PAP-621

TEMPERATURE MONITORING RESULTS

FOR LEWISTON LAKE FLEXIBLE CURTAINS

By

P. L. Johnson

T. B. Vermeyen

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MAR 2 1993

Memorandum

To: Project Superintendent, Redding CA
Attention: SO-400 (Matt Rumboltz)

From: Acting Chief, Hydraulics Branch

Subject: Temperature Monitoring Results for Lewiston Lake Flexible Curtains (Hydraulic Research)

Because of the urgent need to reduce reservoir outflow temperatures, Reclamation initiated an aggressive research program to study, design, and install a prototype temperature control curtain at Lewiston Dam. In the summer of 1992, under a very tight schedule, two curtains were installed in Lewiston Lake. The performance of these curtains was monitored by Reclamation and U.S Fish and Wildlife personnel.

This memorandum's purpose is to distribute the representative Lewiston Lake temperature monitoring data. Included are several charts along with a short description which explains the reservoir response to curtain installation. Additional temperature data which cover several locations for the months of September and October are enclosed, without interpretation, in the appendix.

The Hydraulics Branch intends to produce a more detailed analysis of these data and include it in a comprehensive report. However, because of the strong interest in curtain performance, it is an opportune time to release this package of preliminary data. If any questions or comments arise, please contact Perry Johnson at (303) 236-6160 or Tracy Vermeyen at (303) 236-6151.

Clifford A. Pugh

Enclosure

cc: Regional Director, Sacramento CA, Attn: MP-720 (Jewell), MP-2810 (Read)
(w/encl to each)

bc: D-3750, D-3751, D-3751 (file), D-5930 (Black)
(w/encl to each)

WBR:TBVermeyen:mw/flh:3/12/93:236-6151
(c:\wp\d3751\Lewiston.tbv)

TEMPERATURE MONITORING RESULTS FOR LEWISTON LAKE FLEXIBLE CURTAINS

by

Perry L. Johnson
Tracy B. Vermeyen

March 12, 1993

Introduction

In August 1992, Reclamation constructed and installed an 830-ft-long reservoir curtain in Lewiston Lake. The curtain was installed near the reservoir curtain location identified by the physical model studies conducted by the Hydraulics Branch. The curtain was installed to modify the reservoir's thermal stratification downstream of the reservoir curtain. The exclusion of epilimnion (surface) replacement water will cool the downstream water temperatures, thus allowing cooler water to be diverted to the Sacramento and Trinity Rivers.

In addition to the reservoir curtain, a second curtain funded by the California Department of Fish and Game was installed surrounding the Lewiston fish hatchery intake structure. The hatchery desired both warmer and cooler water, depending on the season and fish requirements. Therefore, a curtain was designed which could skim warmer water or underdraw cooler water depending on whether the curtain was in the sunken or floating position, respectively. By allowing the top boom tanks of this curtain to be partially filled with water, the entire curtain can be submerged, creating an underwater dam which blocks cooler water, while permitting the warmer water to be drawn over the top. Raising this curtain to a floating position is accomplished by evacuating the top boom tanks using compressed air.

Temperature Monitoring Program

Reclamation's Shasta Office, in cooperation with the U.S. Fish and Wildlife Service, established a temperature monitoring program to document the effectiveness of the Lewiston Lake flexible curtains in modifying the reservoir release temperatures. The program included the following monitoring stations:

- Judge Francis Carr Powerplant tailrace.
- Clear Creek Tunnel intake structure.
- Hatchery aerator intake structure.
- Lewiston Dam spillway.
- Trinity River below Lewiston Dam and hatchery.
- Temperature profiles were measured at locations upstream and downstream of the reservoir curtain.
- Additional temperature profiles were measured at several other locations throughout the reservoir.

Reclamation's Shasta Office provided the Hydraulics Branch with raw data collected at the sites mentioned above. The Hydraulics Branch has reduced the data and has produced charts which indicate the effectiveness of the flexible

curtains. The most pertinent data, along with brief comments, are presented within this memorandum.

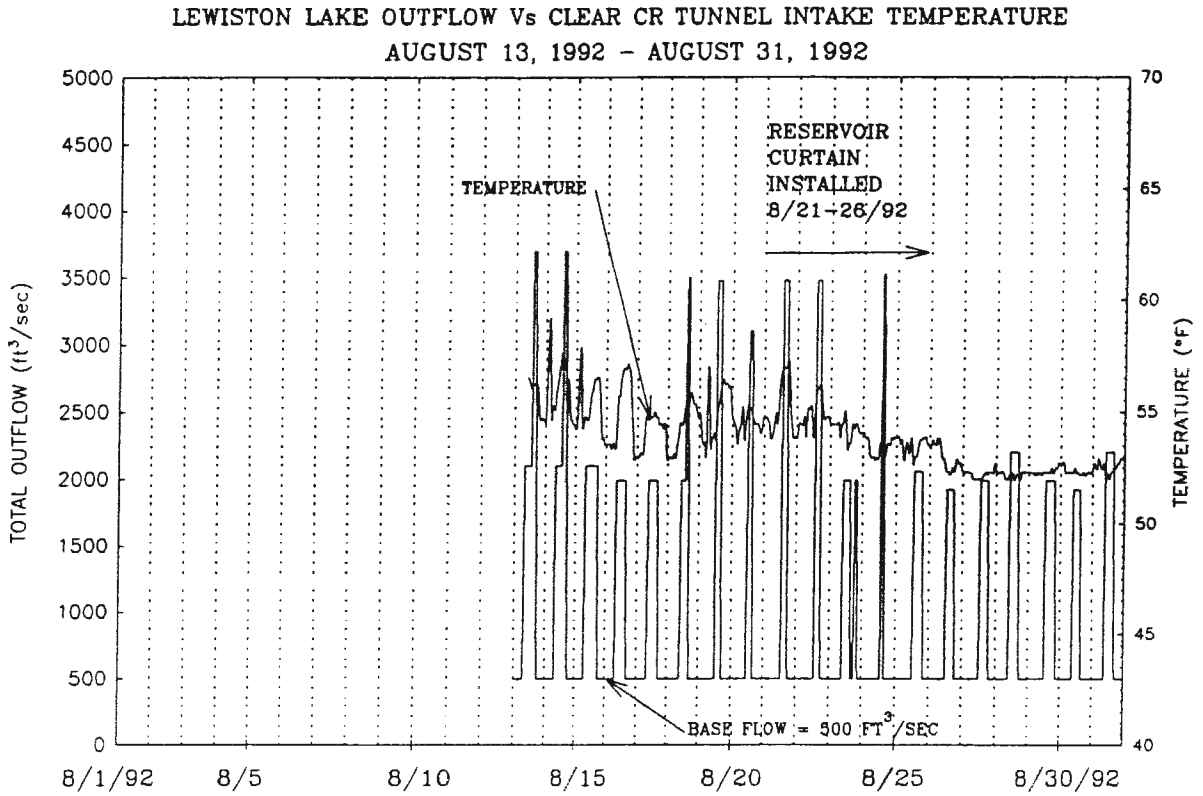


Figure 1. Lewiston Lake Outflow Versus Clear Creek Tunnel Intake Temperatures. *On average, a 2.5 °F reduction in temperature was realized after curtain installation was complete.*

Figure 1 is a plot of the temperatures measured in the Clear Creek Tunnel intake as well as the outflows from Lewiston Lake. Base flows include the hatchery intake (200 ft^3/s), Lewiston Dam spillway (200 ft^3/s), and the Lewiston powerhouse (100 ft^3/s). Clear Creek Tunnel diverts water to Judge Francis Carr Powerplant, and usually diverts 1,500 or 3,000 ft^3/s.

Prior to curtain installation, it appears that withdrawal temperatures increased during power releases, which can be attributed to atmospheric warming and epilimnion withdrawal (the powerplant was operated during the day). However, after curtain installation was complete withdrawal temperatures were lowered by 2.5 °F, and temperatures measured in the intake appear to be independent of power releases. Diurnal fluctuations in surface temperatures are also reduced because the majority of base flows are surface withdrawals (hatchery and spillway) and the curtain blocks epilimnion replacement water. In other words, warm water was withdrawn faster than it could accumulate.

