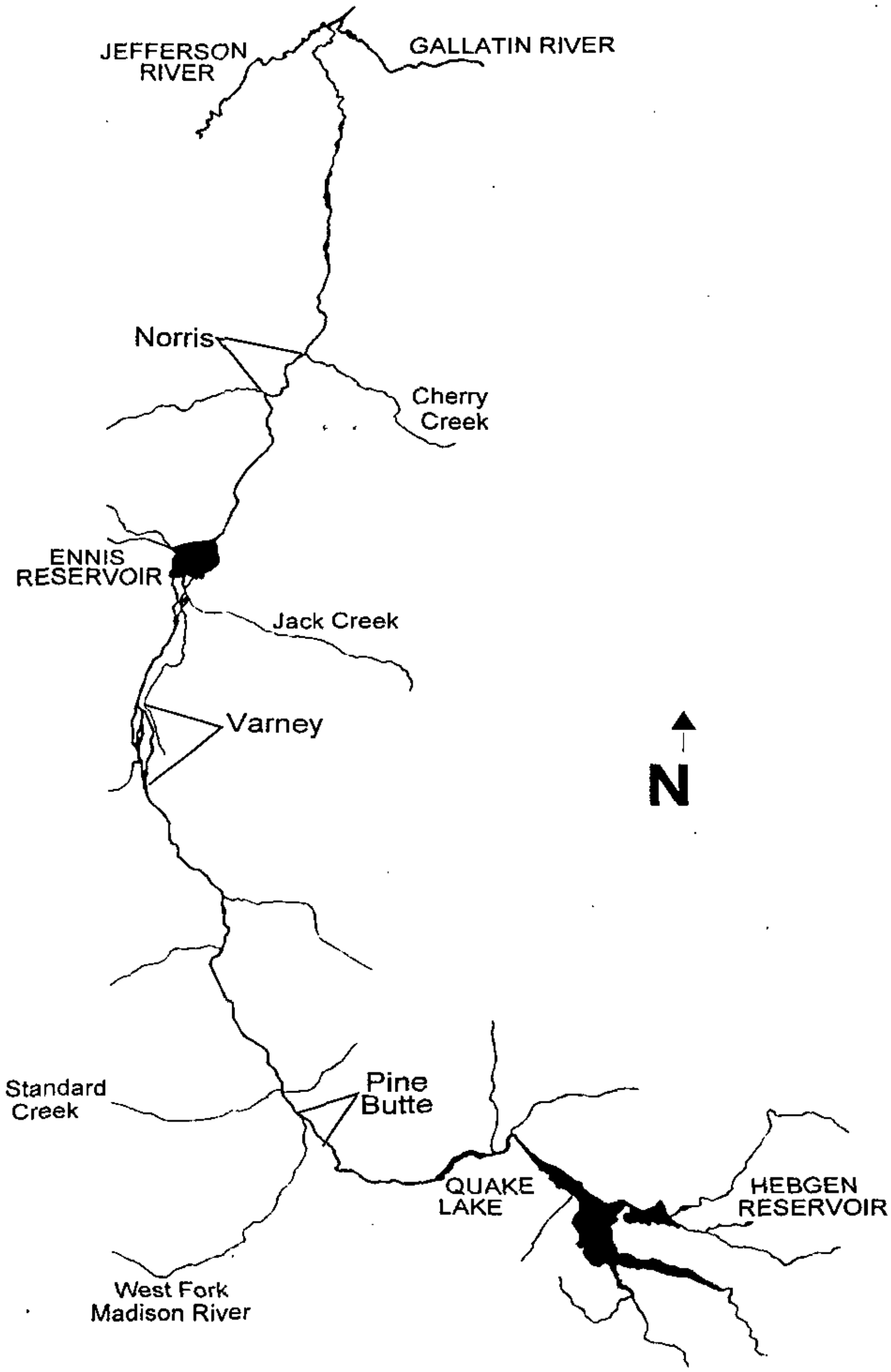

Figure 4. Locations of Montana Fish, Wildlife, & Parks Madison River trout population estimate sections.

In the spatial-series study, lots of 50 YOY rainbow were placed in live cages at sites between Hebgen Dam and the mouth of Cherry Creek for various 10 days periods from May 15 - July 18.

At the end of each ten-day period, each lot of fish was transferred to whirling disease free water in a controlled setting, and maintained for 90 days. After 90 days, the fish were euthanized and examined for whirling disease infection and severity of infection.

Sampling to determine density of YOY rainbow and brown trout along the riverbanks, as conducted from 1995-97, was not conducted in 1998. A Montana State University (MSU) Master of Science graduate program was initiated in 1998, entitled "Spawning and Rearing Ecology of Madison River Rainbow Trout in Relation to Whirling Disease Infection Risk" (Downing pers.comm.). Through this program, the timing and location of rainbow trout spawning, fry emergence and rearing is being studied to relate it to whirling disease infection risk. Twenty redds constructed in 1998 were capped with traps made of cloth mesh netting to capture fry as they emerged from the gravel. The time of fry emergence will be related to the time of redd construction. A backpack-mounted electrofishing unit (shocker) is used to capture YOY rainbow trout to determine rearing locations and densities. MFWP and MSU personnel implanted 28 radio transmitters in mature rainbow trout throughout the Madison River between Quake Lake and Ennis Reservoir during September and October 1998. The transmitters will operate for 9 hours/day for 4 consecutive days per month until February 28, 1999, then will operate 9 hours/day every day until their batteries die, which is expected to be about June 30, 1999. This graduate study is part of a larger effort entitled "Maintaining Wild Trout in Whirling Disease Infected Rivers: Mitigating Trout Declines by Enhancing Habitat and Life History Types of Survivors in the Upper Madison River" (McMahon et al. 1998).

A backpack-mounted shocker is used to collect wild YOY trout from a series of locations throughout the Madison River drainage in December 1998 (Figure 5). These fish are collected solely for determining the presence or absence of whirling disease in a given area and its rate of infection in YOY trout surviving after their first growing season.

Temperature Monitoring

Water and air temperatures are recorded throughout the course of the Madison River from above Hebgen Reservoir to the mouth of the Madison at Headwaters State Park (Figure 6). Optic

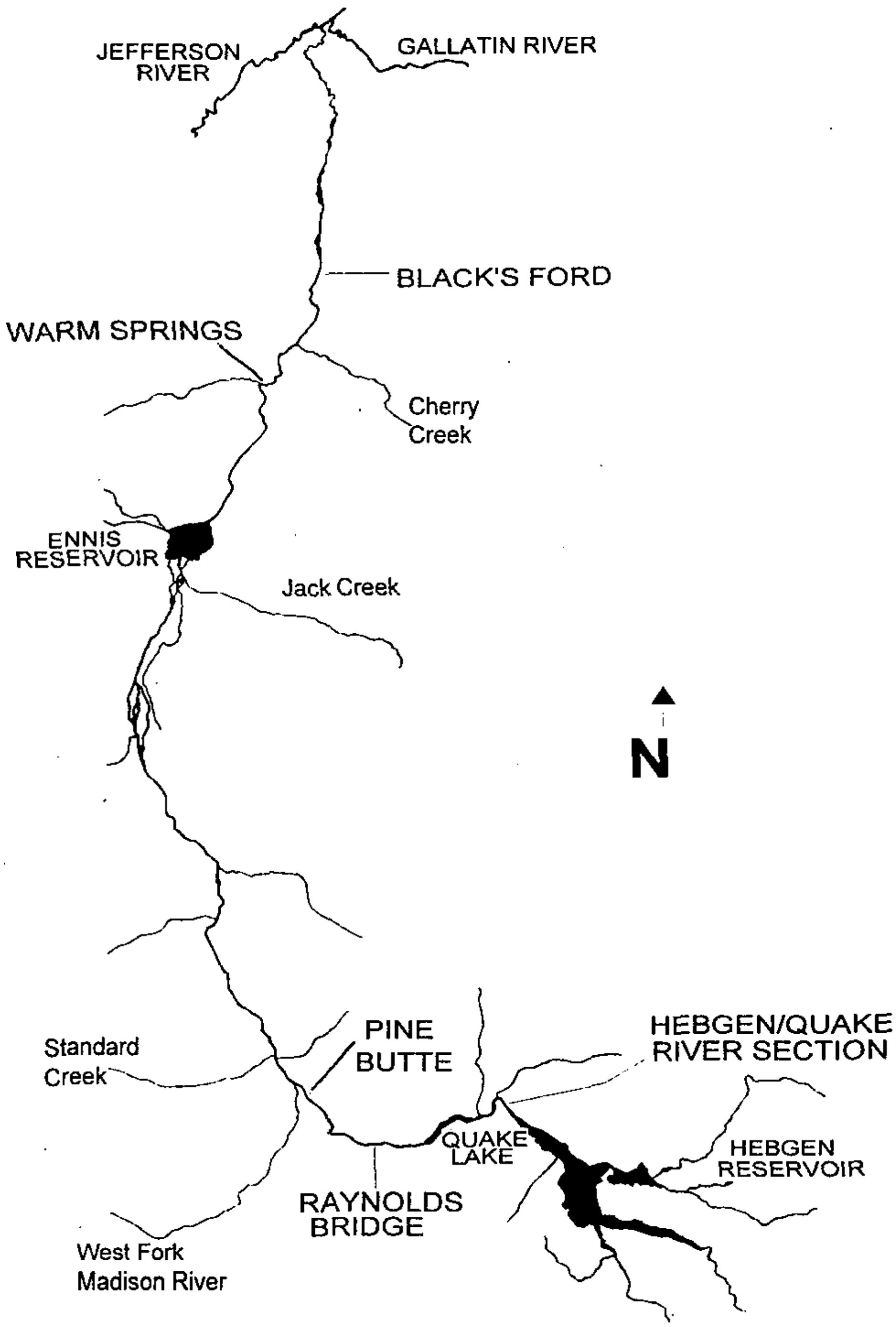

Figure 5. Collection sites of 1998 Madison River young-of-the-year trout for whirling disease testing.

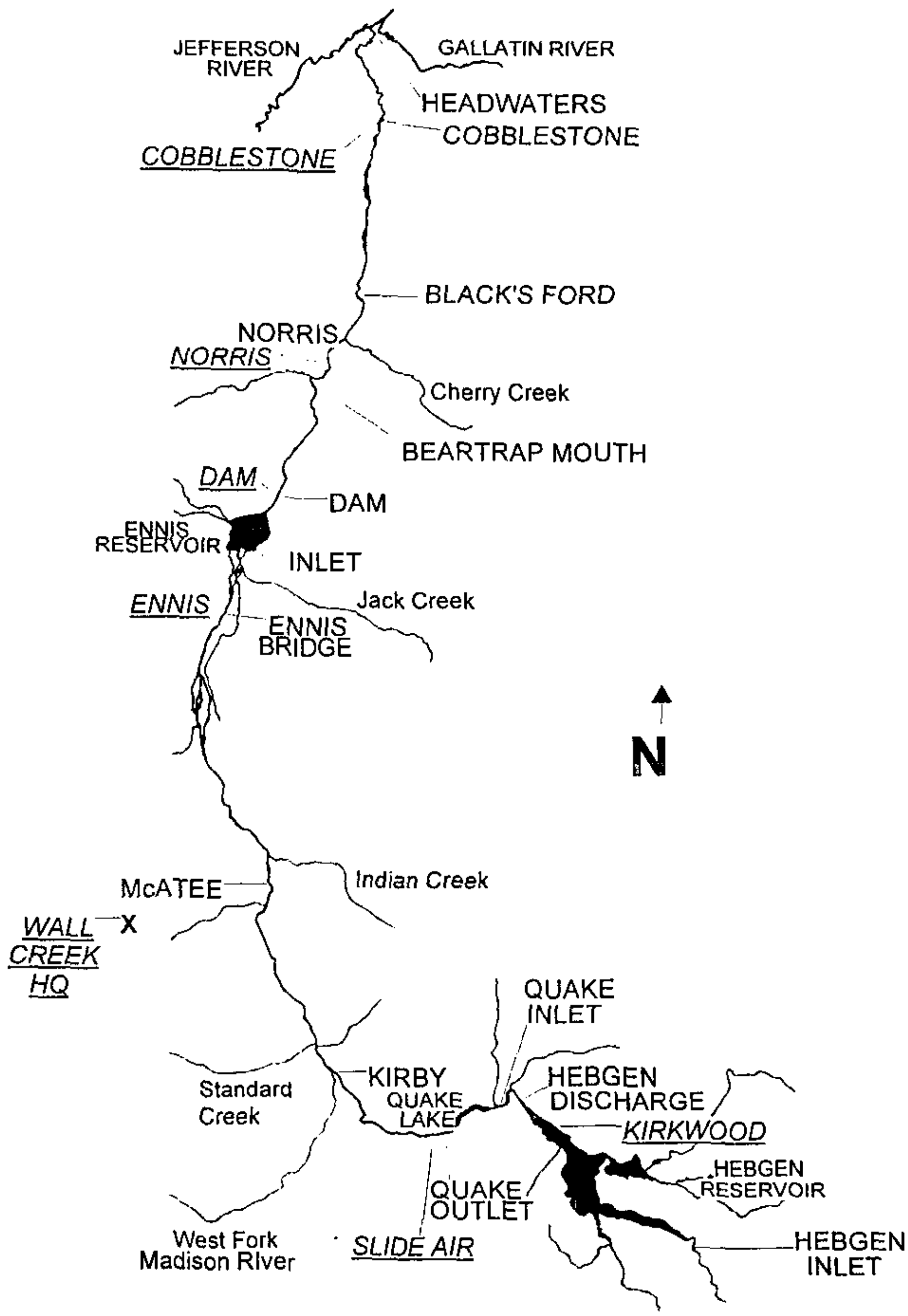

Figure 6. Locations of Montana Fish, Wildlife, & Parks 1998 Madison River temperature monitoring sites. Air temperature sites are underlined.

StowAway temperature loggers were programmed to record every 30 minutes, in Fahrenheit. Recorders deployed to monitor air temperatures were located in areas that were shaded 24 hours per day.

Biological and Biocontaminant Monitoring

As part of its relicensing effort, MPC has initiated a water quality monitoring program. In this program, personnel of MPC and several agencies, including MFWP, conduct biological and biocontaminant monitoring collections at locations within the Madison/Missouri System. Aquatic invertebrate and periphyton samples are collected for biological trend monitoring and contaminant analyses at eight sites from the Madison River within Yellowstone National Park (YNP) to the Missouri River below Morony Dam at Great Falls. Samples are analyzed by a variety of consultants, and reported to the MPC Environmental Division.

Westslope Cutthroat Trout Conservation and Restoration

An MSU Master of Science graduate program was initiated in eastside Madison River tributaries between Ennis Reservoir and Quake Lake in 1998. This project, entitled "Madison Drainage Westslope Cutthroat Trout Survey", is assisting with data collection for the Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program.

MFWP developed an Environmental Assessment (EA) to evaluate the impacts of conducting the Cherry Creek Native Fish Introduction Project (Bramblett 1998). Prior to producing the EA, public scoping meetings were conducted in Three Forks, Ennis, and Bozeman, and a public comment period was open from December 16, 1997 through January 30, 1998. The EA was released on April 24 and the comment period for the EA was open from April 24 through May 26, 1998. During the comment period on the EA, public meetings were held in Three Forks, Bozeman, and Butte.

To successfully introduce native fish, non-native fish presently occupying the Cherry Creek drainage must be removed to eliminate hybridization and competition threats. Presently, only three species of fish occupy the project area- rainbow trout, brook trout, and Yellowstone cutthroat trout (Figure 7). The downstream boundary of the project is a 30-foot waterfall in the northeast quarter of T3S R2E Section 15 (Figure 2). This waterfall is approximately eight stream miles above the mouth of Cherry Creek. The compound antimycin, an antibiotic, will be the primary fish removal agent. Antimycin is useful as a fish toxicant due to its action on trout in extremely low concentrations, about 8-12 parts per billion (ppb) applied for 8-10 hours. It acts on fish by inhibiting respiration (energy production) at the cellular level, causing the fish to

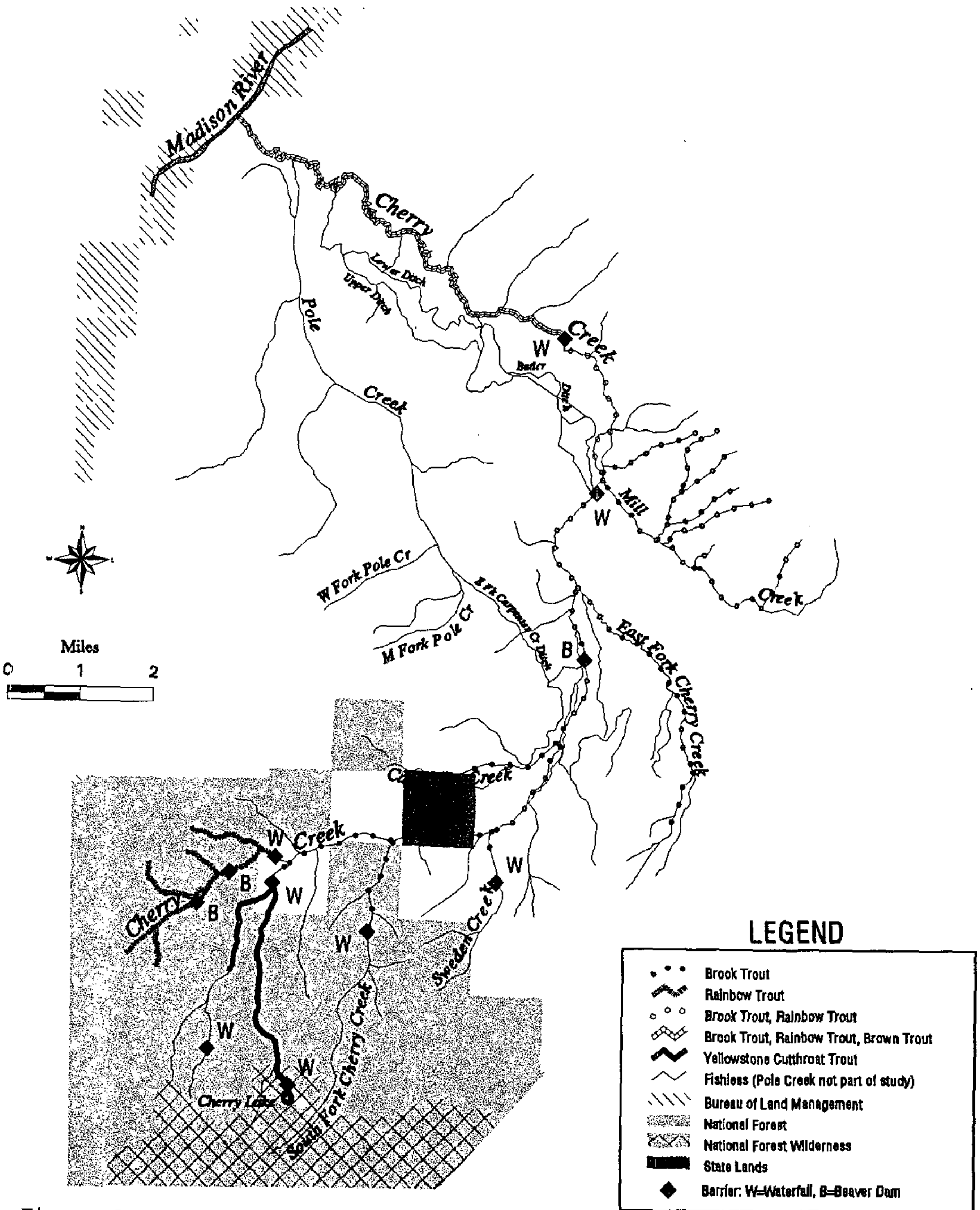

Figure 7. Cherry Creek fish distribution. Map produced by MFWP Information Services Unit.

gradually become listless and die as the bodily systems and functions shut down. Additionally, due to the reduced effectiveness of antimycin in high pH water, rotenone may be applied to high pH waters within the project at ¼ - 1 parts per million (ppm) for 1- 2 hours after those waters are treated with antimycin. It acts on fish in a manner similar to antimycin. Antimycin and rotenone are fish toxicants registered by the Environmental Protection Agency.

Prior to application of the fish toxicants, electrofishing will be conducted where feasible to collect and remove as many fish as possible. These fish will be released in Cherry Creek downstream of the project area.

Bioassays will be conducted prior to treatment each year to determine:
1) the effective concentration of antimycin (brand name Fintrol) necessary to eradicate non-native fish,
2) the frequency (instream travel-time) at which constant flow stations are required to maintain the effective concentration, and,
3) the concentration of potassium permanganate ($KMnO_4$) necessary to neutralize the antimycin.

In 1998, rainbow trout (*Oncorhynchus mykiss*) from MFWP's Giant Springs Hatchery in Great Falls were transported to Cherry Creek and used to conduct the effective concentration and travel time bioassays. These tests were conducted on a tributary of Cherry Creek on the Gallatin National Forest that had been scheduled for treatment in 1998. A constant flow station was deployed fifteen minutes travel-time upstream of the test fish and was used to apply 10 ppb antimycin to the stream for eight hours. To conduct the effective concentration test, 10 test fish were placed in each of five 5-gallon buckets. One bucket served as a control (fish held in antimycin-free water), while the other four were maintained at antimycin concentrations of 4, 6, 8, and 10 ppb. Each test bucket was fed by water pumped from a companion supply bucket. Water for the supply bucket of the 10 ppb exposure was taken directly from the stream, while untreated water was used to dilute the stream water to make up the lower concentrations. The untreated water was collected upstream of the constant flow station. Dissolved oxygen concentration, pH, and water temperature were monitored in all buckets. Mortalities were recorded at 2, 4, 6, 8, 24, and 48 hours from the beginning of exposure.

The travel-time test was conducted concurrently to determine the length of time antimycin remains effective in the stream. For this test, six fish were held in each of three live-cages in the stream 30, 60, and 90 minutes travel-time downstream of the constant flow station. Mortalities were recorded at 8, 24, and 48 hours from the beginning of exposure.

The neutralization test was conducted in main Cherry Creek approximately 2½ miles upstream of the 30 foot waterfall that is the downstream barrier of the project. The test site is approximately 10 miles downstream of the portion of the drainage that was scheduled for treatment in 1998. Brook trout (*Salvelinus fontinalis*) were captured from the stream for use as test fish. Eight test fish were held in each of six containers. One container served as a control (no antimycin or $KMnO_4$), one container held fish exposed to 10 ppb antimycin, and the remaining four containers held fish exposed to 10 ppb antimycin mixed with 1, 2, 3, or 4 ppm $KMnO_4$. Test fish were exposed for eight hours and monitored for a total of 24 hours.

In conjunction with the eradication of non-native fish in the Cherry Creek Drainage, U.S. Forest Service researchers (Thurow and Guzevich 1999) from the Rocky Mountain Research Station in Boise, Idaho, have designed a project with the following objectives:

1) to compare the probabilities of detecting salmonids in small streams using different sampling methods,
2) to compare the detection probabilities with presence/absence and population abundance estimates derived from an unbiased estimate of the true population after toxicant application,
3) to provide the project cooperators with site specific information to describe pre-treatment fish species composition, density, size structure, and biomass, and
4) to provide accurate post-treatment estimates of the effectiveness of the eradication project.

RESULTS AND DISCUSSION

Madison Grayling

Beach seining in Ennis Reservoir was conducted in September. No YOY grayling, whitefish, or trout were captured. Species captured were Utah chub (*Gila atraria*), longnose sucker (*Catostomus catostomus*), white sucker (*Catostomus commersoni*), and mottled sculpin (*Cottus bairdi*). Site descriptions, dates, and catches are listed in Appendix A. Macrophytes (aquatic vegetation) were too dense at some of the standard index sites to seine effectively.

Some anglers and fishing guides reported catching adult grayling in the Madison River between Ennis and McAtee Bridge during the 1998 fishing season. Less than 10 grayling were reported.

