SECTION VII. Q

Wall Creek Watersheds

Ecosystem Analysis

Fish and Aquatic Habitat

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Ecosystem Analysis of Fish and Aquatic Habitat in Wall Creek and its Tributaries

Contents

Fish and Aquatic Habitat in Wall Creek and its Tributaries.

I. INTRODUCTION

This document is one in a set of reports which together constitute an ecosystem analysis of Wall Creek and all lands contained within the Wall Creek Watersheds. Some of the lands and stream reaches are privately owned and very little data about them is available. More complete data sets are available for National Forest land within Wall Creek watersheds. This report concentrates on the fish and aquatic habitat of the watersheds. The other reports focus on other components of the ecosystem. A scoring mechanism which is explained later in this document integrates the reports from the different disciplines.

A. Characterization of the fisheries resource and aquatic habitat in Wall Creek and its tributaries .

Wall Creek is situated in the John Day River subbasin and is tributary to the North Fork John Day River. The John Day River subbasin supports the largest remaining wild stock of Spring Chinook Salmon (*Onchorhynchus tschawytscha*) in the Columbia Basin. The North Fork John Day River and its tributaries account for about 70% of the Salmon production in the in the subbasin (OWRD, 1992). The John Day River basin once supported substantial runs of both spring and fall chinook salmon and summer steelhead. Fall chinook now appear extinct and spring chinook runs have declined to between 2000 and 5000 fish. Recent steelhead runs have ranged from 15,000 to 40,000 fish. (Northwest Power Planning Council, 1989).

The Wall Creek watersheds contain approximately 730 miles of streams (Table 1). Perennial streams comprise approximately 184 of these miles and 107 miles are fish-bearing (Fig. 1). About 96 miles host anadromous *Onchorynchus mykiss* (Steelhead) during some part of the year. The Umatilla National Forest Land and Resource Management Plan (page 2 - 9, 1990) lists Steelhead as an indicator species. Oregon Department of Fish and Wildlife has conducted Steelhead spawning ground surveys in parts of Wall Creek or its tributaries most years (Table 2). ODFW fisheries biologists suspect that Steelhead redd numbers have shown a declining trend over the past few years, but they have not yet been able to perform the statistical tests necessary to substantiate this (Unterwegner, 1995, personal communication).

Chinook Salmon are not known to spawn in Wall Creek or any of its tributaries, but juvenile Chinook have been observed in lower Wall Creek (Lindsay et al, 1985).

Bull Trout (*Salvelinus confluentius*) have not been recorded from the Wall Creek system. Most waters in the Wall Creek system are presently too warm (Table 3) to support Bull Trout. Bull Trout is a sensitive species for the Pacific Northwest Region of the National Forest system.

Brook Trout (*Salvelinus fontinalis*) have been planted in Bull Prairie Lake and have been observed in Wilsón Creek above and below the lake. This species is exotic and could potentially

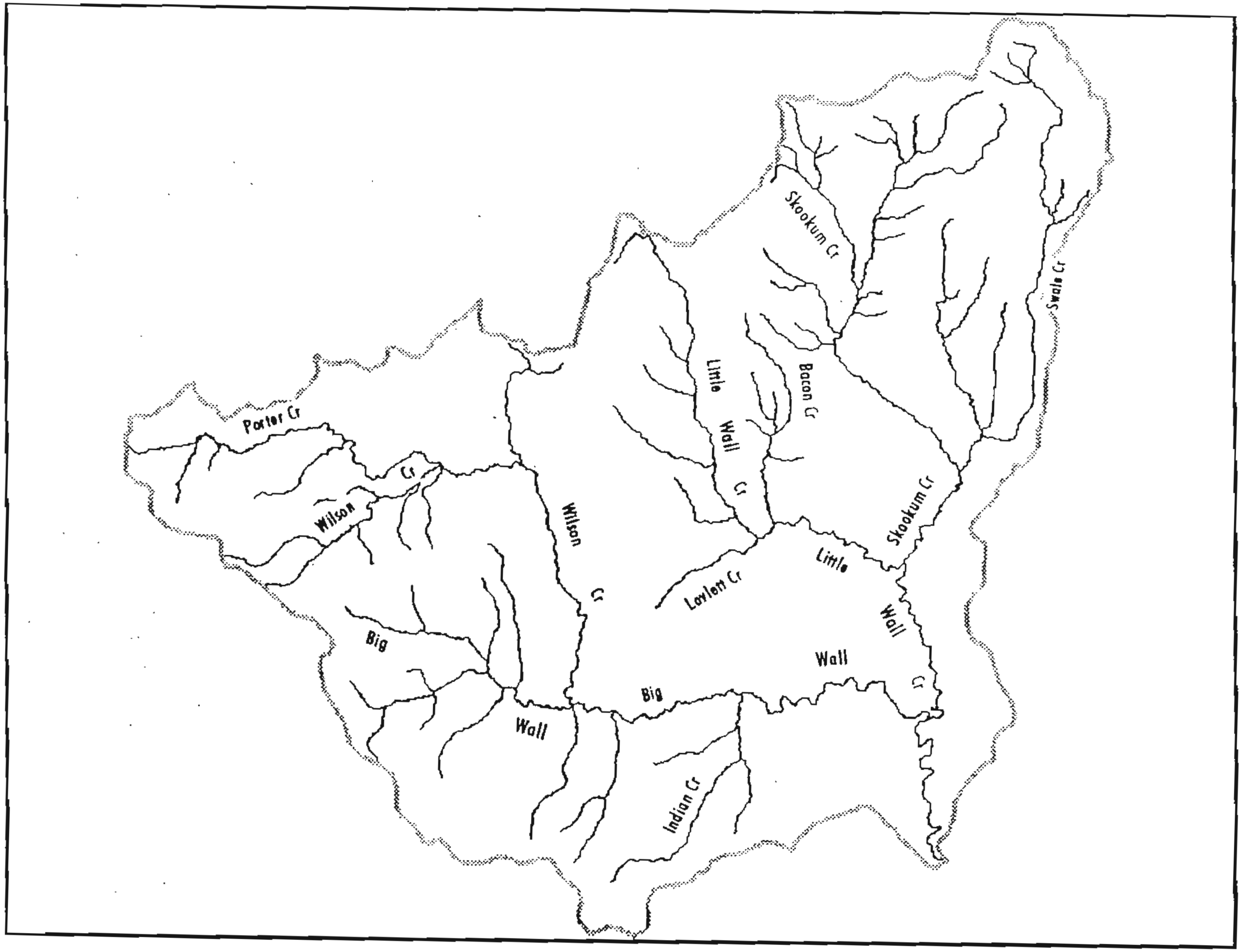


Figure 1
Class 1, 2 and 3 Streams in the Wall Creek Watersheds

cross with and reduce the biotic potential of Bull Trout should they attempt to establish themselves in the system.

Rainbow Trout (non-anadromous *Onchorhynchus mykiss*) are found throughout the fish-bearing portions of the streams in the watershed. They are classified as an indicator species by the Umatilla National Forest Land and Resource Management Plan (1990). O. Mykiss in the upper reaches of some streams (Porter Creek in particular) show meristic characteristics of redband trout

Table 1

Stream Lengths (miles) by Stream Class and Subwatershed

Subwatershed number	**Stream Class**				**Total Fish Bearing**	**Total Perennial**	**Total Stream Miles**
Lower Wall Creek Subwatersheds	1	2	3	4			
23c							
24a	3.5		4.8	55	3.5	8.4	63.2
24g	4.4		5.2	35	4.4	9.6	44.5
Subtotal	7.9	0	10	89.8	7.9	17.9	107.7
Upper Wall Creek Subwatersheds							
24b	3.1		8.8	37	3.1	11.9	48.4
24c	5.2		8.1	47	5.2	13.2	60.0
24d	5.4		7.8	31	5.4	13.2	44.1
24e	5.7	2.8	7.9	36	8.4	16.4	52.1
24f	6.2		4.1	42	6.2	10.4	52.7
Subtotal	25.5	2.8	36.7	192.3	28.3	65.0	257.3

(table continued on next page)

Table 1 (cont.) Stream Lengths (miles) by Stream Class and Subwatershed							
Subwatershed number	**Stream Class**				**Total Fish Bearing**	**Total Perennial**	**Total Stream Miles**
Little Wall Creek Subwatersheds	1	2	3	4			
25a	13.7		1.2	49.4	13.7	14.9	64.3
25b	7.9		5.0	36.6	7.9	12.9	49.5
25c	5.4	3.5		19.2	8.9	8.9	28.1
Subtotal	27.0	3.5	6.2	105.2	30.5	36.7	141.9
Skookum Creek Subwatersheds							
26a	8.3	0.6	3.5	47.1	8.9	12.4	59.5
26b	5.4		5.5	26.6	5.4	10.9	37.5
26c	8.1	3.7	10.2	31.0	11.8	22.0	53.0
26d	11.8		3.7	32.6	11.8	15.5	48.1
26f	2.4		1.2	21.9	2.4	3.6	25.5
Subtotal	36.0	4.3	24.1	159.2	40.3	64.4	223.6
Total	96.4	10.6	77.0	546.5	107.0	184.0	730.5
Data source: Umatilla National Forest MOSS/GIS program							

(S. Mullner, personal communication). The electrophoretic tests necessary to confirm this status have not yet been performed, but the district fish biologist considers them probable redbands, a sensitive species.

Non-game fish found in streams of the Wall Creek watershed include: Dace (*Rhinichthys osculus*), Sculpins (*Cottus bairdi*); Shiners (*Richardsonius balteatus*) and Suckers (*Catostomus columbianus*).

One aquatic invertebrate, the Blue Mountain Cryptochian (*Cryptochia neosa*), is classified as a category 2 candidate for the Federal Rare and Endangered Species List and is on the Regional Foresters Sensitive Species List. *Cryptochia* potentially inhabits the Wall Creek watershed. Wall Creek streams have not been surveyed for *Cryptochia*, but the species has been found in nearby streams on the Heppner Ranger District which are similar in character to some of the Wall Creek

Table 2

Five-year averages of Steelhead redd counts in Wall Creek and its Tributaries reported as redds per mile of stream surveyed

	Year					
Stream	**1980 - 1985**	**1985-1990**	**1986 - 1991**	**1987 - 1992**	**1988 - 1993**	**1989 - 1994**
Wilson Creek	5.7	9.2	3.0	1.2	0.8	2.3
Wall Creek	2.0	7.9	4.3	2.1	no data	2.2

Data source: ODFW Summer Steelhead spawning ground counts, Unpublished data.

System's upper headwater streams. However, studies over the past several years (Betts and Wisseman, 1995) have demonstrated *Cryptochia neosa* to be more common than was originally thought. Betts and Wisseman suggest that the status of *Cryptochia neosa* be changed from Category 2 to Category 3C. Category 3C is for taxa proven to be more abundant or widespread than was previously believed and/or those that are not subject to any identifiable threat.

B. Fish and aquatic habitat issues and key questions:

It has been well established that timber harvest, livestock grazing, the presence of roads and some aspects of recreation can modify stream flows, depress fish populations and degrade water quality and riparian habitat (see Meehan, 1991, Everest et al, 1985, MacDonald, Smart and Wissmar, 1991). Of course, damage to the aquatic environment by the above activities is not inevitable, provided that they are conducted at appropriate intensities, locations and times. The primary concern here is whether these management activities have produced damaging effects in Wall Creek or its tributaries and if so where have they occurred, how severe are they, and what can be done to mitigate the damaging effects and restore and protect depleted fish populations, degraded habitat, and water quality and quantity.

The regional guide for ecosystem analysis instructs analysts to identify issues and key questions for each watershed. The Wall Creek ecosystem analysis team identified the following key questions relating to fish and aquatic habitat.

Table 3					
Temperatures of some streams in the Wall Creek System					
Stream	**Reach**	**Year**	**7-day Moving Avg. Max.***	**Pacfish RMO, deg. F**	**Sub-watershed**
Alder Creek	2	1994	66.5	60	26c
Indian Creek	1	1994	83.4	60	24g
Skookum Creek below Alder	3	1994	69.9	60	26a
Swale Creek, lower	3	1993	68.6	60	26d
Swale Creek, middle	2	1994	84.2	60	26d
Swale Creek, upper	2	1994	70.3	60	26d
Wall Creek at mouth	na	1994	77.6	64	23c
Wall Creek at forest boundary	1	1994	80.4	60	24a
Upper Wall Creek	5	1994	69.1	60	24c
Wilson Creek above Bull Prairie Lake	1	1994	64.6	64	24e
Wilson Creek below Bull Prairie Lake	2	1994	75.8	60	24e
Middle Wilson Creek	2	1994	70.3	60	24f
Wilson Creek above Wall	1	1993	80.0	60	24f

* Seven-day moving average of daily maximum temperature measured as the average of the maximum daily temperature of the warmest consecutive seven-day period.
These are minimum figures, since in some cases instruments stopped recording or were removed before the end of the hot part of the summer.

Specific questions to be addressed include:

1) What is the relationship of the fish populations in the Wall Creek and its tributaries to the fish metapopulation structure of the rest of the John Day River basin?

2) What are the current conditions of the aquatic habitat in the Wall Creek watersheds?

3) Which biophysical factors influence fish habitat in Wall Creek and its tributaries?

4) Do present fish population levels meet Forest Service objectives?

5) What effects has timber harvest had on aquatic habitat. In which stream reaches and subwatersheds are these effects most evident?

6) Has grazing of riparian vegetation by livestock and/or wild ungulates in the Wall Creek Watersheds contributed to changes in water quality? If so, what have the changes been, where have they occurred and how severe are they?

7) Where and how has the current road network affected water quality parameters important to fish and other aquatic organisms?

8) What is the risk of long-term negative effects to fish populations and other aquatic organisms as a result of large (stand replacement type) fires.

9) Which streams or reaches in the Wall Creek watersheds are closest to meeting Pacfish and forest plan DFC's for stream conditions, aquatic habitat, and aquatic habitat diversity. How close are they?

10) Which of the streams or reaches in the Wall Creek watersheds would benefit most from special protection or restoration?

11) Can fish, aquatic habitat, and water be better protected by adjustments to management protocols?

II. Current Conditions

A. Information Sources:

Fish and aquatic habitat evaluations for this report depend heavily upon data gathered by Forest Service stream survey teams or teams contracted by the Forest Service using modified Hankin & Reeves (1988) methodology. All Fish bearing portions of streams in the Wall Creek Watersheds have been surveyed within the past six years.

