TABLE OF CONTENTS

1.0 INTRODUCTION....1
2.0 BASIN OVERVIEW....1
3.0 METHODS....3
3.1 Phase I – Geographic Information Systems (GIS) Database & Coverages Development....3
3.2 Phase II – Refinement of Background Information....3
3.3 Phase III – Fish Barrier Field Investigations....3
3.4 Phase IV – Analysis of Field Work and Production of the Final GIS Coverages....4
4.0 RESULTS....4
4.1 Mission Creek Watershed....4
4.2 Peshastin Creek Watershed....5
4.3 Nason Creek Watershed....7
4.4 Lake Wenatchee Watershed....8
4.5 Chiwawa Creek Watershed....8
4.6 Beaver Creek....9
4.7 Squilchuck Creek....9
4.8 Stemilt Creek....9
4.9 Entiat River Watershed....10
4.10 Habitat Surveys - Priority Index....10
5.0 CONCLUSIONS AND RECOMMENDATIONS....11
6.0 LITERATURE CITED....15
APPENDIX 1 – SUB-BASIN MAPS
APPENDIX 2 – CULVERT SURVEY

TABLES

Table 1. Land use classification by subwatersheds in the Wenatchee Basin (acres). 1
Table 2. Habitat conditions reported for streams in the Peshastin Creek basin. 6
Table 3. Habitat conditions reported for streams in the Nason Creek drainage.................................. 7
Table 4. Summary of Priority Index analyses on selected streams. 11
Table 5. Matrix of known occurrence of spawning and rearing for selected salmonid species in some sub-watersheds of Chelan County 12
Table 6. Estimates of resident and anadromous habitat available in watersheds of Chelan County. ……………………………………………………………………………..12
Table 7. Area above barriers for streams in Chelan County and their relative priority ranking 13

FIGURES

Figure 1. Area map depicting Chelan County and associated watersheds. 2

1.0 INTRODUCTION

In response to the Endangered Species Act and recent listings of spring chinook, summer steelhead, and bull trout, Chelan County contracted with Harza/BioAnalysts to prepare an assessment of barriers to fish migration in those areas of the county land base not under federal or state ownership. Chelan County Planning Department has taken a proactive approach in assessing existing habitat conditions. The basis for the inventory was to assess physical barriers that interrupt adult and juvenile salmonid migrations. Persistent blockages to critical spawning and rearing habitat reduce salmonid productivity and may result in loss of salmonid populations.
This work was designed to:

1) Identify problem culverts within the Wenatchee and Entiat watersheds,
2) Evaluate the effectiveness of barrier removal in terms of restored access to fish habitat, and
3) Make a ranking of recommended project areas.

Further, a database was developed into which future survey efforts can be added and mapped in the county's Geographic Information Systems (GIS).

This report describes the methods used to collect this information, describes each of the sub-basins of the Wenatchee and Entiat Basins, identifies problem areas within those subbasins and makes recommendations on any future projects.

2.0 BASIN OVERVIEW

Chelan County is located in the Cascade Province and is primarily montane. Climate on the east slopes of the Cascade mountain range is much drier than the west slopes, accumulating less than 20 inches of precipitation per year. Chelan County stretches from the Colockum Ridge in the south to the North Cascades Highway (State Route 20), from the Cascade Crest east to the Columbia River. The county is comprised of over 2,900 square miles in area, 90% of which is in public lands, largely national forest. The main watersheds of concern within Chelan County include the various systems draining off the Colockum Ridge, the Wenatchee watershed, the Entiat system, and the Lake Chelan area. Because a majority of these last two watersheds are contained within the National Forest, the emphasis of this study was on the Wenatchee Basin and those watersheds in the southeast portion of the county (Fig. 1). Landuse within this area is dominated by forest, range and agricultural lands (Hindes 1994) (Table 1).

Table 1. Land use classification by subwatersheds in the Wenatchee Basin (acres).

Land Use	Peshastin	Icicle	Nason	Lake Wenat	White	Chiwawa	Chumstick	Mission	Mainstem	Total
Urban		66				25	4	772	2,076	2,942
Agricultural	259	725				296	7,001	2,011	8,487	12,478
Rangeland	1,844	9,383	1,491	2,332	8,913	1,937	531	1,405	25,895	53,730
Forest Land	82,102	119,532	66,068	60,494	71,757	110,107	48,679	55,407	122,529	736,676
Water	32	1,303	159	197	322	90			2,868	4,971
Wetland			82	1,704	3,698	770			490	6,744
Barren Land			16	52		10		6	85	169
Tundra	1,962	5,990	507		666	2,978			1,360	19,462
Perennial Snow and Ice	238	198			8,658	3,647				12,742
Total	86,437	137,197	68,322	64,779	100,012	119,861	49,914	59,601	163,790	849,913

Figure 1. Area map depicting Chelan County and associated watersheds.

3.0 METHODS

3.1 Phase I – Geographic Information Systems (GIS) Database & Coverages Development

Existing knowledge of fish distribution and known barriers to fish migration was researched using reports, databases, and personal communication with local resource managers. Much of the information comes from Mullan et al. (1992), a variety of watershed analyses conducted by the US Forest Service, and fish population and habitat studies completed for the Chelan County Public Utility District (PUD). Further habitat and fish production estimates were obtained from the on-line data repository, StreamNet (www.streamnet.org). Water quality conditions were from the Washington Department of Ecology's (WDOE) 1998 list of impaired water bodies (Section 303(d) list). Fish distribution information and hydrology information was obtained from the U.S. Forest Service, Chelan County, and the Washington Department of Natural Resources (DNR).

3.2 Phase II – Refinement of Background Information

Using input and review from the Technical Advisory Committee (TAC; representing State, Federal, County, the PUD, the Yakama Indian Nation, and others), information regarding fish distributions and locations of fish barriers was updated in a one-day workshop. The county provided GIS-generated maps for each of the sub-watersheds in the Wenatchee Basin. Referencing the Harza/BioAnalysts database and institutional information from the TAC, fish distributions and known migration blockages were discussed and verified within the group. Any new information was noted and incorporated into these map layers and the database.

