12-8-2009

Ex. 279-US-441

United States Forest Service

Long Creek Instream Flow

Introduction

In 1990 the State of Oregon began the process of adjudicating water rights within the Klamath River Basin for water users with pre-1909 claims to water. The U.S. Forest Service (USFS) manages three forests within the Klamath Basin; the Fremont, Klamath, and Winema National Forests.

The Water Resources Team, situated on the Winema National Forest, was charged with quantifying the instream flow and consumptive water uses of the Forest Service Pacific Northwest and Pacific Southwest Regions within Oregon. Part of that charge involved development of fisheries claims based on the Multiple-Use Sustained-Yield Act of 1960. Flow, channel morphology, and fisheries data were collected, compiled, and analyzed in preparation of the fisheries water rights claims. The fisheries claims took the form of monthly minimum values as determined using two methods. An incremental flow model (PHABSIM) was used to determine recommended minimum monthly fisheries streamflows. Flows necessary to maintain fisheries habitat, i.e. channel maintenance flows, are superimposed upon the PHABSIM derived values. Quantities for these higher, less frequent, channel maintaining flows were determined through analysis of bedload sediment transport relationships.

The following report is a summarization of the steps taken to determine fisheries habitat flow recommendations for the adjudication process. It has been prepared to disseminate data to resource personnel for use in forest management decisions.

Methods

Long Creek, a 4th order, spring-fed stream that drains the southeastern slope of Yamsay Mountain (elevation 8196'), flows 16 miles before discharging into the western edge of the Sycan Marsh. The headwaters, river mile (RM) 13.5 to 16.0, lie within the Fremont National Forest. The remaining portion of the stream flows through land managed by U.S. Timberlands and The Nature Conservancy. The 2.5 miles within the Fremont National Forest were surveyed in 1990, using Hankin and Reeves USFS Stream Survey. The headwaters of Long Creek are a steep gradient (4-8%), step-pool and cascade system. This low sinuosity section is confined to a narrow, V-shaped valley with stable banks. Resident brook trout, bull trout, and redband trout occur in the stream. Redband trout occur downstream of National Forest land (Light et. al. 1996). Brook trout were stocked in the 1930's and rainbow trout were stocked in the lower section in the 1940's and 1950's. Bull trout in Long Creek range from RM 13.0 to 15.0 (Light et al. 1996). A four foot falls below the Forest Service boundary (42°54'N, 121°18'W) was believed to be an effective barrier to upstream brook trout migration, but sampling in 1991, 1993, and 1994 determined that brook trout were present above the waterfall (Light et. al. 1996). An eradication effort is currently underway to remove brook trout above the falls (J. Zauner, Oregon Department of Fish and Wildlife, personal communication) to prevent hybridization with bull trout, which is known to occur on Long Creek (Light et al. 1996).

The Physical Habitat Simulation System (PHABSIM) was used to model fish habitat in the stream and to make monthly minimum flow recommendations. The protocol for using PHABSIM is described in detail elsewhere (Milhous et al. 1989) and only a brief overview will be made here. The purpose of PHABSIM is to simulate a relationship between streamflow and physical habitat for various species and lifestages of fish. It consists of overlaying hydraulic simulations that represent the physical properties of the stream channel with Habitat Suitability Index (HSI) curves that represent the biological adequacy of these physical properties for a particular species and lifestage. Combining the physical properties with the suitability curves produces the habitat quantity and quality available for use.

In field measurements, each transect is divided into cells in which depth and velocity are measured over a number of discharges. Cell-by-cell depths and velocities are then simulated over a range of flows using standard hydraulic modeling techniques packaged into the PHABSIM computer software [proper PHABSIM modeling and calibration is technically the most difficult step in analyzing instream flows (Milhous et al. 1989), and is too complicated to discuss here]. Substrate is measured once and assumed to not change over the study period of one field season. It is assumed that the worth of a cell for fish habitat is determined by what the suitability of the depth, velocity, and substrate (represented by HSI curves) would be at a particular discharge. HSI curve values vary from zero (unsuitable) to one (optimal) and were developed for each species and lifestage for the Upper Klamath River Basin by a regional panel of experts using published curves, existing data, and professional judgement. Each cell has an overall suitability derived from the product of the suitability for depth, velocity, and substrate. For example, a cell with a depth suitability of 1.0, velocity suitability of 0.5, and substrate suitability of 0.5 would have an overall suitability of 0.25 (i.e., $1.0 \times 0.5 \times 0.5 = 0.25$). The PHABSIM model uses simulated depths and velocities, and recorded substrate, to determine the overall suitability for each individual cell at a given discharge.

The sum of the surface area of each cell that contains fish habitat, called Weighted Usable Area (WUA), is expressed as units of ft^2/1000 feet of stream length. We produced two quantities of habitat. "Total Weighted Usable Area" is all available habitat, regardless of the overall suitability of each individual cell. Therefore any cell with any suitability (i.e., overall suitability greater than zero) is included in the summation of usable surface area. Cells with overall suitability of 0.75 or greater is included in ">75% Weighted Usable Area". "Total WUA" is therefore defined as the total amount of habitat available for use, whether the quality is high or low, whereas ">75% WUA" is that amount of the total habitat that ranks as optimal habitat.

Continuous water temperature was collected with a datalogger at river elevation 6140' (RM 13.5) from 1992-1997. The datalogger also recorded continuous water elevation in the creek, from which a hydrograph was developed for water years 1993-1995 (Figure 1) and 3-year monthly median discharge values were calculated. Using a regional predictive model developed by P. Bakke of the Winema National Forest's Water Resources Team (unpublished data), these 3-year monthly medians were used to predict long-term (30-year) monthly medians for Long Creek, providing a starting point from which to recommend monthly values for fish habitat. Based on the amount of discharge present for a particular month, we analyzed how much total and optimal habitat would be available for all lifestages present during that month, and adjusted our flow recommendation to maximize fish habitat. We rarely recommended a minimum flow of more water than is available, according to the long-term monthly prediction. Other anecdotal data (e.g., water temperature, upstream diversions) were also considered when selecting a monthly discharge value. Habitat requirements of threatened/endangered and sensitive fish species that currently exist in the stream were given priority over other species.

Sediment movement data were collected, analyzed, and used to determine a habitat maintenance (channel maintenance) discharge. Flows above the habitat maintenance discharge were determined to be those necessary to maintain a functioning stream channel and thereby maintain the fish habitat. For more information on channel maintenance results, see the corresponding channel maintenance folder for this stream. In instances where the PHABSIM-determined fish habitat discharge value exceeded the fish habitat maintenance discharge value, the habitat maintenance value was used as the monthly recommendation. For example, if 20.0 cfs was determined to provide adequate fish habitat for a given month, and flows of 30.0 cfs and greater were determined to be the flows needed for habitat maintenance, then 20.0 cfs would be the minimum fish flow recommendation. All natural flows between 0 and 20.0 cfs would be defined as necessary for fish habitat. When natural flows exceeded 30 cfs, all water would be defined as necessary for maintaining fish habitat. If the fish habitat maintenance value had been 15 cfs, then 15 cfs would be selected as the final flow recommendation value for that month.

Results/Discussion

Water temperatures were remarkably cold throughout the year. Monthly average temperatures ranged from wintertime lows of 1 to 2°C to a high of 8.6°C in July of 1994 (Table 1, Figure 2), an extremely dry year. Instantaneous temperatures were never greater than 11°C, and generally ranged from 8 to 10°C during the summer and 2 to 3°C during the winter (Figures 3 through 8). These water temperatures are below the standard of 17.8°C set by the Oregon Department of Environmental Quality for trout (Boyd and Sturdevant 1996).

Four cross sections, 3 riffles and 1 pool, were established in 1992 near the datalogger site to represent the fish habitat in the stream reach (Figure 9). Water surface elevations and cell velocities

(Figures 10 to 13) were collected on three occasions at discharges of 12.7, 22.7 , and 55.0 cfs, and were used for PHABSIM model calibration and simulations. The riffle cross sections were characterized by shallow depths (less than 1 ft) and high velocities (up to 6 ft/s) at all the calibration discharges. Depths were greater and velocities were considerably slower in the pool transect than in the riffle transects, but still did not appear to provide much fish habitat. The substrate, in the riffle transects, was dominated by cobble and boulder with some large gravel. Generally, the HSI curves ranked velocities of less than 2 to 3 ft/s as suitable for spawning for both bull trout and brook trout (Figures 14 and 15). The suitability of depth varied between species and lifestages, and any substrate was considered suitable for all lifestages except spawning, which generally required small to large gravel sized substrate to provide suitable habitat (Figures 14 and 15). Overall, bull trout prefer greater depths and higher velocities than do brook trout (Figures 14 and 15). HSI curves were not available for bull trout fry.

