Upper White River Spring Chinook Habitat Assessment Study

Interim Report on 1995 Water Temperatures and Spawning Gravel Composition

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Abstract

Stream temperature monitoring and spawning gravel sampling were conducted within the largest non-glacial tributaries to the upper White River in the summer of 1995. The purpose of this monitoring was to provide information on selected habitat parameters in support of plans to improve habitat conditions for the only remaining spring Chinook salmon stock in south Puget Sound. Water temperatures monitored in the Clearwater River, Huckleberry Creek, the Greenwater River, and tributaries to the Greenwater River revealed that some reaches of these streams exceeded water temperature criteria established in the state Water Quality Standards, while other reaches met the criteria during the summer of 1995. Sampling of stream substrate within salmon spawning habitat revealed that 93%, 71%, and 42% of the 1995 gravel samples collected from the Clearwater River, Huckleberry Creek, and the Greenwater River, respectively, had fine sediment levels characterized as "Good" according to the Watershed Analysis resource condition index, with the remainder characterized as "Fair" or "Poor." The results of additional water temperature monitoring, conducted during the summer of 1996, and streambed scour monitoring over the 1995/96 winter period, will be reported on in a later report.

Acknowledgments

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Introduction

The Washington State Department of Ecology (Ecology) conducted habitat monitoring surveys within three non-glacial tributary streams of the upper White River during the summer of 1995. The purpose of these surveys was to assess certain habitat parameters within the Clearwater River, Greenwater River, and Huckleberry Creek that could adversely affect survival of White River spring Chinook salmon. These streams have been identified as supporting spawning, rearing, and adult maturation for White River spring Chinook salmon. This race of fish is the sole remaining spring Chinook stock within south Puget Sound. Due to low numbers of returning adult fish, this stock has been identified as critical by the 1992 Washington State Salmon and Steelhead Stock Inventory report (WDFW, 1994). In addition, these fish have been petitioned to the National Marine Fisheries Service (NMFS) for listing under the Federal Endangered Species Act (ESA). State and federal agencies, as well as four treaty tribes (Muckleshoot, Nisqually, Puyallup, and Squaxin) have collaborated to protect the genetic integrity of these fish and restore them to their historical habitat within the upper White River.

During 1995 scoping for the South Puget Water Quality Management Area by Ecology's Southwest Regional Office, focusing on water quality concerns within those areas utilized by White River spring Chinook salmon emerged as a top priority. The White/Puyallup River system has been impacted in many ways. Some of the impacts in the White River below Mud Mountain Dam have included channelizing, discharges from industrial and municipal activities, riparian cover removal, low instream flows, diversion of flow for power generation, flood control projects (Mud Mountain Dam), and gravel bar scalping. The upper White River (above Mud Mountain Reservoir) also has suffered human-caused impacts. Most of the lands within the upper White River watershed are managed for timber production, which has resulted in increased runoff, increased sediment production and transport, debris flows, and loss of riparian habitat.

The Clearwater and Greenwater Rivers have been listed under section 303(d) of the Federal Clean Water Act for exceeding water quality standards for temperature. Temperature monitoring during 1989, 1990, and 1992 established that temperatures were exceeding the state's Class AA water quality standard for these streams (16.0°C). Temperature impairments within forested watersheds can be indicative of past management practices that degraded riparian habitat and channel morphology. Section 303(d) also requires that Washington State and the federal Environmental Protection Agency (EPA) establish total maximum daily loads (TMDL) for listed water bodies. In response to these listings and the need to protect critical fish habitat, Ecology has initiated phased-TMDL assessment work in the upper White River watershed. A proposed phased-TMDL would provide a structure for combining Washington Forest Practices Board Watershed Analysis (WA) with specific water quality based salmonid habitat targets, restoration needs and associated timelines, and post-implementation monitoring.

A WA was conducted within the Clearwater River watershed during the summer/fall of 1996. A team of interested parties (the Upper White River Chinook TMDL Framework Team) has been formed by Ecology to assess past and present monitoring efforts, participate and provide analysis in the Clearwater River WA, and provide direction and expertise on phased-TMDL needs.

This interim report presents the results of stream temperature and spawning gravel fine sediment monitoring conducted by Ecology and other watershed parties during the summer of 1995, as well as earlier spawning gravel sampling conducted by the Muckleshoot Indian Tribe. In addition to the results presented in this Interim Report, additional field studies were conducted by Ecology and other cooperators as a part of the overall project. These included scour monitoring and cross-section studies in the Clearwater River, conducted by Ecology during fall 1995 to late winter 1996, and follow-up temperature monitoring conducted during the summer of 1996. The combination of temperature, spawning gravel composition, and stream bed scour studies are intended to allow for a more focused view of stream physical habitat, and how well they support the beneficial uses of salmonid spawning and incubation as per the Water Quality Standards. Future TMDL development for Chinook habitat related parameters for streams in the upper White River watershed will benefit from results of field studies and other watershed assessments for determining the most appropriate target habitat parameters and conditions.

Study Objectives

The purpose of this report is to summarize data collected during the summer of 1995 for habitat parameters. Field studies were conducted to:

1. Monitor air and water temperatures regimes within the Clearwater River, Greenwater River and Huckleberry Creek and provide a temperature assessment of riparian conditions within the Greenwater River adjacent to managed and unmanaged lands; and

2. Evaluate fine sediment levels in gravel samples collected within salmon spawning areas.

Field studies were conducted to assess these habitat parameters as they existed during the summer and fall of 1995, and to provide information for the Clearwater River WA and to assist the Upper White River Chinook TMDL Framework Team in developing an approach for a phased-TMDL. In addition to summarizing habitat information collected in 1995 by Ecology and cooperators from the Puyallup Tribe (PT), Muckleshoot Tribe (MT), and the United States Forest Service (USFS) during 1995, this report summarizes certain existing habitat data collected within the upper White River. This report also includes a comparison of past stream temperature monitoring efforts related to 303(d) listings with temperature assessments completed during 1995.

Study Area

The Clearwater River, Greenwater River, and Huckleberry Creek are tributary streams to the upper White River (Figure 1). Each watershed is characterized as flowing from mountainous areas (approximately 3500-4000 feet elevation) into narrow and steep forested valleys. Lower valleys gradually broaden and stream gradients moderate before entering the White River. Other than the small town of Greenwater, located at the mouth of the Greenwater River as it flows into the White River, few people live within these watersheds.

Land use is heavily dominated by timber production. Within the upper White River watershed, the USFS, Weyerhaeuser Corporation, and Washington Department of Natural Resources own 109,000, 68,000, and 7,000 acres, respectively. Logging began early in this century and accelerated during the 1940's with the advent of truck logging. Much of the watershed is in second growth production with patches of old growth conifers remaining. Currently, the three streams support populations of spring Chinook salmon, winter steelhead trout, coho salmon, and resident cutthroat and rainbow trout. During the fall of 1995, pink salmon were observed for the first time spawning in the Clearwater River.

Puyallup/White Water Resource Inventory Area

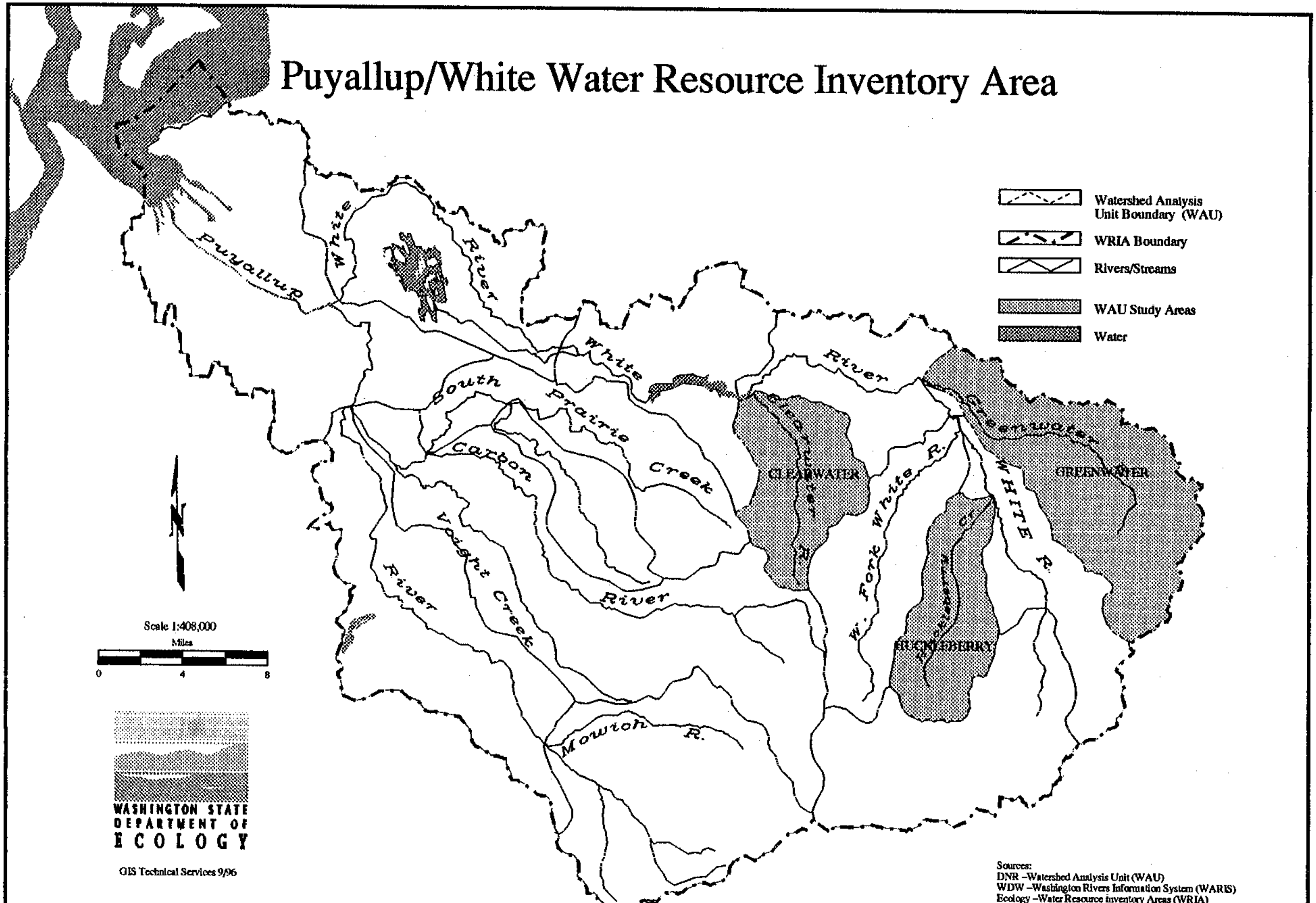

Figure 1. Water Resource Inventory Area #10.

Methods

Data on air and water temperatures, stream flow, stream channel characteristics, riparian condition, and spawning gravel composition were collected from the three largest non-glacial tributary streams flowing into the upper White River: Greenwater River, Huckleberry Creek, and the Clearwater River. Data collecting activities within selected streams are summarized in Table 1.

Stream Segmentation and Reference Points

Established location markers are needed to conduct ambient monitoring surveys (Schuett-Hames et al., 1994a). All three streams were divided into segments. Reference points were established within those segments where monitoring surveys were performed. Segments divide streams into survey units based on stream gradient, channel confinement, and location of tributary streams. These segments can be used for consistent reference locations so that past, present, and future data collection can be referenced back to the segment locations. Segments were delineated using United States Geological Survey 7.5 minute topographic maps, and they vary in length. Reference points are a series of markers established at 100-meter intervals upstream of a segment. Reference points can be used for locating and describing channel and adjacent habitat features, locating specific sampling locations, and providing permanent locations for photo point surveys of the stream channel over time. Both segment and reference points are marked with survey tape (varying colors) and aluminum tags nailed (aluminum nails) to the nearest large tree (preferable conifer). Longevity of these markers is subject to flooding events. Information provided on the tapes and tags were date of survey, segment numbers, and reference point numbers.

Site Selection

Temperature Assessment

All three streams were monitored for air and water temperatures. Recording thermographs were deployed within the three streams to measure temperature variability within varying habitat units. Background temperatures within the Clearwater River and Huckleberry Creek were recorded within riparian zones consisting of old growth conifers. These background temperatures were recorded within or just downstream of designated wilderness areas. Thermographs within all three streams were also placed adjacent to and below managed and unmanaged lands. All three streams had thermographs deployed within approximately one mile of the confluence to the White River. In addition, MT and USFS in 1995 monitored stream water temperatures within the Clearwater and Greenwater River basins, respectively.

Table 1. Data collecting activities conducted within specific streams during 1995.

Stream	Gravel Composition	Temperature Air & Water	Bankfull Width & Depth	Canopy Cover	RMZ Condition	Refence Point (installation only)	Gravel Scour	Channel X - Sections
CLEARWATER RIVER								
Location	RM 2.4 - 3.1	RM 0.7				RM 0.0 - 0.7	RM 0.4	RM 0.4
		RM 2.2				RM 2.3 - 2.6	RM 2.3	RM 0.5
		RM 3.8					RM 2.7	RM 2.3
		RM 5.7						RM 2.4
								RM 2.7
GREENWATER RIVER								
Location	RM 0.0 - 0.6	RM 1.2	RM 5.3 - 5.6	RM 5.3 - 5.6	RM 5.3 -5.6	RM 0.0 - 0.6		
		RM 5.3	RM 5.7 -6.0	RM 5.7 - 6.0	RM 5.7 - 6.0	RM 5.3 - 6.0		
		RM 5.7						
HUCKLEBERRY CREEK								
Location	RM 0.0 - 1.0	RM 1.0				RM 0.0 - 1.0		
		RM 5.5						

Spawning Gravel Composition

Collection of spawning gravel was accomplished on all three streams. Site selection criteria for gravel collection included accessibility, gradient, spawning habitat, and known locations of previous spawning activity. MT and PT were helpful in locating those specific locations where spawning salmon have been observed.

Thermograph Deployment

Hobo temperature data loggers (programmed and deployed by Ecology) were used to record air and water temperatures within Greenwater River and Huckleberry Creek. PT programmed and deployed four Optic Stow Away data loggers in the Clearwater River. The lone air thermograph (Hobo) in the Clearwater River was programmed by Ecology and deployed by PT. In 1995, MT also deployed four maximum-minimum thermometers within the Clearwater River basin (data are unavailable at this time) and the USFS deployed water thermographs within the Greenwater River basin (methods described below). Air and water thermographs were programmed to record hourly temperatures. Thermographs were placed into shaded pools and anchored by rocks or rebar at approximately one-half to two-thirds of pool depth, flowing water. Air thermographs were placed adjacent to these pools, tied to tree limbs or beneath logs, and placed within 10 feet landward of the wetted perimeter and 4-6 feet above the ground taped to a trunk or branch. All thermographs were placed in shade to avoid direct sunlight.

Date of deployment and retrieval varied. Most thermographs were deployed prior to July 15 and retrieved by mid to late-September. Data were analyzed for two recording periods. The period between July 15 to August 15 (known hereafter as the critical monitoring period) was monitored to determine the maximum annual temperatures; the monitoring period between early July to late September (known hereafter as the entire monitoring period) allowed a broader assessment of temperatures over a longer monitoring period. Recording temperatures into late-September allowed a better understanding of temperatures during the anticipated spring Chinook spawning period. Pre- and post-calibrations were performed on all thermographs using a calibration thermometer and an ice bath. Manufacturer's specifications (for the Hobo & Optic) gave these thermographs a resolution accuracy of $\pm$ 0.2°C.

During the summer and early fall of 1995, Greg Laurie of the USFS, Enumclaw, WA, deployed seven water thermographs: six within tributary streams to the Greenwater River and one within the mainstem Greenwater River in the wilderness area near George Creek (Figure 2). The six tributary streams monitored were Burns Creek, Forest Lake Creek, Pyramid Creek, Slide Creek, Straight Creek, and Whistler Creek. Thermographs were adjacent to forested lands previously harvested or within sections of streams that are flowing through or from harvested areas. All probes were set to record for 100 days, from June 22-September 29, 1995.

With the exception of the upper Greenwater River probe, all probes were placed within the first half-mile of each stream. All probes, with the exception of the Whistler Creek thermograph, were set to record the maximum temperature every 2.6 hours (156 minutes); the Whistler Creek thermograph was set to record every 2.4 hours (144 minutes).

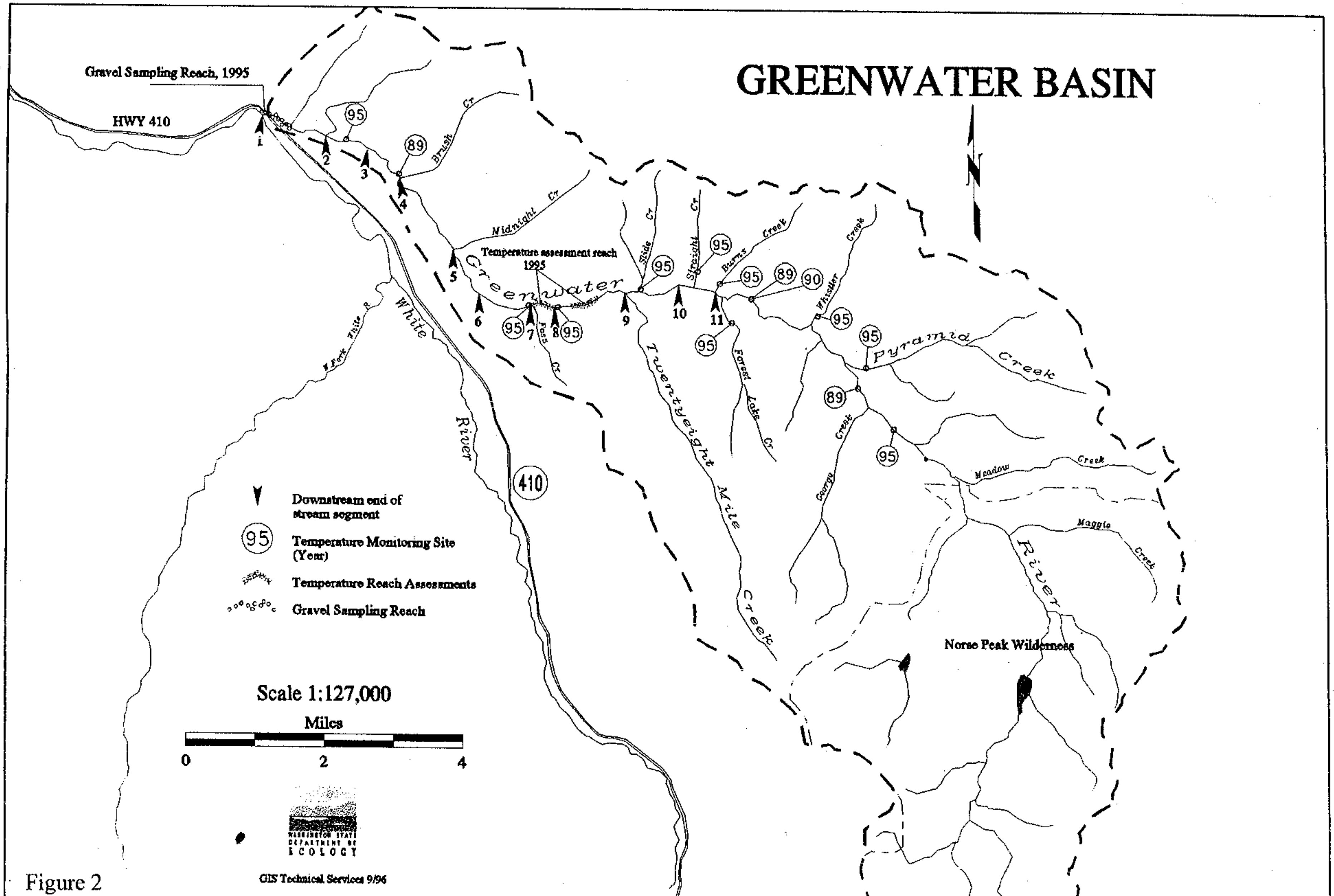

Figure 2

Greenwater River Basin stream temperature monitoring sites,
temperature reach assessments, and spawning gravel fine sediment sampling reach.
Data collected from combined sources: Muckleshoot Tribe, USFS, Ecology.

Temperature Reach Assessment

Due to time restraints, temperature reach assessments were conducted on the Greenwater River only. Thermal reaches were chosen that reflected relatively uniform stream and riparian vegetative zone conditions. Monitoring temperatures at the lower end of a reach consisting of similar habitats increases the possibility that recorded temperatures characterize the entire reach rather than only local conditions. The length of each reach targeted was approximately 600 meters. The TFW Ambient Monitoring Program Manual's Stream Temperature Module (Rashin et al., 1994) protocols were used to assess water and air temperatures.

Other Habitat Characteristics of Temperature Reach Assessments Study Sites

Additional habitat variables were collected and analyzed to assess local habitat conditions within the temperature reach assessment sites on the Greenwater River. These variables are described in the TFW Ambient Monitoring Program Manual's Levels 2 and 3 Methods (Rashin *et al.* 1994). Not all variables contained in Levels 2 and 3 were collected for this study. All of the following variables, except for discharge, were taken at each reference point and for both the left and right banks.

Riparian Vegetative Zone Width – Visually determined if riparian zone width greater than or less than 30 meters from the wetted perimeter.

Dominant Tree Species and Age –Visual observation of dominant tree species and tree age as determined using guidance contained in Watershed Analysis Manual 2.1. The tree species that provided upper canopy shade was considered the dominant species.

Riparian Zone Condition – Visual observation of stream banks being intact or impacted by windthrown trees, bank erosion, debris flows, etc.

Canopy Closure/Stream Shade – A spherical densiometer (Forest Densiometer, Model C) was used. Standing in the center of the wetted perimeter, measurements were taken facing downstream, upstream, and then to the left and right banks. The four readings were added and then multiplied by the correction factor of 1.04.

Bankfull Width & Depth – A fiberglass tape was stretched as tightly as possible between the left and right bankfull height of the stream channel. Measurements were taken every meter of bankfull width and then averaged. A stadia rod was used to measure depths.

Wetted Width and Depth –Wetted widths and depths were taken similar to the bankfull measurements and at the identical stations. Measurements were taken every meter of the wetted width and then averaged.

Discharge – Streamflow measurements were taken at the upper and lower ends of each temperature reach. A Marsh-McBirney or Swoffer flow meter was used to measure flows in cubic feet per second (cfs.). A minimum of 15 velocity and depth measurements was taken at each site. Two flow readings were taken at each station and averaged. Flow data were entered into a computer program to determine discharge. Flow measurements for both reaches were taken during summer low flows, but measurements taken for the upper reach occurred 20 days later than the flow measurements for the lower reach.

Additional information on temperature monitoring and reach assessment procedures are summarized in Appendix A.1.

Spawning Gravel Composition

Gravel was collected within one segment in each of the three streams, according to TFW Ambient Monitoring Program Manual protocols (Schuett-Hames et al., 1994c). Specific locations of individual samples were recorded in relationship to the nearest downstream reference point. A minimum of 12 to 18 samples were required within each segment to maximize sampling of within riffle and between riffle variability. Potential spawning gravel within suitable riffle crests (RC) and patches (P) were inventoried (identified by a specific RC or P number) and then sampled. For each RC and P, we attempted to collect 2-3 and 1-3 samples, respectively. Gravel was collected using a McNeil gravel sampler. Most gravel samples were contained within one five-gallon plastic bucket. Samples collected in deeper water (up to 12 inches) sometimes required two buckets due to increased water volume. Each bucket was marked with a permanent pen recording the specific RC or P number, and the segment and reference point where samples were collected. Samples were processed using the Nisqually Tribal Fishery's mobile gravel sampling station. A volumetric method was used for sorting of gravels. Gravel was poured through twelve varying sized sieves (range greater than 75.0 mm. to less than 0.106 mm.). The smallest sieve (greater than 0.106 mm.) allowed the clays and silts to settle into a graduated cylinder. The smallest of particles sat for one hour before recording the volume.

Additional information regarding study designs and methods for spawning gravel composition is summarized in Appendix A.2.

The Muckleshoot Tribe collected 13 gravel samples from the Clearwater River during the summer and fall of 1993 from segments located upstream of the samples collected in 1995. These samples were collected according to 1993 TFW Ambient Monitoring Protocols.

Results and Discussion

Water Temperature Assessment

Recorded air and stream temperatures are summarized in various appendices and tables. Stream temperatures are summarized by number of days, number of hours, percent of days, and percent of hours exceeding the water temperature criterion in the State Water Quality Standards. For analysis purposes, percent days exceeding criterion are emphasized. Criteria excursions are summarized for two different monitoring periods. The highest water temperatures can generally be expected between July 15-August 15 (Rashin *et al.*, 1994), which is referred to as the critical monitoring period because it encompasses the highest solar radiation and air temperature influences. The secondary monitoring period varies from site to site (depending on deployment time), and occurs between the first week in July to mid/late-September (approx. 5-10 weeks for most sites) and is referred to hereafter as the entire monitoring period. For each site, the dates that temperatures exceeded 16.0°C, the approximate time of day when maximum temperatures were recorded, and approximately the number of hours/day that water temperatures exceeded 16.0°C are summarized in Appendix B. The approximate hours/day that temperatures exceeded 16.0°C were based on total recorded hours when temperatures exceeded 16.0°C. Also included in this estimate is one-half hour prior to the first recorded hourly excursion and one-half hour after the last hourly-recorded excursion. The mean of daily maximum air and water temperatures are analyzed for the critical period only (July 15-August 15).

Greenwater River Basin

Locations of the three mainstem sites monitored by Ecology are shown in Figure 2. Temperature data were collected within the mainstem Greenwater River at Segment 2, river mile (RM) 1.2, (Site 1), Segment 7, RM 5.3, (Site 2), and Segment 8, RM 5.8 (Site 3). The three thermographs were deployed on July 12, 1995 and removed September 14, 1995. Site 1 is located near the confluence with the White River. Riparian vegetation adjacent to this site consisted of second growth conifers. Site 2 lies adjacent to lands having different land uses. The right bank had been harvested within the last 15-20 years; the riparian zone is dominated by young deciduous trees and 10 to 15 foot conifers. The left riparian zone is dominated by young deciduous trees within 15 meters of the wetted perimeter, with mature and old growth conifers dominating from 15 meters of the wetted perimeter to the valley walls. Site 3 lies within a riparian zone consisting largely of old growth conifers, with some areas where young deciduous trees dominate the riparian zone within 5 meters of the wetted perimeter. Those portions of the Greenwater River within Segment 7 (RM 5.3-5.6) and Segment 8 (RM 5.7-6.0) were analyzed for the temperature reach assessment of riparian zone and channel conditions, which is discussed later.

Hourly air and water temperatures for the three mainstem Greenwater River sites are displayed in Appendices C.1, C.2, and C.3. No air thermograph was deployed at Site 1. Site 1 recorded the highest water temperatures (Appendix B.1), between 18.9°C and 18.5°C, during the second and fourth week of July. Sites 2 and 3 recorded maximum water temperatures between 17.3°C° and 16.7°C during the same time period. At Sites 2 and 3, the maximum air temperatures of 28.3°C and

25.1°C were recorded on July 16 and on July 13-14, respectively. The means of daily maximum air and water temperatures for the critical monitoring period between July 15-August 15 are included in Table 2.

Table 2. Mean maximum air and water temperatures for the period of July 15 to August 15, 1995

Site & Location	Mean Maximum Air Temperature	Mean Maximum Water Temperature
Greenwater River		
Site 1, Segment 2, RM 1 2	N/A	15.6°C
Site 2, Segment 2; RM 1.2	18.0°C	14.2°C
Site 3, Segment 8; RM 5 8	16.5°C	14.1°C
Huckleberry Creek		
Site 1, Segment 1; RM 0 7	17.3°C	11.2°C
Site 2, Segment 7: RM 5.7	15.9°C	8.4°C
Clearwater River		
Site 1, Segment 1; RM 0.5	N/A	14.5°C
Site 2, Segment 2; RM 2.3	16.5°C	14.7°C
Site 3, Segment 4; RM 3.8	N/A	14.8°C
Site 4, Segment 6; RM 5.7	N/A	12.2°C

Hourly water temperatures collected in 1995 by USFS for the one mainstem Greenwater River and six Greenwater River tributary sites are displayed in Appendices C. 4, C. 9, C. 10, C. 11, C. 12, C. 13, and C. 14. The thermographs within Burns Creek, Forest Lake Creek, Slide Creek and the upper Greenwater River sites did not record water temperatures exceeding 16.0°C. The Pyramid Creek thermograph recorded maximum water temperatures of 16.7°C on July 19 and 20, 1995 (Appendix B. 1). The Straight Creek thermograph recorded maximum temperatures of 17.7°C and 17.5°C on July 20 and July 19, 1995, respectively. The Whistler Creek thermograph recorded maximum water temperatures of 19.9°C during July 16-19, and on August 4, 1995.

