Snoqualmie Wildlife Area Fish Retrofit

Habitat and Lands Services Program
Salmonid Screening, Habitat Enhancement
and Restoration (SSHEAR) Division

Submitted by

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ABSTRACT

The Department of Fish and Wildlife manages over 840,000 acres, to preserve, protect and perpetuate the state's valuable fish and wildlife resources (RCW 75.08.012, RCW 77.04.055, RCW 77.12.010). In order to maximize accessibility to these lands and other areas for all citizens, several hundred Department of Fish and Wildlife Access Areas have been constructed. Due to the increasing interest of the agency and public in factors affecting fish resources, the Salmonid Screening, Habitat Enhancement and Restoration Division (SSHEAR) initiated an inventory of all fish passage structures (e.g culverts, dams, fishways, lake screens) and unscreened irrigation diversions on agency lands. Potential habitat gain was assessed for features identified as fish passage barriers.

A priority index for order of inventory was calculated for each wildlife area according to the ranking of four separate factors: the number of estimated fish passage problems, fish species status (potential ESA listings or at-risk SASSI stock status), species mobility (resident and/or anadromous fish species), and interest (high profile fish passage issues of public concern). Based on this prioritization the Snoqualmie Wildlife Area and Region 2 Access Areas were selected for the pilot study.

Fish passage barriers alone prevented access to 4,130 square meters and 4,092,185 square meters of spawning and summer rearing habitat, respectively. These barriers were prioritized based on proportion of potential passage improvement, annual adult equivalent production potential per square meter, habitat gain, species mobility, species condition, and a cost modifier. The unscreened water diversions were prioritized based on flow, species mobility, species condition and cost.

If the Snoqualmie Wildlife Area is an indication of the problems with fish passage structures and unscreened water diversions that exist on Department of Fish and Wildlife owned or managed land, there are many corrections that need to be made on the wildlife and access areas. For example, with the Snoqualmie Wildlife Area and Region 2 Access Areas combined, 33% of the culverts (15 of 45), 75% of the dams (3of 4), 100% of the fishways (2), 67% of the lake screen structures (2 of 3) and 100% of the water diversions (1) were partial or total barriers and/or unscreened. To compliment the state salmonid recovery effort, the problem features should be corrected as soon as possible.

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INTRODUCTION

Over the past 58 years, the Washington Department of Fish and Wildlife (WDFW) has purchased approximately 840,000 acres of Wildlife Area sites, scattered throughout almost every county in the state. Due to the increasing interest in fish passage issues, the Habitat and Lands Services Program initiated an inventory of fish passage barriers and water diversions on all state owned and managed lands (Appendix I). The Salmonid Screening, Habitat Enhancement and Restoration Division was assigned this task which began with the Snoqulamie Wildlife Area and Region 4 Access Areas. The purpose of the inventory is to document and prioritize for correction all fish passage problems including culverts, dams, lake screens and water diversions to ensure compliance with Washington State laws (Appendix II). All diversions from waters of the state should be screened to protect fish and all flow control and fish passage structures are to be constructed to provide unobstructed fish passage.

Salmonids of the Pacific Northwest have long been impacted by structures installed in streams incorrectly or with no regard to the salmonid life cycle. Every year thousands of juvenile salmonids are killed when they enter malfunctioning or completely unscreened water diversions, by mutilation from a pump turbine or being stranded in irrigation canals as the irrigation season comes to a conclusion. Culverts, dams, and abandoned lake outlet screens also have a very detrimental impact on salmonid populations. When these facilities result in a barrier to fish migration, spawning and rearing habitat become inaccessible.

Each year more of these structures become barriers to fish migration. Watersheds are continually being altered (e.g. development, logging, roads etc.) which substantially influences the hydraulic dynamics of the watershed. Culverts, fishways, lake outlet screens, and water diversions that were once designed for a defined annual flow, are now incapable of managing the increased flow. Culverts become velocity barriers and eventually scour huge plunge pools that in most circumstances result in large outfall drops. Even hydraulic drops less than one foot are a potential barrier to chum and juvenile salmonids. Recent studies have unveiled that these small hydraulic drops can limit juvenile production by rendering valuable rearing habitat unreachable. Screened water diversions begin impinging salmonids, either killing them or carrying them into the diversion system.

In cooperation with other Habitat and Lands Services Program staff, SSHEAR staff designed a Wildlife Area Scheduling Index to organize the inventory. To establish the scheduling index of wildlife areas, a questionnaire was designed to collect information on the number of known fish passage problems, stock status, stock mobility, and high profile fish passage issues of public interest. This enabled SSHEAR staff to gain the knowledge and expertise of Wildlife Area and Access Area Managers. In December of 1997, the questionnaire was mailed to all Regional Lands Coordinators, Wildlife Area Managers and Access Area Managers. After the index was calculated for each area (Appendix III), they were stratified according to the time of year in which the inventory could be accomplished. Eastern areas will be scheduled in the spring and summer months and the western areas will be inventoried in the fall and winter months. The Snoqualmie Wildlife Area ranked the highest and was chosen as the pilot wildlife area.

SITE DESCRIPTION

The Snoqualmie Wildlife Area is located in King and Snohomish counties of western Washington. A total of six different units (Cherry Valley, Corson, Crescent Lake, Ebey Island, Spencer Island and Stillwater) comprise the 1,982-acre wildlife area. The majority of the units are within the Snoqualmie River or Snohomish River flood plains (Figure 1).

Cherry Valley Unit

The Cherry Valley Unit is located one mile north of Duvall on SR 203, lies within the Snoqualmie River flood plain and is approximately 386 acres (Figure 2). The property was purchased in 1908 by Carnation Farms to convert to dairy land. Most of the property was cleared, but it was too wet for premium dairy land. Over the years the property has changed ownership on numerous occasions, but has always been used as pasture or crop land. The property was purchased in 1974 by WDFW to primarily provide public land for waterfowl and pen-reared pheasant hunting, dog training, and other wildlife oriented recreation. The land is leased to farmers for grazing and grass silage production. About 50 acres of natural wooded swamp and 50 acres of wooded hillside remain.

There are about 15 small human-made ponds and several streams that drain through Cherry Valley Unit. The streams flow off the southern hillside and directly into a main drainage ditch. It is through this main ditch that increased numbers of chinook, coho, steelhead, and resident species would access additional spawning and rearing habitat upstream of the Cherry Valley Unit if barriers and unscreened water diversions were corrected. Flooding is common between October and March with a maximum depth of up to 21 feet, which provides excellent winter rearing habitat. During higher flow periods the water is slowly pumped back into Cherry Creek to maintain water levels within the Cherry Valley (Snoqualmie Wildlife Area Management Plan, 1995).

Crescent Lake Unit

The Crescent Lake Unit is located one half mile west of Highway 203 and about 3 miles south of Monroe (Figure 3). The unit lies within the Snoqualmie River flood plain and is approximately 360 acres. It was logged around the turn of the century and roughly 110 acres are currently farmland. Two dairy farms used the area until the early 1960's. The property was purchased by WDFW in 1974 to provide public land for waterfowl and pen reared pheasant hunting and other wildlife oriented activities. The area is currently sharecropped with a portion of the crop left standing for wildlife utilization. The Department of Corrections is one sharecropper and in exchange for the lease, about 140 acres of their land is available to the public for hunting.

Chinook, coho and resident species use the available rearing habitat in the Crescent Lake system. The heavy beaver activity in the area poses potential fish passage problems by reducing rearing habitat (Snoqualmie Wildlife Area Management Plan, 1995).

Stillwater Unit

The Stillwater Unit is located almost 3 miles north of Carnation (Figure 4). The 456-acre property was logged and cleared by the 1920's. Since then, it has been used as farmland. The property was purchased by WDFW in 1970 to provide more public land for waterfowl and released pheasant hunting, and other wildlife oriented activities. Other uses include fishing, dog training, and nature observation. This unit is currently farmed by sharecroppers which leave a portion of the crops standing for wildlife habitat. Each of the fields are 20-40 acres and edged with heavy brush (Snoqualmie Wildlife Area Management Plan, 1995).

Harris Creek is the main stream that flows through the Stillwater Unit. Chinook, coho and resident species are able to take full advantage of the excellent summer rearing habitat. There are also several backwater sloughs and other small tributaries. Though very little summer rearing habitat is available in these sloughs and small tributaries, winter floods usually inundate 20 to 70 percent of the property, creating excellent winter rearing habitat if accessible.

Corson Unit

The Corson Unit is located approximately 2 miles off Highway 9 north of Lake Stevens (Figure 5). The property is roughly 160 acres of lowland habitat. The property was logged in the 1950's and later gifted to WDFW in 1976 for wildlife enhancement and public recreation. In the past, volunteer groups have cleared alder and brush and planted almost four acres of mixed evergreen trees. Seven acres is cultivated for barley by a contract farmer. The gift deed required vegetative manipulation to enhance wildlife and to provide for public use of the property (Snoqualmie Wildlife Area Management Plan, 1995).

The previous land owner constructed one-acre and eight-acre ponds for increased waterfowl habitat. The ponds do not have anadromous access or a significant habitat gain downstream for resident salmonids. The only other water on the property is Catherine Creek, which runs through the northeast corner of the property and in the near past had a run of coho salmon.

Ebey Island Unit

The Ebey Island Unit is located between Everett and the town of Snohomish and consists of two parcels (Figure 6). These properties were acquired in 1964 for unpaid taxes. One of the parcels is 417 acres and the other is 3.5 acres. The smaller unit is grasslands, while the larger is second growth timber. Some habitat alteration was done by Diking District #1 when the borrow ditch for the dike was realigned. The ditch was widened as much as 120 feet in some places, providing excellent waterfowl habitat. The property is protected from the influence of the Snohomish River by a dike, but is occasionally inundated by a five-year flood event. A large variety of wildlife use the area including waterfowl, songbirds and furbearers. Currently there is no legal public access to either parcel, as they are landlocked on three sides by private land, and the diking district owns the dike on the slough side (Snoqualmie Wildlife Area Management Plan, 1995).

This area is one of the few remaining “natural” wooded swamps in the Snohomish estuary. A large pump station and dike along Ebey Slough maintains the water level on the island. The dike makes the Ebey Unit inaccessible to anadromous salmonids and very poor habitat quality for resident fish that might enter during flood events. The water is classified as a type 9.

Spencer Island Unit

The Spencer Island Unit is located 3 miles northeast of Everett in the Snohomish River Delta (Figure 7). WDFW purchased 174 acres of the northern portion of the island in 1989 with Duck Stamp money. At the same time Snohomish county purchased the other 238 acres with DNR conservation funds. A memorandum of understanding has been developed with Snohomish County Parks and Recreation Division to co-manage the island. The island was probably diked and cleared in the 1920's and was used for cattle grazing until 1988. The earthen dike was enlarged between 1969 to 1978 by hauling in thousands of yards of hog fuel (wood chips). The end of the fill can be seen at the property boundary of the WDFW and County properties. There are roughly 50 acres of alders and the remaining property is covered with reed canary grass. Evergreen blackberries are widely spread along the dike.

In 1993 a 2,200-foot cross levee was built on the southern most portion of the island. Breaches in the dike and cross levee were designed to maintain a regular tidal influence on the WDFW end of the island and to completely top the levee if a five-year flood event were to occur. This was accomplished with the installation of two five-foot culverts fitted with baffles for velocity control to allow fish passage. The outer dike on the southern end of the island, which is county owned, is breeched in three places. This creates about 50 acres of tidally influenced wetlands which provide summer rearing and acclimation habitat for chinook, coho and steelhead. The water level in the northern end of the island, which is WDFW property, is controlled by two flow control structures that protrude through the outer dike to Union and Steamboat Slough. This causes about half of the 300 acres north of the cross levee to be flooded with a maximum water depth of 3 feet. The tidally flooded property is ideal for waterfowl, shorebirds, and many other animals. A large body of water with a stable level and an unpopulated shoreline is a critical habitat in short supply in the region (Snoqualmie Wildlife Area Management Plan, 1995).