3.3 Phase III – Fish Barrier Field Investigations

The field phase concentrated on those high priority watersheds identified from the initial analysis and County input. Using the 1998 Fish Passage Barrier Assessment and Prioritization Manual (WDFW; revised in August, 2000), Harza/BioAnalysts investigated over 200 culverts in the Mission Creek, Peshastin Creek, Nason Creek, Lake Wenatchee, and Chiwawa Creek watersheds, the Entiat River, as well as within Beaver, Stemilt, and Squilchuck creeks. We did not assess culvert barriers in Chumstick Creek because Mitchell and Lobos (1996) investigated them previously.

Priority areas were those affected streams within Chelan County jurisdiction, i.e. county, city, and private roads and driveways that cross over the stream channel of streams that have or were historically used by anadromous salmonids. We also surveyed some areas where private land was within the borders of the Wenatchee National Forest.

The survey method is designed to be a rapid field assessment of culverts resulting in a rating of "passable", "not passable", or "unknown".

Information collected at each culvert site included:

- Location by GPS,
- Core physical measurements of the culvert pipe (size, shape, material, coating, etc.)
- Is streambed material present throughout culvert?
    - If yes, is the culvert width at least 75% of average streambed toe width?
        - If yes, culvert is not a barrier,
        - If no, Level B analysis required.

- If no material present throughout culvert, is there an outfall drop > 0.8 feet?
  - If yes, the culvert is a barrier, additional measurements not required.
  - If no, is the culvert slope greater than or equal to 1%?
    - If yes, the culvert is a barrier,
    - If no, Level B analysis is required.

Barrier Analysis – Level B

- Collect and record measurements required for hydraulic analysis.
- Compare culvert barrel depth and velocity at the high fish passage design flow to the criteria for adult trout in WAC 220-110-070.

Due to limited field time, few culverts were analyzed at the “level B” analysis, since a high priority of this study was to assess all known culverts within county jurisdiction. Level B analyses of the “unknown” culverts would have added additional weeks of survey work, or would have precluded some areas from any analysis. Our “broad brush” approach was designed to get some information on all areas, rather than more detailed information on a smaller set of areas.

After culvert assessments were completed, a limited number of habitat surveys were conducted in tributaries and mainstem areas of Nason Creek, Beaver Creek, Peshastin Creek, and Chiwawa Creek. Chelan County identified these areas as priority locations of which little habitat information was available. Critical components of this survey effort were to determine:

- Is the area accessible to anadromous salmonids?
- Is there at least 200 meters of available habitat above the barrier?
- Quantity and quality of pool, riffle, and rapid habitats available to anadromous salmonids.
- Limiting Factors (Water Quality, Shading, Habitat Complexity, Spawning Gravel Quality) of the affected stream reach.

3.4 Phase IV – Analysis of Field Work and Production of the Final GIS Coverages

The final report phase (IV) incorporated information from the literature review, TAC review, and fieldwork into the final set of GIS coverages and associated attribute tables. A ranking process of fish barrier sites was conducted on those high priority watersheds identified earlier by the county. A ranked list of potential passage improvement projects, suggested solutions, and approximate cost estimates was generated and is included in the discussion section.

4.0 RESULTS

4.1 Mission Creek Watershed

Mission Creek is a third-order stream that joins the Wenatchee River at river mile (RM) 10.5 (Mullan et al. 1992). Watershed area is approximately 82 square-miles, the upper 78 percent owned by the USFS. The town of Cashmere is sited at the mouth, and the accompanying residential areas and surrounding orchards impact the lower reaches of Mission Creek and its lower tributary stream, Brender Creek (water withdrawals, constrained channels, loss of riparian vegetation, lack of large, woody debris (LWD)). Mullan et al. (1992) was opined that Mission Creek represented one of the worst cases of human influence on a subbasin of the Wenatchee River. Those influences and a predominant Swauk sandstone geology are a major source of sediment delivery to the lower Wenatchee River.

Road crossings over Mission Creek are all bridge structures in the lower reaches (below RM 7.4). However, the Natural Resource Conservation Service (NRCS 1996) noted that temporary irrigation dams downstream of the NFS boundary might inhibit juvenile fish passage. Temporary irrigation dams are formed by streambed material, lumber, sheet metal, concrete and visqueen fabric. One dam 200 feet upstream from Brender Creek would limit rearing area of juvenile chinook salmon in Mission Creek (NRCS 1996).

The lower four miles of Brender Creek was surveyed and was found to contain numerous culvert structures (23) as well as two diversion dams and two flumes. All but three culverts were found to limit fish passage, with most of the culvert pipes undersized for the types of flows associated with this creek. This results in higher velocity flows that in turn impede the upstream passage of fish, especially juveniles. Habitat conditions limit salmonid production due to low flow conditions, high temperatures, and poor spawning conditions (high sediment). Yaxon Creek joins Mission Creek at approximately RM 1.8. The first mile and a half of this small tributary was surveyed, resulting in half a dozen impassable culverts as well as a small falls at the confluence with Mission Creek. Yaxon Creek has been severely modified; its course has been straightened and the riparian zone is dominated by Himalayan blackberry, severely limiting any salmonid production. Surveys conducted by NRCS (1996) found juvenile steelhead/rainbow at the outfall of an impassable culvert at RM 1.0 (just upstream of Yaksum Canyon Road). At low flow, a potential natural falls barrier at the mouth may limit juvenile passage to this stream.

The Mission Creek watershed was included on WDOE’s 303(d) impaired water body list due to high temperatures, lack of instream flow (irrigation withdrawals), high fecal coliform counts, and chemical contaminants (DDT, DDE, Guthion) (WDOE 1998). Downstream from the NFS boundary, fish habitat is limited by infrequent pools, lack of LWD and stream channelization.

4.2 Peshastin Creek Watershed

Peshastin Creek is a third-order stream joining the Wenatchee River at RM 17.6 (Mullan et al. 1992). Watershed area is approximately 133 square-miles, with 82 percent within the National Forest. State Highway 97 runs adjacent the mainstem for most of the watershed length. This impacts the stream particularly in the lower reaches by cutting off historic stream meanders and confining the channel. This in turn causes an increase in stream gradient and erosive power. Coupled with historic mining practices, timber harvest, and forest fires, this watershed carries a heavy load of silts and sand, causing localized flooding, channel shifts, and deposition in the mainstem Peshastin Creek and Wenatchee River (Mullan et al. 1992).

