Physical Habitat Availability for Anadromous Salmonids in the Trinity River

By

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ABSTRACT

The availability of physical habitat for anadromous salmonids in relation to flow was determined from a combination of hydraulic and habitat modeling in the Trinity River between Lewiston Dam and the confluence of the Klamath River, California. The study was part of the Trinity River Flow Evaluation conducted by the U.S. Fish and Wildlife Service between 1984 and 1996. A total of 127 stream cross-sections was placed in fourteen study sites within four defined segments of the river. Numerous measurements of water depth, velocity, substrate, and cover were obtained over twelve years at a wide range of river discharges. These data were entered into hydraulic simulation computer models and linked to habitat use criteria for chinook and coho salmon spawning, fry, and juveniles, and steelhead spawning, fry, juveniles, overwintering juveniles, and holding adults, to create flow indices of physical habitat availability (weighted usable area). These indices should be suitable as a partial basis for making instream flow recommendations and evaluating potential management alternatives, provided they are interpreted according to established methods.

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INTRODUCTION

Between 1984 and 1996, the U.S. Fish and Wildlife Service (FWS) conducted the Trinity River Flow Evaluation, a study designed to monitor fishery habitat in the Trinity River, California. Results of the study were to be used as a technical basis for reporting to the Secretary of the Interior on the effectiveness of the Secretary's 1981 decision to increase flow releases from Trinity and Lewiston dams. In addition, the FWS was to describe any other habitat rehabilitation measures that would restore fish populations and aquatic habitat in the Trinity River below Lewiston Dam. The first objective of Task 3 identified during initial study design was to determine: a) the amount of salmon and steelhead habitat available in the Trinity River downstream of Lewiston Dam under various flow conditions, and b) the various levels of habitat rehabilitation that may be achieved either through the Trinity River Basin Fish and Wildlife Management Program or through other resource management actions (Appendix A).

The majority of the study design, field data, and preliminary analyses conducted for the habitat availability task has been previously reported in Annual Reports (FWS 1985-91) and in two reports prepared by the FWS (Gard, 1996; Gard, 1997), partial copies of which are appended (Appendices B-K). This report represents a summary and compilation of the data and analyses conducted to quantify the amount of physical habitat available for anadromous salmonids in the Trinity River downstream of Lewiston Dam under various flow conditions, part (a) of the first objective of Task 3.

STUDY SITES

Fourteen study sites for physical habitat availability analyses were selected within three major river segments between Lewiston Dam and the confluence of the Trinity and Klamath Rivers at Weitchpec, a distance of approximately 110 river miles (Table 1, Figure 1). The segments separate the Trinity River by significant changes in hydrology and overall character from Lewiston Dam to the North Fork Trinity River (40 miles), the North Fork to the South Fork

(40 miles), and the South Fork to the Klamath River confluence (30 miles). The sites were chosen by professional judgment as representative of each segment. Nine study sites were placed in the upper segment (Segment IA & IB) where the majority of spawning activity for all three species occurs and, consequently, is also a critical reach for rearing fry; two were in the middle segment (Segment II); and three sites were placed in the lower segment (Segment III). Subsequently, two of these sites were eliminated: the Indian Creek site in Segment IA had unstable channel conditions due to copious gravel input from Indian Creek (the Steel Bridge site was used to represent the majority of habitat in this area), and the Camp Kimtu site was believed to be adequately represented by the Tish-Tang site within the upper portion of Segment III. A total of 127 transects was placed in the remaining twelve sites. Detailed study site maps are presented in the 1987 Annual Report (Appendix D).

Table 1. Representative Study Reaches, Trinity River Flow Evaluation Study, 1985.

	River Segment	Study Reach	Description	No. Transects
IA	Upper	Lewiston Dam	Lewiston Dam to Old Fish Weir	19
		Cemetery	Old Fish Weir to Rush Creek	13
		Bucktail	Rush Creek to Grass Valley Creek	11
		Poker Bar	Grass Valley Creek to Limekiln Gulch	10
		Steel Bridge	Limekiln Gulch to Indian Creek	12
		Indian Creek	Indian Creek to Douglas City	0
		Steiner Flat	Douglas City to Dutch Creek	10
IB	Upper	Oregon Gulch	Dutch Creek to Canyon Creek	9
		Junction City	Canyon Creek to North Fork Trinity	9
II	Middle	Del Loma	North Fork Trinity to Cedar Flat	11
		Hawkins Bar	Cedar Flat to South Fork Trinity	8
III	Lower	Camp Kimtu	South Fork Trinity to Horse Linto Creek	0
		Tish-Tang	Horse Linto Creek to Hoopa Valley	9
		Hoopa Valley	Hoopa Valley to Weitchpec	6

METHODS

Basic theoretical concepts for the assessment followed those developed for the Physical Habitat Simulation (PHABSIM) component of the Instream Flow Incremental Methodology (Bovee, 1982). PHABSIM is based on a linkage between hydraulic and habitat data obtained from stations (cells) measured along representative stream cross-sections (transects), and habitat suitability criteria (HSC) for hydraulic (depth and velocity) and habitat (substrate and cover) variables. Numerous computer models have been developed as part of PHABSIM, which is described in Milhous et al. (1984). Hydraulic simulations to predict unmeasured flow conditions from measured calibration flow data are optionally part of PHABSIM, as is empirical analysis which computes habitat availability only for the measured flows. Both hydraulic simulation and direct computational analysis were used in this assessment depending on data availability and inherent limitations of the hydraulic models. A customized computer model was written to calculate habitat availability for all direct computation analyses (Hamilton, 1987). Output of either analysis is in the form of a physical habitat availability index called weighted usable area (WUA). WUA at a given streamflow represents the sum of the areas of all transect cells, each of which has been weighted by the product of the suitability values for the habitat variables considered (e.g., depth, velocity, substrate).

The "representative reach" approach, the most common approach for conducting riverine habitat analyses using PHABSIM in the early 1980's, was initially chosen as the method by which physical habitat availability would be quantified on the Trinity River. Using this approach, study sites are considered to be representative of larger sections (reaches) of the river and transects placed in those sites represent the variable physical conditions within the site and thus, the reach. The habitat/streamflow functions (WUA) derived at each representative study site are considered valid for the entire reach. After extensive scoping and on-the-river reconnaissance of the Trinity River, study reaches were identified, study sites were selected, and transects were placed in these sites.

In the mid-1980's an alternative method for representing instream habitat known as habitat mapping (Morhardt *et al.*, 1983) was developed. Using this method, the major habitat types (e.g., riffle, run, deep pool) within a study reach are identified and the linear distance represented by each is determined. Transects are placed in each of these habitat types (replicates are highly desirable) so as to fully represent the range of physical conditions present. Separate WUA functions are derived for each identified habitat type and a total WUA function is calculated for the reach when the representative distances are considered. A comparison was run using both the representative reach and the habitat mapping approach on the approximate 26-mile reach from Lewiston Dam to Dutch Creek. The results of this comparison showed little difference between the two methods in calculating total WUA (p. F-7, Appendix F). The results using habitat mapping were used for this segment of the upper reach (hereafter referred to as Segment IA) and representative reach results were retained for the remainder of the river.

Field data collection methods generally followed those proscribed in Trihey and Wegner (1981) and are described in detail in the 1986 Annual Report (p. C-2, Appendix C). The first year of the study (1985) targeted flows of 300, 450, and 600 cfs to be released from Lewiston Dam for evaluation. Measurements were made at 300 and 450 cfs to obtain hydraulic (depth and velocity) data at all transects and study sites. However, because of dry-year conditions (defined by water supply criteria), water was unavailable for the 600 cfs release. A wetter year followed and measurements were taken at 800 cfs in 1986.

During the 1986 field season it was obvious that some significant morphological changes had occurred within the river channel at sites below Segment IA from Oregon Gulch to Weitchpec (Appendix D). These changes were the result of some major flood events in February and March of that year. The most significant changes occurred downstream of Canyon Creek, the North Fork, and the South Fork Trinity Rivers. It was apparent that streamflows below the North Fork were influenced to such an extent by unregulated tributary accretion that management objectives dependent on controlled releases from the TRD would be difficult to achieve. Therefore, after 1987, data collection was focused on the upper river (Segment IA)

between Lewiston Dam and Dutch Creek. Additional data collected in the lower river segments, however, were enough to complete hydraulic and habitat modeling in these reaches.

Several successive dry years occurred after 1986 and releases from Lewiston Dam did not vary significantly from those at which data had already been gathered. Not until 1989 was a discharge released (2000 cfs) at which data could be collected to expand the capability to estimate habitat availability at higher flows. Very low flows were measured in 1990, a critically dry year, at the five sites in Segment IA when 150 cfs was released from the dam. High flow releases for concurrent, related Trinity River studies of sediment transport and geomorphological processes enabled additional data collection in the later years of the Flow Evaluation. Partial data sets were obtained on most transects in Segment IA at flows of 1500 and 3000 cfs in 1993, and 4500 and 6000 cfs in 1995.

Site-specific habitat suitability criteria (curves) for physical variables such as depth and velocity for the fish species and life stages of concern were developed from direct observation of habitat use in the Trinity River (Hampton, 1988; Hampton, 1997). Development of criteria curves was not finalized until 1991, when early attempts at creating "preference" criteria were abandoned in favor of "utilization" criteria. Any reported results of physical habitat availability indices (WUA) in the annual reports or elsewhere prior to 1991 should be considered superceded by the results presented here.

Data was compiled and data decks were constructed as the study progressed. Hydraulic modeling was done for each study site in every segment, utilizing, at one time or another, all of the models available within PHABSIM (Gard, 1996; Gard, 1997). The cited reports provide complete hydraulic calibration details. The HABTAE modeling program was used to calculate WUA. In Segment IA, WUA was also calculated using hydraulic data obtained by direct measurements as input into a computer program developed by Flow Evaluation biologists (Hamilton, 1987). For both methods, the suitabilities for the velocity, depth, and substrate variables were combined using standard multiplicative defaults and cell offset averaging.

RESULTS

The following is a summary of the sequence of data collection and analyses conducted during the course of the Flow Evaluation study for habitat availability:

1985 - Fourteen study sites established (later reduced to 12), containing 127 transects. Data collected at all transects for flows of 450 and 350 cfs. No analysis. (Appendix B)

1986 - Data collected at all transects for flow of 800 cfs, with additional water surface elevation data for flows of 300 and 600 cfs. Winter flood flows cause channel changes. Preliminary analysis using hydraulic simulation, conducted separately for lower flow and higher flow data. (Appendix C)

1987 - Preliminary habitat availability analysis continued. Eliminated use of substrate and cover attributes for fry and juvenile life stages. Eliminated Lewiston Dam study site due to modification by bulldozer. One transect at Tish-Tang site dropped. Evaluated morphological changes in river channel. Prepared detailed study site maps. (Appendix D)

1988 - Preliminary habitat availability analysis continued using hydraulic simulation. Simulated water surface elevations for a flow of 3500 cfs to test for the creation of stranding pools beyond streambank berms. (Appendix E)

1989 - Data collected on study sites between Cemetery and Steiner Flat for a flow of 2000 cfs. Habitat mapping conducted between Lewiston Dam and Dutch Creek. Preliminary habitat availability analysis continued using empirical method instead of hydraulic simulation and habitat mapping instead of representative reaches. (Appendix F)

1990 - Data collected at five sites (Cemetery, Bucktail, Poker Bar, Steel Bridge, and Steiner Flat) for a flow of 150 cfs. Preliminary habitat availability analysis continued using empirical method. (Appendix G)

1991 - Feasibility of data collection for a flow of 3000 cfs was evaluated. Criteria curves for most fish species and life stages finalized. (Appendix H)

1992 - Data collected on transect margins at four transects of the Junction City site for a flow of 3000 cfs. Detailed habitat maps prepared showing locations and representation of habitat by each study site transect for Lewiston Dam to Dutch Creek. (Appendix I)

1993 - Data collected at five sites (Cemetery, Bucktail, Poker Bar, Steel Bridge, and Steiner Flat) for a flow of 3000 cfs and at two sites (Poker Bar and Steel Bridge) for a flow of 450 cfs.

1994 - Data collected at five sites (Cemetery, Bucktail, Poker Bar, Steel Bridge, and Steiner Flat) for a flow of 1500 cfs.

1995 - Partial data collected at selected transects at four sites (Cemetery, Bucktail, Poker Bar, and Steel Bridge) for a flow of 6000 cfs, at selected transects at five sites (Cemetery, Bucktail, Poker Bar, Steel Bridge, and Steiner Flat) for a flow of 4500 cfs, and at selected transects at the same five sites for various flows between 300 and 500 cfs.

1996 - Physical habitat availability analysis completed for five sites (Cemetery, Bucktail, Poker Bar, Steel Bridge, and Steiner Flat) using hydraulic simulation (Appendix J).

1997 - Physical habitat availability analysis completed for six sites (Oregon Gulch, Junction City, Hawkins Bar, Tish-Tang, Del Loma, and Hoopa Valley) using hydraulic simulation (Appendix K).

A summary of all data by study site and transect is presented in Appendix L.

Physical Habitat Availability

Physical habitat availability as a function of flow was calculated for chinook and coho salmon, and steelhead spawning, fry, and juveniles. In addition, WUA was computed for overwintering juvenile steelhead and holding adults. Depth and velocity HSC were used in computing WUA for steelhead adult holding and for the fry and juvenile life stages, except for overwintering steelhead juveniles. Substrate criteria were included for them, as well as for spawning for all three species. WUA for Segment IA (Lewiston Dam to Dutch Creek) was derived empirically using directly measured data. All WUA results for the segments downstream of Segment IA were derived using output from hydraulic simulation models.

Lewiston Dam to Dutch Creek (Segment IA)

Total WUA for spawning salmon and steelhead varied with discharge and species (Figure 2A, Table 2). Spawning habitat for chinook salmon was maximized at flows between 150 and 350 cfs and decreased as streamflow increased. Spawning habitat for coho and steelhead were both available in amounts greatly lower than for chinook. Both WUA functions decreased steadily from 150 cfs as flows increased. Adult steelhead holding WUA increased rapidly between 150 and 450 cfs and moderately up to 800 cfs.

The WUA functions for salmon and steelhead fry were very similar to each other over the entire flow range (Figure 2B, Table 2). Chinook and steelhead physical habitat was available in nearly equal amounts, which were also consistently greater than that for coho. Fry habitat for all species decreased sharply between 150 and 800 cfs, remained relatively stable to 1500 cfs, and sharply increased as higher flows inundated the heavily vegetated, low velocity habitat on the other side of the stream bank berms.

The habitat-flow relationships for juvenile salmon were similar to those for fry, and to each other, over the entire range of flows (Figure 2C, Table 2). WUA peaked at 150 cfs, decreased up to a flow of 1500 cfs, then increased steadily up to 3000 cfs. Unlike salmon

fry, juvenile WUA was greater at flow levels below about 500 cfs than at flows between 2000 and 3000 cfs. Juvenile steelhead WUA peaked at 450 cfs, decreased to 1500 cfs, and was stable from 1500 to 3000 cfs. Overwintering juvenile steelhead habitat values were greatest at the lowest flows measured (150 cfs).

A subset of ten transects was measured at a flow of 4500 cfs, allowing computation of WUA for salmonid fry and juveniles up to that flow. These transects, selected on the basis of accessibility, safety, and geographic distribution, represented 24 percent of the total habitat in the segment. Computed WUA was combined with that derived for the same ten transects at lower flows (Figure 3, Table 3). Results show increases in WUA between 3000 and 4500 cfs for fry and juveniles of all three species.

Dutch Creek to North Fork Trinity River (Segment IB)

The spawning WUA functions were more complex than those observed in Segment IA (Figure 4A, Table 4). Chinook and coho have very similar habitat-flow relationships, with the greatest habitat values at 150 cfs and a secondary peak at around 1200 cfs. WUA declines after this peak but stabilizes between 1700 and 2500 cfs before gradually declining again. Steelhead spawning habitat is available in much lower quantities in this segment, displaying a sinusoidal function which gradually peaks and declines a number of times over the range of flows evaluated. Steelhead adult holding WUA increases sharply to 450 cfs then drops sharply as flows increase.

It is obvious from the WUA curves for fry (Figure 4B, Table 4) that the stream bank berms characteristic of Segment IA are no longer a factor in Segment IB. Habitat values for all three species are greatest at 150 cfs and decline thereafter. Coho fry have the least amount of habitat and steelhead fry the most. The juvenile WUA curves also do not display the bimodality of the functions in the upper segment (Figure 4C, Table 4). Chinook and coho habitat peaks at 150 cfs and declines, but the decline is very slight over a wide range of flows (700 to 3000 cfs). Steelhead juvenile WUA increases to 450 cfs then steadily declines, while

overwintering juvenile habitat is very stable over the entire range of simulated flows, peaking at 750 cfs. Overall, Segment IB provides a higher physical habitat index quantity of steelhead rearing habitat than for chinook and coho.

North Fork Trinity River to South Fork Trinity River (Segment II)

The spawning functions were bimodal for all three species in Segment II (Figure 5A, Table 5). While the chinook and coho spawning functions were also bimodal in Segment IB, the second peak of the function for both species, and for steelhead, in Segment II occurred at much higher flows (2500 cfs). The adult steelhead holding function is also very different from those in the previous segments. Holding habitat is very limited at 150 cfs, increasing sharply to maximum levels at about 700 cfs which are maintained over a wide range of flows up to about 1700 cfs before declining again.

Fry WUA was highest at 150 cfs for all three species (Figure 5B, Table 5). The amount of habitat decreased steadily before stabilizing at about 1000 cfs (chinook and coho) or 1500 cfs (steelhead); WUA gradually increased as flows increased up to 3000 cfs. Juvenile habitat for chinook and coho salmon was highest at lower flows and decreased steadily (Figure 5C, Table 5). WUA for steelhead juveniles peaked at about 600 cfs. The amount of overwintering steelhead habitat was greatest at 150 cfs and showed about a 50 percent reduction at 600 cfs. This habitat amount was basically maintained at higher flows. Overall, the segment favors chinook salmon rearing over coho and steelhead.

South Fork Trinity River to Weitchpec (Segment III)

Spawning habitat availability in Segment III for chinook and coho was greatest at low flows, while spawning WUA for steelhead was bimodal, increasing from 150 to 500 cfs and decreasing to 1200 cfs before increasing gradually again with flow (Figure 6A, Table 6). Adult steelhead holding WUA was lowest at 150 cfs, climbed sharply to a peak at about 600 cfs and slowly decreased therafter to 3,000 cfs.

The amount of habitat for chinook and coho fry was essentially stable, particularly that for coho (Figure 6B, Table 6). The steelhead fry WUA function had numerous peaks and valleys; flows between 2000 and 2500 cfs provided the greatest WUA. For all juveniles, WUA curves were almost identical in shape to those in Segment IB (Figure 6C, Table 6). Chinook and coho WUA was greatest at 150 cfs, decreased to about 1000 cfs, and remained stable thereafter. The juvenile steelhead WUA function peaks at 350 cfs then declines. Overwintering juvenile steelhead habitat characteristics were identical to those in Segment II.

CONCLUSIONS

Results of physical habitat availability modeling on the Trinity River should be suitable as a partial basis for making instream flow recommendations and evaluating potential management alternatives. As with any use of PHABSIM habitat modeling, the weighted usable area indices need to be interpreted in the context of fish life history patterns and habitat needs, stream flow patterns (both existing and historic), water quality variables (such as water temperature), and changing channel morphology, according to the procedures of the Instream Flow Incremental Methodology.

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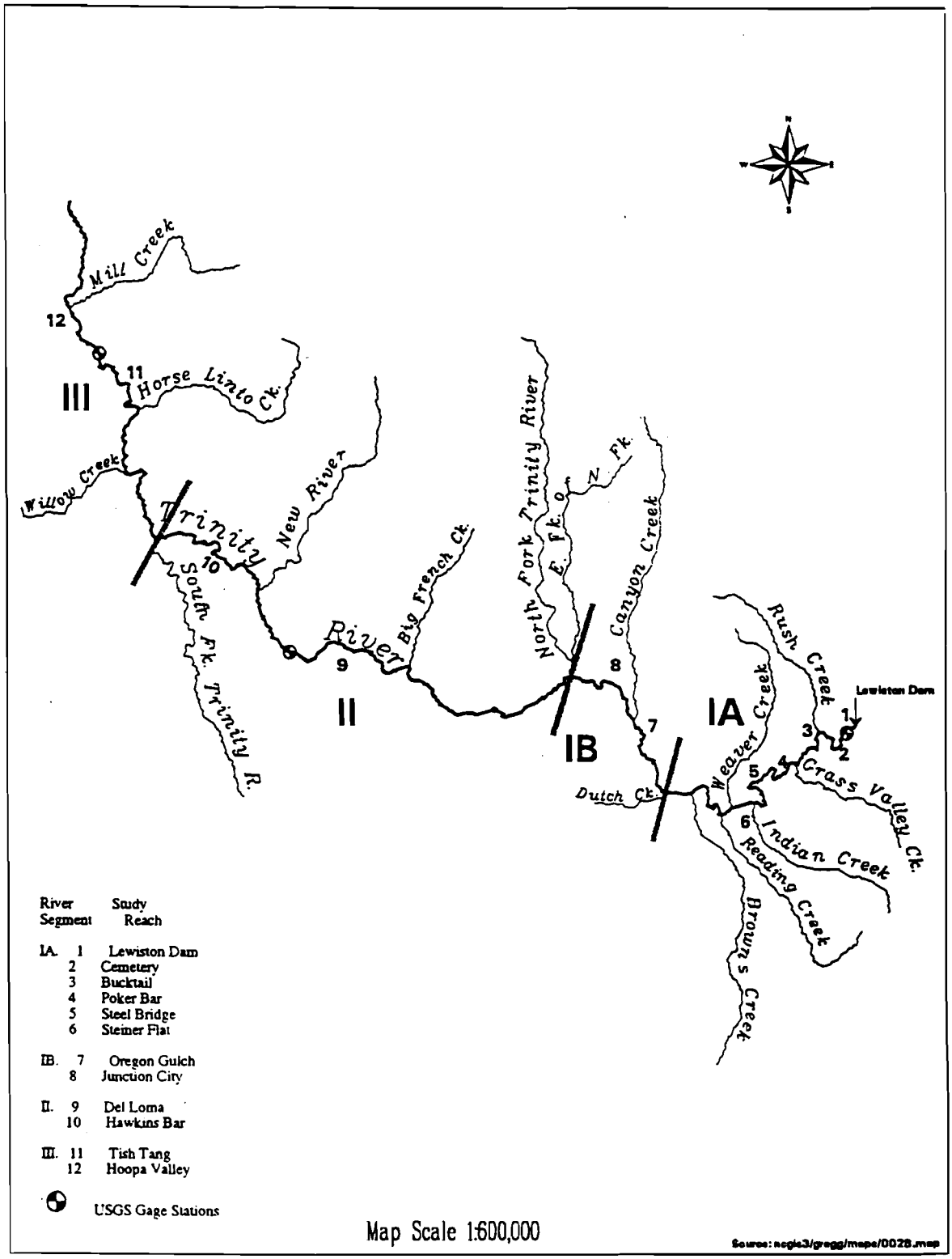

Figure 1. Map of study segments and reaches in the Trinity River basin.

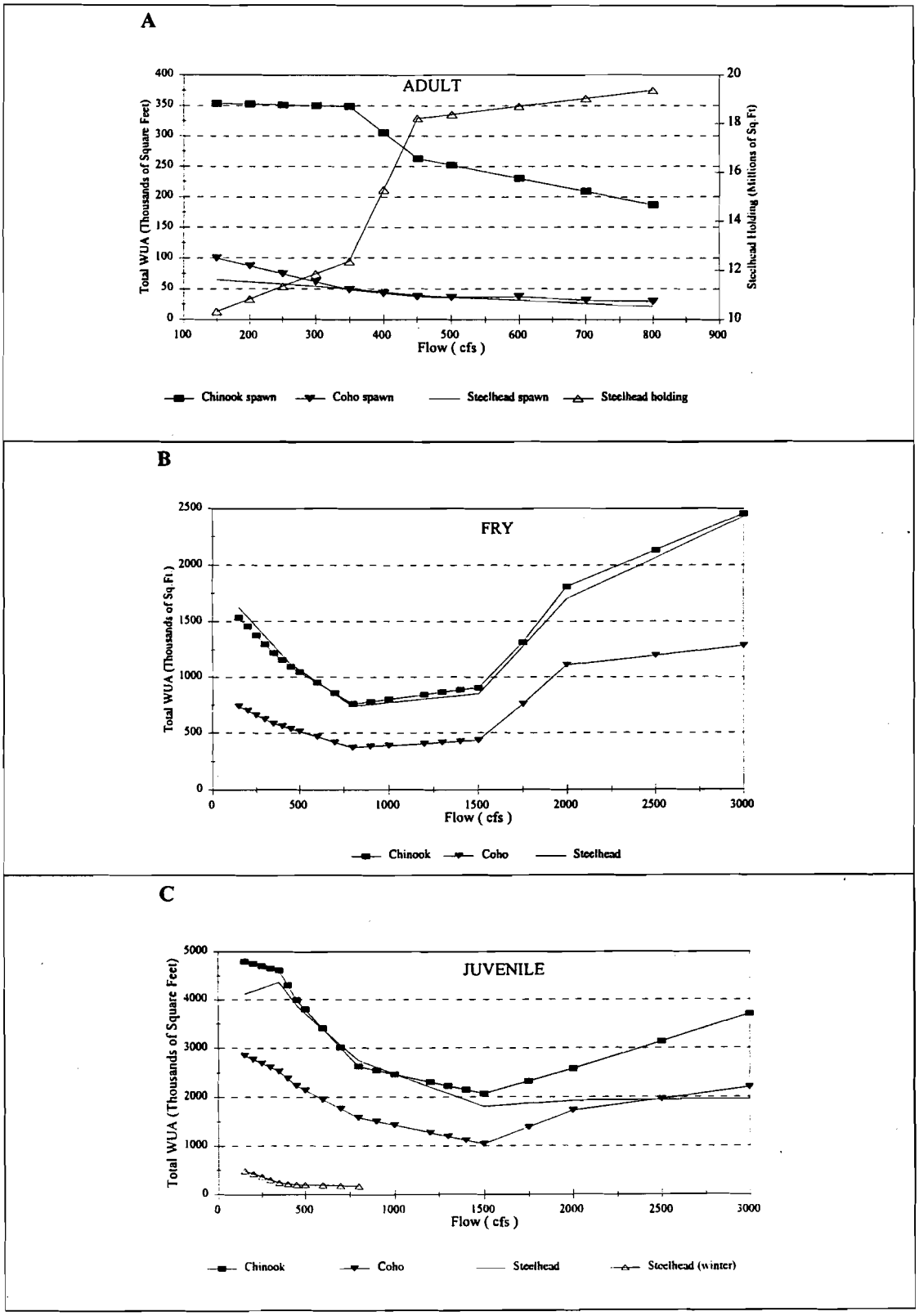

Figure 2. Physical habitat availability for adult (A), fry (B), and juvenile (C) salmon and steelhead in Segment 1A. Values were derived through direct measurement at 150 cfs, 350 cfs, 450 cfs, 800 cfs, 1500 cfs, 2000 cfs, and 3000 cfs. Habitat estimates between measured flows were interpolated.

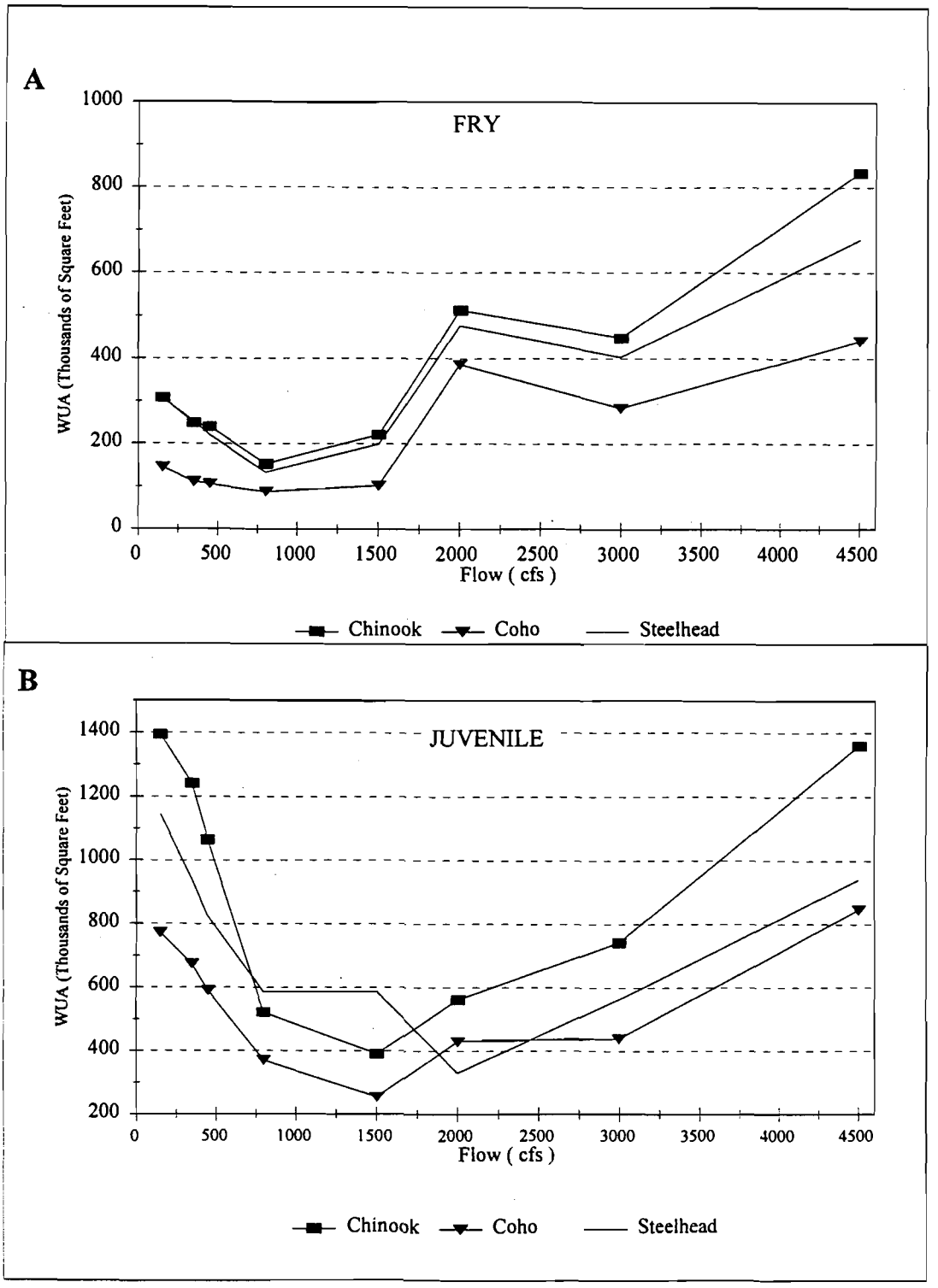

Figure 3. Physical habitat availability for fry (A) and juvenile (B) salmon and steelhead, as estimated through direct measurements of 24% of the physical habitat, in Segment IA. Interpolation was used to determine probable habitat-flow relationships between graph points.

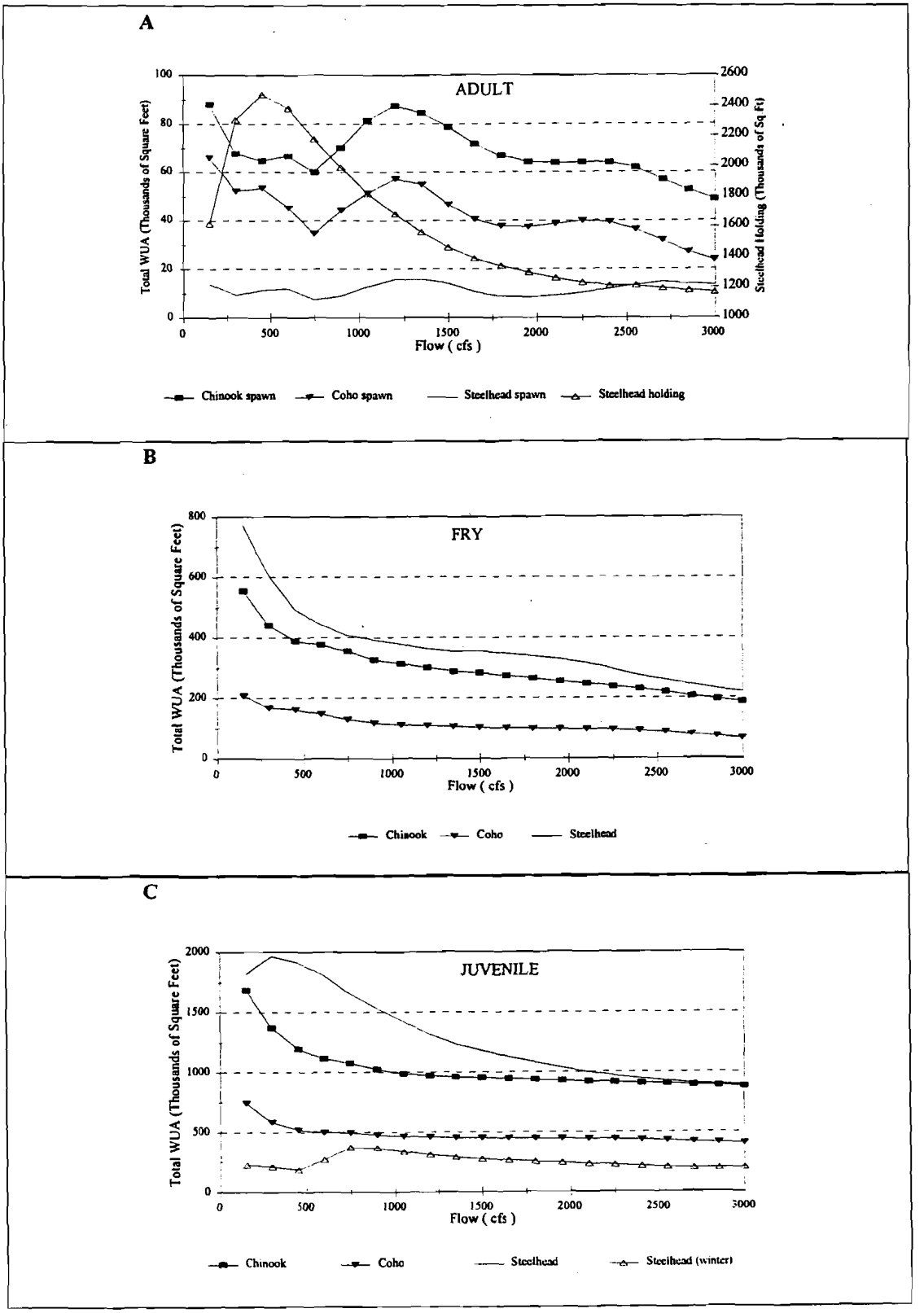

Figure 4. Physical habitat availability for adult (A), fry (B), and juvenile (C) salmon and steelhead in Segment IB. Estimates were derived through model simulation.

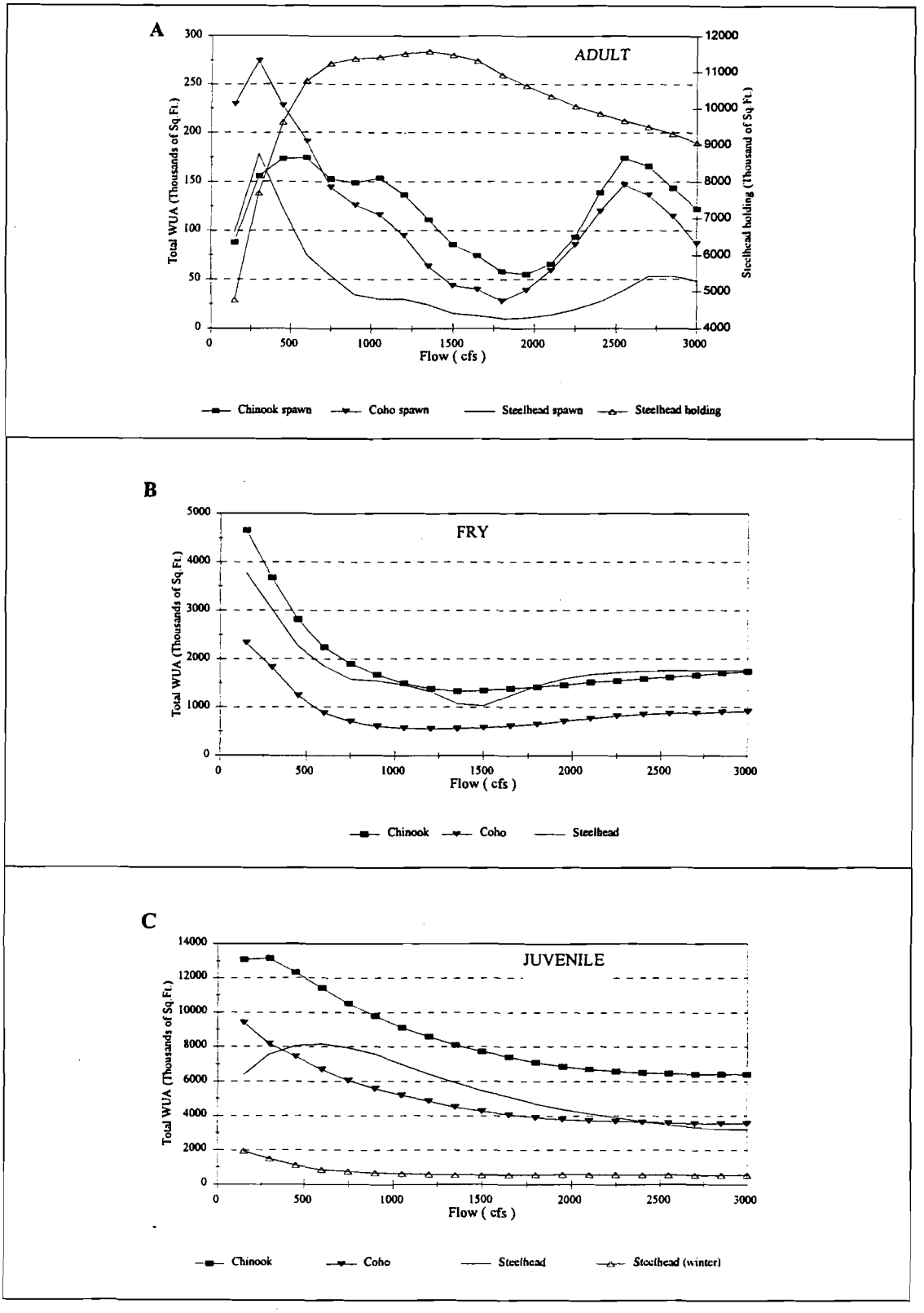

Figure 5. Physical habitat availability for adult (A), fry (B), and juvenile (C) salmon and steelhead in Segment II. Estimates were derived through model simulation.

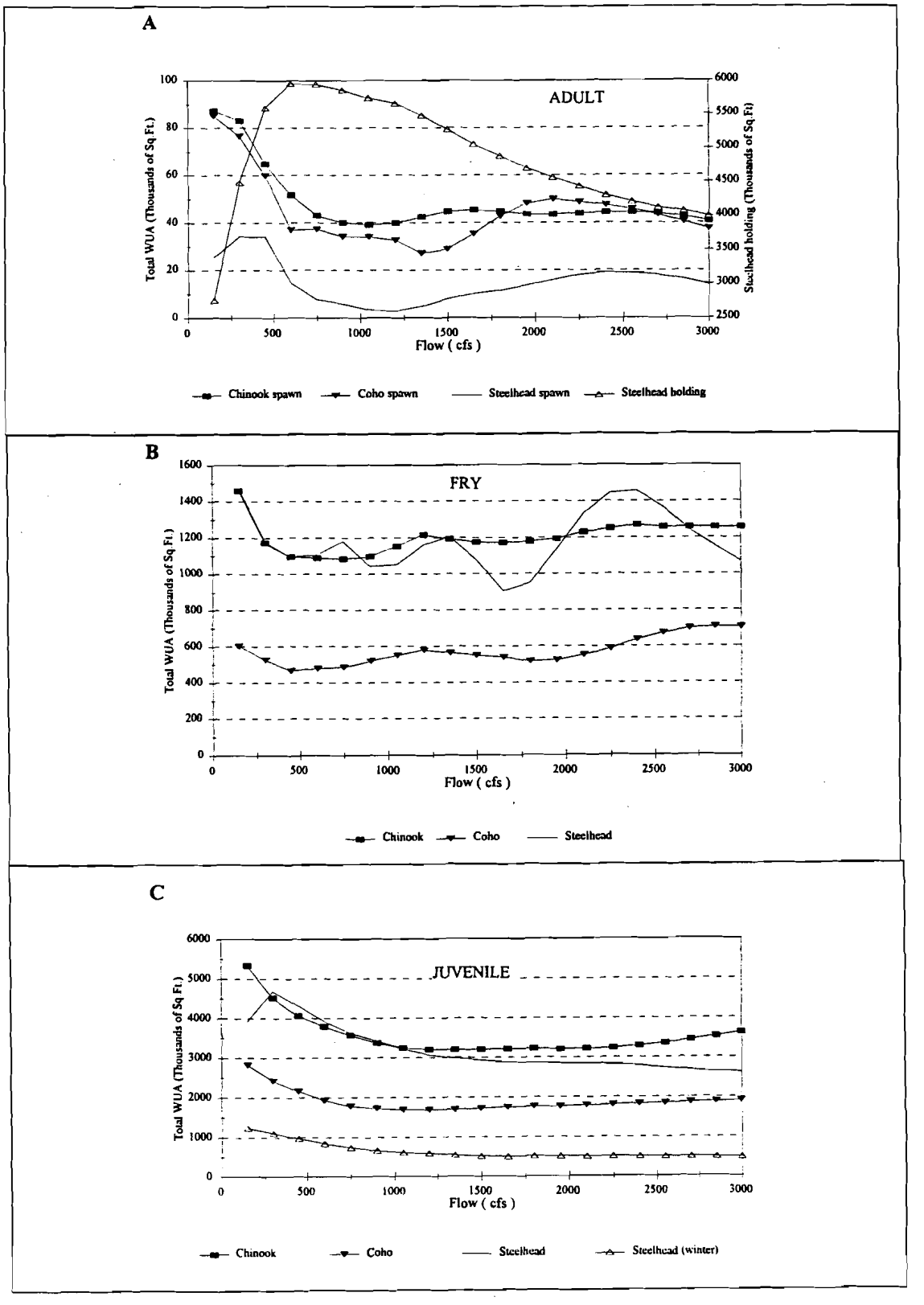

Figure 6. Physical habitat availability for adult (A), fry (B), and juvenile (C) salmon and steelhead in Segment III. Estimates were derived through model simulation.

Table 2. Physical habitat availability in units of weighted usable area (sq ft) for adult, fry, and juvenile salmon and steelhead in Segment IA, determined through empirical data (direct data).

	Chinook Salmon			Coho Salmon			Steelhead				
CFS	Spawn	Fry	Juvenile	Spawn	Fry	Juvenile	Adult Hold	Fry	Juvenile	Winter	Spawn
150	353,585	1,535,920	4,800,121	100,139	740,992	2,853,471	10,336,568	1,629,586	4,118,615	490,720	64,845
350	348,786	1,218,298	1,605,749	48,508	588,956	2,533,325	12,364,303	1,288,740	4,362,687	244,912	50,160
450	262,978	1,093,525	3,995,103	37,256	540,293	2,236,692	18,226,128	1,117,100	3,883,035	202,032	39,062
800	187,259	759,649	2,629,043	29,377	373,014	1,582,475	19,383,117	741,563	2,748,276	176,022	21,310
1,500		904,667	2,068,798		436,092	1,307,224		848,305	1,809,286		
2,000		1,811,076	2,581,869		1,108,144	1,730,979		1,701,365	1,930,369		
3,000		2,455,994	3,705,732		1,285,071	2,200,928		2,432,144	1,965,246		

Table 3. Physical habitat availability for fry and juvenile salmon and steelhead as estimated through direct measurement of 24 percent of the transect at flows up to 4500 cfs in Segment IA.

Chinook Fry

Mesohabitat Transect	Lewiston Dam Release (cfs) 150	350	450	800	1500	2000	3000	4500
C4	40,944	21,627	19,133	14,428	28,904	32,809	52,036	39,970
C6	3,643	3,349	1,565	1,037	9,068	13,873	34,222	19,898
BT2	57,397	40,166	39,049	13,356	21,051	122,769	78,731	75,387
BT8	33,971	25,304	25,536	21,362	8,278	10,508	40,031	14,000
BT9	16,942	21,350	18,956	3,718	66,860	186,312	21,227	278,095
PB1	8,462	5,187	2,085	4,134	1,251	2,563	7,762	6,416
PB3	57,335	33,149	31,783	9,658	50,335	46,341	50,374	24,941
SB3	22,731	5,537	7,037	5,821	4,829	10,780	19,675	45,169
SB6	42,618	60,689	69,486	62,862	20,026	75,545	114,438	115,773
SF4	24,452	32,859	25,371	16,808	10,794	12,384	30,489	214,392
Totals	308,495	249,217	240,001	153,185	221,397	513,684	448,986	834,041

Chinook Juveniles

Mesohabitat Transect	Lewiston Dam Release (cfs) 150	350	450	800	1500	2000	3000	4500
C4	132,451	77,207	77,530	35,721	23,245	37,107	71,232	99,369
C6	7,432	6,214	4,021	2,639	6,125	14,641	36,498	59,635
BT2	132,155	132,269	115,046	58,761	26,277	121,478	166,928	148,423
BT8	134,735	138,222	108,124	85,201	61,669	58,891	41,515	38,641
BT9	76,006	34,305	37,454	16,970	25,145	62,412	37,092	278,851
PB1	56,330	45,874	30,068	23,642	7,254	13,036	18,261	14,220
PB3	178,378	146,417	104,671	52,563	45,224	60,796	86,150	93,434
SB3	69,092	30,039	27,191	18,918	14,032	16,840	29,689	60,126
SB6	128,717	151,312	126,926	122,899	83,728	81,994	112,161	259,958
SF4	479,989	480,161	435,312	105,105	95,430	94,475	144,187	307,168
Totals	1,395,285	1,242,020	1,064,344	522,418	390,129	561,669	743,712	1,359,825

Coho Fry

Mesohabitat Transect	Lewiston Dam Release (cfs) 150	350	450	800	1500	2000	3000	4500
C4	15,775	6,451	5,279	4,312	15,699	17,680	27,407	17,718
C6	1,061	788	330	206	5,825	6,751	18,446	7,859
BT2	29,471	14,574	17,324	5,530	6,685	99,937	109,087	40,456
BT8	24,128	13,595	15,695	18,849	4,458	4,847	3,876	7,587
BT9	4,733	5,929	4,563	1,061	21,923	167,077	13,253	178,076
PB1	3,554	2,461	1,595	2,050	453	586	3,724	3,977
PB3	31,530	15,973	7,459	4,141	34,728	25,788	31,991	11,878
SB3	7,084	1,470	2,137	2,829	1,633	5,213	9,902	27,322
SB6	22,219	40,162	42,969	40,041	7,015	54,512	54,542	49,380
SF4	4,939	9,090	8,582	8,647	3,505	4,327	12,037	97,163
Totals	144,494	110,494	105,932	87,667	101,924	386,719	284,265	441,416

Coho Juveniles

Mesohabitat Transect	Lewiston Dam Release (cfs) 150	350	450	800	1500	2000	3000	4500
C4	63,860	28,991	27,753	12,092	14,605	22,139	39,850	54,264
C6	2,686	2,561	1,276	826	4,592	8,594	24,450	45,738
BT2	75,600	73,343	67,289	37,317	13,433	90,704	88,822	79,641
BT8	116,947	95,445	61,504	65,683	36,219	31,834	30,791	22,104
BT9	27,102	12,610	13,686	5,813	23,211	93,656	18,999	298,809
PB1	16,445	13,949	9,647	10,921	2,452	6,153	8,028	8,067
PB3	116,432	74,151	54,327	24,764	57,694	62,844	58,410	41,096
SB3	25,115	9,777	9,169	7,085	7,337	9,201	17,466	41,407
SB6	71,980	104,724	130,021	144,102	51,446	59,452	89,114	112,550
SF4	256,107	258,756	216,759	61,391	42,426	45,992	64,463	142,251
Totals	772,275	674,307	591,431	369,793	253,414	430,369	440,393	846,126

Steelhead Fry

Mesohabitat Transect	Lewiston Dam Release (cfs) 150	350	450	800	1500	2000	3000	4500
C4	38,850	25,515	22,570	19,269	28,862	34,123	44,455	32,793
C6	4,467	3,458	2,739	1,835	9,781	13,610	29,991	12,312
BT2	42,455	26,781	27,543	10,269	22,930	118,423	58,534	70,273
BT8	28,698	26,085	20,415	18,790	6,840	12,897	43,608	14,235
BT9	25,538	29,984	27,662	8,795	72,644	159,969	29,222	167,303
PB1	21,379	11,899	4,203	3,869	1,205	2,421	7,467	5,628
PB3	43,403	32,749	26,666	9,253	26,294	37,107	44,578	25,172
SB3	25,948	11,221	11,453	7,305	4,912	10,626	18,663	40,030
SB6	46,841	48,444	45,186	35,033	15,564	72,371	91,340	103,246
SF4	29,105	36,898	31,923	19,002	9,952	15,772	36,176	206,512
Totals	306,685	253,033	220,361	133,420	198,785	477,318	404,033	677,503

Steelhead Juveniles

Mesohabitat Transect	Lewiston Dam Release (cfs) 150	350	450	800	1500	2000	3000	4500
C4	123,761	113,031	107,008	64,565	31,204	41,142	54,231	71,862
C6	8,945	6,833	8,615	4,807	8,555	11,847	22,320	30,341
BT2	196,573	143,799	115,773	69,557	53,321	40,651	137,860	136,339
BT8	12,203	20,174	28,149	9,762	74,483	16,394	12,234	15,128
BT9	187,130	95,880	95,389	66,402	140,019	32,382	147,747	189,491
PB1	78,623	115,282	122,742	109,133	25,197	17,533	17,042	16,321
PB3	92,858	103,678	87,634	70,050	139,026	39,936	52,407	87,885
SB3	78,442	60,330	56,174	56,127	23,494	21,589	32,584	36,601
SB6	76,738	76,897	44,731	33,465	44,140	59,316	50,362	201,042
SF4	288,087	205,356	158,099	101,876	46,698	49,157	37,579	155,087
Totals	1,143,358	941,261	824,315	585,743	586,138	329,947	564,366	940,096

Table 4. Physical habitat availability in units of weighted usable area (sq ft) for adult, fry, and juvenile salmon and steehead in Segment IB, determined through empirical data (direct data).

Total Weighted Usable Area of Habitat (thousand sq. ft.)											
River Discharge (cfs)	Chinook Spawn	Chinook Fry	Chinook Juvenile	Coho Spawn	Coho Fry	Coho Juvenile	Steelhead Adult Hold	Steelhead Spawn	Steelhead Fry	Steelhead Juvenile	Steelhead Juv Winter
150	88	556	1,684	66	208	744	1,621	14	772	1,820	226
300	68	442	1,374	52	169	585	2,307	9	606	1,967	212
450	65	389	1,194	54	163	520	2,474	12	494	1,913	185
600	67	377	1,114	45	148	500	2,383	12	444	1,813	269
750	60	356	1,079	35	131	495	2,183	8	408	1,656	374
900	70	328	1,025	44	118	478	1,992	9	393	1,536	368
1,050	82	315	989	52	113	465	1,821	13	379	1,426	337
1,200	88	302	971	57	110	459	1,683	16	363	1,317	311
1,350	85	289	959	55	107	453	1,563	16	354	1,235	289
1,500	79	285	953	47	104	452	1,467	14	356	1,180	273
1,650	72	274	945	41	101	450	1,393	11	346	1,128	262
1,800	67	265	938	38	100	447	1,340	9	339	1,082	252
1,950	64	256	930	37	99	446	1,298	9	329	1,036	242
2,100	64	247	922	39	98	444	1,260	9	317	997	233
2,250	64	237	915	40	96	440	1,233	10	296	967	224
2,400	64	229	907	39	92	435	1,212	12	274	944	213
2,550	62	220	905	36	88	430	1,213	14	260	928	205
2,700	57	206	893	32	80	419	1,196	15	244	908	198
2,850	53	195	886	27	73	412	1,182	14	229	896	197
3,000	49	187	879	24	66	407	1,170	14	220	892	201

[Formula: ((Oregon Gulch WUA x 43,085ft) + (Junction City WUA x 34,848ft))/1,000,000]

Table 5. Physical habitat availability in units of weighted usable area (sq ft) for adult, fry, and juvenile salmon and steehead in Segment II, determined through empirical data (direct data).

Total Weighted Usable Area of Habitat (thousand sq. ft.)											
River Discharge (cfs)	Chinook Spawn	Chinook Fry	Chinook Juvenile	Coho Spawn	Coho Fry	Coho Juvenile	Steelhead Adult Hold	Steelhead Spawn	Steelhead Fry	Steelhead Juvenile	Steelhead Juv Winter
150	88	4,659	13,089	230	2,339	9,402	4,778	98	3,793	6,383	1,959
300	156	3,680	13,161	274	1,819	8,190	7,694	179	3,029	7,571	1,511
450	174	2,818	12,338	228	1,236	7,432	9,623	123	2,269	8,057	1,124
600	174	2,249	11,428	191	881	6,706	10,749	76	1,860	8,186	854
750	153	1,902	10,548	144	707	6,063	11,254	54	1,584	7,955	758
900	149	1,671	9,820	126	611	5,574	11,376	34	1,550	7,585	686
1,050	153	1,493	9,129	116	568	5,198	11,411	30	1,461	7,012	632
1,200	136	1,377	8,582	95	554	4,857	11,508	30	1,321	6,435	591
1,350	111	1,334	8,107	63	560	4,519	11,574	24	1,078	5,938	564
1,500	86	1,344	7,719	44	580	4,266	11,473	15	1,037	5,473	555
1,650	75	1,387	7,434	40	618	4,062	11,315	13	1,242	5,110	575
1,800	58	1,414	7,104	28	652	3,893	10,920	10	1,445	4,705	573
1,950	55	1,464	6,866	39	710	3,803	10,628	11	1,591	4,401	584
2,100	66	1,518	6,704	59	768	3,732	10,344	14	1,678	4,152	587
2,250	94	1,544	6,584	86	819	3,678	10,068	19	1,712	3,913	583
2,400	139	1,583	6,521	120	848	3,636	9,862	27	1,741	3,672	576
2,550	174	1,618	6,465	147	866	3,595	9,662	39	1,760	3,483	562
2,700	166	1,664	6,418	136	885	3,561	9,498	53	1,764	3,337	549
2,850	144	1,706	6,407	114	903	3,550	9,302	53	1,761	3,234	546
3,000	122	1,737	6,422	87	918	3,549	9,063	48	1,765	3,178	547

[Formula:((Del Loma WUA x 131,472 ft)+(Hawkins Bar WUA x86,064 ft.))/1,000,000]

Table 6. Physical habitat availability in units of weighted usable area (sq ft) for adult, fry, and juvenile salmon and steelhead in Segment III, determined through empirical data (direct data).

Total Weighted Usable Area of Habitat (thousand sq. ft.)											
River Discharge (cfs)	Chinook Spawn	Chinook Fry	Chinook Juvenile	Coho Spawn	Coho Fry	Coho Juvenile	Steelhead Adult Hold	Steelhead Spawn	Steelhead Fry	Steelhead Juvenile	Steelhead Juv Winter
150	87	1,460	5,343	85	603	2,833	2,762	25	1,474	3,923	1,247
300	83	1,175	4,523	77	527	2,430	4,493	34	1,180	4,686	1,108
450	65	1,095	4,062	60	466	2,162	5,597	34	1,095	4,326	978
600	52	1,091	3,797	37	479	1,928	5,956	15	1,108	3,937	848
750	43	1,084	3,574	37	486	1,790	5,950	8	1,183	3,631	744
900	40	1,098	3,376	34	520	1,727	5,860	6	1,044	3,425	665
1,050	39	1,154	3,243	34	551	1,693	5,746	3	1,051	3,217	609
1,200	40	1,218	3,207	33	580	1,689	5,664	3	1,161	3,067	593
1,350	42	1,192	3,198	27	564	1,693	5,486	5	1,208	2,985	546
1,500	45	1,176	3,203	29	551	1,718	5,274	8	1,079	2,933	512
1,650	45	1,174	3,217	35	538	1,748	5,059	10	904	2,885	506
1,800	45	1,179	3,223	43	517	1,764	4,885	11	949	2,872	515
1,950	43	1,194	3,207	48	522	1,771	4,700	14	1,135	2,853	512
2,100	43	1,230	3,225	50	552	1,793	4,567	16	1,333	2,848	510
2,250	44	1,251	3,241	49	586	1,810	4,437	18	1,446	2,829	509
2,400	44	1,270	3,293	47	636	1,837	4,306	19	1,457	2,793	508
2,550	44	1,258	3,356	46	672	1,849	4,207	19	1,366	2,737	505
2,700	44	1,258	3,445	43	696	1,866	4,122	18	1,244	2,680	502
2,850	43	1,257	3,534	40	707	1,884	4,073	16	1,155	2,645	497
3,000	41	1,257	3,628	38	704	1,914	4,005	14	1,068	2,627	487

[Formula:((Tish Tang WUA x 80,256 ft)+(Hoopa WUA x 36,960 ft.))/1,000,000]

APPENDIX A

Plan of Study
For Trinity River
Fishery Flow Evaluations

Trinity River, Northwestern California

Lead Agency: U.S. Fish and Wildlife Service
Assisting Agencies: Members of the Trinity River Basin
Fish and Wildlife Task Force

Approved: /sgd/ Ronald E. Lambertson
Acting Director, U.S. Fish and Wildlife Service

DEC - 8 1983
Date

Study Goal: The goal of this study is to monitor the rehabilitation of fishery habitat in the Trinity River below Lewiston Dam in northwestern California. The information from this study together with harvest and escapement information from other ongoing studies will be used to advise the Secretary whether the Department is operating the Trinity River Division consistent with its authorizing provisions for the protection and propagation of fishery resources. This study will meet the intent of the Secretarial decision of January 1981 pertaining to increased flow releases for anadromous fishery protection in the Trinity River downstream of Lewiston Dam - a major feature of the Trinity River Division, Central Valley Project, operated by the U.S. Bureau of Reclamation.

Background and Overview: The Trinity River is a major tributary of the Klamath River in northwestern California. The natural resources of the Trinity River Basin sustain many important resource-based social and economic interests. Historically, the Trinity has been recognized as a major producer of chinook and coho salmon and steelhead trout. Indian, sport and commercial salmon fisheries have operated on these runs. Mineral, timber and water resources have also been developed in the Trinity Basin. These developments together with fisheries harvests are believed to have caused major declines in fall-run chinook and steelhead trout populations over the past two decades. Specific user groups dependent on the fisheries stocks as well as the general northern coastal economics have suffered as a result of the fisheries declines.

These losses are of high concern to this Department for two reasons: First, the Department has Indian Trust responsibilities which extend to protection of Indian fisheries rights and resources; and, second, the act authorizing the construction of the Trinity River Division of the Central Valley Project directs the Secretary to preserve and propagate anadromous fish in the basin.

The Trinity River Division which is the only major water development project in the Trinity River Basin serves to export water from the Trinity River to the Central Valley of California. Since its operation began in 1963, the project has annually exported about 75-90 percent of the runoff at Lewiston Dam. The remainder of flow has been released downstream either for fisheries purposes (about 10 percent annually 1963-73 and somewhat higher in more recent years) or as water surplus to the project's immediate needs.

Coincident with construction and operation of the Trinity River Division, logging accelerated within the Trinity Basin. Higher watershed erosion rates and lowered streamflows downstream of Lewiston Dam resulted in extensive sedimentation of fish habitat. Maintenance of minimum streamflow releases and construction and operation of a fish hatchery were not sufficient to sustain fisheries populations. Declines in some stocks have exceeded 90 percent of former levels.

In December of 1980, the Fish and Wildlife Service and the Bureau of Reclamation reached an agreement to increase releases to the Trinity

River below Lewiston Dam to aid in the rehabilitation of the important and rapidly dwindling anadromous fishery resources. The agreement was approved by the former Secretary Andrus in January 1981 and has been supported by Secretary Watt.

In addition to increasing flow releases for fishery purposes, the agreement also provides for a special study over a 12-year period during which improved releases would be maintained. The Fish and Wildlife Service is to conduct the study in consultation with the Bureau of Reclamation and the California Department of Fish and Game. At the end of the 12-year period, a report will be made to the Secretary describing the effectiveness of the improved flows and any other habitat rehabilitation measures (such as those contained in the proposed Trinity River Basin Fish and Wildlife Management Program) in restoring fishery populations and habitat below Lewiston Dam.

The fishery flow agreement and study are necessary because the congressional authorization for construction and operation of the Trinity River Division provides for the preservation and propagation of the Trinity's indigenous fishery resources by the Secretary and, as previously indicated, these resources are declining.

A number of factors, in combination, including overharvest, are thought to be responsible for fishery declines, but not all are within the jurisdiction of the Secretary of the Interior to correct. Habitat losses due to low riverflows and sediment accumulation in the main stem Trinity River can be restored in part by increasing flows, trapping sediments, and mechanically rehabilitating spawning and rearing areas, and by reducing erosion through improved watershed management in tributary streams. The Department of the Interior is focusing effort on these tasks.

The Secretary has taken the first step towards rehabilitation of fish runs by improving fishery flow releases (at the expense of other project water uses). A sediment control project (Buckhorn Mtn. Dam-Grass Valley Creek Sediment Control Project) has been authorized by Congress and Interior will likely begin work on the project during Fiscal Year 1984. The Trinity River Basin Fish and Wildlife Task Force--a 13-member group of Government specialists advisory to the Bureau of Reclamation--has developed a comprehensive plan for the rehabilitation and management of fish and wildlife resources throughout the Trinity Basin. With the cooperative assistance of the Bureau of Reclamation and Bureau of Indian Affairs, Fish and Wildlife Service is preparing an Environmental Impact Statement on the Task Force management program. Legislation to authorize and fund the program has been introduced in Congress.

The efforts described above will largely rehabilitate salmon and steelhead habitat in the Trinity River system. Restoration of the fish

populations themselves, however, will also be dependent on effective harvest management. This year (1983) the Pacific Fisheries Management Council has adopted a 20-year plan to rebuild salmon runs in the Klamath-Trinity Basin through controlled ocean harvests. Adherence to that plan or even tougher standards, as well as the effective management of Indian and sport fisheries, is vital to the successful replenishment of the anadromous runs.

Although the 12-year study plan presented here addresses habitat restoration, it is clear that consideration will have to be given to the role of harvest management in allowing run goals to be met. It is anticipated that relevant data and evaluations from other monitoring efforts (harvests and escapements) will be considered and included in developing reports and recommendations to the Secretary during this study.

Study Description: The study will span 12 years and consist of 6 major tasks:

1. Study plan review and modification
2. Habitat preference criteria development
3. Habitat availability and need
4. Fish population characteristics and life history relationships
5. Study coordination
6. Reports

The study will require a maximum of 8.8 full-time-equivalent positions depending on work in progress and will require annual funding ranging from $116,431 to $359,273. The study will focus on the main stem Trinity River from Lewsiton Dam to its confluence with the Klamath River at Weitchpec. Each study task is described in the following section. Efforts and funding estimates for each task are presented. Effort is shown in biologist days and total staff days (A biologist-day includes biotechnicians). It is assumed that the Fish and Wildlife Service will be the lead agency. There is opportunity for (and interest in) participation by the California Department of Fish and Game and Water Resources and Hoopa Valley Business Council. Their cooperation will be solicited. Interagency participation may alter effort and funding requirements somewhat.

A matrix table showing task schedules and levels of effort throughout the study period is appended. It is intended that this study: 1) Be conducted by utilizing current scientific methodologies; 2) be flexible to meet changing fishery resource conditions; 3) be closely coordinated with other studies and resource management agencies; and 4) be reported on, by performing timely data analyses, at regular intervals and at the conclusion of the study.

Consequences of Not Performing Study: Without this study the Department of the Interior will be unable to show how it is meeting its commitments and requirements to maintain and propogate fishery resources in the Trinity River Basin. The Department will continue to be challenged by Indian and other fishery resource management and interest groups and the Trinity River Division will continue to be viewed by these elements as a classic example of the incompatibility of water resource development with fishery maintenance and of the failure of the Federal Government to be responsive to area of origin concerns.

TASK 1. Annual Study Plan Review and Modification

Objective: The objective of TASK 1 is to assure that the study plan reflects current findings and data needs.

Need: As the study progresses certain study elements may require an approach modified from that originally envisioned. Changes will be made based on experience gained from previous efforts.

Methods: Each study year the project leader will review the study efforts and findings with the principal resource management agencies in the Trinity River Basin, including the Trinity River Basin Fish and Wildlife Task Force. Based on these meetings a final study plan for the following year will be prepared.

Effort: Work required to complete TASK 1 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1-11	55 (5/yr)	110 (10/yr)
12	0	0
Total	55 days	110 days

Funding: Funding required to complete TASK 1 is estimated to be:

Study Year(s)	Amount
1	$ 1,590
2-11	16,630 ($1,663/yr)
12	0
Total	$18,223

TASK 2. Habitat Preference Criteria Development

Objective: The objective of Task 2 is to develop habitat preference criteria quantifying depths, velocities, substrates, and cover requirements for chinook and coho salmon and steelhead trout spawning, incubation, rearing, holding, and migration. Other factors such as water quality and temperature will also be considered under TASK 3.

Need: Improved preference criteria are needed to use with streamflow hydraulic data to determine the amount of habitat presently existing for salmon and steelhead, to determine the amount required and types required to achieve target levels of natural fish production, and to monitor increases in habitat gained from flow management and mechanical habitat rehabilitation work.

Methods: Field data will be collected using a variety of techniques. Emphasis will be on visual observations through diving and snorkeling where possible. Other techniques may include electrofishing, seining, redd sampling, and other measures as necessary. Where sufficient data are available, a bivariate analysis will be performed using procedures outlined in Instream Flow Information Paper No. 12 (Bovee, FWS/OBS 82/26, 1982) to develop habitat preference criteria for the following species and life stages:

Species	Race	Life Stage
Chinook salmon	Spring run	Adult holding Spawning Incubation Rearing (fry) Juvenile migration
Chinook salmon	Fall run	Adult holding Spawning Incubation Rearing (fry) Juvenile migration
Coho salmon	Fall run	Adult holding Spawning Rearing (fry) Rearing (yearling) Juvenile migration

Steelhead trout	Summer run (possible)	Adult holding Spawning Rearing (fry) Rearing (yearling) Juvenile migration
Steelhead trout	Winter run	Adult holding Spawning Incubation Rearing (fry) Rearing (yearling) Juvenile migration

Effort: Effort needed to complete TASK 2 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	178	356
2	200	400
3	145	290
4-11	88 (11/yr)	176 (22/yr)
12	0	0
Total	611	1,222

Funding: Funding required to complete TASK 2 is estimated to be:

Study Year(s)	Amount
1	$ 56,604
2	66,532
3	48,236
4-11	29,272 ($3,659/yr)
12	0
Total	$200,646

TASK 3. Determination of Habitat Availability and Needs.

Objectives: There are two objectives for TASK 3. The first is to determine the amount of salmon and steelhead habitat available in the Trinity River downstream of Lewiston Dam under various flow conditions and the various levels of habitat rehabilitation that may be achieved either through the Trinity River Basin Fish and Wildlife Management Program or through other resource management actions. The second objective is to determine the amount of habitat required for

each freshwater life stage of salmon and steelhead to sustain those portions of the fish populations in the Trinity Basin that were historically dependent on the Trinity River downstream of Lewiston Dam.

Need: The information from this TASK is needed to evaluate the effectiveness of riverflows and other measures in providing adequate amounts and distribution of fish habitat.

Methods: The Incremental Instream Flow Methodology developed by the Fish and Wildlife Service will be utilized as the primary evaluation tool. The methodology and its uses are described in Instream Flow Information Paper No. 12 (Bovee, FWS/OBS 82/26, 1982) and other publications by the Service's Instream Flow and Aquatic Systems Group. The methodology uses hydraulic and biological data to simulate habitat conditions over a range of potential flows. Water temperatures and other water quality data will be collected and incorporated into the habitat evaluations.

Field data will be collected 3 to 4 times over the 12-year study period from representative study reaches between Lewiston and Weitchpec. This will allow a running tally of habitat conditions and make it possible to account for habitat changes due to flows and watershed restoration, as opposed to any instream habitat rehabilitation by mechanical means.

Calculations of available habitat will be based on habitat preference criteria developed under TASK 2. Determination of habitat eds will also consider population use data to be developed under TASK 4. Minor field and laboratory research investigations may be required to test the validity of assumptions on egg and fry survival under various sediment conditions. It is anticipated that this and other specialized work may be undertaken through cooperative arrangements with research institutions.

The major subtasks of TASK 3 are:

1. Selection, establishment and maintenance (minor brush clearing, surveying, etc.) of measurement stations.

2. Hydraulic data collection over a range of flows at each station--repeated 2-3 times after initial period depending on streamflows and channel conditions (rehabilitation work).

3. Data analysis and habitat projections assuming various channel and flow conditions, and temperature and other water quality conditions.

The field schedule and effort for each subtask is detailed in the appended table.

Effort: Work required to complete TASK 3 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	444	$ 888
2	390	780
4, 6, 8, 10	1,200 (300/yr)	2,400 (600/yr)
3, 5, 7, 9, 11	1,000 (200/yr)	2,000 (400/yr)
12	0	0
Total	3,034	$6,068

Funding: Funding required to complete TASK 3 is estimated to be:

Study Year(s)	Amount
1	$ 141,192
2	129,737
4, 6, 8, 10	399,192 ($99,798/yr)
3, 5, 7, 9, 11	332,660 ($66,532/yr)
12	
Total	$1,002,781

TASK 4. Determination of Fish Population Characteristics and Life History Relationships.

Objective: The objective of TASK 4 is to determine the relative levels of successful use by fish populations of available habitat in the Trinity River downstream of Lewiston Dam.

Need: Although some information is available on spawning escapements and spawning redd numbers in certain areas, very little is known about the total distribution of fish between Lewiston and Weitchpec or their spawning success and the subsequent survival and growth of juveniles. This type of information is needed to determine which habitat factors may be limiting the restoration of fish populations.

Methods: Selected study reaches will be surveyed periodically to develop indices of habitat use, fish distribution, and the survival and growth of juveniles. Survey field methods will include snorkeling, seining, electroshocking, emergent fry trapping, and other techniques found suitable. Survey methods will be refined and standardized based on experimentation during the first year.

Benthic aquatic organisms will also be monitored to determine the overall health and productive capabilities of the Trinity in the established field study reaches. Food habits of juvenile salmonids will be examined to determine utilization of available food supply. Methods for this study element will be patterned after those developed by researchers with the U.S. Forest Service and Brigham Young University (Biotic Condition Index: Integrated Biological, Physical and Chemical Stream Parameters for Management. Robert N. Winget and Fred A. Mangum. October 1979. Intermountain Region, Forest Service, U.S. Dept. of Agriculture) and others.

Effort: The effort required to complete TASK 4 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	93	186
2,4,6,8,10,11	2,232 (372/yr)	4,464 (744/yr)
3,5,7,9	3,736 (684/yr)	7,472 (1,368/yr)
12	0	0
Total	6,061	12,122

Funding: Funding required to complete TASK 4 is estimated to be:

Study Year(s)	Amount
1	$ 29,574
2,4,6,8,10,11	742,500 ($123,750/yr)
3,5,7,9	910,158 ($227,539/yr)
12	0
Total	$1,682,230

TASK 5. Study Coordination

Objective: The objective of TASK 5 is to develop and maintain coordination with other study and resource management agencies in the Trinity River Basin to maximize effective use of available information (and to avoid duplication of work).

Need: Presently, the California Department of Fish and Game, Bureau of Indian Affairs, Forest Service, Bureau of Land Management, Hoopa Valley Business Council (Fisheries Department) and the Fish and Wildlife Service have fisheries studies and management programs underway. Additional study efforts will occur under this program and the comprehensive fish and wildlife management program proposed by the Trinity River Basin Fish and Wildlife Task Force. It is essential that studies be coordinated to prevent unintended interference and to make use of study results in planning future work and making management decisions.

Methods: Coordination will be maintained through both formal and informal contacts. Other study leaders and local fishery resource managers will be contacted on at least a bimonthly basis. Formal coordination meetings will be scheduled twice yearly. Quarterly work progress reports (prepared under TASK 6) and preliminary fisheries reports will be provided to interested agencies.

Effort: The effort required to complete TASK 5 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1-11	220 (20/yr)	440 (40/yr)
12	10	20
Total	230	460

Funding: Funding required to complete TASK 5 is estimated to be:

Study Year(s)	Amount
1	$ 6,360
2-11	66,532 ($6,653/yr)
12	3,327
Total	$76,219

TASK 6. Reports (Progress, Findings and Recommendations)

Objective: The objectives of TASK 6 are: 1) To report on the analysis of information developed from field investigations (TASK 2, 3, and 4) and on relevant information from other studies which have a bearing on the levels of fishery resource rehabilitation achieved in the Trinity River between Lewiston and Weitchpec; and 2) to develop recommendations to the Secretary and to other resource management agencies concerning future management options and needs.

Need: Fishery rehabilitation efforts achieved through improved flow releases from Lewiston Dam and from mechanical aquatic habitat and watershed rehabilitation should be monitored and critically analyzed.

Methods: Three types of reports will be prepared under TASK 6. The first type will be quarterly progress and planning reports detailing study activities and accomplishments during the past quarter and describing anticipated activities during the current quarter. These will generally be prepared and distributed within 2 weeks of the close of each quarter. The second type will be preliminary findings reports containing field data and analyses for major portions of one or more study elements. As an example, this type of report would be produced following completion of the habitat preference criteria study element (TASK 2) and at the end

of each of the 3 to 4 periods of hydraulic streamflow data collection and computer analysis (TASK 3). The preliminary findings reports should be completed after data analysis and during the year following completion of field work. The final type of report will be the concluding report to the Secretary.

The concluding report will summarize the findings of each of the study elements (from various preliminary findings reports), evaluate the results of improved flows and other rehabilitation measures in an overall manner, and convey to the Secretary the Service's recommendations with respect to future management options and needs for the Trinity River downstream of Lewiston Dam.

Effort: Effort needed to complete TASK 6 is estimated to be:

Study Year(s)	Biologist Days	Total Staff Days
1	10	20
2	20	40
4,6,8,10	120 (30/yr)	240 (60/yr)
3,5,7,9,11	130 (26/yr)	260 (52/yr)
12	340	680
Total	620	1,240

Funding: Funding required to complete TASK 6 is estimated to be:

Study Year(s)	Amount
1	$ 3,180
2	6,653
4,6,8,10	39,921 ($9,980/yr)
3,5,7,9,11	43,246 ($8,649/yr)
12	113,104
Total	$206,104

APPENDIX B

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION STUDY

1985

U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento Field Office
Sacramento, California

Prepared by:

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January 1985

DESCRIPTION OF STUDY REACHES

In order to complete study tasks in an organized manner, the mainstem of the Trinity River between Lewiston Dam and Weitchpec (approximately 110 river miles) was partitioned into three general segments: upper, middle, and lower. Each of these broad segments has distinctive features and is used to different degrees by salmon and steelhead. The three segments are: I) Lewiston Dam to North Fork Trinity River; II) North Fork Trinity River to South Fork Trinity River; and III) South Fork Trinity River to the confluence with the Klamath River (Weitchpec).

The upper segment (Lewiston Dam to N.F. Trinity) is probably the most important to salmonid production. The majority of the substrate within this segment is composed of sand, gravel, and cobbles with less bedrock than further downstream. Controlled river flows and encroachment of riparian vegetation are characteristic of this segment. The river itself has largely become constricted into long uniform runs with swift flows.

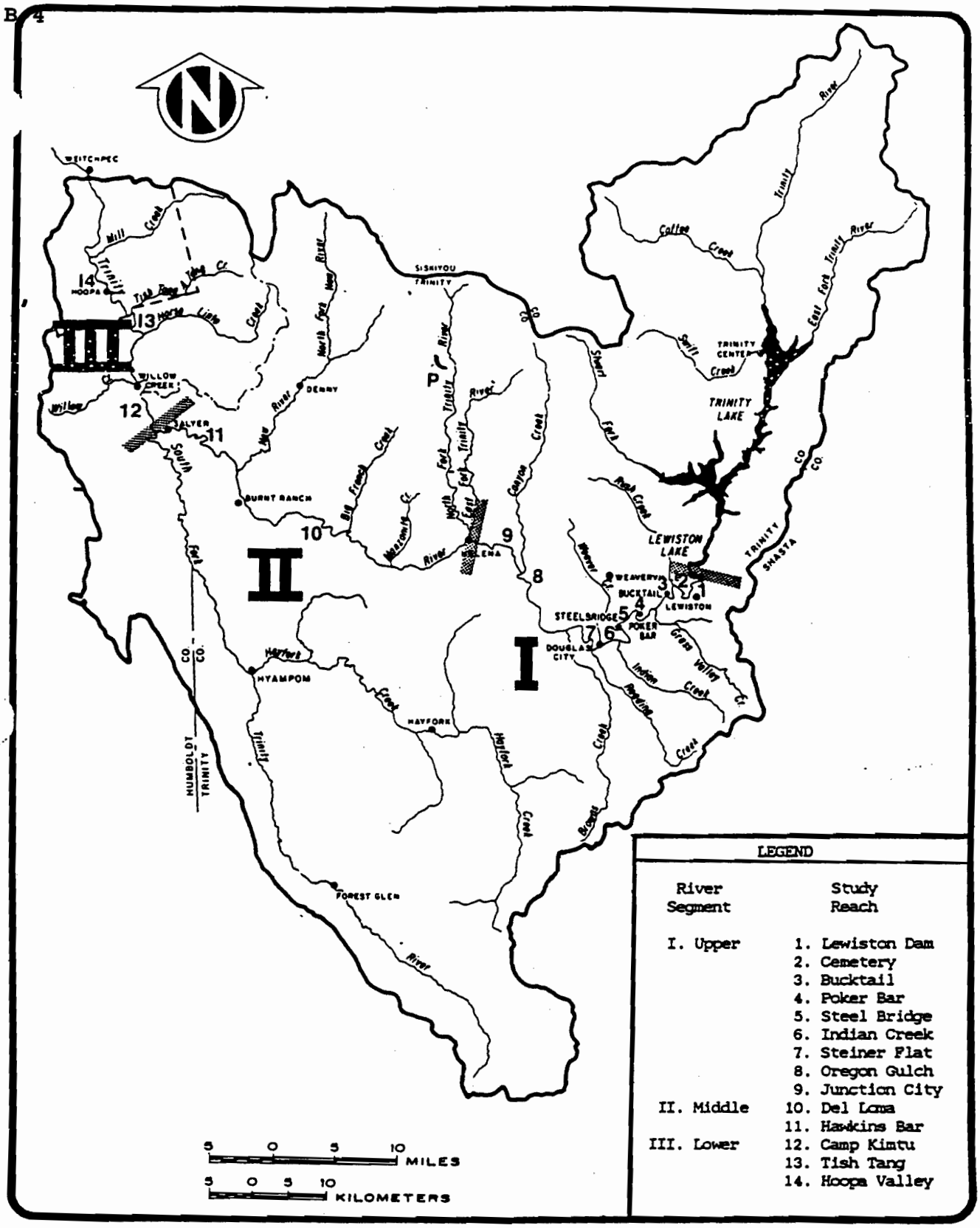
The character of the river within the middle segment (North Fork to South Fork) is quite varied. Although the overall gradient is moderate within this segment it includes the precipitous gorge between China Slide and Gray Falls, the most rugged section of the Trinity River. Here, the river is controlled primarily by a bedrock channel and is characterized by long, moderately deep pools, numerous sandy beaches, and steep wooded hillsides. The river corridor is relatively undeveloped except for a few scattered residences and small communities.

