CHAPTER EIGHT

Stream Habitat and Riparian Areas Analysis

This chapter documents the habitat analysis and summarizes potential solutions to improve and restore habitat conditions in the future.

The aquatic habitat analysis performed for the Clear/Clarks Creek Basin was primarily qualitative. Qualitative factors considered in the analysis included barriers to fish passage, increased peak stream flow rates and availability of perennial streamflows in the basin, streambank erosion and instability, and other conditions that adversely affect aquatic habitat conditions.

The aquatic habitat analysis of the Clear/Clarks Creek Basin included an assessment of stream reaches using the "Urban Stream Baseline Evaluation Method" (USBEM) (R2 Resource Consultants, 1999). The USBEM contains a rating table for characterizing habitat into "good," "fair," and "poor" categories. These categories are used in the project prioritization process presented in Chapter Nine.

Chapter 4 documented the extent of degraded riparian and aquatic habitat in the Clear/Clarks Creek Basin. *Appendix "E"* documents the habitat field investigation conducted for this study. There are a number of interrelated causes for loss of salmonid habitat.

8.1 Summary of Aquatic Habitat Field Investigation

The USBEM in the Tri-County Urban Issues Study was used to classify salmon habitat quality in the Clear/Clarks Creek Basin. The analysis was a two-phase process consisting of a pre-classification screening phase and a field observation phase.

"Phase I" prescreening was performed as part of basin characterization as documented in Chapter Four. "Phase II," field observation, provided a quantitative assessment of habitat characteristics including riparian condition, substrate composition, embeddedness (presence of fine sediments), bank condition, passage barriers, pool frequency, channel pattern and bedform, and large woody debris (LWD).

In addition to field habitat assessment, local residents were interviewed for information on fish use, habitat alteration, land use, water flow fluctuation, and any other factor that might influence habitat condition. Selection of the appropriate recovery options for the species of concern used the results from the USBEM analysis. *Table 8-1* summarizes the USBEM habitat evaluation for each planning unit (subbasin) in the Clear/Clarks Creek Basin. *Appendix "E"* documents the USBEM analysis.

TABLE 8-1
USBEM Phase II Habitat Condition Assessment

Subbasin	Study Reach[a]	Subbasin	Location	USBEM Rating
Swan Creek	A	SW-1	Confluence with Clear Creek to BNSF Railroad	Poor
Swan Creek	B	SW-1	BNSF Railroad to Pioneer Way	Fair
Swan Creek	C	SW-1	Pioneer Way to 41st Street E	Fair
Swan Creek	D	SW-2	41st Street E to 48th Street E	Fair
Swan Creek	E	SW-2	48th Street E to 1500' upstream of 48th Street E	Good
Swan Creek	F	SW-2	Approx. 1500' upstream of 48th Street E to 64th Street E	Poor
Squally Creek	A	SQ-1	Pioneer Way to 48th Street E	Poor
Clear Creek	A	CL-1	River Road to 100' upstream of confluence with Swan Creek	Poor
Clear Creek	B	CL-2	Gay Road to 300' downstream of BNSF Railroad	Poor
Clear Creek	C	CL-2	300' downstream of BNSF Railroad	Poor
Clear Creek	D	CL-2	BNSF Railroad to Pioneer Way	Fair
Clear Creek	E1	CL-4	1800' upstream of Pioneer Way to 49th Street E	Poor
Clear Creek	E2	CL-4	49th Street E to 60th Street E	Poor
Clear Creek	F	CL-5 CL-6	60th Street E to 765' upstream of 72nd Street E	Poor
Canyon Creek	A	CY-1	Confluence with Clear Creek to 44th Street E	Poor
Canyon Creek	B	CY-1	44th Street E to 52nd Street E	Poor
Canyon Creek	C	CY-1	600' reach downstream of Pioneer Road	Poor
Canyon Creek	D1	CY-2	Pioneer Road to first Canyon Road crossing	Poor
Canyon Creek	D2	CY-2	1000' Reach upstream of first Canyon Road crossing	Poor
Canyon Creek	D3	CY-2	650' reach downstream of second Canyon Road crossing	Poor
Canyon Creek	E	CY-2	500' reach upstream of second Canyon Road crossing	Poor
Canyon Creek	F	CY-2	1400' reach downstream of 72nd Street E	Poor
Canyon Creek	G	CY-3	72nd Street E to 80th Street E	Poor
Rody Creek	A	RY-1	Stewart Road to Pioneer Road	Poor
Diru Creek	A	DU-1	72nd Street E to 78th Street extended	Fair
Woodland Creek	A	WO-1	Pioneer Way to 80th Street E	Fair
Woodland Creek	B	WO-2	150' reach upstream of 80th Street E	Poor