All culvert crossings associated with State Highway 97 along the mainstem Peshastin Creek have been surveyed and those found to be problematic have been scheduled for modification by the Washington Department of Transportation (WDOT). Our efforts concentrated on the county and private road crossings on tributary streams and the lower mainstem of Peshastin Creek.

Stream crossings in the lower four miles of Peshastin Creek are bridges, hence pose no barrier to fish migration, however there are several irrigation diversion structures (RM 2.4, 4.8) that are reported to be barriers to fish migration during late summer and early fall (USFS 1999). The WDFW has identified eleven problem culverts along the mainstem Peshastin, the lowest in the system located at approximately RM 5, near the Mill Creek confluence with Peshastin Creek. The remaining Highway 97 crossings occur along the stretch of Peshastin Creek between Ingalls Creek and Scotty Creek.

Our survey findings found problem culverts in Larson Creek (1), Mill Creek (1), Mundon Canyon Creek (4), Scotty Creek (1), and two unnamed tributary streams (Allen Road and Corcoran Road). The most common problem was the presence of an outfall drop distance greater than 0.8 feet. USFS (1999) designated Larsen, Mill and Mundun Canyon Creek as part of the lower Peshastin fish production unit (FPU). These streams have been classified as transport type channels. That is, reaches are morphologically resilient, high gradient supply-limited channels. They are characterized by bedrock, cascade and step-pool habitats that rapidly convey increased sediment inputs. In the Lower Peshastin FPU, Mill Creek was the only stream that was listed as perennial. Larsen and Mundun Canyon creeks are intermittent streams.

Mill Creek gradient near the mouth is 4 to 8 percent and increases to between 8 and 20 percent in the middle reaches, then steeper in tributary headwaters. The USFS (1999) classified this system as predominantly a transport system. Grazing has been continuous since 1925 and logging continues to the present day. USFS (1999) analysis of aerial photographs revealed road failures in segments of the stream drainage. They also reported that sediment and temperatures continue to be problematic in Mill Creek. A diversion dam in the lower stream decreases summer flow and could influence sediment transport (USFS 1999). The diversion dam was not considered a barrier by the USFS in November 1994 (USFS 1999). The stream has a pool/riffle ratio of 4:95 and contains 15.8 pools per mile (Table 2). Gravel is the dominant substrate and the average bankfull channel width is 10.5 feet. There is an average of 47 pieces of large woody debris per mile and canopy cover is between 50 and 75 percent. Fish cover was 21 to 39 percent effective consisting of overhanging vegetation and instream wood structures. The location of the culvert on Mill Creek is at the mouth and is a substantial barrier to fish passage. One resident along Mill Creek reported he had seen steelhead spawning in the stream about ten years ago. The Forest Service fish distribution map indicates the presence of rainbow trout in Mill Creek.

Table 2. Habitat conditions reported for streams in the Peshastin Creek basin (from USFS 1999).

Habitat Attribute	Mill Creek	Larsen Creek	Scotty Creek
Pools/Rifle Ratio	4:95	12.5:86.5	1:1
Substrate Dominant	Gravel	Sand	Gravel
Substrate Subdominant	Cobble	Cobble	Cobble, sand in upper reaches
Stream Gradient	NA	NA	2%
Embeddedness	NA	NA	8 of 21 sites embedded
Pool Depth	NA	NA	1.2 ft
Bankfull width (average)	10.5 ft	9.7 ft	NA
Stream Cover	NA	NA	45% shrubs and brush
Pools/mile	15.8	NA	66.5
Canopy Cover	50-75%	NA	
LWD/Mile	47	4	60
Stream Temperature	NA	NA	54 F average
Fish Cover	21-39% overhang veg. and wood	NA	40% overhang veg. and wood

Larsen Creek is also a transport system with a gradient of 2 to 4 percent at the mouth. The channel morphology of this creek has been defined by catastrophic events like dam breaks and debris flows. A dominant sand substrate and loss of woody debris (4 pieces/mile) are caused by debris flow scour events (USFS 1999). Sediment from mass failures will continue to be problematic for this system. The average bankfull channel width is 9.7 feet and the pool/riffle ratio is 12.5:86.5 (Table 2). The culvert on Larsen Creek is near the mouth and could limit fish passage. Because this stream is intermittent, rearing and spawning potential would be limited to periods of adequate stream flow.

Mundun Creek is an intermittent stream with limited rearing potential throughout the year. However, a resident in the headwaters reported that flow has been perennial since the fire. Culvert surveys were incomplete on this stream because we could not gain access to private property just upstream from the culvert on Corcoran Road. We suspect that there are other culverts that need surveying.

Scotty Creek is part of the Upper Peshastin FPU. Scotty Creek has been impacted by high road density, timber harvest, and mining. As a result, stream banks are destabilized and the stream has a reduced capacity to dissipate high flows. Scotty Creek has reportedly seen the most impact from mining within the entire Peshastin watershed (USFS 1999). Placer claims run the entire length of the mainstem. We found one culvert that could limit fish passage for cutthroat and rainbow trout that reside in the stream. The stream has a pool/riffle ratio of 1:1 with 66.5 pools per mile. Gravel is the dominant substrate followed by cobble. There are an average 60 pieces of large woody debris per mile and canopy cover is 4 percent. Fish cover was 40 percent provided by overhanging shrubs and brush.

4.3 Nason Creek Watershed

Nason Creek is a third-order stream draining approximately 108 square-miles of the lower Cascade Range. Approximately 78 percent of the watershed is within the Wenatchee National Forest, 28 percent of which is designated wilderness area (Mullan et al. 1992). State Route 2 follows alongside Nason Creek for most of its length as well as a Burlington Northern Railroad right-of-way. Though the construction of these two projects likely impact the channel by constricting the meander pattern and flood run-off, as well as cutting off historic channels, we did not find any problem culverts along the mainstem Nason Creek until it joins Stevens Creek (RM 23). This area is upstream of Gaynor Falls, the furthest upstream extent of anadromy within Nason Creek (Mullan et al. 1992).