The lower segment extends 30.8 miles from the South Fork to the confluence with the Klamath River (at Weitchpec). Generally the river gradient is low as the river passes northward through a v-shaped valley, into the settled area around Willow Creek, through a short gorge above Tish-Tang, the Hoopa Valley and finally a narrow gorge before entering the Klamath River. In the valley reaches the river meanders across large gravel and cobble bars which are mostly clear of vegetation. The river flow has been greatly increased due to inflow from the South Fork, broadening and flattening the channel somewhat with numerous gravel deposits and few rapids.

Within these three generalized river segments, 14 representative study reaches were selected: nine in the upper river segment; two in the middle segment; and three in one lower segment (Table 1 and Figure 3).

Table 1. Representative Study Reaches, Trinity River Flow Evaluation Study, 1985. (See also Figure 3 for locations).

	River Segment	Study Reach	Description	No. IFIM Transects
I.	Upper	1. Lewiston Dam	Lewiston Dam to Old Fish Weir	19
		2. Cemetery	Old Fish Weir to mouth of Rush Creek	13
		3. Bucktail	Mouth of Rush Creek to mouth of Grass Valley Creek	11
		4. Poker Bar	Mouth of Grass Valley Creek to Limekiln Gulch	10
		5. Steel Bridge	Limekiln Gulch to the mouth of Indian Creek	12
		6. Indian Creek	Mouth of Indian Creek to Douglas City	0
		7. Steiner Flat	Douglas City to Dutch Creek	10
		8. Oregon Gulch	Dutch Creek to Canyon Creek	9
		9. Junction City	Canyon Creek to North Fork Trinity	9
II.	Middle	10. Del Loma	North Fork Trinity to Cedar Flat	11
		11. Hawkins Bar	Cedar Flat to South Fork Trinity	8
III.	Lower	12. Camp Kimtu	South Fork Trinity to the mouth of Horse Linto Creek	0
		13. Tish Tang	Mouth of Horse Linto to Hoopa Valley	9
		14. Hoopa Valley	Hoopa Valley	6



LEGEND

River Segment	Study Reach
I. Upper	1. Lewiston Dam
	2. Cemetery
	3. Bucktail
	4. Poker Bar
	5. Steel Bridge
	6. Indian Creek
	7. Steiner Flat
	8. Oregon Gulch
	9. Junction City
II. Middle	10. Del Loma
	11. Hawkins Bar
III. Lower	12. Camp Kimtu
	13. Tish Tang
	14. Hoopa Valley

Figure 3. Map of the Trinity River Flow Evaluation Study Area.

DETERMINATION OF HABITAT AVAILABILITY AND NEEDS

(TASK 3)

The Instream Flow Incremental Methodology (IFIM) developed by the Fish and Wildlife Service is being utilized as the primary evaluation tool. The methodology and its uses are described in Instream Flow Information Paper No. 12 (Bovee, FWS/OBS 82/26, 1982) and other publications by the Service's Instream Flow and Aquatic Systems Group. The methodology uses hydraulic and biological data to simulate habitat conditions over a range of flows.

Generally, study sites descriptive of the representative study reaches being used for Tasks 2 and 4 of the study were chosen for the Instream Flow Incremental Methodology data collection.

From mid-April until late June, data-collection transects were chosen and marked with rebar or other monumentation at each of these sites. Survey benchmarks were established, location of transects was documented, brush was cleared, and other preparations were made to allow orderly and timely flow measurement by five to nine-person field crews.

Initially, it was planned to use three evaluation flows (based on releases at Lewiston Dam), 300 cfs, 450 cfs, and 600 cfs. However, because of dry-year conditions, water was available for only two evaluation flows, 350 and 450 cfs at Lewiston Dam. The higher flow was measured at all sites from late June to early August, with a two-week suspension of field activities in mid-July for scheduled personnel training. The 350 cfs

release was measured from September 4 to 19. In all, water depth, velocity, substrate and cover data were collected at 127 transects. Data summary and analysis has begun but is not scheduled for completion until September 1986.

APPENDIX C

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION STUDY

1986

U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento Field Office
2800 Cottage Way, Rm. E-1803
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by

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December 1986

HABITAT AVAILABILITY AND NEEDS (TASK 3)

Introduction

As part of the Trinity River Flow Evaluation Study, an Instream Flow Incremental Methodology hydraulic flow analysis was undertaken in the summers of 1985 and 1986. Our chosen method was to use the IFG-4 computer program to simulate hydraulic conditions throughout the river from Lewiston to Hoopa at a range of flow releases from Lewiston Dam, and to run the results, with added measures of river substrate, through the HABITAT program for an evaluation of the habitat available for anadromous trout and salmon at various flows.

The IFG-4 hydraulic simulation model requires a set of velocity and depth measurements taken at several transects at each study site over a range of flows. During 1985 and 1986 we measured river flows at three Lewiston Dam release levels, at 350, 450 and 800 cubic feet per second (cfs). These data were than used in a series of single-flow IFG-4 models based on each measured discharge and on water surface elevations taken during the three evaluation releases and a fourth release of 300 cfs from Lewiston.

Study Sites

To order our analysis, we divided the Trinity River, which runs approximately 110 miles from the upper end of our study area at Lewiston Dam to its confluence with the Klamath at Weitchpec, into an upper, middle, and lower segment.

The upper segment, running from Lewiston Dam to the North Fork of the Trinity, is the most important for trout and salmon production. The majority of its substrate is sand, gravel, and cobbles, with little bedrock. This area has been heavily affected by the control of the river at Trinity Dam, and its dominant structure is a series of relatively uniform, steep- sided runs, bordered by thick growths of alders and willows. Its tributaries, many of them major steelhead spawning areas, include Deadwood Creek, Rush Creek, Grass Valley Creek, Indian Creek, East Weaver Creek, Reading Creek, Brown's Creek, Dutch Creek, Soldier Creek, and Canyon Creek. Many of the upper creeks and gulches, Grass Valley Creek notable among them, drain watersheds high in decomposed granite soils, and contribute a major sediment load of coarse sand to the river during high runoff.

We chose eight study sites in this segment, each representing a sub-set of upper river habitat conditions. The upper site, which runs adjacent to Trinity River Hatchery from just below Lewiston Dam downstream to the second pool above the old fish weir, represents essentially itself, an area where there has been intensive rehabilitaion work, including gravel importation and riffle construction. In many years, most of the river's spawning occurs here. The second site, adjacent to

the cemetery area in Lewiston, represents conditions from Lewiston to the mouth of Rush Creek, which includes a reconstructed riffle. The third site, which centers on the run-pool-riffle sequence above Bucktail hole, represents the river between Rush Creek and Grass Valley Creek. Poker Bar, about a mile below Grass Valley creek, represents the heavily sedimented reach from the creek to Lime Kiln Gulch. The fifth site, at Steelbridge campground, also represents an area heavily influenced by decomposed granite sediments, from Lime Kiln Gulch to Douglas City.

There is a major change in stream character at Douglas City, where the river enters a canyon with higher gradient and increasing exposed bedrock, and flows past several important spawning tributaries. This area is represented by a site below the BLM campground on Steiner Flat Road. Below the canyon and above Junction City, the gradient lessens and the river runs in a fairly homogeneous sequence of broad meanders toward the area of flood-plain constriction just above the North Fork. This reach is represented by two sites, one on the gravel bar just below Gregon Gulch, and a second at Junction City campground below Canyon Creek, a major tributary.

The middle reach of the river, running from the North Fork to the South Fork, is followed throughout its length by Highway 299, and will be familiar to most readers. It generally follows a bedrock channel. with short rapids and deep pools interspersed at most flows with longer deep glides. From China Slide to Grays Falls the river runs through a steep, white-water gorge, then flows into a series of milder chutes and gravel bars, meandering across a narrow flood plain between steep canyon walls to the South Fork. A large ungauged tributary, the New River, enters the Trinity in this segment, contributing to a change in character above and below the gorge. Our study sites here are located at Del Loma, in a varied stretch of chutes to pools and riffles that are the lowest known area of salmon spawning,and at Hawkins Bar below the gorge.

The lower river segment runs from the South Fork of the Trinity to Weitchpec. Our site at Tish-Tang campground represents its upper reach of deep pools and glides alternating with riffles, narrow, fast chutes, and eddying backwaters. Our lowest site, just below Highway 299 bridge in Hoopa, represents the valley reach of riffle and run meanders, with broad gravel and cobble bars on the insides and swifter water on the outsides of bends.

Methods

We used field methods based on USFWS Instream Flow Group recommended procedures as described in Instream Flow Information Paper No. 5 (FWS/OBS-78/33, June 1978). At each study site we chose from six to nineteen transects proportionally representing the range of hydraulically-defined habitat available, and available proportionally throughout the river reach the site described. Instream observations of habitat utilization and populations had shown that much of

the best fish habitat in the Trinity River occurs in areas that do not coincide with the best areas for hydraulic modeling, and which do not easily lend themselves to necessary measurements and computer input formats. Transverse water surface profiles bulge in the middle or are higher at one side than the other, or may go up and down across an important spawning riffle. Water runs in changing directions with varying flow across riffles; some of the most-used juvenile salmon habitat is in or at the edge of swirling eddies, or near large boulders or rock outcrops that create varying degrees of flow reversal. Where these conditions occurred, we opted to place transects to measure the significant habitat, at the probable expense of hydraulic modeling much beyond the flows we could measure.

We measured water depth and velocity at enough points along each transect to ensure that less than ten percent of total flow occurred between points. We used the same modified Brusven substrate index employed for our habitat utilization curves to characterize the substrate in cells corresponding to the flow measurement points. The majority of 1986 velocity measurements were taken with Marsh- McBurney inductive current meters, although on occasion we used a Price AA meter. In 1986 we used Price meters for all measurements except those requiring sounding equipment. We measured distances across transects with fiberglass or steel tapes zeroed on iron pins, and thalweg distances either with the tape or by tacheometry. We determined water surface elevations through differential leveling from benchmarks with a spirit level and fiberglass leveling rod.

Approximately half of our transects included water over wading depth, and for these, in 1985, we used either an aluminium boat with a USGS sounding reel and cable, anchored to shore with a steel cable, or a six-foot top-setting wading rod used off the edge of a rubber raft hand-held to a static rescue rope stretched across the river. In 1986 we adapted the USGS equipment to a rubber raft and used it instead of the metal boat. In shallower swift areas, we used the rope by itself as a wading aid.

Field measurements were recorded on data sheets photocopied onto 8 1/2 by 11 inch waterproof paper, one set to each transect, since the great number and wide variety of our transects, and the necessity of using several crews with varying personnel throughout the day, precluded the use of a single field-book.

Data was entered directly from field notes into computer files organized with a packaged accounting program, dBASE II, in field- note format. The dBASE data files were then proof-read, and all necessary arithmetic, such as the calculation of bottom elevations and reduction of Price meter records to velocities, was done on the computer. We then translated each dBASE data file to a standard data matrix and used a microprocessor BASIC program to sort it into IFG-4 data decks, which were transmitted to main-frame computers as batch files.

We used provisional habitat utilization curves developed through TASK 2

(previously described).

This report includes an evaluation of habitat availability for chinook salmon spawning, fry, and juveniles at study sites from Hawkins Bar upstream to the hatchery, and for chinook juveniles alone at Tish-Tang and Hoopa Valley.

We have evaluated available habitat for coho salmon fry, juveniles and spawning from Steiner Flat upstream to the dam, for coho fry and juveniles at Oregon Gulch and Junction City, and for coho juveniles from Del Loma down.

Steelhead fry and juvenile habitat is shown from Lewiston to Junction City, and steelhead juvenile habitat from Del Loma to Hoopa Valley. Since we have not yet obtained sufficient data to develop steelhead spawning curves, we have not evaluated steelhead spawning habitat.

Results

Results of the IFG-4 simulation are shown in Figures 21 through 46. The habitat curves shown for sites from Lewiston Dam to Steiner Flat respresent output from simulations based on two sets of data. Habitat available at flows from 200 to 500 cfs is output from a simulation based on flows measured at Lewiston releases of 350 and 450 cfs. Habitat available at flows from 550 to 900 cfs is output from a simulation based on depths and velocities measured at a Lewiston release of 800 cfs, and on transect water surface elevations measured at releases of 600 and 300 cfs. Thus the estimates of available habitat shown can be considered good at about 350, 450, and 800 cfs. Above, below, and between these points the habitat estimates are valid as far as the hydraulic model is valid. The relatively abrupt changes that occur at several sites between 500 and 550 cfs are the result of the mixture of two sets of field observations. The curves could be smoothed in various ways, but since the jumps do not change trends in habitat/flow relationships, we have chosen not to do this.

At sites from Oregon Gulch to Hoopa Valley, the curves show the results of our 1986 800 cfs release simulation. We used only one set of measurements here because the floods of 1985-86 changed channel morphologies at these sites, complicating the task of melding two sets of data.

Figure 21 shows the availability of habitat, expressed as square feet per 1000 linear feet of river, for chinook and coho salmon fry and for steelhead trout fry at the hatchery site. Habitat decreases with increasing flow, probably as a result of increasing velocities that are not tolerable to these small fish.

Figure 22 shows the availability of habitat for juveniles at the hatchery site. Chinook and coho habitat again decreases steadily with increasing discharge. Steelhead juvenile habitat increases to a peak at 450 cfs and then decreases, again probably as a result of increasing velocities.

In Figure 23, coho and chinook spawning habitat are shown peaking at between 350 and 550 cfs.

Figure 24 through 31 show habitat values for the Cemetary, Bucktail, Poker Bar, Steelbridge, and Steiner Flat sites. At most of these sites, there is a tendency for fry and juvenile habitat to decrease with increasing discharge. The exceptions are at the Cemetary site and at Bucktail, two reaches which include major low-gradient side-channels which are progressively inundated with low-velocity water at higher flows. It is probable that without these side-channels, which are a relatively minor component of both sites, rearing habitat would decrease with increasing flow as it does elsewhere. But once the side- channels fill, they provide increasing amounts of optimum habitat that compensates for the sluice-box effect that occurs in the steep-sided main channel.

Chinook and coho spawning habitat in these sites show varied responses to discharge, with a general decrease after early peaks except in the Cemetary site, where increased habitat provided by the complex side-channels probably accounts for a generally increasing spawning habitat availability. The major drops in spawning habitat at Poker Bar and Steelbridge between 500 and 550 cfs may show the result of accumulations of sand brought down by the high winter flows of 1986. These sites are the first two below Grass Valley Creek, which produced major amounts of sand between our two data-gathering periods. This could have affected spawning habitat, which is highly sensitive to changes in the concentration of sand in the substrate.

Figures 32 through 38 show habitat values at Oregon Gulch and Junction City, based on the 800 cfs release data. Fry and juvenile habitat show minor response to flow changes, probably because these sites, especially Oregon Gulch, represent river reaches that though channeled into a trapezoidal shape, still have some gently-sloping gravel and cobble bars that provide rearing habitat when inundated. This compensates somewhat for the higher main-channel velocities that accompany increasing discharge.

The riffles in the Oregon Gulch-Junction City reach are optimum for chinook spawning at low flows, becoming deep-water runs with higher discharge, as shown in Figure 34.

Figures 39 through 43 show habitat/flow relationships at Del Loma and Hawkins Bar. Rearing habitat decreases with increasing discharge, probably because of increasing velocities. Both of the river reaches represented by these sites are generally bordered on one side by steep bedrock walls, and by cobble or heavily-vegetated steep banks on the other, and flow increases tend to increase velocities and provide little extra rearing habitat.

Chinook spawning habitat increases with increasing discharge at Del Loma, where there are wide areas of suitable gravel that are inundated at higher flows. At Hawkins Bar, spawning habitat rises to a peak at 300 to

350 cfs, dropping with increasing flow that obscures the riffles there.

Figures 44 through 46 show rearing habitat availability at Tish-Tang and Hoopa Valley. There is little response to flow changes at Tish-Tang, perhaps because the river channel there is benched, so that increasing discharge, while reducing some habitat by increasing velocities away from the river's edge, also opens up habitat areas along the river margins. In Hoopa Valley, where there are wide, gently-sloping bars of homogeneous substrate, increased flow results in increased salmon rearing habitat, and in decreasing habitat for steelhead, which require faster water.

Discussion

These preliminary findings suggest that, except for spawning, habitat for important anadromous salmonid life stages tend to decrease in availability with increasing flows over about 200 cfs in the upper river segment. Spawning habitat tends to peak at minimal flows, and then decreases rapidly. Below Steiner Flat, the same trends generally occur, although there is a diminishing rearing-habitat response to flow change, and a trend reversal in some instances, notably at Hoopa Valley.

Results suggest that side-channels are now the most important rearing areas in the upper river. Our study sites include part of the most extensive existing side-channel system, at the Cemetary reach, as well as a high-flow side-channel at Bucktail. In these reaches, as increasing discharge diminishes habitat in the main channel, the increasing side-channel area maintains or increases overall rearing habitat availability, even though the side-channels cover a small linear proportion of the sites.

The Hoopa Valley rearing habitat curves are of interest, since the Hoopa Reach, relatively unaffected by flow regulation at Lewiston and unconfined by canyon walls, retains something of the morphology that seems to have predominated in parts of the upper river before diversion. Part of what made the Trinity River a productive salmon stream may have been its regular wide point bars in the valley reaches below Lewiston, which provided extensive salmon rearing habitat during high spring flows.

These results may require major reevaluation following additional IFIM study analysis, for several reasons. First, the IFG-4 procedure provides only provisional estimates of habitat, useful mainly within the range of discharges bracketed by the study flows. Thus potentially important changes in habitat availability occurring at lower and higher Lewiston releases may not be included in projections to date.

A second factor that may modify projections is the planned development of true habitat preference curves and the collection of additional preference data. The provisional curves used in these initial habitat modeling efforts are based on observed habitat use in the existing Trinity River, and may not represent actual preference for

optimum habitat. For example, most juvenile chinook were observed over substrates high in fine material, and this may have inflated the estimate of rearing habitat at Poker Bar, the sandiest site (Figures 24 and 25).

A third major factor that may be of overriding importance on the availability of salmonid habitat is the effect of flow-related temperature changes. The relatively flat curves produced by hydraulic microhabitat and substrate modeling indicate a greater importance of the temperature component, which may be the major flow-related control on fish populations.

APPENDIX D

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION STUDY

1987

U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento Field Office
2800 Cottage Way, Rm. E-1803
Sacramento, California 95825

Prepared by
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The Trinity River Flow Evaluation Study
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HABITAT AVAILABILITY AND NEEDS

The purpose of Task 3 is to determine the amount of anadromous salmonid habitat available in the Trinity River downstream from Lewiston Dam under various flow regimes, and to determine the relative habitat requirements of various in-river life-stages of salmon and steelhead.

This year's Task 3 studies included a re-evaluation of habitat data to determine baseline conditions at the beginning of our 12-year effort, an initial evaluation of morphological changes in the river during the first two years of our study, an evaluation of the river flow needed to maintain flow in several major side-channels, and monitoring of summer water temperatures between Lewiston Dam and the North Fork.

BASELINE HABITAT

METHODS AND ASSUMPTIONS

A major emphasis of our Trinity River flow evaluation is a periodic modeling of available salmon and trout habitat with the USFWS Instream Flow Incremental Methodology. Instream Flow method computer programs allow the development of a picture of the amounts of usable area available for spawning and rearing at various river flows. Methods are described in our 1986 annual report, and in Bovee (1978). The system uses field measurements of water velocity, depth, and other physical conditions to predict conditions over a range of flows, and these are compared to the known habitat requirements of species of interest to calculate the available usable area per 1000 feet of river. The methodology provides an excellent way to keep track of micro-habitat measurements running into the thousands for each study site, and it allows an estimation of optimum flows for fish production.

In our 1986 report, we presented estimations of weighted usable micro-habitat area for spawning and rearing chinook salmon, coho salmon, and steelhead trout throughout the river, based on preliminary habitat utilization curves. On the assumption that river morphology did not change substantially in the upper river down to Steiner Flat over the high-water winter of 1986, we used habitat estimates for our upper sites based on field data collected at low Lewiston releases during the summer of 1985 and high releases in the summer of 1986. We have since found that major changes occurred in the bottom profiles and substrate composition over the winter of 1986 in all our sites, and that combining habitat estimates from both systems is therefore probably not valid. Nor can we confidently determine how the changes in river morphology affected habitat, since the 1985 and 1986 simulations were based on measurement of widely differing flows. Therefore, we have chosen to use the 1986 simulation to describe baseline micro-habitat for comparison with future conditions.

The curves we have used to describe the habitat suitable for each species are Category II utilization curves developed from data we have collected since 1984 in the Trinity River, and described fully elsewhere (Hampton, 1987). The major difference in these curves from those we have used previously is that the amount of substrate suitable for spawning has been greatly restricted by a factor for the degree to which gravel is embedded in sand. Previous curves were base on

dominant gravel size only, where the new curves recognize the effect of sand in the gravel mixture as a limit on spawning use.

We have ceased to use subtrate utilization curves for fry and juvenile life-stages of all three evaluation species, because our observations show that bottom materials make little difference in habitat choice by rearing salmonids, except where large cobbles and boulders provide refuges for juvenile trout. We have not substituted cover curves, although this is frequently done in habitat modeling, because we have seen no clear preferences for cover. We have recorded numerous instances of all species using areas with no apparent cover, and the highest mainstream population densities we have observed are of fry and juvenile chinook holding and feeding over a gravel bar with no nearby cover (see page 65).

In addition to these changes, we have eliminated study of our site adjacent to the Trinity River Fish Hatchery. This reach, just below Lewiston Dam, is unlike any other part of the river, and is the site of extensive habitat manipulation, and indeed underwent modification by bulldozer while we were measuring it in 1986. Because of this continual change, the site is not suitable for our methods.

FINDINGS

Figures 1 through 18 show the relationship between 1986 available micro-habitat and river flow at eleven Instream Flow Incremental Methodology study sites from Lewiston to Hoopa Valley. The species and life-stages were chosen according to our knowledge of macro-habitat and current species distributions in the river, with all species and life-stages modeled from Lewiston to Dutch Canyon, all life stages of chinook as well as juvenile coho and steelhead shown from Dutch Canyon to Willow Creek, and juvenile life-stages shown for our sites below Willow Creek. As noted above, these are habitat simulations based on velocity and depth measurements taken at a release from Lewiston Dam of 800 cfs, and water surface elevations taken at releases of 300 and 600 cfs. They all show available micro-habitat measured in the field at the higher flows, and <u>estimations</u> of available micro-habitat toward the lower end.

In the upper river, salmonid habitat tends to decrease with increasing flow except at the Cemetery and Bucktail sites, where increased flow opens up new habitat areas in side-channels. Available area for chinook salmon spawning peaks between about 450 and 600 cfs at all sites except Steiner Flat, where it is greatest at low flows. Coho spawning area follows the same pattern, except that at Bucktail there is a decrease in available usable area with higher flows. Usable area for steelhead spawning peaks around 700 to 800 cfs at

Cemetery and Steelbridge, and drops from peaks at low discharge in the other three sites.

In the upper river, Steiner Flat and Bucktail have the greatest amount of spawning habitat, and Steiner Flat provides the least rearing habitat, except for steelhead juveniles. This may be because both sites have a high proportion of fast water, although Bucktail has a side channel that provides good rearing habitat, and because they are least affected by sand deposition from the watershed. Bucktail is above Grass Valley Creek, and far enough below Hoadley Gulch to be less affected by its sediments than is the Cemetery Reach. Steiner Flat, the lowest of our upper river sites, is protected from upstream sediment exports by slow glides and pools above Douglas City, and is subject to more intense flushing flows from Weaver Creek and Reading Creek.

Throughout the river, there is substantially less habitat available for rearing fry than there is for juveniles, which we define as fish over 50 mm in fork length. Although we do not yet know what the habitat area requirements are for each life-stage, it appears from the differences in gross available area that fry habitat may limit fish populations in years when there is good spawning recruitment.

MORPHOLOGICAL CHANGES, 1985-1986

The Trinity River underwent a substantial change in morphological detail between the summers of 1985 and 1986. The major hydrologic event in the intervening winter was high water during late February and early March, 1986, which grossly altered the river channel between Steiner Flat and the Klamath River, and which caused visually minimal but measurable physical changes from Steiner Flat upstream to Lewiston.

In late February of 1986, our Instream Flow Incremental Methodology study site at Del Loma, 20 miles below the North Fork was a bankful, raging brown torrent, with islands, side channels, and an entire quarter mile of cobble bar inundated by flood water. Upstream, at Junction City, Oregon Gulch, and Steiner Flat the visual effect, though somewhat diminished, was great. At Steiner Flat we electrofished over rocks that the summer before had served as diving platforms, and even in our uppermost site, adjacent to the Trinity River Fish Hatchery below Lewiston Dam, standing waves replaced riffles.

When the water subsided, it was clear that major changes in channel morphology and substrate composition had occurred between Oregon Gulch and Hoopa Valley, which were below uncontrolled major tributary inflows to the river. At Oregon Gulch the river was narrower, deeper, and faster than it had been the year before. At Junction City Campground a major riffle system and cobble bar had been entirely reshaped. At Del Loma an iron pin we had set on a sand-bar was an estimated ten feet under a new accumulation of sediment, and transects that we had waded the year before were accessible only by raft.

Changes at Steiner Flat and above, where the river was more subject to control at Lewiston and Trinity Dams, never exceeding 6500 cubic feet per second, and where the river edges have been steepened and defined by years of constant flow, were less noticeable. The only gross physical changes were just below the old bridge in Lewiston, where a hole dug in the river in the fall of 1985 by the California Department of Water Resources had been half-filled by sand from Hoadley Gulch, and in the run just below Grass Valley Creek, which was covered by decomposed granite sands. Our study sites looked in the summer of 1986 about the same as they had looked in 1985; yet when we looked at measurements of elevation and substrate taken over the two years we found substantial changes.

There seems to have been a major shifting of bed material. Fines, which we measure as particles less than a tenth of an inch in size, have been redistributed over the underlying substrate of gravel or cobble, changing the shape of most of the 55 transects we have established between Lewiston and Steiner Flat. It appears that the high flows also tended to clear fines from riffles, although a new influx of fines from tributaries continued to move in an almost dune-like pattern down through our study sites under the influence of the normal flows which followed the high water.

Table 1 shows the changes in transect profile elevation between the summer of 1985 and the summer of 1986 at our five uppermost study sites. In the interest of data manageability, these changes are shown as the average of absolute elevation differences over the width of each transect. In reality, the differences in elevation over riffles, caused by a shifting of cobbles and gravel, was generally slight, a matter of a few tenths of a foot, while the difference over pool substrates would reflect the shifting of tons of sand, with down-cutting on one side and deposition on the other.

Figures 1-3 show differences in substrate embeddedness on three transects at our Bucktail site between 1985 and 1986. Embeddedness, shown on the Y-axis, is a measure of the extent to which dominant substrate materials are embedded in fines, expressed as a percentage. Figure 1 shows the embeddedness at a run, Figure 2 at a pool transect, and figure 3 at a riffle.

The run and riffle transects follow what seems to be the general pattern at all our sites, a decrease in embeddedness under runs and riffles following the high water of 1986. Figure 2 shows an increase in embeddedness in pool habitat, which is probably the result of deposition of transported fines following high flows.

Sediments are entrained at very high water velocities, continue to be transported at somewhat lesser velocities, and are deposited at yet lower flows, resulting in uncontrolled rivers in the gradual downstream of sand as bed-load through a relatively stable configuration of riffles and pools (Morisawa, 1968; Leopold et al, 1964). In the controlled upper Trinity, this process seems to have resulted between 1985 and 1986 in a cleaning of sand from many riffles, where velocities were high, and deposition in pools as flooding subsided.

Poker Bar Spawning Substrate Changes

In the late winter of 1986, shortly after the subsidence of tributary flooding and the end of a two-week-long emergency release of 6000 cfs from Lewiston Dam, an observer high on Brown's Mountain Road opposite the mouth of Grass Valley

Creek could see the creek bed and the river below it as a meandering strip of white sand washed down from the disturbed and highly erosive Grass Valley Creek watershed. The Trinity River above the creek mouth was dark green, where below it was covered with white decomposed granite sand. A year and a half later, the same observer could see the lower reaches of the creek still covered with sand, but the Trinity River below the creek was again green, the sand washed down somewhere around the bend.

During the same period, the appearance of our Poker Bar study site, two miles below Grass Valley Creek, changed perceptibly. Passing through it on raft trips to monitor spawning salmon or collect habitat preference data, we noticed a greater expanse of pure sand than we remembered; yet results of our 1986 flow-related habitat evaluation indicated that salmon spawning conditions may have improved in the reach between the two years.

To examine this further, we made an additional survey of substrate types at each transect during the summer of 1987, and compared the substrate suitability for chinook salmon spawning in 1985, 1986, and 1987. The suitability criteria we used were Category II substrate values as presented by Hampton (1987). Figures 4 through 7 show results at two upper transects, 1 and 2, and two lower transects, 8 and 9. The X-axes represent distance across the transects, and the Y-axes shows the suitability for spawning of each substrate mixture on the transects.

The figures show that the value of substrate for spawning increased greatly over the years at transects 1 and 2, and at transects 8 and 9 generally increased in 1986 and then decreased in 1987. At the same time, in intervening transects not depicted, the substrate value was low in all three years or showed patternless changes. Generally the [illegible] of pure sand substrates increased, reflecting an encroaching underwater sand-bar or dune that moved down the right side of the channel below transect 2 all the way to the bottom of the study site.

Riffle areas on all transects were improved by the high water of February, 1986. This improvement continued at the upper transects with normal release flows in late 1986 and in 1987. However, the sand washed out of the upper areas seems to have moved downstream into the lower riffle areas. So the dynamic process of riffle silting and flushing causes continual changes in habitat value as pulses of sand move downstream.

Table 1. 1985-1986 elevation change on 55 transects on the upper Trinity River. Changes are the average of the absolute values of elevation change up or down at profiling stations across each transect, measured in feet.

Cemetery Site		Bucktail Site		Poker Bar Site	
Transect	Change	Transect	Change	Transect	Change
1U	0.2	1	0.2	1	0.1
2U	0.4	2	0.2	2	0.3
3U	0.9	3	0.3	3	0.4
4U	0.9	4	0.3	4	0.5
1L	0.3	6	0.6	5	1.3
2L	0.5	7	0.9	6	0.2
3L	0.3	8	0.5	7	0.2
4L	0.3	9	0.1	8	0.2
5L	0.2	10	0.2	9	0.1
6L	0.3	11	0.2	10	0.3
7L	0.4	12	0.4		
8L	0.4				
9L	1.1				

Steelbridge Site		Steiner Flat Site	
Transect	Change	Transect	Change
1	0.8	1	0.4
2	0.4	2	0.2
3	0.5	3	0.2
4	0.3	4	1.4
5	0.2	5	0.5
6	0.4	6	0.3
7	0.6	7	0.7
8	0.4	8	0.3
9	0.2	9	0.3
10	0.4	10	0.8
11	0.6		

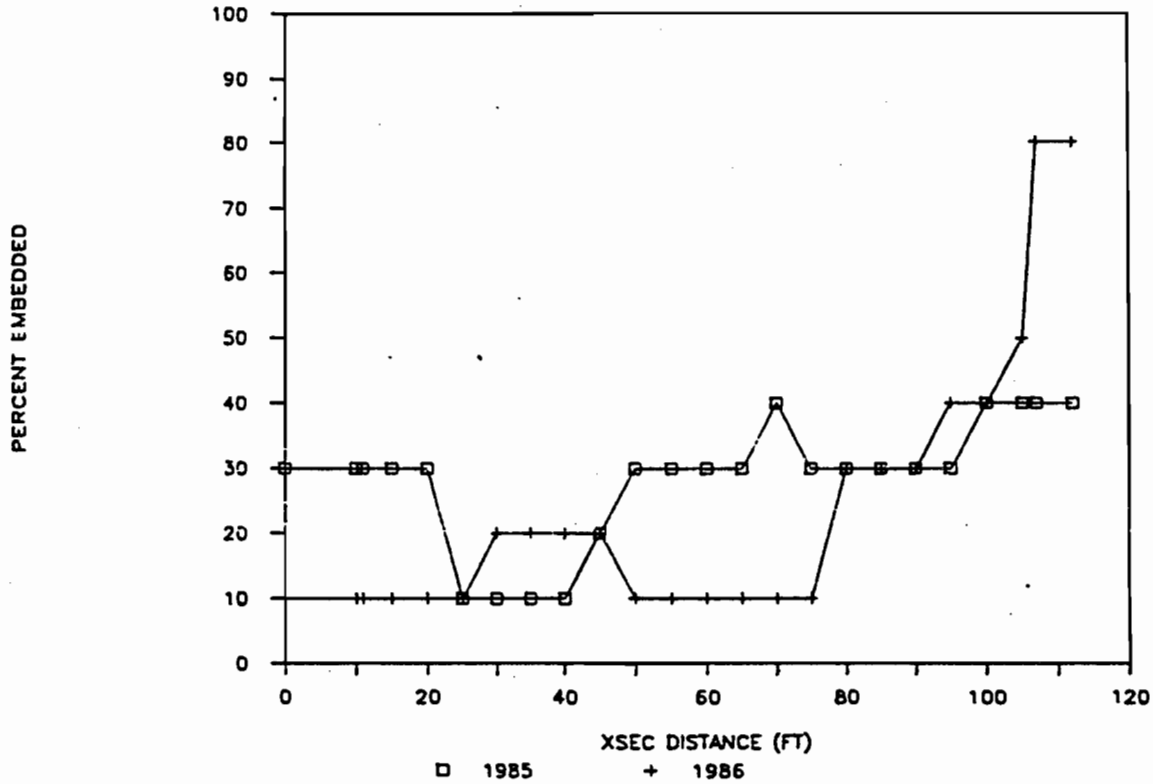


Figure 1. Change in substrate embeddedness, 1985-86, at a Bucktail riffle transect.

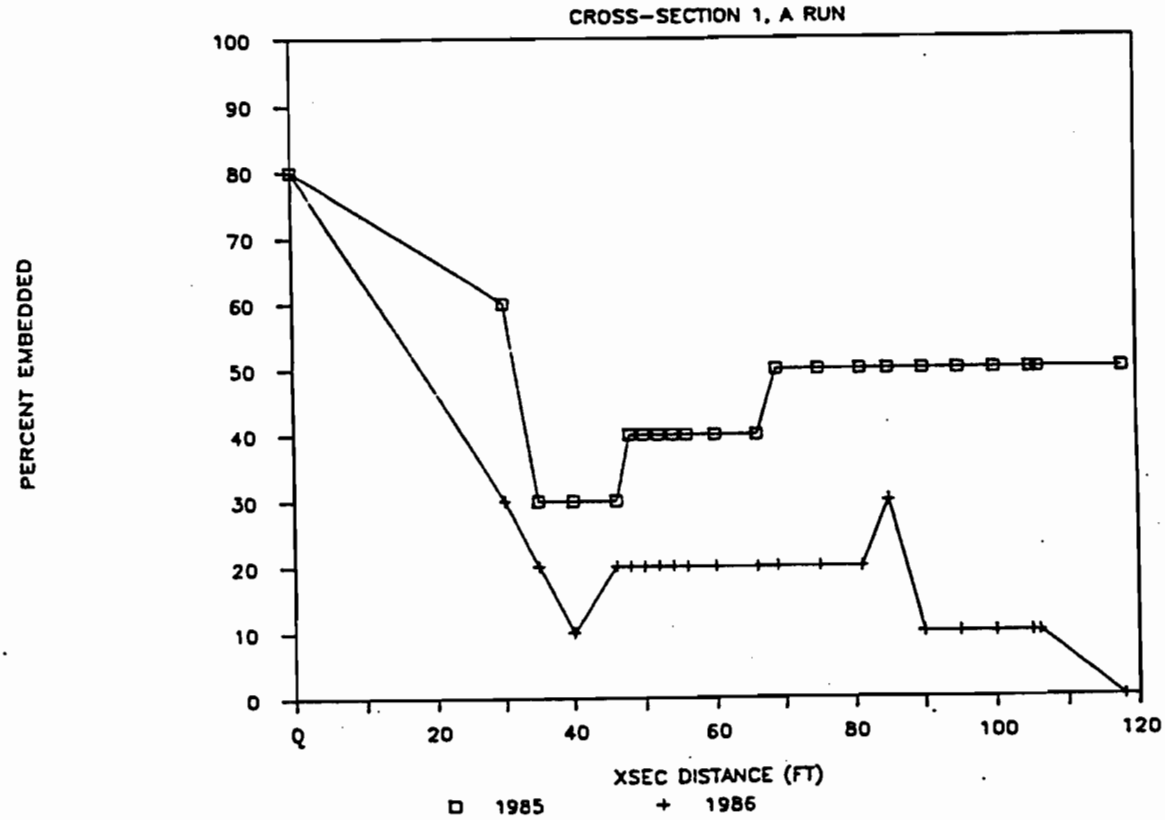


Figure 2. Change in substrate embeddedness, 1985-86, at a Bucktail run transect.

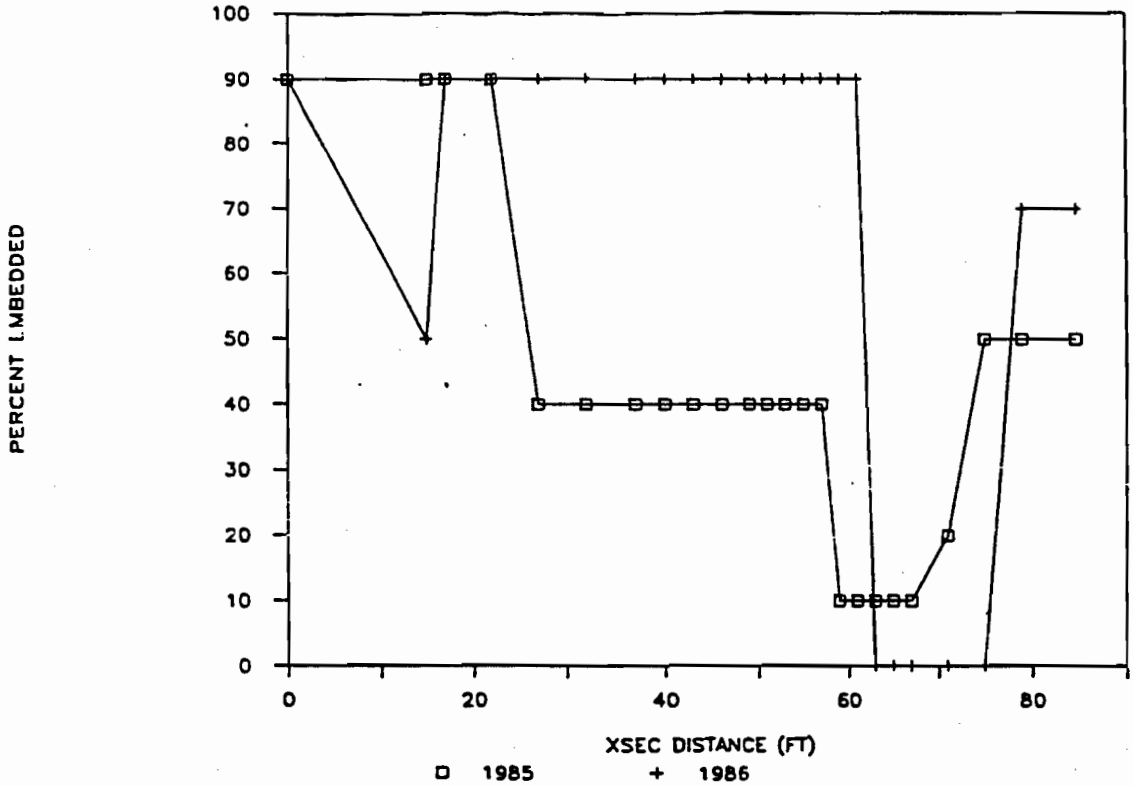


Figure 3. Change in substrate embeddedness, 1985-86, at a Bucktail pool transect.

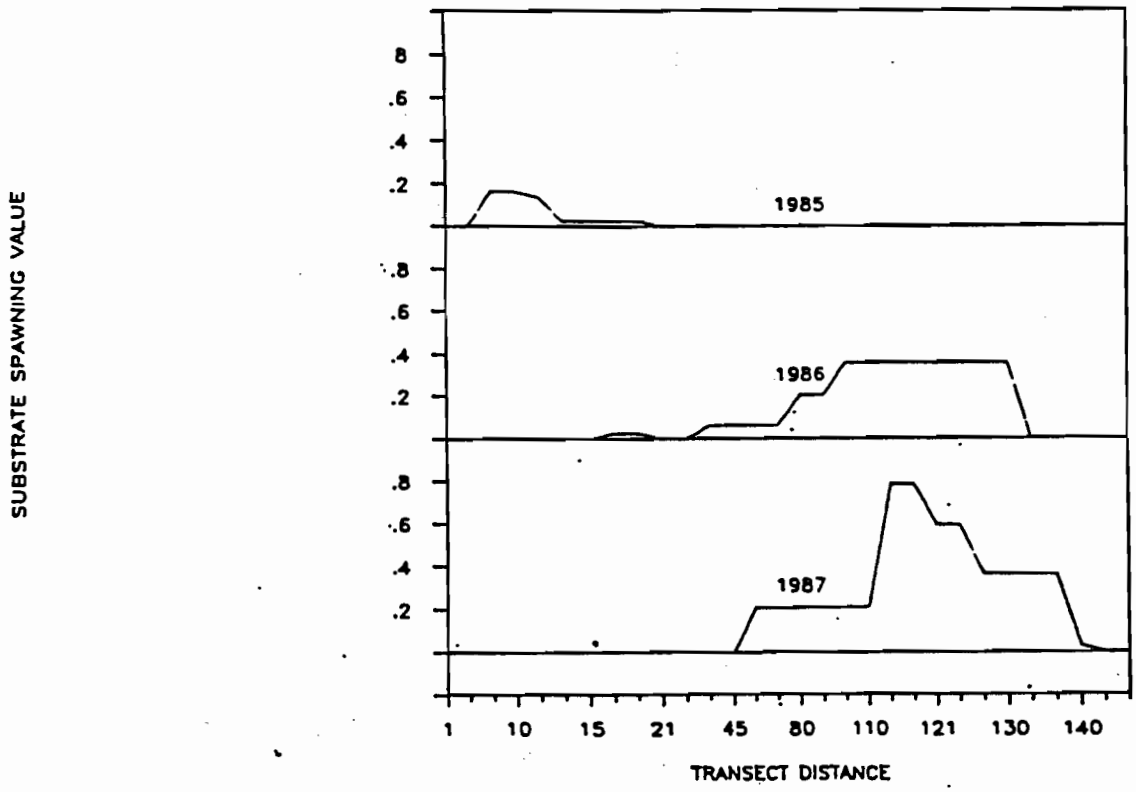


Figure 4. Change in substrate suitability for chinook spawning, 1985-87, at Poker Bar transect 1.

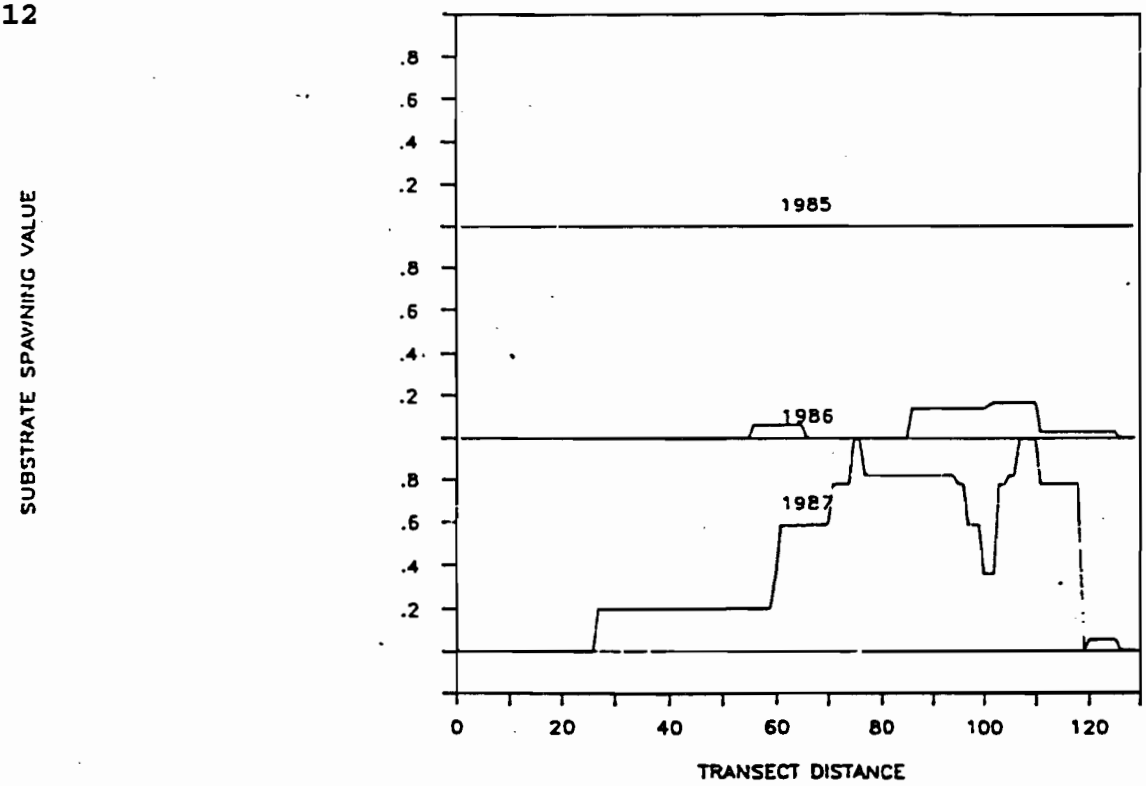


Figure 5. Change in substrate suitability for chinook spawning, 1985-87, at Poker Bar transect 2.

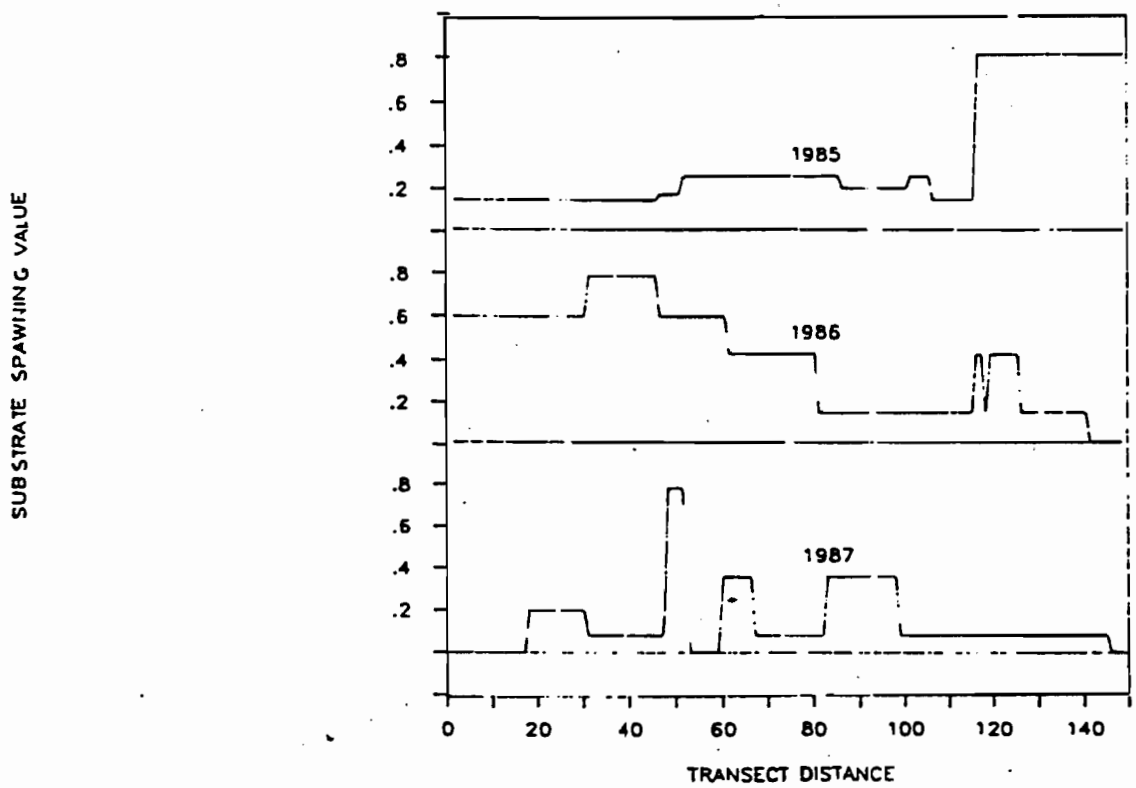


Figure 6. Change in substrate suitability for chinook spawning, 1985-87, at Poker Bar transect 8.

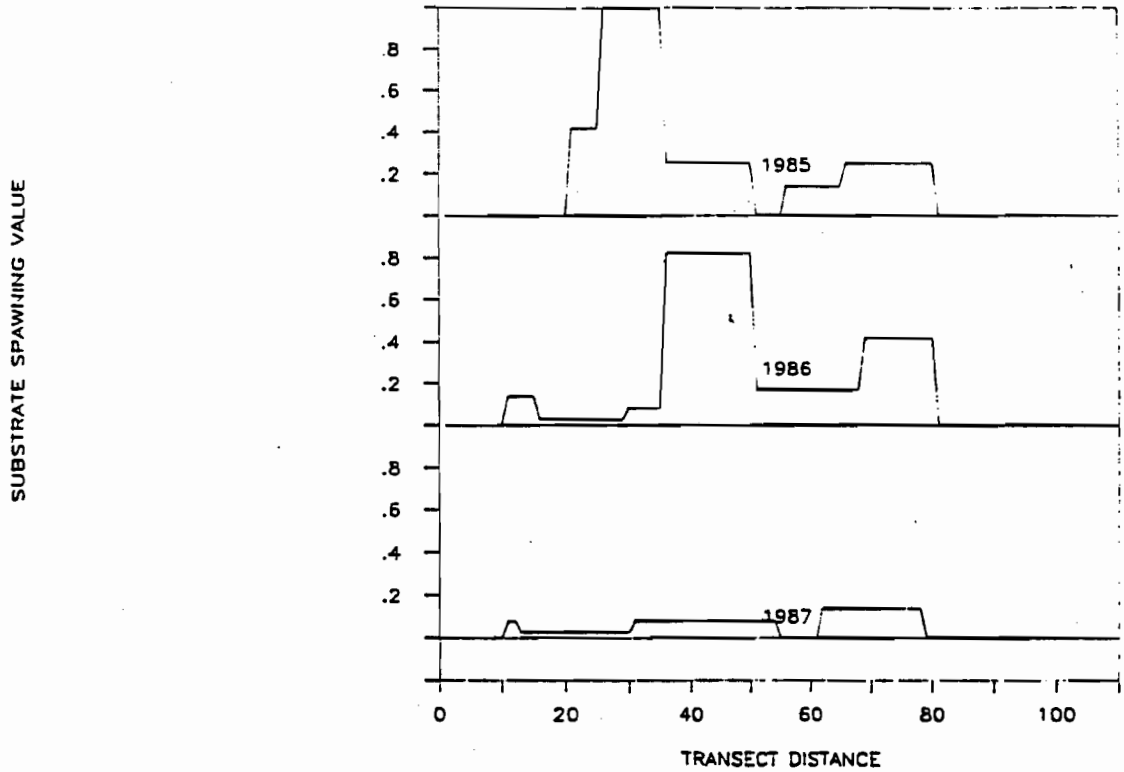
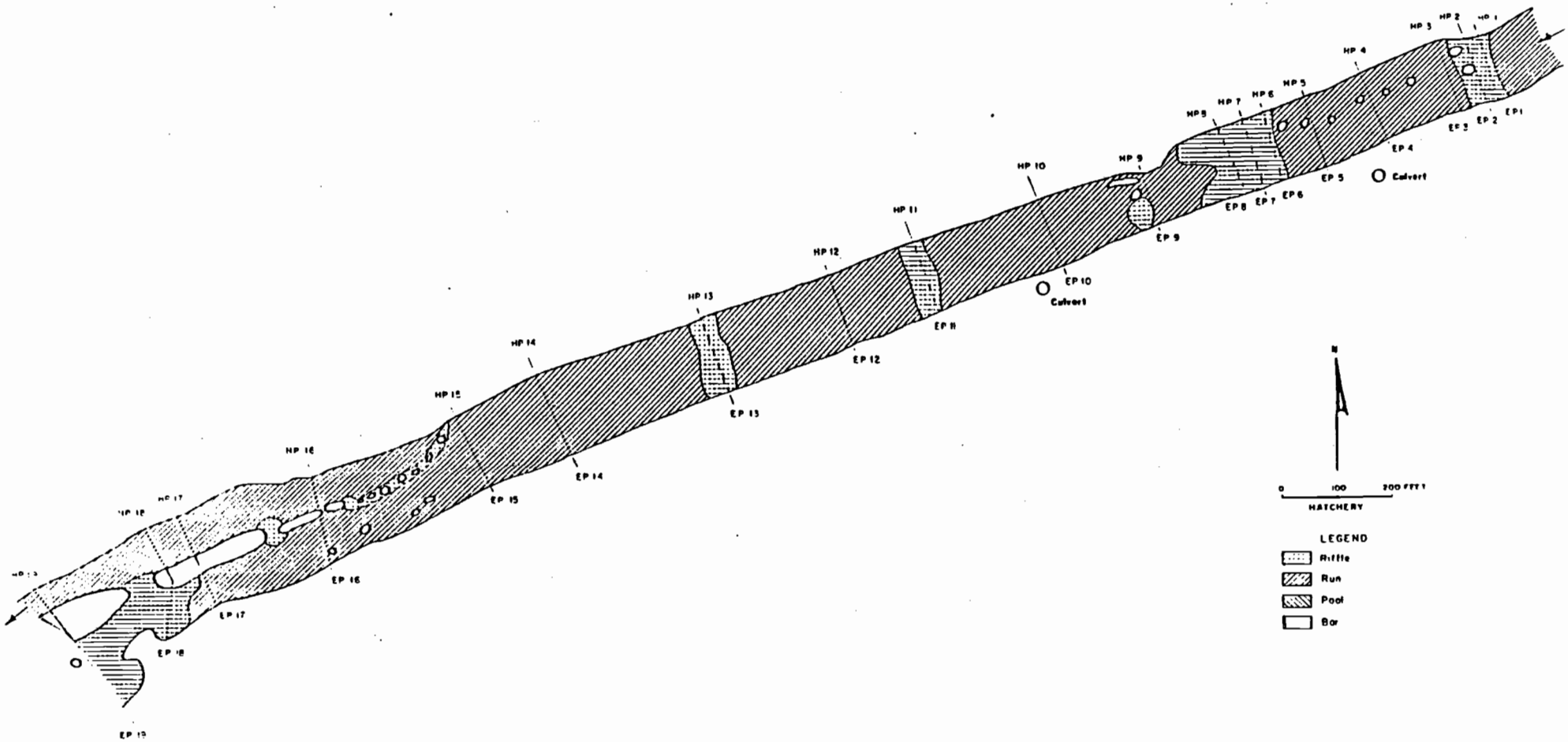


Figure 7. Change in substrate suitability for chinook spawning, 1985-87, at Poker Bar transect 9.

IFIM
Study Site Maps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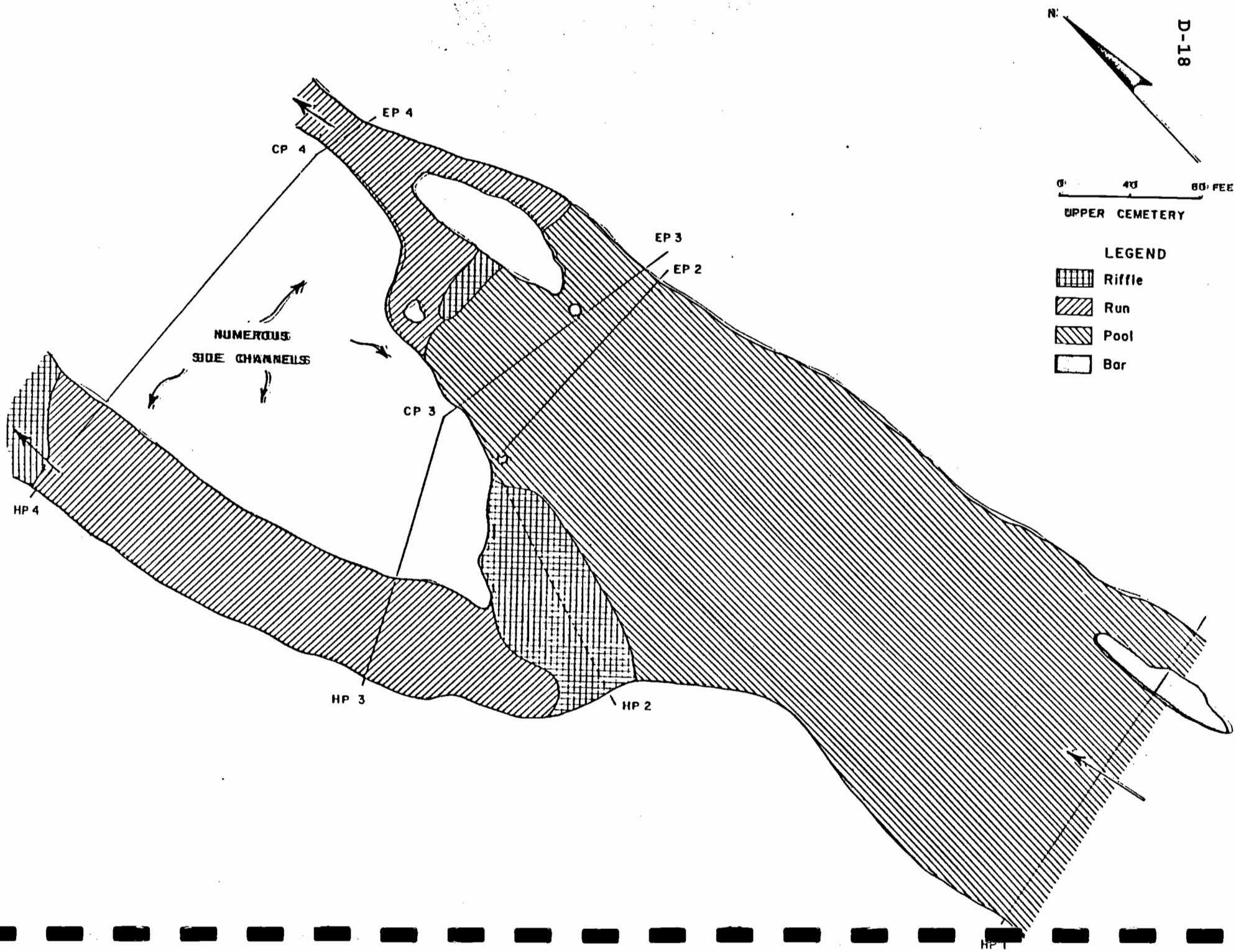
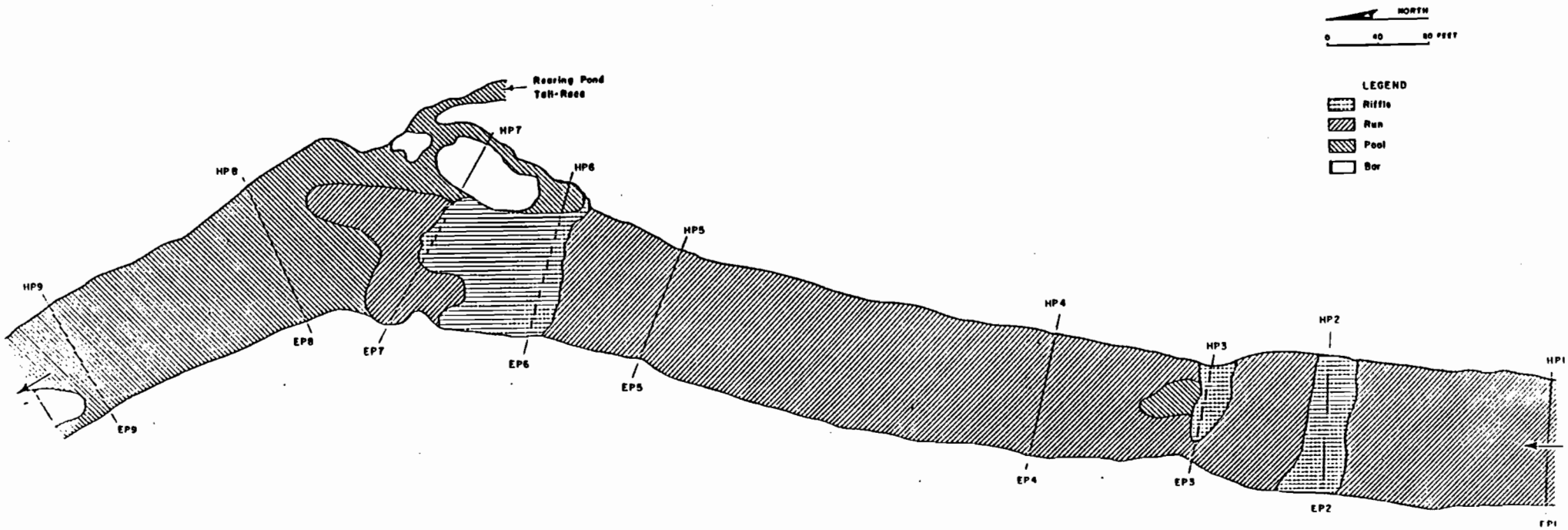
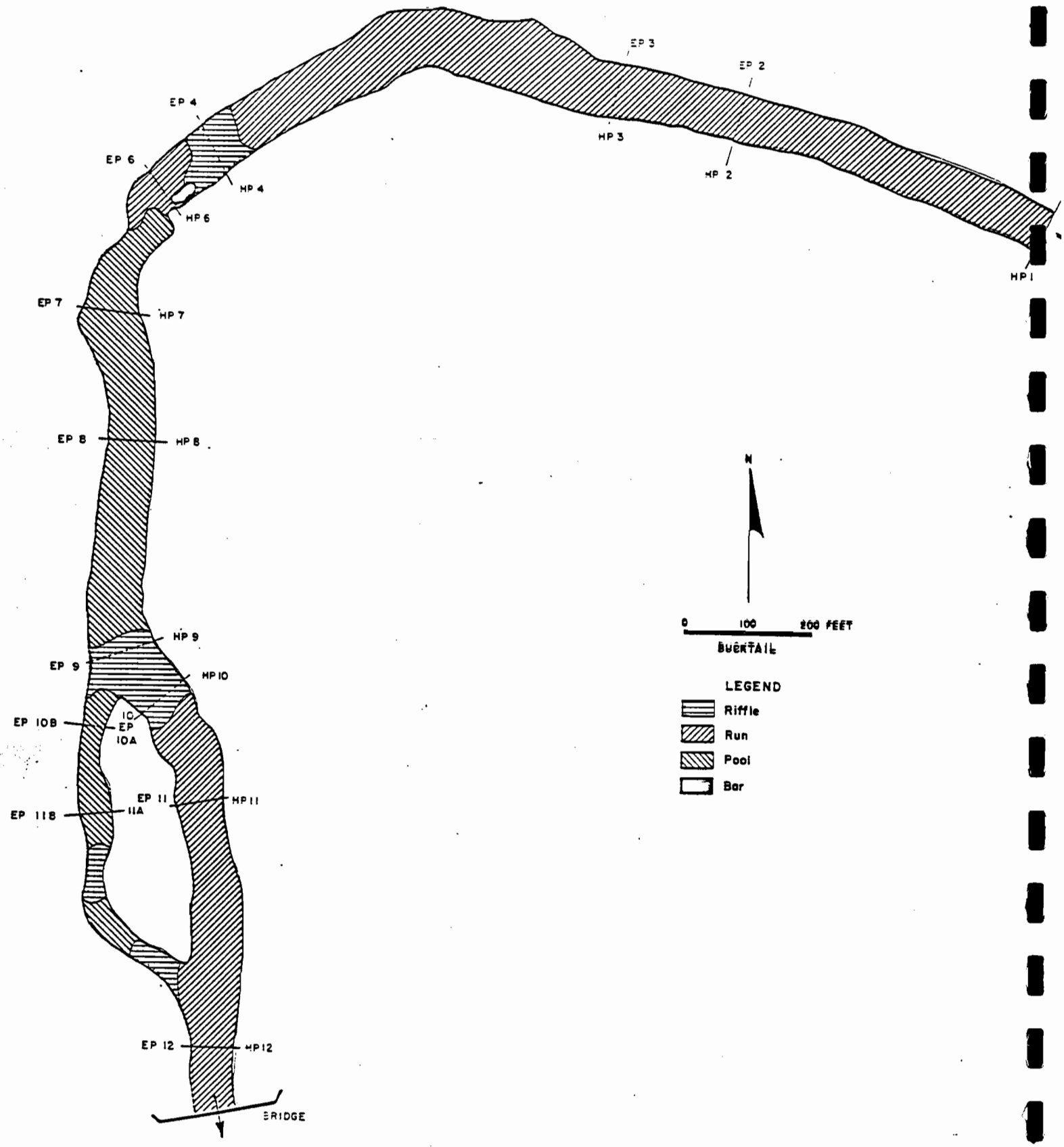
HP 3
HP 4
HP 5
HP 6
HP 7
HP 8
HP 9
HP 10
HP 11
HP 12
HP 13
HP 14
HP 15
HP 16
HP 17
EP 1
EP 2
EP 3
EP 4
EP 5
EP 6
EP 7
EP 8
EP 9
EP 10
EP 11
EP 12
EP 13
EP 14
EP 15
EP 16
EP 17
EP 18
EP 19
Culvert
Culvert
N
0
100
200 FEET
HATCHERY
LEGEND
Riffle
Run
Pool
Bar


N
0
40
80 FEE
UPPER CEMETERY
LEGEND
Riffle
Run
Pool
Bar
EP 4
CP 4
EP 3
EP 2
NUMEROUS
SIDE CHANNELS
CP 3
HP 4
HP 3
HP 2
HP 1


