**Placer County Water Agency**
**Middle Fork American River Hydroelectric Project**
**(FERC No. 2079)**

***DRAFT***

# 2005 WATER TEMPERATURE STUDY REPORT

**Prepared for:**


Placer County Water Agency
144 Ferguson Road
Auburn, CA 95604


January 30, 2006

# Forward

This report entitled *2005 Water Temperature Study Report* is one of several reports which are being prepared to describe existing environmental conditions within the watershed of Placer County Water Agency's (PCWA) Middle Fork American River Hydroelectric Project (MFP). The 2005 Water Temperature Study Report characterizes water temperature conditions in the reservoirs and streams associated with the MFP. A second Water Temperature report will be prepared in late 2006 following another season of data collection and analysis.

The title of the other report in this series is:

- *2005 Physical Habitat Characterization Study Report*, which consists of three components:
  - *Geomorphology Study Report*
  - *Riparian Habitat Characterization Report*
  - *Aquatic Habitat Characterization Report*

The information in these reports will be used by PCWA during preparation of the Pre-Application Document (PAD). The PAD will be submitted in September 2007 to the Federal Energy Regulatory Commission (FERC) to initiate the regulatory process for relicensing the MFP. They will also be used to develop Draft Technical Study Plans by a collaborative of jurisdictional agencies, tribes, non-governmental organizations and the public. The Draft Technical Study Plans will also be included in the PAD submitted to the FERC.

# TABLE OF CONTENTS

Page



## List of Tables



## List of Figures

## List of Appendices

# 1.0 INTRODUCTION

This report documents the results of the first year (Phase I) of Placer County Water Agency's (PCWA) water temperature characterization studies for the Middle Fork American River Hydroelectric Project (Project or MFP). The water temperature characterization studies were carried out as outlined in PCWA's "*2005-2006 Existing Environment Study Plan Package (Study Plan)*," which was developed in coordination with the key resource agencies and distributed in June 2005. This report documents the results of the field work and data analysis conducted during 2005 and is intended to be used as a basis for refining the second year (Phase 2) studies to be conducted in 2006.

## 1.1 STUDY GOALS / OBJECTIVES

The goal of the Water Temperature Study is to characterize water temperature conditions in the reservoirs and streams associated with the MFP. The data will initially be used to evaluate whether water temperatures downstream of Project facilities meet the Cold Freshwater Habitat beneficial use goals identified in the California Regional Water Quality Control Board, Central Valley Region's "*Water Quality Control Plan (Basin Plan) for the Sacramento River and San Joaquin River Basins*" *(1998)*.

The objectives of the Water Temperature Study are to: (1) establish a system of stream water temperature monitoring sites; (2) develop reservoir temperature, dissolved oxygen, and specific conductance profiles; and (3) collect meteorological data (air temperature, relative humidity, solar radiation, wind speed, wind direction, and precipitation) to supplement the water temperature data. Combined, the temperature loggers, reservoir profile, and meteorological stations will allow PCWA to develop a consistent, thorough data set that can be used to adequately characterize water temperatures in the reservoirs and streams associated with the MFP.

A description of the methods used to achieve each objective and the initial results of data collection during 2005 are contained in Sections 2, 3 and 4 of this report. Changes to, and continuation of, each element of the study is discussed in Section 5.

## 1.2 GENERAL APPROACH

The general approach outlined in the Water Temperature Study Plan focused on building upon and supplementing existing stream water temperature, reservoir, and meteorological monitoring that was initiated by PCWA in 2003 and 2004. During 2005, additional stream water temperature and meteorological monitoring sites were installed and some modifications were made to the existing monitoring program. Throughout the summer and fall of 2005, stream water temperature and meteorological data was retrieved from each monitoring site and reservoir profiling was conducted.

## 1.3 STUDY AREA

The MFP is located on the Middle Fork American River, the Rubicon River, and several tributaries in Placer and El Dorado Counties, California. The principal project features include two primary reservoirs, five smaller impoundments, five powerhouses, and water conveyance facilities (Figure 1).

The Water Temperature Study Plan focuses on the primary rivers and tributary streams, upstream and downstream of the MFP dams and reservoirs, as shown on Figures 2 through 5. Monitoring is focused in the following areas, referred to in this report as study streams.

- The Middle Fork American River from upstream of French Meadows Reservoir to its confluence with the North Fork American River;
- The North Fork American River to Folsom Reservoir;
- The Rubicon River from upstream of Hell Hole Reservoir to its confluence with the Middle Fork American River at Ralston Afterbay;
- Duncan Creek from upstream of the Duncan Creek Diversion to its confluence with the Middle Fork American River;
- North Fork Long Canyon Creek from upstream of the North Fork Diversion to its confluence with Long Canyon Creek;
- South Fork Long Canyon Creek from upstream of the South Fork Diversion to its confluence with Long Canyon Creek; and
- Long Canyon Creek from the confluence of North and South Forks of Long Canyon creeks downstream to its confluence with the Rubicon River.

A river mileage stationing system was established along each of these reaches and others in the vicinity of the MFP. As shown on Figure 6, the river mileage stationing system begins at river mile (RM) 0 at Folsom Dam, a point that is unlikely to change in the future. The river miles then ascend upstream following the North Fork of the American River. Every tributary confluence is designated as RM 0 and river miles ascend upstream along each tributary.

## 1.4 HYDROLOGIC SETTING

Based on the Sacramento Valley Water Year Hydrological Index, 2005 was an "above normal (AN)" water year type. Of note, 2005 was characterized by a very wet May (the 3rd wettest on record[1]) and June (the wettest on record), which likely affected water temperatures in the study streams and reservoirs during the monitoring period. Both of the major project reservoirs spilled during May and June. A total of 9,320 acre-feet of water spilled at French Meadows Reservoir during 21 days, and a total of 31,285 acre-feet of water spilled at Hell Hole Reservoir during 26 days. Project water delivery, generation, and maintenance operations were typical for an "AN" water year type, with

[1] Based on precipitation data compiled at Georgetown Ranger Station Headquarters, the nearest complete and summarized data to the Middle Fork Project, between 1948 and 2005.

reservoir levels, water releases, and generation output within normal ranges. Water diversions ceased at the Duncan Creek Diversion around July 12, and the diversions on the North Fork Long Canyon and South Fork Long Canyon creeks were closed on May 26 and June 29, respectively.

## 2.0 STREAM WATER TEMPERATURE MONITORING

PCWA began continuously monitoring water temperatures associated with the MFP in 2003. By October 2004, water temperature was being monitored at 30 sites established by PCWA, and one site each established by U.S. Geological Survey (USGS) and Sacramento Municipal Utility District (SMUD). Pursuant to the request of the Resource Agencies and upon further review of the existing monitoring array by PCWA, additional monitoring sites were selected. The following sections describe the installation of new monitoring sites, the maintenance of original sites, and the stream water data collected during 2005.

### 2.1 INSTALLATION OF NEW SITES

The Water Temperature Study Plan identified 13 new sites to be installed and five additional sites to be installed pending adequate site access. Selection of additional water temperature monitoring sites resulted from evaluation of the available water temperature data and the spatial array of sites, with input from the resource agencies and in consideration of the objectives outlined in the Water Temperature Study Plan. The combined water temperature monitoring array allows PCWA to evaluate: (1) water temperature conditions upstream and downstream of Project facilities; (2) the influence of tributary streams on water temperature; and (3) water temperature persistence in relatively long river reaches.

All new water monitoring sites were installed during the summer and fall of 2005. The use of Onset StowAway Tidbit loggers (set to record data every 15 minutes) was continued in 2005. Table 1 shows site identifications (IDs), names, river miles, locations, and dates installed for the new water temperature monitoring sites.

Installation of many of the new monitoring sites occurred later than desired due to the persistence of unusually high flows. Specifically, both French Meadows and Hell Hole reservoirs were spilling in late spring (early June) through early summer. Installation at other sites was delayed because they were located in remote and extremely steep terrain requiring the use of helicopter (sites MF13, RR7, RR10, and RR11) or river rafts (MF14, MF15, MF16, OC1, and CC1) to reach the installation sites.

A revised installation was utilized for all loggers installed during 2005. The original loggers were installed using a 2x4 wood board secured with concrete two-step anchors to large boulders or bedrock. The 2x4 installation proved to be more visible and prone to detachment than desired. The new installations utilized a stainless steel housing unit and an aircraft wire cable attachment as illustrated on Figure 7.

After locating a suitable monitoring site and placing the logger and housing unit in the water, the wire cable was wrapped around an anchor point (e.g., root, tree trunk, rock, etc.) and the rock spike was hammered into the stream bank. If the wire was wrapped around a tree trunk or root, care was taken not to constrict potential growth of the tree. The new design was easier to install, provided more flexibility for installation locations, and is much less visible than the original.

## 2.2 MAINTENANCE AND DISPOSITION OF ORIGINAL SITES

Site visits that occurred beginning in late June 2005 to download data and install redundant loggers revealed that: (1) several loggers were lost due to high spring flows; (2) two loggers were buried in sediment mobilized by the high flows, and (3) one logger had malfunctioned. The status of the original water temperature monitoring sites based on the 2005 site visits is shown on Table 2. Lost loggers all were reinstalled at or near the original installation site using the revised installation design.

Inspection of previously collected water temperature data indicated that loggers at sites NL1, SL1, and MF5 may have been recording erroneous data; loggers at these sites were reinstalled at nearby locations as a remedy. Site NL1 was found to have been vandalized during the fall of 2004 so the logger was reinstalled at a more discreet location.

## 2.3 REDUNDANT LOGGER INSTALLATION

As a precaution to prevent the loss of water temperature data due to vandalism, logger failure, or other unforeseen events, redundant water temperature loggers were installed at all monitoring locations. The redundant loggers were installed near but not directly adjacent to the primary logger. For example, if the primary logger was installed near the head of a pool, the redundant logger was installed in the tail of the pool, or in the pool immediately upstream or downstream from the primary logger. Because of the extremely remote nature of sites DC3 and MF11, three loggers were installed at each site.

With the installation of the 18 new monitoring sites and maintenance of the 30 existing monitoring sites, a stream monitoring array that consists of 48 water temperature monitoring sites maintained by PCWA and one maintained by USGS was established. The site ID, name, river mile, location and installation date of each of the 49 stations is shown on Table 3.

## 2.4 2005 STREAM WATER RESULTS

The monitoring site visits began at the end of June 2005. Each site was visited throughout the summer and fall according to the schedule established in the Water Temperature Study Plan. Remote sites were accessed once during late September or October, while sites near public access were visited monthly through October. The location of each of the water temperature monitoring sites is shown on Figures 2 through 5.

Water temperatures measured in the study streams appear to have been influenced by a number of factors, including: (1) a relatively wet and prolonged spring runoff period that extended into the summer; (2) local rainstorms and spills from the Project reservoirs; and 3) the outage of the Project powerhouses in early to mid-October. The reservoir spills and powerhouse outage dates for 2005 are shown on Table 4.

Water temperatures abruptly increased and then decreased in early to mid-June. This fluctuation occurred coincident with local rainstorms and spills from the Project reservoirs, suggesting that local rainstorms and spills influenced water temperature. The uppermost (and thus warmest) stratum of water spills from the reservoir, which increases water temperatures downstream.

Water temperatures increased below the Project powerhouses in early to mid-October. The increase in water temperature was coincident with the annual powerhouse maintenance outage. Under normal operating conditions, relatively cold water is routed through the Project tunnels, through the powerhouses, and released to the stream. Thus, water temperatures below the powerhouses tend to be cooler under normal operating conditions. Water temperatures increase downstream of the powerhouses when the powerhouses are not operating.

The following sections present daily average water temperatures during 2005 from June 1, or as soon as the monitoring site was installed, up to the date the site was last downloaded. The data presented in this report focused on the June through October period because: (1) water temperatures recorded at existing monitoring sites prior to June were cold (i.e., less than 55°F at all locations, and less than 50°F at many locations); and (2) data were downloaded for the final time October 2005 to ensure that the sites were accessed before winter environmental conditions (e.g., high streamflow, snow, muddy conditions, etc.) prevented access. Data from three to six sites are presented on each figure to illustrate longitudinal trends in water temperature within specific reaches of rivers and creeks, or to illustrate the water temperatures of tributary streams. Note that the data legends in each figure are presented from upstream to downstream, although in many cases the site names are non-sequential. The site numbering system was sequential when the stream water temperature monitoring program was initiated., However, the sequencing was disrupted when new sites were added as the program was expanded. For example, two new Middle Fork American River monitoring sites, MF11 and MF12, are located between MF2 and MF3. To avoid potential confusion, PCWA proposes to renumber the stream monitoring sites by river mile, as described in Section 5.1.

Daily average water temperature plots for each individual monitoring site, including daily minimum and maximum, beginning on January 1, 2005, or as soon as the monitoring site was installed, are included in Appendix A. Also presented in Appendix A are representative 15-minute plots, illustrating diurnal variations in water temperature.

Water temperature data are not yet available for three sites located on the Middle Fork American River, downstream of Oxbow Powerhouse (MF14, MF15, MF16) or for the sites located on Otter and Canyon Creeks (OC1 and CC1, respectively). The loggers at these sites were installed on August 11, 2005, using a raft guided by a professional commercial outfitter. Data from these sites could not be retrieved during 2005 because the commercial rafting season ended on or around Labor Day, not long after the loggers were installed. Data from these sites will be downloaded in the early spring of 2006, as soon as commercial boating activities begin and a raft can be scheduled.

Corresponding streamflow data is very important to deciphering and understanding observed trends in water temperature data. However, although streamflow monitoring occurs on a continuous basis at several locations along the study streams, these data are not available on a real-time basis (such as in CDEC, for example) and must undergo substantial compilation and review prior to publishing. Consequently, 2005 streamflow data for the study streams are not available for this report. Preliminary Middle Fork American River streamflow data downstream of Oxbow Powerhouse are available at CDEC (http://cdec.water.ca.gov/cgi-progs/queryFx?oxb).

### 2.4.1 Middle Fork American River

Water temperature is monitored at 17 locations in the Middle Fork American River, from upstream of French Meadows Reservoir (MF1) to immediately upstream of the confluence with the North Fork American River (MF8). Water temperature also is monitored in three tributaries (not including Duncan Creek or the Rubicon River) to the Middle Fork American River: the North Fork of the Middle Fork American River (NM1); Otter Creek (OC1); and Canyon Creek (CC1). The site IDs, names, river miles, and locations of the Middle Fork American River monitoring sites are shown in Table 3. Figures 3 through 5 show the Middle Fork American River monitoring site locations.

Water temperatures in the Middle Fork American River from RM 51.9 (MF1), which is located slightly upstream of French Meadows Reservoir, downstream to RM 36.1 (MF3) are shown in Figure 9. In this section of the Middle Fork American River from June through October 2005, water temperature increased with increased distance downstream from French Meadows Dam. Water temperatures from MF2 essentially represent the release water temperatures from French Meadows Reservoir, which is demonstrated in the relatively flat trend in water temperature at this site. However, because MF2 is 0.6 miles downstream from the reservoir release location, ambient conditions (e.g., warm air temperatures) and reservoir spill, when occurring, can influence water temperatures measured at this location. Observed water temperatures generally were lowest during early June and warmest during mid-July. During the warmest period in July, water temperature increased more than 15°F in the approximately 10 mile-long reach between MF2 and MF3. Water temperatures recorded in the Middle Fork American River upstream of French Meadows Reservoir (MF1) were similar to the water temperatures recorded at MF3, the site located approximately 10 miles downstream from French Meadows Dam, from late July through early October. Following the peak in mid-July, water temperature at each site gradually decreased through the final data collection in October. The abrupt increase and decrease in water temperature during mid-June at MF2 and MF3 coincided with spilling from French Meadows Reservoir and local rainstorms.

Water temperatures in the Middle Fork American River from RM 36.1 (MF3) downstream to RM 26.0 (MF10) are shown in Figure 10. In this section of the Middle Fork American River from June through October 2005, water temperatures were noticeably cooler at MF4, particularly during mid-July through early August, when compared to the water temperatures measured at the other three monitoring sites. During this period, water temperatures differed between MF4 and MF3 (located 0.6 miles upstream of MF4) by approximately 20°F. Cold water releases from the Middle Fork Powerhouse (which originate in Hell Hole Reservoir and are routed to the Middle Fork Powerhouse through the Hell Hole-Middle Fork Tunnel) into the Middle Fork American River were responsible for the cool water temperatures recorded at MF4. When power operations were suspended from early to mid-October for a maintenance outage, water temperatures recorded at MF4 were more similar to water temperatures recorded at the other three water temperature sites.

Water temperatures at MF10 and MF3 generally were coldest during early June and warmest during mid-July. The abrupt increase and decrease in water temperature during mid-June at MF3 coincided with spill from French Meadows Reservoir and local rainstorms. Following the peak in mid-July, water temperature at MF10 and MF3 gradually decreased through the final data collection in October. Data at MF13 were available from mid-September through October, during which water temperatures at MF13 generally were consistent with water temperatures recorded at MF10 and MF 3.

Water temperatures in the Middle Fork American River from RM 24.3 (MF6) downstream to RM 0.1 (MF8) are shown in Figure 11. From June through October 2005 in this section of the Middle Fork American River, water temperature increased with increased distance downstream. Water temperatures generally were coldest around June 7-8 and warmest during late July and early August. The abrupt change in water temperature during mid-June measured at all four water temperature monitoring sites coincided with spill from French Meadows and Hell Hole reservoirs and local rainstorms. During the warmest period in July, water temperature increased more than 10°F in the approximately 24 mile-long reach between MF6 and MF8. Following the peak in late July/early August, water temperature at each site generally decreased through early September. When power operations were suspended from early to mid-October for a maintenance outage, water temperatures at all four sites increased.

### 2.4.2 Duncan Creek

Water temperature is monitored at three locations in Duncan Creek, from immediately upstream of the Duncan Creek Diversion Reservoir (DC1) to immediately upstream of the confluence with the Middle Fork American River (DC3). The site IDs, names, and river miles of the Duncan Creek monitoring sites are presented in Table 3. Figure 5 illustrates the Duncan Creek monitoring site locations.

Water temperatures in Duncan Creek from RM 8.8 (DC1) downstream to RM 0.0 (DC3) are shown in Figure 12. Water temperatures in Duncan Creek during June through October 2005 were generally coldest during early June and warmest during mid-July through early August. Water temperatures were warmest at DC2 (RM 8.4) and coldest at DC1 (RM 8.8); trends were not discernible for DC3 because few data were available. From late July through the final data collection in October, water temperatures generally differed between DC2 and DC1 by approximately 4°F. Following peak water temperatures in mid-July through early August, water temperature generally decreased through mid-October.

### 2.4.3 Rubicon River

Water temperature is monitored at 12 locations in the Rubicon River, from upstream of Hell Hole Reservoir (RR1) to Ralston Afterbay Reservoir (OX1) and the confluence with the Middle Fork American River, and in the South Fork Rubicon River immediately upstream of the Rubicon River confluence (SF1). Water temperature is also monitored in Pilot Creek (PC1), a major Rubicon River tributary, and Five Lakes Creek (FL1), a major Hell Hole Reservoir tributary. The site IDs, names, and river miles of the Rubicon River watershed monitoring sites are shown on Table 3. Figures 4 and 5 show the Rubicon River and tributary stream monitoring site locations.

Water temperatures in the Rubicon River from RM 35.9 (RR1) downstream to RM 22.7 (RR5) are shown on Figure 13. Site RR1 is located upstream from Hell Hole Reservoir, while the other four sites are located downstream of Hell Hole Reservoir. Where comparable, water temperatures measured upstream from Hell Hole Reservoir (RR1) were generally colder than downstream at RR2, RR3, RR10, and RR5 during the late spring and early summer and warmer during the mid-summer through the fall. During the summer and fall period, water temperature increased at the four sites downstream of Hell Hole Reservoir with increased distance downstream. Sites RR2 and RR3 remained relatively cool with little variation in water temperature from mid-July through mid-October (the time span data were collected at RR2 and RR3) because of their close proximity to the release point of cool water from Hell Hole Reservoir. Variation in water temperature at RR3 was likely buffered because the river flows subsurface upstream of the monitoring site, limiting the exposure of the water to warming by ambient conditions. During the summer and fall, water temperatures at RR2 and RR3 gradually increased, mirroring the gradual increase in the deep water temperatures in Hell Hole Reservoir (see section 3.2.1). From June through October 2005, water temperatures at RR1, RR10, and RR5 were coldest in early June and warmest from mid-July through mid-August, then generally decreased gradually from mid-August through October. The abrupt change in water temperature during mid-June at RR1, RR10, and RR5 coincided with spill from Hell Hole Dam and local rainstorms.

Water temperatures in the Rubicon River from RM 22.7 (RR5) downstream to RM 5.3 (RR8) are shown in Figure 14. From June through October 2005 in this reach of the Rubicon River, water temperature increased with increased distance downstream. Water temperatures generally were coldest during early June and warmest during mid-July. The abrupt change in water temperature during mid-June at RR8 and RR5 coincided with spill from Hell Hole Reservoir and local rainstorms. During the warmest period in July, water temperature increased more than 10°F in the approximately 17 miles between RR5 and RR8. For the three sites surrounding the Rubicon River-South

Fork Rubicon River confluence, water temperatures during the summer generally were warmest in the South Fork Rubicon River just upstream of the confluence (SF1), and were coldest in the Rubicon River just upstream of the confluence (RR5).

Water temperatures in the Rubicon River from RM 5.3 (RR8) downstream to RM 0.7 (RR4) are shown in Figure 15. From June through October 2005 in this reach of the river, water temperatures were generally coldest during early June and warmest during mid-July. The abrupt change in water temperature during mid-June at RR8 and PC1 coincided with spill from Hell Hole Reservoir and Stumpy Meadows Reservoir, respectively, and local rainstorms. Water temperatures were warmest at the most downstream Rubicon River water temperature monitoring site (RR4), and water temperatures were coldest in Pilot Creek just upstream of the Rubicon River confluence (PC1). During the summer and fall periods, cold water inflow from Pilot Creek caused water temperatures in the Rubicon River downstream of the Pilot Creek confluence to be slightly colder (RR9) than water temperatures upstream of the Pilot Creek confluence (RR8).

### 2.4.4 Long Canyon Creek

Water temperature is monitored at seven locations in Long Canyon Creek (two locations each in the South Fork (SL1 and SL2) and North Fork (NL1 and NL2), and three locations on the main stem), from immediately upstream of the diversions on South Fork (SL1) and North Fork (NL1) Long Canyon creeks to immediately upstream of the confluence with the Rubicon River (LC1). Water temperature also is monitored in Wallace Canyon Creek (WC1), a major tributary to Long Canyon Creek. The site IDs, names, and river miles of the Long Canyon Creek monitoring sites are shown on Table 3. Figures 4 and 5 show the Long Canyon Creek monitoring site locations.

Water temperatures in Long Canyon Creek are shown in Figure 16. During June through October 2005, water temperatures generally were coldest during early June and warmest during mid-July. The abrupt increase and subsequent decrease in water temperature during mid-June recorded at NL1, NL2, and SL2 coincided with local rainstorms (Figure 8). Following the peak in mid-July, water temperature at each site generally decreased through the final data collection in mid-October. Water temperatures in South Fork Long Canyon Creek generally were cooler than water temperatures in North Fork Canyon Creek. In South Fork Canyon Creek, water temperatures just below the South Fork Diversion Dam (SL2) typically were several degrees Fahrenheit warmer than water temperatures just above the South Fork Diversion Dam (SL1). In North Fork Canyon Creek, water temperatures just below the North Fork Long Canyon Diversion (NL2) typically were slightly warmer than water temperatures just above the diversion (NL1).

Water temperatures in Long Canyon Creek from RM 11.1 (LC2) downstream to RM 0.0 (LC1) are shown in Figure 17. Additionally, water temperatures in Wallace Canyon Creek, at RM 1.2 (WC1) from the Long Canyon Creek confluence, are included. Available data indicate that water temperatures were generally warmest during mid-July and coldest during early to mid-October. Following the peak in mid-July, water temperature at each site generally decreased through the final data collection in mid-October. Within Long Canyon Creek, water temperature increased with increased distance downstream. Water temperatures at WC1 were cooler, sometimes by more than 10°F, than water temperatures in Long Canyon Creek.

### 2.4.5 North Fork American River

Water temperature is monitored at three locations in the North Fork American River. PCWA maintains sites in the North Fork American River immediately upstream and downstream of the Middle Fork American River, and the USGS maintains a real-time site (#11433790) at the Auburn Dam site (http://waterdata.usgs.gov/ca/nwis/). The site IDs, names, and river miles of the North Fork American River monitoring sites are shown on Table 3. Figure 3 shows the North Fork American River monitoring site locations.

Water temperatures in the North Fork American River from RM 21.4 (NF1) downstream to RM 14.9 (NFA), and water temperatures in the Middle Fork American River at RM 0.1 (MF8) are shown on Figure 18. From June through October 2005, water temperatures at these locations generally were coldest during early June and warmest during late July to early August. The abrupt change in water temperature during mid-June coincided with spill from upstream reservoirs and local rainstorms. Following the peak in early August, water temperatures at each site generally decreased through September. Water temperatures in the North Fork American River upstream of the Middle Fork confluence (NF1) continued to decrease through October, whereas water temperatures in the Middle Fork American River (MF8) and the North Fork American River downstream of the Middle Fork American River confluence (NF2 and NFA) slightly increased. This occurred coincident with the annual powerhouse maintenance outage during early to mid-October.. Among the water temperature monitoring sites shown on Figure 18, water temperatures were warmest (by over 10°F) at NF1 (located in the North Fork just upstream of the Middle Fork confluence), and coldest at MF8 (located in the Middle Fork just upstream of the North Fork confluence). Cold water inflow from the Middle Fork American River apparently influenced water temperatures in the North Fork American River. During the warmest period in August, water temperature decreased more than 10°F in the approximately 0.8 miles between NF1 (just upstream of the Middle Fork confluence) and NF2 (just downstream of the Middle Fork confluence). It is important to note that the North Fork American River upstream of the Middle Fork American River is not influenced by large storage reservoirs and low-level reservoir (e.g., cold) outlet releases, as is the case for the Middle Fork Middle Fork American River. Some water is stored in Lake Clementine (located approximately 2 miles upstream from the North Fork-Middle Fork confluence) and a small amount of water is diverted from the North Fork of North Fork American River. However, these operations do not substantially effect natural flow.

## 3.0 RESERVOIR PROFILE MONITORING

The primary objective of the reservoir water temperature profiling program is to characterize the water temperatures of the MFP reservoirs and to identify the occurrence, timing, and nature of the thermal processes, such as thermal stratification, occurring in MFP reservoirs. In addition to water temperature, dissolved oxygen and specific conductance also were measured. Specific reservoir profile protocols are presented in the Water Temperature Study Plan.

French Meadows and Hell Hole reservoirs were initially profiled on September 7, 20, 30 and October 13, 2004. Three locations within each reservoir were profiled to identify potential longitudinal water temperature gradients within each reservoir. The locations profiled in 2004 were sampled again in 2005. Pursuant to the Resource Agencies' request, reservoir profiles were also taken at one location in Ralston Afterbay Reservoir during 2005.

## 3.1 FRENCH MEADOWS RESERVOIR

Reservoir profiling of water temperature, dissolved oxygen, and specific conductance was performed at French Meadows Reservoir on June 15, July 15, August 16, September 19, and October 25, 2005. The profiling locations in French Meadows Reservoir are shown on Figure 19.

Throughout the sampling season, the reservoir elevation steadily declined, resulting in a successive decrease in the maximum depth sampled at each profile site. The estimated water surface elevation during each sampling event was as follows:

| Date | Estimated Elevation *(feet above msl)* |
|---|---|
| June 15 | 5,262 |
| July 15 | 5,258 |
| August 16 | 5,248 |
| September 19 | 5,236 |
| October 25 | 5,223 |

For reference, the Middle Fork American River outlet in French Meadows Reservoir is at approximately 5,039 feet above mean sea level (msl), giving a water depth of 184 feet or more below the reservoir water surface during the sampling period.

### 3.1.1 Water Temperature Results

Water temperature profiles at the three profile sites in French Meadows Reservoir sampled on five occasions from mid-June through late October are shown on Figures 20-24. The water temperature profiles at FM1, FM2, and FM3 throughout the sampling period were generally similar. Site FM1 appears to be more strongly stratified during the first two sampling occasions than FM2 and FM3, which were similar. However, during the August, September, and October sampling events, the level of stratification was similar among the three sites. The maximum depths observed differed with FM1 being the deepest and FM3 being the shallowest.

#### 3.1.1.1 June

During June, with distinct warmer surface waters and a cool bottom layer, French Meadows Reservoir was undergoing thermal stratification (Figure 20). The water temperature observed at the three sites sampled were approximately 58°F on the surface and 43°F at the deepest point sampled. Profile site FM1 exhibited the most distinct thermal stratification with a clear epilimnion, metalimnion, and hypolimnion. In contrast, FM2 and FM3 did not exhibit clearly defined epilimnions. Water temperatures at FM1 and FM2 at depths greater than approximately 80 feet did not change.

#### 3.1.1.2 July

By mid-July, surface water temperatures had risen to approximately 72°F; water temperatures measured at the deepest points were about 44°F (Figure 21). Similar to observations during June, FM2 and FM3 did not exhibit epilimnions, but rather water temperature steadily decreased to approximately 51°F at 40 feet. The epilimnion at FM1 occurred at approximately 18 feet. Water temperatures at depths greater than approximately 100 feet were comparable.

#### 3.1.1.3 August

French Meadows Reservoir achieved thermal stratification by mid-August (Figure 22). Water temperatures at FM1, FM2, and FM3 were nearly identical, with surface water temperatures near 71°F and deepest temperatures measured approximately 44°F. The epilimnion extended approximately 30 feet down from the surface, and the most pronounced decrease in water temperature was observed between approximately 30 feet and 40 feet deep. Water temperatures below a depth of 120 feet were nearly identical.

#### 3.1.1.4 September

Between mid-August and mid-September, the surface waters at French Meadows had cooled from approximately 71°F to approximately 64°F and the epilimnion extended to approximately 45 feet deep (Figure 23). The thermal profiles at FM1, FM2, and FM3 were very similar. The water temperature rapidly decreased from 50 feet to 60 feet, and decreased more slowly down to approximately 100 feet. Water temperatures at FM1 and FM2 did not substantially change below 100 feet.

#### 3.1.1.5 October

With the thickening and cooling of the epilimnion, French Meadows Reservoir was undergoing thermal destratification by late October (Figure 24). The thermal profiles of FM1, FM2, and FM3 were nearly identical and exhibited surface water temperatures of approximately 55°F. Water temperatures measured at the deepest point during sampling at FM1 and FM2 were approximately 45°F. Water temperature at the relatively shallow FM3 was within 5°F from the top to the bottom of the water column. The epilimnion extended approximately 70 feet deep.

#### 3.1.1.6 Seasonal Trend / June through October

To observe seasonal trends from mid-June through October all five temperature profiles were displayed on a single plot as shown on Figure 25 for profile site FM1. During this period, surface water temperatures ranged from approximately 55°F to approximately 72°F, and exhibited a warming trend from June through August; then a cooling trend from August through October. The coldest water temperatures measured at FM1 ranged from approximately 43°F in June to approximately 45°F in October. The epilimnion was approximately 20 feet thick during June and July, and steadily increased approximately 70 feet during late October. The reservoir was undergoing destratification by the September sampling date although it had not completely destratified by the last sampling date (October 25).

### 3.1.2 Dissolved Oxygen Results

Dissolved oxygen profiles from June 15, July 15, August 16, September 19, and October 25 at profile site FM1 are shown on Figure 26. The individual monthly dissolved oxygen plots for sites FM1, FM2, and FM3 are included in Appendix B.

The highest average dissolved oxygen levels were observed during June; the lowest average dissolved oxygen levels were observed during October. During June and August, the highest concentrations of dissolved oxygen were observed at a depth of approximately 40 feet, whereas the highest concentrations during July and September occurred at a depth 50 feet. The highest concentrations of dissolved oxygen measured on October 25 were at the surface, and a marked decrease in oxygen levels occurred below approximately 70 feet.

### 3.1.3 Specific Conductance Results

Specific conductance profiles from June 15, July 15, August 16, September 19, and October 25 at site FM1 are shown on Figure 27. Individual monthly specific conductance plots for profile sites FM1, FM2, and FM3 are included in Appendix B.

With some minor variation, specific conductance measured at site FM1 was relatively similar throughout the sampling season and throughout the water column. Overall, specific conductance slightly increased June through October and slightly decreased from the surface to the deepest point measured.

## 3.2 HELL HOLE RESERVOIR

Reservoir profiling of water temperature, dissolved oxygen, and specific conductance was performed at Hell Hole Reservoir on June 15, July 15, August 16, September 20, and October 24, 2005. The profiling sites in Hell Hole Reservoir are shown on Figure 28.

Throughout the sampling season, the reservoir water surface elevation steadily declined though September, resulting in a successive decrease in the maximum depth sampled at each site. The reservoir elevations were the same during the September and October sampling dates. The estimated water surface elevation at Hell Hole Reservoir during each sampling event was as follows:

| Date | Estimated Elevation *(feet above msl)* |
|---|---|
| June 15 | 4,631 |
| July 15 | 4,624 |
| August 16 | 4,605 |
| September 19 | 4,584 |
| October 25 | 4,584 |

For reference, the Rubicon River outlet in Hell Hole Reservoir is at approximately 4,288 msl, giving a water depth of approximately 300 feet or more below the water surface during the sampling period.

### 3.2.1 Water Temperature Results

Water temperature profiles at the three profile sites in Hell Hole Reservoir sampled on the five occasions are shown on Figures 29-33. In general, the water temperature profiles are similar throughout the sampling season at HH1, HH2, and HH3. The deepest maximum depths observed occurred at HH2 and the shallowest occurred at HH3.

#### 3.2.1.1 June

Water surface temperatures measured at the Hell Hole Reservoir were approximately 55°F and decreased to approximately 43°F at the deepest measured point on June 15 (Figure 29). A clear epilimnion was not present at this time which suggests that stratification of the Hell Hole Reservoir was in progress. Some differences in water temperature were observed among the three sites samples, most notably at the surface and at approximately 80 feet to 100 feet deep. Below 140 feet, water temperature was similar among sites and remained relatively constant.

#### 3.2.1.2 July

On July 15, surface water temperatures were approximately 68°F at HH1, and 72°F at HH2 and HH3 (Figure 30). The coldest water temperatures measured (approximately 43°F) occurred at approximately 230 feet. Site HH1 was characterized by a distinct epilimnion approximately 20 feet thick, whereas HH2 and HH3 steadily cooled from the surface to about 170 feet deep. Below 170 feet, water temperatures were relatively constant and similar among the three sites sampled.

#### 3.2.1.3 August

By August 16, an epilimnion was evident at all three sample sites (Figure 31). This uppermost layer was very similar at HH2 and HH3, but slightly warmer and less than that observed at HH1. Below the epilimnion, water temperature steadily cooled and the thermal profiles of the three sample sites were very similar. The warmest water temperatures measured at Hell Hole Reservoir during August were approximately 68°F at the surface and the coldest temperatures measured were approximately 44°F near the bottom.

#### 3.2.1.4 September

Water surface temperatures decreased to approximately 61°F by September 20 (Figure 32). The coldest water temperatures increased to approximately 46°F at HH1 and HH2, and approximately 49°F at HH3. The depth of the epilimnion increased to approximately 80 feet. Below 80 feet water depth, temperatures cooled relatively quickly until approximately 130 feet, after which the rate of cooling slowed. The thermal profiles of HH1, HH2, and HH3 were similar, although the maximum depth at HH3 was approximately 70 feet less than at HH1 and HH2.

#### 3.2.1.5 October

The cooling trend observed from August to September continued through October, when the reservoir was clearly beginning to turnover (Figure 33). Measurements taken at HH3 in October (the shallowest site sampled) indicated that the water temperature was nearly isothermic. The warmest water temperatures measured at the Hell Hole Reservoir surface were approximately 57°F. The coldest water temperatures were approximately 47°F at HH1 and HH2. Other than the differences in depths, water temperature profiles of the three sites sampled were very similar.

#### 3.2.1.6 Seasonal Trend / June through October

The water temperature profiles for site HH1 during each the sampling period were combined on a single plot to observe the seasonal trend from mid-June through October (Figure 34). During the mid-June through September period, surface water temperatures ranged from approximately 54°F to approximately 68°F, and exhibited a warming trend from mid-June to mid-July then a cooling trend from mid-August through October. Measured water temperatures at the Hell Hole Reservoir surface in July and August were similar. The coldest water temperatures measured at HH1 changed from approximately 42°F in mid-June to approximately 47°F in late October. A clear epilimnion had formed in the upper 20 feet of Hell Hole Reservoir by mid-July and appeared to remain relatively unchanged in mid-August. However, during the September and October sampling period the epilimnion appeared to be sinking (thickening) and cooling, characteristic of reservoir turnover. The turnover process had not yet been completed in Hell Hole Reservoir by the end of October when sampling concluded for the year.

### 3.2.2 Dissolved Oxygen Results

The Hell Hole Reservoir dissolved oxygen profiles from June through October at profile site HH1 are shown on Figure 35. Individual monthly dissolved oxygen plots for HH1, HH2, and HH3 are included in Appendix B.

Overall, the highest dissolved oxygen concentrations were observed during June; the lowest were observed during October. During June, July, August, and September the highest concentrations of dissolved oxygen were observed at or near the deepest depths sampled. During October, the highest concentrations were observed at approximately 20 feet from the surface. The locations of the lowest observed dissolved oxygen levels varied among the dates sampled, and were: at approximately 20-30 feet deep in June, July, and August; at approximately 110 feet deep in September; and 170 feet deep in October.

### 3.2.3 Specific Conductance Results

With some minor variation, specific conductance measured at site HH1 in Hell Hole Reservoir was relatively similar throughout the sampling season and throughout the water column. Overall, specific conductance generally increased June through October and decreased from the surface to the deepest point measured (Figure 36).

## 3.3 RALSTON AFTERBAY RESERVOIR

Reservoir profiling of water temperature, dissolved oxygen, and specific conductance was performed at Ralston Afterbay Reservoir on July 14, August 16, September 19, and October 25, 2005. The single profiling site in Ralston Afterbay Reservoir is shown on Figure 37.

Ralston Afterbay Reservoir serves as a re-regulating afterbay for the Ralston Powerhouse with the reservoir surface elevation subject to daily fluctuations that typically remained between approximately 1,170 msl and 1,175 msl during the sampling season. However, the elevation decreased to approximately 1,150 msl, during the MFP powerhouse maintenance outage (Figure 38). Water surface elevations during the four sampling events at Ralston Afterbay Reservoir were as follows:

| **Date** | **Estimated Elevation** ***(feet above msl)*** |
|---|---|
| July 15 | 1,172 |
| August 16 | 1,174 |
| September 19 | 1,172 |
| October 25 | 1,172 |

The October reservoir profile was conducted after the reservoir had returned to its normal operating elevation.

### 3.3.1 Water Temperature Results

Water temperature profiles of Ralston Afterbay Reservoir during each of the four sampling periods are shown on Figure 39. Although not exhibiting the classic characteristics of thermal stratification (an epilimnion, metalimnion, and hypolimnion), surface water warming was evident in Ralston Afterbay Reservoir during 2005. During July, water temperature was approximately 67°F at the surface, cooled relatively quickly to approximately 53°F at 5 feet, and then cooled more gradually to the lowest observed water temperature (49°F) at approximately 23 feet. A similar pattern was evident during the August sampling where water temperature was approximately 64°F at the surface, cooled relatively quickly to approximately 51°F at 10 feet, and then cooled more gradually to the lowest temperature of 47°F at approximately 26 feet.

The water temperature profiles collected in Ralston Afterbay Reservoir during September and October were similar. Water temperatures at the surface were approximately 56°F-57°F and cooled quickly to approximately 52°F at approximately 4 feet. At depths greater than 4 feet, water temperatures cooled more gradually to their coldest point of 50°F-51°F at 23 feet.

### 3.3.2 Dissolved Oxygen Results

Dissolved oxygen profiles of Ralston Afterbay Reservoir from July through October are shown on Figure 40. The dissolved oxygen concentrations measured at the surface ranged from a low of approximately 8.4 milligrams/liter (mg/L) on October 25 to approximately 9.3 mg/L on September 19. The concentration of dissolved oxygen generally increased with increasing depth (and with decreasing water temperature).

### 3.3.3 Specific Conductance Results

Specific conductance measured in Ralston Afterbay Reservoir varied among the four samples taken (Figure 41). The highest levels of specific conductance were observed during the October sampling, and the lowest were observed during the August sampling. Specific conductance levels measured during the July and September sampling occasions were similar and were between the levels measured in August and October.

## 4.0 METEOROLOGICAL MONITORING

PCWA collected meteorological data from 10 monitoring sites in the vicinity of the MFP during 2005. PCWA maintains six of the 10 meteorological (MET) monitoring stations, the remaining four are maintained by other agencies and data from these sites are available to the public. Data at the six sites maintained by PCWA are collected continuously at 15-minute intervals. The locations of the 10 meteorological monitoring stations are shown on Figure 42.

Of the stations maintained by PCWA, two are capable of measuring six parameters: (1) air temperature; (2) relative humidity; (3) solar radiation; (4) wind speed; (5) wind direction; and (6) and precipitation. These two stations are identified as:

- IBR (Middle Fork Interbay); and
- RAB (Ralston Afterbay Dam).

In addition, two of stations maintained by other agencies are capable of measuring these six parameters. These stations are identified as

- HLL (Hell Hole California); and
- DUN (Duncan).

PCWA also maintains four monitoring stations that measure air temperature and relative humidity: These stations are identified as:

- FA1 (on the Middle Fork American River, near the base of French Meadows Dam);
- HA1 (on the Rubicon River, near the base of Hell Hole Dam);
- RA1 (on the Rubicon River, at Ellicott Bridge); and
- NA1 (near the North Fork American River, at the Auburn State Recreation Headquarters).

Air temperature and precipitation data are collected at two sites maintained by other agencies, as follows:

- GKS (Greek Store); and
- GTW (Georgetown).

The meteorological monitoring sites and parameters measured at each site are shown on Table 5. Data collected at sites maintained by other agencies are not presented in this report because it is considered preliminary until quality assurance/quality control is completed.

The plots presented in the following sections are daily averages intended to present summaries of the data collected.

### 4.1 FULL METEOROLOGICAL MONITORING STATIONS

As noted, PCWA maintains two meteorological monitoring sites (IBR and RAB) that monitor six parameters. Meteorological data collected from these sites are presented in the following sections.

#### 4.1.1 Middle Fork Interbay (IBR)

An Onset HOBO Weather Station (model # H21-SYS-A) meteorological monitoring station was installed at Middle Fork Interbay on June 28, 2005, utilizing a tripod and 3-meter mast. The MET station was installed inside of the locked gates at the Middle Fork Powerhouse for protection against vandalism.

The meteorological data collected at Middle Fork Interbay (IRB) were last downloaded in mid-October 2005. The following figures summarize air temperature, relative humidity, solar radiation, and wind speed data that were collected through that time.

#### 4.1.1.1 Air Temperature Results

The daily average, maximum, and minimum air temperature (°F) observed at Middle Fork Interbay (IBR) is shown in Figure 43. For the late June through late October period, the warmest air temperatures at Middle Fork Interbay were observed around mid-July, when daily average air temperatures exceeded 80°F and daily maximum air temperatures approached 100°F. From the mid-July peak through early September air temperature cooled gradually, after which the air temperature cooled relatively quickly. September and October were characterized by warm days and cool nights with high variability. For the late June through late October period, the highest daily maximum air temperature was approximately 98°F and the lowest daily minimum air temperature was approximately 41°F. During this period, the highest daily average air temperature was approximately 81°F and the lowest daily average air temperature was approximately 51°F.

#### 4.1.1.2 Solar Radiation Results

The daily average and maximum solar radiation (watts/meter squared, $W/m^2$) measured at IBR is shown on Figure 44. For the late June through late October period, daily average solar radiation was highest during late June and gradually decreased through mid-October. This same general trend was observed for daily maximum solar radiation. However, the single highest and lowest maximum observed solar radiation values occurred within a few days of one another in late September.

#### 4.1.1.3 Relative Humidity Results

The daily average, maximum, and minimum relative humidity (%) observed at Middle Fork Interbay (IBR) are shown on Figure 45. For the late June through late October period, the daily average relative humidity generally decreased from late June through late August and increased from late August through late October. The highest variability in daily average relative humidity was observed during the fall period. For the late June through late October period, the highest daily average relative humidity was approximately 85% and the lowest was approximately 28%.

#### 4.1.1.4 Wind Speed Results

The daily average wind speed (miles/hour, mph) observed at Middle Fork Interbay (IBR) is shown on Figure 46. For the late June through late October period, daily average wind speed slightly increased from late June through early September and ranged from approximately 0.5 mph to approximately 1.5 mph. From early September through late October, daily average wind speed was highly variable, ranging from over 3 mph to less than 1 mph.

### 4.1.2 Ralston Afterbay (RAB)

The MET station at Ralston Afterbay Dam (RAB) was installed on July 1, 2005 near the center of the Ralston Afterbay Dam, behind a locked gate. Meteorological data collected at RAB were last downloaded during mid-October 2005. The following figures summarize the air temperature, relative humidity, solar radiation, and wind speed data through mid-October.

#### 4.1.2.1 Air Temperature Results

The daily average, maximum, and minimum air temperature (°F) observed at Ralston Afterbay Reservoir (RAB) is shown on Figure 47. From late June through late October, the warmest air temperatures at RAB were observed around mid-July, when daily average air temperatures exceeded 80°F and daily maximum air temperatures were over 100°F. Following the mid-July peak, air temperatures gradually cooled through early September, after which temperatures cooled relatively quickly. Warm days and cool nights with higher daily variability characterized September and October. From late June through late October, the highest daily maximum air temperature was over 100°F, the lowest daily minimum air temperature was approximately 46°F. The highest daily average air temperature was approximately 83°F, and the lowest daily average air temperature was approximately 54°F during this period.

#### 4.1.2.2 Solar Radiation Results

Daily average and maximum solar radiation values (watts/square meter, $W/m^2$) observed at Ralston Afterbay Reservoir (RAB) are shown on Figure 48. The daily average and daily maximum solar radiation observed generally decreased from July through late October, although some deviations from this trend are evident.

#### 4.1.2.3 Relative Humidity Results

The daily average, maximum, and minimum relative humidity (%) observed at RAB is shown on Figure 49. From July through late October, daily average relative humidity generally decreased from July through late August and increased from late August through late October. The highest variability in daily average relative humidity was observed during the fall period. For the July through late October period, the highest daily average relative humidity was approximately 86% and the lowest was approximately 35%.

#### 4.1.2.4 Wind Speed Results

The daily average wind speed (mph) observed at Ralston Afterbay is presented in Figure 50. From late June through early September, daily average wind speed was generally between 2 mph and 3 mph. From early September through late October, daily average wind speed generally decreased and was typically less than 1 mph by late October.

## 4.2 AIR TEMPERATURE/RELATIVE HUMIDITY MONITORING STATIONS

As noted, PCWA also maintains four monitoring stations that measure only ambient air temperature and relative humidity: FA1, HA1, RA1, and NA1. Monitoring results for each of these stations are summarized in the following.

### 4.2.1 Middle Fork American River near French Meadows Dam (FA1)

The air temperature/relative humidity monitoring station at Middle Fork American River near French Meadows Dam (FA1) was initially installed on August 17, 2004 near the French Meadows Dam spillway behind a PCWA locked gate. During July 2005, the monitoring site was relocated a short distance downstream adjacent to the PCWA/USGS flow gage (#11427500) site where water temperature (MF2) also is monitored. The following figures summarize the air temperature and relative humidity data that were collected at this monitoring station through early October during 2005.

#### 4.2.1.1 Air Temperature Results

During 2005, daily average, maximum, and minimum air temperatures measured near French Meadows Dam (FA1) generally increased from January through about mid-July, and then decreased through early October (Figure 51). During winter (January and February), daily minimum air temperatures were generally between 25°F and 35°F, with a low temperature of approximately 17°F. Daily maximum air temperatures were generally 40°F to 50°F, with a high temperature of approximately 70°F.

During spring (March through May), daily minimum air temperatures generally were between 20°F and 40°F, although minimum temperatures exceeded 40°F during late spring. Daily maximum air temperatures during spring were between approximately 30°F to over 80°F.

Daily minimum air temperatures during summer (June through August) increased through early August and were generally between 30°F and 60°F. Daily maximum air temperatures exceeded 90°F on the warmest days, and generally were greater than 70°F.

During September and October, daily minimum air temperatures generally were greater than 40°F, and daily maximum air temperatures generally were less than 80°F.

#### 4.2.1.2 Relative Humidity Results

Daily average, minimum, and maximum relative humidity varied substantially during January through mid-June, with daily minimums ranging from about 10 percent to over 90 percent, and daily maximums ranging from about 50 percent to 100 percent (Figure 52). Relative humidity generally declined from mid-June through mid-August and exhibited much less daily variation in the daily minimum and maximum values than the January through mid-June period. The variation in the daily average, minimum, and maximum relative humidity appeared to increase during the mid-August through early October period.

### 4.2.2 Rubicon River near Hell Hole Dam (HA1)

The air temperature/relative humidity monitoring station at Rubicon River near Hell Hole Dam (HA1) was installed during August 2004 at the PCWA dormitory. This station was relocated on July 20, 2005 to the Rubicon River near Hell Hole Dam, near the PCWA/USGS flow gage (#11428800) site where water temperature (RR2) also is monitored. The following figures summarize the air temperature and relative humidity data that were collected through late October 2005.

#### 4.2.2.1 Air Temperature Results

During 2005, air temperature decreased from mid-July through late October (Figure 53). During mid-July through August, daily average air temperature was generally between 65°F and 75°F, daily minimum air temperature was generally between 50°F and 60°F, and daily maximum air temperature was generally between 80°F and 90°F. Air temperatures observed during the fall exhibited more daily variation than those observed during the summer. During September through late October, daily average air temperature was generally between 45°F and 65°F, daily minimum air temperature was generally between 35°F and about 50°F, and daily maximum air temperature was generally between 55°F and 85°F.

#### 4.2.2.2 Relative Humidity Results

Relative humidity observed during the mid-July through late October period (Figure 54) appeared to increase slightly, although the daily variability in the relative humidity data makes it difficult to discern trends in the data. During the mid-July through late October period, observed daily average relative humidity ranged from 20 percent to 80 percent, daily minimum relative humidity ranged from 10 percent to over 40 percent, and daily maximum relative humidity ranged from about 40 percent to almost 100 percent.

### 4.2.3 Rubicon River near Ellicott Bridge (RA1)

The air temperature/relative humidity monitoring station at Rubicon River near Ellicott Bridge (RA1) was installed during August 2004. The following figures summarize the air temperature and relative humidity data that were collected through late October during 2005. Problems occurred when the RA1 logger was downloaded and subsequently re-launched in early August such that data were not collected from early August through October. The problem was corrected and data collection at RA1 has resumed.

#### 4.2.3.1 Air Temperature Results

Daily average, minimum, and maximum air temperature generally increased from January through early August 2005 (Figure 55). From January through April, daily minimum air temperatures typically were between 30°F and 40°F, and daily average air temperature gradually increased from around 35°F to about 50°F. During this period, daily maximum air temperatures generally increased and varied from about 35°F to about 75°F.

May and June 2005 were characterized by increasing daily average, minimum, and maximum air temperatures and by relatively high daily variation. Maximum air temperatures observed during this period exceeded 80°F, while minimum air temperatures were occasionally below 40°F.

Air temperatures during July and early August were warm, with daily averages that exceeded 70°F and daily maximums that exceeded 90°F. Daily minimum air temperature during this period always was greater than 50°F and often exceeded 60°F.

#### 4.2.3.2 Relative Humidity Results

For the January through early August 2005 period, relative humidity was highly variable from January through mid-June, after which a decreasing trend was observed (Figure 56). During January through June, daily minimum relative humidity ranged from about 15 percent to close to 100 percent and daily maximum relative humidity ranged from 60 percent to 100 percent.

From mid-June through early August, relative humidity steadily decreased and was less variable day-to-day than during the previous five and a half months. Daily average relative humidity typically was between 50 percent and 65 percent, daily minimum relative humidity was generally between 20 percent and 40 percent, and daily maximum relative humidity was between about 60 percent and 85 percent.

### 4.2.4 North Fork American River near the Confluence (NA1)

The air temperature/relative humidity monitoring station at the North Fork American River near the Confluence (NA1) was installed in August 2004. Air temperature and relative humidity data were recorded at this site through early August 2005 and the 2005 data are presented in Figures 57 and 58. Data is not available for this site between early August and late October 2005 due to a programming error that occurred following the August 2005 download. Data collection was resumed in late October 2005 when the error was corrected.

#### 4.2.4.1 Air Temperature Results

Air temperature data collected at North Fork American River near the Confluence are presented in Figure 57. For the period of January through early August 2005, air temperature generally increased from an average of around 45°F during January to about 85°F during July and early August. Observed daily minimum air temperatures were about 35°F during January and up to approximately 75°F during July. Observed daily maximum air temperatures were less than 50°F during January and over 100°F during July. During a particularly warm period in March, air temperature exceeded 80°F.

#### 4.2.4.2 Relative Humidity Results

For the January through early August 2005 period, relative humidity was highly variable from January through mid-June, after which a decreasing trend was observed (Figure 58). During January through June, daily minimum relative humidity ranged from about 10 percent to over 90 percent, and daily maximum relative humidity ranged from 60 percent to close to 100 percent.

From mid-June through early August, relative humidity steadily decreased and was less variable day-to-day than during the previous five and a half months. Daily average relative humidity steadily decreased from about 70 percent to about 35 percent, daily minimum relative humidity steadily decreased from about 45 percent to about 20 percent, and daily maximum relative humidity steadily decreased from about 90 percent to about 55 percent.

## 5.0 NEXT STEPS

Placer County Water Agency will continue to monitor stream water temperature; reservoir water temperature, dissolved oxygen, and specific conductance; and meteorological parameters during 2006, as described in the following.

### 5.1 STREAM WATER TEMPERATURE

PCWA will continue to maintain the 48 water temperature monitoring sites located throughout the study area and download the data from USGS #11433790 (NFA). PCWA initially anticipated utilizing water temperature data collected by SMUD to characterize conditions in the South Fork Rubicon River. However, because PCWA installed a water temperature logger in the South Fork Rubicon River immediately upstream of the Rubicon River confluence (SF1), PCWA suggests that coordination with SMUD regarding water temperature data collection for the South Fork Rubicon River be discontinued because data collected at PCWA's SF1 monitoring site more appropriately achieves the monitoring objective for the South Fork Rubicon River. Should the need arise, PCWA will coordinate with SMUD regarding water temperature monitoring in the South Fork Rubicon River.

PCWA proposes to rename each of the water temperature monitoring sites according to the corresponding river mile. Numerous water temperature monitoring sites have been added since the program was initiated in 2003. Consequently, the current naming scheme is no longer logical. Naming the monitoring sites by river mile allows the sites to be "mentally" mapped and would allow new sites to be added, if necessary, without altering the logical nomenclature. Under the proposed naming scheme, for example, MF1 (the Middle Fork Upstream of French Meadows Reservoir) would be renamed as MF-51.6 and MF8 (the Middle Fork Upstream of the North Fork Confluence) would be renamed as MF-0.1. The two letter combination indicating the river or stream (e.g., MF for Middle Fork American River, RR for Rubicon River, etc.) would remain unchanged.

Monitoring activities during 2005 and inspection of the data collected suggest modifications to some monitoring sites are necessary. Specifically, water temperature loggers IB1 and OX1 need to be relocated so that they are not exposed to ambient air conditions. Daily operations of the Middle Fork and Ralston powerhouses result in fluctuations in the stages of Middle Fork Interbay and Ralston Afterbay reservoirs, respectively. These fluctuations were greater than originally anticipated when the loggers were installed causing the water temperature loggers at IB1 and OX1 to be exposed to ambient air conditions. The loggers at these sites will be relocated to ensure they remain wetted under all foreseeable conditions.

During 2006, PCWA will maintain a monitoring schedule similar to that of 2005. All sites will be visited during May 2006, or as soon as access and runoff conditions permit. The planned stream water temperature data download schedule for 2006 is shown on Table 6.

The stream water temperature data collection, data quality assurance and quality control, and data analysis methodologies/procedures defined in the 2005 Existing Environment Study Plan will be followed in 2006. PCWA will prepare a 2006 stream water temperature summary report following 2006 data collection activities.

### 5.2 RESERVOIR PROFILING

PCWA will conduct reservoir profiling at French Meadows, Hell Hole, and Ralston Afterbay reservoirs in 2006. The 2006 profiling program is planned to begin with sampling in May, or as soon as French Meadows and Hell Hole reservoirs are accessible.

The sampling protocols used during 2004 and 2005 will be followed in 2006, with one exception. Water temperature profiles at French Meadows and Hell Hole reservoirs during 2004 and 2005 indicate that the thermal are similar among the upper (FM3 and HH3), middle (FM2 and HH2), and lower (FM1 and HH1) sampling sites. Because of these similarities, water temperature profiles will only be developed at the lowermost profiling sites in 2006. The sites nearest the dams are FM1 and HH1. Temperature profiles at these sites are expected to characterize the thermal characteristics of French Meadows and Hell Hole reservoirs.

The reservoir data quality assurance and quality control, and data analysis methodologies and procedures established in the Existing Environment Study Plan will be followed in 2006. PCWA will prepare a 2006 summary report following the 2006 reservoir profiling season.

## 5.3 RALSTON AFTERBAY WATER TEMPERATURE INVESTIGATION

PCWA has developed a proposed "*Ralston Afterbay Reservoir Reconnaissance-Level Hardhead Water Temperature Suitability Investigation Study Plan (Hardhead Study Plan).*" This plan will be provided to the resource agencies under separate cover. PCWA expects to implement this plan in 2006, following consultation with the resource agencies.

## 5.4 METEOROLOGICAL MONITORING

The six meteorological monitoring sites maintained by PCWA will continue to be operated during 2006. Data collection, data quality assurance and quality control, and data analysis methodologies / procedures established in the 2005 Existing Environment Study Plan will be followed in 2006. PCWA will continue to download MET data from stations IBR and RAB every two months during the winter, and anticipates downloading data from these stations monthly during the May through October period. Data from the other four monitoring sites will be downloaded in May, or as soon as accessible, and again during October 2006. PCWA will also continue to maintain the real-time monitoring site database.

PCWA will prepare a 2006 meteorological summary report following 2006 data collection activities.

# TABLES

**Table 2. The Site ID's, Site Names, Original Installation Dates, and Statuses of the 30 original water temperature monitoring sites installed by PCWA in 2003 and 2004.**

| Site ID | Site Name | Original Installation Date | Status |
|---|---|---|---|
| DC1 | Duncan Cr Immediately Upstream of Diversion Dam | 9/24/2003 | OK |
| DC2 | Duncan Cr Downstream of Diversion Dam | 9/24/2003 | Lost due to high flows |
| FL1 | Five Lakes Cr Upstream of Hell Hole Reservoir | 9/30/2003 | Lost due to high flows |
| IB1 | MF American R Immediately Downstream of MF Powerhouse Outlet | 8/17/2004 | OK |
| LC1 | Long Canyon Cr Immediately Upstream of Rubicon R | 8/24/2004 | Logger failed |
| MF1 | MF American R Upstream of French Meadows Reservoir | 10/2/2003 | Lost due to high flows |
| MF2 | MF American R Downstream of French Meadows Reservoir | 9/24/2003 | OK |
| MF3 | MF American R Immediately Upstream of MF Powerhouse | 10/9/2003 | OK |
| MF4 | MF American R Immediately Downstream of Interbay Dam | 10/9/2003 | Lost due to high flows |
| MF5 | MF American R Downstream of Ralston Afterbay Dam | 10/9/2005 | OK |
| MF6 | MF American R Immediately Downstream of Oxbow Powerhouse | 10/14/2003 | OK |
| MF7 | MF American R Downstream of NF of the MF American R | 10/15/2003 | OK |
| MF8 | MF American R Immediately Upstream of NF American | 10/15/2003 | OK |
| MF9 | MF American R Downstream of Ruck-a-Chucky Rapids | 8/24/2004 | OK |
| NF1 | NF American Immediately Upstream of MF American | 10/15/2003 | Vandalized |
| NF2 | NF American Immediately Downstream of MF American | 10/15/2003 | OK |
| NL1 | NF Long Canyon Cr Immediately Upstream of Diversion Dam | 10/2/2003 | OK |
| NL2 | NF Long Canyon Cr Immediately Downstream of Diversion Dam | 9/24/2003 | OK |
| NM1 | NF of the MF American R Upstream of MF American | 8/16/2005 | Vandalized |
| OX1 | Rubicon R Immediately Downstream of Ralston Powerhouse | 8/16/2004 | OK |
| PC1 | Pilot Cr Immediately Upstream of Rubicon R | 10/24/2003 | OK |
| RR1 | Rubicon R Upstream of Hell Hole Reservoir | 9/30/2003 | Buried in sediment, some data recovered |
| RR2 | Rubicon R Immediately Downstream of Hell Hole Reservoir | 10/14/2003 | Lost due to high flows; some data recovered |
| RR3 | Rubicon R Downstream of Intermittent Reach | 10/13/2003 | OK |
| RR4 | Rubicon R Immediately Upstream of Ralston Powerhouse | 10/2/2003 | Lost due to high flows |
| RR5 | Rubicon R Upstream of SF Rubicon R | 8/25/2004 | OK |
| RR6 | Rubicon R Immediately Downstream of SF Rubicon R | 8/25/2004 | Lost due to high flows |
| RR8 | Rubicon R Immediately Upstream of Pilot Cr | 8/18/2004 | OK |
| SL1 | SF Long Canyon Cr Immediately Upstream of Diversion Dam | 9/24/2003 | Buried in sediment, some data recovered |
| SL2 | SF Long Canyon Cr Immediately Downstream of Diversion Dam | 9/24/2003 | OK |

**Table 3. The Site IDs, Site Names, River Miles, Site Locations, and Installation Dates for the 49 water temperature monitoring sites established for PCWA's Water Temperature Study Plan. Where River Mile equals 0.0 the site is located immediately upstream of the confluence.**

| Site ID | Site Name | River Mile | Site Location (UTM) N | Site Location (UTM) E | Installation Date |
|---|---|---|---|---|---|
| CC1 | Canyon Cr Immediately Upstream of MF American R | 0.1 | 681766 | 4313543 | 8/11/2005 |
| DC1 | Duncan Cr Immediately Upstream of Diversion Dam | 8.8 | 717877 | 4334888 | 9/24/2003 |
| DC2 | Duncan Cr Downstream of Diversion Dam | 8.4 | 717486 | 4334533 | 9/24/2003 |
| DC3 | Duncan Cr Immediately Upstream of MF American R | 0.0 | 712401 | 4323832 | 9/22/2005 |
| FL1 | Five Lakes Cr Upstream of Hell Hole Reservoir | 0.0 | 729486 | 4329029 | 9/30/2003 |
| IB1 | MF American R Immediately Downstream of MF Powerhouse Outlet | 35.9 | 708045 | 4322282 | 8/17/2004 |
| LC1 | Long Canyon Cr Immediately Upstream of Rubicon R | 0.0 | 700326 | 4318266 | 8/24/2004 |
| LC2 | Long Canyon Cr Immediately Downstream of North and South Fork Long Canyon Crs | 11.1 | 714694 | 4321749 | 7/7/2005 |
| LC3 | Long Canyon Cr Immediately Upstream of Wallace Canyon Cr | 6.8 | 709614 | 4318063 | 7/21/2005 |
| MF1 | MF American R Upstream of French Meadows Reservoir | 51.9 | 724150 | 4335051 | 10/2/2003 |
| MF2 | MF American R Downstream of French Meadows Reservoir | 46.6 | 717787 | 4331970 | 9/24/2003 |
| MF3 | MF American R Immediately Upstream of MF Powerhouse | 36.1 | 708245 | 4322433 | 10/9/2003 |
| MF4 | MF American R Immediately Downstream of Interbay Dam | 35.5 | 707472 | 4322410 | 10/9/2003 |
| MF5 | MF American R Downstream of Ralston Afterbay Dam | 24.6 | 694919 | 4319599 | 10/9/2003 |
| MF6 | MF American R Immediately Downstream of Oxbow Powerhouse | 24.3 | 695064 | 4319894 | 10/14/2003 |
| MF7 | MF American R Downstream of NF of the MF American R | 23.1 | 694003 | 4319890 | 10/15/2003 |
| MF8 | MF American R Immediately Upstream of NF American R | 0.1 | 670230 | 4309051 | 10/15/2003 |
| MF9 | MF American R Downstream of Ruck-a-Chucky Rapids | 8.9 | 678811 | 4314844 | 8/24/2004 |
| MF10 | MF American R Immediately Upstream of Ralston Afterbay Reservoir | 26.0 | 696446 | 4320054 | 7/7/2005 |
| MF11 | MF American R Immediately Upstream of Duncan Cr | 39.7 | 712524 | 4323980 | 9/22/2005 |
| MF12 | MF American R Midway Between French Meadows Reservoir and Duncan Cr | 44.6 | 716586 | 4329530 | 7/8/2005 |
| MF13 | MF American R Downstream of Brushy Canyon Cr | 29.4 | 701020 | 4321465 | 9/13/2005 |
| MF14 | MF American R Downstream of Volcano Canyon Cr | 19.6 | 689844 | 4319176 | 8/11/2005 |
| MF15 | MF American R Immediately Upstream of Otter Cr | 14.3 | 686039 | 4314393 | 8/11/2005 |
| MF16 | MF American R Immediately Upstream of Canyon Cr | 11.0 | 681917 | 4313637 | 8/11/2005 |
| NF1 | NF American Immediately Upstream of MF American R | 21.4 | 670077 | 4309845 | 10/15/2003 |
| NF2 | NF American Immediately Downstream of MF American R | 20.8 | 669884 | 4309201 | 10/15/2003 |
| NFA[1] | NF American R at Auburn Dam Site | 14.9 | 668483 | 4304903 | 7/21/1999 |
| NL1 | NF Long Canyon Cr Immediately Upstream of Diversion Dam | 3.2 | 717936 | 4325485 | 10/2/2003 |
| NL2 | NF Long Canyon Cr Immediately Downstream of Diversion Dam | 3.1 | 717941 | 4325450 | 9/24/2003 |
| NM1 | NF of the MF American R Upstream of MF American R | 2.3 | 697272 | 4321900 | 7/7/2005 |
| OC1 | Otter Cr Immediately Upstream of MF American R | 0.1 | 685812 | 4314064 | 8/11/2005 |
| OX1 | Rubicon R Immediately Downstream of Ralston Powerhouse | 0.5 | 696902 | 4319401 | 7/7/2005 |
| PC1 | Pilot Cr Immediately Upstream of Rubicon R | 0.0 | 700717 | 4316068 | 10/24/2003 |
| RR1 | Rubicon R Upstream of Hell Hole Reservoir | 35.9 | 729446 | 4328809 | 9/30/2003 |
| RR2 | Rubicon R Immediately Downstream of Hell Hole Reservoir | 30.2 | 724199 | 4326074 | 10/14/2003 |
| RR3 | Rubicon R Downstream of Intermittent Reach | 28.8 | 722789 | 4324656 | 10/13/2003 |
| RR4 | Rubicon R Immediately Upstream of Ralston Powerhouse | 0.7 | 697187 | 4319108 | 10/2/2003 |
| RR5 | Rubicon R Upstream of SF Rubicon R | 22.7 | 719244 | 4316581 | 8/25/2004 |
| RR6 | Rubicon R Immediately Downstream of SF Rubicon R | 22.5 | 719150 | 4316361 | 8/25/2004 |
| RR7 | Rubicon R Between SF Rubicon R and Big Grizzly Canyon Cr | 14.3 | 710726 | 4310041 | 9/13/2005 |
| RR8 | Rubicon R Immediately Upstream of Pilot Cr | 5.3 | 700778 | 4315974 | 8/18/2004 |
| RR9 | Rubicon R Immediately Upstream of Long Canyon Cr | 3.7 | 700418 | 4318194 | 7/7/2005 |
| RR10 | Rubicon R Upstream of Deer Cr | 25.3 | 720865 | 4319940 | 9/13/2005 |
| RR11 | Rubicon R Downstream of Big Grizzly Canyon Cr | 9.5 | 705591 | 4313422 | 9/13/2005 |
| SF1 | SF Rubicon R Immediately Upstream of Rubicon R | 0.1 | 719302 | 4316374 | 7/1/2005 |
| SL1 | SF Long Canyon Cr Immediately Upstream of Diversion Dam | 3.4 | 719006 | 4325570 | 9/24/2003 |
| SL2 | SF Long Canyon Cr Immediately Downstream of Diversion Dam | 3.3 | 718818 | 4325494 | 10/2/2003 |
| WC1 | Wallace Canyon Cr Upstream of Long Canyon Cr | 1.2 | 709527 | 4317055 | 7/21/2005 |

**Table 4. The dates of MFP reservoir spills and powerhouse maintenance outages that influenced observed water temperatures at some monitoring sites.**

| Reservoir/Powerhouse | Spilling Dates | Outage Dates |
|---|---|---|
| French Meadows Res | 5/23/05 - 5/31/05; 6/9/05 - 6/20/05 | |
| Hell Hole Res | 5/25/05 - 6/19/05 | |
| Middle Fork Interbay Res | 5/18/05; 5/20/05 - 6/27/05; 10/3/05 | |
| Ralston Afterbay Res | 3/20/05 - 5/5/05; 5/9/05 - 6/29/05 (except 5/19/05) | |
| Hell Hole PH | | -- |
| Middle Fork PH | | 9/26/05 - 10/22/05 |
| Ralston PH | | 10/3/05 - 10/22/05 |
| Oxbow PH | | 10/7/05 - 10/22/05 |

**Table 5. The Site ID's, Site Names, and Parameters Measured for the stations associated with the PCWA MET monitoring program.**

| Site ID | Site Name (Operator) | Parameters Measured | | | | | |
|---|---|---|---|---|---|---|---|
| | | Air Temperature | Relative Humidity | Solar Radiation | Wind Speed | Wind Direction | Precipitation |
| HLL | Hell Hole Reservoir (USFS) | x | x | x | x | x | x |
| RAB | Ralston Afterbay Reservoir (PCWA) | x | x | x | x | x | x |
| IBR | Middle Fork Interbay (PCWA) | x | x | x | x | x | x |
| DUN | Upper Duncan Canyon (USFS) | x | x | x | x | x | x |
| GKS | Greek Store (USBR) | x | | | | | x |
| GTW | Georgetown (USBR) | x | | | | | x |
| NA1 | NF American at Auburn State Rec (PCWA) | x | x | | | | |
| FA1 | MF American downstream of French Meadows Dam (PCWA) | x | x | | | | |
| HA1 | Rubicon downstream of Hell Hole Dam (PCWA) | x | x | | | | |
| RA1 | Rubicon at Ellicott Bridge (PCWA) | x | x | | | | |

**Table 1. The Site ID's, Site Names, River Miles, Site Locations, and Installation Dates of the 18 new water temperature monitoring sites that were installed during 2005.**

| Site ID | Site Name | River Mile | Site Location (UTM) N | Site Location (UTM) E | Installation Date |
|---|---|---|---|---|---|
| CC1 | Canyon Cr Immediately Upstream of MF American R | 0.1 | 681766 | 4313543 | 8/11/2005 |
| DC3 | Duncan Cr Immediately Upstream of MF American R | 0.0 | 712401 | 4323832 | 9/22/2005 |
| LC2 | Long Canyon Cr Immediately Downstream of North and South Fork Long Canyon Crs | 11.1 | 714694 | 4321749 | 7/7/2005 |
| LC3 | Long Canyon Cr Immediately Upstream of Wallace Canyon Cr | 6.8 | 709614 | 4318063 | 7/21/2005 |
| MF10 | MF American R Immediately Upstream of Ralston Afterbay Reservoir | 26.0 | 696446 | 4320054 | 7/7/2005 |
| MF11 | MF American R Immediately Upstream of Duncan Cr | 39.7 | 712524 | 4323980 | 9/22/2005 |
| MF12 | MF American R Midway Between French Meadows Reservoir and Duncan Cr | 44.6 | 716586 | 4329530 | 7/8/2005 |
| MF13 | MF American R Downstream of Brushy Canyon Cr | 29.4 | 701020 | 4321465 | 9/13/2005 |
| MF14 | MF American R Downstream of Volcano Canyon Cr | 19.6 | 689844 | 4319176 | 8/11/2005 |
| MF15 | MF American R Immediately Upstream of Otter Cr | 14.3 | 686039 | 4314393 | 8/11/2005 |
| MF16 | MF American R Immediately Upstream of Canyon Cr | 11.0 | 681917 | 4313637 | 8/11/2005 |
| OC1 | Otter Cr Immediately Upstream of MF American R | 0.1 | 685812 | 4314064 | 8/11/2005 |
| RR7 | Rubicon R Between SF Rubicon R and Big Grizzly Canyon Cr | 14.3 | 710726 | 4310041 | 9/13/2005 |
| RR9 | Rubicon R Immediately Upstream of Long Canyon Cr | 3.7 | 700418 | 4318194 | 7/7/2005 |
| RR10 | Rubicon R Upstream of Deer Cr | 25.3 | 720865 | 4319940 | 9/13/2005 |
| RR11 | Rubicon R Downstream of Big Grizzly Canyon Cr | 9.5 | 705591 | 4313422 | 9/13/2005 |
| SF1 | SF Rubicon R Immediately Upstream of Rubicon R | 0.1 | 719302 | 4316374 | 7/1/2005 |
| WC1 | Wallace Canyon Cr Upstream of Long Canyon Cr | 1.2 | 709527 | 4317055 | 7/21/2005 |

**Table 6. The download frequency for the stream water temperature loggers associated with the MFP Water Temperature Study Plan.**

| Monthly, May* – Oct | May*, July, and October | Semi-annual (May*, Oct) |
|---|---|---|
| MF1 | MF3 | DC1 |
| MF6 | MF4 | DC2 |
| MF8 | MF5 | DC3 |
| NM1 | MF7 | MF2 |
| NF1 | MF9 | MF11 |
| NF2 | MF10 | MF12 |
| IB1 | RR4 | MF13 |
| | RR8 | MF14 |
| | OX1 | MF15 |
| | LC2 | MF16 |
| | NL1 | RR1 |
| | NL2 | RR2 |
| | SL1 | RR3 |
| | SL2 | RR5 |
| | PC1 | RR6 |
| | | RR7 |
| | | RR8 |
| | | RR9 |
| | | RR10 |
| | | CC1 |
| | | OC1 |
| | | LC1 |
| | | LC3 |
| | | SF1 |
| | | FL1 |
| | | WC1 |

*May is the intended first month to download the water temperature data in 2006. However, should a location be inaccessible due to snow, or some other environmental constraint, the data will be downloaded as soon as the site is determined to be safely accessible.

# FIGURES

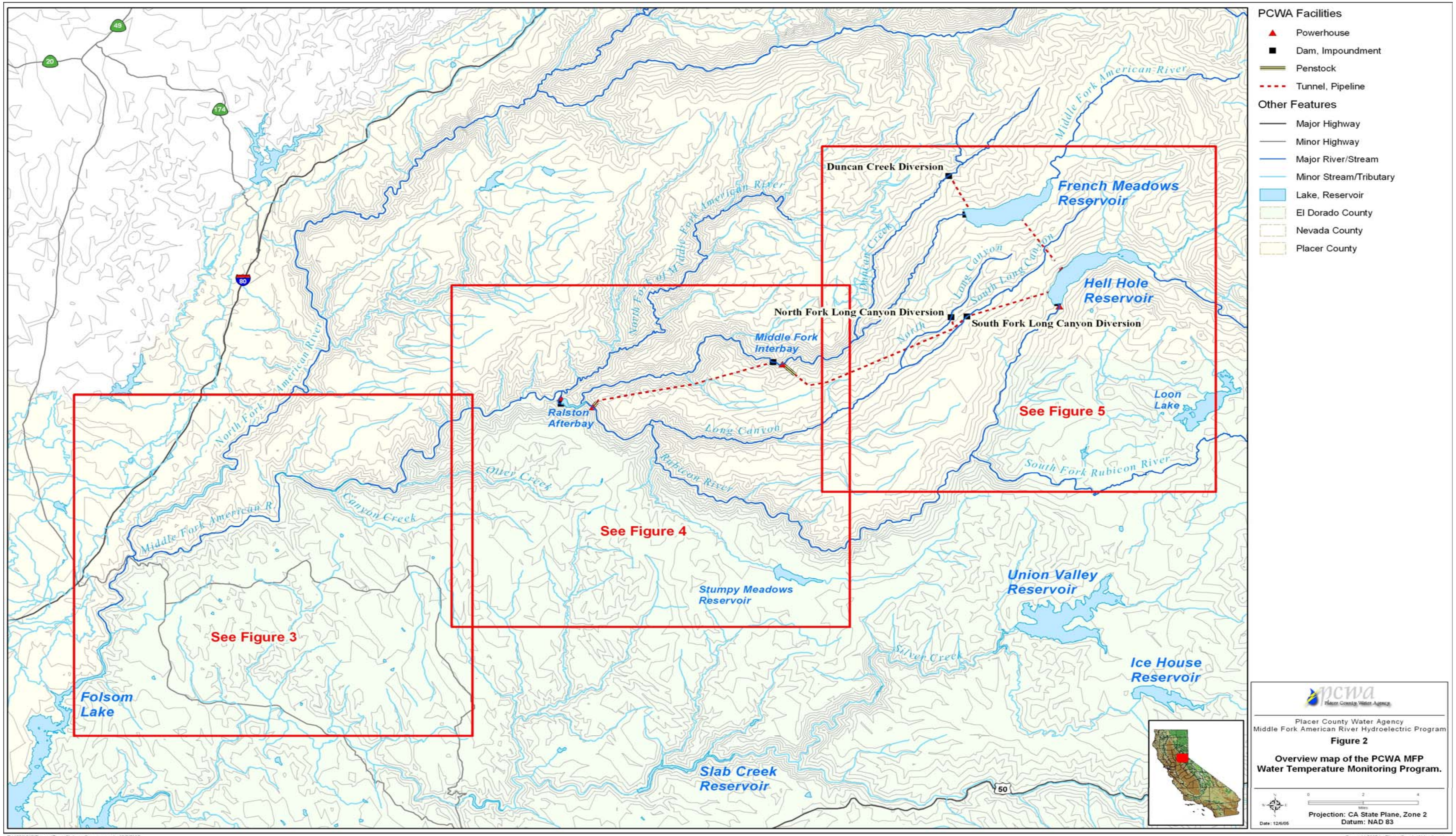
## Placeholder for Figure 1

Figure 1 Principal Project Facilities & Geographic Setting

# Non-Internet Public Information

These Figures have been removed in accordance with the Commission regulations at 18 CFR Section 388.112.

These Figures are considered Non-Internet Public information and should not be posted on the Internet. This information may be accessed from the Placer County Water Agency's (PCWA) Public Reference Room, but is not expected to be posted on PCWA's Website, except as an indexed item.


