RECLAMATION

Managing Water in the West

Technical Memorandum No. 86-68290-02-07

Rogue River Basin Project Coho Salmon Instream Flow Assessment

U.S. Department of the Interior
Bureau of Reclamation
Technical Service Center
Fisheries and Wildlife Resources Group
Denver, Colorado

November 2007

Mission Statements

The mission of the Department of the Interior is to protect and provide access to our Nation's natural and cultural heritage and honor our trust responsibilities to Indian Tribes and our commitments to island communities.

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

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U.S. Department of the Interior
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Lower Columbia Area Office
Portland, Oregon

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Abbreviations

CF	Composite Suitability Factor
EFH	Essential Fish Habitat
ESA	Endangered Species Act
ESU	Evolutionary Significant Unit
FR	Federal Register
GPS	Global Positioning System
HABTAE	Habitat program option in PHABSIM for Windows
HSC	Habitat Suitability Criteria
IFG4	Instream Flow Group 4 model
MANSQ	Mannings equation
MSA	Magnuson-Stevens Fishery Conservation and Management Act
NAD	North American Datum
NMFS	National Marine Fisheries Service
ODEQ	Oregon Department of Environmental Quality
ODFW	Oregon Department of Fish and Wildlife
OWRD	Oregon Water Resources Department
PHABSIM	Physical Habitat Simulation System
Q	Discharge (flow)
Reclamation	Bureau of Reclamation
SI	Suitability index
SONC	Southern Oregon and Northern California
STGQ	Stage-discharge relation
TSC	Technical Service Center
USDA	U.S. Department of Agriculture
USDI	U.S. Department of Interior
USGS	U.S. Geological Survey
VAF	Velocity adjustment factor
WSL	Water surface elevation
WSP	Water surface profile
WUA	Weighted usable area

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EXECUTIVE SUMMARY

The primary objective of this study was to conduct habitat investigations on Bear Creek and Little Butte Creek drainages in southern Oregon to identify stream flow needs to support relevant life history stages of Southern Oregon and Northern California (SONC) coho salmon (*Oncorhynchus kisutch*). The study was intended to develop a tool to allow an assessment of Bureau of Reclamation's Rogue River Basin Project effects on coho salmon. The Physical Habitat Simulation System (PHABSIM) was considered an appropriate methodology for this study since it considers the biological requirements of the fish.

PHABSIM predicts changes in relationships between instream flows and fish habitat for individual species and life stages. Stream flow and habitat data are used in a group of computer models called PHABSIM. This methodology is scientifically tested and is generally an accepted technique for determining flows needed for fish. This method was used in a total of 12 stream segments. In addition to PHABSIM, a two-dimensional hydrodynamic model customized for fish habitat studies, River2D, was used in two stream segments.

Adult passage, spawning, and juvenile life stages were habitat-modeled in each stream segment. Modeling results provided insight into the relationships between flow and habitat and how these results relate to the existing flow conditions. For example, optimal habitat for spawning coho in Emigrant Creek occurred at 60 cfs and flows greater than 31 cfs met 0.6 depth adult passage criteria at a shallow riffle in Emigrant Creek. Natural stream flow estimates showed that monthly flows at the mouth of Emigrant Creek were below 60 cfs November through January and below 31 cfs in November and December (50% exceedance flows). Thus, it can be concluded that there is usually not enough available water supply under estimated natural flow conditions to provide optimal flow conditions for adult spawning and for adult passage, as defined by the 0.6 depth criteria. Also, adult coho may pass shallow bars under lower flow conditions when stream flows naturally rise with fall storm events. In contrast, at the mouth of Bear Creek, optimal habitat for spawning was 60 cfs. Adult passage flow occurred at 30 cfs based on 0.6 depth criteria. These conditions are met November through January based on 50% and 80% exceedance natural stream flow levels.

The decision point in PHABSIM is a comparison of flow regimes. Habitat-discharge curves can be used to estimate how much habitat is gained or lost with incremental flow changes. The effects of flow changes on habitat depend on the shape of the curves. In some cases, small flow changes can result in major habitat increases or decreases. The amount of weighted usable area (WUA) available, in terms of lost or gained, can be determined by comparing WUA for a range of flow alternatives.

1.0 INTRODUCTION

The purpose of this study was to conduct scientific investigations on Bear Creek and Little Butte Creek and associated tributaries affected by the Bureau of Reclamation's (Reclamation) Rogue River Basin Project in southern Oregon (Figure 1) to identify stream flow needs to support relevant life history stages (e.g., adult passage, spawning, egg incubation, etc.) of Southern Oregon and Northern California (SONC) coho salmon (*Oncorhynchus kisutch*). Information gained from this study can be used to assess effects of Project operations on coho habitat and address a portion of Reclamations' obligation under the Endangered Species Act (ESA) and Essential Fish Habitat (EFH) under the Magnuson-Stevens Fishery Conservation and Management Act (MSA).

The Physical Habitat Simulation System (PHABSIM) was considered an appropriate methodology for this study since it considers the biological requirements of the fish. PHABSIM predicts changes in relationships between instream flows and fish habitat for individual species and life stages. PHABSIM is best used for decision-making when alternative flows are being evaluated (Bovee et al. 1998). Stream flow and habitat data are used in a group of computer models called PHABSIM. Hydraulic models are used to calculate water surface elevations and depths and to simulate velocities for specific discharges. Depth, velocity, substrate material, and cover data are used to determine available habitat. The model generates proportions of suitable and unsuitable reaches of the stream and shows how often a specified quantity of suitable habitat is available. This methodology is scientifically tested and is generally an accepted technique for determining flows needed for fish. It is, however, data intensive and it takes time to achieve results. The habitat requirements of a number of species are not known. Therefore, application can be limited unless emphasis is placed on developing habitat suitability criteria (HSC) for species of interest. The model's habitat versus flow relationship output must be integrated with species life history knowledge.

The Technical Service Center (TSC) of Reclamation in Denver, Colorado conducted this study.

1.1 Background

Rivers and streams in the Rogue River valley historically provided migration corridors and productive spawning and rearing habitat for SONC coho salmon. This anadromous salmon species migrates between the Pacific Ocean and their home streams. In the 1940's, wild coho returns at Gold Ray Dam on the upper Rogue River averaged approximately 4,000 fish in the SONC. However, the average coho returns plummeted below 200 by the 1970's, presumably due to low ocean survival and over-harvest factors. Because of these and many other factors, coho salmon were listed as threatened under the ESA in the late 1990's. However, total numbers of coho have been increasing in the Rogue River Basin since the 1990s, likely the result of a variety of factors.

In the Bear Creek and Little Butte Creek watersheds, coho salmon are part of the SONC Evolutionary Significant Unit (ESU) which was listed as threatened by National Marine

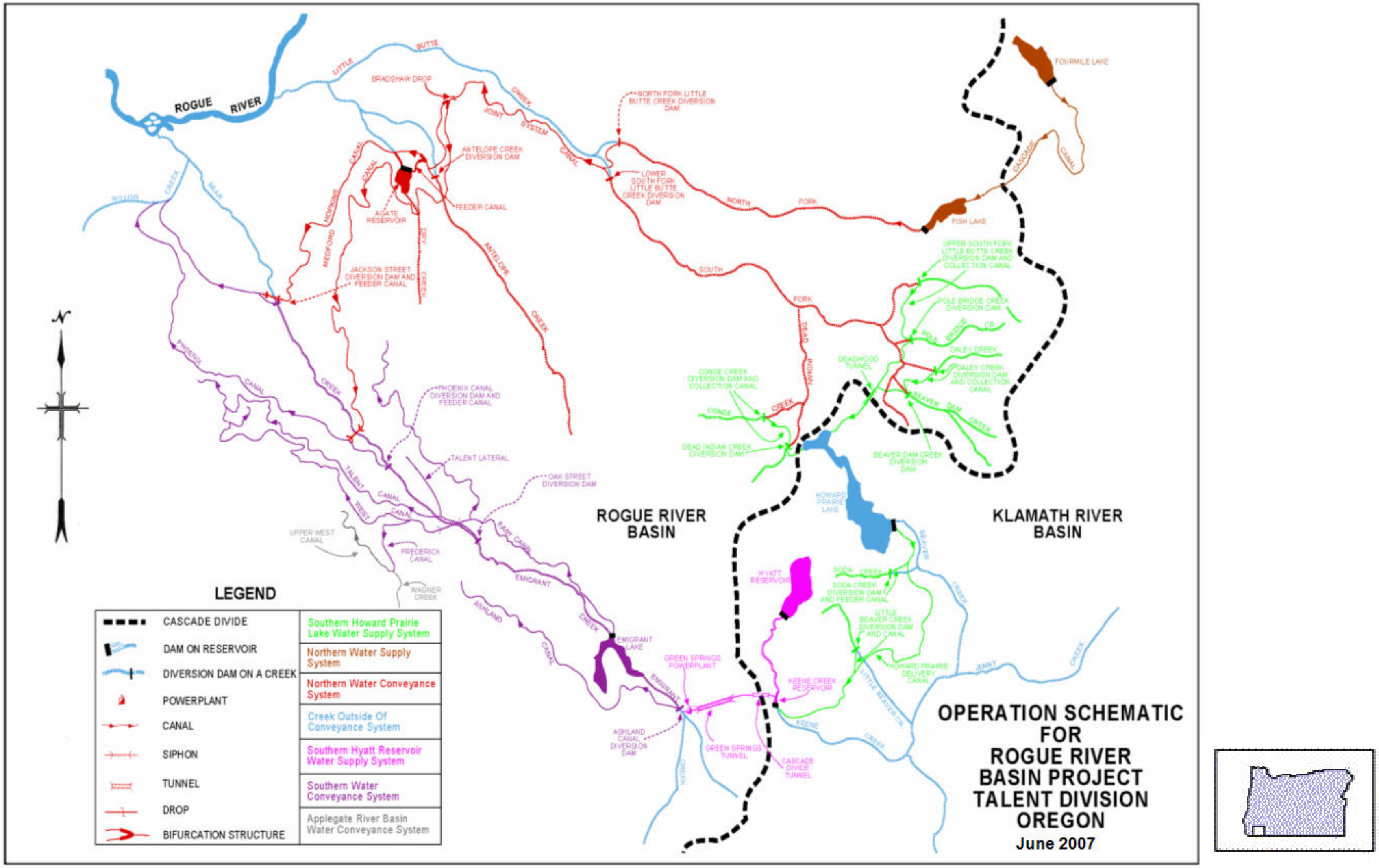


Figure 1 Map of Rogue River Basin Project in southern Oregon.

Fisheries Service (NMFS) on June 28, 2005 (70 FR 37160) (previously listed on May 6, 1997 [62 FR 24588]). The agency announced its final coho critical habitat designation, which includes the project area, on May 5, 1999 (64 FR 24049), and protective regulations were issued under Section 4(d) of the ESA on June 28, 2005 (70 FR 37160) (previously issued on July 18, 1997 [62 FR 38479]).

1.2 Coho Salmon General Fish/Habitat Relationships

At an April 18, 2006 stakeholder meeting, life stages for this study were decided as adult passage, spawning, incubation, and juvenile rearing. The Little Butte Creek basin includes about 55 miles of spawning and rearing habitat for coho salmon (Vogt 2004). Despite poor habitat conditions in the Bear Creek basin, coho spawning and rearing habitat occurs in approximately 30 miles of streams in this basin (Vogt 2004). Table 1 summarizes general habitat requirements for various life stages of coho salmon.

Table 1 General coho habitat requirements.

Life Stage	Depth (ft)	Velocity (ft/sec)	Substrate	Cover
Spawning	≥ 0.5 (Smith 1973)	0.7-2.3 (Smith 1973)	Gravel-small cobble (Platts et al. 1979); 0.5-4.0" diameter with < 5% fines (Burner 1951; Reiser and Bjornn 1979; McMahon 1983)	Often close to or under cover (Burner 1951)
Incubation	Submerge redds (Bjornn and Reiser 1991)	Maintain adequate circulation (Bjornn and Reiser 1991)	Same as spawning (McMahon 1983)	
Juvenile (> 50 mm)	2-3 (Hampton 1988; Beecher et al. 2002)	0.1-1.5 (Hampton 1988; Beecher et al. 2002; Murphy et al. 1989; Dollof and Reeves 1990; Moyle 2002)	Gravel (0.5-2.5") -cobble (2.5-10") with few fines (McMahon 1983)	Large woody debris; overhead cover (Peters 1996; Moyle 2002)

Coho salmon tend to spawn in small streams or in side channels to larger rivers; and at times, they spawn along the river margins of larger streams, but normally not in large numbers (Lestelle 2007). Coho salmon spawn heavily in groundwater channels where these habitats exist along the floodplains of rivers, often in relatively high densities. One of the most important considerations regarding flow needs for egg incubation is maintaining adequate circulation through redds. Circulation in redds should be evaluated based on substrate size, stream gradient, velocity, and water depth sufficient to keep redds fully submerged (Bjornn and Reiser 1991), which is not necessarily the same water depth needed for adult spawning.

Upon emergence, coho fry move quickly to low velocity habitats (< 0.5 ft/sec) (Morsell et al. 1981), typically along the channel margin, or they continue to move downstream. Coho fry have a strong affinity for very low velocity water and generally move there as rapidly as possible. Fish that emerge during high flows can be swept downstream, moving them to less suitable habitats, increasing bioenergetic costs, and increasing predation exposure. Large rivers typically provide little suitable habitat for young coho fry (Lestelle 2007).

Juvenile coho are found residing in a wide variety of stream types and sizes during summer. They are typically found in highest densities within their natal streams since the majority of fry usually do not migrate long distances from spawning sites (Lestelle 2007). The need for low velocity water by juvenile coho remains strong during this life stage. Juvenile Chinook and steelhead will often be found feeding near velocity shears within main channels, while coho remain more closely associated with the shoreline or dense cover of woody debris. This pattern indicates a much stronger affinity for low velocity by coho salmon than the other species during this life stage. Juvenile coho are most often found in pools (Lestelle 2007).

The influence of wood on rearing densities during summer is not the same across all stream types and sizes. Evidence exists that the affinity of juvenile coho salmon for wood accumulations increases through the summer with growth (Lestelle 2007). High water temperatures during summer can be an important factor affecting the distribution, growth, and survival of juvenile coho salmon. High water temperatures can trigger movement of juvenile coho salmon during summer, when little movement typically occurs. Movement occurs as coho seek refuge from high water temperatures (Sutton et al. 2007). In cases such as this, the need to reduce stress from hot temperatures can override physical habitat (e.g. velocity, cover, and depth) preferences.

In many streams, some juvenile coho salmon move from their summer rearing locations in fall, triggered by increased flows associated with autumn rainfall (Lestelle 2007). This movement is another demonstration of the affinity that these fish have for low velocity water. Water velocities increase in main stream habitats with rising flow, either dislodging juveniles from summer rearing sites or stimulating them to move to find more favorable habitats prior to the coming of larger, more frequent winter storm events. During this period of redistribution, some juvenile coho salmon emmigrate into off-channel habitats. These habitats provide refuge from high flow velocities. This movement of juvenile coho salmon from mainstem streams during fall and winter appears to be due to fish leaving unfavorable areas in search of improved survival conditions. Within mainstem streams, they evacuate sites with high exposure to high velocities. Large wood accumulations are especially important as velocity refuge sites during winter, particularly in large streams.

2.0 BASELINE FISHERY, HYDROLOGY, AND TEMPERATURE DATA

Reclamation compiled existing hydrology, water temperature, and fish population data to establish a baseline for the study area. Existing coho population data were used as an index of fish populations in the study streams. Table 2 summarizes periodicity of coho salmon in the Bear Creek and Little Butte Creek watersheds.

Table 2 Fish use in Bear Creek and Little Butte Creek watersheds.

Coho Life Stage	Critical Period
Spawning[1]	November 1 – January 31
Incubation[2]	November 1 – May 31
Smolt emigration/juvenile rearing[3]	February 15 – June 30
Juvenile rearing[4]	July 1 – September 30
Adult passage[5]	October 1 – January 31

Backup sources:
[1] Oregon Department of Fish and Wildlife (ODFW) spawning survey data (1996-2004) provided to GeoEngineers, Inc by Briana Sounhein, ODFW Corvallis Research Office, September 2007
[2] Egg incubation timing based on 700-800 temperature units (ºC) for coho and temperature data from Reclamation's Hydromet Stations
[3] Smolt trap data from ODFW and temperature data from Reclamation's Hydromet Stations
[4] Oregon Department of Environmental Quality (ODEQ) water temperature standard and temperature data from Reclamation's Hydromet Stations
[5] Gold Ray Dam ODFW fish counts and and periodicity charts (Jay Doino, ODFW, personal communication, November 16 and November 17, 2006)

Based on adult passage observations (2001-2006) at Gold Ray Dam, <1 to 6.4% of adults had passed the dam by October 15; and these fish would only then be expected to enter spawning tributaries with the onset of fall freshets (Tom Satterthwaite, ODFW, Personal Communication, February 28, 2007). Most coho pass Gold Ray Dam between mid-October and early December, and then subsequently enter spawning tributaries with the onset of fall rains. Thus, the beginning date of October 1 for passage is very conservative for adult coho passage in spawning tributaries such as in Bear Creek Watershed or Little Butte Creek Watershed.

Coho smolt outmigration trap results that include Little Butte Creek are summarized in Figures 2 and 3 for 1999 and 2000, respectively. Peak emigration in Little Butte Creek occurs in early May. Smolt trapping by ODFW in Bear Creek resulted in coho smolt production estimates of 100, 2,194, and 197 in 2001, 2002, and 2003, respectively (Doino 2006). No coho smolts were captured in 2004 or 2005 in Bear Creek. In 2006, ODFW captured 212 coho smolts in Bear Creek near Phoenix for an estimated outmigrant total of 1,843 (ODFW data base).

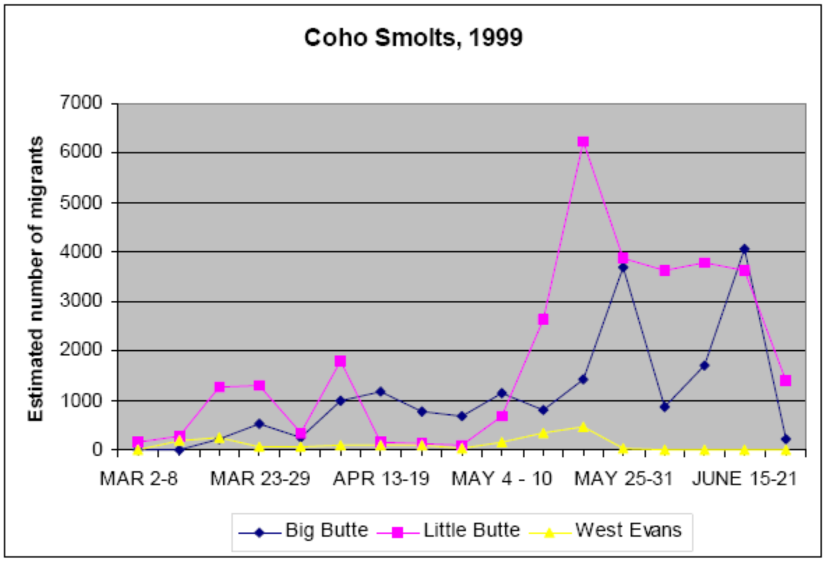


Figure 2 Estimated number of coho smolts out-migrating weekly from various creeks in upper Rogue River Basin, 1999.
Source: Vogt (1999)

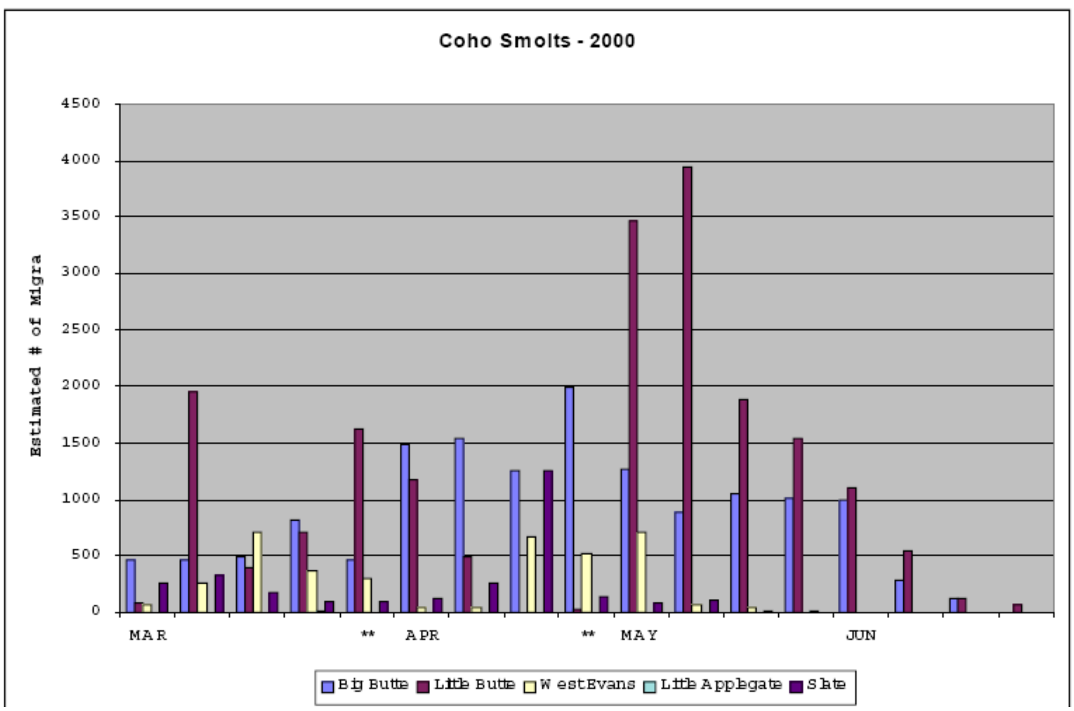


Figure 3 Estimated number of coho smolts out-migrating weekly from various creeks in upper Rogue River Basin, 2000.
Source: Vogt (2000)

Fish surveys were conducted by Reclamation during mid to late summer in 1997 and 1998 to supplement ODFW data on salmon and trout distribution and relative abundance in Bear Creek and Little Butte Creek drainages (Broderick 2000). One coho juvenile was captured in Bear Creek at the North Mountain Avenue Bridge. Two coho juveniles were captured in Little Butte Creek at the Brownsboro Bridge site.

In 2006, Reclamation observed juvenile coho in a pool located at the selected PHABSIM study site on South Fork Little Butte Creek (Figure 4). Also, a coho salmon redd had been flagged at this site during a January, 2005 spawning survey. Transects were placed across the redd and the pool for the PHABSIM study.

Figure 4 Photo of juvenile coho salmon in a pool on South Fork Little Butte Creek, August 17, 2006.

Reclamation supports telemetered gaging stations in the Rogue Project through its Hydromet system (http://www.usbr.gov/pn/hydromet) (Figure 5). Figures 6-9 illustrate recent daily discharges at some of these gages in the Bear Creek and Little Butte Creek watersheds. Table 3 summarizes natural stream flow estimates at various streams in the Rogue Project area. Estimates were obtained from the Oregon Water Resource Department (OWRD) website (http://map.wrd.state.or.us/apps/wr/wr_mapping) at 50 percent and 80 percent exceedance levels. Parkinson and Stillwater (2007) provide more detailed hydrologic analyses.

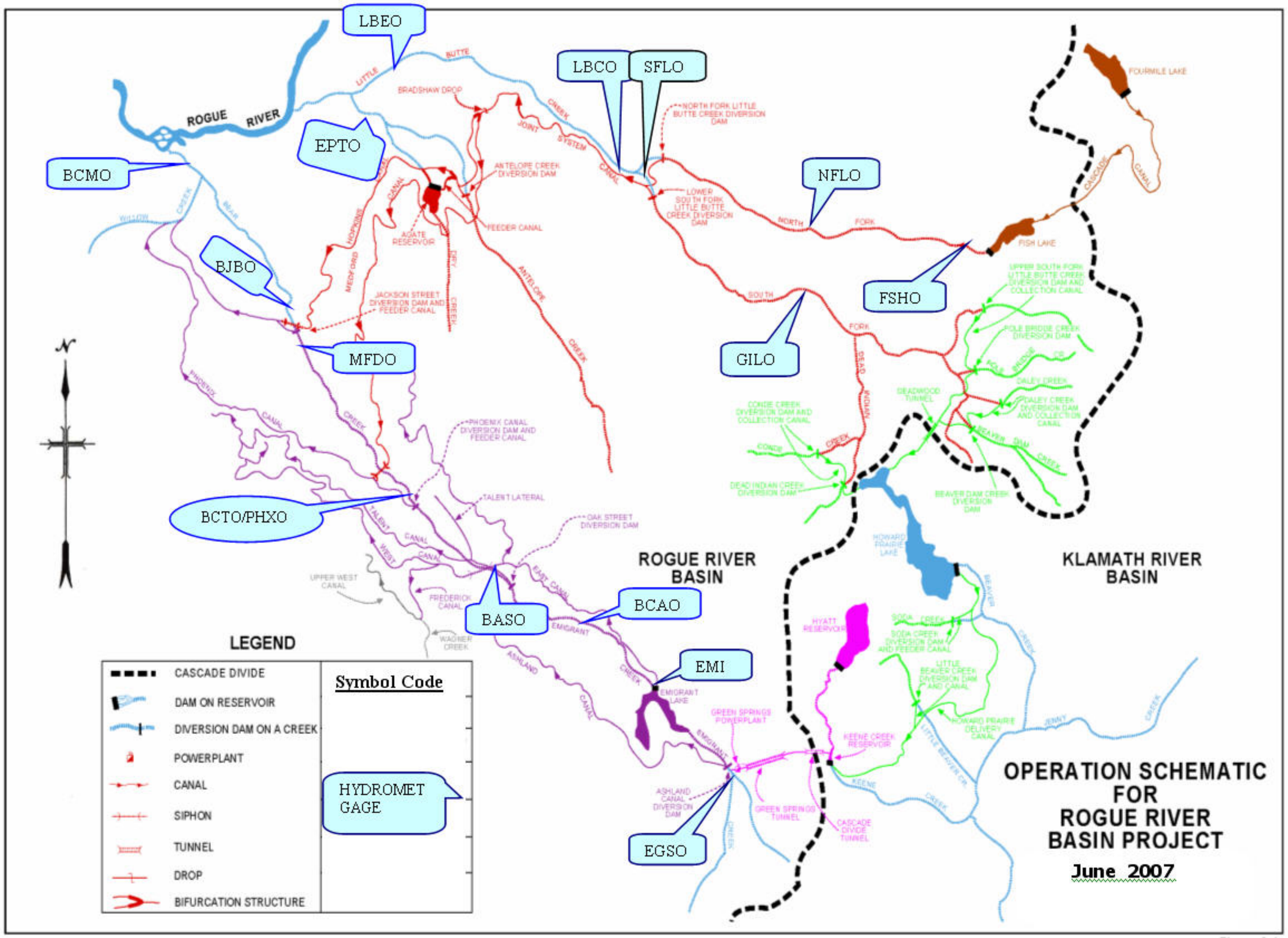


Figure 5 Map of hydromet stream gage locations for Rogue River Basin Project.

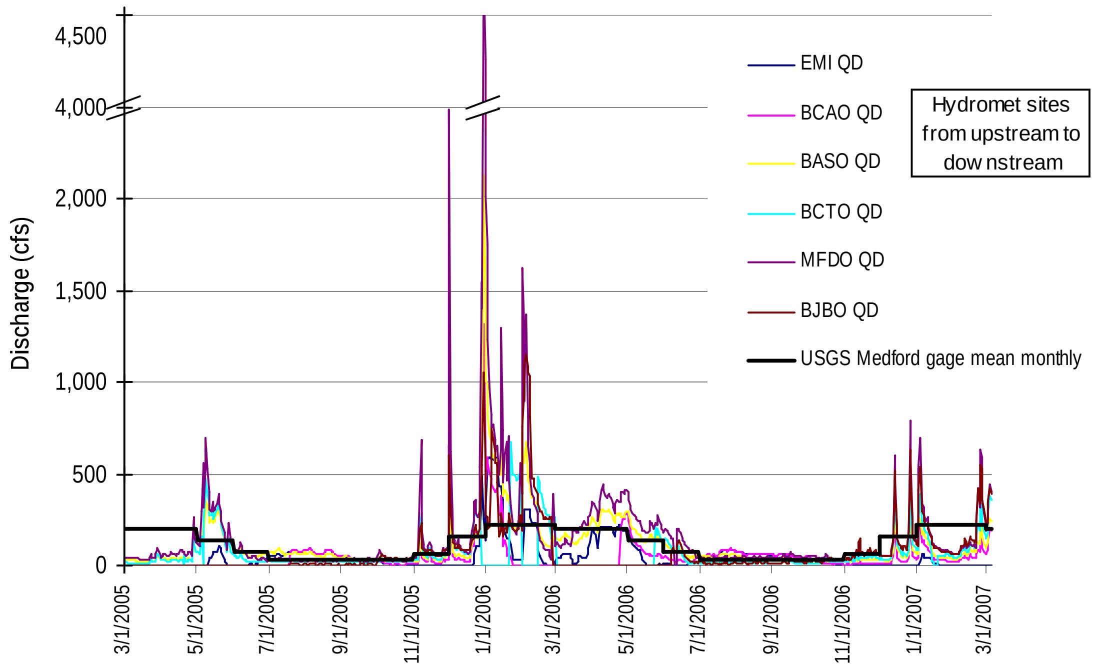


Figure 6 Recent daily discharge for Emigrant Creek and Bear Creek at various locations. Source: Reclamation Hydromet: http://www.usbr.gov/pn/hydromet

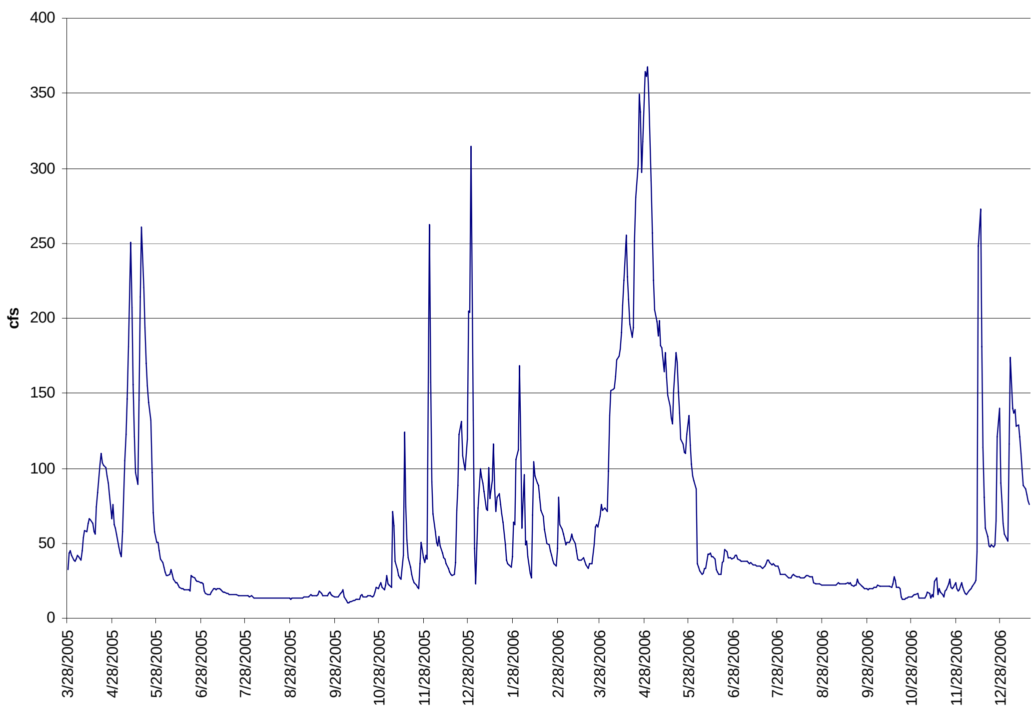


Figure 7 Recent daily discharge for South Fork Little Butte Creek near PHABSIM study site (i.e., GILO Hydromet station). Source: Reclamation Hydromet: http://www.usbr.gov/pn/hydromet

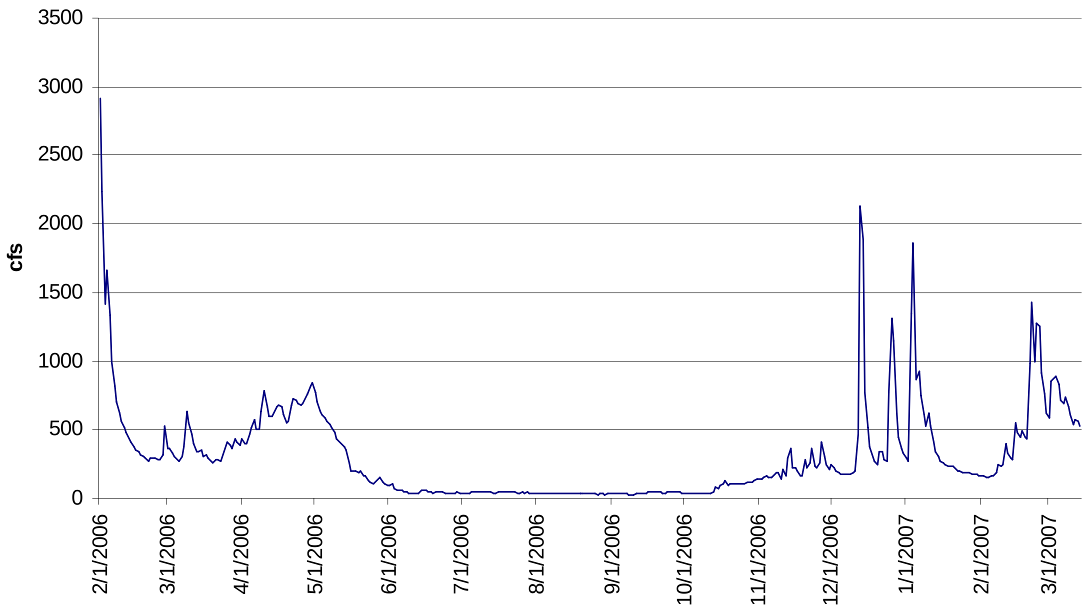


Figure 8 Recent daily discharge for Little Butte Creek below Eagle Point (i.e., LBEO Hydromet station). Source: Reclamation Hydromet: http://www.usbr.gov/pn/hydromet

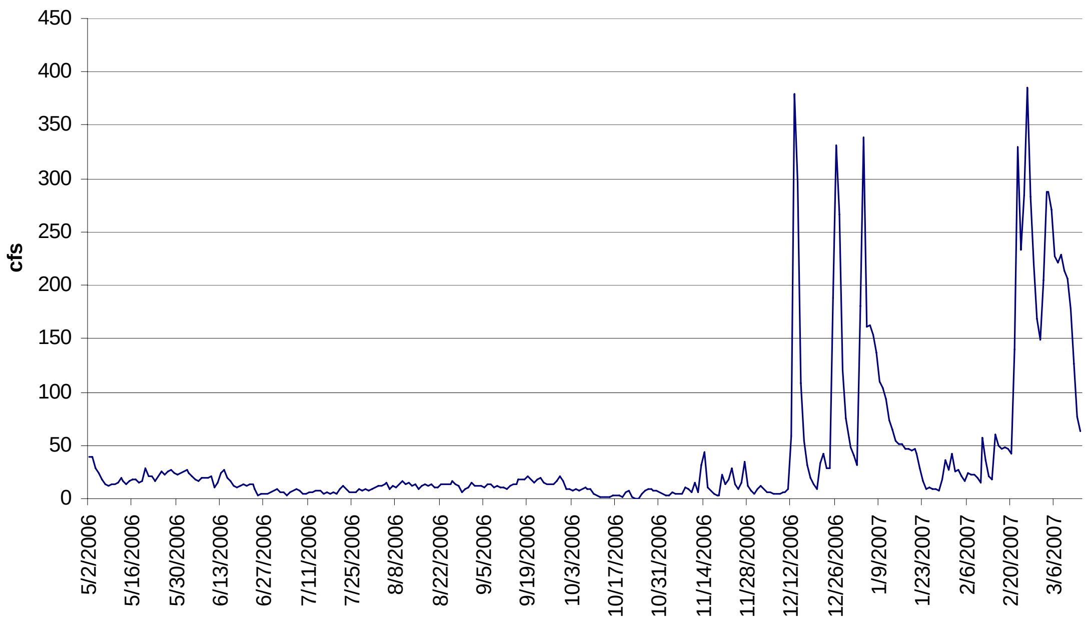


Figure 9 Recent daily discharge for Antelope Creek near Eagle Point (i.e., EPTO Hydromet station). Source: Reclamation Hydromet: http://www.usbr.gov/pn/hydromet

Table 3 Natural stream flow estimates on various streams in Rogue Project area (Source: OWRD website: http://map.wrd.state.or.us/apps/wr/wr_mapping/)

Month	Mouth of Emigrant Creek	Mouth of Walker Creek	Mouth of Griffin Creek	Mouth of Jackson Creek	Mouth of Wagner Creek	Mouth of Bear Creek	Mouth of Little Butte Creek	Mouth of S. Fk. Little Butte Creek	S. Fk. Little Butte Creek above Dead Indian Creek	Mouth of Dead Indian Creek	Mouth of Antelope Creek
	Natural Stream Flow (cfs) (50 percent exceedance)										
January	38.3	29.0	10.2	13.8	15.6	216.0	331.0	140.0	36.4	21.3	50.1
February	47.6	35.7	12.7	17.1	19.3	265.0	406.0	172.0	41.6	26.5	62.9
March	45.6	35.6	11.0	14.3	18.7	241.0	411.0	192.0	50.2	31.2	60.1
April	36.9	30.7	7.1	8.7	14.8	182.0	458.0	253.0	85.5	43.8	57.8
May	37.7	34.5	5.4	6.2	14.8	168.0	299.0	208.0	51.0	39.9	28.0
June	22.3	24.8	2.8	3.2	8.9	101.0	119.0	91.0	78.5	17.9	8.7
July	9.0	10.8	1.0	1.0	3.4	39.5	81.8	64.7	61.5	11.8	5.7
August	5.5	6.9	0.5	0.5	1.9	23.6	62.0	50.0	57.3	8.3	4.1
September	5.2	6.3	0.4	0.4	1.7	20.3	48.1	38.7	45.6	5.8	3.2
October	6.2	7.5	0.5	0.4	2.1	24.1	30.4	23.3	31.6	3.2	1.7
November	12.6	12.9	1.9	2.0	5.3	61.5	61.4	36.3	38.4	5.2	4.5
December	26.6	20.6	6.9	9.3	11.0	153.0	232.0	99.2	42.0	14.9	31.3
	Natural Stream Flow (cfs) (80 percent exceedance)										
January	19.1	14.8	4.6	6.1	7.6	107.0	133.0	59.5	27.0	9.1	17.5
February	23.8	18.4	5.8	7.6	9.6	129.0	206.0	93.6	32.5	14.8	29.0
March	24.3	19.5	5.4	7.0	9.9	129.0	236.0	115.0	38.0	18.9	31.7
April	20.3	18.0	3.6	4.5	8.3	105.0	297.0	176.0	53.3	31.5	34.7
May	17.2	17.0	2.4	2.9	7.0	84.2	141.0	104.0	87.1	21.0	11.7
June	14.1	15.2	1.6	1.7	5.4	61.6	82.5	65.3	54.3	12.2	6.6
July	6.8	7.9	0.6	0.6	2.3	28.1	73.9	58.7	56.8	9.4	5.7
August	4.8	5.6	0.4	0.3	1.5	19.3	70.7	54.6	50.2	7.9	5.9
September	4.2	5.1	0.3	0.3	1.3	17.1	45.9	36.4	41.8	5.2	3.3
October	4.6	5.5	0.4	0.3	1.5	18.3	23.3	18.6	32.3	2.7	1.1
November	7.1	8.2	0.8	0.7	2.8	30.9	34.4	24.2	25.5	3.5	2.2
December	11.9	10.6	2.4	3.1	5.1	65.3	60.8	32.4	27.8	5.4	5.5

The Rogue Valley Council of Governments (2001) ranked the highest priority watershed restoration needs for the Bear Creek mainstem as summer stream flows, summer stream temperature, and water quality. Sedimentation, riparian habitat quality, and aquatic habitat quality were ranked as medium priority. Channel stability, floodplain connectivity and in-stream barriers were ranked as low priority for Bear Creek.

Probably the single most important factor limiting salmonid production and distribution in Bear Creek and Little Butte Creek is high summer stream temperatures (USDI/USDA 1997; Dambacher et al. 1992). Bear Creek and Little Butte Creek drainages are listed as water quality limited for temperature by ODEQ (www.deq.state.or.us/wq/303dlist/303dpage.htm). Oregon water temperature standards are seven-day average maximum temperatures of 13.0°C (55.4°F) for salmon spawning and 18.0°C (64.4°F) for salmon rearing (ODEQ 2004).

Hourly water temperatures in Bear Creek, Little Butte Creek, and Neil Creek were recorded by Reclamation during Summer, 2006 using Onset Tidbit data loggers (Figures 8-10). Oregon standards for coho rearing were exceeded between July and September. Temperature in Bear Creek reached a maximum of 26.2°C (79°F) on June 26 and 27 and July 25 and 26 just upstream from the Jackson Street Diversion (Figure 10). Temperatures were generally higher in the downstream reaches than the upstream reaches (i.e., Oak Street Diversion). Maximum temperatures in Little Butte Creek and Neil Creek of 29.1°C (84°F) and 23.2°C (74°F), respectively, occurred on July 24 (Figures 11 and 12).

Stream temperature is driven by the interaction of many variables, including shade, geographic location, vegetation, climate, topography, and discharge. Discharge levels are affected by weather, snowpack, rainfall, and water withdrawal. Diverted water can reduce water quality. Shallower, slower moving water tends to warm faster than deeper, faster moving water. Warmer water holds less dissolved oxygen than cooler water. The combination of warm water with less dissolved oxygen, especially water temperatures above 20°C (68°F) and dissolved oxygen below 5 milligrams per liter, can stress salmonids (Bjornn and Reiser 1991). The upper lethal limit for juvenile coho is 25.6°C (78°F) (Bell 1991). Additional temperature analyses of the study area are provided in a technical memorandum by Horsburgh (2007).

The average snowpack level in the Rogue and Umpqua Basins on April 1, 2006 was 162 percent (Natural Resources Conservation Service 2007). The April 1 value is the most commonly used indicator of snowpack conditions since, in most years, it is the final value calculated before snowmelt begins. Streamflow forecast on April 1, 2006 called for 130 percent of average flow in the Rogue River at Raygold, April through September (Natural Resources Conservation Service 2007). The mean April 2006 air temperature at Ashland, Oregon was 9.9°C (49.7°F) (Western Regional Climate Center 2007). Average July and August 2006 air temperatures at Ashland were 22.2°C (71.9°F) and 19.7°C (67.5°F), respectively. These compare with period-of-record averages of 20.7°C (69.3°F) for July and 20.1°C (68.2°F) for August (Western Regional Climate Center 2007).

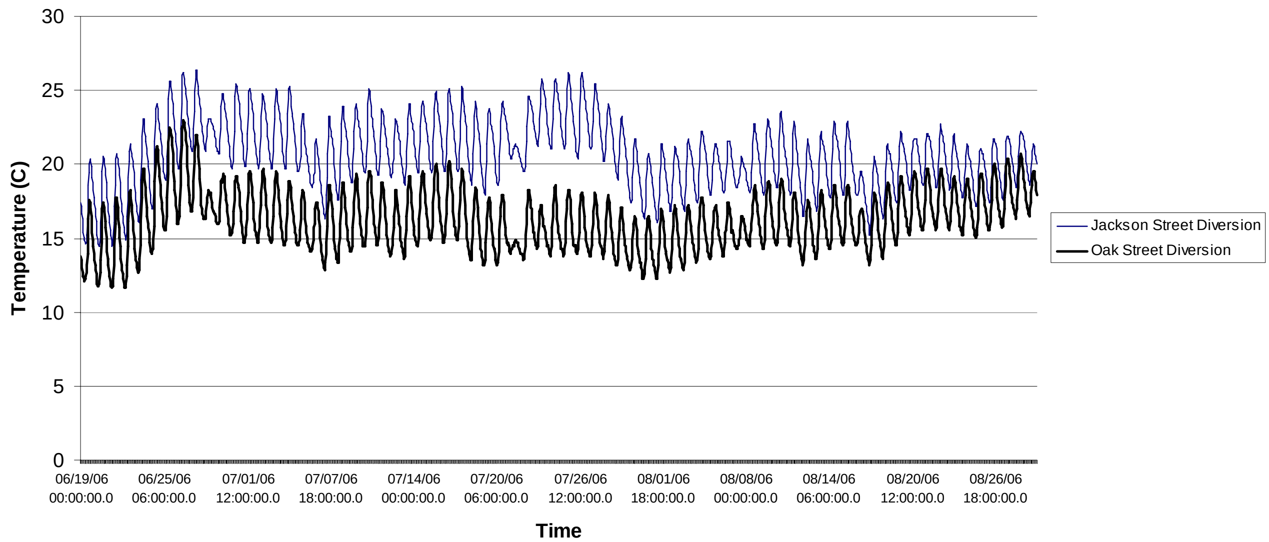


Figure 10 Temperatures measured in Bear Creek during Summer, 2006.

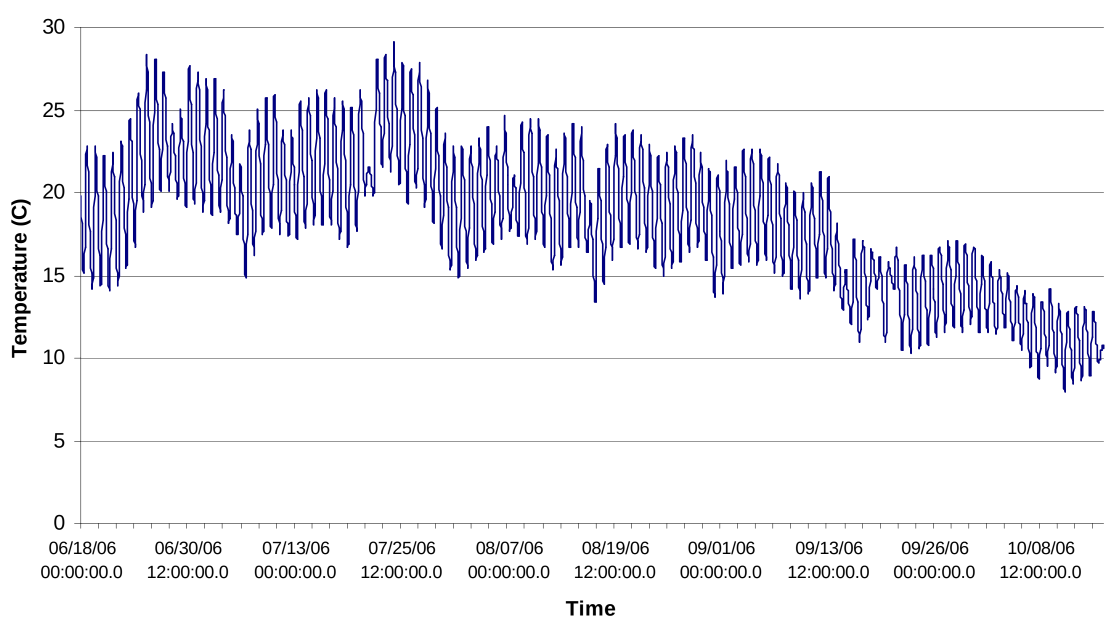


Figure 11 Temperatures measured in Little Butte Creek near Brownsboro during Summer, 2006.

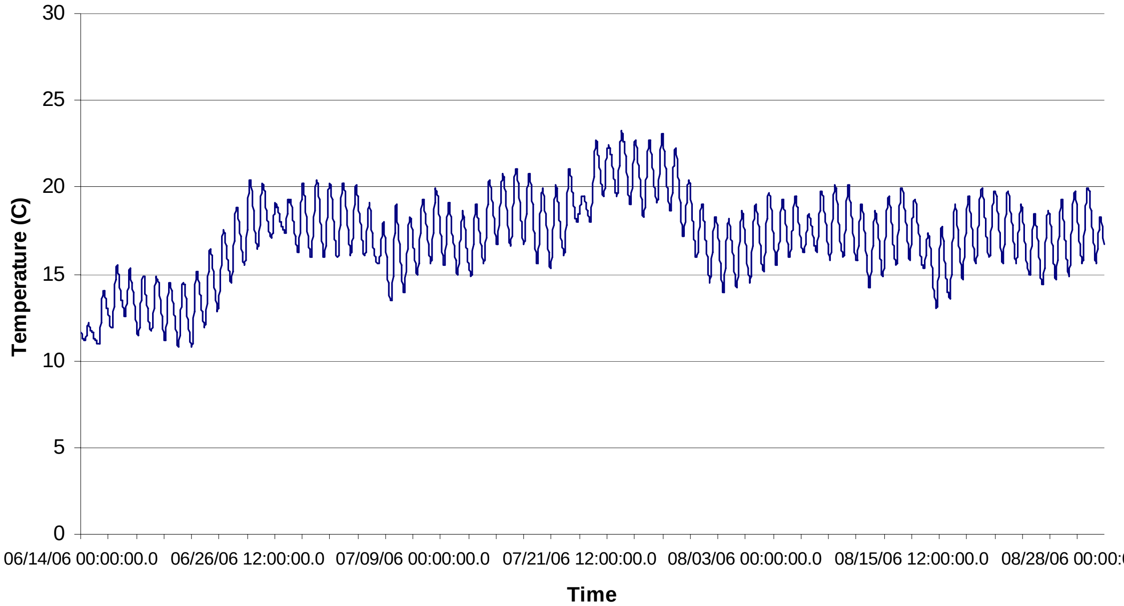


Figure 12 Temperatures measured in Neil Creek near its mouth during Summer, 2006.

3.0 STUDY AREA

The first decisions related to geographic boundaries take into account the number and aggregate length of stream reaches incorporated in the habitat analysis (Bovee et al. 1998). The following definitions apply to this discussion:

Study area – The study area of a stream is bounded by the point at which the impact of flow alteration occurs to where it is no longer significant. Typically, only a small portion of a single stream makes up the study area.

Segment – The portion of the study area that has a homogeneous flow regime and uniform gradient. A study area may have one or more hydrologic segments (+/- 10% of the mean monthly flow).

Study site - A physical aspect of the channel within a stream segment that affects the microhabitat versus flow relationship (e.g., channel morphology, slope, or land use); contains multiple mesohabitat units within a stream segment.

Mesohabitat unit – Habitat types delineated by localized slope, channel shape, and structure (e.g., riffles, runs, pools).

The following sections describe the process and direction that Reclamation followed to identify the geographic area boundaries, stream segments, and study sites impacted by diversions for this study.

3.1 Stakeholders Technical Input

At a meeting among stakeholders on April 18, 2006, Reclamation discussed the proposed PHABSIM study in the Rogue Basin Project area. Reclamation biologists solicited feedback from various organizations on technical issues related to the proposed instream flow study. The study area was addressed and accessibility to stream segments was discussed (i.e., landowner permission). Following the stakeholder meeting, a site reconnaissance was conducted on April 19, 2006 to locate stream segment boundaries and accessible points and determine hydraulic complexity of the stream channels. Technical issues discussed at the meeting were further explored during the site reconnaissance. Based on the additional information gained from the meeting and reconnaissance, the study plan was finalized.

3.2 General Geographic Boundaries

The instream flow study area included the Bear Creek watershed and Little Butte Creek watersheds-with the exception of the North Fork of Little Butte Creek. Specifically, the study area included Bear Creek mainstem between its confluence with the Rogue River upstream to Emigrant Creek and Emigrant Creek upstream to Emigrant Dam. It also included Little Butte Creek mainstem from its confluence with the Rogue River upstream to include South Fork Little Butte Creek and Antelope Creek tributaries. This was a total of five stream reaches. Each stream reach was segmented to bracket major tributaries and federal diversion structures.

3.3 Stream Segment Selection

Final stream segments selected for study represented the few areas in the Bear Creek and Little Butte Creek drainages that shared the following characteristics:

- Uniform gradient and flow regime within segment;
- Known coho salmon use;
- Affected by Reclamation diversions;
- Minimal anthropogenic channel disturbances (e.g., channelization, vegetation removal); and
- Reclamation has landowner permission at all times in at least a portion of the segment.

The following stream segments per stream reach were initially studied:

- Mainstem Bear Creek Reach
  - Confluence with Rogue River upstream to Jackson St Diversion Dam (15.3 miles)
  - Jackson St Diversion Dam upstream to Phoenix Canal Diversion Dam (7.8 miles)
  - Phoenix Canal Diversion Dam upstream to Oak St Diversion Dam (5.2 miles)
  - Oak St Diversion Dam upstream to Emigrant Creek/Neil Creek (3.0 miles)
- Emigrant Creek Reach

- Bear Creek confluence upstream to Emigrant Dam/Bounds Pond (4.6 miles)

- Little Butte Creek Reach
  - Confluence with Rogue River upstream to Antelope Creek confluence (2.5 miles)
  - Antelope Creek confluence upstream to South Fork Little Butte Creek (14.1 miles)
- South Fork Little Butte Creek Reach
  - Confluence with Little Butte Creek upstream to Natural Falls (16.6 miles)

- Antelope Creek Reach
  - Confluence with Little Butte Creek upstream to Dry Creek confluence (2.0 miles)
  - Dry Creek confluence upstream to Antelope Creek Diversion Dam (4.8 miles)

An additional stream segment in Neil Creek between its confluence with Emigrant Creek upstream to Tolman Creek (1.5 miles) was included to represent a relatively undisturbed stream reach with no major diversions. Also, Reclamation placed a study site in Bear Creek between the Oak St Diversion and South Valley View Road (1.8 miles) in October, 2007 after it was observed that there was a change in valley width, channel type and dominant substrate type from bedrock to cobble above and below South Valley View Road Bridge, respectively. This resulted in a total of 12 stream segments (Figure 13).

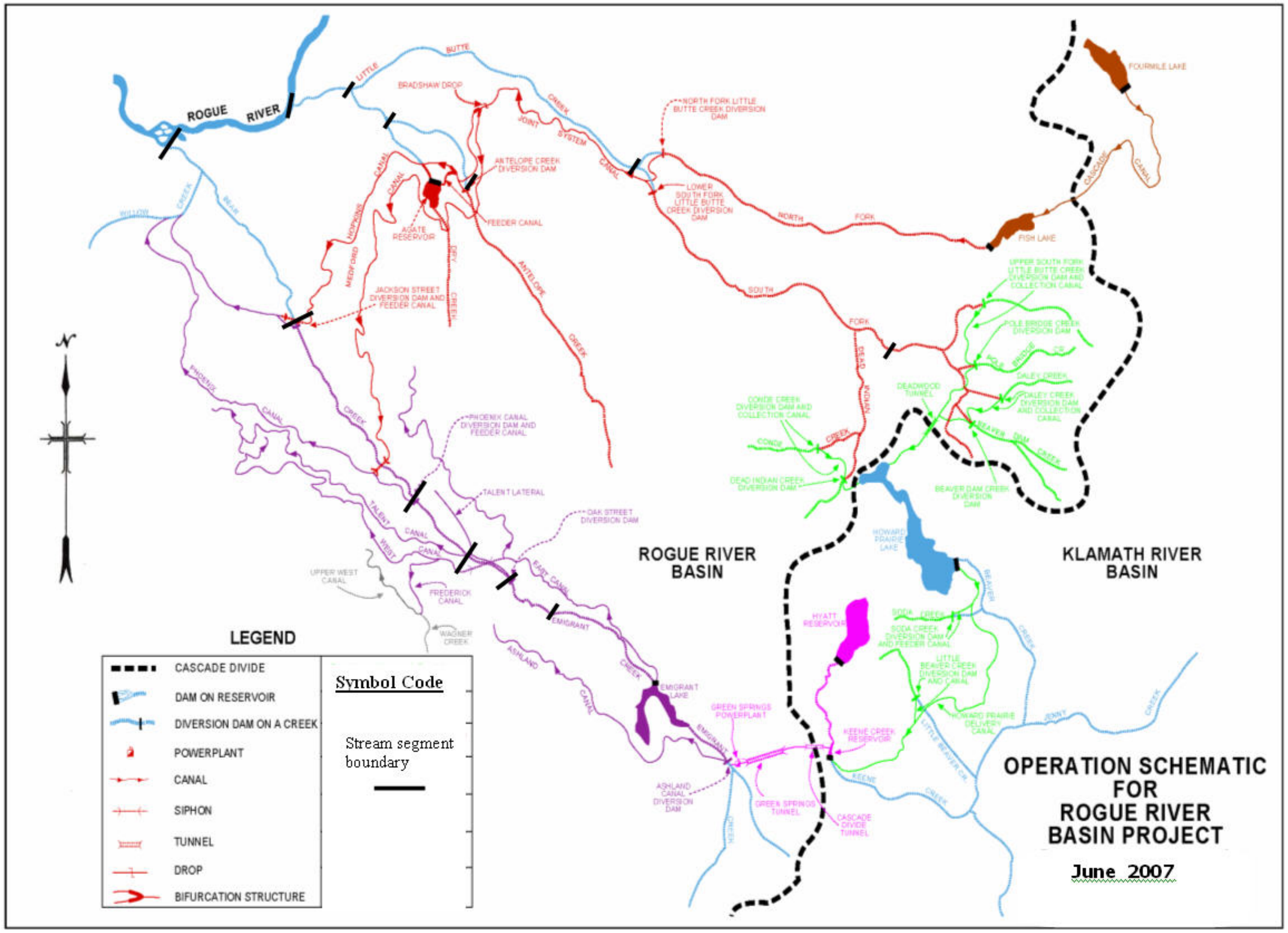


Figure 13 Map showing stream segmentation for Rogue Project instream flow assessment.

3.4 Study Site Selection

In addition to the stakeholder site reconnaissance, Reclamation biologists used aerial photos, topographic maps, and assistance from irrigation district managers to determine accessible areas that represented relatively un-altered habitat conditions (e.g., unchannelized) within each segment. Previous habitat inventory surveys conducted by ODFW and the Forest Service were used to determine major mesohabitat types within each stream segment. Final site selection involved a field trip to select accessible un-altered mesohabitat units representative of each stream segment. Transects were placed within each of these microhabitat study sites as described in Section 4.1.1. A comparison was made between study site habitat conditions and previous habitat surveys to determine how representative each study site was of each stream segment (see Section 5.1). Details of each study site, including maps, coordinates, and photos, are located in Appendix A.

4.0 STUDY METHODS

The planning and execution of the instream flow study involved using PHABSIM methodology in eleven of the stream segments and River2D in two of the stream segments (lower Bear Creek and lower Little Butte Creek). Based on the field reconnaissance, the only segment where PHABSIM was not used was near the mouth of Bear Creek.

4.1 Physical Habitat Simulation System (PHABSIM)

Studies utilizing PHABSIM require extensive data collection and analyses. Figures 14 and 15 illustrate in general how site-specific hydraulic data is integrated with HSCs to develop the habitat-discharge relationship output from PHABSIM. The following sections describe tasks associated with the two methods that were used in the instream flow study.

4.1.1 Collection of hydraulic data

PHABSIM requires hydraulic and habitat suitability data to determine the instream flow requirements for the species and/or life history stage of interest. Several hydraulic submodels can be used with PHABSIM including IFG4, WSP, and MANSQ. Field data collection was designed to accommodate any of these models. PHABSIM data collection includes several steps: study segment location, habitat mapping, transect placement and data collection.

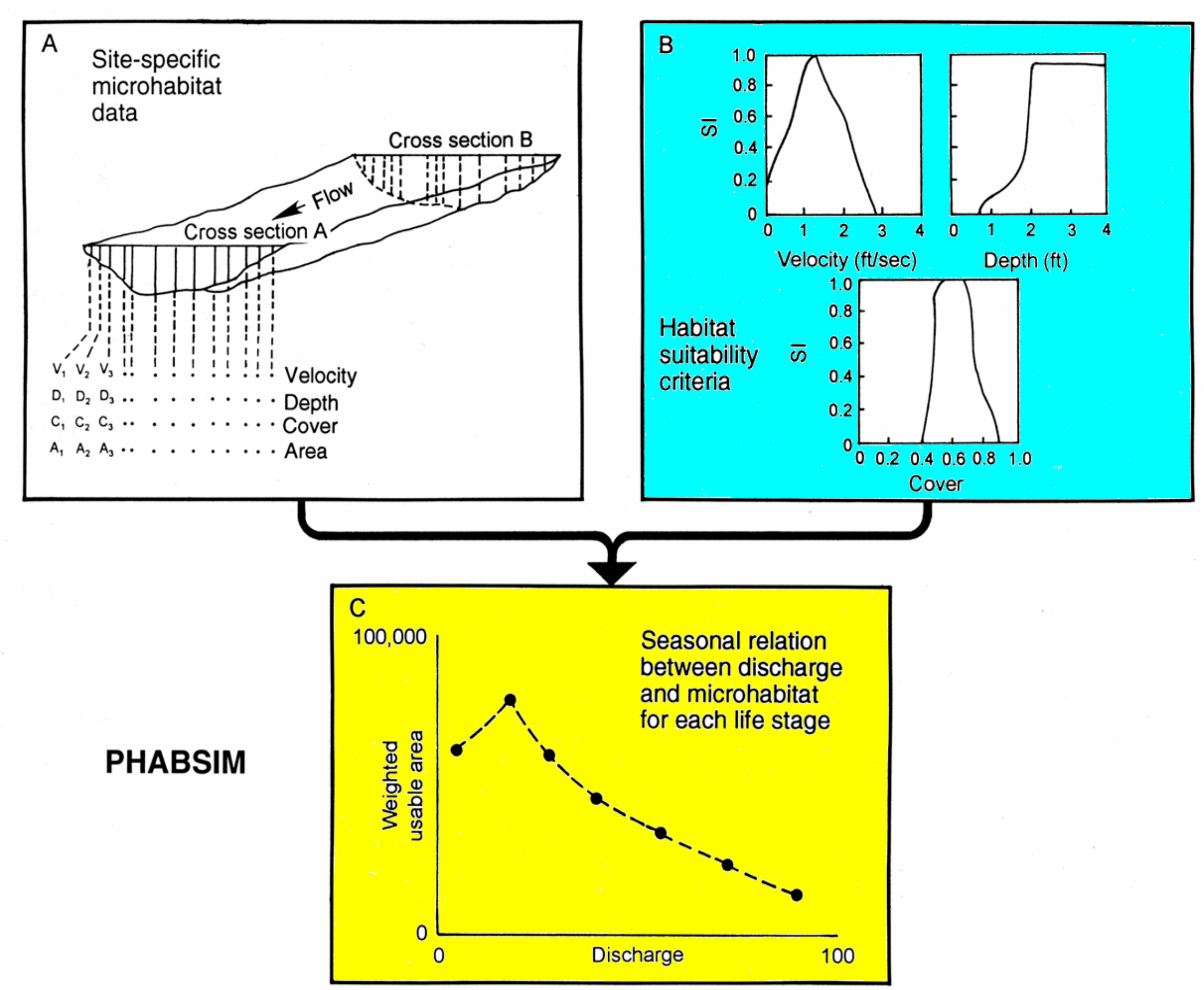


Figure 14 PHABSIM process of integrating hydraulic data with habitat suitability criteria to develop a habitat-discharge relationship.

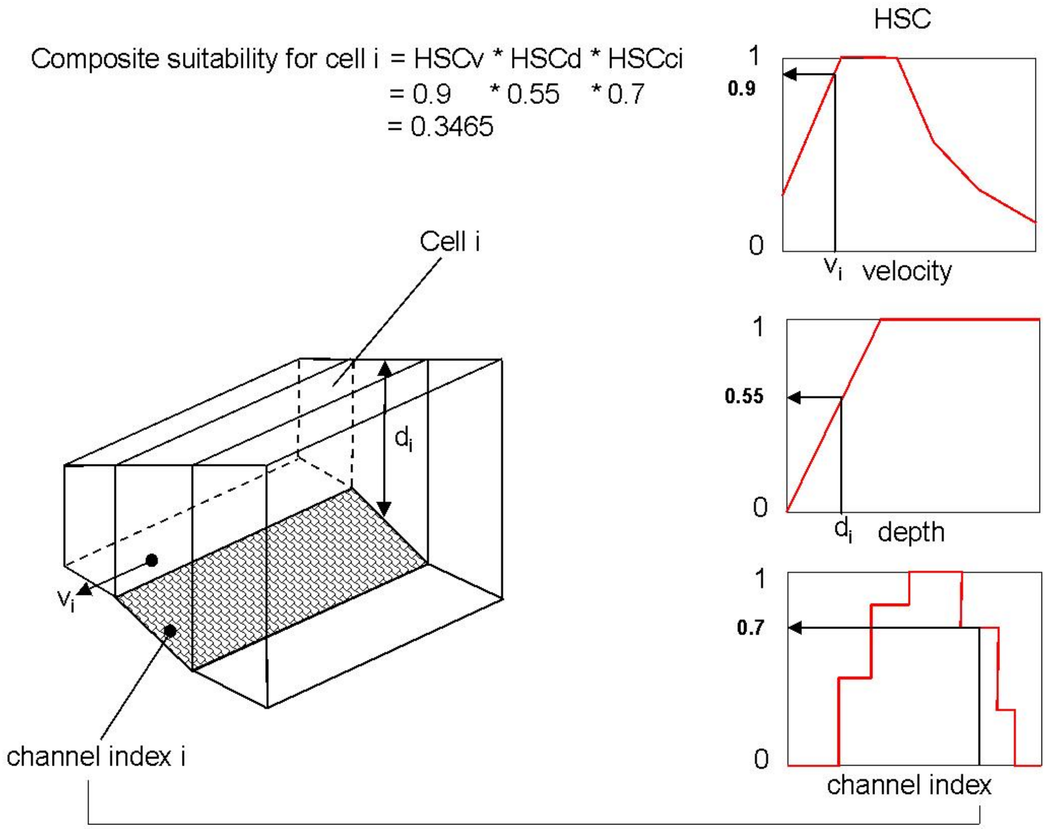


Figure 15 Example of composite habitat suitability calculation procedure to determine weighted usable area (WUA) in one cell.

Specific procedures at each study site included:

- Locate study segments on a topographic map.
- Mapping habitat features for each stream segment. Habitat mapping, or mesohabitat typing, was conducted in the vicinity of each study site by wading and using laser rangefinders. Linear distance of each habitat type (e.g., pool, riffle, glide) was recorded on a data sheet and the total of each habitat type and total length mapped recorded at the end of each segment (cumulative lengths). The mapped data were used to determine percentages of each habitat type that could be used to weight habitat transects. Disturbed stream segments in urban areas were avoided to the extent possible, particularly in Bear Creek mainstem. The active channel of Bear Creek has been sharply restricted by historic development, leaving almost a third of the channel restricted. Bank stability in Bear Creek is about 76% stable, and portions are heavily eroded in flooding events (ODEQ 2000, as cited in Rogue Valley Council of Governments 2001). An analysis of aerial photos on http://earth.google.com showed that most channel disturbance occurs as a result of bridges, diversion structures, roads, and municipalities. The following stream lengths of disturbance were estimated using the ruler tool in Google Earth:

1. Bear Creek in Central Point – 1.7 miles
2. Bear Creek in Medford – 2.7 miles
3. Bear Creek in Phoenix – 1.8 miles
4. Bear Creek in Talent – 1.0 miles
5. Bear Creek in Ashland – 1.3 miles
6. Emigrant Creek – 1.1 miles (includes Bounds Pond)
7. Neil Creek – 0 miles
8. Little Butte Creek mouth to confluence with Antelope Creek – 0.1 miles
9. Little Butte Creek from Antelope Creek to South Fork Little Butte Creek – 2.6 miles
10. South Fork Little Butte Creek mouth to natural falls – 0.3 miles
11. Antelope Creek mouth to Dry Creek – 0.2 miles
12. Antelope Creek from Dry Creek to Antelope Creek Diversion – 0.2 miles

Habitat mapping was conducted in spring and summer, 2006 except in Bear Creek between Oak St. Diversion and South Valley View Road which was mapped in October, 2007.

- Transects were placed perpendicular to the flow in homogeneous habitat types (pool, riffle, glide) with the number of transects dependent upon the physical and hydraulic features of each habitat type. As mentioned above, disturbed areas were avoided to the extent possible. Transects were placed at hydraulic controls by professional judgment.
- At each set of transects in each habitat type the following data were collected: cross-sectional profiles, distance between transects, and reference photos of each transect within each habitat type.
- Vertical elevations were established throughout each habitat type by surveying transect headpins using a total station (Bovee 1997). A benchmark at each study site was established (with rebar) and assigned the arbitrary elevation of 100.00 feet. All differential leveling was referenced to this benchmark. Coordinates (North American Datum (NAD83)) were determined at each benchmark using a handheld Garmin model 12 Global Positioning System (GPS) instrument.
- At each habitat transect, the model requires the following data: stream-bed profile, total depth at each wet vertical, mean column velocity at each vertical, water surface elevation (WSL), linear distance (stationing) between transect headpins, substrate composition, and cover.
- A full set of transect specific data were collected at a minimum of two different flows, including velocities using a Marsh McBirney model 2000 Flo-Mate, discharge, and WSL (see Section 5.1 for dates and flows measured at each transect). For additional flows, only discharge at a best Q (discharge) transect(s) and WSLs were collected. A velocity calibration set generally was not collected at the additional flows. These stage-discharge measurements provided the data necessary for model calibration and extension of the range for hydraulic simulations.

4.1.2 Habitat Suitability Criteria (HSC)

Species HSCs for depth, velocity, and channel index (substrate and/or cover) are required for PHABSIM analysis. Habitat suitability criteria are interpreted on a suitability index (SI) scale of 0 to 1, with 0 being unsuitable and 1 being most utilized or preferred. Criteria that accurately reflect the habitat requirements of the species of interest are essential to developing meaningful and defensible instream flow recommendations. The general process for developing HSCs is shown in Figure 16.

The recommended approach is to develop site-specific criteria for each species and life stage of interest. An alternative involves using existing curves and literature to develop suitability criteria for the species of interest. No site-specific HSCs are available in the Bear Creek/Little Butte Creek watersheds and time and budgetary constraints precluded sampling all streams within the basin or developing HSCs specific to each individual stream within the basin. Thus, as a second option, the TSC conducted two workshops (May 12, 2006 and March 8, 2007) with local experts to evaluate existing HSCs appropriate for the Bear Creek/Little Butte Creek watersheds and develop HSCs based on visual concensus that could be applied across the entire basin, and which represented the general habitat requirements of coho in area streams. Table 4 summarizes life stages and variables modeled as a result of the workshops. The only difference in modeling between summer juvenile and winter juvenile rearing was the HSC for cover (see HSC workshop notes in Appendix C).

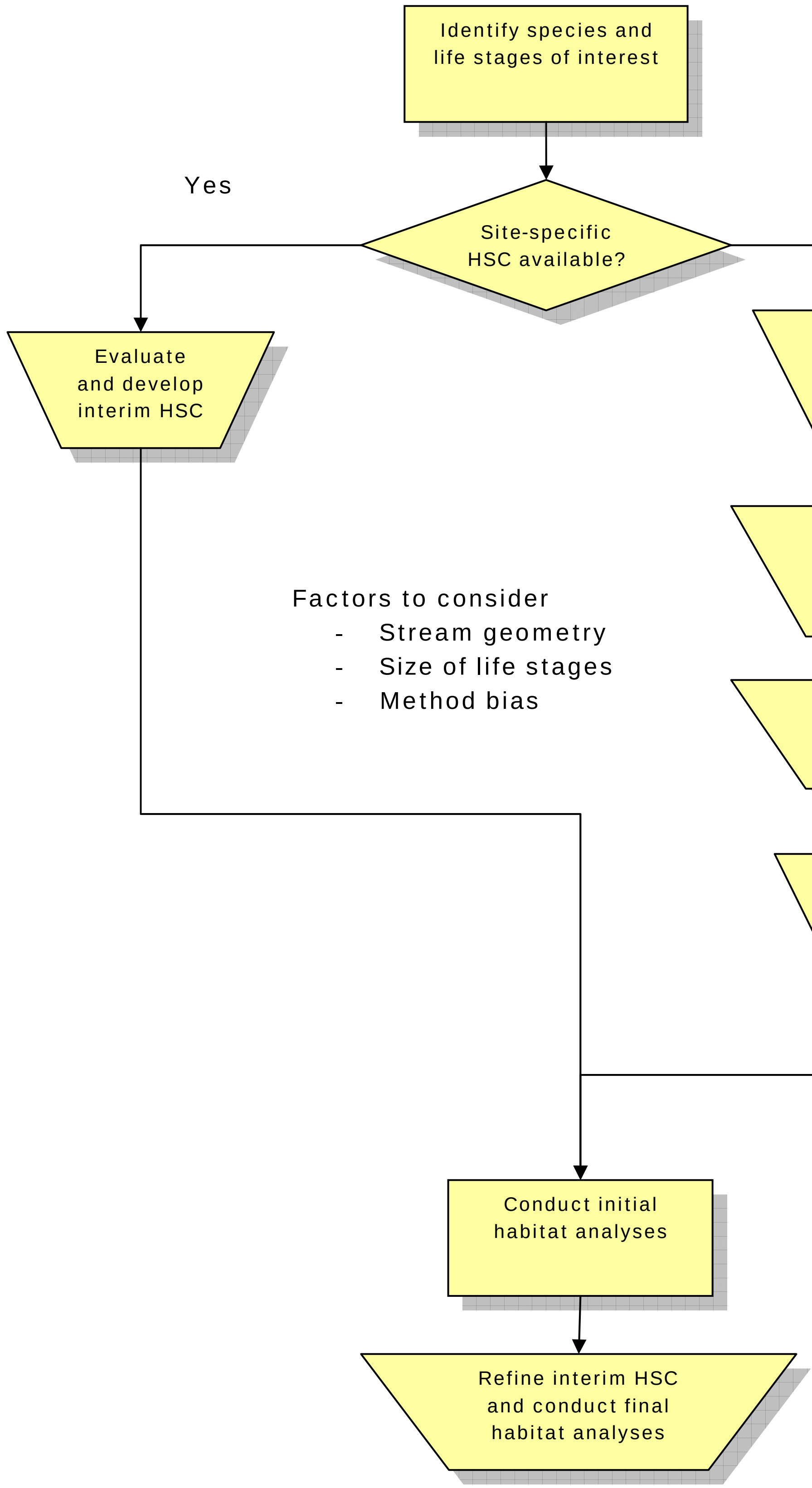


Figure 16 Flow chart for developing habitat suitability criteria.

Table 4 Habitat suitability criteria variables for coho salmon life stages for the Bear Creek/Little Butte Creek instream flow study.

Species/life stage	Depth (ft)	Velocity (ft/sec)	Substrate	Cover
Juvenile	X	X		X
Spawning/incubation	X	X	X	
Adult Passage	X			

One issue that developed during the study was the value of "escape cover" for juvenile life stage. This is a relatively new issue regarding PHABSIM that has been addressed in detail in the Klamath River, located in northern California (Hardy et al. 2006) and in the upper John Day River in Oregon (Sutton et al. 2006). Escape cover is defined as the riverine component that is used, or that could be used, for protection or concealment when fleeing from predators or a threat.

As a result of interest in weighting escape cover HSC higher than depth and velocity HSCs (see HSC workshop notes), Reclamation used a modification of the U.S. Geological Survey (USGS) version of PHABSIM (Version 1.3) to include an additional user-defined variable (e.g., escape cover) as part of the habitat calculation. This modification is described in the PHABSIM Help menu as follows:

The Habitat Calculations portion of PHABSIM controls how habitat suitability indices will be combined. Up to four habitat suitability indices can be combined to form a composite suitability factor used in calculating habitat area. A suitability index variable will not be used unless it has data values (coordinate cells are not blank) and a suitability curve has been defined. Velocity and depth will always be used but channel index and the user defined index must meet the above criteria. The exponent for the geometric mean calculation will vary (0.5 to 0.25) according to how many variables are used. You can exclude channel index or a user defined index (e.g. escape cover) variables from specific cell calculations by leaving their respective data cells blank on the coordinate tab of the Edit|Cross Sections menu.

Modified Geometric Mean = This technique implies that one variable (user defined (ud)) has a greater effect than the others. This variable is multiplied outside of the geometric mean calculation. The Composite Suitability Factor (CF) is computed as
$CF = (f(v) \times g(d) \times h(ci))^{.333} \times i(ud)$

Where: f(v), g(d), h(ci), and i(ud) = variable preferences for velocity, depth, channel index, and user defined index, respectively.

In addition, Reclamation recorded distance to escape cover at each cell during low flow conditions (October, 2006). At each vertical station (cell boundary) along each transect, the observer recorded the closest cover within a 360º circumference and the distance in feet to the closest cover component. Cover located at the point of the vertical was given a distance of "0".

Data input into PHABSIM involved entering, for each cell along each transect, the escape cover code (user defined index) within the threshold distance (i.e., 6 ft for juveniles in summer and 3 ft in winter) (See Appendix C workshop notes, March, 2007). Channel index (e.g., functional cover) was not coded and left blank in the model.

The major advantage of the escape cover modification is that it increases flexibility and number of options in PHABSIM by incorporating an additional channel index parameter that may be considered very important to a specific life stage; in this case, escape cover for fry and juveniles. One weakness of this modification is that the model does not decide whether an escape cover component within a certain distance threshold is actually usable. For example, an escape cover component, such as grass, may be within the threshold distance to a wetted cell at a particular flow. However, the revised model in its present form gives that wetted cell the same escape cover SI for grass whether or not the grass is on dry ground or in water that meets some depth and velocity threshold so that it could actually be used by the fish. This weakness could be resolved by including a "search" algorithm in the model that determines whether escape cover meets distance, depth, and velocity threshold criteria. However, this does not solve an even bigger weakness. Since PHABSIM is a transect-based model, it does not "look" upstream or downstream from a transect for escape cover, only left and right along the transect. Thus, it cannot determine the usability of escape cover that is not on a transect. The only way to solve this problem is to use a 2-dimensional hydrodynamic model, such as River2D (see Section 4.1.4), that could be modified to search around each node for escape cover that meets the threshold criteria necessary for fish use (see Hardy et al. 2006).

Another dilemma with PHABSIM is that the value of cover remains constant at all flows. This can be a problem when the river stage rises to a level sufficient to inundate a bush and provides good overhanging cover for juvenile coho. However, if that bush is dry and its branches are too high above the surface of the water to provide overhanging cover at a lower stage, its value as cover is lower. Again, this issue could be resolved by modifying the model to search for cover that meets certain criteria and change the value of that cover accordingly. However, this solution was beyond the scope of the current study. For this study, a comparison was made at one study site (South Fork Little Butte Creek) with and without the escape cover modification to demonstrate model sensitivity (see Tables D-10 and D-11 in Appendix D).

Passage criteria guidelines for adult coho salmon were taken from Thompson (1972). To determine the recommended flow for passage, the shallowest area most critical to passage of adult fish was located at each study site, and a linear transect was measured which followed the shallowest course from bank to bank. A flow was computed for conditions which equaled or exceeded the minimum depth criteria (0.6 ft for coho) where at least 25% of the total transect width and a continuous portion equaling at least 10% of its total width was maintained (Thompson 1972). The longitudinal distances of the shallow habitats are also important to evaluate passage. However, this parameter was not included in the guidelines developed by Thompson (1972).

4.1.3 Model Selection and Calibration

Reclamation used the USGS Windows version of PHABSIM (Waddle 2001). PHABSIM has several sub-models available for hydraulic simulations. These include STGQ, WSP, and MANSQ (Waddle 2001), with STGQ being the most rigorous in terms of data requirements. Each hydraulic model requires multiple discharge measurements to extend the predictive range. Depending on model performance, the predictive range may be restrictive or wide ranging (i.e., 0.1 to 10 times the measured discharges) (Waddle 2001). We attempted to cover the range of flows for the hydraulic simulations that typically occur April through September during irrigation season (see Section 5.1 for tables of measured and simulated flows).

Field sampling was designed to collect data in formats suitable for application in any of the hydraulic models identified above. The following approach was used:

- Entered field data into appropriate format for water surface simulations;
- Calibrated simulated WSLs for each study site using STGQ, MANSQ or WSP to within 0.05 feet of at least three measured WSLs. WSP (water surface profile) was used for pools (backwaters) with hydraulic controls. STGQ (stage-discharge) was used where a stage-discharge relationship could be developed with at least three reasonably spaced flows. MANSQ (mannings equation) was used where less than three reasonably spaced measured flows occurred or where calibration could not be achieved using STGQ with three flows (see Appendix B for specific model selection per transect);
- Documented calibration procedure;
- Simulated a range of discharges to predict WSLs for each study site;
- Combined transects from all study sites, numbered sequentially from downstream to upstream, and predicted WSLs within a stream segment into one IFG4 data set for the entire stream segment;
- Simulated depths and velocities using the velocity model in PHABSIM for Windows and at least two velocity calibration sets. A minimum of two calibration sets at "high" and "mid" flows was recommended at the stakeholder meeting on April 18, 2006. However, regulated flows confounded our ability to predict whether measured flows would be either "low", "mid", or "high" on any given field survey, resulting in some instances where more than two sets of velocity calibration flows were measured (see Section 5.1 for more information on measured velocity calibration flows);
- Evaluated simulation range based on comparisons of measured and observed velocities;
- Documented acceptable range of simulations;
- Conducted simulation velocity production run for applicable range of discharges;
- Conducted habitat simulations using HABTAE sub-model (geometric mean computation) for each species and life stage of interest to develop WUA versus discharge relationships for each stream segment. Transect lengths in HABTAE were based on habitat mapping proportions and summed to give 1,000 feet of stream. Thus, WUA output was ft^2/1,000 ft reach. Different HSCs for channel indices required separate PHABSIM projects for various life stages; and

- Simulated adult passage using AVDEPTH/AVPERM sub-model.

In addition to these tasks, WUA outputs were analyzed to determine discharges that maximized habitat and produced 60 and 80% of maximum habitat. “Inflection” points (breakpoints) on WUA versus discharge and total wetted area versus discharge curves were calculated using the “slope method” (slope value = 1.0) described by Gippel and Stewardson (1998).

4.2 Description of River2D Hydrodynamic Model

River2D is a two-dimensional depth averaged finite element hydrodynamic model developed by the University of Alberta that has been customized for fish habitat evaluation studies (Steffler and Blackburn 2002). Two-dimensional models are useful for describing more detailed physics (hydrodynamics) of the stream flow than one-dimensional models (e.g., PHABSIM). For example, such things as eddies, split channels and secondary channels associated with islands and flow reversals are more accurately described using two-dimensional models ((Waddle et al. 2000). The River2D model suite consists of several programs typically used in succession. First, a bed topography file is created from raw field data using R2D_Bed. Then the resulting bed topography file is used in the R2D_Mesh program to develop a computational discretization as input to River2D. The River2D program solves for water depths and velocities and is finally used to visualize and interpret the results and perform PHABSIM-type fish habitat analyses. Two-dimensional modeling was conducted at two study sites, one on lower Bear Creek and one on lower Little Butte Creek. The site on Little Butte Creek was used to compare to one-dimensional PHABSIM results.

5.0 RESULTS AND DISCUSSION

Written descriptions, photos, and transect cross-sectional profiles of each study site are provided in Appendix A. Hydraulic calibration results (WSLs, Velocity Adjustment Factors (VAF), and velocity simulations) for each study site are summarized in Appendix B. Habitat suitability criteria (HSCs) developed from the HSC workshops are presented in Appendix C which also includes notes from the workshops. Complete habitat modeling output results (i.e., WUA vs discharge) are summarized in Appendix D for each stream segment.

5.1 Field Surveys

Total linear distances and proportions of each major mesohabitat type used to weight habitat transects from Reclamation’s habitat surveys in 2006 and 2007 are summarized in Table 5 for each stream segment. A comparison of habitat conditions at each study site with previous stream habitat surveys is provided in Appendix E, Table E-1. Examination of Table E-1 shows some general similarities between habitat conditions of each Reclamation study site and stream habitat conditions at large. For example, the gradient in Bear Creek is between about 0 and 1 percent at each stream reach measured by Reclamation (study sites) in 2006 and by ODFW in 1990. Also, there is general agreement of a higher percentage of glides than riffles or pools in Bear Creek. However, it should be noted that many of the differences in habitat parameters among various habitat surveys are the result of different objectives, methodologies, and flow conditions at the time of the surveys. For example, ODFW reports substrate types as a percentage of wetted area, while the Forest Service reports only dominant and subdominant substrate types. Reclamation's substrate results were summarized as percentages of each substrate type from cells among all transects at each site. Also, ODFW and Forest Service surveys include entire stream segments, including channelized areas, whereas Reclamation surveys focused on un-altered habitat reaches. Finally, stream morphology, at least in Bear Creek, was likely affected by the flooding that occurred in December, 2005 (Figure 5). Thus, habitat conditions recorded by Reclamation in the spring and summer of 2006 and fall of 2007 were likely different than before the flood.

Measured discharges and dates of field surveys are summarized in Table 6. Lack of control over regulated stream flows and flashy hydrologic conditions resulted in unpredictable discharges during each survey. In some instances, this complicated our ability to measure at least three distinctly different discharges (e.g., Antelope Creek between Dry Creek and Antelope Creek Diversion) and required additional site visits (Table 6). Measured flows where velocity calibration data sets were compiled are also shown in Table 6. At least two velocity calibration flows were used at all PHABSIM study sites except the study site on Bear Creek between the Oak Street Diversion and South Valley View Road where only one velocity set was measured. In some instances, an additional velocity calibration set was measured on "best Q" transects where a third or fourth discharge was recorded (e.g., transect 1 on Little Butte Creek near Brownsboro). This occurred when the third or fourth discharge measured was higher than at least one of the first two. Time and budgetary constraints did not allow us to collect a third higher velocity calibration set for all transects. Simulated discharge ranges are summarized in Table 7. We were not able to simulate flows much higher than the highest measured flows on several stream segments (e.g., Antelope Creek between Dry Creek and Antelope Creek Diversion and Emigrant Creek) because the measured high water levels inundated some transect headpins.

Table 5 Mesohabitat unit proportions used to weight Rogue PHABSIM transects.

Habitat Type	**Length (ft)**	**Percentage**
Emigrant Creek-between Bear Creek and Emigrant Dam		
Pool	225	15.6
Glide	650	45.1
Riffle	565	39.2
Total	1440	100.0
Bear Creek-between Emigrant Creek and Oak Street Diversion		
Pool	75	5.5
Glide	977	72.0
Riffle	305	22.5
Total	1357	100.0
Bear Creek-between Ashland Creek and S. Valley View Road		
Pool	46	<2
Glide	747	31.1
Riffle	1658	68.9
Total	2451	100.0
Bear Creek-between S. Valley View Road and Phoenix Diversion		
Pool	215	9.4
Glide	1230	53.7
Riffle	845	36.9
Total	2290	100.0
Bear Creek-between Phoenix Diversion and Jackson Street Diversion		
Pool	635	30.2
Glide	620	29.5
Riffle	850	40.4
Total	2105	100.0
Bear Creek-near mouth-2D site		
Pool	976	40.4
Glide	1098	45.5
Riffle	339	14.0
Total	2413	100.0
Little Butte Creek-Brownsboro		
Pool	460	21.9
Glide	1133	53.9
Riffle	508	24.2
Total	2100	100.0
Little Butte Creek-near mouth		
Pool	565	28.4
Glide	755	37.9
Riffle	671	33.7
Total	1991	100.0
Antelope Creek-between Little Butte Creek and Dry Creek		
Pool	1464	45.4
Glide	1189	36.9
Riffle	573	17.8
Total	3226	100.0
Antelope Creek-between Dry Creek and Antelope Creek Diversion		
Pool	110	19.0
Glide	166	28.7
Riffle	302	52.2
Total	578	100.0
S. Fk. Little Butte Creek-Mile marker 12 near Gilkey		
Pool	140	6.9
Glide	1384	68.2
Riffle	504	24.9
Total	2028	100.0
Neil Creek		
Pool	240	19.3
Glide	507	40.9
Riffle	494	39.8
Total	1241	100.0

Table 6 Survey dates and discharges (lowest to highest) for PHABSIM surveys in Rogue Project area.

Stream Segment	Discharge (cfs)	Survey Date	Velocity Calibration Dataset
Emigrant Creek-between Bear Creek and Emigrant Dam			
	1	June 16, 2006	
	8	October 17, 2006; October 25, 2007	X-transects 9 and 10
	30	October 25, 2007	X-transects 9 and 10
	38	June 29, 2006	X-transects 1-8
	64	August 3, 2006	X-transects 1-8
Bear Creek-between Emigrant Creek and Oak Street Diversion			
	18	October 17, 2006	
	39	June 16, 2006	X
	53	June 27, 2006	
	66	August 9, 2006	X
Bear Creek-between Oak Street Diversion and S. Valley View Road			
	23	October 24, 2007	X
Bear Creek-between S. Valley View Road and Phoenix Diversion-lower study site			
	23	October 18, 2006	
	72	June 30, 2006	X
	83	June 13, 2006	X
Bear Creek-between S. Valley View Road and Phoenix Diversion-upper study site			
	20	October 17, 2006	
	51	June 28, 2006	X
	74	June 13, 2006	X
Bear Creek-between Phoenix Diversion and Jackson Street Diversion-lower study site			
	12	June 27, 2006	X
	33	October 18, 2006	X – transect 2
	71	June 12, 2006	X
Bear Creek-between Phoenix Diversion and Jackson Street Diversion-upper study site			
	12	June 27, 2006	X
	33	October 18, 2006	X – transect 15
	71	June 16, 2006	X
Bear Creek-near mouth-2D site			
	21	June 28, 2006	X-lower boundary
	62	October 18, 2006	X-lower boundary
	218	June 14, 2006	X-lower boundary
Antelope Creek-between Little Butte Creek and Dry Creek			
	2	October 19, 2006	
	12	June 30, 2006	X
	24	June 15, 2006	X
Antelope Creek-between Dry Creek and Antelope Creek Diversion			
	2	June 17, 2006	
	3	June 15, 2006	X
	109	March 6, 2007	X
Little Butte Creek-Brownsboro			
	35	July 1, 2006	X
	44	June 17, 2006	X
	67	October 19, 2006	X – transect 1
Little Butte Creek-near mouth			
	37	June 28, 2006	X
	94	October 20, 2006	X – transect 1
	101	June 14, 2006	X
	175	November 18, 2006	X – transect 5
S. Fk. Little Butte Creek-Mile marker 12			
	17	October 19, 2006	
	22	June 17, 2006	X
	35	July 1, 2006	X
	93	January 6, 2007	X – transects 1 and 2
Neil Creek			
	5	October 17, 2006	
	13	June 29, 2006	X
	30	June 13, 2006	X

Table 7 Discharge ranges simulated at Rogue Project instream flow stream segments.

Stream Segment	Discharge Range (cfs)
Emigrant Creek-between Bear Creek and Emigrant Dam	1-80
Bear Creek-between Emigrant Creek and Oak Street Diversion	7-110
Bear Creek-between Oak Street Diversion and S. Valley View Road	1-25
Bear Creek-between S. Valley View Road and Phoenix Diversion	5-130
Bear Creek-between Phoenix Diversion and Jackson Street Diversion	5-200
Bear Creek-near mouth-2D site	10-210
Antelope Creek-between Little Butte Creek and Dry Creek	1-60
Antelope Creek-between Dry Creek and Antelope Creek Diversion	2-109
Little Butte Creek-Brownsboro	15-200
Little Butte Creek-near mouth	15-180
S. Fk. Little Butte Creek-Mile marker 12	7-150
Neil Creek	2-100

5.2 Velocity Calibrations

Multiple velocity calibration data sets were used as independent data sets for velocity modeling purposes. The VAF was one measure of calibration. The VAF is an index used by the velocity simulation model to adjust individual cell velocities/cell discharges. The VAF is the ratio of the flow requested for simulation and the flow calculated from velocity simulations. The VAF adjusts individual cell velocities by multiplying the VAF times the initial velocity to give a new velocity. Generally, the relationship between discharge and VAF is such that at simulated flows lower than the velocity calibration flows, the VAF is less than 1.0 and at simulated flows greater than the velocity calibration flow, VAF is greater than 1.0 (Waddle 2001). Appendix B presents VAFs for all stream segments over a range of simulated flows. The apparent “breaks” in VAF (i.e., occasional declines in VAF as flows increase) are due to using different velocity calibration sets to produce the velocity templates used for velocity simulation. Within the range of discharges for which a particular set of calibration velocity measurements were used to develop the velocity template, ascending VAF versus flow relationships indicated the expected outcome of velocity simulations. There is no basis for judging the “validity” or quality of the hydraulic simulations based strictly on the magnitude of the range in computed VAF values (i.e., no specific set of envelope values that the VAF should absolutely lie within) (Waddle 2001). The “shape” of the VAF versus discharge plot is a better indicator of model performance than the VAF magnitude with increasing VAFs over the range of discharges indicative of good calibration. Based on this criterion, Appendix B calibration results indicate that VAFs generally increase with discharge for each velocity calibration set, suggesting good model performance.

Also, measured velocities across each transect were examined to determine how closely simulated velocities matched calibration velocities. For example, Figures 17 and 18 illustrate how velocities were examined for one transect in lower Little Butte Creek using PHABSIM and River2D, respectively. The outputs overlay simulated and calibration (measured) velocities at two different flows. In PHABSIM, the best velocity simulations occurred using the VAF option with two or three velocity calibration sets, depending on the transect, and running the two-point velocity regression option to simulate velocities between calibration sets. Tables of calibration and simulation velocities are provided for each transect in Appendix B. Examination of these tables shows similar velocity profiles across each transect between measured and simulated velocities at the calibration flows. Thus, we have high confidence in the habitat modeling results within the simulated range of flows (Table 7).

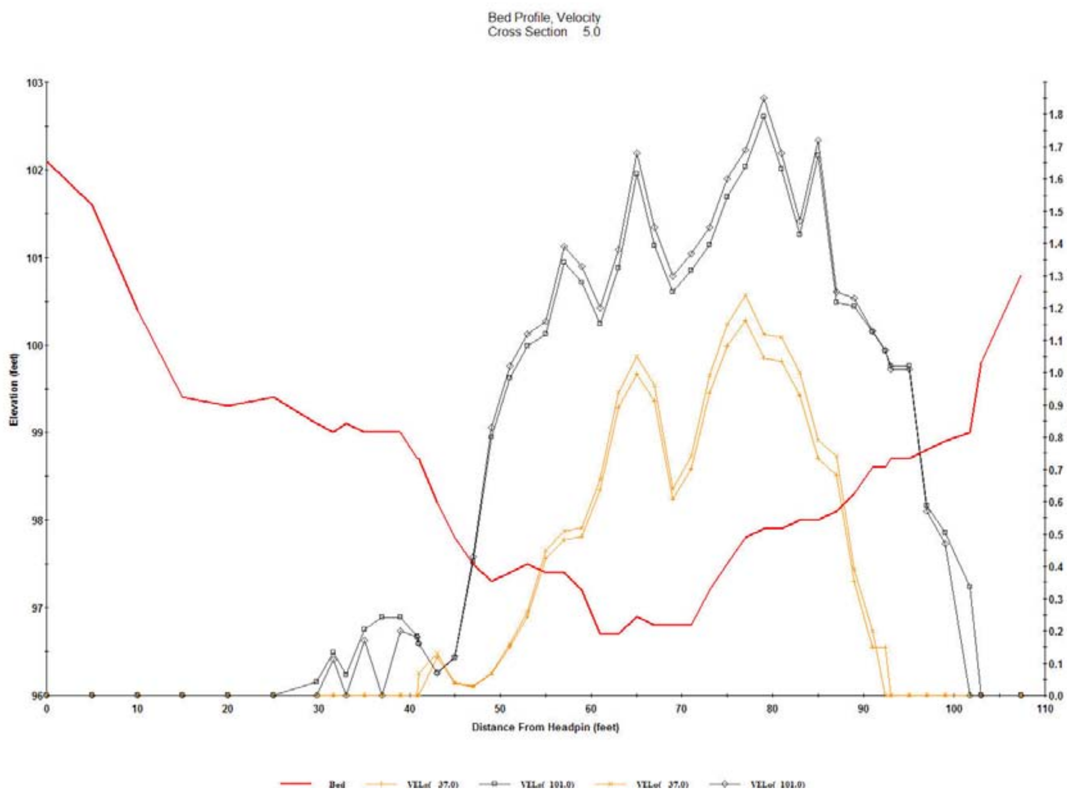
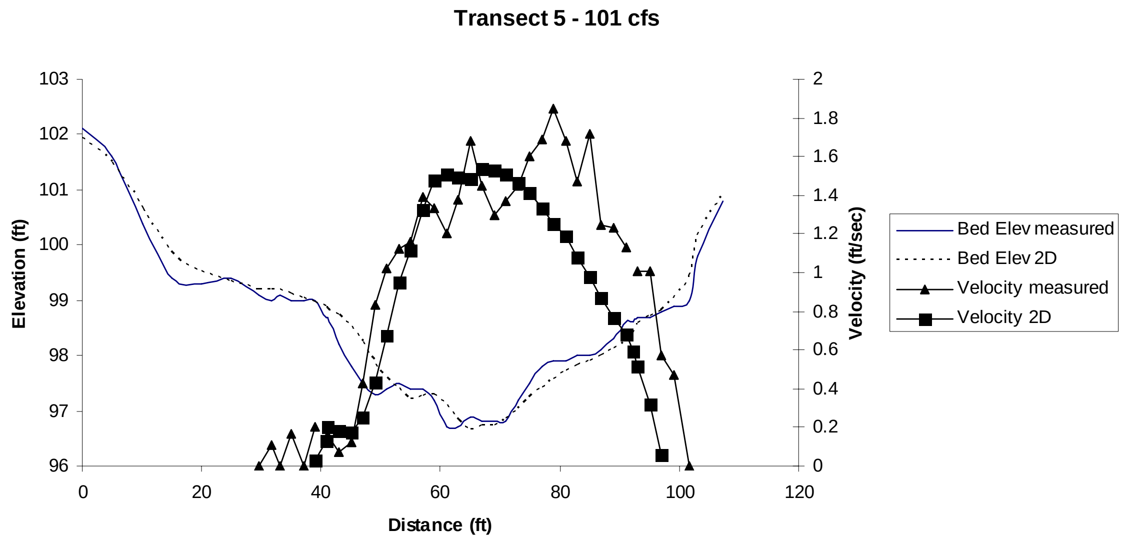


Figure 17 Example of PHABSIM velocity simulation output at one transect in Little Butte Creek near its mouth.