We did find problem culverts in many of the tributary streams that drain into Nason Creek (namely, Butcher Creek, Coulter Creek, Mahar Creek, Mill Creek, and others). However, the river valley through which Nason Creek flows is characterized by a fairly wide, flat valley bottom with steep, rugged slopes rising quickly to the mountain ridge. These tributary streams likely serve as important spring and summer rearing areas for steelhead, cutthroat, and bull trout, and perhaps winter refugia during periods of high flow in the mainstem. But, very little spawning habitat is present, and the rearing areas are in high gradient, riffle/cascade dominated stream habitat. The amount of habitat that would be made available to salmonids if the culvert barriers were fixed would not be appreciable. In most of these streams, the length of stream made available would be less than 1,000 feet, before channel gradients increased in excess of 16 percent. Yet, it is likely these culverts adversely affect some populations of bull trout in the Nason Creek system.

Table 3. Habitat conditions reported for streams in the Nason Creek drainage (Dawson et al. 1999). Values are ranges reported for over different reaches unless only one reach was surveyed.

Habitat Attribute	Mill Creek	Coulter Creek	Butcher Creek
LWD/mile	18-56	43-153	399-511
Pools/Mile	19.9-32.6	NA	9.3-36
Percent Pools	2-21%	NA	3-8%
Bankfull Width (ft)	15-30	NA	10

Logging and roads have impacted Butcher Creek. Butcher Creek embeddedness tests were in excess of 35 percent embeddedness. Sand was the dominant substrate in the lower reach and subdominant in the upper reach. Butcher Creek was considered functioning “at risk” for sediment. Butcher Creek was also considered functioning at risk for percent pool habitat (Table 3). Dawson et al. (1999)

reported that road density, an increased drainage network, and disturbance history all function "at unacceptable risk". Riparian reserves also function "at risk" (Dawson et al. 1999).

Coulter Creek has been impacted by roads and timber harvest. No instream data is available for Coulter Creek, though Dawson et al. (1999) considered Coulter Creek poor fish habitat due to a lack of woody debris, pools and shade. Pools were considered functioning at risk.

Mill Creek is considered functioning at risk for sediment and at unacceptable risk for LWD abundance. Mill Creek was judged functioning appropriately for percent pool habitat, though pools tend to be shallow with only 26 pools exceeding 3 feet in depth. Average residual pool depth is 1.8 feet and there is evidence that pools are filling near the gravel pit. Mill Creek is functioning appropriately for eroded banks, with less than 1% of the total stream bank length actively eroding. The rest of the stream has stable banks with abundant vegetation. Mill Creek is further impacted by a high roading density leading to an increased drainage network (Dawson et al 1999).

4.4 Lake Wenatchee Watershed

Lake Wenatchee is an oligotrophic, glacially-fed lake, serving as the source waters for the Wenatchee River (RM 54.2). The White River (RM 58.6) and the Little Wenatchee River (RM 58.6) are the two main tributary streams, entering the lake from the northwest. We surveyed two smaller tributaries along the north shore of the lake, Fall Creek and Barnard Creek, as well as culverts on an unnamed tributary stream to the White River (RM 6.4).

All six culverts in Fall Creek and Barnard Creek serve as barriers to fish migration, due to high gradient and excessive outfall drops. Habitat is limited in these two tributaries due to high gradient areas and summer low flow conditions. These tributaries are typical of the other small streams draining into Lake Wenatchee, providing very little rearing habitat for salmonids.

The lower reaches of both the White River and Little Wenatchee River are characterized by low gradient, meandering channels, with slow, deep pools and short, pebbly riffle habitats. Dominant substrate is sand, though some spawning areas exist for sockeye and kokanee in the lower reaches. Some chinook spawning occurs in the upper area, downstream of a natural waterfall at RM 14.3 on the White River and falls/cascades on the Little Wenatchee at RM 7.8 (Mullan et al 1992). The unnamed tributary stream on the White River had two impassable culverts at RM 0.2 and 0.3, but a natural falls just upstream of the second culvert limits fish migration up this drainage as well.

4.5 Chiwawa Creek Watershed

Chiwawa River is a fourth-order tributary that drains approximately 182 square-miles and enters the Wenatchee River at RM 48.4 (Mullan et al. 1992). Ninety-six percent of the Chiwawa River basin is within the National Forest, thus only a limited number of streams were surveyed for culvert barriers. The Chiwawa River between Phelps Creek and Chikamin Creek has a stream gradient less than one percent (0.32). Downstream to the mouth, the gradient increases somewhat, but remains below 2 percent. The Chiwawa River is almost in pristine condition with few impacted areas. The basin provides important spawning and rearing habitat for spring chinook salmon, steelhead and bull trout (Mullan et al. 1992). We surveyed the lower portions of Clear, Deep, Alder and Minnow Creek. Most sites were located on private holdings.

Clear Creek enters the Chiwawa River at RM 1.6 and is a small second-order stream with an average stream gradient of 3 percent. The culvert on Clear Creek as it crossed Chiwawa Loop Rd. was found to have a slope gradient of nearly 6 percent (5.7%).

Deep Creek enters the Chiwawa River at RM 4.0 and is a second-order stream with an average stream gradient of 26 percent. We found five culverts that exceeded parameters for either slope or outfall drop. These barriers began at the FS 6100 crossing and extend up the stream to a pond adjacent to FS 6102.

Alder Creek is a second-order stream that enters the Chiwawa River at RM 6.9. The average stream gradient is 12 percent and drains about 7 square-miles. One culvert was surveyed on Alder Creek, where it intersects FS 6208. The culvert slope was 3 percent, likely creating a velocity barrier for salmonids.

Minnow Creek is a second-order tributary to Chikamin Creek. The stream enters Chikamin Creek just upstream of FS 62. The culvert at which FS 6210 crosses Minnow Creek (RM 0.4) exceeded limits for both slope and outfall drop.

4.6 Beaver Creek

Beaver Creek is a second-order tributary draining approximately 10 square-miles, entering the Wenatchee River at RM 46.5 (Mullan et al. 1992). Average gradient remains low throughout its range (<2%) and despite its size, it likely serves as important rearing habitat for juvenile chinook salmon, steelhead, and cutthroat trout. Water quality is good, though late-summer flows may limit fish production, due in part to irrigation withdrawals.