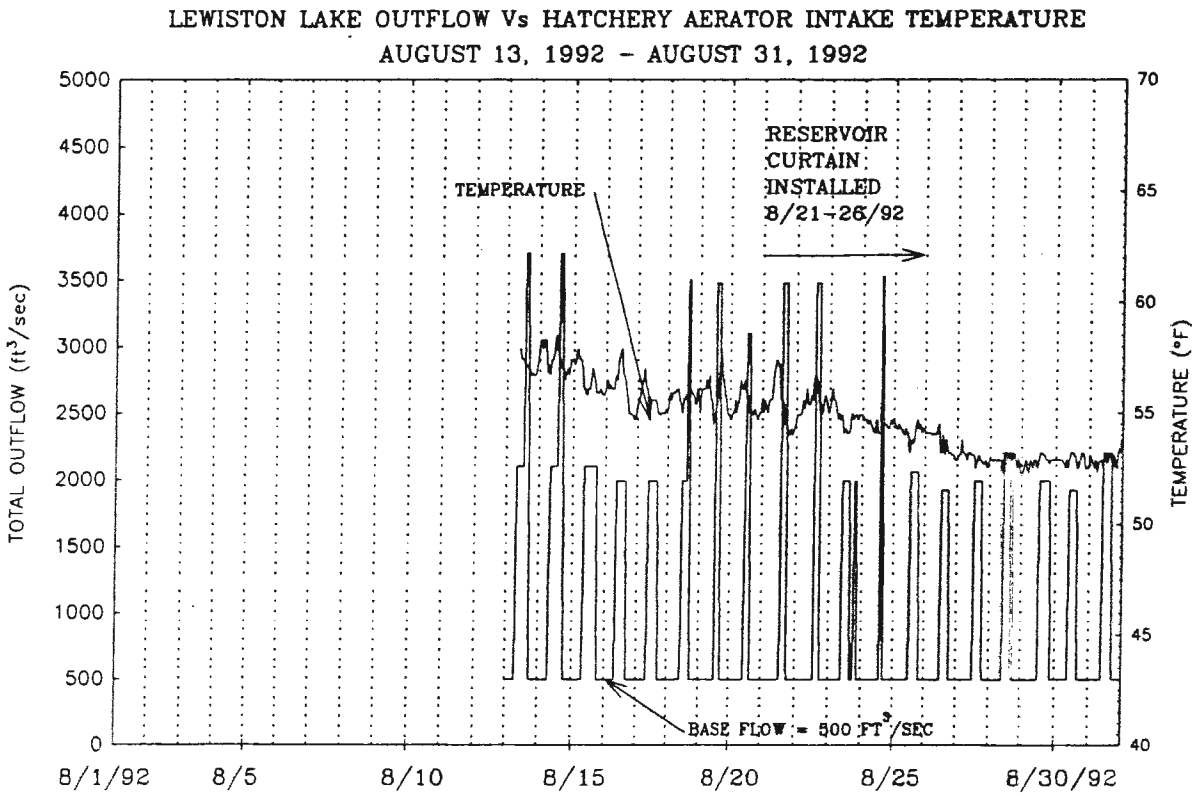


Figure 2. Lewiston Lake Outflow Versus Hatchery Aerator Intake Temperatures (August). *On average, a 3.0 °F reduction in temperature was realized after reservoir curtain installation was complete.*

Figure 2 shows that after August 26, 1992, when the temperature control curtain was fully operational, the hatchery intake temperatures were lowered approximately 3.0 °F. The hatchery intake temperatures were cooled because they withdraw from near the surface. The reservoir curtain prevents epilimnion water from replacing surface withdrawals; consequently, the downstream temperature profile approaches a constant temperature (i.e., a weak stratification) (fig. 3).

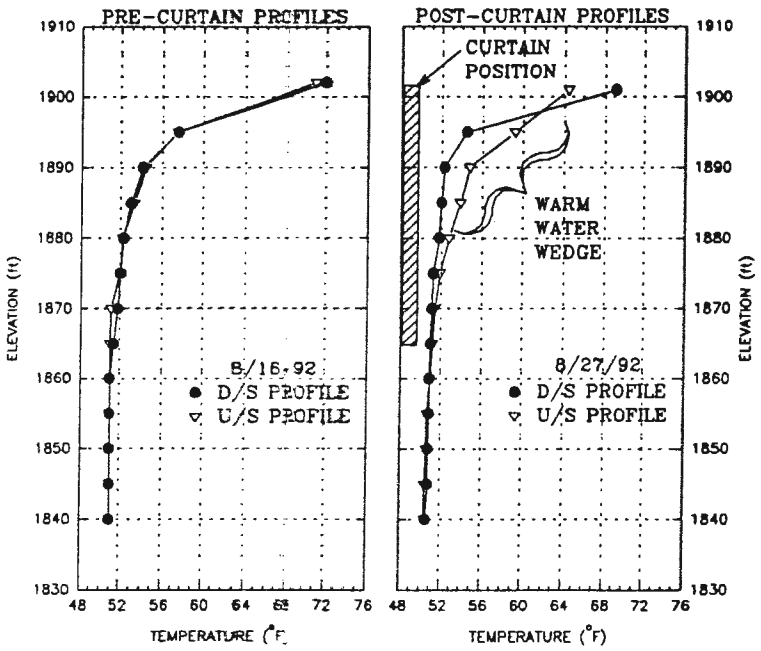


Figure 3. - Temperature profile comparison for pre- and post-curtain (reservoir) conditions. *Profiles were measured for similar powerplant operation schedules.*

Figure 3 shows the modification to the reservoir stratification at monitoring locations upstream and downstream of the reservoir curtain. Note the similarity of the August 16, 1993 pre-curtain temperature profiles and how they differ for post-curtain conditions.

For post-curtain conditions, a comparison of upstream and downstream profiles indicates that the reservoir curtain reduced downstream epilimnion temperatures by as much as 3 °F at elevation 1895. The upstream profile clearly shows the development of a warm-water wedge on the upstream side of the curtain, which indicates the curtain's effectiveness at blocking warm water migration toward the Clear Creek Tunnel and hatchery aerator intakes. Therefore, the epilimnion increases in depth because surface water withdrawals are limited to inside the curtain. For example, on the upstream side of the curtain at elevation 1895, post-curtain temperatures increased 1.5 °F when compared to the pre-curtain profile.

An explanation as to why the post-curtain downstream profile has a warmer surface temperature than the upstream profile is the downstream profile was measured earlier in the day and the surface warmed between measurements.