Temperature Criteria

Mainstem Greenwater River

During the critical monitoring period, 47 percent (15 of 32 days) of the days recorded temperatures that exceeded the criterion at Site 1 (Table 3). By comparison, 22 percent and 19 percent (7 and 6 days) of the days recorded temperatures that exceeded the criterion at Sites 2 and 3, respectively. During the entire monitoring period, 48 percent (31 of 65 days) of the days recorded water temperatures that exceeded the criterion at Site 1 (Table 4). By comparison, 14 percent and 12 percent (9 and 8 days) of the days recorded temperatures that exceeded the criterion, at Sites 2 and 3, respectively.

Table 3. Stream temperature results in relationship to the Class AA water quality criteria of 16.0°C; for the sub-sample days during the critical monitoring period of July 15 to August 15, 1995

Site and location	No. of days sampled (no. of hours monitored)	No. of days (no. of hours) greater than 16.0°C	% days (% hours) greater than 16.0°C
GREENWATER RIVER			
Site 1, Segment 2; RM 1.2	32(768)	15(73)	47(10)
Site 2, Segment 7; RM 5 3	32(768)	7(22)	22(3)
Site 3, Segment 8; RM 5.8	32(768)	6(14)	19(2)
HUCKLEBERRY CREEK			
Site 1, Segment 1 RM 0.7	32(768)	0(0)	0(0)
Site 2, Segment 7; RM 5.7	32(768)	0(0)	0(0)
CLEARWATER RIVER			
Site 1, Segment 1; RM 0.5	32 (768)	4(9)	12(1)
Site 2, Segment 2; RM 2.3	32(768)	6(38)	19(5)
Site 3, Segment 4; RM 3.8	32(768)	11(51)	34(7)
Site 4, Segment 6; RM 5.7	32(768)	0(0)	0(0)
BURNS CREEK			
RM 0.3	32(768)	0(0)	0(0)
FOREST LAKE CREEK			
RM 0.8	32(768)	0(0)	0(0)
PYRAMID CREEK			
RM 0.4	32(768)	4(21)	13(3)
SLIDE CREEK			
RM 0.1	32(768)	0(0)	0(0)
STRAIGHT CREEK			
RM 0.3	32(768)	8(59)	25(8)
UPPER GREENWATER RIVER			
RM 11.7	32(768)	0(0)	0(0)
WHISTLER CREEK			
RM 0.4	32(768)	19(62)	59(8)

Greenwater River tributary streams

During the critical monitoring period, 13 percent (4 of 32 days), 25 percent (8 of 32 days), and 59 percent (19 of 32 days) of the days recorded water temperatures exceeding the criterion at Pyramid Creek, Straight Creek, and Whistler Creek, respectively (Table 3). During the entire monitoring period, 4 percent (4 of 100 days), 9 percent (9 of 100 days), and 42 percent (42 of 100 days) of the days exceeded the criterion at Pyramid Creek, Straight Creek, and Whistler Creek, respectively (Table 4). Whistler Creek had the most number of days exceeding criteria, totaling 42 days (June 23-September 29), with average duration of excursions for all days at approximately 3 hours (Appendix B. 1). Water temperatures at this site reached a high of 19.9°C on July 16-19, and August 4, 1995. Nineteen of the 42 days exceeding criteria occurred during the critical monitoring period.

Table 4. Stream temperature results in relationship to the Class AA water quality criteria of 16.0°C for the entire monitoring period from June to mid-August/mid-September 1995

Site, location and monitoring period	No. of days sampled (no. of hours sampled)	No. of days (no. of hours) greater than 16.0°C	% days (% hours) greater than 16.0°C
GREENWATER RIVER			
Site 1, Segment 2; RM 1.2 July 12 to September 14, 1995	65(1533)	31(128)	48(8)
Site 2, Segment 7; RM 5.3 July 12 to September 14, 1995	65(1527)	9(31)	14(2)
Site 3, Segment 8; RM 5.8 July 12 to September 14, 1995	65(1528)	8(19)	12(1)
HUCKLEBERRY CREEK			
Site 1, Segment 1; RM 0.7 July 14 to September 17, 1995	67 (1585)	0(0)	0(0)
Site 2, Segment 7; RM 5.7 July 14 to August 19, 1995	41 (959)	0(0)	0(0)
CLEARWATER RIVER			
Site 1, Segment 1; RM 0 5 July 14 to September 30, 1995	79 (1884)	4(9)	5(1)
Site 2, Segment 2; RM 2.3 July 6 to September 30, 1995	87(2075)	6(38)	7(2)
Site 3, Segment 4; RM 3.8 July 6 to September 30, 1995	87(2075)	11(51)	12(2)
Site 4, Segment 6; RM 5.7 July 14 to September 30, 1995	79 (1884)	0 (0)	0 (0)
BURNS CREEK			
RM 0.3 June 22 to September 28, 1995	100(2386)	0(0)	0(0)
FOREST LAKE CREEK			
RM 0.8 June 22 to September 28, 1995	100(2387)	0(0)	0(0)
PYRAMID CREEK			
RM 0 4 June 22 to September 28, 1995	100(2387)	4(21)	13(3)

Table 4 (cont'd)

SLIDE CREEK RM 0.1 June 22 to September 28, 1995	100(2386)	0(0)	0(0)
STRAIGHT CREEK RM 0 3 June 22 to September 28, 1995	100(2386)	9(61)	9(3)
UPPER GREENWATER RIVER RM 11.7 June 22 to September 28, 1995	100(2387)	0(0)	0(0)
WHISTLER CREEK RM 0.4 June 22 to September 28, 1995	100(2386)	42(118)	42(5)

Huckleberry Creek

Locations of the two monitored sites are shown in Figure 3. Temperatures were recorded within the mainstem of Huckleberry Creek at Segment 1, RM 0.7 (Site 1) and Segment 7, RM 5.7 (Site 2). Both riparian zones at this site consist of mature to old growth conifers; lands lying outside the left bank riparian zone had been harvested. Site 2 lies upstream of the wilderness boundary, and both riparian zones and adjacent forest consisted of old growth conifers. Both thermographs were deployed on July 14, 1995, and removed on September 18 and August 19, 1995, respectively.

Hourly maximum air and water temperatures for the two sites are displayed in Appendices C. 15 and C. 16. No water temperatures exceeded 16.0°C. Sites 1 and 2 recorded maximum water temperatures of 13.2°C and 10.3°C on July 30 and July 15, 1995 respectively. At both sites, the lowest water temperatures recorded were 7.0°C and 5.7°C on September 17 and August 8, 1995 respectively. The highest air temperature recorded at both sites was 27.1°C on July 14 and 15, 1995. The mean of daily maximum air and water temperatures for the critical monitoring period are shown in Table 2.

Clearwater River

Locations of the four mainstem Clearwater River sites, (monitored by PT), and the Lyle Creek site (monitored by MT) are shown in Figure 4. Temperatures were monitored within the Clearwater River at Segment 1, RM 0.5 (Site 1); Segment 2, RM 2.3 (Site 2); Segment 4, RM 3.8 (Site 3); and Segment 6, RM 5.7 (Site 4). Thermographs at Sites 1 and 4 were deployed on July 14, 1995. Thermographs located at Sites 2 and 3 were deployed July 6, 1995. Only one air thermograph was deployed (Site 2). All thermographs were removed October 22, 1995, but for purposes of this study, only temperature data collected through September 30, 1995 were analyzed. Thermographs at Sites 1, 2, and 3 were deployed at locations within riparian zones consisting of young deciduous trees within 5 to 10 meters of the wetted perimeter, with mature and old growth conifers

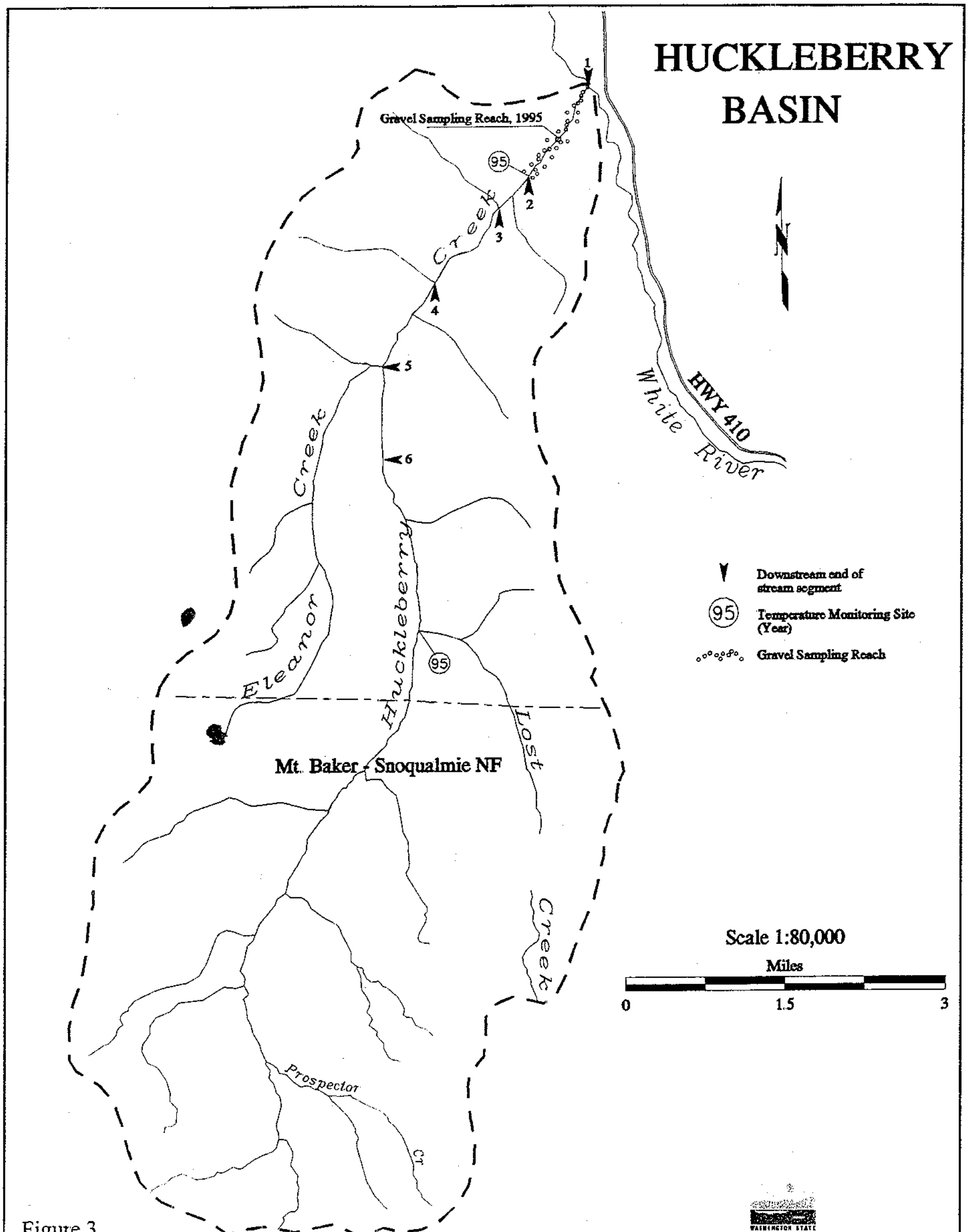

Figure 3

Huckleberry Creek Basin stream temperature monitoring sites, and spawning gravel fine sediment sampling reach. Data collected by Ecology.

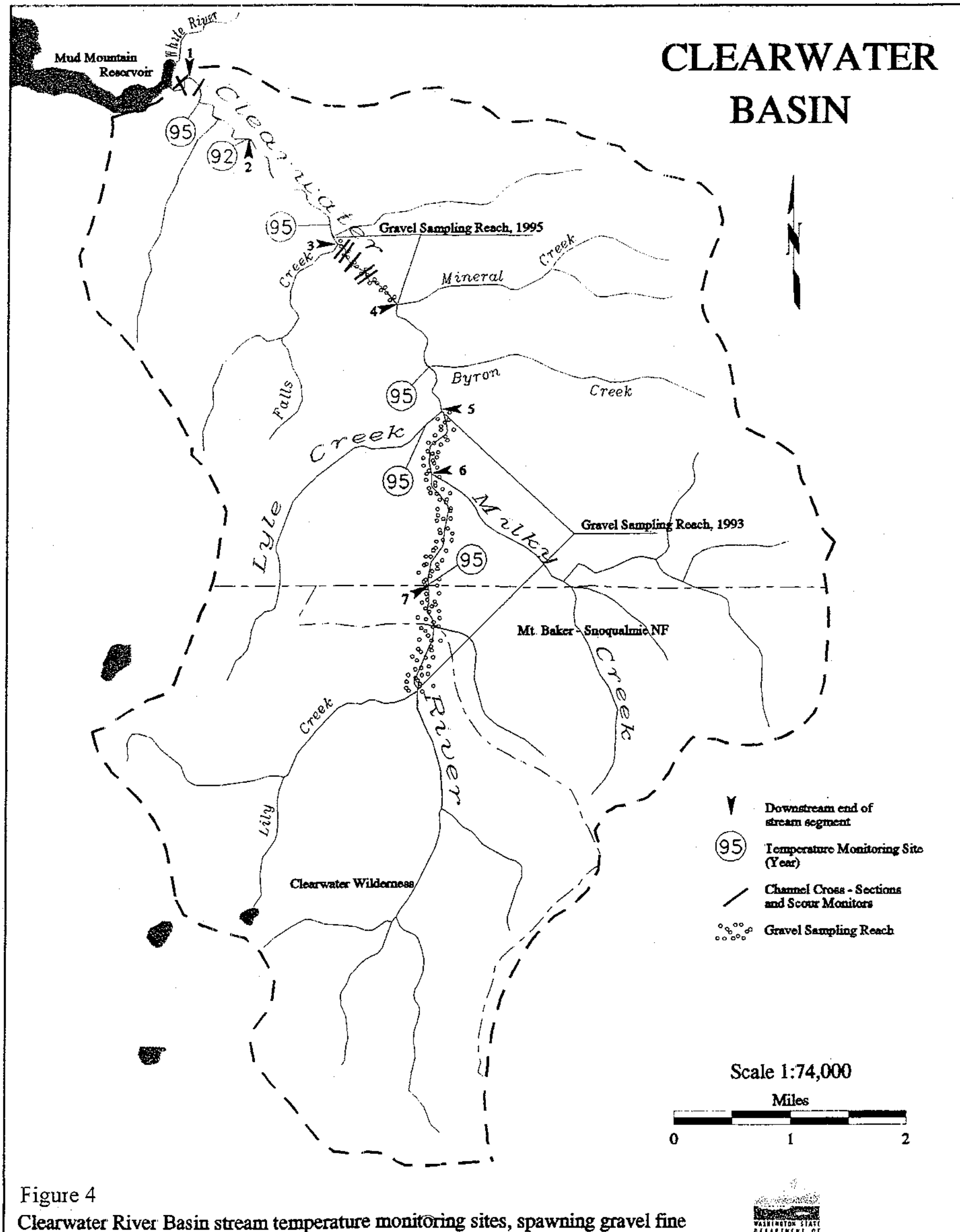

Figure 4
Clearwater River Basin stream temperature monitoring sites, spawning gravel fine sediment sampling reach, and channel cross section and scour monitoring sites. Data collected from combined sources: Muckleshoot and Puyallup Tribes, Ecology.

dominating outside this range. In some areas, mature and old growth conifers were also present adjacent to the wetted perimeter. The thermograph at Site 4 was located adjacent to an old growth-dominated riparian zone.

MT deployed a thermograph within Lyle Creek (Figure 4) located approximately 0.4 mile upstream of the creek's confluence to the Clearwater River. The thermograph was deployed August 9 to December 5, 1995. Lands adjacent to this monitoring site had vegetation consisting of young and second growth conifers.

Hourly maximum air and water temperatures for the four mainstem Clearwater River and Lyle Creek sites are displayed in Appendices C. 17, C. 18, C. 19, C. 20, C. 21, and C. 22. Site 3 recorded the highest maximum water temperatures, ranging between 17.7°C and 18.0°C (Table 2). Site 2 recorded the next highest water temperatures between 17.0°C and 17.4°C, and Site 1 recorded maximum water temperatures between 16.1°C, and 16.5°C. The maximum water temperatures recorded for these three sites occurred during the week of July 16-20, 1995. Site 4 recorded no temperatures exceeding 16.0°C. The maximum water temperatures recorded at Site 4 were 14.8°C and 15.1°C, on July 19 and 20, 1995 respectively. The maximum recorded air temperature at Site 2 was 26.7°C on July 9, 1995. The mean of daily maximum air and water temperatures for the critical monitoring period are included in Table 2. No temperatures above criteria were recorded at the Lyle Creek site during 1995.

Temperature Criteria

During the critical monitoring period, 34 percent (11 of 32 days) of the days had temperatures exceeding the criterion at Site 3 (Table 3). By comparison, at Sites 1 and 2 respectively, 12 percent and 19 percent (4 and 6 days) of the days had temperatures exceeding the criterion. During the entire monitoring period, 7 percent and 12 percent (6 and 11 days out of 87 total) of the days had temperatures exceeding the criterion, at Sites 2 and 3, respectively (Table 4). During a similar monitoring period, 5 percent (4 of 79 days) of the days recorded temperatures that exceeded the criterion at Site 1. Neither Site 4 nor Lyle Creek had recorded temperatures exceeding 16.0°C during the 1996 monitoring period.

Discussion of Temperature Results

Water temperatures within the mainstem Clearwater and Greenwater Rivers (except those monitoring sites within wilderness areas) and some of the Greenwater River tributary streams exceeded the state's Class AA water quality standard at various times during the monitoring period. During the critical monitoring period, three of four monitoring sites on the mainstem Greenwater River, three of six monitoring sites within Greenwater River tributary streams, and three of four monitoring sites on the mainstem Clearwater River recorded stream temperatures exceeding the standard. Weather data from the Regional Climate Center at the Desert Research Institute, University of Nevada, were checked for July, August, and September to determine if abnormal climatic conditions had occurred. The nearest recording station is located at Mud Mountain Dam, located approximately 12 miles west of the confluence of the Greenwater and White Rivers.

Average air temperatures during the 1995 monitoring period were 3.8°C higher, 1.9°C lower and 6.7°C higher for the months of July, August, and September, respectively. USGS flow data from the Greenwater River (gage located at RM 0.7) were reviewed and compared to flows recorded during 1995. The historical data (monthly mean for years 1929-1994; 49 years of record) averaged 147, 66, and 53 cfs for the months of July, August, and September. Compared to the historical data, flows recorded during these same months in 1995 were 107, 56, and 42 cfs. All three average monthly flows were below the historical mean flows.

The Muckleshoot Tribe has recorded stream temperatures in past years. Martin Fox, Muckleshoot Tribal Fisheries, deployed thermographs within the mainstem Greenwater River (1989 and 1990) and the mainstem Clearwater River (1992) (Figure 2). Stream temperatures are summarized both for those individual days recording temperature criteria excursions and for the number of days, number of hours, percent of days, and percent of hours exceeding the temperature criterion (Appendix B. 2).

MT deployed thermographs at three mainstem Greenwater River locations (Figure 2). Hourly air and water temperatures recorded during August 10 to September 22, 1989, at RM 2.2, 8.5, and 11.0, are displayed in Appendices C.5, C.6, and C.7. During 1989, the lowest monitoring site on the Greenwater River (RM 2.2) recorded no temperature criteria excursions. At RM 8.5 water temperatures were exceeded on 8 days and at RM 11.0 temperatures were exceeded on 12 days (Appendix B.2). Generally, the station at RM 11.0 recorded the highest water temperatures, ranging between 16.8°C and 17.3°C, during mid- to late August 1989. At RM 8.5 maximum temperatures between 16.3°C and 16.8°C were recorded during mid-August. During this monitoring period, 18 percent (8 days) and 27 percent (12 days) of the total days at RM 8.5 and RM 11.0, respectively, exceeded the criterion (Table 5).

One site on the mainstem Greenwater River (RM 8.5) was monitored during May 30-September 30, 1990 (Figure 2). Hourly water temperatures recorded during this period are displayed in Appendix C.8. Maximum water temperatures between 16.8°C and 17.3°C were recorded during early to mid-August 1990 (Appendix B.2). During the entire 1990 monitoring period, 12 percent (15 days) of the days exceeded the criterion (Table 5).

The mainstem Clearwater River was monitored at RM 1.2 during the summer of 1992 (Figure 4). Maximum recorded water temperatures between 17.3°C, and 17.6°C occurred between mid-July and mid-August (Appendix B.2). During the 55 monitored days, 29 percent (22 days) of the days exceeded the criterion (Table 5).

Table 5. Stream temperature results in relationship to the Class AA water quality criteria of 16.0°C, late spring, summer and early fall, 1989, 1990, 1992, and 1995

Site, location and monitoring period	# of days sampled (# of hours sampled)	# of days (# of hours) greater than 16.0°C	% days (% hours) greater than 16.0°C
GREENWATER RIVER Segment 3; RM 2.2 August 10 to September 22, 1989	44 (1056)	0 (0)	0 (0)
GREENWATER RIVER Segment 9; RM 8.5 August 10 to September 22, 1989	44 (1056)	8 (10)	18 (1)
GREENWATER RIVER RM 11.0 August 10 to September 22, 1989	44 (1056)	12 (31)	27 (3)
GREENWATER RIVER Segment 9; RM 8.5 May 30 to September 30, 1990	124 (2976)	15 (44)	12 (15)
CLEARWATER RIVER Segment 2; RM 1.2 July 17 to September 9, 1992	55 (1320)	22 (67)	40 (5)
LYLE CREEK RM 0.1 August 9 to September 30, 1995	52 (1248)	0 (0)	0 (0)

Stream temperatures collected in 1995 were compared to past stream monitoring efforts to determine if temperature regimes have changed. Both Ecology and MT monitored stream temperatures between July 17-September 9, during years 1992 (MT) and 1995 (Ecology) at RM 0.4 and 1.2 on the Clearwater River. Even though these sites are approximately 0.8 miles apart, the lower two miles of the Clearwater River exhibit similar channel morphology and riparian zones. Stream temperatures recorded during 1992 were significantly higher than those monitored during 1995. During 1992, 22 of the 55 monitored days (40 percent) had water temperatures exceeding the water quality standard. During 1995, criteria excursions were recorded on 4 of the 55 monitored days (7%). Why recorded temperatures were significantly cooler during 1995 as compared to the temperatures during 1992 are unknown. Information needed to assess those processes that might affect stream temperatures was not collected during 1992.

The mainstem Greenwater River was monitored for stream temperatures by MT at RM 2.2 and 8.5 during August 10-September 22, 1989 and May 30-November 14, 1990 (Figure 2). Stream temperatures recorded during 1995 within the lower Greenwater River (RM 1.2 to 2.2) were significantly higher than those recorded during 1989 and 1990. The water quality standard was exceeded on 14 of the 36 monitored days in 1995 at RM 1.2, while no recorded water temperatures exceeded 16.0°C at RM 2.2 in 1989. During 1990 at RM 8.5, 8 days (22%) of the 36 monitored days exceeded the standard.

While these two sites are approximately one mile apart, the sites are comparable in terms of their channel morphology, riparian zones, and adjacent land use. As previously discussed above, the reason for temperature differences recorded during different years is unknown.

Elevated summer water temperatures can have detrimental effects on spring Chinook salmon and other salmonid species. A general guideline for optimal temperatures for all salmonid life stages is approximately 12 - 14°C (Bjornn and Reiser, 1991). Adult upstream migration and reproductive success can be adversely affected by elevated water temperatures. Upstream migration can be delayed if temperatures are too warm. Delayed migration can cause returning adult salmon to use up energy reserves before reaching their spawning destination leading to disease outbreaks and/or lessened physical fitness. Bell (1986) cites a temperature range of 3.3-13.3°C that enables upstream migration of returning adult spring Chinook salmon and a suitable temperature range between 5.6-13.9°C for spawning. Berman and Quinn (1990) found that elevated temperatures in the range of 19.0°C can lead to greater numbers of pre-hatch mortalities and developmental abnormalities. Elevated water temperatures can also affect yearling resident fish. Elevated water temperatures can stress young fish leading to reduced fitness and limit growth as metabolic rates rise.

Temperature Reach Assessment

Two adjoining sections of the Greenwater River were used for the temperature reach assessments of riparian zone and channel condition (Figure 2). The two reach assessment areas were chosen to reflect different land uses. The lower temperature assessment reach within Segment 7 (RM 5.3 to 5.6) is characterized by the right bank having been recently harvested. The left bank is virtually intact with mature and old growth conifers. Due to the recent harvest along one bank, the assessment reach within Segment 7 is referred to as the impacted reach. The upper temperature assessment reach within Segment 8 (RM 5.7 to 6.0) that flows adjacent to lands consisting of mature and old growth conifers is hereafter known as the control reach.

Both reach assessment lengths where originally 600 meters long but due to a large deep pool that made physical measurements difficult the lower length was shortened to 550 meters. The lower 200 meters of the upper reach was not included in the assessment reach due to a braided channel. The upper reach began 250 meters upstream of the lower boundary of Segment 8 (RM 5.6). The downstream thermograph within the upper reach was located 200 meters upstream of the downstream end of Segment 8, within a split channel near the left bank. The upper reach begins 50 meters upstream of the thermograph location and then extends upstream 600 meters. The thermograph within the lower temperature reach was located seven meters upstream of the downstream end of the reach.

Even though the effects of high flows and debris flows appeared to prevent conifers from re-establishing within the riparian zone, it does not appear that these events physically caused stream bank erosion and undercutting of tree roots. The stream channel and adjacent floodplain up to the valley walls is somewhat uniformly flat with low gradients (approximately 1-2 percent). River flows have not incised the stream bed, and most of the channel, is wide and shallow. Generally, the path of river flows is toward the center of the active channel, thus reducing bank erosion and tree falls that otherwise might occur if the river flowed adjacent to the upper banks. Due to the shallow and wide channel and lack of vertical river banks, high water flows and associated debris appear to flow over the gently sloped banks and onto the floodplain, thus reducing bank scouring.

Table 6 summarizes riparian zones and channel conditions for these two assessment reaches. Dominant tree species, tree age class, percent shading, and condition and widths of riparian zones are summarized. Measurements of wetted and bankfull widths and depths are also evaluated. The left bank riparian zone within the impacted reach is characterized by young deciduous trees (less than 40 years old) sporadically mixed with young conifers. Dominant trees on the valley wall and that portion of the riparian zone adjacent to the valley wall are mature and old growth conifers. The lands adjacent to the right bank riparian zone have been harvested and replanted, leaving a stand of conifers and deciduous trees approximately 10 to 15 years old. Within the riparian zone of the control reach, mature and old growth conifers dominate both banks with some young deciduous trees also present.

Within the impacted reach, shade varied between 2 to 14 percent with an average of 8 percent. For the control reach, shade varied between 4 to 89 percent with an average of 44 percent. Wetted widths and depths for the study reaches are indicative of a wide and shallow stream channel. Within the impacted and control reaches, width to depth ratios of the wetted perimeters are 71.6 and 47.9, respectively. Bankfull width to depth ratios for the impacted and control reaches are 34.2 and 25.2, respectively.

Streamflow measurements are shown in Table 7. Both reaches lost flow between their respective upstream and downstream flow measurement sites. In the control reach, the loss was 0.5 cfs (35.2 to 34.8 cfs), or 1.4 percent of the incoming flow. In the impacted reach, the loss was 4.8 cfs (28.3 to 23.5 cfs), or 17 percent of the incoming flow. Note the loss of flow between the downstream flow site of the control reach compared to the upstream flow site of the impacted reach (34.8 to 28.3 cfs). The loss of 6.5 cfs within this section of stream occurred within 300 meters of stream that included a 200 meter long split channel. All flow measurements were conducted on the same day.