PCWA Facilities
Powerhouse
Dam, Impoundment
Penstock
Tunnel, Pipeline
Other Features
Major Highway
Minor Highway
Major River/Stream
Minor Stream/Tributary
Lake, Reservoir
El Dorado County
Nevada County
Placer County
Duncan Creek Diversion
French Meadows Reservoir
Hell Hole Reservoir
North Fork Long Canyon Diversion
South Fork Long Canyon Diversion
Middle Fork Interbay
Ralston Afterbay
Loon Lake
See Figure 5
See Figure 4
See Figure 3
Long Canyon
Rubicon River
South Fork Rubicon River
Otter Creek
Canyon Creek
Middle Fork American R.
North Fork American River
Stumpy Meadows Reservoir
Union Valley Reservoir
Ice House Reservoir
Silver Creek
Slab Creek Reservoir
Folsom Lake
Middle Fork American River
Placer County Water Agency
Middle Fork American River Hydroelectric Program
Figure 2
Overview map of the PCWA MFP Water Temperature Monitoring Program.
Projection: CA State Plane, Zone 2
Datum: NAD 83

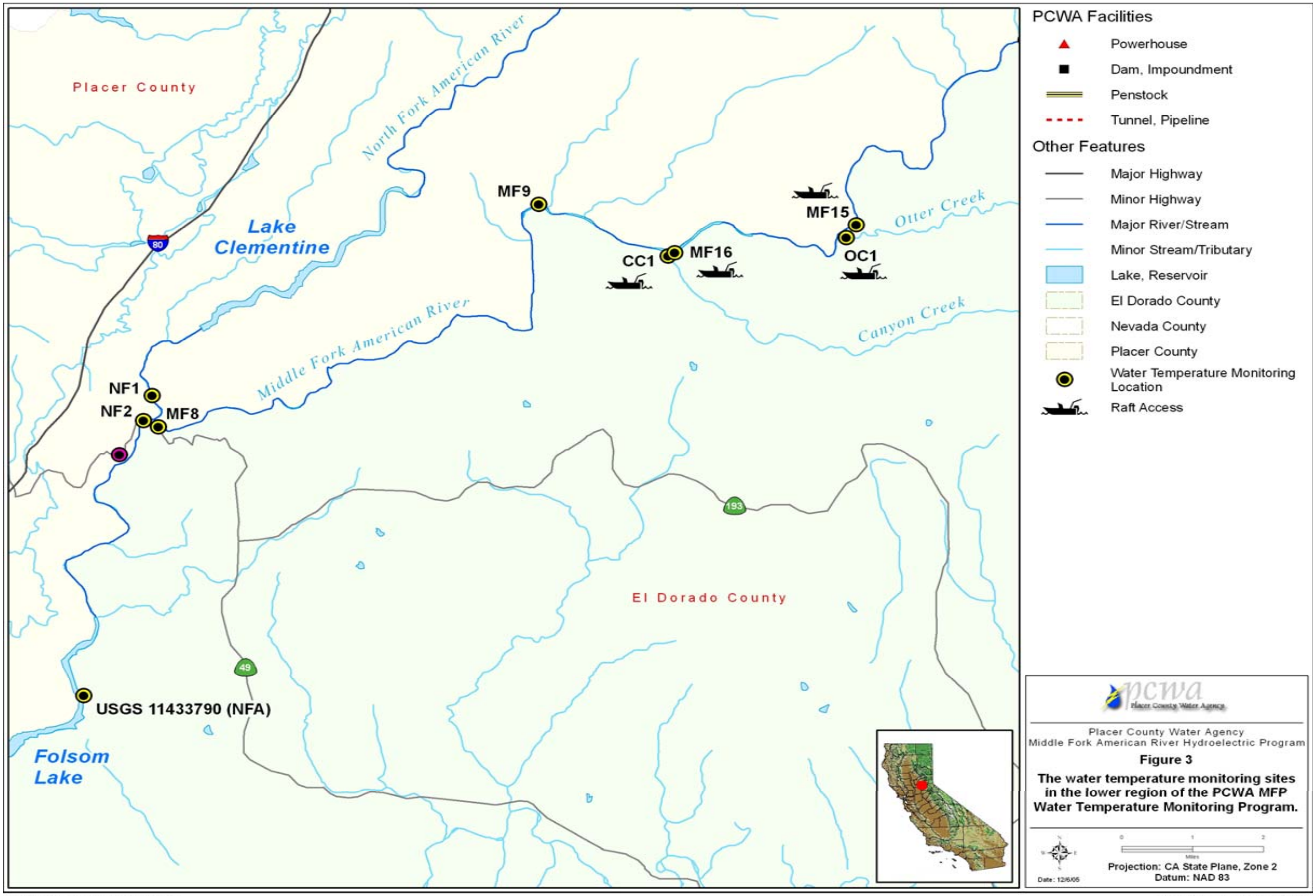
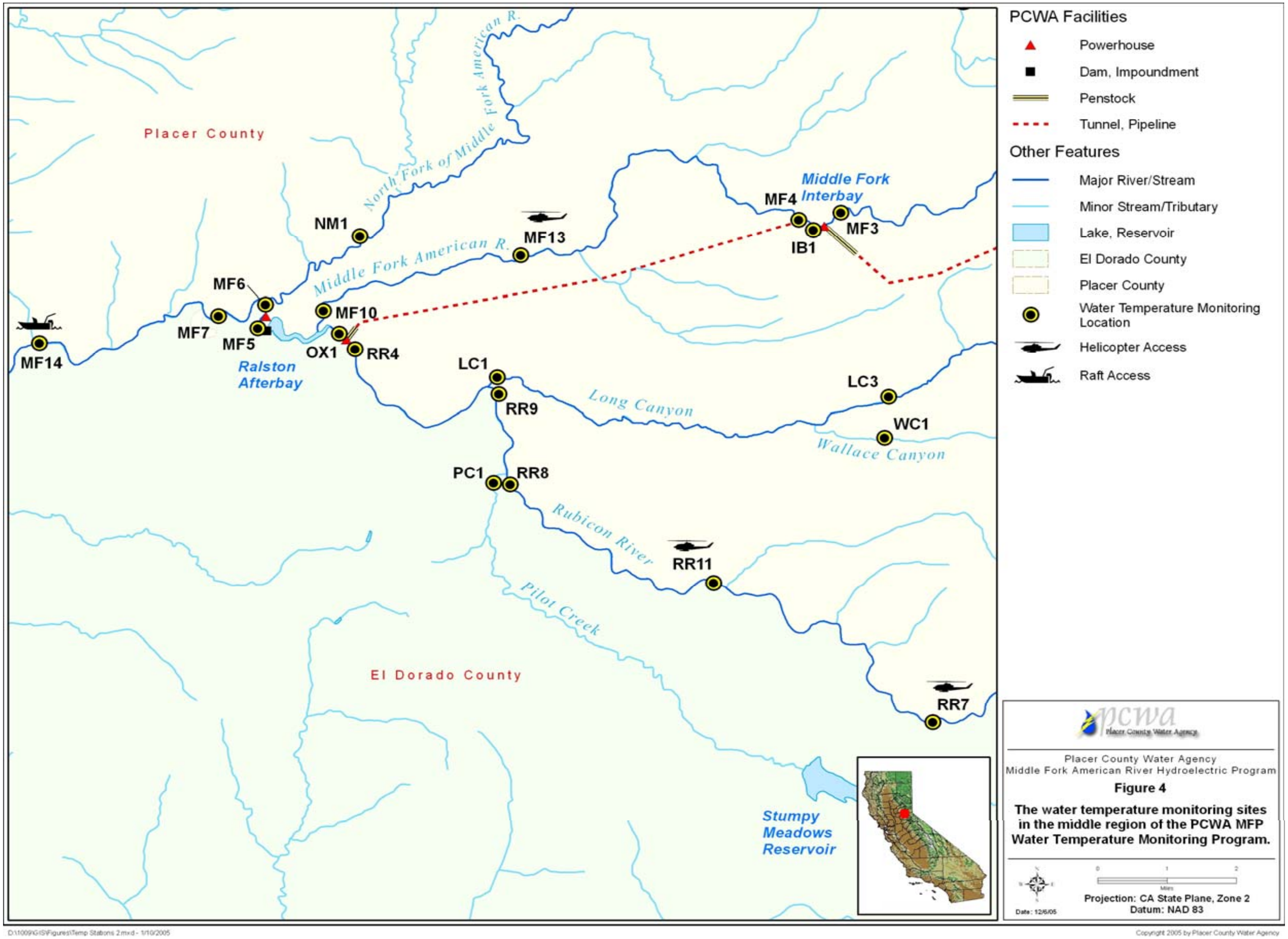
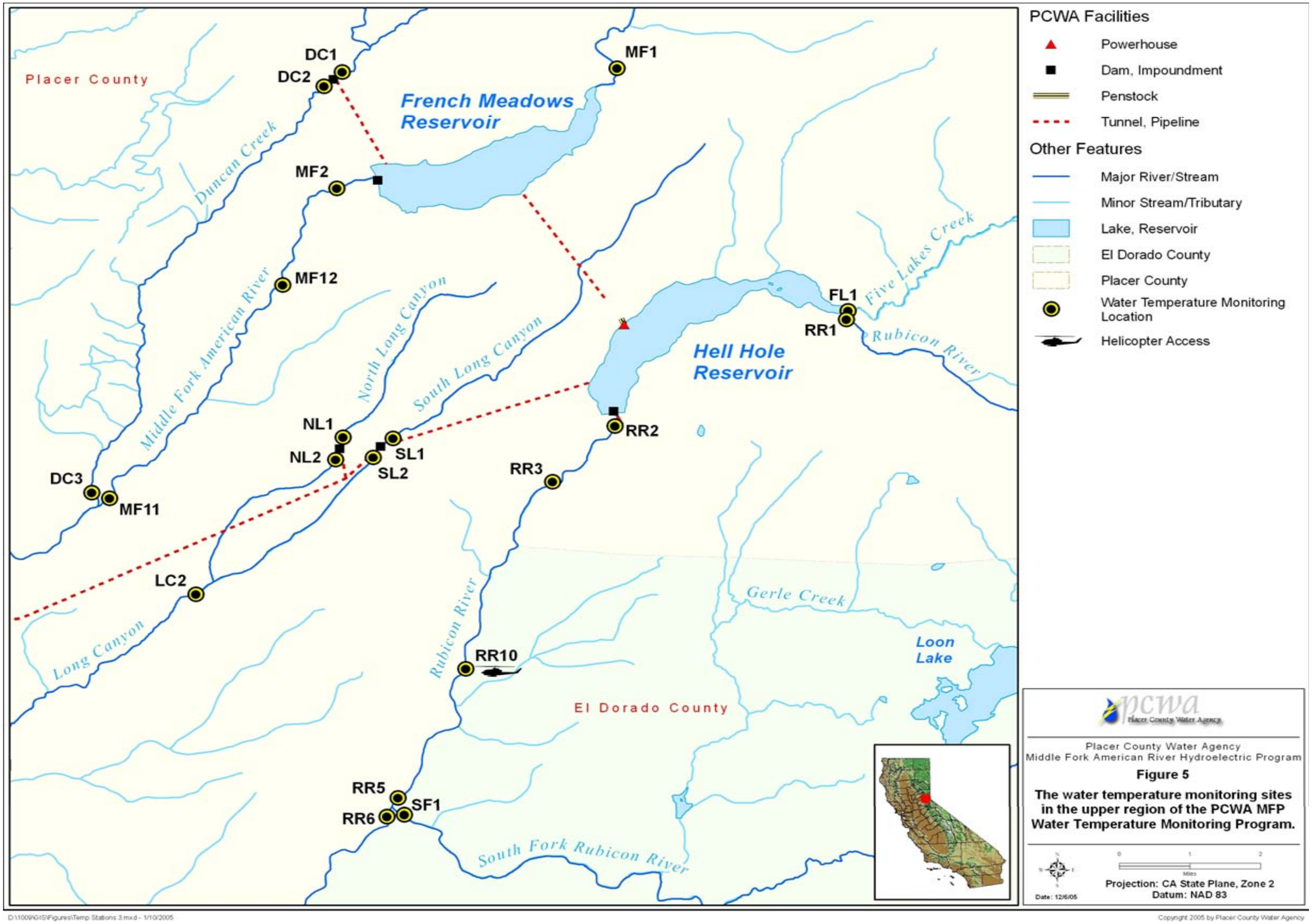



**Figure 3**

**The water temperature monitoring sites in the lower region of the PCWA MFP Water Temperature Monitoring Program.**



PCWA Facilities
Powerhouse
Dam, Impoundment
Penstock
Tunnel, Pipeline
Other Features
Major River/Stream
Minor Stream/Tributary
Lake, Reservoir
El Dorado County
Placer County
Water Temperature Monitoring Location
Helicopter Access
Raft Access
Placer County
El Dorado County
North Fork of Middle Fork American R.
Middle Fork American R.
Middle Fork Interbay
Ralston Afterbay
Long Canyon
Wallace Canyon
Rubicon River
Pilot Creek
Stumpy Meadows Reservoir
NM1
MF13
MF4
MF3
IB1
MF6
MF7
MF5
MF10
OX1
RR4
MF14
LC1
RR9
LC3
WC1
PC1
RR8
RR11
RR7
pcwa
Placer County Water Agency
Middle Fork American River Hydroelectric Program
Figure 4
The water temperature monitoring sites in the middle region of the PCWA MFP Water Temperature Monitoring Program.
Projection: CA State Plane, Zone 2
Datum: NAD 83
Date: 12/6/05
Copyright 2005 by Placer County Water Agency


PCWA Facilities
Powerhouse
Dam, Impoundment
Penstock
Tunnel, Pipeline
Other Features
Major River/Stream
Minor Stream/Tributary
Lake, Reservoir
El Dorado County
Placer County
Water Temperature Monitoring Location
Helicopter Access
Placer County
French Meadows Reservoir
Hell Hole Reservoir
El Dorado County
Loon Lake
Duncan Creek
Middle Fork American River
North Long Canyon
South Long Canyon
Long Canyon
Rubicon River
Five Lakes Creek
Gerle Creek
South Fork Rubicon River
DC1
DC2
DC3
MF1
MF2
MF11
MF12
FL1
RR1
RR2
RR3
RR5
RR6
RR10
SF1
NL1
NL2
SL1
SL2
LC2
Placer County Water Agency
Middle Fork American River Hydroelectric Program
Figure 5
The water temperature monitoring sites in the upper region of the PCWA MFP Water Temperature Monitoring Program.
Projection: CA State Plane, Zone 2
Datum: NAD 83

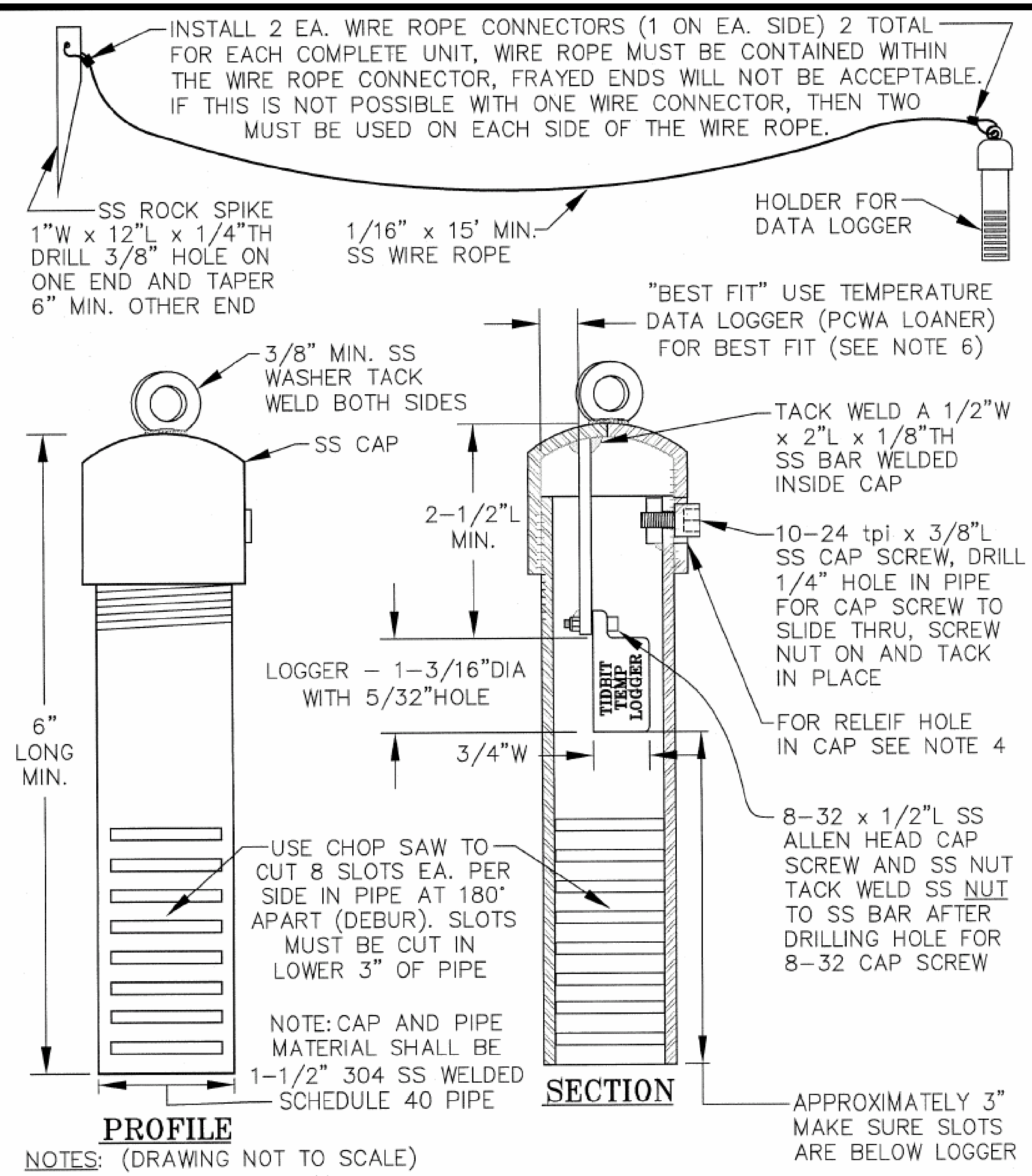
## Placeholder for Figure 6

Figure 6 River Stationing on Project Watercourses

# Non-Internet Public Information

These Figures have been removed in accordance with the Commission regulations at 18 CFR Section 388.112.

These Figures are considered Non-Internet Public information and should not be posted on the Internet. This information may be accessed from the Placer County Water Agency's (PCWA) Public Reference Room, but is not expected to be posted on PCWA's Website, except as an indexed item.




NOTES: (DRAWING NOT TO SCALE)

1. SS = 304 STAINLESS MIN.
2. BEFORE DRILLING SET SCREW HOLE IN PIPE AND CAP, FINGER TIGHTEN CAP.
3. CENTER PUNCH ALIGNMENT OF SET SCREW HOLE IN CAP WITH SET SCREW HOLE IN PIPE (2 & 3 DOTS).
4. AFTER NUT HAS BEEN WELDED TO THE INSIDE OF PIPE. ENLARGE HOLE IN CAP TO 1/16" LARGER THAN CAP SCREW HEAD DIA.
5. DEBURR ALL SHARP EDGES ON OUTSIDE OF HOLDERS AND ROCK SPIKES.
6. A TIDBIT DATA LOGGER HAS BEEN PROVIDED BY PCWA FOR ALIGNMENT PURPOSES PLEASE RETURN THE DATA LOGGER WHEN JOB IS COMPLETE. THANK YOU.

PAGE 2 OF 2

**Figure 7. Water temperature logger housing design schematic.**

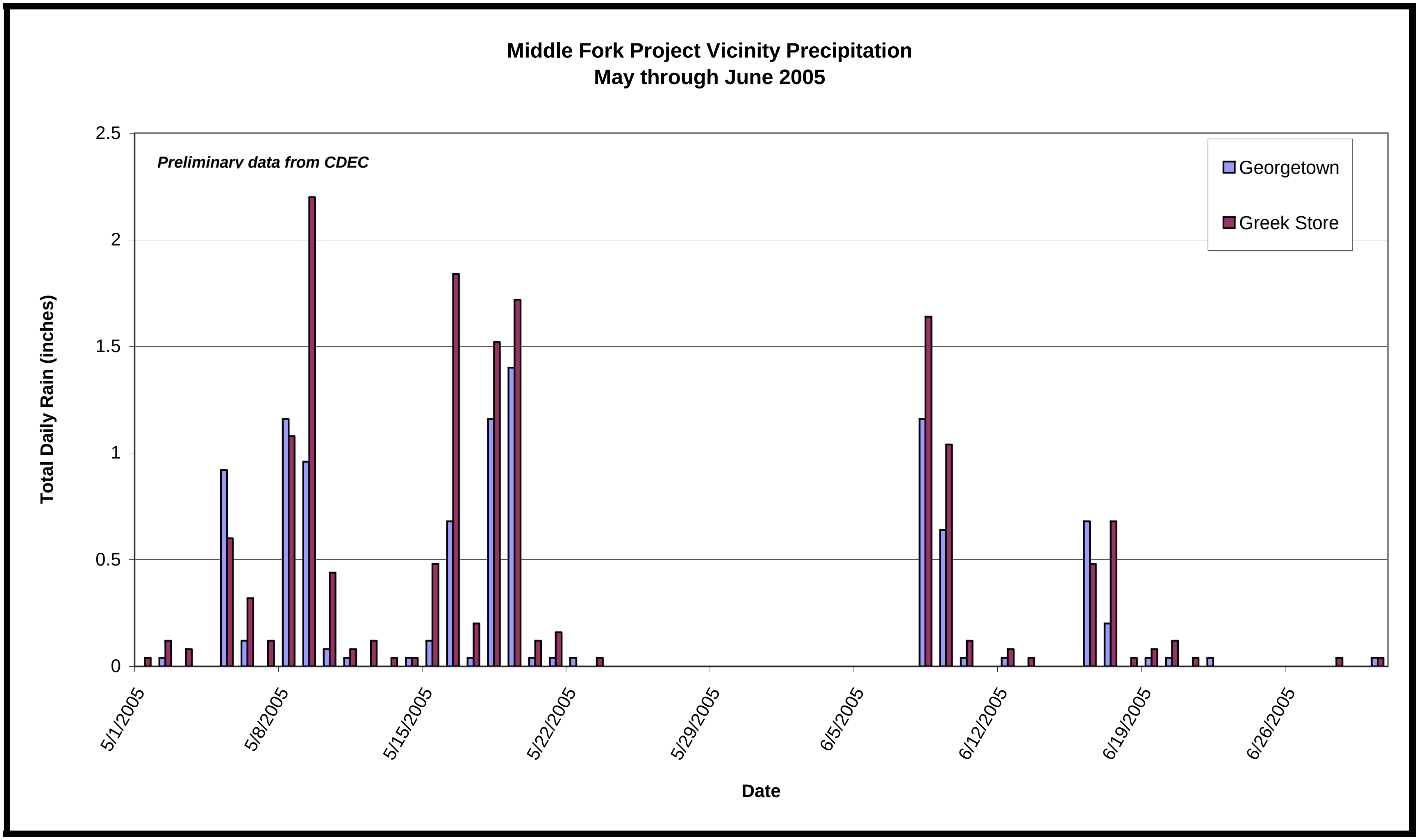



**Figure 8. The preliminary daily rainfall totals from two monitoring sites (Greek Store (GKS) and Georgetown (GTW)) near the Middle Fork Project.**

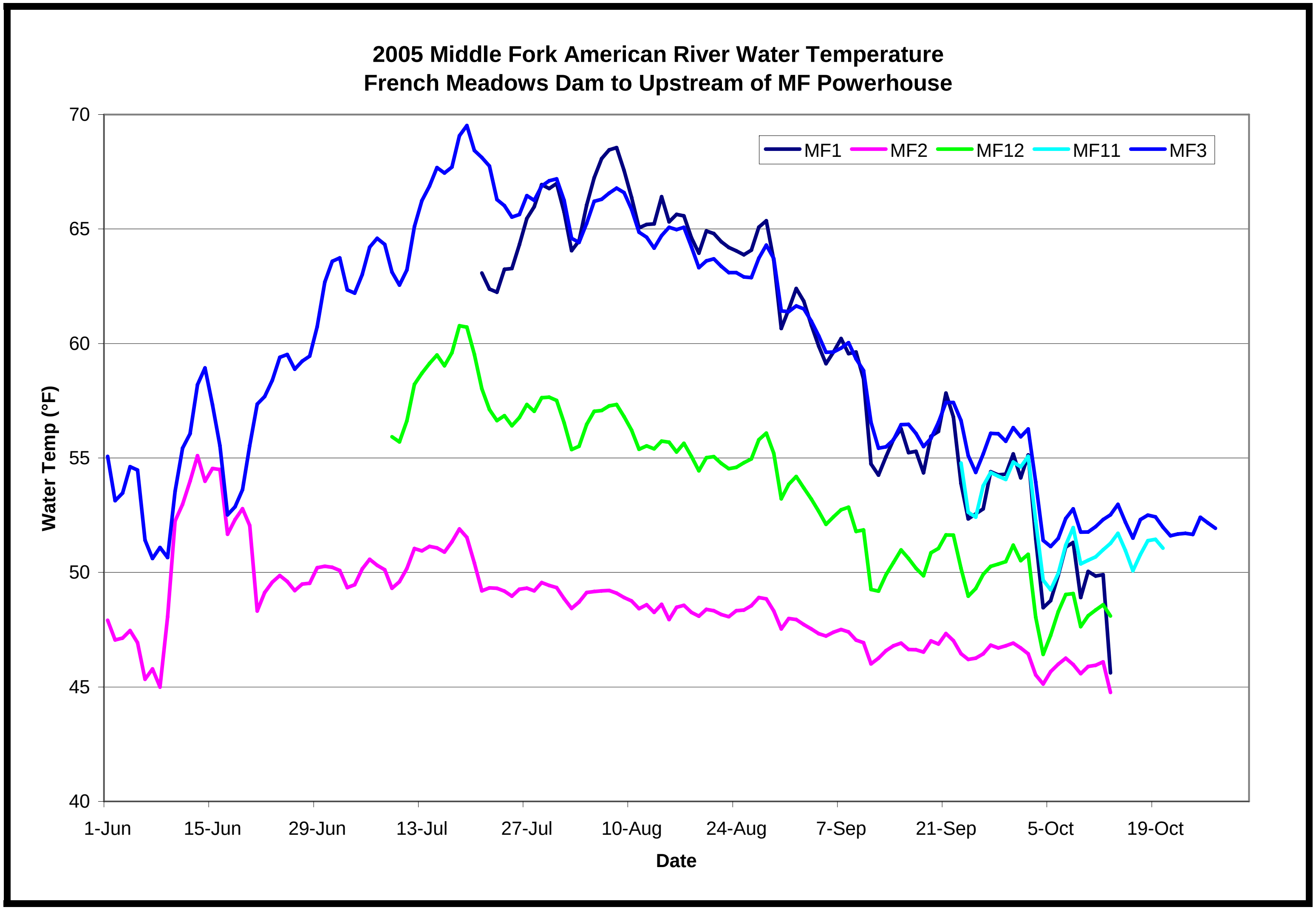



**Figure 9. Summer and fall daily average water temperature data collected in the Middle Fork American River at sites MF1, MF2, MF12, MF11, and MF3. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates.]**

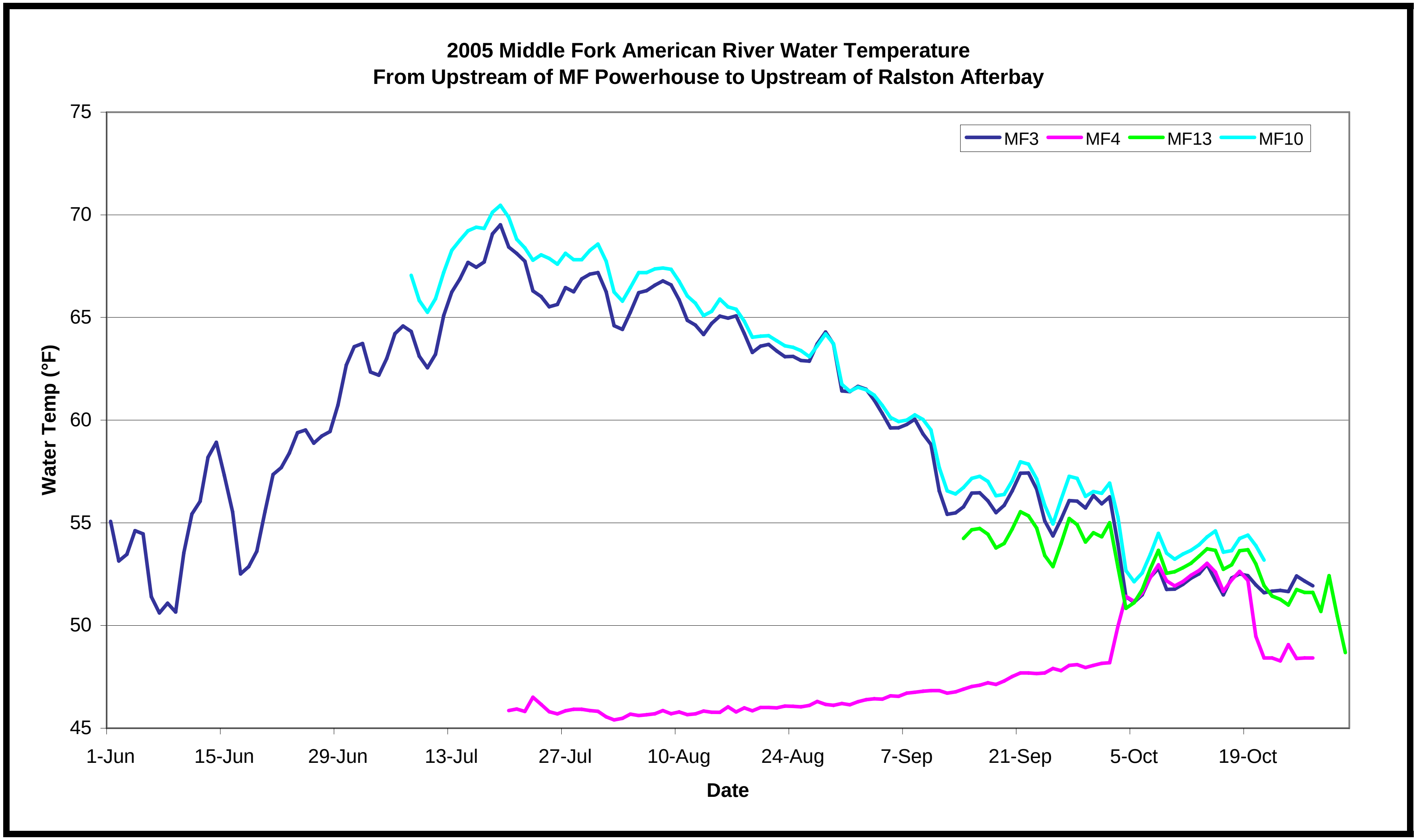



**Figure 10. Summer and fall daily average water temperature data collected in the Middle Fork American River at sites MF3, MF4, MF13, and MF10. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

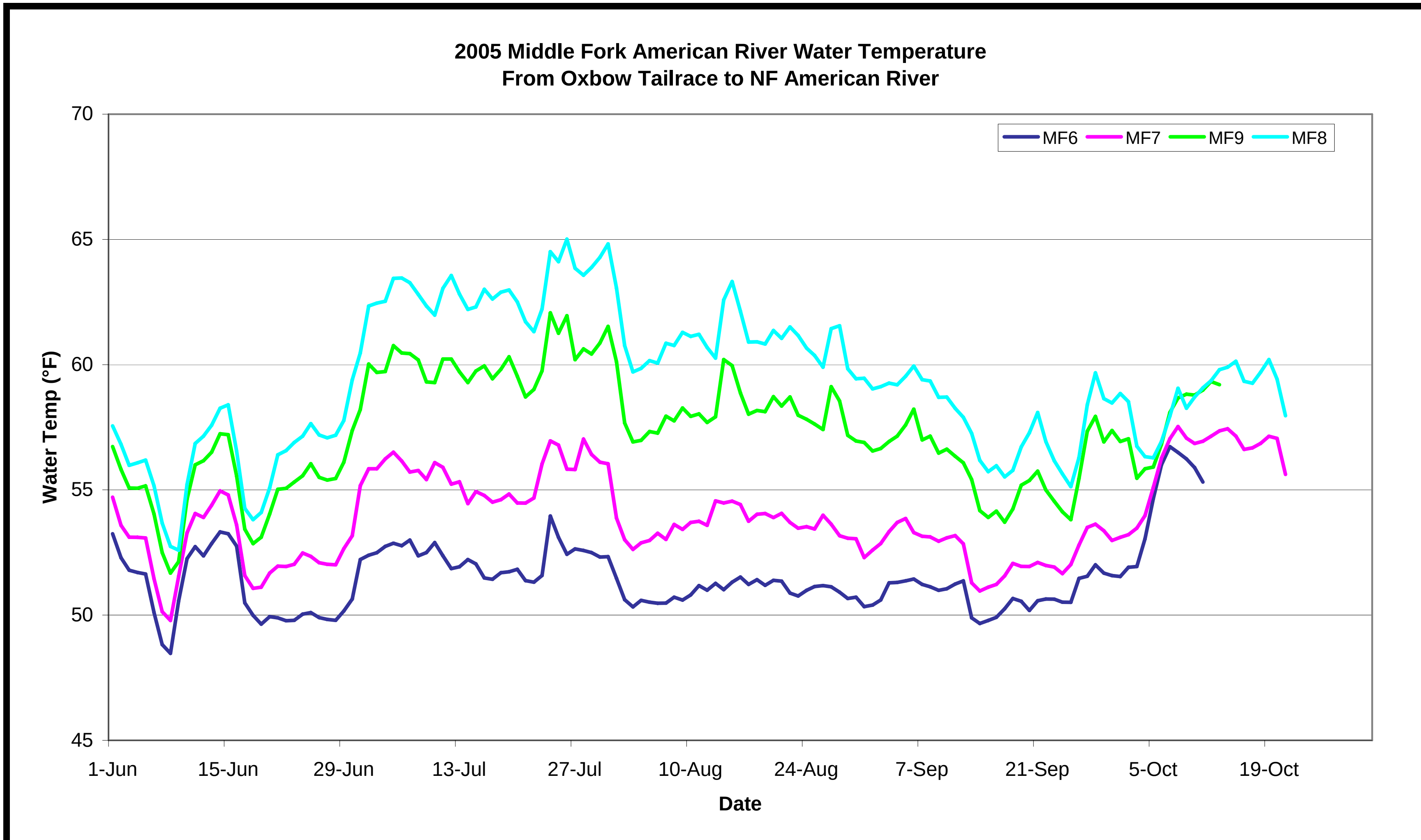



**Figure 11. Summer and fall daily average water temperature data collected in the Middle Fork American River at sites MF6, MF7, MF9, and MF8. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

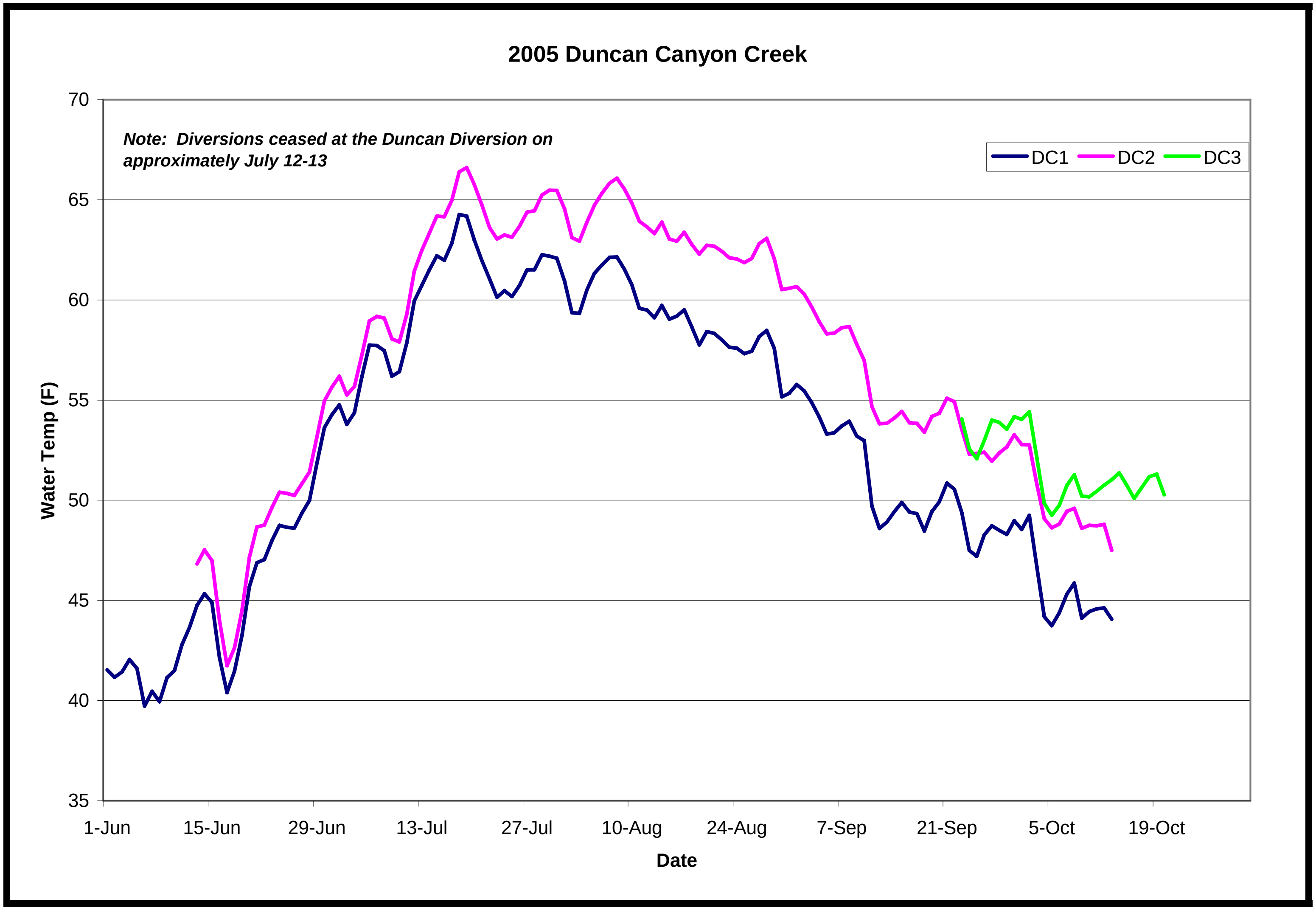



**Figure 12. Summer and fall daily average water temperature data collected in Duncan Canyon Creek at sites DC1, DC2, and DC3. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

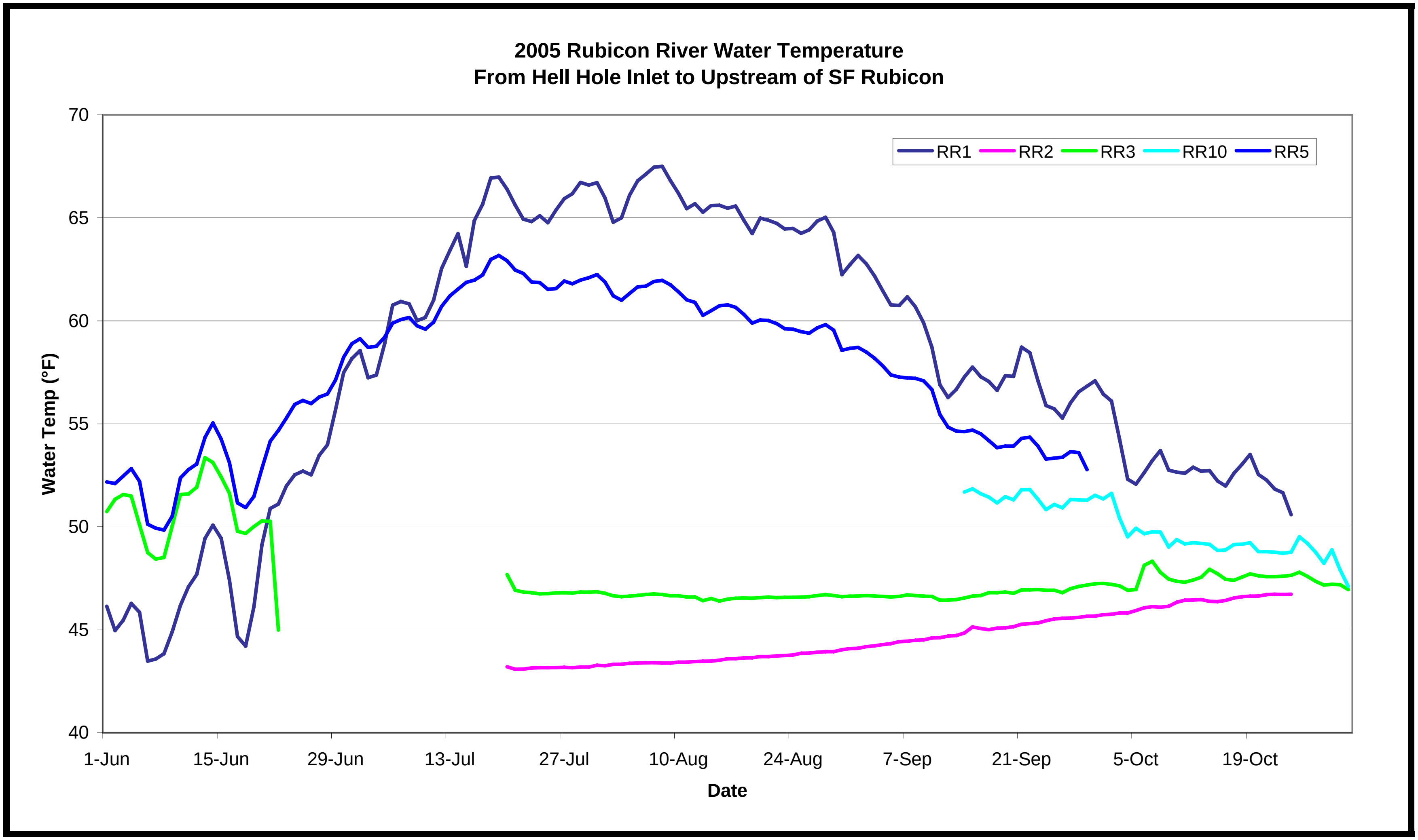



**Figure 13. Summer and fall daily average water temperature data collected in the Rubicon River at sites RR1, RR2, RR3, RR10, and RR5. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

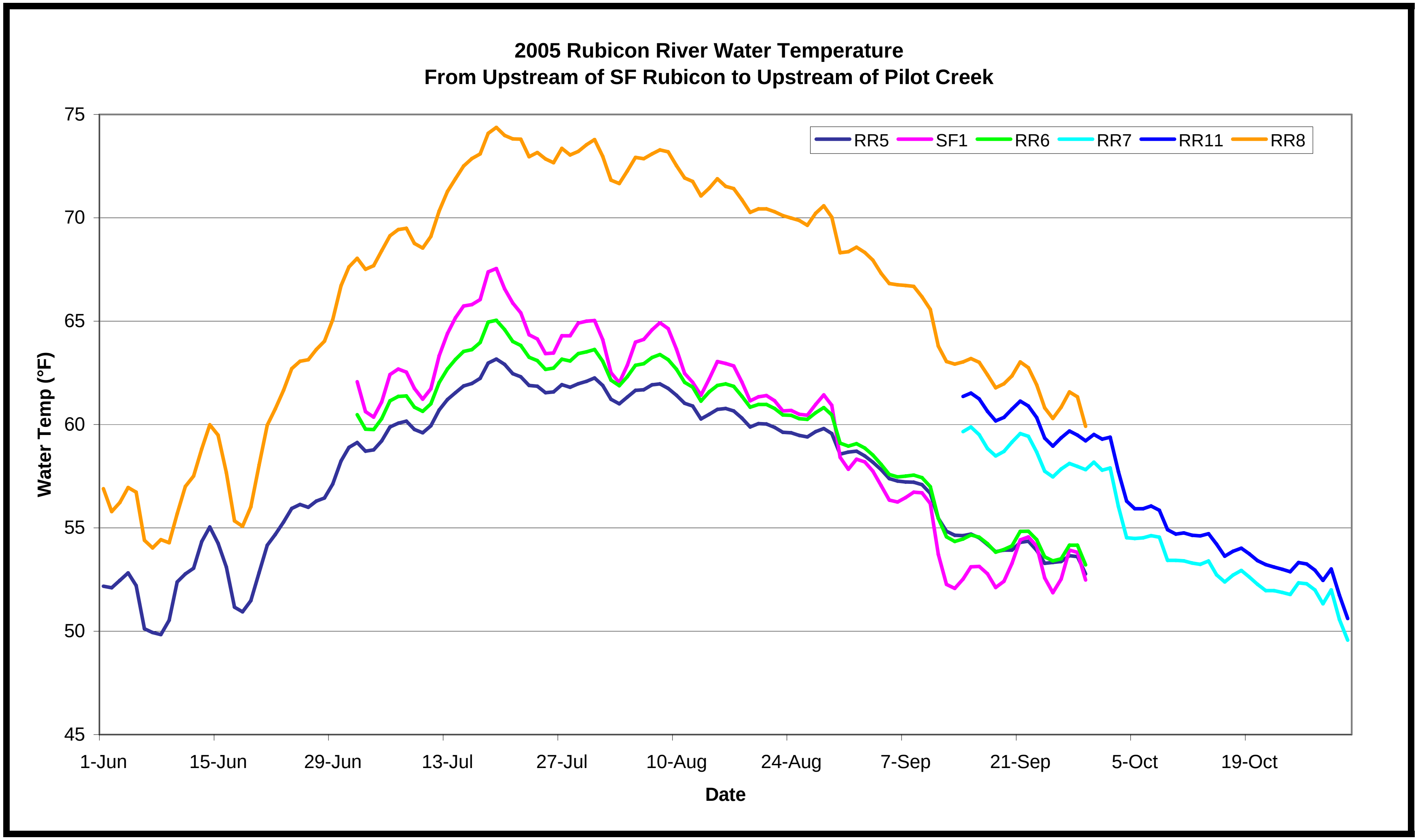



**Figure 14. Summer and fall daily average water temperature data collected in the Rubicon River at sites RR5, SF1, RR6, RR7, RR11, and RR8. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

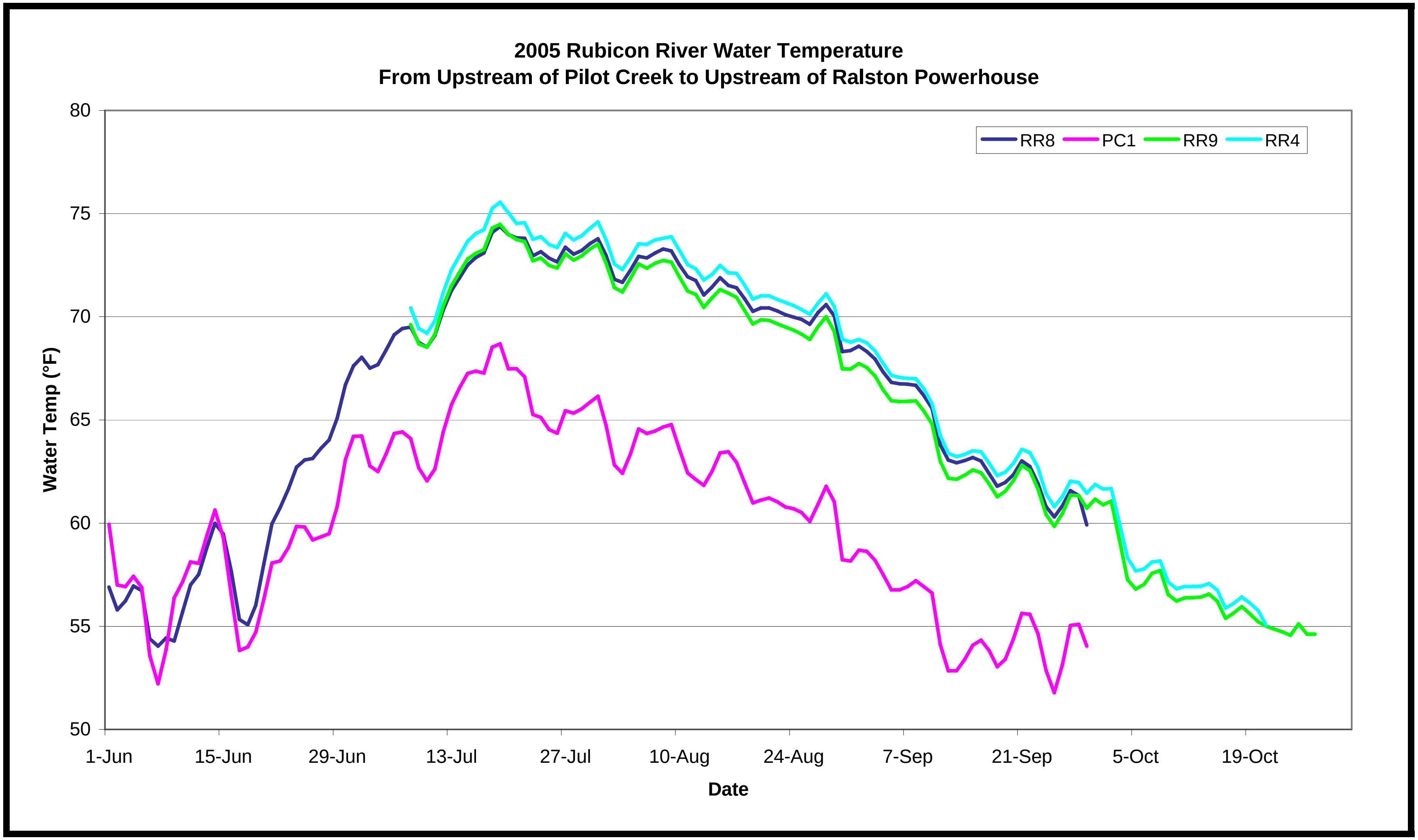



**Figure 15. Summer and fall daily average water temperature data collected in the Rubicon River at sites RR8, PC1, RR9, and RR4. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

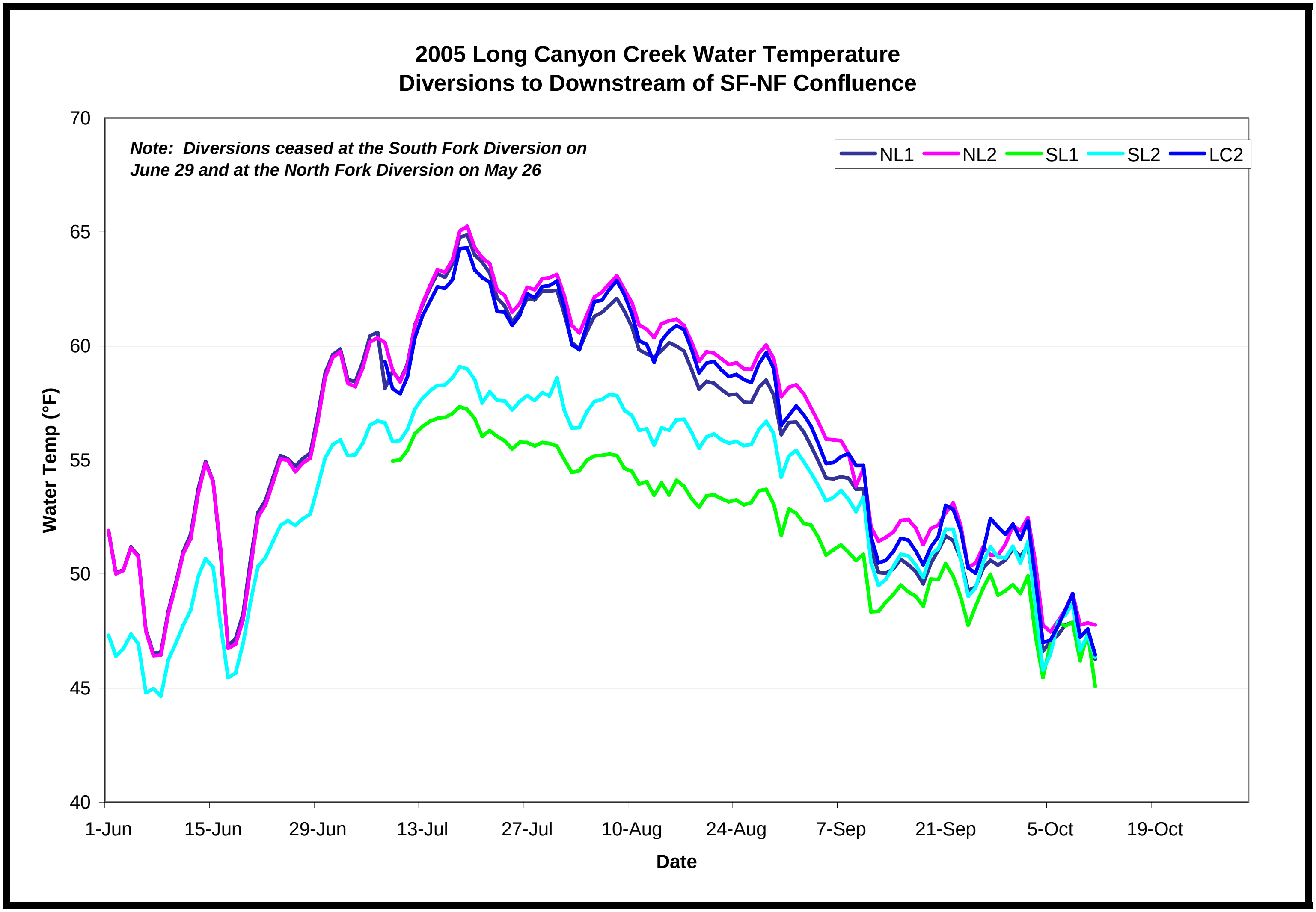



**Figure 16. Summer and fall daily average water temperature data collected in Long Canyon Creek at sites NL1, NL2, SL1, SL2, and LC2. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

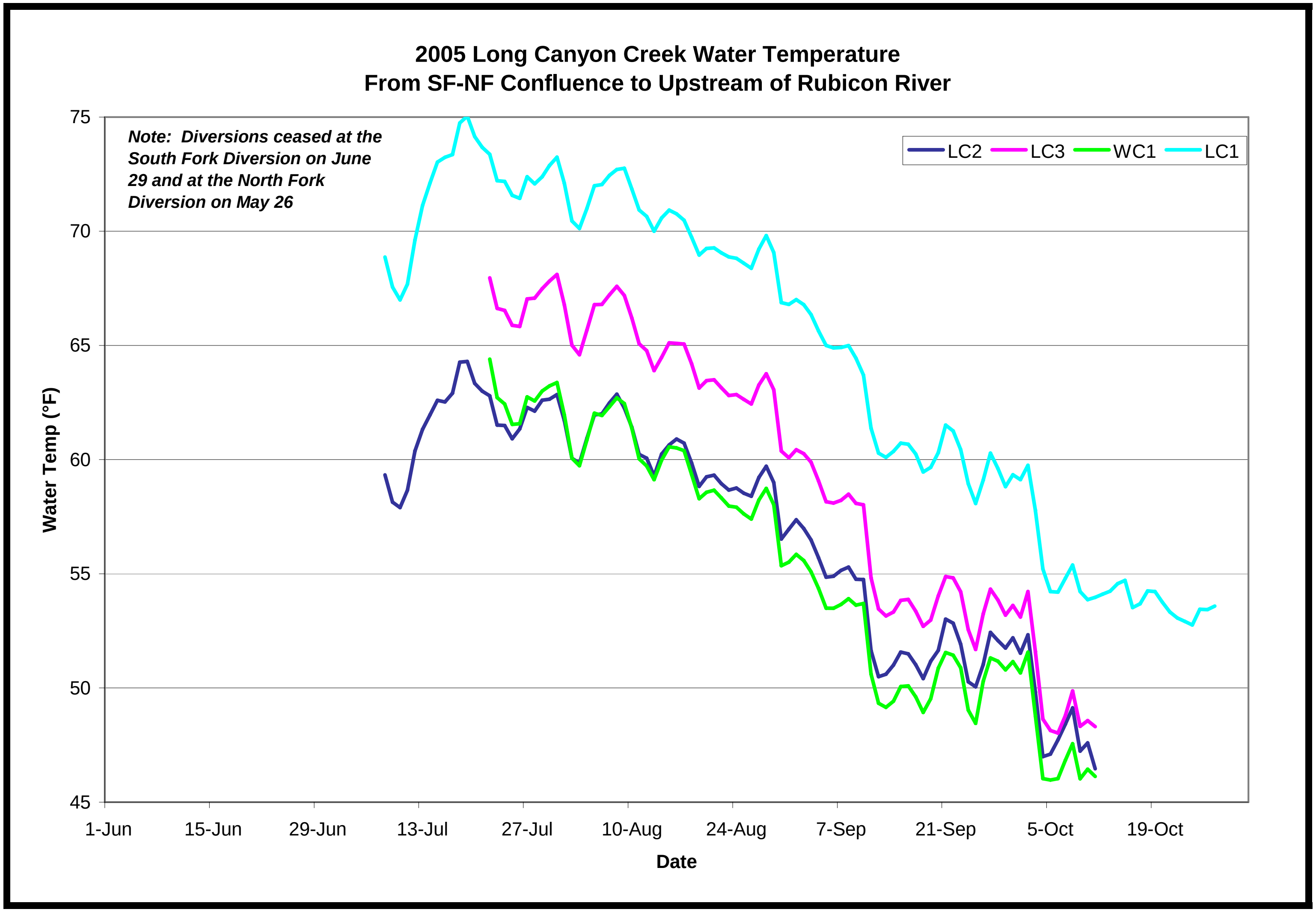



**Figure 17. Summer and fall daily average water temperature data collected in Long Canyon Creek sites LC2, LC3, WC1, and LC1. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

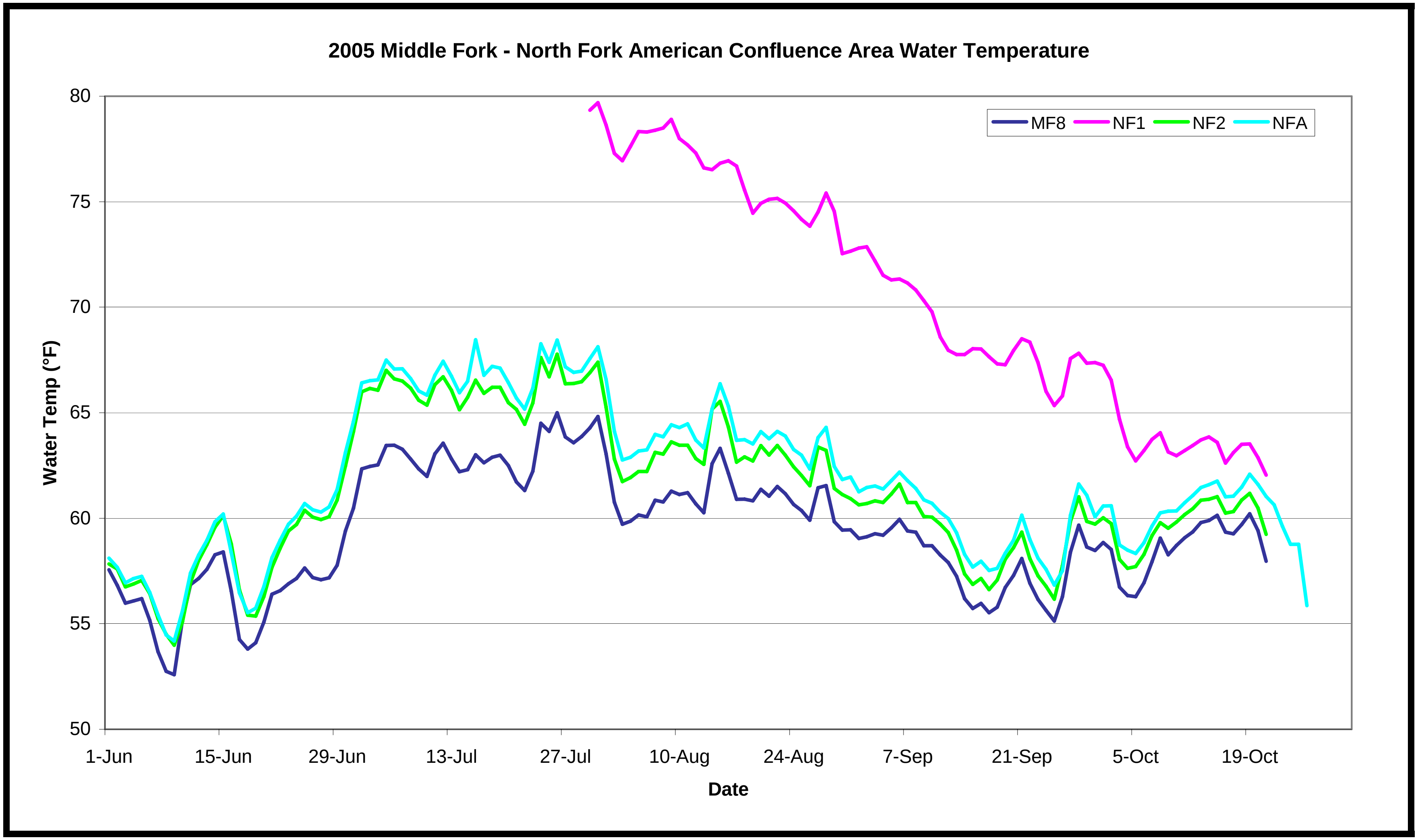



**Figure 18. Summer and fall daily average water temperature data collected in the North Fork American River and in the Middle Fork American River immediately upstream of the North Fork American River confluence. Refer to Figures 3-5 for the relative site locations. [Note: The differences in the durations of the water temperature observations are due to differences in site installation and final download dates].**

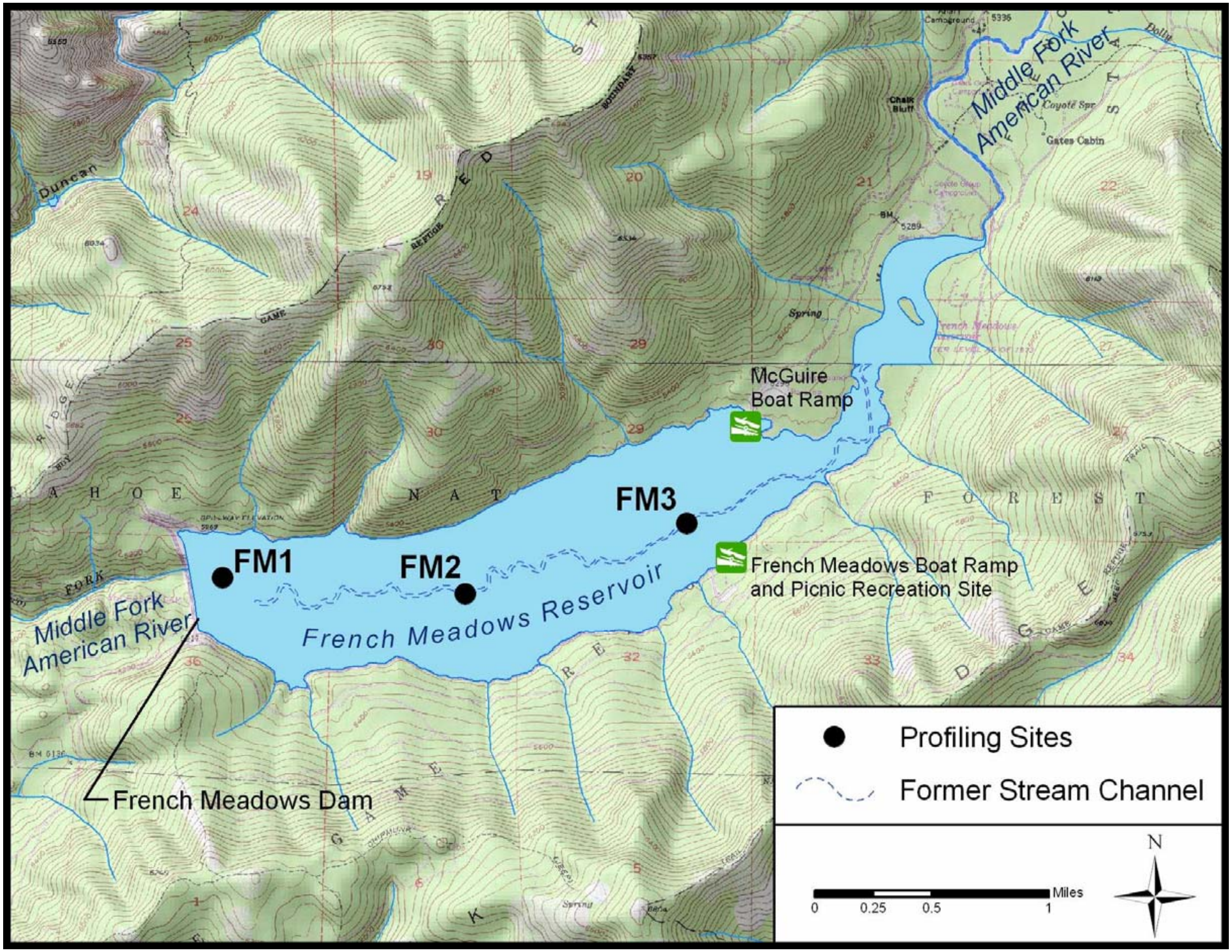



**Figure 19. The water temperature profile locations in French Meadows Reservoir.**

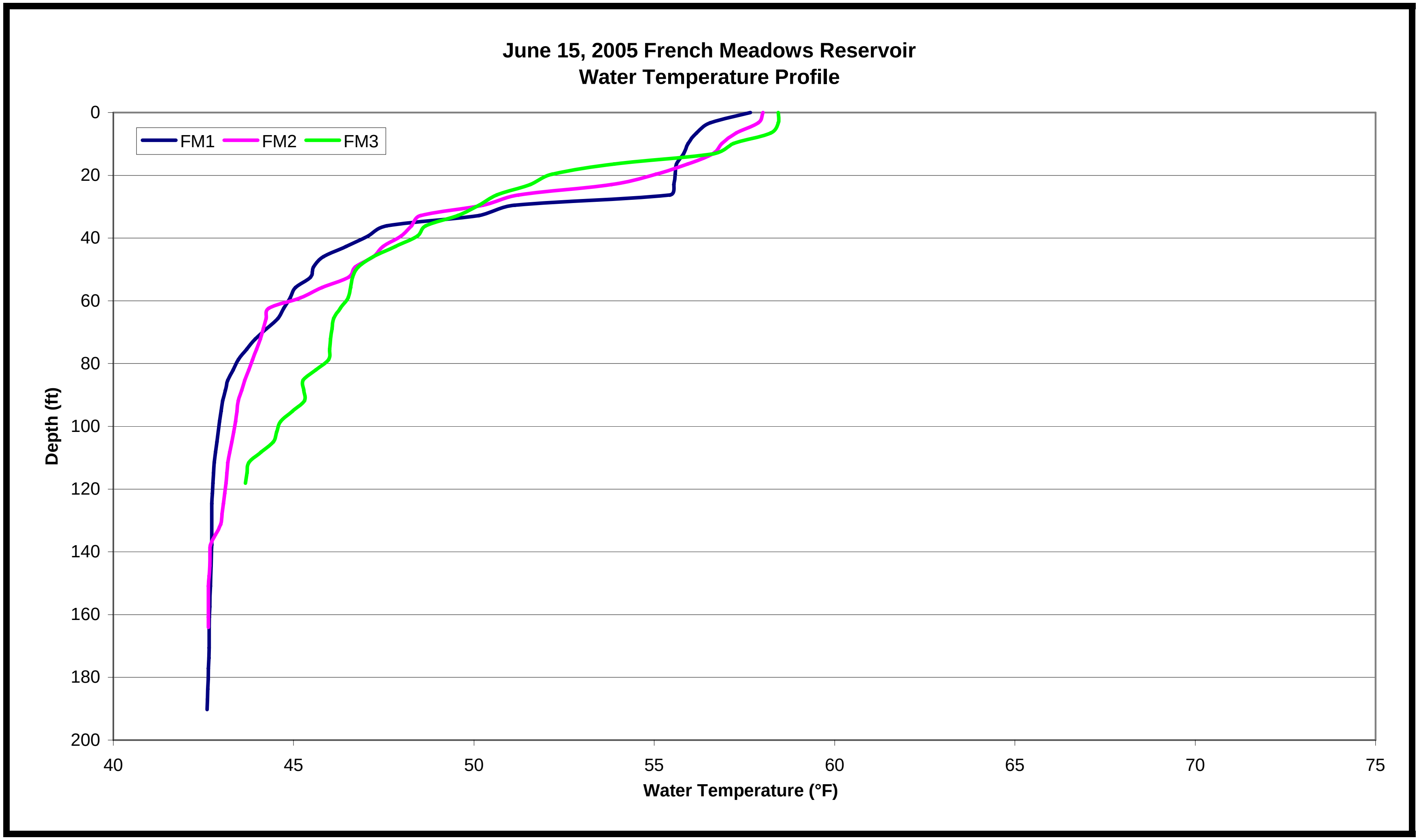



**Figure 20. The French Meadows Reservoir water temperature profiles at sites FM1, FM2, and FM3 on June 15, 2005.**

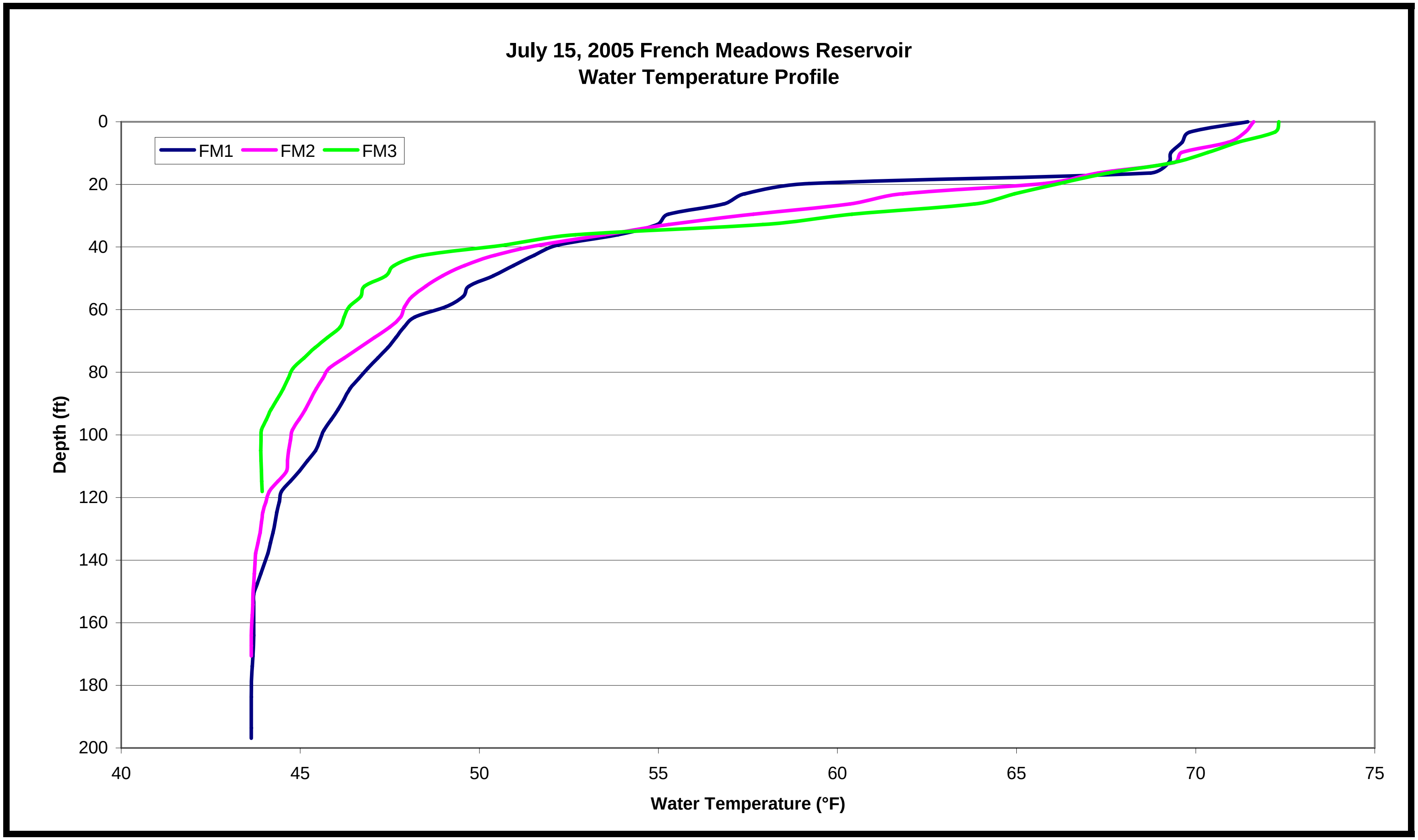



**Figure 21. The French Meadows Reservoir water temperature profiles at sites FM1, FM2, and FM3 on July 15, 2005.**

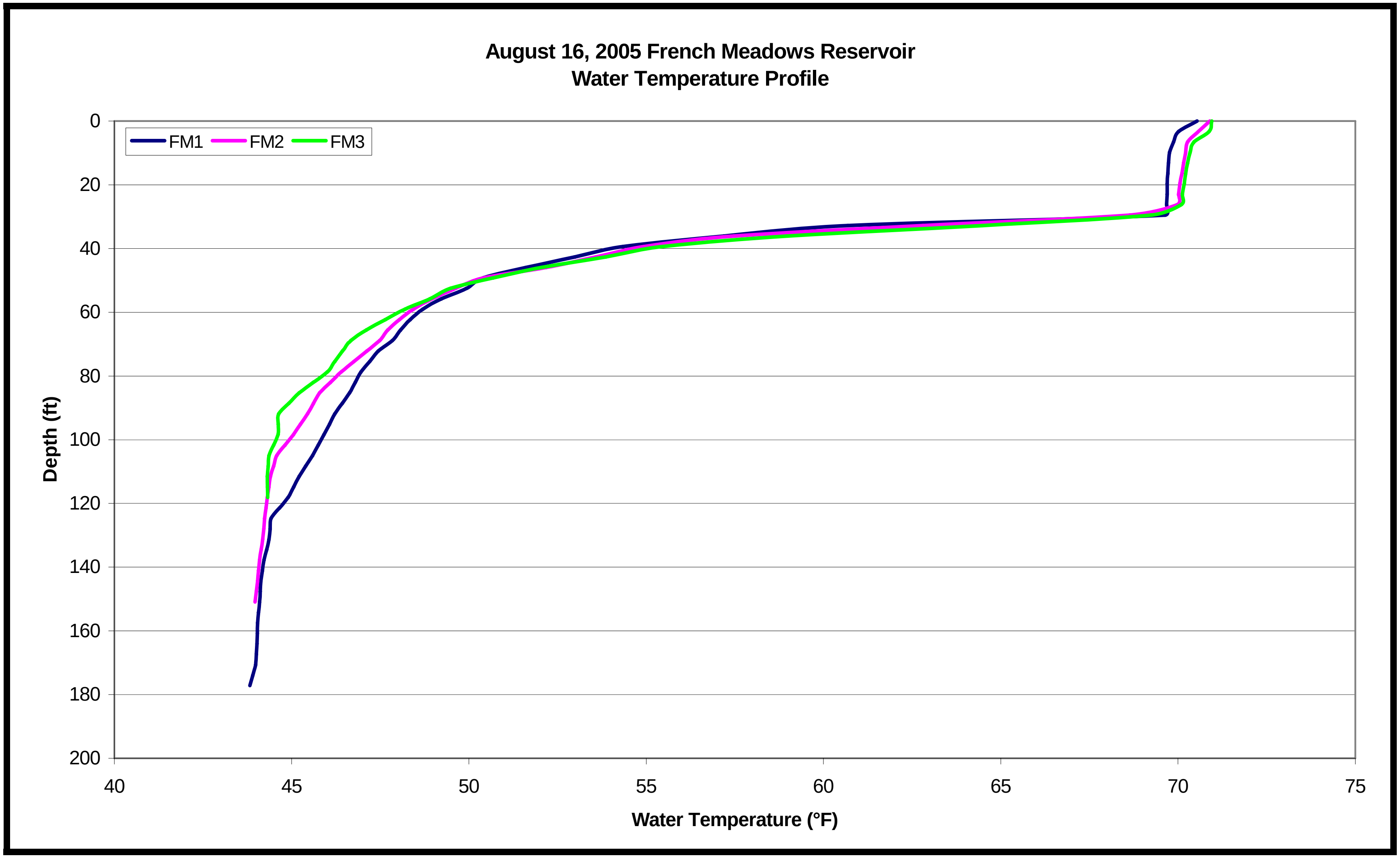



**Figure 22. The French Meadows Reservoir water temperature profiles at sites FM1, FM2, and FM3 on August 16, 2005.**

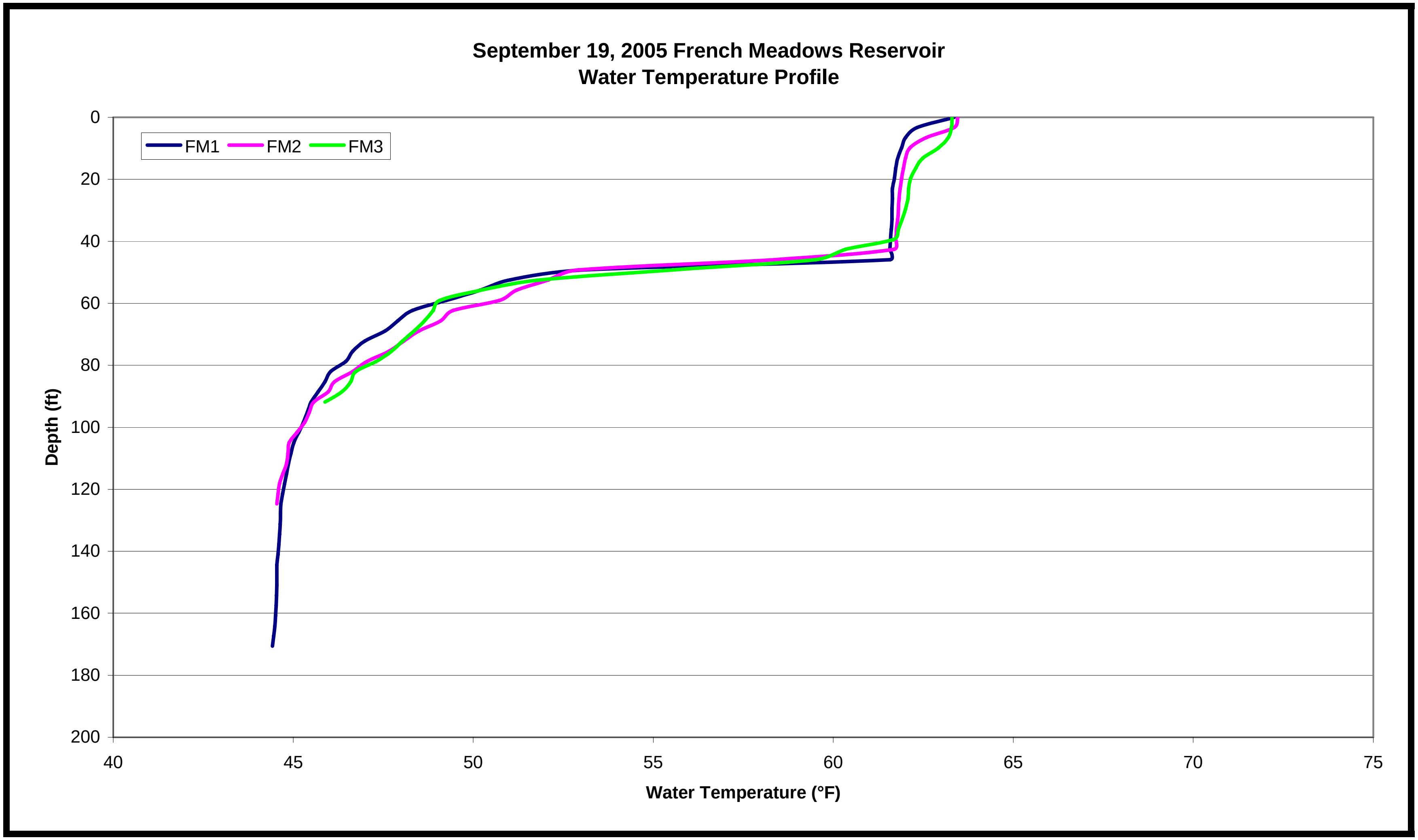



**Figure 23. The French Meadows Reservoir water temperature profiles at sites FM1, FM2, and FM3 on September 19, 2005.**

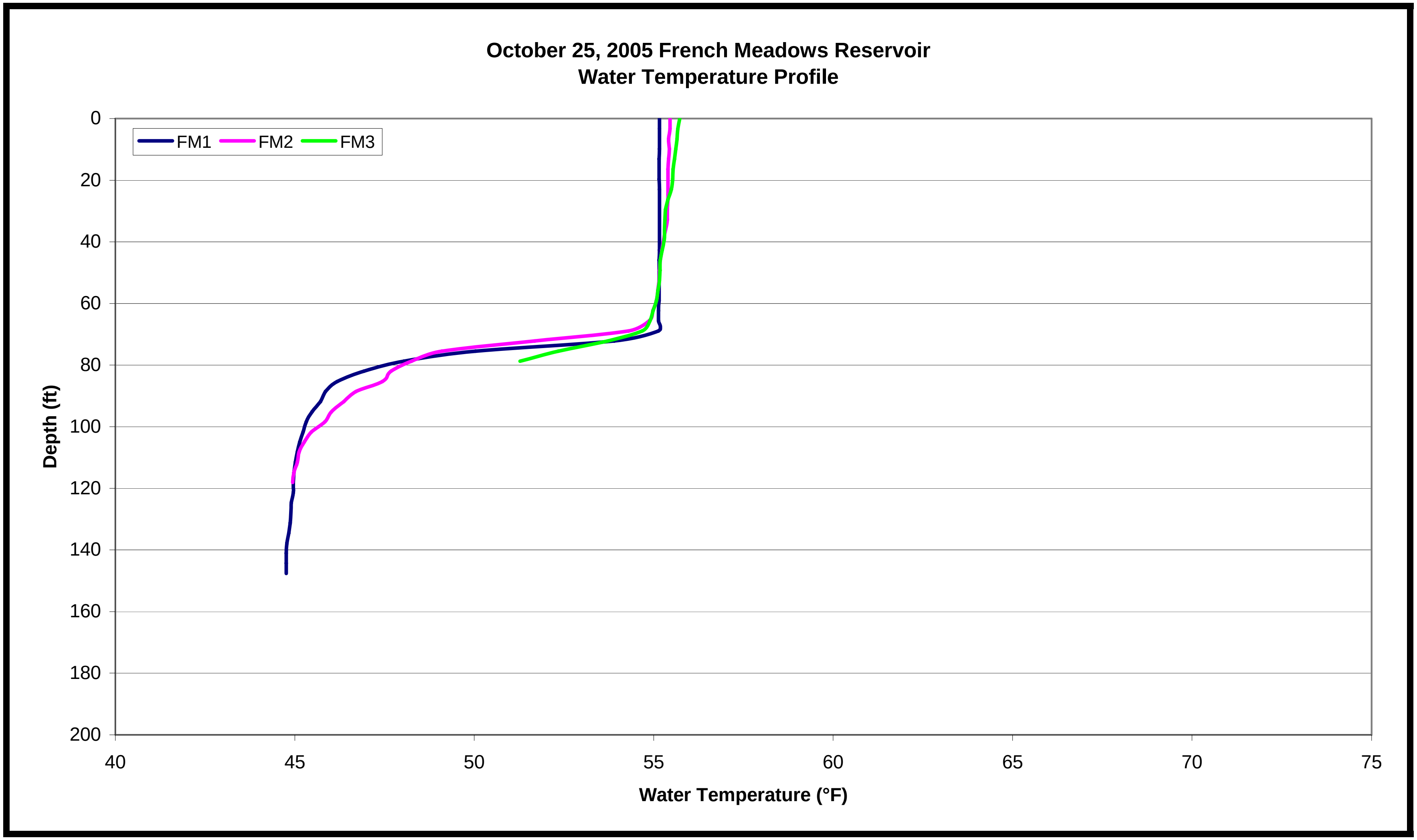



**Figure 24. The French Meadows Reservoir water temperature profiles at sites FM1, FM2, and FM3 on October 25, 2005.**

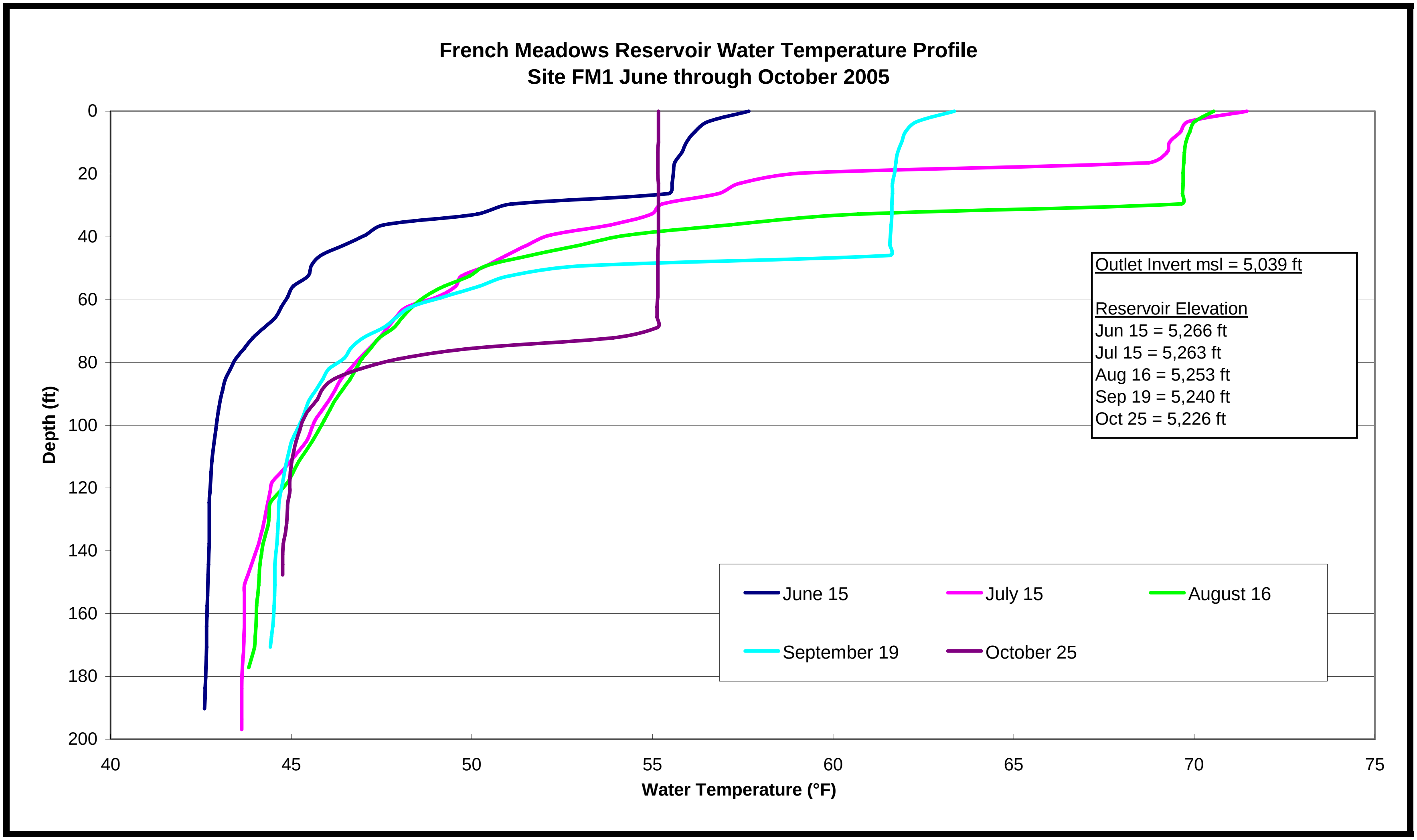



**Figure 25. The French Meadows Reservoir water temperature profiles at site FM1 (nearest French Meadows Dam) on June 15, July 15, August 16, September 19, and October 25, 2005, including the river outlet invert elevation and the approximate reservoir elevation (msl) for each sample date.**