Bull trout, proposed by the US Fish and Wildlife Service for listing as endangered, and native to Long Creek, took precedence over brook trout in our flow recommendations. Although redband trout are a Region 6 USFS sensitive species, they were not considered in our analysis because they reside downstream of the Forest Service boundary (Light et. al. 1996). Bull trout and brook trout have similar timing for spawning and incubation (Table 2). Juvenile and adult lifestages are present all year for both species (Table 2).

Total and optimal fish habitat was simulated for bull and brook trout from 5 to 95 cfs (Figures 16 and 17). The range of simulation was limited at the low end by the lowest discharge recorded during this study, and at the high end by overbank flow conditions, above which we generally did not simulate fish habitat.

Discharge in Long Creek during our study generally ranged from a summer baseflow of less than 10 cfs to greater than 100 cfs during peak spring runoff, though water year 1994 was a particularly dry year and discharge never exceeded 30 cfs (Figure 1). Long-term median monthly discharges ranged from a low of 4 cfs during the summer to a high of 33 cfs in June (Table 3). Based on PHABSIM modeling, moderate amounts of total habitat and very little quality habitat existed for all lifestages of bull and brook trout at or below 20 cfs (Figures 16 and 17). Thus, for all months with median discharges less than 20 cfs, we recommended the monthly median value as necessary for fish habitat (Table 3). Since the flow necessary for maintenance of fish habitat was 16 cfs, all months with fish habitat recommendations greater than 16 cfs were replaced by this fish habitat maintenance recommendation (Table 3). Month by month justification for final fish recommendations also appears in Table 3.

References

Boyd, M., and D. Sturdevant. 1996. The scientific basis for Oregon's stream temperature standard: common questions and straight answers. Oregon Department of Environmental Quality Report.

Light, J., L. Herger, and M. Robinson. 1996. Upper Klamath Basin bull trout conservation strategy: Part I, a conceptual framework for recovery. Final report for the Klamath Basin Bull Trout Working Group. 88p.

Milhous, R. T., M. A. Updike, and D. M. Schneider. 1989. Physical habitat simulation system reference manual - version II. Instream Flow Information Paper 26. U.S. Fish & Wildlife Service, Biol. Rep. 89(16).

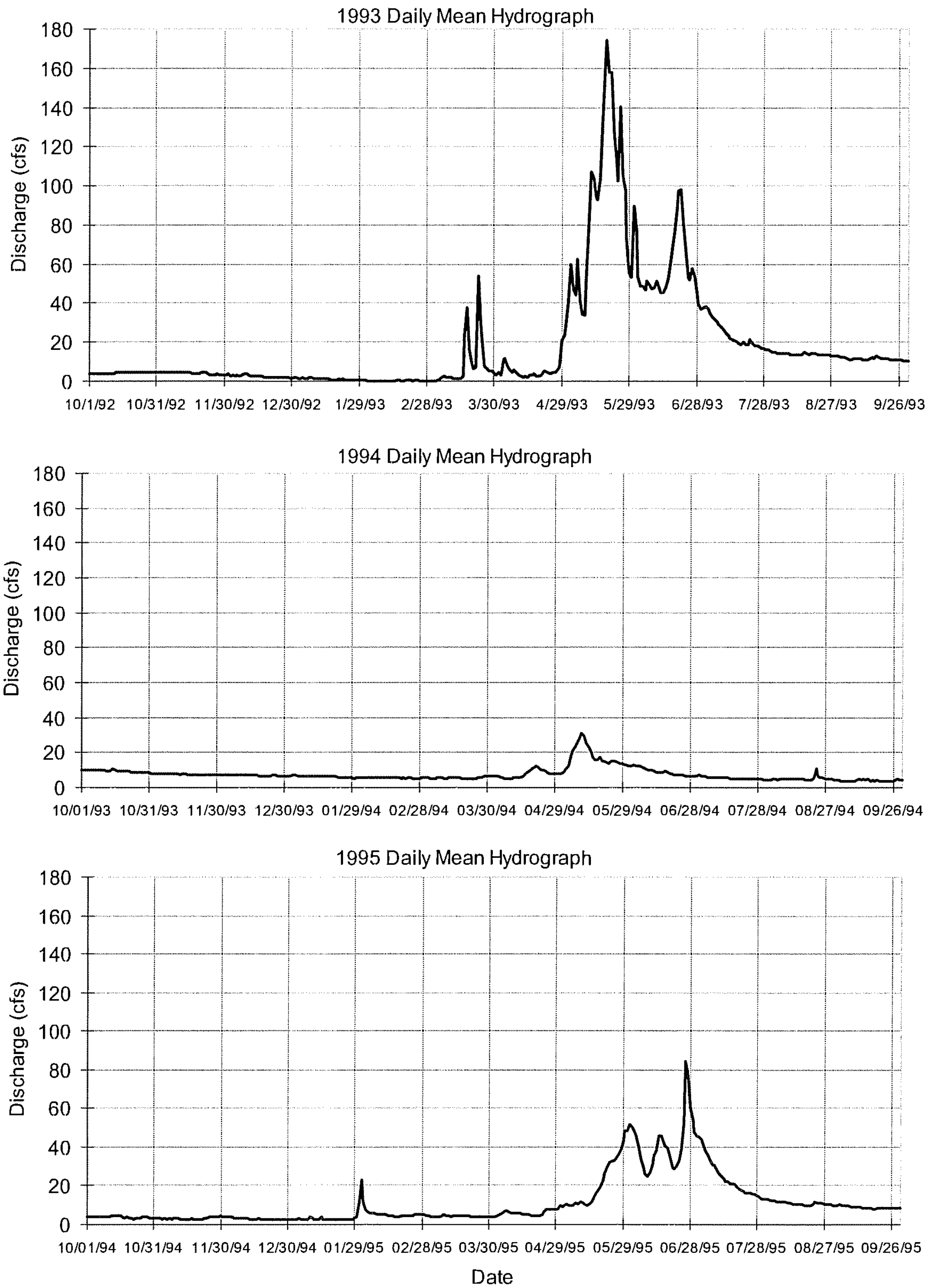


Figure 1. Daily mean discharge for water years 1993-1995 at Long Creek.

Table 1. Monthly maximum and mean temperature values at Long Creek.

	Maximum temperature (°C)					
Month	1992	1993	1994	1995	1996	1997
Jan		2.4	4.1	2.6	3.1	3.0
Feb		2.8		3.3		3.0
Mar		3.0	3.7	3.2	3.7	4.0
Apr		3.8	4.7	4.9	4.2	4.6
May		4.8	7.6	4.9	5.0	5.5
Jun		9.3	10.2	6.4	9.6	9.0
Jul		8.8	10.6	10.2	10.4	11.5
Aug		9.8	10.1	9.6	10.8	10.8
Sep		8.6	8.1	8.3	8.4	9.0
Oct		6.6	7.0	5.9	7.5	7.8
Nov	3.0	4.2	4.1	5.5	4.0	6.4
Dec	2.4	3.3	2.6	3.9	2.7	4.4

	Average temperature (°C)					
Month	1992	1993	1994	1995	1996	1997
Jan		1.6	3.4	2.1	2.3	2.0
Feb		1.8		2.3		2.0
Mar		2.3	2.8	2.0	2.8	2.5
Apr		2.2	3.5	3.0	3.2	2.6
May		2.4	4.6	3.6	3.7	3.8
Jun		4.1	6.6	4.1	5.2	5.5
Jul		6.4	8.6	7.0	7.5	8.7
Aug		6.7	7.5	6.8	7.4	8.1
Sep		5.8	6.4	6.2	5.6	7.0
Oct		4.8	4.2	4.4	4.0	4.7
Nov	1.4	2.7	1.9	3.7	2.4	4.0
Dec	1.3	2.7	2.0	2.2	1.8	3.2