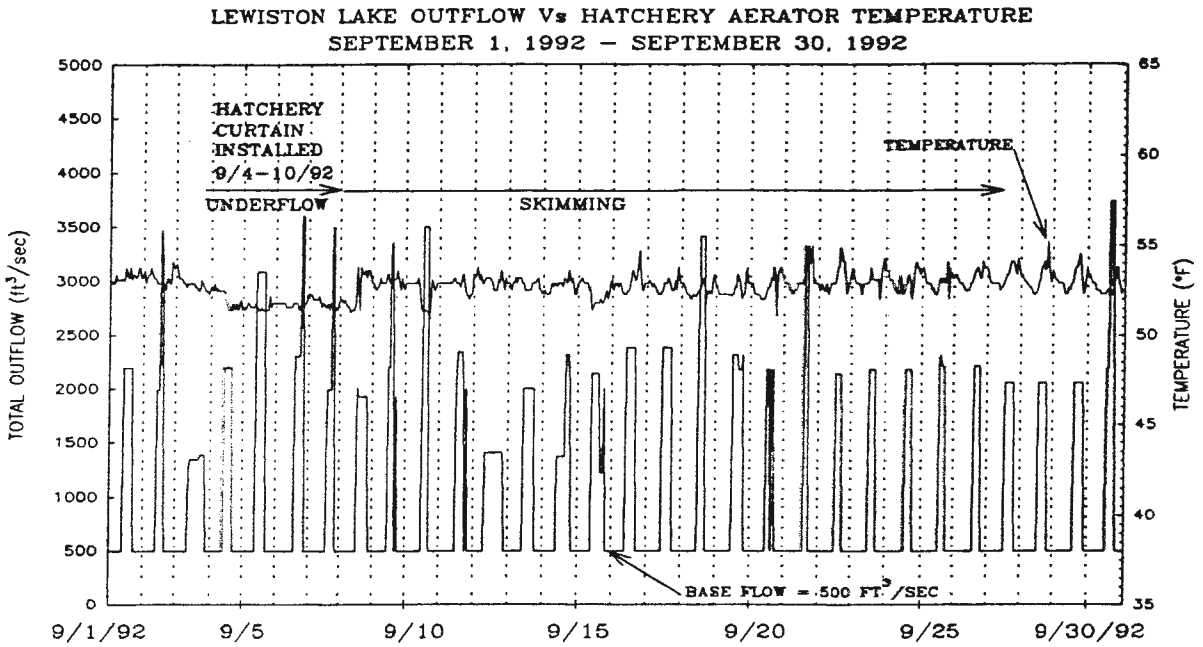


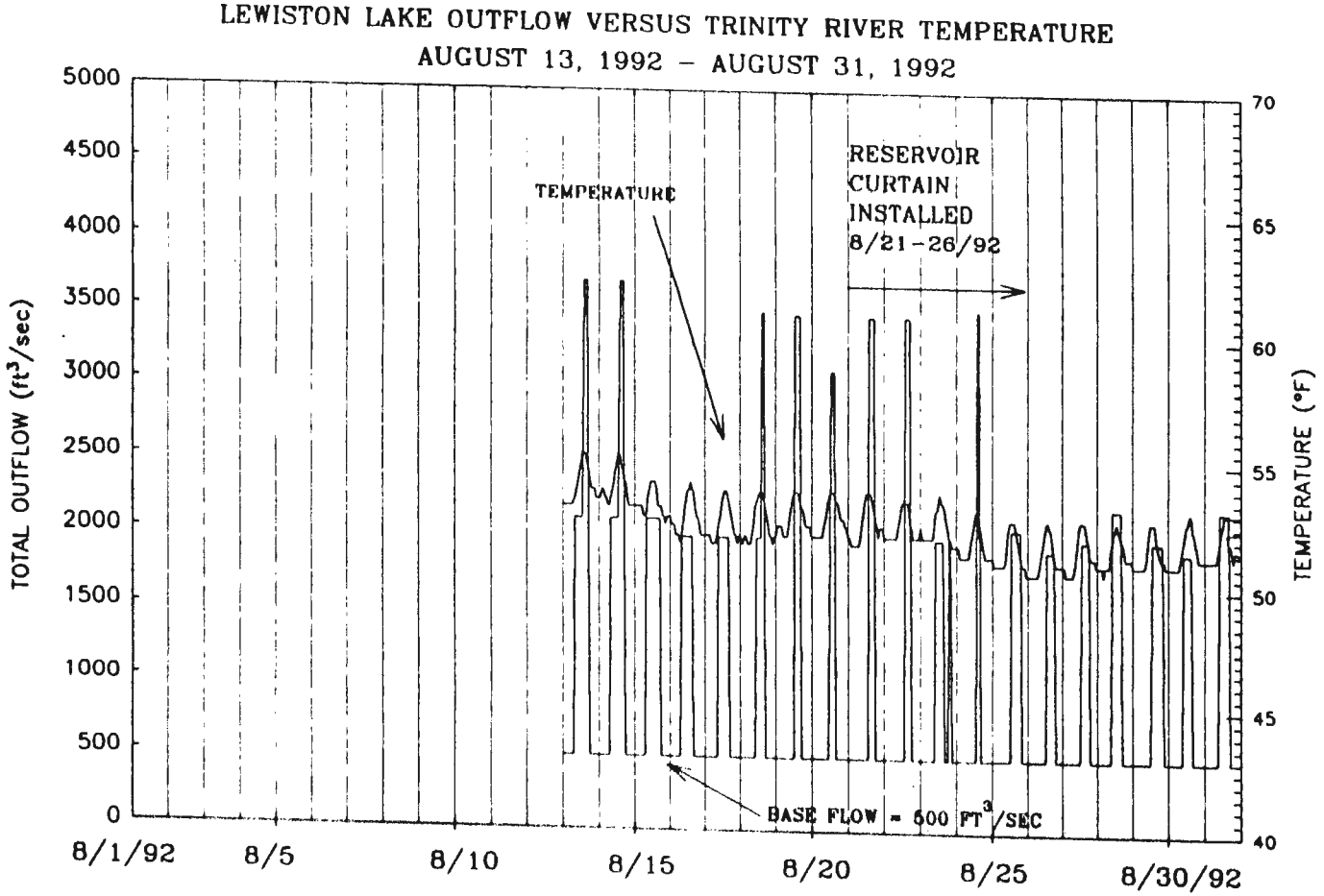
Figure 4. Lewiston Lake Outflow Versus Hatchery Intake Temperatures (Sept.). *The hatchery curtain was initially operated in underdraw mode then was switched to skimming on 9/9/92.*

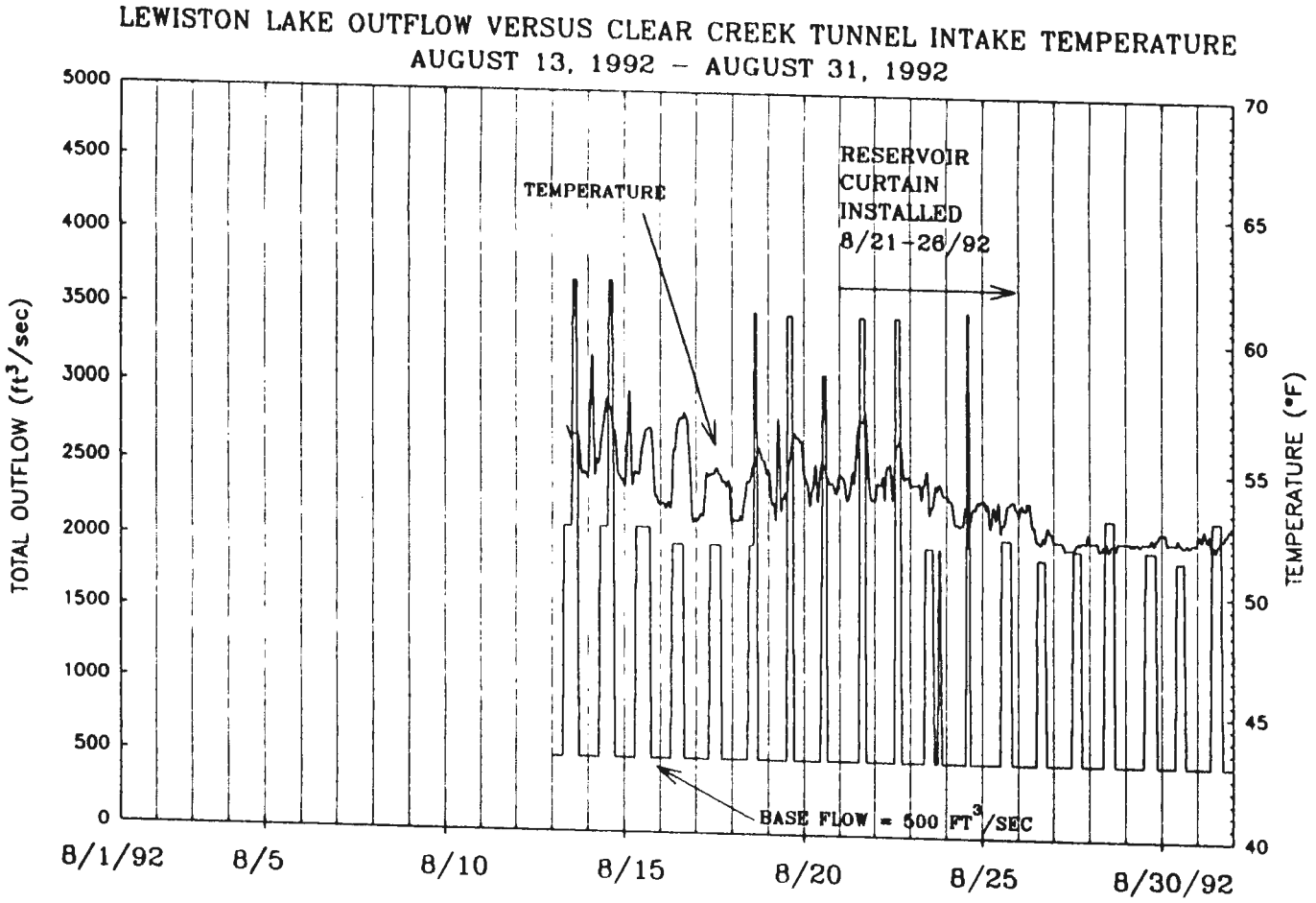
Figure 4 shows the versatility of the hatchery curtain. Initially, it was installed in an underdraw position and later adjusted to a skimming position. Underdraw operation further reduced withdrawal temperatures by 1.5 °F, for a total reduction of 4.5 °F.

