Section D

Riparian Function

Introduction

Mendocino Redwood Company conducted an assessment of riparian function in the Willow/Freezeout Creeks Watershed Analysis Unit (WAU) during the summer of 2000. This assessment is divided into two groups: 1) the potential of the riparian stand to recruit large woody debris (LWD) to the stream channel and 2) a canopy closure and stream temperature assessment. The LWD potential assessment evaluates short-term (the next 2-3 decades) LWD recruitment. It shows the current condition of the riparian stands for generating LWD for stream habitat or stream channel stability. Field observations of current LWD levels in the stream channels and the riparian stand’s ability to recruit LWD are presented in relation to channel sensitivity to LWD in order to determine current instream needs. The canopy closure and stream temperature assessment presents current canopy closure conditions and how these are related to the stream temperature monitoring that has been conducted. The goal of these evaluations is to provide baseline information on the current LWD loading in the channel and current status of riparian stand function in the Willow/Freezeout CreeksWAU.

Large Woody Debris Recruitment

Large woody debris (LWD) is widely recognized as an important part of the aquatic ecosystem (Swanson and Lienkaemper, 1978; Bilby and Likens, 1979; Bisson et. al., 1978) and has been recognized as a vital component of high quality habitat for anadromous fish (Bisson et. al., 1978). LWD provides an organic energy source for aquatic organisms, controls the routing of sediment through stream systems, and provides structure to the streambed and banks (Swanson and Lienkaemper, 1978; Bilby and Likens, 1979). Forest harvesting activities have affected large woody debris recruitment by removal of vegetation which could have been delivered to watercourses and salvage of downed LWD from the watercourse or adjacent banks. In 1970, excessive amounts of slash attributed to land use practices had created many log jams in the upper portion of the drainage. Black Mountain Conservation Camp was contracted to work on removal of these jams (CDFG 1995). As a result, riparian stands on industrial timberlands may not be adequate to provide future LWD to stream channels which are already LWD deficient. Identifying where problems exist and then tailoring management activities to these needs will have long-term benefits to aquatic habitat.

Large Woody Debris Recruitment Potential and In-stream Demand Methods

Short-term LWD recruitment potential (next 20-30 years) was evaluated in designated stream segments within the Willow/Freezeout CreeksWAU. Stream segments were designated in the stream channel condition assessment and are shown on map E-1(Stream Channel Condition module). Generally, stream segments were designated on any watercourse with less than a 20 percent gradient. In this assessment, vegetation type, size and density is assumed to influence LWD recruitment with the best riparian vegetation being large conifer trees.

To determine the LWD recruitment potential, riparian stands were classified using year 2000 aerial photographs and field observations from the summer of 2000. The riparian stands were evaluated for a distance of approximately one tree height on either side of the watercourse. Riparian stands were evaluated seperately for each side of the watercourse. The following vegetation classification scheme for the Mendocino Redwood Company (MRC) timber inventory was used to classify the riparian stands:

Vegetation Classes

RW- greater than 75% of the stand basal area in coast redwood.
RD- combination of Douglas-fir and coast redwood basal area exceeds 75% of the stand, but neither species alone has 75% of the basal area.
MH- mix of hardwood basal area exceeds 75% of the stand, but no one hardwood species has 75% of the basal area.
CH- mix of conifer and hardwood basal area exceeds 75% of the stand, but no one hardwood or conifer species has 75% of the basal area.
Br- Brush

Vegetation Size Classes

1 - <8inches dbh
2 - 8 to 15.9 inches dbh
3 - 16 to 23.9 inches dbh
4 - 24 to 31.9 inches dbh
5 - >32 inches dbh

The size class is determined by looking at the diameters of the trees in the riparian stand. The size class which exceeds 50% of the total basal area is the size class assigned to the stand.

Vegetation Density

O - 5-20% tree canopy cover range
L - 20-40% tree canopy cover range
M - 40-60% tree canopy cover range
D - 60-80% tree canopy cover range
E - >80% tree canopy cover

The codes for vegetation classification of riparian stand condition are based on the three classes listed above. The vegetation code is a string of the classes with the vegetation class first, the size class second, and the vegetation density last. For example, the vegetation code for a redwood stand with greater than 50% of the basal area with 16-23.9 inch dbh or larger and 60-80% canopy cover would be classified RW3D.

In this assessment, vegetation type, size and density is assumed to affect LWD recruitment to the stream channel with the best riparian vegetation being large conifer trees. The LWD recruitment potential ratings reflect this. The following table presents the vegetation classification codes for the different LWD recruitment potential ratings (Table D-1)

Table D-1. Description of LWD Recruitment Potential Rating by Riparian Stand Classification for the Willow/Freezeout CreeksWAU.

Vegetation Type	Size and Density Classes					
	Size Classes 1-2 (Young)		Size Class 3 (Mature)		Size classes 4-5 (Old)	
	Sparse (O,L)	Dense (M, D, E)	Sparse (O,L)	Dense (M, D, E)	Sparse (O,L)	Dense (M, D, E)
RW	Low	Low	Low	Moderate	Moderate	High
RD	Low	Low	Low	Moderate	Moderate	High
CH	Low	Low	Low	Moderate	Low	High
MH	Low	Low	Low	Low	Low	Moderate

LWD was inventoried in watercourses during the stream channel assessment. All "functional" LWD was tallied within the active channel and the bankfull channel for each sampled stream segment. Functional LWD was that which was providing some habitat or morphologic function in the stream channel (i.e. pool formation, scour, debris dam, bank stabilization, or gravel storage). There was no minimum size requirement for functional LWD. The LWD was classified by tree species class, either redwood, fir (Douglas-fir, hemlock, grand fir), hardwood (alder, tan oak, etc.), or unknown (if tree species is indeterminable). Length and diameter were recorded for each piece so that volume could be calculated.

LWD associated with an accumulation of 3 pieces or more was recorded and the number of LWD accumulations in the stream survey reach was tallied. LWD pieces are also assigned attributes if they fell into certain categories. These categories are: if the LWD piece was part of a living tree, root associated (i.e. does it have a rootwad attached to it), was part of the piece buried within stream gravel or the bank, or associated with a restoration structure. By assigning these attributes, the number of pieces in a segment which, for example, have a rootwad associated with the LWD can be noted. This is important as these types of pieces can be more stable or have ecological benefits above that which a LWD piece alone may have.

Pieces that were partially buried were noted, as calculated volume for these pieces represent a minimum. There may likely be a significant amount of volume that is buried that we cannot measure. Also, these pieces are more stable in the channel during high flows. The percentage of total pieces which are partially buried was calculated for each stream segment. Some consideration was given as to what percentage (0-25%, 25-50%, 50-75% and 75-100%) of the LWD pieces in the stream were recently contributed (<10 years). The LWD is further classified as a key LWD piece if it meets the following size requirement:

Table D-2. Key LWD Piece Size Requirements (adapted from Bilby and Ward, 1989)

Bankfull width (ft)	Diameter (in)	Length (ft)
0-20	12	20
20-30	18	30
30-40	22	40
40-60	24	60

Debris jams (>10 pieces) were noted and total dimensions of the jam recorded. This volume was calculated and added to total LWD volume with a correction factor of 50%. In other words, 50% of the total volume of a debris jam was considered to be “air space.” Total number of pieces and number of key pieces were noted. Species and dimensions were not recorded for individual pieces contained in debris jams. All volume estimates and piece counts were seperated in two groups, one not considering jams and one considering all LWD pieces in the segment, debris jams included. The percentage of total volume and total pieces per segment which was contained in debris jams was also calculated.

The quantity of LWD observed was normalized by distance, for comparison through time or to other similar areas, and was presented as a number of LWD pieces per 100 meters. This normalized quantity, by distance, was performed for functional and key LWD pieces within the active and bankfull channel. The key piece quantity in the bankfull channel (per 100 meters of channel) is compared to the target for what would be an appropriate key piece loading. The target for appropriate key piece loading was derived from Bilby and Ward (1989) and Gregory and Davis (1992) and presented in Table D-3.

Table D-3. Target for Number of Key Large Woody Debris Pieces in Watercourses of the Willow/Freezeout CreeksWAU.

	# Key Pieces		
Bankfull Width (ft)	**Per 100 meters**	**Per 1000 feet**	**Per mile**
<15	6.6	20	106
15-35	4.9	15	79
35-45	3.9	12	63
>45	3.3	10	53

An in-stream LWD demand is identified in addition to the riparian stand recruitment potential, discussed previously. The in-stream LWD demand is an indication of what level of concern there is for in-stream LWD for stream channel morphology and fish habitat associations within the Willow/Freezeout CreeksWAU. The in-stream LWD demand is determined by stream segment considering the overall LWD recruitment, the stream segment LWD sensitivity rating (as determined in the Stream Channel and Fish Habitat Assessment for stream geomorphic units), and the level of LWD currently in the stream segment (on target or off target). Table D-4 shows how these three factors are used to determine the in-stream LWD demand.

Table D-4. In-stream LWD Demand

		Channel LWD Sensitivity Rating		
	LWD On Target / **LWD Off Target**	**LOW**	**MODERATE**	**HIGH**
Recruitment Potential Rating	**LOW**	LOW	MODERATE	HIGH
		HIGH	HIGH	HIGH
	MODERATE	LOW	MODERATE	MODERATE
		HIGH	HIGH	HIGH
	HIGH	LOW	MODERATE	MODERATE
		MODERATE	HIGH	HIGH

Low In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are sufficient for LWD function in these stream channel types.

Moderate In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are moderately sufficient for fish habitat and stream channel morphology requirements. Consideration must be given to these areas to improve the LWD recruitment potential of the riparian stand. These areas may also be considered for supplemental LWD or stream structures placed in the stream channel.

High In-stream LWD Demand - this classification suggests that current riparian LWD recruitment conditions and in-stream LWD are at levels which are not sufficient for LWD function in these stream channel types. These areas must consider improvement of the LWD recruitment potential of the riparian stand. These areas should be the highest priority for supplemental LWD or stream structures placed in the stream channel.

Large Woody Debris Recruitment Potential and In-stream Demand Results

The large woody debris recruitment potential and in-stream LWD demand for the Willow/Freezeout CreeksWAU is illustrated in Map D-1. The large woody debris recruitment potential and in-stream LWD demand provides baseline information on the structure and composition of the riparian stand and the level of concern about current LWD conditions in the stream. This map provides a tool for prioritizing riparian and stream management for improving LWD recruitment and in-stream LWD. These areas must be monitored over time to ensure that the recruitment potential is improving and that large woody debris is providing the proper function to the watercourses.