Discussion of Temperature Reach Assessment

To better understand the riparian zone and channel characteristics within these two temperature assessment reaches, a general habitat description is needed. The effects of timber harvests (increased runoff, sedimentation, and debris flows) on lands upstream of Segment 8 have influenced the riparian zones within both temperature assessment reaches. Our observations indicate that increases in over-bank flows, sediment transport, and debris flows from upstream activities have adversely altered the riparian zones within the conifer-dominated forest. Riparian and channel disturbance zones (habitat alteration due to increased runoff, sedimentation, and debris flows) greater than

Table 6. Riparian and channel characteristics for the Greenwater River

SEGMENT 7; RM 5.3 to 5.6

Station (m)*	Percent Shade	Wetted Width (m)	Wetted Depth (m)	Bankfull Width	Bankfull Depth	Riparian Characteristics**	
						Left Bank	Right Bank
0	5	16.5	0.2	18.4	0.5	4AD	7AD
50	4	14.5	0.1	23.5	0.3	4AD	1AD
100	3	12.8	0.2	22.4	0.3	4AD	7AD
150	7	17.7	0.2	20.3	0.6	7AD	4AD
200	5	9.7	0.2	22.2	0.5	4AD	4AD
250	14	16.6	0.2	21	0.6	4AD	4AD
300	11	8.8	0.2	18.2	0.5	4AD	1AD
350	4	17.8	0.1	24.5	0.6	7AD	4AD
400	12	11.5	0.3	16.1	0.9	7AD	4AD
450	3	16.5	0.2	19.9	0.6	4AD	4AD
500	2	14	0.2	18.7	1	4AD	7AD
550	14	12.4	0.2	21.1	0.7	4AD	4AD
MEAN	8	14.1	0.2	20.5	0.6		

SEGMENT 8; RM 5.7 to 6.0

Station (m)*	Percent Shade	Wetted Width (m)	Wetted Depth (m)	Bankfull Width (m)	Bankfull Depth (m)	Riparian Characteristics**	
						Left Bank	Right Bank
50	9	16	0.2	26.7	0.5	9AD	4AD
100	30	11.5	0.2	14.6	0.5	7AD	7AD
150	76	6.7	0.3	12.8	0.9	2AD	4AD
200	89	8	0.2	13.2	0.6	8AD	7AD
250	84	6.4	0.2	11.4	0.5	7AD	7AD
300	31	11.4	0.2	17.9	0.6	7AD	7AD
350	38	10.9	0.2	13.5	0.9	7AD	7AD
400	82	10.6	0.2	14.1	0.4	8AD	7AD
450	53	7.1	0.2	9.8	0.5	7AD	7AD
500	4	6.1	0.3	9.9	0.9	7AD	7AD
550	5	17.6	0.1	22.3	0.3	7AD	7AD
600	17	14.3	0.2	20.8	0.4	7AD	7AD
MEAN	43	10.3	0.2	15.1	0.6		

* Distance upstream of thermograph
** Riparian characteristics key:

Tree Age
Coniferous species: 1 = less than 40 years; 2 = 40 to 120 years; 3 = greater than 120 years.
Deciduous species: 4 = less than 40 years; 5 = 40 to 80 years; 6 = greater than 80 years.
Mixed species: 7 = less than 40 years; 8 = 40 to 80 years; 9 = greater than 80 years.

Riparian Management Zone information
A (intact RMZ)
B (impacted RMZ, - e.g. blowdown or bank erosion)

RMZ width
C (< 30 m.)
D (> 30 m.)

Table 7. Greenwater flow measurements at upper and lower ends of the temperature assessment reaches

Station (m)*	Date	Time	Flow (cfs)
Greenwater River, Segment 7; RM 5.3			
550	8/24/95	1600	28.3
0	8/24/95	1145	23.5
Greenwater River; Segment 8; RM 5.7			
600	9/11/95	1400	35.2
0	9/11/95	1100	34.8
* Distance upstream of data logger			

30 meters from the wetted perimeter exists in many areas within both assessment reaches. High flows, sediment transport, and debris flows have scoured and deposited sediment throughout much of the riparian zones, preventing recruitment of conifers within this zone. Fast growing trees such as alder and maple have re-established within these disturbance zones.

For this study, field observations of dominant tree species and age classes were based on the age and species of those upper canopy trees that provide measurable streamside shade. In those locations where stream banks have not shifted, mature and old growth conifers exist within the riparian zone and adjacent to the wetted perimeter. This condition exists adjacent to the left bank within the control reach. The mature and old growth conifers (up to approximately 200 feet tall) existing on the left bank provide the measurable shade observed within this assessment reach. Even though mature and old growth conifers exist in the right bank riparian zone in the control reach and the left bank riparian zone within the impacted reach, these trees are set back from the wetted perimeter to the extent that their canopies are not reflected in the shade measurements. Measurable shade was generally lacking within Segment 7 due to the dominance of young conifer and deciduous trees adjacent to the wetted perimeter.

Certain riparian and stream channel characteristics within the Greenwater River temperature reach study sites may contribute to elevated stream temperatures:

- Low levels of shade were observed in both temperature reaches. The impacted reach recorded the lowest percent measurable shade. The Washington Forest Practices Board Manual (1995) indicates that a minimum of 52 percent shade is needed for temperature protection for a Class AA stream at an elevation of approximately 1800 feet. Percent shade within the impacted reach ranged from 2 to 14 percent, averaging 8 percent. Within the control reach measurable shade varied between 4 to 89 percent with an average of 44 percent shade, which is close to the minimum shade required. Aerial photos within these two reaches show open channels allowing direct solar input into the wetted channel between the late morning hours and the late afternoon/early evening time period (within these two reaches the stream flows in a westerly direction). Even though the adjacent riparian zone consists of mature and old growth conifers, increased peak flows, sediment transport, and debris flows resulting from upstream activities have widened the stream channel and reduced the number and/or proximity of conifers available to shade the wetted channel.

- Bankfull width to depth ratios were 34.2 and 25.2 within the impacted reach and control reach, respectively. Pfankuch (1978) rates these ratios as "poor." These bankfull width to depth ratios indicate wide, shallow, sediment rich systems. The wide, shallow, and exposed channel allows greater temperature increases through direct solar input and through changes in the microclimate adjacent to the water surface. These ratios indicate channel capacity to transport peak flows is minimal and that overbank flows are frequent.

- Groundwater inflow can be an important local factor in cooling stream temperatures. Limited stream flow measurements found no evidence of groundwater inflow into the stream. Evaporation and subsurface flow loss to the wide, shallow, gravel-rich channel are indicated by our streamflow measurements (Table 7).

- Another factor that may contribute to elevated water temperatures within the control reach is the influence of riparian modification and stream temperature increases within managed lands above this reach. Aerial photos from 1989 show canopy removal from portions of the riparian zone upstream of the control reach. Water temperatures exceeding the standard most likely existed above the upper temperature reach. The thermograph, within the lower end of the control reach, recorded water temperatures exceeding the criteria even though the water had an opportunity to "cool" when flowing through the 600 meter reach. These criteria excursions probably reflect elevated water temperatures entering the control reach from managed lands located upstream, combined with the effects of solar radiation within the moderately low shade of the control reach.

Spawning Gravel Composition

Forty-five gravel samples collected during the summer of 1993 and 1995 from the Clearwater River, Greenwater River, and Huckleberry Creek were processed by Ecology in the fall and winter of 1995. In 1993, MT collected 13 samples from three upper segments of the Clearwater River, which were processed by Ecology. In 1995, Ecology collected 13 samples from a lower segment of the Clearwater River, 7 from Huckleberry Creek and 12 from the Greenwater River. Each of the samples were removed from potential salmonid spawning sites (either riffle crests or gravel patches) as described in the 1994 TFW Ambient Monitoring Manual (Schuett-Hames et al., 1994c). The results of the analysis are summarized below for each segment studied. All of the spawning gravel composition data (1993 and 1995) are presented by site and segment in Appendix D.

The spawning gravel data have been characterized in three ways:

- Percentage of fines less than 0.85 mm (fines);

- Percentage and total number of samples in each segment that fall into the categories less than 12 percent fines, 12-17 percent fines, and greater than 17 percent fines; and

- Cumulative particle size distribution. Figure 5 shows the level of fines as percent of sample volume for each sample, as well as the mean and standard deviation for each of the six

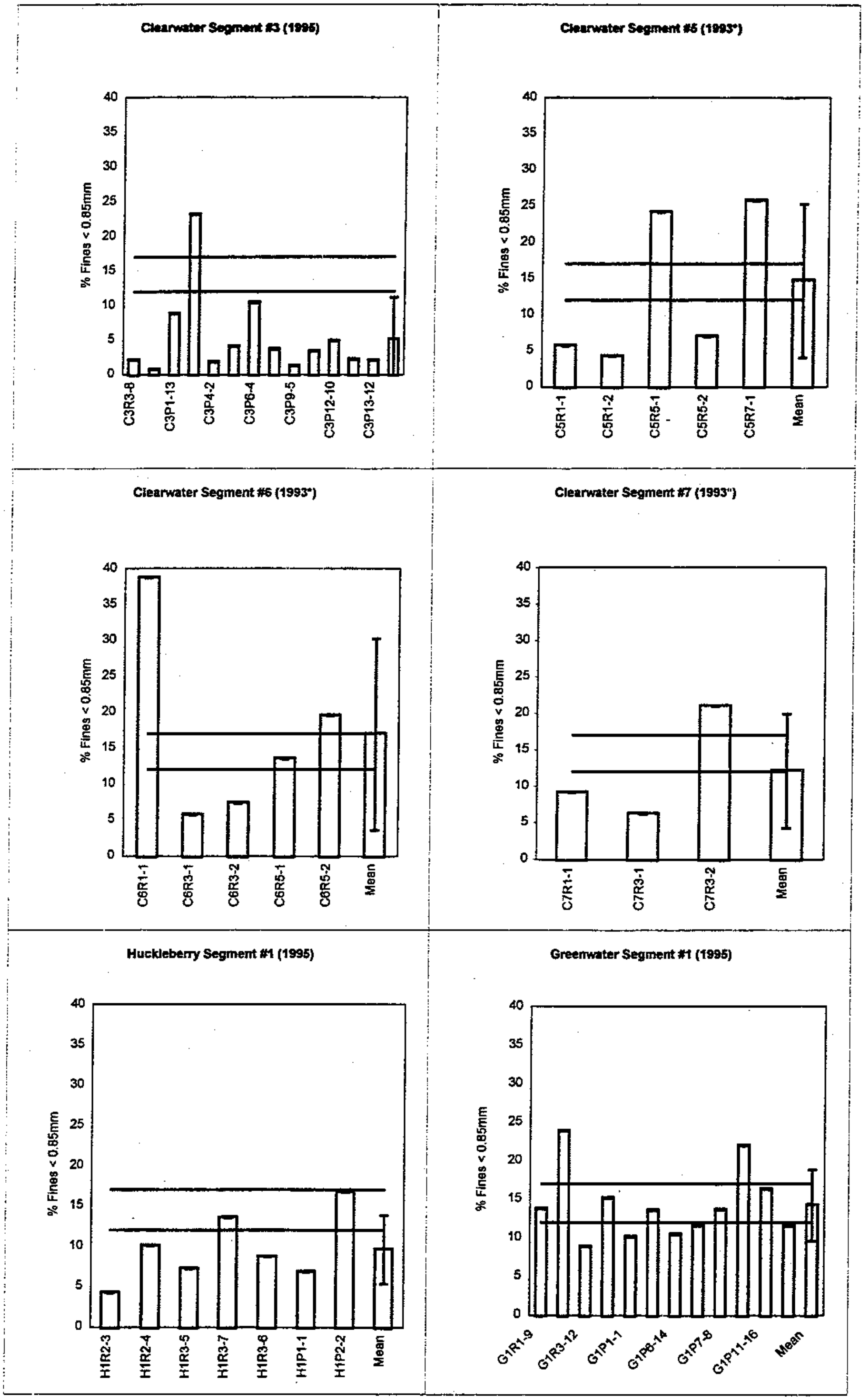

FIGURE 5. Levels of Fine Sediment (<0.85mm) as percent of Total Volume
(Each segment contains the sample number, mean, standard deviation and horizontal bars showing the 12th and 17th percentile)
* Samples collected by the Muckleshoot Tribe Oct 1993

segments. Figure 6 shows the percentage and number of samples falling into the three categories of "good" (less than 12 percent), "fair" (12-17 percent), and "poor" (greater than 17 percent), for each of the six segments based on the percent fines less than 0.85 mm as defined for indices of resource conditions in the Fish Habitat module of Watershed Analysis (WFPB, 1995). Figure 7 shows the mean cumulative particle size as percent of total volume for each of the six segments. In addition, Table 8 shows the sampling level of effort for each of the 1995 segments. The sample identification number for each sample indicates the river or stream, segment number, patch or riffle number, and the individual sample number, as illustrated below.

Stream —— C3R1-1 —— Individual Sample Number

Segment Number   Riffle or Patch Number

Clearwater Segment 3 (1995)

For the 13 samples collected in segment C3, the mean was 5.2 percent fines with a standard deviation of 6.1. The samples ranged from 0.6 to 23 percent fines (Figure 5). Ninety-three percent (12 of 13) of the samples were in the good resource condition category, with 6 percent (1 of 13) falling in the poor category (Figure 6). The median particle size estimated from the mean particle size distribution (Figure 7) was 32 mm. The level of sampling effort required to remove the 13 samples is indicative of the overall character of the substrate, which was dominated by large cobbles and boulders in most spawning habitat areas. These large grains, plus the tight particle packing, limited the depth to which the McNeil sampler could be inserted. For each sample obtained, the average level of effort was 4.4 sampling attempts per sample collected (Table 8). Many of the habitat units identified during reconnaissance of the segment could not be successfully sampled, though attempts were made at each habitat unit.

Clearwater Segments 5, 6 and 7 (1993)

In October 1993, MT collected 13 samples from segments C5, C6, and C7. In segment C5, the five samples had a mean of 14.6 percent fines with a standard deviation of 10.6. The samples ranged from 4.2 to 25.6 percent fines (Figure 5). Sixty percent (3 of 5) of the samples were in the good resource condition category, with 40 percent (2 of 5) falling in the poor category (Figure 6). The median particle size estimated from the mean particle size distribution was 10 mm (Figure 7).

In segment C6, the five samples had a mean of 16.9 percent fines with a standard deviation of 13.3. The samples ranged from 5.6 to 38.7 percent fines (Figure 5). Forty percent (2 of 5) of the samples were in the good resource condition category, 20 percent (1 of 5) were in the fair category, and 40 percent (2 of 5) were in the poor category (Figure 6). The median particle size estimated from the mean particle size distribution (Figure 7) was 8.2 mm.

In segment C7, the mean was 12.1 percent fines with a standard deviation of 7.8. The three samples ranged from 6.2 to 21 percent fines (Figure 5). Sixty-seven percent (2 of 3) of the samples were in the good resource condition category with 33 percent (1 of 3) falling in the poor category (Figure 6). The median particle size estimated from the mean particle size distribution (Figure 7) was 13 mm.

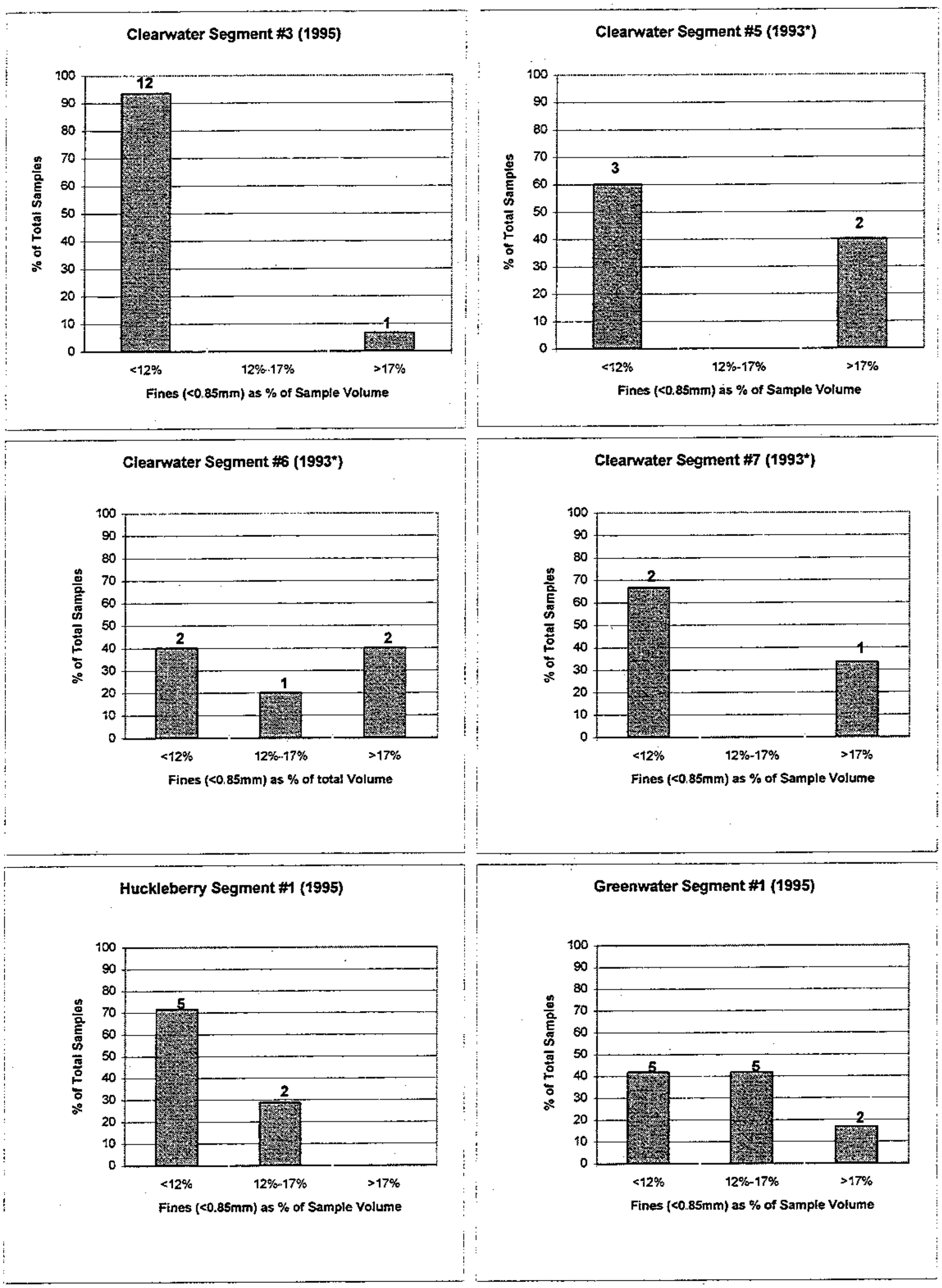

FIGURE 6. Percentage and Number of Samples Showing Fines <0.85mm.
(Bold numbers above bars equal the number of samples)
* Samples collected by the Muckleshoot tribe Oct. 1993.

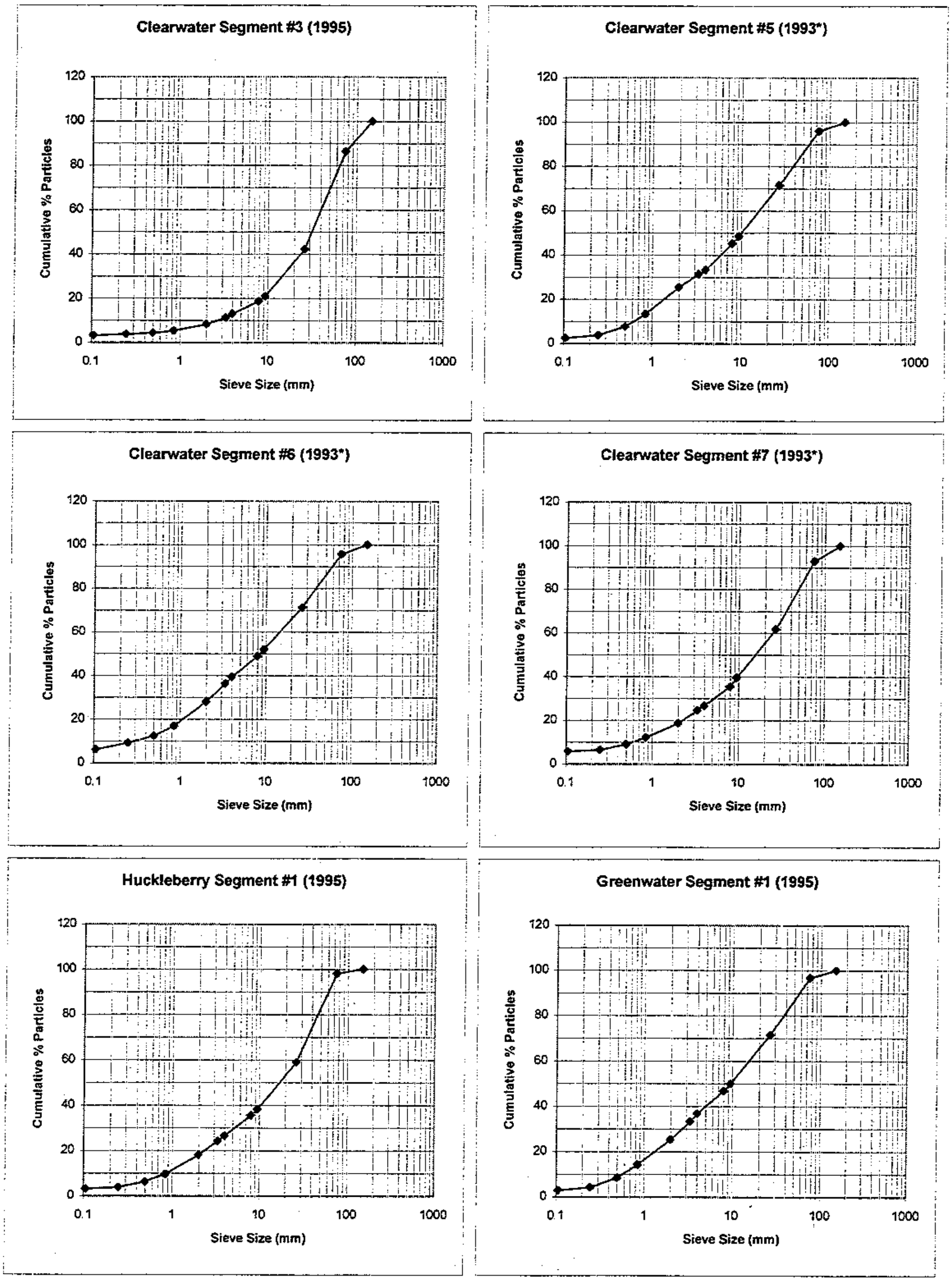

FIGURE 7. Mean Cumulative Particle Size as Percent of Total Volume.
(Plotted as % less than sieve size)
* Samples collected by the Muckleshoot Tribe Oct. 1993

Table 8. Sampling level of effort showing the number of attempts and percentage of successful attempts per habitat unit and per segment

Habitat Unit **	No. of Samples Collected	No. of Attempts	No. of Attempts Per Sample	Percent of Successful Attempts
C3P1	1	5	5	20%
C3P2	0	3	n/a	0%
C3R1	0	3	n/a	0%
C3P3	1	4	4	25%
C3P4	1	2	2	50%
C3P5	1	5	5	20%
C3R2	0	5	n/a	0%
C3P6	1	1	1	100%
C3P7	0	2	n/a	0%
C3P8	0	5	n/a	0%
C3P9	2	2	1	100%
C3P10	0	1	n/a	0%
C3P11	1	1	1	100%
C3R3	2	2	1	100%
C3P12	1	1	1	100%
C3P13	2	2	1	100%
C3R4	0	8	n/a	0%
C3P15	0	5	n/a	0%
Summary	13	57	4.4	23%
G1P1	1	8	8	13%
G1P2	0	6	n/a	0%
G1P5	0	8	n/a	0%
G1P6	2	6	3	33%
G1P7	2	9	4.5	22%
G1P8	0	5	n/a	0%
G1R1	2	9	4.5	22%
G1R2	0	13	n/a	0%
G1P9	0	11	n/a	0%
G1P10	0	10	n/a	0%
G1P11	3	9	3	33%
G1R3	2	17	8.5	12%
Summary	12	111	9.3	11%
H1R1	0	10	n/a	0%
H1P1	1	1	1	100%
H1P2	1	5	5	20%
H1R2	2	7	3 5	29%
H1R3	3	5	1.7	60%
H1P3	0	10	n/a	0%
H1R4	0	10	n/a	0%
H1P4	0	6	n/a	0%
H1R5	0	10	n/a	0%
H1R6	0	6	n/a	0%
H1R7	0	6	n/a	0%
H1P5	0	10	n/a	0%
H1R8	0	8	n/a	0%
Summary	7	94	13.4	7%

** Habitat unit numbers are a combination of the stream, segment number and patch or rifle number

Huckleberry Creek Segment 1 (1995)

From segment H1, the seven samples had a mean of 9.6 percent fines with a standard deviation of 4.2. The samples ranged from 4.2 to 16.6 percent fines (Figure 5). Seventy-one (5 of 7) of the samples were in the good resource condition category and 29 percent (2 of 7) were in the fair category (Figure 6). The median particle size estimated from the mean particle size distribution (Figure 7) was 14.5 mm. The level of sampling effort required to remove the seven samples is indicative of the overall character of the substrate which, even more so than the Clearwater, was very difficult to sample due to tight particle packing and large grains. For each sample obtained, the average level of effort was 13.4 sampling attempts per sample collected (Table 8). The difficulty of obtaining gravel samples exhibits a general lack of spawning gravel in this stream.

Discussion of Gravel Composition Results

Of the three streams where gravel was collected during 1995, the Greenwater River samples contained the highest percent fines less than 0.85 mm (Table 9). Of the 12 samples taken within the Greenwater River (Segment 1, RM 0.0-0.6), the mean percent fines for the 12 samples was 14.2 percent. For the 13 Clearwater River samples (Segment 3, RM 2.4-3.1) and 7 Huckleberry Creek samples (Segment 1, RM 0.0-1.0), the mean percent fines were 5.2 and 9.6 percent, respectively. The Clearwater River, Greenwater River, and Huckleberry Creek had percent fines ranging from 0.6 to 23.0 percent, 8.8 to 23.8 percent, and 4.2 to 16.6 percent, respectively. The Watershed Analysis resource condition index for spawning habitat quality generally rated gravel quality for samples (collected in 1995) as good or fair. Seven of the 32 samples collected in 1995 had a fair rating (12-17 percent fines), while the remaining 22 samples were rated good (less than 12 percent fines). The median particle size (50th percentile) ranged from 9.2 mm (Greenwater River), to 14.5 mm (Huckleberry Creek), and 32 mm (Clearwater River, Segment 3), indicating overall finer substrate in the lower Greenwater River than the lower portion of the two other streams.

However, median particle sizes were 8.2 mm to 13 mm in the upper Clearwater River based on 1993 samples. Clearwater River gravels collected during 1993 also had higher mean percent fines than those collected in 1995 (Table 9). The percent fines (5.2 percent) observed in gravels collected in Segment 3 in 1995 were substantially lower than those collected in upstream samples in 1993 (14.6 percent, 16.9 percent, and 12.1 percent). Also noteworthy is that the median particle size in samples collected in 1995 (32 mm) was substantially larger than the median particle size from 1993 samples (10, 8.2, and 13 mm). Note that mean percent fines in Segment 7 (within unmanaged lands) exceeded 10 percent, however, only three samples were obtained from this segment. The range for percent fines, within these three segments, was quite variable, ranging from 4.2 to 38.7 percent. The Watershed Analysis resource condition index for spawning habitat quality generally rated these samples as good or poor. Of the 13 samples collected in 1993 in Segments 5, 6, and 7 of the Clearwater River, seven (54 percent) were rated good, one (8 percent) was rated fair, and five (38 percent) were rated poor.