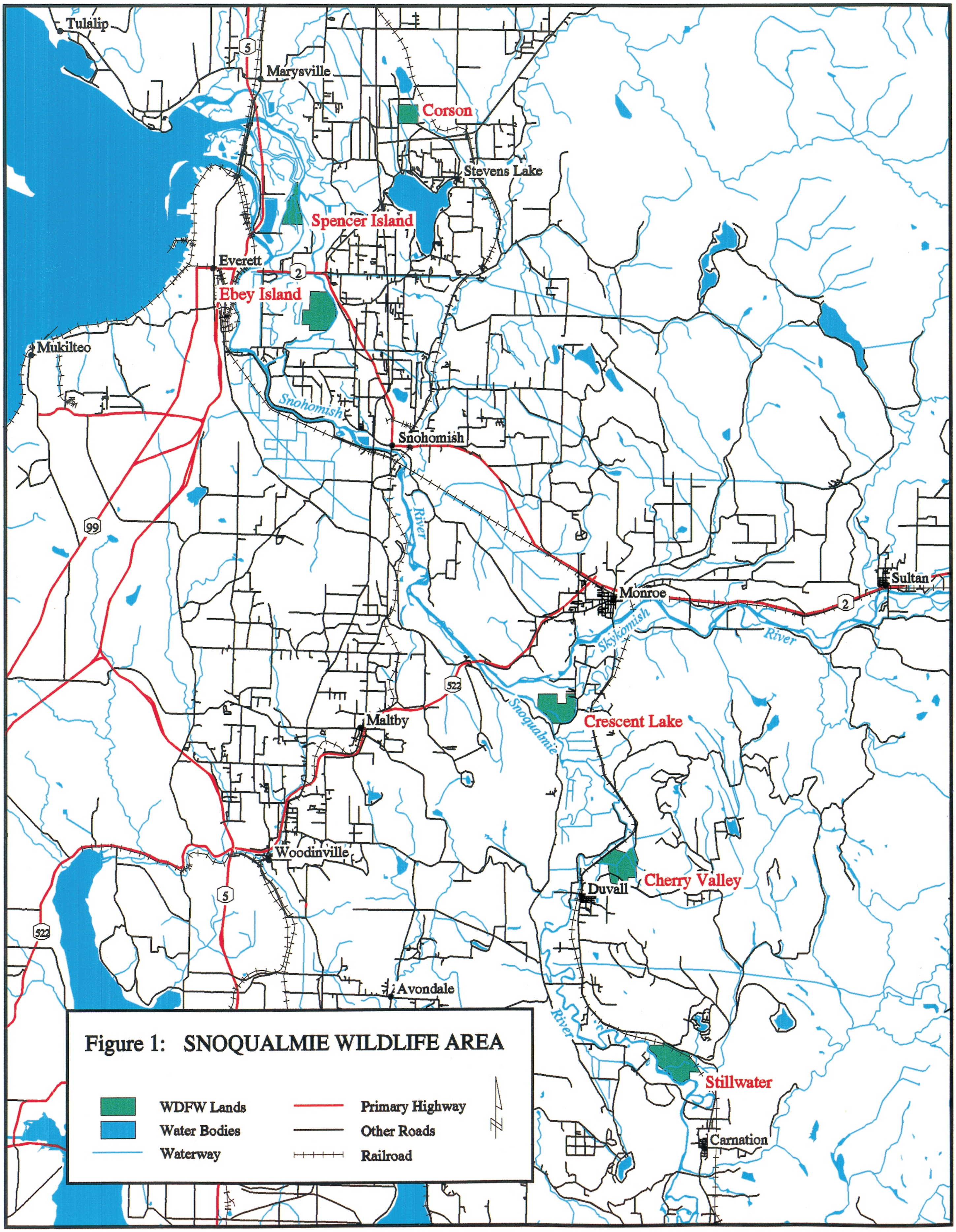


Figure 1: SNOQUALMIE WILDLIFE AREA

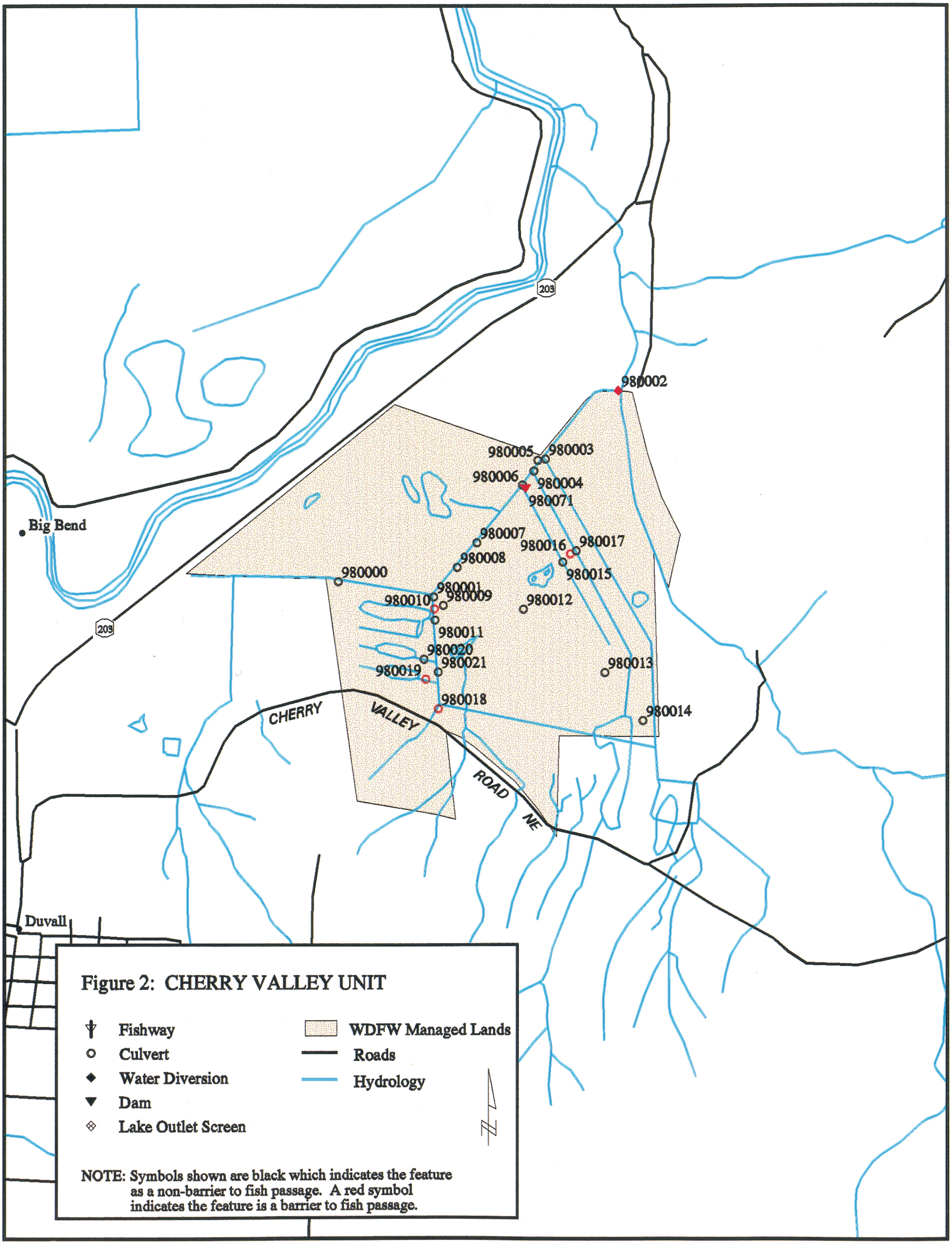


Figure 2: CHERRY VALLEY UNIT

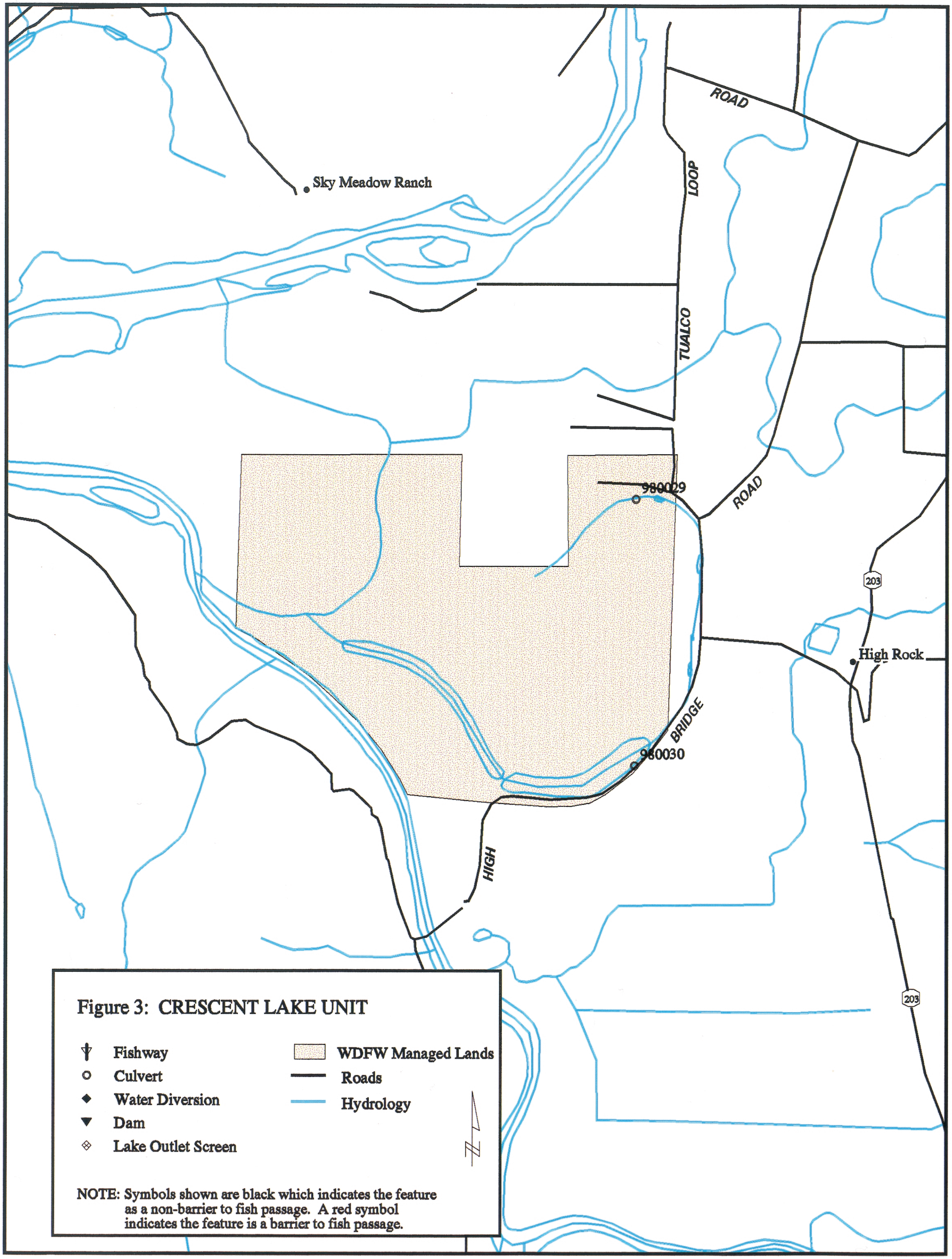
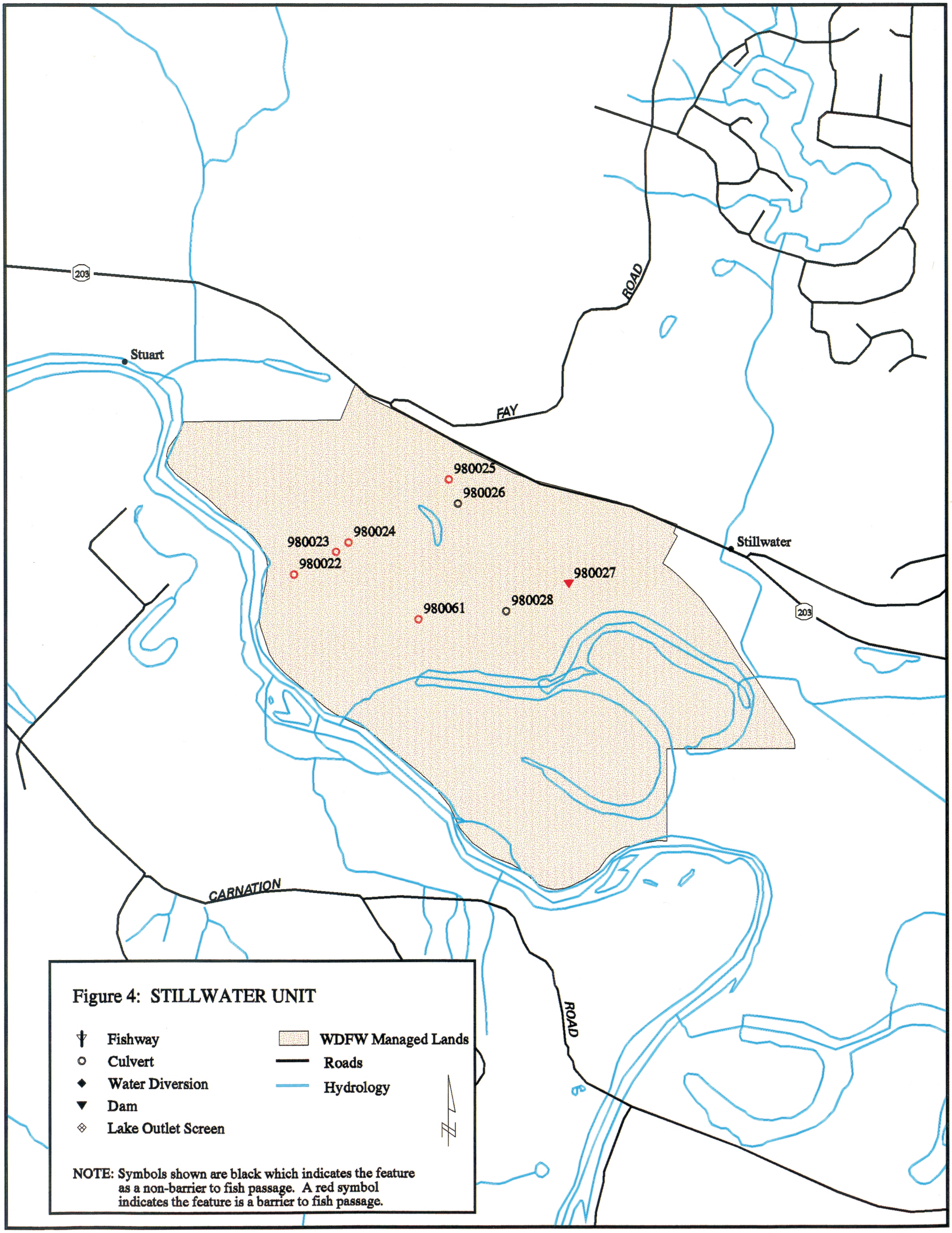


Figure 3: CRESCENT LAKE UNIT



203
Stuart
ROAD
FAY
980025
980026
980023
980024
980022
980027
980028
980061
Stillwater
203
CARNATION
ROAD
Figure 4: STILLWATER UNIT
Fishway
Culvert
Water Diversion
Dam
Lake Outlet Screen
WDFW Managed Lands
Roads
Hydrology
NOTE: Symbols shown are black which indicates the feature as a non-barrier to fish passage. A red symbol indicates the feature is a barrier to fish passage.

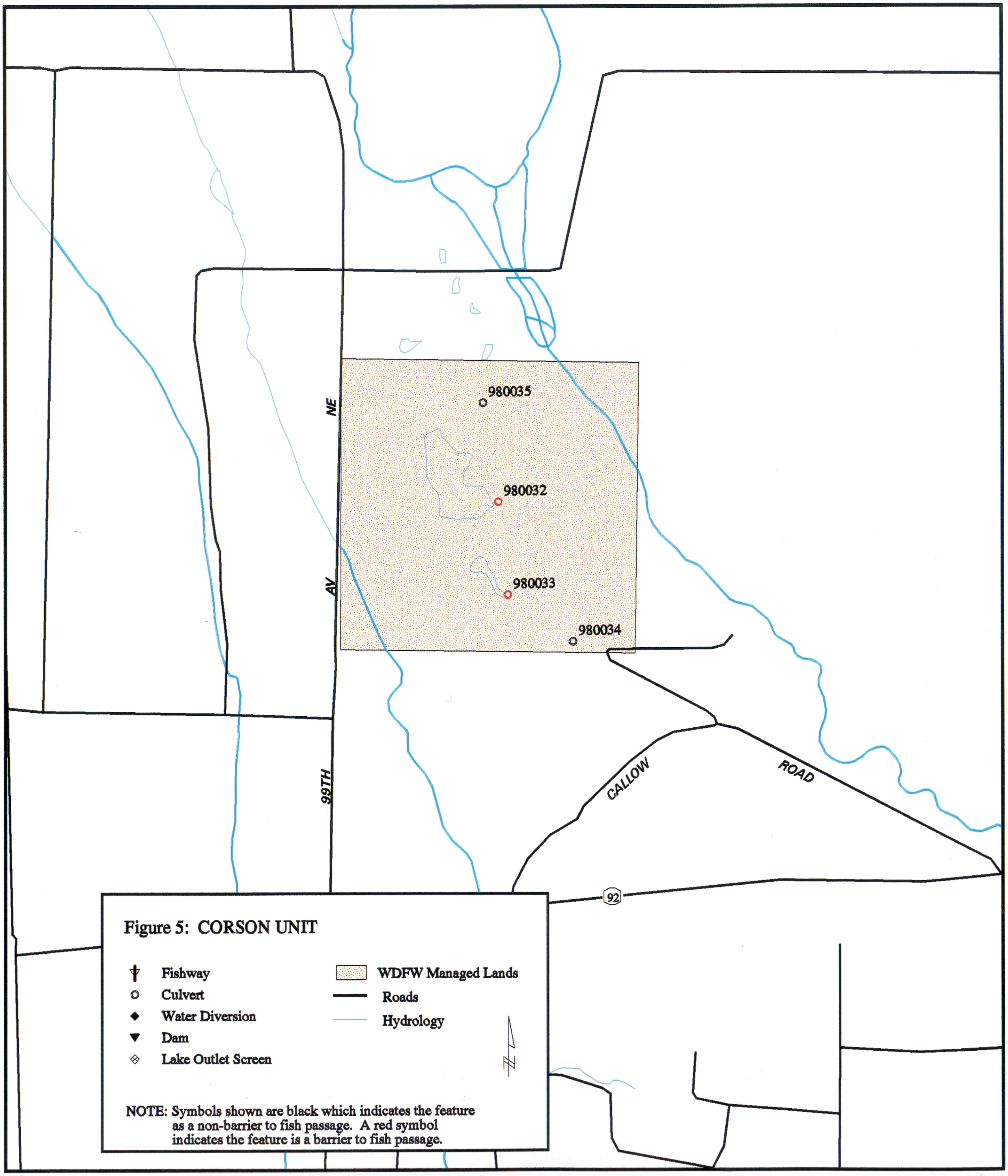
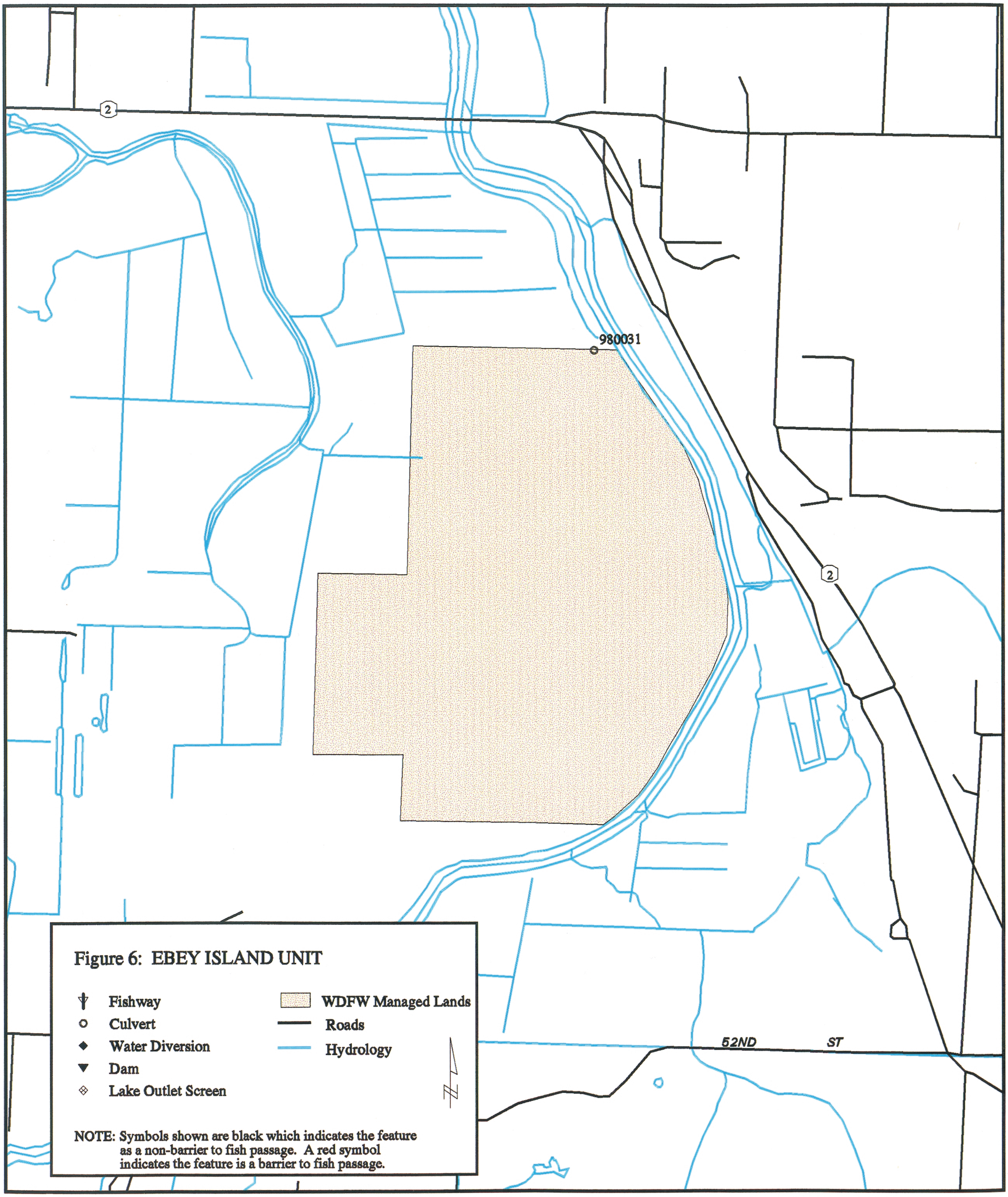
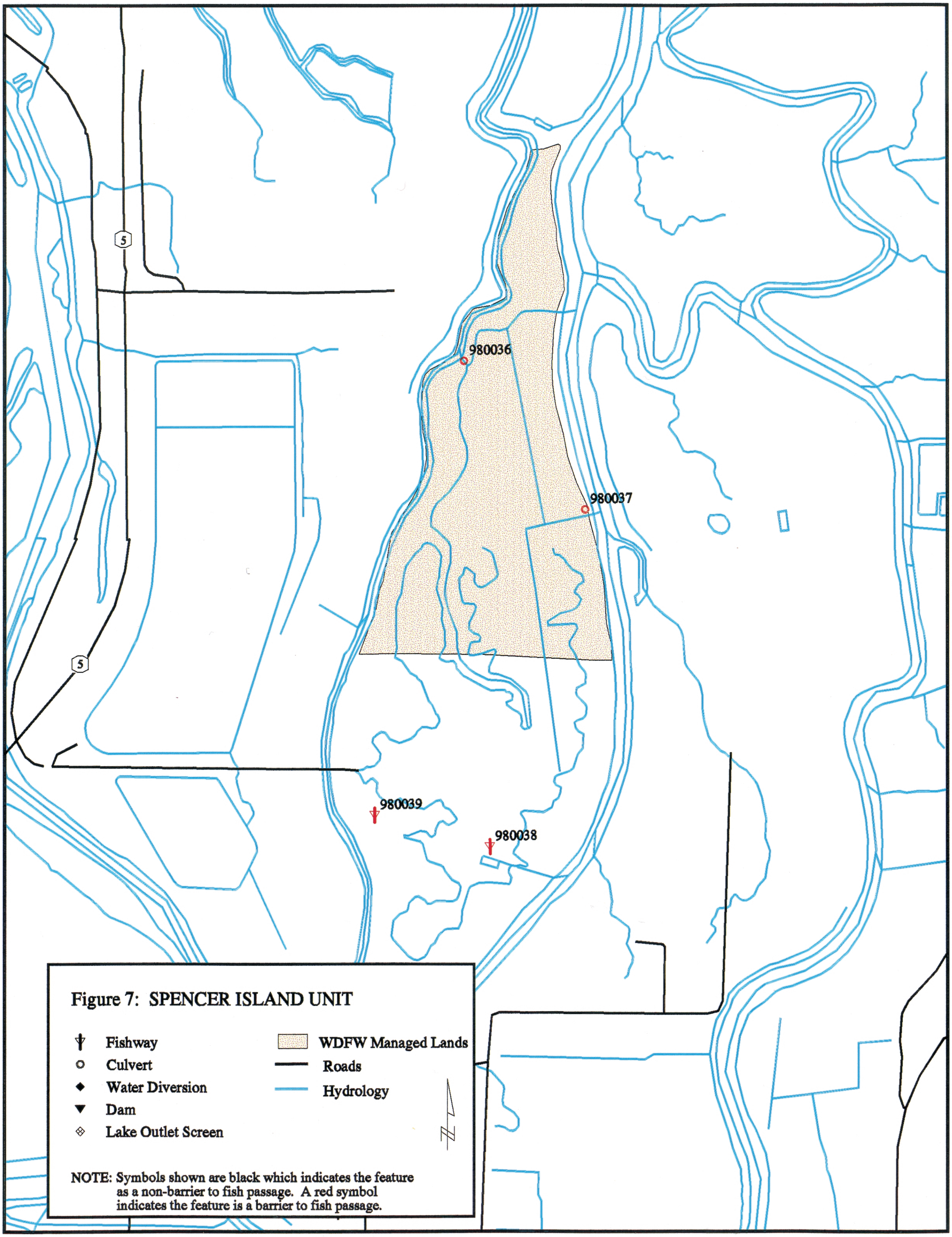


Figure 5: CORSON UNIT


2
980031
2
52ND ST
Figure 6: EBEY ISLAND UNIT
Fishway
Culvert
Water Diversion
Dam
Lake Outlet Screen
WDFW Managed Lands
Roads
Hydrology
NOTE: Symbols shown are black which indicates the feature as a non-barrier to fish passage. A red symbol indicates the feature is a barrier to fish passage.



5
5
980036
980037
980039
980038
Figure 7: SPENCER ISLAND UNIT
Fishway
Culvert
Water Diversion
Dam
Lake Outlet Screen
WDFW Managed Lands
Roads
Hydrology
NOTE: Symbols shown are black which indicates the feature as a non-barrier to fish passage. A red symbol indicates the feature is a barrier to fish passage.

METHODS

Inventory

The Wildlife Area Manager guided the inventory crew to every culvert, dam, fishway, water diversion and lake outlet screen on each unit. In doing so, the structure locations were mapped and evaluated at a later date. The next step was to locate all other potential crossings. This was accomplished by overlaying the Department of Natural Resources hydrology and transportation layers with the use of Arc Info Software. The field crew was then able to search the exact location for potential crossings. In addition to predicting crossing locations, the field crew walked all streams on the wildlife area for any other potential features. All features encountered during the initial inventory, that were on fish bearing or non fish bearing streams, were inventoried**.** Approximately 50% of the time, the inventory crew were able to drive to each targeted crossing. Due to the vast amount of lowland/wetland habitat within the Snoqualmie Wildlife Area, the other 50% of the features needed to be approached by foot or canoe.

Feature Evaluation

Once a feature was located, the evaluation began with recording the site information (Appendix IV). Using a Trimble Pro XR GPS Receiver equipped with a TDC2 data logger, latitude and longitude were recorded for mapping purposes. All positional data were differentially corrected using Trimble's Pfinder software and base files obtained from the Thurston County community base station. All streams were located and, if possible, identified by name and/or Water Resource Inventory Area (WRIA) using U.S.G.S quadrangle maps (1:24000), a DeLorme Atlas of Washington State (DeLorme Mapping 1992), The Thomas Guide (Thomas Bros. Maps 1989), and the Catalog of Washington Streams and Salmon Utilization (Williams et al. 1975). Fish species presence was determined using the Washington State Salmon and Steelhead Stock Inventory (WDF et. al.1992), the Washington Department of Fish and Wildlife Salmonid Stock Inventory Bull Trout and Dolly Varden Appendix (1997), the Wildlife Area Manager, and the Regional Fish Biologist.

Features on non-fish bearing streams required minimum data collection: date, time, survey crew, and potential fish use. Non-barrier culverts, on fish bearing streams, required an intermediate level of data collection, adding to the minimum level: culvert shape, material, interior treatment, diameter, and length. Additionally, any maintenance needs were noted. Barriers on fish bearing streams required the maximum level of data collection that included numerous other measurements of the culvert and surrounding area (Appendix IV).

The water diversions that were encountered were evaluated for screening needs or if screened, if they met current screening requirements (Appendix V). The data collected for gravity diversions and pump diversions, revolved around the cost and feasibility of screening (i.e. flow, size, access) (Appendix IV). If a dam or lake outlet structure (e.g. lake level control or lake screen) was a barrier to fish passage, we recorded all feature specifications: the crest length, which is defined as the total horizontal distance measured along the axis of the dam at the elevation of the top of the dam between abutments or ends of the dam; dam height, which is defined as the vertical distance between the lowest point of the dam crest and the streambed elevation (Inventory of Dams in the State of Washington, Department of Ecology, 1994); and other data (Appendix IV). The passability with all these features varies with flows, tidal influence, and species. All of these factors and more have to be taken into account. A complete description of all the attributes and values are described in Appendix IV.

Feature dimensions were measured in English units, utilizing a Mound City stadia rod (Model 43623). Slope measurements were calculated using a laser from Laser Tech Inc. (Model Impulse 200) mounted on a Bogen Manfrotto monopod (Model 3218). Velocity readings were calculated using a Marsh-McBirney, Inc. FLO-MATE (Model 2000). All data were recorded using a Trimble Pathfinder Pro XR outfitted with a TDC2 data logger. The data were uploaded from the TDC2 data logger to the base computer and converted to ASCII files via Trimbles Pfinder Software and later imported into Paradox for management.

