Literature review of aquatic and recreational resources at Mystic Lake Hydropower Project No. 2301

Mystic Lake, Montana

PPL Montana

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Executive Summary

PPL Montana is the owner of the Mystic Lake and Reregulating Reservoir Project on West Rosebud Creek, Stillwater County, Montana. PPL Montana desired a report that summarizes the existing information about aquatic resources and recreational use at Mystic Lake. GEI Consultants, Inc. (GEI) was hired by PPL Montana to prepare this report.

The geographic area covered by this report includes those waters that could potentially be affected by PPL Montana's Mystic Lake project including West Rosebud Creek from Mystic Lake downstream to the confluence with Fiddler Creek. Three lakes are located within this reach, Mystic Lake, West Rosebud Lake, and Emerald Lake. The report summarizes the available literature on fisheries, zooplankton, water quality, and recreational uses in the project area.

Section 1 – Introduction

PPL Montana is the owner of the Mystic Lake and Reregulating Reservoir Project on West Rosebud Creek, Stillwater County, Montana. PPL Montana desired a report that summarizes the existing information about aquatic resources and recreational use at Mystic Lake. GEI Consultants, Inc. (GEI) was hired by PPL Montana to prepare this report.

1.1 Project Description

The geographic area covered by this report includes those waters that could potentially be affected by PPL Montana's Mystic Lake project including West Rosebud Creek from Mystic Lake downstream to the confluence with Fiddler Creek (Figure 1.1-1). Three lakes are located within this reach, Mystic Lake, West Rosebud Lake, and Emerald Lake. West Rosebud Creek drains an area of 213.4 miles square (552 km square) on the north side of the Beartooth Mountain Range. There are 84 lakes in the West Rosebud Creek drainage, 14 of which are outside of the designated Wilderness Area, including all three of the lakes covered in this report (Marcuson and Poore, 1991). Mystic Lake is the largest lake in the drainage.

Mystic Lake is a natural lake that was enlarged in 1936. At the new outlet of the lake is a concrete arch-type dam 368 feet (112 m) long and 45 feet (13.7 m) high with a spillway 300.5 feet (91.6 m) long at an elevation of 7,670 feet (2,339.3 m) with provision for 6-foot 1.8 m) long stoplog sections. The current reservoir is approximately 1.75 miles (2.8 km) in length and occupies 446 acres (180 ha). It has a usable storage of 20,800 acre-feet (25,656,800 m^3), with a maximum drawdown of 61 feet (18.6 m) (MPC, 1968).

Water is diverted from the lake through a tunnel with a cross section of 6 feet by 7 feet (1.83 m by 2.1 m) for a distance of approximately 1,000 feet (305 m) where previously the tunnel was joined by a wood stave pipe 56 inches (142 cm) in diameter, which then carried the water 9,000 feet (274 m) around a mountainside to a point above the powerhouse. This wood stave pipe has subsequently been replaced by steel pipe. A Johnson surge tank is located at the end of the pipe. From this point a steel penstock 48 inches (122 cm) in diameter and 2700 feet (823 m) long conducts the water to the powerhouse located on the west bank of West Rosebud Creek (MPC, 1968).

The powerhouse, located approximately 2 miles (3.2 km) downstream of Mystic Lake is at an elevation of 6,545 feet (1,996 m). It is a reinforced concrete structure 60 feet (18.3 m) wide and 85 feet (26 m) long which houses two Pelton waterwheels, each rated at 7500 hp at 300 rpm under a head of 1,050 feet (320 m). The Pelton type water wheels are mounted directly on a flange end of the generator shaft. There are two Westinghouse generators; each rated 6250 KVA at 0.8 power factor, 3 phase, 60 cycle, 300 rpm, 6600 volts. The exciters, motors,

transformers, and switchgear are also located in the powerhouse (MPC, 1968). West Rosebud Lake, a regulating reservoir, is situated one mile downstream of the powerhouse.

The plant is rated at a nameplate capacity of 10,000 KW with a maximum capacity of 11,500 KW, and generates, on average, about 52,500,000 KWH (MPC, 1968). Maximum flow through the powerhouse is 164 cfs (4.64 m^3/sec) (MPC, 1985).

1.2 Methods

Information for this report was gathered from the literature and from data sources on the Internet. Montana Fish, Wildlife, and Parks was contacted for fish data. They responded by sending both published reports and unpublished file data. PPL Montana also provided unpublished file data. Discharge data were retrieved from the U.S. Geological Survey website. Other habitat, fish, and recreation data were retrieved from the Natural Resources Information System (NRIS) website and the Mansfield Library at the University of Montana. We also used maps, photographs, and project drawings provided by PPL Montana and in the public domain.

Section 2 – Existing Habitat Conditions

2.1 Mystic Lake

2.1.1 General Description

Mystic Lake is approximately 90 miles (145 km) southwest of Billings, Montana. It is surrounded by the Absaroka-Beartooth Wilderness on three sides. A three-mile (4.8 km) hiking trail through non-wilderness U.S. Forest Service lands provides access to the lake.

Mystic Lake is located in a high mountain canyon and has a maximum pool elevation of 7,673.5 feet (2,340 m) and a minimum pool elevation of 7,612 feet (2,322 m). Under the terms of the license dated October 1962, the licensee was to maintain a minimum water surface elevation of 7663.5 feet (2337.4 m) from July 1 to September 15 each year. This is referred to as the recreational pool elevation. In April 1985, MPC filed an application for amendment of license for Mystic Lake Water Power Project, requesting that the dates for the minimum recreation pool level be modified to between July 10 and September 15. This amendment was granted. Currently, the lake can fluctuate 10 feet (3 m) between recreational pool level and full pool level between July 10 and September 15. The 2002 elevation summary is depicted in Figure 2.1.1-1.

Prior to 1926, Mystic Lake was a natural body of water occupying 342.5 surface acres (138.7 ha). In 1926 MPC built a dam, adding approximately 104.15 surface acres (42.2 ha) (Schollenberger, 1984). Today, at the full pool elevation of 7,673.5 feet (2,340 m), Mystic Lake occupies 446.65 acres (181 ha). At low pool, elevation 7,612 feet (2,322 ha), the lake occupies approximately 1/3 fewer acres (Marcuson and Poore, 1991). Maximum depth at full pool is 205 feet (61.3 m) (Marcuson and Poore, 1991). The majority of the Mystic Lake shoreline is moderate to steep slope. Roughly 62% of the shore has greater than a 5% gradient (MPC, 1985). The Mystic Lake outlet is located at a depth of 60 feet (18.3 m) below full pool (Pickett, PPL Montana, personal communication, March 24, 2003).

Six tributaries drain into Mystic Lake: West Rosebud, Fish, Huckleberry and three unnamed creeks. Marcuson (1976) arbitrarily assigned identification numbers 7, 8, and 10 to the three unnamed Mystic Lake tributaries (Schollenberger, 1984).

2.1.2 Temperature

Temperature profiles in Mystic Lake were measured from June 15, 2002 to September 19, 2002. The average daily temperature profile, measured every five days, at one hour intervals

is plotted on Figures 2.1.2-1 and 2.1.2-2. Dates of temperature logger installation and removal are in Figure 2.1.1-1. In mid-June the lake is nearly isothermal at between 5 and 6°C. As the lake warms in June, stratification begins. By June 30, the epilimnion warms to approximately 10°C, while the hypolimnion remains at 6°C.

In 2002, the warmest water temperatures at the surface were recorded on July 20. On that date the surface water temperature exceeded 61° F (16°C). The hypolimnion on July 20 was less than 45° F (7 °C). On this date there was a strong thermal gradient throughout the depth of the lake, even within the epilimnion, indicating a lack of mixing of the water column. After July 20, the temperature of the epilimnion began to cool and this layer became more isothermal. A strong thermal gradient (thermocline) continued to separate this layer from the hypolimnion below (Figure 2.1.2-2). In August and September, the epilimnion was isothermal and extended to a depth of about 40 feet (12 m). As the epilimnion cooled during September, the depth of that layer increased to about 60 feet (18 m). In 2002 the last temperature profile was measured on September 19. On this date the epilimnion extended to about 60 feet (18 m) in depth and had cooled to about 54° F (12°C). Fall turn over begun, but was not complete.

The hypolimnion exists at depths below 80 feet (24 m). This layer warms slightly from June through August, but stayed below 45 °F (7° C) during the summer of 2002.

Water temperature recorders were installed in the inlet and outlet (60-foot (18 m) depth) of Mystic Lake in the summer of 2000 (Figure 2.1.2-3). The inlet recorder was installed in the stream between Mystic Lake and Island Lake. The outlet recorder was installed in Mystic Lake at the outlet pipe. Diurnal water temperature fluctuations are more extreme in the inlet than in the outlet. Inlet water temperature often fluctuates about 3 – 4° F (2-3°C) between day and night, whereas outlet water temperature fluctuates about 2° F (1 ° C).

The average daily water temperature in the inlet and outlet are compared in Figure 2.1.2-4. Mystic Lake dampens water temperature fluctuations seasonally as well as diurnally. Outlet water temperature is less affected by short-term weather conditions than inlet water temperature, as there is less day to day variation in temperature. Temperature of the outlet water may be just slightly warmer (< 1° F (0.5°C)) than inlet water during late July through mid- August. In late August and early September, outlet water is about 2° F (1 °C) warmer than inlet water.

Also in June 2000, DO and temperature profiles were taken at two locations in Mystic Lake, in the upper and lower lake (Figure 2.1.2-5). The upper lake was just over 40 feet (12 m) deep; the lower lake was about 140 feet (43 m) deep. Temperature of the upper lake was warmer than the lower lake by less than 2 °F (1°C). The dissolved oxygen was the same at both sites. These data indicate that the most significant difference between the upper and lower lake is the depth of the water, but that water temperature and DO are similar.

As shown in Figure 2.1.2-6 and 2.1.2-7, there is year-to-year variation in the rate at which water temperatures warm in Mystic Lake. On June 27, 2001, surface water temperature was nearly 54^{o} F (12 ^{o}C), whereas the surface temperature on the same date in 2002 was just over 46^{o} F (8 ^{o}C). Water temperature data collected on nearly the same date in August on two different years show surface temperatures to be almost 4^{o} F (2^{o}C) different. Year-to-year variations in weather conditions no doubt result in varying limnological conditions.

2.1.3 Dissolved Oxygen

Dissolved oxygen (DO) measurements taken along a depth profile in Mystic Lake on three dates in 2000 indicate that DO declines as water temperature increases between June and August (Figure 2.1.3-1). However, DO in the hypolimnion remains at nearly the same level as DO in the epilimnion in August in spite of the strong thermal stratification that is present at that time. This is indicative of the oligotrophic nature of Mystic Lake. In oligotrophic lakes, DO in the metalimnion and hypolimnion remain essentially at saturation after the spring turnover, in spite of the lack of circulation once stratification has occurred.

In September, DO declines with depth, although it remains above 6.5 ppm at all depths. By September oxidative processes in the hypolimnion have depleted DO, in comparison to DO levels in the epilimnion. However, there is no evidence that Mystic Lake becomes anaerobic at any depth and DO should not be limiting to juvenile and adult salmonids, even at the deepest depths.

Although there is year-to-year variation in water temperature at Mystic Lake, the June DO profiles for 2000 and 2001 were nearly identical (Figure 2.1.3-2). Because of the low productivity of the water, Mystic Lake appears to stay at or near saturation at least until September. This is probably true in almost all years. Only one year of data was found for DO in September, so it was not possible to compare September DO profiles across years.

2.1.4 pH and Conductivity

Conductivity in Mystic Lake is extremely low, with conductivity readings between 20 and 30 æS/cm at all dates and depths measured by PPL Montana. Marcuson and Poore (1991) found somewhat higher conductivity at Mystic Lake with a reading of 35 mhos. The date of their data collection of chemistry at Mystic Lake is unknown. Conductivity is a measure of the resistance of a solution to electrical flow. The resistance of water to an electrical current is reduced with increasing content of ionized salts. Therefore, low conductivity is reflective of water with a low concentration of ionized salts.

Low conductivity results in low levels of productivity in the lake due to the lack of nutrients. Low conductivity also means that the lake is poorly buffered. That is, there is a lack of the

ions needed to resist change in pH in the event that hydrogen or hydroxyl ions are added to the water.

The pH at Mystic Lake is near neutral and ranges from approximately 7 to 8 with higher pH values generally occurring near the surface, probably as a result of photosynthetic uptake of carbon dioxide in the surface waters. Marcuson and Poore (1991) found somewhat lower pH at Mystic Lake with a reading of 6.7.

2.1.5 Discharge and residence time

The useable storage at Mystic Lake is 20,800 acre-feet (25,656,800 m^3) (MPC, 1968). This is the volume of water between full pool elevation and minimum pool elevation, a 60-foot (18 m) elevation difference. GEI Consultants, Inc. estimated the total volume of Mystic Lake in order to calculate approximate residence time.

Assuming that Mystic Lake has a maximum depth of 205 feet (62 m) at full pool (Marcuson and Poore 1991), then maximum depth of the lake at minimum pool is 145 feet (44 m). If the lake were rectangular in cross section, this would be approximately 48,000 acre-feet (59,208,000 m^3) of water. However, the lake is not rectangular, it is probably more similar to a triangular shape in cross section. Therefore, the volume of the lake at minimum pool is approximately 24,000 acre-feet (29,604,000 m^3). The total volume of the lake at full pool is the usable volume plus the volume at minimum pool or, very approximately, 44,000 acre-ft (54,274,000 m^3).

The average annual discharge of West Rosebud Creek downstream of the powerhouse is 123 cfs (3.48 m^3) (USGS, 2003). Therefore, the residence time of the lake at full pool and at average discharge is 180 days. Longer residence times in lakes increase the potential productivity of the lake because nutrients are retained for a longer period of time, allowing phytoplankton to grow and support the food web. Residence times longer than 30 days are generally required to support phytoplankton (Scholz, Eastern Washington University, personal communication, April 22, 2003).

2.2 West Rosebud Creek

2.2.1 West Rosebud Creek from Mystic Lake to the powerhouse (bypass reach)

The portion of West Rosebud Creek upstream the powerhouse has a watershed area of 52 miles square (135 km^2) (MPC, 1979). Streamflow in this section of West Rosebud Creek was measured at a weir just upstream of the powerhouse and read daily by the Mystic plant operators. Because this measuring site is upstream of the powerhouse, it does not reflect

flows through the powerhouse. During the 1929 – 1977 period of record (Figure 2.2-1) the average annual flow at this site was 34 cfs (0.9 m^3/sec) (MPC, 1979). The highest mean monthly flow was in July (211 cfs, 5.97 m^3 /sec) and the lowest mean monthly flow occurred from January through April (3 cfs, 0.8 m^3 /sec). Spill over Mystic Lake Dam generally occurs for about a seven week period in mid-summer (MPC, 1979).

West Rosebud Creek has a gradient of 10% between Mystic Lake and the powerhouse, a distance of about 2 miles (3.2 km) (MPC, 1985). This section of West Rosebud Creek passes through a deep canyon with steep walls of granitic rock. Numerous small, unnamed creeks, many of which are temporary, collect snowmelt waters from high elevations (MPC, 1979).

The stream is characterized by numerous small waterfalls and deep pools. Few riffles are present in the upper reaches. The channel contains large, angular boulders. Numerous natural barriers exist on the stream, which prevent upstream migration of fish. A major barrier occurs about 1,798 feet (548 m) above the powerhouse where a long cascading slope prevents upstream movement of fish. Numerous other barriers consisting of 6.5 – 10 foot (2 -3 m) waterfalls occur in the upper portion of the stream extending for 0.9 mi (1.5 km) below Mystic Dam (MPC, 1979).

The 1976 FERC license for Mystic Lake included a provision that required MPC to determine and recommend a schedule of instream flows in West Rosebud Creek between the project dam and the powerhouse to protect and enhance the fishery resource of the creek. The instream flow studies began in 1977 with the establishment of eight transects in the bypass reach. An attempt was made to use the water surface profile program to develop a stage discharge relationship for these transects. Analytical results were unreliable and did not agree with subsequent field methods. The high gradient and turbulent nature of the bypass reach required alternative field methods (MPC, 1979).

The Oregon method was subsequently selected for determination of minimum instream flow. In this case, the decision was made that if streamflow were sufficient for fish passage, then depth and velocity criteria for spawning, incubation, and rearing would also be met. The Oregon method defines minimum streamflow for fish passage as that flow which meets the depth criterion (0.4 feet (0.1 m) for trout) on at least 25% of the total width of the stream, and at least 10% of the usable width must be continuous. Total width in this study was defined as the wetted width, which corresponds to the average daily flow, 34 cfs (0.96 m^3/sec)(MPC, 1979).

To determine minimum passage flows, six transects were established in June 1978. Transects were placed in broad, shallow, reaches of the stream, which were believed to be critical to passage of large fish, and were placed perpendicular to the direction of flow. Discharge was measured on six occasions over the next year. Discharge was plotted against

width for all profiles and averaged to produce one curve per transect. Then, the stream width necessary to meet the depth criterion on at least 25% of the total width was determined. The flow recommendation generated by the above methods was applied only to the low flow months of September through May. A flow recommendation for the summer months was based on judgment of the biological and physical needs of the stream organisms (MPC, 1979).

The study concluded that a minimum flow of 3 cfs (0.08 m^3 /sec) is appropriate for the months of September through May. This flow agrees closely with the recommended minimum flow of 3.4 cfs (0.09 m^3 /sec) calculated by the Montana method, which recommends 10% of mean flow as a "minimum flow to sustain short term survival habitat for most aquatic life forms" (MPC, 1979).

Greater streamflows are desired for the summer months. Much of the annual growth of trout and aquatic insects, the food supply for stream dwelling trout, takes place in the summer months in response to warmer water temperatures. A minimum flow of 10 cfs (0.28 m^3 /sec) was recommended for the summer months. The average stream width at 3 cfs (0.08 m^3 /sec) is 23.2 feet (7.1 m). An increase of 75% of the stream width is realized by increasing the flow to 10 cfs (0.28 m^3 /sec) (MPC, 1979).

MPC anticipated that meeting the minimum instream flows would require supplemental water to be released from the pipeline at some times. A valve was installed near the upstream end of the pipeline, that can be controlled at the powerhouse, to release water into the stream when needed to meet instream flows (MPC, 1979).

The instream flow study report also commented that the difference between winter and summer flows in this reach of stream is extreme, as it is for many alpine streams. However, the sudden high flows, caused by spill over the dam, creates an unknown degree of stress for the stream organisms. The first spill creates, on average, a sudden 800% increase in streamflow. It comes at a time when trout fry are present. It can dislodge trout fry, riffle insects, and destroy beaver dams and lodges, if any are present. Such surges are mimicked in other, unimpounded streams, on very warm spring days, perhaps to a lesser degree (MPC, 1979).

Efficient plant operation can reduce the peak of the spill discharge by increasing generation in advance of snowmelt. Although this is common practice, its success is limited by unpredictable changes in snowpack and weather conditions. The storage reservoir can fill at a rate 2 to 3 feet (0.6 – 0.9 m) a day in the period prior to spill even if the plant is generating a maximum capacity. At the time the instream flow report was written, the license called for Mystic Lake to reach recreational pool level by July 1. This has subsequently been changed to July 10. By delaying the date of attaining the recreational pool level by 10 days, the level of peak flows in the bypass reach are reduced in some years (MPC, 1979).

2.2.2 West Rosebud Creek from the powerhouse to West Rosebud Lake

West Rosebud Creek has a gentler gradient of 3% between the powerhouse and West Rosebud Lake (MPC, 1985).

Streamflow statistics for West Rosebud Creek below the powerhouse have been maintained by the U.S. Geological Survey since 1965. The mean annual flow of West Rosebud Creek near Roscoe (below the powerhouse but upstream Emerald Lake) is 123 cfs (3.5 m^3 /sec), based on the 1966 to 2000 period of record. Average daily flow in West Rosebud Creek is depicted in Figure 2.2-1 (USGS, 2003).

