CHAPTER 2.0
TYPICAL FISH HABITAT COMPONENT IMPROVEMENTS

In the Fish Habitat section of this report, designs for fish habitat restoration and mitigation for 9 mainstem sites and 11 tributary sites are presented at the 35% design level. Many of these designs recommend common types of fish habitat enhancement measures as noted in Table 2-1. The typical fish habitat enhancement components utilized in this study include: floating woody debris islands, woody debris booms, water tolerant plantings, large woody debris jacks, sub-impoundments, bar apex jams, meander jams, barb jams, mainstem river jam complexes, tributary jam complexes, LWD placement, woody debris reintroduction, riparian forest management, gravel reintroduction, large boulder/clusters placement, and culvert replacement. The general function and typical features of these components are described in the following sections to provide the reader with general background information and to provide a context for reviewing the fish habitat restoration and mitigation designs at each site. During subsequent, more detailed design phases, the features of these typical habitat improvement components will be customized at each location to reflect site-specific conditions and design constraints.

2.1 FLOATING WOODY DEBRIS ISLANDS

Every year, large and small woody debris is collected from Howard Hanson Reservoir as a part of its normal operation and maintenance. Under the AWSP, a portion of this collected wood will be used to for woody debris re-introduction below the dam. Another portion of this wood will be used to create several massive clusters of wood, called floating woody debris islands, which will float on the reservoir water surface in close proximity to the reservoir bank. Ten floating woody debris islands are proposed design components of site MSI-04. Each of these woody debris islands will consist of an octagonal perimeter of 24-inch to 36-inch cedar logs with crossing logs dividing the interior into quarters (Figure TF-01). Unsorted woody debris will be placed within the interior and tied together using chains or cables. When the reservoir water surface rises, the clusters will float. These floating debris islands will be anchored to the reservoir bottom to prevent drifting to other areas of the reservoir. They will provide habitat for wildlife and fish during high pool. The Section 1135 project will also place 10 floating islands within the reservoir.

2.2 WOODY DEBRIS BOOM

During low pool, the mainstem channel and tributaries entering the non-vegetated high pool area have no cover habitat available to fish. During flood flows, substantial volumes of woody debris pass into the HHD Reservoir each year. Selectively placed woody debris booms within the reservoir (Figure TF-02) will retain wood that is transported during flood flows and hold it within the areas that have no vegetation. When the reservoir pool drops as flood flows are released, this wood will settle, some of it within the active channel, providing some cover and variable fish habitat until it is collected as described in Section 2.13. Habitat created through woody debris settling will not consistently form in the same place every year, but will provide more habitat than currently exists. The debris boom will also provide cover habitat during higher pools when log rafts form within the boom area.

Table 2-1 **Site Overview of Typical Fish Habitat Components**																
Site Number	**Typical Fish Habitat Enhancement Measure Utilized**															
	Floating Islands	**Woody Debris Booms**	**Water Tolerant Plantings**	**LWD Jacks**	**Sub-impoundments**	**Bar Apex Jams**	**Meander Jams**	**Barb Jams**	**Mainstem River Jam Complexes**	**Tributary Jam Complexes**	**LWD Placement**	**Woody Debris Reintroduction**	**Riparian Forest Management**	**Gravel Reintroduction**	**Large Boulder/Clusters**	**Culvert Replacement**
GN-FG														X		
GN-KP														X		
MSI-01											X				X	X
MSI-02												X				
MSI-03						X										
MSI-04	X	X	X	X	X	X	X	X	X				X			
MSI-05			X			X			X		X		X			
MSI-06			X			X	X	X	X		X		X			
MSI-07																
TRI-01.1		X	X			X				X	X		X			
TRI-01.2						X	X			X	X		X			
TRI-01.3						X	X			X	X		X			
TRI-02.1		X	X							X	X		X		X	
TRI-02.2										X	X		X		X	
TRI-02.3										X	X		X		X	
TRI-03		X	X							X	X		X		X	
TRI-04			X							X	X		X		X	
TRI-05											X		X			X
TRI-06			X								X		X			X
TRI-07			X								X		X			X