TABLE 8-1
USBEM Phase II Habitat Condition Assessment

Subbasin	Study Reach[a]	Subbasin	Location	USBEM Rating
Woodland Creek	C	WO-2	900' reach downstream of 84th Street E	Poor
Woodland Creek	D2	WO-2	1500' reach upstream of 84th Street E	Poor
Clarks Creek	A	CK-2	W end Tacoma Road to 7th Avenue E	Poor
Clarks Creek	B	CK-3	7th Avenue E to 15th Avenue E	Fair
Clarks Creek	C	CK-3	150' upstream of 15th Avenue E	Fair

[a] See Figure F-1 in Appendix “E”

8.2 Limiting Factors

Limiting factors to fish production were characterized from the results of the USBEM “Phase II” analysis. *Table 8-2* shows the limiting factors in relative order of importance for each of the creeks in the Clear/Clarks Creek Basin. The table shows that low base flow, channel size, and erosion are the most important limiting factors in all streams but Clarks Creek. This table also shows that the benthic invertebrate community and water temperature are generally the least important limiting factors. Section 8.3 presents a comprehensive discussion of the limiting factors is in the Basin.

TABLE 8-2
Limiting Factors[a] in the Clear/Clarks Creek Basin

Stream	Limiting Factors Most Limiting										Least Limiting
Swan Creek	Erosion	LWD	Low Flow	Pool Frequency	Bank Condition	Channel Size	Substrate Composition	Benthic Inv. Comm.	Water Temp.	Passage Barriers	Riparian Condition
Squally Creek	Low Flow	Channel Size	Erosion	Substrate Composition	Pool Frequency	LWD	Bank Condition	Riparian Condition	Passage Barriers	Benthic Inv. Comm.	Water Temp.
Clear Creek[b]	Erosion	Passage Barriers	Low Flow	LWD	Substrate Composition	Pool Frequency	Bank Condition	Channel Size	Riparian Condition	Water Temp.	
Canyon Creek	Low Flow	Channel Size	Erosion	LWD	Pool Frequency	Substrate Composition	Bank Condition	Benthic Inv. Comm.	Passage Barriers	Riparian Condition	Water Temp.
Rody Creek	Low Flow	Channel Size	Erosion	Pool Frequency	LWD	Substrate Composition	Bank Condition	Benthic Inv. Comm.	Riparian Condition	Passage Barriers	Water Temp.
Diru Creek	Low Flow	Channel Size	Erosion	Bank Condition	Pool Frequency	LWD	Substrate Composition	Benthic Inv. Comm.	Riparian Condition	Passage Barriers	Water Temp.
Woodland Creek[a]	Low Flow	Channel Size	Erosion	Bank Condition	LWD	Substrate Composition	Pool Frequency	Riparian Condition	Passage Barriers	Water Temp.	
Clarks Creek	Pool Frequency	LWD	Bank Condition	Riparian Condition	Substrate Composition	Benthic Inv. Comm.	Passage Barriers	Water Temp.	Channel Size	Low Flow	Erosion

[a] Limiting factors from USBEM analysis, see Appendix “E”

[b] Only 10 limiting factors assessed. B-IBI sampling not performed in this reach so the condition of the benthic invertebrate community is not known.

8.3 Existing Aquatic Habitat Problems

8.3.1 Fish Passage Barriers

Maintaining fish passage is particularly important for salmonids. During migration periods to and from the ocean, salmonids frequently encounter instream manmade blockages such as culverts and diversion weirs, or natural barriers, such as beaver dams or overly steepened channels (i.e., cascades). Culvert openings too high above the stream channel for fish to jump into, and culverts too long or positioned at a grade too steep for fish to ascend, can be barriers to fish migration. Fish passage barriers are present in all streams of the Clear/Clarks Creek Basin. All streams in the Basin have total blockages at street crossings at the upstream ends of their canyon reaches. Blockages are present at:

- 64th Street East for Swan Creek
- 58th Street East for Squally Creek
- 72nd Street East for Clear, Rody, and Diru Creeks
- 84th Street East for Woodland Creek
- 96th Street East for Clarks Creek
- Partial blockage at Pioneer Way East on Rody Creek.
- A dam just upstream of the WDFW hatchery on Clarks Creek at Maplewood Springs is a total barrier. The dam, which impounds water for use at the hatchery, is approximately ten feet high and does not have a fish ladder.
- A weir structure on Clear Creek just above Pioneer Way East, operated by Trout Lodge, forms a barrier to salmon migration. According to the WDFW area habitat biologist, the Trout Lodge hatchery has operated the weir under permit from the State since the 1930s.