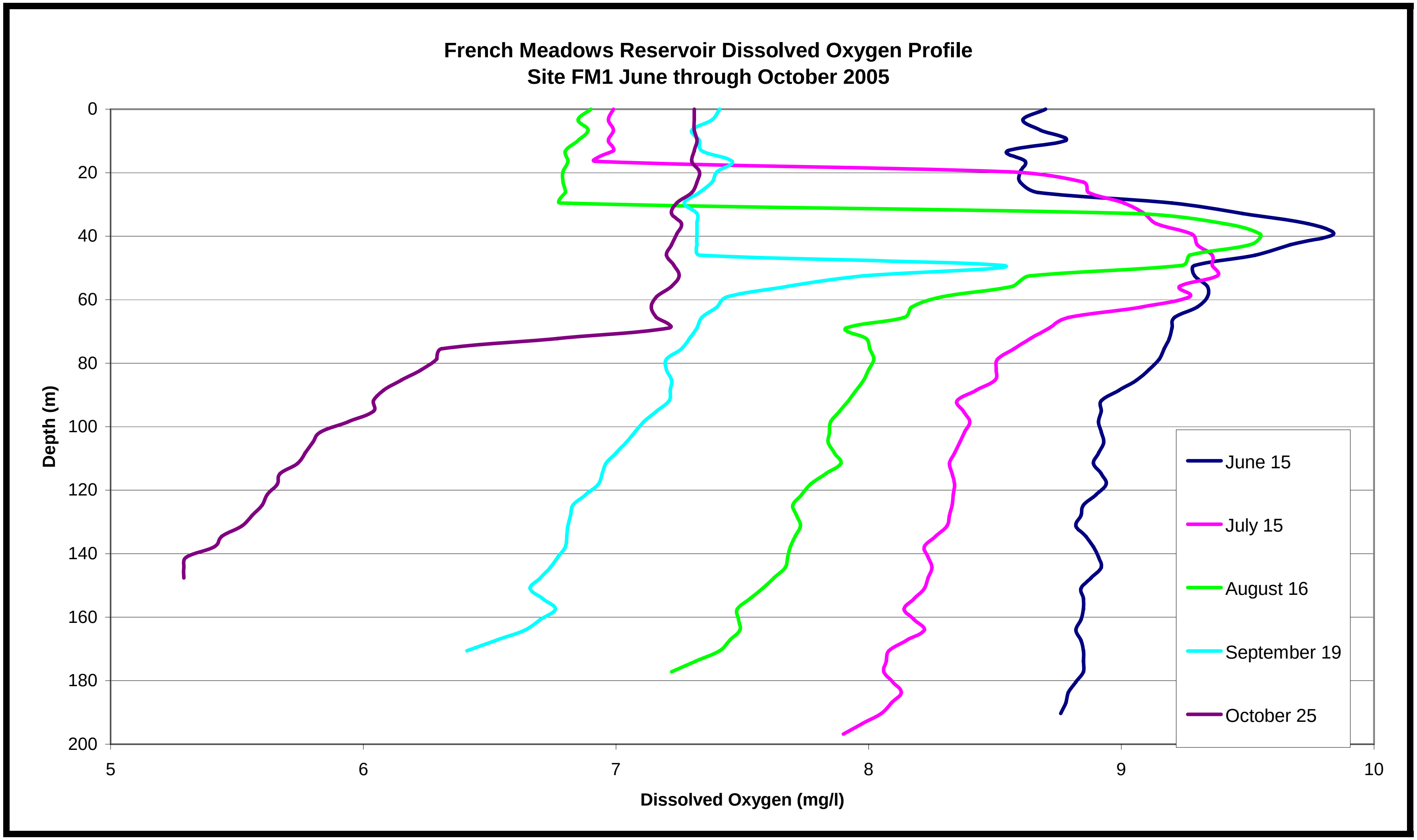



**Figure 26. The French Meadows Reservoir dissolved oxygen profiles at site FM1 (nearest French Meadows Dam) on June 15, July 15, August 16, September 19, and October 25, 2005.**

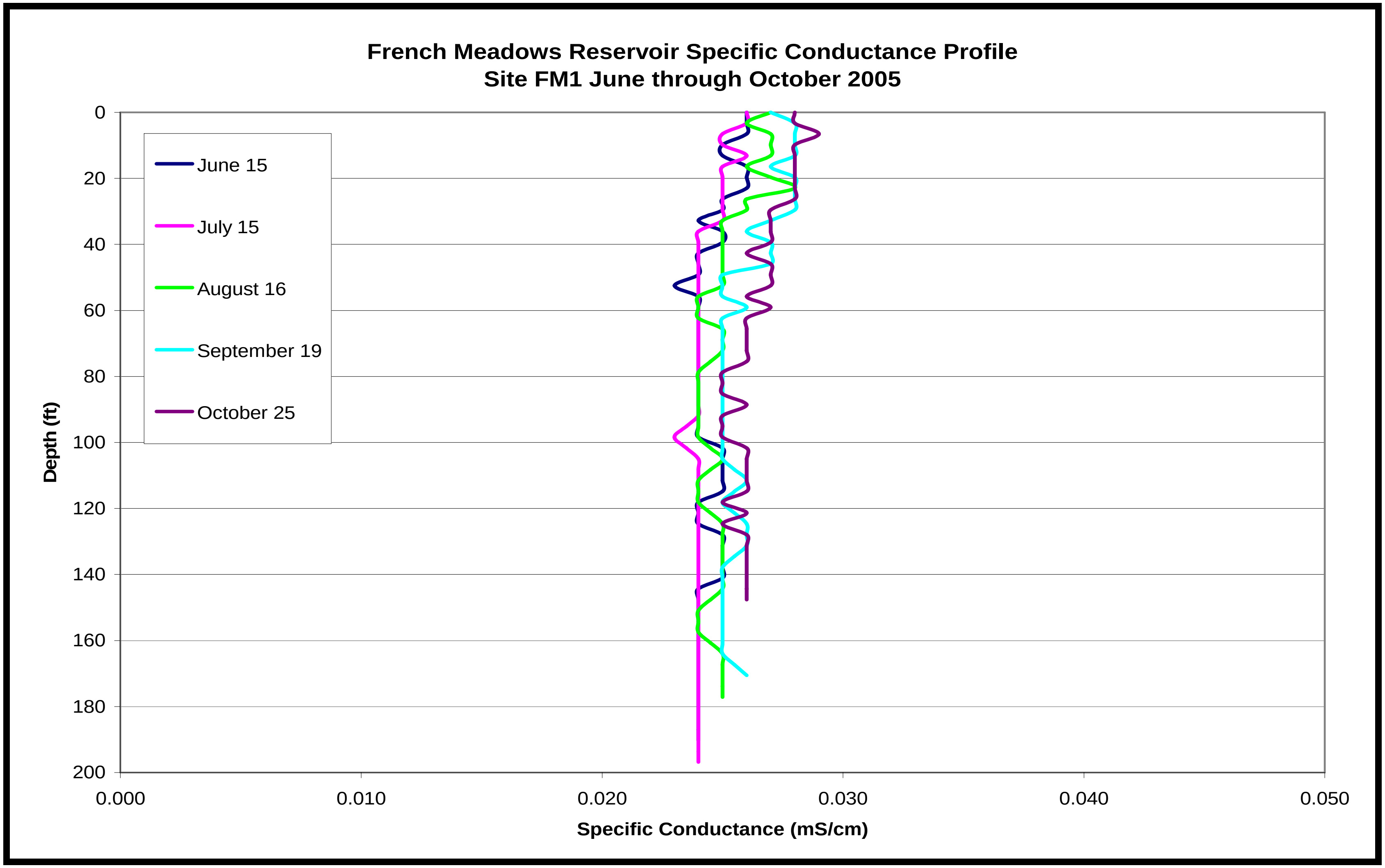



**Figure 27. The French Meadows Reservoir specific conductance profiles at site FM1 (nearest French Meadows Dam) on June 15, July 15, August 16, September 19, and October 25, 2005.**

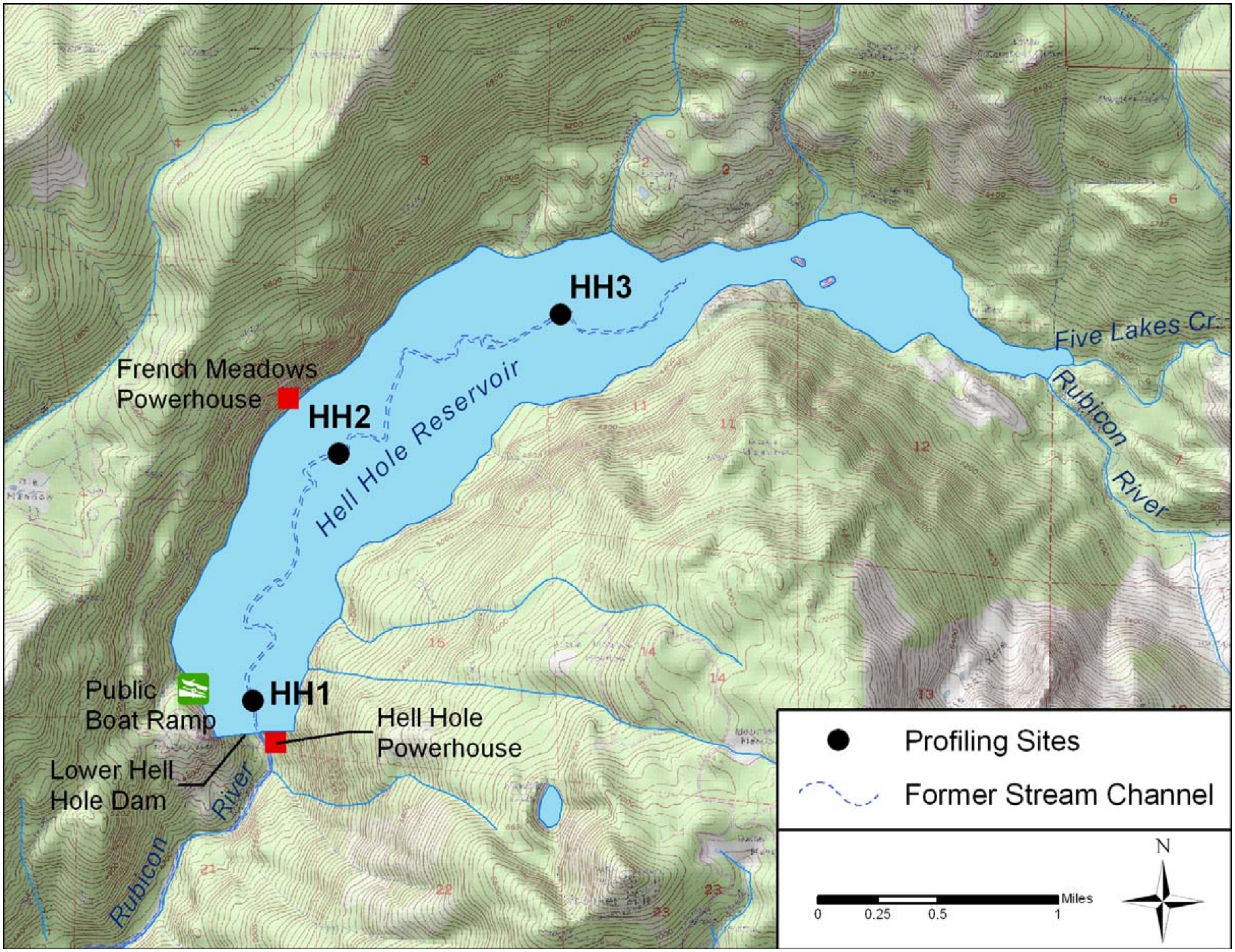



**Figure 28. The water temperature profile locations in Hell Hole Reservoir.**

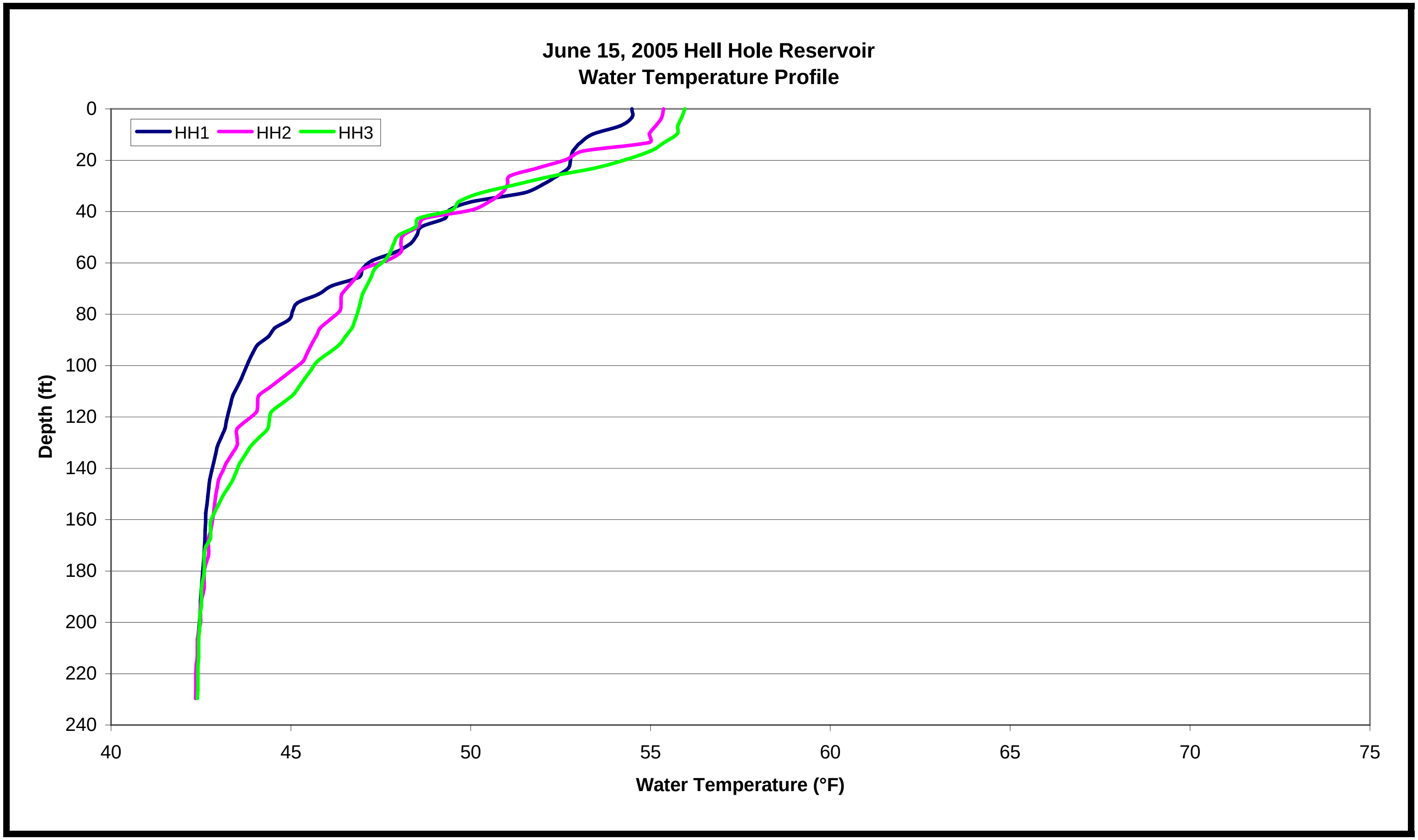



**Figure 29. The Hell Hole Reservoir water temperature profiles at sites HH1, HH2, and HH3 on June 15, 2005.**

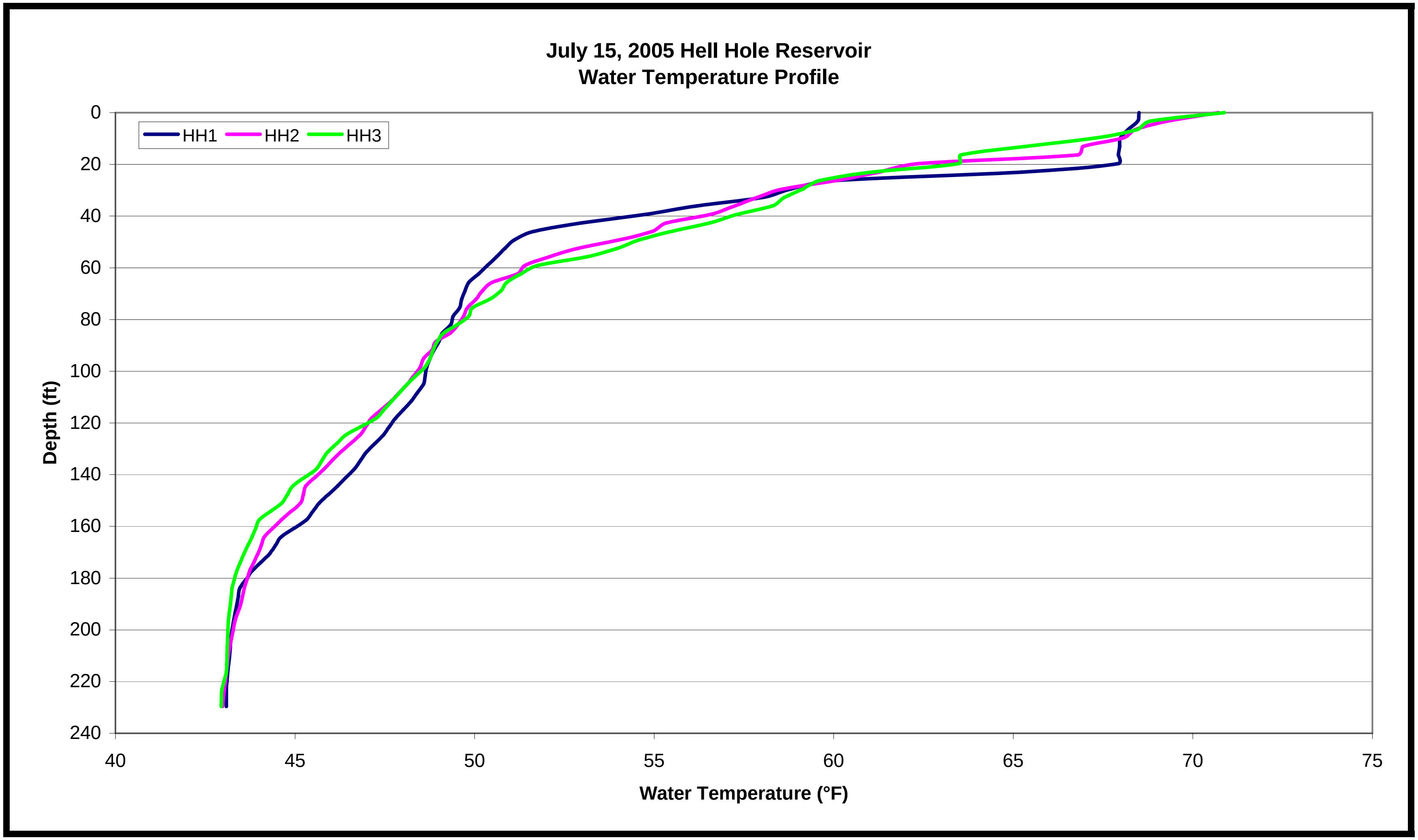



**Figure 30. The Hell Hole Reservoir water temperature profiles at sites HH1, HH2, and HH3 on July 15, 2005.**

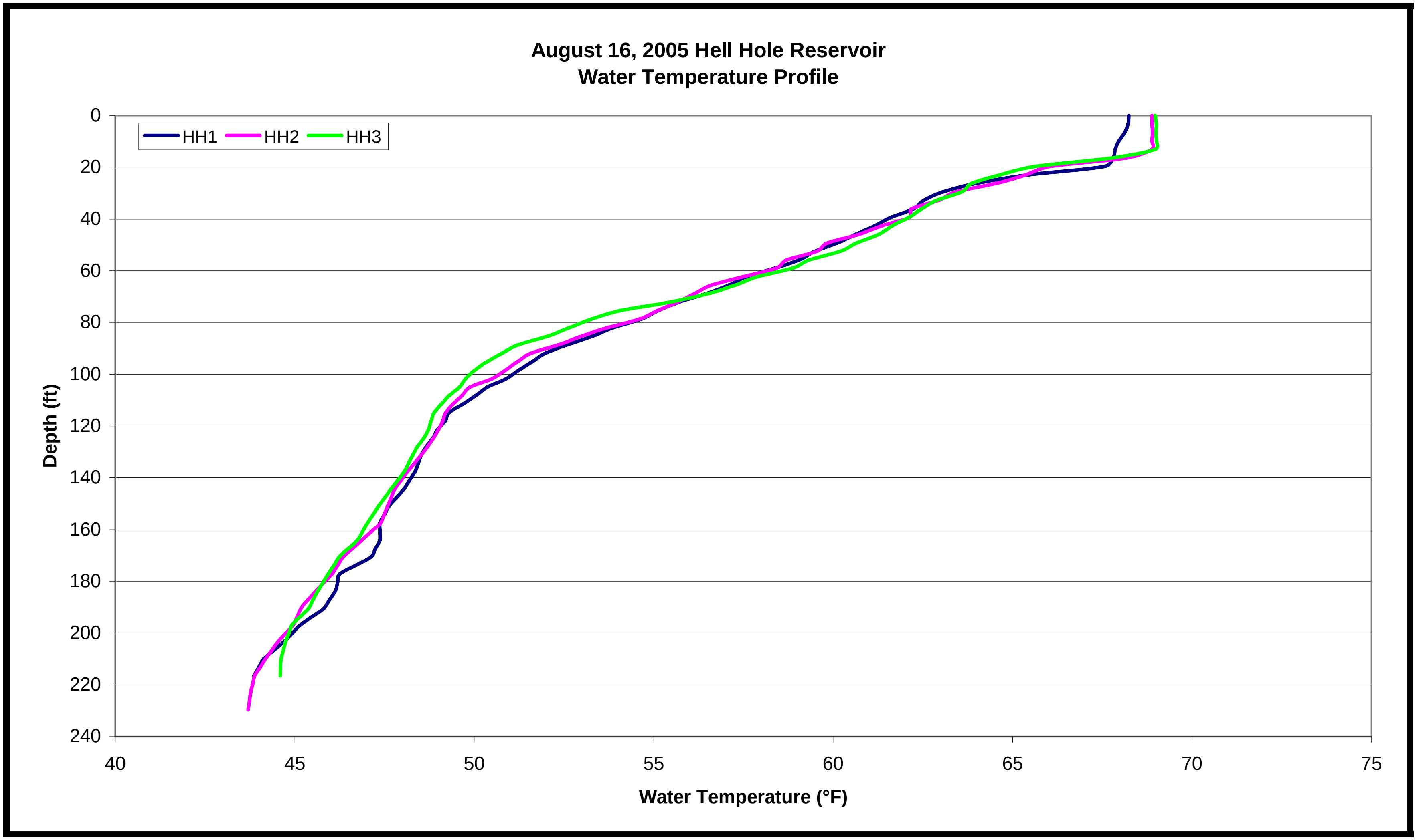



**Figure 31. The Hell Hole Reservoir water temperature profiles at sites HH1, HH2, and HH3 on August 16, 2005.**

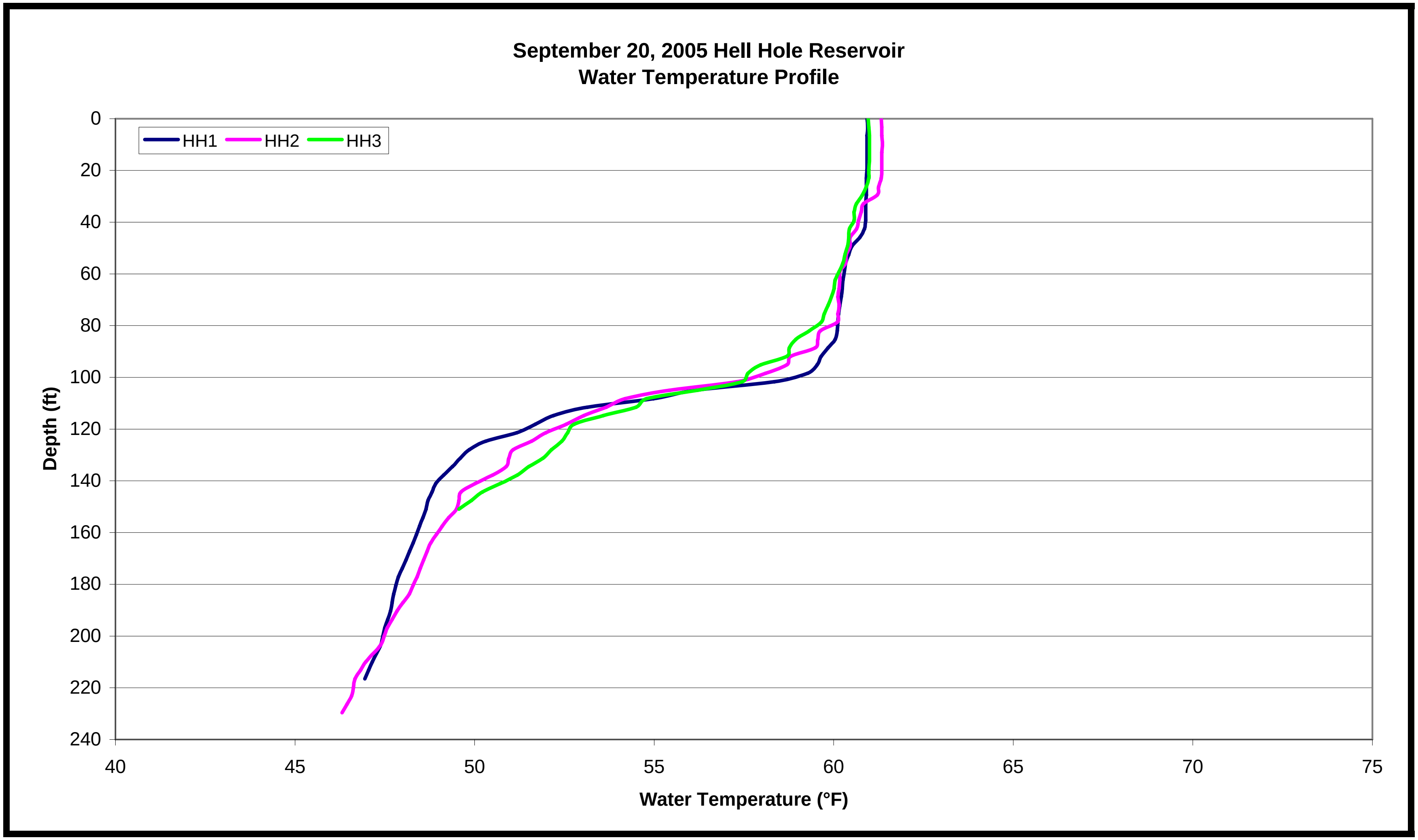



**Figure 32. The Hell Hole Reservoir water temperature profiles at sites HH1, HH2, and HH3 on September 20, 2005.**

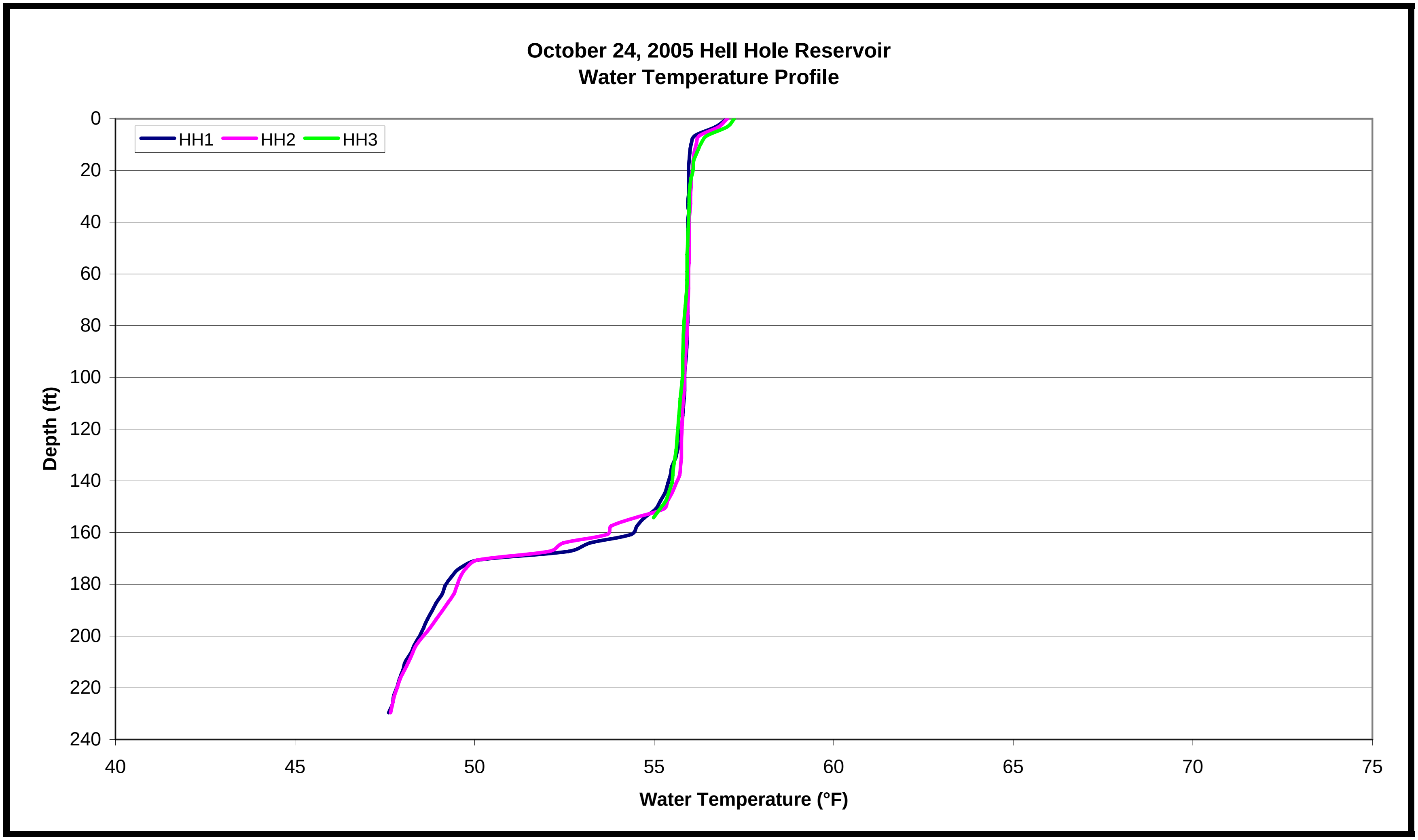



**Figure 33. The Hell Hole Reservoir water temperature profiles at sites HH1, HH2, and HH3 on October 24, 2005.**

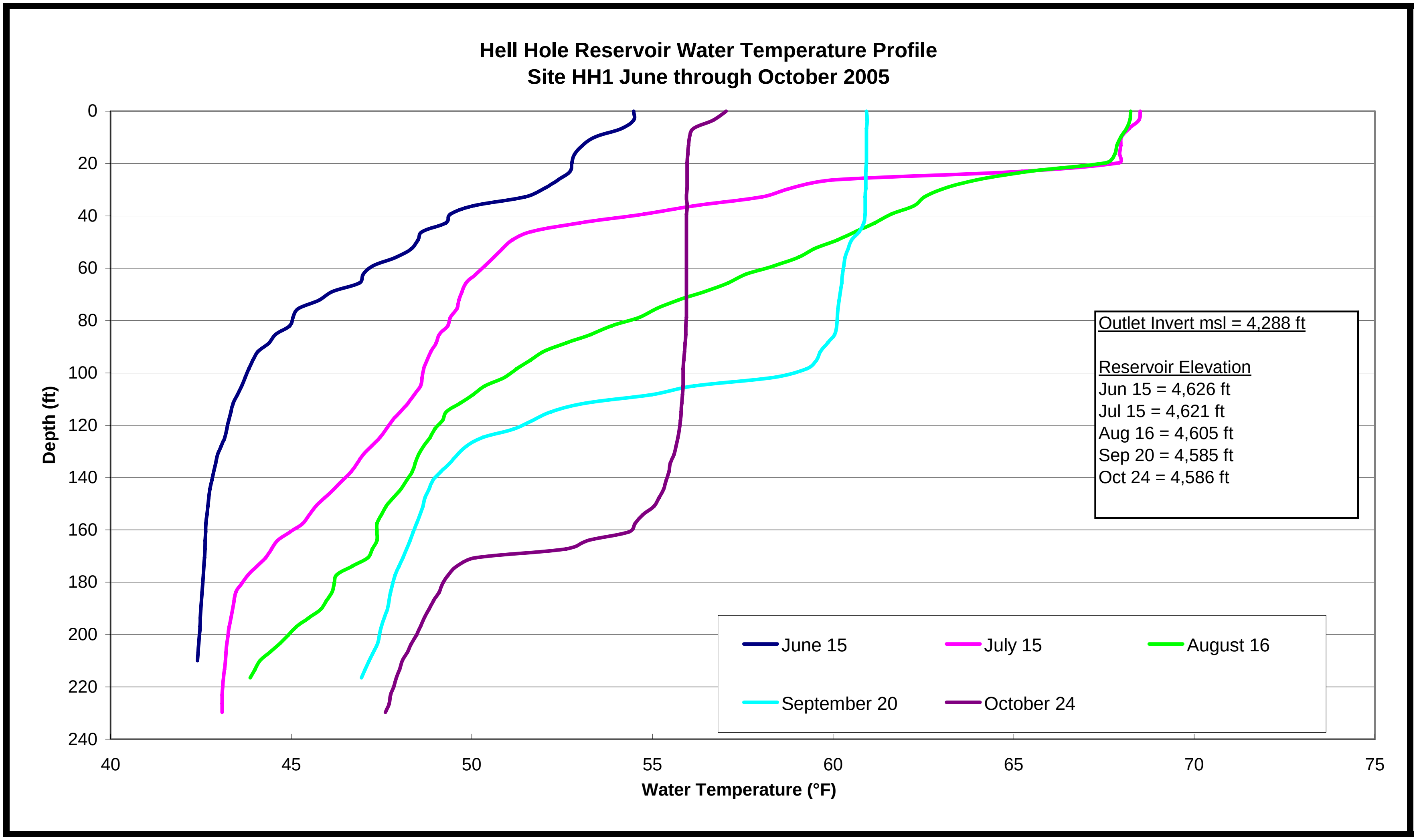



**Figure 34. The Hell Hole Reservoir water temperature profiles at site HH1 (nearest Hell Hole Dam) on June 15, July 15, August 16, September 20, and October 24, 2005, including the river outlet invert elevation and the approximate reservoir elevation (msl) for each sample date.**

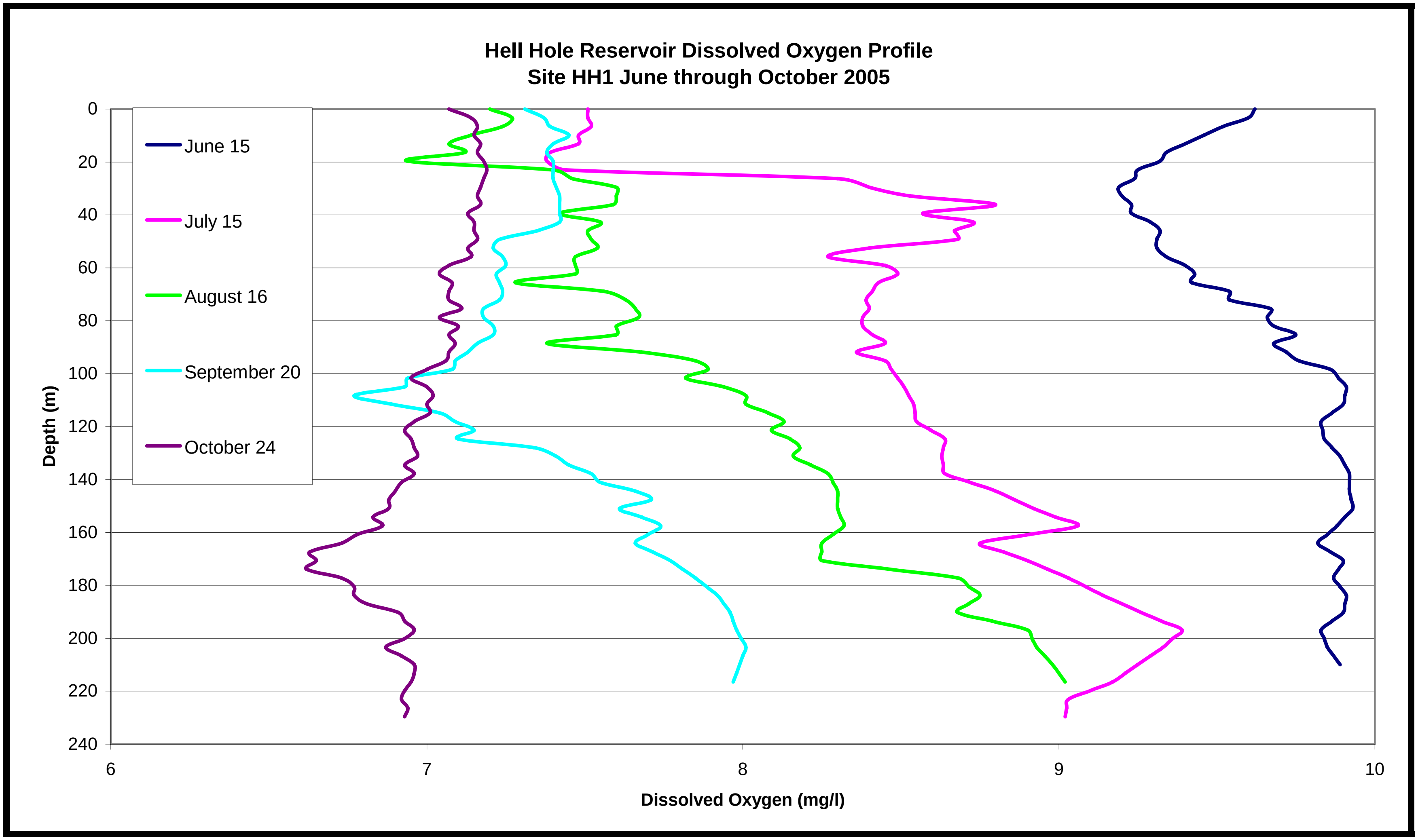



**Figure 35. The Hell Hole Reservoir dissolved oxygen profiles at Site HH1 (nearest Hell Hole Dam) on June 15, July 15, August 16, September 20, and October 24, 2005.**

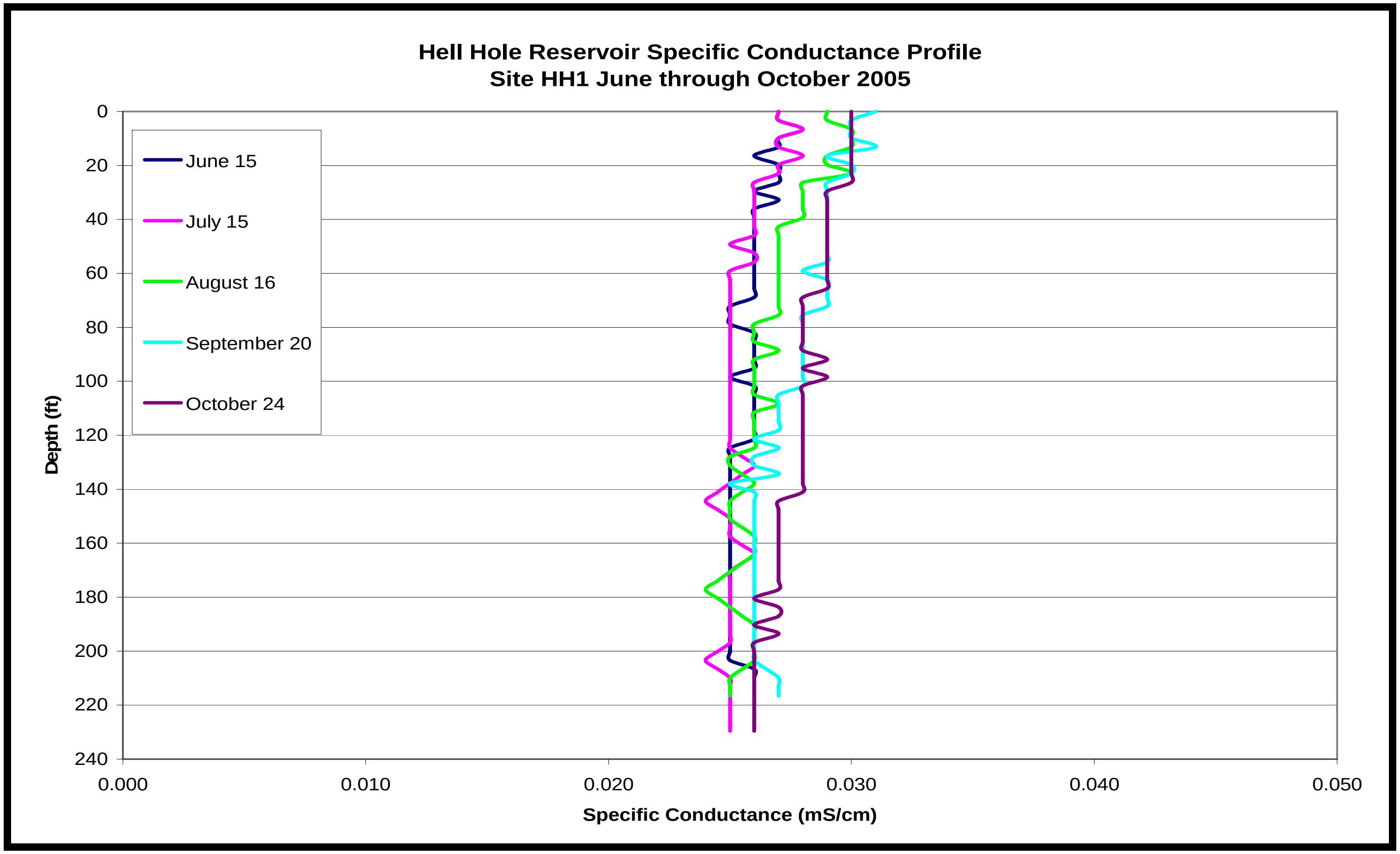



**Figure 36. The Hell Hole Reservoir specific conductance profiles at Site HH1 (nearest Hell Hole Dam) on June 15, July 15, August 16, September 20, and October 24, 2005.**

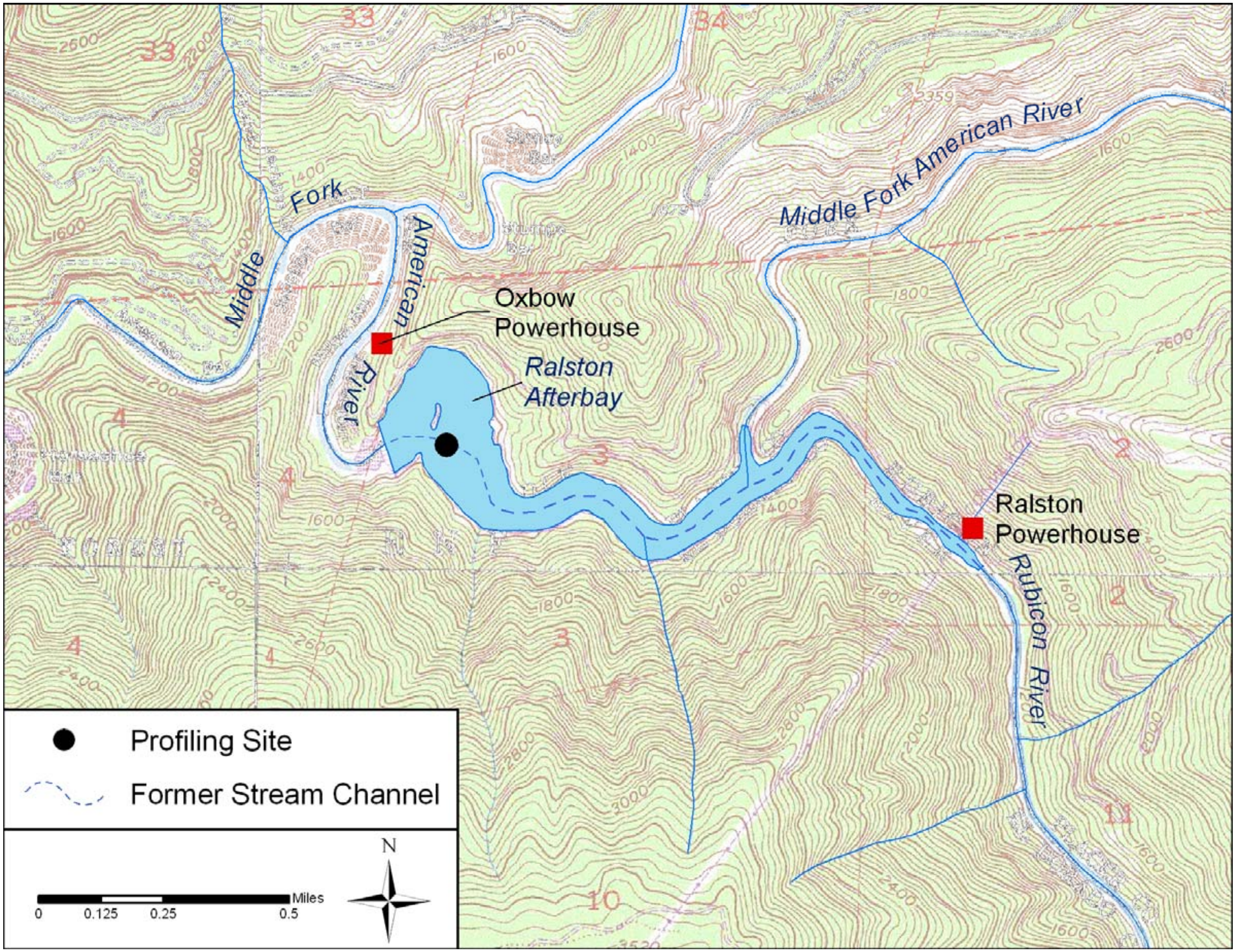



**Figure 37. The water temperature profile location in Ralston Afterbay Reservoir.**

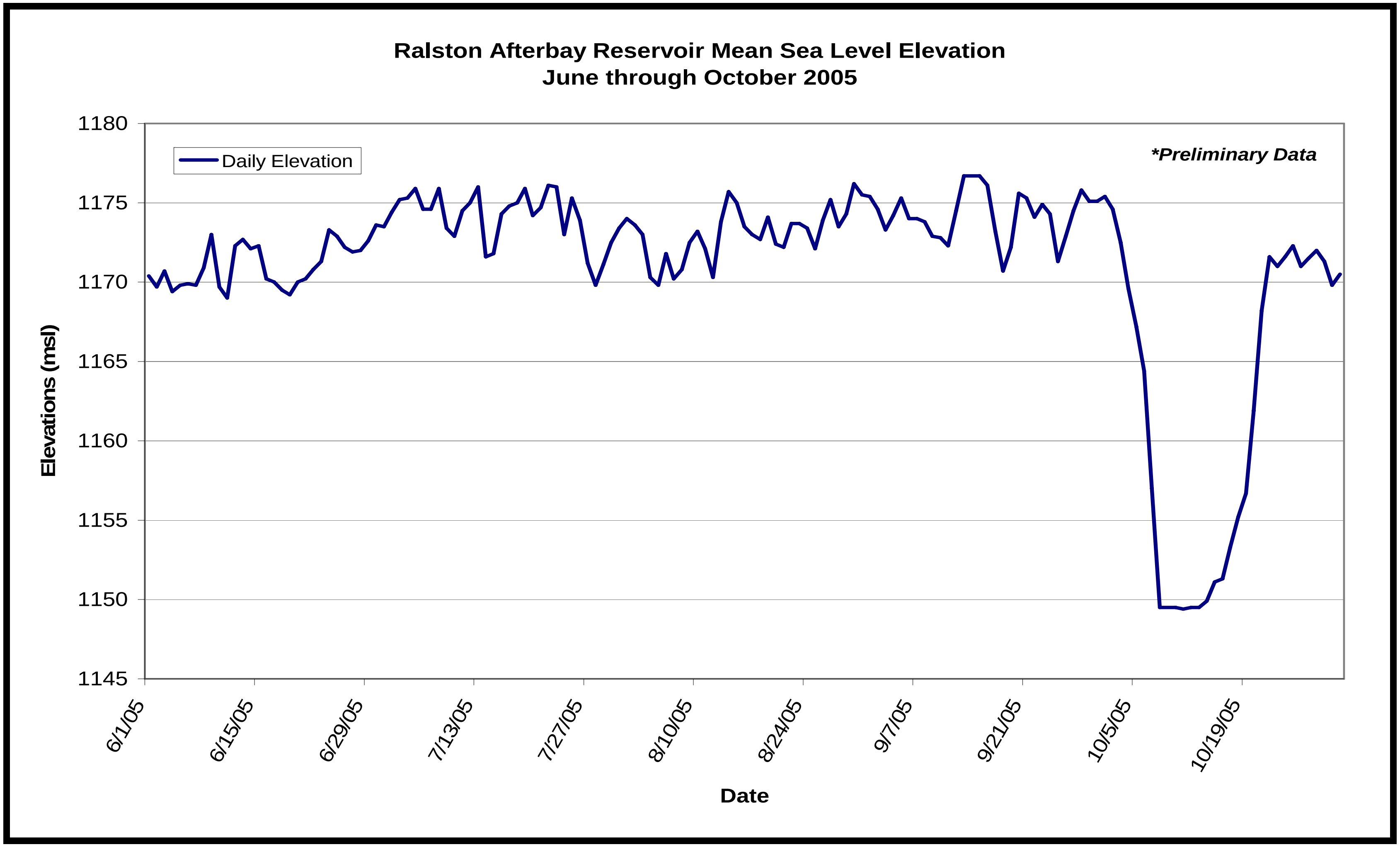



**Figure 38. The daily reservoir elevation at Ralston Afterbay Reservoir during June through October 2005. Note the decrease in reservoir elevation during the MFP powerhouse maintenance outage period during October. Note: Preliminary data.**

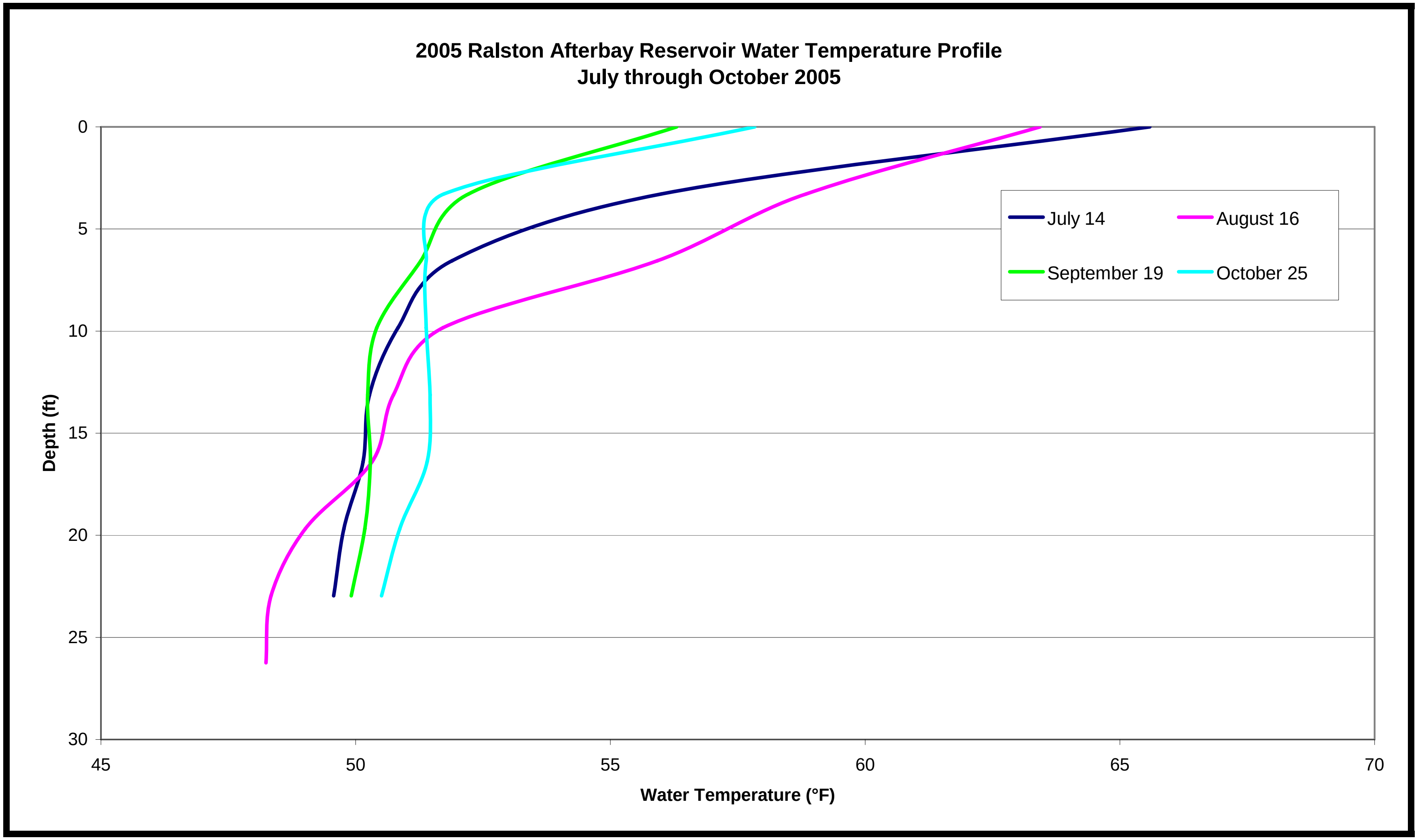



**Figure 39. The Ralston Afterbay Reservoir water temperature profiles on July 14, August 16, September 19, and October 25, 2005.**

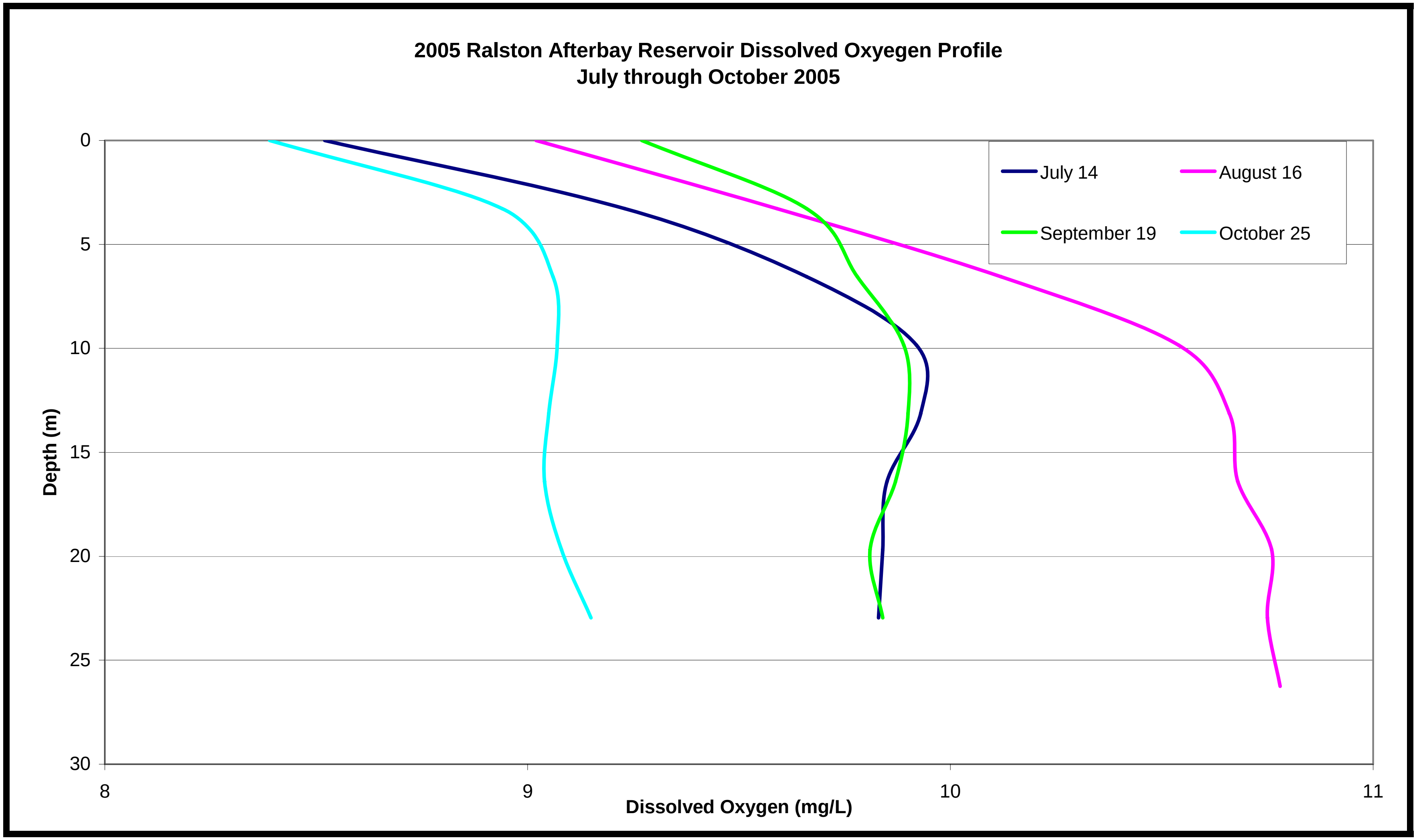



**Figure 40. The Ralston Afterbay Reservoir dissolved oxygen profiles from July 14, August 16, September 19, and October 25, 2005.**

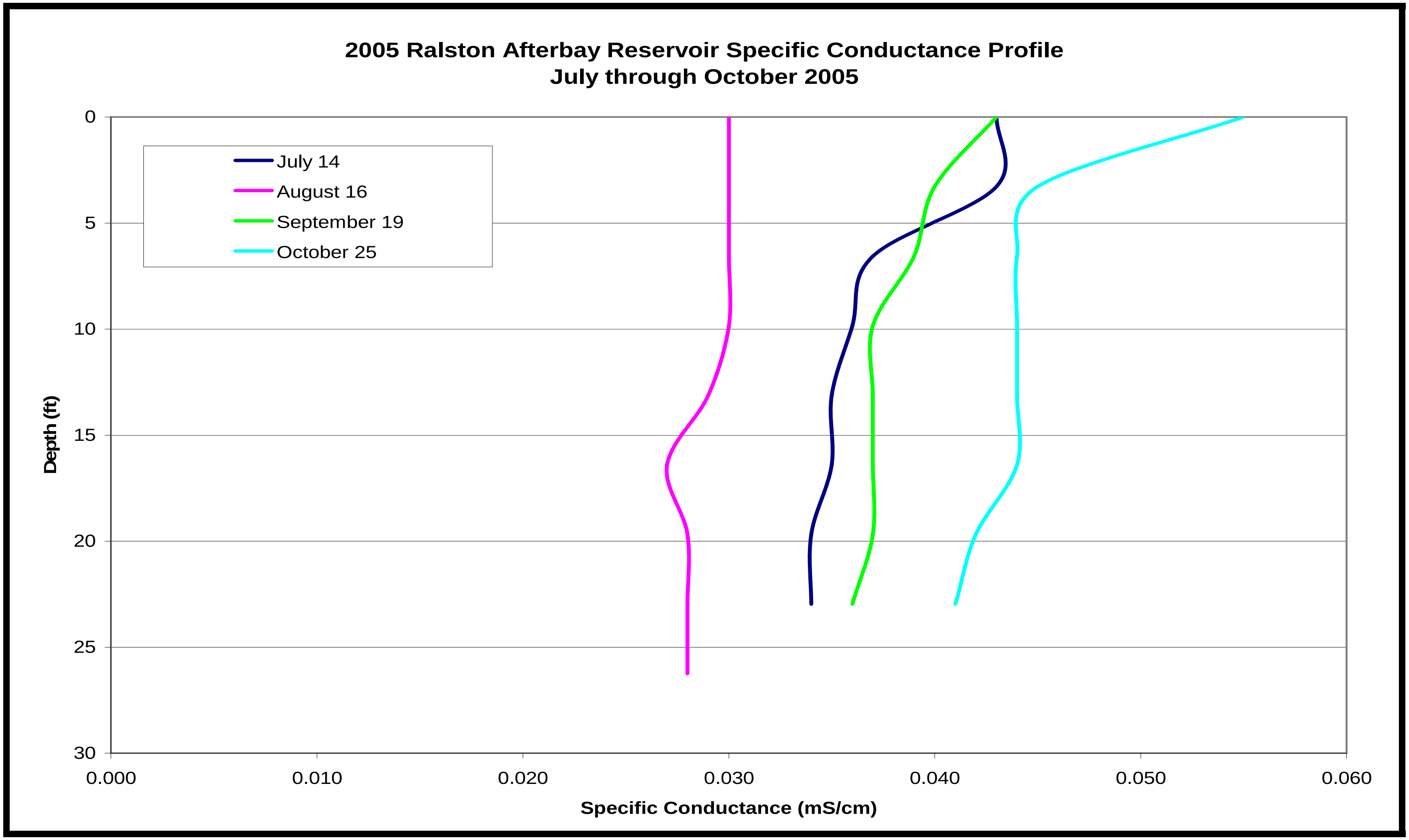



**Figure 41. The Ralston Afterbay Reservoir specific conductance profiles from July 14, August 16, September 19, and October 25, 2005.**

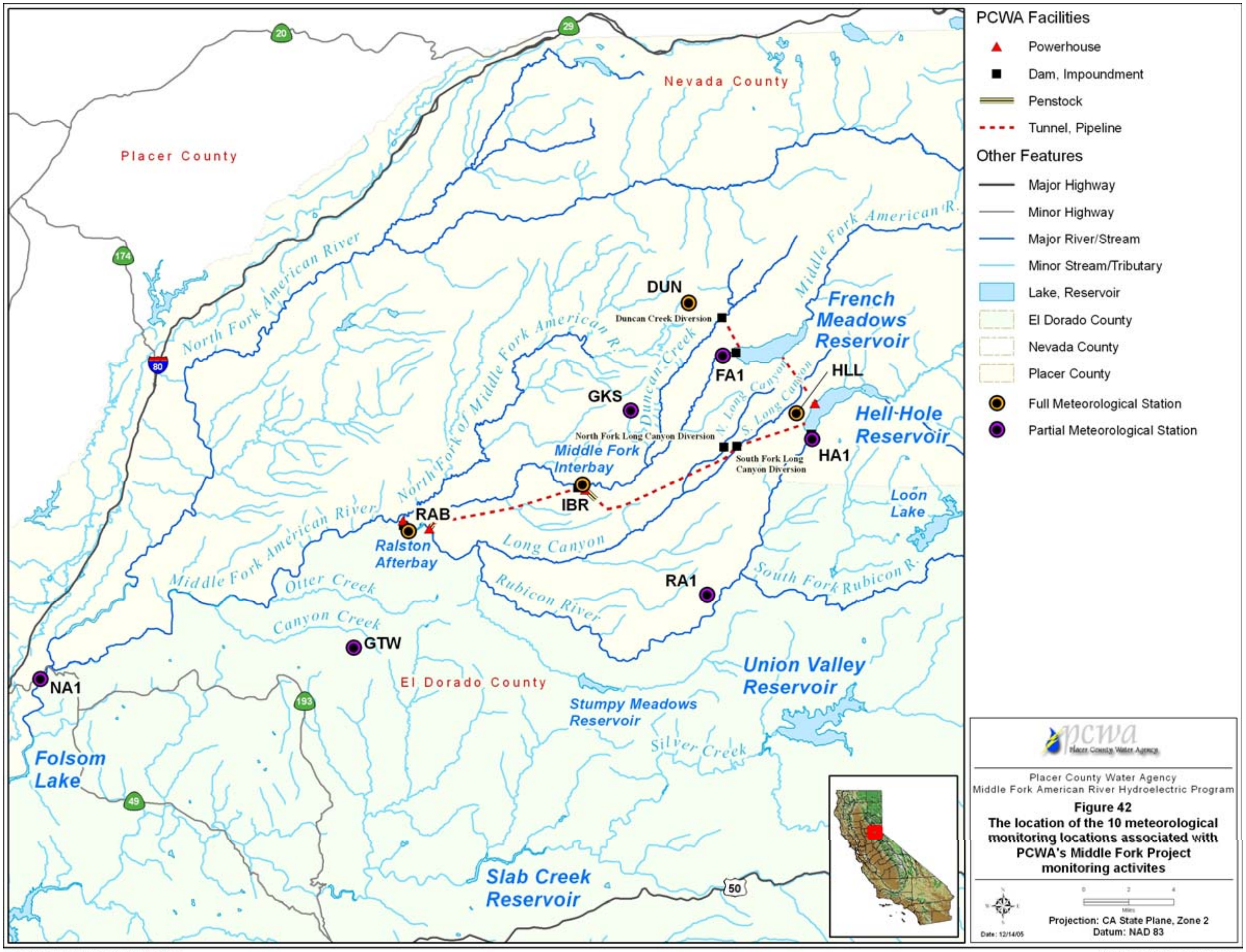



Figure 42
The location of the 10 meteorological monitoring locations associated with PCWA's Middle Fork Project monitoring activites

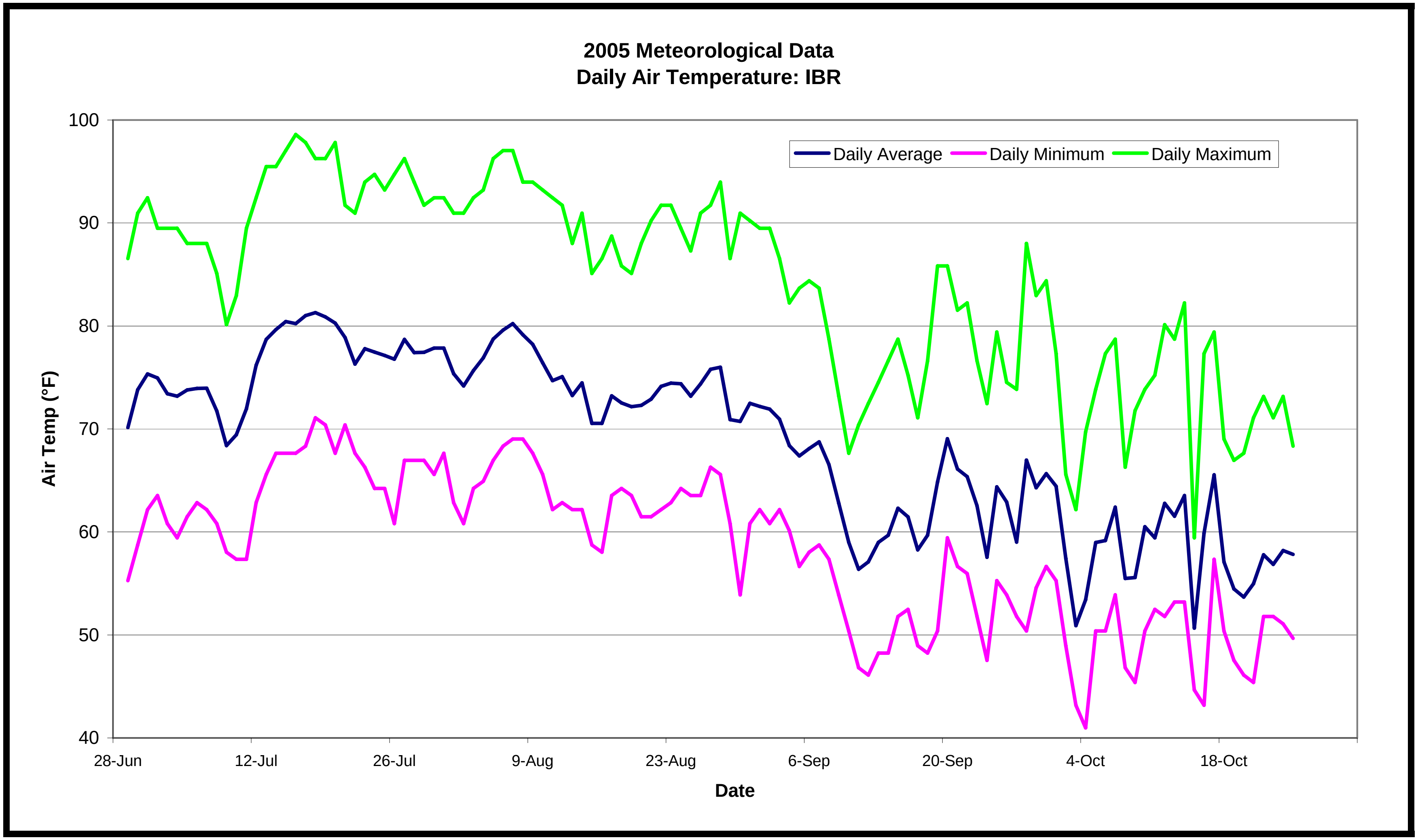



**Figure 43. The daily average, maximum, and minimum air temperatures (°F) at Middle Fork Powerhouse collected during the summer and fall of 2005.**

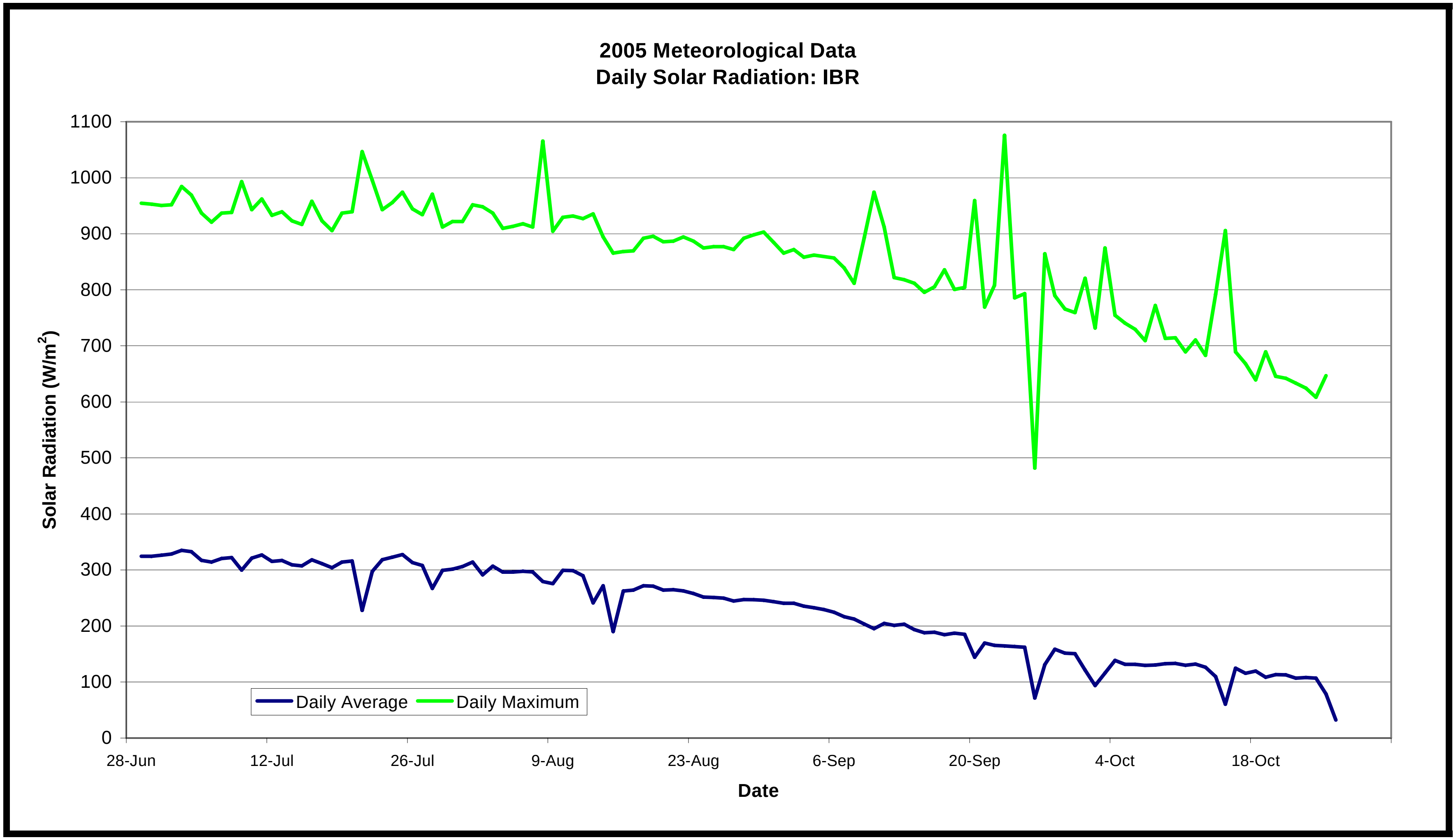



**Figure 44. The daily average and maximum solar radiation (watts/square meter) at Middle Fork Powerhouse collected during the summer and fall of 2005.**

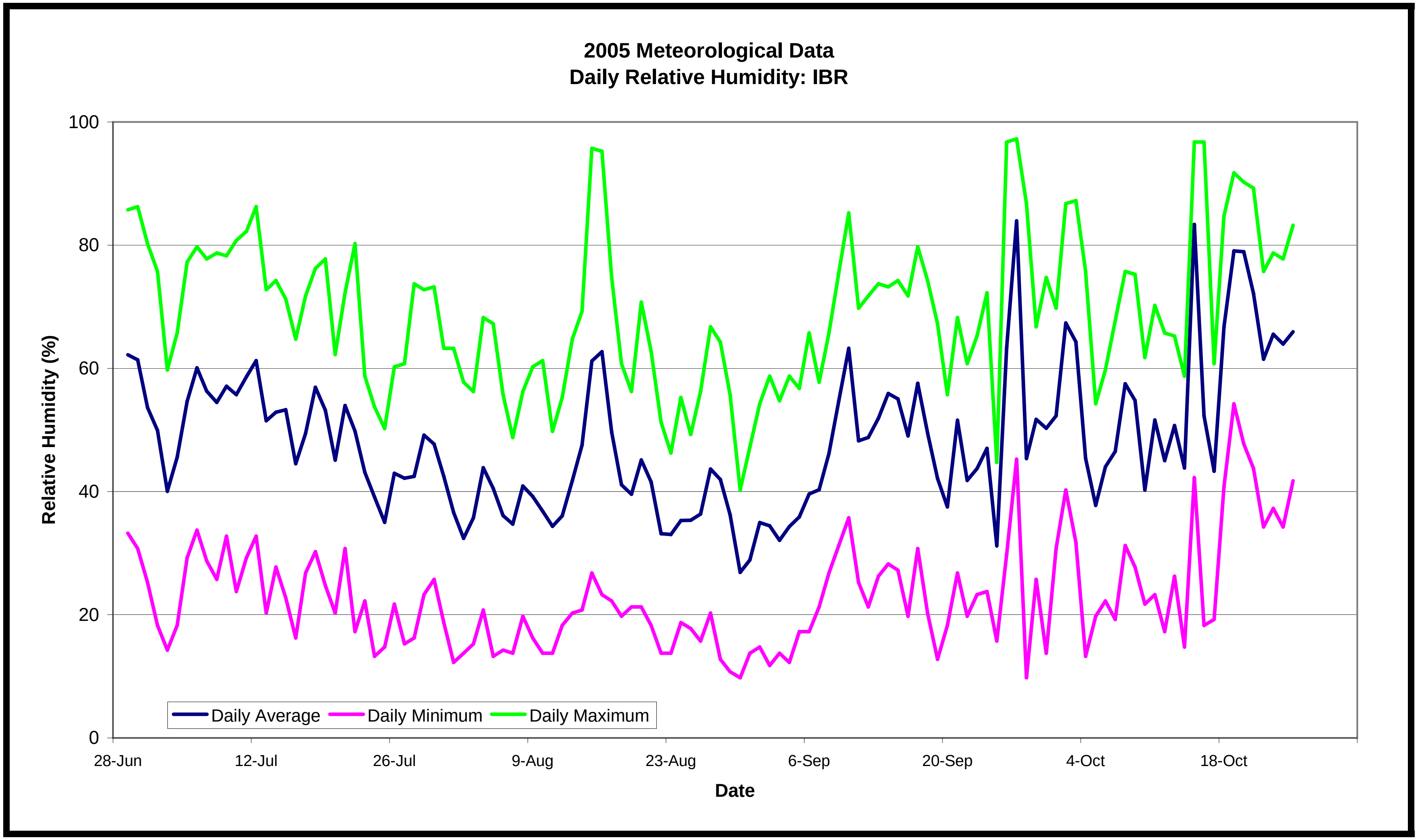



**Figure 45. The daily average, maximum, and minimum relative humidity (%) at Middle Fork Powerhouse collected during the summer and fall of 2005.**

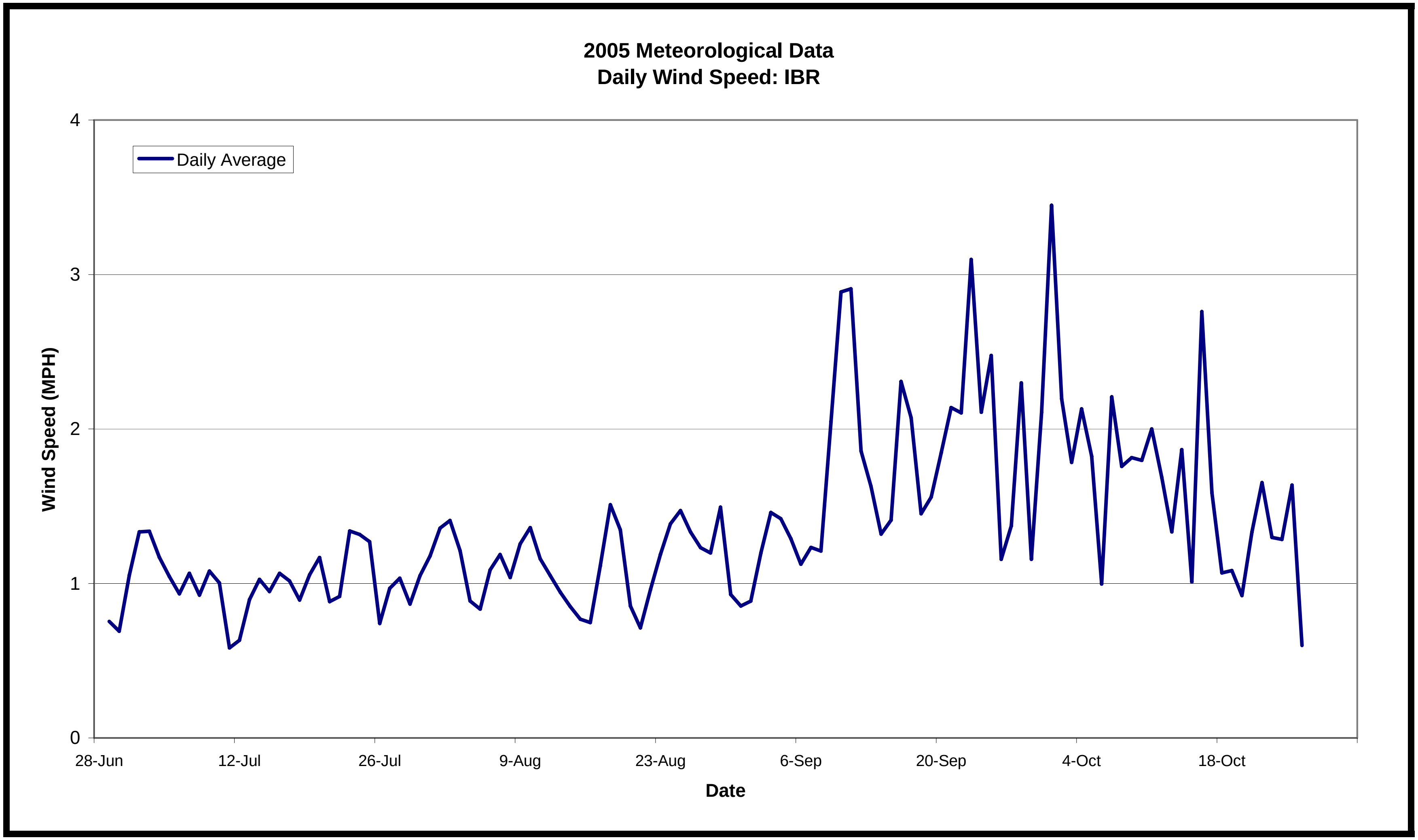



**Figure 46. The daily average wind speed (miles/hour) at Middle Fork Powerhouse collected during the summer and fall of 2005.**

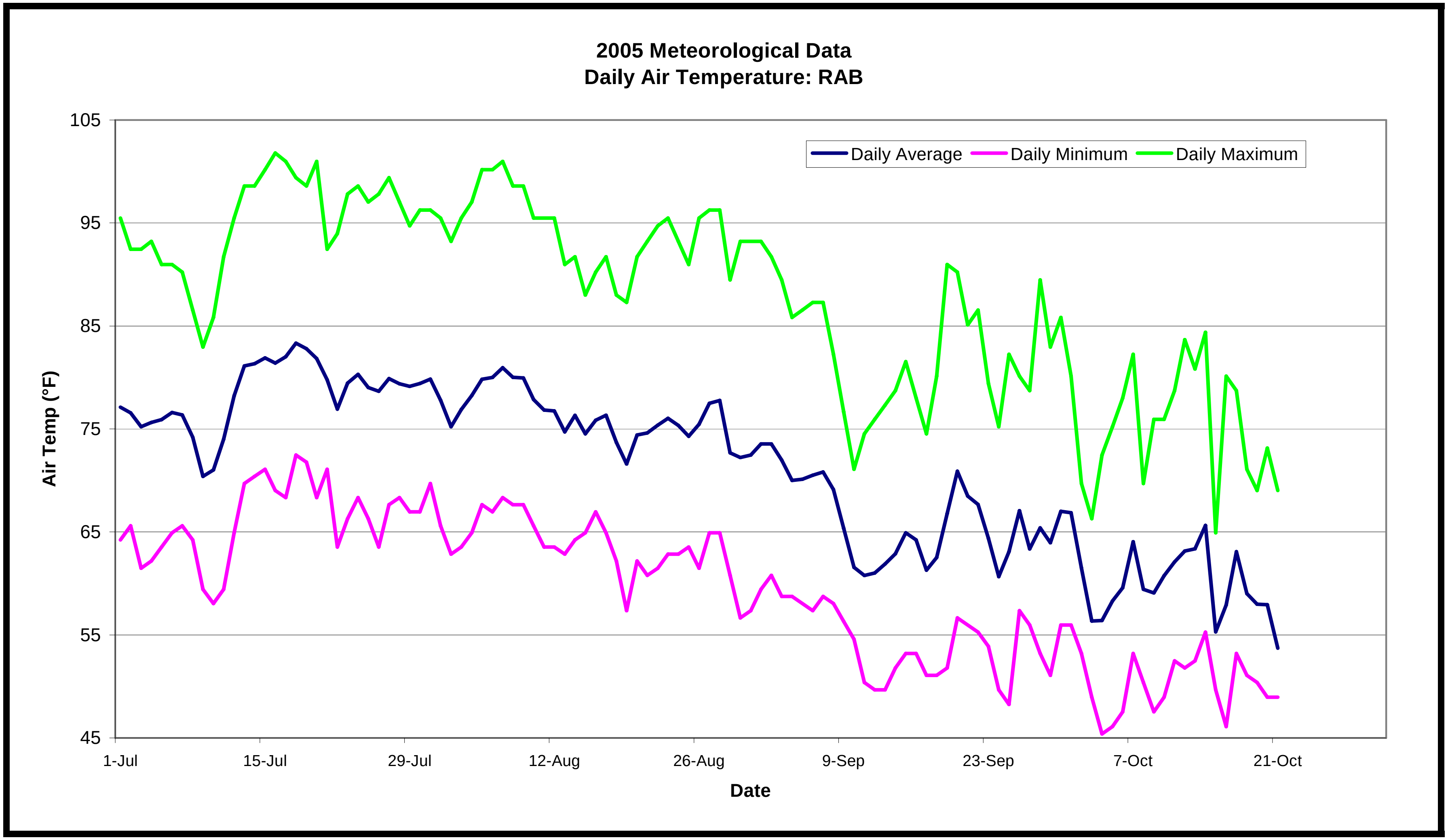



**Figure 47. The daily average, maximum, and minimum air temperatures (°F) at Ralston Afterbay Dam collected during the summer and fall of 2005.**