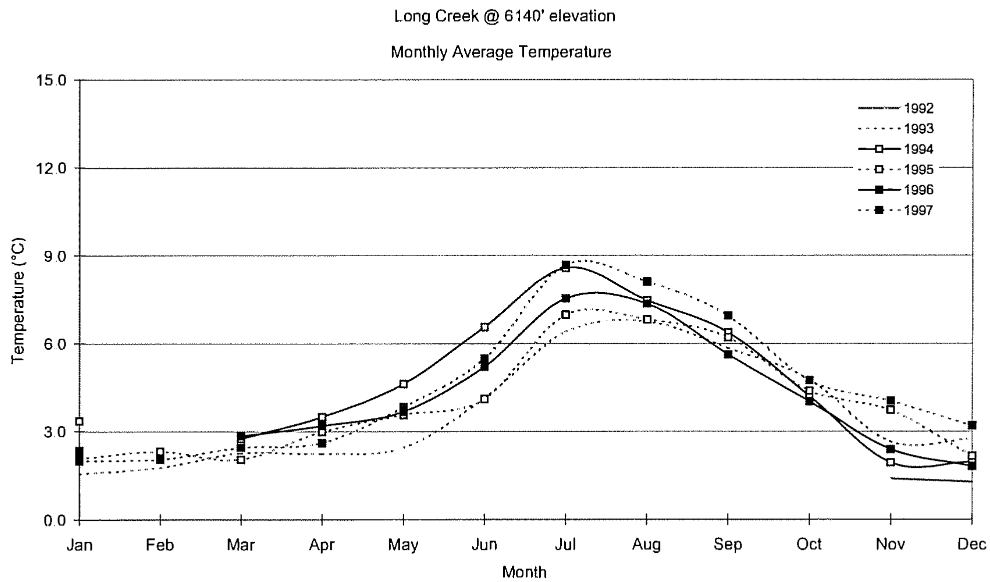


Figure 2. Monthly average temperature from 1992-1997 at Long Creek.

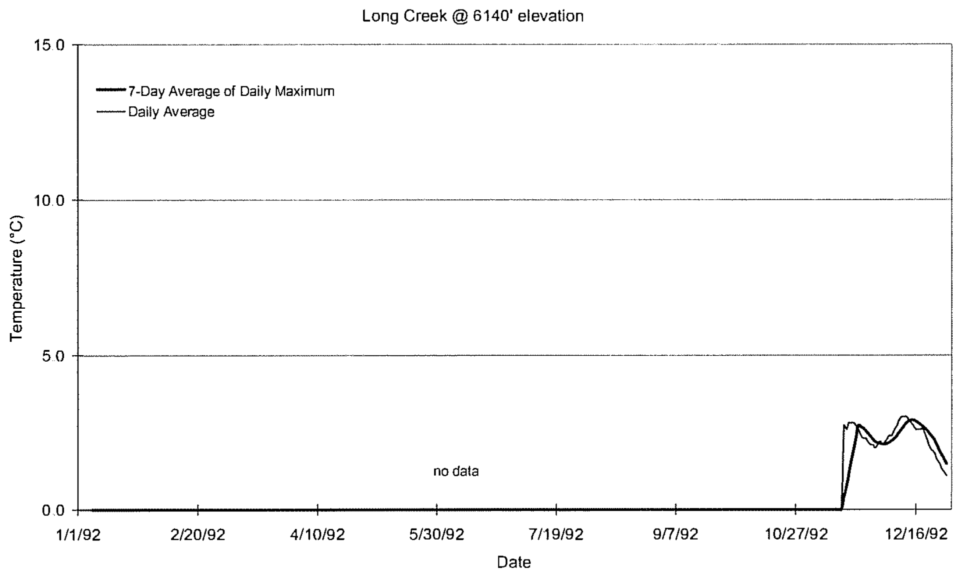


Figure 3. Daily average and 7-day average of the daily maximum temperatures at Long Creek in 1992.

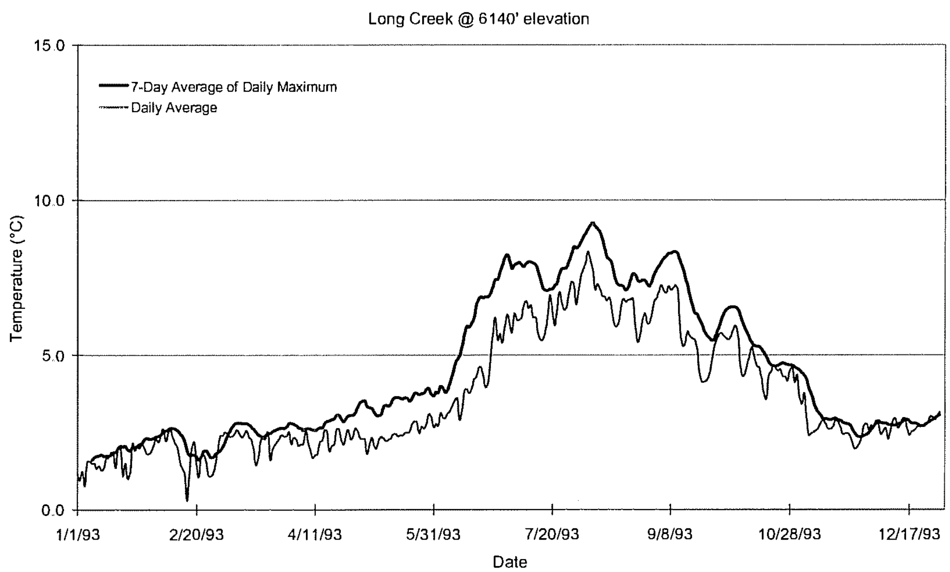


Figure 4. Daily average and 7-day average of the daily maximum temperatures at Long Creek in 1993.

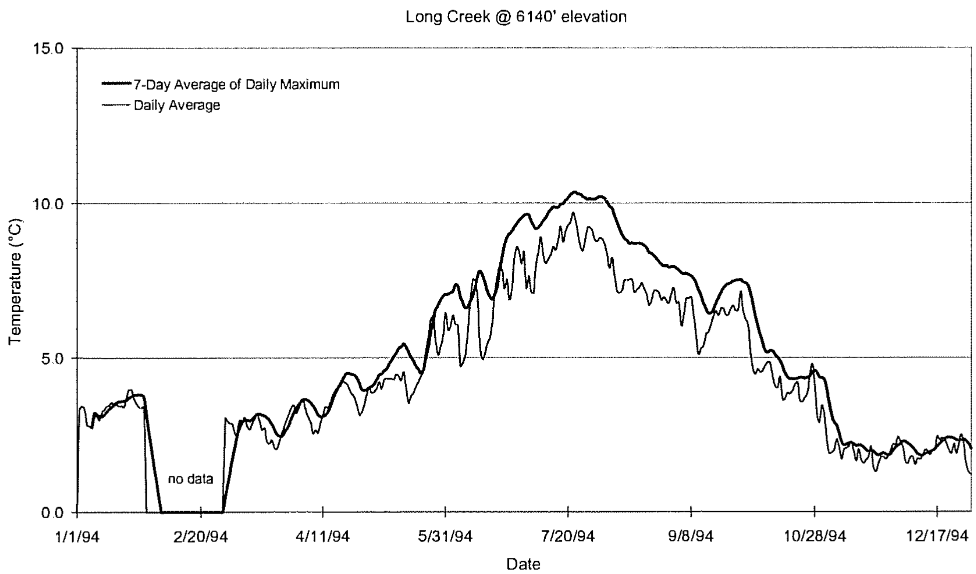


Figure 5. Daily average and 7-day average of the daily maximum temperatures at Long Creek in 1994.

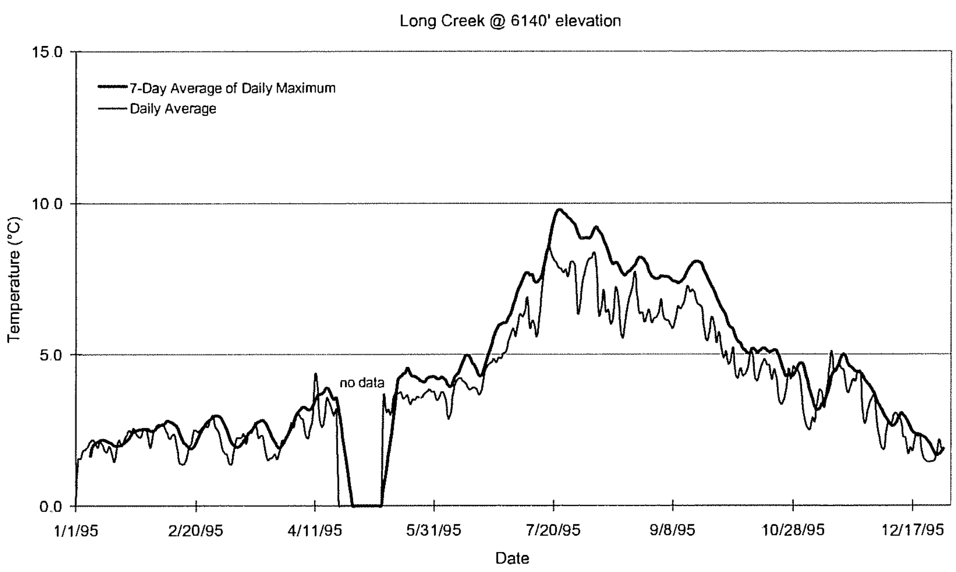


Figure 6. Daily average and 7-day average of the daily maximum temperatures at Long Creek in 1995.