The Forest Service has maintained Temperature monitors during summer in some of the streams for as long as six years.

Figures for Steelhead redd counts were supplied by Tim Unterwegner of the John Day District office of the Oregon Department of Fish and Wildlife.

Data regarding road lengths, riparian vegetation structure, plant association groups and acreages of land within RHCA's came from MOSS/GIS and ARCinfo sources maintained by the Umatilla National Forest.

Scott Mullner, Heppner District Fisheries Biologist, provided much valuable information from his direct personal knowledge of the streams in the Wall Creek system.

B. Methodology:
Summarization, integration, and presentation of large amounts of data covering a wide variety of parameters in a style and format that is coherent, clear and understandable to the non-specialist reader, but still accurate and informative is a tall order. The need to integrate results from several different disciplines further complicates the task. We have attempted to accomplish this by means of a scoring mechanism through which each habitat parameter receives two scores, one for the condition of the habitat parameter (1 = good, 2 = marginally useable, but not good, 3 = poor) and another for the relative importance (3 = high, 2 = moderate, 1 = low) of that habitat factor to the organisms or environment under evaluation.

Where data was available, each stream reach was scored for each parameter (Appendix A). Where stream reaches crossed subwatershed boundaries, the score was assigned to the subwatershed which contained the largest proportion of the reach. Scoring was automated through a Lotus spreadsheet which assigned scores based upon the criteria given below:

1. Temperature score:
As part of the Pacfish amendment to the Forest Plan, the Forest Service recently adopted specific water temperature standards for streams in anadromous fish producing watersheds in eastern Oregon and Washington, Idaho and portions of California (USFS, BLM, 1995). These standards specify maximum seven-day running average temperatures below 60 degrees Fahrenheit within spawning habitats and below 64 degrees Fahrenheit within migration and rearing habitats of anadromous fish (Table 3, col. 5).

The score for temperature applies these standards for fish bearing waters in the Wall Creek watersheds. Data used here were recorded by in-stream temperature monitors maintained by the Forest Service (Fig. 2). Scores for stream reaches that do not bear fish follow the Oregon State standard of 68 degrees Fahrenheit. Stream reaches that do not meet the applicable standard are assigned a score of three. Stream reaches with water temperatures under these maxima by two degrees or less are given a score of two. Stream reaches more than two degrees below the Pacfish or State standard are scored one.

2. Width/depth ratio score:
Data available for Wall Creek at this time are bankfull width/depth ratios from SMART program reports. Bankfull width/depth ratios are used mainly as indicators of channel stability rather than

estimates of quality of fish habitat. However, cursory observation suggests that lower bankfull width/depth ratios may be associated with bank undercutting which provides hiding cover for fish. and may also be associated with low wetted width/depth ratios. Low wetted width/depth ratios usually correspond to better quality fish habitat. On the other hand, low bankfull width/depth ratios imply higher risk of bank erosion and sediment movement within the stream and perhaps recent channel down cutting.. Since the relationship of bankfull width/depth ratios to fish habitat is indirect and the effects to fish are mixed, they are assigned an importance value of 1. Scoring reflects the probable relationships to fish cover, rather than to sedimentation, since sedimentation is dealt with in terms of cobble embeddedness and dominant/subdominant substrate types. Here reaches having width/depth ratios ≤10 score one. Reaches with width/depth ratios >10 and ≤ 15 score two. Reaches with width/depth ratios >15 receive a score of three.

3. Canopy cover score:
Region six stream survey protocol divides canopy cover (usually taken as a surrogate for stream shade) into four classes:

class 1	0 - 19%
class 2	20 - 30%
class 3	31 - 60%
class 4	>60%

For the purposes of this analysis, categories two and three have been combined. This gives scores as follows:

Canopy cover class 1	Score = 3
Canopy cover class 2 or 3	Score = 2
Canopy cover class 4	Score = 1

One of the most important functions of canopy cover is provision of shade over the stream to help maintain low water temperatures. Since canopy cover is a measurement of a potential modification of a habitat parameter (temperature) rather than a direct measurement of the habitat parameter itself, it was assigned a relative importance rating of two.

4. Substrate score:
Components of substrate quality for which data are available for Wall Creek streams include cobble embeddedness and particle size class (dominant and subdominant). Generally, an excess of fine sediments degrades salmonid habitats. Steelhead and resident trout require cobble and gravel sized substrate for spawning. Open interstices among cobbles and small boulders provide escape and hiding cover, an important component of rearing habitat.

Cobble embeddedness is one measure of sedimentation which is available from stream survey reports. Drawbacks to use of cobble embeddedness as an estimate of sedimentation or habitat

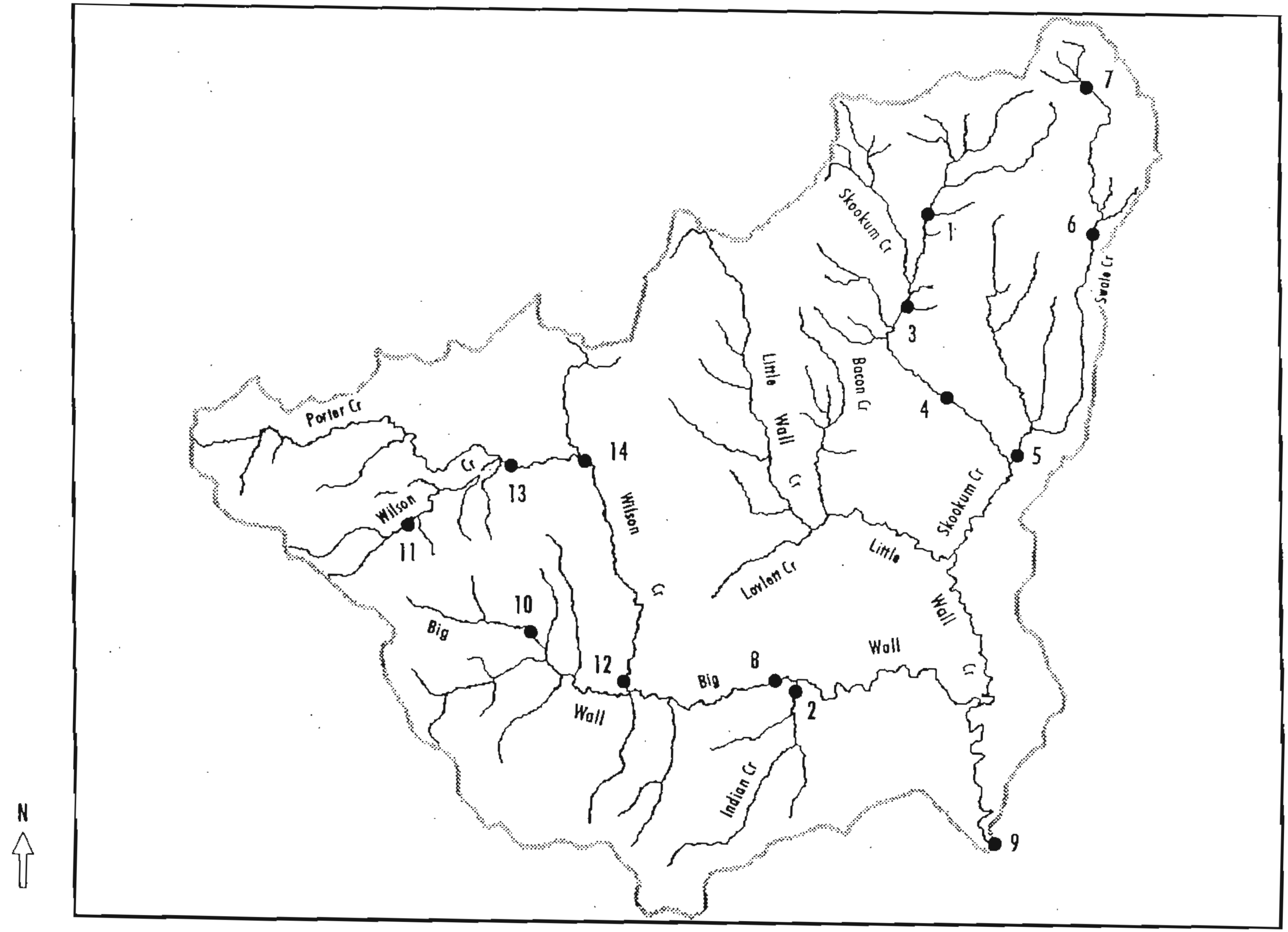


Figure 2
1993 and 1994 Thermograph locations in Wall Creek and Tributaries

quality include potential observer and sampling bias (Torquemada and Platts, 1988), applicability to Basalt dominated parent materials (Chapman and McLeod, 1987), and the state of development of the technique. Regarding the relationship of cobble embeddedness measurements to quality of rearing habitat, Chapman and McLeod (1987) concluded:

> Available information on the effects of fines on salmonid rearing densities does not permit a broad statement on effects of embeddedness level or various percentages of surface fines. A very conservative view of the data would be to state that rearing densities are often lower at embeddedness levels greater than 50%. A conservative view in habitat protection, on the other hand might state that any embeddedness level greater than 25% in rearing areas risks loss of winter habitat in interstices and should be avoided until better information becomes available.

Since open interstices in cobble or small boulder substrate can be an important component of hiding cover for salmonids it seems important to secure some measure of standards for that component. Stream survey protocol for USFS Region Six requires surveyors to estimate whether cobble embeddedness for aquatic habitat units is above or below 35%. Streams with embeddedness greater than 35% are recorded as embedded.

Scoring of stream reaches for watershed analysis integrates stream survey data for cobble embeddedness with dominant and subdominant substrate size categories. Reaches reported as embedded score 3 (poor). Scoring of reaches that were not embedded was determined from dominant and subdominant substrate. Generally, reaches classified as spawning habitat were scored one (good) when gravel was present as either a dominant or subdominant substrate and sand was neither dominant nor subdominant. Rearing reaches scored one if cobble or small boulder was present as either a dominant or subdominant substrate and sand was neither dominant nor sub-subdominant. Tables 4 and 5 show scoring of non embedded reaches by dominant and subdominant stream bed substrate size category.

5. Large wood score:

Scoring of large woody debris was based on the PACFISH RMO of 20 pieces/mile of size > 12 inches minimum diameter and at least 35 feet in length. The SMART program reports frequencies of woody debris in three categories:

> Large = 20 inches minimum diameter and 35 feet minimum length
> Small = 12 inches minimum diameter and 35 feet minimum length
> Brush = 8 inches minimum diameter and 20 feet minimum length

Frequencies (pieces/mile) of large woody debris in the first two categories were summed and the sum scored as follows:

Frequency < 20	Score = 3
20 ≤ frequency < 40	Score = 2
Frequency ≥ 40	Score = 1

Table 4
Spawning Stream Substrate Scoring for Non-embedded Reaches

Dominant/Subdominant Substrate Size Category*	Habitat Quality Score	Dominant/Subdominant Substrate Size Category*	Habitat Quality Score
sa/sa	3	sb/sa	3
sa/gr	3	sb/gr	2
sa/co	3	sb/co	3
sa/sb	3	sb/sb	3
sa/lb	3	sb/lb	3
sa/br	3	sb/br	3
gr/sa	3	lb/sa	3
gr/gr	1	lb/gr	2
gr/co	1	lb/co	3
gr/sb	1	lb/sb	3
gr/lb	2	lb/lb	3
gr/br	2	lb/br	3
co/sa	2	br/sa	3
co/gr	1	br/gr	2
co/co	1	br/co	3
co/sb	2	br/sb	3
co/lb	3	br/lb	3
co/br	3	br/br	3

*sa = sand (0-0.08in), gr = gravel (0.08-2.5 in), co = cobble (2.5 -10 in), sb = small boulder (10 - 40 in), lb = large boulder (>40 in).

Table 5 Rearing Stream Substrate Scoring for Non-embedded Reaches			
Dominant/Subdominant Substrate Size Category*	**Habitat Quality Score**	**Dominant/Subdominant Substrate Size Category***	**Habitat Quality Score**
sa/sa	3	sb/sa	3
sa/gr	3	sb/gr	2
sa/co	3	sb/co	1
sa/sb	3	sb/sb	1
sa/lb	3	sb/lb	2
sa/br	3	sb/br	2
gr/sa	3	lb/sa	3
gr/gr	2	lb/gr	2
gr/co	1	lb/co	1
gr/sb	1	lb/sb	1
gr/lb	2	lb/lb	2
gr/br	2	lb/br	3
co/sa	2	br/sa	3
co/gr	2	br/gr	3
co/co	1	br/co	3
co/sb	1	br/sb	3
co/lb	2	br/lb	3
co/br	2	br/br	3

*sa = sand (0-0.08in), gr = gravel (0.08- 2.5 in), co = cobble (2.5 - 10 in), sb = small boulder (10 - 40 in), lb = large boulder (>40 in).

6. Fish cover score:

Hankin and Reeves type stream survey protocol produces four categories of fish cover:

0 to 5% of area of habitat unit as cover	cover class 1
6 to 20% of area of habitat unit as cover	cover class 2
21 to 40% of area of habitat unit as cover	cover class 3
>40% of area of habitat unit as cover	cover class 4

Fish cover scoring used stream survey categories given as stream reach averages by the SMART program reports. The middle two categories were combined for scoring purposes here:

Fish cover category 1	Score = 3
Fish cover category 2 or 3	Score = 2
Fish cover category 4	Score = 1

7. Pools:

a) Pool frequency score:

Pacfish includes pool frequency standards which vary according to stream width. However those standards are intended to be applied to unconstrained "C" type streams (Rosgen 1988). Most of the streams in the Wall Creek watersheds are not type "C." Standards for scoring pool frequency were therefore developed from consultations with fisheries biologists well acquainted with the streams of the blue mountains and constitute preliminary estimates of pool frequencies that could be expected under the best (for a score of one) natural local conditions. Scoring was as follows:

pools/mile >30	score = 1
12< pools/mile ≤30	score = 2
pools/mile ≤12	score = 3

b) Residual pool depth score:

residual pool depths were taken directly from SMART program reports of stream survey data as average values for each reach. In the absence of established standards for streams of the Blue mountains, categories for scoring residual pool depths were determined through consultations with several local fisheries biologists. Scoring categories used were as follows:

Average residual pool depth ≥ 3	Score = 1
3 > Average residual pool depth ≥ 1.5	Score = 2
Average residual pool depth < 1.5	Score = 3

c) Deep pools score:

Only pools > 3 feet deep were counted as deep pools. Counts of deep pools were derived from a Paradox database which had been downloaded from SMART program files. Counts for all reaches were converted to pool frequency by dividing by reach length in miles. Scoring was as follows:

Deep pool frequency > 10/mile	Score = 1
10/mile≥ deep pool frequency > 5/mile	Score = 2
Deep pool frequency ≤ 5/mile	Score = 3

8. Summaries of scores:
The methodology agreed upon by the watershed analysis team for evaluation of the Wall Creek watersheds included a subwatershed by subwatershed condition summary. This made it necessary to summarize stream conditions separately for each subwatershed. Therefore parameter scores for stream survey reaches within subwatersheds were combined and reported as length-weighted averages for the subwatershed (Table 6). Scores for the habitat parameters could then be combined in several different ways (for example, by relative importance, simple counts of the number of parameters rated poor, counts of parameters of high relative importance and in poor condition, the product of relative importance and condition, averages of subsets of the parameters) in order to arrive at overall scores for the fisheries and aquatic habitat condition of the subwatershed.

