Umpqua Basin Watershed Council

Analysis of 1937 Stream Temperature Data From the Tiller Region of the South Umpqua River

by
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Summary

In the summer of 1937 A.R. Roth, Junior Biologist, conducted a detailed assessment and report of the biological and physical stream characteristics of the South Umpqua and tributaries above Tiller. (Roth, 1937). Data were collected from 86 sites that included stream temperature readings along with time, location and other descriptive information.

In 1999 a stream temperature characterization study was done on the South Umpqua Basin using 119 continuously sampling temperature data loggers (UBWC, 1999). Twenty-one of the monitoring sites match the same general areas as the Roth study sites. Comparison of the temperature data from the two studies indicates that, in spite of some unknown accuracy factors, the stream temperatures <u>may</u> have been as much as 4°F cooler in 1937. Applying this interpretation to the 1999 data leads to the conclusion that many of the streams in this area exceeded the 64°F 7-day moving average under 1937 conditions.

Conditions as described by Roth indicate that the study area was quite pristine with about 40 miles of road as opposed to the current level of about 1,900 miles. Data from the 1999 study indicate that stream temperatures in the interior Umpqua Basin below Tiller tend to be higher, so it is likely that most of the interior streams in the Umpqua Basin also exceeded the 64°F standard under pre-anthropogenic, conditions.

This finding does not negate the fact that the present-day streams in the watershed may be warmer than they were historically and that the cold-water fishery resource would benefit from cooler temperatures in virtually all of the streams.

Objective and scope of the study:

Stream temperature is a key management issue in the Umpqua Basin since it affects water quality in general and has a strong influence on the aquatic ecosystem with particular emphasis on cold-water fish. Of particular interest is the achievability of the Oregon DEQ 64°F stream temperature standard since most streams in the Umpqua Basin presently exceed this standard (UBWC, 1999, UBWC, 1998). Current policy in Oregon requires that a stream temperature management plan be developed for listed streams to bring stream temperatures to an acceptable level. For that reason, knowledge of historical stream temperature conditions becomes important to establish meaningful management objectives.

The temperature information and other data in the 1937 Roth study, "A Survey of the Waters of the South Umpqua Ranger District, Umpqua National Forest," and the 1999 "South Umpqua Watershed Temperature Study" provide a rather unique opportunity to compare historic and current stream temperature conditions.

The objective of this report is to present the relevant available data and make a preliminary analysis of the relative stream temperatures. Typically, historic data is not complete and the collection methodology and data accuracy information is not fully available. Also, stream temperatures are highly variable with limited historic data of many of the factors contributing to this variability. Consequently, a definitive, direct comparison is not possible. However, by applying a few assumptions to the information available, a general indication of the temperature differences between the two periods can be determined. This report provides a rather simple comparison and it is hoped that the interested reader will find the data sufficient to try other, more sophisticated, approaches.

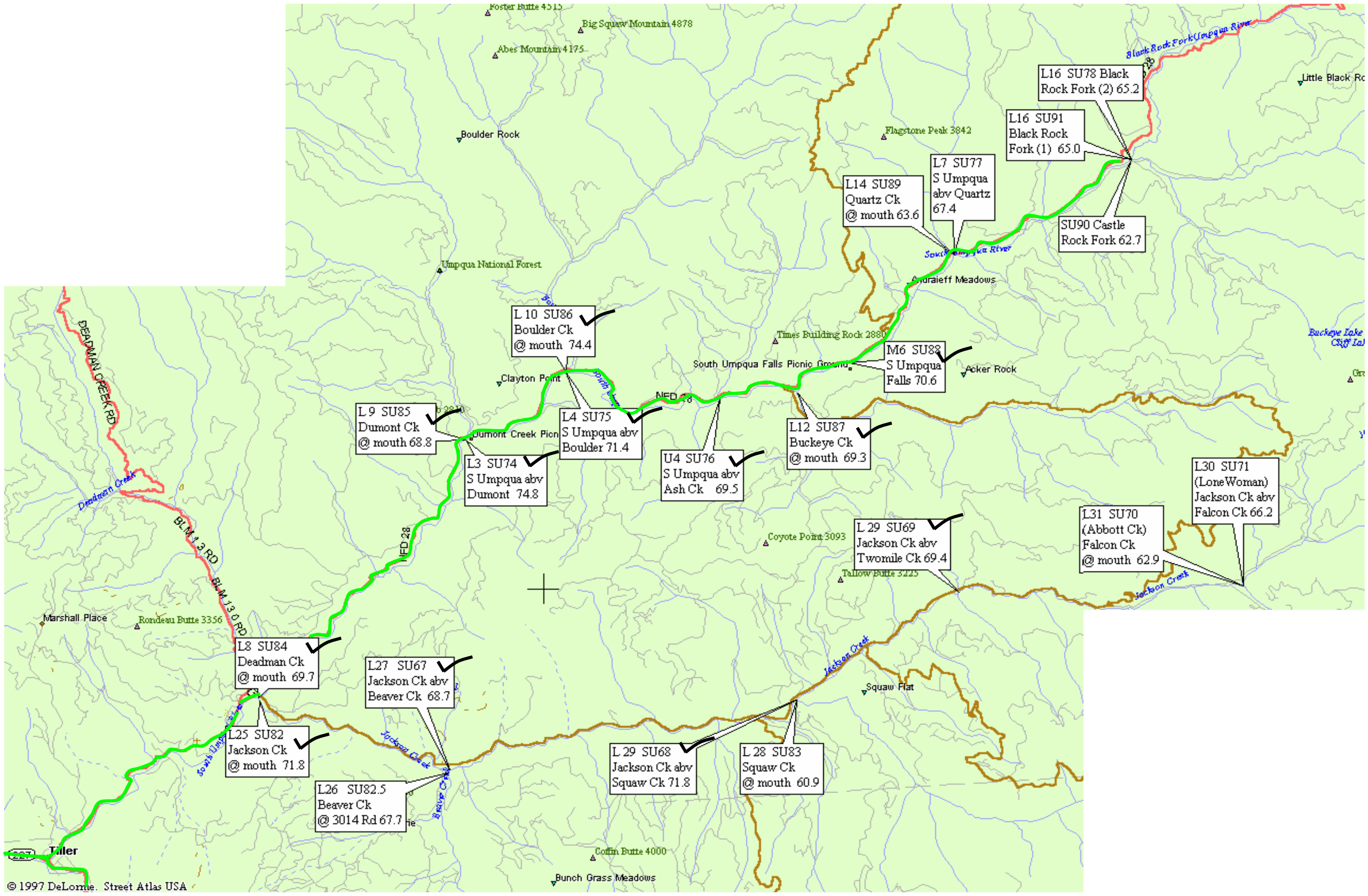
This report also discusses processes that would account for the possible temperature increase observed in the 1999 data, implications and suggestions for further study.

Background:

In the summer of 1937 A.R Roth conducted a detailed investigation of conditions in the upper South Umpqua area with three specific objectives. (1) gather information to develop a stocking policy (2) identify lake and stream improvement opportunities and (3) assess the fish passage situation at South Umpqua Falls. The product of this effort included a report, "A Survey of the Waters of the South Umpqua Ranger District, Umpqua National Forest" (Roth, 1937) which provides a tantalizing glimpse of the prevailing physical and biological conditions from that time period. Included in the report are 86 stream temperature readings with information on general location, date, time, and weather conditions.

In 1999 a detailed temperature monitoring study involving 119 temperature data loggers was conducted on the South Umpqua watershed as part of a stream temperature characterization project sponsored by the Umpqua Basin Watershed Council (UBWC). The associated report (UBWC, 1999) contains all of the data and some basic analysis from this study.

The map shows the location of the sites that were common to both studies.



1937 Road System
First Number "L8" denotes Roth Reach
Second Number "SU84" denotes 1999 site number
Last Number "69.7" denotes 1999 7-day average maximum temperature
✓ Checked sites may have exceeded the 64 °F standard in 1937

1937 Conditions

As indicated above, the Roth report provides an abundance of details that help to characterize the 1937 conditions in what is now the Tiller Ranger District of the Umpqua National Forest. Based on Roth's description, it appears that portions of the study area were in relatively pristine condition and would be a good approximation of pre-anthropogenic conditions. The following are some highlights that support that observation:

1. There were about 40 miles of road on the entire Tiller Ranger District, which included a road up the South Umpqua to Camp Comfort near the confluence of Castle Rock and Black Rock Creeks and a road up Elk Creek. Notably, there were no roads up Jackson Creek or up the other tributaries. An elaborate trail system provided access to the upstream areas.

2. Flow volumes were observed by Roth to fluctuate between reaches due to "sinking" of water in many sections. This suggests significant hyporheic flows, which can have a strong influence on local stream temperatures during low flow (peak temperature) conditions.

3. The report mentions that about 7,000 acres were in a "burned over" condition with rapid, ongoing reproduction. The location of the burned areas was not identified.

4. Beaver were scarce because of illegal trapping but Roth noted that they had been abundant in the area prior to settlement.

5. Roth observed that virtually all of the tributaries were well shaded with about 2/3 dominated by tall timber and the remainder with low brush.

Table 1 contains some additional information from the Roth report for the specific reaches addressed in this report.

Roth #	Stream	Reach Location	Bottom	Shade	Riffles	Pools
3 lower	S. Umpqua	Dumont Cr. to bend in river	Gravel rubble	Semi-arboreal	Short, narrow	S1 T1 F1
4 lower	S. Umpqua	Boulder Cr. to Big Bend	gravel,rubble	Arboreal	Short, shallow	S1 T1 F1
4 upper	S. Umpqua	Ash Cr. to Buckeye Cr	gravel,rubble	Arboreal	Short, shallow	S1 T1 F1
6 middle	S. Umpqua	Large V Falls to Russian P1	gravel, bedrock, rubble	Semi-arboreal	Long Shallow, short deep	S1 T2 F2
7 lower	S. Umpqua	Quartz Cr. to Flood Cr	rubble gravel	Arboreal, semi-arboreal	Long Shallow	S1 T2F2
8 lower	Deadman Cr.	Mouth to old cabin	gravel, bedrock	Arboreal	Narrow, deep	S1 T1 F1
10 lower	Boulder Cr.	Mouth to Slick Creek	gravel, bedrock	low brush, Arboreal	short deep, long deep	S1 T1 F1
12 lower	Buckeye Cr.	Mouth to trail crossing	rubble gravel	Arboreal	Short, rapid, Long, shallow	S1 T1 F1
14 lower	Quartz Cr.	Mouth to 1st main trib	gravel, bedrock, rubble	Arboreal	Short deep, long, shallow	S1 T1 F1
16 lower	Black Rock Fork	Mouth to Boze Creek	boulders, gravel	Arboreal	Long Shallow, short, deep	S1 T1 F1
18 lower	Fish Lake Cr	Mouth to telephone	gravel,rubble	Arboreal	Long Shallow	S1 T1 F3
24 lower	Elk Creek	Mouth to Callahan Cr.	gravel,rubble	semi-exposed	Long Shallow	S1 T1 F1
25 lower	Jackson Cr.	Mouth to 3-point Camp	gravel,rubble	Arboreal	Long Shallow	S1 T1 F2
26 lower	Beaver Cr.	Mouth to Beaver Lake	gravel, silt, rubble	low brush, Arboreal	Long Shallow	S1 T1 F1
27 lower	Jackson Cr.	Beaver Cr. to Surveyor Cr.	gravel,rubble	Arboreal	Long Shallow	S1 T1 F2
28 lower	Squaw Creek	Mouth to trail crossing	gravel,rubble	low brush	Long Shallow	S1 T1 F1
29 lower	Jackson Cr.	Squaw Cr. to Two Mile Cr.	gravel,rubble	low brush, Arboreal	Long Shallow	S1 T1 F1
29 middle	Jackson Cr.	Two Mile Cr. to Cow Camp Cr.	gravel,rubble	Arboreal	Long Shallow	S1 T1 F1
30 lower	Lonewoman Cr.	Mouth to 2nd main trib.	gravel,rubble	low brush	Long Shallow	S2 T2 F2
31 lower	Abbott Cr.	Mouth to Falcon Creek	gravel,rubble	low brush	Long Shallow	S1 T1 F1
19 lower	Castle Rock Ck	Camp Comfort to trail cross.	gravel,rubble	low brush, Arboreal	Long Shallow	S1 T1 F1

The following criteria and definitions used by Roth for his survey were copied directly from his report:

Bottom Types
Due to the great amount of bedrock and the number of steep canyons throughout this area, there is a predominance of rubble in all streams. An abundance of gravel, which provides excellent spawning conditions, and some sand, were also found in the riffles below pools.

Shade - The following terms have been used to designate the types of shade existing on the streams throughout this area:
exposed, no shade
Semi-exposed, not more than a third of the water shaded
Arboreal, tall timber along banks, shading most of the stream
Low brush, overhanging trees and brush, heavily shading entire stream and making fishing somewhat difficult.

Due to extreme width, the lower sections of the South Umpqua River near Tiller are almost entirely exposed. The upper section of the main stream and most of the tributaries are heavily shaded and hence classed as arboreal or low brushed, which makes angling rather difficult. However, these conditions provide lower water temperatures, protection for fish, and a plentiful supply of terrestrial foods.

Riffles
One of the primary reasons for the plentiful food supply existing in the South Umpqua River and its tributaries is the large number of riffles areas throughout the entire system.

Color and Turbidity
The waters of this area are very clear and free from sediment except after heavy rains or during early spring freshets.

Pools
In the lower stretches of the South Umpqua River, pools are of good size but are few and far between. In the upper sections many of the tributaries contain from 20 to 100 pools per mile.

The pools are classified as to size, type, and frequency as follows:

Size		S	
	1 -	good	2 times width of stream
	2 -	fair	equal to width of stream
	3	pool	less than width of stream
Type		T	
	1	good	deep, sheltered, boulders
	2	fair	shallow, open, huge rocks
	3	poor	shallow, open, bedrock
Frequency		F	
	1	good	continuous
	2	fair	close succession
	3	poor	low

Current Conditions:

Recent stream survey data for the study area is available but was not reviewed for this report. The riparian areas are currently managed by the USDA Forest Service under the direction of the Northwest Forest Plan that requires that the riparian zone be managed to better achieve old growth characteristics.

Currently there are 1,920 miles of road on the Tiller Ranger District.

Flow and Precipitation

Varying streamflow can affect temperature in several ways:

1. Higher flows mean greater stream depth and generally lower temperatures because the heat energy intercepted by the water surface has to warm a deeper column of water.
2. Flow velocities increase with streamflow that influences how heated water moves downstream.
3. As flows diminish to the low flow condition, the proportion of groundwater/ hyporehic contribution to the surface flow can increase. Since the groundwater is typically cooler, this effect can tend to counteract the effect of item 1.

Figure 1 Precipitation and flow data.