In 1999, MFWP will initiate a public participation process and produce an Environmental Assessment which will determine the feasibility of introducing fluvial (river-dwelling) Arctic grayling in the Madison River between Quake Lake and Ennis Reservoir, and at the Missouri Headwaters area, including the lower Madison River from Greycliff to the Jefferson confluence.

Several sources conducting whirling disease research have reported that grayling do not become infected with the *Myxobolus* parasite (Vincent, pers.comm., Kaya pers.comm.).

Population Estimates

Population estimates were conducted in the Norris section in March and in the Pine Butte and Varney sections in September (Figure 4). Appendix B contains historic population levels of two year old & older rainbow and brown trout (± 80% C.I.) for each section. Because Norris estimates are conducted in March each year, yearling fish are too small to capture in adequate numbers to derive an estimate of their abundance.

The charts illustrating annual population trends in Pine Butte and Varney are presented in a different format than in previous years (MFWP 1995, 1996, 1997a, 1998a). In this report, stacked bars represent yearling and age 2 & older classes, with the top of the combined bars illustrating the total population.

Figures 8-10 illustrate historic population levels of rainbow trout per mile. Rainbow trout numbers remain suppressed in sections upstream from Ennis Reservoir in 1998, but in the Norris section below Ennis Reservoir have returned to levels seen in 1990-93.

Brown trout numbers per mile are illustrated in Figures 11-13. In 1998, their populations remain similar to recent years in the Pine Butte and Norris sections, and appear to have increased markedly in the Varney section due to a high number of yearlings.

Whirling Disease

Preliminary results of the live-cage experiments conducted in 1998 appear to show that *Tubifex* production of whirling disease spores occurs more proficiently in rainbow trout spawning areas than in nearby areas which rainbow trout do not use for spawning (Vincent pers.comm.). Sentinel YOY rainbow trout held in a live-cage in an area of dense rainbow trout spawning, about one mile below the Quake Lake outlet, exhibited an average infection severity of 3.48 on a scale of 0.0-4.0 (Table 1). Water flowing out of Quake Lake is free of whirling disease spores.

Early results of the 1998 time series tests in the Madison River seem to indicate that water temperature plays a crucial role in the production of triactinomyxons (TAM's) and infection of YOY trout (Vincent pers. comm.). Though the data set is not yet fully analyzed, it appears that when mean daily water temperature reaches the optimum for production of TAM's, around

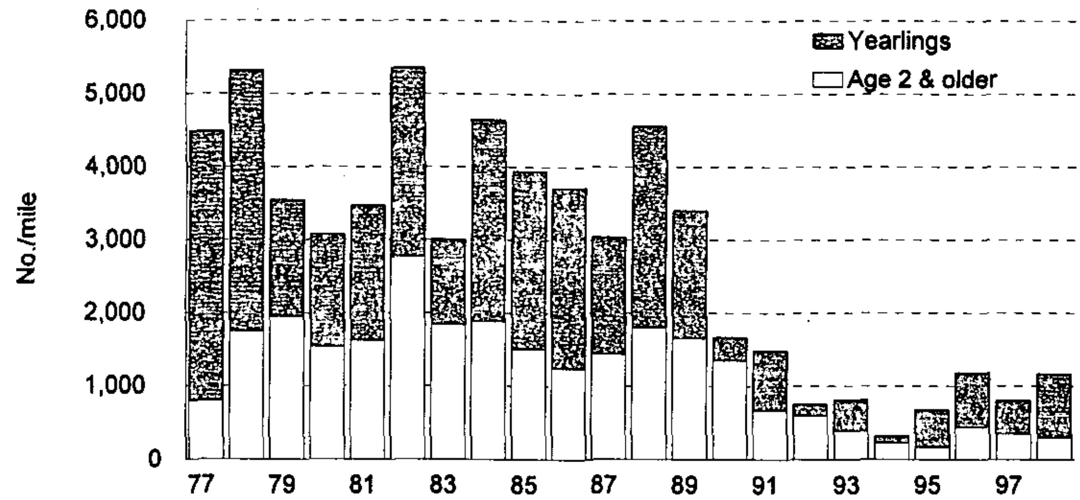

Figure 8. Rainbow trout populations in the Pine Butte section of the Madison River, 1977-1998, fall estimates.

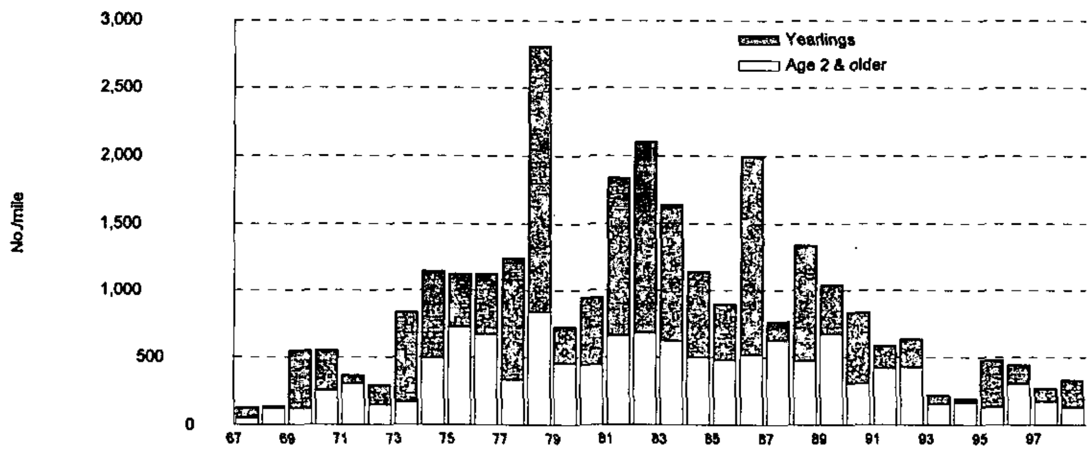

Figure 9. Rainbow trout populations in the Varney section of the Madison River, 1967-1998, fall estimates.

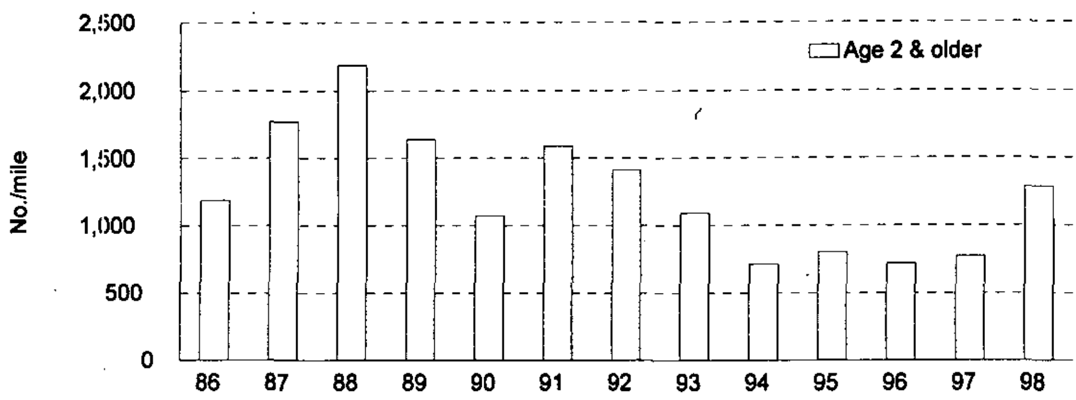

Figure 10. Rainbow trout populations in the Norris section of the Madison River, 1986-1998, spring estimates.

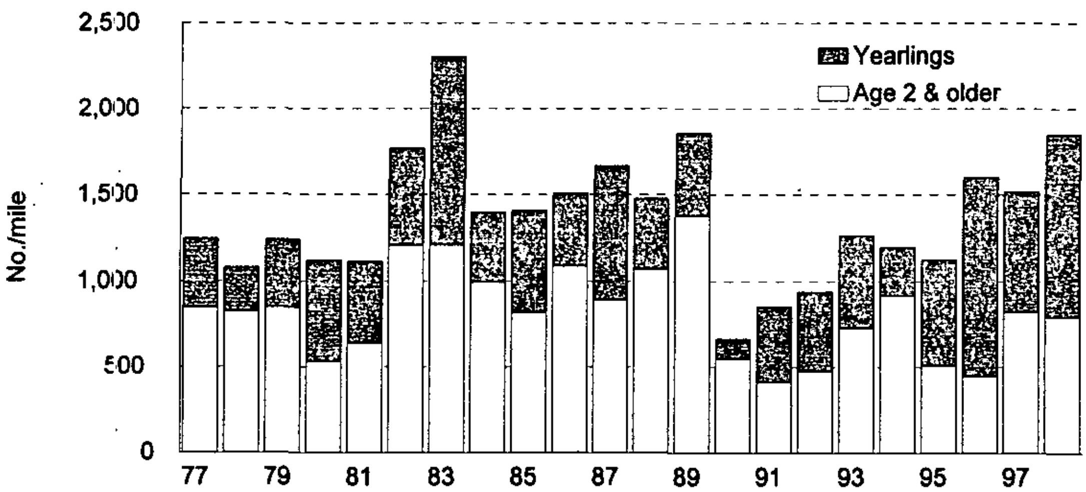

Figure 11. Brown trout populations in the Pine Butte section of the Madison River, 1977-1998, fall estimates.

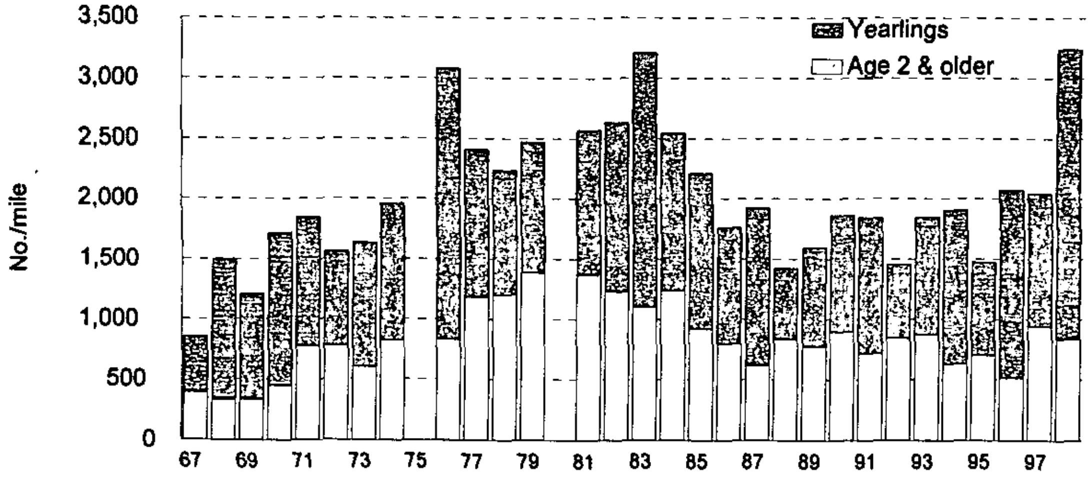

Figure 12. Brown trout populations in the Varney section of the Madison River, 1967-1998, fall estimates.

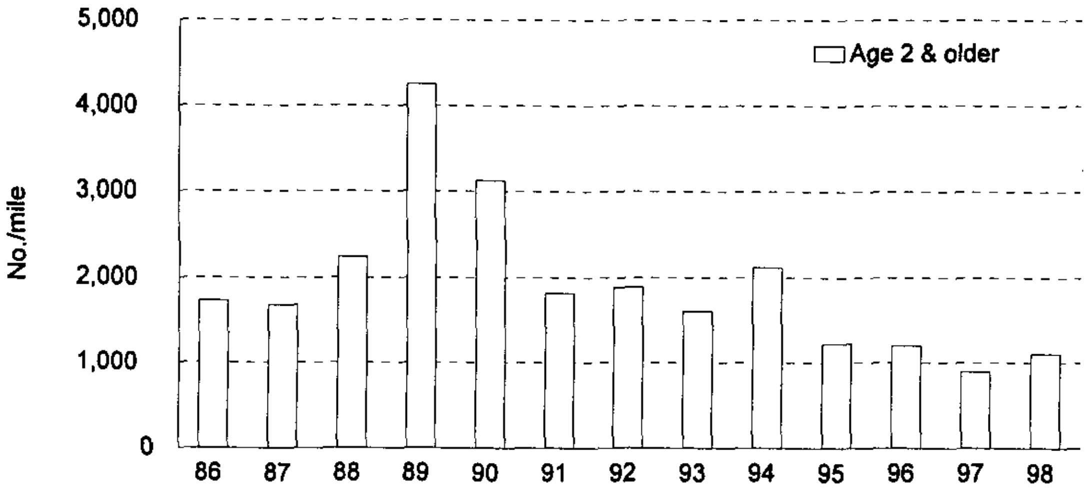

Figure 13. Brown trout populations in the Norris section of the Madison River, 1986-1998, spring estimates.

Table 1. Whirling disease grade-of-severity definitions.

Grade 0:	no infection noted
Grade 1:	discrete small island of infection with minimal tissue inflammation
Grade 2:	a single locally extensive focus (or several small foci) with mild tissue inflammation
Grade 3:	multiple foci of cartilage necrosis, moderate tissue inflammation, and trophozoites/spores present.
Grade 4:	extensive cartilage necrosis and severe tissue inflammation with trophozoites/spores present.

54-55° F, average severity of infection of YOY rainbow trout is about Grade 3 or higher, virtually guaranteeing mortality. At higher and lower average daily maximum temperatures, infection occurs, but due to the lower abundance of TAM's in the water and the resulting lighter infection, may not be severe enough to result in mortality. Trout that hatch during cooler water temperatures early in the spring seem to get a light infection of whirling disease, which prevents a heavier, and most likely fatal, infection when the whirling disease TAMS become abundant after average daily maximum water temperature warms to the optimum range. The physiological mechanism through which this occurs is not known. Vincent (pers. comm.) has also found evidence that infection may occur within hours of the egg hatching, while the fry are still living in the inter-gravel spaces and living off their yolk-sac. He has also found evidence that sentinel YOY rainbow infected at a severity level of 2.5 ceased growing about 80 days after the initial infection, and did not resume growing until 120-140 days post-infection, sometime in the early fall. The interruption in growth may be due to the consumption of energy by the fish to fight the invasion of the *M. cerebralis* parasite, and reduces the fish's condition heading into its first winter. It is not known if higher rates of infection have more severe affects on growth. Vincent (pers.comm.) also found that more severe infections affected the ability of YOY rainbow to hold position in the water column.

In the spatial series tests, Vincent (pers.comm.) determined that the infection rate of YOY rainbows is not uniform throughout the length of the river.

Data collected during the first year of field studies conducted by MSU in the Master of Science Program "Spawning and Rearing Ecology of Madison River Rainbow Trout in Relation to

Whirling Disease Infection Risk" (Downing pers.comm.) revealed 853 rainbow trout redds in the Madison River between Quake Lake outlet and McAtee Bridge, a distance of approximately 36 miles. Four hundred ninety five (495) of the redds were between Quake Lake and Raynolds Bridge, 141 between Raynolds Bridge and the Big Bend, 126 between Big Bend and the mouth of the West Fork, 53 between the West Fork and the mouth of Wall Creek, and 38 between Wall Creek and McAtee Bridge. Over 100 redds were counted during the initial survey in mid-April. Spawning activity peaked in late April-early May, and continued through mid June.

Another aspect of the study is to determine emergence timing and locate fry rearing areas. Fourteen of the 20 redds capped with traps captured fry as they emerged from the gravel. Emergence occurred from mid-May through late July, and seemed to peak in the third week of June (Downing pers.comm.). YOY rearing was also monitored, but those data are not yet summarized (Downing pers.comm.).

Relocations of radio tagged adult rainbow trout were initiated in October. Only 2 or 3 fish were not relocated in November and December, and one fish was not relocated at all. By the end of 1998, none of the relocated fish had moved out of the immediate area in which they were captured for implanting with the radio transmitter (Downing pers.comm.).

In December 1998, YOY rainbow and brown trout were collected at five sites in the Madison River (Figure 5) by MFWP personnel and sent to the Washington Animal Disease Diagnostic Laboratory (WADDL) for analyses of presence (Table 2) and severity (Table 3) of whirling disease infection.

Temperature Monitoring

StowAway and Optic StowAway temperature recorders were deployed throughout the Madison River to document air and water temperatures (Figure 6). Table 4 summarizes the data collected at each location in 1998, and Appendix C contains thermographs for each location. The recorder monitoring Hebgen discharge temperature malfunctioned on September 13. From 10:30 a.m. on that date until it ceased recording on October 2, it registered a temperature of 100°F. The recorder in the Madison River above Hebgen Reservoir became dewatered for over 16 days, beginning on August 12. During that time, it recorded air temperatures rather than water temperature. Erroneous data from these two episodes are omitted from Table 4 and from the thermographs in Appendix C.

Table 2. Results of analyses of fish collected during annual series sampling for whirling disease in the Madison River, December 1998.

Sample site	Rainbow trout # WD+/# sampled	Brown trout # WD+/# sampled
Black's Ford	0/20	1/20
Warm Springs	0/20	1/20
Pine Butte	5/19	2/5
Raynolds Pass	5/20	1/4
Hebgen/Quake River section	0/22	0/3

Table 3. Grade of infection severity of rainbow and brown trout samples determined to be whirling disease positive. See Table 1 for definitions of severity ratings.

	Grade			
	1	2	3	4
Raynolds rainbow	5	0	0	0
Raynolds brown	1	0	0	0
Pine Butte rainbow	2	0	1	2
Pine Butte brown	2	0	0	0
Warm Springs brown	1	0	0	0
Black's Ford brown	1	0	0	0

Biological and Biocontaminant Monitoring

Biological and biocontaminant monitoring was conducted at seven index sites established in previous years (3 Madison River sites & 4 Missouri River sites) (MFWP 1997a), and at an eighth site established at the Ennis Fishing Access Site. Analyses of the 1998 collections have not been completed (Dan McGuire pers. comm.). Montana State University (MSU) researchers sampled the Madison River in Yellowstone National Park (YNP) in March and July, 1998, for New Zealand Mud Snails (NZMS) (*Potomopyrgus antipodarum*), but data are not yet analyzed (B. Kerans, Wild Trout Lab, pers.comm.). In 1997, MSU researchers sampled eight sites in

Table 4. Maximum and minimum temperatures (°F), the dates of each, the period monitored, and the number of recordings at selected locations in the Madison River drainage, 1998. Charts for each location are in Appendix C.

Site	Maximum	Minimum	Period	# readings
water				
Hebgen inlet	76.96 (7/19)	47.54 (5/15)	4/20-10/2	7144①
Hebgen discharge	65.25 (9/8)	38.25 (4/20,21)	4/20-9/13	7029②
Quake Lake inlet	64.73 (8/17)	38.03 ( )③	4/20-10/2	7944
Quake Lake outlet	62.95 (9/5)	38.19 (4/20,21)	4/20-10/2	7944
Kirby Bridge	69.60 (8/13)	37.06 (4/21)	4/20-10/2	7944
McAtee Bridge	70.35 (7/26)	35.85 (4/26)	4/20-10/2	7944
Ennis Bridge	71.51 (8/12)	38.97 (4/26)	4/20-10/2	7944
Ennis Reservoir Inlet	72.30 (8/12,13)	39.12 (4/26)	4/20-10/2	7944
Ennis Dam	74.22 (7/20)	45.52 (4/20)	4/20-10/2	7944
Beartrap Mouth	76.34 ( )④	45.59 (4/20)	4/20-10/2	7944
Norris	76.80 ( )⑤	44.76 (4/20)	4/20-10/2	7944
Black's Ford	78.14 (8/12)	42.15 (4/20)	4/20-10/2	7944

Table 4, continued.

Cobblestone	78.60 (7/20)	41.47 (4/20)	4/20-10/2	7944
Headwaters S.P. (Madison mouth)	79.98 (7/20)	44.09 (4/26)	4/20-10/2	7944
air				
Kirkwood Store air	93.78 (7/17,18)	23.43 (4/21,26,27)	4/20-10/2	7944
Slide air	98.24 (7/17-20)	27.40 (4/26)	4/20-10/2	7944
Wall Creek HQ air	100.62 (7/18,19)	25.15 (4/26)	4/20-10/2	7944
Ennis Fisheries office air	100.43 (9/4)	23.40 (4/26,27)	4/20-10/2	7944
Ennis Dam air	92.80 (7/17)	28.59 (4/26)	4/20-10/2	7944
Norris air	96.64 (7/17)	26.36 (4/26)	4/20-10/2	7944
Cobblestone air	92.09 (9/2)	25.51 (4/26)	4/20-10/2	7944

① recorder was dewatered from 8:30 p.m. August 12 through 11:30 a.m. August 29, therefore, those data points are omitted.

② recorder malfunctioned between 10:30 & 11:00 a.m. on September 13. All data after 10:30 a.m. on September 13 are omitted.

③ 4/20-22,26-30, 5/1,2

④ 7/21,25,28,29

⑤ 7/20,21,25,28

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the Madison River in YNP using a 100 micron (1 micron = 1/1000th millimeter) mesh netting. From those samples, they calculated NZMS densities to range between 46,000 and 299,000/m^2 (B. Kerans, Wild Trout Lab, pers.comm.). National Park Service personnel have confirmed the presence of NZMS in the Firehole, Gardner, and Snake rivers in YNP (D. Mahoney, NPS, pers.comm.). Data collected during the MPC monitoring program in 1994-97 are in Table 5.

Westslope Cutthroat Trout Conservation and Restoration

During 1998, personnel from Montana State University continued data collection for the Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program (Shepard et al. in prep). They surveyed all or parts of 14 streams on the west slope of the Madison Mountain Range, and found no westslope

Table 5. Density (#/m^2) and relative abundance (percent of all organisms collected) of New Zealand Mud Snails, and mesh size (microns) of sampling screen used during biological monitoring to collect samples in the Madison River in Yellowstone National Park, September 1994, August 1995-98.

	Density	relative abundance	mesh size
1994	19	7	1700
1995	156	8	800
1996	2187	52	800
1997	7345	62	560
1998	not yet summarized		

cutthroat trout. Several streams which originate on the Beaverhead National Forest and course across private property were not surveyed in 1998. With the permission of the interested landowner, three of these streams will be surveyed in 1999.

In 1997, Turner Enterprises, Incorporated, owners of the Flying D Ranch, offered MFWP access to the Cherry Creek Drainage on the ranch to evaluate it for inclusion in the Madison River Drainage Westslope Cutthroat Trout Conservation and Restoration Program. The upper end of the drainage is public land, managed by the U.S. Forest Service and the State of Montana, while the remainder of the drainage is owned by the Flying D (Figure 2). MFWP conducted fisheries and aquatic habitat surveys throughout the Cherry Creek drainage in 1997, and arranged an on-site inspection by a Fish & Wildlife Service (FWS) Fisheries Program Manager experienced with conducting similar projects in other western states. Results of the surveys and a favorable assessment by the FWS Biologist led MFWP to determine that the drainage is well suited for westslope cutthroat introduction. MFWP produced an Environmental Assessment (EA) which fulfilled requirements of the Montana Environmental Policy Act (MEPA) and the National Environmental Policy Act (NEPA) (Bramblett 1998). Six alternatives were discussed in the EA:

1) Eradication of non-native fish followed by native fish introduction.
2) No action.
3) Introduction of native fish without removal of existing non-native fish species.
4) Eradication of existing non-native fish species without subsequent introduction of native fish species.
5) Removal of non-native fish species by mechanical methods (electrofishing, netting, etc.) followed by native fish introduction.

6) Chemical treatment of Cherry Lake without the use of an outboard motor.

Alternatives 1 and 2 were given detailed consideration, all others were evaluated and dismissed as not being feasible for successful completion of the proposal.