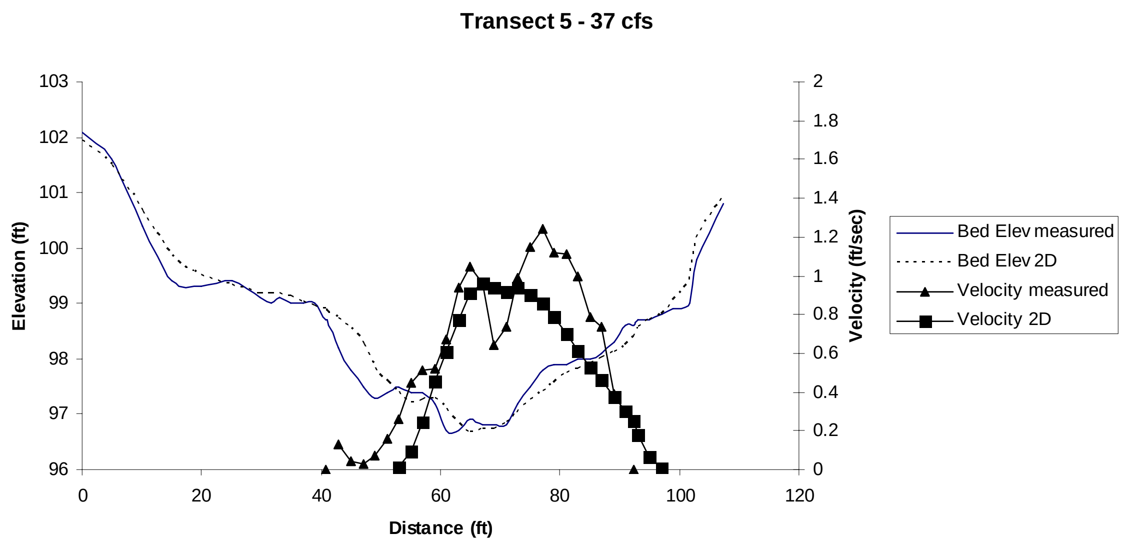


Figure 18 Example of River2D velocity simulation output at two flows compared with measured velocities along one PHABSIM transect in Little Butte Creek near its mouth.

5.3 PHABSIM Habitat Simulations

Graphical representations of normalized WUA versus discharge relationships are presented for each segment in Figures 19-42. Habitat modeling results (i.e., curve shapes) reflected differences in existing stream channel hydraulics among study sites. WUA is a measure of the existing available habitat for each segment at various discharges. WUA does not necessarily represent the amount of habitat available under pristine or un-altered conditions. Comparisons of stream segments showed that less flow was typically needed to optimize fish habitat in the narrower, more confined stream channels with less wetted surface area per given flow. For example, the stream channel in Neil Creek was deeper and narrower than Bear Creek between Emigrant Creek and the Oak Street Diversion. Optimal coho salmon spawning/incubation habitat in Neil Creek occurred at 25 cfs and trended downward at higher flows (Figure 41). In contrast, coho spawning/incubation WUA increased as flows increased up to 60 cfs in nearby Bear Creek between Emigrant Creek and the Oak Street Diversion (Figure 23). As is always necessary, assumptions were made about how to extrapolate PHABSIM model results both above and below measured discharges. Some of these assumptions resulted in maximum habitat occurring at highest simulated discharges (e.g., juvenile winter rearing habitat in Emigrant Creek). However, this is the best that can be done without collecting additional transect data at higher flows.

The WUA versus discharge curves also provide information in terms of how much benefit can be achieved with incremental flow changes. For example, in Bear Creek between Phoenix Diversion and Jackson Street Diversion, if discharge increases from 5 to 20 cfs, habitat for spawning/incubation dramatically increases from about 33 to 71 percent of maximum (Table D-5). Comparatively, for juvenile coho in winter, habitat only increases from about 85 to 100 percent. This helps decision-makers determine whether additional water substantially benefits the species.

Juvenile WUA vs discharge curves had relatively flat relationships in most stream segments at mid-high flows. These flat curves suggest that incremental discharge increases beyond a certain minimum flow that maximizes habitat do not substantially affect habitat. The reason for the flat nature of these curves is illustrated in Figures 43-45 which show coho juvenile winter WUA plan map views of the Bear Creek site near its mouth using River2D at 10, 100, and 200 cfs. Color-coding is based on the amount of WUA (m^2) within the cell. Dark (blue) shade indicates no habitat is present. The shaded legends are misleading and need to be examined closely (i.e., same shades with different amounts of WUA at 10 and 100 cfs). These maps clearly demonstrate that WUA is an index that cannot be measured directly and combines elements of habitat quantity and habitat quality (Bovee et al. 1994).

Examination of these maps shows that habitat occurs throughout most of the channel at low flows and is more restricted to the stream margins at higher flows. This makes sense within the modified geometric mean calculation for habitat (i.e., most habitat occurs along the stream margin where wood and overhanging cover have higher cover suitability criteria than the hard substrates in the stream channel). Also, although velocities restrict habitat in channel center at higher flows, more habitat is created along the stream margins as depths and velocities become more suitable. At 10 cfs, most of the wetted channel contains some low quantity habitat, resulting from a combination of depths, velocities, and escape cover values within suitable ranges for juveniles. At 100 cfs, more of the center of the channel becomes unusable due to velocities exceeding their upper suitability limits. Most habitat occurs along the shallow stream margin in slower velocity water and better cover. At 200 cfs, less total area is suitable habitat due to higher velocities, but the area that is available has a higher weight than 10 cfs due to higher velocity and depth suitabilities. Thus, more area of low-quality habitat at 10 cfs produces the same amount of WUA as a small area of high-quality habitat at 200 cfs, resulting in relatively little overall habitat change between 10 and 200 cfs.

Selection of an appropriate escape cover HSC coding system for juvenile coho will continue to be a matter of professional opinion until there is a better understanding of fish behavior in the Bear Creek and Little Butte Creek watersheds. Although site-specific fish observations would help determine an appropriate escape cover HSC, a well designed site-specific HSC study for juvenile coho could be complicated by the mobile nature of this life stage and rapidly changing use of habitat over time and space. Seasonal and diel shifts in habitat use by young salmonids are well documented (Everest & Chapman 1972; Bustard and Narver 1975; Hillman and Griffith 1987; Blatz et al. 1991; Roper et al. 1994; Thurow 1997; Spangler and Scarnechhia 2001; Kahler et al. 2001). Habitat selection also depends on variables such as temperature, food, stream flow, cover, predators, and population densities (Bjornn 1971; Bugert et al. 1991; Nielsen and Lisle 1994; Shirvell 1994). For models to be useful, they must include all the factors that regulate standing crop (Bjornn & Reiser 1991). Ignoring the spatial positioning of habitats and the dispersal capabilities of fish between them affects estimates of habitat quality and production (Kocik & Ferreri 1998). In summary, habitat modeling of juvenile salmonids is a highly complex science involving many interacting variables. Further exploration is needed.

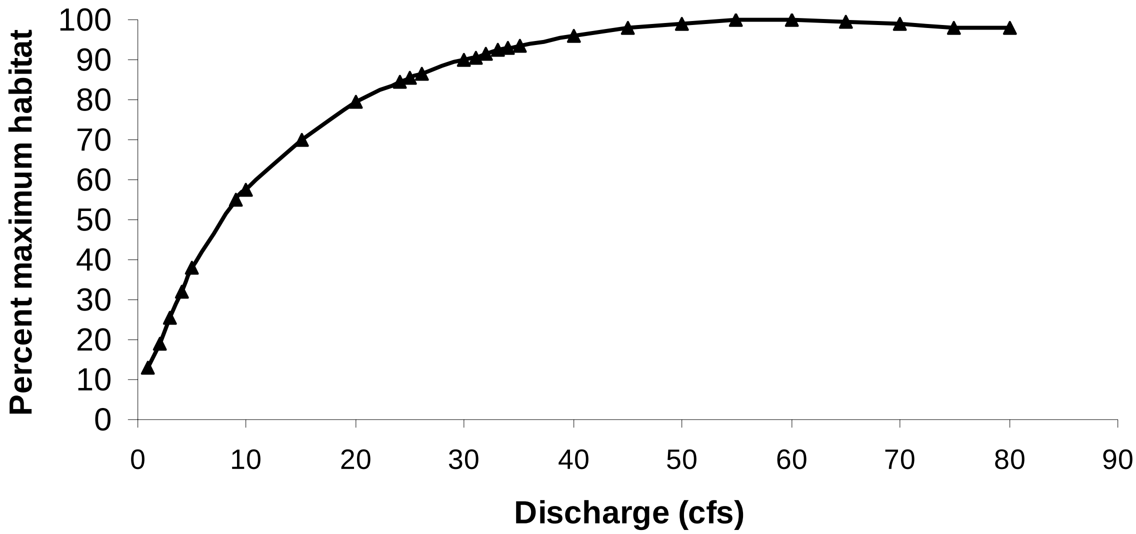


Figure 19 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Emigrant Creek.

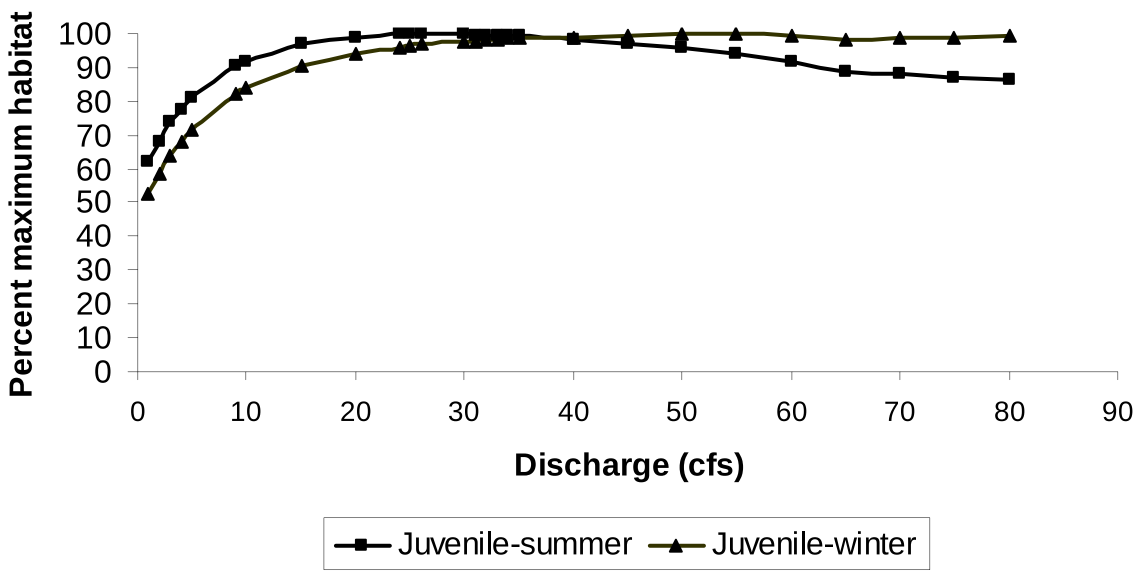


Figure 20 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Emigrant Creek.

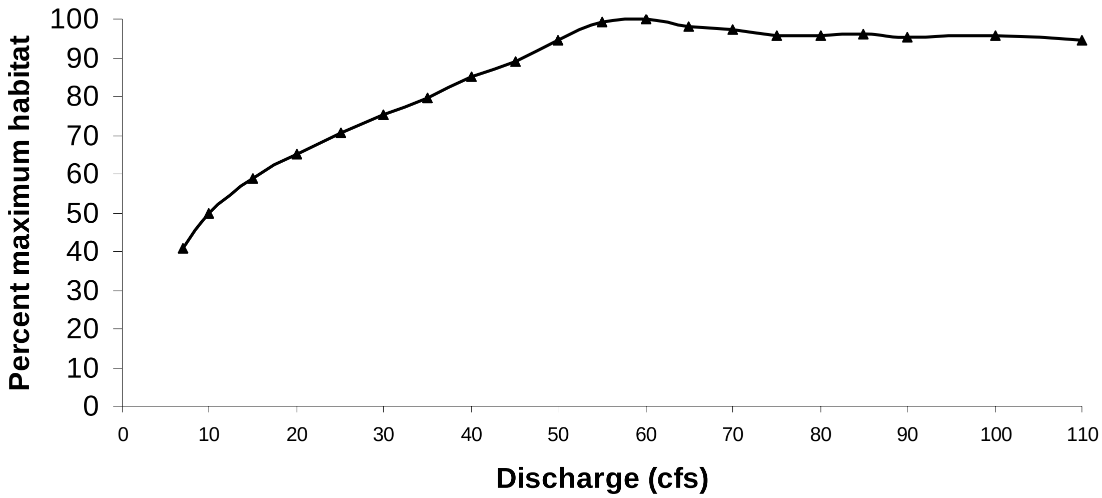


Figure 21 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Bear Creek between Emigrant Creek and Oak Street Diversion.

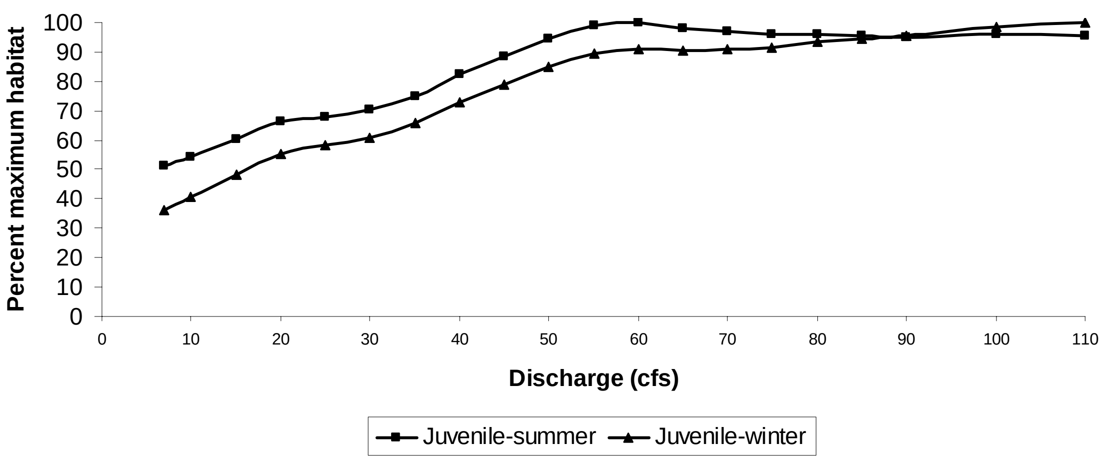


Figure 22 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Bear Creek between Emigrant Creek and Oak Street Diversion.

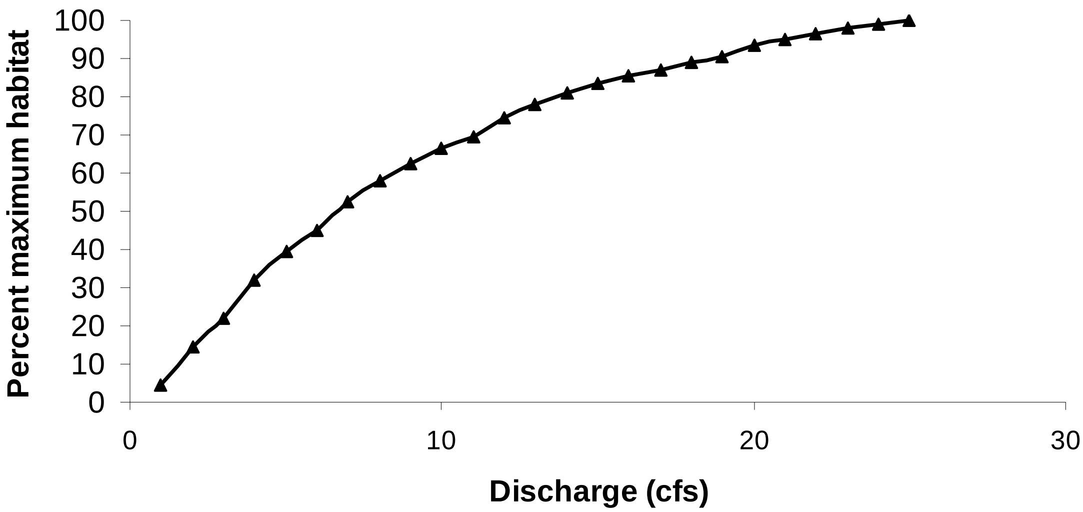


Figure 23 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Bear Creek between Oak Street Diversion and South Valley View Road.

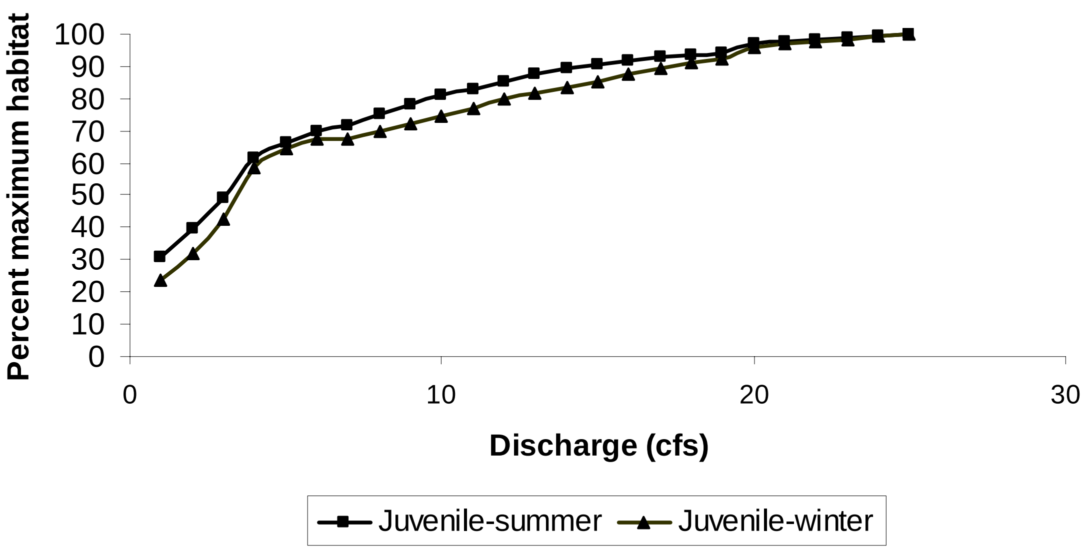


Figure 24 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Bear Creek between Oak Street Diversion and South Valley View Road.

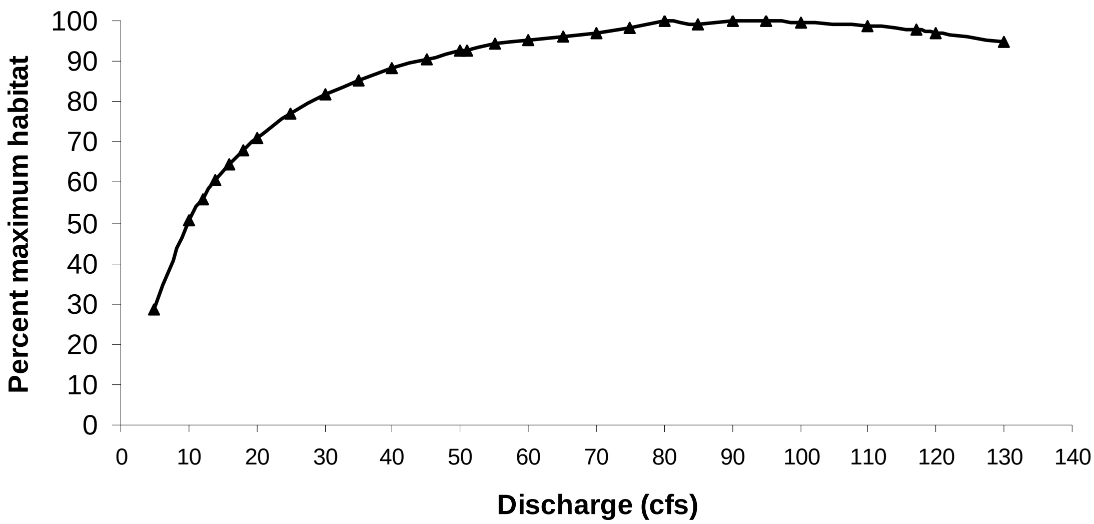


Figure 25 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Bear Creek between South Valley View Road and Phoenix Diversion.

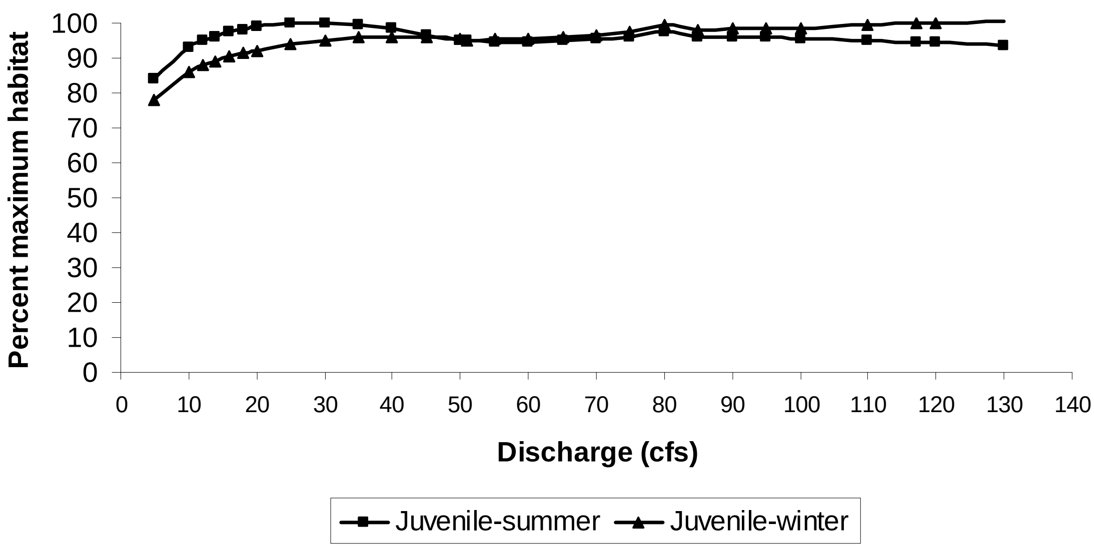


Figure 26 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Bear Creek between South Valley View Road and Phoenix Diversion.

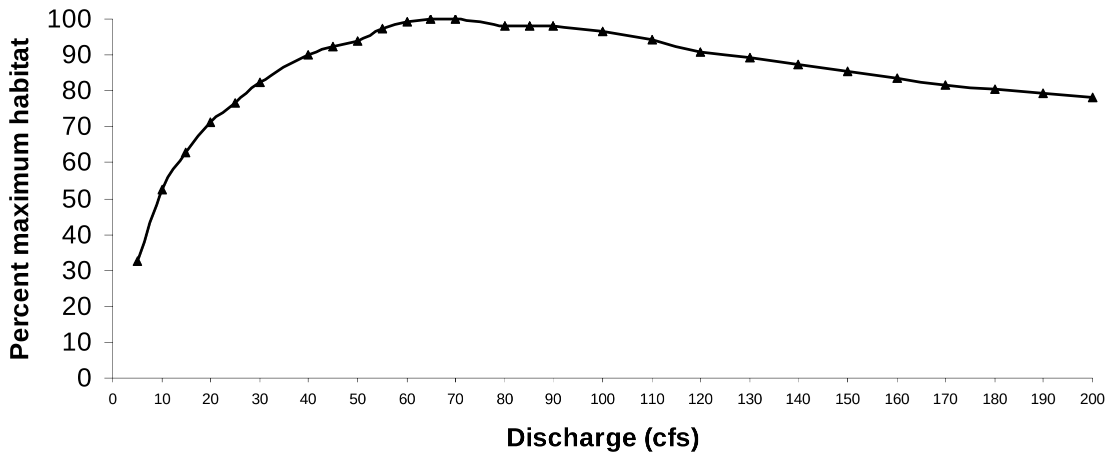


Figure 27 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Bear Creek between Phoenix Diversion and Jackson Street Diversion.

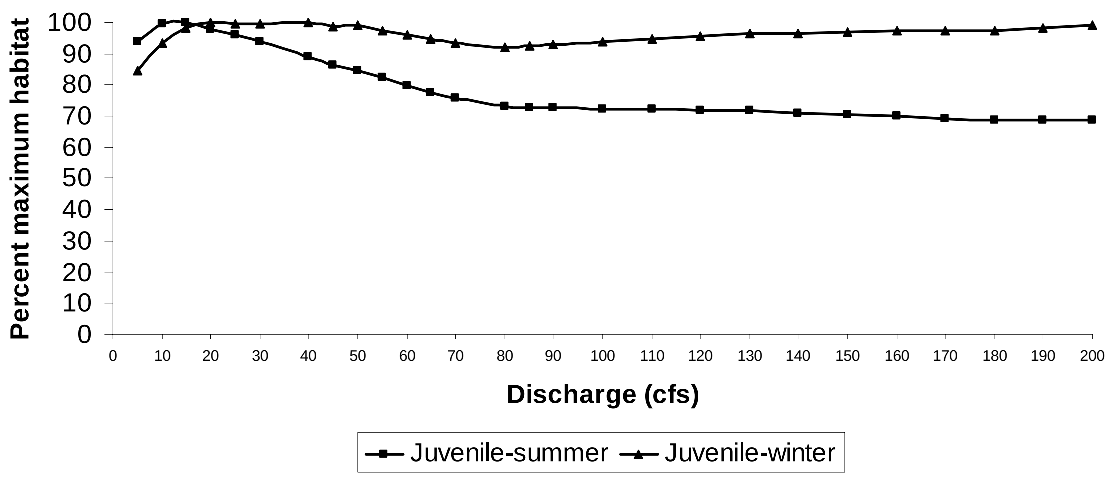


Figure 28 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Bear Creek between Phoenix Diversion and Jackson Street Diversion.

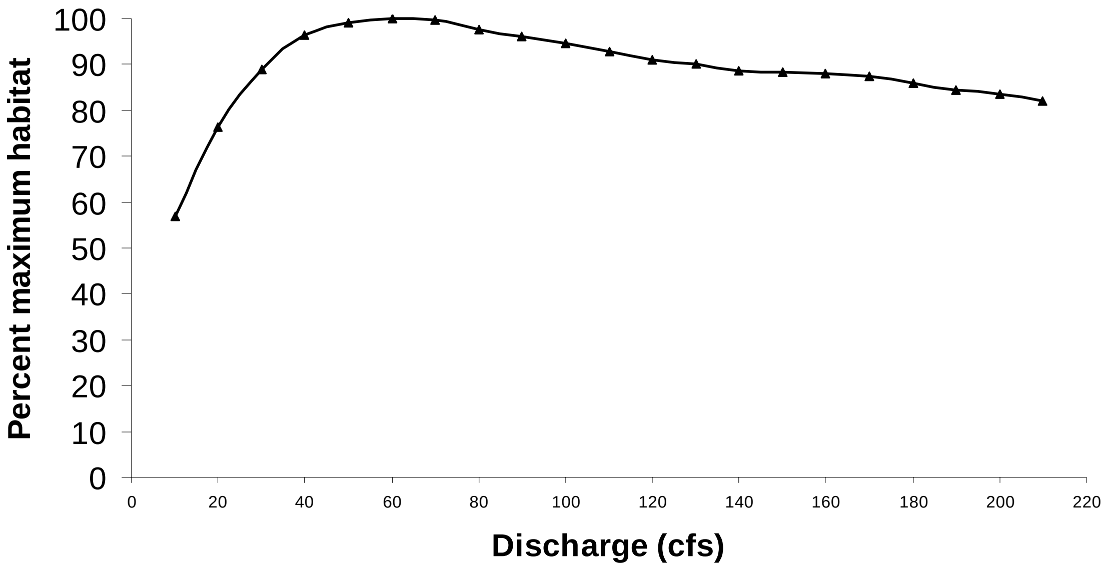


Figure 29 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Bear Creek near its mouth.

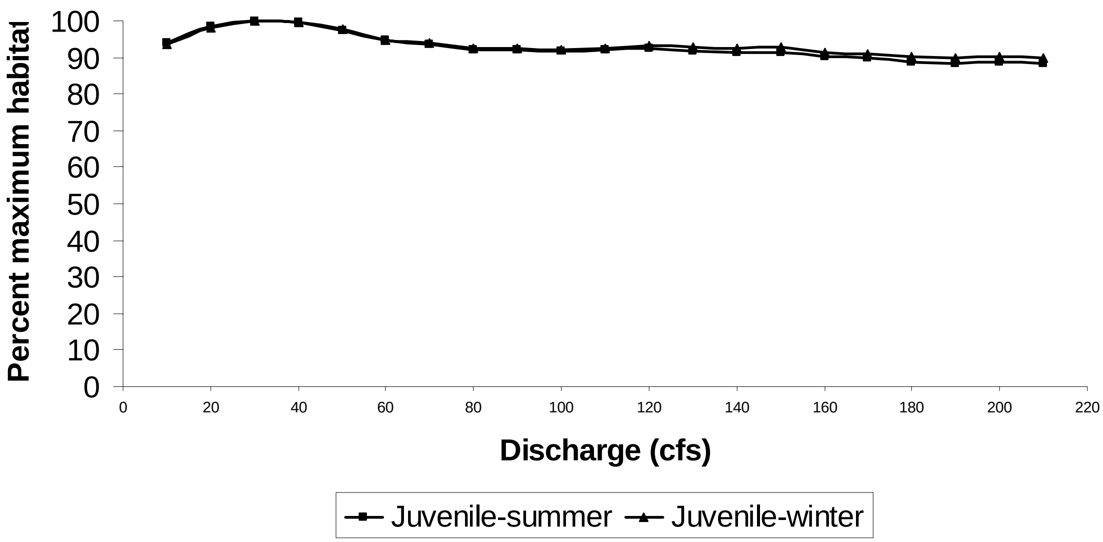


Figure 30 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Bear Creek near its mouth.

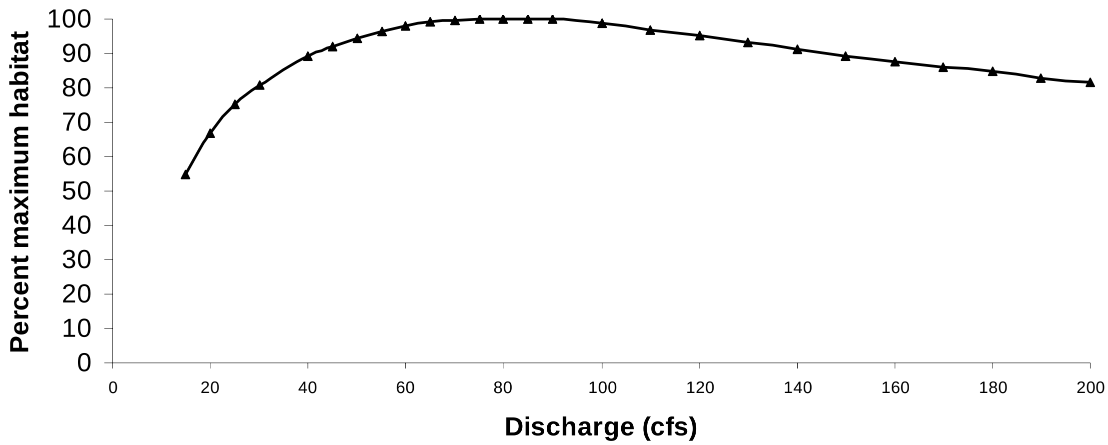


Figure 31 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Little Butte Creek near Brownsboro.

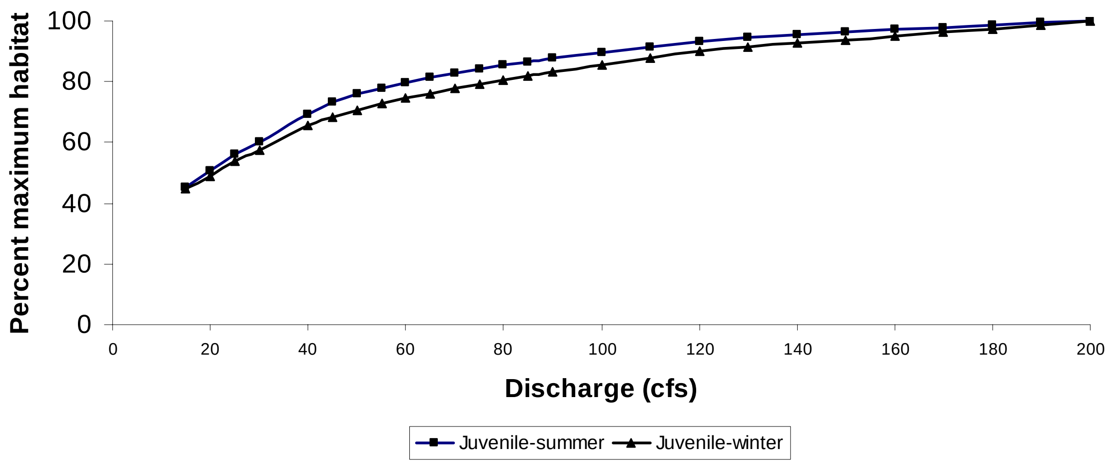


Figure 32 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Little Butte Creek near Brownsboro.

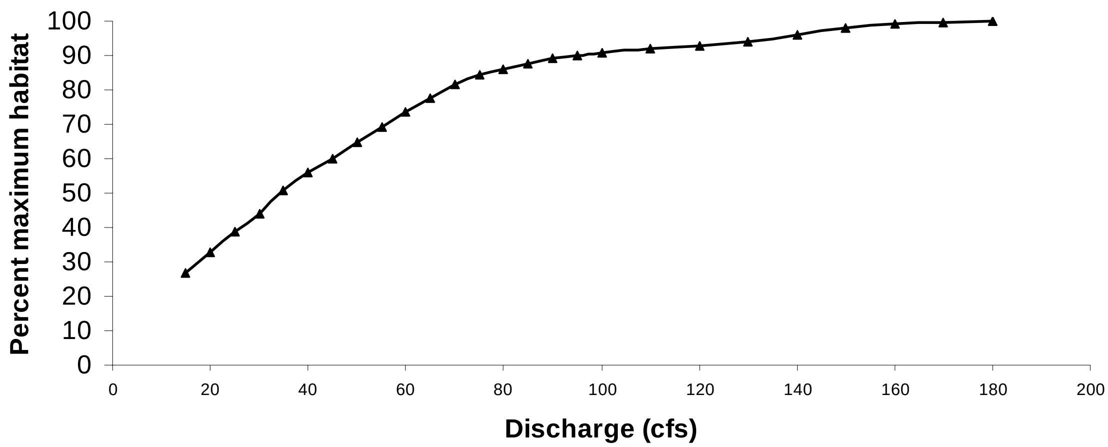


Figure 33 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Little Butte Creek near its mouth (1D results).

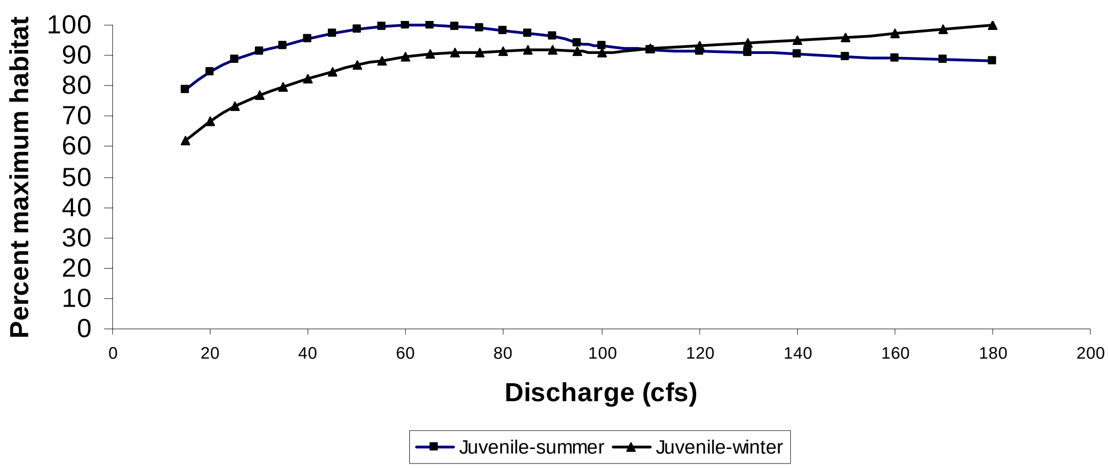


Figure 34 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Little Butte Creek near its mouth.

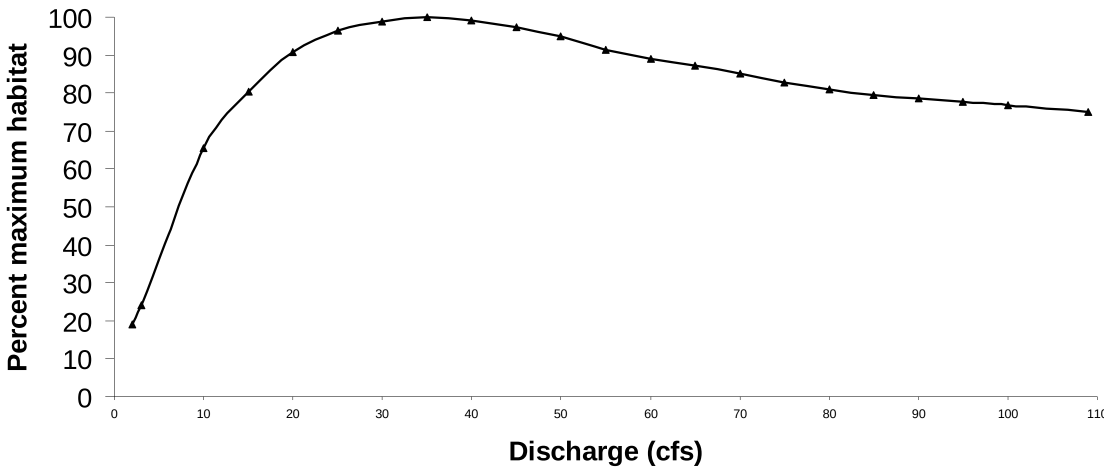


Figure 35 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Antelope Creek between Dry Creek and Antelope Creek Diversion.

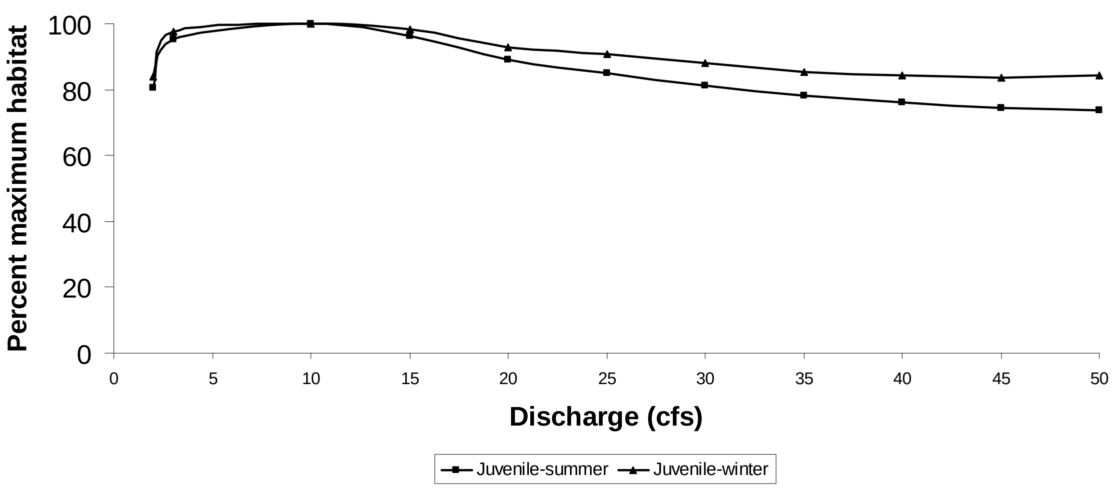


Figure 36 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Antelope Creek between Dry Creek and Antelope Creek Diversion.

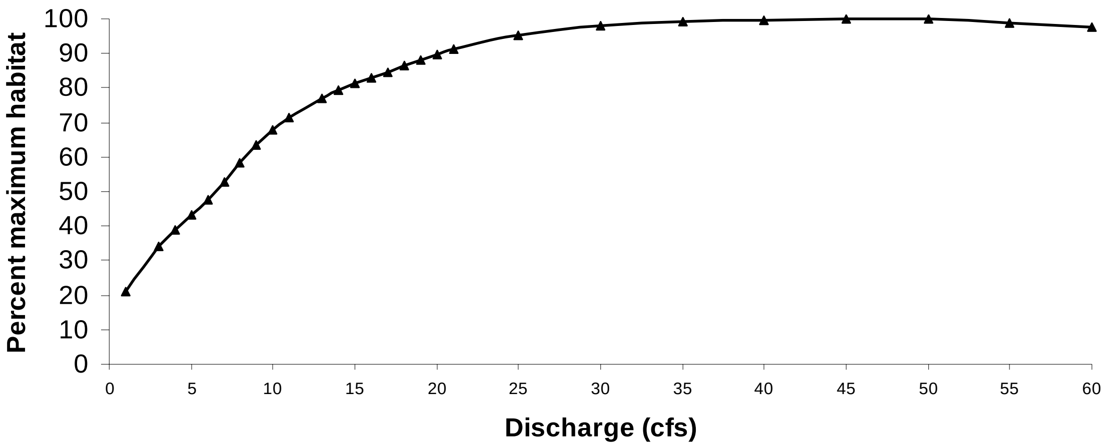


Figure 37 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Antelope Creek between Little Butte Creek and Dry Creek.

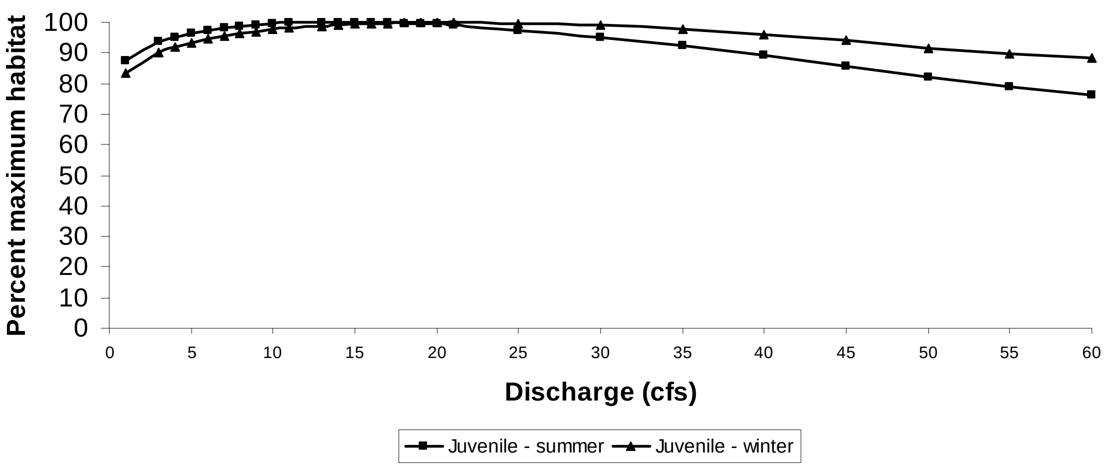


Figure 38 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Antelope Creek between Little Butte Creek and Dry Creek.

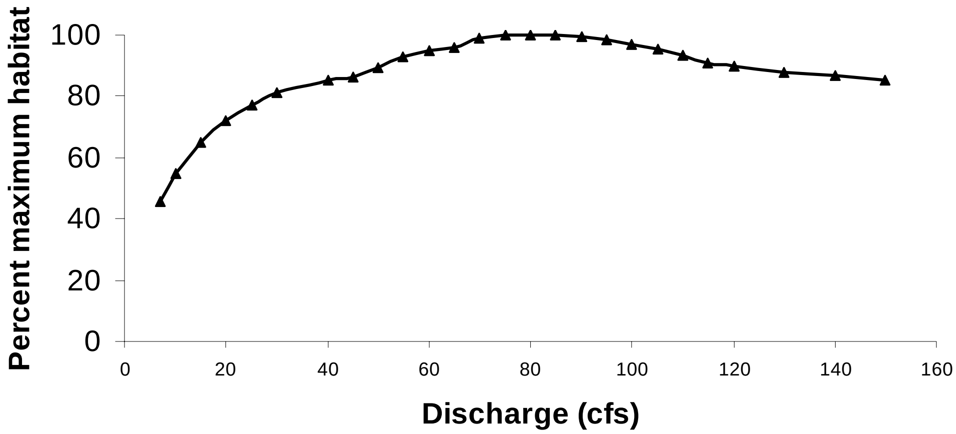


Figure 39 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in South Fork Little Butte Creek near Gilkey.

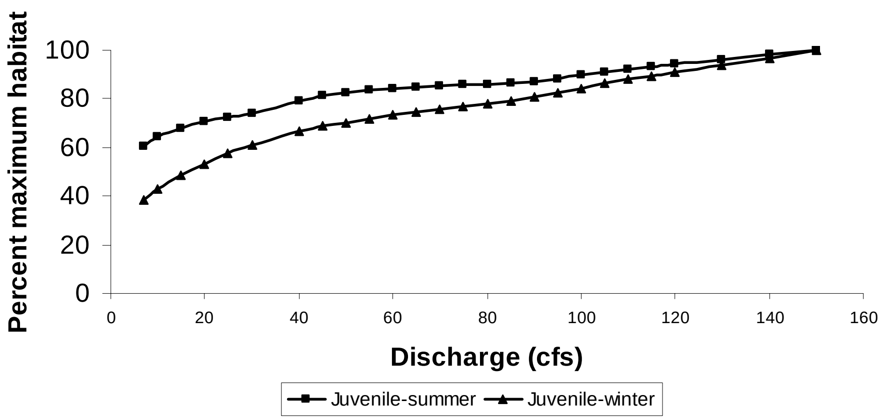


Figure 40 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in South Fork Little Butte Creek near Gilkey.

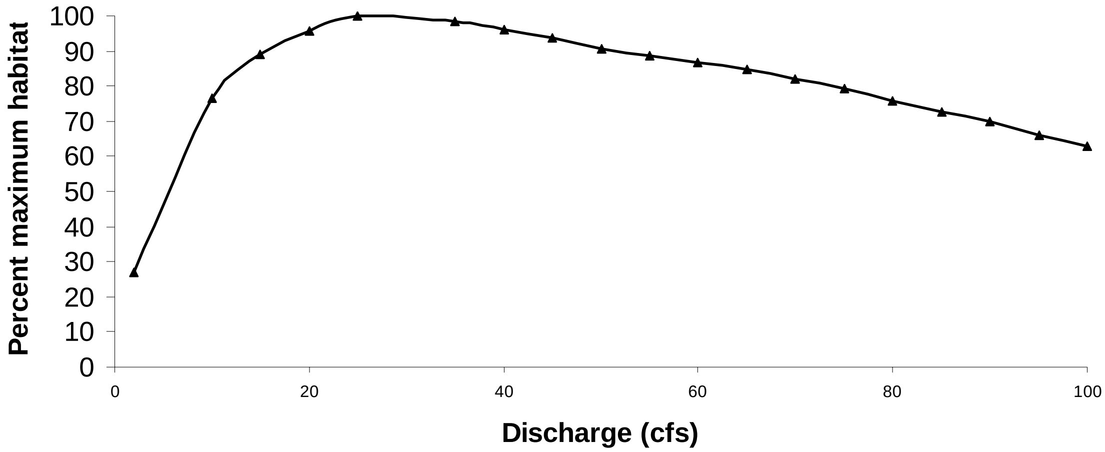


Figure 41 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationship for coho spawning/incubation in Neil Creek near its mouth.

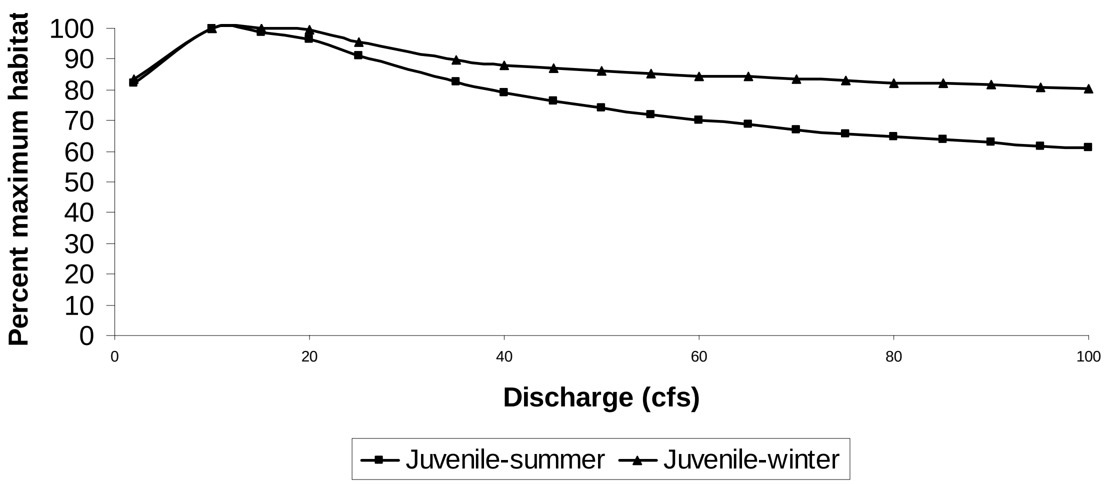


Figure 42 Normalized (% of maximum habitat) weighted usable area (WUA) versus discharge relationships for coho juveniles in Neil Creek near its mouth.

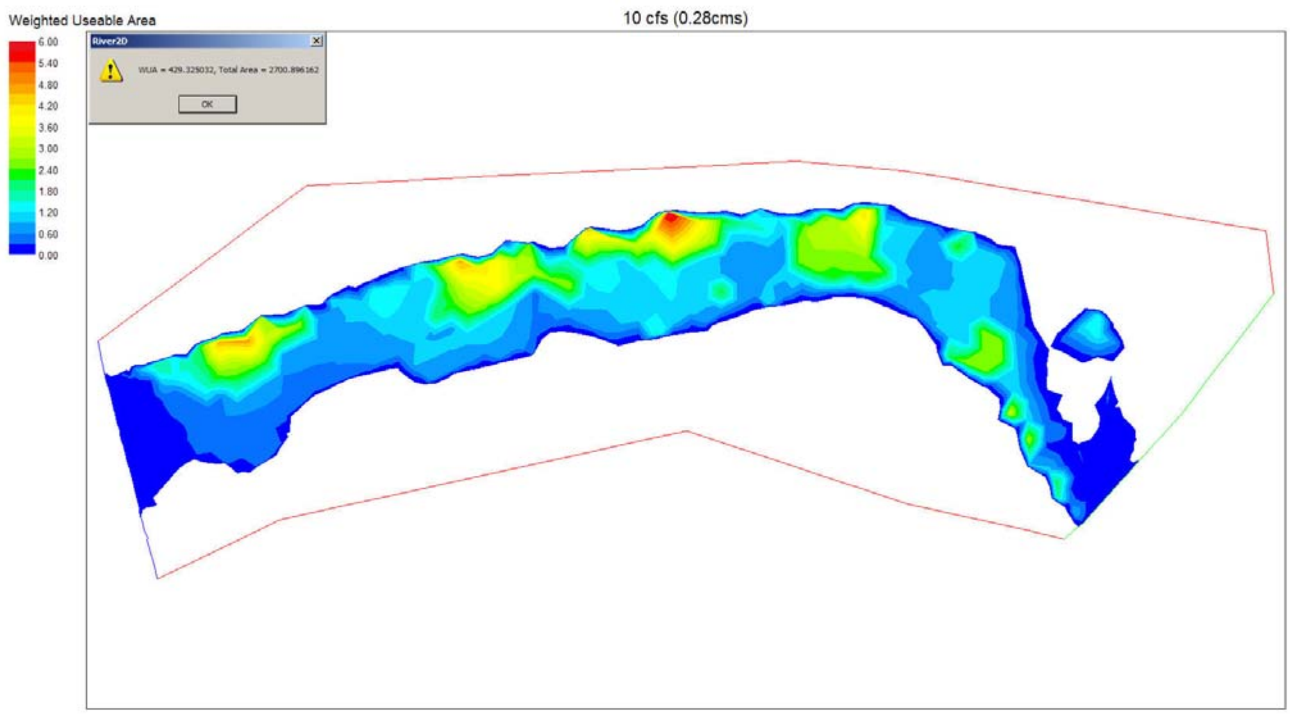


Figure 43 Weighted usable area (WUA) map for coho juvenile winter habitat at Bear Creek near its mouth at 10 cfs (WUA = 429 m^2).

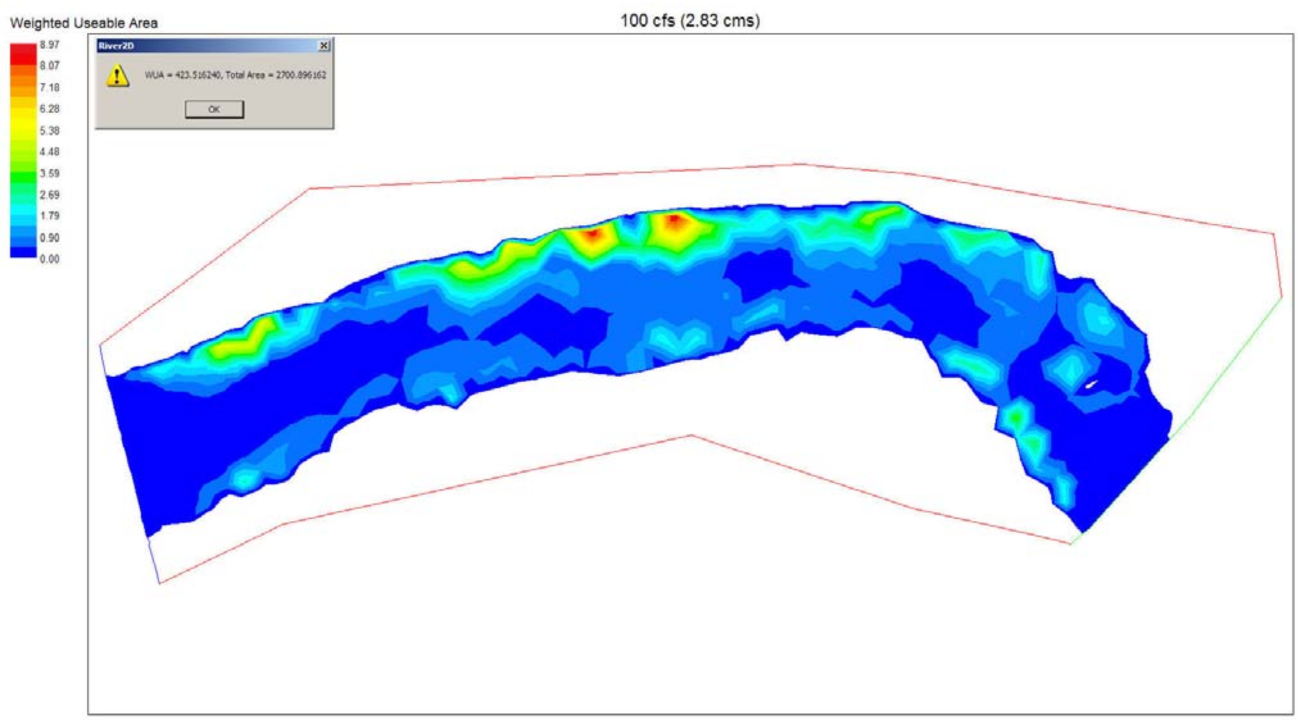


Figure 44 Weighted usable area (WUA) map for coho juvenile winter habitat at Bear Creek near its mouth at 100 cfs (WUA = 424 m^2).

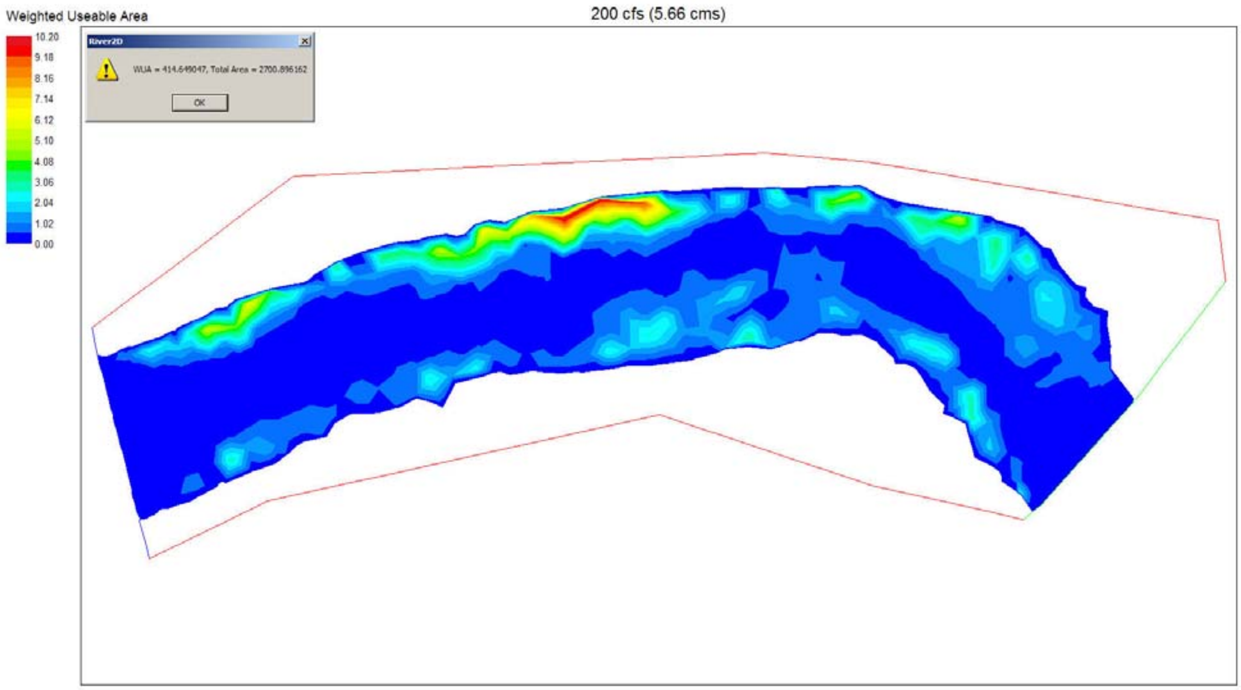


Figure 45 Weighted usable area (WUA) map for coho juvenile winter habitat at Bear Creek near its mouth at 200 cfs (WUA = 415 m^2).

5.4 Adult Fish Passage

An example of a cross-sectional profile of a shallow riffle used in the adult passage analysis on Emigrant Creek is shown in Figure 46. The water surface elevation drawn in the figure at 31 cfs satisfies both passage criteria (Figure 47). It should be noted that the method borrowed Thompson (1972) criteria for depth, but the results may not be as conservative as the Thompson (1972 transect method which follows a linear line across the shallowest course from bank to bank instead of a straight transect perpendicular to the flow. Passage results for the other stream segments are shown in Figures 48-58.

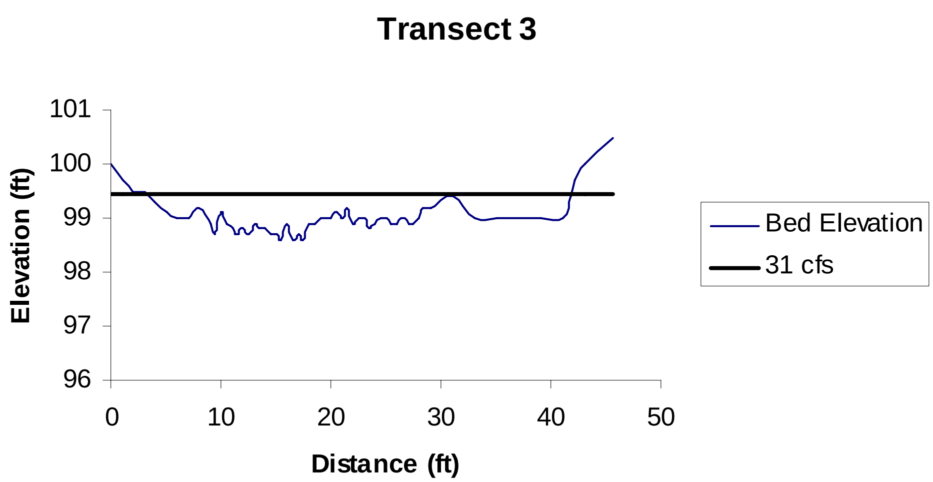


Figure 46 Cross-sectional profile of riffle transect in Emigrant Creek used in passage analysis.

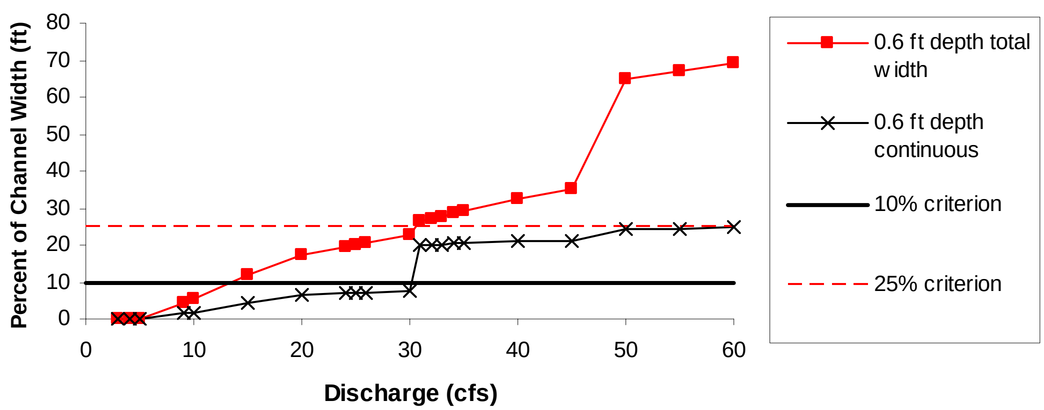


Figure 47 Percent of channel width at depths greater than passage criteria at a shallow riffle transect (40 ft longitudinal length) on Emigrant Creek at Gun Club.

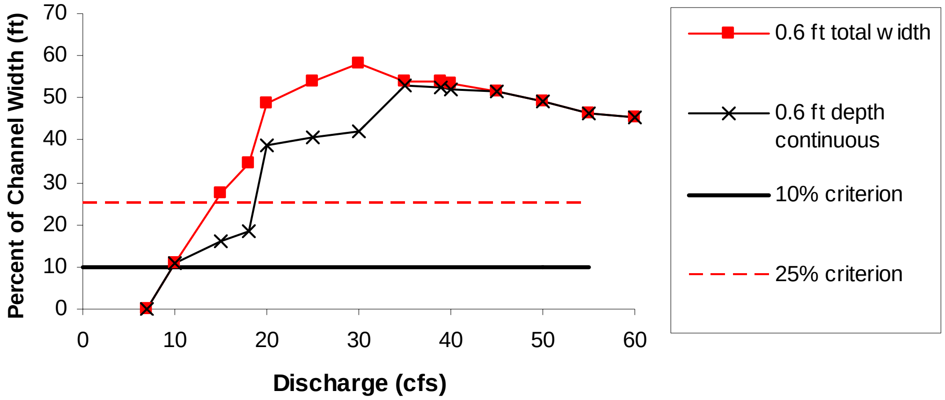


Figure 48 Percent of channel width at depths greater than passage criteria at a shallow riffle transect (50 ft longitudinal length) on Bear Creek between Emigrant Creek and Oak Street Diversion.

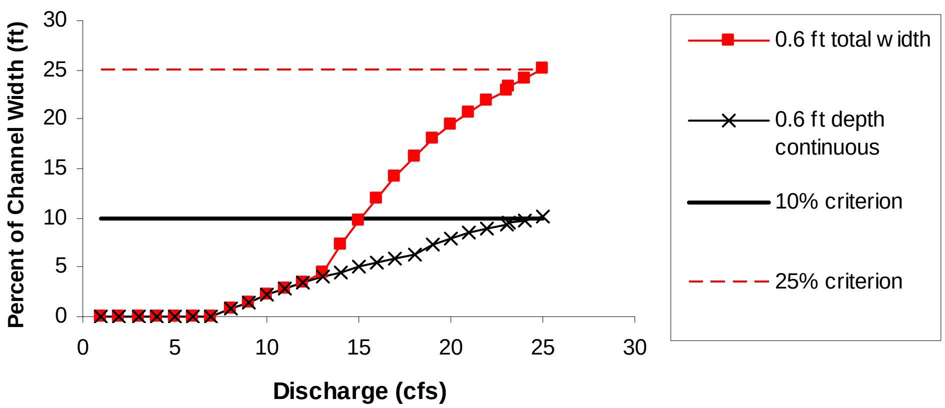


Figure 49 Percent of channel width at depths greater than passage criteria at a shallow riffle transect (10 ft longitudinal length) on Bear Creek between Oak Street Diversion and South Valley View Road.

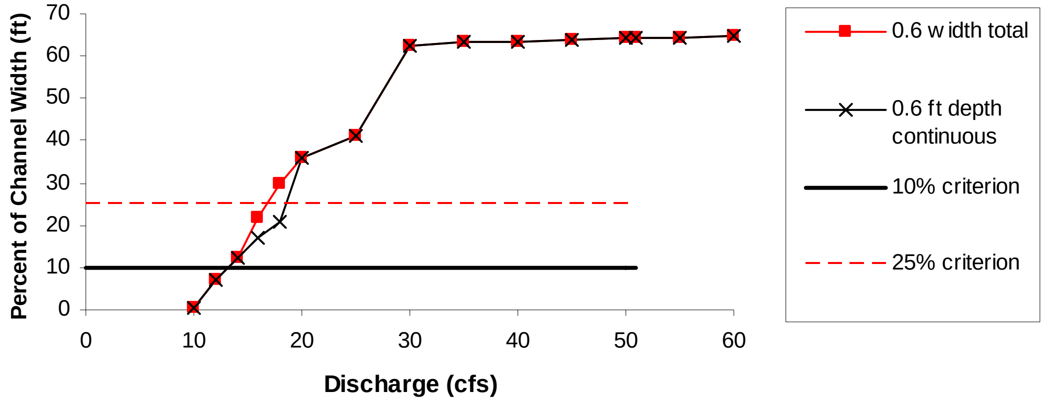


Figure 50 Percent of channel width at depths greater than passage criteria at a shallow riffle transect (85 ft longitudinal length) on Bear Creek between South Valley View Road and Phoenix Diversion.

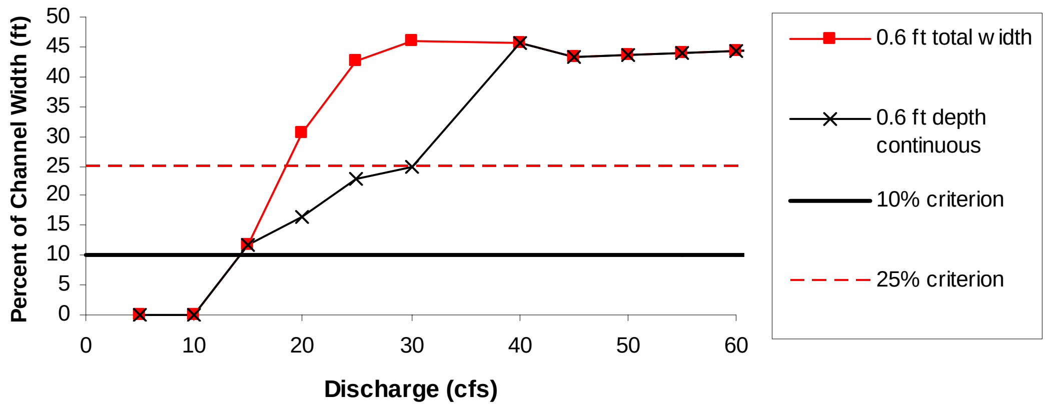


Figure 51 Percent of channel width at depths greater than passage criteria at a shallow riffle transect (20 ft longitudinal length) on Bear Creek between Phoenix Diversion and Jackson Street Diversion.

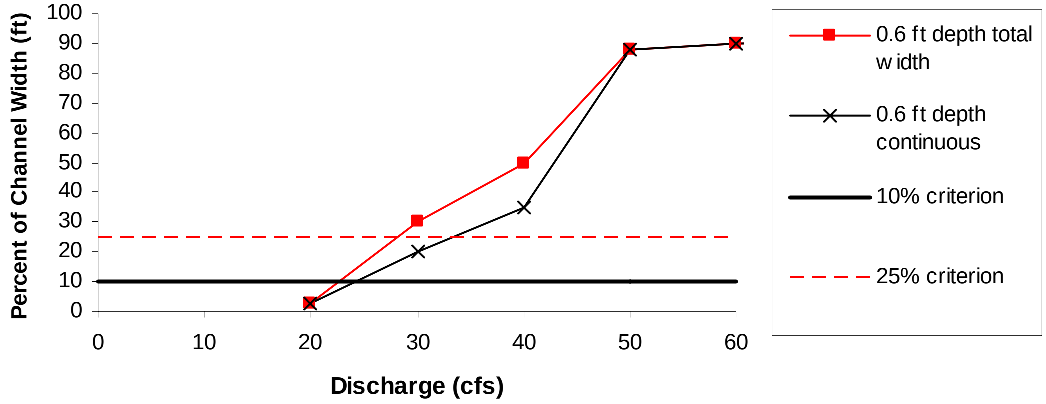


Figure 52 Percent of channel width at depths greater than passage criteria at a shallow riffle on Bear Creek near its mouth.

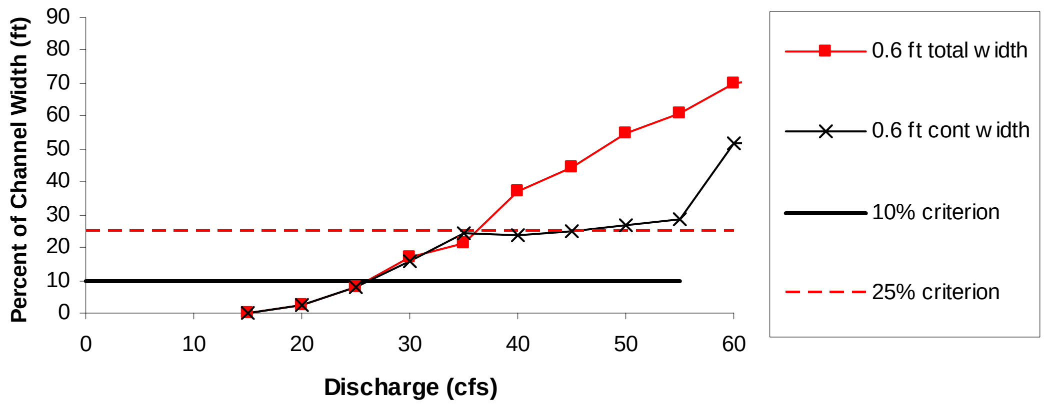


Figure 53 Percent of channel width at depths greater than passage criteria at a shallow riffle (85 ft longitudinal length) on Little Butte Creek near Brownsboro.

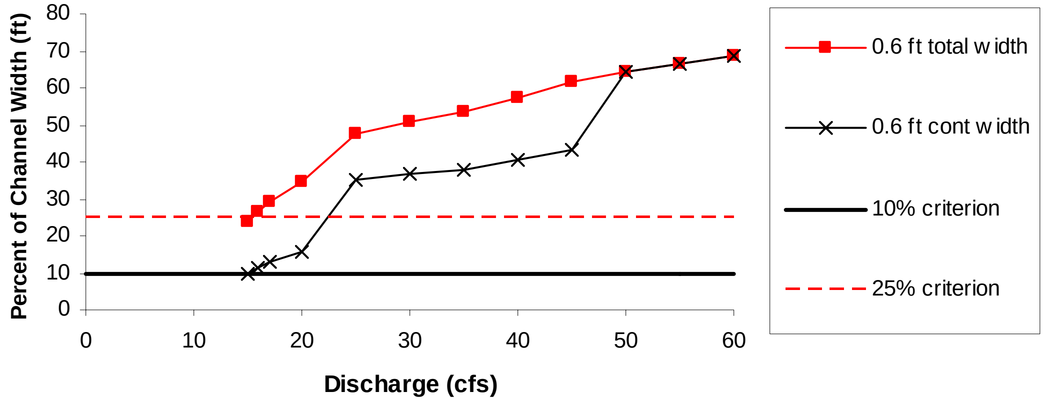


Figure 54 Percent of channel width at depths greater than passage criteria at a shallow transect (TX3) (24 ft longitudinal length) on Little Butte Creek near its mouth.

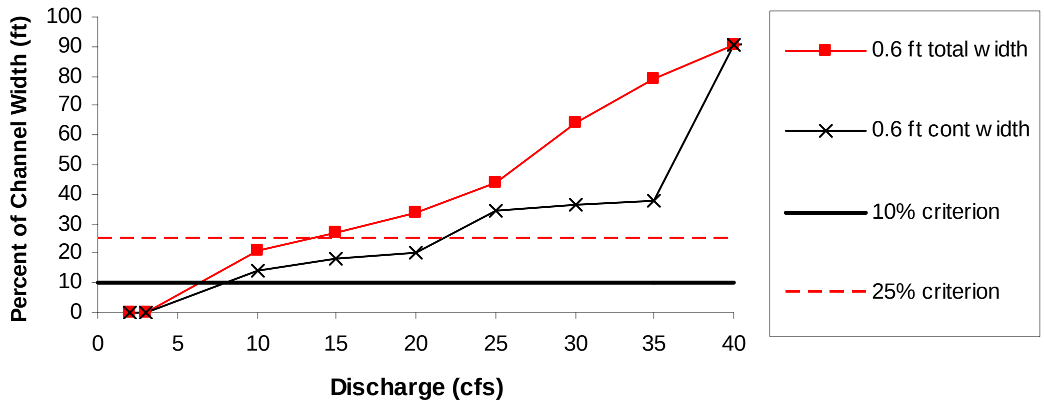


Figure 55 Percent of channel width at depths greater than passage criteria at a shallow riffle (13 ft longitudinal length) on Antelope Creek between Dry Creek and Antelope Creek Diversion.

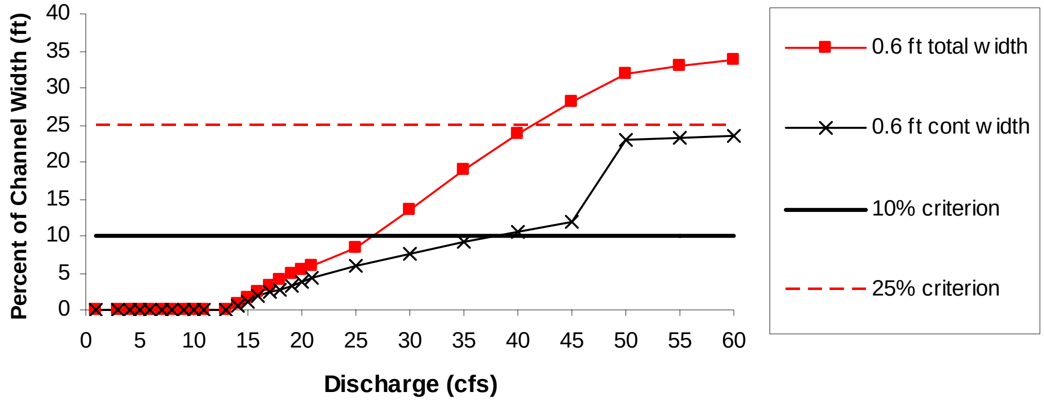


Figure 56 Percent of channel width at depths greater than passage criteria at a shallow riffle (21 ft longitudinal length) on Antelope Creek between Dry Creek and Little Butte Creek.

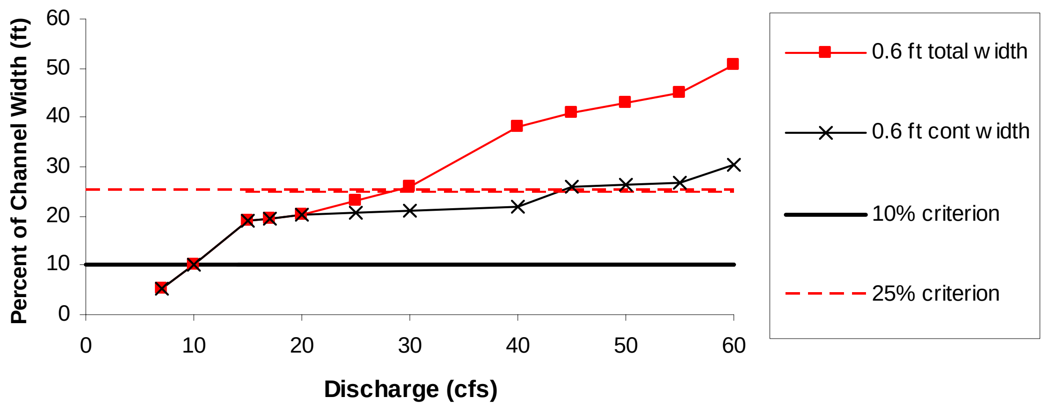


Figure 57 Percent of channel width at depths greater than passage criteria at a shallow riffle (70 ft longitudinal length) on South Fork Little Butte Creek near Gilkey.

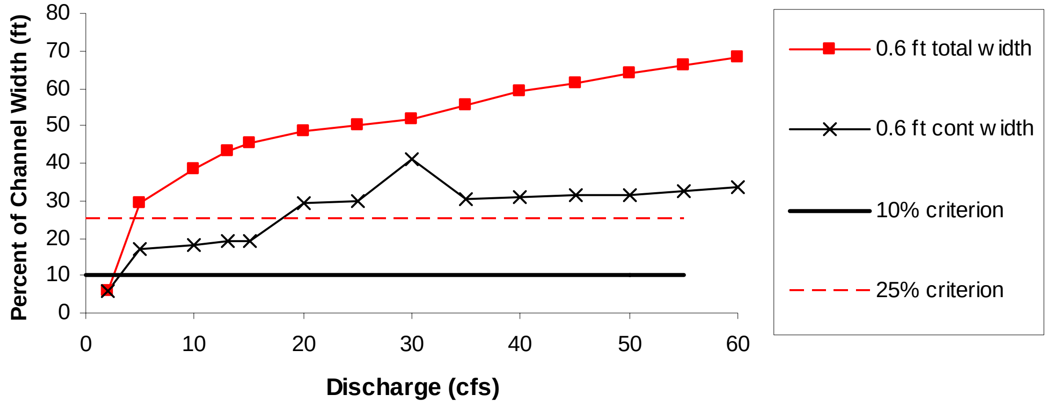


Figure 58 Percent of channel width at depths greater than passage criteria at a shallow riffle (78 ft longitudinal length) on Neil Creek near its mouth.

5.5 Field Validation of PHABSIM results

As mentioned in Section 2.0, evidence of coho summer juvenile rearing and spawning was found along one pool transect at the South Fork Little Butte Creek PHABSIM study site. As a check of model performance, composite suitability index maps were generated for spawning and summer juvenile at this site at typical summer and winter flows and compared with locations where coho spawning and juvenile rearing occurred (Figure 59). The circled areas on the maps indicate locations of spawning and rearing. Examination of these maps demonstrates that highest habitat suitabilities, indicated by the red (or dark) coloring, occurred in areas were spawning and rearing activity was observed. Although not within the original scope of the study, it does provide some limited evidence that the model predicted habitat quality in a reasonable manner. Figure 60 shows a habitat map of the same study site for coho juvenile summer rearing without the escape cover modifier using the traditional PHABSIM approach with the geometric mean habitat calculation. This map does not appear to validate the model output in terms of better habitat quality where juveniles were observed. Thus, despite its limitations, the escape cover modification seems to reflect more realistic conditions than modeling without the modifier. It should be noted that this type of evidence would need to be collected at many more locations to further validate results. Tables D-11 and D-12 show higher WUA values without the escape cover modifier compared to with the modifier. This is a reflection of the differences in the habitat calculations between the two approaches (i.e., geometric mean vs modified geometric mean).

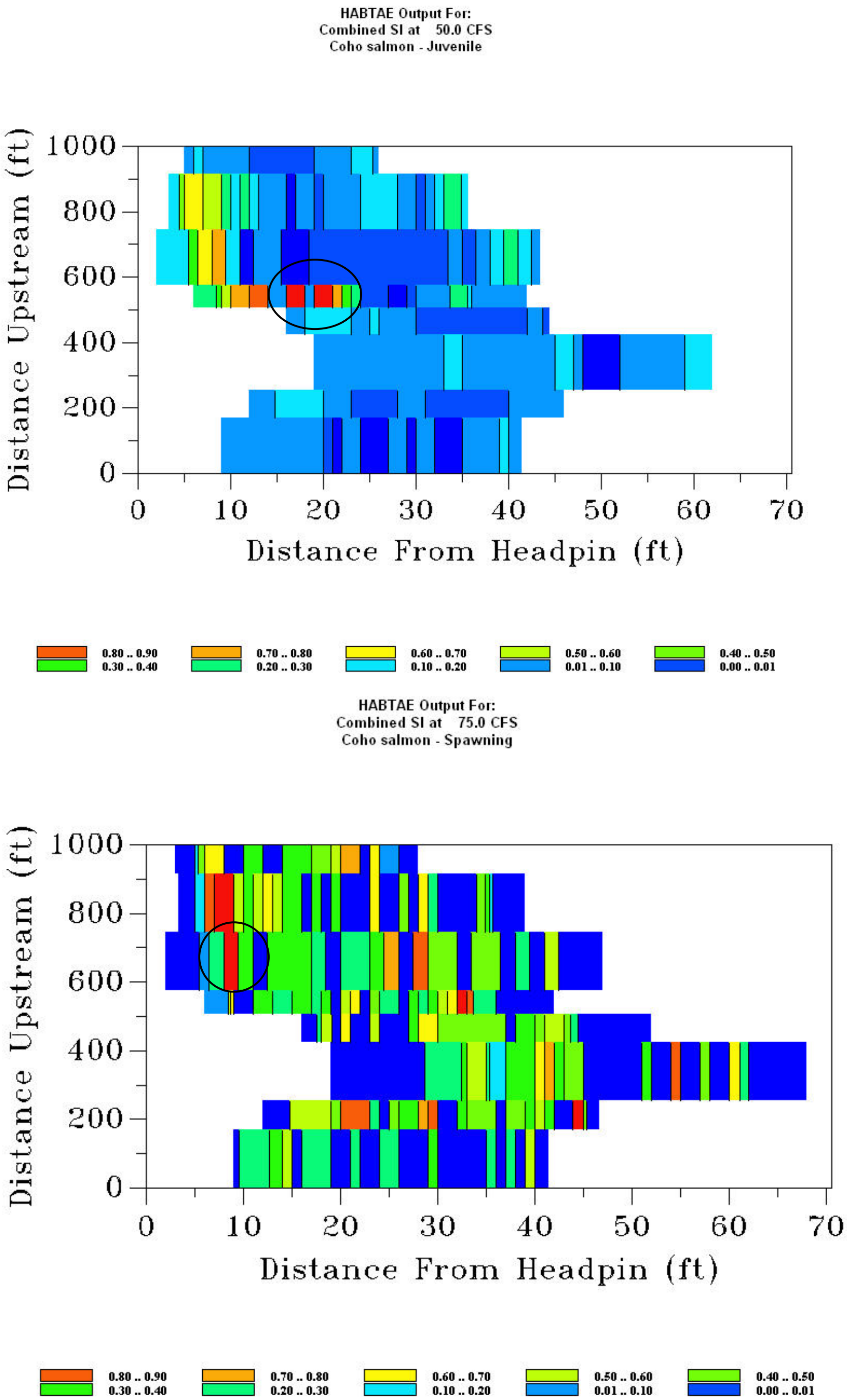


Figure 59 Combined suitability index maps from PHABSIM output for coho summer juveniles with escape cover modifier (top) and spawning (bottom) at South Fork Little Butte Creek study site. Circled areas indicate locations of observed life stage activity.

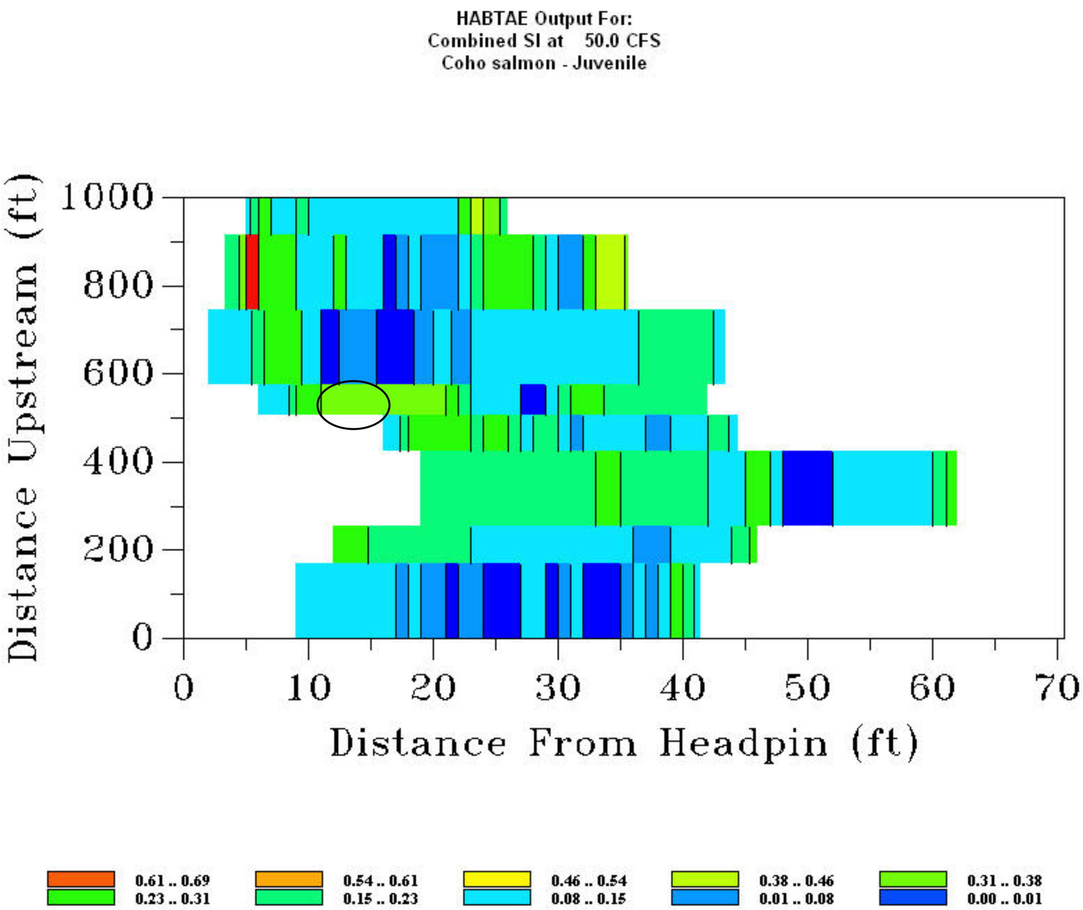


Figure 60 Combined suitability index map from PHABSIM output for coho summer juveniles without escape cover modifier at South Fork Little Butte Creek study site. Circled area indicates location of observed coho juveniles.

5.6 Summary Results

Summaries of PHABSIM results are provided in Tables 8-10. Inflection point graphs for total wetted area vs. discharge and WUA vs. discharge are located in Appendix F.

Emigrant Creek discharges required for maximum WUA ranged from about 25 cfs for juvenile summer rearing to 60 cfs for spawning/incubation (Table 8). Maximize habitat for juvenile winter rearing occurred at 50 cfs. Discharge required for adult passage over a shallow riffle habitat transect was 31 cfs, based on the 0.6 ft depth criteria (Table 9). Inflection point discharges for WUA curves ranged from 3 cfs for summer juvenile rearing to 13 cfs for spawning/incubation. Wetted surface area inflection point discharge occurred at 6 cfs (Table 10).

Bear Creek discharges required for maximum WUA ranged from 15 cfs for coho summer juvenile rearing between the Phoenix Diversion and the Jackson Street Diversion to 130 cfs for juvenile winter rearing between South Valley View Road and the Phoenix Diversion (Table 8). Discharges required for adult passage ranged from 15 to 30 cfs, depending on stream segment (Table 9). Inflection point discharges for wetted surface area ranged from 4 to 24 cfs, depending on stream segment (Table 10). It should be noted that the Oak Street Diversion to South Valley View Road study site was only measured at one flow, which restricted model calibration and simulation capabilities.

Optimal discharges for spawning/incubation in Little Butte Creek ranged from 75 cfs near Brownsboro to 180 cfs near the mouth of Little Butte Creek. Juvenile discharges ranged from 60 cfs for summer rearing near the mouth to 200 cfs for summer and winter rearing near Brownsboro (Table 8). Adult coho passage flows ranged from 16 cfs near the mouth to 40 cfs near Brownsboro (Table 9). Inflection point discharge for wetted surface area occurred at 15 and 21 cfs near Brownsboro and the mouth of Little Butte Creek, respectively (Table 10).

Discharges needed to maximize habitat in Antelope Creek were higher in the lower reach (between Little Butte Creek and Dry Creek) than the upper reach (between Dry Creek and Antelope Creek Diversion) (Tables 8 and 9). Inflection point discharge for wetted surface area occurred at 1 and 5 cfs in lower and upper Antelope Creek, respectively (Table 10).

South Fork Little Butte Creek discharges required for maximum coho WUA ranged from 75 cfs for spawning/incubation to 150 cfs for juvenile summer and winter rearing (Table 8). A flow of 30 cfs was required for adult passage (Table 9). Inflection point discharge for wetted surface area occurred at 26 cfs (Table 10).

Neil Creek required the least amount of discharge to maximize coho habitat among all stream reaches. This was likely because Neil Creek was the smallest stream surveyed. Adult passage flow was 5 cfs, spawning/incubation habitat was maximized at 25 cfs, and juvenile habitat was maximized at 10 cfs (Tables 8 and 9). Inflection point discharge for wetted surface area occurred at 4 cfs (Table 10).

Modeling results provided insight into the relationships between discharge and habitat and how these results relate to the existing hydrologic conditions. For example, optimal habitat for spawning coho in Emigrant Creek occurred at 60 cfs and discharge greater than 31 cfs was needed for adult passage. Natural stream flow estimates showed that monthly flows at the mouth of Emigrant Creek were below 60 cfs November through January and below 31 cfs in November and December (50% exceedance level) (Table 3). Thus, it can be concluded that there is usually not enough available water supply under estimated natural flow conditions to provide optimal flow conditions for adult spawning and for adult passage, as defined by the 0.6 depth criteria. Also, adult coho may pass shallow bars under lower flow conditions when stream flows naturally rise with fall storm events. In contrast, at the mouth of Bear Creek, optimal habitat for spawning was 60 cfs. Adult passage flow occurred at 30 cfs based on 0.6 depth criteria. These conditions are met November through January (50% and 80% exceedance levels) based on natural stream flow estimates.

Table 8 Habitat modeling summary for Rogue Project instream flow study.

Stream Segment/ life stage	Discharge (cfs) at maximum (100%) habitat	80% of maximum habitat (cfs)	60% of maximum habitat (cfs)	Inflection point[1]
Emigrant Creek-between Bear Creek and Emigrant Dam				
Spawning/incubation	60	20,>80[2,3]	10,>80	13
Juvenile – summer	25	4,>80	1,>80	3
Juvenile - winter	50	7,>80	2,>80	6
Bear Creek-between Emigrant Creek and Oak Street Diversion				
Spawning/incubation	60	35,>110	15,>110	12
Juvenile – summer	60	35,>110	15,>110	9
Juvenile - winter	110[2]	45,>110	30,>110	26
Bear Creek-between Oak Street Diversion and S. Valley View Road				
Spawning/incubation	25[2]	14,>25	8,>25	8
Juvenile – summer	25[2]	10,>25	4,>25	5
Juvenile - winter	25[2]	12,>25	4,>25	6
Bear Creek-between S. Valley View Road and Phoenix Diversion				
Spawning/incubation	90	25,>130	14,>130	20
Juvenile – summer	30	<5,>130	<5,>130	2
Juvenile - winter	130[2]	<10,>130	<10,>130	5
Bear Creek-between Phoenix Diversion and Jackson Street Diversion				
Spawning/incubation	70	25,180	10,>200	16
Juvenile – summer	15	<10,60	<10,>200	1
Juvenile - winter	20	<10,>200	<10,>200	2
Bear Creek-near mouth-2D site				
Spawning/incubation	60	20,>210	10,>210	10
Juvenile – summer	30	<10,>210	<10,>210	1
Juvenile - winter	30	<10,>210	<10,>210	1
Little Butte Creek-between S.Fk. Little Butte Creek and Antelope Creek				
Spawning/incubation	75	30,>200	15,>200	19
Juvenile – summer	200[2]	60,>200	30,>200	41
Juvenile - winter	200[2]	75,>200	30,>200	42

Stream Segment/ life stage	Discharge (cfs) at maximum (100%) habitat	80% of maximum habitat (cfs)	60% of maximum habitat (cfs)	Inflection point[1]
Little Butte Creek-near mouth				
Spawning/incubation	180[2]	65,>180	45,>180	56
Juvenile – summer	60	15,>180	<15,>180	8
Juvenile - winter	180[2]	35,>180	<15,>180	23
Antelope Creek-between Little Butte Creek and Dry Creek				
Spawning/incubation	45	14,>60	8,>60	10
Juvenile – summer	14	<1,55	<1,>60	1
Juvenile - winter	19	<1,>60	<1,>60	1
Antelope Creek-between Dry Creek and Antelope Creek Diversion				
Spawning/incubation	35	15,85	<10,>109	9
Juvenile – summer	10	2,35	<2,>109	1
Juvenile - winter	10	<2,-	<2,-	1
S. Fk. Little Butte Creek-Mile marker 12				
Spawning/incubation	75	25,>150	10,>150	15
Juvenile – summer	150[2]	40,>150	7,>150	14
Juvenile - winter	150[2]	85,>150	30,>150	25
Neil Creek-between mouth and Tolman Creek				
Spawning/incubation	25	10,75	<10,>100	5
Juvenile – summer	10	<2,40	<2,>100	1
Juvenile - winter	10	<2,100	<2,>100	1

1 Discharge where fitted curve slope = 1.0 on ascending limb of habitat/discharge curve.
2 Maximum habitat assumed to occur at maximum simulated discharge.
3 First value on ascending limb of WUA curve and second value on descending limb.

Table 9 Adult fish passage results for Rogue Project instream flow study.

Stream Segment	Discharge (cfs)[1]
Emigrant Creek-between Bear Creek and Emigrant Dam	31
Bear Creek-between Emigrant Creek and Oak Street Diversion	15
Bear Creek-between Oak Street Diversion and S. Valley View Road	25
Bear Creek-between S. Valley View Road and Phoenix Diversion	18
Bear Creek-between Phoenix Diversion and Jackson Street Diversion	20
Bear Creek-near mouth-2D site	30
Little Butte Creek-Brownsboro	40
Little Butte Creek-near mouth	16
Antelope Creek-between Little Butte Creek and Dry Creek	40
Antelope Creek-between Dry Creek and Antelope Creek Diversion	15
S. Fk. Little Butte Creek-Mile marker 12	30
Neil Creek	5

[1] Discharge that equaled or exceeded the minimum depth criteria (0.6 ft for coho) where at least 25% of the total transect width and a continuous portion equaling at least 10% of its total width was maintained.

Table 10 Summary of inflection point values from wetted surface area/discharge relationships at each Rogue study site.

Stream Segment	Discharge (cfs)[1]
Emigrant Creek-between Bear Creek and Emigrant Dam	6
Bear Creek-between Emigrant Creek and Oak Street Diversion	19
Bear Creek-between Oak Street Diversion and S. Valley View Road	4[2]
Bear Creek-between S. Valley View Road and Phoenix Diversion	18
Bear Creek-between Phoenix Diversion and Jackson Street Diversion	24
Bear Creek-near mouth-2D site	10
Little Butte Creek-Brownsboro	15
Little Butte Creek-near mouth	21
Antelope Creek-between Little Butte Creek and Dry Creek	1
Antelope Creek-between Dry Creek and Antelope Creek Diversion	5
S. Fk. Little Butte Creek-Mile marker 12	26
Neil Creek	4

[1] Discharge where slope approached 1.0.
[2] Simulated discharges only extend to 25 cfs based on one measured flow.

5.7 Comparison of PHABSIM with River2D Habitat Modeling

Figure 61 compares habitat analysis results for coho spawning between PHABSIM (one dimensional hydrodynamic model (1d)) and River2D (two dimensional hydrodynamic model (2d)) on lower Little Butte Creek. This life stage was chosen because the same channel index coding system and habitat calculation could be used; specifically, the modified geometric mean calculation could only be done using PHABSIM. The comparison is intended to highlight both similarities and differences that arise from using different approaches to field data collection, hydraulic modeling, and the way habitat is computed. Examination of this figure based on percent of maximum habitat relationships over the same flow range shows similar overall relationships in the habitat versus discharge functions for spawning. The differences between models reflect differing respective hydraulic modeling approaches (e.g., transect-based 1d vs topography-based 2d).

Waddle et al. (2000) reported that whether based on one-dimensional or two-dimensional flow models, the sensitivity of calculated habitat to errors in simulated depth and velocity ultimately depends on the sensitivity of target species' habitat suitability indices to depth and velocity. For this study, the major advantage of River2D modeling over PHABSIM is the attractive visual aids generated to display hydraulic and habitat results (Figure 62). However, River2D is also more labor intensive and as much as two times more expensive, depending on experience, than PHABSIM. Thus, PHABSIM analysis was considered sufficient for purposes of this study since the river channels were not hydrodynamically complex enough to justify using River2D (i.e., few eddies, intermittent backwaters, transverse flows, and braided channels) and similar habitat-discharge relationships would be expected with either model. Waddle et al. (2000) suggested that in areas with generally straight or gradually bending single channels, the one-dimensional approach may suffice. This generally describes most segments of Bear Creek and Little Butte Creek and their tributaries.