Seven road crossings were surveyed within the lower 2.5 miles of Beaver Creek. Chiwawa Loop Road crosses Beaver Creek at RM 0.3. Two culvert pipes carry the flow, though they are undersized and exceed 1 percent gradient, causing migration blockages during high stream flows. Two perched culverts and a diversion dam near RM 2 and an undersized culvert at RM 2.5 further block migration.

4.7 Squilchuck Creek

Not much has been documented about this smaller watershed. Land-use is dominated by agriculture practices, namely orchards, and residential development. Impacts to this stream are similar as that encountered in Mission Creek, i.e. low flow problems during the late summer months, minimal riparian zones, a lack of LWD, and a history of channel modifications and constrictions.

We encountered six problem culverts along this creek, beginning at RM 1.3. Further, at approximately RM 1.9, the stream flows through two concrete flumes, the first extending for nearly 300 meters (over 900 feet long). It is out of the scope of our survey to determine if this structure blocks fish passage, but streambed material was present in only the lower half of the structure. Water velocities in the upper portion of the structure may be too fast for juvenile salmonids. Over nine miles of Squilchuck Creek were surveyed.

4.8 Stemilt Creek

Like Squilchuck Creek, little is known about Stemilt Creek. It has similar habitat problems, i.e. low flows, elevated temperatures, a simplified and channelized stream course, a lack of riparian vegetation, etc. We surveyed the lower seven miles of creek and found only one problem structure at RM 6.5. This box culvert has no natural stream substrate through it and there is an excessive outfall drop (28 cm or 11”) at the downstream end of the structure.

4.9 Entiat River Watershed

The Entiat River basin drains an area of approximately 419 square-miles and is about 90 percent publicly owned (Mullan et al. 1992). A natural barrier at RM 29 is the upstream limit of anadromy. There, the average stream gradient is about 2.3 percent and decreases to less than 0.3 percent downstream from RM 15. The majority of the lower watershed is privately owned, containing an estimated 75 percent of the anadromous salmonid habitat (Bugert et al. 1997). The lower watershed acts as a catchment for sediment upstream. Fire in the last 25 years has burned large portions of the basin and the resulting unstable slopes have probably contributed to the amount of sediment in the lower Entiat River (Bugert et al. 1997). Forest practices have impacted Burns, Preston, Brenegan, and McCree creeks. Forest roads near the stream have contributed to a reduced riparian canopy, less pool habitat, reduced off-channel habitat, and increased fine sediment for Potato, Mud, and Crum watersheds. Perennial streams in the Entiat basin include the N. F. Mad R., Lake, Stormy, Preston, Ice, Snow Brushy, and Mud creeks (Mullan et al. 1992).

Soils in the Entiat River drainage are highly erodable and unstable. When combined with periodic fires, overgrazing, and large runoff events, degraded in-stream habitat has resulted (USFS 1996b). The USFS (1996b) divided the Entiat River basin into three broad areas. The broad areas were categorized as transport, transitional and depositional. The basis for this stratification was to group areas of similar ecosystem function, process and condition by the criteria of percent fine sediment in substrate gravels and land-type association. The areas we surveyed were part of the transitional and depositional zones.

Fish habitat in streams of the transitional zone for all life phases were considered fair to excellent as well as stream channel function, as indicated by instream wood levels. Riparian habitat condition based on LWD recruitment and shade levels were rated as fair to excellent. Examples of streams within the transitional zone include Brennegan, Burns, McCrea, and Preston creeks.

Fish habitat in streams of the depositional zone for all life phases was rated as fair to poor. Accelerated sedimentation, low baseflows, habitat simplification, increased water temperature and human influence were the primary factors that contributed to the degraded fish habitat condition. Examples of streams in the depositional zone include Dill, Mud, Potato and Stormy creeks.

We surveyed the lower portions of eight streams. Most of the culverts surveyed were where the Entiat River Road intersected with tributary streams. The majority of culverts (9 of 11) were considered to be barriers because they exceeded the criteria for slope. Three of the nine were also considered barriers because they had an outfall drop in excess of 0.8 feet. The only culvert measured that was not considered a barrier was on Potato Creek.

4.10 Habitat Surveys - Priority Index

A limited number of streams were surveyed to quantify habitat conditions in the reach directly upstream of specific barrier culverts. Chelan County was asked for a priority list of sub-watersheds in which they wanted more habitat information. They requested we look at tributary streams within Nason, Chiwawa, and Peshastin creeks, as well as Beaver Creek. Fourteen sites were evaluated using the techniques outlined in WDFW (1998). Two hundred meters of stream habitat was measured in terms of pool and riffle habitat dimensions, riparian and instream cover conditions, dominant substrate, and a qualitative rating of spawning and rearing potential (poor, fair, or good/excellent). Channel conditions for reaches further upstream though still accessible to fish, were taken from USGS topographic maps (drainage area and channel gradient). Data were entered into a WDFW-generated spreadsheet program to calculate potential habitat above the barrier. This estimate was then used to calculate the Priority Index number for each of the 14 streams (Table 4).

Table 4. Summary of Priority Index analyses on selected streams.

Stream Name	Sub-Basin	PI - CH	PI - SH	PI - CT	PI - RB	PI -BT	PI Total
Alder	Chiwawa	5.8	3.1	5.4	2.8	2.3	19.3
Beaver	Wenatchee	6.5	3.5	6.1	3.1	2.5	21.7
Coulter	Nason	4.2	2.3	3.9	2.0	1.7	14.1
Crescent	Nason	0.0	1.0	1.7	0.8	0.7	4.2
Larson	Nason	4.1	2.2	3.8	2.0	1.6	13.7
Mahar	Nason	2.5	1.3	2.3	1.2	1.0	8.2
Mill Cr - N	Nason	0.0	2.9	0.0	2.5	2.1	7.5
Mill Cr - P	Peshastin	4.8	2.6	4.5	2.3	1.9	16.1
Minnow Cr	Chiwawa	6.0	3.3	5.7	2.9	2.4	20.3
Mundon Cr	Peshastin	3.0	1.7	2.9	1.5	1.2	10.2
Skinney Cr	Chiwaukum	5.0	2.7	4.7	2.4	2.0	16.9
Stevens Cr	Nason	0.0	0.0	0.0	2.1	1.7	3.8
Trib 915	Nason	1.5	0.8	1.4	0.7	0.6	5.0
Trib 908	Nason	1.7	0.9	1.6	0.8	0.7	5.8

Ch = Chinook, **SH** = Steelhead, **CT** = Cutthroat Trout, **RB** = Rainbow Trout, **BT** = Bull Trout.