Skimming operations increased hatchery withdrawal temperatures by approximately 1.5 °F, which is close to the withdrawal temperatures measured prior to installation of the hatchery curtain. This indicates that a very weak stratification exists downstream of the reservoir curtain. However, hatchery withdrawal temperatures might be further increased in the fall and winter by breaching the reservoir curtain to allow any available warm surface water (upstream of the reservoir curtain) to replace surface withdrawals.

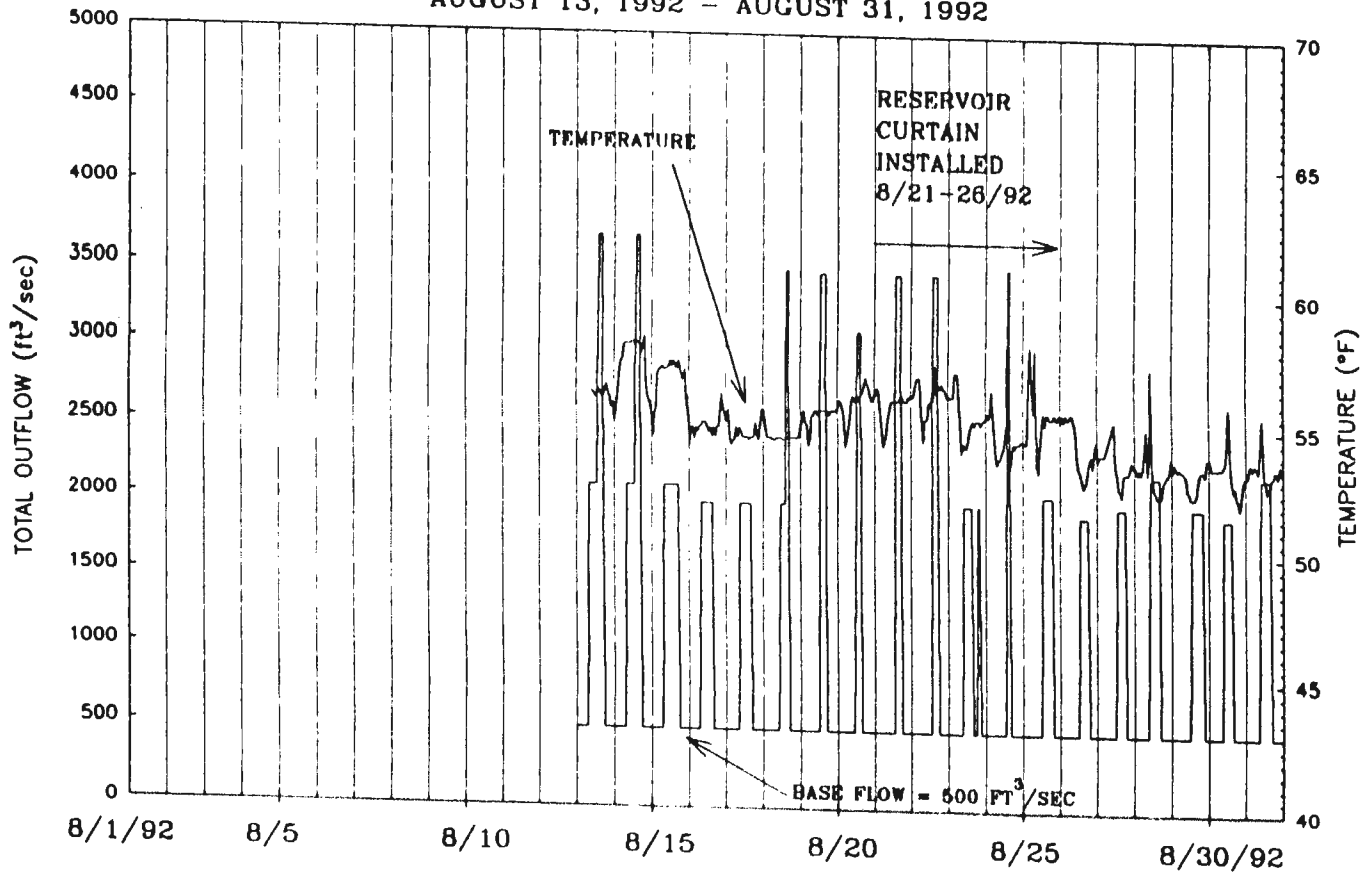
The rest of the monitoring data is enclosed in the appendix. These data show little additional information related to curtain performance, but may be useful to others.