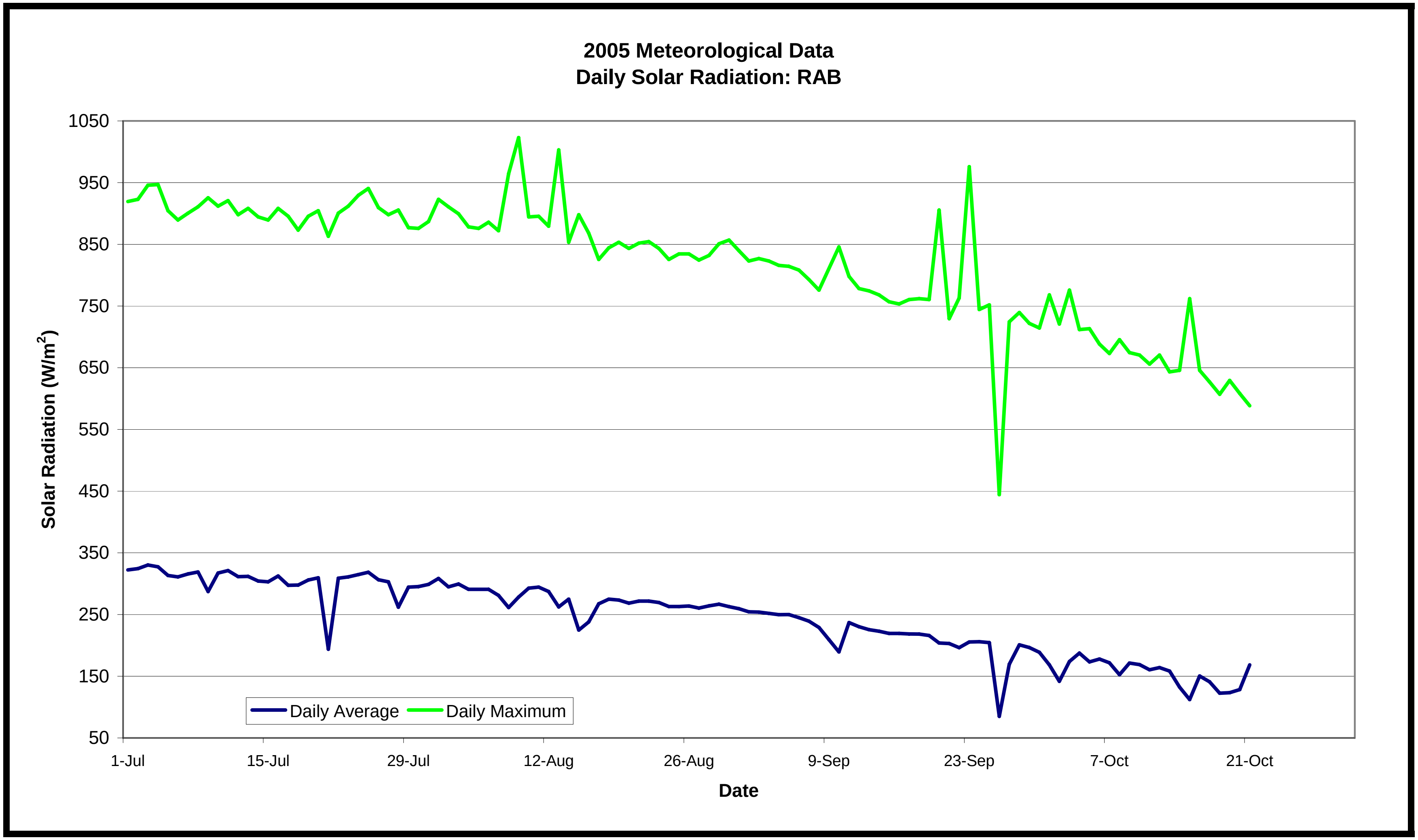



**Figure 48. The daily average and maximum solar radiation (watts/square meter) at Ralston Afterbay Dam collected during the summer and fall of 2005.**

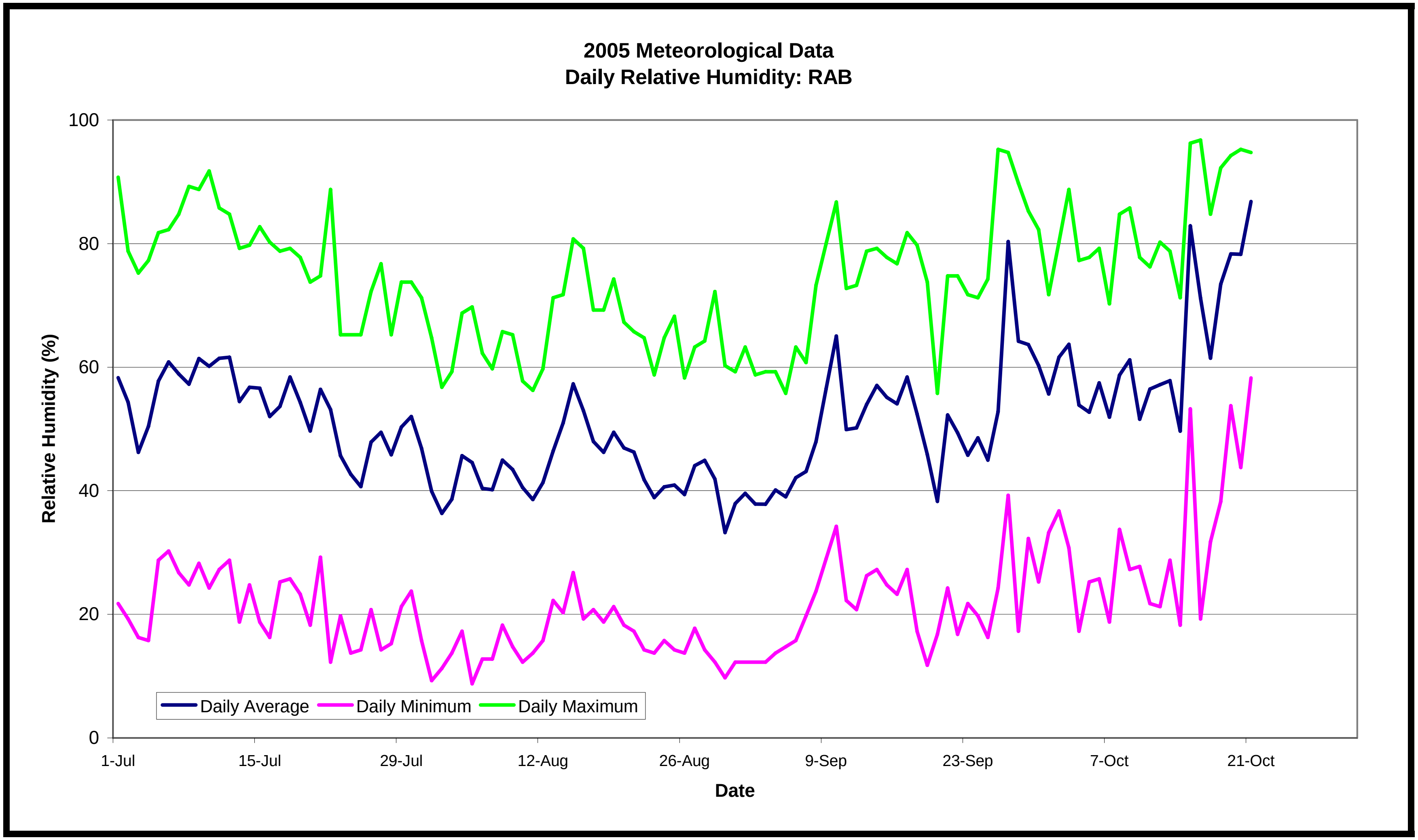



**Figure 49. The daily average, maximum, and minimum relative humidity (%) at Ralston Afterbay Dam collected during the summer and fall of 2005.**

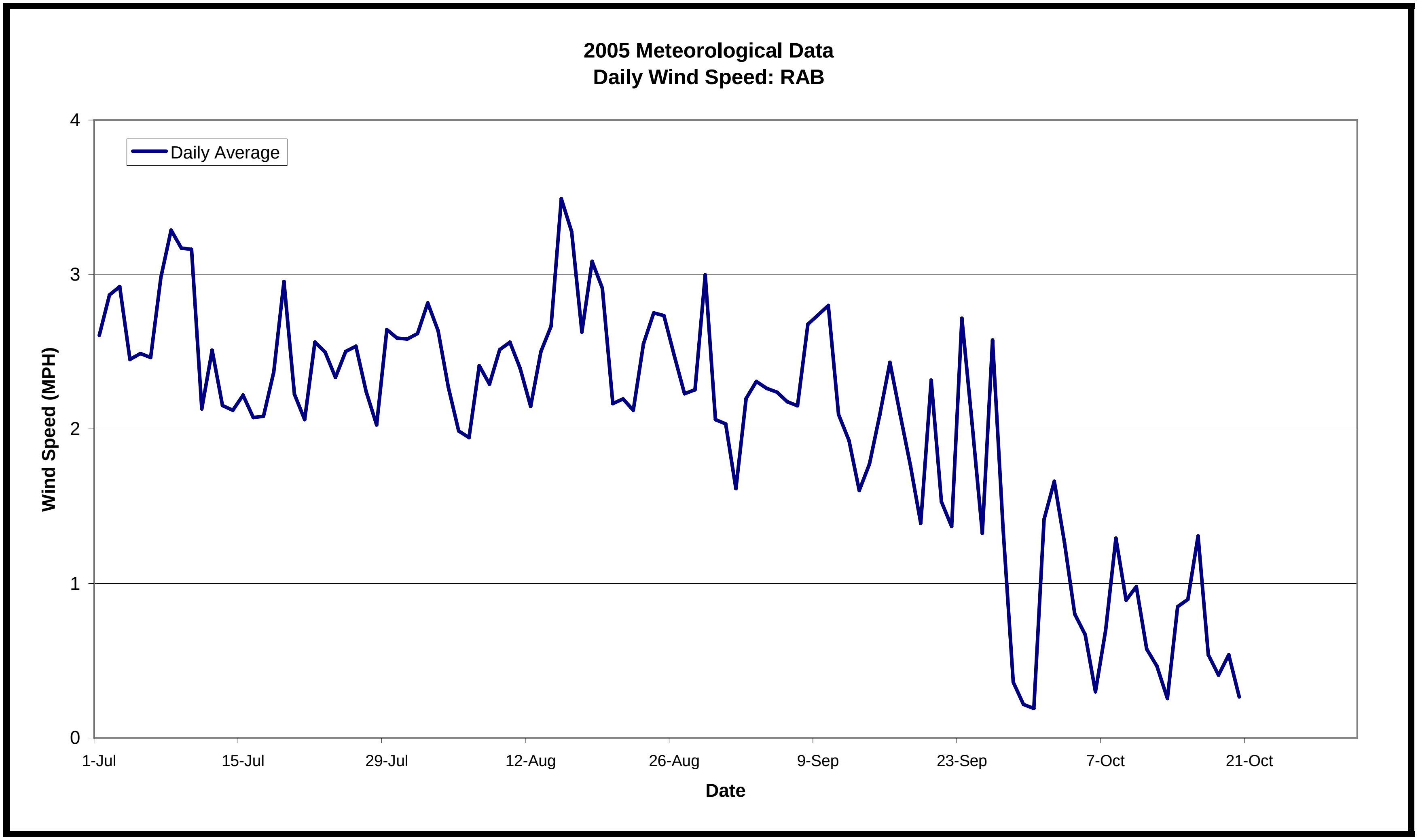



**Figure 50. The daily average wind speed (miles/hour) at Ralston Afterbay Dam collected during the summer and fall of 2005.**

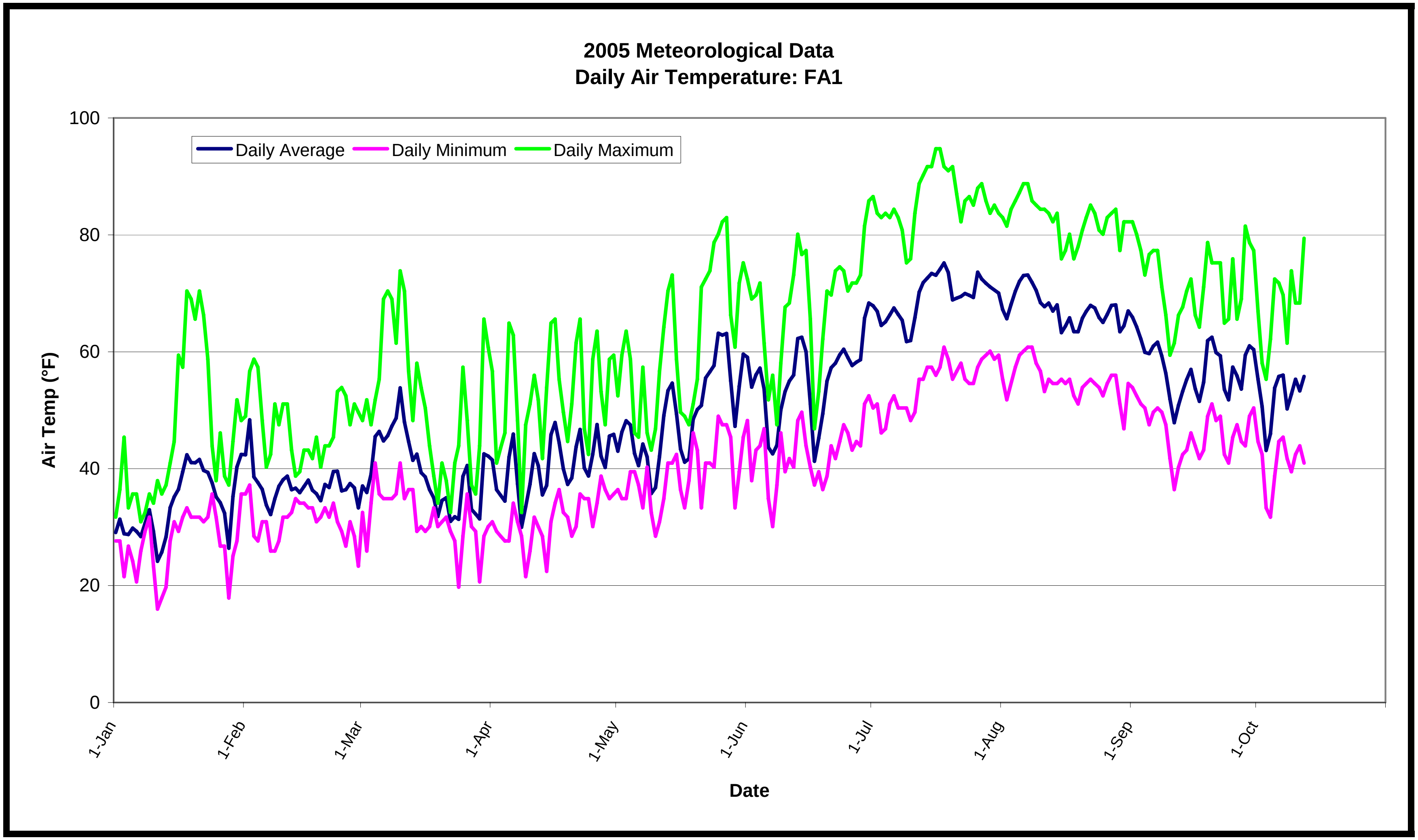



**Figure 51. The daily average, maximum, and minimum air temperatures (°F) at Middle Fork American River near French Meadows Dam collected during the summer and fall of 2005.**

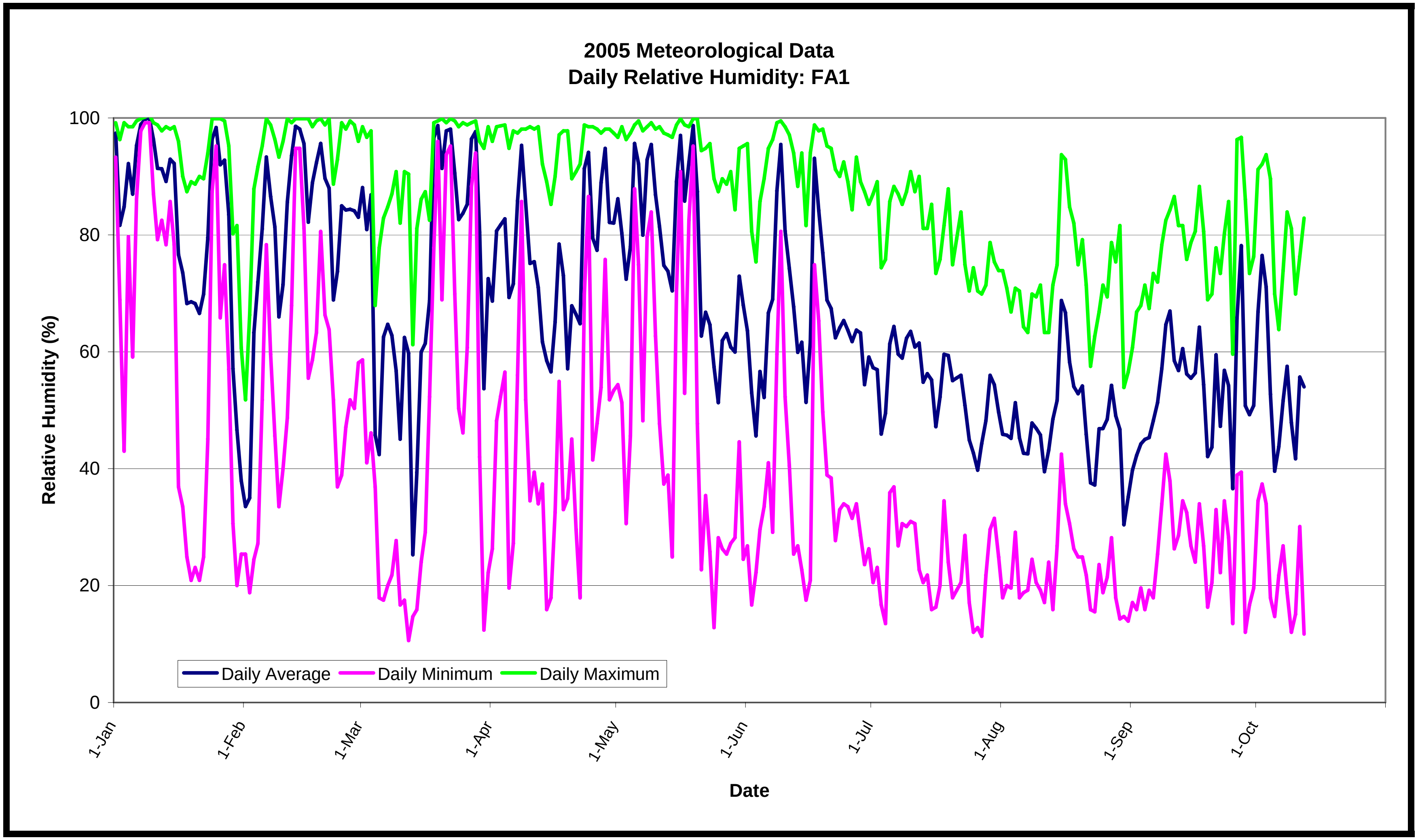



**Figure 52. The daily average, maximum, and minimum relative humidity (%) at the Middle Fork American River near French Meadows Dam collected during the summer and fall of 2005.**

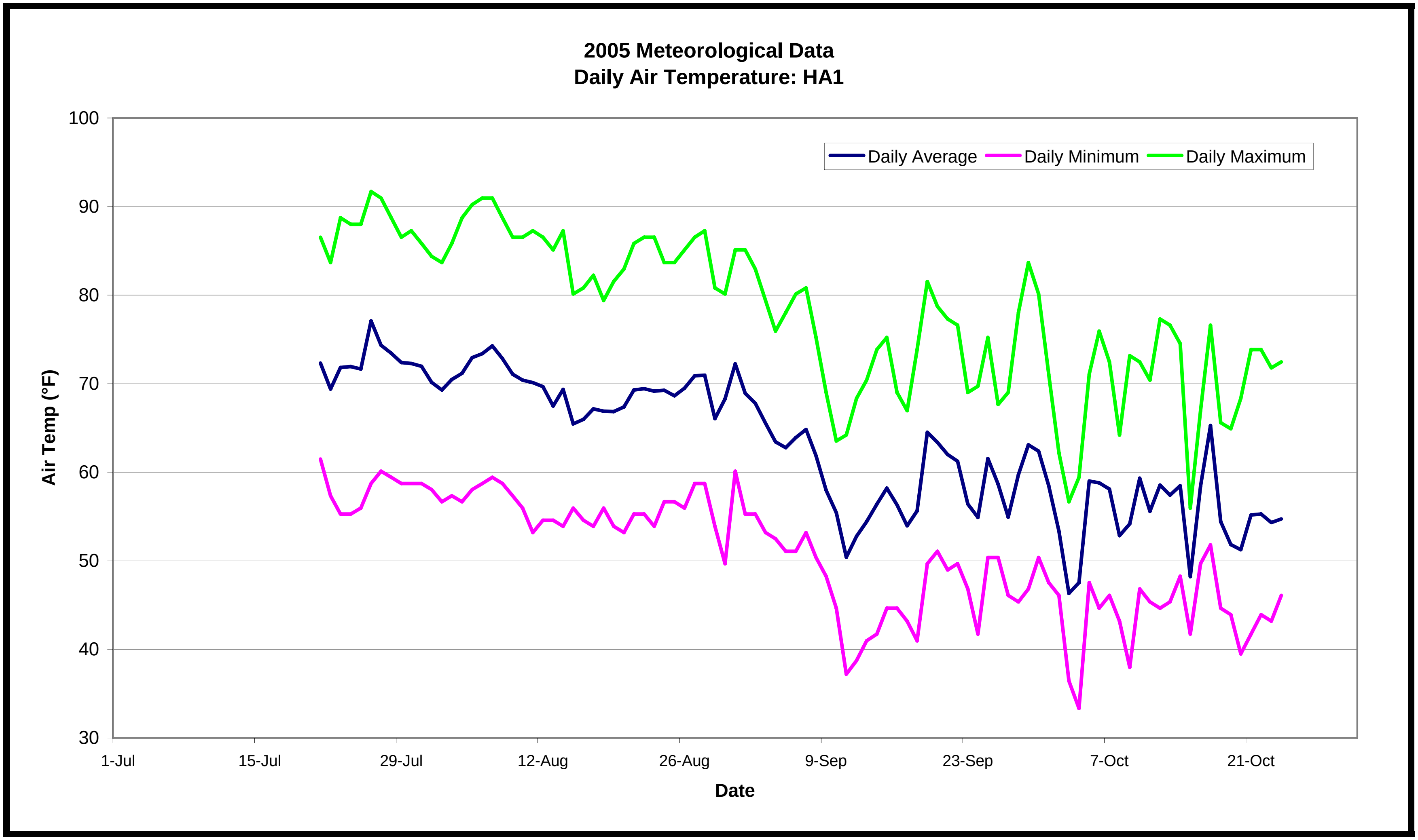



**Figure 53. The daily average, maximum, and minimum air temperatures (°F) at the Rubicon River near Hell Hole Dam collected during the summer and fall of 2005.**

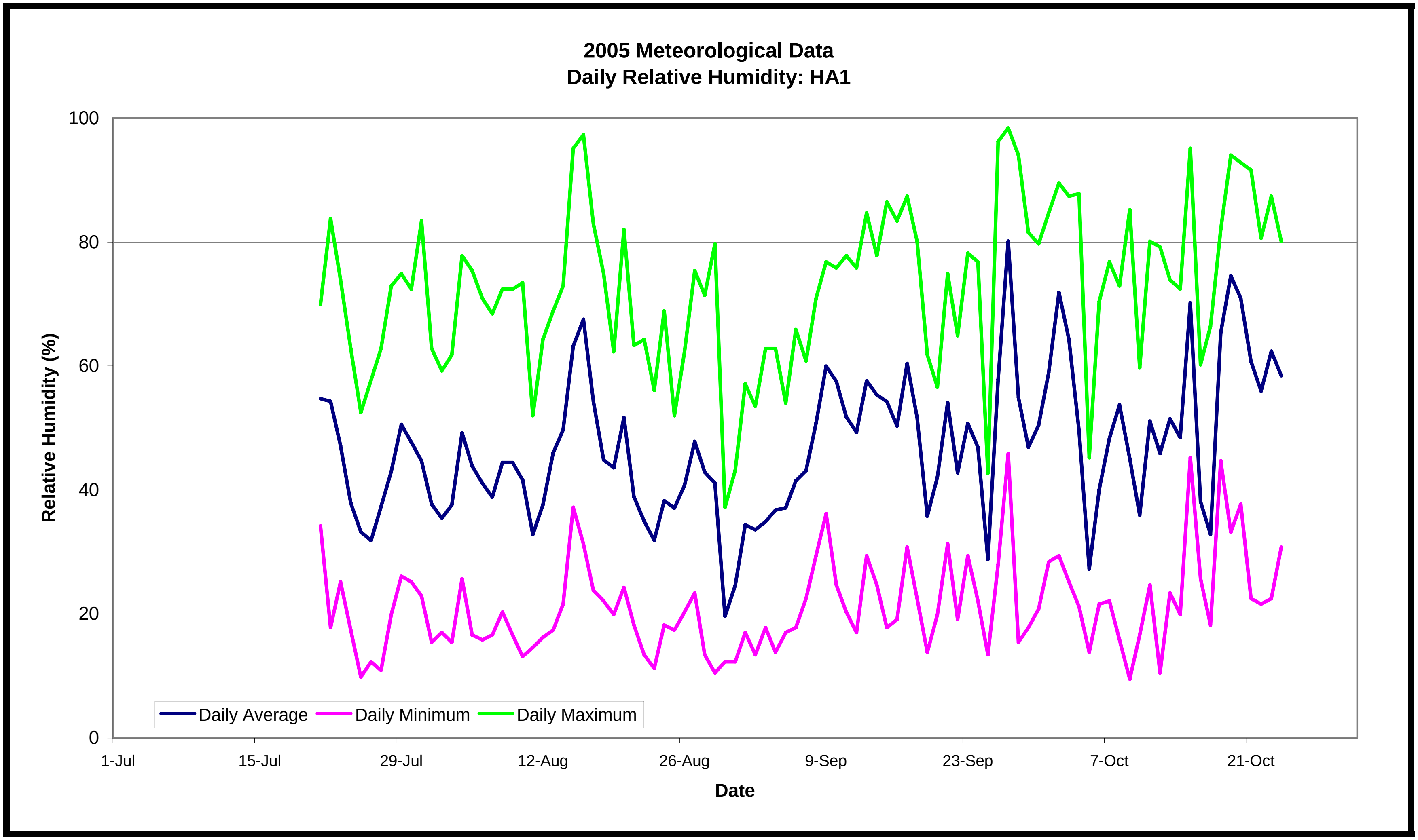



**Figure 54. The daily average, maximum, and minimum relative humidity (%) at the Rubicon River near Hell Hole Dam collected during the summer and fall of 2005.**

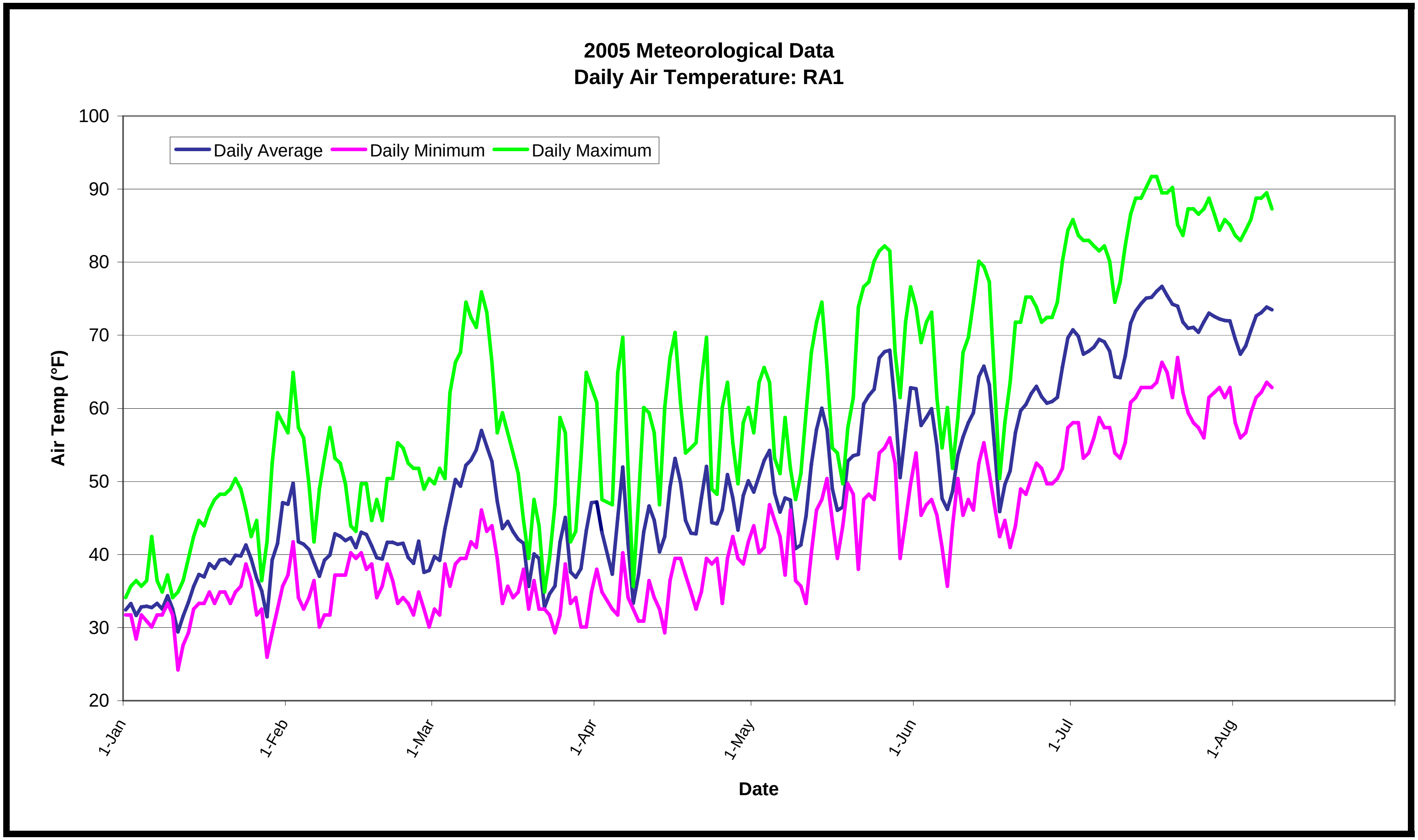



**Figure 55. The daily average, maximum, and minimum air temperatures (°F) at the Rubicon River near Ellicott Bridge collected from January through early August 2005.**

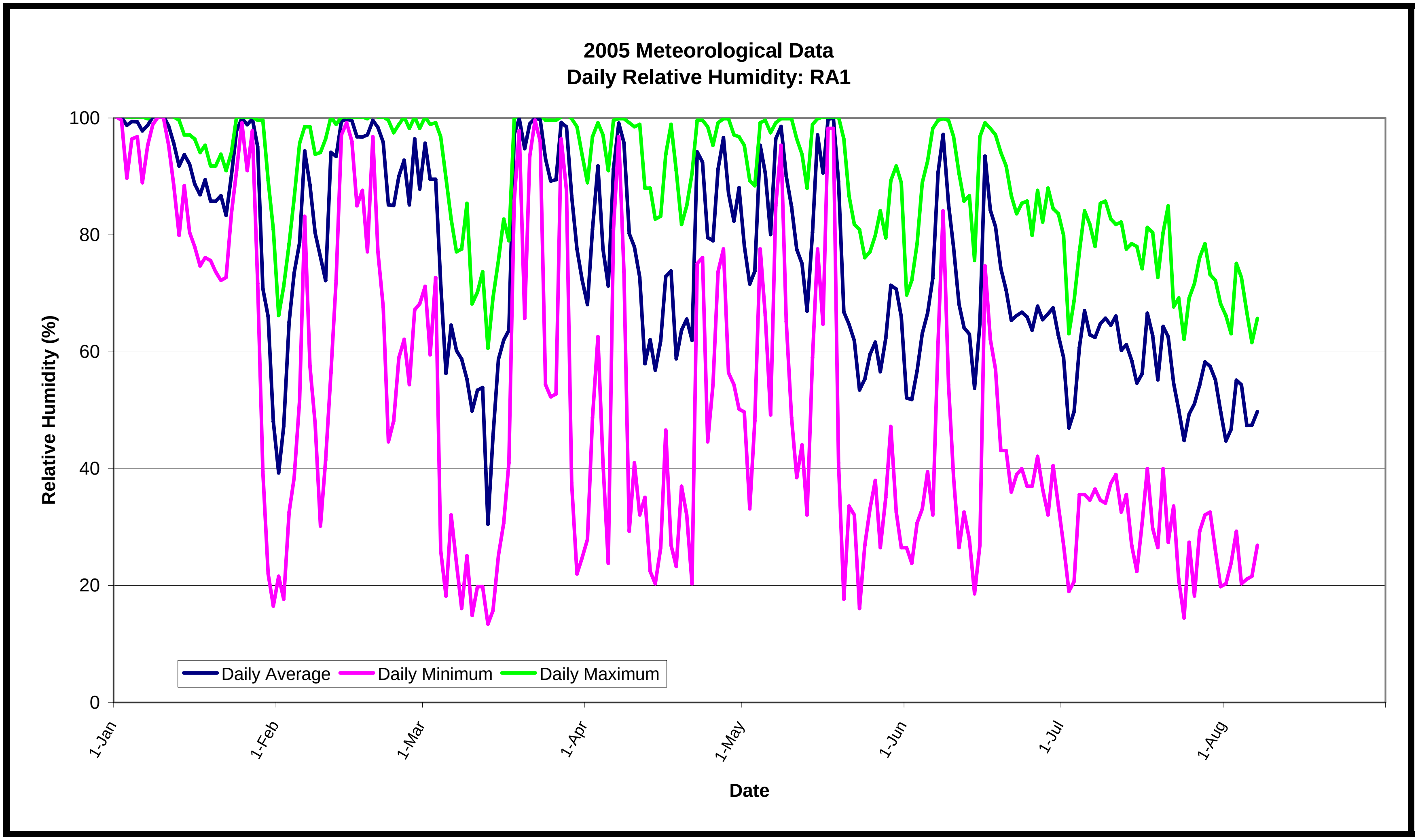



**Figure 56. The daily average, maximum, and minimum relative humidity (%) at the Rubicon River near Ellicott Bridge collected during January through early August 2005.**

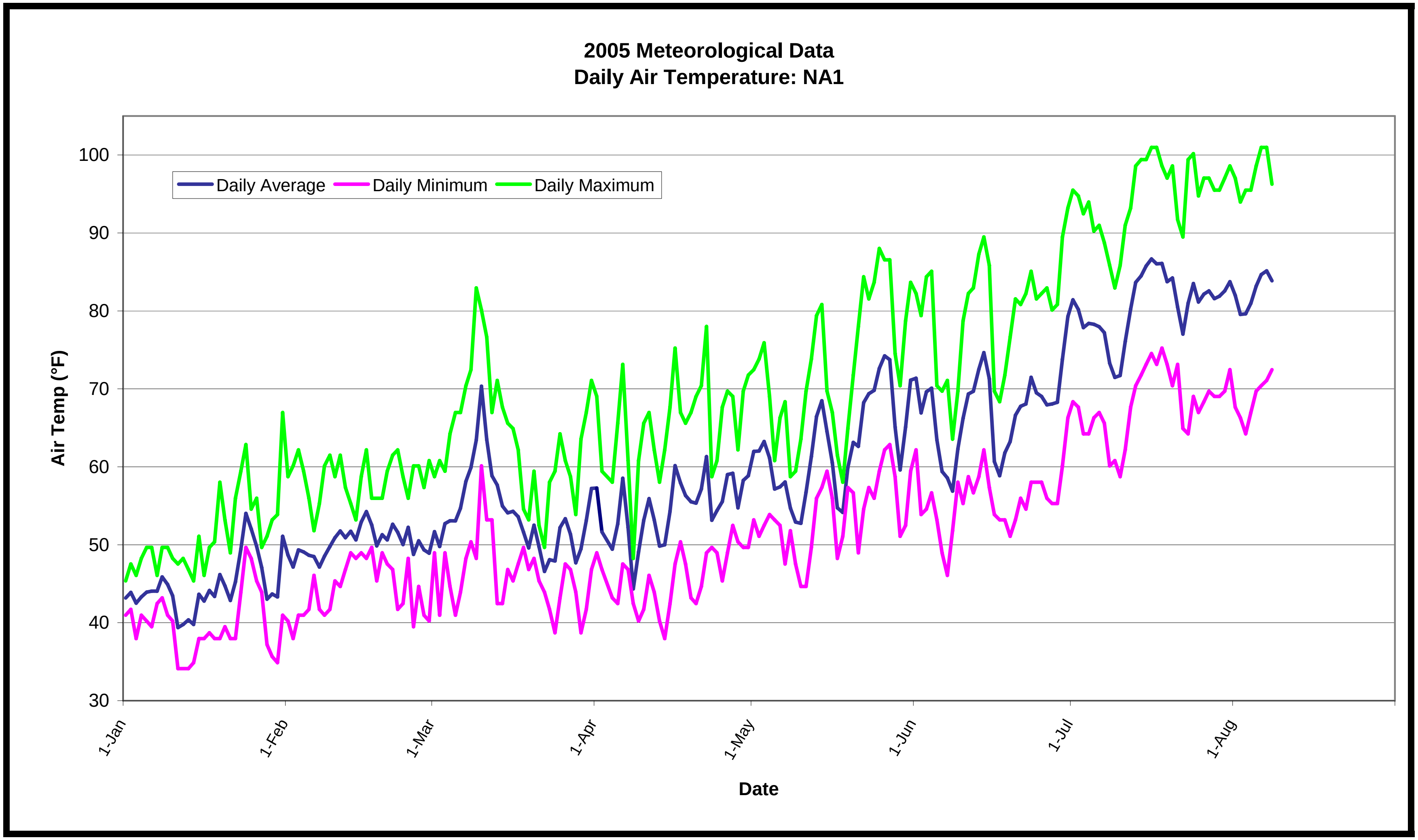



**Figure 57. The daily average, maximum, and minimum air temperatures (°F) at the North Fork American River near the confluence collected from January through early August 2005.**

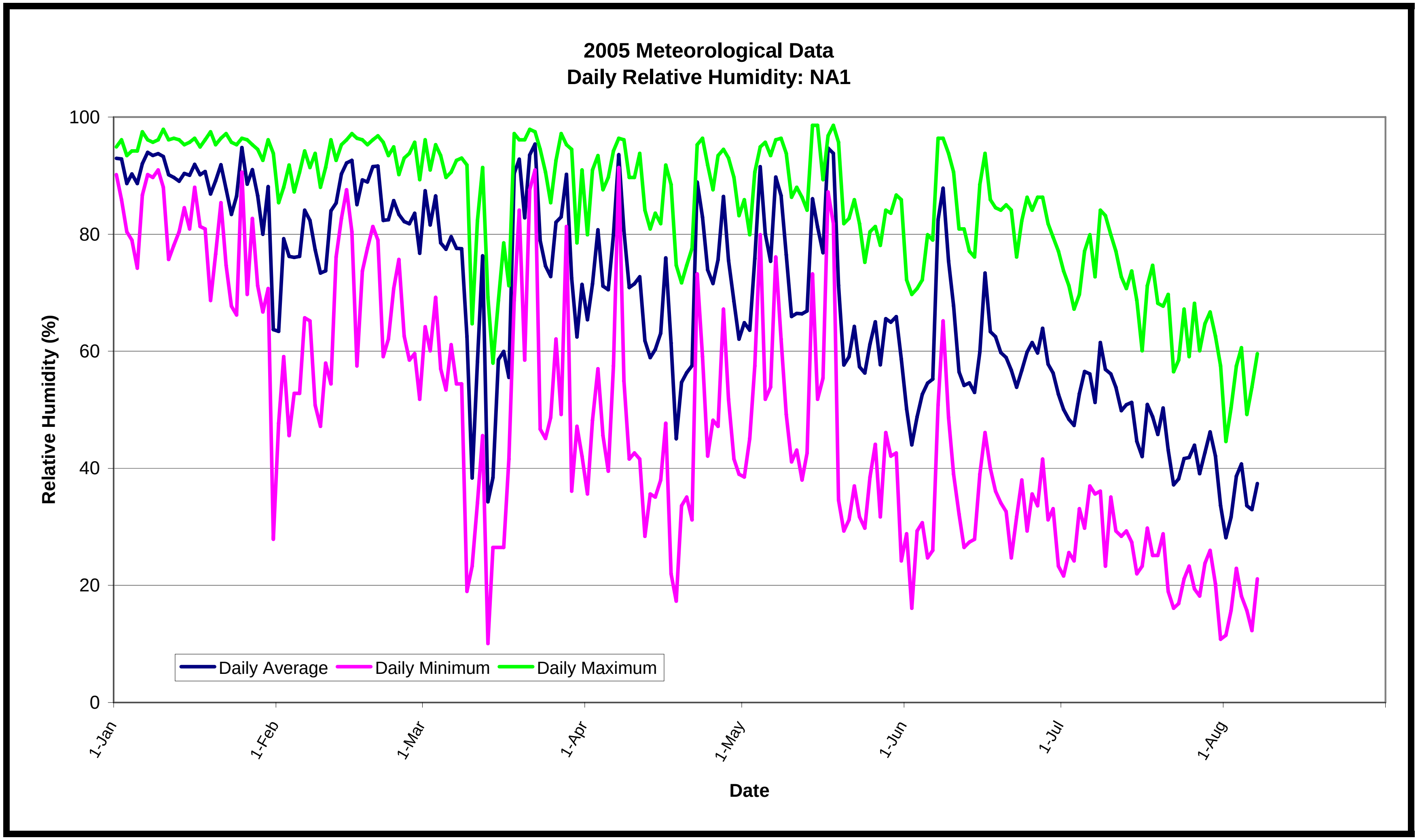



**Figure 58. The daily average, maximum, and minimum relative humidity (%) at the North Fork American River near the confluence collected from January through early August 2005.**

# APPENDIX A

## Plots of 2005 Daily Stream Water Temperature

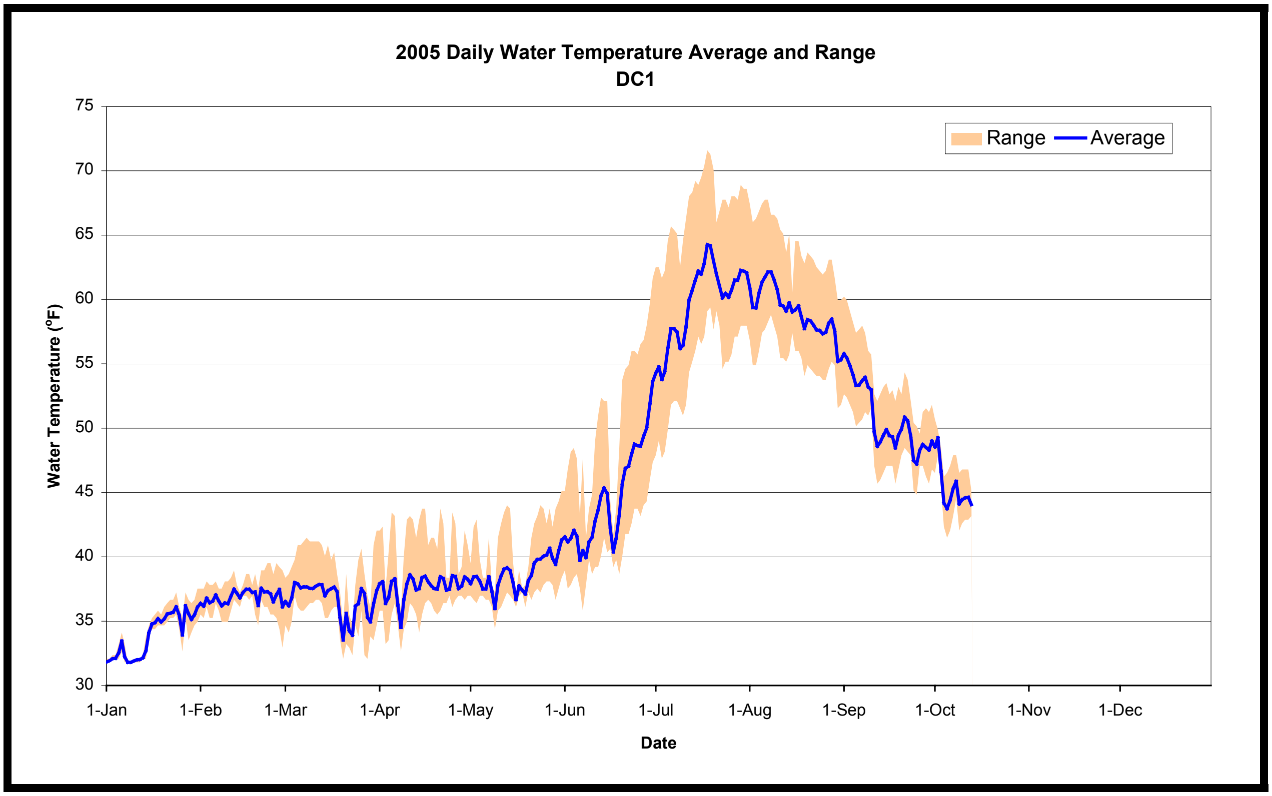



**Figure A- 1. The daily water temperature average and range measured at DC1 during 2005.**

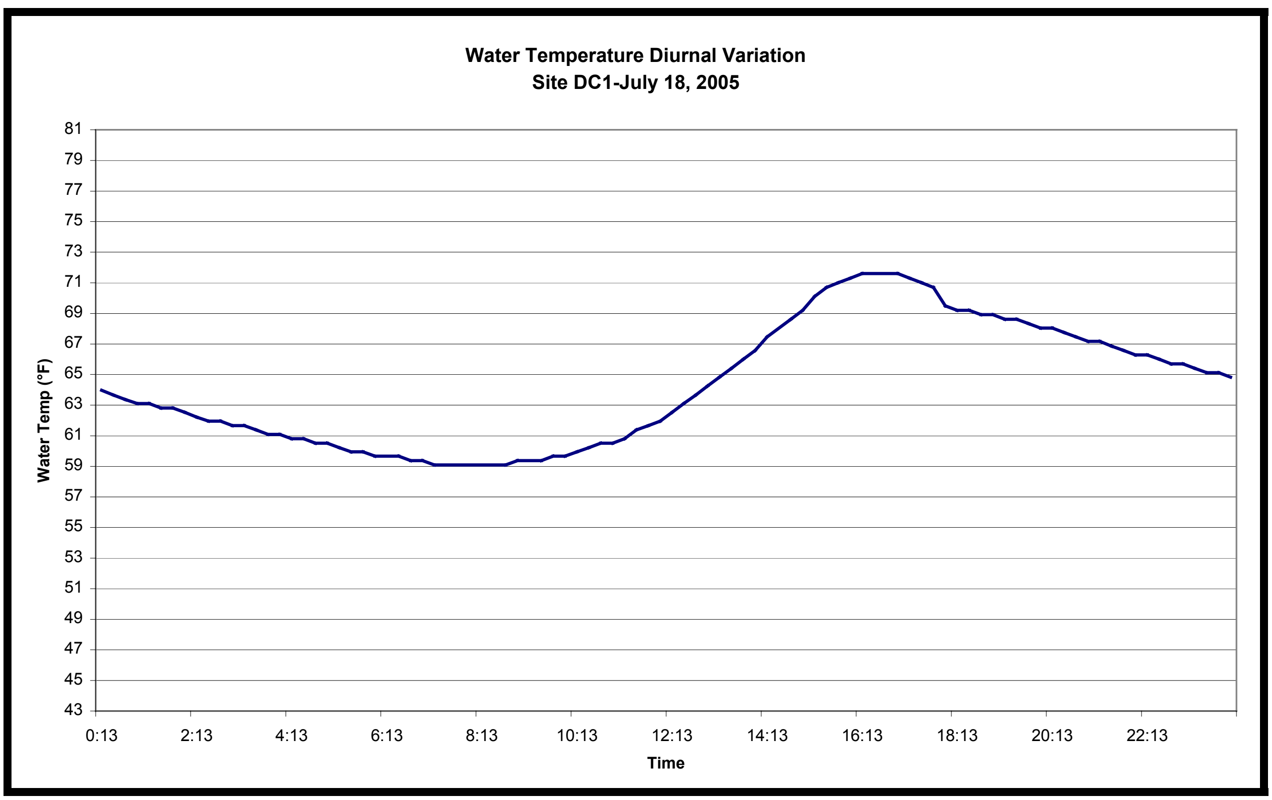



**Figure A- 2. The 15-minute interval water temperature data observed at DC1 during a particularly warm day in July to illustrate diurnal variation.**

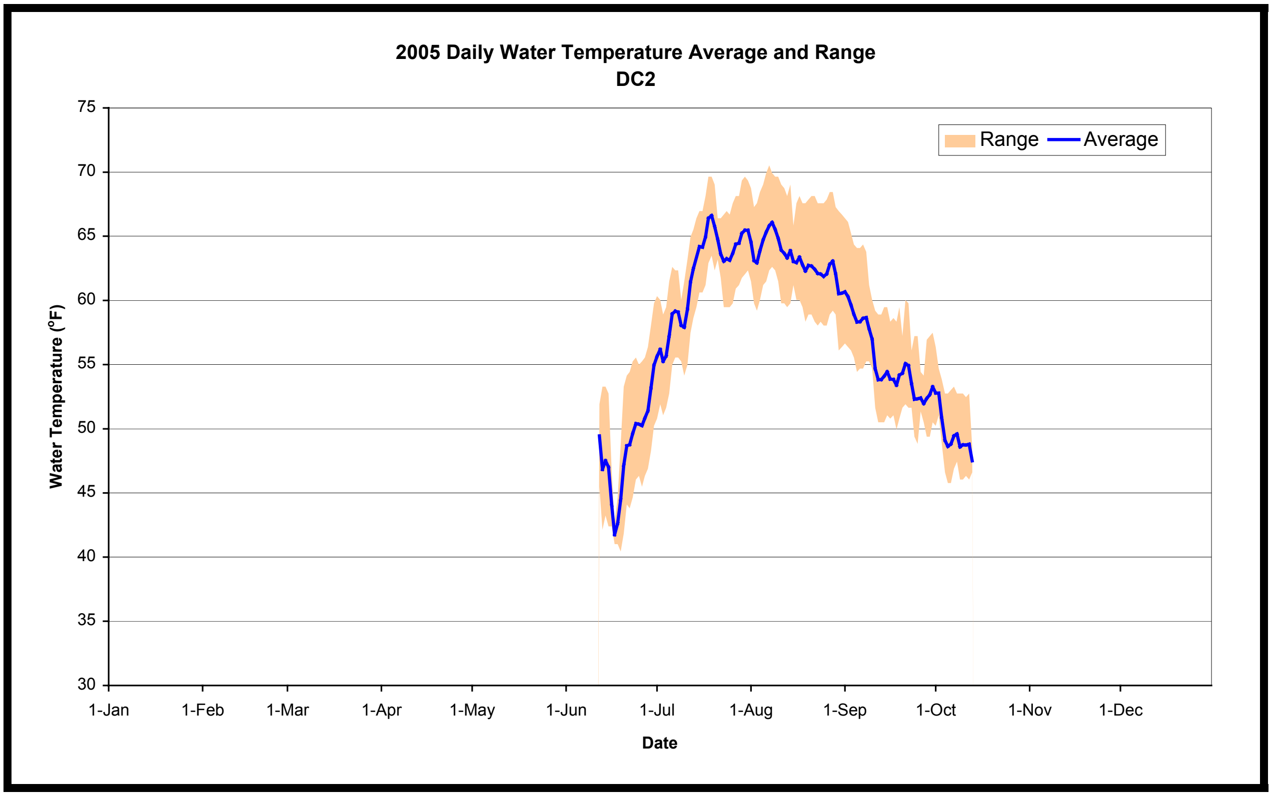



**Figure A- 3. The daily water temperature average and range measured at DC2 during 2005.**

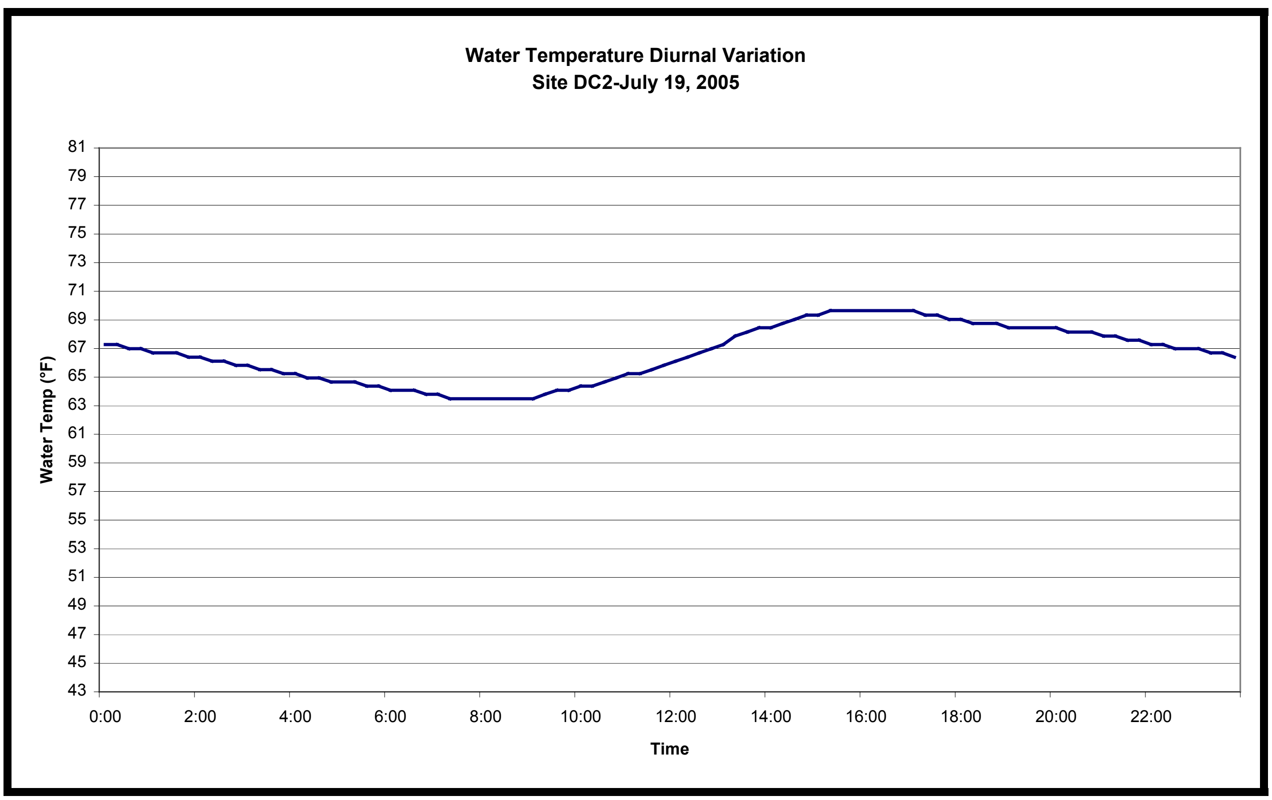



**Figure A- 4. The 15-minute interval water temperature data observed at DC2 during a particularly warm day in July to illustrate diurnal variation.**

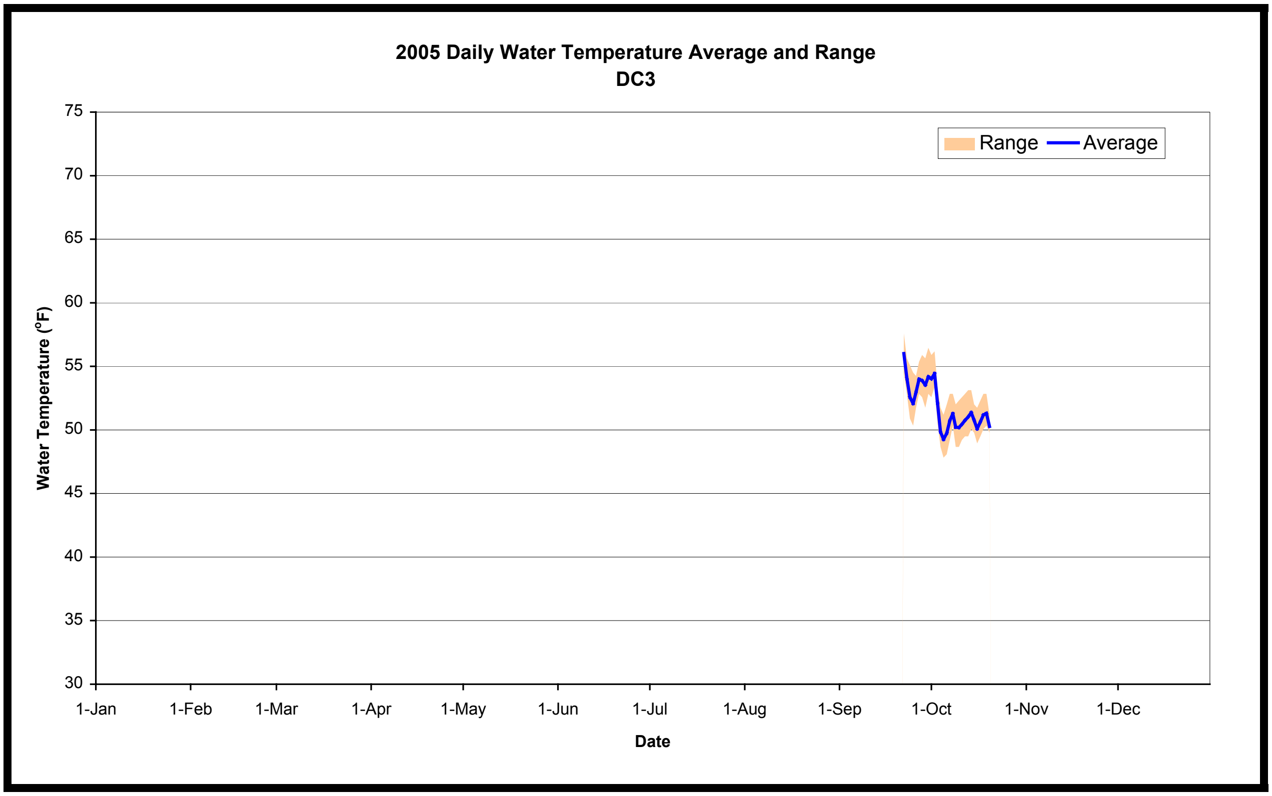



**Figure A- 5. The daily water temperature average and range measured at DC3 during 2005.**

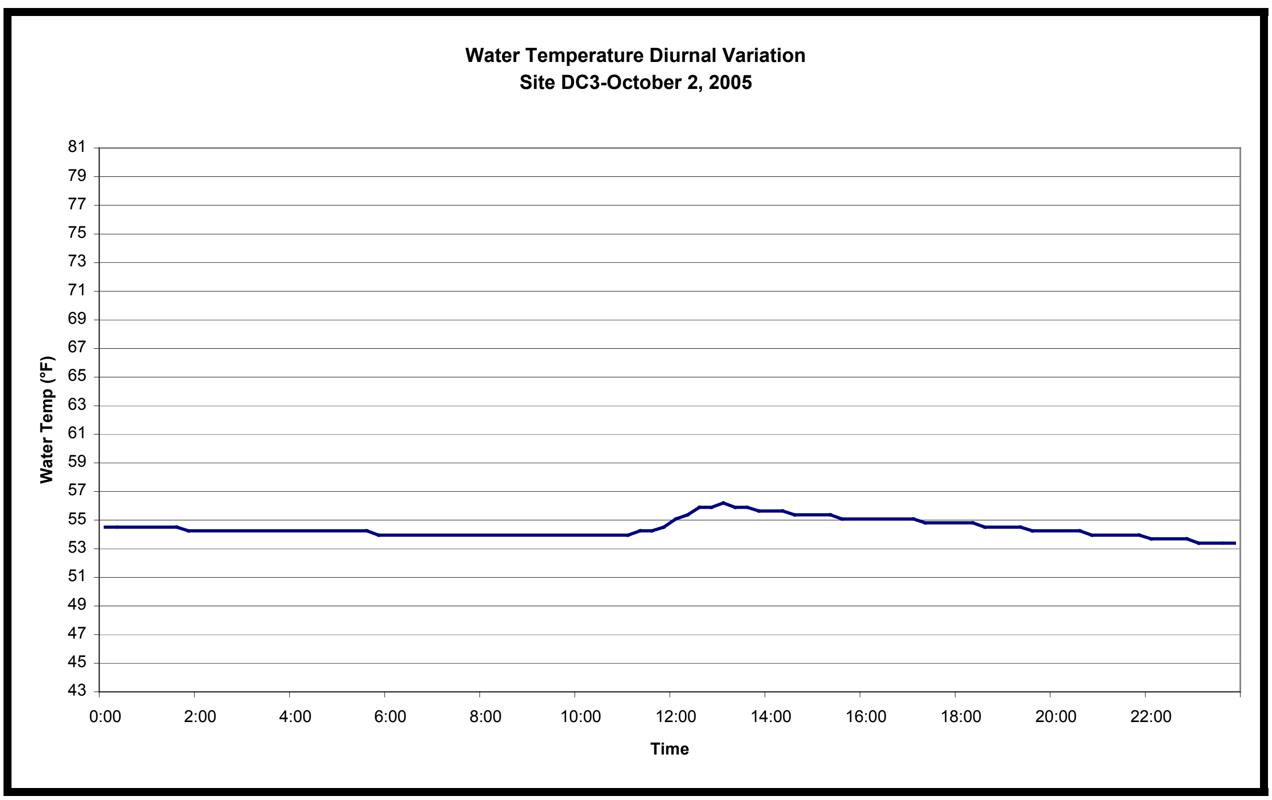



**Figure A- 6. The 15-minute interval water temperature data observed at DC3 during a particularly warm day in October to illustrate diurnal variation.**

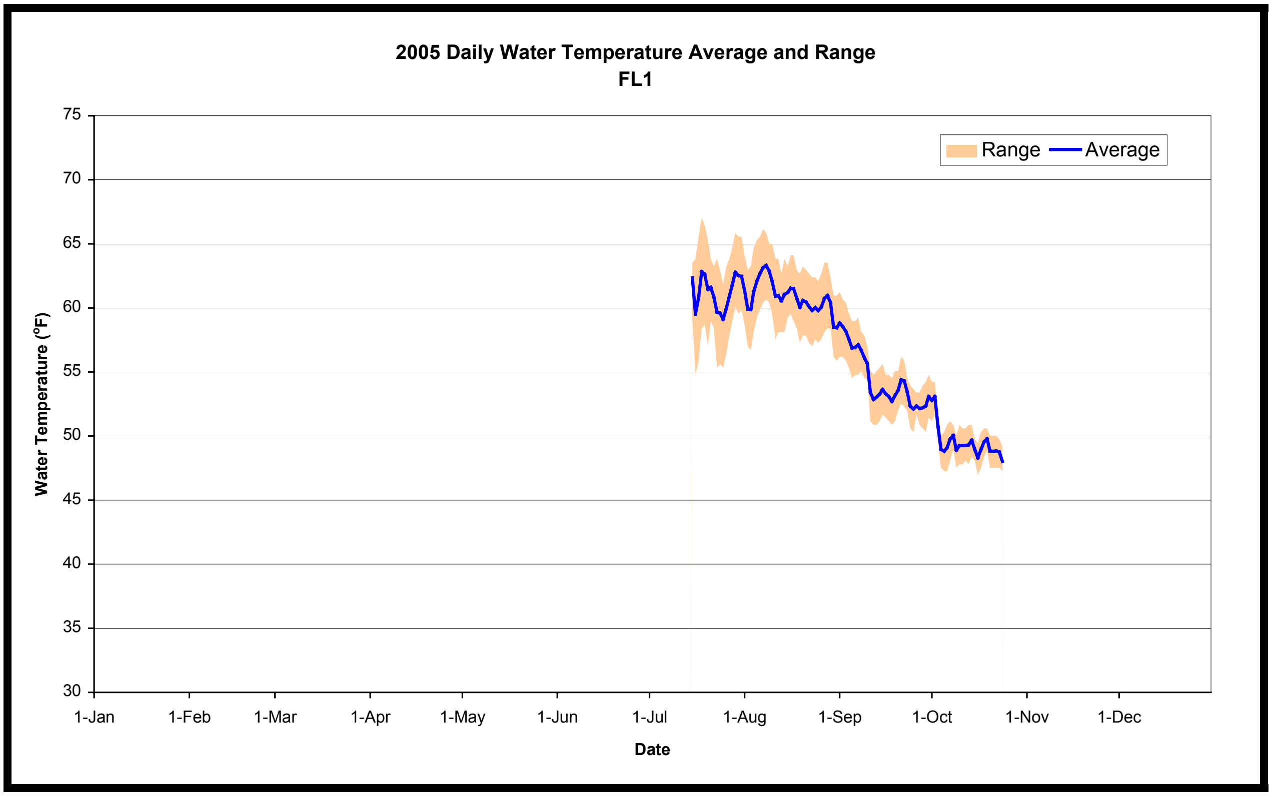



**Figure A- 7. The daily water temperature average and range measured at FL1 during 2005.**

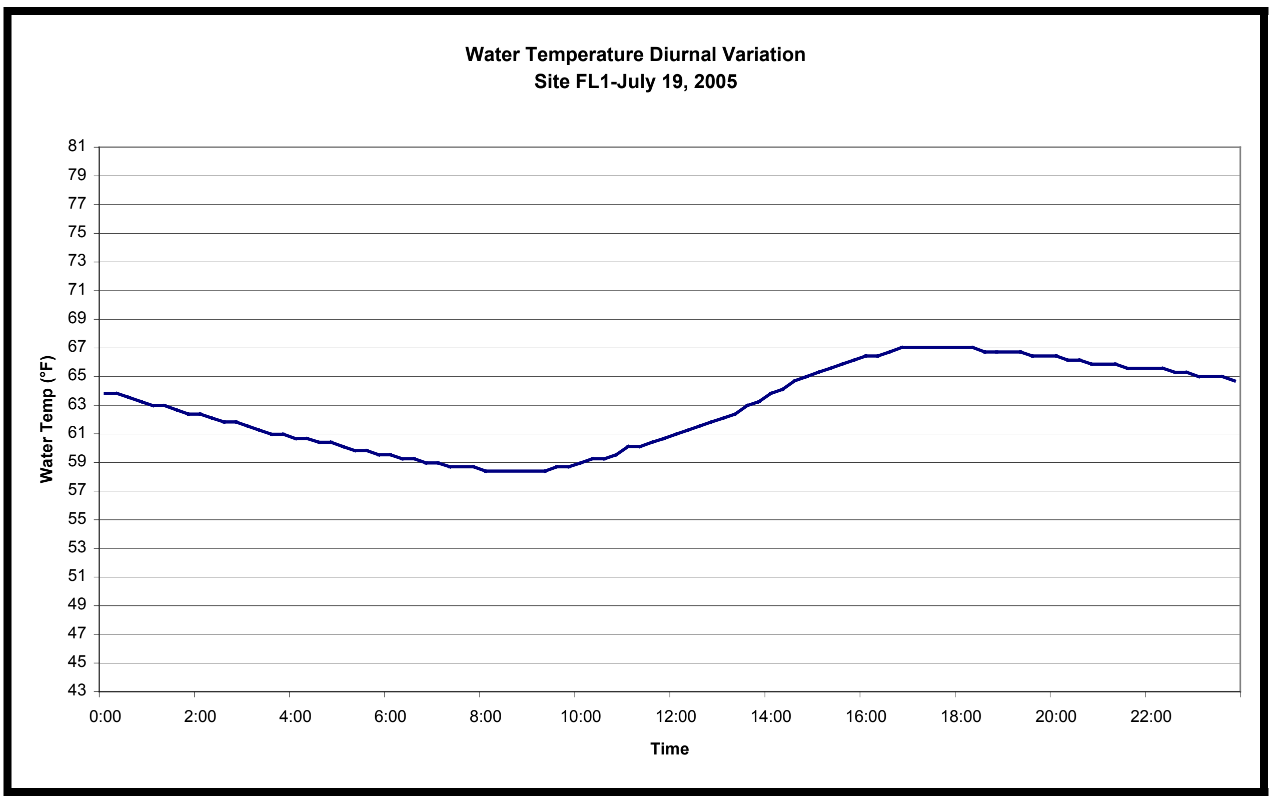



**Figure A- 8. The 15-minute interval water temperature data observed at FL1 during a particularly warm day in July to illustrate diurnal variation.**

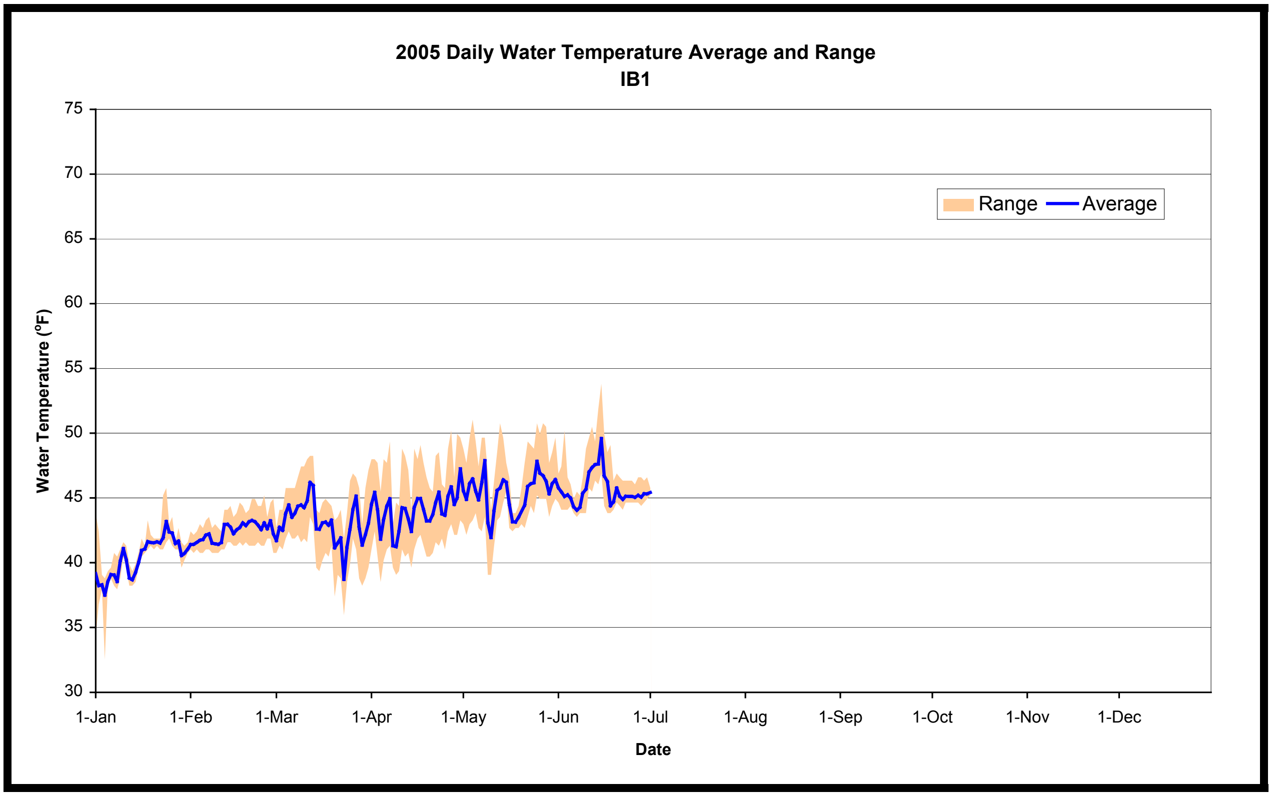



**Figure A- 9. The daily water temperature average and range measured at IB1 during 2005.**

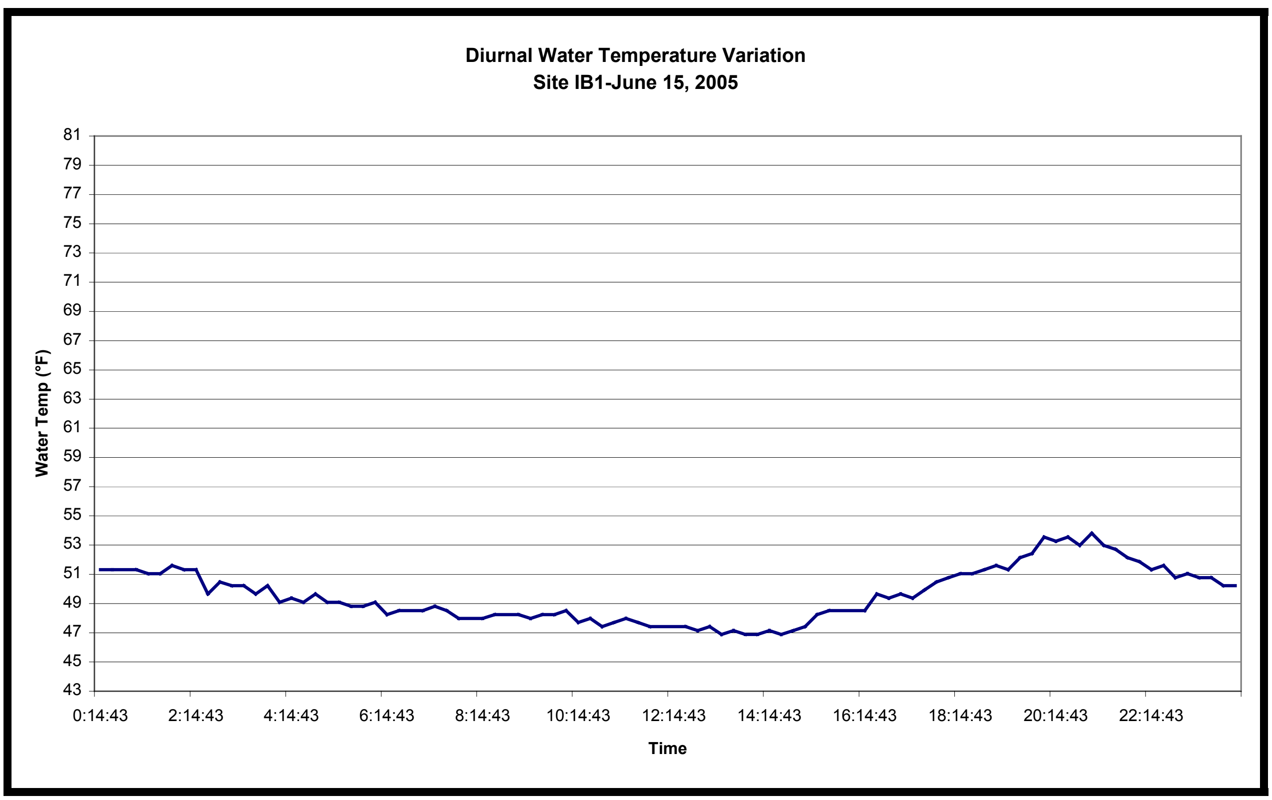



**Figure A- 10. The 15-minute interval water temperature data observed at IB1 during a particularly warm day in June to illustrate diurnal variation.**

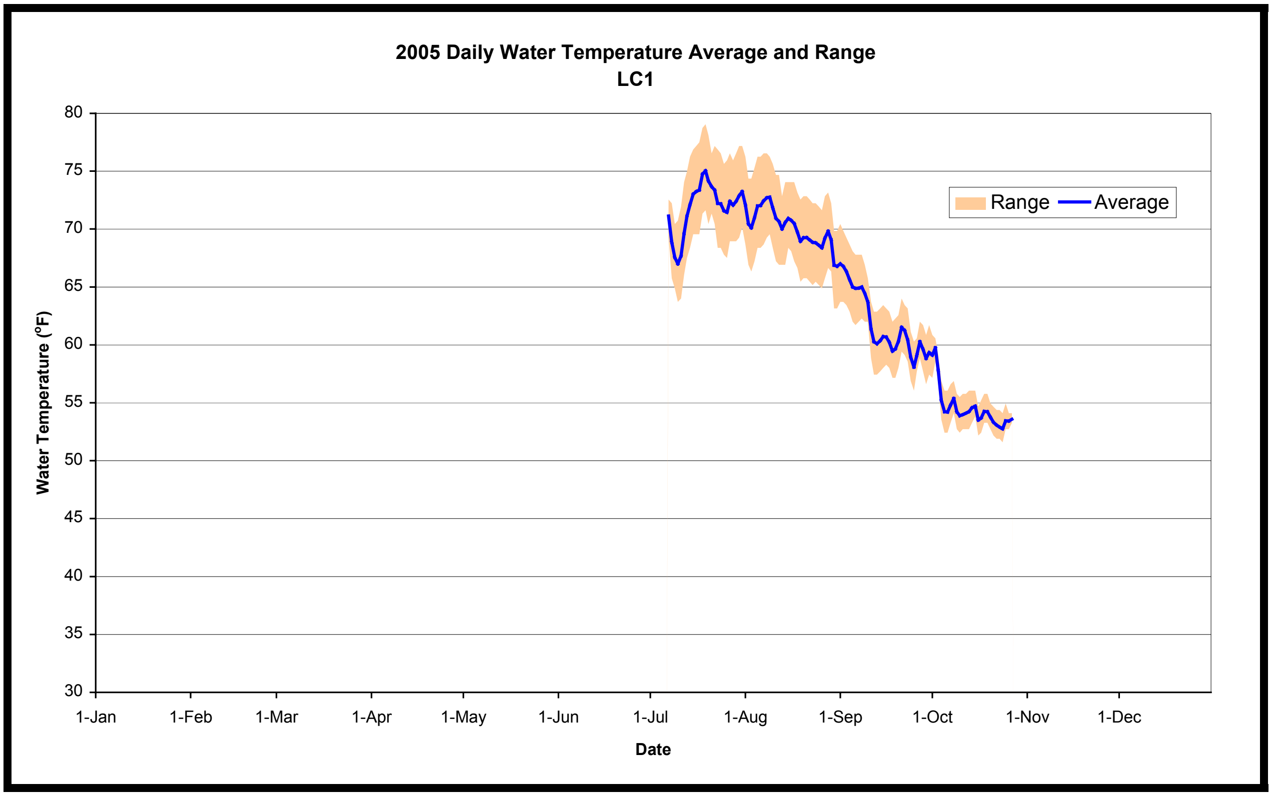



**Figure A- 11. The daily water temperature average and range measured at LC1 during 2005.**

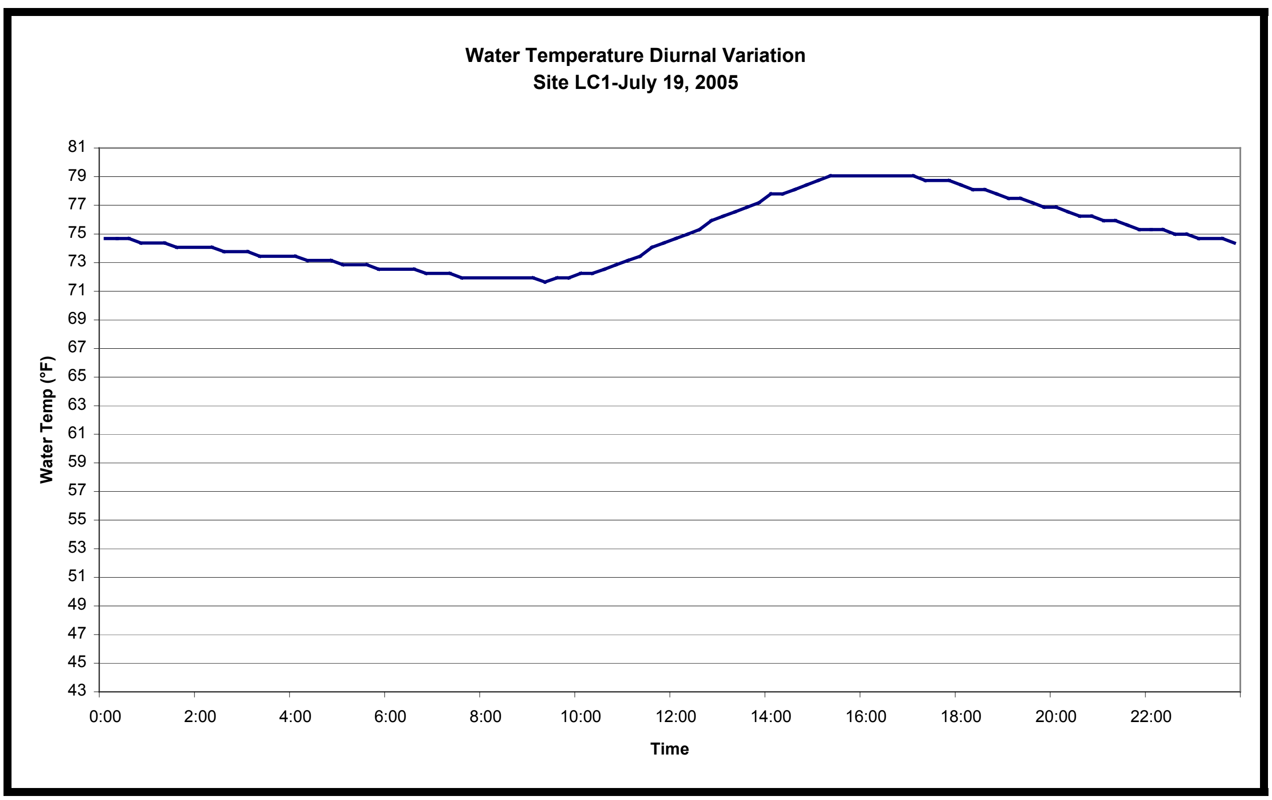



**Figure A- 12. The 15-minute interval water temperature data observed at LC1 during a particularly warm day in July to illustrate diurnal variation.**