As of the May 26 public comment deadline, MFWP had received comment from 264 individuals and organizations. These included written comment from 52 parties, oral comment from 12 parties at public meetings (6 of which also submitted written comment), and 206 signatures on a form letter. Twenty commentors favored the proposal, 37 opposed, and all signatories of the form letter opposed. One commentor, the Montana Department of Natural Resources and Conservation, submitted a list of questions and concerns, but did not take a stance on the proposal.

Additionally, several commentors did not mail their comments by the May 26, 1998, deadline. These included one letter of support, three letters of opposition, and 16 signatures on the form letter. None of these commentors raised issues beyond those raised by punctual commentors.

Written and oral comments were categorized into 17 major issues, and responses to comments were developed by MFWP, attached to the July 6 Decision Notice, and mailed to the entire mailing list of 361 individuals and organizations (MFWP 1998b).

The project was scheduled to be implemented in August, 1998, but was delayed for one year pending an internal review by TEI of their involvement. The scheduled treatment area was the mainstem of Cherry Creek and four tributaries upstream of a waterfall in T4S R2E Section 19 (Figure 2). Prior to postponement of the project, bioassays were conducted to determine the effective concentration of antimycin and the concentration of potassium permanganate necessary to neutralize the antimycin. Results of the bioassays are presented in Tables 6-8. The MFWP Giant Springs Hatchery provided the rainbow trout used in the effective concentration and travel time bioassays in Great Falls. They were transported from Great Falls to the Flying D Ranch in an MFWP hatchery truck following standard transport procedures, then were transferred from the hatchery truck to water-filled plastic bags, supersaturated with oxygen, placed in coolers, iced, and transported to the bioassay location in a pick-up truck. The fish were noticeably stressed prior to the transfer to the coolers, which was believed to be part of the cause of the high mortality rate of the control fish which reached 30% after 24 hours and 90% after 48 hours (Tables 6 & 7). Other stressors to the fish may have been associated with problems maintaining adequate flow-through conditions in the exposure buckets, which led to depressed dissolved oxygen concentrations and high water temperatures. In spite of these problems, antimycin concentrations of 6 ppb or greater seemed to clearly lead to mortality after 24 hours (Table 6).

Table 6. Percent mortality of rainbow trout 8, 24, and 48 hours post exposure to various concentrations of antimycin during bioassays. Test fish were held 15 minutes travel time below the constant flow station.

		Concentration (ppb)			
Time post-exposure	Control (0)	4	6	8	10
8 hours	0	0	30	40	50
24 hours	30	40	90	100	100
48 hours	90	100	100	100	100

The travel time test showed a clear negative relationship between mortality and travel time (Table 7). After 24 hours, 100% of fish died in the 15 minute travel time bucket, while mortality decreased to 83%, 67%, and 40%, respectively, for the 30, 60, and 90 minute travel time exposures.

Table 7. Percent mortality of rainbow trout 8, 24, and 48 hours post exposure to 10 ppb antimycin 15, 30, 60, and 90 minutes travel time below the constant flow station. Fish were exposed to antimycin for 8 hours.

		Travel time (minutes)			
Time post-exposure	Control[1] (0 ppb)	15[1]	30	60	90
8 hours	0	50	50	0	0
24 hours	30	100	83	67	40
48 hours	90	100	100	83	50

[1]Control and 15 minute travel time values taken from the effective concentration tests.

Based on the results of the bioassays, constant flow stations were to be deployed every 30 minutes flow time to apply a 10 ppb antimycin concentration.

In the neutralization test, control fish (no exposure to antimycin or $KMnO_4$) showed no mortality (Table 8). This was probably due to the fact that the brook trout used were collected on-site, and had not been stressed like the rainbow trout. The fish exposed to 10 ppb antimycin showed 100% mortality after 24 hours, consistent with the results of the bioassays conducted with rainbow trout. Fish exposed to 10 ppb antimycin mixed with 1, 3, and 4 ppm $KMnO_4$ exhibited 100% mortality after 24 hours, while those exposed to 10 ppb antimycin and 2 ppm $KMnO_4$ showed 86% mortality after 24 hours. This test was hampered by high turbidity levels in the stream which was caused by the activity of heavy machinery several miles upstream. The high turbidity began several hours after the test was initiated and slowly diminished after about 10 hours. This turbidity confounded the interpretation of results because the sediment particles interact with the $KMnO_4$. The turbidity appeared to have the effect of reducing about 1 ppm of $KMnO_4$, given that the 1 ppm exposure bucket became largely reduced (inferred by the brown rather than purple color of the solution). Therefore, our interpretation of the results is that the antimycin was the probable cause of mortality of the fish in the 1 ppm $KMnO_4$ container, while in the 2 ppm bucket, the $KMnO_4$ was probably reducing the antimycin and affording some measure of protection to the fish. In the 3 and 4 ppm $KMnO_4$ containers, the high levels of $KMnO_4$ were again toxic to the fish. Additional bioassays to more precisely determine the non-fatal $KMnO_4$ concentration necessary for neutralization of the antimycin were not conducted due to the postponement of the project. These bioassays will be conducted again in 1999.

Also prior to postponement, 108 rainbow trout were removed from the 1998 section of the project area and released in Cherry Creek at the State Highway 84 Bridge near the mouth of Cherry Creek.

A Memorandum of Agreement is being developed and will be implemented between TEI, MFWP, and the USFS, which details the responsibilities of each party necessary to bring the project to a successful conclusion. The areas scheduled for treatment in 1999 are Cherry Lake and its two inlet streams, the unnamed stream draining Cherry Lake, and its tributary, upstream of a waterfall in T4S R2E Section 19, and the area that was scheduled for treatment in 1998 (Figure 2).

Researchers from the Rocky Mountain Research Station conducted snorkel and electrofishing estimates in twenty 100 meter reaches which were stratified based on stream size, channel gradient, valley bottom type, and channel features (Thurow and Guzevich 1999, Appendix D). Snorkel counts were not a reliable

Table 8. Percent mortality of brook trout during bioassays to determine the concentration of potassium permanganate (KMnO4) necessary to neutralize 10 ppb antimycin. Test fish were exposed for 8 hours and monitored for 24 hours after initiation of exposure.

	Control 1 (no antimycin)	Control 2 (10 ppb antimycin)	10 ppb antimycin plus KMnO4 (ppm)			
			1	2	3	4
2 hours	0	0	0	0	0	0
8 hours	0	50	25	63	100	100
24 hours	0	100	100	86	100	100

method of detecting fish or estimating fish populations due to poor water clarity, which impaired the snorkelers visibility. Visibility ranged from 0.5 - 1.7 meters. Snorkelers observed fish in 15 of 20 reaches, while electrofishing crews captured fish in 18 of 20 reaches. Additionally, electrofishing estimates consistently showed higher densities of fish than snorkel estimates (Appendix D Tables 3 & 4).

CONCLUSIONS AND FUTURE PLANS

During 1999, an Environmental Assessment will be produced which will evaluate the feasibility of re-establishing fluvial (river-dwelling) Arctic grayling in three rivers in southwest Montana, including the Madison River between Quake Lake and Ennis Reservoir. Public meetings will be held to gather scoping comments prior to production of the EA, and again after the release of the EA to gather public comment on the proposal.

In October 1998, MPC entered into an agreement to sell its electrical generating system, including the 2188 Project, to PP&L Global, a subsidiary of Pennsylvania Power & Light, Inc. The purchaser of the facilities will be responsible for meeting the conditions of the FERC license. It is unknown if PP&L will enter into a similar agreement with MFWP to conduct fisheries mitigation and enhancement work in the Madison River Drainage after the sale is completed.

The Federal Energy Regulatory Commission is expected to release the Final Environmental Impact Statement for the relisencing of the Madison/Missouri Hydropower Project in 1999.

The primary focus of the Madison/Ennis Project in 1999 will again be the Madison River Drainage Westslope Cutthroat Trout (UMWCT) Conservation and Restoration Program. Due to the immediate opportunity presented at Cherry Creek, much effort will be spent on that project.

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Appendix A

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

Species abbreviations:

AG	arctic grayling
MWF	mountain whitefish
WSu	white sucker
LSu	longnose sucker
UC	Utah chub
Sc	mottled sculpin

September 4, 1998

Site seined/time	AG	MWF	Note
east end of willows between Meadow Creek Bay and Peterson Property ($1000 house)	0	0	100's of Wsu, Lsu & UC; macrophytes extremely dense, interfering with seining
west end of willows 1217 hours	0	0	100's of Wsu, Lsu & UC; macrophytes extremely dense, interfering with seining
east of willows at Meadow Creek picnic area 1244 hours	0	0	10's of Wsu, Lsu & UC; macrophytes extremely dense, interfering with seining
point west of Fletchers 1321 hours	0	0	≈ 20 YOY UC; few macrophytes
just west of shrubs at mouth of main channel 1346 hours	0	0	<10 Wsu & UC, 1 Sc; sparse macrophytes

Appendix B

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

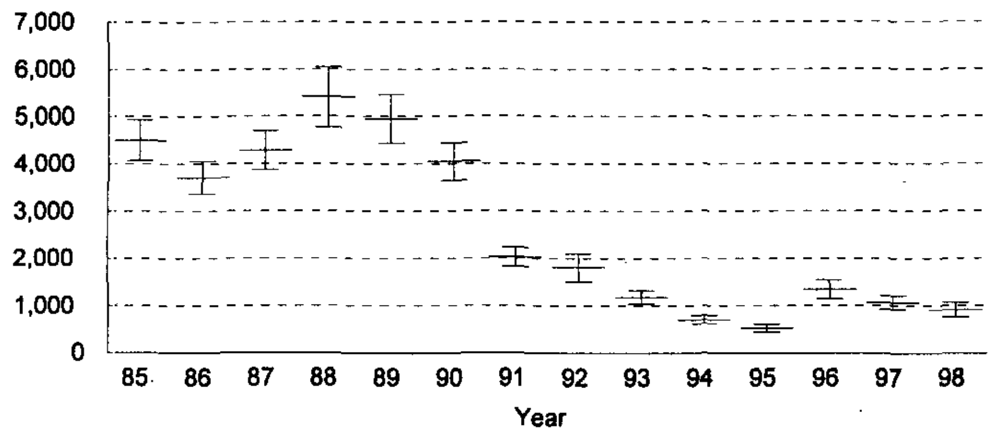
section lengths

Pine Butte - 3 miles
Varney - 4 miles
Norris - 4 miles

Pine Butte

Rainbow Trout

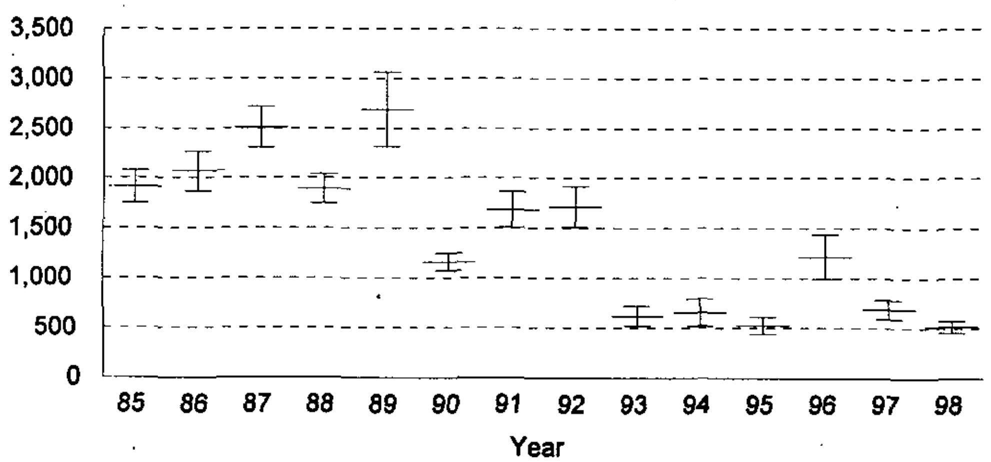
Age 2 & older

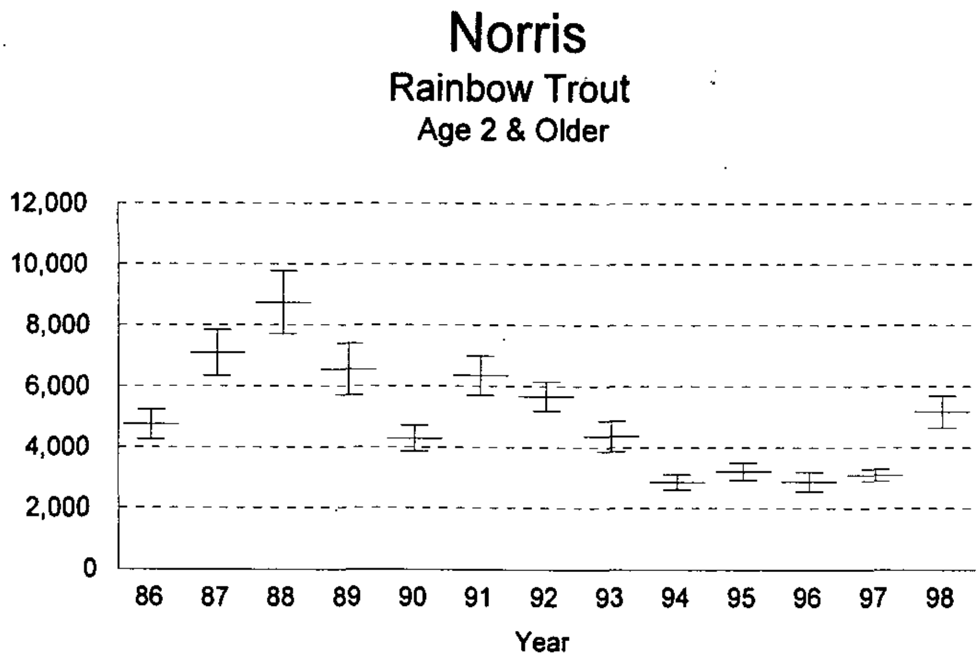


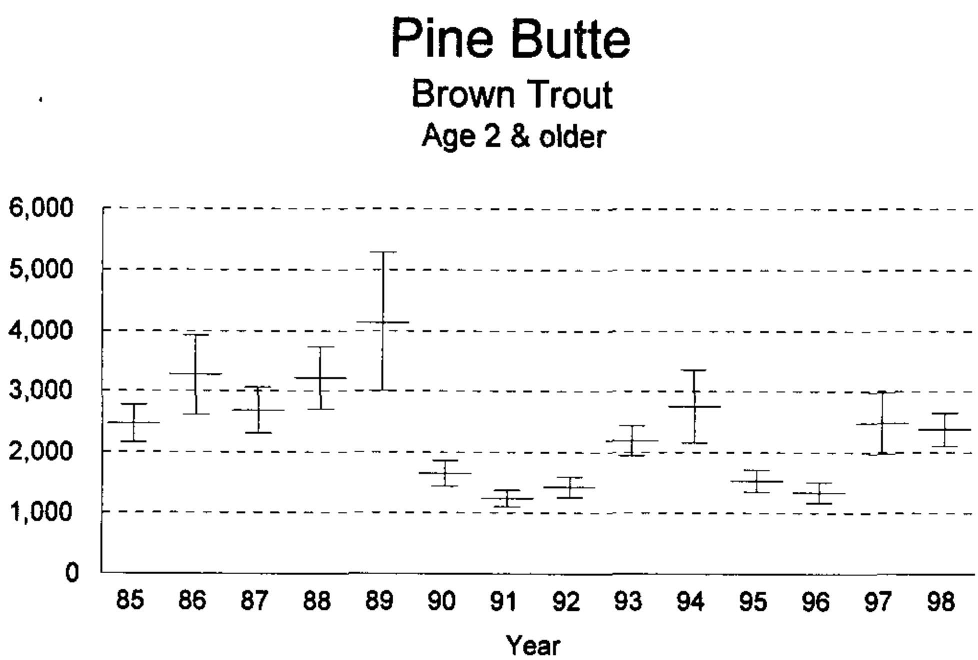
Varney

Rainbow Trout

Age 2 & Older




Norris
Rainbow Trout
Age 2 & Older
12,000
10,000
8,000
6,000
4,000
2,000
0
86
87
88
89
90
91
92
93
94
95
96
97
98
Year


Pine Butte
Brown Trout
Age 2 & older
6,000
5,000
4,000
3,000
2,000
1,000
0
85
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87
88
89
90
91
92
93
94
95
96
97
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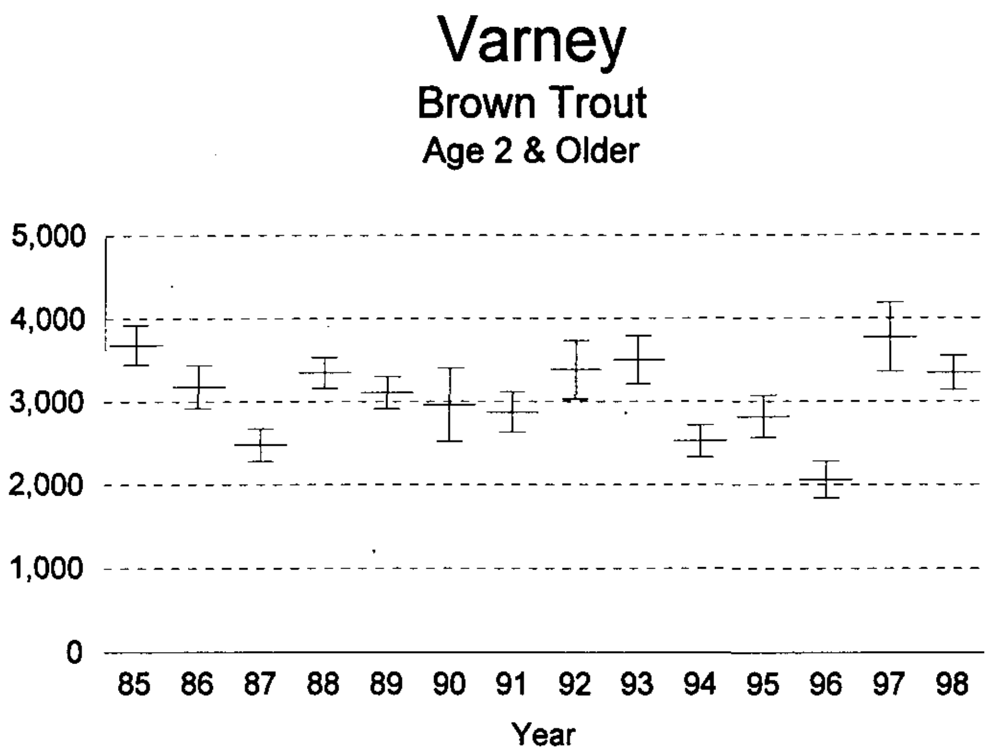
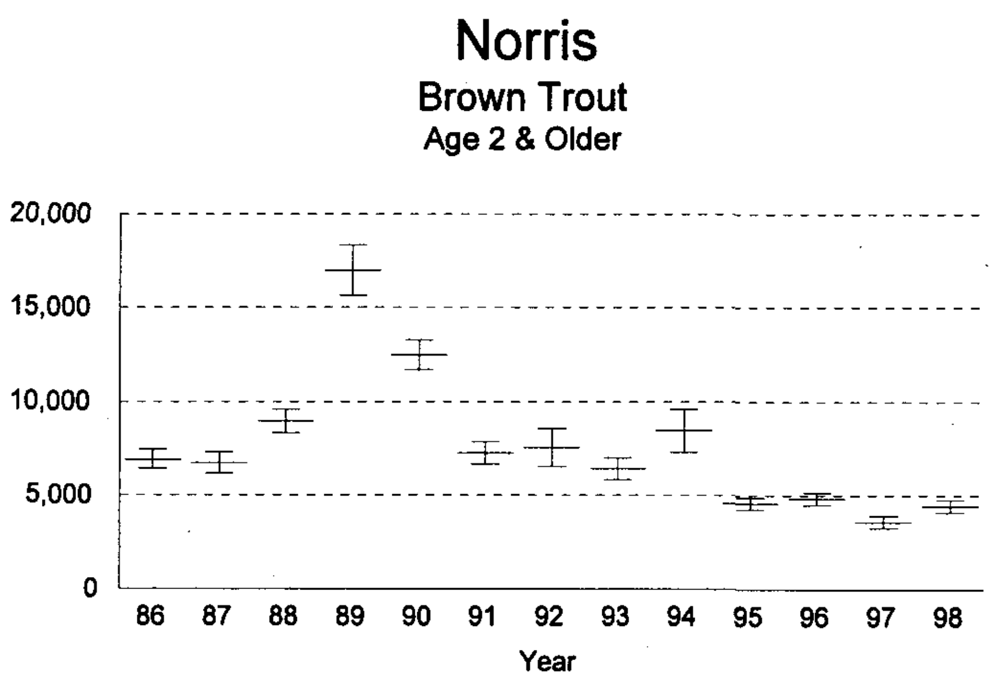
Year



Varney
Brown Trout
Age 2 & Older
5,000
4,000
3,000
2,000
1,000
0
85
86
87
88
89
90
91
92
93
94
95
96
97
98
Year



Norris
Brown Trout
Age 2 & Older
20,000
15,000
10,000
5,000
0
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88
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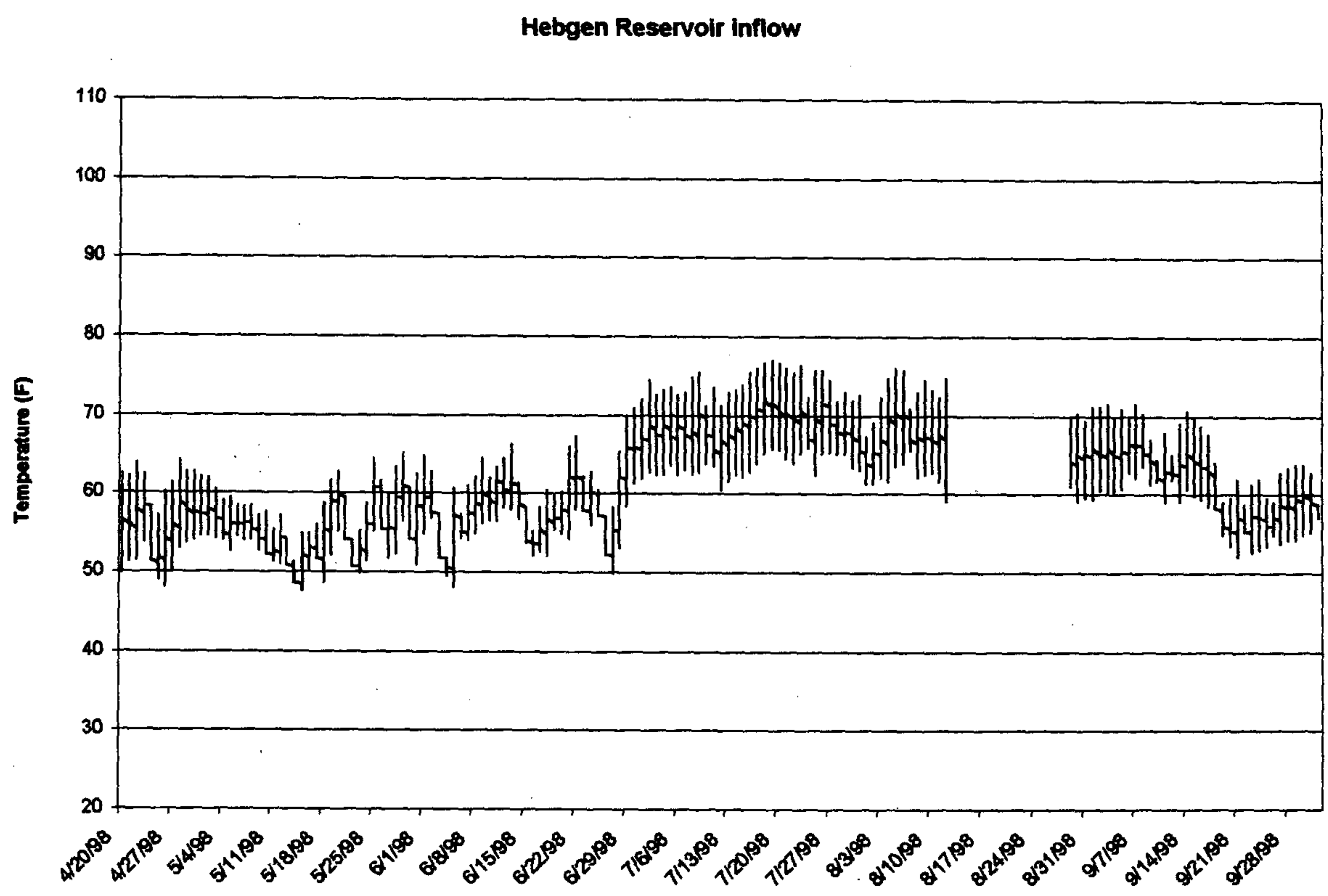
97
98
Year