2.3 WATER TOLERANT PLANTING

Currently there is a mature mixed forest in the 1147' to 1177' zone surrounding the reservoir (Figure TF-03A). However, this existing vegetation will not tolerate periodic inundation that will occur under the Phase I and II AWSP pool raises. As existing species die over time after the AWSP is implemented, new inundation tolerant plantings must be introduced at selected locations to provide desired riparian structure and cover (see sites MSI-04, MSI-05, MSI-06, TRI-01.1, TRI-02.1, TRI-03, TRI-04). The Howard Hanson Dam Section 1135 Fish and Wildlife Restoration Report (HDR Engineering and Beak Consultants 1996) provides guidance for future plantings in the Howard Hanson Reservoir Inundation Zone Revegetation Plan. Portions of this Section 1135 report are included in Appendix G of this document. Water-tolerant trees, shrubs, and forbs, including Pacific Willow, Oregon Ash, Baldcypress and sedges, could be planted within the reservoir Phase I and II inundation zones (El. 1147 to 1177') along the reservoir shoreline as noted in Figures TF-03B. Although Oregon Ash and Baldcypress are not native species, they could be utilized to provide riparian structure not possible with native plants due to fluctuating water levels. However, a final decision regarding the utilization of non-native plantings must be reached among watershed managers and fisheries agencies.

Water tolerant plantings are also recommended on exposed point bars and in the arcuate bars that form immediately downstream of BAJs for sites MSI-05 and MSI-06. These plantings will provide cover habitat, promote stable bar formation, and increase overbank roughness of exposed bars. Water tolerant plantings are also recommended within the channel for sites TRI-06 and TRI-07 to reduce water temperature, increase dissolved oxygen levels and bind soils. Suitable plantings at these four sites include Sitka Willow and Sitka Alder.

2.4 LARGE WOODY DEBRIS (LWD) JACKS

During reservoir low pool periods, the lack of vegetation in the mainstem channel between elevations 1130' and 1177' tends to create a channel bed with a high width to depth ratio (wide and shallow). This channel geometry, coupled with poor cover habitat, makes upstream fish passage difficult. To establish a low flow channel that is deeper and narrower, large woody debris (LWD) jacks could be placed between the high and low pool elevations. The jacks, shown in Figure TF-04, and a recommended component for site MSI-04, would have a tendency to collect smaller wood material. The objective of LWD jack placement is to establish roughness elements within the low and high pool interface that will allow the channel to scour a deeper channel adjacent to each jack. The LWD jacks would be anchored in place for stability during high pool elevations.

2.5 SUB-IMPOUNDMENT CREATION

Sub-impoundments, such as those shown in Figure TF-05 can be used to create wetlands and/or ponds along the reservoir shore within the 1147 to 1167-foot elevation zone for fish rearing habitat and wildlife benefits. As the reservoir water surface elevation rises above the sub-impoundment elevation these types of pond/wetland complexes will be created. Outlet flow-control structures, such as timber check dams or notched weirs, are important features of sub-impoundment design. They are designed to slowly release the impounded water once the reservoir water surface recedes below the sub-impoundment surface and also to provide a passage to prevent fish stranding (Figure TF-05).

2.6 BAR APEX JAMS

Historically, debris jams in Puget Sound rivers have created floodplain channels, deep pools and a dynamic channel-floodplain connection. Bar apex jams (BAJs) are a common debris deposit type that have formed naturally within the Green River mainstem and its tributaries. BAJs are naturally created in northwest gravel bed rivers when large key members deposit parallel to the direction of flow with root wads facing upstream. Subsequently, woody debris that is transported downstream during highs racks perpendicular to the key member root wad face or stacks over key member boles.

BAJs induce the formation of a low gradient depositional area downstream and a crescent-shaped pool upstream and adjacent to the jam as shown in Figure TF-06 (Abbe and Montgomery, 1996). In the Queets River, large woody debris jams are associated with 70 percent of all pools that are typically deeper than free-formed pools. BAJs form mid-channel islands and split flow into smaller side channels that exhibit a broad range of velocities and depths. Therefore, they contribute to a mosaic of forest patches of different ages and associated terrestrial habitats (Perkins, 1999).

In a review of existing studies of larger rivers, Perkins (1999) found that the presence of natural log jams and debris jams is significantly higher in unconfined reaches than in confined reaches. This was attributed to the tendency of confined reaches have much deeper, faster flows, narrower floodplains and low channel migration rates than unconfined reached. In the Queets River, confined reaches had 20-30 pieces of debris per kilometer and 1-1.5 pieces per channel width while unconfined reaches had 310-530 pieces of debris per kilometer and 51-87 pieces per channel width (Hyatt 1998). In the Green River, 7-18 pieces per kilometer are found in confined reaches while 21-59 pieces per kilometer were found in unconfined reaches.