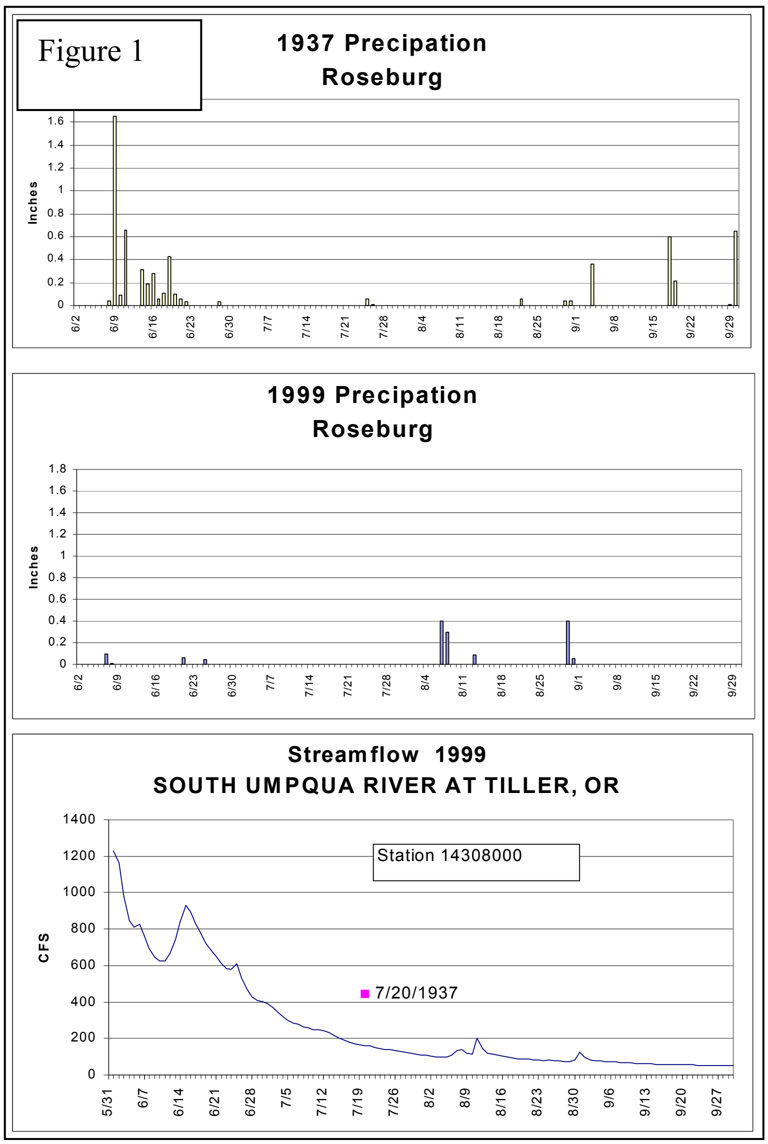


Figure 1 shows some precipitation and flow information for the area. Since the precipitation data is from Roseburg, over 60 miles away, the exact quantities in the study area are not certain but the data does provide a general comparison of the seasonal precipitation pattern. The 1999 flow data is from the South Umpqua Tiller gage that is upstream from the confluence of Elk Creek.

Roth took flow measurements as part of his reach surveys but it is uncertain exactly where and how he made the measurements. He indicates that several cross sections were taken in each reach with a velocity determination for each section. However, there is no description of methodology or any indication that a current meter was used.

Unfortunately, there is no flow record for the Tiller gage available for 1937. The Roth flow measurement at Tiller was 445.7 cfs on 7/20/37, which appears to be high. The statistical summary for the Tiller station indicates that the 5% exceedance value for July is only 334 cfs. However, it is very possible that his measurements at Tiller included Elk Creek since that stream was included in his study.

Temperature Measurements

Roth did not indicate the exact location of his temperature measurements. His study is divided into reaches and each reach had typically three sections; lower, middle and upper each of which had a temperature value and an associated date. There is no indication of what portion of each section the reading was taken. For the 1999 data, the sites typically are located at the low end of the Roth reach.

There is also no mention of the accuracy of the thermometer used by Roth but an accuracy of +/- 1°F is reasonable. There is no calibration information available for the Forest Service instruments but an accuracy of +/- .3°F is assumed for the type of instrument used.

Analysis

As mentioned previously, there is insufficient information to make a definitive comparison for each site. The goal of this analysis is to use the existing information with some basic assumptions to try to determine the range of error for the data.

Matching the Roth sample time with a corresponding value from the continuous 1999 record tended to reduce the error due to diurnal variation. However, the 1999 data indicates that the stream temperature can change as much as 4°F per hour during the period of maximum solar flux. Therefore, the results still remain sensitive to the exact time of measurement. It was assumed that the 1999 data was taken on Daylight Savings Time and that the 1937 data was on regular time. For that reason, the time of the Roth data was advanced one hour to make it equivalent to the 1999 data.

No direct adjustments were made for flow but the precipitation and flow record indicates that 1937 was a wetter year and the streams may have been experiencing higher flows during the study period.

Correction for Climatic conditions

Daily air temperature records from Roseburg were used to attempt to adjust the measurements for prevailing climatic conditions for the two different years. Chart 1 shows that there is a loose correlation between the 1999 stream temperatures and the corresponding Roseburg air temperatures. The regression of maximum water against maximum air was not used because it had an R squared of only 0.21.

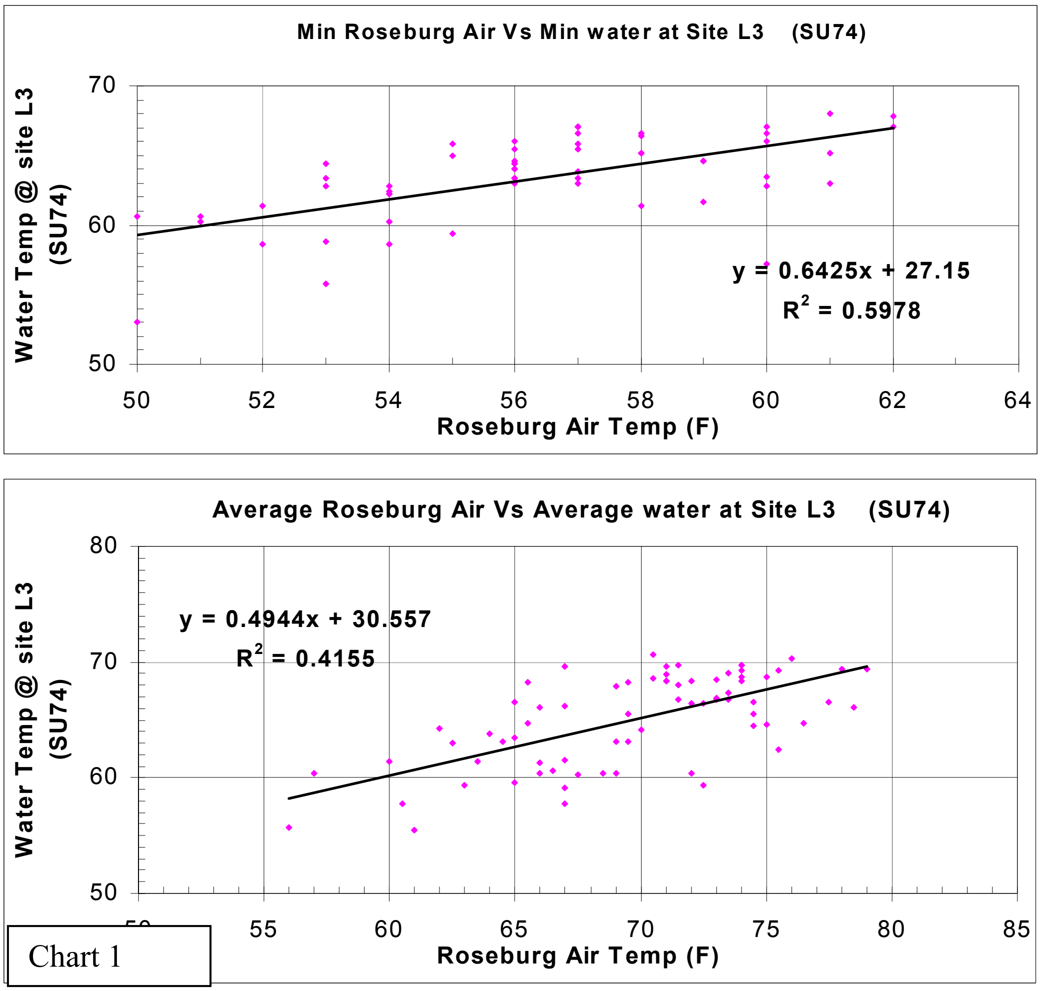
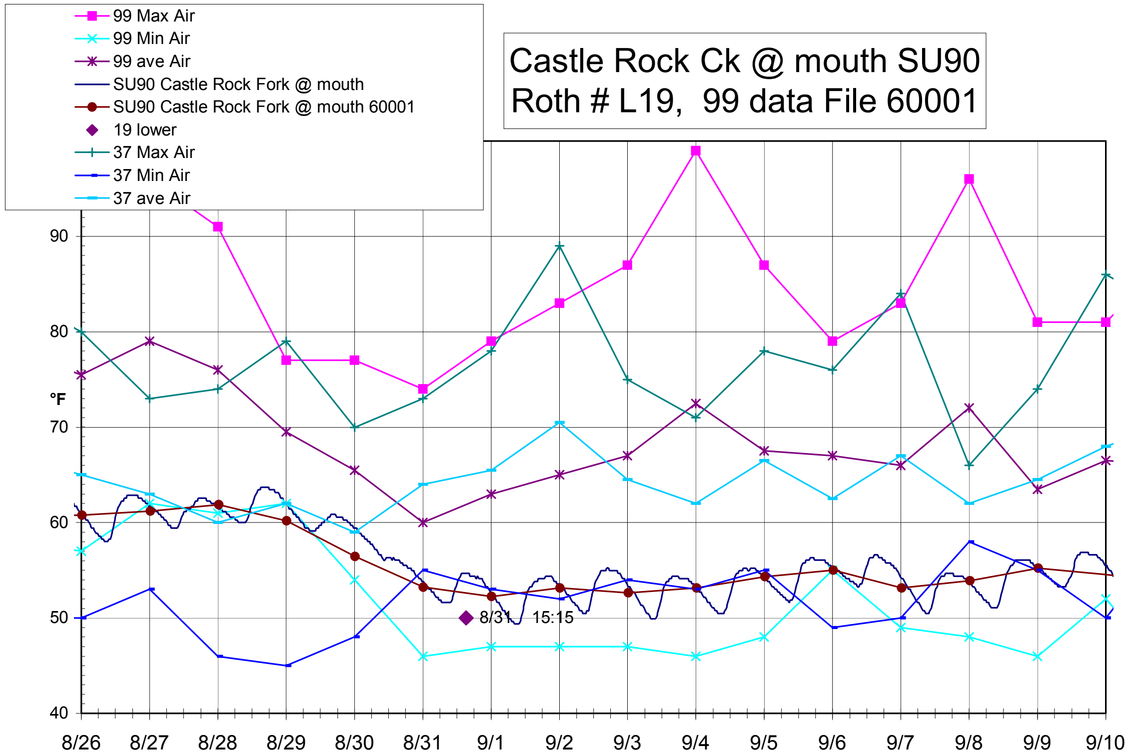


Chart 1

Chart 2 is a typical plot that compares the 1937 air and stream temperature data with the corresponding 1999 temperatures for a particular site. Similar comparison charts for all of the sites are included in the Appendix.

The two jagged curves at the top of the chart are the daily maximum air temperature values for the two years. The values are plotted on each date line but represent the maximum that actually occurred later in the indicated day.



The next pair of jagged curves shows the average air values that were calculated as the simple mean between the max and minimum values.

The sinusoidal curve extending across the lower center of the chart is the 1999 stream temperature record. Water temperatures were measured at 30-minute intervals to generate this curve. The round dots joined by a line represent the daily average temperature for the day to the right of the point. This average was determined from the 48 data points associated with the given day.

The single diamond shaped point with the date and time label is the 1937 Roth temperature value. The 1999 temperature reading that corresponded to the time of the Roth reading was determined from the 1999 record and recorded (in Table 1) as the 1999 Roth equivalent temperature.

The lower pair of jagged curves represents the daily minimum values.

Methodology used for correction factors

Several different methods were used to try to adjust for prevailing climatic conditions. Table 1 shows two sets of analysis: one using the daily average air temperature and other using the daily minimum air temperature data.

Method 1 uses the simple difference between the stream temperatures for the respective years. The corresponding difference in air temperatures was provided for comparison. Note that the average difference in water temperature was larger than the air temperature differences even though more variation occurred in the air data.

Table 1

Predicting 1937 Value using 1999 water and Average Air correction factors

1937 Roth Reach #	1999 Data: FS Data 99Roth	1999 Data: Roseburg Ave Air	1937 Data: Roth 37Roth	1937 Data: Roseburg Ave Air	Method 1: 99W-37W	Method 1: 99Air-37Ai	Method 2: Predicted 37Roth	Method 2: Predicted-Actual 37 Roth	Method 3: Predicted 37Roth	Method 3: Predicted-Actual 37 Roth
L1			70						0.49	
L3	64	74.5	60	71.5	4	3.0	61.0	1.0	62.5	2.5
L4	63.5	73	62	75	1.5	-2.0	65.5	3.5	64.5	2.5
U4	63.9	73	66	75	-2.1	-2.0	65.9	-0.1	64.9	-1.1
M6	62.3	78	56	67	6.3	11.0	51.3	-4.7	56.9	0.9
L7	66.5	75.5	64	65	2.5	10.5	56.0	-8.0	61.4	-2.6
L8	69	74	59	65	10	9.0	60.0	1.0	64.6	5.6
L9	69	74	62	74	7	0.0	69.0	7.0	69.0	7.0
L10	65.6	74	61	72	4.6	2.0	63.6	2.6	64.6	3.6
L12	65	65.5	62	76.5	3	-11.0	76.0	14.0	70.4	8.4
L14	62.1	73.5	61	73.5	1.1	0.0	62.1	1.1	62.1	1.1
L16	57.7	65.5	50	59	7.7	6.5	51.2	1.2	54.5	4.5
L16	59.2	65.5	50	59	9.2	6.5	52.7	2.7	56.0	6.0
L19	54.7	60	50	64	4.7	-4.0	58.7	8.7	56.7	6.7
L24	56.2	63	56	65.5	0.2	-2.5	58.7	2.7	57.4	1.4
L25	63.2	69	66	78	-2.8	-9.0	72.2	6.2	67.6	1.6
L26	60.7	73	60	72.5	0.7	0.5	60.2	0.2	60.5	0.5
L27	58.1	66	61	70.5	-2.9	-4.5	62.6	1.6	60.3	-0.7
L28	52.5	66.5	51	68	1.5	-1.5	54.0	3.0	53.2	2.2
L29	58.3	63.5	56	64.5	2.3	-1.0	59.3	3.3	58.8	2.8
M29	56.8	63.5	52	64.5	4.8	-1.0	57.8	5.8	57.3	5.3
L30	53.6	66	50	67	3.6	-1.0	54.6	4.6	54.1	4.1
L31	55	66	52	67	3	-1.0	56.0	4.0	55.5	3.5
Average	60.77	69.20	57.59	68.82	3.18	0.39	60.38	2.79	60.58	2.99

Predicting 1937 using 1999 water and Minimum Air correction factors

1937 Roth Reach #	1999 Data: FS Data 99Roth	1999 Data: Roseburg Min Air	1937 Data: Roth 37Roth	1937 Data: Roseburg Min Air	Method 1: 99W-37W	Method 1: 99Air-37Ai	Method 2: Predicted 37Roth	Method 2: Predicted-Actual 37 Roth	Method 3: Predicted 37Roth	Method 3: Predicted-Actual 37 Roth
L1			70						0.642	
L3	64	56	60	55	4	1.0	63.0	3.0	63.4	3.4
L4	63.5	56	62	58	1.5	-2.0	65.5	3.5	64.8	2.8
U4	63.9	56	66	58	-2.1	-2.0	65.9	-0.1	65.2	-0.8
M6	62.3	58	56	50	6.3	8.0	54.3	-1.7	57.2	1.2
L7	66.5	57	64	50	2.5	7.0	59.5	-4.5	62.0	-2.0
L8	69	56	59	46	10	10.0	59.0	0.0	62.6	3.6
L9	69	55	62	50	7	5.0	64.0	2.0	65.8	3.8
L10	65.6	56	61	59	4.6	-3.0	68.6	7.6	67.5	6.5
L12	65	60	62	61	3	-1.0	66.0	4.0	65.6	3.6
L14	62.1	60	61	55	1.1	5.0	57.1	-3.9	58.9	-2.1
L16	57.7	54	50	48	7.7	6.0	51.7	1.7	53.8	3.8
L16	59.2	54	50	48	9.2	6.0	53.2	3.2	55.3	5.3
L19	54.7	46	50	55	4.7	-9.0	63.7	13.7	60.5	10.5
L24	56.2	47	56	53	0.2	-6.0	62.2	6.2	60.1	4.1
L25	63.2	58	66	65	-2.8	-7.0	70.2	4.2	67.7	1.7
L26	60.7	47	60	51	0.7	-4.0	64.7	4.7	63.3	3.3
L27	58.1	44	61	59	-2.9	-15.0	73.1	12.1	67.7	6.7
L28	52.5	52	51	50	1.5	2.0	50.5	-0.5	51.2	0.2
L29	58.3	46	56	55	2.3	-9.0	67.3	11.3	64.1	8.1
M29	56.8	46	52	55	4.8	-9.0	65.8	13.8	62.6	10.6
L30	53.6	49	50	50	3.6	-1.0	54.6	4.6	54.2	4.2
L31	55	49	52	50	3	-1.0	56.0	4.0	55.6	3.6
Average	60.77	52.82	57.59	53.86	3.18	-0.86	61.63	4.04	61.32	3.73

Method 2 predicts the 1937 value by subtracting the difference between the 1999 and 1937 air values from the 1999 water temperature. The difference between the predicted and actual 1937 values is also shown.