Differences between the upper and lower Clearwater River gravel samples may be attributed to combined differences between the locations and the years of sampling. Mass wasting sediment sources in the Milky Creek basin are a possible reason for high levels of fines found in two of the five samples collected in Segment 5 (Ladley, 1995).

Table 9. Summary of gravel sampling results

Site, Location & # of Samples	Mean ercent fines (<0.85mm)	Standard Deviation	Percent fines range	Median Particle Size (mm)
Greenwater River				
Segment 1; RM 0 0 to 0. 12 samples*	14 2	4 6	8 8 - 23 8	9 2
Huckleberry Creek				
Segment 1, RM 0.0 - 1.0 7 samples *	9.6	4 2	4.2 - 16.6	14.5
Clearwater River				
Segment 3; RM 2.4 - 3.1 13 samples*	5 2	6.1	0.6 - 23.0	32
Segment 5; RM 4.2 - 4 9 5 samples **	14.6	10.6	4.2 - 25.6	10
Segment 6; RM 4.9 - 5 9 5 samples **	16.9	13.3	5 6 - 38.7	8.2
Segment 7; RM 5 9 - 6.8 3 samples **	12.1	7.8	6.2 - 21.0	13

* Samples collected by Ecology, 1995.
** Samples collected by Muckleshoot Tribal Fisheries, 1993.

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Appendices

Appendix A.

Quality Assurance/Quality Control (QA/QC) Plans

A.1 QA\QC plan for 1995 temperature assessment of White River drainages.

A.2 QA\QC plan for 1995 spawning gravel samples in the White River drainages.

APPENDIX A.1

September 19, 1995

TO: White River Spawning Temperature Assessment Sample Files
FROM: Joanne Schuett-Hames, SWRO Water Quality Program
RE: Finalized QA/QC plan for 1995 temperature assessment of White River drainages.

This memo and attached or associated documents constitutes the QA/QC documentation for temperature assessment studies lead by DOE in the upper White River in 1995. These studies are being done in cooperation with other parties in the White River. The Puyallup Tribal Fisheries department is the lead on temperature data collection for the Clearwater River. They deployed water thermographs in four locations in the Clearwater; we provided an air thermograph for one of these locations and will do upstream thermal reach assessment work where possible at their thermographs. The USFS is additionally doing temperature anlaysis in upper tributaries of the Greenwater River.

Sampling purpose: The Greenwater and Clearwater Rivers are documented as temperature impaired on the state's 303d list. These rivers and others in the upper Whiter River drainge are important historical habitat for White River Spring Chinook, a state critical species. Water temperature is important to the health of spring chinook. Also of importance to chinook are the physical habitat aspects of riparian health and channel morphology that are manifested in temperature exceedences. For example, channels that have become wider and shallower due to landslides and loss of riparian integrity are likely to have higher temperatures. These channel characteristics may also reflect other impairments of fish habitat. Because of this, studies other than temperature are also occurring (fine sediment levels and spawning gravel scour) and additional streams within the White River drainage important to chinook are being assessed. In particular, Huckleberry Creek was choosen for temperature assessment work.

The purpose of temperature assessment work in 1995 is two-fold:
1. To take thermograph readings to better understand the extent, locations, and nature of temperature impairments; and,
2. To assess thermal reaches upstream of locations where thermographs are deployed for riparian and channel morpological factors that influence temperature.

Thermograph and thermal reach data collection and analysis has three components:

1. Sample design and data collection;
2. Data analysis; and,
3. Equipment calibration.

These components and their respective QA/QC measures are described below.

1. Sample Design and Data Collection.

Methodology -
Study site selection.--
Study site stratification is based on dividing spawning streams into segments based on gradient, tributaries and valley confinement according to Schuett-Hames et al. (1994). Segments for sampling are chosen based primarily on locations where a thermal reach of approximately 600m upstream of the thermograph will provide similar shade characteristics. Of interest are shade characteristics reflecting forest management, and

additionally those reflecting unmanaged conditions. This, however, is not intended as a paired watershed study; instead the focus is to learn as much as possible about temperature regimes within differring canopy, channel and watershed locations.

Thermographs Deployment.--
Thermographs used are Hobo tempmentors, model ___ H20 and model ___ air. The water tempmentors come with a small white, water-tight canister. This equipment does not use an external probe. Before deployment the canister is spray painted with a concealment pattern to lessen chances of vandalism.

Air tempmentors come with several feet of cord and an external probe. To lessen chances of animal and weather damage, the cord and thermograph are concealed in a spray painted water-tight plastic zip-lock bag. The probe is made to protrude from the bag.

Water thermographs are located in shaded pool or glide habitat recieving a steady flow of mixed water from the stream. A combination of wire, rocks and/or rebar is used to locate the thermograph at 1/3 to 1/2 the water depth from the bottom of the stream. This is done to prevent air exposure at lower stream flows.

Air tempmentor packages are attached with duck tape about 1 to 1.5 meters in bank vegetation near the water thermographs.

The following site information was taken at the time of installation:

- Date
- Crew
- Weather
- Site number and identification
- Themograph ID number
- Probe site description including water depth at probe and probe depth
- Air probe height and site description
- Shade description
- Time of installation for air and for water
- Air and water temperature with hand held thermometer
- Photographs
- Location on map or aerial photo
- Elevation of the monitoring site (using GPS or topographic map)

Similar information will be taken at thermograph removal along with any observations that may be relevant to data interpretation.

Thermographs are deployed prior to July 15, 1995 to document the primary July 15 to August 15 temperature data collection window. They are left as long as possible into September (before flows rise and make retrieval difficult) to continue collection through the time period of spring chinook spawning.

Temperature Reach Assessments.--
Within chosen sampling segments, reference points according to TFW ambient monitoring protocols (Schuett-Hames et al. 1994) are established at 100 meter intervals for future comparison and for sample design layout. Starting at the thermograph deployment location, and then consecutively at 50 meter intervals (coinciding with reference points and half way points) for a thermal reach of 600m, the following information is gathered (note: reference for methods or method specifics are in parenthesis):

- Reference point number and distance

- Bankful width and depth (Schuett-Hames et al. 1994)
- Wetted channel width and depth (measurements taken similar to bankful width and depth, but measurement interval doubled)
- Observations of areas where flow may have been gained or lost
- Observations of channel disturbance factors such as landslides that may have affected channel morphology
- Canopy closure taken by densiometer (Schuett-Hames et al. 1994)
- RMZ width each side of stream (measured or if over 30m estimated as >30m)
- Dominant RMZ trees each side of stream (Watershed Analysis Manual 2.1)
- Seral stage of RMZ trees each side of stream (Watershed Analysis Manual 2.1)
- RMZ condition each side of stream (either intact, or impacted by blowdown, bank erosion, debris flows etc.)

Streamflow measurements are taken at the thermograph location and at the upstream end of the thermal assessment reach (usually 600m) using a Swoffer flow meter. The meter is located on a wading rod and adjusted to register flow at .6 of the water depth for each station. At least 15 flow, depth and cell width measurements spaced across the wetted channel are taken for each streamflow measurement.

Due to time and locational constraints, it may not be possible to assess upstream reaches for each thermograph site. In this case, sites will be prioritized based on upcoming watershed analyses for the Clearwater and Greenwater, site accessabliity, and expected importance of the site for understanding watershed management relationships to stream temperature.

Training - Thermograph deployment and temperature reach data collection will be accomplished by lead Ecology personnel with training and/or experience in methods being used. Interns and additional parties supporting accomplishment of field work will be given in-field briefing and training on methods.

Quality Control - Sample layout and sample collection will be done by, or under the supervision of experienced Ecology lead staff.

After deployment all thermographs will be checked at least once to determine that they are still correctly deployed (i.e. shaded with water over them).

All finished field data forms will be reviewed by lead staff for completenes. If errors occur that can not be rectified, affected portions of the data set will be discarded.

2. Data Analysis.

Methodology - Water temperature data will be analyzed for adherance to state water quality temperature criteria, for watershed specific relationships important for TMDL development, and to meet needs of use for Chapter 222 WAC Watershed Analysis. Some specific factors to be looked at are:

- Percent of and number of days exceeding standard (July 15 to Aug. 15 as well as full length of study)
- Percent of time exceeding standards(July 15 to Aug. 15 as well as full length of study)
- Relevance of temperature reach conditions to documented temperature regime

- 1995 climatic and streamflow conditions relative to study results and historical conditions
- Recommendations for future temperature monitoring, watershed based temperature needs, and TMDL needs.

In addition, it will be important to review and include stream temperature data being gathered by others this year, and in past years, in this analysis to provide a comprehensive overview of existing temperature information.

Training - Data analysis will be accomplished by or under the supervision of experience Ecology lead staff.

Quality Control - Data processing and analysis will be done by or under supervision of lead Ecology staff. All data will be error-checked, and calculations repeated to identify potential errors. All calibration information will be reviewed and summarized prior to data analysis.

3. **Equipment Calibration.**

As per TFW ambient monitoring protocols, equipment will be calibrated and periodically inspected for accuracy. Thermographs will receive pre and post deployment calibration. Attached sheets will be used to record calibration information.

REFERENCES CITED:

Schuett-Hames, D., A. Pleus, L. Bullchild and S. Hall. 1994. Timber-Fish-Wildlife ambient monitoring program manual. Northwest Indian Fisheries Commission. Olympia.

Watershed anlaysis - complete citation

Attachmetns: Calibration form(s)
Map of monitoring locations

file: tpqa8-95

APPENDIX A.2

August 8, 1995

TO: White River Spawning Gravel Sample Files
FROM: Joanne Schuett-Hames, SWRO Water Quality Program JS-H
RE: QA/QC plan for 1995 spawning gravel samples in the White River drainages.

This memo and attached or associated documents constitutes the QA/QC documentation for spawning gravel studies lead by DOE SWRO in the upper White River in 1995.

Sampling purpose: To develop replicable spawning gravel fine sediment data useful as baseline water quality information for upper White River tributaries.

Spawning gravel fine sediment sampling and analysis has four components:

1. Sample design and collection;
2. Sample processing;
3. Data analysis; and,
4. Equipment calibration.

These components and their respective QA/QC measures are described below.

1. Sample design and collection.

Methodology - Sampling will be accomplished according to standard methodologies in Schuett-Hames et al. (1994). Study site selection is done based on dividing spawning streams into segments based on gradient, tributaries and valley confinement. Appropriate segments for sampling are chosen based on accessibility, gradient and spawning habitat and or use. Within chosen sampling segments, reference points are established for future comparative needs and for sample design layout. Riffle crests and in some cases spawning gravel patches are inventoried to develop a statistically based sampling design that insures 12 to 18 samples are taken in a manner to maximize sampling of within riffle and between riffle variability.

Samples are taken with a 6 inch diameter McNeil gravel sampler adapted with a plunger to capture fine suspended sediments. The sampler is inserted to a depth of 9 inches following strict adherence to measures which promote an undisturbed sample from being taken. Samples are transferred in the field to a five gallon bucket with tight lid and labeling and remain in the bucket until sieving.

Training - Each sampling day will be lead by Ecology regional personnel with training and experience in gravel sample methodology. Interns working with sampling have additionally attended gravel sample training in July 1995 put on by the Northwest Indian Fisheries Commission.

Quality Control - Sample layout and sample collection will be done by, or under the supervision of experienced Ecology lead staff. Any samples that deviate from the sampling procedure will be discarded and redone. All samples will be labeled at the time of collection for positive identification during processing.

2. Sample processing.

Methodology - Volumetric sample processing adhering to methodologies in Schuett-Hames et al. (1994) will be done. Each sample will be wet sieved through the recommended series of 12 inch diameter Tyler Sieves. After sieve contents are allowed to drain to remove excess water, contents are placed in a volume displacement flask for volumetric measurement. Silt passing through the finest sieve will be allowed to settle one hour before its volume is read.

Training - Lead staff working on sample processing will either have prior experience and training, or will receive training on methodologies. Several regional staff have received training from the Northwest Indian Fisheries Commission.

Quality Control - All samples will be processed by, or under the supervision of experienced, trained Ecology staff. In instances where deviations from proscribed processes may occur, all information will be noted; if such deviations compromise sample quality, those samples will be discarded.

3. Data analysis.

Methodology - Data will be analyzed for mean percent fine sediments less than .85mm for individual samples and as a composite for complete stream segments ; other specific data analysis may also be accomplished. Analysis meeting needs for Chapter 222 WAC Watershed Analysis will be done.

Quality control - Data processing and analysis will be done by or under supervision of lead Ecology staff. All data will be error-checked, and calculations repeated to identify potential errors.

4. Equipment calibration.

As per TFW ambient monitoring protocols, equipment will be calibrated and periodically inspected for accuracy. Attached sheets will indicate calibration information.

REFERENCE CITED:

Schuett-Hames, D., A. Pleus, L. Bullchild and S. Hall. 1994. Timber-Fish-Wildlife ambient monitoring program manual. Northwest Indian Fisheries Commission. Olympia.

file: sgqa8-95

Appendix B.1

1995 Daily Stream Temperatures that Exceeded the Class AA Water Quality Criterion of 16.0°C

Appendix B.1
Daily stream temperatures that exceeded the Class AA water quality criteria of 16.0°C.

Site & location	Date	Daily maximum high (°C)	Approx. time daily max. high	Approx. hours/day greater than16.0°C
GREENWATER RIVER				
Segment 2; RM 1.2	Jul-12	17 7	1530	5
Site No. 1	Jul-13	18.5	1530	7
July 12 to September 14, 1995	Jul-14	18.6	1530	7
	Jul-15	18.8	1530	7
	Jul-16	18.9	1430	7
	Jul-20	16.5	1430	4
	Jul-21	17.8	1530	6
	Jul-23	17.8	1430	6
	Jul-24	17.5	1430	5
	Jul-26	17.2	1430	4
	Jul-27	17.5	1430	5
	Jul-28	18.0	1430	6
	Jul-29	18.5	1430	6
	Jul-30	18.6	1430	7
	Jul-31	18.9	1430	2
	Aug-1	16.4	1430	2
	Aug-5	17.0	1430	4
	Aug-15	16.4	1430	2
	Aug-16	17.0	1430	4
	Aug-17	16.9	1430	4
	Aug-18	17.0	1330	4
	Aug-27	16 5	1530	2
	Aug-28	17.2	1530	4
	Aug-29	17.3	1530	4
	Aug-30	16.2	1430	2
	Sep-5	16.2	1430	2
	Sep-6	16.2	1430	2
	Sep-7	16.2	1430	2
	Sep-10	16.5	1530	2
	Sep-11	16.4	1430	2
	Sep-12	16.1	1330	2
Segment 7; RM 5 3	Jul-13	16.9	1330	4
Site No. 2	Jul-14	17.2	1330	5
July 12 to September 14, 1995	Jul-15	17.2	1330	5
	Jul-16	17 3	1330	5
	Jul-21	16.2	1330	2
	Jul-28	16.2	1330	2
	Jul-29	16 2	1330	2
	Jul-30	16 7	1230	3
	Jul-31	16.9	1330	3

Appendix B.1
Daily stream temperatures that exceeded the Class AA water quality criteria of 16.0°C.

Segment 8; RM 5.8	Jul-13	16.7	1330	2
Site No. 3	Jul-14	17.0	1330	3
July 12 to September 14, 1995	Jul-15	17.2	1330	3
	Jul-16	17.3	1330	4
	Jul-21	16.1	1330	1
	Jul-29	16.2	1330	1
	Jul-30	16.5	1330	2
	Jul-31	16.7	1330	3
HUCKLEBERRY CREEK				
Segment 1; RM 0 7				
Site 1	No exceedences greater than 16.0°c			
July 14 to September 18, 1995				
Segment 7; RM 5.7				
Site 2	No exceedences greater than 16.0°C			
July 14 to August 23, 1995				
CLEARWATER RIVER				
Segment 1; RM 0.5	Jul-17	16.1	1230	1
Site 1	Jul-18	16.5	1230	3
July 14 to September 30, 1995	Jul-19	16.5	1230	3
	Jul-20	16.5	1230	2
Segment 2; RM 2.3	Jul-17	16.9	1600	6
Site 2	Jul-18	17.3	1600	7
July 6 to September 30, 1995	Jul-19	17.3	1700	8
	Jul-20	17.4	1600	8
	Aug-3	16.5	1400	4
	Aug-4	16.6	1600	5
Segment 4; RM 3.8	Jul-16	16.6	1600	3
Site 3	Jul-17	17.7	1600	6
July 6 to Septmber 30, 1995	Jul-18	17.9	1600	8
	Jul-19	18.0	1600	8
	Jul-20	18.0	1600	8
	Jul-25	16.4	1600	3
	Jul-27	16.1	1600	1
	Aug-1	16.2	1600	1
	Aug-2	16.4	1600	3
	Aug-3	16.7	1600	4
	Aug-4	17.2	1600	6

Appendix B.1
Daily stream temperatures that exceeded the Class AA water quality criteria of 16.0°C.

Segment 6; RM 5.7				
Site 4	No exceedences greater than 16.0 °C			
July 14 to September 30, 1995				
BURNS CREEK				
RM 0.3				
June 22 to September 29, 1995	No exceedences greater than 16.0°C			
FOREST LAKE CREEK				
RM 0.8				
June 22 to September 29, 1995	No exceedences greater than 16.0°C			
PYRAMID CREEK				
RM 0.4	Jul-17	16.4	1735	3
June 22 to September 29, 1995	Jul-18	16.5	1735	3
	Jul-19	16.7	1600	8
	Jul-20	16.7	1425	8
SLIDE CREEK				
RM 0.1				
June 22 to September 29, 1995	No exceedences greater than 16.0°C			
STRAIGHT CREEK				
RM 0.3	Jul-1	16.2	1600	3
June 22 to September 29, 1995	Jul-16	16.4	1600	8
	Jul-17	16.9	1600	8
	Jul-18	17.3	1425	10
	Jul-19	17.5	1425	10
	Jul-20	17.7	1425	10
	Aug-2	16.4	1600	5
	Aug-3	16.1	1600	3
	Aug-4	16.5	1600	5
UPPER GREENWATER RIVER				
RM 11.7				
June 22 to September 29, 1995	No exceedences greater than 16.0°C			

Appendix B.1
Daily stream temperatures that exceeded the Class AA water quality criteria of 16.0°C.

WHISTLER CREEK				
RM 0.4	Jun-23	16.9	1640	3
June 22 to September 29, 1995	Jun-24	18.1	1640	3
	Jun-25	18.5	1640	3
	Jun-26	17.8	1640	3
	Jun-27	18.3	1640	3
	Jun-28	17.8	1640	3
	Jun-29	17.5	1640	3
	Jun-30	18.3	1640	3
	Jul-1	17.0	1640	3
	Jul-5	18.0	1640	3
	Jul-12	19.0	1640	3
	Jul-13	17.3	1640	3
	Jul-15	19.3	1640	3
	Jul-16	19.9	1425	5
	Jul-17	19.9	1425	5
	Jul-18	19.9	1425	5
	Jul-19	19.9	1425	5
	Jul-20	19.4	1425	5
	Jul-25	16.2	1425	5
	Jul-26	16.9	1425	3
	Jul-27	17.3	1425	5
	Jul-28	17.0	1425	3
	Jul-30	16.1	1425	3
	Jul-31	16.7	1425	3
	Aug-1	18.1	1425	3
	Aug-2	19.1	1425	3
	Aug-3	19.4	1425	3
	Aug-4	19.9	1425	3
	Aug-5	17.2	1640	3
	Aug-9	18.3	1640	3
	Aug-13	16.4	1640	3
	Aug-19	17.5	1640	3
	Aug-20	17.8	1640	3
	Aug-21	17.5	1640	3
	Aug-22	17.3	1640	3
	Aug-24	16.5	1640	3
	Aug-25	16.2	1640	3
	Aug-26	16.2	1640	3
	Aug-31	16.4	1640	3
	Sep-1	16.1	1640	3
	Sep-2	16.9	1640	3
	Sep-3	16.7	1640	3
LYLE CREEK				
RM 0.1	No exceedences greater than 16 0°C			
August 9 to December 5, 1995				

Appendix B.2

Stream Temperatures that Exceeded the Class AA Water Quality Criterion of 16.0°C during 1989, 1990, and 1992

Appendix B.2
Stream temperatures that exceeded the Class AA water quality criteria of 16.0°C during 1989, 1990 and 1992.

Site, location and monitoring period	Date	Daily maximum high (°C)	Approx. time daily maximum high	Approx. hours/day greater than 16.0°C
GREENWATER RIVER				
Segment 3; RM 2.2				
August 10 to September 22, 1989	No exceedences greater than 16.0°C			
GREENWATER RIVER				
Segment 9; RM 8.5	11-Aug	16.3	1500	1.0
August 10 to September 22, 1989	12-Aug	16.1	1500	1.0
	13-Aug	16.3	1500	1.0
	17-Aug	16.1	1500	1.0
	18-Aug	16.8	1500	3.0
	26-Aug	16.1	1500	1.0
	27-Aug	16.1	1500	1.0
	29-Aug	16.1	1500	1.0
GREENWATER RIVER				
RM 11.0	11-Aug	16.6	1600	3.0
August 10 to September 22, 1989	12-Aug	16.1	1600	1.0
	13-Aug	16.6	1500	3.0
	17-Aug	16.6	1600	3.0
	18-Aug	17.3	1600	5.0
	20-Aug	16.1	1600	1.0
	25-Aug	16.3	1600	2.0
	26-Aug	17.1	1600	4.0
	27-Aug	16.6	1600	2.0
	28-Aug	16.6	1500	2.0
	29-Aug	16.8	1600	4.0
	8-Sep	16.1	1600	1.0

Appendix B.2

Stream temperatures that exceeded the Class AA water quality criteria of 16.0°C during 1989, 1990 and 1992.

GREENWATER RIVER				
Segment 9; RM 8.5	30-Jul	16.3	1300	1.0
May 30 to November 11, 1990	31-Jul	16.3	1400	2.0
	1-Aug	16.1	1400	1.0
	2-Aug	16.1	1400	1.0
	3-Aug	16.3	1400	2.0
	4-Aug	16.8	1400	4.0
	5-Aug	17.3	1400	5.0
	6-Aug	16.8	1400	4.0
	7-Aug	16.8	1400	3.0
	8-Aug	16.6	1500	2.0
	10-Aug	16.8	1400	1.0
	11-Aug	16.3	1200	4.0
	12-Aug	17.1	1300	5.0
	14-Aug	16.6	1400	3.0
	5-Sep	16.1	1400	1.0
CLEARWATER RIVER				
Segment 2; RM1.2	18-Jul	17.6	1512	4.0
July 17 to September 9, 1992	19-Jul	16.8	1512	3.0
	26-Jul	16.6	1512	2.0
	27-Jul	16.3	1424	1.0
	28-Jul	16.6	1512	2.0
	29-Jul	16.6	1512	2.0
	30-Jul	16.8	1512	3.0
	31-Jul	17.3	1424	4.0
	1-Aug	17.3	1512	6.0
	4-Aug	16.6	1512	2.0
	10-Aug	16.1	1512	1.0
	11-Aug	16.6	1424	2.0
	12-Aug	17.1	1424	3.0
	13-Aug	16.8	1424	3.0
	14-Aug	17.6	1424	6.0
	15-Aug	17.3	1424	5.0
	16-Aug	16.8	1424	4.0
	17-Aug	16.8	1512	3.0
	18-Aug	17.1	1512	4.0
	19-Aug	16.8	1424	3.0
	20-Aug	16.6	1424	3.0
	21-Aug	16.1	1424	1.0

Appendix C.

Temperature Graphs
(Hourly maximum air and water temperatures)

C.1 Greenwater River (Segment 2; RM 1.2) 1995
C.2 Greenwater River (Segment 7; RM 5.3) 1995
C.3 Greenwater River (Segment 8; RM 5.8) 1995
C.4 Greenwater River (RM 11.7) 1995
C.5 Greenwater River (RM 2.2) 1989

C.6 Greenwater River (RM 8.5) 1989
C.7 Greenwater River (RM 11.0) 1989
C.8 Greenwater River (RM 8.5) 1990
C.9 Burns Creek (RM 0.3) 1995
C.10 Forest Lake Creek (RM 0.8) 1995

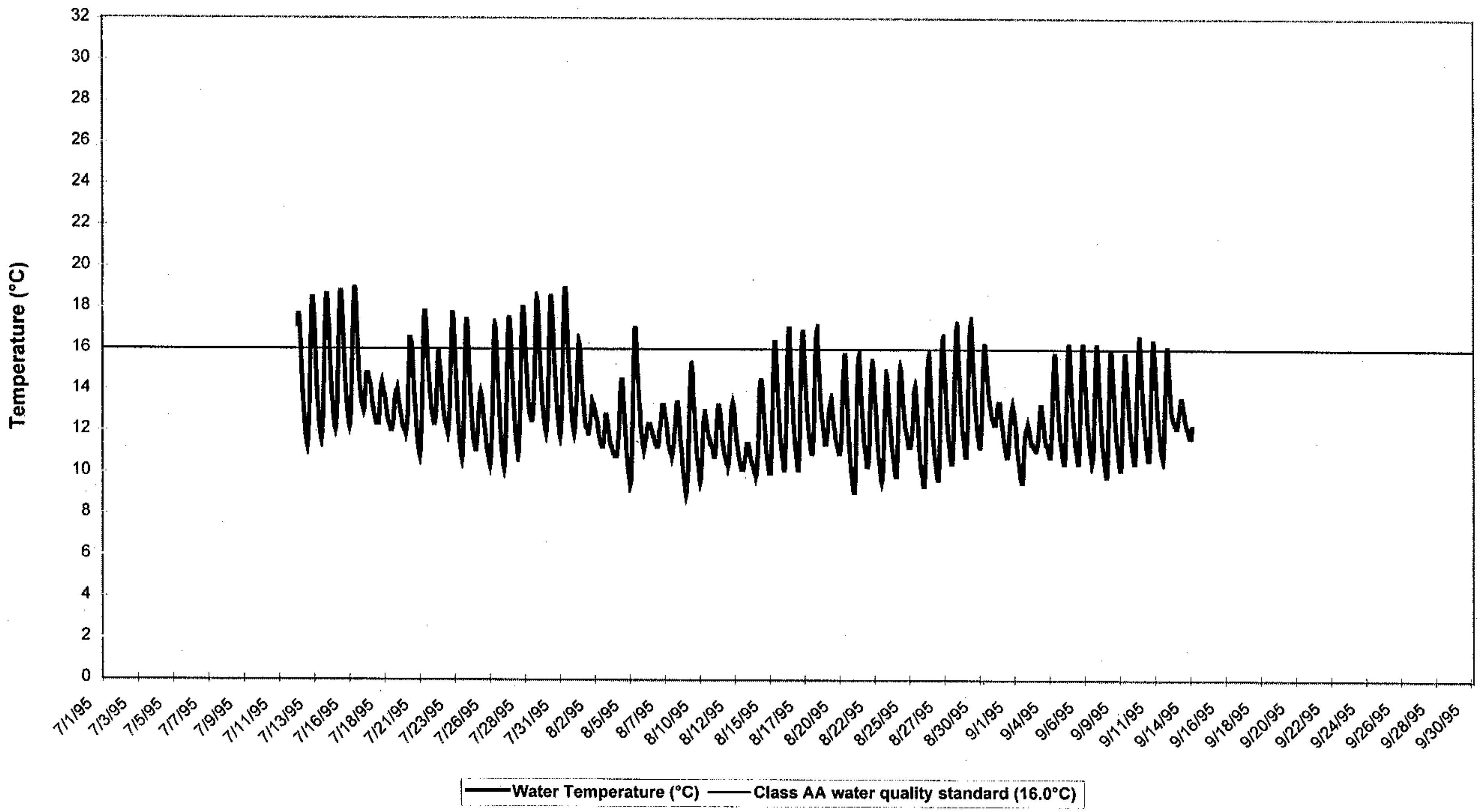
C.11 Pyramid Creek (RM 0.4) 1995
C.12 Slide Creek (RM 0.1) 1995
C.13 Straight Creek (RM 0.3) 1995
C.14 Whistler Creek (RM 0.4) 1995
C.15 Huckleberry Creek (Segment 1; RM 0.7) 1995

C.16 Huckleberry Creek (Segment 7; RM 5.7) 1995
C.17 Clearwater River (Segment 1; RM 0.4) 1995
C.18 Clearwater River (Segment 3; RM 2.3) 1995
C.19 Clearwater River (Segment 4; RM 3.1) 1995
C.20 Clearwater River (Segment 7; RM 4.1) 1995