NORTH
0
40
80 FEET
LEGEND
Riffle
Run
Pool
Bar
Rearing Pond
Tall-Reed
HP1
HP2
HP3
HP4
HP5
HP6
HP7
HP8
HP9
EP1
EP2
EP3
EP4
EP5
EP6
EP7
EP8
EP9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EP 2
EP 4
HP 3
EP 6
HP 2
HP 4
HP 6
HP 1
EP 7
HP 7
EP 8
HP 8
N
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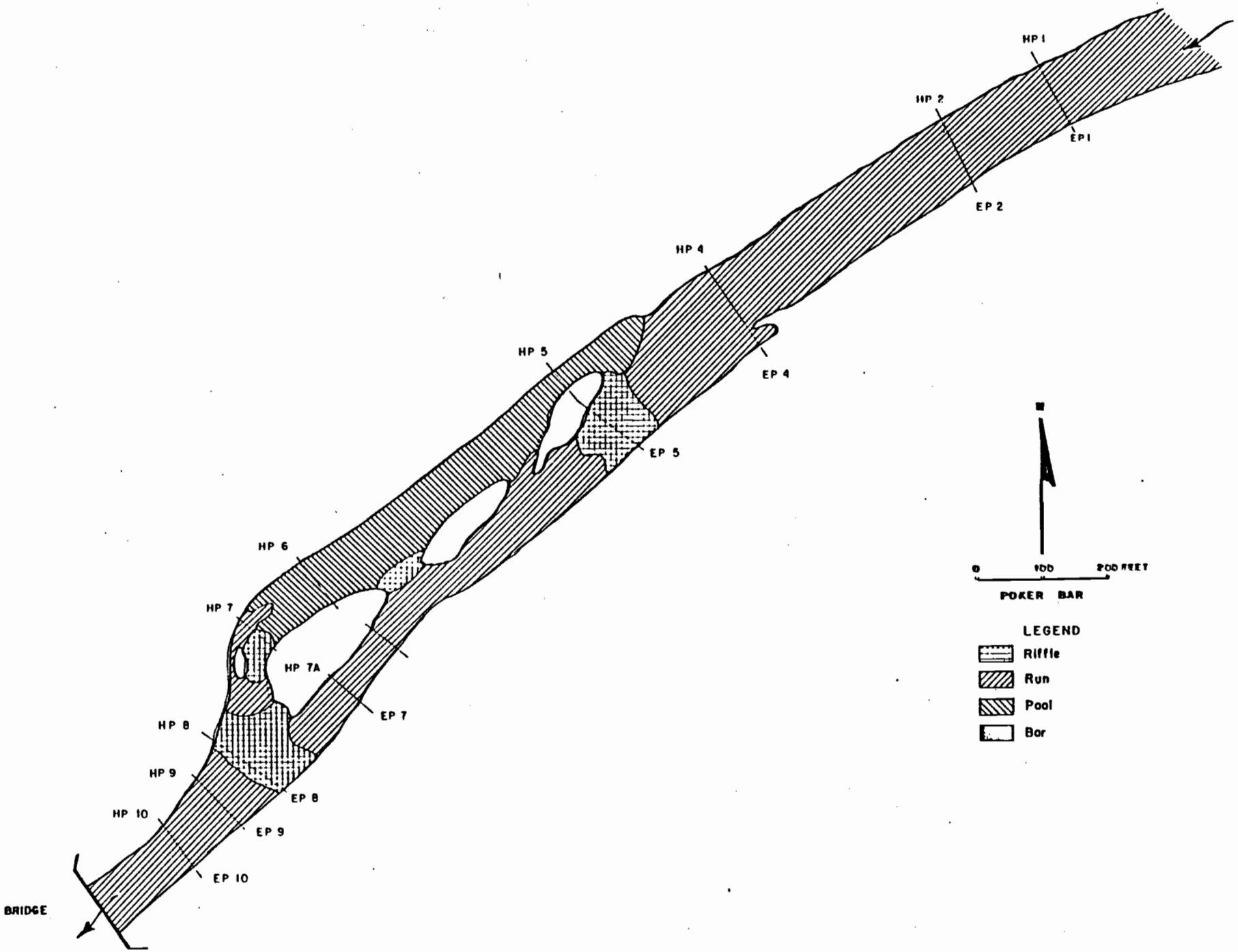
100
200 FEET
BUCKTAIL
HP 9
EP 9
HP 10
LEGEND
Riffle
Run
Pool
Bar
EP 10B
10
EP
10A
EP 11
HP 11
EP 11B
11A
EP 12
HP 12
BRIDGE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EP 1
HP 2
EP 2
HP 4
EP 4
HP 5
EP 5
HP 6
HP 7
HP 7A
EP 7
HP 8
HP 9
EP 8
HP 10
EP 9
EP 10
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N
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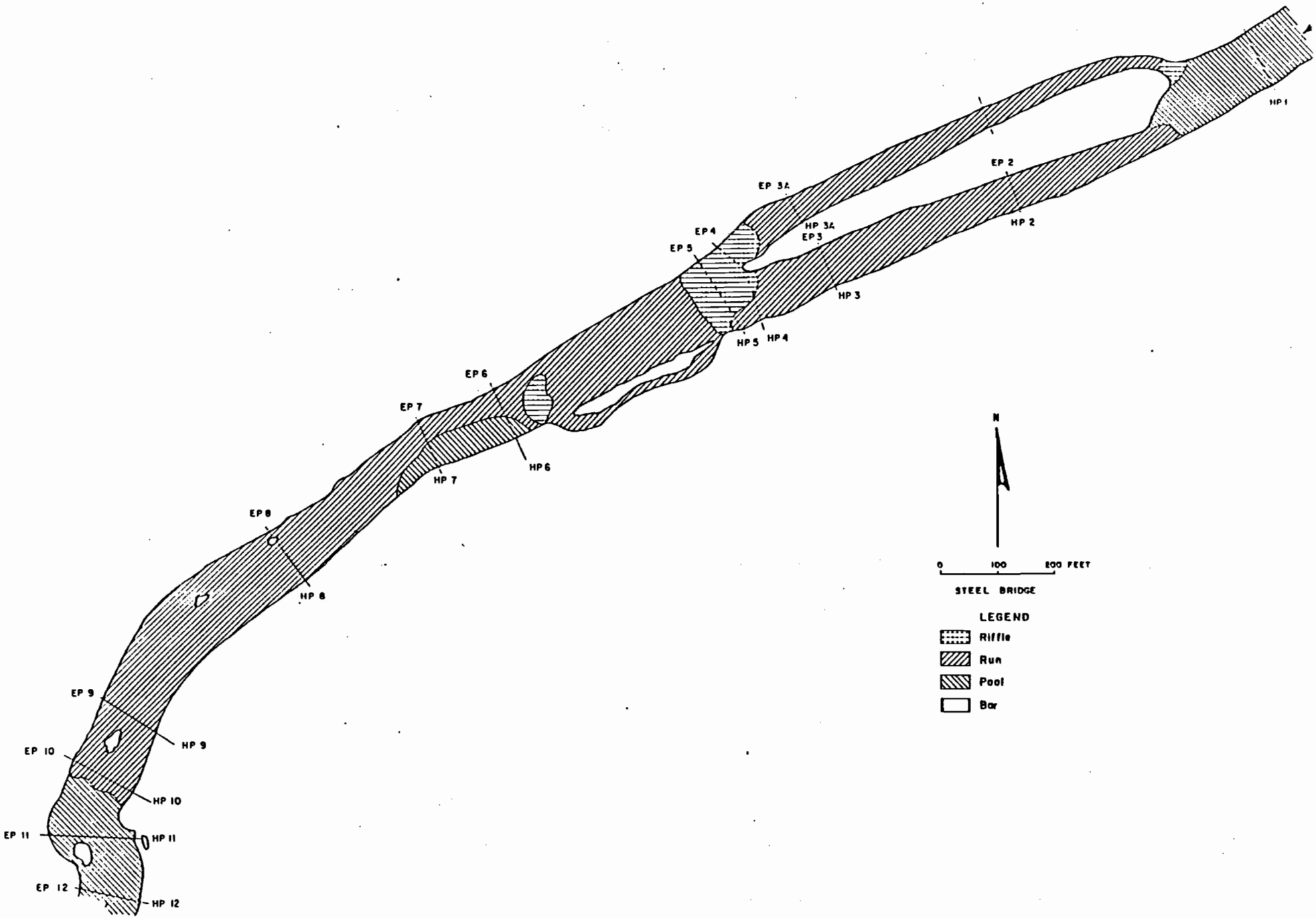
100
200 FEET
POKER BAR
LEGEND
Riffle
Run
Pool
Bar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HP 2
EP 3A
HP 3A
EP 3
HP 3
EP 4
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HP 5
HP 4
EP 6
HP 6
EP 7
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HP 8
EP 9
HP 9
EP 10
HP 10
EP 11
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EP 12
HP 12
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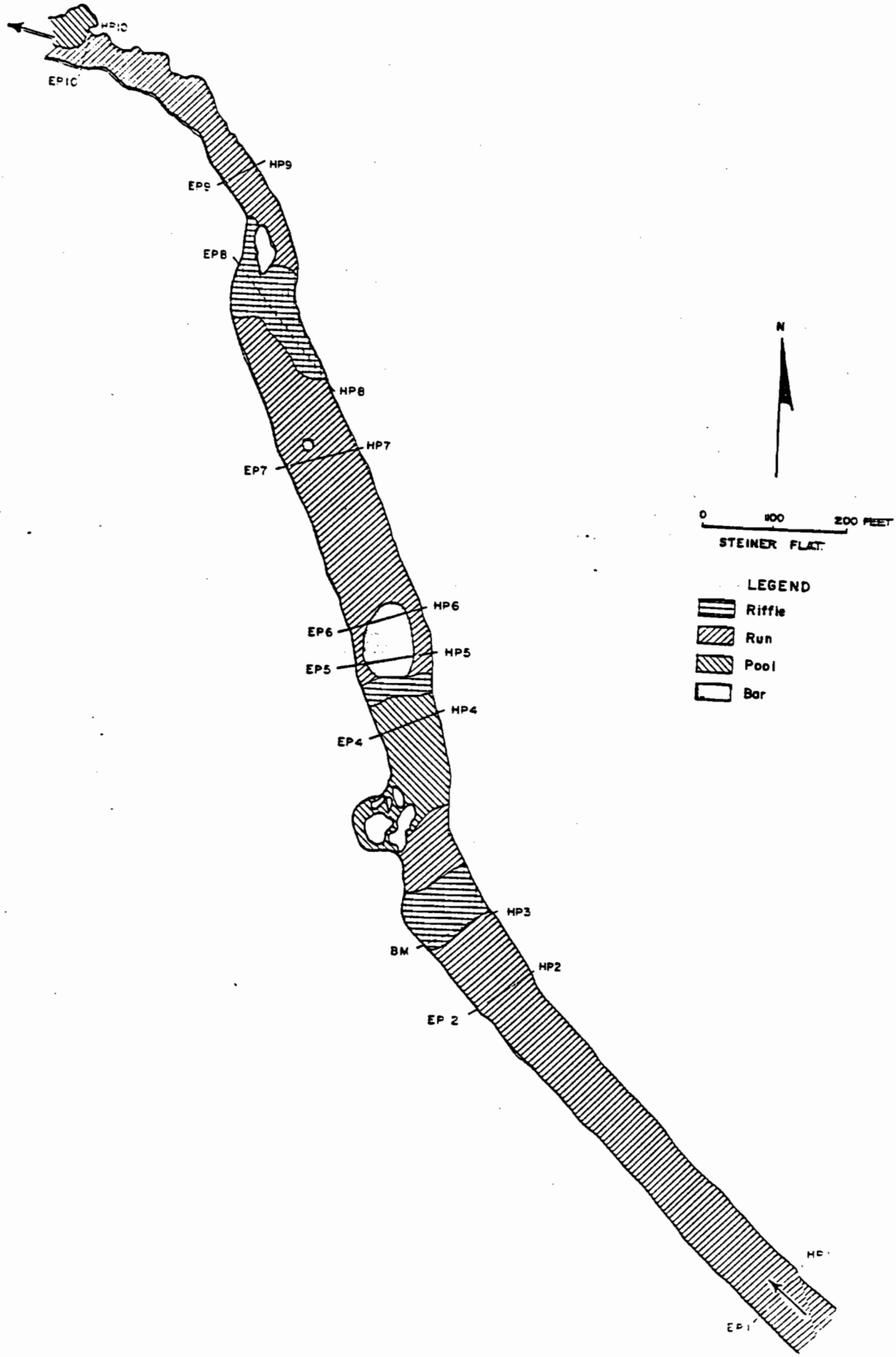
0
100
200 FEET
STEEL BRIDGE
LEGEND
Riffle
Run
Pool
Bar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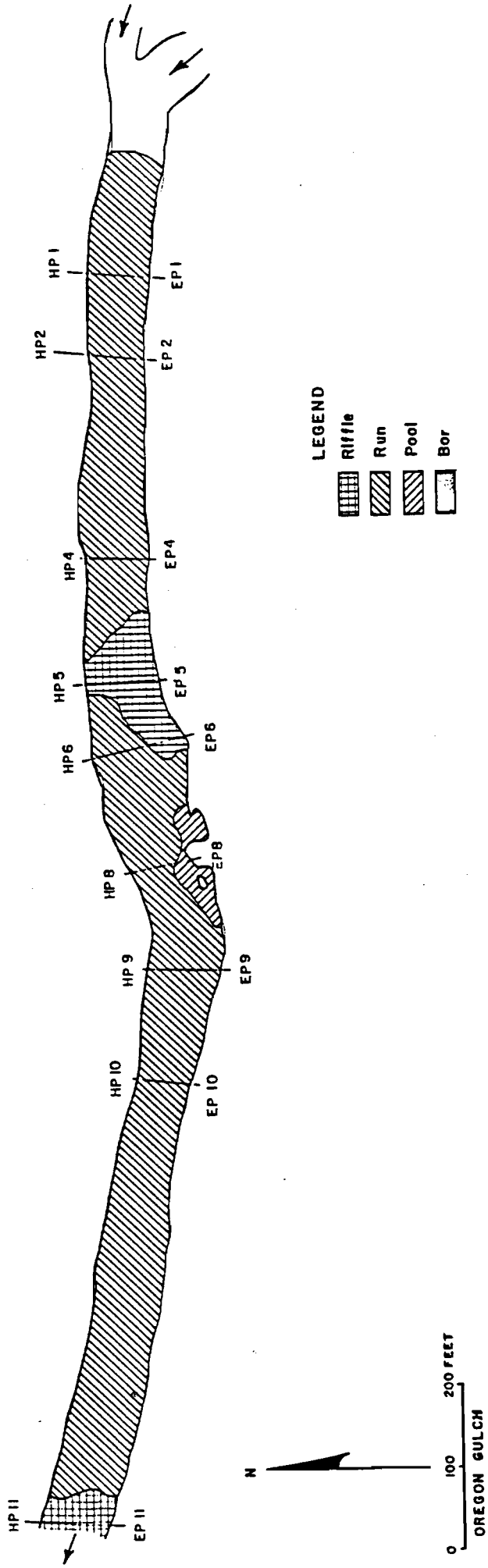
HP9
EP9
EP8
HP8
HP7
EP7
HP6
EP6
HP5
EP5
HP4
EP4
HP3
BM
HP2
EP 2
EP1
N
0
100
200 FEET
STEINER FLAT
LEGEND
Riffle
Run
Pool
Bar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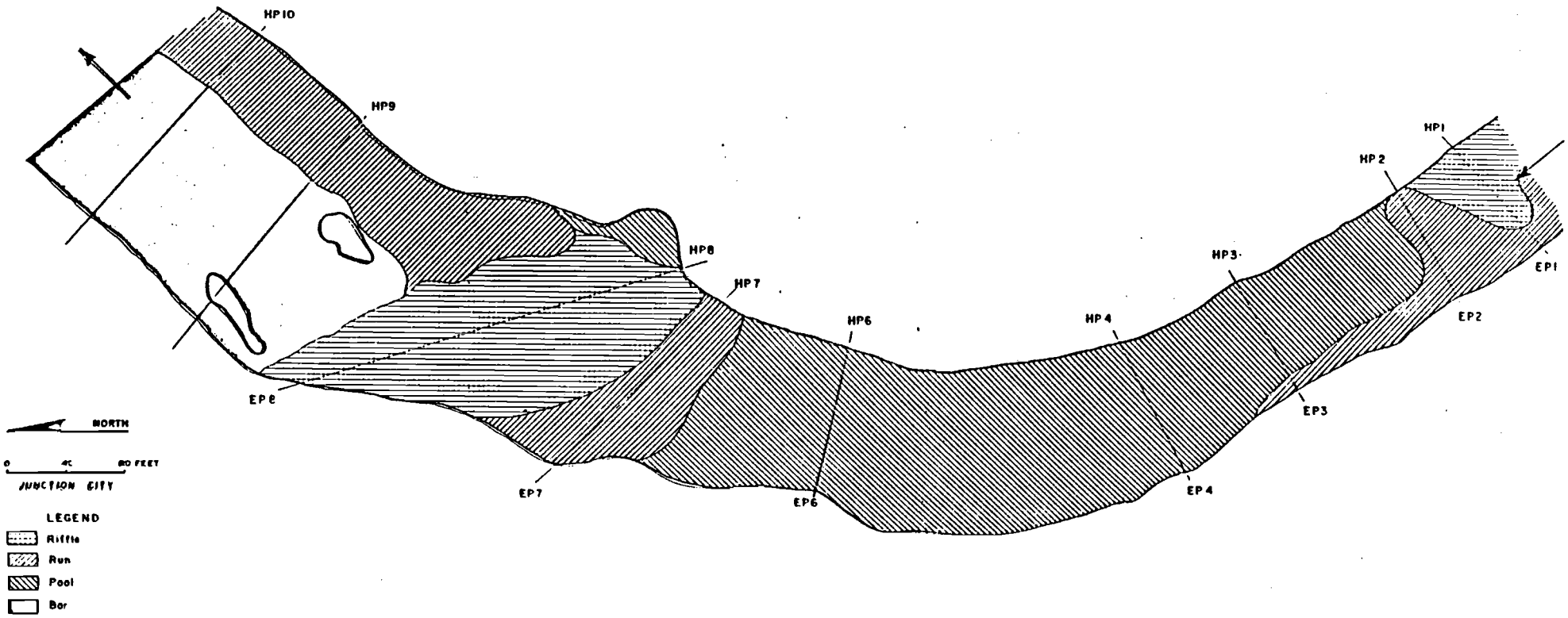
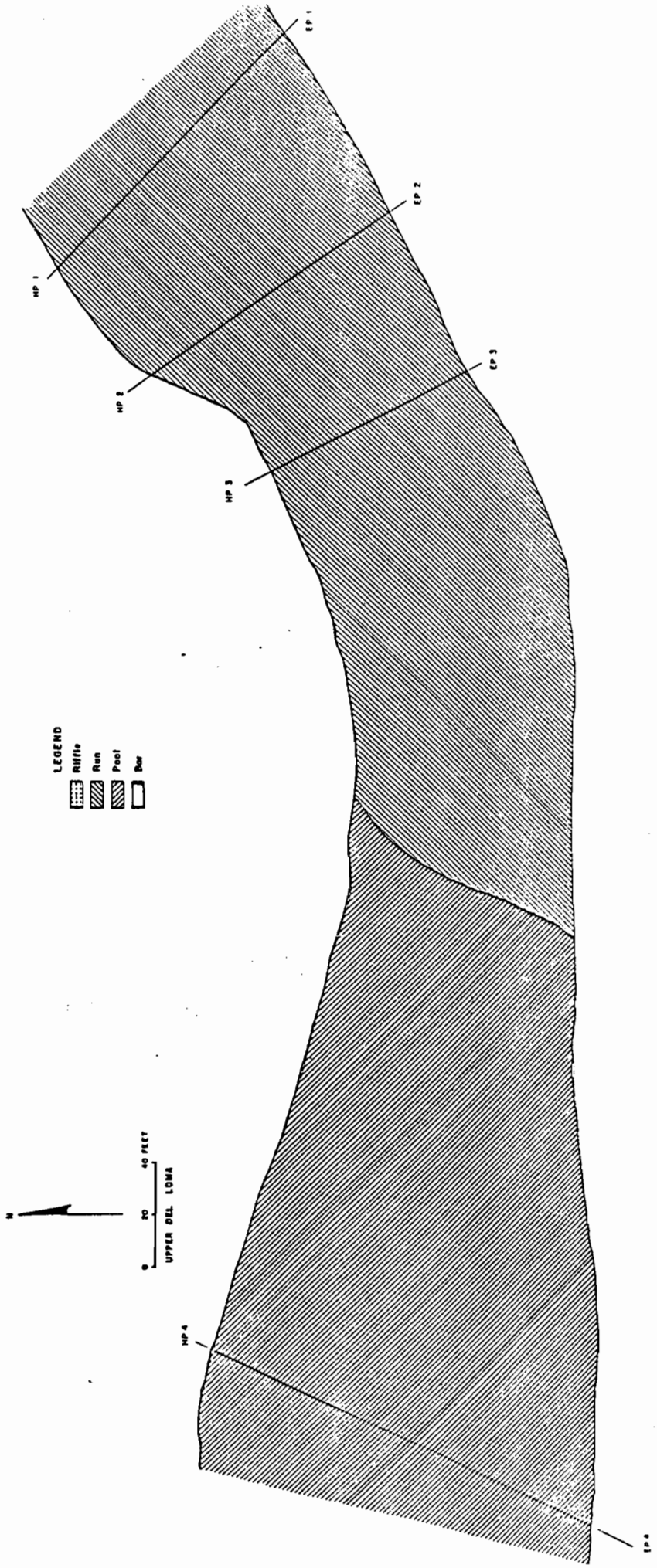
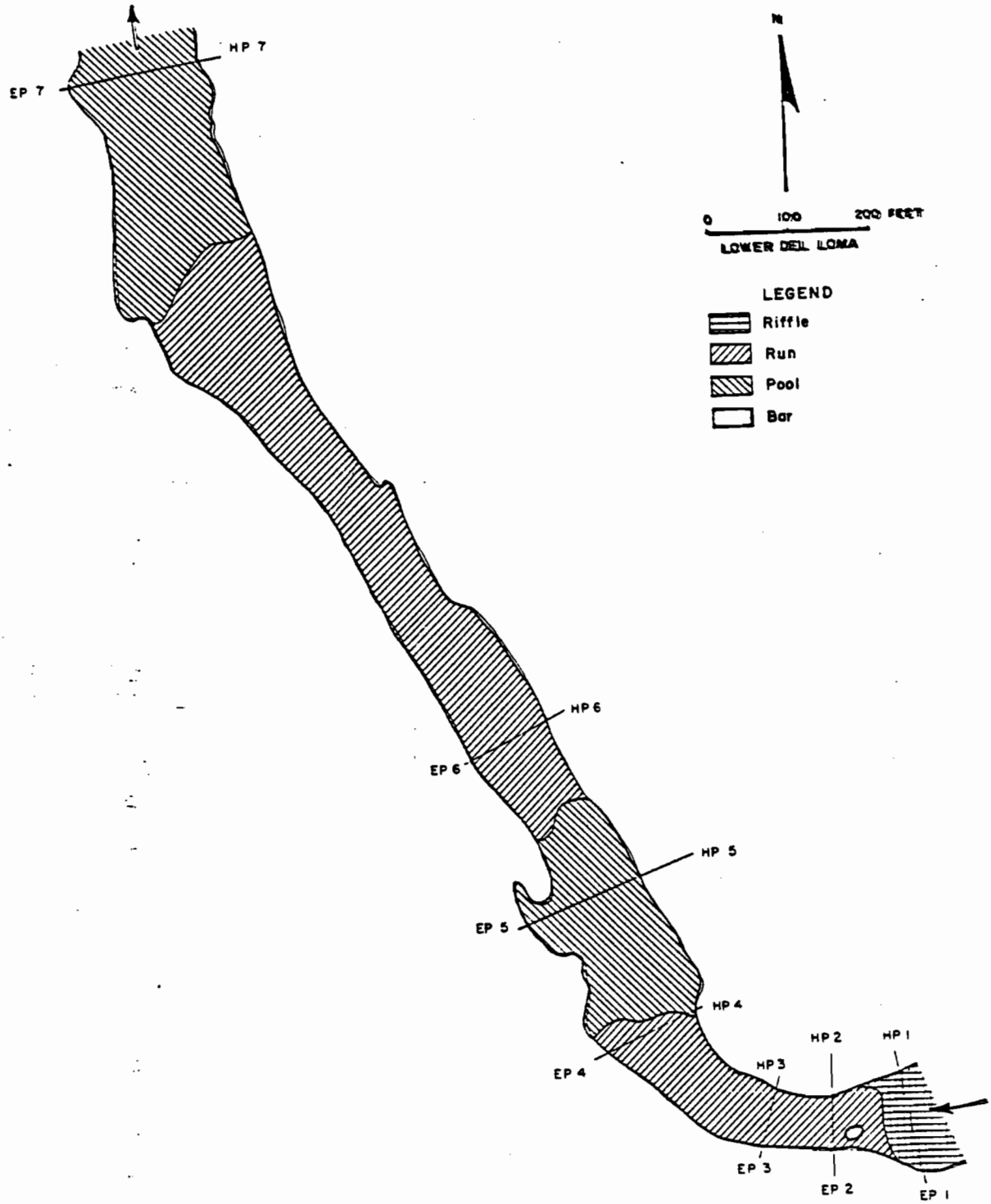
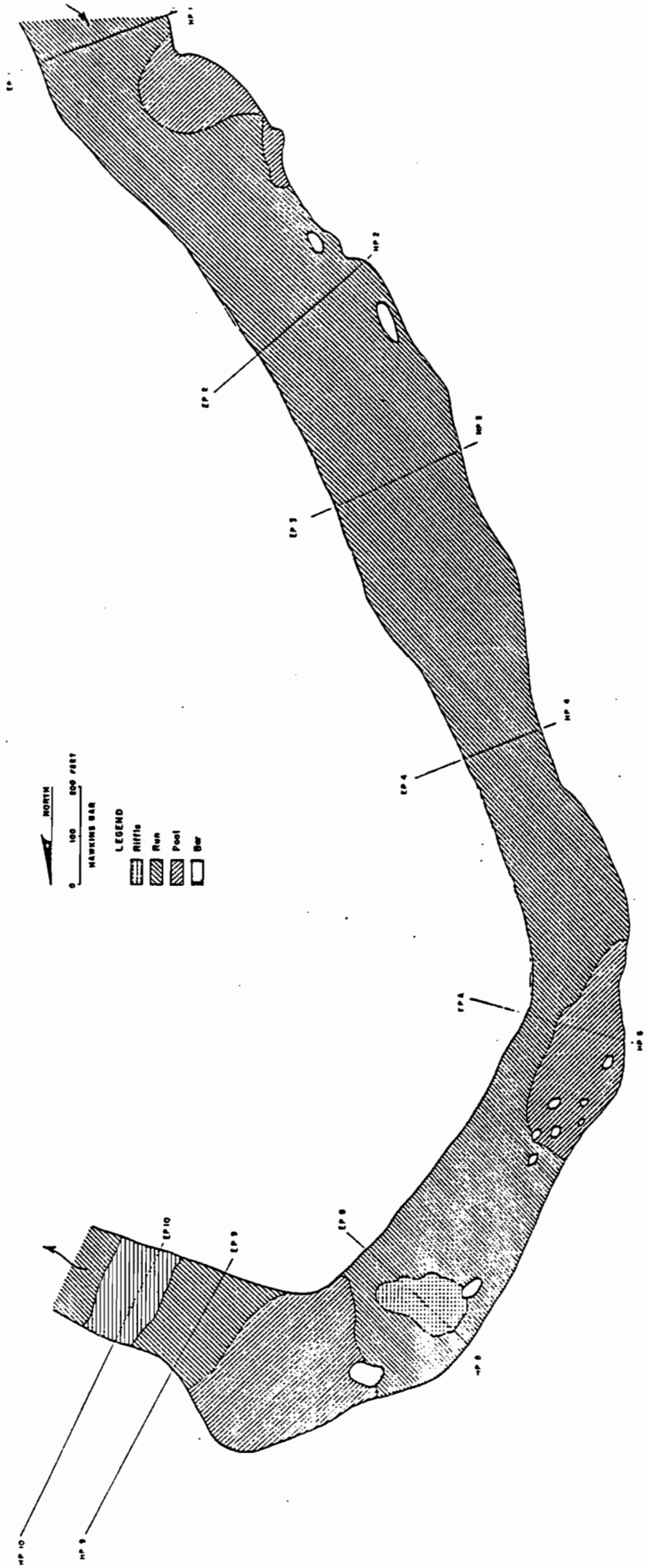
EP 1
HP2
EP 2
HP4
EP4
HP5
EP5
HP6
EP6
HP 8
EP8
HP 9
EP9
HP 10
EP 10
HP 11
EP 11
LEGEND
Riffle
Run
Pool
Bar
N
0
100
200 FEET
OREGON GULCH


HP10
HP9
HP8
HP7
HP6
HP4
HP3
HP2
HP1
EP1
EP2
EP3
EP4
EP6
EP7
EP8
NORTH
0
40
80 FEET
JUNCTION CITY
LEGEND
Riffle
Run
Pool
Bar


EP 1
EP 2
EP 3
EP 4
HP 1
HP 2
HP 3
HP 4
LEGEND
Riffle
Run
Pool
Bar
N
0
20
40 FEET
UPPER DEL LOMA


N
0
100
200 FEET
LOWER DEL LOMA
LEGEND
Riffle
Run
Pool
Bar
HP 7
EP 7
HP 6
EP 6
HP 5
EP 5
HP 4
EP 4
HP 3
HP 2
HP 1
EP 3
EP 2
EP 1


NORTH
0
100
200 FEET
HAWKINS BAR
LEGEND
Riffle
Run
Pool
Bar
EP 1
EP 2
EP 3
EP 4
EP 5
EP 6
EP 7
EP 8
EP 9
EP 10
HP 1
HP 2
HP 3
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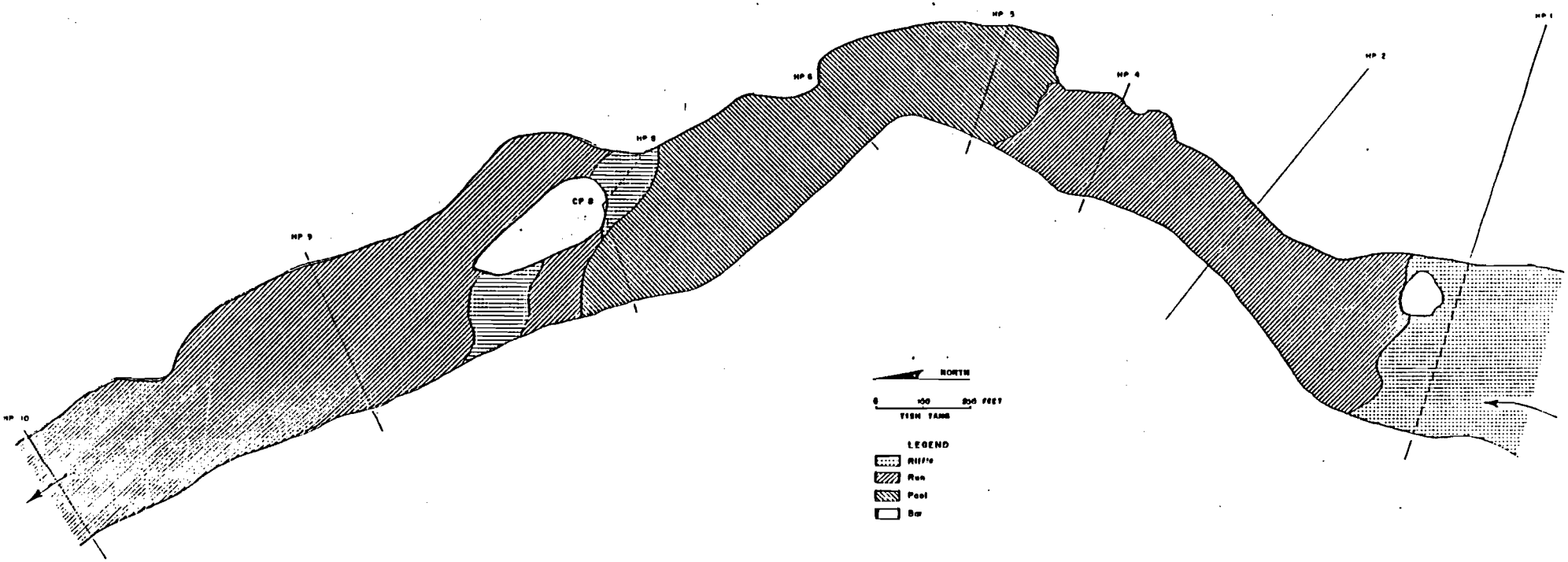
HP 6
HP 7
HP 8
HP 9
HP 10


HP 1
HP 2
HP 3
HP 4
HP 5
HP 6
HP 7
HP 8
HP 9
HP 10
CP 8
NORTH
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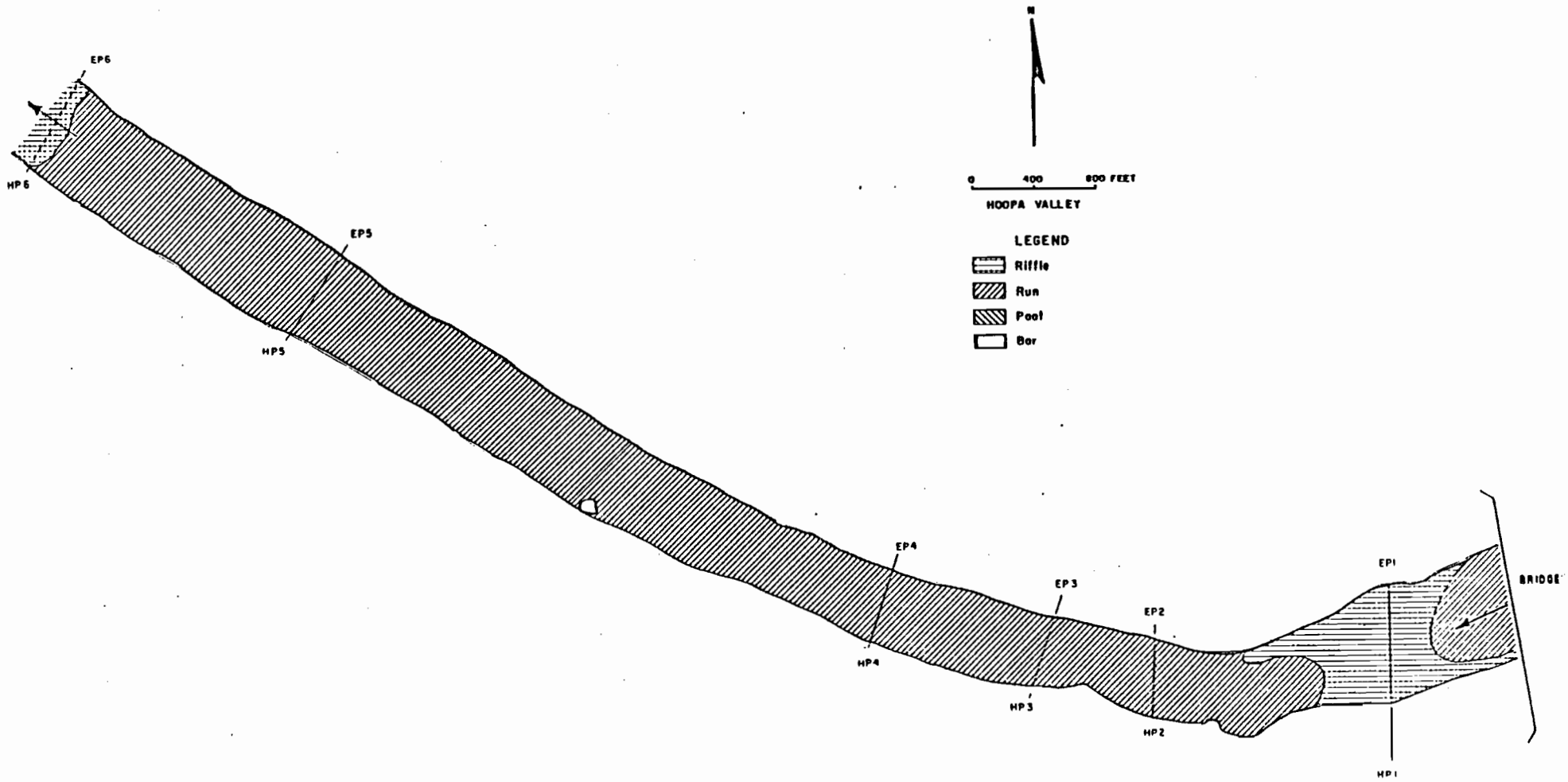
100
200 FEET
FISH TANK
LEGEND
Riffle
Run
Pool
Bar


N
0 400 800 FEET
HOOPA VALLEY
LEGEND
Riffle
Run
Pool
Bar
EP6
HP6
EP5
HP5
EP4
HP4
EP3
HP3
EP2
HP2
EP1
HP1
BRIDGE

APPENDIX E

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION

1988

U.S. Fish and Wildlife Service
Division of Ecological Services
Sacramento Field Office
2800 Cottage Way, Rm. E-1803
Sacramento, California 95825

Prepared by
the Staff of

The Trinity River Flow Evaluation
P.O. Box 174
Lewiston, California 96052

December 1988

II. HABITAT AVAILABILITY AND NEEDS

1. FURTHER CONSIDERATION OF FLOW MODEL DATA

Introduction

This year we further analyzed our IFIM flow model data from 1986 field work in order to present a clearer picture of the effects of flow on available habitat, given the present channel morphology, and to follow up on a few of its many implications.

The results include first the following overview of the current total available Weighted Usable Area, a measure of fish habitat based in this case on water velocity, depth, and substrate, in a modification of the three river segments we used to organize our study at its inception. Secondly, we investigated the potential detrimental effects that high spring Lewiston releases, up to 3500 cfs, might have through creating off-channel pools that would strand rearing fish. Finally, we looked at the relationship between higher flows and rearing habitat at the Hoopa Valley site, which seems to retain some of the morphological characteristics of the pre-project upper Trinity River, and provides some indication of the appropriate way to proceed in rehabilitating the river's habitat.

Habitat by River Segment

Figures 1 through 5 show rearing and spawning habitat of our target species and life stages in three river segments. These segments are the upper river between the New Bridge in Lewiston and Weaver Creek, the middle river between Weaver Creek and the North Fork, and the lower river between the North Fork and Hoopa Valley. The upper segment includes our Cemetery, Bucktail, Poker Bar, and Steelbridge study sites. The middle river includes our Steiner Flat, Oregon Gulch, and Junction City sites. The lower river includes our Del Loma, Hawkins Bar, Tish-Tang, and Hoopa Valley sites. Our target species are chinook salmon and steelhead trout, along with coho salmon, which are a species of lesser import to the Trinity, and which exhibit habitat needs that would be answered by the provision of habitat for the other two species.

To prepare these data, the PHABSIM output, which is expressed as square feet of Weighted Usable Area per 1000 feet of river, was multiplied by the number of thousands of feet in the river reach represented by each of our study sites. The resulting habitat values were then summed over each river segment.

We used the same fish habitat utilization curves that were used in 1987 (Hampton, 1987, Appendix A). These curves reflect the fact that chinook, coho and steelhead fry live in slow to very slow water, and that their preferences change at varying rates as they grow. Once they have reached juvenile size, about two inches, coho maintain a preference for slow water, chinook move to somewhat faster water, and steelhead select yet faster currents. The fastest current in which we find significant numbers of young steelhead is 4.0 feet per second, which can be waded with little trouble at knee-high depth. We used no substrate criteria, since we have not found that rearing Trinity river salmonids require any special substrate or cover types during the spring and summer, except where large rocks and woody debris may create limited areas of low velocity immediately downstream.

Our spawning habitat curves show that spawning salmonids require moving water, peaking at between 1.0 and 2.0 feet per seconds, and clean gravel of an appropriate size.

Upper River The resulting habitat curves shown in Figures 1 through 5 are smoother than the collection of individual curves for each site presented in our 1987 annual report. They show a smaller variation in habitat with changes in flow, and permit a clearer comparison of the relationships between fry and juvenile habitat availability for the various salmonids.

The reduction in variation in rearing habitat in the upper segment (Figure 1) is caused mostly by a spreading of the effects of side-channel inundation at Cemetery and Bucktail over the entire upper river, which tends to maintain total fry and juvenile habitat at a consistent level as flows increase. Total available habitat still drops with increasing flows, because of the steep-sided configuration of the river channel, which forces added water to flow faster.

The rearing curves show that the river provides more juvenile habitat than spawning habitat at all flows. The least amount of habitat is available for coho fry, which select water of zero velocity and avoid velocities above 1.0 foot per second. The most is available to steelhead juveniles, which prefer velocities between 1.0 and 2.0 feet per second.

Coho and steelhead spawning habitat in the upper river is seen in Figure 2 to be relatively insignificant. The lack of steelhead spawning habitat is probably caused by an absence of clean gravel in the appropriate sizes. The apparent lack of coho spawning habitat may be an artifact of our curve-development procedures, which require field observations of spawning fish to define habitat-use curves. During use data collection most of the coho in the mainstem Trinity spawned in the reach directly below Lewiston Dam, where gravel is cleaner than it is in the rest of the upper segment. The

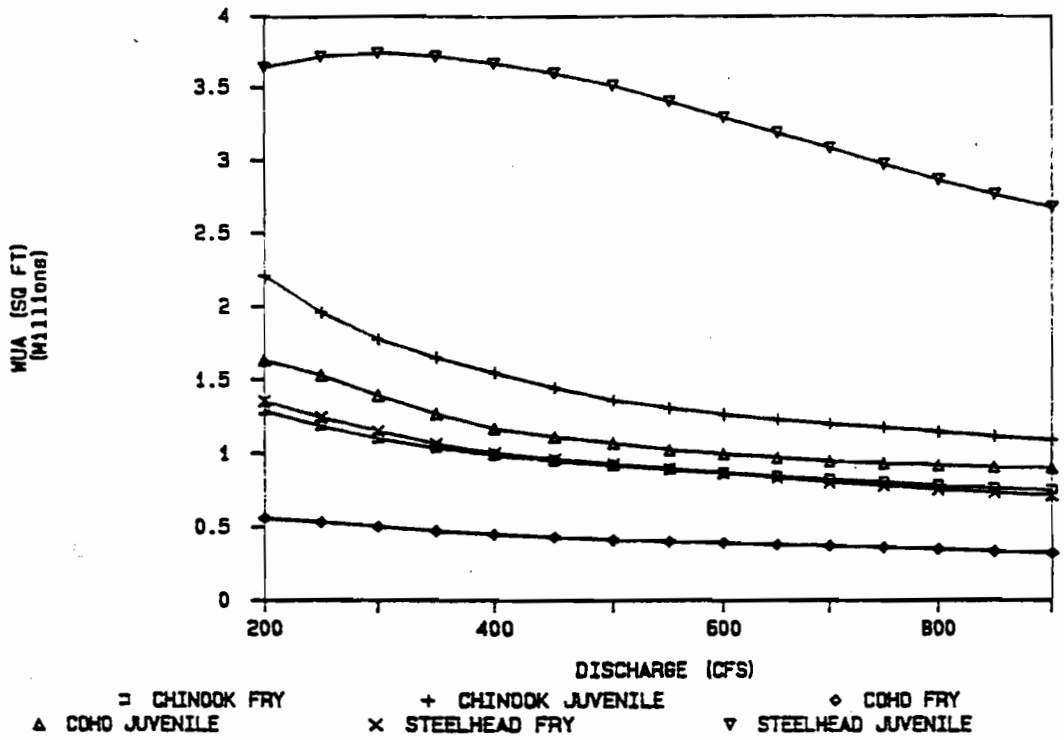


Figure 1. Weighted Usable Area for Fry and Juveniles, Lewiston to Douglas City.

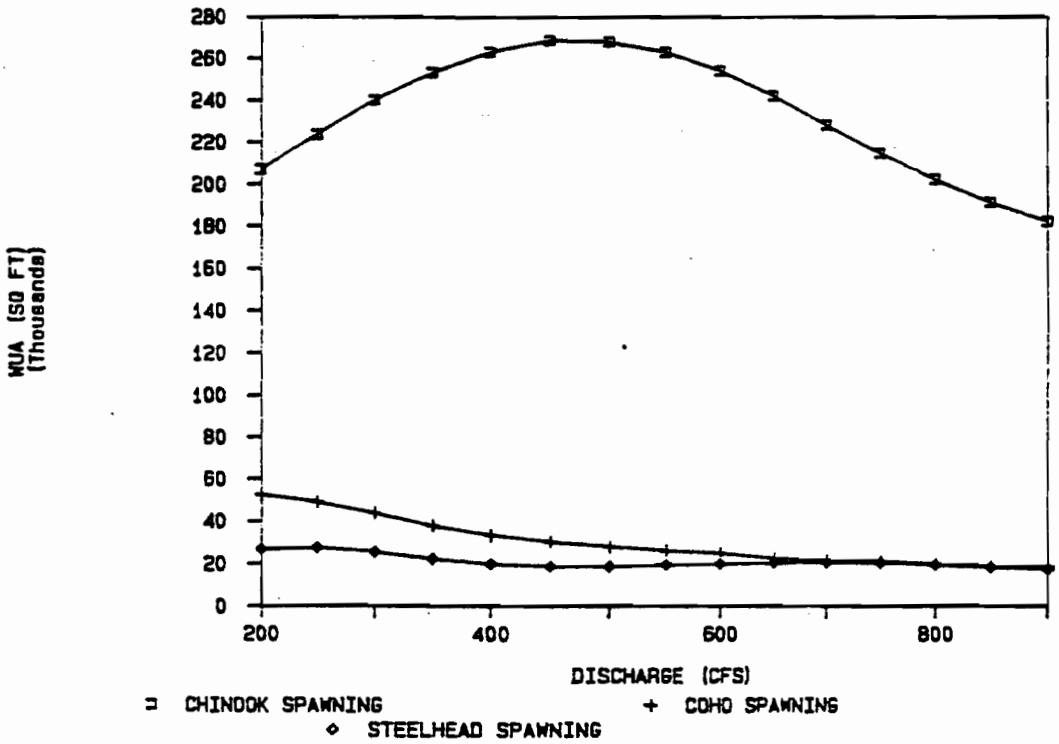


Figure 2. Weighted Usable Area for Spawning, Lewiston to Douglas City.

resulting curves, applied to the sandy bottom below Lewiston, show little available habitat for coho spawning.

Upper-reach spawning habitat for chinook salmon peaks at about 425 cfs, when an estimated 265,000 square feet of spawning habitat are available above Douglas City. This drops to about 240,000 square feet at the currently scheduled spawning release of 300 cfs.

Middle and Lower River Habitat trends in the middle river segment, from Weaver Creek to the North Fork, are similar to those in the upper river. Once again the habitat curves are smoother and clearer. Figure 3 indicates that increasing river flow depresses rearing habitat somewhat, and that there is more habitat for juveniles than for fry. Figure 4 shows substantially more habitat for spawning chinook than for coho or steelhead.

For the lower river segment, from the North Fork to Hoopa Valley, we simulated only chinook and steelhead rearing habitat, and we increased the range of flows simulated from 900 to 3500 cfs. The habitat curves for fry (Figure 5) generally descend until about 900 cfs, and then begin to increase slightly, mostly because the segment includes Hoopa Valley, where increased flows result in an increased area of slow-water habitat (see below). Chinook fry and juvenile habitat drops steadily from peaks near the low end of simulated flows. At flows above about 2000 cfs, the curves at all sites other than Hoopa begin to take radical turns, indicating that the habitat simulation, which is based on field data taken at much lower flows, is no longer a trustworthy reflection of reality.

Relationship to Fish We have found by measuring chinook redds that they take up an average of about 50 square feet. Adding room for separation between redds, 100 square feet is another reasonable estimate for the amount of spawning area required for a pair of chinook. Based on these high and low estimates, in the reach between Lewiston and Douglas City, there is habitat for from 2,700 to 5,400 spawning pairs. In the reach between Weaver Creek and the North Fork, about 5,500 to 11,000 pairs should be able to spawn, for a total between Lewiston and the North Fork of 8,200 to 16,400 pairs.

We as yet have incomplete information on area needs of rearing salmonid fry and juveniles. The highest density of juvenile salmonids we have seen was 1.06 chinook fry per square foot in March at the upper electrofishing site at the Moose side-channel in Lewiston (Section III.4). Peak Weighted Usable Area for chinook fry between Lewiston and Weaver Creek is 1,294,548 square feet, which would provide habitat for about 1.4 million fry. There are an additional maximum 770,861 square feet of chinook fry Weighted Usable

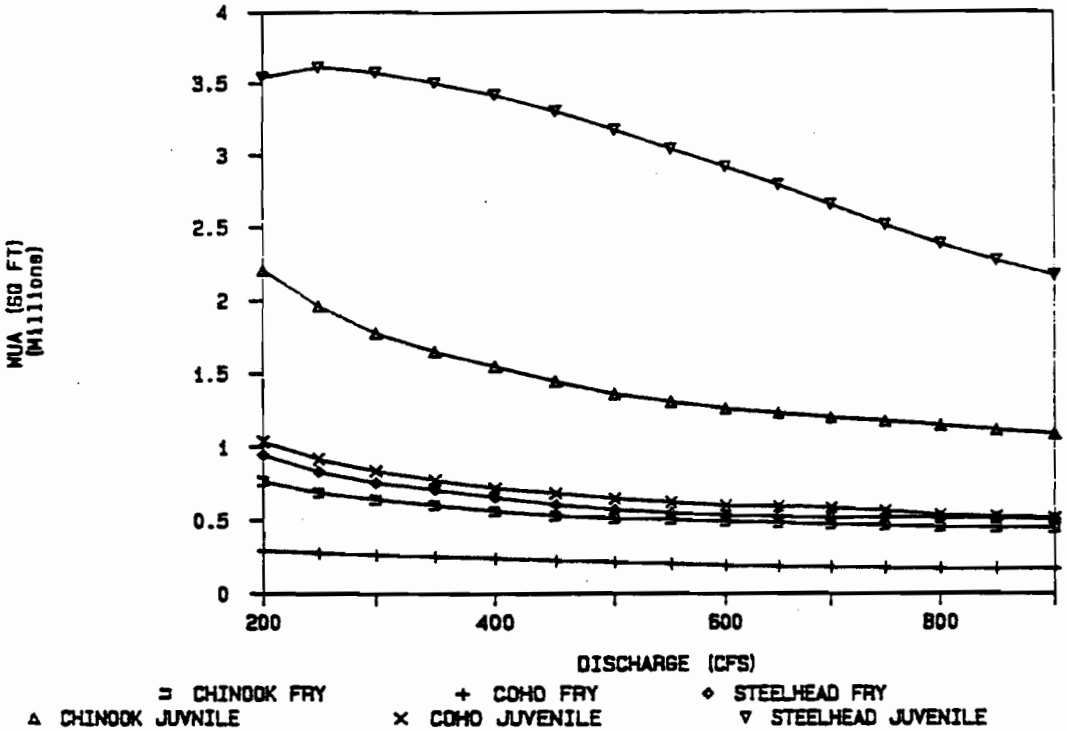


Figure 3. Weighted Usable Area for Fry and Juveniles, Douglas City to North Fork.

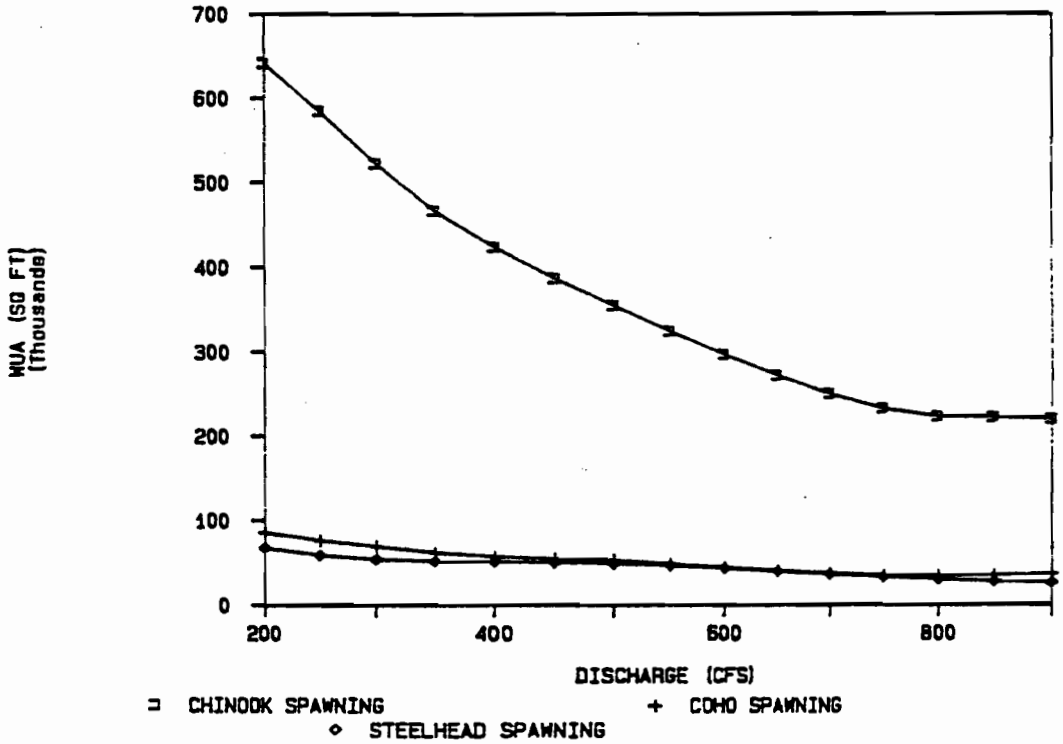


Figure 4. Weighted Usable Area for Spawning, Douglas City to North Fork.

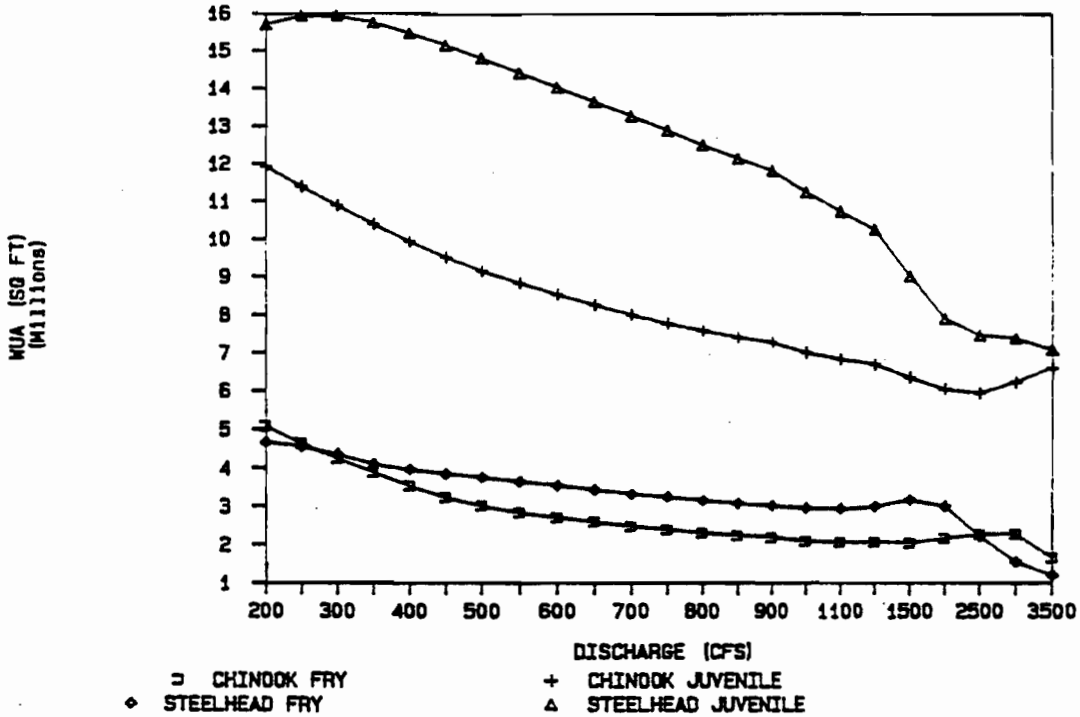


Figure 5. Weighted Usable Area for Fry and Juveniles, North Fork to Hoopa Valley.

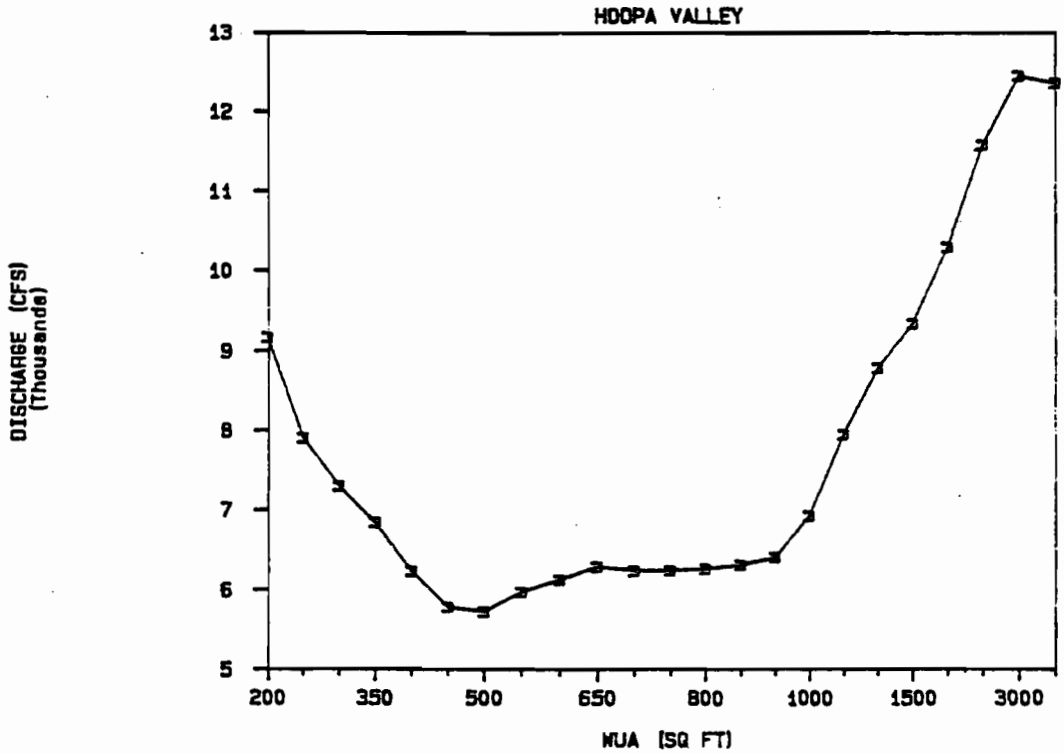


Figure 6. Weighted Usable Area for Chinook Salmon Fry at Hoopa Valley IFIM Site.

Area between Weaver Creek and the North Fork, which at the maximum observed density would provide habitat for 817,113 fry. A total of approximately 2.2 million resident fry could be supported between Lewiston and the North Fork. According to our simulations, in the river between the North Fork and Hoopa Valley there could be a maximum of 5,098,305 square feet of chinook fry habitat, although here it is possible that actual habitat could be reduced or eliminated if temperatures are not suitable for salmonids.

The total chinook fry Weighted Usable Area between Lewiston and Hoopa Valley, without consideration of temperature, is 7,163,714 square feet. At our highest observed densities, this could support approximately 7.6 million chinook fry.

We do not have good electrofishing information on what might be considered maximum chinook juvenile densities, because only the side-channels are amenable to electrofishing, and most chinook evidently leave the side-channels by the time they have reached the 50 mm in length that we define as juvenile size. Generally, from our snorkel population observations (Section III.2), it may be assumed that we see juvenile densities at most an order of magnitude below fry densities. Lister and Genoe (1970) found maximum juvenile chinook densities of about 4.5 per square meter, or 0.42 per square foot, in the Big Qualicum River in British Columbia, and with some license this may be taken as an upper density for juvenile chinook. According to our PHABSIM output, there is a maximum of 2,925,700 square feet of juvenile chinook habitat in the upper segment, 2,212,253 square feet in the middle river, and about 12,000,000 square feet from the North Fork to Hoopa Valley. Thus the river, at 0.42 juveniles per square foot of suitable habitat, could support about 1.2 million fish in the upper segment, about 1.0 million in the middle segment, and if temperature is not a factor about 5.0 million in the lower segment, for a total of 7.2 million.

Table 1 shows these relationships between habitat and the life-stages of chinook it might support.

Table 1. Estimated Maximum Trinity River Chinook Salmon Populations for Various Life Stages Supportable with Maximum Habitat Available.

Segment	Fry	Juvenile	Spawning Pairs
Lewiston to Douglas City	1,372,220	1,228,794	5,400
Douglas City to North Fork	817,113	929,146	11,000

North Fork to Hoopa Valley	5,404,203	5,040,000	--
Total	7,593,536	7,197,940	16,400

Assuming that naturally-produced chinook juveniles can out-compete the millions of hatchery fish that are released each year at Lewiston, and that the density values for fry and juveniles are reasonable, it appears that there is adequate juvenile habitat to accommodate the fry that can successfully rear within the river.

It further appears that there is adequate spawning habitat to produce the numbers of fry that the river can be expected to support. Female chinook at the Trinity River Fish Hatchery produce about 2,800 eggs each, and hatchery egg-to-fry survival is about 84 percent. If naturally-spawning fish produce as many eggs, and have a 50 percent egg-to-fry mortality, then 5,400 pairs spawning above Douglas City, adequately spaced in the available spawning area, could fully seed the entire river.

Effects of High Flow on the Formation of Isolated Pools

Occasional high releases from Lewiston Dam to help wash accumulated sediments from the mainstem Trinity River, prevent the encroachment of riparian vegetation on the river channel, and maintain the channel in its natural shape, have been consistently recommended by various organizations concerned with the management of the Trinity River since the river was first controlled by the Trinity River Project (e.g. VTN, 1979, Section II-28).

Major objections to such flushing flows on the Trinity have been:

1) high water is to be avoided because it can cause property damage to persons who have built in the flood-plain,

2) excessive amounts of water are required to flush sediments, causing lost benefits in power generation and water supply to the Central Valley Project, and

3) water at some indeterminate level above 800 cfs will overtop a berm that has developed along the river and create numerous isolated pools that will strand and kill fish.

In order to evaluate the third of these objections, we undertook a review of our IFIM data to determine if it supports the idea that a flushing flow will create significant stranding areas.

Current Conditions Sediment is entrained and transported at high water velocities, and deposited at lower velocities. When a river overtops its banks it may fill a wide flood channel with water high in suspended fines, which may subsequently be deposited along the channel in a natural levee or berm, possibly creating isolated channels or backwaters on the flood-plain. Where vegetation has encroached along the river bank, it may slow flood-waters so that they deposit sediments adjacent to the low-flow channel while the river is still in flood, increasing the height of the berm.

Such berms are evident along the Trinity River in some areas. They are most evident between the California Department of Fish & Game counting weir above Junction City, at river mile 86, and Cooper's Bar at river mile 75. In this section, many of the inside bends of the main channel are bordered by berms covered with a thick growth of willow, alder, and blackberry. The berms tail off to the height of the natural bank-full edges of the river at their upper and lower ends, where the occasional flood-water that forms them enters and leaves the flood channel behind them. They are generally interspersed with low sections where the inland gravel or cobble bars slope gently to the river. Many of these low points have been further lowered by fishermen, who have cut foot-trails and boat-launching access from dirt roads behind the berm.

The river below the North Fork has no berms. The steep canyon walls and the unregulated flows prevent their formation. Above the Department of Fish & Game weir their are a few discernable berms. Isolated berms have developed on some of the gravel bars between the end of Steiner Flat road and the BLM Steiner Flat campground upstream. Between Indian Creek and Limekiln Gulch there are a few areas where an irregular, low sandy berm is present. There is a broken berm of soil and sand on the left bank of the river above Bucktail hole, and there are indications that a berm may be forming on parts of the left bank between Rush Creek and Lewiston.

IFIM Data We have established 126 transects across the river from Lewiston Dam to Hoopa valley, and have developed stage-discharge relationships at these transects based on Lewiston releases between 300 and 800 cfs.

The stage-discharge relationships permit the estimation of the river's water surface elevation at various flows. Transect profile data permits us to predict where the water level will be in relation to the river bank at these flows.

Since we established them to measure discharges up to about 1000 cfs, and because extending them further would have served no purpose within IFIM, most of our transects begin

and end on the bank-full edge of the river, inside any berms. As a result, flow that keeps within our transect end-pins can be considered to remain within the channel.

To determine the effects of a 3,500 cfs release, we simulated this flow in IFIM hydraulic computer programs, and examined results for the creation of any fish-stranding pools beyond the berm.

Results Our two sites within the area of definable berms are at Oregon Gulch and Junction City Campground.

At Junction City Campground, a simulated flow of 3,500 cfs backed water up into the side-channel on the right bank of the river, overtopping our riverbank pin by 2.8 feet. This was well below the height of the berm, but it is possible that the discharge could cause flow in the side-channel on the Highway 299 side of the berm. However, on several occasions during the past three years we have seen the channel watered behind the berm at flows up to about 10,000 cfs, and have seen no subsequent formation of isolated pools.

At Oregon Gulch, the berm is more well-defined than at Junction City. Our simulation of a 3,500 cfs flow showed no approach by flood waters to the berm top, or even overtopping of our pins along the berm, which are set close to the bottom of its higher terrace. There would be no stranding of fish with a 3,500 cfs flow at Oregon Gulch.

At our Steiner Flat site there is a discernable berm and potential flood channel along the right bank between transects 1 and 4. The 3,500 cfs water surface elevation does not come near to overtopping the berm in this area. We have seen the channel behind the berm flowing during flood stages. It drains back into the main river at the location of our transect 4 without forming noticeable isolated pools.

Further upstream at our Steelbridge site the right bank between transects 6 and 10 is benched and fairly level, and could form a side-channel at high flows. The 3,500 water surface elevations is higher than our pins, though whether it is high enough to encroach widely on the benched area is unknown. The bench is irregular, composed of recently-deposited decomposed granite sediments, and thickly covered with blackberries, alders, and willows. It is difficult to predict if any stranding would occur there. There is no record of any biological survey of the area during flood recession, and we do not know whether isolated pools would form there. In the river reach between Steelbridge and Limekiln Gulch the right bank generally has the same configuration, and several minor side-channels form there during higher flows, including our Limekiln Gulch study side-channel (Section II.2).

Along portions of our Poker Bar study site there is a sandy berm on the right bank, but the 3,500 cfs flow does not overtop it. Formation of isolated off-channel pools is not probable at Poker Bar.

At our Bucktail site some of the transect end-pins along the left bank would be overtopped by a 3,500 cfs flow. These areas would drain without forming significant isolated pcols, and significant stranding would not occur.

At our Cemetery site there is some elevation of the bank adjacent to the river, but no real berm. A 3,500 cfs flow would spill over into low brushy areas above a small side-channel on the right bank above the chute in the area of transect 5 and 6. This would be a natural upstream extension of the existing side-channel, and would drain without creating significant isolated pools.

At the upper section of the Cemetery site a 3,500 cfs flow would overtop some of our pins on both sides of the river. This section consists of a defined river channel, a smaller but well-defined side-channel, and a broad area of broken, shallow, brushy side-channel between them. The central channel is increasingly inundated from flows over about 350 cfs, and provides the best extended area of salmonid fry rearing habitat on the Trinity River. Isolated pools form here every spring as the water recedes, and this is the only area where we saw stranding after the floods that subsided in March, 1986. Formation of isolated pools will occur here at any flow above about 350 cfs. Since most young-of-the-year salmonids leave side-channels before mid-May, there is insignificant stranding in years when water remains high until the last week of that month.

In conclusion, there is no physical evidence suggesting that a spring release of 3,500 cfs from Lewiston Dam would have any measurable detrimental effect on rearing salmonids. It is probable that water higher than the regulated flows that have been normal over the past decades would form some isolated pools that would strand fish if fish were present in the main river. It does not appear from our data, however, that the effect would go beyond the range that could be expected in a natural, unregulated system, or that it would seriously affect fish production in the Trinity River.

Hoopa Valley Flow/Habitat Relationships

As noted in our 1987 annual report, the river at Hoopa Valley is a series of meanders with wide, gently-sloping point bars where increases in flow create increased areas of slow water that provide ideal rearing velocities.

Figure 6 shows the chinook fry Weighted Usable Area response

to flows from 200 to 3500 cfs at our Hoopa Valley site. Weighted Usable Area in this case measures availability of suitable velocities and depths, and actual habitat in the Hoopa area may be limited by temperature or other factors. At 500 cfs there is an increase in Weighted Usable Area with increasing flows, and the rate of increase rises dramatically at 950 cfs. The reason is to be found in the shape of the river cross-sections at Hoopa, which are shown in Figure 7.

Habitat for salmonid rearing at our Hoopa Valley site increases at an increasing rate with higher flows as water encroaches on a wide gravel bar that is evident at the right in transects 2 through 4, and somewhat less evident in transect 5 and 6. At this site, the river takes a broad turn to the right, toward a shallow slope that can be seen by motorists on the Highway 96 bridge. On such a bar, the water is slowed both by the friction of shallow flow over a rough substrate, and by the vector of flow past the obtruding point, which leaves a kind of velocity shadow on the bar's downstream edge. This velocity shadow creates ideal habitat for rearing salmonids, which can school at the shear zone between slow and fast water, and feed on the drift that the main current brings past their protected area of relatively still water.

Through inspection of aerial photographs, personal memory of pre-dam conditions, field observation of existing morphology, and discussion with persons familiar with the pre-dam Trinity River, it seems evident that similar gravel point bars existed in the river from Douglas City to Lewiston prior to flow control. Since that time the river, under its controlled flow regime, has channelized, developing steep banks with a broad, canal-like expanse of fast water between them. This new channel shape has reduced the habitat available for rearing salmonids, and may have skewed the flow-habitat relationship so that more water, up to bankful depth, results in less rearing habitat, although the needs of fish for variations in flows for downstream transport, invertebrate production, temperature control, and definition of river morphology may still be the same.

<u>Management Implications</u> Our evidence that point bars are necessary on the Trinity River consists of personal recollections of pre-dam conditions, unverifiable statements in various documents that high returns of fish existed then, our flow-model evidence at Hoopa Valley, suppositions about the relationship between high flows and river morphology, empirical knowledge of the salmonid production capability of other rivers such as the Sacramento, and our recent observations on the habitat preferences of Trinity River salmonids and on existing Trinity River habitat. All of these bits of information seem to point to the idea that reshaping the river channel and maintaining that shape with sustained high flows during at least part of the year are

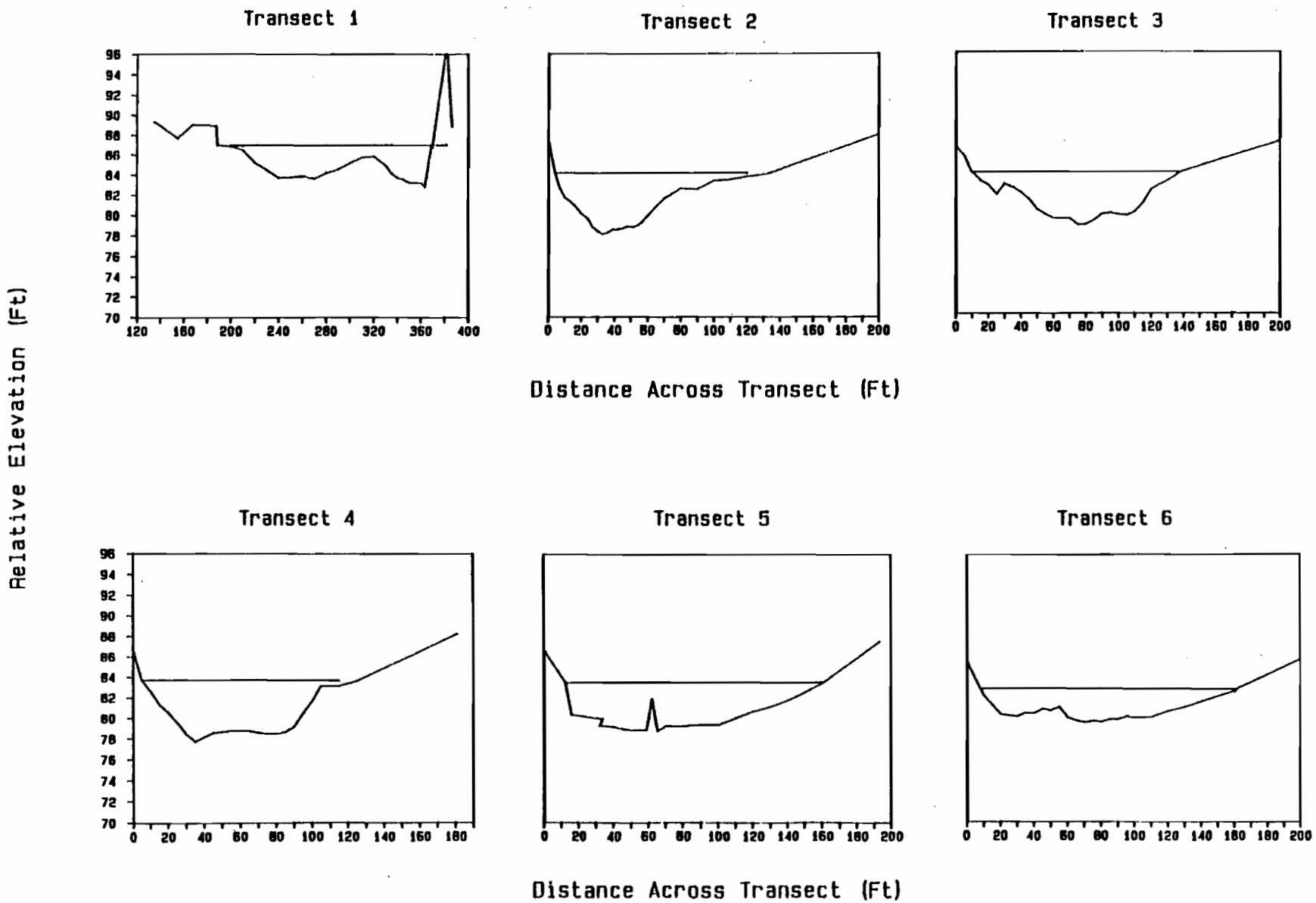


Figure 7. Transect Profiles at Hoopa Valley IFIM Site.

necessary actions if the Trinity River is to be rehabilitated as a natural system.

Fredericksen, Kamine and Associates (1980) faced the same scientific or informational limitations when they stated, with no supporting evidence other than qualitative observation by fisheries biologists, that increasing the flows in the Trinity would not increase habitat unless the channel were widened, which presumably meant the re-creation by heavy equipment of a point bar configuration. Fredericksen, Kamine and Associates seem to have discounted this strategy as infeasible.

The arguments against reshaping portions of the river channel are that it would be costly and that it would reduce the riparian habitat, which is the almost continuous thicket of willow, alders, blackberry brambles, and a few other plant species which has grown up over the old overflow plain of the Trinity River from Lewiston to the North Fork since discharge was controlled.

The dollar costs for reshaping a river bank can be fairly easily calculated. Environmental costs are less easy to quantify. Riparian habitat in California has been much reduced by farming, residential development, and flood control, and the thickets that have grown up along the Trinity River may be considered replacement for some of this lost habitat. Recreating salmonid rearing habitat in the river would destroy some of the post-dam riparian, and might require the provision of compensatory habitat elsewhere.

Reshaping the river, like the provision of flushing flows, is an old idea that has taken a less prominent position than projects of more immediate concern such as the improvement of the Trinity River Fish Hatchery, construction of sedimentation control facilities on Grass Valley Creek, manipulation of steelhead cover and spawning habitat on National Forest lands, and required state stock monitoring in the main-stem and its tributaries. Our data on existing habitat-flow relationships at Hoopa Valley, along with our observations in the upper river, indicate that the provision of fish habitat by mechanical manipulations of the channel should be reconsidered.

APPENDIX F

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION

1989

U.S. Fish and Wildlife Service
Fish and Wildlife Enhancement
Sacramento Field Office
2800 Cottage Way, Rm. E-1803
Sacramento, California 95825

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II. HABITAT AVAILABILITY AND NEEDS

1989 MAIN-STEM HABITAT MEASUREMENTS

In 1985 and 1986 we carried out main-stem salmonid habitat studies based on Instream Flow Incremental Methodology estimates of hydraulic conditions at Lewiston Dam releases from 350 to 800 cfs. Preliminary analysis, presented in our 1988 annual report, showed that salmonid rearing Weighted Usable Area (WUA, an index of available habitat) generally decreases with increases in flow. We simulated conditions at flows only slightly above the highest flow we measured, because it was apparent that at somewhat higher flows the existing river banks would be overtopped in many places, causing radically different stage/discharge relationships and habitat patterns. Any habitat estimate based on extrapolation of our data to higher flows would probably be wrong. So in 1989 we studied a Lewiston Dam release of 2000 cfs to obtain an accurate estimate of high-flow habitat.

METHODS:

To date, we have based habitat estimates on IFG-4, a PHABSIM computer program that allows simulation of unmeasured flows. This technique is necessary in short-term studies where a range of flows over several orders of magnitude must be quickly evaluated.

During 1989 we limited measurement at some transects to portions of the channel that provide fish habitat, not gauging high-velocity thalweg areas. We were able to measure conditions at sites from Lewiston to Del Loma in the limited time that high flows were available.

The measured flows presented below are Lewiston releases of 350 and 450 cfs in the summer of 1985, a release of 800 cfs in the summer of 1986, and a release of 2000 cfs in May, 1989.

To define habitat suitability, we used final preference criteria developed in our preference studies (Hampton 1988, appendix E). Earlier annual reports used initial use criteria then under development.

To determine the total habitat availability between Lewiston and Douglas City, WUA estimated at each transect was multiplied by the distance of the river most closely represented by the transect, as described in Section II.2.

RESULTS:

Figures 1 through 4 show WUA estimates based on our four measured flows between Lewiston and Douglas City.

The most striking pattern is for chinook fry (Figure 1). These fish prefer water velocities at or close to zero, and the higher flow increased the habitat available to them by providing extensive areas of slow water in side-channels and backwaters through most of the river.

Chinook juveniles are tolerant of a wider range of velocities, and this is reflected in Figure 2. The habitat opened up by overtopping channelized banks was balanced by a reduction in the large areas of sub-optimal but usable velocities provided by lower flows.

Steelhead fry WUA increased substantially from 350 to 2000 cfs, after an initial drop, following the pattern for chinook fry (Figure 3). Steelhead juvenile WUA decreased with increasing flows because the slow edge areas provided by high discharge did not compensate for lost mid-stream habitat (Figure 4).

Coho fry and juvenile WUA, not pictured, follow the chinook fry pattern, with greater relative increases in available habitat at the highest flows. This is because both life-stages of coho are dependent on slow water.

DISCUSSION:

These results are derived from a fairly simple process:

1) Watch fish and measure the velocities and depths they use.

2) Measure velocities and depths at various flows in the river.

3) Compare the conditions required by fish and the conditions present in the river at various flows, to determine relative levels of suitable fish habitat.

The results indicate that survival within certain critical life-stages would be enhanced by seasonal high flows in the Trinity River. The difference in habitat availability is pronounced for fry chinook, where there is an approximate doubling of suitable area between 350 and 2,000 cfs.

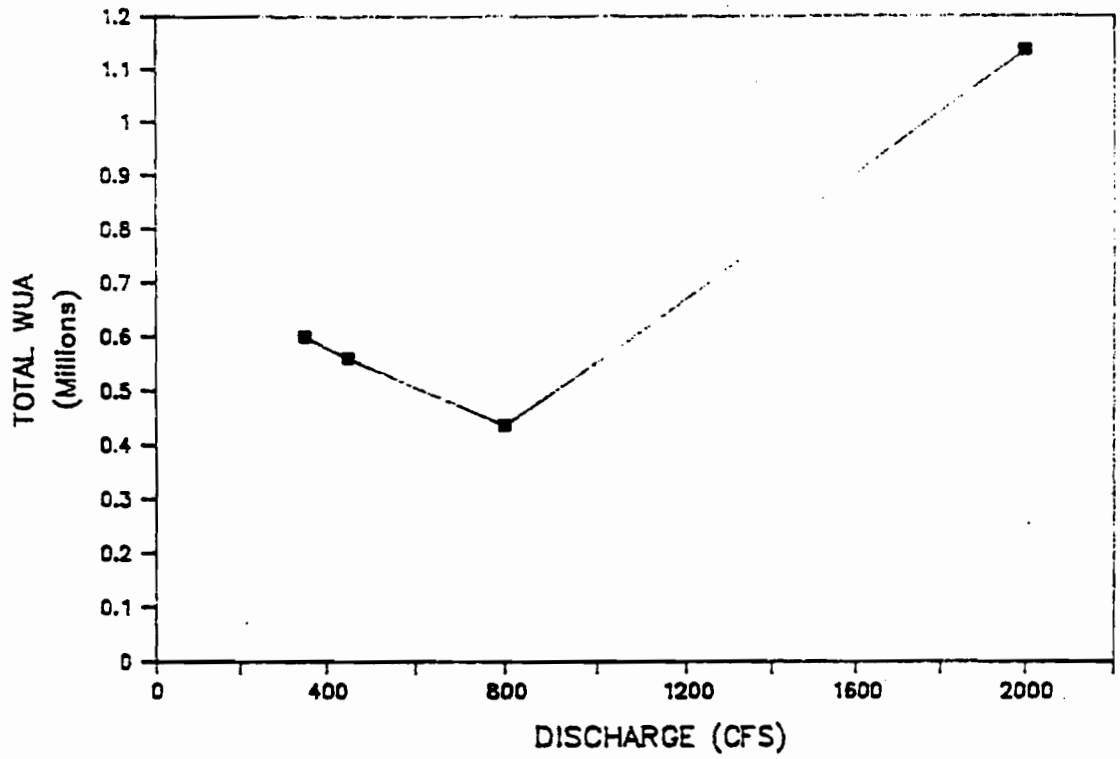


Figure 1. Chinook fry WUA, Lewiston to Douglas City.

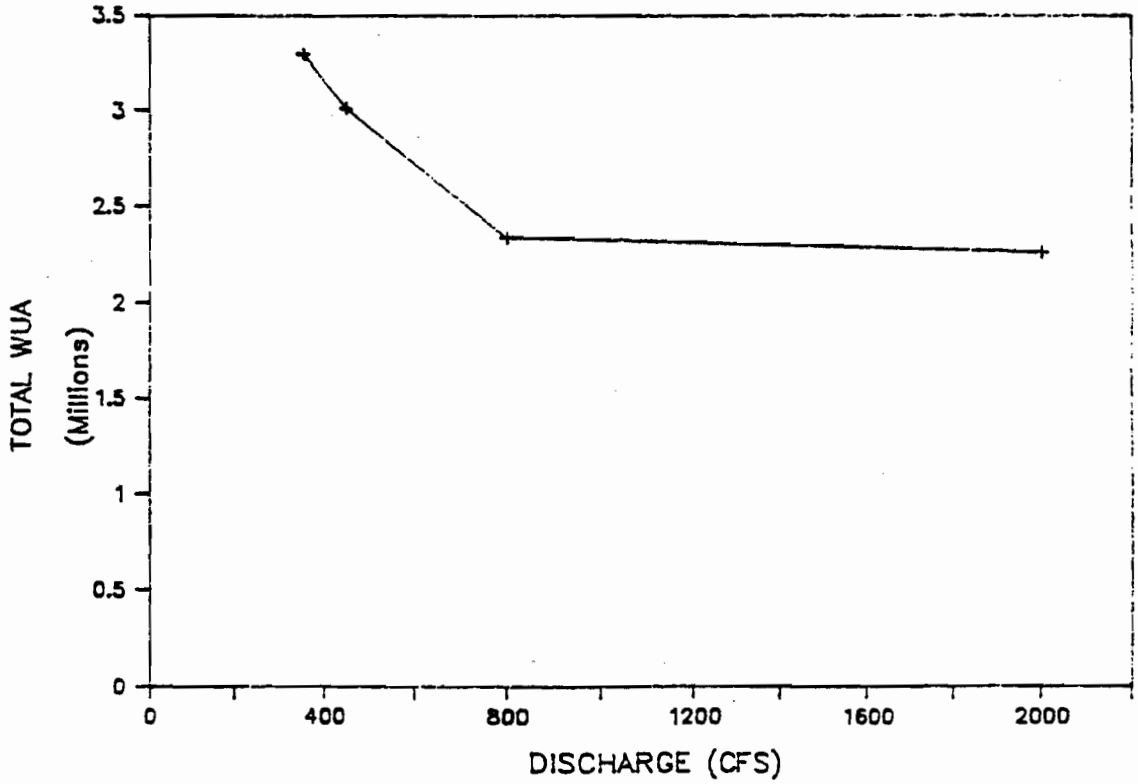


Figure 2. Chinook juvenile WUA, Lewiston to Douglas City.

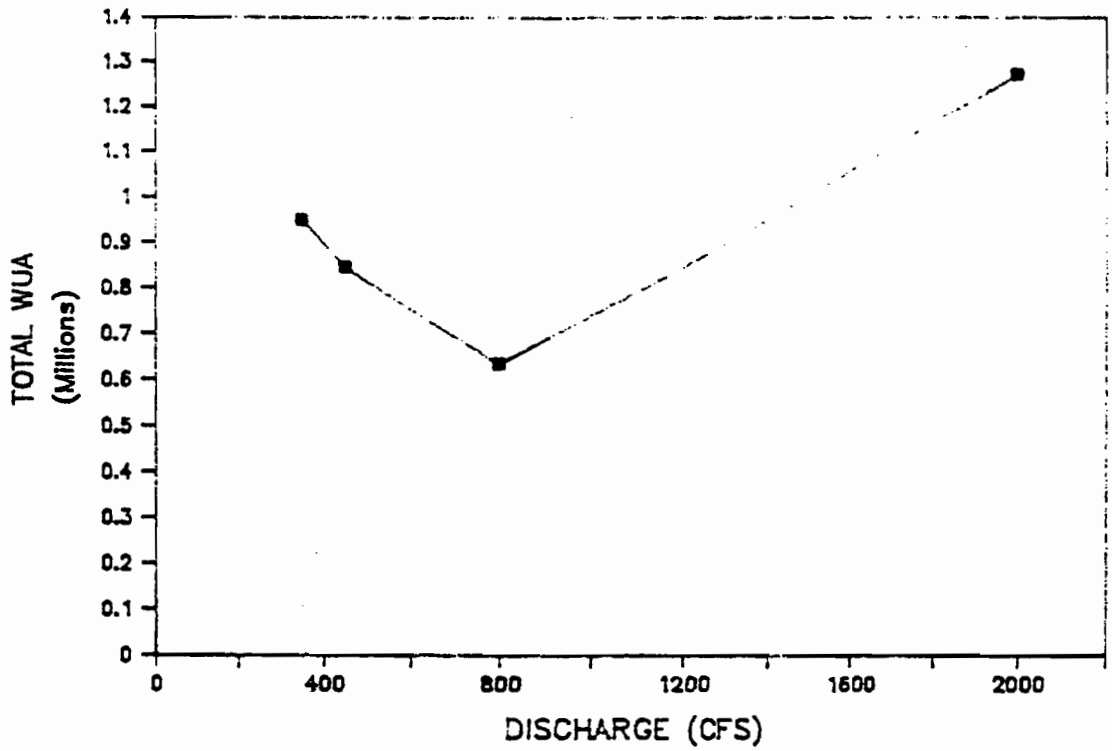


Figure 3. Steelhead fry WUA, Lewiston to Douglas City.

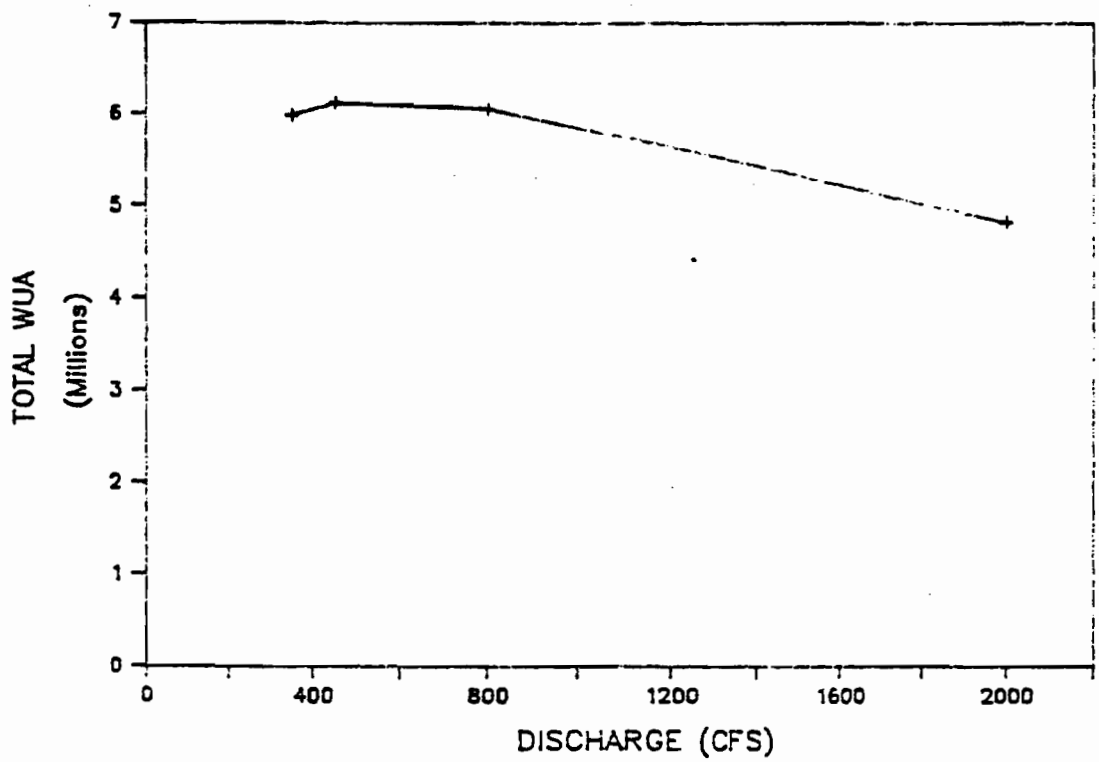


Figure 4. Steelhead juvenile WUA, Lewiston to Douglas City.

Findings:

1. Our mainstem habitat studies to date suggest that water volumes substantially over what is currently allotted may be necessary to meet habitat needs for the Trinity River fishery.

2. A drawback of IFIM studies has been that in each specific case there has only been one of them. Study results have not been confirmed independently, which opens the results to question. With only one study to look at, and no other relevant data, the tendency can be to discuss a study's deficiencies in comparison to a host of alternative studies that could theoretically have produced different results if they had been made.

This could be avoided if interested parties would undertake studies of their own. Independent study results would make it possible to avoid arguments about such elements of habitat estimation as number and location of study sites, computer modeling techniques, transect selection and weighting, computer calibration and flow simulation, and many others. Such studies would be relatively inexpensive, especially if the goal were to provide a check on methods.

The promise of this approach is that future debate on the relationship between instream flows and fishery resources need not be speculative discussions of procedural variations having negligible effect on study results; discussions could be based on reality rather than conjecture.

We encourage parties with a potential interest in validating or invalidating our main-stem habitat estimates undertake independent studies as a means of focusing discussion.

HABITAT MAPPING

We chose our IFIM sites in 1985 based on the representative reach concept. This assumes that it is possible to choose sites within a river reach that represent conditions within a larger segment, because channel characteristics repeat themselves at regular intervals, five to seven times the width of the channel. If a study site ten to fourteen times the channel width is chosen at random it has been assumed to have a good chance of representing segment conditions (USFWS 1982). Practices recommended to improve the representative reach method include various techniques for regularizing or randomizing site selection, thus reducing subjective judgements. Another recently developed approach is to study WUA in representative habitat types such as run, riffle, and pool, and multiply results by the amounts of the various habitat types in a segment. In 1989 we recalculated estimated WUA from Lewiston to Dutch Creek, the lower end of our Steiner Flat site, based on a variation of this second approach.

To reduce disadvantages of static habitat types such as run, riffle, and pool, we mapped the river segments between Lewiston and Dutch Creek according to the characteristics of each transect of the study sites representing the segments. For example, rather than categorizing a length of river in the Steelbridge section as a "run", we would designate it as similar to Steelbridge site Transect 8, based on depth, velocity, bank morphology, and the presence or absence of higher-flow side-channels or potential over-bank slow-water areas. Depending on its similarity to the transect, such a portion of the river should present the flow-dependent habitat characteristics measured there.

RESULTS

Effects of Mapping on WUA Estimates: Results of mapping compared with the extrapolation of representative reach values is shown in Figures 1 through 2, representing the differences in chinook salmon fry in the river from Lewiston to Douglas City, and between Douglas City and Dutch Creek.

The insignificant change in pattern between the estimated WUA based on mapping and the estimate based on representative reaches shows either that our initial study sites are indeed representative, or that flow-related habitat conditions in the Trinity River are consistent enough that variations in the professional judgement that must go into transect selection will not seriously affect an evaluation of overall hydrologic conditions.