The highest ranked streams in this analysis were Beaver Creek, Alder Creek, Minnow Creek, Skinney Creek, and Mill Creek (Peshastin). A similar ranking approach, but encompassing all the culvert sites surveyed is described in the following section.

5.0 CONCLUSIONS AND RECOMMENDATIONS

Given that few field-based habitat surveys have documented current stream conditions within the Wenatchee and Entiat watersheds, a broad-based prioritization of culvert improvement projects was created, based on the criteria outlined in WDFW (1998). This prioritization of barrier correction in Chelan County is based heavily on the presence of ESA-listed species within a sub-watershed and the potential increment of habitat gain with each barrier correction. We used four tiers to qualify our selection. On the first tier, we placed tributaries of the Chiwawa, Nason, and Entiat basins because each watershed supports spawning for summer steelhead, bull trout and spring chinook (Table 5). On the second tier, we placed Peshastin Creek because spring chinook are not as abundant here as in those watersheds on the first tier. On the third tier we placed Mission Creek due to steelhead presence. On the last tier, we placed the minor tributaries draining directly to the Wenatchee River.

Table 5. Matrix of known occurrence of spawning and rearing for selected salmonid species in some sub-watersheds of Chelan County (Information from Mullan et al 1992; Dawson et al. 1999; Hillman and Miller 1997; Chapman et al. 1994; USFS 1999).

	Spring Chinook		Steelhead		Bull Trout		Cutthroat Trout	
Stream	Spawning	Rearing	Spawning	Rearing	Spawning	Rearing	Spawning	Rearing
Entiat River	X	X	X	X	X	X	X	X
Mission Creek			X	X			X	X
Peshastin Creek	X	X	X	X	X	X	X	X
Nason Creek	X	X	X	X	X	X	X	X
Chiwawa River	X	X	X	X	X	X	X	X

Next, we weight those basin tributaries against the increment of habitat gain and potential production in a system (Table 6).

Table 6. Estimates of resident and anadromous habitat available (Mullan et al. 1992) in watersheds of Chelan County. Steelhead production potential for watersheds of the Wenatchee Basin calculated by WDFW (1999) reported as the number of 1+ parr. Smolt density model reported by StreamNet for spring chinook salmon and steelhead.

	Anadromous Habitat		Resident Habitat		Potential Production	Spring Chinook	Steelhead
Stream	Miles	Acres	Miles	Acres	Number of 1+ Parr	Numbers of Smolts	Number of Smolts
Entiat River	46	308	117	199	-	-	-
Mission Creek	-	15	-	23	34,072	-	2,552
Peshastin Creek	-	58	-	88	63,782	6,793	7,676
Nason Creek	-	106	-	158	51,191	346,960	28,918
Chiwawa River	40.2	195	-	-	75,126	334,951	41,286
Little Wenatchee River	-	52	-	132	6,731	53,910	8,742
Icicle Creek	-	32	-	170	NA	23,782	4,445
White River	-	115	-	186	24,030	123,053	18,048

Finally, we ranked the top 25 culvert corrections in increments of five (Table 7). This selection was based on biological criteria only and may have to be adjusted for jurisdictional or financial considerations. That is, some corrections may have a greater financial burden than several corrections combined or a cooperative effort by several entities would share the financial burden. This would be particularly pertinent for those corrections to culverts on private lands that are accessed by Forest Services roads. A cost-sharing program may be advantageous to all involved parties. Of those select streams surveyed this past summer and assigned a high Priority Index number, nearly all of them received a high ranking in this latter process. Beaver Creek was the only area not given a high rating. This is largely due to the lack of information about Beaver Creek in the existing literature and reports, and likely will move up in importance as more information is gathered.

Table 7. Area above barriers for streams in Chelan County. Ranking of culvert correction in increments of five up to 25 corrections.