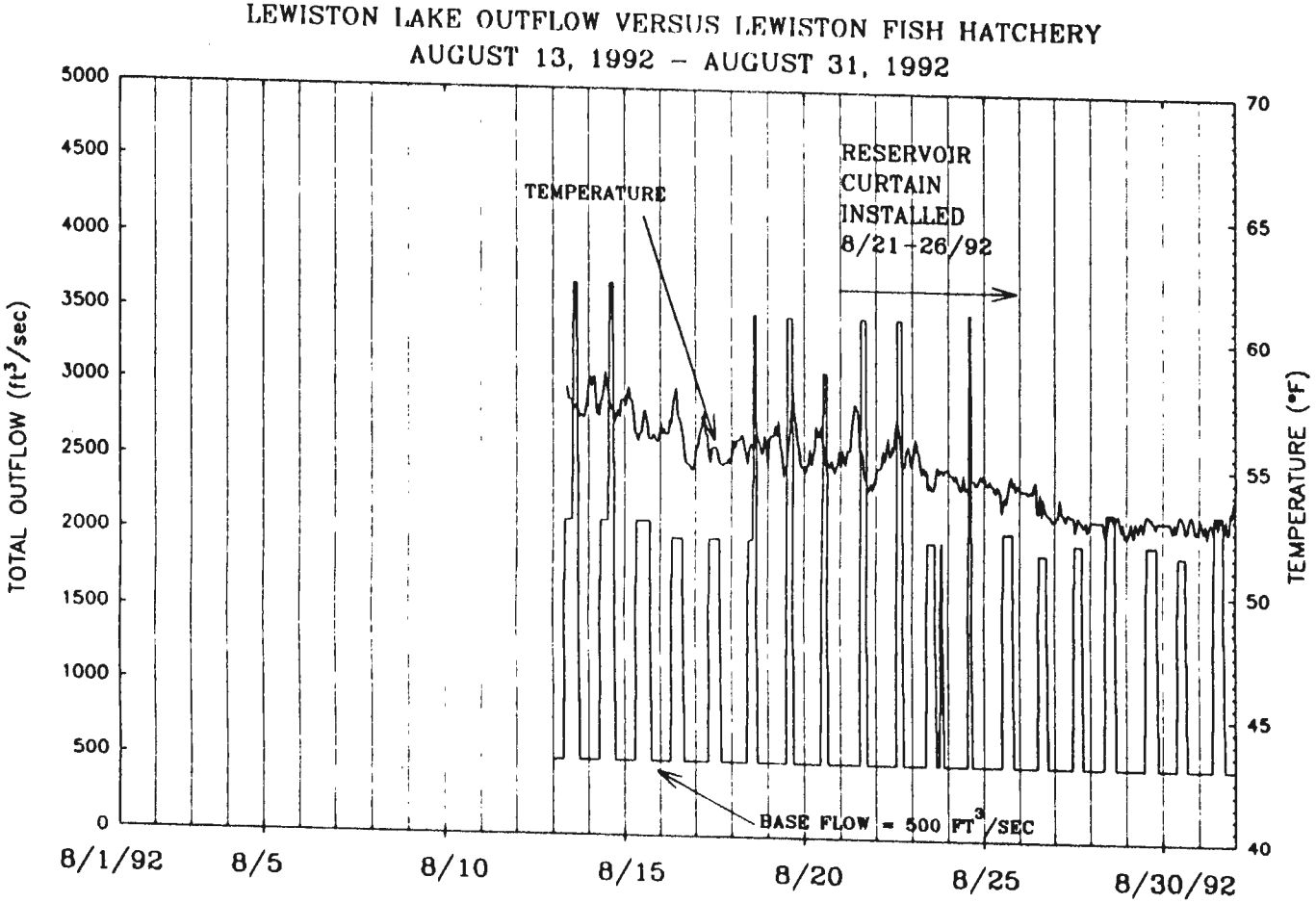
APPENDIX

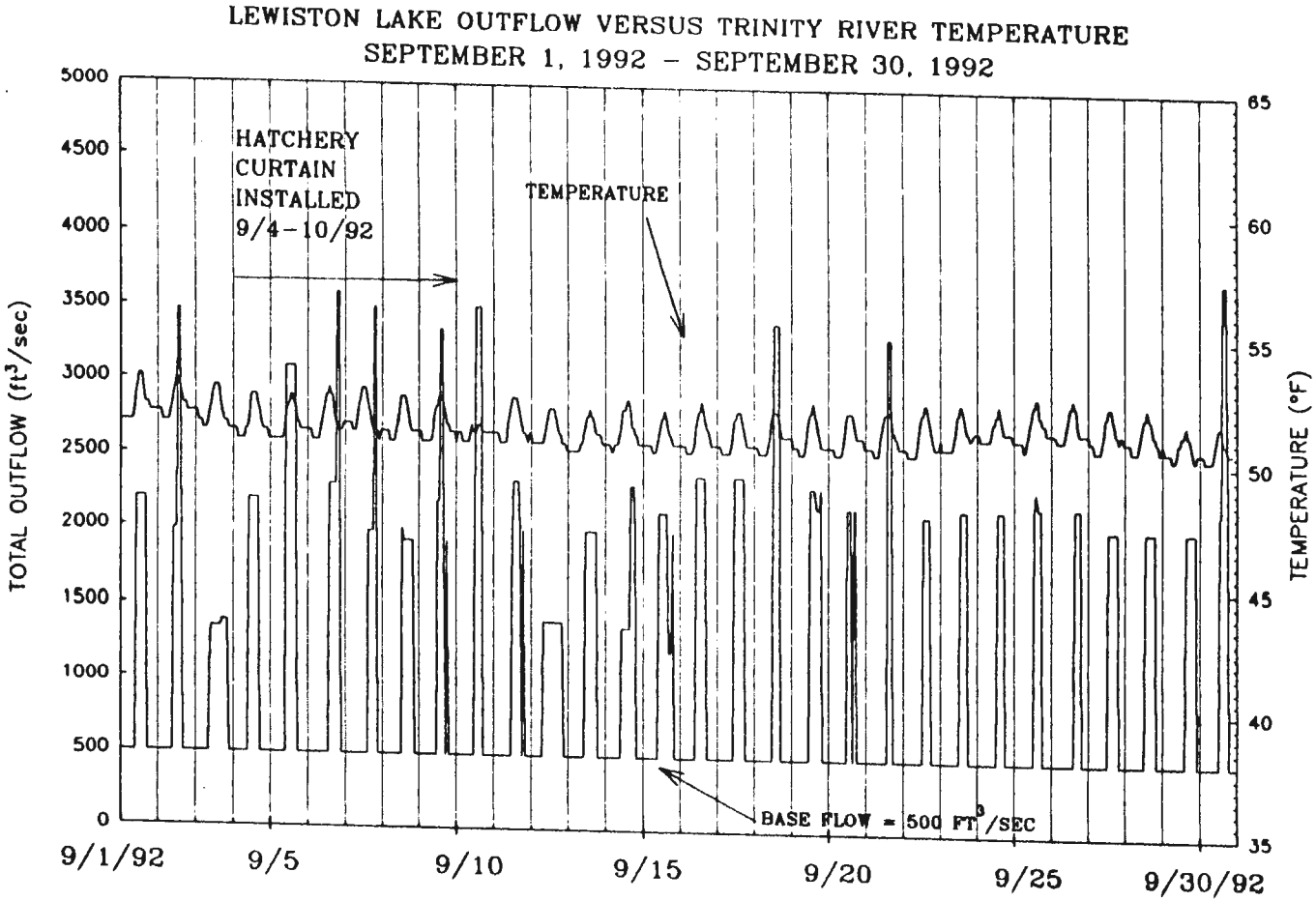

LEWISTON LAKE OUTFLOW VERSUS TRINITY RIVER TEMPERATURE
AUGUST 13, 1992 – AUGUST 31, 1992
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
70
65
60
55
50
45
40
8/1/92
8/5
8/10
8/15
8/20
8/25
8/30/92
TEMPERATURE
RESERVOIR CURTAIN INSTALLED 8/21-26/92
BASE FLOW = 500 FT³/SEC