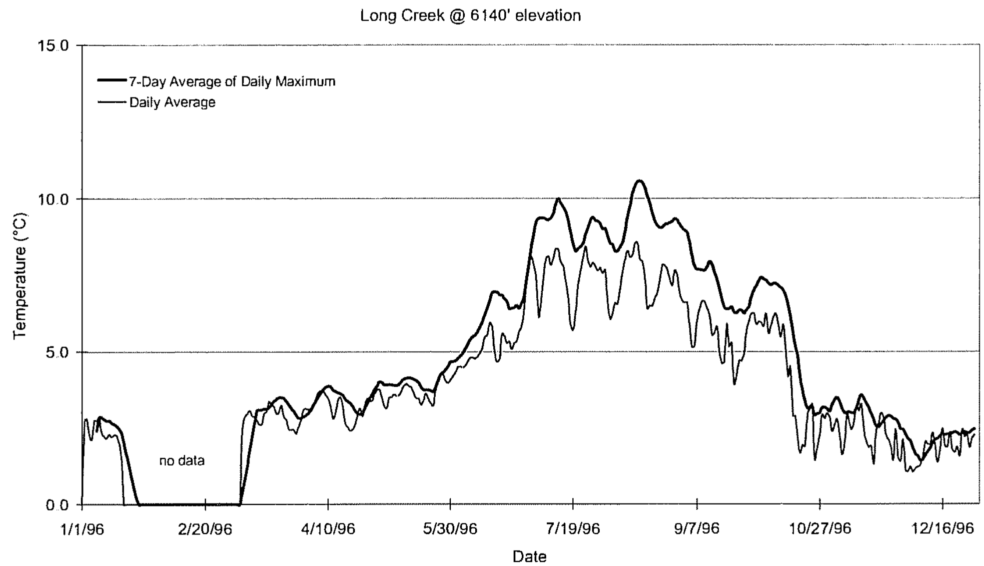


Figure 7. Daily average and 7-day average of the daily maximum temperatures at Long Creek in 1996.

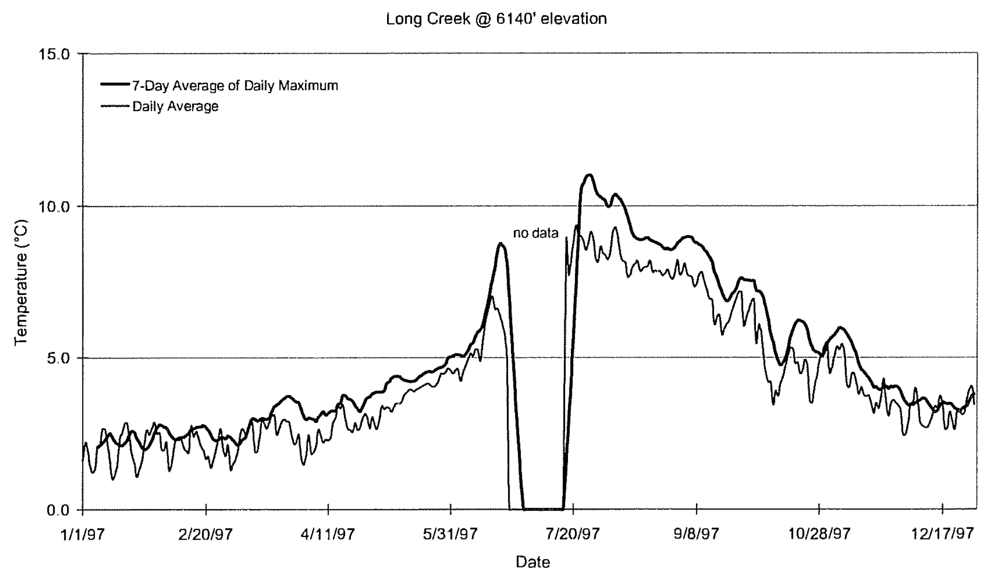


Figure 8. Daily average and 7-day average of the daily maximum temperatures at Long Creek in 1997.

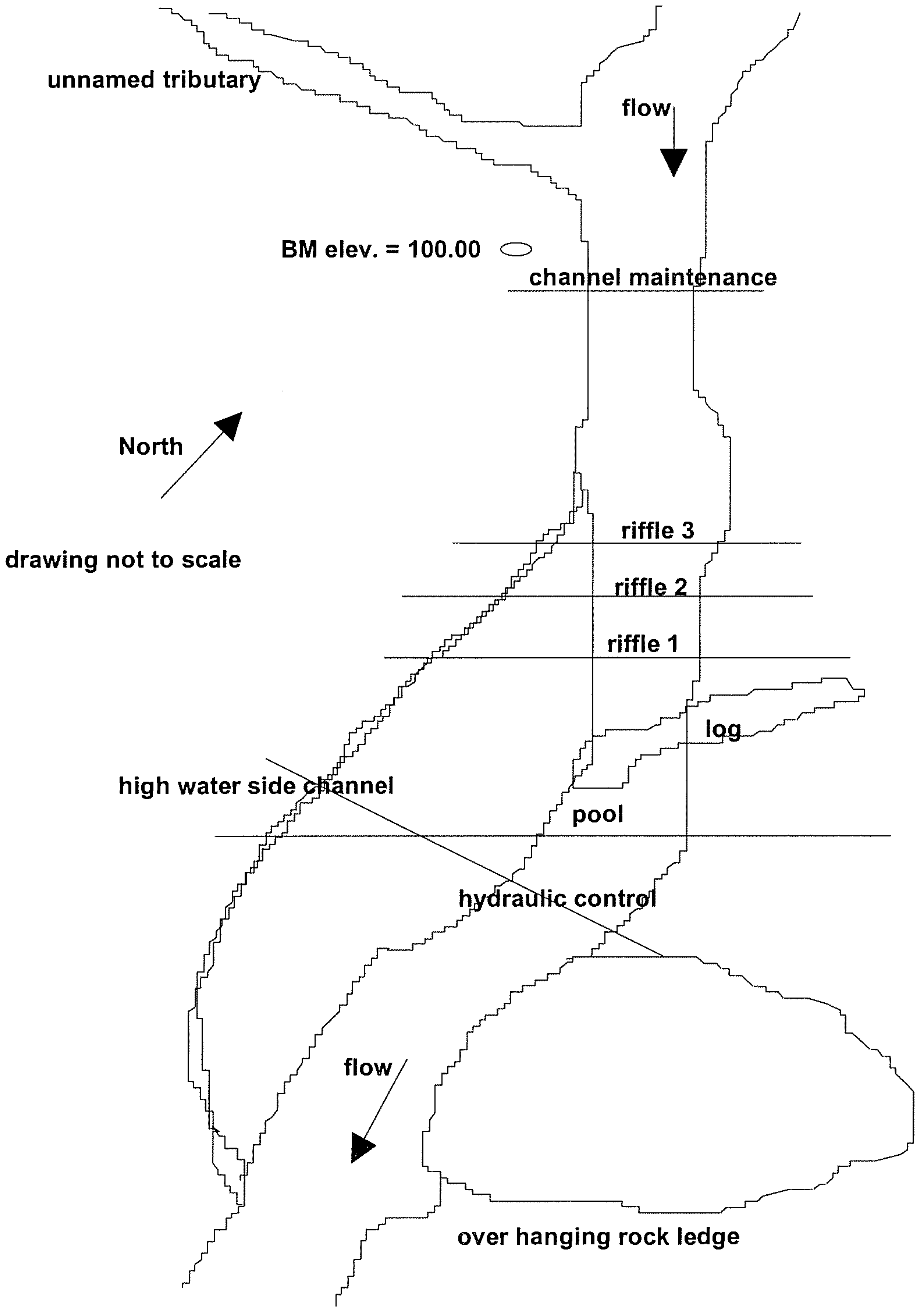


Figure 9. Map of Long Creek study site showing the PHABSIM transect layout.