Subbasin	Stream	River Mile	Culvert Measures (m)			Problems	Subbasin Area Above Barrier (mi²)	Top 5	Top 10	Top 15	Top 20	Top 25
			Width	Height	Length							
Squilchuck	Miners Run Cr	1.5	1.77	1.77	57.0	Slope, Outfall Drop	Neglible					
	Miners Run Cr	1.6	1.74	1.74	27.2	Outfall Drop	Neglible					
	Pitcher Cyn Cr	0.1	2.95	2.26	14.7	Outfall Drop, Slope	5.8					
	Squilchuck Cr	1.3	1.16	1.16	6.2	Slope, Velocity	20.0					
	Squilchuck Cr	2.9	2.00	2.00	9.2	Slope	13.3					
	Squilchuck Cr	5.6	2.50	2.50	16.4	Outfall Drop, Slope	7.8					
	Squilchuck Cr	5.8	2.50	2.50	28.1	Outfall Drop	6.4					
	Squilchuck Cr	7.9	2.90	2.90	43.9	Slope, Velocity	2.0					
	Squilchuck Cr	8.2	1.80	1.80	23.3	Outfall Drop, Slope	1.3					
Stemilt	Stemilt Cr	6.5	3.70	1.93	13.3	Outfall Drop, Slope	6.2					
	Orr Cr	0.1	2.10	2.10	11.7	Outfall Drop, Slope	8.3					
	Orr Cr	0.7	1.21	1.21	17.9	Outfall Drop, Slope	3.5					
Entiat	Brennegan Cr	0.2	1.80	1.03	13.00	Slope	4.9	1	1	1	1	1
	Burns Cr	0.1	0.91	0.91	10.50	Slope, Outfall Drop	2.3				1	1
	Dill Cr	0.2	0.63	0.63	12.10	Slope	0.1					
	McCree Cr	0.1	1.77	1.19	11.60	Outfall Drop, Slope	2.0			1	1	1
	Mud Cr	0.9	1.92	1.12	11.60	Slope	21.7	1	1	1	1	1
	Preston Cr	0.1	2.64	0.64	11.05	Slope	6.9			1	1	1
	Preston Cr	0.2	2.82	2.82	21.70	Slope	6.8			1	1	1
	Stormy Cr	0.2	1.85	1.10	14.70	Outfall Drop, Slope	9.0					1
	Stormy Cr	0.7	0.60	1.08	6.50	Outfall Drop, Slope	8.7					1
	Stormy Cr	0.9	1.15	0.72	6.60	Outfall Drop, Velocity	8.6					1
Beaver Cr.	Beaver Cr.	0.3	0.73	0.73	8.23	Velocity, Slope	10.0				1	1
	Beaver Cr.	0.3	0.63	0.63	8.62	Velocity, Slope	10.0				1	1
	Beaver Cr.	1.9	0.93	0.93	1.30	Outfall Drop, Slope	9.0				1	1
	Beaver Cr.	2.0	1.18	1.18	6.50	Outfall Drop, Velocity	8.8				1	1
	Beaver Cr.	2.5	1.12	1.12	6.40	Velocity, Slope	8.0					1
Chiwawa	Alder Cr.	0.9	1.76	2.30	10.60	Slope, Velocity	4.3	1	1	1	1	1
	Clear Cr.	0.5	0.60	0.60	10.80	Slope, Velocity	3.7		1	1	1	1
	Deep Cr.	0.4	0.60	0.60	12.60	Slope, Velocity	2.8					
	Deep Cr.	0.8	0.46	0.46	7.50	Slope, Velocity	2.5					
	Deep Cr.	1.0	0.90	0.90	12.30	Outfall Drop, Depth	2.7					
	Deep Cr.	1.5	0.90	0.90	8.40	Slope, Velocity	1.5					
	Deep Cr.	2.0	0.32	0.32	6.10	Outfall Drop	Negligible					
	Deep Cr.	2.0	0.45	0.45	7.40	Outfall Drop	Negligible					
	Goose Cr.	0.4	0.60	0.60	8.30	Velocity, Slope	2.3					
	Goose Cr.	0.5	0.93	0.93	12.50	Slope, Velocity	2.2					
Chikamin Cr.	Minnow Cr.	0.4	1.40	1.40	16.00	Outfall Drop, Slope	2.6	1	1	1	1	1
Chiwaukum Cr.	Skinney Cr.	1.5	1.90	1.40	10.90	Outfall Drop, Velocity	7.0					1
Nason Cr.	Butcher Cr.	0.1	0.60	0.60	11.80	Outfall Drop, Velocity	1.4		1	1	1	1
	Coulter Cr.	0.4	1.07	0.72	9.40	Outfall Drop	4.3			1	1	1
	Coulter Cr.	0.4	0.45	0.45	0.00	Outfall Drop, Slope	4.3			1	1	1
	Crescent Cr.	0.2	3.05	2.15	28.50	Outfall Drop, Slope	0.6					
	Mahar Cr.	0.1	1.23	1.23	7.60	Slope, Velocity	1.7					
	Mill Cr.	0.1	3.00	3.00	0.17	Outfall Drop	8.8	1	1	1	1	1
	Nason Cr.	23.0	1.50	1.50	18.00	Slope	3.1					
	Nason Cr.	23.0	1.55	1.55	18.00	Slope	3.1					
	Nason Cr.	23.0	1.50	1.50	18.00	Slope	3.1					
	Unnamed trib.	0.2	1.30	0.77	8.80	Outfall Drop	0.3					
White	Unnamed trib 1	0.3	0.62	0.62	7.25	Slope	1.2					
	Unnamed trib 2	0.2	0.96	0.96	9.12	Slope, Velocity	0.1					

Table 7. (continued)