Montana Fish, Wildlife and Parks holds instream flow water rights to West Rosebud Creek. The amount of water reserved is listed by month in Table 2.2.2-1. The rights have a priority date of December 15, 1978 (NRIS, 2003).

2.3 Emerald Lake

Emerald Lake has a surface area of 33.7 surface acres (13.6 ha) and sits at an elevation of 6,396 feet (1,950 m) in the Beartooth Mountain Range of Montana (NRIS, 2003). The maximum depth of the lake is 7 feet (2.1 m)(Marcuson and Poore, 1991). It is located entirely on public lands managed by the Custer National Forest. The lake is accessible by a maintained forest road. It is considered to be oligotrophic and is not known to winter kill (NRIS, 2003).

Using the same procedure as for Mystic Lake, we calculated a very approximate residence time assuming 34 surface acres (13.6 ha), a maximum depth of 7 feet (2.1 m), a triangular profile, and 123 cfs (3.5 m^3 /sec) average outflow. Based on these numbers, Emerald Lake has a total storage of 119 acre-feet (146,786 m^3) and an average residence time of 11.7 hours.

2.4 West Rosebud Lake

West Rosebud Lake is operated as a reregulating reservoir for the Mystic Lake Hydroelectric project. The dam on West Rosebud Lake was built in 1978 (FWP, 1994). West Rosebud Lake has a surface area of 19 acres (7.6 ha), sits at an elevation of 6,387 feet (1,948 m), and has a maximum depth of 6 feet (2 m)(Marcuson and Poore, 1991). It is located 100% on public lands managed by the Custer National Forest. The lake is considered to be oligotrophic and is not known to winter kill (NRIS, 2003).

Using the same procedure as for Mystic Lake, we calculated a very approximate residence time assuming 19 surface acres (7.6 ha), a maximum depth of 6 feet (2 m), a triangular

profile, and 123 cfs (3.5 m^3 /sec) average outflow. Based on these numbers, West Rosebud Lake has a total storage of 57 acre-feet (70,309 m^3) and an average residence time of 5.6 hours.

Section 3 – Zooplankton

Zooplankton often provide an important food resource for salmonids in lentic systems. In the lakes of the study area, rainbow trout are the species of greatest interest to anglers. Zooplankton often make up a substantial portion of the diet of rainbow trout. Although rainbow trout consume a wide array of prey organisms, many populations of rainbow trout in lakes and reservoirs feed primarily on large zooplankton, particularly those greater than 0.05 in (1.3 mm) total length (Galbraith, 1967).

Calanoid and cyclopoid copepods are one type of zooplankton that occupy a significant intermediate position in aquatic food chains, are usually omnivorous in habit, and when possible, tend to be food selective. A wide variety of foods have been found in copepod guts including algae, pollen, detritus, bacteria and rotifers (reviewed by Sandercock and Scudder, 1994). For these reasons, the abundance and composition of zooplankton populations in the study area lakes are of interest to fisheries managers.

3.1 Mystic Lake

Montana Fish, Wildlife and Parks sampled zooplankton in Mystic Lake on three occasions in 1976, on March 18 and 19 and August 19. Results are displayed in Table 3.1-1. Zooplankton samples were also taken in 1983 and 1984.

The primary species of large zooplankton was *Diaptomus shoshone. D. shoshone* has been described as omnivorous, consuming both algae and other small species of *Diaptomus* (Anderson, 1967; Wong, 1984). Calanoid copepods such as *D. shoshone* have been reported to be a food source for cyclopoid copepods, for chironomid insect larvae, Chaoborus sp. and for juvenile fish (reviewed by Sandercock and Scudder, 1994).

Mystic Lake also had *Holopedium gibberum*, a large cladoceran, which may reach 0.08 in (2.2 mm) in length in these waters. *H. gibberum* numbers were not enumerated with the numbers of zooplankton or the numbers of large zooplankton in Table 3.1-1. However the volumetric measurement reflects everything in the tow sample (Marcuson and Poore, 1991). *H. gibberum* is a very distinct organism relative to other cladocerans. The organism ranges from approximately 0.05 – 0.08 in (1.5-2.2 mm) in length for females and 0.01 - .02 in (0.5-0.6 mm) for males. *H. gibberum* prefer mainly cool, oligotrophic, soft water lakes with low pH (4.8-7.5). It may be found in some "hard" water situations. They may be found in both littoral and pelagic regions of the lake (CMU, 2003).

H. gibberum is an omnivore. The organism filters mainly phytoplankton, and in some cases it has been found to consume mostly nannoplankton. A "T" shaped gap in the transparent mantle on the organisms ventral surface allows it to take in filtered food. *H. gibberum* seems to be adapted to survival in areas where food is scarce. The organism undergoes a diurnal

migration each day. *H. gibberum* moves towards the surface near sunset and returns to deeper waters during daylight hours. The gelatinous mantle may aid the organism in this migration (CMU, 2003).

The timing of the zooplankton development in Mystic Lake differed in 1983 and 1984 (Schollenberger, 1984). Copepod nauplii and juvenile cladocerans were observed in 1983 from late June to mid-July. By mid-July, adult forms of *H. gibberum* appeared in vertical tows. Nauplii and juveniles were not present in late July samples. In 1984, *D. shoshone* and *H. gibberum* were first observed in late June, approximately 2 weeks earlier than in 1983. Early developmental stages of both copepods and cladocerans were also present. In mid-July the adult forms of both species predominated the sample (Schollenberger, 1984).

PPL Montana sampled zooplankton in Mystic Lake on two occasions in both 2000 and 2001. Results are depicted in Tables 3.1-2 and 3.1-3. Although the zooplankton density estimates from 2001 and 2002 are significantly higher than those reported in Marcuson and Poore (1991), this might be an artifact of different sampling protocols. Marcuson and Poore (1991) do not detail their zooplankton sampling methods, thus making comparisons difficult. However, the more recent samples did not pick up any *H. gibberum* although the samples were consistent in their detection of *D. shoshone*.

Zooplankton provide food for fish in these lakes. The relationship between zooplankton and fish is discussed further in section 4 of this report.

3.2 Emerald Lake

Montana Fish, Wildlife and Parks sampled zooplankton in Emerald Lake on July 19, 1979. Results are displayed in Table 3.1-1 (Marcuson and Poore, 1991). No large zooplankton were identified. The relationship between zooplankton and fish is discussed in section 4 of this report.

3.3 West Rosebud Lake

Montana Fish, Wildlife and Parks sampled zooplankton in West Rosebud Lake on July 19, 1979. Results are displayed in Table 3.1-1 (Marcuson and Poore, 1991). No large zooplankton were identified. The relationship between zooplankton and fish is discussed in section 4 of this report.

Section 4 – Fisheries Resources

4.1 Mystic Lake

According to information presented in Marcuson and Poore (1991), rainbow trout were first planted in Mystic Lake by a forest ranger by the name of Harry Kaufman in 1909. These fish were brought in on horseback via the East Rosebud-Mystic Trail. The fish were supplied by the National Fish Hatchery in Bozeman. Montana Fish, Wildlife and Parks (FWP) also stocked rainbow trout into Mystic Lake between 1946 and 1951 (Marcuson and Poore, 1991).

In addition to rainbow trout, Mystic Lake contains a few mountain whitefish. Cutthroat trout may also have been present historically. Although the falls below the dam appears to be a fish passage barrier, it is thought that these species were likely present in the lake prior to the construction of Mystic Lake Dam in 1936. There is no direct evidence that cutthroat were native to the lake, however the presence of mountain whitefish argues that the lake was not historically fishless. Mountain whitefish were not generally stocked, and were rarely used as bait (Marcuson and Poore, 1991). According to the University of Montana Genetics Database, trout currently in Mystic Lake are introgressed Yellowstone cutthroat and rainbow trout.

Gill nets set in Mystic Lake in August 1984 found an average of 23 rainbow trout per net with an average length of 10.3 inches (261 mm). They were found to be a self-sustaining population (Marcuson and Poore, 1991).

Gill nets set in Mystic Lake prior to 1980 captured an average of 28 rainbow per net with an average length of 9.3 inches (236 mm) and an average weight of 0.32 lbs.(145 g) (Marcuson, 1980). Length at age of rainbow trout in Mystic Lake in 1983 and 1984 is displayed in Table 4.1-1.

4.1.1 Spawning in Mystic Lake

Major rainbow trout spawning areas in Mystic Lake are at the west end of the lake in the West Rosebud full-pool inlet, in Creek #10 above the full pool elevation, and in the low-pool confluence area of Huckleberry and West Rosebud creeks (Figure 4.1-1). The rainbow trout spawning period in Mystic Lake is early to mid-June (Schollenberger, 1984).

Rainbow trout spawning in the area of Creek #7, Creek #8, and Fish Creek was found to be negligible, probably because of a lack of suitable spawning habitat and coldwater temperatures. At the confluence of these tributaries with Mystic Lake, the tributaries tumbled down steep, exposed shoal areas, making fish movement into them difficult. In addition,

June and July water temperatures in Creek #7, Creek #8, and Fish Creek were between 30 – 42^{o}F (-0.5 - 6^{o} C)(Schollenberger, 1984). The optimum water temperature needed to induce rainbow trout to spawn is between 50 – 55^{o}F (10 – 13^{o} C) (Piper et al., 1982). Cold water temperatures may have discouraged spawning in these tributaries (Schollenberger, 1984). In contrast, water temperature in Huckleberry Creek, Creek # 10, and West Rosebud Creek were between 44 – 53 ^{o} F (7 – 12 ^{o}C) during that same time period (Schollenberger, 1984).

Schollenberger (1984) made weekly counts of rainbow trout using spawning areas in Mystic Lake in 1983 and 1984. He found that the West Rosebud Creek full-pool inlet was used by 55 percent of the total observed spawners in 1983 and 61 percent in 1984. The Creek #10 inlet was used by 24 percent and 21 percent of the spawners in 1983 and 1984. The remainder of the spawning activity took place at the Huckleberry-West Rosebud Creek confluence. Spawning fish were observed from early June until early July (Schollenberger, 1984).

Dissolved oxygen sampling of the spawning gravels in Mystic Lake found that DO met or exceeded the 5 ppm minimum required for healthy egg development at the substrate surface and at 6 inches (152 mm) below the surface. The DO at 10 inches below the surface declined to below 5 ppm in late July and August (Schollenberger, 1984).

The incubation period for rainbow trout eggs in the West Rosebud full pool inlet was approximately 34 days. The incubation period in the confluence of Huckleberry and West Rosebud creeks was longer, at 44 days (Schollenberger, 1984).

An experiment was conducted placing bags of rainbow trout eggs in the gravel to test hatching success. It was found that 60 percent of the eggs in the middle and lower stations in the West Rosebud full pool inlet either hatched or were well developed in the eyed egg stage. Egg bags placed at a lower station had lower success, 20 percent, possibly because the site had been disturbed. Egg bags placed in the Huckleberry – West Rosebud Creek spawning area had between 0 and 23 percent hatching success (Schollenberger, 1984). No reason for the lower hatching success at the Huckleberry - West Rosebud spawning area is given in the report.

4.1.2Rainbow trout food habits and behavior

Rainbow trout food habits were reviewed in 1983 and 1984 (Schollenberger, 1984). Aquatic and semi-aquatic insects were the preferred food item in June of both years when fish were in tributary streams selecting spawning sites. In mid-July, Diptera larvae and pupae were the dominant food group. In 1983, copepod nauplii and juvenile cladocerans and adult forms were also observed in mid-July. In 1984, only adult zooplankton were present in the diet in mid-July. By late August when rainbow trout were distributed throughout the lake, adult zooplankton were the dominant food item (Schollenberger, 1984).

In 2002, PPL Montana traversed Mystic Lake in a boat and recorded the depths of fish using a depth sounder on five different dates. On June 14, when the lake was still isothermal and water temperature was below 43° F (6 °C), fish were widely distributed at depths between 20 feet (6 m) and 110 feet (33 m) (Figure 4.1-2). The average depth of the 39 fish detected was 65 feet (20 m) on that date. Based on information in Schollenberger (1984) it is likely that adult rainbow trout were spawning at this time, presumably in shallow areas near tributaries. On September 20, the lake was still stratified, however the epilimnion had cooled to about 54° F (12 °C). On this date, fish seemed to avoid the surface and the bottom, but were relatively evenly distributed between depths of 40 and 80 feet (12 – 24 m) (Figure 4.1-2). The average depth of the 83 fish detected was 62 feet (19 m) on that date.

In between these two dates, depth distributions were monitored three times (Figure 4.1-3). During the mid-summer time period fish appear to move to progressively deeper depths. By August 6, fish seem to be concentrated at depths between 70 and 80 feet (21 – 24 m), with a moderate numbers at depths between 40 and 70 feet (12 – 21 m). The average depth of the 111 fish detected was 54 feet (16 m) on that date. On this date the epilimnion water temperature was 59° F (15°C), extending to a depth of 40 feet (12 m). Overall, it appears that fish in Mystic Lake move to deeper water in the mid-summer months (July and August). Two explanations are possible: thermal preference and food supply.

Zooplankton distribution is a factor that could influence fish distribution. Some species of zooplankton are known to migrate vertically on a diurnal cycle. Therefore, time of day can influence the distribution of zooplankton in the water column. It is possible that fish are also moving in response to movements of zooplankton, their prey base. Sampling of fish occurred only during daylight hour, thus it is not possible to know whether trout were making diurnal movement associated with food.

4.1.3 Impacts of hydropower operations on rainbow trout

In 1982, MPC requested a variance to their license to delay the date of refill (to the recreational pool level) of Mystic Lake, from July 1 to July 10. Under the earlier refill date power generation was lost in 19 out of 50 years because reduced generation was needed in June to refill the reservoir by July 1. By extending the refill date to July 10, increased generation (over 38,000 megawatt hours over a 50 year time period) is possible (MPC, 1985).

A study was initiated in response to concerns that the delay of refill could affect rainbow trout spawning movement into tributaries and interfere with the life cycle of zooplankton. Schollenberger (1984) reviewed the refill schedule of Mystic Lake and potential impacts on rainbow trout in two years, an early refill year and a late refill year. He found trout movement into spawning areas was not affected by the delayed refill of Mystic Lake.

Spawning rainbows were confronted with equal low pool water conditions and subsequent rising water levels as the lake approached the recreational pool elevation in both study years. Use of all three spawning areas was similar in both years. Attainment of the recreation pool did not affect water levels in the West Rosebud full pool inlet or in the Creek #10 spawning area. Access into both these areas was adequate in both years (Schollenberger, 1984).

The Huckleberry-West Rosebud confluence area was inundated with lake water before the recreational pool was attained in both years. Despite flooding of this area, 23 percent of the rainbow trout eggs in the egg incubation stations hatched. Observed spawners imprinting on this spawning areas implies that rainbow tout eggs deposited there in the past have developed and hatched (Schollenberger, 1984).

The time of adult zooplankton appearance in Mystic Lake was not significantly different in the two study years (MPC, 1985).

Schollenberger (1984) concluded that the rainbow trout population of Mystic Lake is abundant and self-sustaining, and that past operation of the power plant has not threatened the fishery. He further concluded that delaying the refill of Mystic Lake from July 1 to July 10 would not have a significant impact on the rainbow trout fishery of Mystic Lake (Schollenberger, 1984).

In 1985, MPC applied for an amendment of the license to permanently modify the date when the recreational pool level is attained from July 1 to July 10. The application was granted.

4.2 West Rosebud Creek

4.2.1 West Rosebud Creek bypass reach from Mystic Lake Dam to the powerhouse

Fish were collected in August 1977 at three sections within this bypass reach of West Rosebud Creek. Section #1 began at the mouth of Maxie Creek and extended upstream 1,059 feet (323 m). Section #2 began 600 feet (183 m) below the footbridge and extended 882 feet (269 m) upstream. Section #3 extended from the upper weir 1,752 feet (534 m) upstream. Sections # 1 and #2 were also sampled in May 1978 (one pass estimate) and Section #3 was sampled (one pass estimate) in October 1977. Average flow in this reach of West Rosebud Creek in May 1978 was 16 cfs (0.4 m^3 /sec) and in October 1977 it was 5 cfs (0.14 m^3 /sec) (MPC, 1979).

A number of events dictated the termination of further fish sampling. Spill flows did not occur in 1977, a unique event for the Mystic project. Consequently, average monthly flows in June and July 1977 were 16 and 14 cfs (0.4 and 0.3 m^3/sec), as compared to a 1929 – 1977 average monthly flow of 95 and 211 cfs (2.7 and 6 m^3 /sec) for those months. In

addition, the pipeline to the powerhouse collapsed on May 2, 1978, introducing an unknown quantity of silt to the stream below the break. During the resulting plant outage, higher than normal flows occurred as a result of spill over the dam, which began on June 23, 1978 and continued to February 1979 when pipeline repairs were complete. The unusual flow conditions of 1977 and 1978 caused unknown effects to the trout populations below the reservoir. Further estimates of fish populations would likely be unrepresentative of the normal conditions; therefore further sampling was not conducted (MPC, 1979).

Rainbow trout were the only species of fish collected in sections #1 and #2. Both brown and rainbow trout were found in section #3. Two fish in section #1 were identified as rainbow cutthroat trout hybrids, but were treated as rainbow trout for the purposes of calculations (MPC, 1979). Population estimates are given in Table 4.2.1-1. Section #2 had the highest numbers of trout, but section #3 had the greatest biomass. No marked fish were recaptured in sections other than the section where they were originally marked, indicating little movement between sections (MPC, 1979).

Rainbow trout collected in this study ranged in length from 2 – 12 inches (50 – 298 mm) and in weight from 0.01 – 0.55 lb (5 to 250 g). Brown trout collected in this study ranged in length from 2 – 14 inches (50 – 360 mm) and in weight from 0.01 – 0.88 lb (3 to 400 g). Average condition factors are given in Table 4.2.1-2. Relatively few young-of-the-year and Age 0 brown trout were collected. Most brown trout in section #3 were between 8.8 – 14 inches (225 and 350 mm). Rainbow trout had higher mean condition factors, indicating that they are heavier per unit length (MPC, 1979).

Of the rainbow trout collected in section #1 in August 1977, 38% were recaptured in May 1978. This suggests that over winter survival in this section is relatively high. Section #1 contains large, deep pools, which may provide good over winter habitat. Of the rainbow trout collected in section #2 in August 1977, only 5% were recaptured in May 1978. It is possible that rainbow trout either died or moved out of this section in between sampling periods, although they were not found in either of the other sampling sections. The majority of section #2 is broad riffles with fast flowing water, with only occasional large pools. The lack of pool habitat may result in lower over winter survival (MPC, 1979).

Brown trout collected in October 1977 were ripe for spawning. However, as mentioned above, few young fish were collected. This may imply that this reach of stream is not good brown trout juvenile rearing habitat (MPC, 1979). A 4.5 foot (1.3 m) lower weir is present downstream of the powerhouse. Although fish have been sighted jumping the lower weir, it is thought that this weir is an impediment to upstream fish passage, limiting access for fish from West Rosebud Lake from accessing the reach of stream above the weir (MPC, 1979). No brown trout have been found in Mystic Lake or the upstream sections of the bypass reach.

4.2.2 West Rosebud Creek from Emerald Lake to Fiddler Creek

On October 28, 1983, FWP electrofished two sections of West Rosebud Creek downstream of Emerald Lake. One section began 0.25 miles (402 m) below Emerald Lake and extended for 1,000 feet (300 m) downstream. Capture efficiency was not measured, but was noted by the sampling team to be low due to swift water conditions. Fifty-two brown trout were collected, of which 50 were between 3.2 – 12.5 inches (81 – 317 mm). Most of those in the 8 – 12 inch (203 – 305 mm) range were ripe males or gravid females. FWP concluded that these fish were resident fish in the stream (FWP unpublished file data, 1983).

There were two brown trout collected that were 19.7 and 17.9 inches (500 and 454 mm) in length. Both were females in near spawning condition. The 17.9 inch (454 mm) fish had been previously tagged in the Yellowstone River 2.6 miles downstream of Columbus, at least 30 miles (48 km) downstream from where it was recaptured. At the time of tagging (3/21/1983) it was 15.1 inches (383 mm) and 0.90 lbs (408 g) (FWP unpublished file data, 1983). Therefore it grew 2.8 inches (71 mm) in 221 days, or 0.013 inches (0.3 mm) per day between initial marking and recapture. It had also moved from the Yellowstone River into the Stillwater River and then upstream into West Rosebud Creek in that time period.