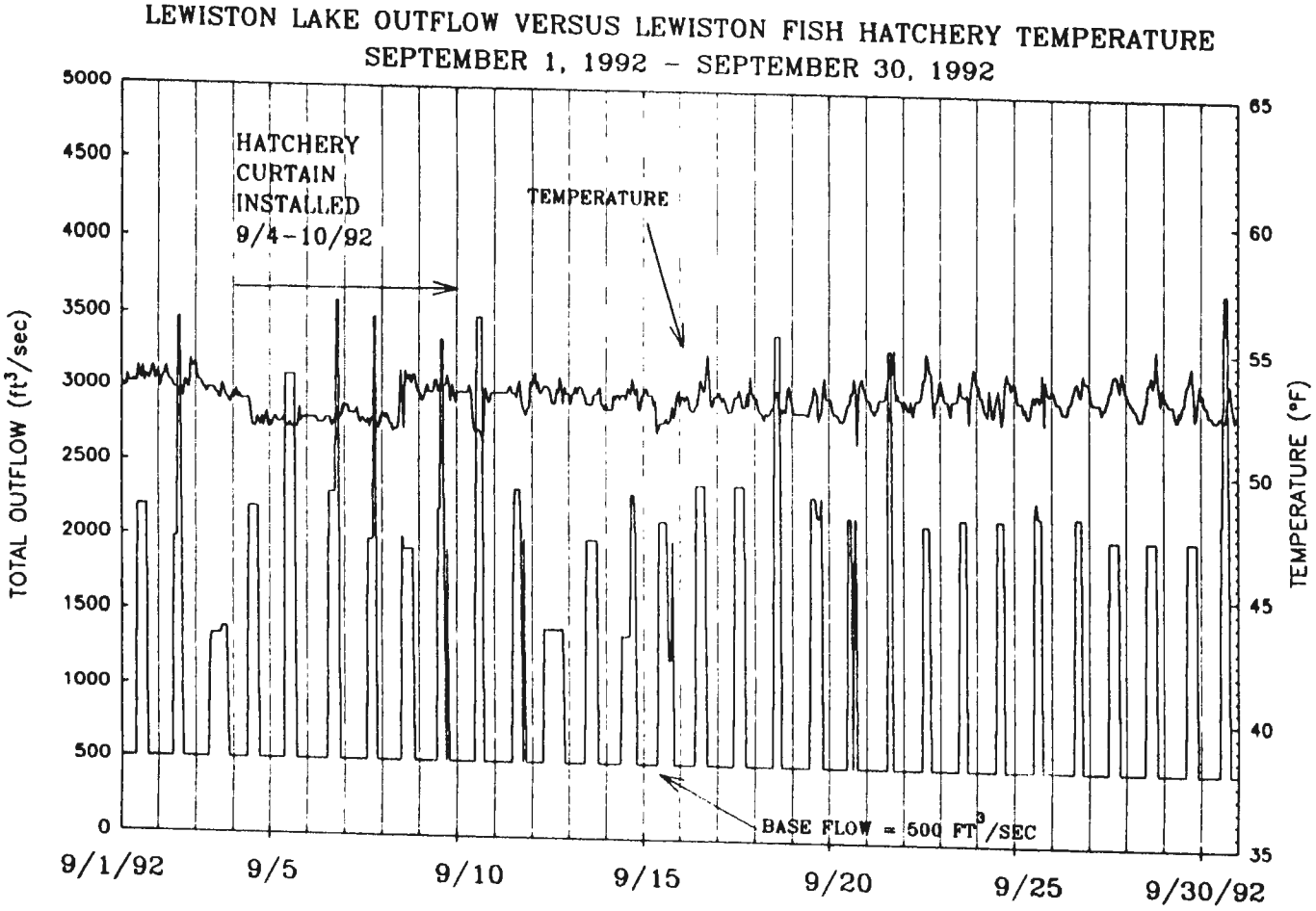

LEWISTON LAKE OUTFLOW VERSUS CLEAR CREEK TUNNEL INTAKE TEMPERATURE
AUGUST 13, 1992 – AUGUST 31, 1992
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
70
65
60
55
50
45
40
8/1/92
8/5
8/10
8/15
8/20
8/25
8/30/92
TEMPERATURE
RESERVOIR CURTAIN INSTALLED 8/21-26/92
BASE FLOW = 500 FT³/SEC

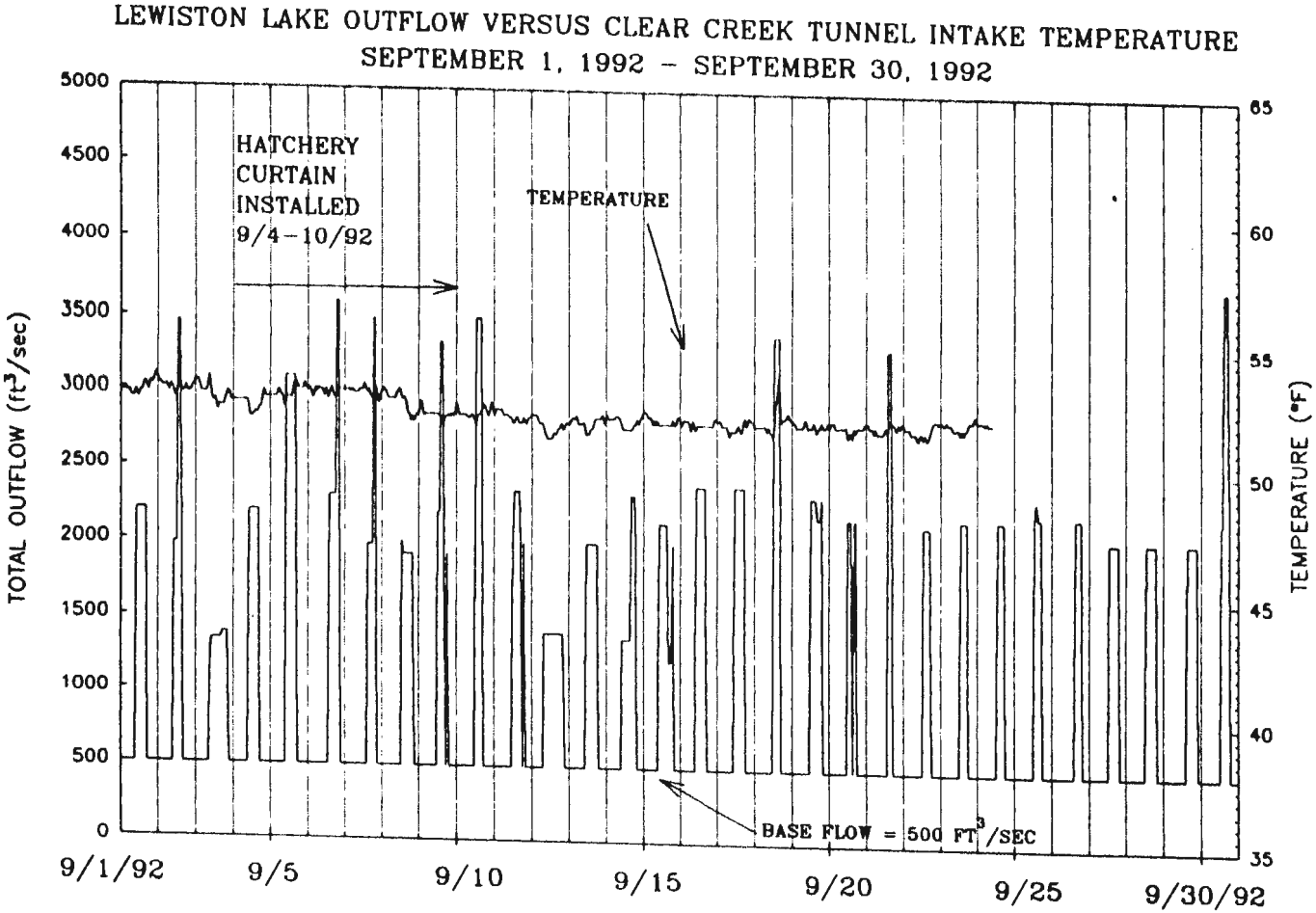
LEWISTON LAKE OUTFLOW VERSUS CARR POWERPLANT TEMPERATURE
AUGUST 13, 1992 – AUGUST 31, 1992