Fish passage barriers were identified during the field investigation and from the Pierce Conservation District (PCD) database. Field observation and the hydrologic analysis showed that most of the creeks run dry during the summer months. For this reason, the fish passage analysis for culverts was limited to the lower canyon and floodplain areas where year-round base flow is present.

Culverts were assessed during the field investigation using the WDFW "Level A" Criteria (WDFW, 2000). *Tables 4-23, 5-1* and *5-2* list the locations of barriers to fish passage in the Clear/Clarks Creek Basin. Location of the barriers to fish passage identified during "Phase I" are shown on *Figures 5-1* and *5-2*.

A "Level B" analysis was performed using the culvert analysis model HY-8 on publicly owned culverts with barrier status of "unknown" but with known fish use. *Table 8-3* presents the results of the "Level B" analysis. The table reports that the culverts at Clear Creek and Pioneer Way East, Clear Creek and Gay Road East, and Rody Creek at Pioneer Way East are not barriers to fish passage. However, the velocity of Woodland Creek through a culvert on the Washington State University (WSU) Experimental Farm is a barrier.

TABLE 8-3
"Level B" Fish Passage Barrier Analysis

Problem ID[a]	Location	Design Discharge (cfs)	Culvert Length (feet)	Hydraulic Drop (feet)	Depth of Flow (feet)	Average Velocity (fps)	Barrier Status
CL-30	Clear Creek at Gay Road	24.5	45	0.08	3.25	1.9	No
CL-31	Clear Creek at Pioneer Way E	15.5	80	0.2	1.9	1.0	No
RY-20	Rody Creek at Pioneer Way E	4.5	113	0.7	1.4	3.9	No
WO-30	Woodland Creek - WSU Experimental Farm	13.1	1,115	3.2	1.4	5.5	Yes, Velocity

[a] See Figures 5-1 and 5-2
[b] Existing and future conditions design discharge are approximately equal
Source: CH2M HILL Habitat Analysis

Low flow conditions in the summer prevent passage of fish in all streams low in their watersheds. Swan Creek was dry at a point about halfway between 64th Street East and Pioneer Way East when surveyed in July 2001. Squally, Diru, Woodland, and Rody Creeks are very small streams and prevent adult salmon passage at low flow. When chinook salmon return to the Puyallup Tribal Hatchery in September and October, Diru Creek is too small for the fish to get up to the hatchery. Even if no dam existed on Clarks Creek at Maplewood Springs, the flow above Maplewood Springs is very low during the dry season.

8.3.2 Altered Stream Flows

Many of the habitat problems in the Clear/Clarks Creek Basin result from the altered hydrologic regime caused by the conversion of forested land to agricultural, residential and commercial uses. The relationship between urbanization in a watershed and the resulting impacts on stream flows is well documented.

Before development, rain falls on forested areas, is retained in the layer of forest duff, and is slowly released to the stream system. The natural retention ability of the forest reduces peak stream flows and provides a base flow during the dry summer months.

As development occurs, pervious areas are paved or hardened, and stormwater runs off into constructed drainage systems that quickly convey rainwater to a receiving stream or wetland. As a result, less rainwater is able to infiltrate and peak stream flows have increased significantly in the Clear/Clarks Creek system.