Several other large brown trout were observed in the sampling section, but not captured. FWP concluded that these large fish were all migratory brown trout that had come from the Yellowstone River (FWP unpublished file data, 1983).

The second 1983 electrofishing section went from the bridge at the Pine Grove Campground 1000 feet (300 m) upstream. Again, capture efficiency was not measured but was noted by the sampling team to be quite low. Thirteen brown trout (4.5 – 15.1 inches, 114 – 383 mm) along with one rainbow trout (6.8 inches, 173 mm) were collected (FWP unpublished file data, 1983).

The conclusions of this sampling were that this reach supports a resident brown trout fishery as well as providing a spawning area for migratory brown trout from the Yellowstone River (FWP unpublished file data, 1983).

The 1,000 foot (300 m) section below Emerald Lake was sampled again April 5, 1984. A total of 55 brown trout were collected with an average length of 8.4 inches (213 mm) (length range 4.4 – 12.2 inches, 112 – 310 mm), confirming the presence of a resident brown trout fishery in this reach. In addition, two possible rainbow trout were observed, 12 inches (305 mm) and 16 inches (406 mm) (FWP unpublished file data, 1984).

Ages of brown trout were estimated from scales collected in the October 1983 sampling. Of the 52 fish in the sample, two were believed to be migratory fish from the Yellowstone River. These fish were estimated to be Age 3 (19.7 inches, 500 mm) and Age 4 (17.9 inches, 454

mm). Another seven brown trout were suspected to have been lake residents that had moved downstream into West Rosebud Creek because of the wider spaced circuli observed on their scales. These fish had an average length of 11.6 inches (295 mm) and were all estimated to be Age 3. The average length-at-age of the remaining fish was as follows: Age 0, 3.2 inches (81 mm); Age 1, 5.4 inches (137 mm); Age 2, 7.0 inches (178 mm); Age 3, 8.6 inches (218 mm); Age 4, 9.5 inches (241 mm), Age 5, 10.2 inches (259 mm) (FWP unpublished file data, 1984). In comparison to the median calculated total length at age for brown trout in streams in the United States, these brown trout are smaller and slower growing (Carlander, 1969). Growth can be affected by a variety of factors including water temperature and food supply. No data have been found that identify the cause of the slow growth in these brown trout. The suspected lake resident brown trout had faster growth rates than the stream resident brown trout.

In 1986, 1994, and 1998 a 7,900 foot (2,409 m) section of West Rosebud Creek was sampled from the Pine Grove Campground to the McKay Ranch (Figure 4.2.2-1). This section is near the Custer National Forest boundary near where the stream leaves the steep Beartooth Mountain face. Fishing pressure within this section, particularly on the upstream end near the campground, is relatively heavy (Poore, 2000). Current Montana fishing regulations in the Stillwater River and tributaries are two trout daily, only one over 13 inches (330 mm). High fishing pressure can affect population densities.

In 1986 brown trout longer than 5 inches (127 mm) were estimated to be 947 fish/mile (1,523 fish/km). Fish over 13 inches (330 mm) composed 6% of the sample (Poore, 1987). In 1994 there were estimated to be 1,164 brown trout larger than 5 inches (127 mm) per mile (1,873 fish/km) (FWP, 1997). The 1986 and 1994 samples were collected in the fall. In 1998 FWP switched to spring estimates to provide a better estimate of the numbers of resident brown trout, without influence from migratory brown trout that enter the section in the fall for spawning. The 1998 spring brown trout population estimate was 901 brown trout over 5 inches (127 mm) per mile (1,449 fish/mile) (Poore, 2000). The most notable change in brown trout numbers over time has been the large number of Age 1 and 2 brown trout in the 1994 sample (Figure 4.2.2-1). Numbers of brown trout found in the 1986 sample was very similar to the numbers found in 1998, despite the change in seasons of sampling.

In addition, in 1998 rainbow trout were estimated at 107 fish per mile (172 fish/km). Due to the low numbers of recaptured fish, the estimate is not statistically reliable. Rainbow trout in the sample ranged from 4.5 – 17.2 inches (114 – 437 mm). In addition, 13 brook trout and one Yellowstone cutthroat trout were collected during electrofishing (Poore, 2000).

4.3 Emerald Lake

Emerald Lake contains a mixed population of brown trout, brook trout, mountain whitefish, and longnose suckers. The FWP stocked rainbow trout into Emerald Lake from the

Yellowstone River Trout Hatchery (Big Timber) most years beginning in 1931 (Marcuson and Poore, 1991), with limited success (Poore and Frazer, 1990). From 1986 through 1989, approximately 2,400 McBride cutthroat were stocked in an effort to produce a self-sustaining fishery (Poore and Frazer, 1990). This species was selected because it had done well in other moderate to high elevation lakes located in the Beartooth Mountains (Fredenberg and Poore, 1989). Growth and survival of McBride cutthroats was poor (Poore and Frazer, 1990). DeSmet strain rainbow trout were selected to replace McBride cutthroat and 1,500 were planted each year from 1990 to 1995. Beginning in 1996, 1,800 Arlee strain rainbow trout have been planted each year, with the exception of 1997 when McBride cutthroat were substituted. The plants are spread over three time periods from late May through late July (FWP, 2000). Fish stocking history (since 1990) is presented in Table 4.3-1.

Gill nets set in Emerald Lake in May 1990 found an average of 13 brook trout, 1 cutthroat trout, 28 brown trout, 13 mountain whitefish, and 1 longnose sucker per net. All species except cutthroat trout were found to be self-sustaining populations. The longnose sucker were the largest fish with an average length of 14.3 inches (363 mm). Cutthroat trout (1 fish) was the smallest at 8 inches (203 mm) (Marcuson and Poore, 1991).

Gill nets set in Emerald Lake from 1996 – 2001 took no cutthroat and only two rainbows (Table 4.3-2). Electrofishing in a section of West Rosebud Creek located three miles downstream from Emerald Lake in the spring of 1998 took one cutthroat trout (Section 4.2). Brown trout and brook trout were more abundant in the nets than rainbow and cutthroat trout. The smallest fish sampled during the period was a 6.9-inch (175 mm) brown trout. Overwinter survival of planted DeSmet and Arlee strain rainbow trout was poor (FWP, 2000).

Montana Fish, Wildlife and Parks believe that brown trout are preying on stocked fish and all other small fishes in the lake. This, they believe, is the explanation for the lack of small fish in this lake and also West Rosebud Lake. They are moving to stocking larger sized rainbow in an attempt to reduce brown trout predation on hatchery fish and increase angler enjoyment of the lake.

4.4 West Rosebud Lake

West Rosebud Lake contains a mixed population of brown trout, brook trout, mountain whitefish, and longnose suckers. The FWP stocked rainbow trout from the Yellowstone River Trout Hatchery in Big Timber most years beginning in 1931 (Marcuson and Poore, 1991). Rainbow trout plants from 1955 to 1985 were judged to be a limited success (Poore and Frazer, 1990). McBride cutthroat were stocked in West Rosebud Lake in the 1980's in an attempt to establish a self- sustaining fishery. For example, in June 1986, 359 18-22 inch (457 – 559 mm) brood stock and 2,448 7.4 inch (188 mm) McBride cutthroat were introduced into the lake. Gillnetting in May 1987 found 10 cutthroat ranging in length from

9.1– 12.1 inch (231 – 307 mm). These fish were an average length of 10.6 inch (269 mm) and were all 2 years old, indicating they had come from the previous year's plant. They had grown an average of 3.2 inch (81 mm) since stocking almost a year before (Fredenberg and Poore, 1989; FWP unpublished file data). Gillnetting in 1990 also found only small numbers of cutthroat remaining from the previous year's plants (Table 4.4-1). These plants were judged, "to have failed to achieve the desired management objective" (Poore and Frazer, 1990).

Because of the slow growth and poor survival of stocked cutthroat trout, 2,500 DeSmet strain rainbow trout were planted into West Rosebud Lake each year from 1990 through 1995. Beginning in 1996, 3,000 Arlee strain rainbows were planted each year, except 1997 when cutthroat trout were stocked (Table 4.4-2). These plants were spread over three time periods from late May through late July (FWP, 2000).

Three gill nets set in the spring of 1996 and 1997 took no cutthroat, but in the spring of 1998 three gill nets took 11 cutthroat (9.6 – 12.2 inch (244 – 310 mm) from the 1997 plant. Also taken were 17 rainbows. Brown trout outnumbered rainbows more than 4 to 1. Mountain whitefish and brook trout were the only other species taken in significant numbers (FWP, 2000).

McBride cutthroat have shown poor growth and survival. No evidence of natural reproduction or spawning fish have been found. Survival of DeSmet and Arlee strain rainbow trout has also been marginal, although growth has been better than exhibited by cutthroat (FWP, 2000).

FWP has concluded that the well-established brown trout population crops sub-adult fish of all species in this lake and in Emerald Lake as well. Over time it has been found that larger planted fish have better survival rates than smaller planted fish. It appears that stocked fish must be larger than 8 inches to survive predation from brown trout (FWP, 2000).

Section 5 – Recreational uses associated with Mystic Lake Project

A recreational use study was commissioned by PPL Montana in 2001. The study area was from the Pine Grove Campground, 9 miles (14.5 km) down West Rosebud Road to the Mystic powerhouse. It also included backcountry areas along the Mystic Lake trail, including Mystic Lake itself. The study was conducted from May 26 to September 30, 2001 (American Public Land Exchange and REC Resources, 2002).

It was found that 88 percent of the visitors live in Montana and the vast majority comes from the local region. Visitors from Billings accounted for 63 percent of the recreationists. Visitors were 75 percent male and had an average age of 39. Most visitors (75 percent) were between age 20 and 49. Nearly two thirds of the visitors had visited the area before. Forty two percent of the recreationists used the area for the day, 58 percent spent at least one night. Visitors that had visited the area before were more likely to stay overnight (American Public Land Exchange and REC Resources, 2002).

Of the recreation activities surveyed, camping, fishing, and hiking were the most popular. RVs were used by 17 percent of visitors; car and tents were used in developed areas by 30 percent, and 11 percent camped in the backcountry (American Public Land Exchange and REC Resources, 2002).

Hiking was pursued by 40 percent of visitors. Nearly 75 percent of hikers used the trail from the powerhouse to Mystic Lake or trails at Mystic Lake (American Public Land Exchange and REC Resources, 2002).

Most visitors (92 percent) did not want to see any changes in recreation area facilities or management. Of the visitors that did want change, the most popular changes desired were cleaner or better maintained toilets or better maintained roads (American Public Land Exchange and REC Resources, 2002).

Sixteen percent of visitors reported encountering a problem during their visit. The problems most commonly mentioned were the bad condition of the road, closure of the Mystic Lake trail, flies, and dirty toilets (American Public Land Exchange and REC Resources, 2002).

Ninety percent of visitors reported being very or extremely satisfied with their recreation experience (American Public Land Exchange and REC Resources, 2002).

5.1 Angler use in the project area

Fishing was pursued by 47 percent of visitors in 2001. Anglers were 85 percent male with an average age of 39. As with recreationists in general, anglers came mostly from the local area. Seventy one percent of the recreationists had been to the area before, indicating that recreationists who fish are more likely to return to the area. Anglers were more likely to spend the night than non-anglers, with 66 percent spending at least one night (American Public Land Exchange and REC Resources, 2002).

Anglers reported catching between 0 and 125 fish, with the average being 4.1 and the median being 2. One third of anglers caught no fish. Anglers that caught fish kept an average of 1.5, with the maximum being 12. Almost half of the successful anglers released all their catch, 4 percent kept 6 or more fish (American Public Land Exchange and REC Resources, 2002).

Eighty-two percent of anglers said it was extremely or very important to go fishing. A majority of anglers felt it was not very or not at all important to catch their limit (69 percent), or to catch large fish (59 percent). However, anglers (80 percent) did feel it was very or extremely important to catch at least one fish (American Public Land Exchange and REC Resources, 2002).

Fifty-six percent of anglers reported being very or extremely satisfied with their fishing experience. Successful anglers were more likely to be satisfied with their experience (70 percent). These data was not broken down by location so it is not possible to determine if some project area waters are providing more angling satisfaction than others (American Public Land Exchange and REC Resources, 2002).

As part of the biological analysis performed by GEI, data from the 2001 Recreation Use Study Report conducted by the American Public Land Exchange and REC Resources were used to provide estimates of total season angling usage and to estimate overall catch and harvest rates.

The data were first processed to back calculate when the recreationists were actually at the site. Since the interview day was often the day the recreationists were leaving, and the days they were present were in many cases several days prior to the day the interview was taken, calculations were done to determine when the recreationists were actually present at a particular place. After computing actual recreationist dates, a function was applied to determine whether the recreation person-day was on a weekday, or a weekend. Holidays were counted as, and included in the weekend day set. These data were then used to determine the proportion of weekday to weekend fishing pressure.

During the recreation survey, anglers were not asked the length of time of their fishing trip. Consequently no data were available on the actual length of time fished. In order to calculate pressure and harvest it was necessary to make an assumption about the length of an angler

day. It was assumed that on any given day, an angler would spent a total of four hours of each day fishing in each 24-hour period.

The creel data were compiled and queried to calculate the number of fish caught at each location by size and species. The number of angler hours invested at each site was determined by computing how many days each visitor was present in the study reach. For cases where individuals fished for multiple days at multiple locations, the times spent at each site were distributed evenly across all locations and all days the recreationist was present at the study reach. This enabled an average value to be determined for the number of angler hours required to produce a harvested fish at the various sites.

The projections for the total number of fish caught were determined by calculating the ratio of fish harvested to the number of fish released. Since no data were collected on the size, species and location of fish released, the values used were in the same proportion as those for harvested fish. For example, if 50% of the fish caught at Mystic lake were rainbow trout, 25% were cutthroat trout, and 25% were brown trout, and 100 fish were harvested out of 400 caught, then we would project that a total of 200 rainbow, 100 brown, and 100 cutthroat trout were caught at Mystic lake. This extrapolation was applied at all of the locations delineated in the creel survey. Capture rates at any location were then determined as a function of angler hours expended to calculate how many fish of each species are harvested. The harvest to capture ratio was used to calculate the total number of fish caught at each site.

The base values to determine the catch rates and species and size distributions at the various locations were taken from the harvest data. The species and size distributions of fish caught were also assumed to be equivalent to that for the fish harvested, since no data were available to define the species and size distributions or the locations for fish that were caught but not kept. In addition, the survey did not specify the time and date when the angler harvested a particular fish, so in cases where anglers spent several days in the survey area, it could not be determined when they actually caught the fish. The only information available was that a certain number of total hours spent fishing resulted in a particular number of fish being harvested.

The ratio of anglers to non-anglers was determined from the distribution found among the 935 individuals who were interviewed (approximately 49 to 51% respectively). Using the group size and this proportion, the total number of anglers present during the interview period was calculated. This number of recreationists and anglers then represented 84% of the total number of people present on any given weekend or weekday. The study had concluded that 16% was the rate of drive by for people that did not stop to be interviewed. To obtain the actual number of recreationist hours spent on each day, the total interviewed group time was divided by the value 0.84.

Table 5.1-1 shows the results of the harvest analysis for the interviewed angler group who kept every fish they caught. This computation was carried out in an attempt to characterize the species distribution of the fish that were caught by analyzing the instances where no fish were released.

Table 5.1-2 shows the results of the table created to show the species and location distributions for all harvested fish. In this case, the anglers may not have harvested every fish they caught, but for the fish they did keep, the location information was recorded. Figure 2 was then used as the basis to calculate the number of fish harvested per angler hour spent at each location. Note that no angler ever kept a fish caught in the reach from the Powerhouse to Mystic Lake, so all subsequent projections will also indicate that no fish are being harvested in this reach.

Table 5.1-3 shows the projection distribution of the total fish caught and harvested in each location. From this table, the final distribution of species caught in each location may be extrapolated (for example using Figure 2 proportions with Figure 3 totals). Table 3 was generated using the ratio of fish harvested per unit angler hour spent at each location. The extrapolation of the number caught was determined by comparing the ratio of fish caught to fish kept per unit angler hour. The weekday catch rates vs. the weekend catch rates are functions of the proportion of anglers present on weekdays to those present on weekends.

This analysis should be considered as an approximation of the seasonal angler pressure, catch, and harvest in 2001 in the project area.

5.2 Mystic Lake

Access to Mystic Lake is via the West Rosebud Trail; a three mile long foot trail from the powerhouse to the dam on nonwilderness National Forest System land. Trailhead facilities including rest rooms, garbage facilities, information, and trail register are provided. The Forest Service maintains the trail and recreation facilities (MPC, 1985).

There are no public recreation facilities at the lake. “No trace” camping is encouraged and concentrated on the south shore. A forest Service wilderness guard periodically patrols the area (MPC, 1985).

In the past, the Forest Service issued a special use permit to the Mystic Lake Boating Association to keep motorboat storage lockers adjacent to the Project boundary on the southeast shore. In the past, approximately 10 boats and lockers were stored at the site (MPC, 1985). However, no boats or lockers are presently stored at Mystic Lake (J. Jourdannais, personal communication, May 2003).

The Custer National Forest conducted a recreation use survey on the West Rosebud Trail from 1978 – 1982. The survey instrument was a trailhead electronic eye counter with two actual counts to determine accuracy. Results of the survey are in Table 5.1-4. The Forest Service data indicates total visitation during this time period between 3,400 – 4,600 per year. Between 41 – 48 persons per day were estimated during the month of July for those years. The average duration of stay for day users was 4.9- 5.5 hours. The average overnight stay was 4.0 – 5.1 recreation visitor days. Average group size was 3.5-4.2 persons (Custer National Forest cited in MPC, 1985).

In 1983 and 1984 a recreation use study was conducted between July 1 and July 10. An average of 35.4 persons per day visited Mystic Lake during that study period. It is assumed that these numbers are smaller than the numbers found by the Forest Service in 1978 – 1982 because the study time period was early in July when the weather is less favorable (MPC, 1985).

The recreation surveys show that the majority of Mystic Lake use is day use. Overnight use is generally concentrated on weekends or holidays. The main purpose for visitation to the site is either "catching fish" or "enjoying with family and friends." The primary activities engaged in at Mystic are fishing, hiking, and camping (MPC, 1985). The trail to Mystic is a primary access route to the Absarokee-Beartooth Wilderness and Granite Peak, the highest point in Montana. Almost 40 percent of the respondents in the 1984 survey indicated they visited Mystic in order to access those sites (MPC, 1985).

Most respondents, 93 percent in 1984 and 72 percent in 1983, rated their visit to Mystic Lake as good or better. Weather and fishing success are the two factors that primarily influence the quality of the recreation experience (MPC, 1985).

A creel census from 1966 to 1978 revealed a catch of 1.2 rainbow trout per hour for fly fisherman at Mystic Lake. Bait and lure anglers caught rainbow at a rate of 0.6 and 0.7 fish/hour (Marcuson and Poore, 1991).

The GEI re-analysis of the 2001 recreation data indicates that 18% of anglers in the project area fish at Mystic Lake. Total harvest was estimated at 444 fish and total catch was estimated at 1853 fish for the 2001 season (Table 5.1-3). The anglers who were surveyed reported catching 56% rainbow trout, 23% cutthroat trout, 5% brown trout, 1% brook trout, and 15% other species. This highlights one of the difficulties with creel surveys that rely on self- reporting of angling data. There are no known brown trout or brook trout in Mystic Lake, therefore angler reports of catch of these species probably reflect incorrect species identification.