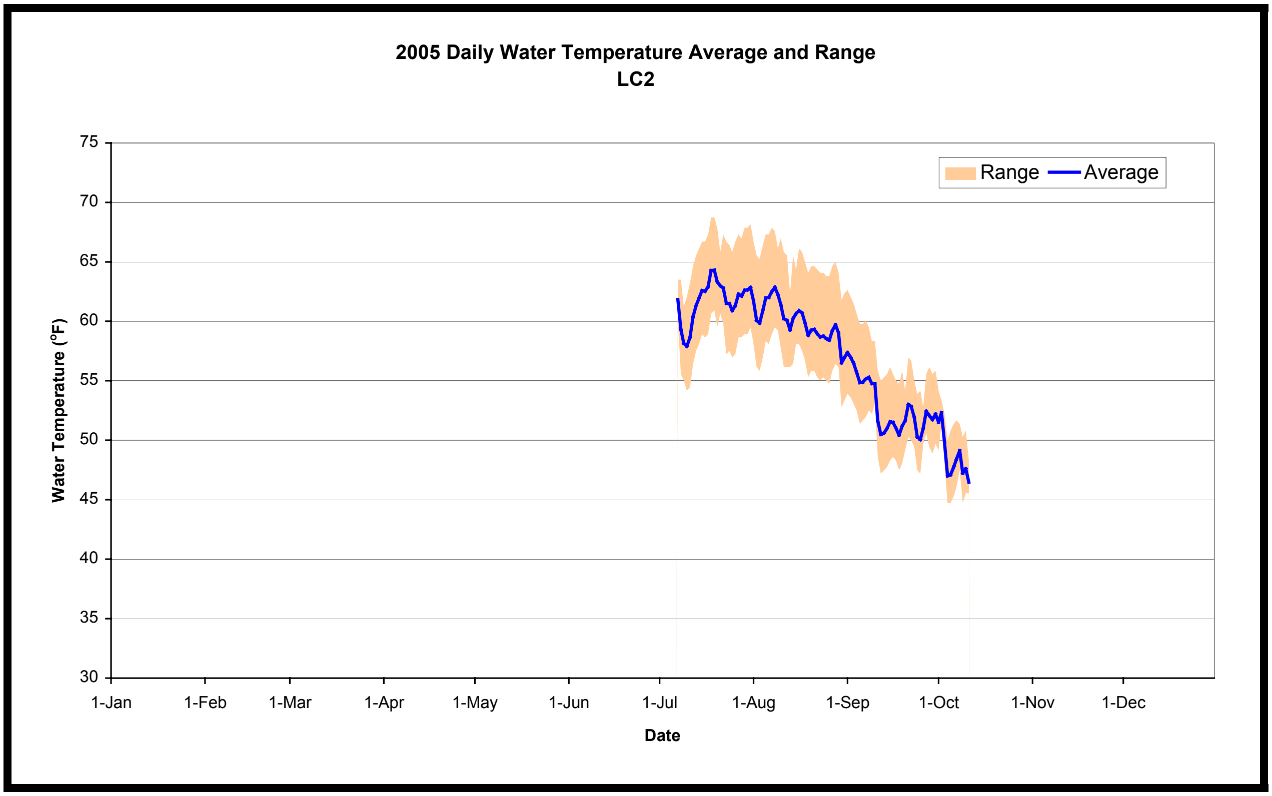



**Figure A- 13. The daily water temperature average and range measured at LC2 during 2005.**

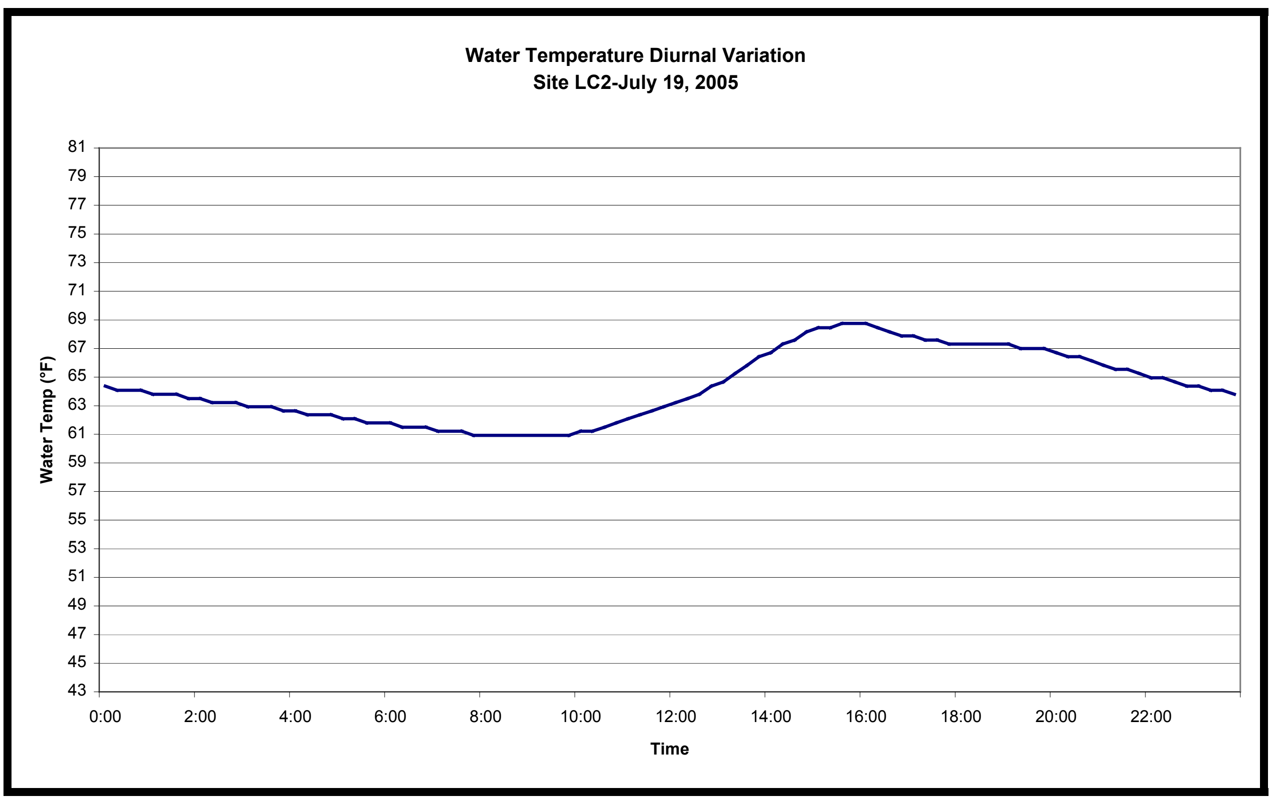



**Figure A- 14. The 15-minute interval water temperature data observed at LC2 during a particularly warm day in July to illustrate diurnal variation.**

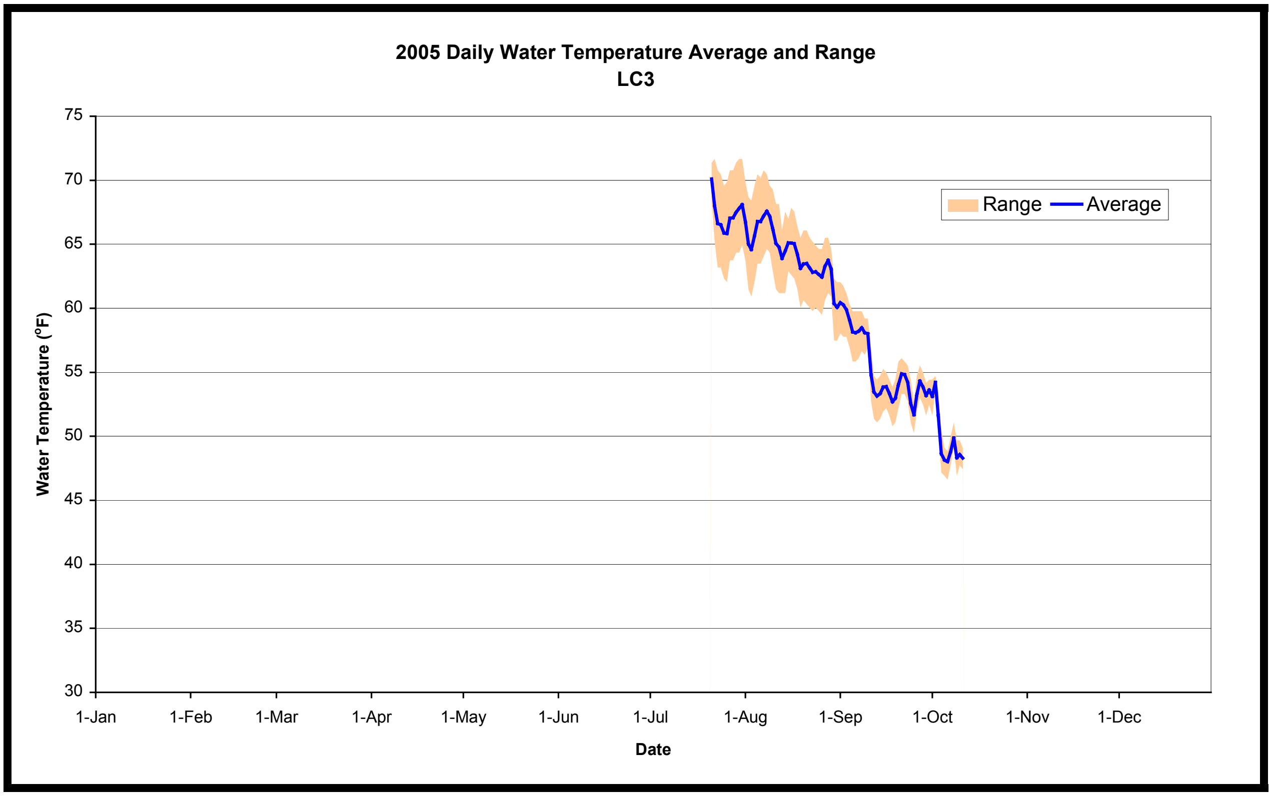



**Figure A- 15. The daily water temperature average and range measured at LC3 during 2005.**

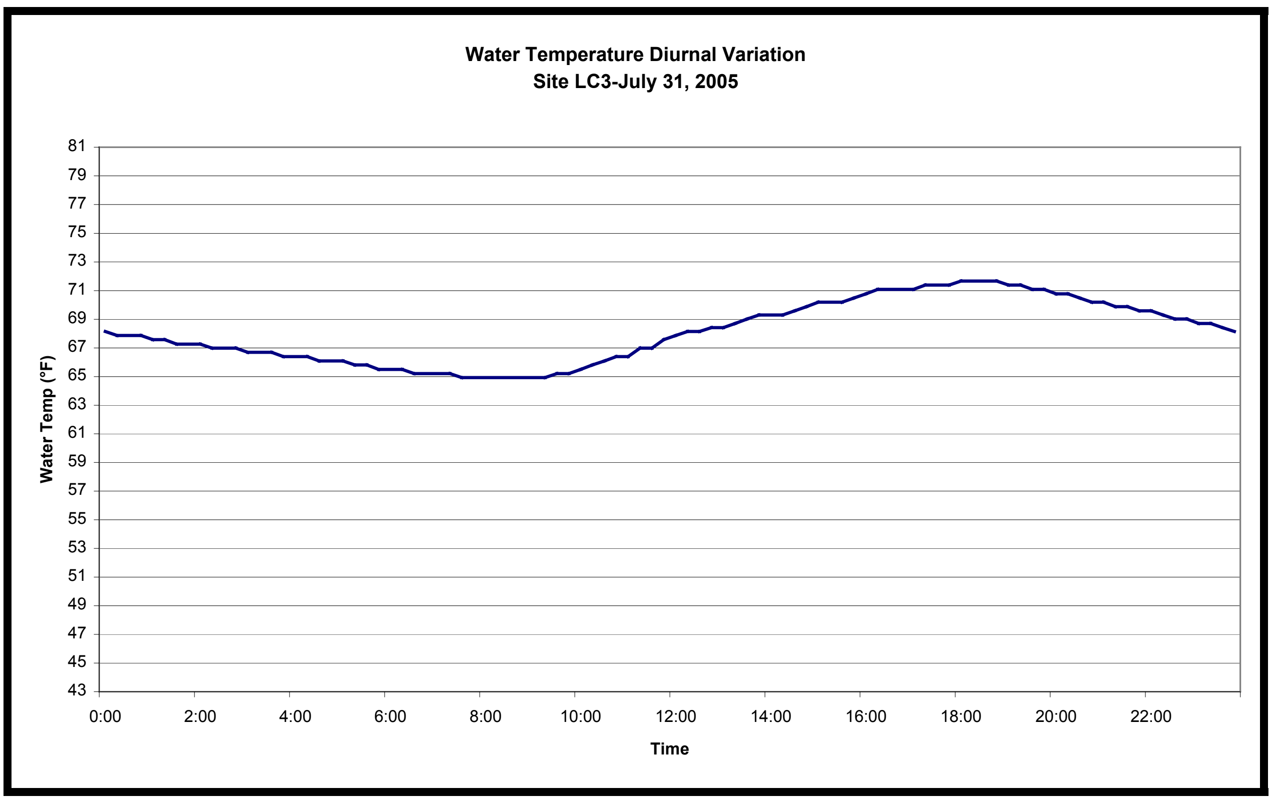



**Figure A- 16. The 15-minute interval water temperature data observed at LC3 during a particularly warm day in July to illustrate diurnal.**

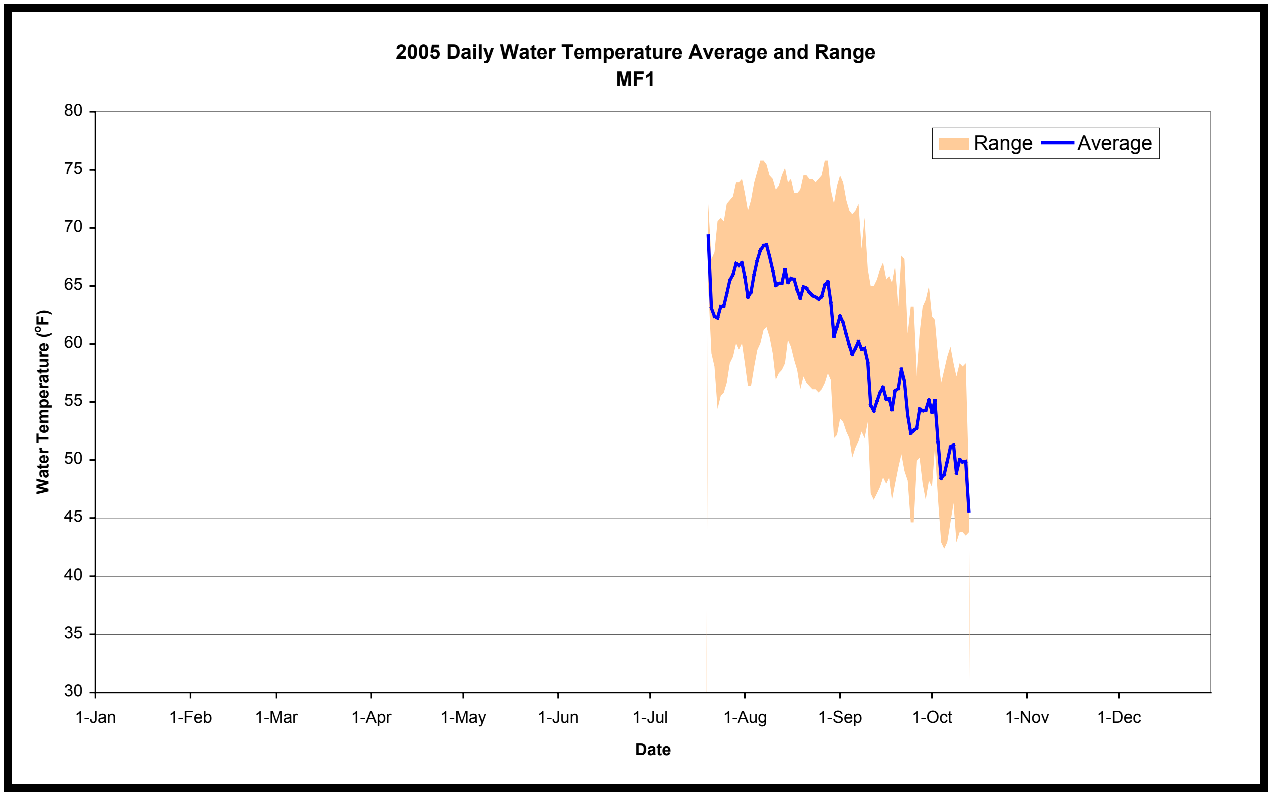



**Figure A- 17. The daily water temperature average and range measured at MF1 during 2005.**

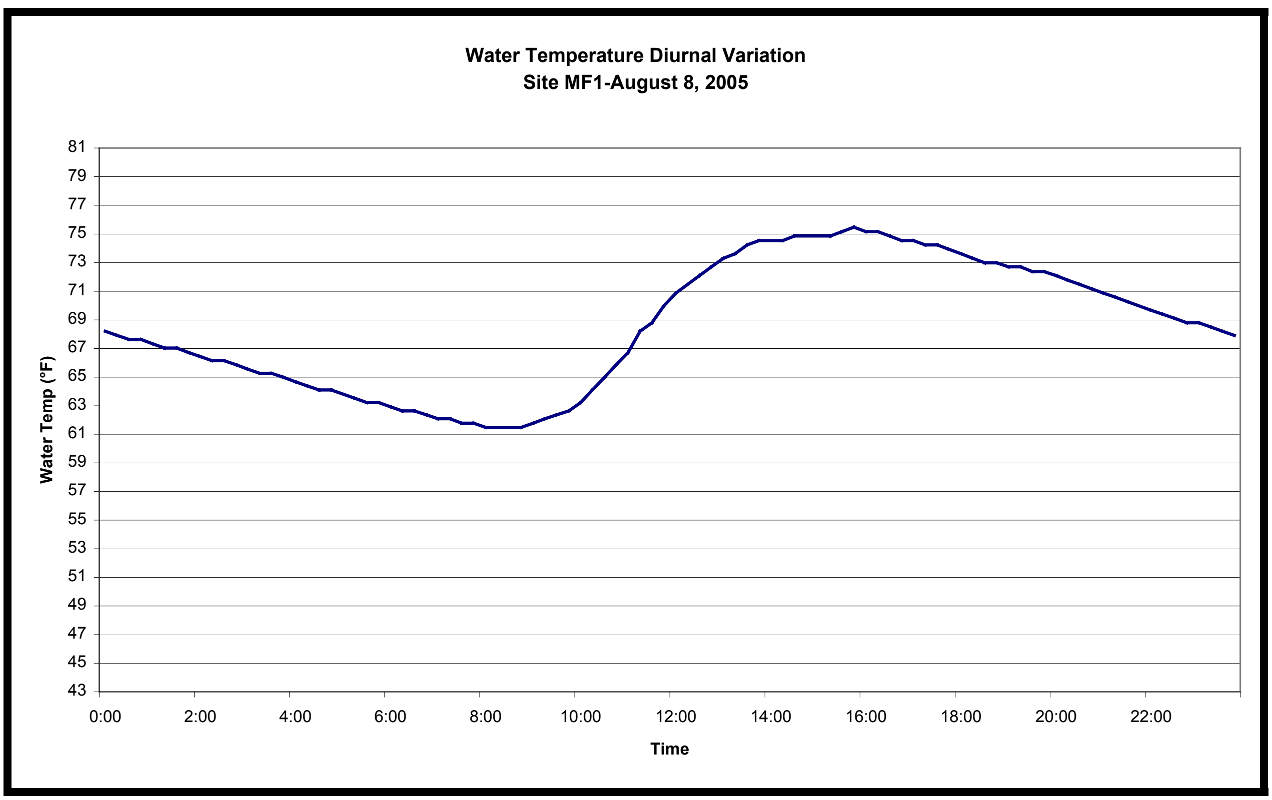



**Figure A- 18. The 15-minute interval water temperature data observed at MF1 during a particularly warm day in August to illustrate diurnal variation.**

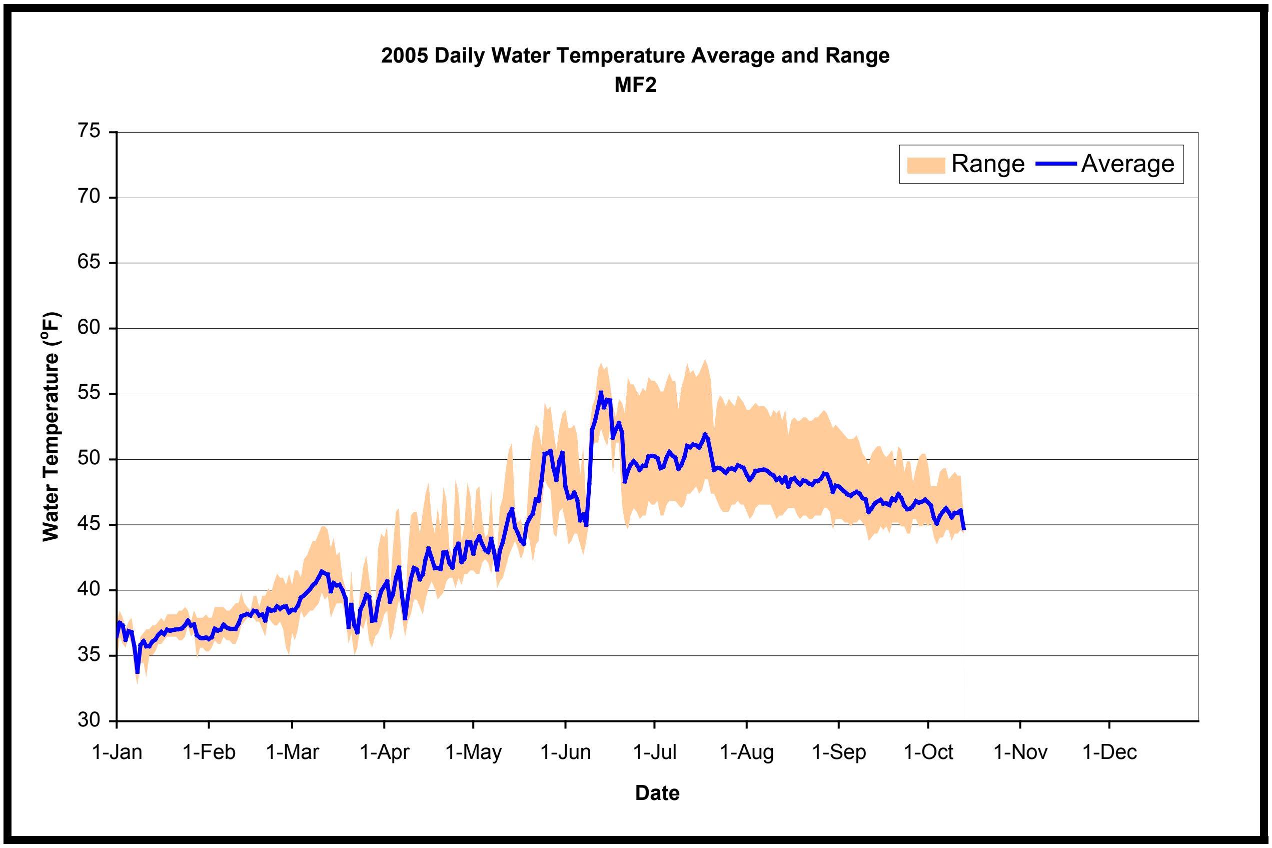



**Figure A- 19. The daily water temperature average and range measured at MF2 during 2005.**

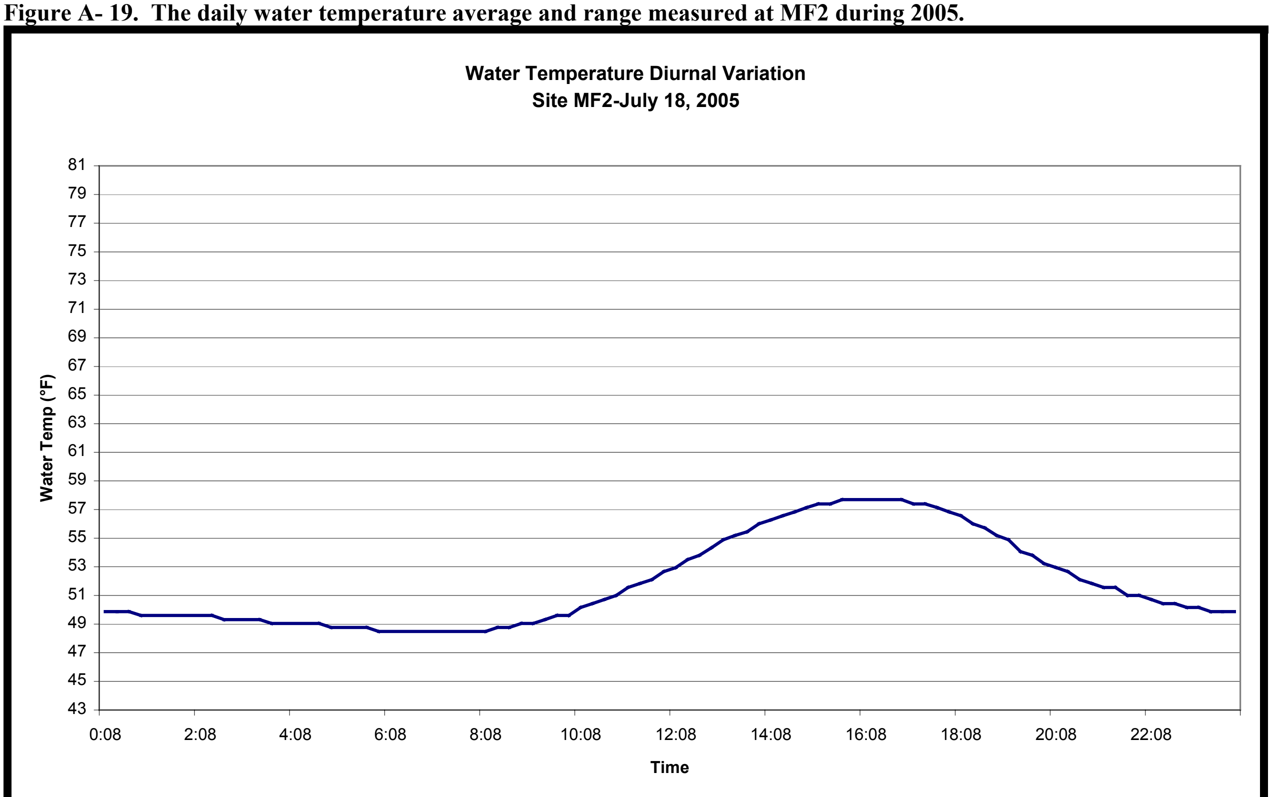



**Figure A- 20. The 15-minute interval water temperature data observed at MF2 during a particularly warm day in July to illustrate diurnal variation.**

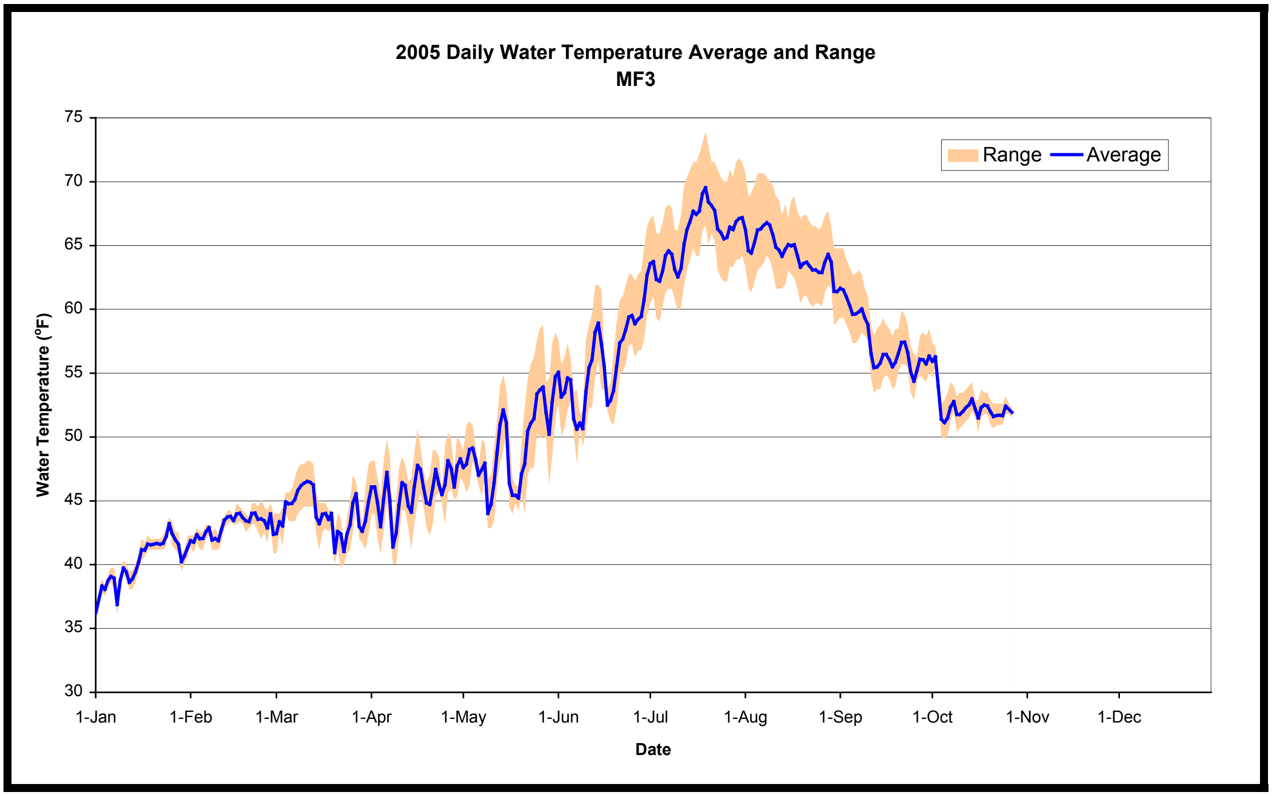



**Figure A- 21. The daily water temperature average and range measured at MF3 during 2005.**

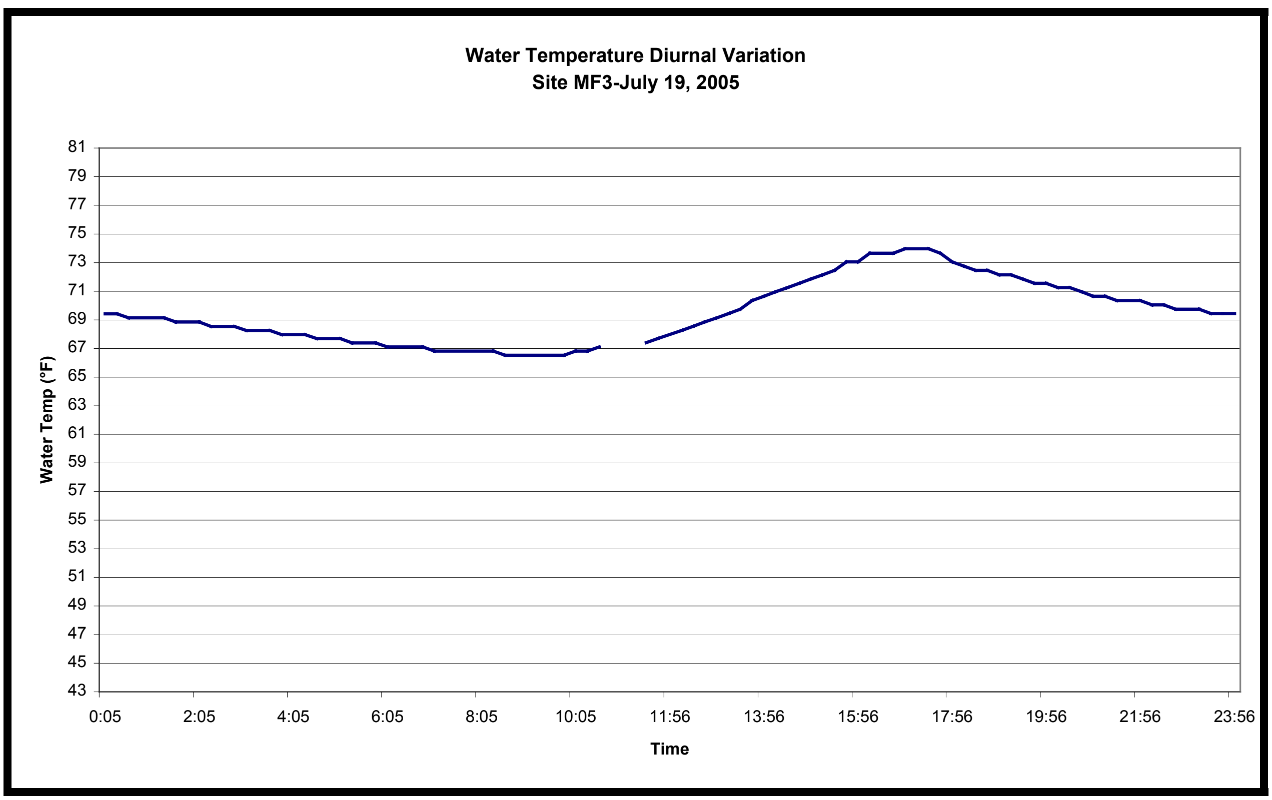



**Figure A- 22. The 15-minute interval water temperature data observed at MF3 during a particularly warm day in July to illustrate diurnal variation.**

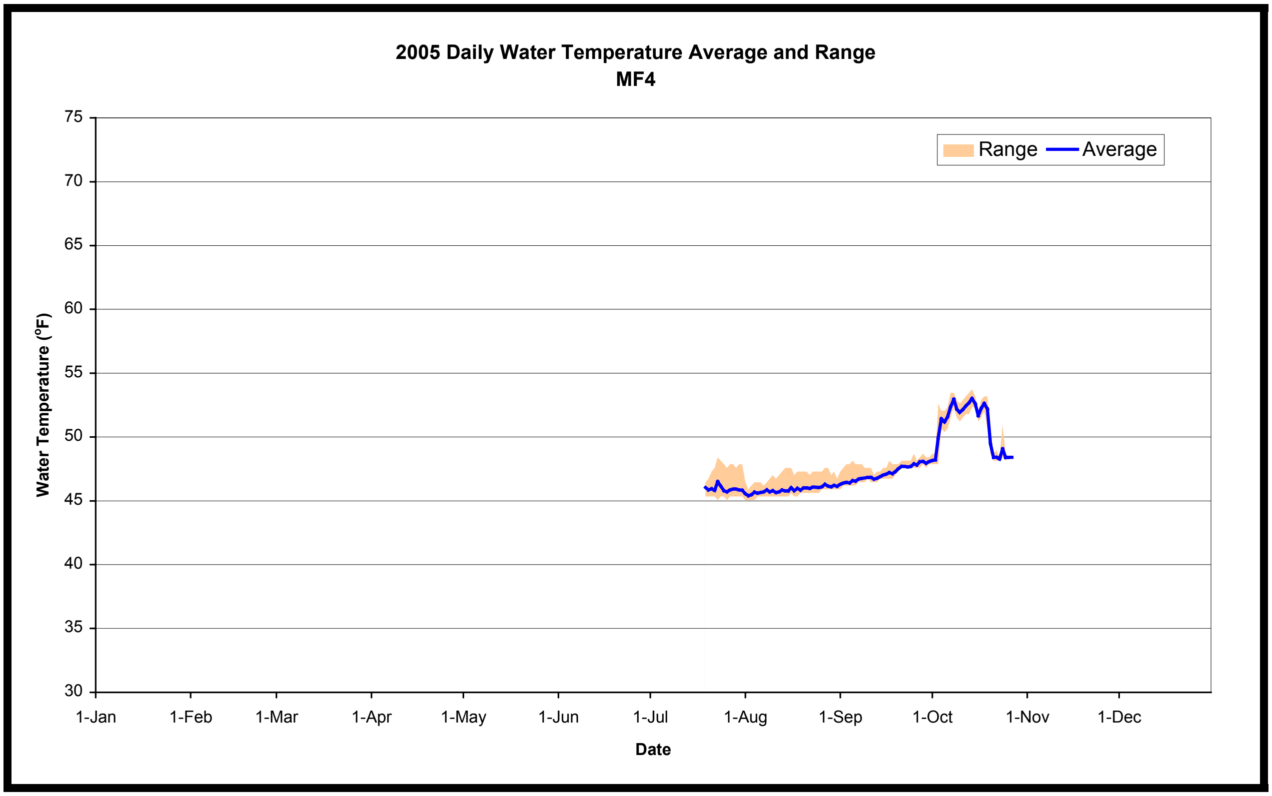



**Figure A- 23. The daily water temperature average and range measured at MF4 during 2005.**

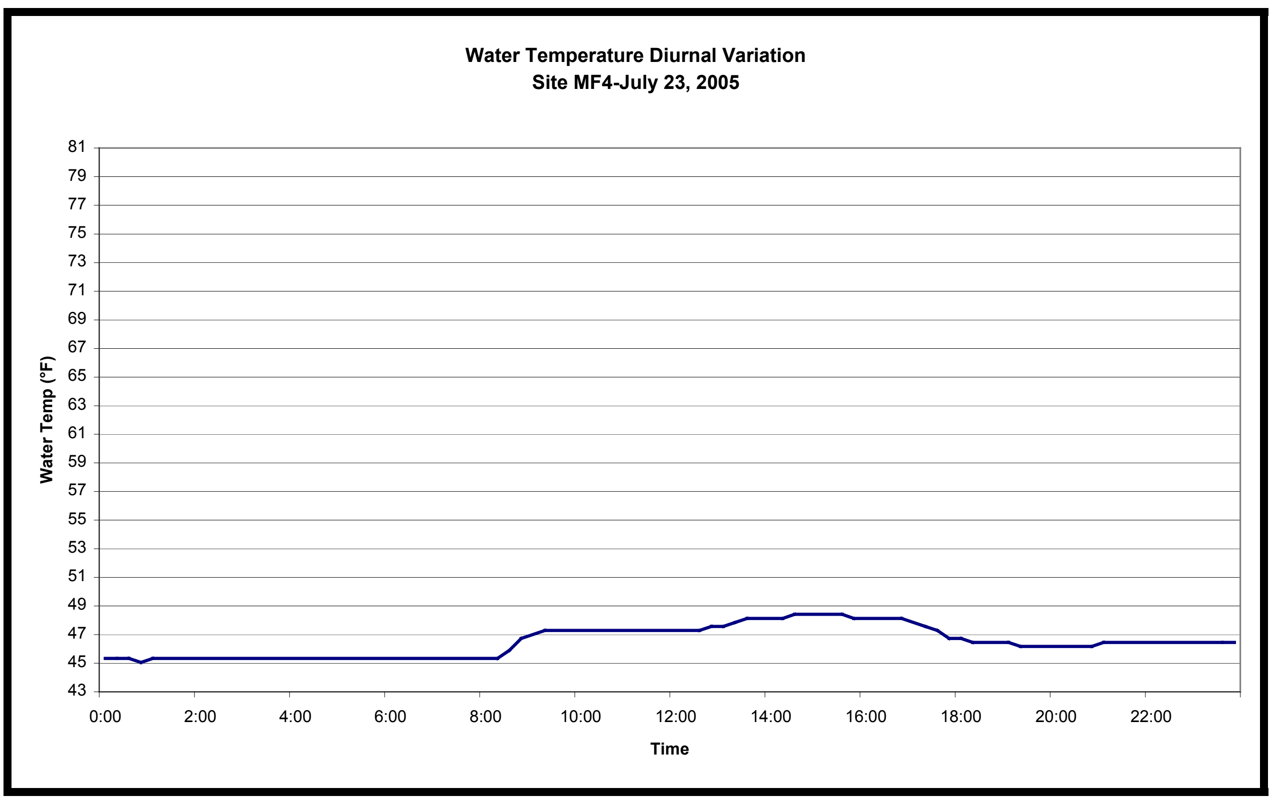



**Figure A- 24. The 15-minute interval water temperature data observed at MF4 during a particularly warm day in July to illustrate diurnal variation.**

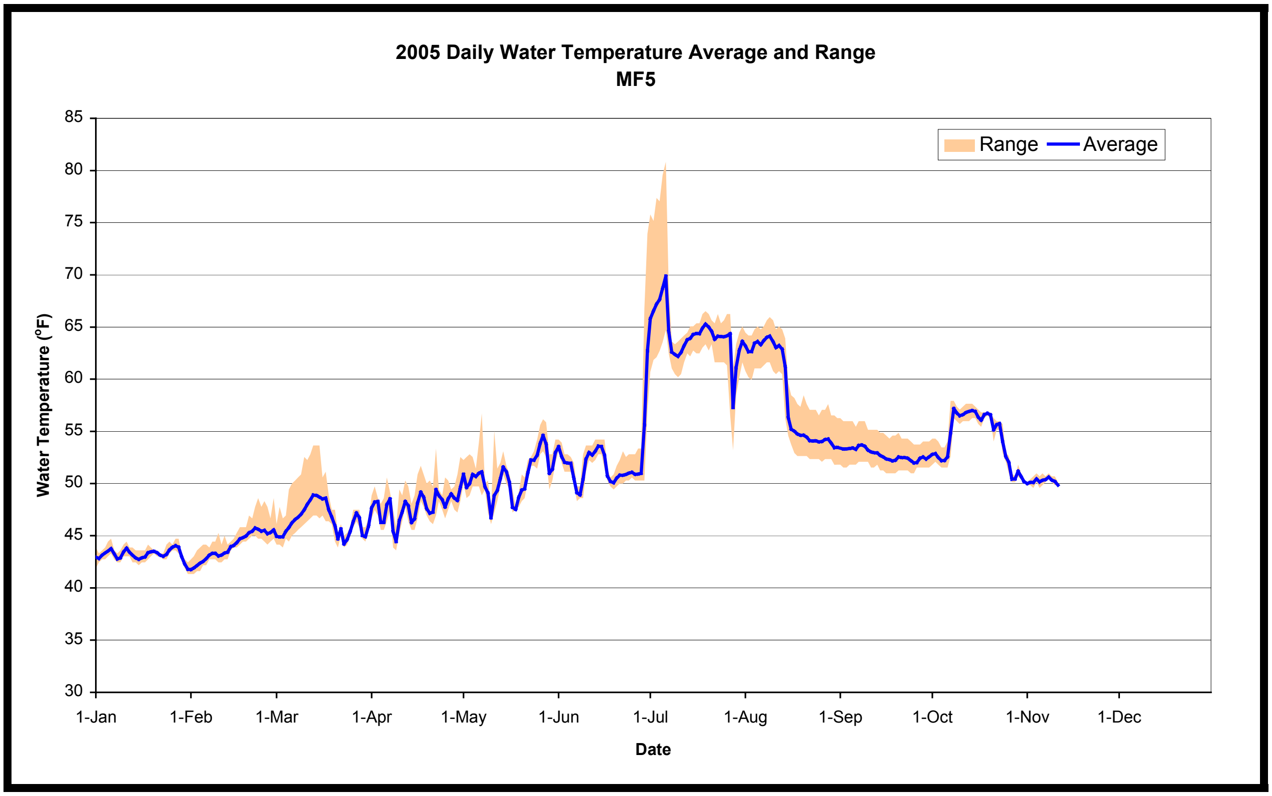



**Figure A- 25. The daily water temperature average and range measured at MF5 during 2005.**

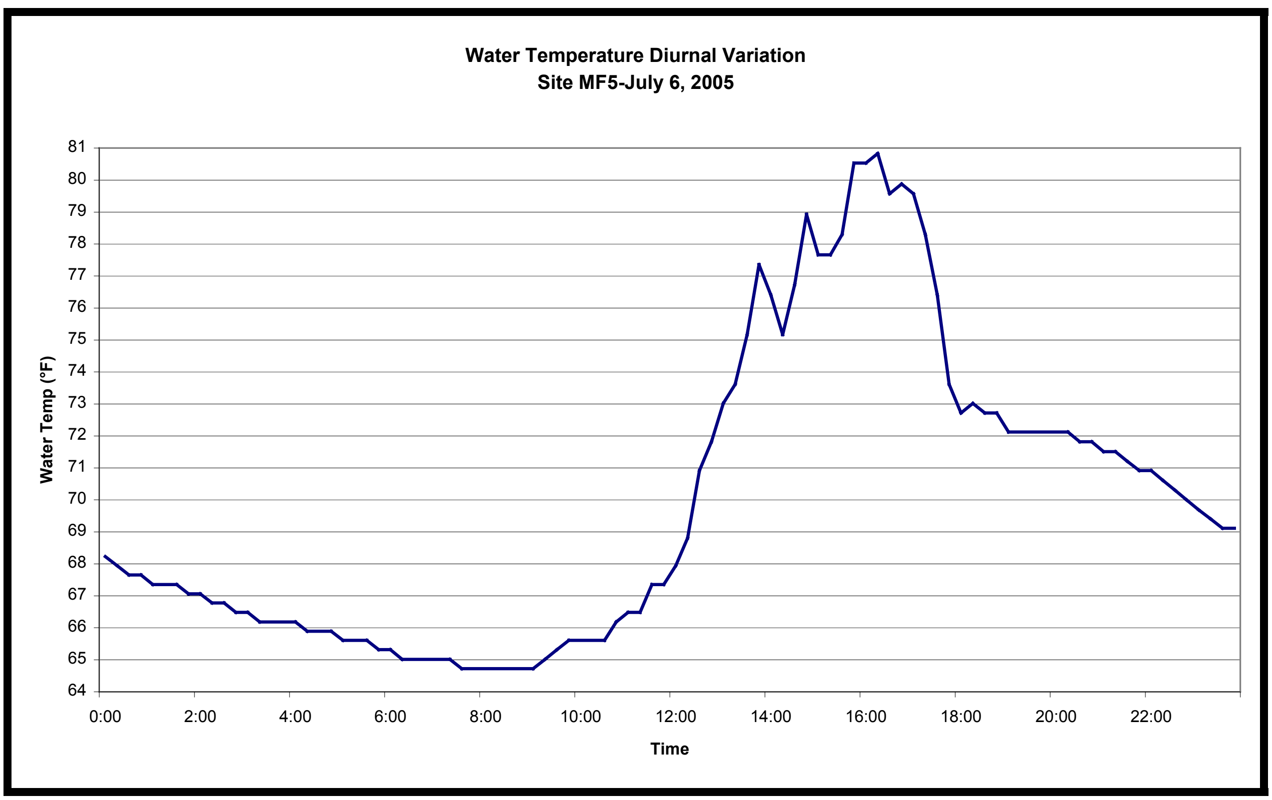



**Figure A- 26. The 15-minute interval water temperature data observed at MF5 during a particularly warm day in July to illustrate diurnal variation.**

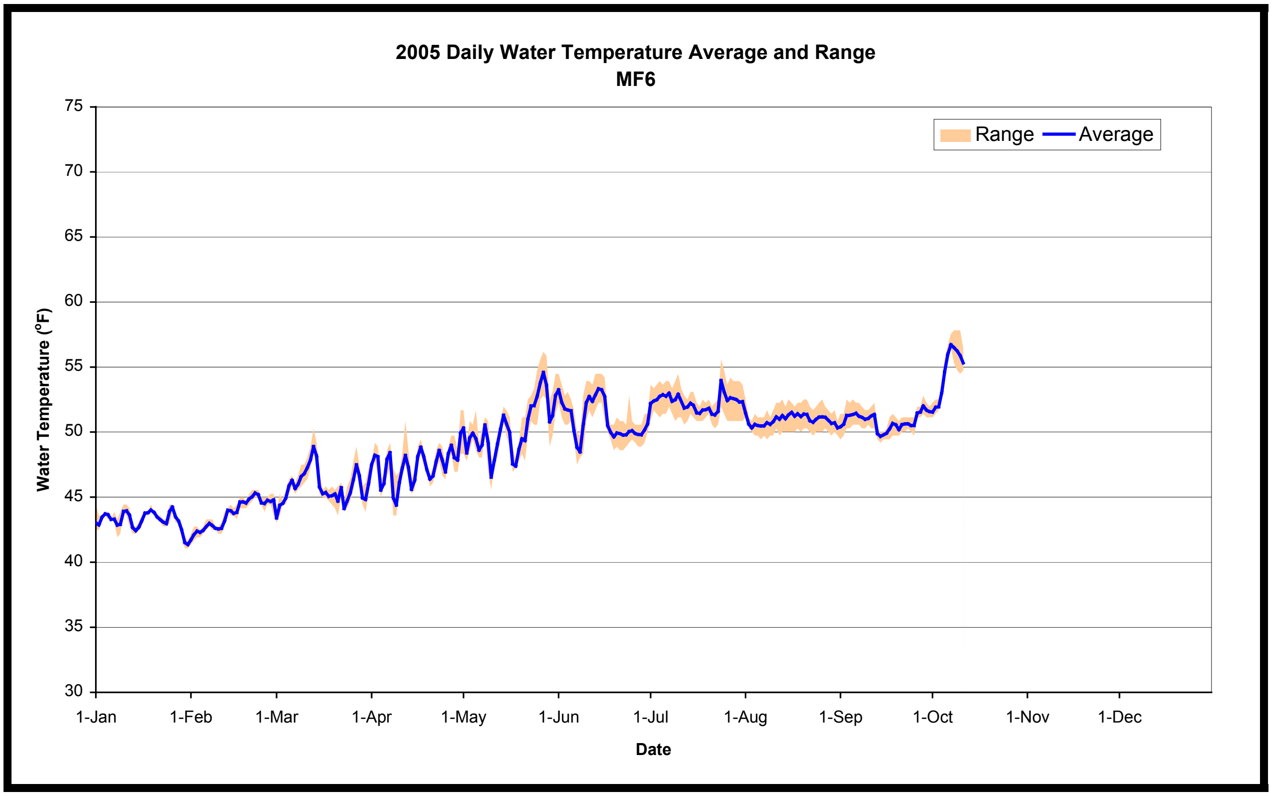



**Figure A- 27. The daily water temperature average and range measured at MF6 during 2005.**

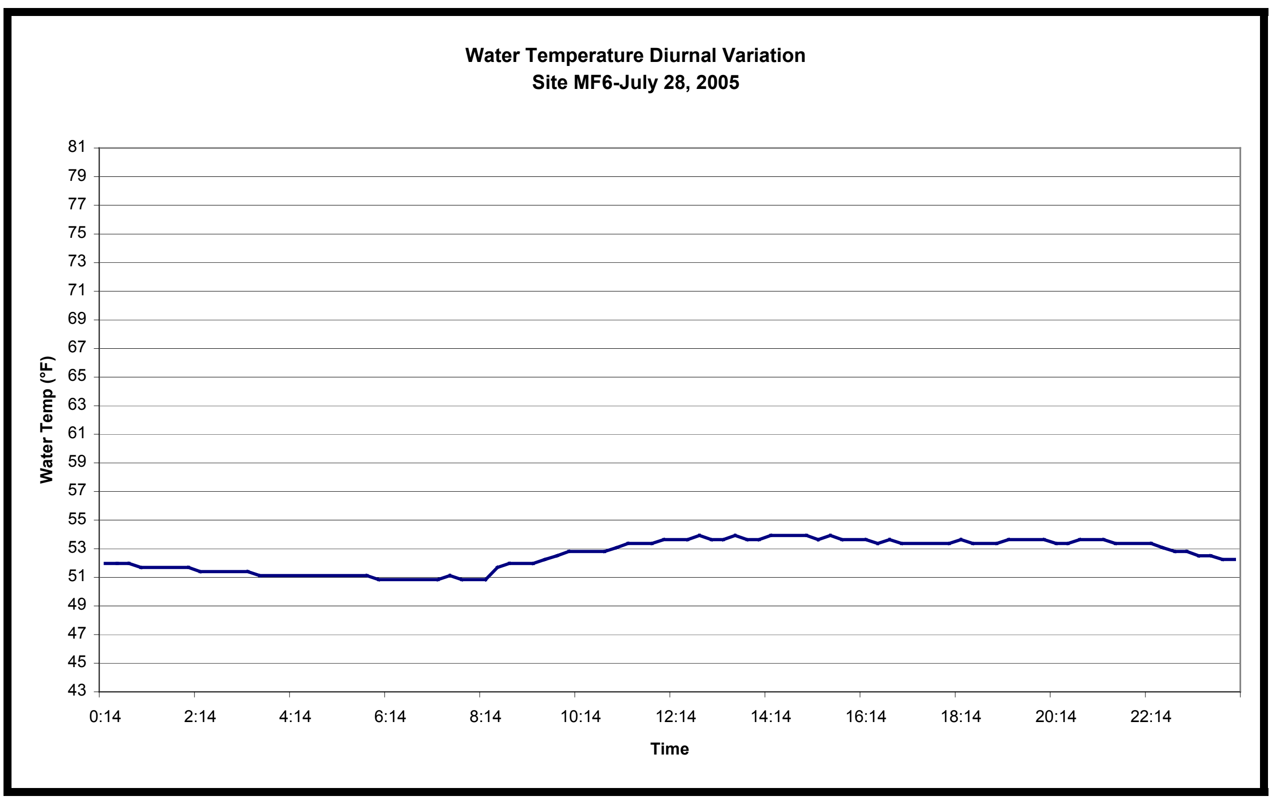



**Figure A- 28. The 15-minute interval water temperature data observed at MF6 during a particularly warm day in July to illustrate diurnal variation.**

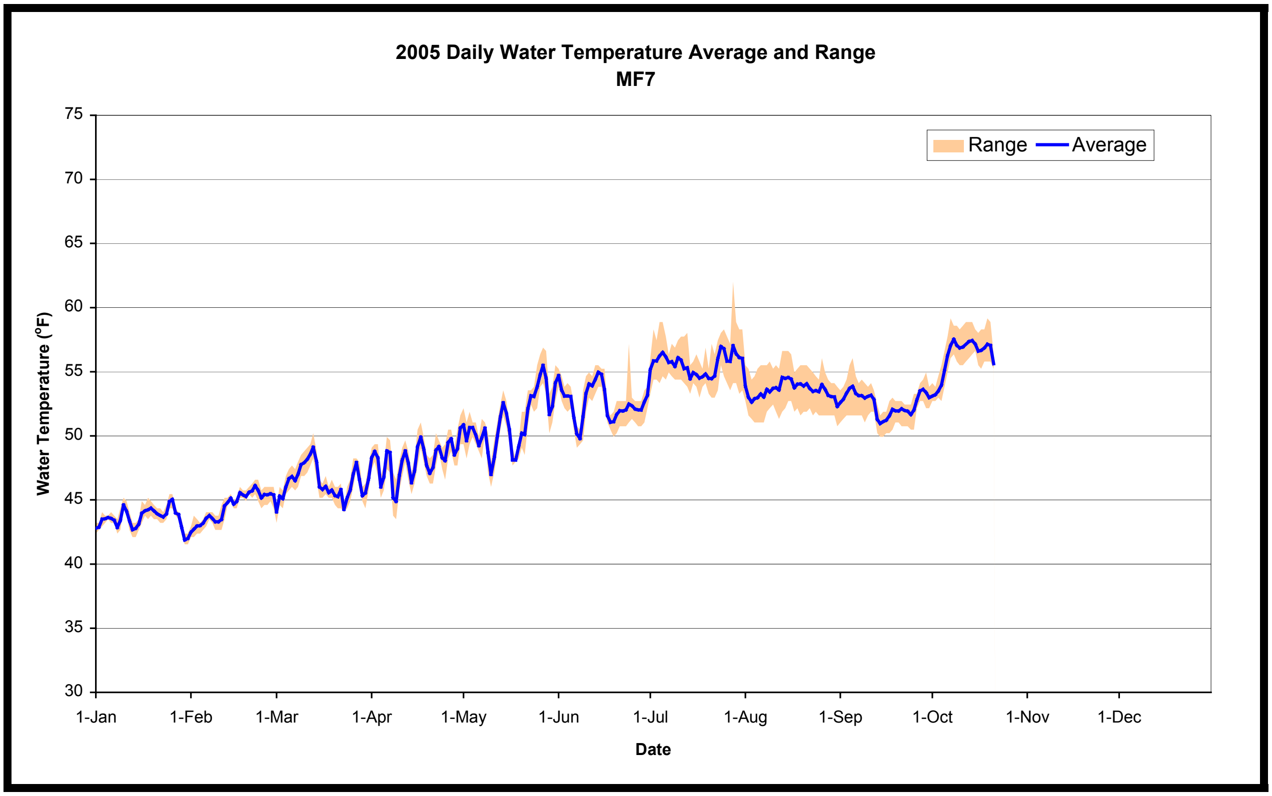



**Figure A- 29. The daily water temperature average and range measured at MF7 during 2005.**

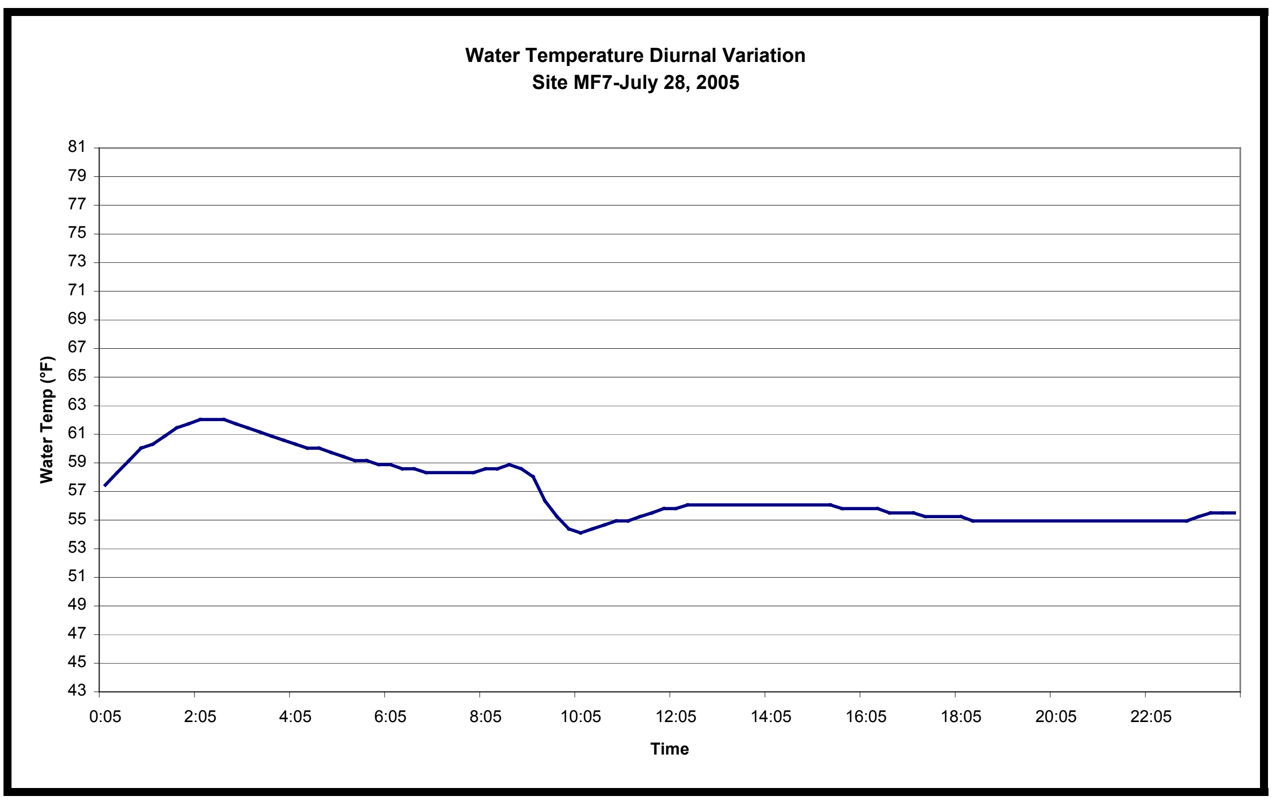



**Figure A- 30. The 15-minute interval water temperature data observed at MF7 during a particularly warm day in July to illustrate diurnal.**

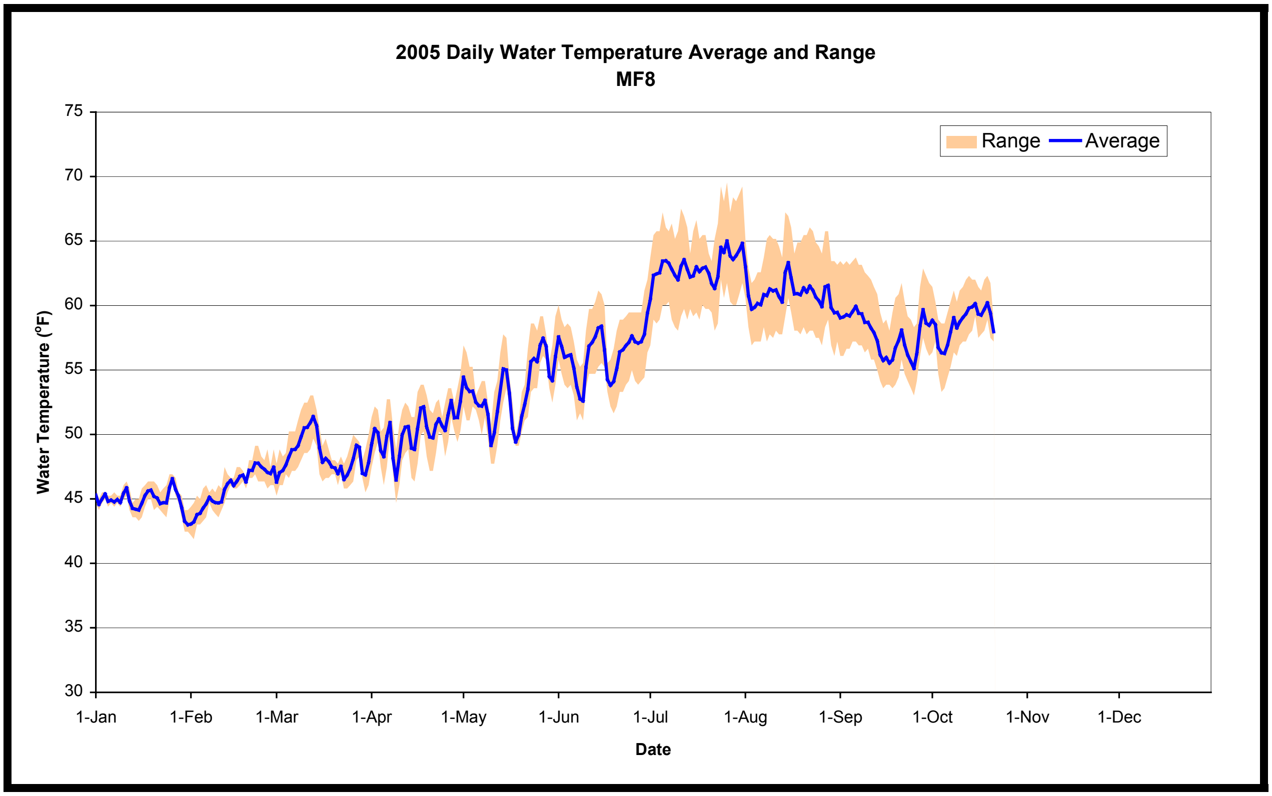



**Figure A- 31. The daily water temperature average and range measured at MF8 during 2005.**

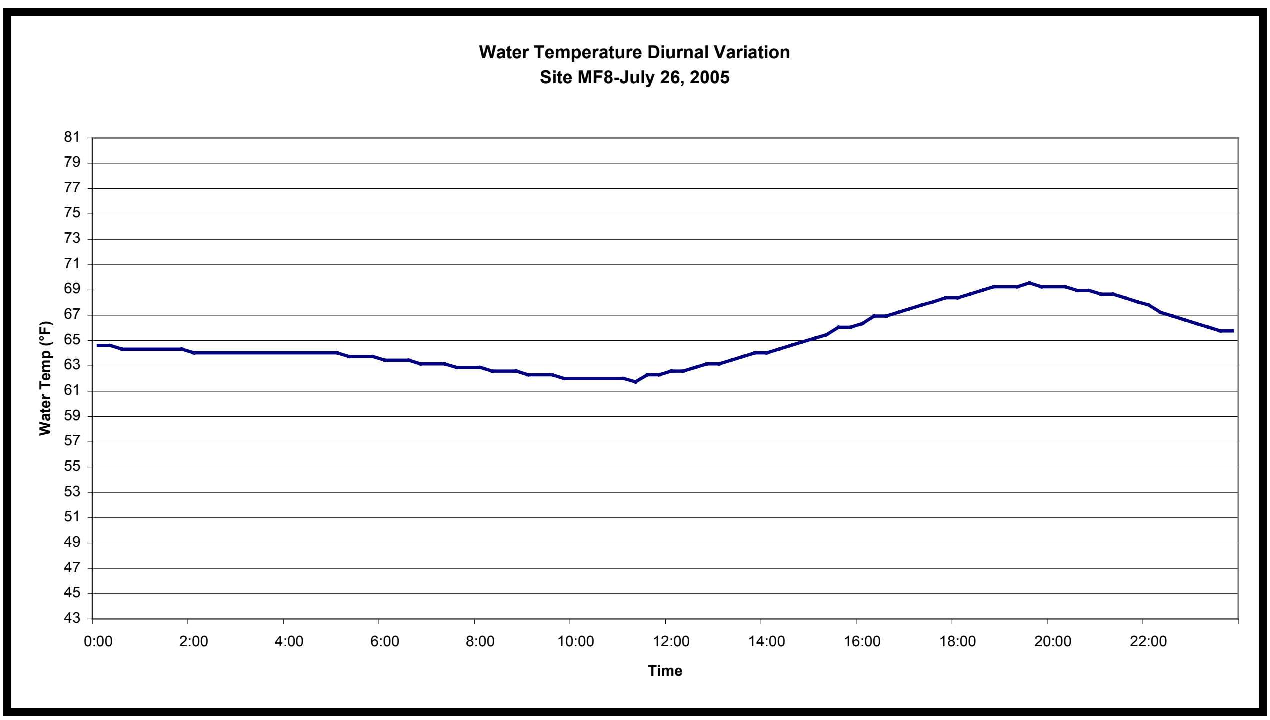



**Figure A- 32. The 15-minute interval water temperature data observed at MF8 during a particularly warm day in July to illustrate diurnal variation.**

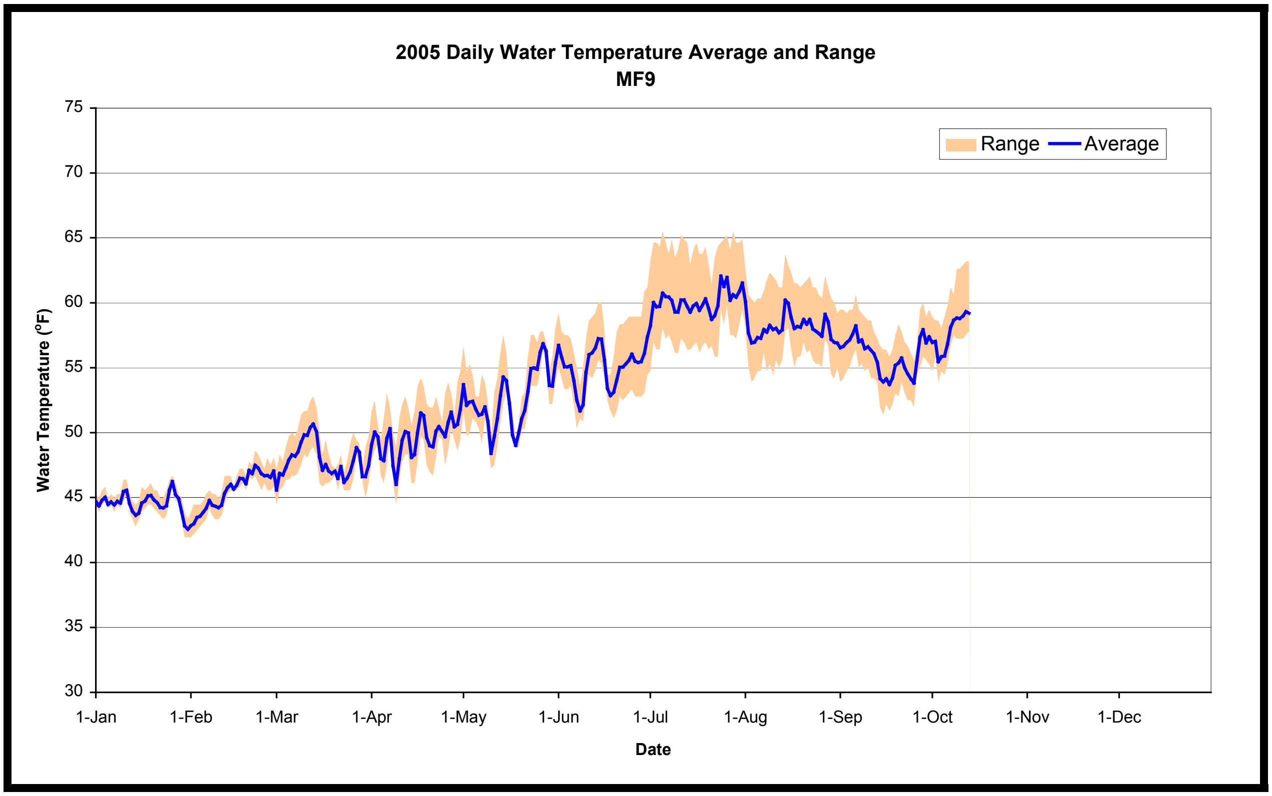



**Figure A- 33. The daily water temperature average and range measured at MF9 during 2005.**

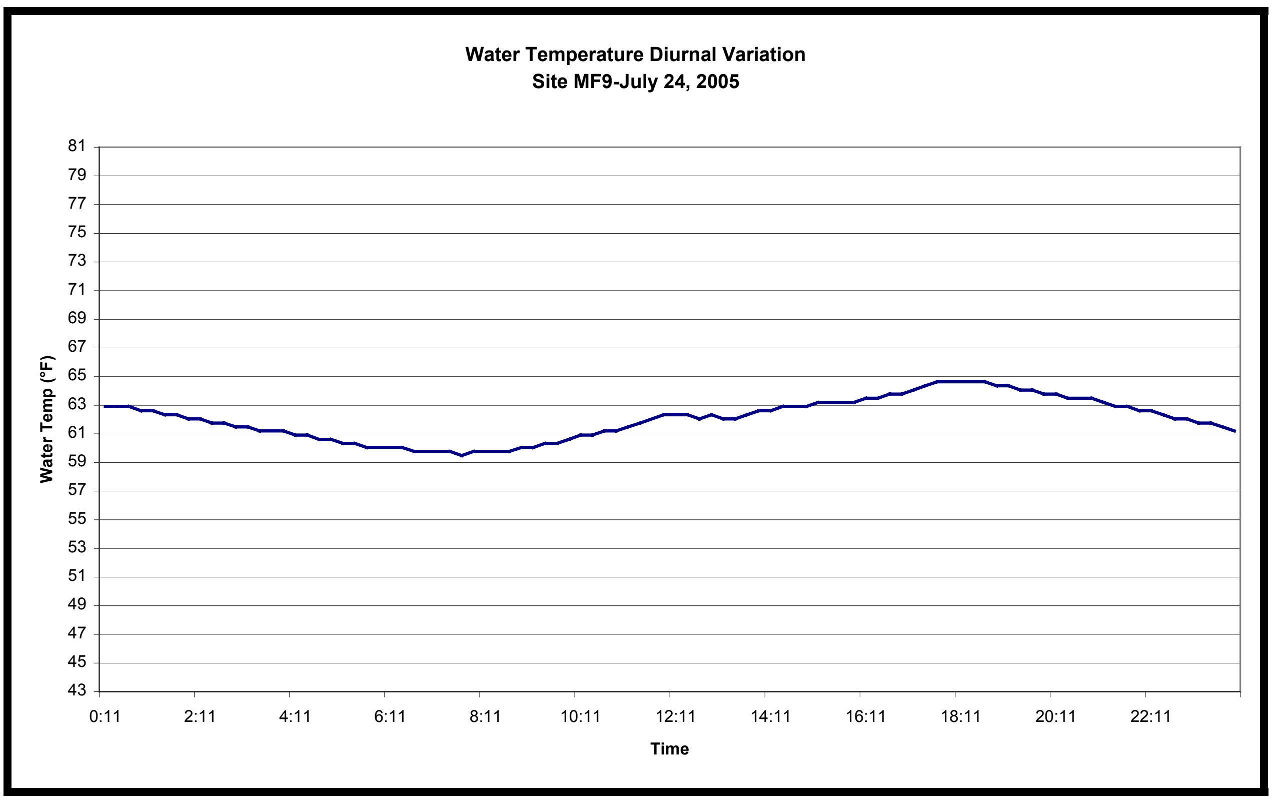



**Figure A- 34. The 15-minute interval water temperature data observed at MF9 during a particularly warm day in July to illustrate diurnal variation.**

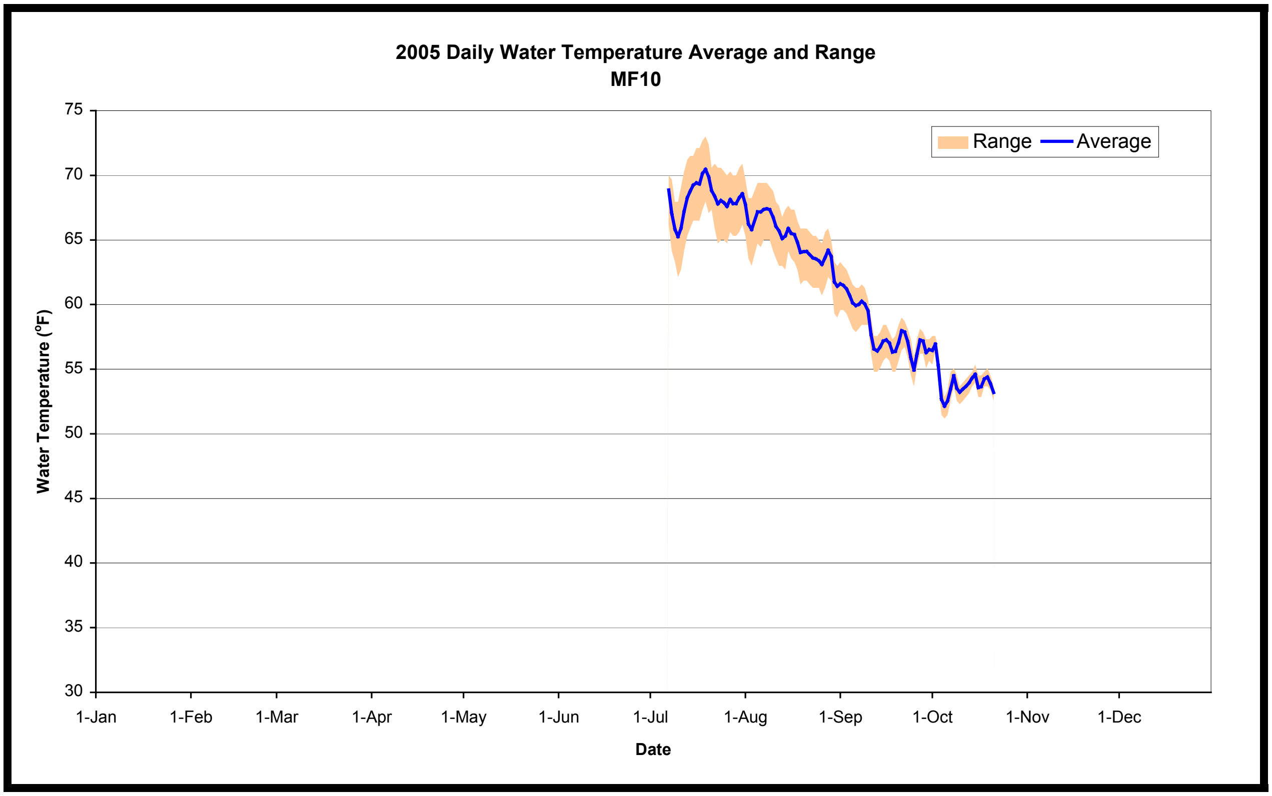



**Figure A- 35. The daily water temperature average and range measured at MF10 during 2005.**

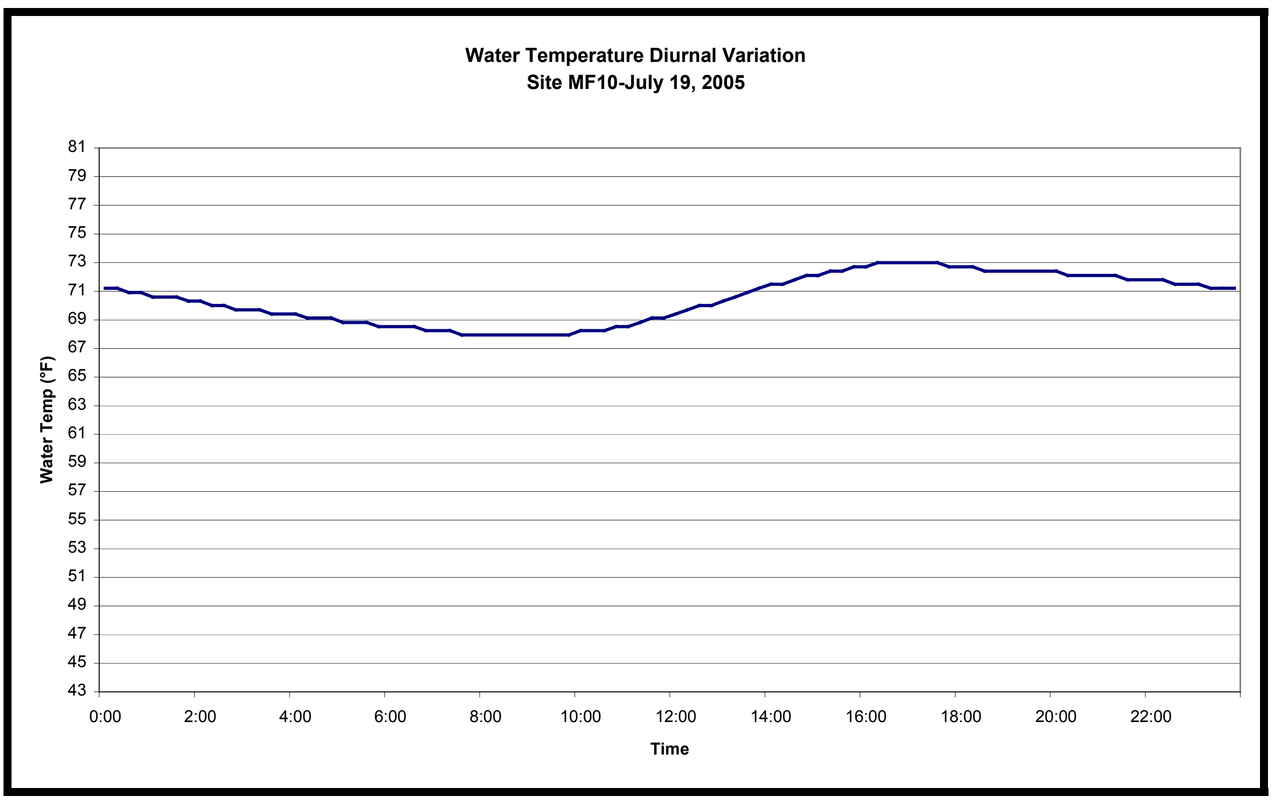



**Figure A- 36. The 15-minute interval water temperature data observed at MF10 during a particularly warm day in July to illustrate diurnal variation.**

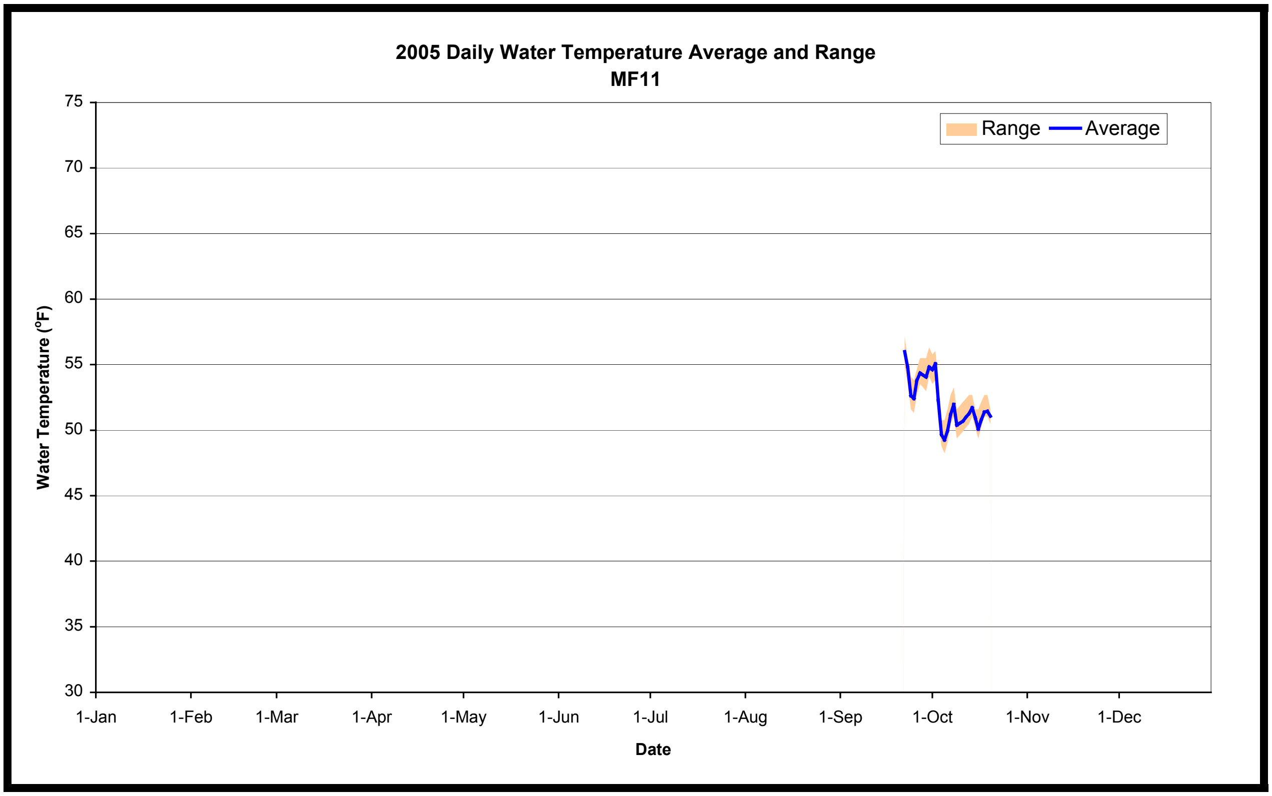



**Figure A- 37. The daily water temperature average and range measured at MF11 during 2005.**

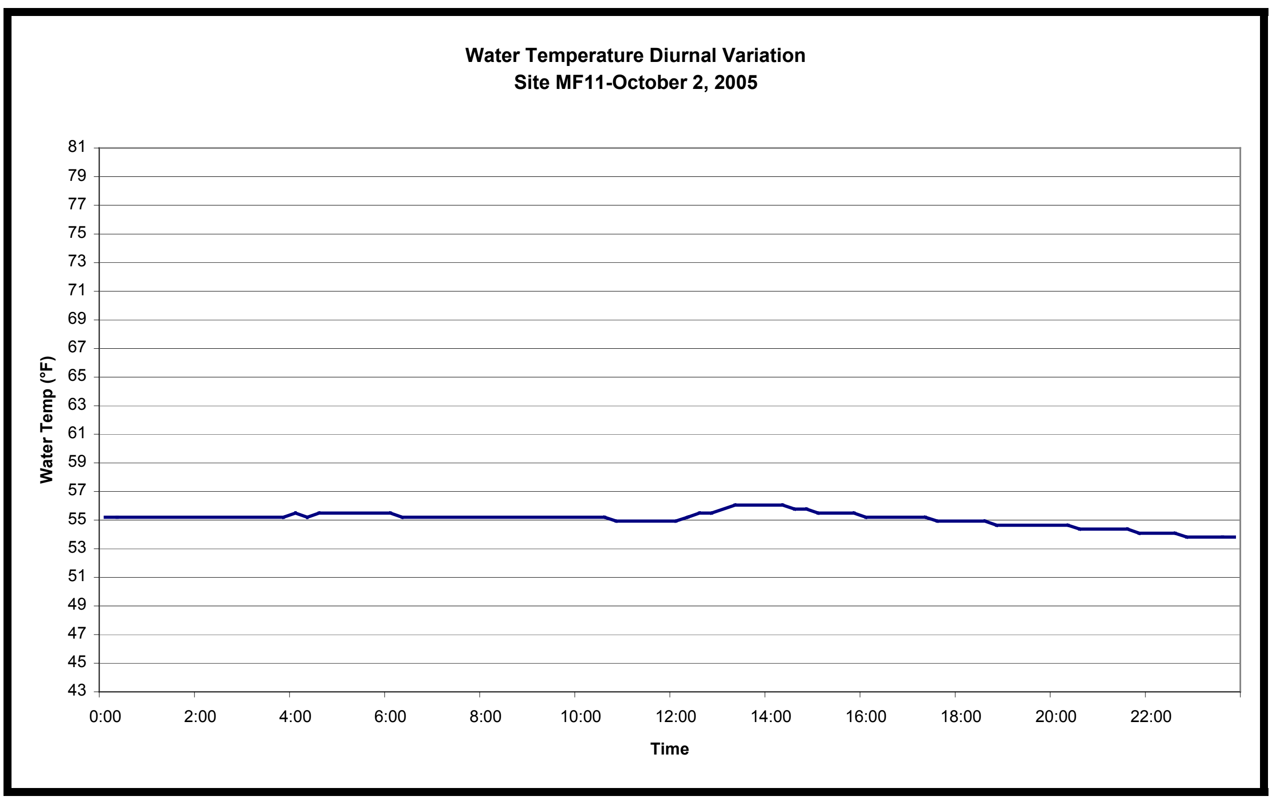



**Figure A- 38. The 15-minute interval water temperature data observed at MF11 during a particularly warm day in October to illustrate diurnal variation.**