Evaluation methodologies using scoring mechanisms such as this can give misleading results because: 1) a "poor" rating in one parameter may be counterbalanced by a good rating in several others, giving the appearance of fair to good rating overall, while in reality, a poor rating in certain categories may be indicative of habitat that is nearly unusable regardless of the quality in other categories. and 2) The values for these ratings are weighted averages of all the stream reaches in the subwatershed and may therefore mask a critical condition of a particular stream or reach within the subwatershed.

For these reasons, such habitat quality scores should be used only to help single out subwatersheds that should be further studied. Moreover, extra effort must be expended to ensure that individual streams or stream reaches in particularly critical condition are not overlooked. A stream reach that scores three (poor) in any category should receive further examination before implementation of any management activities.

This scoring mechanism serves primarily to facilitate integration of the findings of various specialists participating in the analysis. Discussion and interpretation of fisheries and aquatic habitat findings in the remainder of this report will be in the context of more specific riparian and aquatic habitat goals, desired conditions, or needs of aquatic species.

C. Findings: Existing conditions.
Results of the above scoring system for all parameters is given in appendix A by stream reach. Summaries for individual parameters are discussed below.

1. Stream temperature:
None of the stream reaches for which data were available met the applicable scoring conventiuons (Pacfish or Oregon State standards) for water temperature. All were scored three. In other words, present summer water temperatures in most streams in the Wall Creek system are warm (Table 3) compared to established needs of most Salmonids. Bjornn and Reiser (1991) give 23.9°C (75°F) as the upper lethal limit for Steelhead and 29.4°C (84.9°F) or 25.0°C (77°F) -- depending on acclimation temperature -- as the upper lethal limit for Rainbow Trout. Although

some salmonids can survive at relatively high, but sublethal, temperatures, most are placed in life threatening conditions when temperatures exceed 23 - 25°C (73-77°F). Vigor and productivity are usually reduced and susceptibility to disease increased when temperatures vary much from the optima. Bjornn and Reiser (1991) list preferred temperatures for Steelhead as 10 - 13°C (50 - 55.4°F). Temperature records are not available for all Wall Creek system streams, but most of the streams for which records are available exceed this range nearly every day for much of the summer.

2. Width/depth ratios:

Bankfull width/depth ratios ranged from 2.0 (Alder Creek, reach three) to 35.3 (Wilson Creek, reach one). Out of 48 stream reaches with data available, 20 showed a width/depth ratio >ten. Using the scoring system described previously, four subwatersheds scored three (poor), five scored two and five scored one (good) for average bankfull width/depth.

3. Canopy cover:

Table 7 summarizes canopy cover as reported by the SMART program for streams in the Wall Creek system. Stream reaches with canopy cover in category 1 are: Reaches 1,2,3 of Big Wall Creek, reach 2 of Colvin Creek, reaches 1 and 2 of Wilson Creek, reach 3 of Lovlett Creek, all of Three-trough Creek and reach 3 of Little Wall Creek. Stream reaches in categories two and three would score two in the subwatershed scoring system developed by the watershed analysis team (see table 4). Twenty-nine stream reaches would fit this scoring category. Eleven stream reaches have enough canopy cover that stream shade should not be a major concern. Stream survey reports mention evidence of past stream side timber harvest in many reaches throughout the Wall Creek watersheds.

Table 7

Summary of canopy cover from stream surveys as reported by the SMART program

Stream survey canopy cover class	Percent canopy cover	Number of stream reaches
1	0 - 19	9
2	20 - 30	10
3	31 - 60	19
4	>60	11

4. Substrate:

a) Embeddedness:

Average cobble embeddedness of streams in the Wall Creek system is reported as greater than 35% for 22 of the 52 stream reaches for which data are available (see appendix B). Sand is given as the dominant substrate for an additional five streams for which embeddedness data is not available. These streams should probably also be considered embedded. Yet another four stream segments are reported as not embedded but list sand as the dominant substrate. This seems problematic. The report for one of the streams (East Fork Alder Creek) states: "...sand, which was mostly silt and clay, was the much larger percentage of the substrate, and in many units it was the only substrate." and: "Embeddedness was low due to the low percentage of gravel and cobble." (Hoedads Inc., 1993). More sand and less cobble should equate to higher, not lower, embeddedness!

It is difficult to know how to use this information, but the most reasonable approach at this juncture seems to be to consider these reaches as severely embedded -- probably near 100%, and certainly the substrate cannot be considered as a high quality component of the fish habitat for 31 of the 52 reaches with data available. Of course, in some settings, for example, some meadow streams, high levels of fine sediments may be a natural, normal condition.

b) Rearing substrate:

Another six (non-embedded) reaches list gravel as the dominant stream substrate. Although gravel is a necessary component of the substrate in *spawning* habitat, it provides little or no hiding cover for juvenile fish and therefore does not qualify as high quality *rearing* habitat.

In summary, the stream survey data suggest that in 37 out of 63 reaches, substrate contributes little to the quality of rearing habitat for salmonids. This makes other components of hiding cover (deep pools, in-stream wood, overhanging vegetation, bank undercutting) more important.

c) Spawning substrate:

Cobble embeddedness bears a less direct relationship to quality of spawning habitat, since salmonids tend to flush at least some of the fine sediments from the gravel during redd construction. However, to the extent that high cobble embeddedness indicates a high sediment load for the stream, it also indicates a potential reduction in quality of spawning habitat. Sediment deposition during the time that eggs are in the gravel warrants the greatest concern, since sediment deposited over the redd can restrict the flow of water through the redd, reducing oxygen and metabolite flux. In excessive quantities, fine sediment could also form a cap over the red, preventing the emergence of alevins from the gravel.

The 31 out of 63 reaches which are (presumed) embedded should be considered poor spawning habitat. The six reaches which are not embedded and have gravel as the dominant substrate are counted as good quality spawning substrate. Another 13 reaches which have cobble as the dominant substrate have gravel as subdominant substrate and can also be counted as good quality component of spawning habitat.

Summarizing substrate quality then, 31 of 63 stream reaches should be considered poor salmonid habitat for both rearing and spawning functions due to excessive amounts of fine sediment. An additional six reaches provide poor quality substrate for rearing. It seems clear that measures to reduce production and delivery of fine sediments to streams could improve salmonid habitat in Wall Creek and its tributaries.

When substrate quality was summarized by subwatershed (table 6), subwatersheds 25b and 25c scored one (good) and seven subwatersheds scored three (poor) because of excessive fine sediments.

Of course, while bank erosion and channel down cutting introduces more fine sediment to the channel downstream, at the point of erosion it removes soils and floodplain deposits. These alluvial deposits function not only in supporting riparian vegetation, but also as shallow aquifers that recharge at high flows and drain at low flows. Disruption of normal geomorphic or hydrologic function or damage to the vegetation on which it depends usually results in impairment to overall riparian resource values (Van Haveren and Jackson, 1987). Mullner (1995b, 1995c) describes these sorts of effects in Wilson and Indian Creeks and their tributaries in the Wall Creek System. In fact, he reports that much of the lower portion of both creeks has already cut down to bedrock.

5. In-stream woody debris:

Woody debris frequency data for Wall Creek system was collected following at least two different protocols. In at least some of the stream surveys prior to 1993, standing trees which might fall into the stream or into the bankfull width area were counted as well as wood that was actually down and in the stream. Beginning in 1993, only wood that was actually down and in the stream or down and at least partially within the bankfull width area was counted.

Standing trees and snags within the riparian zone may represent future large woody debris, but since they are not yet functioning in the hydrologic system or aquatic habitat of the stream, they are best counted separately. The Pacfish RMO of 20 large (>12" x 35') pieces of woody debris per mile for streams east of the Cascade crest does not seem to contemplate counting trees or snags which are still standing, but does include large down wood which is at least partially within the bankfull width (Pacfish, 1995 and USFS Section 7 fish habitat monitoring protocol for the Upper Columbia River Basin, 1994). At least twenty-six stream reaches have been surveyed using the later protocol. Of these, 19 meet the Pacfish RMO's. In fact, eight reaches average more than 40 pieces per mile. This in spite of evidence of past logging which, in many places, removed trees right down to the stream bank. When reaches surveyed before 1993 are included, 47 reaches out of 52 for which data are available contain more than 20 pieces of large wood per mile. In fact, as of fall 1994, the median value for woody debris frequency for stream reaches in the Wall Creek system was 32.95 pieces of large wood per mile. The overall range is from 0.8 (Dark Canyon Fork -- 1994 data)) to 202.1 (Hog Creek reach 2 -- 1992 data) with an arithmetic mean for all reaches of 38.8 pieces/mile (std. dev. = 26.97).

6. Fish cover:
Stream survey reports rated most streams in the Wall Creek system as cover class 1 or 2 (32 out of 52 for which data were available). Only eight were rated in cover class four (> 40% cover). All eight of these reaches were in three streams, Alder Creek, Dark Canyon Creek, and Dark Canyon Fork. Hiding cover is not abundant in the remainder of the Wall Creek system.

7. Pools:
a) Pool frequency:
Pool frequency in the Wall Creek system varies from 0.54 pools per mile (reach two of Alder Creek) to 32.1 pools per mile (Wilson Creek, reach 1). Most of the pools in reach one of Wilson Creek were constructed by the Forest Service in an attempt to provide deep water micro-habitat and improve summer survival of fish. In fact all stream reaches with pool frequencies >15 pools/mile contain a high proportion of constructed pools.

b) Residual pool depth:
Not only are pools relatively scarce in the Wall Creek system, those pools that are present are mostly shallow. Average residual pool depth was 1.5 ft. or less for 40 out of 58 reaches for which data was available. Only four reaches had average residual pool depths of three feet or greater, and for one of these the data seems anomalous.

This information must be interpreted with care, as residual pool depth taken out of context can be very misleading.

For example, stream survey data as reported by the SMART program for reach two of Alder Creek shows a residual pool depth of 1.6 ft., which is above the median (1.4 ft.) for the system. This would imply a better than average (for Wall Creek) pool habitat. However, the pool frequency for that reach was 0.54 pools/mile. Reach two of Alder Creek was 1.7 miles long. The conclusion is that there was only one pool in the entire reach and that pool was 1.6. feet deep. Hardly above average quality pool habitat! This situation illustrates the critical importance of incorporating a sufficient variety of parameters in any evaluation of habitat quality.

c) Deep pools per mile:
Only 12 reaches had pools deeper than three feet. Of those 12, only two had more than ten deep pools per mile. Both of those were reaches with many pools that had been mechanically constructed as mitigation/habitat restoration by the Forest Service.. In fact it is likely that all of the deep pools in these reaches were mechanically constructed. Natural deep pool habitat is clearly scarce in the Wall Creek system.

III. Reference Conditions:

A. Prior stream surveys:

Forest Service stream surveys of Wall Creek system streams were apparently begun in 1989. Data for the parameters discussed above are mostly unavailable prior to the USFS 1989 stream surveys. However, the Oregon State Game Commission inventoried some of the Wall Creek streams in 1963 (Oregon State Game Commission, 1963). They report pool/riffle ratios and stream flows. A flow volume for mainstem Wall Creek of 6.3 cuft/sec. was measured in July, which is 31 times larger than the summer low flow (0.2 cuft/sec) reported by recent (1992) Forest Service surveys. The Forest Service surveys reported data gathered in August, so perhaps this could explain some of the difference. However, most streams in the southern Blue Mountains have reached low flow by early July, so such a large difference must be partly explained by other factors, perhaps the continuing drought and/or differences in measuring methodology. In any case, several years of flow data in combination with precipitation data would be required for meaningful comparisons.

For other fish habitat parameters, the OSGC inventories used a different protocol, so that direct comparisons of results to data produced by current Hankin and Reeves type surveys is not possible.

For example, the OSGC reports give percent riffles and pools for stream segments surveyed. Hankin and Reeves procedures (and the SMART program) produce figures for percent riffles, percent pools and percent glides. It seems likely that some of the Hankin and Reeves glides would have been counted as pools and some as riffles by the earlier OSGC inventories. Within the context of this analysis, there does not seem to be any way to divide the Hankin and Reeves glides into OSGC riffles and pools. In any case, the OSCG 1963 figures would not be the preferable reference data because quite a lot of management activities had already been concluded by that date. For example, intense livestock grazing was already occurring by 1880.

B. Qualitative and anecdotal information:

Although quantatative information is scarce, there are earlier qualitative reports about the fisheries resource in the Wall Creek stream system which hint at earlier conditions.

Oregon Department of Fish and Wildlife reports finding juvenile Chinook Salmon in Wall Creek in 1982 and 1983, the only years in which this creek was sampled for them (Lindsay et al, 1985). Chinook redds have not been found in the Wall Creek system, so it is presumed that these fish were spawned elsewhere and then moved into Wall Creek as juveniles seeking rearing habitat, and perhaps cooler water.

It is conceivable that these fish represent a relict portion of a once larger population which spawned in the John Day River and used Wall Creek as part of their rearing habitat. If so, habitat conditions in Wall Creek could be at least a small factor in the recovery of John Day River Chinook Salmon populations.

The John Day River Subbasin Salmon and Steelhead Production Plan (1990) report three traditional fishing sites on Wall Creek and Little Wall Creek used by the Umatilla and Columbia River Indian tribes. Apparently fish in Wall Creek were once sufficiently numerous to support a native fishery.