5.3 West Rosebud Creek

5.2.1 Upper West Rosebud Creek, within Wilderness Area

During the recreation survey in 2001, areas upstream of Mystic Lake were fished by 11 percent anglers in the project area (Table 5.1-3). A total of 61 fish were harvested by the visitors sampled, 27 rainbow trout, 23 cutthroat trout, 3 brown trout, 2 brook trout, and 6 other species (American Public Land Exchange and REC Resources, 2002). However, it should be noted that fish sampling of areas above Mystic Lake has not found brown or brook trout to be present. Anglers probably misidentified these fish. The GEI re-analysis of the data indicates that the approximate seasonal harvest was 282 fish in this area.

A voluntary trailhead creel was conducted on West Rosebud Creek from July 18, 1995 to September 4, 1995. Survey cards were placed at the West Rosebud Creek trailhead for anglers to fill out at the completion of their trip. The response rate was low at 37. Anglers reported fishing an average of 2.37 hours for an overall catch rate of 2.2 fish/hour. Anglers reported keeping 41.7 percent of the fish they caught. The high percentage of rainbow trout in the creel (60 percent) along with the creel card information indicates that most of the fishing pressure is concentrated on the Mystic-Island-Silver Lake complex and interconnecting stream system.

Questions on the survey asked about fishing regulations. Sixty –eight percent felt limits are satisfactory, and 67 percent said limits should be reduced to five fish in some areas. When asked if their latest wilderness trip met their expectations, 85 percent said yes. It should be noted that there were only 20 respondents to this portion of the questionnaire.

5.3.1 West Rosebud Creek between West Rosebud Lake and Mystic Lake

Although a foot trail parallels the stream for about 0.9 mi (1.5 km) above the powerhouse, fishing use of the stream in this area is insignificant. A recreation survey was conducted in 1974 by the Custer National Forest by means of a trail head register. Of 1600 respondents, none indicated their destination and purpose was to fish in West Rosebud Creek between Mystic Lake and West Rosebud Lake (Schaller, 1977, personal communication, cited in MPC, 1979). During the recreation survey in 2001, West Rosebud Creek between West Rosebud Lake and Mystic Lake was fished by 1 percent of anglers in the project area and no fish were harvested.

5.4 Emerald Lake

During the recreation survey in 2001, a total of 123 fish were harvested by the visitors sampled, 56 rainbow trout, 7 cutthroat trout, 46 brown trout, 12 brook trout, and 2 other species (American Public Land Exchange and REC Resources, 2002). This was projected by GEI to represent approximately 680 fish harvested and 2,837 fish caught in the 2001

season. Approximately 1,452 of the fish caught were rainbow or cutthroat trout. In 2001 1,830 rainbow trout were stocked in Emerald Lake. Assuming no carry over from previous year's plants, this means close to 80% of the stocked fish were caught by anglers.

Montana Fish, Wildlife and Parks conducted a creel census on Emerald Lake and West Rosebud Lake in 1995. The census was conducted between July 18 and September 4. Results were reported for both lakes combined (FWP, 2000). During the duration of the creel, the lakes received an estimated 1,001 angler days of fishing pressure. Most of the use on these lakes is by Montana residents, with 90 percent of that use from people living within the three closest counties. Of the 357 people interviewed, those who had fished the lakes before had been fishing them for an average of 14 years (FWP, 2000).

The average number of hours fished per angler was 3.13 for a total of 3,133 hours fished and a catch rate of 0.70 fish/hour. The estimated total catch was 2,192, of which 1,272 were rainbow, 544 brown, 93 cutthroat, 216 brook, 50 mountain whitefish, and 17 other. Anglers released 60 percent of the fish caught and harvested the other 40 percent (FWP, 2000).

Stocked rainbow and cutthroat trout made up 62 percent of the total angler catch, even though brown trout outnumber them over five to one in the previous three years of gill net data. Although brown trout are the most abundant species in these lakes, they are relatively difficult for anglers to catch. Most of the pressure is concentrated on the more easily caught cutthroat, rainbow, and brook trout (FWP, 2000).

Of the 194 return anglers who expressed an opinion, 60 percent felt the fishing had not changed or had improved, while 40 percent felt the fishing had gotten worse. Of the 352 anglers who expressed an opinion, 81 percent were satisfied with their fishing experience, while 19 percent were not satisfied (FWP, 2000).

On June 13, 1995, 6.4 inches rainbow were stocked into these two lakes, 2,423 in West Rosebud Lake and 1,520 in Emerald Lake. Assuming that all the rainbow trout caught during the 1995 creel were stocked in 1995 (no carry over from previous year's plants), this means that anglers caught 33 percent of the stocked rainbow trout during the summer season.

The creel results indicate that 93 cutthroat trout were collected during the census period. The creel census was conducted in 1995, six years after the last stocking of cutthroat trout. It is highly unlikely that cutthroat trout would survive for six years after stocking. The gill net data do not indicate that natural reproduction of either rainbow or cutthroat trout is occurring in these lakes. No gill net data for these lakes for 1995 were found during the preparation of this report, however gill net data from 1996 do not indicate the presence of cutthroat trout. Therefore, these 93 trout were likely other species of trout that were misidentified as cutthroat trout.

The creel survey data for the two lakes were lumped together in the analysis. This makes it impossible to compare angler pressure, catch, and harvest between the two lakes.

Montana conducts a statewide angler survey every other year (every year in the mid-1980's). Results are displayed in Figure 5.3-1. Although fishing pressure appears to have declined in the 1990's in comparison to the 1980's, the error limits to the data have gotten smaller in more recent surveys. The apparent change in angler pressure may not be as large as it appears. Almost all angler use appears to be by residents of Montana (NRIS, 2003).

5.5 West Rosebud Lake

During the recreation survey in 2001, West Rosebud Lake was fished 31 percent of the anglers in the project area. A total of 134 fish were harvested by the visitors sampled, 80 rainbow trout, 1 cutthroat trout, 40 brown trout, 12 brook trout, and 1 other species. GEI estimates that the seasonal harvest was approximately 620 fish with a total catch of 2,586 fish. Of the total fish caught, approximately 1552 were rainbow trout. In 2001, 3002 catchable rainbow trout were stocked in West Rosebud Lake. Therefore, approximately 52 percent of the stocked fish were caught by anglers in 2001.

Brown trout is the most abundant and successful species in this lake. However, brown trout are relatively difficult for anglers to catch. Most of the fishing pressure is concentrated on the more easily caught cutthroat, brook, and rainbow trout (FWP, 2000).

A creel census on West Rosebud and Emerald lakes was conducted in the summer of 1995. Results are summarized in section 5.3.

Montana conducts a statewide angler survey every other year (every year in the mid-1980's). Results are displayed in Figure 5.4-1. In appears that angling use increased in 1999 and 2001, however large statistical confidence limits makes this interpretation uncertain. Most angler use appears to be by residents of Montana (NRIS, 2003).

Section 6 – Study plan 2003

PPL Montana is proposing several aquatic studies in the Mystic Lake area in the summer of 2003. These studies are described below.

6.1 Mystic Lake

No quantitative fisheries sampling has been conducted in Mystic Lake since the mid-1980s. In the summer of 2003 PPL Montana will use hook and line sampling in Mystic Lake in June. Fish collected during this sampling will be weighed, measured, marked, and released. PPL Montana will attempt to mark as many fish as possible so that a mark-recapture population estimate can be calculated.

Later in the summer PPL Montana will attempt to duplicate the gill net sampling that was conducted by Montana Fish, Wildlife, and Parks in 1984 and 1985, to the degree that the previous sampling details can be determined. That is, PPL Montana will attempt to mimic the date of sampling, number of nets set, types of set, locations of net sets, and mesh sizes if that information is available. If it is not available, gill netting will be conducted in August 2003 using sinking research nets with variable mesh sizes.

Fish collected will be weighed, measured and checked for marks. If enough marked fish are recaptured, a mark-recapture population estimate will be calculated. Scale samples and stomach samples will be gathered from a subsample of the fish collected. Scales will be reviewed to determine age and estimate growth of fish. Stomach samples will be analyzed to determine diet.

In addition, zooplankton and phytoplankton will be collected as well as temperature, dissolved oxygen, specific conductance, and turbidity profiles.

6.2 Bypass reach

No up-to-date fisheries information is available for West Rosebud Creek between Mystic Lake and the powerhouse (the bypass reach). In the bypass reach, PPL Montana will attempt to make fish population estimates in the summer of 2003. Very low conductivity makes electrofishing problematic in this stream. Therefore, a hook and line mark recapture estimate will be attempted in the upper reach of the bypass reach. Snorkeling will be used in the lower portion of the bypass reach.

6.3 Downstream lakes

PPL Montana will take zooplankton samples in West Rosebud Lake and Emerald Lake. In addition, PPL Montana would like to collaborate with Montana Fish, Wildlife, and Parks during their periodic gill net sampling of these lakes. If stomach samples could be collected from fish in these lakes it would help in determining what the food base is for rainbow trout and if brown trout are in fact the cause of the low survival of stocked fish.

Section 7 – Cultural Resources

At the request of PPL-Montana (PPLM), Legacy Consulting Services (LCS) completed limited searches of Cultural Resource Management (CRM) sources, potentially applicable to the location and area of the Mystic Hydroelectric Generating Project (Project). The purpose of this search was to identify at least some of the known Cultural Properties in the area and/or on the Project (LCS, 2003).

Previous file searches identified two previously-recorded cultural properties in the area of the transmission lines associated with the Mystic project. The Montana State Historic Preservation Office conducted one search on September 18, 2002 and reported that 24ST35 and 24ST51 are in the project vicinity. Also in mid-September, 2002, a search of records on file with the Custer National Forest (CNF) identified four other Prehistoric Cultural Properties in the vicinity, but all are at least ¾ mile from parcels of land being inventoried as part of compliance requirements by the CNF for proposed upgrades of the Project-associated transmission lines (LCS, 2003).

Properties 24ST35 and 24ST651, are both prehistoric habitation properties adjacent to West Rosebud Creek. The former consisted of lithic debitage, bone, and a piece of ground stone when recorded in 1975. There are no professional reports about the cultural property since that time. Property 24ST651 is located at the inlet for West Rosebud Lake and within 165 feet of the transmission line inventory corridor. It was excavated in the late 1970s, and yielded projectile points dating to all periods of prehistory except Paleo-Indian. The habitation function was tool manufacture and resharpening and possibly wood or bone tool manufacture. The scientific value of 24ST651 is limited by the shallowness and disturbed nature of the sediments and poor preservation (LCS, 2003).

Prehistoric properties in the vicinity were documented in 1990 during an inventory of alpine-zone cultural properties in the Beartooth District of the CNF. All are lithic scatters. Two are located below the high-water level of Mystic Lake and are reported to include fire hearth remnants and formal lithic tools. Property 24ST232 includes a reworked projectile point which is suggestive of a Late Plains Archaic occupation. Property 23ST233, near the opposite end of Mystic Lake from the 2002 inventory area, includes the base of an Early Archaic projectile point. Properties 24ST259 and 24ST260, involve very small collections of lithic debitage. Little more detailed information is recorded for these properties. Additional studies of the two properties reported to be below the high-water level of Mystic Lake could be required as part of the CRM studies for relicensing (LCS, 2003).

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Section 9 – Tables

Table 2.2.2-1. Water reservation for instream flow in West Rosebud Creek from Fiddler Creek to Line Creek. Rights held by Montana Fish, Wildlife and Parks with a priority date of December 15, 1978.

Month	Flow
Jan	38.2
Feb	38.4
March	41.6
April	56.7
May	192.7
June	358.4
July	162
Aug	77.9
Sept	66.9
Oct	59.2
Nov	50.7
Dec	42.8

Table 3.1. Zooplankton in lakes of the project area. Source: Marcuson and Poore, 1991

Lake	Date	Volume of zooplankton (cc/m^3)	Number/m^3 zooplankton	Number of large zooplankton (number/ m^3)	Species of large zooplankton
Emerald	7/16/79	3.83	1340		
West Rosebud	7/16/79	0.48	4786		
Mystic	3/18/76	4.10	1660	415	*Diaptomus shoshone*
Mystic	3/19/76	4.80	360	35	*Diaptomus shoshone*
Mystic	8/19/76	2.87	598		

Table 3.2 Mystic Lake zooplankton density estimates: per m^3 in 2000. All samples vertical tows. Source: PPL Montana unpublished file data

Date, time, distance and depth	8/16/00 1830 hrs 55 ft	8/16/00 QA/QC Sample reanalyzed	9/13/00 1620 hrs 60 ft
Cladocera			
Daphnia schodleri	1857.1	1909.5	3881.6

Date, time, distance and depth	**8/16/00 1830 hrs 55 ft**	**8/16/00 QA/QC Sample reanalyzed**	**9/13/00 1620 hrs 60 ft**
Epiphipial eggs		6.7	
Copepoda			
Diaptomus shoshone	3742.9	4063.8	3960.5
Cyclops sp.	8.6		
"nauplii"			

Table 3.3 Mystic Lake zooplankton density estimates: per m^3 in 2001. All samples vertical tows. Source: PPL Montana unpublished file data

Date, time, distance and depth	**6/27/01 0950 hrs 60 ft**	**6/27/01 1010 hrs 60 ft**	**8/31/01 1000 hrs 75 ft**	**8/31/01 1018 hrs 75 ft**
Cladocera				
Daphnia schodleri	3459.6	2687.7	5460.1	5232.2
Epiphipial eggs			44.1	26.6
Copepoda				
Diaptomus shoshone	2609.6	1750.0	2256.6	4151.0
Cyclops sp.			154.5	106.3
"nauplii"	10856.1	18848.2	132.2	212.6
Rotifera				
Filinia sp.	32210.5	42969.3		
Kellicottia sp.	50.0	30.7		
Keratella sp.		30.7		
Chironomidae				
Chironomimi (first instar)	12.3			

Table 4.1-1. Rainbow trout length at age, Mystic Lake, 1983 – 1984. Source: Schollenberger, 1984.

Age Class	**Size range (inches)**	**Ave Length (inches)**	**Ave weight (lb)**
I	unknown	unknown	unknown
II	6.0-8.5	7.0	0.14
III	7.9-10.1	9.4	0.23
IV	9.0-11.3	10.3	0.35
IV+	10.6-13.6	12.2	0.50

Table 4.2.1-1. Fish population estimates from West Rosebud Creek below Mystic Lake, August 1977. Source: MPC, 1979.

Section	Species	Number/km (all sizes)	Kg/km
1	rainbow	722	52.8
2	rainbow	977	58.5
3	rainbow	575	39.0
	brown	226	48.8
	Total	**798**	**87.8**

Table 4.2.1-2. Condition factors for rainbow and brown trout collected in the bypass reach of West Rosebud Creek in 1977 and 1978. Source: MPC, 1979.

Date	Species	Mean condition factor
8/ 15-16/1977	rainbow	1.31
	brown	1.07
8/22-23/1977	rainbow	1.38
	brown	1.00
10/11/1977	rainbow	1.03
	brown	1.02
5/20-21/1977	rainbow	2.16
	brown	Not available

Table 4.3-1. Fish stocking history since 1990 in Emerald Lake. Source: NRIS, 2003

Date	Species	# of Fish	Ave Length (inches)
5/15/1990	RB	1516	6.7
5/13/1991	RB	1501	7.5
5/4/1992	RB	1529	8.1
9/8/1993	RB	1568	6.3
6/22/1994	RB	1406	7.1
6/13/1995	RB	1520	6.4
6/19/1996	RB	1580	6.1
1/21/1997	AGR	3499	4.9
5/8/1997	YCT	620	6.1

Date	Species	# of Fish	Ave Length (inches)
6/16/1997	YCT	622	7
7/30/1997	YCT	589	7.7
5/7/1998	RB	619	6.7
6/30/1998	RB	605	7.8
6/16/1999	RB	595	8.5
4/20/2000	RB	1203	6.7
6/20/2000	RB	600	8.1
5/2/2001	RB	632	6.2
6/21/2001	RB	601	7.2
8/1/2001	RB	597	8.3

RB = rainbow trout, YCT = Yellowstone cutthroat trout, AGR = Arctic grayling. Source: NRIS, 2003

Table 4.3-2. Emerald Lake Gill Net Data. Numbers in parenthesis are mean length in inches and length range. Samples collected in spring.

Year	# Nets	Rainbow	Brown	Cutthroat	Brook	Mtn. Whitefish
2001	?	0	25 (11.78, 8.3-15.9)	0	23 (10.43, 7-13.6)	5 (16.48, 11.8-18.5)
1998*	1	0	12	0	1	36
1997	1	0	12	0	1	16
1996	1	2	6	0	5	6
1990*	1	0	26 (10.8)	1 (8.0)	13 (11.0, 9.7 – 13.5)	13 (13.1,11.4 – 16.1)
1989	1	0	11 (10.9, 9.0 – 11.8)	4 (9.4, 8.6 – 9.8)	24 (10.3, 7.6 – 16.9)	1 (15.4)
1988*	1	0	15 (9.9, 6.9 – 13.8)	0	7 (10.5, 8.8 – 12.8)	8 (13.4, 10.7 – 15.8)
1987*	1	0	32 (12, 8.6 – 27.5)	5 (10.6, (9.6 – 11.4)	16 (10.5, 8.5 – 12.1)	30 (14.0, 11.8 – 16.8)

*Also caught one longnose sucker.
Source: FWP, 2000; FWP unpublished file data, Poore and Frazer, 1990.

Table 4.4-1 . Gill net data for West Rosebud Lake. Numbers in parenthesis are mean length and length range, in inches. Samples collected in spring.

Year	# Nets	Rainbow	Brown	Cutthroat	Brook	Mtn whitefish	Longnose sucker
2001	?	5 (10.7, 6.9-11.8)	88 (12.29, 8.9-13.3)	0	0	0	4 (13.75, 11.5-14.9)
1998	2	4 (11.8, 9.7-12.8)	48 (13.6, 7.3 –17.8)	11 (10.8, 9.6 – 12.2)	7 (13.2, 10.3 – 15.2)	14 (16.8, 13.2 – 18.2)	2 (16.8, 16.0 – 17.6)
1997	3	13 (11.8, 9.9-14.1)	63 (12.8, 6.4-16.7)	0	4 (12.5, 10.0-13.9)	21 (15.5, 10.5 – 20.4)	10 (15.9, 14-18.9)
1996	3	0	11 (14.6, 11.5-17.1)	0	2 (13.9, 13.3-14.4)	11 (16.5, 14.4 –19.1)	4 (15.1, 12.0 – 17.8)
1990	3	0	39 (12.3, 6.6 – 18.8)	13 (10.6, 9.2 – 13.6)	0	22 (14.9, 8.7 – 18.4)	3 (14.3, 12.7 – 16.1)
1989	3	2 (10,6.6 – 13.5)	81 (13.4, 7 – 27.8)	8 (10.8, 8.4 – 14.8)	9 (11.9, 10.4 – 13.4)	12 (14.5 – 11.7 – 19.3)	7 (14.6, 13.3 – 17.4)
1988	2	0	13 (13.3, 11.0 –17.6)	2 (11.3, 11.1 – 11.5)	3 (13.9, 12.5 – 16.1)	2 (16.1, 15.6-16.6)	0
1987	2	0	19 (13.9, 10.2 – 16.4)	10 (10.6, 9.1 –12.1)	3 (11.2, 10.8 – 11.4)	5 (15.0, 10.4-17.0)	6 (11.5, 9.0 – 14.7)
1984	3	9 (10.3, 8.2-11.4)	46 (11.9, 6.3 –16.2)	0	1 (9.4)	17 (15.6, 12.8 – 17.8)	20 (11.6, 8.6-17.5)
12/3/ 1958	6	7 (10.3, 8.5- 11.5)	10 (11.9, 8.1-15.3)	0	2 (9.1, 4.8-10.4)	10 (11.9, 7.8 –13.8)	2 (11.6, 7.0-16.3)
7/8/ 1958	6	56	97	0	34	32	42

Source: FWP, 2000; FWP unpublished file data, (Poore and Frazer, 1990).

Table 4.4-2 . Stocking history, since 1990, West Rosebud Lake. Source: NRIS, 2003.