Method 3 is similar to Method 2 except the difference in the air values is adjusted by the slope value from the regression lines in Chart 1. This correction adjusts for the fact that the stream temperatures do not vary as much as the air temperatures. The value 0.49 was used to adjust the average air values, and 0.642 was used with the minimum air values.

Note that there are two sets of data for Roth reach L16. In 1999 this site was independently monitored by two different agencies to test the repeatability of the data at a typical site. The difference between these sites is an indication of the within-site variability of the 1999 data.

Summary of Results

Five different ways of evaluating the difference in the 1999 and the 1937 stream temperatures in terms of climatic conditions indicated that the 1937 streams were, on the average, between 3 and 4°F cooler than the 1999 streams. The corresponding average difference between the air temperatures was less than one degree for the minimum and average air temperatures.

Because details of the historical data are not available, the final result should be considered provisional since it is possible that other factors are influencing the results. Possible sources of additional error include:

- The accuracy of the 1937 thermometer is unknown. It is assumed to be +/- 1°F but there is a possibility that it could be greater.

- The record suggests that flows were higher in 1937. This condition would probably tend to produce lower stream temperatures. A detailed analysis of the existing flow data may reduce this source of error.

- There is no information about the sampling technique or exact locations. While it is unlikely that it would contribute to a significant fixed error, the possibility should be noted.

Other studies have noted changes in stream temperature associated with age of the stand age and have suggested that the change represents a cumulative effect. For example: Hatten and Conrad (1995); Beschta and Taylor (1988).

Over the past 62 years there have been many changes in the forest environment; both natural processes and management related. Some of the changes that can have a direct effect on stream temperature are:

1. Changes in channel condition. Large down wood can persist for as long as two hundred years which, when left in place, results in a high natural accumulation on the forest floor and in the streams. Decades of stream clean out and wood removal for various reasons have drastically reduced the amount of structure and associated gravel / water storage in the streams. Consequently there may be reductions in the amount of stored water that augments summer flow and also reductions in the amount of hyporehic flow that results in cooler flows.

   A trend of stream channel widening has also been documented in this area. (Dose and Roper,1994). Wider channels are more exposed to solar heating and generally shallower - both factors tend to increase stream temperature.

2. The extent and quality of the riparian shade can affect stream heating. It is well established that increased shade reduces solar heating and typically produces cooler temperatures. There is also evidence that the intensity of the secondary long-wave heat reaching the stream from the vegetative canopy is less from tall trees due to the increased distance. Consequently, tall shade trees may be more effective than shorter ones.

3. Extensive timber harvest and associated activities may cause other subtle changes to local microclimates through changes in wind patterns, ground temperature, evaporation and transpiration rates etc. that could contribute to an effect.

4. Changes to the surface by ditching or compaction can affect local hydrology that can influence the quantity and timing of surface runoff.

Management Implications

Managing the riparian area for site-potential shade vegetation is a long-term but effective strategy. Increasing and maintaining channel structure would also be helpful.

It is unknown whether the temperature differences observed in the study area are more or less critical than possibly greater temperature differences further downstream. An answer to this question would be helpful for setting temperature management priorities.

It should be noted that many of the streams in the study area probably exceeded the current 64°F 7-day average maximum temperature criteria in 1937. The map in this report shows the 1999 7-day average maximum values. Making the conservative assumption that all of the stream temperatures in 1937 were 4°F lower than the 1999 values still results in 12 out of the 20 streams probably exceeding the standard.

The 1999 study showed that the streams in this area were among the coolest in the South Umpqua watershed. The corresponding implication is that most of the rest of the streams in the basin probably historically exceeded the 64°F standard as well.

It should be noted that even if the standard was exceeded historically, the fact remains that it is very likely that the current stream temperatures are higher than they were in the past. It follows that the fishery resource could benefit if the current stream temperatures were lowered toward previous levels.

Further Study

A more rigorous statistical analysis could be done on this data.

Roth collected temperatures at about 96 sites. A more extensive temperature monitoring project on more of the Roth sites could increase the comparison sample size.

Stream temperature modeling work could be done on the Roth reaches using existing flow and stream survey data to better identify the critical factors contributing to stream heating.

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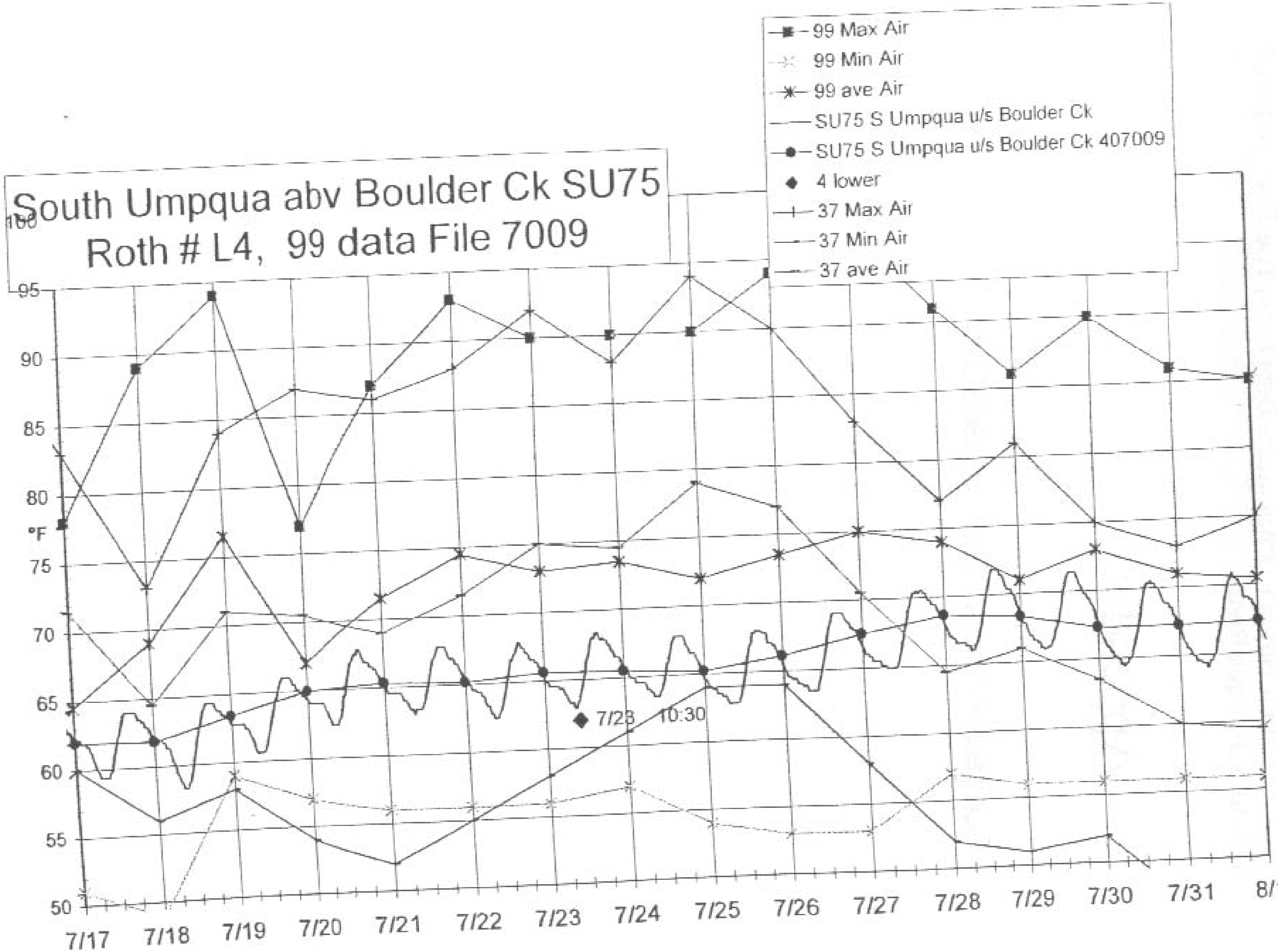
Appendix

Comparison Charts - 1937 and 1999 Data



South Umpqua abv Boulder Ck SU75
Roth # L4, 99 data File 7009
99 Max Air
99 Min Air
99 ave Air
SU75 S Umpqua u/s Boulder Ck
SU75 S Umpqua u/s Boulder Ck 407009
4 lower
37 Max Air
37 Min Air
37 ave Air
°F
100
95
90
85
80
75
70
65
60
55
50
7/23 10:30
7/17
7/18
7/19
7/20
7/21
7/22
7/23
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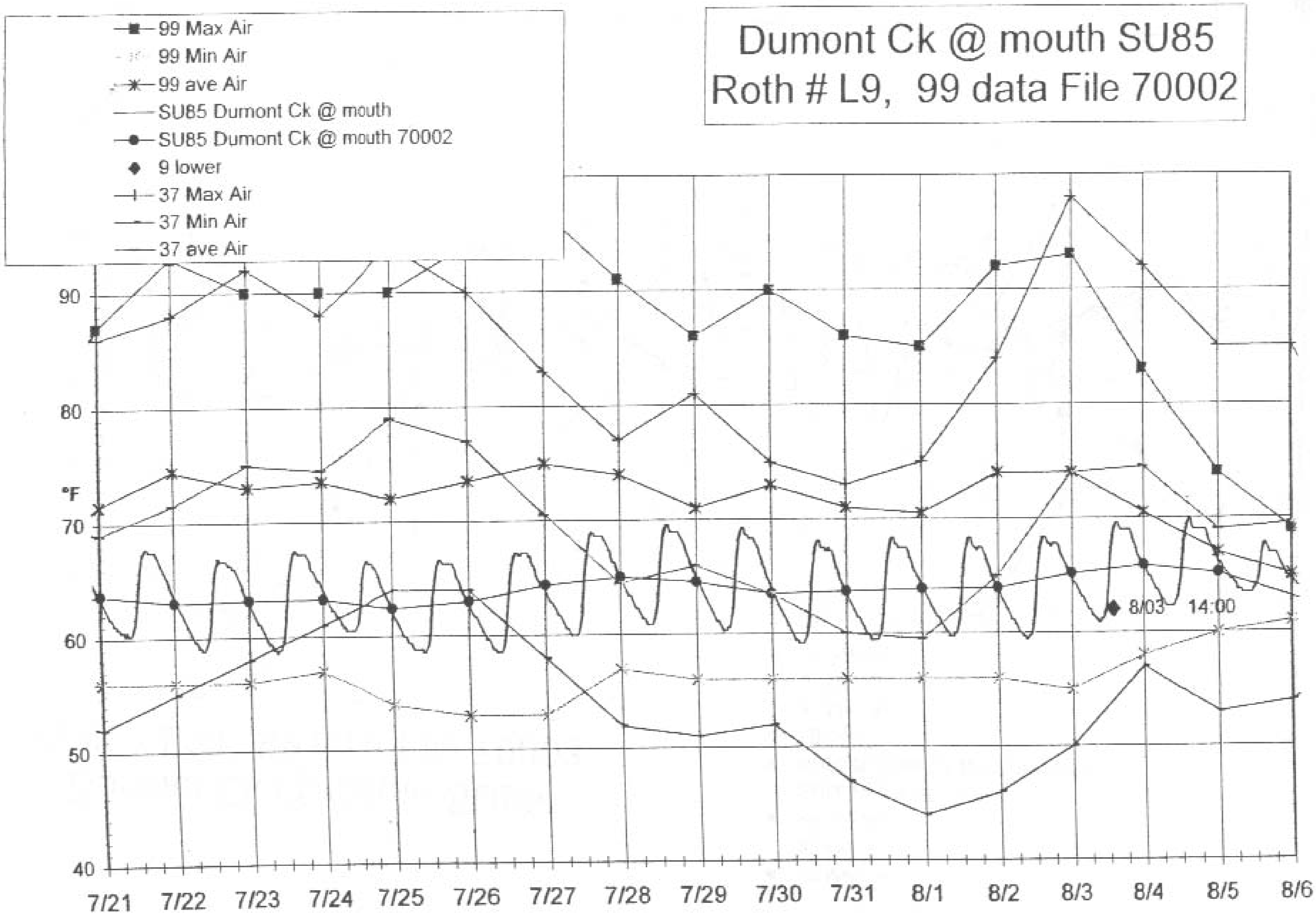
7/29
7/30
7/31
8/1