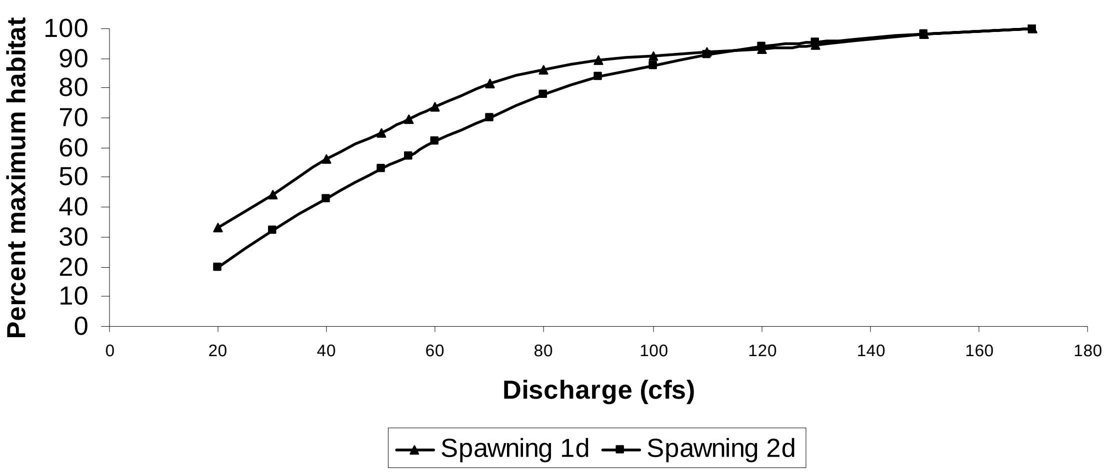


Figure 61 Comparison of coho spawning habitat modeling results between River 2D (2d) and PHABSIM (1d) at Little Butte Creek study site near mouth.

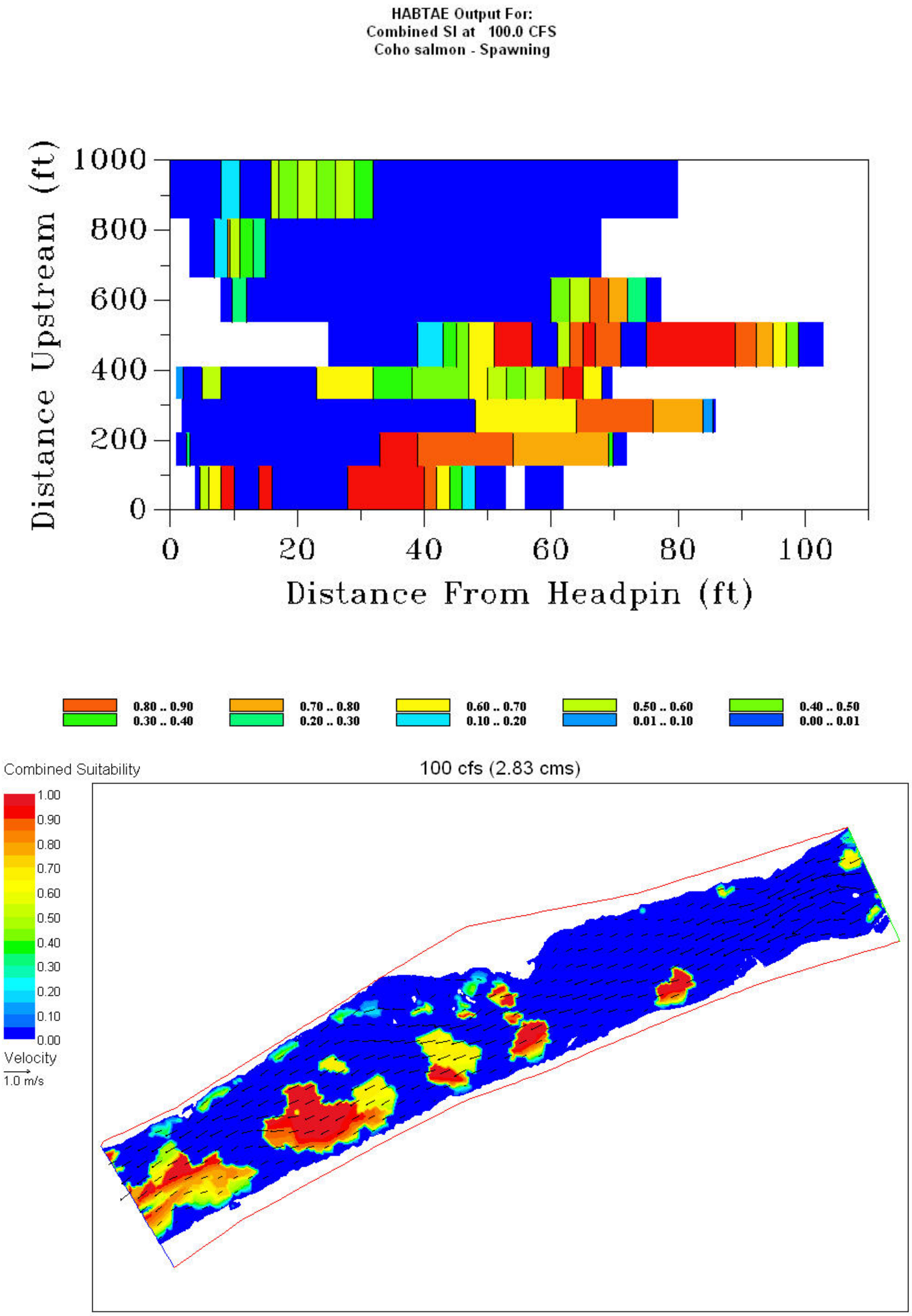


Figure 62 Comparison of combined suitability index mapping at 100 cfs for coho spawning between PHABSIM (1d) (top) and River2D (2d) (bottom) modeling in lower Little Butte Creek.

5.8 Guidelines for Using Study Results

The results summarized the hydrology, habitat, and temperature characteristics of selected stream segments within the Bear Creek and Little Butte Creek watersheds. PHABSIM analysis of the data collected and compiled for this study resulted in a series of graphs that illustrate relations between a dimensionless value called weighted usable area (WUA) and discharge (Figures 19-42). The highest point on each curve represents the discharge at which habitat is optimized for spawning or juvenile life stages for SONC coho salmon. These optimized values rarely coincide between life stages. Furthermore, adult migration, spawning, juvenile life stages occur at different times of the year (Table 2). These results imply that the optimum amount of water needed for adult, spawning, and juvenile life stages is not constant, but varies during the year.

The breakpoint on wetted total area, or wetted perimeter, versus discharge curves and WUA versus discharge curves is often referred to as a point of "inflection" (Gippel and Stewardson 1998). These systematically defined values typically occur on these curves where the slope (first derivative dy/dx) equals 1. Gippel and Stewardson (1998) recommended that the breakpoint on curves relating flowing water perimeter and discharge be viewed as a minimum flow to be applied only during dry periods when the flow in the stream would be low under unregulated conditions.

Habitat-discharge curves can be used to estimate how much habitat is gained or lost with incremental flow changes. In some cases, small flow changes can result in major habitat changes. WUA is an instantaneous representation of how much water it takes to create a certain amount of habitat. In general, it simply says that if there is "X" amount of flow present, that equates to "Y" amount of habitat. It is without reference to time or period of the year. WUA says NOTHING about how much water may or may not be present, and thus habitat, at any particular season of the year. Seasonal, monthly, or daily flow regimes have to be applied to the instantaneous WUA curves to get an indication of how much habitat is actually present. The way to use that information is, if there is "X" flow currently, that equates to "A" habitat, but if "Y" amount of flow is added, that equates to "B" amount of habitat. Depending on the shape of the curve, that change in habitat from "A" to "B" may be an increase or a decrease.

The actual habitat experienced by fish in any river depends on the flow regime of the river. The development of habitat conditions over a period of time is an integral part of the comparison of flow regimes. Habitat time series analysis involves interfacing a time series of streamflow data with the functional relationship between streamflow and habitat (WUA) (Bovee et al. 1998). This computational process is done for each flow regime alternative and life stage. Flow and habitat duration statistics are developed that allow a direct comparison of the changes that occur in both flow and habitat under a range of conditions. The amount of WUA available, in terms of lost or gained, can be determined by comparing WUA for a range of flow alternatives. The decision point in PHABSIM is a comparison of flow regimes.

Although high summer water temperature appears to limit fish survival in late July and early August, fish populations continue to exist within available physical habitat throughout the year in the upper Rogue River Basin. In fact, coho counts at Gold Ray Dam have increased since the late 1990s. However, lower Bear Creek is often too hot for salmonids in summer (Dambacher et al. 1992). Therefore, modeled habitat results for Bear Creek concerning juvenile summer rearing should be considered along with temperature in Bear Creek. Although temperature modeling would help determine the benefits of additional flow, if any, to thermal regimes within the upper Rogue River Basin, temperature modeling was beyond the scope of this study. However, Horsburgh (2007) conducted a temperature analysis that tended to show summer water temperatures in lower Bear Creek do not appear to be affected by changes in flow, which may preclude the use of this stream in summer by juvenile coho and other salmonids, except in thermal refugia.

Actual flow levels needed for adult passage may differ from those predicted by the model. Adult coho may pass shallow bars under lower flow conditions when stream flows naturally rise with fall storm events. Modeled depths are only an approximation of conditions present at any given site and flow, and therefore, actual depths may vary from those predicted and could be sufficient for passage.

As discussed in Section 1.2, flow needs for egg incubation are not necessarily the same flows needed for adult spawning (Bjornn and Reiser 1991). Lower flows than those predicted for spawning could likely maintain adequate circulation through redds and meet egg incubation needs. However, as agreed upon by participants at the March, 2007 HSC workshop, the same HSCs were used for spawning and incubation (Appendix C). This is a conservative approach regarding flow needs for egg incubation. A separate study that evaluates water circulation in redds based on substrate size, stream gradient, velocity, and water depth sufficient to keep redds fully submerged would be needed to determine flow needs specific for incubation.

Although the escape cover modifier is an improvement over the traditional PHABSIM model, the modified version still has limitations (see Section 4.1.2). Thus, PHABSIM results should be interpreted as an approximation of how physical habitat availability changes relative to discharge or stream hydraulics. Other limiting factors beyond the scope of this study should also be considered (e.g., water quality, disease, competition, predation) when evaluating the effects of different proposed flow regimes on coho and the stream environment. PHABSIM is not intended to generate a single solution, but to predict the impacts of different alternatives. Users seeking a mechanistic solution to a problem may find this method difficult to understand. The value of PHABSIM is that it offers an objective water management tool to provide science-based linkage between biology and river hydraulics with results to be used in negotiations or mediated settlements (Arthaud et al. 2001).

6.0 RECOMMENDATIONS

This study would benefit from additional information that could be obtained from the following tasks:

- Verify and refine HSCs with site-specific HSC data collection in the Little Butte Creek Watershed to validate habitat suitabilities of various coho salmon life stages;

- Modify the River2D model to incorporate a modified geometric mean habitat calculation option;

- Modify the PHABSIM and River2D hydrodynamic models to include an algorithm for cover that searches for nearby cover components that meet certain threshold depths and velocities and has the ability to change the value of cover depending on discharge;

- Additional water temperature and discharge monitoring in areas not being monitored, such as Bear Creek between Emigrant Creek and Oak Street Diversion;

- Apply a temperature model such as SSTEMP to identify streamflow or shading required to minimize temperature effects on coho salmon;

- Transect surveys at higher flows to extend the upper flow predictive range of the models and allow a better evaluation of habitat during winter high-flow conditions;

- Periodically (every few years) re-survey transects to determine whether the stream channels are aggrading or degrading; and

- Map habitat in longer reaches of stream to refine stream length estimates represented by non-disturbed vs. disturbed channels.

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APPENDICES

Appendix A – Study Site and Transect Descriptions, Photos, and Cross-sectional Profiles with Measured Water Surface Elevations

Appendix B – Hydraulic Calibration Results

Appendix C – Habitat Suitability Criteria

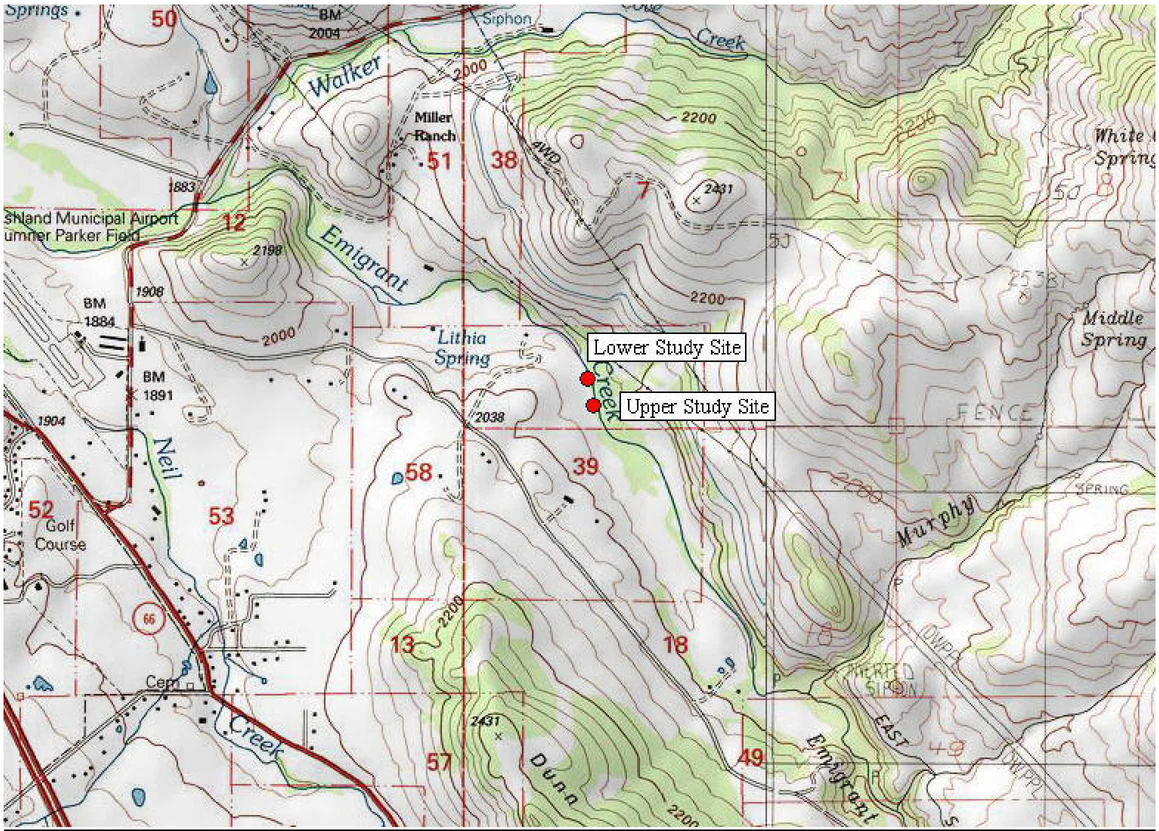
Appendix D – Weighted Usable Area (WUA) Versus Discharge Relationships

Appendix E – Stream Habitat Surveys

Appendix F – Inflection Points

Appendix A – Study Site and Transect Descriptions, Photos, and Cross-sectional Profiles with Measured Water Surface Elevations – Coordinate datum is NAD83

Emigrant Creek



Lower study site:_N42°11.220’ W122°38.057’
Transect 1 – glide (most downstream transect)
Transect 2 – glide
Transect 3 – riffle (passage)
Transect 4 – glide
Transect 5 – hydraulic control
Transect 6 – pool
Transect 7 – pool
Transect 8 – riffle(most upstream transect)

Upper study site:_N42°11.171’ W122°38.032’
Transect 9 – riffle
Transect 10 – riffle (most upstream transect)


T4
T3
T2
T1

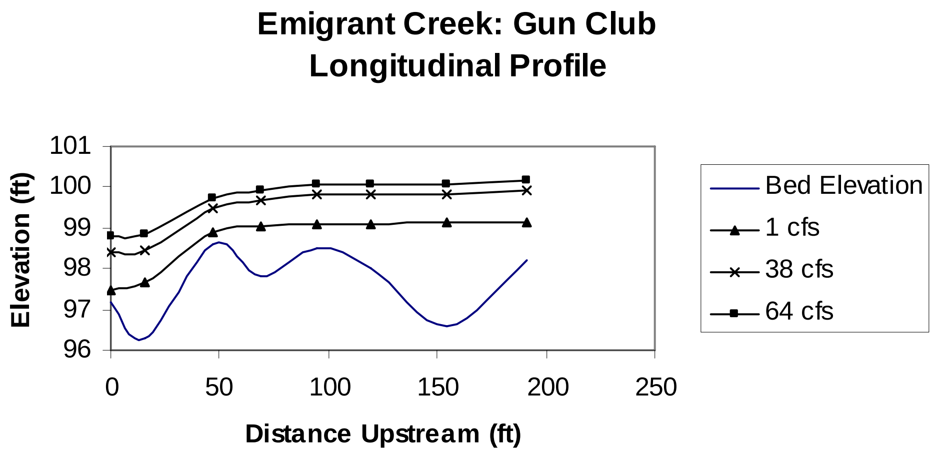

T5
T6
T7
T8

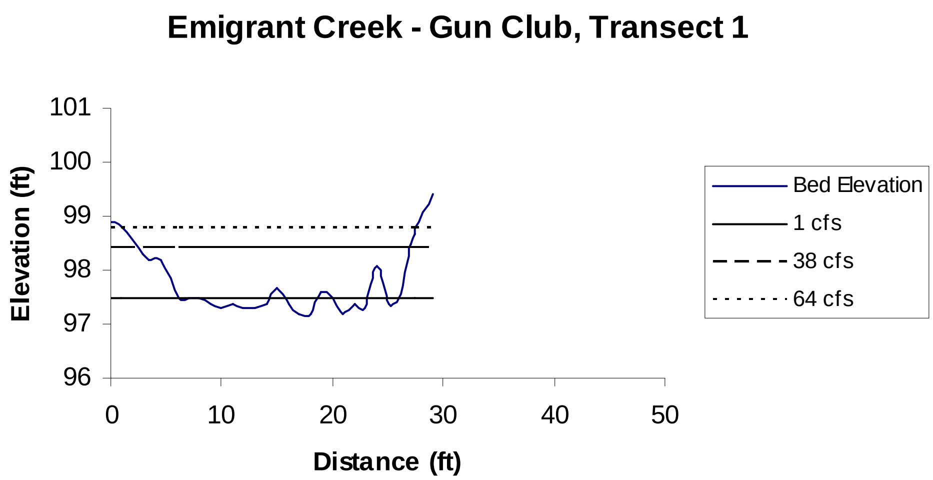

T10
T9

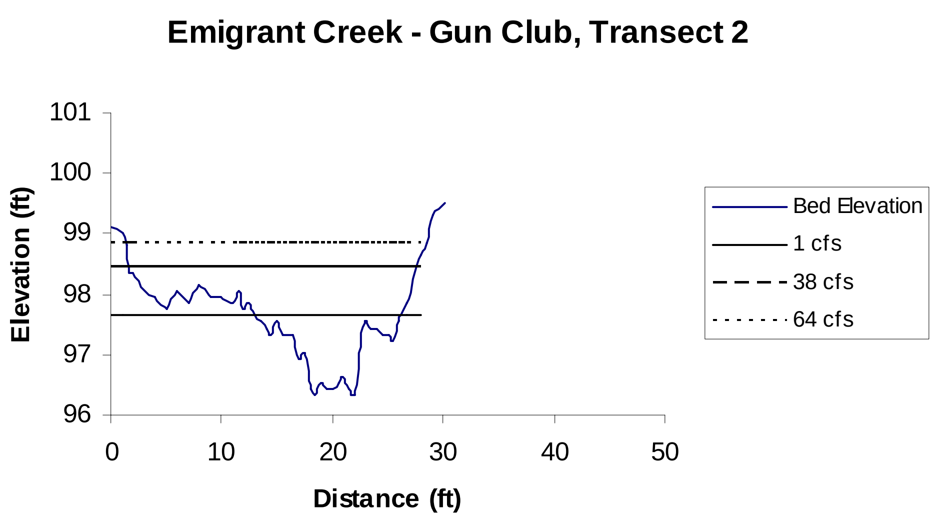

1 cfs – June 16, 2006


40 cfs – June 29, 2006

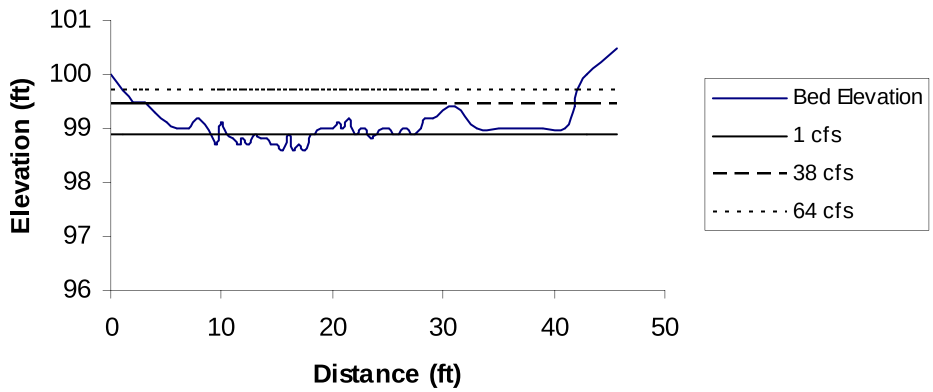

64 cfs – August 3, 2006


Emigrant Creek: Gun Club
Longitudinal Profile
Elevation (ft)
Distance Upstream (ft)
Bed Elevation
1 cfs
38 cfs
64 cfs

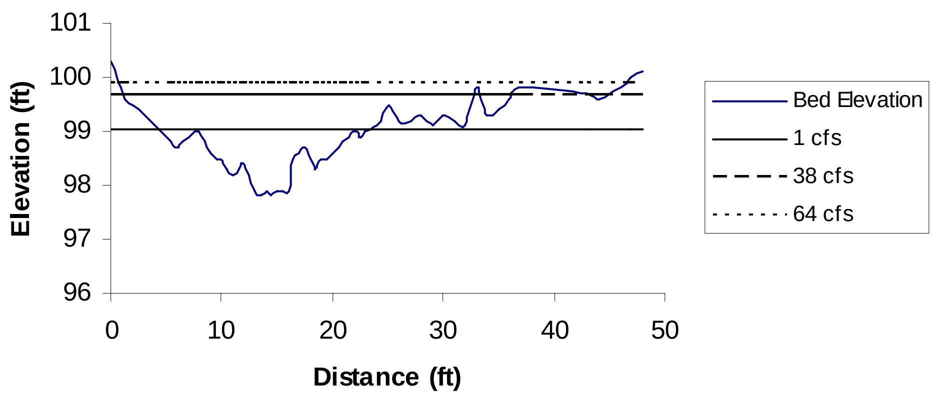

Emigrant Creek - Gun Club, Transect 1
Elevation (ft)
Distance (ft)
Bed Elevation
1 cfs
38 cfs
64 cfs


Emigrant Creek - Gun Club, Transect 2
Elevation (ft)
Distance (ft)
Bed Elevation
1 cfs
38 cfs
64 cfs

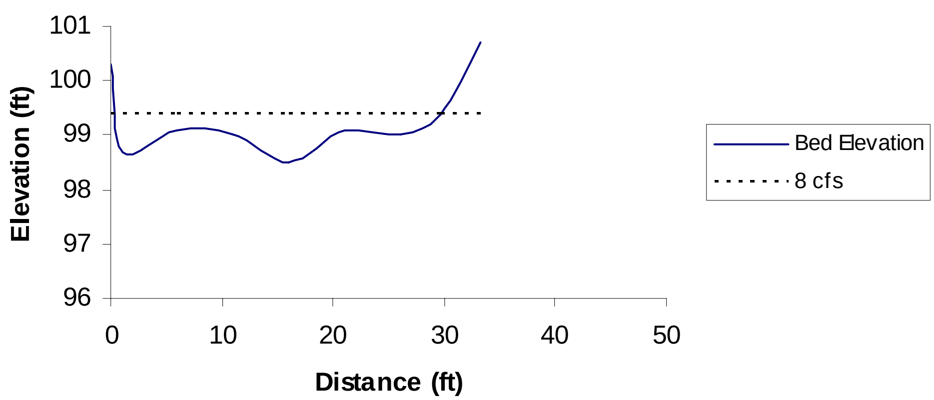
Emigrant Creek - Gun Club, Transect 3



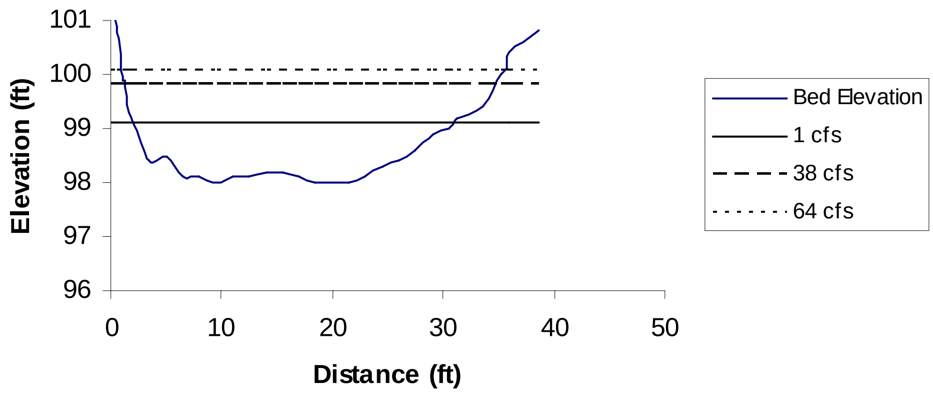
Emigrant Creek - Gun Club, Transect 4



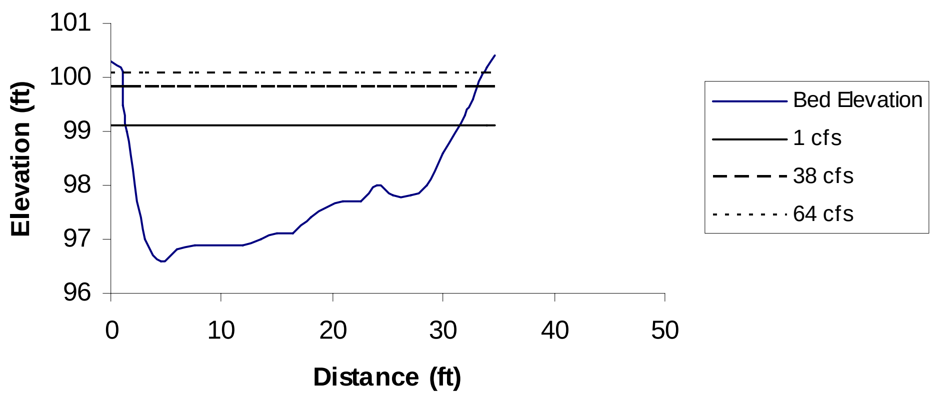
Emigrant Creek - Gun Club, Transect 5



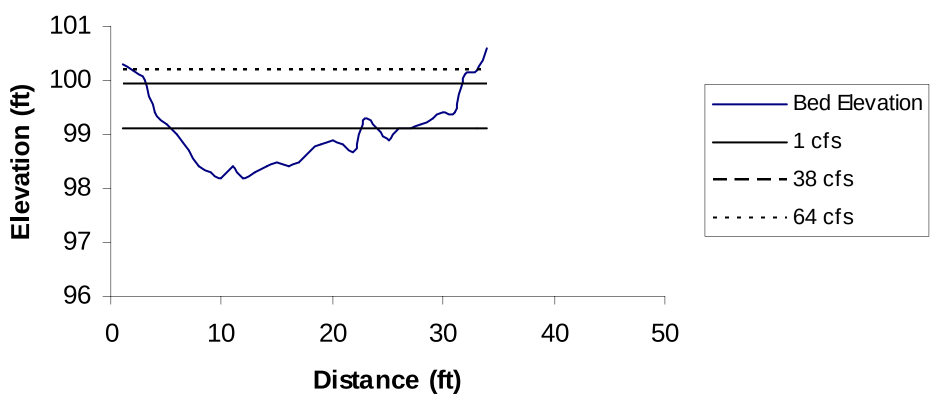
Emigrant Creek - Gun Club, Transect 6

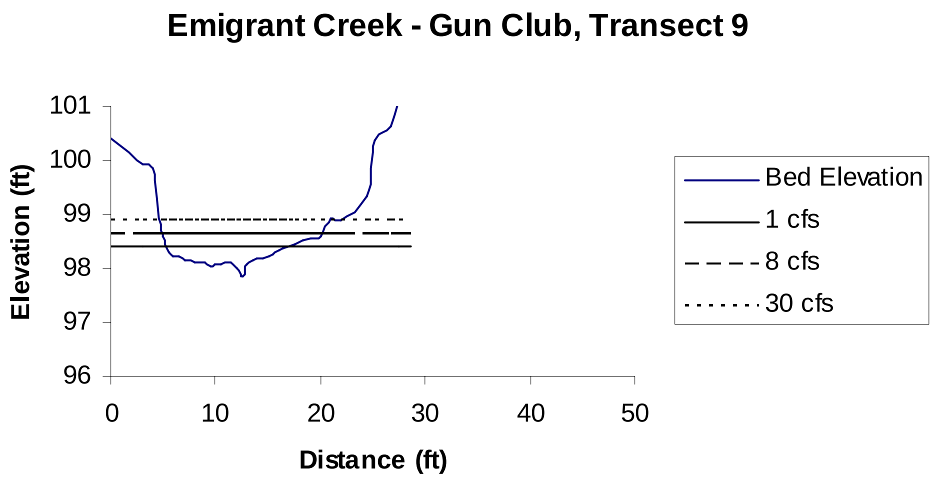


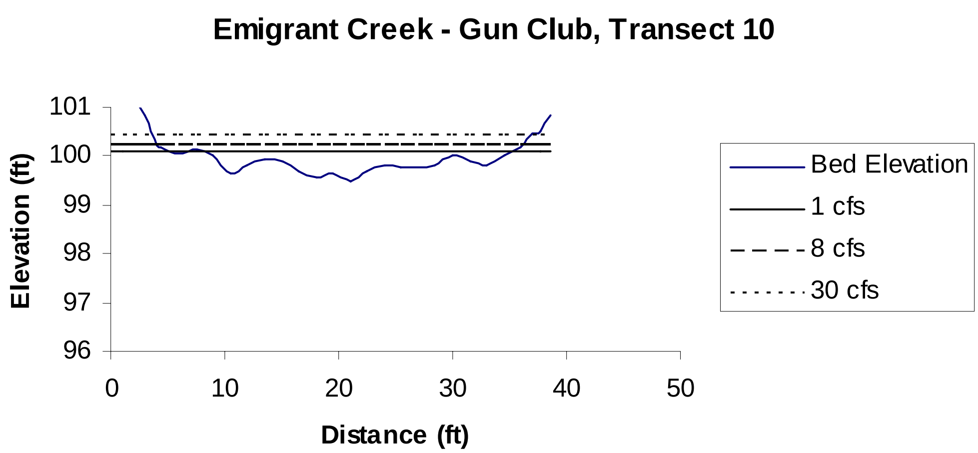
Emigrant Creek - Gun Club, Transect 7



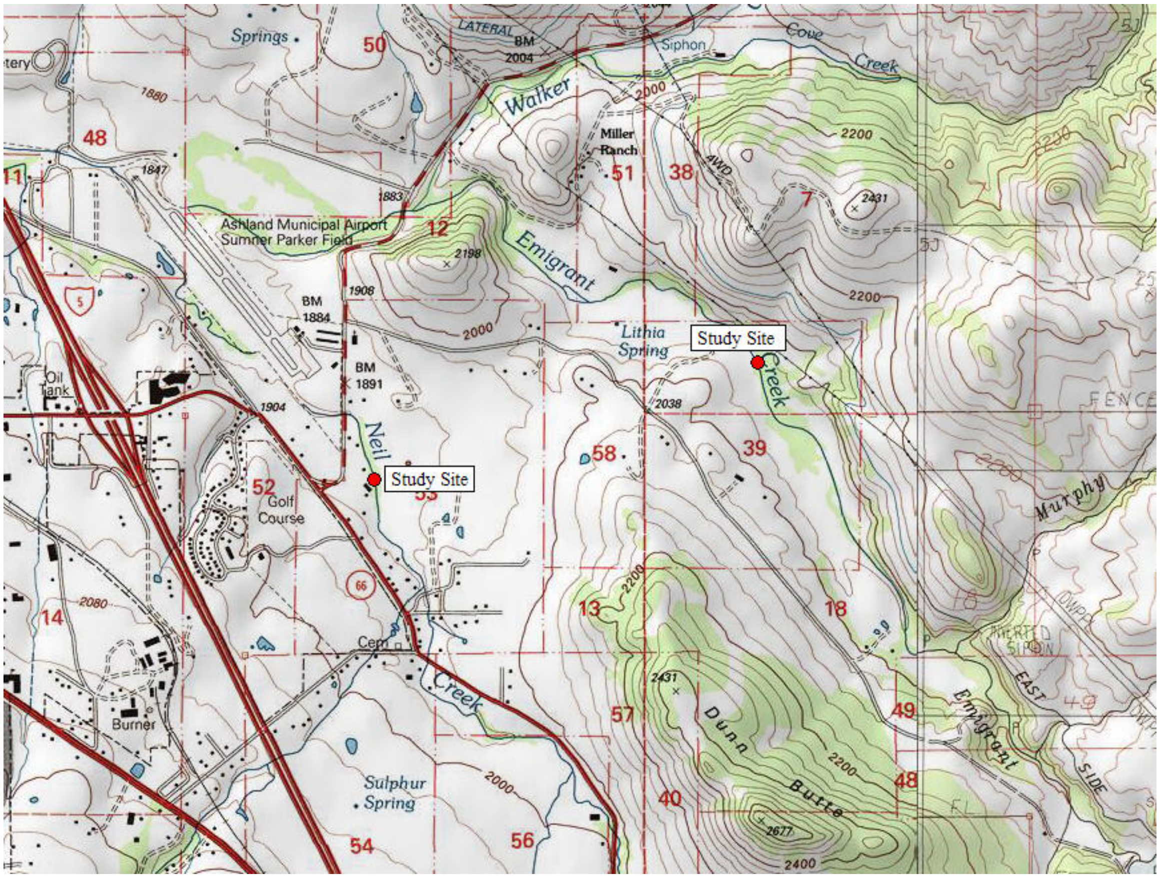
Emigrant Creek - Gun Club, Transect 8




Emigrant Creek - Gun Club, Transect 9
Elevation (ft)
101
100
99
98
97
96
0
10
20
30
40
50
Distance (ft)
Bed Elevation
1 cfs
8 cfs
30 cfs


Emigrant Creek - Gun Club, Transect 10
Elevation (ft)
101
100
99
98
97
96
0
10
20
30
40
50
Distance (ft)
Bed Elevation
1 cfs
8 cfs
30 cfs

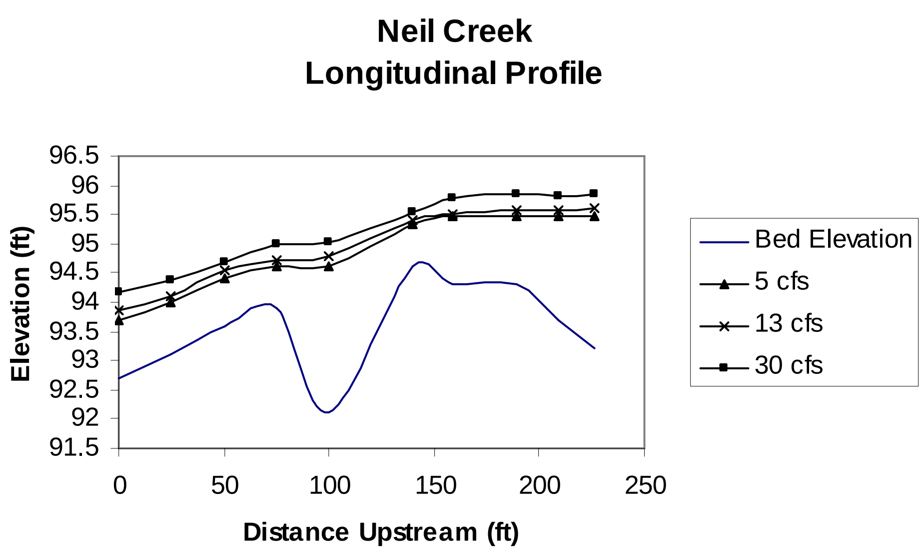
Neil Creek



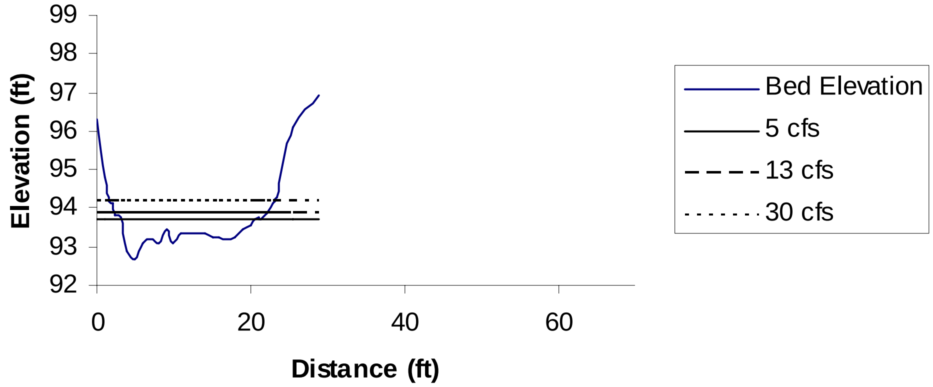
<u>Study Site</u> N42°10.961’ W122°39.174’
Transect 1 – glide (most downstream transect)
Transect 2 – riffle
Transect 3 – riffle (passage)
Transect 4 – hydraulic control
Transect 5 – pool
Transect 6 – riffle (passage)
Transect 7 – glide
Transect 8 – glide
Transect 9 - pool
Transect 10 - pool (most upstream transect)


T5
T4
T3
T2
T1

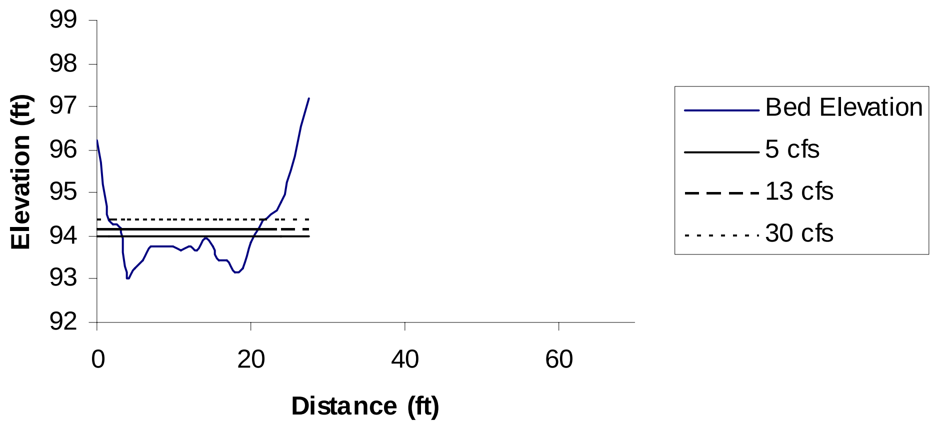

T6
T7
T8
T9
T10


Neil Creek
Longitudinal Profile
Elevation (ft)
96.5
96
95.5
95
94.5
94
93.5
93
92.5
92
91.5
0
50
100
150
200
250
Distance Upstream (ft)
Bed Elevation
5 cfs
13 cfs
30 cfs

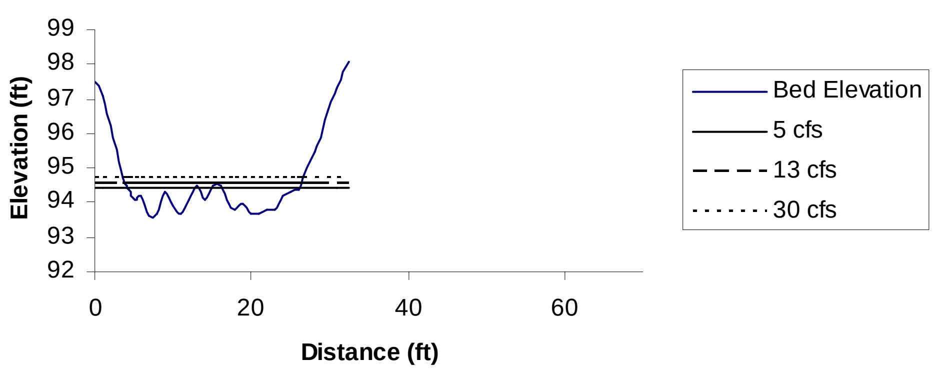
Neil Creek, Transect 1



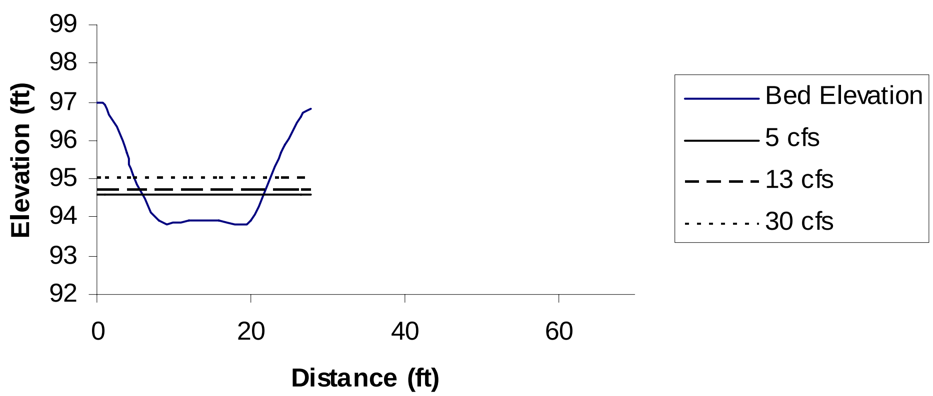
Neil Creek, Transect 2



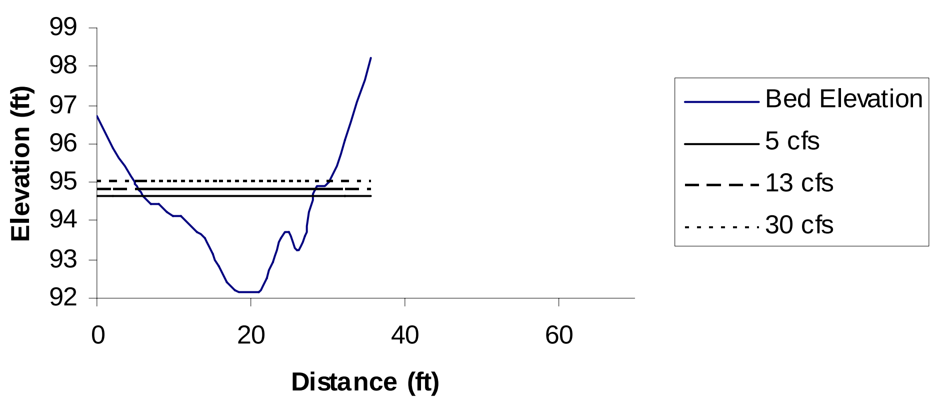
Neil Creek, Transect 3



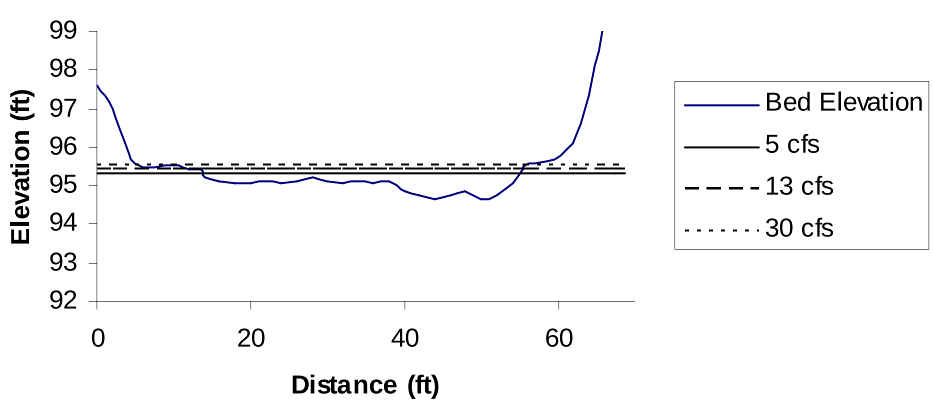
Neil Creek, Transect 4



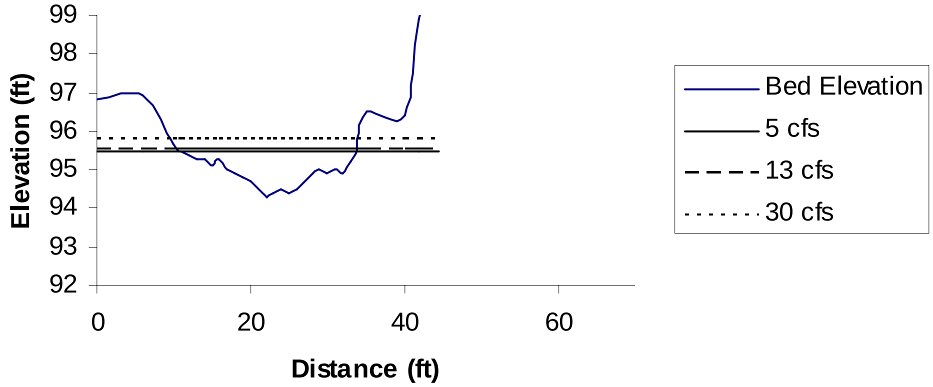
Neil Creek, Transect 5



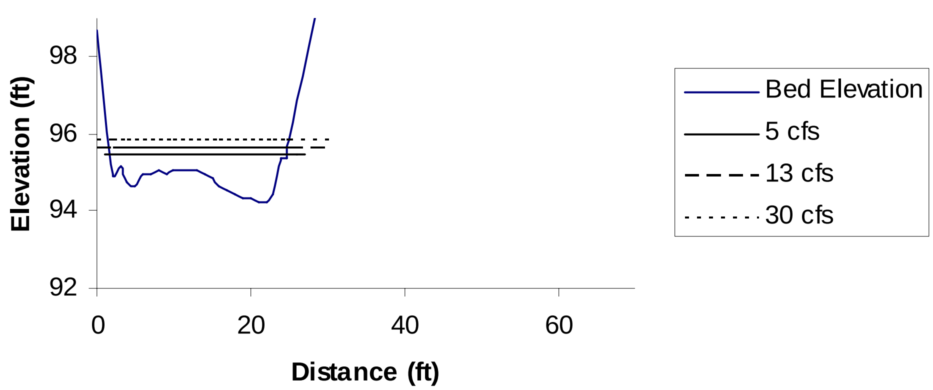
Neil Creek, Transect 6



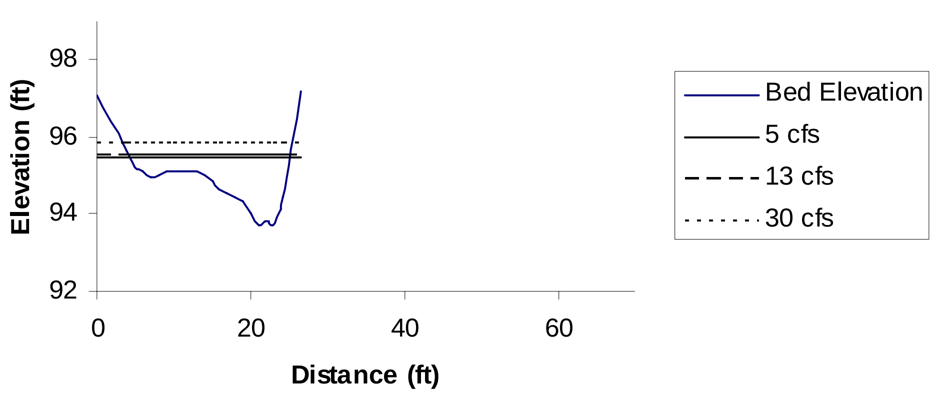
Neil Creek, Transect 7



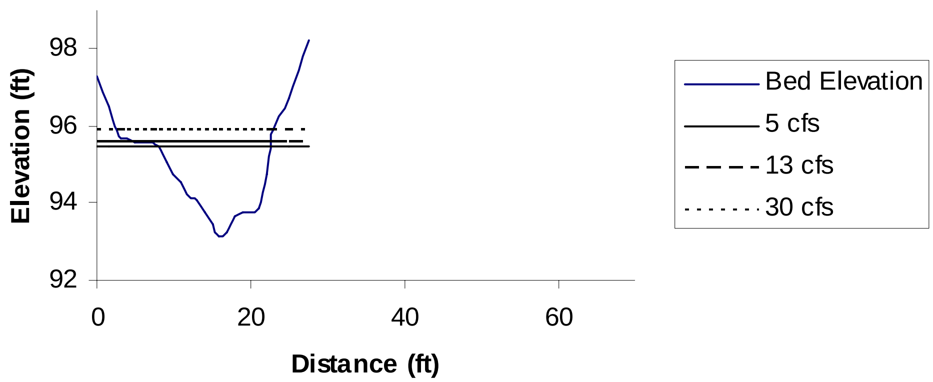
Neil Creek, Transect 8



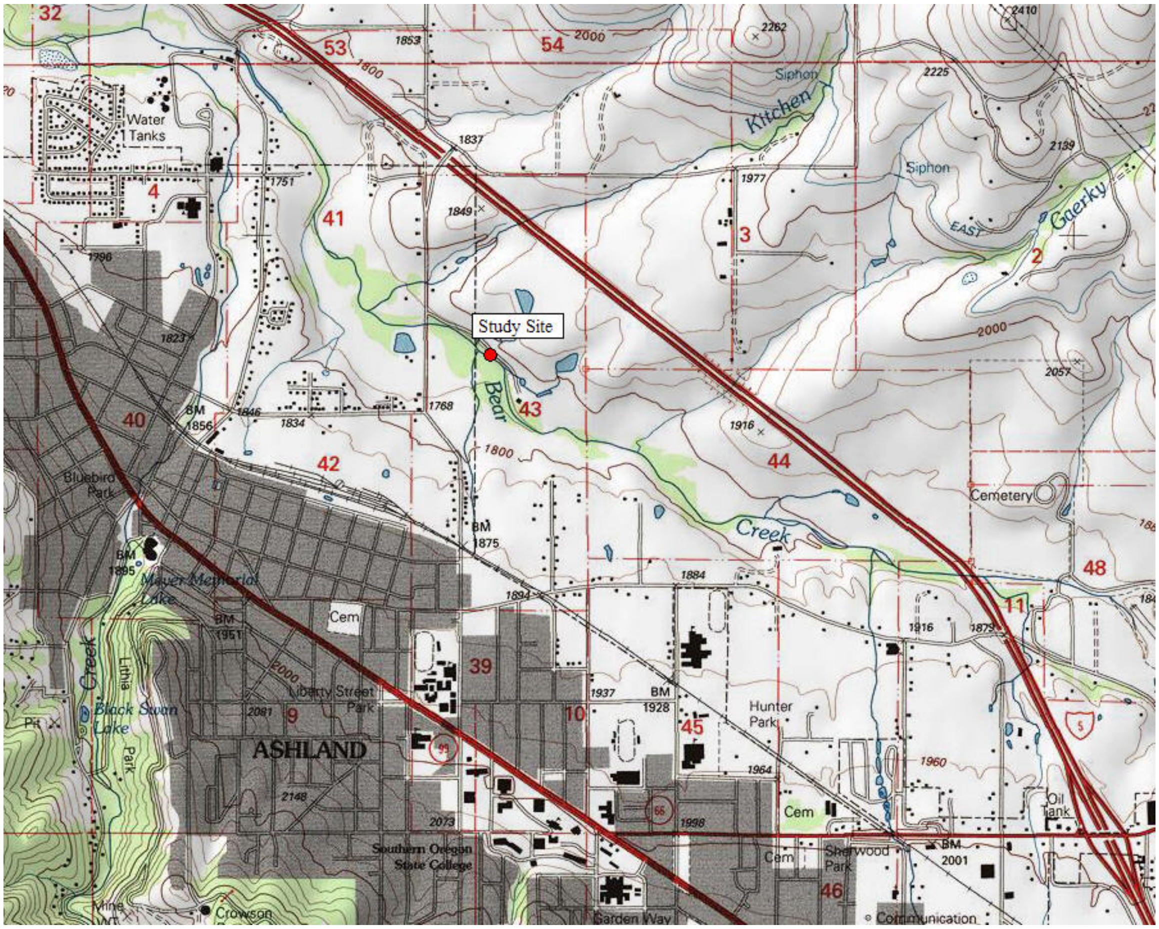
Neil Creek, Transect 9



Neil Creek, Transect 10



Bear Creek between Emigrant Creek and Oak Street Diversion

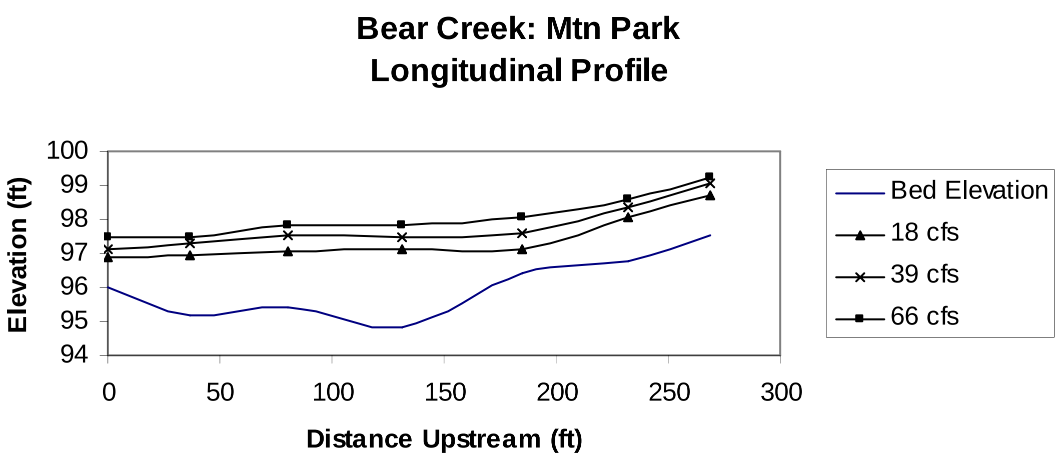


<u>Study Site</u> N42°12.251’ W122°41.828’
Transect 1 – hydraulic control/glide (most downstream transect)
Transect 2 – pool
Transect 3 – glide
Transect 4 – pool
Transect 5 – riffle (passage)
Transect 6 – riffle
Transect 7 – glide (most upstream transect)

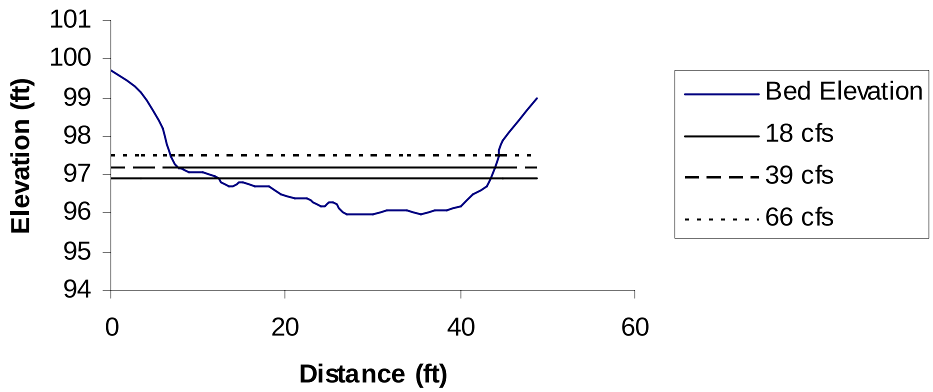

T2
T1


T3
T4
T5

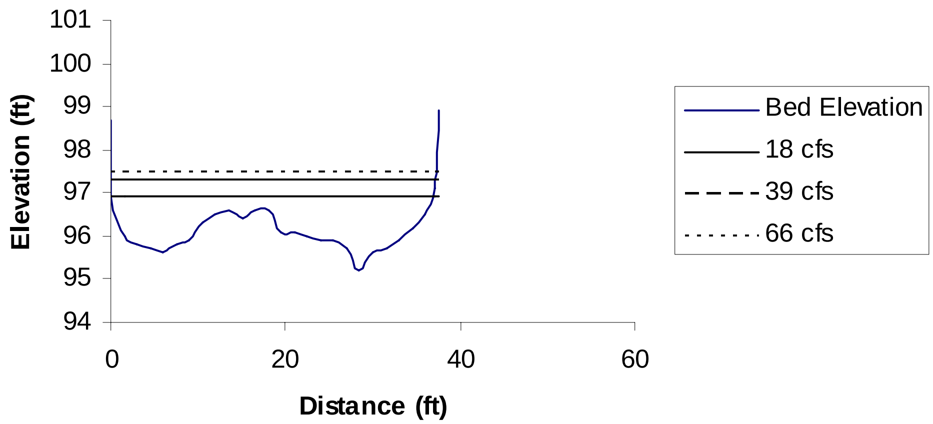

T6
T7


Bear Creek: Mtn Park
Longitudinal Profile
Elevation (ft)
100
99
98
97
96
95
94
0
50
100
150
200
250
300
Distance Upstream (ft)
Bed Elevation
18 cfs
39 cfs
66 cfs

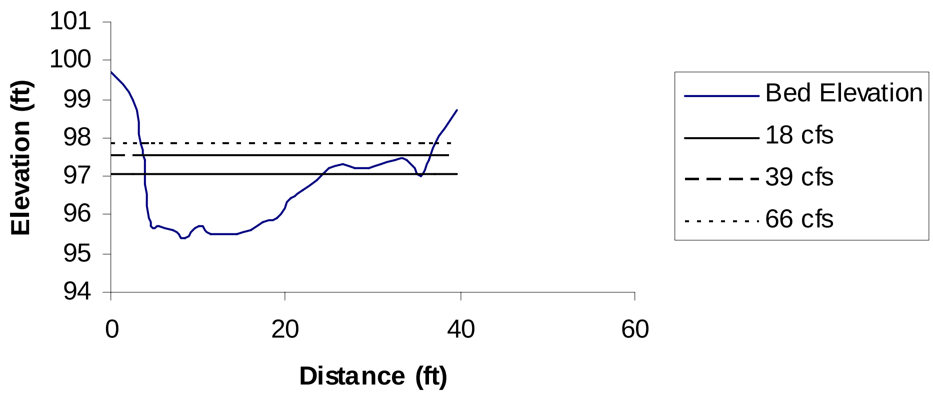
Bear Creek - Mtn Park, Transect 1

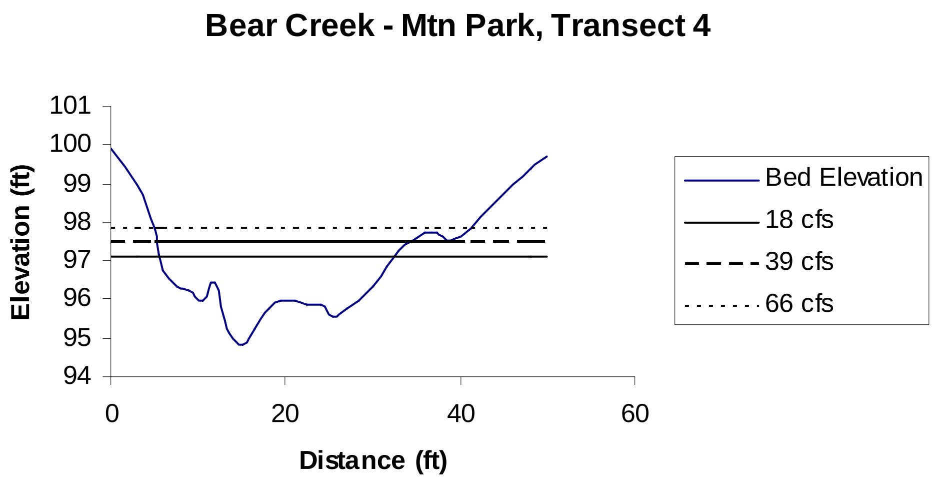


Bear Creek - Mtn Park, Transect 2

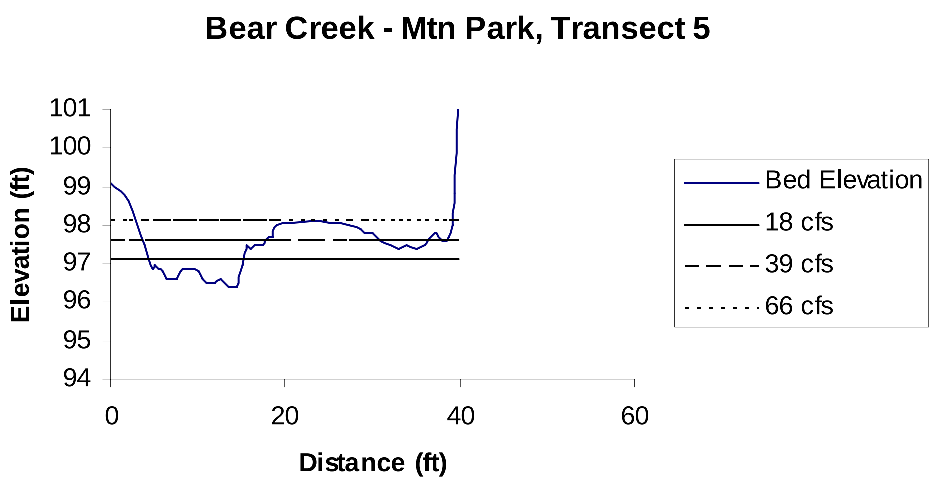


Bear Creek - Mtn Park, Transect 3

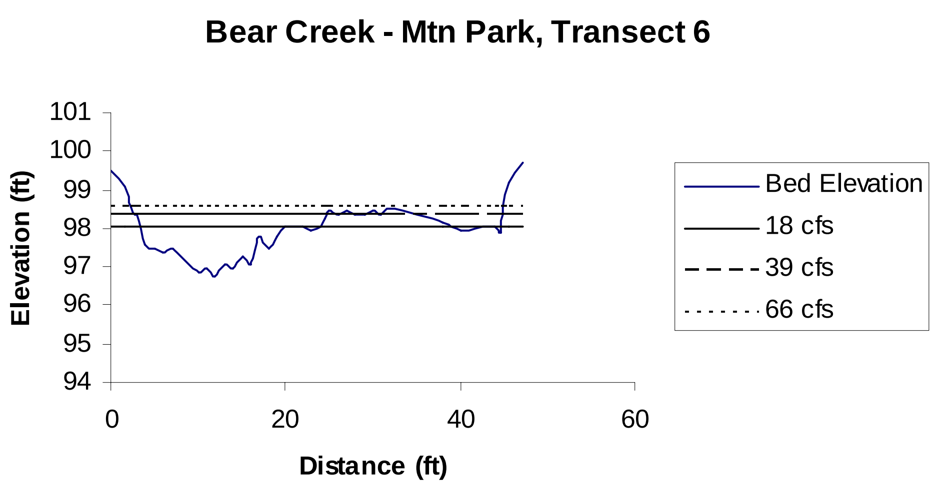




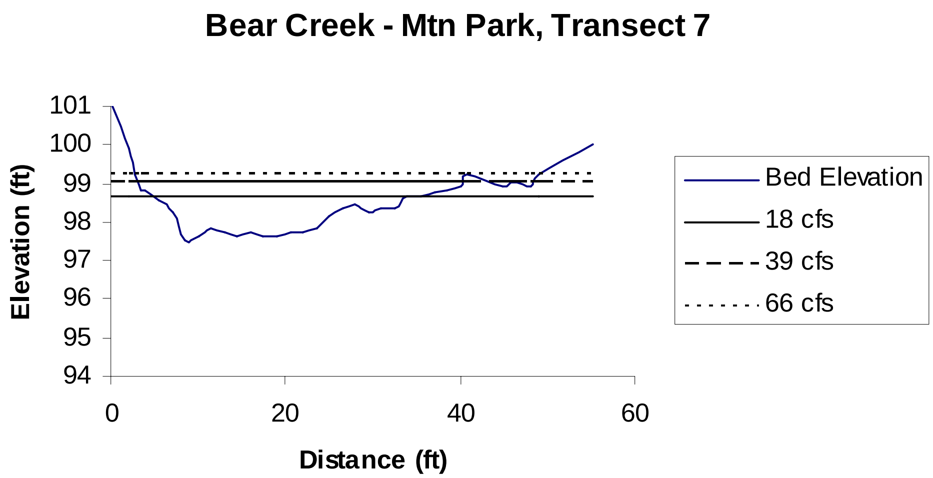
Bear Creek - Mtn Park, Transect 4
Elevation (ft)
101
100
99
98
97
96
95
94
0
20
40
60
Distance (ft)
Bed Elevation
18 cfs
39 cfs
66 cfs



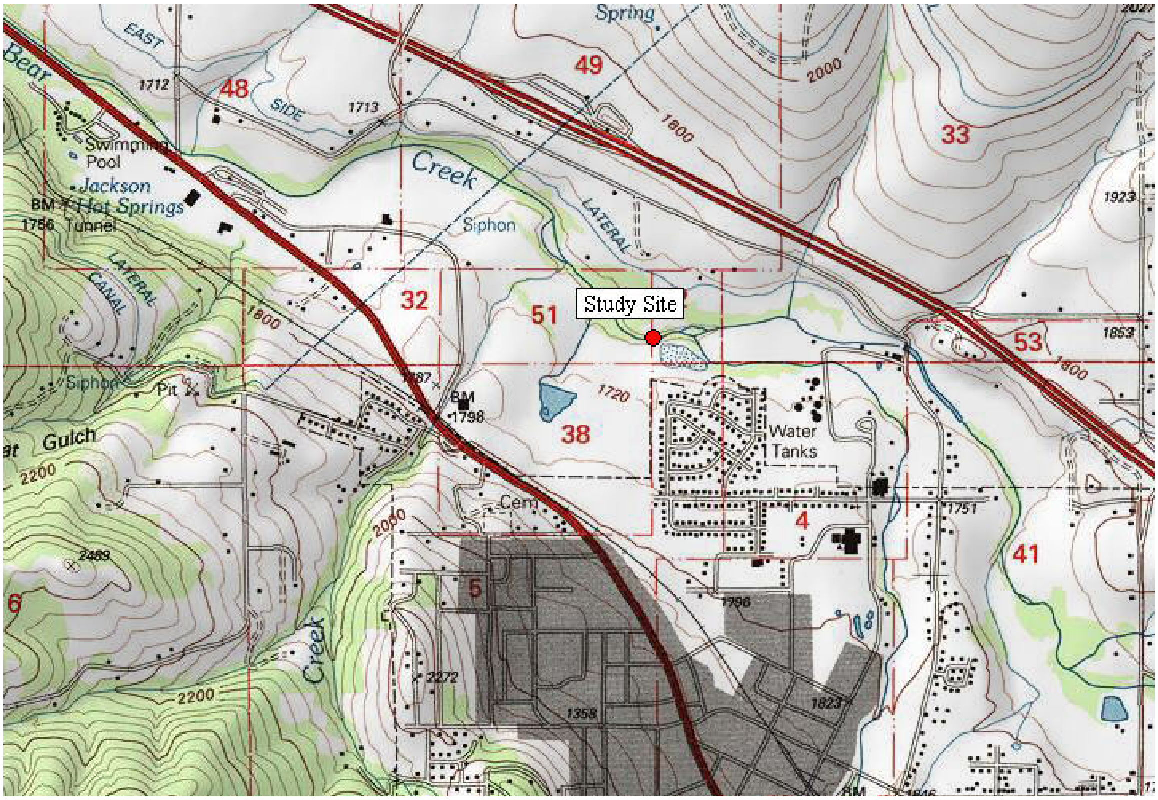
Bear Creek - Mtn Park, Transect 5
Elevation (ft)
101
100
99
98
97
96
95
94
0
20
40
60
Distance (ft)
Bed Elevation
18 cfs
39 cfs
66 cfs



Bear Creek - Mtn Park, Transect 6
Elevation (ft)
101
100
99
98
97
96
95
94
0
20
40
60
Distance (ft)
Bed Elevation
18 cfs
39 cfs
66 cfs

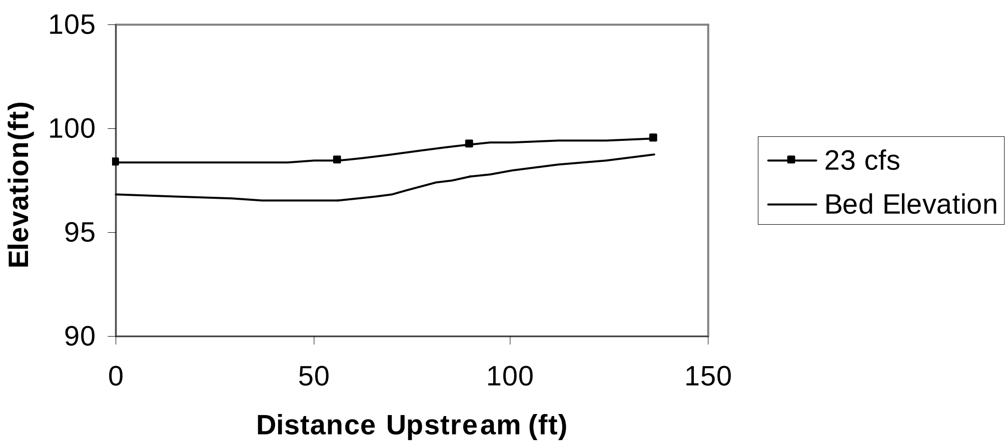

Bear Creek - Mtn Park, Transect 7
Elevation (ft)
101
100
99
98
97
96
95
94
0
20
40
60
Distance (ft)
Bed Elevation
18 cfs
39 cfs
66 cfs

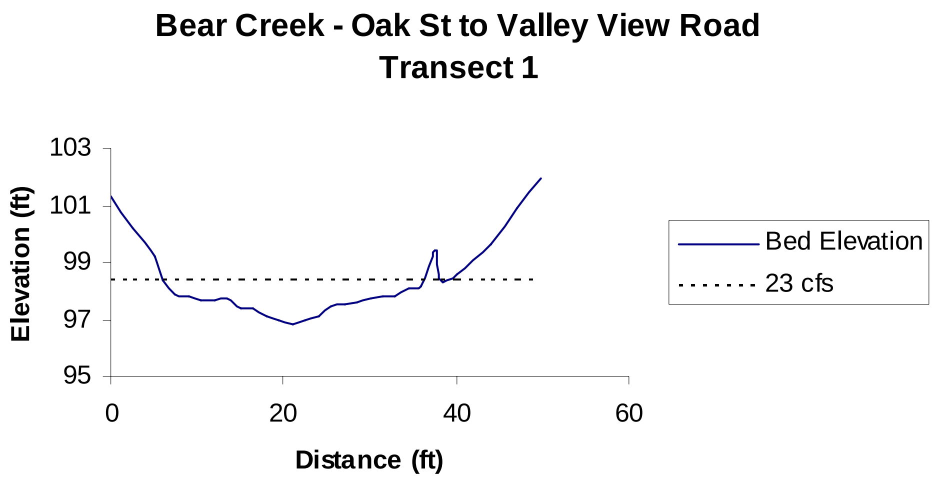
Bear Creek between Oak Street Diversion and Valley View Road

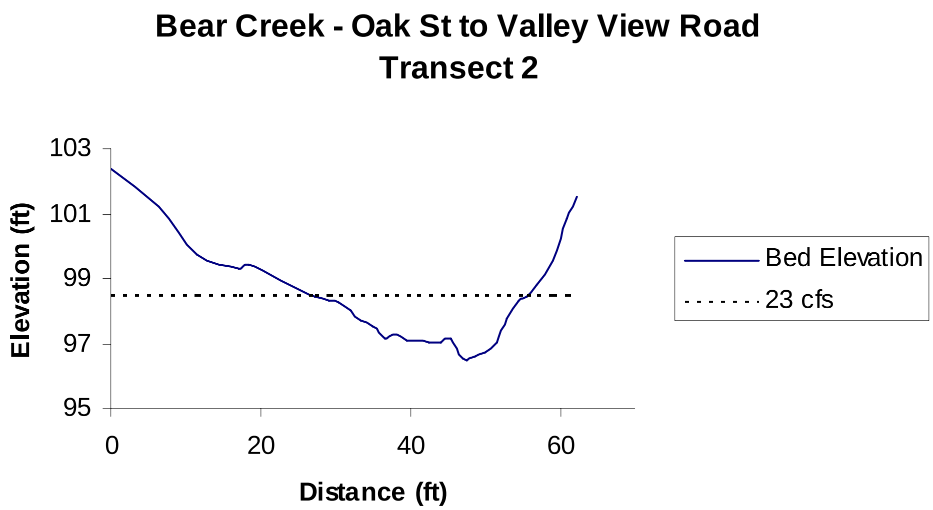


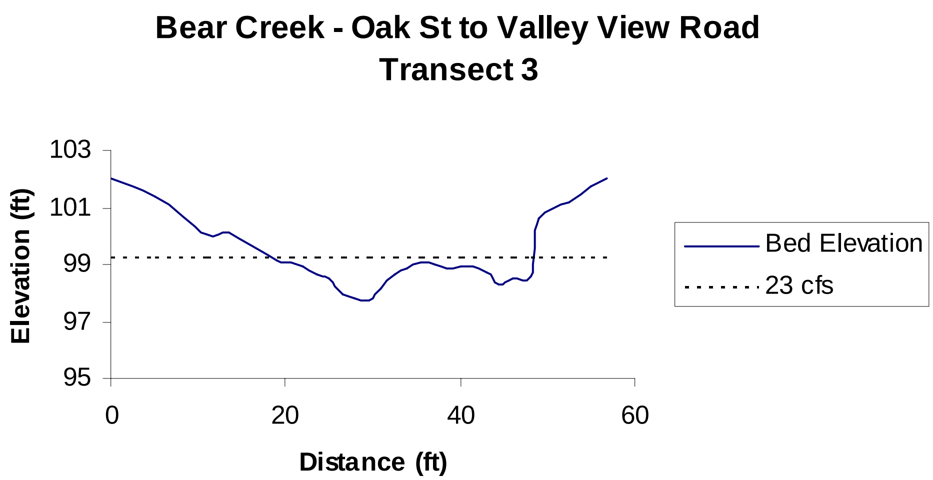
Study Site N42°12.926’ W122°43.256’
Transect 1 – glide (most downstream transect)
Transect 2 – glide
Transect 3 – riffle
Transect 4 – riffle (passage) (most upstream transect)

Bear Creek - Oak St to Valley View Road
Longitudinal Profile

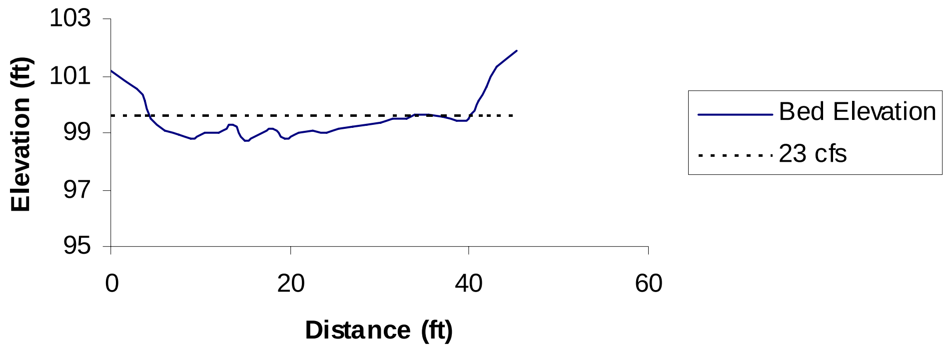



Bear Creek - Oak St to Valley View Road
Transect 1
103
101
99
97
95
Elevation (ft)
0
20
40
60
Distance (ft)
Bed Elevation
23 cfs

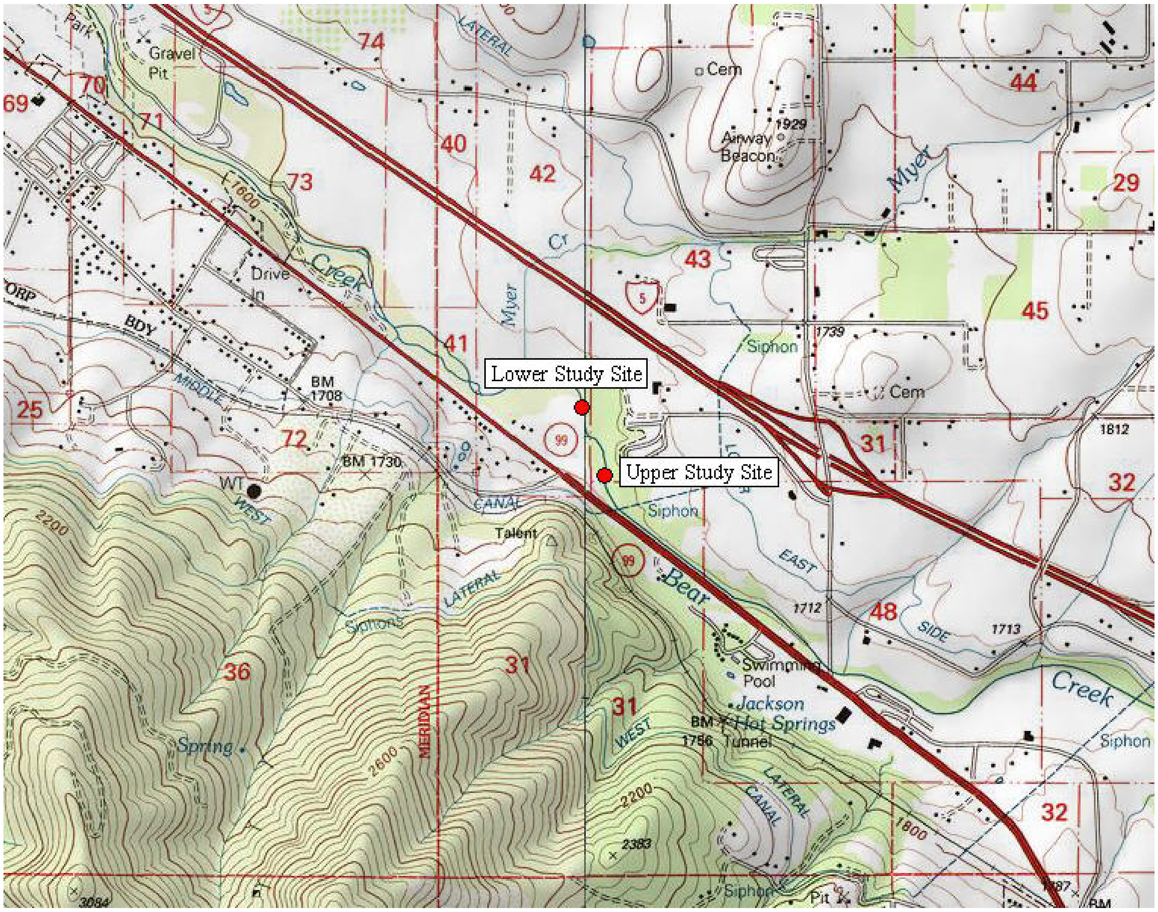

Bear Creek - Oak St to Valley View Road
Transect 2
103
101
99
97
95
Elevation (ft)
0
20
40
60
Distance (ft)
Bed Elevation
23 cfs


Bear Creek - Oak St to Valley View Road
Transect 3
103
101
99
97
95
Elevation (ft)
0
20
40
60
Distance (ft)
Bed Elevation
23 cfs

Bear Creek - Oak St to Valley View Road
Transect 4



Bear Creek between Valley View Road and Phoenix Diversion



<u>Study Site</u>
Lower study site: N42°13.777' W122°45.077'
Transect 1 – riffle (most downstream transect)
Transect 2 – hydraulic control
Transect 3 – pool
Transect 4 – pool
Transect 5 – pool
Transect 6 – glide
Transect 7 – glide/hydraulic control (passage)
Transect 8 – pool
Transect 9 - riffle
Transect 10 – glide (most upstream transect)

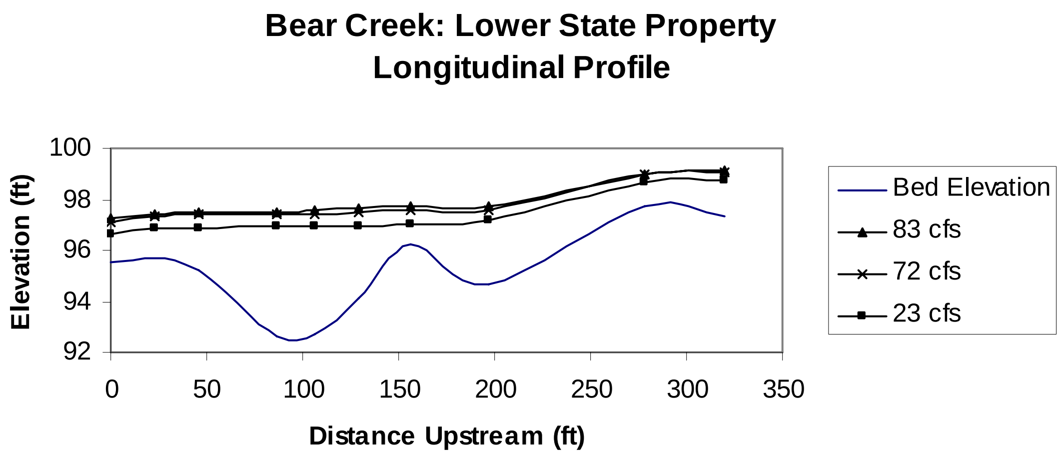
Upper study site: N42°13.658' W122°45.031'
Transect 11 – riffle (most downstream transect)
Transect 12 – riffle
Transect 13 – riffle (most upstream transect)

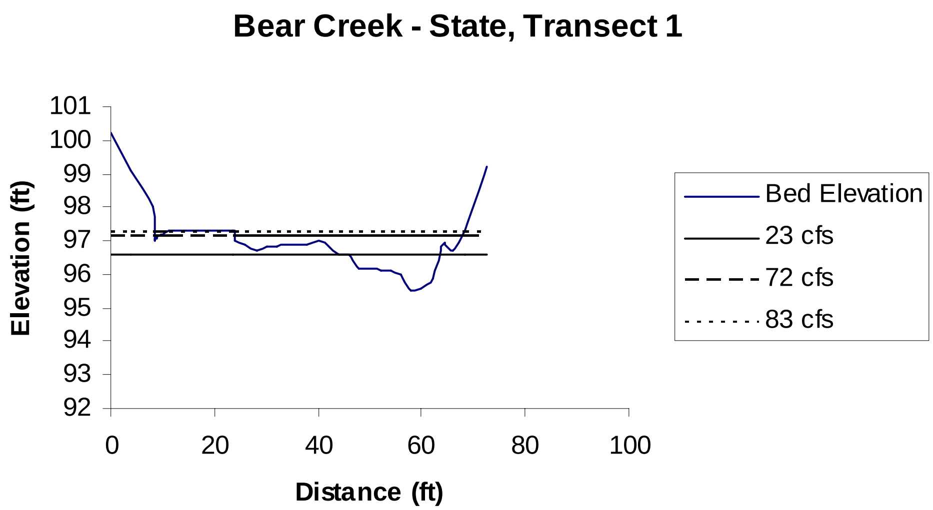

T5
T4
T3
T2
T1

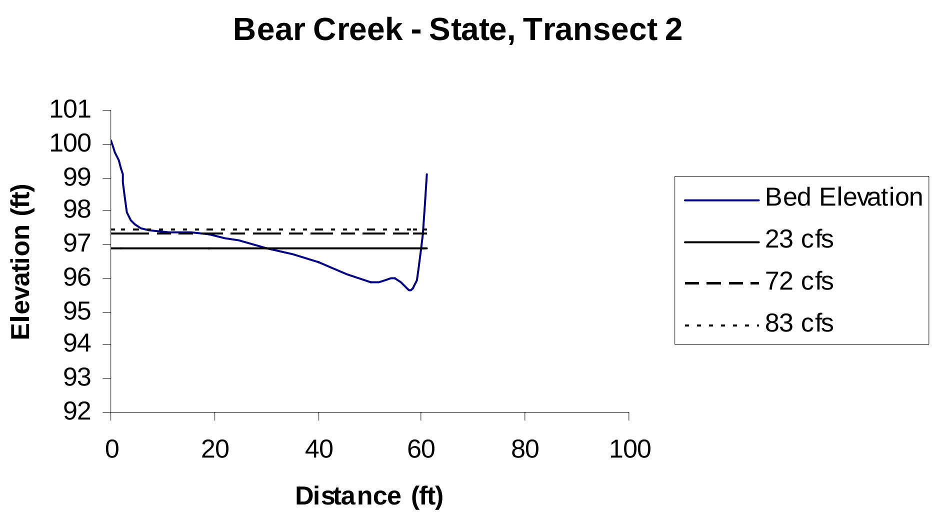

T6
T7
T8


T9
T10

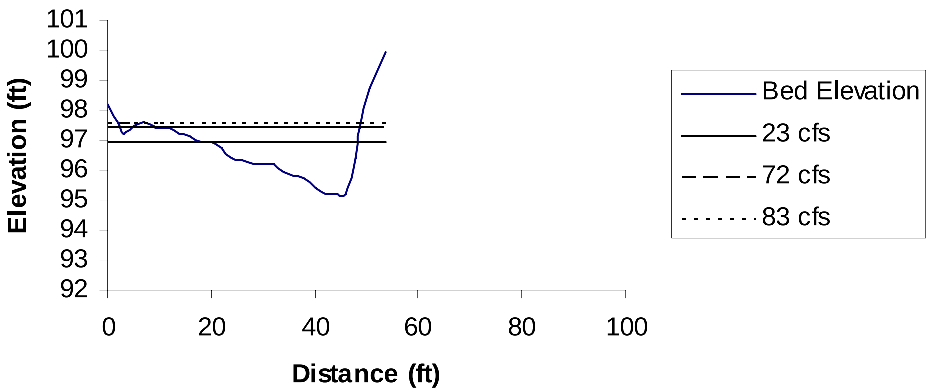

T13
T12
T11


Bear Creek: Lower State Property
Longitudinal Profile
Elevation (ft)
100
98
96
94
92
0
50
100
150
200
250
300
350
Distance Upstream (ft)
Bed Elevation
83 cfs
72 cfs
23 cfs

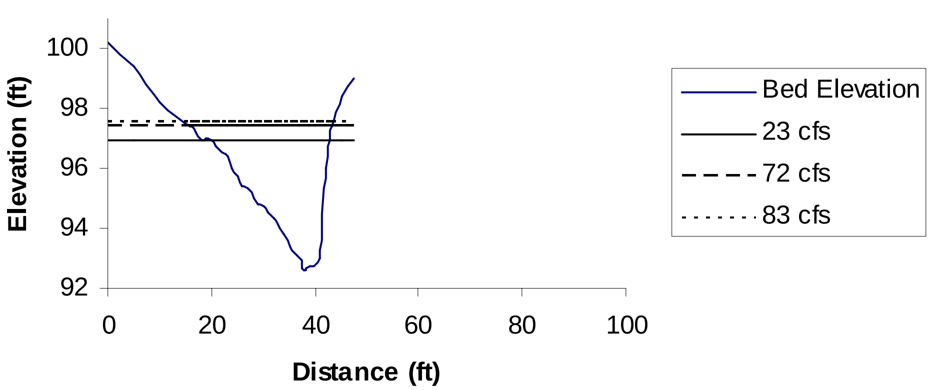

Bear Creek - State, Transect 1
Elevation (ft)
101
100
99
98
97
96
95
94
93
92
0
20
40
60
80
100
Distance (ft)
Bed Elevation
23 cfs
72 cfs
83 cfs


Bear Creek - State, Transect 2
Elevation (ft)
101
100
99
98
97
96
95
94
93
92
0
20
40
60
80
100
Distance (ft)
Bed Elevation
23 cfs
72 cfs
83 cfs

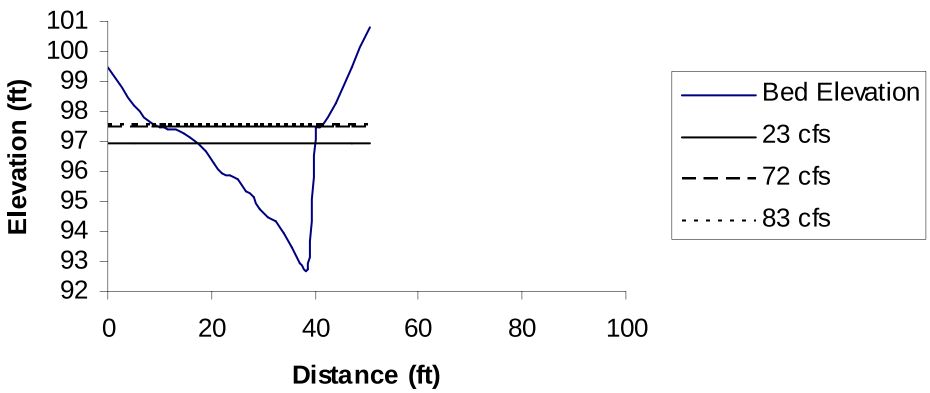
Bear Creek - State, Transect 3



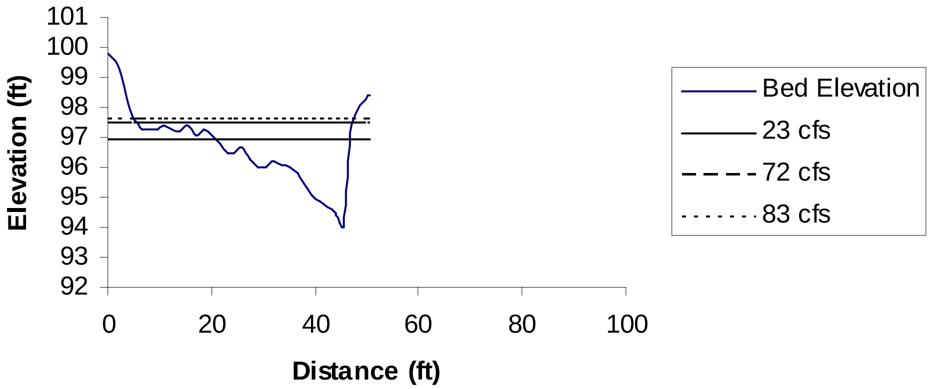
Bear Creek - State, Transect 4



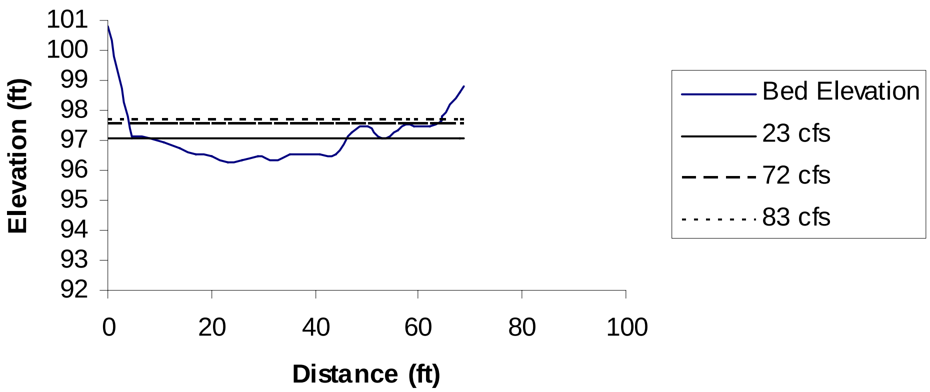
Bear Creek - State, Transect 5



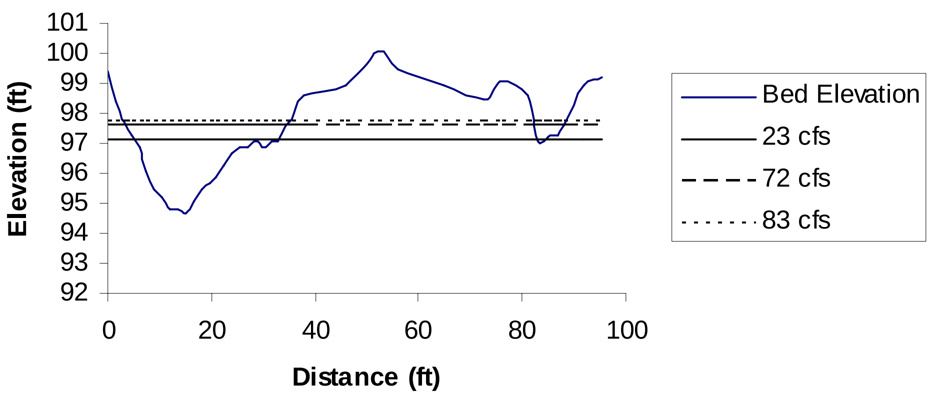
Bear Creek - State, Transect 6

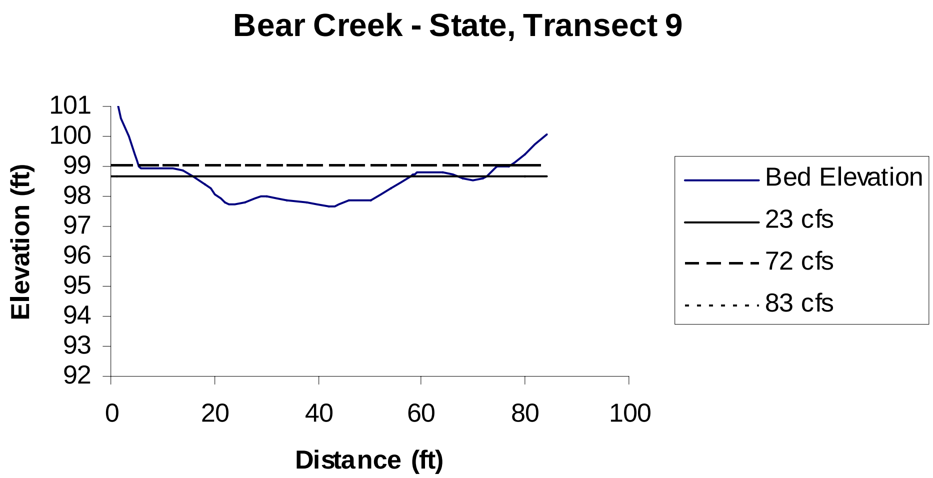


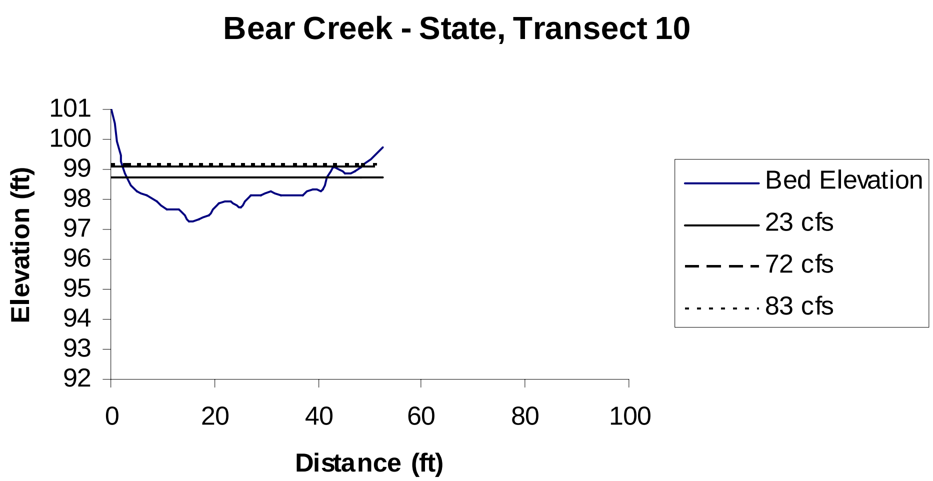
Bear Creek - State, Transect 7

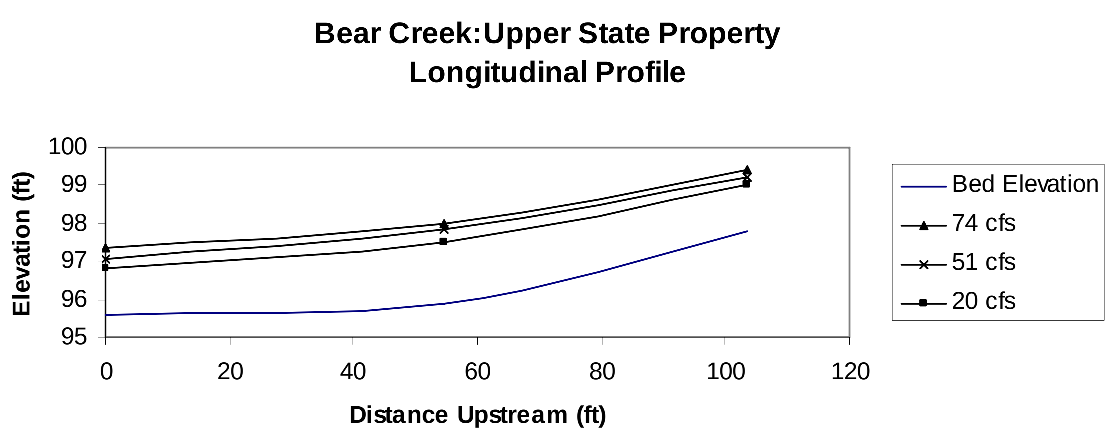


Bear Creek - State, Transect 8

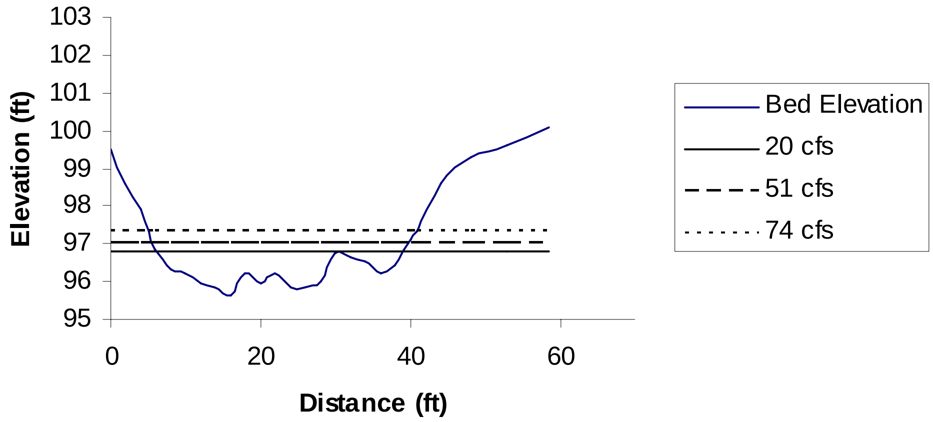



Bear Creek - State, Transect 9
Elevation (ft)
101
100
99
98
97
96
95
94
93
92
0
20
40
60
80
100
Distance (ft)
Bed Elevation
23 cfs
72 cfs
83 cfs