Current LWD loading is shown in Tables D-5a and b . Only one of the channels in Willow Creek, SW2(2), met the LWD target. LWD was determined to be sparse in all segments in Willow Creek except for segments SW2(2) and SW23. One segment in Freezeout Creek (SF1/2) did meet the target.

Debris jams, where they occurred, were shown to be a significant portion of the total number of piece and total volume. In the Willow/Freezeout Creek WAU, debris jams occurred in three segments and contained up to 48.3% of the total pieces and 30% of the total volume (see Table D-5a and b). In the case of segment SW2(2), debris jams actually affected whether or not the segment met the LWD target. It was only with adding in the key pieces that were contained in debris jams that the segment exceeded the LWD target. Although there obviously can be a significant amount of LWD trapped in debris jams, the ecological function may not be accurately represented by numbers alone. All of the pieces in a debris jam may actually have more habitat value if they were spread out in the stream as opposed to being piled up in one spot.

A significant amount of the LWD volume in the Willow/Freezeout CreeksWAU was also contained in debris accumulations (>3 pieces). Up to 61 % of the volume of a segment could be found in these accumulations. Buried LWD pieces were common in these streams. Up to 50% of the pieces in any given segment were at least partially buried. This indicates that we are unable to quantify a significant portion of the LWD volume which may eventually be useful to the stream

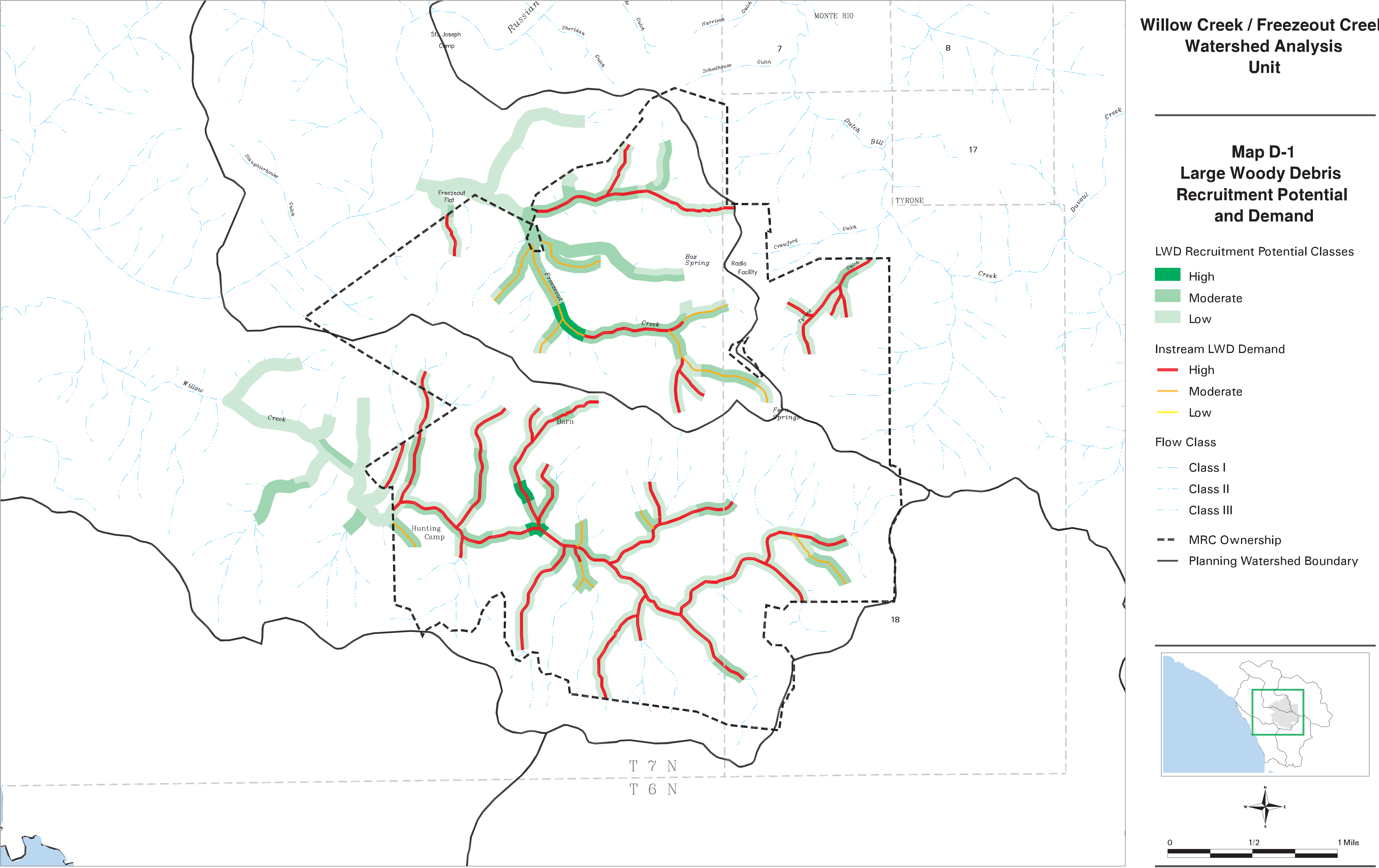
LWD species composition was largely redwood dominated (Table D-5b). This analysis was limited to pieces not contained within debris jams. Almost 90% of all LWD pieces in the Willow/Freezeout Creeks WAU were redwood. The remainder of pieces consisted of an even mixture of fir, alder, hardwood, and unknown species. This may not be surprising as these streams flow through a redwood forest but it does show that the LWD currently found in Willow and Freezeout Creeks is more stable as redwood breaks down more slowly in streams than hardwood species.

All segments in the Willow/Freezeout Creeks WAU contained LWD that was not recently contributed to the stream. All inventoried segments fell into a 0-25% category for pieces recently contributed (<10 yrs). It did not appear that many of the LWD pieces had been contributed within the last 10 years. This may be a result of past riparian harvest and more LWD must be contributed to the stream channel in future years.

As shown in tables D-5a and b, there is a need for large woody debris in most of the channel segments of the Willow/Freezeout Creeks WAU. Channel segments with LWD levels that are well below the target will need to be the priority for monitoring future recruitment and restoration work. Even the segment that met the target need LWD levels to be maintained to ensure LWD is providing fish habitat and morphological function in the stream channels.

Riparian recruitment potential in the Willow/Freezeout Creeks WAU is moderate to low (See Map D-1). Past harvesting activities in riparian areas have resulted in many streamside small hardwood or mixed conifer/hardwood stands. These streamside stands need to be managed to be become large conifer stands to provide a natural source of LWD over time.

Currently, all of the stream segments in the Willow/Freezeout CreeksWAU are in the high and moderate in-stream LWD demand classification (Map D-1). The high in-stream LWD demand in the WAU are primarily due to low levels of LWD in the stream channels compounded by many riparian stands with moderate to low LWD recruitment potential.



February 15, 2001

Table D-5a.-Large Woody Debris Piece Count in Selected Stream Segments of the Willow/Freezeout Creeks WAU.

Stream Segment Name	Stream Segment ID#	Functional LWD Pieces w/o Debris Jams	Functional LWD Pieces w/ Debris Jams	Total # of Debris Jams	Total # of Debris Accumulations	Functional LWD (#/100m) w/o Debris Jams	Functional LWD (#/100m) w/ Debris Jams	Key LWD Pieces w/o Debris Jams	Key LWD Pieces w/ Debris Jams	Key LWD Pieces/100m w/o Debris Jams	Key LWD Pieces/100m w/Debris Jams	% of Total Pieces in Debris Jams
Willow Creek	SW1	48	48	0	2	21.6	21.6	3	3	1.3	1.3	0.0%
Willow Creek	SW2	42	65	1	6	22.0	34.1	2	5	1.0	2.6	35.0%
Willow Creek	SW2(2)	92	178	3	9	50.9	98.5	7	13	3.9	7.2	48.3%
Willow Creek	SW3	43	43	0	3	23.7	23.7	5	5	2.8	2.8	0.0%
Willow Creek	SW20	31	57	1	4	24.4	44.8	3	4	2.4	3.1	45.6%
Willow Creek	SW23	62	62	0	4	48.3	48.3	0	0	0.0	0.0	0.0%
Freezeout Creek	SF1/2	49	49	0	2	39.5	39.5	7	7	5.6	5.6	0.0%
Freezeout Creek	SF10	79	79	0	6	51.9	51.9	4	4	2.6	2.6	0.0%

Table D-5b.-Large Woody Debris Volume Information in Select Stream Segments of the Willow/Freezeout Creeks WAU.

Stream Segment Name	Stream Segment ID#	Total Volume (yd^3) w/o Debris Jams	Total Volume (yd^3) w/ DebrisJams	Total Vol/100m (yd^3) w/o Debris Jams	Total Vol/100m (yd^3) w/ Debris Jams	% of Total Volume in Debris Accumulations	% of Total Volume in Debris Jams	% of Vol in Key Pieces w/o Jams	% of Total Volume By Species w/o Jams: Redwood	Fir	Alder	Hardwood	Unknown	% Current Recruitment (<10 yrs)
Willow Creek	SW1	50.2	50.2	22.6	22.6	25.9%	0.0%	33.0%	87.2%	0.0%	12.0%	0.8%	0.0%	0-25
Willow Creek	SW2	56.6	78.9	29.7	41.4	61.1%	30.0%	24.0%	80.7%	0.0%	9.4%	0.9%	9.0%	0-25
Willow Creek	SW2(2)	104.1	137.4	57.6	76.0	42.3%	24.0%	59.0%	88.4%	0.0%	9.6%	1.4%	0.6%	0-25
Willow Creek	SW3	42.1	42.1	23.2	23.2	40.5%	0.0%	45.0%	86.2%	0.0%	4.8%	3.6%	5.4%	0-25
Willow Creek	SW20	29.6	40.7	23.3	32.0	39.9%	27.0%	64.0%	98.7%	0.0%	0.6%	0.4%	0.3%	0-25
Willow Creek	SW23	35.3	35.3	27.5	27.5	17.8%	0.0%	0.0%	95.2%	0.0%	0.0%	1.4%	3.5%	0-25
Freezeout Creek	SF1/2	25.5	25.5	20.5	20.5	21.4%	0.0%	51.0%	93.7%	0.0%	0.0%	4.0%	2.3%	0-25
Freezeout Creek	SF10	39.4	39.4	25.9	25.9	14.6%	0.0%	30.0%	59.1%	19.4%	20.8%	0.5%	0.1%	0-25

Canopy Closure and Stream Temperature

Canopy cover is important in reducing the net gain of solar radiation. Stream water temperature responds to the input of solar radiation and is directly proportional to exposed stream surface area (Brown and Krygier, 1970) and inversely proportional to discharge (Sullivan et. al., 1990). Wide stream exposures receive greater solar radiation then streams with good canopy cover and narrow solar exposure. Several studies have shown that an intact streamside forest canopy will shade streams and minimize increases in summer water temperature. Brown and Krygier (1970) found diurnal variations in a well-shaded coastal Oregon stream to be less than 1^{o} C. However, complete removal of the forest canopy has been shown to increase summer maximum temperatures $3\text{-}8^{o}$ C (see review Beschta et. al., 1987). In a comparison of 20 years of temperature records from Steamboat Creek, Oregon, Hostetler (1991) found that streamside canopy cover was the most important variable linked to changes in stream temperature.