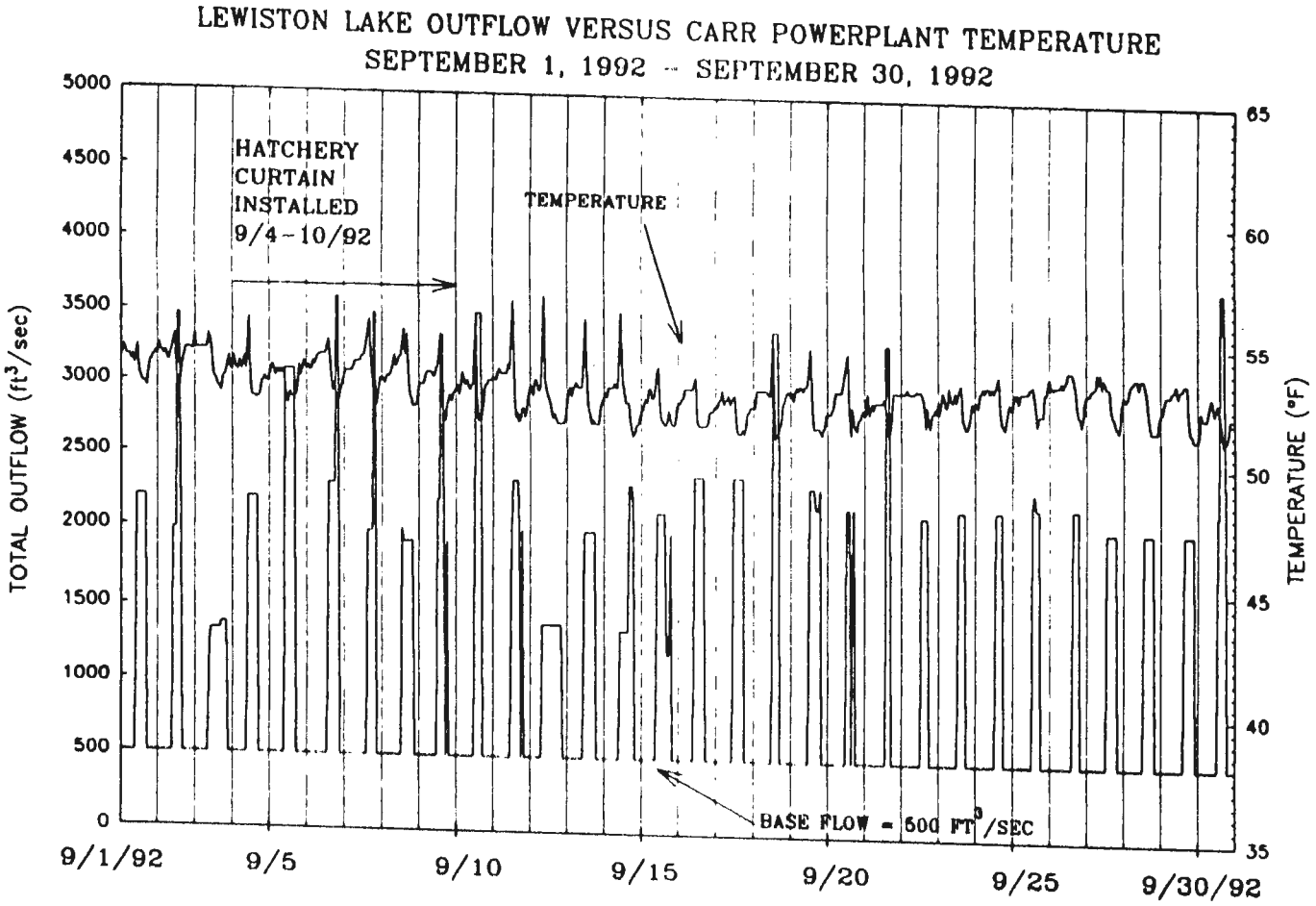


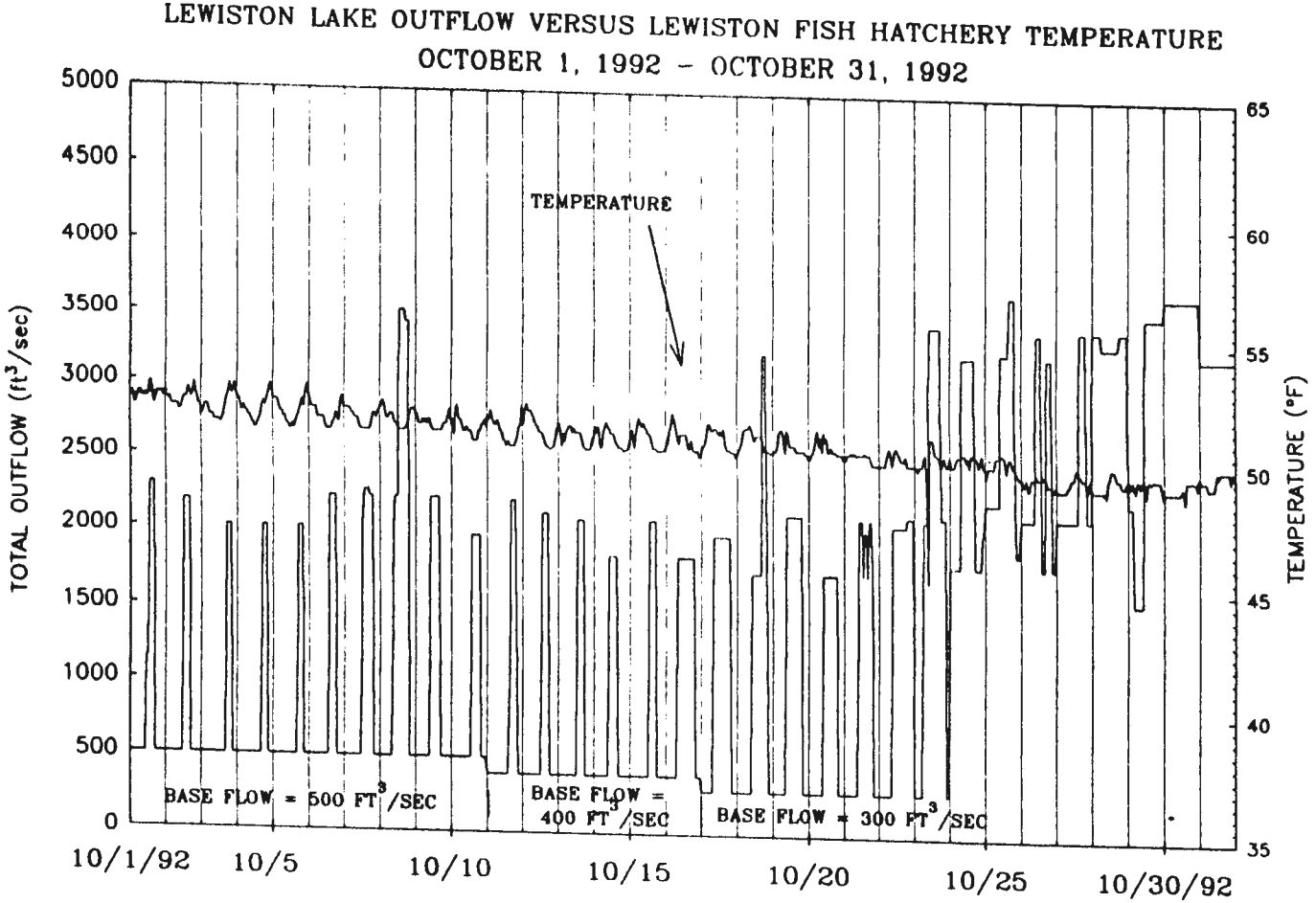

LEWISTON LAKE OUTFLOW VERSUS LEWISTON FISH HATCHERY
AUGUST 13, 1992 - AUGUST 31, 1992
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
70
65
60
55
50
45
40
8/1/92
8/5
8/10
8/15
8/20
8/25
8/30/92
TEMPERATURE
RESERVOIR CURTAIN INSTALLED 8/21-26/92
BASE FLOW = 500 FT³/SEC