Date	Species	# of Fish	Ave Length (inches)
5/14/1990	RB	2400	6.7
5/15/1991	RB	1501	7.5
5/20/1991	RB	904	7.5
4/28/1992	RB	1219	8.1
4/29/1992	RB	1219	8.1
9/8/1993	RB	2717	6.3
6/22/1994	RB	2294	7.1
6/13/1995	RB	2423	6.4
6/19/1996	RB	2507	6.1
5/8/1997	YCT	992	6.1
6/16/1997	YCT	996	7
7/30/1997	YCT	992	7.7
5/7/1998	RB	1035	6.7
6/30/1998	RB	999	7.8
7/29/1998	RB	1000	8.6
5/19/1999	RB	933	7.4
6/16/1999	RB	1013	7.3
7/27/1999	RB	1004	8.5
4/20/2000	RB	2016	6.7
6/20/2000	RB	600	8.1
5/2/2001	RB	1001	6.2
6/21/2001	RB	1004	7.2
8/1/2001	RB	997	8.3

RB = rainbow trout, YCT = Yellowstone cutthroat trout. Source: NRIS, 2003

Total Harvest by Anglers who Kept Every Fish Caught																				
		Rainbow			Cutthroat			Brown			Brook			Other Species			Unknown Species			
Size and Species by Location	**AREA**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**total**
Emerald Lake	0	10	22	0	0	2	0	9	11	0	8	1	0	0	0	0	0	0	0	63
Creek Between Pine Grove and West Rosebud Lake	1	7	2	0	0	0	0	4	0	0	1	0	0	0	0	0	1	0	0	15
West Rosebud Lake	2	31	19	0	0	0	0	9	10	0	8	0	0	0	0	1	0	0	0	78
W.R. Lake to Powerhouse	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Powerhouse to Mystic Lake	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mystic Lake	5	3	31	0	1	17	0	1	2	0	0	0	0	5	6	0	0	0	0	66
Above Mystic Lake	6	2	3	1	0	5	1	0	3	0	0	0	0	5	1	0	0	0	0	21
	total	53	77	1	1	24	1	23	26	0	17	1	0	10	7	1	1	0	0	243

Species by Location	**AREA**	**Rainbow**	**Cutthroat**	**Brown**	**Brook**	**Other Species**	**Unknown Species**	**total**
Emerald Lake	0	32	2	20	9	0	0	63
Creek Between Pine Grove and West Rosebud Lake	1	9	0	4	1	0	1	15
West Rosebud Lake	2	50	0	19	8	1	0	78
W.R. Lake to Powerhouse	3	0	0	0	0	0	0	0
Powerhouse to Mystic Lake	4	0	0	0	0	0	0	0
Mystic Lake	5	34	18	3	0	11	0	66
Above Mystic Lake	6	6	6	3	0	6	0	21
	total	131	26	49	18	18	1	243

Species Percentage by Location	**AREA**	**Rainbow**	**Cutthroat**	**Brown**	**Brook**	**Other Species**	**Unknown Species**	**total**
Emerald Lake	0	50.79%	3.17%	31.75%	14.29%	0.00%	0.00%	100.00%
Creek Between Pine Grove and West Rosebud Lake	1	60.00%	0.00%	26.67%	6.67%	0.00%	6.67%	100.00%
West Rosebud Lake	2	64.10%	0.00%	24.36%	10.26%	1.28%	0.00%	100.00%
W.R. Lake to Powerhouse	3							0.00%
Powerhouse to Mystic Lake	4							0.00%
Mystic Lake	5	51.52%	27.27%	4.55%	0.00%	16.67%	0.00%	100.00%
Above Mystic Lake	6	28.57%	28.57%	14.29%	0.00%	28.57%	0.00%	100.00%

Table 5.1-1. Total harvest for anglers who kept every fish they caught in the study reach.

Total Harvest																				
		Rainbow			Cutthroat			Brown			Brook			Other Species			Unknown Species			
Size and Species by Location	**AREA**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**small**	**medium**	**large**	**total**
Emerald Lake	0	22	34	0	5	2	0	17	29	0	11	1	0	2	0	0	0	0	0	123
Creek Between Pine Grove and West Rosebud Lake	1	8	2	0	0	0	0	8	1	0	3	1	0	0	0	0	1	0	0	24
West Rosebud Lake	2	47	33	0	1	0	0	23	17	0	12	0	0	0	0	1	0	0	0	134
W.R. Lake to Powerhouse	3	0	1	0	0	0	0	1	4	0	4	0	0	0	0	0	0	0	0	10
Powerhouse to Mystic Lake	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mystic Lake	5	7	47	0	3	19	0	3	2	0	1	0	0	8	6	0	0	0	0	96
Above Mystic Lake	6	6	20	1	5	17	1	0	3	0	2	0	0	5	1	0	0	0	0	61
	total	90	137	1	14	38	1	52	56	0	33	2	0	15	7	1	1	0	0	448

Species by Location	**AREA**	**Rainbow**	**Cutthroat**	**Brown**	**Brook**	**Other Species**	**Unknown Species**	**total**
Emerald Lake	0	56	7	46	12	2	0	123
Creek Between Pine Grove and West Rosebud Lake	1	10	0	9	4	0	1	24
West Rosebud Lake	2	80	1	40	12	1	0	134
W.R. Lake to Powerhouse	3	1	0	5	4	0	0	10
Powerhouse to Mystic Lake	4	0	0	0	0	0	0	0
Mystic Lake	5	54	22	5	1	14	0	96
Above Mystic Lake	6	27	23	3	2	6	0	61
	total	228	53	108	35	23	1	448

Species Percentage by Location	**AREA**	**Rainbow**	**Cutthroat**	**Brown**	**Brook**	**Other Species**	**Unknown Species**	**total**
Emerald Lake	0	45.53%	5.69%	37.40%	9.76%	1.63%	0.00%	100.00%
Creek Between Pine Grove and West Rosebud Lake	1	41.67%	0.00%	37.50%	16.67%	0.00%	4.17%	100.00%
West Rosebud Lake	2	59.70%	0.75%	29.85%	8.96%	0.75%	0.00%	100.00%
W.R. Lake to Powerhouse	3	10.00%	0.00%	50.00%	40.00%	0.00%	0.00%	100.00%
Powerhouse to Mystic Lake	4							0.00%
Mystic Lake	5	56.25%	22.92%	5.21%	1.04%	14.58%	0.00%	100.00%
Above Mystic Lake	6	44.26%	37.70%	4.92%	3.28%	9.84%	0.00%	100.00%

Table 5.1-2. Total harvest for all locations within the study reach.

Projected Harvest Rates

weekday						weekend				
Location	total angler hours spent	total projected fish harvested	fish harvested / angler hour	angler location distribution		Location	total angler hours spent	total projected fish harvested	fish harvested / angler hour	angler location distribution
1	2395.13	247.9	0.1035	37.67%		1	4181.62	432.8	0.1035	37.67%
2	1984.19	226.0	0.1139	31.21%		2	3464.15	394.6	0.1139	31.21%
3	55.09	16.9	0.3061	0.87%		3	96.19	29.4	0.3061	0.87%
4	75.89	0.0	0	1.19%		4	132.50	0.0	0	1.19%
5	1149.36	161.9	0.1409	18.08%		5	2006.65	282.7	0.1409	18.08%
6	698.50	102.9	0.1473	10.99%		6	1219.50	179.6	0.1473	10.99%

Total Projected Fish Harvested

Location	total angler hours spent	total fish harvested	fish harvested / angler hour	angler location distribution	projected total fish caught
1	6576.75	680.75	0.1035	37.67%	2837.0
2	5448.34	620.55	0.1139	31.21%	2586.1
3	151.28	46.31	0.3061	0.87%	193.0
4	208.39	0.00	0	1.19%	0.0
5	3156.01	444.57	0.1409	18.08%	1852.7
6	1917.99	282.49	0.1473	10.99%	1177.2
totals	17458.8	2074.7			8646.0

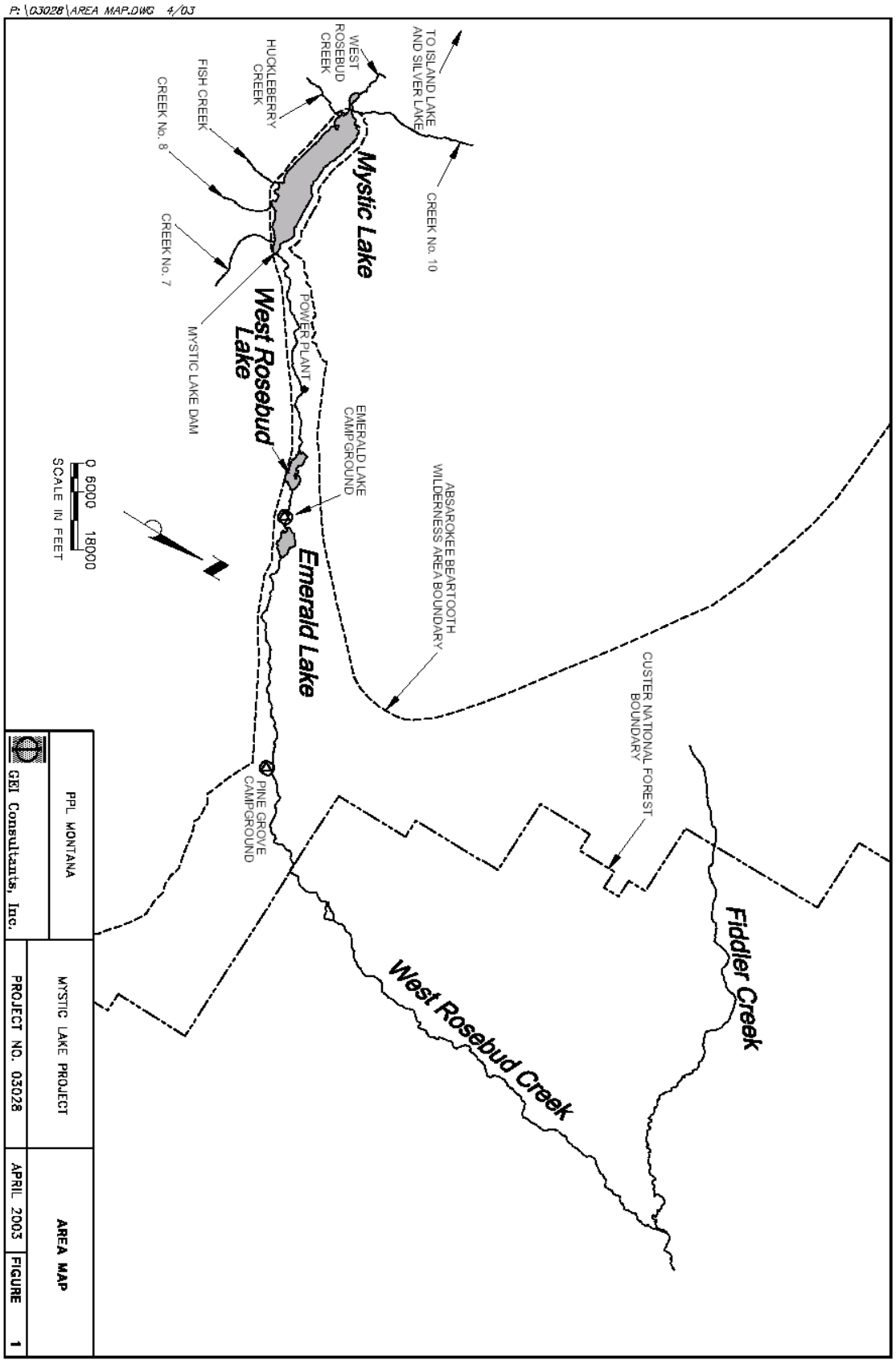
Location Index	Location Description
1	Emerald Lake and the creek between Pine Grove and West Rosebud Lake
2	West Rosebud Lake
3	West Rosebud Lake to Powerhouse
4	Powerhouse to Mystic Lake
5	Mystic Lake
6	Beyond Mystic Lake

Table 5.1-3. Projected harvest and total projected catch rates by location. This table is independent of species, and the rate of capture of various species would depend on the preferred estimate of species distribution in the harvested group.

Table 5.1-4. West Rosebud Trail Use, 1978 – 1982. Source: Custer National Forest, cited in MPC 1985. Note: the results of the actual counts show 5.1% error frequency.

Year	Study period	Total Visitation	Visitors per day in July
1978	June 1 – Aug 31	3,431	41
1979	June 15 – Sept 30	3,846	41
1980	May 1 – Sept 30	4,574	41
1981	June 1 – Aug 31	3,883	-
1982	June 1 – Sept 31	4,000	-

Section 10. Figures


P:\03028\AREA MAP.DWG 4/03
TO ISLAND LAKE AND SILVER LAKE
WEST ROSEBUD CREEK
HUCKLEBERRY CREEK
FISH CREEK
CREEK No. 8
CREEK No. 7
CREEK No. 10
Mystic Lake
West Rosebud Lake
MYSTIC LAKE DAM
POWER PLANT
EMERALD LAKE CAMPGROUND
Emerald Lake
ABSAROKEE BEARTOOTH WILDERNESS AREA BOUNDARY
CUSTER NATIONAL FOREST BOUNDARY
PINE GROVE CAMPGROUND
Fiddler Creek
West Rosebud Creek
0 6000 18000
SCALE IN FEET
PPL MONTANA
GEI Consultants, Inc.
MYSTIC LAKE PROJECT
PROJECT NO. 03028
APRIL 2003
AREA MAP
FIGURE 1

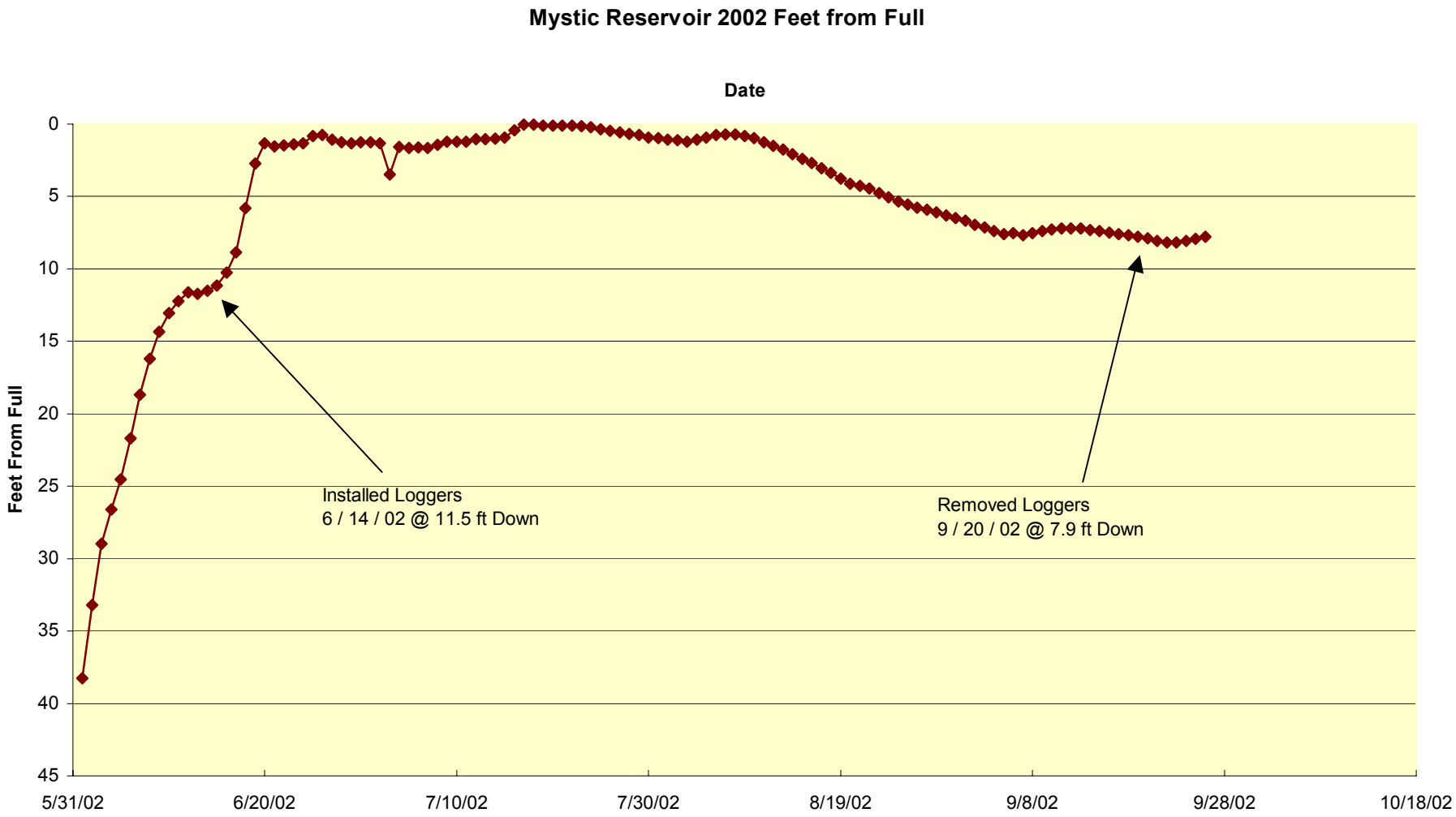


Figure 2.1.1-1. Water surface elevations at Mystic Lake May 31, 2002 to September 26, 2002.

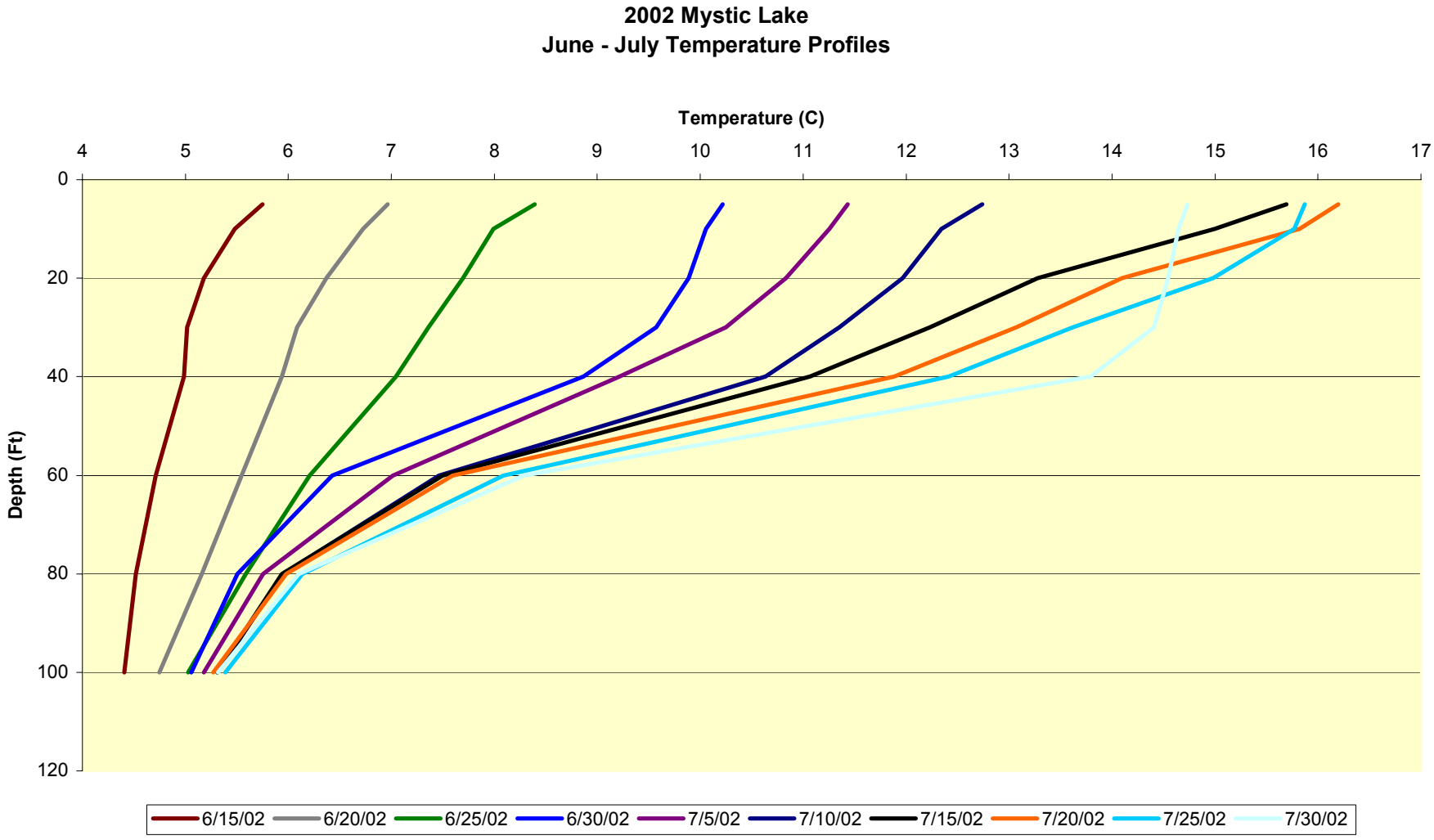


Figure 2.2.1-1. Temperature profiles collected in Mystic Lake June and July, 2002. Source: PPL Montana unpublished file data.