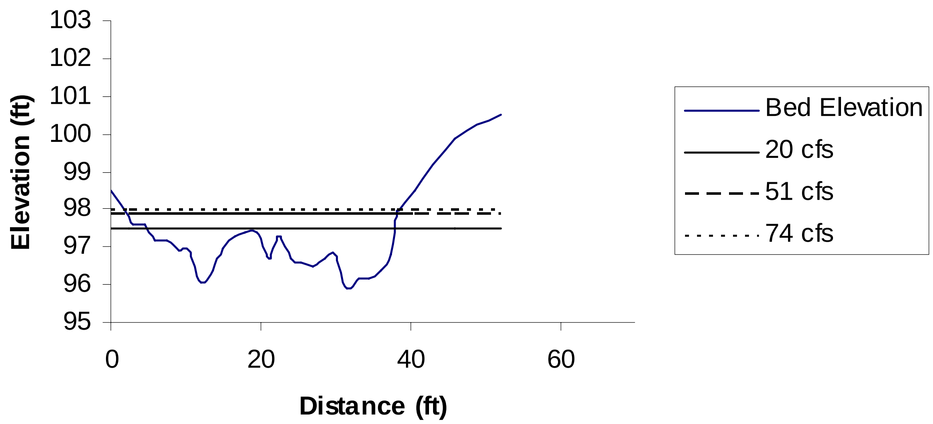

Bear Creek - State, Transect 10
Elevation (ft)
101
100
99
98
97
96
95
94
93
92
0
20
40
60
80
100
Distance (ft)
Bed Elevation
23 cfs
72 cfs
83 cfs


Bear Creek:Upper State Property
Longitudinal Profile
Elevation (ft)
100
99
98
97
96
95
0
20
40
60
80
100
120
Distance Upstream (ft)
Bed Elevation
74 cfs
51 cfs
20 cfs

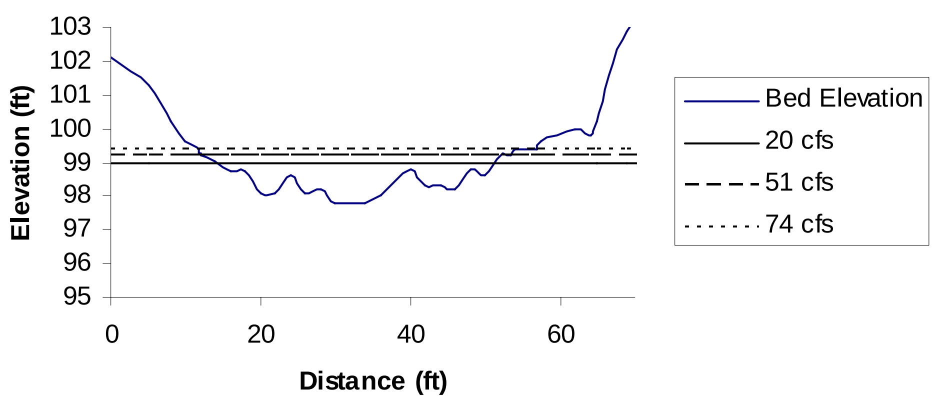
Bear Creek - State-upper site, Transect 11



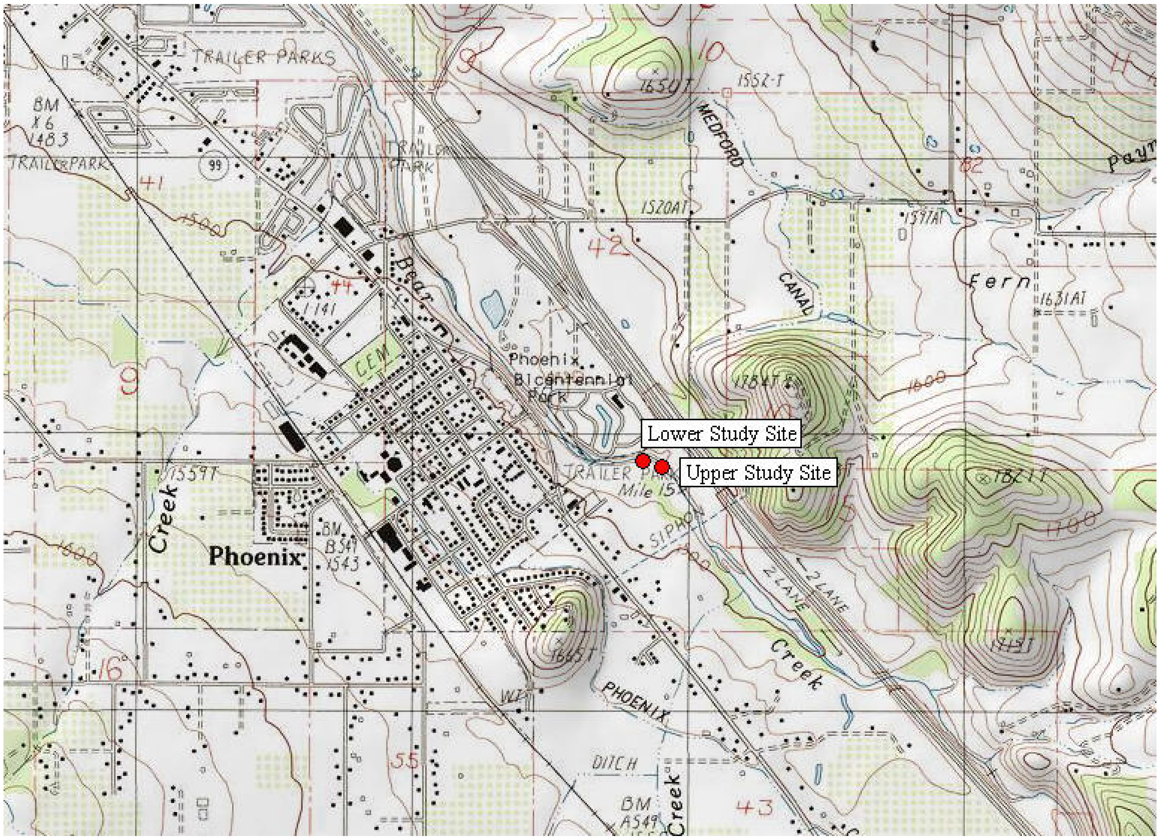
Bear Creek - State-upper site, Transect 12



Bear Creek - State-upper site, Transect 13



Bear Creek between Phoenix Diversion and Jackson Street Diversion



<u>Study Site</u>

Lower study site: N42°16.382’ W°122°48.546’
Transect 1 – hydraulic control (most downstream transect)
Transect 2 – pool
Transect 3 – pool
Transect 4 – pool
Transect 5 – pool
Transect 6 – pool
Transect 7 – glide
Transect 8 – glide (most upstream transect)

Upper study site: N42°16.373’ W122°48.500’
Transect 9 – riffle (most downstream transect)
Transect 10 – glide
Transect 11 – glide
Transect 12 – glide
Transect 13 – glide
Transect 14 – riffle (passage)
Transect 15 – glide/hydraulic control
Transect 16 – pool (most upstream transect)

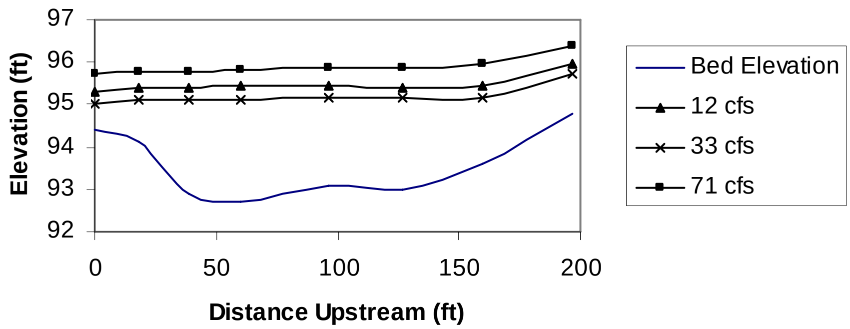

T4
T3
T2
T1


T8
T7
T6
T5

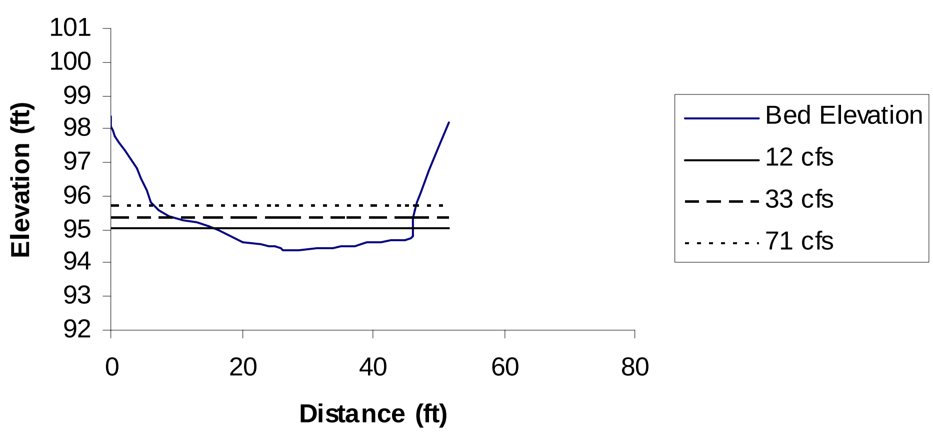

T13
T12
T11
T10
T9


T14
T15
T16

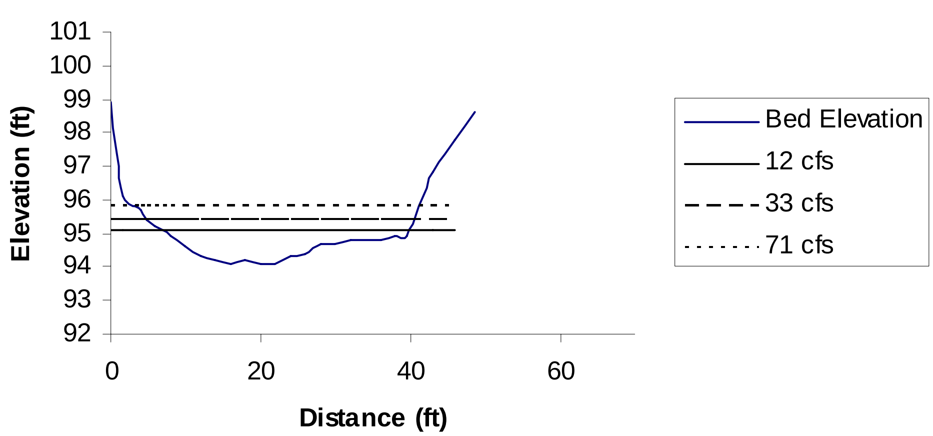
Bear Creek: Lower Heron Park Longitudinal Profile



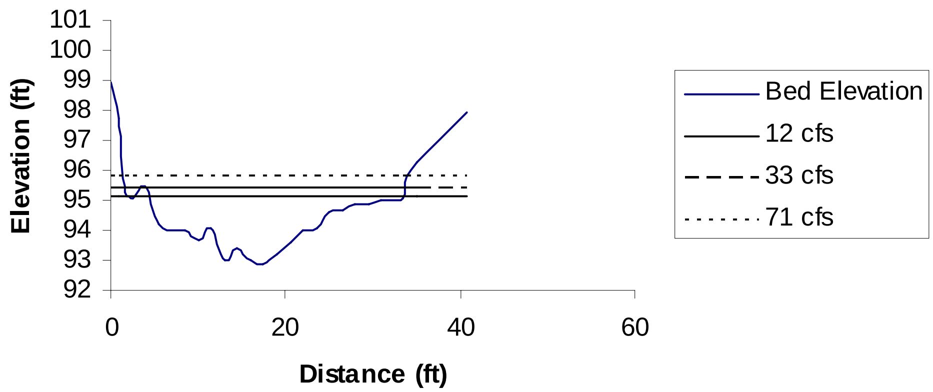
Bear Creek - Heron Park-lower site, Transect 1



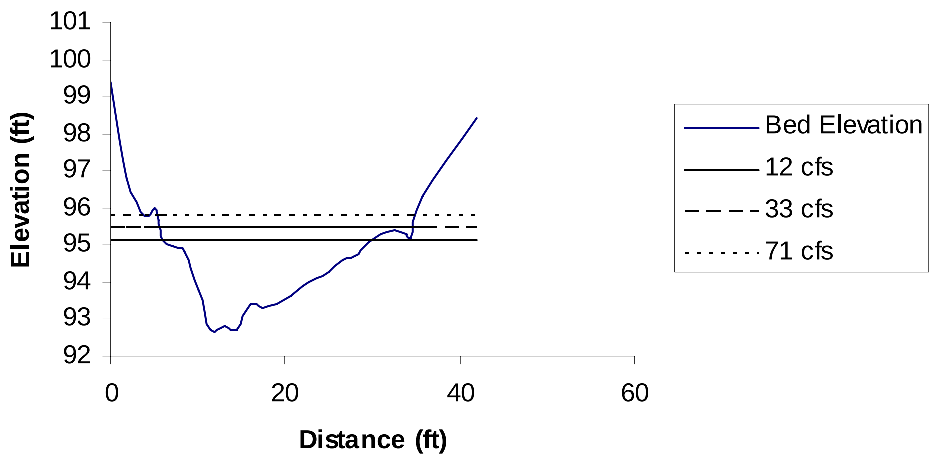
Bear Creek - Heron Park-lower site, Transect 2



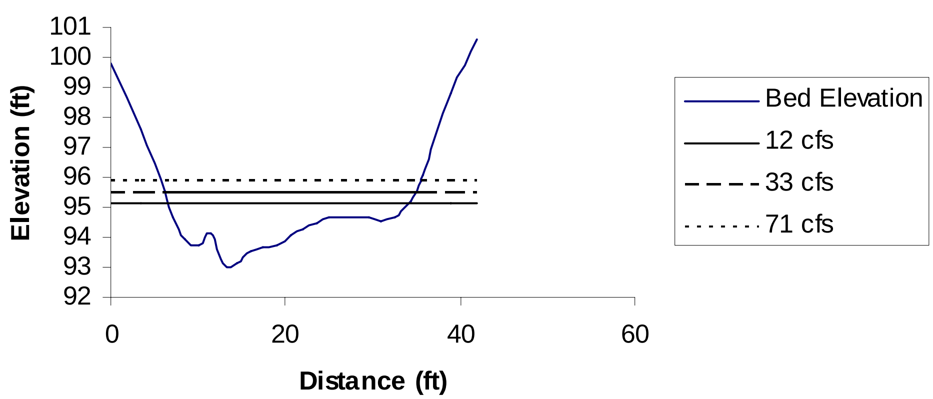
Bear Creek - Heron Park-lower site, Transect 3



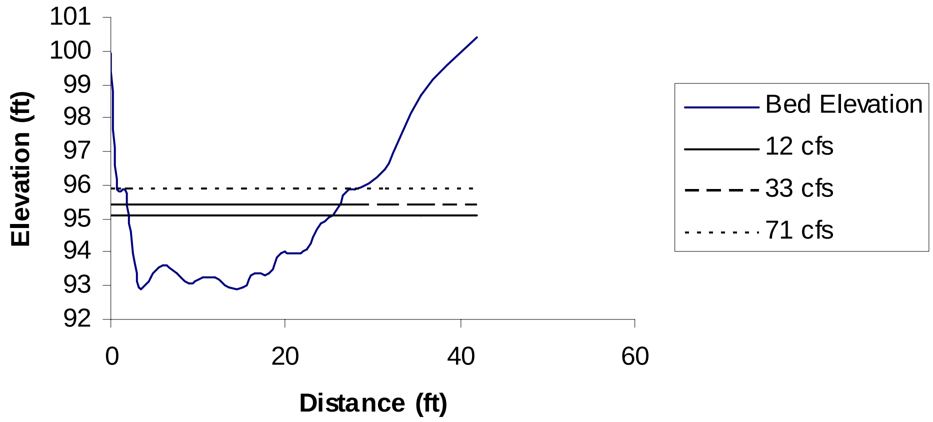
Bear Creek - Heron Park-lower site, Transect 4



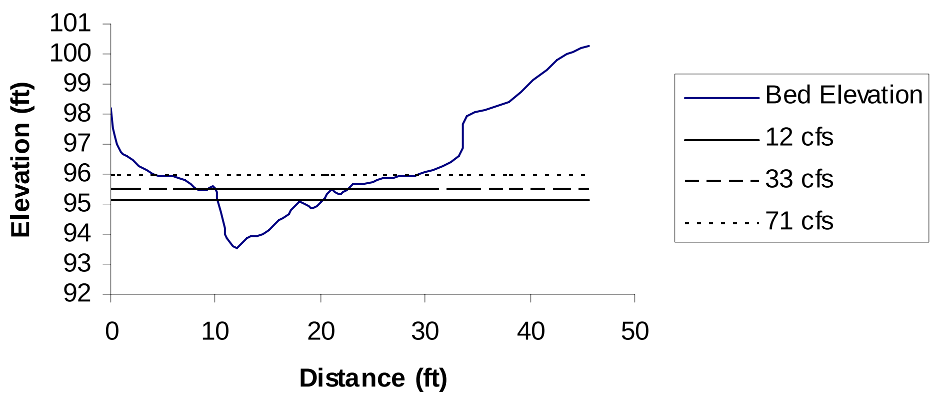
Bear Creek - Heron Park-lower site, Transect 5



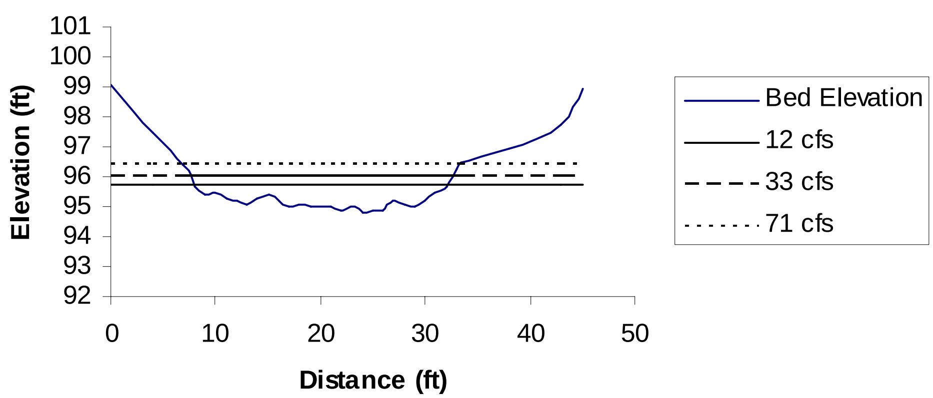
Bear Creek - Heron Park-lower site, Transect 6



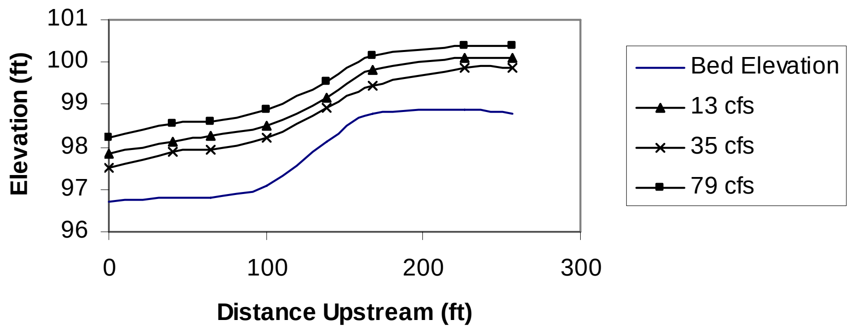
Bear Creek - Heron Park-lower site, Transect 7



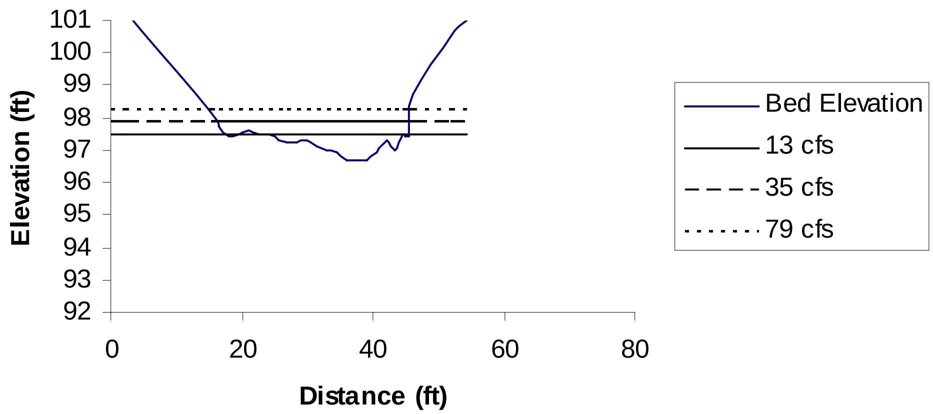
Bear Creek - Heron Park-lower site, Transect 8



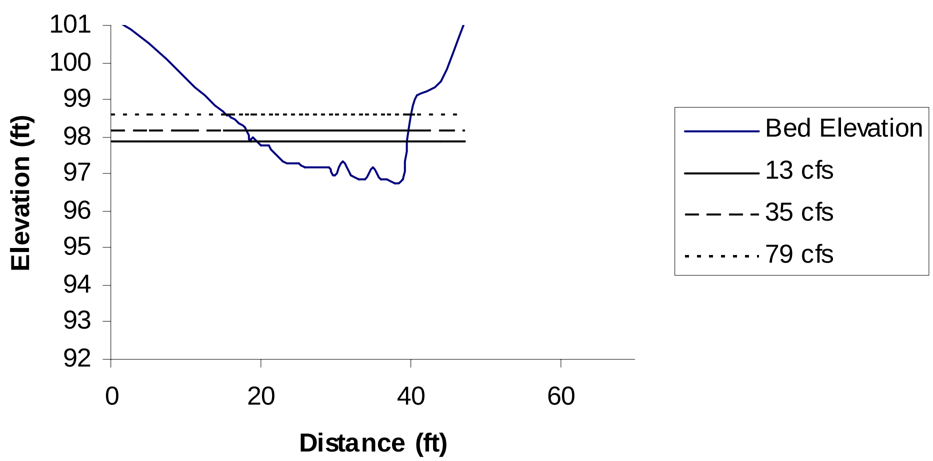
Bear Creek: Upper Heron Park Longitudinal Profile



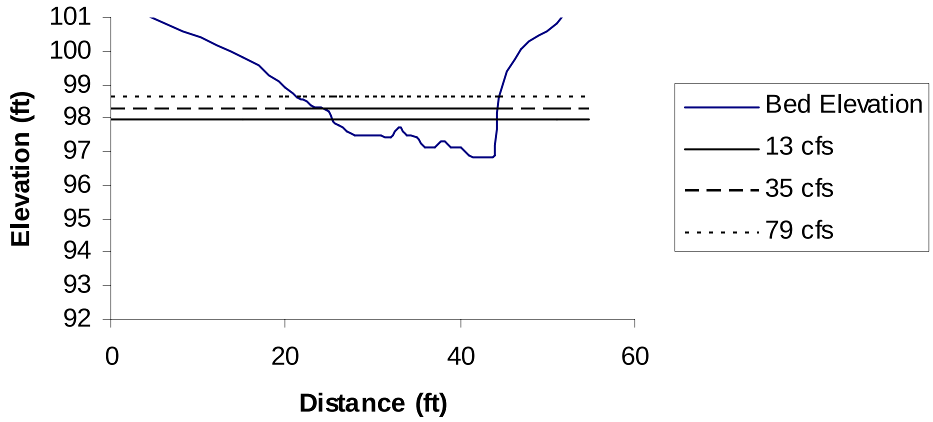
Bear Creek - Heron Park-upper site, Transect 9



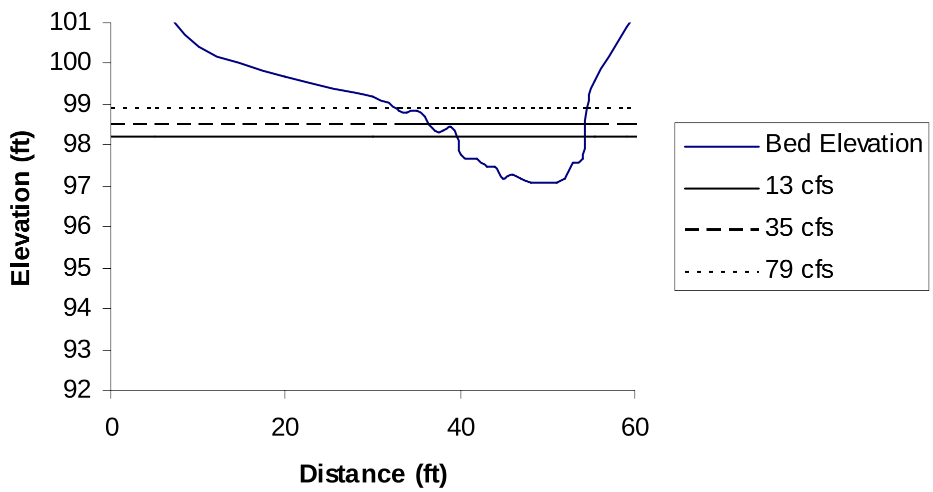
Bear Creek - Heron Park-upper site, Transect 10



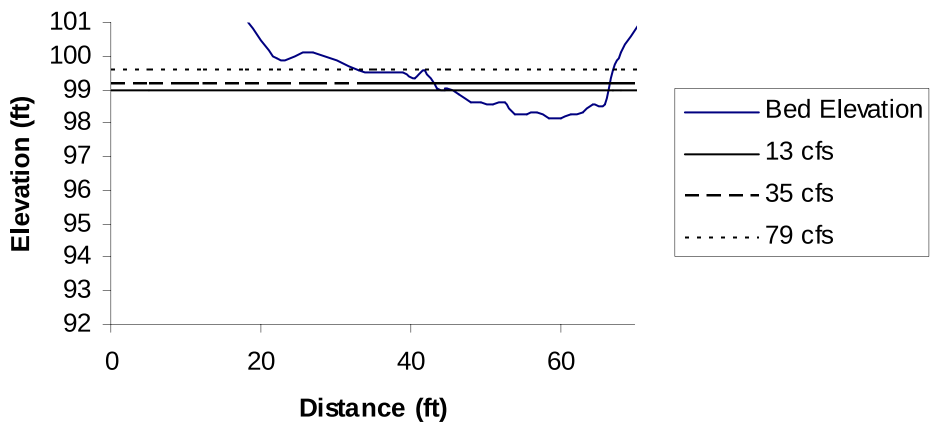
Bear Creek - Heron Park-upper site, Transect 11



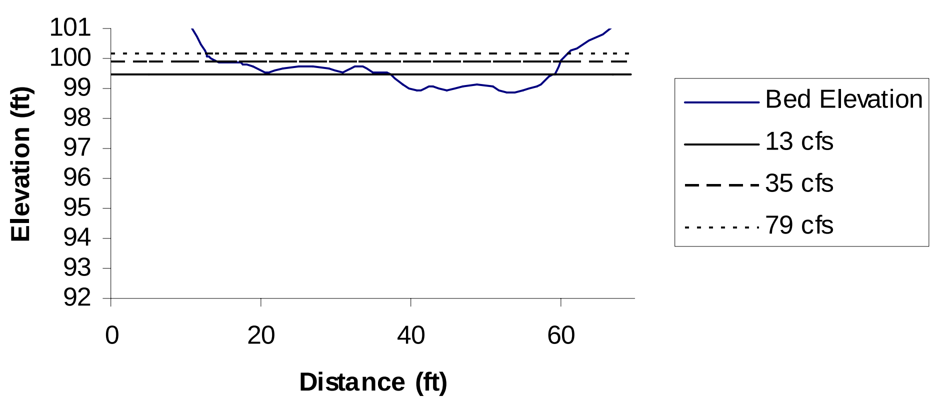
Bear Creek - Heron Park-upper site, Transect 12



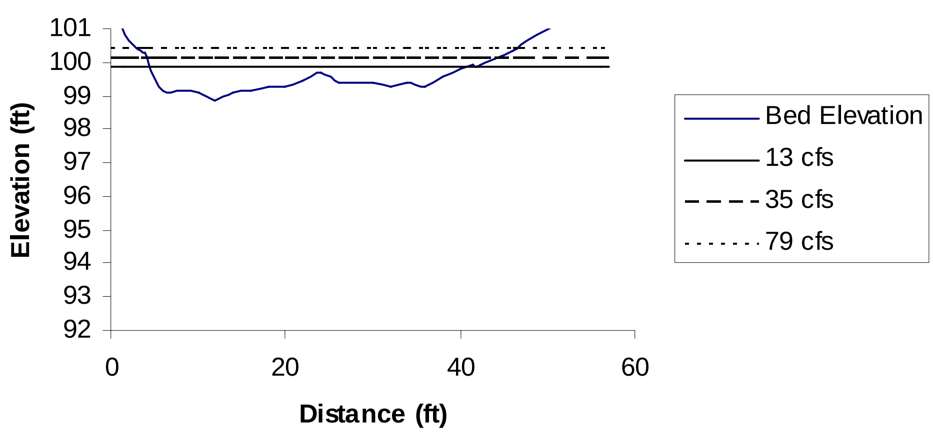
Bear Creek - Heron Park-upper site, Transect 13



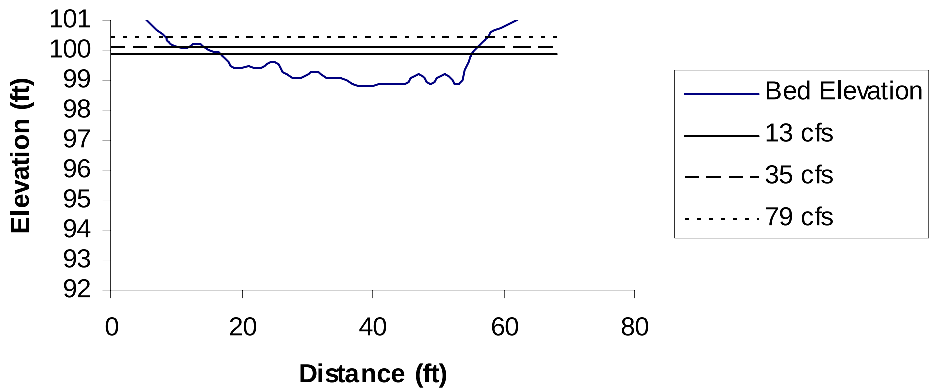
Bear Creek - Heron Park-upper site, Transect 14



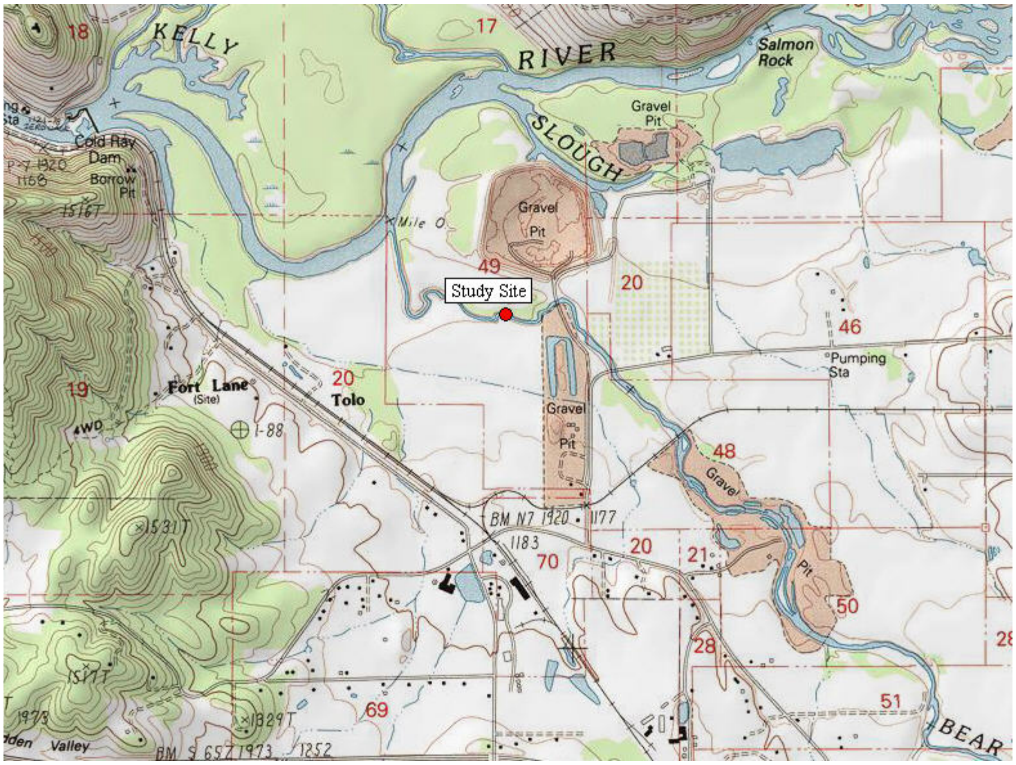
Bear Creek - Heron Park-upper site, Transect 15



Bear Creek - Heron Park-upper site, Transect 16



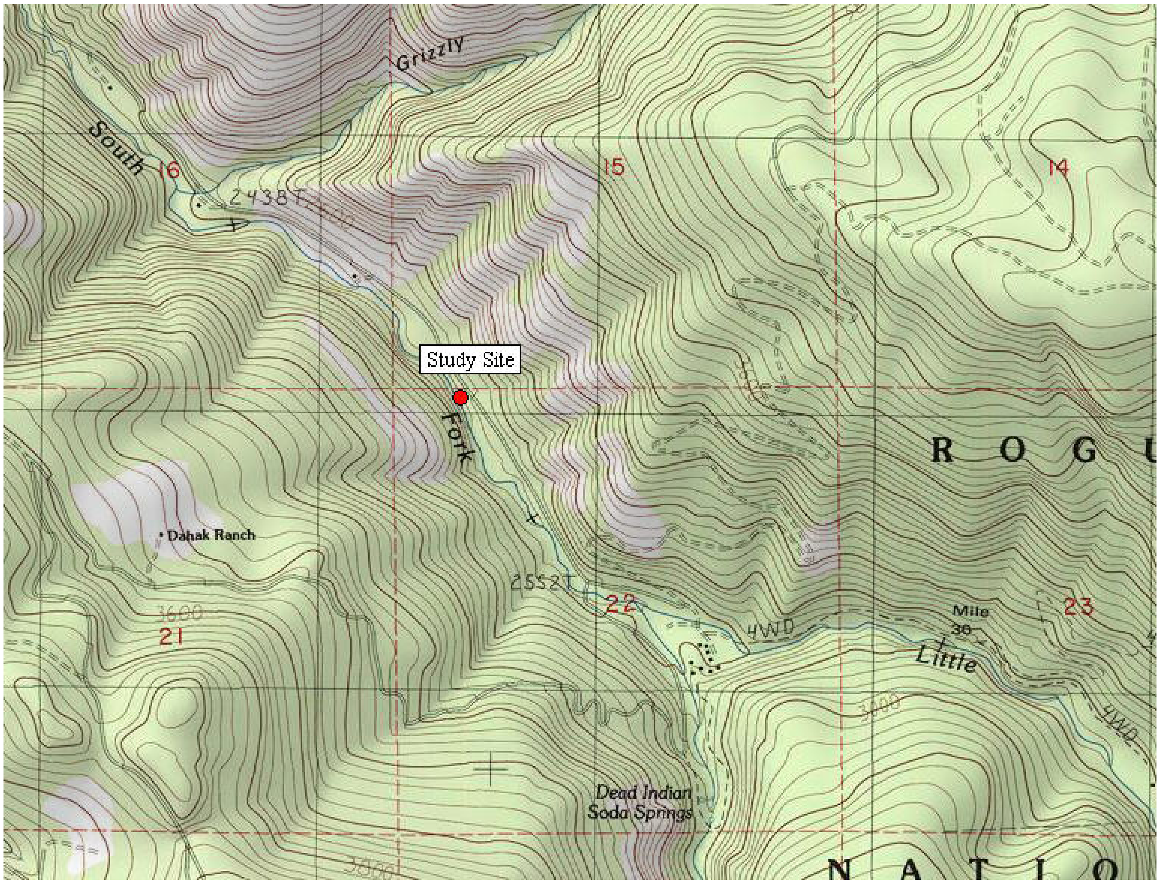
Bear Creek near mouth (2D site)



Study Site - N42°25.757' W122°57.771'

Looking downstream from upper boundary and benchmark

South Fork Little Butte Creek



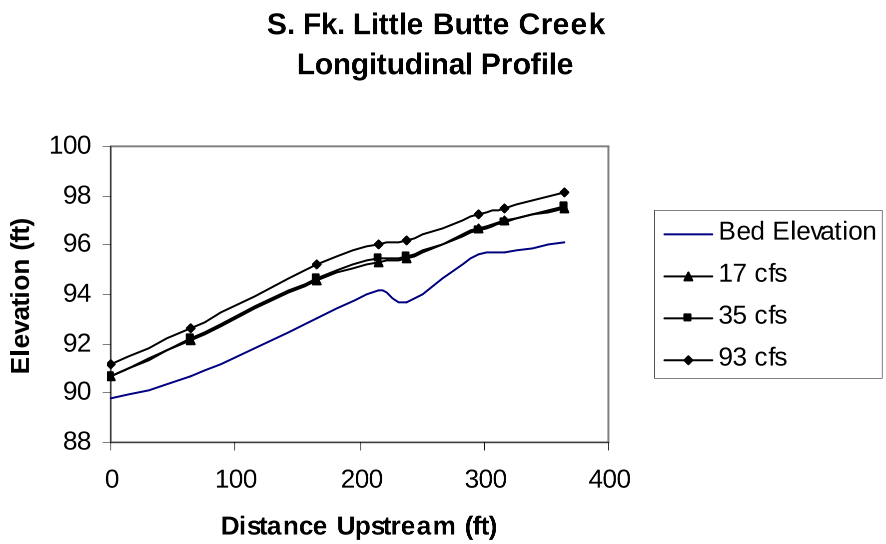
<u>Study Site</u> N42°°20.725' W122°27.646'

Transect 1 – riffle (most downstream transect) (passage)
Transect 2 – glide
Transect 3 – riffle
Transect 4 – hydraulic control/glide
Transect 5 – pool (juvenile coho observed)
Transect 6 – riffle (coho redd flagged)
Transect 7 – riffle
Transect 8 – glide (most upstream transect)

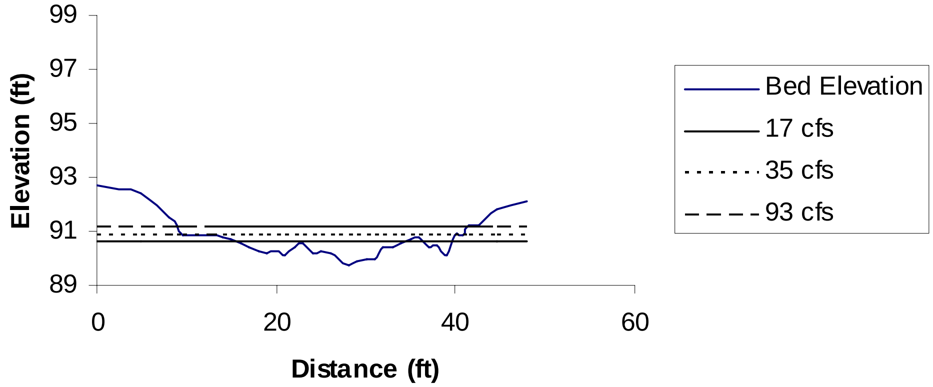

T2
T1


T3
T4
T5

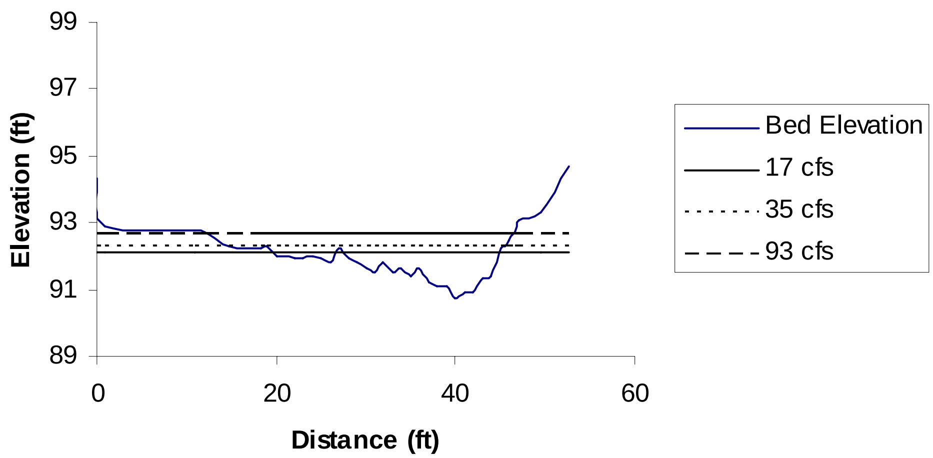

T6
T7
T8


S. Fk. Little Butte Creek
Longitudinal Profile
Elevation (ft)
Distance Upstream (ft)
Bed Elevation
17 cfs
35 cfs
93 cfs

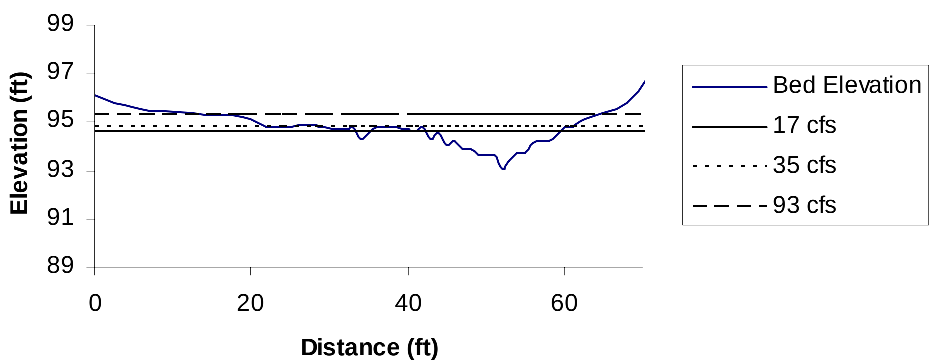
S. Fk. Little Butte Creek, Transect 1

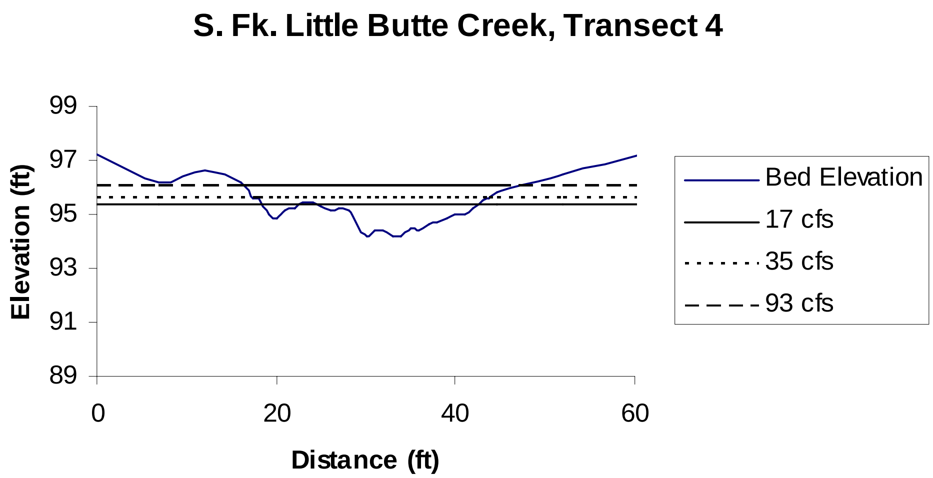


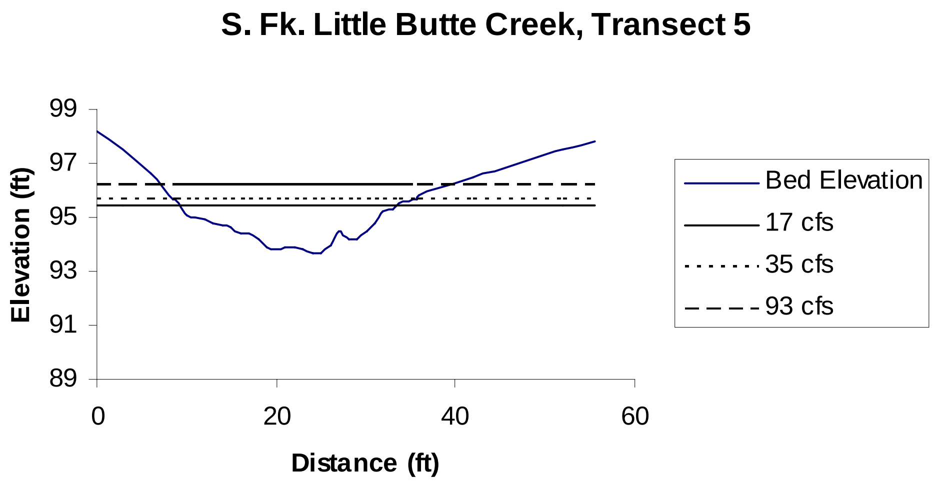
S. Fk. Little Butte Creek, Transect 2

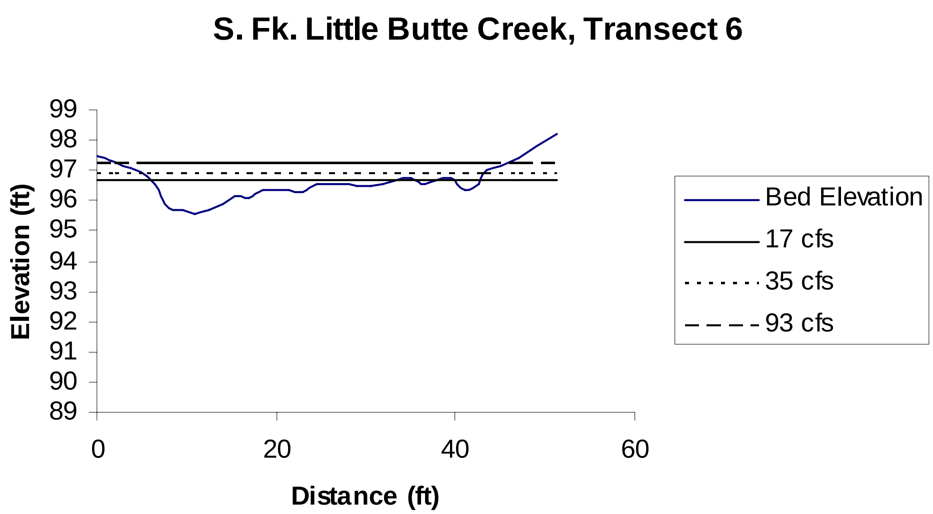


S. Fk. Little Butte Creek, Transect 3

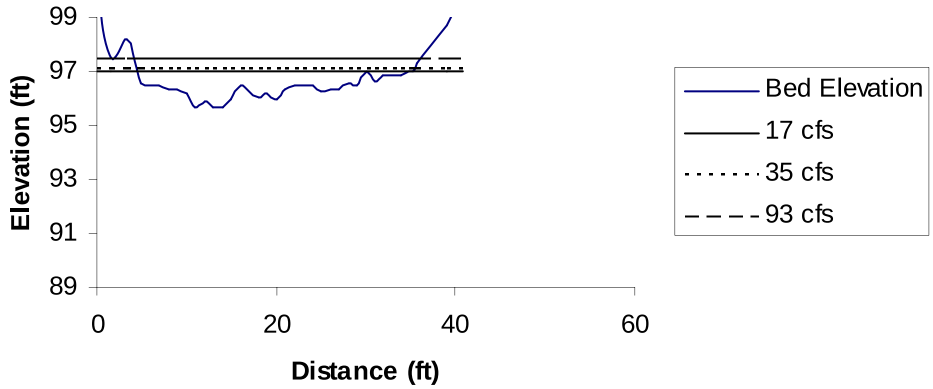



S. Fk. Little Butte Creek, Transect 4
Elevation (ft)
99
97
95
93
91
89
0
20
40
60
Distance (ft)
Bed Elevation
17 cfs
35 cfs
93 cfs

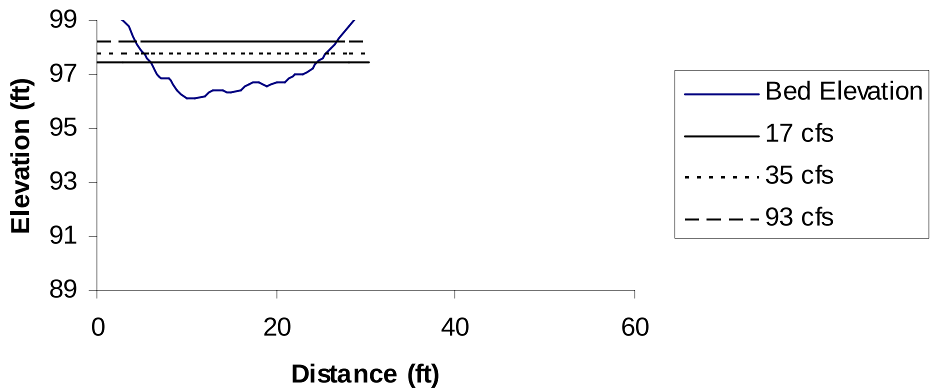

S. Fk. Little Butte Creek, Transect 5
Elevation (ft)
99
97
95
93
91
89
0
20
40
60
Distance (ft)
Bed Elevation
17 cfs
35 cfs
93 cfs


S. Fk. Little Butte Creek, Transect 6
Elevation (ft)
99
98
97
96
95
94
93
92
91
90
89
0
20
40
60
Distance (ft)
Bed Elevation
17 cfs
35 cfs
93 cfs

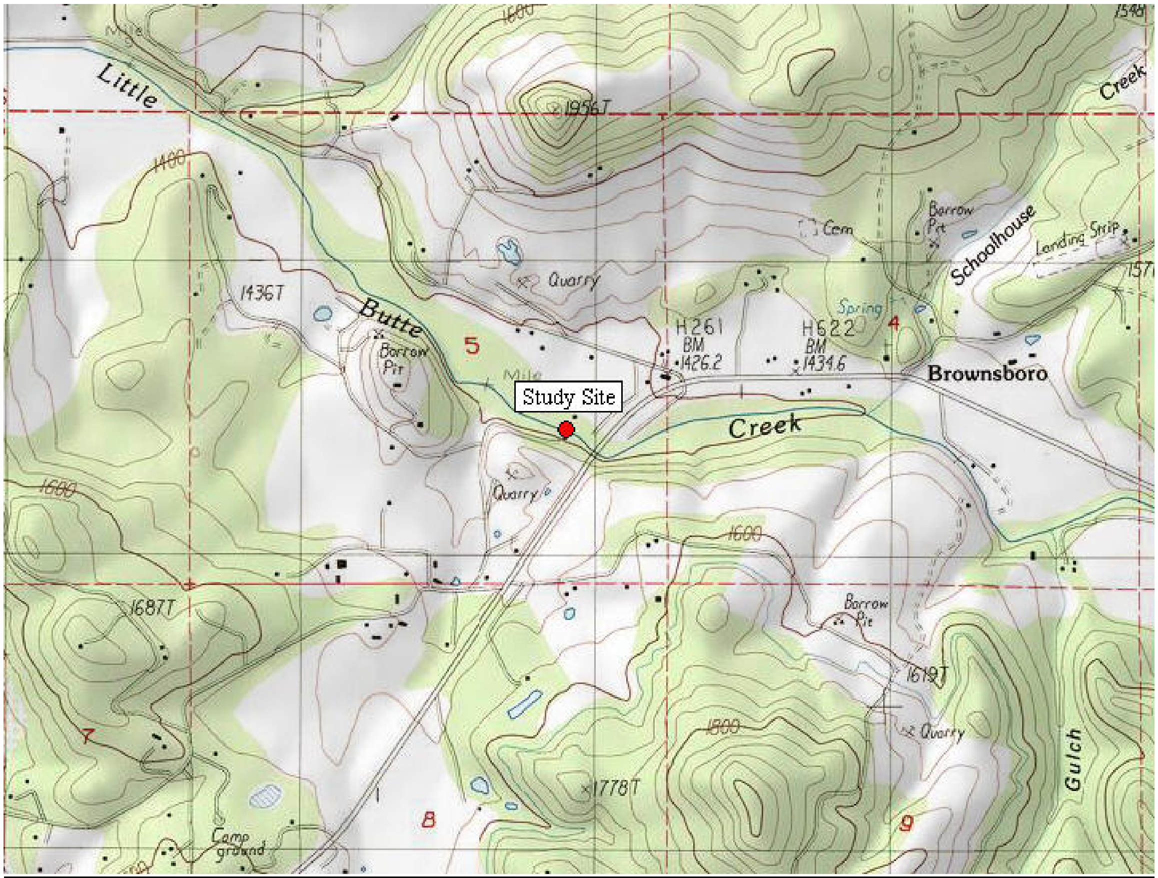
S. Fk. Little Butte Creek, Transect 7



S. Fk. Little Butte Creek, Transect 8



Little Butte Creek between S. Fk. Little Butte Creek and Antelope Creek

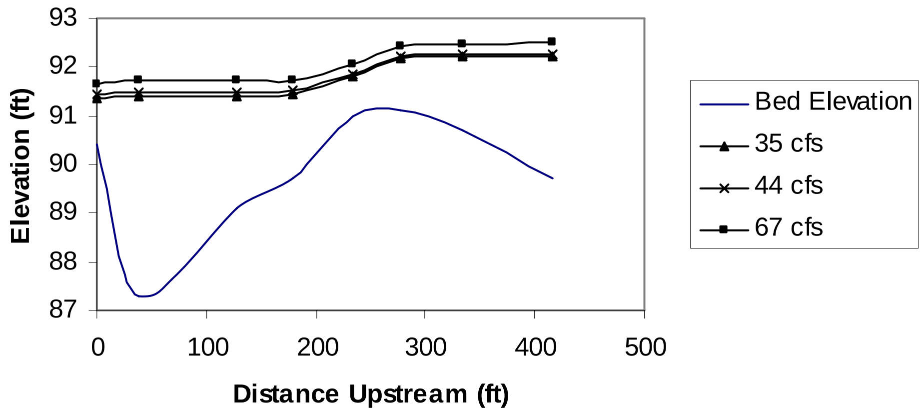


Study Site N42°28.006' W122°43.355'
Transect 1 – hydraulic control/pool (most downstream transect)
Transect 2 – pool
Transect 3 – pool
Transect 4 – glide
Transect 5 – riffle (passage)
Transect 6 – glide/hydraulic control
Transect 7 – glide
Transect 8 – pool (most upstream transect)

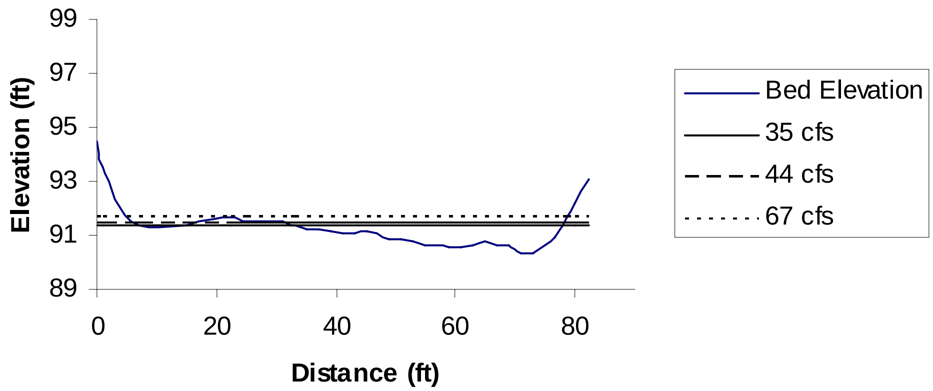

T3
T2
T1


T8
T7
T6
T5
T4

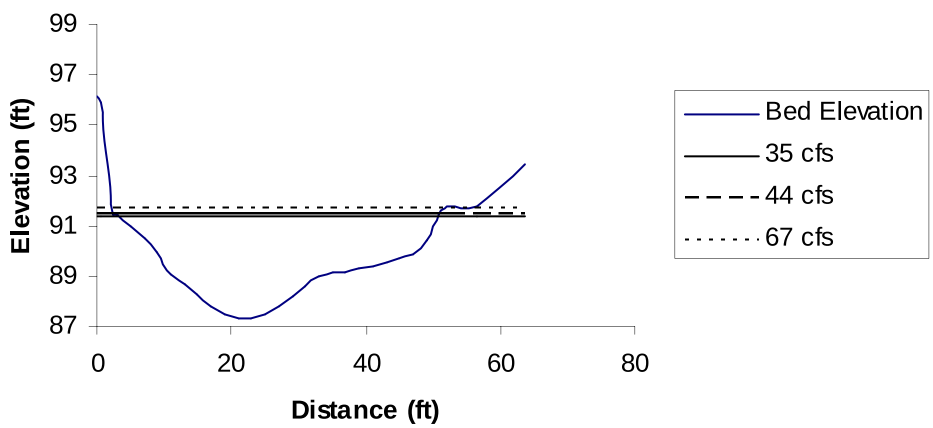
Little Butte Creek @ HWY 140
Longitudinal Profile



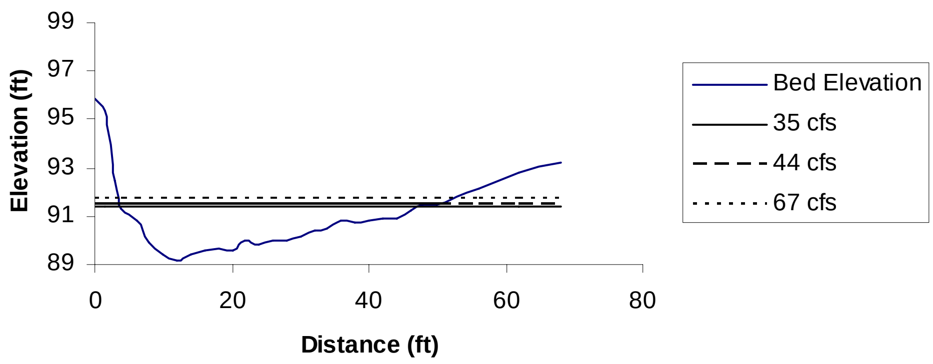
Little Butte Creek HWY 140, Transect 1



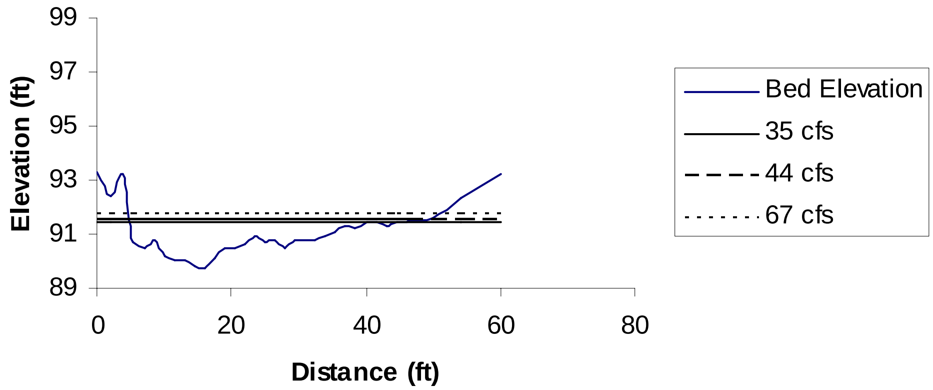
Little Butte Creek HWY 140, Transect 2



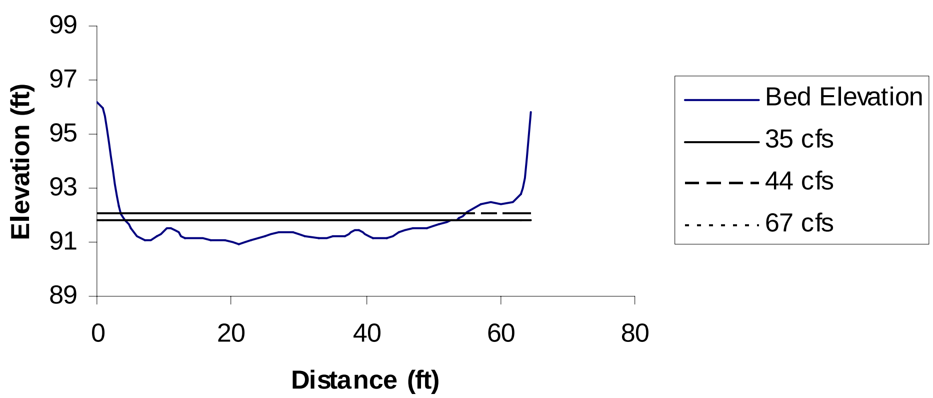
Little Butte Creek HWY 140, Transect 3



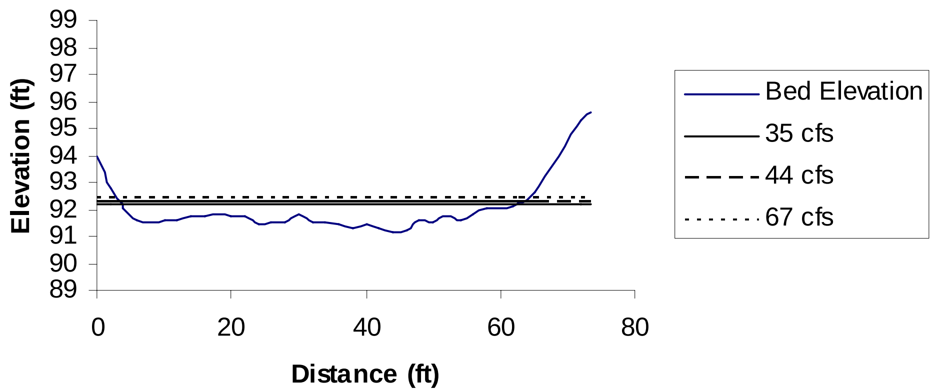
Little Butte Creek HWY 140, Transect 4



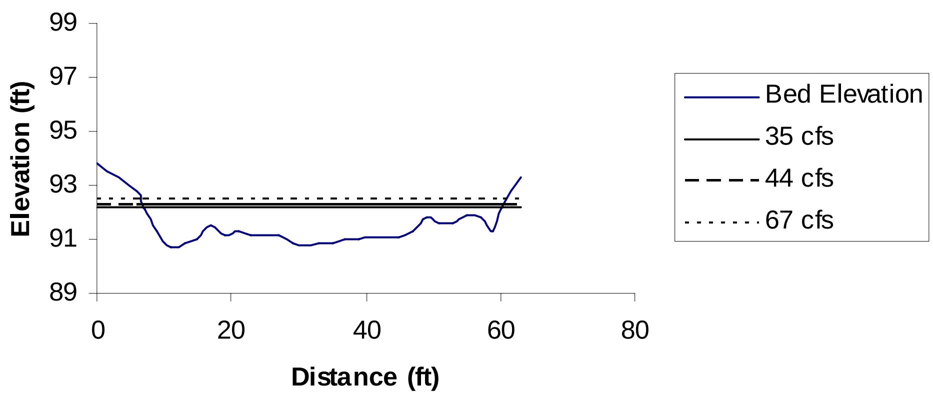
S. Fk. Little Butte Creek, Transect 5



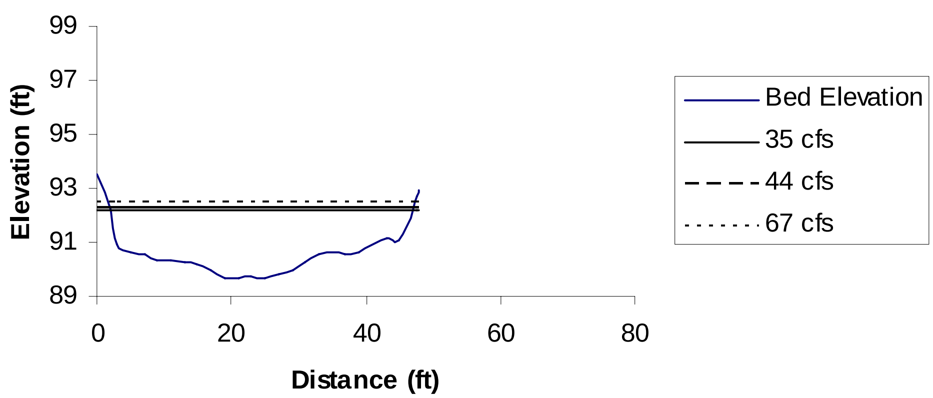
Little Butte Creek HWY 140, Transect 6



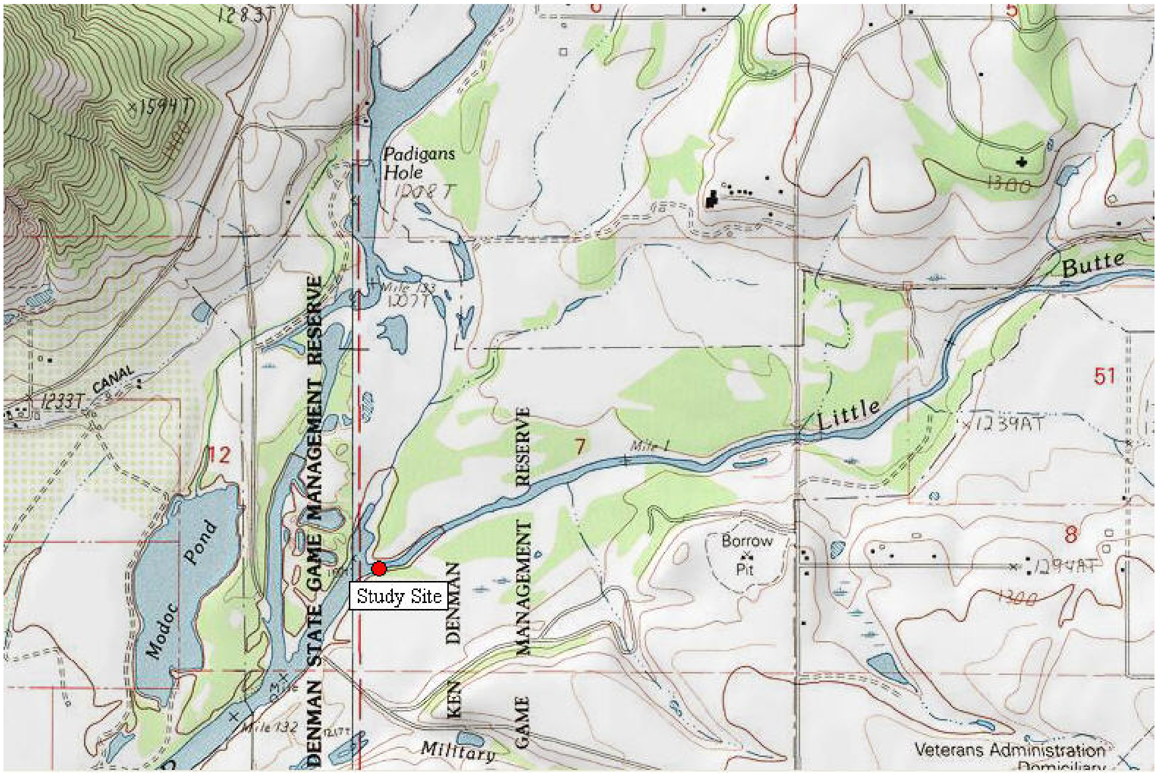
Little Butte Creek HWY 140, Transect 7



Little Butte Creek HWY 140, Transect 8



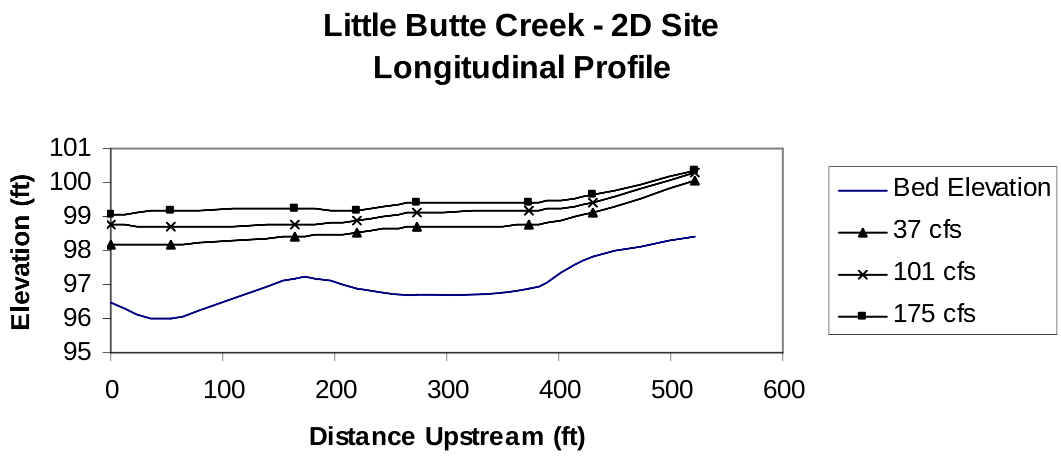
Little Butte Creek between Antelope Creek and the confluence with the Rogue River (1D and 2D site)

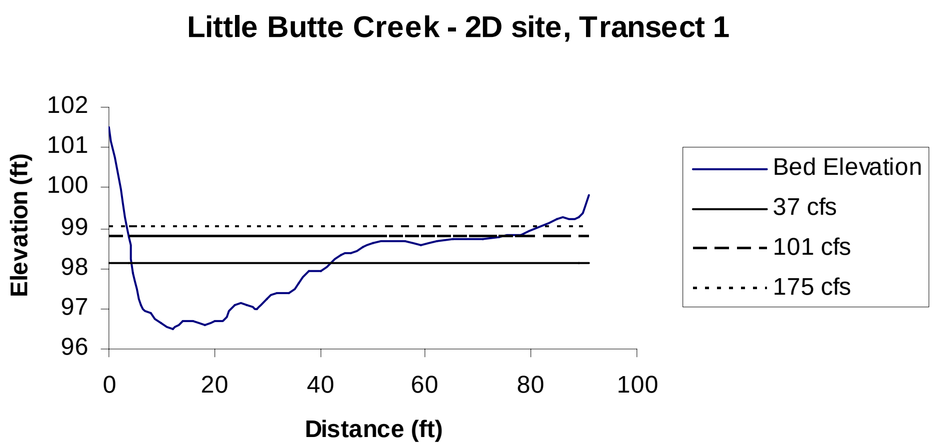


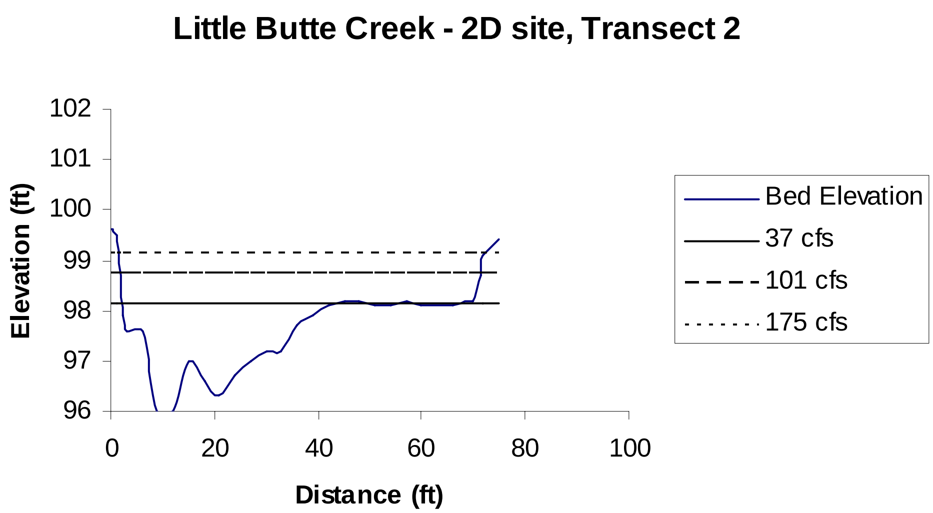
<u>Study Site</u> N42°27.066’ W122°52.498’
Transect 1 – hydraulic control/glide (most downstream transect)
Transect 2 – pool
Transect 3 – pool
Transect 4 – pool
Transect 5 – glide
Transect 6 – glide
Transect 7 – riffle
Transect 8 – riffle (most upstream transect)

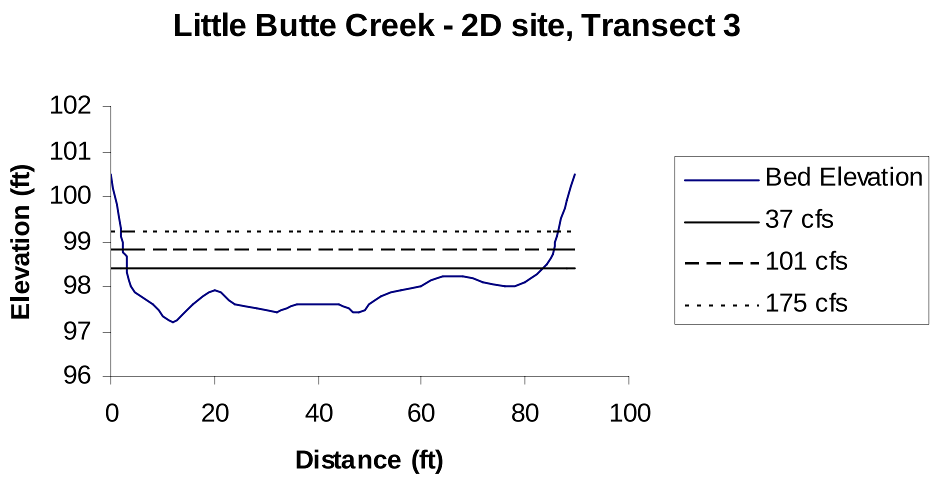

T5
T4
T3
T2
T1

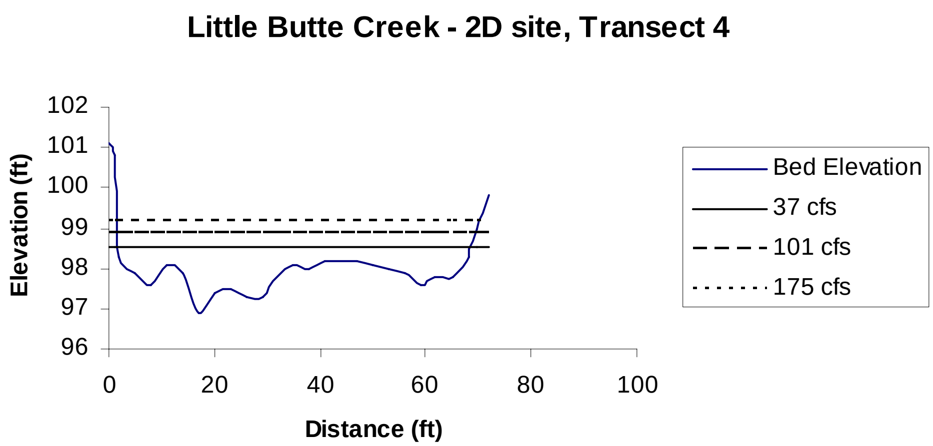

T6
T7
T8

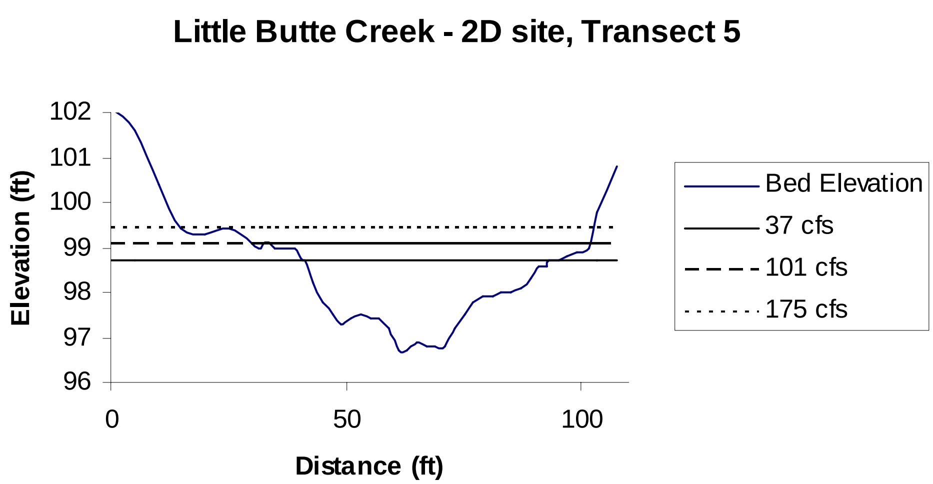

Little Butte Creek - 2D Site
Longitudinal Profile
Elevation (ft)
Distance Upstream (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs

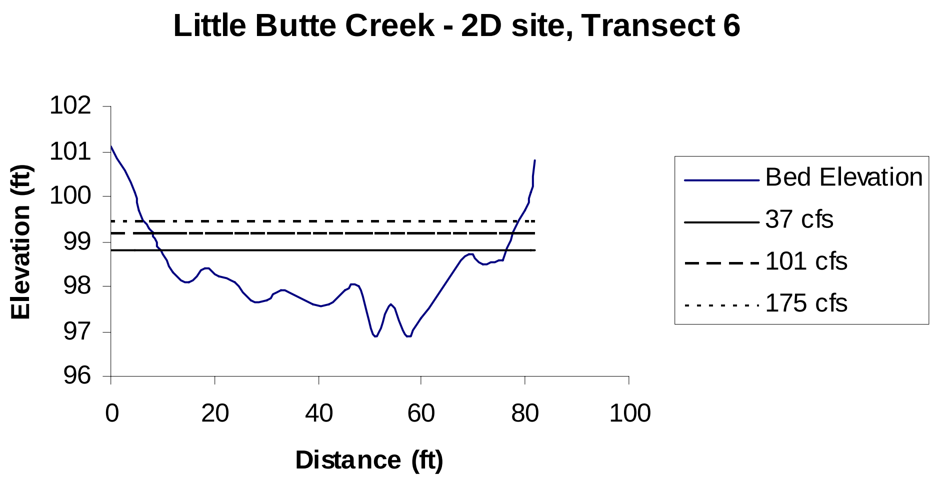

Little Butte Creek - 2D site, Transect 1
Elevation (ft)
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs

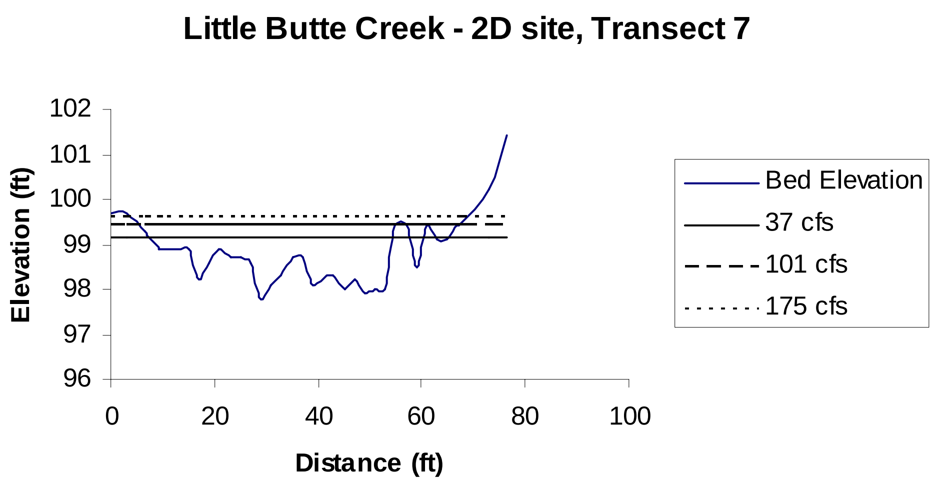

Little Butte Creek - 2D site, Transect 2
Elevation (ft)
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs

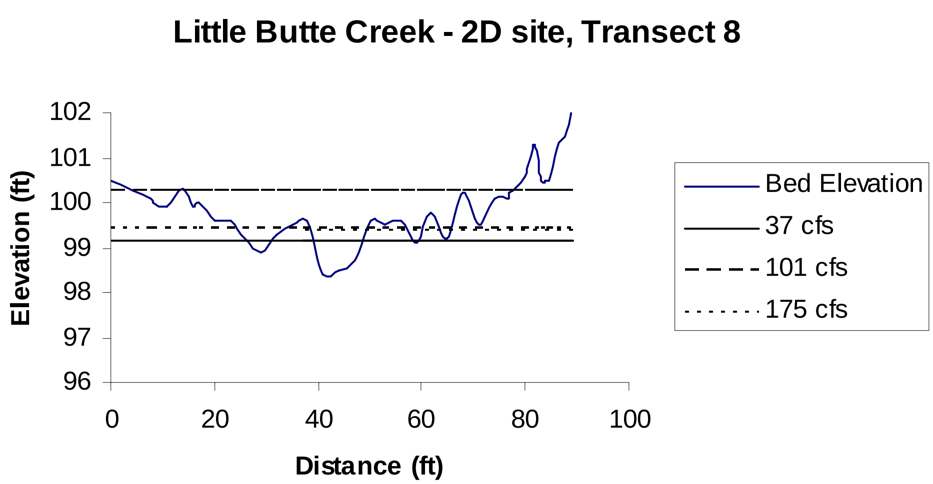

Little Butte Creek - 2D site, Transect 3
Elevation (ft)
102
101
100
99
98
97
96
0
20
40
60
80
100
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs


Little Butte Creek - 2D site, Transect 4
Elevation (ft)
102
101
100
99
98
97
96
0
20
40
60
80
100
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs

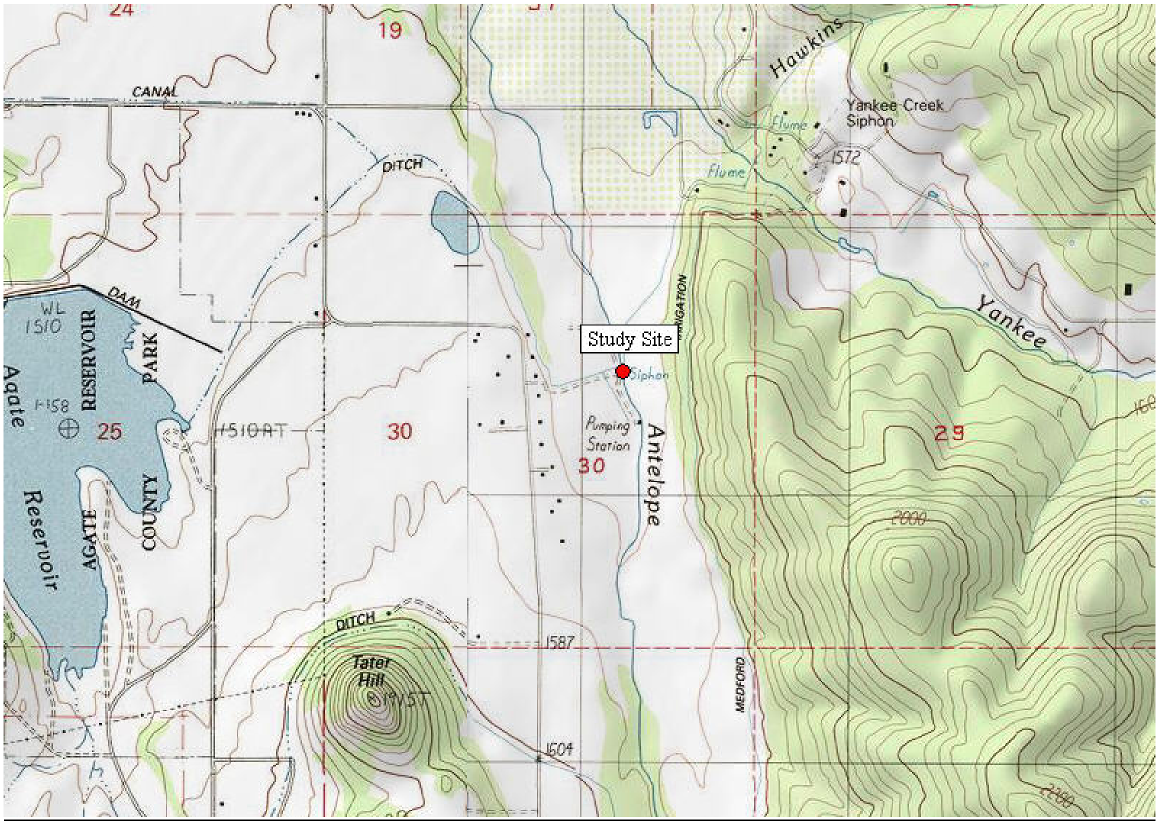

Little Butte Creek - 2D site, Transect 5
Elevation (ft)
102
101
100
99
98
97
96
0
50
100
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs


Little Butte Creek - 2D site, Transect 6
Elevation (ft)
102
101
100
99
98
97
96
0
20
40
60
80
100
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs


Little Butte Creek - 2D site, Transect 7
Elevation (ft)
102
101
100
99
98
97
96
0
20
40
60
80
100
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs


Little Butte Creek - 2D site, Transect 8
Elevation (ft)
102
101
100
99
98
97
96
0
20
40
60
80
100
Distance (ft)
Bed Elevation
37 cfs
101 cfs
175 cfs

Antelope Creek between Dry Creek and Antelope Creek Diversion

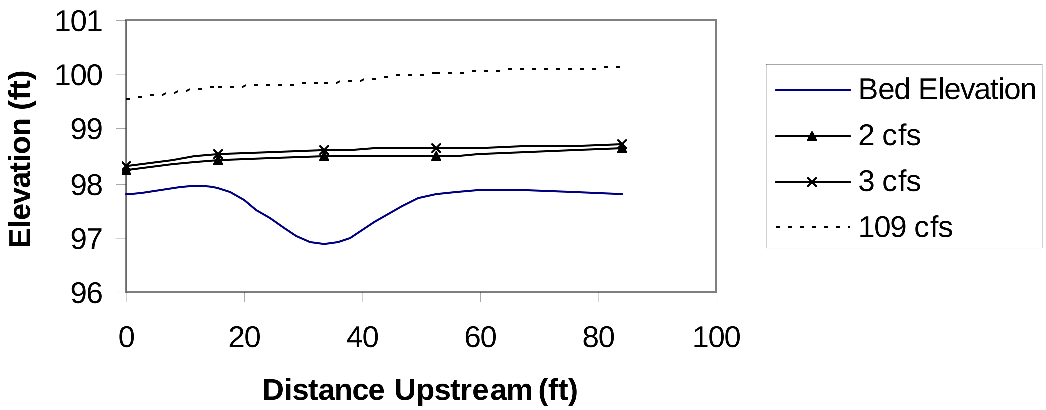


Study Site N42°24.784' W122°44.619'
Transect 1 – riffle (passage) (most downstream transect)
Transect 2 – hydraulic control/riffle
Transect 3 – pool
Transect 4 – glide
Transect 5 – glide (most upstream transect)

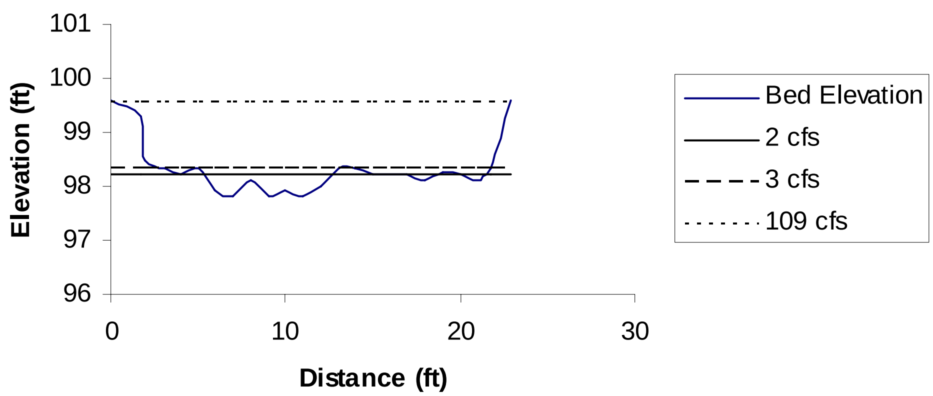

T3
T2
T1


T4
T5

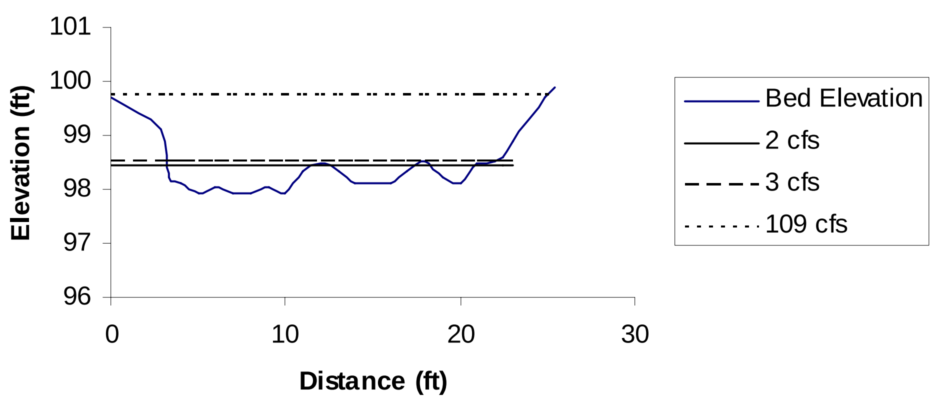
**Antelope Creek-upper site
Longitudinal Profile**



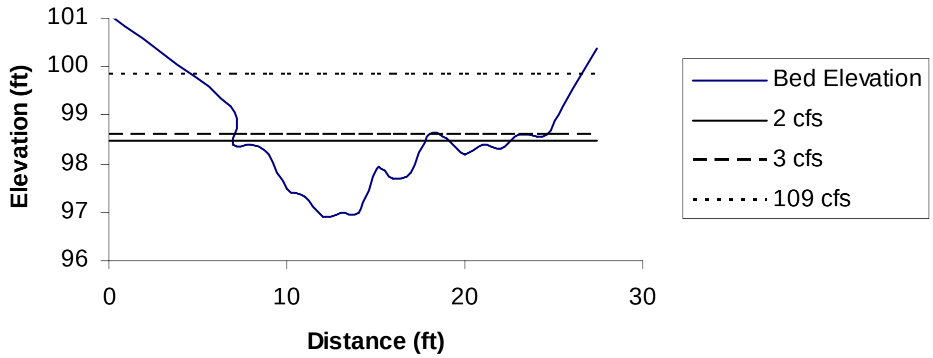
Antelope Creek-upper, Transect 1



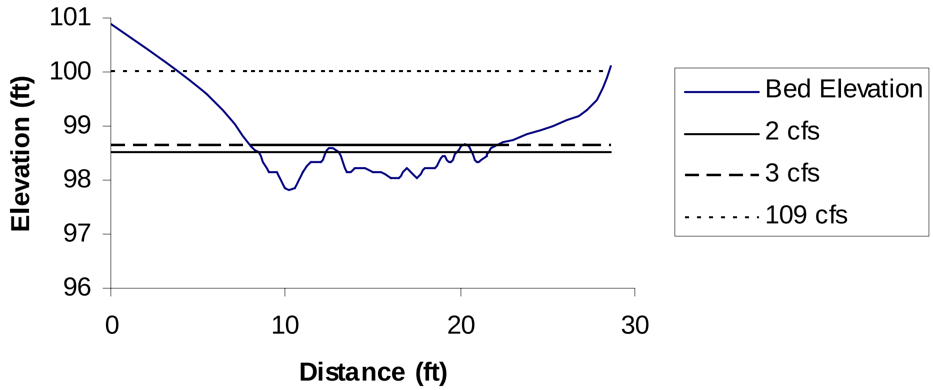
Antelope Creek-upper, Transect 2



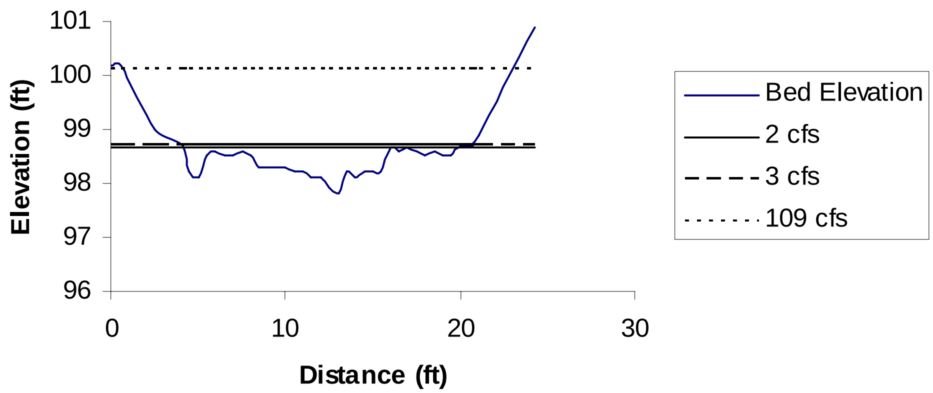
Antelope Creek-upper, Transect 3



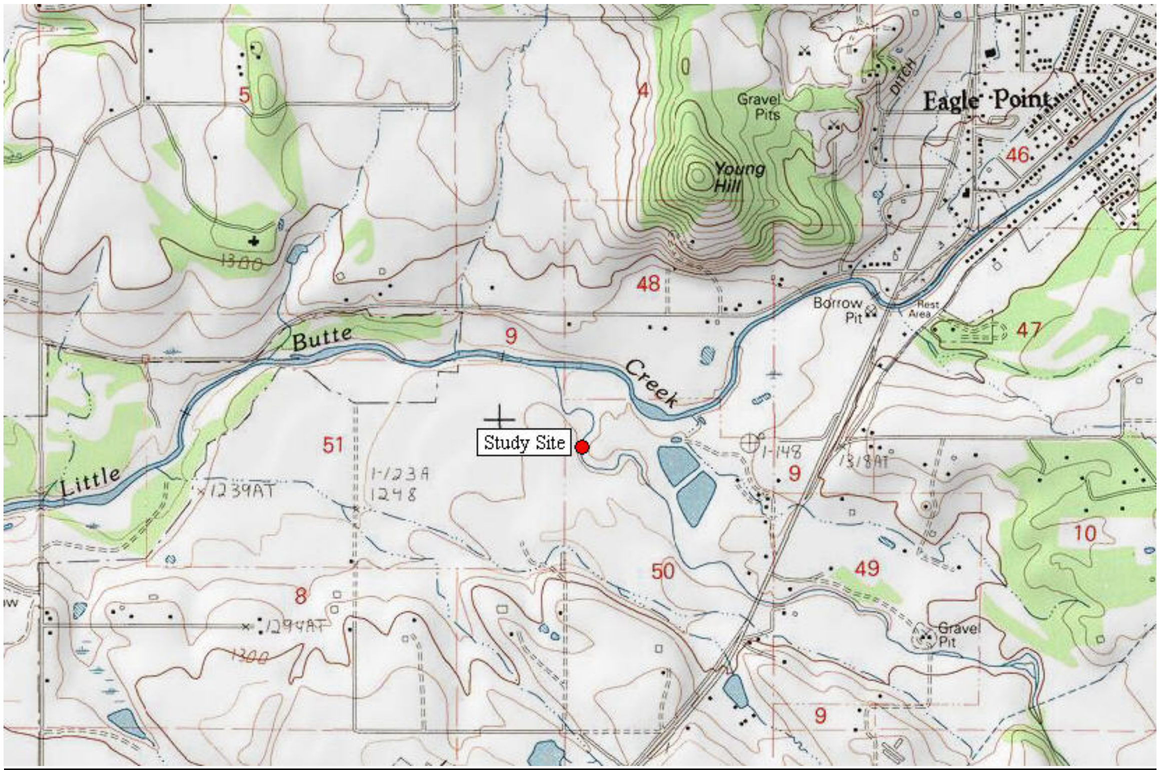
Antelope Creek-upper, Transect 4



Antelope Creek-upper, Transect 5



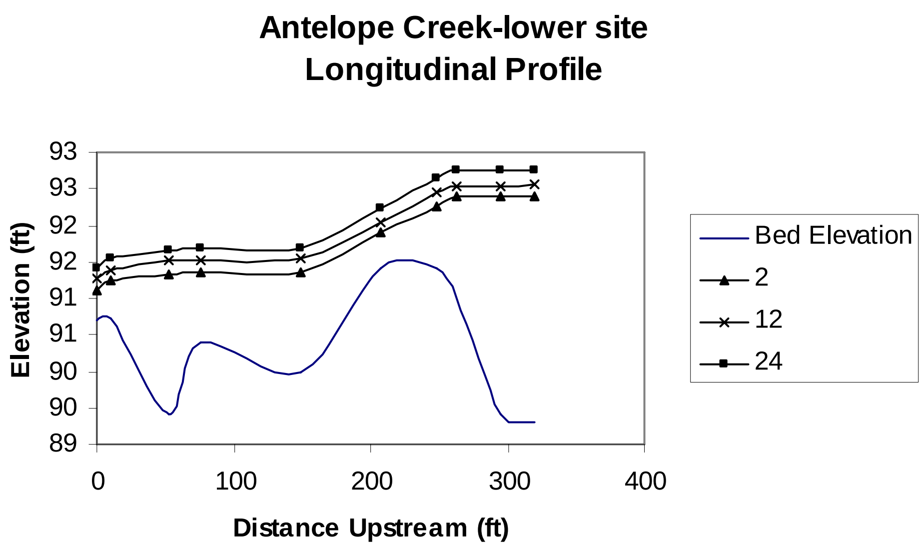
Antelope Creek between Dry Creek and the confluence with Little Butte Creek

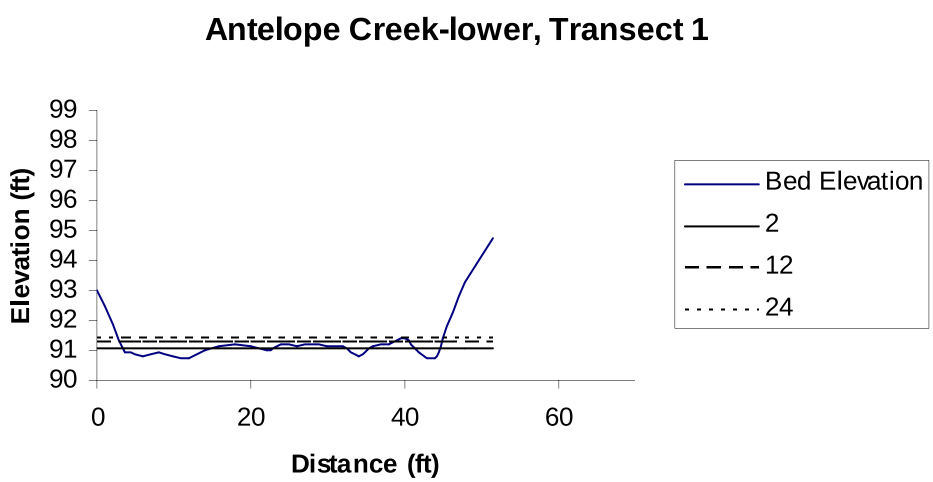


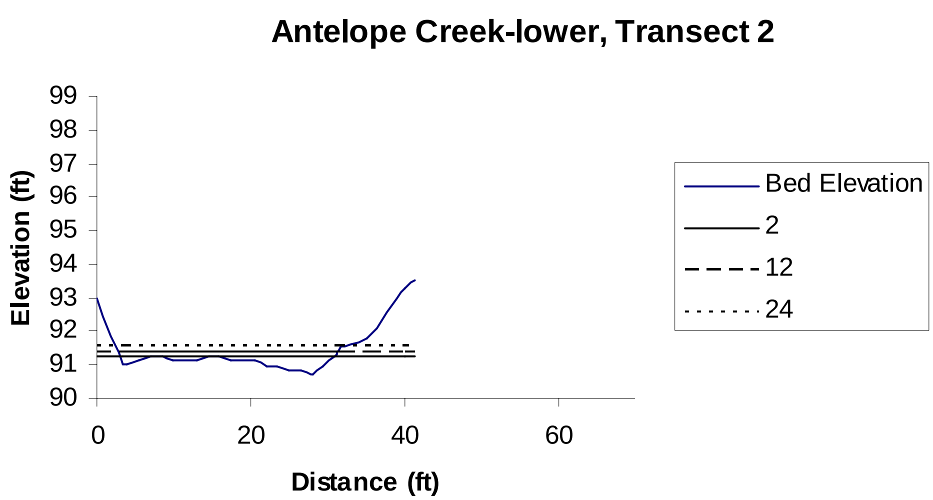
<u>Study Site</u> N42°27.321' W122°49.602'
Transect 1 – riffle (passage) (most downstream transect)
Transect 2 – hydraulic control/riffle
Transect 3 – glide
Transect 4 – glide
Transect 5 – glide
Transect 6 – riffle
Transect 7 – hydraulic control
Transect 8 – pool
Transect 9 – pool
Transect 10 - pool (most upstream transect)


T5
T4
T3
T2
T1

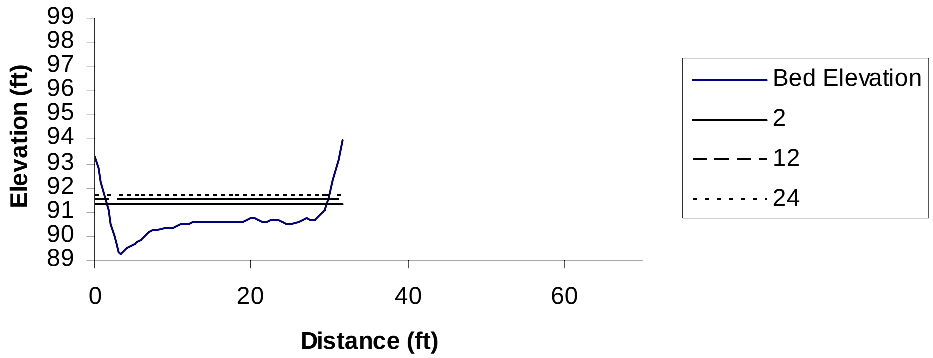

T10
T9
T8
T7
T6


Antelope Creek-lower site
Longitudinal Profile
Elevation (ft)
93
93
92
92
91
91
90
90
89
0
100
200
300
400
Distance Upstream (ft)
Bed Elevation
2
12
24

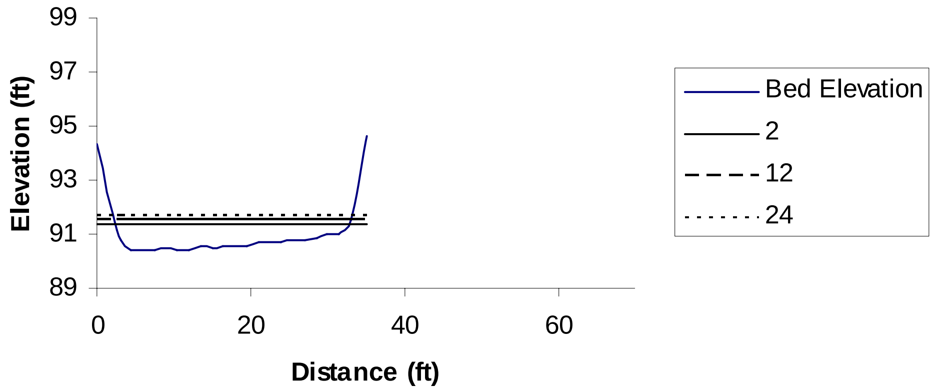

Antelope Creek-lower, Transect 1
Elevation (ft)
99
98
97
96
95
94
93
92
91
90
0
20
40
60
Distance (ft)
Bed Elevation
2
12
24


Antelope Creek-lower, Transect 2
Elevation (ft)
99
98
97
96
95
94
93
92
91
90
0
20
40
60
Distance (ft)
Bed Elevation
2
12
24

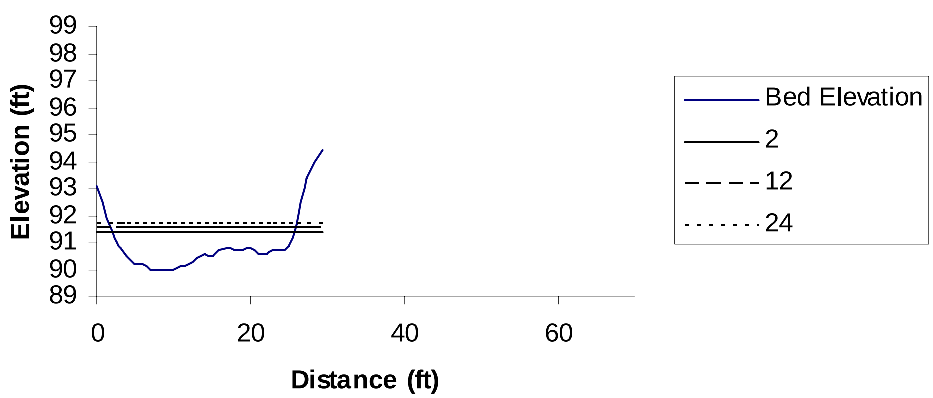
Antelope Creek-lower, Transect 3



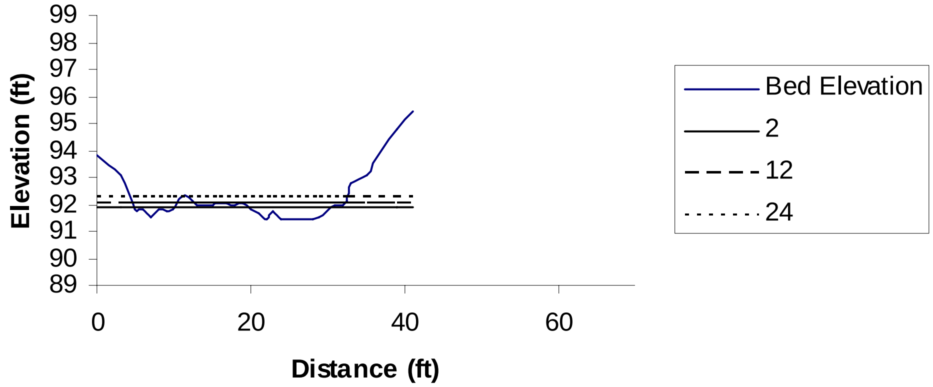
Antelope Creek-lower, Transect 4



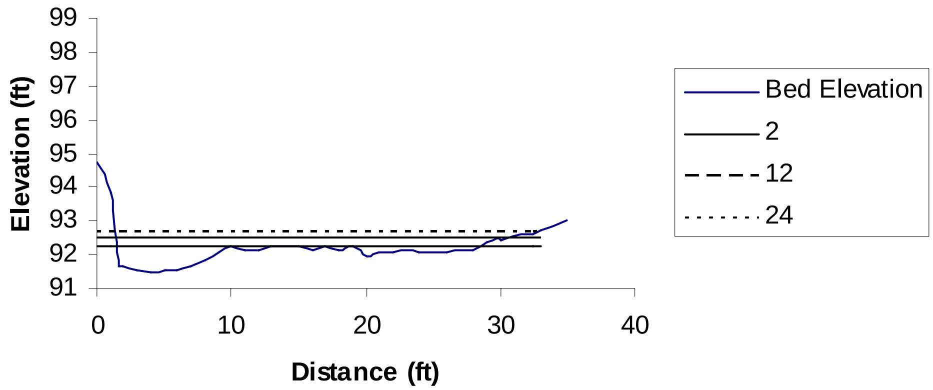
Antelope Creek-lower, Transect 5



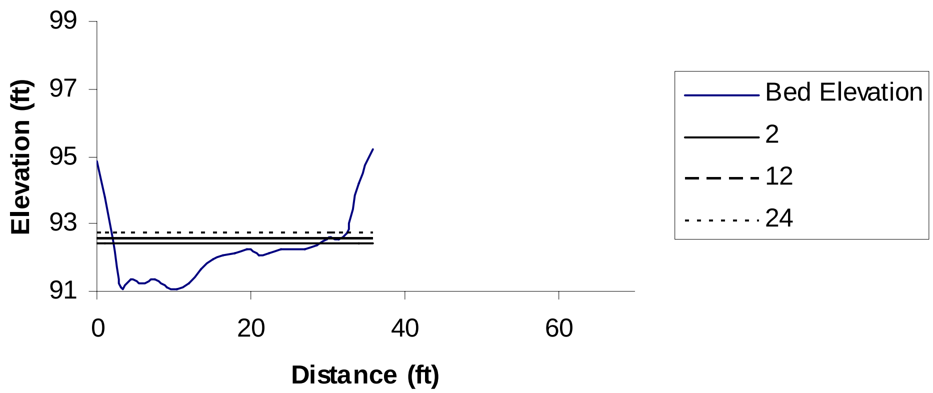
Antelope Creek-lower, Transect 6



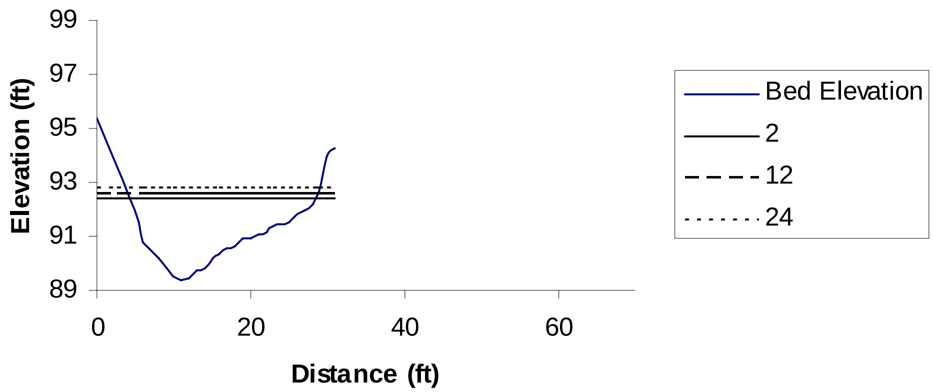
Antelope Creek-lower, Transect 7



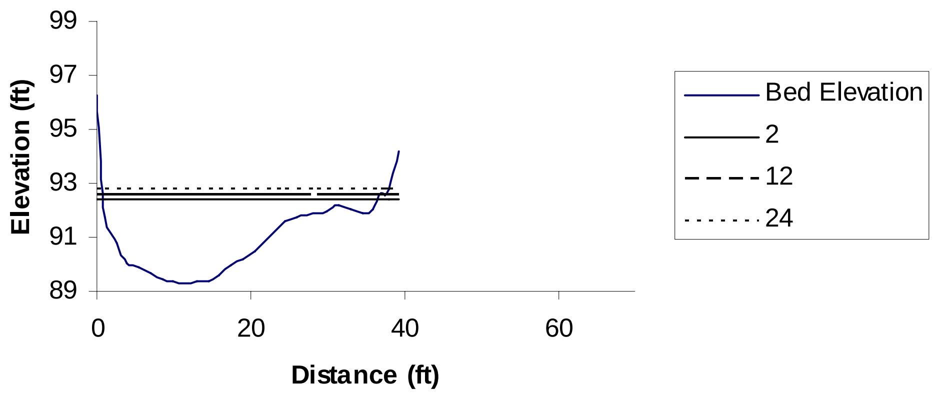
Antelope Creek-lower, Transect 8



Antelope Creek-lower, Transect 9



Antelope Creek-lower, Transect 10



Appendix B – Hydraulic Calibration Results

Table B-1. Water surface elevation calibration results (ft) for Emigrant Creek (Gun Club) (lower site) using STGQ for transects 1-2 and WSP for transects 3-8.