Many physical factors can influence stream temperature. These include: solar radiation, air temperature, relative humidity, water depth and ground water inflow. Forest management can most influence solar radiation input, riparian air temperature and relative humidity by alteration of streamside vegetation and cover. Water depth and ground water inflow are more difficult to correlate to forest management practices. Therefore, our analysis focused on present canopy cover conditions for consideration for future forest management actions.

The optimal temperature for Pacific salmonids has been hypothesized to range from between 12 and 14^{o} C (Brett, 1952), though there is considerable debate about what exactly is the optimal temperature and what it means. Temperatures lethal to salmonids have been determined in the laboratory and range from 23-29 ^{o}C (Beschta et. al., 1987). Though these temperatures are possible in some small, forested streams, they would generally only occur for short periods of time in the summer.

Methods

Canopy closure, over watercourses, was estimated from year 2000 aerial photographs. Five canopy closure classes were determined using the aerial photographs. These classes are shown in Table D-6. A map was produced for the Willow/Freezeout CreeksWAU based on the aerial photograph interpretations.

Table D-6. Estimated levels of Canopy Closure from Aerial Photographs.

Stream surface not visible	>90% shade
Stream surface visible or visible in patches	70-90% shade
Stream surface visible but banks are not visible	40-70% shade
Stream surface visible and banks visible at times	20-40% shade
Stream surface and banks visible	0-20% shade

During year 2000 field measurements of canopy closure over select stream channels were performed. The field measurements were taken during the stream channel assessments in the Willow/Freezeout Creeks WAU. The field measurements consisted of estimating canopy closure over a watercourse using a spherical densiometer. The densiometer estimates were taken at approximately 3-5 evenly spaced intervals along a channel sample segment, typically a length of 20-30 bankfull widths. The results of the densiometer readings were averaged across the channel to represent the percentage of canopy closure for the channel segment. The streamside canopy for the Willow/Freezeout Creeks WAU is mapped in Map D-2.

Stream temperature has been monitored in the Willow/Freezeout Creeks WAU, by Louisiana-Pacific Corp., 1994-97 and MRC in 1999 and 2000. Stream temperature monitoring involved use of electronic temperature recorders (Stowaway, Onset Instruments) which monitor the water temperature continuously at 2 hour intervals. Stream temperatures are monitored during the summer months when the water temperatures are highest. The stream temperature recorders were typically placed in shallow pools (<2 ft. in depth) directly downstream of riffles. Map D-2 shows the temperature monitoring locations and Table D-7 describes the temperature monitoring locations.

Table D-7. Stream Temperature Monitoring Locations and Time Periods in the Willow/Freezeout CreeksWAU (see map D-2)

Temperature Monitoring Station	**Stream Segment Number**	**Stream Name**	**Years Monitored**
98-1	SW1	Willow Creek	’94, ’95, ’96, ’99, ‘00
98-3	SW3	Willow Creek	’94, ’95, ’96, ’99, ‘00
98-4	SF10	Freezeout Creek	’96, ’97, ’99, ‘00

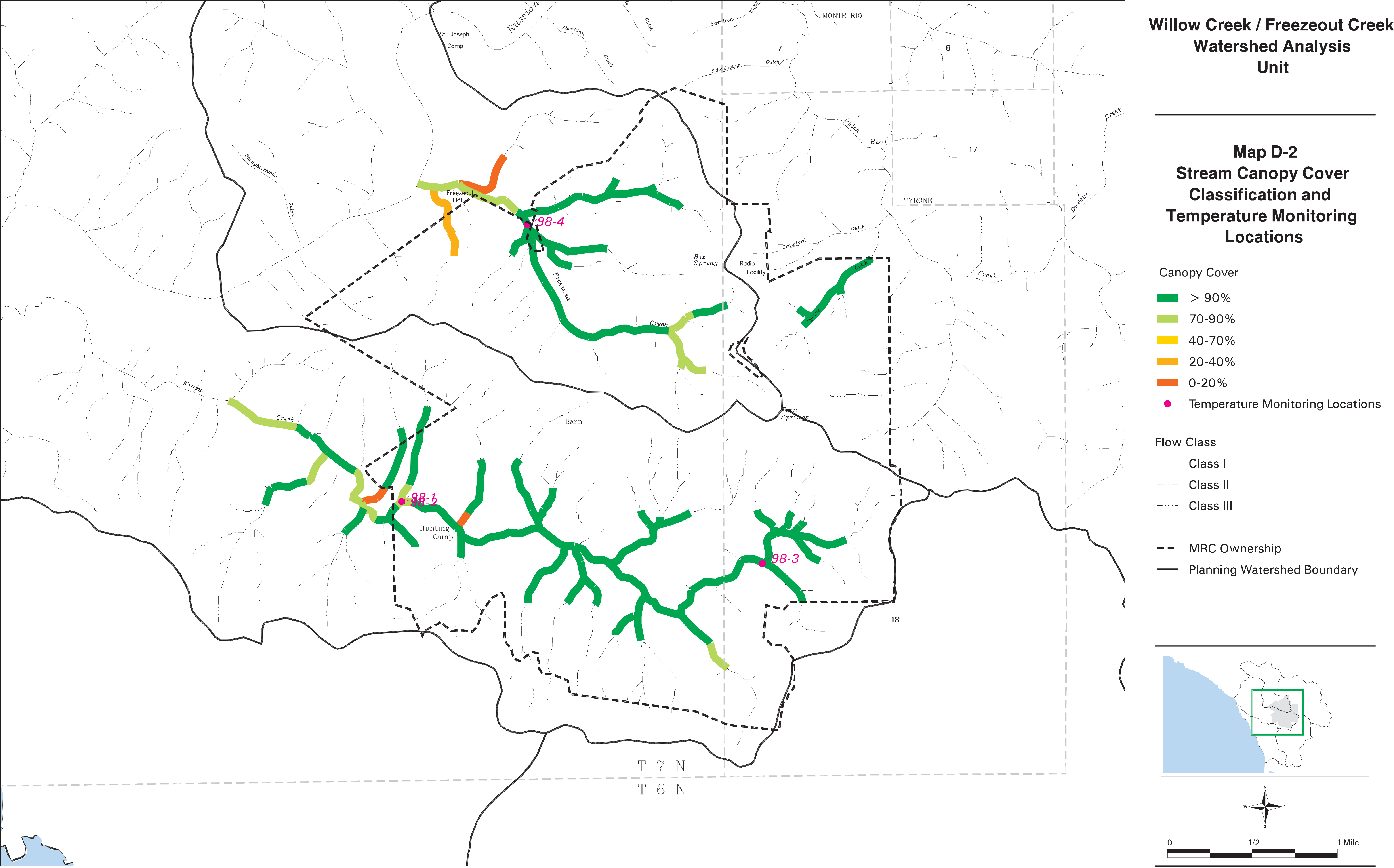
Maximum and mean daily temperatures were calculated for each temperature monitoring site and year and are presented in Appendix D. Maximum weekly average temperatures (MWATs) and maximum weekly maximum temperatures were calculated for the stream temperatures by taking a seven day average of the mean and maximum daily stream temperature.

Results

Canopy closure over watercourses is generally very good throughout the Willow/Freezeout CreeksWAU (Map D-2 and Table D-8). The canopy closure map shows almost all Class I and II stream with a high streamside canopy classification (>90% cover)(Map D-2). Only a few channels have a moderate streamside canopy classification (70-90% cover) with just a fraction of the channels having a low streamside canopy classification (20-40% or <20% cover).

Willow Creek / Freezeout Creek Watershed Analysis Unit

Map D-2 Stream Canopy Cover Classification and Temperature Monitoring Locations



February 21, 2001

Table D-8. 2000 Field Observations of Stream Canopy Closure for Select Stream Channel Segments in the Willow/Freezeout CreeksWAU.

Stream Name	Segment Number	Mean Shade Canopy
Willow Creek	SW1	94%
Willow Creek	SW2	94%
Willow Creek	SW2(2)	94%
Willow Creek	SW3	95%
Willow Creek	SW20	97%
Willow Creek	SW23	97%
Freezeout Creek	SF1/2	98%
Freezeout Creek	SF10	90%

Stream temperatures in the Willow/Freezeout CreeksWAU are at favorable levels for salmonids. Instantaneous maximum temperatures recorded in Lower Willow Creek, Upper Willow Creek and Freezeout Creek are higher than the preferred temperature ranges for coho salmon (12-14 C^{o}) and steelhead trout (10-13 C^{o})(Brett, 1952 and Bell, 1986). However, these are maximums and are infrequent or of short duration. More important are MWAT values for these streams. The three temperature sites in the Willow/Freezeout CreeksWAU show MWATs which are well below the maximums for coho salmon (17-18C^{o})(Brett, 1952 and Becker and Genoway, 1979). These MWAT values almost always fall within the preferred temperature range of coho as defined by Brett (1952). See Tables D-9, D-10 and D-11.

Table D-9. Maximum Daily Temperatures for each station in the WillowCreek/Freezeout WAU.

Station No.	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
98-1	13.7	16.8	15.1	n/a	n/a	16.2	16.3
98-3	17.2	16.9	15.9	n/a	n/a	14.5	17.6
98-4	n/a	n/a	14.8	n/a	n/a	15.8	15.1

Table D-10. Maximum Weekly Average Temperature (MWAT) for each station in the Willow/Freezeout CreeksWAU.