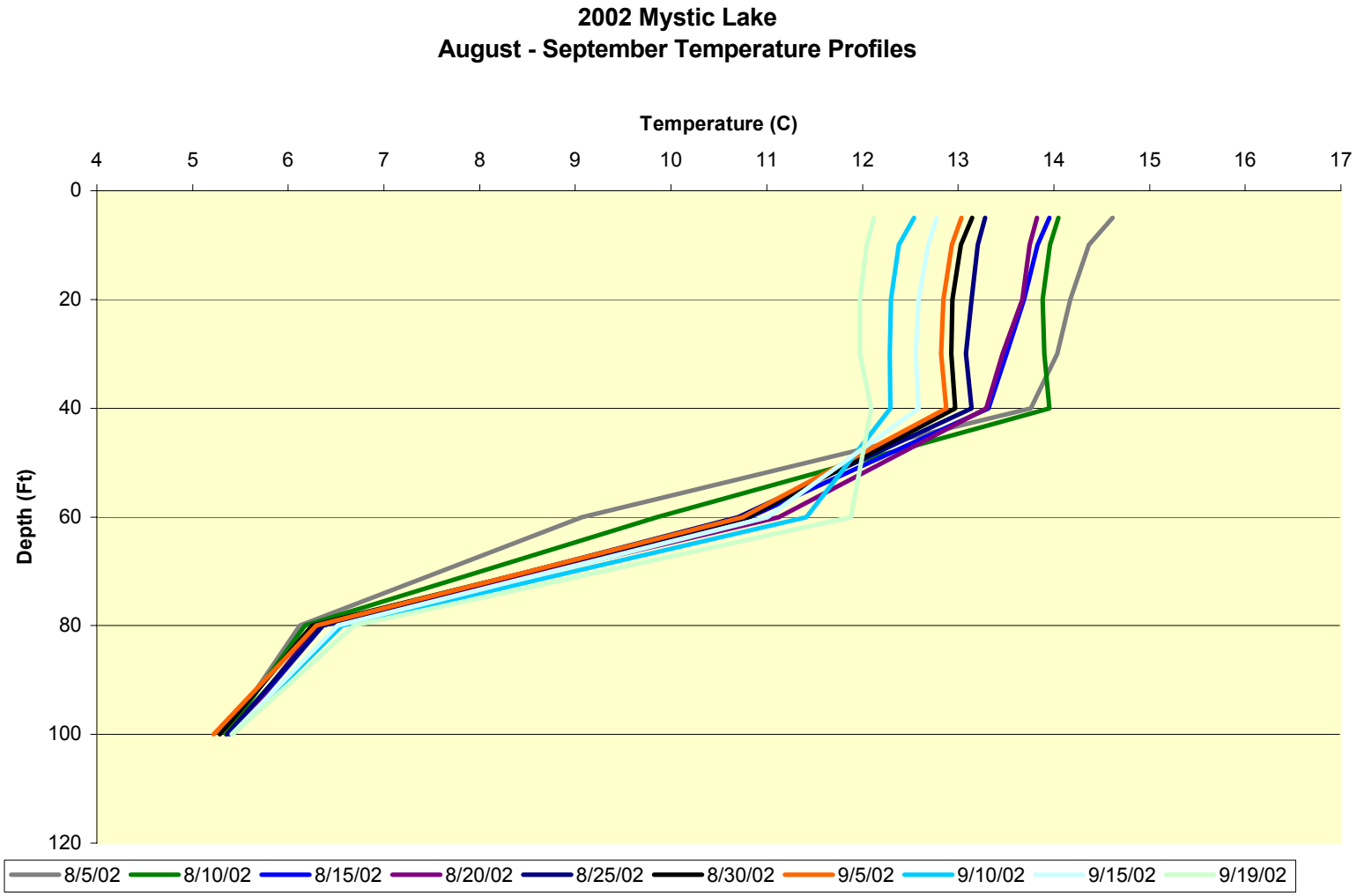


Figure 2.2.1-2. Temperature profiles collected in Mystic Lake, August – September 2002. Source: PPL Montana unpublished file data.

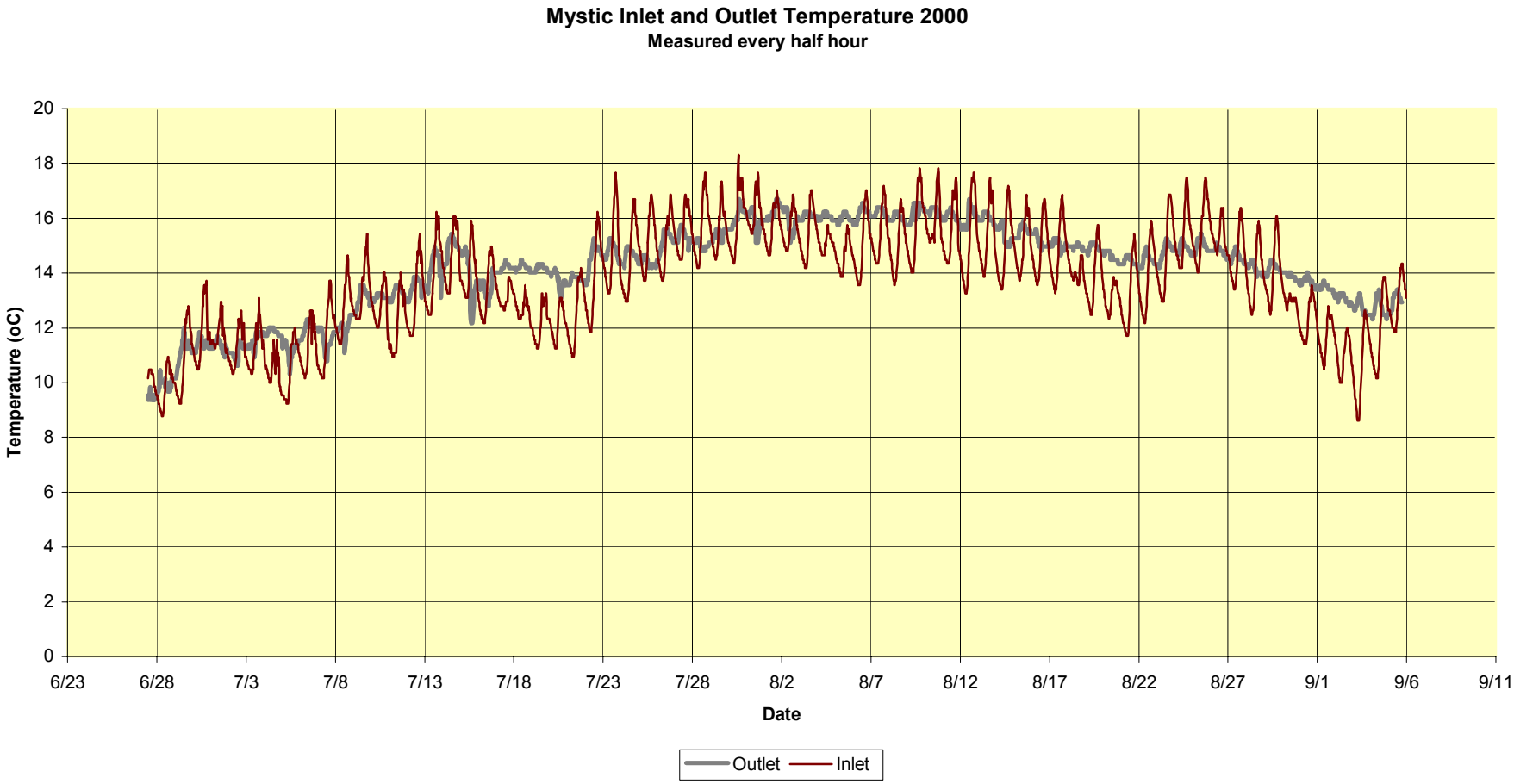


Figure 2.1.2-3. Water temperatures, measured every half hour, at the inlet and outlet of Mystic Lake, between June 28 and September 5, 2000. Source: PPL Montana unpublished file data.

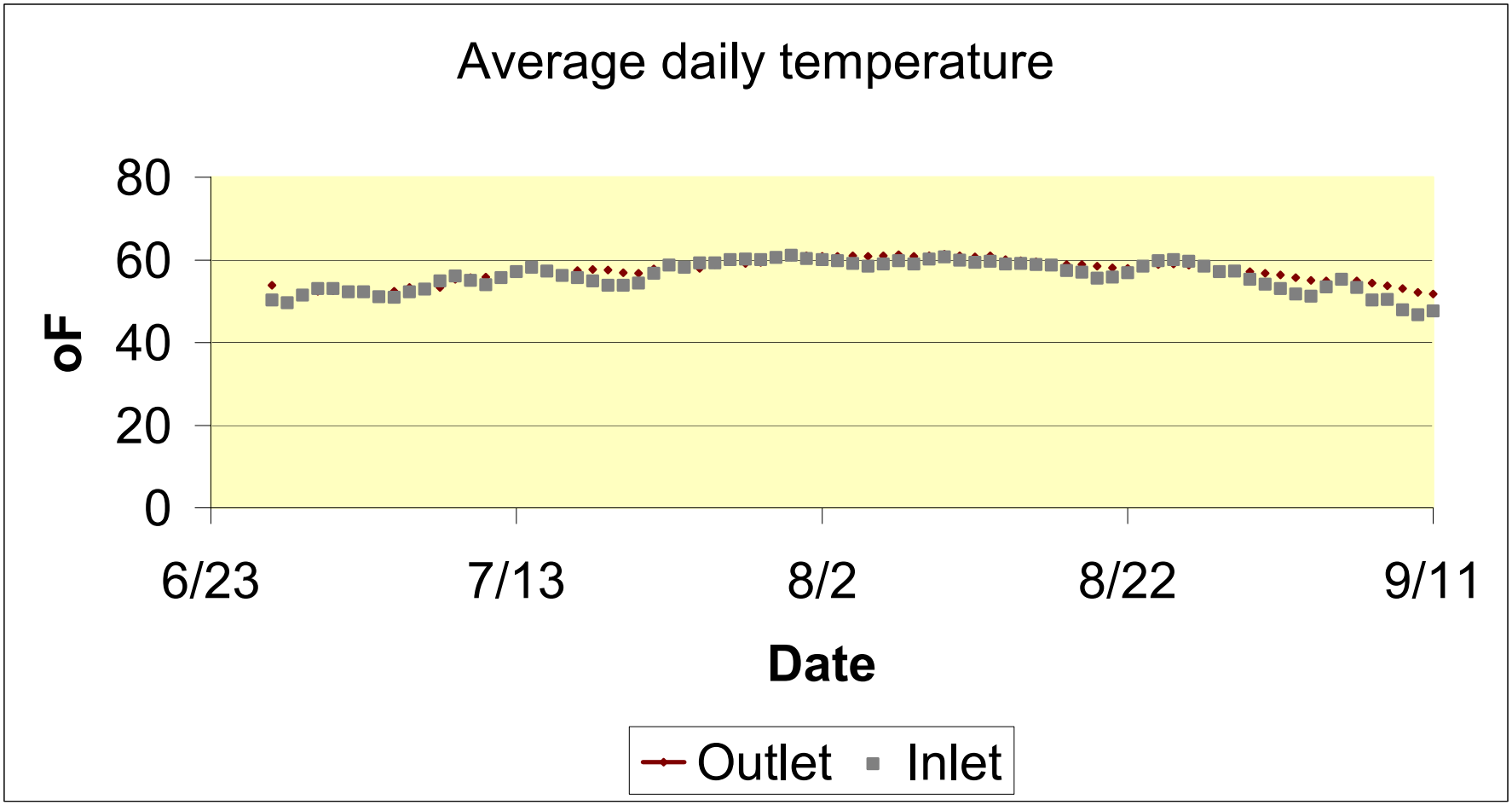


Figure 2.1.2-4. Average daily water temperatures at the inlet and outlet of Mystic Lake, June 16 – September 11, 2000. Source: PPL Montana unpublished file data.

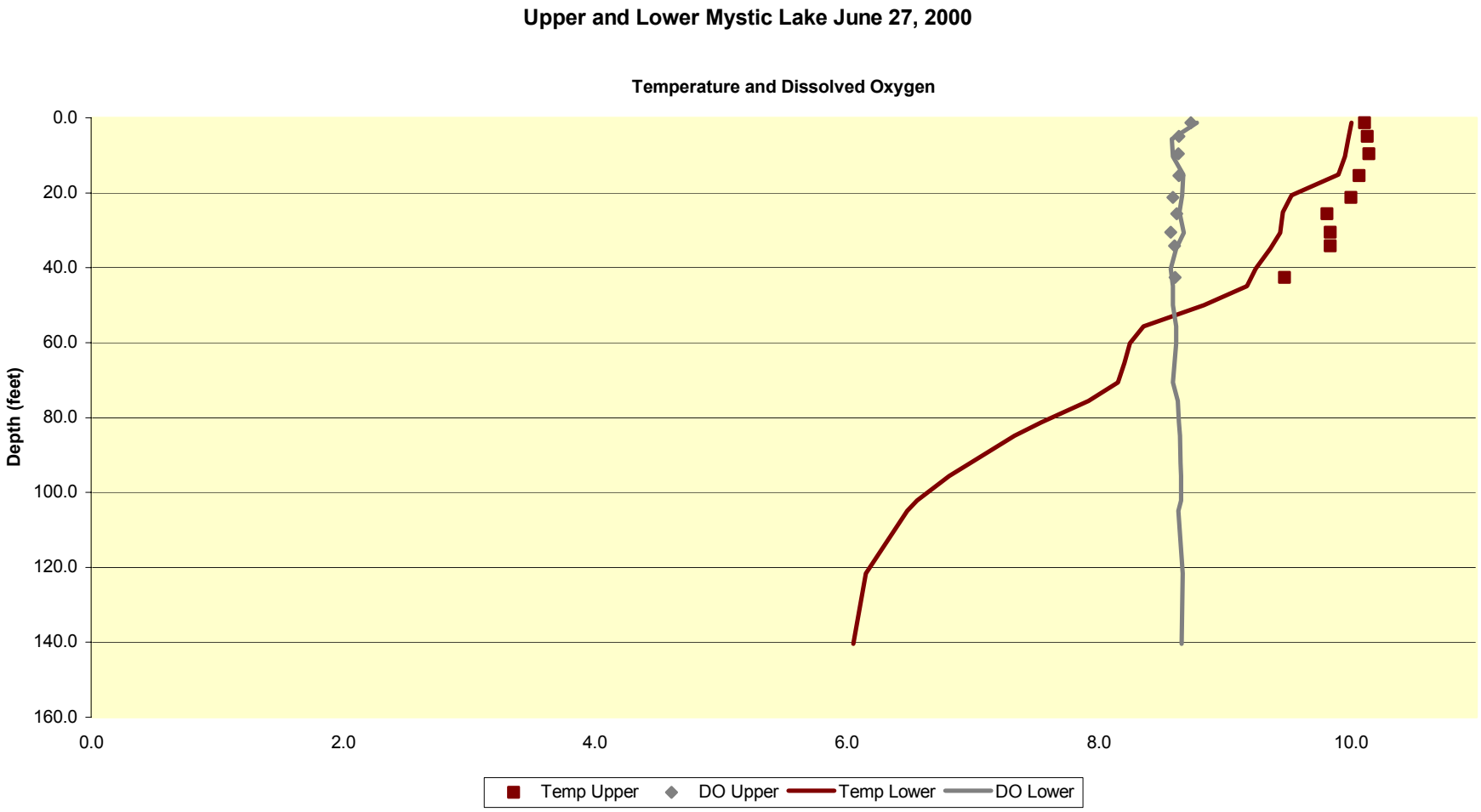


Figure 2.1.2-5. Temperature and DO profile s at upper and lower Mystic Lake o on June 27, 2000. Temperature is in oC and Do is measured in mg/l.

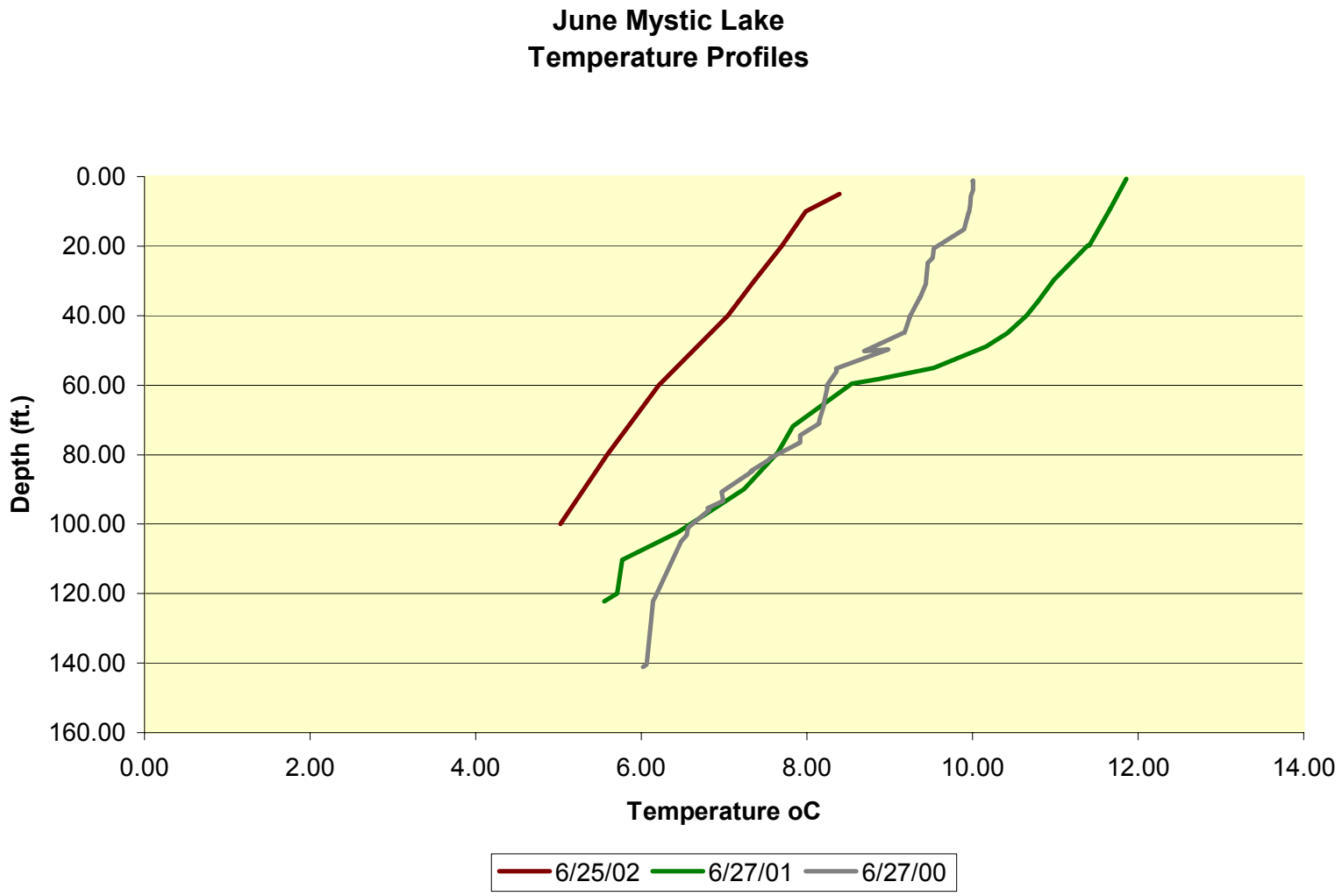


Figure 2.1.2-6. Water temperature profiles at Mystic Lake taken in June in three consecutive years. Source: PPL Montana unpublished file data.