BAJs can be engineered and constructed to imitate naturally occurring jams (Figure TF-06) and to promote establishment of the desirable physical and ecological conditions that they commonly induce. Construction of engineered BAJs is proposed for many of the fish habitat enhancement sites on the Green River mainstem, both above and below HHD, as well as some tributaries as indicated in Table 2.1. These synthetic jams can be carefully designed and sited to restart or improve flow into existing or historical side-channels to provide summer fish rearing habitat. However, in contrast to naturally occurring jams, their placement and structure is based on a rigorous engineering analysis of jam stability, channel hydraulics and flooding potential.

BAJ formation can be engineered by partially embedding a large key member into the center of the river, root wad pointed upstream, bole downstream. As other large woody debris travels down the river, it will accumulate on the key member. As the river evolves, one side of the BAJ will erode while vegetation and gravel fills in the other.

Alternatively, the BAJ can be designed and constructed in a more complete form with carefully sizing and placed key, racked and stacked members. Engineered BAJ design requires hydrologic, hydraulic, geomorphic and structural analyses to help ensure stability of the apex jam under high flows, address the potential impacts of the jam on channel migration, and address potential backwater effects. The placement and number of jams within a reach should be determined based on these comprehensive analyses that reflect site-specific Green River dynamics.

BAJ design and construction can be costly and is best considered in areas where jam stability is essential to protect infrastructure (Perkins 1999). Key members should be size based on bankfull channel dimensions and installed below maximum predicted channel scour depth. Both key and stacked members should have intact root wads. Anchoring jams in confined reaches should be done with caution, if at all, since scour could cause bank erosion and expose the cables.

2.7 MEANDER JAM AND COVER HABITAT

Another type of jam is the meander jam (MJ) shown in Figure TF-07. Meander Jams are proposed at selected sites above the reservoir both on the mainstem and its tributaries as indicated in Table 2.1.

MJs are more common to be naturally formed as river size increases. They are similar to the BAJ with key pieces beginning the formation of the jam and smaller pieces racking up against key piece root wads facing upstream. MJs are generally located at the upstream end of a point bar. Once established and stable, a MJ will prevent lateral migration and can compress and shorten the bend radius of a meander. This produces complex pool and cover habitat for aquatic habitat. The introduction of MJs to create complex pools along the outside bends of rivers and creeks will provide missing complexity in water depth, velocity, and habitat quality.

Along some bends subject to erosion, MJs will be specifically constructed to protect the bank and establish growing site for riparian vegetation. The logs are held in place by reburial with alluvium, with large boulders, and eventually with the root structure of new plantings.

2.8 BARB JAMS

Barb jams are constructed for three primary purposes:

1. to protect and stabilize undercutting slopes
2. to establish vegetation where minimal riparian space is available on steeper banks, and
3. to induce meandering on straight, shallow “chute” reaches of a river.

Barb jams are built as shown in Figure TF-08 by placing key LWD members along the bank with limited burial (ground disturbance and embedment). Large boulders and racked LWD members are added to the key members to provide mass for stability under high flow conditions. Soil is placed on top of the barb jam and it is planted to stabilize the structure.

Barb jams will deflect flow away from the bank they are built on, steering the flow toward the opposite bank of the river. The barb jam also creates a constriction in the channel that results in stacking of water above the jam and increases water velocities past the jam. The higher velocities tend to scour the bed of the channel and create pool habitat beside and immediately upstream of the barb jam. The pool occurs adjacent to the jam, and in combination with the LWD nooks and crannies, provides excellent fish habitat. Vegetation planted on top of the barb jam and on the river bank provides shading and a long-term source of LWD.

The opposing bank of the river will retreat with time and introduce greater sinuosity into the reach. Barb jams can be built in series to re-introduce more extensive sinuosity to the channel and to provide an even greater diversity of fish and wildlife habitat.

2.9 MAINSTEM RIVER JAM COMPLEX

A typical mainstem jam complex, shown in Figure TF-09, contains BAJs, MJs and large wood deposits that collectively work to provide desired fish habitat complexity and channel stability. These complexes can form naturally or can be carefully engineered and constructed to create desired fish habitat and enhance channel stability. Jam complexes are less frequently found in more confined segments of northwest rivers.