Appendix C

Temperature recordings from monitoring sites on the Madison River


Hebgen Reservoir Inflow
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90
80
70
60
50
40
30
20
4/20/98
4/27/98
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8/10/98
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8/24/98
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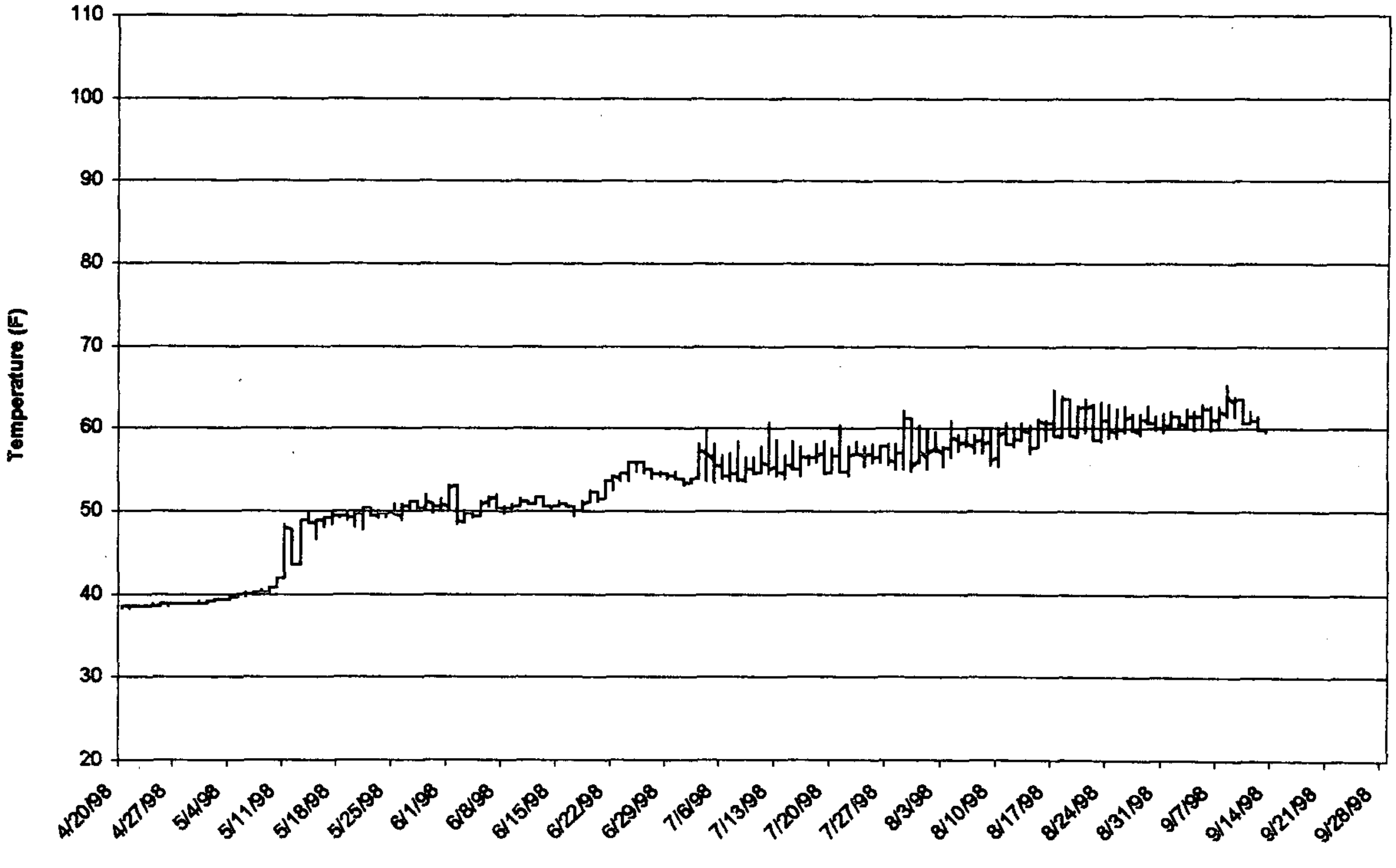
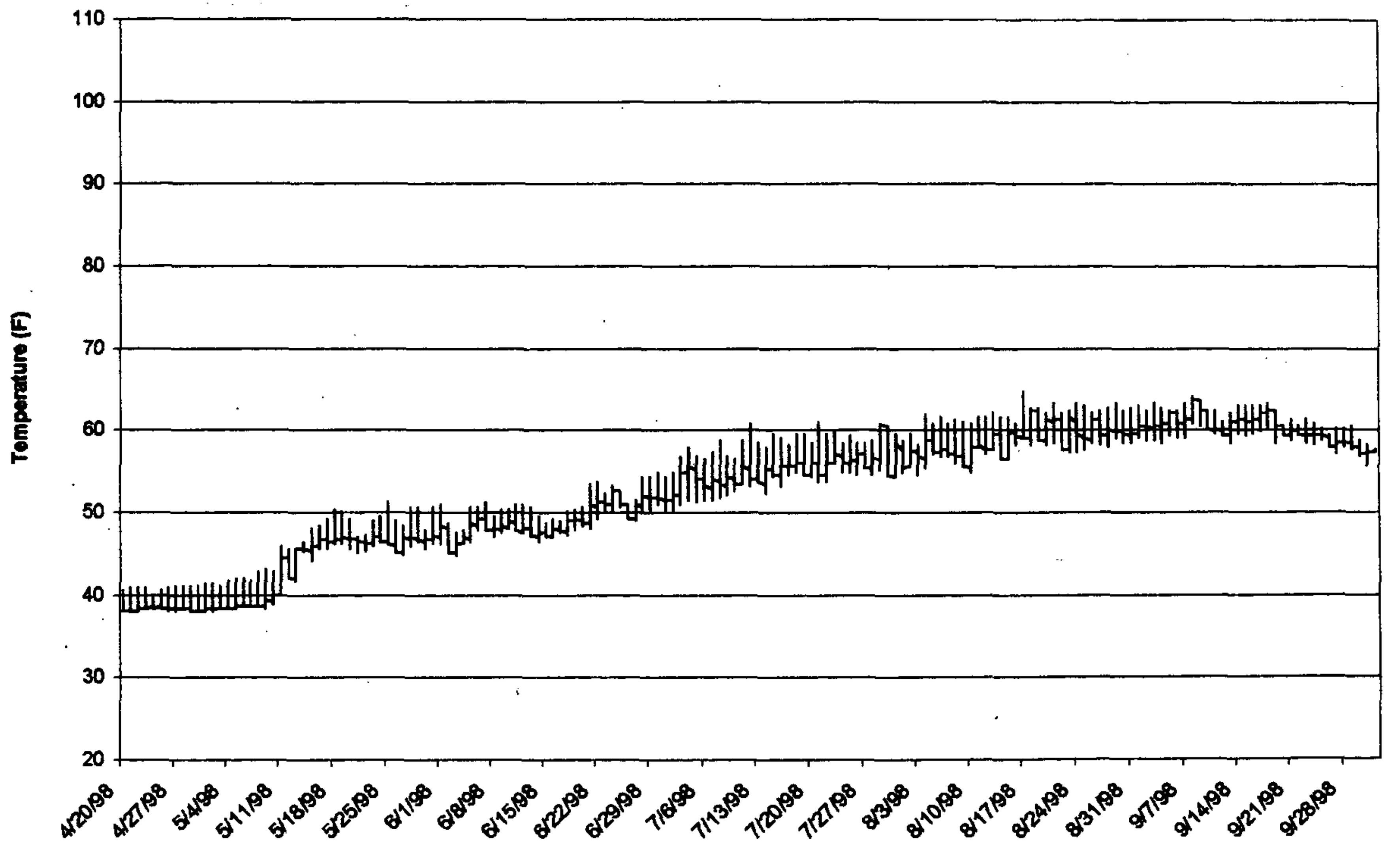
9/21/98
9/28/98

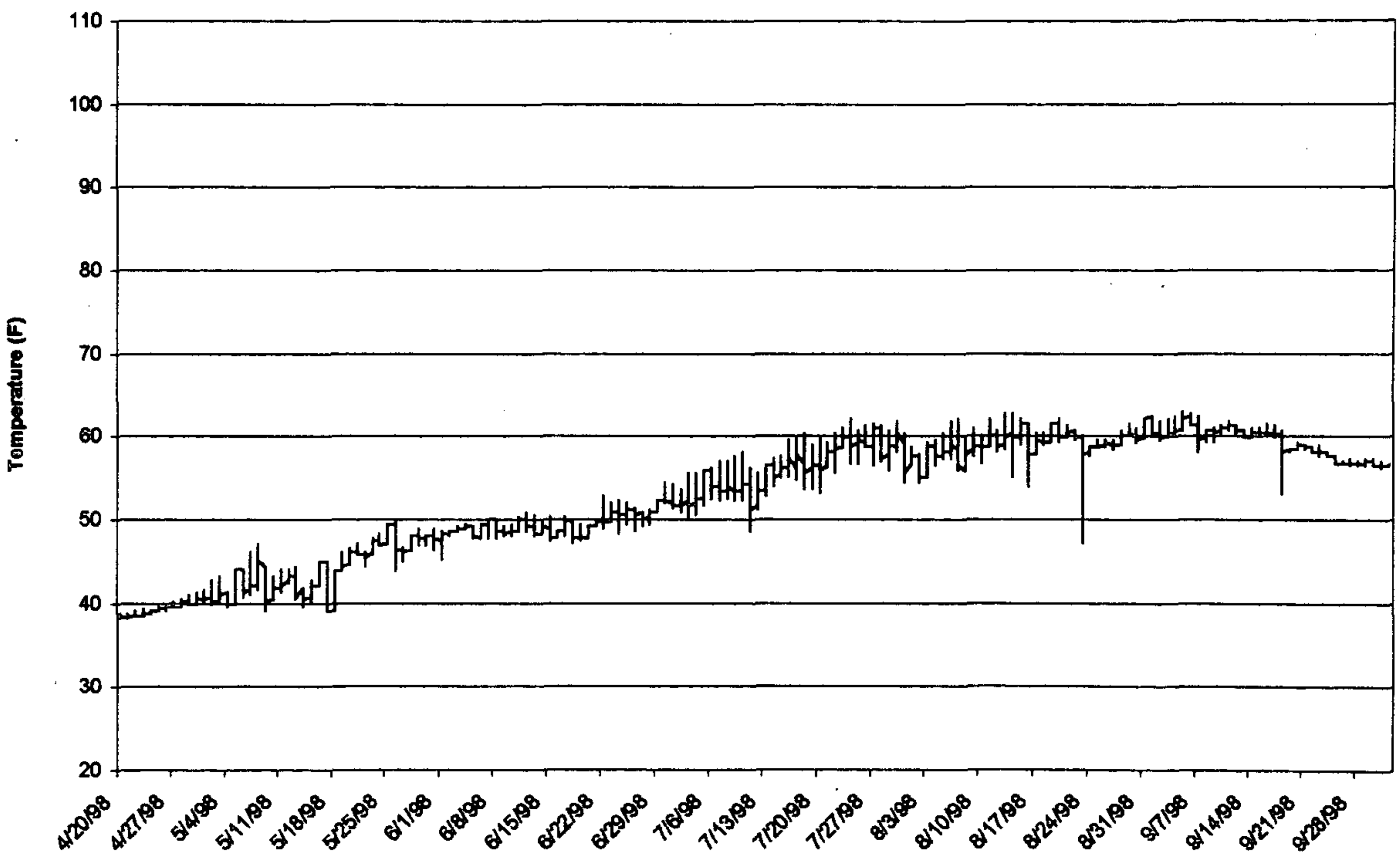
Hebgen Dam discharge

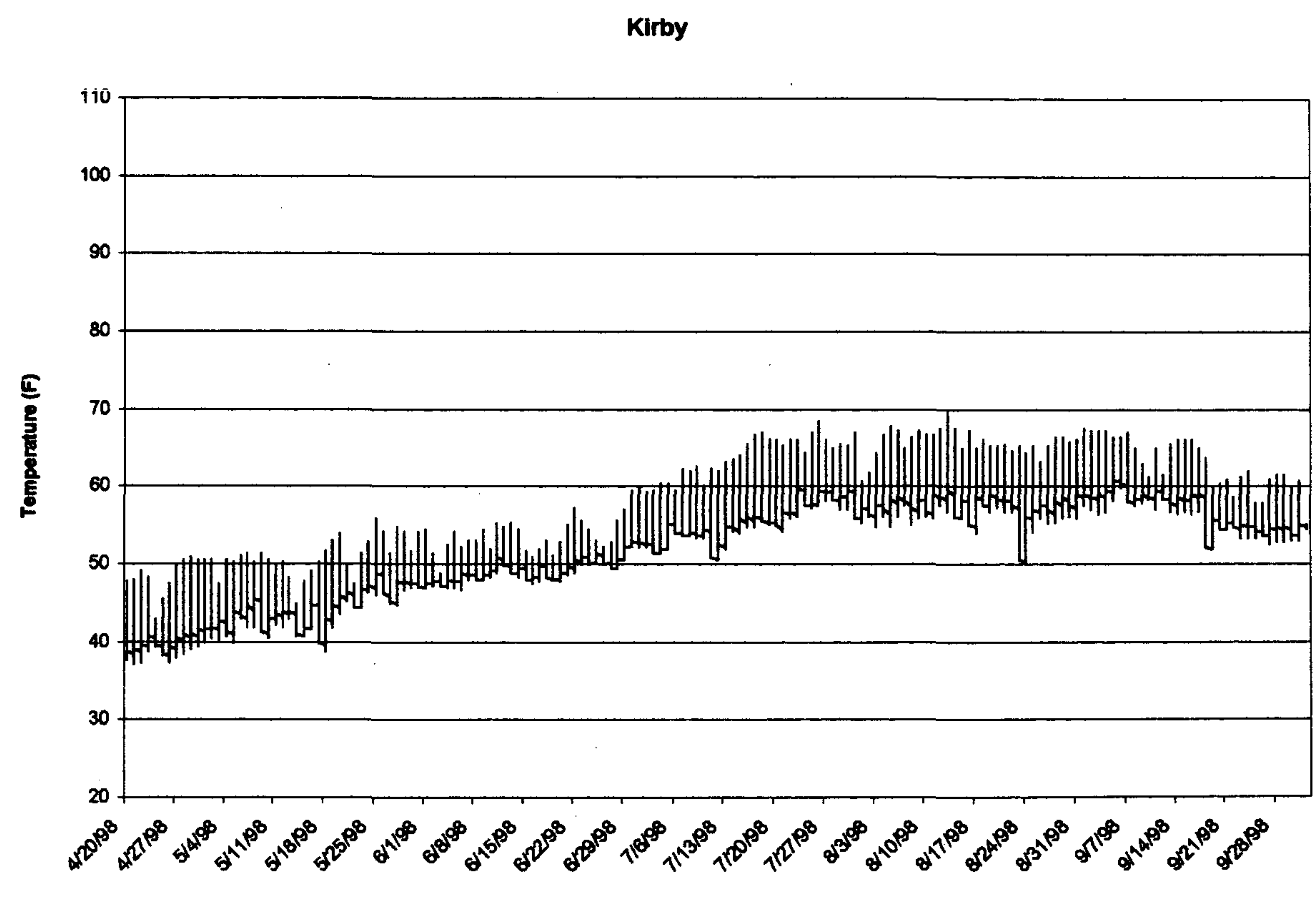


Hebgen/Quak river section



Quake Lake outflow




Kirby
Temperature (F)
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40
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8/3/98
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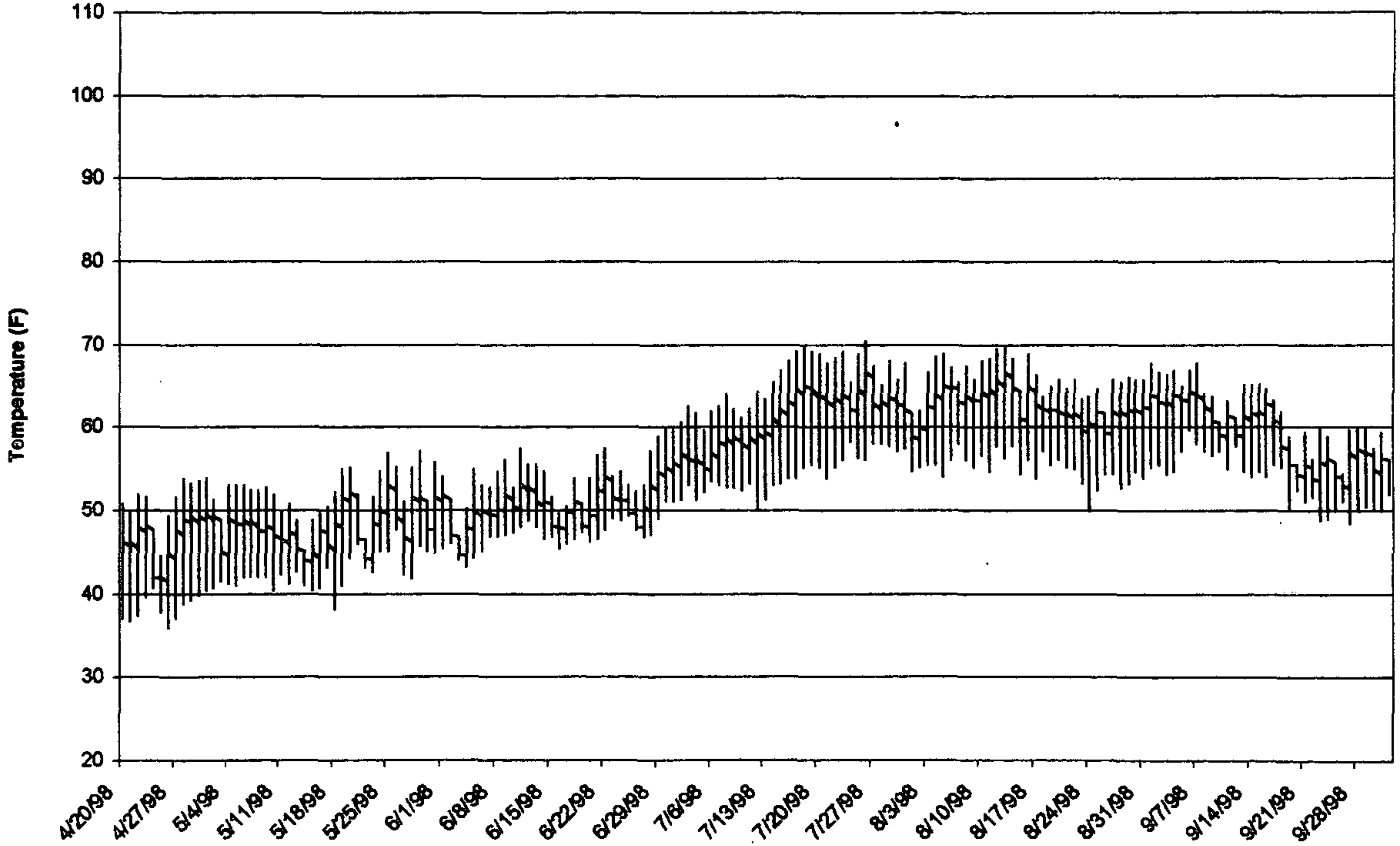
9/28/98

McAtee


Temperature (F)
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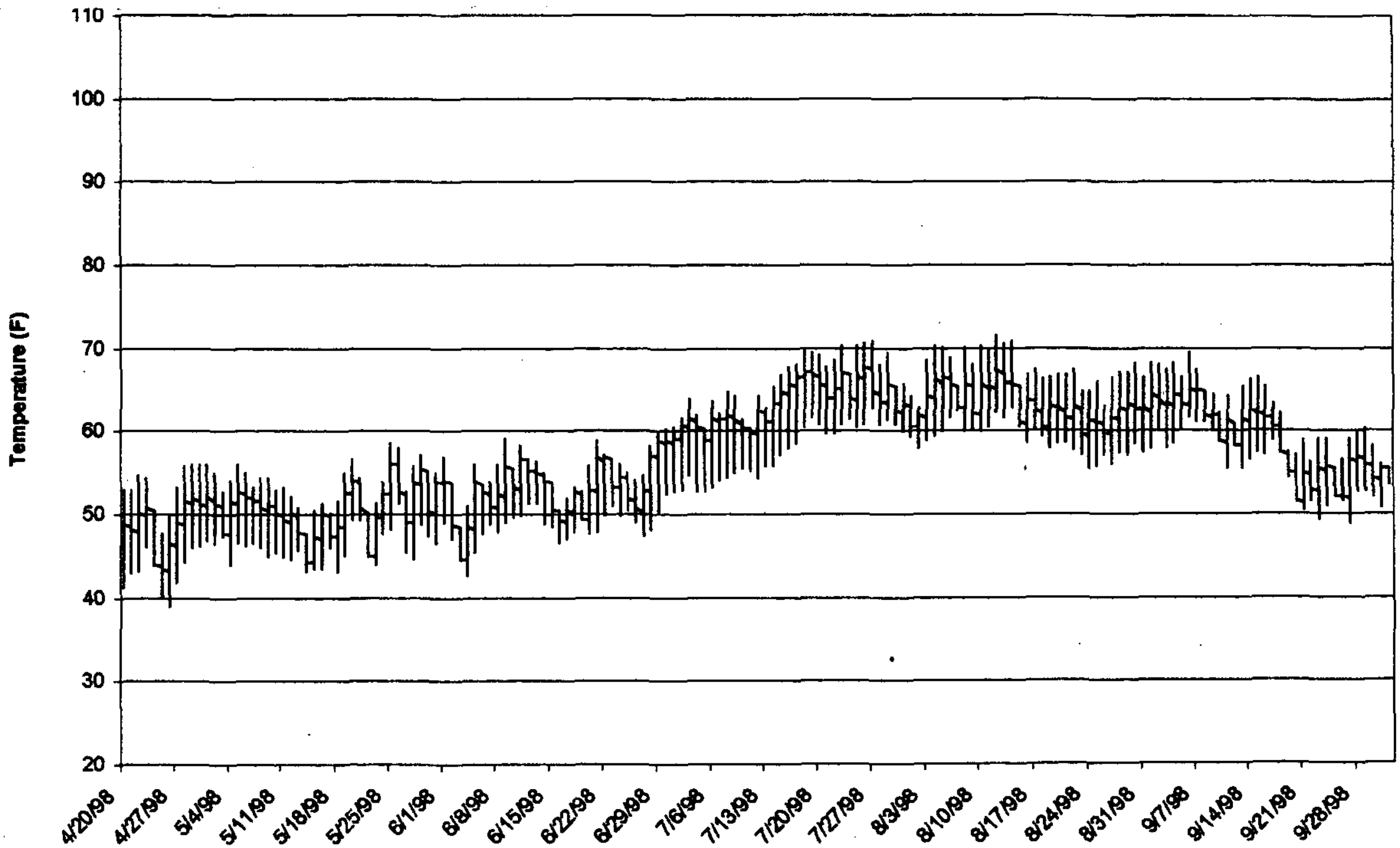
9/28/98