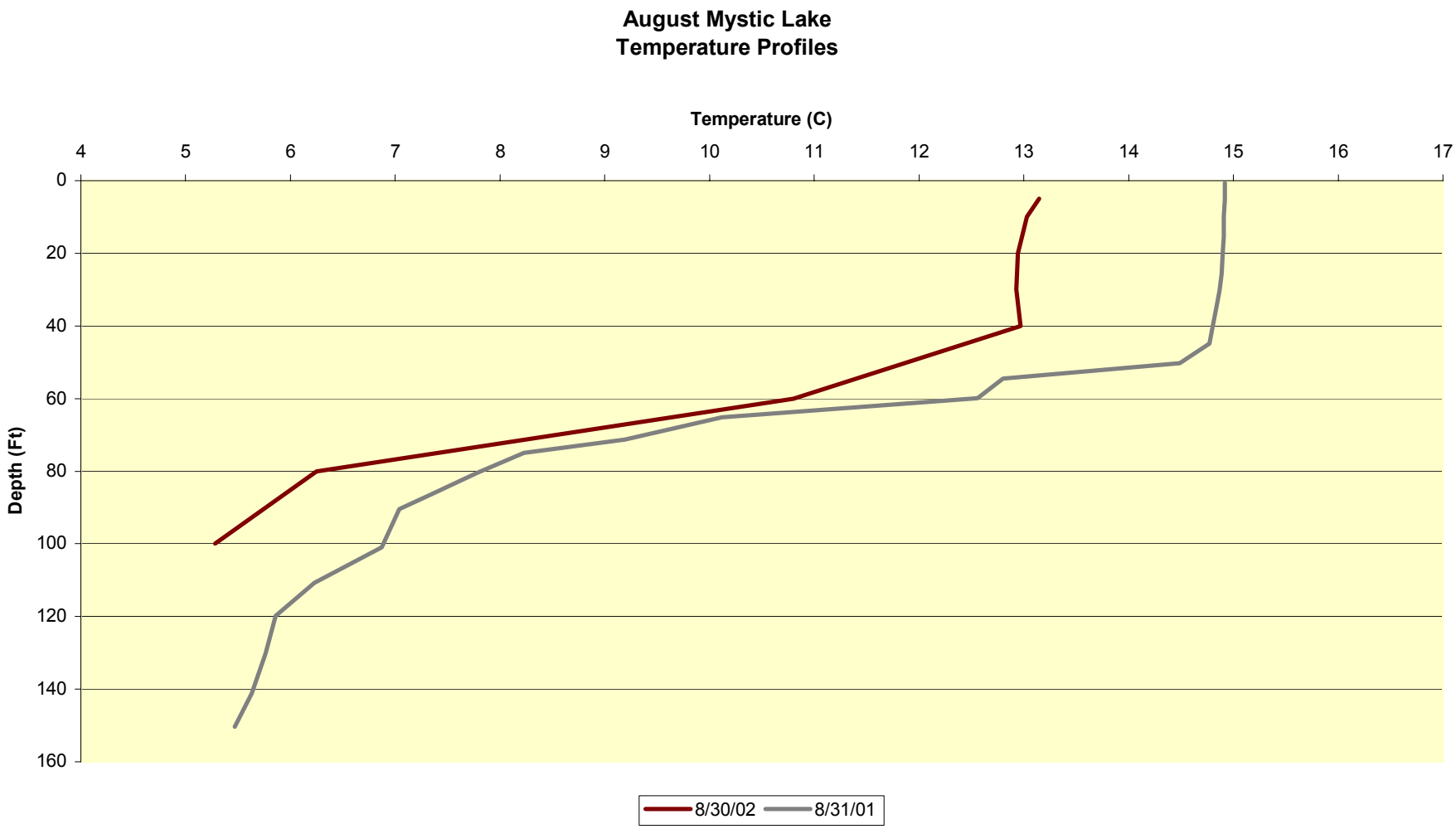


Figure 2.1.2-7. Water temperature profiles at Mystic Lake taken in August 2001 and 2002. Source: PPL Montana unpublished file data.

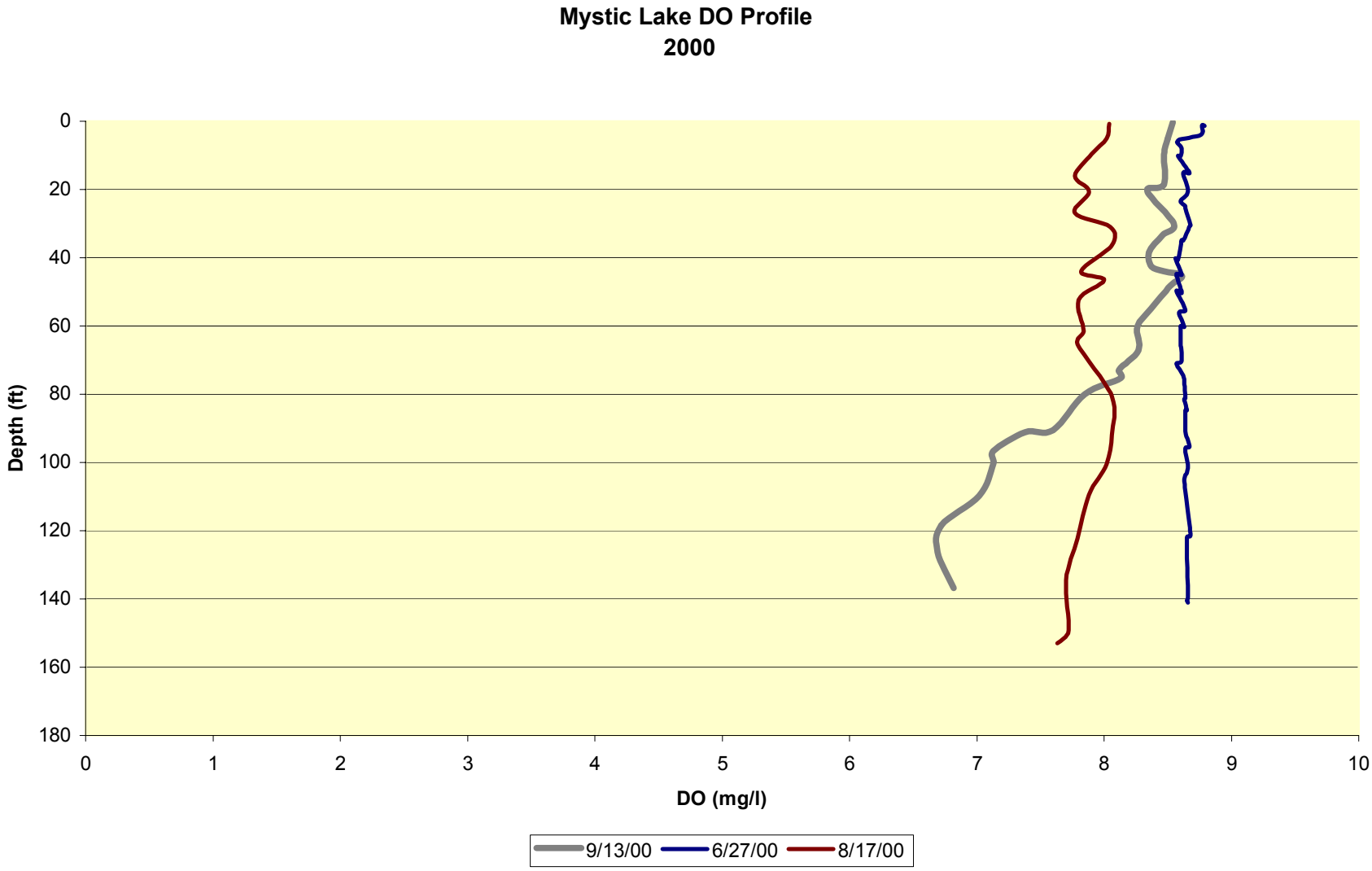


Figure 2.1.3-1. Dissolved oxygen profile on three dates in 2000 in Mystic Lake. Source: PPL Montana.

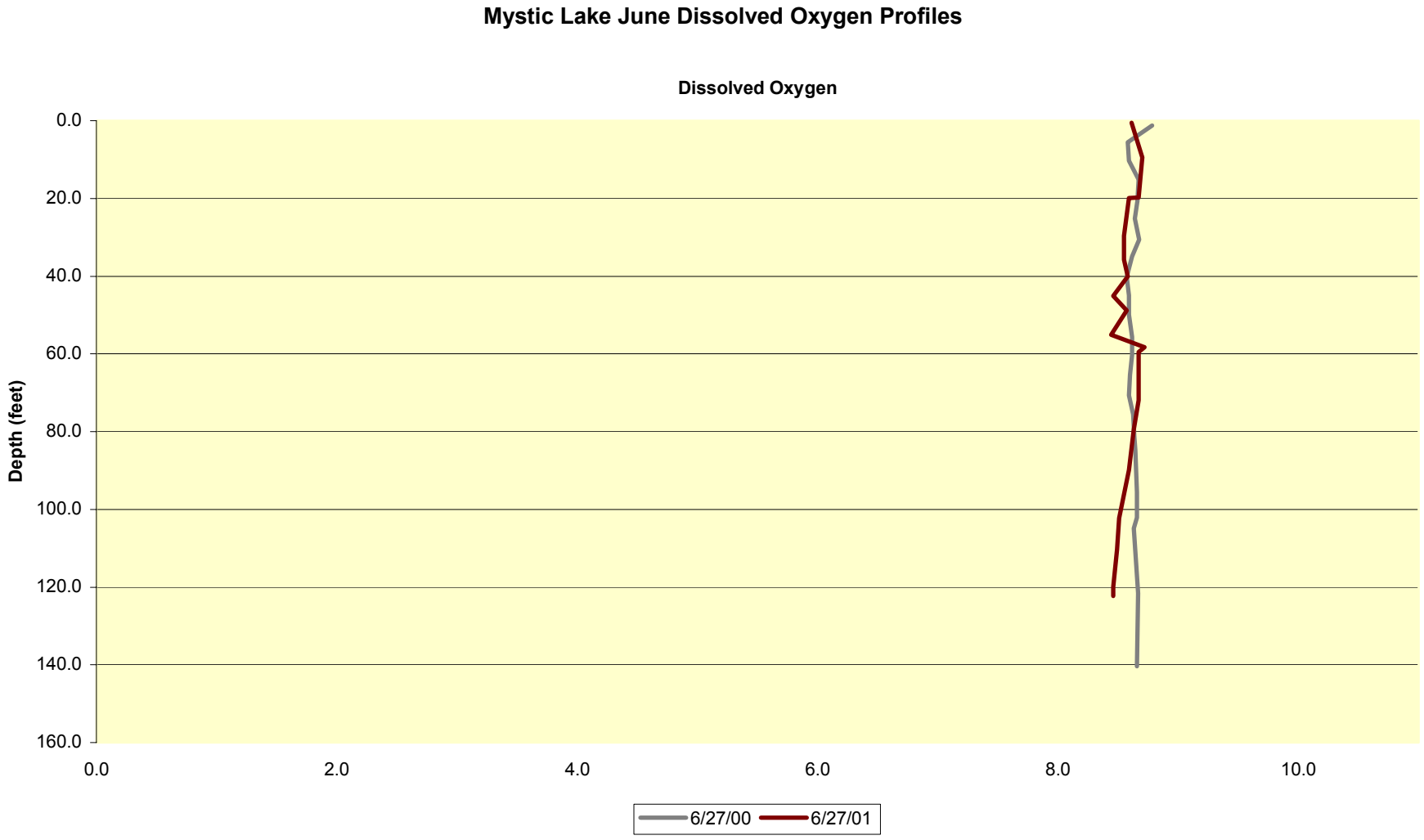


Figure 2.1.3-2. Dissolved oxygen profiles taken in June 2000 and June 2001 at Mystic Lake. Source: PPL Montana unpublished file data.

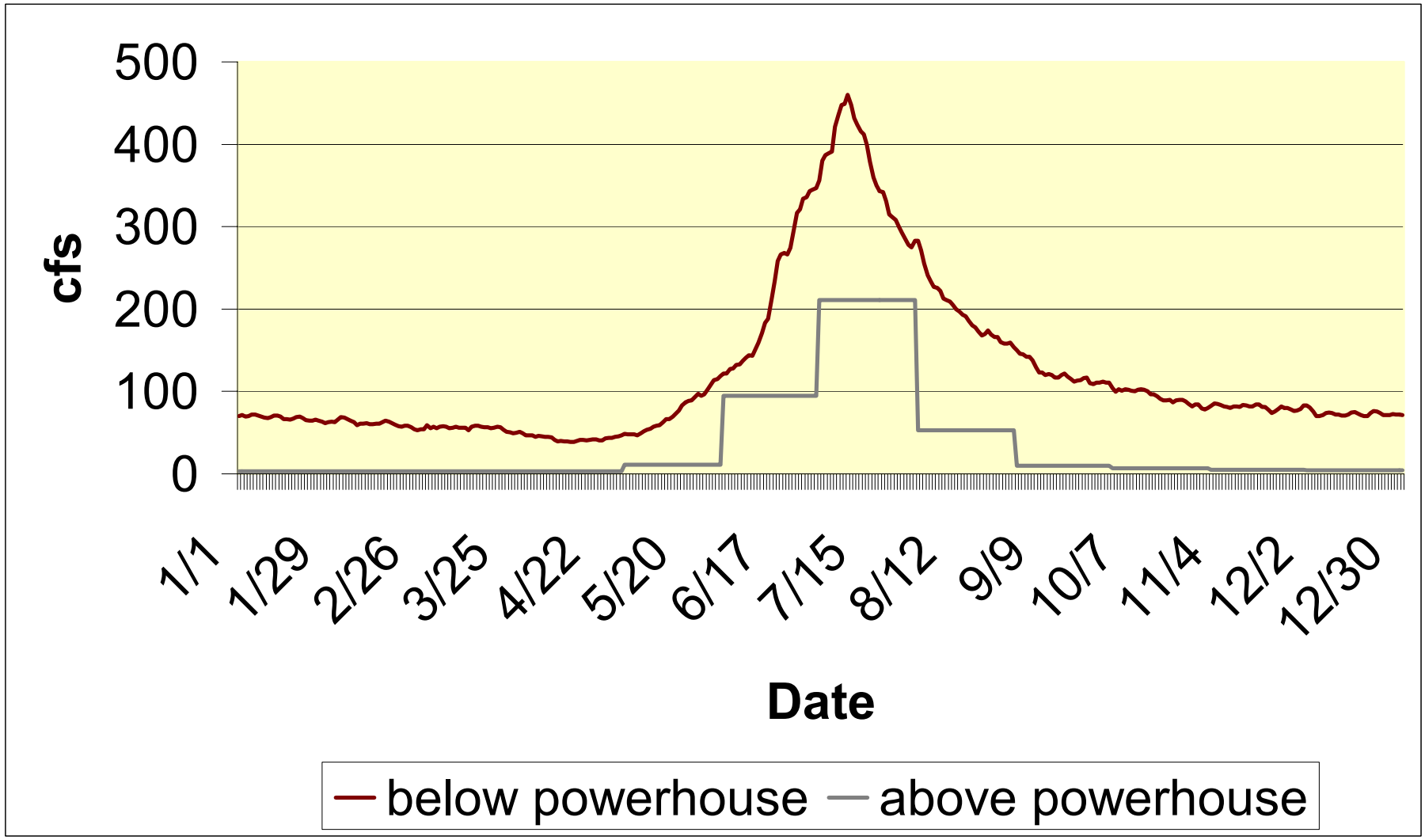


Figure 2.2-1. Mean daily flows recorded in West Rosebud Creek near Roscoe, Montana. Above powerhouse flows are of the period of record 1965 – 2001. Source: U.S. Geological Survey. Flows below the powerhouse are for the period of record 1929 – 1977. Source: MPC, 1979. The difference between the two flows is the flow through the powerhouse

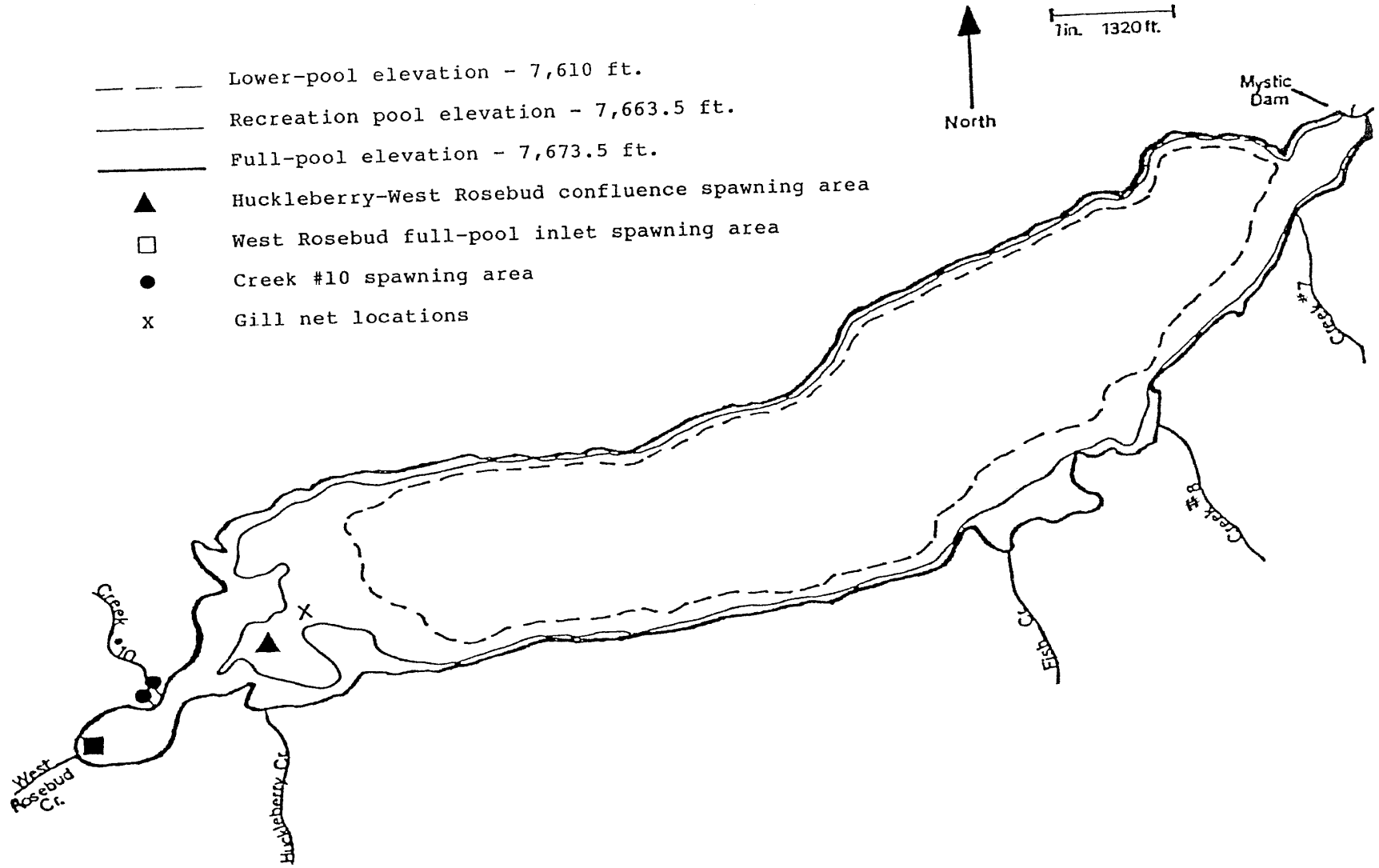


Figure 4.1-1. Spawning locations in Mystic Lake. Source: Schollenberger, 1984.