It seems entirely reasonable to expect that prior to intensive livestock grazing, riparian road construction and logging, stream shade would have been higher, sediment delivery to streams would have been lower, and fish cover in the streams would have been greater. It is probably not now possible to determine the precise magnitude of the differences, but it follows that stream temperatures should have been cooler and cobble embeddedness would have been lower, large woody debris more common and pool frequencies and depths greater. Although historic data specific to The Wall Creek system is not available for comparison, studies of the John Day Basin as a whole (Wissmar et. al., 1994) and the interior Columbia River Basin (Mcintosh et. al., 1994) support these expectations. Studies of a Montana stream (Gunderson, 1968) indicated that stream side cover, such as overhanging banks, brush and debris was 76.4% greater in an ungrazed area than in a grazed area. Average eroded channel width, wetted width, percent of stream in riffles were all greater in grazed riparian areas while percent of total stream as pools and glides was greater in ungrazed areas. Educated guesses as to which stream reaches in Wall Creek have been most affected by management might be derived from timber harvest records, road densities and livestock numbers, but would be pretty speculative. In the absence of specific historical data for fish and aquatic habitat parameters, Pacfish RMO's and fish habitat requirements reported in scientific literature and discussed above will be taken as reference conditions.

C. Reference reaches:

Statistics for streams which presently appear to be in best condition might also be taken as baseline for reasonable expectations for fish habitat, but no streams in this watershed are completely unaffected by the past 100 years of livestock grazing, timber harvest and road construction. In other words, even the best remaining reaches should not be assumed in excellent condition. Such "best remaining" reaches might be taken as examples of the *minimum* that should be expected under sensitive management. Such reference reaches should be compared only to reaches in similar geophysical (elevation, aspect, geology) settings.

Based on available data and suggestions form Scott Mullner, Heppner District Fisheries Biologist, two stream reaches in the Wall Creek watershed might be considered as reference reaches:

1. Little Wilson Creek (northerly aspect streams).

2. Upper Skookum Creek, reach five, especially in the vicinity of the hydro study site. (high elevation, southerly aspect streams).

These stream reaches may in fact have already been highly altered and are here presented, not as the best which the system can produce, but rather as some of the *best remaining* fish habitat in the

Wall Creek drainage.

Other stream reaches may seem from the statistics to constitute better fish habitat, but in most cases the better appearing statistics stem from pools data taken from reaches which contain mechanically constructed pools. Little Wilson and Upper Skookum creeks are probably unnaturally low in pool quality and frequency, but stream segments in which pool frequencies and depths had been artificially augmented would not really be comparable to the system potential either.

None of the stream reaches within the Wall Creek drainage would serve satisfactorily as a low elevation, south aspect reference reach. Kaylor Creek, in an adjacent drainage to the west has been recommended (Scott Mullner, personal communication) as a potential reference reach for such streams.

IV. Interpretation:

A. Limitations due to quality and availability of information:

It would probably be most useful in this sort of report to identify subwatersheds or stream reaches which are in best (or worst) condition and then to correlate this situation directly to past management practices and/or to natural conditions or events -- to be able to say, for example, that subwatershed X has high pool frequency and high residual pool depth because management has reserved the trees in the riparian zone for wildlife and in-stream needs and protected floodplain soils by ensuring a substantial vegetative root system through restriction of cattle access in the riparian to a few water gaps.

Unfortunately, data at this level of specificity has not been available within the allotted time frame for these watersheds. Apparently livestock use of the watersheds cannot be readily broken down by subwatersheds or stream reaches. Timber harvest records prior to 1987 are not sufficiently specific about harvest prescription or geographic location to permit such correlations, either.

However, experience and research have abundantly established the harmful effects that roads, timber harvest and cattle grazing may exert on aquatic habitat (Meehan, 1991; Platts, 1991).

Therefore, wherever there is degraded aquatic habitat in conjunction with a history of high road density or heavy grazing or timber harvest, the weight of evidence will indicate management responsibility. The burden of proof to the contrary lies with the defence of past levels or styles of grazing, road building, or timber harvest. Lacking evidence to the contrary, we must assume, for the present, that where degraded aquatic conditions are found in the Wall Creek watersheds, they must be, in large part, a result of past management activities.

B. Specific habitat parameters:

1. Water temperatures:

As noted previously, the recently adopted water temperature standards (RMO's) for streams in anadromous fish producing watersheds specify maximum seven-day running average temperatures below 60 degrees Fahrenheit within spawning habitats and below 64 degrees Fahrenheit within migration and rearing habitats of anadromous fish. Spawning and rearing habitats have not yet been specifically delineated in the Wall Creek system, so, with the exception of lower Wall Creek (below the forest boundary), those portions of streams which are known to host adult Steelhead during the spawning season have been taken as spawning habitat for the purpose of this investigation. Wall Creek below the forest boundary is not believed to be steelhead spawning habitat (Mullner, 1995, pers. comm.) and so has been treated as migration and rearing habitat. Waters in which only resident salmonids have been observed are designated as rearing habitat. These stream delineations correspond to the Class I & II streams in table one. Waters which are not salmonid habitat must still meet the Oregon State standard of 68°F maximum (no increase above 68°F permitted). None of the streams for which temperature data is available in the Wall Creek watersheds meet these standards.

Bull Trout require cooler temperatures than Steelhead or Chinook, but since they are not known to be present in the Wall Creek system, the Pacfish and Oregon State standards apply. In any case, since Wall Creek stream temperatures do not meet Pacfish nor Oregon State standards they would not meet the even cooler temperature needs of Bull Trout. It may be important to note that Bull trout have been reported from the North Fork of the John Day River at the mouth of Wall Creek. It is conceivable that were water temperatures in Wall Creek cooler, it might be used by Bull Trout.

High stream temperature in Wall Creek and its tributaries is probably the factor most limiting for fish production. It may be that soil, geological and precipitation conditions in the Wall Creek system have always been such that summer flows have always been low (see hydrology specialists report for Wall Creek watershed analysis). If so, late summer temperatures in these streams have probably always been relatively warm. On the other hand, it also seems clear that past livestock grazing, road construction, and logging have reduced stream side shade and increased the wetted width/depth ratios. Stream reaches with low flow, low shade and a high wetted width/depth ratio are especially vulnerable to temperature increases. Trapping of headwater springs in stock ponds may also have contributed to lowered late season stream flows which tend to increase water temperatures (Beschta et. al., 1987).

Presently, fencing along portions of some streams excludes cattle. This in conjunction with riparian planting, encourages vegetative recovery along these streams and over the long term should increase shade and help reduce water temperatures. However, cattle have access to and use the riparian zone along other parts of these streams and along many other streams. Fences which create livestock exclusion zones must be regularly maintained if they are to be effective. At least one exclosure in Wall Creek has been breached for most of the grazing season this year and cattle have been grazing inside it, setting back the recovery process.

Logging, roads and livestock grazing might also have altered timing and volumes of stream flows. This is impossible to substantiate because of lack of flow data, but if true, it would have most likely have produced higher early spring and lower late summer stream flows, tending to increase late summer water temperatures even more.

Water temperatures in many of the headwater springs in the Wall Creek system have been measured (Mullner, 1995, personal communication). They are consistently cool (mostly in the low 50's). However, the flow of many of them (estimates run as high as 1/3) are trapped as stock ponds. This has the effect of keeping the stream flows lower than they otherwise might be. In those cases in which some of the spring water escapes the stock pond and reaches the stream, it has been considerably warmed by detention time and greater surface area in the pond.

Bull Prairie Lake appears to have a similar warming effect to the waters of Wilson Creek. Wilson Creek water temperature was 64.6°F above Bull Prairie Lake and 75.8°F (7-day running avg. max.) below the lake in the summer of 1994. There is little doubt that the detention time and greater surface area exposed to insolation by the lake is responsible for most of the temperature increase.

There seems to be little reason to doubt that past management of the Wall Creek watershed has contributed to increased stream temperatures. In the future, carefully designed and implemented management could help to reduce stream temperatures.

2. Width/depth ratios:
Twenty out of 48 stream reaches with data have bankfull width/depth ratios >ten. These reaches probably have less fish cover provided through undercutting than the other reaches. Reasons for the higher bankfull width/depth ratio may include less consolidated bank substrates and past management activities, especially intense riparian grazing which eliminates protective roots and ground cover in addition to physically breaking down the bank. Those reaches with low substrate consolidation are expected to show higher width/depth ratios naturally. Of course, on the other hand, they are also more susceptible to breakdown by heavy livestock or big game use or to decreased protection from reduction in large wood quantities or loss of plant roots. The upper reaches of many of the streams in the Wall Creek subwatersheds are in ash soils with very low consolidation. The Wall Creek drainage has a long history of easy access for livestock to the creeks. The generally high bankfull width/depth ratios are most probably related to this history.

3. Canopy cover:
Canopy cover in the Wall Creek streams does not seem as low as might have been expected from the extent of grazing and logging reported. It appears that in some cases, logging removed only high value Ponderosa Pines and Larch, leaving most of the Grand fir. Aerial photographs of the Wall Creek drainage show that the bottoms of many of the canyons hold considerably more trees than the uplands. In fact, the photographs give the impression that in some parts of the Wall Creek drainage, most of the trees that remain are in the canyon bottoms. Nevertheless, only 11 of 49 stream reaches have canopy cover that scores as good. In other words, 37 reaches need improvement. The most immediate effect of low canopy cover is to expose stream waters to insolation , usually with a resultant temperature increase. The establishment of Pacfish specified RHCA's should help in the recovery of these areas, especially if livestock management can be adjusted to permit riparian vegetation recovery. It seems clear that continuation of past grazing practices in riparian areas will prevent attainment of RMO's. On the other hand, recent observation seems to indicate that the construction of livestock exclusion fences is already beginning to improve the vegetative condition of riparian zone in some areas.

More dense riparian vegetation that should result from a lessened impact of livestock will improve bank stability through plant root development and will tend to reduce stream temperatures through increased stream shade. Developement of several canopy layers will produce the most effective stream shade.

4. Substrate quality:
Stream surveyors and report writers (Hoedads, Inc. 1993) seem to have been confused about

protocol for gathering and interpreting cobble embeddedness data. This appears to have led to underestimates of cobble embeddedness for many, perhaps all of the streams surveyed in 1993. Incorporating the recorded dominant and subdominant particle size into the substrate evaluation procedure helps to correct for the methodology used to collect the cobble embeddedness data. As corrected, the data indicate that about half of all surveyed reaches in the Wall Creek watersheds contain poor quality substrate for either spawning or rearing or both. The specific problem is an overabundance of fine sediments in the stream beds.

The soils of the Wall Creek watersheds are composed largely of volcanic ash and when not protected by vegetation or soil surface litter are easily eroded. Livestock grazing, timber harvest and especially the roads associated with timber harvest all contribute to erosion and sedimentation problems (Furniss, Relofs and Yee, 1991; Everest et al, 1985; Cederholm and Salo, 1979; Platts, 1991). Stream survey report narratives for the Wall Creek system cite multiple instances of livestock congregating in the streams, breaking down stream banks, and retarding regrowth of riparian vegetation. They also report numerous instances of past timber harvests right down to the stream (stumps on the bank, or even in the creek) and roads closely paralleling the stream. Purser (1991) pointed out several instances of timber harvest, livestock grazing and roads causing erosion and sedimentation in the Wall Creek system. There seems little doubt that past management of the watershed has been responsible for soil erosion and stream sedimentation rates well above background for many years.

The existing road system is the almost certainly a major source of management produced fine sediment for Wall Creek system streams. Roads parallel streams within RHCA's for 39.5 miles (5.44% of total stream miles, Figures 3 & 4). Most of the riparian roads (21.45 miles) parallel class one and two streams. Overall for the Wall Creek watershed, roads within the RHCA accompanied nearly 21% of fish bearing streams. Subwatersheds 25b, 24e, 25c, 24c, and 24g stand out as being high in total riparian road density (calculated as miles of streams with roads in RHCA's/total miles of streams). Subwatersheds 24g, 24b and 24c have the highest riparian road density along class one and two streams. When all stream classes are included, subwatersheds 24e, 25b and 25c also stand out for high riparian road density. The above figures include only roads mapped in the GIS road layer.

Intensive livestock grazing also contributes to introduction of excessive fine sediment into the stream, primarily by removal of soil protecting vegetation and breaking down of stream banks. Stream survey reports cite multiple instances of such situations in the wall creek system.