C.21 Clearwater River (RM 1.2) 1992
C.22 Lyle Creek (RM 0.1) 1995

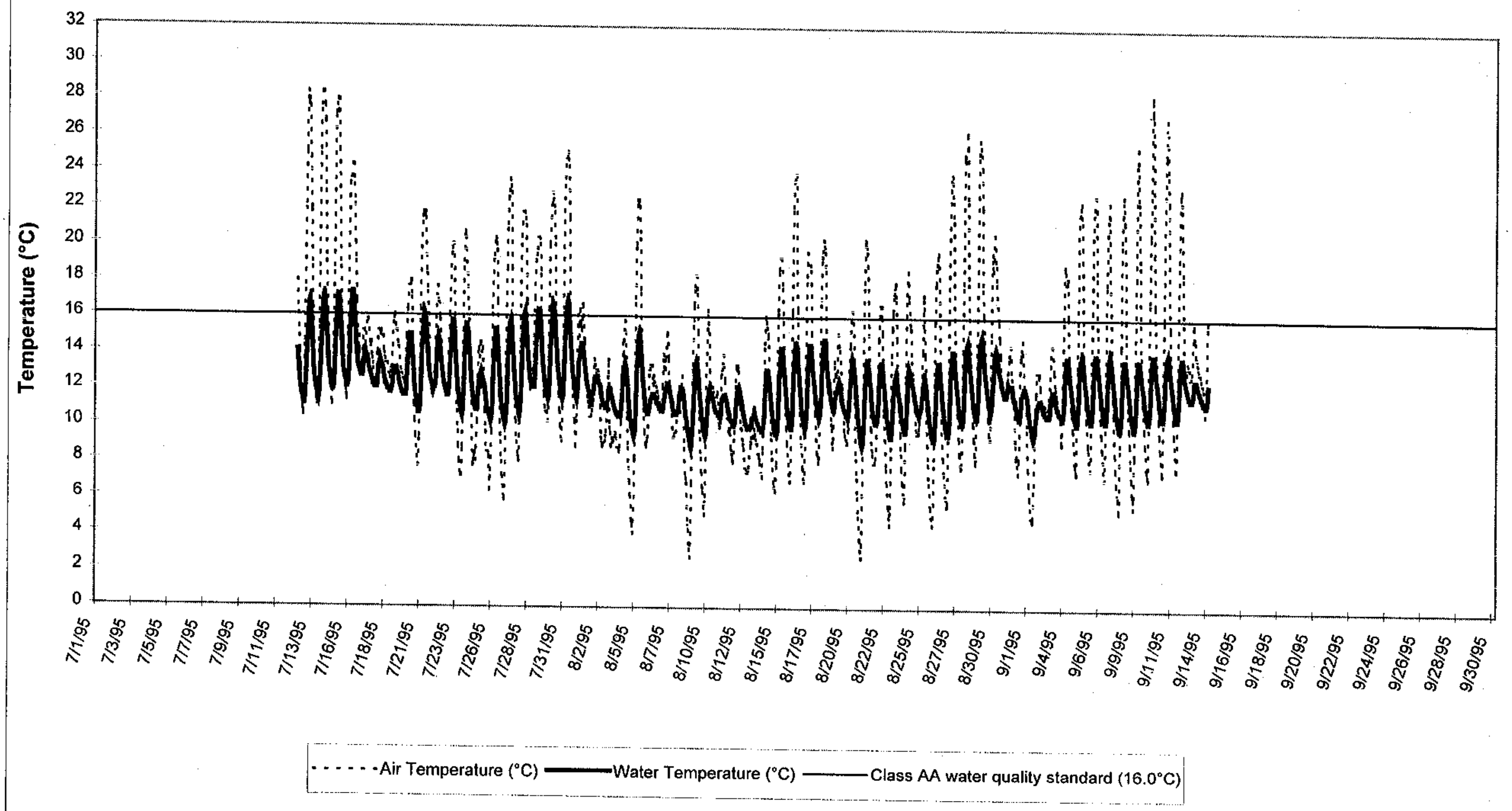
Appendix C.1

Greenwater River (Segment 2; RM 1.2) Hourly Maximum Water Temperatures
July 12 to September 14, 1995



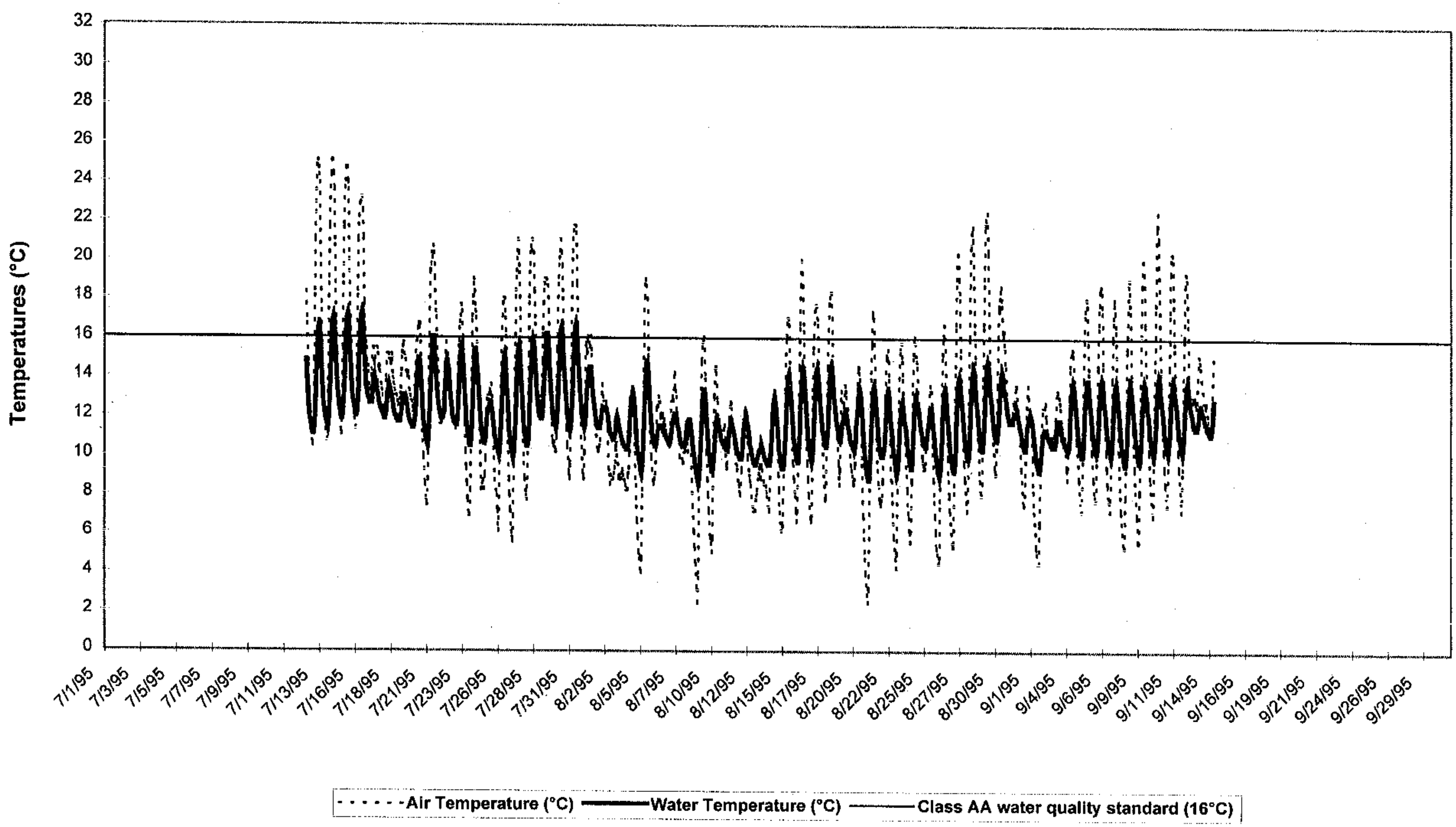
Appendix C.2

Greenwater River (Segment 7; RM 5.3) Hourly Maximum Air and Water Temperatures
July 12 to September 14, 1995



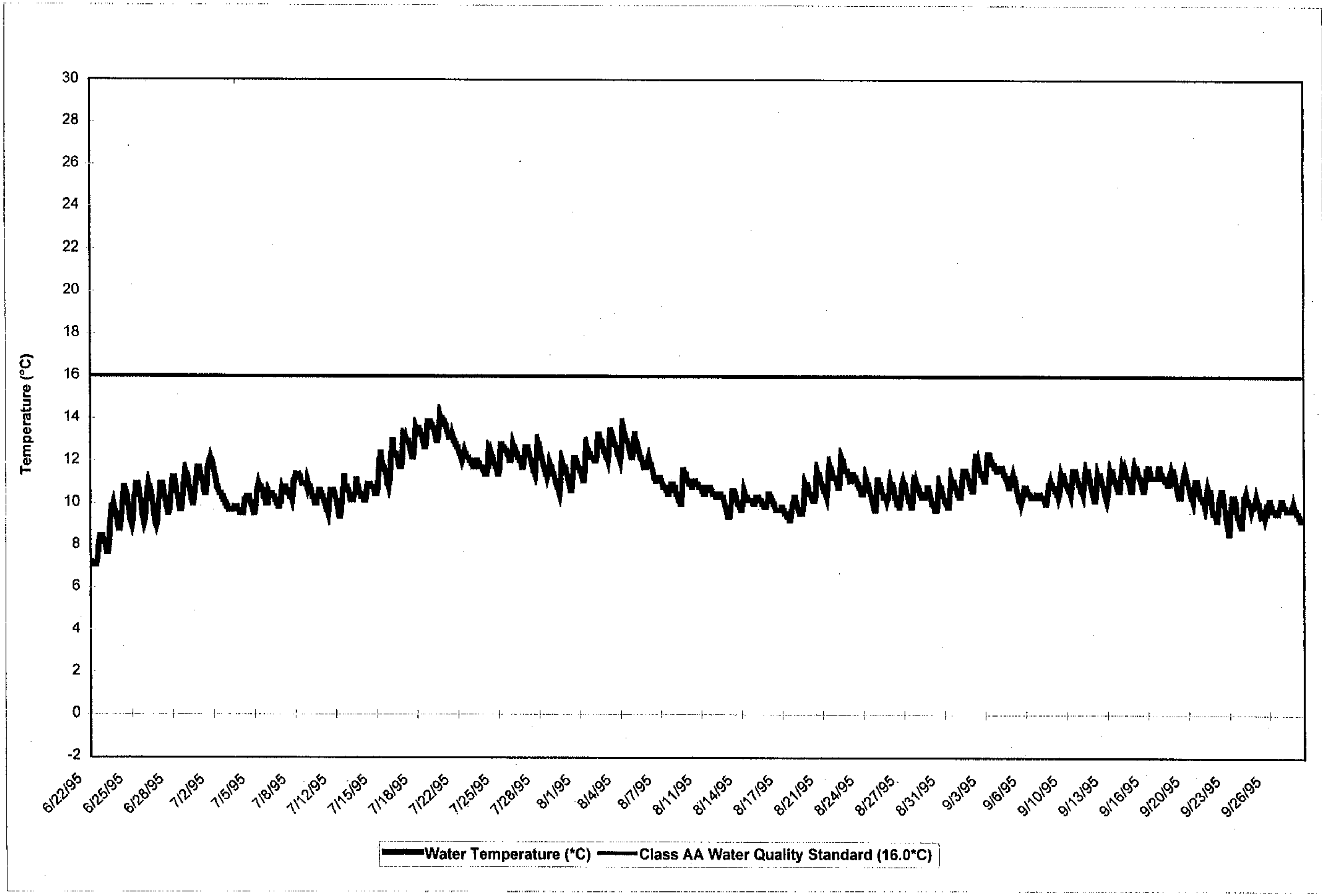
Appendix C.3

Greenwater River (Segment 8; RM 5.8) Hourly Maximum Air and Water Temperatures
July 12 to September 14, 1995



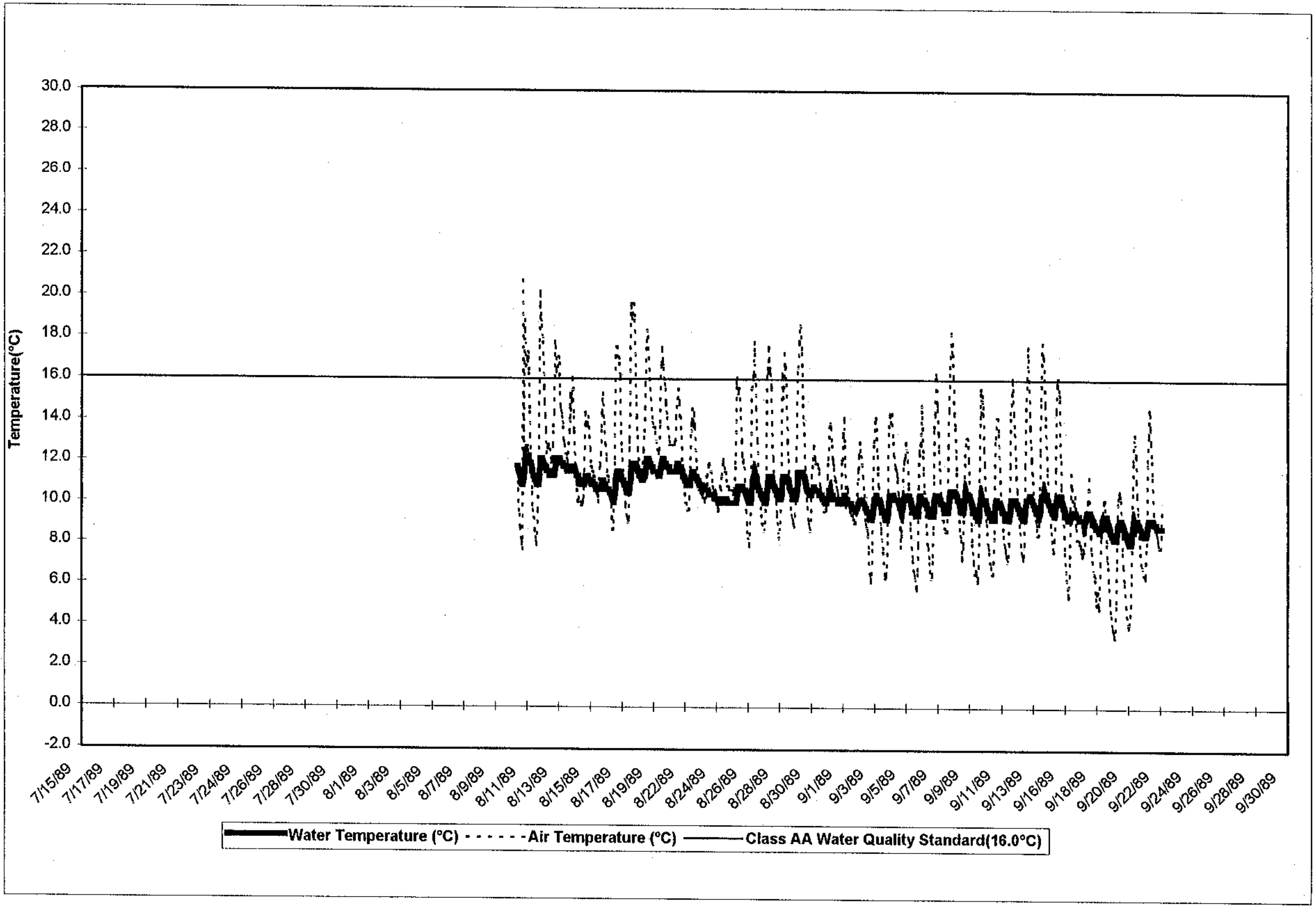
Appendix C.4

Greenwater River (RM 11.7) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



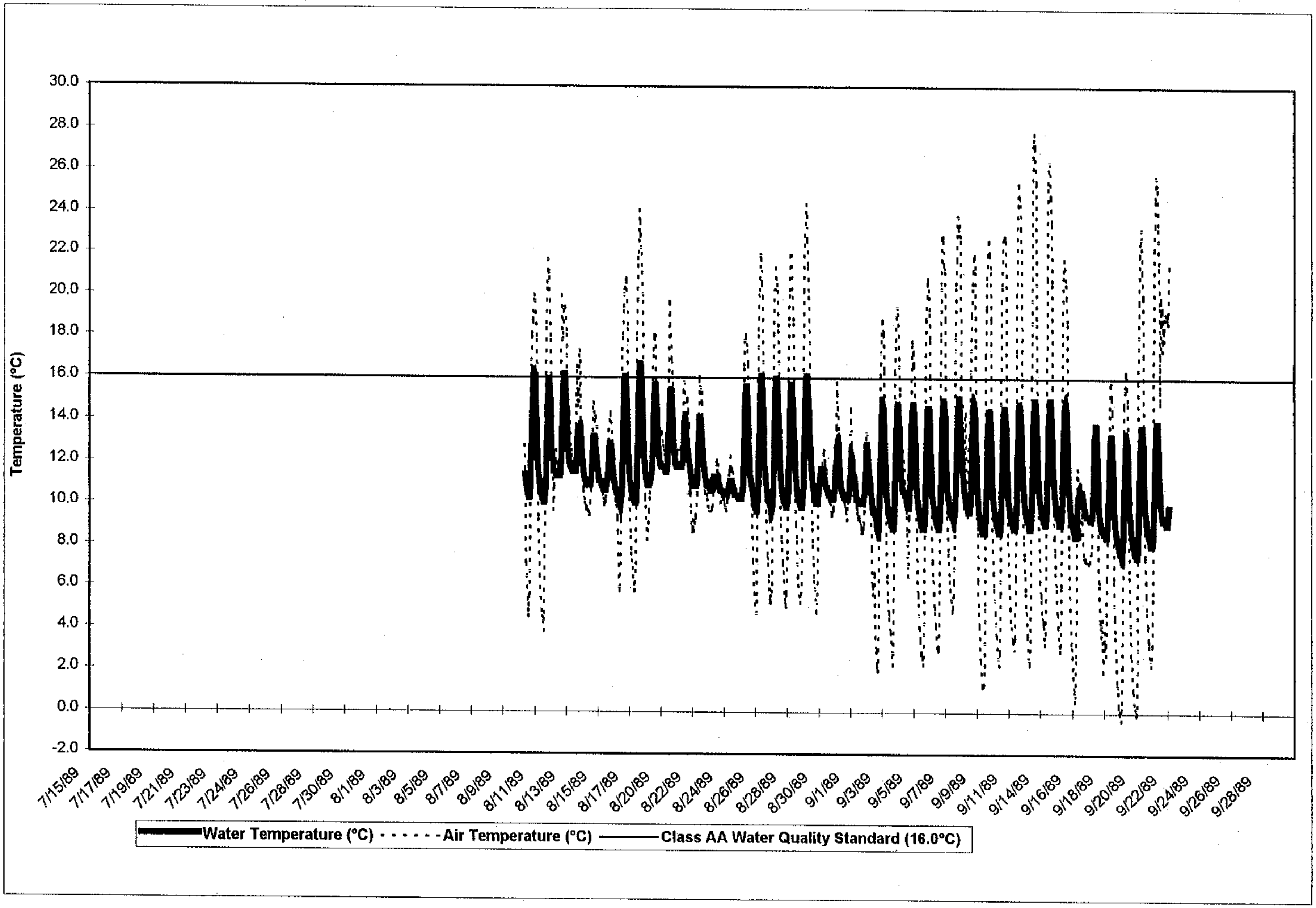
Appendix C.5

Greenwater River (RM 2.2) Hourly Maximum Air and Water Temperatures
August 10 to September 22, 1989



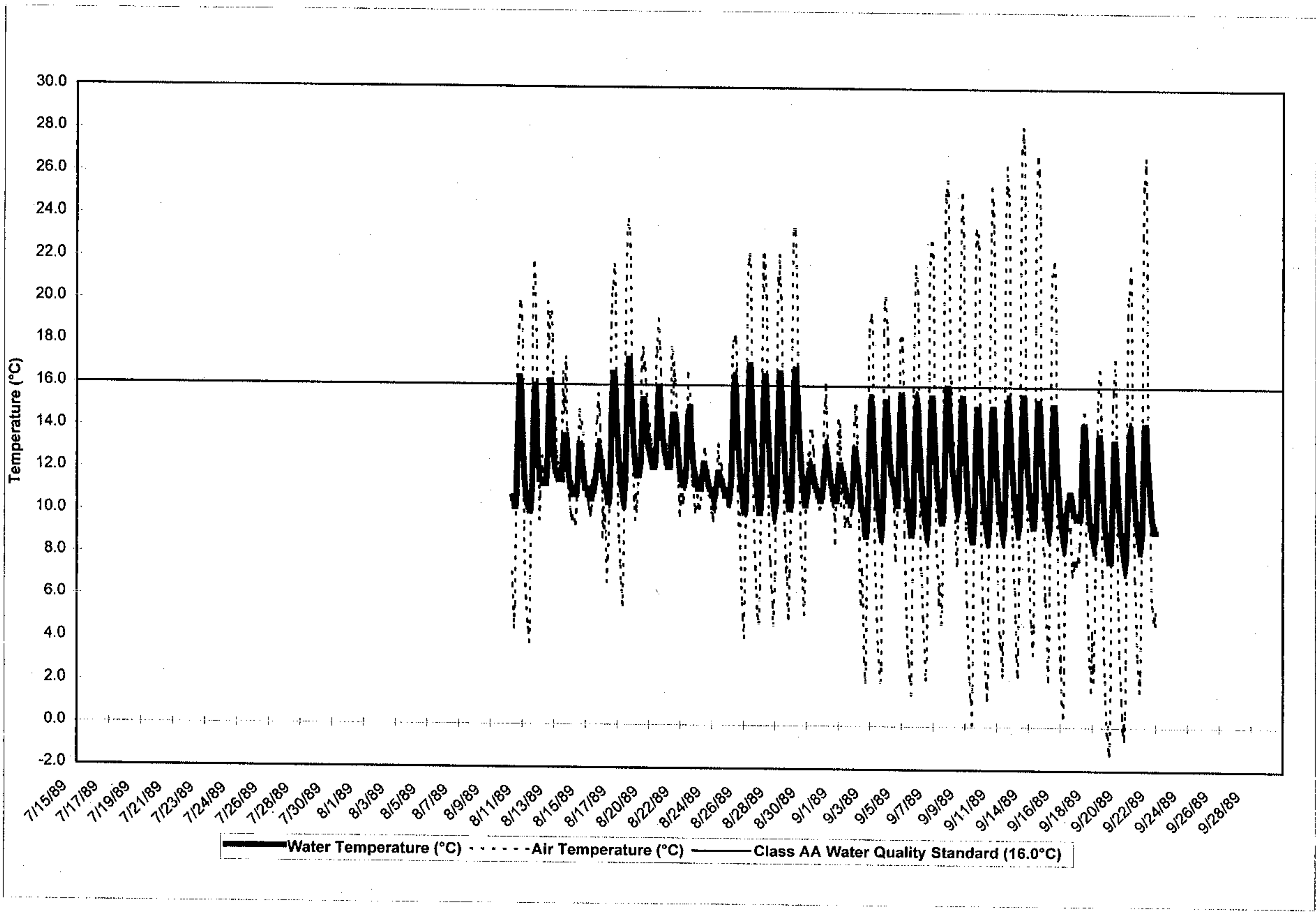
Appendix C.6

Greenwater River (RM 8.5) Hourly Maximum Air and Water Temperatures
August 10 to September 22, 1989



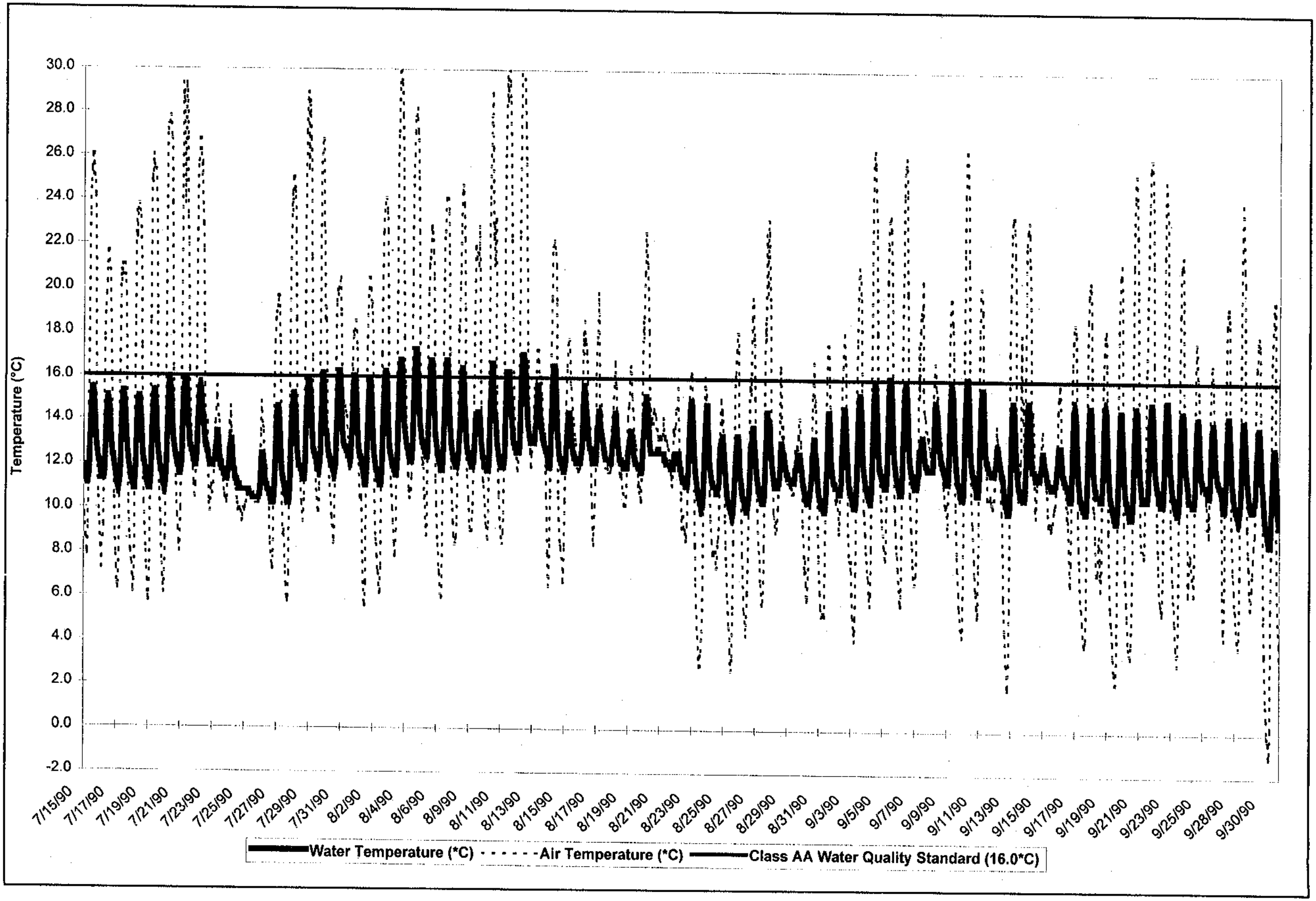
Appendix C.7

Greenwater River (RM 11.0) Hourly Maximum Air and Water Temperatures
August 11 to September 22, 1989