Station No.	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
98-1	13.0	15.3	13.9	n/a	n/a	13.6	14.5
98-3	13.9	15.1	13.9	n/a	n/a	13.9	14.6
98-4	n/a	n/a	13.4	15.1	n/a	14.1	13.6

Table D-11. 7-Day Moving Average of the Daily Maximum for each station in the Willow/Freezeout CreeksWAU.

Station No.	1994	1995	1996	1997	1998	1999	2000
98-1	13.2	16.2	14.6	n/a	n/a	15.2	15.2
98-3	16.4	16.0	15.2	n/a	n/a	14.1	15.9
98-4	n/a	n/a	14.3	16.3	n/a	14.8	14.6

Canopy cover and stream temperatures in the Willow/Freezeout CreeksWAU are not of immediate concern. The relatively favorable stream temperatures in the Willow/Freezeout CreeksWAU can generally be attributed to high stream canopy levels and the small, coastal nature of the streams in these watersheds.

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Appendix

Riparian Function

Figure 162. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Willow Creek (Site 98-3), Sonoma County, California.

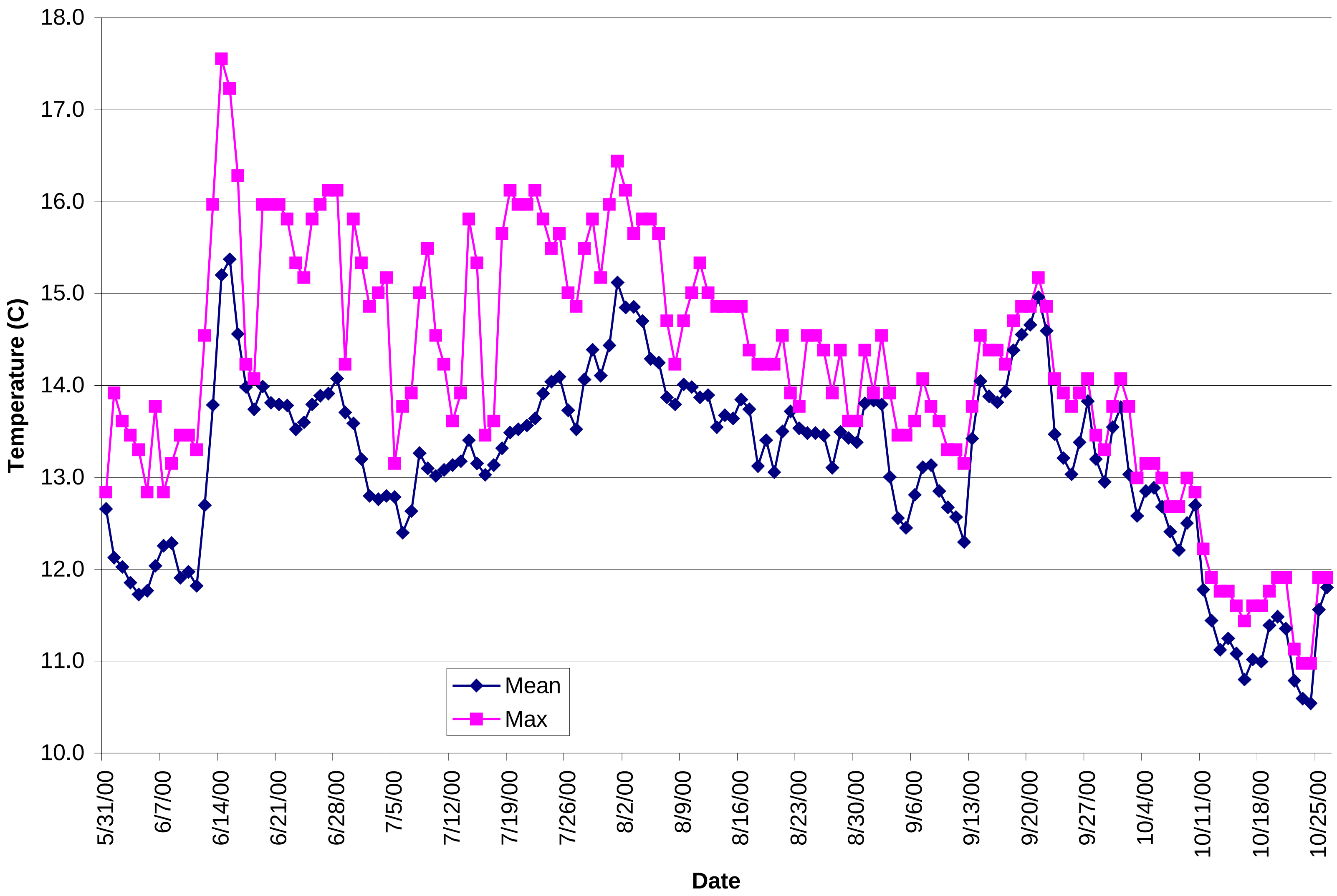

Figure 160. Mean and Maximum Daily Stream Temperatures During Summer 2000 at Willow Creek (Site 98-1), Sonoma County, California.

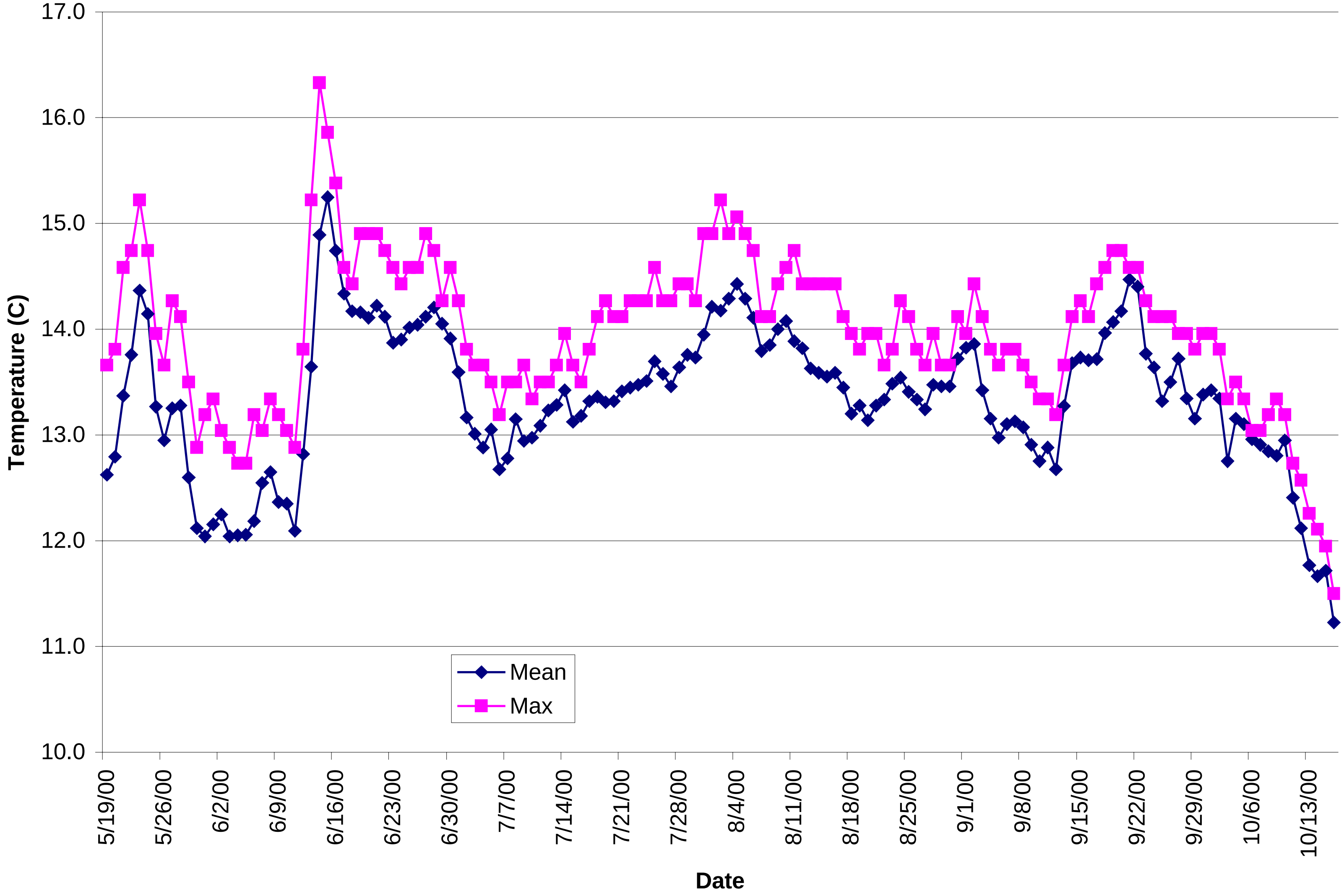

Figure 159. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Willow Creek (Site 98-1), Sonoma County, California.