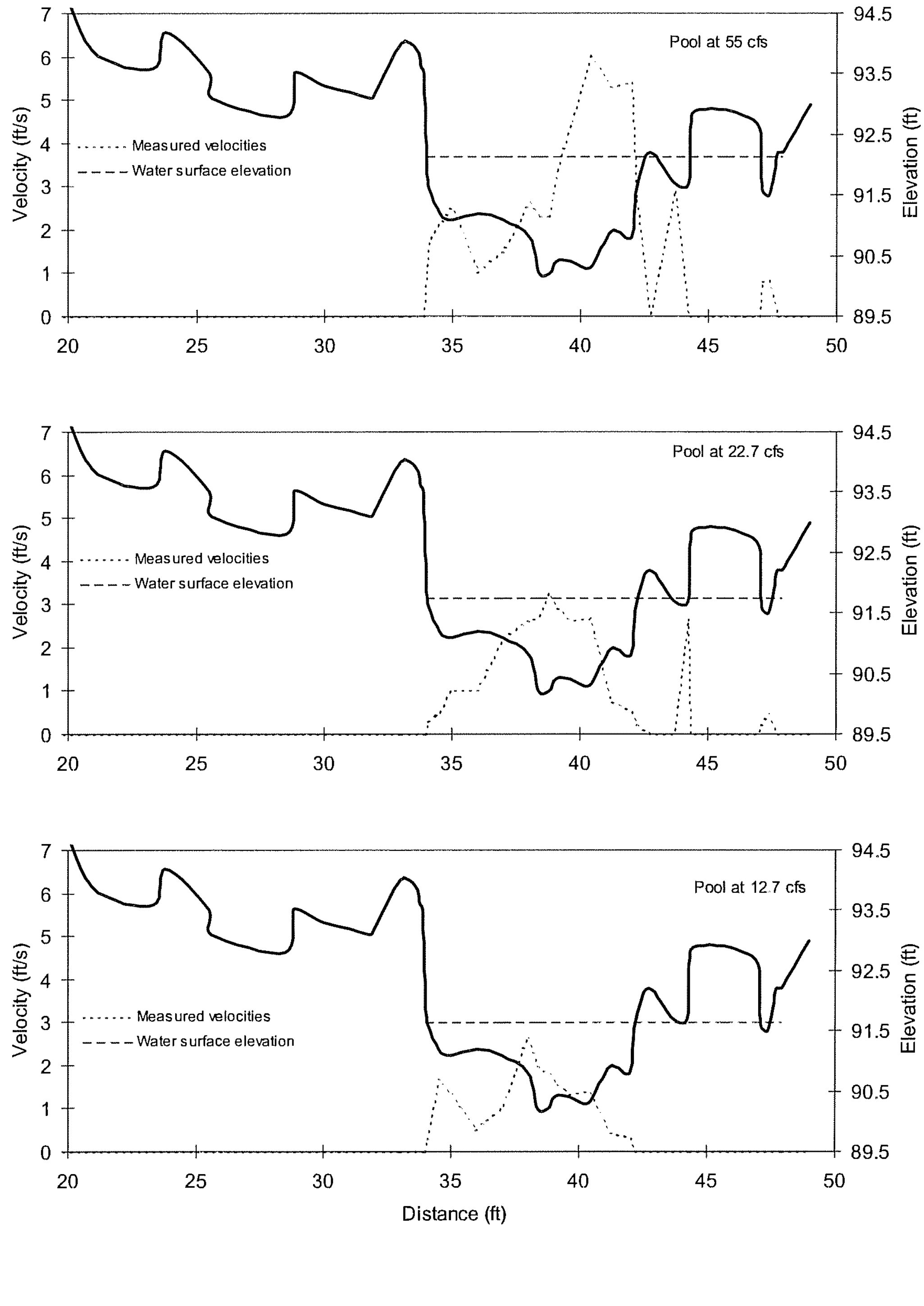


Figure 10. Pool depth and velocities at calibration discharges of 55.0, 22.7, and 12.7 cfs at Long Creek.

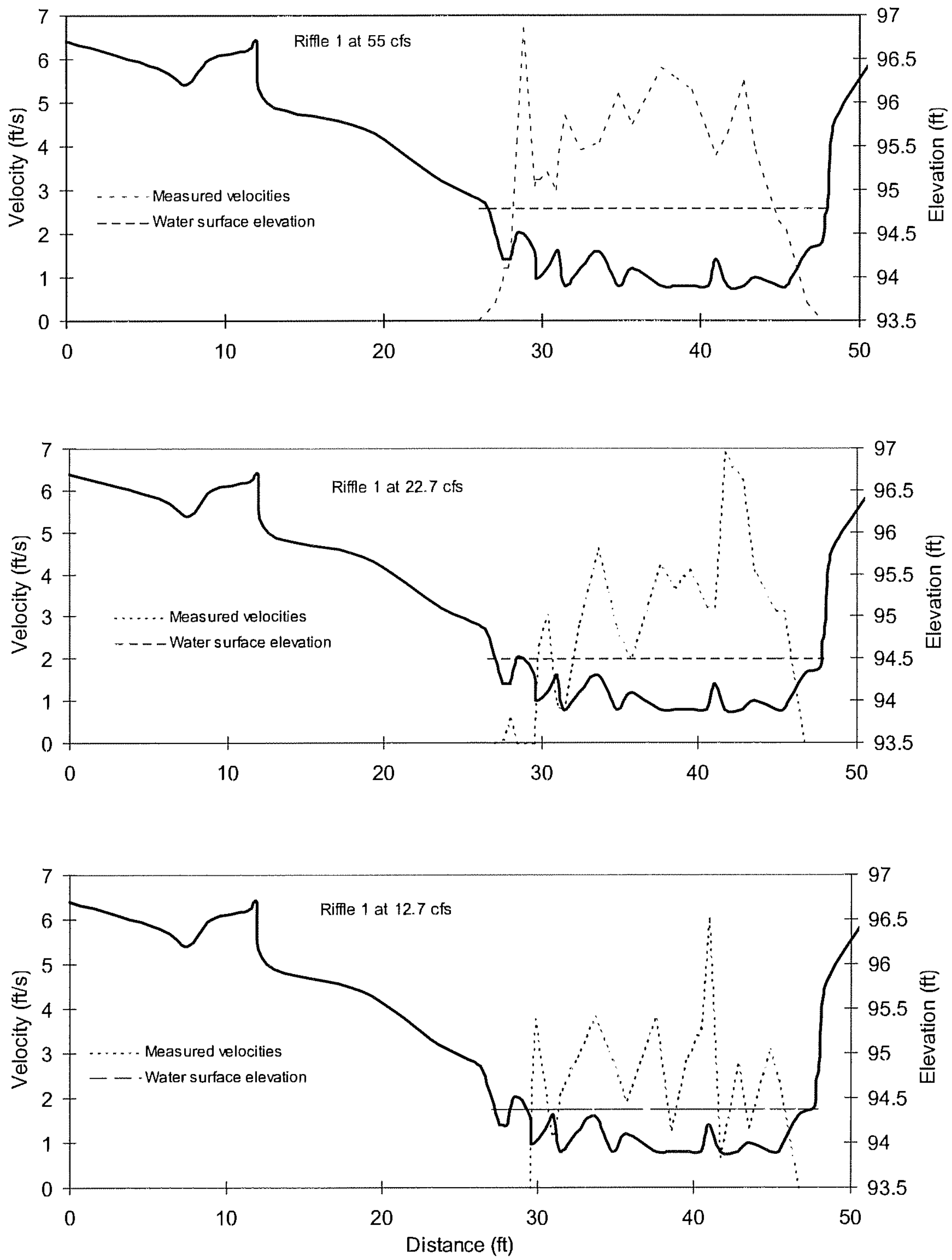


Figure 11. Riffle 1 depth and velocities at calibration discharges of 55.0, 22.7, and 12.7 cfs at Long Creek.