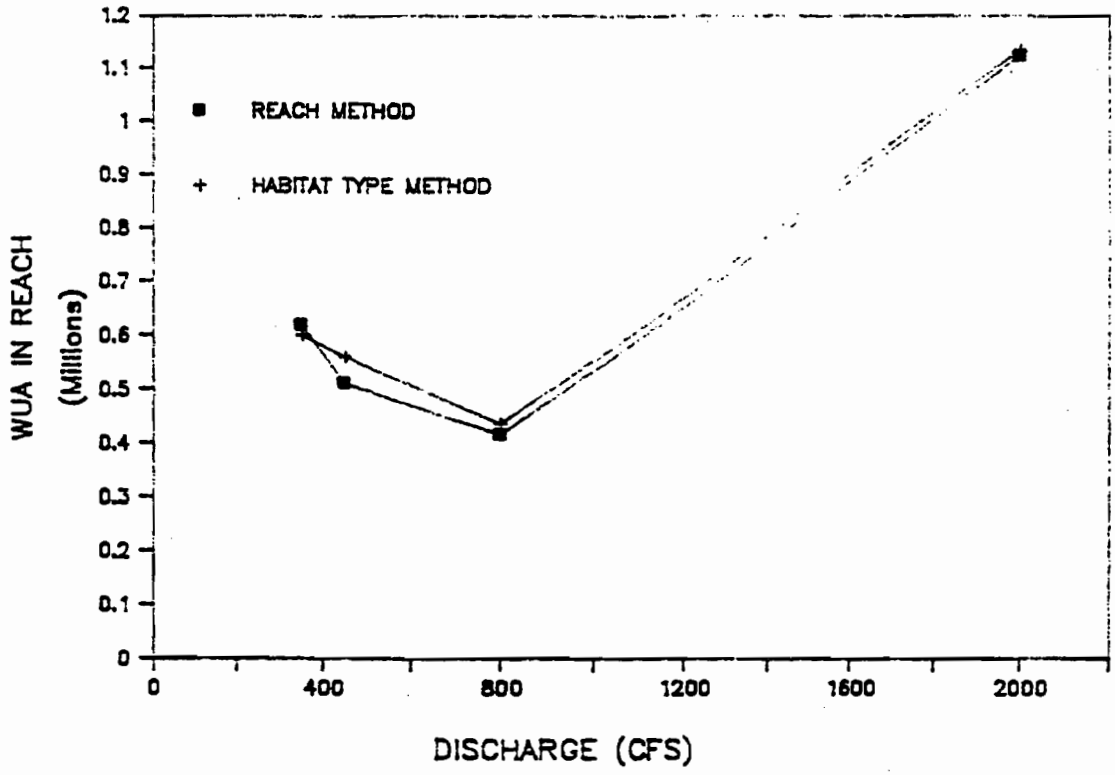


Figure 1. Chinook fry WUA between Lewiston and Douglas City based on reoresentative reach and habitat typing methods.

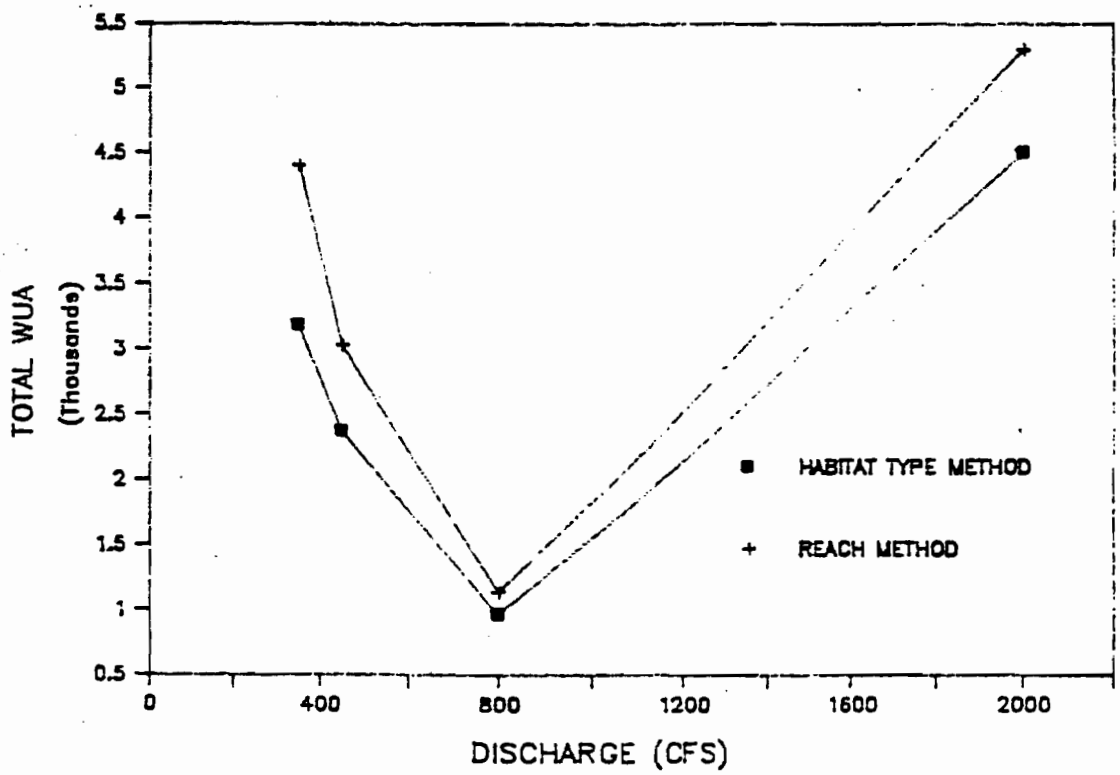


Figure 2. Chinook fry WUA between Douglas City and Dutch Creek based on representative reach and habitat typing methods.

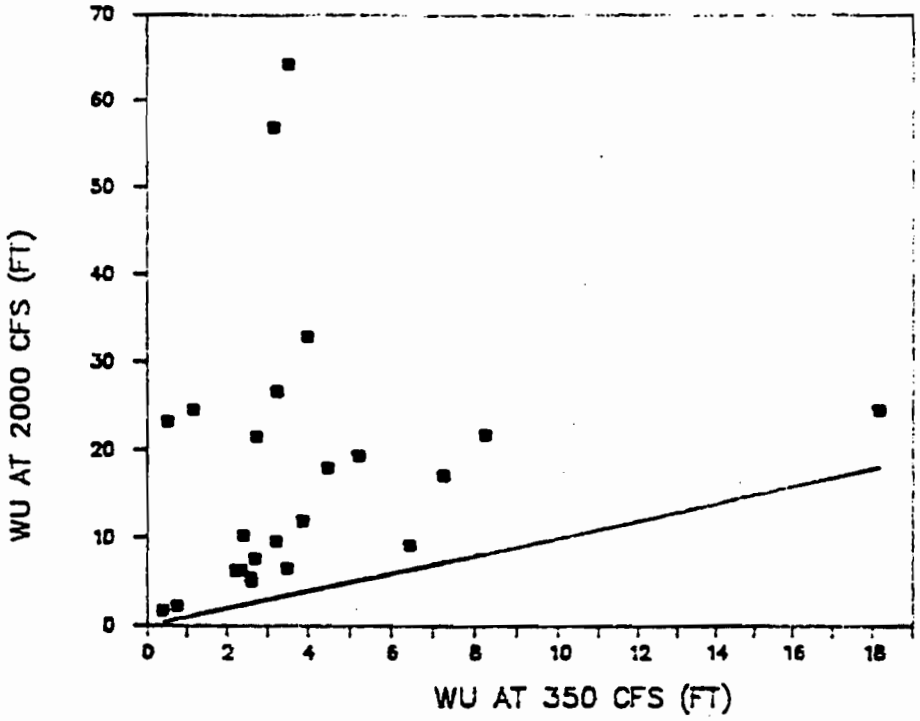


Figure 3. Chinook fry WUA at 350 and 2000 cfs on run transects between Lewiston and Dutch Creek.

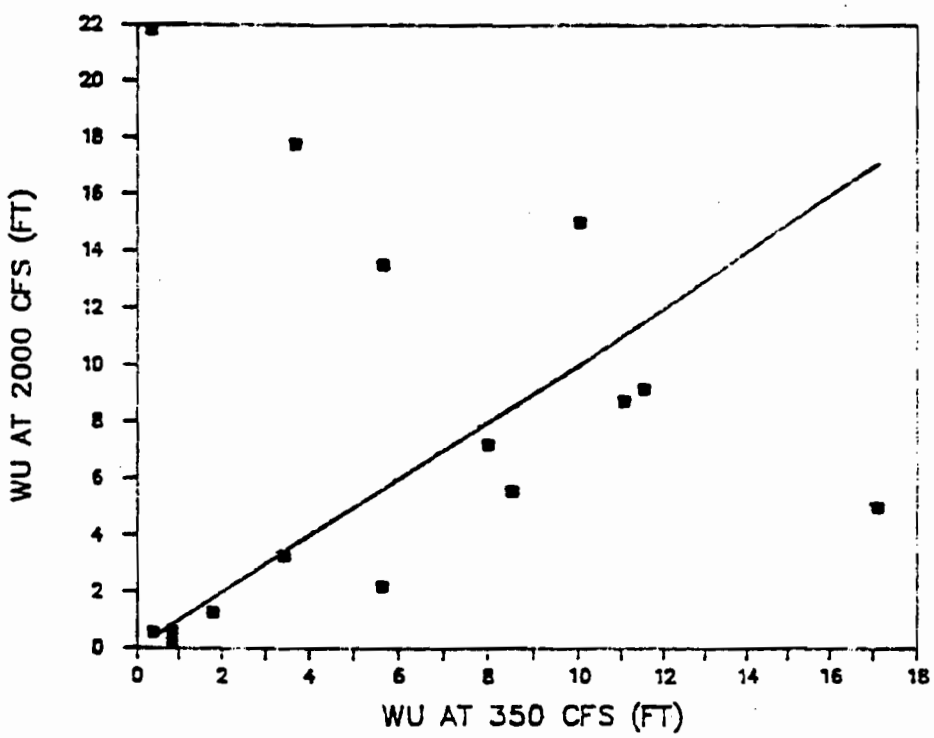


Figure 4. Chinook fry WUA at 350 and 2000 cfs on riffle transects between Lewiston and Dutch Creek.

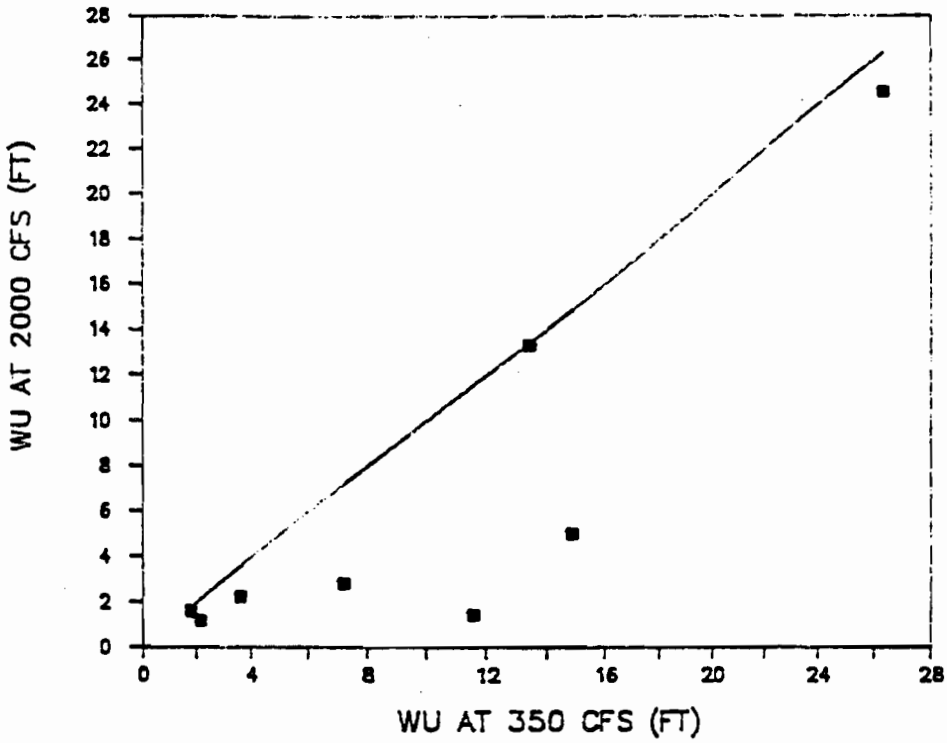


Figure 5. Chinook fry WUA at 350 and 2000 cfs on pool transects between Lewiston and Dutch Creek.

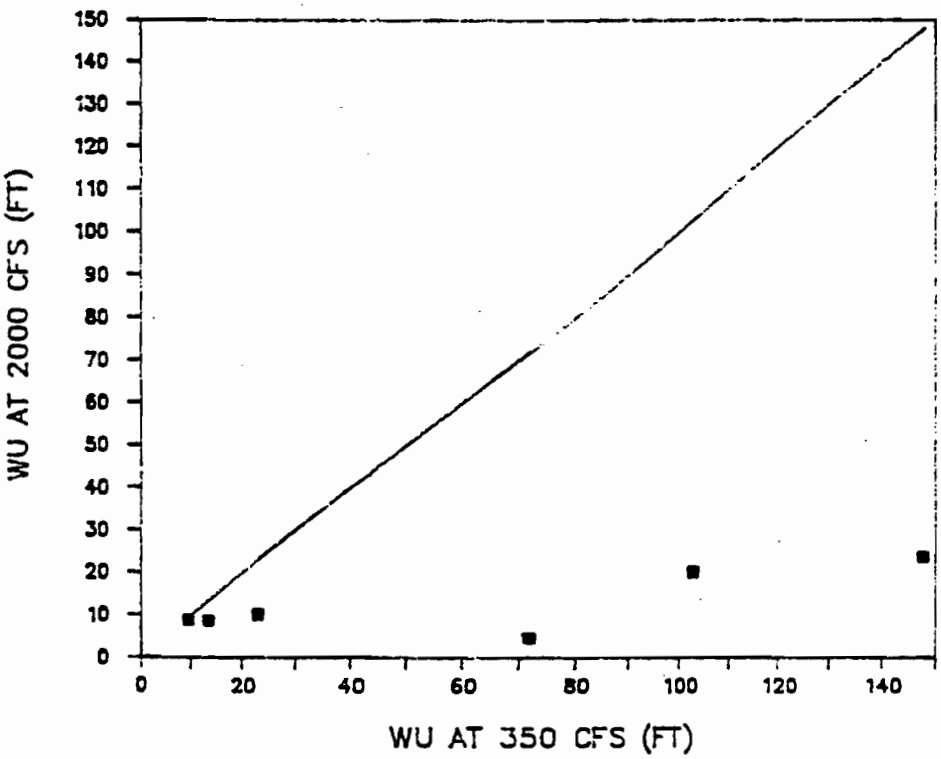


Figure 6. Chinook fry WUA at 350 and 2000 cfs on atypical transects between Lewiston and Dutch Creek.

Characteristcs of Transects Within Habitat Types: For Chinook fry, both methods of determining absolute habitat show a drop in WUA from 350 to around 800 cfs, and an increase between 800 and 2000 cfs. This is the result of development of large areas of low-velocity water where the river overtops the steep banks that are found in run sections or where backwaters form at the tops of riffles.

Figures 3 through 5 show the relationship between chinook fry WUA at 250 and 2000 cfs for individual transects between Lewiston and Dutch Creek that fit the classification of run, riffle, and pool. Figure 6 shows the relationship for atypical transects that are either split by islands with different habitat types in each channel, or are located above Cemetery hole in Lewiston in an area that can be described as marsh or flooded riparian. Each graph includes a line where the ratio is zero, separating transects which show increasing WUA with increasing flow from those showing decreasing WUA.

The run transects all show increasing fry WUA at the highest flow because generally these high discharges overtop the river's channelized banks and create areas of slow water on the pre-project channel. These slow-water areas are wider than the narrow strips that develop at lower flows on the steep, vegetated edges of the low-flow channnel. Typical run transect profiles at Bucktail and Steelbridge are shown in Figures 7 and 8. At Bucktail transect 2 the run evident at 350 and 800 cfs becomes deeper and faster at 2000 cfs, and a slow side-channel develops on the left, providing overall increased rearing habitat at the highest flow. The habitat type that provides the best rearing habitat at high flow does not exist at 350 cfs. At Steelbridge transect 9 two small side-channels develop on the right, and a larger side-channel appears on the left. The feathered bank on the left, one of the few left on the upper river, provides slow-water rearing areas as flow increases.

There is no consistent pattern in riffle transects, because in some cases WUA is reduced as higher water moves uniformly over the steep slopes, and in other cases the riffles form the tops of old side-channels, and extensive back-waters develop at their edges. Figures 9 and 10 show representative riffle transects at Bucktail and Steiner Flat with 350, 800, and 2000 cfs water surface elevations. At Bucktail Transect 9 rearing habitat decreases at higher flows, although an extensive shoal develops on the left. At Steiner Flat Transect 8, a side-channel develops on the left at 2000 cfs, providing extensive rearing habitat that does not exist at 350 or 800 cfs. If either transect were habitat-typed at 350 or 800 cfs, they would clearly be typed as riffles. At 2000 cfs they could be called runs, although the habitat type of biological significance at Steiner Flat Transect 8 is the side-channel.

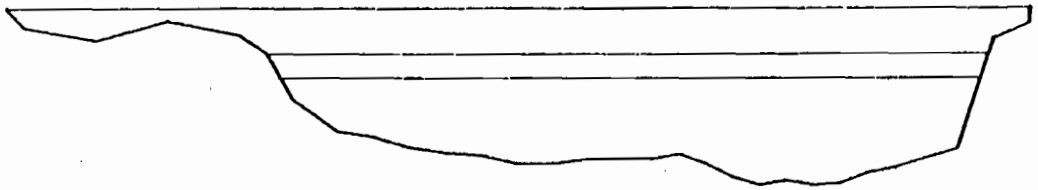


Figure 7. Bucktail transect 2 with 2000, 800, and 350 cfs water surface elevations. Vertical scale multiplied by three.

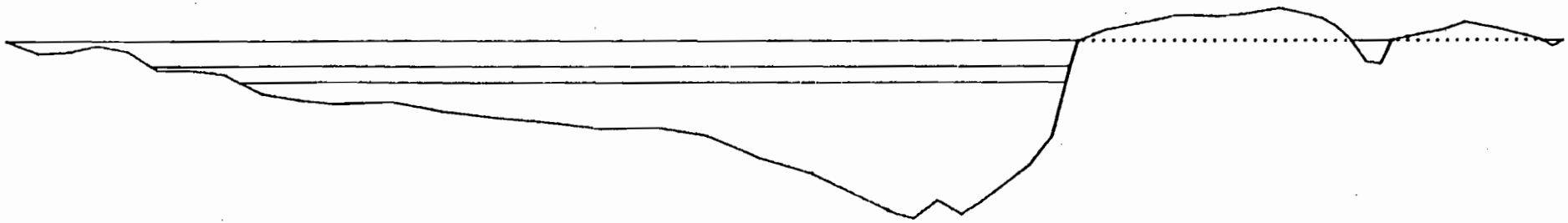


Figure 8. Steelbridge transect 9 with 2000, 800, and 350 cfs water surface elevations. Vertical scale multiplied by three.

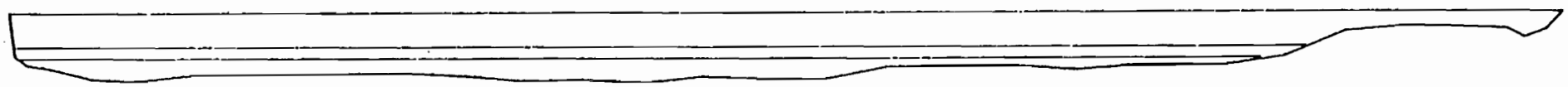


Figure 9. Steiner Flat transect 8 profile with 2000, 800, and 350 cfs warer surface elevations. Vertical scale multiplied by three.

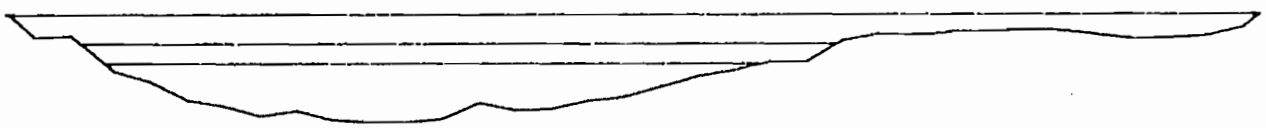


Figure 10. Bucktail transect 9 profile with 2000, 800, and 350 cfs water surface elevations. Vertical scale multiplied by three.

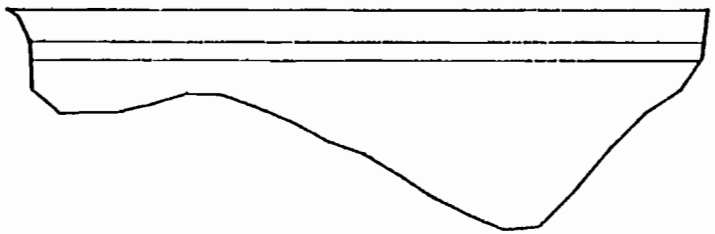


Figure 11. Bucktail transect 7 with 2000, 800, and 350 cfs water surface elevations. Vertical scale multiplied by three.

Figure 12. Steiner Flat transect 4 with 2000, 800, and 350 cfs water surface elevations. Vertical scale multiplied by three.

The pool transects all show decreasing fry WUA at higher flows, because slightly higher velocities are capable of moving the large volumes of water through existing pool channels, and there is no overtopping of the banks. Figures 11 and 12 show profiles of pool transects at Bucktail and Steiner Flat with 250, 800, and 2000 cfs water levels. Little new channel area opens up within this range of flows, and the pools become deeper and faster. If the difference between pools and runs is defined by velocity, then these 350 cfs pools would be typed as runs at higher flows.

DISCUSSION

Habitat typing can improve site representativeness to the degree that the habitat types mapped stay constant over the full range of flows and are relevant to fish behavior. For example, fine delineations of habitat type may wash out at high flows when fish are present but map technicians are not; or a habitat type that appears morphologically dominant to biologists standing on the bank may mean little to a fish that stays within a small area of slow water near the stream's edge.

On much of the Trinity River above the North Fork, the major habitat type could be described as "run", so long as flow is no more than about 800 cfs. At a flow of 2000 cfs, these runs become complex combinations of backwaters, bars, shelving riffles, flooded riparian vegetation, and slow edge waters. Side-channels develop, each with its own assortment of habitat types. As flows drop from 800 to 300 cfs, runs tend to become riffles and pocket water, and glides become runs. Fish do not respond to these type names, but rather to microhabitat conditions such as velocity and depth. When considering habitat typing, it must be kept in mind that habitat changes with changes in flow, while mapped type names stay the same. To gain much advantage from habitat typing, we would have to assign types over the range of flows we examine, and develop a patchwork of habitat types changing with flow, especially in the river below Dutch Creek.

However, these data suggest that for describing critical slow-water habitat in the Trinity River, the PHABSIM transect extrapolation procedures provide a robust modeling technique. Most of the river has been molded into a run by project flows, and run transects show a consistent pattern; results from any set of transects, which would necessarily be placed preominantly in run areas, would present a picture similar to the one presented here.

APPENDIX G

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION

1990

U.S. Fish and Wildlife Service
Fish and Wildlife Enhancement
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825

Prepared by
the Staff of

The Trinity River Flow Evaluation
P.O. Box 630
Lewiston, California 96052

II. HABITAT AVAILABILITY AND NEEDS

1990 MAIN-STEM HABITAT MEASUREMENTS

In 1990 we planned to measure habitat provided by a Lewiston release of 3000 cfs. Relatively dry conditions, however, led to the adoption of a critical dry-year flow regime, with 120,000 acre-feet available and flows dropped to 150 cfs in early June. Late spring rains allowed reversion to a dry-year regime, but the increase was not enough to provide a 3,000 cfs study flow.

To accommodate the critical dry-year water availability, Lewiston releases were dropped to 150 cfs by June 7 and remained at this level until June 15, by which time it had been determined that inflow to Shasta Lake were adequate for a dry-year schedule. We took advantage of the low flows to measure microhabitat provided by 150 cfs at five sites in the upper river, to be used as a check on low-flow habitat estimates provided by the PHABSIM model.

Methods

We re-established transects used since 1985 at our study sites at Cemetery, Bucktail, Poker Bar, Steelbridge, and Steiner Flat, and carried out microhabitat measurements following US Fish and Wildlife Service Instream Flow Group procedures (USFWS 1986). Data were collected on depths, water velocity, substrate characteristics, and cover at least twenty points on each transect.

To determine weighted usable area (WUA), we calculated the suitable area available by applying Trinity River preference criteria (Hampton 1988, appendix E) to the actual depths and velocities measured, rather than using a hydraulic simulation.

To determine the total habitat availability between Lewiston and Douglas City, WUA estimated at each transect was multiplied by the distance of the river most closely represented by the transect, as described in Section II.2 of our 1989 annual report. A similar procedure was used to estimate representative habitat within the Steiner Flat site.

The habitat relationships presented below include similar direct calculation of available habitat at Lewiston releases of 350, 450, 800, and 2000 cfs, as described in our 1989 report.

Results

Figures 1 through 4 show WUA estimates based on our five measured flows between Lewiston and Douglas City. Figures 5 and 6 show estimates at the Steiner Flat site, which is representative of the additional eight miles of river to Dutch Creek. Figures 1 through four are equivalent to those presented in our 1989 report, with the addition of direct data for the 150 cfs flow.

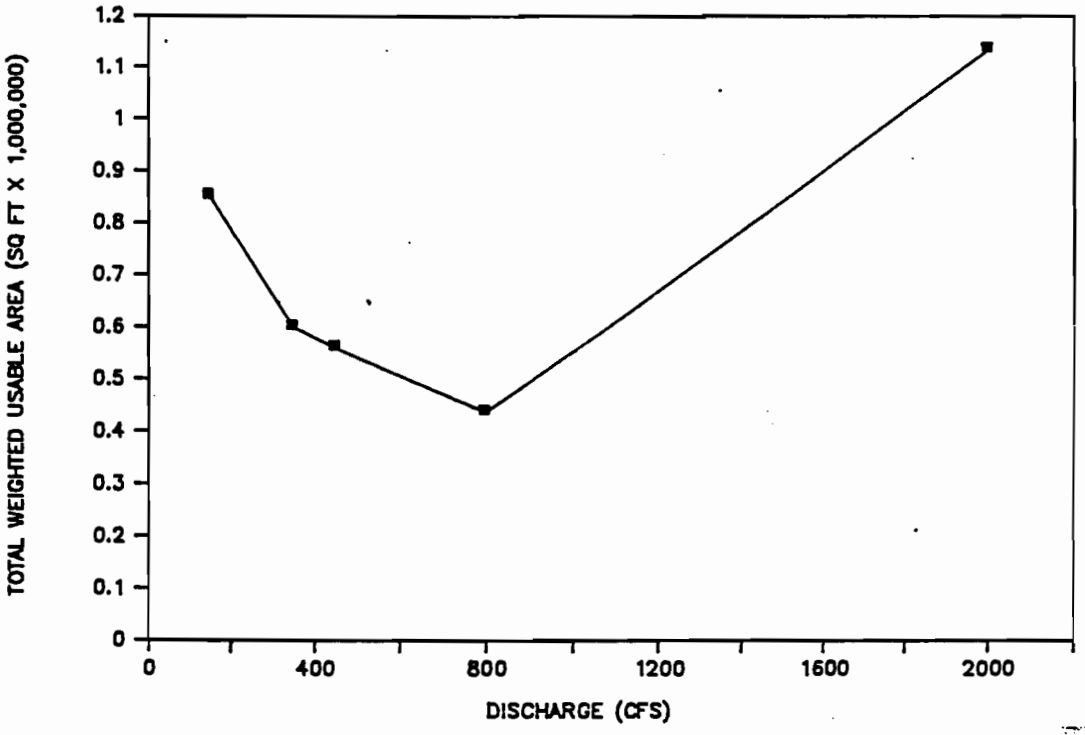


Figure 1. Weighted usable area for chinook fry as a function of discharge between Lewiston and Douglas City in the Trinity River.

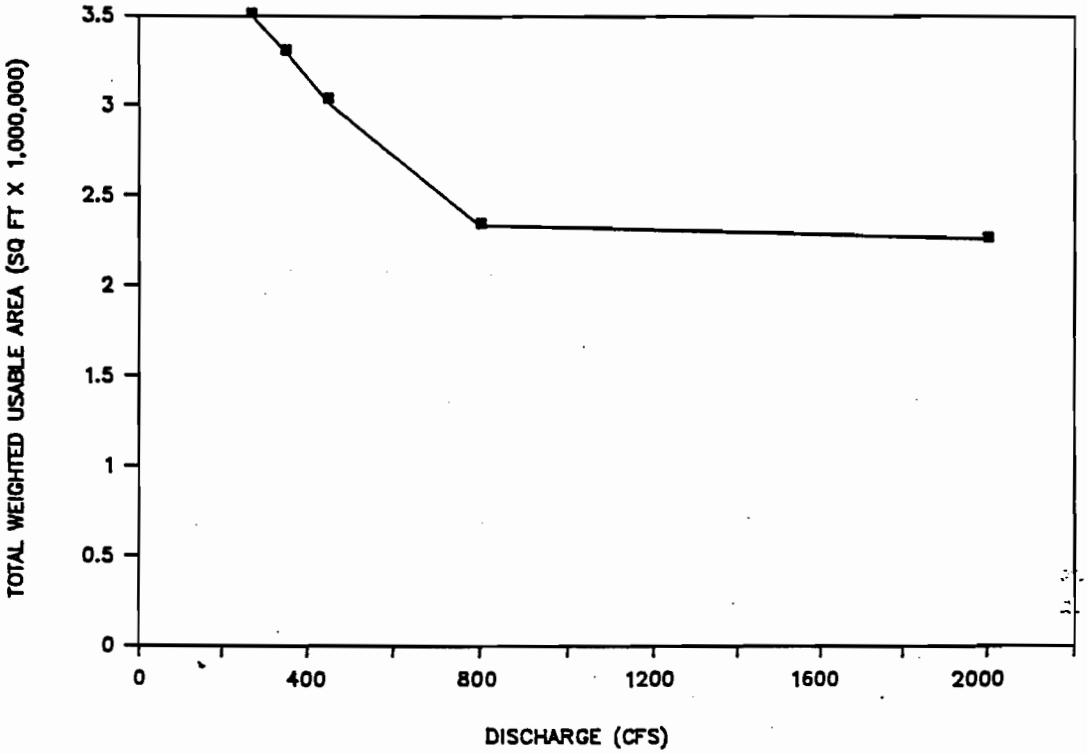


Figure 2. Weighted usable area for chinook juveniles as a function of discharge between Lewiston and Douglas City in the Trinity River.

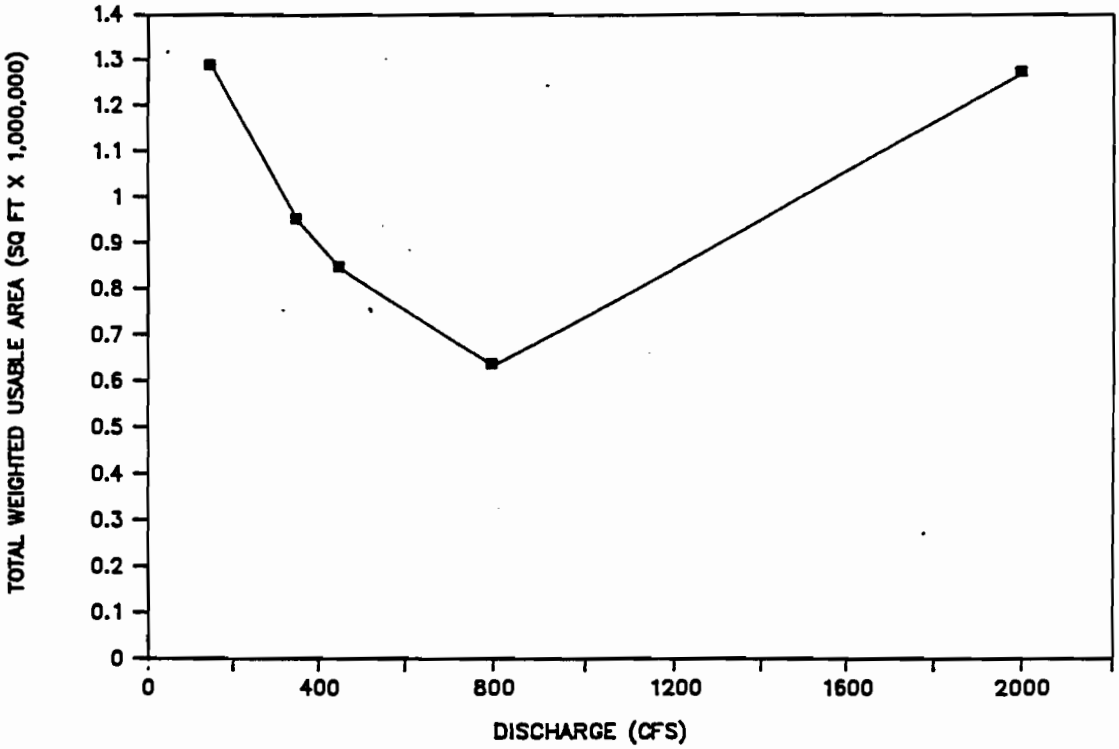


Figure 3. Weighted usable area for steelhead fry as a function of discharge between Lewiston and Douglas City in the Trinity River.

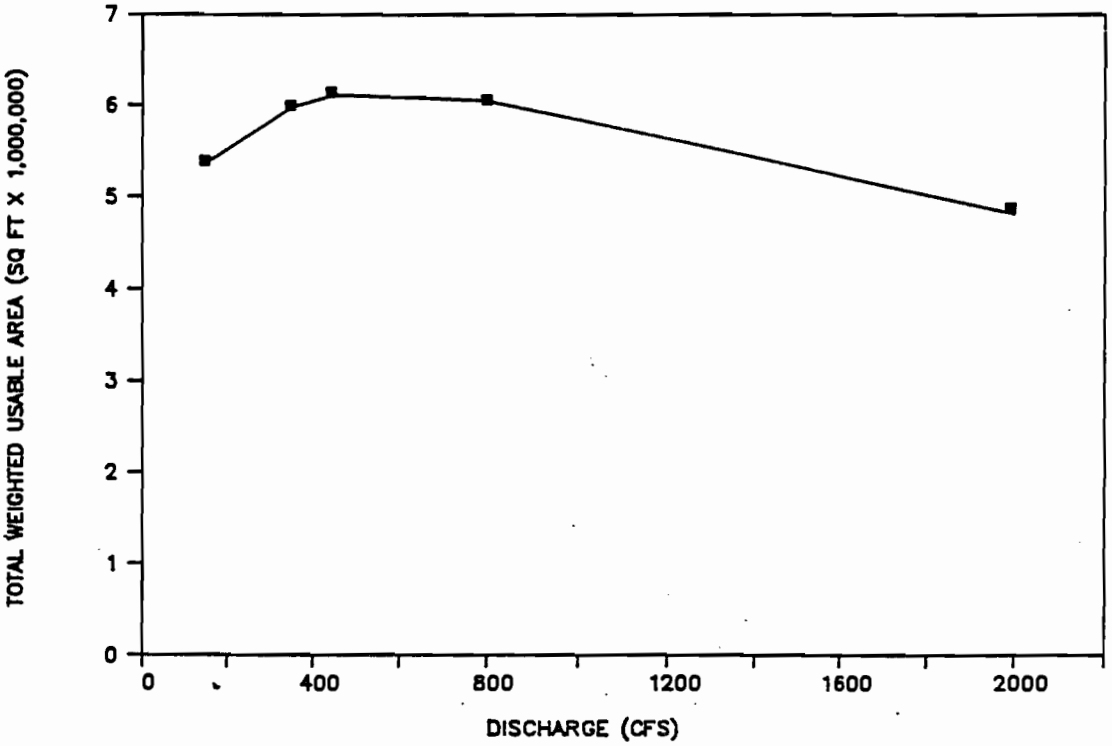


Figure 4. Weighted usable area for steelhead juveniles as a function of discharge between Lewiston and Douglas City on the Trinity River.

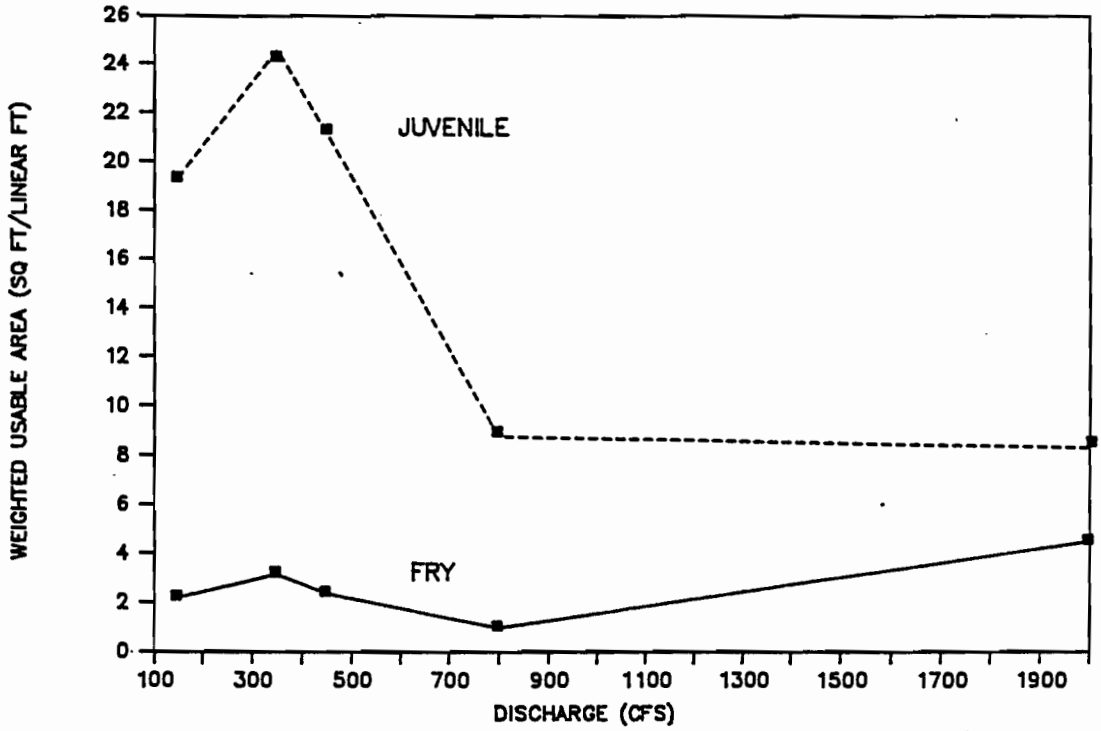


Figure 5. Weighted usable area for chinook fry and juveniles as a function of discharge in the Steiner Flat reach of the Trinity River.

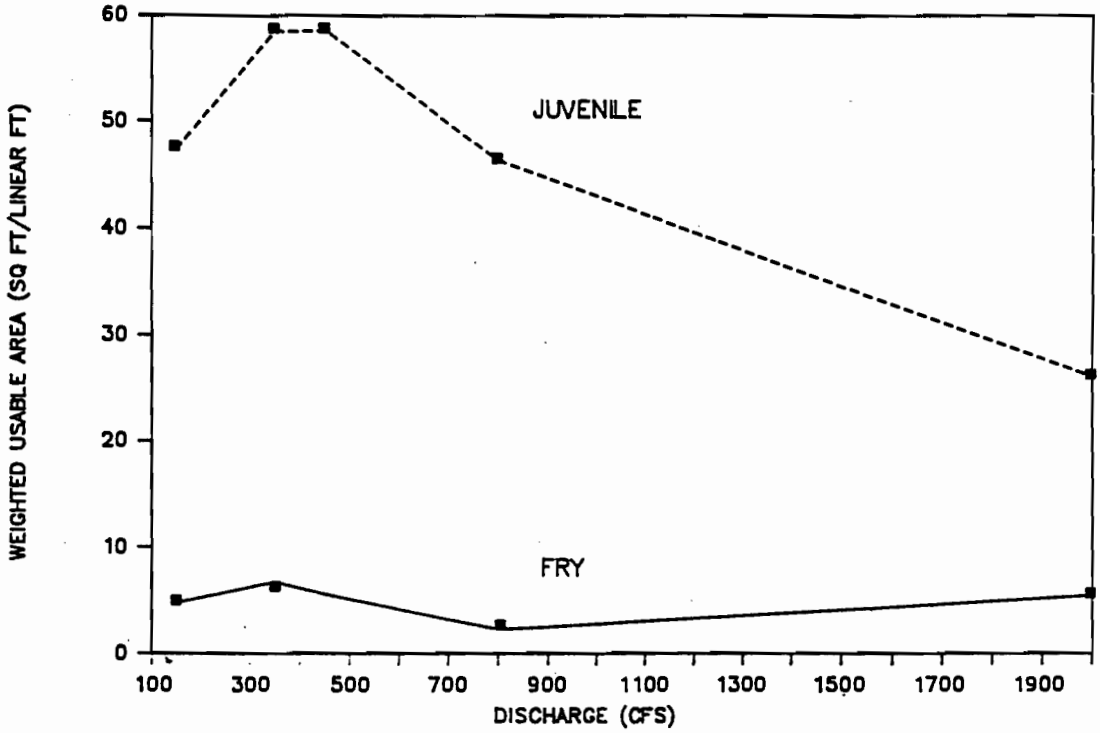


Figure 6. Weighted usable area for steelhead fry and juveniles as a function of discharge in the Steiner Flat reach of the Trinity River.

The addition of 150 cfs measurements for the four upper-river sites accentuates the bi-modal pattern for fry life-stages, with available slow-water WUA increasing with decreasing flows. The patterns for juvenile life-stages also extend in a consistent pattern, juvenile chinook WUA continuing to increase with decreasing flows and juvenile steelhead WUA continuing to decrease with decreasing flows.

At the Steiner Flat site WUA for all life-stages decreases between the measured 350 and 150 cfs flows.

Discussion

The measurement at low flow in the upper river provided no surprises, since the PHABSIM hydraulic programs gave similar results when measured conditions were projected downward.

The major difference between measured WUA and low-flow WUA that we have estimated by hydraulic modeling is that generally the direct measurements show more WUA than is estimated by modeling. This is probably because most of the best fish habitat is in slower water at the edges of the river. The IFG-4 hydraulic model seems to tend to overestimate lower-flow edge velocities unless adjustments are made to account for shifting the high-friction area at the river's edge.

The decrease in WUA for all life-stages at Steiner Flat seems to be the result of a substantial decrease in surface area at gently-sloping backwater margins, coupled with insubstantial increases in slow water with reduced flow through much of this relatively steep and predominantly narrow reach.

WINTER STEELHEAD HABITAT AVAILABILITY

During field-work in the winter of 1985-86, we noted that once the water temperature dropped below about 48 degrees Fahrenheit steelhead juveniles retreat to spaces between cobbles on the river-bottom, and are not seen swimming in the day-time. Subsequent winter electrofishing revealed dense populations of steelhead in side-channels and mainstem areas where the substrate was composed of clean cobbles with little sand. Since these conditions are extremely rare in the Trinity River, we concluded that availability of winter habitat may be an important factor limiting steelhead production.

In 1986 and 1987 we conducted studies of habitat for over-wintering salmonids, and in our 1988 annual report we presented winter habitat use curves for steelhead and brown trout, and coho salmon. For steelhead, by far the most important criterion for habitat utilization is the presence of cobbles from six to twelve inches in diameter free of sand or silt.

This report section presents results of applying the steelhead winter use curves to upper-river conditions.

Methods

To analyze the available habitat provided by the upper Trinity for over-wintering steelhead, we used the microhabitat data collected from 1985 to 1990 in our IFIM studies (Section II.1). Weighted usable area (WUA) was calculated at our five upper-river sites: Cemetery, Bucktail, Poker Bar, Steelbridge, and Steiner Flat.

In addition to calculating steelhead winter WUA based on existing conditions, including depth, velocity, and substrate, we calculated it based on depth, velocity, and substrate without the embeddedness component. To achieve this we simply prepared a utilization curve with the effects of embeddedness removed. This gives an estimate of habitat gains that would be realized if the decomposed granite sand that has accumulated in cobble substrates were removed.

Results

Figure 1 shows the winter WUA at 350 cfs at our five upper sites for existing conditions and with sand removed. It also shows existing WUA for free-swimming juvenile chinook.

A comparison between existing overwinter habitat and potential increases with clean substrate shows that winter WUA would increase in the Cemetery reach by about 750 percent, Bucktail by 820 percent, Poker Bar and Steelbridge by about 2000 percent each, and Steiner Flat by about 300 percent.

Figure 2 shows the same WUA normalized by rough estimates of the densities of steelhead that each type of habitat might support. Existing and potential winter WUA is multiplied by 0.1124 fish/ft^2 (1.21/m^2), based on densities at clean-cobble sites we studied in 1987 (USFWS 1988, page 36). Available rearing WUA is multiplied by 0.0357 fish/ft^2, based on a radius of three feet,

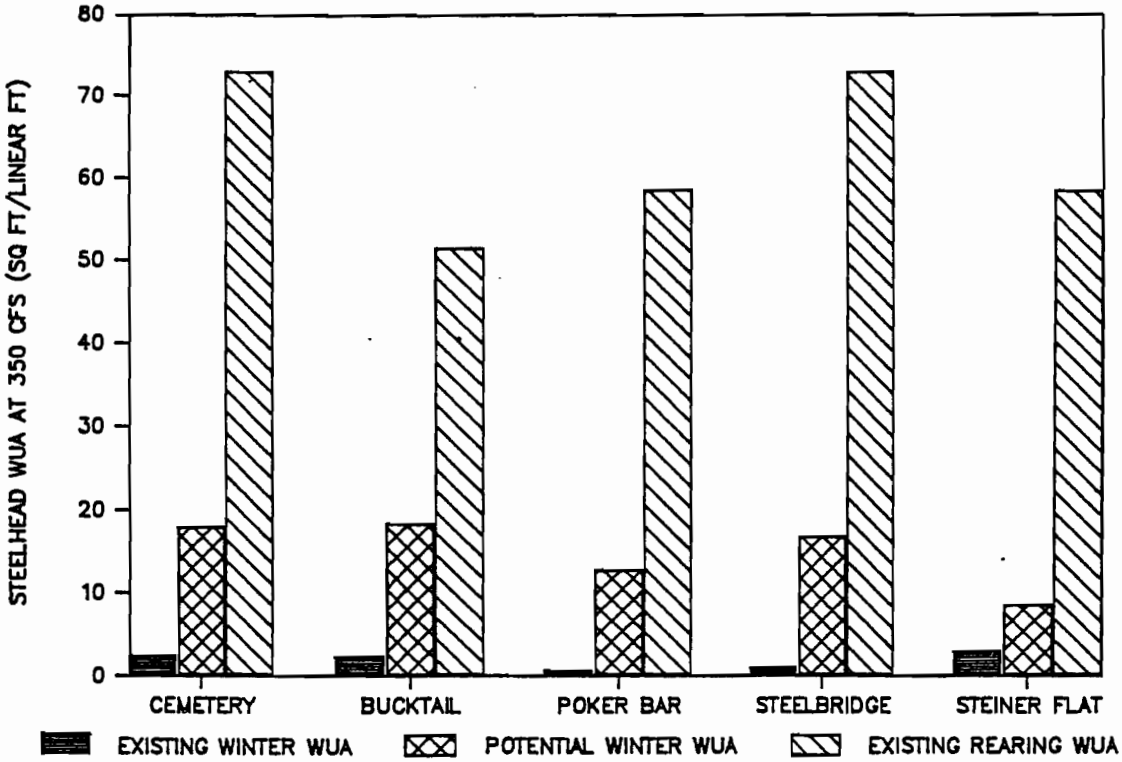


Figure 1. Weighted usable area for existing steelhead overwintering habitat, overwintering habitat with all sand removed, and existing spring–through–fall steelhead rearing habitat at five study sites in the Trinity River, 1990.

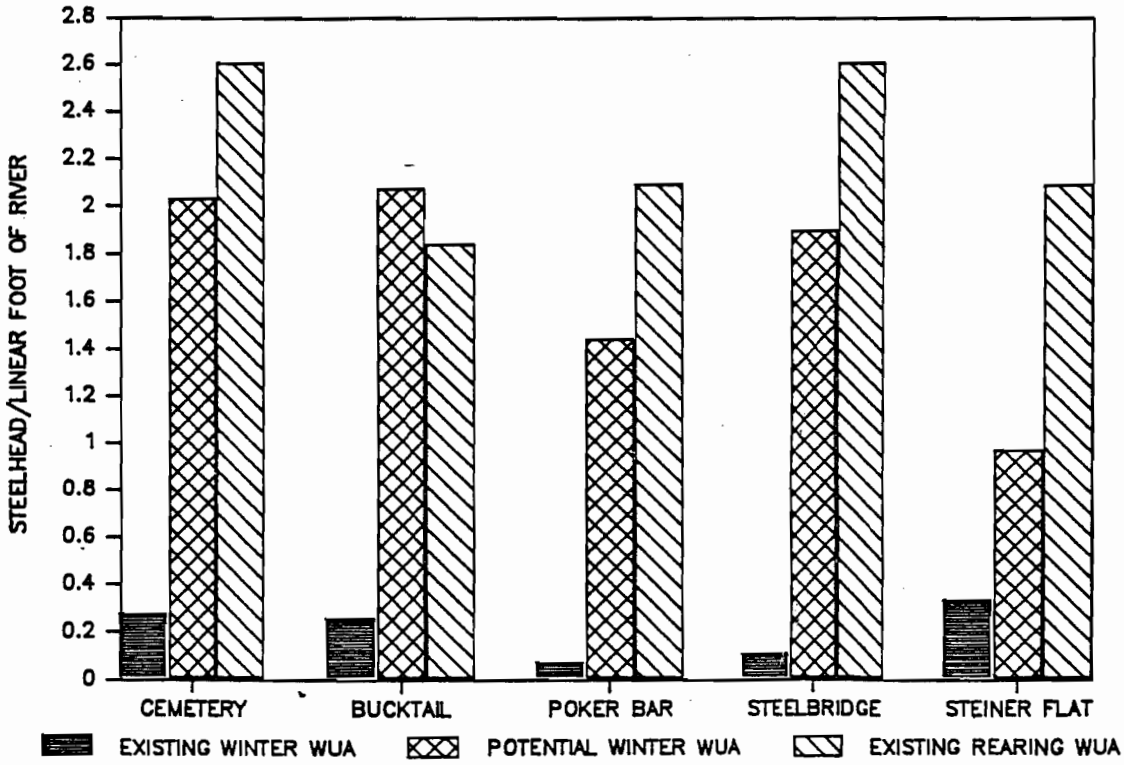


Figure 2. Estimated juvenile steelhead per linear foot of river permitted by existing and potential winter habitat and by existing rearing habitat. Based on 0.1124 fish/sq. ft. of winter WUA and 0.0357 fish/sq. ft. of rearing WUA.

equivalent to the maximum distance traveled by most fish from feeding stations during our adjacent-velocity habitat studies (USWFS 1989, page 75).

If the estimated densities are roughly correct, the presence of interstitial sand in upper-river cobble substrates is clearly limiting overall habitat for juvenile steelhead. The numbers of juveniles that could be accommodated by existing spring-through-fall conditions cannot be supported over the winter.

Discussion

In the past, in-river projects for sand removal have generally been justified on the basis of improved spawning conditions and provision of resting pools for adult fish, though neither habitat type appears to be in critically short supply. Evaluation of winter habitat availability, however, indicates that the major direct benefit of sand reduction would be in improving steelhead winter survival.

Although pool dredging will have a secondary effect by removing stored sand that could later cover down-river cobbles, a more immediate improvement in the fishery would be realized by directly cleaning sand from cobbles, perhaps by suction dredging appropriate substrates and returning cleaned rocks to the river.

As recommended in Sections II.3 and II.4 of this report, dredged cobbles should be replaced after any pool-dredging operation, and clean cobbles should be placed or replaced in any constructed side-channel.

Provision of high flows to scour substrates and remove sand may be the most effective means of improving steelhead winter habitat. We are currently funding a cooperative agreement with the University of California and the Johns Hopkins University to determine the sand-transport effects of higher Lewiston releases in the upper river. An element of this study, which is scheduled for completion in 1993, is an analysis of the extent to which higher flows are capable of removing sand from cobble substrates.

APPENDIX H

ANNUAL REPORT

TRINITY RIVER FLOW EVALUATION

1991

U.S. Fish and Wildlife Service
Fish and Wildlife Enhancement
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, California 95825

Prepared by
the Staff of

The Trinity River Flow Evaluation
P.O. Box 630
Lewiston, California 96052

II. HABITAT AVAILABILITY AND NEEDS

ACTIVITIES IN THE MAINSTEM

In the winter of 1990-91 precipitation in the upper Trinity River watershed was minimal, and the availability of water for fishery releases was questionable until early in the spring. By late May, 1991, it was determined that approximately 290,000 acre-feet would be available under then-existing fishery flow provisions. Most of this water volume over that necessary for a base fishery flow was used for a 3,000 cfs release from May 28 through June 3. This high flow was expected to help maintain mainstem salmonid habitat by mobilizing gravel and increasing transport of accumulated sediments through the system. In addition, the high flow was timed to coincide with downstream migration of naturally-rearing chinook salmon, and with the release and emigration of chinook fingerlings from the Trinity River Hatchery.

Sand Transport Study

During the 3,000 cfs release, first-year field studies for our three-year investigation of sand transport mechanics below Grass Valley Creek were carried out. This study is a cooperative investigation between the Trinity River Flow Evaluation, the Johns Hopkins University, and the University of California, intended to combine recent research in sand-transport mechanics with high-flow field measurements to develop an estimate of habitat improvement provided by a range of feasible Lewiston flushing-flow releases.

Sand-transport study field work in 1991 included the installation of scour chains and marked-substrate MacNeil samples, codification of pre- and post-flow substrate materials, pre- and post-flow mapping of pools and profiling of river transects, and intensive measurement of three-dimensional flow patterns and bed-load movement during peak releases. Similar work is to be undertaken in 1992 and 1993, with results to be presented at the end of 1993.

Salmonid Habitat Studies

Since 3,000 cfs at Lewiston is representative of pre-project spring flow conditions, it is necessary to directly measure habitat at all up-river Instream Flow Incremental Methodology study sites before the termination of the Flow Evaluation. The short duration of the 1991 releases did not permit this, but evaluation of potential field methods was carried out. Results show that although habitat measurement at 3000 cfs is difficult, full evaluation will be possible during a high release lasting at least fifteen working days. Such a flow is consistent with use of fishery water for optimization of salmonid habitat and life-history requirements, and we expect to pattern 1993 spring releases to permit the required field investigations.

As flows dropped following the 3,000 cfs release, we surveyed the river from Lewiston to the North Fork for stranding of juvenile salmonids. No significant stranding was observed.

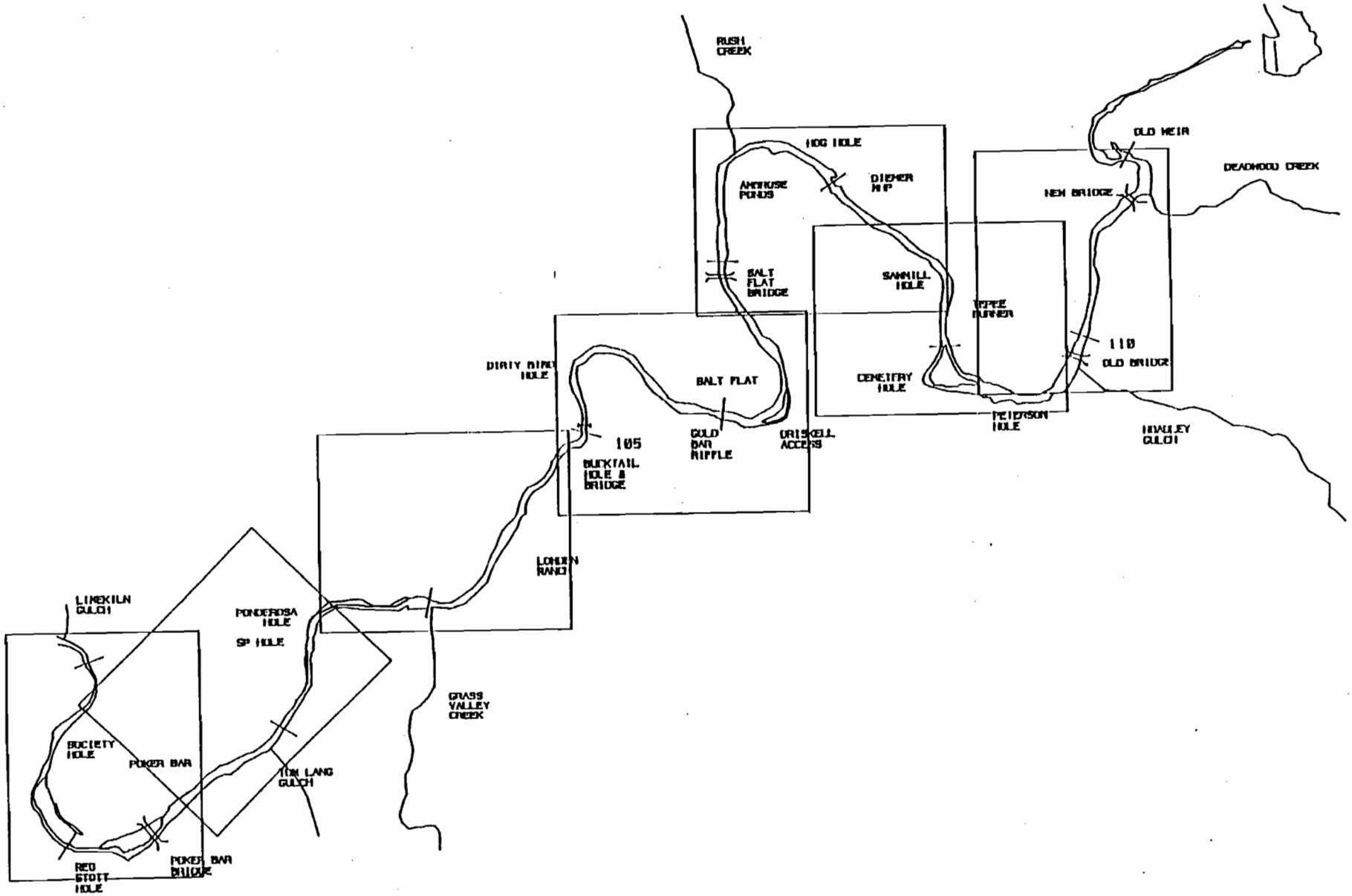
National Ecology Research Center Model

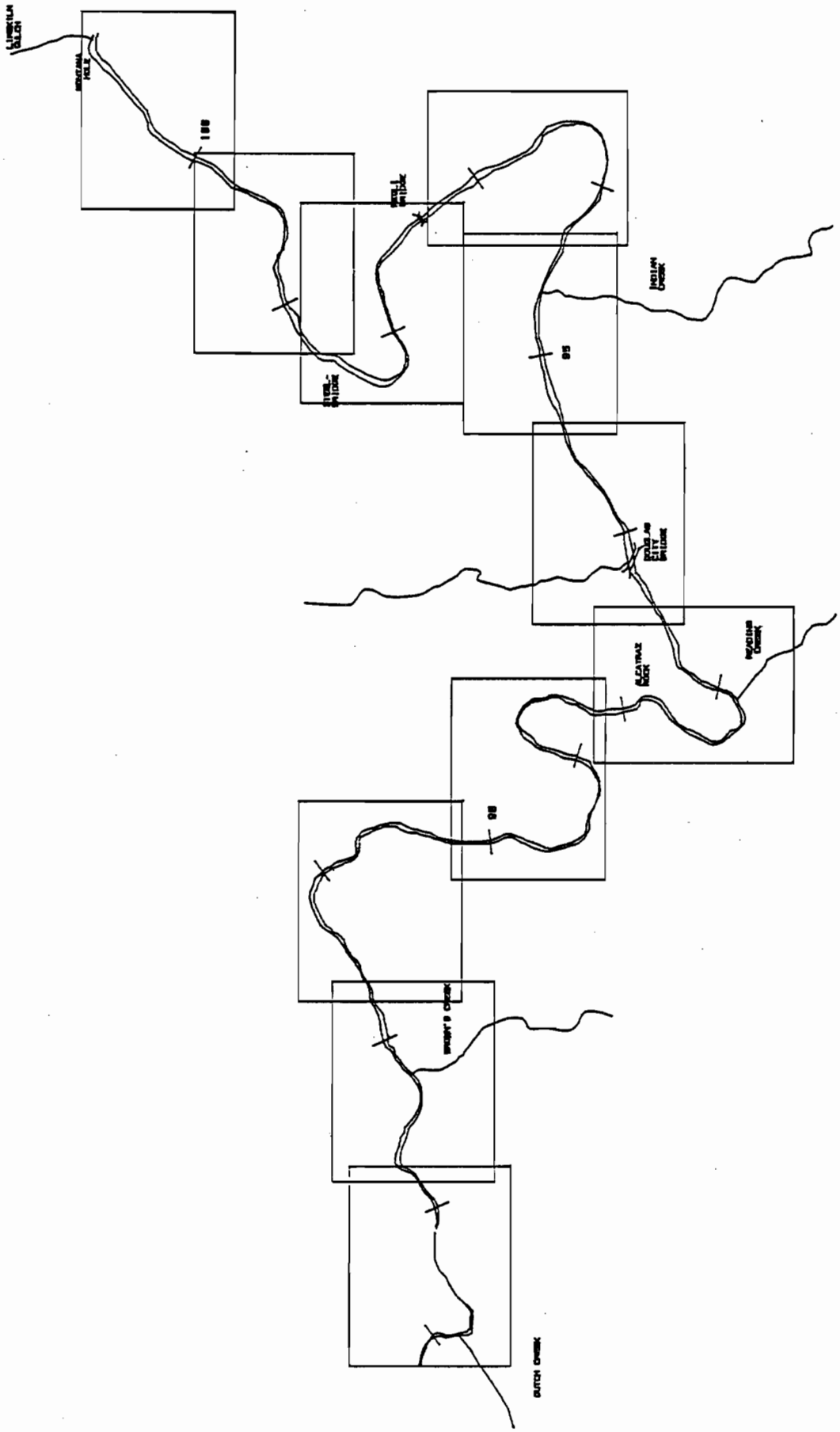
A developing adjunct to the Trinity River Flow Evaluation is the US Fish and Wildlife Service National Ecology Research Center (NERC) fish population model for the Trinity River. This model, an attempt to relate PHABSIM Weighted Usable Area (WUA) estimates with fish population responses, is under development based on field data from the Trinity River and the Gunnison River in Colorado. In 1991 we worked closely with NERC personnel, providing direct mainstem WUA measurements at a variety of flows, codifying and presenting habitat-

mapping data developed for mainstem habitat estimates, and coordinating efforts to relate population model results with Trinity River population observations. These efforts will continue through the remainder of the Flow Evaluation.