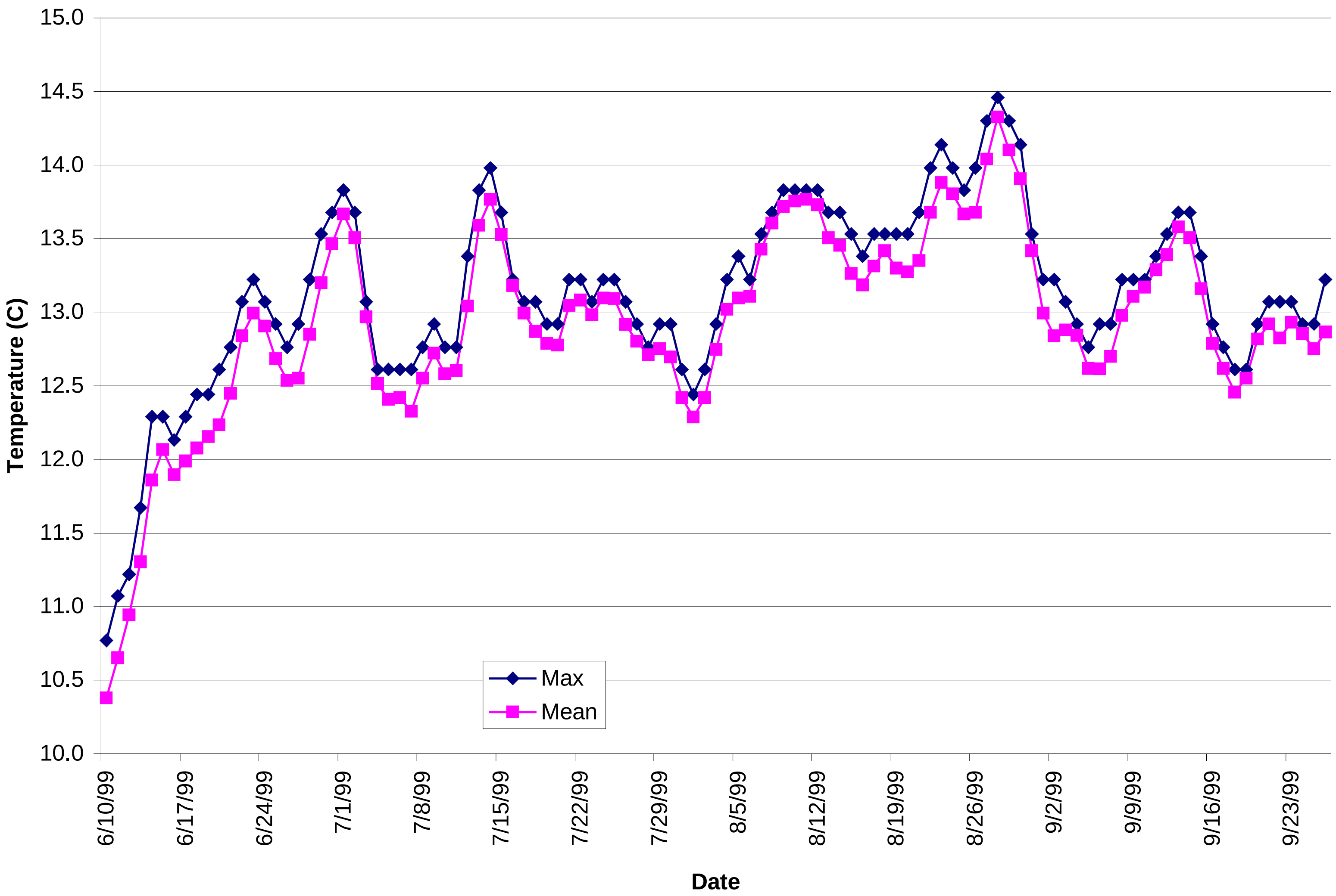

Figure 161. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Willow Creek (Site 98-3), Sonoma County, California.

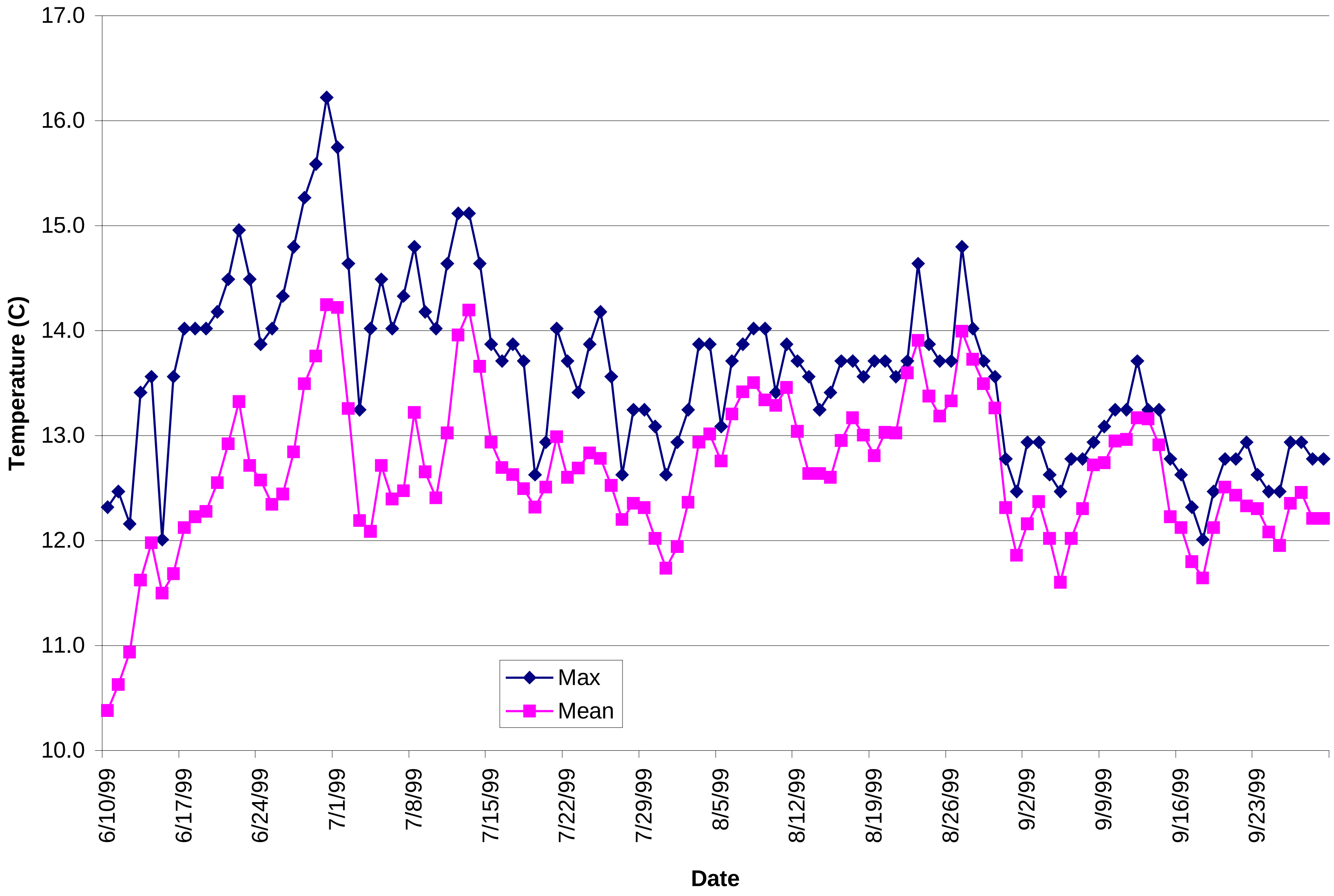

Figure 164. Mean and Maximum Daily Stream Temperatures During Summer 1999 at Freezeout Creek (Site 98-4), Sonoma County, California.

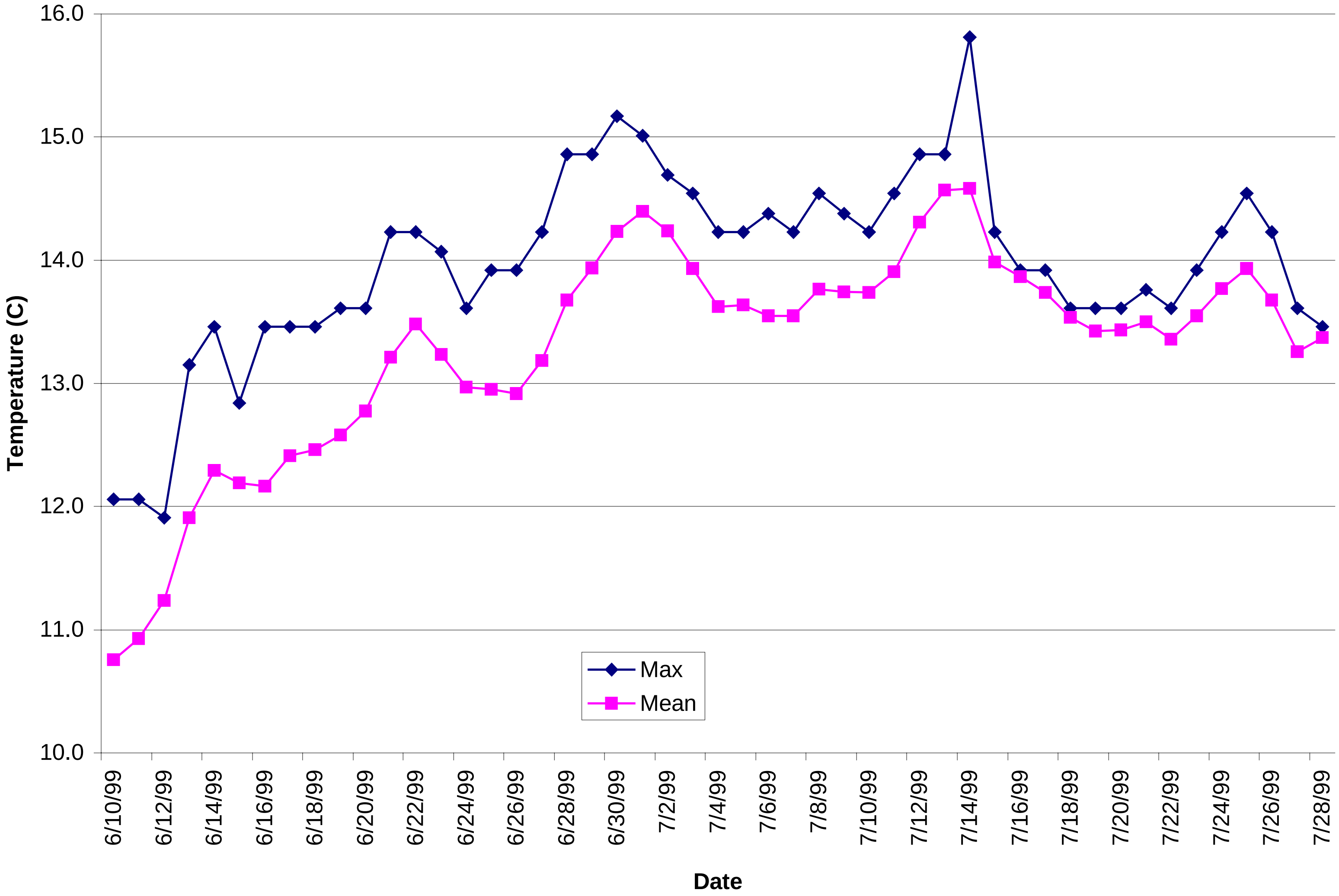

Figure 163. Mean and Maximum Daily Stream Temperatures During Summer 1997 at Freezeout Creek (Site 98-4), Sonoma County, California.