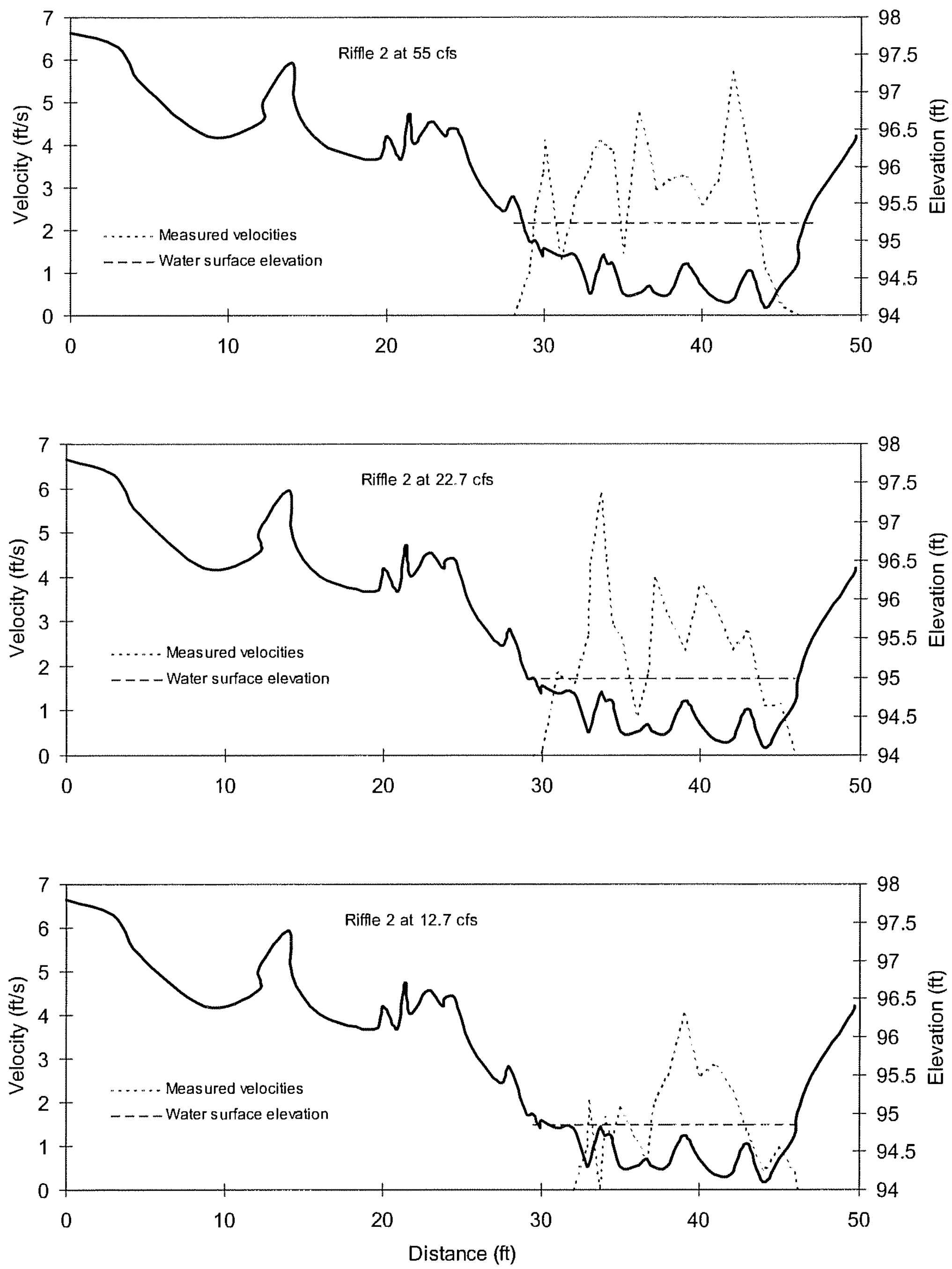


Figure 12. Riffle 2 depth and velocities at calibration discharges of 55.0, 22.7, and 12.7 cfs at Long Creek.

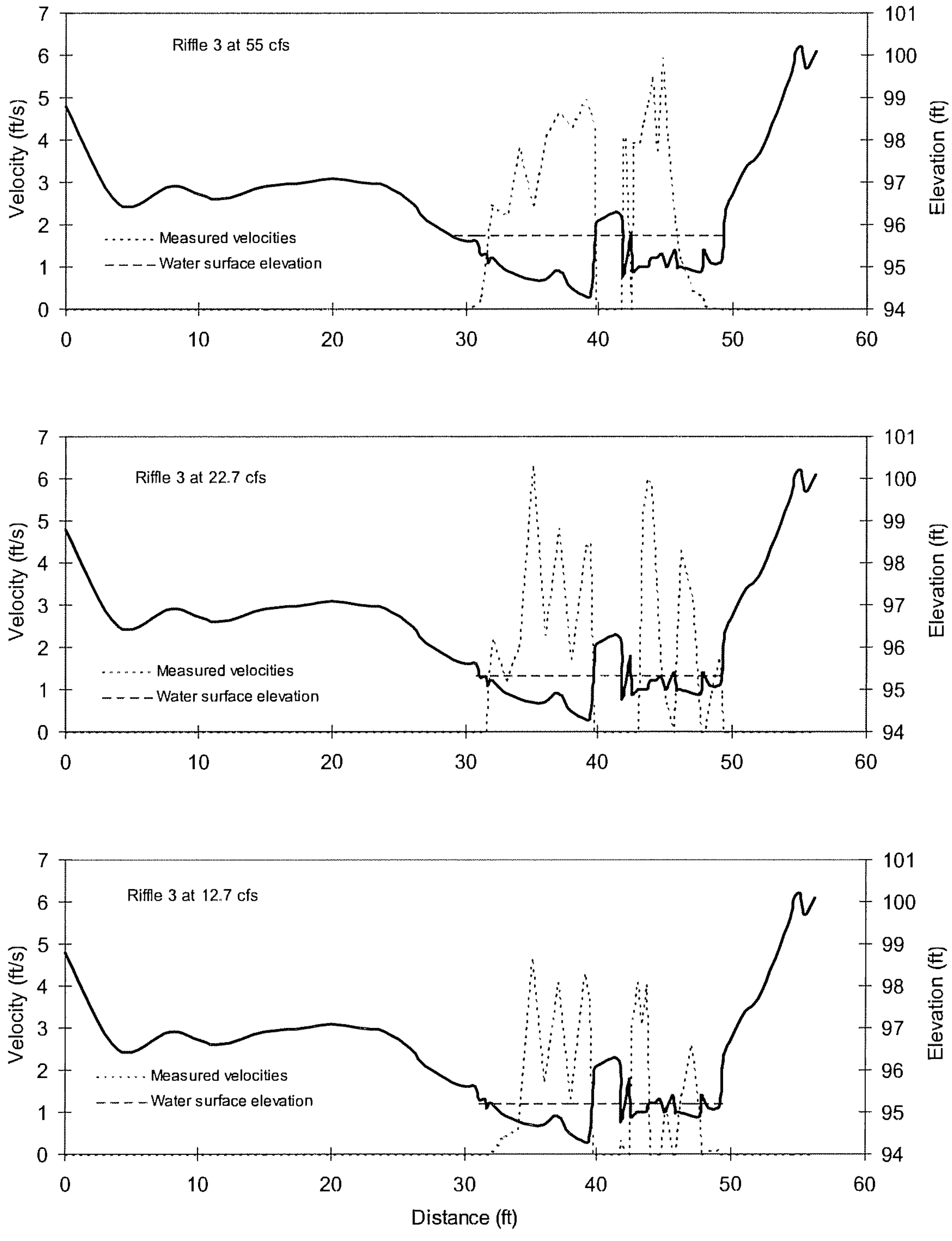


Figure 13. Riffle 3 depth and velocities at calibration discharges of 55.0, 22.7, and 12.7 cfs at Long Creek.