Above HHD, the mainstem channel is less confined and opportunities to place jam complexes are greater. Mainstem jam complexes are proposed above the reservoir for sites MSI-04, MSI-05, and MSI-06. These mainstem complexes also call for the placement of large wood in overbanks areas to increase roughness and reduce channel avulsion potential.

Below HHD, the stream channel is more confined than above the dam. Opportunities to re-establish large wood jam accumulations below the dam will focus on areas that are more likely to allow deposition of large woody debris moving downstream during flood events. Large trees with root wads and/or secured smaller material will be used to provide the mass needed to resist design flood force. The jams will be constructed to allow accumulation and racking of material floating downstream. The addition of overbank roughness elements below the dam needs to be carefully evaluated and may be infeasible in areas where the floodplain and channel are disconnected.

2.10 TRIBUTARY JAM COMPLEX

Tributary jam complex development is recommended for the tributary sites TRI-01, TRI-02, TRI-03 and TRI-04 above HHD. Jam complex habitat in smaller streams can be more extensive because the ability of the water to move and shift large wood is decreased.

A typical tributary jam complex, formed through selective LWD placement is shown in Figure TF-10. Where appropriate, channel-spanning logjams will be constructed. In previously degraded segments the jams will aggrade the stream channel and provide low velocity areas where spawning gravel can deposit during discharge events that mobilize upstream bed material. Pool forms can also be excavated and improved at appropriate locations while placing and constructing log jams. Through this work the overall complexity, cover habitat, floodplain connectivity, and spawning gravel retention for fish will be improved.

Tributary jam complexes may also include selective placement of boulders/clusters. BAJ and MJ designs are often incorporated into tributary jam complex design in higher flow tributaries such as the North Fork Green River (TRI-01.1, TRI-01.2, and TRI-01.3).

2.11 LARGE WOODY DEBRIS PLACEMENT

Large woody debris (LWD) placement refers to the general reintroduction of large woody debris to form pools and cover habitat, promote gravel retention and jam formation, and enhance bar or overbank roughness at appropriate locations throughout the watershed. LWD placement is recommended downstream of the reservoir at Signani Slough (MSI-01), in the mainstem Green River both above and below the reservoir, and at all of the fish habitat tributary sites as indicated in Table 2.1. LWD sizing and placement at these locations must reflect the site-specific reach characteristics and the intended geomorphic and habitat enhancement objectives.

Within low gradient tributary reaches, LWD is typically placed in tributary jam configurations shown in Figure TF-09. In steeper tributary reaches, such as those found in Gale Creek (sites TRI-02.2 and TRI-02.3), LWD placement is more likely to resemble the configuration shown in Figure TF-10.

An example of LWD placement in the mainstem above HHD is shown in Figure TF-08. General LWD reintroduction is also recommended at site MSI-02 located on the Green River below HHD as described in the Section 2.12.

2.12 WOODY DEBRIS RE-INTRODUCTION

Woody debris reintroduction is recommended below HHD in designated locations at Site MSI-02 (see figures MSI-02A and MSI-02B). This action is recommended because, similar to gravel, nearly all of the large and small woody debris entering the HHD reservoir is captured and retained within the reservoir, unable to pass the dam to the mainstem river below. The amount of woody debris in the Green River below the TWDD has also been greatly reduced by timber harvest and active removal from the river. As recently as 1994, a King County survey indicated that only 46 pieces of woody debris were available per stream mile (21-59 per km) or 1 to 3 pieces per channel width in the middle Green River downstream of HHD (Perkins 1999). In a comparable-sized, unmanaged river basin, Queets River, debris pieces range from 310-530 km or 51-87 per channel width in unconfined channel reaches (Hyatt 1998). LWD abundance in the Green River below the TWDD is 1/10 or less that of the unmanaged Queets River. Restoring large woody debris to the Green River will help restore some of the aquatic habitat that has been lost and degraded during the last 100 years (Perkins 1999).

Woody debris will be collected at the head of the reservoir and at the mouths of selected tributaries via selectively placed log booms described in Section 2.2. During low pool periods, LWD and some amount of small wood will be collected and loaded into trucks for transport around the two dams as prescribed in Tacoma Public Utilities Habitat Conservation Plan (Tacoma, 1999). This transported wood can then be unloaded onto the select river bank locations along the mainstem during low flow periods. During subsequent high flow periods, the woody debris poised on the bank will be mobilized and re-introduced to the mainstem Green River where it can resume its natural downstream movement, create log jams, and diversify fish habitat.