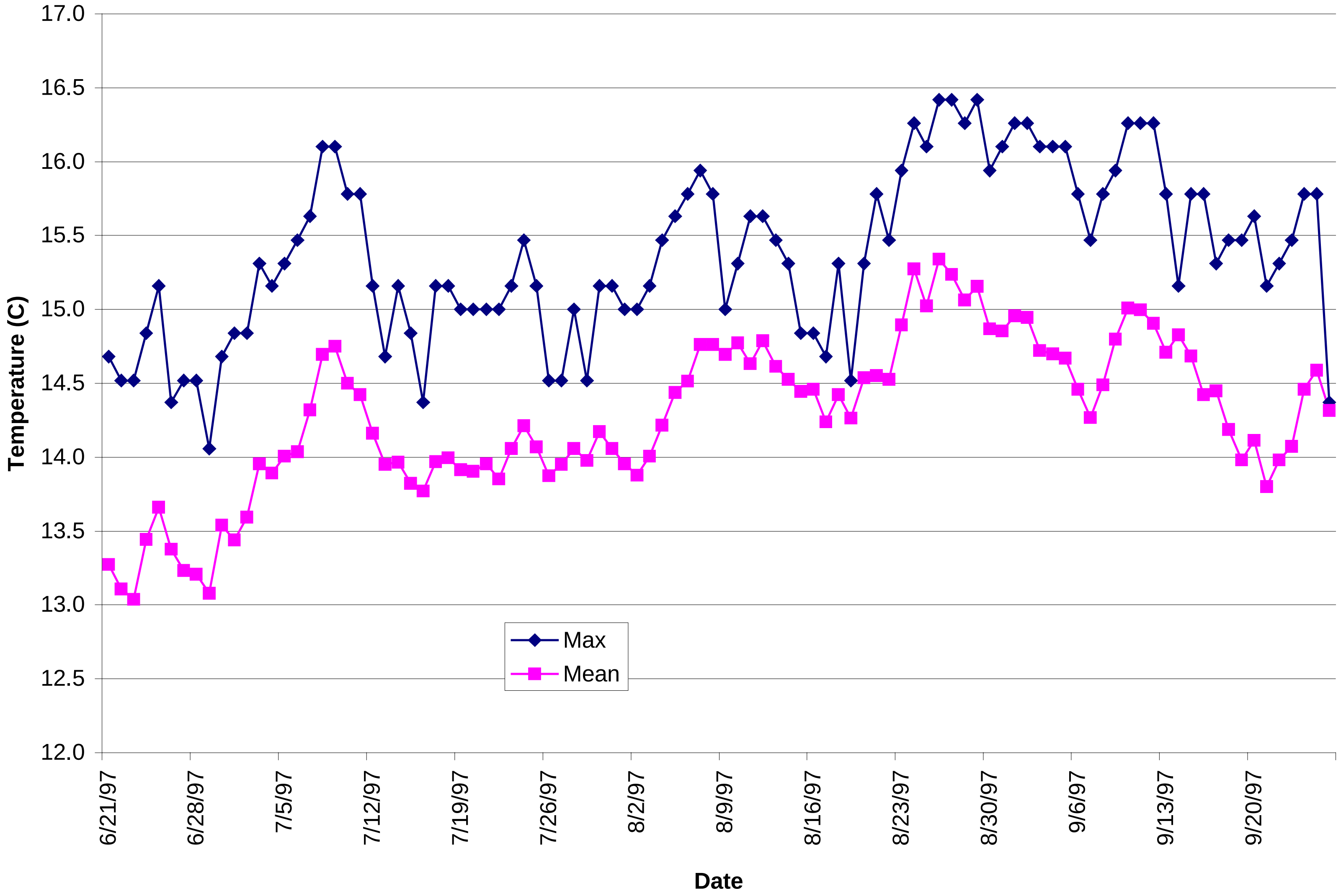

FIGURE 118. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1996) AT FREEZEOUT CREEK (MAP NO. 26; MONITORING SITE NO. 98-4), SONOMA CO., CALIFORNIA.

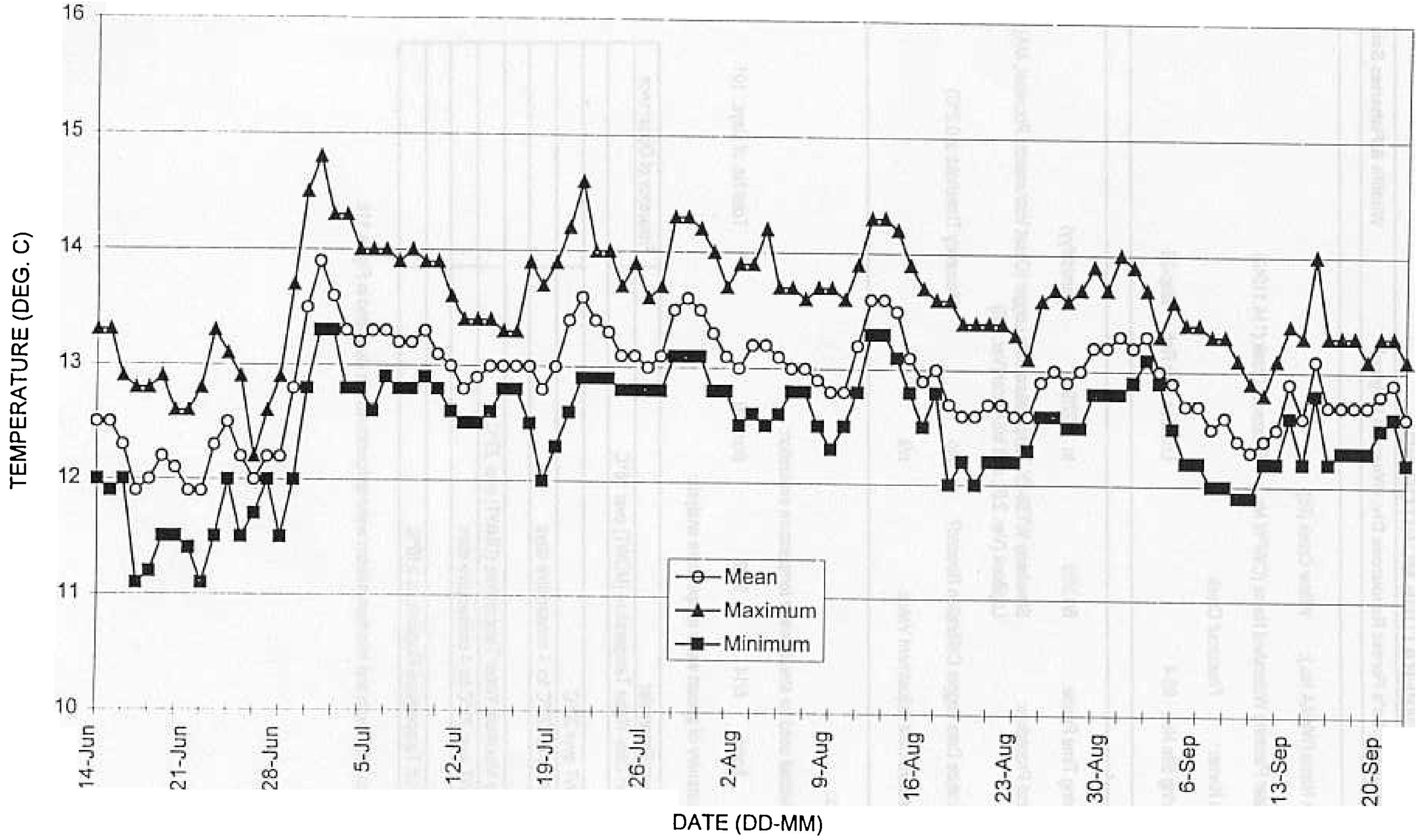

FIGURE 114. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1996) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-1), SONOMA CO., CALIFORNIA.

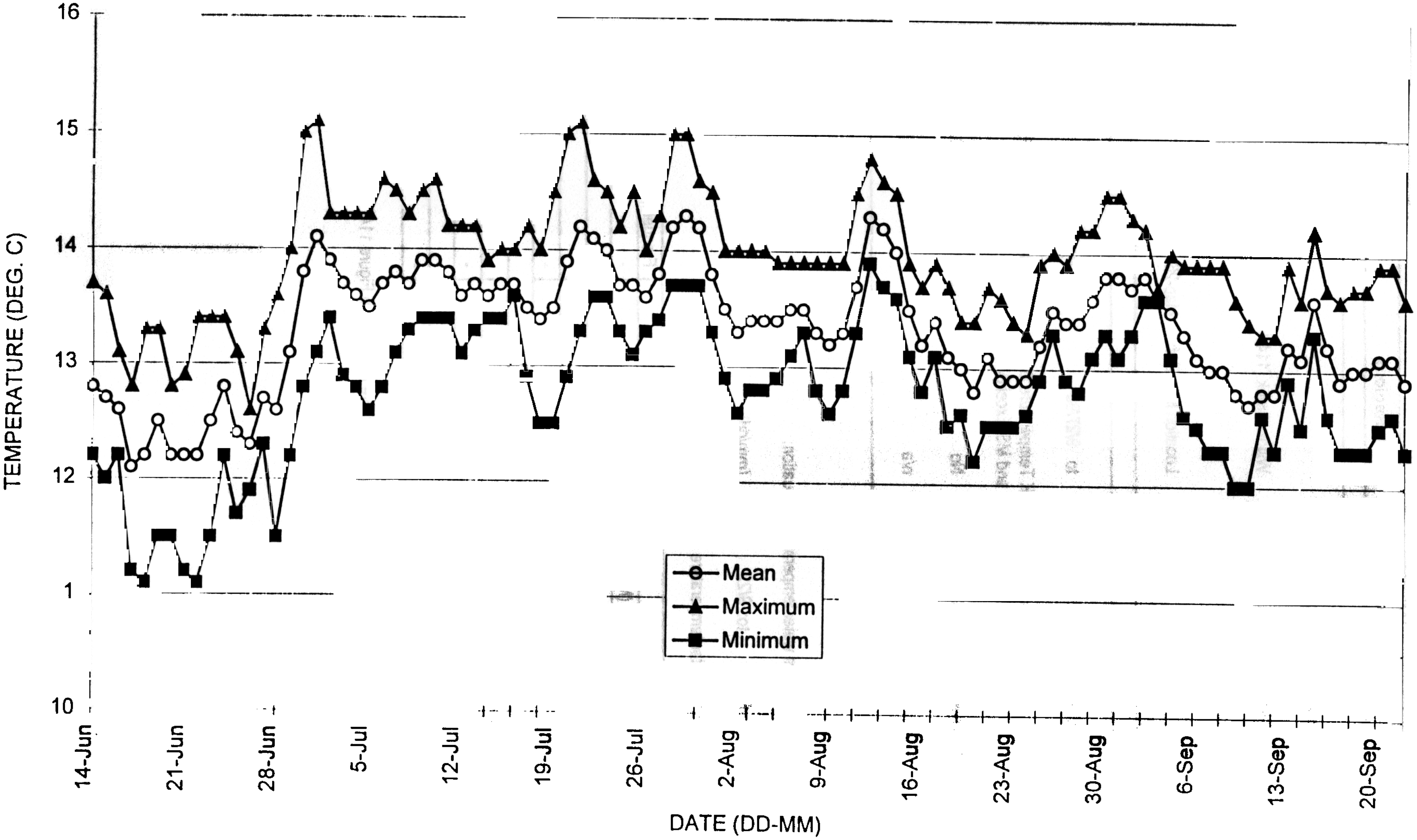

FIGURE 117. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1996) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-3), SONOMA CO., CALIFORNIA.