Ennis Bridg



Temperature (F)
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8/3/98
8/10/98
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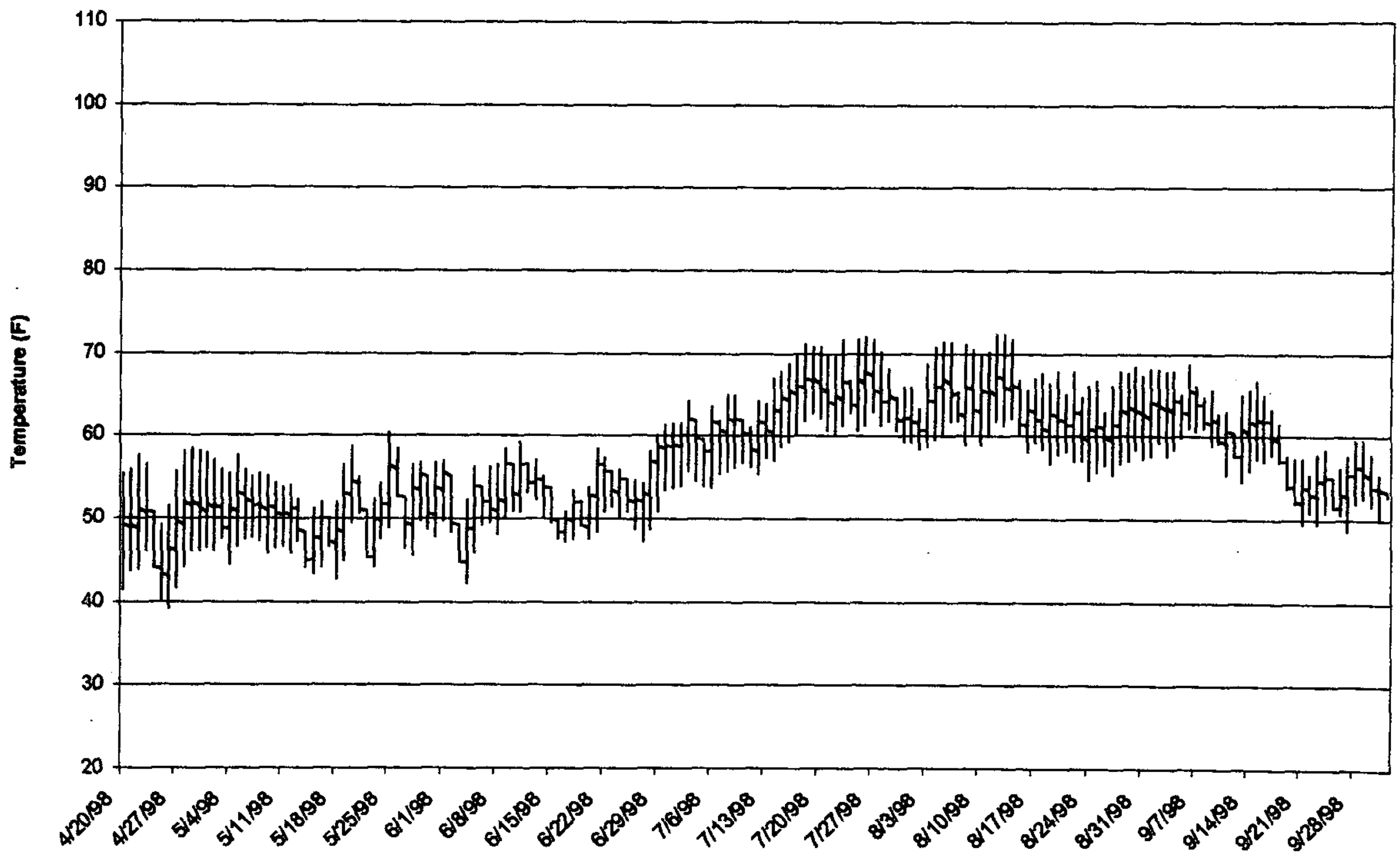
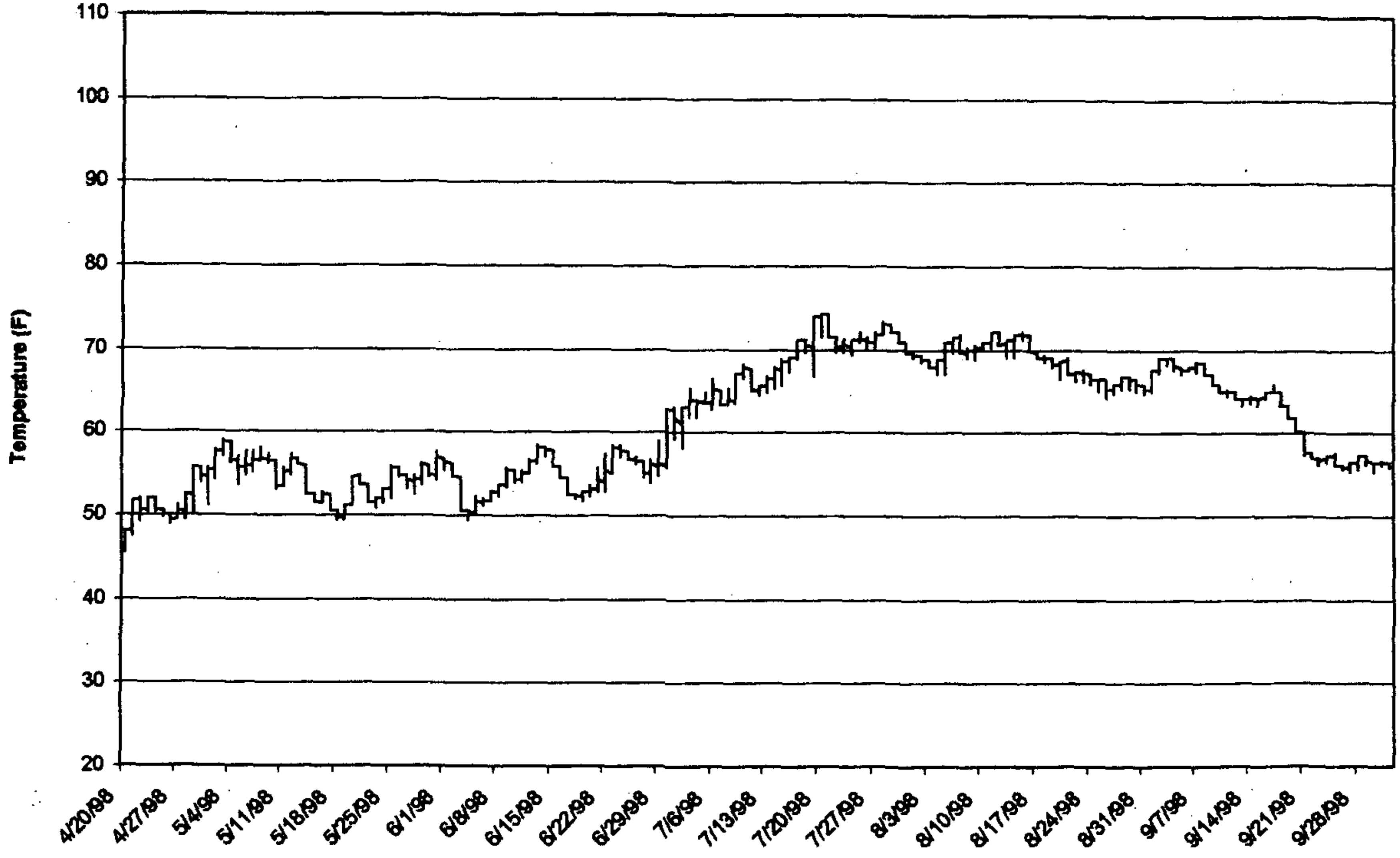
9/28/98

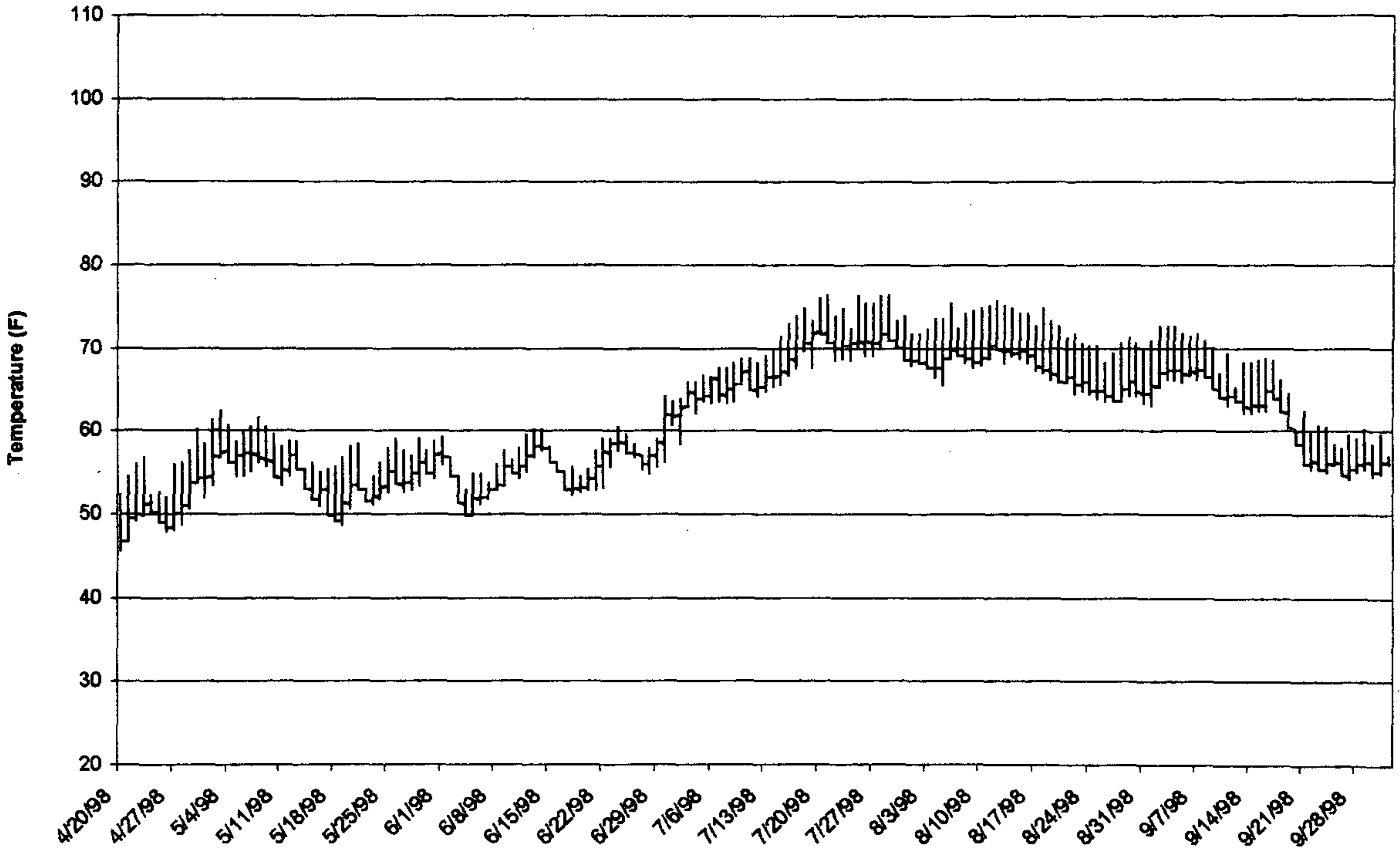
Ennis Reservoir inflow



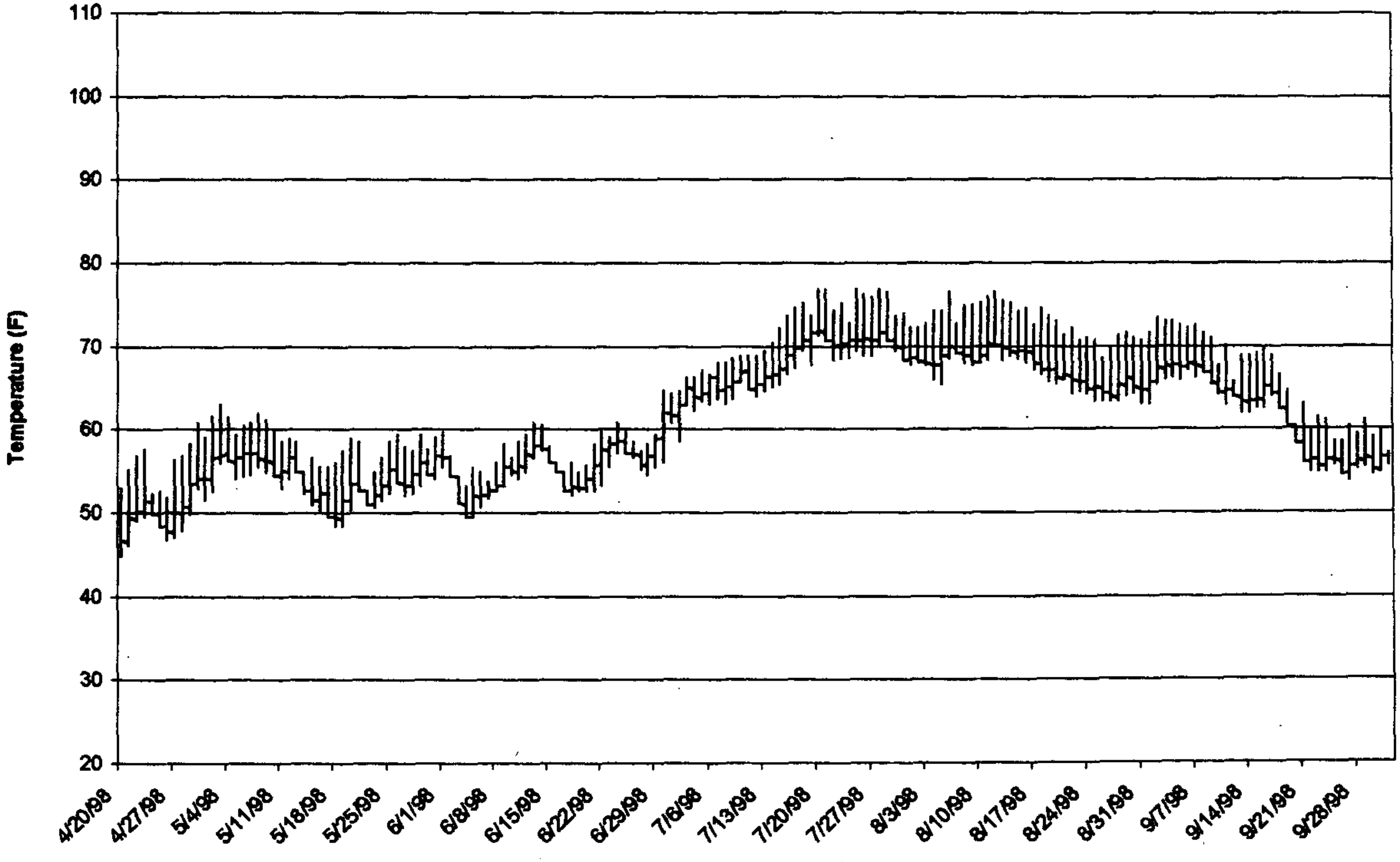
Ennis Reservoir at Dam



Bear Trap mouth



Norri



Temperature (F)
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100
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80
70
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40
30
20
4/20/98
4/27/98
5/4/98
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5/18/98
5/25/98
6/1/98
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8/3/98
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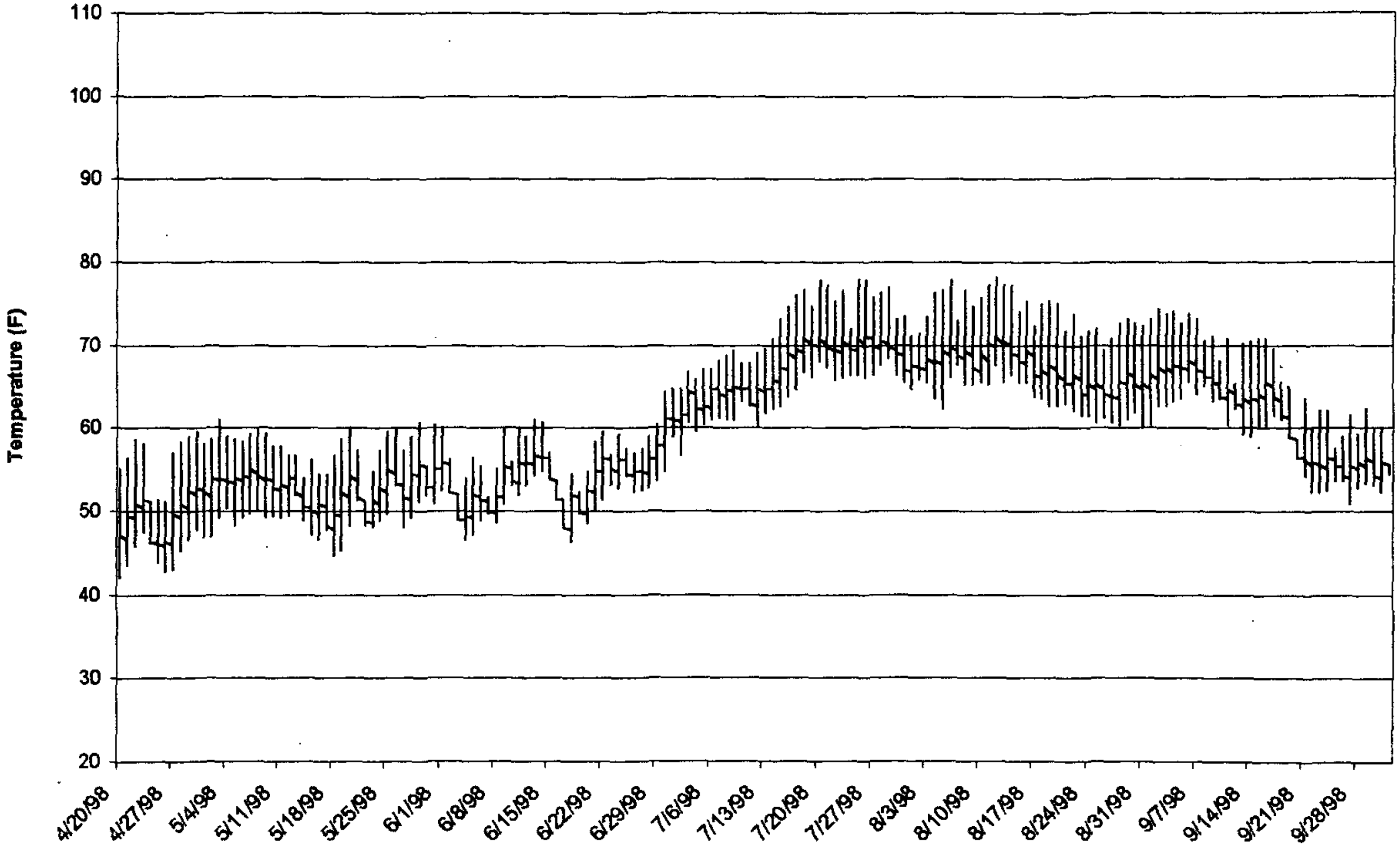
9/28/98

Black's Ford



Temperature (F)
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80
70
60
50
40
30
20
4/20/98
4/27/98
5/4/98
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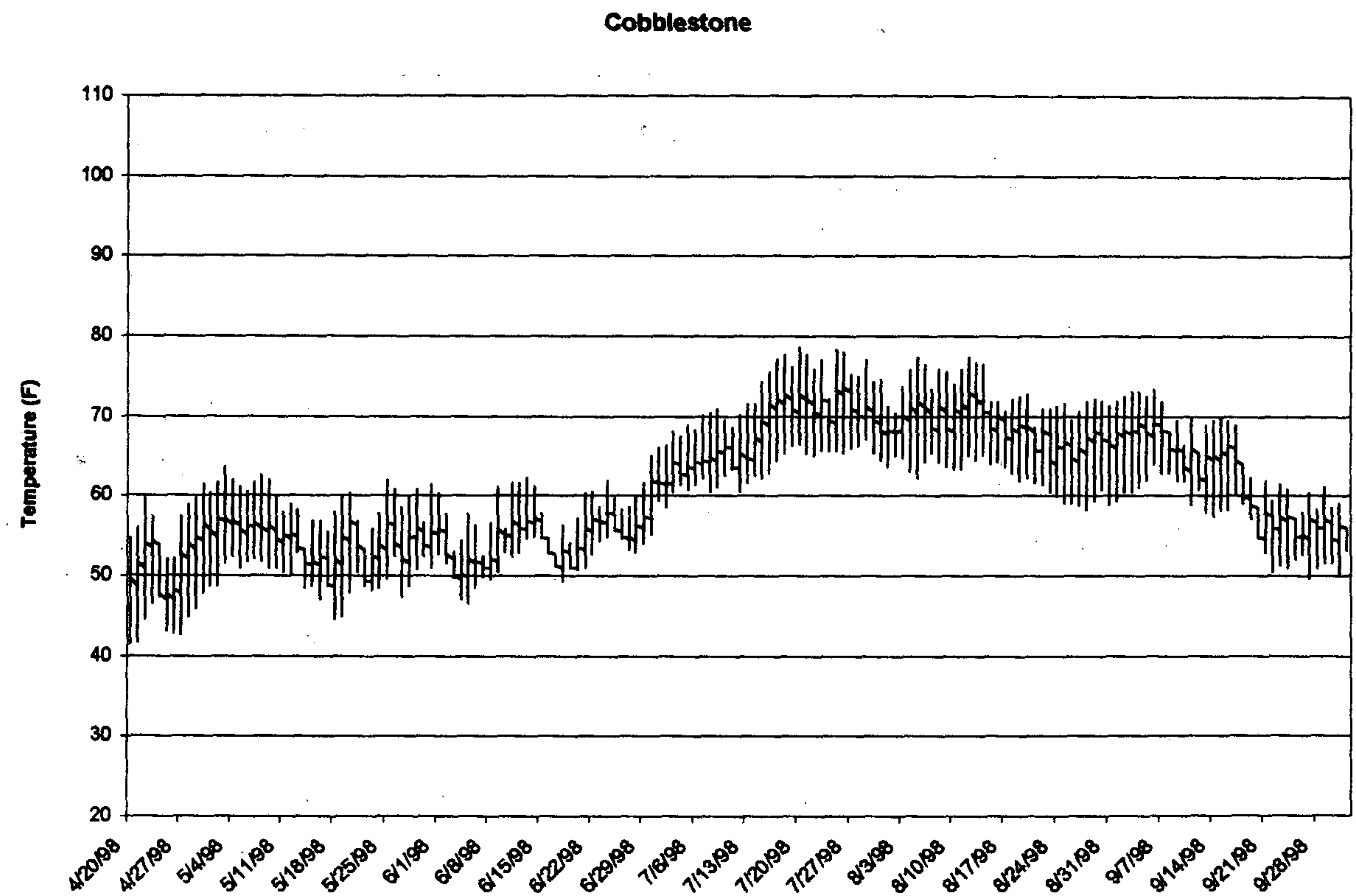
9/28/98