5. Large woody debris:

Most forest management activities in the past have been of the type that tend to reduce the sources of large woody debris for streams. Logging in riparian areas removes trees that might have become in-stream wood, intensive grazing tends to prevent or retard regeneration of riparian trees, and riparian roads occupy land that might otherwise produce trees. Studies have found large woody debris to be either less frequent (Heifetz et al, 1986) or of smaller size classes (Toews and Moore, 1982; Bryant 1983) in watersheds or stream reaches with clearcuts. Over

Figure 4

Proportions of Stream Lengths with Roads in RHCA's of Class 1 & 2 Streams in Wall Subwatersheds

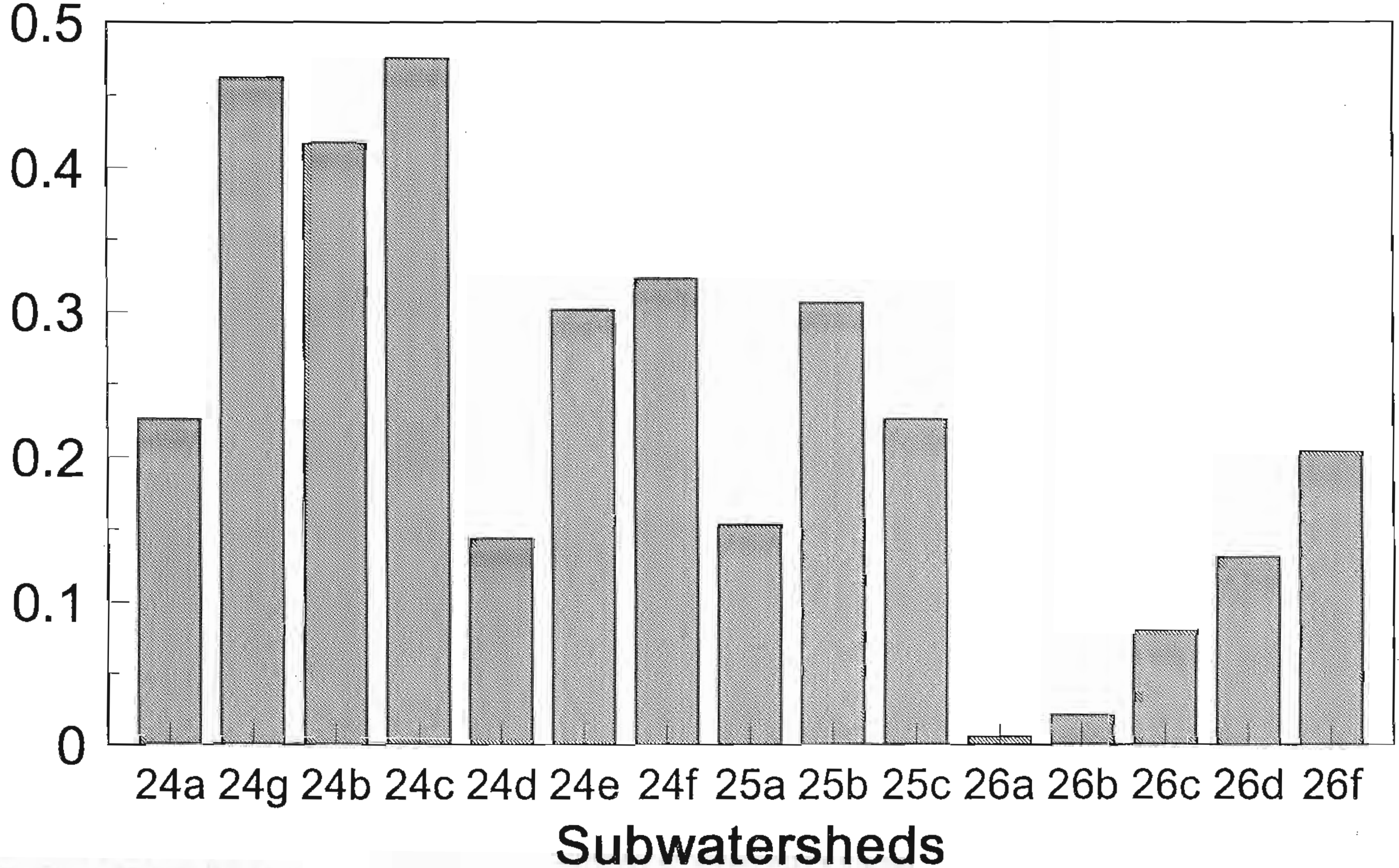
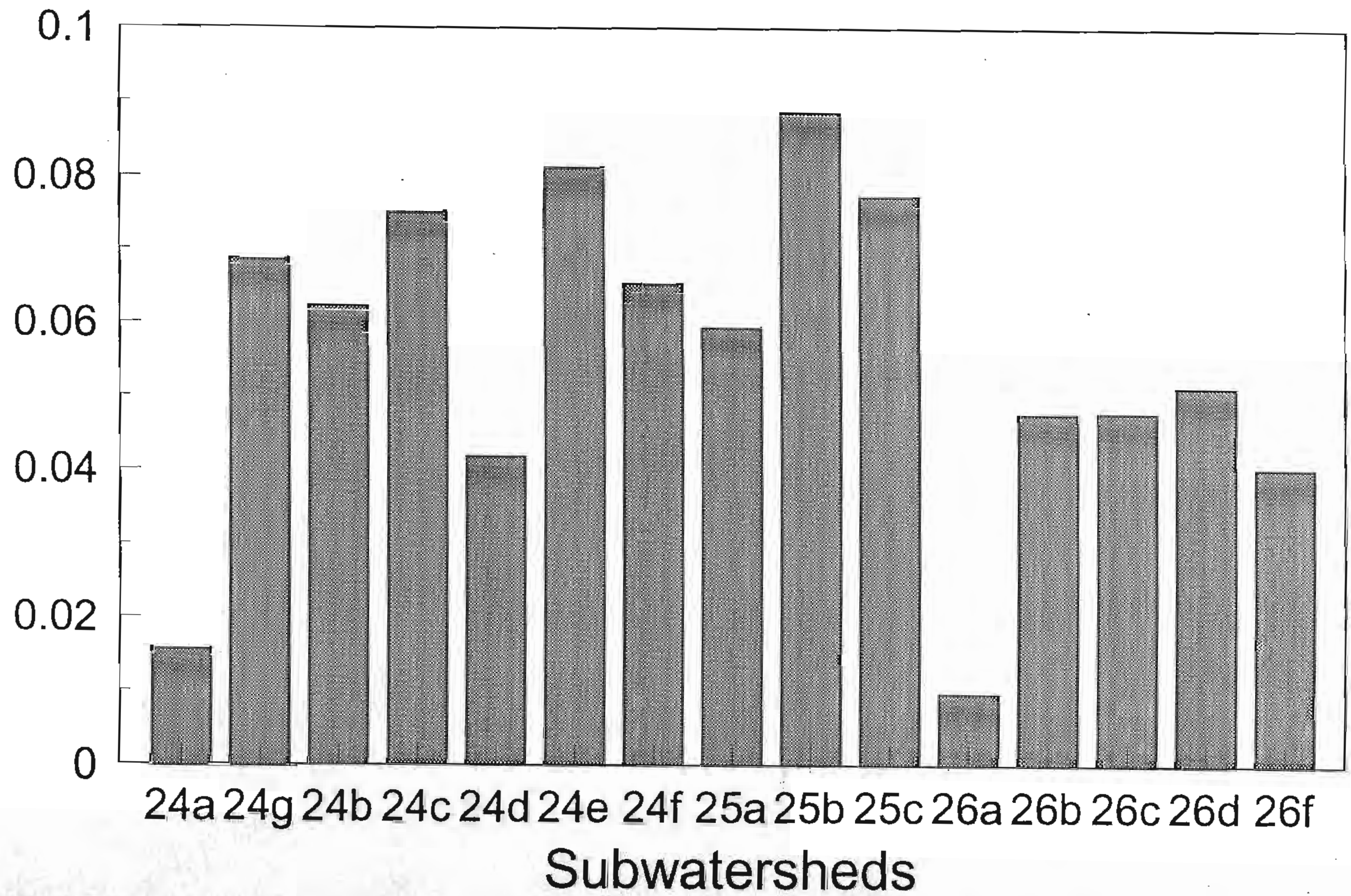


Figure 5

Proportions of Roaded and Unroaded RHCA's
for all Stream Classes in Wall Subwatersheds



the short term, logging debris left behind may become in-stream woody debris, but will likely be of smaller size classes and while it may persist for a few years, it will eventually disappear due to decomposition or episodic floods. On the Olympic Peninsula and in southwestern Washington measurable contributions of new wood after harvest may not occur for 60 to 70 years (Grette, 1985; Bilby and Wasserman, 1989). In more arid eastern Oregon, it seems reasonable to conclude that significant new wood contributions would take even longer.

Currently, in the Wall Creek system, a majority of stream reaches meet the Pacfish RMO of 20 pieces of large wood per mile whether or not standing trees and snags are included in the tally. It is instructive to note that compared to west side standards, PACFISH RMO's for streams in the interior Columbia Basin are less stringent for woody debris frequency (20 pieces/mile, >12" diameter x 35' long *vs* 80 pieces/mile, >24" diameter x 35' long for the west side). Clearly, more than 20 pieces of large wood per mile would make for better aquatic habitat. It appears that Pacfish standards were adjusted simply to accommodate the realities of the less productive east side forests, not because of any less need for wood in the streams.

Data from MOSS/GIS (Table 7) indicates that all but three of the subwatersheds (subwatersheds 24d, 24e, 24f) contain more than half of their RHCA's in a late/old or middle structural stage. Although this information source does not provide information about density of large trees (except that there are more than ten/acre), it implies that at least some large wood could be available to streams in the future. In any case, the forest in the Wall Creek watershed certainly seems capable of producing more than a mere 20 pieces of large woody debris per mile. Local, long term goals of considerably more than 20 pieces of large wood per mile seem reasonable. In the context of Watershed analysis, PACFISH (page C-7) allows for adjustment of RMO's to fit local conditions.

6. Fish cover:
Sources of fish cover in mountain streams may include woody debris, low overhanging vegetation, undercut banks, interstitial spaces in cobble or larger substrate, water depth greater than three feet, aquatic vegetation or stream turbulence. Some management activities affect cover directly: Breaking down of stream banks via riparian livestock grazing eliminates bank undercutting. Livestock consumption of low overhanging vegetation eliminates that as a source of cover. Any management activity that causes sediment deposition in streams may fill insterstitial spaces in the substrate, rendering it ineffective as cover. In years past, woody debris was sometimes removed from streams, which directly removed fish cover. Riparian timber harvest removes trees which would otherwise have eventually have become fish cover in the form of large woody debris. Riparian road construction, which often straightens and simplifies the channel usually eliminates overhanging vegetation, pools and undercut banks. Natural phenomena also affect fish cover. Very high stream flows may flush wood far downstream and in the process fill in pools or wash out the step/plunge producing structures, thereby eliminating pools, which if deep enough, would have served as cover. It is at least conceivable that the 1964 floods could have destroyed many pools in the Wall Creek system streams. The Forest service has built pools in many of the Wall Creek streams. However, even reaches with constructed pools may provide

Table 7			
Wall Creek Subwatersheds			
Acreages of RHCA's in Late/old or Middle Structural stages			
Subwatershed number	**Total acres in RHCA's**	**Acres in Late/old or Middle Structural Stage**	**Percent Late/old or Middle**
24a	1063.58	709.23	66.68%
24g	890.95	706.65	79.31%
24b	943.51	857.85	90.92%
24c	1178.16	1119.67	95.04%
24d	1016.02	300.97	29.62%
24	1276.86	580.17	45.44%
24f	1062.96	726.67	68.36%
25a	1550.35	684.93	44.18%
25b	1166.68	847.52	72.64%
25c	836.18	616.49	73.73%
26a	1286.55	1002.89	77.95%
26b	882.33	451.68	51.19%
26c	1536.66	1432.82	93.24%
26d	1318.25	978.77	74.25%
26f	464.72	384.5	82.74%
Total	16477.17	11400.81	69.19%

little cover for fish. In order to secure the best return on the investment in the pools it is important to ensure that other habitat factors are improved along with the pool depth and frequency. Measures such as including root wads in the pools, planting of shrubs and trees, and exclusion of livestock to improve shade and overhanging vegetation should be part any rehabilitation plan. In some areas, Wilson Creek for example, some such rehabilitation has already been implemented, but it will be many years before the full benefits are realized.

7. Pool habitat quality:
Historical data is insufficient for quantative comparisons with present habitat conditions in the Wall Creek system. Nevertheless, it is well established that intense livestock grazing, road building and removal of trees from the riparian zone will retard or defeat natural pool forming processes and result in a lowered pool frequency and less habitat diversity (Meehan, 1991). Pool frequency in Wall Creek seems low to most specialists consulted and the low pool frequency probably results from a combination of geologic and hydrologic conditions, natural phenomena (i.e. the 1964 floods) and past management activities (riparian harvest, road construction, and livestock grazing).

While pool frequency and depth are important components of high quality fish habitat, other habitat factors must also be of high quality in order to produce good fish habitat. Water temperatures in Wilson Creek do not meet Pacfish RMO's (see table 3) and in fact approach or surpass upper lethal limits for steelhead and rainbow trout. Higher pool frequencies cannot compensate for this.

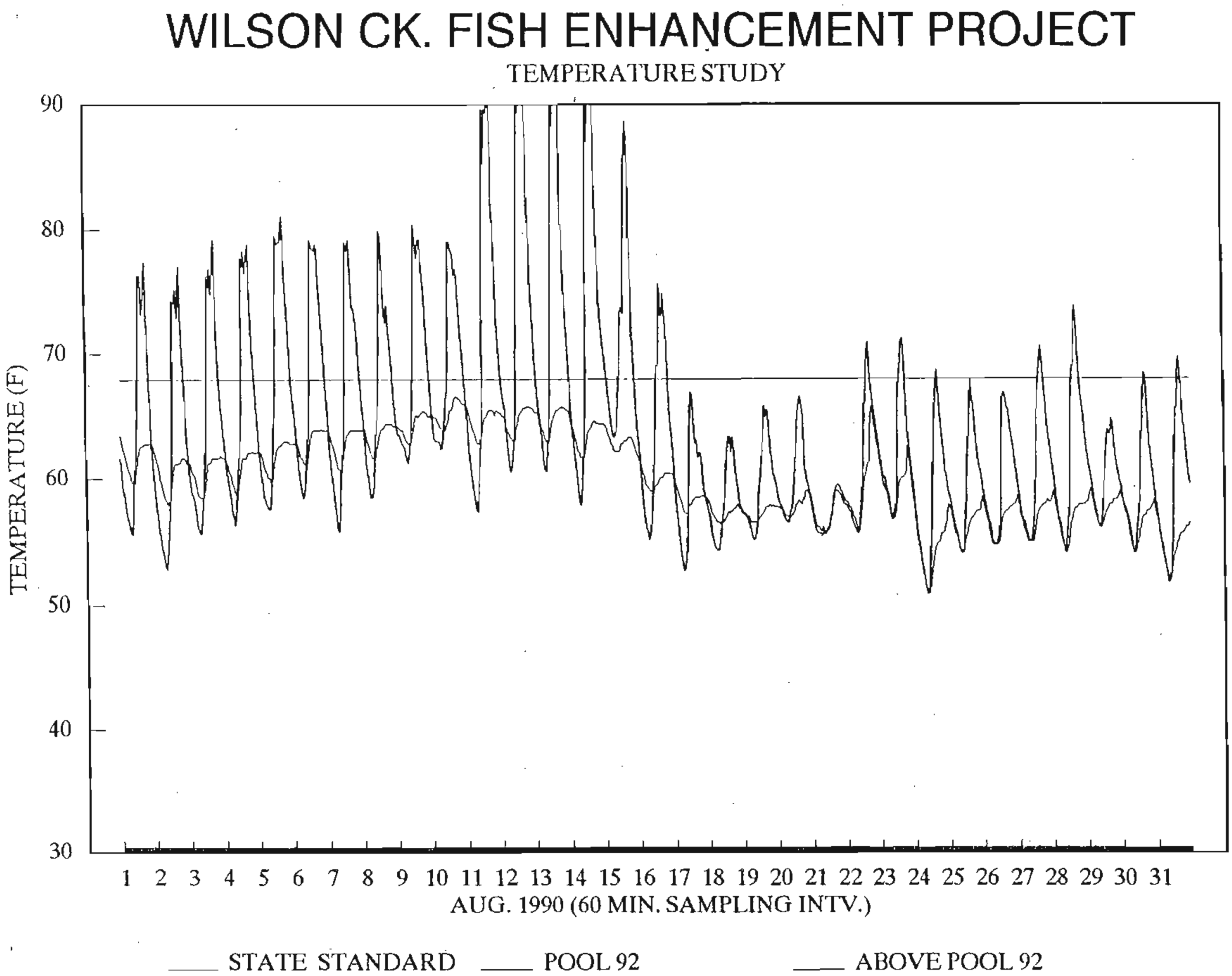
Furthermore, some such constructed pools have trapped fish as stream flow decreased during the summer. In some pools these fish died as water further receded. Had these pools not been present, these fish might have moved down (or up) stream to reaches where flow persisted throughout the summer. Of course it is also possible that some could have been trapped between sections of dry channel and perished anyway.