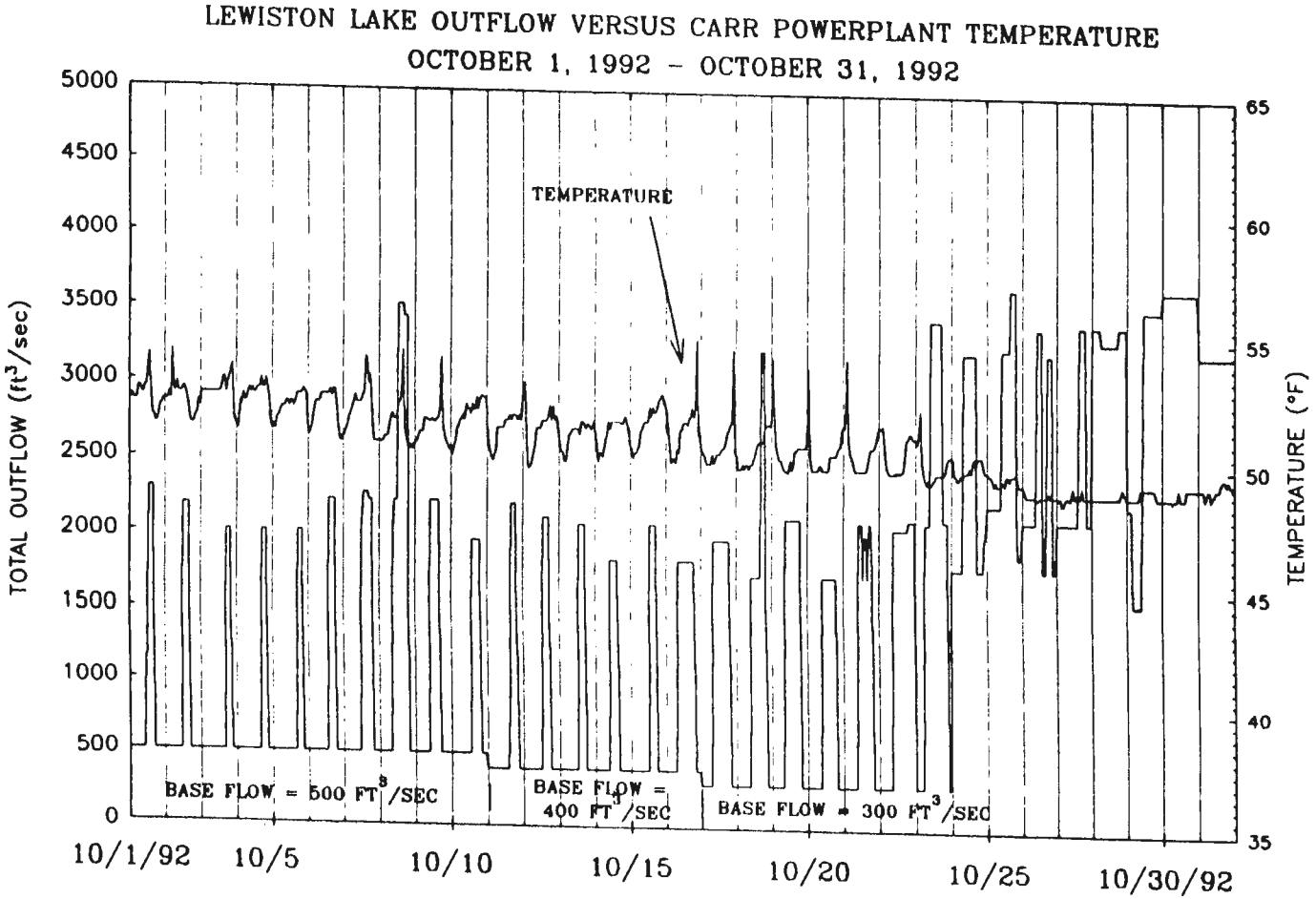

LEWISTON LAKE OUTFLOW VERSUS TRINITY RIVER TEMPERATURE
SEPTEMBER 1, 1992 - SEPTEMBER 30, 1992
HATCHERY CURTAIN INSTALLED 9/4-10/92
TEMPERATURE
BASE FLOW = 500 FT³/SEC
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
9/1/92
9/5
9/10
9/15
9/20
9/25
9/30/92

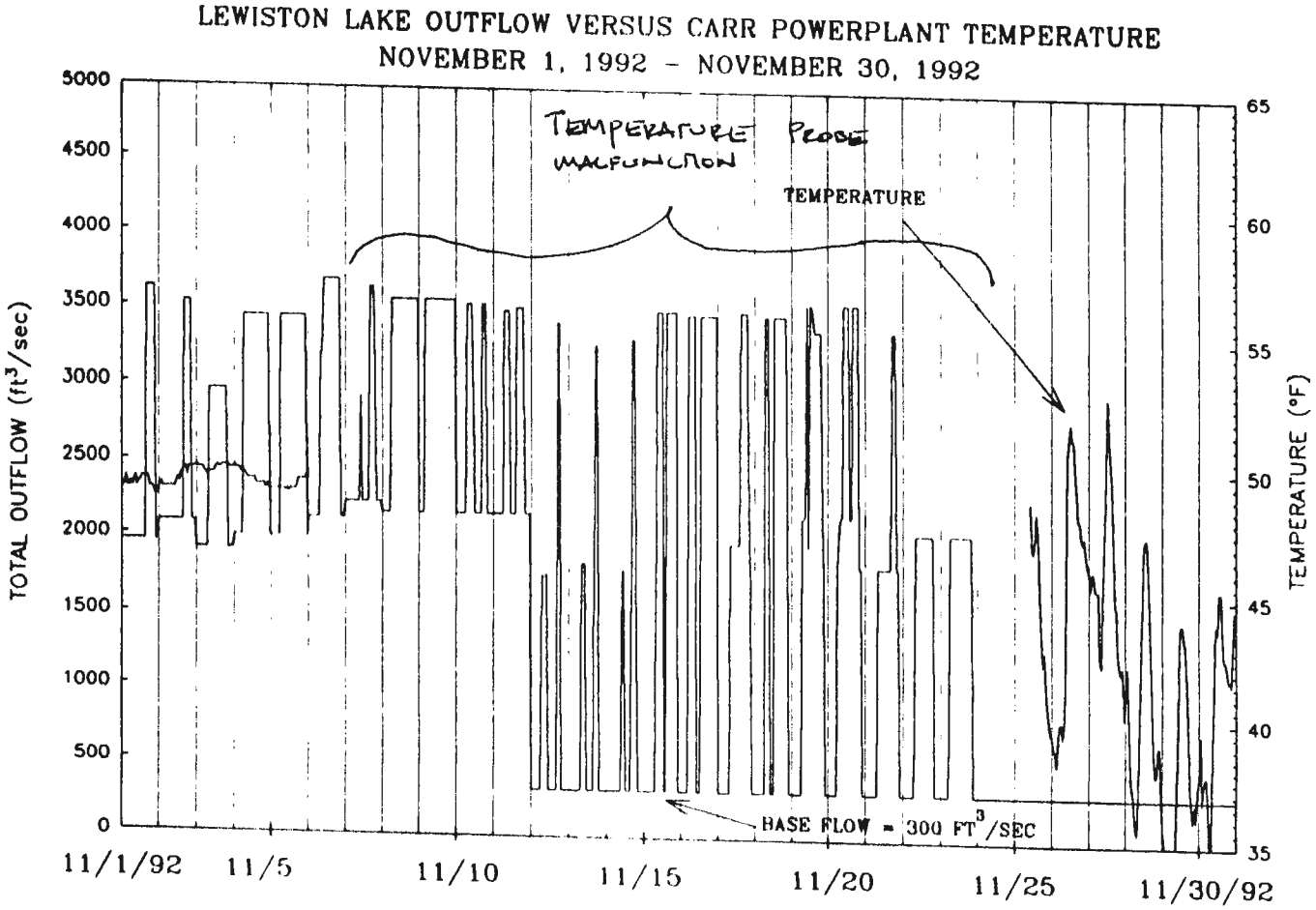

LEWISTON LAKE OUTFLOW VERSUS LEWISTON FISH HATCHERY TEMPERATURE
SEPTEMBER 1, 1992 - SEPTEMBER 30, 1992
HATCHERY CURTAIN INSTALLED 9/4-10/92
TEMPERATURE
BASE FLOW = 500 FT3/SEC
TOTAL OUTFLOW (ft3/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
9/1/92
9/5
9/10
9/15
9/20
9/25
9/30/92


LEWISTON LAKE OUTFLOW VERSUS CLEAR CREEK TUNNEL INTAKE TEMPERATURE
SEPTEMBER 1, 1992 - SEPTEMBER 30, 1992
HATCHERY CURTAIN INSTALLED 9/4-10/92
TEMPERATURE
BASE FLOW = 500 FT3/SEC
TOTAL OUTFLOW (ft3/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
9/1/92
9/5
9/10
9/15
9/20
9/25
9/30/92


LEWISTON LAKE OUTFLOW VERSUS CARR POWERPLANT TEMPERATURE
SEPTEMBER 1, 1992 - SEPTEMBER 30, 1992
HATCHERY CURTAIN INSTALLED 9/4-10/92
TEMPERATURE
BASE FLOW = 600 FT³/SEC
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
9/1/92
9/5
9/10
9/15
9/20
9/25
9/30/92


LEWISTON LAKE OUTFLOW VERSUS LEWISTON FISH HATCHERY TEMPERATURE
OCTOBER 1, 1992 - OCTOBER 31, 1992
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
TEMPERATURE
BASE FLOW = 500 FT³/SEC
BASE FLOW = 400 FT³/SEC
BASE FLOW = 300 FT³/SEC
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
10/1/92
10/5
10/10
10/15
10/20
10/25
10/30/92


LEWISTON LAKE OUTFLOW VERSUS CARR POWERPLANT TEMPERATURE
OCTOBER 1, 1992 - OCTOBER 31, 1992
TOTAL OUTFLOW (ft³/sec)
TEMPERATURE (°F)
TEMPERATURE
BASE FLOW = 500 FT³/SEC
BASE FLOW = 400 FT³/SEC
BASE FLOW = 300 FT³/SEC
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
10/1/92
10/5
10/10
10/15
10/20
10/25
10/30/92


LEWISTON LAKE OUTFLOW VERSUS CARR POWERPLANT TEMPERATURE
NOVEMBER 1, 1992 - NOVEMBER 30, 1992
TEMPERATURE PROBE MALFUNCTION
TEMPERATURE
BASE FLOW = 300 FT3/SEC
TOTAL OUTFLOW (ft3/sec)
TEMPERATURE (°F)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
65
60
55
50
45
40
35
11/1/92
11/5
11/10
11/15
11/20
11/25
11/30/92

LEWISTON LAKE OUTFLOW VERSUS LEWISTON FISH HATCHERY TEMPERATURE
NOVEMBER 1, 1992 – NOVEMBER 30, 1992