Downstream Check

The purpose of the downstream check was to determine if the barrier was physically accessible to anadromous salmonids or if a significant quantity of resident salmonid habitat existed immediately downstream. Anadromous salmonid access was verified by walking downstream to a point known to be free of barriers or until a natural barrier was encountered. All human-made barriers were considered repairable and evaluated, and the survey continued. If a permanent natural point barrier was present (vertical drop of >12 feet) or the stream gradient exceeded 12% for 161 meters (continuous), the barrier was considered to be inaccessible to anadromous species. For resident salmonids, a significant habitat reach must be at least 200 meters in length, have a gradient <20% (or < 16% if the channel width is less than 2 feet wide at ordinary high water) and be free of other natural point barriers.

If there was no anadromous salmonid access or significant resident salmonid habitat below the barrier, no further evaluation was conducted. Fish passage repairs would not be warranted since there would be insignificant gain in habitat or fish production. Conversely, verifying anadromous access or a significant resident reach downstream of a barrier established the need to measure potential habitat gains upstream.

Physical Habitat Surveys

The physical survey provides the data to estimate the potential habitat gains upstream of the human-made barrier. At a minimum, a significant habitat reach as described above must exist upstream of the barrier to justify repair. The physical survey methodology is described in detail in Appendix VI and is briefly summarized below.

Prior to beginning the survey, the length of the stream was estimated from U.S.G.S. quadrangle maps (1:24,000), to determine the appropriate sampling frequency. For streams less than 1.6 kilometers (1 mile) in length, protocol called for sampling 30 meters of habitat every 161 meters (one-tenth mile). For streams greater than 1.6 kilometers, it was necessary to sample 60 meters every 322 meters. This method resulted in a 20% sampling level. Habitat surveys proceeded from the barrier and continued upstream until encountering a natural point barrier or gradient in excess of 20% which continued for more than 161 meters (or a gradient in excess of 16% which continued for 161 meters if the channel width was less than 2 feet). Streams were broken into reaches based on changes in channel morphology including gradient, bed form, channel size and tributary flow. The physical characteristics of the stream, such as the lengths, wetted widths, ordinary high water widths and average depth of riffles and pools were measured to the nearest 1/10 meter using a Mound City stadia rod, Forest Supplies Inc. belt chain and Sokkia fiberglass measuring tape. Stream gradient was measured using the Impulse 200 by Laser Tech. Water temperature was recorded to the nearest degree centigrade with a Taylor Pocket thermometer (Model 21410-1) and flow measurements were calculated using the Marsh-McBirney FLOW-MATE. Canopy composition, percent cover, instream cover, juvenile fish abundance (a visual estimate of fry densities) and a subjective evaluation of habitat quality were recorded for each reach. Any additional human-made salmonid passage impediments were evaluated.

Expanded Threshold Determination

When complete physical habitat surveys were not practical, an expanded threshold determination (ETD) was conducted to estimate the amount of habitat upstream of a barrier. This methodology requires the verification of a significant reach and a physical habitat survey within the first 200 meters upstream and downstream of the barrier. Stream widths measured in the survey are extrapolated throughout the watershed via the following process. Using a U.S.G.S. quadrangle map (1:24,000), the stream is divided into reaches based on gradient and tributaries contributing at least 20 percent of the flow. The watershed area is calculated for each reach and the percentage of the total watershed area associated with each reach is used to reduce the stream widths. For example, if the riffle width in the sample reach (reach one) is four meters and the watershed area of reach two is 75% of reach one (the total watershed), then the riffle width assigned to reach 2 would be three meters (4m x 0.75). The pool, riffle, and rapid ratios and substrate composition assigned to each reach are taken from tables of averages derived from historical WDFW physical survey data. Values are assigned based on reach gradient and general location (eastern vs western Washington). These derived habitat measurements are then used to calculate potential habitat gain.

This method does not identify or verify the presence of additional human-made or natural barriers or assess habitat quality outside the sample area. Since the gradient or reach breaks are derived from maps, natural point or gradient barriers to fish migration may be misinterpreted, resulting in over or under estimation of potential habitat gain.(S. Cierebiej-Kanzler and M. Barber, Washington Department of Fish and Wildlife, personal communications).

Data Analysis

Physical habitat survey data are used to estimate habitat gains in terms of fish production potential. Habitat gain is expressed in square meters of either spawning or summer rearing habitat. These values are key variables in the Priority Index Model (described below) which is used to prioritize barrier correction. Spawning area is used for those species (chum, pink, and sockeye salmon) whose production is limited by spawning habitat. Summer rearing area is used for those species (coho and chinook salmon, steelhead, cutthroat, rainbow, bull, brook, and brown trout) whose production is limited by rearing habitat.
Physical habitat survey data were processed in a customized spreadsheet which generated a detailed report for each stream surveyed. The reports contain the total habitat gain per species, habitat measurements for each stream reach and the total survey, habitat quality information, and other fundamental survey data.

Spawning area was calculated as the sum of the areas of each habitat type, measured at ordinary high water, multiplied by the gravel percentage in each habitat type. Widths at ordinary high water are determined during the survey using the bank vegetation line and other hydrologic evidence.

Rearing area was calculated using a projected 60-day low flow. Sixty-day low flow is defined as the lowest average flow occurring over any period of 60 consecutive days during the year. The 60-day low flow methodology is described in detail in Appendix VII. The entire stream area calculated using the 60-day low flow is considered rearing area. This methodology allows comparison of rearing areas regardless of the season in which the stream was surveyed (Bates, et al., 1995).

Both the spawning and rearing areas can be adjusted by a Habitat Quality Modifier, which is a subjective estimate of habitat quality. It has a value which ranges in increments of from zero to one. A separate modifier is assigned to each habitat type within each stream reach. This modifier serves to decrease the habitat areas in degraded streams to reflect the lower production potential.

Gains in spawning or rearing area are calculated for each species (potential presence) for each sample reach within a survey. Reach values are then subjected to an analysis of species interaction. Competition between species with similar freshwater life histories tends to reduce the production rate below single species production values. For example, optimum single species productivity for two species within the same complex (coho and steelhead) is estimated at 0.05 and 0.0021 adults/m^2 respectively. If the single species values are added, a total production value of 0.0521 is the result. To adjust for competition within species complexes, the species complex factor was developed to reduce multiple species production values below the simple total of individual values.

Species Complex Factor (CF) = production value species 1 + 0.66 (production value species 2) + 0.33 (production value species 3) / production value species 1 + production value species 2 + production value species 3

In the case of coho and steelhead the species complex production value would be reduced from 0.0521 to 0.0514 or [*0.0521 x (0.05+0.66(0.0021)/0.05+0.0021)*].

In practice, the species complex factor is used to reduce the habitat area (H) used in the Priority Index formula. The habitat area value is adjusted on a reach by reach basis for each species present. In the case where coho and steelhead use the same stream reach the total rearing area available would be multiplied by the species complex factor [H = habitat gain (m^2) x *(0.05+0.66(0.0021)/0.05+0.0021)*]. The adjusted habitat values for each reach are summed and used to calculate single species PI values using the full single species adult production value. This is similar in effect to adjusting the adult production value. However, it is more sensitive to changes in species composition throughout a drainage.

Barrier Priority Index

The variety in costs, amounts of habitat gain, and species utilizing potential project sites throughout Washington State can make the characterization and prioritization of corrections to fish passage barriers complex. The WDFW Fish Passage Inventory process uses a Priority Index model (Bates, et al., 1995) to consolidate the many factors which affect a project's feasibility (expected passage improvement, production potential of the blocked stream, fish stock health, etc.) into a manageable framework for developing prioritized lists of projects. The result is a numeric indicator giving each project's relative priority that includes production benefits to both anadromous and resident salmonid species adjusted for sympatric species interactions (species complexes). The Priority Index (PI) for each barrier is calculated as follows:

$$PI = \sum_{all\ stocks} \sqrt[4]{[(BPH)\ x\ MDC]}$$

Where:

PI = Priority Index

- Relative project benefit considering cost.
- The PI is actually the sum ($\sum_{all\ species}$)of individual PI values, one of which is calculated for each species present in a stream (e.g., PI_{coho} is added to PI_{chum} to obtain $PI_{all\ species}$).
- The quadratic root in the equation is used because it provides a more manageable number and represents a geometric mean of factors used.

B = **Proportion of passage improvement**

- Proportion of fish run expected to gain access due to the project (passability after project minus passability before project); gives greater weight to projects providing a greater margin of improvement in passage.

P = **Annual adult equivalent production potential per m^2**

- Estimated number of adult salmonids that can potentially be produced by each m^2 of habitat annually.
- The values (adults/m^2) are species specific; chinook salmon = 0.016, chum salmon = 1.25, coho salmon = 0.05, pink salmon = 1.25, sockeye salmon = 3.00, steelhead = 0.0021, brook trout = 0.04, brown trout = 0.0019, bull trout = 0.0007, cutthroat trout = 0.037, and rainbow trout = 0.0048.

H = **Habitat gain in m^2**

- Measured/calculated from physical survey; gives greater weight to projects which will make greater amounts of habitat available.

- Spawning area values used for species complexes normally limited by spawning habitat (sockeye, chum, pink salmon) and rearing area values used for species complexes normally limited by rearing habitat [(coho, chinook, steelhead) and (cutthroat, rainbow, bull trout) and (brook and brown trout)].

- When more than one species within a species complex is present H is modified to reflect sympatric interactions among species with similar freshwater life histories. The result is a reduction of single species habitat area values when competing species coexist.

M = **Mobility Modifier**

- Accounts for benefits to each fish stock for increased mobility (access to habitat being evaluated); gives greater weight to projects that increase productivity of species that are highly mobile and subject to geographically diverse recreational and commercial fisheries by providing access to habitat currently limiting productivity.

- 2 = Highly mobile stock subject to geographically diverse recreational and commercial fisheries (anadromous species)

- 1 = Moderately mobile stock subject to local recreational fisheries (resident species)

- 0 = Increased mobility of stock would have negative or undesirable impacts on productivity or would be contrary to fish management policy. By default, exotic salmonid species such as brook trout, brown trout and Atlantic salmon will be assigned a 0 value unless they are the only salmonid species present in the system.

D = Species Condition Modifier

- Representation of status of species present; gives greater weight to less healthy species as listed in the Washington State Salmon and Steelhead Stock Inventory (SASSI) report (WDF, et al., 1993). In the absence of a SASSI assignment, stock condition should be estimated using the best available information.

  3 = Condition of species considered critical.

  2 = Condition of species considered depressed or stock of concern.

  1 = species not meeting the conditions for 2 or 3.

C = Cost Modifier

- Representation of projected cost of project; gives greater weight to less costly projects.

  3 = incremental funds needed ≤ $100,000...

  2 = incremental funds needed >$100,000 and ≤$500,000...

  1 = incremental funds needed >$500,000...

Screening Priority Index

The fluctuation in numbers of potential fish saved, which is approximated by design flow and the variable costs due to the intricacy of different screen designs, can make the prioritization of corrections to unscreened or ineffectively screened diversions complicated. The Screening Priority Index (SPI) model is a hybrid of the original quadratic formula used in prioritizing fish passage barriers. The SPI was created to consolidate the many factors of water diversions into a manageable framework for developing a prioritized lists of projects. The SPI for each unscreened or ineffectively screened diversion is calculated as follows:

$$SPI = \sum_{all\,species} \sqrt[4]{(DF)(M)(D)(C)}$$

Where:

SPI = **Priority Index**

- Relative project benefit considering cost.

- The SPI is actually the sum ($\sum_{\text{all species}}$)of individual SPI values, one of which is calculated for each species present in a stream (e.g., SPI_{coho} is added to SPI_{chum} to obtain $SPI_{\text{all species}}$).

DF = Design Flow

- The legal water right for which the headgate and water diversion canal were originally constructed or current maximum use, whichever is less (measured in gallons per minute).

- Design flow is used as an estimate of potential fished saved (i.e. more flow is related to more fish).

M = Mobility Modifier

- Accounts for benefits to each fish stock for increased mobility (access to habitat being evaluated); gives greater weight to projects that increase productivity of species that are highly mobile and subject to geographically diverse recreational and commercial fisheries by providing access to habitat currently limiting productivity.

- 2 = Highly mobile stock subject to geographically diverse recreational and commercial fisheries (anadromous species)

- 1 = Moderately mobile stock subject to local recreational fisheries (resident species)

D = Species Condition Modifier

- Representation of status of species present; gives greater weight to less healthy species as listed in the Washington State Salmon and Steelhead Stock Inventory (SASSI) report, (WDF, et. al., 1992). In the absence of a SASSI assignment, stock condition should be estimated using the best available information.

  3 = Condition of species considered critical.

  2 = Condition of species considered depressed or stock of concern.

  1 = species not meeting the conditions for 2 or 3.

C = Cost Modifier

Representation of projected cost of project; gives greater weight to less costly projects.

3 = incremental funds needed $1,000...

2 = incremental funds needed >$1,000 and $5,000...

1 = incremental funds needed >$5,000...

Winter Rearing

Several barriers, often associated with dikes or complex of dikes, block access to valuable winter rearing habitat and pose a serious risk to fish emigration. Though the methodology does not account for winter rearing habitat, it is crucial for the healthy production of salmonids. The Snoqualmie Wildlife Area contains a substantial amount of winter rearing habitat that could be made accessible if barriers were corrected. The habitat gains for these barriers were calculated using a combination of modified physical habitat surveys, U.S.G.S. quadrangle maps and aerial photos.

RESULTS

Inventory

On the Snoqualmie Wildlife Area a total of 42 features were evaluated at 41 individual sites (37 culverts, two dams, two fishways and one pump diversion). All were on fish bearing streams or lakes. Within the Cherry Valley Unit, 21 culverts, one dam, and one pump diversion were encountered. The dam and one culvert are total barriers, three culverts are partial barriers and the pump diversion structure is a partial barrier, and migration hazard. The Crescent Lake Unit contains two culverts, neither of which were barriers. On the Stillwater Unit there are seven culverts and one dam. Two culverts and the dam are total barriers and three others are partial barriers. The Corson Unit contains four culverts, of which two are total barriers. On the edge of the Ebey Island Unit there is one culvert, which is a partial barrier due to beaver activity in the area. The Spencer Island Unit has two culverts and two fishways. All four are considered to be partial barriers due to tidal influence. Table 1 lists all the culverts, dams, fishways, water diversions and lake outlet screens at each Wildlife Area Unit. Table 2 lists the locations of all features by Wildlife Area Unit and there passability.

Table 1. Total culverts, dams, fishways, water diversions, and lake outlet screens evaluated at each Wildlife Area Unit.

Feature Type	Cherry Valley	Corson	Crescent Lake	Ebey	Spencer Island	Stillwater
Culverts	21	4	2	1	2	7
Dams/ Lake Level Control	1	0	0	0	0	1
Fishways	0	0	0	0	2	0
Water Diversions	1	0	0	0	0	0
Lake Outlet Screens	0	0	0	0	0	0
Features in Fish Bearing Streams	23	4	2	1	4	9
Number of Total Barriers	2	2	0	0	0	3
Number of Partial Barriers	4	0	0	0	4	3

Table 2. Location and status of all features by Wildlife Area Unit. Status indicates whether the feature has no significant habitat gain (NG), the feature requires repair (RR) or if the feature does not require repair (OK).

Site ID	Wildlife Area	Unit	Stream	Trib to	WRIA	Feature	% Passability	Status
980000	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980001	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980002	Snoqualmie W.A.	Cherry Valley	Cherry Cr	Snoqualmie R	07.0240	Pump	33	RR
980003	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980004	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980005	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980006	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980007	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980008	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980009	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980010	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	0	RR
980011	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980012	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980013	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980014	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980015	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980016	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	33	RR
980017	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK

Site ID	Wildlife Area	Unit	Stream	Trib to	WRIA	Feature	% Passability	Status
980018	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	33	RR
980019	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	67	RR
980020	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980021	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr	07.0000	Culvert	100	OK
980071	Snoqualmie W.A.	Cherry Valley	Unnamed	Cherry Cr/	07.0000	Dam	0	RR
980022	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	0	RR
980023	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	0	RR
980024	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	33	RR
980025	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	0	RR
980026	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	100	OK
980027	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Dam	0	RR
980028	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	100	OK
980061	Snoqualmie W.A.	Stillwater	Unnamed	Snoqulamie R	07.0000	Culvert	67	RR
980029	Snoqualmie W.A.	Crescent Lake	Unnamed	Snoqulamie R	07.0224	Culvert	100	OK
980030	Snoqualmie W.A.	Crescent Lake	Unnamed	Snoqulamie R	07.0224	Culvert	100	OK
980031	Snoqualmie W.A.	Ebey Island	Unnamed	Ebey Sl	07.0000	Culvert	100	OK
980032	Snoqualmie W.A.	Corson	Unnamed	Catherine Cr	07.0000	Culvert	0	NG
980033	Snoqualmie W.A.	Corson	Unnamed	Catherine Cr	07.0000	Culvert	0	NG
980034	Snoqualmie W.A.	Corson	Unnamed	Catherine Cr	07.0000	Culvert	100	OK

Site ID	Wildlife Area	Unit	Stream	Trib to	WRIA	Feature	% Passability	Status
980035	Snoqualmie W.A.	Corson	Unnamed	Catherine Cr	07.0000	Culvert	100	OK
980036	Snoqualmie W.A.	Spencer Island	Unnamed	Union Slough	07.0016	Culvert	33	RR
980037	Snoqualmie W.A.	Spencer Island	Unnamed	Steamboat Sl	07.0015	Culvert	33	RR
980038	Snoqualmie W.A.	Spencer Island	Unnamed	Steamboat Sl	07.0015	Fishway	67	RR
980039	Snoqualmie W.A.	Spencer Island	Unnamed	Union Sl	07.0016	Fishway	67	RR

Prioritization

The inventory and physical habitat surveys covered approximately 16 miles of stream. The total potential spawning and summer rearing habitat gains for the Snoqualmie Wildlife Area are 2,951 and 1,207,258 square meters respectively. The Spencer Island Unit has little if any spawning value, but 1,193,400 square meters of potential summer rearing habitat gain. The Cherry Valley Unit has 2,951 and 13,858 spawning and summer rearing area, respectively. Table 3 is a prioritized list of barriers within the Snoqualmie Wildlife Area ranked by PI and the number of additional human-made barriers, including non-state ownership, within the drainage. The potential spawning and summer rearing habitat gain for each barrier is also listed in Table 3. Figures 2-7 show the feature locations within each Wildlife Area Unit.

The winter rearing habitat estimates are not used in the typical prioritization scheme. The barriers at the Stillwater Unit were ranked by potential winter rearing habitat gain upstream, but for the most part do not pose the high risk of entrapment. Upstream migration is the problem. Winter flooding inundates 20 to 70 percent of the land at the Stillwater Unit, which substantially increases rearing area potential. At 70 percent inundation there is approximately 1,291,756 square meters of potential winter rearing area. The barriers located on dead-end drainage ditches at the Cherry Valley Unit, that were strictly for flood runoff, were prioritized based on ordinary high water area above the barrier (i.e. the larger the area at ordinary high water above the barrier, the higher the risk of entrapment during runoff flows). Winter rearing on the Cherry Valley Unit is approximately 1,562,087 square meters behind the dike.

The complex of dikes has little affect on the winter rearing area at the Cherry Valley Unit. The entire area behind the dike is considered winter rearing area. If the dike was removed, the only variation would be the valley flooding sooner, but also draining off quicker. Therefore, there would be no substantial change in the duration of available winter rearing habitat if the dike was removed (Curt Young, pers comm).

Within the Snoqualmie Wildlife Area all 18 barriers affect both anadromous and resident salmonids. Two of these barriers were no gainers and the others require repair. The barrier status is displayed in Table 2. These values are only intended as a guide to prioritizing projects. Other factors can and need to be considered when selecting projects. For example, the PI values do not reflect the possibility of additional human-made barriers. The true habitat gain can only be realized if all other human-made barriers are repaired. Table 3 includes the number of additional human-made barriers upstream and downstream of the feature.

The PI should be regarded as a dynamic index as it can change as new information becomes available and inputs are refined. Table 3 also lists features that require repair only for winter rearing purposes.

Table 3. A prioritized list and ranking of barriers at Snoqualmie Wildlife Area. The number of additional human-made barriers, including non-state ownership, within the drainage is also represented.