Dumont Ck @ mouth SU85
Roth # L9, 99 data File 70002
99 Max Air
99 Min Air
99 ave Air
SU85 Dumont Ck @ mouth
SU85 Dumont Ck @ mouth 70002
9 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
7/21
7/22
7/23
7/24
7/25
7/26
7/27
7/28
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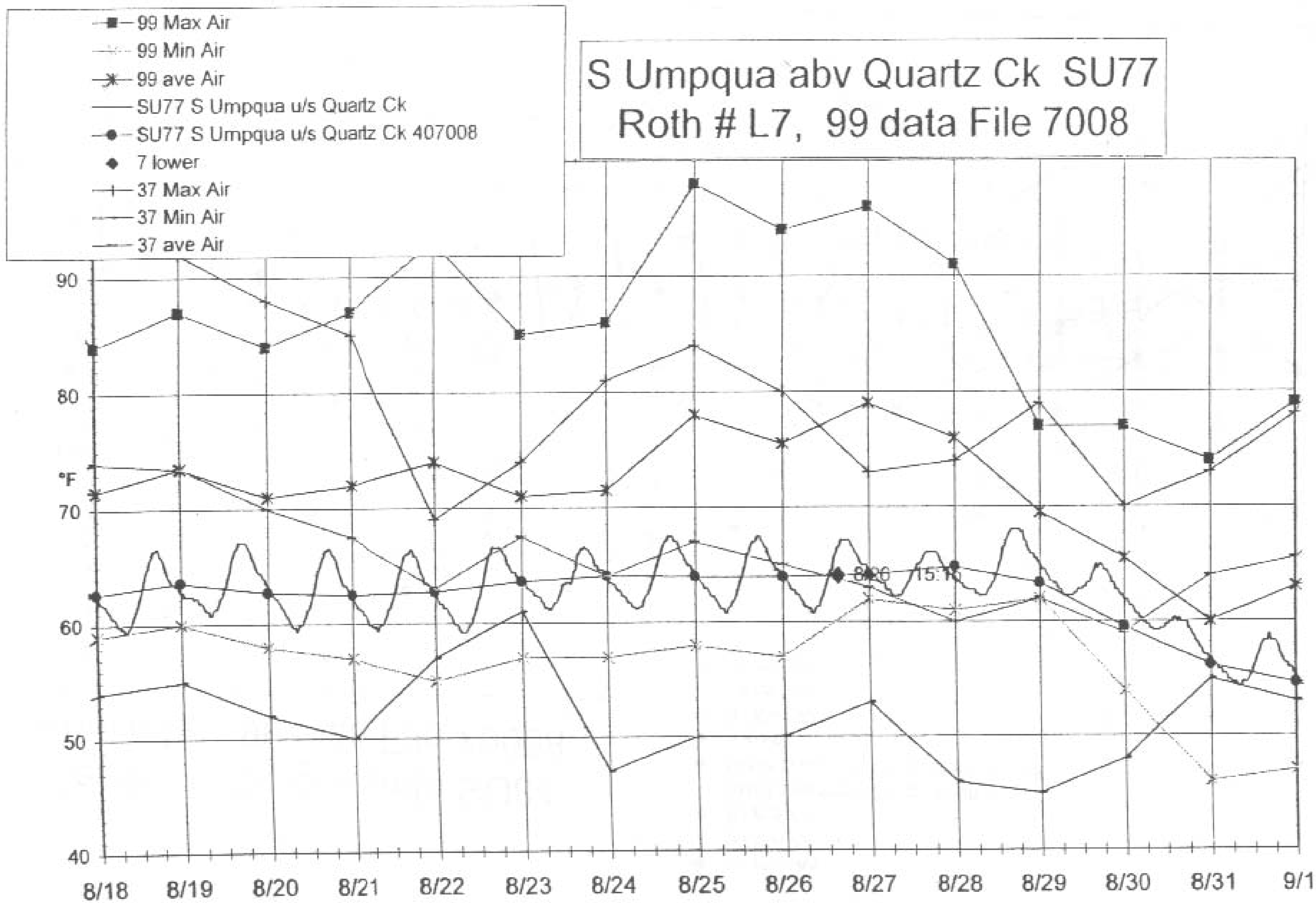
7/30
7/31
8/1
8/2
8/3
8/4
8/5
8/6
8/03 14:00


S Umpqua abv Quartz Ck SU77
Roth # L7, 99 data File 7008
99 Max Air
99 Min Air
99 ave Air
SU77 S Umpqua u/s Quartz Ck
SU77 S Umpqua u/s Quartz Ck 407008
7 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
8/26 15:1
8/18
8/19
8/20
8/21
8/22
8/23
8/24
8/25
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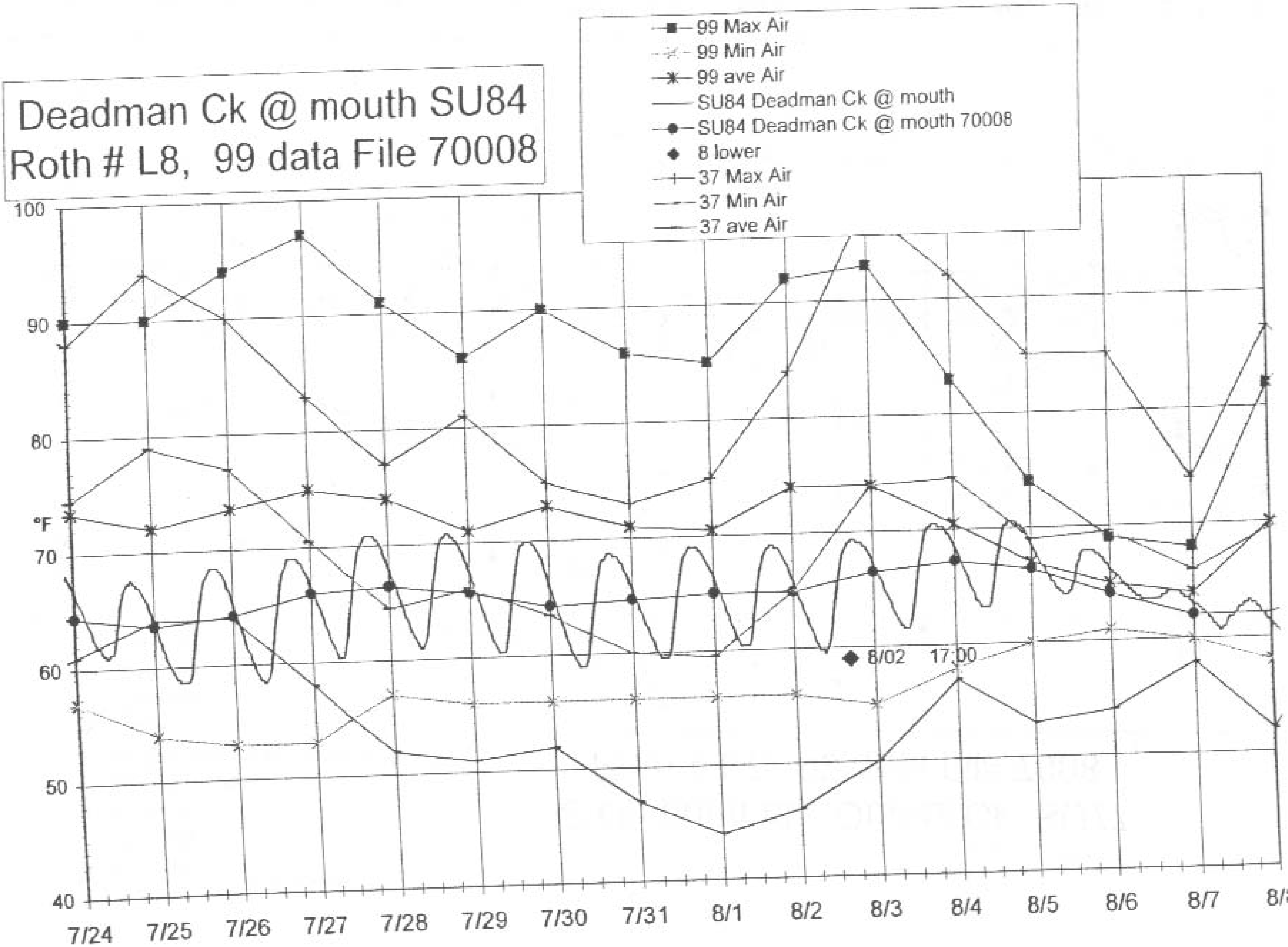
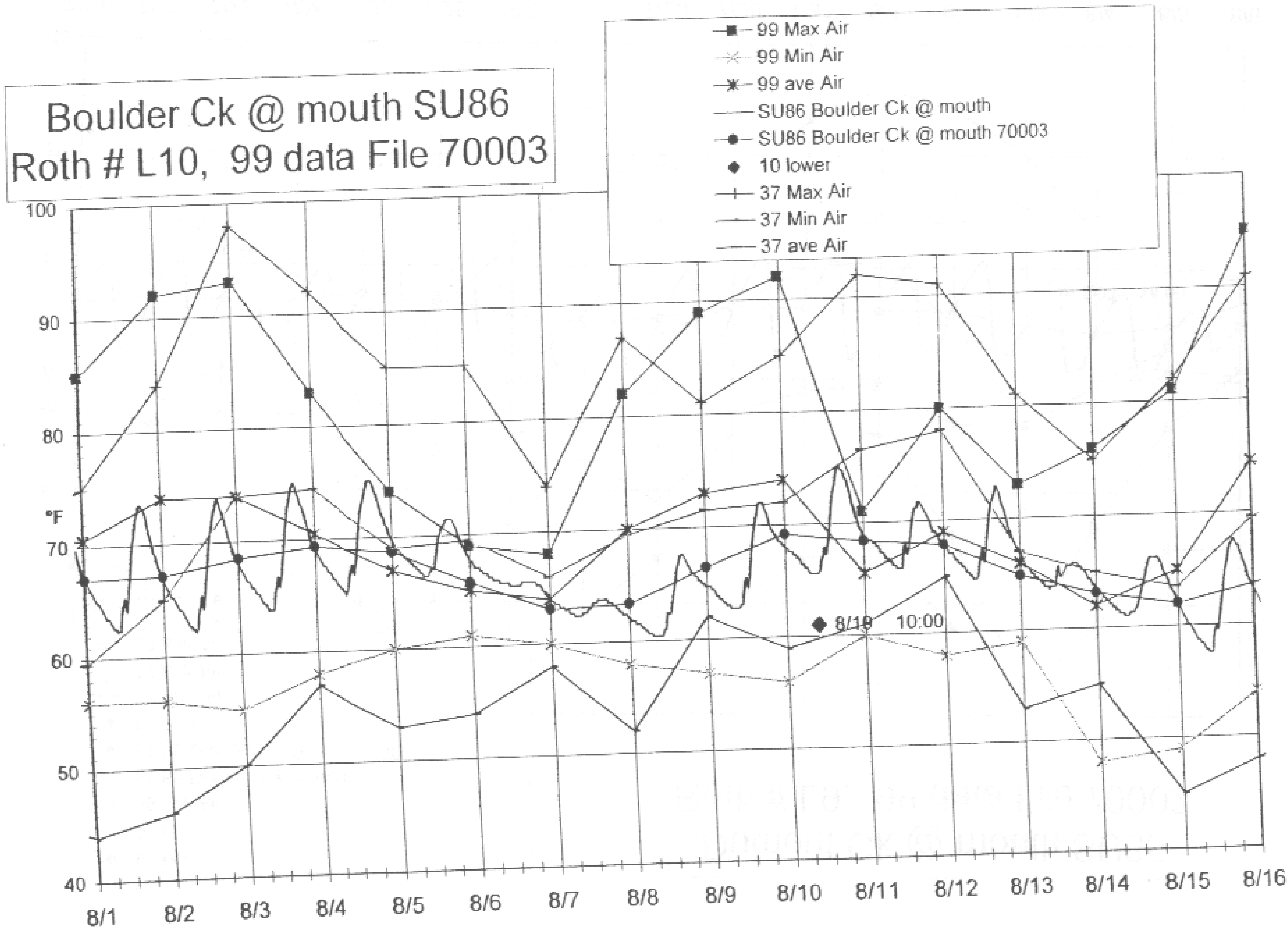
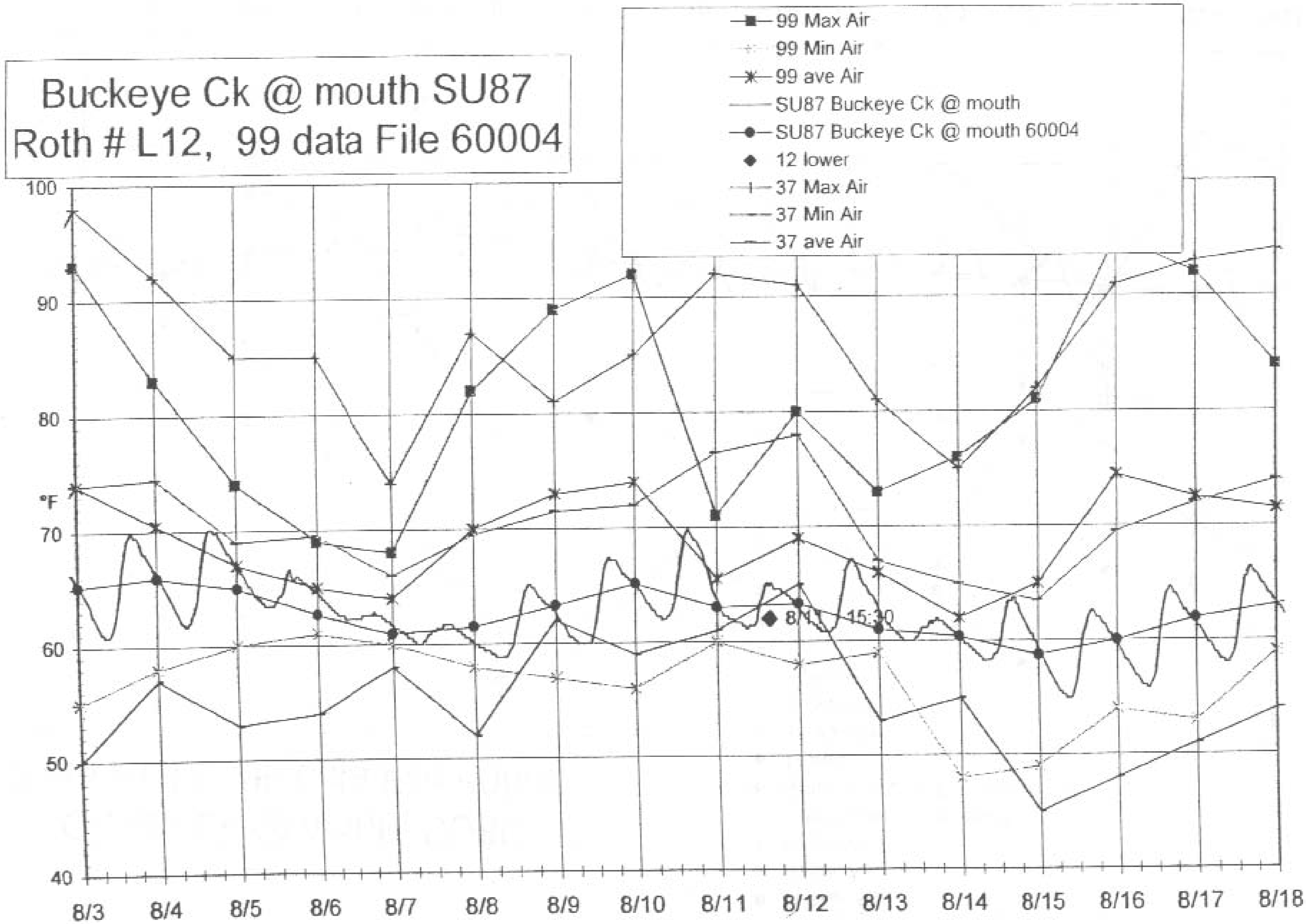
8/29
8/30
8/31
9/1