APPENDIX I

Habitat Mapping
Lewiston Dam to Dutch Creek


RUSH CREEK
HOG HOLE
AMERUSE PONDS
DIEMER MP
SALT FLAT BRIDGE
SAWMILL HOLE
TIPPE RUNNER
CEMETERY HOLE
PETERSON HOLE
OLD WEIR
NEW BRIDGE
DEADWOOD CREEK
110
OLD BRIDGE
HAWLEY GULCH
DIRTY DIRK HOLE
BALT FLAT
105
BUCKTAIL HOLE & BRIDGE
GOLD BAR RIFFLE
GRISSELL ACCESS
LOHMAN RANCH
LIMEKILN GULCH
PONDEROSA HOLE
SP HOLE
GRASS VALLEY CREEK
SOCIETY HOLE
POKER BAR
TEN LANG GULCH
RED STOTT HOLE
POKER BAR BRIDGE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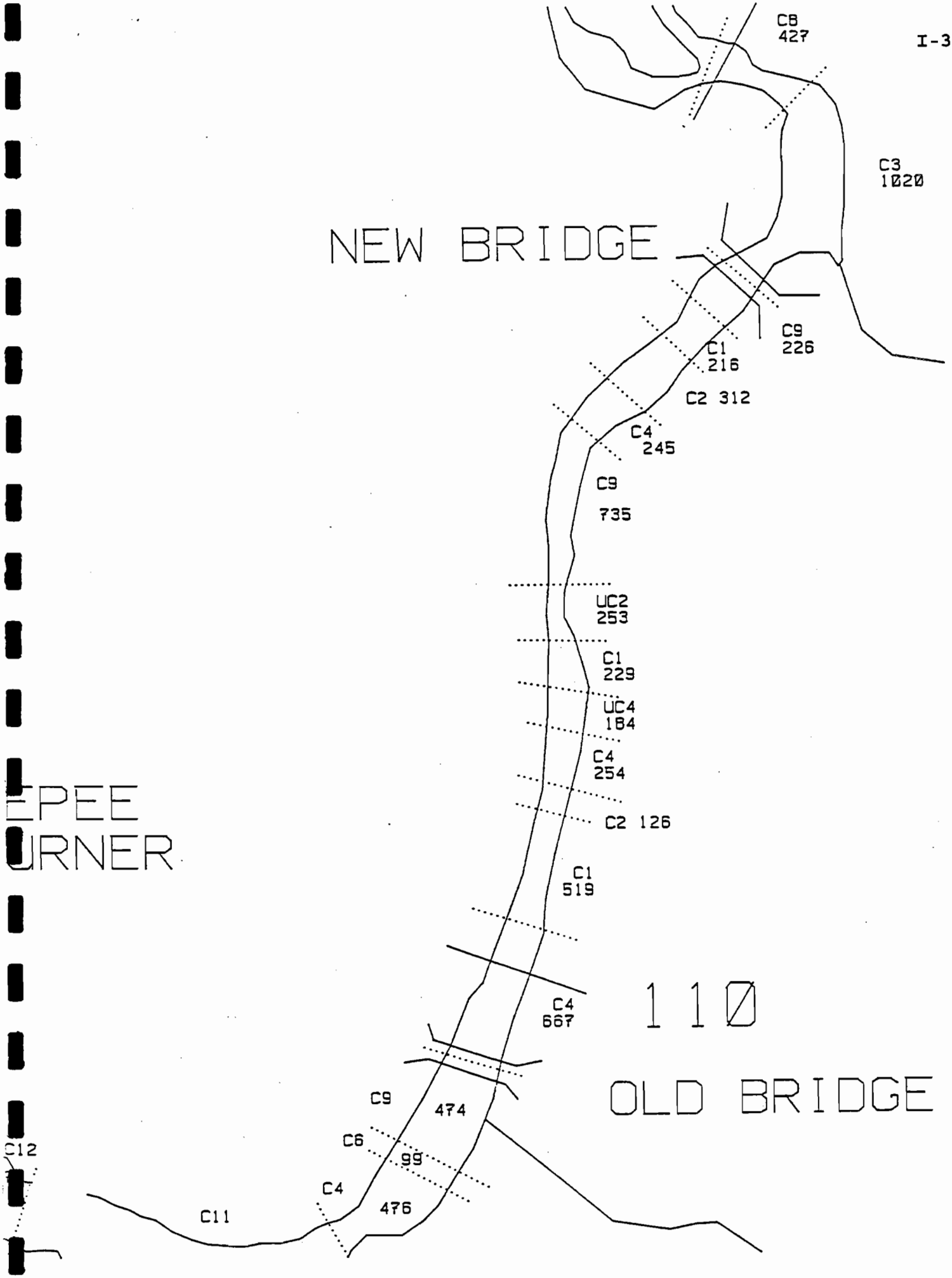
WHISKY CREEK
DUTCH CREEK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C2 312
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C1
229
UC4
184
C4
254
C2 126
EPEE
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OLD BRIDGE
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C6
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C12
C4
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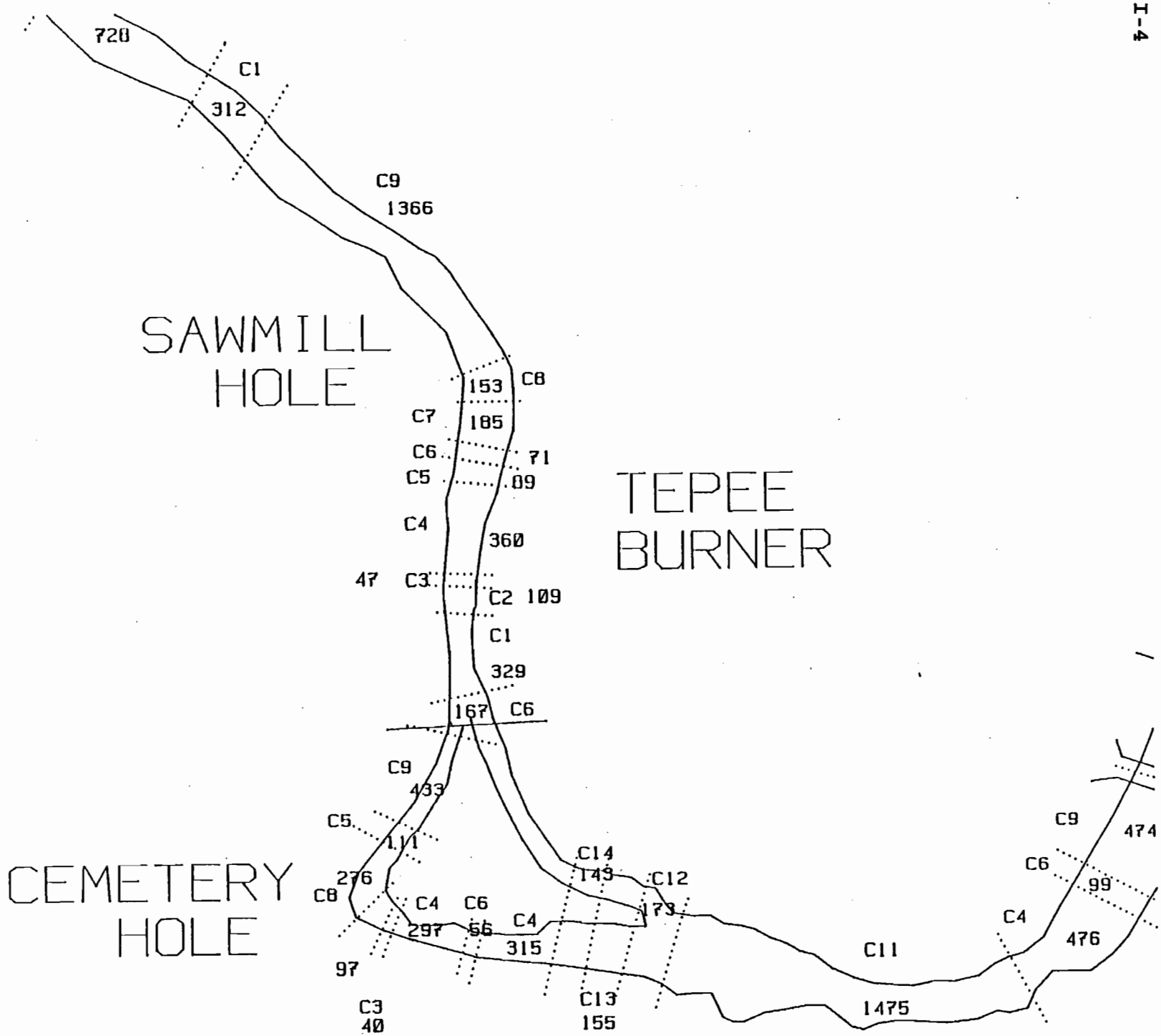
C11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47
C3
C2
109
C1
329
167
C6
TEPEE
BURNER
C9
433
C5
111
CEMETERY
HOLE
276
C8
C4
C6
297
66
C4
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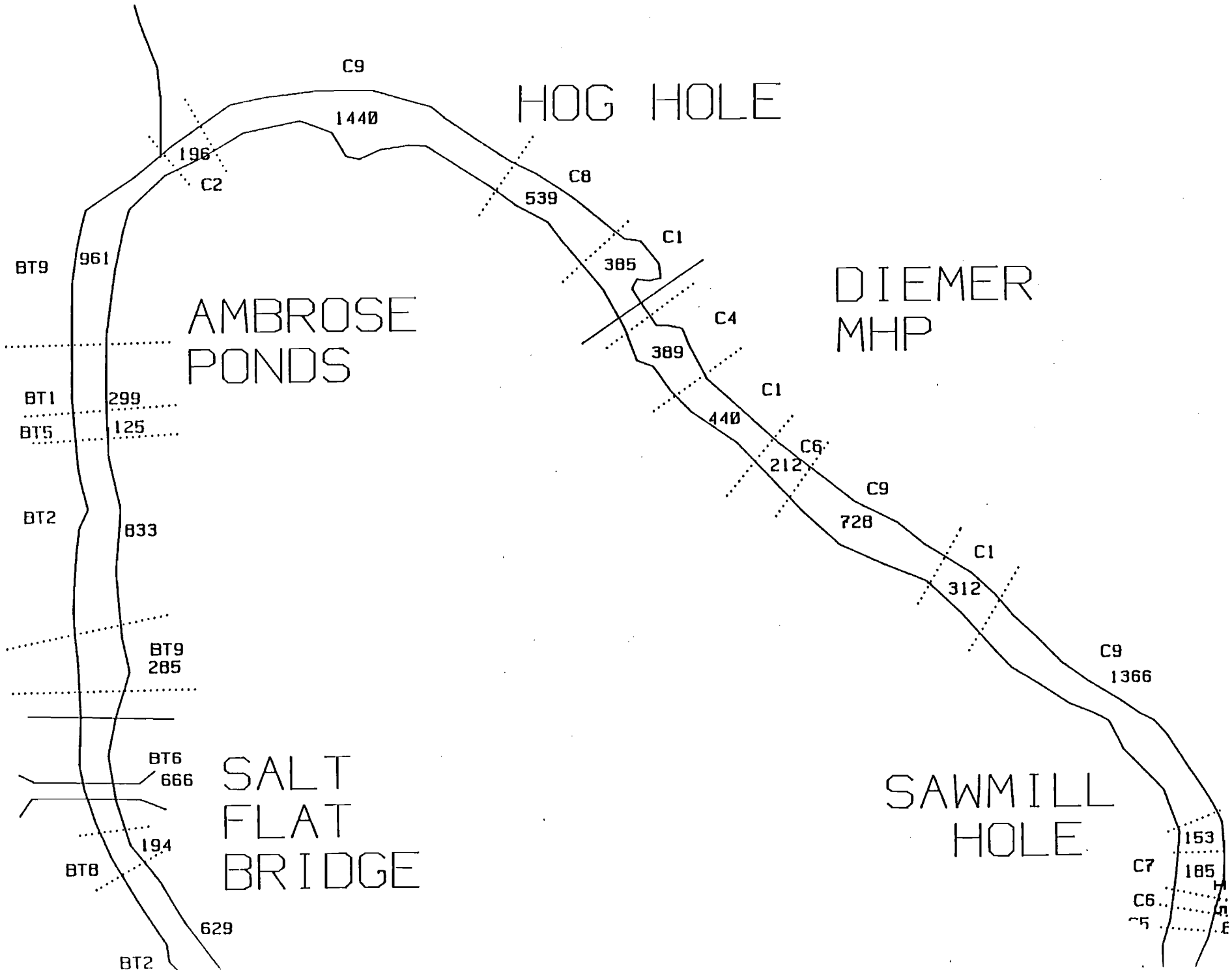
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385
C4
389
C1
440
C6
212
C9
728
C1
312
C9
1366
153
185
C7
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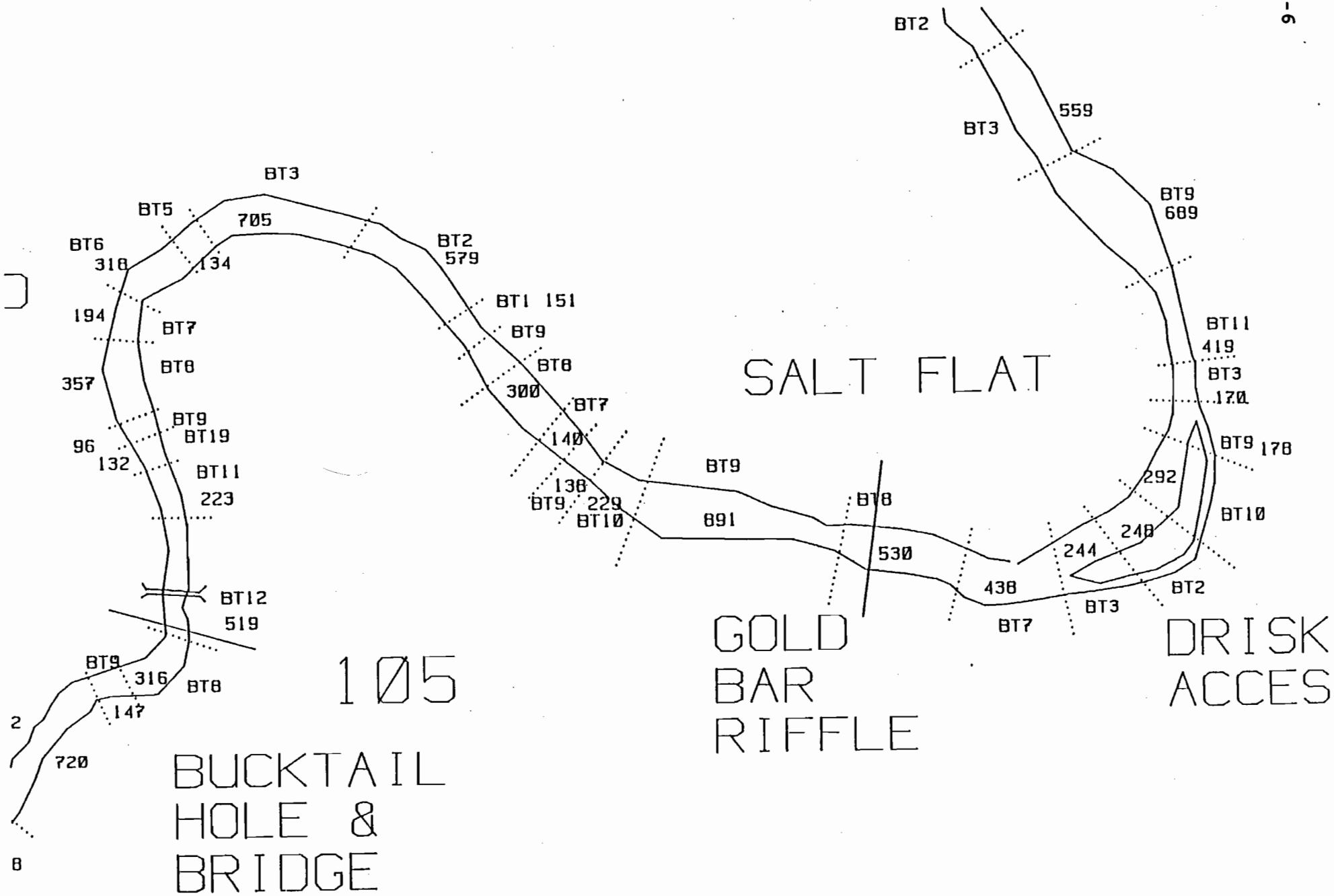
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BT8
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720
8
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BUCKTAIL
HOLE &
BRIDGE
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BT1 151
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BT8
300
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BT9
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RIFFLE
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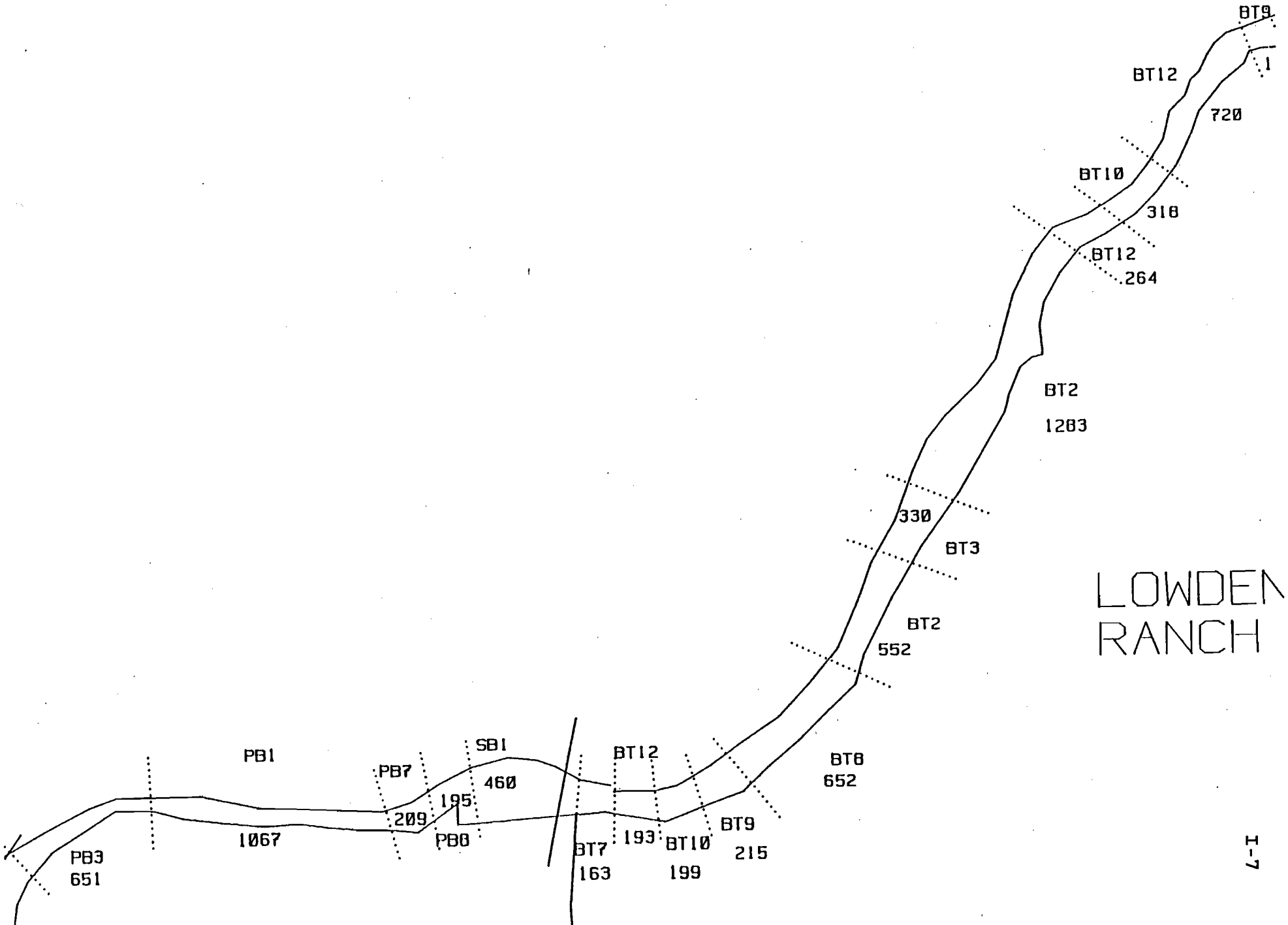
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PB1
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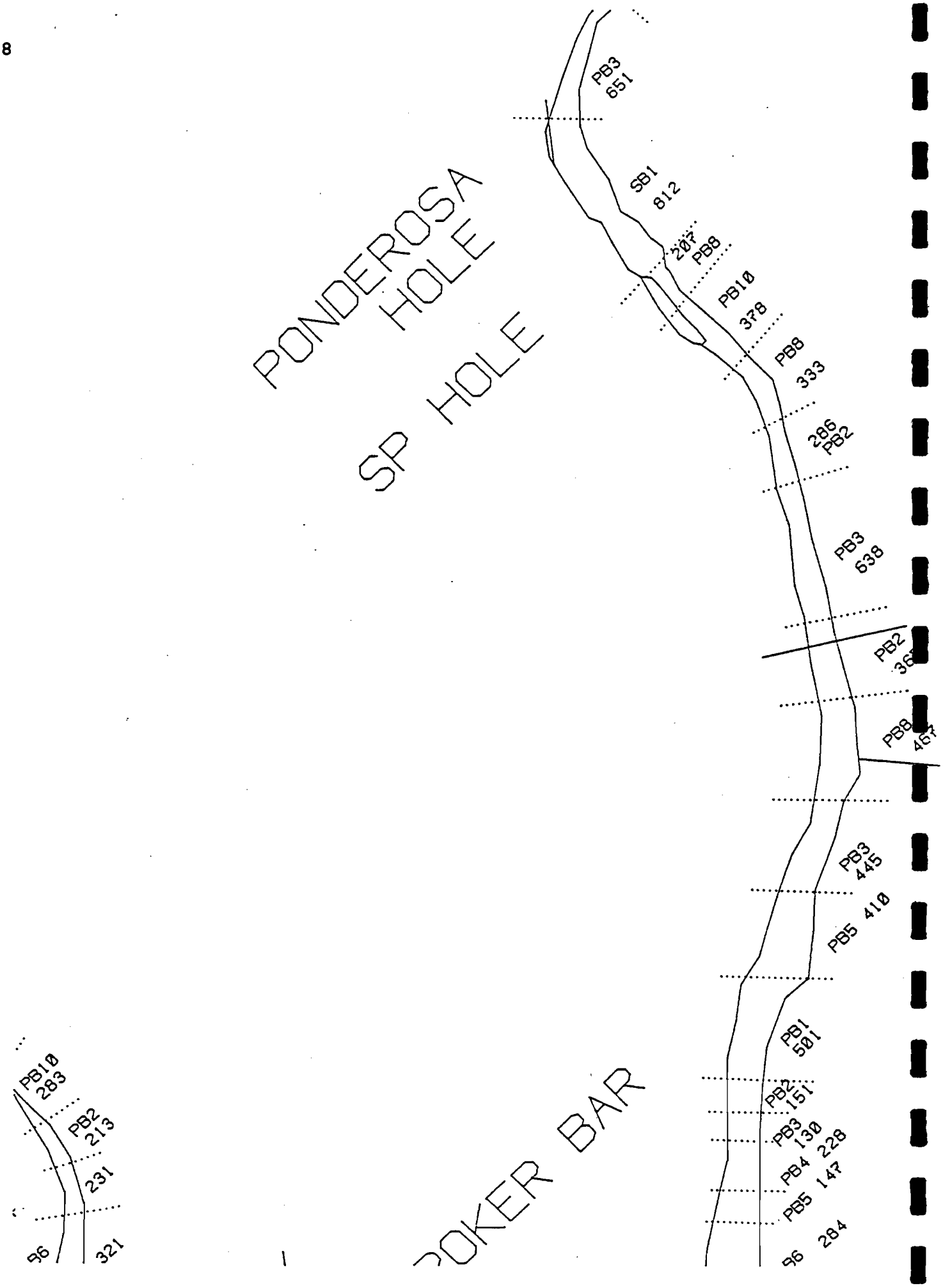
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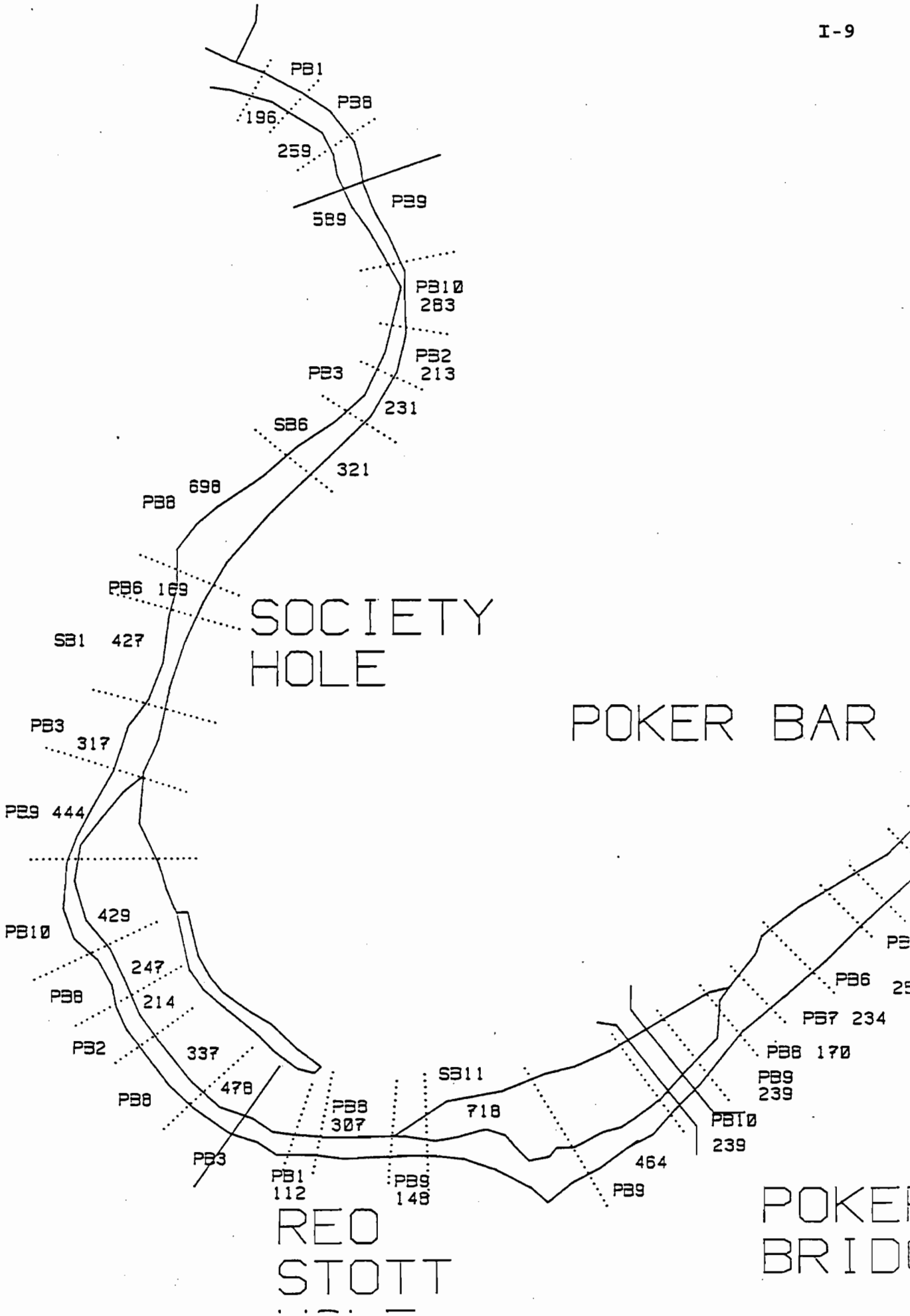
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HOLE
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POKER BAR
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337
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PB3
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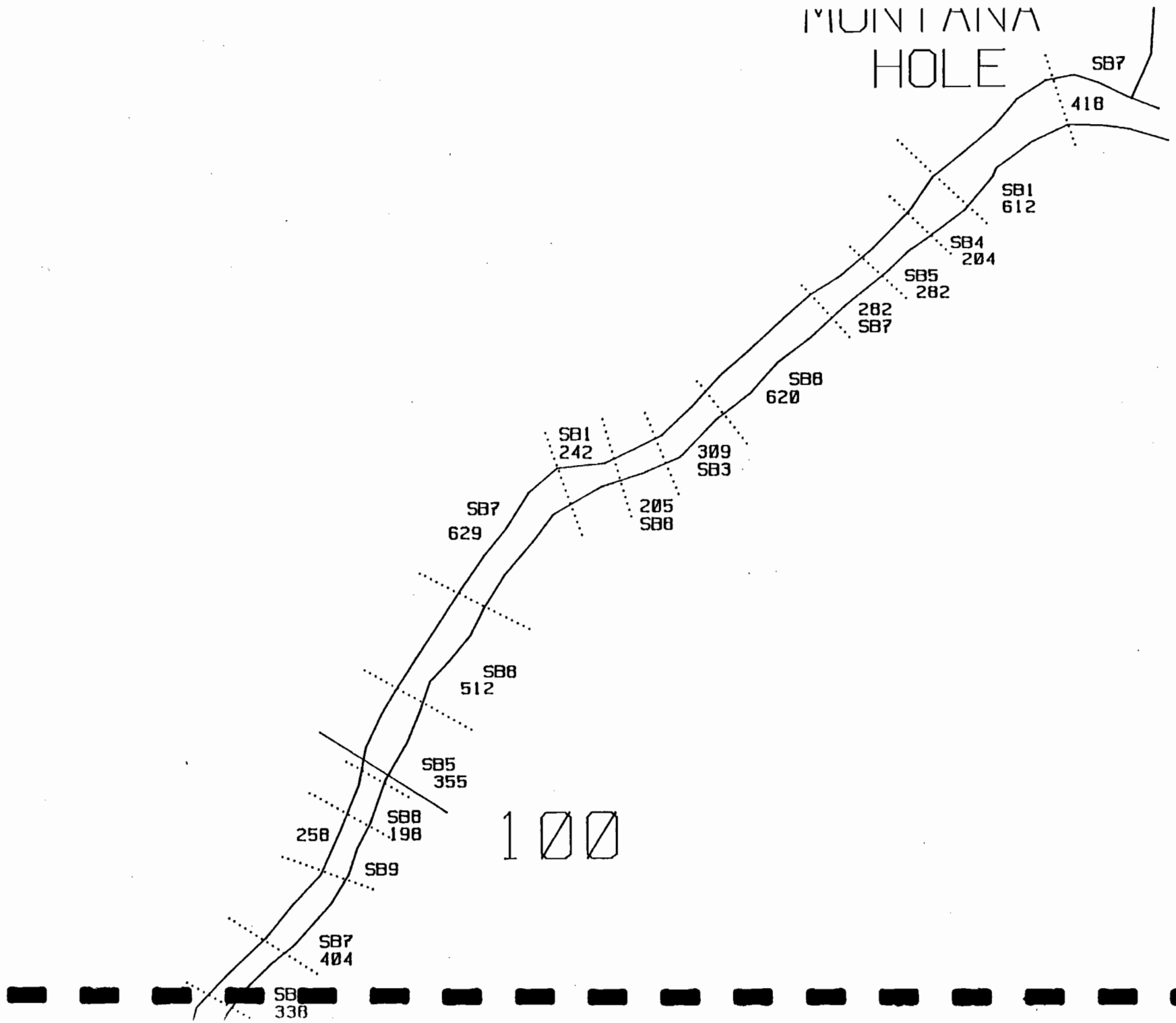
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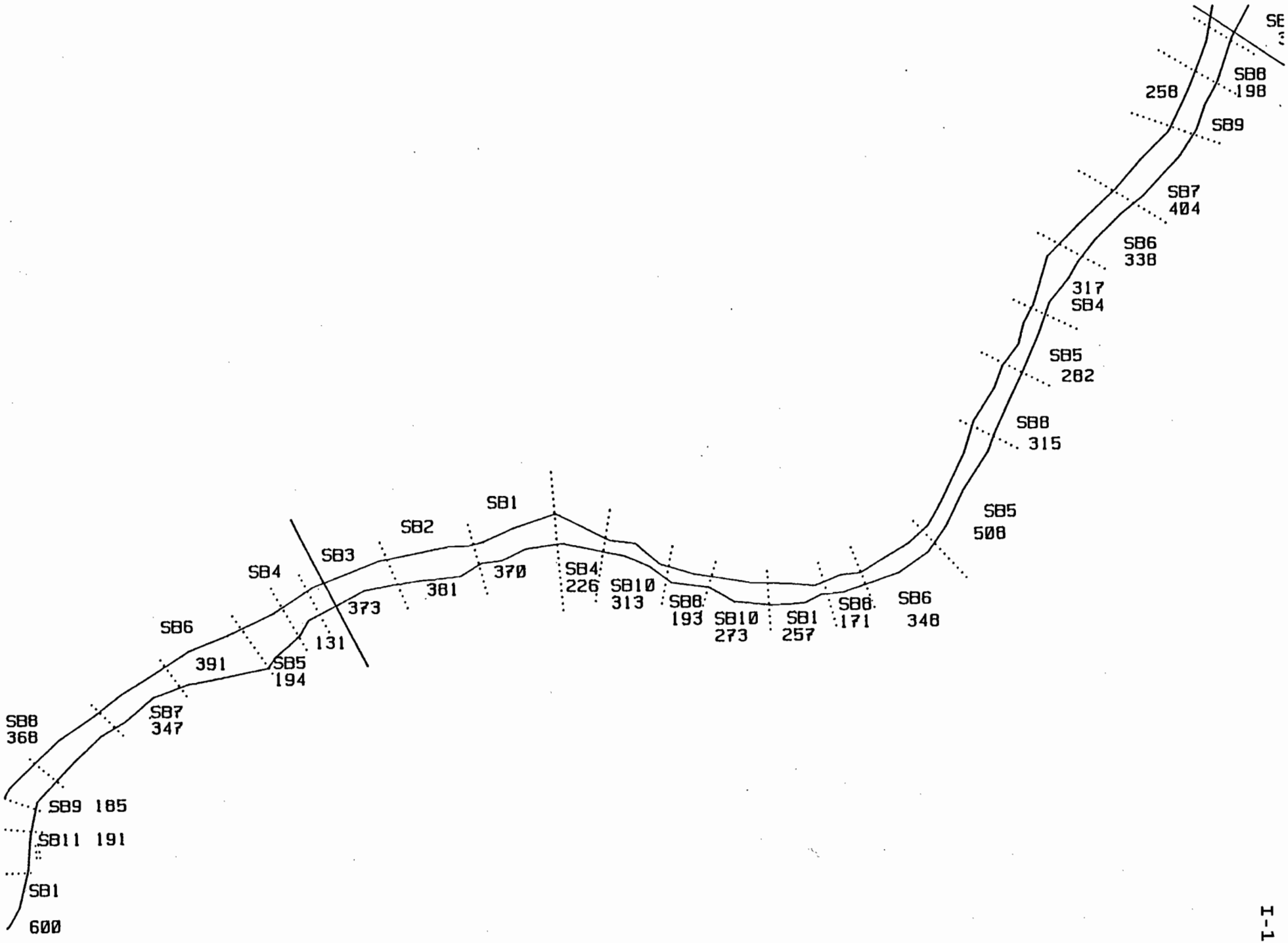
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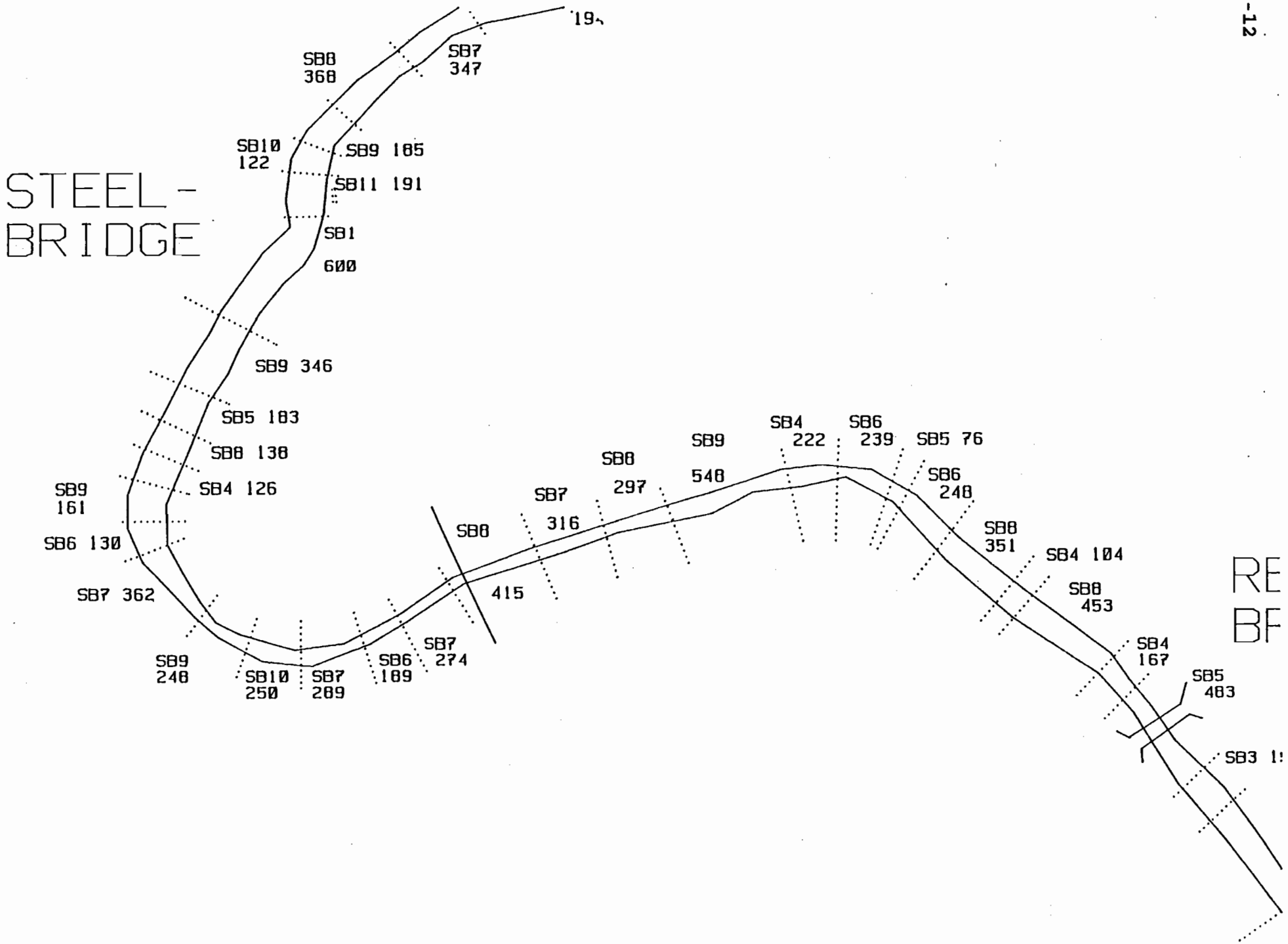
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SB7 362
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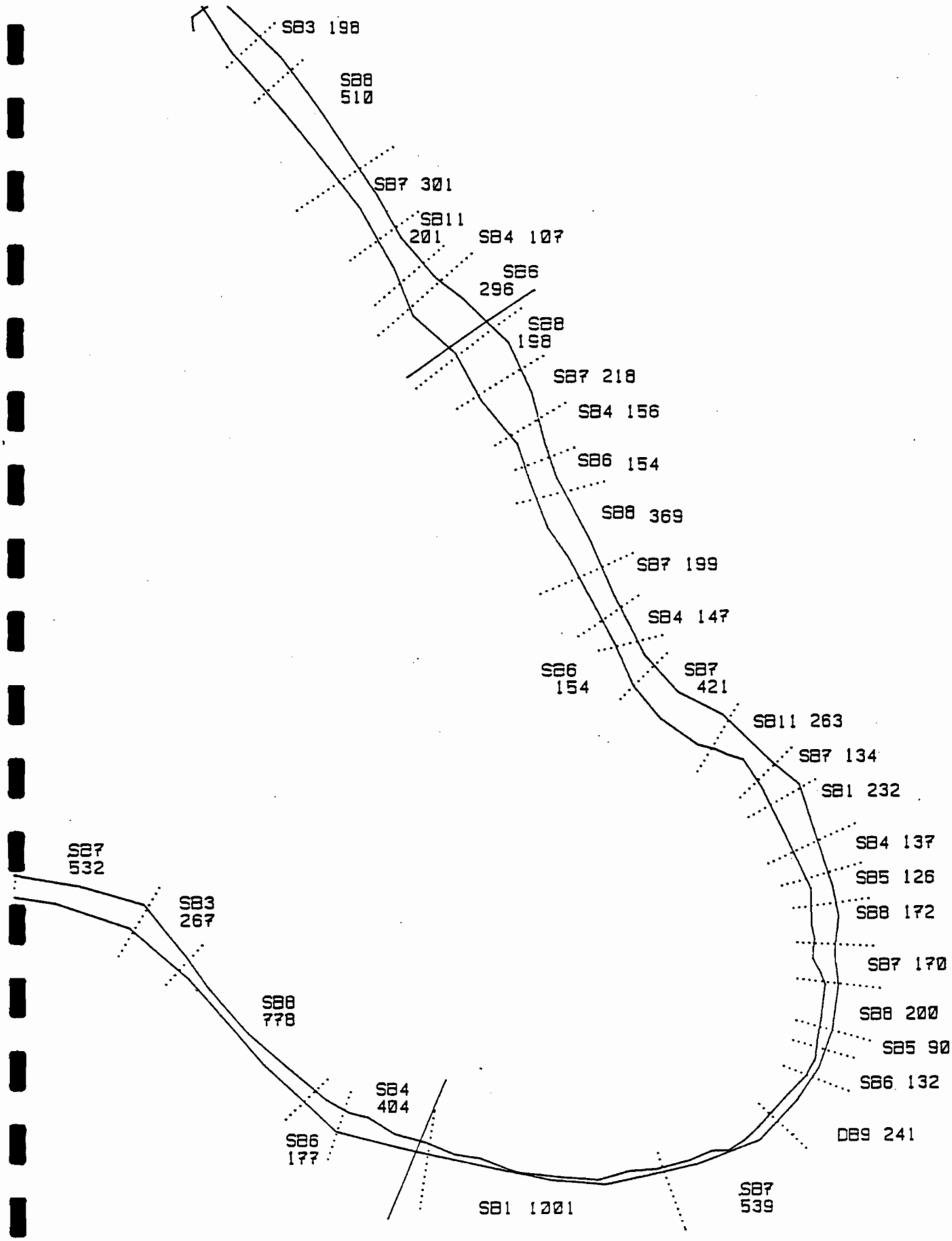
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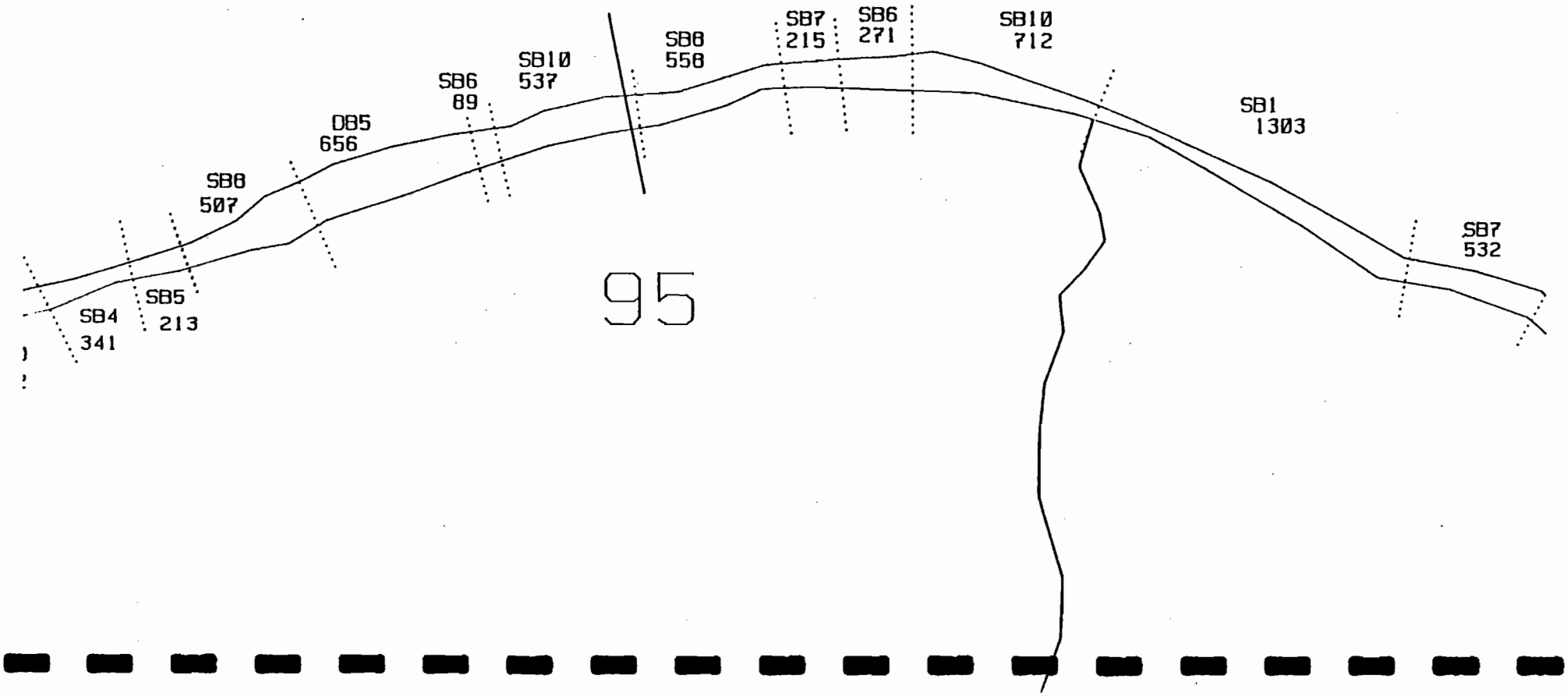
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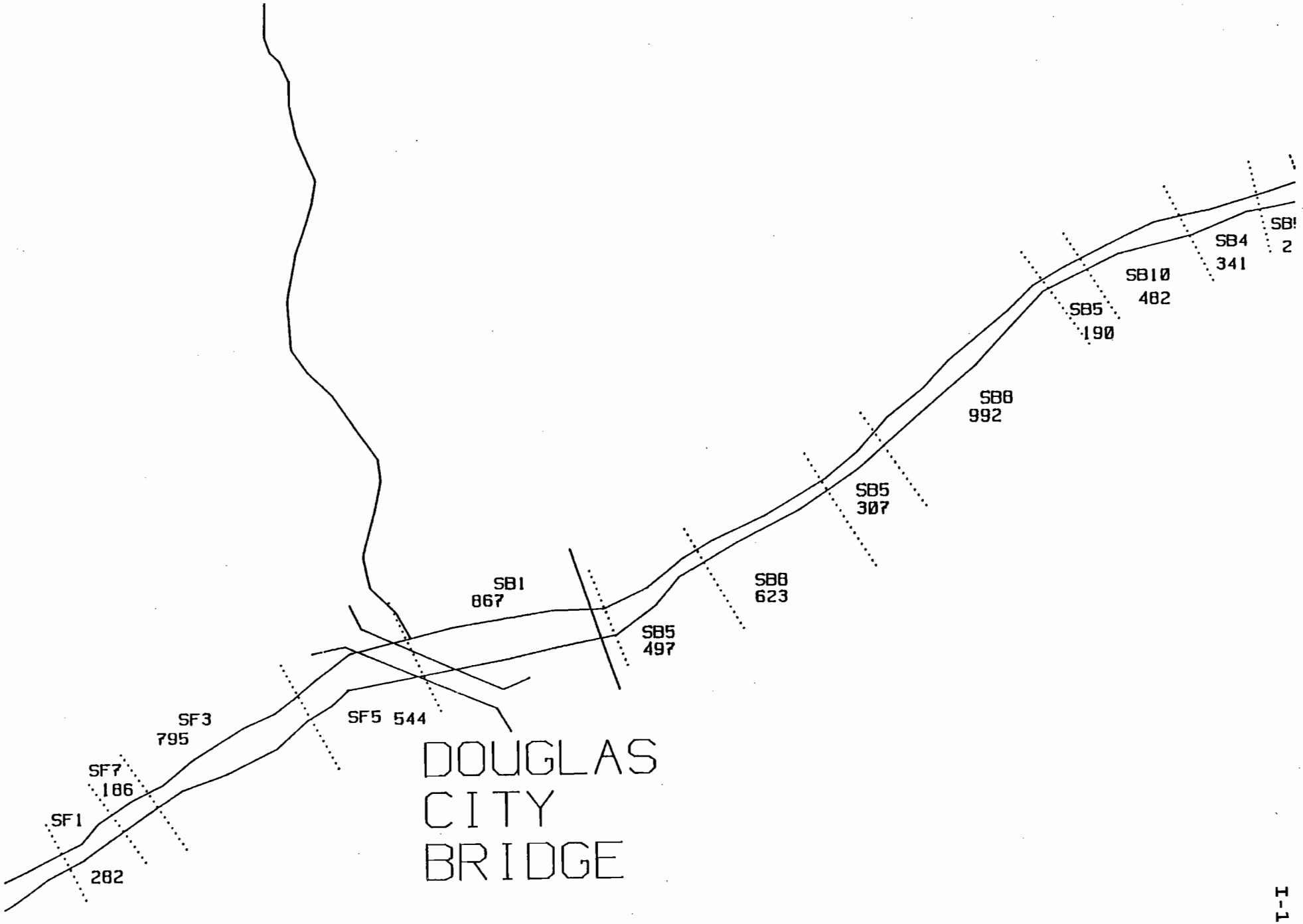
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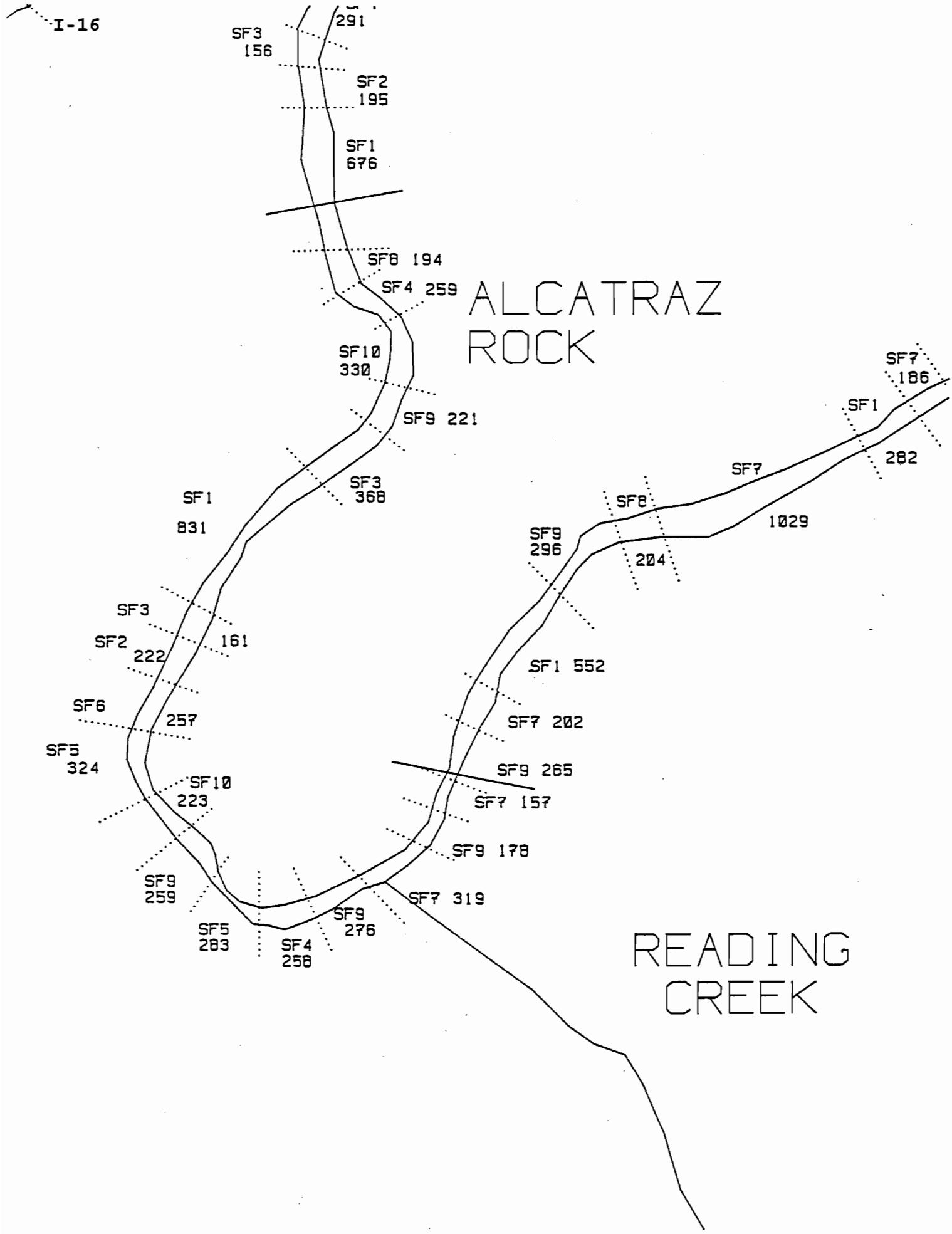
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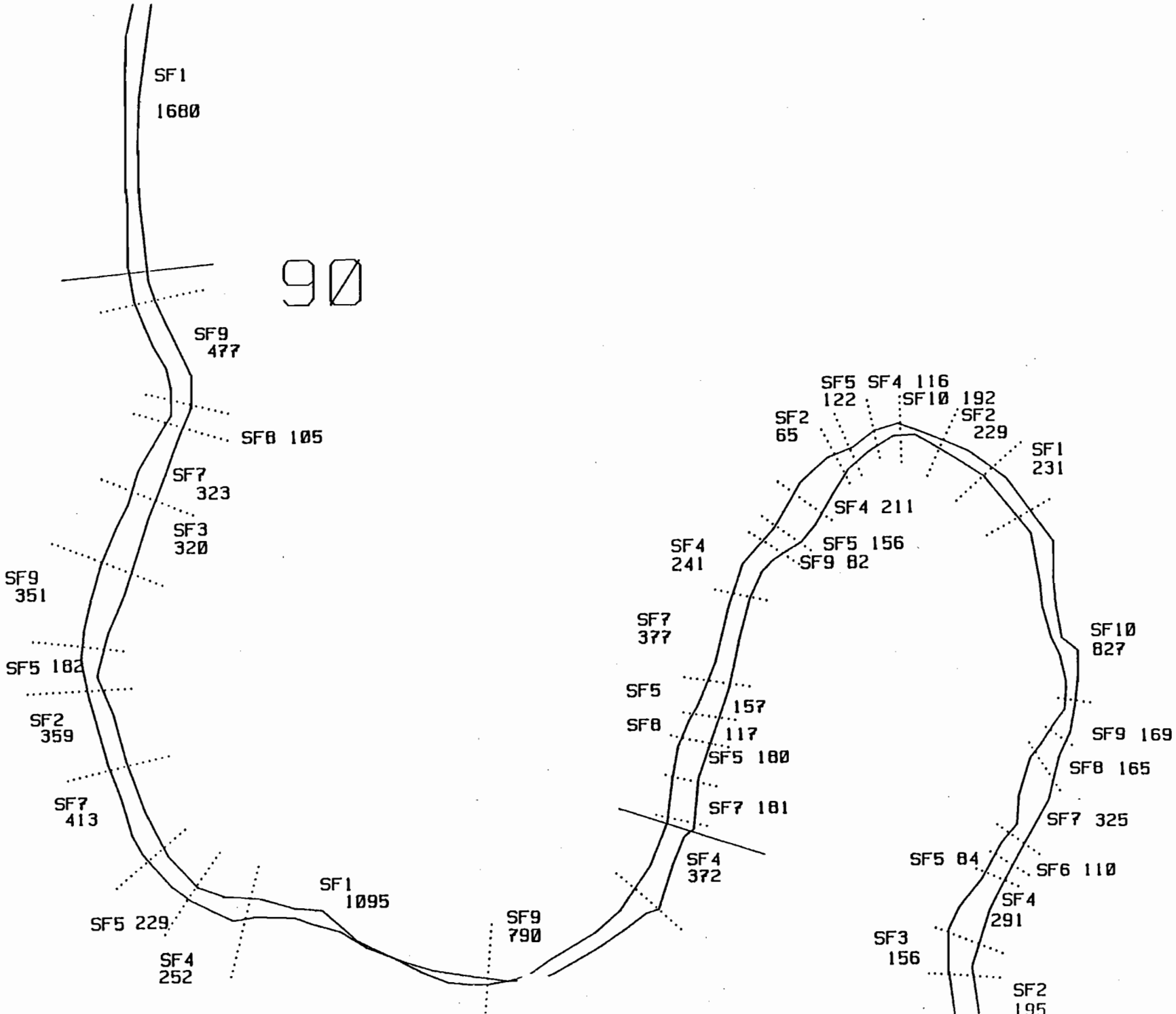
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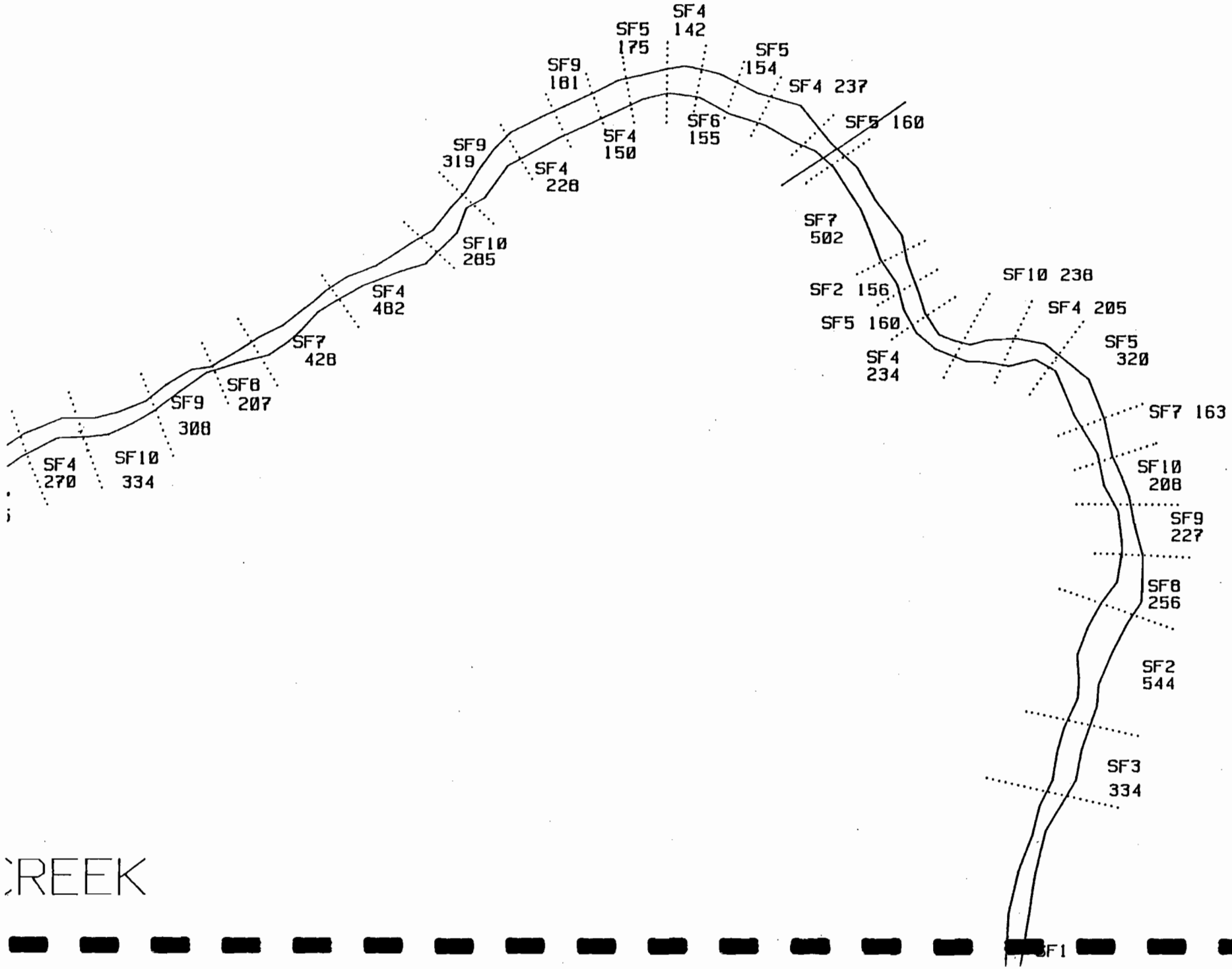
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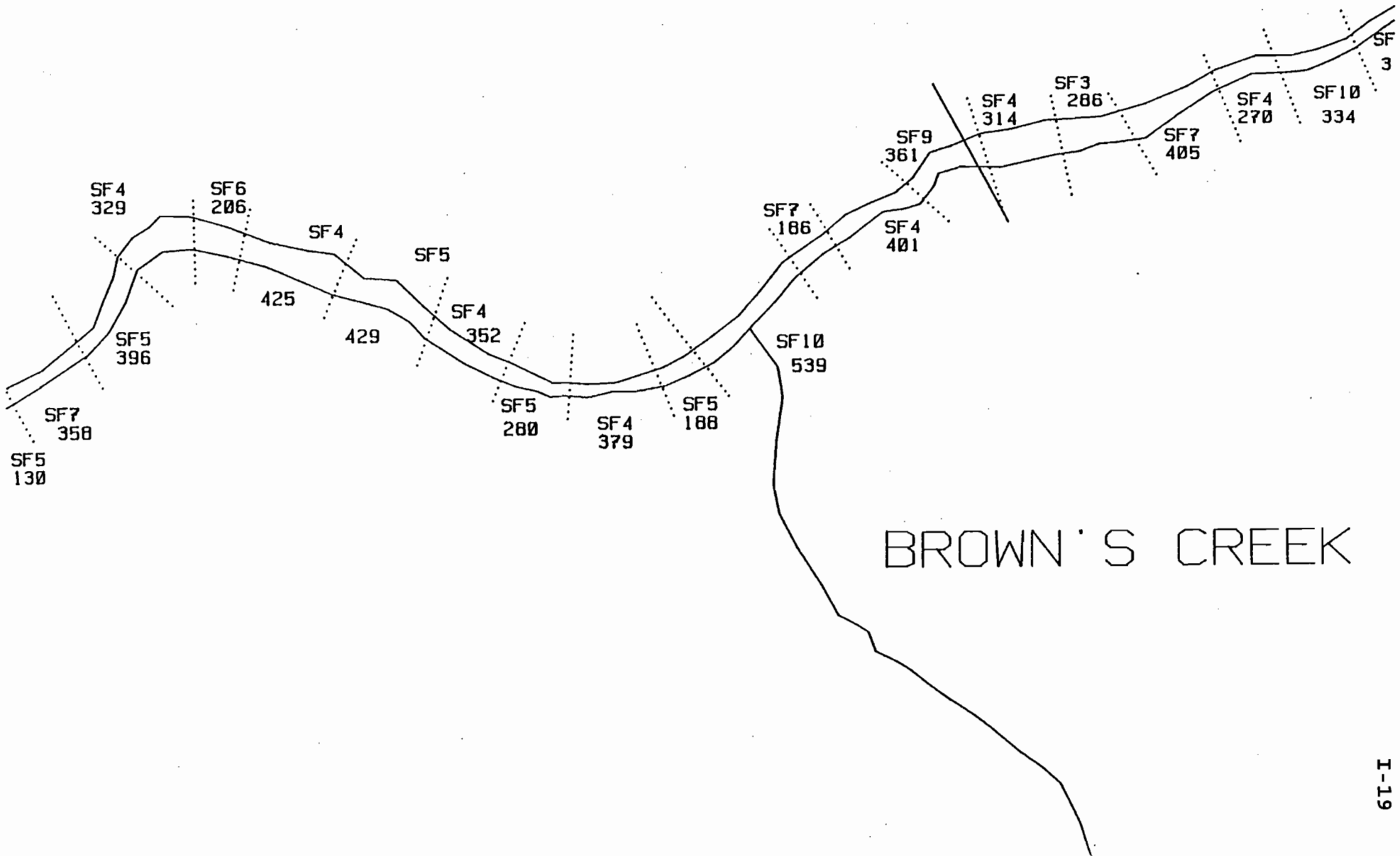
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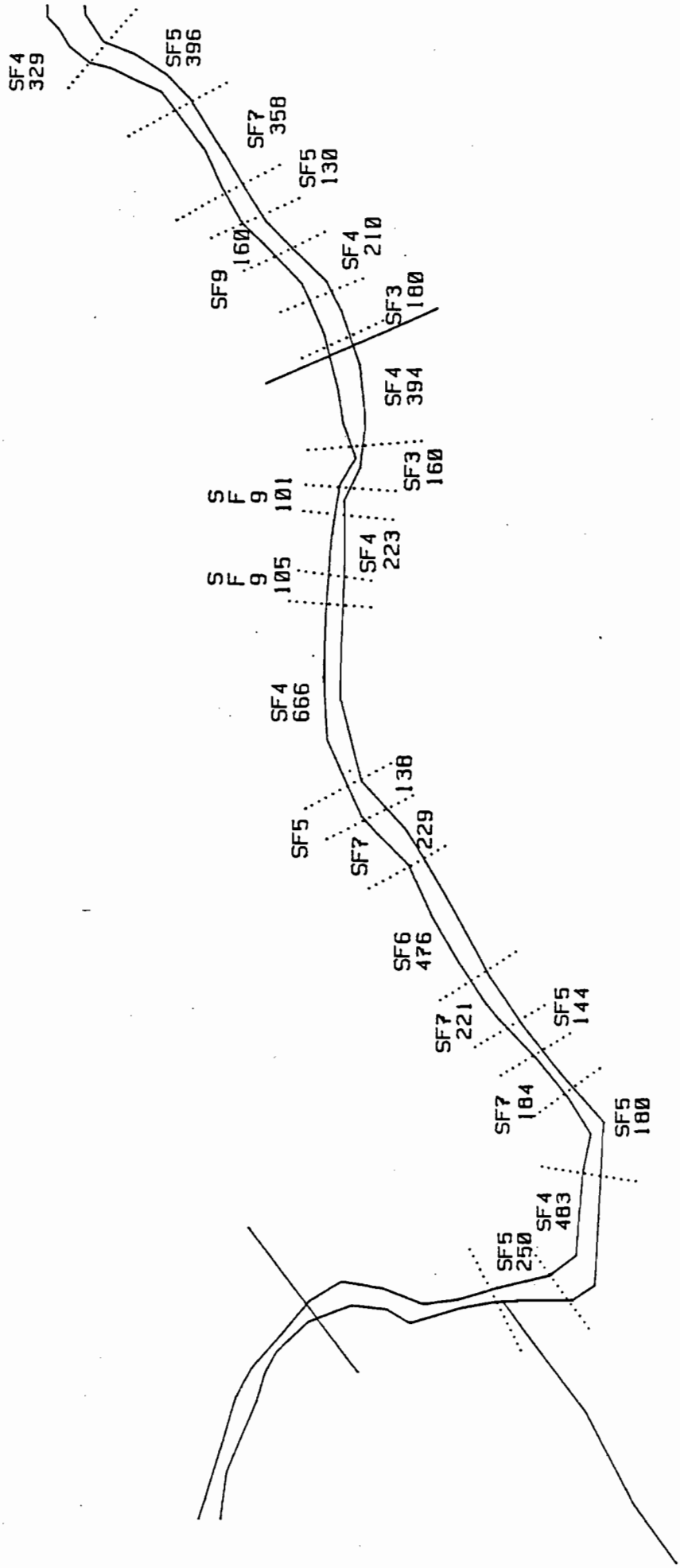
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SF5
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SF5
250
SF9
160
SF9
101
SF9
105

APPENDIX J

SIMULATION OF PHYSICAL HABITAT FOR ANADROMOUS SALMONIDS IN THE TRINITY RIVER

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Ecological Services
Sacramento Field Office
2800 Cottage Way, Room E-1803
Sacramento, CA 95825

Prepared by

Mark Gard
Instream Flow Assessments Branch

TRINITY RIVER PHYSICAL HABITAT SIMULATION

I. INTRODUCTION

A total of 53 transects were established in 1985 at five study sites (Lower Cemetery, Bucktail, Poker Bar, Steelbridge and Steiner Flat), on the Trinity River between Lewiston Dam and Douglas City, to determine the relationship between Trinity River flows and the amount of physical habitat available for anadromous salmonids (chinook and coho salmon and steelhead). Up to twelve sets of water surface elevations (WSELs) and depth/velocity data were collected on these transects between June of 1985 and July of 1995 (Table 1). Feathered edge projects were constructed on six of these transects (Bucktail 1, Steelbridge 8 to 10, Steiner Flat 1 and 2) between 1991 and 1993. Since there is a separate evaluation of the habitat available on the feathered edge projects, these transects were eliminated from this analysis. An additional three transects (Lower Cemetery 8 and Bucktail 4 and 5) could not be located in 1995. Since bed elevation data above the 300-500 cfs water surface (up to 6600-7000 cfs WSEL) was not collected until June and July of 1995, these transects were also eliminated from this analysis. An additional two transects (Bucktail 8 and Poker Bar 8) were eliminated during the analysis, for reasons discussed below, leaving 42 transects for computation of weighted useable area versus flow.

II. METHODS

The first step in the analysis was to set up spreadsheets with horizontal distances, depths, velocities and bed elevations for each transect at each measured flow. Bed elevations below the water surface for a given flow were calculated by subtracting the depth from the WSEL. Bed elevations above the water surface were generally taken from the June-July 1995 surveyed bed elevation measurements. Consistent horizontal distances between different flows were established by reference to the head pin (where such information was available), or by matching bed profile (bed elevation versus horizontal distance) plots if the head pin distance was not available. For each transect, bed profiles for 1985 to 1994 data sets were compared to the 1995 bed profile. Where significant changes in bed profile were observed, the corresponding WSEL and depth/velocity data were not used in any further analysis. The bed profile plots were also used to check for obvious data entry errors. Finally, the bed elevations at each transect, and those on downstream transects, were examined to determine the stage-of-zero-flow (SZF), an important parameter in WSEL calibration, for each transect.

The next step in the analysis was to determine the flows for each site which would be used in the calibration of WSELs and for velocity simulation. Flows were calculated from depths, velocities and horizontal distances for the transects for each site that were judged to be best for flow measurements (Lower Cemetery 1, 2 and 4; Bucktail 2, 3, 9 and 12; Poker Bar 1 and 2; Steelbridge 3, 5 and 7; and Steiner Flat 3 and 7). When flows could be calculated for all of the above transects for each site, the flow used in calibrating WSELs and velocity simulation

Table 1
Flows used for Calibrating WSELs and for Velocity Sets

Month	Gage Flow (cfs)[1]	Calibration & Velocity Flows (cfs)				
		Cemetery	Bucktail	Poker Bar	Steelbridge	Steiner Flat
6-7/85	450	369	444	431	460	431
9/85	350	325	330	329	356	326
7/86	800	740	777	780	761	801
8/86	600	620	586	---	---	512
8/86	500	503	---	---	---	643
5/89	2000	1911	2087	2001	1941	1983
6/90	150	162	185	210	233	274
4/93	3000	2941	2898	2827	2727	3128
8/93	450	---	---	480	488	---
4-5/94	1500	1433	1535	1525	1530	1547
3/95	6000	6436/6710	6807	6684	6684	---
5/95	4500	4917/5130	5317	5021	5099	5318
6-7/95	300 to 500	279/299	347	533	550	505/641

(Table 1) was calculated as the average of the flows for the above transects. When flows could not be calculated for all of the above transects for each site, the flow in Table 1 was calculated from, in priority: 1) the average of flows that were available for any of the above transects; 2) the flow from one of the above transects (if that was the only flow available for the above transects); 3) the flow from some other transect at that site. In general, WSELs were not used when there was no flow measured at that site, with the following exceptions: 1) for Lower Cemetery, the USGS Lewiston gage flow was used; 2) for the March 1995 flow, the flow at each site was computed from the USGS Lewiston gage flow plus measured flows on tributaries. For 1995 flows for Lower Cemetery 9, flows were increased from the flows used at the other Lower Cemetery transects to account for side-channel flows. Since June-July 1995 WSELs and velocity/depth data was collected at different flows for Steiner Flat 3-5 versus Steiner Flat 6-10,

[1] Approximate

the flow calculated for Steiner Flat 3 (505 cfs) was used for Steiner Flat 3-5, while the flow calculated for Steiner Flat 7 (641 cfs) was used for Steiner Flat 6-10.

Spreadsheets were set up for each site with the flows in Table 1 and the WSELs which were not eliminated due to changes in bed profiles. Some additional WSELs were then deleted after careful examination of the spreadsheets revealed irregularities (i.e., a higher WSEL at a lower flow for the same transect; WSELs for downstream transects that were higher than WSELs for upstream transects; WSELs, measured at almost identical flows, differing by more than 0.1 foot for the same transect). In addition, plots of log (flow) versus log (WSEL - SZF) were prepared for each transect, and WSELs that were outliers from the prevailing linear pattern from 150 to 800 cfs were also eliminated. It was concluded that the WSELs eliminated in this step were erroneous either due to measurement error or a change in the reference elevation (WSELs were commonly determined relative to the headpin elevations, some of which could easily have changed over the 11-year period of the study). The log-log plots were also used to determine for what ranges of flow there was a linear log-log relationship between flow and WSEL; these ranges of flows were used for WSEL calibration.

The accepted WSELs, along with the distances between transects, were then used to compute the slope to be used for each transect, as follows. For each transect, two slopes were computed at each measured flow, one using the difference in WSELs between the transect and the next transect downstream divided by the distance between the two, and the other in the same fashion using the next transect upstream. Each of these two slopes were averaged for all measured flows, and these two averages were then averaged again to determine the final slope used in the velocity simulation. For transects at either end of the study site (where either an adjacent upstream or downstream transect was absent), slopes were calculated minus the final averaging step.

Decks were then assembled for WSEL calibration by printing the necessary information from the spreadsheets to ASCII files, and then using the FLOGARD program (Hamilton 1995) to convert the ASCII files into IN4 input decks. This process eliminated any potential data errors which could be encounted if the data for the decks were entered manually. Two or three input decks (low flow, mid flow and high flow) were constructed for each study site.

The first step in calibration is to establish the stage-discharge relationship for each transect. Three separate models are available within PHABSIM to predict this relationship, enabling the modeler to predict water depths for flows at which WSELs were not measured. These models are: 1) *IFG4*, which uses a log-log linear rating curve to predict WSELs; 2) *MANSQ*, which operates under the assumption that the condition of the channel and the nature of the streambed controls the WSELs; and 3) *WSP*, the water surface profile model which calculates the energy loss between transects to determine WSELs. *IFG4*, the most versatile of these models, is considered to have worked well if the following standards are met: 1) the beta value (a measure of the change in channel roughness with changes in streamflow) is between 2.0 and 4.5; 2) the mean error in calculated versus given discharges is less than 10%; 3) there is no more than

a 25% difference for any calculated versus given discharge; and 4) there is no more than a 0.1 foot difference between measured and simulated WSELs (Bovee 1994). The fourth standard is also used for *WSP* and *MANSQ*. *WSP* calibration involves adjusting values for Manning's n and roughness multipliers, while *MANSQ* calibration involves adjusting beta values (a different beta than for *IFG4*). Acceptable ranges of Manning's n and beta (for *MANSQ*) are, respectively, 0.04 to 0.07 and 0 to 0.5. In addition, there should be a linear log-log relationship between flow and roughness multiplier values when using *WSP*.

In general, ranges of flows and models were selected (Appendix A) which minimized the difference between measured and simulated WSELs. In most cases, it was possible to get no more than a 0.1foot difference between measured and simulated WSELs (Appendix A). However, 20 simulated WSELs could not be brought within 0.1 foot of the measured WSEL; eleven of these were for flows greater than 4000 cfs, where there was often as much as a 0.2 foot variation in measured WSEL across the transect. Since in all 11 cases there was less than a 0.2 foot difference between simulated and measured WSELs, this level of accuracy was accepted. For the remaining nine simulated WSELs that could not be brought within 0.1foot of the measured elevations, all three models were tried if possible,[2] and the model which produced the lowest overall difference between measured and simulated WSELs was used. For these simulations, the maximum difference between measured and simulated WSELs was 0.22 feet. For *IFG4* simulations, all mean errors were less than 10% (the greatest value was 8.14%) and all calculated discharges were within 25% of given discharges (maximum difference was 11.8%). However, ten beta values were less than 2.0. Since seven of these values were between 1.9 and 1.99, and the lowest beta value was 1.53, this was accepted. For *WSP*, roughness multipliers for simulated flows were usually generated using a log-log regression of flow and calibrated roughness multiplier values for the calibration flows. While four Manning's n values less than 0.04 were used in *WSP* calibrations, none of the Manning's n values were less than 0.03; accordingly, the Manning's n values were judged to be acceptable. All but one of the beta values used in *MANSQ* calibrations were between 0 and 0.5, with the exception (0.52) just barely exceeding the acceptable range for beta values for *MANSQ*. One transect (Bucktail 8) could not be calibrated for flows above 800 cfs using any of the three models, and was thus dropped from further analysis.

After the preliminary calibration of WSELs, WSELs were simulated on each transect for all flows to be evaluated and entered into a spreadsheet for each site. WSELs generated using *IFG4* and *MANSQ* were checked for a breakdown in calibration (i.e., water flowing uphill); where this was noted, *WSP* was used for the range of flows where this occurred. In addition, the difference between successive flows for a single transect were examined; if the difference was too large (more than 0.1 foot greater than the adjacent differences) or negative (typically where there was a

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[2] The *WSP* model, by design, links transects from downstream up and thus cannot be used for the furthest downstream transect.

switch from one WSEL calibration deck to another), a weighted average of WSELs from the two calibration decks were computed for typically around five flows, so as to smooth the WSEL/flow relationship. This problem was often avoided by overlapping one WSEL/flow in the two calibration decks (ie, the low flow in the higher flow range deck = the high flow in the lower flow range deck). All WSELs were written into the final *IFG4* decks, with IOC 8 set equal to 1.

The second, and final, step in the calibration process involves examining various parameters associated with the prediction of water velocities by the *IFG4* model. Water velocities are simulated in *IFG4* using Manning's equation where:

$$\text{Velocity} = (1.49/N)(R^{.667})(S^{.5})$$

R = Hydraulic radius (IFG4 uses depth as an estimate of R)
S = Energy slope

The N value in the above equation is a roughness coefficient which is calculated when a measured velocity from a transect cell is supplied in the equation. If a measured velocity is not supplied for a cell, as is the case when flows exceeding the velocity measurement flow are simulated, the model supplies the last N value derived from the previous cell to those cells. Typically, the last wet cell had a measured velocity of 0 ft/s. These velocities were arbitrarily set to a low value (typically 0.05 ft/s) to get reasonable simulated velocities in cells that were dry at the velocity measurement flow. This practice is judged to be reasonable, since the measurement error of velocities is in the range of 0.05 ft/s. For some transects for flows greater than 1600 cfs, only edge velocities were measured. In these cases, a uniform N value for the middle cells with unmeasured velocities was determined in a spreadsheet which resulted in the total calculated flow equaling the flow to be used with the velocity set. The horizontal distances and bed elevations for these middle cells were taken from the data collected in 1995 at 300-500 cfs, and the N values derived were written into the *IFG4* input decks for these cells.

Substrate data (for spawning and steelhead winter juvenile rearing) was taken from *IFG4* data decks prepared by Andy Hamilton in 1986. This assumes that there has been no major change in substrate composition since 1986. Since the substrate data in these decks were only collected up to a 800 to 2000 cfs discharge[3], the upper flow limit for simulating spawning and steelhead winter juvenile rearing habitat was in this range. Since different verticals were used for different flows, the substrate which was coded (Table 2) into each vertical in the spreadsheets was the substrate of the nearest vertical in the 1986 decks.

Final decks were then assembled for velocity and habitat simulation using the same procedure described above. Three decks were assembled for each site: a low-flow deck, using a low-flow

[3] The upper flow limit for substrate data varied from site to site.

Table 2
Substrate Descriptors and Codes

Code	Type	Particle Size (mm)
0	Fines	< 4
1	Small Gravel	4 - 25
2	Medium Gravel	25 - 50
3	Large Gravel	50 - 75
4	Small Cobble	75 - 150
5	Medium Cobble	150 - 225
6	Large Cobble	225 - 300
7	Small Boulder	300 - 600
8	Large Boulder	> 600
9	Bedrock	

velocity set (usually from 1995 - Table 3) and two high-flow decks, using a high-flow velocity set (Table 4). One of the high-flow velocity decks included simulated flows from 150 cfs to around 2000 cfs, while the other high-flow deck simulated flows from around 2000 cfs to 6600-7000 cfs. Flows could not be simulated any higher than 6600-7000 cfs due to limitations on bed elevation data. Where a velocity set from 1989 was suitable for use, this was generally used in the high flow decks. In other cases, where there had been a significant change in bed profile since 1989, the velocity set from the highest suitable flow (typically from 1994) was used. For two transects (Steelbridge 11 and Steiner 3), due to channel changes in the winter of 1995, only one velocity set (i.e., from 1995) was suitable for use, and thus was used in both the low and high-flow decks. Flows were simulated in 50 cfs increments up to 1000 cfs, in 100 cfs increments from 1000-3000 cfs, and in 200 cfs increments above 3000 cfs.

The major technique used to check that velocity predictions were acceptable was to examine the velocity adjustment factors (VAFs). In mass balancing, the program calculates VAFs by determining the ratio of the discharge for which velocities are being simulated to the discharge calculated using the initial simulation of cell velocities. VAFs typically increase monotonically with increasing flows. Only Poker Bar 8 deviated significantly from this expected pattern (Appendix B); as a result, Poker Bar 8 was dropped from any further analysis. Further, VAFs should be in the range of 0.2 and 5.0 to be considered acceptable (Bovee 1994). The VAFs for all transects were within this range (Appendix B).

Table 3
Low Flow Velocity Sets

XS #	Lower Cemetery	Bucktail	Poker Bar	Steelbridge	Steiner Flat
1	279	---	533	550	---
2	279	347	533	550	---
3	279	347	533	550	505
4	279	---	533	550	505
5	279	---	533	550	505
6	279	347	533	550	431
7	279	347	480	550	641
8	---	347	533	---	431
9	299	347	533	---	641
10	---	347	533	---	431
11	---	347	---	550	---
12	---	347	---	550	---

The final step in the process was to simulate available habitat for each transect. Habitat suitability criteria (HSC or SI Curves) are used within PHABSIM to translate hydraulic and structural elements of rivers into indices of habitat quality (Bovee 1994). The HSC used in this study were site specific, having been developed as part of the Trinity River Flow Evaluation (Hampton 1988). Although juvenile criteria were developed that included cover, these were not used, since cover data was not available for any transects above the 2000 cfs WSEL. After calibration of hydraulic data decks habitat modeling proceeded. An input file was creatdd containing the digitized HSC developed on the Trinity River (Appendix C). The HABTAE program was used to compute WUA for each transect over the desired range of stream flows (150 cfs to 6600-7000 cfs). WUA for each transect for the low-flow and high-decks were entered into a spreadsheet. A composite WUA curve was developed by switching from the low-flow deck WUA to the high-flow deck WUA where the WUA curves crossed. The flow where I switched from the low-flow deck to the high-flow deck was different for different HSI curves and different transects. If the curves did not cross, only the high-flow WUA was used. The composite WUA curves for each transect constituted the final product of this effort.

Table 4
High Flow Velocity Sets

XS #	Lower Cemetery	Bucktail	Poker Bar	Steelbridge	Steiner Flat
1	1911	---	2001	1941	---
2	1911	2087	2001	2727	---
3	1911	2087	2001	2727	505
4	1911	---	2001	1941	1983
5	1911	---	1525	1941	3128
6	1911	1535	1525	1941	1983
7	1911	2087	1525	1530	801
8	---	2087	1525	---	1983
9	1911	2087	1525	---	1983
10	---	2087	1525	---	1547
11	---	1535	---	550	---
12	---	2087	---	761	---

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APPENDIX A
WSEL CALIBRATION

Calibration Methods and Parameters Used

Lower Cemetery Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-700	162, 279, 503, 620	IFG4	---
1	750-2900	740, 1433, 1911, 2941	IFG4	---
1	3000-6600	2941, 4917, 6436	IFG4	---
2	150-1100	279, 503, 620	IFG4	---
2	1200-2900	1433, 1911, 2941	IFG4	---
2	3000-6600	2941, 4917, 6436	IFG4	---
3	150-650	162, 279, 503, 620	IFG4	---
3	700-6000	740, 4917, 6436	WSP	n = 0.04, 740 RM = 0.01, 4917 RM = 0.2, 6436 RM = 1.0
4	150-650	162, 279, 620	IFG4	---
4	700-1700 *	620, 740, 1433	IFG4	---
4	1200-6600 *	1911, 2941, 4917, 6436	IFG4	---
5	150-700 *	162, 279, 503, 620	IFG4	---
5	650-2900 *	740, 1433, 1911, 2941	IFG4	---
5	3000-6600	2941, 4917, 6436	IFG4	---
6	150-650	279, 620, 740	IFG4	---
6	700-1400	620, 740, 1433	IFG4	---
6	1500-2900	1433, 1911, 2941	IFG4	---
6	3000-6600	2941, 4917, 6436	IFG4	---
7	150-700 *	162, 279, 369, 620	IFG4	---
7	650-2400 *	740, 1433, 1911	IFG4	---
7	2000-6600 *	740, 1433, 1911	WSP	n = 0.045, 740 RM = 0.76, 1433 RM = 0.64, 1911 RM = 0.6
9	150-350	162, 299, 325, 369	IFG4	---
9	400-1400 *	503, 620, 740	IFG4	---
9	1000-2900 *	1433, 1911, 2941	IFG4	---
9	3000-6600	2941, 5130, 6710	IFG4	---

* WSELs for flows listed for two calibrations were calculated as the weighted average of WSELs for those flows from the two calibrations.

Bucktail Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
2	150-400	185, 347, 444	IFG4	---
2	450-3000	444, 586, 777, 2898	IFG4	---
2	3200-6800	2898, 5317, 6807	IFG4	---
3	150-550	185, 347, 444	IFG4	---
3	600-6800	586, 777, 2898, 5317, 6807	IFG4	---
6	150-750	185, 347	WSP	n = 0.03, all RM = 1.0
6	800-6800	347, 5317, 6807	WSP	n = 0.03, 347 RM = 1.05, 5317 RM = 0.76, 6807 RM = 0.74
7	150-750	185, 347, 777	WSP	n = 0.045, all RM = 1.0
7	800-2900	777, 2087, 2898	MANSQ	CALQ = 2898, β = 0.52
7	3000-6800	2898, 5317, 6807	IFG4	---
8	150-750	185, 347, 444, 586, 777	WSP	n = 0.035, all RM = 1.0
8	800-6800	unable to calibrate		
9	150-550	185, 347, 444, 586	IFG4	---
9	600-2000	586, 777, 2087	IFG4	---
9	2100-6800	2087, 5317, 6807	IFG4	---
10	150-400	185, 347, 444	IFG4	---
10	450-750	444, 586, 777	IFG4	---
10	800-6800	777, 2087, 2898	WSP	n = 0.035, 777 RM = 1.16, 2087 RM = 0.81, 2898 RM = 0.72
11	150-400	185, 347, 444	WSP	n = 0.06, 185 RM = 1.4, 347 RM = 1.07, 444 RM = 0.96
11	450-750	444, 586, 777	IFG4	---
11	800-6800	777, 2898, 5317, 6807	IFG4	---
12	150-400	185, 347, 444	IFG4	Cal WSEL for 185 = 90.05
12	450-1500	444, 586, 777	IFG4	---
12	1600-6800	2087, 5317, 6807	IFG4	---

Poker Bar Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-500	210, 329, 431, 533	IFG4	---
1	550-7000	533, 780, 5021, 6684	IFG4	---
2	150-500	210, 329, 431, 533	IFG4	---
2	550-7000	533, 780, 5021, 6684	IFG4	---
3	150-500	210, 329, 533	WSP	n = 0.04, 210 RM = 1.92, 329 RM = 1.48, 533 RM = 1.13
3	550-750	533, 780, 2001	IFG4	---
3	800-3200	780, 2001, 5021	WSP	n = 0.04, 780 RM = 0.62, 2001 RM = 0.48, 5021 RM = 0.37
3	3400-7000	2001, 5021, 6684	IFG4	---
4	150-750	210, 533, 780	WSP	n = 0.05, 210 RM = 1.92, 533 RM = 1.13, 780 RM = 0.91
4	800-7000	780, 5021, 6684	IFG4	---
5	150-7000	533	WSP	n = 0.04, 533 RM = 1.13
6	150-250	533	WSP	n = 0.07, RM = 1
6	300-7000	533, 5021, 6684	IFG4	---
7	150-2800	533, 2827	MANSQ	CALQ =2827, β = 0.36
7	2900-7000	2827, 5021, 6684	IFG4	---
8	150-7000	533, 6684	MANSQ	CALQ = 6684, β = 0.06
9	150-7000	533, 5021, 6684	IFG4	---
10	150-7000	533, 5021, 6684	IFG4	---

Steelbridge Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-750	233, 550, 761	IFG4	---
1	800-2600	761, 1941, 2727	IFG4	---
1	2700-6800	2727, 5099, 6684	IFG4	---
2	150-550	356, 460, 550	IFG4	---
2	600-6800	550, 5099, 6684	IFG4	---
3	150-550	356, 550	MANSQ	CALQ = 550, β = 0.5
3	600-6800	550, 2727, 5099, 6684	IFG4	---
4	150-550	233, 356, 550	WSP	n = 0.045, 233 RM =0.85, 356 RM =1.97, 550 RM = 1.27
4	600-6800	550, 761, 5099, 6684	IFG4	---
5	150-750	233, 550, 761	WSP	n = 0.07 , 233 RM = 2.58, 550 RM =1.28, 761 RM = 1.44
5	800-6800	761, 5099, 6684	IFG4	---
6	150-750	550	WSP	n = 0.045 , RM = 1.0
6	800-6800	761, 1941, 5099, 6684	IFG4	---
7	150-750 *	356, 460, 550	IFG4	---
7	600-6800 *	761, 5099, 6684	IFG4	---
11	150-1500	550	WSP	n = 0.045 , RM = 1.0
11	1600-6800	550, 5099, 6684	IFG4	---
12	150-750	550, 761	MANSQ	CALQ = 761, β = 0.42
12	800-6800	761, 5099, 6684	IFG4	---

* WSELs for flows listed for two calibrations calculated as weighted average of WSELs for those flows from the two calibrations.