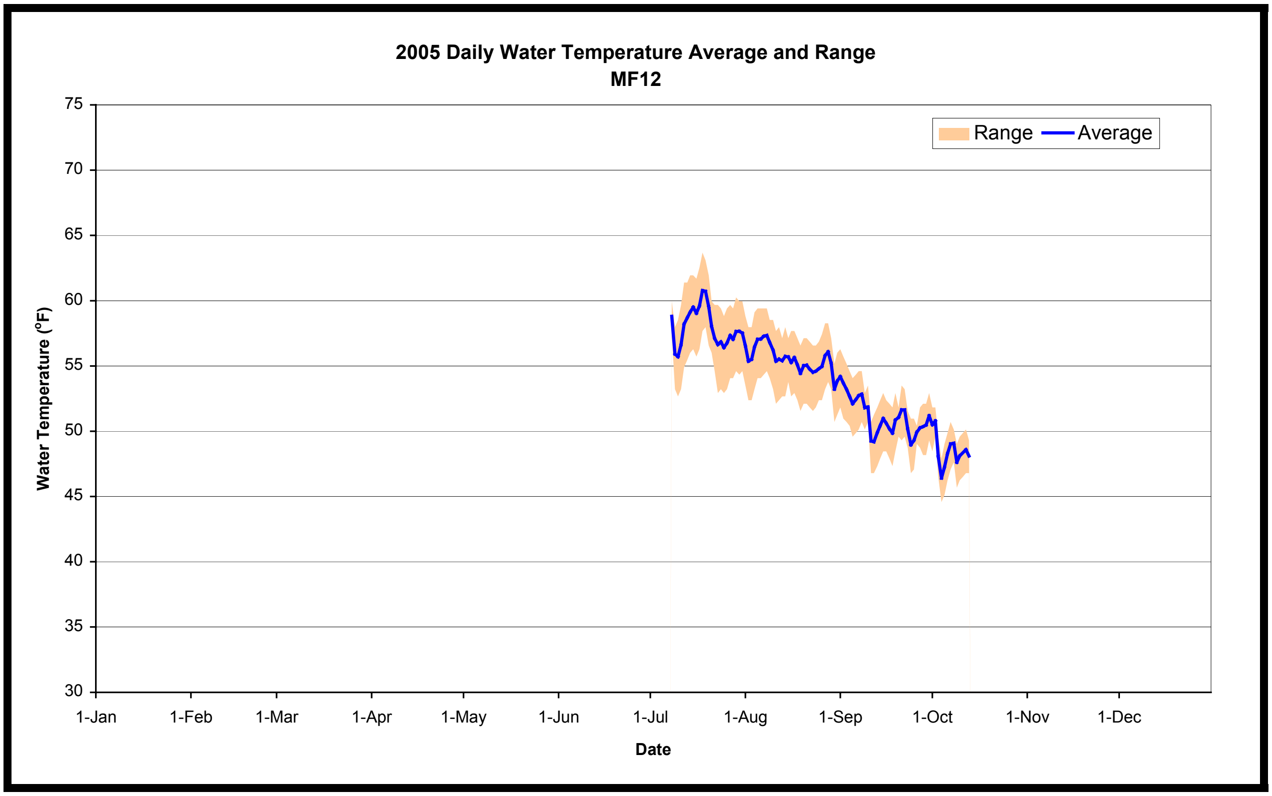



**Figure A- 39. The daily water temperature average and range measured at MF12 during 2005.**

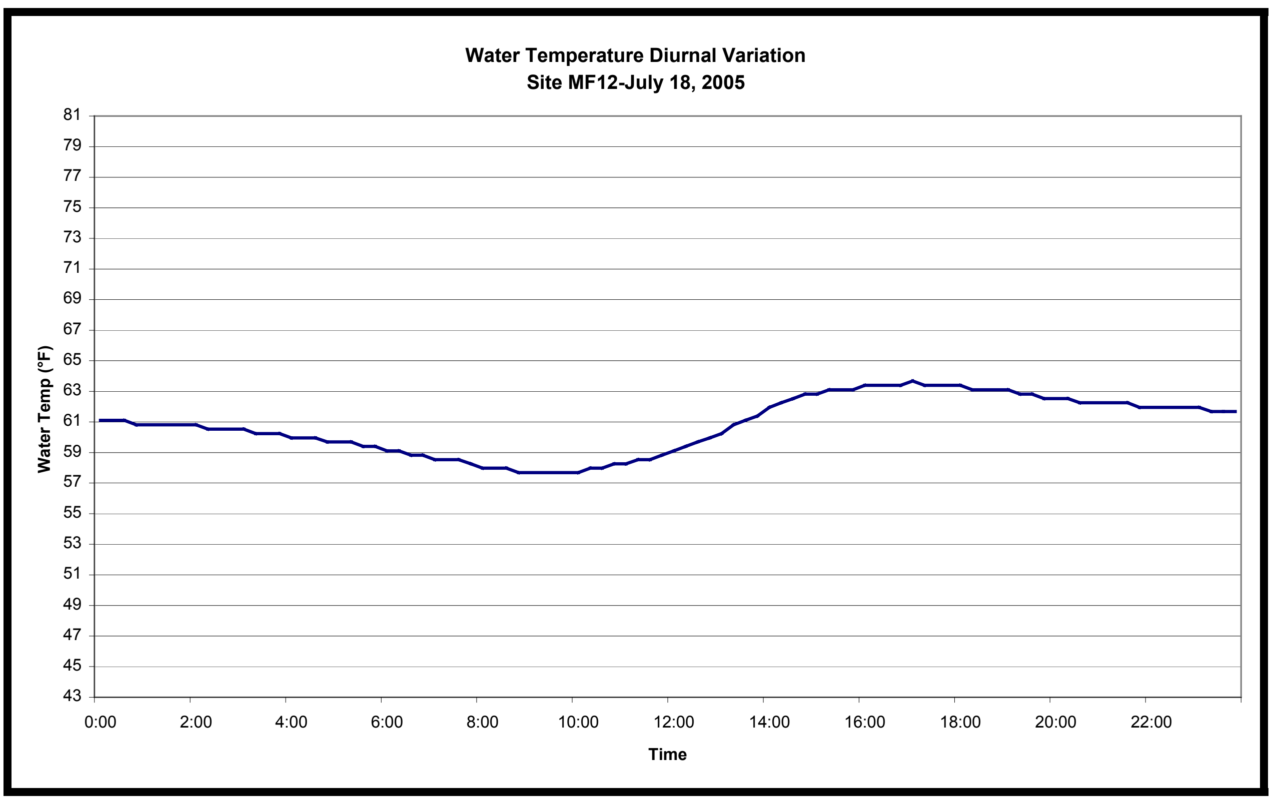



**Figure A- 40. The 15-minute interval water temperature data observed at MF12 during a particularly warm day in July to illustrate diurnal variation.**

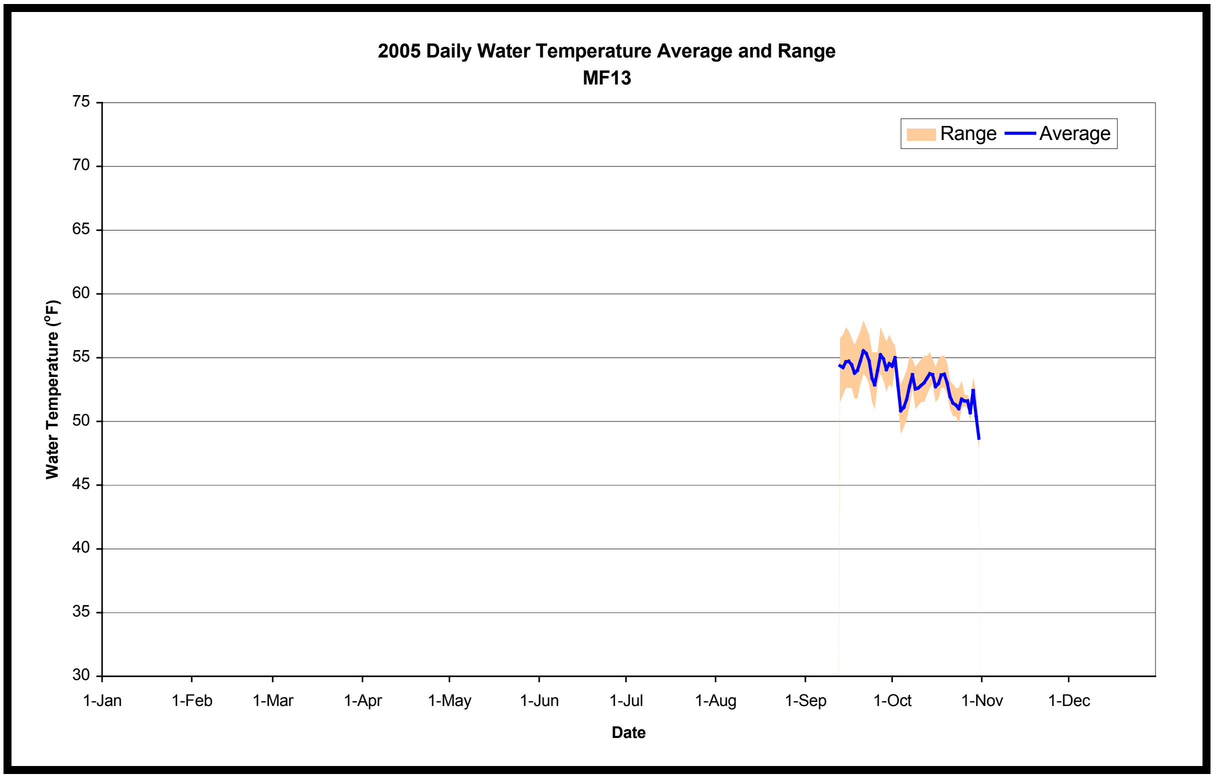



**Figure A- 41. The daily water temperature average and range measured at MF13 during 2005.**

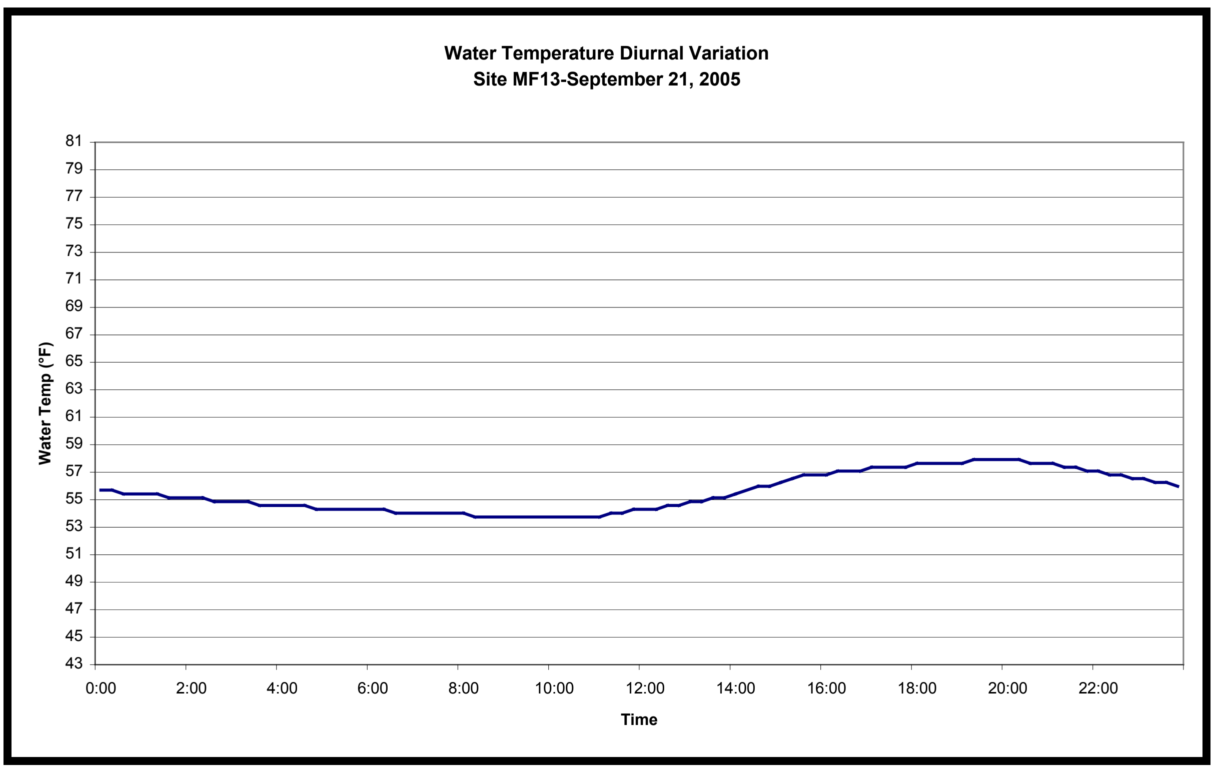



**Figure A- 42. The 15-minute interval water temperature data observed at MF13 during a particularly warm day in September to illustrate diurnal variation.**

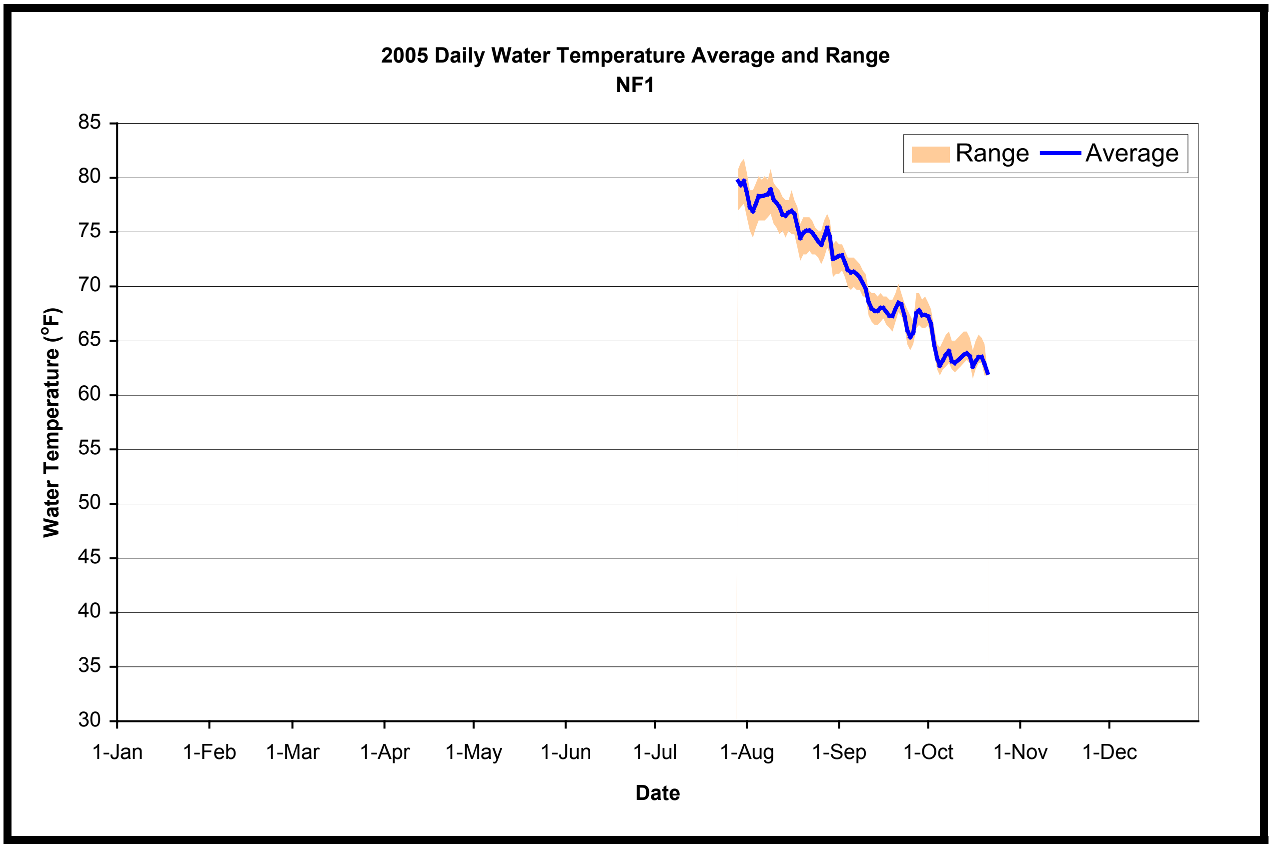



**Figure A- 43. The daily water temperature average and range measured at NF1 during 2005.**

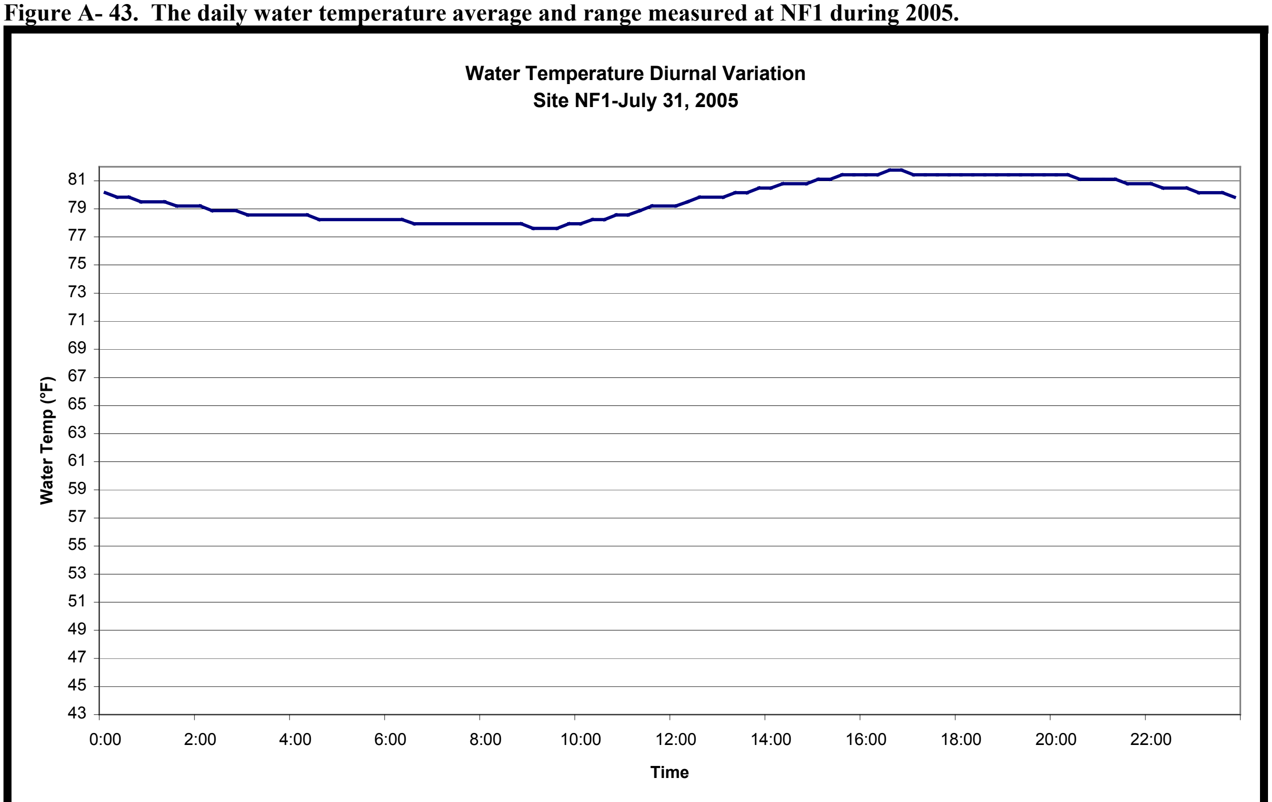



**Figure A- 44. The 15-minute interval water temperature data observed at NF1 during a particularly warm day in July to illustrate diurnal.**

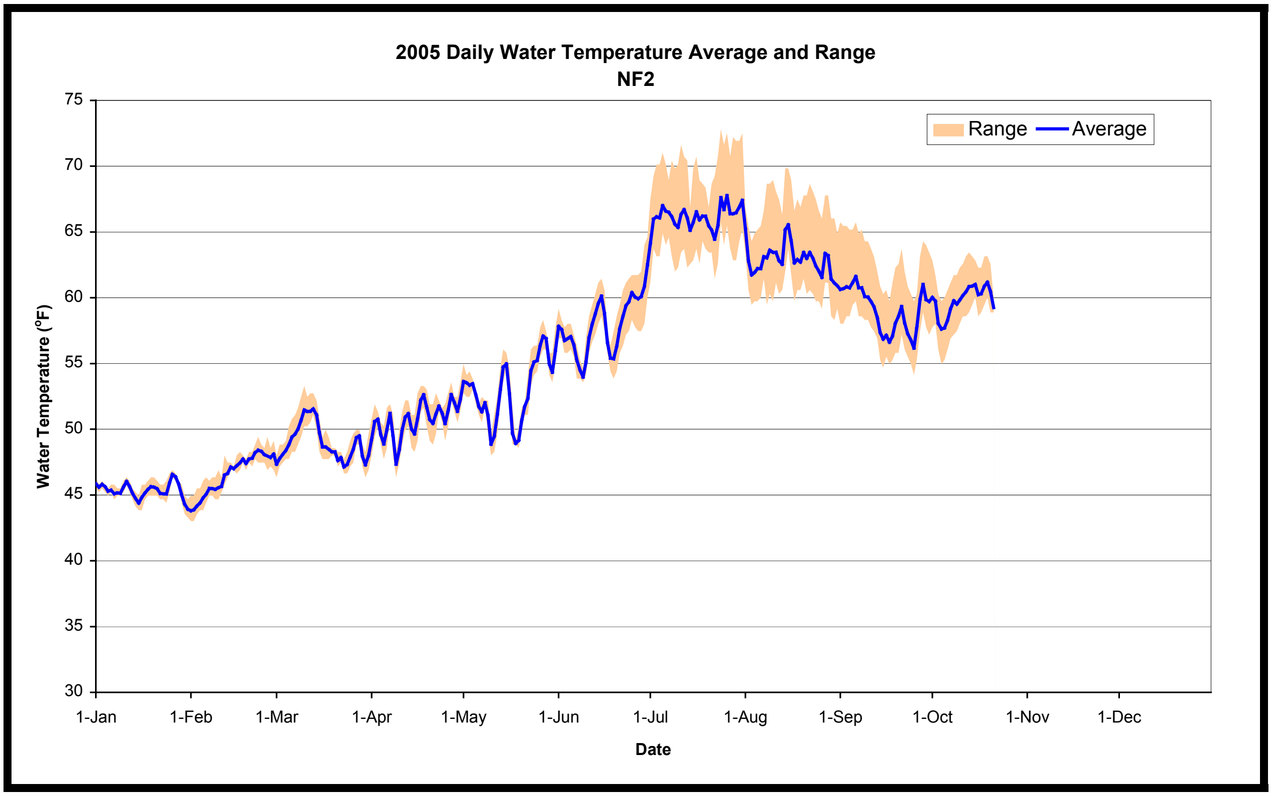



**Figure A- 45. The daily water temperature average and range measured at NF2 during 2005.**

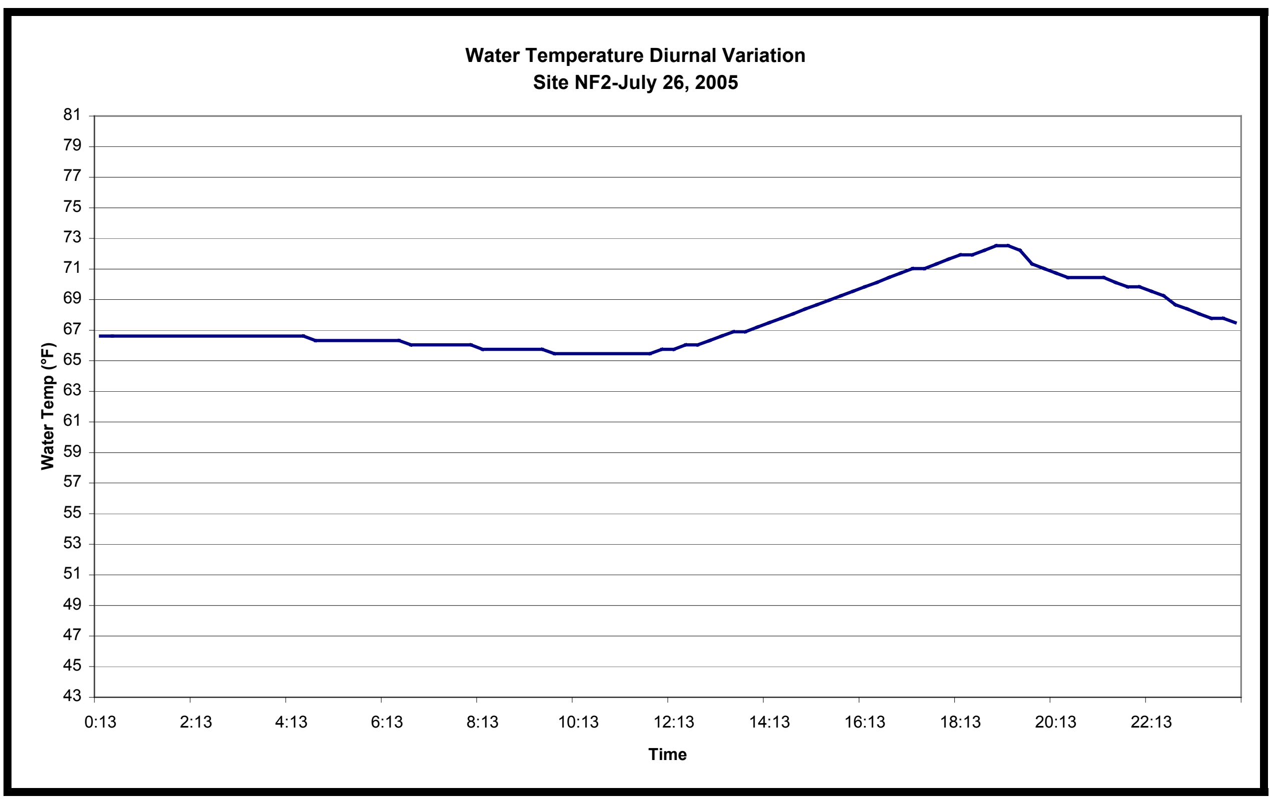



**Figure A- 46. The 15-minute interval water temperature data observed NF2 during a particularly warm day in July to illustrate diurnal.**

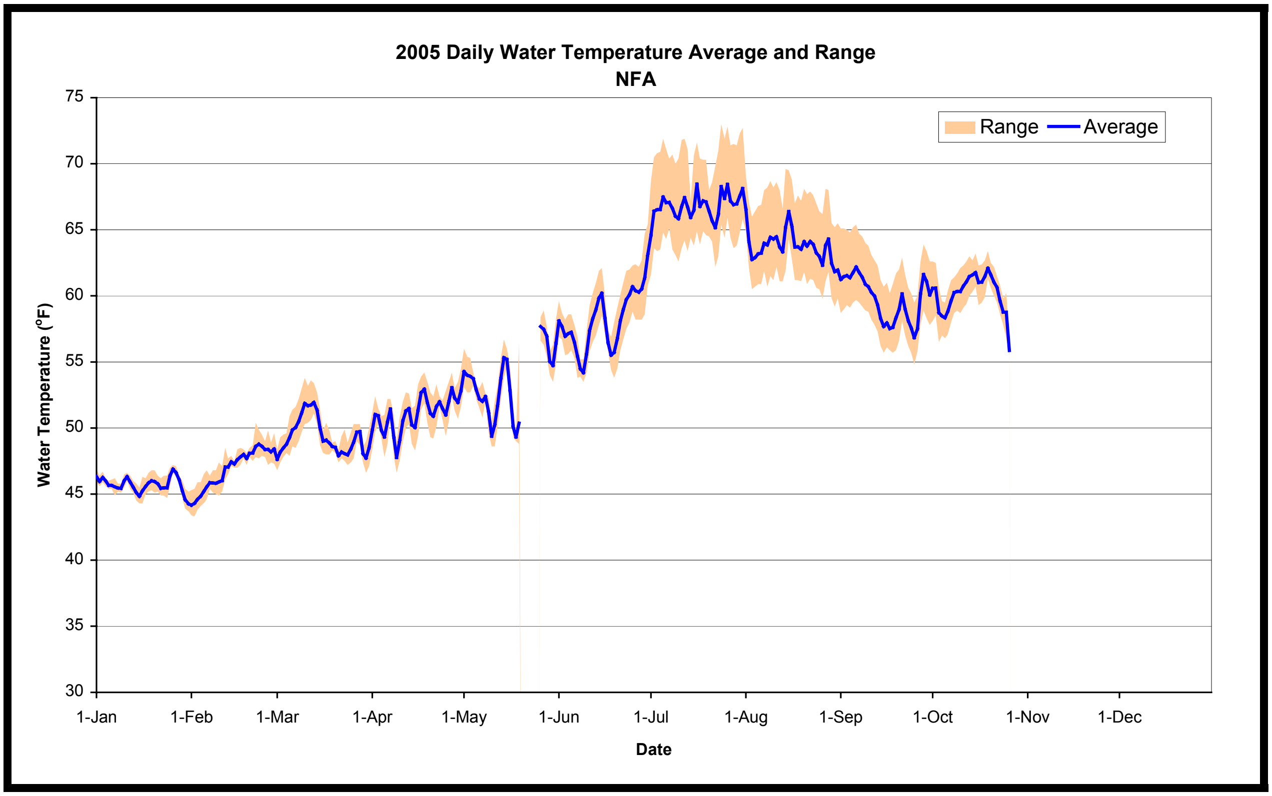



**Figure A- 47. The daily water temperature average and range measured at NFA during 2005.**

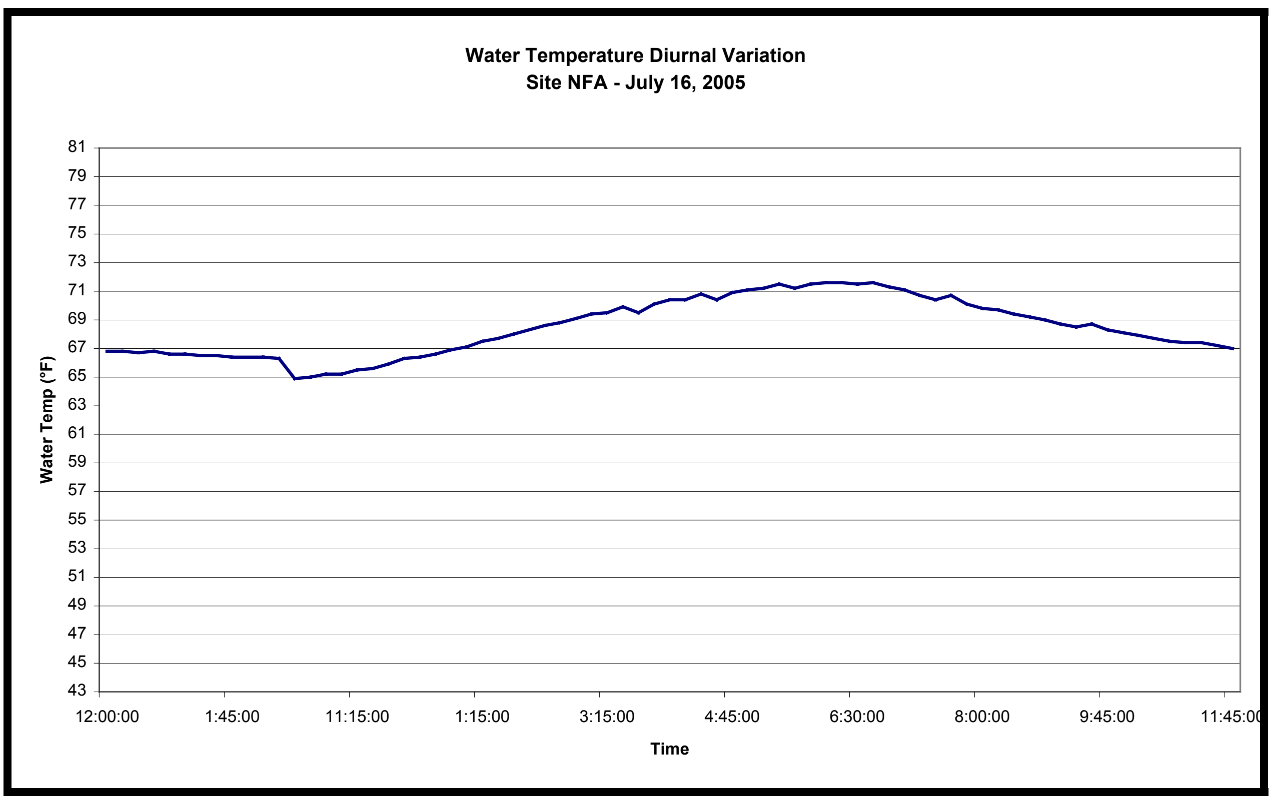



**Figure A- 48. The 15-minute interval water temperature data observed at NFA during a particularly warm day in July to illustrate diurnal.**

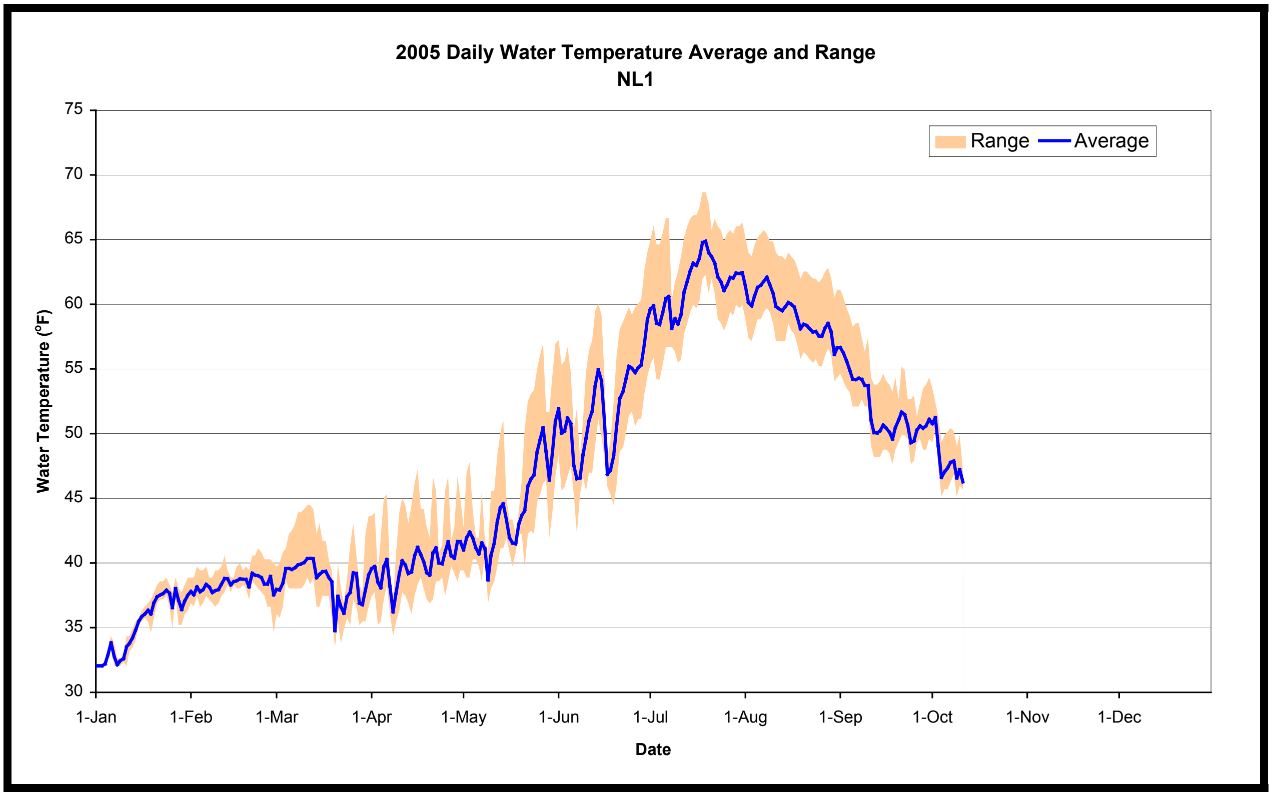



**Figure A- 49. The daily water temperature average and range measured at NL1 during 2005.**

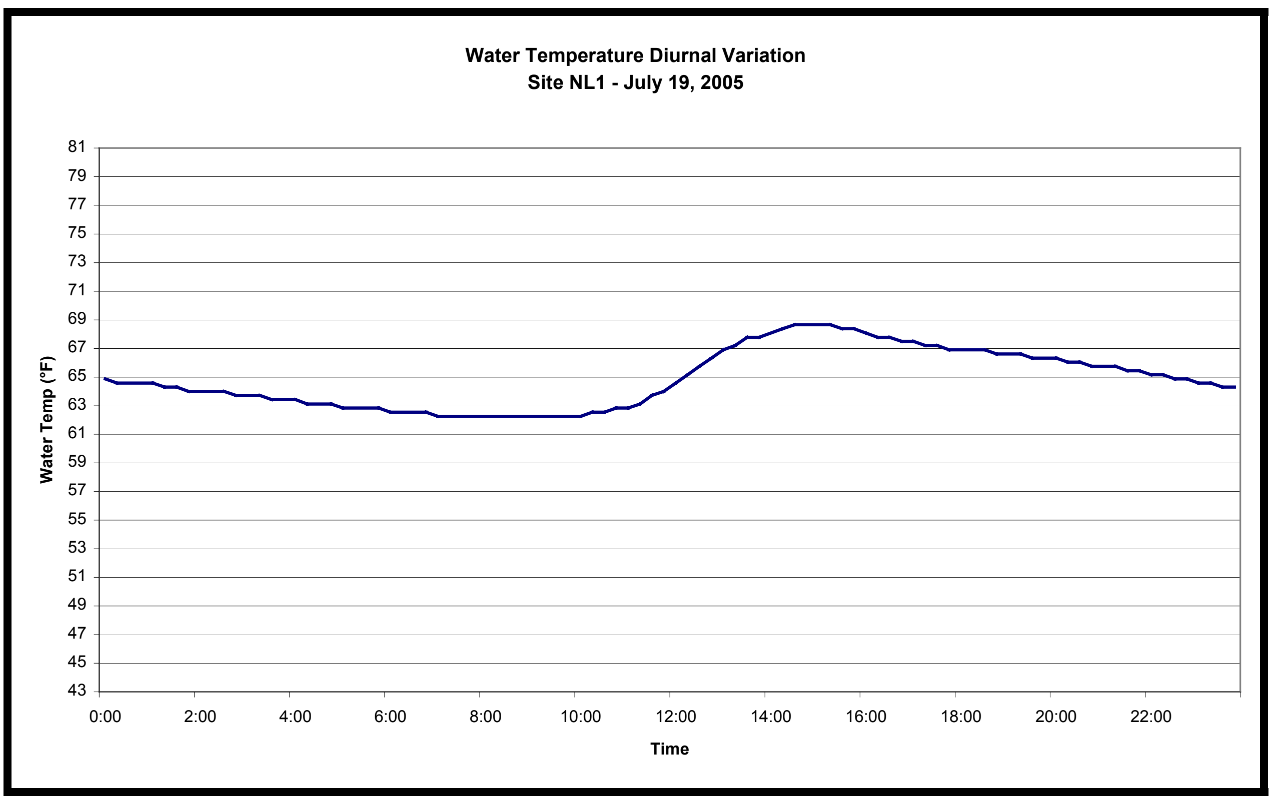



**Figure A- 50. The 15-minute interval water temperature data observed at NL1 during a particularly warm day in July to illustrate diurnal.**

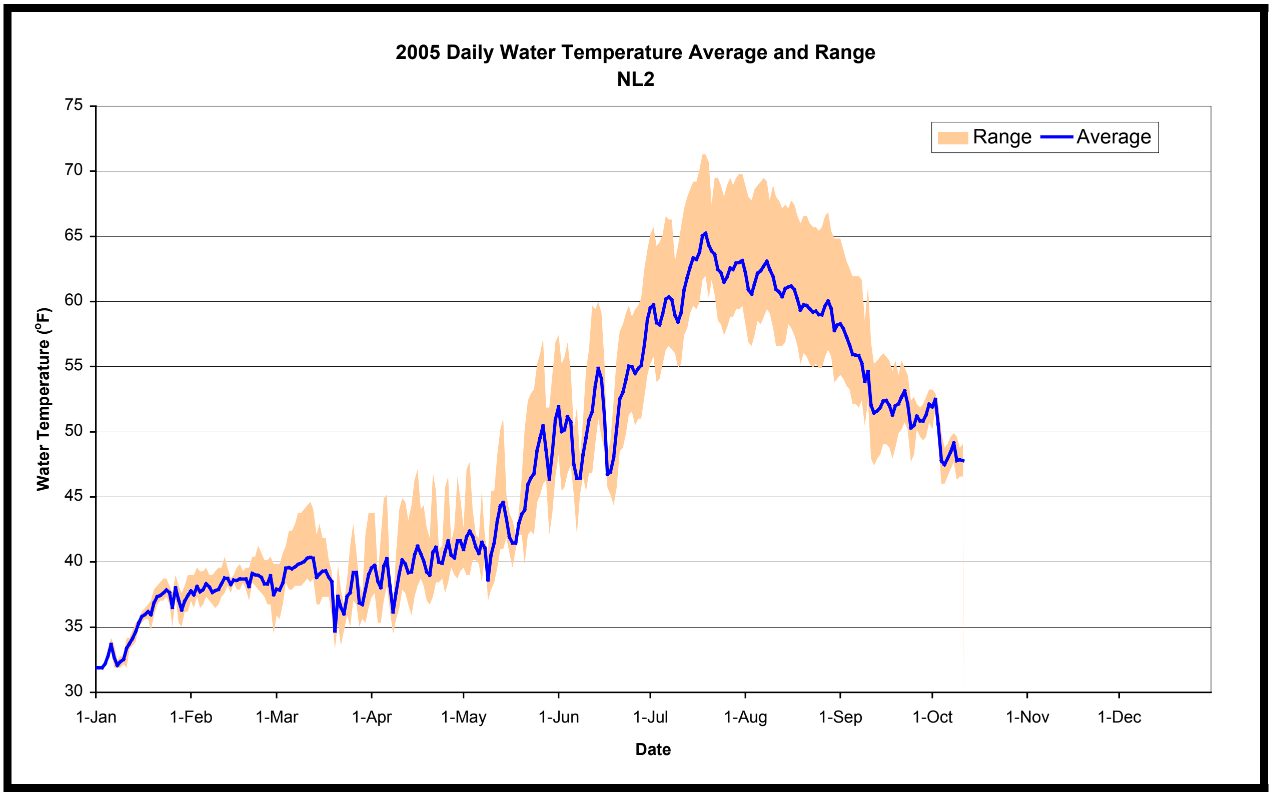



**Figure A- 51. The daily water temperature average and range measured a NL2 during 2005.**

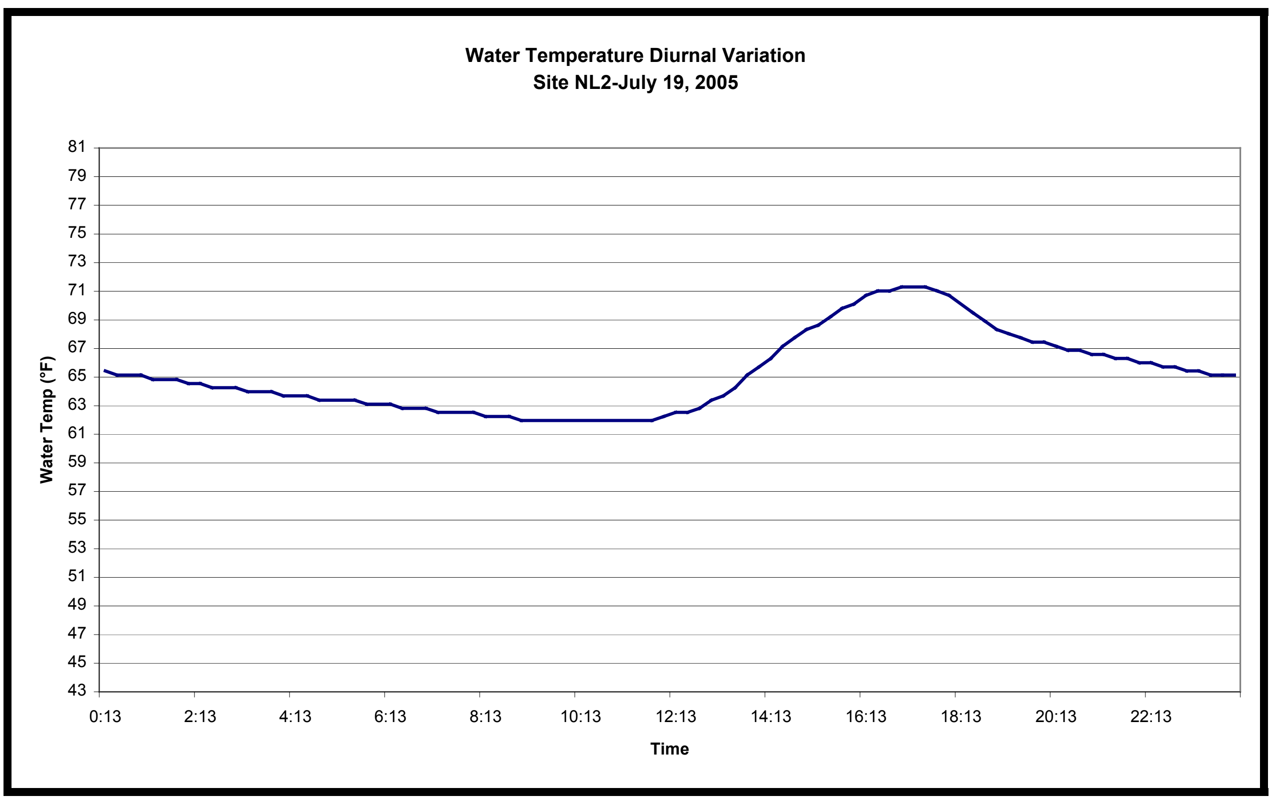



**Figure A- 52. The 15-minute interval water temperature data observed at NL2 during a particularly warm day in July to illustrate diurnal variation.**

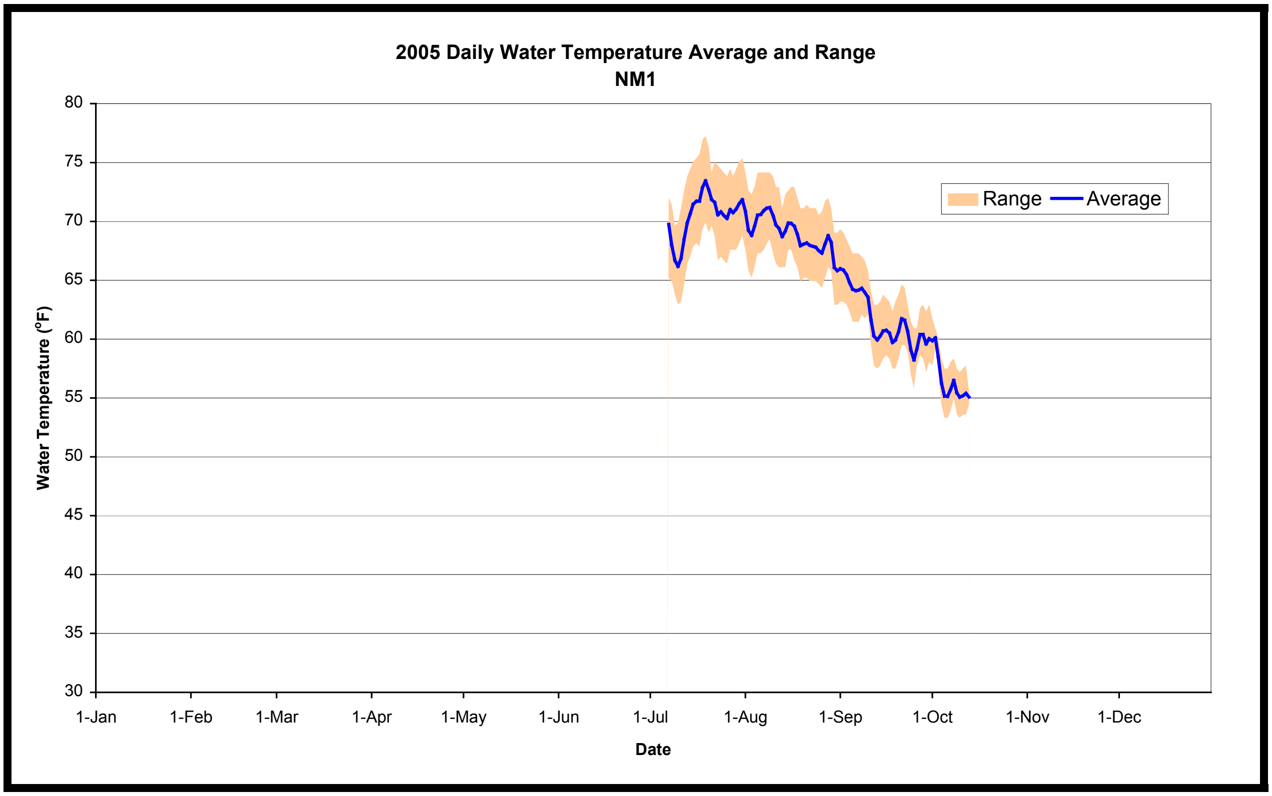



**Figure A- 53. The daily water temperature average and range measured at NM1 during 2005.**

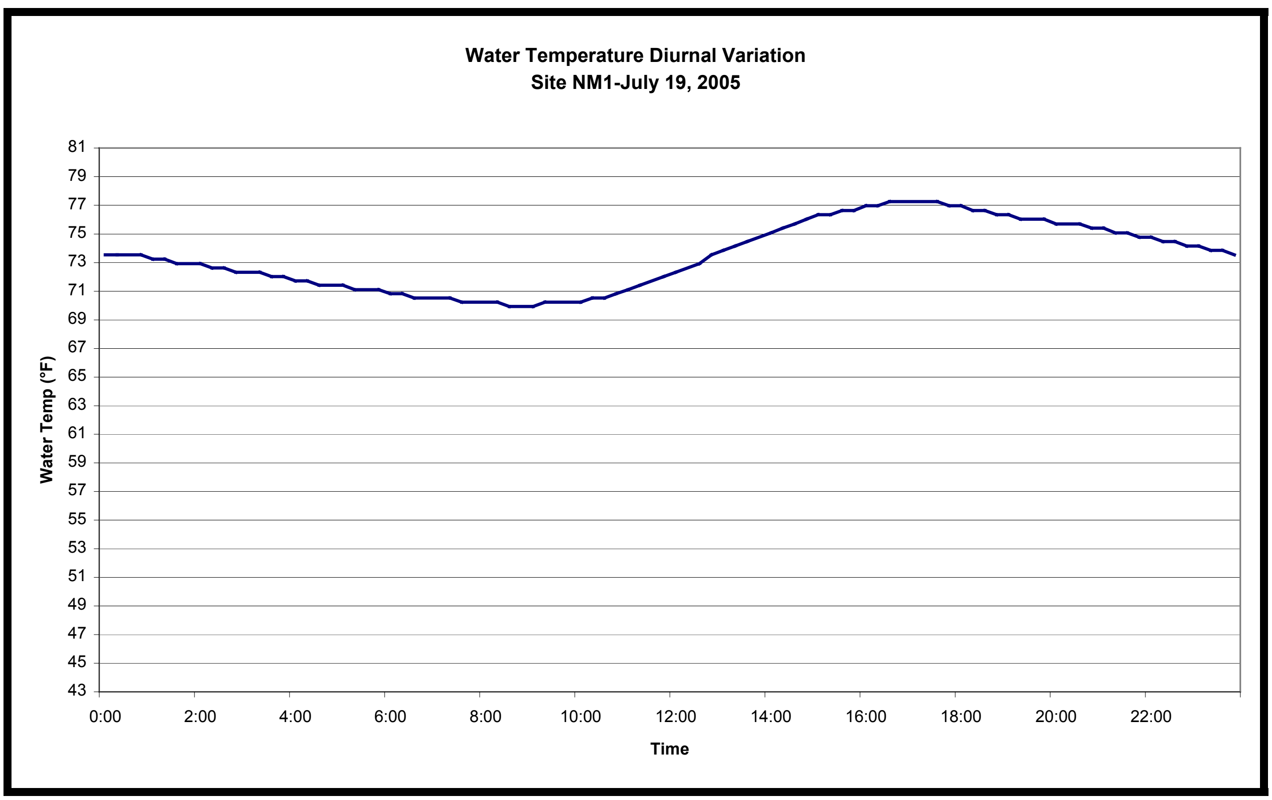



**Figure A- 54. The 15-minute interval water temperature data observed at NM1 during a particularly warm day in July to illustrate diurnal.**

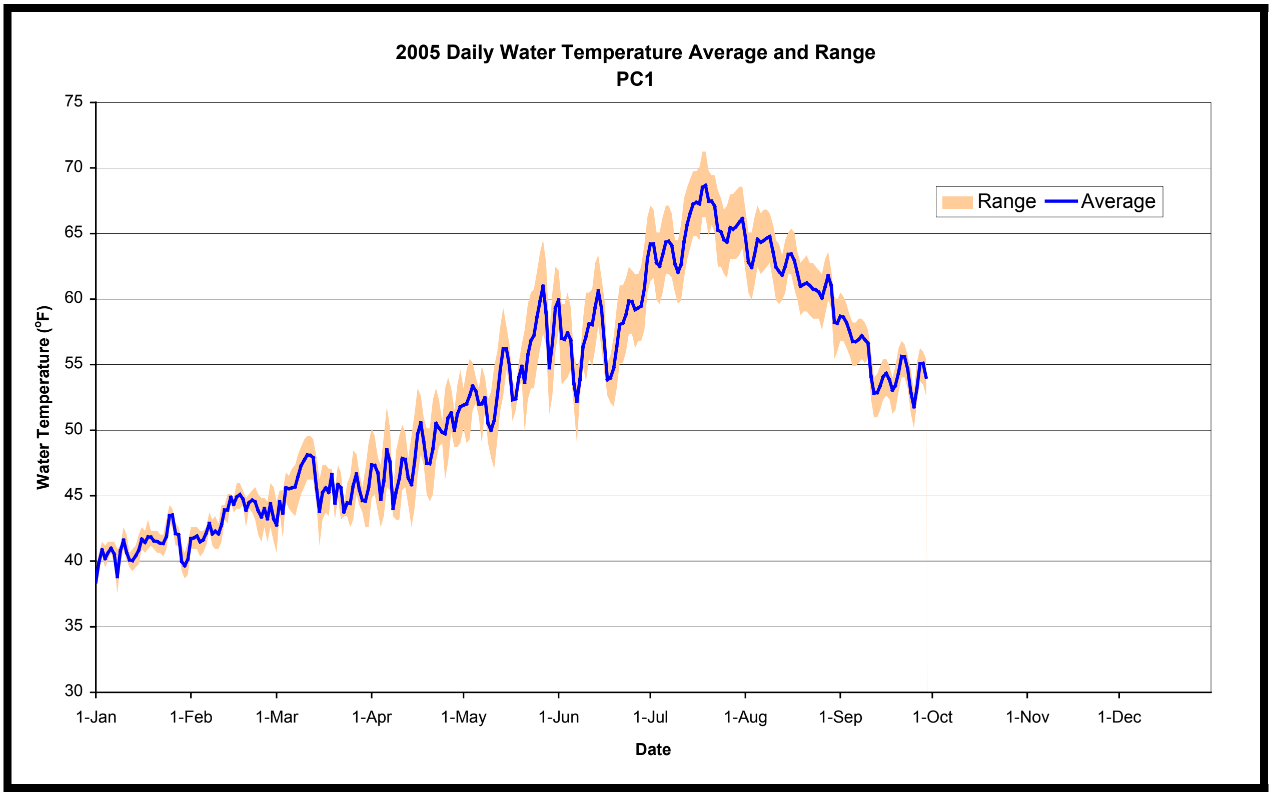



**Figure A- 55. The daily water temperature average and range measured at PC1 during 2005.**

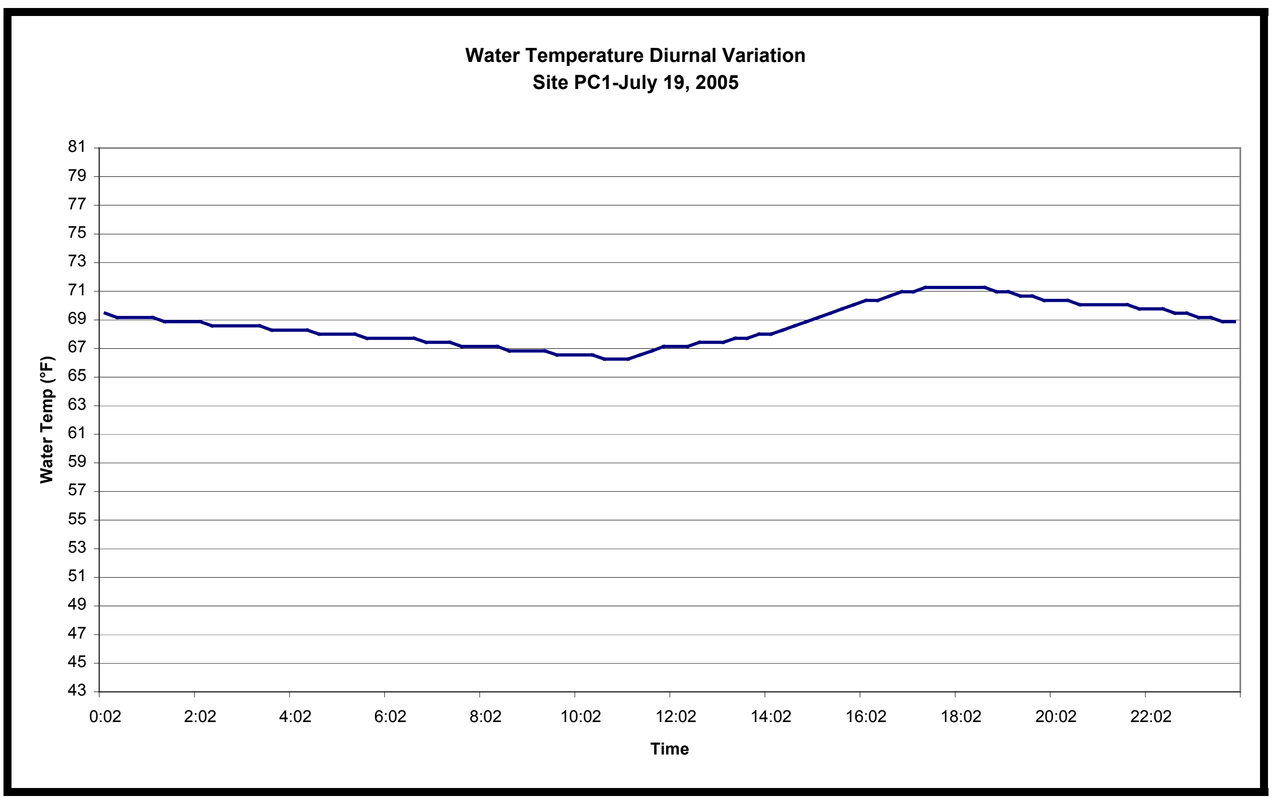



**Figure A- 56. The 15-minute interval water temperature data observed at PC1 during a particularly warm day in July to illustrate diurnal variation.**

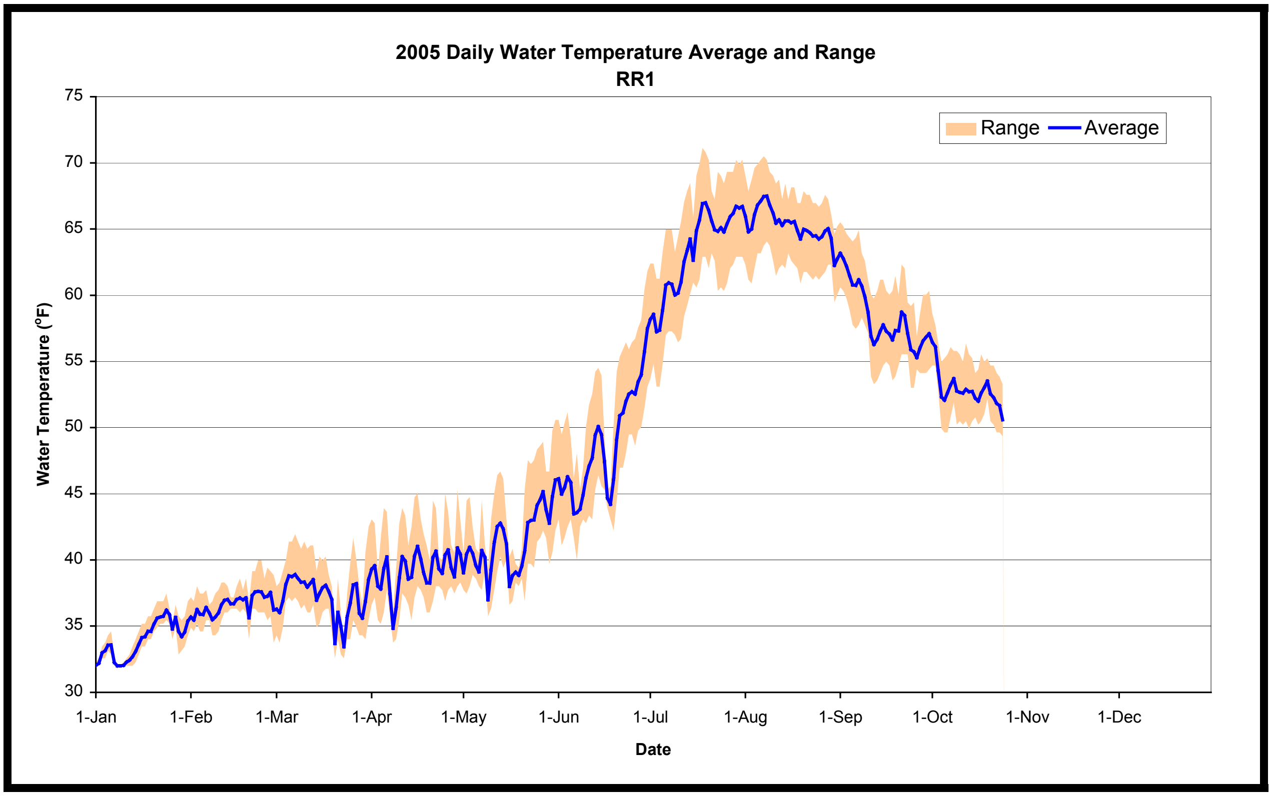



**Figure A- 57. The daily water temperature average and range measured at RR1 during 2005.**

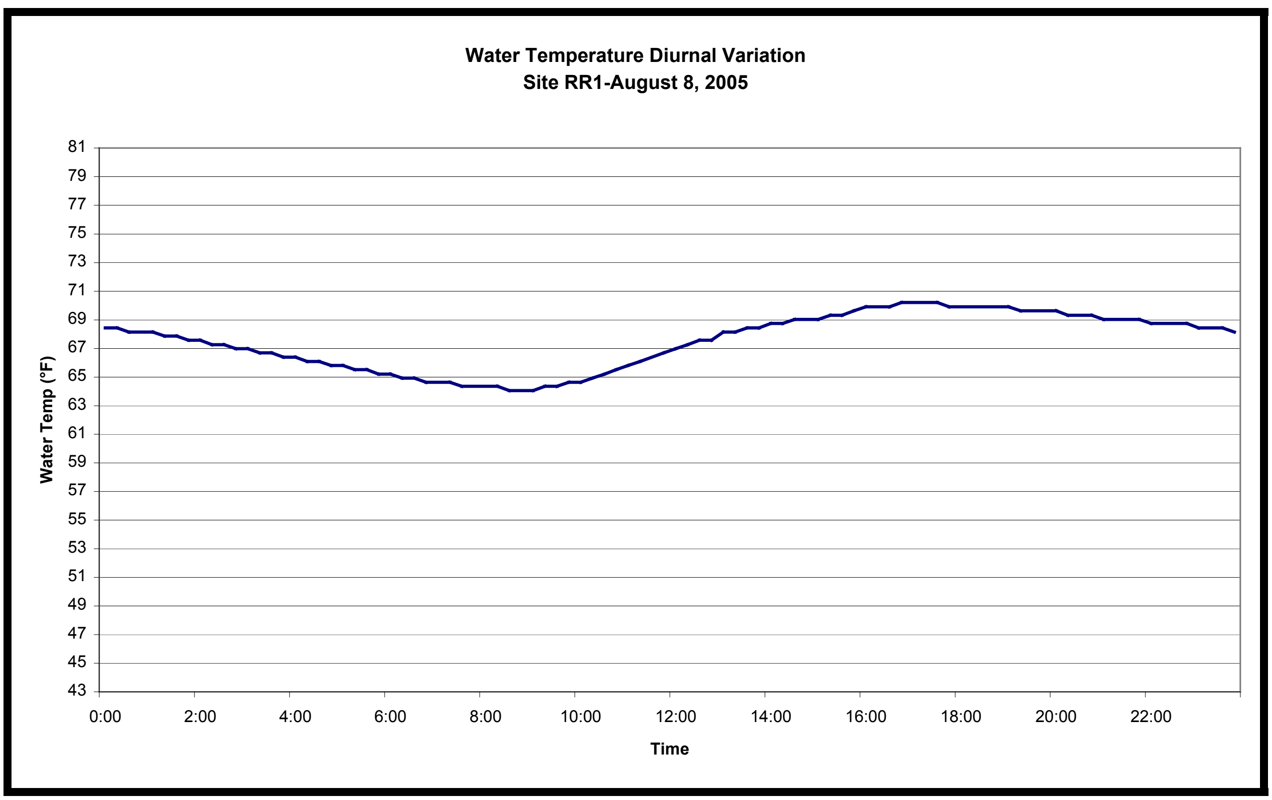



**Figure A- 58. The 15-minute interval water temperature data observed at RR1 during a particularly warm day in August to illustrate diurnal.**

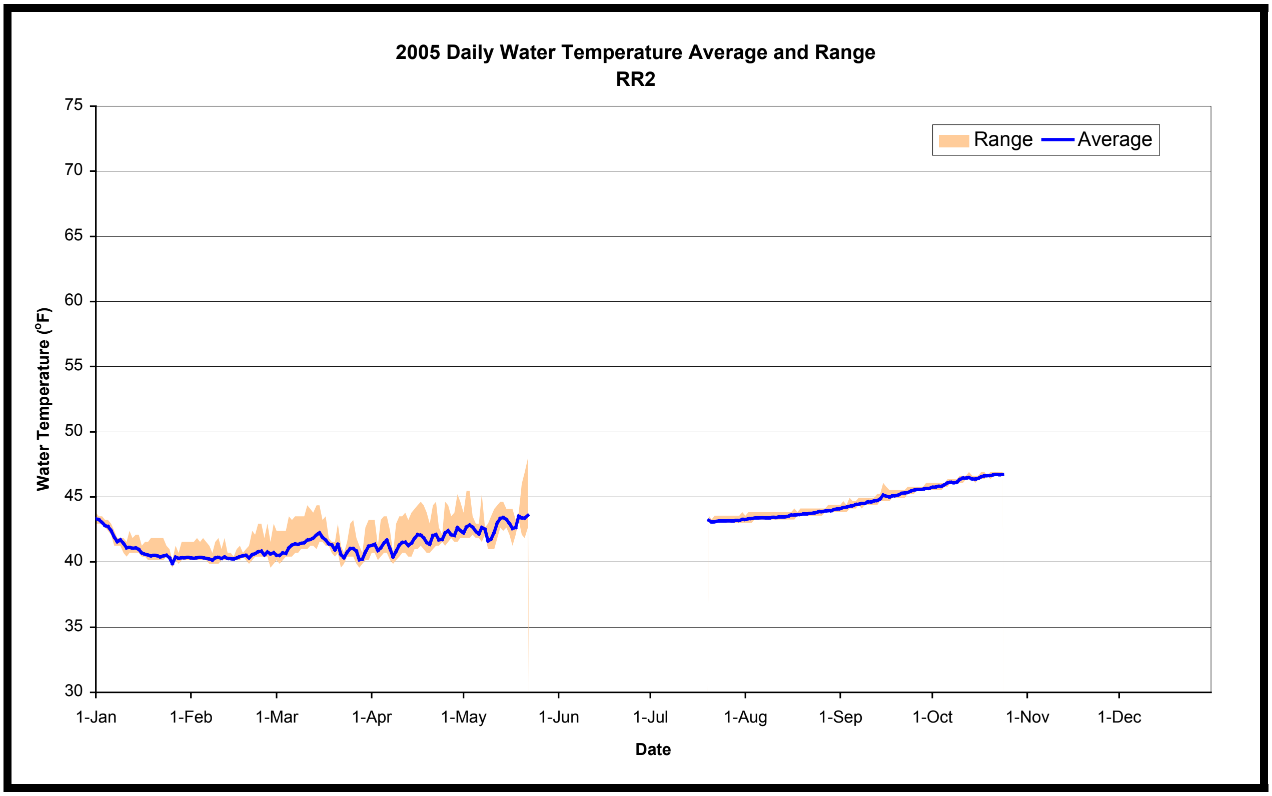



**Figure A- 59. The daily water temperature average and range measured at RR2 during 2005.**

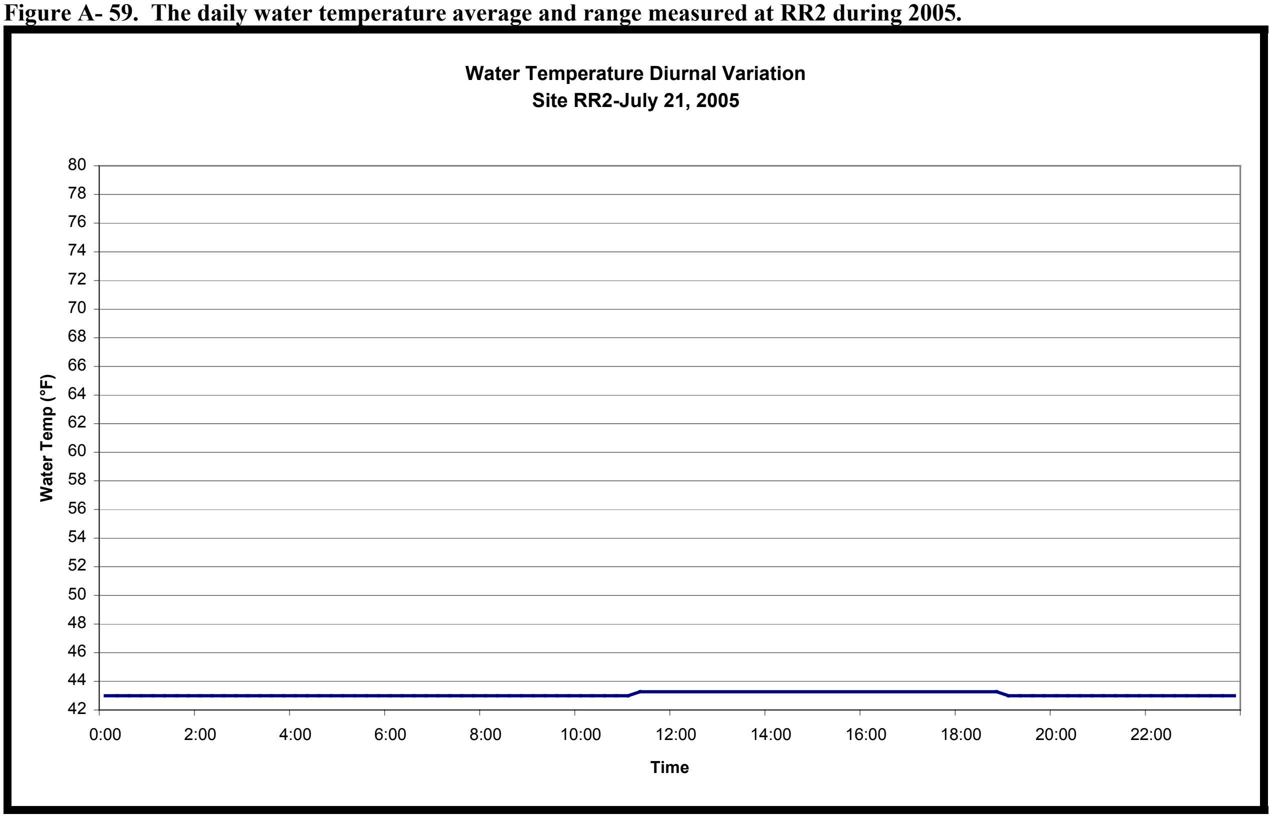



**Figure A- 60. The 15-minute interval water temperature data observed at RR2 during a particularly warm day in July to illustrate diurnal variation.**

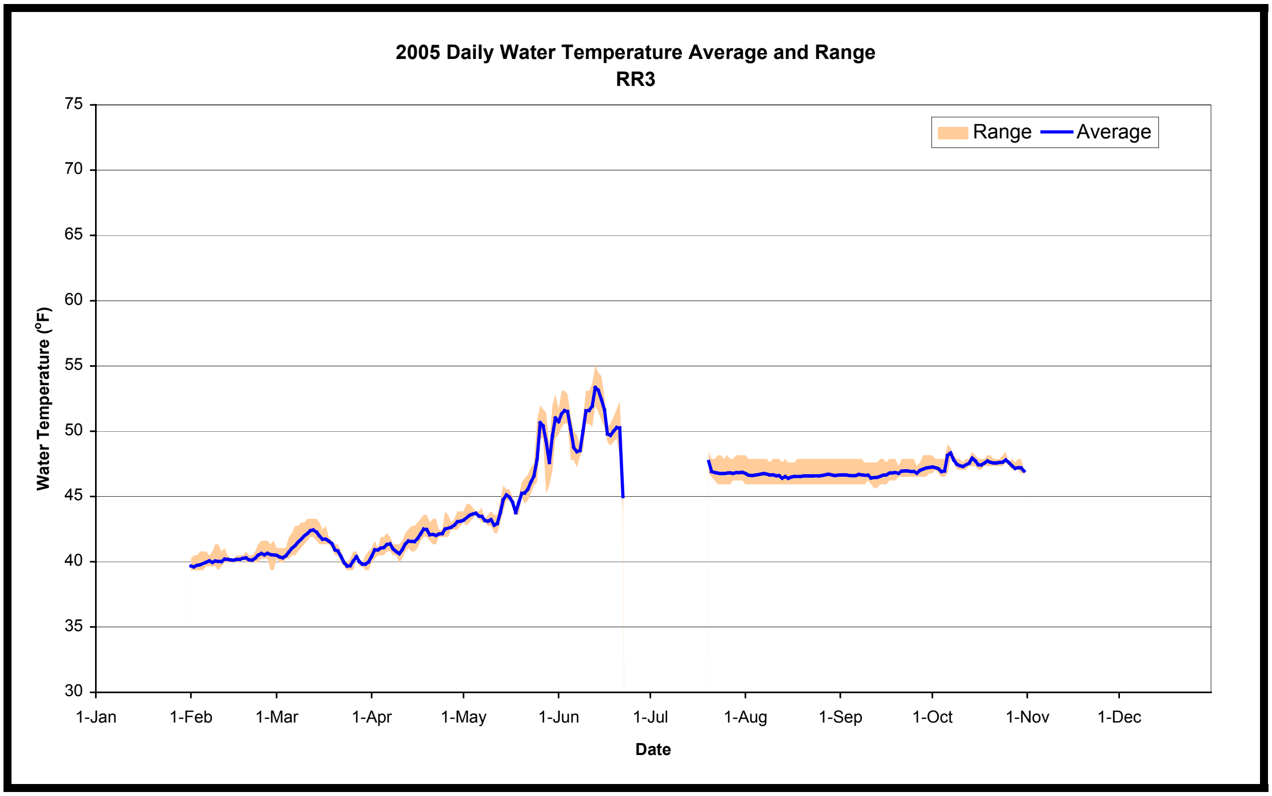



**Figure A- 61. The daily water temperature average and range measured at RR3 during 2005.**

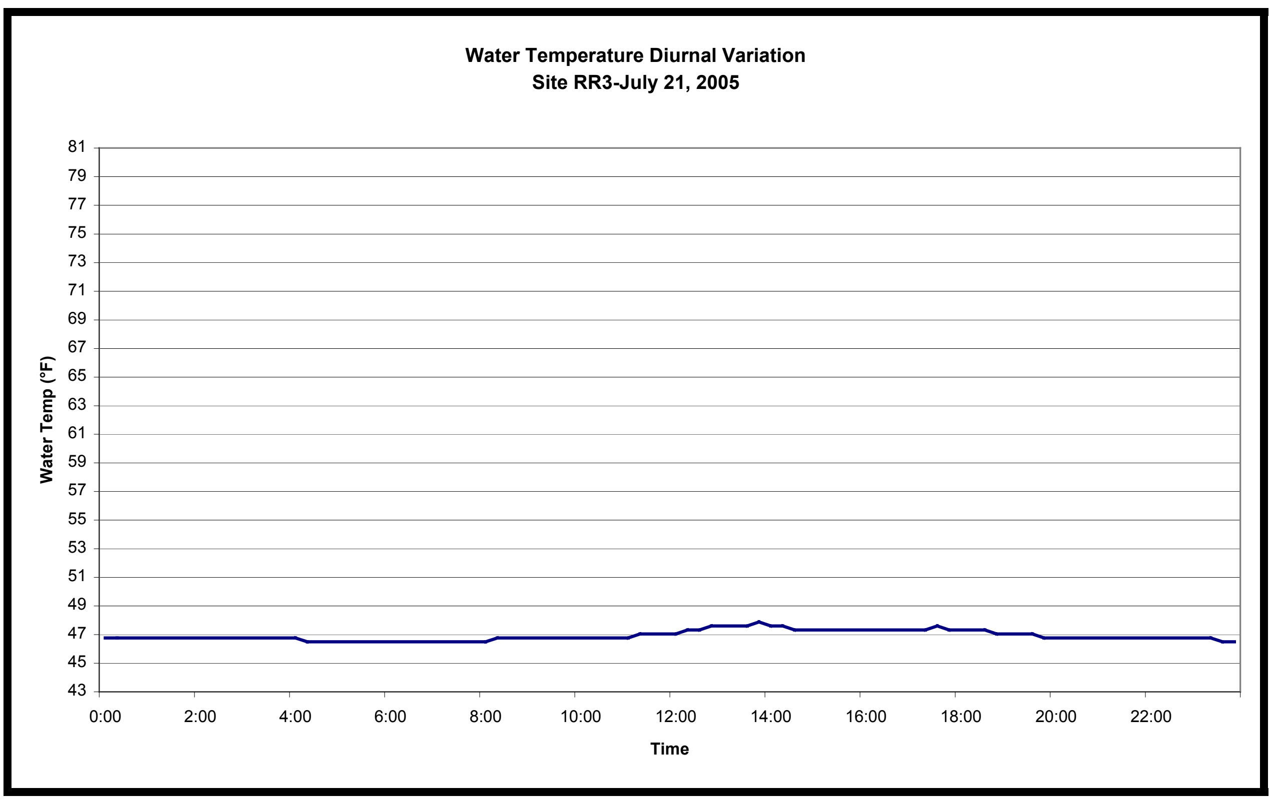



**Figure A- 62. The 15-minute interval water temperature data observed at RR3 during a particularly warm day in July to illustrate diurnal variation.**

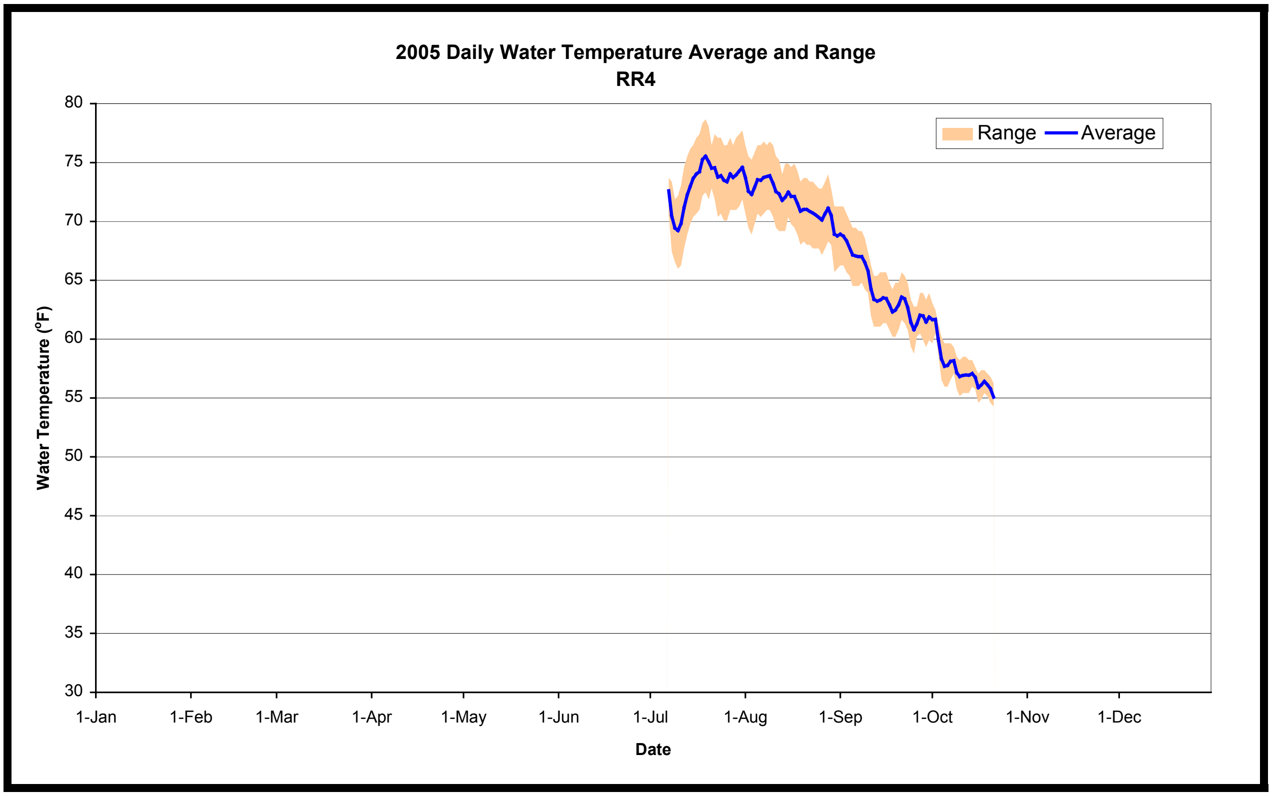



**Figure A- 63. The daily water temperature average and range measured at RR4 during 2005.**

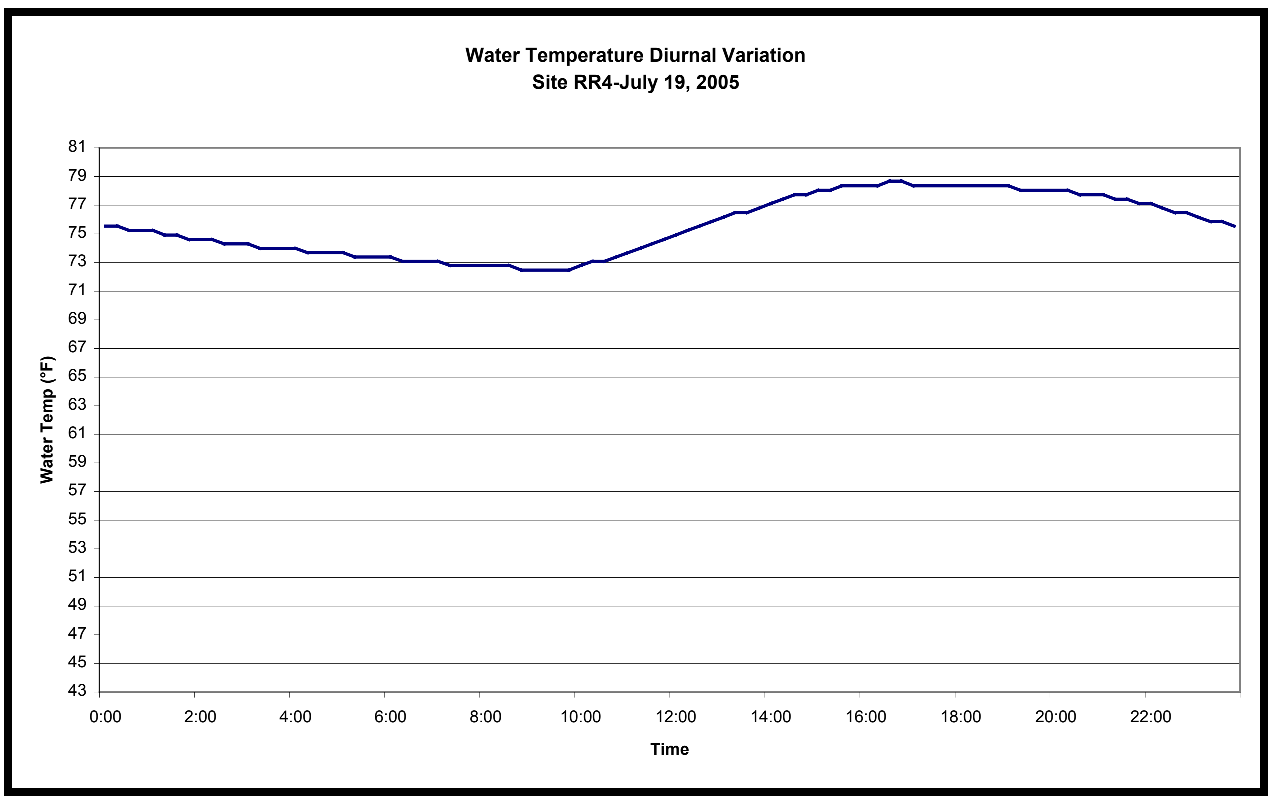



**Figure A- 64. The 15-minute interval water temperature data observed at RR4 during a particularly warm day in July to illustrate diurnal variation.**