PI	Site	Wildlife Area	Unit	Trib to	WRIA	Spawning (m2)	Rearing (m2)	% Passable	Barriers Upstream	Barriers Downstream
52.64	980036	Snoqualmie	Spencer Island	Union Sl	07.0016	0	1,193,400	33	0	0
52.64	980037	Snoqualmie	Spencer Island	Steamboat Sl	07.0015	0	1,193,400	33	0	0
44.1	980038	Snoqualmie	Spencer Island	Steamboat Sl	07.0015	0	1,193,400	67	0	0
44.1	980039	Snoqualmie	Spencer Island	Union Sl	07.0016	0	1,193,400	67	0	0
35.73	980010	Snoqualmie	Cherry Valley	Cherry Cr	07.0240	2,758	9,475	0	13	1
31.95	980002	Snoqualmie	Cherry Valley	Cherry Cr	07.0240	2,951	13,858	33	17	0
28.95	980018	Snoqualmie	Cherry Valley	Cherry Cr	07.0240	2,758	5,948	33	12	2
Rank	**Site**	**Wildlife Area**	**Unit**	**Trib to**	**WRIA**	**Spawning (m2)**	**Rearing (m2)**	**% Passable**	**Barriers Upstream**	**Barriers Downstream**
1	980022	Snoqualmie	Stillwater	Snoqualmie	07.0219	0	170,458	0	4	0
2	980023	Snoqualmie	Stillwater	Snoqualmie	07.0219	0	166,618	33	3	1
3	980024	Snoqualmie	Stillwater	Snoqualmie	07.0219	0	116,099	33	1	2
4	980025	Snoqualmie	Stillwater	Snoqulamie	07.0219	0	66,449	0	0	3
5	980061	Snoqualmie	Stillwater	Snoqualmie	07.0219	0	66,076	67	67	2
6	980027	Snoqualmie	Stillwater	Snoqualmie	07.0219	0	44,498	0	0	2
7	980071	Snoqualmie	Cherry Valley	Cherry Cr	07.0240	0	6,324	0	0	1
8	980016	Snoqualmie	Cherry Valley	Cherry Cr	07.0240	0	2,191	33	0	1
9	980019	Snoqualmie	Cherry Valley	Cherry Cr	07.0240	0	1,184	67	0	2

Note: Sites 980016, 980019, 980071, 980022, 980023, 980024, 980025, 980027 and 980061 are prioritized based on potential winter rearing estimates only. Therefore, a rank in order for repair is used. Repairing these sites would allow for earlier passage during high flows and ensure emigration as flows recede.

DISCUSSION / RECOMMENDATIONS

The fact that most the Snoqualmie Wildlife Area Units are within a flood plain, were logged and cleared in the early 1900's and then purchased by Washington Department of Fish and Wildlife primarily to provide waterfowl habitat, can make characterization and prioritization of correction to fish passage barriers and screening issues very complex. Before most of the barrier corrections on Snoqualmie Wildlife Area Units can be initiated, the agency must establish what the Wildlife Area management priorities are, waterfowl, fish or both. Several of the features inventoried are barriers because their primary function is to control the water level for waterfowl nesting habitat. If this is to remain constant, then means other than removal must be addressed. The ideal theory is to protect and preserve fish, wildlife, and their habitat. Table 4 lists project recommendations and estimated costs at Snoqualmie Wildlife Area. Ranking is for the entire Wildlife Area and within each unit.

Cherry Valley Unit

The Cherry Valley Unit has one pump station and several other barriers that require attention (Figure 2) . The pump station (Site 980002) (Photos 1, 2 & 3) presents a significant fish passage barrier and the possible solutions can have a significant cost. Based on the PI, the pump station is secondary due to the cost, but in order for any habitat gain to be achieved above other barriers, it should be repaired first. It is the key to all potential habitat gain. The biggest problem with the pump station is the potential entrainment of smolts and fry in the spring when the fish are actively migrating. The existing pumps are not screened and the flap gate structure creates a potential barrier to fish passage, particularly for juvenile salmonids. The solutions will require both operational and structural modifications.

The structural modifications involve the need for the flap gates between April and Mid October. One or more of the 4-foot gates could be modified to allow its removal from mid October - March to eliminate any passage barrier. It could also be removed during the summer months or any other time that pumping is not required. The cost is difficult to estimate without exact plans of the structure, but would likely be less than $5,000 for a single gate. Possible solutions include, (1) screening the pumps and adding a fish pump, (2) moving the pump station nearer the fields that need dewatered, and (3) purchasing properties that are being farmed or changing crops and subsequently removing the pump station and flap gates (Heiner, 1995).

Option 1 would include design and installation of screens on the existing pumps. A bypass would also be required to pass fish back into Cherry Creek. Costs for WDFW approved screens could be $6,000 - $8,000 per cfs for this site. The fish pump (6-8") and associated structures would be $10,000 - $12,000. Required pumping rates are not known at this time, so a PI value is not calculated for the pump itself. The PI value is based on the pumping structure being a partial barrier for anadromous and resident species alike.

Option 2 is probably unreasonable because the fields being protected are at opposite ends of the drainage and would require additional diking and separate pump stations. This would only be applicable if the dike was removed and the farms were not purchased.

Option 3 would be the best option for fish habitat. The primary cost of over $500,000, would be the land purchase and dike removal, which are being determined by others. Dismantling costs for the existing pump station are estimated at $3,000.

Approximately 20% of the Cherry Valley Unit is inundated with water between October and March. The frequent flooding tends to fill the Cherry Valley drainage ditch system with sediment, therefore all the culverts on the Cherry Valley unit will become barriers and strand fish if not maintained. Drainage ditches should either be dredged regularly or outfitted with another type of crossing structure to ensure immigration as well as emigration or be completely removed. With this in mind, normal culvert installation criteria are probably not applicable. One of the culverts in particular (Site 980010) (Photos 4 & 5), which also functions as a pond level control structure for increased waterfowl nesting habitat, should be replaced with a three-sided precast concrete utility vault on the upstream side of the culvert for fish passage. The vault would have guides for stoplog placement to allow water elevation manipulations. A maximum of 6" steps between stoplogs will allow passage for juvenile salmonids, assuming the culvert is passable. If the pond was made accessible, it would provide additional rearing habitat. (Heiner, 1995). Site 980018 (Photo 7) is currently undersized and constitutes a partial barrier to upstream fish migration. It is the primary access to additional spawning habitat upstream of the Cherry Valley Unit drainage ditch system.

In order to make all valuable habitat accessible for winter rearing and to ensure emigration after the winter high flow has ended, sites 980016, 980019 and 980071 (Photos 6 &8) should also be replaced or removed. The culverts (980016 and 980019) are completely inundated with silt and vegetation. Site 980071 is a dam that was created for crossing from field to field. The dam is a blockage to and from additional winter rearing habitat. It should be removed, or if absolutely necessary, a passable crossing be installed. These sites are located on dead-end drainage ditches that will tend to strand fish if not addressed. Correction of sites downstream before correcting these sites would increase the potential of fish being stranded during higher flows. Once all crossings on dead end drainage ditches have been addressed, then the pumping station (site 980002) should be corrected, along with sites 980010, 980018 and any other barrier crossings further upstream, including ownership other than state.

Crescent Lake

The Crescent Lake Unit contains two culverts, both are passable under normal circumstances (Figure 3). Heavy beaver activity at the head of one culvert (Site 980030), creates a potential fish passage barrier for juveniles and adults. Regularly removing the dam would allow access to additional summer rearing habitat. At the time of evaluation, several juvenile salmonids were observed at the downstream end.

Stillwater Unit

The Stillwater Unit has six barriers in need of correction (Figure 4), including five culverts (Sites 980022, 980023, 980024, 980025, 980061) (Photos 9, 10, 11 & 13) and one dam (Site 980027) (Photo 12). Correcting these barriers will ensure fish passage to winter rearing habitat and downstream migration after winter high flows. These barrier culverts can be repaired utilizing standard culvert installation criteria. The only dam on the Stillwater Unit, which was constructed to provide additional waterfowl habitat, should be removed to allow unobstructed emigration after winter flows.

Site 980022 (Photo 9) is a large corrugated steel culvert, which is severely undersized for winter flows and has created a huge plunge pool, rendering the culvert a barrier to fish passage. The culvert should be replaced with a substantially larger one or completely removed to allow access to additional winter rearing. Site 980024 (Photo 10) is located on an unnamed tributary to the Snoqualmie River. Even though two culverts have been used at this crossing, during winter flow, they are still undersized. Repair would allow access to additional winter rearing habitat. Site 980025 (Photo 11) is located on the same tributary as site 980024. This small corrugated steel culvert is undersized and influenced by heavy beaver activity. If repaired additional winter rearing habitat would become accessible. Site 980027 (Photo 12) is a small human-made dam that was constructed to increase waterfowl habitat. At the same time it created a barrier for salmonids. The dam should be removed or a small fishway installed. Site 980061 (Photo 13) is a round concrete culvert located on the same tributary as Site 980027 and is severely undersized for winter flows. A huge plunge pool has formed due to the velocities the culvert creates. Again, the primary benefit in replacing this culvert is for winter rearing habitat.

Corson Unit

The Corson Unit contains two barriers, a pond level control structure on a human-made pond (Site 980033) and a culvert on the outlet of a pond (Site 980032) (Figure 5). Neither of the barriers have anadromous access or a significant reach downstream and/or upstream. No further evaluation is required.

Ebey Island

The Ebey Island Unit contains one culvert (Site 980031) (Figure 6), which was not a human-made barrier. Beaver activity constituted a partial barrier at the upstream end of the culvert, but it does not warrant correction due to water quality.

Spencer Island

On the Spencer Island Unit two culverts are installed in the perimeter dike and the two other culverts/fishways are located on the cross levee. Two of the culverts are designed to control tidal influence and the water level within the Spencer Island Unit (Figure 7). The other two control the water level and attempt to provide fish passage. The maintenance is a cooperative agreement between WDFW and Snohomish County. The two culverts across the dike have tidegates at their outlets and water level control structures at the inlets, which constitute a total barrier to some salmonids if not all (Photos 14, 15 & 16). The culverts/fishways installed in the cross levee are barriers due to the water level control structures at the head of the culvert and to heavy debris accumulation (Photos 17, 18, 19 & 20). The baffles within the culvert could be reconfigured and the debris should be removed regularly to increase fish passage. Formal fishways are also an option that would allow salmonids access to additional acclimation habitat and maintain water levels for waterfowl nesting.

Table 4. A list of project recommendations and estimated costs at Snoqualmie Wildlife Area.

Area Rank	Unit Rank	Site	Wildlife Area	Unit	Feature	Stream	Project Description	Cost
1	1	980036	Snoqualmie	Spencer Island	Culvert/H2O Lvl	Unnamed	Redesign and Replacement	$200,000
2	2	980037	Snoqualmie	Spencer Island	Culvert/H2O Lvl	Unnamed	Redesign and Replacement	$200,000
3	3	980038	Snoqualmie	Spencer Island	Fishway/H2O Lvl	Unnamed	Redesign and Replacement	$200,000
4	4	980039	Snoqualmie	Spencer Island	Fishway/H2O Lvl	Unnamed	Redesign and Replacement	$200,000
Note: Site 980038 and 980039 are owned by Snohomish County. Management is a cooperative agreement between Snohomish County and WDFW.							**TOTAL**	**$800,000**
5	1	980010	Snoqualmie	Cherry Valley	Culvert/H2O Lvl	Unnamed	Refurbish culvert as a fishway.	$15,000
6	2	980002	Snoqualmie	Cherry Valley	Pump Station	Unnamed	Option 1,2, or 3.	Pending
7	3	980018	Snoqualmie	Cherry Valley	Culvert	Unnamed	Replace culvert with steel bridge.	$5,000
8	4	980071	Snoqualmie	Cherry Valley	Dam	Unnamed	Removal.	$1,000
9	5	980016	Snoqualmie	Cherry Valley	Culvert	Unnamed	Replace culvert with steel bridge.	$5,000
10	6	980019	Snoqualmie	Cherry Valley	Culvert	Unnamed	Replace culvert with steel bridge.	$5,000
Note: Replacing culverts with bridges will only maintain passability for a longer period of time between dredging. Canals need to be dredged periodically to maintain passability at all crossings. Sites 980016, 980019 and 980071 are for winter rearing and emigration.							**TOTAL**	**$31,000**
11	1	980022	Snoqualmie	Stillwater	Culvert	Unnamed	Replacement	$20,000
12	2	980023	Snoqualmie	Stillwater	Culvert	Unnamed	Replacement	$15,000
13	3	980024	Snoqualmie	Stillwater	Culvert	Unnamed	Replacement	$15,000
14	4	980025	Snoqualmie	Stillwater	Culvert	Unnamed	Replacement	$15,000
15	5	980061	Snoqualmie	Stillwater	Culvert	Unnamed	Replacement	$15,000
16	6	980027	Snoqualmie	Stillwater	Dam	Unnamed	Removal	$5,000
Note: Stillwater culverts are primarily for winter rearing.							**TOTAL**	**$85,000**
Note: Grand total does not include the Cherry Valley Unit pump station							**GRAND TOTAL**	**$916,000**

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APPENDIX I

Memorandum of Project Initiation

STATE OF WASHINGTON
DEPARTMENT OF FISH & WILDLIFE
LANDS AND RESTORATION SERVICES PROGRAM

DATE: 7/11/97

TO: Betty Buckley
Larry Peck

FROM: Elyse Kane Elyse

SUBJECT: Fish Passage Barriers and Screens at State Facilities and on State Lands

The inventory, prioritization and correction of man-made barriers to fish passage and of unscreened facilities is a major endeavor that must be embraced by our programs. Several laws and the recently adopted agency policy require that we do so. Considerable effort has been placed by the Lands and Restoration Services Program on identifying and resolving problem culverts and diversions owned by other jurisdictions and private entities. Unfortunately, there exist a number of barriers and unscreened facilities at WDFW hatcheries, on agency owned lands, and at lake outlet screens and structures maintained by the Engineering Division.

For those barriers associated with State hatcheries, SSHEAR has completed an inventory and prioritized the barriers for correction. A report of our findings is attached. Please note that there are priorities for correction assigned to each of the hatchery facilities, but there still remain immediate questions regarding the resolution of these barriers: 1) pathogen issues, 2) operational procedures at each hatchery, and 3) other issues that may arise from the Wild Salmonid Policy. In addition, Ken Bates has worked directly with the Hatcheries Program to inventory screening problems.

For those barriers and unscreened water diversions associated with WDFW lands, we are just beginning to formulate a program to inventory and prioritize for correction those problems pursuant to the ongoing budget discussions. For lake outlet screens and structures, it is my understanding that Ken Nolan is compiling an inventory meant to address their future use and required maintenance or correction.

Within the next few weeks I would like to discuss the aforementioned issues in order to develop a plan for consolidating the results of these inventories, addressing the associated questions, and budgeting for maintenance or correction of man made problems at our facilities and on our lands. In light of what we expect from outside jurisdictions and private entities, I'm sure you can appreciate the sensitivity of this subject for our agency and the need to expedite the needed corrections. Please respond at your earliest convenience.

Attachment

cc: Bern Shanks
Ken Bates
Paul Sekulich
Rocky Beach

Appendix II

RCW 75.10.110
RCW 75.20.040
RCW 75.20.060
RCW 75.20.061
RCW 75.20.100
RCW 77.12.425
RCW 77.16.160
RCW 77.16.210
RCW 77.16.220
RCW 77.21.010

RCW 75.10.110 General penalties for violations--Seizure and forfeiture. (1) Unless otherwise provided for in this title, a person who violates this title or rules of the department is guilty of a gross misdemeanor, and upon a conviction thereof shall be subject to the penalties under RCW 9.92.020. Food fish or shellfish involved in the violation shall be forfeited to the state. The court may forfeit seized articles involved in the violation.

(2) The commission may specify by rule, when not inconsistent with applicable statutes, that violation of a specific rule is an infraction under chapter 7.84 RCW. [1996 c 267 º 10; 1990 c 144 º 6; 1987 c 380 º 16; 1983 1st ex.s. c 46 º 42; 1979 ex.s. c 99º 1; 1955 c 12 º 75.08.260. Prior: 1949 c 112 º 75; Rem. Supp. 1949 º 5780-601. Formerly RCW 75.08.260.]

RCW 75.20.040 Fish guards required on diversion devices--Penalties, remedies for failure. A diversion device used for conducting water from a lake, river, or stream for any purpose shall be equipped with a fish guard approved by the director to prevent the passage of fish into the diversion device. The fish guard shall be maintained at all times when water is taken into the diversion device. The fish guards shall be installed at places and times prescribed by the director upon thirty days' notice to the owner of the diversion device. It is unlawful for the owner of a diversion device to fail to comply with this section.

Each day the diversion device is not equipped with an approved fish guard is a separate offense. If within thirty days after notice to equip a diversion device the owner fails to do so, the director may take possession of the diversion device and close the device until it is properly equipped. Expenses incurred by the department constitute the value of a lien upon the diversion device and upon the real and personal property of the owner. Notice of the lien shall be filed and recorded in the office of the county auditor of the county in which the action is taken. [1983 1st ex.s. c 46 º 70; 1955 c 12 º 75.20.040. Prior: 1949 c 112 º 45; Rem. Supp. 1949 º 5780-319.]

RCW 75.20.060 Fishways required in dams, obstructions, - Penalties, remedies for failure. A dam or other obstruction across or in a stream shall be provided with a durable and efficient fishway approved by the director. Plans and specifications shall be provided to the department prior to the director's approval. The fishway shall be maintained in an effective condition and continuously supplied with sufficient water to freely pass fish. It is unlawful for the owner, manager, agent, or person in charge of the dam or obstruction to fail to comply with this section. If a person fails to construct and maintain a fishway or to remove the dam or obstruction in a manner satisfactory to the director, then within thirty days after written notice to comply has been served upon the owner, his agent, or the person in charge, the director may construct a fishway or remove the dam or obstruction. Expenses incurred by the department constitute the value of a lien upon the dam and upon the personal property of the person owning the dam. Notice of the lien shall be filed and recorded in the office of the county auditor of the county in which the dam or obstruction is situated. The lien may be foreclosed in an action brought in the name of the state.

If, within thirty days after notice to construct a fishway or remove a dam or obstruction, the owner, his agent, or the person in charge fails to do so , the dam or obstruction is a public nuisance and the director may take possession of the dam or obstruction and destroy it. No liability shall attach for the destruction. (1983 1st ex.s. c 46 § 72; 1955 c 12 § 75.20.060. Prior: 1949 c 112 § 47; Rem. Supp. 1949 § 5780-321.)

RCW 75.20.061 Director may modify inadequate fishways and fish guards. If the director determines that a fishway or fish guard described in RCW 75.20.040 and 75.20.060 and in existence on September 1, 1963, is inadequate, in addition to other authority granted in this chapter, the director may remove, relocate, reconstruct, or modify the device, without cost to the owner. The director shall not materially modify the amount of flow of water through the device. After the department has completed the improvements, the fishways and fish guards shall be operated and maintained at the expense of the owner in accordance with RCW 75.20.040 and 75.20.060. (1983 1st ex.s. c 46 § 73; 1963 c 153 § 1.)

RCW 75.20.100 Hydraulic projects or other work--Plans and specifications--Permits--Approval--Criminal penalty--Emergencies. (1) In the event that any person or government agency desires to construct any form of hydraulic project or perform other work that will use, divert, obstruct, or change the natural flow or bed of any of the salt or fresh waters of the state, such person or government agency shall, before commencing construction or work thereon and to ensure the proper protection of fish life, secure the approval of the department as to the adequacy of the means proposed for the protection of fish life. This approval shall not be unreasonably withheld.

(2)(a) Except as provided in RCW 75.20.1001, the department shall grant or deny approval of a standard permit within forty-five calendar days of the receipt of a complete application and notice of compliance with any applicable requirements of the state environmental policy act, made in the manner prescribed in this section. (b) The applicant may document receipt of application by filing in person or by registered mail. A complete application for approval shall contain general plans for the overall project,complete plans and specifications of the proposed construction or work within the mean higher high water line in salt water or within the ordinary high water line in fresh water, and complete plans and specifications for the proper protection of fish life. (c) The forty-five day requirement shall be suspended if: (i) After ten working days of receipt of the application, the applicant remains unavailable or unable to arrange for a timely field evaluation of the proposed project; (ii) The site is physically inaccessible for inspection; or (iii) The applicant requests delay. Immediately upon determination that the forty-five day period is suspended, the department shall notify the applicant in writing of the reasons for the delay. (d) For purposes of this section, "standard permit" means a written permit issued by the department when the conditions under subsections (3) and (6)(b) of this section are not met.

(3)(a) The department may issue an expedited written permit in those instances where normal permit processing would result in significant hardship for the applicant or unacceptable damage to the environment. In cases of imminent danger, the department shall issue an expedited written permit, upon request, for work to repair existing structures, move obstructions, restore banks, protect property, or protect fish resources. Expedited permit requests require a complete written application as provided in subsection (2)(b) of this section and shall be issued within fifteen calendar days of the receipt of a complete written application. Approval of an expedited permit is valid for up to sixty days from the date of issuance. (b) For the purposes of this subsection, "imminent danger"means a threat by weather, water flow, or other natural conditions that is likely to occur within sixty days of a request for a permit application. (c) The department may not require the provisions of the state environmental policy act, chapter 43.21C RCW, to be met as a condition of issuing a permit under this subsection. (d) The department or the county legislative authority may determine if an imminent danger exists. The county legislative authority shall notify the department, in writing, if it determines that an imminent danger exists.

(4) Approval of a standard permit is valid for a period of up to five years from date of issuance. The permittee must demonstrate substantial progress on construction of that portion of the project relating to the approval within two years of the date of issuance. If the department denies approval, the department shall provide the applicant, in writing, a statement of the specific reasons why and how the proposed project would adversely affect fish life. Protection of fish life shall be the only ground upon which approval may be denied or conditioned. Chapter 34.05 RCW applies to any denial of project approval, conditional approval, or requirements for project modification upon which approval may be contingent.

(5) If any person or government agency commences construction on any hydraulic works or projects subject to this section without first having obtained approval of the department as to the adequacy of the means proposed for the protection of fish life, or if any person or government agency fails to follow or carry out any of the requirements or conditions as are made a part of such approval, the person or director of the agency is guilty of a gross misdemeanor. If any such person or government agency is convicted of violating any of the provisions of this section and continues construction on any such works or projects without fully complying with the provisions hereof, such works or projects are hereby declared a public nuisance and shall be subject to abatement as such.