Transect	Distance from next downstream transect (ft)	8 cfs			38 cfs			64 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	97.88	97.87	-0.01	98.40	98.45	0.05	98.77	98.73	-0.04
2	15.5	98.00	98.00	0.00	98.53	98.55	0.02	98.79	98.77	-0.02
3	31.5	99.24	99.24	0.00	99.51	99.51	0.00	99.71	99.71	0.00
4	22	99.31	99.27	-0.04	99.67	99.65	-0.02	99.92	99.88	-0.04
5	26	99.38	99.38	0.00	99.79	99.79	0.00	100.06	100.06	0.00
6	24.5	99.39	99.39	0.00	99.80	99.83	0.03	100.08	100.12	0.04
7	35	99.39	99.39	0.00	99.82	99.84	0.02	100.09	100.14	0.05
8	36.5	99.44	99.40	-0.04	99.92	99.87	-0.05	100.18	100.18	0.00

Table B-2. Water surface elevation calibration results (ft) for Emigrant Creek (Gun Club) (upper site) using STGQ.

Transect	Distance from next downstream transect (ft)	1 cfs			8 cfs			30 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
9	0	98.39	98.39	0.00	98.63	98.63	0.00	98.89	98.89	0.00
10	49	100.11	100.10	-0.01	100.23	100.26	0.03	100.43	100.41	-0.02

Table B-3. Water surface elevation calibration results (ft) for Neil Creek Study Site using STGQ for transects 1-3 and WSP for transects 4-10.

Transect	Distance from next downstream transect (ft)	5 cfs			13 cfs			30 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	93.69	93.68	-0.01	93.88	93.91	0.03	94.17	94.15	-0.02
2	24.5	93.99	93.97	-0.02	94.12	94.15	0.03	94.36	94.34	-0.02
3	25.5	94.41	94.41	0.00	94.56	94.56	0.00	94.70	94.70	0.00
4	25	94.61	94.61	0.00	94.72	94.72	0.00	95.01	95.01	0.00
5	25	94.63	94.62	-0.01	94.77	94.75	-0.02	95.03	95.08	0.05
6	39.5	95.44	95.44	0.00	95.47	95.47	0.00	95.68	95.68	0.00
7	19.5	95.46	95.44	-0.02	95.51	95.49	-0.02	95.76	95.72	-0.04
8	30	95.47	95.46	-0.01	95.59	95.55	-0.04	95.85	95.84	-0.01
9	20.5	95.46	95.46	0.00	95.57	95.57	0.00	95.87	95.87	0.00
10	16.5	95.45	95.46	0.01	95.58	95.57	-0.01	95.87	95.89	0.02

Table B-4. Water surface elevation calibration results (ft) for Bear Creek between Emigrant Creek and Oak Street Diversion using STGQ for transect 3 and MANSQ for transects 1-2 and 4-7.

Transect	Distance from next downstream transect (ft)	18 cfs			39 cfs			66 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	96.90	96.85	-0.05	97.15	97.16	0.01	97.45	97.41	-0.04
2	36.5	96.92	96.91	-0.01	97.27	97.22	-0.05	97.50	97.50	0.00
3	44	97.08	97.07	-0.01	97.48	97.46	-0.02	97.82	97.78	-0.04
4	51	97.13	97.15	0.02	97.52	97.48	-0.04	97.83	97.85	0.02
5	53	97.18	97.17	-0.01	97.55	97.57	0.02	97.86	97.83	-0.03
6	47.5	98.01	98.05	0.04	98.36	98.34	-0.02	98.60	98.56	-0.04
7	37	98.68	98.73	0.05	99.04	98.99	-0.05	99.22	99.17	-0.05

Table B-5. Water surface elevation calibration results (ft) for Bear Creek between Oak Street Diversion and Valley View Road using MANSQ.

Transect	Distance from next downstream transect (ft)	23 cfs		
		Water surface elevations (ft)		
		Measured	Simulated	Difference
1	0	98.37	98.37	0.00
2	56.5	98.43	98.43	0.00
3	33	99.19	99.18	-0.01
4	47	99.53	99.55	0.02

Table B-6. Water surface elevation calibration results (ft) for Bear Creek Study Site between Valley View Road and Phoenix Diversion (lower site) using STGQ for transect 1 and WSP for transects 2-10.

Transect	Distance from next downstream transect (ft)	23 cfs			72 cfs			83 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	96.62	96.61	-0.01	97.10	97.14	0.04	97.26	97.22	-0.04
2	23	96.86	96.86	0.00	97.33	97.33	0.00	97.43	97.43	0.00
3	23	96.90	96.91	0.01	97.42	97.43	0.01	97.52	97.53	0.01
4	40	96.95	96.92	-0.03	97.43	97.47	0.04	97.54	97.57	0.03
5	20.5	96.95	96.92	-0.03	97.45	97.47	0.02	97.56	97.58	0.02
6	22.5	96.94	96.92	-0.02	97.48	97.48	0.00	97.60	97.59	-0.01
7	27.5	97.06	97.06	0.00	97.55	97.55	0.00	97.69	97.69	0.00
8	40.5	97.12	97.10	-0.02	97.60	97.62	0.02	97.75	97.75	0.00
9	81	98.69	98.69	0.00	98.97	98.97	0.00	99.00	99.00	0.00
10	41.5	98.73	98.73	0.00	99.06	99.09	0.03	99.11	99.14	0.03

Table B-7. Water surface elevation calibration results (ft) for Bear Creek Study Site between Valley View Road and Phoenix Diversion (upper site) using STGQ.

Transect	Distance from next downstream transect (ft)	20 cfs			51 cfs			74 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	96.79	96.78	-0.01	97.06	97.10	0.04	97.27	97.25	-0.02
2	54.5	97.51	97.51	0.00	97.85	97.84	-0.01	97.99	97.99	0.00
3	49	99.00	98.99	-0.01	99.23	99.26	0.03	99.41	99.39	-0.02

Table B-8. Water surface elevation calibration results (ft) for Bear Creek Study Site between Phoenix Diversion and Jackson Street Diversion (lower site) using WSP for transects 1-7 and STGQ for transect 8.

Transect	Distance from next downstream transect (ft)	12 cfs			33 cfs			71 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	95.06	95.06	0.00	95.36	95.36	0.00	95.74	95.74	0.00
2	18.5	95.12	95.08	-0.04	95.40	95.39	-0.01	95.81	95.78	-0.03
3	20.5	95.12	95.10	-0.02	95.41	95.41	0.00	95.78	95.81	0.03
4	21	95.11	95.10	-0.01	95.44	95.42	-0.02	95.81	95.83	0.02
5	36	95.16	95.11	-0.05	95.44	95.43	-0.01	95.85	95.85	0.00
6	31	95.12	95.11	-0.01	95.38	95.44	0.06	95.87	95.86	-0.01
7	32.5	95.16	95.17	0.01	95.47	95.49	0.02	95.92	95.89	-0.03
8	37	95.73	95.72	-0.01	95.98	96.01	0.03	96.28	96.28	0.00

Table B-9. Water surface elevation calibration results (ft) for Bear Creek Study Site between Phoenix Diversion and Jackson Street Diversion (upper site) using STGQ for transects 9-14 and WSP for transects 15-16.

Transect	Distance from next downstream transect (ft)	13 cfs			35 cfs			79 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
9	0	97.52	97.52	0.00	97.85	97.85	0.00	98.22	98.22	0.00
10	41	97.87	97.85	-0.02	98.15	98.19	0.04	98.56	98.54	-0.02
11	24	97.94	97.94	0.00	98.25	98.26	0.01	98.61	98.60	-0.01
12	36	98.21	98.20	-0.01	98.51	98.53	0.02	98.88	98.87	-0.01
13	37.5	98.95	98.93	-0.02	99.16	99.21	0.05	99.54	99.51	-0.03
14	29.5	99.46	99.45	-0.01	99.70	99.72	0.02	100.03	100.02	-0.01
15	58.5	99.86	99.86	0.00	100.10	100.10	0.00	100.38	100.38	0.00
16	30.5	99.88	99.88	0.00	100.11	100.14	0.03	100.44	100.45	0.01

Table B-10. Water surface elevation calibration results (ft) for South Fork Little Butte Creek Study Site using STGQ for transects 1-3 and 6-8 and WSP for transects 4-5.

Transect	Distance from next downstream transect (ft)	22 cfs			35 cfs			93 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	90.69	90.72	0.03	90.88	90.84	-0.04	91.15	91.17	0.02
2	64.5	92.19	92.18	-0.01	92.31	92.32	0.01	92.65	92.65	0.00
3	101.5	94.67	94.67	0.00	94.82	94.84	0.02	95.25	95.24	-0.01
4	50	95.44	95.44	0.00	95.62	95.62	0.00	96.01	96.01	0.00
5	21	95.52	95.53	0.01	95.70	95.72	0.02	96.19	96.24	0.05
6	58.5	96.63	96.65	0.02	96.80	96.81	0.01	97.22	97.21	-0.01
7	20.5	96.96	96.98	0.02	97.13	97.12	-0.01	97.46	97.46	0.00
8	49	97.55	97.54	-0.01	97.72	97.72	0.00	98.16	98.16	0.00

Table B-11. Water surface elevation calibration results (ft) for Little Butte Creek Study Site near Hwy 140 Bridge using WSP for transects 1-4 and 6-8 and STGQ for transect 5.

Transect	Distance from next downstream transect (ft)	35 cfs			44 cfs			67 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	91.36	91.36	0.00	91.43	91.43	0.00	91.65	91.65	0.00
2	38.5	91.40	91.41	0.01	91.48	91.49	0.01	91.71	91.72	0.01
3	89.5	91.42	91.42	0.00	91.50	91.50	0.00	91.72	91.73	0.01
4	50.5	91.43	91.44	0.01	91.51	91.53	0.02	91.72	91.76	0.04
5	54.5	91.81	91.80	-0.01	91.86	91.88	0.02	92.06	92.05	-0.01
6	45	92.17	92.17	0.00	92.23	92.23	0.00	92.41	92.41	0.00
7	**56.5**	92.21	92.21	0.00	92.29	92.28	-0.01	92.48	92.47	-0.01
8	**81.5**	92.22	92.22	0.00	92.27	92.30	0.03	92.50	92.50	0.00

Table B-12. Water surface elevation calibration results (ft) for Little Butte Creek Study Site near confluence with Rogue River using WSP for transects 1-4 and STGQ for transects 5-8.

Transect	Distance from next downstream transect (ft)	37 cfs			101 cfs			175 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	98.17	98.17	0.00	98.74	98.74	0.00	99.03	99.03	0.00
2	52.8	98.20	98.19	-0.01	98.73	98.78	0.05	99.15	99.10	-0.05
3	110.8	98.45	98.45	0.00	98.79	98.79	0.00	99.22	99.22	0.00
4	56.8	98.50	98.47	-0.03	98.86	98.82	-0.04	99.19	99.24	0.05
5	52.0	98.70	98.68	-0.02	99.09	99.12	0.03	99.44	99.40	-0.04
6	101.5	98.79	98.77	-0.02	99.16	99.16	0.00	99.42	99.40	-0.02
7	55.8	99.14	99.13	-0.01	99.44	99.42	-0.02	99.62	99.61	-0.01
8	92.0	100.04	100.05	0.01	100.28	100.25	-0.03	100.34	100.37	0.03

Table B-13. Water surface elevation calibration results (ft) for Antelope Creek Study Site between Dry Creek and upstream diversion using MANSQ for transects 1 and 4-5 and WSP for transects 2-3.

Transect	Distance from next downstream transect (ft)	2 cfs			3 cfs			109 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	98.24	98.25	0.01	98.32	98.31	-0.01	99.54	99.54	0.00
2	15.5	98.48	98.48	0.00	98.58	98.58	0.00	99.74	99.74	0.00
3	18	98.50	98.48	-0.02	98.60	98.58	-0.02	99.85	99.83	-0.02
4	19	98.53	98.54	0.01	98.61	98.62	0.01	100.01	100.01	0.00
5	31.5	98.67	98.65	-0.02	98.72	98.72	0.00	100.11	100.11	0.00

Table B-14. Water surface elevation calibration results (ft) for Antelope Creek Study Site near confluence with Little Butte Creek using STGQ for transects 1 and 6 and WSP for transects 2-5 and 7-10.

Transect	Distance from next downstream transect (ft)	2 cfs			12 cfs			24 cfs		
		Water surface elevations (ft)								
		Measured	Simulated	Difference	Measured	Simulated	Difference	Measured	Simulated	Difference
1	0	91.10	91.10	0.00	91.27	91.29	0.02	91.40	91.39	-0.01
2	10	91.36	91.36	0.00	91.48	91.48	0.00	91.55	91.55	0.00
3	43	91.36	91.36	0.00	91.52	91.51	-0.01	91.66	91.64	-0.02
4	23	91.36	91.36	0.00	91.54	91.52	-0.02	91.69	91.66	-0.03
5	73	91.34	91.36	0.02	91.53	91.55	0.02	91.68	91.72	0.04
6	59	91.92	91.90	-0.02	92.05	92.10	0.05	92.23	92.20	-0.03
7	40	92.38	92.38	0.00	92.55	92.55	0.00	92.74	92.74	0.00
8	15	92.40	92.38	-0.02	92.55	92.57	0.02	92.75	92.77	0.02
9	32.5	92.40	92.38	-0.02	92.53	92.57	0.04	92.75	92.79	0.04
10	24	92.40	92.38	-0.02	92.56	92.57	0.01	92.76	92.79	0.03

Velocity Adjustment Factors

Table B-15. Emigrant Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																			
Transect	1	2	3	4	5	8	9	10	15	20	24	25	26	30	31	32	33	34	35	38
1	0.60	0.77	0.74	0.74	0.74	0.75	0.76	0.77	0.81	0.84	0.86	0.86	0.87	0.89	0.89	0.89	0.90	0.90	0.91	0.92
2	0.08	0.16	0.20	0.23	0.27	0.35	0.37	0.39	0.49	0.58	0.64	0.66	0.67	0.73	0.74	0.76	0.77	0.78	0.79	0.83
3	0.32	0.39	0.42	0.45	0.47	0.58	0.54	0.56	0.63	0.70	0.75	0.76	0.77	0.81	0.82	0.83	0.83	0.85	0.85	0.97
4	0.09	0.17	0.22	0.27	0.32	0.45	0.47	0.50	0.62	0.73	0.80	0.81	0.83	0.88	0.90	0.91	0.92	0.93	0.95	1.01
5	Hydraulic control																			
6	0.08	0.13	0.18	0.22	0.26	0.39	0.39	0.42	0.56	0.67	0.76	0.78	0.80	0.88	0.90	0.91	0.93	0.95	0.97	1.05
7	0.05	0.09	0.13	0.17	0.20	0.31	0.33	0.36	0.51	0.64	0.74	0.76	0.79	0.88	0.90	0.93	0.95	0.97	0.99	1.08
8	0.22	0.38	0.46	0.52	0.57	0.78	0.72	0.75	0.87	0.96	1.03	1.04	1.06	1.11	1.12	1.13	1.15	1.16	1.17	1.27
9	0.47	0.58	0.67	0.74	0.80	0.94	0.68	0.71	0.83	0.94	1.02	1.04	1.05	1.12	1.16	1.16	1.17	1.19	1.20	1.21
10	0.28	0.41	0.51	0.59	0.67	0.86	0.58	0.62	0.79	0.94	1.05	1.07	1.10	1.20	1.24	1.25	1.28	1.30	1.32	1.37

Table B-15 (continued). Emigrant Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)									
Transect	40	45	50	55	60	64	65	70	75	80
1	1.00	1.02	1.04	1.06	1.08	1.09	1.10	1.11	1.13	1.14
2	0.87	0.92	0.98	1.03	1.08	1.12	1.13	1.18	1.22	1.27
3	0.88	0.93	0.96	1.00	1.04	0.96	1.07	1.10	1.14	1.17
4	0.86	0.91	0.95	0.98	1.02	1.01	1.05	1.07	1.10	1.12
5	Hydraulic control									
6	0.85	0.91	0.97	1.03	1.08	1.07	1.14	1.19	1.23	1.28
7	0.77	0.84	0.91	0.97	1.04	1.05	1.10	1.16	1.22	1.27
8	1.02	1.07	1.11	1.14	1.18	1.12	1.21	1.24	1.26	1.29
9	1.27	1.34	1.41	1.47	1.53	1.56	1.59	1.64	1.69	1.74
10	1.44	1.55	1.66	1.76	1.86	1.92	1.95	2.05	2.14	2.23

Table B-16. Neil Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																					
Transect	2	5	10	13	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
1	0.71	0.72	0.83	0.88	0.89	0.97	1.04	1.12	1.16	1.23	1.29	1.34	1.40	1.43	1.48	1.53	1.59	1.62	1.67	1.70	1.75	1.79
2	0.70	0.98	1.20	1.33	1.05	1.12	1.22	1.31	1.38	1.43	1.50	1.55	1.64	1.67	1.74	1.80	1.85	1.90	1.94	1.98	2.05	2.08
3	0.35	0.54	0.78	0.86	0.76	0.88	0.99	1.10	1.19	1.27	1.36	1.45	1.52	1.59	1.65	1.74	1.79	1.88	1.92	1.99	2.06	2.13
4	Hydraulic control																					
5	0.20	0.42	0.76	0.96	0.61	0.75	0.89	0.99	1.11	1.21	1.31	1.40	1.48	1.55	1.62	1.68	1.75	1.80	1.86	1.92	1.95	2.00
6	0.14	0.20	0.36	0.49	0.32	0.37	0.42	0.46	0.51	0.56	0.59	0.64	0.68	0.71	0.74	0.78	0.81	0.85	0.88	0.90	0.94	0.97
7	0.26	0.42	0.74	0.98	0.78	0.91	1.06	1.15	1.27	1.38	1.47	1.56	1.63	1.72	1.78	1.86	1.93	1.97	2.04	2.10	2.18	2.23
8	0.31	0.50	0.83	1.05	0.75	0.87	0.96	1.03	1.11	1.17	1.23	1.27	1.31	1.36	1.38	1.42	1.45	1.47	1.50	1.52	1.54	1.57
9	0.22	0.40	0.69	0.87	0.61	0.71	0.81	0.89	0.96	1.02	1.07	1.13	1.18	1.22	1.26	1.29	1.33	1.36	1.38	1.41	1.44	1.47
10	0.18	0.38	0.70	0.90	0.60	0.73	0.85	0.96	1.06	1.15	1.23	1.30	1.37	1.44	1.50	1.55	1.60	1.66	1.70	1.75	1.79	1.83

Table B-17. Bear Creek between Emigrant Creek and Oak Street Diversion Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																					
Transect	7	10	15	18	20	25	30	35	39	40	45	50	55	60	65	66	70	75	80	85	90	100
1	0.90	0.93	0.91	0.92	0.95	0.97	1.00	1.03	1.00	1.01	1.04	1.06	1.07	1.09	1.11	1.11	1.13	1.14	1.14	1.15	1.17	1.19
2	0.53	0.62	0.75	0.82	0.86	0.96	1.03	1.11	1.16	0.88	0.92	0.97	0.99	1.04	1.07	1.07	1.10	1.14	1.16	1.19	1.21	1.27
3	0.64	0.76	0.91	1.00	1.05	1.17	1.27	1.36	1.43	0.99	1.04	1.08	1.12	1.15	1.19	1.20	1.22	1.26	1.29	1.32	1.35	1.40
4	0.53	0.63	0.77	0.84	0.88	0.99	1.08	1.16	1.22	1.02	1.09	1.15	1.18	1.20	1.20	1.21	1.24	1.29	1.34	1.38	1.42	1.50
5	1.19	1.27	1.33	1.36	1.35	1.36	1.38	1.12	1.15	1.55	1.55	1.56	1.56	1.61	1.59	1.58	1.62	1.65	1.64	1.65	1.66	1.55
6	0.78	0.89	1.01	0.99	0.93	1.04	1.14	1.22	1.27	1.03	1.07	1.03	1.02	1.07	1.12	1.11	1.16	1.19	1.20	1.25	1.28	1.32
7	0.61	0.73	0.84	0.90	0.95	1.03	1.13	1.19	1.22	0.99	1.04	1.09	1.14	1.19	1.23	1.25	1.29	1.34	1.37	1.41	1.46	1.55

Table B-18. Bear Creek between Oak Street Diversion and Valley View Road Study Site velocity adjustment factors (VAF).

Transect	Discharge (cfs) 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
1	0.51	0.54	0.56	0.57	0.63	0.67	0.72	0.75	0.79	0.82	0.84	0.85	0.87	0.90	0.92	0.94	0.96	0.98	1.00	1.02	1.03	1.05
2	0.39	0.49	0.57	0.63	0.68	0.73	0.77	0.81	0.85	0.89	0.92	0.95	0.98	1.01	1.04	1.07	1.09	1.12	1.15	1.10	1.11	1.13
3	1.29	1.23	1.17	1.04	1.09	1.09	1.07	1.07	1.04	1.02	0.99	0.97	0.95	0.94	0.94	0.94	0.93	0.93	0.93	0.93	0.93	0.93
4	0.68	0.74	0.78	0.81	0.83	0.85	0.87	0.84	0.86	0.88	0.89	0.90	0.91	0.91	0.92	0.92	0.92	0.93	0.93	0.91	0.92	0.93

Table B-18 (continued). Bear Creek between Oak Street Diversion and Valley View Road Study Site velocity adjustment factors (VAF).

Transect	Discharge (cfs) 23	23.2	24	25
1	1.06	1.07	1.08	1.09
2	1.15	1.15	1.17	1.19
3	0.93	0.93	0.93	0.93
4	0.94	0.94	0.95	0.95

Table B-19. Bear Creek between Oak Street Diversion and Phoenix Diversion Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																					
Transect	10	12	14	16	18	20	23	25	30	35	40	45	50	51	55	60	65	70	72	75	80	83
1	0.98	0.97	0.96	0.96	0.97	0.97	0.97	0.98	0.98	0.99	0.99	0.99	0.98	0.98	0.97	0.96	0.95	0.94	0.94	0.95	0.95	0.94
2	Hydraulic control																					
3	0.45	0.48	0.52	0.55	0.58	0.60	0.64	0.66	0.71	0.75	0.79	0.82	0.86	0.86	0.89	0.91	0.94	0.97	0.99	0.94	0.96	0.96
4	0.23	0.27	0.31	0.34	0.38	0.41	0.46	0.49	0.57	0.64	0.71	0.78	0.84	0.86	0.91	0.97	1.03	1.08	1.11	0.91	0.95	0.98
5	0.26	0.30	0.34	0.38	0.42	0.45	0.50	0.54	0.61	0.69	0.76	0.82	0.89	0.90	0.95	1.01	1.07	1.12	1.15	0.88	0.92	0.94
6	0.51	0.55	0.59	0.63	0.66	0.69	0.73	0.76	0.82	0.87	0.91	0.95	0.99	1.00	1.02	1.06	1.08	1.11	1.13	0.95	0.96	0.96
7	0.87	0.86	0.86	0.86	0.86	0.86	0.86	0.87	0.87	0.88	0.89	0.89	0.90	0.90	0.90	0.91	0.91	0.92	0.96	0.87	0.87	0.84
8	0.57	0.64	0.70	0.75	0.80	0.84	0.88	0.91	0.95	0.98	1.00	1.01	1.03	1.03	1.04	1.05	1.05	1.06	1.10	0.84	0.85	0.84
9	0.31	0.34	0.37	0.40	0.42	0.45	0.48	0.50	0.55	0.60	0.64	0.68	0.72	0.73	0.76	0.79	0.82	0.85	0.85	0.77	0.79	0.81
10	0.40	0.44	0.48	0.51	0.54	0.57	0.62	0.65	0.71	0.77	0.82	0.87	0.91	0.92	0.96	1.00	1.04	1.07	1.08	0.81	0.83	0.85
11	0.53	0.56	0.59	0.61	0.63	0.65	0.69	0.69	0.73	0.77	0.80	0.83	0.86	0.84	0.86	0.89	0.91	0.94	0.93	0.96	0.99	1.00
12	0.41	0.44	0.47	0.49	0.52	0.54	0.58	0.59	0.63	0.67	0.71	0.74	0.78	0.76	0.79	0.82	0.84	0.87	0.87	0.90	0.92	0.94
13	0.44	0.48	0.51	0.54	0.57	0.60	0.65	0.66	0.72	0.77	0.82	0.86	0.91	0.92	0.96	0.99	1.03	1.07	1.07	1.10	1.14	1.16

Table B-19 (continued). Bear Creek between Oak Street Diversion and Phoenix Diversion Study Site velocity adjustment factors (VAF).

	Discharge (cfs)							
Transect	85	90	95	100	110	117	120	130
1	0.94	0.93	0.93	0.93	0.92	0.92	0.91	0.91
2	Hydraulic control							
3	0.98	1.00	1.02	1.03	1.07	1.09	1.10	1.13
4	1.00	1.04	1.08	1.12	1.20	1.25	1.28	1.35
5	0.95	0.99	1.03	1.06	1.13	1.18	1.19	1.26
6	0.98	0.99	0.99	1.00	1.02	1.03	1.04	1.05
7	0.88	0.88	0.88	0.88	0.89	0.89	0.89	0.90
8	0.87	0.88	0.89	0.90	0.92	0.94	0.94	0.96
9	0.81	0.83	0.85	0.86	0.90	0.92	0.93	0.96
10	0.85	0.87	0.89	0.91	0.95	0.97	0.98	1.02
11	1.01	1.03	1.05	1.07	1.12	1.14	1.16	1.19
12	0.95	0.97	1.00	1.02	1.07	1.10	1.11	1.15
13	1.17	1.20	1.24	1.27	1.33	1.37	1.38	1.44

Table B-20. Bear Creek between Phoenix Diversion and Jackson Street Diversion Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																				
Transect	5	10	12	15	20	25	30	33	40	45	50	55	60	65	70	71	80	85	90	100	110	120
1	Hydraulic control																					
2	0.85	1.09	1.14	0.80	0.87	0.93	0.99	1.05	0.88	0.91	0.94	0.97	1.00	1.02	1.05	1.03	1.09	1.11	1.13	1.17	1.20	1.24
3	0.75	1.21	1.35	1.57	1.86	2.12	2.35	2.52	0.79	0.84	0.89	0.93	0.97	1.01	1.05	1.05	1.13	1.16	1.20	1.26	1.32	1.37
4	0.59	0.97	1.09	1.27	1.52	1.74	1.93	2.07	0.73	0.78	0.83	0.87	0.91	0.95	0.99	0.99	1.06	1.09	1.13	1.19	1.24	1.29
5	0.74	1.11	1.21	1.38	1.59	1.78	1.94	2.07	0.83	0.87	0.92	0.96	0.99	1.03	1.06	1.06	1.13	1.16	1.19	1.25	1.30	1.34
6	0.45	0.76	0.85	1.01	1.23	1.43	1.61	1.74	0.65	0.69	0.74	0.78	0.83	0.87	0.90	0.91	0.98	1.01	1.05	1.11	1.17	1.23
7	0.87	1.28	1.37	1.58	1.81	2.02	2.20	2.35	1.07	1.09	1.12	1.15	1.17	1.19	1.21	1.20	1.26	1.28	1.30	1.31	1.30	1.29
8	0.56	0.71	0.75	0.82	0.91	0.98	1.06	1.10	0.85	0.89	0.93	0.97	1.00	1.04	1.07	1.08	1.13	1.16	1.19	1.25	1.30	1.35
9	0.94	1.00	0.96	1.06	1.10	1.14	1.17	1.14	0.86	0.88	0.90	0.91	0.93	0.94	0.96	0.88	0.99	1.00	1.01	1.04	1.06	1.09
10	0.86	1.12	1.15	1.31	1.48	1.62	1.74	1.76	0.86	0.90	0.94	0.97	1.01	1.04	1.08	1.02	1.14	1.17	1.20	1.25	1.30	1.35
11	0.59	0.72	0.72	0.82	0.90	0.98	1.05	1.05	0.81	0.84	0.88	0.91	0.95	0.98	1.01	0.95	1.06	1.09	1.12	1.17	1.21	1.26
12	0.47	0.67	0.70	0.82	0.95	1.06	1.17	1.19	0.77	0.81	0.86	0.90	0.94	0.97	1.01	0.96	1.07	1.11	1.14	1.20	1.25	1.31
13	0.58	0.72	0.72	0.82	0.91	0.99	1.06	1.05	0.84	0.88	0.91	0.94	0.97	1.00	1.03	0.96	1.08	1.10	1.12	1.16	1.19	1.22
14	0.90	1.00	0.97	1.09	1.15	1.20	1.25	1.21	1.01	1.01	1.02	1.02	1.03	1.03	1.04	0.94	1.05	1.05	1.06	1.07	1.08	1.09
15	0.75	0.89	0.87	0.76	0.83	0.88	0.94	0.96	0.93	0.97	1.00	1.04	1.07	1.10	1.13	1.05	1.19	1.21	1.24	1.29	1.34	1.39
16	0.51	0.72	0.75	0.88	1.02	1.14	1.25	1.29	0.71	0.75	0.79	0.83	0.87	0.91	0.94	0.90	1.01	1.04	1.07	1.13	1.18	1.23

Table B-20 (continued). Bear Creek between Phoenix Diversion and Jackson Street Diversion Study Site velocity adjustment factors (VAF).

	Discharge (cfs)							
Transect	130	140	150	160	170	180	190	200
1	Hydraulic control							
2	1.27	1.29	1.32	1.35	1.37	1.40	1.42	1.44
3	1.42	1.48	1.52	1.57	1.61	1.66	1.70	1.74
4	1.34	1.39	1.43	1.48	1.52	1.56	1.59	1.63
5	1.38	1.43	1.47	1.51	1.54	1.58	1.62	1.65
6	1.28	1.34	1.39	1.44	1.48	1.53	1.57	1.61
7	1.28	1.27	1.26	1.26	1.25	1.24	1.23	1.22
8	1.40	1.45	1.49	1.54	1.58	1.62	1.66	1.70
9	1.11	1.13	1.15	1.17	1.19	1.21	1.22	1.24
10	1.40	1.44	1.48	1.53	1.57	1.60	1.64	1.68
11	1.31	1.35	1.39	1.43	1.47	1.51	1.54	1.58
12	1.36	1.41	1.46	1.50	1.55	1.59	1.63	1.67
13	1.25	1.28	1.30	1.33	1.35	1.38	1.40	1.42
14	1.10	1.11	1.12	1.14	1.15	1.16	1.17	1.18
15	1.44	1.48	1.52	1.56	1.60	1.64	1.68	1.72
16	1.28	1.32	1.36	1.40	1.44	1.47	1.51	1.54

Table B-21. South Fork Little Butte Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																								
Transect	7	10	15	17	20	22	25	30	35	40	45	50	55	60	65	70	75	80	85	90	93	95	100	105	110
1	1.01	0.99	0.98	0.97	0.98	0.98	1.09	1.11	1.12	1.12	1.13	1.15	1.16	1.17	1.19	1.20	1.21	1.23	1.24	1.25	1.26	1.27	1.28	1.29	1.31
2	0.59	0.67	0.77	0.81	0.86	0.89	0.86	0.91	0.96	0.76	0.79	0.82	0.84	0.87	0.89	0.92	0.94	0.96	0.98	1.00	1.01	1.02	1.04	1.06	1.08
3	0.67	0.74	0.82	0.85	0.89	0.92	0.95	1.02	1.07	1.12	1.16	1.21	1.24	1.28	1.32	1.35	1.38	1.41	1.44	1.47	1.49	1.50	1.53	1.55	1.58
4	0.51	0.58	0.67	0.72	0.75	0.77	0.81	0.86	0.87	0.94	0.98	1.01	1.05	1.08	1.11	1.14	1.17	1.20	1.22	1.25	1.29	1.27	1.30	1.32	1.34
5	0.52	0.63	0.78	0.84	0.90	0.94	0.80	0.87	0.93	1.01	1.06	1.12	1.17	1.22	1.26	1.30	1.34	1.38	1.42	1.45	1.48	1.49	1.52	1.55	1.58
6	0.89	0.94	0.98	0.99	1.00	0.99	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.16	1.16	1.17	1.18	1.18	1.19	1.20	1.20	1.21	1.21	1.22	1.23
7	0.67	0.75	0.86	0.90	0.95	0.98	0.85	0.90	0.95	0.99	1.04	1.08	1.11	1.15	1.19	1.22	1.25	1.29	1.32	1.35	1.36	1.38	1.41	1.43	1.46
8	0.57	0.66	0.78	0.82	0.88	0.92	0.86	0.94	1.00	1.06	1.12	1.18	1.23	1.28	1.33	1.38	1.42	1.47	1.51	1.55	1.58	1.59	1.63	1.67	1.71

Table B-21 (continued). South Fork Little Butte Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)				
Transect	115	120	130	140	150
1	1.32	1.33	1.35	1.38	1.40
2	1.10	1.12	1.15	1.19	1.22
3	1.61	1.63	1.68	1.73	1.77
4	1.36	1.39	1.43	1.47	1.50
5	1.61	1.64	1.69	1.74	1.79
6	1.24	1.24	1.26	1.27	1.28
7	1.49	1.52	1.57	1.62	1.67
8	1.75	1.78	1.85	1.92	1.99

Table B-22. Little Butte Creek between Antelope Creek and South Fork Little Butte Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																							
Transect	15	20	25	30	35	40	44	45	50	55	60	65	67	70	75	80	85	90	100	110	120	130	140	150
1	1.34	1.27	1.21	1.17	1.11	1.07	1.09	1.11	1.10	1.09	1.08	1.07	1.06	1.06	1.06	1.05	1.04	1.04	1.03	1.03	1.02	1.02	1.02	1.02
2	0.59	0.74	0.87	0.99	1.10	0.94	1.01	1.02	1.09	1.17	1.24	1.31	1.33	1.37	1.44	1.50	1.56	1.62	1.73	1.84	1.94	2.03	2.12	2.21
3	0.68	0.81	0.92	1.02	1.10	1.02	1.08	1.08	1.14	1.20	1.25	1.30	1.32	1.35	1.40	1.45	1.49	1.53	1.61	1.69	1.76	1.83	1.89	1.95
4	0.89	0.97	1.04	1.11	1.15	0.95	1.00	0.99	1.02	1.05	1.08	1.11	1.12	1.14	1.16	1.19	1.21	1.23	1.27	1.31	1.35	1.38	1.41	1.44
5	1.09	1.01	0.96	0.93	0.92	0.90	0.90	0.90	0.89	0.89	0.89	0.89	0.89	0.89	0.90	0.90	0.90	0.90	0.91	0.92	0.92	0.93	0.94	0.94
6	0.85	0.85	0.86	0.87	0.87	0.87	0.90	0.88	0.89	0.91	0.92	0.94	0.93	0.95	0.96	0.98	0.99	1.00	1.03	1.05	1.07	1.09	1.12	1.14
7	0.73	0.83	0.91	0.98	1.03	0.96	1.01	1.01	1.05	1.10	1.13	1.17	1.18	1.21	1.24	1.27	1.31	1.34	1.39	1.45	1.50	1.55	1.59	1.64
8	0.49	0.60	0.70	0.79	0.87	0.79	0.85	0.85	0.91	0.97	1.03	1.08	1.10	1.13	1.18	1.23	1.28	1.33	1.41	1.50	1.58	1.65	1.73	1.80

Table B-22 (continued). Little Butte Creek between Antelope Creek and South Fork Little Butte Creek Study Site velocity adjustment factors (VAF).

Transect	Discharge (cfs)				
	160	170	180	190	200
1	1.02	1.02	1.02	1.02	1.02
2	2.29	2.37	2.45	2.52	2.59
3	2.01	2.06	2.11	2.16	2.21
4	1.47	1.49	1.52	1.54	1.57
5	0.95	0.96	0.96	0.97	0.98
6	1.16	1.18	1.19	1.21	1.23
7	1.68	1.72	1.76	1.80	1.84
8	1.86	1.93	1.99	2.06	2.12

Table B-23. Little Butte Creek between Antelope Creek and Rogue River Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																			
Transect	15	20	25	30	35	37	40	45	50	55	60	65	70	75	80	85	90	94	95	100
1	0.72	0.80	0.87	0.93	0.98	0.98	0.62	0.65	0.68	0.71	0.73	0.75	0.78	0.80	0.82	0.84	0.86	0.95	1.01	1.03
2	0.59	0.67	0.75	0.81	0.88	0.88	0.86	0.89	0.91	0.93	0.95	0.96	0.98	0.99	1.01	1.02	1.03	1.15	1.05	1.06
3	0.91	0.91	0.89	0.88	0.87	0.77	0.92	0.92	0.93	0.93	0.94	0.95	0.95	0.96	0.97	0.98	0.98	1.10	0.99	1.00
4	1.37	1.29	1.22	1.17	1.15	1.01	1.00	0.99	0.99	0.99	0.99	0.99	1.00	1.00	1.01	1.01	1.02	1.13	1.03	1.03
5	0.64	0.73	0.80	0.87	0.94	0.96	0.62	0.66	0.69	0.72	0.75	0.78	0.81	0.83	0.86	0.88	0.90	0.92	0.93	0.95
6	0.77	0.83	0.90	0.95	1.01	1.03	0.76	0.80	0.83	0.87	0.90	0.93	0.96	0.99	1.01	1.04	1.07	1.09	1.09	1.12
7	0.72	0.77	0.81	0.85	0.88	0.90	0.81	0.84	0.87	0.89	0.92	0.95	0.97	0.99	1.01	1.04	1.06	1.07	1.06	1.06
8	0.49	0.58	0.66	0.73	0.80	0.83	0.51	0.55	0.59	0.62	0.65	0.68	0.71	0.74	0.77	0.80	0.82	0.85	0.85	0.88

Table B-23 (continued). Little Butte Creek between Antelope Creek and Rogue River Study Site velocity adjustment factors (VAF).

	Discharge (cfs)			
Transect	160	170	175	180
1	1.23	1.26	1.27	1.29
2	1.18	1.20	1.21	1.22
3	1.09	1.11	1.02	1.12
4	1.12	1.13	1.05	1.14
5	1.00	1.03	1.05	1.06
6	1.39	1.43	1.45	1.47
7	1.12	1.13	1.13	1.14
8	1.15	1.19	1.21	1.23

Table B-24. Antelope Creek between Antelope Creek Diversion and Dry Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																					
Transect	2	3	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	109
1	0.72	0.75	0.86	0.92	0.96	0.99	1.01	1.03	1.05	1.06	1.08	1.09	1.10	1.11	1.12	1.12	1.13	1.13	1.13	1.13	1.13	1.13
2	0.71	0.73	0.65	0.70	0.76	0.80	0.83	0.86	0.88	0.90	0.92	0.94	0.96	0.97	0.98	1.00	1.01	1.02	1.03	1.04	1.05	1.06
3	0.73	0.92	0.39	0.48	0.56	0.63	0.68	0.73	0.78	0.82	0.85	0.89	0.92	0.95	0.98	1.01	1.03	1.06	1.08	1.10	1.12	1.15
4	0.78	0.85	0.55	0.62	0.67	0.72	0.76	0.79	0.83	0.85	0.88	0.91	0.93	0.94	0.95	0.97	0.98	0.99	1.00	1.02	1.03	1.05
5	0.79	0.90	0.57	0.64	0.69	0.74	0.77	0.81	0.84	0.86	0.88	0.91	0.93	0.94	0.96	0.97	0.98	1.00	1.01	1.02	1.03	1.05

Table B-25. Antelope Creek between Dry Creek and Little Butte Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)																							
Transect	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	24	25	30	35
1	0.50	0.65	0.71	0.76	0.81	0.83	0.84	0.85	0.86	0.87	0.88	0.90	0.93	0.95	0.97	0.98	1.00	1.01	1.03	1.04	1.06	1.10	1.11	1.18	1.24
2	0.12	0.18	0.24	0.29	0.33	0.37	0.42	0.46	0.49	0.53	0.57	0.62	0.54	0.57	0.60	0.62	0.65	0.68	0.71	0.73	0.76	0.82	0.86	0.98	1.09
3	0.12	0.23	0.32	0.41	0.50	0.58	0.66	0.74	0.82	0.89	0.96	1.04	0.67	0.71	0.75	0.78	0.82	0.86	0.89	0.92	0.96	1.04	1.08	1.21	1.32
4	0.14	0.24	0.35	0.44	0.53	0.62	0.70	0.78	0.86	0.93	1.00	1.08	0.70	0.73	0.77	0.81	0.84	0.88	0.91	0.94	0.97	1.05	1.08	1.20	1.30
5	0.13	0.24	0.34	0.44	0.53	0.62	0.70	0.79	0.87	0.94	1.01	1.09	0.64	0.68	0.71	0.75	0.78	0.81	0.84	0.87	0.90	0.97	1.00	1.10	1.20
6	0.24	0.35	0.43	0.50	0.56	0.62	0.67	0.72	0.76	0.80	0.85	0.89	0.78	0.81	0.84	0.87	0.90	0.93	0.96	0.99	1.01	1.09	1.11	1.23	1.34
7	Hydraulic control																								
8	0.20	0.31	0.43	0.53	0.62	0.70	0.78	0.85	0.92	0.99	1.06	1.23	0.69	0.73	0.76	0.80	0.83	0.86	0.89	0.92	0.95	0.98	1.05	1.18	1.29
9	0.18	0.32	0.47	0.61	0.74	0.87	0.99	1.11	1.23	1.35	1.47	1.64	0.68	0.73	0.77	0.81	0.86	0.90	0.94	0.98	1.02	1.12	1.18	1.37	1.55
10	0.17	0.31	0.46	0.59	0.72	0.85	0.98	1.10	1.22	1.34	1.46	1.62	0.57	0.60	0.64	0.67	0.71	0.74	0.78	0.81	0.84	0.92	0.97	1.12	1.27

Table B-25 (continued). Antelope Creek between Dry Creek and Little Butte Creek Study Site velocity adjustment factors (VAF).

	Discharge (cfs)				
Transect	40	45	50	55	60
1	1.29	1.35	1.40	1.45	1.50
2	1.20	1.31	1.42	1.52	1.62
3	1.42	1.51	1.59	1.65	1.71
4	1.39	1.46	1.52	1.58	1.62
5	1.28	1.35	1.41	1.46	1.51
6	1.44	1.53	1.63	1.71	1.80
7	Hydraulic control				
8	1.40	1.49	1.58	1.66	1.73
9	1.73	1.89	2.05	2.20	2.34
10	1.40	1.53	1.65	1.77	1.88

Table B-26. Velocity calibration results for Emigrant Creek Study Site.

Trans 1		38 cfs		64 cfs		Trans 2		38 cfs		64 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	98.9					0.0	99.1				
0.9	98.8			0.0	0.0	1.1	99.0				
2.8	98.3	0.0	0.5	0.1	0.1	1.4	98.8			0.0	0.0
3.5	98.2	0.6	0.7	0.7	0.7	1.7	98.3	0.0	0.0	0.2	0.2
4.5	98.2	0.2	0.2	0.4	0.4	2.0	98.3	0.0	0.0	0.2	0.2
6.2	97.5	0.7	0.7	0.9	1.0	3.0	98.0	0.4	0.4	0.1	0.1
7.0	97.5	0.9	0.9	0.9	0.9	4.0	97.9	0.4	0.4	0.4	0.4
8.0	97.5	1.1	1.1	1.3	1.4	5.0	97.7	0.4	0.3	1.1	1.2
9.0	97.4	1.2	1.2	1.4	1.5	6.0	98.0	0.4	0.4	0.5	0.5
10.0	97.3	1.0	1.0	1.5	1.5	7.0	97.8	0.6	0.5	0.4	0.5
11.0	97.4	1.1	1.0	1.3	1.3	8.0	98.1	0.0	0.4	0.8	0.9
12.0	97.3	1.0	0.9	1.4	1.5	9.0	97.9	0.5	0.5	0.9	1.0
13.0	97.3	1.1	1.0	1.4	1.5	10.0	97.9	0.5	0.5	0.8	0.9
14.0	97.4	0.7	0.7	1.0	1.1	11.0	97.8	0.2	0.2	0.6	0.7
15.0	97.7	1.9	1.8	2.1	2.2	11.6	98.0	0.3	0.3	0.7	0.7
16.0	97.4	2.5	2.3	2.4	2.6	12.0	97.7	0.3	0.3	0.6	0.7
17.0	97.2	2.5	2.4	2.4	2.6	12.5	97.8	0.4	0.4	0.8	0.8
18.0	97.2	2.7	2.6	3.0	3.2	13.0	97.6	0.6	0.5	0.9	1.0
19.0	97.6	3.5	3.3	3.6	3.9	13.5	97.5	0.6	0.5	1.2	1.3
20.0	97.5	4.2	4.0	4.3	4.6	14.0	97.4	0.9	0.8	1.7	1.8
21.0	97.2	4.0	3.7	4.3	4.6	14.5	97.3	1.2	1.1	1.8	1.9
22.0	97.4	3.9	3.7	4.4	4.7	15.0	97.5	1.2	1.0	1.9	2.1
23.0	97.3	2.9	2.8	4.5	4.9	15.5	97.3	1.3	1.2	2.1	2.3
24.0	98.1	1.4	1.4	2.9	3.0	16.0	97.3	1.9	1.7	2.6	2.8
25.0	97.4	0.3	0.3	0.2	0.2	16.5	97.3	2.3	2.0	3.1	3.4
26.0	97.5	0.0	0.0	0.1	0.1	17.0	96.9	2.5	2.1	3.0	3.3
27.0	98.5	0.0	0.0	0.4	0.4	17.5	97.0	3.0	2.6	3.0	3.3
27.4	98.7	0.0	0.0	0.3	0.2	18.0	96.4	3.6	3.1	2.4	2.7
27.5	98.8			0.0	0.0	18.5	96.3	4.1	3.5	2.8	3.1
29.0	99.4					19.0	96.5	3.0	2.6	3.3	3.7

Trans 1		38 cfs		64 cfs		Trans 2		38 cfs		64 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
30.4	99.5					19.5	96.4	4.0	3.4	3.8	4.2
						20.0	96.4	3.2	2.8	3.7	4.0
						20.5	96.5	3.1	2.7	3.0	3.2
						21.0	96.6	2.8	2.4	2.7	3.0
						21.5	96.4	1.8	1.6	2.5	2.8
						22.0	96.3	1.2	1.0	2.3	2.5
						22.5	97.2	0.9	0.8	2.3	2.5
						23.0	97.5	0.2	0.2	1.5	1.6
						23.5	97.4	0.1	0.1	0.8	0.9
						24.0	97.4	0.3	0.2	0.7	0.7
						24.5	97.3	0.3	0.3	0.4	0.5
						25.0	97.3	0.4	0.4	0.1	0.1
						25.5	97.2	0.5	0.4	0.1	0.1
						26.0	97.5	0.6	0.5	0.4	0.4
						26.2	97.6	0.5	0.4	0.6	0.6
						26.8	97.8	0.7	0.6	0.6	0.7
						28.0	98.6	0.0	0.0	0.4	0.4
						28.5	98.8			0.0	0.0
						29.0	99.3				
						30.1	99.5				

Table B-26 (continued)

Trans 3		38 cfs		64 cfs		Trans 4		38 cfs		64 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	100.0					0.0	100.3				
1.0	99.7			0.0	0.1	0.5	100.0				
2.0	99.5			0.6	0.6	0.9	99.8			0.1	0.1
2.6	99.5	0.0	0.0	0.4	0.4	1.2	99.6	0.0	0.0	0.1	0.1
3.0	99.5	0.0	0.0	0.3	0.3	2.0	99.5	0.0	0.0	0.1	0.1
4.0	99.3	0.1	0.1	0.5	0.5	3.0	99.3	0.8	0.8	0.1	0.0
5.0	99.1	0.5	0.5	0.1	0.1	4.0	99.1	0.0	0.0	0.2	0.2
6.0	99.0	1.4	1.5	1.9	1.8	5.1	98.9	0.0	0.0	0.2	0.2
7.0	99.0	1.5	1.6	2.5	2.4	5.5	98.8	0.0	0.0	0.2	0.2
8.0	99.2	1.7	1.8	2.8	2.7	6.0	98.7	0.1	0.0	0.1	0.1
9.0	98.9	1.7	1.8	2.6	2.5	6.5	98.8	0.0	0.0	0.3	0.3
9.5	98.7	1.4	1.4	2.1	2.0	7.0	98.9	0.0	0.0	1.0	1.0
10.0	99.1	2.2	2.4	3.2	3.1	7.5	99.0	0.1	0.1	1.7	1.7
10.5	98.9	0.4	0.4	0.2	0.2	8.0	99.0	0.1	0.1	2.3	2.3
11.0	98.8	2.3	2.4	3.1	3.0	8.5	98.8	0.2	0.2	2.7	2.7
11.5	98.7	2.4	2.5	3.2	3.0	9.0	98.6	0.3	0.3	2.7	2.7
12.0	98.8	2.2	2.3	3.1	3.0	9.5	98.5	1.0	1.0	2.3	2.3
12.5	98.7	2.2	2.2	2.4	2.3	10.0	98.5	1.3	1.3	2.6	2.6
13.0	98.9	2.3	2.4	3.2	3.0	10.5	98.3	1.7	1.7	2.5	2.5
13.5	98.8	1.6	1.6	2.4	2.3	11.0	98.2	2.1	2.1	2.5	2.6
14.0	98.8	1.8	1.8	2.4	2.3	11.5	98.3	2.5	2.5	2.6	2.6
14.5	98.7	2.3	2.4	3.3	3.2	12.0	98.4	2.7	2.6	2.8	2.8
15.0	98.7	2.5	2.5	3.2	3.1	12.5	98.2	2.3	2.3	2.6	2.6
15.5	98.6	2.6	2.7	3.5	3.3	13.0	97.9	1.9	1.9	1.9	1.9
16.0	98.9	2.8	2.8	3.4	3.3	13.5	97.8	1.4	1.4	1.2	1.2
16.5	98.6	2.3	2.3	2.8	2.7	14.0	97.9	1.3	1.3	1.2	1.2
17.0	98.7	2.2	2.2	3.1	2.9	14.5	97.8	1.1	1.1	1.2	1.2
17.5	98.6	2.3	2.3	3.5	3.4	15.0	97.9	1.1	1.1	1.5	1.5
18.0	98.9	3.0	3.1	4.0	3.9	15.5	97.9	1.6	1.6	2.2	2.2
18.5	98.9	3.2	3.3	4.2	4.1	16.0	97.9	1.9	1.9	2.5	2.5

Trans 3		38 cfs		64 cfs		Trans 4		38 cfs		64 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
19.0	99.0	2.9	3.0	4.1	4.0	16.5	98.5	2.2	2.2	2.9	2.9
19.5	99.0	3.3	3.4	3.8	3.6	17.0	98.6	2.4	2.4	3.0	3.0
20.0	99.0	3.9	4.1	3.8	3.7	17.5	98.7	2.6	2.6	2.9	2.9
20.5	99.1	0.4	0.4	4.3	4.1	18.2	98.4	2.2	2.2	2.4	2.4
21.0	99.0	3.5	3.6	3.7	3.6	18.5	98.3	1.8	1.8	2.5	2.5
21.5	99.2	4.1	4.5	4.6	4.5	19.0	98.5	2.0	2.0	2.7	2.7
22.0	98.9	3.4	3.5	2.7	2.6	19.5	98.5	2.3	2.3	2.4	2.4
22.5	99.0	2.7	2.8	3.6	3.5	20.0	98.6	2.3	2.3	2.2	2.2
23.0	99.0	3.6	3.8	3.8	3.7	20.6	98.7	2.0	2.0	2.4	2.4
23.5	98.8	3.4	3.4	3.9	3.8	21.0	98.8	2.0	2.0	2.3	2.3
24.0	98.9	3.2	3.3	3.8	3.7	21.5	98.9	2.2	2.2	2.6	2.6
24.5	99.0	2.8	2.9	4.1	4.0	22.0	99.0	1.5	1.5	2.5	2.5
25.0	99.0	3.9	4.1	3.7	3.5	22.5	98.9	1.1	1.1	1.5	1.4
25.5	98.9	3.7	3.8	3.4	3.3	23.0	99.0	2.1	2.0	2.1	2.1
26.0	98.9	2.9	3.0	2.2	2.1	24.0	99.1	1.9	1.9	2.3	2.2
26.5	99.0	3.8	3.9	2.8	2.7	25.0	99.5	1.0	0.9	1.9	1.9
27.0	98.9	2.4	2.5	3.2	3.1	26.0	99.2	1.1	1.1	1.7	1.7
27.5	98.9	2.5	2.5	2.6	2.5	27.0	99.2	1.5	1.5	1.5	1.5
28.0	99.0	3.0	3.1	3.3	3.1	28.0	99.3	0.9	0.9	1.5	1.4
28.4	99.2	2.2	2.5	3.0	2.9	29.0	99.1	1.0	0.9	1.6	1.6
29.0	99.2	1.6	1.7	2.9	2.8	30.0	99.3	1.4	1.3	1.7	1.7
31.0	99.4	0.0	0.9	2.7	2.6	31.0	99.2	1.3	1.2	1.8	1.8
33.0	99.0	0.7	0.8	1.7	1.6	32.0	99.1	1.5	1.5	1.9	1.8
35.0	99.0	0.2	0.2	0.9	0.9	33.0	99.8			0.1	0.1
37.0	99.0	0.2	0.2	0.2	0.1	34.0	99.3	1.1	1.0	0.8	0.7
39.0	99.0	0.2	0.2	0.2	0.2	35.0	99.4	0.1	0.1	0.4	0.4
41.0	99.0	0.2	0.2	0.5	0.4	36.0	99.6	0.1	0.1	0.3	0.3
41.9	99.4	0.0	0.1	0.2	0.2	36.9	99.8	0.0	0.0	0.1	0.1
42.1	99.7			0.0	0.0	43.0	99.7			0.2	0.2
43.0	100.0					44.0	99.6	0.0	0.1	0.1	0.1
45.7	100.5					46.6	99.9			0.0	0.0

Trans 3		38 cfs		64 cfs		Trans 4		38 cfs		64 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
						47.0	100.0				
						48.1	100.1				

Table B-26 (continued)

Trans 6		38 cfs		64 cfs		Trans 7		38 cfs		64 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	101.3					0.0	100.3				
0.6	100.9					1.0	100.1			0.0	0.0
1.1	99.9			0.0	0.0	1.1	99.5	0.0	0.0	0.1	0.1
1.2	99.9	0.0	0.0	0.0	0.0	1.5	99.0	0.0	0.0	0.1	0.1
1.7	99.3	0.2	0.2	0.1	0.1	3.0	97.0	0.0	0.0	0.0	0.0
2.0	99.1	0.2	0.2	0.2	0.2	4.5	96.6	0.2	0.2	0.2	0.2
3.5	98.4	0.3	0.3	0.3	0.3	6.0	96.8	0.7	0.8	0.3	0.3
5.0	98.5	0.6	0.6	0.6	0.6	7.5	96.9	1.1	1.2	1.2	1.3
6.5	98.1	0.5	0.5	0.8	0.8	9.0	96.9	1.1	1.2	1.6	1.7
8.0	98.1	0.8	0.9	1.0	1.1	10.5	96.9	1.0	1.1	1.5	1.6
9.5	98.0	1.1	1.1	1.4	1.5	12.0	96.9	0.8	0.9	1.3	1.3
11.0	98.1	1.0	1.1	1.4	1.6	13.5	97.0	0.5	0.6	1.0	1.1
12.5	98.1	1.1	1.2	1.4	1.5	15.0	97.1	0.2	0.2	0.9	0.9
14.0	98.2	1.1	1.2	1.4	1.5	16.5	97.1	0.1	0.1	0.6	0.7
15.5	98.2	1.0	1.0	1.3	1.4	18.0	97.4	0.1	0.1	0.3	0.3
17.0	98.1	0.8	0.8	1.2	1.3	19.5	97.6	0.1	0.1	0.9	1.0
18.5	98.0	0.8	0.8	1.2	1.3	21.0	97.7	0.8	0.9	0.8	0.8
20.0	98.0	0.7	0.7	1.1	1.2	22.5	97.7	0.8	0.9	0.8	0.8
21.5	98.0	0.8	0.8	1.0	1.1	24.0	98.0	0.7	0.7	1.0	1.1
23.0	98.1	0.8	0.8	1.1	1.2	25.5	97.8	0.3	0.3	0.9	1.0
24.5	98.3	0.9	0.9	1.1	1.2	27.0	97.8	0.1	0.1	0.2	0.2
26.0	98.4	0.7	0.7	1.2	1.3	28.5	98.0	0.1	0.1	0.2	0.2
27.5	98.6	0.7	0.7	1.1	1.2	30.0	98.6	0.1	0.1	0.2	0.2
29.0	98.9	0.6	0.6	1.0	1.1	31.9	99.3	0.0	0.0	0.1	0.1
30.5	99.0	0.5	0.5	0.9	1.0	32.7	99.6	0.0	0.0	0.1	0.1

Trans 6		38 cfs		64 cfs		Trans 7		38 cfs		64 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
31.3	99.2	0.5	0.5	0.9	1.0	33.4	100.0	0.0	0.0	0.1	0.2
33.5	99.4	0.3	0.3	0.6	0.7	33.7	100.1			0.0	0.1
35.2	100.0	0.0	0.0	0.2	0.3	34.0	100.2				
35.8	100.1			0.0	0.1	34.6	100.4				
36.0	100.4										
38.6	100.8										

Table B-26 (continued)

Trans 8		38 cfs		64 cfs		Trans 9		8 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	100.3					0.0	100.4				0.0
0.2	100.2			0.0	0.0	3.0	99.9				0.0
0.6	100.0	0.0	0.0	0.2	0.2	4.0	99.8			0.0	0.0
1.5	99.4	0.2	0.2	0.2	0.2	4.7	98.7	0.0	0.0	0.2	0.2
2.2	99.2	0.1	0.1	0.1	0.1	5.0	98.6	0.0	0.0	0.1	0.1
3.0	99.0	0.2	0.2	0.1	0.1	5.5	98.3	0.0	0.1	0.1	0.1
4.5	98.7	0.1	0.2	0.4	0.4	6.0	98.2	0.1	0.1	0.0	0.0
6.0	98.4	0.2	0.3	0.3	0.3	6.5	98.2	0.1	0.1	0.1	0.1
7.5	98.3	0.2	0.2	0.3	0.3	7.0	98.2	0.4	0.4	0.6	0.6
9.0	98.2	0.2	0.2	0.0	0.0	7.5	98.2	0.2	0.2	0.6	0.7
10.5	98.4	0.2	0.3	0.2	0.2	8.0	98.1	0.1	0.1	0.6	0.6
12.0	98.2	0.4	0.5	0.6	0.6	8.5	98.1	1.7	1.6	1.3	1.4
13.5	98.3	0.6	0.7	0.6	0.6	9.0	98.1	2.0	1.8	2.6	3.0
15.0	98.4	0.6	0.7	1.0	1.1	9.5	98.0	2.2	2.1	3.8	4.2
16.5	98.5	0.6	0.7	1.0	1.1	10.0	98.1	2.2	2.1	4.5	5.0
18.0	98.4	0.8	1.0	1.4	1.5	10.5	98.1	1.8	1.7	4.4	4.9
19.5	98.5	0.8	0.9	1.0	1.2	11.0	98.1	1.6	1.5	4.4	4.9
21.0	98.7	0.9	1.1	1.3	1.5	11.5	98.1	2.5	2.4	4.2	4.7
22.5	98.8	1.0	1.2	0.9	1.0	12.0	98.0	2.5	2.3	4.5	5.0
24.0	98.9	1.0	1.2	1.8	2.0	12.5	97.9	1.3	1.2	2.9	3.3
25.5	98.8	1.1	1.4	1.7	1.9	13.0	98.1	1.4	1.3	3.5	4.0

Trans 8		38 cfs		64 cfs		Trans 9		8 cfs		30 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
27.0	98.7	1.4	1.7	2.1	2.4	13.5	98.1	1.8	1.7	4.4	5.0
28.5	99.3	1.7	2.0	2.2	2.5	14.0	98.2	1.3	1.2	2.5	2.8
30.0	99.1	1.3	1.6	2.2	2.5	14.5	98.2	1.6	1.5	3.9	4.4
31.5	98.9	1.4	1.7	2.1	2.3	15.0	98.2	0.7	0.7	4.4	5.0
33.0	99.1	1.4	1.7	1.8	2.0	15.5	98.3	2.3	2.2	3.8	4.2
34.5	99.1	1.2	1.4	1.7	1.9	16.0	98.3	2.8	2.6	3.8	4.2
36.0	99.2	1.3	1.5	1.4	1.6	16.5	98.4	2.5	2.4	3.0	3.4
37.5	99.3	1.1	1.4	1.2	1.4	17.0	98.4	2.3	2.1	3.0	3.4
39.0	99.4	1.0	1.1	1.1	1.2	17.5	98.5	1.1	1.1	2.4	2.7
41.0	99.4	0.9	1.1	0.8	0.9	18.3	98.5	0.8	0.8	2.1	2.4
43.7	100.1	0.0	0.0	0.1	0.1	19.0	98.6	0.0	0.3	2.0	2.2
43.8	100.2			0.0	0.0	20.0	98.6		0.3	1.4	1.5
45.3	100.6					21.0	98.9			0.9	0.0
						22.0	98.9			0.0	0.0
						24.5	99.4				
						25.2	100.4				
						26.8	100.6				
						27.5	101.1				
						28.6	101.6				

Table B-26 (continued)

Trans 10		8 cfs		30 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	101.7				
1.0	101.4				
2.0	101.2				
3.0	100.8				
4.0	100.2	0.0	0.1	0.0	0.1
4.3	100.2	0.0	0.1	0.1	0.1
6.0	100.0	0.3	0.3	1.2	1.4
7.5	100.2	0.4	0.5	1.4	1.6

Trans 10		8 cfs		30 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
9.0	100.0	0.7	0.7	1.5	1.7
10.5	99.6	0.2	0.2	0.5	0.6
12.0	99.8	0.1	0.1	0.4	0.5
13.5	99.9	0.4	0.3	1.1	1.3
15.0	99.9	0.8	0.7	0.5	0.6
16.5	99.7	0.1	0.1	0.1	0.1
18.0	99.6	1.1	1.0	1.4	1.6
19.5	99.6	0.2	0.2	0.8	0.9
21.0	99.5	0.6	0.6	1.5	1.7
22.5	99.7	0.9	0.8	2.4	2.8
24.0	99.8	1.2	1.1	2.9	3.4
25.5	99.8	0.3	0.3	2.5	2.9
27.0	99.8	0.3	0.3	1.4	1.6
28.5	99.8	1.2	1.1	2.0	2.3
30.0	100.0	0.7	0.7	0.9	1.1
31.5	99.9	0.8	0.8	2.4	2.8
33.0	99.8	1.7	1.5	2.1	2.5
34.5	100.0	2.0	1.8	1.9	2.1
36.0	100.2	0.2	0.3	2.1	2.3
37.0	100.5	0.0	0.0	0.0	0.0
37.7	100.5			0.0	0.0
38.6	100.8				

Table B-27. Velocity calibration results for Neil Creek Study Site.

Trans 1		13 cfs		30 cfs		Trans 2		13 cfs		30 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	96.3					0.0	96.2				
1.0	94.8					1.6	94.4			0.0	0.0
1.5	94.2			0.0	0.0	2.0	94.3	0.4	0.0	1.0	1.0
2.0	94.1			0.0	0.0	3.0	94.2	0.0	0.0	2.9	3.4
2.3	93.8	0.0	0.1	0.0	0.0	4.0	93.1	1.8	2.4	2.3	3.0
3.0	93.8	0.1	0.1	0.1	0.1	5.0	93.3	1.1	1.5	1.4	1.8
4.0	92.9	0.6	0.6	0.6	0.7	6.0	93.5	1.4	1.9	1.9	2.4
5.0	92.7	0.9	0.8	1.0	1.1	7.0	93.8	1.6	2.2	2.1	2.7
6.0	93.1	1.6	1.5	1.6	1.7	8.0	93.8	0.2	0.2	1.7	2.2
7.0	93.2	1.5	1.3	1.8	2.0	9.0	93.8	0.9	1.2	2.2	2.8
8.0	93.1	1.2	1.1	2.0	2.2	10.0	93.8	1.1	1.6	1.5	1.9
9.0	93.5	1.0	0.9	2.1	2.3	11.0	93.7	0.9	1.3	1.6	2.0
10.0	93.1	1.1	1.0	1.4	1.5	12.0	93.8	0.4	0.5	1.1	1.4
11.0	93.4	1.0	0.9	1.7	1.9	13.0	93.7	0.3	0.4	2.9	3.7
12.0	93.4	1.2	1.1	1.6	1.8	14.0	94.0	1.9	3.0	3.5	4.5
13.0	93.4	1.5	1.4	1.8	2.0	15.0	93.8	0.3	0.4	0.9	1.2
14.0	93.4	1.4	1.3	2.2	2.4	16.0	93.5	1.1	1.5	3.1	4.0
15.0	93.3	2.1	1.9	2.2	2.4	17.0	93.5	0.7	0.9	2.1	2.7
16.0	93.3	2.3	2.1	2.9	3.2	18.0	93.2	2.0	2.7	2.7	3.5
17.0	93.2	1.8	1.7	2.1	2.3	19.0	93.3	0.8	1.1	0.4	0.5
18.0	93.3	0.9	0.9	2.5	2.8	20.0	93.9	0.6	0.8	0.0	0.0
19.0	93.5	1.4	1.3	1.9	2.1	21.0	94.2	0.0	0.0	0.1	0.2
20.0	93.6	0.9	0.8	1.8	2.0	21.6	94.4			0.0	0.0
20.5	93.7	0.4	0.4	1.4	1.5	24.0	94.8				
21.0	93.8	0.0	0.0	1.1	1.2	27.5	97.2				
21.3	93.7	0.0	0.0	0.8	0.9						
22.0	93.9			0.4	0.5						
23.0	94.1			0.0	0.2						
23.2	94.2			0.0	0.0						
23.5	94.3										

Trans 1		13 cfs		30 cfs		Trans 2		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
25.5	96.1										
28.9	96.9										

Table B-27 (continued)

Trans 3		13 cfs		30 cfs		Trans 5		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	97.5					0.0	96.7				
1.0	97.1					2.0	95.9				
3.5	94.7			0.0	0.0	4.9	95.0			0.0	0.1
4.0	94.5			0.2	0.2	5.0	94.9			0.1	0.1
4.3	94.4	0.0	0.0	0.1	0.2	5.4	94.8	0.0	0.0	0.1	0.1
5.0	94.1	0.0	0.0	0.1	0.1	6.0	94.6	0.2	0.1	0.0	0.0
6.0	94.2	1.0	0.9	1.2	1.3	7.0	94.4	0.1	0.1	1.3	1.4
7.0	93.6	1.1	1.0	1.7	1.9	8.0	94.4	0.7	0.6	1.3	1.3
8.0	93.7	2.4	2.1	2.4	2.6	9.0	94.2	1.0	0.9	1.5	1.6
9.0	94.3	2.4	2.1	3.1	3.4	10.0	94.1	0.2	0.2	0.0	0.0
10.0	93.9	1.4	1.2	2.4	2.6	11.0	94.1	0.2	0.2	0.2	0.2
11.0	93.7	1.4	1.2	2.2	2.5	12.0	93.9	0.2	0.2	0.1	0.1
12.0	94.1	1.2	1.0	1.1	1.2	13.0	93.7	0.3	0.2	0.0	0.0
13.0	94.5	0.0	0.3	1.4	1.6	14.0	93.5	0.3	0.3	0.3	0.3
14.0	94.1	1.3	1.2	1.2	1.3	15.0	93.1	0.5	0.4	0.4	0.4
15.0	94.5	0.8	0.7	2.3	2.6	16.0	92.8	0.6	0.6	0.4	0.4
16.0	94.5	0.0	0.7	2.3	2.6	17.0	92.4	0.9	0.8	0.7	0.7
17.0	94.0	1.4	1.2	1.8	1.9	18.0	92.2	1.0	0.9	0.9	0.9
18.0	93.8	1.4	1.2	1.3	1.5	19.0	92.1	0.8	0.7	1.5	1.5
19.0	94.0	0.9	0.8	2.6	2.8	20.0	92.1	0.6	0.5	1.9	1.9
20.0	93.7	0.4	0.4	2.4	2.7	21.0	92.1	0.3	0.3	1.6	1.6
21.0	93.7	2.3	1.9	2.5	2.7	22.0	92.5	0.2	0.2	1.0	1.0
22.0	93.8	1.9	1.7	1.6	1.8	23.0	92.9	0.0	0.0	0.6	0.6
23.0	93.8	1.3	1.1	2.4	2.6	24.0	93.5	0.1	0.1	0.3	0.3
24.0	94.2	1.3	1.1	1.6	1.8	25.0	93.7	0.2	0.1	0.0	0.0

Trans 3		13 cfs		30 cfs		Trans 5		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
25.0	94.3	0.3	0.2	0.9	1.0	26.0	93.2	0.1	0.1	0.2	0.2
25.8	94.4	0.0	0.2	0.5	0.6	27.0	93.6	0.1	0.1	0.2	0.2
26.0	94.4			0.0	0.0	28.3	94.8	0.0	0.0	0.1	0.1
26.6	94.7			0.0	0.0	30.2	95.0			0.0	0.0
28.0	95.5					32.2	96.1				
31.0	97.3					35.7	98.2				
32.4	98.1										

Table B-27 (continued)

Trans 6		13 cfs		30 cfs		Trans 7		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	97.6					0.0	96.8				
2.0	97.0					6.0	96.9				
5.0	95.6					10.0	95.7			0.0	0.0
10.0	95.5			0.0	0.0	10.7	95.5	0.0	0.0	0.2	0.2
12.0	95.4			0.6	0.5	11.0	95.5	0.1	0.0	0.5	0.4
13.6	95.4	0.0	0.0	0.7	0.5	12.0	95.4	0.0	0.0	0.3	0.4
14.0	95.2	0.2	0.1	0.8	0.4	13.0	95.3	0.5	0.5	1.2	1.2
16.0	95.1	0.7	0.4	1.6	0.9	14.0	95.3	0.5	0.5	1.1	1.1
18.0	95.0	1.2	0.7	2.2	1.2	15.0	95.1	0.8	0.7	1.4	1.5
20.0	95.0	0.8	0.4	1.7	0.9	16.0	95.3	0.8	0.7	1.8	1.9
22.0	95.1	0.2	0.1	1.5	0.9	17.0	95.0	0.4	0.4	1.7	1.8
24.0	95.0	0.2	0.1	1.4	0.8	18.0	94.9	0.9	0.9	1.4	1.6
26.0	95.1	0.0	0.0	1.3	0.7	19.0	94.8	1.0	0.9	1.7	1.9
28.0	95.2	0.0	0.3	2.1	1.3	20.0	94.7	1.0	0.9	1.7	1.9
30.0	95.1	0.7	0.4	2.1	1.2	21.0	94.5	1.1	1.1	1.9	2.1
32.0	95.0	0.6	0.4	0.9	0.5	22.0	94.3	1.2	1.1	1.7	1.9
34.0	95.1	0.4	0.2	2.6	1.4	23.0	94.4	1.2	1.2	1.3	1.5
36.0	95.0	0.6	0.3	1.7	0.9	24.0	94.5	1.2	1.2	1.6	1.8
38.0	95.1	0.6	0.3	1.6	0.9	25.0	94.4	1.3	1.2	1.5	1.7
40.0	94.8	1.1	0.6	2.7	1.4	26.0	94.5	1.1	1.0	1.5	1.6

Trans 6		13 cfs		30 cfs		Trans 7		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
42.0	94.7	2.1	1.1	1.9	1.0	27.0	94.7	1.1	1.1	1.8	2.0
44.0	94.6	2.5	1.3	2.8	1.4	28.0	94.9	1.0	0.9	1.5	1.6
46.0	94.7	1.3	0.7	1.4	0.7	29.0	95.0	1.2	1.2	1.7	1.9
48.0	94.8	1.8	0.9	2.0	1.1	30.0	94.9	0.3	0.3	0.9	1.0
50.0	94.6	1.6	0.9	2.2	1.1	31.0	95.0	1.0	1.0	1.3	1.4
52.0	94.7	1.6	0.8	2.4	1.2	32.0	94.9	0.7	0.7	0.9	0.9
54.0	95.0	0.7	0.4	0.2	0.1	33.0	95.2	0.4	0.4	0.3	0.3
55.5	95.4	0.0	0.1	0.1	0.1	33.7	95.5	0.0	0.0	0.1	0.1
55.8	95.5			0.0	0.1	33.9	95.8			0.0	0.0
62.0	96.1					35.0	96.5				
65.5	98.8					40.0	96.4				
67.5	100.9					42.0	98.9				
68.6	101.1					44.5	101.1				

Table B-27 (continued)

Trans 8		13 cfs		30 cfs		Trans 9		13 cfs		30 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	98.7					0.0	97.1				
2.0	95.0	0.0	0.0	0.0	0.0	3.5	95.8			0.0	0.0
3.0	95.2	0.0	0.0	0.2	0.2	4.0	95.6	0.1	0.0	0.0	0.0
4.0	94.8	0.4	0.4	0.9	0.9	5.0	95.2	0.0	0.0	0.2	0.1
5.0	94.7	0.8	0.8	1.1	1.1	6.0	95.1	0.4	0.4	0.6	0.6
6.0	95.0	0.8	0.8	1.1	1.1	7.0	94.9	0.5	0.4	0.8	0.7
7.0	95.0	0.6	0.6	1.4	1.4	8.0	95.0	0.5	0.5	0.8	0.8
8.0	95.1	0.7	0.6	1.4	1.5	9.0	95.1	0.5	0.4	0.9	0.9
9.0	95.0	0.8	0.8	1.6	1.6	10.0	95.1	0.6	0.5	1.2	1.1
10.0	95.1	0.7	0.7	1.5	1.6	11.0	95.1	0.7	0.6	1.2	1.1
11.0	95.1	0.7	0.7	1.7	1.7	12.0	95.1	0.7	0.6	1.2	1.1
12.0	95.1	0.9	0.8	1.6	1.6	13.0	95.1	0.7	0.7	1.3	1.2
13.0	95.1	0.9	0.9	1.6	1.6	14.0	95.0	0.8	0.7	1.4	1.3
14.0	95.0	0.9	0.9	1.7	1.7	15.0	94.8	0.8	0.7	1.6	1.5

Trans 8		13 cfs		30 cfs		Trans 9		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
15.0	94.9	1.0	1.0	1.6	1.7	16.0	94.6	1.0	0.9	1.6	1.5
16.0	94.7	1.1	1.1	1.6	1.6	17.0	94.5	1.0	0.9	1.6	1.5
17.0	94.6	1.1	1.1	1.8	1.8	18.0	94.4	1.0	0.9	1.8	1.6
18.0	94.5	1.2	1.2	1.6	1.7	19.0	94.3	1.1	1.0	1.8	1.7
19.0	94.4	1.2	1.2	1.7	1.8	20.0	94.0	1.1	0.9	1.8	1.6
20.0	94.4	1.1	1.1	1.6	1.7	21.0	93.7	1.1	1.0	1.9	1.7
21.0	94.3	0.9	0.9	1.4	1.4	22.0	93.8	0.8	0.7	1.8	1.6
22.0	94.3	0.6	0.6	1.0	1.0	23.0	93.7	0.7	0.6	1.1	1.0
23.0	94.5	0.3	0.3	0.3	0.3	24.0	94.1	0.2	0.1	0.2	0.2
24.0	95.4	0.0	0.0	0.1	0.1	24.2	94.4	0.1	0.1	0.2	0.2
24.8	95.4	0.0	0.0	0.0	0.0	26.6	97.2				
25.0	95.9			0.0	0.0						
30.8	101.3										

Table B-27 (continued)

Trans 10		13 cfs		30 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	97.3				
1.5	96.5				
2.5	95.9			0.0	0.0
3.0	95.7			0.1	0.1
4.0	95.7			0.2	0.2
5.0	95.6			0.3	0.3
6.0	95.6			0.4	0.4
7.0	95.6			0.3	0.3
7.3	95.6	0.0	0.0	0.3	0.3
8.0	95.5	0.1	0.1	0.3	0.3
9.0	95.1	0.1	0.1	0.3	0.2
10.0	94.8	0.1	0.1	0.2	0.2
11.0	94.6	0.1	0.1	0.1	0.1
12.0	94.2	0.2	0.2	0.1	0.1

13.0	94.1	0.3	0.2	0.5	0.5
14.0	93.8	0.5	0.4	1.1	1.1
15.0	93.5	0.6	0.6	1.3	1.3
16.0	93.2	0.9	0.8	1.4	1.3
17.0	93.3	1.2	1.1	1.7	1.6
18.0	93.7	1.0	0.9	2.2	2.1
19.0	93.8	1.0	0.9	1.9	1.8
20.0	93.8	0.9	0.8	1.5	1.5
21.0	93.9	0.9	0.8	1.5	1.4
22.0	94.8	0.3	0.3	1.2	1.1
22.6	95.6	0.0	0.0		
22.8	95.9			0.0	0.0
25.0	96.7				
27.5	98.2				

Table B-28. Velocity calibration results for Bear Creek between Emigrant Creek and Oak Street Diversion Study Site.

Trans 1		39 cfs		66 cfs		Trans 2		39 cfs		66 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	99.7					0.0	98.7				
3.5	99.1					0.1	96.9	0.1	0.1	0.1	0.1
6.0	98.2					1.5	96.0	0.0	0.0	0.1	0.1
6.8	97.5			0.0	0.0	3.0	95.8	0.1	0.1	0.1	0.1
7.8	97.2			0.3	0.3	4.5	95.7	0.5	0.6	0.0	0.0
8.1	97.2	0.0	0.0	0.3	0.3	6.0	95.6	0.5	0.6	0.1	0.1
9.0	97.1	0.0	0.0	0.7	0.7	7.5	95.8	0.5	0.6	0.1	0.1
10.5	97.1	0.0	0.1	0.9	0.9	9.0	95.9	0.5	0.6	0.1	0.1
12.0	97.0	0.2	0.2	1.2	1.2	10.5	96.3	0.4	0.5	0.2	0.2
13.5	96.7	1.3	1.3	1.1	1.2	12.0	96.5	0.3	0.3	0.3	0.3
15.0	96.8	0.3	0.3	1.4	1.4	13.5	96.6	0.1	0.1	0.3	0.3
16.5	96.7	1.4	1.4	1.8	1.9	15.0	96.4	0.1	0.1	0.4	0.5
18.0	96.7	1.8	1.9	1.6	1.7	16.5	96.6	0.2	0.2	0.6	0.6
19.5	96.5	1.5	1.5	1.8	1.8	18.0	96.6	0.3	0.3	0.8	0.8
21.0	96.4	1.7	1.7	1.7	1.8	19.5	96.1	0.4	0.5	1.0	1.1
22.5	96.4	1.9	1.9	2.0	2.1	21.0	96.1	0.5	0.6	1.4	1.4
24.0	96.2	2.0	2.0	2.2	2.3	22.5	96.0	0.7	0.8	1.7	1.8
25.5	96.3	2.0	2.0	2.2	2.4	24.0	95.9	1.0	1.1	2.8	3.0
27.0	96.0	2.0	2.0	2.3	2.4	25.5	95.9	1.5	1.7	2.8	3.0
28.5	96.0	1.5	1.5	2.0	2.1	27.0	95.7	1.4	1.5	2.4	2.6
30.0	96.0	1.7	1.7	2.3	2.5	28.5	95.2	1.5	1.8	2.3	2.5
31.5	96.1	1.8	1.8	2.0	2.1	30.0	95.6	1.6	1.8	2.6	2.8
33.0	96.1	1.8	1.8	2.1	2.2	31.5	95.7	1.5	1.7	2.3	2.5
34.0	96.1	1.7	1.7	2.2	2.4	33.0	95.9	1.7	1.9	2.0	2.1
35.5	96.0	1.9	1.9	2.2	2.4	34.5	96.2	1.4	1.6	1.2	1.2
37.0	96.1	1.3	1.3	2.2	2.3	36.0	96.5	0.1	0.2	0.0	0.0
38.5	96.1	1.3	1.3	1.8	1.9	37.0	97.1	0.1	0.1	0.1	0.1
40.0	96.2	0.6	0.6	0.8	0.8	37.6	98.9				
41.5	96.5	0.2	0.2	0.1	0.1						
43.0	96.7	0.1	0.1	0.3	0.3						

Trans 1		39 cfs		66 cfs		Trans 2		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
44.0	97.2	0.0	0.0	0.1	0.1						
44.4	97.5			0.0	0.0						
45.0	97.9										
48.7	99.0										

Table B-28 (continued)

Trans 3		39 cfs		66 cfs		Trans 4		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	99.7					0.0	99.9				
2.5	99.0					3.0	99.0				
3.4	97.8			0.0	0.0	5.0	97.9			0.0	0.0
3.9	97.4	0.1	0.1	0.2	0.2	5.4	97.2	0.0	0.0	0.2	0.2
4.0	96.8	0.1	0.1	0.1	0.2	6.0	96.8	0.0	0.0	0.1	0.2
4.5	95.7	0.6	0.8	0.1	0.1	7.5	96.4	0.0	0.0	0.1	0.1
5.5	95.7	1.0	1.4	0.5	0.6	9.0	96.3	0.2	0.3	0.0	0.1
7.0	95.6	1.1	1.5	0.6	0.7	10.5	96.0	0.2	0.2	0.1	0.1
8.5	95.4	1.7	2.4	0.6	0.7	12.0	96.5	0.1	0.2	0.4	0.4
10.0	95.7	1.6	2.2	1.2	1.4	13.5	95.2	0.0	0.0	0.3	0.4
11.5	95.5	1.4	1.9	1.6	1.9	15.0	94.9	0.0	0.0	0.5	0.7
13.0	95.5	1.1	1.5	1.9	2.2	16.5	95.3	0.0	0.0	0.6	0.7
14.5	95.5	0.8	1.2	2.3	2.7	18.0	95.8	0.1	0.1	0.4	0.4
16.0	95.6	0.4	0.6	2.3	2.8	19.5	96.0	0.6	0.7	0.8	1.0
17.5	95.8	0.0	0.0	2.3	2.7	21.0	96.0	1.8	2.2	1.9	2.3
19.0	95.9	0.1	0.2	1.6	1.9	22.5	95.9	0.4	0.6	3.2	3.8
20.5	96.4	0.2	0.3	1.4	1.6	24.0	95.9	1.9	2.3	1.5	1.9
22.0	96.6	0.3	0.3	1.0	1.2	25.5	95.6	2.9	3.6	3.4	4.1
23.5	96.9	0.3	0.4	0.7	0.8	27.0	95.8	2.5	3.1	2.7	3.2
25.0	97.2		0.2	0.4	0.4	28.5	96.0	2.0	2.5	1.4	1.7
26.5	97.3		0.2	0.4	0.5	30.0	96.4	0.3	0.4	0.7	0.8
28.0	97.2		0.2	0.8	1.0	31.5	96.9	0.1	0.1	0.1	0.2
29.5	97.2		0.2	0.9	1.1	33.0	97.3	0.5	0.7	0.1	0.1

Trans 3		39 cfs		66 cfs		Trans 4		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
31.0	97.3		0.2	0.2	0.2	34.5	97.7	0.6	0.0	0.2	0.3
32.5	97.4		0.1	0.1	0.1	36.0	97.8	0.0	0.0	0.4	0.4
34.0	97.4		0.1	0.1	0.1	37.0	97.8	0.0	0.0	0.3	0.3
35.5	97.0	0.0	0.0	0.1	0.2	37.3	97.8			0.4	0.4
36.5	97.4			0.2	0.2	39.0	97.6			0.3	0.3
37.0	97.8					41.3	97.9			0.0	0.0
39.6	98.7					44.0	98.5				
						48.0	99.4				
						50.0	99.7				

Table B-28 (continued)

Trans 5		39 cfs		66 cfs		Trans 6		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	99.1					0.0	99.5				
2.0	98.6					1.5	99.1				
4.0	97.5			-0.2	-0.2	2.4	98.6			0.0	0.0
4.8	96.9	0.4	0.5	-0.2	-0.3	2.7	98.4			0.1	0.1
5.0	97.0	0.2	0.2	-0.3	-0.4	3.0	98.4	0.0	0.0	0.0	0.0
5.5	96.9	0.3	0.3	-0.3	-0.4	4.0	97.6	0.6	0.7	0.2	0.2
6.0	96.8	0.3	0.3	-0.4	-0.6	5.0	97.5	0.8	1.0	0.3	0.4
6.5	96.6	0.3	0.3	-0.3	-0.4	6.0	97.4	1.1	1.3	0.7	0.7
7.0	96.6	0.3	0.3	0.2	0.3	7.0	97.5	0.9	1.2	0.8	0.9
7.5	96.6	0.2	0.2	0.6	0.9	8.0	97.3	1.4	1.7	1.1	1.2
8.0	96.8	1.2	1.4	1.1	1.6	9.0	97.1	2.1	2.6	1.3	1.4
8.5	96.9	2.3	2.6	2.1	2.8	10.0	96.9	1.2	1.5	2.0	2.2
9.0	96.9	4.6	5.3	3.2	4.3	11.0	97.0	3.3	4.2	2.3	2.6
9.5	96.9	6.4	7.4	4.8	6.5	12.0	96.8	3.1	3.8	3.6	4.0
10.0	96.8	5.8	6.7	5.4	7.5	13.0	97.1	3.3	4.1	4.4	4.9
10.5	96.6	6.8	7.8	6.1	8.5	14.0	97.0	1.8	2.2	3.0	3.3
11.0	96.5	5.6	6.4	5.9	8.3	15.0	97.3	1.6	2.0	3.6	4.0
11.5	96.5	4.5	5.2	5.2	7.4	16.0	97.1	1.4	1.7	1.8	2.0

Trans 5		39 cfs		66 cfs		Trans 6		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
12.0	96.5	6.0	6.9	5.0	7.0	17.0	97.8	2.2	2.7	4.9	5.4
12.5	96.6	4.6	5.3	5.0	7.0	18.0	97.5	1.3	1.5	2.2	2.4
13.0	96.5	4.8	5.5	5.4	7.6	19.0	97.8	0.1	0.1	3.6	4.0
13.5	96.4	5.1	5.9	5.3	7.6	20.0	98.1	2.1	2.4	4.0	4.5
14.0	96.4	3.5	4.0	4.9	7.0	21.0	98.1	1.5	1.8	4.1	4.5
14.5	96.4	4.7	5.4	4.9	7.0	22.0	98.1	0.1	0.1	2.5	2.8
15.0	97.0	4.5	5.1	5.5	7.4	23.0	98.0	0.1	0.1	0.9	1.0
15.5	97.5	3.1	3.5	4.7	5.1	24.0	98.1	0.2	0.3	1.3	1.4
16.0	97.4	2.6	3.0	4.1	4.8	24.6	98.3	0.0	0.1	2.0	2.2
16.5	97.5	1.6	1.9	3.6	4.0	25.0	98.5			1.3	1.4
17.0	97.5	1.2	1.3	3.8	4.1	26.0	98.4			1.0	1.1
17.5	97.5	0.6	0.7	3.2	3.4	27.0	98.5			0.6	0.7
18.0	97.7	0.3	0.0	2.3	1.8	28.0	98.4			0.1	0.1
18.5	97.7	0.3	0.0	0.5	0.4	29.0	98.4			0.7	0.8
19.0	98.0			0.8	0.0	30.0	98.5			0.1	0.1
23.0	98.1					31.0	98.4			0.0	0.0
27.2	98.0			0.1	0.0	32.0	98.5			0.0	0.0
28.6	97.9			0.6	0.0	38.0	98.2	0.0	0.2	2.0	2.2
29.0	97.8			0.6	0.2	39.0	98.1	0.2	0.2	0.4	0.4
30.0	97.8			1.2	0.4	40.0	98.0	0.0	0.0	2.3	2.5
31.0	97.6	0.0	0.0	1.5	1.5	40.5	98.0			1.9	2.1
32.0	97.5	0.0	0.0	0.3	0.3	43.0	98.1	0.0	0.0	1.5	1.6
33.0	97.4	0.2	0.2	1.9	2.2	44.0	98.1	0.6	0.7	2.1	2.4
34.0	97.5	0.1	0.1	1.8	1.9	44.6	97.9	0.3	0.3	0.7	0.8
35.0	97.4	0.0	0.0	1.7	2.0	44.8	98.6			0.0	0.0
36.0	97.5	0.1	0.1	1.8	1.9	45.5	99.2				
37.0	97.8			0.9	0.3	47.1	99.7				
38.0	97.6	0.0	0.0	0.4	0.4						
38.7	97.7			0.1	0.1						
39.2	98.0			0.0	0.0						
39.5	98.8										

Trans 5		39 cfs		66 cfs		Trans 6		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
39.9	101.1										

Table B-28 (continued)

Trans 7		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	101.1				
2.0	99.9				
2.8	99.2			0.0	0.0
3.5	98.8			0.3	0.3
4.0	98.8	0.1	0.1	0.2	0.2
5.5	98.5	0.2	0.2	0.8	0.9
7.0	98.2	0.7	0.9	1.3	1.5
8.5	97.5	1.1	1.3	1.1	1.3
10.0	97.6	1.2	1.4	1.7	2.1
11.5	97.8	1.3	1.5	2.3	2.8
13.0	97.7	0.4	0.5	1.5	1.8
14.5	97.6	1.3	1.6	2.0	2.4
16.0	97.7	1.5	1.7	2.0	2.5
17.5	97.6	1.3	1.5	1.8	2.1
19.0	97.6	1.2	1.4	1.6	2.0
20.5	97.7	0.9	1.1	1.3	1.5
22.0	97.7	0.9	1.0	0.9	1.0
23.5	97.8	1.0	1.1	0.8	0.9
25.0	98.1	1.3	1.6	1.3	1.6
26.5	98.3	1.5	1.7	1.4	1.6
28.0	98.4	1.3	1.5	1.5	1.7
29.5	98.2	1.2	1.4	1.3	1.5
31.0	98.3	0.5	0.6	1.1	1.3
32.5	98.3	0.9	1.1	1.1	1.3
34.0	98.6	0.8	0.9	1.3	1.5
35.5	98.6	0.9	1.0	1.0	1.1

Trans 7		39 cfs		66 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
37.0	98.7	0.2	0.2	1.0	1.1
38.5	98.8	0.1	0.1	0.5	0.6
40.0	98.9			0.4	0.4
40.8	99.2				
44.8	98.9			0.5	0.5
46.0	99.0			1.1	1.0
48.2	98.9			0.1	0.1
49.0	99.2			0.0	0.0
55.1	100.0				

Table B-29. Velocity calibration results for Bear Creek between Oak Street Diversion and Valley View Road Study Site.