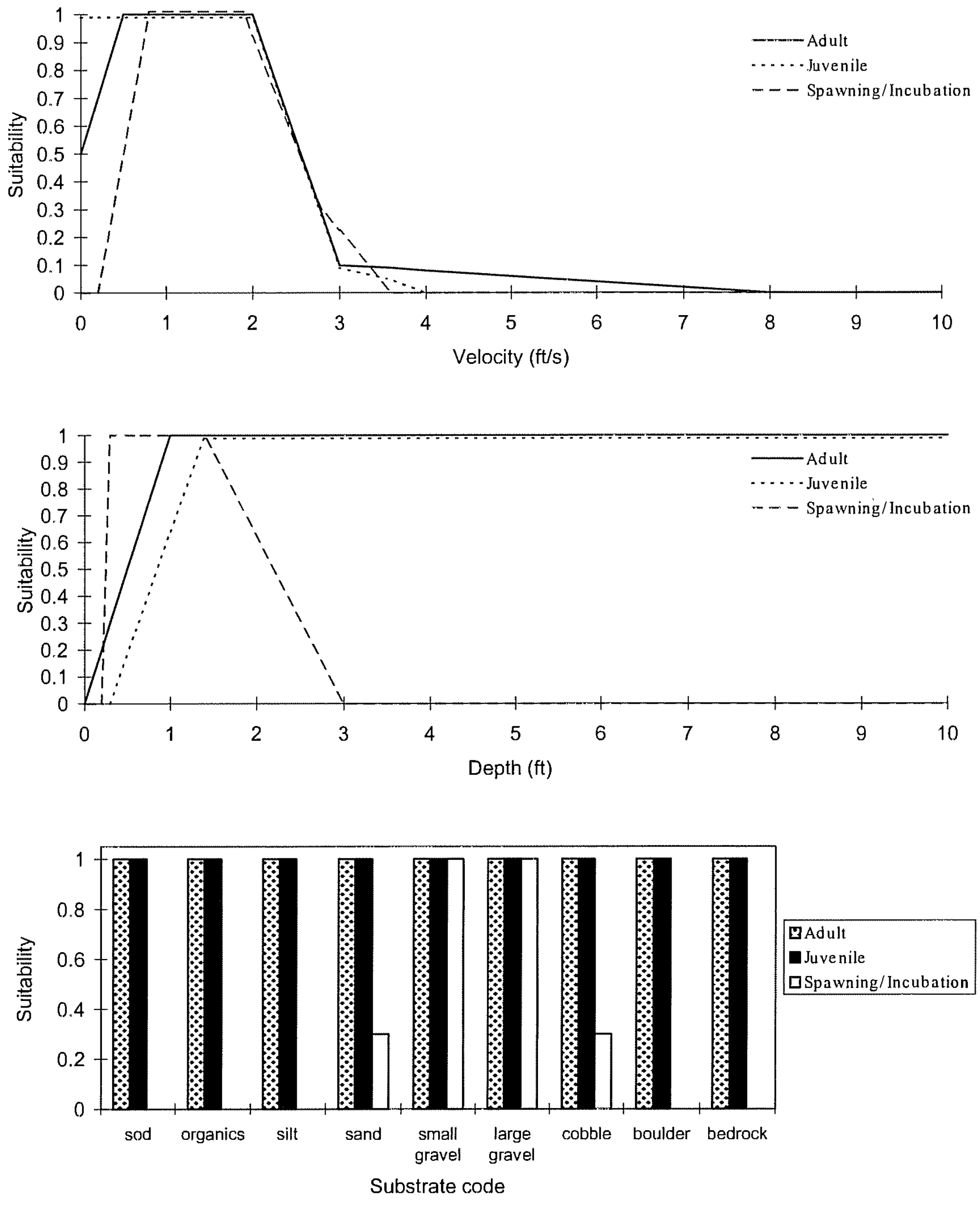


Figure 14. Habitat Suitability Index (HSI) curves used for bull trout.

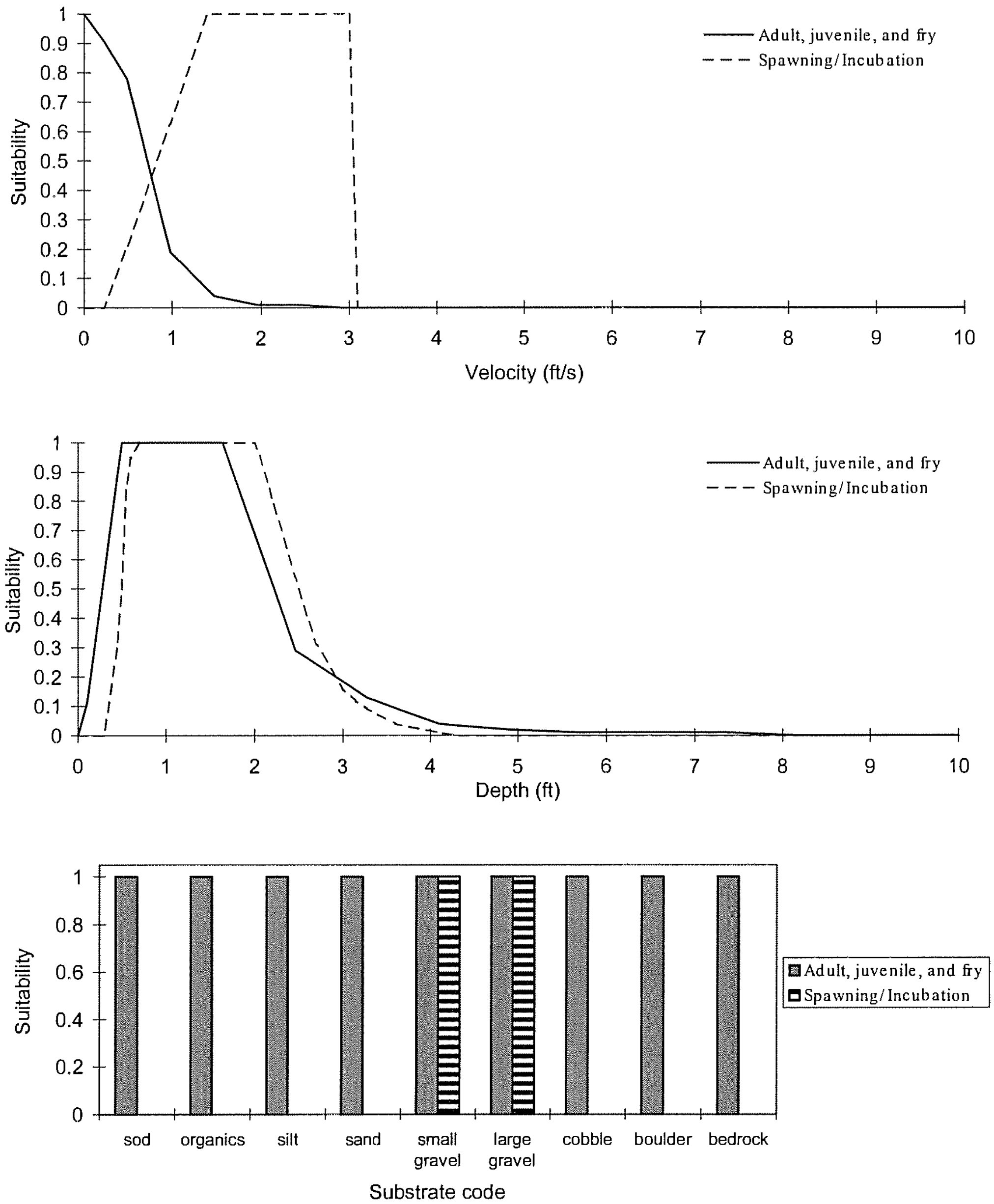


Figure 15. Habitat Suitability Index (HSI) curves used for brook trout.

Table 2. Periodicity chart for bull trout and brook trout in Long Creek.

Species/ Lifestage	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bull Trout Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Bull Trout Adult	X	X	X	X	X	X	X	X	X	X	X	X
Bull Trout Spawning/Incubation	X	X	X	X					X	X	X	X
Brook Trout Spawning/Incubation	X	X	X	X					X	X	X	X
Brook Trout Fry			X	X	X	X						
Brook Trout Juvenile	X	X	X	X	X	X	X	X	X	X	X	X
Brook Trout Adult	X	X	X	X	X	X	X	X	X	X	X	X