Cobblestone
Temperature (F)
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50
40
30
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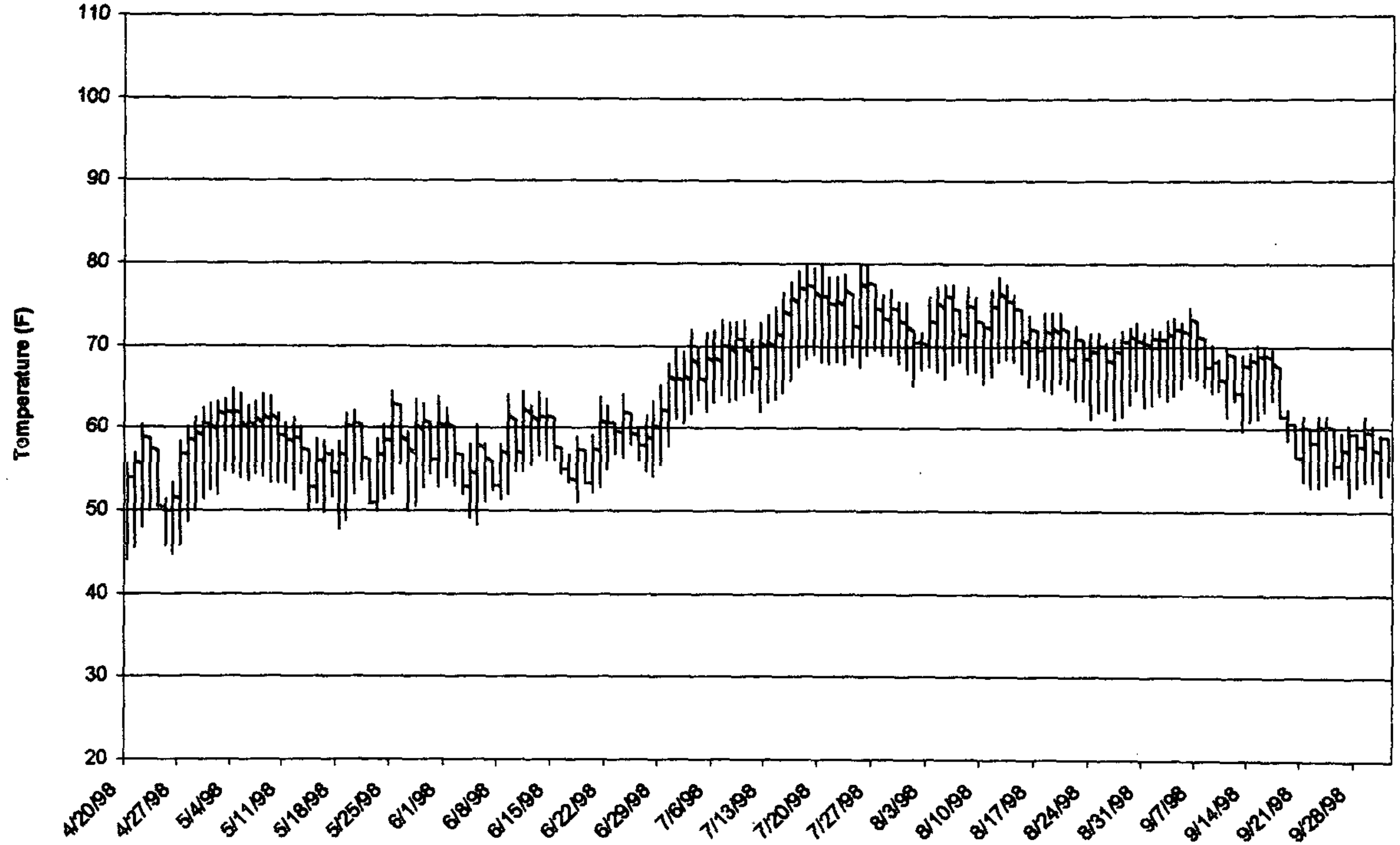
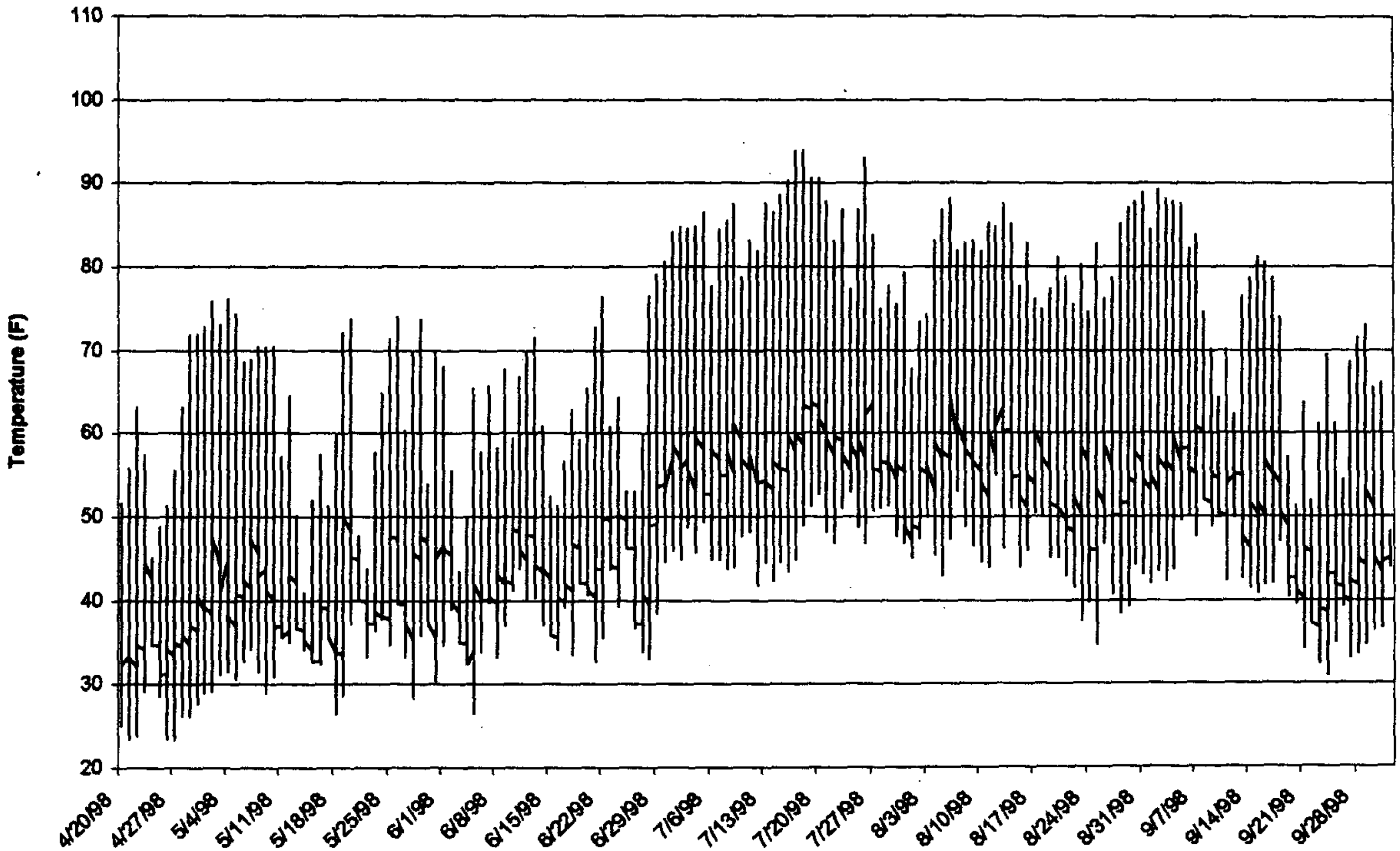
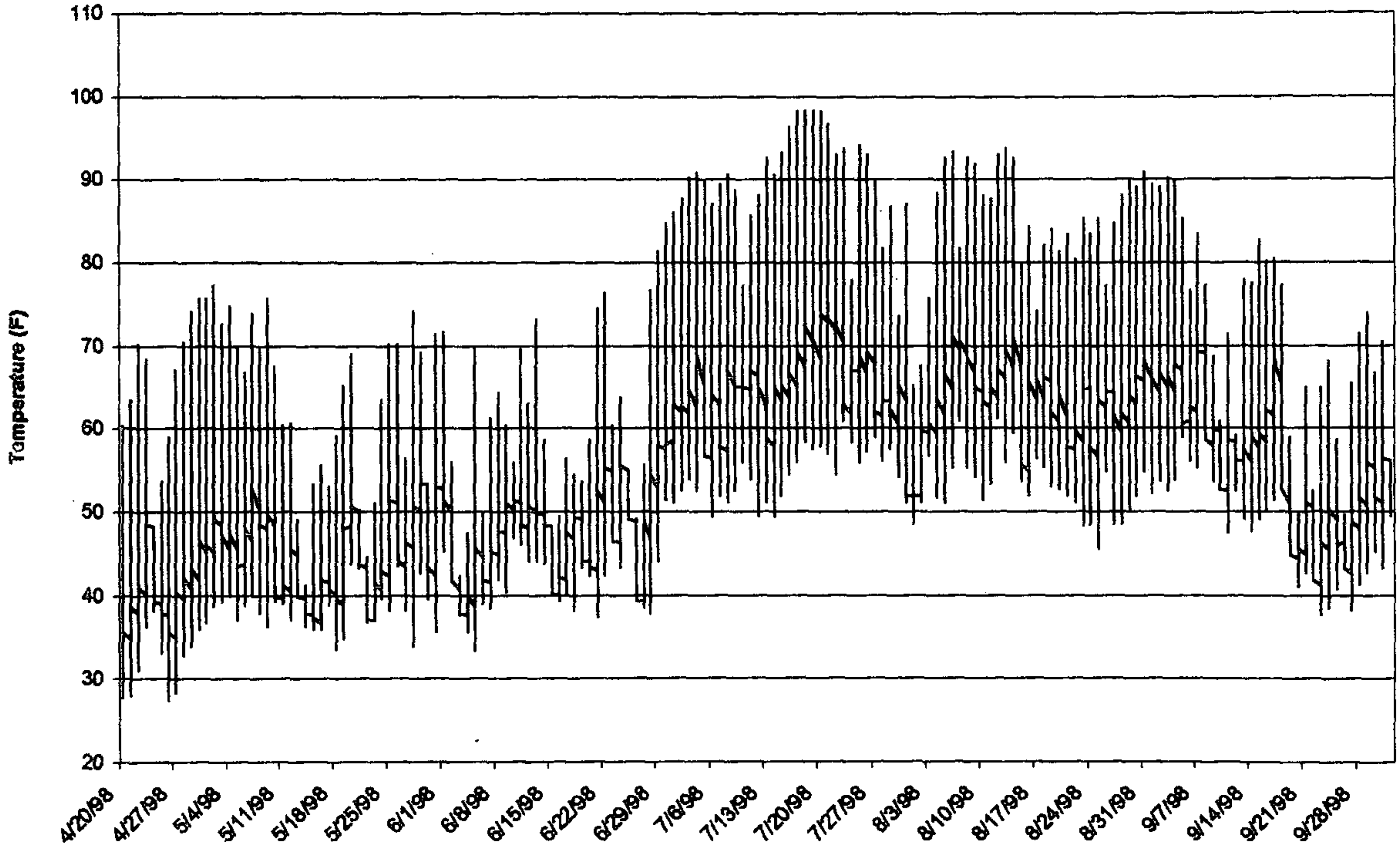
Headwater State Park (Madison mouth)



Kirkwood Store air



Slide air



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80
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30
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4/20/98
4/27/98
5/4/98
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5/18/98
5/25/98
6/1/98
6/8/98
6/15/98
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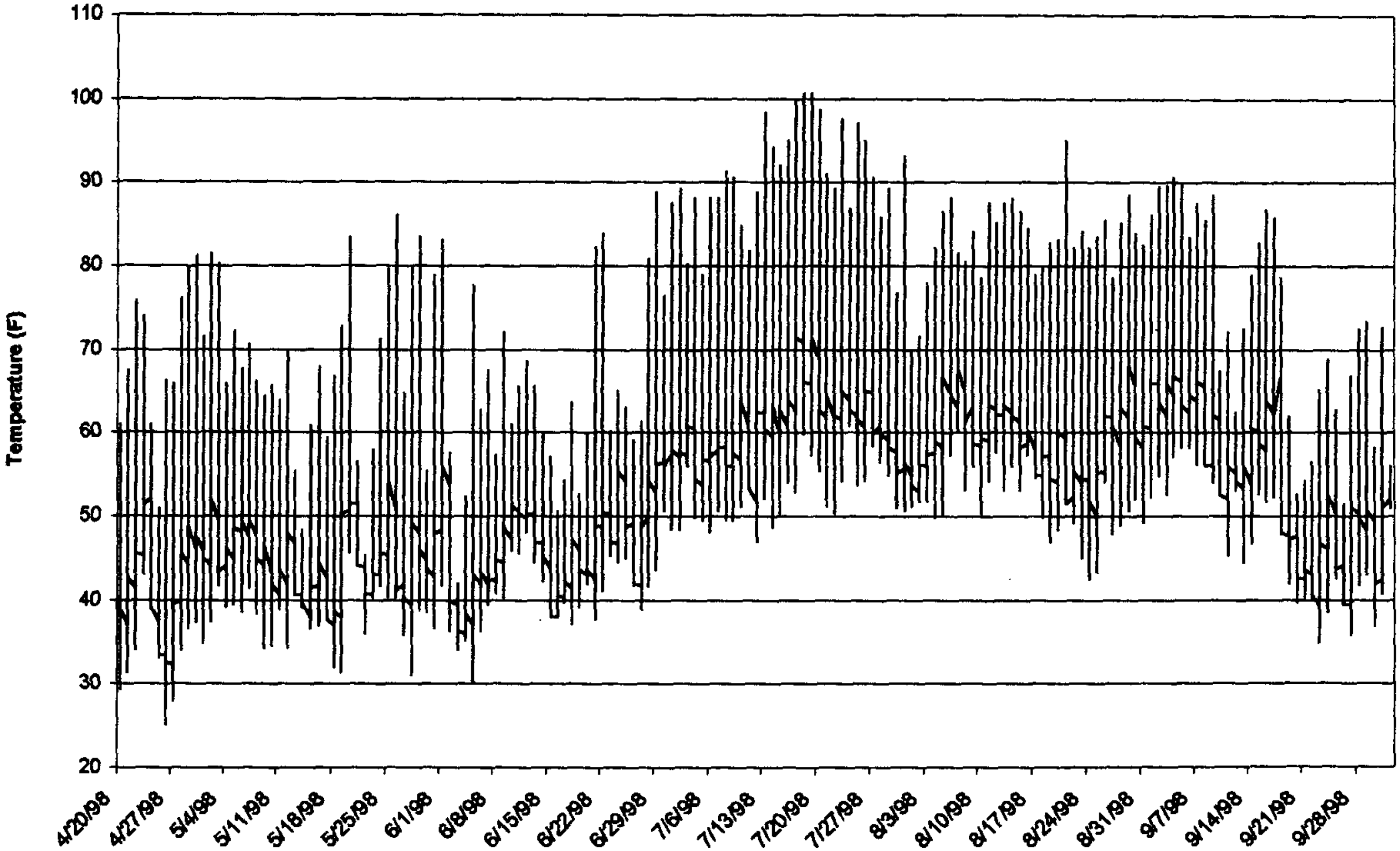
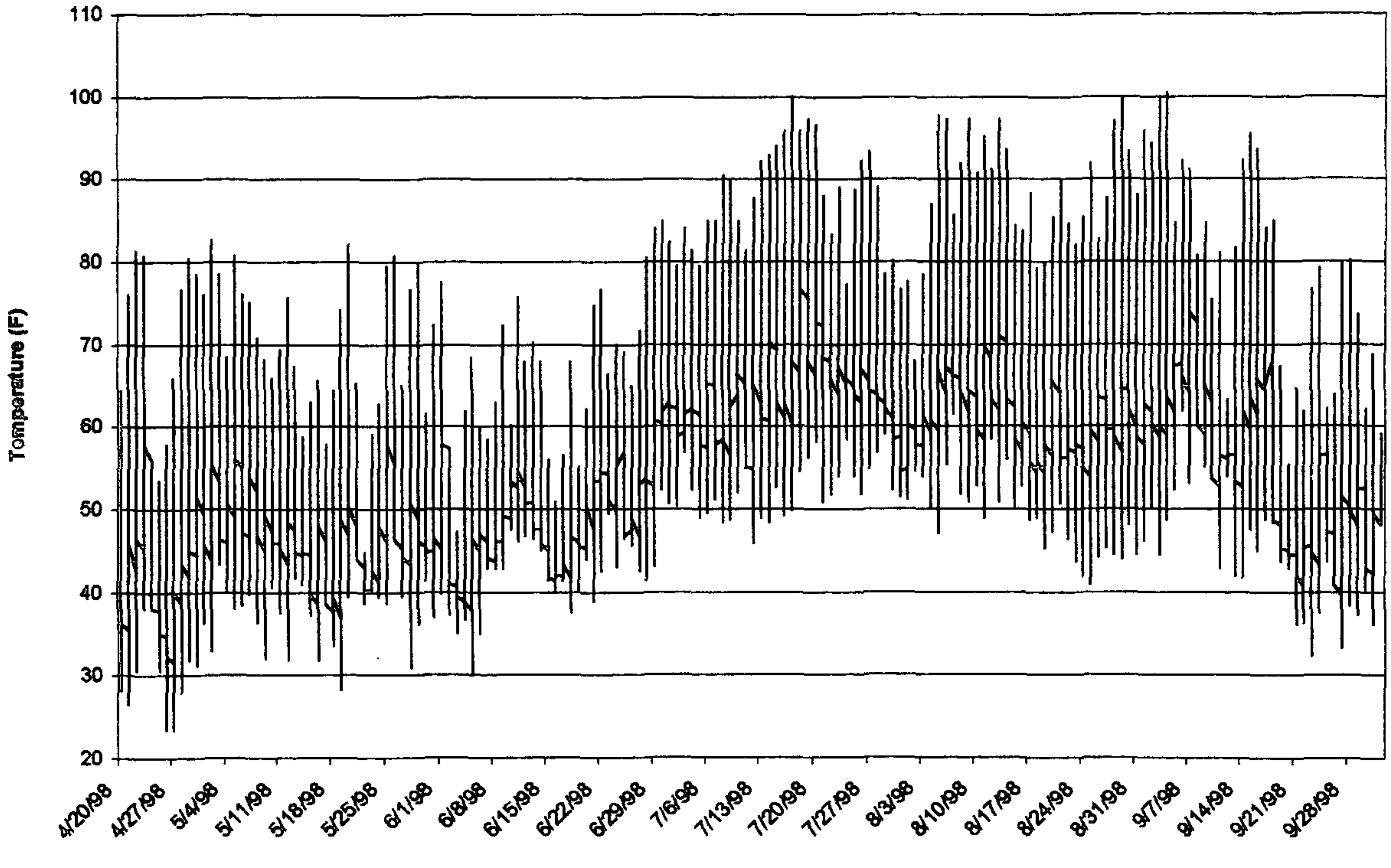
9/28/98

Wall Creek HQ air



Ennis air



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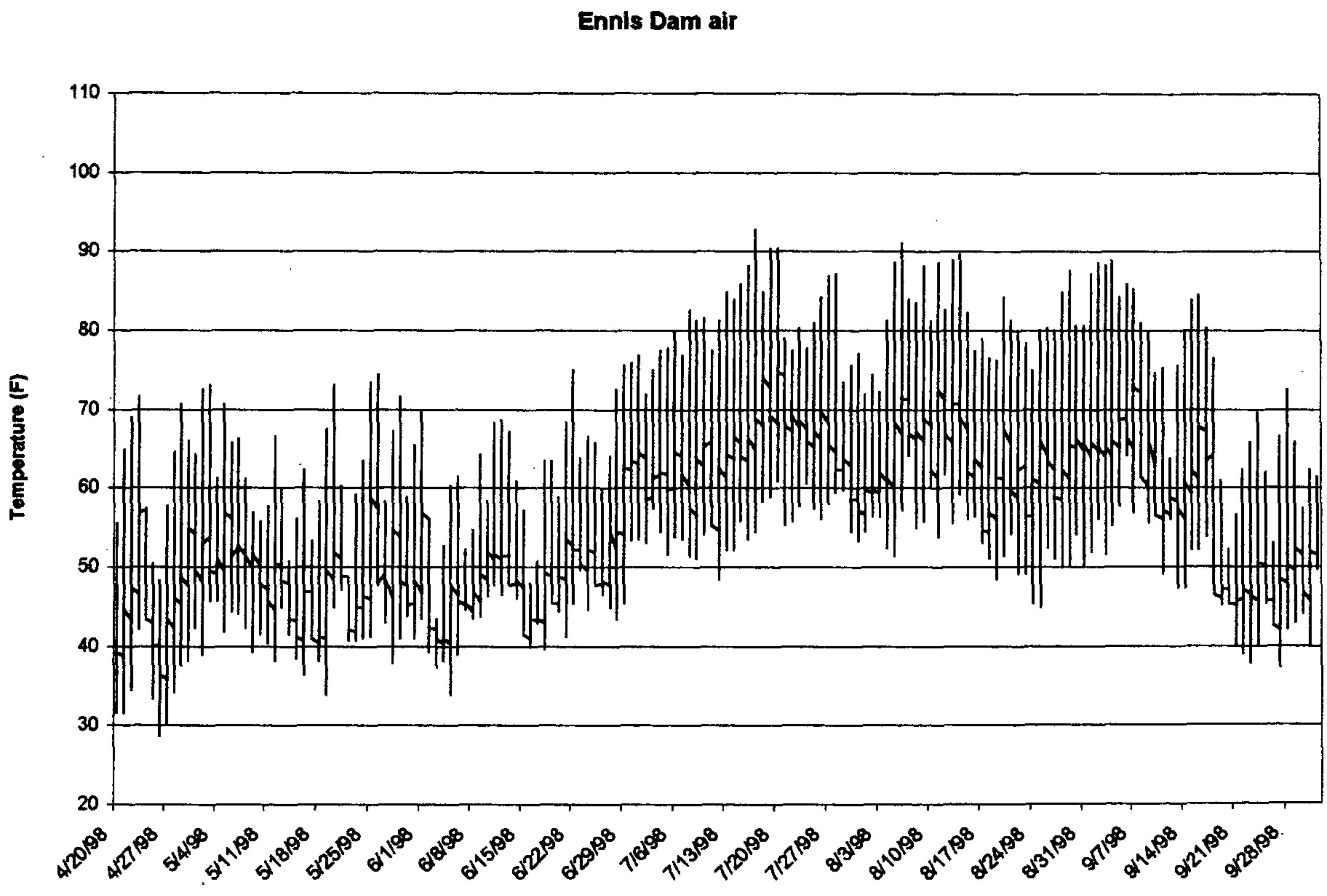
9/28/98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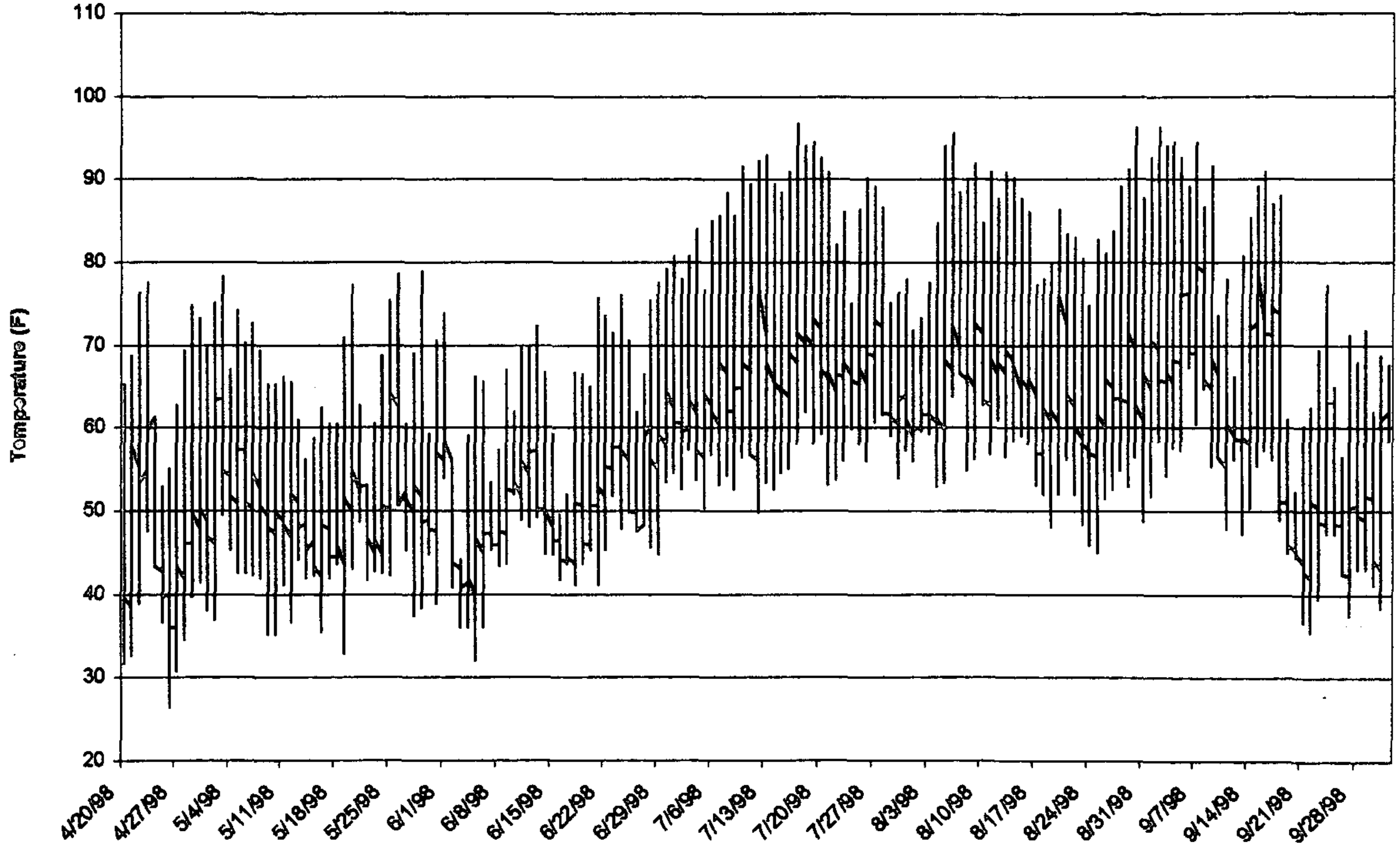
9/21/98
9/28/98