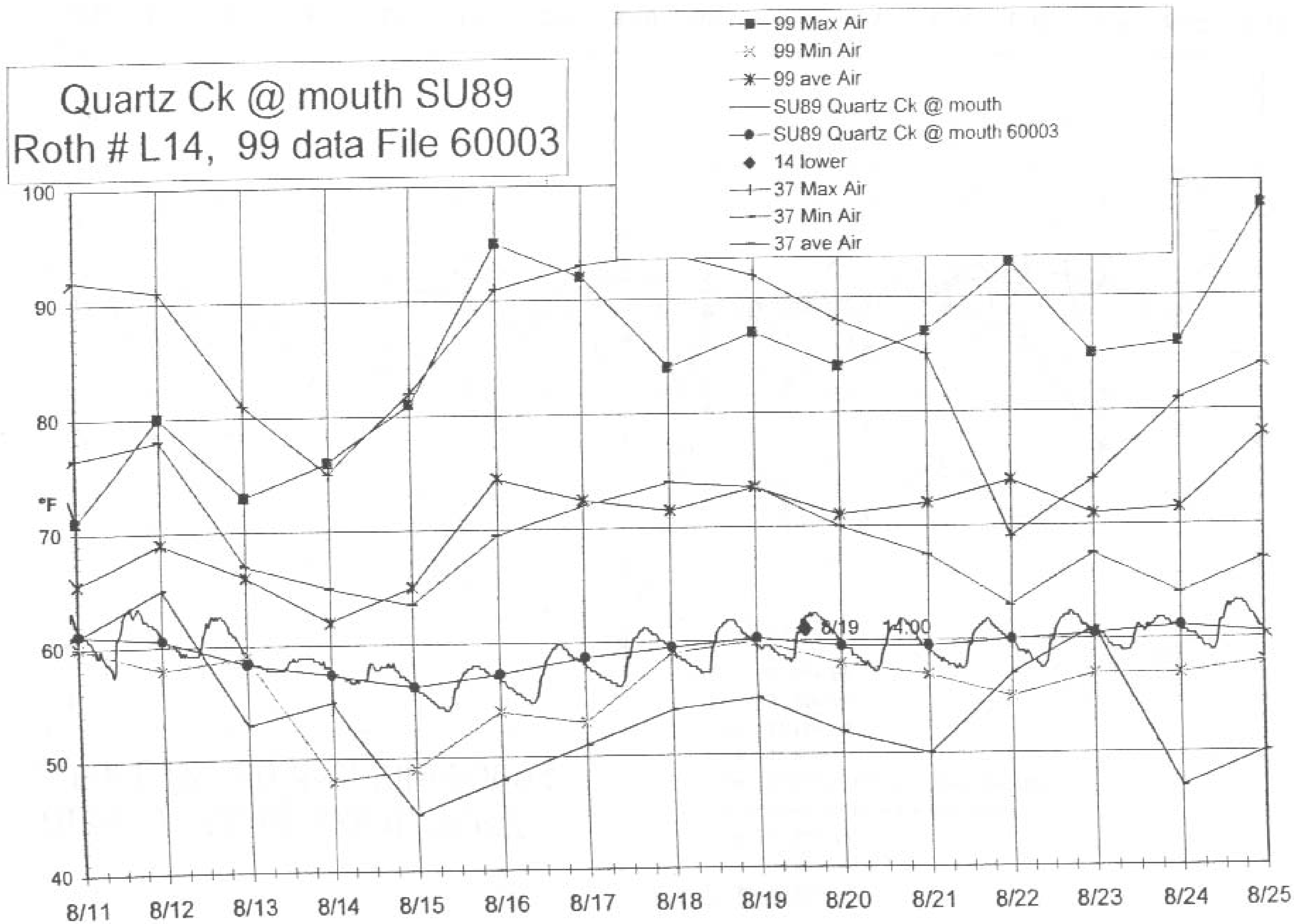
Deadman Ck @ mouth SU84
Roth # L8, 99 data File 70008

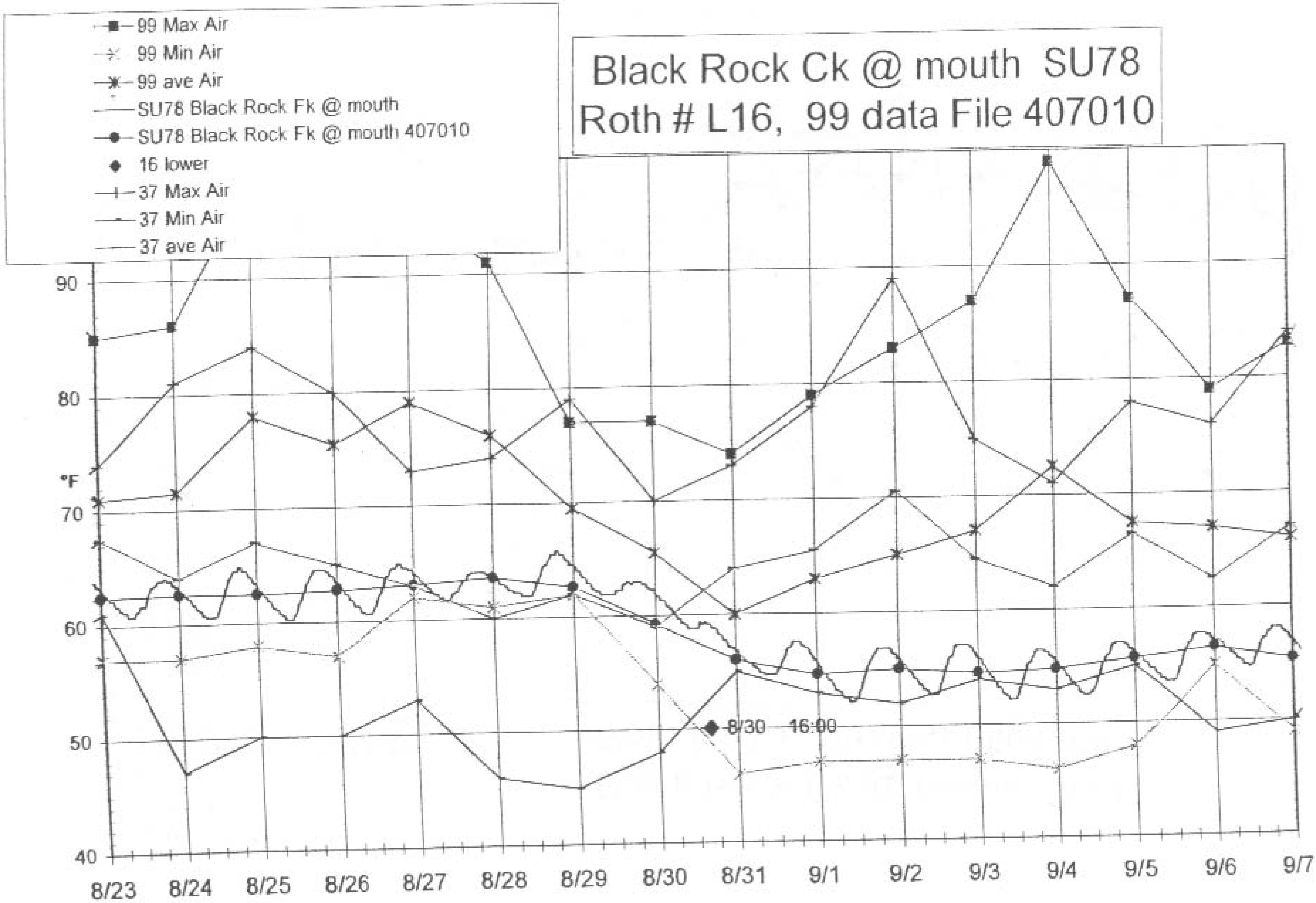



Boulder Ck @ mouth SU86
Roth # L10, 99 data File 70003
99 Max Air
99 Min Air
99 ave Air
SU86 Boulder Ck @ mouth
SU86 Boulder Ck @ mouth 70003
10 lower
37 Max Air
37 Min Air
37 ave Air
°F
100
90
80
70
60
50
40
8/1
8/2
8/3
8/4
8/5
8/6
8/7
8/8
8/9
8/10
8/11
8/12
8/13
8/14
8/15
8/16
8/10 10:00

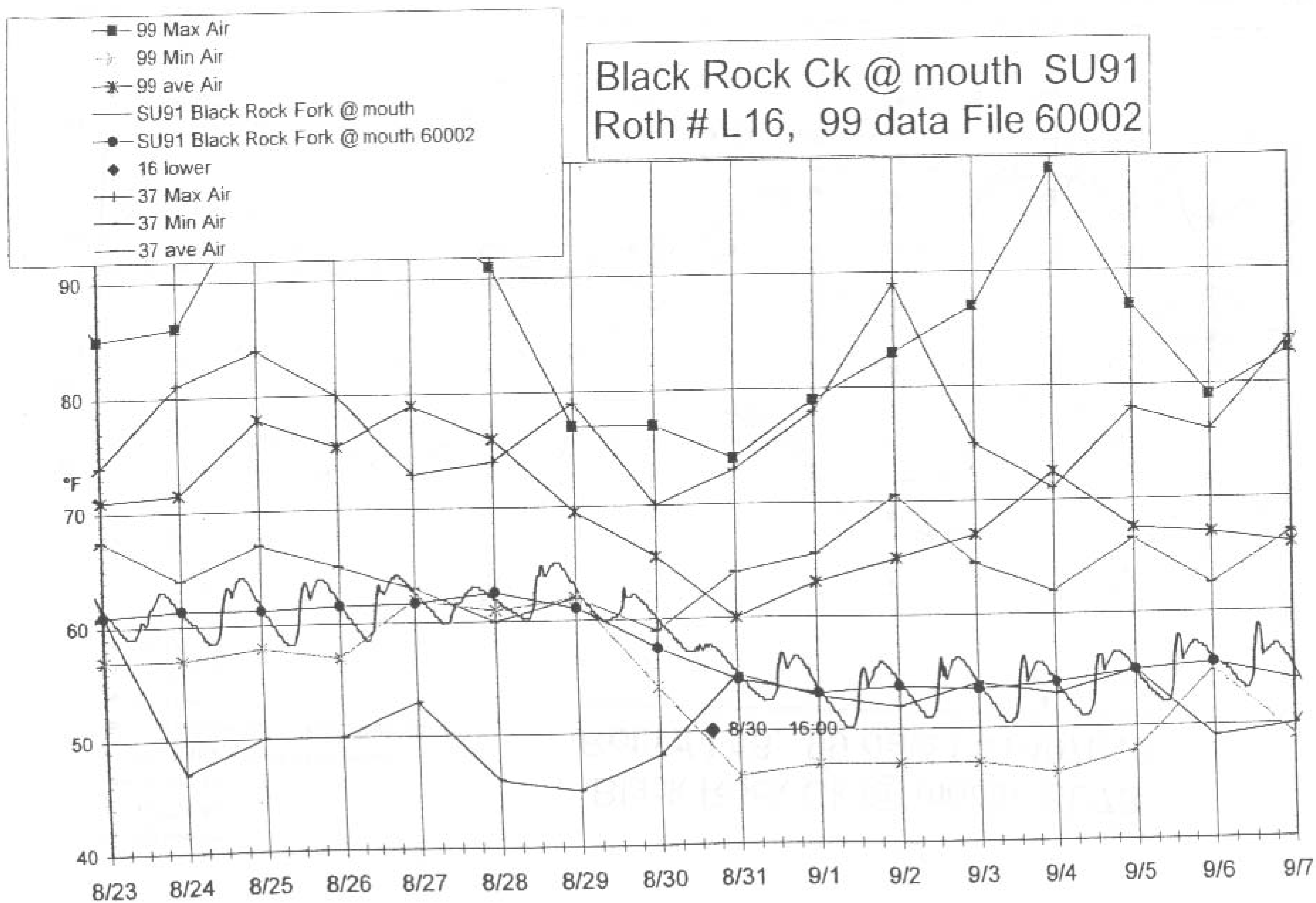


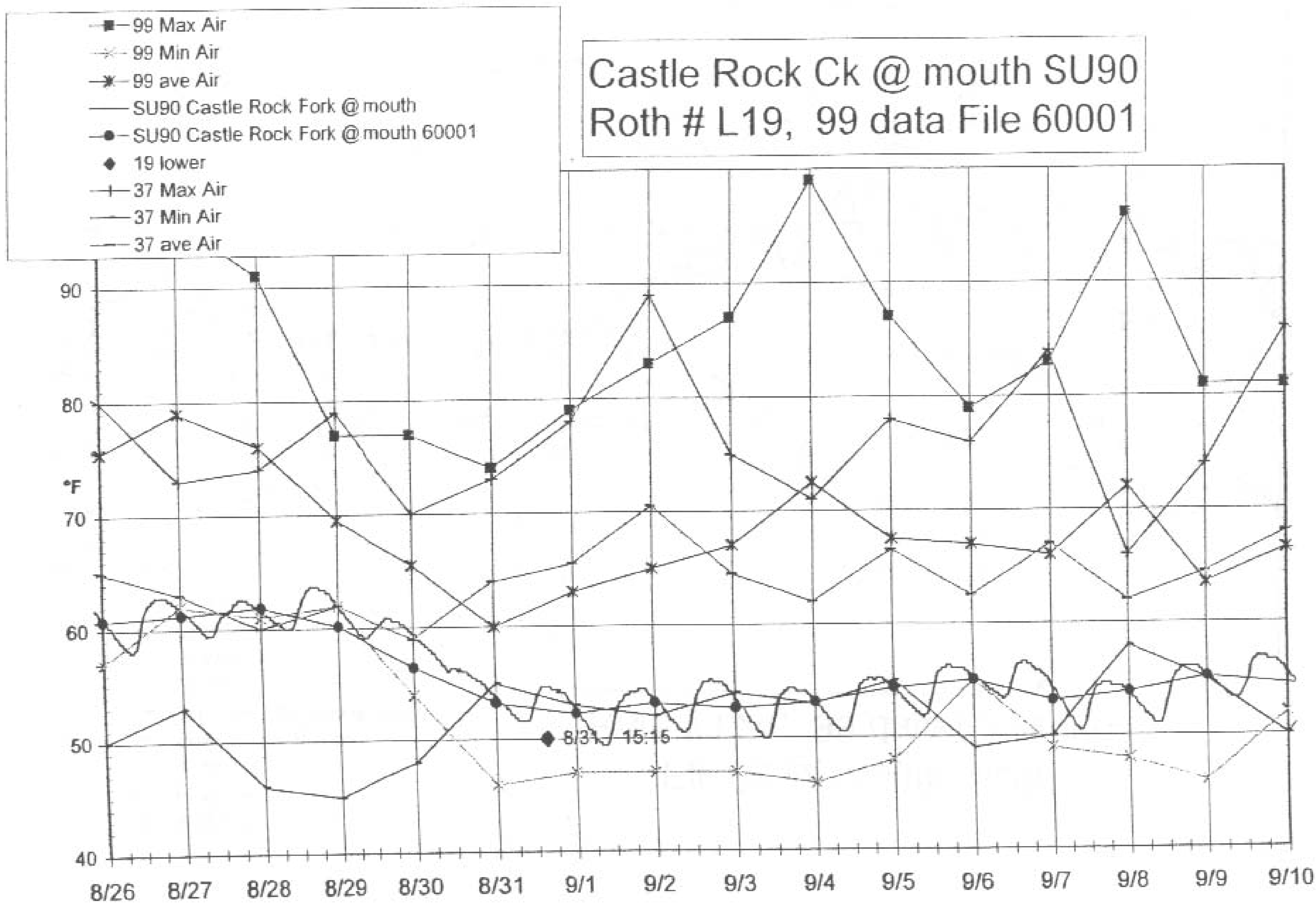
Buckeye Ck @ mouth SU87
Roth # L12, 99 data File 60004
99 Max Air
99 Min Air
99 ave Air
SU87 Buckeye Ck @ mouth
SU87 Buckeye Ck @ mouth 60004
12 lower
37 Max Air
37 Min Air
37 ave Air
°F
100
90
80
70
60
50
40
8/3
8/4
8/5
8/6
8/7
8/8
8/9
8/10
8/11
8/12
8/13
8/14
8/15
8/16
8/17
8/18
8/11 15:30


Quartz Ck @ mouth SU89
Roth # L14, 99 data File 60003
99 Max Air
99 Min Air
99 ave Air
SU89 Quartz Ck @ mouth
SU89 Quartz Ck @ mouth 60003
14 lower
37 Max Air
37 Min Air
37 ave Air
°F
100
90
80
70
60
50
40
8/19 14:00
8/11
8/12
8/13
8/14
8/15
8/16
8/17
8/18
8/19
8/20
8/21
8/22
8/23
8/24
8/25