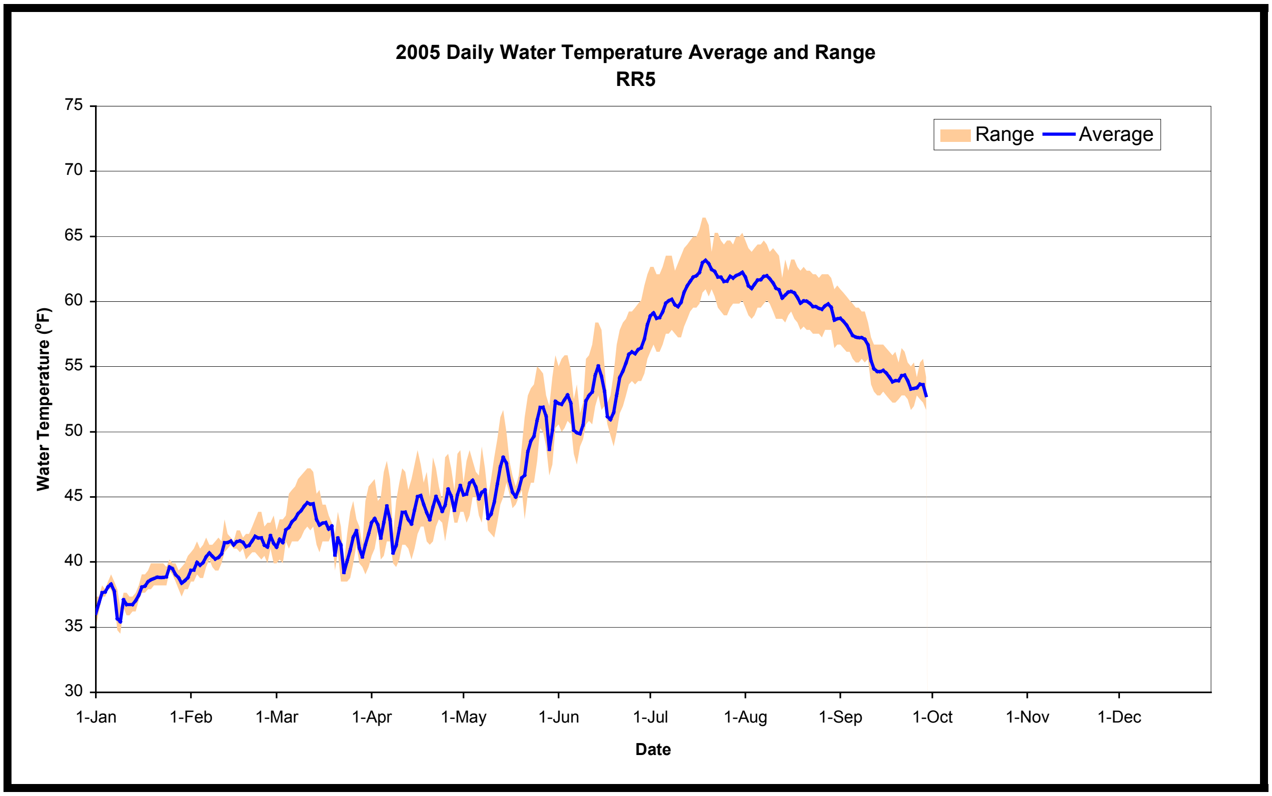



**Figure A- 65. The daily water temperature average and range measured at RR5 during 2005.**

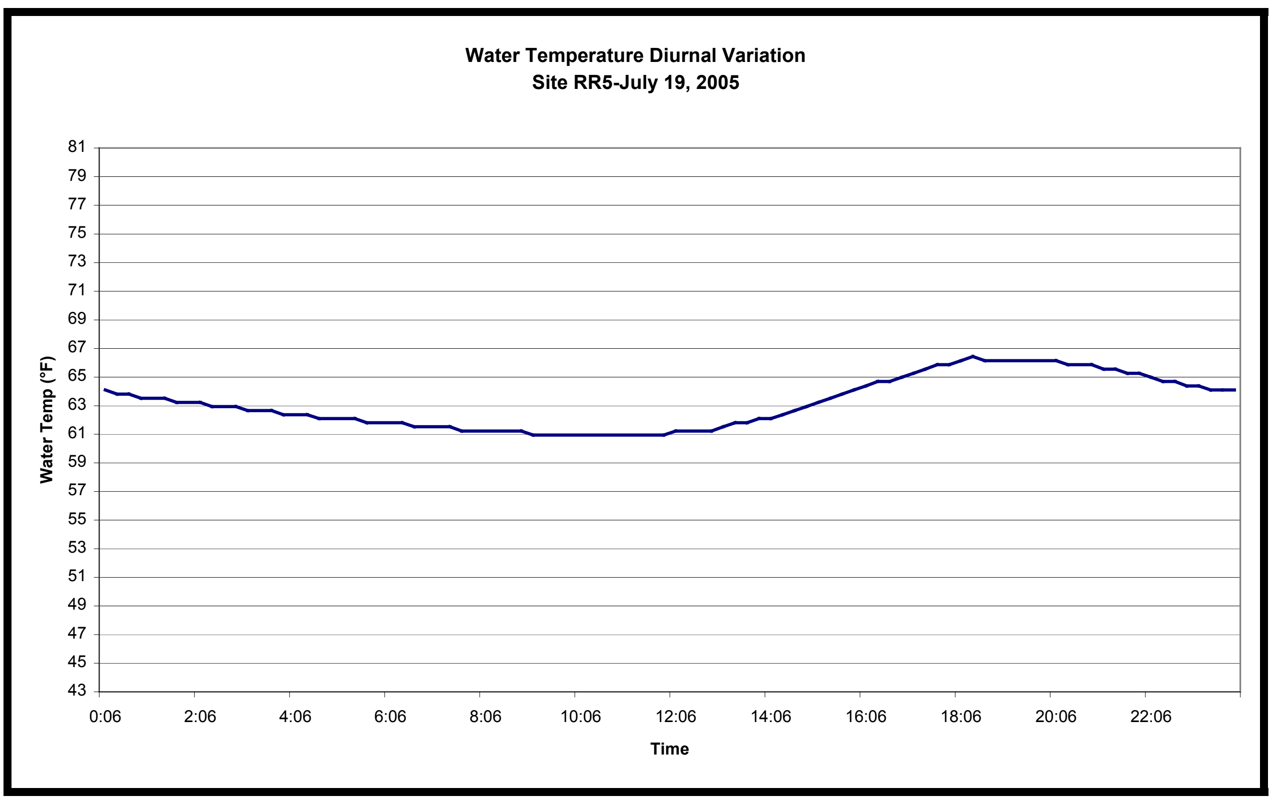



**Figure A- 66. The 15-minute interval water temperature data observed at RR5 during a particularly warm day in July to illustrate diurnal variation.**

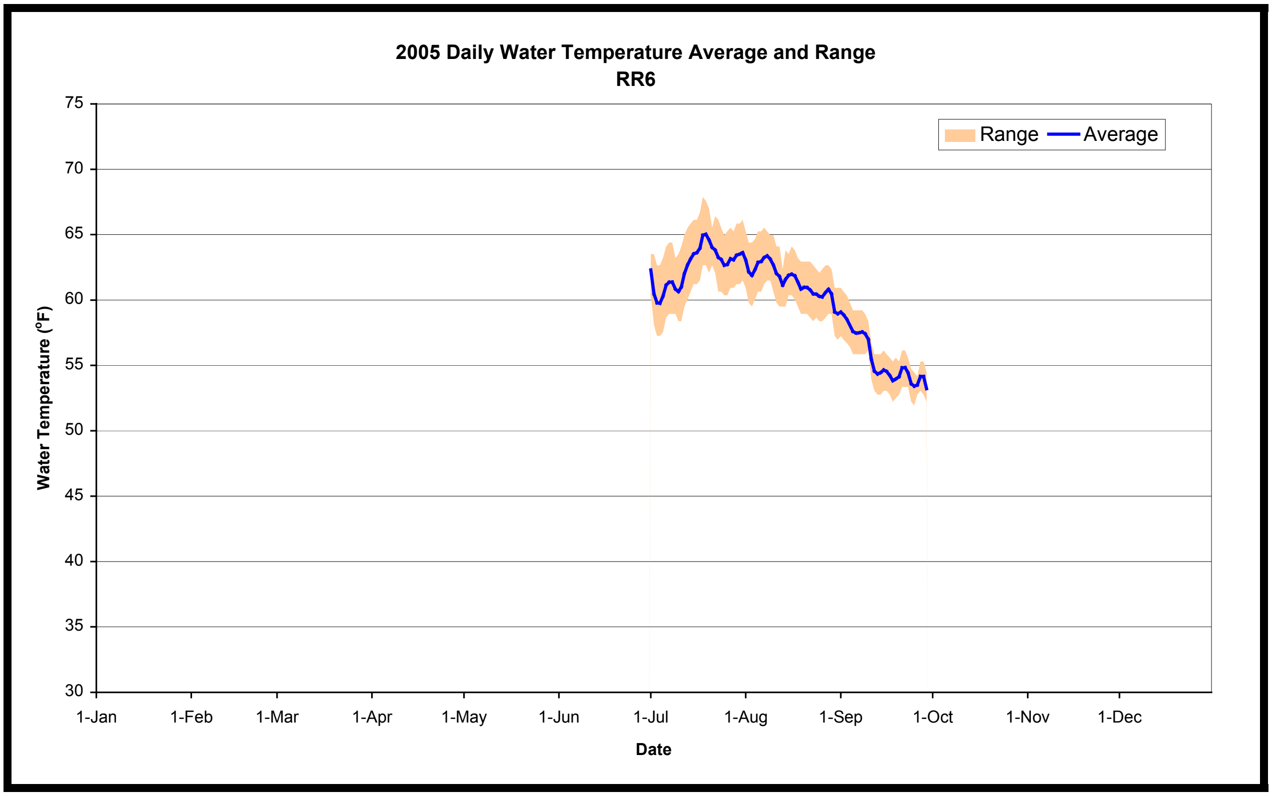



**Figure A- 67. The daily water temperature average and range measured at RR6 during 2005.**

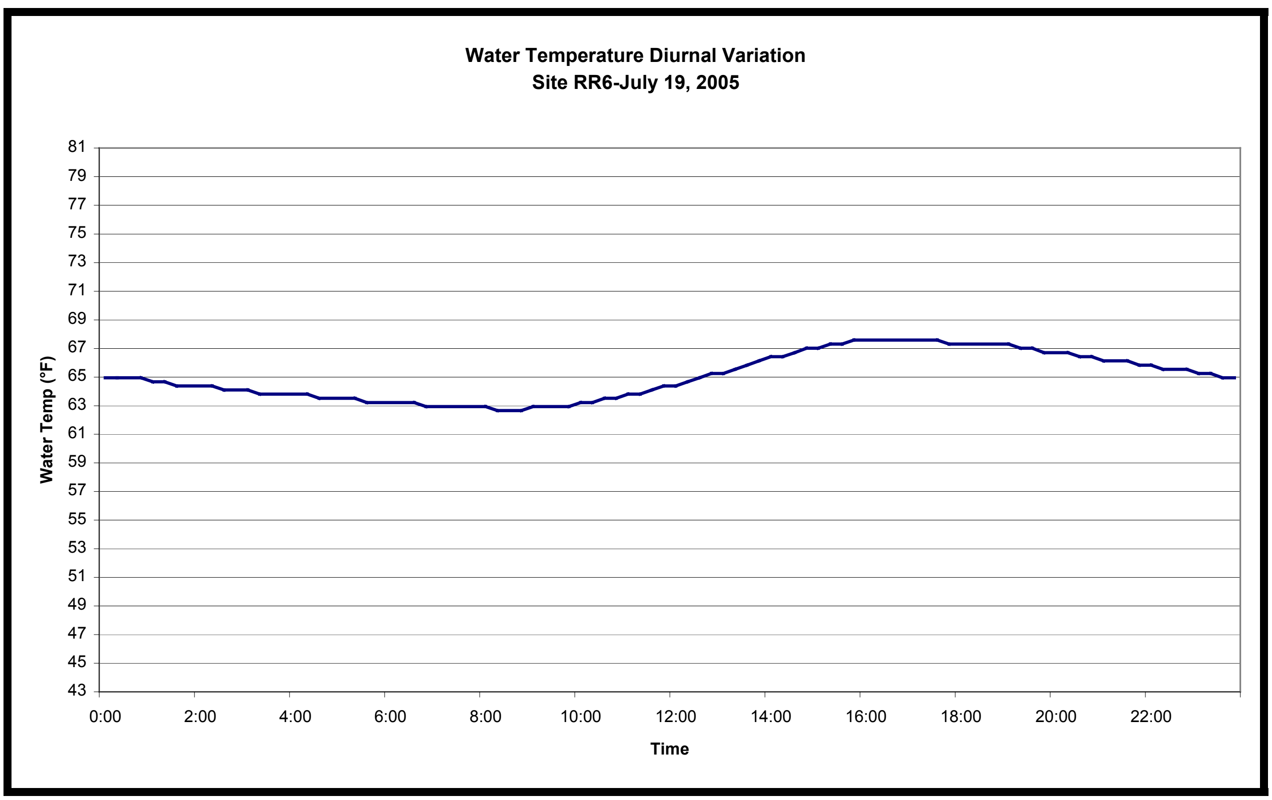



**Figure A- 68. The 15-minute interval water temperature data observed at RR6 during a particularly warm day in July to illustrate diurnal variation.**

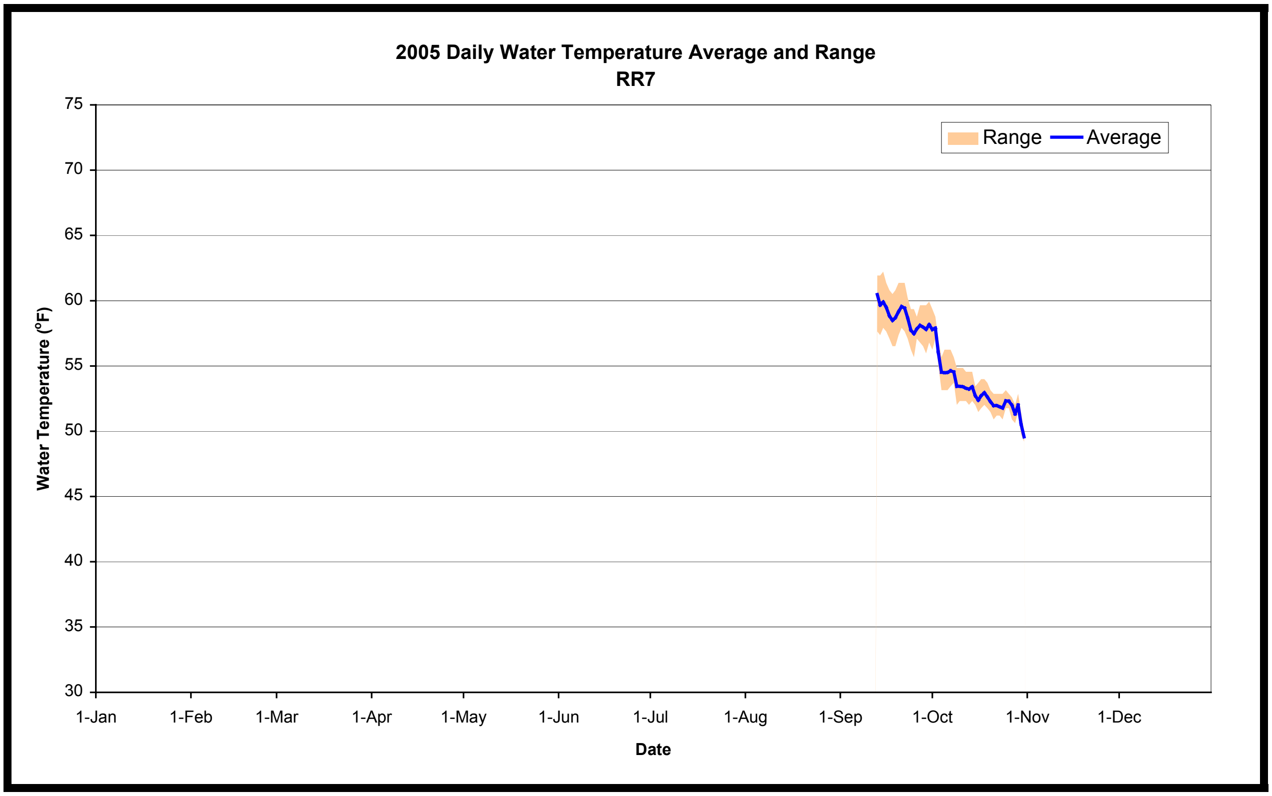



**Figure A- 69. The daily water temperature average and range measured at RR7 during 2005.**

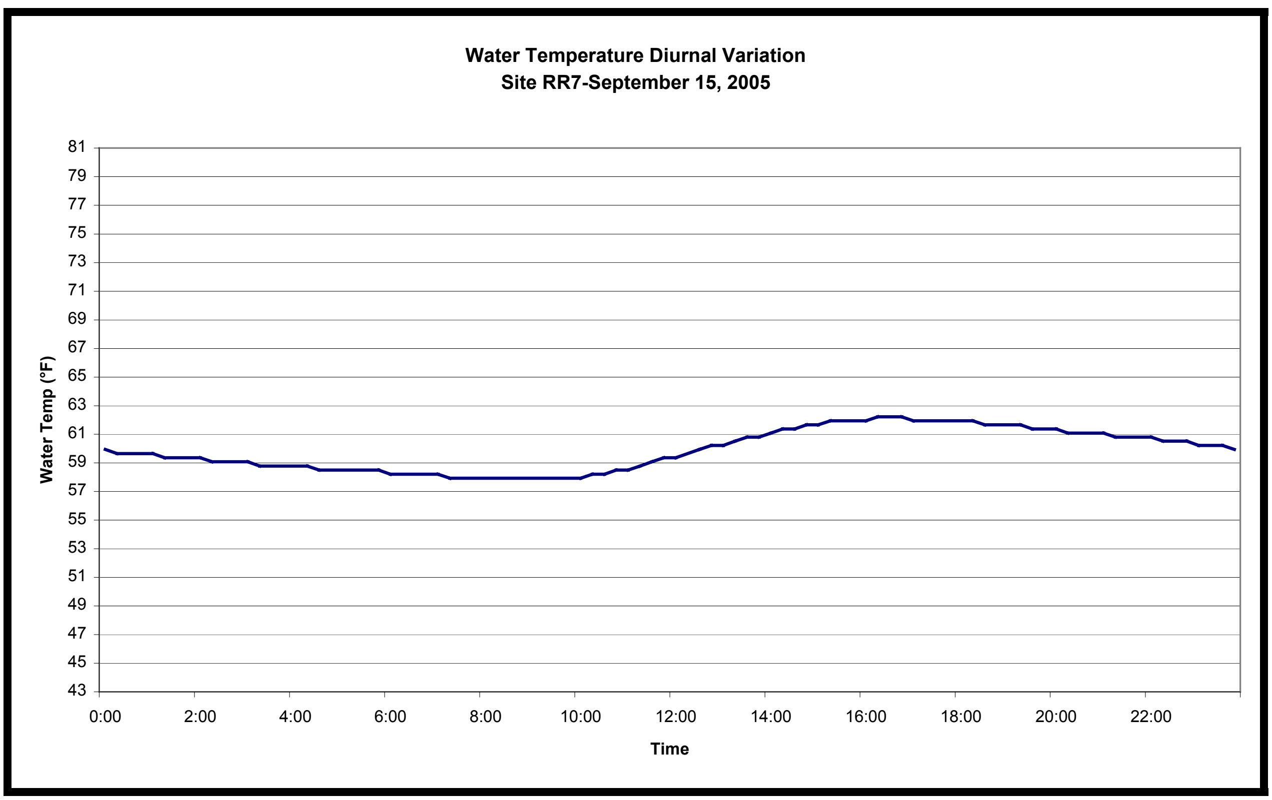



**Figure A- 70. The 15-minute interval water temperature data observed at RR7 during a particularly warm day in September to illustrate diurnal variation.**

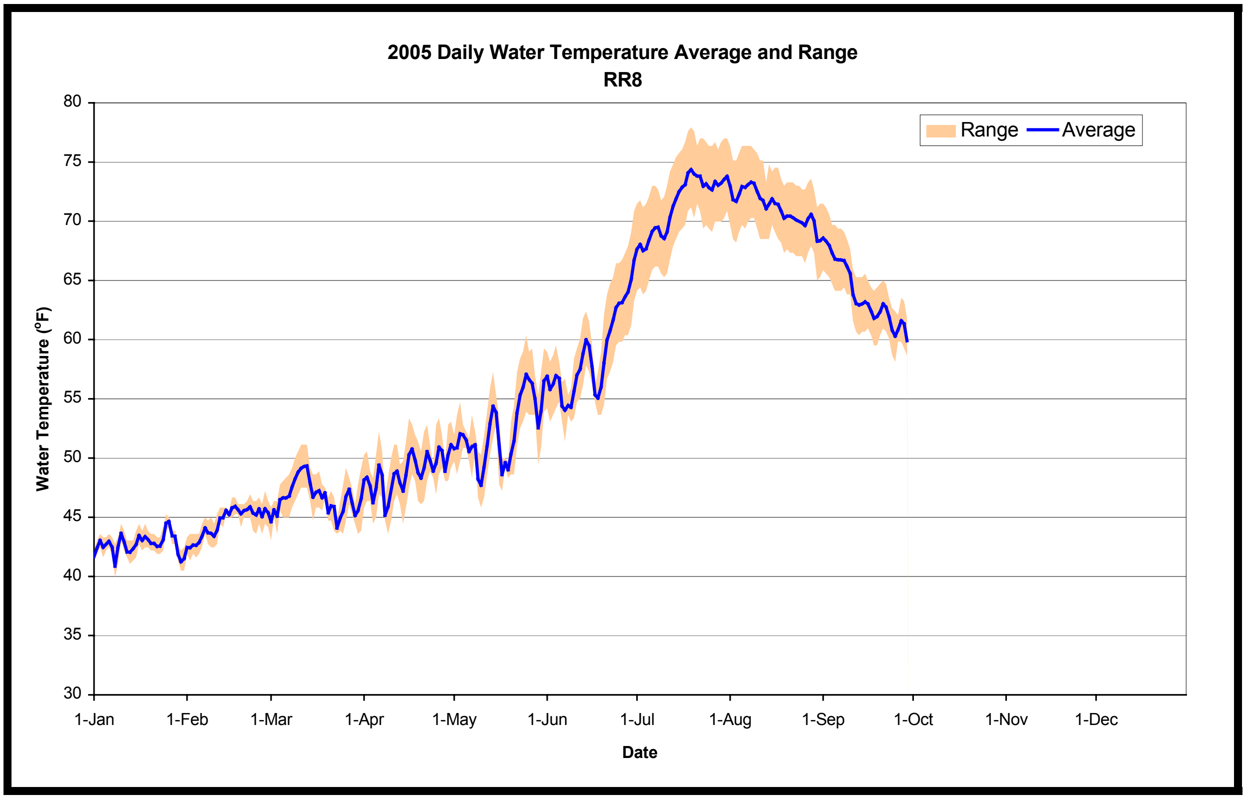



**Figure A- 71. The daily water temperature average and range measured at RR8 during 2005.**

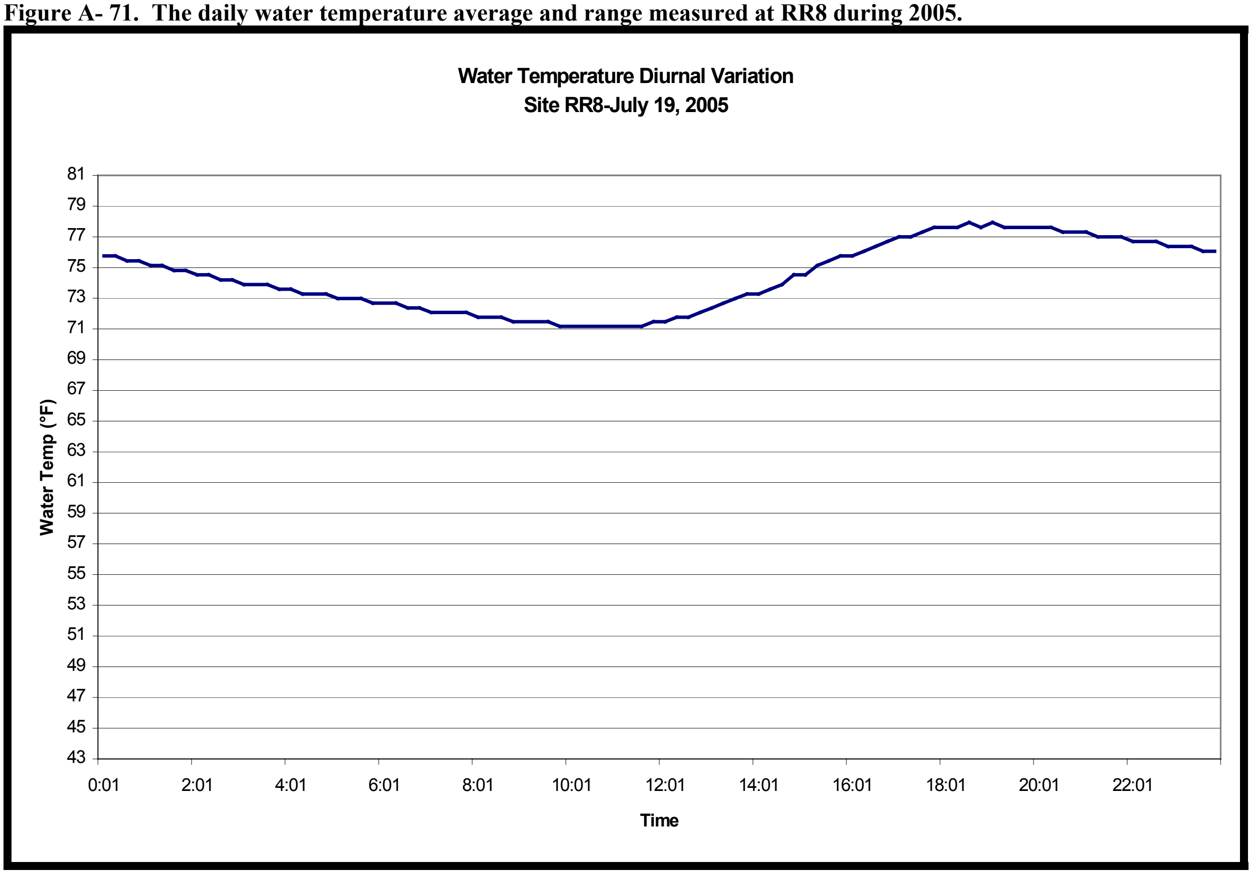



**Figure A- 72. The 15-minute interval water temperature data observed at RR8 during a particularly warm day in July to illustrate diurnal variation.**

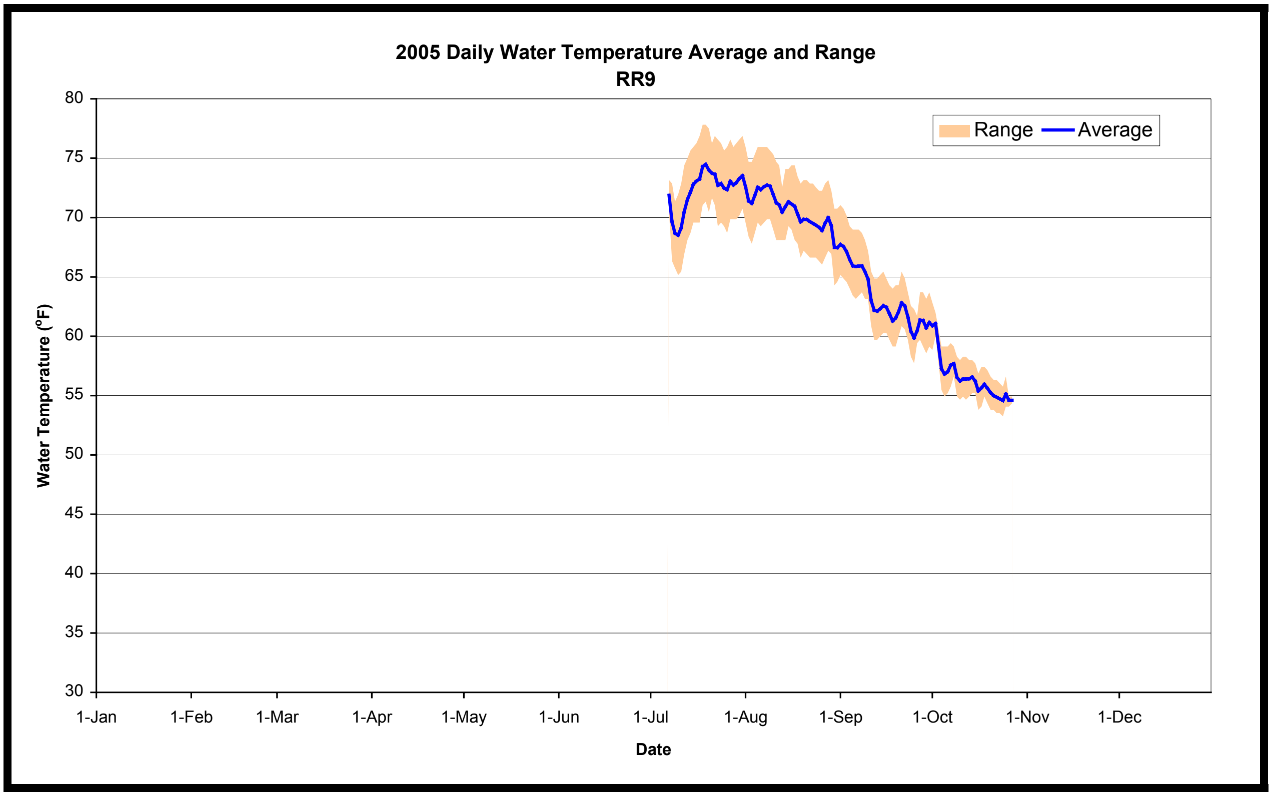



**Figure A- 73. The daily water temperature average and range measured at RR9 during 2005.**

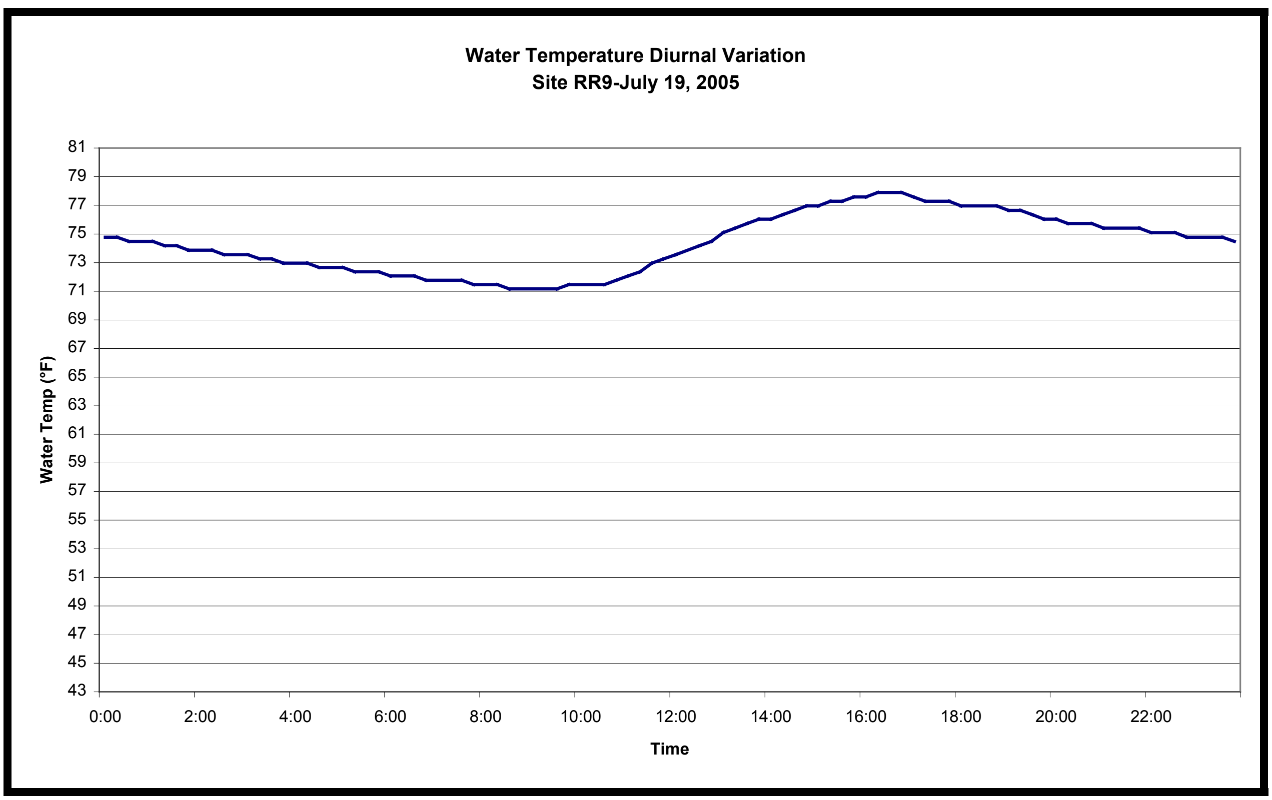



**Figure A- 74. The 15-minute interval water temperature data observed at RR9 during a particularly warm day in July to illustrate diurnal variation.**

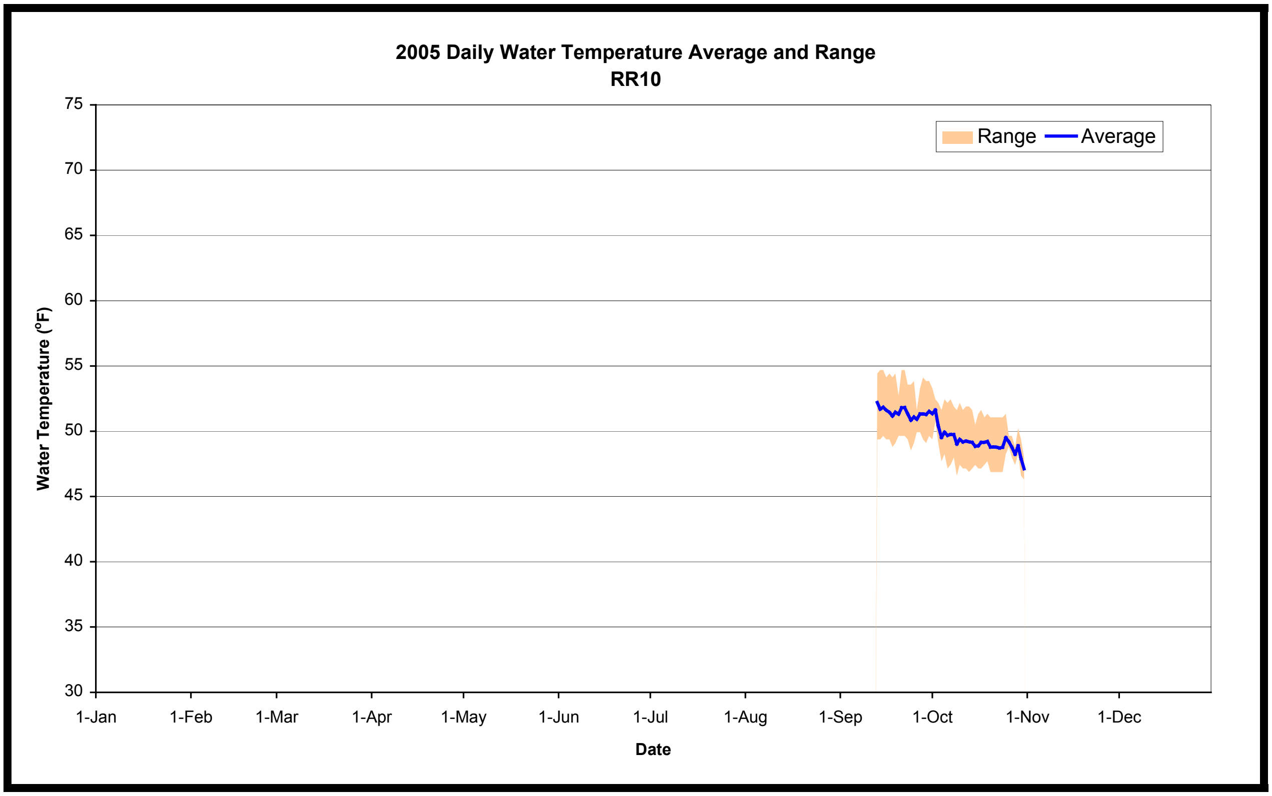



**Figure A- 75. The daily water temperature average and range measured at RR10 during 2005.**

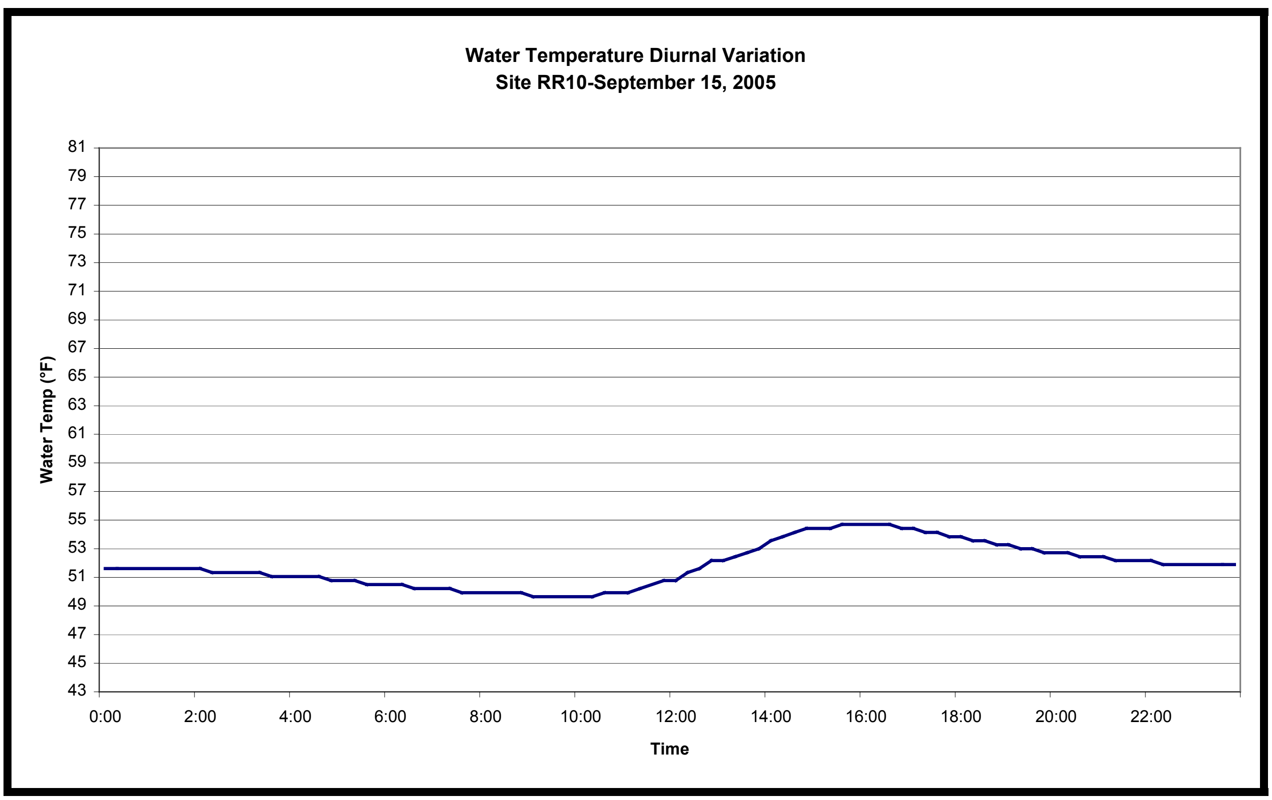



**Figure A- 76. The 15-minute interval water temperature data observed at RR10 during a particularly warm day in September to illustrate diurnal variation.**

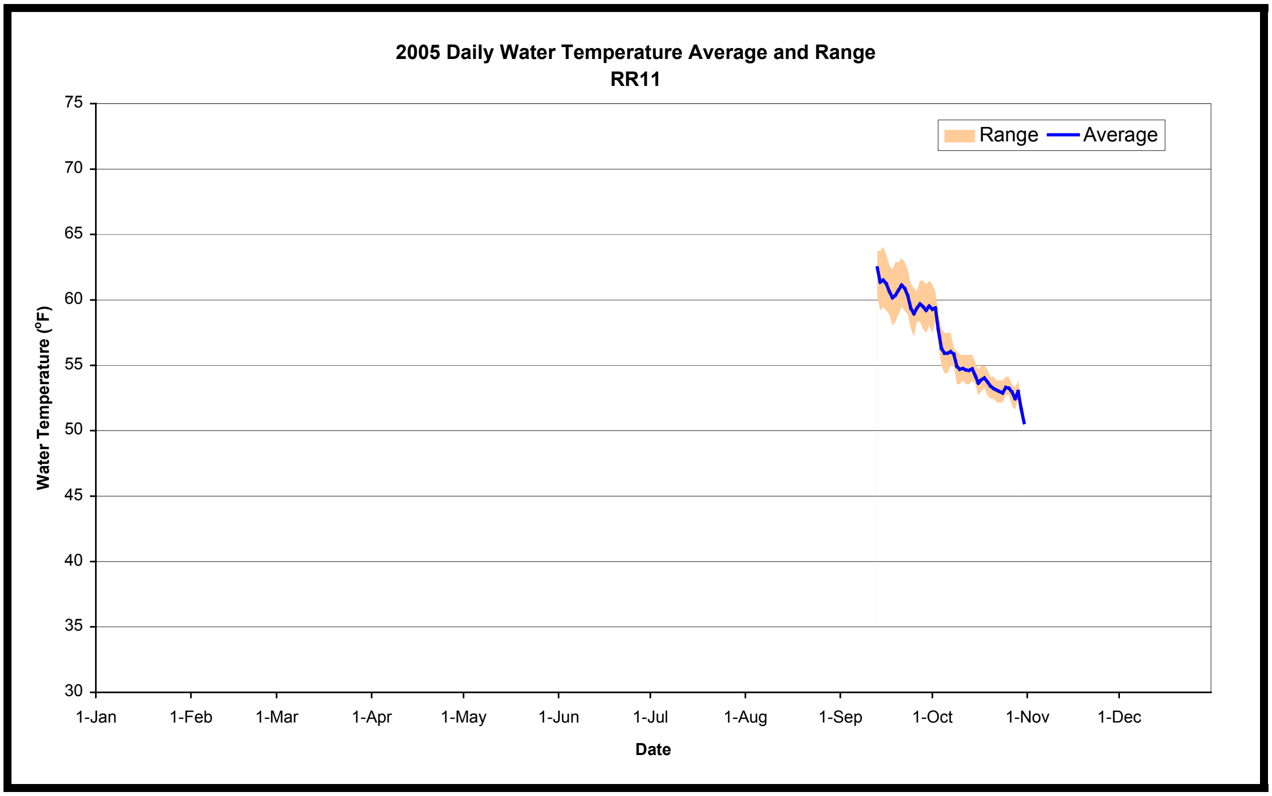



**Figure A- 77. The daily water temperature average and range measured at RR11 during 2005.**

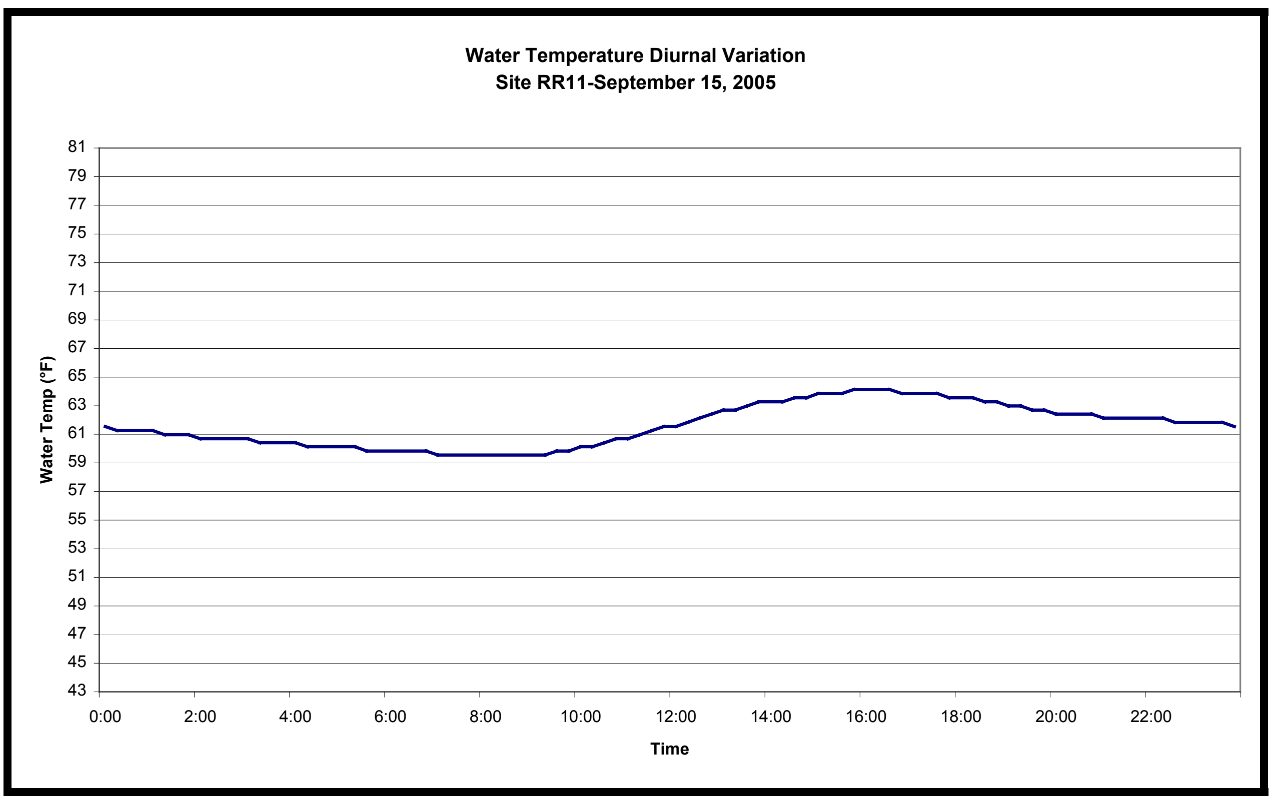



**Figure A- 78. The 15-minute interval water temperature data observed at RR11 during a particularly warm day in September to illustrate diurnal variation.**

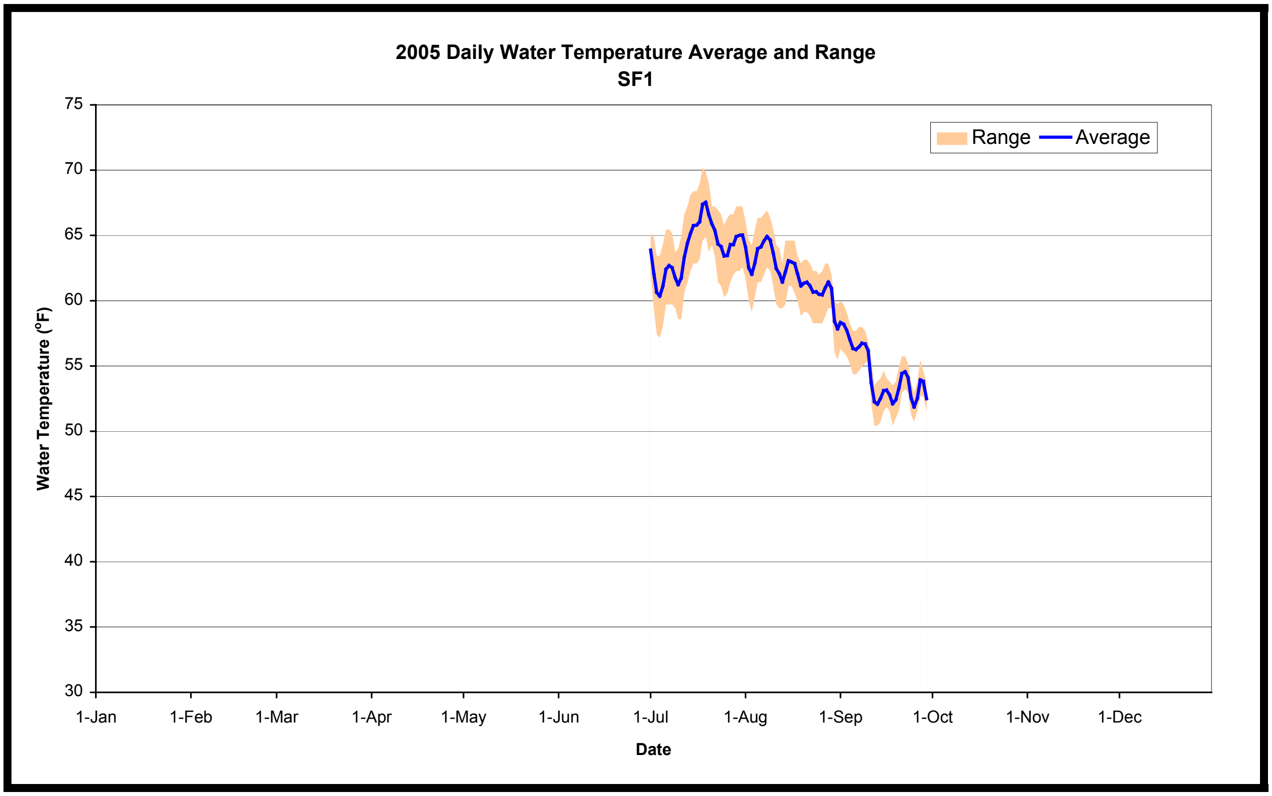



**Figure A- 79. The daily water temperature average and range measured at SF1 during 2005.**

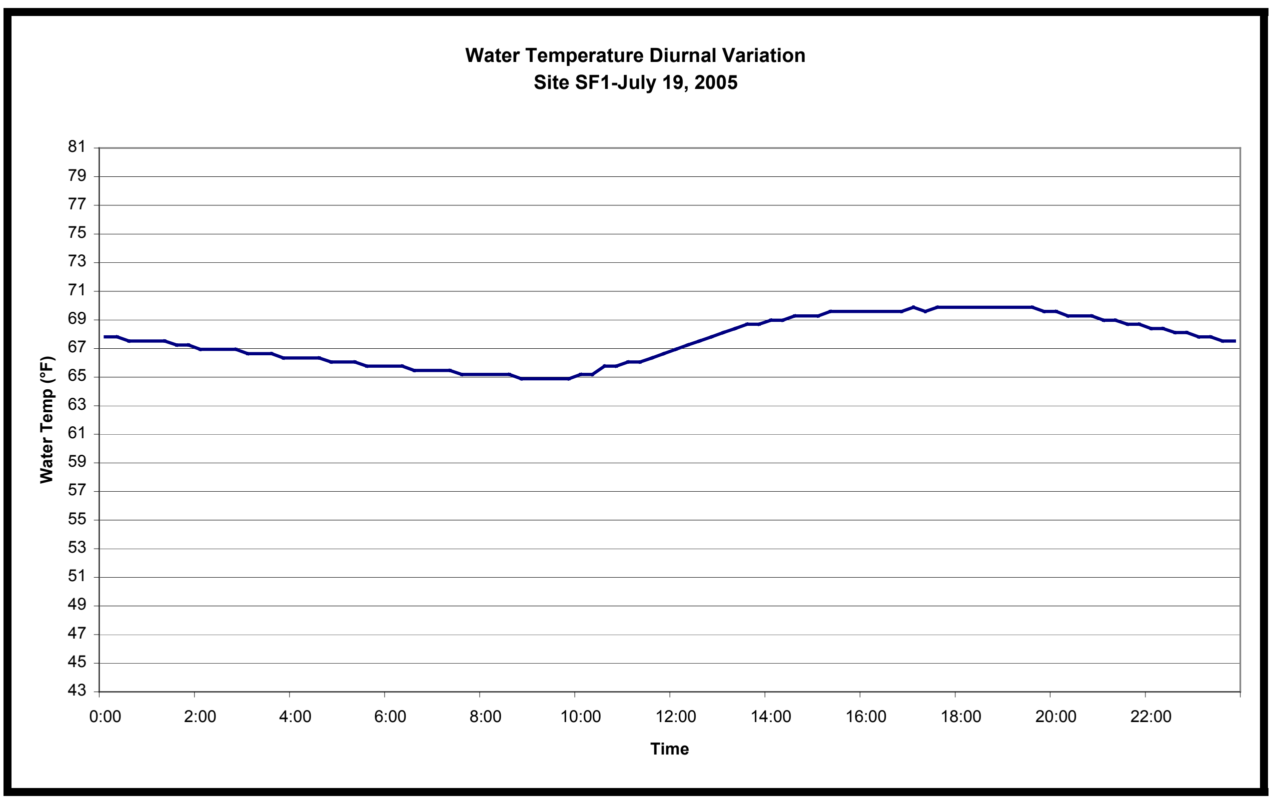



**Figure A- 80. The 15-minute interval water temperature data observed at SF1 during a particularly warm day in July to illustrate diurnal variation.**

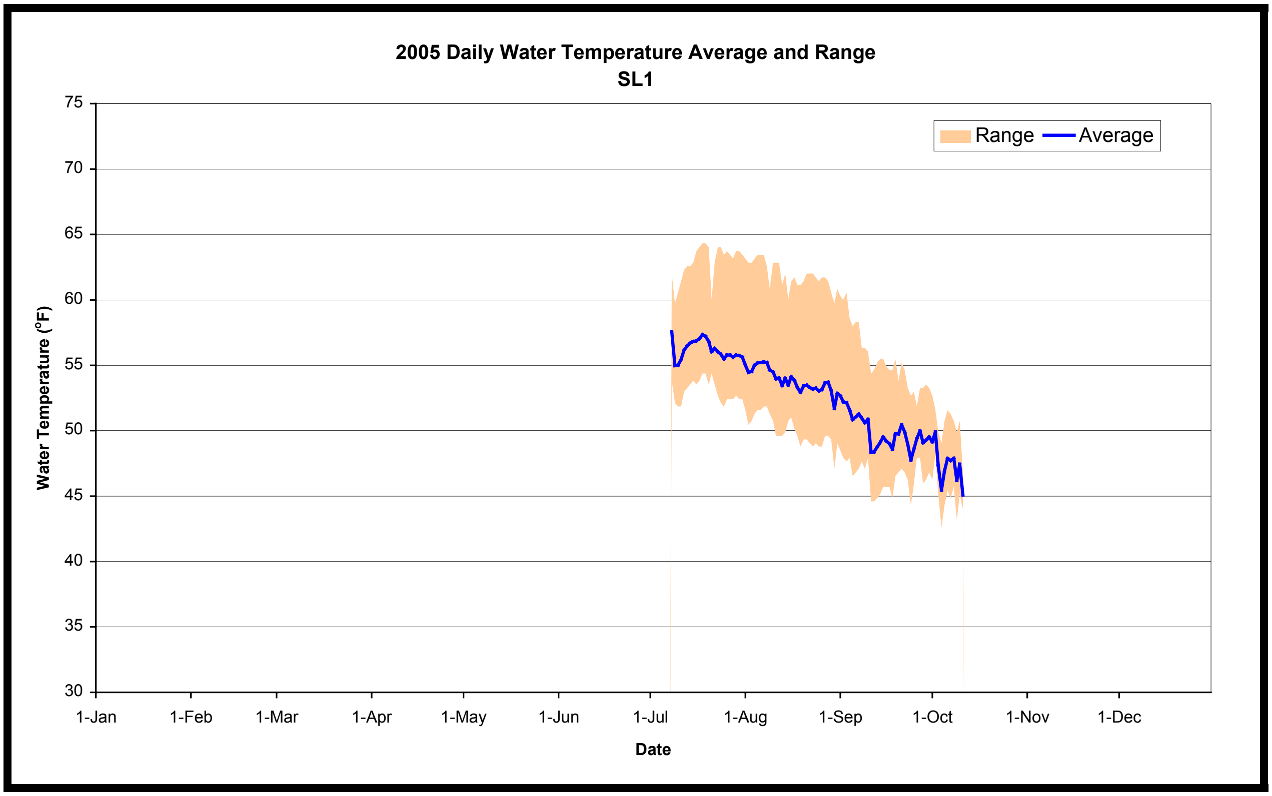



**Figure A- 81. The daily water temperature average and range measured at SL1 during 2005.**

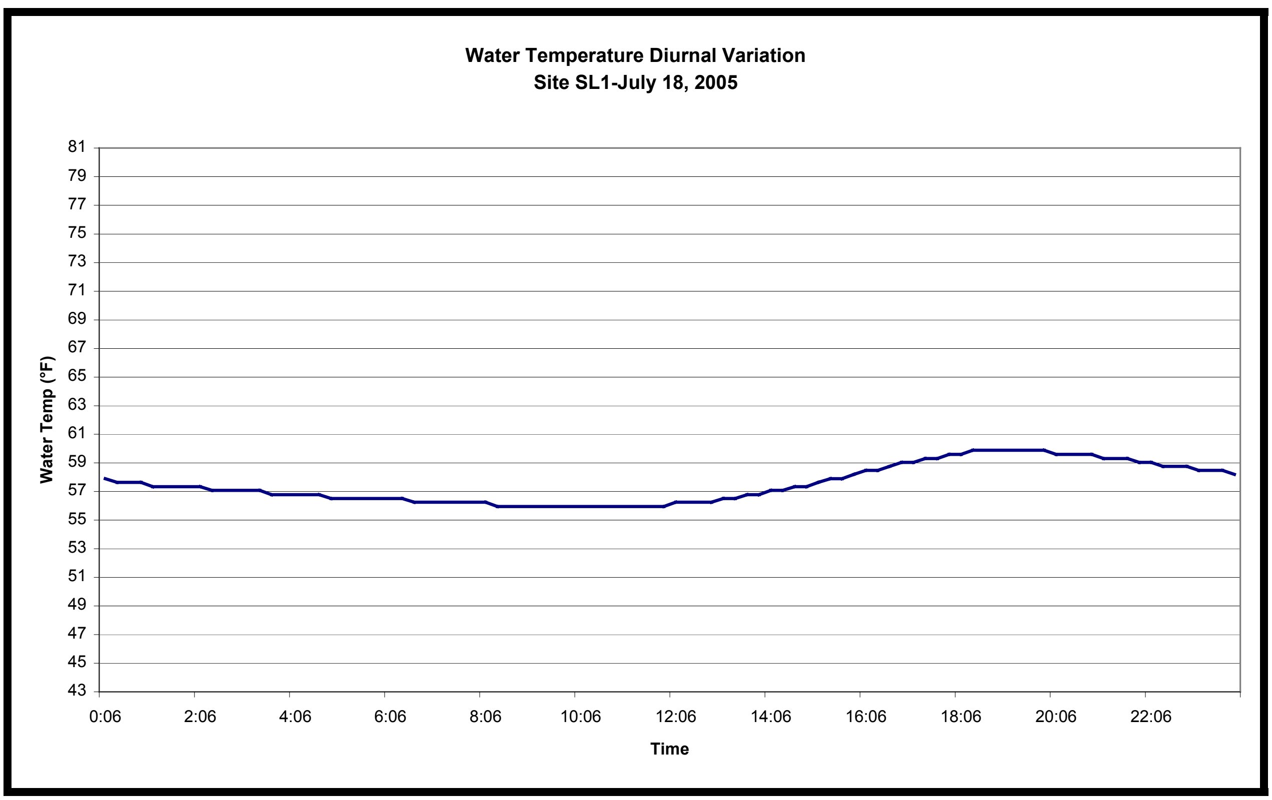



**Figure A- 82. The 15-minute interval water temperature data observed at SL1 during a particularly warm day in July to illustrate diurnal variation.**

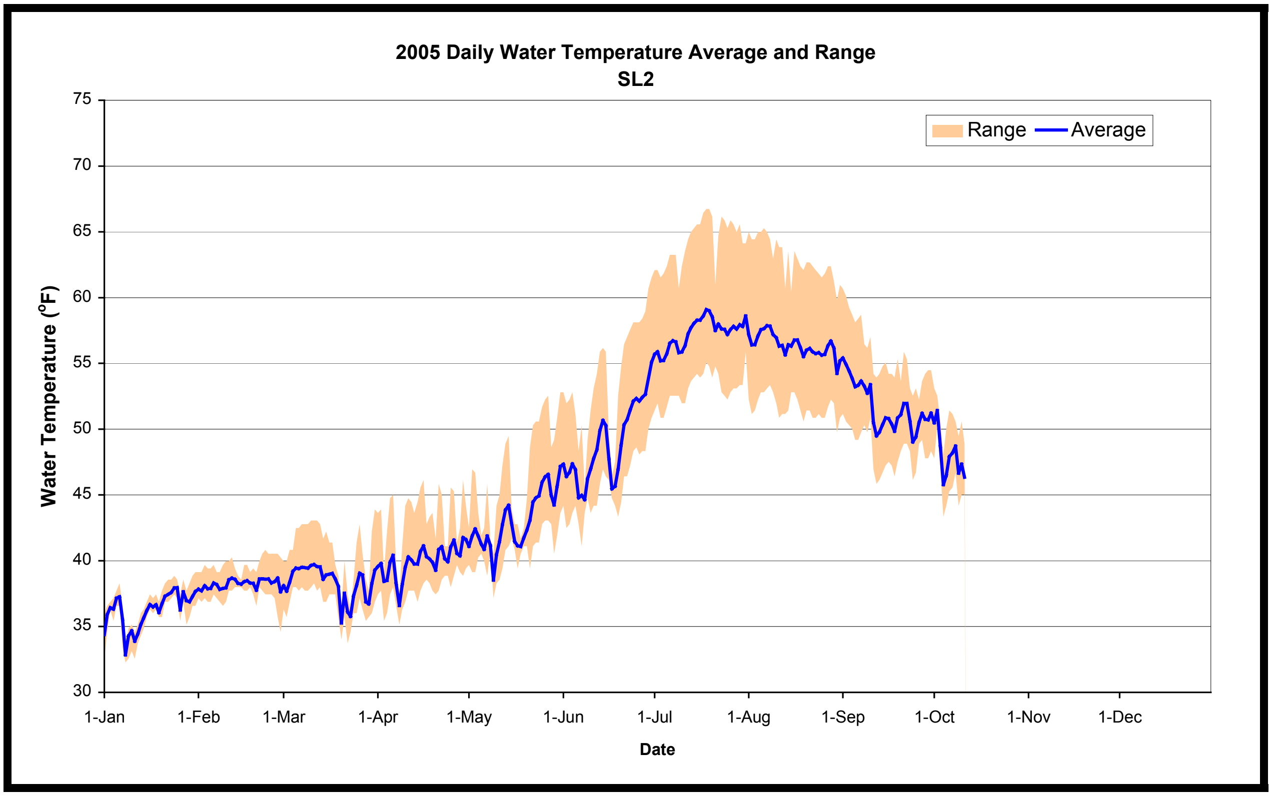



**Figure A- 83. The daily water temperature average and range measured at SL2 during 2005.**

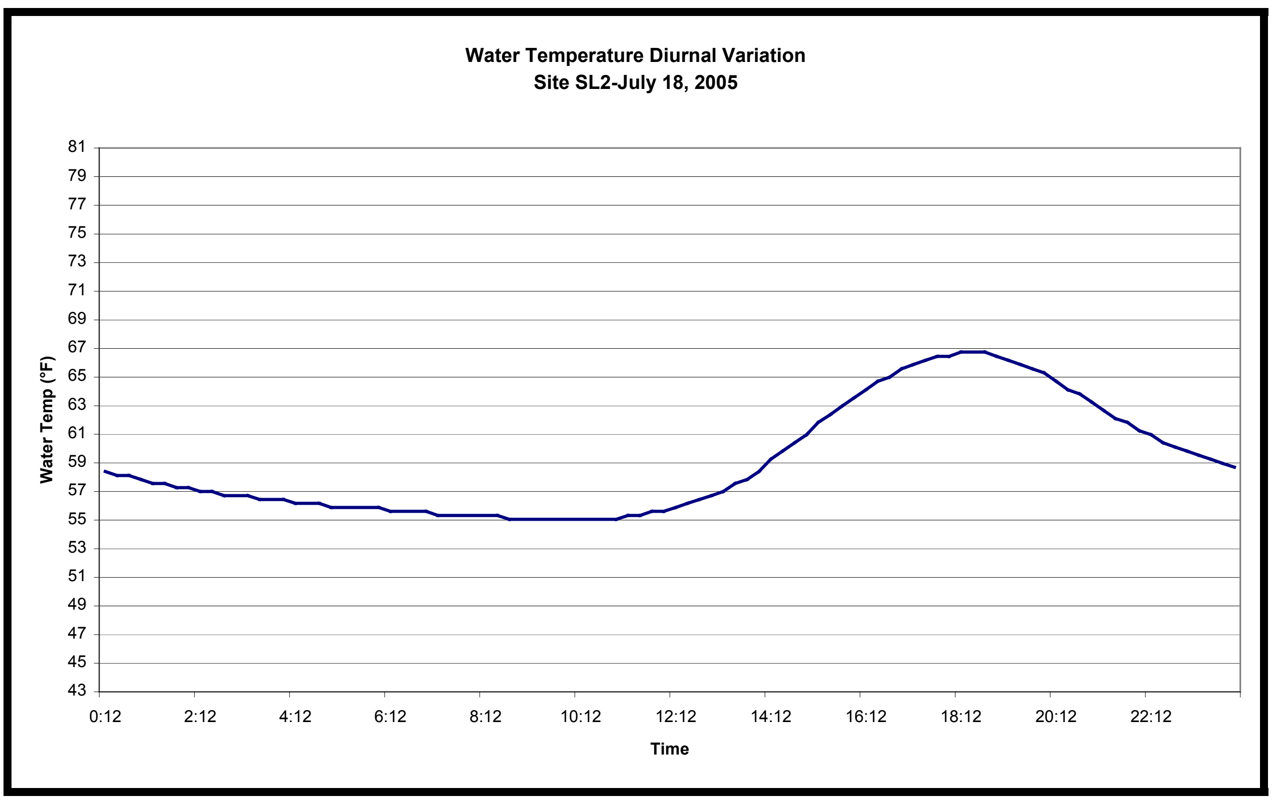



**Figure A- 84. The 15-minute interval water temperature data observed at SL2 during a particularly warm day in July to illustrate diurnal variation.**

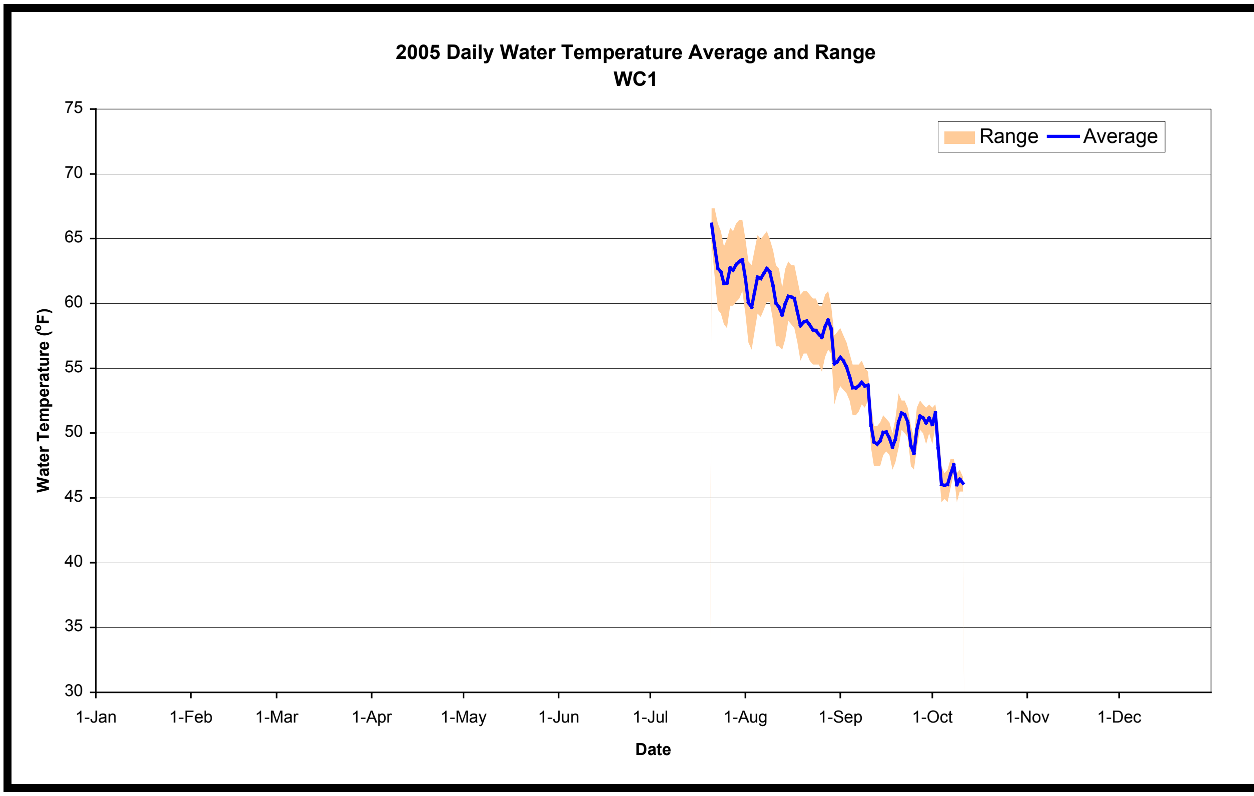



**Figure A- 85. The daily water temperature average and range measured at WC1 during 2005.**

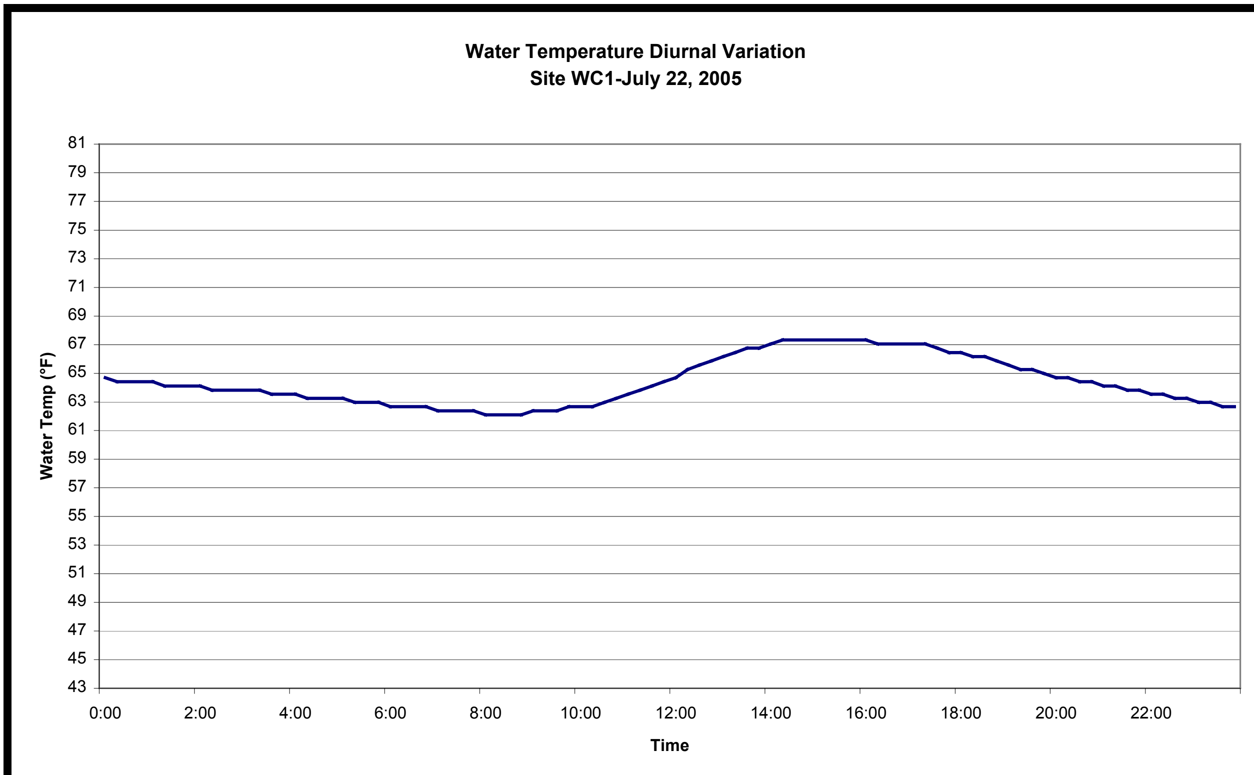



**Figure A- 86. The 15-minute interval water temperature data observed at WC1 during a particularly warm day in July to illustrate diurnal variation.**