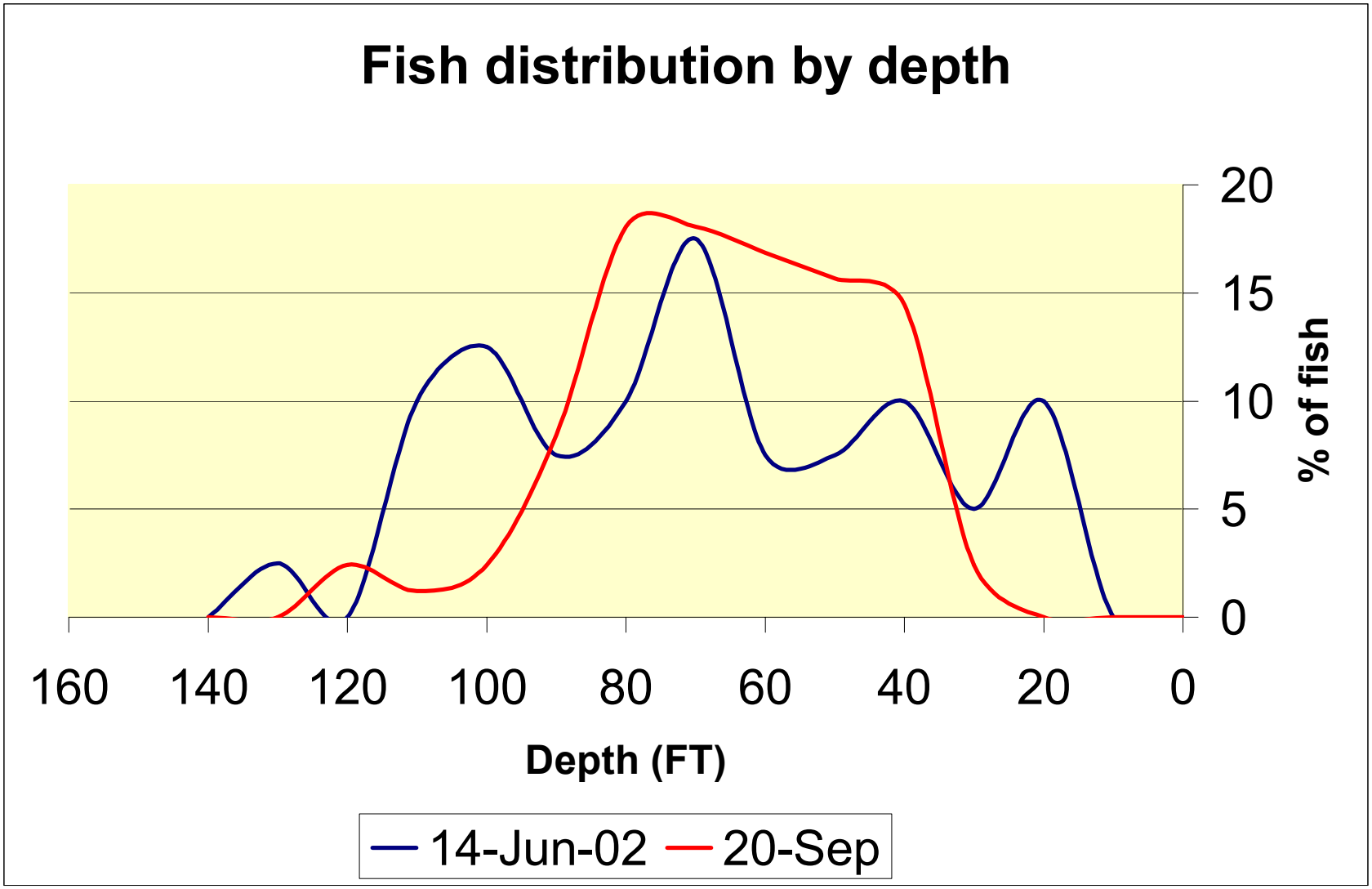


Figure 4.1-2. Fish depth distribution in Mystic Lake on two dates in 2002. Source: PPL Montana unpublished file data.

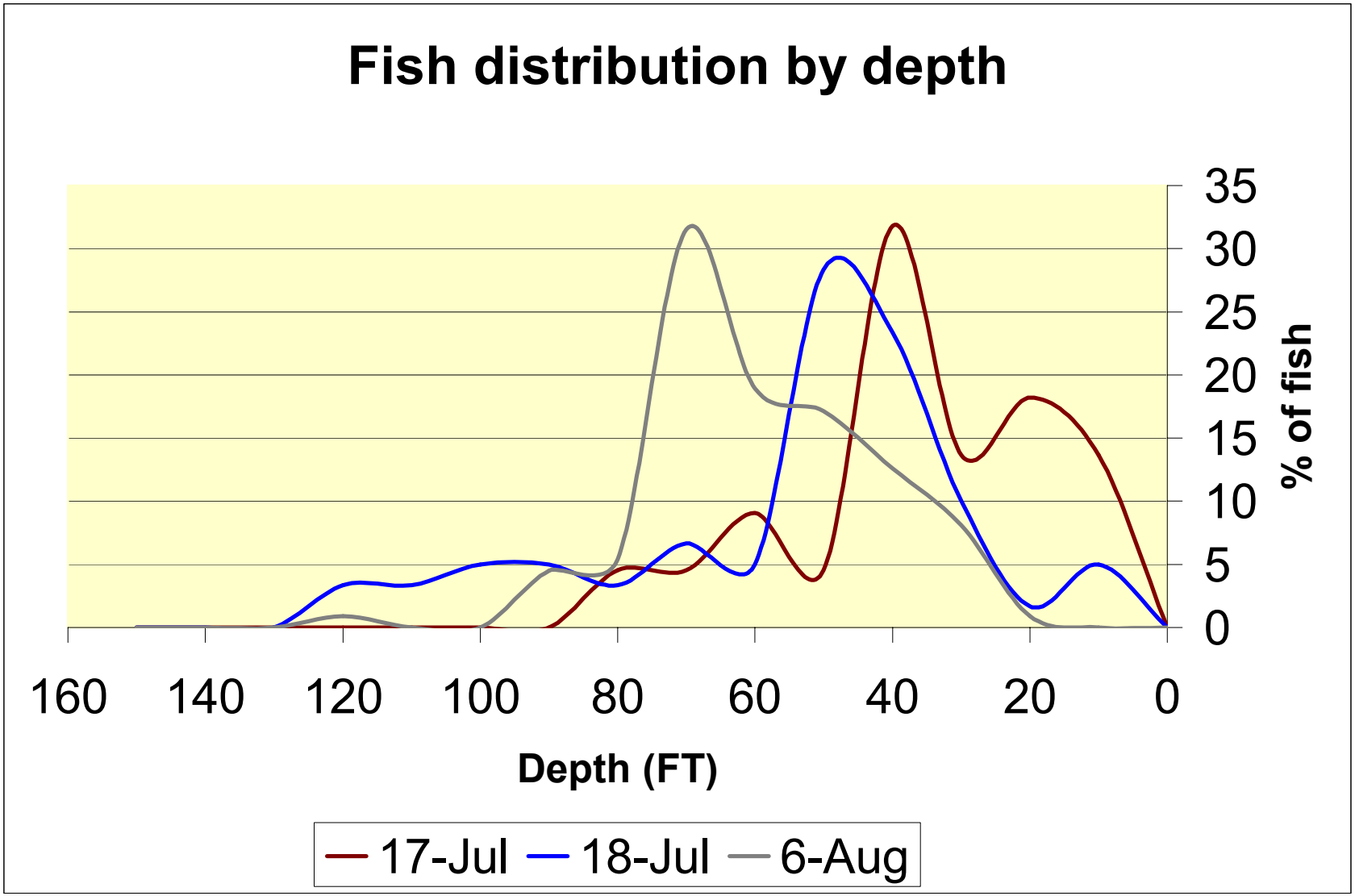


Figure 4.1-3. Fish depth distribution at Mystic Lake on three dates in mid-summer 2002. Source: PPL Montana unpublished file data.

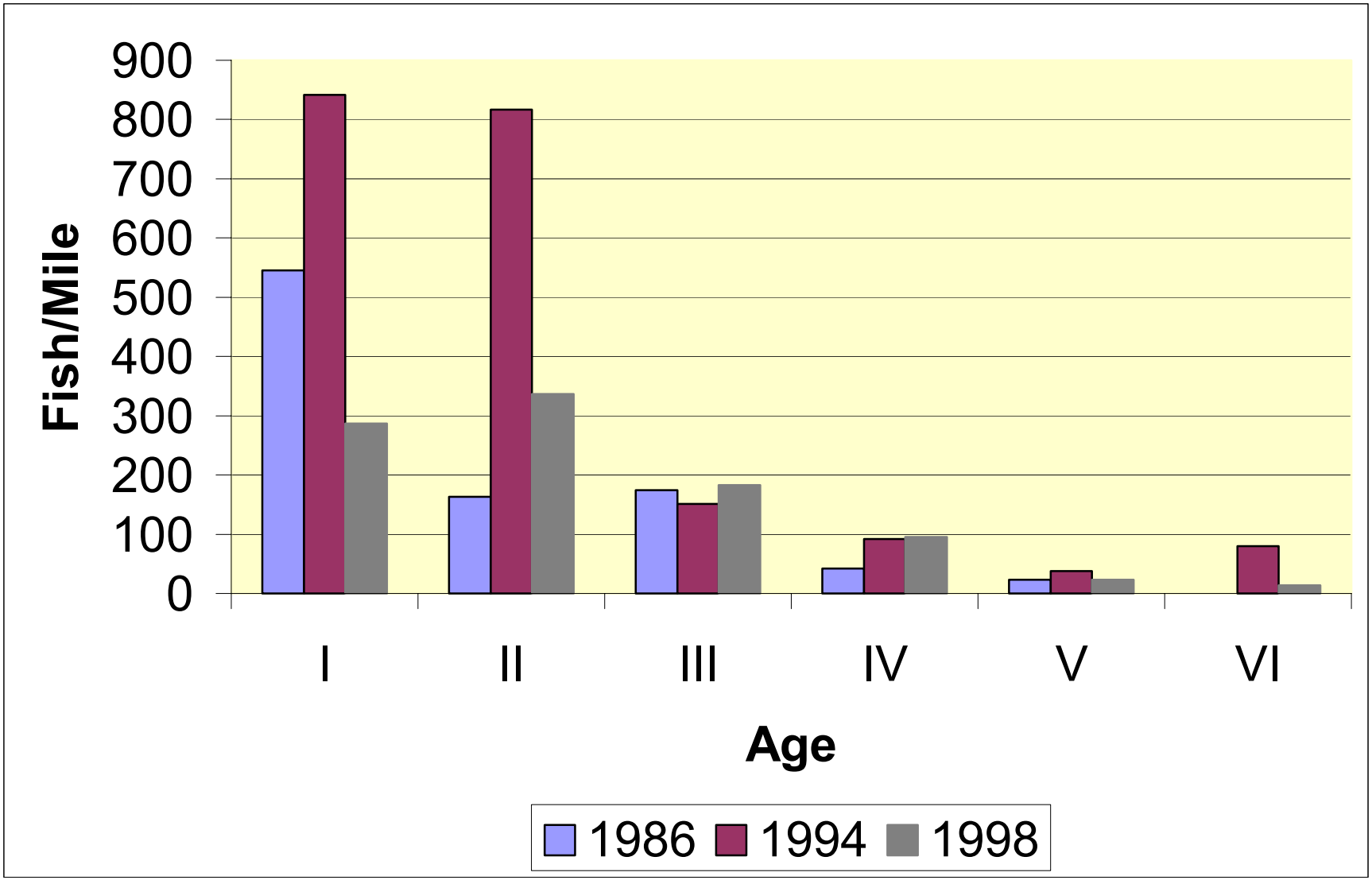


Figure 4.2.2-1. Numbers of brown trout per mile in the McKay section of West Rosebud Creek. Sources: Poore, 1987; FWP, 1994; Poore, 2000.

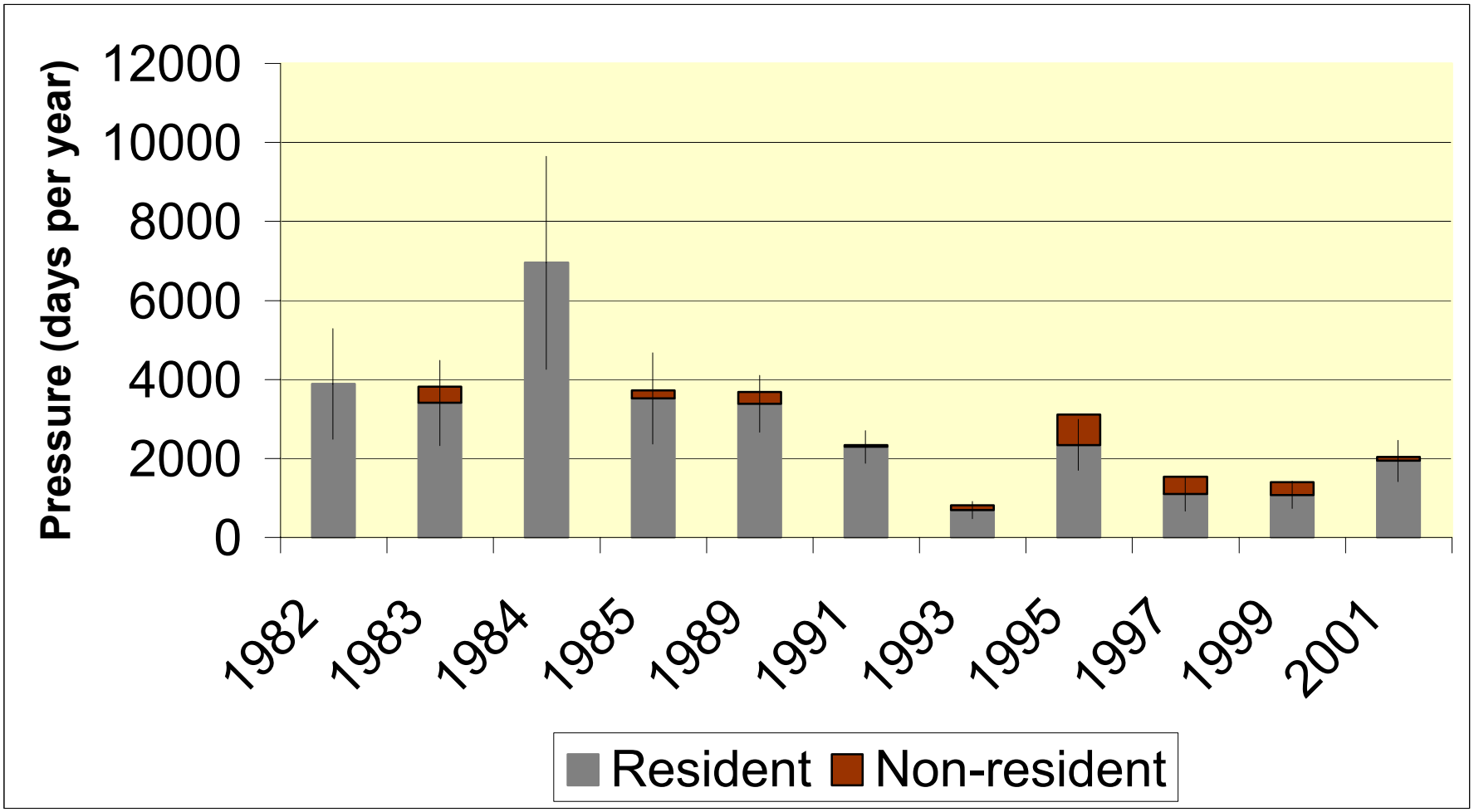


Figure 5.3-1. Angling pressure in Emerald Lake as estimated by the Montana Fish, Wildlife and Parks statewide mail-in creel census. Error bars represent one standard deviation.
Source: NRIS, 2003

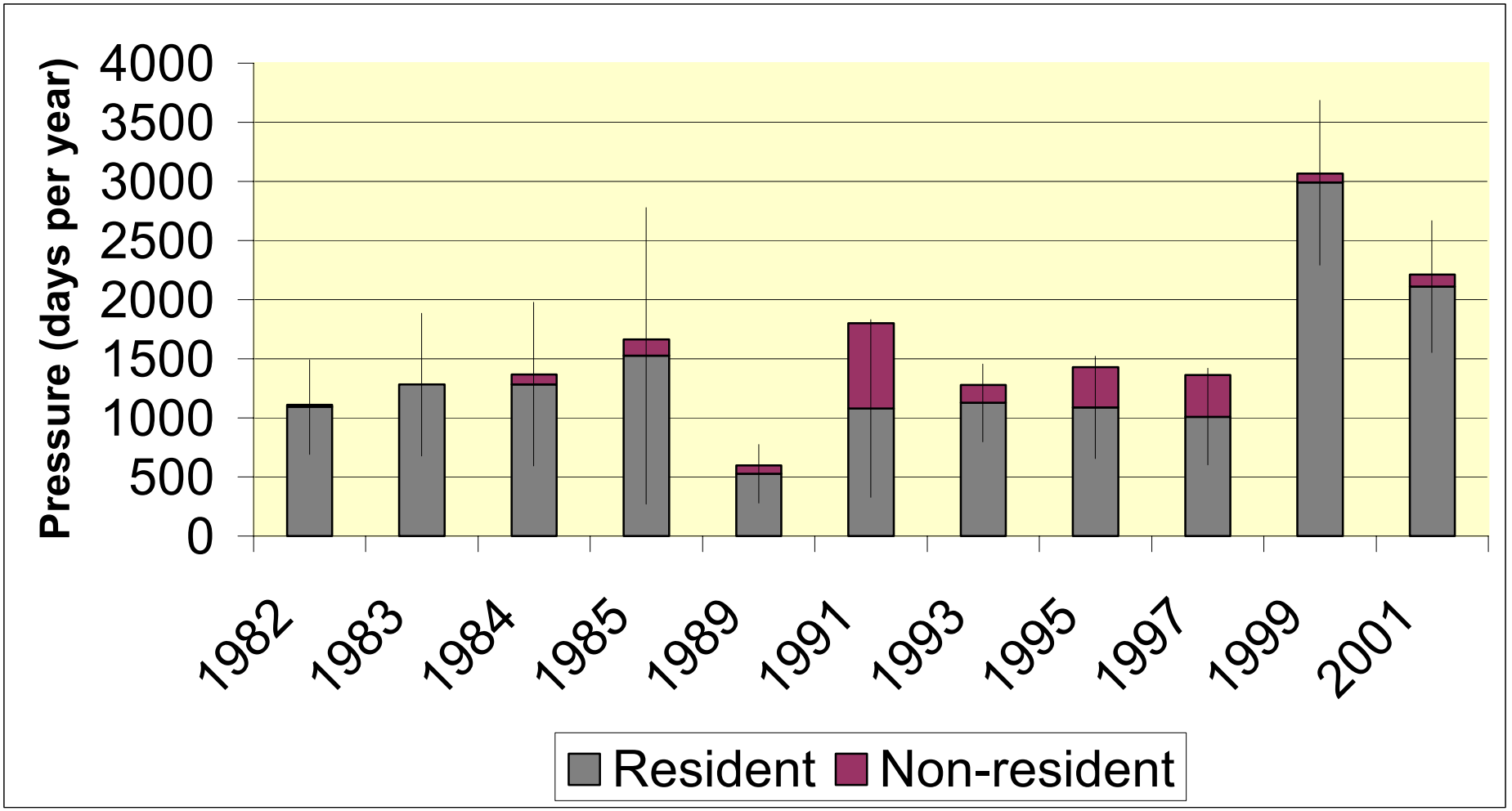


Figure 5.4-1. Angling pressure (days per year) at West Rosebud Lake as determined by the Montana Fish, Wildlife and Parks statewide mail in creel census.