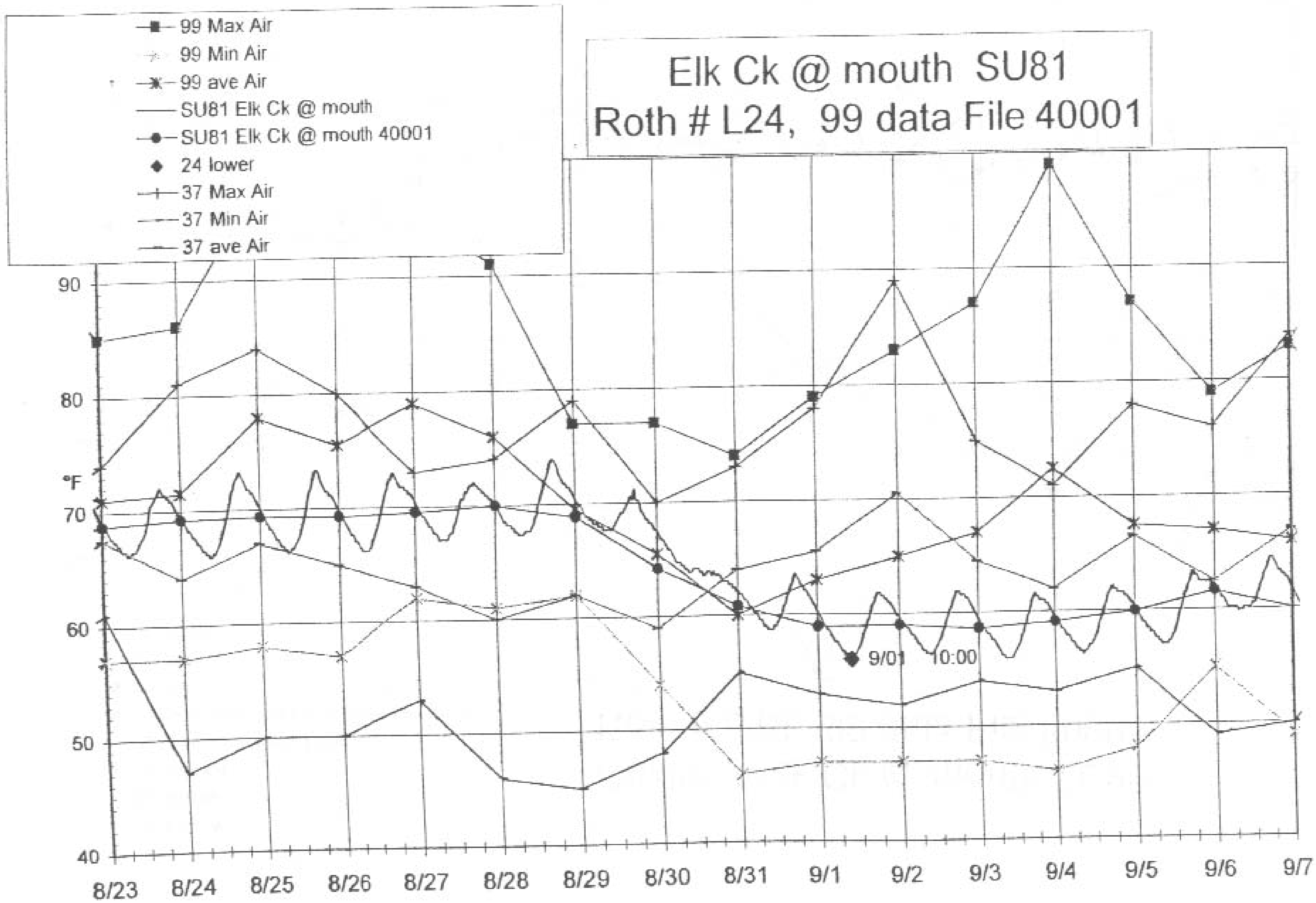


Black Rock Ck @ mouth SU78
Roth # L16, 99 data File 407010
99 Max Air
99 Min Air
99 ave Air
SU78 Black Rock Fk @ mouth
SU78 Black Rock Fk @ mouth 407010
16 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
8/30 16:00
8/23
8/24
8/25
8/26
8/27
8/28
8/29
8/30
8/31
9/1
9/2
9/3
9/4
9/5
9/6
9/7

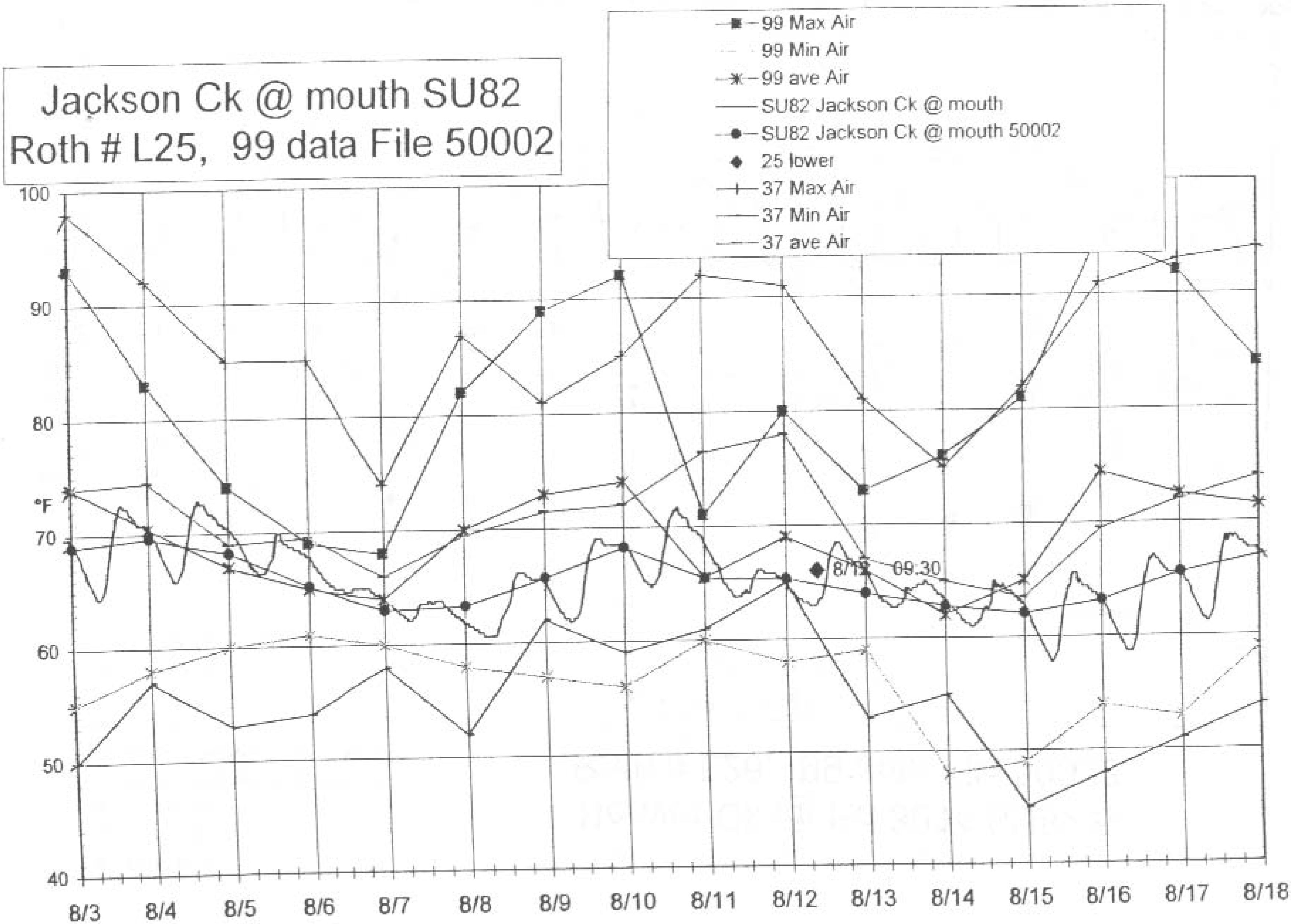

Black Rock Ck @ mouth SU91
Roth # L16, 99 data File 60002
99 Max Air
99 Min Air
99 ave Air
SU91 Black Rock Fork @ mouth
SU91 Black Rock Fork @ mouth 60002
16 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
8/30 16:00
8/23
8/24
8/25
8/26
8/27
8/28
8/29
8/30
8/31
9/1
9/2
9/3
9/4
9/5
9/6
9/7

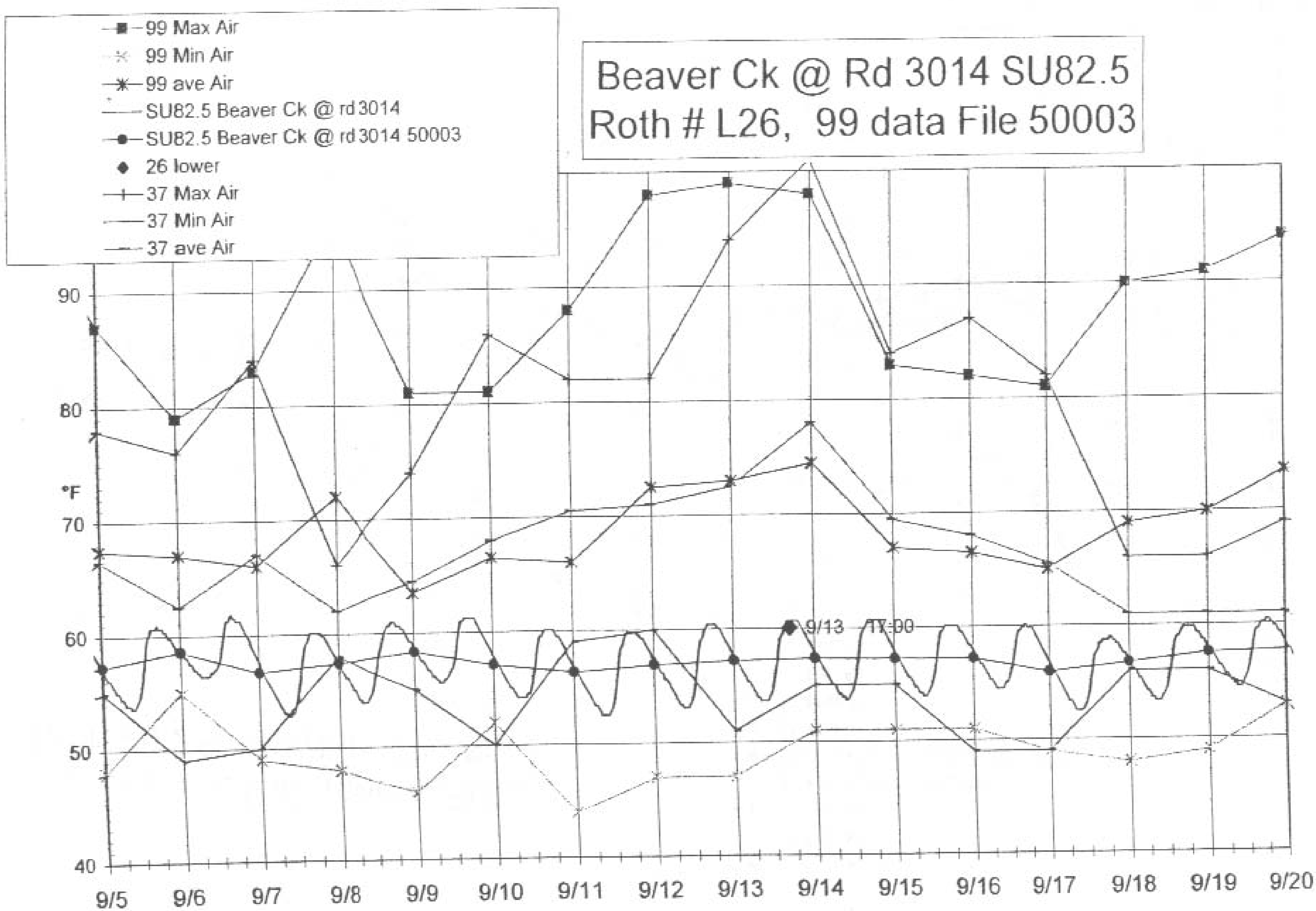


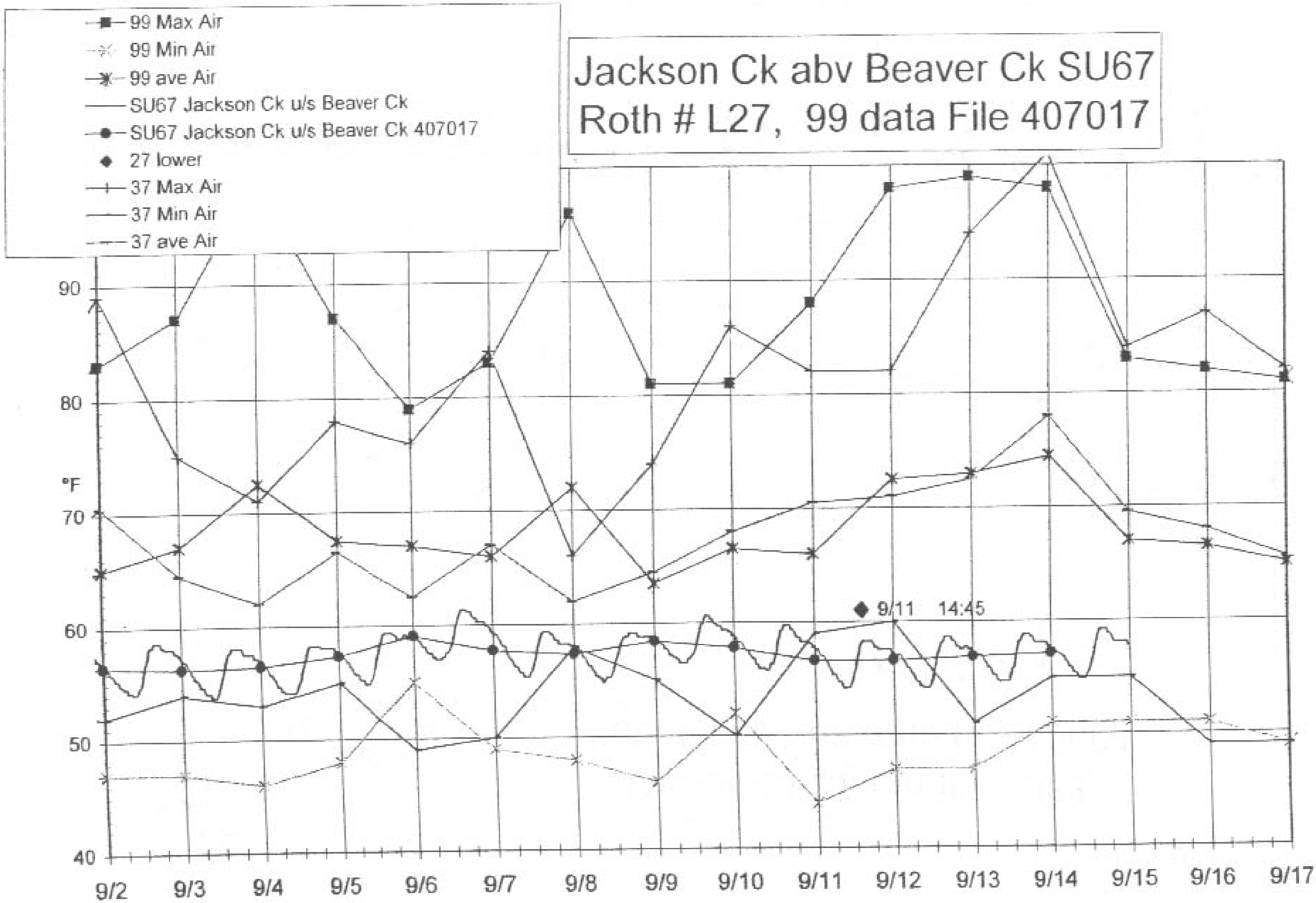
Castle Rock Ck @ mouth SU90
Roth # L19, 99 data File 60001
99 Max Air
99 Min Air
99 ave Air
SU90 Castle Rock Fork @ mouth
SU90 Castle Rock Fork @ mouth 60001
19 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
8/31 15:15
8/26
8/27
8/28
8/29
8/30
8/31
9/1
9/2
9/3
9/4
9/5
9/6
9/7
9/8
9/9
9/10