# APPENDIX B

## Plots of 2005 Reservoir Water Temperature, Dissolved Oxygen, and Specific Conductance Profiles

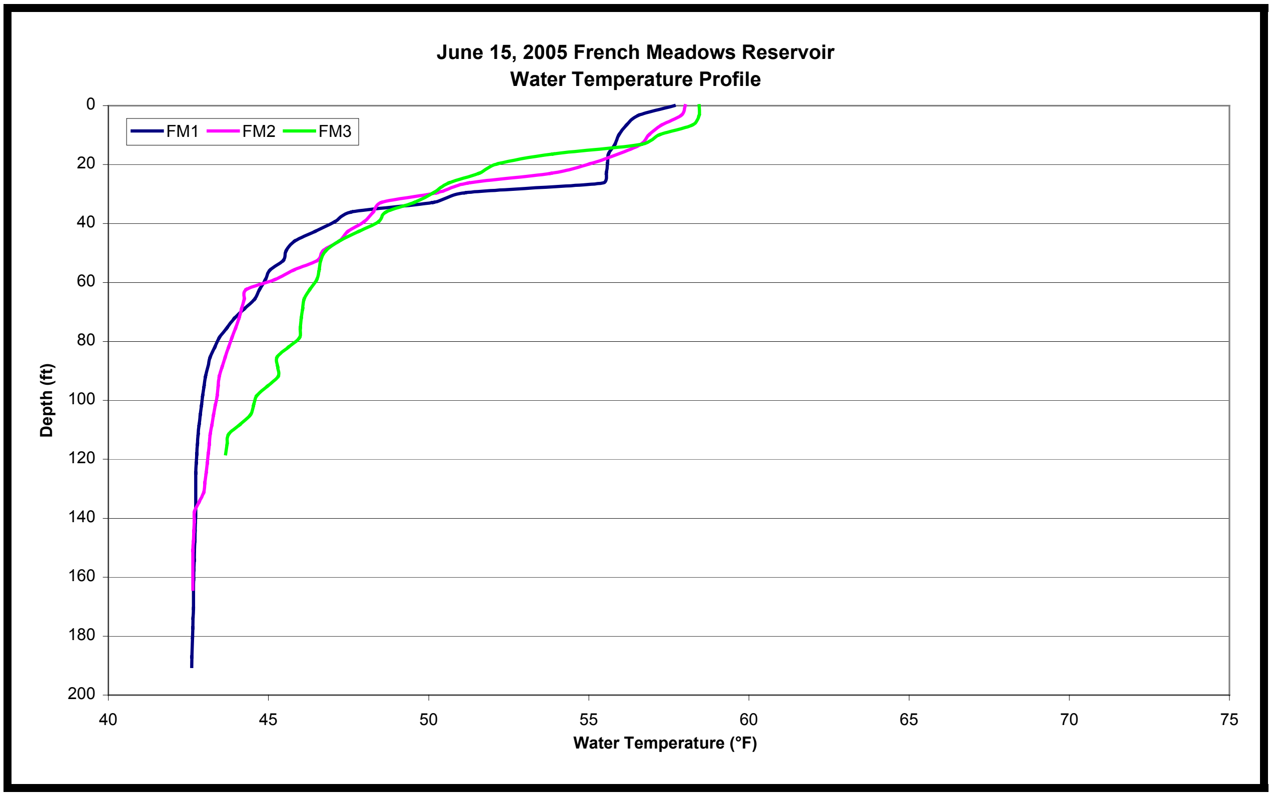



**Figure B- 1. The French Meadows Reservoir water temperature profiles at FM1, FM2, and FM3 on June 15, 2005.**

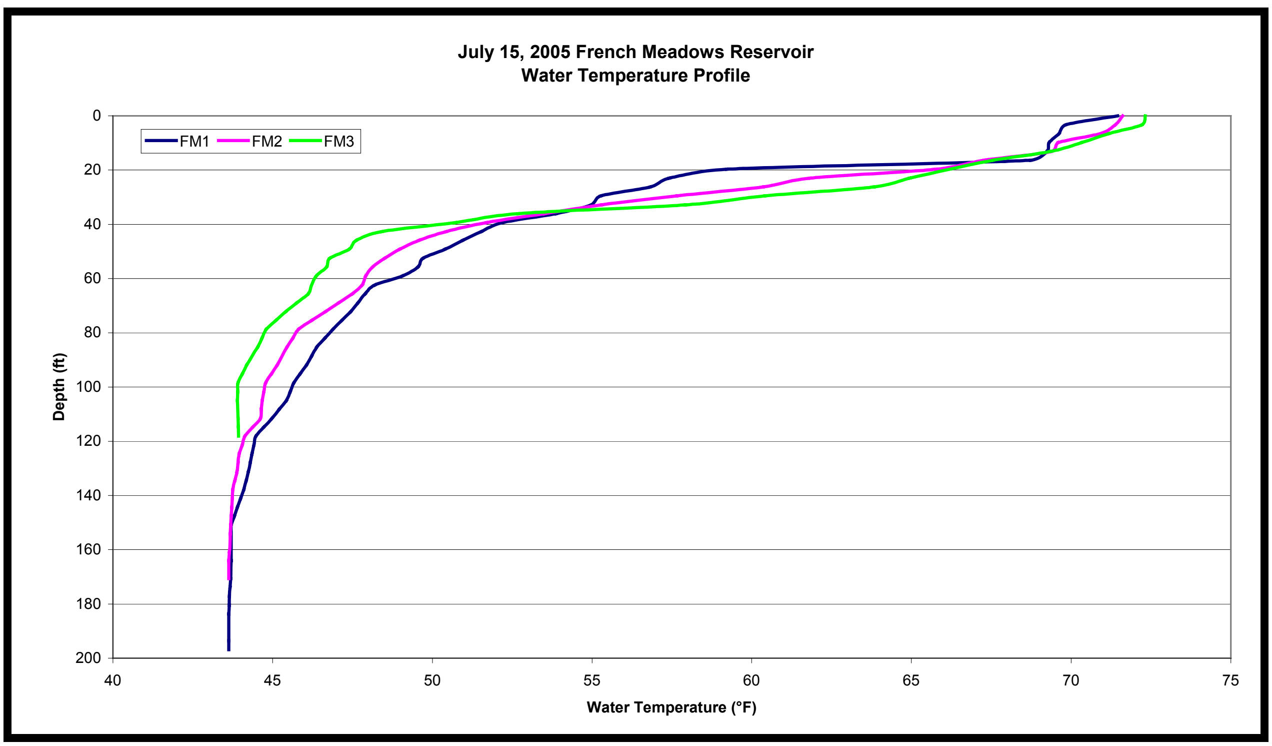



**Figure B- 2. The French Meadows Reservoir water temperature profiles at FM1, FM2, and FM3 on July 15, 2005.**

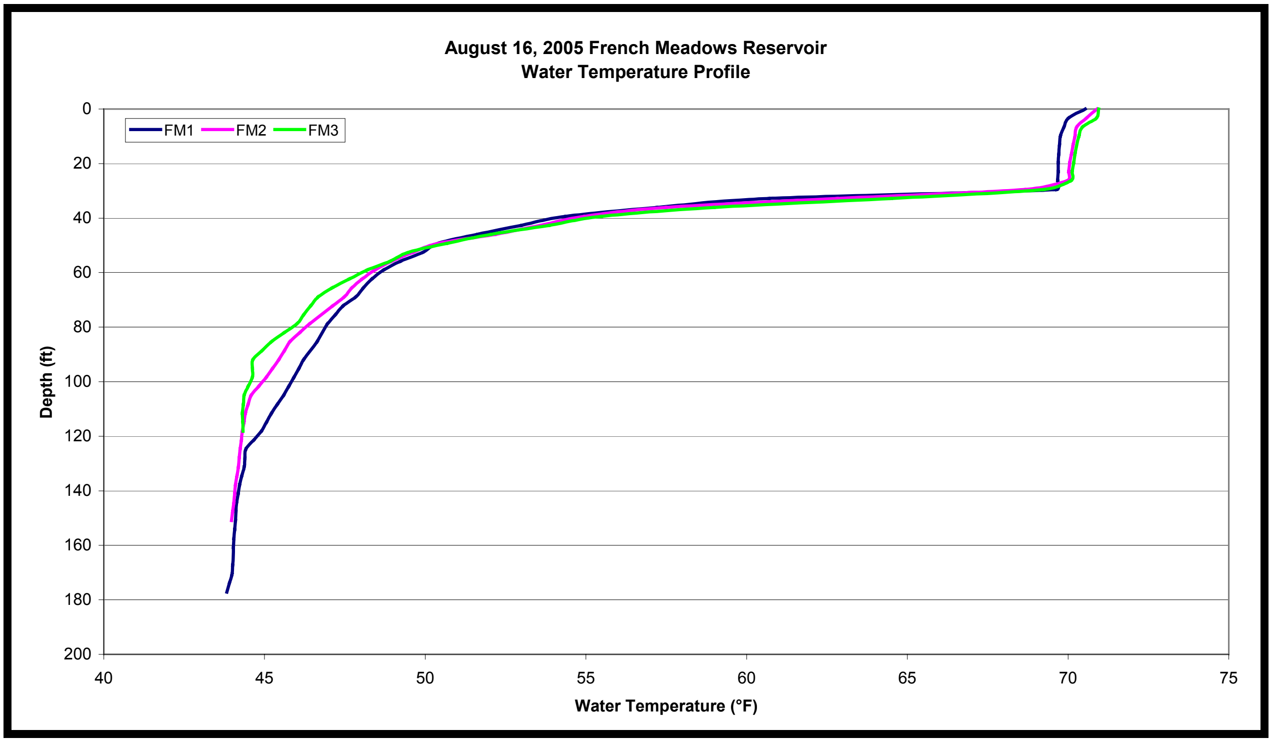



**Figure B- 3. The French Meadows Reservoir water temperature profiles at FM1, FM2, and FM3 on August 16, 2005.**

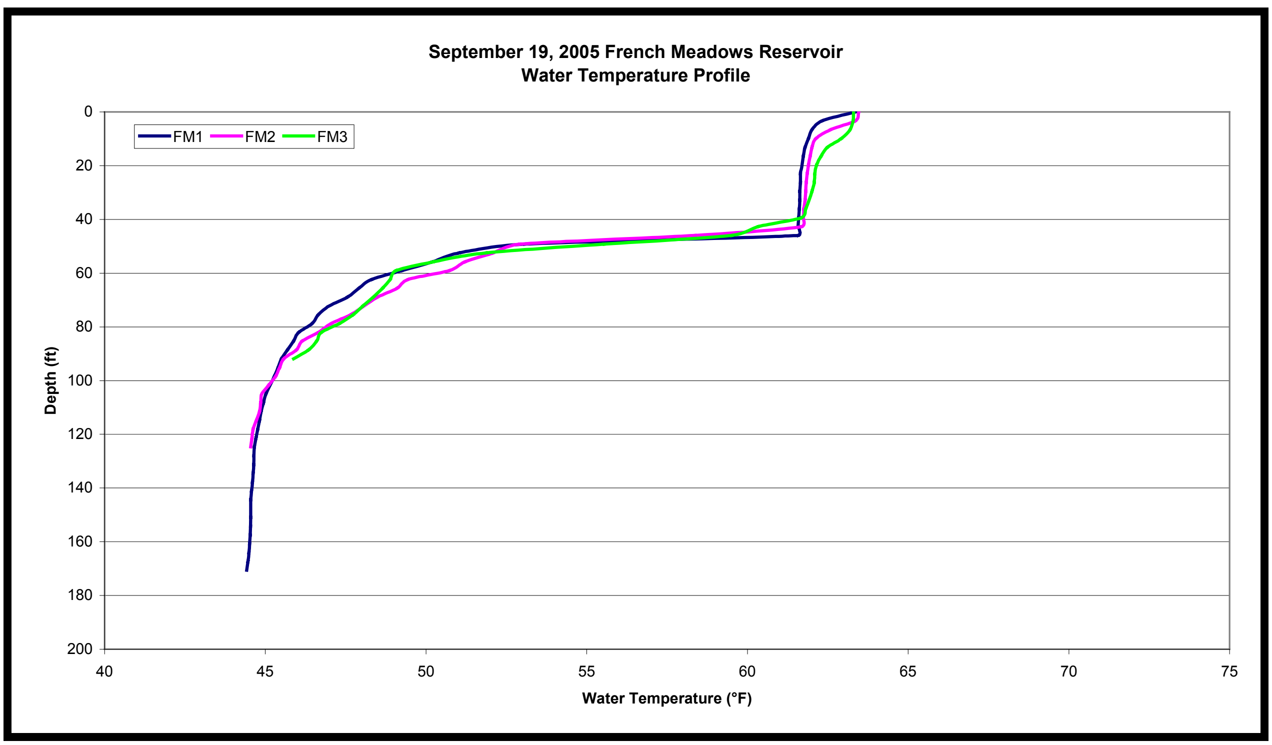



**Figure B- 4. The French Meadows Reservoir water temperature profiles at FM1, FM2, and FM3 on September 19, 2005.**

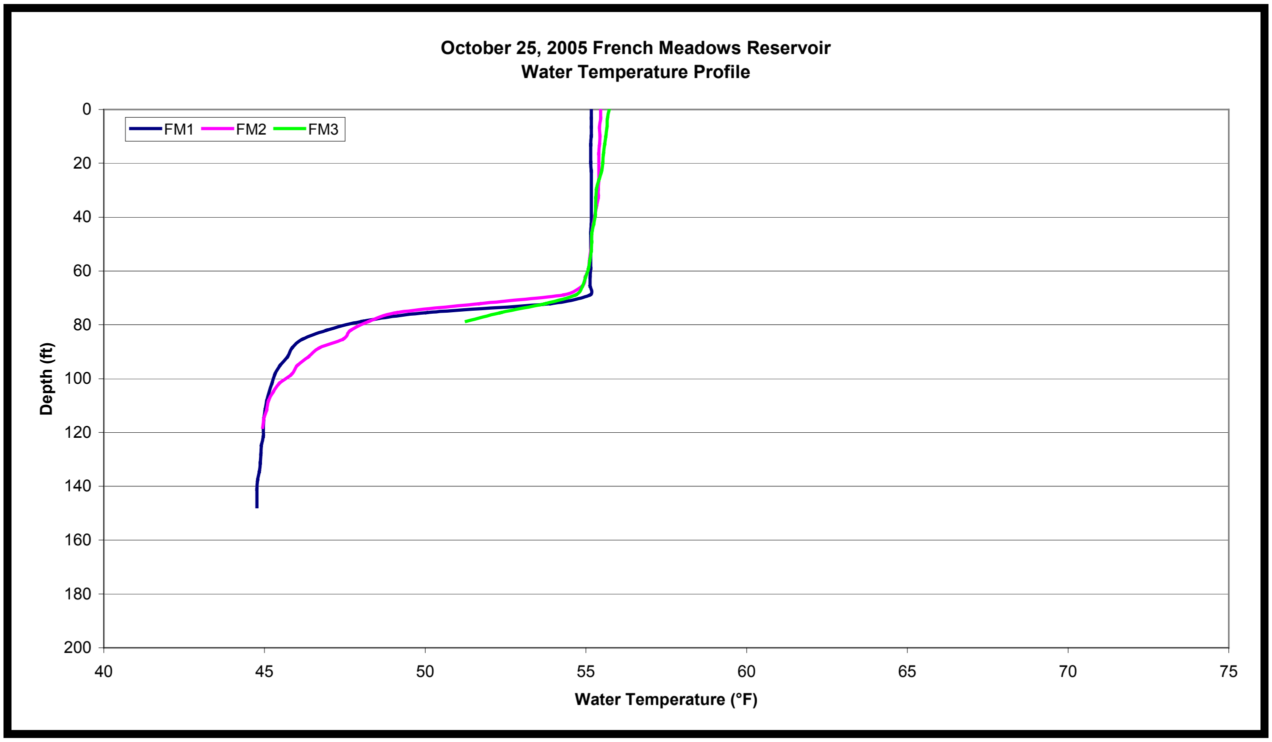



**Figure B- 5. The French Meadows Reservoir water temperature profiles at FM1, FM2, and FM3 on October 25, 2005.**

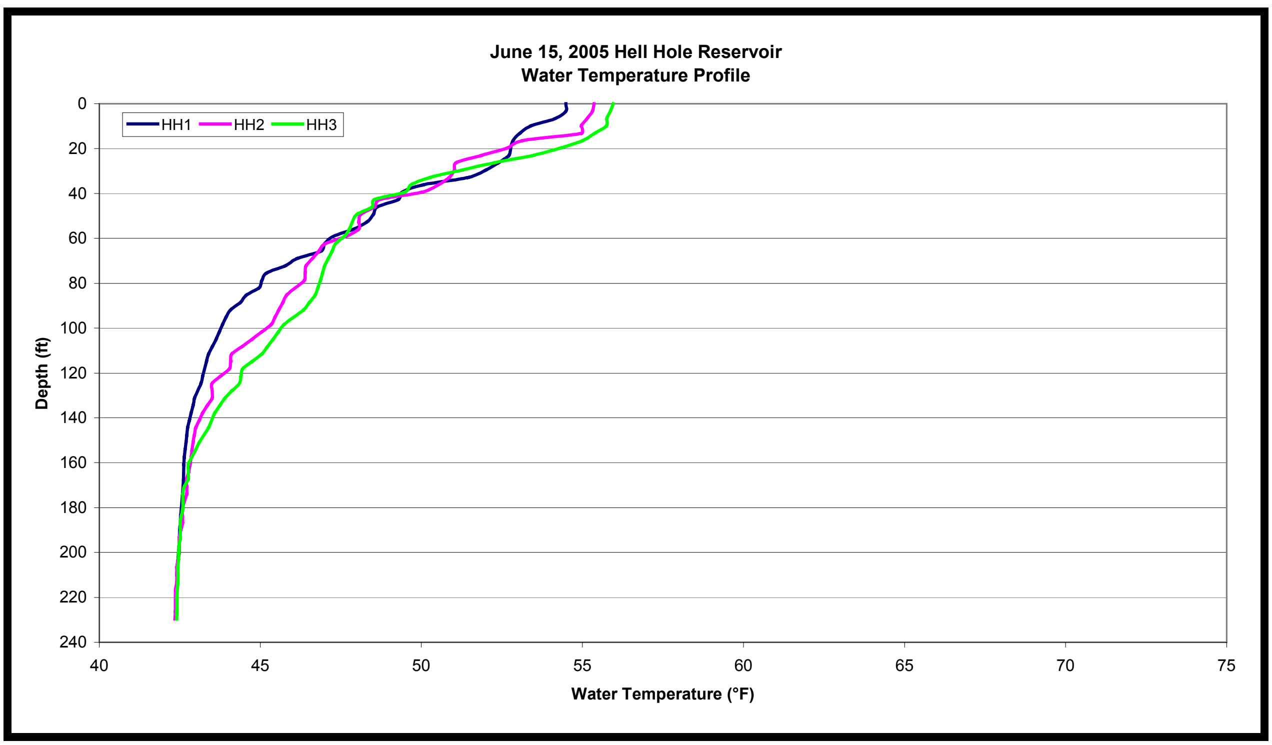



**Figure B- 6. The Hell Hole Reservoir water temperature profiles at HH1, HH2, and HH3 on June 15, 2005.**

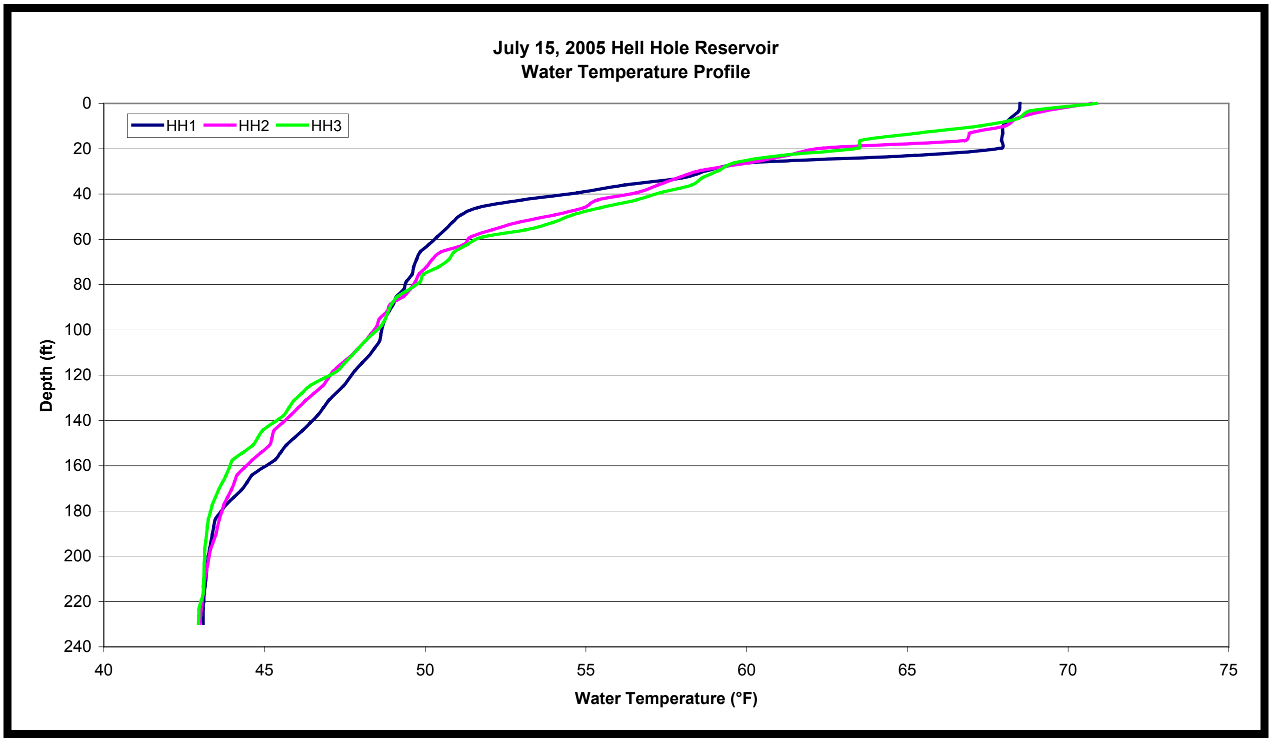



**Figure B- 7. The Hell Hole Reservoir water temperature profiles at HH1, HH2, and HH3 on July 15, 2005.**

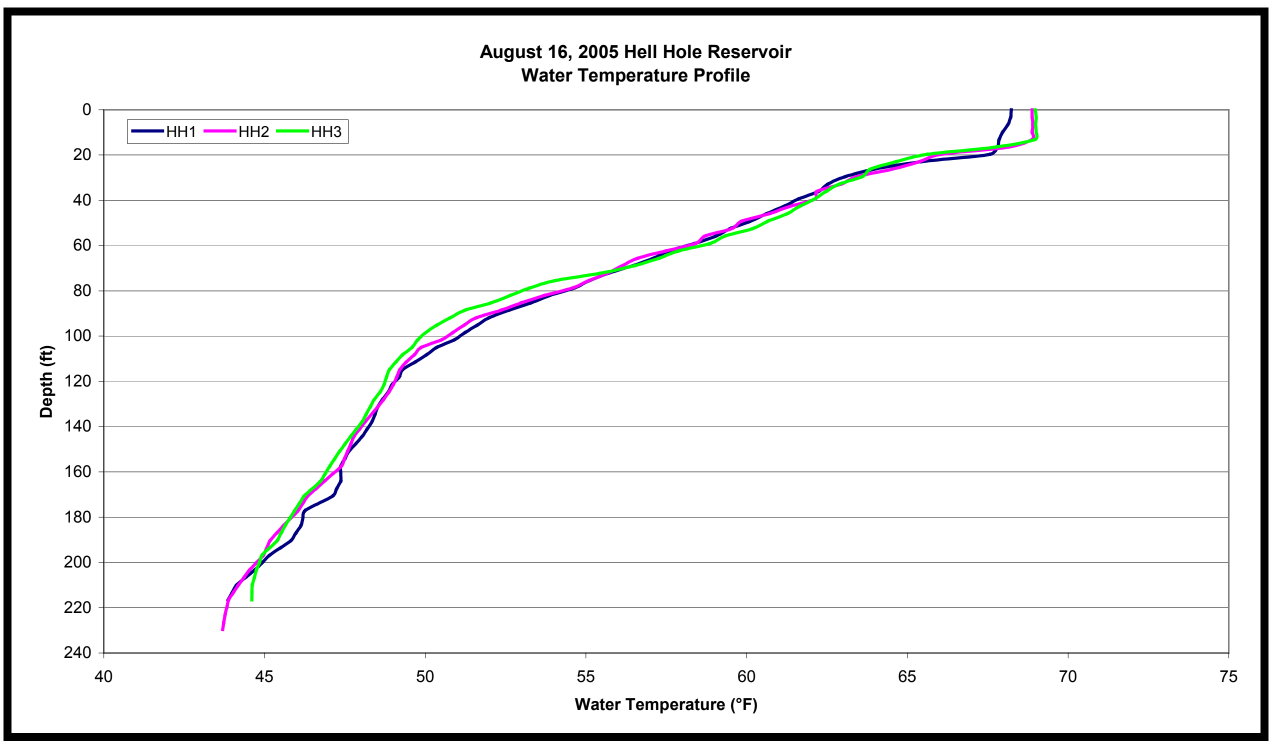



**Figure B- 8. The Hell Hole Reservoir water temperature profiles at HH1, HH2, and HH3 on August 16, 2005.**

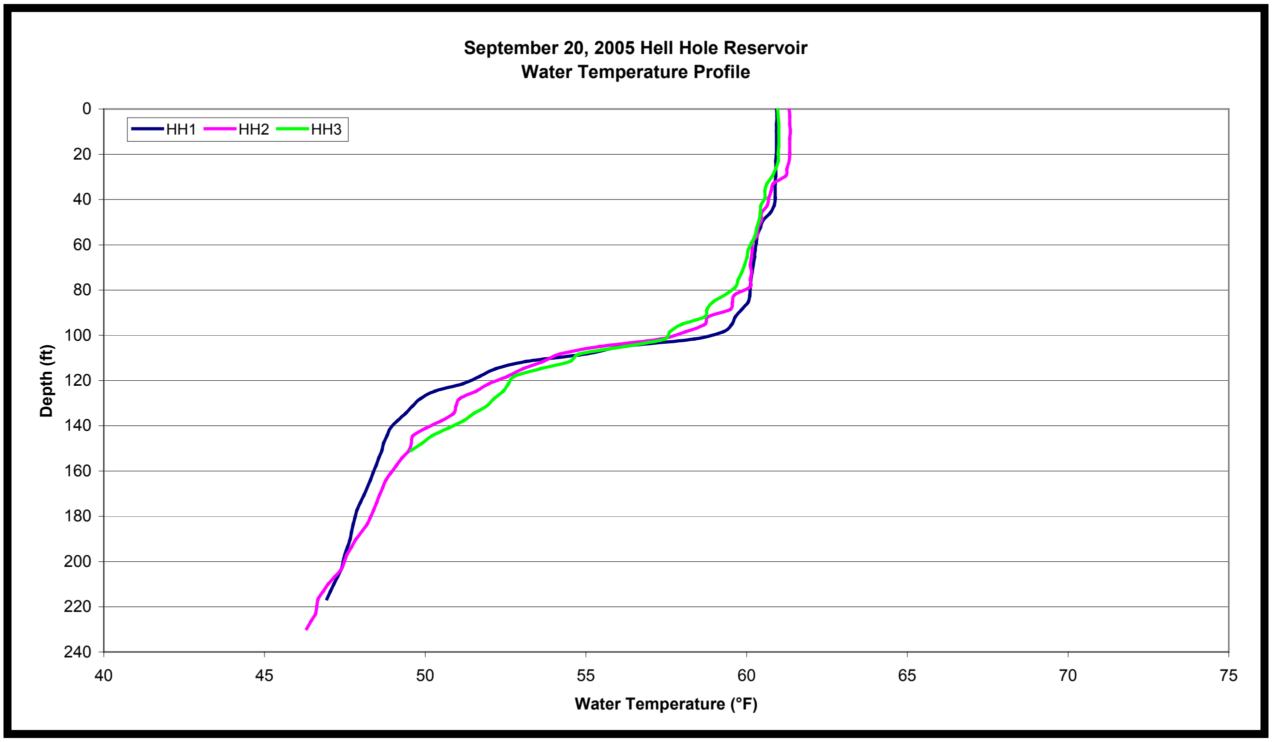



**Figure B- 9. The Hell Hole Reservoir water temperature profiles at HH1, HH2, and HH3 on September 20, 2005.**

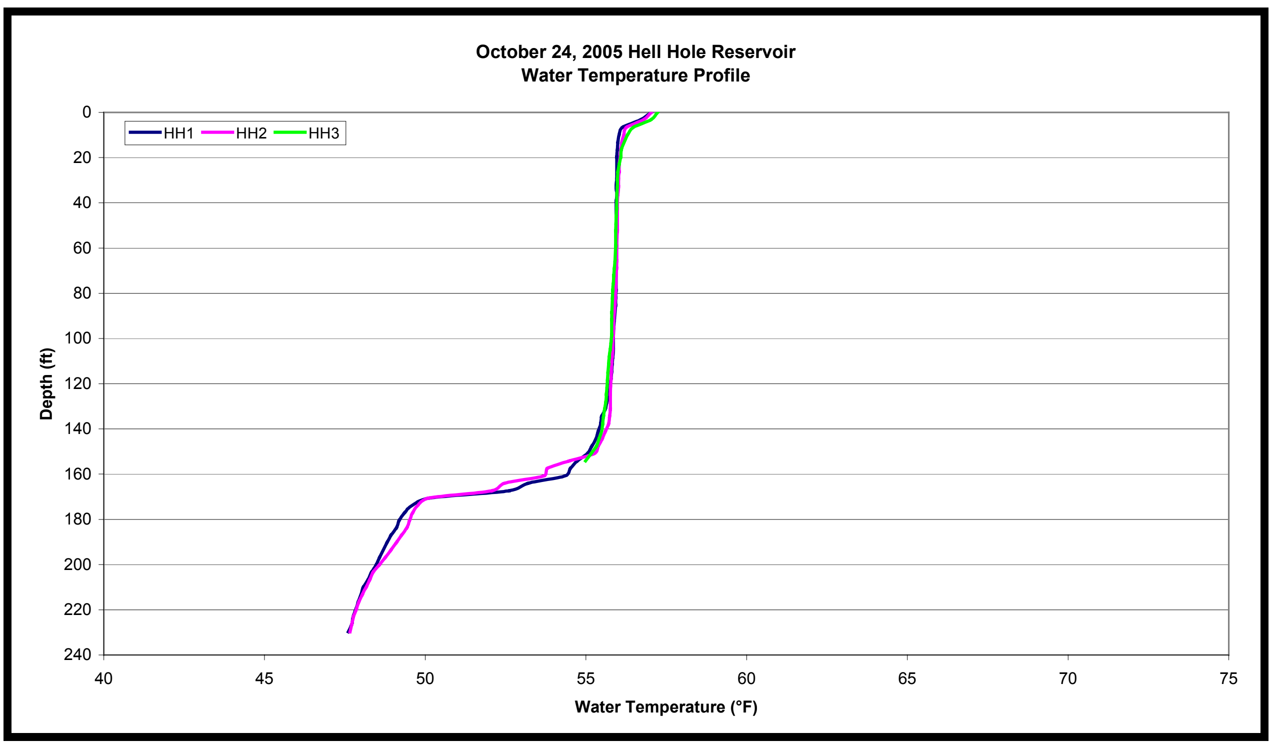



**Figure B- 10. The Hell Hole Reservoir water temperature profiles at HH1, HH2, and HH3 on October 24, 2005.**

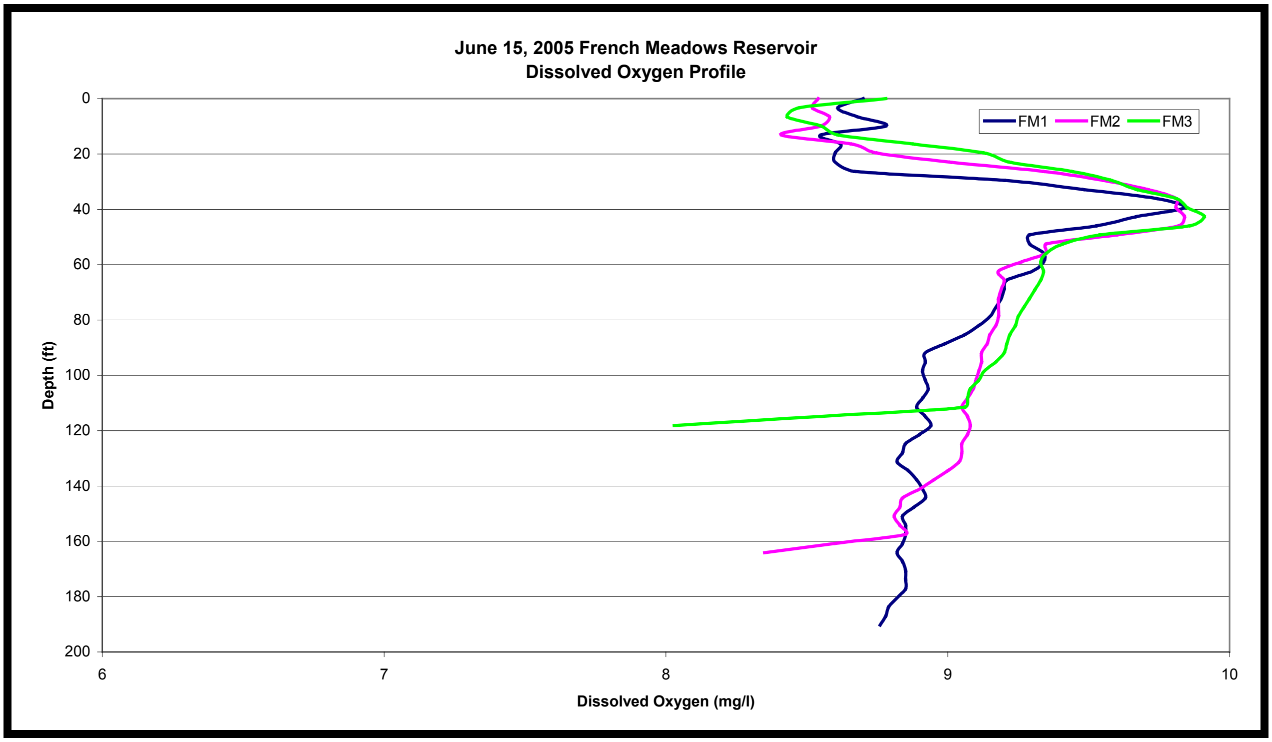



**Figure B- 11. The French Meadows Reservoir dissolved oxygen profiles at FM1, FM2, and FM3 on June 15, 2005.**

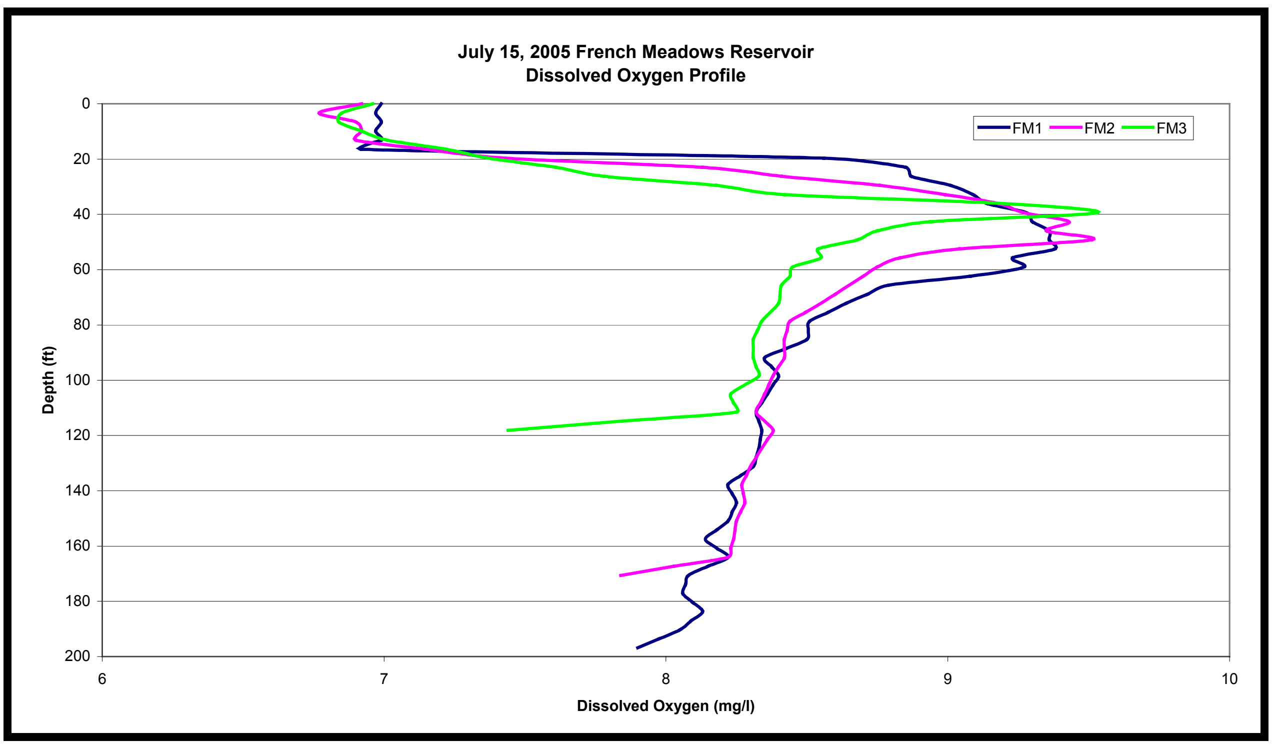



**Figure B- 12. The French Meadows Reservoir dissolved oxygen profiles at FM1, FM2, and FM3 on July 15, 2005.**

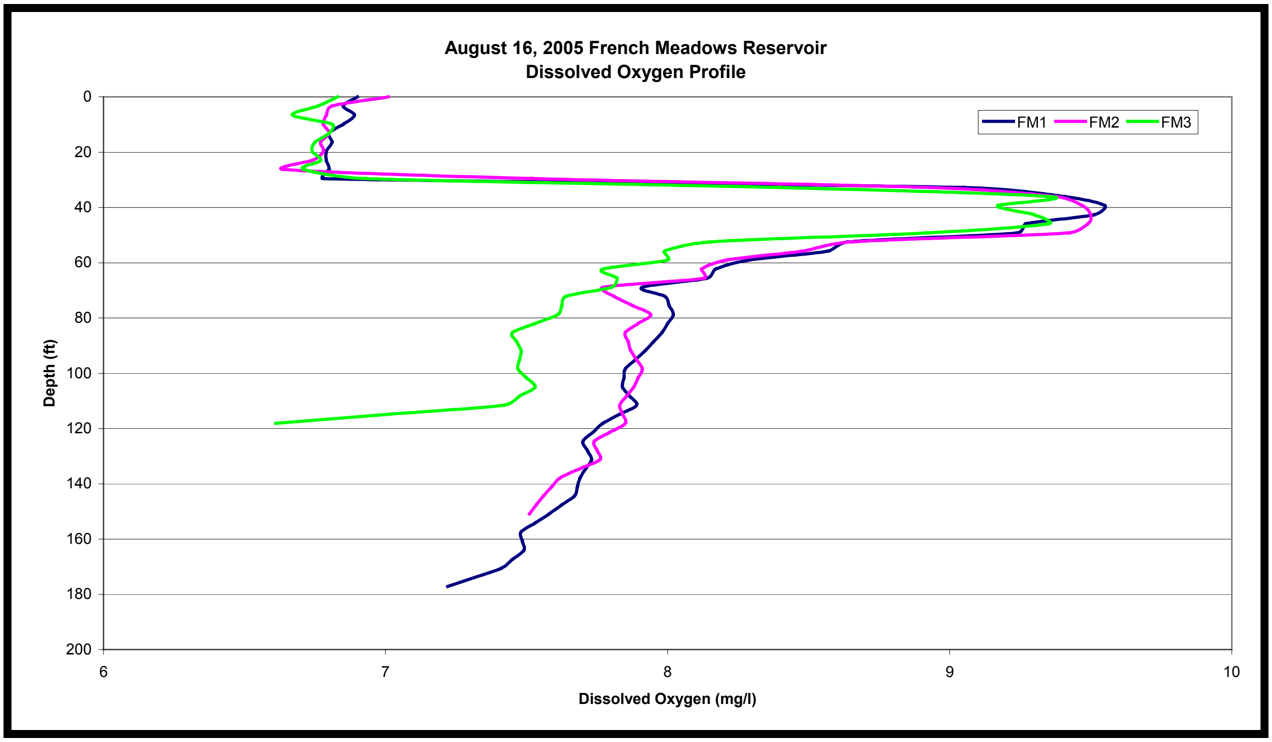



**Figure B- 13. The French Meadows Reservoir dissolved oxygen profiles at FM1, FM2, and FM3 on August 16, 2005.**

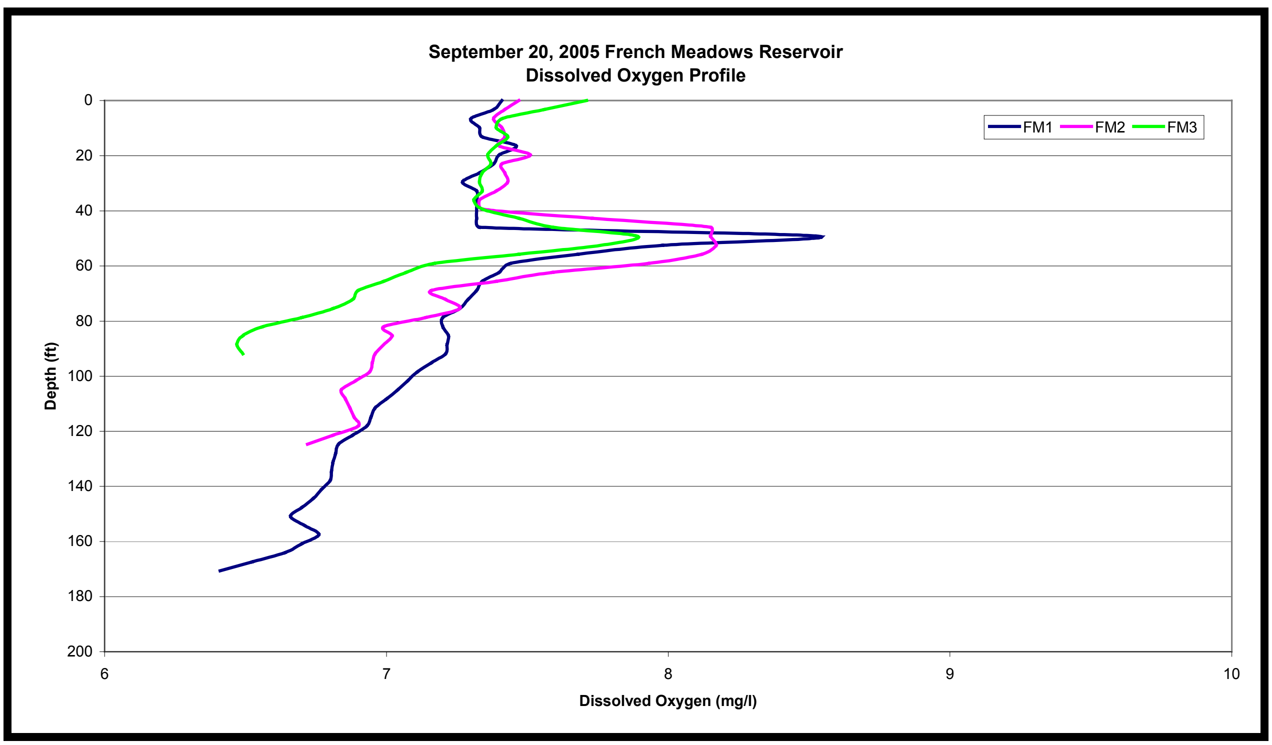



**Figure B- 14. The French Meadows Reservoir dissolved oxygen profiles at FM1, FM2, and FM3 on September 20, 2005.**

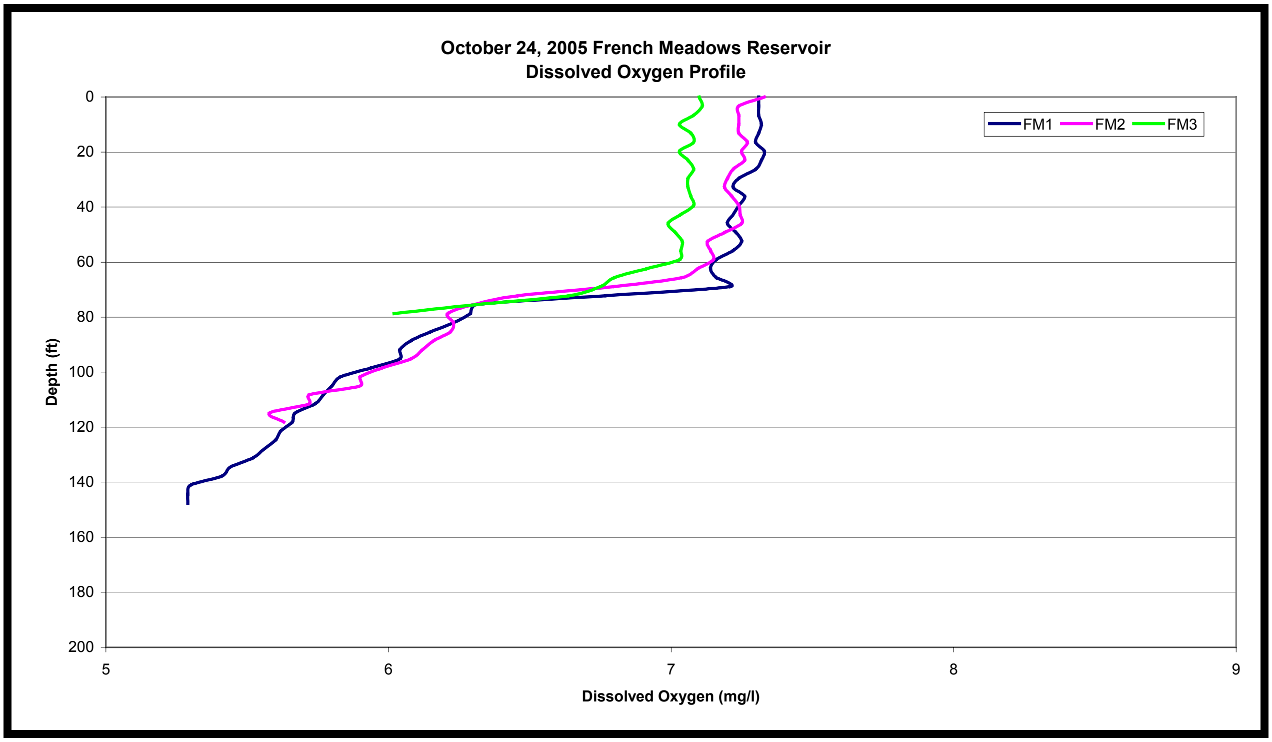



**Figure B- 15. The French Meadows Reservoir dissolved oxygen profiles at FM1, FM2, and FM3 on October 24, 2005.**

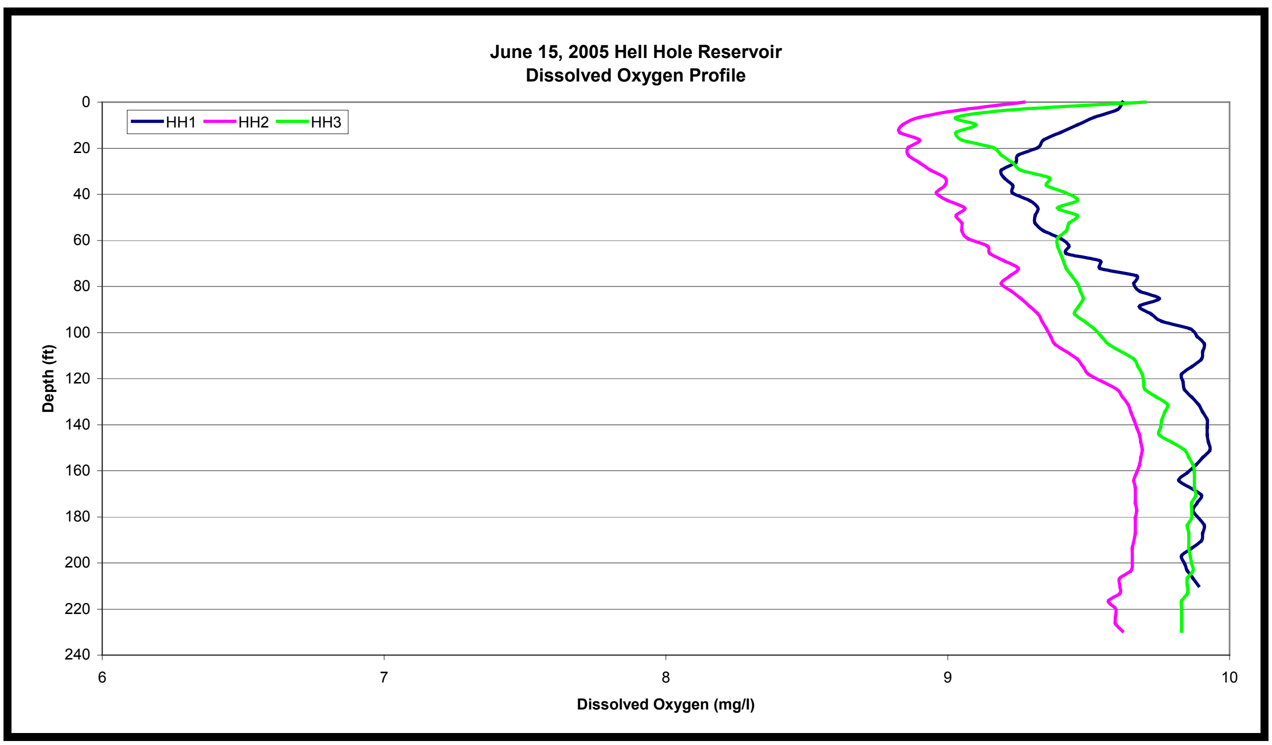



**Figure B- 16. The Hell Hole Reservoir dissolved oxygen profiles at HH1, HH2, and HH3 on June 15, 2005.**

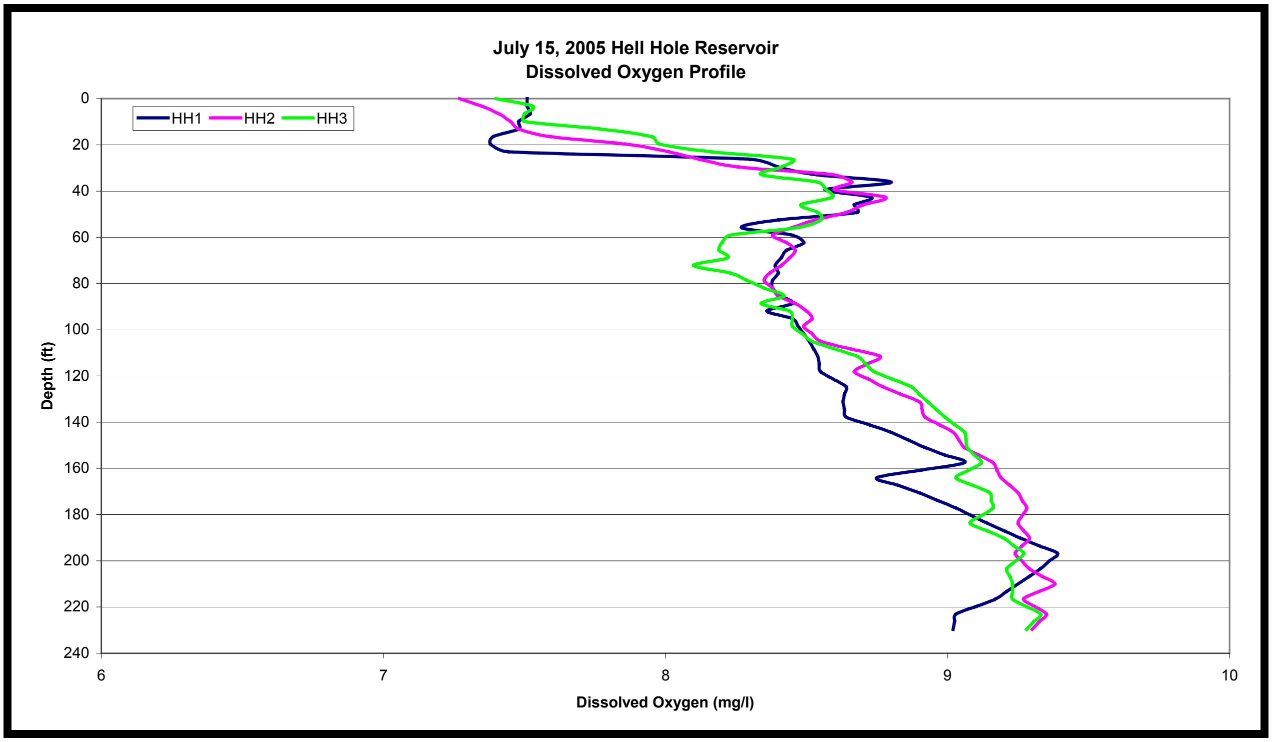



**Figure B- 17. The Hell Hole Reservoir dissolved oxygen profiles at HH1, HH2, and HH3 on July 15, 2005.**

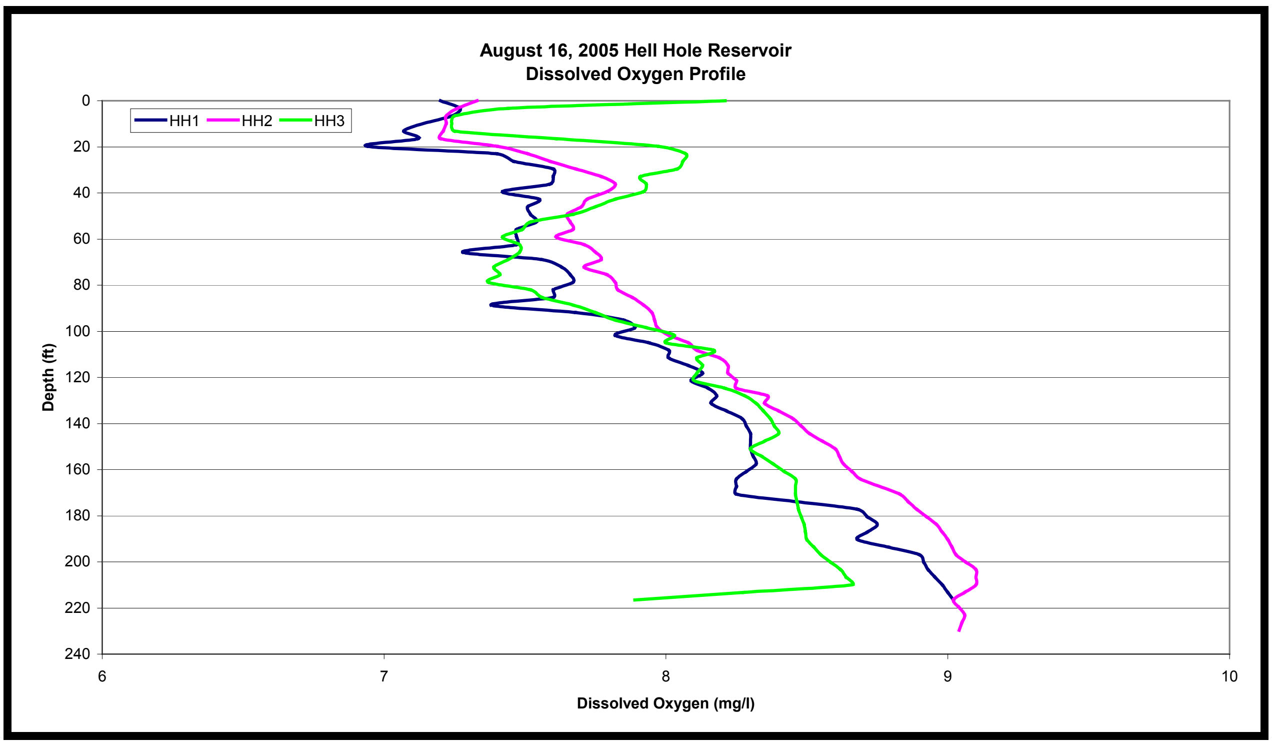



**Figure B- 18. The Hell Hole Reservoir dissolved oxygen profiles at HH1, HH2, and HH3 on August 16, 2005.**

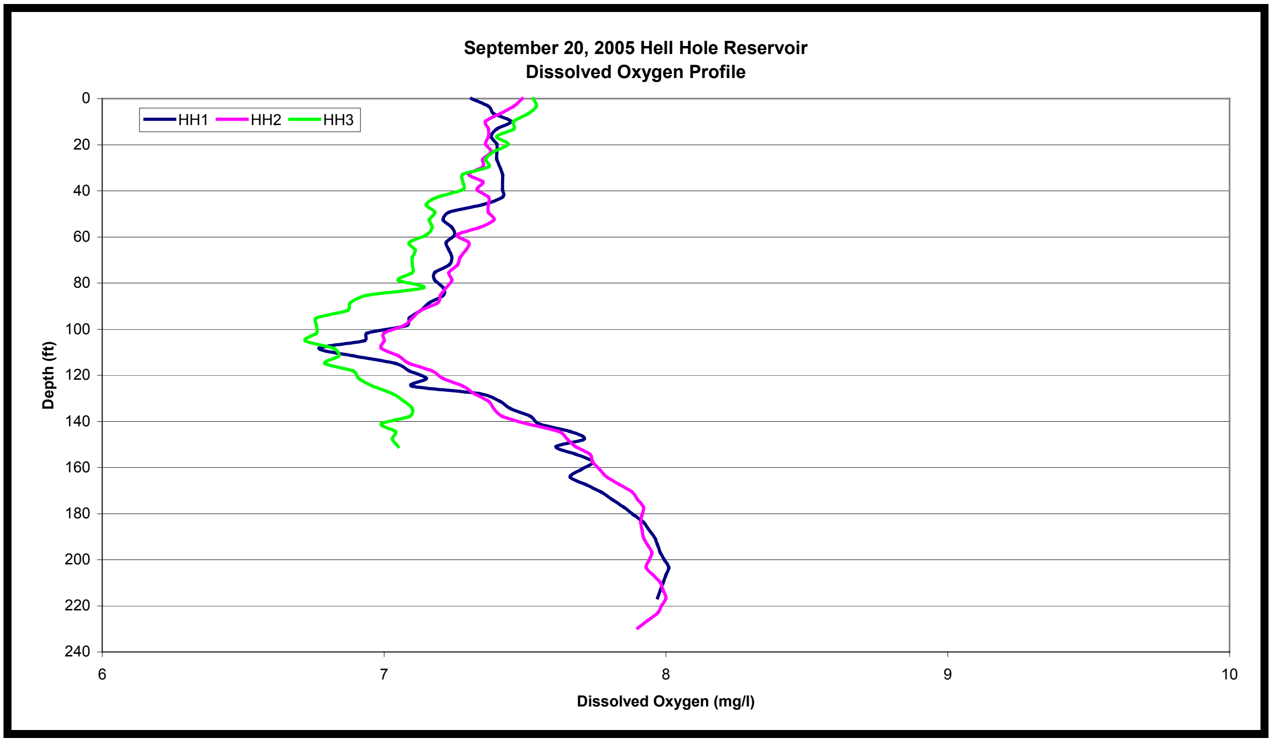



**Figure B- 19 The Hell Hole Reservoir dissolved oxygen profiles at HH1, HH2, and HH3 on September 20, 2005.**

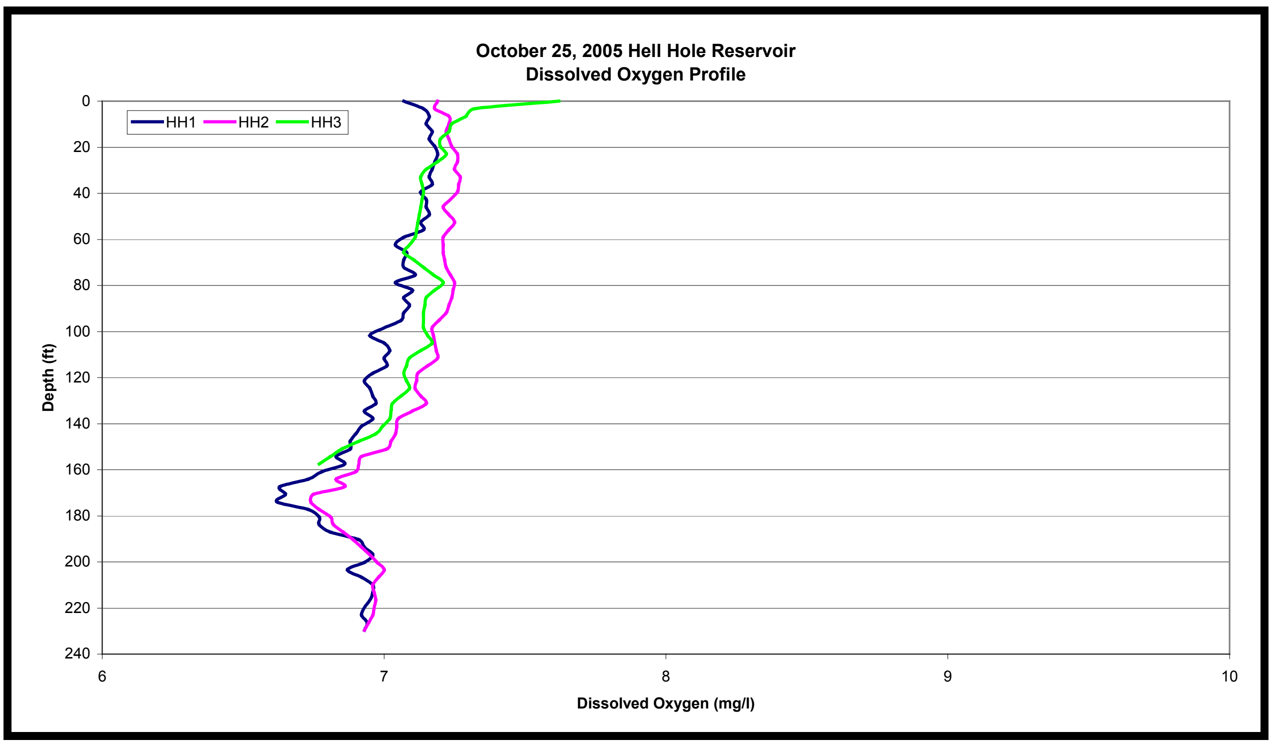



**Figure B- 20. The Hell Hole Reservoir dissolved oxygen profiles at HH1, HH2, and HH3 on October 25, 2005.**

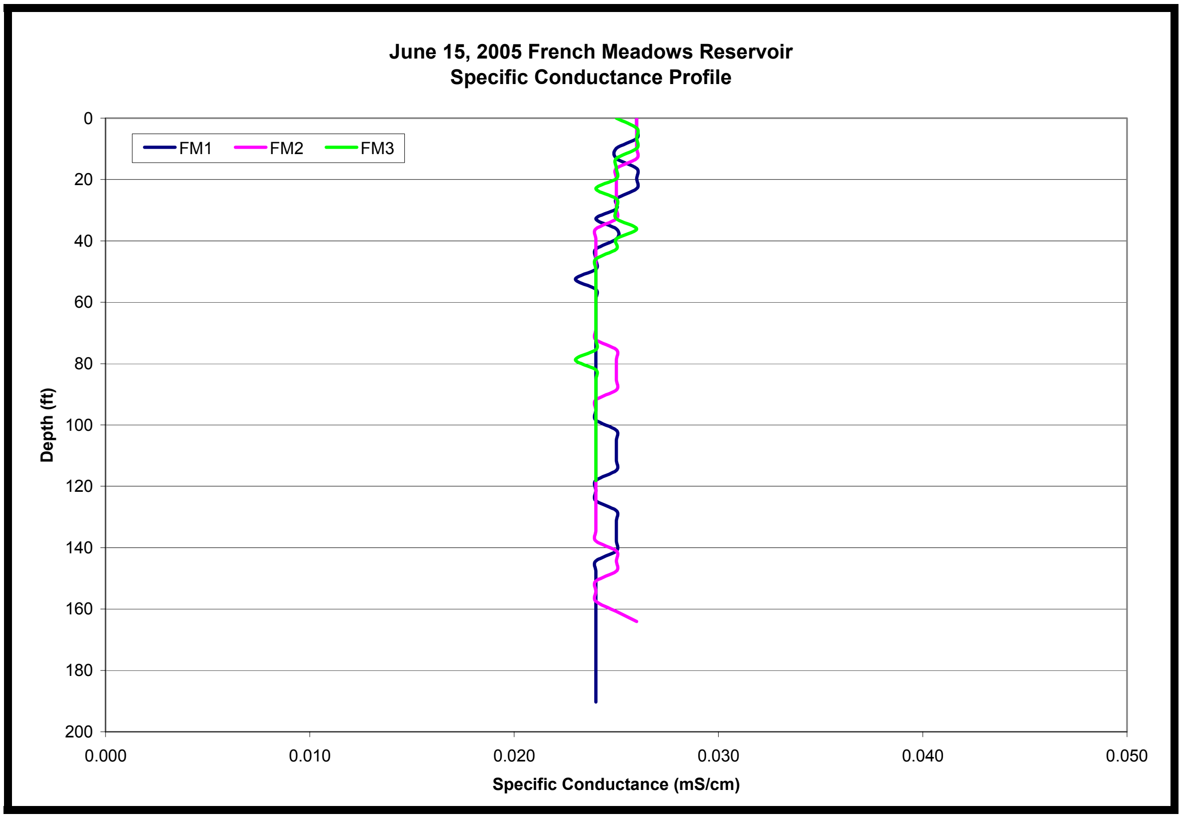



**Figure B- 21. The French Meadows Reservoir specific conductance profiles at FM1, FM2, and FM3 on June 15, 2005.**

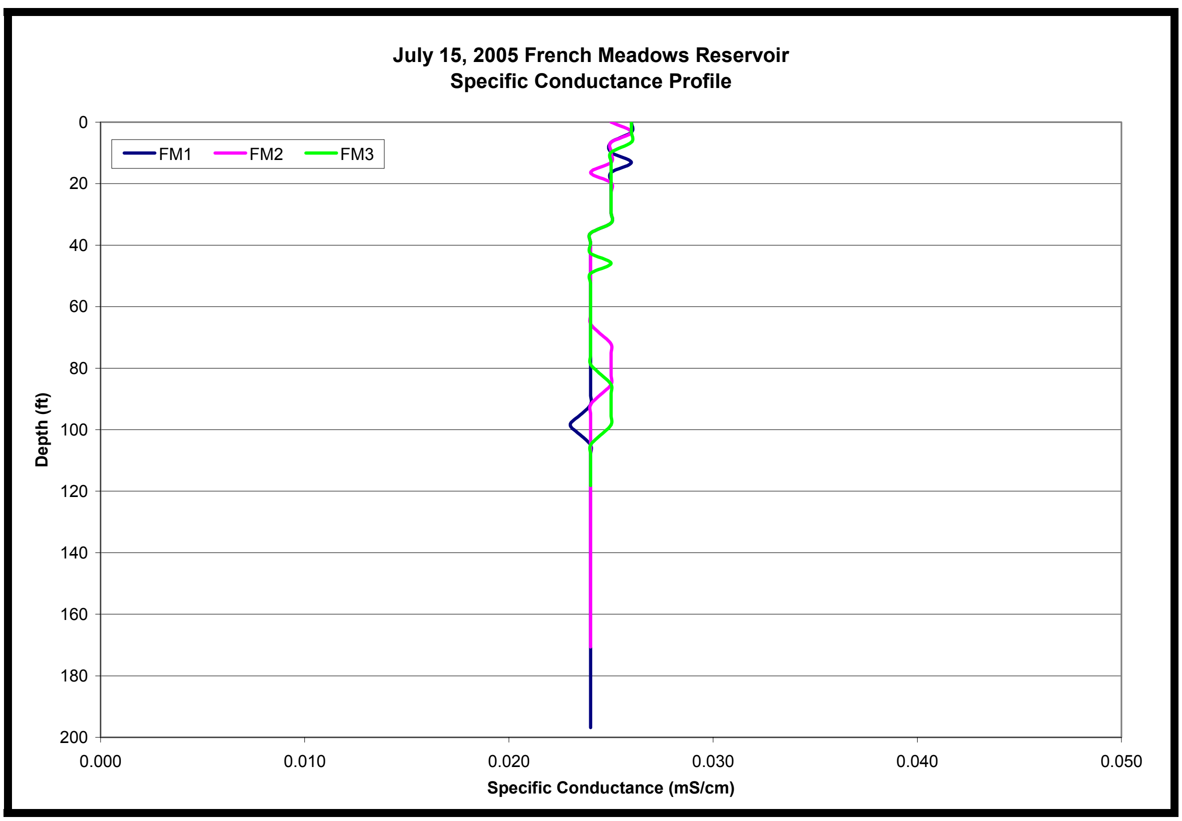



**Figure B- 22. The French Meadows Reservoir specific conductance profiles at FM1, FM2, and FM3 on July 15, 2005.**

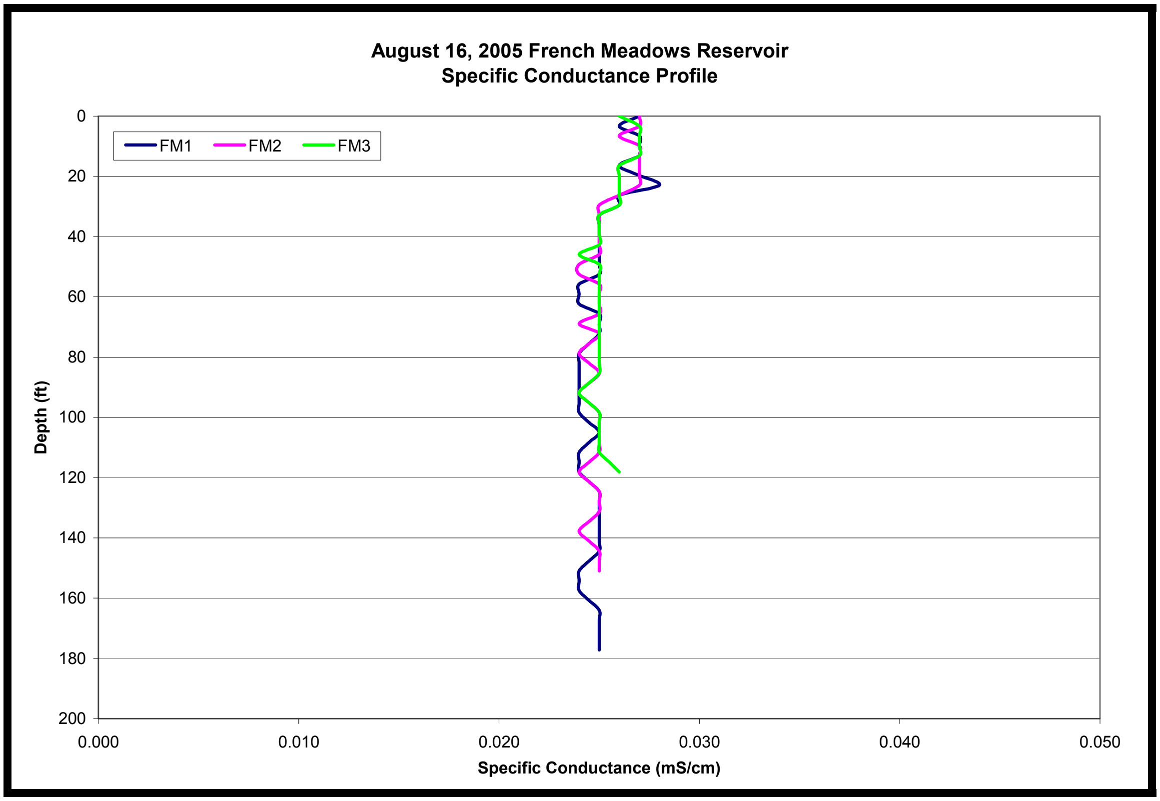



**Figure B- 23. The French Meadows Reservoir specific conductance profiles at FM1, FM2, and FM3 on August 16, 2005.**

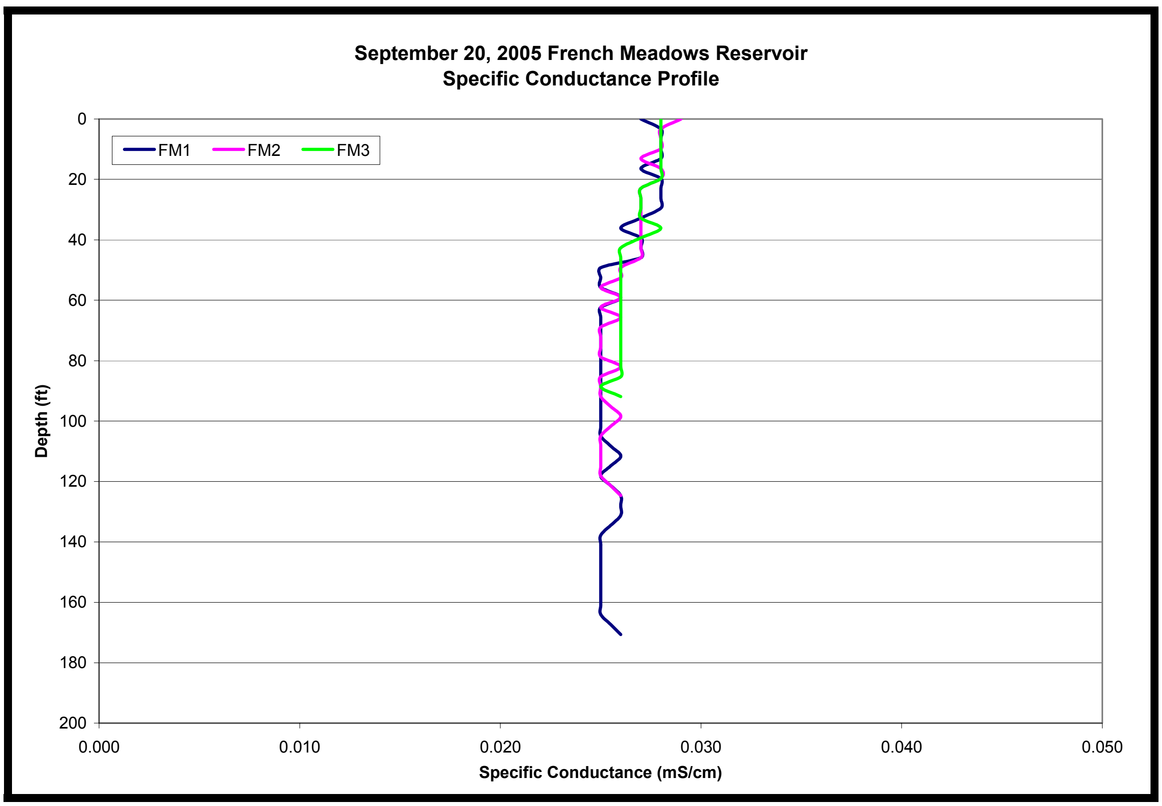



**Figure B- 24. The French Meadows Reservoir specific conductance profiles at FM1, FM2, and FM3 on September 20, 2005.**

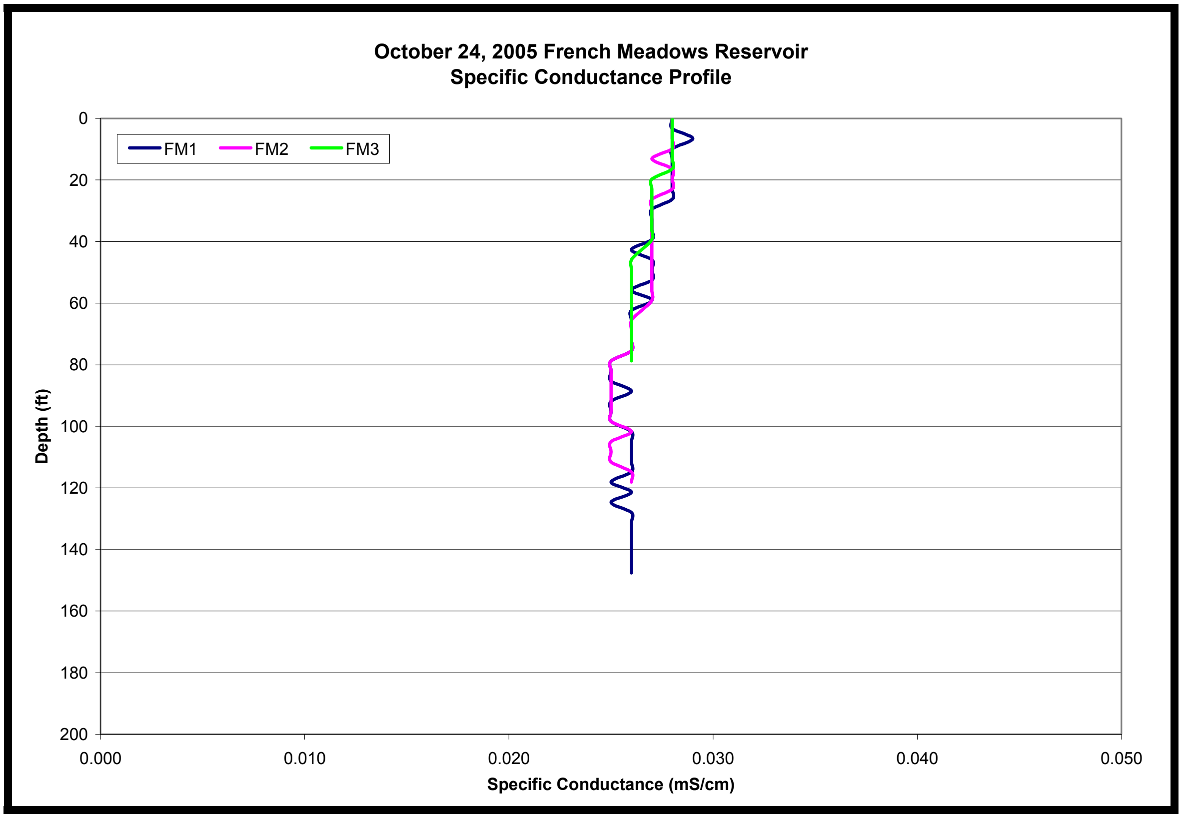



**Figure B- 25. The French Meadows Reservoir specific conductance profiles at FM1, FM2, and FM3 on October 24, 2005.**

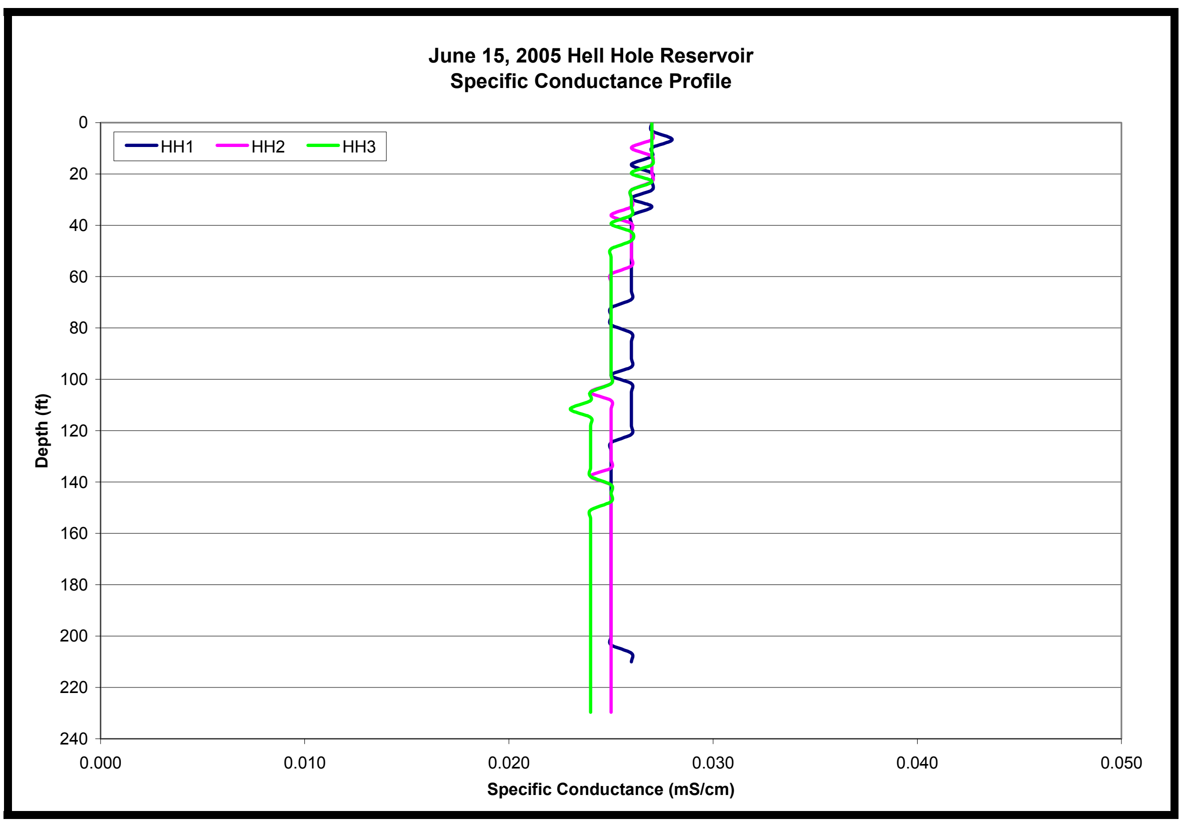



**Figure B- 26. The Hell Hole Reservoir specific conductance profiles at HH1, HH2, and HH3 on June 15, 2005.**

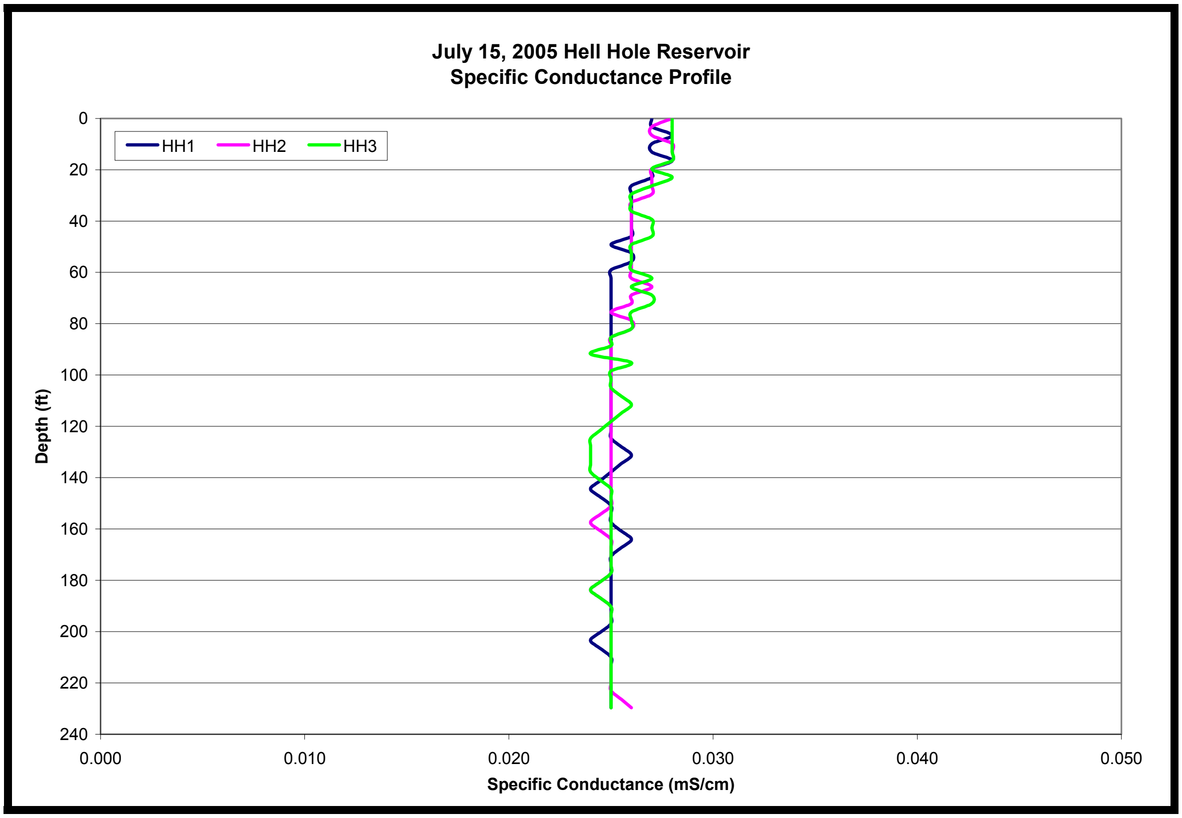



**Figure B- 27. The Hell Hole Reservoir specific conductance profiles at HH1, HH2, and HH3 on July 15, 2005.**

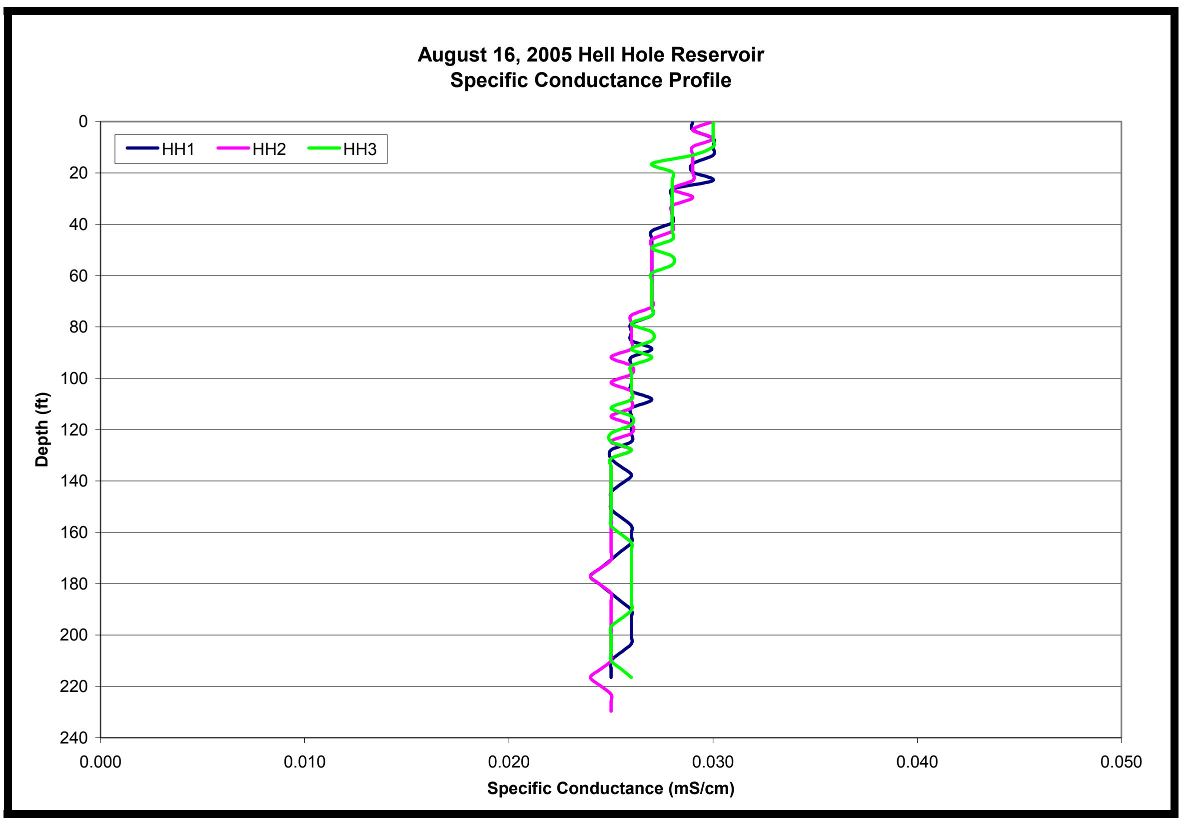



**Figure B- 28. The Hell Hole Reservoir specific conductance profiles at HH1, HH2, and HH3 on August 16, 2005.**

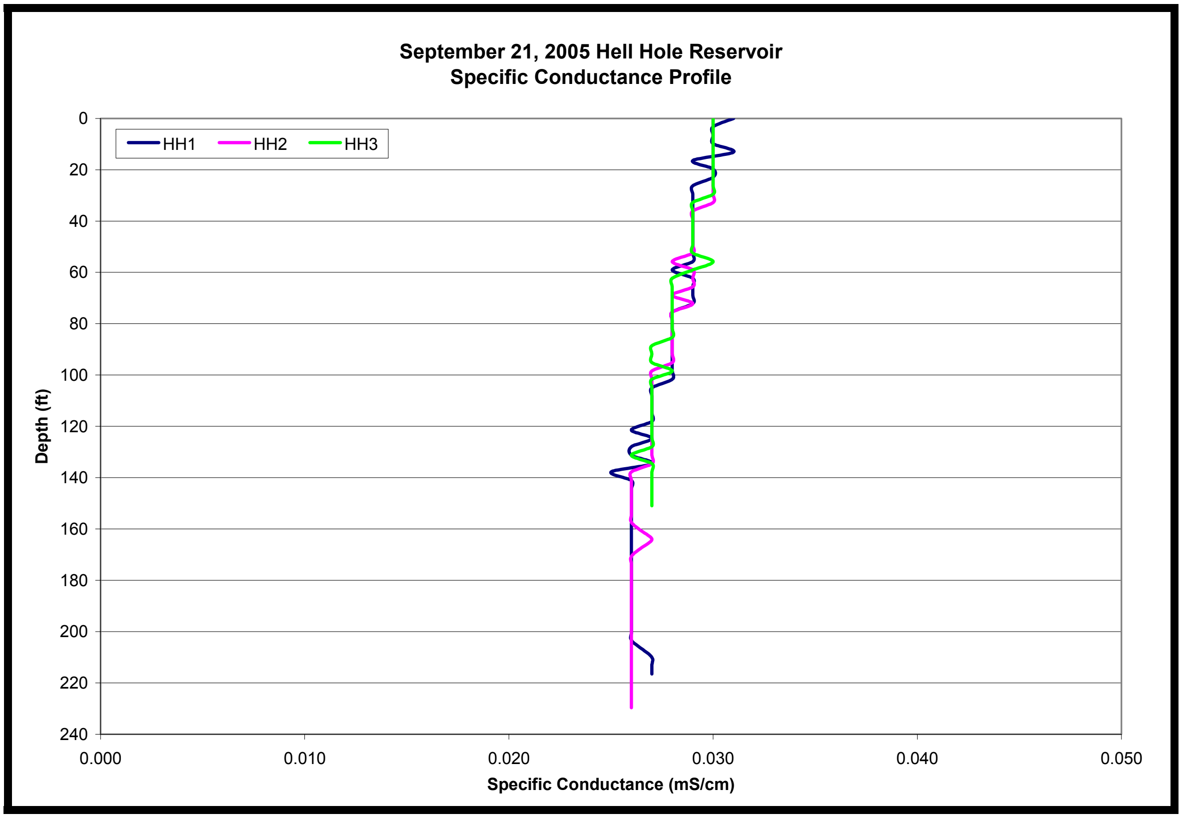



**Figure B- 29. The Hell Hole Reservoir specific conductance profiles at HH1, HH2, and HH3 on September 21, 2005.**

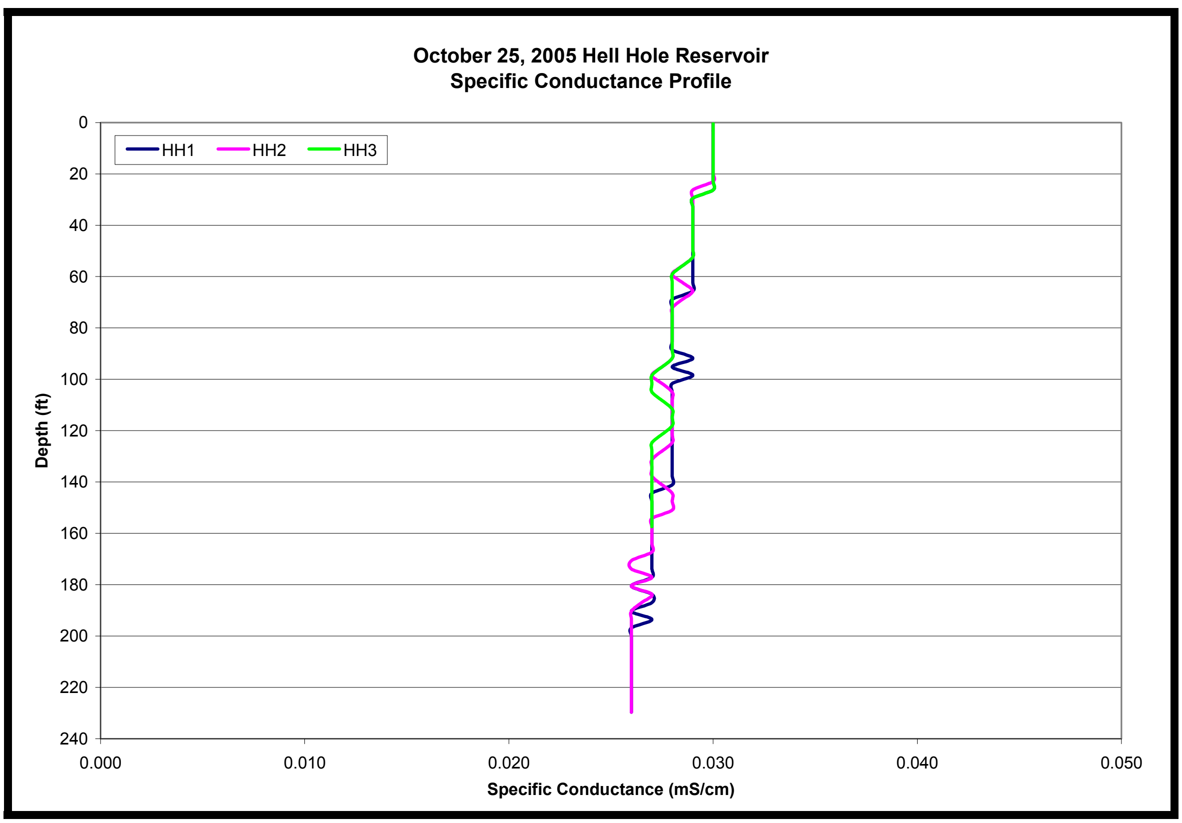



**Figure B- 30. The Hell Hole Reservoir specific conductance profiles at HH1, HH2, and HH3 on October 25, 2005.**