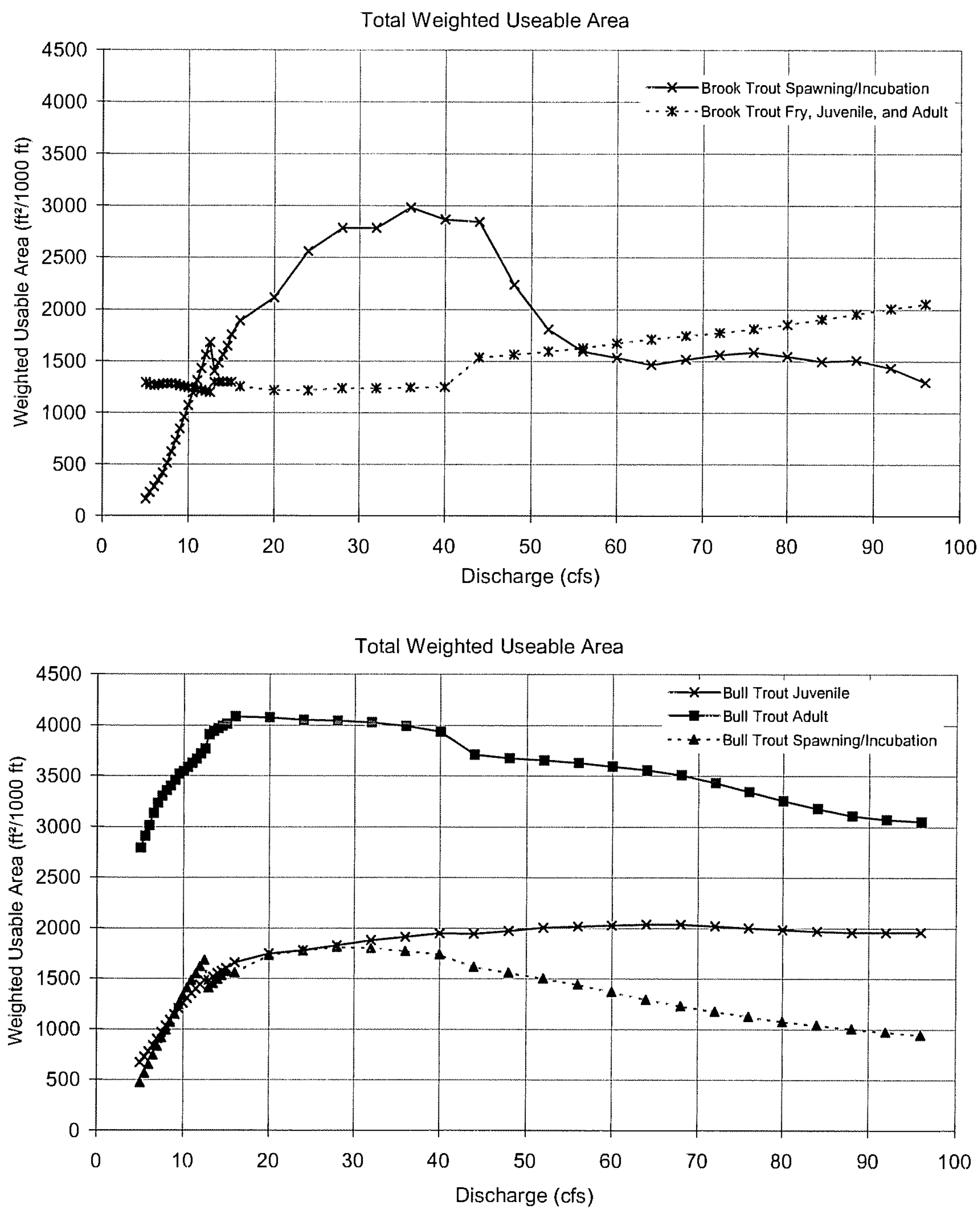
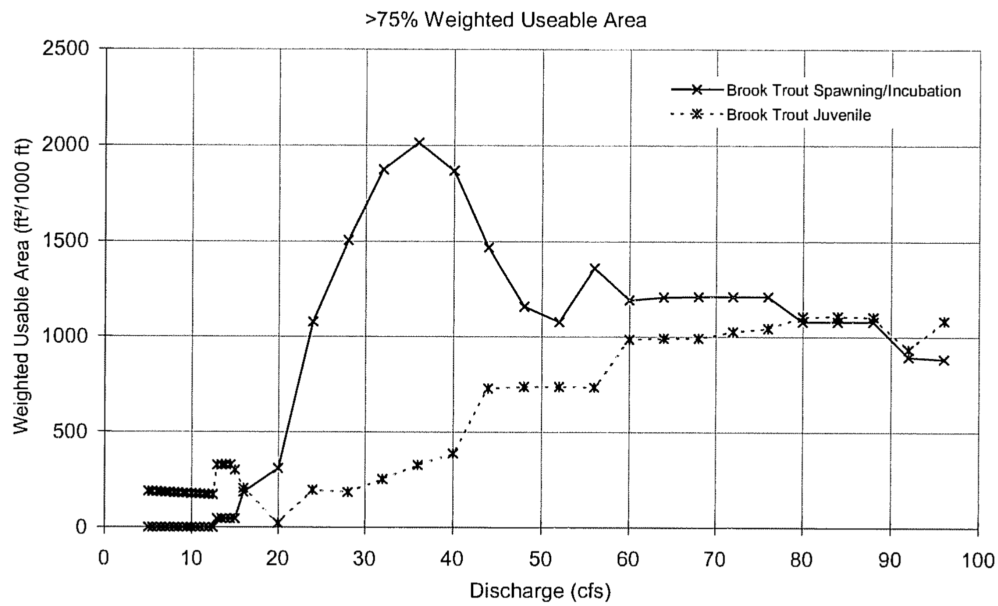


Figure 16. Total weighted usable area vs. discharge for bull and brook trout in Long Creek.



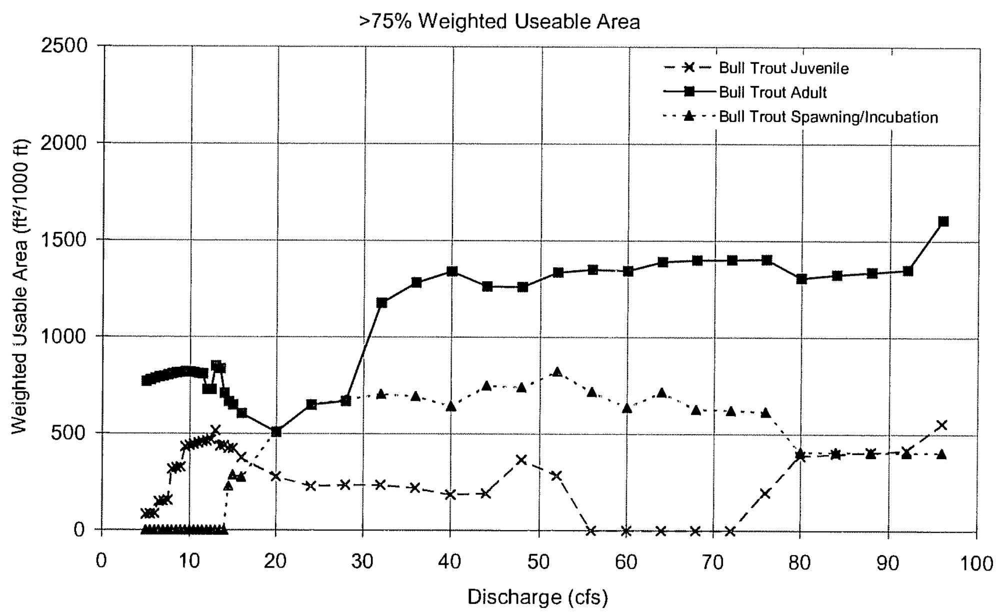


Figure 17. Optimal (>75% suitability) weighted usable area vs. discharge for bull and brook trout in Long Creek.

Table 3. Summary of rationale for final fish flow recommendations at Long Creek.

Stream: Long Creek					Species present: brook trout, bull trout							
Selection crew: T. Smith, K. Meyer												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Long Term Median Discharge	4.1	8.8	7.4	6.1	22.3	33.1	12.3	9.4	8.5	7.2	6.8	4.2
Fish Habitat Recommendation	4.1	8.8	7.4	6.1	20	33	12	9.4	8.5	7.2	6.8	4.2
Fish Habitat Maintenance Recommendation	16	16	16	16	16	16	16	16	16	16	16	16
Final Fish Recommendation	4.1	8.8	7.4	6.1	16	16	12	9.4	8.5	7.2	6.8	4.2

Comments:	with our lowest calibration point of 12.7 cfs, we could extrapolate at the low end only to about 5 cfs bull trout received much higher consideration for habitat amounts than did brook trout
Jan	very little habitat at the lower end and continues to drop at flows below the monthly median; also, temperatures are low and could become a stressful factor if they dropped much lower (if flows were reduced); therefore recommend monthly median flow
Feb	same as Jan; recommend monthly median
Mar	same as Jan except that temperatures have started to rise; recommend monthly median
Apr	same as Mar; recommend monthly median
May	13.0 maximizes the quality of habitat when considering all bull trout lifestages, but when considering ALL habitat, the total WUA is reduced below 20 cfs for bull trout juveniles; therefore recommend 20 cfs;
Jun	quality adult bull trout habitat drops drastically below 32 cfs; therefore recommend monthly median
Jul	habitat is already quite low at the monthly median and drops at flows below the monthly median; therefore recommend monthly median
Aug	same as Jul; recommend monthly median
Sep	total spawning habitat for bull trout drops at flows below monthly median; therefore recommend monthly median
Oct	same as Jan except that temperatures are not yet a potential problem; recommend monthly median
Nov	same as Jan except that temperatures may not be a potential problem yet; recommend monthly median
Dec	same as Jan; recommend monthly median