Steiner Flat Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
3	150-5400	505, 5318	WSP	n = 0.07, 505 RM = 0.88, 5318 RM = 1.47
4	150-500	326, 431, 505	IFG4	---
4	550-5400	505, 1983, 5318	IFG4	---
5	150-6800	505, 5318	MANSQ	CALQ =5318, β = 0.05
6	150-800	274, 299, 431, 641, 801	IFG4	---
6	850-6200	801, 1983, 5318	IFG4	---
7	150-800	299, 512, 641, 801	WSP	n = 0.04, 299 RM = 1.01, 512 RM = 0.89, 641 RM = 0.85, 801 RM = 0.81
7	850-6800	641, 801	MANSQ	CALQ =801, β = 0.03
8	150-800	299, 431, 512, 641, 801	IFG4	---
8	850-6800	801, 1983, 5318	IFG4	---
9	150-500	274, 299, 512	IFG4	---
9	550-800	512, 641, 643, 801	IFG4	---
9	850-6800	801, 1983, 5318	IFG4	---
10	150-300	274, 299, 326	IFG4	---
10	350-650	326, 431, 512, 641	IFG4	---
10	700-6800	641, 801, 1983, 5318	IFG4	---

LOWER CEMETERY STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 162 cfs	279 cfs	369 cfs	740 cfs	Difference (measured vs. pred. WSELs) 162 cfs	279 cfs	369 cfs	503 cfs	620 cfs	740 cfs
1	3.92	2.54	2.7	5.1	---	---	0.01	0.04	---	0.03	0.01	---
2	3.18	1.43	---	0.5	---	---	---	None	---	0.02	0.02	---
3	3.78	2.61	3.3	5.4	---	---	0.03	0.05	---	None	0.02	---
4	3.84	2.01	1.9	3.1	---	---	0.01	0.03	---	---	0.01	---
5	3.72	3.15	3.1	5.7	---	---	0.02	0.04	---	0.03	0.01	---
6	2.34	2.65	---	1.0	---	3.0	---	0.01	---	---	0.03	0.04
7	3.61	0.92	0.2	1.4	1.6	---	None	0.01	0.01	---	None	---

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 162 cfs	299 cfs	369 cfs	Difference (measured vs. pred. WSELs) 162 cfs	299 cfs	325 cfs	369 cfs
9	4.06	6.86	4.9	5.1	9.2	0.03	0.03	0.06	0.06

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 740 cfs	Difference (measured vs. pred. WSELs) 503 cfs	620 cfs	740 cfs
9	2.39	2.38	1.4	0.03	0.05	0.02

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 740 cfs	1433 cfs	1911 cfs	Difference (measured vs. pred. WSELs) 620 cfs	740 cfs	1433 cfs	1911 cfs	2941 cfs
1	2.96	3.64	5.8	3.0	1.7	---	0.04	0.03	0.10	0.09
2	2.29	3.74	---	5.4	2.7	---	---	0.05	0.12	0.07
4	2.51	0.41	0.5	0.6	---	0.01	0.01	None	---	---
5	2.83	2.63	4.9	0.5	---	---	0.01	0.07	0.08	0.02
6	1.94	1.04	0.4	1.2	---	0.01	0.02	0.01	---	---
6	1.99	0.73	---	1.1	---	---	---	0.01	0.02	0.01
7 (IFG4)	2.27	0.91	0.4	1.4	1.0	---	0.01	0.03	0.03	---
7 (WSP)	---	---	---	---	---	---	0.04	0.06	0.09	---
9	4.12	2.11	---	3.1	1.7	---	---	0.02	0.04	0.02

LOWER CEMETERY STUDY SITE (continued)

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1911 cfs	Difference (measured vs. pred. WSELs) 740 cfs	1911 cfs	2941 cfs	4917 cfs	6436 cfs
1	2.33	1.22	---	---	---	0.02	0.06	0.04
2	2.02	0.3	---	---	---	None	0.02	0.01
3	---	---	---	0.10	---	---	0.05	0.03
4	2.67	2.3	2.0	---	0.04	0.05	0.09	0.09
5	1.99	1.12	---	---	---	0.01	0.06	0.05
6	1.90	0.43	---	---	---	0.01	0.02	0.02

XSEC	BETA COEFF.	%MEAN) ERROR	Difference (measured vs. pred. WSELs) 2941 cfs	5130 cfs	6710 cfs
9	1.97	2.31	0.03	0.15	0.12

BUCKTAIL STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 185 cfs	347 cfs	444 cfs	777 cfs	Difference (measured vs. pred. WSELs) 185 cfs	347 cfs	444 cfs	586 cfs	777 cfs
2	4.05	4.51	7.1	2.7	4.0	---	0.02	0.05	0.03	---	---
3	4.11	6.07	9.6	4.0	5.0	---	0.03	0.08	0.05	---	---
6	---	---	---	---	---	---	0.06	0.07	---	---	---
7	---	---	---	---	---	---	0.06	0.06	---	---	0.01
8	---	---	---	---	---	---	0.05	0.03	0.09	0.05	0.01
9	3.03	8.14	11.8	8.4	5.3	---	0.07	0.10	0.05	0.08	---
10	3.12	7.92	---	5.7	6.0	---	0.04	0.09	0.05	---	---
11	---	---	---	---	---	---	0.02	0.10	0.09	---	---
12	1.82	3.48	5.4	1.9	3.2	---	0.06	0.10	0.07	---	---

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 444 cfs	777 cfs	2087 cfs	Difference (measured vs. pred. WSELs) 444 cfs	586 cfs	777 cfs	2087 cfs	2898 cfs
2	2.54	2.95	5.7	4.1	---	0.05	0.09	0.02	---	0.02
7	---	---	---	---	---	---	---	0.04	0.02	None
9	3.16	1.89	---	2.9	0.5	---	0.03	0.03	0.01	---
10	3.46	2.09	1.8	---	---	0.01	0.03	0.01	---	---
11	3.65	2.51	---	---	---	0.02	0.03	0.01	---	---
12	3.62	2.33	1.4	3.6	---	0.02	0.04	0.02	---	---

BUCKTAIL STUDY SITE (continued)

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 777 cfs	2087 cfs	Difference (measured vs. pred. WSELs) 347 cfs	586 cfs	777 cfs	2087 cfs	2898 cfs	5317 cfs	6807 cfs
2	2.25	0.47	---	---	---	---	---	---	0.01	0.03	0.02
3	2.72	3.52	5.1	---	---	0.07	0.09	---	0.06	0.13	0.09
6	---	---	---	---	None	---	---	---	---	None	0.02
7	2.23	0.3	---	---	---	---	---	---	None	0.02	0.01
9	2.01	0.94	---	1.4	---	---	---	0.01	---	0.06	0.05
10	---	---	---	---	---	---	0.04	0.05	0.03	---	---
11	2.03	1.64	---	---	---	---	0.02	---	0.10	0.10	0.01
12	2.25	0.47	---	---	---	---	---	None	---	0.01	0.01

POKER BAR STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 210 cfs	329 cfs	431 cfs	533 cfs	Difference (measured vs. pred. WSELs) 210 cfs	329 cfs	431 cfs	533 cfs	780 cfs
1	3.27	4.61	6.7	2.8	5.5	3.5	0.02	0.05	0.03	0.06	---
2	4.89	5.57	9.0	2.3	5.3	5.6	0.02	0.04	0.04	0.06	---
3	---	---	---	---	---	---	0.03	0.17	---	0.17	---
4	---	---	---	---	---	---	0.06	---	---	0.10	0.16
5	---	---	---	---	---	---	---	---	---	0.14	---
6	---	---	---	---	---	---	---	---	---	0.05	---

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 533 cfs	780 cfs	2001 cfs	Difference (measured vs. pred. WSELs) 533 cfs	780 cfs	2001 cfs	2087 cfs	5021 cfs	6684 cfs
1	2.27	0.35	0.4	0.4	---	None	0.01	---	---	0.01	0.01
2	2.58	2.17	3.2	4.0	---	0.04	0.07	---	---	0.04	0.01
3	2.62	3.96	3.9	5.7	2.1	0.05	0.09	0.05	---	---	---
3	---	---	---	---	---	---	None	0.07	---	0.05	---
3	2.58	0.98	---	---	0.4	---	---	0.01	---	0.05	0.04
4	2.76	1.25	---	1.9	---	---	None	---	---	0.06	0.05
6	2.52	1.72	0.3	---	---	None	---	---	---	0.08	0.08
7	---	---	---	---	---	0.01	---	---	None	---	---
7	2.23	1.84	---	---	---	---	---	---	0.03	0.09	0.06
8	---	---	---	---	---	0.06	---	---	---	---	None
9	1.90	0.84	0.1	---	---	None	---	---	---	0.05	0.05
10	2.45	0.13	0.2	---	---	None	---	---	---	0.01	0.01

STEELBRIDGE STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 233 cfs	356 cfs	460 cfs	550 cfs	761 cfs	Difference (measured vs. pred. WSELs) 233 cfs	356 cfs	460 cfs	550 cfs	761 cfs
1	3.22	0.21	0.3	---	---	0.1	0.2	None	---	---	None	None
2	4.20	1.18	---	0.9	0.8	1.8	---	---	0.01	0.01	0.01	---
3	---	---	---	---	---	---	---	---	0.09	---	None	---
4	---	---	---	---	---	---	---	None	None	---	None	---
5	---	---	---	---	---	---	---	0.01	None	---	None	---
6	---	---	---	---	---	---	---	---	---	---	0.04	---
7	4.37	2.88	---	1.9	2.4	4.4	---	---	0.04	0.07	0.03	---
11	---	---	---	---	---	---	---	---	---	---	0.04	---
12	---	---	---	---	---	---	---	---	---	---	0.10	None

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 550 cfs	761 cfs	1941 cfs	2727 cfs	Difference (measured vs. pred. WSELs) 550 cfs	761 cfs	1941 cfs	2727 cfs	5099 cfs	6684 cfs
1	2.93	2.29	---	1.1	3.5	2.4	---	0.02	0.08	0.06	---	---
1	3.37	3.61	---	---	---	2.1	---	---	---	0.05	0.15	0.10
2	2.44	0.8	0.1	---	---	---	None	---	---	---	0.04	0.04
3	2.41	0.72	0.1	---	---	---	None	---	---	0.01	0.05	0.04
4	2.31	2.84	2.2	3.0	---	---	0.03	0.04	---	---	0.11	0.09
5	2.56	2.12	---	0.5	---	---	---	0.01	---	---	0.09	0.09
6	3.87	4.28	---	3.7	5.6	---	---	0.07	0.10	---	0.10	0.16
7	4.20	1.43	---	0.3	---	---	---	0.01	---	---	0.06	0.06
11	3.67	2.7	0.6	---	---	---	0.01	---	---	---	0.11	0.11
12	4.41	5.49	---	1.6	---	---	---	0.02	---	---	0.18	0.16

STEINER FLAT STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 274 cfs	326 cfs	431 cfs	505 cfs	Difference (measured vs. pred. WSELs) 274 cfs	299 cfs	326 cfs	431 cfs	505 cfs
4	2.3	5.33	---	2.8	5.1	8.4	---	---	0.06	0.10	0.04
10	1.64	1.39	1.4	0.7	---	---	0.03	0.04	0.01	---	---

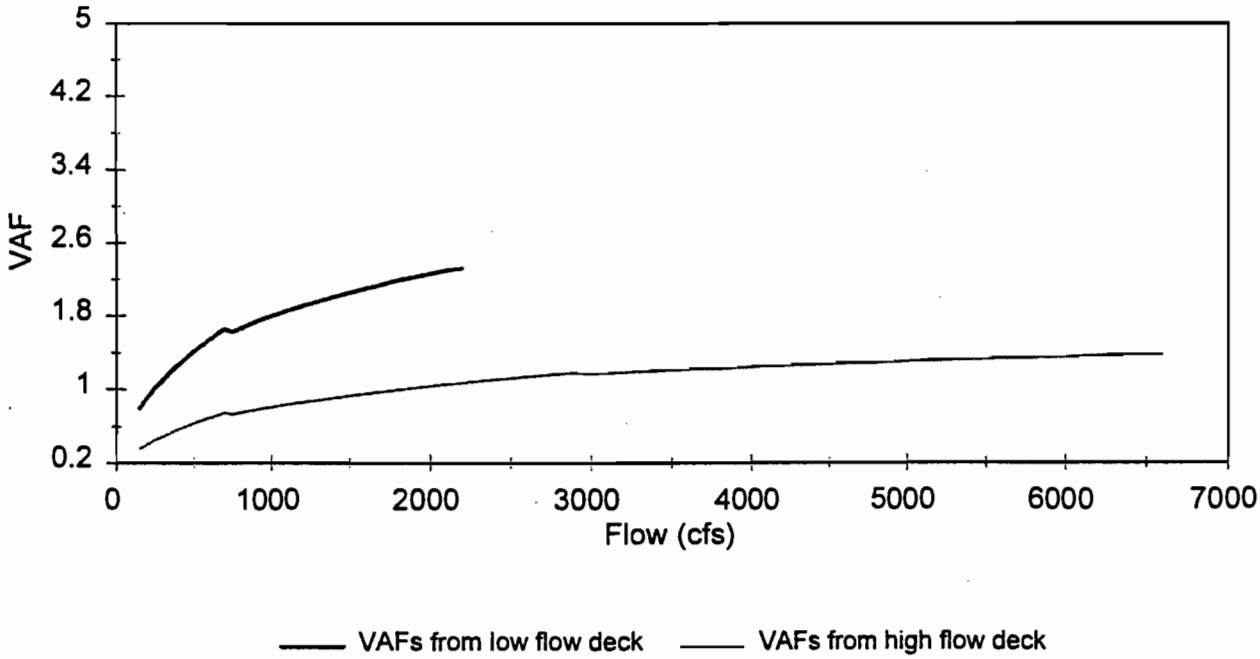
XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 274 cfs	431 cfs	641 cfs	801 cfs	Difference (measured vs. pred. WSELs) 274 cfs	299 cfs	431 cfs	512 cfs	641 cfs	801 cfs
6	2.52	3.76	3.1	6.5	1.0	0.2	0.05	0.07	0.01	---	0.03	None
7	---	---	---	---	---	---	---	0.04	---	0.01	0.10	0.08
7	---	---	---	---	---	---	---	---	---	---	None	None
8	3.48	4.2	---	5.9	1.3	0.7	---	0.01	0.05	0.03	0.02	None
9	3.05	1.2	0.2	---	---	---	0.02	0.02	---	0.02	---	---

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 326 cfs	431 cfs	641 cfs	801 cfs	Difference (measured vs. pred. WSELs) 326 cfs	431 cfs	512 cfs	641 cfs	643 cfs	801 cfs
9	2.62	2	---	---	2.0	1.1	---	---	0.03	0.07	0.02	0.02
10	4.69	3.32	4.0	2.8	1.6	---	0.02	0.04	0.01	0.03	---	---

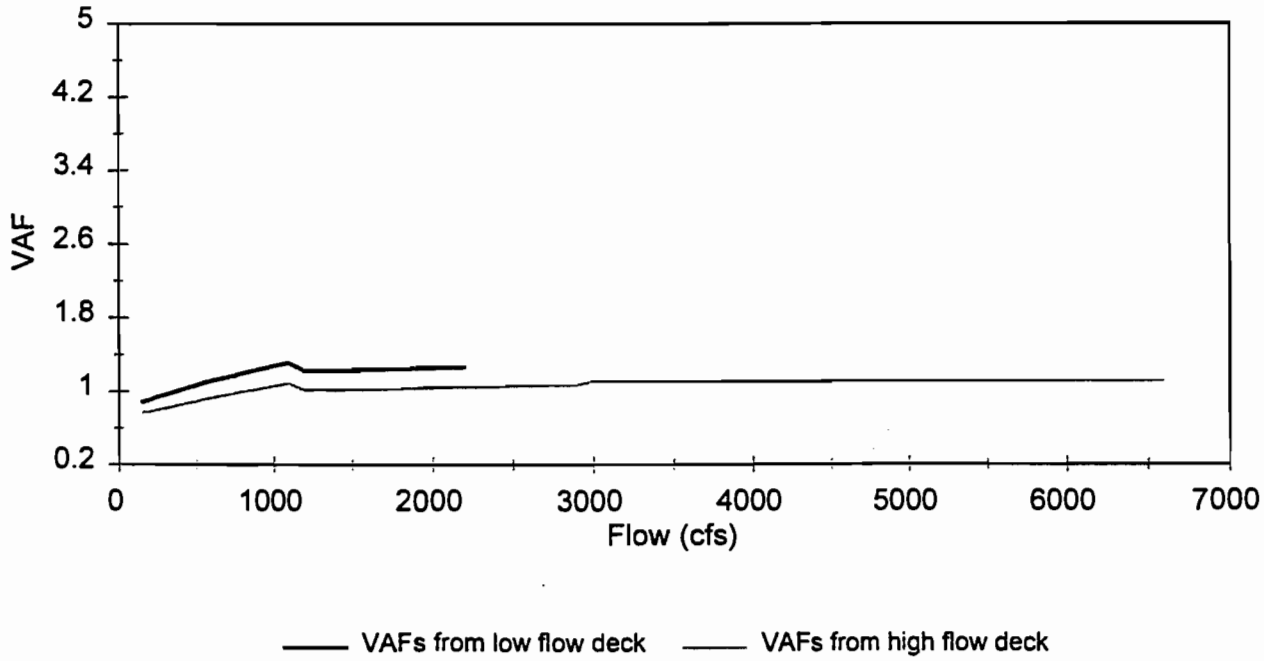
XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 505 cfs	641 cfs	801 cfs	1983 cfs	Difference (measured vs. pred. WSELs) 505 cfs	641 cfs	801 cfs	1983 cfs	5318 cfs
3	---	---	---	---	---	---	None	---	---	---	0.01
4	2.41	6.25	4.6	---	---	9.9	0.06	---	---	0.22	0.18
5	---	---	---	---	---	---	0.05	---	---	---	None
6	1.91	3.2	---	---	2.7	4.9	0.04	---	---	0.12	0.09
8	1.53	3.63	---	---	2.6	5.3	---	---	0.04	0.15	0.14
9	2.15	3.82	---	---	2.7	---	---	---	0.06	0.20	0.16
10	2.2	1.4	---	2.1	1.9	---	---	0.04	0.04	0.03	0.03

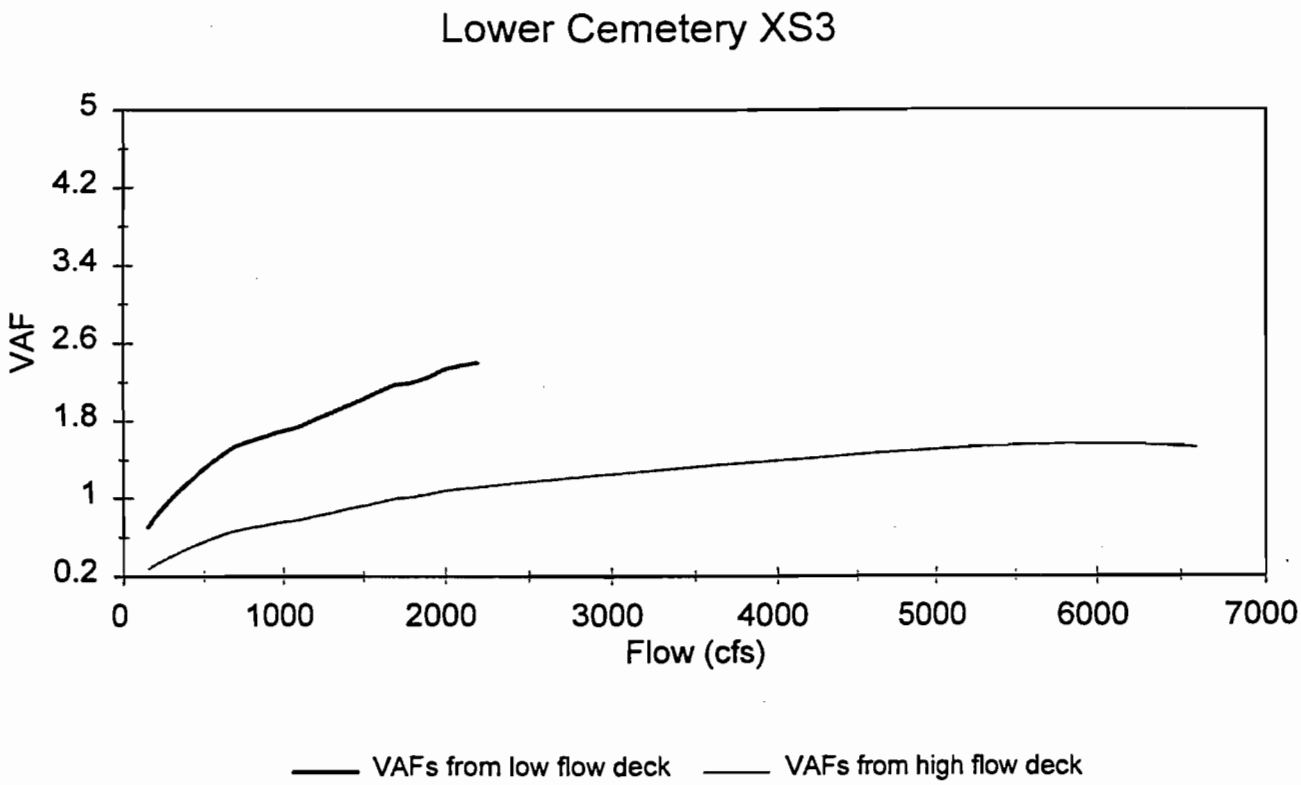
APPENDIX B
VELOCITY CALIBRATION

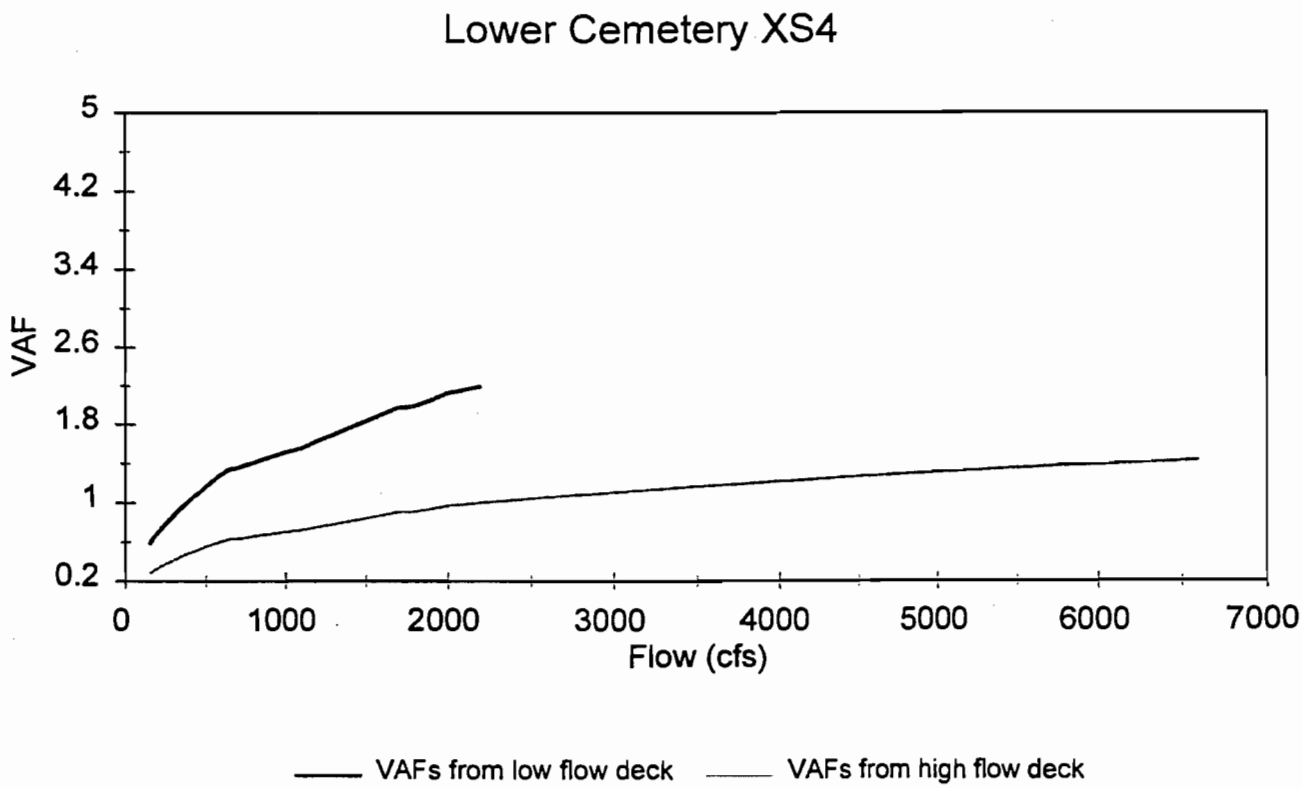
Lower Cemetery XS1

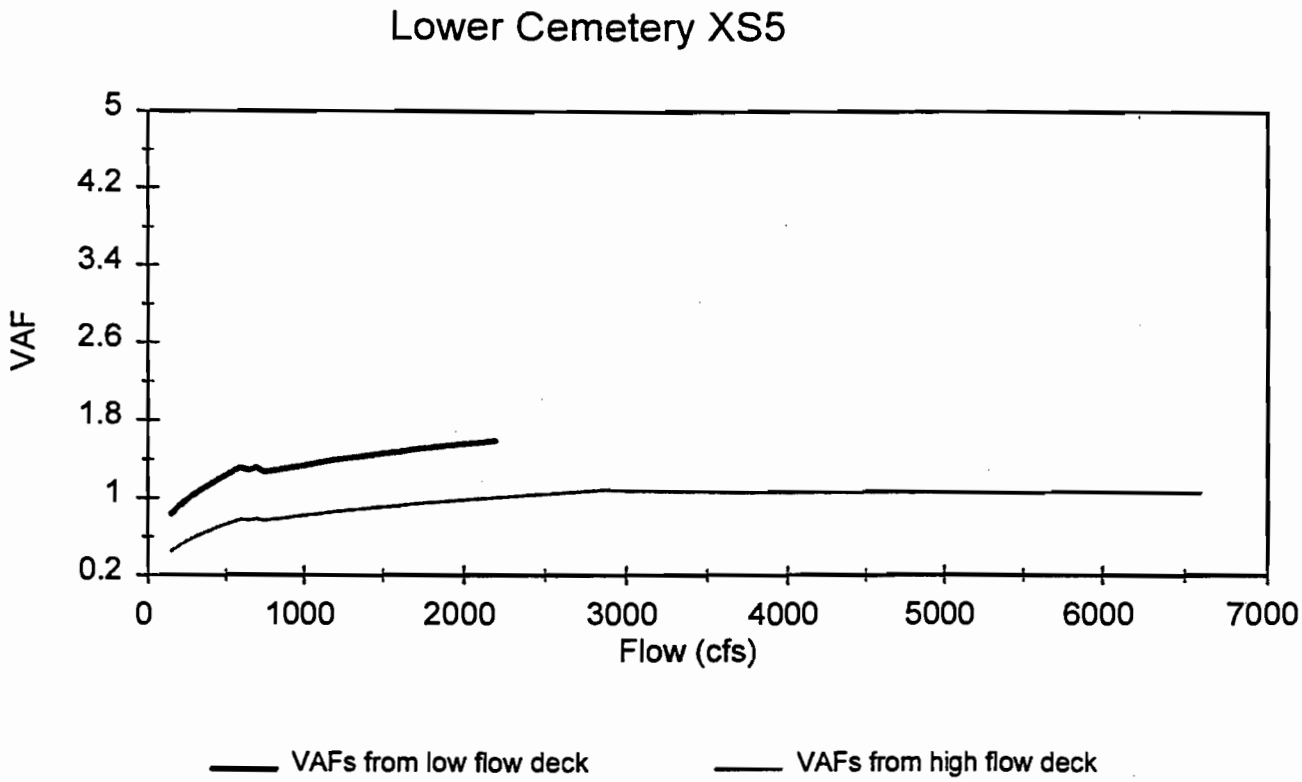


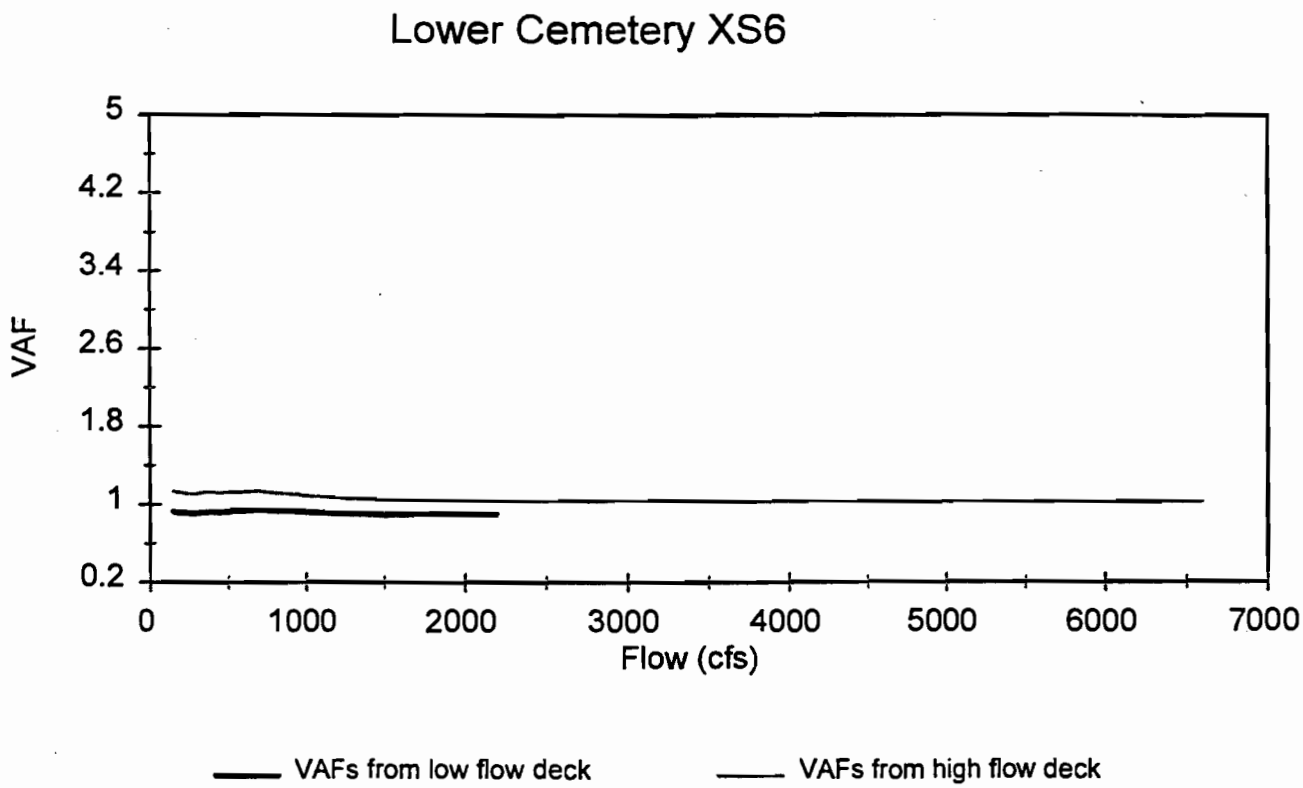
Lower Cemetery XS2



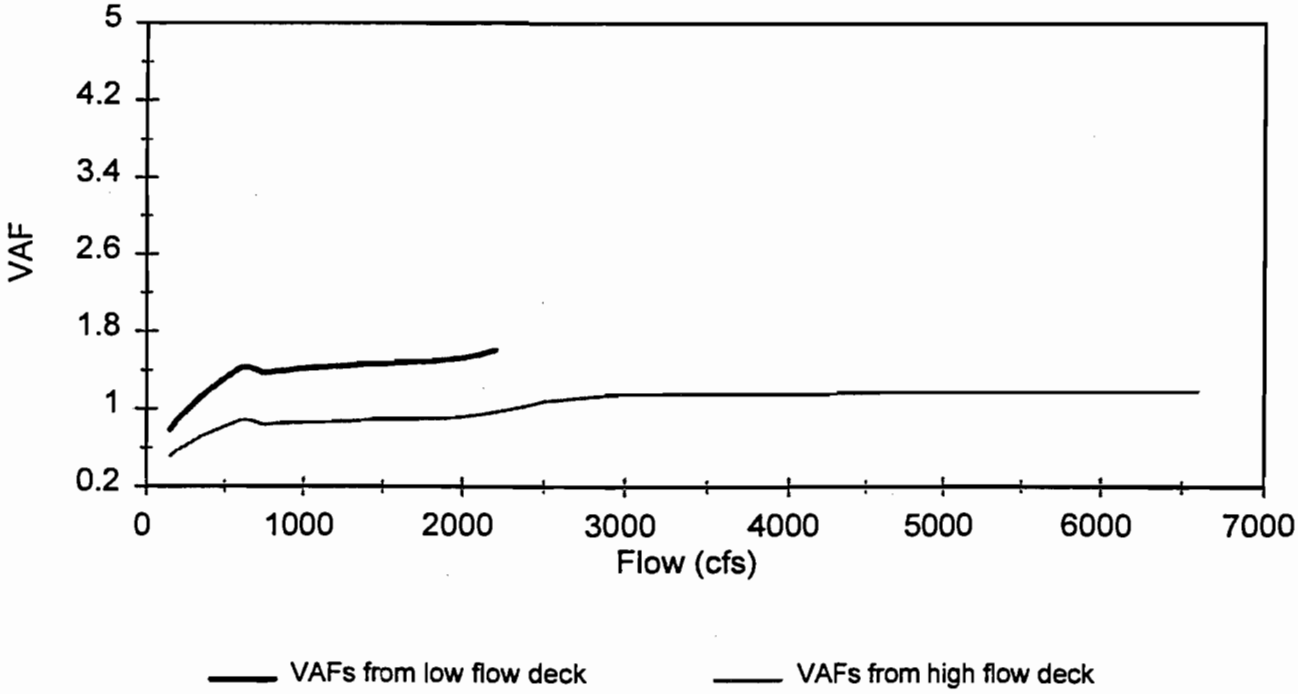

Lower Cemetery XS3
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck


Lower Cemetery XS4
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

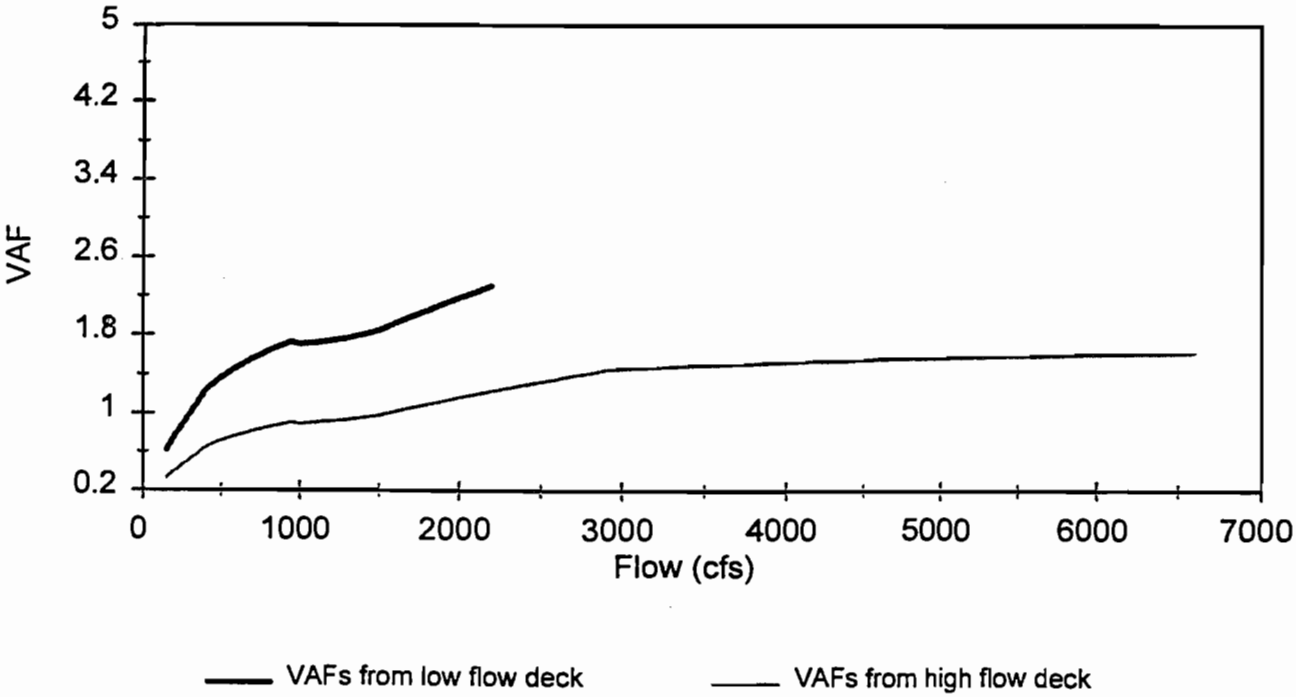

Lower Cemetery XS5
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck


Lower Cemetery XS6
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

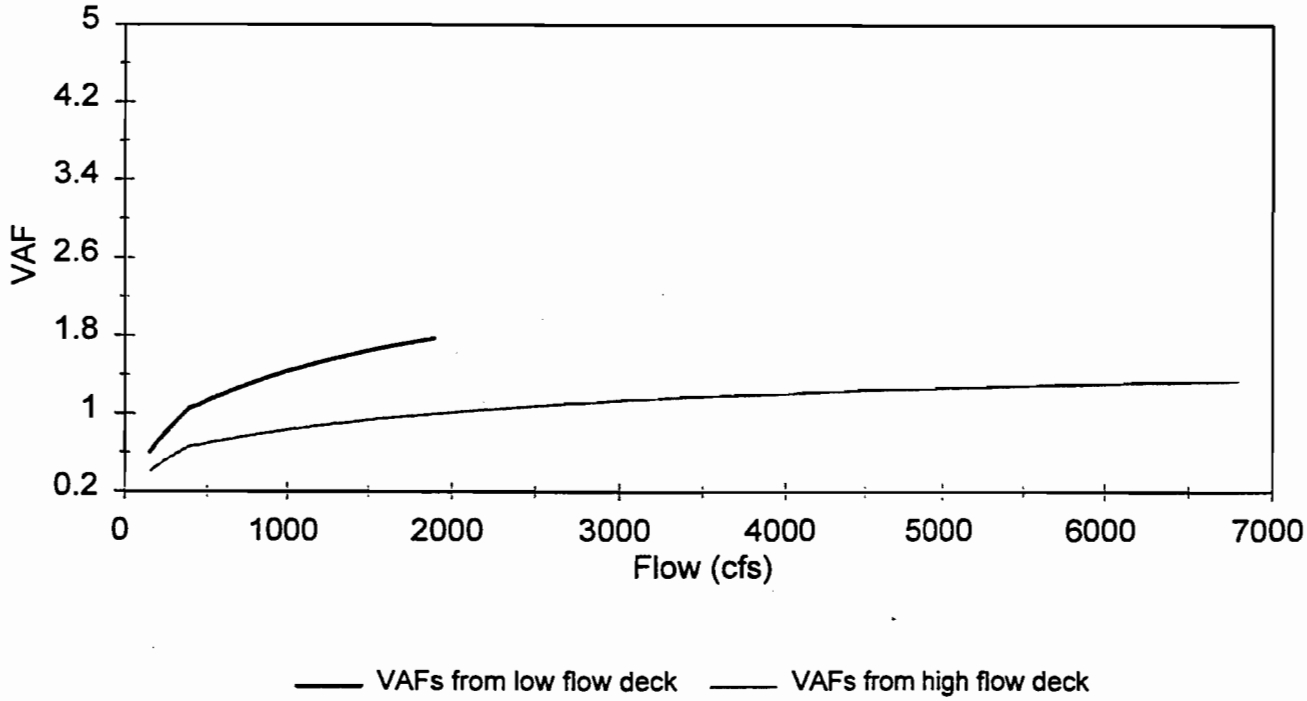
Lower Cemetery XS7



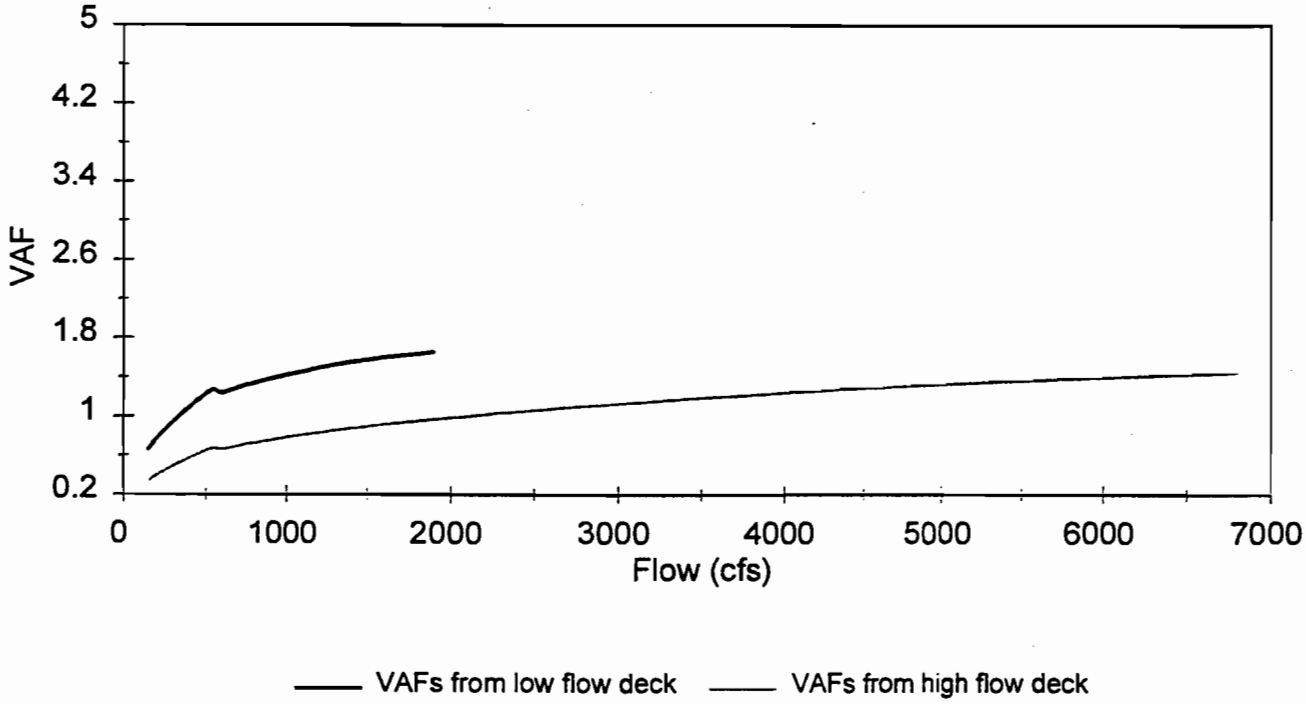
Lower Cemetery XS9

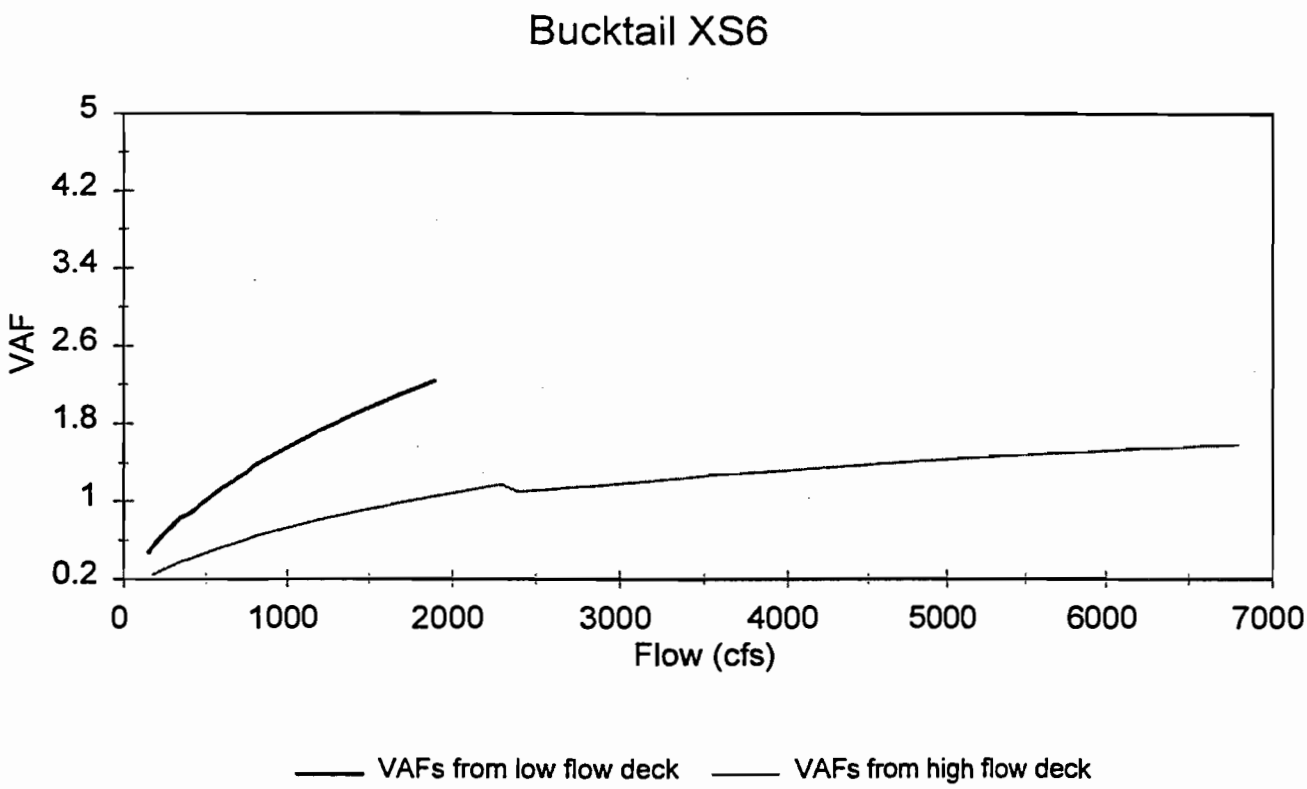


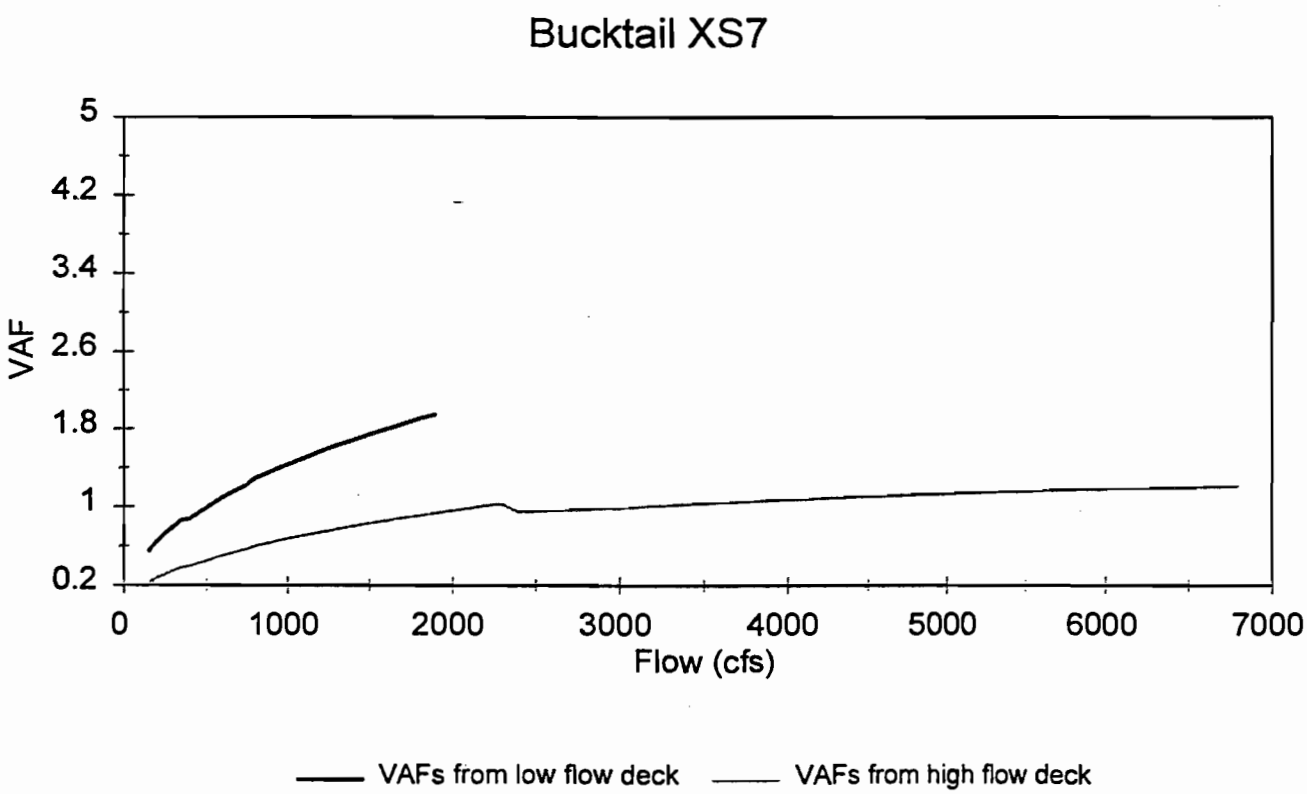
Bucktail XS2



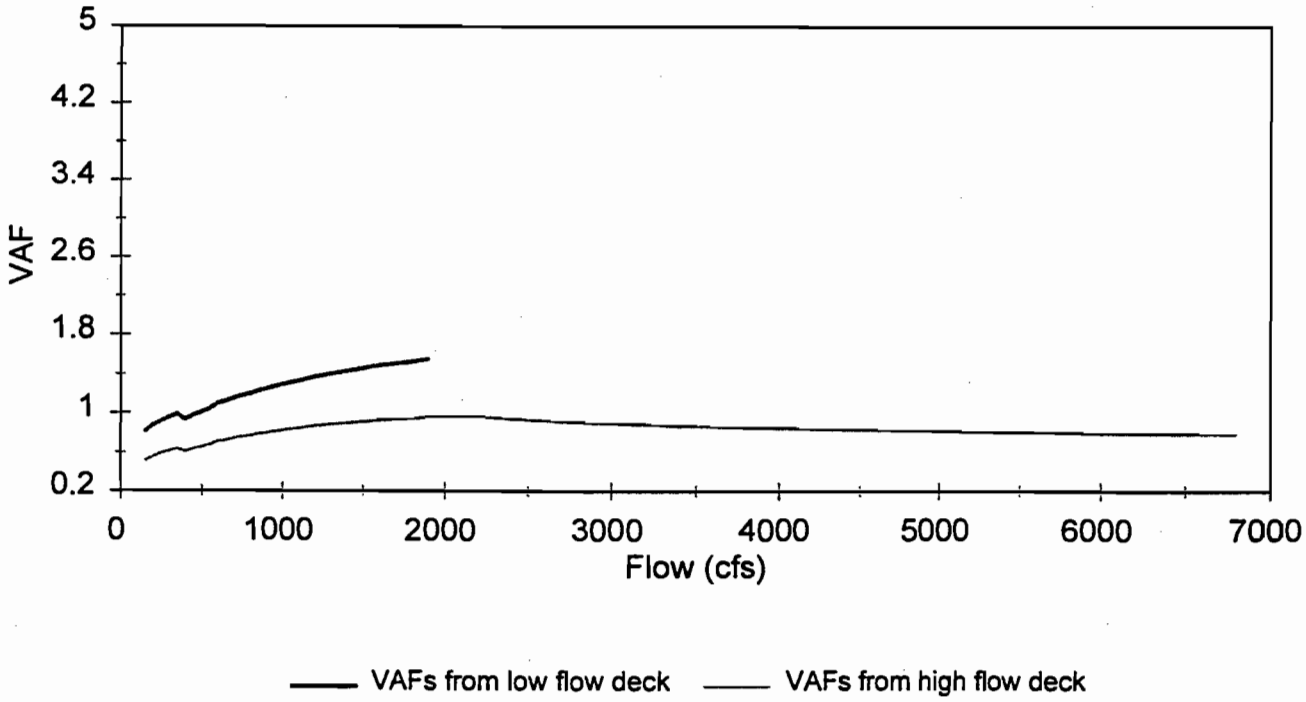
Bucktail XS3



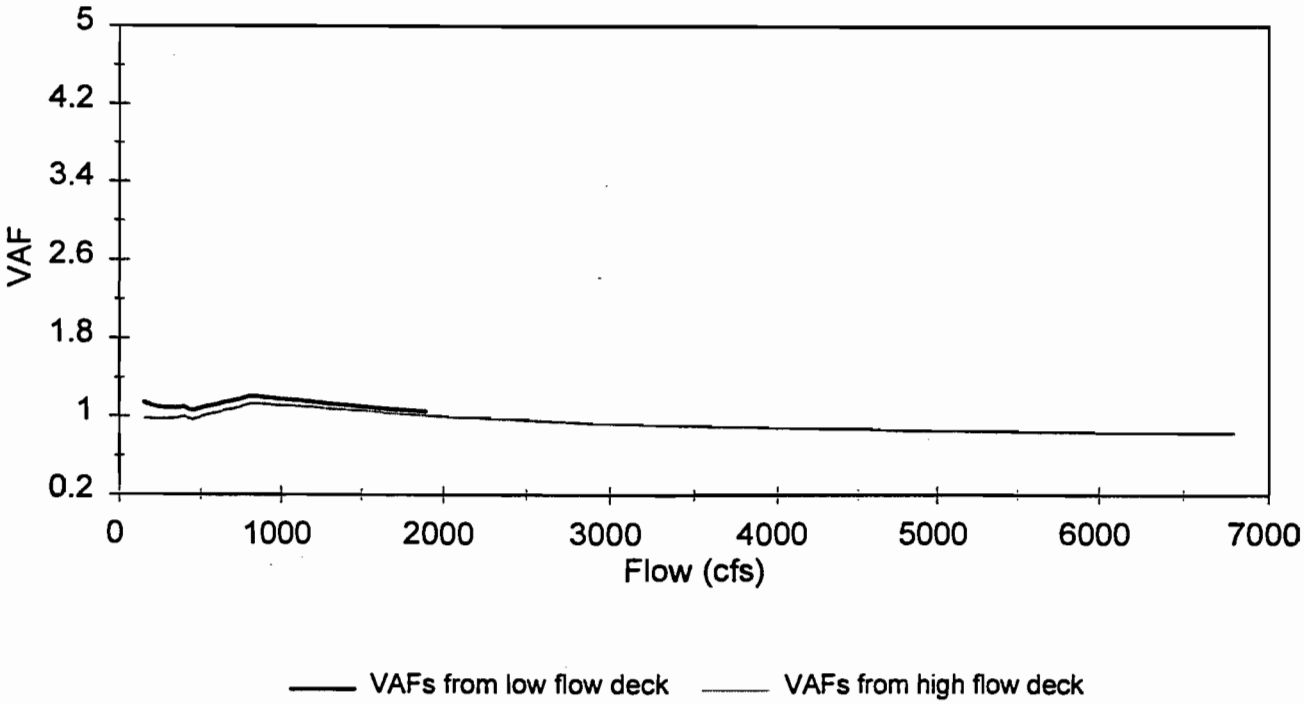

Bucktail XS6
5
4.2
3.4
2.6
1.8
1
0.2
VAF
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck


Bucktail XS7
5
4.2
3.4
2.6
1.8
1
0.2
VAF
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