Constructed pools in Wilson Creek may possess one redeeming virtue which could prove especially important during summer low flows, though. Temperature records from the deepest part of the pool and from water entering the pool indicate that water at the bottom of the pool can be notably cooler than water entering the pool (Figure 5). These pools are apparently intercepting some subsurface flow. So at least some of the pools may enhance fish survival by providing a small cool water refuge area during low, late summer stream flows. Whether constructed pools on balance enhance or decrease fish survival will depend upon the late summer flow characteristics of the stream, the location of the pool and other habitat factors such as cover over the stream and hiding cover within the pool.

C. Fish Populations:
The Umatilla National Forest Land and Resource Management Plan (1990), in Chapter 4 (Forest Management Directions), states that by the year 2000, "The number of rainbow trout on the forest... will have increased as a result of habitat improvements" and "Anadromous fish production will increase dramatically."

Lacking historic or recent data for fish numbers in the Wall Creek system, it is simply impossible to substantiate changes in rainbow trout populations since development of the Forest Plan.

Figure ~~3~~ 5



WILSON CK. FISH ENHANCEMENT PROJECT
TEMPERATURE STUDY
TEMPERATURE (F)
90
80
70
60
50
40
30
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31
AUG. 1990 (60 MIN. SAMPLING INTV.)
STATE STANDARD
POOL 92
ABOVE POOL 92

However, previously mentioned data from ODFW for steelhead redd counts (table 2) clearly indicate that numbers of anadromous fish have most definitely not increased dramatically. We are now halfway through the ten-year period of the Forest Plan and it is quite clear that the Forest is nowhere near to reaching the goal described on pages 4 - 7 and 4 - 8, at least not in the Wall Creek system. Since both rainbow trout and steelhead are identified by the Forest Plan as indicator species, it must be concluded that the lot of the other species using the aquatic habitat has not substantially improved either.

V. Summary and Recommendations:

A. Watershed management:

1. Authority and Responsibility.

The fish habitat in many of the stream reaches in the Wall Creek system is clearly in poor condition. Sediment levels are high in many reaches and although in many reaches Wall Creek streams meet Pacfish RMO's for frequency of large woody debris, wherever temperature data is available, streams do not meet PACFISH RMO's for that parameter. Livestock and past timber management appear to have contributed significantly to temperature increases. Numeric data is in most cases insufficient to determine whether Wall Creek system streams meet RMO's for bank stability, lower bank angle or wetted width/depth ratios but stream survey narratives imply that they most likely do not. In any case, since the Wall Creek streams do not meet water temperature RMO's, the Umatilla National Forest is committed to silvicultural and grazing management in riparian areas as follows:

> Prohibit timber harvest, including fuel wood cutting, in Riparian Habitat Conservation areas, except as described below...
>
> a) Where catastrophic events...result in degraded riparian conditions, allow salvage and fuel wood cutting in Riparian Habitat Conservation Areas only where present and future woody debris needs are met , where cutting would not retard or prevent attainment of other Riparian Management Objectives...
>
> b) Apply silvicultural practices for Riparian Habitat Conservation Areas to acquire desired vegetation characteristics where needed to attain Riparian Management Objectives... (Appendix C to Pacfish, page 10).
>
> Modify grazing practices (e.g., accessibility of riparian areas to livestock, length of grazing season, stocking levels, timing of grazing, etc.) that retard or prevent attainment of Riparian Management Objectives...(Appendix C to Pacfish, page 12).

2. Specific recommendations:

a) Reference and refuge reaches.

Some of the Wall Creek RHCA's have been identified as important wildlife travel/migration routes

(Boula, 1995, pers. comm.). Among these narrow strips of land are several which have also been singled out as aquatic habitat reference reaches or refuge areas. These are: Little Wilson Creek and Upper Skookum Creek (stream survey reach 5, from about T6S, R27E, S3, 1/16SE, 1/4SE to headwater springs). Because of their dual function, these RHCA's merit special protection, perhaps including somewhat wider RHCA's.

b) Middle Skookum Creek from about ½ mile below the confluence with Hog Creek to the mouth of Alder Creek has water that is nearer to Pacfish RMO's than most other reaches and appears to have good potential for restoration. It seems that this reach might merit special management consideration as both a wildlife travel/migration corridors and restorable aquatic habitat.

c) Additionally, the upper part of reach one and the lower part of reach two of Swale Creek, although containing very warm water, has cooler water both above and below (see table 3). This stream seems like a good candidate for special restoration efforts to improve stream shade, maintain late season flow and decrease width/depth ratios.

d) Alder Creek also has some of the coolest water in the Wall Creek watersheds and with a little protection and/or restoration could probably meet Pacfish RMO's for temperature. It also seems like a good place to focus restoration efforts.

e) Very recently, large adult trout (11 inches in length) which are thought to be redbands (Mullner, 1995. pers. comm.) were found in Upper Porter Creek (upstream of highway 207). These were found well upstream of previously known extent of fish in Porter Creek. If these fish are redband trout, it would be well to provide some special protection and or restoration for this stream segment.

In most of the above cases (items a - e), restoration should include measures to ensure increase in shade, stabilize stream banks, increase fish cover and reduce management introduced sediment. These would have to be long term projects and might include activities such as planting of over-story, mid-story and under-story species in areas where they are deficient and giving them protection from excessive grazing so they can provide streambank stabilization, fish cover and shade to the stream.

f) New allotment management plans (AMP's) for the Tamarack-Monument and Hardman allotments have recently been prepared. These plans address some of the recommendations given above. Although the new AMP's should certainly cause less degradation of the riparian areas than past management practices, it is not clear that the proposed action (alternative #2) will be sufficient to assure overall improvement of riparian conditions and aquatic habitat. Enforcement and monitoring of the new management plans will be very important to ensure their thorough implementation and to evaluate their effectiveness in achieving RMO's.

g) The Tamarack-Monument and Hardman allotments cover only part of the Wall Creek watersheds. Continuing degradation of aquatic and riparian habitat in the remaining part of the watershed will not be arrested unless livestock management in that portion is also addressed without delay.

h) If streams and riparian areas outside of the Tamarack/Monument and Hardman allotments are to recover to the point of meeting PACFISH RMO's, livestock access to streams must be further limited. Fencing is one method of accomplishing this. For fencing to be effective, it must be regularly inspected and maintained. If budgets, personnel and priorities are not directed towards inspection and maintenance, fences will prove expensive but not effective.

I) Obliterating and blocking some roads may help, as livestock use some old roads along and leading to streams.

j) In areas in which there are large numbers of dead trees 100 or more feet from the stream because of the recent budworm infestation, it may be feasible to fall some of them in ways which limit access to the stream, perhaps by blocking roads and trails. Since cattle are capable of circumventing many such obstructions, this would not be a panacea, but might be an effective use of some budworm killed trees in some cases. In most cases trees which are near to and leaning towards the stream should be left to fall on their own.

k) Since stock ponds that trap headwater springs can contribute to increased stream temperatures, it would be appropriate to re-evaluate livestock water developments. Consider replacing some stock ponds with troughs located outside of the riparian area and which could be fitted with float valves or overflow return devices so that water not consumed by livestock could be reserved for instream uses?

l) The number and distribution of water developments (stock ponds) might also be re-evaluated. During a quick tour of the area late this summer, it appeared that in some areas water developments were common and close together. Data on the distribution and numbers of water developments were not available at this writing. Cattle were commonly observed using the streams, but seldom (actually never) the water developments. Are all of the stock ponds necessary and useful?

m) The increase in stream temperature caused by Bull Prairie Lake might be minimized by drawing water for the outflow from the bottom rather than the surface of the lake. It appears that the dam was constructed with provisions for drawing water from the bottom of the lake. It would probably be feasible to do so for the purpose of water temperature control. If this is possible it could help to keep temperatures cooler well downstream. District personnel believe that sediment delivered to the lake by Wilson Creek and Bull Creek has significantly reduced the water depth in the lake and there has been some discussion of dredging the lake to deepen it. Deepening the lake would probably also increase its cool water storage capacity and in conjunction with drawing of water from the deeper portions, could help maintain a cooler water supply to Wilson Creek downstream of the dam. Dredging operations during a time when water was not flowing over the spillway (or by briefly lowering the water level prior to initiating dredging operations) should not cause sedimentation problems.

n) Sheep can convert forage to red meat without direct, significant effects on riparian habitats (Platts, 1991) The Walla Walla Ranger District (Umatilla National Forest) has found that sheep can be more easily managed in ways less damaging to streams and riparian areas than can cattle (Leinbach, 1995. pers. comm.). Consider converting some of the cattle allotments to sheep allotments.

o) Access and travel management plans for the Heppner district include closing some roads. Many are already officially closed. This is an important step towards reducing the sediment introduction into streams. Because of the topography of the Heppner ranger district, some officially closed roads are still easily accessible to four wheel drive vehicles and are reportedly used by motor vehicles. Where possible, more effective road closures would, over the long term, further reduce the sediment load to streams.

p) Both open and closed (but not obliterated) roads must be well maintained in order to avoid production of sediment which could be damaging to stream habitat. Heppner District personnel have documented locations of specific road repairs needed. Implementation of these repairs will help prevent further degradation of streams.

q) Cool water production and sediment trapping:
The northern parts of subwatersheds 26B, 26C and 26D contain the headwaters of Bear, Alder, Skookum and Swale creeks. This area is a cool, high elevation environment with good potential for production of cool water. There are a number of meadows in this area which are used as cattle pasture. The banks and substrate of these streams are composed almost entirely of very fine (sand/silt size) particles and are easily broken down by trampling. Although some of these streams seem stable and well vegetated, others appear to be eroding their banks at an accelerated rate. Some have been downcut or are in the process of downcutting. A cattle exclosure has been constructed on part of one of these streams (upper Dry Swale Creek). This should help with reestablishment of vegetation and perhaps sediment trapping to help aggrade the stream channel.

Cool Water production for the downstream environment could be enhanced by any management activities which maintain a higher water table in these meadows later into the summer season. A possible method of accomplishing this and also reversing downcutting might be re-introduction of beavers to the area. Dams constructed by beavers could trap sediment, aggrade the channel and detain cool water at the higher elevations for augmentation of late season stream flows. This could help mitigate one of the most serious habitat deficiencies (late season high stream temperatures and low flows) of streams in the Wall Creek system. Alternatively, judicious installation of log weirs/dams in conjunction with more restriction of cattle access might serve a similar function. Even simple introduction of large wood to the stream channel could help, especially if done in conjunction with restriction of cattle access.

B. Amendments to Forest Plan

1. Change of Riparian Management Objective:

Pacfish (appendix C page 3) allows for modifications of Riparian Management Objectives based on local geology, topography, climate, and potential vegetation (generally in the context of a watershed analysis). Given that even after years of riparian logging and grazing, the majority of stream reaches in the Wall Creek drainage still contain more than 30 pieces of large wood per mile, it seems clear that the Wall Creek watersheds are capable of producing at least this quantity. Since more large woody debris would improve fish habitat, a recommendation to upgrade the RMO seems in order. Based on the data available, 30 pieces of large wood per mile should be an easily reached objective over the long term and 40 pieces per mile would be appropriate as an average for a subwatershed. The standard east side PACFISH dimensions of 12 inch minimum diameter and 35 ft minimum length would be appropriate for this wood.

2. Fishing access goals:

The Umatilla National Forest Land and Resource Management Plan (the Forest Plan) states on page 4-8, third paragraph, that "The opportunity to catch fish will have increased" based partly upon "better access from roads." Given the effects of roads upon stream channels and aquatic habitats, plans to construct more roads in or leading to riparian areas does not seem wise. At present and in the foreseeable future, it seems much more likely that best management practices will continue to include reducing the amount of roaded area on the Forest, especially in riparian areas. The Heppner Ranger District has already begun closing and obliterating some roads. It seems appropriate at this point to recommend deletion of the phrase "better access from roads" from page 4 - 8, paragraph three of the Forest Plan.

C. Information management:

1. Development of a mechanism to assure updating stream class and fish distribution information

The quality of an analysis and the effectiveness of management depends very largely upon the quality and accessibility of information to analysts and managers. During the process of this analysis, information in MOSS/GIS on stream class and fish distribution was found to disagree with information received from the Heppner district. Inconsistencies in data from different sources lead to confusion and loss of time in the analysis process and may result in less than best management.

The MOSS/GIS information is probably old and ought to be updated to reflect new knowledge. There does not seem to be any consistent mechanism to ensure regular, frequent updating. Accomplishment of Riparian Management Objectives (and probably most other management objectives) would be furthered over the long run by development of a mechanism to ensure such updating on a regular basis.

2. Linking SMART to MOSS/GIS

It would be very useful for this type of analysis, and probably for management as well, to have the SMART database linked to MOSS/GIS. This would allow procurement of a large amount of geographically specific information from one source. Protocol for making this link is established.

There seem to have been some difficulties in implementing the process. Higher prioritization of the task and better communication between Heppner district personnel and MOSS/GIS personnel at the UNF supervisor's office could probably solve this problem.

3. Data quality control

As reported earlier in this document, the quality of some of the stream survey data (Hoedads Inc., 1993) seems suspect because of misunderstanding on the part of the data gatherers of the concept of cobble embeddedness. It is critical for any scientific investigation that the original data be gathered by knowledgeable persons using techniques and instruments appropriate to the task and which are representative of methodology accepted by the scientific community. If the original data is flawed, the entire analysis will be in question (the old garbage in -- garbage out concept). Selection of field data collectors must ensure qualifications for the specific task. Qualifications for gathering biologic or hydrologic data include several years of college including class work in upper division science classes with field laboratories. For Hankin and Reeves type stream surveys, additional training in the specific techniques is critical as is quality control monitoring of surveyors during the data gathering process.