Norris air



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Temperature (F)
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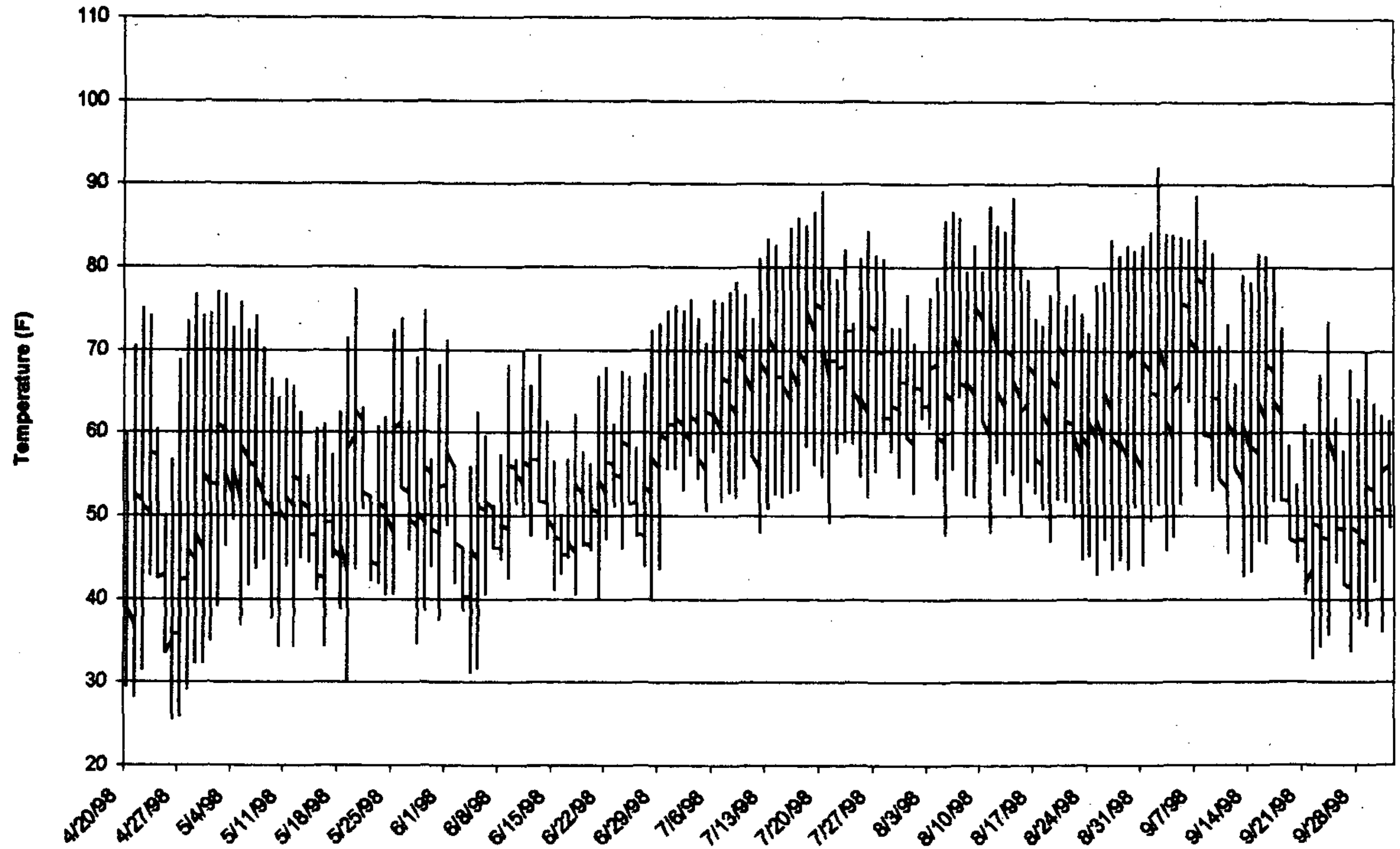
9/21/98
9/28/98

Cobblestone air



Appendix D

Cherry Creek Native Fish Introduction Project.
Progress Report of 1998 Activities, Evaluation Phase. U.S. Forest Service, Rocky Mountain Research Station, Boise, Idaho.

Russell F. Thurow and John W. Guzevich.

1999

Cherry Creek Native Fish Introduction Project

Progress Report of 1998 Activities
Evaluation Phase

by

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January 1999

Introduction

Biologists and managers need reliable methods to assess the distribution and status of fishes. Accurate knowledge of stream fish populations and communities is necessary for a variety of ecological and management concerns (Bayley and Dowling 1993). Throughout the range of many native fishes, there is incomplete information, even to determine species presence and absence (Lee et al. 1997). Protocols for sampling abundance and size structure of many species are lacking across the range of potential habitats (Thurow and Schill 1996). Fish sampling efficiency is influenced by the size and species of fish (Bagenal 1977; Reynolds 1983; Riley et al. 1993) as well as physical habitat features (Bayley and Dowling 1993; Peterson 1996). Failure to account for differences in sampling efficiency introduces an error or bias into the data, which can significantly affect abundance (status) estimates (Bayley and Dowling 1993). Presence and absence (distribution) estimates are similarly affected by sampling efficiency because the probability of detecting a species is a function of its probability of capture and its density, and both are influenced by habitat features that vary.

One of the limitations of most sampling efficiency studies is the difficulty of obtaining an unbiased estimate of the true population. Bayley and Dowling (1993), for example applied a fish toxicant to obtain reliable estimates of the true population. The Cherry Creek enhancement project provides a unique opportunity to evaluate sampling efficiencies for stream salmonids. Because a fish toxicant will be used to eradicate non-native salmonids, the project will enable us to estimate population abundance and size structure through post treatment recovery of marked fish.

Our primary objectives are: 1.) To compare the probabilities of detecting salmonids in small streams using different sampling methods; 2.) To compare the detection probabilities with presence/absence and population abundance estimates derived from an unbiased estimate of the true population after toxicant application; 3.) To provide the project cooperators (Montana Fish Wildlife, and Parks (MFWP), Turner Enterprises (TE), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Forest Service) with site specific information to describe pre-treatment fish species composition, density, size structure, and biomass; and 4.) To provide accurate post-treatment estimates of the effectiveness of the eradication project.

Methods

Sampling units.-Our intent was to select sampling units throughout the treatment area with a range of physical habitat conditions. We stratified streams into reaches based on stream size, channel gradient, valley bottom type, and channel features using both map-level information and empirically derived data. Within each defined reach, we selected starting points near toxicant drip stations. Random start points were located in the field, flagged and marked on a topographic map. At each start point, we paced a sampling unit approximately 100 m in length and selected hydraulic controls for upper and lower boundaries.

In 1998, we selected 20 sampling units and numbered them consecutively moving upstream. Twelve units were located in Cherry Creek upstream from its confluence with Cherry Lake Creek, three units in Tributary 20.8, four units in tributary 21.8, and one unit in tributary 22.8 (Figure 1). Throughout this report, we adopt the naming conventions proposed by P. Clancey of MFWP. High turbidity levels precluded us from selecting sampling units between Cherry Creek units 5 and 6 and above unit 12.

We installed block nets at the upper and lower unit boundaries and inspected them to insure they were barriers to movement. We installed nine thermograph among the sampling units and recorded hourly water temperatures (Figure 1).

Pre-Treatment biological data.-Prior to application of the fish toxicant, we first snorkeled and counted all fish in each unit and then completed a multiple-pass electrofishing estimate. Although our original objective was to also complete a night snorkel count of fish in each unit, the poor (<2 m) visibility we encountered during day snorkel surveys caused us to terminate night snorkel counts.

Two teams of one experienced snorkeler and one data recorder each completed counts. Snorkelers practiced size estimation with submerged wooden dowels prior to completing counts. All counts were completed in a single upstream pass. We snorkeled each unit between 1000 and 1800, counted the total number of age one and older salmonids by species, and estimate size classes to the nearest 100 mm size group. We recorded the presence of young-of-the-year (YOY) salmonids all other fishes and amphibians by species and life stage (YOY, juvenile, adult). The snorkeler carried a small halogen light to facilitate spotting fish concealed in shaded locations.

We record starting and ending times and water temperatures with a calibrated hand-held thermometer. Several times each day, we took three measurements of the underwater visibility of a salmonid silhouette by suspending the silhouette in the water column and measuring the distance at which the object could clearly be distinguished (via a secchi-disk like approach). We inspected and cleaned block nets before moving to the next unit.

After snorkeling was completed, we electrofished each unit. A total of three electrofishing crews consisting of three people each completed the surveys. Crews were briefed on techniques and safety considerations. We used low frequency pulsed or unpulsed Direct Current (DC) where feasible to reduce the potential for injuring fish. We recorded the waveform and voltage used, starting and ending times, and water temperatures.

Crews completed two upstream passes through each unit, captured all fish, and placed them in live wells along the stream margins. We recorded data by individual pass using two live wells at each fish holding location. Captured fish were anesthetized, measured, and fin clipped. We measured and weighed a subsample of fish to enable us to estimate biomass. We used differential fin clips for each unit (top caudal, bottom caudal, anal, etc.) in an attempt to detect movements through block nets. Fish were released and block nets cleaned before moving to the next unit.

Post-Treatment biological data.-The toxicant application was abruptly terminated in 1998 and we were unable to collect any post-treatment data.

Physical habitat data.-Following fish sampling, we used an abbreviated habitat inventory procedure to measure physical attributes of each unit. We used a tape to measure the centerline of each unit and established transects at 20m intervals. At each transect, we recorded the habitat type, measured wetted channel width perpendicular to the flow, measured mean and maximum depth, and visually classified the substrate into four size classes. We classified habitats as slow (pools) or fast (riffles, pocket-water, runs, or glides) and referred to printed forms to maintain consistency in classifying habitats. We calculated mean depth by measuring the depth at approximately 1/4, 1/2, and 3/4 the channel width and dividing the sum by four to account for zero depth at each bank. We classified the substrate in about a one meter band parallel to the transect into four substrate size classes: fines (< 6 mm), gravel (6-75 mm), cobble (75-150 mm), and rubble (> 150 mm). To measure velocity, we selected a habitat type with relatively uniform flow, placed a rubber ball immediately upstream, and timed its movement over a measured length. We made a rough discharge calculation using channel width, mean depth, and velocity.

In the stream segment between each transect, we counted the number of pools, measured the length of pools, and counted the number of pieces of large woody debris (LWD). Pools were defined as either having a length greater than or equal to the wetted channel width, or occupying the entire wetted width. We recorded the dominant pool forming features in the unit (boulder, LWD, meander, bedrock, beaver dams, etc.). LWD was defined as a piece of wood, lying above or within the active channel, at least 3 m long by 10 cm in diameter. Wood was also recorded as the number of large aggregates (more than four single pieces acting as a single component) or rootwads.

We measured the total length of each unit by summing the number of 20 m transects and adding the length of the final segment. For the entire unit, we measured or estimated the percent cover for each of four cover types (undercut, overhead, submerged, and turbulence). Undercut bank and overhead vegetative cover were expressed as a percent of the length of the unit. We measured the length of undercut and overhanging vegetation along each bank. Overhead cover was within 0.5 m of the water surface. Turbulence and submerged cover were expressed as a percent of the surface area of the unit. We defined turbulence as locations where abrupt changes in water velocity occurred near changes in gradient (riffles), near physical obstructions to flow (LWD or boulders), and along irregular shorelines. Submerged cover included large boulders, bedrock, LWD, etc.

To measure water conductivity we collected a water sample, fixed with two drops of $CHCl_3$, and place in a cooler. Conductivities were later measured at the RMRS laboratory. Finally, we retrieve all flagging, removed block nets and recovered the thermographs.

Data analysis.-We compiled physical habitat data at the reach and sampling unit scale. Features including elevation, gradient, sample unit dimensions, depth, velocity, discharge, habitat types, cover, and substrate were summarized. We also summarized the underwater visibility and water conductivity by sampling unit. Hourly thermograph records were used to calculate maximum, minimum, and mean water temperatures during the sampling period.

Number of salmonids observed or captured during snorkel and electrofishing surveys were summarized by sampling unit, We calculated the number of fish counted by snorkeling and captured by electrofishing by size class. We used the CAPTURE program (White et al. 1982, Rexstad and Burnham 1991) to calculate population estimates for electrofishing surveys based on fish captured during multiple passes. We estimated the density of salmonids >70 mm by relating total number counted by snorkeling or the total population estimate derived from electrofishing to the surface area of each unit. Because the toxicant treatment was terminated, we were unable to derive an unbiased estimate of the true population. As an alternative, we assumed the total population estimate (derived by electrofishing) reflected the "true" estimate of the population in each sample unit.

Lengths of fish captured during electrofishing surveys were compiled by 10 mm increments and summarized by sampling unit. We used a scatter plot to illustrate the relationship between weight (W) to the nearest g and length (TL) to the nearest mm of rainbow trout. Linear regression of logarithmically transformed ($\log_{10}$) length-weight data was used to estimate parameters *a* and *b* (Ricker 1975) in the equation

$$logW = a + (b \times logTL)$$

Water clarity can limit a snorkelers ability to reliably detect fish. Palmer and Graybill (1986) observed a significant positive correlation between underwater visibility and numbers of fish observed as visibility increased above 2 m. We evaluated the influence of visibility on the accuracy of our snorkel counts by calculating the percentage of the "true" population estimate (derived by electrofishing as explained above) we observed by snorkeling, and plotting that percentage against the measured underwater visibility. The arcsine square root transformation was applied to the percentage data (Zar 1996).

Results

Physical characteristics of sampling units.-All 1998 sample units were located above 2100 m elevation with reach gradients from 4-10 % (Table 1). Sample units ranged from 36-120 m long and from 1-3 m wide. Average depths were shallow and ranged from 6-28 cm and average maximum depths from 10-65 cm. Riffles were the most common habitat type and boulders the dominant pool forming features. The frequency of pools was highly variable; pools comprised from 12-70 % of the sample unit lengths. Undercut banks were common but not abundant as only five units had more than 20% of their length supporting undercuts. Overhanging vegetation was abundant, particularly in the tributaries. Surface turbulence did not exceed 20% in any units and submerged cover was highly variable, ranging from 10-80 %. Large wood was present in 12 units but uncommon in most. Rubble was the most dominant substrate followed by fines, gravel, and cobble.

Underwater visibilities were poor in Cherry Creek and tributaries, ranging from 0.5-1.7 m (Table 2). Conductivities ranged from 63-87 Umhos/cm. Water temperatures averaged 12-16 °C. Maximum temperatures exceeded 20 °C in a few units and minimum temperatures less than 10 °C were uncommon.

Snorkel counts.-Snorkelers observed rainbow trout (*Oncorhynchus mykiss gairdneri*) in fifteen of twenty sample reaches (Table 3). Three of the units where no trout were observed had underwater visibilities from 0.5-0.6 m (Table 2). Total numbers of trout observed ranged from one to 22 at densities ranging from 0.7-14.8 trout per 100 m^2. Most trout were small; roughly equal numbers were observed in the 70-99 mm and 100-199 mm size classes.

Electrofishing surveys.-We captured rainbow trout in eighteen of twenty sample units (Table 4). Total numbers of trout captured were highly variable and ranged from one to 51 at densities ranging from 0.7-30.5 trout per 100 m^2. Most captured trout ranged from 100-199 mm and few exceeded 200 mm. Calculated population estimates were within one fish of the total catch in all units.

A total of 373 rainbow trout were captured, measured, and marked during electrofishing surveys (Table 5). Numbers of fish by 10 mm length increments suggest multiple age classes in the population. Captured trout ranged from young-of-the-year less than 70 mm to one fish larger than 270 mm.

A scatter plot of length-weight data illustrated a curvilinear relationship; as fish became longer, weight increased at a more rapid rate (Figure 2). The length-weight relationship was best described by the equation $\log W = -4.925 + (2.993 \times \log TL)$. The coefficient of determination (r2) equaled 0.99 for the logarithmically transformed ($\log_{10}$) length-weight data. Standard errors equaled 0.0358 for *a* and 0.0238 for *b*.

Underwater visibility influenced the percentage of fish observed, but the relationship was not linear (Figure 3). Although the percentage of fish observed increased as underwater visibility increased from 0.5 to 1.2 m, the relationship was less clear as visibilities increased above 1.6 m.

We observed adult spotted frogs (*Rana pretiosa*) in several sampling units during snorkeling and electrofishing surveys.

Discussion

We were able to meet two of our four objectives: 1.) To compare the probabilities of detecting salmonids in small streams using different sampling methods; and 3.) To provide the project cooperators (Montana Fish Wildlife, and Parks (MFWP), Turner Enterprises (TE), the U.S. Fish and Wildlife Service (USFWS), and the U.S. Forest Service) with site specific information to describe pre-treatment fish species composition, density, size structure, and biomass. As a result of the termination of the toxicant application, we were unable to meet two objectives: 2.) To compare the detection probabilities with presence/absence and population abundance estimates derived from an unbiased estimate of the true population after toxicant application; and 4.) To provide accurate post-treatment estimates of the effectiveness of the eradication project.

As a result of the poor visibilities we encountered in the sample sites, snorkeling was not a reliable method for assessing fish population abundance. Minimum visibilities from 1.5-4 m have been recommended by a variety of researchers (Griffth et al. 1984; Zubick and Fraley 1988; Hillman et al. 1992). Thurow (1994) noted that the water must be clear enough to view the substrate in the deepest pools and to detect fish trying to avoid the snorkeler. He suggested minimum visibilities of 3-4 m in small streams. None of the visibilities we measured exceeded 1.7 m and visibilities in twelve of 20 units were less than 1 m.

Despite our failure to meet objectives 2 and 4, data we collected on the physical characteristics of the streams and the density, size structure, and biomass of the trout population may prove useful for future native trout introduction efforts. If a decision is made to proceed with the eradication of non-native trout in the future, we look forward to working with the project cooperators to meet all of our stated objectives. Based on our 1998 results, we would likely confine our comparison of sampling methods to stream reaches with underwater visibilities exceeding 3 m.

Acknowledgments

Dedicated people from a variety of agencies and sources made this work possible. The following personnel completed the fish and habitat sampling: Mike Jakober and Chuck Dentino-Bitterroot NF; Glenn Boltz and Jerry Big Eagle-USFWS; Stan Vansickle, Dan Downing, and Kris Whitaker-Lewis-Clark NF; Pat Clark and Greg Gibbon-MFWP; and Chris Seal and Jason Pete-LC Staffing. Pat Clancey and Brad Shepard-MFWP assisted with logistical considerations and acquisition of crews and equipment. Chris Francis-TE assisted with logistics, provide access to sampling areas, established catered meals, and provided camping facilities. Kevin Duffy and David Meyer-TE further assisted with logistical considerations. We also thank Rick Torquemada-Bitterroot NF, Mike Enk-Lewis-Clark NF, and Lynn Kaeding-USFWS for providing hard working and efficient field personnel.

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Table 1. – *Physical dimensions and characteristics of reaches and sampling units in the* Cherry Creek, Montana drainage, August 9-12, 1998.

Physical dimensions and characteristics	Cherry Creek								
	1	2	3	4	5	6	7	8	9
Sample Date	08/09/98	08/11/98	08/11/98	08/11/98	08/11/98	08/10/98	08/10/98	08/10/98	08/09/98
Reach Elevation (m)	2106	2121	2128	2134	2143	2193	2202	2204	2216
Reach Gradient (%)	9.8	9.8	9.8	9.8	9.8	4.2	4.2	4.2	4.2
Length (m)	71.3	88.6	118.0	96.9	116.2	90.7	36.6	89.9	91.5
Average Width (m)	2.97	2.26	3.83	2.72	2.33	1.64	1.35	1.82	1.83
Area (m2)	212.11	200.24	399.23	263.57	271.13	147.60	49.41	163.79	167.26
Average Depth (m)	0.137	0.091	0.058	0.109	0.068	0.142	0.104	0.281	0.228
Average Maximum Depth (m)	0.250	0.186	0.135	0.268	0.165	0.240	0.175	0.648	0.440
Average Velocity (m/s)	0.347	0.242	0.219	0.237	0.277	0.353	0.059	0.143	0.143
Average Discharge (m3/s)	0.069	0.048	0.042	0.037	0.037	0.021	0.011	0.012	0.012
Number of Habitat Types	2	2	2	2	3	3	2	2	2
Dominant Habitat Type	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle	Riffle
Dominant Pool Forming Feature	*Boulder*	*Boulder*	*Boulder*	*Boulder*	*Boulder*	*Meander*	*Meander*	*Meander*	*Boulder*
Total Length of Pools (m)	29.40	11.10	16.10	24.00	53.40	32.30	14.90	63.10	36.05
Unit Length in Pools (%)	41.23	12.53	13.64	24.77	45.96	35.61	40.71	70.19	39.39
Unit Length in Undercut Banks (%)	3.72	1.69	3.77	4.13	4.52	27.01	11.15	23.25	15.90
Unit Length in Overhead Vegetation (%)	14.58	33.24	3.52	2.84	2.41	19.29	43.10	17.29	30.27
Unit Area in Surface Turbulence (%)	20	15	15	15	15	0	5	10	10
Unit Area in Submerged Cover (%)	30	15	25	25	30	10	20	30	80
Large Wood Pieces in Unit	3	1	12	6	18	0	0	0	0
Density of Large Wood (#/m2)	0.014	0.005	0.030	0.022	0.066	0.000	0.000	0.000	0.000
Surface Fine Sediment (%)	11.0	15.0	27.0	17.0	17.5	36.0	75.0	13.0	20.0
Surface Gravel (%)	15.0	15.0	11.0	16.0	19.0	25.0	15.0	52.0	14.0
Surface Cobble (%)	15.0	23.0	23.0	17.0	27.5	26.0	5.0	20.0	22.0
Surface Rubble (%)	59.0	47.0	39.0	50.0	36.0	13.0	5.0	15.0	44.0

Table 1. – Extended.