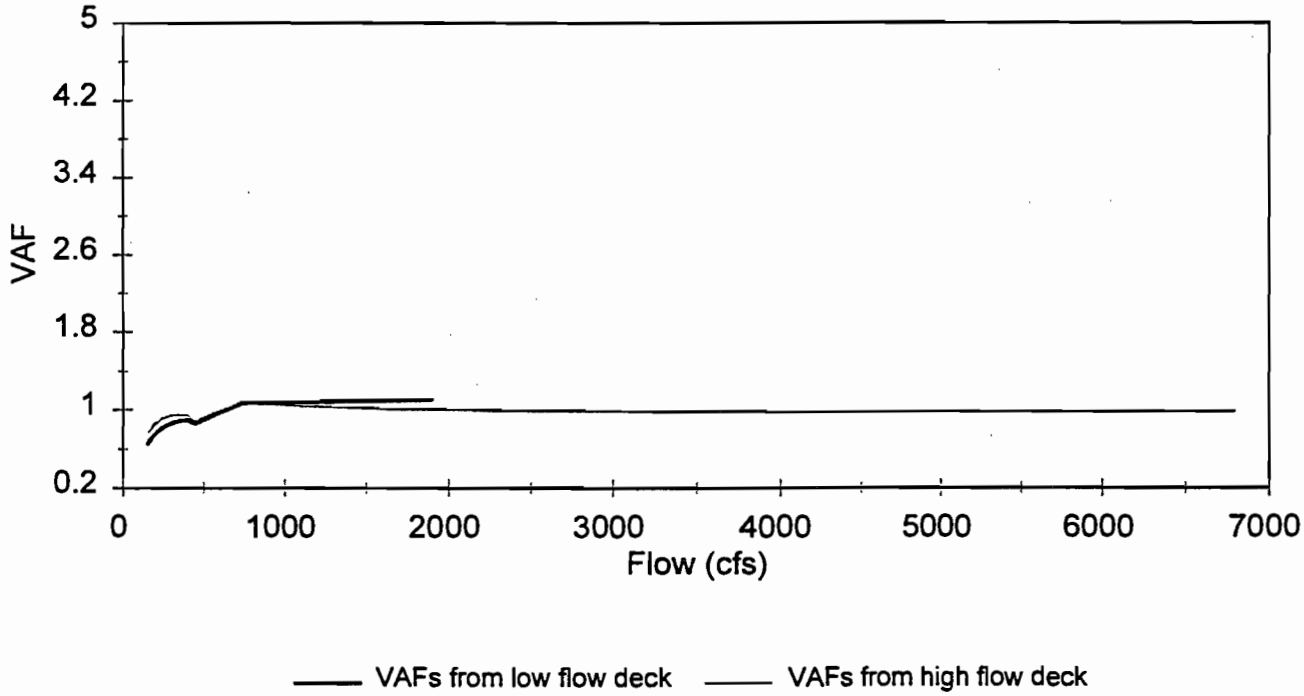
Bucktail XS9



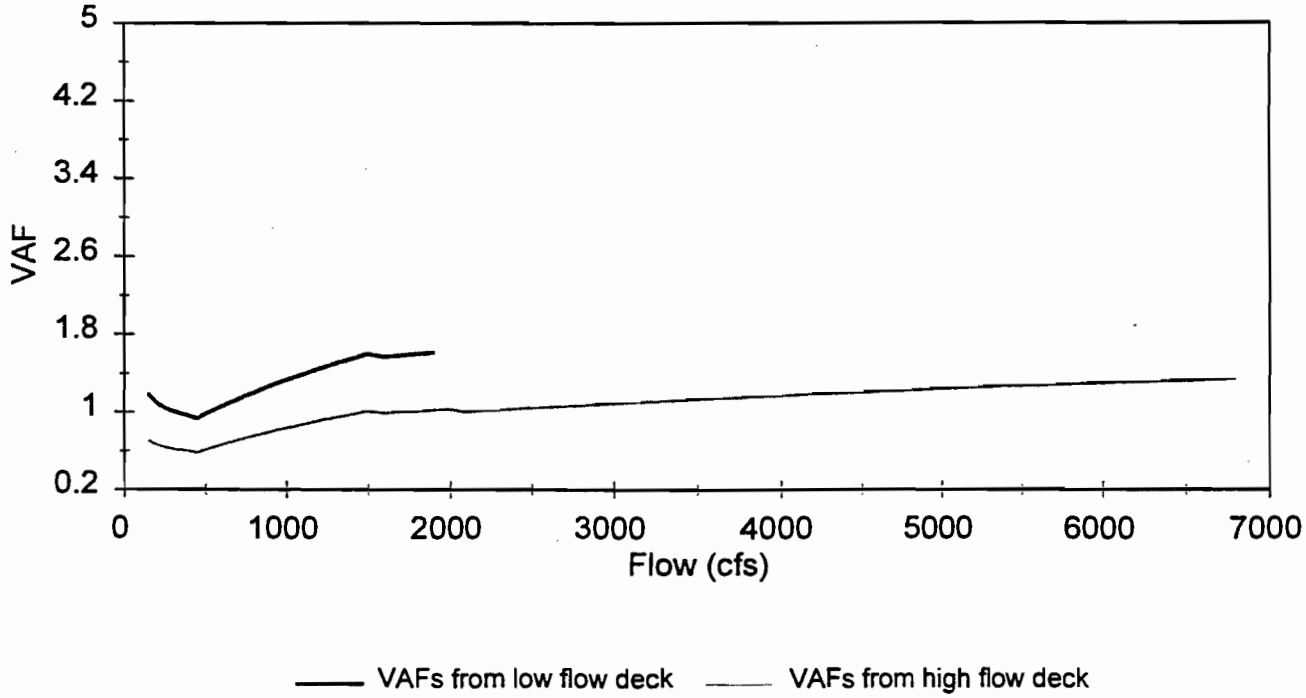
Bucktail XS10



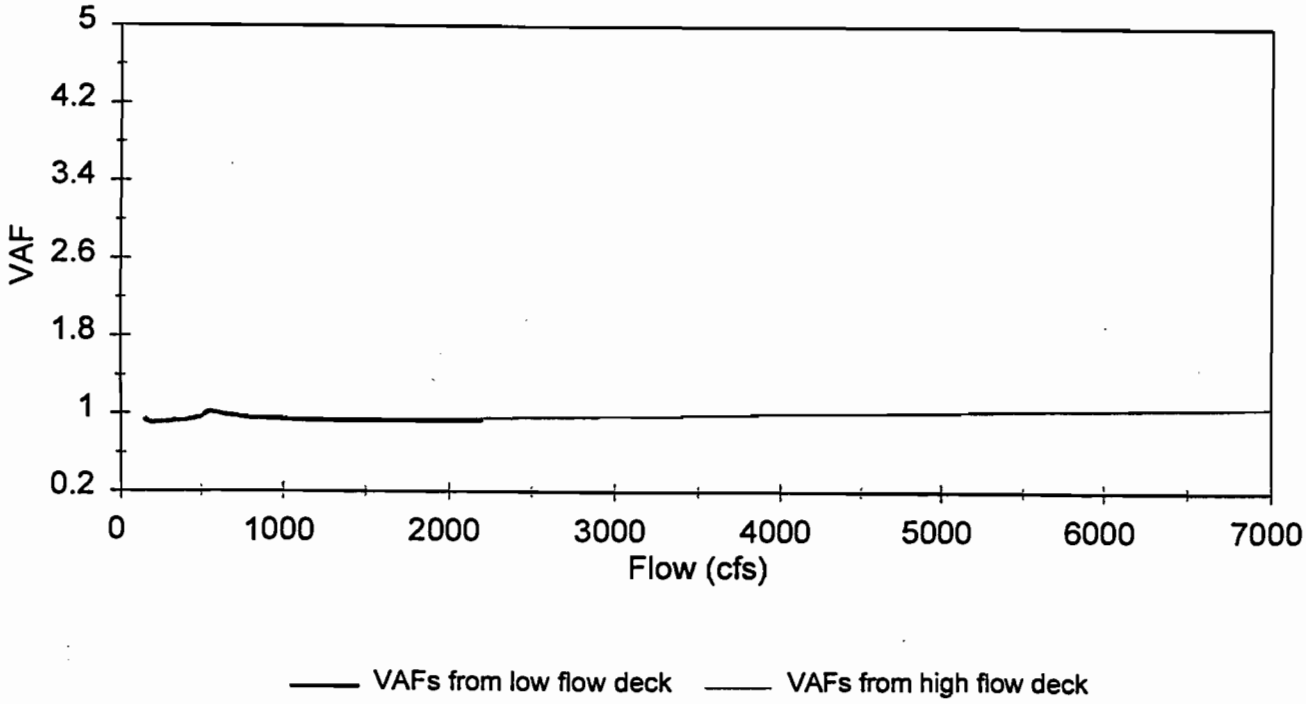
Bucktail XS11



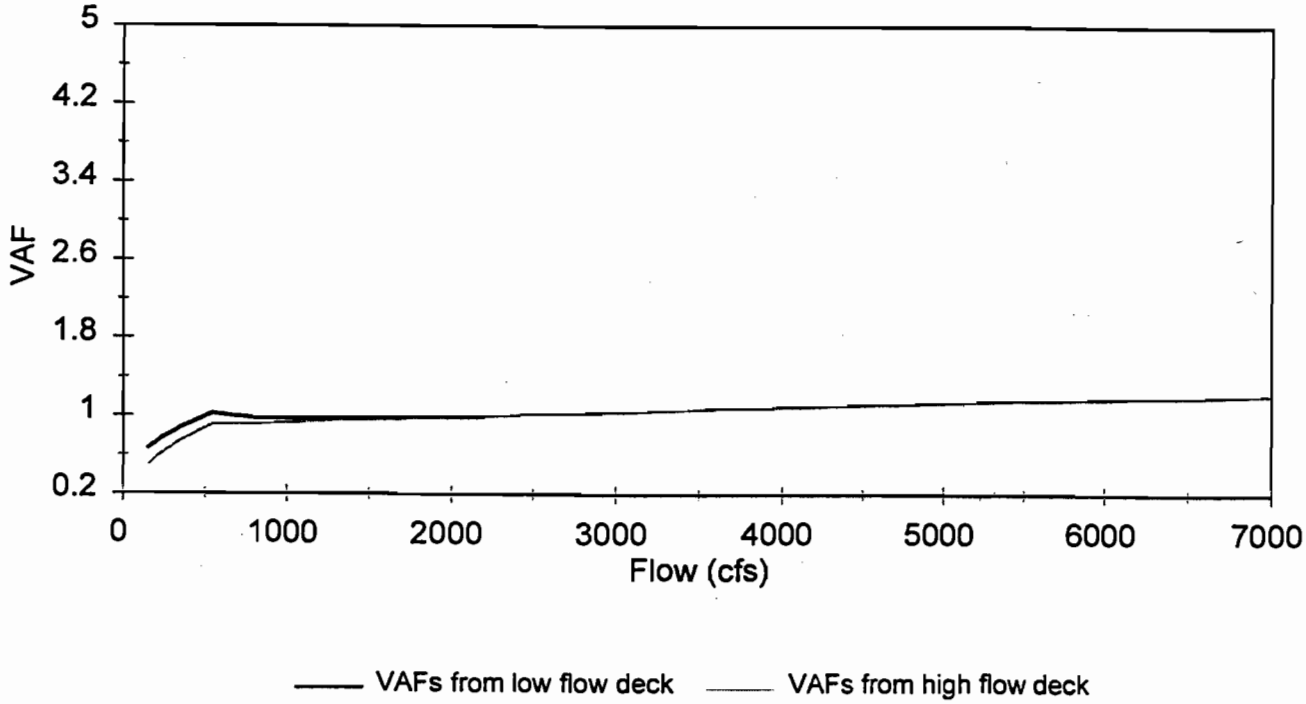
Bucktail XS12

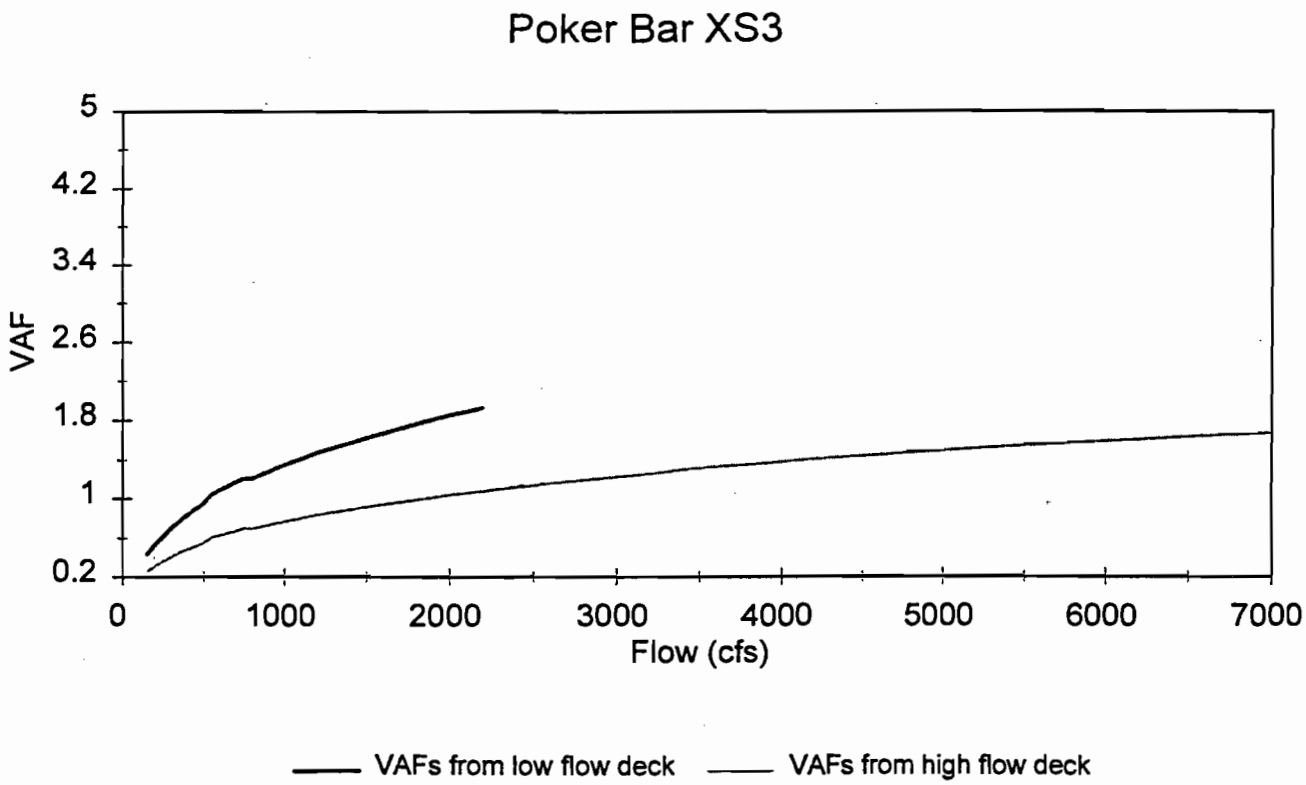


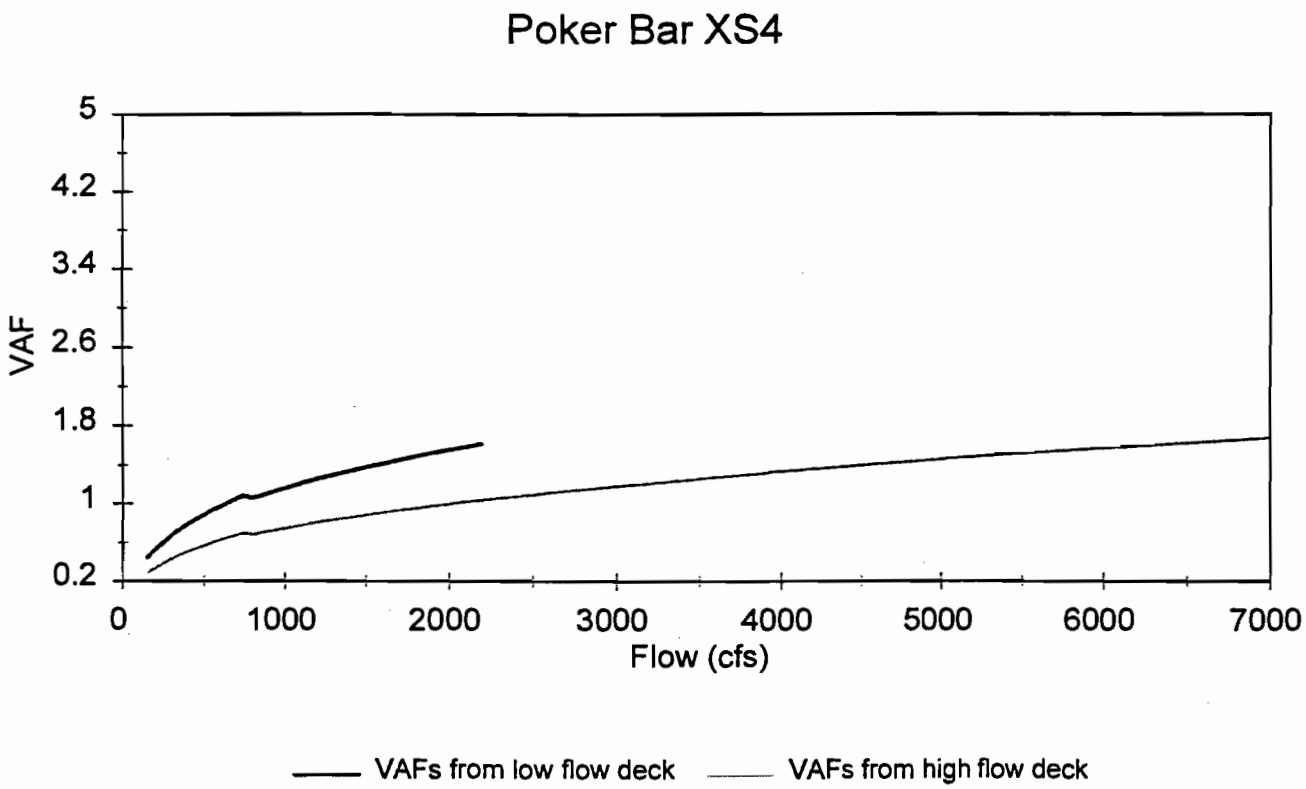
Poker Bar XS1



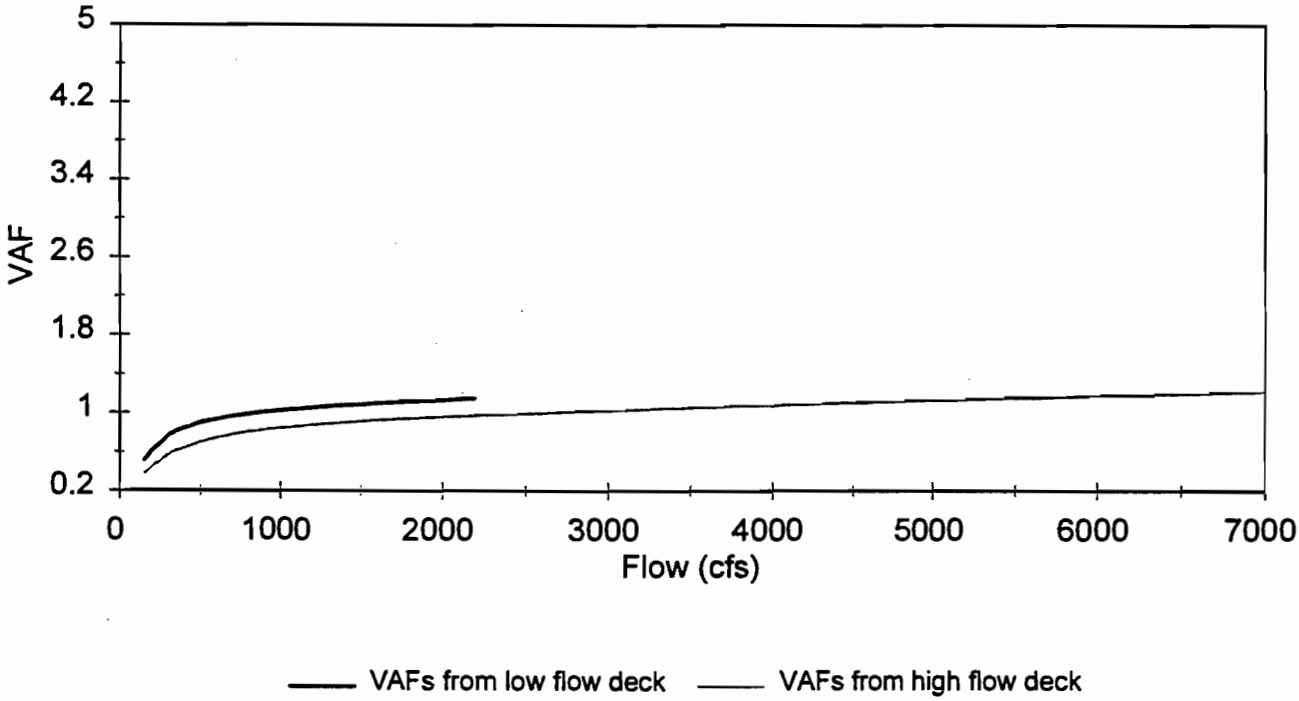
Poker Bar XS2



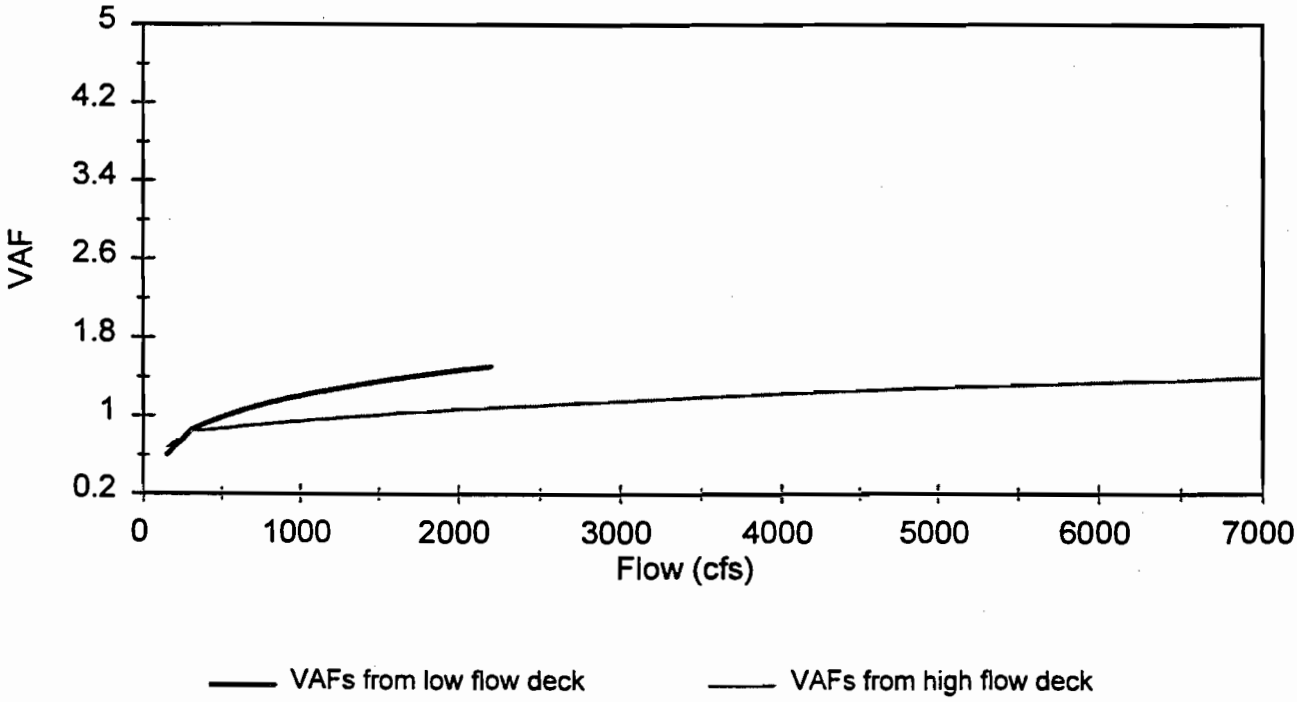

Poker Bar XS3
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

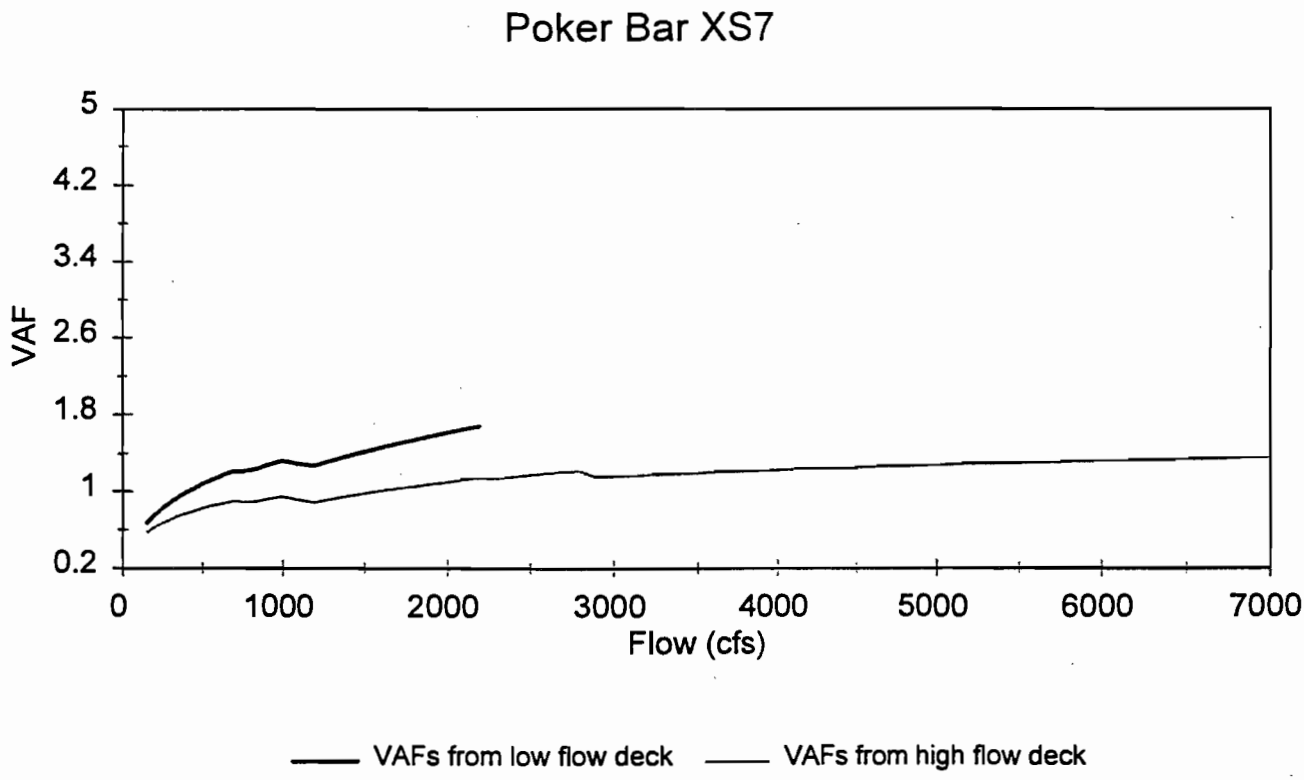

Poker Bar XS4
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

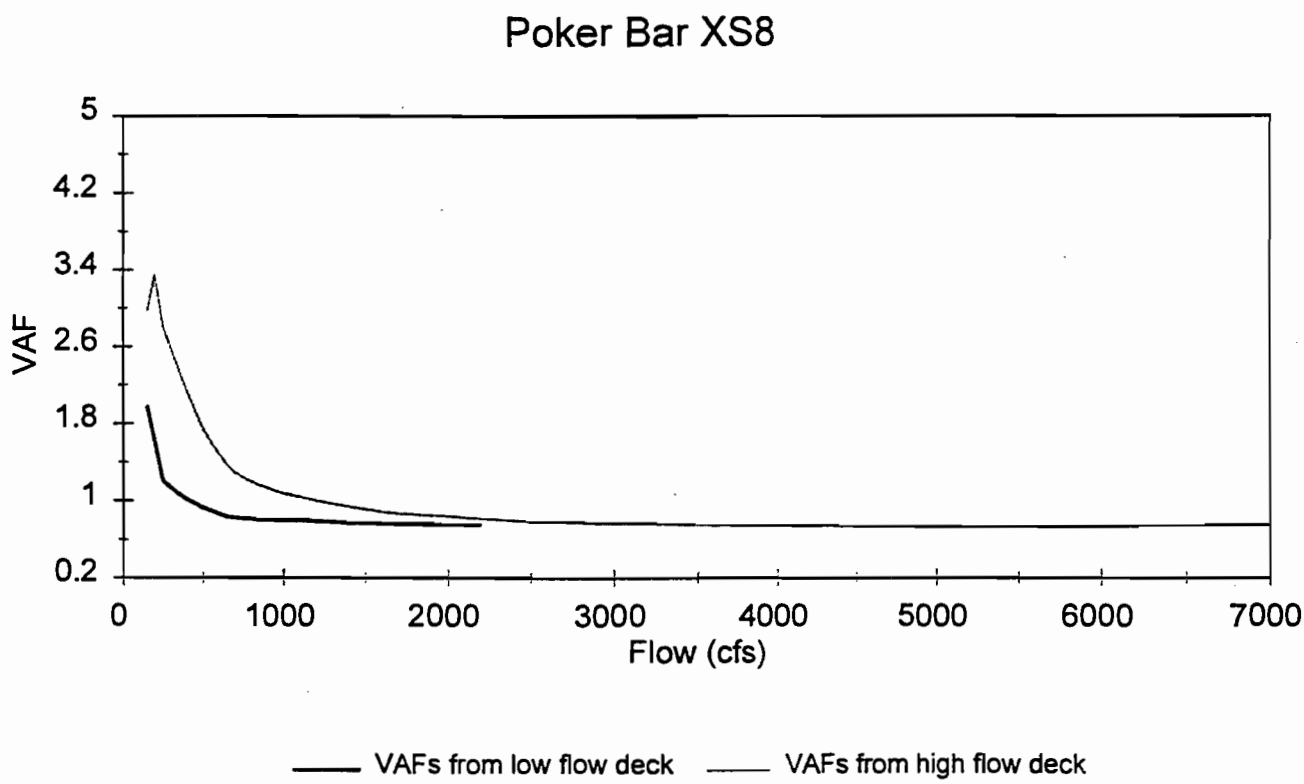
Poker Bar XS5



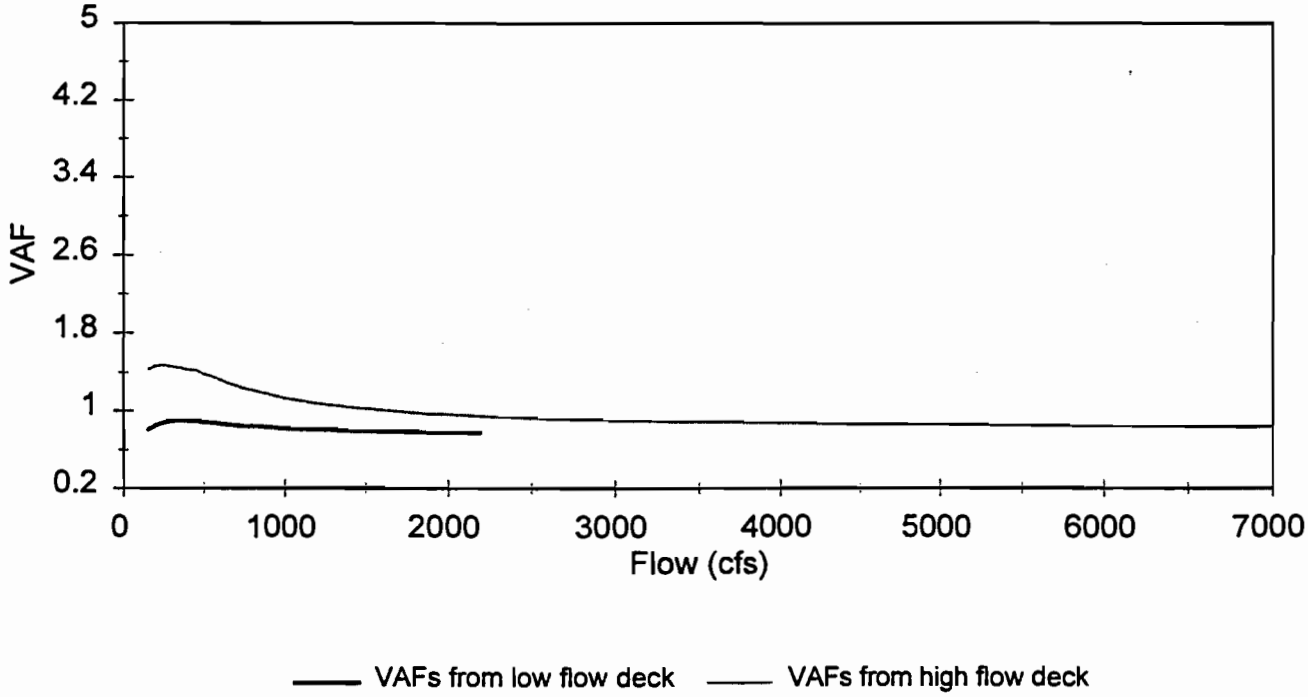
Poker Bar XS6



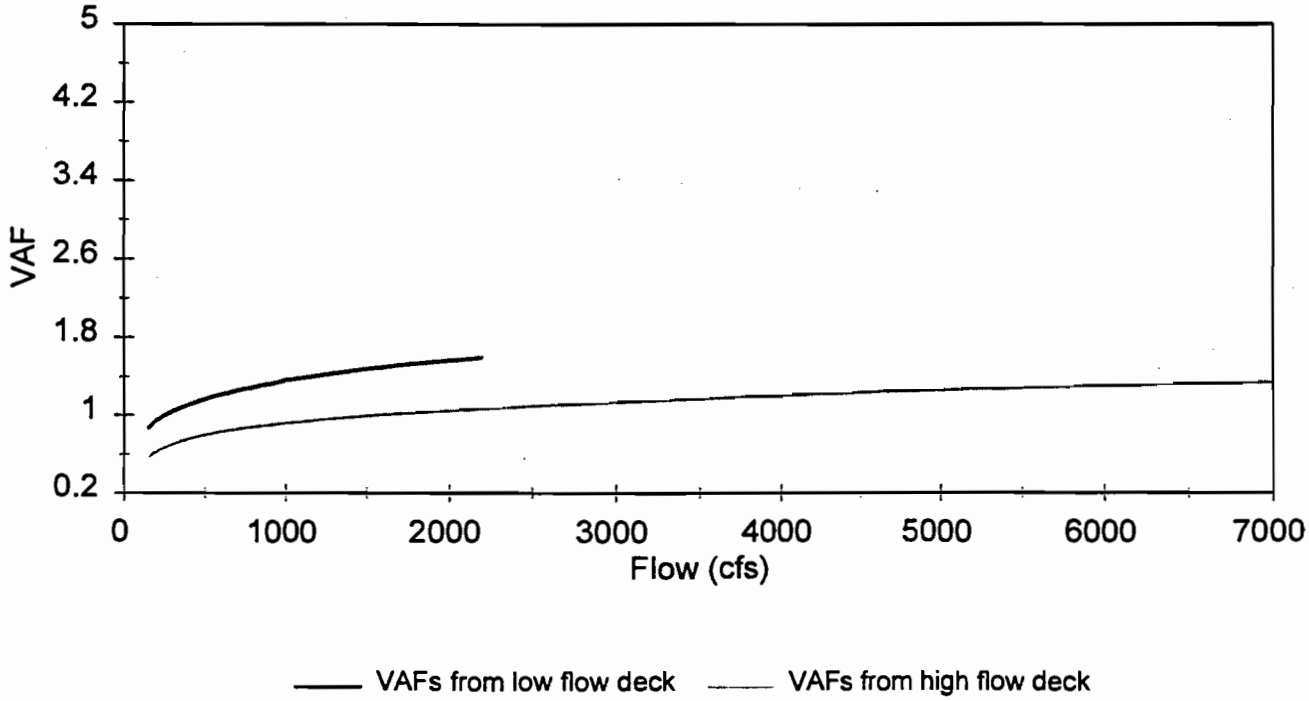

Poker Bar XS7
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

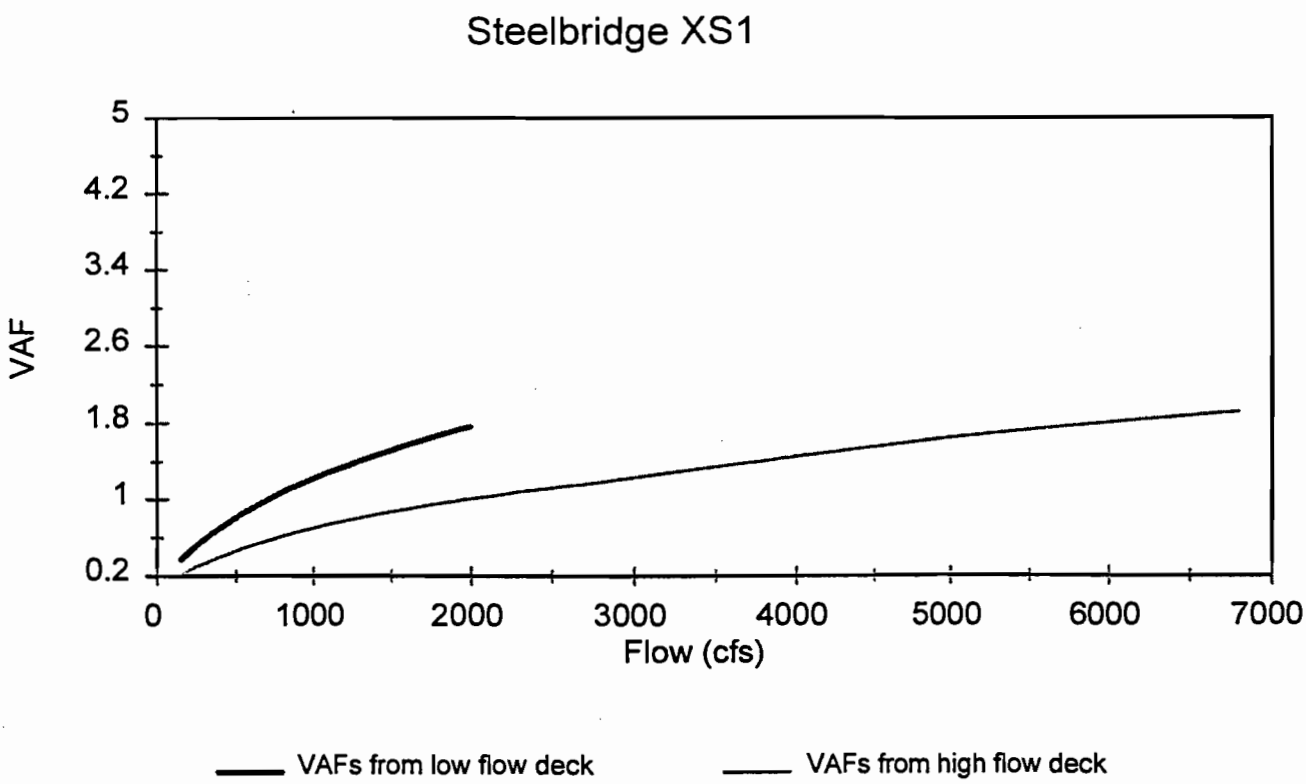

Poker Bar XS8
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

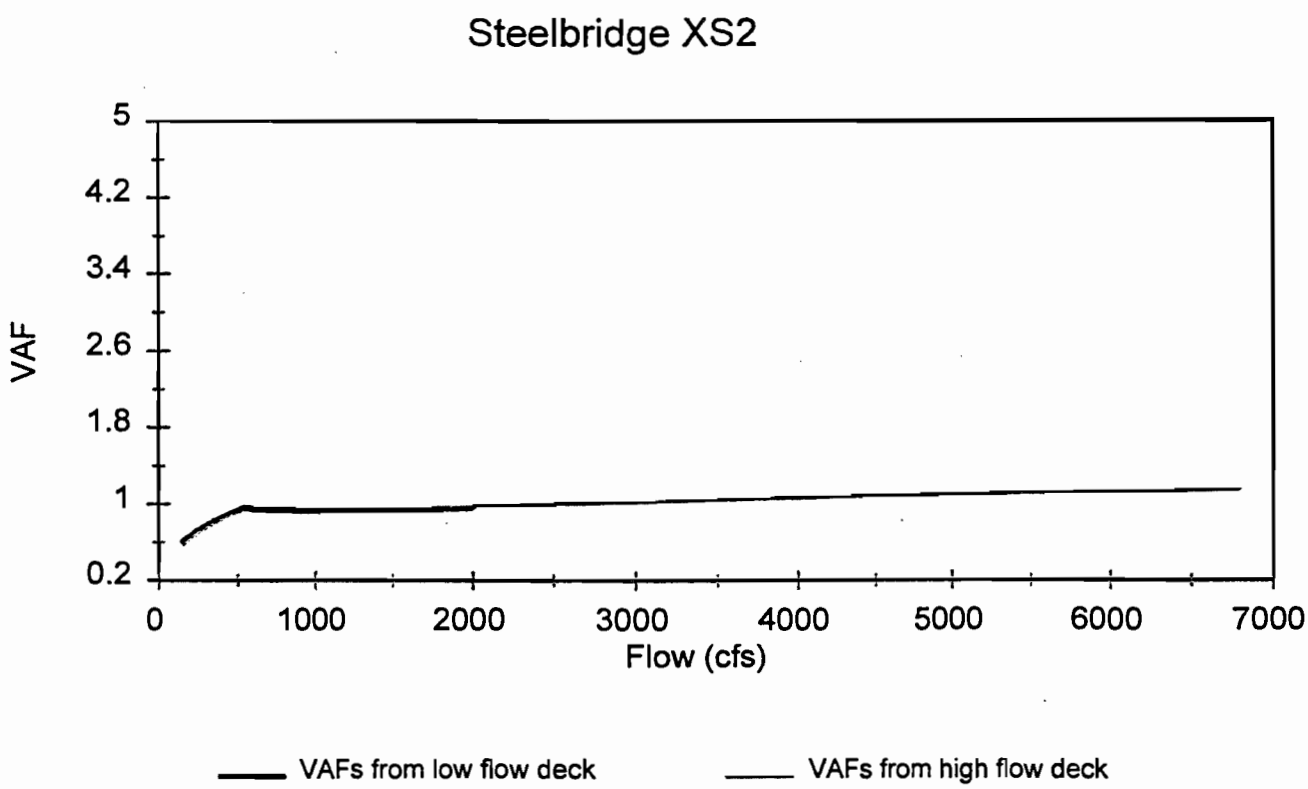
Poker Bar XS9



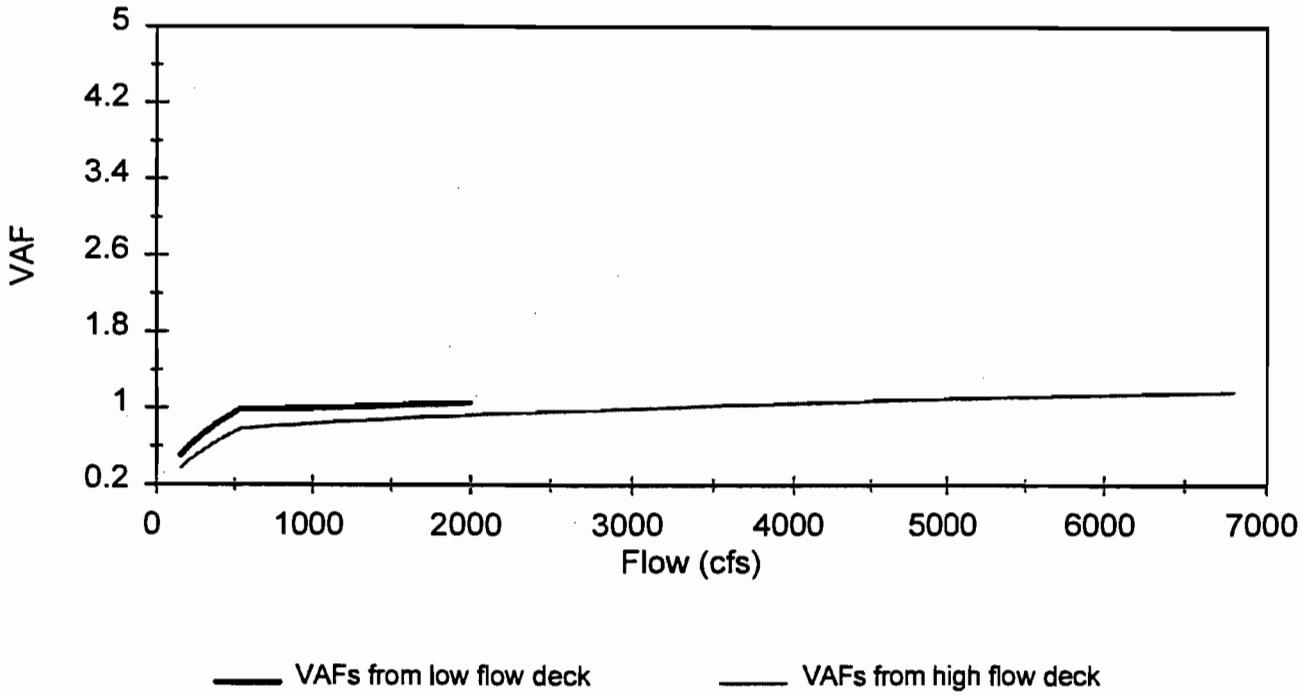
Poker Bar XS10



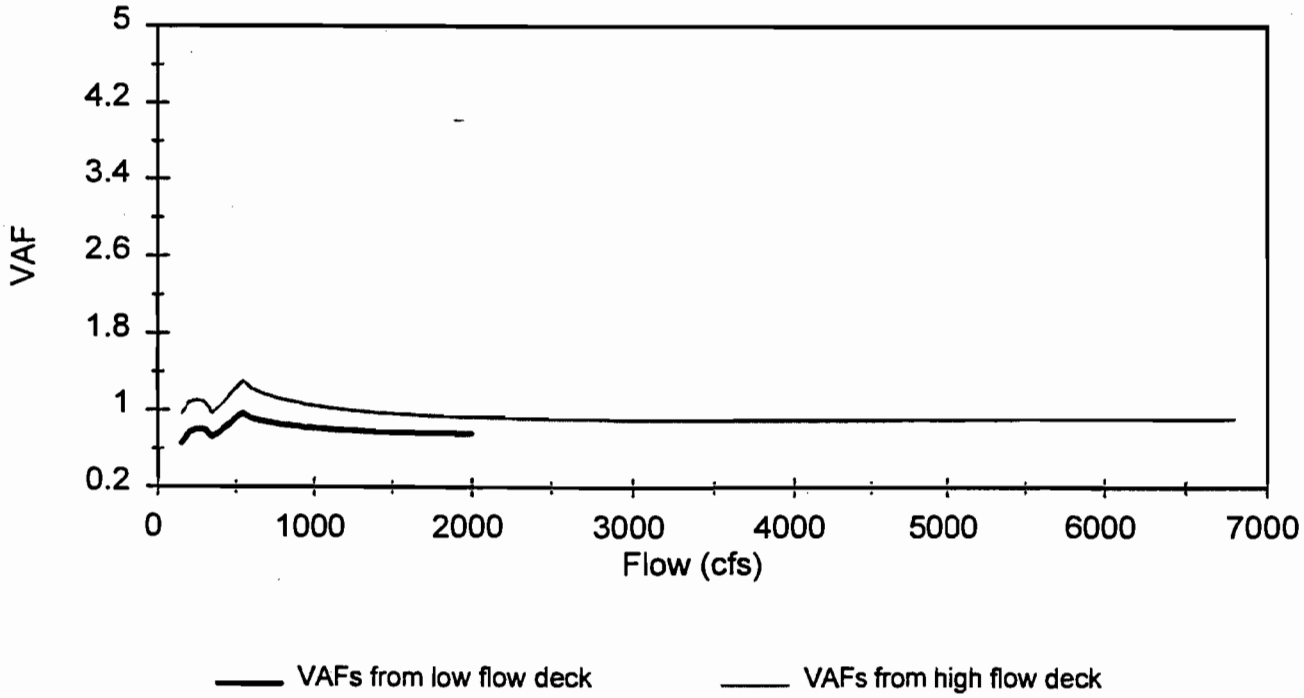

Steelbridge XS1
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

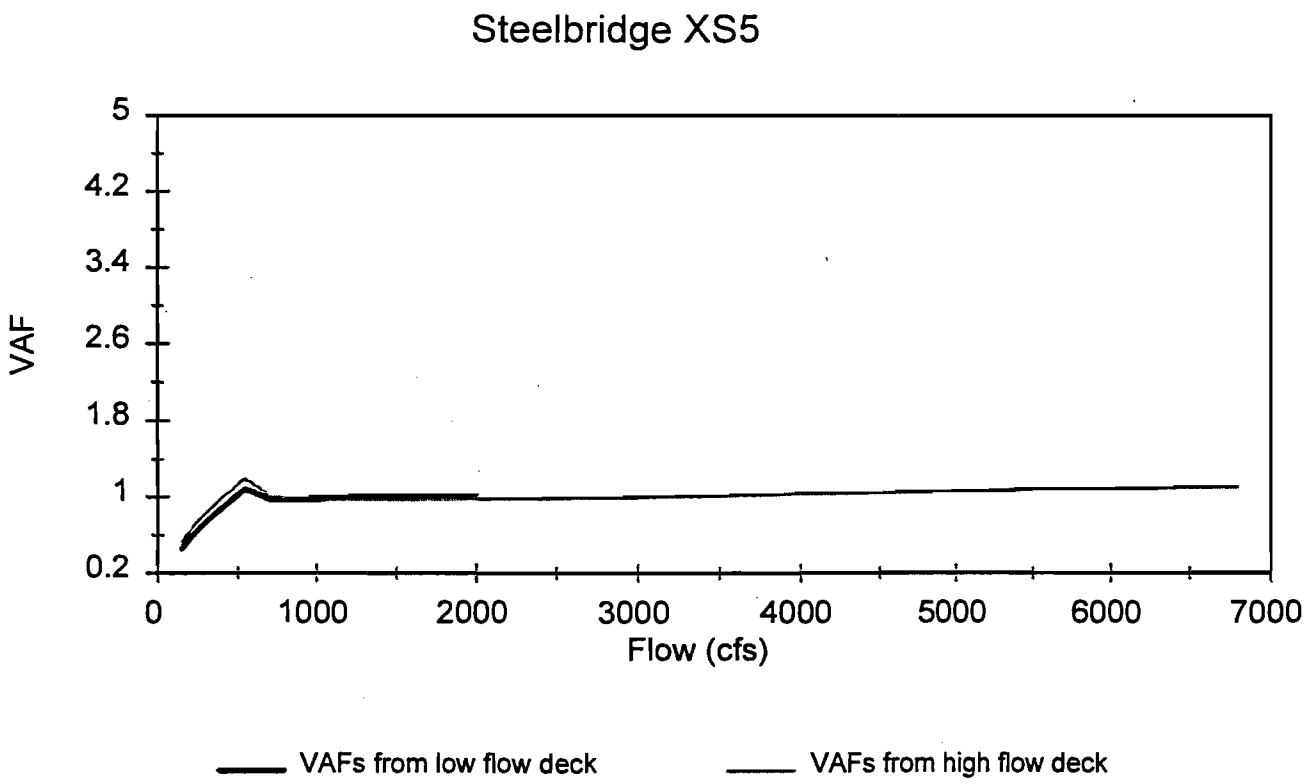

Steelbridge XS2
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

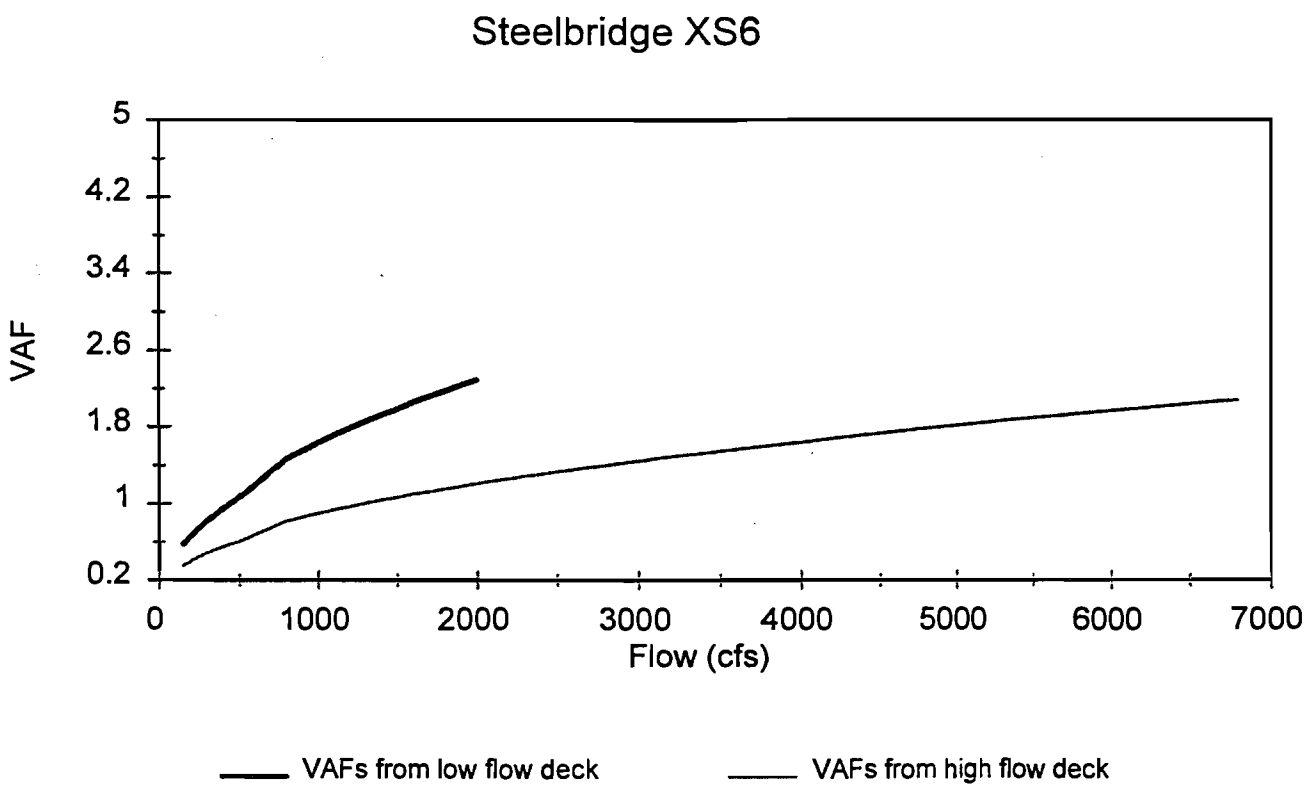
Steelbridge XS3

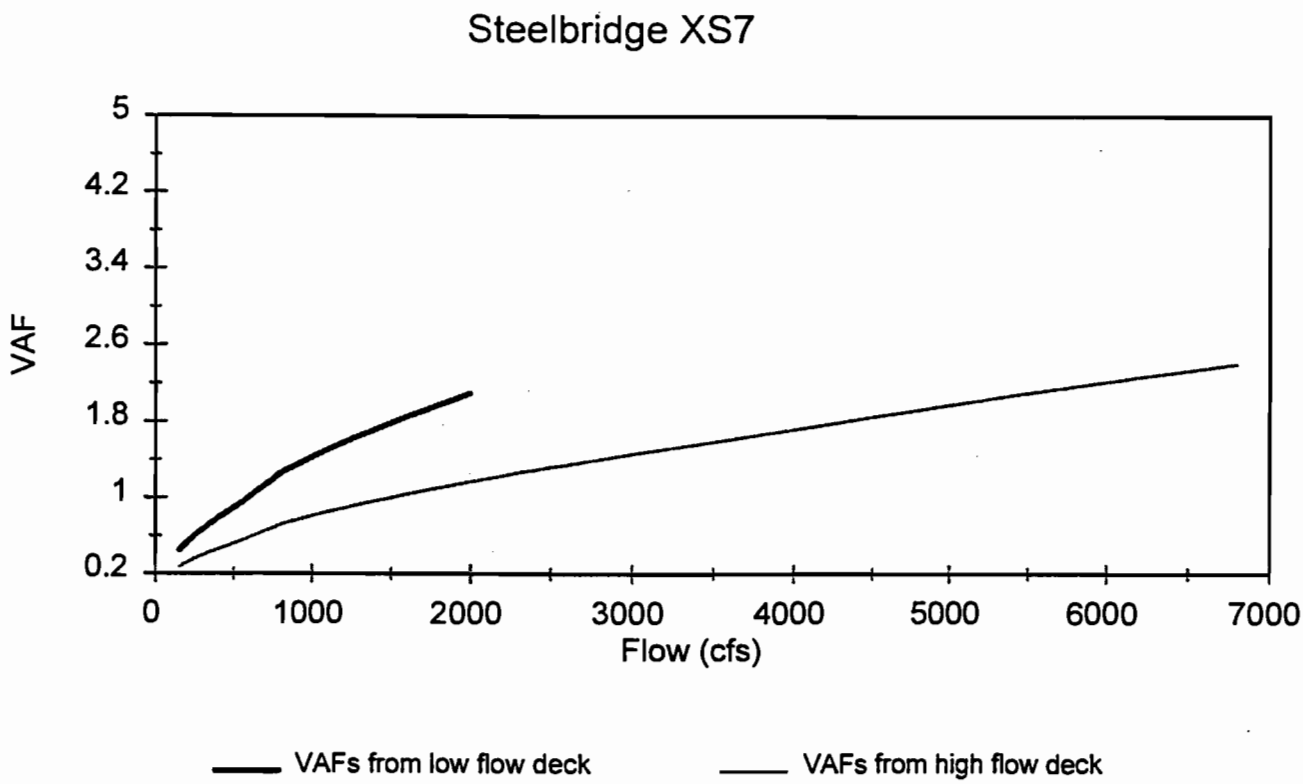


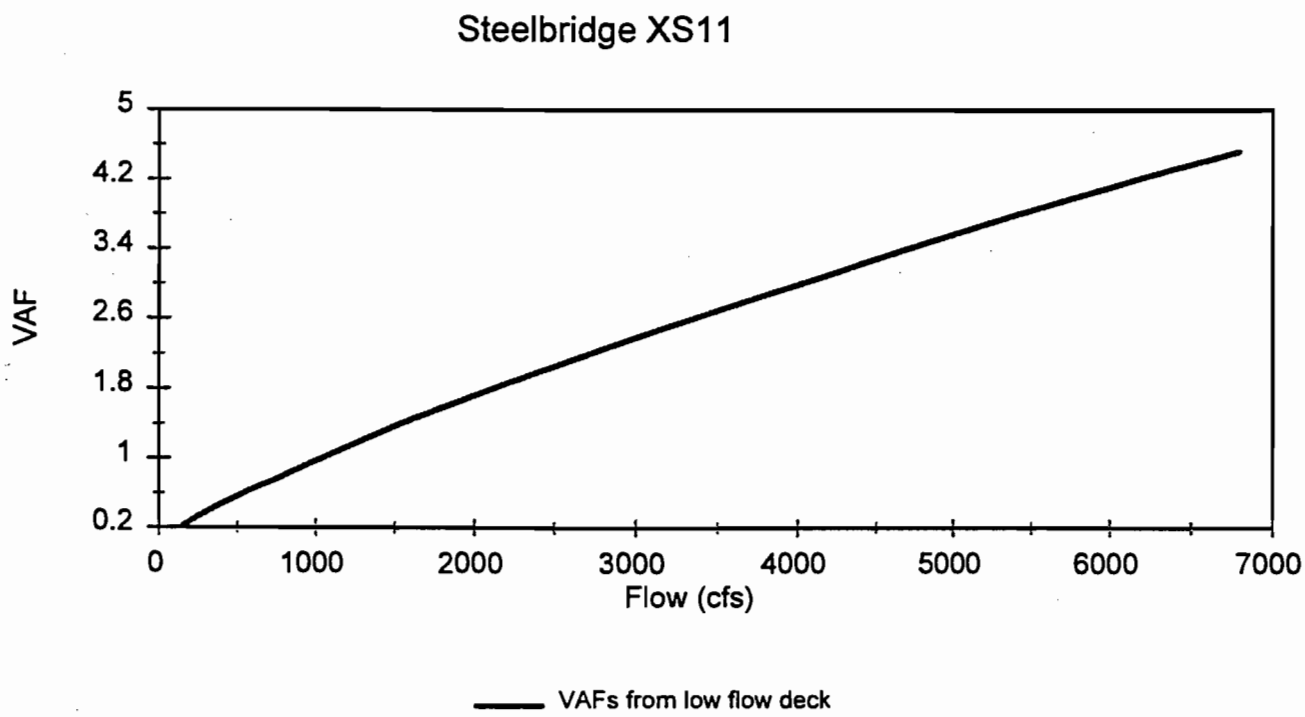
Steelbridge XS4



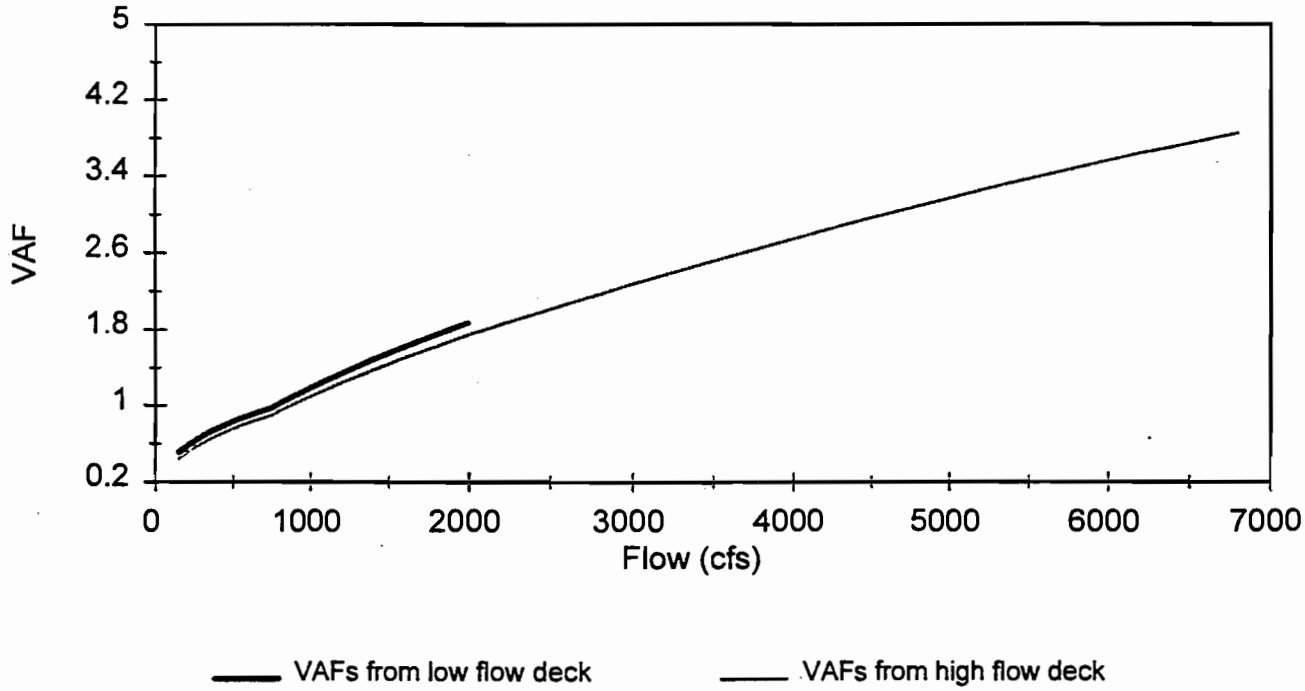

Steelbridge XS5
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck


Steelbridge XS6
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

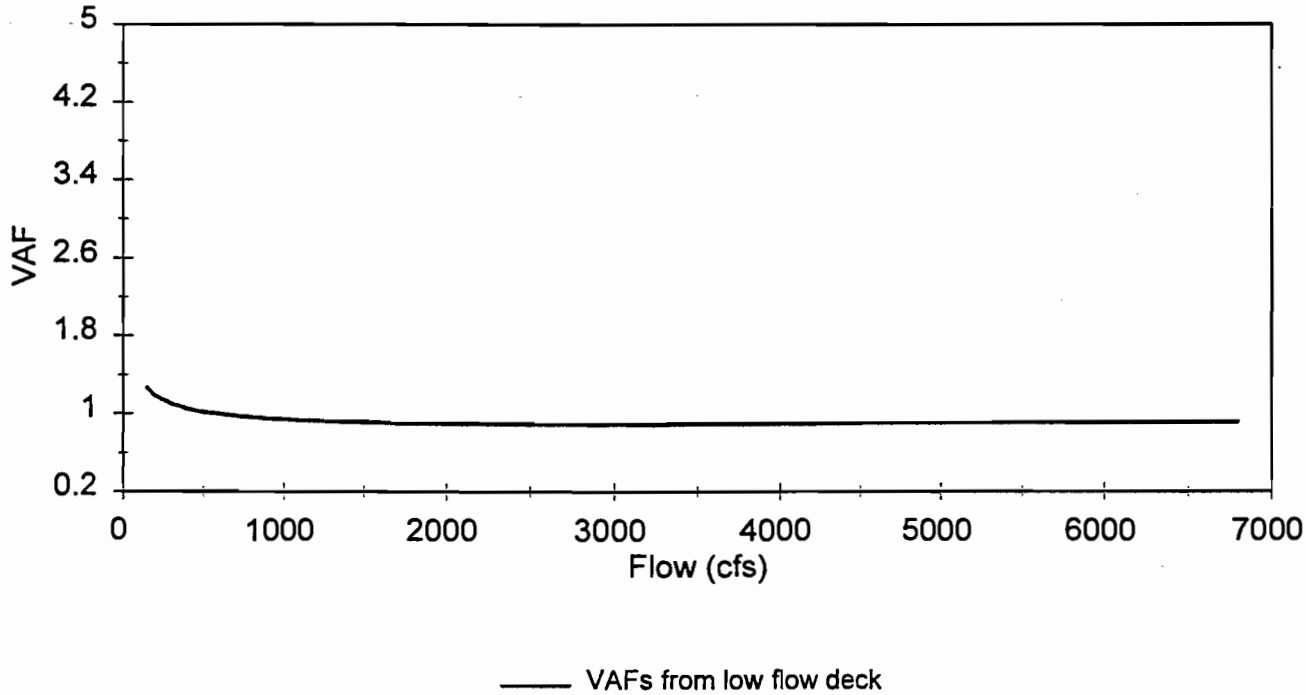

Steelbridge XS7
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck


Steelbridge XS11
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck

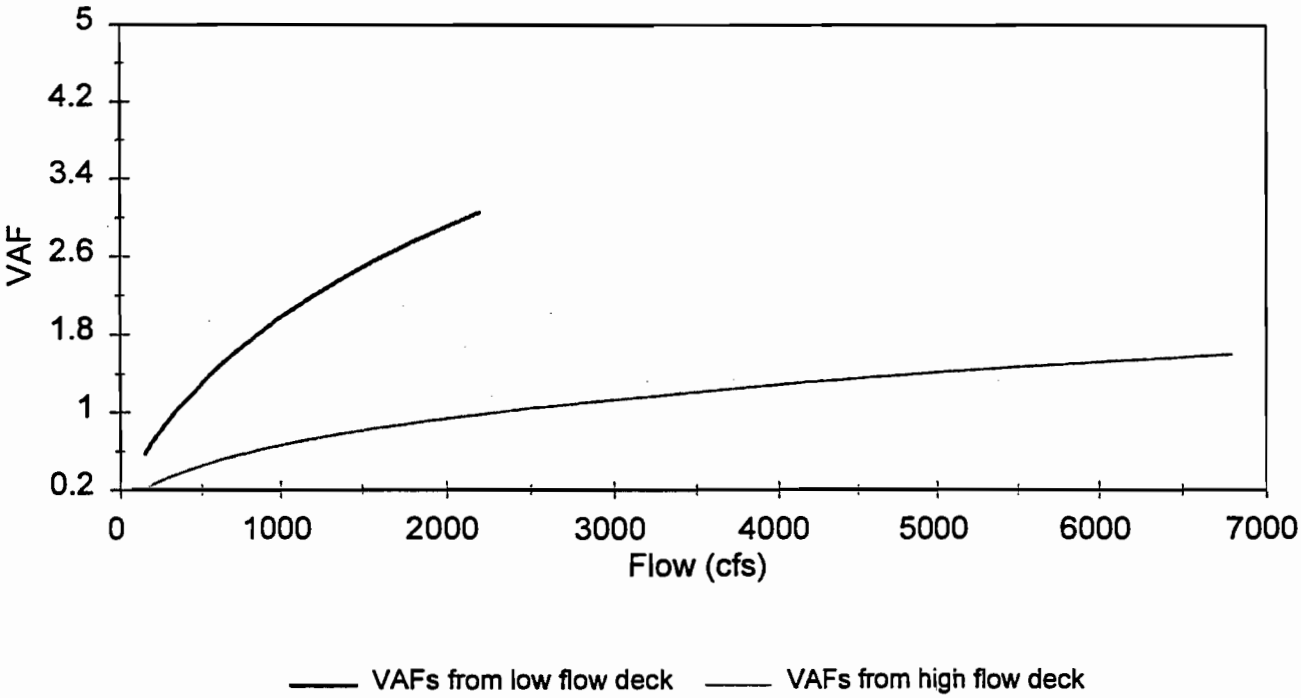
Steelbridge XS12



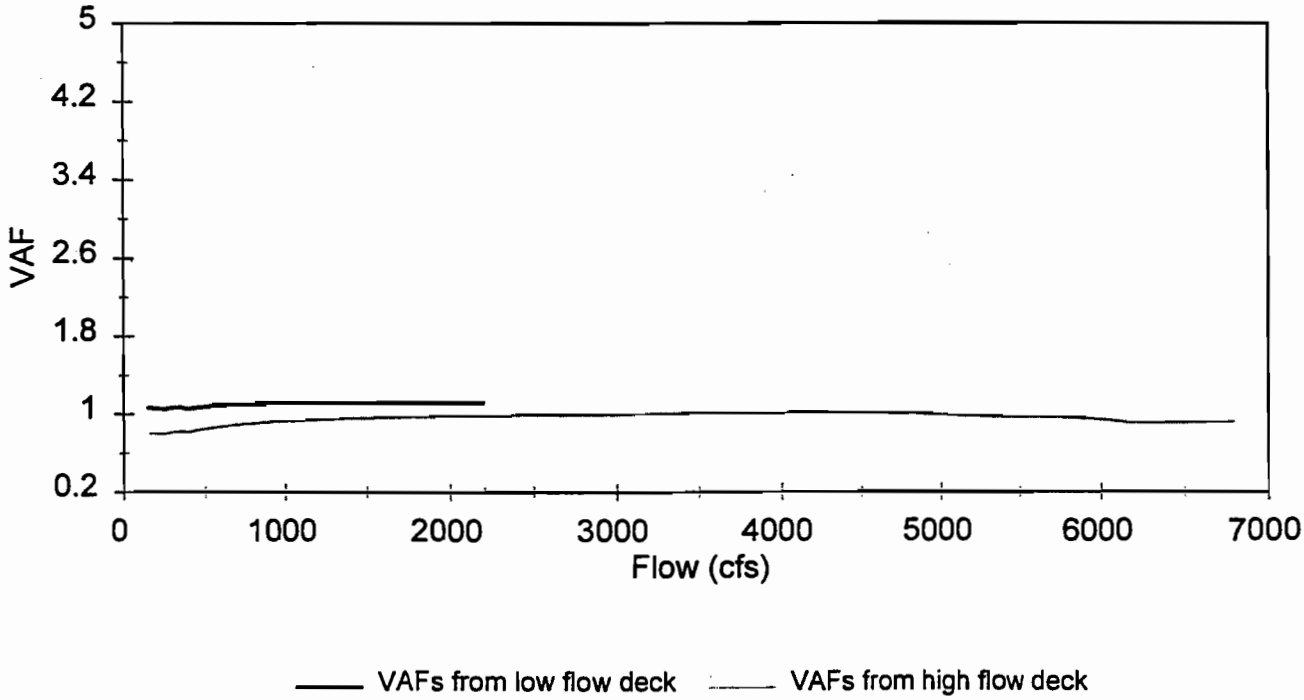
Steiner Flat XS3



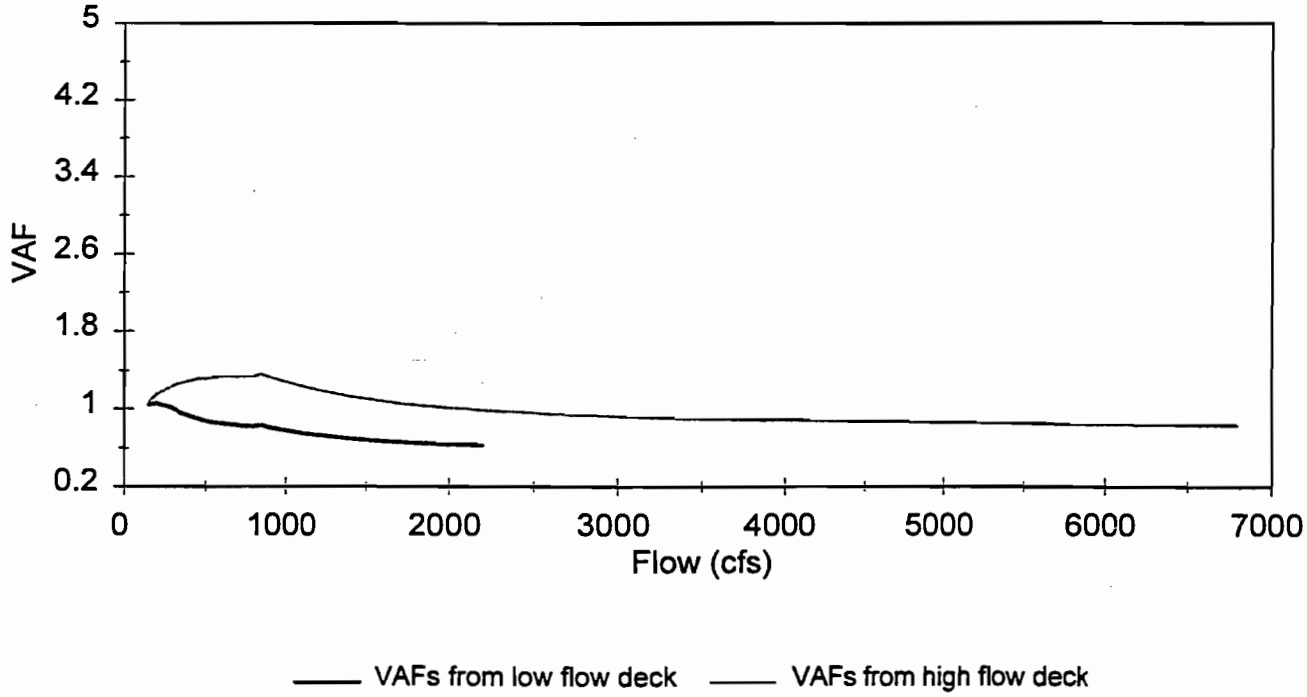
Steiner Flat XS4



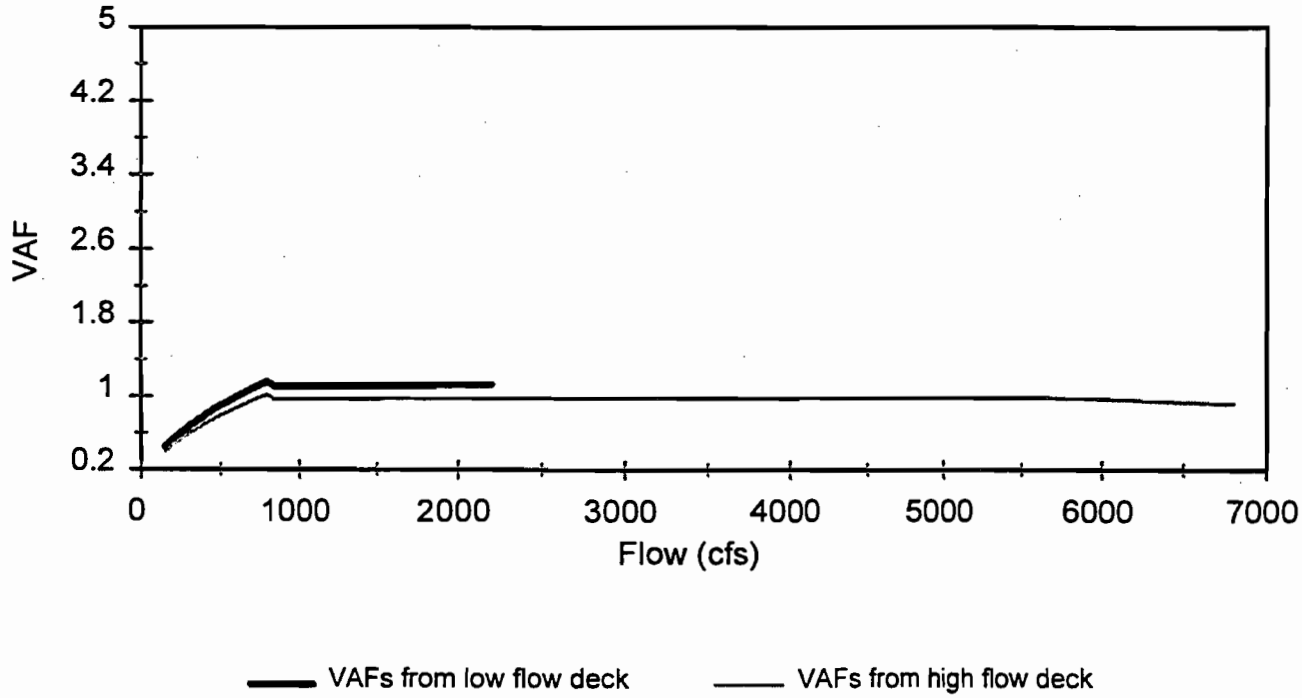
Steiner Flat XS5



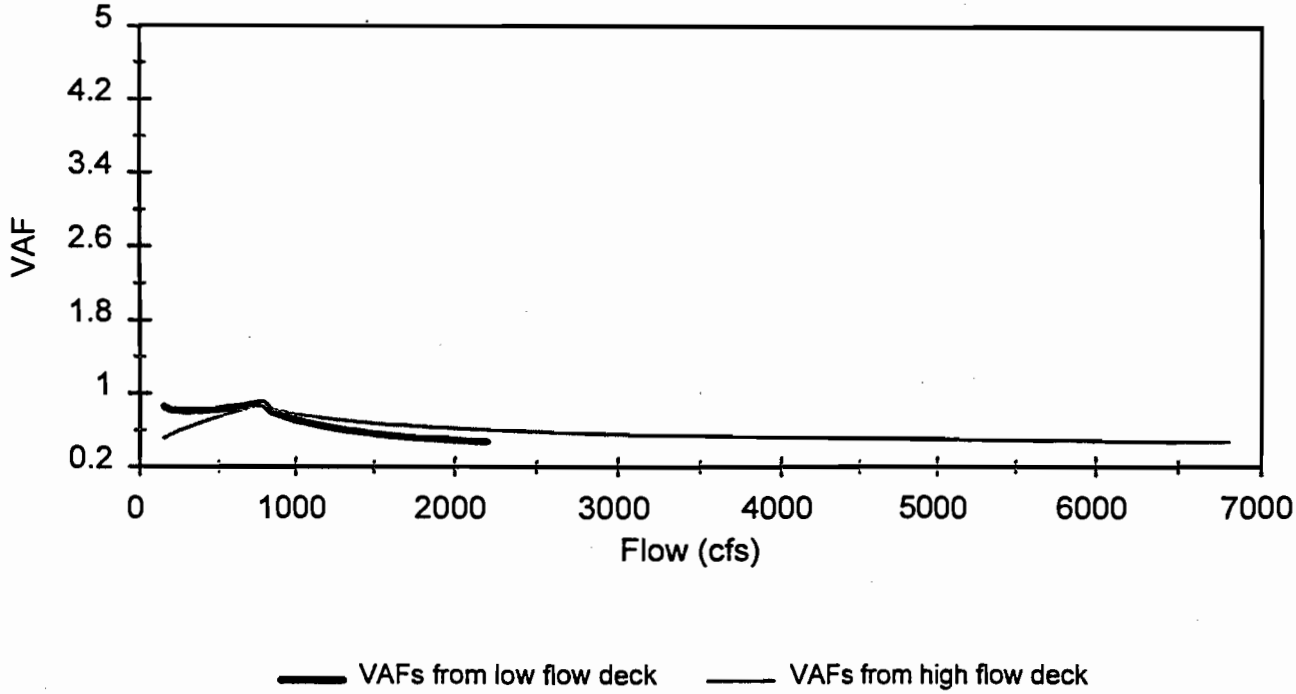
Steiner Flat XS6



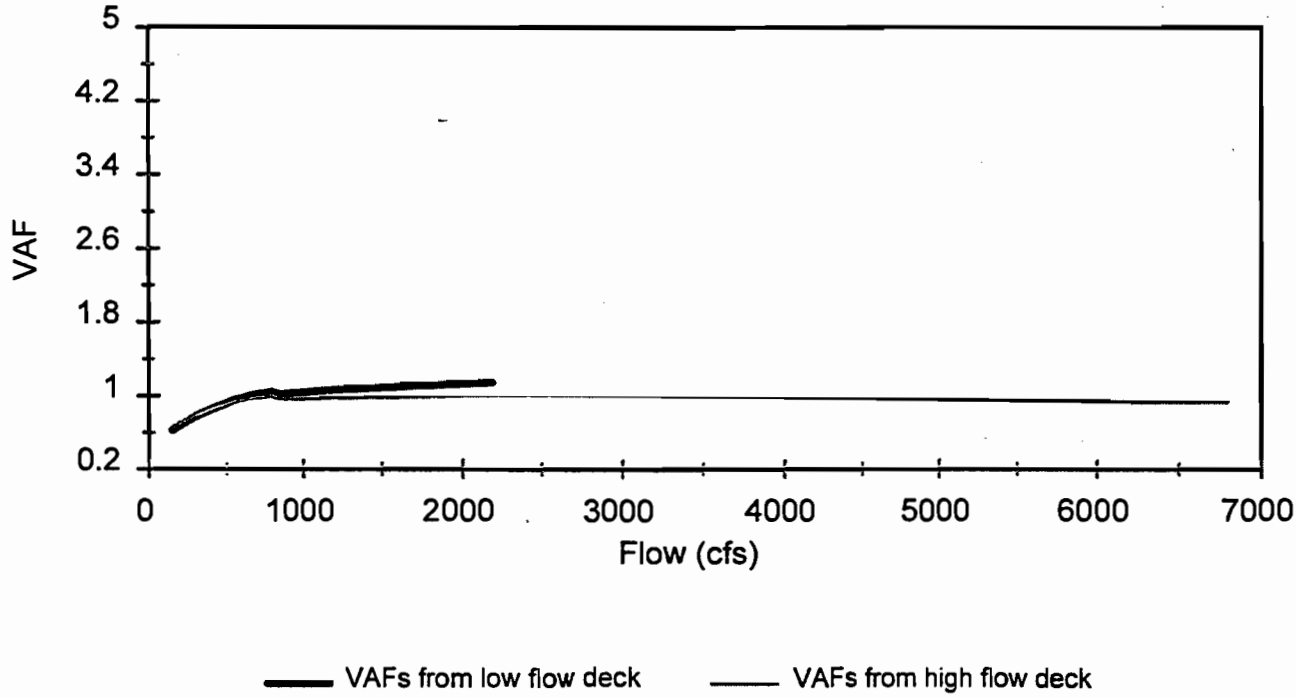
Steiner Flat XS7

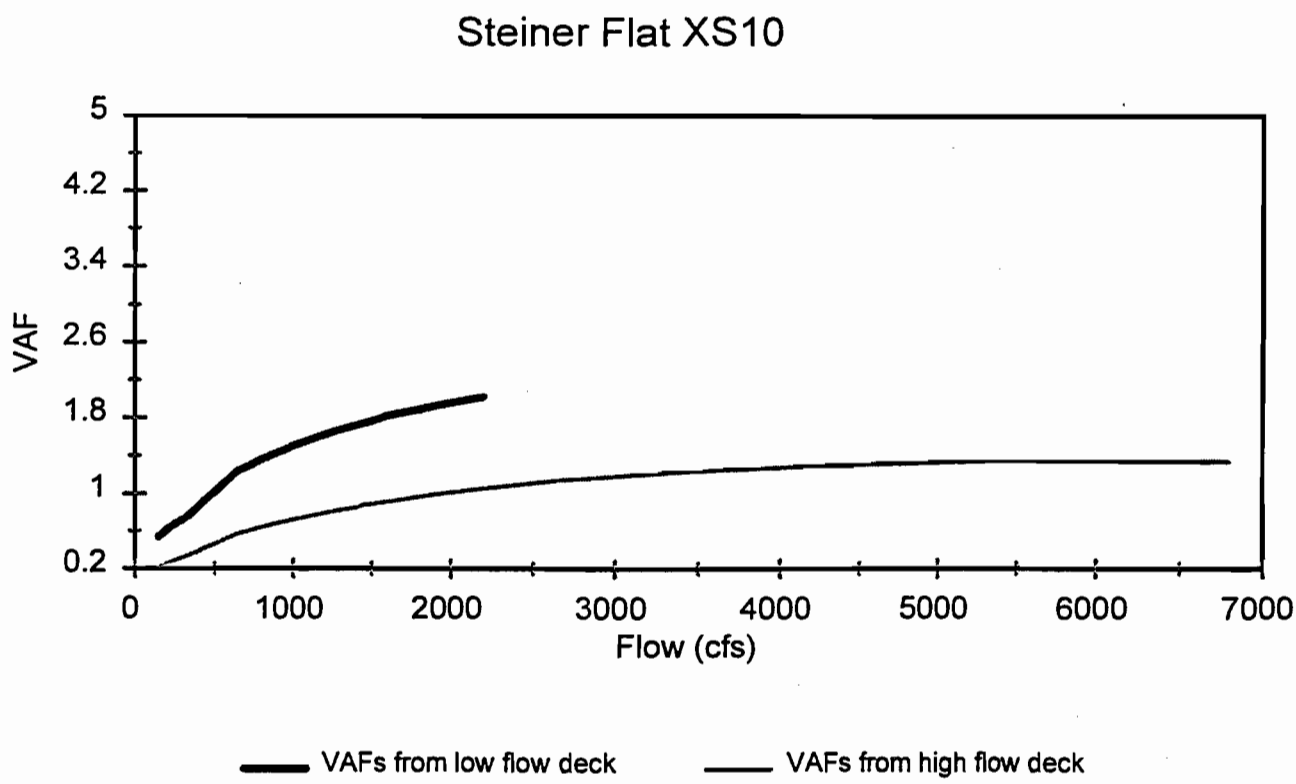


Steiner Flat XS8



Steiner Flat XS9




Steiner Flat XS10
5
4.2
3.4
2.6
1.8
1
0.2
VAF
0
1000
2000
3000
4000
5000
6000
7000
Flow (cfs)
VAFs from low flow deck
VAFs from high flow deck

APPENDIX C
HSI CRITERIA

Chinook Fry Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	1	0	0	0	1
0.1	0.91	0.2	0.3	100	1
0.2	0.75	0.5	0.64		
0.3	0.59	0.6	0.74		
0.4	0.44	0.7	0.83		
0.5	0.33	0.8	0.91		
0.6	0.25	1.2	1		
0.7	0.18	1.3	0.99		
0.8	0.14	1.5	0.95		
0.9	0.1	1.7	0.84		
1	0.08	1.8	0.77		
1.1	0.05	1.9	0.7		
1.2	0.03	2.4	0.48		
1.3	0.02	2.7	0.4		
1.4	0.01	2.8	0.37		
1.5	0.01	2.9	0.34		
1.6	0	3	0.3		
100	0	3.1	0.27		
		3.6	0.16		
		3.7	0.15		
		3.8	0.13		
		3.9	0.12		
		4	0.1		
		4.1	0.08		
		4.2	0.07		
		4.3	0.05		
		4.4	0.03		
		4.5	0.02		
		4.6	0.01		
		4.7	0.01		
		4.8	0.02		
		6.6	0.01		
		6.7	0		
		100	0		

Chinook Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.38	0	0	0	1
0.1	0.72	0.1	0.07	100	1
0.2	0.95	0.2	0.15		
0.3	1	0.3	0.22		
0.4	0.95	0.4	0.3		
0.5	0.85	0.5	0.38		
0.6	0.77	0.6	0.46		
0.7	0.7	0.7	0.54		
0.8	0.64	0.8	0.62		
0.9	0.59	0.9	0.7		
1	0.53	1	0.79		
1.1	0.47	1.1	0.87		
1.2	0.4	1.2	0.94		
1.3	0.33	1.3	0.98		
1.4	0.26	1.4	1		
1.5	0.21	100	1		
1.6	0.17				
1.7	0.14				
1.8	0.11				
1.9	0.07				
2	0.07				
2.1	0.07				
2.2	0.07				
2.3	0.07				
2.4	0.06				
2.5	0.05				
2.6	0.04				
2.7	0.03				
2.8	0.03				
2.9	0.03				
3.2	0.01				
3.3	0				
100	0				

Coho Fry Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	1	0	0	0	1
0.1	0.73	0.1	0.01	100	1
0.2	0.48	0.2	0.06		
0.3	0.28	0.3	0.15		
0.4	0.17	0.4	0.26		
0.5	0.11	0.5	0.39		
0.6	0.08	0.6	0.53		
0.7	0.06	0.7	0.66		
0.8	0.04	0.8	0.79		
0.9	0.03	0.9	0.91		
1	0.02	1	0.97		
1.1	0.01	1.1	1		
1.2	0.01	1.2	0.98		
1.3	0	1.3	0.98		
100	0	1.4	0.86		
		1.5	0.78		
		1.6	0.68		
		1.7	0.57		
		1.8	0.48		
		1.9	0.41		
		2	0.36		
		2.1	0.31		
		2.2	0.26		
		2.3	0.22		
		2.4	0.19		
		3.7	0.11		
		3.8	0.11		
		3.9	0.09		
		4	0.07		
		4.1	0.05		
		4.2	0.04		
		4.3	0.02		
		4.5	0		
		100	0		

Coho Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	1	0	0	0	1
0.1	0.83	0.1	0.05	100	1
0.2	0.68	0.2	0.09		
0.3	0.56	0.3	0.14		
0.4	0.5	0.4	0.19		
0.5	0.46	0.5	0.23		
0.6	0.44	0.6	0.28		
0.7	0.4	0.7	0.32		
0.8	0.35	0.8	0.37		
0.9	0.29	0.9	0.42		
1	0.22	1	0.46		
1.1	0.17	1.1	0.51		
1.2	0.12	1.2	0.57		
1.3	0.11	1.3	0.62		
1.4	0.1	1.4	0.68		
1.5	0.09	1.5	0.73		
1.6	0.08	1.6	0.78		
1.7	0.06	1.7	0.82		
1.8	0.04	1.8	0.87		
1.9	0.02	1.9	0.9		
2.8	0.02	2	0.94		
2.9	0.01	2.1	0.97		
3	0	2.2	1		
100	0	100	1		

Steelhead Fry Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.78	0	0	0	1
0.1	0.79	0.1	0.11	100	1
0.2	0.85	0.2	0.2		
0.3	0.94	0.3	0.22		
0.4	1	0.4	0.46		
0.5	0.91	0.5	0.76		
0.6	0.78	0.6	0.91		
0.7	0.54	0.7	1		
0.8	0.4	0.8	0.92		
0.9	0.25	0.9	0.86		
1	0.23	1	0.74		
1.1	0.21	1.1	0.65		
1.2	0.19	1.2	0.56		
1.5	0.11	1.3	0.47		
1.6	0.11	1.4	0.4		
1.7	0.11	1.5	0.27		
1.8	0.11	1.6	0.24		
1.9	0.1	1.7	0.21		
2	0.1	1.8	0.18		
2.1	0.1	1.9	0.15		
2.2	0.1	2	0.12		
2.6	0.03	2.1	0.08		
2.7	0	2.2	0.05		
100	0	2.3	0.04		
		3	0		
		100	0		

Steelhead Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.17	0	0	0	1
0.1	0.43	0.3	0	100	1
0.2	0.66	0.4	0.02		
0.3	0.82	0.6	0.08		
0.4	0.91	0.8	0.16		
0.5	0.93	1	0.26		
0.7	0.93	1.1	0.32		
0.8	0.94	1.3	0.46		
0.9	0.95	1.4	0.52		
1	0.97	2	0.9		
1.3	1	2.2	0.99		
1.4	1	2.3	1		
1.5	0.97	2.4	0.99		
1.6	0.91	2.6	0.97		
1.8	0.73	2.7	0.95		
1.9	0.66	2.9	0.86		
2	0.62	3.4	0.54		
2.3	0.56	3.9	0.33		
2.4	0.51	4	0.3		
2.6	0.38	4.2	0.28		
2.7	0.33	4.5	0.28		
2.8	0.31	4.8	0.25		
3	0.31	4.9	0.23		
3.2	0.26	5.4	0.16		
3.4	0.16	6.1	0.08		
3.6	0.09	6.2	0.06		
3.7	0.07	6.4	0.05		
3.9	0.04	7	0.04		
4.3	0	7.1	0.03		
100	0	7.2	0.02		
		7.3	0.02		
		7.4	0.01		
		9.1	0.01		
		9.2	0		
		100	0		

Steelhead Adult Holding

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	1
0.6	0.36	0.5	0	100	1
1	0.66	0.6	0.06		
1.5	0.76	0.7	0.11		
1.6	0.81	0.9	0.23		
2	1	1	0.28		
2.5	0.66	1.1	0.34		
3	0.4	1.2	0.39		
3.1	0.34	1.4	0.51		
3.2	0.23	1.5	0.56		
3.3	0.22	1.7	0.68		
3.5	0.1	1.8	0.73		
3.6	0.1	2	0.85		
3.7	0.09	3.5	1		
3.8	0.09	100	1		
3.9	0.08				
4	0.08				
4.3	0.05				
4.4	0.03				
4.5	0.02				
4.6	0.02				
4.7	0.01				
4.8	0.01				
4.9	0				
100	0				

Chinook Spawning - New Substrate Criteria

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.1	0.03	0.4	0.24	31.9	0
0.3	0.11	0.5	0.37	32	0.25
0.5	0.23	0.6	0.51	32.5	0
0.7	0.39	0.7	0.64	32.9	0
0.9	0.59	0.8	0.75	33	0.75
1.1	0.83	0.9	0.83	33.5	0
1.2	0.94	1.1	0.94	41.9	0
1.3	1	1.2	0.98	42	0.75
1.4	1	1.3	1	42.5	0
1.5	0.96	1.4	0.98	42.9	0
1.8	0.78	1.5	0.94	43	1
2.2	0.5	2.3	0.5	43.5	0
2.3	0.44	2.7	0.24	43.9	0
2.6	0.3	2.8	0.19	44	0.75
2.9	0.2	2.9	0.16	44.5	0
3.1	0.16	3.1	0.12	51.9	0
3.9	0.04	3.2	0.11	52	0.25
4	0.04	3.3	0.09	52.5	0
4.1	0.03	3.5	0.07	52.9	0
4.2	0.02	3.6	0.05	53	0.25
4.4	0.01	3.9	0.02	53.5	0
5.6	0	4.1	0.01	53.9	0
100	0	4.6	0	54	0.1
		100	0	54.5	0
				100	0

Chinook Spawning - No Substrate Criteria

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	1
0.1	0.03	0.4	0.24	100	1
0.3	0.11	0.5	0.37		
0.5	0.23	0.6	0.51		
0.7	0.39	0.7	0.64		
0.9	0.59	0.8	0.75		
1.1	0.83	0.9	0.83		
1.2	0.94	1.1	0.94		
1.3	1	1.2	0.98		
1.4	1	1.3	1		
1.5	0.96	1.4	0.98		
1.8	0.78	1.5	0.94		
2.2	0.5	2.3	0.5		
2.3	0.44	2.7	0.24		
2.6	0.3	2.8	0.19		
2.9	0.2	2.9	0.16		
3.1	0.16	3.1	0.12		
3.9	0.04	3.2	0.11		
4	0.04	3.3	0.09		
4.1	0.03	3.5	0.07		
4.2	0.02	3.6	0.05		
4.4	0.01	3.9	0.02		
5.6	0	4.1	0.01		
100	0	4.6	0		
0	0	100	0		

Chinook Spawning - New Criteria with no Embeddedness

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.1	0.03	0.4	0.24	31.9	0
0.3	0.11	0.5	0.37	32	0.25
0.5	0.23	0.6	0.51	32.9	0.25
0.7	0.39	0.7	0.64	33	0.75
0.9	0.59	0.8	0.75	33.9	0.75
1.1	0.83	0.9	0.83	34	0
1.2	0.94	1.1	0.94	41.9	0
1.3	1	1.2	0.98	42	0.75
1.4	1	1.3	1	42.9	0.75
1.5	0.96	1.4	0.98	43	1
1.8	0.78	1.5	0.94	43.9	1
2.2	0.5	2.3	0.5	44	0.75
2.3	0.44	2.7	0.24	44.9	0.75
2.6	0.3	2.8	0.19	45	0
2.9	0.2	2.9	0.16	51.9	0
3.1	0.16	3.1	0.12	52	0.25
3.9	0.04	3.2	0.11	53.9	0.25
4	0.04	3.3	0.09	54	0.1
4.1	0.03	3.5	0.07	54.9	0.1
4.2	0.02	3.6	0.05	55	0
4.4	0.01	3.9	0.02	100	0
5.6	0	4.1	0.01		
100	0	4.6	0		
		100	0		

Chinook Spawning - Old Substrate Criteria

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.2	0.07	0.1	0.02	31.9	0
0.4	0.17	0.2	0.06	32	0.08
0.7	0.39	0.3	0.13	32.2	0.19
1.2	0.94	0.8	0.75	32.4	0.19
1.3	1	0.9	0.83	32.5	0.17
1.4	1	1.2	0.98	32.6	0.06
1.5	0.96	1.3	1	32.8	0
2.5	0.35	1.4	0.98	32.9	0
3.1	0.16	2.1	0.61	33	0.08
4	0.04	2.7	0.24	33.2	0.19
4.5	0.01	2.8	0.19	33.4	0.19
5.5	0.01	3	0.14	33.5	0.17
5.6	0	3.5	0.07	33.6	0.06
100	0	3.8	0.03	33.8	0
		4.6	0	41.9	0
		100	0	42	0.06
				42.1	0.17
				42.2	0.25
				42.4	0.25
				42.6	0
				42.9	0
				43	0.29
				43.1	0.52
				43.2	0.82
				43.3	1
				43.8	0.06
				43.9	0
				44.1	0.08
				44.2	0.17
				44.3	0.42
				44.5	0.14
				44.7	0
				44.9	0
				53.1	0.08
				53.4	0.28
				53.5	0.14
				53.7	0
				53.9	0
				54.2	0.17
				54.3	0.42
				54.5	0.14
				54.7	0
				63.1	0
				63.3	0.08
				63.5	0.03
				63.6	0.03
				63.7	0
				64.1	0
				64.3	0.08
				64.5	0.03
				64.6	0.03
				64.7	0
				100	0

Coho Spawning

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.1	0	0.2	0	20.9	0
0.2	0.21	0.4	0.22	21	0.1
0.3	0.37	0.5	0.35	21.5	0
0.4	0.52	0.6	0.5	21.9	0
0.5	0.66	0.7	0.67	22	0.25
0.6	0.79	0.8	0.83	22.5	0
0.7	0.9	0.9	0.95	30.9	0
0.8	0.98	1	1	31	0.1
0.9	1	1.1	1	31.5	0
1	0.99	1.3	0.9	31.9	0
1.1	0.95	1.8	0.63	32	1
1.2	0.92	1.9	0.52	32.5	0
1.3	0.88	2	0.39	32.9	0
1.5	0.77	2.1	0.26	33	1
1.7	0.65	2.2	0.24	33.5	0
2.3	0.21	2.8	0.18	40.9	0
2.4	0.17	2.9	0.16	41	0.1
2.6	0.11	3	0.13	41.5	0
2.7	0.07	3.2	0.05	41.9	0
3	0.06	3.3	0.03	42	1
3.4	0.05	3.8	0.01	42.5	0
3.6	0.04	4	0	42.9	0
3.8	0.03	100	0	43	1
4.3	0.03			43.5	0
4.4	0.02			43.9	0
4.6	0.01			44	0.25
4.8	0			44.5	0
100	0			51.9	0
				52	0.1
				52.5	0
				52.9	0
				53	0.1
				53.5	0
				100	0

Steelhead Spawning

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.3	0.15	0.3	0.07	20.9	0
0.5	0.39	0.4	0.11	21	0.3
0.6	0.55	0.5	0.19	21.5	0
0.7	0.72	0.6	0.31	21.9	0
0.8	0.85	0.7	0.47	22	0.3
0.9	0.94	0.8	0.64	22.5	0
1	0.99	0.9	0.82	30.9	0
1.1	1	1	0.96	31	0.75
2	0.65	1.1	1	31.5	0
2.1	0.59	1.2	0.9	31.9	0
2.2	0.48	1.3	0.72	32	1
2.3	0.37	1.4	0.54	32.5	0
2.4	0.29	1.5	0.4	32.9	0
2.5	0.25	1.6	0.31	33	1
2.6	0.23	1.7	0.25	33.5	0
2.7	0.23	1.8	0.21	41.9	0
2.8	0.22	1.9	0.18	42	0.5
2.9	0.2	2	0.16	42.5	0
3	0.17	2.1	0.12	42.9	0
3.1	0.13	2.2	0.08	43	0.3
3.2	0.12	2.3	0.05	43.5	0
3.7	0.11	2.4	0.03	100	0
3.9	0.07	2.9	0.03		
4.1	0.03	3	0.02		
4.4	0	3.1	0.01		
100	0	3.2	0.01		
		3.3	0		
		100	0		

Steelhead Winter Juvenile Rearing

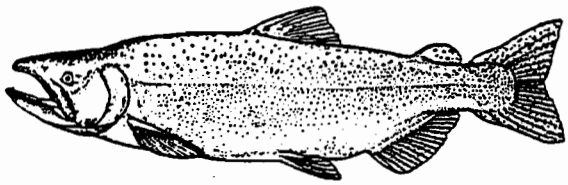
Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.6	0	0	0	0
0.3	1	0.4	1	21.9	0
0.8	0.86	100	1	22	0.3
1.3	0.42			22.5	0
1.8	0.13			31.9	0
2.5	0.04			32	0.3
3.8	0.04			32.5	0
4	0.03			32.9	0
4.7	0.03			33	0.3
5.3	0			33.5	0
100	0			41.9	0
				42	0.3
				42.5	0
				42.9	0
				43	0.3
				43.5	0
				43.9	0
				44	1
				44.5	0
				51.9	0
				52	0.3
				52.5	0
				52.9	0
				53	0.3
				53.5	0
				53.9	0
				54	1
				54.5	0
				54.9	0
				55	1
				55.5	0
				61.9	0
				62	0.3
				62.5	0
				62.9	0
				63	0.3
				63.5	0
				63.9	0
				64	1
				64.5	0
				64.9	0
				65	1
				65.5	0
				65.9	0
				66	1
				66.5	0
				71.9	0
				72	0.3
				72.5	0
				72.9	0
				73	0.3
				73.5	0
				73.9	0
				74	1
				74.5	0
				74.9	0
				75	1
				75.5	0
				75.9	0

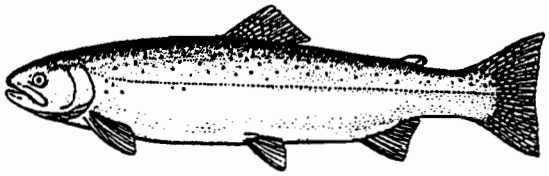
Steelhead Winter Juvenile Rearing (Continued)

Substrate Composition	SI Value
76	1
76.5	0
76.9	0
77	0.75
77.5	0
81.9	0
82	0.3
82.5	0
82.9	0
83	0.3
83.5	0
83.9	0
84	1
84.5	0
84.9	0
85	1
85.5	0
85.9	0
86	1
86.5	0
86.9	0
87	0.75
87.5	0
87.9	0
88	0.75
88.5	0
100	0

APPENDIX K

SIMULATION OF PHYSICAL HABITAT FOR ANADROMOUS SALMONIDS IN THE LOWER TRINITY RIVER





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Prepared by

Mark Gard

LOWER TRINITY RIVER PHYSICAL HABITAT SIMULATION

I. INTRODUCTION

A total of 58 transects were established in 1985 at six study sites (Hoopa, Del Loma, Tish Tang, Hawkins Bar, Junction City and Oregon Gulch), on the Trinity River between Douglas City and Weitchpec, to determine the relationship between Trinity River flows and the amount of physical habitat available for anadromous salmonids (chinook and coho salmon and steelhead). Nine of these transects (Junction City 5, Hawkins Bar 5 and 7, Oregon Gulch 3, 7 and 10, Del Loma 12[1], and Tish Tang 3 and 6) were eliminated by 1986 because they were not needed to represent the habitat at the sites or because of morphological changes to the channel at the transects as a result of high flows in 1986. The remaining 49 transects were used in this analysis for computation of weighted useable area versus flow. The transects were numbered so that the highest numbered transect was at the downstream end of each site. Three or four sets of water surface elevations (WSELs) and one set of depth/velocity data were collected on these transects between July of 1986 and April of 1993 (Table 1).

Table 1
Flows used for Calibrating WSELs and for Velocity Sets

Month	7/86	8/86	?	4/93
Gage Flow (cfs)[2]	800	600	300	3000
Oregon Gulch Flow	830	600	303	-----
Junction City Flow	935	620	311	2354
Del Loma Flow	945	696	346	2950
Hawkins Bar Flow	1090	680	442	-----
Tish Tang Flow	1245	857	581	-----
Hoopa Flow	1310	857	581	-----

[1] The transects at the Del Loma Site were originally designated as Lower Del Loma 1 - 7 and Upper Del Loma 1 - 4. Subsequently, the designation of the Lower Del Loma transects was changed from 1 - 7 to 11 - 17.

[2] Approximate

II. METHODS

The analysis began with PHABSIM input decks prepared for each site in 1986 by Andy Hamilton. These decks had three calibration flows and simulated up to 1200 cfs. An additional calibration flow (2950) was added to the Del Loma deck. A WSEL that was collected at 2345 cfs at Junction City cross-section 10 was not used for calibration because there had been significant morphological changes to the channel at that transect between 1986 and 1993. All other WSELs were used for hydraulic calibration. The bed profile was extended at the ends of the transects where necessary, to allow flows up to 3000 cfs to be simulated. The bed profile was extended by adding verticals with bed elevations calculated so that the slope of the extended bed profile was the same as the slope of the bed profile at the ends of the original transects. Substrate data (Table 2) for the extended bed profile was entered assuming the same substrate for these cells as the substrate at the ends of the original transects. Flows to be used in calibration of WSELs and for velocity simulation were calculated from depths, velocities and horizontal distances for the transects at each site that were judged to be the best for flow measurements.

The first step in calibration is to establish the stage-discharge relationship for each transect. Three separate models are available within PHABSIM to predict this relationship, enabling the modeler to predict water depths for flows at which WSELs were not measured. These models are: 1) *IFG4*, which uses a log-log linear rating curve to predict WSELs; 2) *MANSQ*, which operates under the assumption that the condition of the channel and the nature of the streambed controls the WSELs; and 3) *WSP*, the water surface profile model which calculates the energy loss between transects to determine WSELs. *IFG4*, the most versatile of these models, is considered to have worked well if the following standards are met: 1) the beta value (a measure of the change in channel roughness with changes in streamflow) is between 2.0 and 4.5; 2) the mean error in calculated versus given discharges is less than 10%; 3) there is no more than a 25% difference for any calculated versus given discharge; and 4) there is no more than a 0.1 foot difference between measured and simulated WSELs (Bovee 1994). The fourth standard is also used for *WSP* and *MANSQ*. *WSP* calibration involves adjusting values for Manning's n and roughness multipliers, while *MANSQ* calibration involves adjusting beta values (a different beta than for *IFG4*). Acceptable ranges of Manning's n and beta (for *MANSQ*) are, respectively, 0.04 to 0.07 and 0 to 0.5. In addition, there should be a linear log-log relationship between flow and roughness multiplier values when using *WSP*.

In most cases, it was possible to get no more than a 0.1 foot difference between measured and simulated WSELs (Appendix A). However, 28 simulated WSELs could not be brought within 0.1 foot of the measured WSEL. For the simulated WSELs that could not be brought within 0.1foot of the measured elevations, all three models were tried if possible,[3] and the model which

Table 2

[3] The *WSP* model, by design, links transects from downstream up and thus cannot be used for the furthest downstream transect.