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Appendix A

Wall Creek Aquatic Habitat Quality Scores

by Stream Reach

Appendix A

Wall Creek Stream Reaches

Habitat Quality Scores

Stream	Reach	Year Surveyed	Watershed	Sub-Watershed	1994 Seven-day Temperature Score	Bankfull Width/Depth Score	Canopy Cover Score
Big Wall Creek			23	c	3.0	na	na
Big Wall Creek	1	1992	24	a	3.0	3.0	3.0
Big Wall Creek	2	1992	24	a	no data	3.0	3.0
Big Wall Creek	3	1992	24	a	no data	3.0	3.0
Little Wilson Creek	1	1993	24	a	no data	2.0	1.0
Big Willow Spring Cr.	1	1993	24	g	no data	1.0	1.0
East Fk Indian Creek	1	1993	24	g	no data	1.0	1.0
Indian Creek	1	1993	24	g	3.0	2.0	2.0
Indian Creek	2	1993	24	g	no data	1.0	2.0
Indian Creek	3	1993	24	g	no data	na	2.0
Dark Canyon	1	1994	24	b	no data	2.0	2.0
Dark Canyon	2	1994	24	b	no data	3.0	1.0
Dark Canyon	3	1994	24	b	no data	2.0	2.0
Dark Canyon Fk	1	1994	24	b	no data	1.0	2.0
Happy Jack Creek	1	1989	24	b	no data	1.0	na
Happy Jack Creek	2	1989	24	b	no data	na	na
Happy Jack Creek	3	1989	24	b	no data	1.0	na
Happy Jack Creek	4	1989	24	b	no data	1.0	na
Happy Jack Creek	5	1989	24	b	no data	1.0	na
Willow Spring Creek	1	1993	24	b	no data	1.0	2.0
Big Wall Creek	4	1992	24	b	no data	1.0	2.0
Big Wall Creek	5	1992	24	c	3.0	3.0	2.0
Grassy Butte Creek	1	1993	24	c	no data	1.0	1.0
Keating Creek	1	1993	24	c	no data	1.0	1.0
Keating Creek	2	1993	24	c	no data	1.0	1.0
South Fk. Big Wall Cr.	1	1993	24	c	no data	2.0	1.0
South Fk. Big Wall Cr.	2	1993	24	c	no data	1.0	2.0
South Fk. Big Wall Cr.	3	1989	24	c	1.0	na	na
South Fk. Big Wall Cr.	4	1989	24	c	1.0	na	na
Colvin Creek	1	1992	24	d	no data	1.0	2.0
Colvin Creek	2	1992	24	d	no data	na	3.0
Porter Creek	1	1993	24	d	no data	3.0	2.0

Appendix A
Wall Creek Stream Reaches
Habitat Quality Scores

Stream	Reach	Year Surveyed	Water-shed	Sub-Water-shed	1994 Seven-day Temperature Score	Bankfull Width/Depth Score	Canopy Cover Score
Bull Creek	1	1991	24	e	no data	na	2.0
Wilson Creek above Bull Prari	1	1991	24	e	3.0	na	2.0
Wilson Creek	1	1990	24	f	3.0	3.0	3.0
Wilson Creek	2	1990	24	f	3.0	na	3.0
Little Wall Creek	1	1993	25	a	no data	3.0	2.0
Lovlett Creek	1	1993	25	a	no data	3.0	2.0
Lovlett Creek	2	1993	25	a	no data	na	3.0
Three) Trough Creek	1	1992	25	a	no data	1.0	3.0
Little Wall Creek	2	1993	25	a,b	3.0	3.0	2.0
Little Wall Creek	3	1993	25	b	no data	2.0	3.0
Squaw Creek	1	1993	25	b	no data	1.0	2.0
Bacon Creek	1	1993	25	c	no data	2.0	2.0
Bacon Creek	2	1993	25	c	no data	1.0	2.0
Skookum Creek	1	1990	26	a	3.0	2.0	na
Skookum Creek	2	1990	26	a	no data	3.0	na
Skookum Creek	3	1990	26	a	3.0	1.0	na
Wildcat Creek	1	1992	26	a	no data	na	2.0
Bear Creek	1	1991	26	b	no data	na	2.0
Little Bear Creek	1	1991	26	b	no data	1.0	2.0
Two Spring Creek	1	1991	26	b	no data	1.0	2.0
Alder Creek	1	1991	26	c	no data	na	1.0
Alder Creek	2	1991	26	c	3.0	na	1.0
Alder Creek	3	1991	26	c	no data	1.0	1.0
East Fk. Alder Creek	1	1993	26	c	no data	1.0	2.0
Skookum Creek	4	1990	26	c	no data	na	na
Skookum Creek	5	1990	26	c	no data	1.0	na
Dry Swale	1	1991	26	d	no data	1.0	2.0
Swale Creek	1	1991	26	d	no data	1.0	na
Swale Creek	2	1991	26	d	3.0	1.0	na
Swale Creek	2	1991	26	d	3.0	na	na
Swale Creek	3	1991	26	d	3.0	na	na
Hog Creek	1	1992	26	f	no data	3.0	2.0

Appendix A

Wall Creek Stream Reaches

Habitat Quality Scores

Stream	Reach	Year Surveyed	Watershed	Sub-Watershed	1994 Seven-day Temperature Score	Bankfull Width/Depth Score	Canopy Cover Score
Hog Creek	2	1992	26	f	no data	na	2.0
Hog Creek	3	1992	26	f	no data	1.0	2.0

Appendix A
Wall Creek Stream Reaches
Habitat Quality Scores

Stream	Reach	Channel entrenchment Score	Substrate Score	Large Wood Score	Fish Cover Score	Pool Frequency Score	Pool Residual Depth Score	Deep Pools score
Big Wall Creek		1.0	no data	na	na	na	na	3.0
Big Wall Creek	1	3.0	1.0	2.0	2.0	2.0	1.0	2.0
Big Wall Creek	2	3.0	1.0	2.0	2.0	2.0	1.0	2.0
Big Wall Creek	3	3.0	3.0	3.0	3.0	3.0	2.0	3.0
Little Wilson Creek	1	2.0	2.0	2.0	2.0	3.0	3.0	3.0
Big Willow Spring Cr.	1	2.0	2.0	2.0	2.0	3.0	3.0	3.0
East Fk Indian Creek	1	2.0	3.0	2.0	2.0	3.0	3.0	3.0
Indian Creek	1	3.0	1.0	2.0	2.0	2.0	3.0	3.0
Indian Creek	2	3.0	1.0	1.0	2.0	2.0	3.0	3.0
Indian Creek	3	3.0	3.0	na	na	na	na	3.0
Dark Canyon	1	2.0	3.0	3.0	1.0	3.0	3.0	3.0
Dark Canyon	2	2.0	2.0	3.0	1.0	3.0	3.0	3.0
Dark Canyon	3	2.0	3.0	3.0	1.0	na	na	3.0
Dark Canyon Fk	1	2.0	3.0	3.0	1.0	3.0	3.0	3.0
Happy Jack Creek	1	3.0	3.0	na	na	na	3.0	3.0
Happy Jack Creek	2	1.0	3.0	na	na	na	na	3.0
Happy Jack Creek	3	3.0	3.0	na	na	na	3.0	3.0
Happy Jack Creek	4	3.0	3.0	na	na	na	3.0	3.0
Happy Jack Creek	5	3.0	3.0	na	na	na	3.0	3.0
Willow Spring Creek	1	2.0	2.0	3.0	2.0	3.0	3.0	3.0
Big Wall Creek	4	2.0	3.0	2.0	2.0	2.0	2.0	3.0
Big Wall Creek	5	2.0	3.0	2.0	2.0	3.0	3.0	3.0
Grassy Butte Creek	1	3.0	3.0	1.0	3.0	3.0	3.0	3.0
Keating Creek	1	2.0	3.0	2.0	3.0	3.0	3.0	3.0
Keating Creek	2	2.0	3.0	1.0	2.0	3.0	2.0	3.0
South Fk. Big Wall Cr.	1	3.0	3.0	1.0	3.0	3.0	3.0	3.0
South Fk. Big Wall Cr.	2	3.0	2.0	2.0	3.0	3.0	3.0	3.0
South Fk. Big Wall Cr.	3	1.0	no data	na	na	na	na	3.0
South Fk. Big Wall Cr.	4	1.0	no data	na	na	na	na	3.0
Colvin Creek	1	2.0	3.0	1.0	3.0	3.0	3.0	3.0
Colvin Creek	2	1.0	3.0	2.0	2.0	na	na	3.0
Porter Creek	1	3.0	1.0	2.0	2.0	2.0	1.0	1.0

Appendix A
Wall Creek Stream Reaches
Habitat Quality Scores

Stream	Reach	Channel entrenchment Score	Substrate Score	Large Wood Score	Fish Cover Score	Pool Frequency Score	Pool Residual Depth Score	Deep Pools score
Bull Creek	1	na	3.0	2.0	2.0	na	1.0	3.0
Wilson Creek above Bull Prari	1	na	3.0	1.0	2.0	3.0	3.0	3.0
Wilson Creek	1	1.0	2.0	1.0	2.0	1.0	2.0	3.0
Wilson Creek	2	1.0	1.0	2.0	2.0	2.0	2.0	3.0
Little Wall Creek	1	2.0	1.0	2.0	2.0	3.0	3.0	3.0
Lovlett Creek	1	2.0	3.0	1.0	2.0	2.0	3.0	3.0
Lovlett Creek	2	1.0	3.0	na	na	3.0	3.0	3.0
Three) Trough Creek	1	2.0	3.0	2.0	2.0	3.0	3.0	3.0
Little Wall Creek	2	2.0	1.0	2.0	3.0	2.0	2.0	1.0
Little Wall Creek	3	2.0	1.0	1.0	2.0	3.0	2.0	3.0
Squaw Creek	1	2.0	1.0	2.0	3.0	3.0	3.0	3.0
Bacon Creek	1	3.0	1.0	1.0	2.0	2.0	3.0	3.0
Bacon Creek	2	3.0	1.0	2.0	2.0	3.0	3.0	3.0
Skookum Creek	1	3.0	2.0	2.0	2.0	2.0	3.0	3.0
Skookum Creek	2	2.0	2.0	2.0	2.0	3.0	3.0	3.0
Skookum Creek	3	2.0	3.0	1.0	2.0	3.0	3.0	3.0
Wildcat Creek	1	3.0	2.0	1.0	2.0	3.0	3.0	3.0
Bear Creek	1	3.0	1.0	2.0	2.0	na	na	3.0
Little Bear Creek	1	2.0	3.0	2.0	2.0	3.0	3.0	3.0
Two Spring Creek	1	3.0	3.0	3.0	2.0	3.0	3.0	3.0
Alder Creek	1	2.0	3.0	2.0	1.0	2.0	2.0	2.0
Alder Creek	2	2.0	3.0	2.0	1.0	3.0	2.0	3.0
Alder Creek	3	2.0	3.0	1.0	1.0	3.0	3.0	3.0
East Fk. Alder Creek	1	3.0	3.0	1.0	1.0	3.0	2.0	3.0
Skookum Creek	4	3.0	1.0	3.0	2.0	3.0	3.0	3.0
Skookum Creek	5	2.0	3.0	2.0	2.0	3.0	3.0	3.0
Dry Swale	1	3.0	3.0	2.0	2.0	3.0	3.0	3.0
Swale Creek	1	2.0	1.0	na	na	na	2.0	3.0
Swale Creek	2	2.0	3.0	na	na	na	2.0	3.0
Swale Creek	2	na	no data	na	na	na	na	3.0
Swale Creek	3	3.0	3.0	na	na	na	na	3.0
Hog Creek	1	2.0	1.0	1.0	2.0	3.0	3.0	3.0

Appendix A
Wall Creek Stream Reaches
Habitat Quality Scores

Stream	Reach	Channel entrenchment Score	Substrate Score	Large Wood Score	Fish Cover Score	Pool Frequency Score	Pool Residual Depth Score	Deep Pools score
Hog Creek	2	1.0	3.0	1.0	3.0	3.0	3.0	3.0
Hog Creek	3	1.0	3.0	1.0	2.0	3.0	3.0	3.0

Appendix B

Wall Creek Stream Data Summaries

by Stream Reach.