Trans 1		23 cfs		Trans 2		23 cfs		Trans 3		23 cfs	
Station	Elevation	Measured	Simulated	Station	Elevation	Measured	Simulated	Station	Elevation	Measured	Simulated
0.0	101.4			0.0	102.4			0.0	102.0		
2.5	100.2			6.5	101.2			5.0	101.4		
5.0	99.2			11.5	99.8			11.0	100.0		
6.1	98.4	0.0	0.0	17.0	99.3			13.4	100.1		
7.5	97.9	0.2	0.2	18.5	99.4			19.0	99.2	0.0	0.0
9.0	97.8	0.2	0.3	27.3	98.4	0.0	0.0	20.5	99.1	0.0	0.0
10.5	97.7	0.4	0.4	29.0	98.3	0.0	0.1	22.0	98.9	1.5	1.4
12.0	97.7	0.5	0.5	30.5	98.3	0.2	0.2	23.5	98.6	1.5	1.4
13.5	97.7	0.7	0.7	32.0	98.0	0.1	0.1	25.0	98.5	1.4	1.3
15.0	97.4	0.9	0.9	33.5	97.7	0.5	0.6	26.5	97.9	1.5	1.4
16.5	97.4	0.9	1.0	35.0	97.5	0.8	0.9	28.0	97.8	0.9	0.9
18.0	97.1	1.1	1.2	36.5	97.2	1.6	1.9	29.5	97.7	1.2	1.1
19.5	97.0	1.2	1.3	38.0	97.3	1.7	2.0	31.0	98.2	1.3	1.2
21.0	96.8	1.2	1.3	39.5	97.1	1.0	1.2	32.5	98.7	1.3	1.2
22.5	97.0	1.4	1.4	41.0	97.1	0.8	0.9	34.0	98.9	1.4	1.3
24.0	97.1	1.5	1.6	42.5	97.1	0.9	1.0	35.5	99.1	2.1	2.0
25.5	97.5	1.2	1.3	44.0	97.0	0.6	0.7	37.0	99.0	1.4	1.3
27.0	97.6	0.8	0.8	45.5	97.2	0.5	0.6	38.5	98.8	0.4	0.3

Trans 1		23 cfs		Trans 2		23 cfs		Trans 3		23 cfs	
Station	Elevation	Measured	Simulated	Station	Elevation	Measured	Simulated	Station	Elevation	Measured	Simulated
28.5	97.6	0.7	0.7	47.0	96.5	0.3	0.3	40.0	99.0	1.6	1.5
30.0	97.8	0.6	0.6	48.5	96.6	0.4	0.5	41.5	98.9	2.5	2.4
31.5	97.8	0.5	0.6	50.0	96.7	0.5	0.6	43.0	98.7	3.7	3.4
33.0	97.8	0.1	0.1	51.5	97.1	0.6	0.7	44.5	98.3	3.2	3.0
34.5	98.1	0.1	0.1	53.0	97.8	0.2	0.2	46.0	98.5	1.0	0.9
36.0	98.1	0.1	0.1	54.5	98.3	0.2	0.2	48.0	98.6	0.0	0.1
37.5	99.4	0.0	0.0	55.5	98.4	0.0	0.1	49.0	100.6		
38.3	98.4			57.0	98.8			52.5	101.2		
40.0	98.6			59.0	99.6			55.0	101.7		
44.0	99.6			61.0	100.8			56.7	102.0		
47.0	100.9			62.2	101.5						
49.8	102.0										

Table B-29 (continued)

Trans 4		23 cfs	
Station	Elevation	Measured	Simulated
0.0	101.2		
3.0	100.6		
3.8	100.1		
4.5	99.5	0.0	0.0
6.0	99.1	0.6	0.5
7.5	98.9	1.2	1.1
9.0	98.8	1.7	1.6
10.5	99.0	1.4	1.3
12.0	99.0	1.7	1.6
13.5	99.3	1.8	1.6
15.0	98.7	2.2	2.1
16.5	98.9	2.5	2.4
18.0	99.1	1.5	1.4
19.5	98.8	2.5	2.3
21.0	99.0	2.8	2.6

Trans 4		23 cfs	
Station	Elvevation	Measured	Simulated
22.5	99.1	2.7	2.5
24.0	99.0	2.3	2.2
25.5	99.1	2.7	2.6
27.0	99.2	1.3	1.2
28.5	99.3	0.8	0.7
30.0	99.3	2.0	1.9
31.5	99.5	0.0	0.0
33.0	99.5	0.1	0.1
34.0	99.6	0.0	0.0
35.5	99.6		
37.0	99.6		
38.5	99.4	0.0	0.0
40.0	99.5	0.0	0.0
41.0	100.1		
42.0	100.6		
43.0	101.3		
45.3	101.9		

Table B-30. Velocity calibration results for Bear Creek between Valley View Road and Phoenix Diversion Study Site.

Trans 1		72 cfs		83 cfs		Trans 3		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	100.2					0.0	98.2				
4.0	99.1					2.5	97.5			0.0	0.0
8.0	98.0			0.0	0.0	3.0	97.2			0.0	0.0
8.5	97.0			1.6	1.4	3.5	97.3			0.1	0.1
9.0	97.1			1.7	1.4	5.1	97.5			0.0	0.0
9.5	97.2			0.9	0.5	7.0	97.6			0.0	0.0
10.0	97.2			0.6	0.3	8.7	97.5			0.0	0.0
11.1	97.3			0.0	0.0	10.0	97.4			0.1	0.1
23.5	97.3			0.0	0.0	12.0	97.4	0.0	0.0	0.0	0.3
23.8	97.1	0.0	0.2	0.0	0.0	14.0	97.2	0.1	0.1	0.6	0.6
24.0	97.0	0.4	0.5	0.0	0.0	16.0	97.1	0.6	0.6	1.0	1.0
26.0	96.9	0.9	0.9	1.5	1.3	18.0	96.9	1.2	1.2	1.2	1.2
28.0	96.7	2.0	2.0	2.4	2.1	20.0	96.9	1.2	1.2	1.4	1.4
30.0	96.8	1.4	1.4	1.3	1.1	22.0	96.7	1.3	1.3	1.6	1.5
32.0	96.8	1.5	1.5	1.4	1.3	24.0	96.4	1.4	1.4	1.7	1.6
34.0	96.9	0.9	1.0	1.1	1.0	26.0	96.3	1.5	1.5	1.7	1.6
36.0	96.9	0.4	0.5	1.3	1.1	28.0	96.2	1.5	1.5	1.7	1.7
38.0	96.9	0.4	0.4	1.5	1.3	30.0	96.2	1.6	1.6	1.9	1.9
40.0	97.0	0.7	0.8	1.5	1.3	32.0	96.2	1.8	1.8	2.0	2.0
42.0	96.8	1.3	1.3	2.0	1.7	34.0	95.9	1.9	1.9	2.2	2.2
44.0	96.6	1.4	1.4	1.7	1.6	36.0	95.8	2.1	2.1	2.0	2.0
46.0	96.6	2.0	2.0	2.8	2.5	38.0	95.7	2.0	2.0	2.1	2.0
48.0	96.2	2.3	2.2	2.8	2.6	40.0	95.4	2.0	2.0	2.2	2.1
50.0	96.2	3.1	3.0	4.0	3.7	42.0	95.2	2.0	2.0	2.0	1.9
52.0	96.1	3.7	3.5	3.5	3.2	44.0	95.2	1.7	1.7	1.8	1.7
54.0	96.1	3.9	3.8	3.7	3.4	46.0	95.2	1.3	1.3	1.3	1.3
56.0	96.0	3.3	3.2	3.8	3.5	48.0	96.4	0.1	0.1	0.0	0.8
58.0	95.5	3.3	3.1	3.5	3.3	48.7	97.4	0.0	0.0	0.0	0.2
60.0	95.6	3.4	3.3	3.5	3.3	50.5	98.7				
62.0	95.9	3.7	3.5	3.7	3.4	53.6	99.9				

Trans 1		72 cfs		83 cfs		Trans 3		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
64.0	96.9	1.6	1.7	1.5	1.4						
66.0	96.7	1.5	1.5	1.7	1.6						
68.0	97.2			0.0	0.0						
68.4	97.3			0.0	0.0						
72.5	99.2										

Table B-30 (continued)

Trans 4		72 cfs		83 cfs		Trans 5		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	100.2					0.0	99.5				
5.0	99.4					5.0	98.2				
10.0	98.2					8.5	97.6			0.0	0.0
16.0	97.4	0.0	0.1	0.0	0.2	10.0	97.5			0.0	0.0
16.4	97.4	0.2	0.1	0.0	0.2	10.5	97.4	0.0	0.0	0.0	0.0
17.0	97.2	0.3	0.2	0.2	0.3	11.5	97.4	0.0	0.0	0.0	0.0
18.0	96.9	0.1	0.2	0.2	0.1	13.0	97.4	0.0	0.0	0.0	0.0
19.0	97.0	0.2	0.2	0.2	0.2	14.5	97.2	0.0	0.0	0.0	0.0
20.0	96.9	0.2	0.2	0.1	0.2	16.0	97.1	0.1	0.1	0.1	0.1
21.0	96.7	0.2	0.2	0.2	0.2	17.5	96.9	0.1	0.1	0.0	0.0
22.0	96.5	0.1	0.2	0.1	0.1	19.0	96.6	0.1	0.1	0.0	0.0
23.0	96.4	0.1	0.1	0.1	0.1	20.5	96.2	0.0	0.0	0.0	0.0
24.0	96.0	0.1	0.1	0.1	0.0	22.0	95.9	0.0	0.0	0.1	0.1
25.0	95.7	0.1	0.1	0.1	0.1	23.5	95.8	0.1	0.1	0.8	0.8
26.0	95.4	0.5	0.1	0.1	0.5	25.0	95.7	0.3	0.4	1.3	1.2
27.0	95.3	0.6	0.3	0.3	0.6	26.5	95.3	0.9	1.1	1.4	1.3
28.0	95.0	0.8	0.6	0.5	0.8	28.0	95.1	1.3	1.5	1.4	1.3
29.0	94.8	1.0	0.7	0.6	1.0	29.5	94.7	1.4	1.6	2.1	2.0
30.0	94.7	0.9	0.9	0.8	0.9	31.0	94.4	1.6	1.9	2.2	2.1
31.0	94.5	1.0	1.0	0.9	1.0	32.5	94.3	1.6	1.9	2.3	2.1
32.0	94.3	1.0	1.1	1.0	1.0	34.0	93.9	1.6	1.9	2.0	1.9
33.0	94.1	1.1	1.1	1.0	1.1	35.5	93.4	1.6	1.9	1.8	1.7

34.0	93.8	1.3	1.4	1.2	1.3	37.0	92.9	1.4	1.6	1.6	1.5
35.0	93.4	1.7	1.1	1.0	1.6	38.5	92.7	0.8	0.9	1.2	1.2
36.0	93.2	1.8	1.4	1.3	1.7	40.0	97.4	0.0	0.1	0.2	0.2
37.0	93.0	1.9	1.6	1.4	1.8	41.0	97.4	0.0	0.1	0.0	0.2
38.0	92.6	2.1	2.0	1.8	2.1	44.0	98.3				
39.0	92.7	2.0	1.9	1.7	2.0	47.0	99.5				
40.0	92.8	1.8	1.7	1.5	1.7	50.7	100.8				
41.0	93.0	1.6	1.4	1.2	1.5						
42.0	96.0	0.1	0.0	0.0	0.0						
43.0	97.1	0.0	0.1	0.1	0.0						
43.3	97.4	0.0	0.0	0.0	0.0						
45.0	98.4										
47.3	99.0										

Table B-30 (continued)

Trans 6		72 cfs		83 cfs		Trans 7		72 cfs		83 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	99.8					0.0	100.8				
2.0	99.4					4.5	97.1	0.0	0.0	0.2	0.2
5.0	97.6			0.0	0.0	5.0	97.1	0.2	0.2	0.5	0.4
5.7	97.5	0.0	0.0	0.0	0.1	8.0	97.0	0.7	0.7	0.9	0.8
6.5	97.3	0.1	0.1	0.3	0.3	11.0	96.9	1.4	1.3	1.5	1.3
8.0	97.3	0.1	0.1	0.6	0.6	14.0	96.7	1.6	1.5	1.9	1.6
9.5	97.3	0.1	0.1	0.6	0.6	17.0	96.5	2.1	2.0	2.5	2.1
11.0	97.4	0.5	0.5	0.8	0.7	20.0	96.4	2.1	2.0	3.0	2.5
12.5	97.3	0.2	0.3	0.7	0.7	23.0	96.2	2.1	2.0	2.4	2.0
14.0	97.2	0.0	0.0	1.5	1.4	26.0	96.3	2.3	2.2	2.5	2.1
15.5	97.4	0.0	0.4	1.6	1.5	29.0	96.4	2.5	2.4	3.0	2.5
17.0	97.1	0.9	1.0	1.5	1.4	32.0	96.3	1.9	1.8	2.2	1.8
18.5	97.3	0.2	0.2	1.7	1.6	35.0	96.5	2.2	2.2	2.6	2.2
20.0	97.1	0.4	0.4	1.5	1.4	38.0	96.5	1.7	1.6	1.9	1.6
21.5	96.8	0.7	0.8	1.7	1.6	41.0	96.5	1.2	1.2	0.9	0.8
23.0	96.5	1.1	1.3	1.7	1.6	44.0	96.5	0.7	0.7	0.2	0.1

Trans 6		72 cfs		83 cfs		Trans 7		72 cfs		83 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
24.5	96.5	1.2	1.4	2.2	2.1	47.0	97.2	0.1	0.1	0.1	0.1
26.0	96.7	1.5	1.8	2.7	2.6	50.0	97.5	0.0	0.0	0.3	0.3
27.5	96.3	1.7	1.9	2.3	2.2	53.0	97.0	1.1	1.1	1.1	0.9
29.0	96.0	1.9	2.2	2.6	2.5	56.0	97.3	0.9	0.8	1.3	1.1
30.5	96.0	1.9	2.1	2.3	2.2	57.5	97.5	0.0	0.0	1.1	0.9
32.0	96.2	2.5	2.9	2.5	2.4	59.0	97.5			1.0	0.8
33.5	96.1	2.3	2.6	2.7	2.6	62.0	97.5			0.6	0.5
35.0	96.0	2.2	2.5	2.8	2.7	64.0	97.6			0.1	0.1
36.5	95.8	2.2	2.5	2.5	2.4	64.3	97.7			0.0	0.0
38.0	95.5	1.1	1.2	1.3	1.2	64.5	97.8				
39.5	95.1	1.3	1.5	1.6	1.5	68.0	98.6				
41.0	94.9	1.4	1.6	1.5	1.4	68.7	98.8				
42.5	94.7	1.2	1.4	1.5	1.4						
44.0	94.5	0.9	1.0	0.9	0.8						
45.5	94.1	0.6	0.7	0.6	0.5						
47.2	97.5	0.0	0.0	0.0	0.0						
50.0	98.4										
50.5	98.4										

Table B-30 (continued)

Trans 8		72 cfs		83 cfs		Trans 9		72 cfs		83 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	99.4					0.0	103.3				
1.6	98.4					1.2	101.2				
2.6	97.8			0.0	0.0	5.3	99.0	0.0	0.0	0.3	0.0
3.0	97.7			0.0	0.0	6.0	98.9	0.1	0.1	2.0	1.6
3.5	97.6	0.0	0.0	0.1	0.1	10.0	98.9	0.1	0.1	1.7	1.4
4.5	97.3	0.0	0.0	0.1	0.1	14.0	98.9	0.2	0.2	1.2	1.0
6.0	96.9	0.2	0.2	0.1	0.1	18.0	98.4	0.9	0.8	1.7	1.3
7.5	96.1	0.2	0.2	0.1	0.1	22.0	97.8	1.9	1.7	2.3	1.9
9.0	95.5	0.2	0.2	0.1	0.1	26.0	97.8	1.9	1.6	1.6	1.3

Trans 8		72 cfs		83 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
10.5	95.2	0.0	0.0	0.5	0.4
12.0	94.8	0.7	0.7	0.9	0.8
13.5	94.8	1.3	1.5	2.3	1.9
15.0	94.7	1.3	1.5	2.4	2.0
16.5	95.1	1.2	1.3	2.8	2.3
18.0	95.5	1.2	1.3	3.4	2.9
19.5	95.7	1.1	1.2	2.6	2.2
21.0	95.9	2.5	2.8	2.0	1.7
22.5	96.3	2.8	3.1	2.2	1.8
24.0	96.7	3.2	3.6	3.0	2.5
25.5	96.9	4.0	4.5	3.5	2.9
27.0	96.9	3.8	4.3	3.5	3.0
28.5	97.1	5.1	5.8	4.4	3.7
30.0	96.9	3.9	4.4	3.6	3.0
31.5	97.1	3.1	3.5	2.6	2.2
33.0	97.1	1.0	1.1	2.9	2.4
34.2	97.6	0.0	0.1	0.0	0.0
35.5	97.8			0.0	0.0
38.0	98.6				
46.0	98.9				
52.0	100.1				
56.0	99.5				
65.0	98.9				
72.7	98.5				
76.0	99.1				
81.0	98.6				
82.2	97.6	0.0	0.1	0.0	0.0
83.0	97.1	0.8	0.9	0.9	0.7
84.0	97.1	1.5	1.8	1.9	1.6
85.0	97.2	0.4	0.5	1.1	1.0
86.0	97.3	0.2	0.2	0.3	0.2

Trans 9		72 cfs		83 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
30.0	98.0	2.1	1.8	2.2	1.7
34.0	97.9	2.4	2.0	2.5	2.0
38.0	97.8	2.3	2.0	2.6	2.1
42.0	97.7	2.2	1.9	2.7	2.2
46.0	97.9	1.8	1.5	2.1	1.7
50.0	97.9	2.3	2.0	2.8	2.3
54.0	98.3	1.5	1.3	2.3	1.9
58.0	98.7	0.3	0.2	1.5	1.2
60.0	98.8	1.1	0.9	1.1	0.9
64.0	98.8	0.8	0.7	0.1	0.1
68.0	98.6	0.9	0.7	1.1	0.9
72.0	98.6	1.3	1.1	1.1	0.9
74.6	99.0	0.0	0.0	0.1	0.0
76.0	99.0			0.0	0.0
76.8	99.0			0.0	0.0
80.0	99.4				
84.3	100.1				

Trans 8		72 cfs		83 cfs		Trans 9		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevevation	Measured	Simulated	Measured	Simulated
87.0	97.3	0.2	0.3	0.3	0.3						
88.0	97.6	0.0	0.0	0.0	0.1						
92.0	98.9										
95.5	99.2										

Table B-30 (continued)

Trans 10		72 cfs		83 cfs		Trans 11		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevevation	Measured	Simulated	Measured	Simulated
0.0	101.1					0.0	99.5				
2.4	99.1	0.0	0.0	0.1	0.2	2.0	98.6				
3.0	98.8	0.2	0.2	0.2	0.2	4.0	97.9				
5.0	98.3	0.6	0.7	1.0	0.9	5.2	97.3	0.0	0.0	0.0	0.0
7.0	98.2	0.8	0.9	1.2	1.0	6.0	96.8	0.2	0.1	0.1	0.1
9.0	98.0	0.8	0.8	1.7	1.5	8.0	96.3	2.7	2.1	2.3	2.3
11.0	97.7	1.3	1.4	2.3	2.0	10.0	96.2	2.8	3.1	3.3	3.4
13.0	97.7	1.9	2.1	3.4	2.9	12.0	95.9	2.3	2.3	2.5	2.5
15.0	97.3	2.5	2.7	2.9	2.5	14.0	95.8	2.8	2.7	3.0	3.0
17.0	97.4	2.5	2.7	3.5	3.0	16.0	95.6	2.7	2.5	2.7	2.7
19.0	97.5	2.6	2.8	3.2	2.8	18.0	96.2	2.1	2.4	2.6	2.7
21.0	97.9	2.3	2.5	2.6	2.2	20.0	95.9	1.7	2.3	2.5	2.5
23.0	98.0	1.8	2.0	2.5	2.1	22.0	96.2	1.7	2.4	2.6	2.6
25.0	97.8	1.6	1.7	1.7	1.5	24.0	95.8	1.6	2.4	2.6	2.7
27.0	98.2	1.3	1.5	1.9	1.7	26.0	95.8	0.6	0.8	0.9	0.9
29.0	98.2	1.2	1.3	2.0	1.7	28.0	96.0	1.6	1.3	1.5	1.5
31.0	98.3	1.2	1.4	1.6	1.4	30.0	96.7	1.8	2.1	2.3	2.3
33.0	98.2	1.2	1.4	1.6	1.4	32.0	96.6	1.1	1.2	1.3	1.3
35.0	98.2	0.8	0.9	1.6	1.4	34.0	96.5	0.1	0.6	0.6	0.6
37.0	98.2	1.1	1.3	1.6	1.4	36.0	96.2	2.1	1.6	1.8	1.8
39.0	98.4	0.9	1.0	1.5	1.3	38.0	96.4	1.2	2.0	2.2	2.2

Trans 10		72 cfs		83 cfs		Trans 11		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
41.0	98.4	0.6	0.7	0.9	0.8	40.0	97.1	0.1	0.2	0.2	0.2
43.0	99.1	0.0	0.0	0.1	0.2	41.0	97.3			0.0	0.0
45.0	98.9	0.0	0.0	0.2	0.2	44.0	98.6				
47.0	99.0	0.0	0.0	0.6	0.6	48.0	99.3				
48.2	99.1	0.0	0.0	0.0	0.2	53.0	99.6				
52.5	99.7					58.4	100.1				

Table B-30 (continued)

Trans 12		72 cfs		83 cfs		Trans 13		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	98.5					0.0	102.1				
2.4	97.8			0.1	0.1	5.0	101.3				
3.0	97.6	0.4	0.3	0.3	0.3	8.0	100.2				
4.5	97.6	0.8	1.1	1.3	1.3	10.0	99.6				
6.0	97.2	1.1	0.9	1.0	1.0	11.7	99.4			0.0	0.2
7.5	97.2	2.6	2.6	3.0	2.9	12.0	99.2	0.0	0.7	0.7	0.8
9.0	96.9	3.0	2.9	3.4	3.3	14.0	99.0	0.1	0.3	0.3	0.3
10.5	96.9	1.0	0.5	0.5	0.5	16.0	98.7	1.6	2.3	2.2	2.6
12.0	96.1	0.2	0.2	0.3	0.2	18.0	98.7	0.6	0.4	0.3	0.4
13.5	96.4	2.7	2.1	2.4	2.3	20.0	98.1	2.3	2.0	1.9	2.2
15.0	97.0	1.1	1.3	1.5	1.5	22.0	98.1	2.0	2.5	2.4	2.8
16.5	97.3	4.0	2.8	3.2	3.2	24.0	98.6	0.2	1.0	0.9	1.1
18.0	97.4	0.0	0.8	1.0	1.0	26.0	98.1	0.8	1.2	1.1	1.3
19.5	97.4	1.4	1.2	1.3	1.3	28.0	98.2	2.7	3.0	2.9	3.4
21.0	96.7	3.4	4.7	5.4	5.2	30.0	97.8	1.5	1.7	1.6	1.8
22.5	97.3	0.1	0.0	0.0	0.0	32.0	97.8	2.0	2.3	2.2	2.6
24.0	96.7	0.9	0.7	0.8	0.8	34.0	97.8	1.6	1.6	1.5	1.8
25.5	96.6	1.7	2.0	2.3	2.2	36.0	98.0	2.7	3.1	2.9	3.4
27.0	96.5	2.4	2.7	3.1	3.0	38.0	98.4	0.9	1.9	1.8	2.1
28.5	96.7	0.2	0.9	1.0	1.0	40.0	98.8	1.3	1.8	1.8	2.1
30.0	96.8	0.0	0.3	0.4	0.4	42.0	98.3	1.2	1.7	1.6	1.9

Trans 12		72 cfs		83 cfs		Trans 13		72 cfs		83 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
31.5	95.9	3.9	3.4	4.0	3.8	44.0	98.3	2.0	2.1	2.0	2.3
33.0	96.2	3.3	2.5	2.9	2.8	46.0	98.2	1.8	1.2	1.1	1.3
34.5	96.2	3.5	3.2	3.7	3.5	48.0	98.8	0.1	0.1	0.1	0.1
36.0	96.4	1.3	1.4	1.6	1.5	50.0	98.6	0.9	1.7	1.6	1.9
37.5	96.8	0.0	0.1	0.1	0.1	52.0	99.2	0.0	0.2	0.2	0.2
38.2	97.9	0.1	0.0	0.0	0.1	53.4	99.2	0.0	0.1	0.1	0.1
38.5	98.0			0.0	0.0	54.0	99.4			0.0	0.0
40.5	98.5					56.0	99.4			0.0	0.0
46.0	99.9					57.0	99.4			0.0	0.0
52.0	100.5					57.5	99.6				
						62.0	100.0				
						64.0	99.8				
						65.0	100.2				
						69.0	102.9				
						74.8	103.2				

Table B-31. Velocity calibration results for Bear Creek between Phoenix Diversion and Jackson Diversion Study Site.

Trans 2		12 cfs		33 cfs		71 cfs		Trans 3		12 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	98.9							0.0	98.9				
1.5	96.1							1.0	97.7			0.1	0.0
3.3	95.8					0.0	0.0	1.5	95.3			0.1	0.1
4.0	95.7					0.1	0.1	2.5	95.1			0.0	0.0
4.8	95.4			0.0	0.0	0.3	0.3	4.0	95.5	0.1	0.0	0.0	0.0
6.0	95.2			0.3	0.3	0.5	0.5	5.5	94.2	0.1	0.1	0.3	0.4
7.0	95.1	0.0	0.0	0.4	0.4	0.6	0.6	7.0	94.0	0.0	0.0	0.5	0.5
8.0	94.9	0.1	0.1	0.5	0.5	0.7	0.7	8.5	94.0	0.0	0.0	0.7	0.8
10.0	94.6	0.3	0.3	0.6	0.7	1.0	1.0	10.0	93.7	0.3	0.4	1.2	1.3
12.0	94.3	0.4	0.4	0.9	0.9	1.3	1.4	11.5	94.1	0.4	0.6	1.8	1.9
14.0	94.2	0.6	0.6	1.1	1.2	1.9	1.9	13.0	93.0	0.4	0.5	1.8	1.9
16.0	94.1	0.6	0.7	1.1	1.2	2.3	2.3	14.5	93.4	0.2	0.2	1.0	1.1
18.0	94.2	0.6	0.7	1.2	1.2	2.0	2.0	16.0	93.0	0.4	0.5	1.9	2.0
20.0	94.1	0.7	0.8	1.4	1.4	2.0	2.0	17.5	92.9	0.4	0.5	1.6	1.7
22.0	94.1	0.8	0.9	1.4	1.5	2.0	2.1	19.0	93.2	0.4	0.5	1.4	1.5
24.0	94.3	0.7	0.8	1.4	1.5	2.0	2.0	20.5	93.6	0.4	0.5	1.6	1.7
26.0	94.4	0.7	0.8	1.3	1.4	1.8	1.8	22.0	94.0	0.4	0.5	1.5	1.6
28.0	94.7	0.8	0.8	1.2	1.3	1.7	1.8	23.5	94.1	0.5	0.6	1.5	1.6
30.0	94.7	0.6	0.7	1.2	1.2	1.7	1.7	25.0	94.6	0.3	0.4	1.3	1.4
32.0	94.8	0.4	0.4	1.1	1.1	1.6	1.6	26.5	94.7	0.3	0.4	1.2	1.3
34.0	94.8	0.3	0.3	0.7	0.7	1.4	1.4	28.0	94.9	0.1	0.1	1.9	2.0
36.0	94.8	0.4	0.4	0.9	0.9	1.3	1.3	29.5	94.9	0.1	0.1	0.9	1.0
38.0	94.9	0.2	0.2	0.5	0.5	1.1	1.1	31.0	95.0	0.1	0.1	0.8	0.8
39.6	94.9	0.1	0.1	0.6	0.6	0.5	0.5	32.5	95.0	0.2	0.2	0.7	0.8
43.0	96.8							33.5	95.1	0.0	0.0	0.0	0.0
46.0	97.8							33.9	95.8			0.0	0.0
48.7	98.6							35.0	96.3				
								40.8	97.9				

Table B-31 (continued)

Trans 4		12 cfs		71 cfs		Trans 5		12 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	99.4					0.0	99.8				
1.8	96.8					3.5	97.6				
4.0	95.8			0.0	0.0	6.2	95.6	0.0	0.0	0.0	0.0
5.0	96.0					7.0	94.7	0.1	0.1	0.0	0.0
5.5	95.7			0.1	0.1	8.5	94.0	0.1	0.1	0.5	0.5
6.0	95.1	0.0	0.0	0.2	0.2	10.0	93.8	0.2	0.2	0.7	0.7
7.0	95.0	0.2	0.2	0.2	0.2	11.5	94.2	0.2	0.3	1.0	1.0
8.5	94.8	0.2	0.2	1.1	1.1	13.0	93.1	0.2	0.3	1.3	1.3
10.0	93.8	0.0	0.0	0.1	0.1	14.5	93.2	0.5	0.6	1.6	1.7
11.5	92.7	0.0	0.0	0.6	0.6	16.0	93.6	0.6	0.7	2.1	2.2
13.0	92.8	0.1	0.2	1.2	1.2	17.5	93.7	0.8	0.9	2.3	2.4
14.5	92.7	0.7	0.7	2.2	2.1	19.0	93.8	0.7	0.8	2.5	2.7
16.0	93.4	0.6	0.7	2.3	2.3	20.5	94.1	0.6	0.8	2.3	2.4
17.5	93.3	0.6	0.6	2.3	2.3	22.0	94.3	0.5	0.6	2.2	2.3
19.0	93.4	0.5	0.5	2.2	2.2	23.5	94.5	0.5	0.5	2.1	2.2
20.5	93.6	0.5	0.5	2.0	2.0	25.0	94.7	0.5	0.5	1.7	1.8
22.0	93.9	0.5	0.5	1.7	1.7	26.5	94.7	0.5	0.6	1.7	1.8
23.5	94.1	0.5	0.5	1.4	1.4	28.0	94.7	0.4	0.4	1.5	1.6
25.0	94.3	0.5	0.5	1.8	1.7	29.5	94.7	0.3	0.3	1.3	1.3
26.5	94.6	0.4	0.5	1.4	1.3	31.0	94.6	0.1	0.1	0.4	0.4
28.0	94.7	0.1	0.1	1.1	1.1	32.5	94.7	0.1	0.1	0.8	0.9
29.5	95.1	0.0	0.0	0.6	0.6	34.0	95.1	0.1	0.0	0.2	0.2
31.0	95.3			0.6	0.6	34.3	95.2	0.0	0.0	0.1	0.1
32.5	95.4			0.4	0.4	35.5	95.9			0.0	0.0
34.0	95.3			0.8	0.8	35.7	96.1				
35.8	96.3					39.0	98.8				
41.9	98.4					42.0	100.6				

Table B-31 (continued)

Trans 6		12 cfs		71 cfs		Trans 7		12 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	99.9					0.0	98.2				
0.8	95.9			0.0	0.0	0.6	97.0				
1.5	95.9			0.0	0.0	1.6	96.6				
2.0	95.1	0.0	0.0	0.2	0.2	4.0	96.0				
3.3	93.0	0.0	0.0	0.4	0.4	6.0	96.0			0.0	0.0
4.5	93.3	0.0	0.0	0.6	0.5	7.0	95.8			3.1	2.3
6.0	93.6	0.1	0.1	0.5	0.4	8.0	95.6			3.7	3.5
7.5	93.4	0.1	0.1	0.8	0.7	9.0	94.7	0.9	0.9	4.3	4.4
9.0	93.1	0.7	0.6	2.1	1.9	10.0	94.6	2.6	2.8	3.9	4.0
10.5	93.3	0.0	0.0	1.5	1.3	11.0	93.9	0.5	0.5	4.2	4.4
12.0	93.3	0.2	0.2	0.2	0.2	12.0	93.6	2.2	2.4	4.5	4.7
13.5	93.0	0.2	0.2	1.8	1.6	13.0	93.9	1.5	1.7	4.1	4.3
15.0	93.0	0.9	0.8	3.6	3.2	14.0	94.0	1.3	1.5	3.7	3.9
16.5	93.4	1.5	1.3	3.0	2.7	15.0	94.2	1.0	1.1	3.5	3.7
18.0	93.4	0.8	0.7	2.5	2.3	16.0	94.5	0.6	0.6	4.1	4.2
19.5	94.0	0.5	0.4	1.9	1.7	17.0	94.7	0.6	0.6	3.4	3.5
21.0	94.0	0.3	0.3	1.5	1.3	18.0	95.1	0.4	0.5	3.3	3.3
22.5	94.1	0.1	0.0	1.3	1.1	19.0	94.9	0.0	0.0	2.3	2.3
24.0	94.9	0.1	0.1	0.2	0.2	20.0	95.1	0.0	0.0	1.8	1.8
25.5	95.1	0.0	0.0	0.3	0.2	20.5	95.2	0.0	0.0	1.9	1.9
27.0	95.8			0.0	0.0	21.0	95.5			2.1	2.0
28.0	95.9			0.0	0.0	22.0	95.4			1.6	1.6
31.3	96.5					23.0	95.7			0.8	0.7
35.5	98.7					24.0	95.7			0.1	0.1
42.0	100.4					25.0	95.7			0.0	0.1
						26.0	95.9			0.2	0.0
						27.0	95.9			0.3	0.0
						28.0	95.9			0.0	0.0
						29.0	96.0			0.0	0.0
						30.0	96.1				

Trans 6		12 cfs		71 cfs		Trans 7		12 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
						33.3	96.6				
						34.0	97.9				
						38.0	98.4				
						42.5	99.8				
						45.6	100.3				

Table B-31 (continued)

Trans 8		12 cfs		71 cfs		Trans 9		12 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	99.1					0.0	102.0				
4.0	97.5					2.0	101.3				
6.9	96.4					15.2	98.2			0.0	0.1
7.6	96.1			0.3	0.3	16.5	97.7			0.7	0.6
8.0	95.7	0.5	0.3	1.7	1.8	18.0	97.4	0.0	0.0	0.8	0.7
9.0	95.4	0.5	0.4	1.7	1.8	19.5	97.5	0.0	0.0	0.6	0.5
10.0	95.5	1.0	0.7	1.9	2.0	21.0	97.6	0.0	0.0	2.0	1.7
11.0	95.3	0.3	0.2	2.0	2.1	22.5	97.5	0.0	0.1	1.9	1.6
12.0	95.2	0.9	0.7	2.3	2.4	24.0	97.5	0.0	0.1	1.6	1.4
13.0	95.1	0.0	0.0	2.2	2.3	25.5	97.3	0.5	0.5	2.3	2.1
14.0	95.3	1.1	0.8	2.4	2.5	27.0	97.2	0.1	0.1	1.7	1.5
15.0	95.4	0.8	0.6	1.7	1.9	28.5	97.2	0.0	0.0	3.5	3.1
16.0	95.2	0.9	0.6	2.7	2.9	30.0	97.3	1.1	1.1	3.0	2.7
17.0	95.0	1.5	1.1	2.3	2.4	31.5	97.1	1.6	1.5	2.6	2.3
18.0	95.1	1.6	1.2	2.4	2.6	33.0	97.0	1.7	1.6	3.4	3.0
19.0	95.0	1.6	1.2	2.8	2.9	34.5	96.9	2.1	2.0	3.6	3.2
20.0	95.0	1.4	1.0	2.8	2.9	36.0	96.7	1.9	1.8	3.6	3.2
21.0	95.0	1.4	1.0	2.8	3.0	37.5	96.7	1.7	1.6	3.0	2.7
22.0	94.9	1.1	0.8	2.8	2.9	39.0	96.7	1.0	0.9	3.3	2.9
23.0	95.0	1.8	1.4	3.0	3.2	40.5	96.9	1.3	1.2	3.5	3.1
24.0	94.8	1.4	1.1	3.2	3.4	42.0	97.3	1.4	1.3	3.4	3.0
25.0	94.9	1.9	1.4	3.3	3.5	43.5	97.0	0.5	0.5	3.0	2.7

Trans 8		12 cfs		71 cfs		Trans 9		12 cfs		71 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
26.0	94.9	1.6	1.2	3.1	3.3	44.5	97.5	0.0	0.1	1.6	1.4
27.0	95.2	0.8	0.6	2.5	2.6	45.0	97.4		0.0	0.2	0.2
28.0	95.1	1.7	1.3	2.3	2.4	45.5	97.4		0.0	0.0	0.0
29.0	95.0	1.0	0.7	2.3	2.4	46.0	98.7				
30.0	95.2	0.2	0.2	2.1	2.3	52.0	100.5				
31.0	95.5	0.0	0.1	0.9	0.9	54.5	101.0				
32.0	95.7	0.0	0.0	0.8	0.8						
33.0	96.3			0.0	0.0						
33.4	96.5										
38.0	96.9										
43.0	97.7										
45.0	98.9										

Table B-31 (continued)

Trans 10		12 cfs		71 cfs		Trans 11		12 cfs		71 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	101.2					0.0	101.5				
5.0	100.5					15.0	99.8				
10.0	99.6					20.0	98.9				
15.0	98.7					21.2	98.6			0.0	0.0
15.5	98.6			0.0	0.0	22.0	98.6			0.0	0.0
16.0	98.5			0.0	0.1	23.0	98.4			0.0	0.0
17.0	98.4			0.2	0.2	24.0	98.3			0.4	0.4
18.0	98.3			0.5	0.5	25.0	98.2			1.2	1.1
18.7	97.9	0.0	0.0	0.6	0.6	25.4	97.9	0.0	0.0	1.1	1.1
19.0	98.0	0.0	0.0	0.6	0.6	26.0	97.8	0.0	0.0	1.1	1.0
20.0	97.8	0.1	0.1	0.5	0.5	27.0	97.6	0.1	0.1	0.5	0.4
21.0	97.8	0.0	0.0	1.2	1.2	28.0	97.5	1.4	1.0	2.4	2.2
22.0	97.6	0.0	0.0	1.6	1.6	29.0	97.5	0.6	0.5	1.8	1.7
23.0	97.4	0.3	0.3	1.8	1.8	30.0	97.5	1.3	0.9	2.0	1.9
24.0	97.3	0.4	0.4	1.9	2.0	31.0	97.5	0.5	0.3	2.4	2.2

Trans 10		12 cfs		71 cfs		Trans 11		12 cfs		71 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
25.0	97.3	0.4	0.4	2.2	2.3	32.0	97.4	0.8	0.5	3.3	3.1
26.0	97.2	0.2	0.2	1.5	1.6	33.0	97.7	0.0	0.9	3.9	3.7
27.0	97.2	0.3	0.4	2.3	2.3	34.0	97.5	1.9	1.4	4.1	3.9
28.0	97.2	0.6	0.6	2.4	2.5	35.0	97.4	1.1	0.8	4.6	4.3
29.0	97.2	0.4	0.5	2.0	2.0	36.0	97.1	2.3	1.6	4.0	3.7
30.0	97.0	0.4	0.5	3.3	3.4	37.0	97.1	0.8	0.6	3.9	3.7
31.0	97.4	0.8	0.9	3.9	4.0	38.0	97.3	1.6	1.2	4.3	4.1
32.0	97.0	0.7	0.7	3.1	3.1	39.0	97.1	2.3	1.7	3.1	2.9
33.0	96.9	1.0	1.1	3.3	3.3	40.0	97.1	2.3	1.6	4.1	3.8
34.0	96.9	1.4	1.6	3.1	3.2	41.0	96.9	1.5	1.1	3.2	3.0
35.0	97.2	1.4	1.6	3.9	4.0	42.0	96.8	1.8	1.3	3.5	3.3
36.0	96.9	1.7	1.9	3.5	3.5	43.0	96.8	1.6	1.2	3.2	3.0
37.0	96.9	1.6	1.8	3.9	4.0	44.0	96.9	0.2	0.1	0.3	0.3
38.0	96.8	1.2	1.4	2.9	2.9	44.4	98.6	0.4	0.0	0.0	0.0
39.0	96.9	0.4	0.4	1.2	1.2	47.0	100.1				
39.5	97.9	0.0	0.0	0.6	0.6	51.0	100.8				
40.0	98.6			0.0	0.0	54.8	102.2				
41.0	99.1										
44.0	99.5										
47.4	101.1										

Table B-31 (continued)

Trans 12		12 cfs		71 cfs		Trans 13		12 cfs		71 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	102.4					0.0	106.9				
5.0	101.6					5.0	105.2				
10.0	100.4					10.0	104.3				
20.0	99.7					12.2	101.9				
30.0	99.2					18.0	101.1				
32.7	98.9			0.0	0.0	22.2	99.9				
33.0	98.8			0.0	0.1	27.0	100.1				

Trans 12		12 cfs		71 cfs		Trans 13		12 cfs		71 cfs	
Station	Elevevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
34.0	98.8			0.1	0.1	33.0	99.5			0.0	0.2
35.0	98.8			0.0	0.0	34.5	99.5			0.0	0.2
36.0	98.7			0.0	0.0	35.0	99.5			0.0	0.2
37.0	98.4			0.2	0.1	36.0	99.5			0.0	0.2
38.0	98.4			0.4	0.4	37.5	99.5			0.0	0.2
39.0	98.5			1.5	1.4	39.0	99.5			0.4	0.2
39.7	98.2	0.0	0.0	1.4	1.3	40.5	99.3			0.7	0.6
40.0	97.8	0.1	0.0	1.4	1.3	42.0	99.5			0.0	0.1
41.0	97.7	0.3	0.2	2.0	1.9	43.5	99.0			1.5	1.4
42.0	97.7	0.6	0.4	3.0	2.9	44.5	99.0	0.0	0.0	1.7	1.6
43.0	97.5	0.7	0.5	2.3	2.2	45.0	99.0	0.0	0.0	1.9	1.7
44.0	97.5	1.2	0.8	3.2	3.0	46.5	98.8	0.0	0.1	2.3	2.2
45.0	97.2	1.1	0.8	3.5	3.3	48.0	98.6	0.3	0.2	1.0	0.9
46.0	97.3	2.0	1.4	3.9	3.7	49.5	98.6	0.2	0.1	2.0	1.9
47.0	97.2	2.4	1.7	4.1	3.9	51.0	98.5	1.7	1.2	2.3	2.1
48.0	97.1	2.1	1.4	4.6	4.4	52.5	98.6	1.0	0.7	4.2	4.0
49.0	97.1	2.0	1.4	4.0	3.9	54.0	98.2	1.4	1.0	2.6	2.5
50.0	97.1	2.8	1.9	4.9	4.7	55.5	98.2	1.8	1.3	3.2	3.1
51.0	97.1	1.8	1.3	3.5	3.4	57.0	98.3	3.5	2.5	3.9	3.7
52.0	97.2	0.5	0.3	3.1	2.9	58.5	98.1	1.8	1.3	3.6	3.4
53.0	97.6	0.0	0.0	3.2	3.0	60.0	98.1	1.6	1.1	4.7	4.4
54.0	97.7	0.1	0.1	1.3	1.2	61.5	98.2	1.6	1.1	3.2	3.1
54.5	98.9	0.0	0.0	0.0	0.0	63.0	98.3	1.2	0.8	4.0	3.8
55.5	99.6					64.5	98.5	1.4	1.0	3.6	3.4
59.0	100.9					66.0	98.5	0.9	0.6	1.1	1.0
64.5	102.4					67.0	99.5	0.0	0.0	0.0	0.1
						68.0	100.1				
						71.2	101.1				

Table B-31 (continued)

Trans 14		12 cfs		71 cfs		Trans 15		12 cfs		33 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated	Measured	Simulated
0.0	103.7					0.0	102.2						
5.0	103.4					1.5	100.8						
10.0	101.5					3.4	100.3						0.1
12.5	100.3					4.0	100.3					0.1	0.1
12.8	100.1			0.0	0.0	4.4	99.9	0.0	0.0	0.0	0.0	0.2	0.2
13.0	100.0			0.0	0.0	6.0	99.2	0.0	0.0	0.1	0.1	0.2	0.2
14.0	99.9	0.0	0.0	0.4	0.4	8.0	99.2	0.4	0.4	0.4	0.4	0.5	0.5
15.0	99.8	0.0	0.0	0.9	0.8	10.0	99.1	0.6	0.5	0.7	0.7	0.7	0.8
17.0	99.8	0.0	0.0	0.1	0.1	12.0	98.9	1.0	0.8	1.0	0.9	1.1	1.1
17.5	99.8	0.0	0.0	0.0	0.8	14.0	99.1	1.2	1.1	1.5	1.5	1.4	1.5
19.0	99.7	0.1	0.0	1.2	1.1	16.0	99.2	1.1	1.0	1.7	1.7	1.4	1.4
21.0	99.5	0.0	0.0	1.9	1.8	18.0	99.3	1.4	1.2	2.0	2.0	1.9	1.9
23.0	99.6	0.0	0.0	1.6	1.5	20.0	99.3	1.0	0.8	2.1	2.0	2.1	2.2
25.0	99.7	0.0	0.0	1.7	1.5	22.0	99.5	1.1	1.0	1.8	1.8	2.6	2.7
27.0	99.7	0.0	0.0	1.8	1.7	24.0	99.7	1.0	0.9	1.9	1.8	2.5	2.6
29.0	99.6	0.0	0.0	1.6	1.5	26.0	99.4	0.9	0.8	1.7	1.7	2.6	2.7
31.0	99.5	0.0	0.0	2.1	2.0	28.0	99.4	0.8	0.7	1.6	1.5	2.4	2.5
33.0	99.7	0.0	0.0	2.5	2.3	30.0	99.4	0.2	0.2	1.2	1.1	2.5	2.6
35.0	99.5	0.0	0.0	3.3	3.0	32.0	99.3	0.5	0.4	1.3	1.2	2.5	2.6
37.0	99.5	0.1	0.0	2.9	2.7	34.0	99.4	0.5	0.5	1.3	1.2	2.7	2.8
39.0	99.1	0.8	0.8	2.0	1.8	36.0	99.3	0.4	0.4	1.2	1.1	2.7	2.8
41.0	98.9	0.6	0.5	2.9	2.7	38.0	99.6	0.0	0.2	0.9	0.9	2.2	2.3
43.0	99.0	1.6	1.6	3.3	3.1	40.0	99.8	0.1	0.1	0.3	0.3	1.9	1.9
45.0	98.9	1.8	1.7	3.1	2.9	41.5	99.9	0.0	0.0	0.1	0.1	1.5	1.5
47.0	99.0	1.9	1.9	3.0	2.8	42.0	99.9			0.2	0.2	1.1	1.1
49.0	99.1	1.6	1.6	3.0	2.8	44.0	100.1			0.0	0.0	0.5	0.5
51.0	99.0	1.5	1.5	3.0	2.8	46.0	100.3					0.0	0.2
53.0	98.8	1.4	1.4	2.5	2.3	46.5	100.4					0.0	0.0
55.0	98.9	1.2	1.2	2.5	2.3	47.0	100.5						
57.0	99.0	0.5	0.5	1.9	1.8	56.0	102.0						

Trans 14		12 cfs		71 cfs		Trans 15		12 cfs		33 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated	Measured	Simulated
59.0	99.4	0.0	0.1	1.1	1.0	57.0	102.9						
59.4	99.5	0.0	0.0	0.6	0.6								
61.0	100.1			0.0	0.0								
67.0	101.1												
69.4	102.0												

Table B-31 (continued)

Trans 16		12 cfs		71 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	102.0				
8.4	100.4				
8.7	100.4			0.0	0.0
9.0	100.3			0.0	0.0
11.0	100.1			0.0	0.0
13.0	100.2			0.1	0.1
15.0	100.0			0.1	0.1
16.4	99.9	0.0	0.0	0.1	0.1
17.0	99.8	0.0	0.0	0.1	0.1
19.0	99.4	0.0	0.1	0.1	0.1
21.0	99.5	0.1	0.0	0.2	0.2
23.0	99.4	0.1	0.1	0.2	0.2
25.0	99.6	0.1	0.1	0.2	0.2
27.0	99.2	0.1	0.1	0.1	0.1
29.0	99.1	0.1	0.0	0.1	0.1
31.0	99.3	0.0	0.0	0.0	0.0
33.0	99.1	0.0	0.0	0.0	0.0
35.0	99.1	0.0	0.1	0.2	0.2
37.0	98.9	0.1	0.1	0.8	0.7
39.0	98.8	0.1	0.1	1.4	1.2
41.0	98.9	0.2	0.1	1.4	1.2
43.0	98.9	1.0	0.7	3.1	2.8

Trans 16		12 cfs		71 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
45.0	98.9	2.4	1.8	3.2	2.9
47.0	99.2	3.1	2.3	3.9	3.5
49.0	98.9	0.1	0.1	4.3	3.8
51.0	99.2	1.8	1.3	4.3	3.8
53.0	98.9	0.1	0.1	3.8	3.4
55.0	99.8	0.0	0.0	1.0	0.9
55.3	99.9	0.0	0.0	0.5	0.5
57.0	100.3			0.0	0.2
57.4	100.4			0.0	0.1
58.0	100.6				
62.0	101.0				
68.0	102.0				

Table B-32. Velocity calibration results for South Fork Little Butte Creek Study Site.

Trans 1		22 cfs		35 cfs		93 cfs		Trans 2		22 cfs		35 cfs		93 cfs	
Station	Elev	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elev	Measured	Simulated	Measured	Simulated	Measured	Simulated
0.0	92.7							0.0	94.3						
5.0	92.4							1.0	92.9						
8.0	91.5							11.0	92.8						
9.0	91.2					0.0	0.0	12.0	92.7					0.0	0.0
9.6	90.9			0.0	0.0	0.0	1.6	14.8	92.3			0.0	0.1	1.6	1.6
12.7	90.8	0.0	0.0		0.5	1.9	2.0	18.3	92.2	0.0	0.0	0.4	0.4	1.9	1.9
13.0	90.8	0.0	0.0		0.5	2.1	2.2	19.0	92.3	0.0	0.0	0.0	0.1	2.7	2.7
14.0	90.8	0.0	0.0	0.7	0.5	2.7	2.8	20.0	92.0	0.0	0.6	0.7	0.7	1.7	1.7
15.0	90.7	0.6	0.1	0.8	0.7	3.3	3.6	21.0	92.0	0.7	0.6	1.4	1.4	1.7	1.8
16.0	90.6	0.2	0.2	1.0	1.1	3.2	3.5	22.0	91.9	0.5	0.5	0.1	0.1	2.0	2.0
17.0	90.4	2.2	2.3	2.4	2.5	3.7	4.2	23.0	91.9	0.9	0.8	1.8	1.7	3.0	3.0
18.0	90.3	1.5	1.5	1.6	1.7	4.3	5.0	24.0	92.0	1.3	1.1	2.2	2.1	3.2	3.3
19.0	90.2	3.3	3.3	2.5	2.7	3.5	4.1	25.0	91.9	0.6	0.5	1.9	1.8	3.3	3.3
20.0	90.3	3.4	3.4	2.8	3.0	4.1	4.7	26.0	91.8	1.3	1.1	1.6	1.6	3.7	3.7
21.0	90.1	2.5	2.5	2.4	2.6	4.6	5.4	27.0	92.2	0.0	0.0	1.2	1.2	4.3	4.4
22.0	90.4	3.7	3.8	3.8	4.1	3.5	4.1	28.0	91.9	1.1	1.0	1.5	1.5	3.5	3.5
23.0	90.6	0.5	0.5	1.5	1.5	4.8	5.4	29.0	91.8	0.6	0.5	0.6	0.6	1.9	1.9
24.0	90.2	0.9	0.9	2.9	3.2	3.3	3.9	30.0	91.6	1.1	1.0	1.6	1.5	3.4	3.4
25.0	90.3	3.5	3.5	3.7	4.0	3.9	4.6	31.0	91.5	1.8	1.6	1.8	1.7	2.5	2.5
26.0	90.2	3.8	3.8	3.9	4.2	4.4	5.2	32.0	91.8	1.7	1.5	2.0	1.9	3.3	3.4
27.0	90.0	1.3	1.3	2.2	2.4	4.8	5.7	33.0	91.5	1.6	1.4	1.6	1.5	3.5	3.5
28.0	89.8	0.1	0.0	0.1	0.1	1.1	1.4	34.0	91.6	1.7	1.5	2.4	2.3	4.4	4.5
29.0	89.9	2.7	2.7	3.8	4.1	5.0	6.0	35.0	91.4	1.7	1.5	1.7	1.6	4.6	4.6
30.0	90.0	3.5	3.5	3.9	4.2	1.6	2.0	36.0	91.6	2.1	1.8	3.0	2.8	4.5	4.5
31.0	90.0	2.8	2.8	2.7	3.0	3.1	3.7	37.0	91.2	2.2	1.9	2.8	2.7	4.5	4.6
32.0	90.4	0.5	0.5	0.9	0.9	6.0	7.0	38.0	91.1	2.5	2.2	3.1	3.0	4.2	4.3
33.0	90.4	4.3	4.4	4.8	5.1	4.4	5.1	39.0	91.1	2.1	1.9	2.7	2.6	3.5	3.6
34.0	90.6	3.4	4.0	3.9	4.0	4.5	5.0	40.0	90.7	2.1	1.9	1.9	1.8	3.0	3.0
35.0	90.7	1.4	1.0	2.7	2.7	5.9	6.4	41.0	90.9	1.7	1.5	1.9	1.8	3.4	3.5

Trans 1		22 cfs		35 cfs		93 cfs		Trans 2		22 cfs		35 cfs		93 cfs	
Station	Elev	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elev	Measured	Simulated	Measured	Simulated	Measured	Simulated
36.0	90.8				1.2	0.2	0.2	42.0	90.9	1.4	1.2	1.5	1.5	2.2	2.2
37.0	90.4	0.1	0.1	2.6	2.8	4.2	4.8	43.0	91.3	1.7	1.5	1.9	1.8	2.3	2.4
38.0	90.5	2.4	2.6	2.0	2.1	2.9	3.3	43.9	91.4	0.8	0.7	1.4	1.3	1.6	1.6
39.0	90.1	0.6	0.6	0.5	0.5	0.8	0.9	45.0	92.2	0.0	0.0	0.4	0.4	1.1	1.1
40.0	90.9	0.0	0.0	0.0	0.0	0.6	0.6	45.4	92.3	0.0	0.0	0.0	0.1	1.0	1.0
40.9	90.9	0.0	0.0	0.0	0.0	0.1	0.1	46.0	92.5					0.0	0.6
41.5	91.2					0.0	0.0	46.7	92.7					0.0	0.0
42.6	91.2					0.0	0.0	47.0	93.1						
44.7	91.8							49.5	93.3						
48.0	92.1							52.7	94.7						

Table B-32 (Continued)

Trans 3		22 cfs		35 cfs		Trans 4		22 cfs		35 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	96.1					0.0	97.2				
6.0	95.5					7.0	96.2				
19.0	95.2					12.0	96.6				
21.9	94.8			0.0	0.1	16.0	96.2				
24.0	94.8			0.0	0.1	17.3	95.6			0.0	0.0
28.0	94.9					17.6	95.6	0.0	0.0	0.0	0.0
28.7	94.8			0.0	0.1	18.0	95.6	0.0	0.0	0.0	0.0
32.5	94.7	0.0	0.0	0.1	0.1	19.1	95.0	0.1	0.1	0.5	0.4
33.0	94.8	0.0	0.0	0.0	0.1	20.0	94.8	0.2	0.2	0.7	0.6
34.0	94.3	0.2	0.1	0.5	0.6	21.0	95.1	0.2	0.2	0.6	0.5
35.0	94.5	0.0	0.3	0.1	0.1	22.0	95.2	0.0	0.0	0.3	0.3
35.4	94.7	0.0	0.0	0.1	0.1	23.0	95.4	0.1	0.1	0.3	0.3
37.0	94.8			0.0	0.0	24.0	95.4	0.1	0.1	0.0	0.0
39.8	94.7	0.0	0.0	0.1	0.1	25.0	95.3	0.2	0.2	0.7	0.6
40.0	94.7	0.0	0.0	0.0	0.0	26.0	95.1	0.1	0.1	0.6	0.6
41.0	94.6	0.0	0.2	0.4	0.4	27.0	95.2	0.0	0.4	1.4	1.2

Trans 3		22 cfs		35 cfs		Trans 4		22 cfs		35 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
42.0	94.8			0.0	0.3	28.0	95.1	0.0	0.5	1.9	1.7
43.0	94.3	0.6	0.6	1.6	1.8	29.0	94.6	1.3	1.0	0.2	0.1
44.0	94.5	1.4	1.3	1.9	2.1	30.0	94.2	1.6	1.3	2.9	2.5
45.0	94.0	2.0	1.8	0.4	0.4	31.0	94.4	2.5	2.0	2.8	2.4
46.0	94.2	0.0	1.5	0.3	0.3	32.0	94.4	3.2	2.5	3.1	2.7
47.0	93.9	2.2	2.0	0.8	0.9	33.0	94.2	3.2	2.5	2.6	2.2
48.0	93.9	3.1	2.8	3.4	3.7	34.0	94.2	2.7	2.1	2.8	2.4
49.0	93.6	2.3	2.2	3.5	3.8	35.0	94.5	2.8	2.2	3.0	2.7
50.0	93.6	2.5	2.3	2.5	2.8	36.0	94.4	2.3	1.8	2.5	2.2
51.0	93.6	2.4	2.2	3.5	3.8	37.0	94.6	2.6	2.0	3.2	2.8
52.0	93.0	1.9	1.7	2.0	2.2	38.0	94.7	2.1	1.7	3.1	2.7
53.0	93.4	1.4	1.3	2.3	2.5	39.0	94.8	2.3	1.8	2.7	2.3
54.0	93.7	1.2	1.1	1.1	1.2	40.0	95.0	1.9	1.5	2.4	2.1
55.0	93.7	1.4	1.3	1.5	1.7	41.0	95.0	0.4	0.3	1.7	1.5
56.0	94.1	1.1	1.0	1.7	1.9	42.0	95.2	0.0	0.2	1.0	0.8
57.0	94.2	1.3	1.2	1.8	1.9	43.0	95.5	0.0	0.0	0.5	0.4
58.0	94.2	1.1	1.1	1.5	1.6	43.7	95.6			0.0	0.1
59.0	94.4	1.0	0.9	1.2	1.4	44.5	95.8				
60.0	94.8	0.0	0.0	0.0	0.3	52.0	96.5				
60.7	94.8	0.0	0.0	0.0	0.3	61.6	97.3				
61.1	94.8			0.0	0.3						
62.0	95.0										
68.0	95.8										
70.6	96.8										

Table B-32 (Continued)

Trans 5		22 cfs		35 cfs		Trans 6		22 cfs		35 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	98.2					0.0	97.5				
3.0	97.5					2.0	97.3				
6.0	96.6					5.5	96.8				

Trans 5		22 cfs		35 cfs		Trans 6		22 cfs		35 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
8.5	95.7			0.0	0.0	6.5	96.6	0.0	0.0	0.1	0.0
8.7	95.7	0.0	0.0	0.0	0.0	8.0	95.8	0.2	0.2	0.2	0.2
9.0	95.6	0.0	0.0	0.1	0.1	9.5	95.7	1.7	1.7	1.3	1.4
10.0	95.1	0.2	0.2	0.2	0.2	11.0	95.6	2.8	2.8	3.8	4.3
11.0	95.0	0.3	0.2	0.2	0.2	12.5	95.7	2.9	2.9	2.7	3.0
12.0	94.9	0.3	0.3	0.2	0.2	14.0	95.9	1.5	1.6	2.5	2.8
13.0	94.8	0.3	0.2	0.2	0.2	15.5	96.2	4.0	4.1	2.8	3.0
14.0	94.7	0.3	0.2	0.2	0.2	17.0	96.1	3.6	3.7	3.1	3.4
15.0	94.6	0.2	0.2	0.2	0.2	18.5	96.4	2.5	2.7	3.0	3.1
16.0	94.4	0.2	0.2	0.2	0.1	20.0	96.4	0.1	0.1	1.5	1.6
17.0	94.4	0.1	0.1	0.0	0.0	21.5	96.4	1.5	1.6	2.6	2.7
18.0	94.2	0.0	0.0	0.2	0.1	23.0	96.3	1.5	1.5	1.9	2.1
19.0	93.9	0.1	0.1	0.3	0.3	24.5	96.6	1.2	1.7	1.3	1.3
20.0	93.8	0.4	0.4	0.3	0.3	26.0	96.6	0.2	0.3	0.9	0.9
21.0	93.9	0.6	0.6	0.8	0.7	27.5	96.6	0.5	0.7	1.4	1.3
22.0	93.9	0.7	0.7	0.9	0.9	29.0	96.5	0.3	0.3	0.9	1.0
23.0	93.8	1.0	0.9	1.6	1.5	30.5	96.5	0.7	0.7	1.9	1.9
24.0	93.7	1.3	1.2	2.1	2.0	32.0	96.6	0.6	0.9	1.5	1.4
25.0	93.7	1.8	1.6	2.3	2.2	33.5	96.7	0.4	0.0	0.9	0.8
26.0	94.0	1.8	1.6	2.1	2.0	35.0	96.8				0.1
27.0	94.5	2.0	1.9	2.7	2.5	36.5	96.6	0.8	1.2	1.4	1.3
28.0	94.2	2.1	1.9	3.4	3.2	38.0	96.7	0.0	0.0	0.2	0.1
29.0	94.2	2.0	1.8	2.8	2.6	39.5	96.8				0.0
30.0	94.5	1.4	1.3	1.8	1.7	41.0	96.4	0.1	0.1	0.2	0.2
31.0	94.8	1.1	1.0	0.9	0.9	42.5	96.6	0.8	1.2	1.6	1.6
32.0	95.2	0.3	0.3	0.6	0.5	43.0	96.9	0.0	0.0	0.0	0.0
33.0	95.3	0.1	0.0	0.0	0.5	43.5	97.0				
33.7	95.5	0.0	0.0	0.1	0.0	47.0	97.4				
35.6	95.7			0.0	0.0	51.4	98.2				
36.0	95.8										
42.0	96.5										

Trans 5		22 cfs		35 cfs		Trans 6		22 cfs		35 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
52.0	97.5										

Table B-32 (Continued)

Trans 7		22 cfs		35 cfs		Trans 8		22 cfs		35 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	100.0					0.0	99.5				
1.6	97.5					3.0	99.0				
3.3	98.2					5.0	97.9				
4.5	97.1	0.0	0.0	0.0	0.0	5.3	97.7	0.0	0.0	0.0	0.0
5.0	96.6	0.1	0.1	0.1	0.1	6.0	97.4	0.2	0.2	0.3	0.3
6.0	96.5	0.2	0.2	0.1	0.1	7.0	96.9	0.4	0.4	0.9	0.9
7.0	96.5	0.7	0.7	0.7	0.7	8.0	96.8	0.7	0.7	1.5	1.5
8.0	96.4	0.6	0.6	0.9	0.9	9.0	96.4	1.1	1.0	1.3	1.3
9.0	96.4	0.6	0.6	0.8	0.8	10.0	96.1	1.6	1.4	1.5	1.5
10.0	96.2	1.7	1.7	2.1	2.1	11.0	96.1	1.5	1.4	2.0	2.0
11.0	95.7	1.9	1.9	2.3	2.3	12.0	96.2	1.8	1.6	1.6	1.6
12.0	95.9	0.7	0.7	0.9	0.9	13.0	96.4	2.5	2.3	2.4	2.4
13.0	95.7	0.9	0.9	1.3	1.3	14.0	96.4	1.5	1.3	2.0	2.0
14.0	95.7	1.9	1.9	1.8	1.8	15.0	96.3	1.9	1.7	2.3	2.3
15.0	96.0	1.6	1.7	1.9	1.9	16.0	96.4	2.0	1.9	2.4	2.4
16.0	96.5	1.1	1.1	2.9	3.0	17.0	96.6	1.7	1.6	2.4	2.4
17.0	96.3	2.0	2.0	2.8	2.8	18.0	96.7	1.0	0.9	2.0	2.0
18.0	96.1	1.5	1.5	2.3	2.3	19.0	96.5	0.6	0.6	1.8	1.8
19.0	96.2	2.6	2.7	2.8	2.7	20.0	96.7	1.0	0.9	1.3	1.3
20.0	96.0	1.8	1.8	2.9	2.9	21.0	96.7	1.0	0.9	1.4	1.4
21.0	96.4	1.8	1.8	2.5	2.5	22.0	97.0	1.0	0.9	1.2	1.2
22.0	96.5	1.3	1.3	2.5	2.6	23.0	97.0	0.7	0.6	0.8	0.8
23.0	96.5	1.2	1.2	1.6	1.7	24.0	97.2	0.0	0.5	0.0	0.0
24.0	96.5	0.5	0.5	0.5	0.5	25.4	97.7			0.0	0.0
25.0	96.3	0.2	0.2	0.2	0.2	26.0	98.0				
26.0	96.4	0.1	0.1	0.2	0.2	28.0	98.8				

Trans 7		22 cfs		35 cfs		Trans 8		22 cfs		35 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
27.0	96.4	0.4	0.4	0.2	0.2	30.4	99.7				
28.0	96.6	1.3	1.3	0.8	0.8						
29.0	96.5	0.9	0.9	1.4	1.4						
30.0	97.0	0.0	0.0	1.3	1.9						
31.0	96.7	1.8	1.9	2.6	2.8						
32.0	96.9	0.0	0.8	1.0	1.2						
33.0	96.9	0.2	0.2	0.7	0.8						
34.0	96.9	0.0	0.2	0.2	0.2						
34.9	97.0				0.1						
35.3	97.0				0.1						
35.7	97.3										
39.0	98.7										
40.9	99.9										

Table B-33. Velocity calibration results for Little Butte Creek between Antelope Creek and South Fork Little Butte Creek Study Site.

Trans 1		35 cfs		44 cfs		67 cfs		Trans 2		35 cfs		44 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	94.5							0.0	96.1				
1.0	93.5							0.5	95.9				
7.0	91.4							2.5	91.4			0.0	0.0
22.5	91.7					0.0	0.0	3.0	91.4	0.0	0.0	0.0	0.0
24.5	91.6			0.0	0.0	0.1	0.1	5.0	91.0	0.1	0.1	0.0	0.0
25.0	91.6			0.0	0.0	0.0	0.0	7.0	90.5	0.1	0.1	0.1	0.1
27.0	91.6			0.0	0.0	0.1	0.1	9.0	90.0	0.1	0.1	0.1	0.1
29.0	91.6			0.0	0.0	0.1	0.1	11.0	89.1	0.1	0.1	0.0	0.0
31.0	91.6			0.0	0.0	0.3	0.3	13.0	88.7	0.1	0.1	0.0	0.0
32.3	91.4			0.0	0.1	0.5	0.5	15.0	88.3	0.1	0.1	0.0	0.0
33.0	91.4			0.1	0.1	0.4	0.5	17.0	87.8	0.1	0.1	0.1	0.1
35.0	91.3		0.4	0.6	0.7	1.0	1.1	19.0	87.5	0.0	0.0	0.2	0.2
37.0	91.3		0.4	0.7	0.7	1.2	1.2	21.0	87.3	0.1	0.1	0.3	0.3
39.0	91.2	0.8	0.9	1.2	1.3	1.6	1.7	23.0	87.3	0.2	0.2	0.4	0.4
41.0	91.1	0.8	0.9	1.1	1.2	1.4	1.5	25.0	87.5	0.3	0.3	0.5	0.5
43.0	91.1	0.9	1.0	1.2	1.4	1.5	1.5	27.0	87.8	0.4	0.4	0.5	0.5
45.0	91.2	1.4	1.6	1.6	1.8	1.8	1.9	29.0	88.2	0.4	0.5	0.6	0.6
47.0	91.1	1.1	1.2	0.7	0.7	1.5	1.6	31.0	88.6	0.5	0.5	0.6	0.6
49.0	90.9	1.6	1.8	1.9	2.1	1.8	1.9	33.0	89.0	0.5	0.6	0.5	0.5
51.0	90.9	1.4	1.6	1.4	1.6	1.9	2.0	35.0	89.2	0.5	0.5	0.7	0.7
53.0	90.8	1.5	1.7	2.0	2.2	2.1	2.2	37.0	89.2	0.5	0.6	0.5	0.5
55.0	90.7	1.8	2.0	2.0	2.2	2.1	2.3	39.0	89.3	0.5	0.5	0.6	0.6
57.0	90.7	1.8	2.0	2.0	2.1	2.2	2.3	41.0	89.4	0.5	0.6	0.6	0.6
59.0	90.6	1.9	2.1	2.1	2.3	2.4	2.5	43.0	89.6	0.4	0.5	0.6	0.6
61.0	90.6	1.8	2.0	2.0	2.2	2.4	2.5	45.0	89.7	0.4	0.5	0.5	0.5
63.0	90.7	1.9	2.1	2.1	2.3	2.3	2.5	47.0	89.9	0.4	0.5	0.5	0.5
65.0	90.8	1.8	2.0	2.1	2.3	2.3	2.5	49.0	90.4	0.5	0.6	0.6	0.6
67.0	90.7	1.8	2.0	2.0	2.2	2.2	2.4	51.0	91.5	0.0	0.0	0.0	0.0
69.0	90.7	1.7	1.9	1.8	2.0	2.2	2.3	52.5	91.8				
71.0	90.4	1.3	1.5	1.5	1.7	1.5	1.6	56.5	91.8				

Trans 1		35 cfs		44 cfs		67 cfs		Trans 2		35 cfs		44 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
73.0	90.4	1.3	1.5	1.3	1.4	1.7	1.8	63.6	93.4				
75.0	90.7	0.4	0.4	0.7	0.8	0.7	0.7						
76.6	91.0	0.1	0.2	0.2	0.3	0.3	0.4						
78.0	91.4					0.0	0.2						
78.7	91.7												
80.0	92.2												
82.4	93.1												

Table B-33 (Continued)

Trans 3		35 cfs		44 cfs		Trans 4		35 cfs		44 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	95.9					0.0	93.3				
1.5	95.4					2.0	92.4				
3.0	92.5					4.0	93.2				
3.8	91.3		0.0	0.0	0.0	5.2	91.1	0.0	0.3	0.6	0.6
4.0	91.2	0.0	0.0	0.0	0.0	5.5	90.7	0.5	0.6	0.5	0.5
6.0	90.8	0.0	0.0	0.1	0.1	7.0	90.5	0.9	1.1	0.9	0.9
8.0	89.9	0.1	0.1	0.0	0.0	8.5	90.8	1.8	2.1	2.0	2.0
10.0	89.4	0.2	0.2	0.9	0.9	10.0	90.2	1.2	1.3	1.2	1.2
12.0	89.2	1.0	1.1	0.8	0.9	11.5	90.0	1.5	1.7	2.1	2.1
14.0	89.4	0.8	0.9	1.0	1.1	13.0	90.0	1.9	2.2	2.1	2.1
16.0	89.6	1.1	1.3	1.5	1.6	14.5	89.8	1.5	1.7	3.0	3.0
18.0	89.7	1.3	1.4	1.2	1.3	16.0	89.7	0.9	1.0	1.8	1.8
20.0	89.6	0.9	1.0	1.2	1.3	17.5	90.1	1.3	1.5	1.4	1.4
22.0	90.0	0.8	0.9	1.0	1.0	19.0	90.5	1.2	1.3	1.4	1.4
24.0	89.8	0.6	0.7	0.8	0.9	20.5	90.5	1.0	1.1	1.3	1.3
26.0	90.0	0.5	0.6	0.8	0.9	22.0	90.6	1.2	1.4	1.3	1.3
28.0	90.0	0.6	0.6	0.5	0.5	23.5	90.9	1.4	1.6	1.8	1.8
30.0	90.2	0.5	0.5	0.5	0.6	25.0	90.7	0.7	0.8	0.4	0.4
32.0	90.4	0.4	0.5	0.5	0.6	26.5	90.8	0.4	0.4	0.5	0.5
34.0	90.5	0.2	0.2	0.3	0.3	28.0	90.5	0.1	0.1	0.6	0.6

Trans 3		35 cfs		44 cfs		Trans 4		35 cfs		44 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
36.0	90.8	0.3	0.4	0.4	0.4	29.5	90.8	0.4	0.4	0.3	0.3
38.0	90.7	0.3	0.3	0.3	0.4	31.0	90.8	0.7	0.8	0.8	0.8
40.0	90.8	0.1	0.2	0.3	0.3	32.5	90.8	0.4	0.4	0.9	0.9
42.0	90.9	0.2	0.2	0.3	0.3	34.0	90.9	0.1	0.1	0.1	0.1
44.0	90.9	0.0	0.0	0.1	0.1	35.5	91.1	0.1	0.1	0.1	0.1
46.0	91.2	0.1	0.1	0.0	0.0	37.0	91.3	0.0	0.0	0.1	0.1
48.0	91.4	0.0	0.0	0.0	0.0	38.5	91.2	0.1	0.1	0.1	0.1
50.0	91.5			0.0	0.0	40.0	91.4	0.0	0.0	0.0	0.0
56.0	92.1					41.5	91.4	0.0	0.0	0.0	0.0
62.0	92.8					43.0	91.3	0.0	0.1	0.1	0.1
68.1	93.2					43.8	91.4	0.0	0.0	0.0	0.0
						44.5	91.5			0.0	0.0
						46.0	91.5			0.0	0.0
						46.5	91.5			0.0	0.0
						50.0	91.6				
						54.0	92.3				
						60.0	93.2				
						62.4	94.1				

Table B-33 (Continued)

Trans 5		35 cfs		44 cfs		Trans 6		35 cfs		44 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	96.2					0.0	94.0				
1.0	96.0					2.0	92.8				
3.3	92.3					3.8	92.2	0.0	0.0	0.0	0.0
5.1	91.6	0.1	0.1	0.2	0.2	4.0	92.0	0.0	0.0	0.1	0.1
7.0	91.1	0.6	0.5	0.5	0.5	6.0	91.6	0.3	0.3	0.4	0.4
9.0	91.3	1.9	1.7	1.5	1.4	8.0	91.5	0.4	0.3	0.5	0.4
11.0	91.6	1.8	1.6	1.8	1.7	10.0	91.6	0.8	0.7	0.7	0.7
13.0	91.2	2.2	2.0	1.5	1.3	12.0	91.6	1.0	0.8	1.3	1.2
15.0	91.2	2.7	2.5	3.1	2.8	14.0	91.7	1.0	0.9	1.2	1.1

Trans 5		35 cfs		44 cfs		Trans 6		35 cfs		44 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
17.0	91.1	2.7	2.5	3.1	2.8	16.0	91.7	1.1	1.0	1.4	1.3
19.0	91.1	2.7	2.4	2.8	2.5	18.0	91.8	0.9	0.8	1.2	1.1
21.0	91.0	1.3	1.2	1.7	1.6	20.0	91.7	1.2	1.1	1.4	1.3
23.0	91.1	1.7	1.5	2.2	2.0	22.0	91.7	1.3	1.1	1.9	1.7
25.0	91.3	1.2	1.1	1.4	1.3	24.0	91.4	0.9	0.8	1.2	1.1
27.0	91.4	2.0	1.8	2.1	1.9	26.0	91.5	1.4	1.2	1.5	1.3
29.0	91.4	2.1	1.9	2.2	2.0	28.0	91.5	1.5	1.3	1.7	1.5
31.0	91.3	2.0	1.8	2.1	1.9	30.0	91.8	1.3	1.1	1.8	1.7
33.0	91.2	1.5	1.4	1.8	1.7	32.0	91.5	1.4	1.2	1.7	1.5
35.0	91.3	2.0	1.8	2.0	1.9	34.0	91.5	1.6	1.4	1.5	1.4
37.0	91.3	1.5	1.3	1.6	1.5	36.0	91.4	1.6	1.4	1.5	1.3
39.0	91.5	1.7	1.6	2.1	2.0	38.0	91.3	1.5	1.3	1.2	1.1
41.0	91.2	1.7	1.5	1.8	1.7	40.0	91.4	1.7	1.4	1.8	1.6
43.0	91.2	1.6	1.5	1.5	1.4	42.0	91.3	1.7	1.5	1.9	1.7
45.0	91.4	0.8	0.7	0.8	0.8	44.0	91.1	1.6	1.4	1.7	1.6
47.0	91.6	0.2	0.2	0.2	0.2	46.0	91.2	1.4	1.2	1.1	1.0
49.0	91.6	0.4	0.4	0.5	0.5	48.0	91.6	1.3	1.2	2.0	1.8
51.0	91.7	0.0	0.2	0.0	0.0	50.0	91.5	1.3	1.1	1.0	0.9
53.0	91.8	0.0	0.0	0.0	0.0	52.0	91.7	1.2	1.0	1.5	1.3
53.2	91.8	0.0	0.0	0.0	0.0	54.0	91.6	0.6	0.5	0.8	0.7
53.8	91.9			0.0	0.0	56.0	91.8	0.4	0.4	0.5	0.4
57.0	92.4					58.0	92.0	0.2	0.2	0.3	0.3
63.0	92.8					60.0	92.0	0.0	0.0	0.1	0.1
64.6	95.8					62.0	92.1	0.0	0.0	0.0	0.1
						62.7	92.2	0.0	0.0	0.0	0.0
						63.0	92.2			0.0	0.0
						65.0	92.6				
						72.0	95.3				
						73.5	95.6				

Table B-33 (Continued)

Trans 7		35 cfs		44 cfs		Trans 8		35 cfs		44 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	93.8					0.0	93.5				
6.0	92.8					2.1	92.2	0.0	0.0	0.0	0.0
6.8	92.2	0.0	0.0	0.0	0.0	3.0	91.0	0.1	0.1	0.0	0.0
7.0	92.1	0.0	0.0	0.1	0.1	5.0	90.7	0.6	0.6	0.6	0.5
9.0	91.3	0.1	0.1	0.0	0.0	7.0	90.6	0.9	0.8	1.0	0.8
11.0	90.7	0.0	0.0	0.0	0.0	9.0	90.4	1.2	1.0	1.1	0.9
13.0	90.9	0.2	0.2	0.3	0.3	11.0	90.4	1.2	1.1	1.4	1.2
15.0	91.0	0.6	0.6	0.6	0.6	13.0	90.3	1.2	1.1	1.5	1.3
17.0	91.5	0.9	0.9	0.9	0.9	15.0	90.2	1.1	0.9	1.4	1.2
19.0	91.2	0.5	0.5	0.8	0.8	17.0	90.0	0.9	0.8	1.3	1.2
21.0	91.3	1.1	1.2	1.3	1.4	19.0	89.7	0.7	0.6	0.9	0.8
23.0	91.2	0.9	0.9	1.2	1.2	21.0	89.7	0.5	0.5	0.7	0.6
25.0	91.2	1.0	1.0	1.1	1.1	23.0	89.8	0.4	0.4	0.6	0.5
27.0	91.2	1.0	1.0	1.3	1.3	25.0	89.7	0.2	0.2	0.4	0.3
29.0	90.9	0.9	0.9	1.1	1.1	27.0	89.9	0.2	0.1	0.3	0.2
31.0	90.8	1.0	1.0	1.2	1.2	29.0	90.0	0.0	0.0	0.1	0.1
33.0	90.9	1.0	1.0	1.1	1.2	31.0	90.3	0.1	0.0	0.2	0.2
35.0	90.9	0.9	0.9	1.1	1.1	33.0	90.6	0.1	0.1	0.1	0.1
37.0	91.0	0.9	0.9	0.9	0.9	35.0	90.7	0.1	0.1	0.1	0.1
39.0	91.0	0.8	0.8	0.9	0.9	37.0	90.6	0.1	0.1	0.1	0.1
41.0	91.1	0.7	0.7	0.8	0.8	39.0	90.7	0.2	0.2	0.1	0.1
43.0	91.1	0.7	0.8	0.9	0.9	41.0	91.0	0.2	0.2	0.2	0.2
45.0	91.1	0.6	0.6	0.8	0.8	43.0	91.2	0.2	0.2	0.2	0.1
47.0	91.3	0.5	0.5	0.6	0.6	45.0	91.1	0.2	0.2	0.3	0.3
49.0	91.8	0.6	0.6	0.7	0.7	47.0	92.2	0.0	0.0	0.0	0.0
51.0	91.6	0.4	0.4	0.4	0.4	47.5	92.7				
53.0	91.6	0.5	0.5	0.6	0.7	48.0	92.9				
55.0	91.9	0.3	0.3	0.4	0.4						
57.0	91.8	0.2	0.2	0.2	0.2						
59.0	91.3	0.1	0.1	0.0	0.0						

Trans 7		35 cfs		44 cfs		Trans 8		35 cfs		44 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
60.5	92.3	0.0	0.0	0.0	0.0						
63.0	93.3										

Table B-34. Velocity calibration results for Little Butte Creek between Antelope Creek and Rogue River Study Site.

Trans 1		37 cfs		94 cfs		101 cfs		Trans 2		37 cfs		101 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	101.5							0.0	99.6				
3.9	98.8					0.0	0.0	1.0	99.5				
4.0	98.5					0.1	0.1	2.5	97.9	0.0	0.0	0.1	0.1
4.6	97.9	0.1	0.1	0.2	0.2		0.3	3.0	97.6	0.0	0.0	0.0	0.0
6.0	97.1	0.3	0.3	1.3	1.2	0.4	0.4	6.0	97.6	0.0	0.0	1.2	1.2
8.0	96.9	1.0	1.0	2.2	2.1	1.5	1.4	9.0	96.0	0.6	0.6	1.1	1.1
10.0	96.7	1.2	1.2	2.2	2.1	2.0	1.9	12.0	96.0	1.4	1.2	1.1	1.1
12.0	96.5	1.2	1.2	2.4	2.3	1.9	1.8	15.0	97.0	1.4	1.3	1.9	1.9
14.0	96.7	1.3	1.3	2.7	2.6	2.2	2.1	18.0	96.6	1.5	1.3	1.7	1.7
16.0	96.7	1.3	1.3	2.3	2.2	2.2	2.1	21.0	96.3	1.3	1.1	1.2	1.2
18.0	96.6	1.1	1.1	2.4	2.3	2.0	1.9	24.0	96.7	0.7	0.6	1.3	1.3
20.0	96.7	1.0	1.0	1.5	1.5	1.9	1.8	27.0	97.0	0.7	0.6	0.9	0.9
22.0	96.7	1.0	1.0	1.6	1.6	1.9	1.8	30.0	97.2	1.0	0.9	1.0	1.0
24.0	97.1	1.0	0.9	1.9	1.8	2.0	1.9	33.0	97.2	0.3	0.3	1.0	1.0
26.0	97.1	0.8	0.8	1.7	1.7	1.9	1.8	36.0	97.7	0.0	0.0	1.5	1.5
28.0	97.0	0.9	0.8	1.7	1.6	1.8	1.7	39.0	97.9	0.2	0.2	1.2	1.3
30.0	97.2	0.6	0.6	1.5	1.5	1.7	1.6	42.0	98.1	0.2	0.3	1.1	1.2
32.0	97.4	0.7	0.7	1.3	1.3	1.6	1.5	45.0	98.2	0.0	0.0	1.0	1.1
34.0	97.4	0.5	0.5	1.2	1.2	1.4	1.4	48.0	98.2	0.0	0.0	1.1	1.1
36.0	97.6	0.4	0.4	0.9	0.9	1.5	1.4	51.0	98.1	0.0	0.0	1.0	1.1
38.0	97.9	0.2	0.2	0.9	0.9	1.2	1.1	54.0	98.1	0.1	0.1	0.9	0.9
40.0	97.9	0.2	0.2	0.8	0.8	1.0	0.9	57.0	98.2	0.0	0.0	0.7	0.7
42.0	98.1	0.0	0.1	0.5	0.5	0.8	0.7	60.0	98.1	0.1	0.1	0.7	0.7
44.0	98.3			0.2	0.2	0.4	0.4	63.0	98.1	0.1	0.1	0.7	0.7
46.0	98.4			0.0	0.1	0.3	0.3	66.0	98.1	0.1	0.1	0.7	0.7

Trans 1		37 cfs		94 cfs		101 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Measured	Simulated
48.0	98.5			0.0	0.1	0.1	0.1
50.0	98.6					0.0	0.1
53.0	98.7					0.0	0.0
56.0	98.7					0.0	0.0
59.0	98.6					0.0	0.0
62.0	98.7					0.0	0.0
65.0	98.7					0.0	0.0
68.0	98.7					0.0	0.0
71.0	98.7					0.0	0.0
74.0	98.8					0.0	0.0
77.0	98.8					0.0	0.0
78.0	98.8					0.0	0.0
85.0	99.2						
89.0	99.3						
91.0	99.8						

Trans 2		37 cfs		101 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
69.0	98.2	0.0	0.0	0.4	0.4
69.7	98.2	0.0	0.0	0.2	0.2
71.5	98.7			0.0	0.0
72.0	99.1				
75.0	99.4				
81.3	100.3				

Table B-34 (Continued)

Trans 3		37 cfs		101 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	100.5				
1.8	99.3				
2.5	98.8			0.0	0.0
3.0	98.6			0.1	0.1
3.8	98.0	0.2	0.2	0.0	0.0
8.0	97.6	0.7	0.6	0.3	0.4
12.0	97.2	0.5	0.4	0.2	0.3
16.0	97.6	0.0	0.0	0.0	0.0
20.0	97.9	0.9	0.8	1.0	1.1
24.0	97.6	0.2	0.1	0.9	1.0
28.0	97.5	1.6	1.3	1.4	1.6

Trans 4		37 cfs		101 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	101.1				
1.0	100.8				
2.0	98.3		0.0	0.2	0.2
5.0	97.9	0.1	0.0	0.6	0.7
8.0	97.6	0.0	0.0	0.4	0.5
11.0	98.1	0.1	0.1	0.2	0.2
14.0	97.9	0.1	0.1	0.0	0.0
17.0	96.9	0.1	0.1	0.1	0.1
20.0	97.4	0.7	0.7	0.5	0.6
23.0	97.5	0.2	0.2	1.7	1.8
26.0	97.3	0.6	0.6	1.4	1.5

Trans 3		37 cfs		101 cfs		Trans 4		37 cfs		101 cfs	
Station	Elevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
32.0	97.4	1.1	0.9	1.5	1.7	29.0	97.3	1.4	1.3	1.0	1.1
36.0	97.6	1.1	0.8	1.7	1.8	32.0	97.8	2.4	2.2	2.6	2.8
40.0	97.6	1.0	0.8	1.2	1.3	35.0	98.1	2.0	1.9	2.4	2.5
44.0	97.6	1.5	1.2	1.5	1.7	38.0	98.0	1.5	1.4	2.5	2.6
48.0	97.4	0.5	0.4	1.4	1.5	41.0	98.2	0.6	0.5	2.2	2.3
52.0	97.8	0.7	0.6	1.3	1.4	44.0	98.2	2.0	1.8	2.2	2.3
56.0	97.9	0.7	0.6	1.1	1.2	47.0	98.2	1.3	1.1	2.3	2.4
60.0	98.0	0.3	0.2	1.2	1.3	50.0	98.1	1.7	1.5	2.3	2.5
64.0	98.2	1.0	0.9	1.3	1.4	53.0	98.0	1.9	1.8	2.8	2.9
68.0	98.2	0.8	0.7	1.4	1.6	56.0	97.9	1.6	1.5	2.6	2.8
72.0	98.1	1.3	1.1	1.9	2.1	59.0	97.6	1.6	1.5	2.5	2.7
76.0	98.0	1.7	1.4	2.0	2.2	61.8	97.8	1.8	1.7	1.7	1.8
80.0	98.1	2.0	1.6	2.3	2.5	65.0	97.8	0.6	0.6	1.5	1.7
84.0	98.5	0.0	0.0	0.1	0.1	68.0	98.3	0.1	0.1	0.0	0.0
85.5	98.7			0.0	0.1	68.3	98.5	0.0	0.0	0.0	0.0
86.0	99.1					69.7	99.0			0.0	0.0
88.0	99.9					72.0	99.8				
89.6	100.5					74.0	100.1				

Table B-34 (Continued)

Trans 5		37 cfs		101 cfs		175 cfs		Trans 6		37 cfs		101 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	102.1							0.0	101.1				
5.0	101.6							4.5	100.1				
10.0	100.4							5.5	99.7				
15.0	99.4							7.5	99.3				
20.0	99.3						0.2	8.0	99.2			0.0	0.0
25.0	99.4						0.0	9.0	98.9			0.2	0.2
29.7	99.1			0.0	0.0		0.5	9.8	98.8	0.0	0.0		0.0
31.6	99.0			0.1	0.1		0.6	12.0	98.3	0.1	0.1	0.1	0.1
33.0	99.1			0.0	0.1		0.5	15.0	98.1	0.4	0.4	0.2	0.2
35.0	99.0			0.2	0.2		0.6	18.0	98.4	0.7	0.7	0.9	1.0
37.0	99.0			0.0	0.2		0.6	21.0	98.2	0.6	0.6	1.5	1.7
39.0	99.0			0.2	0.2		0.6	24.0	98.1	1.6	1.6	2.3	2.6
40.8	98.7	0.0	0.0	0.2	0.2		0.9	27.0	97.7	1.2	1.2	2.1	2.4
41.0	98.7	0.1	0.0	0.2	0.2	0.2	0.9	30.0	97.7	1.6	1.6	2.4	2.7
43.0	98.2	0.1	0.1	0.1	0.1	0.0	1.2	33.0	97.9	1.3	1.3	1.9	2.1
45.0	97.8	0.0	0.0	0.1	0.1	0.4	1.5	36.0	97.8	0.9	0.9	1.9	2.1
47.0	97.5	0.0	0.0	0.4	0.4	0.9	1.7	39.0	97.6	0.6	0.6	1.5	1.7
49.0	97.3	0.1	0.1	0.8	0.8	1.7	1.8	42.0	97.6	1.2	1.3	1.4	1.6
51.0	97.4	0.2	0.2	1.0	1.0	2.2	1.8	45.0	97.9	0.9	0.9	1.5	1.7
53.0	97.5	0.3	0.2	1.1	1.1	2.2	1.7	48.0	98.0	0.6	0.6	1.5	1.6
55.0	97.4	0.4	0.4	1.2	1.1	2.0	1.8	51.0	96.9	0.4	0.5	0.9	1.0
57.0	97.4	0.5	0.5	1.4	1.3	2.1	1.8	54.0	97.6	0.3	0.3	0.6	0.6
59.0	97.2	0.5	0.5	1.3	1.3	2.0	1.9	57.0	96.9	0.1	0.1	0.3	0.3
61.0	96.7	0.7	0.6	1.2	1.2	1.6	2.1	60.0	97.3	0.1	0.1	0.0	0.0
63.0	96.7	0.9	0.9	1.4	1.3	1.8	2.1	63.0	97.8	0.0	0.0	0.4	0.5
65.0	96.9	1.0	1.0	1.7	1.6	1.9	2.0	66.0	98.3	0.0	0.0	0.1	0.1
67.0	96.8	1.0	0.9	1.5	1.4	1.9	2.1	69.0	98.7	0.1	0.1	1.5	1.7
69.0	96.8	0.6	0.6	1.3	1.2	1.6	2.1	72.0	98.5	0.0	0.0	0.1	0.1

Trans 5		37 cfs		101 cfs		175 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Measured	Simulated
71.0	96.8	0.7	0.7	1.4	1.3	1.7	2.1
73.0	97.2	1.0	0.9	1.5	1.4	1.9	1.9
75.0	97.5	1.1	1.1	1.6	1.5	2.0	1.7
77.0	97.8	1.2	1.2	1.7	1.6	1.9	1.5
79.0	97.9	1.1	1.0	1.9	1.8	1.9	1.4
81.0	97.9	1.1	1.0	1.7	1.6	1.9	1.4
83.0	98.0	1.0	0.9	1.5	1.4	1.6	1.4
85.0	98.0	0.8	0.7	1.7	1.7	1.6	1.4
87.0	98.1	0.7	0.7	1.3	1.2	1.8	1.3
89.0	98.3	0.4	0.4	1.2	1.2	1.4	1.2
91.0	98.6	0.2	0.1	1.1	1.1	1.6	0.9
92.4	98.6	0.0	0.1	1.1	1.1	1.4	0.9
93.0	98.7			1.0	1.0	1.3	0.9
95.0	98.7			1.0	1.0	1.3	0.9
97.0	98.8			0.6	0.6	0.9	0.8
99.0	98.9			0.5	0.5	0.9	0.7
101.7	99.0			0.0	0.3	0.3	0.6
103.0	99.8						
107.4	100.8						

Trans 6		37 cfs		101 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
75.0	98.6	0.1	0.1	0.1	0.1
75.7	98.6	0.0	0.1		0.1
77.5	99.2			0.0	0.0
80.0	99.7				
81.0	100.1				
81.9	100.8				

Table B-34 (Continued)

Trans 7		37 cfs		101 cfs		Trans 8		37 cfs		101 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	99.7					0.0	100.5				
3.0	99.7					7.7	100.1			0.0	0.0
6.6	99.3			0.0	0.0	8.0	100.0		0.2	0.0	0.0
7.0	99.2				0.0	11.0	99.9		0.3	0.3	0.2
9.0	99.0		0.9	0.1	0.1	14.0	100.3			0.0	0.0
9.4	98.9	0.0	1.4		2.4	15.8	99.9	0.0	0.3	0.8	0.6
11.0	98.9		1.4	2.3	2.4	17.0	100.0		0.2	1.5	1.2
13.0	98.9		1.4	3.3	3.5	20.0	99.6	0.9	0.7	2.2	1.9
15.0	98.9	1.6	1.4	2.6	2.7	23.0	99.6	0.6	0.5	3.0	2.6
17.0	98.2	2.3	2.1	2.3	2.4	26.0	99.2	1.3	1.0	2.5	2.1
19.0	98.6	0.4	0.4	1.1	1.1	29.0	98.9	2.1	1.8	2.6	2.3
21.0	98.9		1.6	3.2	3.4	32.0	99.3	1.3	1.1	3.4	3.0
23.0	98.7	2.8	2.4	4.6	4.8	35.0	99.5	1.8	1.5	1.8	1.6
25.0	98.7	4.2	3.7	4.1	4.3	38.0	99.6	0.1	0.1	2.2	1.9
27.0	98.6	4.7	4.2	5.0	5.2	41.0	98.4	0.5	0.4	2.8	2.5
29.0	97.8	2.7	2.4	4.1	4.3	44.0	98.5	1.6	1.3	2.4	2.1
31.0	98.1	3.5	3.1	3.4	3.6	47.0	98.7	1.4	1.2	2.6	2.2
33.0	98.3	1.9	1.7	2.7	2.8	50.0	99.6	0.8	0.6	1.7	1.4
35.0	98.7	0.2	0.2	0.5	0.5	53.0	99.5	0.6	0.5	0.9	0.8
37.0	98.7		0.2	1.0	1.1	56.0	99.6	1.2	1.0	3.2	2.8
39.0	98.1	0.0	0.0	0.1	0.1	59.0	99.1	2.1	1.7	3.3	2.8
41.0	98.2	0.1	0.0	0.3	0.4	61.8	99.8	0.0	0.7	0.3	0.2
43.0	98.3	0.4	0.4	0.3	0.3	64.9	99.2	0.0	1.6	1.7	1.5
45.0	98.0	0.2	0.2	0.7	0.7	68.0	100.2			0.8	0.5
47.0	98.2	0.6	0.6	1.0	1.1	71.0	99.5	0.6	0.5	1.2	1.0
49.0	97.9	0.1	0.1	1.8	1.9	74.0	100.1			3.0	2.3
51.0	98.0	0.3	0.3	1.2	1.3	76.8	100.1	0.0	0.0	2.5	1.9
53.0	98.0	0.6	0.5	0.4	0.4	77.0	100.2			2.1	1.3

Trans 7		37 cfs		101 cfs		Trans 8		37 cfs		101 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
55.0	99.4	0.0	0.0	2.0	1.7	80.0	100.6				
57.0	99.4	0.0	0.0	2.1	1.8	82.0	101.3				
58.9	98.5	0.2	0.2	1.7	1.8	83.0	100.5				
61.0	99.4	0.0	0.0	3.0	2.5	84.0	100.5				
63.0	99.1	1.9	1.4	3.3	3.4	84.5	100.5				
65.0	99.1	1.7	1.3	3.9	4.1	86.0	101.2				
66.7	99.4	0.0	0.0		0.7	88.0	101.6				
67.0	99.4			0.4	0.3	89.3	102.3				
68.0	99.5			0.0	0.0						
73.0	100.2										
76.4	101.4										

Table B-35. Velocity calibration results for Antelope Creek between Antelope Creek Diversion and Dry Creek Study Site.