(6)(a) In case of an emergency arising from weather or stream flow conditions or other natural conditions, the department, through its authorized representatives, shall issue immediately, upon request, oral approval for removing any obstructions, repairing existing structures, restoring stream banks, or to protect property threatened by the stream or a change in the stream flow without the necessity of obtaining a written approval prior to commencing work. Conditions of an oral approval to protect fish life shall be established by the department and reduced to writing within thirty days and complied with as provided for in this section. Oral approval shall be granted immediately, upon request, for a stream crossing during an emergency situation. (b) For purposes of this section and RCW 75.20.103, "emergency" means an immediate threat to life, the public, property, or of environmental degradation. (c) The department or the county legislative authority may declare and continue an emergency when one or more of the criteria under (b) of this subsection are met. The county legislative authority shall immediately notify the department if it declares an emergency under this subsection.

(7) The department shall, at the request of a county, develop five-year maintenance approval agreements, consistent with comprehensive flood control management plans adopted under the authority of RCW 86.12.200, or other watershed plan approved by a county legislative authority, to allow for work on public and private property for bank stabilization, bridge repair, removal of sand bars and debris, channel maintenance, and other flood damage repair and reduction activity under agreed-upon conditions and times without obtaining permits for specific projects.

(8) This section shall not apply to the construction of any form of hydraulic project or other work which diverts water for agricultural irrigation or stock watering purposes authorized under or recognized as being valid by the state's water codes, or when such hydraulic project or other work is associated with streambank stabilization to protect farm and agricultural land as defined in RCW 84.34.020. These irrigation or stock watering diversion and streambank stabilization projects shall be governed by RCW 75.20.103. A landscape management plan approved by the department and the department of natural resources under RCW 76.09.350(2), shall serve as a hydraulic project approval for the life of the plan if fish are selected as one of the public resources for coverage under such a plan.

(9) For the purposes of this section and RCW 75.20.103, "bed" means the land below the ordinary high water lines of state waters. This definition does not include irrigation ditches, canals, storm water run-off devices, or other artificial watercourses except where they exist in a natural watercourse that has been altered by man.

(10) The phrase "to construct any form of hydraulic project or perform other work" does not include the act of driving across an established ford. Driving across streams or on wetted stream beds at areas other than established fords requires approval. Work within the ordinary high water line of state waters to construct or repair a ford or crossing requires approval. [1997 c 385 º 1; 1997 c 290 º 4; 1993 sp.s. c 2 º 30; 1991 c 322 º 30; 1988 c 272 º 1; 1988 c 36 º 33; 1986 c 173 º 1; 1983 1st ex.s. c 46 º 75; 1975 1st ex.s. c 29 º 1; 1967 c 48 º 1; 1955 c 12 º 75.20.100. Prior: 1949 c 112 º 49; Rem. Supp. 1949 º 5780-323.]

RCW 77.12.425 Director may modify inadequate fishways and protective devices. The director may authorize removal, relocation, reconstruction, or other modification of an inadequate fishway or fish protective device required by RCW 77.16.210 and 77.16.220 which device was in existence on September 1, 1963, without cost to the owner for materials and labor. The modification may not materially alter the amount of water flowing through the fishway or fish protective device. Following modification, the fishway or fish protective device shall be maintained at the expense of the person or governmental agency owning the obstruction or water diversion device. (1980 c 78 § 90; 1963 c 152 § 1. Formerly RCW 77.16.221.)

RCW 77.16.160 Damaging or interfering with fish ladders, guards, screens, etc. It is unlawful to damage or interfere with a fish ladder, guard, screen, stop, protective device, bypass, or trap operated by the department. [1980 c 78 º 84; 1955 c 36 º 77.16.160. Prior: 1947 c 275 º 55; Rem. Supp. 1947 º 5992-64.]

RCW 77.16.210 Fishways to be provide and maintained. Persons or government agencies managing, controlling, or owning a dam or other obstruction across a river or stream shall construct, maintain, and repair durable fishways and fish protective devices that allow the free passage of game fish around the obstruction. The fishways and fish protective devices shall be provided with sufficient water to insure the free passage of fish. (1980 c 78 § 88; 1955 c 36 § 77.16.020. Prior: 1947 c 275 § 60; Rem. Supp. 1947 § 5992-69.)

RCW 77.16.220 Diversion of water--Screen, bypass required. It is unlawful to divert water from a lake, river, or stream containing game fish unless the water diversion device is equipped at or near its intake with a fish guard or screen to prevent the passage of game fish into the device and, if necessary, with a means of returning game fish from immediately in front of the fish guard or screen to the waters of origin. A person who is *now otherwise lawfully diverting water from a lake, river or stream shall not be deemed guilty of a violation of this section.
Plans for the fish guard, screen, and bypass shall be approved by the director prior to construction. The installation shall be approved by the director prior to the diversion of water.
The director may close a water diversion device operated in violation of this section and keep it closed until it is properly equipped with a fish guard, screen, or bypass. [1980 c 78 º 89; 1955 c 36 º 77.16.220. Prior: 1947 c 275 º 61; Rem. Supp. 1947 º 5992-70.]

RCW 77.21.010 Penalties--Confiscated articles and devices, disposal--Placing traps on private property--Jurisdiction of courts. (1) A person violating RCW 77.16.040, 77.16.050, 77.16.060, 77.16.080, 77.16.210, 77.16.220, 77.16.310, 77.16.320, or 77.32.211, or committing a violation of RCW 77.16.020 or 77.16.120 involving 77.16.210, 77.16.220, 77.16.310, 77.16.320, 77.16.340, or 77.32.211, or committing a violation of RCW 77.16.020 or 77.16.120 involving big game or an endangered species is guilty of a gross misdemeanor and shall be punished by a fine of not less than two hundred fifty dollars and not more than one thousand dollars or by imprisonment in the county jail for not less than thirty days and not more than one year or by both the fine and imprisonment. Each subsequent violation within a five-year period of RCW 77.16.040, 77.16.050, or 77.16.060, or of RCW 77.16.020 or 77.16.120 involving big game or an endangered species, as defined by the commission under the authority of RCW 77.04.090, shall be prosecuted and punished as a class C felony as defined in RCW 9A.20.020. In connection with each such felony prosecution, the director shall provide the court with an inventory of all articles or devices seized under this title in connection with the violation. Inventoried articles or devices shall be disposed of pursuant to RCW 77.21.040.

(2) A person violating or failing to comply with this title or rules adopted pursuant to this title for which no penalty is otherwise provided is guilty of a misdemeanor and shall be punished for each offense by a fine of five hundred dollars or by imprisonment for not more than ninety days in the county jail or by both the fine and imprisonment. The commission may provide, when not inconsistent with applicable statutes, that violation of a specific rule is an infraction under chapter 7.84 RCW.

(3) A person placing traps on private property without permission of the owner, lessee, or tenant where the land is improved and apparently used, or where the land is fenced or enclosed in a manner designed to exclude intruders or to indicate a property boundary line, or where notice is given by posting in a conspicuous manner, is guilty of the misdemeanor of trespass as defined and established in RCW 9A.52.010 and 9A.52.080 and shall be punished for each offense by a fine of not less than two hundred fifty dollars.

(4) Persons convicted of a violation shall pay the costs of prosecution and the penalty assessment in addition to the fine or imprisonment.

(5) The unlawful killing, taking, or possession of each wildlife member constitutes a separate offense.

(6) District courts have jurisdiction concurrent with the superior courts of misdemeanors and gross misdemeanors committed in violation of this title or rules adopted pursuant to this title and may impose the punishment provided for these offenses. Superior courts have jurisdiction over felonies committed in violation of this title. [1988 c 265 º 3. Prior: 1987 c 506 º 69; 1987 c 380 º 19; 1987 c 372 º 2; 1982 c 31 º 1; 1981 c 310 º 6; 1980 c 78 º 92; 1955 c 36 º 77.16.240; prior: 1947 c 275 º 63; Rem. Supp. 1947º 5992-72. Formerly RCW 77.16.240.]

APPENDIX III

Wildlife Area Scheduling Index

STATE OF WASHINGTON

FISH PASSAGE PRIORITIZATION QUESTIONNAIRE

STATEWIDE WDFW LANDS INVENTORY

DEPARTMENT OF FISH & WILDLIFE

LANDS and HABITAT SERVICES PROGRAM
SALMONID SCREENING, HABITAT ENHANCEMENT & RESTORATION SERVICES (SSHEAR)

Wildlife Area: Snoqualmie
Wildlife Area Manager: Curt Young

1. NUMBER OF FISH PASSAGE FACILITIES. Wildlife Areas will be ranked first according to the number of known fish passage problems. Please include additional *Wildlife Units* to the table below to update the area list. Estimate the total number of fish passage facilities within each unit of the Snoqualmie Wildlife Area and record the number of facilities that present either a partial or total barrier to fish passage:

WILDLIFE AREA UNIT	NUMBER OF FISH PASSAGE FACILITIES											
	CULVERTS		DAMS		FISHWAYS		DIVERSIONS		LAKE OUTLET SCREENS		PASSAGE CONCERNS	
	NUMBER OF CULVERTS ON STREAMS BEARING RESIDENT AND / OR ANADROMOUS FISH	NUMBER OF CULVERTS THAT MAY PRESENT FISH PASSAGE PROBLEMS	NUMBER OF DAMS	NUMBER OF DAMS THAT MAY PRESENT FISH PASSAGE PROBLEMS	NUMBER OF FISHWAYS	NUMBER OF FISHWAYS THAT MAY PRESENT FISH PASSAGE PROBLEMS	NUMBER OF DIVERSIONS	NUMBER OF DIVERSIONS THAT MAY PRESENT FISH BYPASS PROBLEMS	NUMBER OF LAKE OUTLET SCREENS	NUMBER OF LAKE OUTLET SCREENS THAT MAY PRESENT FISH PASSAGE PROBLEMS	ARE THERE ANY HIGH PROFILE FISH PASSAGE ISSUES OF PUBLIC INTEREST?	ARE THERE ANY FISH PASSAGE PROBLEMS THAT REQUIRE IMMEDIATE ATTENTION?
1.												
2.												
3.												
4.												
5.												
6.												

2. NUMBER OF FISH STOCKS. Wildlife Areas will also be ranked according to proposed Federal ESA listings. Any discrete at-risk salmonid stocks not included in the proposed ESA listing process, will be ranked according to SASSI (Washington Salmon and Steelhead Stock Inventory). Record the number of anadromous and resident fish stocks in the table below. Please be sure that you do not record the same stock for both the ESA listing and the SASSI stock status categories:

WILDLIFE AREA UNIT	NUMBER OF PROPOSED ESA LISTINGS						NUMBER OF AT-RISK SASSI STOCKS			
	ANADROMOUS			RESIDENT			ANADROMOUS		RESIDENT	
	ENDANGERED	THREATENED	CANDIDATE	ENDANGERED	THREATENED	CANDIDATE	CRITICAL	DEPRESSED	CRITICAL	DEPRESSED
1. Cherry Valley										
2. Crescent Lake										
3. Stillwater										
4. Corson										
5. Ebey Island										
6. Spencer Island										
ADDITIONAL UNITS:										

Wildlife Area Fish Retrofit Prioritization

A Priority Index (PI) was calculated for each Wildlife Area according to the ranking of four separate factors: estimated total problem features, anadromous and/or resident utilization of the Wildlife Area, stock status, and the existence of any high profile fish passage issues of public interest within the Wildlife area boundaries. After the PI was calculated for each Wildlife Area, the inventory logistics were stratified according to the time of year in which the inventory could be accomplished. For example, the Eastern Washington inventories will be scheduled during the spring and summer months and the Western Washington inventories will be scheduled during the fall and winter months.

$$PI = \sqrt[4]{(P)(M)(S)(I)}$$

Where:

PI = Priority Index

- A ranking of Wildlife Areas to be inventoried based on four separate factors.
- A quadratic root in the equation was used to provide a more manageable number and represents a geometric mean of the factors used. The PI for each Wildlife Area was calculated as follows:

P = Number of Estimated Fish Passage Problems

- The number of fish passage problems was estimated with the addition of: the number of features (e.g culverts, dams, fishways, water diversions, and lake screens) reported by Wildlife Area Managers and potential crossings calculated utilizing DNR hydrology and transportation overlays derived from 1:24000 data.

M = Mobility Modifier

- Accounts for benefits to each fish stock for increased mobility (access to habitat being evaluated); gives greater weight to projects that increase productivity of species that are highly mobile and subject to geographically diverse recreational and commercial fisheries by providing access to habitat currently limiting productivity.
- 2 = Highly mobile stock subject to geographically diverse recreational and commercial fisheries (anadromous species)
- 1 = Moderately mobile stock subject to local recreational fisheries (resident species)

S = **Fish Stock Status**

- Representation of status of stocks present; gives greater weight to less healthy stocks that have Federal ESA status or as listed in the Washington State Salmon and Steelhead Stock Inventory (SASSI) report, (WDF, et. al., 1992). The greatest value between ESA and SASSI was used in the quadratic equation. In the absence of Federal ESA status or SASSI assignment, stock condition should be estimated using the best available information.

ESA

3 = 2 or more species of ESA concern.

2 = 1 species of ESA concern.

1 = No species of ESA concern.

SASSI

3 = 2 or more species depressed or critical.

2 = 1 species depressed or critical.

1 = No species depressed or critical

I = **Interest**

- Representation of Wildlife Areas that have high profile fish passage issues of public interest.

3 = There are currently high profile fish passage issues within the Wildlife Area boundaries that require immediate attention..

2 = There are currently high profile fish passage issues within the Wildlife Area boundaries.

1 = There are currently no high profile fish passage issues within the Wildlife Area boundaries.

WILDLIFE AREA	WILDLIFE AREA FISH RETROFIT PRIORITY INDEX												
EASTERN WA	TOTAL CULVERTS	X TO FIX	POTENTIAL X TO FIX	TOTAL OTHER	OTHER TO FIX	TOTAL TO FIX	SASSI	ESA	STATUS	STOCK MOBILITY	INTEREST	PRODUCT	RANK	LC RANK
CHIEF JOSEPH	1	1	1	7	0	2	3	3	3	2	2	2.21	9	10
COLOCKUM	15	3	2	0	0	5	2	2	2	2	2	2.51	8	9
COLUMBIA	1	1	2	26	21	24	3	3	3	1	1	2.91	7	7
KLICKITAT	0	0	1	0	0	1	2	2	2	2	2	1.68	11	6
LECLERC	0	0	1	0	0	1	1	2	2	1	1	1.19	15	15
METHOW	3	3	2	8	3	8	3	3	3	2	3	3.46	2	1
LT. MURRAY	50	5	3	10	0	8	2	3	3	2	2	3.13	5	4
OAK CR	1	0	2	4	3	5	3	3	3	2	3	3.08	6	5
SCOTCH CR	5	0	1	3	2	3	1	1	1	2	1	1.57	13	13
SHERMAN CR	0	0	1	4	1	2	1	2	2	1	1	1.41	14	14
SINLAHEKIN	6	6	1	5	5	12	3	3	3	2	2	3.46	2	8
SUNNYSIDE	9	0	1	3	0	1	2	2	2	2	2	1.68	11	12
SWANSON	0	0	1	0	0	1	1	1	1	1	1	1	16	16
WELLS	2	1	2	10	10	13	2	3	3	2	2	3.53	1	11
WENAS	4	2	3	4	4	9	3	3	3	2	2	3.22	4	3
WOOTEN	0	0	1	12	0	1	3	3	3	2	3	2.06	10	2
WESTERN WASHINGTON														
COWLITZ	18	2	2	4	3	7	3	3	3	2	2	3.03	3	3
LK TERRELL	1	1	1	1	1	3	2	2	2	2	1	1.86	8	8
OLYMPIC	14	4	1	0	0	5	3	3	3	2	3	3.08	2	2
REGION 7	0	1	1	0	0	2	3	3	3	2	2	2.21	7	7
SCATTER CR	0	0	1	0	0	1	2	2	2	2	2	1.68	9	9
SHILLAPOO	4	2	1	6	1	4	3	3	3	2	2	2.63	4	4
SKAGIT	6	0	1	3	3	4	2	2	2	2	3	2.63	4	4
SNOQUALMIE	25	19	1	3	2	22	2	2	2	2	3	4.03	1	1
PUGET SOUND	5	1	1	3	8	10		2	2	2	1	2.51	6	6

Wildlife Area Prioritization
Table Definitions

Total Culverts, X to Fix, Total Other and Other to Fix are dams, diversions, fishways, and lake outlet screens recorded from prioritization questionnaire.

SASSI and ESA based on questionnaire results received from Wildlife Area Managers.

Potential X to Fix based on DNR Hydrology and Transportation overlays.

Total to Fix is the addition of X to Fix, Potential X to Fix and Other to Fix.

Stock Status is the larger of SASSI or current ESA Listing values.

ESA encompasses stocks currently "listed", " proposed", or "candidate".

Total to Fix, Stock Status, Stock Mobility and Interest used to calculate Product (Geometric Mean).

LC Rank represents ranking order after interaction with Lands Coordinators.

Potential X: 1=0-200 Potential x-ings, 2=200-400 Potential x-ings, 3=400 or more Potential x-ings

SASSI: 1=No Stocks Depressed or Critical, 2=1 Stock Depressed or Critical, 3=2 or more Stocks Depressed or Critical.

ESA: 1=No Stocks of ESA Concern, 2=1 Stock of ESA Concern, 3=2 or more Stocks of ESA Concern.

Mobility: 1=Primarily Resident Salmonids, 2=Mixture of Resident and Anadromous Salmonids.

Interest: 1=There are currently no high profile fish passage issues within the Wildlife Area boundaries. 2=There are currently high profile fish passage issues within the Wildlife Area boundaries. 3=The are currently high profile fish passage issues that require immediate attention.

Shading = Top 3 for eastern and western Washington

APPENDIX IV

Inventory Features Attributes & Values

Inventory Feature Attributes & Values

Site Description

Field Name	Description
SITE ID	Unique identifier for site, used to link to child tables. Format is variable. Required entry.
FEATURE	Name of item being evaluated (culvert, fishway, etc.)
EAST	State plane co-ordinate, generated by GPS, used for mapping and GIS.
NORTH	State plane co-ordinate, generated by GPS, used for mapping and GIS.
GPSTIME	Date and time of culvert evaluation, in UTM, generated by GPS, also used to track data logger files.
OWNER	Owner of culvert, if known, capitalize first letter of proper names, abbreviate county as Co(no period), use acronyms for state agencies (e.g. WSDOT).
ADDRESS	Street or PO Box.
CITY	
STATE	State - abbreviated.
ZIPCODE	
CONTACT	Name and phone number of responsible individual.
ROAD NUMBER	Number designator assigned to road by county, if available, source is typically CRIS database (county road inventory system).
ROAD NAME	Road name.
MILE POST	Distance in miles from the beginning of the road to the culvert location.
COUNTY	County in which feature is located.
REGION	WDFW Region in which the feature is located.
DISTRICT	Watershed Management District in which feature is located.
STREAM	Name of the stream surveyed, 25 character maximum, Capitalize first letter of names, signify river with R and creek with Cr, forks abbreviated to upper case initials MF, NF, etc, no period. If stream has no name use unnamed.
TRIB_TO	Name of the stream to which the surveyed stream is connected, 25 character maximum, Capitalize first letter of names, signify river with R and creek with Cr, forks abbreviated to upper case initials MF, NF, etc, no periods. WRIA number may be included after name.
WRIA	WRIA and stream number for the stream on which the barrier is located, 10 character maximum consisting of 6 digits, 1 decimal point, and up to 3 upper case letters (00.0000ABC). If the stream number is not known enter the WRIA number only (first 2 digits).
RM	River mile where feature is located.

Field Name	Description
HUC	Hydrologic Unit Code
WAU	Watershed Assessment Unit
QSEC	Quarter section.
SECTION	Section number: 01 - 36
TOWNSHIP	Township number
RANGE	Range number
LOCATION	Description of feature location relative to local landmarks, driving directions etc.
FISH USE	Subjective evaluation of fish use. Answer determines level of feature evaluation.
FU CRITERIA	Criteria used for fish use decision.
SPECIES	Species utilizing stream or expected to use stream if no barriers were present. Limited to those species use in the Priority Index Model: so = sockeye, ch = chum, pk = pink, co = coho , ck = chinook, sh = steelhead, ct = cutthroat, rb = rainbow, db = dolly/bull trout, eb = brook trout, bt = brown trout.

Dam

Field Name (Attribute)	Value/Unit	Description
Site ID	varies/unique	Unique identifier for site, used to link to parent/child tables.
Fr Crew	name	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
FR Date	mm/dd/yy	Field review date.
FR Time	hh:mm:ss	Field review time - 24 hour format.
DamName	see description	Recorded legal name, or local name.
ResvName	see description	Recorded legal name, or local name.
Fishway	yes, no	Presence of fishway incorporated with dam.
FishPass	0,33,66,100,	Percentage of passability in regards to anadromous and/or resident fish.
Span	full,partial	Does the structure span completely or only partially across the stream.
Type	va,cb,cn,re,pg,ms,mt, mv,er,st,tb,ot	Type of dam: va = arch, cb = buttress, cn = concrete, re = earthfill, pg = gravity, ms = masonry, mt = metal, mv = multi-arch, er= rockfill, st = stone, tb = timber, and ot = other.