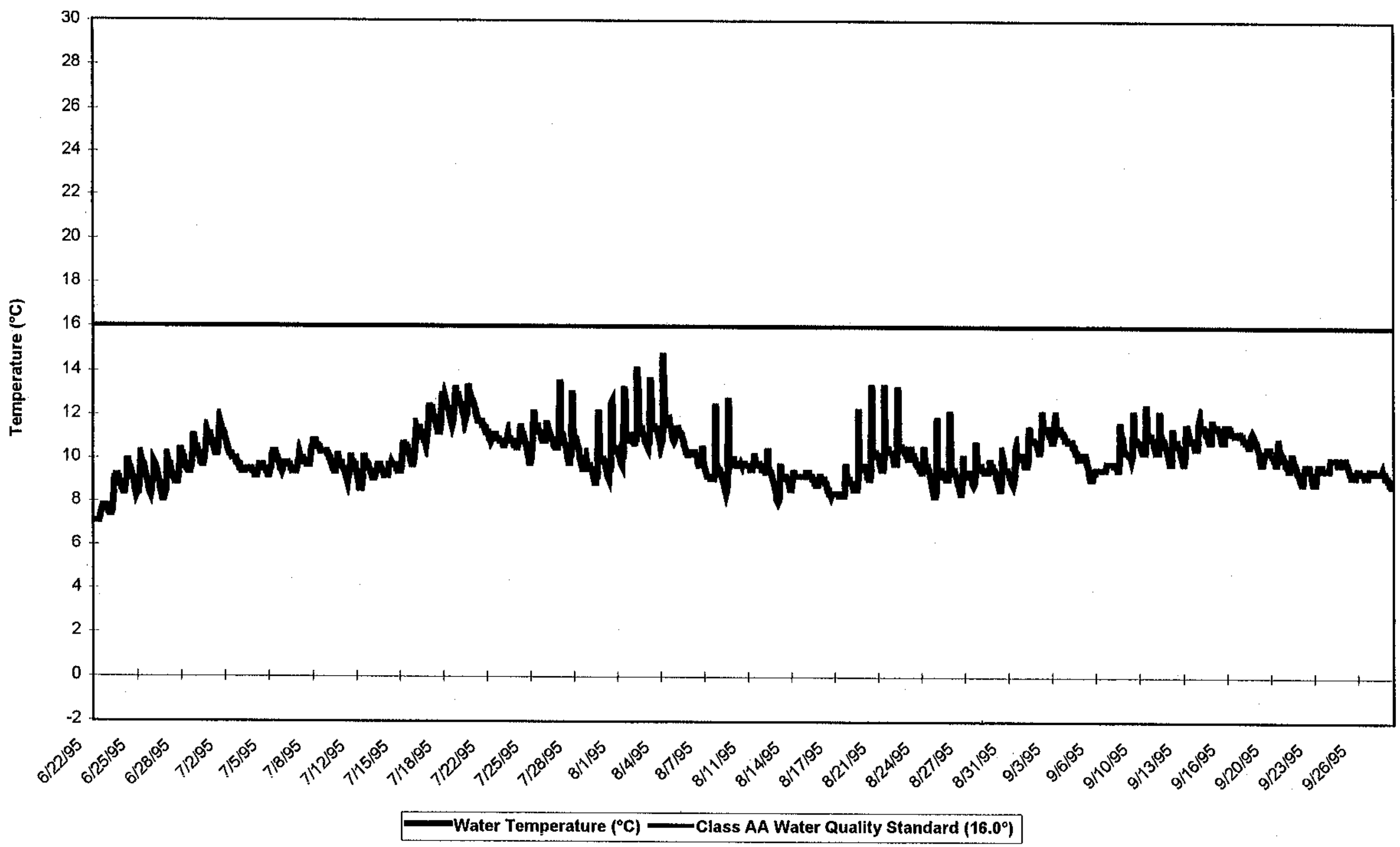
Appendix C.8

Green River (RM 8.5) Hourly Maximum Air and Water Temperatures
July 15 to September 30, 1990



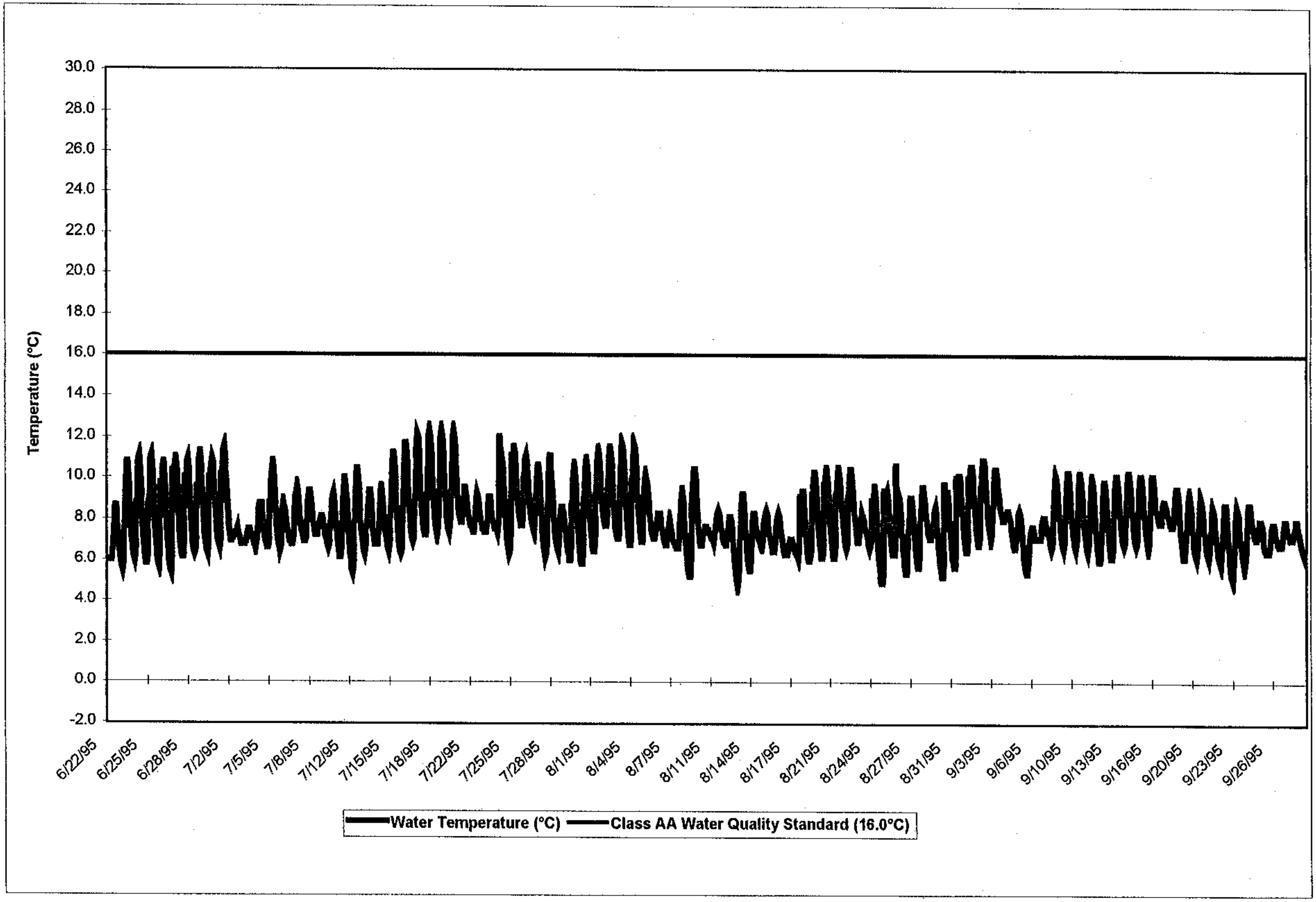
Appendix C.9

Burns Creek (RM 0.3) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



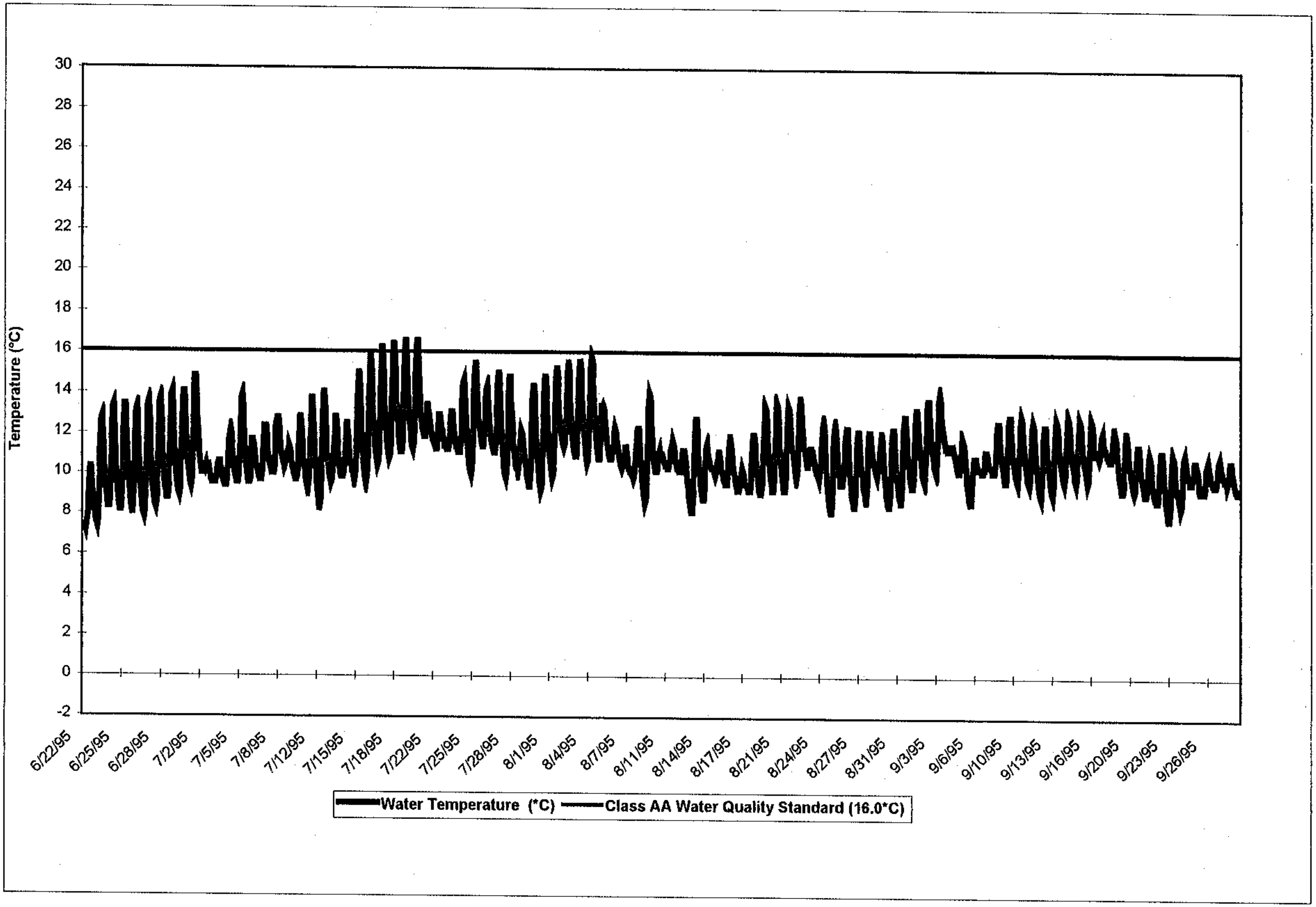
Appendix C.10

Forest Lake Creek (RM 0.8) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



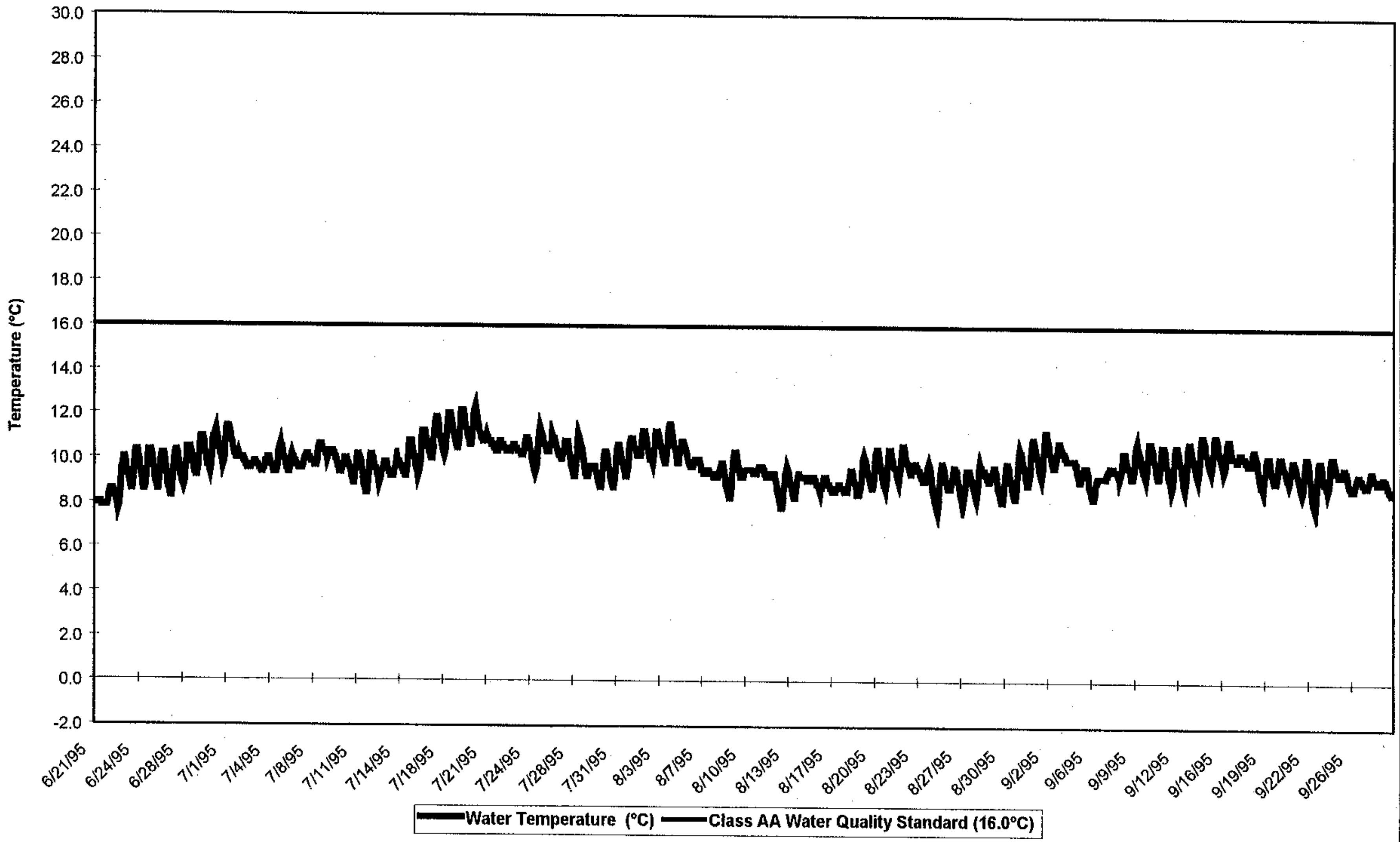
Appendix C.11

Pyramid Creek (RM 0.4) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



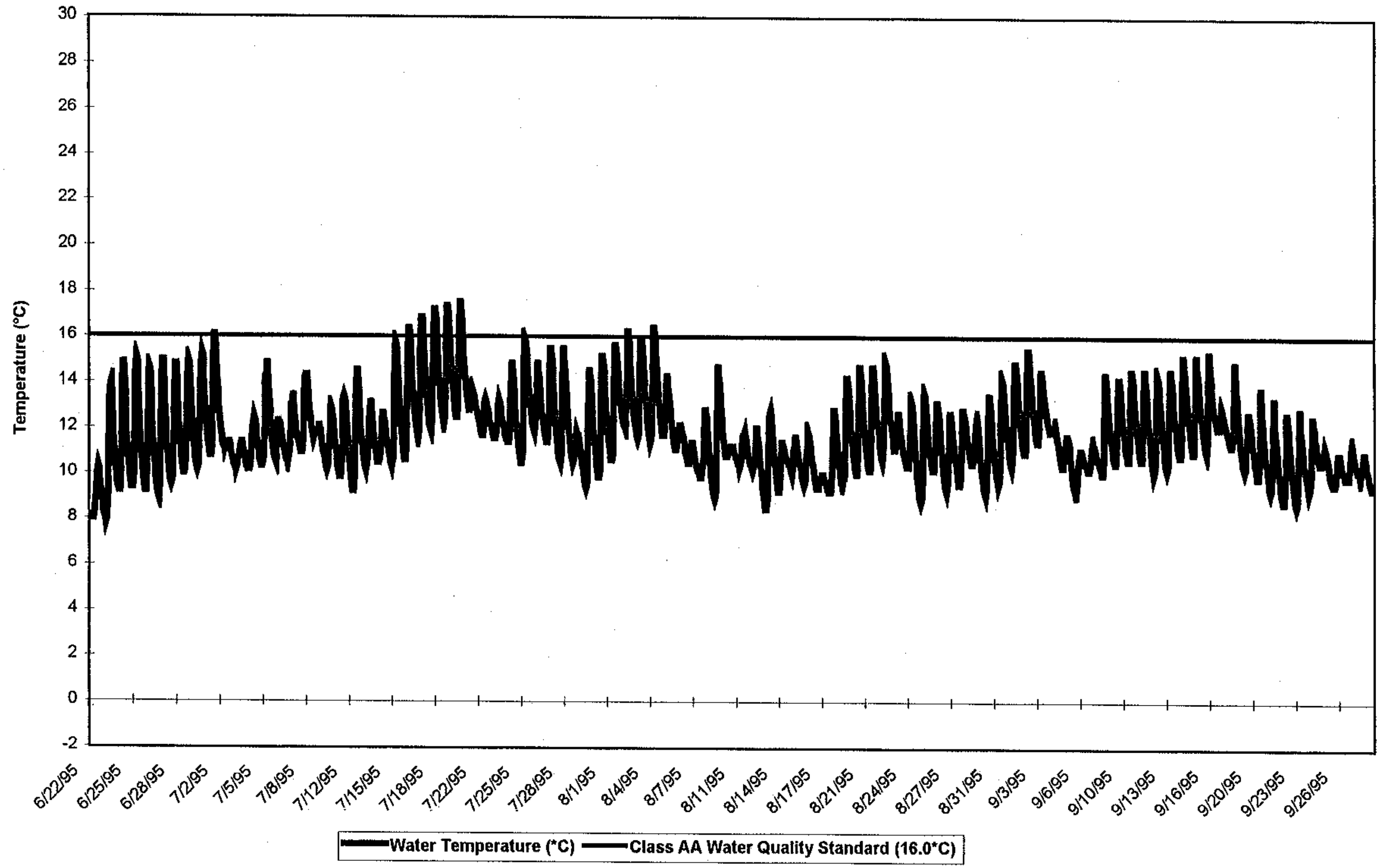
Appendix C.12

Slide Creek (RM 0.1) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



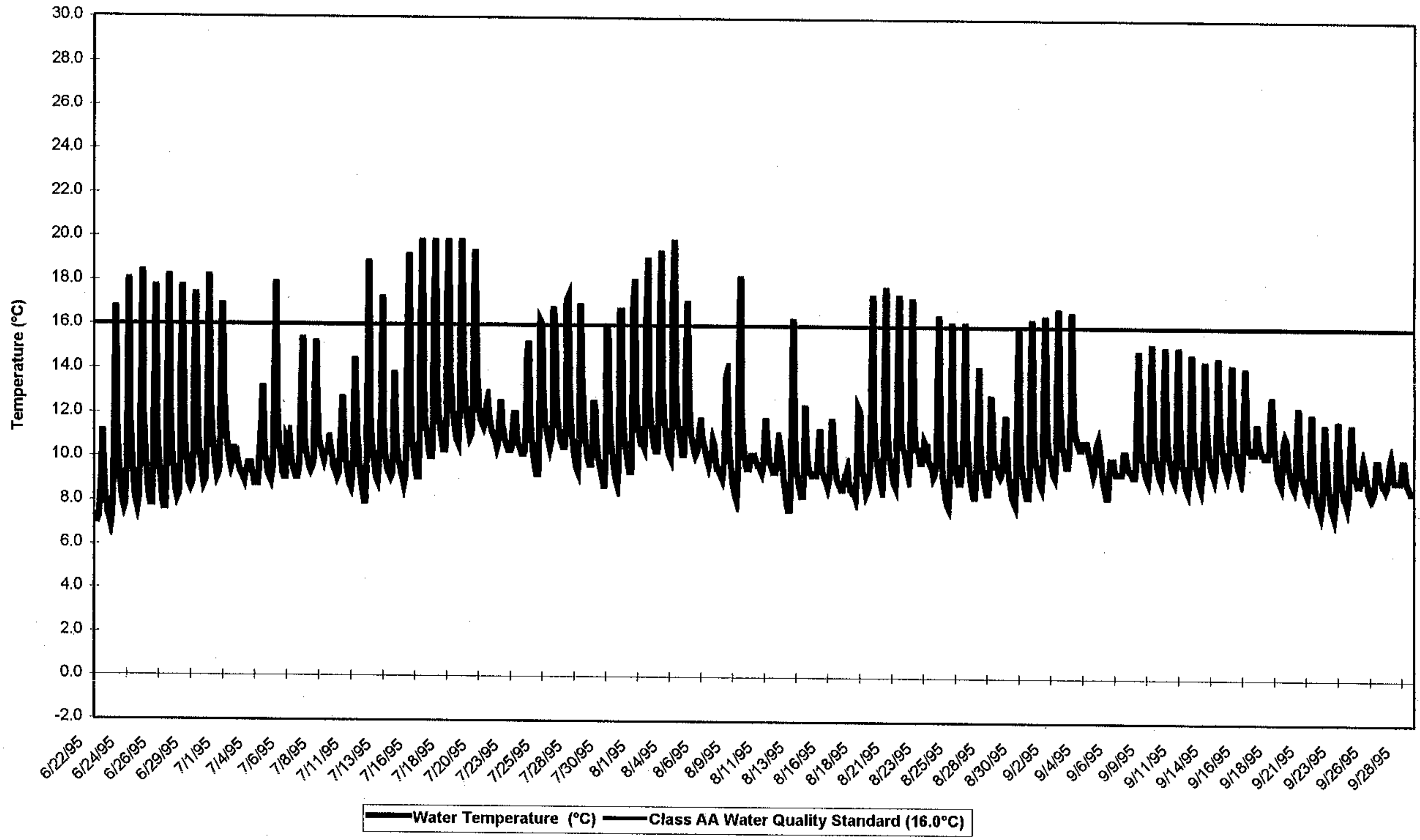
Appendix C.13

Straight Creek (RM 0.3) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



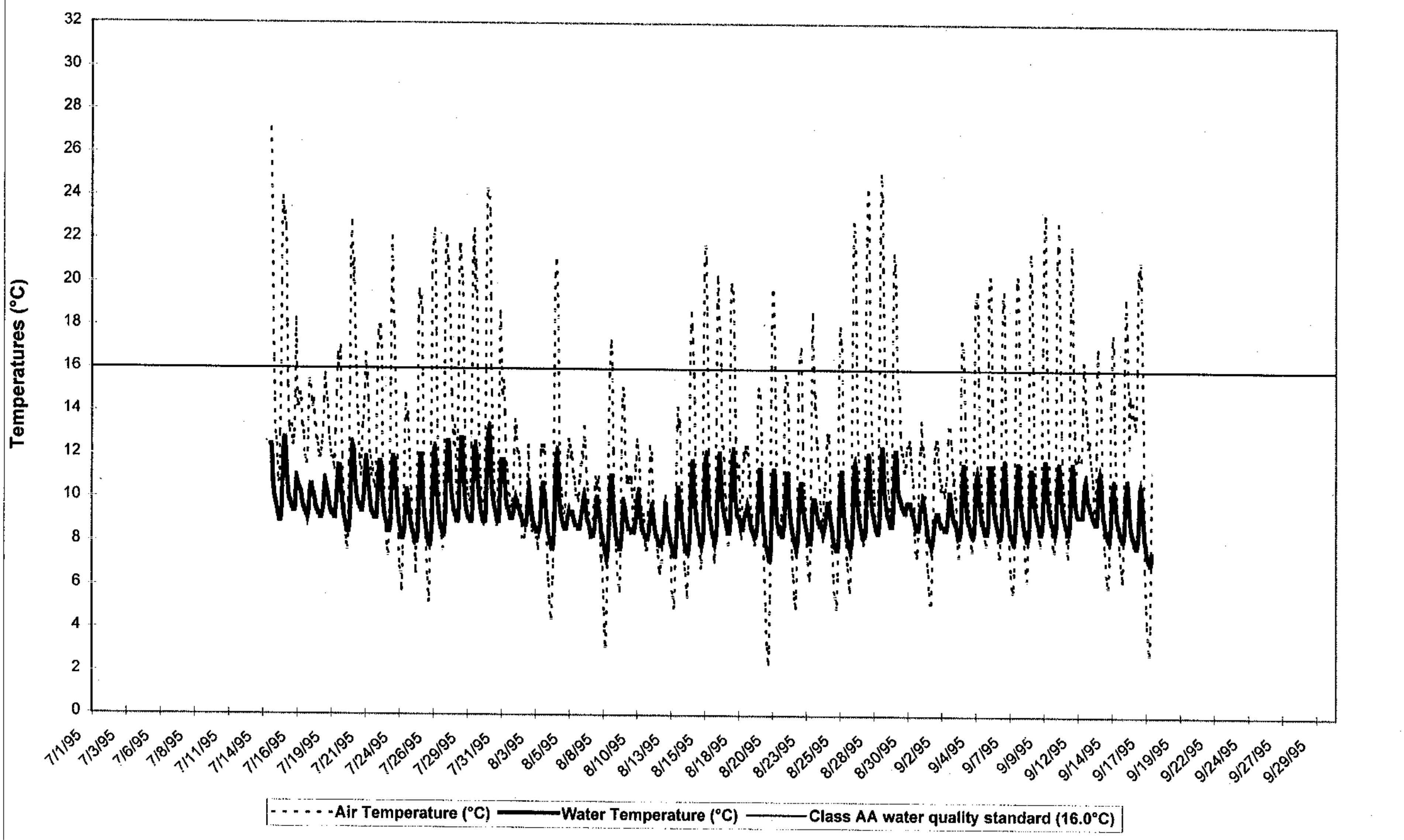
Appendix C.14

Whistler Creek (RM 0.4) Hourly Maximum Water Temperatures
June 22 to September 29, 1995



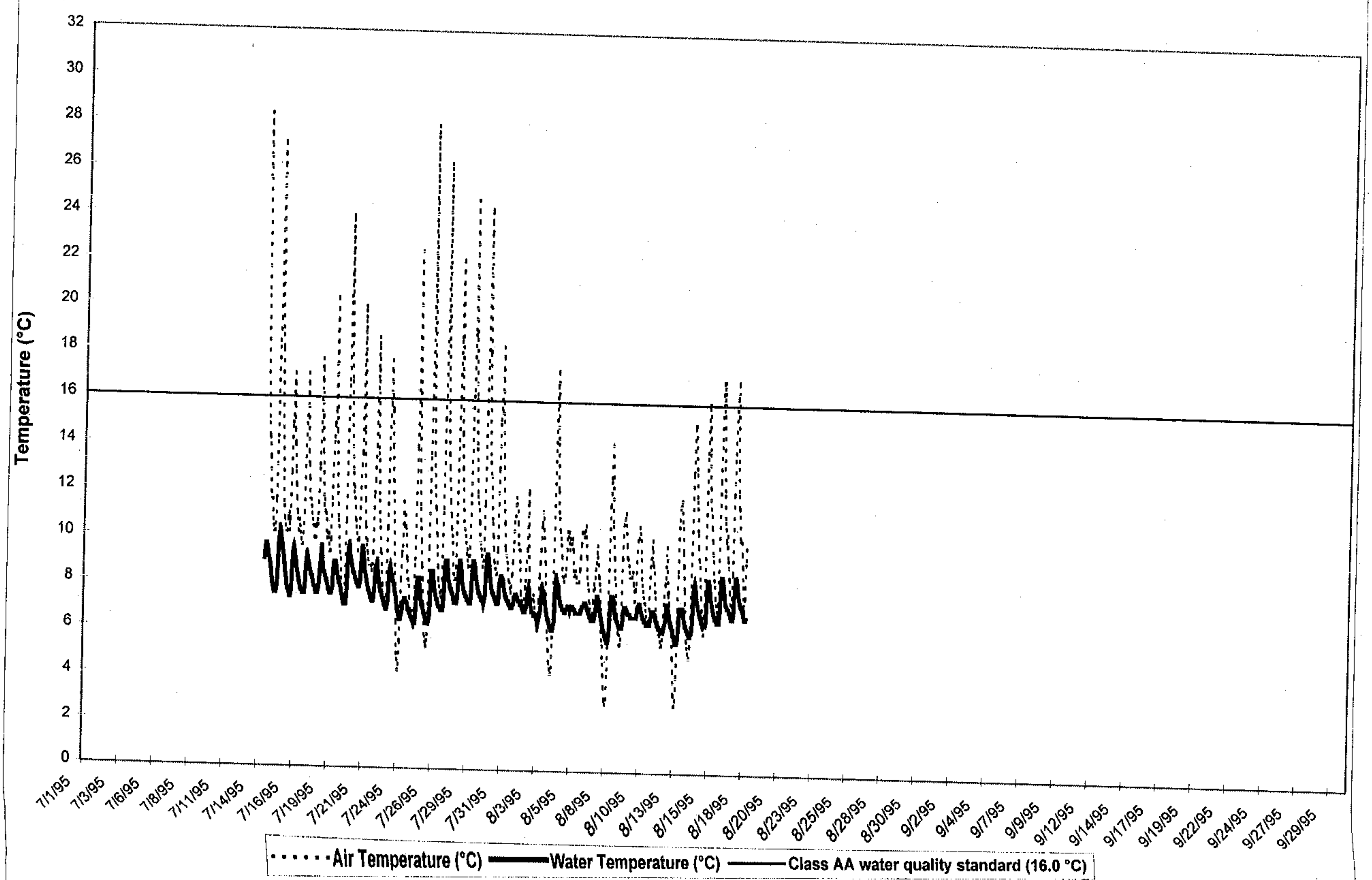
Appendix C.15

Huckleberry Creek (Segment 1; RM 0.7) Hourly Maximum Air and Water Temperatures
July 14 to September 17, 1995