Elk Ck @ mouth SU81
Roth # L24, 99 data File 40001
99 Max Air
99 Min Air
99 ave Air
SU81 Elk Ck @ mouth
SU81 Elk Ck @ mouth 40001
24 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
8/23
8/24
8/25
8/26
8/27
8/28
8/29
8/30
8/31
9/1
9/2
9/3
9/4
9/5
9/6
9/7
9/01 10:00

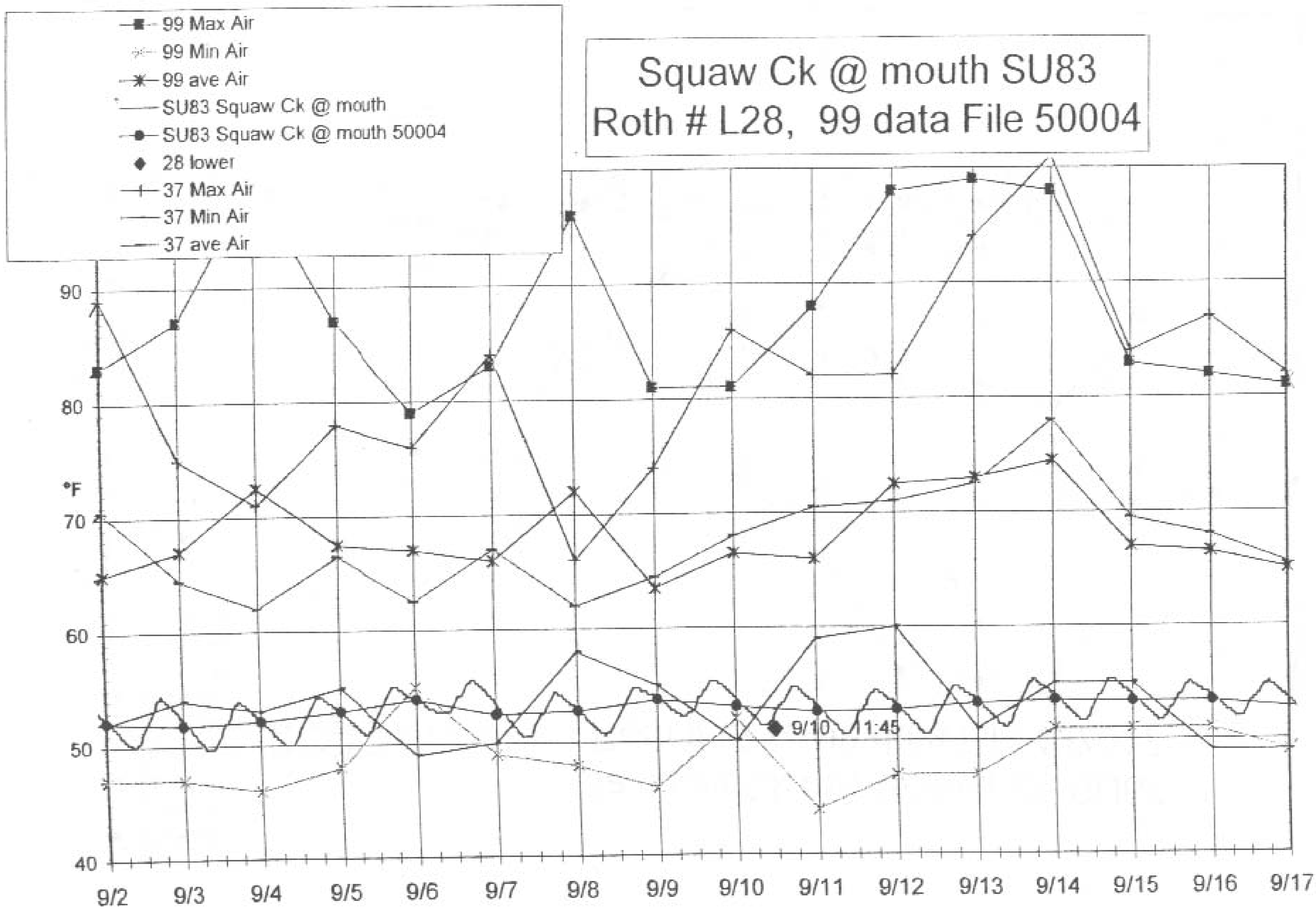
Jackson Ck @ mouth SU82
Roth # L25, 99 data File 50002



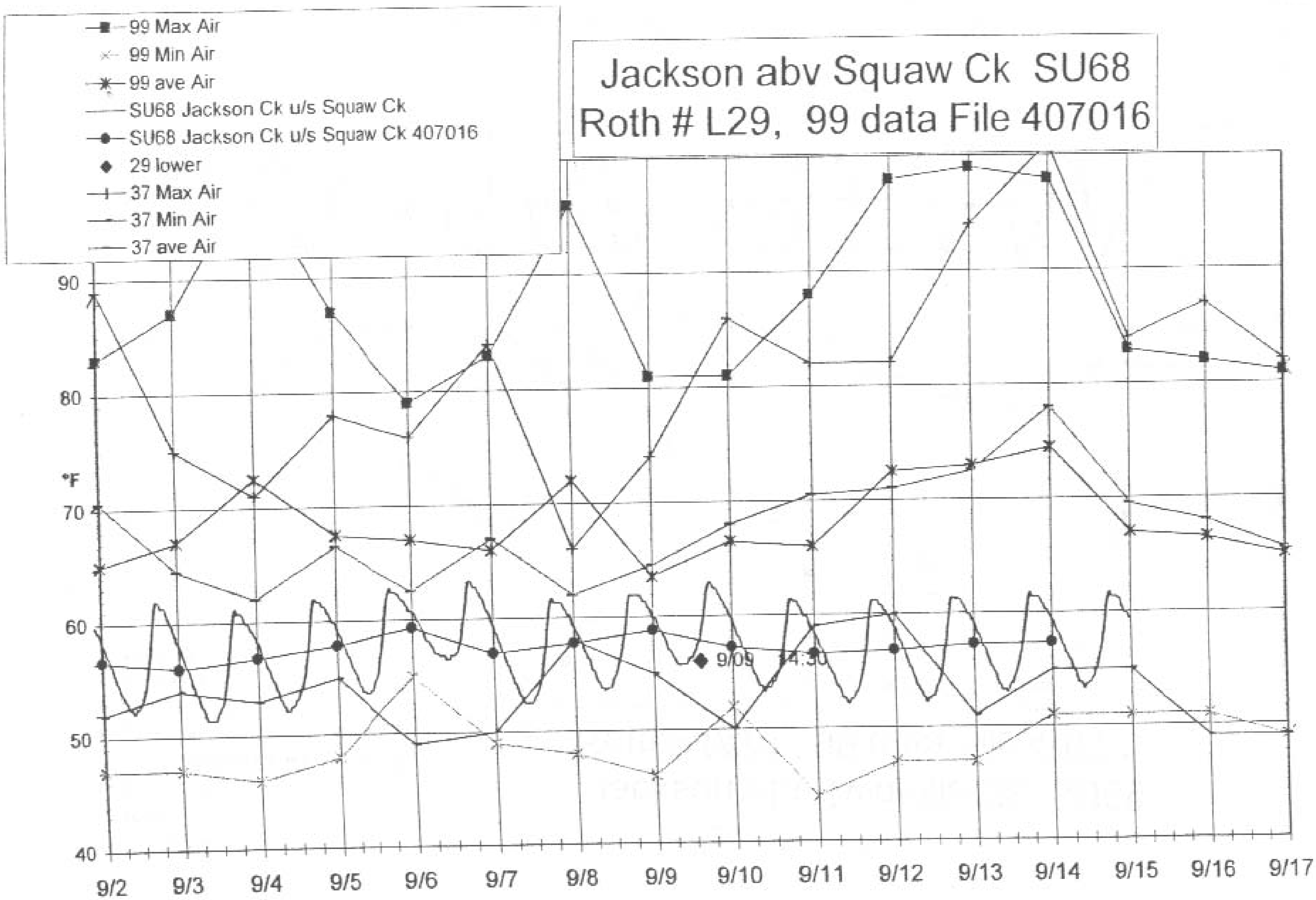

Beaver Ck @ Rd 3014 SU82.5
Roth # L26, 99 data File 50003
99 Max Air
99 Min Air
99 ave Air
SU82.5 Beaver Ck @ rd3014
SU82.5 Beaver Ck @ rd3014 50003
26 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
9/5
9/6
9/7
9/8
9/9
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17
9/18
9/19
9/20
9/13 17:00



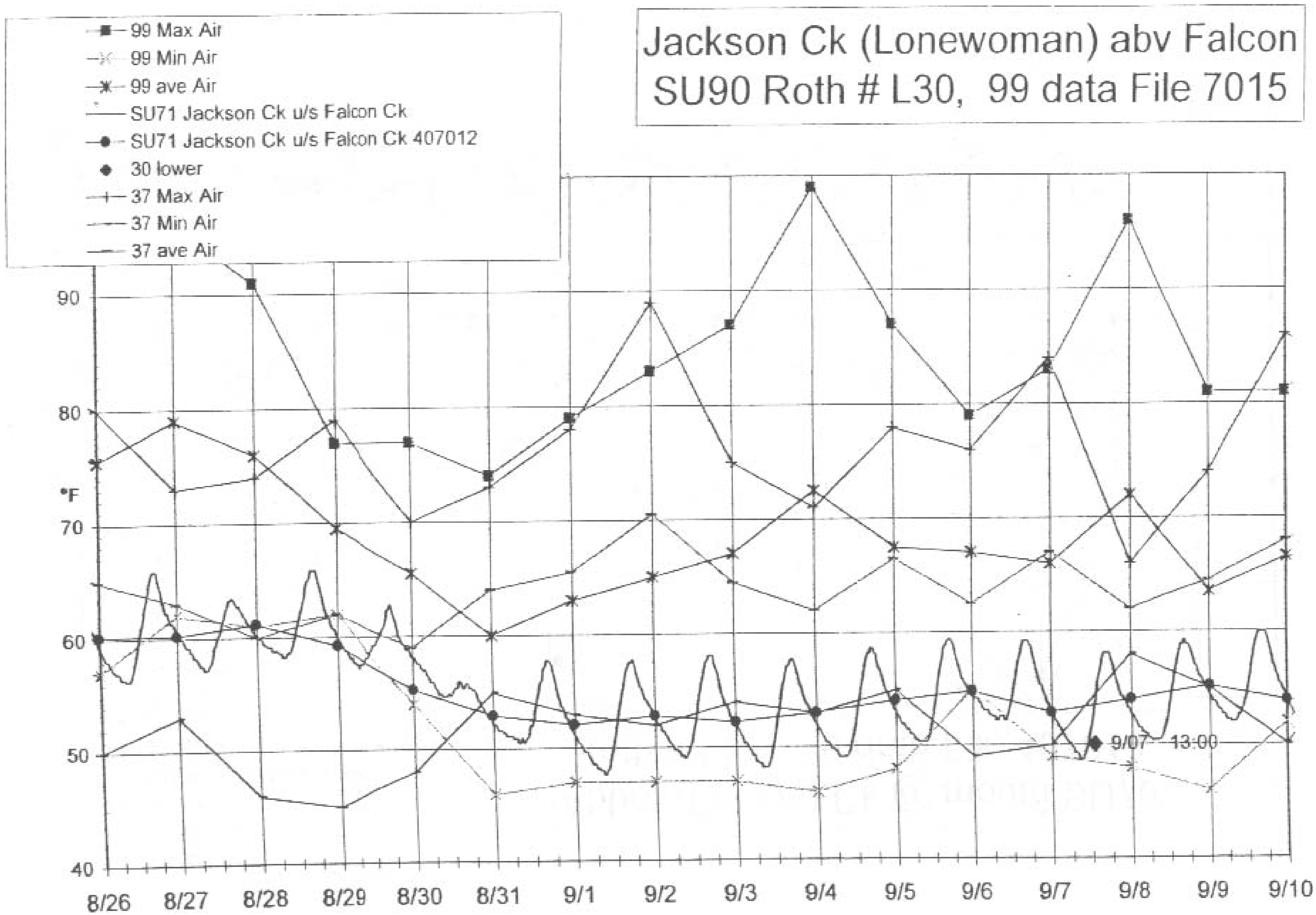
Jackson Ck abv Beaver Ck SU67
Roth # L27, 99 data File 407017
99 Max Air
99 Min Air
99 ave Air
SU67 Jackson Ck u/s Beaver Ck
SU67 Jackson Ck u/s Beaver Ck 407017
27 lower
37 Max Air
37 Min Air
37 ave Air
9/11 14:45
°F
90
80
70
60
50
40
9/2
9/3
9/4
9/5
9/6
9/7
9/8
9/9
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17



Squaw Ck @ mouth SU83
Roth # L28, 99 data File 50004
99 Max Air
99 Min Air
99 ave Air
SU83 Squaw Ck @ mouth
SU83 Squaw Ck @ mouth 50004
28 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
9/2
9/3
9/4
9/5
9/6
9/7
9/8
9/9
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17
9/10 11:45



Jackson abv Squaw Ck SU68
Roth # L29, 99 data File 407016
99 Max Air
99 Min Air
99 ave Air
SU68 Jackson Ck u/s Squaw Ck
SU68 Jackson Ck u/s Squaw Ck 407016
29 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
9/2
9/3
9/4
9/5
9/6
9/7
9/8
9/9
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17