Subbasin	Stream	River Mile	Culvert Measures (m)			Problems	Subbasin Area Above Barrier (mi²)	Top 5	Top 10	Top 15	Top 20	Top 25
			Width	Height	Length							
Lk. Wenatchee	Barnard Cr.	0.1	0.92	0.92	6.18	Outfall Drop, Slope	0.3					
	Barnard Cr.	0.1	0.64	0.64	19.50	Slope, Velocity	0.3					
	Barnard Cr.	0.1	0.40	0.40	11.70	Slope	0.3					
	Fall Cr.	0.1	0.62	0.62	12.30	Slope, Velocity	0.2					
	Fall Cr.	0.1	0.62	0.62	19.80	Outfall Drop, Slope	0.2					
	Fall Cr.	0.1	0.30	0.30	5.00	Slope, Velocity	0.2					
Peshastin	Larson Cr.	0.1	0.90	0.90	0.00	Velocity, Depth	3.1		1	1	1	1
	Mill Cr.	0.1	1.55	1.25	15.05	Outfall Drop	5.5		1	1	1	1
	Mundon Cyn Cr	0.1	0.93	0.93	0.00	Outfall Drop	2.1					
	Mundon Cyn Cr	0.2	0.92	0.92	13.20	Outfall Drop, Velocity	2.0					
	Mundon Cyn Cr	0.8	0.62	0.62	13.00	Outfall Drop, Slope	1.6					
	Mundon Cyn Cr	0.9	0.72	0.72	12.70	Outfall Drop, Velocity	1.5					
	Unknown trib 1	0.1	0.48	0.48	11.70	Outfall Drop	0.1					
	Unknown trib 2	0.1	0.95	0.95	13.50	Outfall Drop, Slope	0.1					
	Scotty Cr.	1.6	1.52	1.52	8.55	Depth, Slope	2.7		1	1	1	1
Mission	Brender Cr.	0.1	1.24	0.60	7.47	Outfall Drop, Velocity	9.5					
	Brender Cr.	0.1	1.25	1.25	25.90	Velocity, Depth	9.5					
	Brender Cr.	0.2	1.25	1.25	43.89	Velocity, Slope	9.4					
	Brender Cr.	0.9	0.92	0.92	21.95	Velocity	9.1					
	Brender Cr.	1.5	1.17	1.17	6.03	Depth	8.7					
	Brender Cr.	1.7	0.75	0.75	7.55	Velocity, Depth	8.6					
	Brender Cr.	1.8	1.13	0.90	7.60	Outfall Drop	8.4					
	Brender Cr.	2.1	0.75	0.75	17.40	Outfall Drop, Velocity	8.3					
	Brender Cr.	2.6	0.90	0.90	29.60	Velocity, Slope	8.0					
	Brender Cr.	2.7	0.80	0.80	5.18	Velocity, Depth	7.5					
	Brender Cr.	2.9	0.60	0.60	14.30	Velocity	7.3					
	Brender Cr.	3.1	0.88	0.88	15.40	Velocity	7.3					
	Brender Cr.	3.2	0.70	0.70	5.18	Velocity, Slope	7.3					
	Brender Cr.	3.2	0.97	0.97	19.35	Outfall Drop, Depth	7.3					
	Brender Cr.	3.3	0.76	0.76	15.58	Velocity, Depth	7.1					
	Brender Cr.	3.4	0.70	0.70	4.27	Slope, Velocity	6.5					
	Brender Cr.	3.6	0.65	0.65	7.90	Slope, Velocity	6.5					
	Brender Cr.	3.6	1.20	1.20	3.81	Velocity, Depth	6.4					
	Brender Cr.	3.7	0.47	0.47	14.37	Velocity	6.4					
	Brender Cr.	3.8	0.40	0.40	2.65	Depth, Velocity	5.2					
	Yaxon Cr.	0.1	0.49	0.49	8.54	Slope, Velocity	4.6					
	Yaxon Cr.	0.1	0.56	0.31	0.00	Outfall Drop	4.6					
	Yaxon Cr.	0.1	0.30	1.00	0.73	Outfall Drop	4.6					
	Yaxon Cr.	0.1	0.35	0.35	23.20	Velocity, Slope	4.6					
	Yaxon Cr.	0.2	0.61	0.61	10.66	Slope, Velocity	4.5					
	Yaxon Cr.	0.5	0.61	0.61	30.48	Slope	4.4					
	Yaxon Cr.	0.8	0.90	0.90	24.60	Slope, Velocity	4.1					
	Yaxon Cr.	1.1	0.90	0.90	0.00	Slope, Velocity	4.0					
	Yaxon Cr.	1.3	0.00	0.00	0.00	Depth, Velocity	3.9					
	Yaxon Cr.	1.5	0.50	0.50	12.92	Depth, Velocity	3.8					
	Yaxon Cr.	1.6	0.25	0.25	5.10	Outfall Drop, Velocity	3.6					
Lower Wenatchee	Anderson Cr.	0.1	0.78	0.78	0.00	Outfall Drop	1.7					
	Anderson Cr.	0.2	0.90	0.90	20.50	Outfall Drop, Slope	1.6					
	Derby Cyn Cr.	0.8	0.91	0.91	0.00	Outfall Drop, Velocity	13.3					
	Derby Cyn Cr.	0.8	0.96	0.96	6.20	Depth, Velocity	13.3					
	Derby Cyn Cr.	1.1	0.74	0.74	5.90	Slope, Velocity	12.8					
	Posey Cr.	0.5	0.95	0.95	21.60	Outfall Drop, Velocity	1.4					

6.0 LITERATURE CITED

Anderson, D. 1989. Smolt Density Model. System Planning Group.

Bugert, R. M., D. Bambrick, L. LaVoy, S. Noble, B. Cates, K. MacDonald, S. Carlon, S. G. Hays, J. Lukas, and P. Archibald. 1997. Aquatic species and habitat assessment: Wenatchee, Entiat, Methow and Okanogan watershed, Mid-Columbia mainstem conservation plan, DRAFT. Chelan, Douglas and Grant County Public Utility District.

Bugert, R., D. Bambrick, L. LaVoy, S. Noble, B. Cates, K. MacDonald, S. Carlon, S. Hays, J. Lukas, P. Archibald, K. March, K. Bauersfield, and S. Bickford. 1998. Aquatic species and habitat assessment: Wenatchee, Entiat, Methow, and Okanogan Watersheds-FINAL. Chelan County Public Utility District Number 1.

Chapman, D. W., A. E. Giorgi, T. W. Hillman, C. Peven, and F. M. Utter. 1994. Status of summer steelhead in the mid-Columbia River. Don Chapman Consultants, Inc.

Dawson, P., D. Driscoll, J. Haskins, E. Johnson, C. Raekes, and D. Rife. 1999. Biological assessment for steelhead, spring chinook, bull trout and westslope cutthroat trout in mainstream Wenatchee watershed. Baseline condition and effects of ongoing activities, including grazing and recreation, effective January 1999.

Heath, R. 1995. Mission Creek Watershed. Wenatchee National Forest.

Hillman, T. W., and M. D. Miller. 1997. Abundance and total numbers of chinook salmon and trout in the Chiwawa River Basin, Washington, 1996. BioAnalysts.

Hindes, R. 1994. Wenatchee river watershed ranking project/watershed characterization and ranking report. Chelan County Conservation District.

Mitchell, G. A., and R. A. Lobos. 1996. Chumstick stream survey & flood damage assessment. USDA/NRCS.

Mullan, J. W., K. R. Williams, G. Rhodus, T. W. Hillman, and J. D. McIntyre. 1992. Production and habitat of salmonids in mid-Columbia River tributary streams. U. S. Fish and Wildlife Service, Monograph #1.

US Forest Service. 1996a. Nason Creek watershed analysis, Lake Wenatchee Ranger District. Forest Service, Wenatchee National Forest w/ appendices.

US Forest Service. 1996b. Watershed Assessment Entiat Analysis Area. Wenatchee National Forest. USDA Forest Service.

US Forest Service. 1999. Peshastin watershed assessment. Wenatchee National Forest.

Washington Department of Fish and Wildlife. 1998. Fish passage barrier assessment and prioritization manual. Washington Department of Fish & Wildlife Habitat and Land Services Program. Salmon screening, habitat enhancement, and restoration (SSHEAR) Division. Washington Department of Fish and Wildlife.

Washington Department of Fisheries and Wildlife. 1999. Wenatchee subbasin rainbow/steelhead parr production model.

Wenatchee River Watershed Steering Committee. 1996. Wenatchee river watershed ranking report addendum, Technical Supplement 1/DRAFT. Chelan County Conservation District.

Washington Department of Fish and Wildlife. 1998. Washington state salmonid stock inventory-Appendix bull trout and Dolly Varden. Washington Department of Fish and Wildlife.

Appendix 1

Sub-Basin Maps

Appendix 2

Culvert Survey