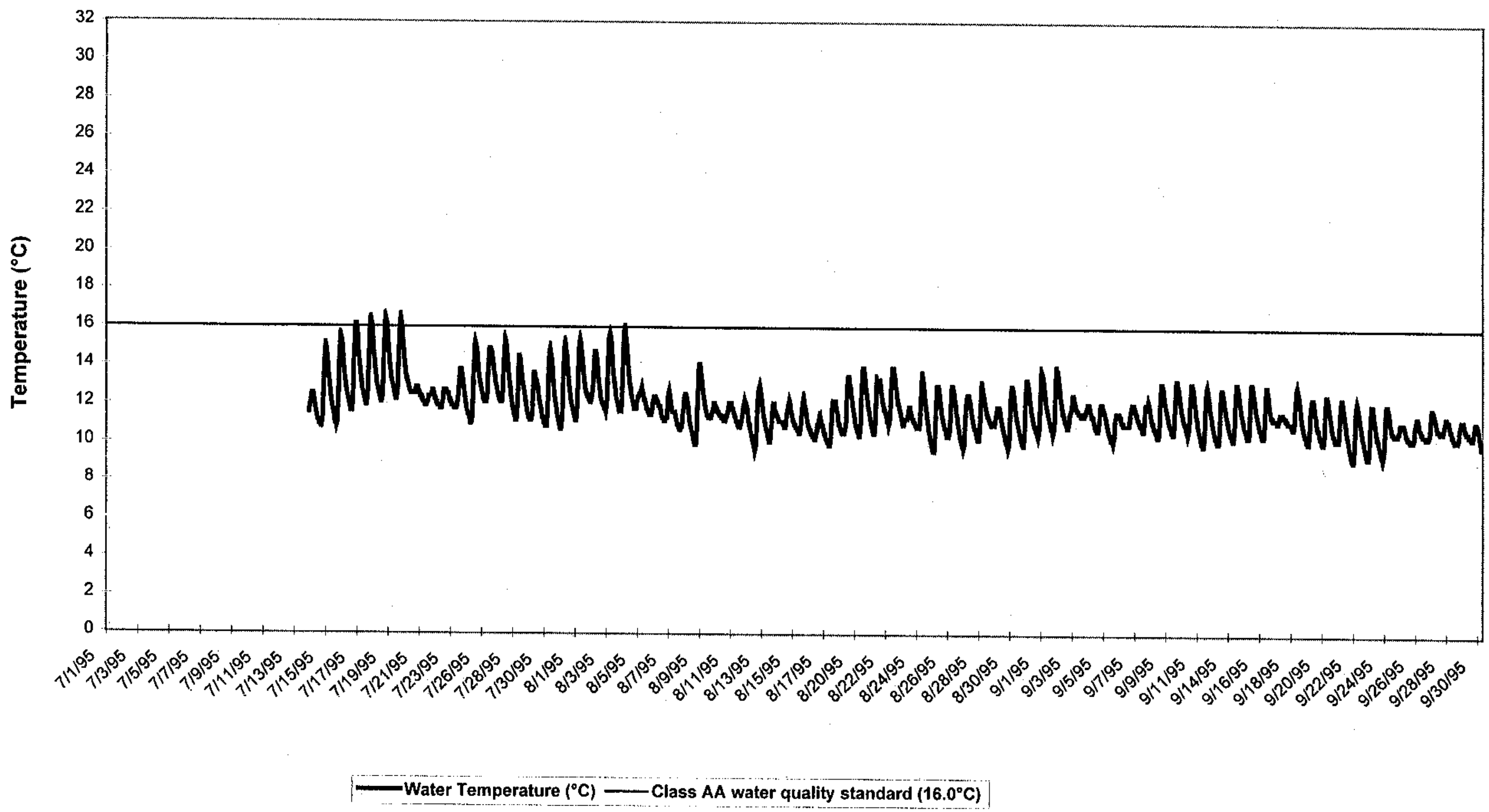
Appendix C.16

Huckleberry Creek (Segment 7; RM 5.7) Hourly Maximum Air and Water Temperatures
July 14 to August 19, 1995



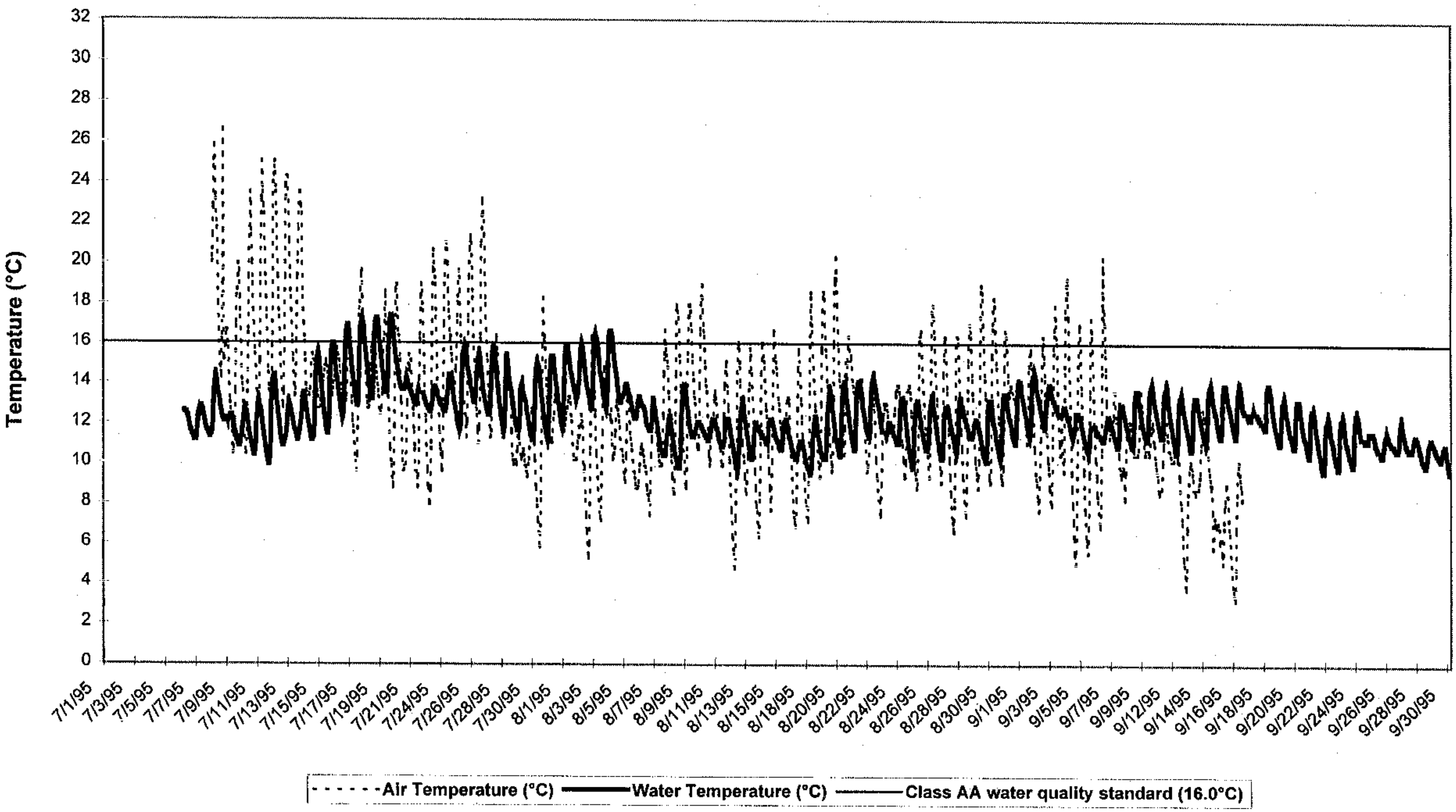
Appendix C.17

Clearwater River (Segment 1; RM 0.4) Hourly Maximum Water Temperatures
July 14 to September 30, 1995



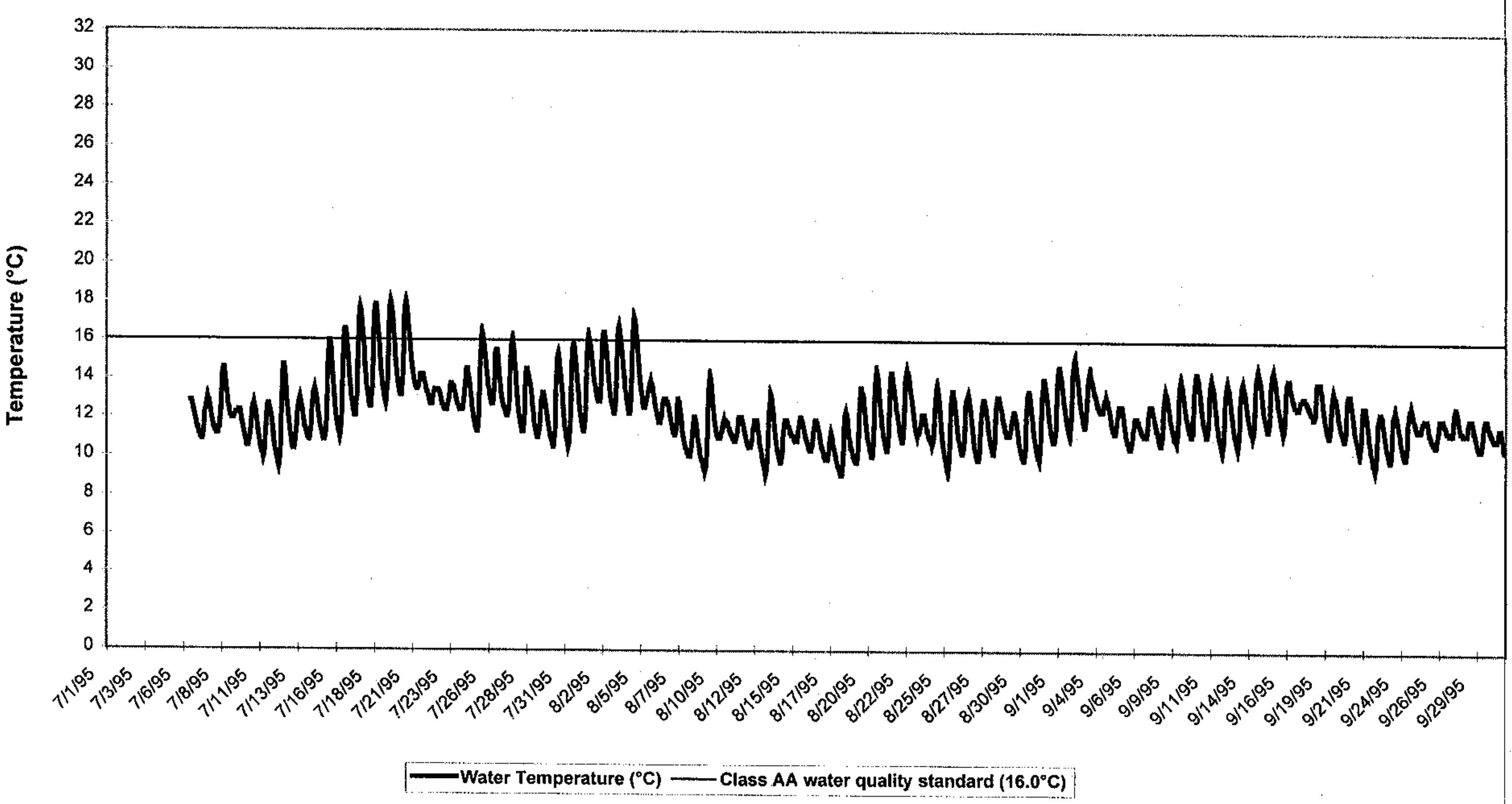
Appendix C.18

Clearwater River (Segment 3; RM 2.3) Hourly Maximum Air and Water Temperatures
For air: July 8 to September 16,1995
For water: July 8 to September 30, 1995



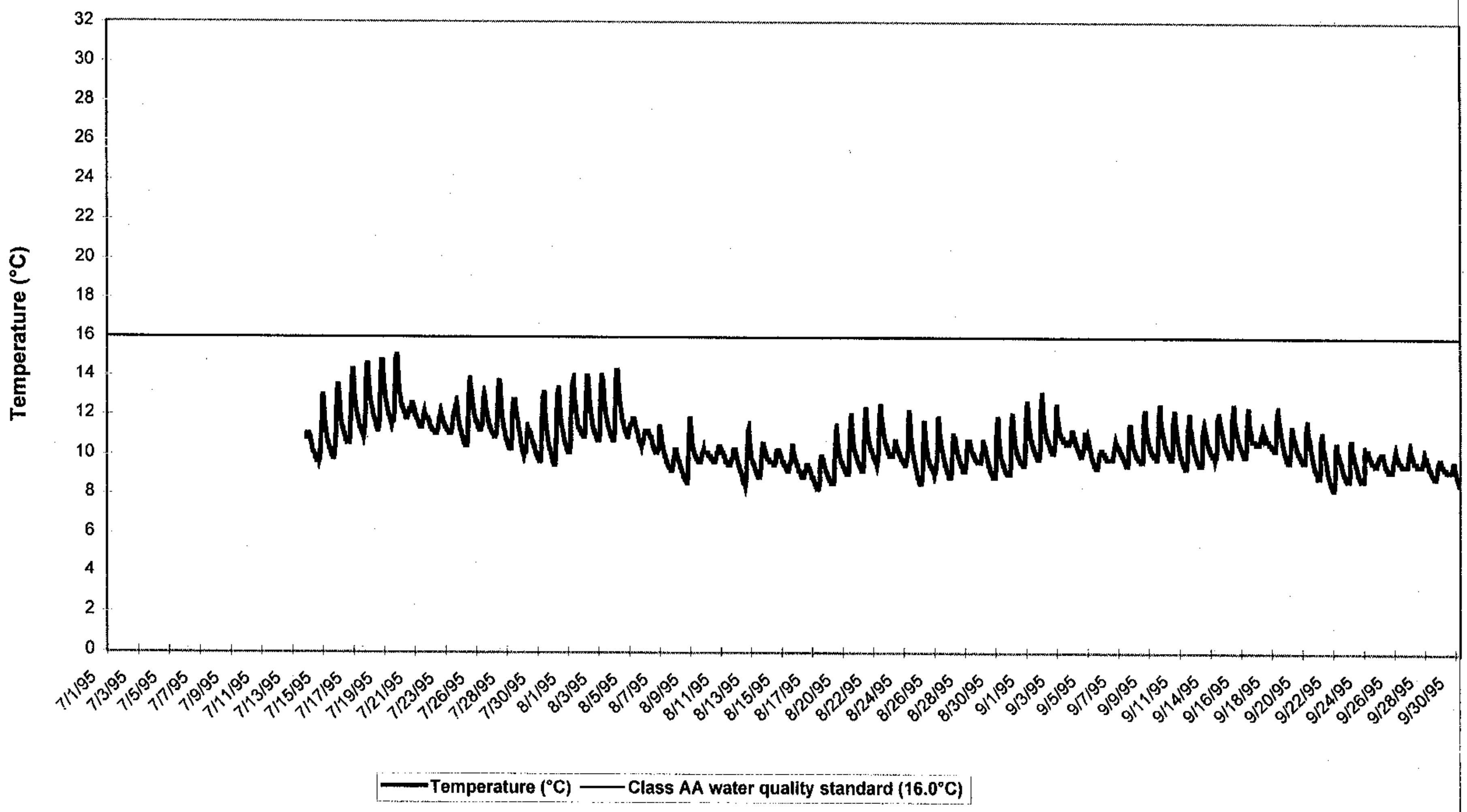
Appendix C.19

Clearwater River (Segment 4; RM 3.1) Hourly Maximum Water Temperatures
July 6 to September 30, 1995



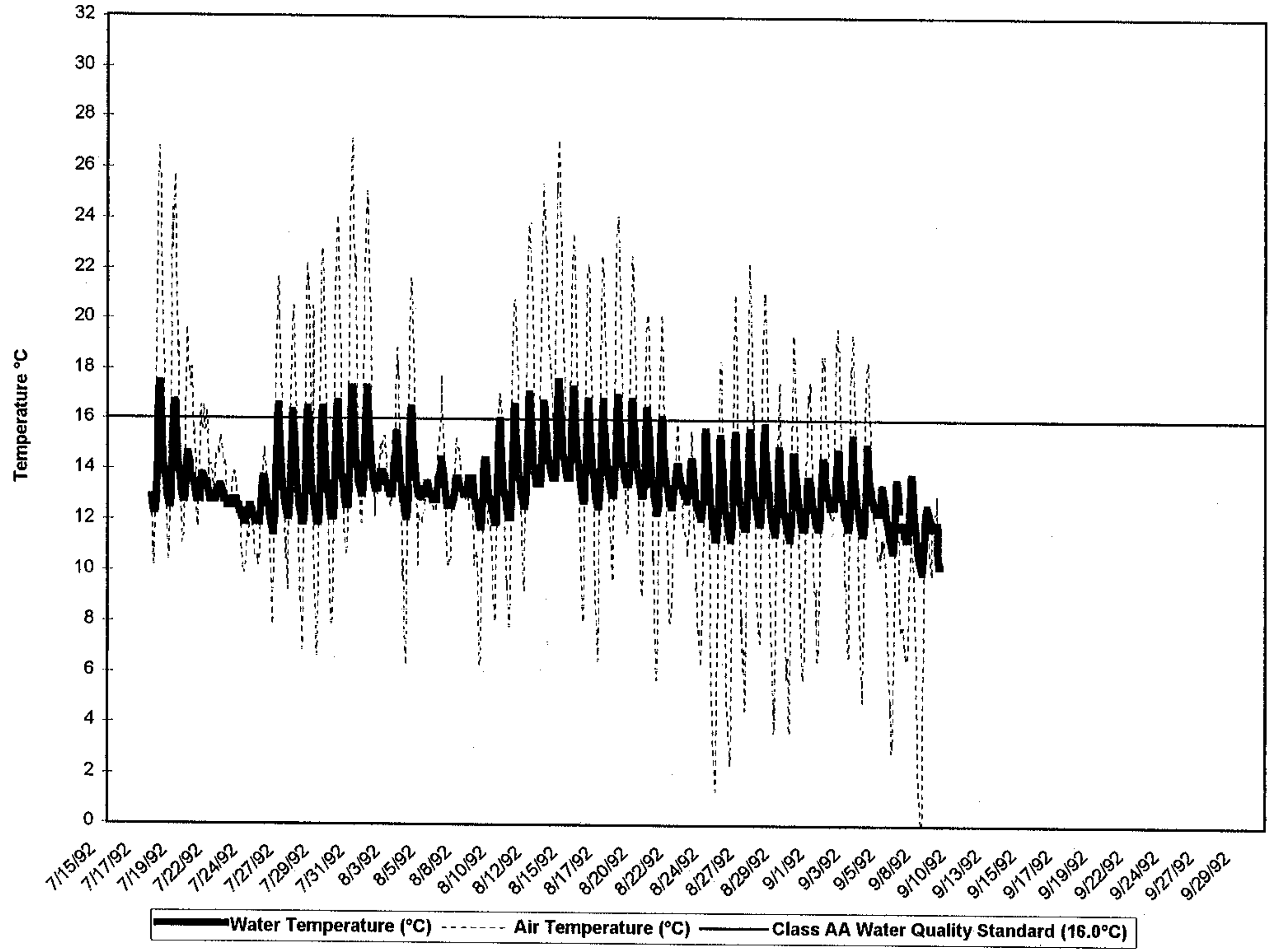
Appendix C.20

Clearwater River (Segment 7; RM 4.1) Hourly Maximum Water Temperatures
July 14 to September 30, 1995



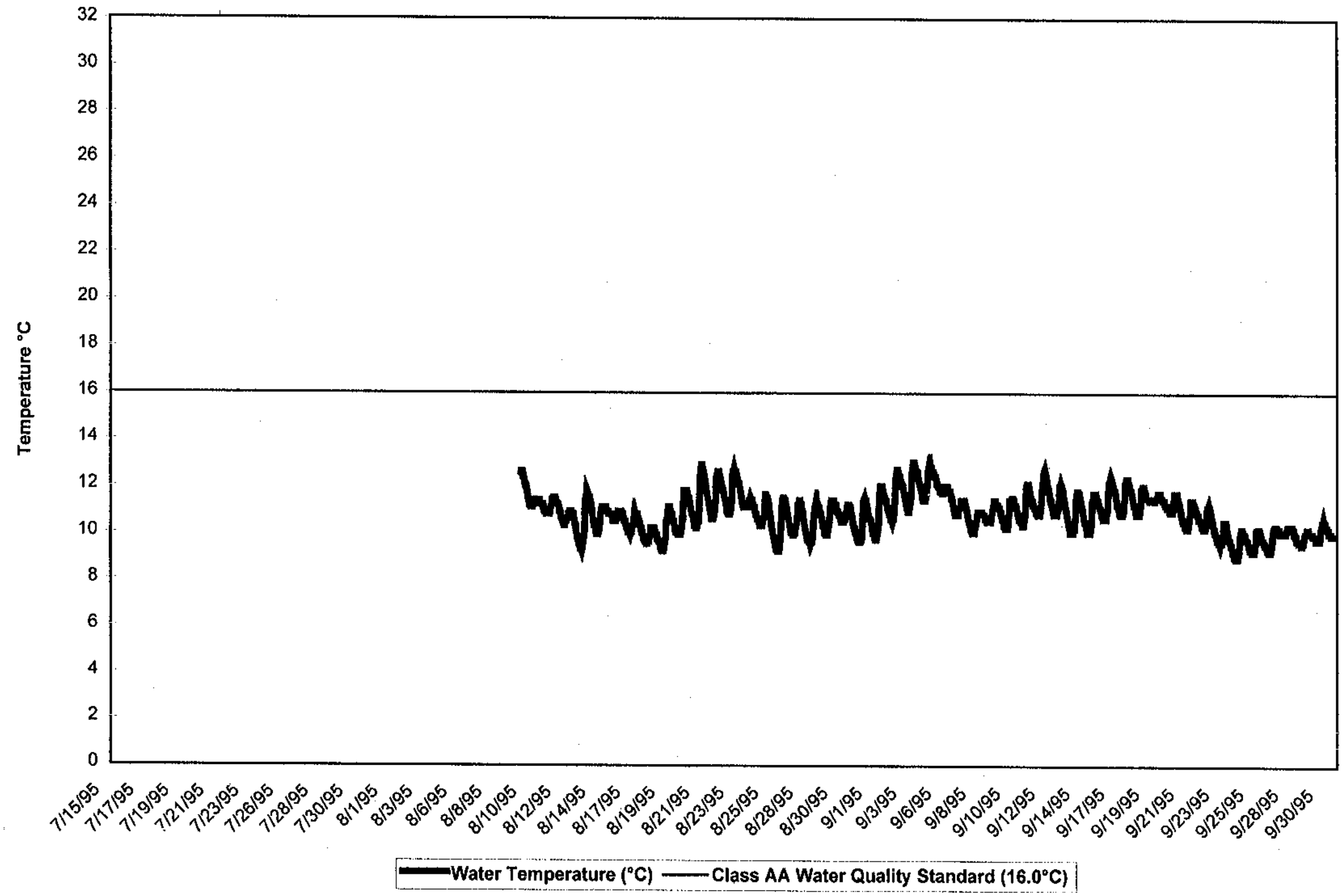
Appendix C.21

Clearwater River (RM 1.2) Hourly Maximum Air and Water Temperatures
July 18 to September 9, 1992



Appendix C.22

Lyle Creek (RM 0.1) Hourly Maximum Water Temperatures
August 9 to September 30, 1995



Appendix D.