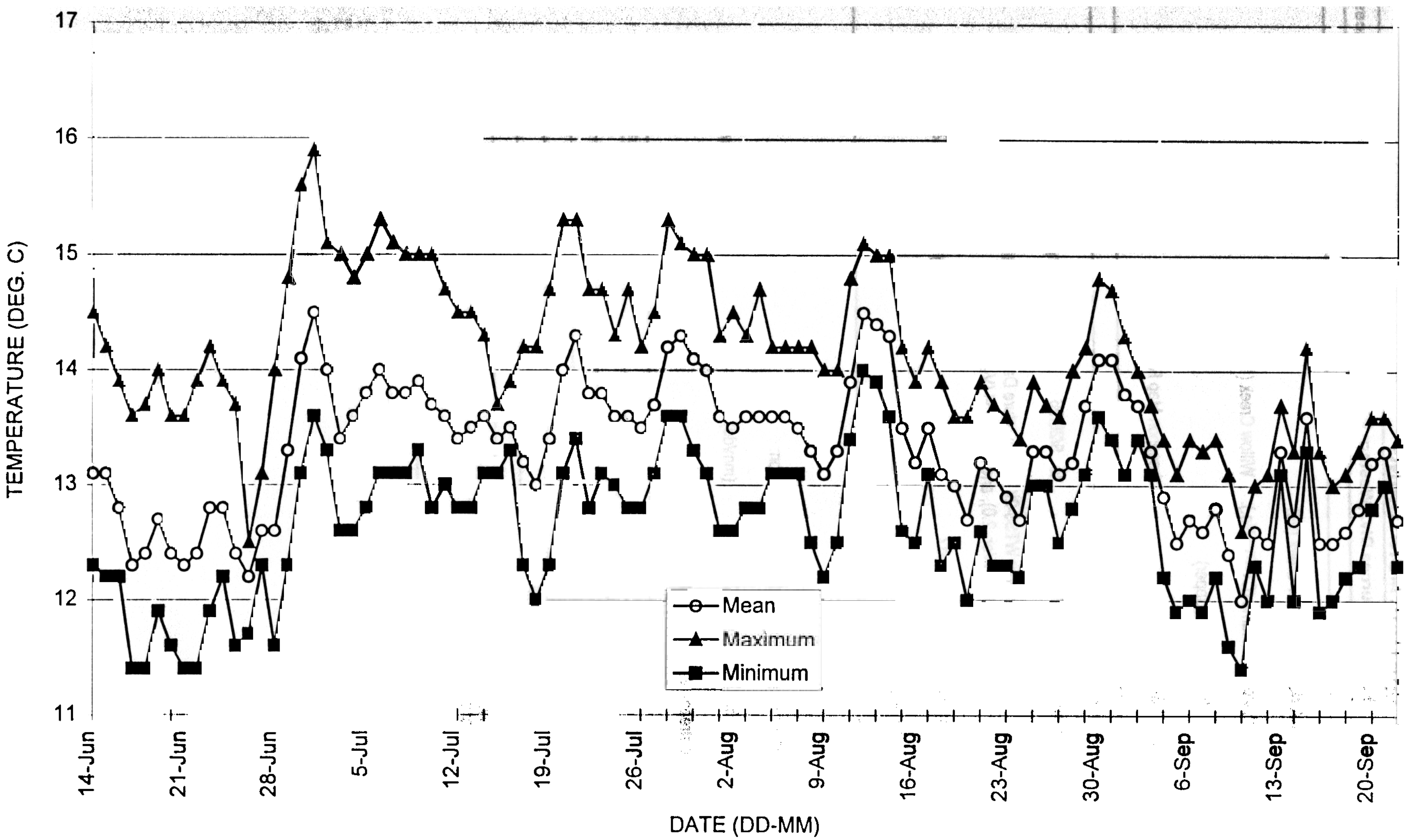

FIGURE 116. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JULY- SEPTEMBER 1995) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-3), SONOMA CO., CALIFORNIA.

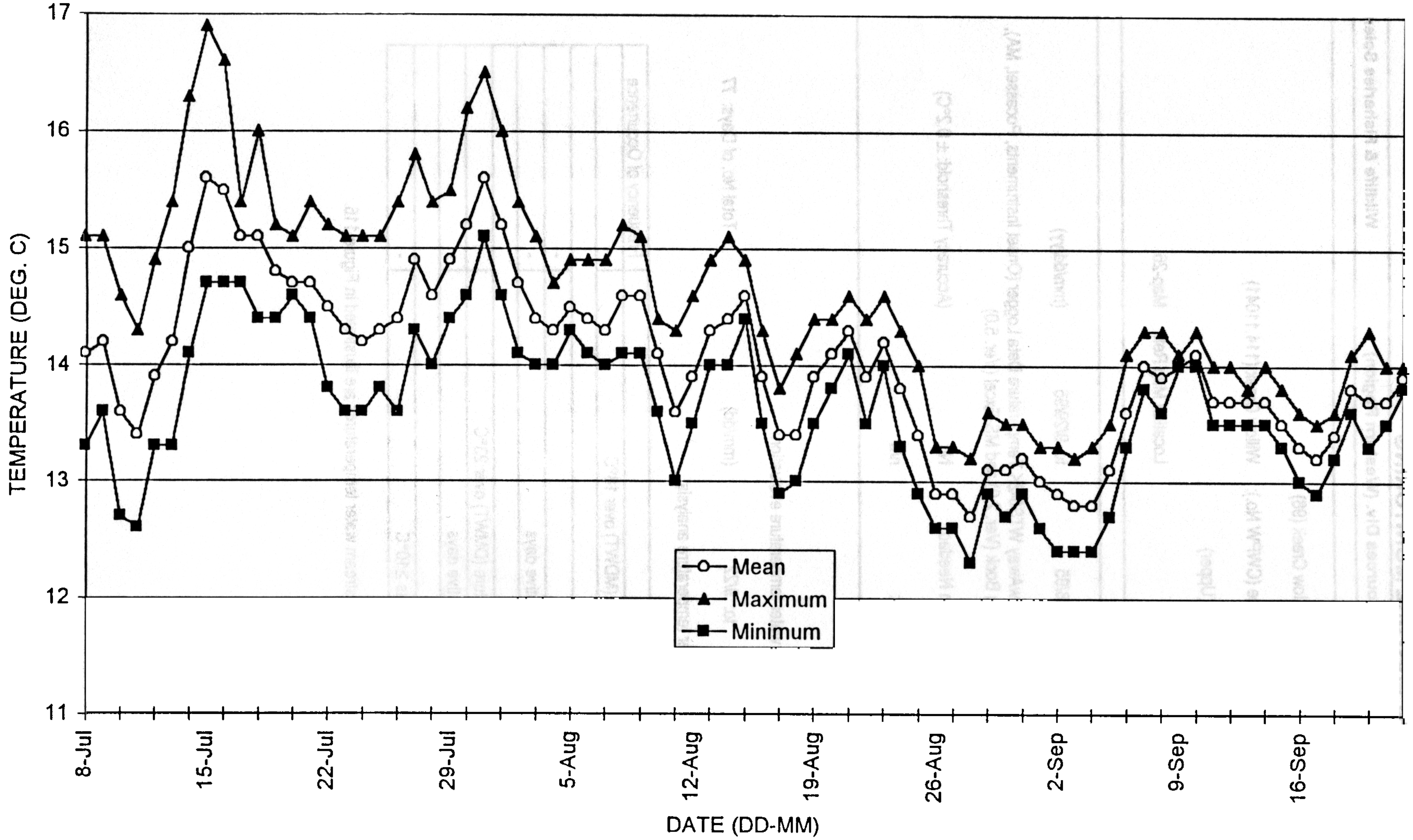

FIGURE 113. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JULY-SEPTEMBER 1995) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-1), SONOMA CO., CALIFORNIA.