Physical dimensions and characteristics	Cherry Creek			Trib 20.8			Trib 21.8				Trib 22.8
	10	11	12	1	2	3	1	2	3	4	1
Sample Date	08/10/98	08/09/98	08/09/98	08/09/98	08/09/98	08/10/98	08/10/9[illegible]	08/11/98	08/11/98	08/10/98	08/09/98
Reach Elevation (m)	2231	2233	2249	2150	2164	2173	2201	2207	2219	2222	2245
Reach Gradient (%)	4.2	4.2	4.2	9.7	9.7	9.7	7.8	7.8	7.8	7.8	7.2
Length (m)	74.1	117.0	96.4	104.2	110.4	121.9	114.0	79.2	122.0	81.8	92.2
Average Width (m)	2.16	1.76	1.22	1.44	1.32	1.40	1.30	1.22	1.28	1.07	1.20
Area (m2)	159.87	205.73	117.61	150.05	145.36	170.66	148.20	97.02	156.56	87.93	110.64
Average Depth (m)	0.176	0.099	0.085	0.065	0.060	0.060	0.085	0.065	0.092	0.076	0.070
Average Maximum Depth (m)	0.340	0.178	0.150	0.138	0.111	0.101	0.164	0.135	0.186	0.165	0.132
Average Velocity (m/s)	–	0.143	–	0.298	0.239	0.209	–	0.181	–	–	–
Average Discharge (m3/s)	–	0.017	–	0.019	0.009	0.013	–	0.017	–	–	–
Number of Habitat Types	2	2	2	2	3	3	2	3	2	2	2
Dominant Habitat Type	Pool	Riffle	Riffle	Pool	Riffle	Pool	Riffle	Riffle	Pool	Riffle	Riffle
Dominant Pool Forming Feature	Boulder	Boulder	Boulder	Boulder	Boulder	Meander	LWD	Boulder	Boulder	Boulder	Boulder
Total Length of Pools (m)	26.60	27.40	36.80	18.40	25.70	22.50	29.30	14.10	26.60	31.70	33.70
Unit Length in Pools (%)	35.89	23.42	38.17	19.08	23.27	18.45	25.70	17.80	21.80	38.75	36.55
Unit Length in Undercut Banks (%)	17.75	5.68	28.53	3.45	5.03	3.97	12.72	8.21	25.82	18.34	32.81
Unit Length in Overhead Vegetation (%)	76.38	45.68	34.23	15.36	30.93	24.61	29.82	22.09	55.73	29.34	29.28
Unit Area in Surface Turbulence (%)	10	10	0	20	10	5	0	0	0	10	10
Unit Area in Submerged Cover (%)	80	80	30	15	15	20	80	80	80	80	60
Large Wood Pieces in Unit	0	0	0	5	5	2	3	0	2	1	1
Density of Large Wood (#/m2)	0.000	0.000	0.000	0.033	0.034	0.012	0.020	0.000	0.013	0.011	0.009
Surface Fine Sediment (%)	12.5	15.9	25.0	22.6	22.5	17.0	40.0	7.6	15.9	20.0	39.0
Surface Gravel (%)	5.0	8.3	26.0	30.8	44.2	49.0	20.0	26.2	18.3	21.3	24.0
Surface Cobble (%)	10.0	8.3	26.0	18.3	10.0	14.0	18.0	31.2	28.3	28.7	20.0
Surface Rubble (%)	72.5	67.5	23.0	28.3	23.3	20.0	22.0	35.0	37.5	30.0	17.0

Table 2.- Underwater visibility, conductivity, and water temperatures measured in the Cherry Creek, Montana drainage, August 9-12, 1998.

				Water temperature (degrees Centigrade)				
Stream	Sampling unit	Underwater visibility (m)	Conductivity (Umhos/cm)	# Hourly records	Maximum temperature	Minimum temperature	Average temperature	Percent of records less than 10 C
Cherry Creek	1	0.73	73.6	66	18	11	14	0
Cherry Creek	2	1.09	71.9	66	18	11	14	0
Cherry Creek	3	0.5	71.9	23	17	13	15	0
Cherry Creek	4	0.6	71.9	23	17	13	15	0
Cherry Creek	5	0.53	71.9	23	17	13	15	0
Cherry Creek	6	1.67	74.6	47	23	11	16	0
Cherry Creek	7	1.67	74.6	46	22	10	16	0
Cherry Creek	8	1.67	71.9	46	22	10	16	0
Cherry Creek	9	1.7	73.3	48	19	11	14	0
Cherry Creek	10	1.7	73.3	74	19	10	14	0
Cherry Creek	11	1.7	67.3	74	19	10	14	0
Cherry Creek	12	0.6	67.3	---	---	---	---	---
Tributary 20.8	1	0.9	63.3	67	16	9	12	12
Tributary 20.8	2	0.9	63.3	67	16	9	12	12
Tributary 20.8	3	1.5	63.3	67	16	9	12	12
Tributary 21.8	1	0.8	86.8	44	19	10	14	0
Tributary 21.8	2	0.8	86.8	44	19	10	14	0
Tributary 21.8	3	0.95	86.8	44	19	10	14	0
Tributary 21.8	4	0.95	86.8	44	19	10	14	0
Tributary 22.8	1	0.95	67.3	---	---	---	---	---

Table 3.-Numbers of rainbow trout observed by snorkeling in the Cherry Creek, Montana drainage, August 9-12, 1998.

Stream	Sampling unit	Number of trout counted by size class					
		Trout <70 mm present (+)	70-99 mm	100-199 mm	200-299 mm	Total >70 mm	Density #/100 m2
Cherry Creek	1	-	0	1	1	2	0.94
Cherry Creek	2	-	1	2	0	3	1.49
Cherry Creek	3	-	0	0	0	0	0
Cherry Creek	4	-	0	0	0	0	0
Cherry Creek	5	-	1	2	0	3	1.11
Cherry Creek	6	+	5	6	2	13	8.81
Cherry Creek	7	-	2	2	0	4	8.09
Cherry Creek	8	-	11	3	2	16	9.76
Cherry Creek	9	-	5	8	3	16	9.56
Cherry Creek	10	-	3	4	1	8	5
Cherry Creek	11	-	0	3	0	3	1.46
Cherry Creek	12	-	0	0	0	0	0
Tributary 20.8	1	-	0	0	0	0	0
Tributary 20.8	2	-	0	1	0	1	0.68
Tributary 20.8	3	-	0	0	0	0	0
Tributary 21.8	1	-	15	7	0	22	14.84
Tributary 21.8	2	+	2	2	1	5	5.15
Tributary 21.8	3	+	6	1	0	7	4.47
Tributary 21.8	4	-	0	10	1	11	12.51
Tributary 22.8	1	-	1	1	0	2	1.81
Total		3 units	52	53	11	116	

Table 4.- Numbers of rainbow trout captured by electrofishing in the Cherry Creek, Montana drainage August 9-12, 1998.

		Number of trout caught by size class						
Stream	Sampling unit	70-99 mm	100-199 mm	200-299 mm	Total catch	Population estimate	Standard error	Density #/100m2
Cherry Creek	1	0	4	2	6	6	0.72	2.82
Cherry Creek	2	0	2	2	4	4	0	1.99
Cherry Creek	3	0	3	0	3	3	0	0.75
Cherry Creek	4	0	8	1	9	9	0.37	3.41
Cherry Creek	5	0	12	1	13	13	0.07	4.79
Cherry Creek	6	6	11	0	17	17	0.15	11.51
Cherry Creek	7	2	6	0	8	8	0.4	16.19
Cherry Creek	8	19	19	0	38	38	0.91	23.2
Cherry Creek	9	9	40	2	51	51	0.6	30.49
Cherry Creek	10	1	27	0	28	28	1.21	17.51
Cherry Creek	11	3	35	3	41	41	0.68	19.92
Cherry Creek	12	0	2	1	3	3	0	2.55
Tributary 20.8	1	0	0	0	0	0	0	0
Tributary 20.8	2	0	1	0	1	0	0	0.68
Tributary 20.8	3	0	0	0	0	0	0	0
Tributary 21.8	1	42	6	0	48	49	1.69	33.06
Tributary 21.8	2	12	14	0	26	26	0.18	26.79
Tributary 21.8	3	16	18	0	34	34	1	21.71
Tributary 21.8	4	9	25	1	35	35	0.28	39.8
Tributary 22.8	1	1	7	0	8	8	0.11	7.23
Total		120	240	13	373	373		

Table 5.- Lengths of rainbow trout captured during electrofishing surveys in the Cherry Creek, Montana drainage, August 9-12, 1998

	Number of trout captured by unit											
	Cherry Creek											
Length range (mm)	1	2	3	4	5	6	7	8	9	10	11	12
< 70 mm	0	0	0	0	0	14	0	0	0	0	0	0
70-79	0	0	0	0	0	1	0	2	0	0	0	0
80-89	0	0	0	0	0	3	0	10	4	0	0	0
90-99	0	0	0	0	0	2	2	7	5	1	3	0
100-109	0	0	0	0	0	3	3	4	5	2	2	0
110-119	0	0	0	0	0	2	0	1	2	0	1	0
120-129	0	0	0	0	3	1	0	1	2	0	4	0
130-139	0	0	0	2	2	2	0	3	3	3	1	0
140-149	0	0	0	0	1	0	0	1	4	9	4	0
150-159	0	0	0	2	1	1	1	3	6	3	5	0
160-169	1	0	2	1	1	1	1	2	10	2	10	0
170-179	1	2	1	0	2	0	1	2	3	4	6	0
180-189	2	0	0	1	1	1	0	2	4	3	0	1
190-199	0	0	0	2	1	0	0	0	1	1	2	1
200-209	1	1	0	1	1	0	0	0	0	0	1	0
210-219	0	1	0	0	0	0	0	0	1	0	1	0
220-229	1	0	0	0	0	0	0	0	0	0	1	1
230-239	0	0	0	0	0	0	0	0	0	0	0	0
240-249	0	0	0	0	0	0	0	0	0	0	0	0
250-259	0	0	0	0	0	0	0	0	0	0	0	0
260-269	0	0	0	0	0	0	0	0	0	0	0	0
270-279	0	0	0	0	0	0	0	0	1	0	0	0
280-289	0	0	0	0	0	0	0	0	0	0	0	0
290-299	0	0	0	0	0	0	0	0	0	0	0	0
Total > 70 mm	6	4	3	9	13	17	8	38	51	28	41	3

Table 5. – Extended.

	Number of trout captured by unit								
	Trib 20.8			Trib 21.8				Trib 22.8	
Length range (mm)	1	2	3	1	2	3	4	1	Total by size class
< 70 mm	0	0	0	1	5	0	0	1	21
70-79	0	0	0	11	3	1	0	0	18
80-89	0	0	0	22	3	5	6	1	54
90-99	0	0	0	9	6	10	3	0	48
100-109	0	0	0	0	1	1	1	0	22
110-119	0	0	0	2	1	4	2	3	18
120-129	0	0	0	1	3	4	2	1	22
130-139	0	0	0	0	2	2	2	0	22
140-149	0	0	0	1	3	2	3	1	29
150-159	0	0	0	1	1	0	5	2	31
160-169	0	1	0	0	2	3	5	0	42
170-179	0	0	0	0	0	2	3	0	27
180-189	0	0	0	1	1	0	0	0	17
190-199	0	0	0	0	0	0	2	0	10
200-209	0	0	0	0	0	0	0	0	5
210-219	0	0	0	0	0	0	0	0	3
220-229	0	0	0	0	0	0	1	0	4
230-239	0	0	0	0	0	0	0	0	0
240-249	0	0	0	0	0	0	0	0	0
250-259	0	0	0	0	0	0	0	0	0
260-269	0	0	0	0	0	0	0	0	0
270-279	0	0	0	0	0	0	0	0	1
280-289	0	0	0	0	0	0	0	0	0
290-299	0	0	0	0	0	0	0	0	0
Total > 70 mm	0	1	0	48	26	34	35	8	373

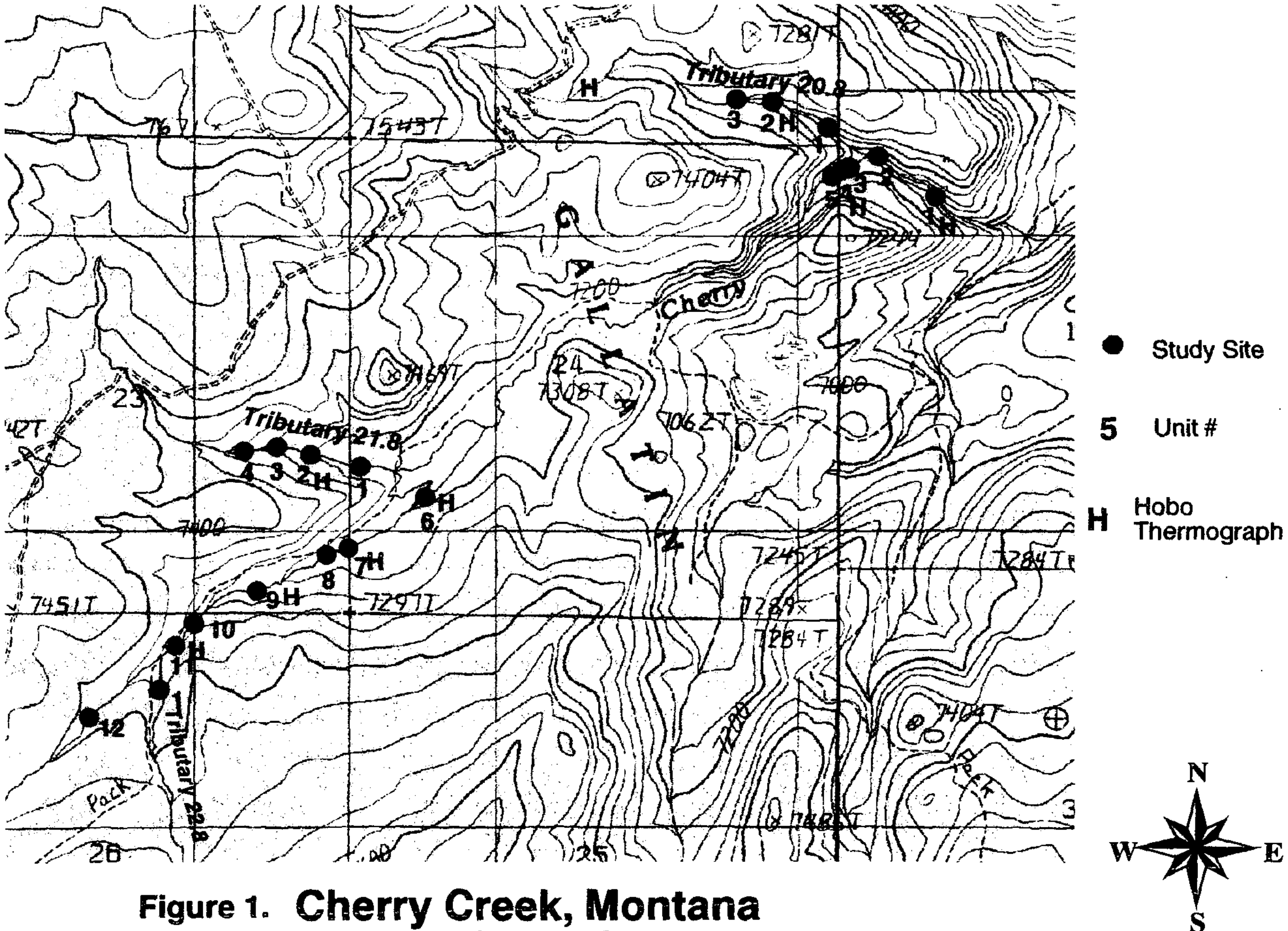

Figure 1. Cherry Creek, Montana 1998 Study Sites

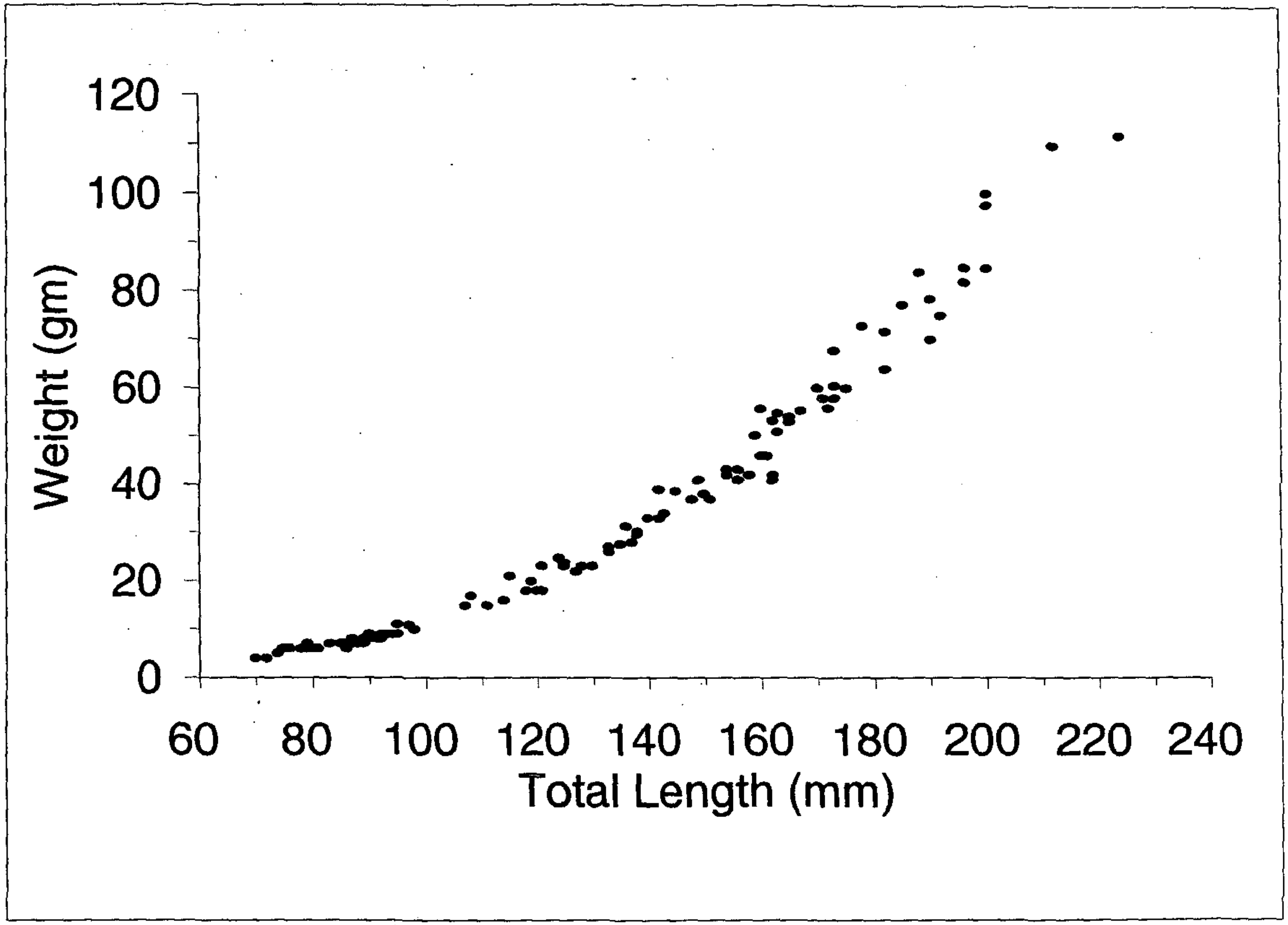

Figure 2. Scatter plot of weight versus length of 120 rainbow trout sampled in the Cherry Creek, Montana drainage, August 9-12, 1998.

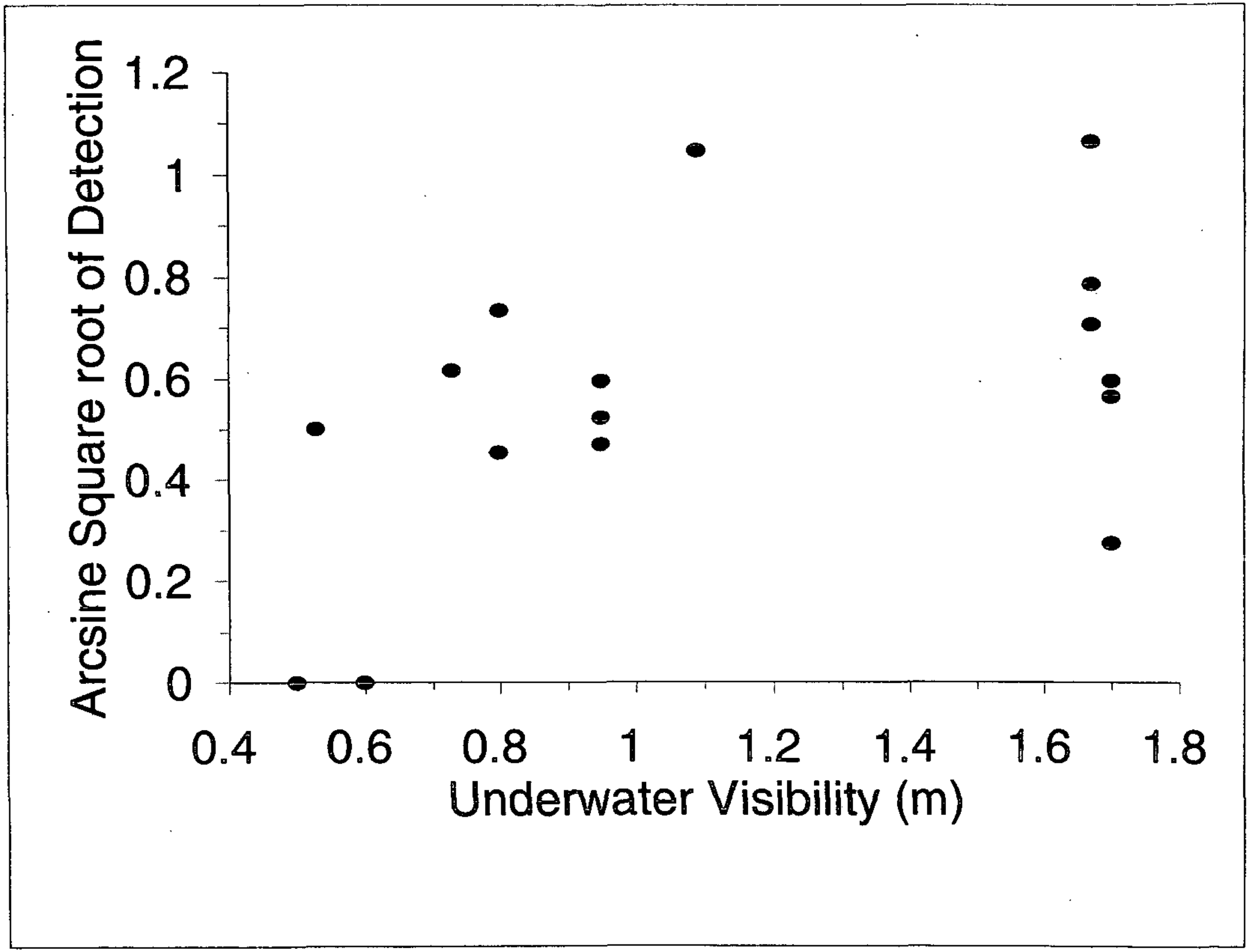

Figure 3. Plot of the arcsine square root of detection (number observed by snorkeling/the "true" population number) versus underwater visibility.