Summary of Spawning Gravel Composition Data

Appendix D. Huckleberry Creek Segment #1

		*Sample		Volume in ml.												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	< 0.85	Volume (ml)
Huckleberry	H1	H1R2-3	1995	45	7	15	35	88	90	38	165	80	590	970	300	4.21	2423
Huckleberry	H1	H1R2-4	1995	190	41	80	105	380	275	130	503	145	830	1470	0	10.03	4149
Huckleberry	H1	H1R3-5	1995	60	15	50	85	215	122	52	195	70	555	1500	0	7.19	2919
Huckleberry	H1	H1R3-7	1995	200	40	170	350	895	525	175	540	115	910	1700	0	13.52	5620
Huckleberry	H1	H1R3-6	1995	120	28	85	140	450	325	130	500	125	850	1550	0	8.67	4303
Huckleberry	H1	H1P1-1	1995	100	35	112	12	74	88	38	235	105	1100	1910	0	6.8	3809
Huckleberry	H1	H1P2-2	1995	215	33	205	340	490	440	130	465	125	810	1510	0	16.65	4763
Mean				132.86	28.43	102.43	152.43	370.29	266.43	99	371.86	109.29	806.43	1515.7	42.86	9.58	3998
Std. Dev.				69.27	12.88	66.3	138.25	285.1	175.27	55.24	165.01	26.52	186.83	286	113.39	4.26	1081.09
C.V. %				52.14	45.31	64.73	90.7	76.99	65.78	55.8	44.37	24.27	23.17	18.87	264.58	44.45	27.04

		Sample		Individual Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	< 0.85	Volume (ml)
Huckleberry	H1	H1R2-3	1995	1.86	0.29	0.62	1.44	3.63	3.71	1.57	6.81	3.3	24.35	40.03	12.38	4.21	2423
Huckleberry	H1	H1R2-4	1995	4.58	0.99	1.93	2.53	9.16	6.63	3.13	12.12	3.49	20	35.43	0	10.03	4149
Huckleberry	H1	H1R3-5	1995	2.06	0.51	1.71	2.91	7.37	4.18	1.78	6.68	2.4	19.01	51.39	0	7.19	2919
Huckleberry	H1	H1R3-7	1995	3.56	0.71	3.02	6.23	15.93	9.34	3.11	9.61	2.05	16.19	30.25	0	13.52	5620
Huckleberry	H1	H1R3-6	1995	2.79	0.65	1.98	3.25	10.46	7.55	3.02	11.62	2.9	19.75	36.02	0	8.67	4303
Huckleberry	H1	H1P1-1	1995	2.63	0.92	2.94	0.32	1.94	2.31	1	6.17	2.76	28.88	50.14	0	6.8	3809
Huckleberry	H1	H1P2-2	1995	4.51	0.69	4.3	7.14	10.29	9.24	2.73	9.76	2.62	17.01	31.7	0	16.65	4763
Mean				3.14	0.68	2.36	3.4	8.4	6.14	2.34	8.97	2.79	20.74	39.28	1.77	9.58	3998
Std. Dev.				1.11	0.24	1.18	2.46	4.66	2.78	0.87	2.44	0.5	4.44	8.46	4.68	4.26	1081.09
C.V. %				35.24	34.69	50.01	72.3	55.55	45.34	37.31	27.22	17.97	21.42	21.54	264.58	44.45	27.04

		Sample		Cumulative Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	< 0.85	Volume (ml)
Huckleberry	H1	H1R2-3	1995	1.86	2.15	2.77	4.21	7.84	11.56	13.12	19.93	23.24	47.59	87.62	100	4.21	2423
Huckleberry	H1	H1R2-4	1995	4.58	5.57	7.5	10.03	19.19	25.81	28.95	41.07	44.56	64.57	100	100	10.03	4149
Huckleberry	H1	H1R3-5	1995	2.06	2.57	4.28	7.19	14.56	18.74	20.52	27.2	29.6	48.61	100	100	7.19	2919
Huckleberry	H1	H1R3-7	1995	3.56	4.27	7.3	13.52	29.45	38.79	41.9	51.51	53.56	69.75	100	100	13.52	5620
Huckleberry	H1	H1R3-6	1995	2.79	3.44	5.41	8.67	19.13	26.68	29.7	41.32	44.22	63.98	100	100	8.67	4303
Huckleberry	H1	H1P1-1	1995	2.63	3.54	6.48	6.8	8.74	11.05	12.05	18.22	20.98	49.86	100	100	6.8	3809
Huckleberry	H1	H1P2-2	1995	4.51	5.21	9.51	16.65	26.94	36.17	38.9	48.67	51.29	68.3	100	100	16.65	4763
Mean				3.14	3.82	6.18	9.58	17.98	24.12	26.45	35.42	38.21	58.95	98.23	100	9.58	3998
Std. Dev.				1.11	1.28	2.24	4.26	8.31	11.01	11.77	13.57	13.41	9.83	4.68	0	4.26	1081.09
C.V. %				35.24	33.39	36.2	44.45	46.23	45.66	44.49	38.31	35.09	16.67	4.76	0	44.45	27.04

* Segment number is a combination of segment number riffle or patch number followed by the sample number within that riffle or patch

Appendix D. Greenwater River Segment #1

Stream	Segment	*Sample Number	Year	Volume in ml. <0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.00	>26.50	>75.00	% Fines < 0.85	Total Sample Volume (ml)
Greenwate	G1	G1R1-9	1995	65	45	165	230	485	315	115	400	105	825	930	0	13.72	3680
Greenwate	G1	G1R1-10	1995	170	100	420	370	320	135	68	345	120	1155	935	310	23.83	4448
Greenwate	G1	G1R3-12	1995	105	48	13	175	518	335	105	460	115	790	1200	0	8.83	3864
Greenwate	G1	G1R3-11	1995	80	49	180	230	340	240	85	125	115	920	1205	0	15.1	3569
Greenwate	G1	G1P1-1	1995	100	48	140	150	195	165	70	340	120	715	1630	655	10.12	4328
Greenwate	G1	G1P6-13	1995	200	40	145	195	465	435	415	420	115	810	760	280	13.55	4280
Greenwate	G1	G1P6-14	1995	75	39	120	175	450	290	105	420	115	880	1255	0	10.42	3924
Greenwate	G1	G1P7-7	1995	145	50	115	195	620	440	95	420	140	790	1370	0	11.53	4380
Greenwate	G1	G1P7-8	1995	165	75	165	260	600	405	120	470	140	1250	1230	0	13.63	4880
Greenwate	G1	1P11-1	1995	180	90	270	365	495	415	170	660	185	815	485	0	21.91	4130
Greenwate	G1	1P11-1	1995	75	29	175	290	570	495	165	465	90	740	405	0	16.26	3499
Greenwate	G1	1P11-1	1995	90	35	140	170	275	245	100	395	145	825	955	415	11.48	3790
Mean				120.8	54	170.7	233.8	444.4	326.3	134.4	410	125.4	876.3	1030	138.3	14.2	4064.33
Std. Dev.				48	22.27	97.83	74.26	134.2	115	93.9	121.6	24.35	163	358.2	222.8	4.6	413.44
C.V. %				39.72	41.24	57.32	31.77	30.2	35.25	69.86	29.65	19.42	18.6	34.77	161.1	32.39	10.17

Stream	Segment	*Sample Number	Year	Individual Percent Volume <.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.00	>26.50	>75.00	% Fines < 0.85	Total Sample Volume (ml)
Greenwate	G1	G1R1-9	1995	1.77	1.22	4.48	6.25	13.18	8.56	3.13	10.87	2.85	22.42	25.27	0	13.72	3680
Greenwate	G1	G1R1-10	1995	3.82	2.25	9.44	8.32	7.19	3.04	1.53	7.76	2.7	25.97	21.02	6.97	23.83	4448
Greenwate	G1	G1R3-12	1995	2.72	1.24	0.34	4.53	13.41	8.67	2.72	11.9	2.98	20.45	31.06	0	8.83	3864
Greenwate	G1	G1R3-11	1995	2.24	1.37	5.04	6.44	9.53	6.72	2.38	3.5	3.22	25.78	33.76	0	15.1	3569
Greenwate	G1	G1P1-1	1995	2.31	1.11	3.23	3.47	4.51	3.81	1.62	7.86	2.77	16.52	37.66	15.13	10.12	4328
Greenwate	G1	G1P6-13	1995	4.67	0.93	3.39	4.56	10.86	10.16	9.7	9.81	2.69	18.93	17.76	6.54	13.55	4280
Greenwate	G1	G1P6-14	1995	1.91	0.99	3.06	4.46	11.47	7.39	2.68	10.7	2.93	22.43	31.98	0	10.42	3924
Greenwate	G1	G1P7-7	1995	3.31	1.14	2.63	4.45	14.16	10.05	2.17	9.59	3.2	18.04	31.28	0	11.53	4380
Greenwate	G1	G1P7-8	1995	3.38	1.54	3.38	5.33	12.3	8.3	2.46	9.63	2.87	25.61	25.2	0	13.63	4880
Greenwate	G1	1P11-1	1995	4.36	2.18	6.54	8.84	11.99	10.05	4.12	15.98	4.48	19.73	11.74	0	21.91	4130
Greenwate	G1	1P11-1	1995	2.14	0.83	5	8.29	16.29	14.15	4.72	13.29	2.57	21.15	11.57	0	16.26	3499
Greenwate	G1	1P11-1	1995	2.37	0.92	3.69	4.49	7.26	6.46	2.64	10.42	3.83	21.77	25.2	10.95	11.48	3790
Mean				2.92	1.31	4.19	5.78	11.01	8.11	3.32	10.11	3.09	21.57	25.29	3.3	14.2	4064.33
Std. Dev.				0.97	0.47	2.25	1.82	3.36	2.99	2.21	3.07	0.55	3.08	8.45	5.31	4.6	413.44
C.V. %				33.39	35.58	53.72	31.51	30.52	36.81	66.47	30.37	17.8	14.3	33.41	160.8	32.39	10.17

Stream	Segment	*Sample Number	Year	Cumulative Percent Volume <.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.00	>26.50	>75.00	% Fines < 0.85	TotalSample Volume (ml)
Greenwate	G1	G1R1-9	1995	1.77	2.99	7.47	13.72	26.9	35.46	38.59	49.46	52.31	74.73	100	100	13.72	3680
Greenwate	G1	G1R1-10	1995	3.82	6.07	15.51	23.83	31.03	34.06	35.59	43.35	46.04	72.01	93.03	100	23.83	4448
Greenwate	G1	G1R3-12	1995	2.72	3.96	4.3	8.83	22.23	30.9	33.62	45.52	48.5	68.94	100	100	8.83	3864
Greenwate	G1	G1R3-11	1995	2.24	3.61	8.66	15.1	24.63	31.35	33.73	37.24	40.46	66.24	100	100	15.1	3569
Greenwate	G1	G1P1-1	1995	2.31	3.42	6.65	10.12	14.63	18.44	20.06	27.91	30.68	47.2	84.87	100	10.12	4328
Greenwate	G1	G1P6-13	1995	4.67	5.61	9	13.55	24.42	34.58	44.28	54.09	56.78	75.7	93.46	100	13.55	4280
Greenwate	G1	G1P6-14	1995	1.91	2.91	5.96	10.42	21.89	29.28	31.96	42.66	45.59	68.02	100	100	10.42	3924
Greenwate	G1	G1P7-7	1995	3.31	4.45	7.08	11.53	25.68	35.73	37.9	47.49	50.68	68.72	100	100	11.53	4380
Greenwate	G1	G1P7-8	1995	3.38	4.92	8.3	13.63	25.92	34.22	36.68	46.31	49.18	74.8	100	100	13.63	4880
Greenwate	G1	1P11-1	1995	4.36	6.54	13.08	21.91	33.9	43.95	48.06	64.04	68.52	88.26	100	100	21.91	4130
Greenwate	G1	1P11-1	1995	2.14	2.97	7.97	16.26	32.55	46.7	51.41	64.7	67.28	88.43	100	100	16.26	3499
Greenwate	G1	1P11-1	1995	2.37	3.3	6.99	11.48	18.73	25.2	27.84	38.26	42.08	63.85	89.05	100	11.48	3790
Mean				2.92	4.23	8.41	14.2	25.21	33.32	36.64	46.75	49.84	71.41	96.7	100	14.2	4064.33
Std. Dev.				0.97	1.28	3.07	4.6	5.57	7.5	8.56	10.58	10.69	10.91	5.31	0	4.6	413.44
C.V. %				33.39	30.24	36.45	32.39	22.11	22.51	23.36	22.62	21.45	15.28	5.49	0	32.39	10.17

* Sample number is a combination of segment number riffle or patch number followed by the sample number within that riffle or patch.

Appendix D. Clearwater River Segment #3

Stream	Segment	* Sample Number	Year	Volume in ml. <0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	% Fines <0.85	Total Sample Volume (ml)
Clearwater	C3	C3R3-8	1995	40	13	5	3	3	12	10	16	22	257	2315	305	2.03	3001
Clearwater	C3	C3R3-9	1995	15	1	1	1	1	6	0	12	6	145	725	1880	0.64	2793
Clearwater	C3	C3P1-13	1995	150	22	49	79	210	215	105	440	130	840	860	335	8.73	3435
Clearwater	C3	C3P3-1	1995	475	75	7	3	4	4	7	8	9	350	1480	0	23.12	2422
Clearwater	C3	C3P4-2	1995	30	3	2	18	90	120	140	350	150	940	900	300	1.74	3043
Clearwater	C3	C3P5-3	1995	30	6	23	55	210	165	67	200	65	590	975	445	4.03	2831
Clearwater	C3	C3P6-4	1995	140	48	135	170	385	355	172	580	145	780	1425	410	10.39	4745
Clearwater	C3	C3P9-6	1995	80	4	7	20	45	48	30	195	110	1290	1235	0	3.62	3064
Clearwater	C3	C3P9-5	1995	30	2	2	2	3	17	0	0	0	560	2080	405	1 16	3101
Clearwater	C3	C3P11-7	1995	60	5	14	25	27	20	24	115	60	890	1870	0	3.34	3110
Clearwater	C3	C3P12-10	1995	50	20	40	60	230	180	90	370	115	760	1610	0	4.82	3525
Clearwater	C3	C3P13-11	1995	50	3	3	3	3	11	14	85	70	625	1360	543	2.13	2770
Clearwater	C3	C3P13-12	1995	45	1	3	7	145	180	75	185	40	750	720	670	1.99	2821
Mean				91.92	15.62	22.38	34.31	104.3	102.5	56.46	196.6	70.92	675.2	1350	407.2	5.21	3127.77
Std. Dev.				122.3	22.2	37.18	48.21	122.4	110	56.86	187.1	54.23	306.9	517.1	495.7	6.1	563.94
C.V. %				133	142.2	166.1	140.5	117.4	107.3	100.7	95.15	76.46	45.45	38.29	121.7	117.08	18.03

Stream	Segment	* Sample Number	Year	Individual Percent Volume <0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	% Fines <0.85	Total Sample Volume (ml)
Clearwater	C3	C3R3-8	1995	1.33	0.43	0.17	0.1	0.1	0.4	0.33	0.53	0 73	8.56	77.14	10 16	2.03	3001
Clearwater	C3	C3R3-9	1995	0.54	0.04	0.04	0.04	0.04	0.21	0	0.43	0.21	5.19	25.96	67.31	0.64	2793
Clearwater	C3	C3P1-13	1995	4.37	0.64	1.43	2.3	6.11	6.26	3.06	12.81	3.78	24.45	25.04	9.75	8.73	3435
Clearwater	C3	C3P3-1	1995	19.61	3.1	0.29	0.12	0.17	0.17	0.29	0.33	0.37	14.45	61.11	0	23 12	2422
Clearwater	C3	C3P4-2	1995	0 99	0 1	0 07	0 59	2 96	3.94	4.6	11.5	4.93	30.89	29.58	9.86	1.74	3043
Clearwater	C3	C3P5-3	1995	1.06	0.21	0.81	1.94	7.42	5.83	2.37	7.06	2.3	20.84	34.44	15.72	4.03	2831
Clearwater	C3	C3P6-4	1995	2.95	1.01	2.85	3.58	8.11	7.48	3.62	12.22	3.06	16.44	30.03	8.64	10.39	4745
Clearwater	C3	C3P9-6	1995	2.61	0.13	0.23	0.65	1.47	1 57	0.98	6 36	3.59	42 1	40.31	0	3.62	3064
Clearwater	C3	C3P9-5	1995	0.97	0.06	0.06	0.06	0.1	0.55	0	0	0	18.06	67.08	13.06	1.16	3101
Clearwater	C3	C3P11-7	1995	1.93	0.16	0.45	0.8	0.87	0.64	0.77	3.7	1.93	28.62	60.13	0	3.34	3110
Clearwater	C3	C3P12-10	1995	1.42	0.57	1.13	1.7	6.52	5.11	2.55	10.5	3.26	21.56	45.67	0	4.82	3525
Clearwater	C3	C3P13-11	1995	1.81	0.11	0.11	0.11	0.11	0.4	0.51	3.07	2.53	22.56	49.1	19.6	2 13	2770
Clearwater	C3	C3P13-12	1995	1.6	0.04	0.11	0.25	5.14	6.38	2.66	6.56	1.42	26.59	25.52	23.75	1.99	2821
Mean				3.17	0.51	0.59	0.94	3.01	2.99	1.67	5.78	2.16	21.56	43.93	13.68	5.21	3127.77
Std. Dev.				5.05	0.83	0.81	1.11	3.18	2.86	1.54	4.83	1.55	9.66	17.67	17.87	6.1	563.94
C.V. %				159.3	164	136.2	117.7	105.7	95.62	92.14	83.56	71.66	44.8	40.22	130.6	117.08	18.03

Stream	Segment	* Sample Number	Year	Cumulative Percent Volume <0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	% Fines <0.85	Total Sample Volume (ml)
Clearwater	C3	C3R3-8	1995	1.33	1.77	2	2.03	2.13	2.53	2.87	3.4	4 13	12.7	89 84	100	2 03	3001
Clearwater	C3	C3R3-9	1995	0 54	0.57	0.61	0.64	0.68	0.9	0 9	1.32	1.54	6.73	32.69	100	0.64	2793
Clearwater	C3	C3P1-13	1995	4.37	5.01	6.43	8.73	14.85	21.11	24.16	36.97	40.76	65.21	90.25	100	8.73	3435
Clearwater	C3	C3P3-1	1995	19.61	22.71	23	23.12	23.29	23.45	23.74	24.07	24.44	38.89	100	100	23.12	2422
Clearwater	C3	C3P4-2	1995	0.99	1.08	1.15	1.74	4.7	8.64	13.24	24.75	29.67	60.57	90.14	100	1.74	3043
Clearwater	C3	C3P5-3	1995	1 06	1.27	2.08	4.03	11.44	17.27	19.64	26 7	29	49.84	84.28	100	4.03	2831
Clearwater	C3	C3P6-4	1995	2 95	3.96	6.81	10.39	18.5	25.99	29.61	41.83	44.89	61.33	91.36	100	10.39	4745
Clearwater	C3	C3P9-6	1995	2.61	2.74	2 97	3.62	5.09	6.66	7.64	14	17.59	59.69	100	100	3.62	3064
Clearwater	C3	C3P9-5	1995	0.97	1.03	1 1	1.16	1.26	1.81	1.81	1.81	1.81	19.86	86.94	100	1.16	3101
Clearwater	C3	C3P11-7	1995	1.93	2 09	2 54	3 34	4.21	4.86	5.63	9.32	11.25	39.87	100	100	3.34	3110
Clearwater	C3	C3P12-10	1995	1.42	1.99	3.12	4 82	11.35	16.45	19.01	29.5	32.77	54.33	100	100	4.82	3525
Clearwater	C3	C3P13-11	1995	1.81	1.91	2.02	2.13	2.24	2.64	3.14	6.21	8.74	31.3	80.4	100	2.13	2770
Clearwater	C3	C3P13-12	1995	1.6	1.63	1.74	1.99	7.13	13.51	16.16	22.72	24.14	50.73	76.25	100	1.99	2821
Mean				3.17	3.67	4.27	5.21	8.22	11.22	12.89	18.66	20.83	42.39	86.32	100	5.21	3127.77
Std. Dev.				5.05	5.85	5.94	6.1	7.16	8.88	9.84	13.6	14.57	19.53	17.87	0	6.1	563.94
C.V. %				159.3	159.2	139	117.1	87.05	79.21	76.32	72.86	69.96	46.08	20.71	0	117.08	18.03

* Segment number is a combination of segment number riffle or patch number followed by tha sample number within that riffle or patch

Appendix D. Clearwater River Segment #5 - 1993 Muckleshoot Tribe Data

		Sample		Volume in ml.												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	>0.85	Volume (ml)
Clearwater	C5	C5R1-1	1993	40	13	25	110	145	165	85	535	145	1070	730	275	5.6	3338
Clearwater	C5	C5R1-2	1993	40	19	28	40	215	260	15	525	110	750	1010	0	4.2	3012
Clearwater	C5	C5R5-1	1993	140	145	485	325	240	70	35	230	150	1150	1025	550	24	4545
Clearwater	C5	C5R5-2	1993	70	13	40	90	470	140	90	365	90	600	1115	0	6.9	3083
Clearwater	C5	C5R7-1	1993	170	60	225	523	1075	395	100	365	95	480	325	0	26	3813
Mean				92	50	160.6	217.6	429	206	65	101	118	810	841	165	13	3558
Std. Dev.				60	57	199.9	202.6	381.2	125.7	38	127.6	28	291.5	322.5	246	11	634.7
C.V. %				65	113.2	124.5	93	89	61	58	32	24	36	38	149	80	17.84

		Sample		Individual Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	>0.85	Volume (ml)
Clearwater	C5	C5R1-1	1993	1.2	0.39	0.8	3.3	4.3	4.9	2.6	16	4.34	32.1	21.9	8.24	5.6	3338
Clearwater	C5	C5R1-2	1993	1.33	0.63	0.9	1.3	7.1	8.6	0.5	17	3.65	24.9	33.5	0	4.2	3012
Clearwater	C5	C5R5-1	1993	3.08	3.19	11	7.2	5.3	1.5	0.8	5.1	3.3	25.3	22.6	12.1	24	4545
Clearwater	C5	C5R5-2	1993	2.27	0.42	1.3	2.9	15	4.5	2.9	12	2.92	19.5	36.2	0	6.9	3083
Clearwater	C5	C5R7-1	1993	4.46	1.57	5.9	14	28	10	2.6	9.6	2.49	12.6	8.52	0	26	3813
Mean				2	1	4	6	12	6	2	12	3	23	25	4.1	13	3558
Std. Dev.				1	1	4	5	10	4	1	5	1	7	11	5.7	11	634.7
C.V. %				55	96	111	88	83	58	61	42	21	32	45	141	80	17.84

		Sample		Cumulative Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	>0.85	Volume (ml)
Clearwater	C5	C5R1-1	1993	1.2	1.59	2.3	5.6	10	15	17.5	33	37.8	69.9	91.8	100	5.6	3338
Clearwater	C5	C5R1-2	1993	1.33	1.96	2.9	4.2	11	20	20.5	38	41.6	66.5	100	100	4.2	3012
Clearwater	C5	C5R5-1	1993	3.08	6.27	17	24	29	31	31.7	37	40	65.4	87.9	100	24	4545
Clearwater	C5	C5R5-2	1993	2.27	2.69	4	6.9	22	27	29.6	41	44.4	63.8	100	100	6.9	3083
Clearwater	C5	C5R7-1	1993	4.46	6.03	12	26	54	64.2	66.8	76.4	78.9	91.5	100	100	26	3813
Mean				2	4	8	13	25	31	33	45	49	71	96	100	13	3558
Std. Dev.				1	2	9	11	18	19	20	18	17	11	6	0	11	634.7
C.V. %				55	61	85	80	70	62	59	39	35	16	6	0	80	17.84

* Sample number is a combination of segment number riffle or patch number followed by the sample number within that riffle or patch

Appendix D. Clearwater River Segment #7 - 1993 Muckleshoot Tribe Data

		* Sample		Volume in ml.												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	<0.85	Volume (ml)
Clearwater	C7	C7R1-1	1993	65	25	105	95	124	77	35	125	255	915	1370	0	9.09	3191
Clearwater	C7	C7R3-1	1993	50	8	32	115	325	260	75	330	80	680	1040	315	6.19	3310
Clearwater	C7	C7R3-2	1993	455	34	110	100	190	255	100	405	75	570	655	380	21	3329
Mean				190	22.33	82.33	103.3	213	197.3	70	286.7	136.7	721.7	1022	231.7	12.09	3276.67
Std. Dev.				229.6	13.2	43.66	10.41	102.5	104.2	32.79	144.9	102.5	176.2	357.9	203.2	7.85	74.8
C.V. %				120.9	59.12	53.03	10.07	48.1	52.83	46.84	50.58	75.01	24.42	35.03	87.73	64.88	2.28

		* Sample		Individual Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	<0.85	Volume (ml)
Clearwater	C7	C7R1-1	1993	2.04	0.78	3.29	2.98	3.89	2.41	1.1	3.92	7.99	28.67	42 93	0	9.09	3191
Clearwater	C7	C7R3-1	1993	1.51	0.24	0.97	3.47	9.82	7.85	2.27	9.97	2.42	20.54	31.42	9.52	6.19	3310
Clearwater	C7	C7R3-2	1993	13.67	1.02	3.3	3	5.71	7.66	3	12.17	2.25	17.12	19.68	11.41	21	3329
Mean				6	0.68	2.52	3.15	6	5.98	2	8.68	4.22	22.11	31.34	6.98	12.09	3276.67
Std. Dev.				6.87	0.4	1.35	0.28	3.04	3.09	0.96	4.27	3.27	5.93	11.63	6.12	7.85	74.8
C.V. %				119.8	58.57	53.39	8.87	46.97	51.66	45.31	49.19	77.4	26.83	37.1	87.66	64.88	2.28

		* Sample		Cumulative Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	<0.85	Volume (ml)
Clearwater	C7	C7R1-1	1993	2.04	2.82	6.11	9.09	12.97	15.39	16.48	20.4	28.39	57.07	100	100	9.09	3191
Clearwater	C7	C7R3-1	1993	1.51	1.75	2.72	6.19	16.01	23.87	26.13	36.1	38.52	59.06	90.48	100	6.19	3310
Clearwater	C7	C7R3-2	1993	13.67	14.69	17.99	21	26.7	34.36	37.37	49.53	51.79	68.91	88.59	100	21	3329
Mean				6	6.42	8.94	12.09	19	24.54	27	35.35	39.57	61.68	93.02	100	12.09	3276.67
Std. Dev.				6.87	7.18	8.02	7.85	7.21	9.51	10.45	14.58	11.73	6.34	6.12	0	7.85	74.8
C.V. %				119.8	111.8	89.71	64.88	38.85	38.74	39.2	41.25	29.65	10.28	6.58	0	64.88	2.28

* Sample number is a combination of segment number riffle or patch number followed by the sample number within that riffle or patch.

Appendix D. Clearwater River Segment #6 - 1993 Muckleshoot Tribe Data

		* Sample		Volume in ml.												% Fines	Total Sample
Stream	Segment	Number	Year	<0.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	<0.85	Volume (ml)
Clearwater	C6	C6R1-1	1993	530	135	165	175	440	355	102	410	70	180	34	0	38.71	2596
Clearwater	C6	C6R3-1	1993	35	6	32	115	295	195	70	300	110	665	1495	0	5.67	3318
Clearwater	C6	C6R3-2	1993	60	13	75	155	510	370	110	385	96	810	1025	555	7.28	4164
Clearwater	C6	C6R5-1	1993	75	315	35	120	420	335	140	490	123	1032	965	0	13.46	4050
Clearwater	C6	C6R5-2	1993	230	92	265	245	280	225	125	62	180	1055	1160	355	19.47	4274
Mean				186	112	114	162	389	296	109	329	116	748.4	935.8	182	16.92	3680.4
Std. Dev.				206.9	125.7	99.86	52.63	98.64	27	24.13	164.1	40.92	356.5	544.3	259.1	13.35	712.41
C.V. %				111.3	112	87.29	32.49	25.36	80.19	26.4	49.83	35.33	47.63	58.16	142.3	78.93	19.36

		* Sample		Individual Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	<0.85	Volume (ml)
Clearwater	C6	C6R1-1	1993	20.42	5.2	6.36	6.74	16.95	13.67	3.93	15.79	2.7	6.93	1.31	0	38.71	2596
Clearwater	C6	C6R3-1	1993	1.05	0.18	0.96	3.47	8.89	5.88	2.11	9.04	3.32	20.04	45.06	0	5.67	3318
Clearwater	C6	C6R3-2	1993	1.44	0.31	1.8	3.72	12.25	8.89	2.64	9.25	2.31	19.45	24.62	13.33	7.28	4164
Clearwater	C6	C6R5-1	1993	1.85	7.78	0.86	2.96	10.37	8.27	3.46	12.1	3.04	25.48	23.83	0	13.46	4050
Clearwater	C6	C6R5-2	1993	5.38	2.15	6.2	5.73	6.55	5.26	2.92	1.45	4.21	24.68	27.14	8.31	19.47	4274
Mean				6.03	3.12	3.24	4.52	11	8.39	3.01	9.53	3.11	19.32	24.39	4.33	16.92	3680.4
Std. Dev.				8.23	3.3	2.8	1.63	3.92	3.33	0.71	5.28	0.72	7.43	15.55	6.19	13.35	712.41
C.V. %				136.4	105.5	86.5	35.93	35.67	39.63	23.46	55.4	23.16	38.45	63.77	143	78.93	19.36

		* Sample		Cumulative Percent Volume												% Fines	Total Sample
Stream	Segment	Number	Year	<.106	>0.106	>0.25	>0.50	>0.85	>2.00	>3.35	>4.00	>8.00	>9.50	>26.50	>75.00	<0.85	Volume (ml)
Clearwater	C6	C6R1-1	1993	20.42	25.62	31.97	38.71	55.66	69.34	73.27	89.06	91.76	98.69	100	100	38.71	2596
Clearwater	C6	C6R3-1	1993	1.05	1.24	2.2	5.67	14.56	20.43	22.54	31.59	34.9	54.94	100	100	5.67	3318
Clearwater	C6	C6R3-2	1993	1.44	1.75	3.55	7.28	19.52	28.41	31.05	40.3	42.6	62.06	86.67	100	7.28	4164
Clearwater	C6	C6R5-1	1993	1.85	9.63	10.49	13.46	23.83	32.1	35.56	47.65	50.69	76.17	100	100	13.46	4050
Clearwater	C6	C6R5-2	1993	5.38	7.53	13.73	19.47	26.02	31.28	34.21	35.66	39.87	64.55	91.69	100	19.47	4274
Mean				6.03	9.15	12.39	16.92	27.92	36.31	39.32	48.85	51.96	71.28	95.67	100	16.92	3680.4
Std. Dev.				8.23	9.89	11.95	13.35	16.12	19.03	19.64	23.26	22.97	17.12	6.19	0	13.35	712.41
C.V. %				136.4	108.1	96.4	78.93	57.73	52.4	49.94	47.61	44.2	24.02	6.46	0	78.93	19.36

* Sample number is a combination of segment number riffle or patch number followed by the sample number within that riffle or patch