Select pieces of LWD reintroduced below HHD may be anchored in the river, rather than allowing flows to distribute the pieces naturally. If anchored, fewer pieces would be added to the river to ensure implementation costs remain comparable to those of placing unanchored LWD. LWD anchored in the channel will have a volume of at least 11 cubic yards, or will be installed in groups that have a collective volume of 11 cubic yards, which is consistent with the minimum key piece size for larger rivers (WFPB 1997). The total volume may be composed of a single piece with an average diameter of 24 inches that is at least 105 feet long, shorter pieces with larger diameters (NWIFC 1997), or a group of smaller pieces with a collective volume of at least 11 cubic yards.

2.13 GRAVEL RE-INTRODUCTION

Very nearly all of the sediments, bed load and suspended load, entering the HHD reservoir are captured and retained within the reservoir. As a result, many reaches below the reservoir are gravel starved. Gravel must be reintroduced below HHD to provide adequate fish spawning habitat. Gravel reintroduction is discussed further for mainstem sites GN-FG and GN-KP located downstream of HHD.

Local sources of suitable quality gravel, selectively sized and graded, should be identified. The gravel will be transported from these source locations and unloaded onto select points along the mainstem. Gravel will typically be reintroduced to the river at locations upstream of gravel-starved reaches that are either historical or potential salmon spawning areas.
Gravel placement should occur during low flow periods when the mainstem banks are accessible. Properly placed gravels will be mobilized and re-introduced to the river during subsequent high flow periods. Under high flow conditions, the gravel poised on the bank will resume its natural downstream movement and sorting. The gravel will deposit in appropriate locations where velocities are lower and promote the creation of high-quality fish spawning habitat.

2.14 RIPARIAN FOREST MANAGEMENT

The objectives of managing the adjacent riparian forest are twofold. First, there is a need to selectively fell wood material, lost from logging activity, to increase floodplain roughness and provide floodplain resiliency during large floods as shown in Figure TF-09. Secondly, active planting and thinning are needed to accelerate natural succession to an old growth forest environment, providing long-term floodplain resiliency and wood recruitment for future fish habitat.

These objectives will be accomplished by actively placing large wood throughout the active floodplain within existing riparian vegetation. Standing live trees will be managed by thinning to selectively retain the most desirable trees, planting new trees missing within the corridor, and optimizing the growth potential of both. Non-inundation tolerant riparian plantings prescribed in Tacoma Utility District's Habitat Conservation Plan (HCP), such as Douglas-fir, will be used (Tacoma, 1999). Within the Bonneville Power Administration's (BPA) right-of-way, low-height planting should be limited to low-height species such as vine maple, ocean spray, hazelnut, red elderberry, Indian plum, snowberry, red huckleberry, and willow.

All of the Fish Habitat sites above HHD are within either a Natural Forest Management Zone or a No Harvest Riparian Buffer as designated in Tacoma's HCP. Any modification to the riparian management prescribed in the HCP will require approval by the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS).

2.15 LARGE BOULDER/CLUSTER PLACEMENT

Introduction and manipulation of large boulders and/or boulder clusters is a general tool that could be used within some stream reaches to form habitat feeding sites, create pools, and provide cover, grade control, and logjam ballast,. Local habitat objectives, and site-specific geomorphology, hydrology, hydraulics, and logjam design would determine size, location, and the timing of placement.

2.16 CULVERT REPLACEMENT

Culvert replacement for fish passage is recommended at Signani Slough (site MSI-01), and at sites TRI-05, TRI-06 and TRI-07, located on Green River tributaries upstream of HHD. At these sites, the existing culverts are perched and obstruct spawning and rearing habitat. Replacement of perched culverts with properly sized bottomless arch culverts or bridges will allow fish passage to upstream habitat to resume. Culvert designs should follow Washington Department of Fish and Wildlife (WDFW) guidance (WDFW, 1999). Habitat enhancement measures such as LWD placement and riparian planting and management are also recommended as noted in the specific Fish Habitat site descriptions.

Insert the following figures here:

TF-01
TF-02
TF-03A
TF-03B
TF-04
TF-05
TF-06
TF-07
TF-08
TF-09
TF-10
TF-11