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Year Surveyed	Stream Class	Water-shed	Sub-Water-shed	Applicable State or Pacfish Temp std.	1994 (or 93) Seven-day Running Avg. Max. Temp.	Bankfull Width/Depth Ratio
Big Wall Creek			1	23	c	64	77.6	
Big Wall Creek	1	1992	1	24	a	60	80.4	24.40
Big Wall Creek	2	1992	1	24	a	60		22.00
Big Wall Creek	3	1992	1	24	a	60		28.13
Little Wilson Creek	1	1993	2	24	a	64		10.01
Big Willow Spring Cr.	1	1993	3	24	g	68		7.83
East Fk Indian Creek	1	1993	3	24	g	68		8.13
Indian Creek	1	1993	1	24	g	60	83.4	12.77
Indian Creek	2	1993	1	24	g	60		9.35
Indian Creek	3	1993	3	24	g	68		
Dark Canyon	1	1994	1	24	b	60		10.90
Dark Canyon	2	1994	2	24	b	64		15.80
Dark Canyon	3	1994	3	24	b	68		14.00
Dark Canyon Fk	1	1994	4	24	b	68		9.06
Happy Jack Creek	1	1989	3	24	b	68		6.20
Happy Jack Creek	2	1989	3	24	b	68		
Happy Jack Creek	3	1989	3	24	b	68		6.40
Happy Jack Creek	4	1989	3	24	b	68		7.20
Happy Jack Creek	5	1989	3	24	b	68		6.00
Willow Spring Creek	1	1993	3	24	b	68		6.31
Big Wall Creek	5	1992	1	24	c	60	69.1	21.00
Grassy Butte Creek	1	1993	3	24	c	68		7.96
Keating Creek	1	1993	3	24	c	68		7.41
Keating Creek	2	1993	3	24	c	68		8.57
South Fk. Big Wall Cr.	1	1993	1	24	c	60		11.45
South Fk. Big Wall Cr.	2	1993	1	24	c	60		7.95
South Fk. Big Wall Cr.	3	1989	2	24	c	64		
South Fk. Big Wall Cr.	4	1989	3	24	c	68		
Colvin Creek	1	1992	1	24	d	60		5.93
Colvin Creek	2	1992	1	24	d	60		
Porter Creek	1	1993	1	24	d	60		15.28
Bull Creek	1	1991	2	24	e	64		

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Year Surveyed	Stream Class	Water-shed	Sub-Water-shed	Applicable State or Pacfish Temp std.	1994 (or 93) Seven-day Running Avg. Max. Temp.	Bankfull Width/Depth Ratio
Wilson Creek above Bull Prarie	1	1991	2	24	e	64	64.6	
Wilson Creek below Bull Prarie lake		1991	1	24	e	60	75.8	
Wilson Creek	1	1990	1	24	f	60	79.95	35.31
Wilson Creek	2	1990	1	24	f	60	70.3	
Little Wall Creek	1	1993	1	25	a	60		15.39
Lovlett Creek	1	1993	2	25	a	64		18.46
Lovlett Creek	2	1993	2	25	a	64		
Three) Trough Creek	1	1992	1	25	a	60		9.44
Little Wall Creek	2	1993	1	25	a,b	60	69.9	16.82
Little Wall Creek	3	1993	1	25	b	60		10.73
Squaw Creek	1	1993	3	25	b(not a)	68		6.33
Bacon Creek	1	1993	1	25	c	60		13.73
Bacon Creek	2	1993	1	25	c	60		5.77
Skookum Creek	1	1990	1	26	a	60	67.9	12.40
Skookum Creek	2	1990	1	26	a	60		18.50
Skookum Creek	3	1990	1	26	a	60	69.9	8.20
Wildcat Creek	1	1992	2	26	a	64		
Bear Creek	1	1991	1	26	b	60		
Little Bear Creek	1	1991	1	26	b	60		6.60
Two Spring Creek	1	1991	3	26	b	68		5.00
Alder Creek	1	1991	1	26	c	60		
Alder Creek	2	1991	1	26	c	60	66.5	
Alder Creek	3	1991	2	26	c	64		2.00
East Fk. Alder Creek	1	1993	2	26	c	64		5.88
Skookum Creek	4	1990	1	26	c	60		
Skookum Creek	5	1990	1	26	c	60		5.60
Dry Swale	1	1991	1	26	d	60		9.30
Swale Creek	1	1991	1	26	d	60		3.60
Swale Creek	2	1991	1	26	d	60	70.3	2.10
Swale Creek	2	1991	1	26	d		84.2	
Swale Creek	3	1991	3	26	d	68	68.6	
Hog Creek	1	1992	1	26	f	60		20.00

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Year Surveyed	Stream Class	Water-shed	Sub-Water-shed	Applicable State or Pacfish Temp std.	1994 (or 93) Seven-day Running Avg. Max. Temp.	Bankfull Width/Depth Ratio
Hog Creek	2	1992	1	26	f	60		
Hog Creek	3	1992	1	26	f	60		3.50

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Canopy Cover Class	Pools/mile	Channel entrenchment	Dominant Substrate	Subdominant Substrate	Embedded?
Big Wall Creek							
Big Wall Creek	1	1	15.46	s	co	gr	n
Big Wall Creek	2	1	17.47	s	co	co	n
Big Wall Creek	3	1	3.95	s	co	sb	y
Little Wilson Creek	1	4	4.4	m	co	gr	n
Big Willow Spring Cr.	1	4	4.7	m	co	gr	n
East Fk Indian Creek	1	4	3.3	m	co	gr	y
Indian Creek	1	3	16	s	co	gr	n
Indian Creek	2	3	14.1	s	gr	gr	n
Indian Creek	3	3		s	sa	gr	
Dark Canyon	1	3	4.76	m	co	gr	y
Dark Canyon	2	4	5.3	m	co	gr	n
Dark Canyon	3	3		m	sa	co	y
Dark Canyon Fk	1	3	2.45	m	sa	co	y
Happy Jack Creek	1			s	co	gr	
Happy Jack Creek	2			d	co	gr	
Happy Jack Creek	3			s	co	gr	
Happy Jack Creek	4			s	sa	gr	
Happy Jack Creek	5			s	sa	gr	
Willow Spring Creek	1	3	2.41	m	co	gr	n
Big Wall Creek	5	2	4.58	m	co	gr	y
Grassy Butte Creek	1	4	5.5	s	sa	gr	n
Keating Creek	1	4	6.37	m	co	gr	y
Keating Creek	2	4	1.05	m	sa	gr	n
South Fk. Big Wall Cr.	1	4	10.9	s	gr	gr	y
South Fk. Big Wall Cr.	2	3	5	s	co	sb	n
South Fk. Big Wall Cr.	3						
South Fk. Big Wall Cr.	4						
Colvin Creek	1	2	6.7	m	sa	gr	y
Colvin Creek	2	1		d	sa	co	y
Porter Creek	1	2	26.78	s	co	co	n
Bull Creek	1	3			sa	co	y

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Canopy Cover Class	Pools/mile	Channel entrenchment	Dominant Substrate	Subdominant Substrate	Embedded?
Wilson Creek above Bull Prarie	1	3	1.03		sa	co	y
Wilson Creek below Bull Prarie lake							
Wilson Creek	1	1	32.14	d	co	sb	n
Wilson Creek	2	1	27.67	d	co	gr	n
Little Wall Creek	1	2	5	m	co	gr	n
Lovlett Creek	1	3	13.8	m	sa	gr	n
Lovlett Creek	2	1	2.5	d	sa	gr	
Three) Trough Creek	1	1	4.55	m	co	gr	y
Little Wall Creek	2	2	15.4	m	gr	co	n
Little Wall Creek	3	1	8.5	m	co	gr	n
Squaw Creek	1	3	4.1	m	gr	co	n
Bacon Creek	1	3	17.3	s	gr	co	n
Bacon Creek	2	3	5.2	s	co	gr	n
Skookum Creek	1		12.17	s	co	sb	n
Skookum Creek	2		7.23	m	co	sb	n
Skookum Creek	3		6.42	m	lb	lb	n
Wildcat Creek	1	2	6.71	s	co	gr	n
Bear Creek	1	3		s	gr	gr	n
Little Bear Creek	1	3	1.45	m	co	gr	y
Two Spring Creek	1	3	3.2	s	co	co	y
Alder Creek	1	4	28.87	m	gr	sb	y
Alder Creek	2	4	0.54	m	sa	gr	y
Alder Creek	3	4	0.67	m	sa	co	y
East Fk. Alder Creek	1	2	5.61	s	sa	sa	n
Skookum Creek	4		1.85	s	co	gr	n.
Skookum Creek	5		1.27	m	gr	sa	n
Dry Swale	1	2	1.02	s	co	sa	y
Swale Creek	1			m	co	gr	
Swale Creek	2			m	sa	gr	
Swale Creek	2				na	na	
Swale Creek	3			s	sa	gr	
Hog Creek	1	2	3.8	m	co	gr	n

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Canopy Cover Class	Pools/mile	Channel entrenchment	Dominant Substrate	Subdominant Substrate	Embedded?
Hog Creek	2	2	4	d	co	gr	n/y
Hog Creek	3	3	11.8	d	co	gr	y

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Large Wood/mile	Medium Wood/mile	Fish Cover Class	Pool Residual Depth	Pools > 3' Deep Count	Reach Length, miles
Big Wall Creek						na	
Big Wall Creek	1	8.8	15.5	2	3.5	5	0.7
Big Wall Creek	2	10.9	17.5	2	3	6	0.8
Big Wall Creek	3	6.4	4.9	1	2.8	3	1.5
Little Wilson Creek	1	13.4	22.5	2	1.2	0	3.2
Big Willow Spring Cr.	1	10.7	28.4	2	0.9	0	1.9
East Fk Indian Creek	1	14.7	11	2	0.9	0	1.8
Indian Creek	1	13.3	14.5	2	1.3	0	1.5
Indian Creek	2	18.3	22.9	2	1.5	0	3.2
Indian Creek	3					0	1.3
Dark Canyon	1	2	2	4	0.4	0	1.6
Dark Canyon	2	1.5	8	4	0.7	0	3.1
Dark Canyon	3	5.1	0	4		0	0.5
Dark Canyon Fk	1	0	0.8	4	0.3	0	1.6
Happy Jack Creek	1				0.8	0	0.4
Happy Jack Creek	2					0	0.1
Happy Jack Creek	3				1.4	0	0.7
Happy Jack Creek	4				1.4	0	0.7
Happy Jack Creek	5				1.5	0	1.8
Willow Spring Creek	1	10.2	8.8	2	1.1	0	3.4
Big Wall Creek	5	15.1	16.5	2	1.4	0	2.7
Grassy Butte Creek	1	22	26.1	1	1	0	2
Keating Creek	1	7.3	17.3	1	0.9	0	0.6
Keating Creek	2	12.6	43	2	1.8	0	0.7
South Fk. Big Wall Cr.	1	22.9	41.5	1	1.3	0	2.3
South Fk. Big Wall Cr.	2	4.1	21.1	1	1.3	0	2.2
South Fk. Big Wall Cr.	3					0	
South Fk. Big Wall Cr.	4					0	
Colvin Creek	1	39.6	37.2	1	1.1	0	1.2
Colvin Creek	2	15	24.2	3		0	0.8
Porter Creek	1	1.1	23.4	2	3	16	0.9
Bull Creek	1	11.3	22.6	3	3.9	1	2.4

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Large Wood/mile	Medium Wood/mile	Fish Cover Class	Pool Residual Depth	Pools > 3' Deep Count	Reach Length, miles
Wilson Creek above Bull Prarie	1	11.9	29.2	3	1	0	
Wilson Creek below Bull Prarie lake						0	
Wilson Creek	1	33.1	23.1	2	2.3	0	2.2
Wilson Creek	2	7	14.1	2	2.1	0	3.8
Little Wall Creek	1	14.4	23.5	2	1.4	1	5.6
Lovlett Creek	1	17.1	25.3	3	1.5	0	1.3
Lovlett Creek	2				1.5	0	0.4
Three) Trough Creek	1	15.2	17.4	2	0.9	0	1.6
Little Wall Creek	2	13.8	24.2	1	2.5	38	3
Little Wall Creek	3	16.2	24.1	2	1.7	0	2.6
Squaw Creek	1	15	18	1	1.5	0	1.7
Bacon Creek	1	20	28.4	2	1.5	0	1.1
Bacon Creek	2	6.9	15.8	2	1.4	1	4.8
Skookum Creek	1	16.5	16.1	3	1.5	1	2.5
Skookum Creek	2	14.3	19.1	2	1.5	1	4.5
Skookum Creek	3	12.8	32.3	3	0.9	0	1.3
Wildcat Creek	1	38.6	41.9	3	0.6	0	0.7
Bear Creek	1	3.8	17.1	3		0	5.4
Little Bear Creek	1	11.6	18.8	3	0.9	0	3.3
Two Spring Creek	1	4	8	2	1.2	0	2.8
Alder Creek	1	22.6	7.9	4	2.2	7	0.8
Alder Creek	2	20.5	12.4	4	1.6	0	1.7
Alder Creek	3	20	20.9	4	1.3	0	3.2
East Fk. Alder Creek	1	36.7	86	4	1.6	0	3.7
Skookum Creek	4	3.7	14.8	3	1	0	1
Skookum Creek	5	8.9	24.6	3	1.1	0	3.5
Dry Swale	1	8.2	20.9	3	1.1	0	3.3
Swale Creek	1				1.9	0	2
Swale Creek	2				2.7	0	5.2
Swale Creek	2						
Swale Creek	3					0	0.5
Hog Creek	1	72.4	65	2	1.1	0	0.8

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Large Wood/mile	Medium Wood/mile	Fish Cover Class	Pool Residual Depth	Pools > 3' Deep Count	Reach Length, miles
Hog Creek	2	70.8	27	1	1	0	0.5
Hog Creek	3	54.7	33	2	1	0	1.1

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Deep Pools per mile
Big Wall Creek		none
Big Wall Creek	1	7.14
Big Wall Creek	2	7.50
Big Wall Creek	3	2.00
Little Wilson Creek	1	none
Big Willow Spring Cr.	1	none
East Fk Indian Creek	1	none
Indian Creek	1	none
Indian Creek	2	none
Indian Creek	3	none
Dark Canyon	1	none
Dark Canyon	2	none
Dark Canyon	3	none
Dark Canyon Fk	1	none
Happy Jack Creek	1	none
Happy Jack Creek	2	none
Happy Jack Creek	3	none
Happy Jack Creek	4	none
Happy Jack Creek	5	none
Willow Spring Creek	1	none
Big Wall Creek	5	none
Grassy Butte Creek	1	none
Keating Creek	1	none
Keating Creek	2	none
South Fk. Big Wall Cr.	1	none
South Fk. Big Wall Cr.	2	none
South Fk. Big Wall Cr.	3	none
South Fk. Big Wall Cr.	4	none
Colvin Creek	1	none
Colvin Creek	2	none
Porter Creek	1	17.78
Bull Creek	1	0.42

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Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Deep Pools per mile
Wilson Creek above Bull Prarie	1	none
Wilson Creek below Bull Prarie lake		none
Wilson Creek	1	none
Wilson Creek	2	none
Little Wall Creek	1	0.18
Lovlett Creek	1	none
Lovlett Creek	2	none
Three) Trough Creek	1	none
Little Wall Creek	2	12.67
Little Wall Creek	3	none
Squaw Creek	1	none
Bacon Creek	1	none
Bacon Creek	2	0.21
Skookum Creek	1	0.40
Skookum Creek	2	0.22
Skookum Creek	3	none
Wildcat Creek	1	none
Bear Creek	1	none
Little Bear Creek	1	none
Two Spring Creek	1	none
Alder Creek	1	8.75
Alder Creek	2	none
Alder Creek	3	none
East Fk. Alder Creek	1	none
Skookum Creek	4	none
Skookum Creek	5	none
Dry Swale	1	none
Swale Creek	1	none
Swale Creek	2	none
Swale Creek	2	
Swale Creek	3	none
Hog Creek	1	none

Appendix B

Wall Creek Stream Reaches:

Summary of Stream Survey Data

Stream	Reach	Deep Pools per mile
Hog Creek	2	none
Hog Creek	3	none