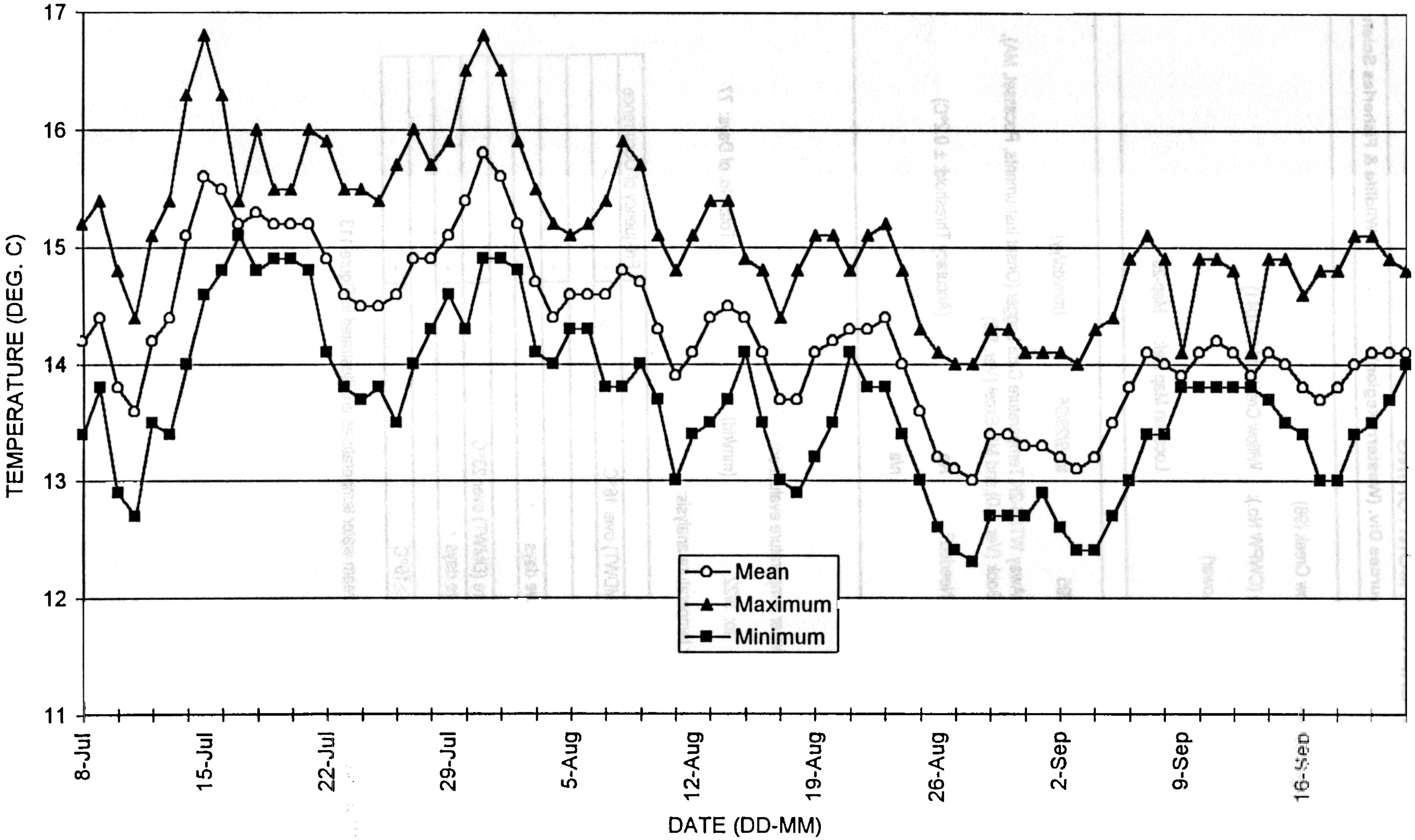

FIGURE 113. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JULY-SEPTEMBER 1995) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-1), SONOMA CO., CALIFORNIA.

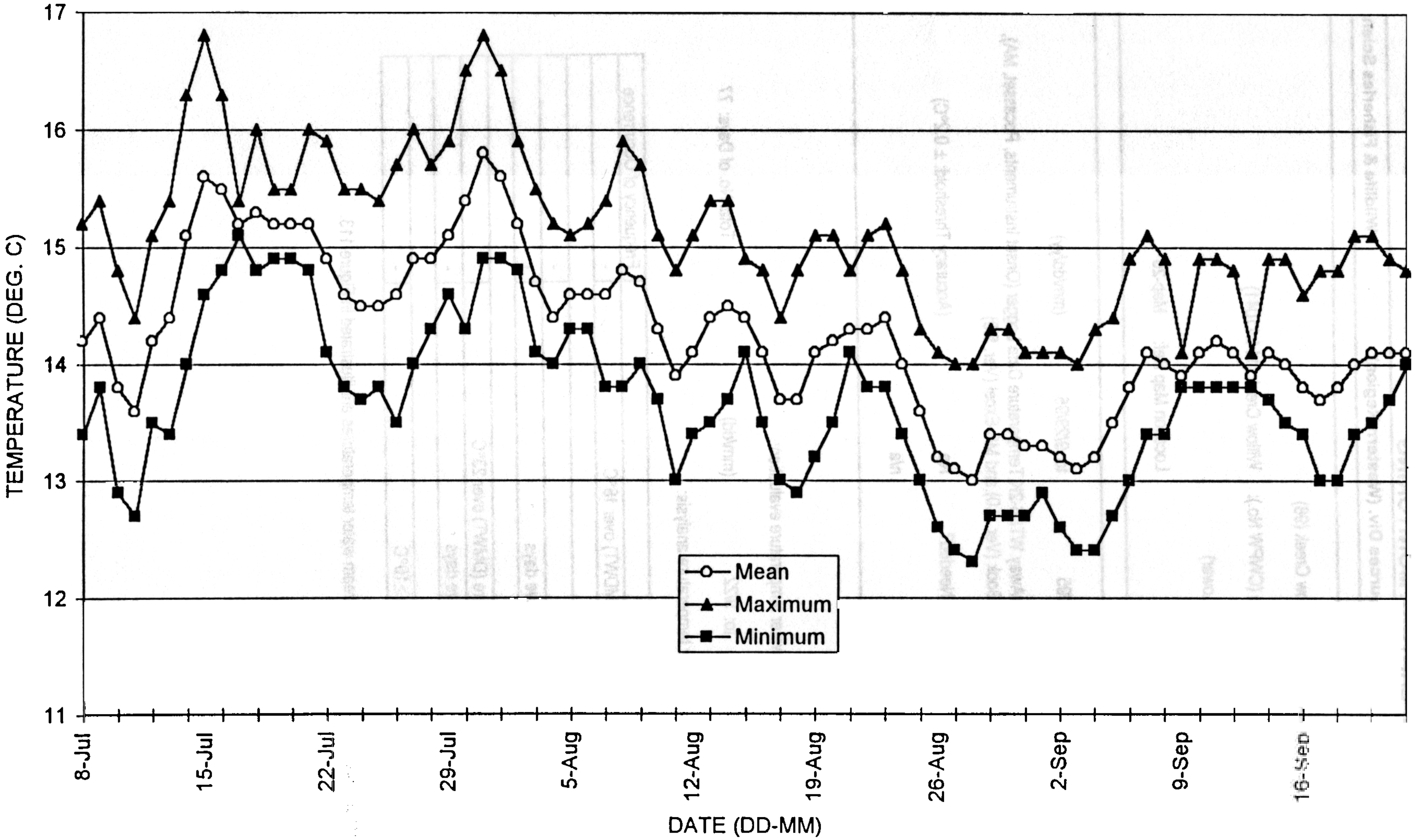

FIGURE 115. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-3), SONOMA CO., CALIFORNIA.

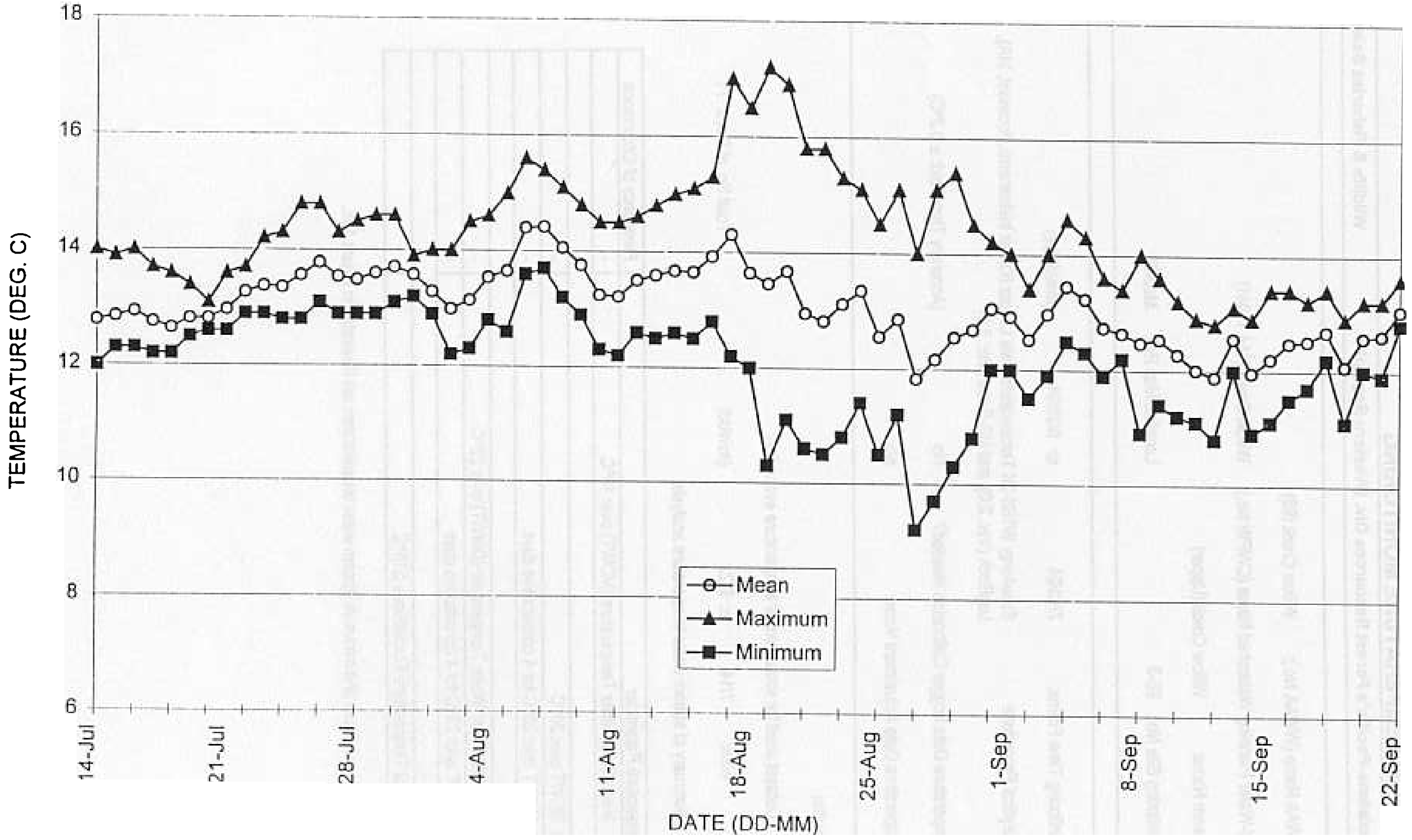

FIGURE 112. MEAN, MAXIMUM, AND MINIMUM DAILY STREAM WATER TEMPERATURES DURING SUMMER (JUNE-SEPTEMBER 1994) AT WILLOW CREEK (MAP NO. 26; MONITORING SITE NO. 98-1), SONOMA CO., CALIFORNIA.