Substrate Descriptors and Codes

Code	Type	Particle Size (mm)
0	Fines	< 4
1	Small Gravel	4 - 25
2	Medium Gravel	25 - 50
3	Large Gravel	50 - 75
4	Small Cobble	75 - 150
5	Medium Cobble	150 - 225
6	Large Cobble	225 - 300
7	Small Boulder	300 - 600
8	Large Boulder	> 600
9	Bedrock	

produced the lowest overall difference between measured and simulated WSELs while still keeping water flowing downhill was used. For these simulations, the maximum difference between measured and simulated WSELs was 0.18 feet, except for the Junction City site, where the maximum difference between measured and simulated WSELs was 0.75 feet. We were unable to successfully model Junction City transects 1 through 8 with *IFG4* and *MANSQ*, in that we were unable to prevent water from going uphill for some range of the simulated flows. While we were able to capture the general water surface profile of Junction City transects 1 through 8 at the three calibration flows with *WSP*, we were unable to keep differences between specific measured and simulated WSELs within a normally acceptable range. For *IFG4* simulations, all mean errors were less than 10% (the greatest value was 7.8%) and all calculated discharges were within 25% of given discharges (maximum difference was 15.3%). However, six beta values were less than 2.0. Since the lowest beta value was 1.68, this was accepted. For *WSP*, roughness multipliers for simulated flows were usually generated using a log-log regression of flow and calibrated roughness multiplier values for the calibration flows. While three Manning's n values less than 0.04 were used in *WSP* calibrations, none of the Manning's n values were less than 0.035; accordingly, the Manning's n values were judged to be acceptable. All of the beta values used in *MANSQ* calibrations were between 0 and 0.5.

Final decks were made for velocity and habitat simulation by adding WSEL lines to the decks of sites where some of the transects were modeled with MANSQ or WSP, with IOC 8 set equal to 1. Flows were simulated in 150 cfs increments from 150 to 3000 cfs.
The second, and final, step in the calibration process involves examining various parameters

associated with the prediction of water velocities by the *IFG4* model. Water velocities are simulated in *IFG4* using Manning's equation where:

$$\text{Velocity} = (1.49/N)(R^{.667})(S^{.5})$$

R = Hydraulic radius (IFG4 uses depth as an estimate of R)
S = Energy slope

The N value in the above equation is a roughness coefficient which is calculated when a measured velocity from a transect cell is supplied in the equation. If a measured velocity is not supplied for a cell, as is the case when flows exceeding the velocity measurement flow are simulated, the model supplies the last N value derived from the previous cell to those cells. Typically, the last wet cell had a measured velocity of 0 ft/s. These velocities were arbitrarily set to a low value (typically 0.05 ft/s) to get reasonable simulated velocities in cells that were dry at the velocity measurement flow. This practice is judged to be reasonable, since the measurement error of velocities is in the range of 0.05 ft/s.

The major technique used to check that velocity predictions were acceptable was to examine the velocity adjustment factors (VAFs). In mass balancing, the program calculates VAFs by determining the ratio of the discharge for which velocities are being simulated to the discharge calculated using the initial simulation of cell velocities. VAFs typically increase monotonically with increasing flows. None of the transects deviated significantly from this expected pattern (Appendix B). Further, VAFs should be in the range of 0.2 and 5.0 to be considered acceptable (Bovee 1994). The VAFs for all transects were within this range (Appendix B).

The final step in the process was to simulate available habitat for each transect. Habitat suitability criteria (HSC or SI Curves) are used within PHABSIM to translate hydraulic and structural elements of rivers into indices of habitat quality (Bovee 1994). The HSC used in this study were site specific, having been developed as part of the Trinity River Flow Evaluation (Hampton 1988). The criteria supplied by Mark Hampton had to be modified slightly to enable them to be used in HABTAE. Specifically, points were deleted from the curves, from parts of the curves that were nearly linear, so that there would be a total of at most 100 points. It should be noted that the differences between the depth and velocity curves in "Chinook Spawning - New Substrate Criteria" and "Chinook Spawning - Old Substrate Criteria" in Gard (1996) were solely due to different individuals deleting different points in the two criteria to meet the 100-points-total requirement. Thus, the only real difference between these two criteria was the substrate criteria. The chinook spawning curve in Appendix C is the "Chinook Spawning - New Substrate Criteria." Although juvenile criteria were developed that included cover, these were not used, since cover data was not available. After calibration of hydraulic data decks habitat modeling proceeded. An input file was created containing the digitized HSC developed on the Trinity River (Appendix C). The HABTAE program was used to compute WUA for each transect over the desired range of stream flows (150 cfs to 3000 cfs). The WUA curves for each transect constituted the final product of this effort.

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ACKNOWLEDGMENTS

Much of the data was provided in electronic form by Andy Hamilton. Jeff Thomas, Sean Gallagher and Paul Zedonis assisted with the data entry and analysis. HSI criteria were provided by Mark Hampton.

APPENDIX A
WSEL CALIBRATION

Calibration Methods and Parameters Used

Hoopa Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-3000	581, 857, 1310	IFG4	---
2	150-2100	581, 857, 1310	IFG4	---
2	2250-3000	1310	WSP	n = 0.035, RM = 1
3	150-2100	581, 857, 1310	IFG4	---
3	2250-3000	1310	WSP	n = 0.035, RM = 1
4	150-2100	581, 857, 1310	IFG4	---
4	2250-3000	1310	WSP	n = 0.035, RM = 1
5	150-3000	581, 857, 1310	IFG4	---
6	150-3000	581, 857, 1310	IFG4	---

Tish Tang Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-3000	581, 857, 1245	IFG4	---
2	150-3000	581, 857, 1245	IFG4	---
4	150-3000	581, 857, 1245	WSP	n = 0.04, RM = 1
5	150-3000	581, 857, 1245	IFG4	---
7	150-3000	581, 857, 1245	IFG4	---
8	150-3000	581, 857, 1245	IFG4	---
9	150-3000	581, 857, 1245	MANSQ	CALQ =857, β = 0.21
10	150-3000	581, 857, 1245	MANSQ	CALQ =857, β = 0.49

Junction City Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
2	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
3	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
4	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
6	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
7	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
8	150-3000	311, 620, 935	WSP	n = 0.04, RM = 1
9	150-3000	311, 620, 935	IFG4	---
10	150-3000	311, 620, 935	IFG4	---

Hawkins Bar Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-3000	442, 680, 1090	IFG4	---
2	150-3000	442, 680, 1090	IFG4	---
3	150-3000	442, 680, 1090	IFG4	---
4	150-3000	442, 680, 1090	WSP	n = 0.07, 442 RM = 1.58, 680 RM = 1.36, 1090 RM = 1.15
6	150-3000	442, 680, 1090	IFG4	---
8	150-3000	442, 680, 1090	IFG4	---
9	150-3000	442, 680, 1090	IFG4	---
10	150-3000	442, 680, 1090	WSP	n = 0.04, 442 RM = 1, 680 RM = 0.5, 1090 RM = 0.1

Oregon Gulch Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-3000	303, 600, 830	IFG4	---
2	150-3000	303, 600, 830	IFG4	---
4	150-3000	303, 600, 830	IFG4	---
5	150-3000	303, 600, 830	IFG4	---
6	150-3000	303, 600, 830	IFG4	---
8	150-3000	303, 600, 830	IFG4	---
9	150-3000	303, 600, 830	IFG4	---
11	150-3000	303, 600, 830	IFG4	---

Del Loma Study Site

XS	Flow Range	Calibration Flows	Method	Parameters
1	150-3000	346, 696, 945, 2950	MANSQ	CALQ = 2950, β = 0.08
2	150-3000	346, 696, 945, 2950	IFG4	---
3	150-3000	346, 696, 945 *	MANSQ	CALQ = 945, β = 0.3
4	150-3000	346, 696, 945, 2950	IFG4	---
11	150-3000	346, 696, 945 *	IFG4	---
13	150-3000	346, 696, 945 *	IFG4	---
14	150-3000	346, 696, 945, 2950	IFG4	---
15	150-3000	346, 696, 945, 2950	IFG4	---
16	150-3000	346, 696, 945, 2950	IFG4	---
17	150-3000	346, 696, 945, 2950	IFG4	---

* WSELs were not measured at these transects at 2950 cfs.

HOOPA STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1310	Difference (measured vs. pred. WSELs) 1310	857	581
1	4.13	3.6	3.2	0.03	0.05	0.02
2	2.34	4.2	3.8	0.07	0.11	0.04
3	2.27	3.6	3.1	0.06	0.09	0.03
4	1.79	1.7	1.3	0.03	0.05	0.02
5	2.22	3.7	3.3	0.06	0.08	0.03
6	2.32	3.8	3.3	0.05	0.07	0.02

WSP Calibration

XSEC	Difference (measured vs. pred. WSELs) 1310
2	None
3	None
4	0.02

TISH TANG STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1245	Difference (measured vs. pred. WSELs) 1245	857	581
1	2.84	3.2	0.5	0.04	0.06	0.02
2	2.69	2.2	13.9	0.02	0.04	0.01
4	---	---	---	0.05	0.09	0.10
5	2.00	5.2	15.3	None	0.13	0.04
7	2.03	4.6	13.2	0.09	0.11	0.03
8	2.01	5.7	2.2	0.11	0.14	0.04
9	---	---	---	0.07	None	0.06
10	---	---	---	0.09	None	0.03

JUNCTION CITY STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 935	Difference (measured vs. pred. WSELs) 935	620	311
1	---	---	---	0.08	0.04	0.38
2	---	---	---	0.34	0.30	0.75
3	---	---	---	0.08	0.23	0.24
4	---	---	---	0.05	0.21	0.25
6	---	---	---	0.23	0.27	0.32
7	---	---	---	0.19	0.27	0.08
8	---	---	---	0.15	0.32	0.02
9	3.78	1.9	2.9	0.02	0.03	0.05
10	3.06	0.1	1.6	0.10	None	None

DEL LOMA STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 945	Difference (measured vs. pred. WSELs) 2950	945	696	346
1	---	---	---	None	0.08	0.10	0.08
2	3.07	3.6	2.8	0.05	0.04	0.05	0.04
3	---	---	---	---	None	0.04	0.06
4	4.12	2.7	2.6	0.09	0.09	0.10	0.10
11	2.64	7.8	6.0	---	0.06	0.10	0.05
13	1.92	2.4	2.3	---	0.04	0.05	0.01
14	1.90	1.5	2.9	0.03	0.05	0.02	None
15	1.84	1.7	3.3	0.04	0.06	0.01	0.01
16	1.82	1.0	0.5	0.01	0.01	0.03	0.01
17	1.68	7.7	8.3	0.14	0.11	0.09	0.09

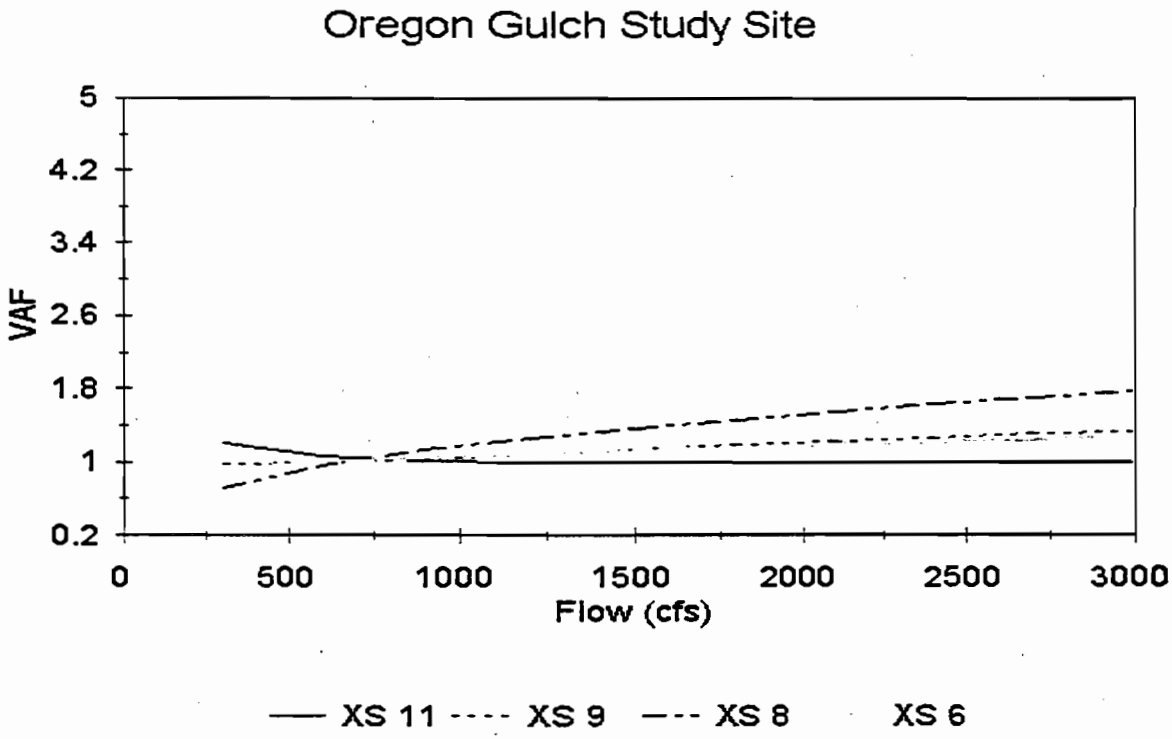
OREGON GULCH STUDY SITE

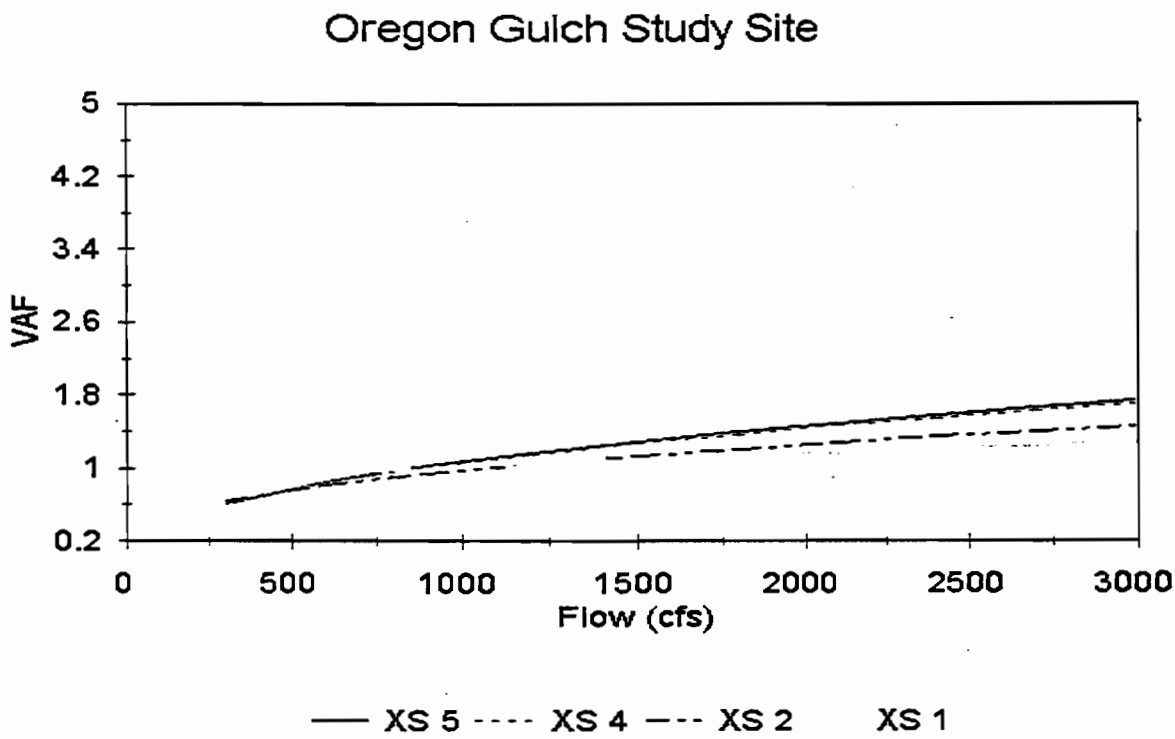
XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 830	Difference (measured vs. pred. WSELs) 830	600	303
1	2.51	3.2	1.0	0.05	0.06	0.01
2	2.83	3.7	5.1	0.05	0.06	0.01
4	2.90	3.0	0.2	0.04	0.05	0.01
5	2.86	3.4	1.0	0.05	0.05	0.01
6	2.79	4.7	9.3	0.07	0.07	0.01
8	3.08	3.0	6.7	0.04	0.04	0.02
9	3.00	2.0	4.7	0.03	0.04	0.01
11	2.14	1.1	4.1	0.02	0.02	0.01

HAWKINS BAR STUDY SITE

XSEC	BETA COEFF.	%MEAN ERROR	Calculated vs. Given Disch. (%) 1090	Difference (measured vs. pred. WSELs) 1090	680	442
1	3.51	5.3	4.9	0.07	0.10	0.03
2	3.84	6.3	6.1	0.06	0.09	0.03
3	---	---	---	0.16	0.18	0.10
4	2.75	5.9	5.7	0.09	0.13	0.04
6	4.31	3.6	3.1	0.04	0.07	0.03
8	5.22	5.3	4.9	0.05	0.07	0.03
9	---	---	---	0.14	0.11	0.05
10	2.94	5.4	5.1	0.08	0.11	0.04

APPENDIX B
VELOCITY CALIBRATION


Oregon Gulch Study Site
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
500
1000
1500
2000
2500
3000
Flow (cfs)
XS 11
XS 9
XS 8
XS 6


Oregon Gulch Study Site
VAF
5
4.2
3.4
2.6
1.8
1
0.2
0
500
1000
1500
2000
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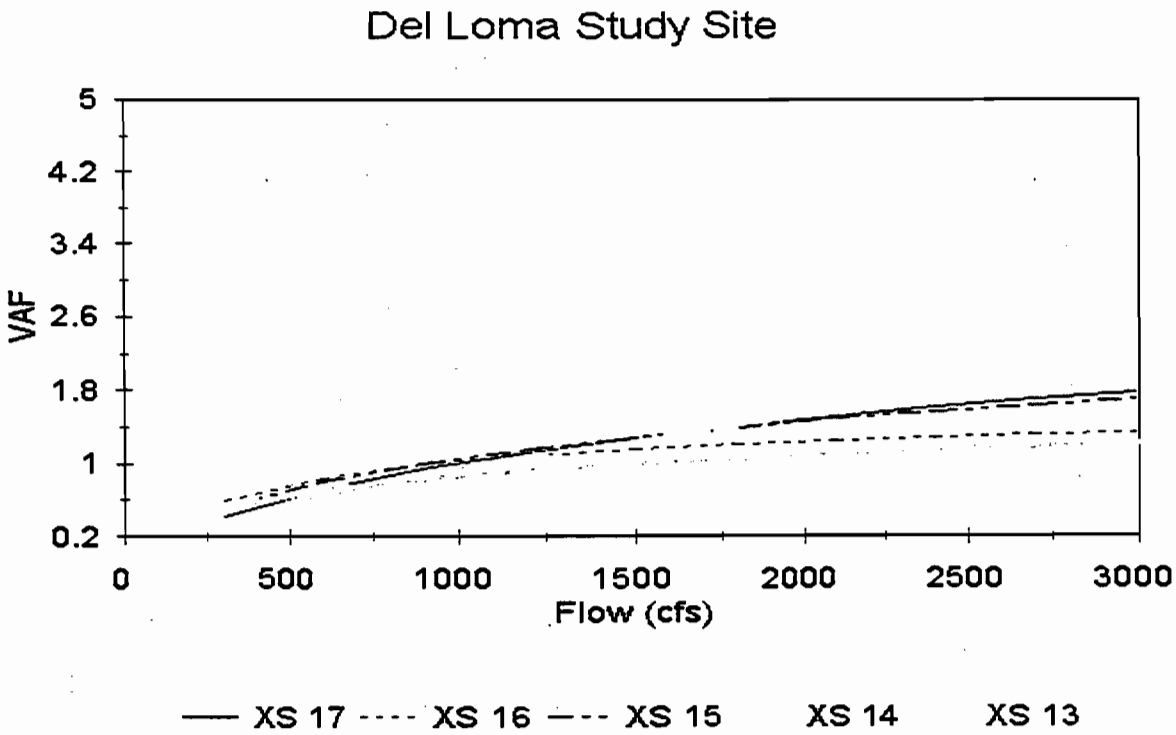
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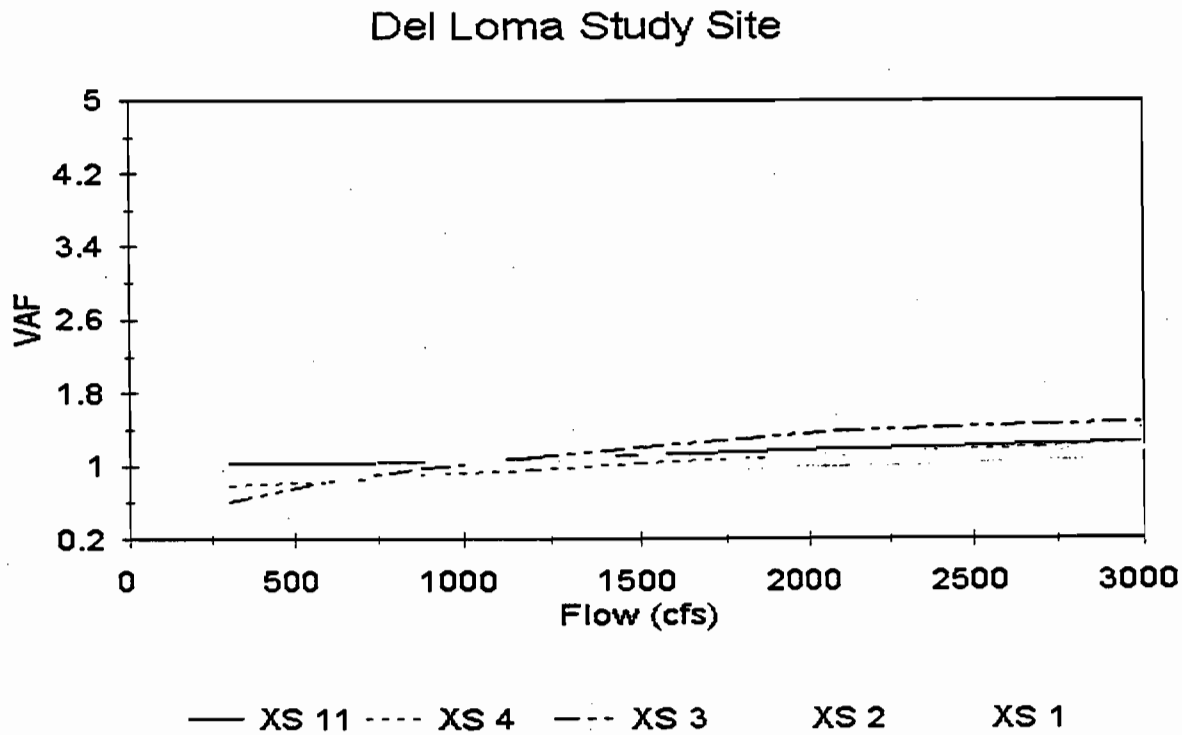
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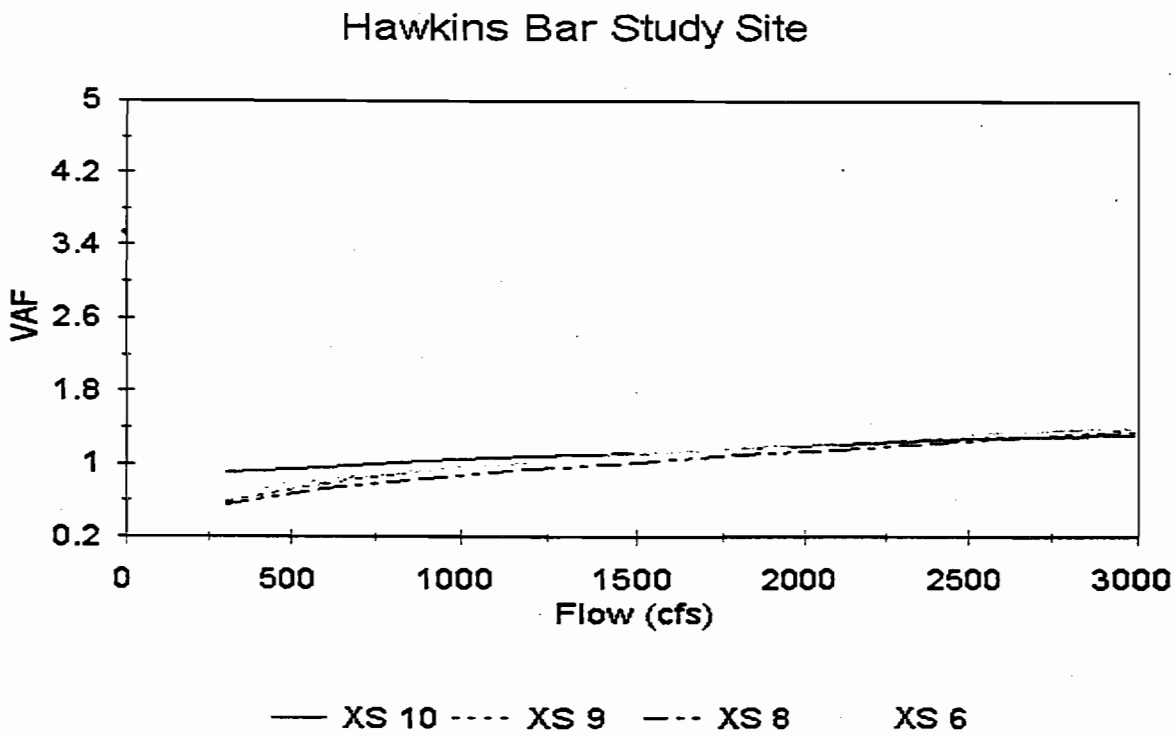
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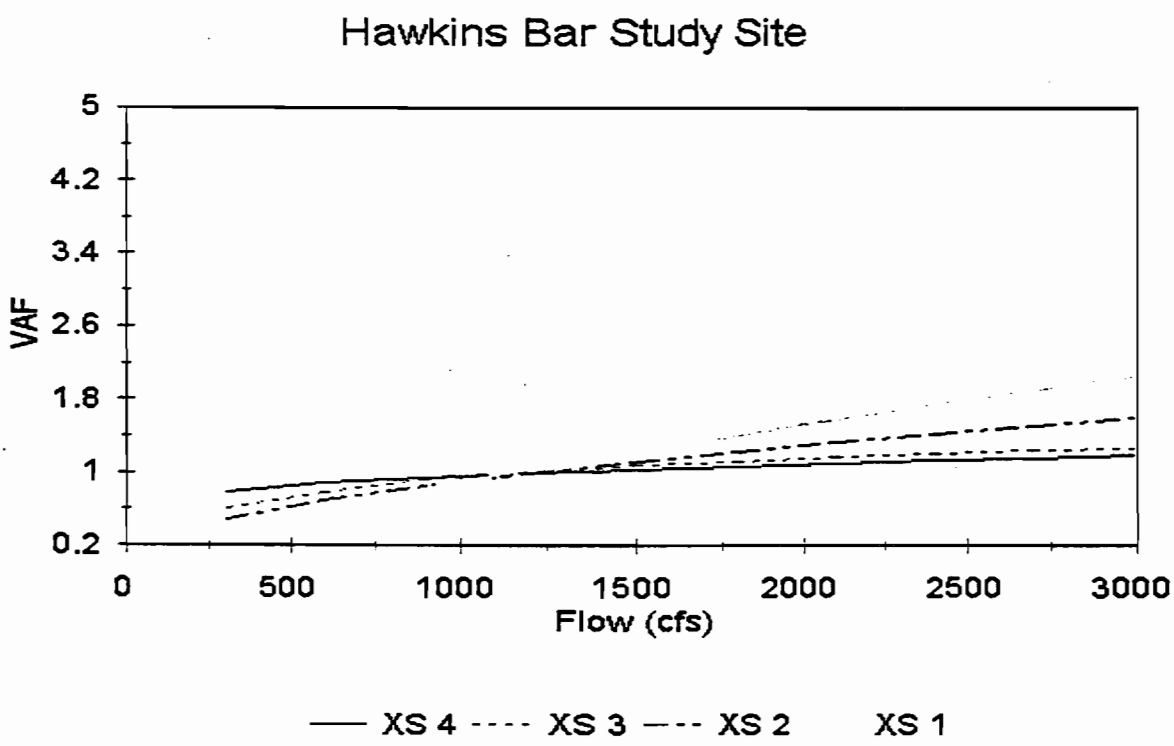
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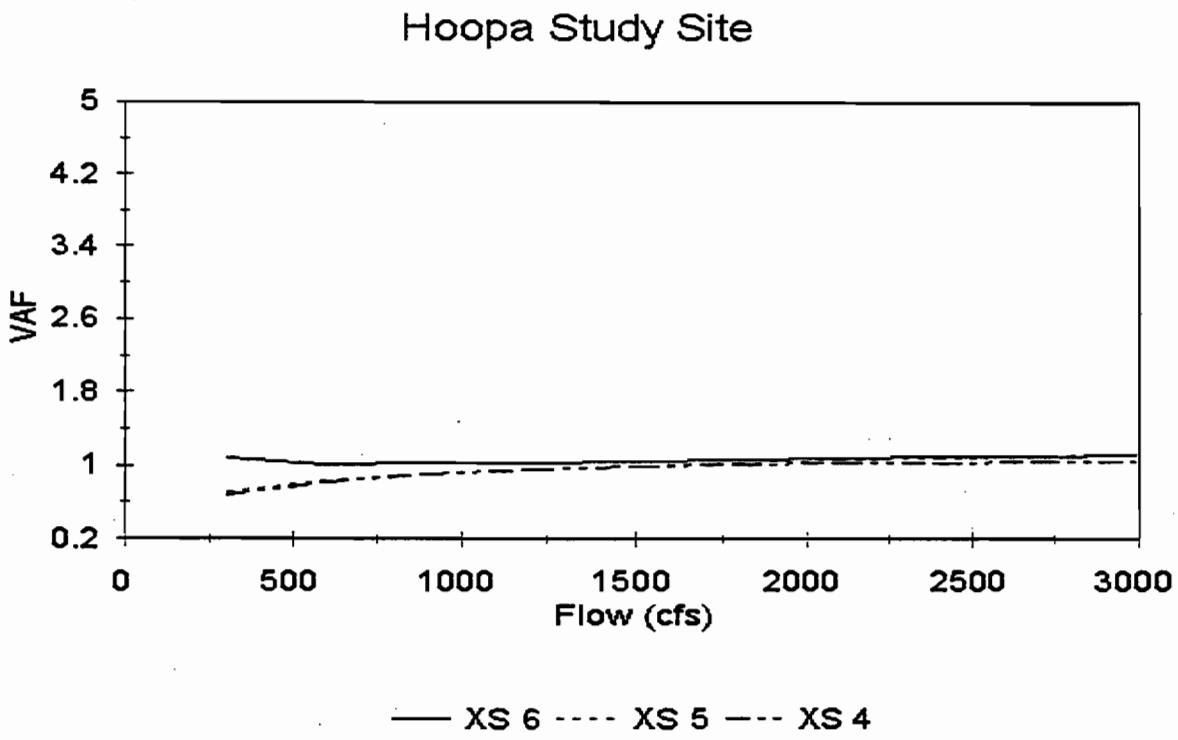
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XS 5
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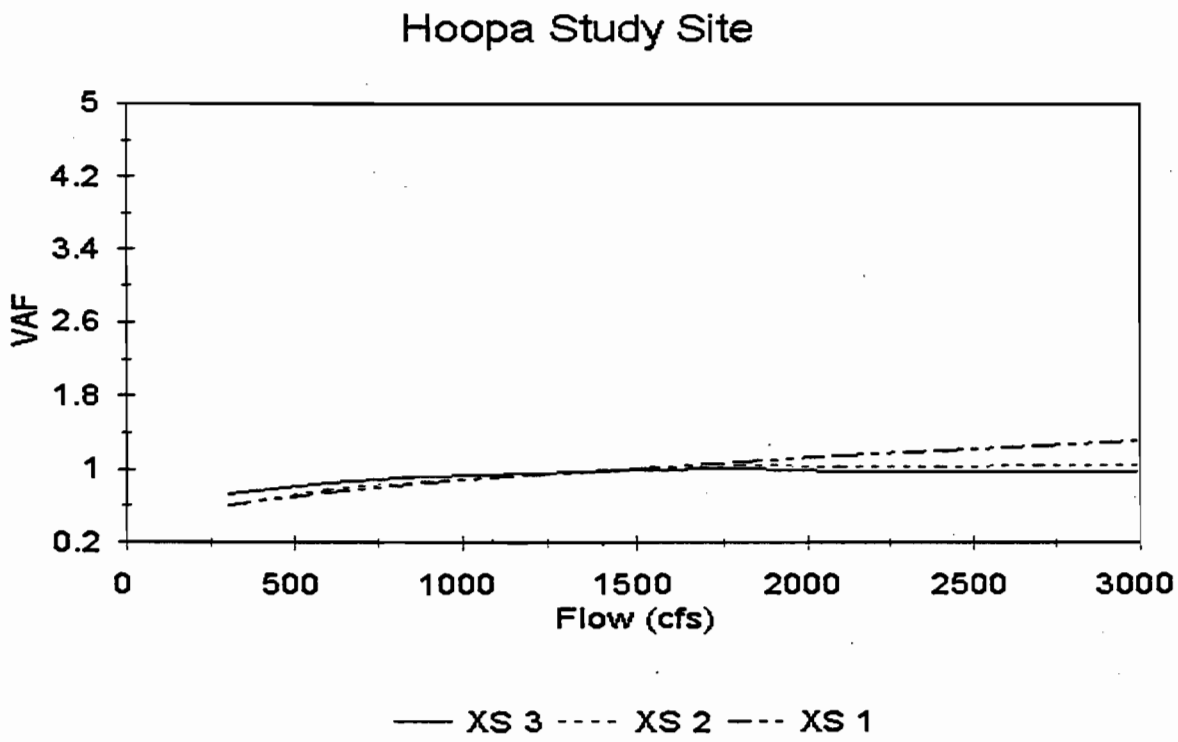
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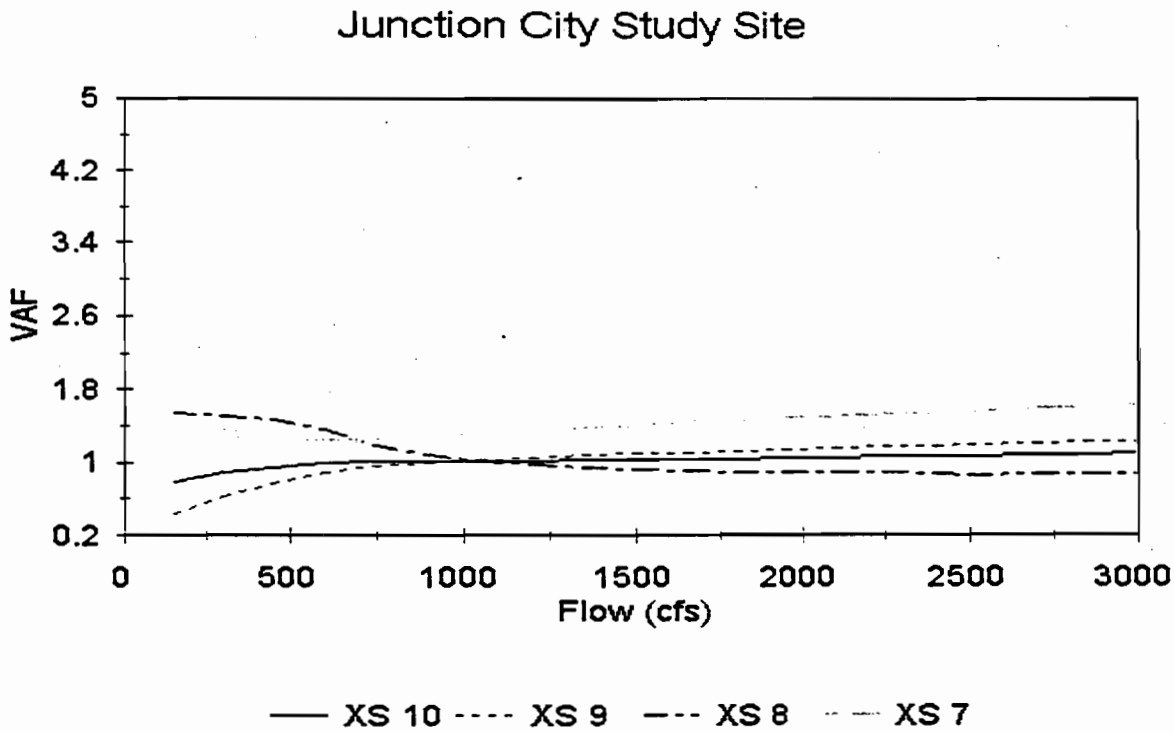
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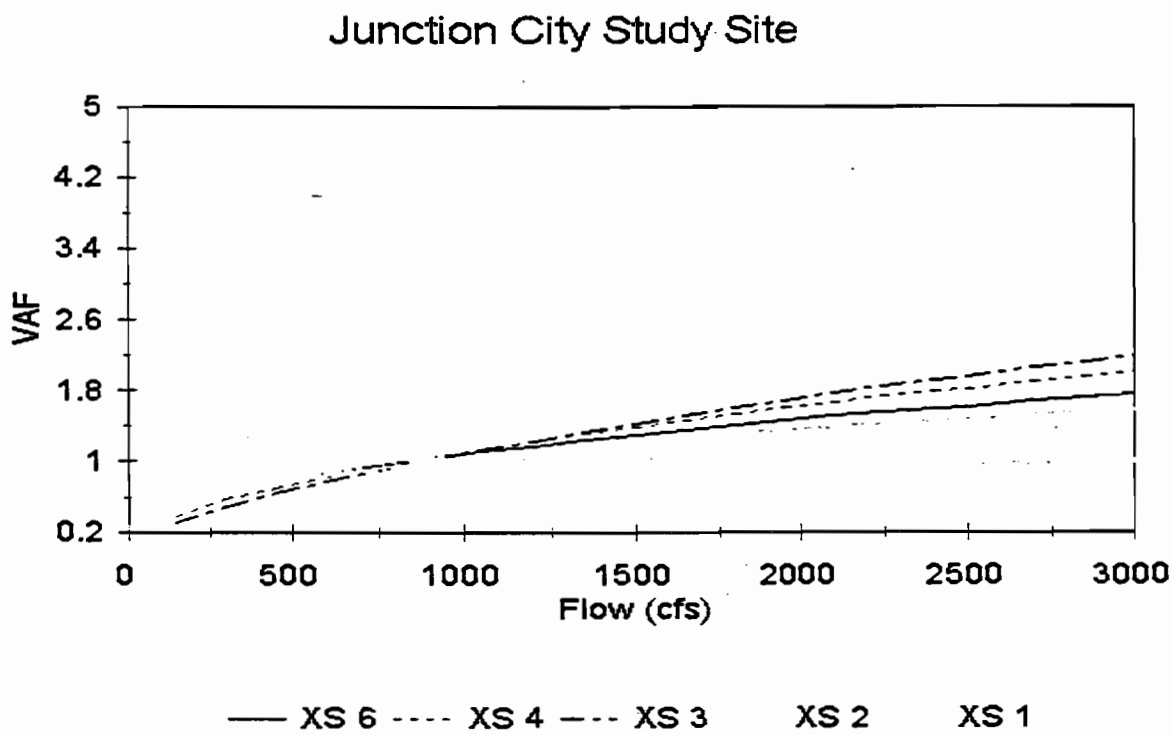
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3.4
2.6
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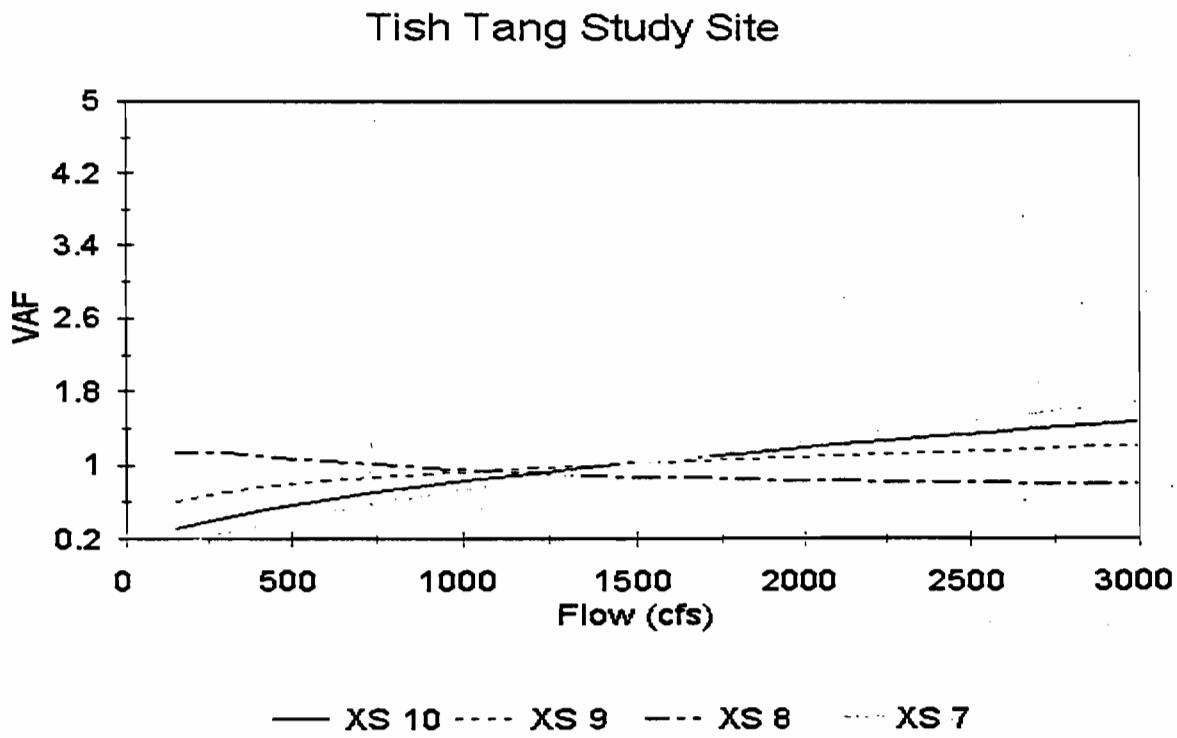
XS 4
XS 3
XS 2
XS 1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Flow (cfs)
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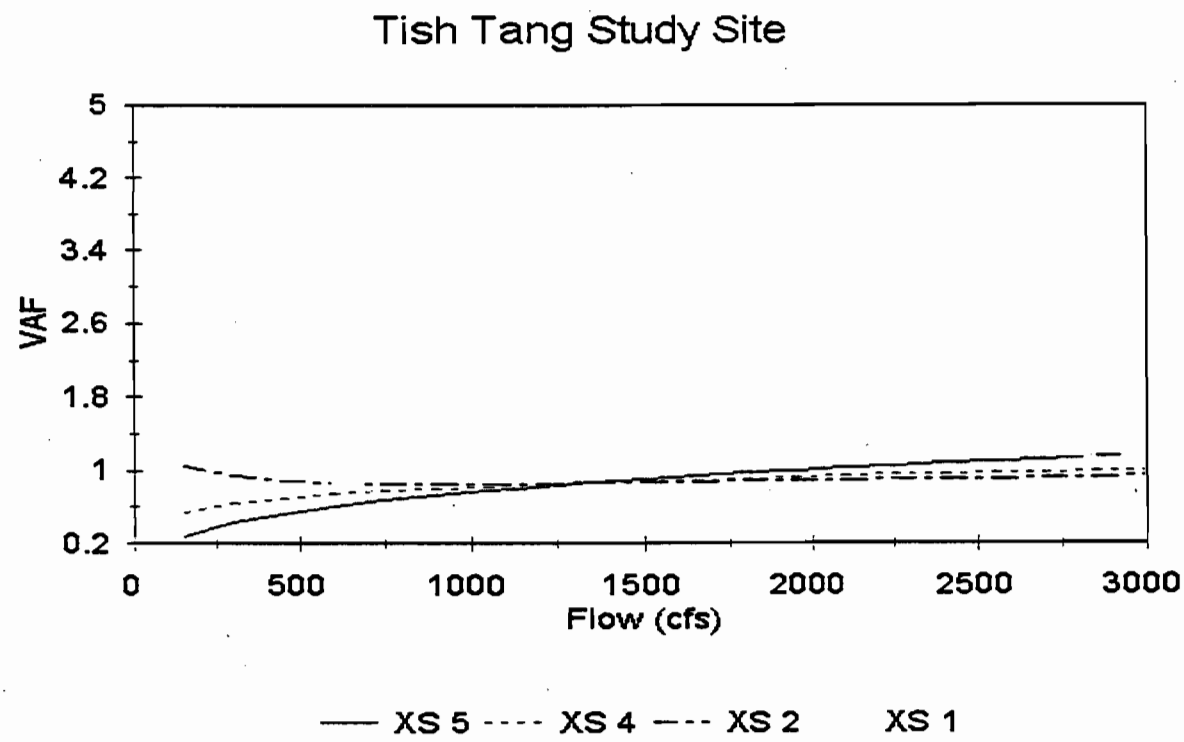
XS 8
XS 7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5
4.2
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1.8
1
0.2
0
500
1000
1500
2000
2500
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Flow (cfs)
XS 5
XS 4
XS 2
XS 1

APPENDIX C
HSI CRITERIA

Chinook Fry Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	1	0	0	0	1
0.1	0.91	0.2	0.3	100	1
0.2	0.75	0.5	0.64		
0.3	0.59	0.6	0.74		
0.4	0.44	0.7	0.83		
0.5	0.33	0.8	0.91		
0.6	0.25	1.2	1		
0.7	0.18	1.3	0.99		
0.8	0.14	1.5	0.95		
0.9	0.1	1.7	0.84		
1	0.08	1.8	0.77		
1.1	0.05	1.9	0.7		
1.2	0.03	2.4	0.48		
1.3	0.02	2.7	0.4		
1.4	0.01	2.8	0.37		
1.5	0.01	2.9	0.34		
1.6	0	3	0.3		
100	0	3.1	0.27		
		3.6	0.16		
		3.7	0.15		
		3.8	0.13		
		3.9	0.12		
		4	0.1		
		4.1	0.08		
		4.2	0.07		
		4.3	0.05		
		4.4	0.03		
		4.5	0.02		
		4.6	0.01		
		4.7	0.01		
		4.8	0.02		
		6.6	0.01		
		6.7	0		
		100	0		

Chinook Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.38	0	0	0	1
0.1	0.72	0.1	0.07	100	1
0.2	0.95	0.2	0.15		
0.3	1	0.3	0.22		
0.4	0.95	0.4	0.3		
0.5	0.85	0.5	0.38		
0.6	0.77	0.6	0.46		
0.7	0.7	0.7	0.54		
0.8	0.64	0.8	0.62		
0.9	0.59	0.9	0.7		
1	0.53	1	0.79		
1.1	0.47	1.1	0.87		
1.2	0.4	1.2	0.94		
1.3	0.33	1.3	0.98		
1.4	0.26	1.4	1		
1.5	0.21	100	1		
1.6	0.17				
1.7	0.14				
1.8	0.11				
1.9	0.07				
2	0.07				
2.1	0.07				
2.2	0.07				
2.3	0.07				
2.4	0.06				
2.5	0.05				
2.6	0.04				
2.7	0.03				
2.8	0.03				
2.9	0.03				
3.2	0.01				
3.3	0				
100	0				

Coho Fry Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	1	0	0	0	1
0.1	0.73	0.1	0.01	100	1
0.2	0.48	0.2	0.06		
0.3	0.28	0.3	0.15		
0.4	0.17	0.4	0.26		
0.5	0.11	0.5	0.39		
0.6	0.08	0.6	0.53		
0.7	0.06	0.7	0.66		
0.8	0.04	0.8	0.79		
0.9	0.03	0.9	0.91		
1	0.02	1	0.97		
1.1	0.01	1.1	1		
1.2	0.01	1.2	0.98		
1.3	0	1.3	0.93		
100	0	1.4	0.86		
		1.5	0.78		
		1.6	0.68		
		1.7	0.57		
		1.8	0.48		
		1.9	0.41		
		2	0.36		
		2.1	0.31		
		2.2	0.26		
		2.3	0.22		
		2.4	0.19		
		3.7	0.11		
		3.8	0.11		
		3.9	0.09		
		4	0.07		
		4.1	0.05		
		4.2	0.04		
		4.3	0.02		
		4.5	0		
		100	0		

Coho Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	1	0	0	0	1
0.1	0.83	0.1	0.05	100	1
0.2	0.68	0.2	0.09		
0.3	0.56	0.3	0.14		
0.4	0.5	0.4	0.19		
0.5	0.46	0.5	0.23		
0.6	0.44	0.6	0.28		
0.7	0.4	0.7	0.32		
0.8	0.35	0.8	0.37		
0.9	0.29	0.9	0.42		
1	0.22	1	0.46		
1.1	0.17	1.1	0.51		
1.2	0.12	1.2	0.57		
1.3	0.11	1.3	0.62		
1.4	0.1	1.4	0.68		
1.5	0.09	1.5	0.73		
1.6	0.08	1.6	0.78		
1.7	0.06	1.7	0.82		
1.8	0.04	1.8	0.87		
1.9	0.02	1.9	0.9		
2.8	0.02	2	0.94		
2.9	0.01	2.1	0.97		
3	0	2.2	1		
100	0	100	1		

Steelhead Fry Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.78	0	0	0	1
0.1	0.79	0.1	0.11	100	1
0.2	0.85	0.2	0.2		
0.3	0.94	0.3	0.22		
0.4	1	0.4	0.46		
0.5	0.91	0.5	0.76		
0.6	0.78	0.6	0.91		
0.7	0.54	0.7	1		
0.8	0.4	0.8	0.92		
0.9	0.25	0.9	0.86		
1	0.23	1	0.74		
1.1	0.21	1.1	0.65		
1.2	0.19	1.2	0.56		
1.5	0.11	1.3	0.47		
1.6	0.11	1.4	0.4		
1.7	0.11	1.5	0.27		
1.8	0.11	1.6	0.24		
1.9	0.1	1.7	0.21		
2	0.1	1.8	0.18		
2.1	0.1	1.9	0.15		
2.2	0.1	2	0.12		
2.6	0.03	2.1	0.08		
2.7	0	2.2	0.05		
100	0	2.3	0.04		
		3	0		
		100	0		

Steelhead Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.17	0	0	0	1
0.1	0.43	0.3	0	100	1
0.2	0.66	0.4	0.02		
0.3	0.82	0.6	0.08		
0.4	0.91	0.8	0.16		
0.5	0.93	1	0.26		
0.7	0.93	1.1	0.32		
0.8	0.94	1.3	0.46		
0.9	0.95	1.4	0.52		
1	0.97	2	0.9		
1.3	1	2.2	0.99		
1.4	1	2.3	1		
1.5	0.97	2.4	0.99		
1.6	0.91	2.6	0.97		
1.8	0.73	2.7	0.95		
1.9	0.66	2.9	0.86		
2	0.62	3.4	0.54		
2.3	0.56	3.9	0.33		
2.4	0.51	4	0.3		
2.6	0.38	4.2	0.28		
2.7	0.33	4.5	0.28		
2.8	0.31	4.8	0.25		
3	0.31	4.9	0.23		
3.2	0.26	5.4	0.16		
3.4	0.16	6.1	0.08		
3.6	0.09	6.2	0.06		
3.7	0.07	6.4	0.05		
3.9	0.04	7	0.04		
4.3	0	7.1	0.03		
100	0	7.2	0.02		
		7.3	0.02		
		7.4	0.01		
		9.1	0.01		
		9.2	0		
		100	0		

Steelhead Adult Holding

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	1
0.6	0.36	0.5	0	100	1
1	0.66	0.6	0.06		
1.5	0.76	0.7	0.11		
1.6	0.81	0.9	0.23		
2	1	1	0.28		
2.5	0.66	1.1	0.34		
3	0.4	1.2	0.39		
3.1	0.34	1.4	0.51		
3.2	0.23	1.5	0.56		
3.3	0.22	1.7	0.68		
3.5	0.1	1.8	0.73		
3.6	0.1	2	0.85		
3.7	0.09	3.5	1		
3.8	0.09	100	1		
3.9	0.08				
4	0.08				
4.3	0.05				
4.4	0.03				
4.5	0.02				
4.6	0.02				
4.7	0.01				
4.8	0.01				
4.9	0				
100	0				

Chinook Spawning

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.1	0.03	0.4	0.24	31.9	0
0.3	0.11	0.5	0.37	32	0.25
0.5	0.23	0.6	0.51	32.5	0
0.7	0.39	0.7	0.64	32.9	0
0.9	0.59	0.8	0.75	33	0.75
1.1	0.83	0.9	0.83	33.5	0
1.2	0.94	1.1	0.94	41.9	0
1.3	1	1.2	0.98	42	0.75
1.4	1	1.3	1	42.5	0
1.5	0.96	1.4	0.98	42.9	0
1.8	0.78	1.5	0.94	43	1
2.2	0.5	2.3	0.5	43.5	0
2.3	0.44	2.7	0.24	43.9	0
2.6	0.3	2.8	0.19	44	0.75
2.9	0.2	2.9	0.16	44.5	0
3.1	0.16	3.1	0.12	51.9	0
3.9	0.04	3.2	0.11	52	0.25
4	0.04	3.3	0.09	52.5	0
4.1	0.03	3.5	0.07	52.9	0
4.2	0.02	3.6	0.05	53	0.25
4.4	0.01	3.9	0.02	53.5	0
5.6	0	4.1	0.01	53.9	0
100	0	4.6	0	54	0.1
		100	0	54.5	0
				100	0

Coho Spawning

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	0	0	0	0
0.1	0	0.2	0	20.9	0
0.2	0.21	0.4	0.22	21	0.1
0.3	0.37	0.5	0.35	21.5	0
0.4	0.52	0.6	0.5	21.9	0
0.5	0.66	0.7	0.67	22	0.25
0.6	0.79	0.8	0.83	22.5	0
0.7	0.9	0.9	0.95	30.9	0
0.8	0.98	1	1	31	0.1
0.9	1	1.1	1	31.5	0
1	0.99	1.3	0.9	31.9	0
1.1	0.95	1.8	0.63	32	1
1.2	0.92	1.9	0.52	32.5	0
1.3	0.88	2	0.39	32.9	0
1.5	0.77	2.1	0.26	33	1
1.7	0.65	2.2	0.24	33.5	0
2.3	0.21	2.8	0.18	40.9	0
2.4	0.17	2.9	0.16	41	0.1
2.6	0.11	3	0.13	41.5	0
2.7	0.07	3.2	0.05	41.9	0
3	0.06	3.3	0.03	42	1
3.4	0.05	3.8	0.01	42.5	0
3.6	0.04	4	0	42.9	0
3.8	0.03	100	0	43	1
4.3	0.03			43.5	0
4.4	0.02			43.9	0
4.6	0.01			44	0.25
4.8	0			44.5	0
100	0			51.9	0
				52	0.1
				52.5	0
				52.9	0
				53	0.1
				53.5	0
				100	0

Steelhead Spawning

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0	.0	0	0	0
0.3	0.15	0.3	0.07	20.9	0
0.5	0.39	0.4	0.11	21	0.3
0.6	0.55	0.5	0.19	21.5	0
0.7	0.72	0.6	0.31	21.9	0
0.8	0.85	0.7	0.47	22	0.3
0.9	0.94	0.8	0.64	22.5	0
1	0.99	0.9	0.82	30.9	0
1.1	1	1	0.96	31	0.75
2	0.65	1.1	1	31.5	0
2.1	0.59	1.2	0.9	31.9	0
2.2	0.48	1.3	0.72	32	1
2.3	0.37	1.4	0.54	32.5	0
2.4	0.29	1.5	0.4	32.9	0
2.5	0.25	1.6	0.31	33	1
2.6	0.23	1.7	0.25	33.5	0
2.7	0.23	1.8	0.21	41.9	0
2.8	0.22	1.9	0.18	42	0.5
2.9	0.2	2	0.16	42.5	0
3	0.17	2.1	0.12	42.9	0
3.1	0.13	2.2	0.08	43	0.3
3.2	0.12	2.3	0.05	43.5	0
3.7	0.11	2.4	0.03	100	0
3.9	0.07	2.9	0.03		
4.1	0.03	3	0.02		
4.4	0	3.1	0.01		
100	0	3.2	0.01		
		3.3	0		
		100	0		

Steelhead Winter Juvenile Rearing

Water Velocity (ft/s)	SI Value	Water Depth (ft)	SI Value	Substrate Composition	SI Value
0	0.6	0	0	0	0
0.3	1	0.4	1	21.9	0
0.8	0.86	100	1	22	0.3
1.3	0.42			22.5	0
1.8	0.13			31.9	0
2.5	0.04			32	0.3
3.8	0.04			32.5	0
4	0.03			32.9	0
4.7	0.03			33	0.3
5.3	0			33.5	0
100	0			41.9	0
				42	0.3
				42.5	0
				42.9	0
				43	0.3
				43.5	0
				43.9	0
				44	1
				44.5	0
				51.9	0
				52	0.3
				52.5	0
				52.9	0
				53	0.3
				53.5	0
				53.9	0
				54	1
				54.5	0
				54.9	0
				55	1
				55.5	0
				61.9	0
				62	0.3
				62.5	0
				62.9	0
				63	0.3
				63.5	0
				63.9	0
				64	1
				64.5	0
				64.9	0
				65	1
				65.5	0
				65.9	0
				66	1
				66.5	0
				71.9	0
				72	0.3
				72.5	0
				72.9	0
				73	0.3
				73.5	0
				73.9	0
				74	1
				74.5	0
				74.9	0
				75	1
				75.5	0
				75.9	0

Steelhead Winter Juvenile Rearing (Continued)

Substrate Composition	SI Value
76	1
76.5	0
76.9	0
77	0.75
77.5	0
81.9	0
82	0.3
82.5	0
82.9	0
83	0.3
83.5	0
83.9	0
84	1
84.5	0
84.9	0
85	1
85.5	0
85.9	0
86	1
86.5	0
86.9	0
87	0.75
87.5	0
87.9	0
88	0.75
88.5	0
100	0

APPENDIX L

Physical Habitat Availability
Field Data Collection

Trinity River Flow Evaluation
Physical Habitat Availability Field Data

Mainstem Trinity River Study Sites:

Name	RM	1985[1]	1986	1987	1988	1989[2]	1990	1991	1992	1993	1994	1995
1. Hatchery	111.9	X	X									
2a. Upper Cemetery	109.0	X	X			X	X			X	X	
2b. Lower Cemetery	109.0	X	X			X	X			X	X	X
3. Bucktail	105.0	X	X			X	X			X	X	X
4. Poker Bar	102.0	X	X			X	X			X	X	X
5. Steel Bridge	99.0	X	X			X	X			X	X	X
6. Indian Creek	96.0	Site was not used for Physical Habitat Availability										
7. Steiner Flat	92.0	X	X			X	X			X	X	X
8. Oregon Gulch	81.0	X	X			X	X					
9. Junction City	80.0	X	X			X	X		X			
10. Del Loma	50.0	X	X			X						
11. Hawkins Bar	39.0	X	X									
12. Camp Kimtu	26.0	Site was not used for Physical Habitat Availability										
13. Tish Tang	17.0	X	X									
14. Hoopa Valley	11.0	X	X									

Site: Hatchery
Location: just downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Dates	Dam Release																			
7/8-9/85	454	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
9/11/85	351	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	N	N
11/5/85	316	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
7/2-3/86	813	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
8/4-5/86	620	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
11/12/86	312	N	N	N	N	N	N	N	N	A	A	A	A	A	A	A	A	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Dates	Dam Release																			
7/8-9/85	454	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
8/4-5/86	813	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Trinity River Flow Evaluation
Physical Habitat Availability Field Data

Mainstem Trinity River Study Sites:

Name	RM	1985[1]	1986	1987	1988	1989[2]	1990	1991	1992	1993	1994	1995
1. Hatchery	111.9	X	X									
2a. Upper Cemetery	109.0	X	X			X	X			X	X	
2b. Lower Cemetery	109.0	X	X			X	X			X	X	X
3. Bucktail	105.0	X	X			X	X			X	X	X
4. Poker Bar	102.0	X	X			X	X			X	X	X
5. Steel Bridge	99.0	X	X			X	X			X	X	X
6. Indian Creek	96.0	Site was not used for Physical Habitat Availability										
7. Steiner Flat	92.0	X	X			X	X			X	X	X
8. Oregon Gulch	81.0	X	X			X	X					
9. Junction City	80.0	X	X			X	X		X			
10. Del Loma	50.0	X	X			X						
11. Hawkins Bar	39.0	X	X									
12. Camp Kimtu	26.0	Site was not used for Physical Habitat Availability										
13. Tish Tang	17.0	X	X									
14. Hoopa Valley	11.0	X	X									

Site: Hatchery
Location: just downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Dates	Dam Release																			
7/8-9/85	454	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
9/11/85	351	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	N	N
11/5/85	316	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
7/2-3/86	813	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
8/4-5/86	620	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A	A
11/12/86	312	N	N	N	N	N	N	N	N	A	A	A	A	A	A	A	A	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Dates	Dam Release																			
7/8-9/85	454	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
8/4-5/86	813	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Upper Cemetery

Location: 3 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4
Dates	Dam Release				
7/1/85	456	A	A	A	A
9/12/85	350	A	A	A	A
11/5/85	316	A	A	A	A
7/7/86	819	A	A	A	A
8/5/86	620	A	A	A	A
8/19/86	503	A	A	A	A
10/21/86	318	A	A	A	A
5/8/89	1900	A	A	A	N
6/7/90	242	A	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Depth/Velocity Data

	Transect	1	2	3	4
Dates	Dam Release				
7/1/85	456	F	F	F	F
9/12/85	350	F	F	F	F
7/7/86	819	F	F	F	F
5/9/89	1900	F	F	P	F
4/14/93	3040	F	E	N	N
5/17/94	1600	F	N	E	P

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Lower Cemetery
Location: 3 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9
Dates	Calibration Flow									
6/25/85	369	Q	Q	Q	Q	Q	Q	G	A	G
9/12/85	325	Q	Q	Q	Q	Q	Q	Q	A	G
7/7/86	740	G	Q	G	G	G	G	G	A	G
8/5/86	620	G	G	G	G	G	G	G	A	G
8/19/86	503	G	G	G	Q	G	Q	Q	A	G
5/9/89	1911	G	G	Q	G	G	G	G	A	G
6/8/90	162	G	Q	G	G	G	Q	G	A	G
4/14-19/93	2941	G	G	Q	G	G	G	Q	N	G
3/2/93	1433	G	G	Q	G	G	G	G	N	G
3/29/95	6436/6710	G	G	G	G	G	G	N	N	G
5/8/95	4917/5130	G	G	G	G	G	G	Q	N	G
6/28/95	279/299	G	G	G	G	G	G	G	N	G

Codes: G = good data
Q = data questionable due to changes in bed profile, or due to irregularities attributed to measurement error or change in reference elevation.
A = data available (data quality not evaluated because data was not used in physical habitat simulation)
N = not available (not measured or data lost or no reference elevation)

Note: For 1995, the first flow is for Transects 1 through 7 (not including side channel flow), while the second flow is for Transect 9 (downstream of where the sidechannel reenters the main river). Side channel flows were minimal prior to 1995, so only one flow was necessary for previous years.

Site: Lower Cemetery

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9
Dates	Calibration Flow									
6/25/85	369	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F, G
9/12/85	325	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F, G
7/7/86	740	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F, G
5/9/89	1911	F, G	F, G	F, G	F, G	E, G	E, G	F, G	F	F, G
6/7-12/90	162	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F, G
4/14-19/93	2941	F, G	E, G	E, G	E, G	E, G	E, G	E, G	E	P, G
4/18-19/94	1433	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F, G
5/8/95	4917/5130	N	N	N	E, G	N	E, G	N	N	N
6/27-28/95	279/299	F, G	F, G	F, G	F, G	F, G	F, G	F, G	N	F, G

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect (the middle of the channel and one edge)
G = good data
Q = data questionable due to changes in bed profile
N = not available (not measured or data lost)

Note: For 1995, the first flow is for Transects 1 through 7 (not including side channel flow), while the second flow is for Transect 9 (downstream of where the sidechannel reenters the main river). Side channel flows were minimal prior to 1995, so only one flow was necessary for previous years.

Site: Bucktail
Location: 7 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4/5	6	7	8	9	10	11	12
Dates	Calibration Flow											
7/11, 29/85	444	A	G	G	A	Q	Q	G	G	G	G	G
9/10/85	330	A	Q	Q	A	Q	Q	Q	Q	Q	Q	Q
7/8/86	777	A	G	G	A	Q	G	G	G	G	G	G
8/6/86	586	A	G	G	A	Q	Q	G	G	G	G	G
5/10/89	2087	A	Q	N	A	Q	G	N	G	G	Q	G
6/11-12/90	185	A	G	G	A	G	G	G	G	G	G	G
4/16/93	2898	A	G	G	N	N	G	N	N	G	G	N
3/2/93	1535	A	Q	Q	N	N	Q	N	N	Q	Q	Q
3/29/95	6807	N	G	G	N	G	G	G	Q	Q	G	G
5/9/95	5317	N	G	G	N	G	G	G	Q	Q	G	G
6/28/95	347	N	G	G	N	G	G	G	G	G	G	G

Codes: G = good data
Q = data questionable due to changes in bed profile, or due to irregularities attributed to measurement error or change in reference elevation.
A = data available (data quality not evaluated because data was not used in physical habitat simulation)
N = not available (not measured or data lost or no reference elevation)

Site: Bucktail

Depth/Velocity Data

	Transect	1	2	3	4/5	6	7	8	9	10	11	12
Dates	Calibration Flow											
7/11, 29/85	444	F	F, G	F, G	F	F, Q	F, Q	F, G	F, G	P, G	P, G	F, G
9/10/85	330	F	F, G	F, G	F	F, Q	F, Q	F, G	F, G	P, G	P, G	F, G
7/8/86	777	F	F, G	F, G	F	F, Q	F, G	F, G	F, G	P, G	P, G	F, G
8/6/86	586	N	N	N	N	N	N	N	F, G	N	N	N
5/10/89	2087	E	F, G	E, G	E	F, Q	F, G	F, G	F, G	E, G	E, Q	E, G
6/11-12/90	185	F	F, G	F, G	F	F, G	F, G	F, G	F, G	F, G	F, G	F, G
4/16-19/93	2898	E	E, G	E, G	E	E, G	F, G	N	E, G	E, Q	E, G	F, G
4/20-21/94	1535	F	F, G	F, G	F	F, G	F, G	F, G	F, G	F, G	F, G	F, G
5/9/95	5317	N	N	E, G	N	N	N	F, G	E, G	N	N	N
6/28-29/95	347	N	F, G	F, G	N	F, G	F, G	F, G	F, G	F, G	F, G	F, G

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of transect (not including side channel)
G = good data
Q = data questionable due to changes in bed profile
N = not available (not measured or data lost)

Site: Poker Bar
Location: 10 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Calibration Flow										
7/30/85	431	G	G	Q	Q	Q	Q	Q	Q	Q	Q
9/19/85	329	G	G	G	Q	Q	Q	Q	Q	Q	Q
7/9/86	780	G	G	G	G	Q	Q	Q	Q	Q	Q
5/11/89	2001	N	N	G	N	N	Q	Q	Q	Q	Q
6/13/90	210	G	G	G	G	Q	Q	Q	Q	Q	Q
4/20/93	2827	N	N	N	N	N	N	G	N	N	N
8/6/93	480	Q	Q	Q	Q	N	Q	Q	Q	Q	Q
3/30/95	6684	G	G	G	G	N	G	G	G	G	G
5/9/95	5021	G	G	G	G	N	G	G	Q	G	G
7/6-7/95	533	G	G	G	G	G	G	G	G	G	G

Codes: G = good data
Q = data questionable due to changes in bed profile, or due to irregularities attributed to measurement error or change in reference elevation.
N = not available (not measured or data lost or no reference elevation)

Site: Poker Bar

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Calibration Flow										
7/30/85	431	F, G	F, G	F, G	F, G	F, Q	F, Q	F, G	P, Q	P, G	P, G
9/19/85	329	F, G	F, G	F, G	F, G	F, Q	F, Q	F, G	P, Q	P, G	P, G
7/9/86	780	F, G	F, G	F, G	F, G	F, Q	F, Q	F, Q	P, Q	P, G	P, G
5/11/89	2001	F, G	F, G	F, G	F, G	F, Q	F, Q	F, Q	F, Q	E, G	E, G
6/13/90	210	F, G	F, G	F, G	F, G	F, Q	F, Q	F, G	P, G	P, G	P, G
4/20/93	2827	E, G	E, G	E, G	F, G	E, G	E, G	E, G	E, G	E, G	E, G
8/5-16/93	480	F, G	F, G	F, G	F, G	F, G	F, G	F, G	P, G	P, G	N
4/26-5/2/94	1525	F, G	F, G	F, G	F, G	F, G	F, G	F, G	P, G	P, G	P, G
5/9/95	5021	F, G	N	E, G	N	N	N	N	N	N	N
7/6-7/95	533	F, G	F, G	F, G	F, G	F, G	F, G	N	F, G	P, G	P, G

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of transect (not including side channel)
G = good data
Q = data questionable due to changes in bed profile
N = not available (not measured or data lost)

Site: Steelbridge
Location: 13 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10	11	12
Dates	Calibration Flow												
7/31-8/1/85	460	Q	G	Q	Q	Q	Q	G	A	A	A	Q	N
9/18/85	356	Q	G	G	G	Q	Q	G	A	A	A	Q	N
7/9-10/86	761	G	Q	Q	G	G	G	G	A	A	A	Q	G
5/12/89	1941	G	Q	Q	N	N	G	Q	A	A	A	Q	Q
6/13/90	233	G	Q	Q	G	G	N	N	A	A	A	N	N
4/22/93	2727	G	N	G	N	N	N	N	A	A	A	N	Q
8/23-25/93	488	N	N	N	N	N	Q	Q	A	A	A	Q	Q
5/4/93	1530	Q	Q	Q	Q	Q	Q	Q	A	A	A	Q	Q
3/30/95	6684	G	G	G	G	G	G	G	N	N	N	G	G
5/10/95	5099	G	G	G	G	G	G	G	N	N	N	G	G
7/10-11/95	550	G	G	G	G	G	G	G	N	N	N	G	G

Codes: G = good data
Q = data questionable due to changes in bed profile, or due to irregularities attributed to measurement error or change in reference elevation.
A = data available (data quality not evaluated because data was not used in physical habitat simulation)
N = not available (not measured or data lost or no reference elevation)

Site: Steelbridge

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10	11	12
Dates	Calibration Flow												
7/31-8/1/85	460	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F	F	F, Q	N
9/18/85	356	F, G	F, G	F, G	F, G	F, G	F, G	F, G	F	F	F	F, Q	N
7/9-10/86	761	F, G	F, Q	F, Q	F, G	F, G	F, G	F, G	F	F	F	F, Q	F, G
5/12-15/89	1941	F, G	F, Q	F, Q	F, G	F, G	F, G	F, Q	F	F	F	F, Q	F, Q
6/13-14/90	233	F, G	F, Q	F, Q	F, G	F, G	F, G	F, Q	F	F	F	F, Q	F, G
4/21-29/93	2727	F, G	E, G	E, G	E, G	E, G	E, G	F, G	E	E	E	F, Q	F, Q
8/17-25/93	488	F, G	P, G	F, G	F, G	F, G	F, G	F, G	F	F	F	F, Q	F, Q
4/22-5/3/94	1530	F, G	F, Q	F, Q	F, G	F, G	F, G	F, G	N	F	F	F, Q	F, Q
5/10/95	5099	N	N	E, G	N	N	E, G	N	N	N	N	N	N
7/10-11/95	550	F, G	F, G	F, G	F, G	F, G	F, G	F, G	N	N	N	E, G	F, G

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of transect (not including side channel)
G = good data
Q = data questionable due to changes in bed profile
N = not available (not measured or data lost)

Site: Steiner Flat
Location: 20 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Calibration Flow										
7/2-3/85	431	A	A	Q	G	Q	G	Q	G	Q	G
9/13/85	326	A	A	Q	G	Q	Q	Q	Q	Q	G
7/14/86	801	A	A	Q	Q	Q	G	G	G	G	G
8/21/86	512	A	A	Q	Q	Q	Q	G	G	G	G
8/7/86	643	A	A	Q	Q	Q	Q	Q	Q	G	Q
9/10/86	299	A	A	Q	Q	Q	G	G	G	G	G
5/16/89	1983	A	A	Q	G	Q	G	Q	G	G	G
6/14-15/90	274	A	A	Q	Q	Q	G	Q	Q	G	G
5/10/95	5318	N	N	G	G	G	G	N	G	G	G
6/30/95	505	N	N	G	G	G	N	N	N	N	N
7/5/95	641	N	N	N	N	N	G	G	G	G	G

Codes: G = good data
Q = data questionable due to changes in bed profile, or due to irregularities attributed to measurement error or change in reference elevation.
A = data available (data quality not evaluated because data was not used in physical habitat simulation)
N = not available (not measured or data lost or no reference elevation)

Site: Steiner Flat

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Calibration Flow										
7/23/85	431	F	F	F, Q	F, G	F, Q	F, G	F, Q	F, G	F, G	F, G
9/13/85	326	F	F	F, Q	F, G	F, Q	F, G	F, Q	F, G	F, G	F, G
7/10/86	801	F	F	F, Q	F, Q	F, Q	F, G	F, G	F, G	F, G	F, G
8/21/86	512	F	N	N	N	N	N	N	N	N	N
8/7/86	643	F	N	N	N	N	N	N	N	N	N
9/10/86	299	F	N	N	N	N	N	N	N	N	N
5/16/89	1983	F	F	F, Q	F, G	E, Q	F, G	F, Q	F, G	E, G	E, G
6/14-15/90	274	F	F	F, Q	F, Q	F, Q	F, G	F, Q	F, G	F, G	F, G
4/26-27/93	3128	F	E	E, G	F, G	E, G	E, G	E, G	E, G	F, G	E, G
5/4, 16/94	1547	N	N	F, Q	F, G	F, Q	F, G	F, Q	F, Q	F, G	F, G
5/10/95	5318	N	N	N	E, G	N	N	N	N	N	N
6/30/95	505	N	N	F, G	F, G	F, G	N	N	N	N	N
7/5/95	641	N	N	N	N	N	F, G	F, G	N	F, G	E, G

Codes: F = data for full transect
E = data for edge cells only
G = good data
Q = data questionable due to changes in bed profile
N = not available (not measured or data lost)

Site: Oregon Gulch
Location: 41 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10	11
Dates	Dam Release											
8/5-6/85	450	A	A	N	A	A	A	N	A	A	A	A
9/16-17/85	354	A	A	N	A	A	A	N	A	A	A	A
11/7/85	315	A	A	N	A	A	A	N	A	A	A	A
7/15/86	793	A	A	N	A	A	A	N	A	A	A	A
8/11/86	621	A	A	N	A	A	A	N	A	A	A	A
9/11/86	307	A	A	N	A	A	A	N	A	A	A	A
5/22/89	1960	N	N	N	N	N	A	N	N	A	N	A
7/24/90	351	N	A	A	A	A	N	N	N	A	A	A
5/30/90	613	N	A	A	N	A	A	A	N	N	A	N

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Site: Oregon Gulch

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10	11
Dates	Dam Release											
8/5-6/85	450	F	F	N	F	F	F	N	F	F	F	F
9/16-17/85	354	F	F	N	F	F	F	N	F	F	F	F
7/15/86	793	F	F	N	F	F	F	N	F	F	F	F
5/22/89	1960	N	N	N	N	N	F	N	N	F	N	F
7/24/90	351	N	F	F	F	F	F	N	N	F	F	F

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Junction City
Location: 42 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Dam Release										
8/5-7/85	449	A	A	A	A	N	A	A	A	A	A
9/16/85	354	A	A	A	A	N	A	A	A	A	A
11/7/85	315	A	A	A	A	N	A	A	A	A	A
7/16/86	793	A	A	A	A	N	A	A	A	A	A
8/12/86	622	A	A	A	A	N	A	A	A	A	A
9/11/86	307	A	A	A	A	N	A	A	A	A	A
5/19-22/89	1960	A	A	A	A	N	A	A	N	N	A
5/30/90	613	A	A	A	A	N	N	N	N	N	N

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Site: Junction City

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Dam Release										
8/5-7/85	449	F	F	F	F	N	F	F	F	F	F
9/16/85	354	F	F	F	F	N	F	F	F	F	F
7/16/86	793	F	F	F	F	N	F	F	F	F	F
5/19-22/89	1960	F	E	E	F	N	F	F	N	N	F
6/15/92	6420	E	E	E	E	N	N	N	N	N	N

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Del Loma
Location: 56 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	Upper 1	Upper 2	Upper 3	Upper 4	Lower 1	Lower 2	Lower 3	Lower 4	Lower 5	Lower 6	Lower 7
Dates	Dam Release											
7/10/85	465	A	A	A	A	A	A	A	A	A	A	A
9/9/85	350	A	A	A	A	A	A	A	A	A	A	A
11/7/85	315	A	A	A	A	A	A	A	A	A	A	A
7/17/86	787	A	A	A	A	A	A	A	A	A	A	A
8/18/86	540	A	A	A	A	A	N	A	A	A	A	A
9/10/86	304	A	A	A	A	A	N	A	A	A	A	A
5/17/89	1850	A	A	N	A	N	N	N	A	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Site: Del Loma

Depth/Velocity Data

	Transect	Upper 1	Upper 2	Upper 3	Upper 4	Lower 1	Lower 2	Lower 3	Lower 4	Lower 5	Lower 6	Lower 7
Dates	Dam Release											
7/10/85	465	F	F	F	F	F	F	F	F	F	F	F
9/9/85	350	F	F	F	F	F	F	F	F	F	F	F
7/17/86	787	F	F	F	F	F	F	F	F	F	F	F
5/17/89	1850	E	E	E	E	P	E	E	F	E	E	E

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Hawkins Bar
Location: 73 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Dam Release										
6/28/85	459	A	A	A	A	N	A	A	N	A	A
9/6/85	348	A	A	A	A	N	A	A	N	A	A
7/22/86	810	A	A	A	A	N	A	N	A	A	A
8/14/86	619	A	A	A	A	N	A	N	A	A	A
9/9/86	303	A	A	A	A	N	A	N	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Dam Release										
6/28/85	459	F	F	F	F	N	F	N	F	F	F
9/6/85	348	F	F	F	F	N	F	N	F	F	F
7/22/86	810	F	F	F	F	N	F	N	N	F	F
8/14/86	619	N	F	N	F	N	N	N	N	N	N

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Tish Tang
Location: 95 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Dam Release										
6/27/85	460	A	A	N	A	A	A	A	A	A	A
9/5/85	344	A	A	N	A	A	A	A	A	A	A
7/23/86	818	A	A	N	A	A	N	A	A	A	A
8/14/86	619	A	N	N	N	N	N	A	A	A	A
9/9/86	303	A	A	N	A	A	N	A	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Depth/Velocity Data

	Transect	1	2	3	4	5	6	7	8	9	10
Dates	Dam Release										
6/27/85	460	F	F	N	F	F	F	F	F	F	F
9/5/85	344	F	F	N	F	F	F	F	F	F	F
7/23/86	818	F	F	N	F	F	N	F	F	F	F

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)

Site: Hoopa Valley
Location: 101 miles downstream of Lewiston Dam

Water Surface Elevation Data

	Transect	1	2	3	4	5	6
Dates	Dam Release						
6/26/85	460	A	A	A	A	A	A
9/5/85	344	A	A	A	A	A	A
7/24/86	818	A	A	A	A	A	A
8/14/86	619	A	A	A	A	A	A
9/9/86	303	A	A	A	A	A	A

Codes: A = data available
N = not available (not measured or data lost or no reference elevation)

Depth/Velocity Data

	Transect	1	2	3	4	5	6
Dates	Dam Release						
6/26/85	460	F	F	F	F	F	F
9/5/85	344	F	F	F	F	F	F
7/24/86	818	F	F	F	F	F	F

Codes: F = data for full transect
E = data for edge cells only
P = data for only part of the transect
N = not available (not measured or data lost)