Jackson Ck (Lonewoman) abv Falcon
SU90 Roth # L30, 99 data File 7015
99 Max Air
99 Min Air
99 ave Air
SU71 Jackson Ck u/s Falcon Ck
SU71 Jackson Ck u/s Falcon Ck 407012
30 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
9/07 13:00
8/26
8/27
8/28
8/29
8/30
8/31
9/1
9/2
9/3
9/4
9/5
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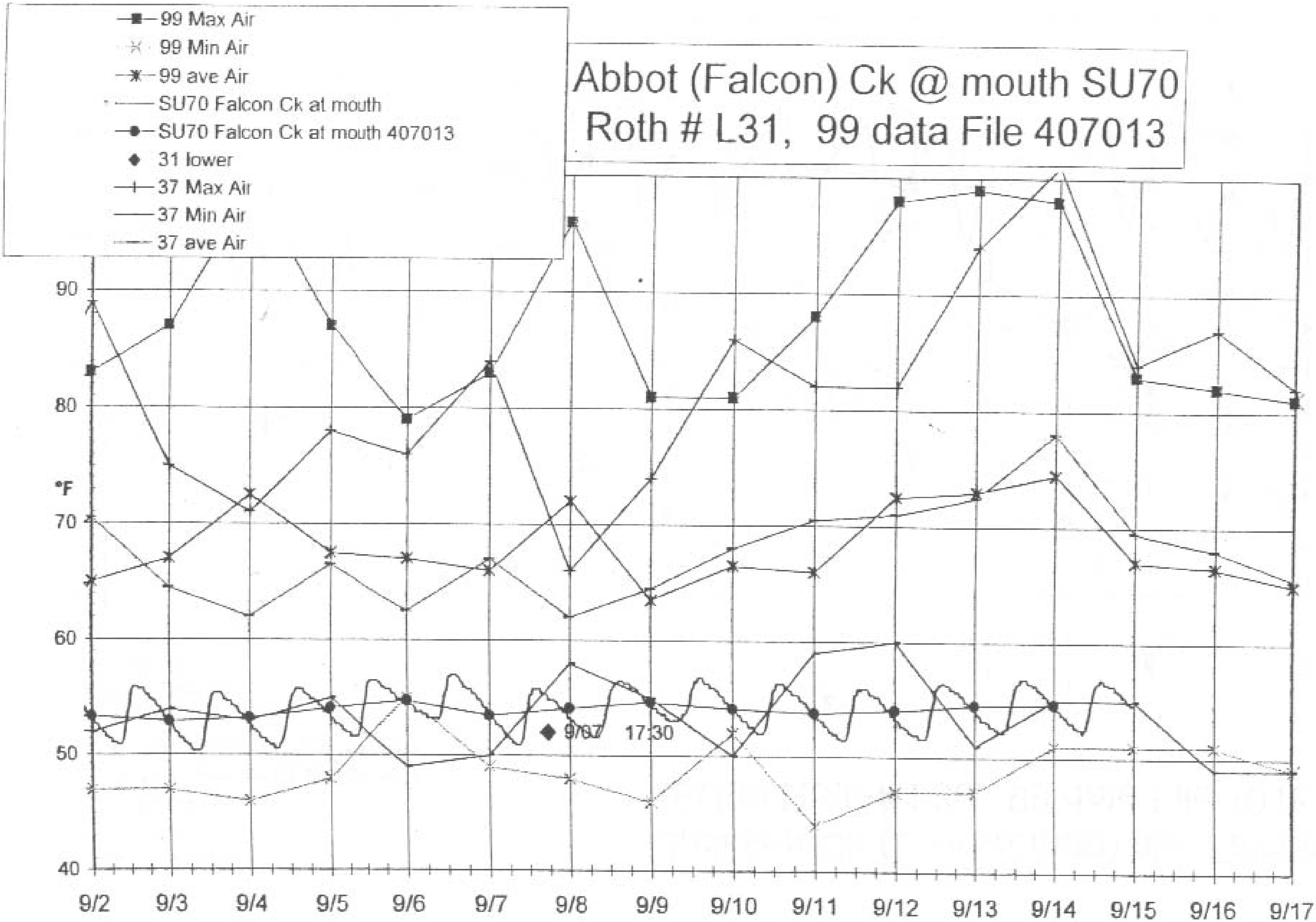
9/8
9/9
9/10


Abbot (Falcon) Ck @ mouth SU70
Roth # L31, 99 data File 407013
99 Max Air
99 Min Air
99 ave Air
SU70 Falcon Ck at mouth
SU70 Falcon Ck at mouth 407013
31 lower
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
9/07 17:30
9/2
9/3
9/4
9/5
9/6
9/7
9/8
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9/10
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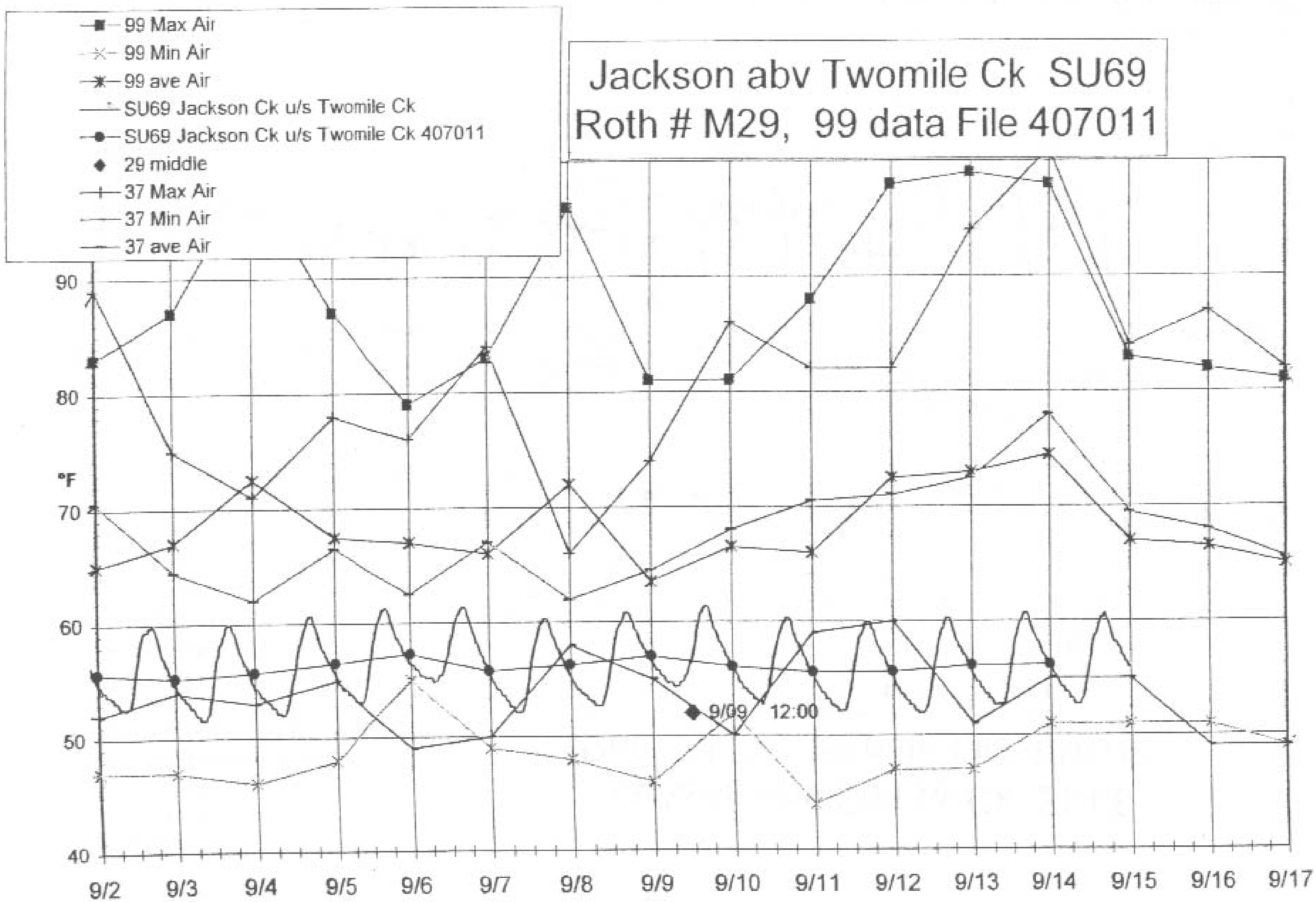
9/14
9/15
9/16
9/17


Jackson abv Twomile Ck SU69
Roth # M29, 99 data File 407011
99 Max Air
99 Min Air
99 ave Air
SU69 Jackson Ck u/s Twomile Ck
SU69 Jackson Ck u/s Twomile Ck 407011
29 middle
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
9/2
9/3
9/4
9/5
9/6
9/7
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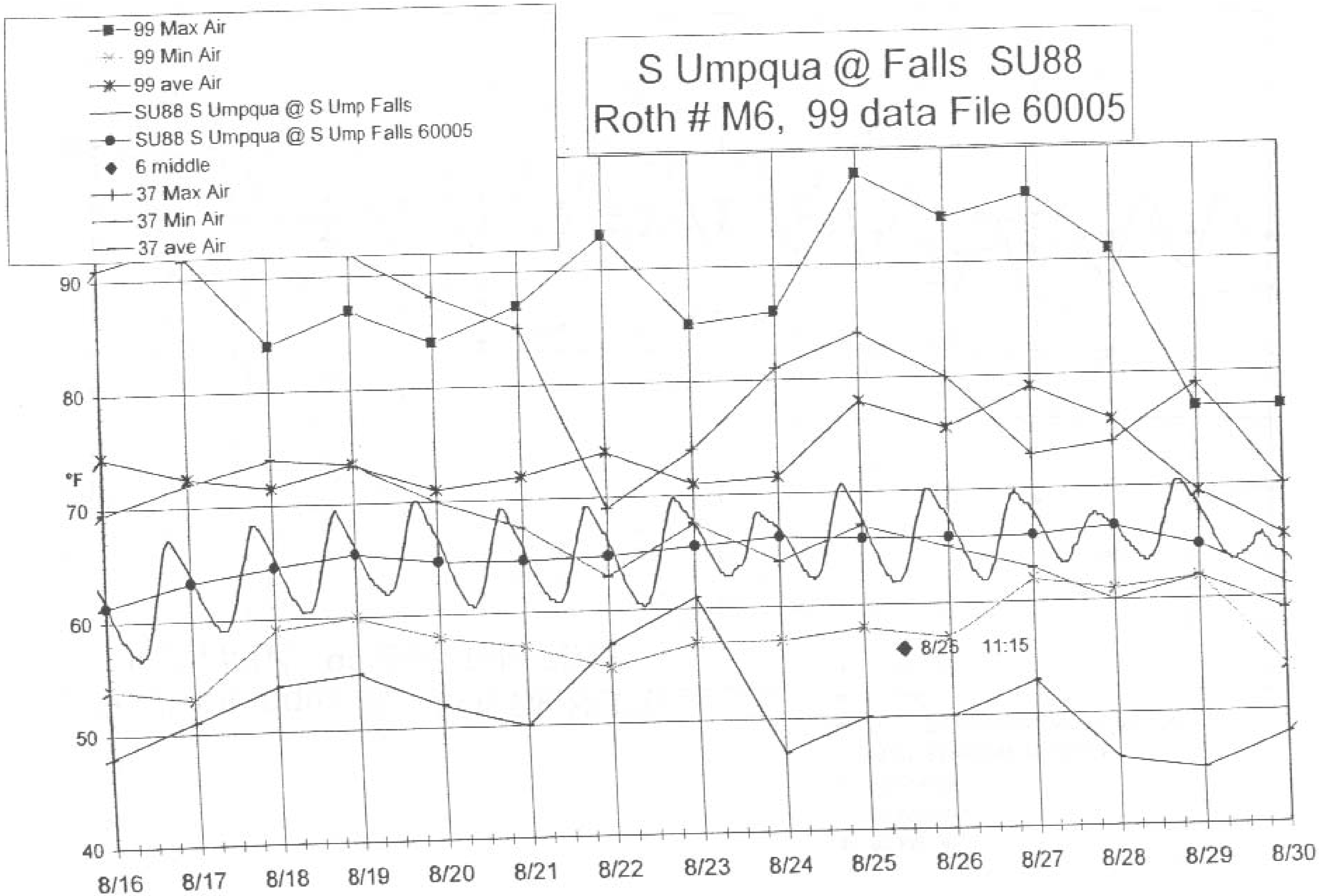
9/10
9/11
9/12
9/13
9/14
9/15
9/16
9/17
9/09 12:00


S Umpqua @ Falls SU88
Roth # M6, 99 data File 60005
99 Max Air
99 Min Air
99 ave Air
SU88 S Umpqua @ S Ump Falls
SU88 S Umpqua @ S Ump Falls 60005
6 middle
37 Max Air
37 Min Air
37 ave Air
°F
90
80
70
60
50
40
8/16
8/17
8/18
8/19
8/20
8/21
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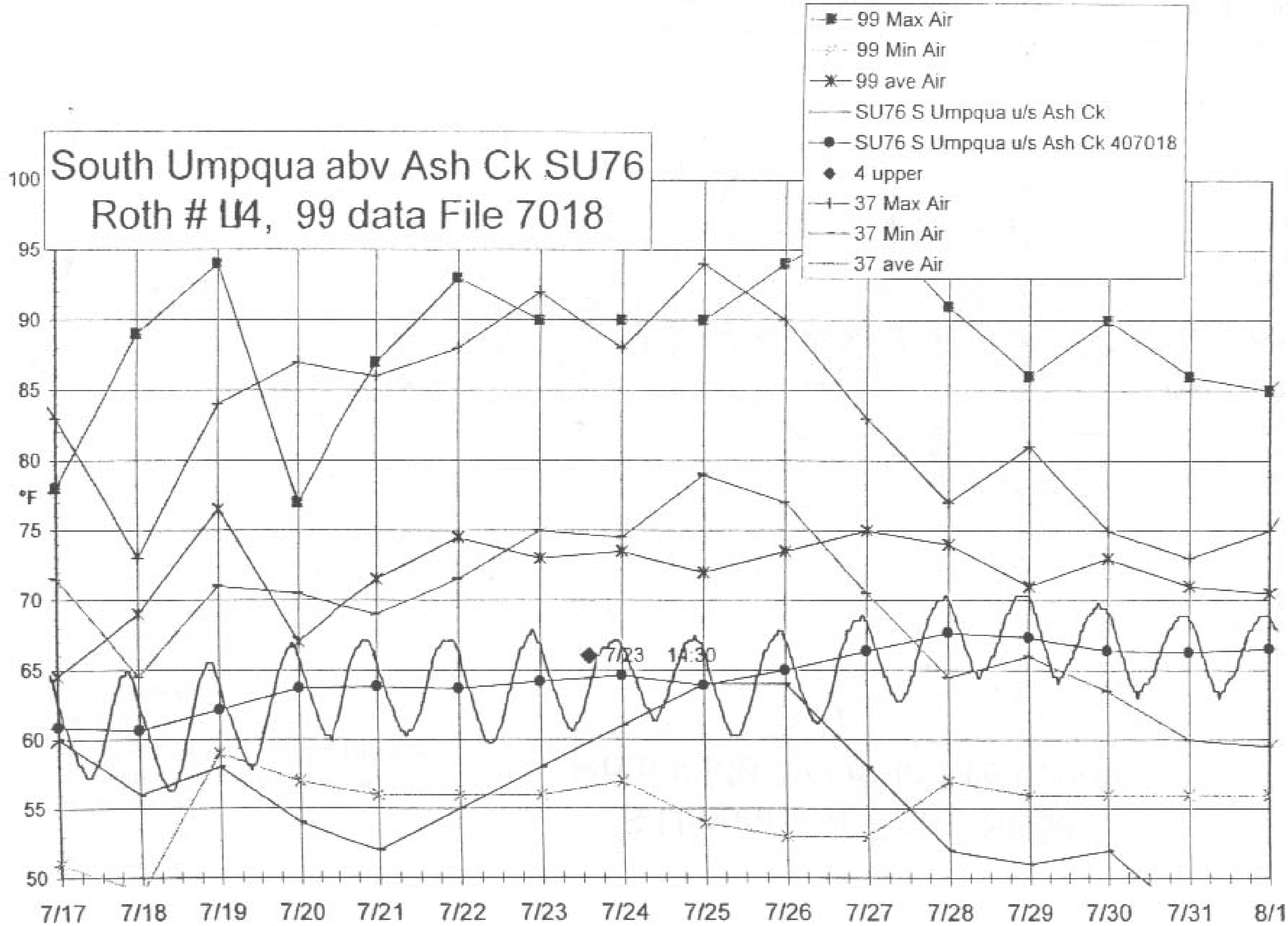
8/30
8/25 11:15


South Umpqua abv Ash Ck SU76
Roth # U4, 99 data File 7018
99 Max Air
99 Min Air
99 ave Air
SU76 S Umpqua u/s Ash Ck
SU76 S Umpqua u/s Ash Ck 407018
4 upper
37 Max Air
37 Min Air
37 ave Air
°F
100
95
90
85
80
75
70
65
60
55
50
7/23 14:30
7/17
7/18
7/19
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