Trans 1		3 cfs		109 cfs		Trans 2		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	99.6			0.0	0.0	0.0	99.8			0.0	0.0
1.7	99.3			1.5	1.7	1.0	99.7			0.0	0.3
1.9	98.5			2.1	2.3	2.9	99.1			1.6	1.8
3.1	98.3	0.0	0.0	3.1	3.6	3.3	98.2	0.1	0.1	1.8	2.0
4.0	98.2	0.0	0.2	0.2	0.2	4.0	98.1	0.2	0.1	2.6	2.7
5.0	98.3	0.0	0.0	5.5	6.2	5.0	97.9	0.8	0.6	3.7	3.9
6.0	97.9	0.6	0.5	5.0	5.7	6.0	98.0	0.9	0.7	4.4	4.6
7.0	97.8	1.7	1.3	3.7	4.2	7.0	97.9	1.1	0.8	3.7	3.9
8.0	98.1	2.2	1.6	3.7	4.2	8.0	97.9	0.8	0.6	3.8	4.0
9.0	97.8	0.6	0.5	4.1	4.6	9.0	98.0	0.3	0.2	4.0	4.2
10.0	97.9	1.0	0.8	3.9	4.4	10.0	97.9	0.3	0.2	4.6	4.8
11.0	97.8	1.8	1.3	3.2	3.7	11.0	98.3	0.4	0.4	2.2	2.3
12.0	98.0	1.3	0.9	2.4	2.8	12.0	98.5	0.0	0.2	3.2	3.4
13.0	98.3	0.0	0.1	3.6	4.1	13.0	98.3	0.8	0.7	3.8	4.1

Trans 1		3 cfs		109 cfs		Trans 2		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
14.0	98.3	0.0	0.1	3.5	4.0	14.0	98.1	0.3	0.3	4.2	4.4
15.0	98.2	0.6	0.4	3.8	4.3	15.0	98.1	0.1	0.0	3.2	3.4
16.0	98.2	1.1	0.8	2.3	2.6	16.0	98.1	0.7	0.5	2.4	2.5
17.0	98.2	0.4	0.3	2.9	3.3	17.0	98.3	0.4	0.3	3.3	3.5
18.0	98.1	1.5	1.1	3.4	3.8	18.0	98.5	0.0	0.2	3.0	3.2
19.0	98.3	0.0	0.1	4.0	4.5	19.0	98.2	0.1	0.0	1.5	1.6
20.0	98.2	0.1	0.1	3.5	4.0	20.0	98.1	0.2	0.1	3.1	3.3
21.0	98.1	0.2	0.2	2.7	3.0	21.0	98.5	0.0	0.0	3.7	3.9
21.2	98.1	0.1	0.1	2.4	2.8	21.2	98.5	0.0	0.0	3.5	3.7
21.5	98.0	0.0	0.1	1.6	1.8	21.5	98.5	0.0	0.0	3.0	3.2
21.7	98.3	0.0	0.0	1.1	1.2	22.0	98.6	0.0	0.0	2.0	2.2
22.5	98.8	0.0	0.0	1.5	1.7	22.5	98.8	0.0	0.0	1.5	1.6
22.9	99.6			0.0	0.0	23.0	98.6			2.0	2.1
						24.9	99.7			0.0	0.2
						25.4	99.9				

Table B-35 (Continued)

Trans 3		3 cfs		109 cfs		Trans 4		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	101.1					0.0	100.9				
3.7	99.8			0.0	0.1	1.5	100.0			0.0	0.0
4.0	99.7	0.0	0.0	0.2	0.2	5.5	99.6			0.3	0.3
6.8	99.2	0.1	0.0	3.3	3.8	6.5	98.8			2.4	2.6
7.0	98.4	0.1	0.1	2.3	2.6	8.0	98.6	0.0	0.0	3.1	3.2
8.0	98.4	0.1	0.1	0.4	0.5	8.5	98.5	0.2	0.1	3.5	3.6
9.0	98.2	0.0	0.4	4.0	4.6	8.8	98.2	0.4	0.3	3.0	3.1
10.0	97.5	0.8	0.7	4.1	4.7	9.0	98.1	0.6	0.5	3.0	3.1
11.0	97.3	0.7	0.6	3.2	3.7	9.5	98.1	0.9	0.7	3.7	3.9
12.0	96.9	0.3	0.3	3.1	3.6	10.0	97.8	0.9	0.8	3.6	3.8
13.0	97.0	0.3	0.3	4.3	5.0	10.5	97.8	0.6	0.5	3.5	3.7

Trans 3		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
14.0	97.0	0.2	0.2	3.6	4.1
15.0	97.9	0.0	0.0	3.7	4.2
16.0	97.7	0.0	0.0	2.6	3.0
17.0	97.8	0.1	0.1	1.3	1.4
18.0	98.6	0.0	0.0	3.9	4.5
19.0	98.5	0.2	0.1	0.2	0.2
20.0	98.2	0.1	0.0	3.1	3.6
21.0	98.4	0.0	0.0	3.0	3.4
22.0	98.3	0.2	0.1	2.3	2.7
23.0	98.6	0.0	0.0	0.6	0.7
24.0	98.6	0.0	0.0	0.0	0.0
24.6	98.6	0.0	0.0	0.3	0.3
25.0	98.9			0.3	0.3
26.5	99.8			0.0	0.0
27.4	100.4				

Trans 4		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
11.0	98.1	0.9	0.7	3.6	3.8
11.5	98.3	0.8	0.7	3.8	4.0
12.0	98.3	0.1	0.1	4.2	4.4
12.5	98.6	0.0	0.0	4.6	4.9
13.0	98.5	0.9	0.7	4.3	4.6
13.5	98.1	0.7	0.6	4.0	4.2
14.0	98.2	0.9	0.7	4.4	4.6
14.5	98.2	0.2	0.2	3.7	3.9
15.0	98.1	0.0	0.0	3.8	4.0
15.5	98.1	0.6	0.5	3.7	3.9
16.0	98.0	1.1	0.9	4.2	4.4
16.5	98.0	1.2	1.0	4.0	4.2
17.0	98.2	1.4	1.2	3.6	3.7
17.5	98.0	0.8	0.7	3.2	3.4
18.0	98.2	0.9	0.7	3.3	3.4
18.5	98.2	0.1	0.1	3.5	3.6
19.0	98.4	0.4	0.3	3.1	3.3
19.5	98.3	0.1	0.1	2.9	3.0
20.0	98.6	0.0	0.0	2.8	3.0
20.5	98.6	0.0	0.0	2.3	2.4
21.0	98.3	0.1	0.1	2.6	2.8
21.6	98.4	0.1	0.1	2.3	2.4
22.0	98.5	0.0	0.0	2.3	2.4
23.0	98.6		0.0	2.0	2.1
27.3	99.3			0.8	0.8
28.6	100.1			0.0	0.0

Table B-35 (Continued)

Trans 5		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	100.2				
0.6	100.1			0.0	0.1
2.0	98.8			1.3	1.4
2.5	98.6		0.2	2.6	2.7
4.1	98.5	0.0	0.3	3.4	3.6
4.5	98.2	0.6	0.6	3.3	3.5
5.0	98.1	0.7	0.6	2.8	3.0
5.5	98.5	0.4	0.4	2.9	3.0
6.0	98.6	0.1	0.1	3.0	3.1
6.5	98.5	0.1	0.1	3.7	3.9
7.0	98.5	0.3	0.3	3.8	3.9
7.5	98.6	0.5	0.5	3.6	3.8
8.0	98.5	0.4	0.4	3.2	3.4
8.5	98.3	0.2	0.2	3.0	3.2
9.0	98.3	0.2	0.2	3.2	3.4
9.5	98.3	0.9	0.8	3.7	3.8
10.0	98.3	1.0	0.9	4.0	4.2
10.5	98.2	1.2	1.1	3.9	4.1
11.0	98.2	1.4	1.3	3.2	3.4
11.5	98.1	1.5	1.4	3.0	3.1
12.0	98.1	1.3	1.2	3.5	3.7
12.5	97.9	0.6	0.5	3.8	4.0
13.0	97.8	0.3	0.3	4.0	4.2
13.5	98.2	0.2	0.2	3.4	3.5
14.0	98.1	0.2	0.2	2.7	2.8
14.5	98.2	0.2	0.2	2.7	2.8
15.0	98.2	0.1	0.0	3.2	3.4
15.5	98.2	0.1	0.0	3.1	3.3
16.0	98.7	0.0	0.0	2.3	2.4
16.5	98.6	0.0	0.0	2.8	2.9
17.0	98.7	0.0	0.0	2.8	2.9

Trans 5		3 cfs		109 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
17.5	98.6	0.0	0.0	3.6	3.8
18.0	98.5	0.1	0.1	2.9	3.1
18.5	98.6	0.1	0.1	2.5	2.7
19.0	98.5	0.1	0.1	2.8	2.9
19.5	98.5	0.0	0.0	3.2	3.3
20.0	98.7	0.0	0.0	3.0	3.2
20.5	98.7	0.0	0.0	1.9	2.0
21.1	98.9			0.9	0.9
22.0	99.7			1.8	1.8
23.6	100.1			0.0	0.2
24.3	100.9				

Table B-36. Velocity calibration results for Antelope Creek between Dry Creek and Little Butte Creek Study Site.

Trans 1		12 cfs		24 cfs		Trans 2		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	93.0					0.0	93.0				
3.6	90.9	0.0	0.0	0.0	0.0	3.4	91.0	0.1	0.1	0.1	0.0
4.0	90.9	0.1	0.1	0.2	0.2	4.0	91.0	2.0	1.4	1.6	1.4
6.0	90.8	1.6	1.5	2.0	2.2	5.5	91.1	2.1	1.5	3.1	2.6
8.0	90.9	1.7	1.6	1.4	1.5	7.0	91.2	1.8	1.4	3.7	3.1
10.0	90.8	1.3	1.2	2.0	2.1	8.5	91.2	2.4	1.8	3.2	2.7
12.0	90.7	1.4	1.3	1.7	1.8	10.0	91.1	2.1	1.5	2.7	2.3
14.0	91.0	0.8	0.8	2.5	2.7	11.5	91.1	2.2	1.5	2.7	2.3
16.0	91.1	1.1	1.1	1.7	1.8	13.0	91.1	1.0	0.7	1.2	1.0
18.0	91.2	1.5	1.6	3.1	3.2	14.5	91.2	1.0	0.8	1.9	1.6
20.0	91.1	1.9	1.8	2.0	2.1	16.0	91.2	1.0	0.8	1.1	0.9
22.0	91.0	0.9	0.9	2.0	2.1	17.5	91.1	1.1	0.8	1.8	1.5
24.0	91.2	1.7	1.7	1.4	1.4	19.0	91.1	1.2	0.9	2.2	1.8
26.0	91.1	1.0	0.9	2.0	2.2	20.5	91.1	1.5	1.1	2.2	1.8
28.0	91.2	1.4	1.5	1.1	1.2	22.0	90.9	1.3	0.9	1.6	1.3
30.0	91.1	1.2	1.2	1.5	1.6	23.5	90.9	1.5	1.0	2.2	1.8
32.0	91.1	1.4	1.3	1.6	1.7	25.0	90.8	1.2	0.8	1.9	1.6

Trans 1		12 cfs		24 cfs		Trans 2		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
34.0	90.8	1.7	1.6	1.7	1.8	26.5	90.8	1.4	0.9	2.2	1.8
36.0	91.1	1.3	1.3	2.1	2.2	28.0	90.7	1.2	0.8	1.8	1.4
38.0	91.2	0.1	0.1	0.5	0.5	29.5	90.9	0.6	0.4	1.3	1.1
40.0	91.4					31.0	91.2	0.1	0.1	0.1	0.1
42.0	90.9	0.0	0.3	0.0	0.0	31.3	91.4	0.0	0.0		0.0
44.0	90.7	0.0	0.4	0.1	0.1	31.7	91.5			0.0	0.0
45.0	91.4	0.0	0.0	0.0	0.0	35.0	91.8				
48.0	93.3					40.0	93.3				
51.5	94.7					41.4	93.5				

Table B-36 (Continued)

Trans 3		12 cfs		24 cfs		Trans 4		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	93.3					0.0	94.3				
3.0	89.4	0.0	0.0	0.0	0.0	2.5	91.2	0.1	0.1	0.0	0.0
4.0	89.5	0.1	0.1	0.3	0.3	3.0	90.8	0.3	0.3	0.3	0.3
5.0	89.7	0.5	0.5	0.7	0.7	4.5	90.4	0.5	0.5	0.8	0.8
6.0	89.9	0.5	0.5	0.9	1.0	6.0	90.4	0.5	0.6	0.8	0.9
7.0	90.2	0.5	0.5	0.9	0.9	7.5	90.4	0.5	0.5	1.0	1.1
8.0	90.3	0.5	0.5	0.9	0.9	9.0	90.5	0.6	0.6	1.0	1.1
9.0	90.4	0.5	0.5	0.9	1.0	10.5	90.4	0.7	0.8	1.0	1.0
10.0	90.4	0.6	0.6	0.9	0.9	12.0	90.4	0.5	0.6	0.9	1.0
11.0	90.5	0.6	0.6	0.9	0.9	13.5	90.6	0.4	0.5	0.8	0.8
12.0	90.5	0.5	0.5	0.9	1.0	15.0	90.5	0.4	0.4	0.8	0.8
13.0	90.6	0.5	0.6	1.0	1.0	16.5	90.6	0.4	0.4	0.9	0.9
14.0	90.6	0.6	0.6	0.9	0.9	18.0	90.6	0.4	0.5	0.8	0.9
15.0	90.6	0.5	0.5	0.9	0.9	19.5	90.6	0.4	0.5	0.9	0.9
16.0	90.6	0.5	0.5	0.9	0.9	21.0	90.7	0.5	0.5	0.8	0.8
17.0	90.6	0.4	0.5	0.9	1.0	22.5	90.7	0.4	0.5	0.9	0.9
18.0	90.6	0.4	0.5	0.8	0.8	24.0	90.7	0.5	0.5	0.8	0.9
19.0	90.6	0.5	0.5	0.9	0.9	25.5	90.8	0.4	0.4	0.8	0.9
20.0	90.8	0.5	0.5	0.8	0.8	27.0	90.8	0.2	0.2	0.5	0.5

Trans 3		12 cfs		24 cfs		Trans 4		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
21.0	90.7	0.4	0.5	0.8	0.8	28.5	90.9	0.1	0.1	0.2	0.2
22.0	90.6	0.5	0.6	0.8	0.8	30.0	91.0	0.1	0.1	0.2	0.2
23.0	90.7	0.5	0.6	0.9	0.9	31.5	91.0	0.0	0.1	0.1	0.1
24.0	90.6	0.3	0.3	0.8	0.8	33.0	91.5	0.0	0.0	0.0	0.0
25.0	90.5	0.4	0.4	0.8	0.8	35.0	94.6				
26.0	90.6	0.4	0.4	0.7	0.8						
27.0	90.8	0.2	0.2	0.4	0.4						
28.0	90.7	0.1	0.1	0.3	0.3						
29.0	91.0	0.0	0.0	0.1	0.1						
29.5	91.1	0.0	0.0	0.1	0.1						
31.7	94.0										

Table B-36 (Continued)

Trans 5		12 cfs		24 cfs		Trans 6		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elevation	Measured	Simulated	Measured	Simulated
0.0	93.1					0.0	93.8				
2.6	91.0	0.0	0.0	0.0	0.0	3.0	93.1				
3.0	90.8	0.0	0.0	0.1	0.1	5.0	91.8	0.4	0.4	0.3	0.3
4.0	90.5	0.0	0.0	0.2	0.2	6.0	91.8	1.0	1.0	0.8	0.8
5.0	90.2	0.1	0.1	0.6	0.6	7.0	91.5	3.2	3.1	2.9	3.0
6.0	90.2	0.4	0.4	1.0	1.0	8.0	91.8	2.7	2.7	2.9	3.1
7.0	90.0	0.8	0.9	1.4	1.4	9.0	91.7	1.2	1.2	2.5	2.6
8.0	90.0	1.1	1.2	1.7	1.6	10.0	91.8	1.5	1.5	1.3	1.4
9.0	90.0	1.1	1.2	1.5	1.5	11.0	92.2			0.0	0.0
10.0	90.0	0.8	0.8	1.3	1.3	12.0	92.2			0.0	0.0
11.0	90.1	0.5	0.6	1.0	1.0	13.0	91.9	0.5	0.6	1.2	1.2
12.0	90.2	0.2	0.3	0.7	0.7	14.0	91.9	0.1	0.1	0.9	0.9
13.0	90.4	0.3	0.3	0.6	0.6	15.0	91.9	0.6	0.7	1.0	1.1
14.0	90.6	0.1	0.1	0.2	0.2	16.0	92.0		0.2	0.9	0.9
15.0	90.5	0.2	0.2	0.1	0.1	17.0	92.0		0.2	1.2	1.2
16.0	90.7	0.2	0.2	0.3	0.3	18.0	91.9		0.3	0.8	0.8
17.0	90.8	0.1	0.2	0.5	0.5	19.0	92.0		0.2	1.1	1.1

Trans 5		12 cfs		24 cfs		Trans 6		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
18.0	90.7	0.2	0.3	0.3	0.2	20.0	91.8		0.5	1.2	1.3
19.0	90.7	0.4	0.4	0.7	0.7	21.0	91.6	0.7	0.6	1.5	1.5
20.0	90.8	0.5	0.6	1.2	1.2	22.0	91.4	1.3	1.2	2.0	2.1
21.0	90.6	0.6	0.7	1.4	1.4	23.0	91.7	1.7	1.7	2.4	2.5
22.0	90.6	0.6	0.7	1.2	1.2	24.0	91.4	1.9	1.8	2.9	3.1
23.0	90.7	0.4	0.5	1.2	1.2	25.0	91.4	1.7	1.6	2.7	2.9
24.0	90.7	0.1	0.1	0.6	0.6	26.0	91.4	1.1	1.0	1.5	1.6
25.0	90.9	0.0	0.0	0.1	0.1	27.0	91.4	1.4	1.3	2.8	3.0
26.0	91.7	0.0	0.0	0.0	0.0	28.0	91.4	1.6	1.5	2.4	2.6
27.3	93.4					29.0	91.5	1.1	1.0	1.9	2.1
29.5	94.4					30.0	91.7	0.7	0.7	1.4	1.4
						31.0	91.9	0.2	0.2	0.4	0.4
						32.0	92.0	0.0	0.1	0.1	0.1
						32.5	92.1		0.0	0.0	0.0
						33.0	92.8				
						35.0	93.0				
						37.0	93.9				
						39.0	94.8				
						41.0	95.4				

Table B-36 (Continued)

Trans 8		12 cfs		24 cfs		Trans 9		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated	Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	94.9					0.0	95.4				
1.0	93.8					2.5	93.6				
2.1	92.5	0.1	0.2	0.0	0.0	5.4	91.6	0.0	0.0	0.0	0.0
3.0	91.1	0.3	0.3	0.5	0.5	6.0	90.8	0.0	0.0	0.0	0.0
4.5	91.3	0.6	0.7	0.6	0.6	7.0	90.5	0.0	0.1	0.1	0.1
6.0	91.2	0.4	0.5	0.7	0.7	8.0	90.2	0.1	0.1	0.2	0.2
7.5	91.3	0.5	0.6	0.9	0.9	9.0	89.9	0.1	0.1	0.3	0.3
9.0	91.1	0.4	0.5	0.9	0.9	10.0	89.6	0.1	0.1	0.4	0.4
10.5	91.0	0.3	0.4	0.8	0.8	11.0	89.4	0.2	0.4	0.6	0.7

Trans 8		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
12.0	91.2	0.4	0.5	0.8	0.8
13.5	91.6	0.5	0.6	1.0	1.0
15.0	91.9	0.4	0.6	1.1	1.1
16.5	92.0	0.4	0.6	1.2	1.2
18.0	92.1	0.5	0.6	1.1	1.1
19.5	92.2	0.4	0.6	1.1	1.2
21.0	92.0	0.5	0.6	1.0	1.1
22.5	92.1	0.5	0.6	1.0	1.0
24.0	92.2	0.5	0.6	1.1	1.1
25.5	92.2	0.5	0.6	1.0	1.0
27.0	92.2	0.3	0.4	1.0	1.0
28.5	92.3	0.1	0.1	0.8	0.8
30.0	92.5		0.0	0.3	0.3
30.4	92.6	0.0	0.0	0.0	0.2
31.5	92.5		0.0	0.0	0.0
32.5	92.7			0.0	0.0
34.0	94.2				
35.8	95.2				

Trans 9		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
12.0	89.5	0.2	0.4	0.7	0.8
13.0	89.8	0.3	0.4	0.7	0.8
14.0	89.9	0.2	0.4	0.6	0.7
15.0	90.2	0.3	0.4	0.6	0.7
16.0	90.4	0.3	0.5	0.6	0.6
17.0	90.6	0.3	0.5	0.6	0.7
18.0	90.7	0.3	0.5	0.6	0.6
19.0	91.0	0.2	0.3	0.5	0.6
20.0	91.0	0.2	0.3	0.5	0.6
21.0	91.1	0.1	0.2	0.5	0.6
22.0	91.2	0.2	0.3	0.4	0.4
23.0	91.4	0.1	0.2	0.4	0.5
24.0	91.5	0.2	0.3	0.2	0.3
25.0	91.6	0.1	0.2	0.2	0.2
26.0	91.9	0.1	0.1	0.1	0.2
27.0	92.0	0.0	0.1	0.1	0.2
28.0	92.2	0.0	0.0	0.1	0.1
28.7	92.5	0.0	0.0	0.1	0.1
29.0	92.7			0.1	0.2
30.0	94.0				
31.0	94.3				

Table B-36 (Continued)

Trans 10		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
0.0	96.3				
1.0	91.8	0.0	0.0	0.0	0.0
2.5	90.8	0.1	0.1	0.1	0.1
4.0	90.1	0.1	0.1	0.1	0.1
5.5	89.9	0.1	0.1	0.2	0.1
7.0	89.7	0.0	0.0	0.1	0.1
8.5	89.5	0.1	0.1	0.1	0.1

Trans 10		12 cfs		24 cfs	
Station	Elvevation	Measured	Simulated	Measured	Simulated
10.0	89.4	0.1	0.2	0.2	0.2
11.5	89.3	0.2	0.3	0.4	0.4
13.0	89.4	0.3	0.4	0.6	0.5
14.5	89.4	0.1	0.2	0.6	0.6
16.0	89.6	0.2	0.2	0.6	0.6
17.5	90.0	0.2	0.3	0.6	0.6
19.0	90.2	0.2	0.3	0.5	0.5
20.5	90.5	0.2	0.2	0.4	0.4
22.0	91.0	0.2	0.2	0.5	0.4
23.5	91.3	0.2	0.3	0.4	0.4
24.5	91.6	0.1	0.1	0.3	0.3
26.0	91.8	0.0	0.0	0.3	0.3
28.5	91.9	0.0	0.1	0.2	0.2
30.0	92.0	0.0	0.0	0.2	0.2
31.5	92.2	0.0	0.0	0.2	0.1
33.0	92.1	0.0	0.1	0.2	0.2
34.5	91.9	0.0	0.0	1.0	0.9
36.0	92.1		0.0	0.0	0.0
37.0	92.6	0.0	0.0		0.0
37.5	92.6			0.1	0.1
38.0	92.8			0.0	0.0
39.3	94.2				

Rogue PHABSIM Project Coho Salmon Habitat Suitability Criteria Workshop – May 12, 2006

Meeting Notes

Attendees:
Ron Sutton, Bureau of Reclamation
Chelsie Morris, Bureau of Reclamation
Rich Pastor, Bureau of Reclamation
Dan Van Dyke, Oregon Department of Fish and Wildlife
Ken Phippen, National Marine Fisheries Service
Randy Frick, U.S. Forest Service
Gene Shull, Bureau of Land Management
Cindy Deacon Williams, Headwaters
Jason Scott, GeoEngineers
Aaron Maxwell, Southern Oregon University

Ron provided handouts of regional habitat suitability criteria (HSC) for discussion purposes.
Ken – in currently degraded systems (e.g. Bear Creek), SONCC coho may use less than optimal habitat due to what is available.

Adult Passage –

Randy – passage is a very important aspect of diversion effects;
concern about reduction of flows (e.g. Little Butte Creek) during late fall/winter due to diversion and storage of irrigation water by BOR and IDs, when coho migrate upstream and spawn.
Concensus – use Thompson (1972) criteria:
Minimum depth for coho – 0.6 ft – Procedure:

- Locate shallow bars most critical to passage
- Mark linear transect that follows shallowest course bank to bank
- Flow selected that meets depth criteria at least 25% of total transect width and continuous portion equaling at least 10% of its total width

Adult Spawning –

Ron showed video of SONCC coho spawning in a Klamath River tributary.
Randy, Ken, Gene, Dan – SONCC coho generally spawn in fairly small tributaries (upper watersheds) versus mainstem rivers.

Depth –
Dan – be careful using upper Trinity HSCs because of different geology

Gene and Dan – preferred depth = 1 to 2 ft – if too deep, lose velocity and get more fines
Dan noted that Oregon coastal and Trinity curves flatten out at 3 ft depth – suggested combining these two curves.
Concensus – see Table 1.

Velocity –
Randy said coho spawn at high velocities and in turbid water – can't see fish
Jason wanted some suitability at 0.3 ft/sec
Concensus – see Table 1.

Substrate –
It was noted that the only site-specific HSCs in the handout was for upper Trinity River
Randy, Gene, Dan – geology and substrates are different between upper Rogue basin and Trinity River (Klamath Basin); and also different between Bear Creek Valley tributary streams, East side (Cascade Mtns basalt) and West side (Siskiyou Mtns granitic).

Dan, Randy, Gene, Ken – SONCC coho often use sandy substrates in granitic systems (eg. Evans Ck?) due to availability; probably not preferred or optimal spawning habitat.

Dan said large gravel (2-3") was the best substrate – small-medium gravel next preferred.

There was discussion about the use of the Wolman pebble count method for measuring substrate in the field. Ken said that pebble counts don't really work for PHABSIM because you would need a large sample size within each cell for the statistics. Although there are problems with ocular estimates of substrate size (e.g., bias towards large size), concensus was to use the ocular approach and take photos of substrates with a wading rod to show how substrates were categorized.

Dan, Randy – suggest conducting substrate measurements during low flows and high water clarity (eg. after irrigation water deliveries during Fall season in Bear Creek).

Incubation –

Cindy said incubation was related to embeddedness. PHABSIM assumes stable channel, but embeddedness changes depending on water year type (scour and substrate mobility) – doesn't fit PHABSIM. There are other factors that affect incubation (sediment, temp, etc.) Concensus was to combine spawning and incubation life stages and not model incubation separately.

All attendees – there are probably large effects on possible spawning substrate and egg incubation habitat due to fine sediment plumes which are released from many Rogue Project diversions and others at the end of irrigation season (eg. BOR's Oak Street Diversion Dam on Bear Creek with boards operated by TID).

Cindy - BOR/TID canal crossings of Neil Creek, Wagner Creek, and other Bear Creek tributary streams use boards to manage water flows and irrigation deliveries (also

possible sediment plume effects to substrates for spawning/incubation when boards are removed by TID at end of irrigation season).
incubation success is assumed to be directly related to spawning habitat conditions.

Juveniles (0+) –

Ron showed video of SONCC coho juveniles in a Klamath River tributary.
Aaron - capturing coho higher upstream in Bear Creek – lower traps not catching chinook

Depth –
Aaron only finds juveniles in the mainstem Bear Creek at tributary mouths – shallow and cool
Concensus was to mimic upper Trinity HSCs (see Table 1)

Velocity -
Gene - winter backwaters that are not modeled are important, but no good winter habitat exists now – need velocity refuges; record velocity shelters in the field.

Many attendees – during high water temperatures, juvenile coho have higher metabolism requirements, and resulting higher oxygen and food needs (e.g. in local streams, juvenile coho may use laminar flow areas with higher velocities than other streams).
- juvenile coho often use lower reaches of tributary streams at the confluence with Bear Creek as refugia from high summer water temperatures and high velocities due to irrigation water deliveries in Bear Creek..

Dan – the managed hydrograph for irrigation project water in Bear Creek and Little Butte Creek probably has the largest effect on juvenile coho rearing (eg. lack of velocity barriers in Bear Creek during the summer irrigation water delivery season).

Concensus – see Table 1

Substrate – Concensus - don't model for juveniles

Cover –
Many attendees – lack of existing instream cover may be one of the most limiting factors in the Bear Creek watershed.
- in local streams with minimal structural complexity to provide cover habitat, juvenile coho often use deep water with lower velocity (e.g. pools) as hiding cover from avian predators.

Concensus was to use cover coding in Table 1 and record all cover types in the field. Initially, combine cover types into binary cover coding for modeling and use separate HSCs for winter and summer (see Table 1).

Table C-1. Interim habitat suitability criteria for use in Bear Creek and Little Butte Creek watersheds for SONC Coho Salmon

Life Stage:	Depth (ft)	Velocity (ft/sec)	Substrate	Cover
Adult Passage	Use Thompson (1972)			
Adult Spawning	Ft SI 0 0 0.2 0 0.5 0.5 1.0 1.0 2.0 1.0 2.5 0.5 3.0 0.1 10 0.1	Ft/sec SI 0 0 0.3 0.1 0.5 0.66 1.0 1.0 2.0 1.0 2.3 0.5 2.5 0.2 3.0 0.1 4.5 0.1 5.0 0	Code SI Organic 0 Silt 0 Sand 0.1 Small Gr 0.7 Med Gr 1.0 Lrg Gr/sm Cobb 1.0 Med Cobb 0.3 Lg Cobb 0 Boulder 0 Bedrock 0	
Juvenile	Ft SI 0 0 0.1 0.05 1.5 1.0 3.5 1.0 4.0 0.5 5.5 0.2 10 0.2	Ft/sec SI 0 0.8 0.15 1.0 0.8 1.0 1.0 0.6 1.5 0.1 2.0 0.05 3.0 0.05	Do not model	Code SI Summer: 0 no cover 0.5 1 cover 1.0 Winter: 0 no cover 0.0 1 cover 1.0 Type each cover type

Substrate codes:
0 – organic detritus
1 – silt, clay
2 – sand
3 – small gravel 0.25-0.75”
4 - medium gravel 0.75-1.5”
5 – large gravel-sm cobb 1.5-3.5”
6– med cobble 3.5-6”
7 – large cobble 6-12”
8 – boulder >12”
9 – bedrock

Cover codes:
0 – no cover
1 – undercut bank
2 – overhanging vegetation
3 - rootwad
4 - logjam
5 – large wood
6 – non-emergent rooted aquatic
7 – fine organic substrate
8 – grass
9 – bushes
10 – boulders

Rogue PHABSIM Project Coho Salmon Habitat Suitability Criteria Workshop – March 8, 2007
Meeting Notes

Attendees:
Ron Sutton, Bureau of Reclamation
Karen Blakney, Bureau of Reclamation
Ron Eggers, Bureau of Reclamation
Craig Tuss, U.S. Fish and Wildlife Service
Jay Doino, Oregon Department of Fish and Wildlife
George Robison, Oregon Department of Fish and Wildlife
Rich Domingue, National Marine Fisheries Service (via conference call)
Ken Phippen, National Marine Fisheries Service
Ian Reid, U.S. Forest Service
Rich Piaskowski, GeoEngineers
Wayne Wright, GeoEngineers
Brian Barr, National Center Cons Sci & Policy
Larry Menteer, Oregon Water Resources Department
Bruce Sund, Oregon Water Resources Department

Ron reviewed PHABSIM and process for developing habitat suitability criteria (HSC). He also reviewed interim HSCs developed at last workshop on May 12, 2006. River 2D output results were shown at a site on Little Butte Creek. Each HSC is discussed below.

Adult Passage –

No changes suggested for Thompson (1972) criteria:
Minimum depth for coho – 0.6 ft – Procedure:

- Locate shallow bars most critical to passage
- Mark linear transect that follows shallowest course bank to bank
- Flow selected that meets depth criteria at least 25% of total transect width and continuous portion equaling at least 10% of its total width

Adult Spawning –

Ron showed coho spawning weighted usable area (WUA) results from one study site on South Fork Little Butte Creek that showed most WUA occurred in a cell that was located exactly where a coho redd had been flagged. Ron felt that this was good validation of the interim HSCs. Ian said that he might have been the one that placed the flag during a spawning survey.

George said that interim spawning HSCs match well with information in a paper by Smith (1973). George will scan that paper and distribute to the group.

General concensus was not to change interim spawning HSCs and to combine spawning/incubation realizing that this provides a conservative estimate of incubation flow needs (i.e., more water than incubation may need).

Juveniles (0+ and 1+) –

Rich D. – one set of criteria for 0+ and 1+ could be an issue because of behavioral differences between ages – smaller coho can utilize smaller habitat.

George – cover drives suitability – 0+ and 1+ coho may act differently, but both key on cover.

Rich D. agreed with George, but if cover is so important, don't use binary system. George said that we need to distinguish between cover types.

Velocity -
Rich P. and George agreed that velocity should have a suitability of 0 at about 2 ft/sec. George suggested keeping 1 ft/sec=1.0 SI – this creates a range – problem with focal point.

Rich D. and Wayne disagreed that SI=1.0 at 1 ft/sec – not appropriate

Ron E. had a problem with extending velocity SI's at higher velocities because coho like slow water. Rich D. said that if you have 0 velocity suitability, doesn't matter what cover is. He suggested 1.5 ft/sec SI = 0.1 and 3.5 ft/sec SI = 0.

Ian and Rich P. suggested changing 0 ft/sec SI to 1.0.
Consensus – see Table 1.

Depth –
Ken asked if juveniles used deep water. In previous workshop, the group tried to mimic the Trinity data set.
Ian snorkels Bear Creek and Little Butte Creek and observes coho where there is cover in shallow water – potential sample bias because it is hard to snorkel deep water.
Concensus - change 6 ft depth to 0 SI from previous workshop – see Table 1.

Cover –
1) Distance to cover - Ron showed a photo of a pool transect on S. Fk. Little Butte Creek where juvenile coho were observed near cover, but cover as about 4 ft upstream from transect. He also showed data from the Klamath River that showed over 90% of juvenile coho observations in a thermal refugia study were located within 6 ft of cover.
Ian – find most coho on edge habitat in undercut and wood – could be in open water near cover; side channels and beaver ponds get high use; he doesn't snorkel in winter
Wayne suggested using 6 ft distance to cover in summer. Winter distance 3 ft based on Bustard and Narver (1975) paper.

Rich D. – one dilemma – search distance issue if cover is out of water – suggestion – recognize fish use distance to cover with no search criteria.

Ron S. – distance to escape cover was modeled on John Day project using PHABSIM, recognizing this weakness. Suggested doing the same for this project and discuss strengths and weaknesses.

2) Cover type suitabilities – George – wood dominant use based on Bustard and Narver (1975) – a lot of wood on Carnation Creek where that study occurred.

Ian suggested separate suitabilities summer vs winter

Ron reviewed field notes and photos and checked with the field crew on the following cover coding interpretations:
- grass (free-standing vertically oriented?)
- fine organics – twigs and leaves?
- difference between overhanging and bush cover types

The crew did not record any fine organics. Grass was coded as the photos show below - some free standing vertical, some at the bank's edge. If it looked like grass, free-standing or otherwise, it was coded as grass. The difference in the coding for bushes and overhanging was that, at the low flow that they recorded cover, they interpreted any bush that was in the water as overhanging and any bush that was out of water as a bush because it wasn't overhanging at the time they took their measurements.

The following feedback was from email correspondence:

George and Brian felt that bushes should have a lower suitability relative to overhanging vegetation since the overhanging vegetation is "in the water" and bushes can be back away from the water. George suggested bushes SI = 0.5 and overhanging cover SI = 0.7 in the criteria table.

Brian suggested that if there's a way to increase the cover value when a bush is in the water (e.g., at a higher flow) then we should do that.

Ron responded that the PHABSIM and River2D models in their present form are not dynamic enough to change the channel index coding as discharge changes. This is a similar issue as "distance to cover" where some cover within a specified distance from a fish might be on dry land at a low flow and wetted at a high flow. One option would be to have different suitability indices for "bushes" (SI = 0.5) and "overhanging" (SI = 0.7) and discuss the weaknesses and strengths of the models with this approach.

Brian was not sure there was a good solution to this issue since, clearly, once river stage rises to a level sufficient to inundate a bush, it provides good cover for coho. However, if that bush is high and dry and branches are clear of the water at a lower stage, its value as cover is lower.

Possible options:
Option 1 - suitability of bushes that are out of water at low flows same as overhanging veg and explain likely overestimation of cover at lower flows in narrative.

Option 2 - suitability of bushes that are out of water at low flows lower than overhanging veg and explain likely underestimate of cover at higher flows in narrative.

With no further discussion, Option 2 was implemented in the model using the cover coding in Table 1.

3) Cover weighting – George wanted cover weighted higher than depth and velocity; Ron suggested using the modified geometric mean habitat calculation from a newer version of PHABSIM that places cover variable outside the geo-mean calculation. The description of this approach in PHABSIM is as follows:

Habitat Calculations (IOC 9) - Controls how habitat suitability indices will be combined. Up to four habitat suitability indices can be combined to form a composite suitability factor used in calculating habitat area. A suitability index variable will not be used unless it has data values (coordinate cells are not blank) and a suitability curve has been defined. Velocity (v) and depth (d) will always be used but channel index (ci) and the user defined index (ud) must meet the above criteria. The exponent for the geometric mean calculation will vary (.5 to .25) according to how many variables are used. You can exclude channel index or a user defined index (e.g. escape cover) variables from specific cell calculations by leaving their respective data cells blank on the coordinate tab of the Edit|Cross Sections menu.

Modified Geometric Mean = This technique implies that one variable (user defined (ud)) has a greater effect than the others. This variable is multiplied outside of the geometric mean calculation. The Composite Suitability Factor (CF) is computed as
$CF = (f(v) \times g(d) \times h(ci))^{.333} \times i(ud)$

Concensus – use modified geometric mean

.

Figures below Table 1 show how HSCs from this workshop compare with regional HSCs.

Neil Creek – Left side cover interpreted as “overhanging”; right side cover interpreted as “overhanging” in the water and “bushes” out of the water.

Neil Creek – Cover along transect interpreted as “overhanging” in the water and “bushes” out of the water.

Bear Creek – Cover on the left interpreted as “grass” from water’s edge to where it meets “bushes”.

Little Butte Creek – cover in center of photo interpreted as “grass” (vertically oriented).

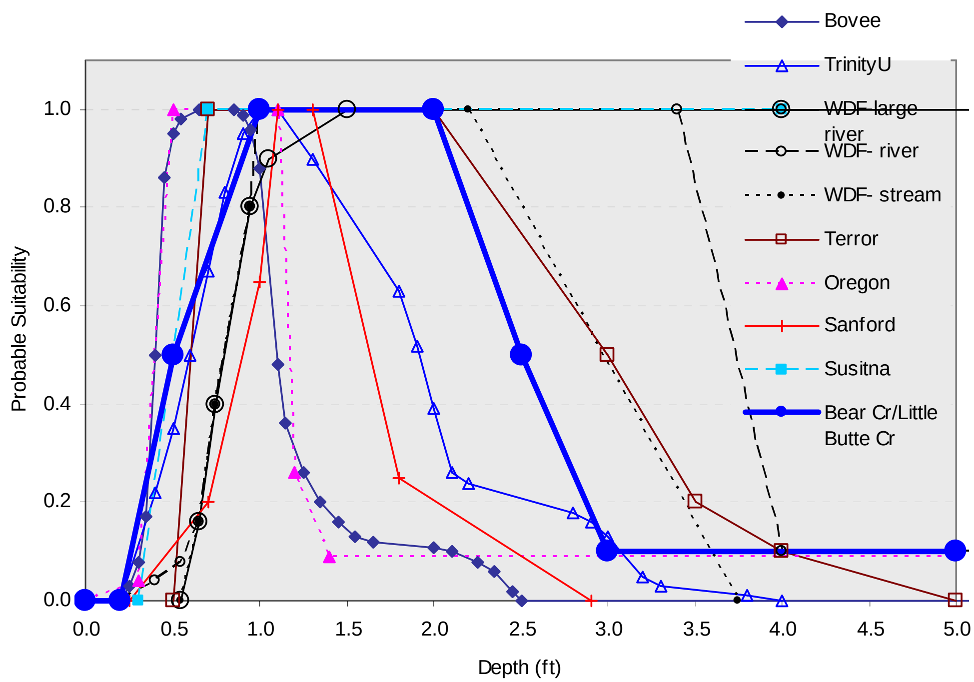
Emigrant Creek – cover at top of photo interpreted as “bush” out of water and “overhanging” in the water along transect. Cover at bottom of photo interpreted as “rootwad”.

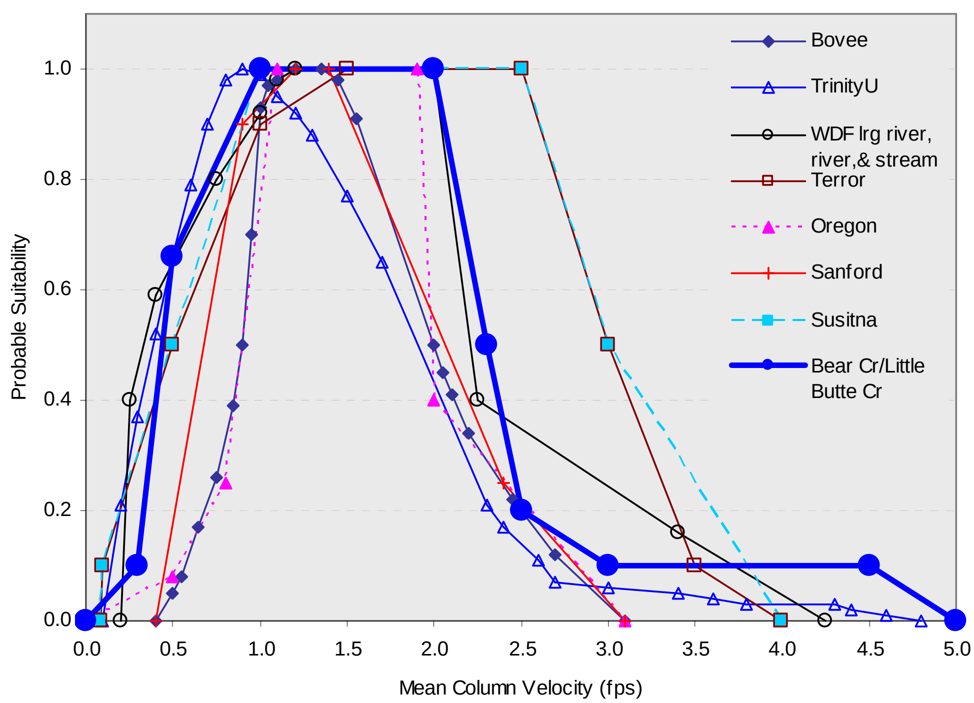
S. Fk. Little Butte Creek – escape cover to the left interpreted as “large wood”.

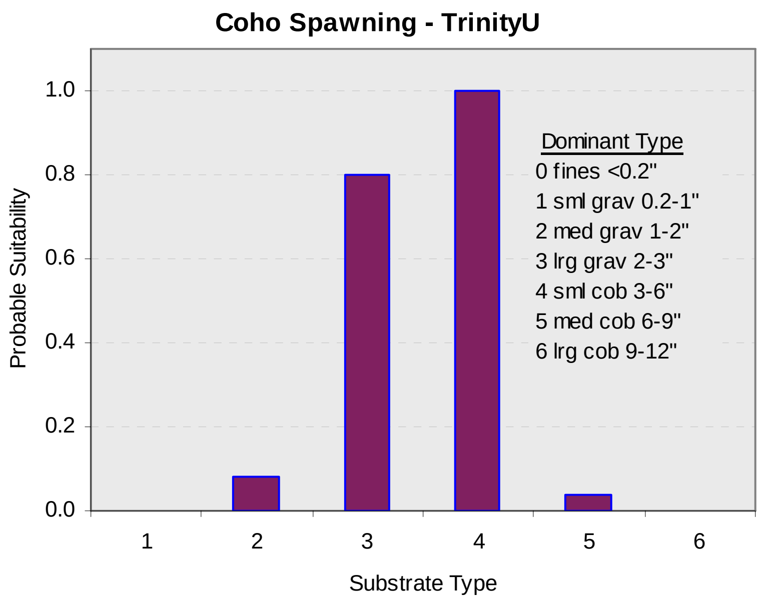
Table C-2. Habitat suitability criteria for use in Bear Creek and Little Butte Creek watersheds for SONC Coho Salmon (from March 8, 2007 workshop)

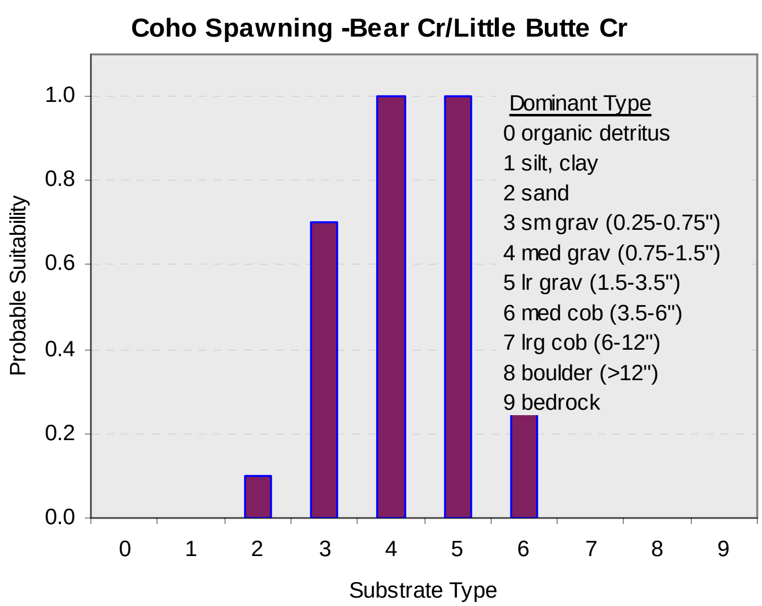
Life Stage:	Depth (ft)	Velocity (ft/sec)	Substrate	Cover
Adult Passage	Use Thompson (1972)			
Adult Spawning	Ft SI 0 0 0.2 0 0.5 0.5 1.0 1.0 2.0 1.0 2.5 0.5 3.0 0.1 10 0.1	Ft/sec SI 0 0 0.3 0.1 0.5 0.66 1.0 1.0 2.0 1.0 2.3 0.5 2.5 0.2 3.0 0.1 4.5 0.1 5.0 0	Substrate codes: SI 0 – organic detritus 0 1 – silt, clay 0 2 – sand 0.1 3 – small gravel 0.25-0.75” 0.7 4 - medium gravel 0.75-1.5” 1.0 5 – lrg gravel-sm cobb 1.5-3.5” 1.0 6– medium cobble 3.5-6” 0.3 7 – lrg cobble 6-12” 0 8 – boulder >12” 0 9 – bedrock 0	Do not model
Juvenile	Ft SI 0 0 0.1 0.05 1.5 1.0 3.5 1.0 4.0 0.5 5.5 0.2 6.0 0	Ft/sec SI 0 1.0 0.5 1.0 1.0 0.6 1.5 0.1 2.0 0.05 3.5 0	Do not model	Cover codes: SI (summer) SI (winter) 0 – no cover 0.05 0.05 1 – undercut bank 0.8 1.0 2 – overhanging vegetation 0.7 0.7 3 – rootwad 1.0 1.0 4 – logjam 1.0 1.0 5 – large wood 1.0 1.0 6 – non-emergent rooted aquatic 0.3 0.05 7 – fine organic substrate 0.3 0.3 8 – grass 0.2 0.4 9 – bushes 0.5 0.5 10 – boulders 0.2 0.1

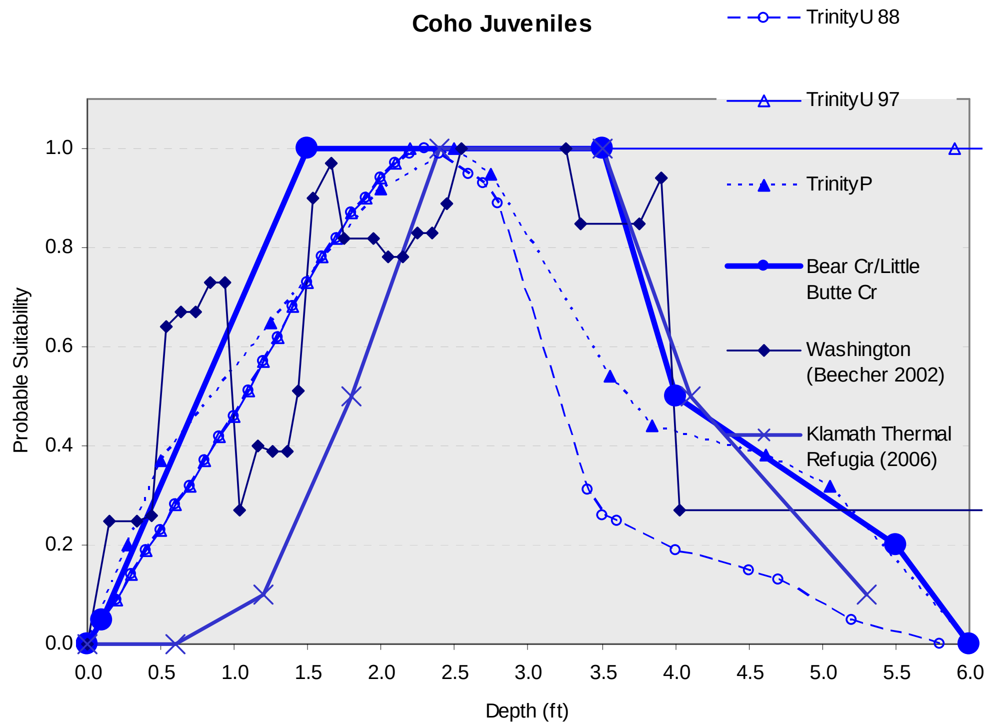
Coho Spawning - All HSCs

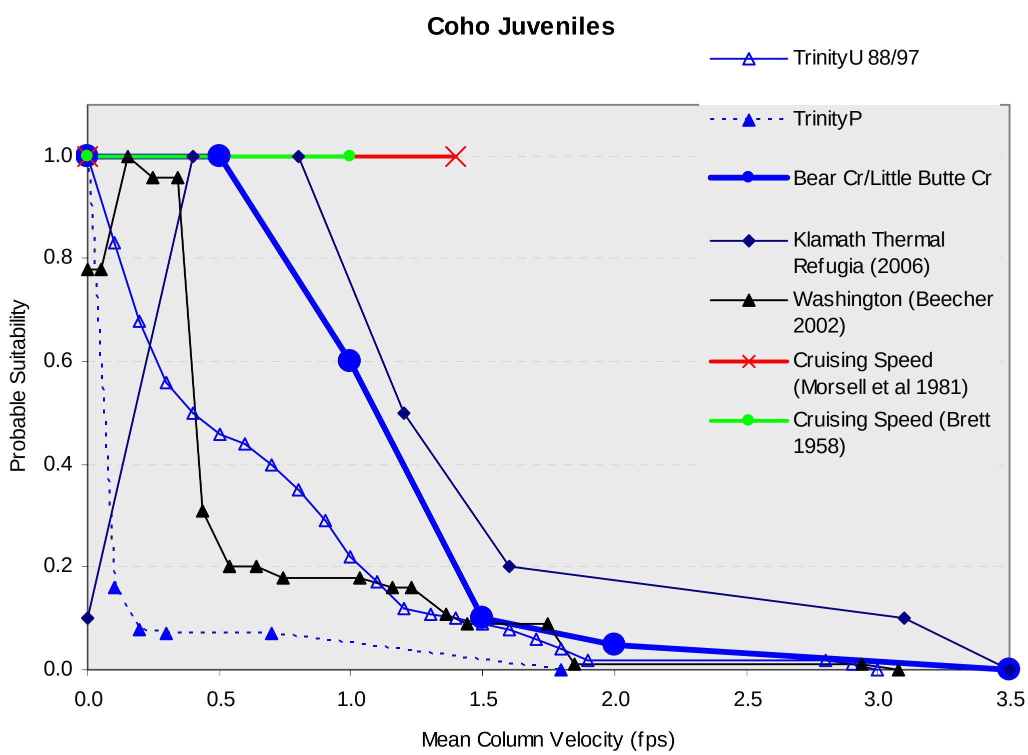


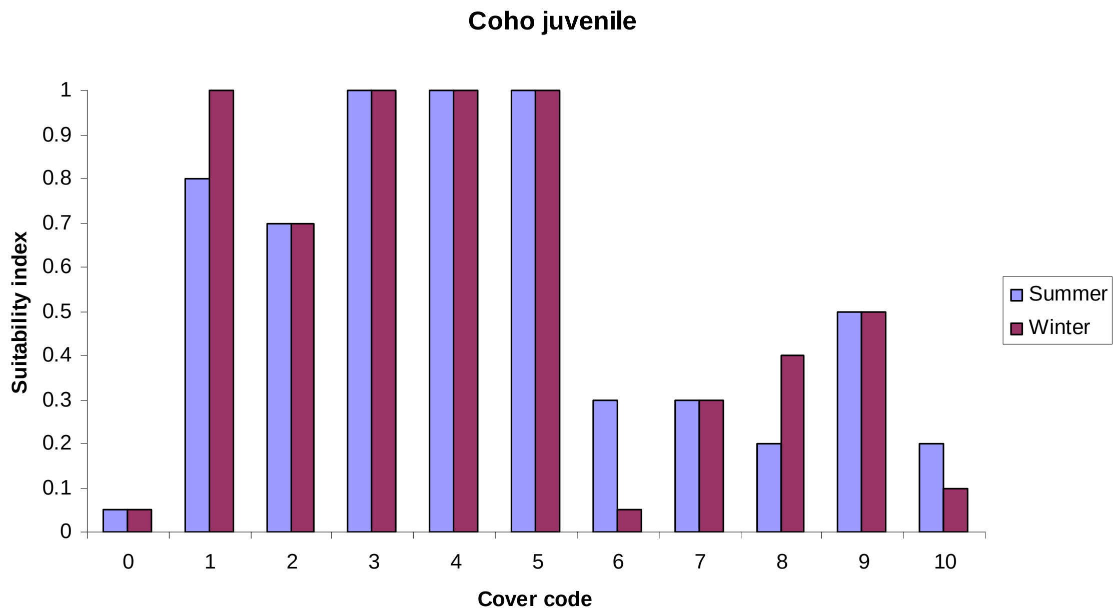



Coho Spawning - TrinityU
Probable Suitability
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
4
5
6
Substrate Type
Dominant Type
0 fines <0.2"
1 sml grav 0.2-1"
2 med grav 1-2"
3 lrg grav 2-3"
4 sml cob 3-6"
5 med cob 6-9"
6 lrg cob 9-12"


Coho Spawning -Bear Cr/Little Butte Cr
Probable Suitability
1.0
0.8
0.6
0.4
0.2
0.0
0
1
2
3
4
5
6
7
8
9
Substrate Type
Dominant Type
0 organic detritus
1 silt, clay
2 sand
3 sm grav (0.25-0.75")
4 med grav (0.75-1.5")
5 lr grav (1.5-3.5")
6 med cob (3.5-6")
7 lrg cob (6-12")
8 boulder (>12")
9 bedrock


Coho Juveniles
TrinityU 88
TrinityU 97
TrinityP
Bear Cr/Little Butte Cr
Washington (Beecher 2002)
Klamath Thermal Refugia (2006)
Probable Suitability
1.0
0.8
0.6
0.4
0.2
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5 4.0 4.5 5.0 5.5 6.0
Depth (ft)


Coho Juveniles
TrinityU 88/97
TrinityP
Bear Cr/Little Butte Cr
Klamath Thermal Refugia (2006)
Washington (Beecher 2002)
Cruising Speed (Morsell et al 1981)
Cruising Speed (Brett 1958)
Probable Suitability
1.0
0.8
0.6
0.4
0.2
0.0
0.0 0.5 1.0 1.5 2.0 2.5 3.0 3.5
Mean Column Velocity (fps)



Cover codes:

0 – no cover
1 – undercut bank
2 – overhanging vegetation
3 – rootwad
4 – logjam
5 – large wood
6 – non-emergent rooted aquatic
7 – fine organic substrate
8 – grass
9 – bushes
10 – boulders

Appendix D – Weighted Usable Area (WUA) Versus Discharge Relationships

Table D-1. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Emigrant Creek.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
0.5	17335	866	3920	2354	7.8	50.9	42.1
1	21403	1418	4804	2941	12.8	62.4	52.5
2	22446	2130	5252	3274	19.2	68.2	58.5
3	23477	2847	5679	3586	25.7	73.8	64.1
4	24471	3571	5986	3819	32.2	77.7	68.2
5	25423	4223	6233	4012	38.1	81.0	71.7
6	26311	4859	6450	4181	43.8	83.8	74.7
7	27178	5332	6645	4334	48.1	86.3	77.4
9	27968	6087	6958	4589	54.9	90.4	82.0
10	28217	6397	7076	4695	57.7	91.9	83.9
15	29088	7787	7468	5069	70.2	97.0	90.6
20	29679	8829	7629	5273	79.6	99.1	94.2
24	30136	9359	7692	5377	84.4	99.9	96.1
25	30212	9458	7697	5397	85.3	100.0	96.4
26	30286	9567	7700	5417	86.3	100.0	96.8
30	30546	9955	7689	5473	89.8	99.9	97.8
31	30702	10060	7671	5475	90.7	99.6	97.8
32	30877	10160	7676	5495	91.6	99.7	98.2
33	30953	10239	7672	5510	92.3	99.6	98.5
34	31024	10308	7656	5516	93.0	99.4	98.5
35	31095	10396	7639	5519	93.7	99.2	98.6
40	31434	10668	7545	5536	96.2	98.0	98.9
45	31938	10872	7477	5572	98.0	97.1	99.6
50	32543	11004	7379	5595	99.2	95.8	100.0
55	33118	11071	7229	5597	99.8	93.9	100.0
60	33408	11090	7056	5564	100.0	91.6	99.4
65	33581	11044	6849	5514	99.6	89.0	98.5
70	33752	10960	6779	5527	98.8	88.0	98.7
75	33917	10870	6708	5540	98.0	87.1	99.0
80	34096	10889	6644	5553	98.2	86.3	99.2

Table D-2. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Bear Creek between Emigrant Creek and Oak Street Diversion.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
7	21046	5981	2613	1531	40.8	51.0	36.4
10	21865	7275	2779	1718	49.6	54.2	40.9
15	24392	8629	3092	2024	58.9	60.4	48.1
20	26600	9530	3400	2321	65.0	66.4	55.2
25	28127	10345	3472	2453	70.6	67.8	58.3
30	29777	11012	3602	2562	75.1	70.3	60.9
35	31953	11698	3831	2772	79.8	74.8	65.9
40	33963	12479	4224	3064	85.1	82.4	72.9
45	34639	13064	4541	3326	89.1	88.6	79.1
50	35813	13829	4837	3571	94.3	94.4	84.9
55	36639	14546	5066	3761	99.2	98.9	89.4
60	36994	14660	5123	3827	100.0	100.0	91.0
65	37504	14380	5027	3801	98.1	98.1	90.4
70	37726	14239	4980	3831	97.1	97.2	91.1
75	37919	14002	4924	3848	95.5	96.1	91.5
80	38139	14032	4923	3923	95.7	96.1	93.3
85	38315	14059	4879	3966	95.9	95.2	94.3
90	38488	13994	4873	4016	95.5	95.1	95.5
100	39586	14018	4911	4139	95.6	95.9	98.4
110	39899	13878	4889	4205	94.7	95.4	100.0

Table D-3. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Bear Creek between Oak Street Diversion and Valley View Road.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
1	11651	208	759	403	4.7	31.0	23.5
2	14175	646	976	551	14.6	39.8	32.2
3	16259	961	1200	735	21.8	49.0	42.9
4	18804	1419	1502	1003	32.1	61.3	58.6
5	19529	1739	1630	1105	39.4	66.5	64.5
6	20163	1977	1709	1152	44.8	69.7	67.2
7	20814	2309	1761	1157	52.3	71.8	67.5
8	21902	2560	1837	1197	58.0	75.0	69.8
9	22607	2749	1910	1237	62.3	77.9	72.2
10	23244	2931	1981	1282	66.4	80.8	74.8
11	23940	3075	2028	1323	69.6	82.7	77.2
12	24842	3286	2088	1365	74.4	85.2	79.7
13	25476	3447	2149	1396	78.1	87.7	81.5
14	26029	3570	2193	1432	80.8	89.5	83.6
15	26491	3681	2225	1463	83.4	90.8	85.4
16	26940	3773	2254	1495	85.4	92.0	87.3
17	27366	3852	2276	1527	87.2	92.9	89.1
18	27762	3922	2292	1559	88.8	93.5	91.0
19	28043	3986	2305	1582	90.3	94.0	92.4
20	29326	4126	2382	1645	93.4	97.2	96.0
21	29609	4198	2399	1663	95.0	97.9	97.1
22	29849	4261	2414	1677	96.5	98.5	97.8
23	30044	4319	2422	1686	97.8	98.8	98.4
24	30245	4375	2434	1700	99.1	99.3	99.2
25	30407	4417	2451	1713	100.0	100.0	100.0

Table D-4. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Bear Creek between Valley View Road and Phoenix Diversion.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
5	26805	6626	4095	2998	28.4	83.8	77.9
10	29799	11826	4540	3319	50.8	92.9	85.9
12	30506	13062	4637	3385	56.1	94.8	87.6
14	31216	14123	4703	3428	60.6	96.2	88.8
16	32063	15010	4760	3476	64.4	97.4	90.0
18	32564	15797	4803	3517	67.8	98.2	91.1
20	33049	16584	4831	3549	71.2	98.8	91.9
25	34617	17996	4879	3619	77.2	99.8	93.7
30	35760	19080	4889	3666	81.9	100.0	94.9
35	36709	19920	4862	3691	85.5	99.4	95.6
40	38199	20596	4807	3701	88.4	98.3	95.9
45	39401	21060	4730	3695	90.4	96.7	95.7
50	40880	21558	4643	3671	92.5	95.0	95.1
51	41109	21632	4634	3667	92.8	94.8	94.9
55	42559	21940	4624	3673	94.2	94.6	95.1
60	44078	22172	4618	3684	95.2	94.4	95.4
65	45585	22373	4643	3701	96.0	95.0	95.8
70	46101	22642	4658	3708	97.2	95.3	96.0
75	46560	22903	4695	3751	98.3	96.0	97.1
80	47111	23265	4759	3822	99.8	97.3	99.3
85	47580	23137	4704	3781	99.3	96.2	97.9
90	47832	23302	4696	3789	100.0	96.1	98.1
95	48972	23282	4682	3789	99.9	95.8	98.1
100	49131	23229	4668	3802	99.7	95.5	98.5
110	49453	22981	4634	3822	98.6	94.8	99.0
117	49672	22761	4620	3843	97.7	94.5	99.5
120	49764	22642	4614	3851	97.2	94.4	99.7
130	50056	22123	4570	3862	94.9	93.5	100.0

Table D-5. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Bear Creek between Phoenix Diversion and Jackson Street Diversion.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile- summer	Juvenile- winter	Spawning/ incubation	Juvenile- summer	Juvenile- winter
5	21306	3487	3843	2358	32.5	94.4	85.3
10	23360	5622	4058	2587	52.4	99.6	93.6
15	25131	6758	4072	2714	63.0	100.0	98.1
20	27187	7648	3987	2765	71.3	97.9	100.0
25	28477	8239	3899	2757	76.8	95.7	99.7
30	29666	8844	3820	2757	82.4	93.8	99.7
40	31287	9651	3626	2758	89.9	89.0	99.7
45	32114	9893	3520	2732	92.2	86.4	98.8
50	32489	10075	3432	2730	93.9	84.3	98.7
55	32763	10417	3340	2692	97.0	82.0	97.4
60	33021	10647	3237	2645	99.2	79.5	95.7
65	33292	10728	3148	2606	99.9	77.3	94.3
70	33628	10734	3076	2570	100.0	75.5	93.0
80	34492	10553	2967	2535	98.3	72.9	91.7
85	34673	10570	2958	2553	98.5	72.6	92.3
90	34853	10557	2945	2563	98.3	72.3	92.7
100	35294	10408	2940	2587	97.0	72.2	93.6
110	35625	10125	2935	2613	94.3	72.1	94.5
120	35953	9752	2925	2637	90.8	71.8	95.4
130	36268	9561	2915	2662	89.1	71.6	96.3
140	36559	9359	2880	2673	87.2	70.7	96.7
150	36843	9178	2861	2683	85.5	70.3	97.0
160	37133	8960	2847	2689	83.5	69.9	97.3
170	37420	8763	2819	2686	81.6	69.2	97.1
180	37701	8618	2788	2694	80.3	68.5	97.4
190	38012	8523	2790	2714	79.4	68.5	98.2
200	38313	8379	2793	2735	78.1	68.6	98.9

Table D-6. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Bear Creek near its mouth (River2D results).

Discharge (cfs)	WUA (m^2)/93 m			Percent of maximum habitat		
	Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
10	353	427	429	56.8	93.8	93.7
20	474	448	452	76.3	98.5	98.3
30	553	455	460	89.0	100.0	100.0
40	598	454	459	96.3	99.8	99.8
50	616	443	449	99.2	97.4	97.6
60	621	431	436	100.0	94.7	94.8
70	619	426	432	99.7	93.6	93.9
80	606	419	425	97.6	92.1	92.4
90	597	419	425	96.1	92.1	92.4
100	588	417	424	94.7	91.6	92.2
110	577	419	426	92.9	92.1	92.6
120	566	421	429	91.1	92.5	93.3
130	560	418	428	90.2	91.9	93.0
140	550	416	426	88.6	91.4	92.6
150	548	416	427	88.2	91.4	92.8
160	546	411	421	87.9	90.3	91.5
170	542	408	419	87.3	89.7	91.1
180	534	404	415	86.0	88.8	90.2
190	525	402	414	84.5	88.4	90.0
200	518	403	415	83.4	88.6	90.2
210	510	402	414	82.1	88.4	90.0

Table D-7. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Little Butte Creek between South Fork Little Butte Creek and Antelope Creek (near Brownsboro).

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile- summer	Juvenile-winter	Spawning/ incubation	Juvenile- summer	Juvenile- winter
15	43012	14279	3877	2877	54.7	45.5	44.7
20	44812	17467	4319	3158	66.9	50.7	49.1
25	46538	19616	4769	3455	75.2	55.9	53.7
30	47634	21091	5149	3708	80.8	60.4	57.6
40	49386	23305	5892	4212	89.3	69.1	65.4
45	50476	24018	6235	4405	92.0	73.1	68.4
50	51190	24644	6464	4550	94.4	75.8	70.7
55	51622	25155	6651	4679	96.4	78.0	72.7
60	52025	25562	6809	4796	97.9	79.9	74.5
65	52787	25863	6943	4905	99.1	81.4	76.2
70	53176	26041	7079	5008	99.8	83.0	77.8
75	53531	26092	7194	5102	100.0	84.4	79.2
80	53969	26064	7297	5196	99.9	85.6	80.7
85	54180	26101	7385	5283	100.0	86.6	82.0
90	54385	26065	7466	5359	99.9	87.6	83.2
100	54774	25741	7637	5514	98.6	89.6	85.6
110	55127	25307	7810	5659	97.0	91.6	87.9
120	55438	24842	7952	5786	95.2	93.3	89.9
130	55755	24322	8065	5889	93.2	94.6	91.5
140	56159	23818	8147	5969	91.3	95.6	92.7
150	56544	23329	8221	6045	89.4	96.4	93.9
160	56919	22912	8290	6125	87.8	97.2	95.1
170	57277	22477	8344	6192	86.1	97.9	96.2
180	57652	22134	8401	6270	84.8	98.5	97.4
190	58029	21657	8469	6358	83.0	99.3	98.8
200	58391	21294	8526	6438	81.6	100.0	100.0

Table D-8. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Little Butte Creek between Antelope Creek and the mouth.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
15	48723	5542	3446	1976	26.8	78.7	61.9
20	51787	6812	3707	2181	32.9	84.6	68.3
25	54050	8042	3894	2343	38.8	88.9	73.4
30	55162	9133	4009	2454	44.1	91.5	76.9
35	57792	10497	4090	2538	50.7	93.4	79.5
40	59745	11606	4187	2632	56.0	95.6	82.4
45	60379	12468	4265	2708	60.2	97.3	84.8
50	61424	13403	4322	2768	64.7	98.6	86.7
55	62011	14347	4362	2819	69.3	99.5	88.3
60	62553	15219	4380	2855	73.5	100.0	89.4
65	63079	16102	4382	2882	77.7	100.0	90.3
70	63602	16864	4362	2897	81.4	99.5	90.7
75	64105	17456	4334	2906	84.3	98.9	91.0
80	65093	17837	4304	2921	86.1	98.2	91.5
85	65599	18169	4260	2926	87.7	97.2	91.6
90	66153	18505	4226	2933	89.3	96.4	91.9
95	67278	18668	4130	2912	90.1	94.3	91.2
100	67879	18775	4075	2906	90.6	93.0	91.0
110	70251	19084	4028	2950	92.1	91.9	92.4
120	70849	19233	4009	2979	92.9	91.5	93.3
130	71864	19479	3992	3009	94.0	91.1	94.3
140	72280	19913	3960	3032	96.1	90.4	95.0
150	72946	20271	3927	3062	97.9	89.6	95.9
160	73751	20512	3901	3107	99.0	89.0	97.3
170	74522	20661	3881	3154	99.8	88.6	98.8
180	75001	20713	3859	3192	100.0	88.1	100.0

Table D-9. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Antelope Creek between Dry Creek and Antelope Creek Diversion.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
2	15467	1027	1540	1046	19.1	80.7	83.9
3	17630	1304	1813	1217	24.2	95.1	97.6
10	19121	3529	1908	1247	65.5	100.0	100.0
15	19587	4332	1838	1224	80.4	96.3	98.2
20	19874	4886	1702	1157	90.7	89.2	92.8
25	20100	5194	1622	1130	96.4	85.0	90.6
30	20297	5321	1550	1099	98.8	81.2	88.1
35	20435	5385	1492	1066	100.0	78.2	85.5
40	20588	5344	1450	1052	99.2	76.0	84.4
45	20797	5242	1417	1043	97.3	74.3	83.6
50	20991	5106	1404	1051	94.8	73.6	84.3
55	21173	4929	1388	1057[1]	91.5	72.8	-[1]
60	21347	4798	1375	1067[1]	89.1	72.1	-
65	21599	4698	1363	1077[1]	87.2	71.5	-
70	21843	4587	1343	1076[1]	85.2	70.4	-
75	22073	4458	1329	1086[1]	82.8	69.7	-
80	22297	4360	1326	1101[1]	81.0	69.5	-
85	22575	4283	1336	1124[1]	79.5	70.0	-
90	22841	4228	1343	1149[1]	78.5	70.4	-
95	23088	4185	1363	1184[1]	77.7	71.4	-
100	23321	4139	1379	1215[1]	76.9	72.3	-
109	23800	4042	1393	1263[1]	75.1	73.0	-

[1] Modeled habitat values reflect increased habitat with discharge due to “bank full” hydraulic conditions (not plotted in main text).

Table D-10. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Antelope Creek between Dry Creek and Little Butte Creek.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
1	26635	3830	9296	6550	20.9	87.4	83.2
3	27956	6230	9950	7099	34.0	93.6	90.2
4	28392	7147	10127	7245	39.0	95.2	92.0
5	28747	7895	10257	7353	43.1	96.5	93.4
6	29054	8695	10361	7446	47.5	97.4	94.6
7	29196	9655	10438	7520	52.7	98.2	95.5
8	29321	10673	10497	7580	58.3	98.7	96.3
9	29435	11630	10546	7635	63.5	99.2	97.0
10	29538	12424	10582	7683	67.9	99.5	97.6
11	29708	13045	10614	7727	71.3	99.8	98.1
13	29817	14078	10628	7778	76.9	99.9	98.8
14	29867	14505	10633	7801	79.2	100.0	99.1
15	29915	14865	10631	7821	81.2	100.0	99.3
16	29962	15199	10626	7838	83.0	99.9	99.6
17	30008	15504	10618	7853	84.7	99.9	99.7
18	30050	15803	10603	7864	86.3	99.7	99.9
19	30092	16122	10586	7872	88.1	99.6	100.0
20	30127	16426	10563	7873	89.7	99.3	100.0
21	30160	16687	10535	7873	91.1	99.1	100.0
25	30337	17473	10370	7852	95.4	97.5	99.7
30	30440	17950	10125	7791	98.0	95.2	98.9
35	30525	18162	9814	7693	99.2	92.3	97.7
40	30605	18261	9478	7564	99.7	89.1	96.1
45	30682	18309	9100	7405	100.0	85.6	94.1
50	30756	18285	8712	7218	99.9	81.9	91.7
55	30828	18086	8376	7068	98.8	78.8	89.8
60	30898	17837	8095	6960	97.4	76.1	88.4

Table D-11. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in South Fork Little Butte Creek near Gilkey.

Discharge (cfs)	Total (ft²)/1000 ft	WUA (ft²)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile-summer	Juvenile-winter	Spawning/ incubation	Juvenile-summer	Juvenile-winter
7	17529	4146	2297	991	45.6	60.6	38.2
10	19938	5008	2442	1111	55.0	64.4	42.8
15	22081	5894	2572	1254	64.8	67.9	48.4
20	24702	6575	2668	1383	72.3	70.4	53.3
25	26476	7042	2749	1491	77.4	72.5	57.5
30	28637	7403	2808	1580	81.4	74.1	60.9
40	32003	7745	2998	1724	85.1	79.1	66.5
45	32635	7855	3080	1784	86.3	81.3	68.8
50	32947	8110	3126	1823	89.1	82.5	70.3
55	33245	8467	3166	1861	93.1	83.5	71.7
60	33558	8618	3199	1900	94.7	84.4	73.2
65	33878	8751	3217	1933	96.2	84.9	74.5
70	34183	9003	3241	1968	99.0	85.5	75.9
75	34471	9098	3254	1999	100.0	85.9	77.1
80	34747	9089	3264	2027	99.9	86.1	78.1
85	35014	9089	3270	2053	99.9	86.3	79.1
90	35423	9069	3297	2090	99.7	87.0	80.6
95	35817	8972	3349	2140	98.6	88.4	82.5
100	36194	8841	3399	2190	97.2	89.7	84.4
105	36761	8668	3446	2236	95.3	90.9	86.2
110	37131	8512	3490	2280	93.6	92.1	87.9
115	37498	8255	3530	2320	90.7	93.2	89.4
120	37855	8159	3572	2360	89.7	94.2	91.0
130	38538	7971	3648	2434	87.6	96.3	93.8
140	39327	7883	3716	2508	86.6	98.0	96.7
150	40221	7749	3790	2594	85.2	100.0	100.0

Table D-12. Weighted usable area (WUA) versus discharge relationships for coho juveniles without escape cover modifier in South Fork Little Butte Creek near Gilkey.

Discharge (cfs)	Total (ft²)/1000 ft	WUA (ft²)/1000 ft		Percent of maximum habitat	
		Juvenile-summer	Juvenile-winter	Juvenile-summer	Juvenile-winter
7	17529	3477	3487	65.3	67.1
10	19938	3746	3759	70.3	72.3
15	22081	3939	3955	73.9	76.1
20	24702	4124	4142	77.4	79.7
25	26476	4322	4342	81.1	83.6
30	28637	4504	4525	84.5	87.1
40	32003	4735	4753	88.9	91.5
45	32635	4795	4806	90.0	92.5
50	32947	4782	4789	89.7	92.2
55	33245	4777	4780	89.7	92.0
60	33558	4745	4744	89.0	91.3
65	33878	4692	4688	88.1	90.2
70	34183	4655	4647	87.4	89.4
75	34471	4632	4621	86.9	88.9
80	34747	4615	4601	86.6	88.6
85	35014	4607	4590	86.5	88.3
90	35423	4627	4604	86.8	88.6
95	35817	4678	4648	87.8	89.5
100	36194	4733	4694	88.8	90.4
105	36761	4785	4738	89.8	91.2
110	37131	4842	4786	90.9	92.1
115	37498	4901	4836	92.0	93.1
120	37855	4956	4882	93.0	94.0
130	38538	5063	4970	95.0	95.7
140	39327	5167	5054	97.0	97.3
150	40221	5328	5196	100.0	100.0

Table D-13. Weighted usable area (WUA) versus discharge relationships for coho juveniles and spawning/incubation in Neil Creek between its mouth and Tolman Creek.

Discharge (cfs)	Total (ft^2)/1000 ft	WUA (ft^2)/1000 ft			Percent of maximum habitat		
		Spawning/ incubation	Juvenile- summer	Juvenile-winter	Spawning/ incubation	Juvenile- summer	Juvenile- winter
2	21038	3039	4628	2704	27.0	81.9	83.4
5	22940	6050	5576	3212	53.7	98.7	99.1
10	24012	8628	5649	3243	76.6	100.0	100.0
15	24970	10032	5573	3240	89.1	98.7	99.9
20	25807	10789	5436	3223	95.8	96.2	99.4
25	26151	11263	5157	3098	100.0	91.3	95.5
35	26620	11091	4662	2913	98.5	82.5	89.8
40	26799	10835	4460	2850	96.2	78.9	87.9
45	26980	10540	4325	2819	93.6	76.6	86.9
50	27120	10213	4176	2788	90.7	73.9	86.0
55	27259	9977	4059	2764	88.6	71.8	85.2
60	27402	9779	3951	2739	86.8	69.9	84.5
65	27542	9550	3881	2739	84.8	68.7	84.5
70	27652	9244	3791	2713	82.1	67.1	83.6
75	27775	8916	3715	2692	79.2	65.8	83.0
80	27887	8516	3647	2670	75.6	64.6	82.3
85	27995	8171	3595	2657	72.5	63.6	81.9
90	28114	7875	3548	2642	69.9	62.8	81.5
95	28201	7442	3492	2616	66.1	61.8	80.7
100	28299	7089	3447	2605	62.9	61.0	80.3

Appendix E – Stream Habitat Surveys

Table E-1. Comparisons of stream habitat conditions among ODFW, U.S. Forest Service Level II, and Reclamation's habitat typing for Rogue Project instream flow assessment.

Stream	Reach	Survey Date	Total pools (%)	Riffles (%)	Glides (%)	Other (%)	Avg Gradient (%)	Width/Depth Ratio	Substrate percent wetted area				
									Sand (%)	Grav (%)	Cob (%)	Boul (%)	Bed (%)
Reclamation stream segments													
Bear Creek	Mouth to Jackson St Div	8/15/06	40	14	46		0	26	34	55	3	0	0
	Jackson St Div to Phoenix Div	8/16/06	30	40	30		0	39	14	18	38	9	8
	Phoenix Div to Valley View Road	8/16/06	9	37	54		1	22	18	43	14	3	0
	Valley View Road to Oak St Div	10/23/07	<2	69	31		0.7	24	18	15	14	2	42
	Oak St Div to Emigrant Cr	8/16/06	6	23	72	<3	0.8	23	19	25	16	4	20
	Avg		17	37	47		1	27	21	31	17	4	14
Emigrant Creek	Mouth to Emigrant Dam	8/17/06	16	39	45			20	13	26	17	3	18
Little Butte Creek	Mouth to Antelope Creek	8/17/06	28	34	38		0.3	53	5	31	15	1	31
	Antelope Creek to S.Fk. Little Butte Creek	8/17/06	22	24	54		0.2	24	9	41	30	1	4
	Avg		25	29	46		0	39	7	36	23	1	18
S. Fk. Little Butte Creek	Mouth to natural falls	8/17/06	7	25	68	<1	1.7	19	5	28	62	3	0
Antelope Creek	Mouth to Dry Creek	5/11/06	45	18	37		0.4	16	21	57	16	0	0
	Dry Creek to Antelope Creek Div	8/15/06	19	52	29	<3	0.6	45	3	16	25	18	21
	Avg		32	35	33		1	31	12	37	21	9	11
Neil Creek	Mouth to Tolman Creek	6/13/06	19	40	41	<2	0.7	15	53	14	15	3	0
Oregon Dept Fish and Wildlife													
Bear Creek[a]	1-Mouth to	6/27/1990	24	2	73	1	0		35	49	14	2	0

Stream	Reach	Survey Date	Total pools (%)	Riffles (%)	Glides (%)	Other (%)	Avg Gradient (%)	Width/Depth Ratio	Substrate percent wetted area				
									Sand (%)	Grav (%)	Cob (%)	Boul (%)	Bed (%)
	west Medford												
	2-West Medford to Jackson St Diversion	6/27/1990	20	12	66	1	0		21	43	28	6	2
	3-Jackson St Diversion to I-5 crossing east of Barnett Road	6/27/1990	26	6	67	1	0		14	22	21	9	34
	4- I-5 crossing to Phoenix Diversion	6/27/1990	33	3	63	1	0		16	30	23	1	29
	5-Phoenix Diversion to Oak St Diversion	6/27/1990	50	8	40	2	0		21	23	29	3	24
	6-Oak St Diversion to Jct of Emigrant Cr and Neil Cr	6/27/1990	19	3	66	12	1		25	29	35	1	10
	Avg		29	6	63	3	0		22	33	25	4	17
Antelope Creek[b]	1	4/3/91	25	29	45	1	1	2	13	42	42	0	3
	2	4/3/91	25	52	22	1	1	12	10	41	48	1	1
	3	4/8/91	21	49	29	2	1	24	9	39	48	1	5
	4	4/8/91	25	45	15	16	2	18	4	33	56	5	1
	5	4/9/91	15	36	26	20	2	14	6	24	58	9	3
	6	4/11/91	23	10	33	33	2	11	7	17	40	12	25
	Avg		22	37	28	12	1	13	8	33	48	5	6
Little Butte Creek[b]	1	6/2/94	40	28	28	4	3	69	0	35	13	0	29
	2	6/7/94	51	27	14	8	1	66	1	36	16	3	2
	3	6/28/94	26	17	3	47	3	25	7	32	22	13	5
	Avg		39	24	15	21	2	53	3	34	17	5	12
S Fk Little Butte Creek[b]	1	7/11/94	29	35	18	18	1	53	2	42	25	10	2
	2	7/12/94	31	18	3	48	2	27	3	36	31	12	3
	3	7/12/94	33	31	10	26	2	41	5	39	30	9	1
	4	7/14/94	36	26	4	32	1	54	4	37	34	8	1
	5	7/18/94	29	25	0	46	1	51	7	31	30	12	5

Stream	Reach	Survey Date	Total pools (%)	Riffles (%)	Glides (%)	Other (%)	Avg Gradient (%)	Width/Depth Ratio	Substrate percent wetted area				
									Sand (%)	Grav (%)	Cob (%)	Boul (%)	Bed (%)
	6	7/19/94	36	29	1	33	2	35	6	36	30	6	0
	7	7/21/94	24	20	1	52	3	28	6	34	33	12	1
	8	7/26/94	22	8	1	65	3	27	15	26	27	16	2
	9	7/26/94	16	9	0	70	4	35	19	29	26	16	1
	10	8/1/94	5	4	0	81	6	35	11	22	22	31	2
	11	8/3/94	4	0	0	95	4	12	0	16	16	29	24
	Avg		24	19	4	52	3	36	7	32	28	15	4
S Fk Little Butte Creek[c]		6/2/1969	86										
U.S. Forest Service Level II Surveys													
Neil Creek[d]	1- Mouth to Tolman Creek	8/30/2002	42	58			1.6	19	DOM	SUB			
	2	8/30/2002	45	55			1	17	DOM	SUB			
	3	8/30/2002	24	75		1	2.1	18	DOM	SUB			
	4-restricted	8/30/2002					4.3						
	5	8/30/2002	24	67		9	4.7	20	DOM				SUB
	6	8/30/2002	14	77		9	6.6	13	DOM			SUB	
	Avg		30	66		6	3	17					
Neil Creek[c]	1	8/20/1990	7	79	12		10	6			SUB	DOM	
	2	8/20/1990	2	95	2		12	4			SUB	DOM	
	3	8/20/1990	4	85	8		20	5				DOM	SUB
	Avg		4	86	7		14	5					
Neil Creek[c]		1969-1970	15				7						
S Fk Little Butte Creek[b]	1	8/1990	19	70	8	0	1	15		SUB	DOM		
	2	8/1990	21	72	3	0	7	7		DOM		SUB	
	3	8/1990	4	94	1	0	18	15				DOM/SUB	
	4	8/1990	3	95	0	0	8	7			SUB	DOM	
	5	8/1990	0	65	33	0	2	11		SUB	DOM		
	6	8/1990	9	0	90	0	1	6	DOM/SUB				
	Avg	8/1990	9	66	23	0	6	10					
	1	9/6/97	18	82		0	1	55		SUB	DOM		
	2	9/6/97	4	96		0	4	15		SUB	DOM		
	3	9/6/97	20	80		0	8	17		SUB		DOM	
	4	9/6/97	11	89		0	5	30			DOM	SUB	
	5	9/6/97	41	59		0	1	10	DOM	SUB			
	6	9/6/97	52	48		0	2	12	SUB	DOM			
	Avg	9/6/97	24	76		0	4	23					
S Fk Little Butte Creek[c]		1969-1970	10	86		14	4-5						

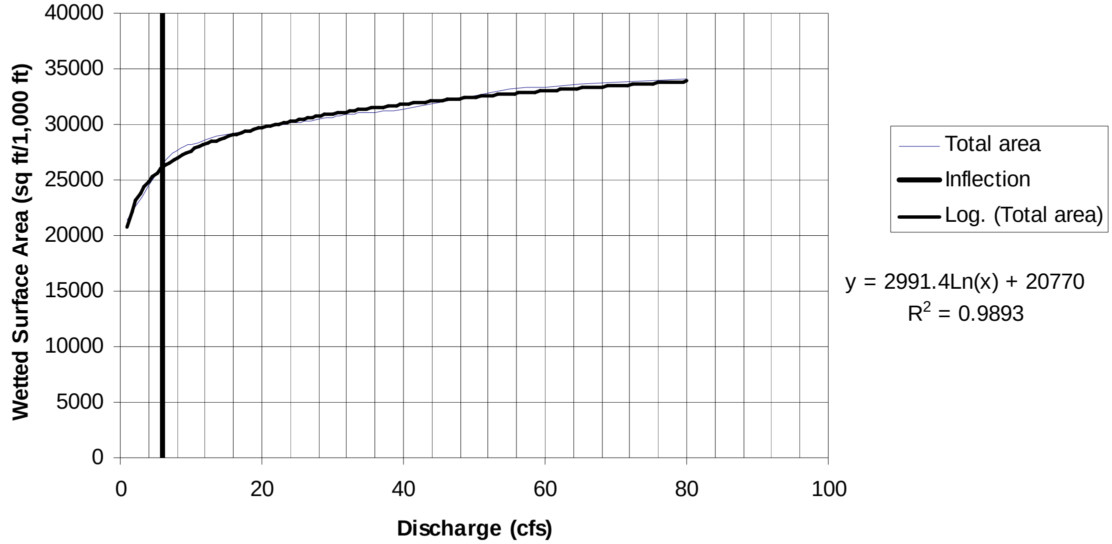
Sources:
[a] Dambacher et al. (1992)
[b] Talabere (1994)
[c] GeoEngineers, Inc. (2004)
[d] Siskiyou Research Group (2002)

DOM – Dominant Substrate Type
SUB – Sub Dominant Substrate Type

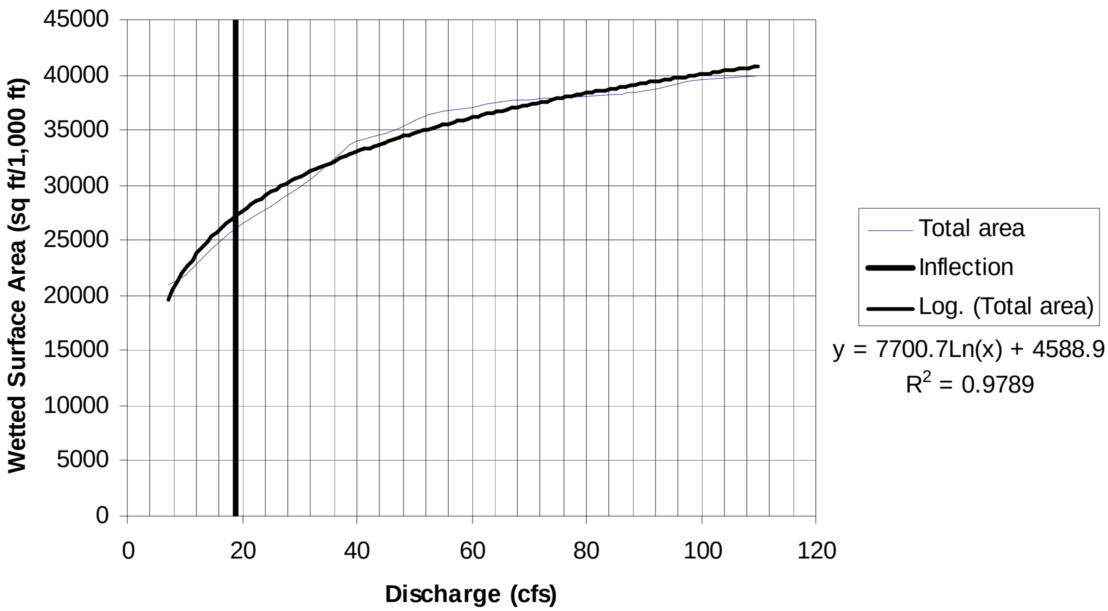
Appendix F – Inflection Points

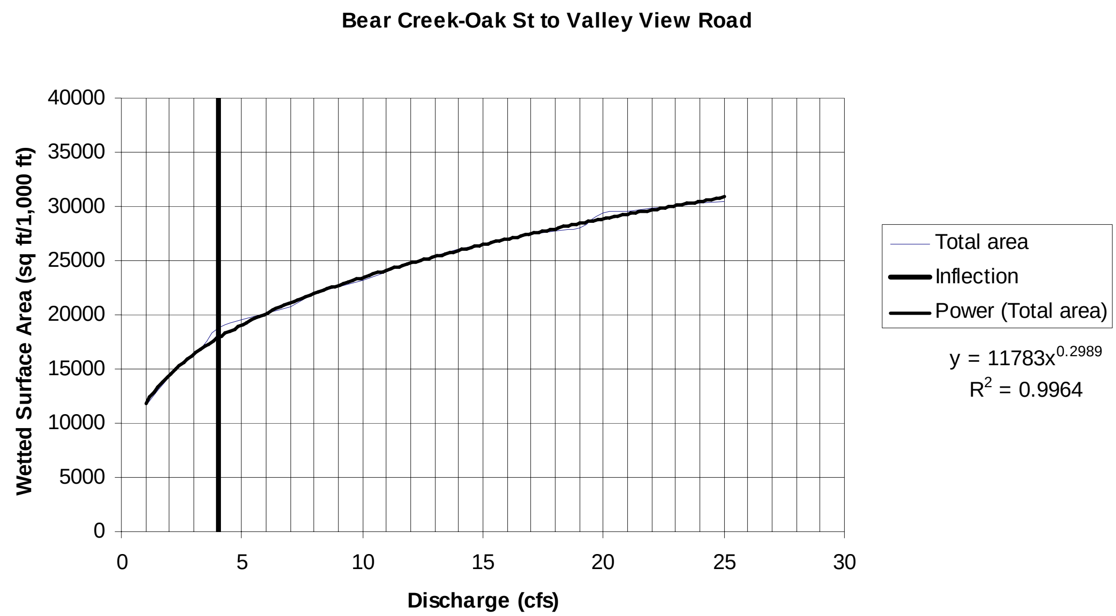
Relationships between wetted surface area and discharge at Rogue Project PHABSIM study sites (inflection points)