Field Name (Attribute)	Value/Unit	Description
PrimePurp	d,c,h,i,n,p,q,r, s,t,o	Primary purpose of dam: d = debris control, c = flood control, h = hydroelectric, i = irrigation, n = navigation, p = stock or farm pond, q = water quality, r = recreation, s = water supply, t = tailings, o = other.
Length	feet (0.1)	The distance, the dam spans across the stream.
Height	feet (0.1)	The height from the front base of the dam, to the crest.
Impoundmnt	acre/ft (10.0)	The volume of water impounded by the dam.
Recheck	no,gps,photo,pass hf,pass lf	Reasons to revisit site: no = no need, gps = need gps position, photo = need photo, pass hf = evaluate passability at high flow, pass lf = evaluate passability at low flow.
Problem	comment	Description of problems associated dam.
DComments	comment	Additional comment space

Culvert

Field Name (Attribute)	Value/Unit	Description
Site ID	varies/unique	Unique identifier for site, used to link to parent/child tables.
FR Crew	name	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
FR Date	mm/dd/yy	Field review date.
FR Time	hh:mm:ss	Field review time - 24 hour format.
FishPass	0, 33, 66, 100, unknown	The percentage of all species that use the stream system in question that for which passability is achievable.
Recheck	no,gps,photo, pass hf,pass lf	Reasons to revisit site: no = no need, gps = need gps position, photo = need photo, pass hf = evaluate passability at high flow, pass lf = evaluate passability at low flow.
Shape	rnd,pip,box, arch,ell,oth	rnd = round, pip = squash, box = box, arch = bottomless arch, ell = ellipse, oth = other.
Material	pcc,cst,cal, sps,spa,cpc, pvc,tmb,mry, oth	pcc = precast concrete, cst = corrugated steel, cal = corrugated aluminum, sps = structural plate steel, spa = structural plate aluminum, cpc = cast in place concrete, pvc = plastic, tmb = timber, mry = masonry, oth = other.
Coating	non,gal,bit, epx,fbg,con,pol, oth	non = none, gal = galvanized, bit = bituminous (asphalt), epx = epoxy, fbg = fiberglass, con = concrete (on pcc or cpc use non), pol = polymeric, oth = other.
Span/Diar	feet (0.1)	Inside horizontal dimension of pipe.
Rise	feet (0.1)	Height, inside dimension of arch, box, and squash pipes..

Field Name (Attribute)	Value/Unit	Description
Length	feet (1.0)	Length of pipe.
Slope	(%)	Incline of pipe measured with stadia rod and level or clinometer.
CulH2ODepth	feet (0.1)	Depth of water inside pipe, used to evaluate sheetflow.
OutfallDrop	feet (0.1)	At the downstream end of the pipe, the distance from the water surface within the pipe, to water surface of the plunge pool.
PPLength	feet (0.1)	Linear distance of the plunge pool, used to evaluate velocity problems.
PPWetWidth	feet (0.1)	The wetted width of the plunge pool, used to evaluate velocity problem.
PPOHWWidth	feet (0.1)	The width measured at the ordinary high water mark, used to evaluate velocity problems.
PPMaxDepth	feet (0.1)	The depth measured at the deepest part of the plunge pool, used to evaluate velocity problems.
PPTailDepth	feet (0.1)	The depth measured at the middle of the tailout, used to evaluate velocity problems.
PPDomSub	sand,gravel, rubble, boulder, rip rap, boulder	Type of dominate substrate, used to evaluate velocity problems.
ChannelWidth	feet (0.1)	A measurement taken at ordinary high water, used to evaluate pipe sizing problems.
Skew	degrees r or l	Description of angle stream enters pipe from the r = right or l = left. (e.g. 45l).
FillDepth	feet (1.0)	The depth of fill measured from the pipe to road surface, used to estimate replacement cost.
Headwall	none,upstream, downstream, both ends	Presence and location of pipe headwalls.
Wingwall	none,upstream, downstream, both ends	Presence and location of pipe wingwalls.
Apron	none,upstream, downstream, both ends	Presence and location of pipe aprons.
Tidegate	yes,no	Presence of tidegate.

Fishway

Field Name (Attribute)	Value/Unit	Description
Site ID	varies/unique	Unique identifier for site, used to link to parent/child tables.
FR Crew	name	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
FR Date	mm/dd/yy	Field review date.
FR Time	hh:mm:ss	Field review time - 24 hour format.
FW Type	bc,bf,cc,sp,gc,lc, rc,scc,th,wp,vs,pcbl	bc = baffled culvert, bf = baffled flume, cc = concrete control, sp = steep pass, gc = gabion control, lc = log control, rc = rock control, scc = sacrete control, th = trap and haul, wp = weir pool, vs = vertical slot, pc = pool chute, bl = blasted falls.
FWmaterial	concrete, rock, wood, metal , other	The primary material composing the fishway.
Number of pools	number	The number of pools or steps within the fishway structure.
EntDepth	feet (0.1)	The depth measured outside of the fishway structure at the downstream end.
HeadDiff	feet (0.1)	The hydraulic drop measured at each weir or baffle from water surface to water surface.
Number of Baffles	number	The number of baffles within a baffled culvert or flume.
Baffle Type	concrete, metal, plastic, wood, rock, other	The type of material of which the baffles are composed.
Number of Weirs	number	The number of weirs used within the fishway.
Weir Type	concrete, metal, plastic, wood, other	The type of material of which the weirs are composed.
Bed Control	none, upstream, downstream, both	Presence and location of streambed controls.
Control Type	concrete, rock, plank, log, plastic, metal, other	The type of material of which the streambed control is composed.
Aux Water	yes, no, unknown	The presence of an auxiliary water supply used within the fishway structure.
Trash Rack	yes, no, unknown	The presence of a trash rack associated with the fishway structure.
FishPass	mn,mnc,mnr	mn = maintenance is needed to ensure fish passage, mnc = fishway is in chronic need of maintenance (e.g. fishway is prone to debris build up and requires continual monitoring and maintenance to ensure fish passage, mnr = fishways receiving this designation require reconstruction and are not passable to fish in their present condition.
Recheck	no,gps,photo,pass hf,pass lf	Reasons to revisit site: no = no need, gps = need gps position, photo = need photo, pass hf = evaluate passability at high flow, pass lf = evaluate passability at low flow.

Gravity Diversion Protocol

Field Name (Attribute)	Value/Unit	Description
Site ID	varies/unique	Unique identifier for site, used to link to parent/child tables.
FR Crew	name	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
FR Date	mm/dd/yy	Field review date.
FR Time	hh:mm:ss	Field review time - 24 hour format.
Access	foot, orv, vehicle	Type of transportation capable of accessing site.
POD	lb, rb	Point of diversion: lb = left bank, rb = right bank, referenced looking downstream.
DvsnDam	yes ,no	Presence of instream diversion structure.
HgTrashRk	yes, no	Presence of headgate trash rack.
Headgate	yes, no	Presence of headgate.
DitchWidth	feet (0.1)	Wetted width of diversion ditch or canal.
DitchDepth	feet (0.1)	Depth of diversion ditch or canal.
Flow	cfs (0.1)	Flow in cubic feet per second of diversion. If obtained in other units, convert prior to entry.
Derivation	measured, water right, other	How flow was derived: measured = gauge/flow meter is present, water right = legal documentation.
DistoPower	feet (range)	Distance from screen/diversion to electrical power in a range of distances (0-500, 500-2500, >2500ft)
Meter No	meter I.D. #	Identification number of power meter if present.
Screened	yes, no, unknown	Reports whether the diversion is screened for fish protection.
ScnTrashRk	yes, no	Presence of trash rack at screen.
ScreenType	rd,tr,f2,f1,ot,xx	Type of screening device: rd = rotary drum, tr = traveling screen, f2 = two track flat, f1 = one track flat, ot = other, xx = none.
ScreenMat	wm,pm,pp,pb, em,oth	Material screen is constructed of: wm = wire mesh, pm = plastic mesh, pp = perf plate, pb = profile bar, em = expanded metal, oth = other.
Diameter	feet (0.1)	Diameter of drum screens.
Height	feet (0.1)	Height of traveling, or flat screens.
Length	feet (0.1)	Length of screen (all types).
Area	sq.feet (0.1)	Area of screen, calculated using above dimensions.

OpenDmnsn	inches (0.00)	Dimension of the screen material opening. Single entry indicates diameter, rectangular openings entered as 0.00 x 0.00.
ScrnThick	inches (0.00)	Thickness dimension screen plate or wire .
Skew	degrees r or l	Angle of screen relative to flow, referenced looking downstream, r = right, l = left.
Cleaning	manual, spray, brush	Screen cleaning mechanism.
ScFunction	ok, mn, mnc, mnr, unknown	Descriptor of screen function and/or maintenance requirements: ok = functioning properly, mn = minor maintenance needed, mnc = chronic maintenance needs, mnr = major rebuild needed, unknown = functional status unknown.
Bypass	yes, no	Presence of fish bypass.
DistoScrn	feet (0.1)	Distance from screen to bypass entrance.
BpFeasible	n/a, no, yes, unknown	Feasibility of bypass if one is not present, also to be completed if diversion is not screened (n/a = not applicable, bypass is present).
DistoStrm	feet (0.1)	Distance from potential bypass location to stream.
ElevDrop	feet (0.1)	Elevation drop from potential bypass location to stream.
Recheck	no, gps, photo, flow, function	Reasons to revisit site: no = no need, gps = need gps position, photo = need photo, flow = need to measure flow, function = need to evaluate screen function.
Problems	comment	Description of problems associated with screen, bypass, etc.
SealCond	comment	Comments specific to the condition of the screen seals.
GDComments	comment	Additional comment space.
WaterRight	water right I.D. #	Water right number associated with diversion.

Pump Diversion

Field Name (Attribute)	Value/Unit	Description
Site ID	varies/unique	Unique identifier for site, used to link to parent/child tables.
FR Crew	name	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
FR Date	mm/dd/yy	Field review date.
FR Time	hh:mm:ss	Field review time - 24 hour format.
Access	foot, orv vehicle	Type of transportation capable of accessing site.
POD	lb, rb	Point of diversion: lb = left bank, rb = right bank, referenced looking downstream.

Field Name (Attribute)	Value/Unit	Description
Location	rb,os,ln,cv	Location of pump intake: rb = river bank, os = off shore, ln = lagoon, cv = cove. A lagoon is separated from river by pipe or channel. A cove is open to the river.
DvsnDam	yes, no	Presence of instream diversion structure (If yes complete dam protocol).
Screened	yes, no, unknown	Reports whether the diversion is screened for fish protection.
ScreenType	bx,br,cy,cn,st, ot, xx	Type of screening device: bx = box, br = barrel, cy = cylinder, cn = cone, st = strainer, ot = other, xx = none.
NoScnOpen	# of openings, (screen area)	Provide number of structure openings on vaulted structure or number of individual screens on barrel, box and other types.
ScreenMat	wm,pm,pp,pb,em, ot	Material screen is constructed of: wm = wire mesh, pm = plastic mesh, pp = perf plate, pb = profile bar, em = expanded metal, ot = other.
Diameter	feet (0.1)	Diameter of barrel, cylinder or cone screen.
Height/Length	feet (0.1)	Height of barrel, box or cone screen / Length of box or cylinder screen
Area	feet (0.1)	Area of screen, calculated using above dimensions.
OpenDmnsn	inches (0.00)	Dimension of the screen material opening. Single entry indicates diameter, rectangular openings entered as 0.00 x 0.00.
ScnThick	inches (0.00)	Thickness dimension of screen plate or wire.
ScFunction	ok, mn, mnc, unknown	Descriptor of screen function and/or maintenance requirements: ok = functioning properly, mn = minor maintenance needed, mnc = chronic maintenance needs, mnr = major rebuild needed, unknown = functional status unknown.
PipeIDia	inches (0.1)	If possible, measured inside diameter of intake pipe.
PipeODia	inches (0.1)	If possible, measured outside diameter of pipe.
NoOfPumps	# of pumps	The total number of pipes used at site.
PumpType	centrifugal, turbine	Type of pump design.
TotalHP	number	Accumulative horsepower rating for all pumps at site.
Meter No	meter I.D. #	Meter identification number.
Capacity	gpm/cfs (0.1)	Volume of water, measured or calculated in gpm or cfs.
Units	gpm, cfs	Type of units used: gallons per minute or cubic feet per second.
Derivation	calculated, measured, water right	How flow was derived. calculated = pump rating, measured = gauge present, verbal = verbal agreement between WDFW and owner, water right = legal documentation.

Field Name (Attribute)	Value/Unit	Description
Bypass	yes ,no	Presence of fish bypass.
BpFeasible	n/a, no, yes, unknown	Feasibility of bypass if one is not present, also to be completed if diversion is not screened (n/a = not applicable, bypass is present).
DistoStrm	feet (0.1)	Distance from potential bypass location to stream.
ElevDrop	feet (0.1)	Elevation drop from potential bypass location to stream.
Recheck	no,gps,photo, flow, function	Reasons to recheck/revisit site. No = no need, gps = need gps position, photo = need photos, flow = need to measure flow, function = need to evaluate screen function.
Problem	comment	Description of problems associated with screen, bypass, etc.
SealCond	comment	Comments specific to the condition of the screen seals.
PGComments	comment	Additional comment space.
WaterRight	water right ID.	Water right number associated with diversion.

Lake Screen

Field Name (Attribute)	Value/Units	Description
Site ID	varies/unique	Unique identifier for site, used to link to parent/child tables.
FR Crew	name	Last name(s) of the field review team responsible for data, individuals separated by / (e.g. Gower/Cox).
FR Date	mm/dd/yy	Field review date.
FR Time	hh:mm:ss	Field review time - 24 hour format.
Access	foot, orv, vehicle, hv, equip	Type of transportation capable of accessing site.
Abandoned	yes, no, unknown	In regards to the screen itself, has the screening device been removed.
Structure	see description	Type of structure: stop dam, stop apron, permeable dam, earthen dam, wood w/screen, concrete w/screen, other.
StrLength	feet (0.1)	The linear distance of the structure.
Str Width	feet (0.1)	The distance the structure spans across the lake outlet
StrHeight	feet (0.1)	The head differential between the structure crest and plunge pool surface.

Field Name (Attribute)	Value/Units	Description
ScnTrashRk	yes, no	Presence of a trash rack in front of screen.
ScreenType	rd,tr,f2,f1ot,xx	Type of screening device: rd = rotary drum, tr = traveling screen, f2 = two track flat, f1 = one track flat, ot = other, xx = none.
ScreenMat	wm,pm,pp,pb, em,ot	Material screen is constructed of: wm = wire mesh, pm = plastic mesh, pp = perf plate, pb = profile bar, em = expanded metal, ot = other.
ScDiameter	feet (0.1)	Diameter of drum screens.
ScHeight	feet (0.1)	Height of traveling, or flat screens.
ScLength	feet (0.1)	Length of screen (all types).
ScArea	sq.feet (0.1)	Area of screen, calculated using above dimensions.
OpenDmnsn	inches (0.00)	Dimension of the screen material opening. Single entry indicates diameter, rectangular openings entered as 0.00 x 0.00.
ScrnThick	inches (0.00)	Thickness dimension of screen plate or wire.
Skew	degrees r or l	Angle of screen relative to flow, referenced looking downstream, r = right, l = left.
Cleaning	manual, spray, brush	Screen cleaning mechanism.
Condition	ok, mn, mnc, mnr, unknown	Descriptor of screen function and/or maintenance requirements: ok = functioning properly, mn = minor maintenance needed, mnc = chronic maintenance needs, mnr = major rebuild needed, unknown = functional status unknown.
FishPass	0, 33, 66, 100, unknown,	The percentage of all species that use the stream system in question that for which passability is achievable.
Recheck	no,gps,photo, pass hf,pass lf	Reasons to revisit site: no = no need, gps = need gps position, photo = need photo, pass hf = evaluate passability at high flow, pass lf = evaluate passability at low flow.
OrigPurp	impound, prevent	Original purpose of structure; impound = keep fish in lake, prevent = keep fish from entering lake.
CurrPurp	impound, prevent, lake level	Current purpose of structure; impound = keep fish in lake, prevent = keep fish from entering lake, lake level = control lake level.
Adjudicatd	yes, no, unknown	Is there legal documentation establishing water rights?
WaterMastr	yes, no, unknown	Is there a Water Master?
WMName	see discription	Water master name.
WMAddress	see discription	Water master address.
WMCity	see discription	Water master City.
WMState	see discription	Water master State.
WMZip	see discription	Water master zipcode

Field Name (Attribute)	Value/Units	Description
WMPhone	see discription	Water master phone.
Problems	Comment	Description of problems with structure or screen. 200 characters.
LSComments	Comment	General comments on lake screens.
OperMaint	see discription	Description of who performs operations and maintenance. 100 characters.
LandUseNo	see discription	Land use agreement number for non-agency owned lands.
DateAbandn	mm/dd/yy	Date structure was abandoned.

APPENDIX V

Screening Requirements

SCREENING REQUIREMENTS FOR WATER DIVERSIONS

Washington State Laws (RCW 77.16.220; RCW 75.20.040, RCW 75.20.061) require all diversions from waters of the state to be screened to protect fish.

These laws and the following design criteria are essential for the protection of fish at surface water diversions. Fish drawn into hydropower, irrigation, water supply, and other diversions are usually lost from the fish resources of the state of Washington.

The following criteria are based on the philosophy of physically excluding fish from being entrained in water diverted without becoming impinged on the diversion screen. The approach velocity and screen mesh opening criteria are based upon the swimming stamina of emergent size fry in low water temperature conditions. It is recognized that there may be locations at which design for these conditions may not be warranted. Unless conclusive data from studies acceptable to Washington Department of Fish and Wildlife indicate otherwise, it is assumed that these extreme conditions exist at some time of the year at all screen sites.

Additional criteria may be required for unique situations, large facilities or intakes within marine waters.

I. Screen Location and Orientation

A. Fish screens in rivers and streams shall be constructed within the flowing stream at the point of diversion and parallel to the stream flow. The screen face shall be continuous with the adjacent bankline. A smooth transition between the screen and bankline shall be provided to prevent eddies in front, upstream and downstream of the screen.

Where it can be thoroughly demonstrated that flow characteristics or site conditions make construction or operation of fish screens at the diversion entrance impractical, the screens may be installed in the canal downstream of the diversion.

B. Diversion intakes in lakes and reservoirs shall be located offshore in deep water to minimize the exposure of juvenile fish to the screen. Salmon and trout fry generally inhabit shallow water areas near shore.

C. Screens constructed in canals and ditches shall be located as close as practical to the diversion. They shall be oriented so the angle between the face of the screen and the approaching flow is no more than 45°. All screens constructed downstream of the diversion shall be provided with an efficient bypass system.

II. Approach Velocity

The approach velocity is defined as the component of the local water velocity vector perpendicular to the face of the screen. Juvenile fish must be able to swim at a speed equal or greater than the approach velocity for an extended length of time to avoid impingement on the screen. The following approach velocity criteria are maximum velocities that shall not be exceeded anywhere on the face of the screen. A maximum approach velocity of 0.4 feet per second is allowed.

The approach velocity is calculated based on the gross screen area not the net open area of the screen mesh.

The intake structure and/or fish screen shall be designed to assure that the diverted flow is uniformly distributed through the screen so the maximum approach velocity is not exceeded.

III. Minimum Screen Area

The minimum required screen area is determined by dividing the maximum diverted flow by the maximum allowable approach velocity. To find the screen area in square feet, divide the diverted flow in cubic feet per second (450 gpm = 1.0 cubic foot per second) by the approach velocity 0.4 feet per second):

$$Minimum\,Screen\,Area = \frac{Diverted\,Flow\,(cubic\,feet/second)}{Approach\,Velocity\,(feet\,per\,second)}$$

The minimum required screen area must be submerged during lowest stream flows and may not include any area that is blocked by screen guides or structural members.

Diversions less than or equal to 180 gallons/minute (0.4 cfs) require a minimum submerged screen area of 1.0 square foot, which is the smallest practical screening device.

IV. Sweeping Velocity

The sweeping velocity is defined as the component of the water velocity vector parallel to and immediately upstream of the screen surface. The sweeping velocity shall equal or exceed the maximum allowable approach velocity. The sweeping velocity requirement is satisfied by a combination of proper orientation (angle of screen 45° to the approaching flow) of the screen relative to the approaching flow and adequate bypass flow.

Screen bay piers or walls adjacent to the screen face shall be flush with screen surfaces so the sweeping velocity is not impeded.

V. Screen Mesh Size, Shape, and Type of Material

Screen openings may be round, square, rectangular, or any combination thereof, provided structural integrity and cleaning operations are not impaired.

Screen mesh criteria is based on the assumption that steelhead and/or resident trout fry are ubiquitous in the state of Washington and will be present at all diversion sites.

Following are the maximum screen openings allowable for emergent salmonid fry. The maximum opening applies to the entire screen structure including the screen mesh, guides, and seals. The profile bar criteria is applied to the narrow dimension of rectangular slots or mesh.

Woven Wire Mesh	Profile Bar	Perforated Plate
0.087 inch (6-14 mesh)	1.75 mm (0.069 inch)	0.094 inch (3/32 inch)

The allowable woven wire mesh openings is the greatest open space distance between mesh wires. An example allowable mesh specifications is provided; there are other standard allowable openings available. The mesh specification gives the number of mesh openings per lineal inch followed by the gauge of the wires. For example, 6-14 mesh has six mesh openings per inch of screen. It is constructed with 6, 14-gauge (0.080 inch diameter) wires per inch.