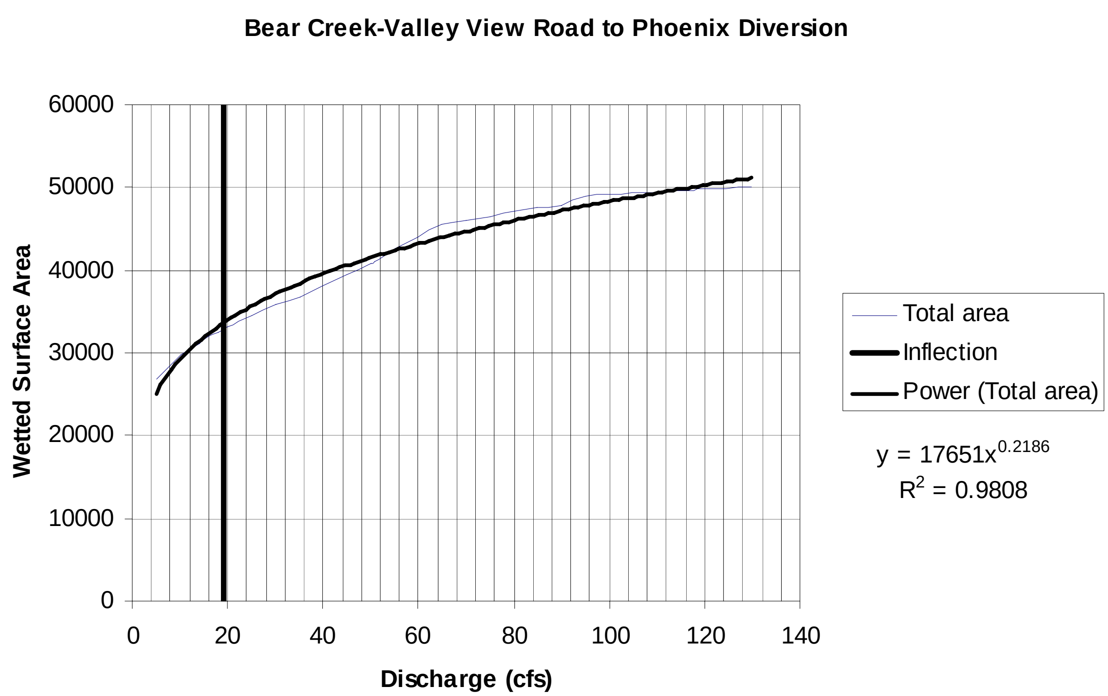
Emigrant Creek

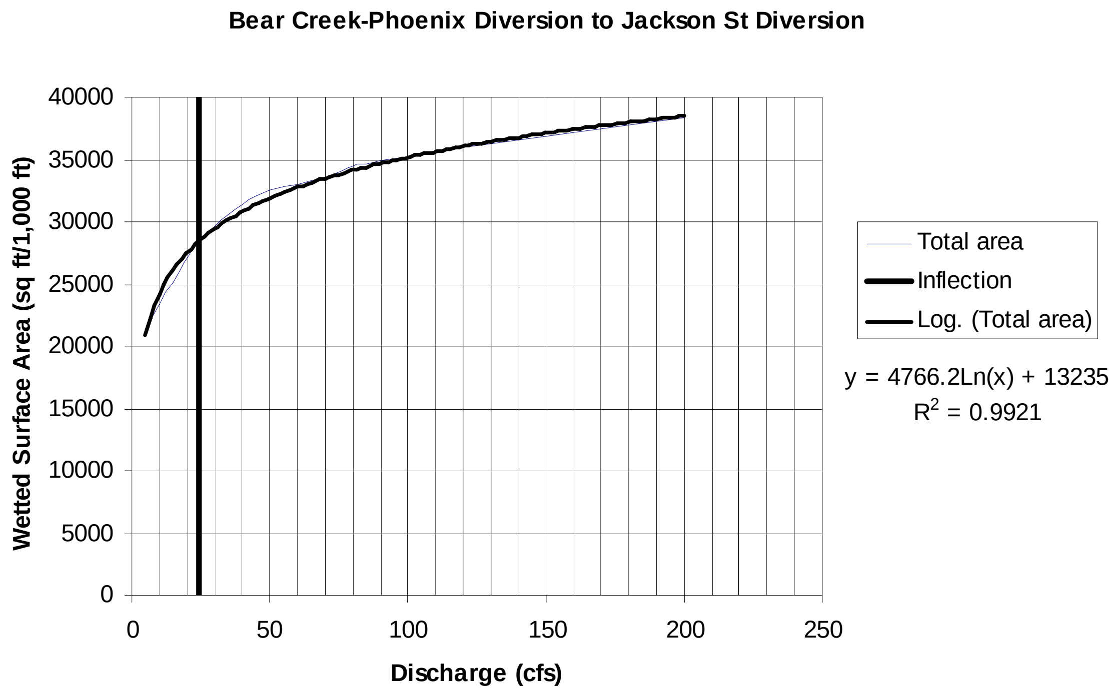


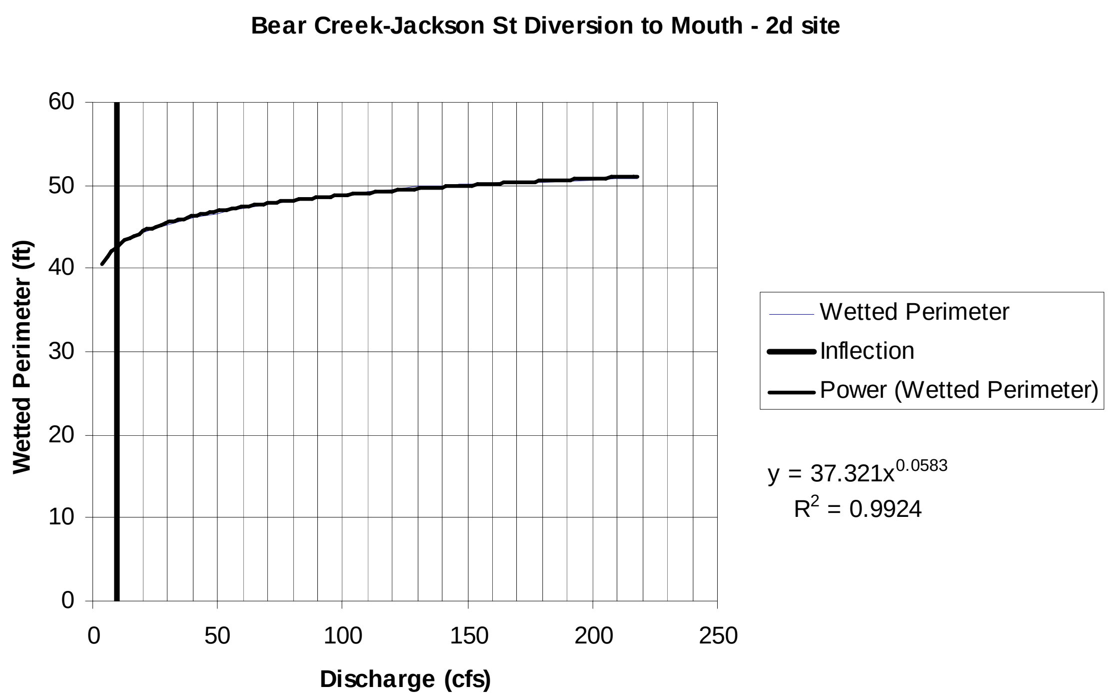
Bear Creek-Emigrant Cr to Oak St Diversion

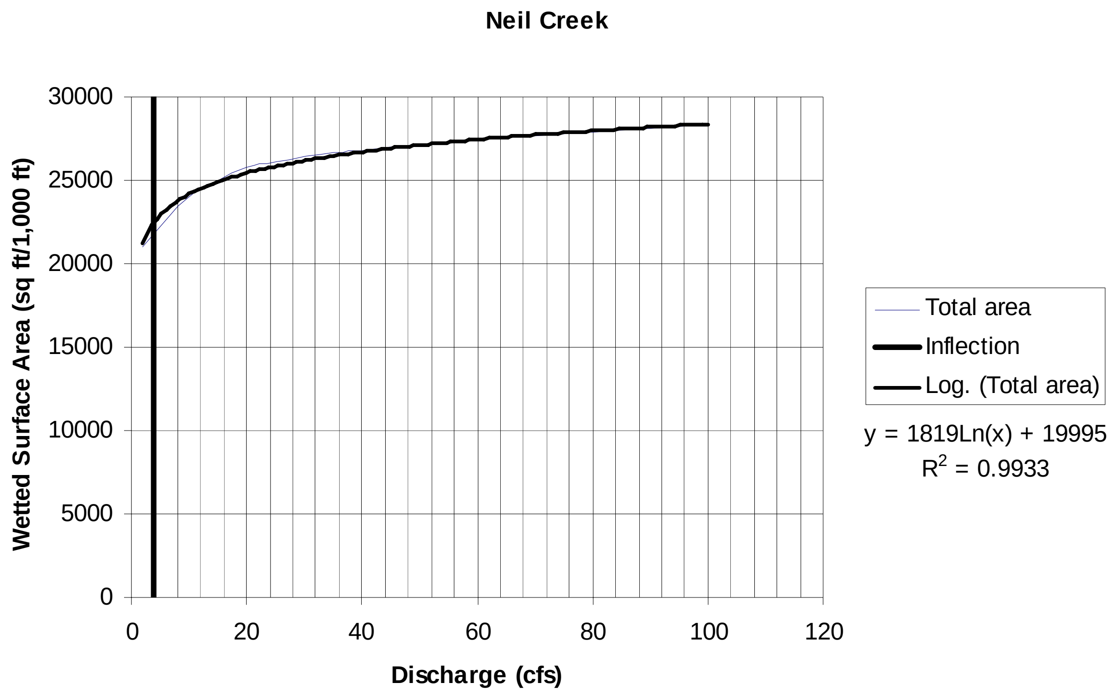


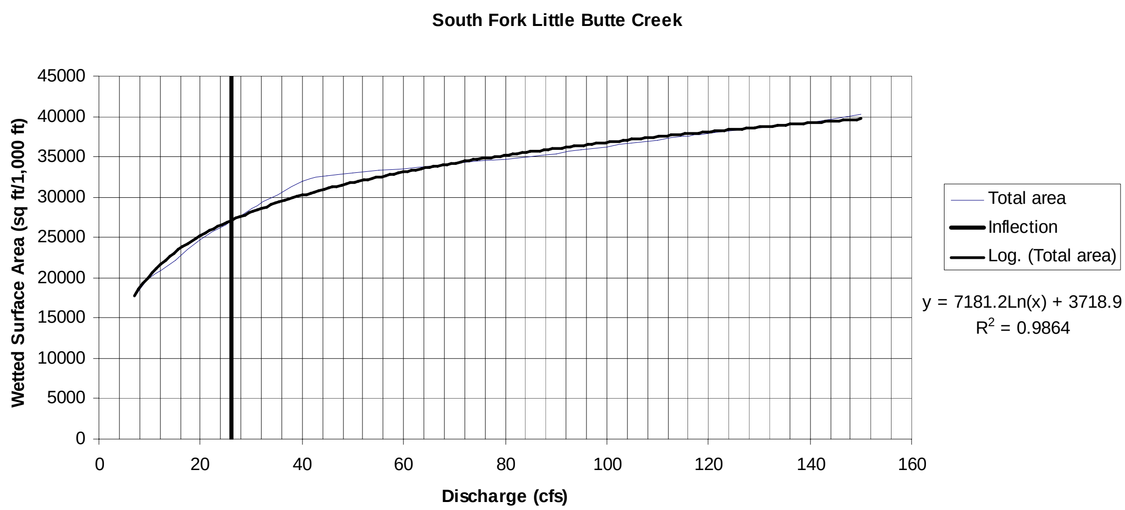

Bear Creek-Oak St to Valley View Road
Wetted Surface Area (sq ft/1,000 ft)
Discharge (cfs)
Total area
Inflection
Power (Total area)
y = 11783x^0.2989
R^2 = 0.9964


Bear Creek-Valley View Road to Phoenix Diversion
Wetted Surface Area
Discharge (cfs)
Total area
Inflection
Power (Total area)
y = 17651x^0.2186
R^2 = 0.9808

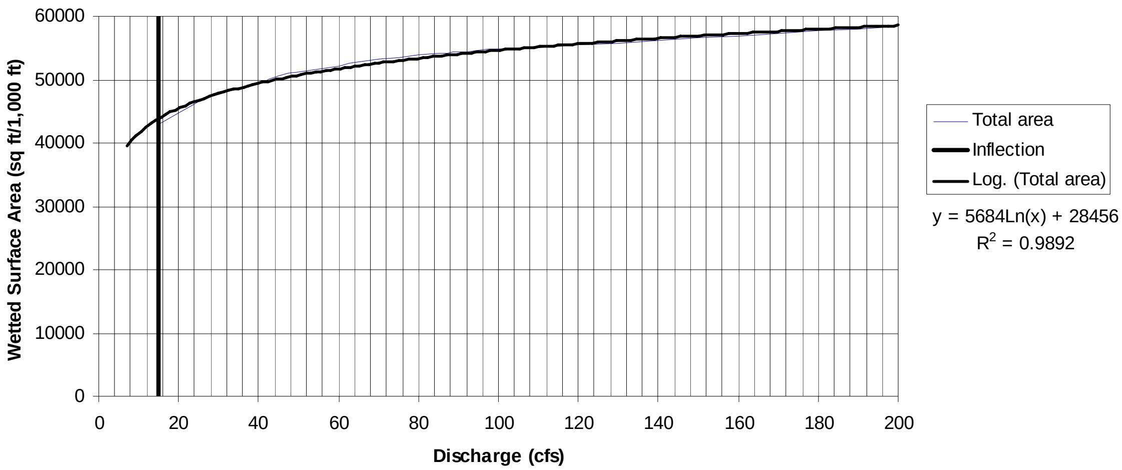

Bear Creek-Phoenix Diversion to Jackson St Diversion
Wetted Surface Area (sq ft/1,000 ft)
40000
35000
30000
25000
20000
15000
10000
5000
0
0
50
100
150
200
250
Discharge (cfs)
Total area
Inflection
Log. (Total area)
y = 4766.2Ln(x) + 13235
R2 = 0.9921


Bear Creek-Jackson St Diversion to Mouth - 2d site
Wetted Perimeter (ft)
60
50
40
30
20
10
0
0
50
100
150
200
250
Discharge (cfs)
Wetted Perimeter
Inflection
Power (Wetted Perimeter)
y = 37.321x0.0583
R2 = 0.9924

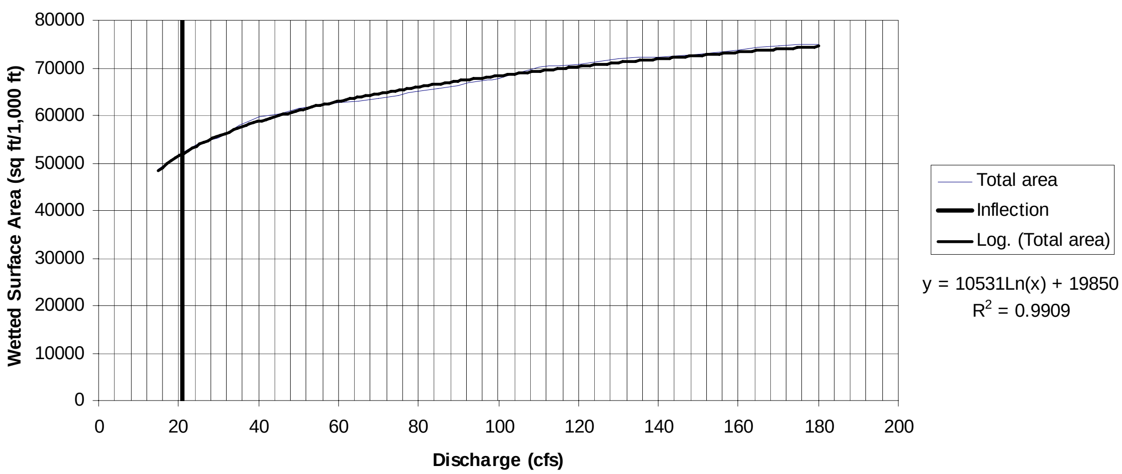

Neil Creek
Wetted Surface Area (sq ft/1,000 ft)
0
5000
10000
15000
20000
25000
30000
Discharge (cfs)
0
20
40
60
80
100
120
Total area
Inflection
Log. (Total area)
y = 1819Ln(x) + 19995
$R^2 = 0.9933$

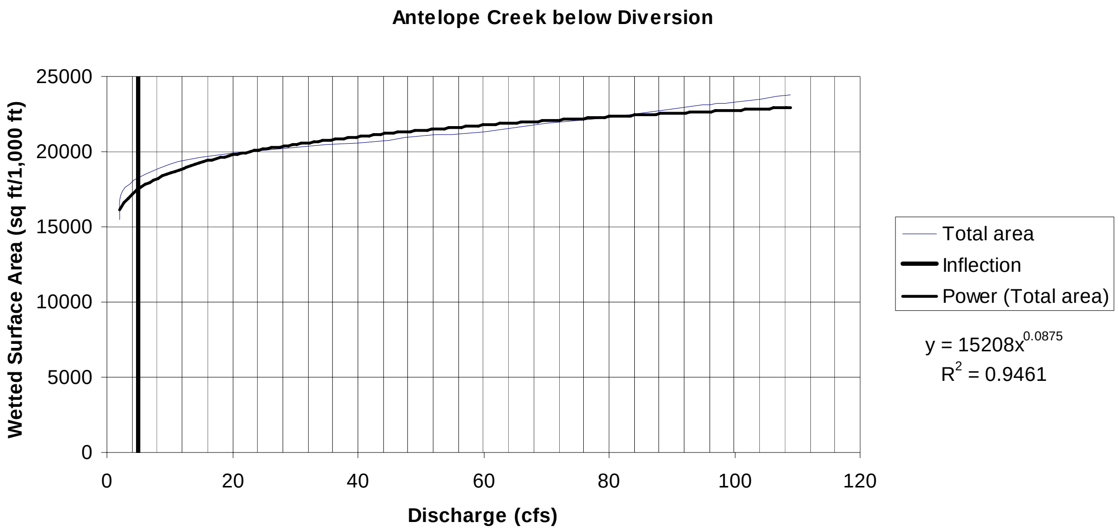

South Fork Little Butte Creek
Wetted Surface Area (sq ft/1,000 ft)
0
5000
10000
15000
20000
25000
30000
35000
40000
45000
Discharge (cfs)
0
20
40
60
80
100
120
140
160
Total area
Inflection
Log. (Total area)
y = 7181.2Ln(x) + 3718.9
$R^2 = 0.9864$

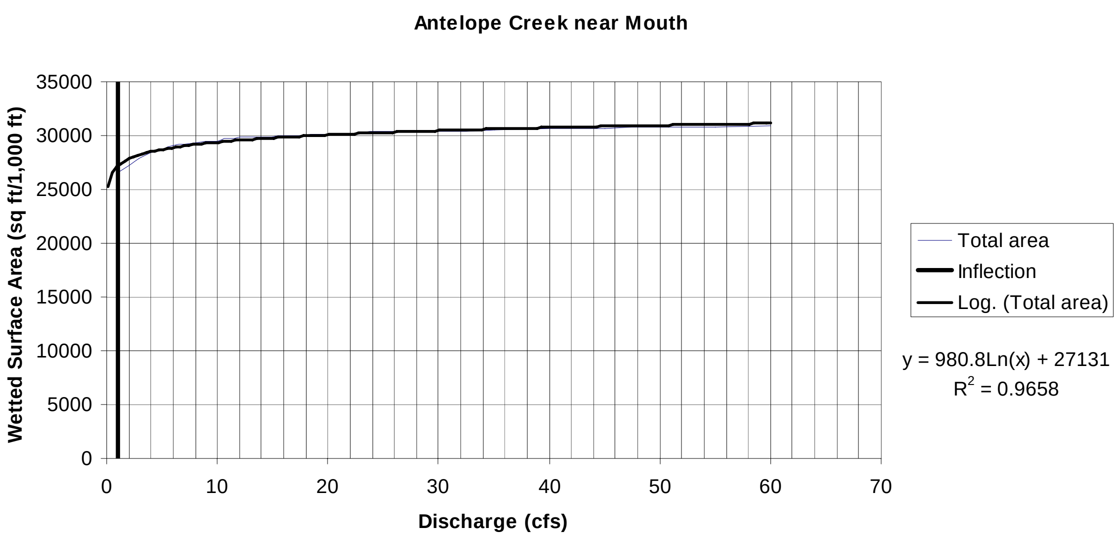
Little Butte Creek @ HWY 140 Bridge



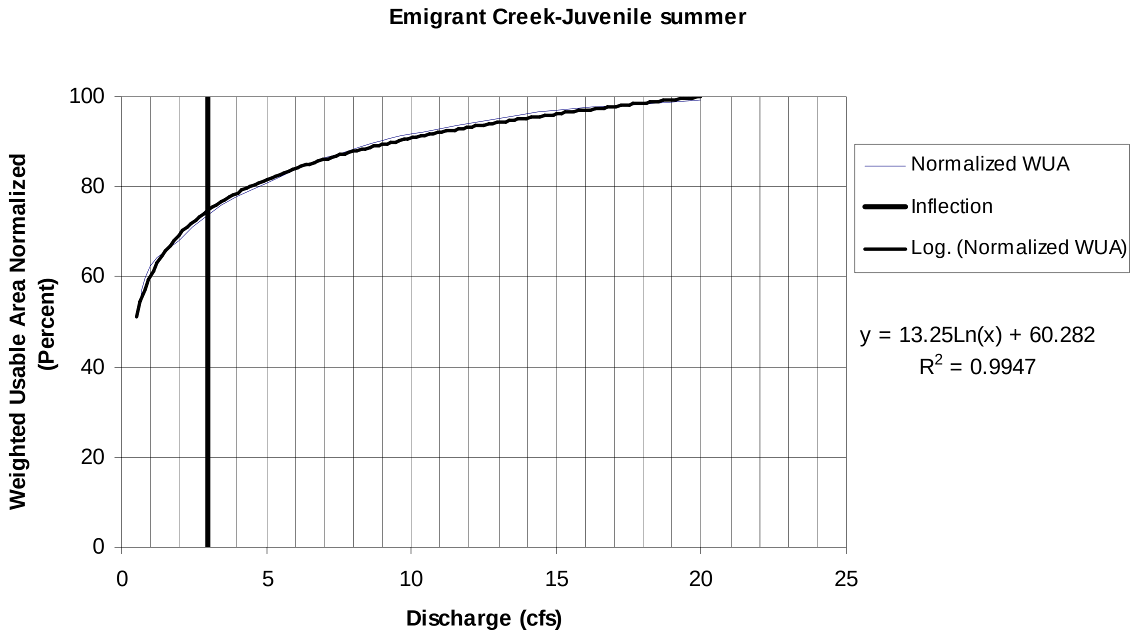
Little Butte Creek @ Mouth



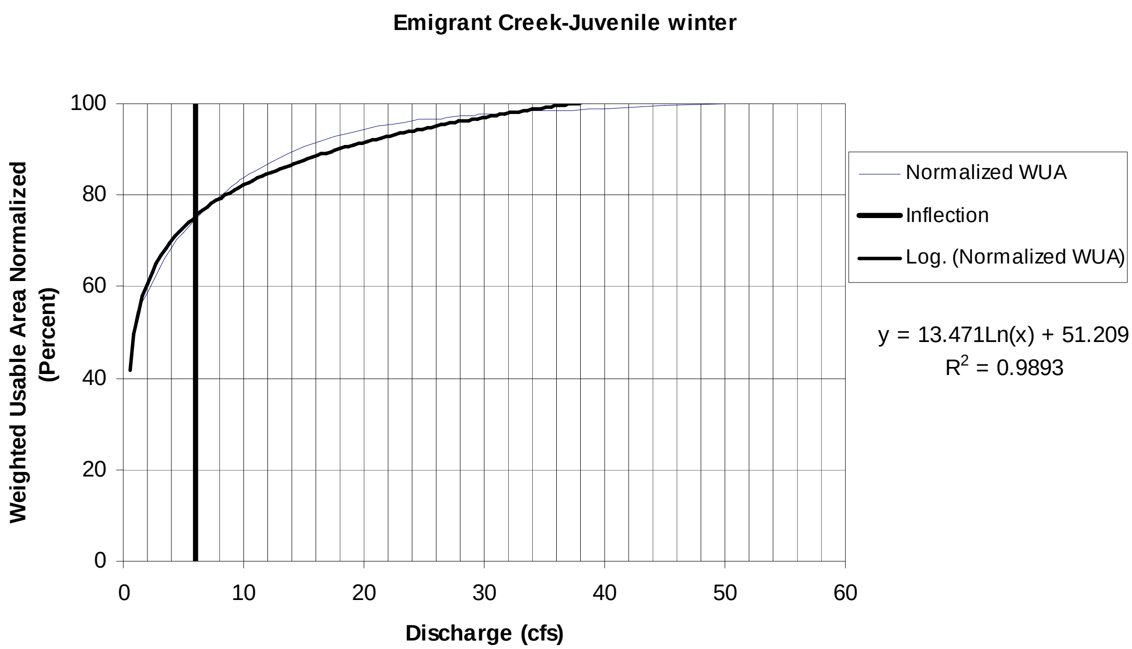




Relationships between weighted usable area (WUA) and discharge at Rogue Project PHABSIM study sites (inflection points)

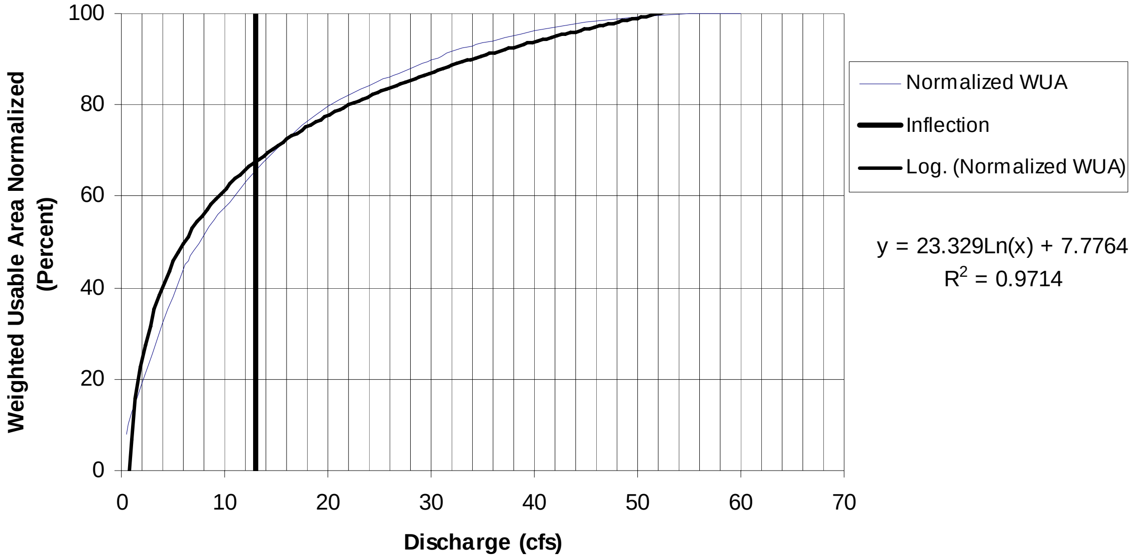


Emigrant Creek-Juvenile summer
100
80
60
40
20
0
Weighted Usable Area Normalized (Percent)
0
5
10
15
20
25
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 13.25Ln(x) + 60.282
R^2 = 0.9947

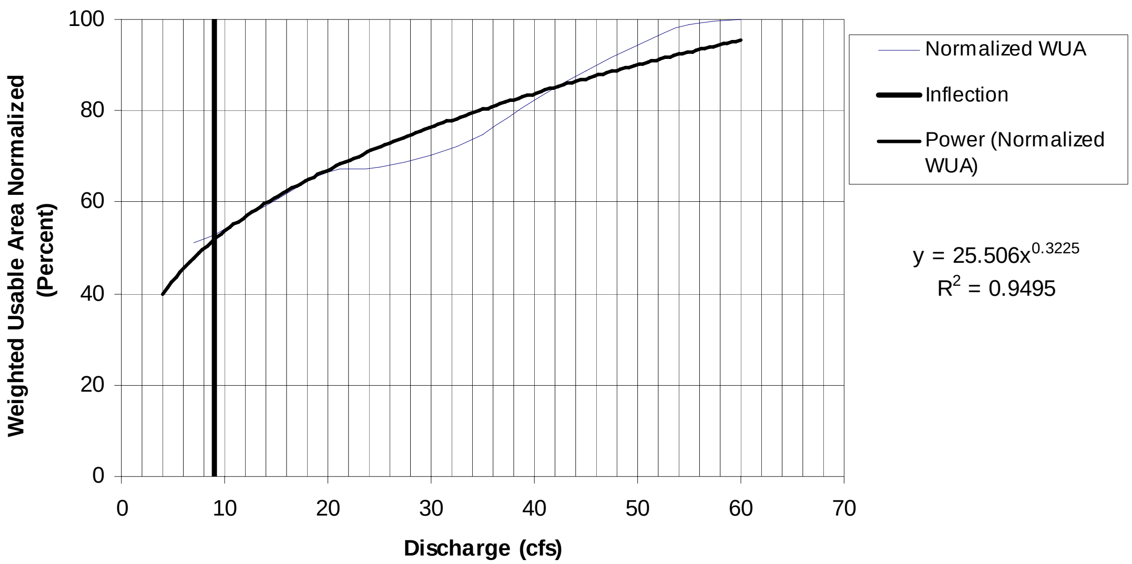


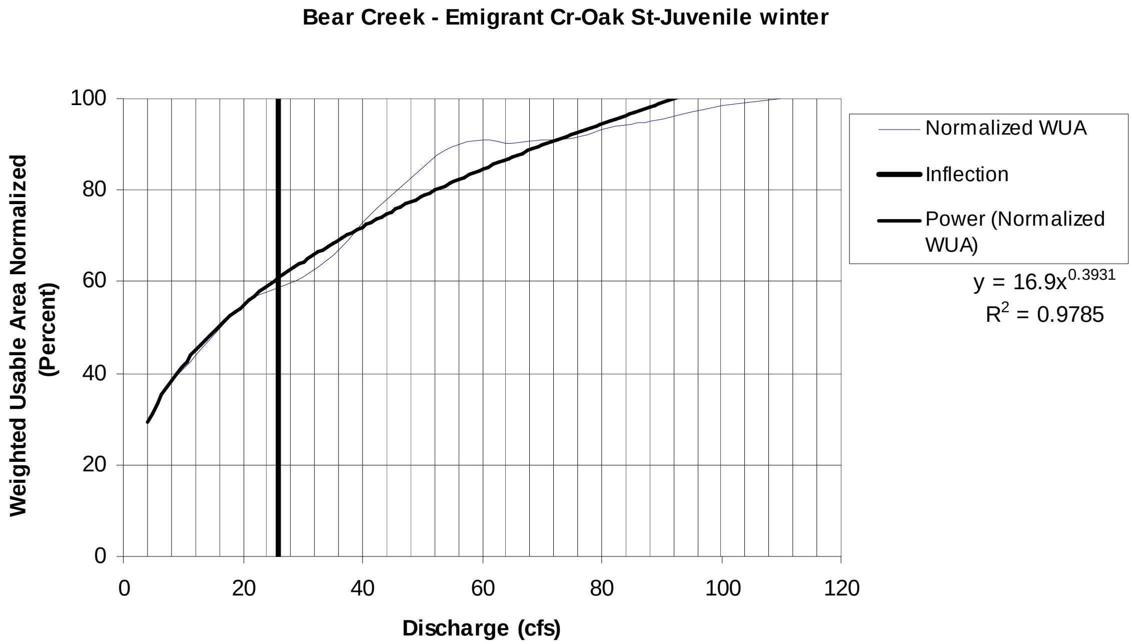
Emigrant Creek-Juvenile winter
100
80
60
40
20
0
Weighted Usable Area Normalized (Percent)
0
10
20
30
40
50
60
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 13.471Ln(x) + 51.209
R^2 = 0.9893

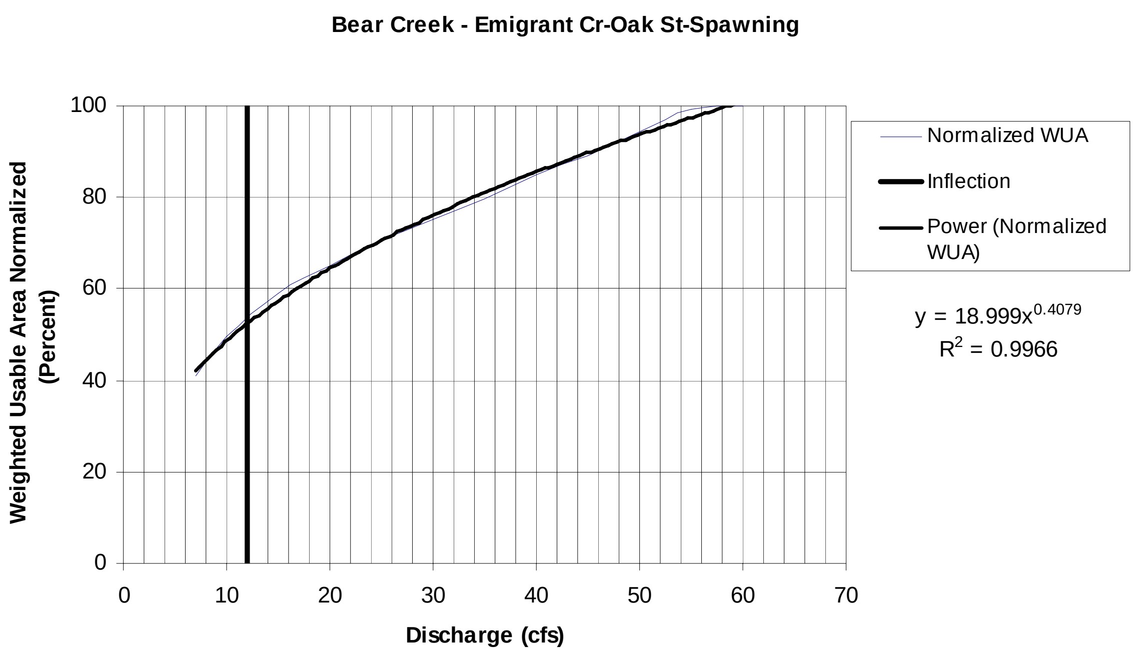
Emigrant Creek-Spawning



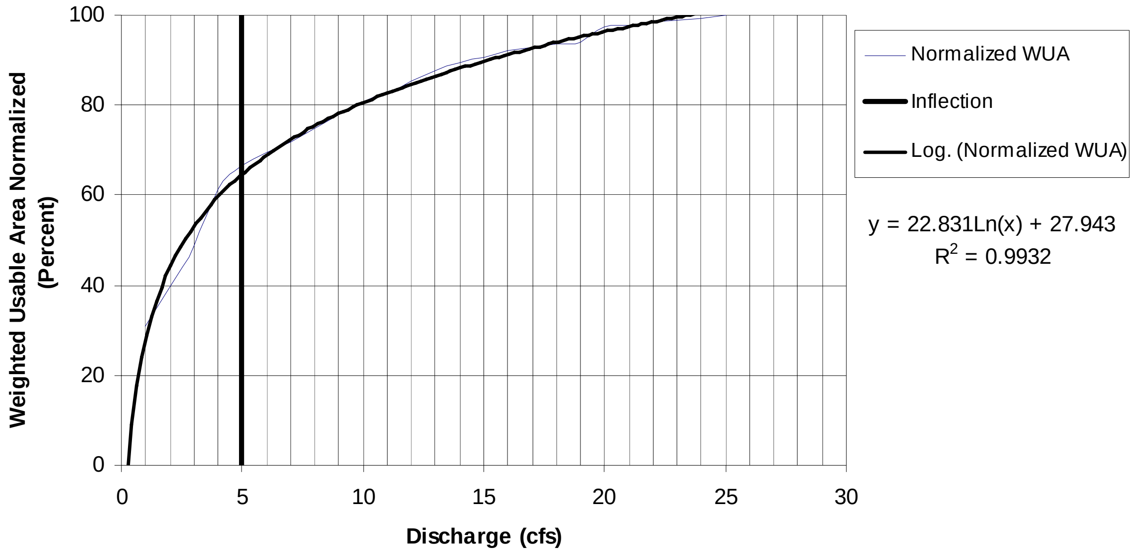
Bear Creek - Emigrant Cr-Oak St-Juvenile summer



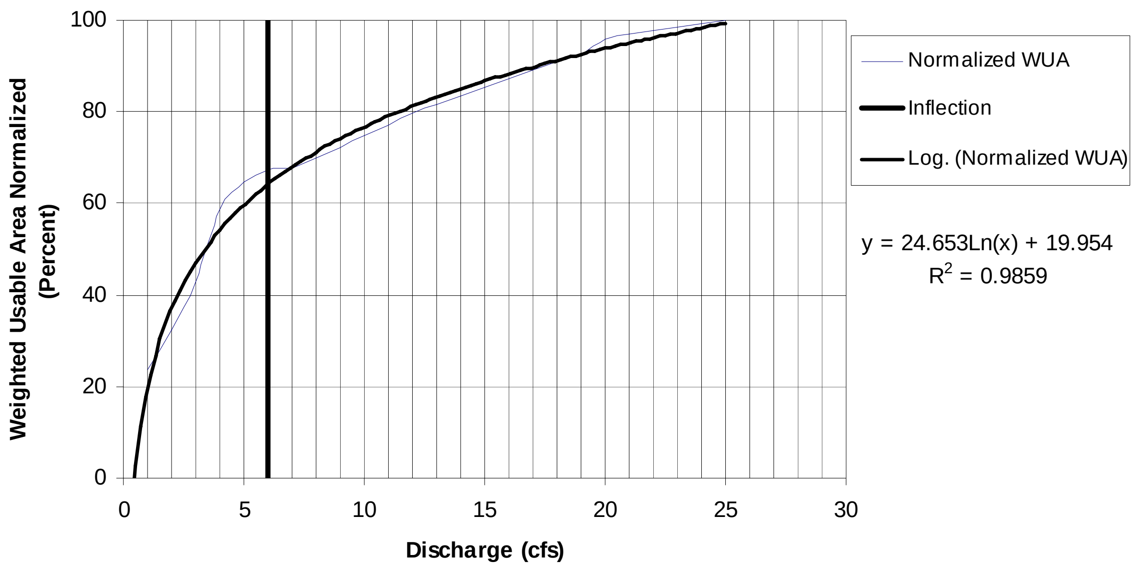

Bear Creek - Emigrant Cr-Oak St-Juvenile winter
Weighted Usable Area Normalized (Percent)
Discharge (cfs)
Normalized WUA
Inflection
Power (Normalized WUA)
y = 16.9x^0.3931
R^2 = 0.9785


Bear Creek - Emigrant Cr-Oak St-Spawning
Weighted Usable Area Normalized (Percent)
Discharge (cfs)
Normalized WUA
Inflection
Power (Normalized WUA)
y = 18.999x^0.4079
R^2 = 0.9966

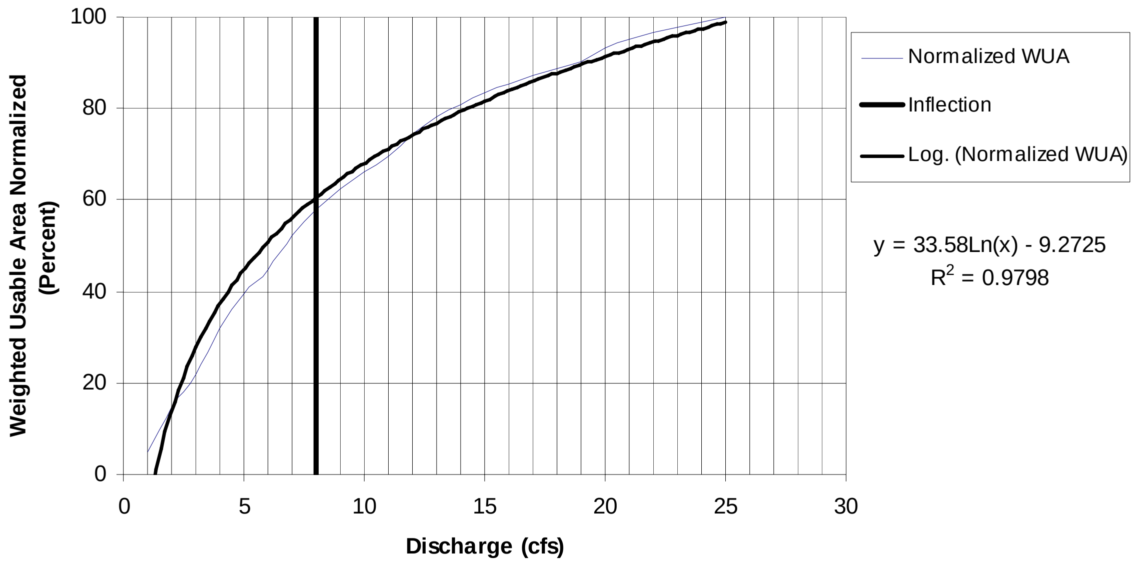
Bear Creek - Oak St to Valley View Road-Juvenile summer



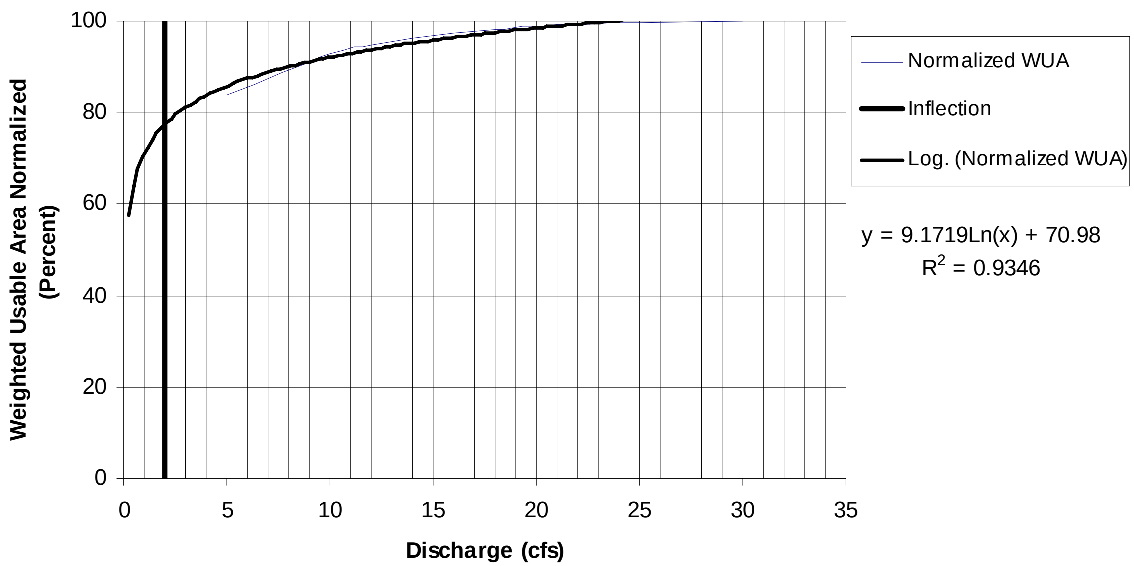
Bear Creek - Oak St to Valley View Road-Juvenile winter

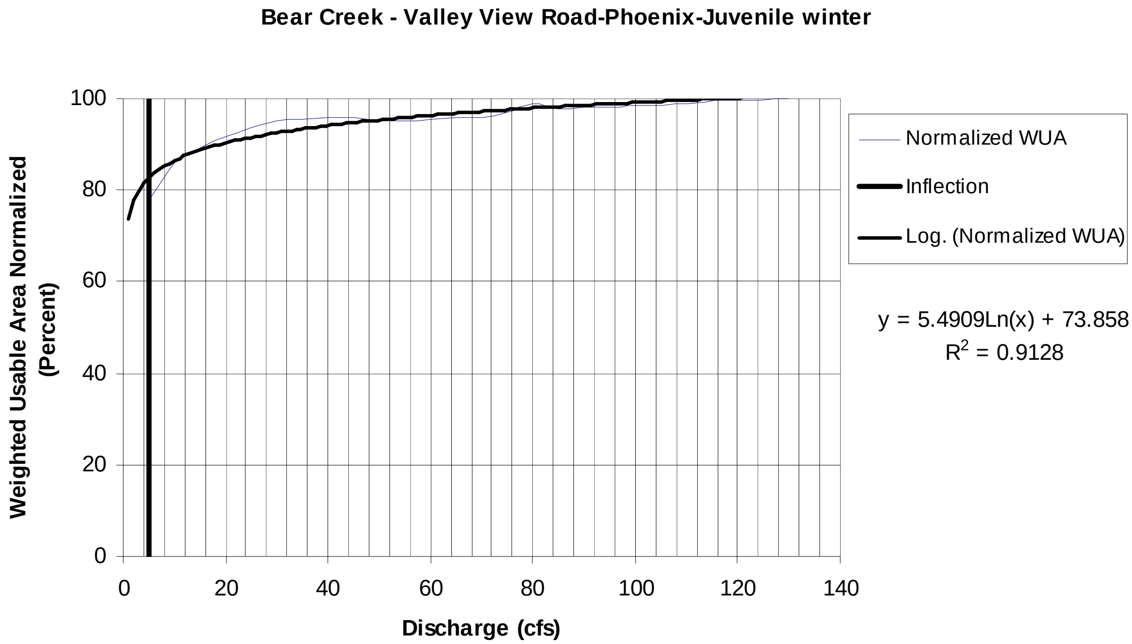


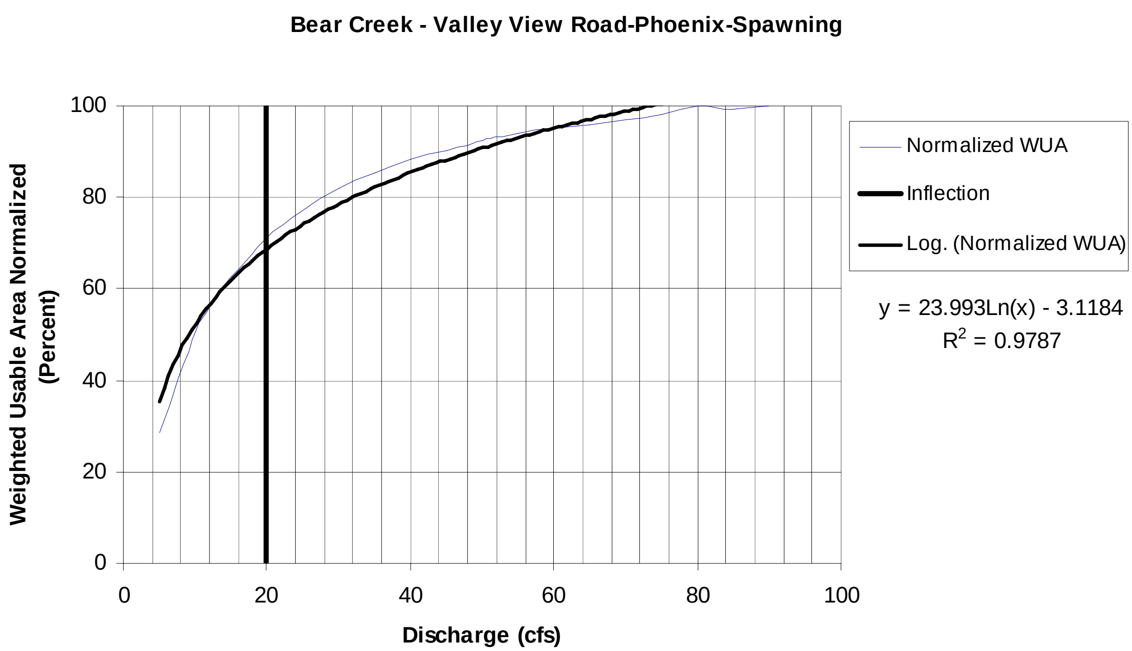
Bear Creek - Oak St to Valley View Road-Spawning



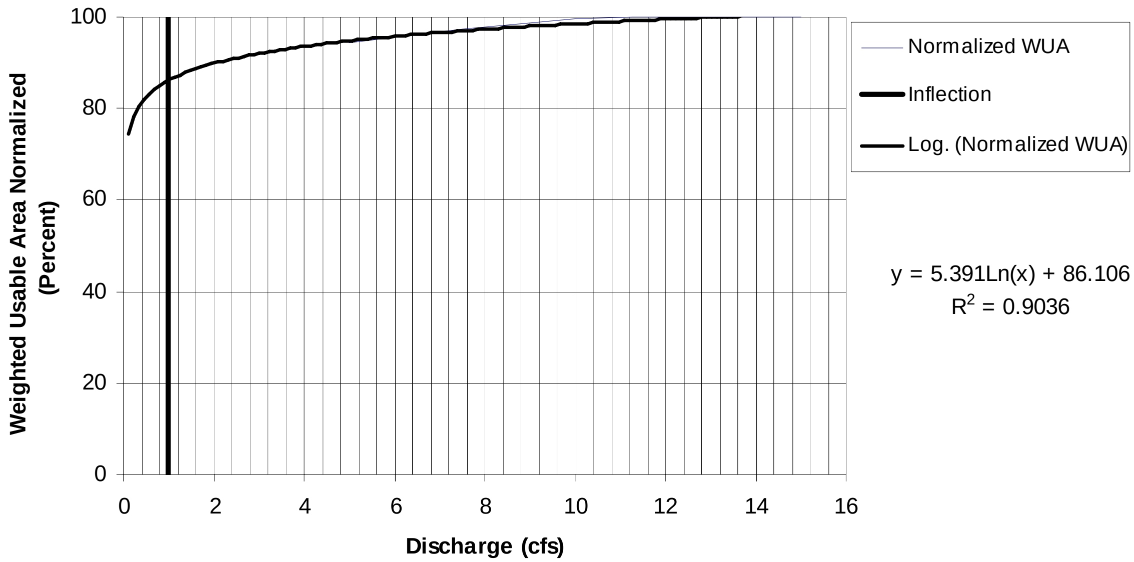
Bear Creek - Valley View Road-Phoenix-Juvenile summer



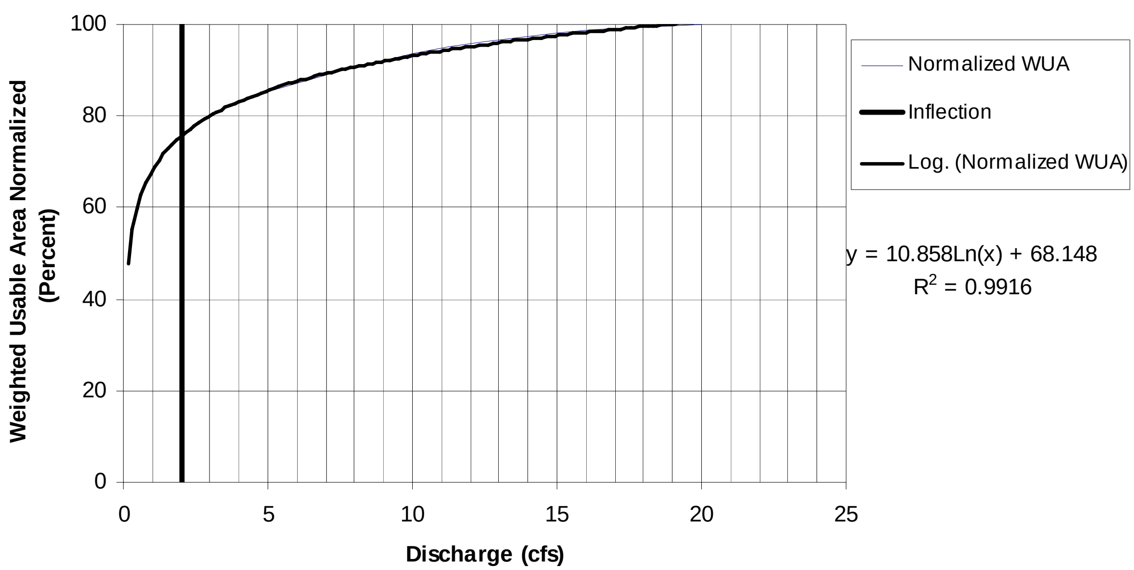

Bear Creek - Valley View Road-Phoenix-Juvenile winter
Weighted Usable Area Normalized (Percent)
100
80
60
40
20
0
0
20
40
60
80
100
120
140
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 5.4909Ln(x) + 73.858
$R^2 = 0.9128$


Bear Creek - Valley View Road-Phoenix-Spawning
Weighted Usable Area Normalized (Percent)
100
80
60
40
20
0
0
20
40
60
80
100
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 23.993Ln(x) - 3.1184
$R^2 = 0.9787$

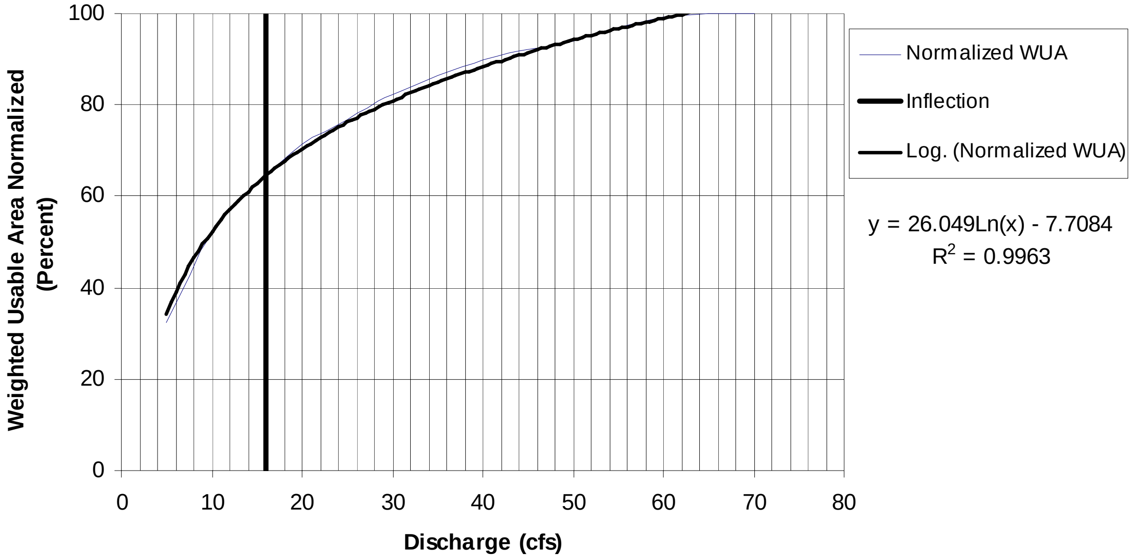
Bear Creek - Phoenix to Jackson St-Juvenile summer



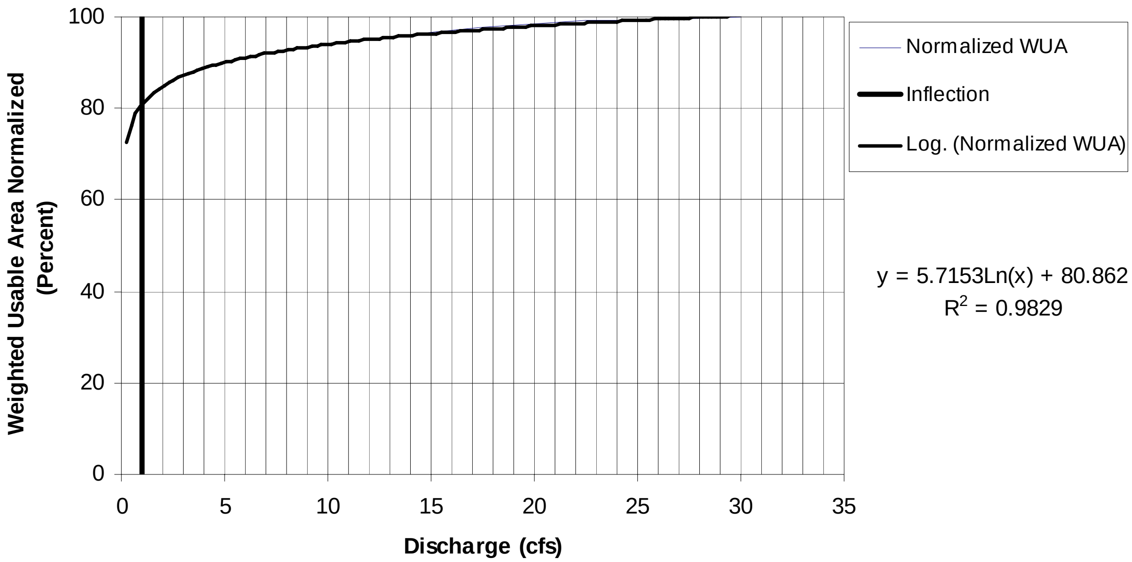
Bear Creek - Phoenix to Jackson St-Juvenile winter



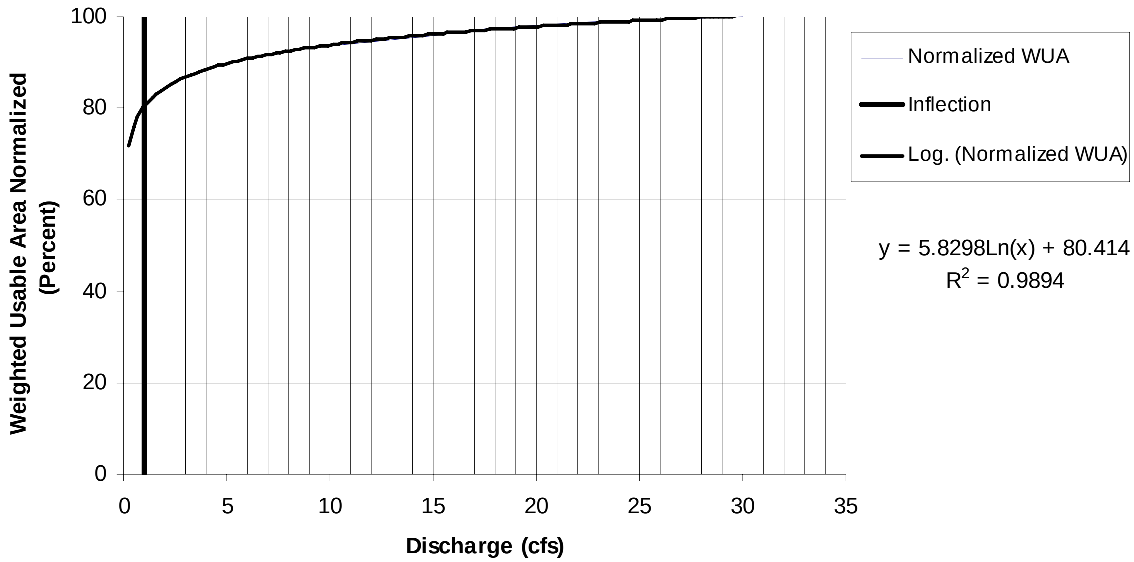
Bear Creek - Phoenix to Jackson St-Spawning



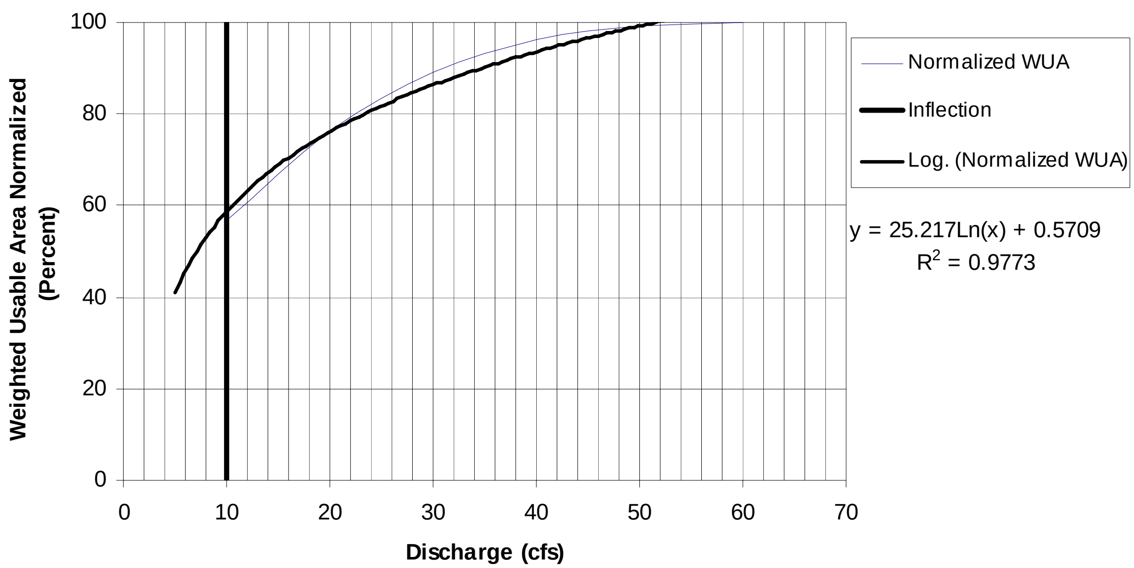
Bear Creek - Jackson St to mouth-Juvenile summer

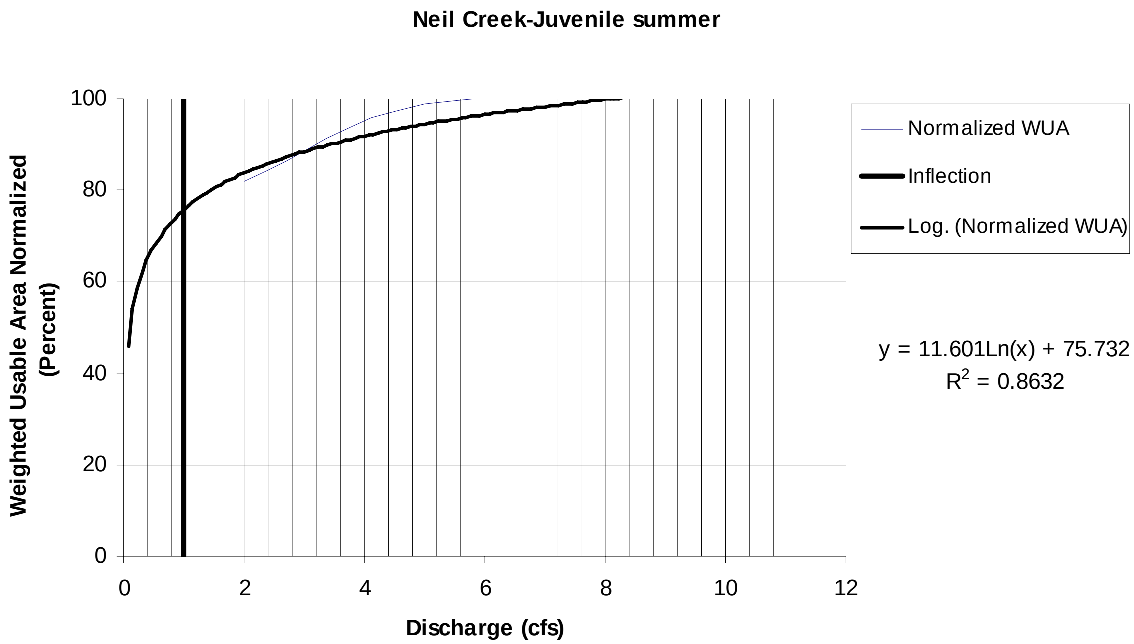


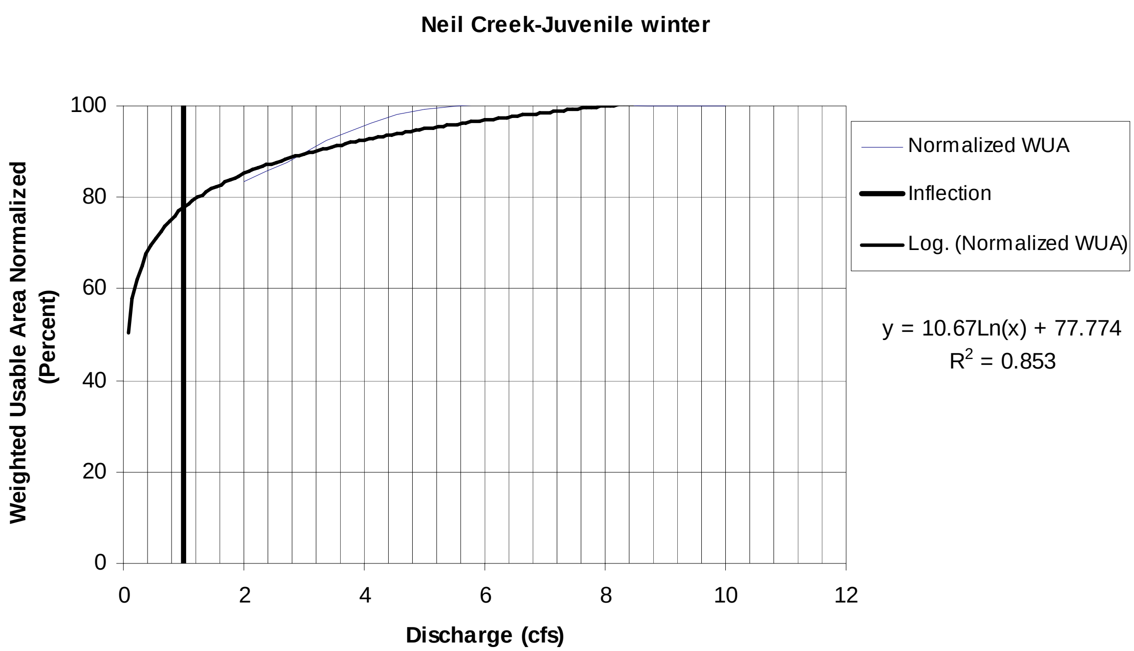
Bear Creek - Jackson St to mouth-Juvenile winter



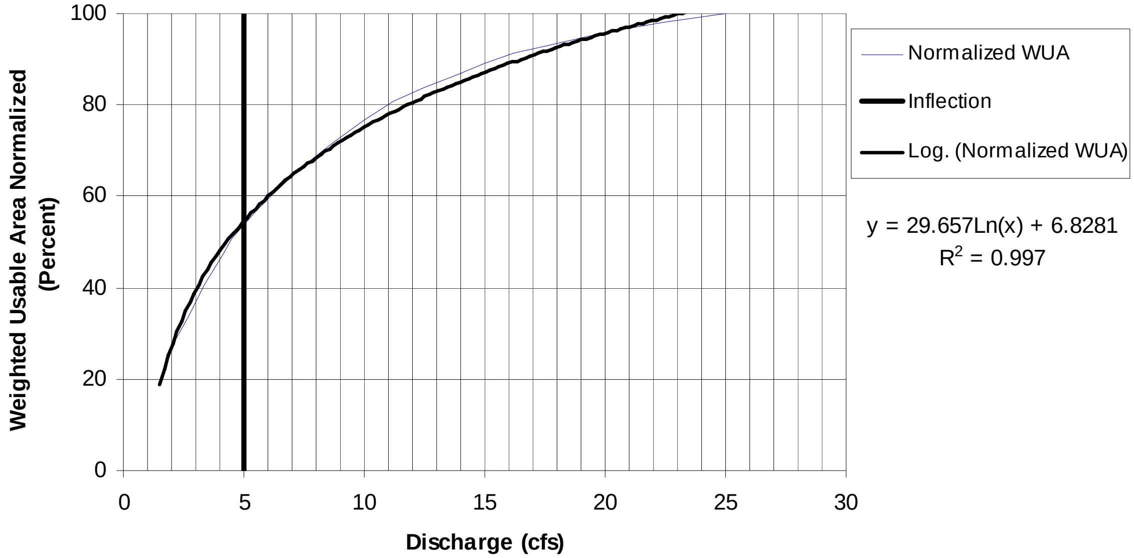
Bear Creek - Jackson St to mouth-Spawning



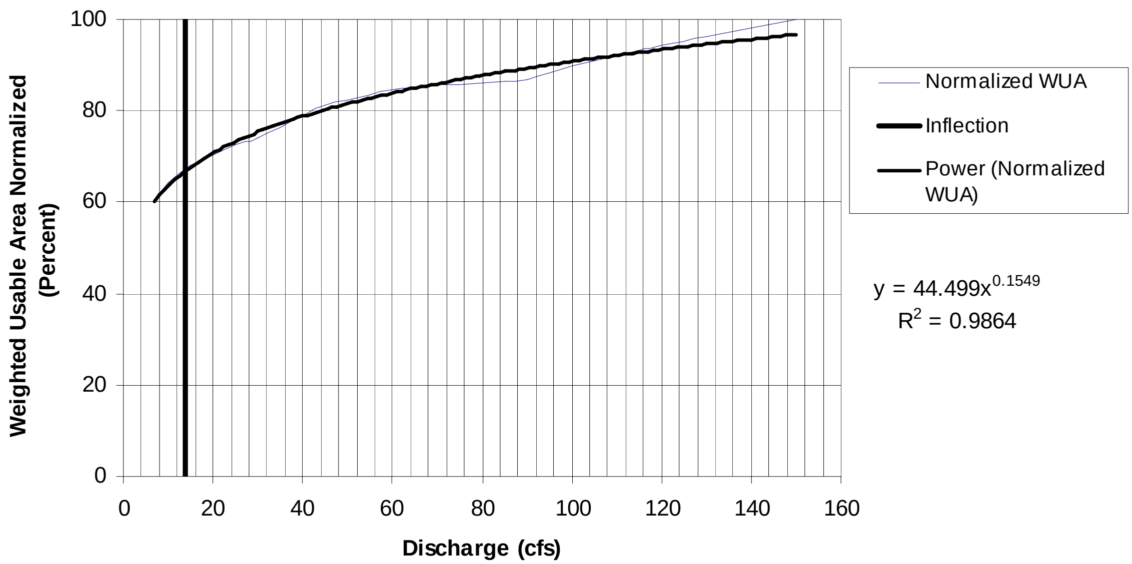

Neil Creek-Juvenile summer
Weighted Usable Area Normalized (Percent)
100
80
60
40
20
0
0
2
4
6
8
10
12
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 11.601Ln(x) + 75.732
R^2 = 0.8632


Neil Creek-Juvenile winter
Weighted Usable Area Normalized (Percent)
100
80
60
40
20
0
0
2
4
6
8
10
12
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 10.67Ln(x) + 77.774
R^2 = 0.853

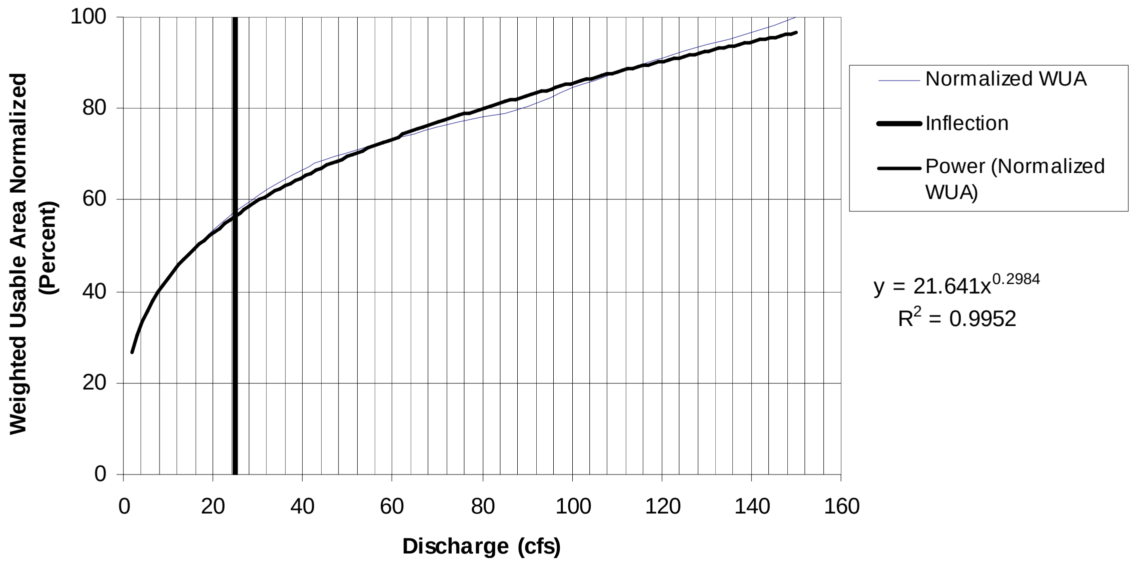
Neil Creek-Spawning



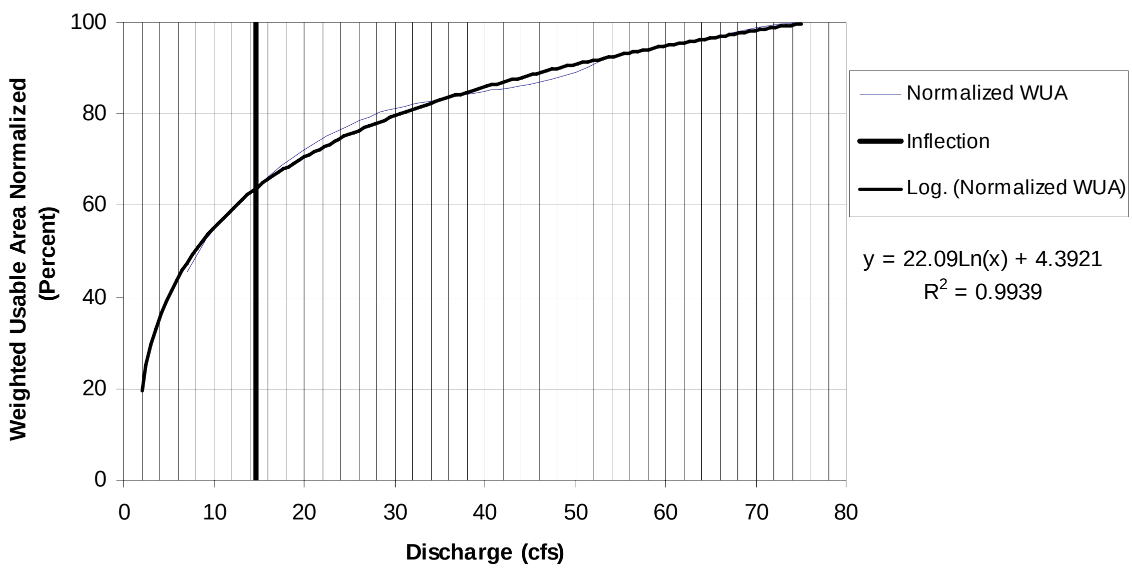
South Fork Little Butte Creek-Juvenile summer



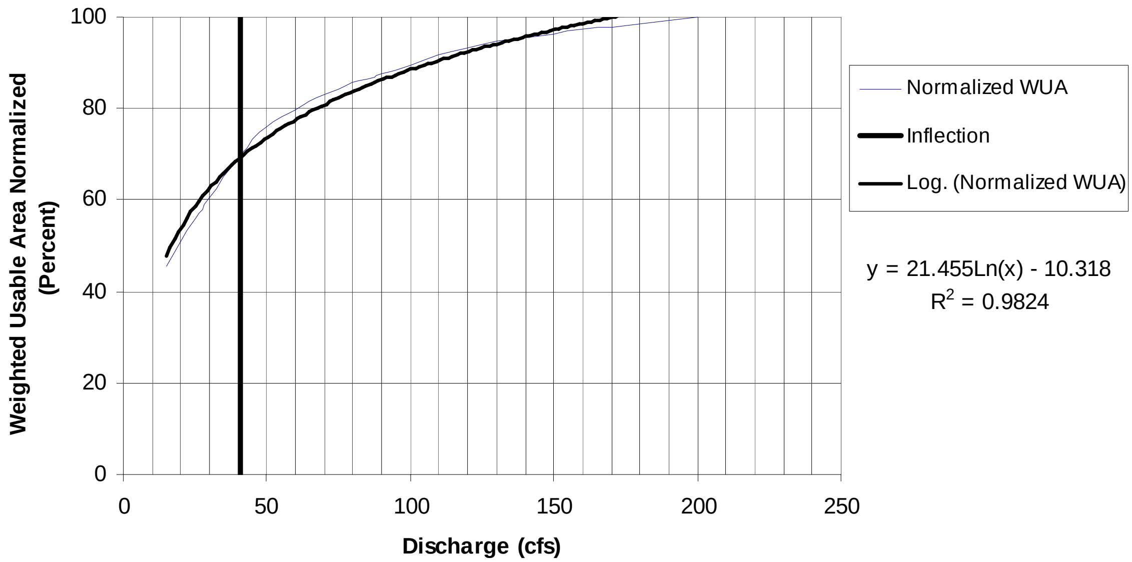
South Fork Little Butte Creek-Juvenile winter



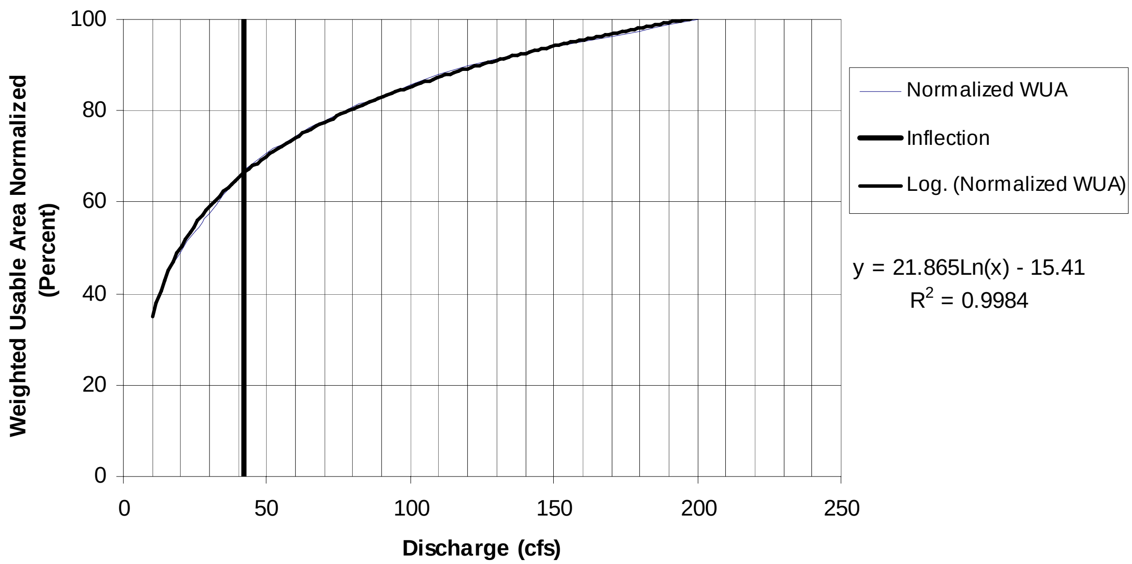
South Fork Little Butte Creek-Spawning



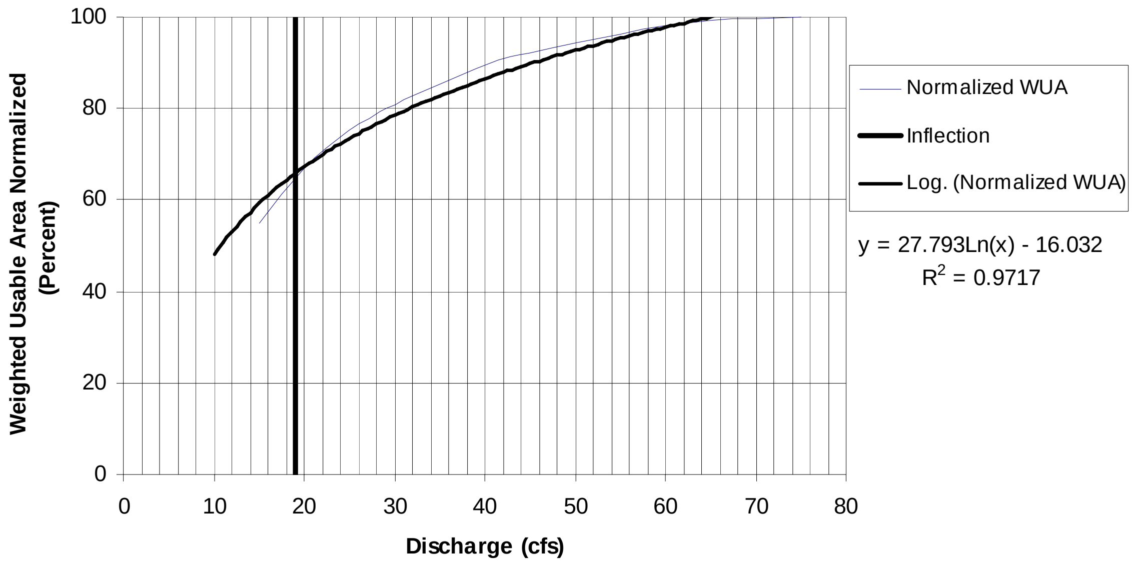
Little Butte Creek near Brownsboro-Juvenile summer



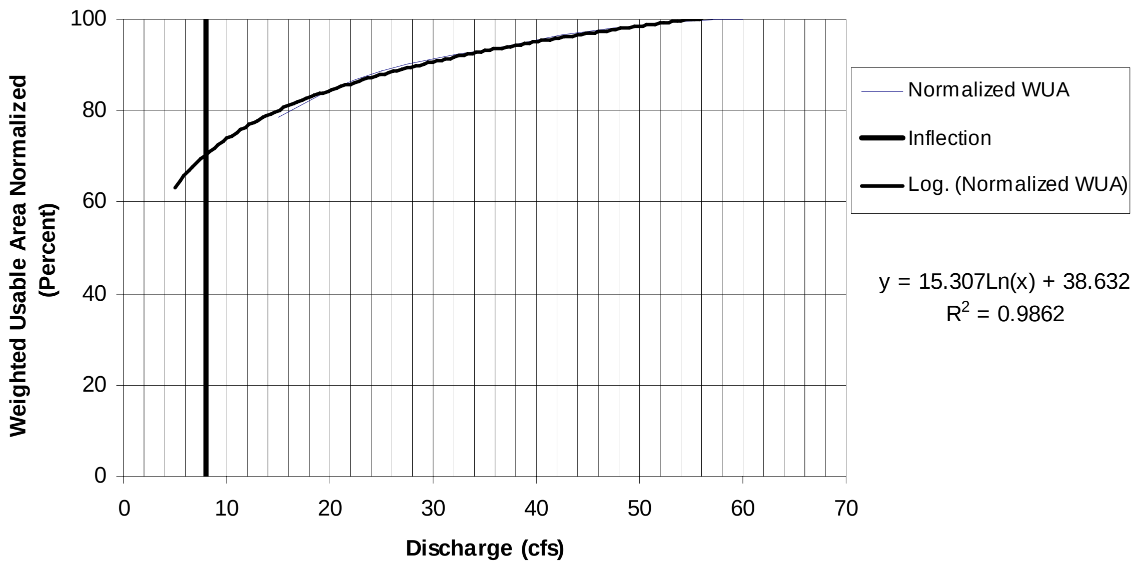
Little Butte Creek near Brownsboro-Juvenile winter



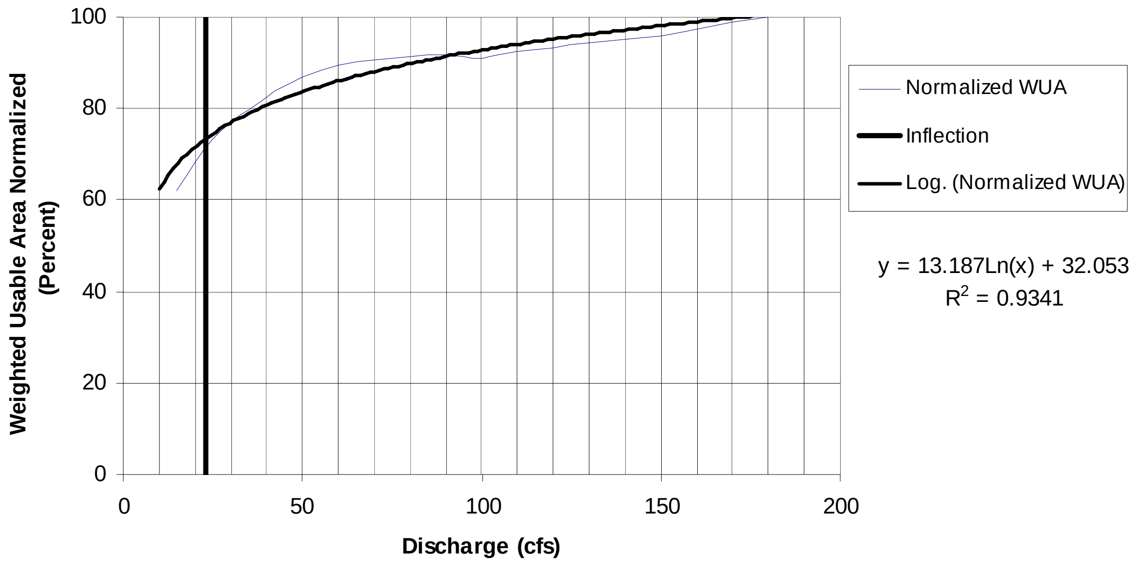
Little Butte Creek near Brownsboro-Spawning



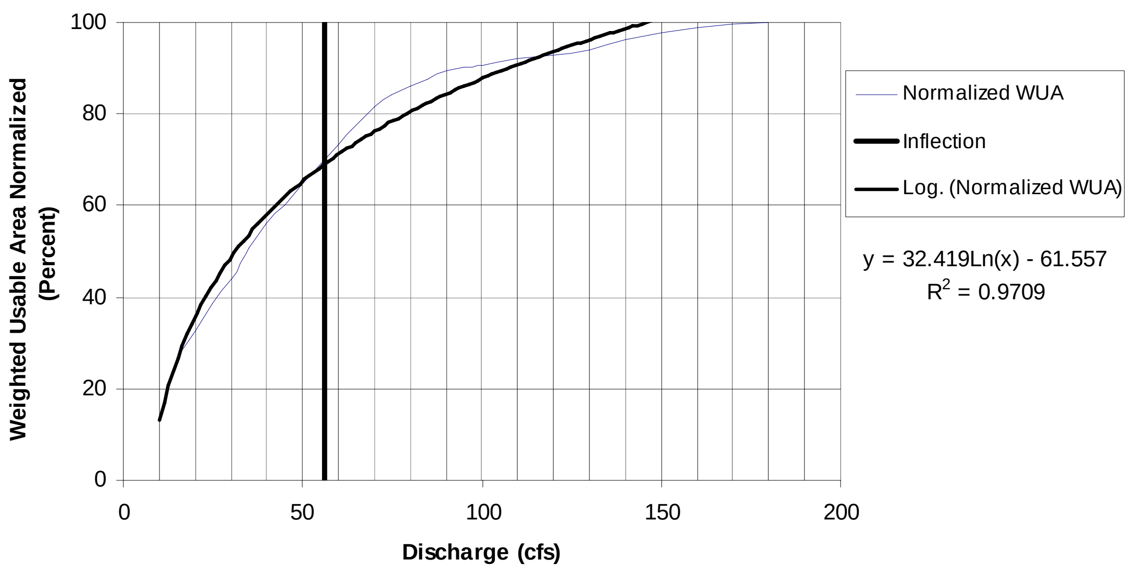
Little Butte Creek near mouth-Juvenile summer



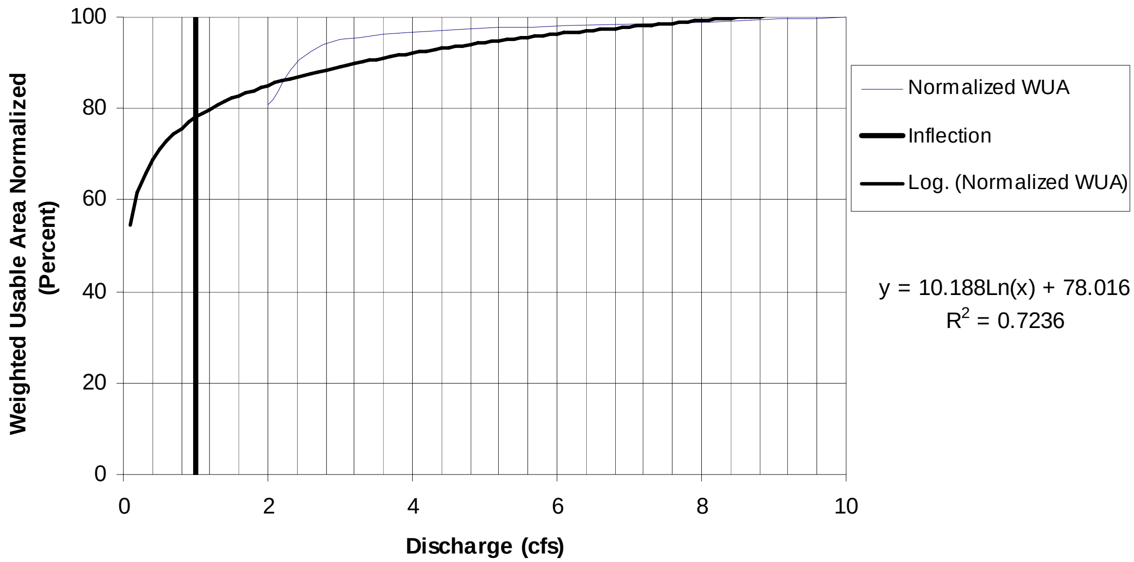
Little Butte Creek near mouth-Juvenile winter



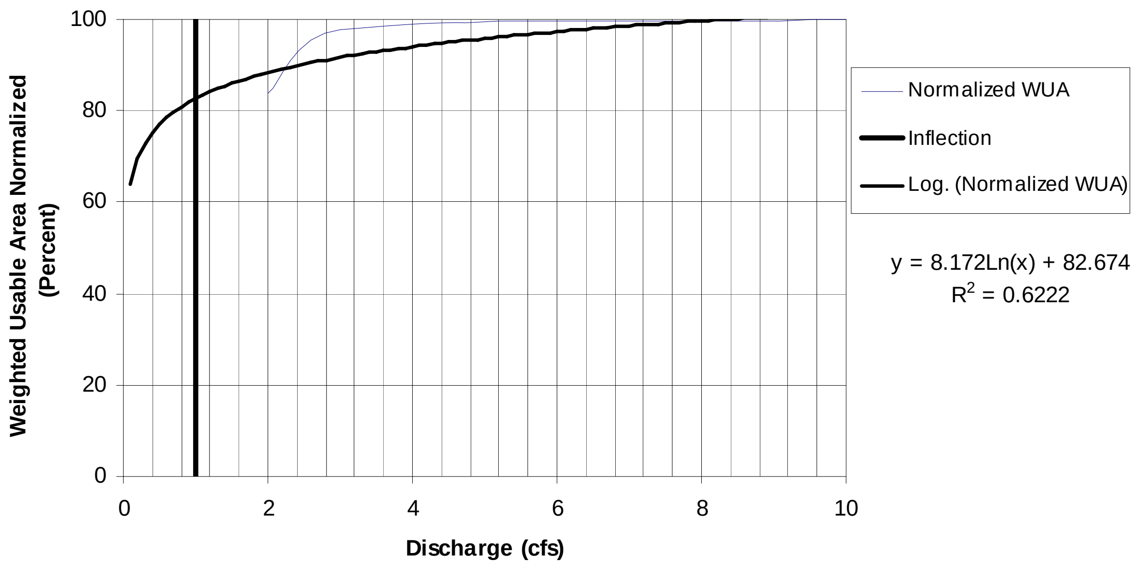
Little Butte Creek near mouth-Spawning



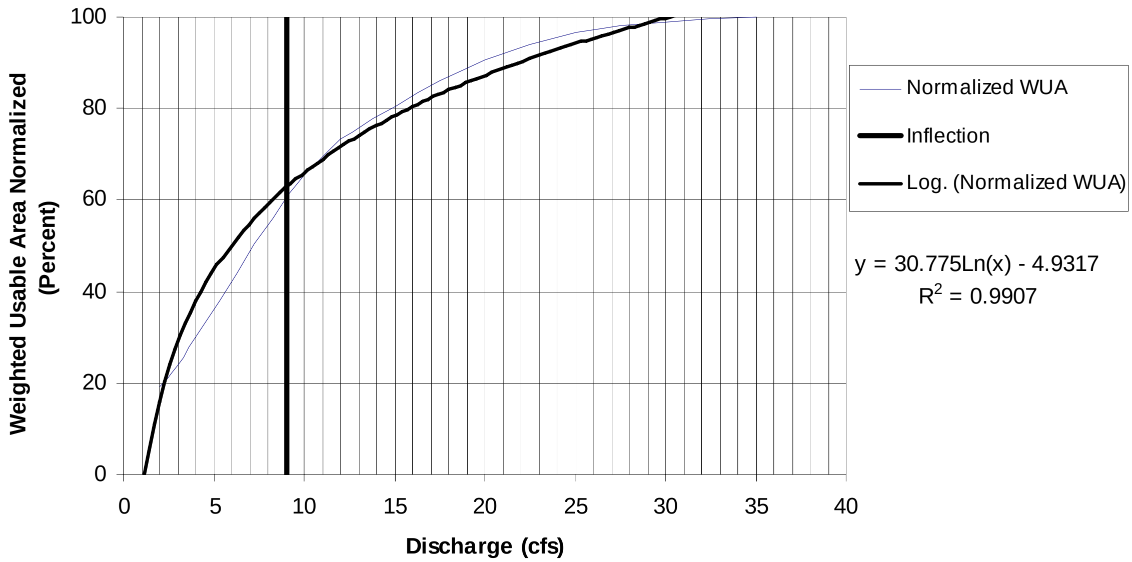
Antelope Creek below Diversion-Juvenile summer



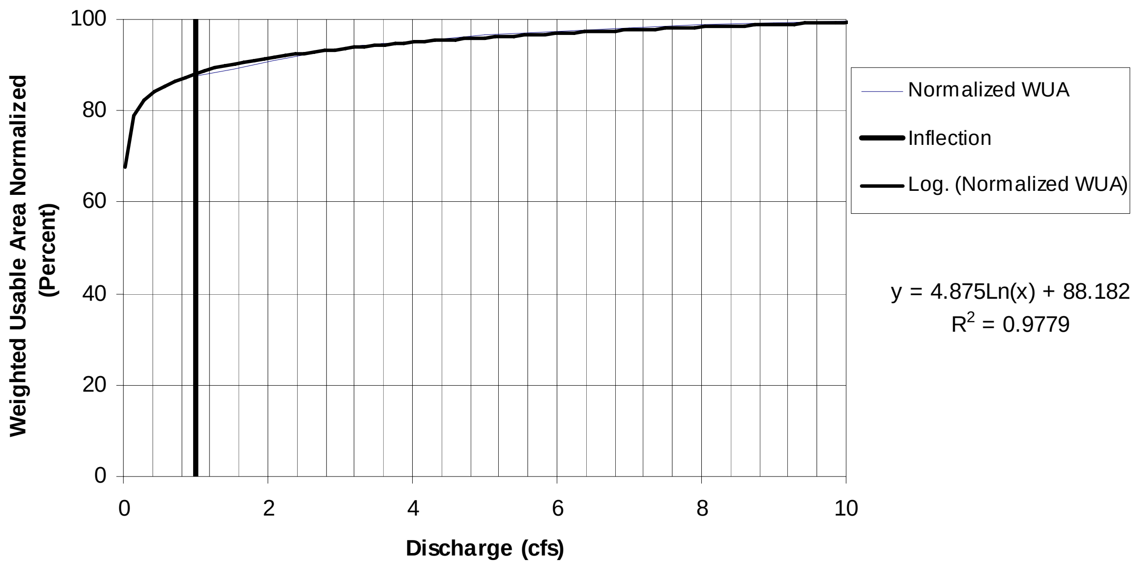
Antelope Creek below Diversion-Juvenile winter

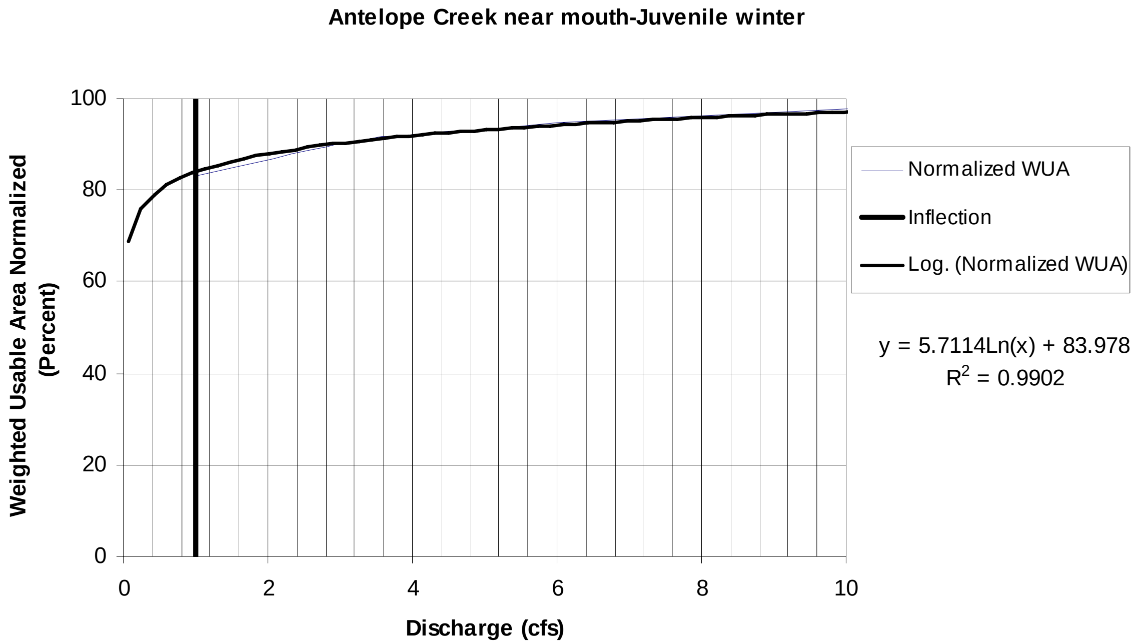


Antelope Creek below Diversion-Spawning

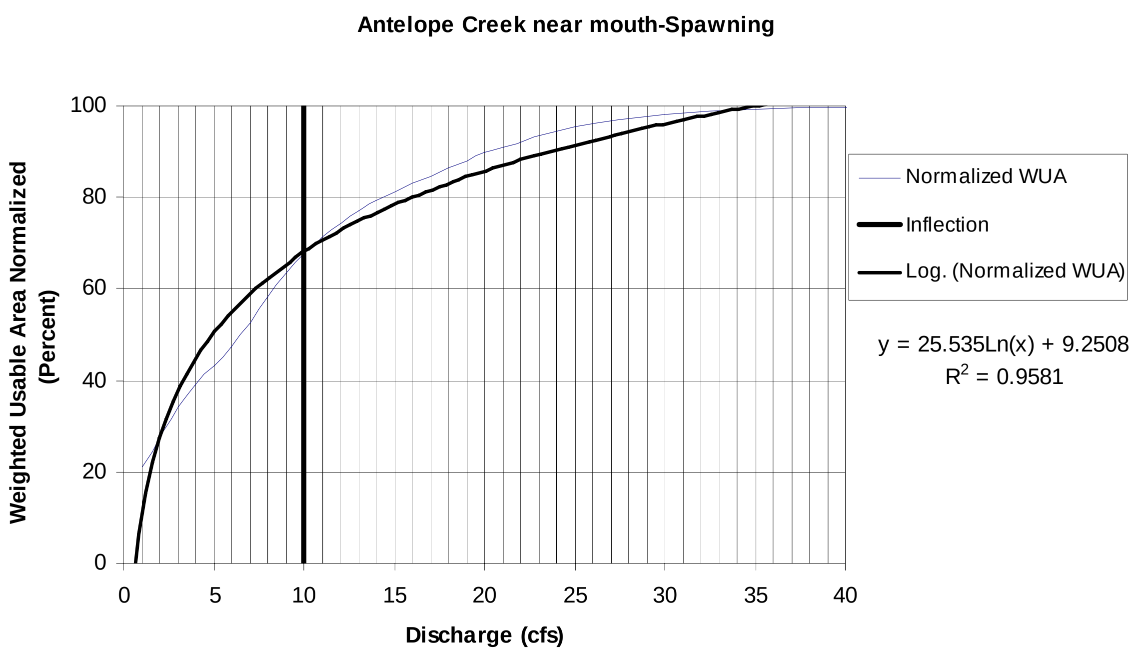


Antelope Creek near mouth-Juvenile summer





Antelope Creek near mouth-Juvenile winter
Weighted Usable Area Normalized (Percent)
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 5.7114Ln(x) + 83.978
R^2 = 0.9902



Antelope Creek near mouth-Spawning
Weighted Usable Area Normalized (Percent)
Discharge (cfs)
Normalized WUA
Inflection
Log. (Normalized WUA)
y = 25.535Ln(x) + 9.2508
R^2 = 0.9581