The profile bar openings are the maximum allowable space between bars. The allowable perforated plate openings are the diameter of circular perforations. Perforated slots are treated as profile bars.

Screens may be constructed of any durable material; woven, welded, or perforated. The screen material must be resistant to corrosion and ultraviolet damage.

For longevity and durability, minimum wire diameter for woven mesh shall be 0.060 inch (18 gauge) on fixed panel screens, where they are not subjected to impact of debris. Minimum wire diameter for woven mesh shall be 0.080 inch (14 gauge) for rotary drum screens, traveling belt screens, and in areas where there is a potential for damage from floating debris or cleaning operations.

VI. Bypass

All screens constructed downstream of the diversion shall be provided with an efficient bypass system to rapidly collect juvenile fish and safely transport them back to the river. The downstream end of the screen shall terminate at the entrance to the bypass system. It is the water diversion owner's responsibility to obtain necessary water rights to operate the fish bypass; failure to do so may be considered failure to meet state screening law requirements.

VII. Cleaning

Fish screens shall be cleaned as frequently as necessary to prevent obstruction of flow and violation of the approach velocity criterion. Automatic cleaning devices will be required on large screen facilities.

Additional detailed information is available explaining the background and justification of these criteria and showing standard details of flow distributors, acceptable bypass designs, and screen areas required for various flows.

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APPENDIX VI

Physical Survey Methodology

WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE SALMONID SCREENING; HABITAT ENHANCEMENT AND RESTORATION(SSHEAR)DIVISION REVISED PHYSICAL SURVEY METHODS, EQUIPMENT, AND MATERIALS

July 30, 1998

METHODS

Date, Stream Name, Tributary To, and Section Surveyed

The date, stream name, tributary to and WRIA number are noted prior to beginning the survey. The stream reach surveyed is identified as meters above the starting point (e.g. - Mouth to 1000 M upstream).

Survey Reaches Will Be Broken Out By Channel Morphology and at all man made barriers

The stream to be surveyed will be broken out into reaches with similar gradient, bed form and channel size (break out at each significant tributary => 20% of parent stream flow). The following gradient breaks will be used as reach breaks.

GRADIENT REACH STRATA	NORMAL UPPER LIMIT OF SPECIES USE
0 - 1 %	Chum
1 - 3	Chum
3 - 5	Pink, Coho, Sockeye, Chin
5 - 7	Pink, Coho, Sockeye, Chin
7 - 12	Steelhead and resident Salmonid Species
12 - 16	Resident Salmonid Species
16 - 20	Resident Salmonid Species

A gradient reach strata must have a sustained gradient for at least **160 meters (0.1 mile)**. The survey will be terminated at a natural point barrier (waterfall >12 feet vertical height) or when a sustained gradient >20% is encountered for a distance 160 meters, or when the channel has a sustained gradient >16% for a distance 160 meters <u>and</u> a channel width <2 feet in Western Washington and <3 feet in Eastern Washington ***measured at the ordinary high water width.***

Since you won't always know how long the stream continues at a particular gradient, it will be necessary to measure the first 160 meters by belt chain to verify the need to create a new reach when a new gradient reach stratum is encountered. Sample frequency should continue uninterrupted across gradient reaches, to avoid unnecessary sampling should the gradient change occur in less than 160 meters. This will be an exception to the way you will handle other types of reach breaks (bed form change, land use change, secondary man made barriers etc), where a new sampling frequency will begin at the reach break point.

Changes in bed form that require a reach break would be any change which significantly effects pool:riffle:rapid ratio, substrate composition, or channel width. Changes in bed form need not be 0.1 mile long to qualify as a reach. An example would be a stream which has a significant sediment source (feeder bluff) at river mile 1 which provides good spawning gravel in riffle areas downstream but is boulder and bed rock (gravel poor) upstream from this point. In this case a reach break at river mile 1 would be necessary to keep from biasing your gravel composition assessments. If the sediment source were a sand bluff which shifted bed composition to a high percentage sand (low percentage spawning gravel) below river mile 1 and low sand (high percentage spawning gravel) above river mile 1 a reach break would also be required.

Other bed form shifts which could require a reach break would be a change from a forested high quality channel (high level of LWD) which emerges into a highly impacted dairy or cattle grazing reach of lower productivity (cattle waste, low LWD, or lack of stream bank vegetation and hiding cover).

As a rule of thumb a reach break should be made whenever a change in stream characteristic will affect one of the measured parameters used to calculate species-specific production potential (gradient, channel width, riffle area, pool area, bed composition or habitat quality modifier). ***In addition, a reach break will be made at each additional man made barrier encountered during the survey.***

Sample Frequency Within A Sample Reach - Samples shall be taken within each sample reach to provide statistically valid estimates of measured criteria. A 20% sampling level can be achieved by taking habitat measurements in the first 60 meters representative of each 320 meter section walked on streams longer than one mile and the first 30 meters representative of each 160 meters on streams less than 1 mile. In cases where a reach break is caused by a gradient change the sample section will be located based upon the appropriate distance (320 M or 160 M) from the previous sample point regardless of the reach break location.

Two Habitat Quality Modifiers (HQM) shall be assigned to each survey reach to identify productive capability of the habitat. The HQM rating will be used as a multiplier of the square meter habitat number to obtain H in the Priority Index (PI) model (H= habitat quality modifier x habitat in square meters). Since a separate production rate is used for each species present in the PI model and the production rate is calculated using square meters of spawning habitat for species that normally do not rear in streams (chum, sockeye and pink salmon), and square meters of rearing habitat for species dependant upon stream rearing habitat, ***the habitat quality modifier must be applied independently to spawning and rearing habitat***. Often the habitat quality modifier will be the same for both. But in some situations, for example silt bottom creeks rearing habitat may be excellent (rearing HQM = 1) but, due to a high percentage of fines (grain size <0.85 mm) mixed in with spawnable size gravel, spawning habitat would be of reduced quality.

HABITAT QUALITY MODIFIER (HQM)			
HABITAT CONDITION	**HQM VALUE**	**REARING HABITAT CRITERIA[1]**	**SPAWNING HABITAT CRITERIA**
GOOD TO EXCELLENT	1	Rearing habitat is stable and in a normal productive state with all components functional	Spawning gravel patches have 16% fine particle sizes that are <0.85mm in diameter
FAIR	2/3	Rearing habitat shows significant moderate widespread signs of instability and/or disturbance known to reduce productive capability (one or more habitat components missing or significantly reduced presence)	Spawning gravel patches/riffles show moderate widespread signs of instability (scour/filling) and/or >16% and 21 fine particle sizes <0.85mm in diameter
POOR	1/3	Rearing habitat shows signs of major/widespread disturbance likely to cause major reductions in its production capabilities (two or more habitat components missing or severely reduced presence)	Spawning gravel patches/riffles show major/widespread signs of instability (scour/filling) and or >21% and 26% fine particle sizes <0.85mm in diameter
NO VALUE	0	Rearing habitat severely disturbed so that production capabilities are with out value to salmonids at this time	Spawning gravel patches with >26% fine particle sizes <0.85mm in diameter

1/ Rearing habitat components/function are riparian vegetation/shade & cover, channel morphology/pool, riffle, undercut, in stream cover/LWD, boulder matrix, seasonal flow and temperature. Components are to be evaluated within the context of expected normal density, occurrence and function given the stream gradient, elevation and geographical location.

Limiting Factor - If a habitat quality modifier other than 1 is assigned to a reach indicate why in this space. A simple note will suffice (dairy waste, unstable channel, >16% fines, lacking riparian vegetation, lacking in stream cover, irrigation return water, stream dry, high summer temperatures etc.

Survey All Potential Habitat Above A Human-Made Barrier - All habitat measured above a barrier up to a sustained gradient >20% or a natural point barrier (12' vertical falls) is potential habitat. This will include habitat above secondary human-made barriers upstream of the subject barrier provided the barrier has a reasonable potential for correction. For example, we can assume that all road culvert barriers have a reasonable potential for correction, if they meet a threshold habitat gain criteria (200 meters). However, we have found that some human-made dams that are barriers have been approved by WDFW and cannot be required to be fixed. ***When secondary barriers are encountered follow the documentation protocol outlined under 1)c below.***

1) Stream length

a) A belt chain measuring in meters and using a 3 strand, biodegradable thread is worn, and the stream is walked from the downstream end of the survey area.

b) To determine total potential habitat available above a barrier, the survey is continued to a point when a sustained gradient greater than 20% is encountered for a distance of at least 160 meters, when a natural point barrier is reached, or when a sustained gradient of greater than 16% for a distance of at least 160 meters and a channel width of less than 2 feet in Western Washington and less than 3 feet in Eastern Washington ***measured at the ordinary high water width.***

c) **MULTIPLE BARRIERS** Frequently, additional human-made barriers exist which may need to be corrected to realize the potential habitat gain above or below the primary barrier. In this case, the barrier location should be entered into the “multiple barriers” space in your field data notebook as distance in meters above or below the primary barrier. Identify your method of measurement (belt chain, stream catalogue, aerial photo, USGS quadrangle). ***Where possible collect a G.P.S. position.***

I) Complete a fish passage barrier evaluation form (electronic or paper) for each human-made barrier encountered per the appropriate evaluation protocol. Forms and protocol are type specific (culvert, dam, water diversion etc.).

ii) Each secondary human-made barrier will appear as an additional record in the WDFW fish passage database.

iii) A reach break will be made at each human-made barrier encountered.

2) Sample Frequency

a) Where the survey is predicted to be over 1.0 mile long, sample sections are 60 meters in length and taken at the beginning of each 0.2 mile (320 meters) section of stream. b) Where the survey is predicted to be under 1.0 mile long, sample sections are 30 meters in length and taken at the beginning of each 0.1 mile (160 meters) section of stream. Note: Depending upon the location of the end of the survey, this rate of sampling will result in no less than 18.6% of the total stream length surveyed.

3) Pool:riffle:rapid area

a) The length in meters of each pool, riffle and rapid within the sample section is recorded.

b) Two representative channel width measurements are taken to the nearest 0.1 meter 1) wetted width and 2) ordinary high water (OHW) width.

c) An average depth to the nearest 0.01 meter is taken at the cross section location of each wetted width measurement. No residual pool depth measurements will be taken.

d) Width measurements (wetted & OHW) are taken at the first two pool, riffle and rapid sections found within the sample section that are representative of conditions within the section. Depth measurements for each wetted width are also taken. Ordinary high water mark depths will not be taken. A staff marked for metric lengths and meter tape are used.

e) The pool:riffle:rapid areas in m^2 for each reach is calculated using the following formula. Total (pool) area = total reach length x **average wetted pool width**[1] x (sum of sampled pool lengths/total sample lengths).

1\ Calculated channel width based upon calculated 60 day summer low flow and measured wetted channel width and depth may be used to calculate rearing area. OHW width should be used to calculate spawning area. Wetted width can be used as a default to calculate rearing area in the event that the above information is not available, or the calculated 60 day summer low flow area is ambiguous. Methodology for the 60 day summer low flow calculation is per Ken Bates October 17, 1994 unpublished paper titled "Estimate Of Potential Summer Habitat".

4) Pool:riffle:rapid ratio

Pool:riffle:rapid areas for each survey reach shall be calculated as follows: sum all areas (pool + riffle + rapid) = Total reach area then: pool area/total reach area x 100 = % pool, and riffle area/total reach area X 100 = % riffle area and so on.

5) Substrate composition

Substrate composition of pool, riffle and rapid areas are visually estimated in each sample pool, riffle, rapid measured. The method estimates the percent of total area of each sample pool, riffle, rapid measured that is occupied by each substrate category listed below. The process should be completed by both observers independently and then estimates combined into one sample estimate in a collaborative process. For example to estimate substrate composition for a sample pool, each surveyor would visually observe the most abundant substrate type and estimate the percent of the total pool area it occupies. Repeat the process for estimates of the second most abundant substrate type then the third and finally the forth or least abundant. Substrate particles are sorted by stream channel hydraulic forces that tend to group substrate particles of similar size categories. Once all four substrate categories have been estimated they should be totaled and equal 100%.

The following substrate categories shall be used to break out mean particle diameter size of substrate composition:

MEAN PARTICLE DIAMETER SIZE CLASS RANGES		
CATEGORY NAME	**SIZE CLASS RANGE (in)**	**SIZE CLASS RANGE (mm)**
Boulder	>12 in	>47 mm
Rubble	3 to 12 in	76.2 to 47 mm
Gravel	0.20 to 3 in	5.1 to 47 mm
Sand/Fines	<0.20 in	< 5.0 mm

Spawning Habitat Quality Modifier The second part of the gravel composition estimate process is to visually estimate the percent fine particle composition less than 0.85mm, **of the substrate area/patches that you classified as "gravel" (0.20 to 3 inches diameter particles)**. The estimating procedure combines subjective evaluations of the surface composition, silt plume characteristics as a boot heal is dug 8 - 10 inches into a "gravel" patch substrate, and the composition of several handfuls of the underlying substrate. The procedure should be repeated several times at each site to estimate the percent fines (<0.85 mm) in the "gravel" for each reach. The following categories shall be used along with stream stability observations to determine the spawning habitat quality modifier.

HABITAT QUALITY	HABITAT QUALITY MODIFIER	CRITERIA[1]
GOOD TO EXCELLENT	1	Stream is stable and spawning gravel patches have 16% fines (particles <0.85mm in diameter)
FAIR	2/3	Spawning gravel patches/riffles show moderate signs of instability (scour/filling) and/or >16% and 21% fines (particles <0.85mm in diameter)
POOR	1/3	Spawning gravel patches/riffles show major/widespread signs of instability (scour/filling) and or >21% and 26% fines (particles <0.85mm in diameter)
NO PRODUCTION VALUE	0	Spawning habitat severely disturbed production capabilities effectively with out value at this time. Spawning gravel patches with >26% fines(particles <0.85mm in diameter)

1/Use attached "Suggested Methodology of Visually Estimating Gravel" and Spawning Gravel Habitat Quality Modifier Rational spreadsheet to test visual estimate accuracy and calibrate among observers.

Once all bottom composition estimates have been made for the sample reach, the mean substrate composition for the entire reach is calculated by summing the % composition for each substrate category (boulder, rubble, gravel, sand/fines) and dividing by the sample number. Example: Mean Boulder composition = Sum of all boulder samples/ Total Sample Number.

Substrate composition estimates are very important because the production estimates for spawning limited species such as Chum, Pink and Sockeye salmon will be calculated using the estimated percent gravel by pool/riffle/rapid area.

6) **Spawning area** - Spawning area for each habitat category (pool, riffle, rapid) will be calculated for each reach (e.g. total OHW (pool) area x % gravel/100 x habitat quality modifier. Total spawning area for the reach shall be calculated as the sum of spawning area calculated for pool, riffle and rapid categories. Total spawning area for the stream system surveyed will be the sum of spawning area calculated for each reach. Reaches that are unstable and/or disturbed resulting in a significant reduction in production capabilities (scour/filling/dewatering/% fines present in spawning gravel >16% should be assigned the appropriate habitat quality modifier (see habitat quality modifier explanation), effectively reducing the production rate of the spawning area.

7) **Rearing area** - The sum of pool, riffle, rapid area totals for each reach x the habitat quality modifier = total rearing area within the reach. The sum of all rearing area within reaches = total rearing area surveyed. Reaches that are unstable and/or disturbed resulting in a significant reduction in production capabilities should be assigned the appropriate habitat quality modifier (see habitat quality modifier explanation), effectively reducing the production rate of the rearing area.

Sixty day summer low flow calculated areas should be used in all cases except where measured wetted area is less that the 60 day summer low flow area and wetted measurements were taken during a season when flows should be greater than those during the 60 day summer low flow period (generally August and September).

8) **Spring influence** Calculation of the 60 day summer low flow requires identification of the degree of “spring influence” as described in the 60 day summer low flow methodology. The spring influence factor is used to ***minimize the reduction of measured wetted area in streams that have springs contributing a substantial part of the flow during the summer low flow period.*** The range of influence the spring factor has on the 60 day low flow calculated area ranges from, no influence spring factor = 0, to completely canceling the reduction of measured wetted area for the summer flow period and effectively saying that the stream runs at a constant flow perpetually with no summer low flow area reduction (spring influence = 3). Few streams are unaffected by summer drought, so it is important to use good judgement when applying the spring factor. Use the following guidelines to assign the spring factor.

SPRING INFLUENCE FACTOR (SPRING FACTOR)		
SPRING INFLUENCE	**SPRING FACTOR**	**CRITERIA**
ABSENT	0	normal channel morphology with evidence of a range of flows (scoured pool riffle sequence)
SLIGHT	1	rectangular x-sec with minor variations in depth (less evidence of scour and bed transport than above) ***(Summer low flow width = 1/3 OHW width)***
MODERATE	2	as above but even less sediment transport and scour with low flat flood plains and little evidence of freshet activity ***(Summer low flow width = 2/3 OHW width)***
PRONOUNCED	3	bank vegetation established with a distinct line a small distance above the water surface during summer flow period, heavy moss growth on the exposed stream rocks can indicate freshet activity is very week. *Must flow at nearly constant flow level year around* ***(OHW width = Summer low flow width)***

9) **Pond habitat** Pond habitat has a different production value than stream habitat. For this reason ponds will be broken out as separate reaches and pond area measured and rated using the habitat quality modifier. A standard pond habitat production value of 3000 coho smolts/acre = .74 smolts/m2 will be used. Production rates for other species utilizing ponds will be the same as stream rearing production rates. This base production level will be used for good to excellent habitat, in lesser quality pond systems the habitat quality modifier should be used to arrive at a production figure for the pond reach. Pond rearing area for each pond reach shall be calculated as total pond area x habitat quality modifier = total rearing area within the reach.

Pond habitat shall be defined as a zero gradient channel reach having a average width at least five times that of the average pool width and five times the average pool length in the downstream reach. In the event short, high quality riffles exist between a series of high quality rearing ponds, exceptions to reach lengths can be made (<.1 mile) to capture these high quality areas in the survey.

10) **Flow**

a) A flow measurement should be taken at the beginning of each survey (using a flow meter if possible) and periodically as proceeding upstream as flow conditions change such as tributary or groundwater input areas (using the chip method).

b) The three chip flow method or flow meter is used.

1) Measure flows at a culvert, sharp crested weir riffle area or other uniform cross section when possible.

2) The average width and average depth of the selected cross section is determined with at least 3 measurements of each.

3) Flow velocity measurements are taken using a flow meter or a stop watch and meter tape to time a chip traveling over the length of the sample riffle or a distance up to 10 meters immediately upstream of the cross section. A minimum of three flow velocities are recorded.

c) Flow in cubic feet per second (CFS) is roughly calculated using the simplified continuity equation Q = Flow Cross Section Area X Velocity.

11) Water temperature

a) Water temperature is normally taken at the same general time and location as the flow.

b) A hand-held mercury thermometer, calibrated for centigrade readings is used. Temperature is recorded to the nearest degree centigrade.

12) Gradient

a) Gradients are taken at a rate of at least one per sample section.

b) A hand or tripod mounted level or clinometer and stadia rod is used.

c) Gradients are shot over as long a stream section as visibility allows, and back sights are taken where possible as a double check.

d) Mean gradient for each reach is calculated by summing all gradient samples taken in the reach and dividing by the sample number.

13) Comments

a) Principal stream features, road crossings, and other man made features, etc., are noted (in meters from the beginning of the survey) as they are encountered.

b) The end of the survey and the reason for ending the survey are noted.

c) Notes are added to the "Comments" section of the database

d) All streams surveyed should be flowing at the time of the survey.

14) **Canopy composition** - Visually estimate percent area shaded by the streams riparian canopy assuming full leaf out condition. Note major tree and shrub species within stream corridor. The estimate should represent the percent of wetted stream area that would be shaded during summer full leaf out conditions. One canopy composition estimate should be made for each reach. Periodic use of a densiometer is advised to calibrate survey observations and to train new survey teams.

15) **Water diversions** - Other water uses are noted in the "Comments" section of the field notes as encountered (e.g. - privately owned pump drawing water from stream). When major water diversions or dams are encountered they should be evaluated using the appropriate evaluation protocol and forms for that feature as provided in our current Wildlife Area Inventory Protocol.

16) **In stream cover** - In stream cover density such as large woody debris (LWD), undercut banks, large boulders, close overhanging vegetation (etc) is visually estimated as high, medium or low. A low in stream cover rating should be reflected in the rearing habitat modifier rating. One estimate of instead cover density should be made for each reach.

17) **Juvenile abundance**

a) A subjective visual estimate of fry densities is noted by species if possible.
b) The density is denoted as either low, medium, or high.
c) One juvenile abundance estimate for each reach shall be made.

18) **Blockage location**

a) The location of the problem culvert or other blockage in question is recorded by belt chain measurement in meters above survey starting point (reference point) and converted to river mile using USGS Quadrangle map and map wheel if necessary.
b) Blockage location on tributaries shall be recorded as meters above the confluence with the parent stream.
c) **Whenever possible G.P.S. coordinates** for the problem culvert should be recorded and the standard barrier culvert assessment data collected.

19) **Production calculations** shall be the sum of all rearing habitat within the survey which occurs within the gradient reaches appropriate for the species of concern, where rearing habitat is limiting production. In cases where spawning habitat is limiting (chum, sockeye and pink salmon) production shall be based upon the sum of all spawning habitat within the survey which occurs within the gradient reaches appropriate for the species of concern (e.g. 0 to 3% for chum salmon). In cases where it is know that a species utilizes habitat outside of its normal (assigned) gradient range, production for that species may be assigned as an exception to the higher gradient range.

<u>Equipment</u>

1) **Belt chain**
2) **Meter tape or calibrated staff**
3) **Hand level**
4) **Stadia rod**
5) **Flow meter**
6) **Thermometer**
7) **Stop Watch**
8) **Densiometer**
9) **Computer and software (Quattro)**
10) **Clinometer**
11) **Global positioning system (GPS)**

<u>Materials</u>

1) **String for belt chain** (1991 Mallory cost = $5.15 per 2,743 meter roll)

2) **Surveyors ribbon** (1991 Mallory cost = $0.58 per roll)

Definitions Explanation of terms used in this survey format shall be as shown in attachments and in the Aquatic Habitat Inventory Glossary and Standard Methods produced by the Western Division American Fisheries Society unless otherwise defined herein. Use of the Rosgen stream classification system is recommended to identify channel form defined reach breaks.

APPENDIX VII

Estimate of Potential Summer Habitat

October 17, 1994

ESTIMATE OF POTENTIAL SUMMER HABITAT

Objective

The objective of this study is to estimate, from channel characteristics which are measurable throughout the field season, the relative areas of summer low flow rearing habitat in streams across the state.

Method

This method for estimating relative potential aquatic habitat is based on regional estimates of 60-dy low flow per unit watershed area (i.e., cubic feet per second per square mile) combined with channel characteristics measured in the physical survey.

The physical survey distinguishes four geomorphic stream features: riffles, rapids, pools, and ponds. These features are generally categorized into two habitat types: pools (i.e., pools and ponds), and riffles (i.e., all other habitat types). Pools are characterized by low gradients (<1%), reduced flow velocities, and often greater water depths than in surrounding areas. Ponds are pools which have average widths and lengths at least five times the average widths and lengths of pools in the downstream reach. Riffle habitat types are characterized by shallow, swift, turbulent flow over completely or partially submerged obstructions.

Regional stream gage data were used to generate regression equations of the form:

$$Q_{60} = (CA) / 35.3 \qquad \text{(Eq. 1)}$$

where Q_{60} = 60-day low flow (cubic meters per second),
A = watershed area (square miles), and
C = a regional constant.

From this equation, Q_{60} can be estimated for each stream in the survey. In this preliminary study, Washington was divided into four hydrologic regions: 1) Olympic Peninsula/south coast, 2) Cascade (east Puget Sound), 3) Columbia/eastern Washington, and 4) Northern/North-eastern mountains. These divisions are based on evaluation of USGS analyses of low flow characteristics of streams in Washington rather than on direct statistical analysis of low flow data. Due to scarcity of 60-day low flow data, regression relationships for the Olympic/south coast and the Northern/north-eastern mountain regions were developed from 7-day low flow data and increased by a factor representing the regional relationship between 60-day low flow and 7-day low flow. The Cascade/east Puget Sound 60-day low flow values were interpolated from 30-day and 90-day low flow data. Regional constants are shown in Table 1.

Table 1. Regional constants for 60-day low flow per square mile of watershed area.

Region	Constant	Standard Error	R^2	Observations
Olympic/coastal	0.49	0.023	0.36	168
Cascade/east Puget	1.04	0.140	0.28	46
Columbia/Eastern Washington	0.12	0.021	0.22	17
Northern/N-E mountains	0.097	0.011	0.22	70

Water surface area at 60-day low flow conditions was used to estimate relative potential habitat. Two hydraulic equations were used to estimate average flow geometry in the riffles:

$$Q = AV, \qquad \text{(Eq. 2)}$$

where Q = flow, in cubic meters per second,
A = cross-sectional area of flow, in square meters,
V = average velocity of flow, in meters per second;

and Manning's equation,

$$V = (1/n)\, R^{2/3} S^{1/2}, \qquad \text{(Eq. 3)}$$

where n = Manning's roughness factor,
R = the hydraulic radius (in m) = flow area/wetted perimeter,
S = the gradient.

Certain simplifying assumptions were made in order to estimate the low flow riffle area:

1) the riffles are wide in relation to their depth (i.e., width/depth > 10) during the period of measurement and at low flow;

2) the width/depth ratio (W/D) remains constant between the time of the stream survey and summer low-flow conditions,

3) the cross-sectional shape of the riffle bottom is approximately triangular, i.e., the depth increases gradually from the banks to the thalweg so that

$$A = (WD) / 2 \tag{Eq. 4}$$

4) the surface area of rapids changes, in response to changes in flow, by the same factor as that of the riffles;

5) the roughness factor, n, is approximately 0.1 under low-flow conditions.

By combining equations 2, 3, and 4, average 60-day low-flow riffle depth (D_{60}) and width (W_{60}) were calculated as

$$D_{60} = [(0.318\ Q_{60} D_s) / (S^{0.5} W_s)]^{0.375} \tag{Eq. 5}$$

where D_s = the average riffle depth (in m) measured during the survey,
W_s = the average riffle width (in m) measured during the survey, and

$$W_{60} = (W_s\ D_{60}) / D_s \tag{Eq. 6}$$

The ratio W_{60}/W_s is the factor used in calculating riffle and rapid surface areas at Q_{60}, i.e.,

A_{60} (riffle) = A_s (riffle) $*W_{60}/W_s$, and (Eq. 7)
A_{60} (rapid) = A_s (rapid) $*W_{60}/W_s$ (Eq. 8).

Pool depth is assumed to change by an amount equal to the change in the riffle depth. Pool area is assumed to change by a factor equal to the square of the ratio of the low-flow depth to the average measured depth, i.e.,

$$A_{60}\,(\text{pool}) = A_s\,(\text{pool}) * [D_s(\text{pool}) - (D_s - D_{60})]^2 / D_s(\text{pool}). \tag{Eq. 9}$$

Pond depth and surface area is assumed to be relatively insensitive to changes in flow. It is suggested that a factor of 1.0 be assigned to pond area, i.e.,

$$A_{60}\,(\text{pond}) = A_s\,(\text{pond}). \tag{Eq. 10}$$

Discussion

Individual stream systems may vary substantially in their low-flow characteristics from the regional averages developed for use in this habitat estimate. One particularly important aspect of streams which will cause them to deviate from regional low-flow estimates is contributions to base flow by springs; the habitat offered by these streams will be seriously underestimated by this method.

It is suggested that the physical survey of streams include a checklist designed to identify spring-fed systems. Indicators of spring-dominated hydrology include:

1) a relatively regular, rectangular cross-section, with minor variations in depth,

2) very low, flat floodplains, and

3) bank vegetation established along a distinct line, at a small distance above the water surface; moss on the exposed surfaces of rocks in the channel is a strong indicator of spring-fed flow.

The presence of these indicators could be noted in the physical survey on a scale of zero to three as: absent (0), slight (1), moderate (2), and pronounced (3).

The low-flow habitat factors estimated by this method should be increased according to the degree of spring influence, as identified in the physical survey, i.e.,

$$F_{sp} = 1.0 - \frac{(1-F)\ (3-N)}{3} \qquad \text{(Eq. 11)}$$

where F_{sp} = the low flow habitat factor, modified for spring influence,
F = the previously calculated low flow habitat factor, and
N = the degree of indicators of spring influence identified during the physical survey.

Thus, where the indicators are identified as pronounced, the habitat factors will be 1.0; where no spring-fed indicators are evident the habitat factors will be as previously calculated.

Several other possibilities exist for the improvement of the estimates yielded by this method. For example, the regional low-flow constants (C) could be improved by subdividing the regions, by the inclusion of a larger number of stream gages, and by considering climatic and watershed factors such as precipitation and elevation.

Additionally, this method assumes that the resistance offered to flow by the streambed is constant. Resistance is represented by the roughness factor, n, in Manning's equation. Manning's n becomes highly variable when the average substrate particle is more than 10% of flow depth. The Manning's n assumed for this analysis (i.e., 0.1) would occur throughout a range of depths and substrate textures, for instance, at an average depth of 1 foot and an average particle size (by weight) of 6.2 inches, at an average depth of 8 inches and an average particle size of 4.5 inches, and at an average depth of 4 inches and an average particle size of 2.5 inches. The effect of assuming this constant value for Manning's n is that the low-flow surface areas of streams with fine-textured, smooth substrates may be overestimated. Thus, the hydraulic calculations could be refined by varying the roughness factor according to the substrate texture and the Q_{60}.

APPENDIX VIII

Inventory of Features at Region 4 Access Areas

Introduction

In cooperation with the Access Area Managers and as part of the Wildlife Area Fish Retrofit project, SSHEAR evaluated fish passage and water diversion conditions at all Washington Department of Fish and Wildlife (WDFW) Access Areas in Region 4. The methodology used for the Region 4 Access Area inventory was identical to that used for the Snoqualmie Wildlife Area Fish Retrofit. Both are an attempt to bring all features on WDFW lands into compliance with RCW's 75.20.40, 75.20.060, 75.20.100, 77.12.425, 77.16.210 and 77.16.220.

Results / Discussion

A total of 15 features were evaluated at 13 individual sites. There are 10 (67%) culverts, three (20%) abandoned lake outlet screens and two (13%) lake level control structures. Ten sites are considered to be on fish bearing streams or lakes. Four of these 10 sites were identified as barriers, one is a partial barrier and three are total barriers. Habitat assessment revealed only three barriers with significant habitat gain. They are located at Lake Bosworth, Shoecraft Lake and Shadow Lake. Table 1 summarizes the number of features and fish bearing status at each Access Area. Table 2 contains the PI, the Access Area, barrier type, status, stream name, tributary to, and water resource inventory area (WRIA). Barrier status indicates whether the feature has no significant habitat gain (NG), requires repair (RR), or does not require repair (OK). Table 3 lists the Access Area recommendations, estimated costs and ranked bases on PI.

The barrier at Lake Bosworth is an abandoned WDFW lake screen located on the outlet stream (Site 980049) (Photo 22). Lake Bosworth (WRIA 07.0163) is a tributary to the Pilchuck River near Granite Falls (Figure 1). Coho and probably other salmonids, spawn in the outlet stream up to the structure. The lake inlet stream provides excellent spawning habitat for coho, steelhead, and sea-run cutthroat trout. The structure was originally used to keep planted trout in the lake. Currently, the facility is used to control lake levels. Although numerous sets of guide slots exist in the remaining concrete structure, the slots alone are probably not sufficient to build a pool and weir fishway. The existing slots are too close together to provide adequate energy dissipation between drops. Without adequate dissipation, excessive turbulence will make fish passage difficult over a wide range of flows. The existing structure will probably have to be extended downstream so each pool can be sufficiently large and drops through the pools small enough to meet fish passage criteria. The cost of retrofitting the abandoned lake screen as a fishway is estimated at $80,000-$100,000. A pool and weir fishway is recommended.

At the outlet of Shoecraft Lake there is an abandoned WDFW lake screen structure (Site 980047) (Photo 21). Shoecraft Lake is part of the headwaters to Tulalip Creek (WRIA 07.0001), which flows into Tulalip Bay (Figure 1). Due to Tulalip Tribal hatcheries and several other dams, Shoecraft Lake is inaccessible to anadromous fish. . Though there is very little, if any spawning area upstream, reconstructing the structure would allow access to a large amount of rearing area for resident fish, therefore it should be repaired. If the abandoned lake screen were to be repaired and still maintain lake level control function, the same methodology and estimated cost would apply as Lake Bosworth.

The culvert at Shadow Lake (Site 9800051) (Photo 23) is inaccessible due to several human-made barriers downstream. A recent court decision by the Forest Practices Appeals Board, reclassified the outlet of Shadow Lake as a Type 4 stream above 180th Street. Shadow Lake has been planted several times, therefore, resident species can be applied towards the Priority Index. The habitat upstream is primarily rearing and the quality fairly poor. The barrier does meet the criteria for correction, but funding could be better used elsewhere.

On the Silver Lake Access Area there is one culvert that is undersized and therefore a barrier (Site 980040). However, there is no significant habitat gain and repair for fish use is not warranted. The adjacent property owner stated that during high runoff periods, the crossing washes out and requested it be replaced with a larger culvert which would save WDFW money in repetitive maintenance. Even though there is no significant habitat gain, to warrant repair, repairing the culvert for maintenance would allow the resident species to access the limited habitat and promote better public relations.

Table 1. Total culverts, dams, fishways, diversions, and lake outlet screens evaluated at Region 4 Access Areas.

	Culverts	Dams	Fishways	Diversions	Lake Outlets	Features / Fish	Barriers
Bosworth Lake	0	0	0	0	1	1	1
Campbell Lake	1	0	0	0	0	0	0
Dolloff Lake	0	1	0	0	0	1	0
Hat Slough	1	0	0	0	0	0	0
Howard Lake	1	0	0	0	0	1	0
Martha Lake	1	0	0	0	0	0	0
Martha Lake	2	0	0	0	0	2	0
Seaport Bridge	2	0	0	0	0	2	0
Shadow Lake	1	0	0	0	0	1	1
Shady Lake	0	0	0	0	1	1	0
Shoecraft Lake	0	0	0	0	1	1	1
Silver Lake	1	0	0	0	0	1	1
Sixteen Lake	0	1	0	0	0	1	0

Table 2. A Prioritized list of barriers at Region 4 Access Areas.

PI	Site	Feature	Access	Stream	WRIA	Spawning (m2)	Rearing (m2)	Passability	Status
43.02	980049	Lake Screen	Bosworth Lake	Bosworth Lake Cr	07.0163	1,179	224,718	0	RR
36.86	980047	Lake Screen	Shoecraft Lake	Tulalip Cr	07.0001	0	2,638,728	0	RR
5.67	980051	Culvert	Shadow Lake	Dry Cr	09.0089	0	1481.64	0	RR

Table 3. Region 4 Access Area Recommendations and Cost Estimates. Site 980047 and 980049 are currently used as H2O level control structures.

Rank	Site	Feature	Access Area	Stream	Reccommendation	Cost
1	980049	Abandoned Screen	Bosworth Lake	Bosworth Lake Cr	Refurbish as a fishway	$80,000
2	980047	Abandoned Screen	Shoecraft Lake	Tulalip Cr	Refurbish as a fishway	$80,000
3	980052	Culvert	Shadow Lake	Dry Cr	Removal	$5,000
					TOTAL	$170,000

APPENDIX IX

Photographs of Fish Passage Barriers and Unscreened Hydraulic Diversions
On Snoqualmie Wildlife Area and Region 4 Acess Areas

Snoqualmie Wildlife Area / Cherry Valley Unit / Site 980002

Photo 1. Pump house view from Wildlife Area side.

Photo 2. Flood Gates.

Photo 3. Pump motors inside pump house.

Cherry Valley Unit pump house. Located upon the left bank of Cherry Creek (WRIA 07.0240), the pump house controls fluctuations in the water levels in Cherry Valley. The flap gates pictured above constitute a partial barrier and the pump intake is currently unscreened. The most serious problem is potential entrainment of fry and smolts in the spring when fish are actively migrating.

Snoqulamie Wildlife Area / Cherry Valley Unit / Site 980010

Photos 4. Unnamed tributary to Cherry Creek within the drainage ditch system. The upstream end of the culvert is fabricated with a pond level control structure to increase waterfowl habitat. Currently, it is a partial barrier to fish migration and requires repair in order for migrating fish to reach available spawning habitat.

Photo 5. The downstream end of the culvert poses no serious problems to fish movement. It is 100% submerged.

Snoqulamie Wildlife Area / Cherry Valley Unit / Site 980016

Photo 6. Unnamed tributary to Cherry Creek. Located on a dead end drainage ditch, this barrier culvert is completely inundated with silt and vegetation. Repair would allow fish passage to and from additional winter rearing habitat.

Snoqualmie Wildlife Area / Cherry Valley Unit / Site 980018

Photo 7. Unnamed tributary to Cherry Creek. This culvert is currently undersized and constitutes a partial barrier to upstream fish migration. It is the primary access to additional spawning habitat upstream of the Cherry Valley Unit drainage ditch system.

Snoqualmie Wildlife Area / Cherry Valley Unit / Site 980019

Photo 8. One of many culverts located on a dead end drainage ditch. This culvert is completely inundated with silt and vegetation. To ensure passage to and from additional winter rearing area, the culvert should be removed, reconfigured or the drainage ditch dredged more frequently.

Snoqualmie Wildlife Area / Stillwater Unit / Site 980022

Photo 9. This large corrugated steel culvert is severely undersized for winter flows and has created a huge plunge pool, rendering the culvert a barrier to fish. The culvert should be replaced with a substantially larger one or completely removed to allow access to additional winter rearing.

Snoqualme Wildlife Area / Stillwater Unit / Site 980024

Photo 10. Unnamed tributary to Snoqualmie River. Even though two culverts have been used at this crossing, during winter flow, it is still undersized. Repair would allow access to additional winter rearing habitat.

Snoqualmie Wildlife Area / Stillwater Unit / Site 980025

Photo 11. Unnamed tributary to Snoqualmie River. Located on the same tributary as site 980024, this small corrugated steel culvert is undersized and influenced by heavy beaver activity. If repaired additional winter rearing habitat would be accessible.

Snoqualmie Wildlife Area / Stillwater Unit / Site 980027

Photo 12. Unnamed tributary to Snoqualmie River. This small human-made dam was constructed to increase waterfowl habitat. At the same time it created a barrier for salmonids. Beavers have added to the size of the dam. The dam should be removed or a small fishway installed.

Snoqualmie Wildlife Area / Stillwater Unit / Site 980061

Photo 13. Unnamed tributary to Snoqualmie River. This round concrete culvert is located on the same tributary as Site 980027 and is severely undersized for winter flows. A huge plunge pool has formed due to the velocities the culvert creates. Again, the primary benefit in replacing this culvert is for winter rearing habitat.

Snoqualmie Wildlife Area / Spencer Island Unit / Site 980036

Photos 14 & 15. Wetland drainage. Installed through the dike, this large culvert is designed with a water level control structure on the upstream end and a tidegate on the downstream end, creating a barrier to potential summer rearing habitat.

Snoqualmie Wildlife Area / Spencer Island Unit / Site 980037

Photo 16. Installed through the same dike as Site 980036, and has the identical design for water level control.

Snoqualmie Wildlife Area / Spencer Island Unit / Site 980038

Photos 17 & 18. The photo on the left illustrates a flow control device installed on the tidal side and the photo on the right illustrates the large debris contributing to the barrier. This structure was designed as a flow control structure / fishway, but is still a partial barrier during tidal exchange and low tide.

Snoqualmie Wildlife Area / Spencer Island Unit / Site 980039

Photos 19 & 20. Identical design as Site 980038, the tidal side of the culvert / fishway is heavily influenced with tidal debris and the upstream end is designed for water level control, creating a barrier at various tide levels.

Region 4 Access Area / Lake Shoecraft / Site 980047

Photo 21. Tulalip Creek (07.0001). The feature was originally designed as a drum screen lake outlet structure. The screen has been removed and the structure is currently used as a lake level control device. It is a total barrier and requires repair.

Region 4 Access Area / Bosworth Lake / Site 980049

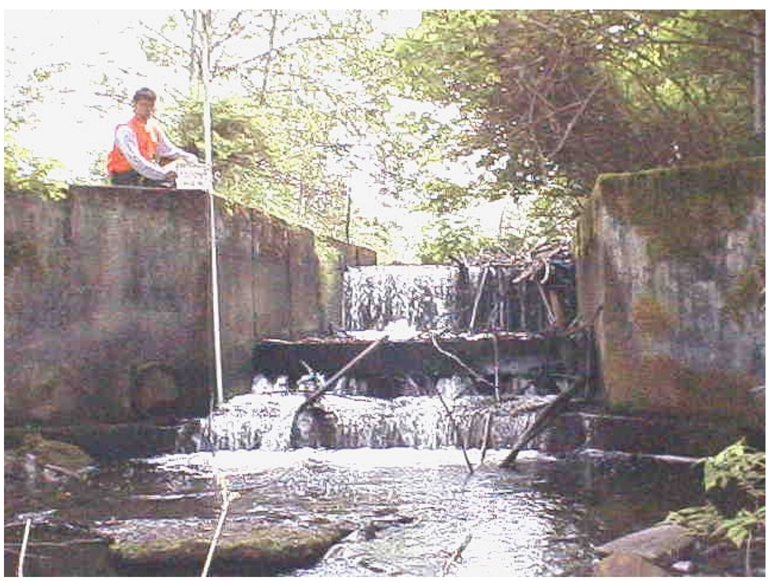

Photo 22. Bosworth Lake Creek (WRIA 07.0163). This feature was originally designed as a drum screen lake outlet structure. The screen has been removed and the structure is currently used as a lake level control device. Coho and other salmonids have been known to spawn immediately downstream. A pool and weir fishway is recommended.

Region 4 Access Area / Shadow Lake / Site 980051

Photo 23. Dry Creek (WRIA 09.0089). There are several human-made barriers downstream of site 980051 and since the Forest Practices Appeals Board reversed DNR's determination that 09.0089 was a Type 3 water above 180th Street and reclassified it as a Type 4, those additional barriers will probably not be addressed. If all human made barriers were repaired fish would probably move up the stream again.