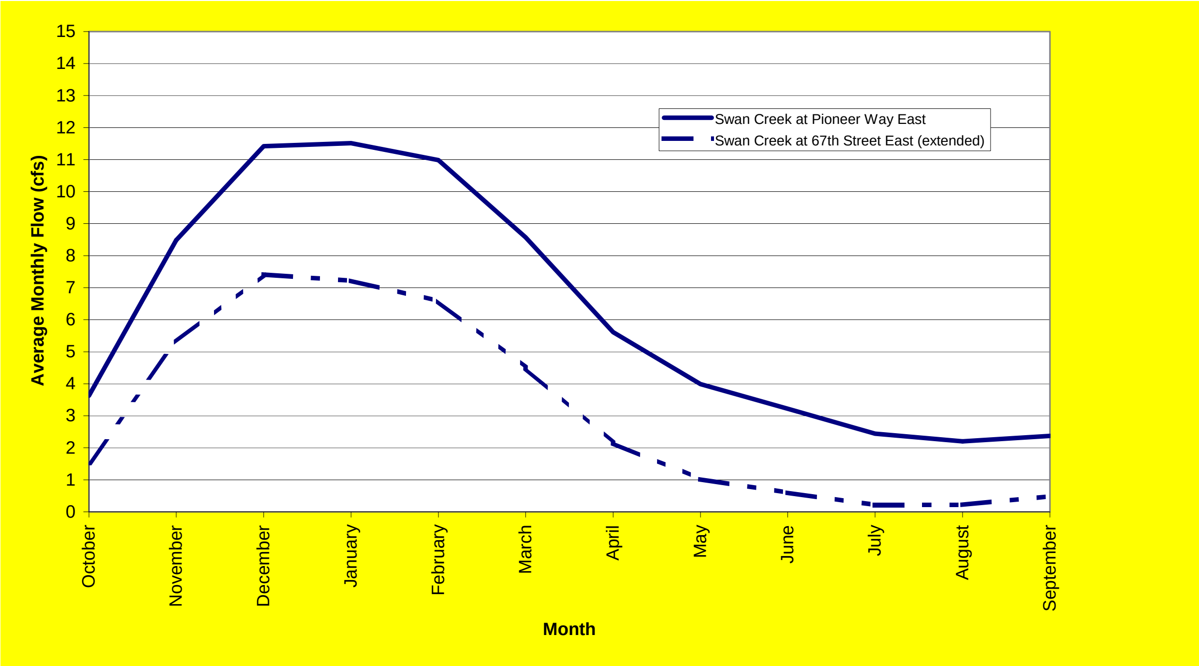
Low Summer Base Flow

During the summer months, intermittent low flow conditions exist in all streams low in the watersheds, as discussed above in terms of fish passage. In their mid-canyon reaches, Swan, Clear, Canyon, and Clarks Creek receive considerable groundwater and gain in flow as they proceed down into the Puyallup River Valley. Above these points, the streams are essentially dry during the late summer. Even if blocking culverts did not exist at 64th Street East, 72nd

Street East, 84th Street East, and 96th Street East, fish habitat would not be available due to an absence of perennial flow. Low flows in the canyons prevent the canyon reaches from providing high-quality spawning habitat. Due to the absence of historic flow data, it is not possible to quantify the effects of land development on base flow in the creeks.

The hydrologic analysis in Chapter Six predicted that nearly all the canyon reaches of the creeks dry up during the late spring and summer months. *Figure 8-1* illustrates the results from the analysis of Swan Creek. The figure shows the average monthly flow for a canyon and lowland reach in Swan Creek. The canyon reach is located above 67th Street East and the lowland reach is located at Pioneer Way East. *Figure 8-1* shows that perennial stream flow occurs in the lowland reach of Swan Creek year round. In comparison, stream flow occurs in the canyon reach only during the winter months and essentially disappears during the summer months. *Figures 5-1* and *5-2* in Chapter Five show the approximate location in each stream where perennial flow starts.

FIGURE 8-1
Average Monthly Flow at Swan Creek (from HSPF analysis)



Increased Peak Discharge Rates

Urbanization typically results in increase of peak stream flows, with the largest relative increase occurring for more frequent flow events. These increased peak flows tend to increase the depth and frequency of streambed scour (Booth, 1990). Land development removes trees, understory and groundcover plants, and top soil. It increases impervious surfaces. Consequently, peak stream flow rates increase, and erosive flows increase in their frequency and duration. The high velocity flows pick up and transport sediment to less steep stream reaches and pools where sediment settles, and buries sources of fish food.

Higher peak flows also negatively affect fish habitat by causing channel erosion and stream bank instability. Direct impacts to salmon can occur when bed scour depth during the egg incubation period exceeds the nest (redd) depth.

Field observation of bank instability provides evidence that peak flow rates are increasing in the subbasins. The banks of the Swan Creek channel downstream of 64th Street East have eroded to nearly vertical, 12-foot high walls. This erosion pattern is typical of a lower gradient stream where increased flow rates create lateral erosive forces that cut into channel walls and cause the channel to widen into a rectangular shaped channel section with steeply sloped channel walls.

The near-vertical walls indicate that the Swan Creek channel has not yet reached equilibrium (Booth, 1990). Vertical channel downcutting, or incision, usually occurs rapidly in response to increased peak flow rates in relatively higher gradient streams. In steep terrain, peak flows scour and incise stream channels, sometimes to the point of creating barriers to fish passage and creating landslides. The steep reach of Woodland Creek downstream of 84th Street East exhibits significant incision to accommodate increased peak flows resulting from urbanization.

8.3.3 Riparian Corridors

Riparian corridors play an important role in supporting aquatic habitat conditions in a stream system. Streamside vegetation contributes large woody debris for pool habitat and complexity, shades streams to maintain cool temperatures, stabilizes streambanks and reduces fine sediment, supports wildlife, provides food and food-generating leaf litter, and provides floodplain storage of stormwater.

Vegetated buffers also help reduce or eliminate impacts to streams from nearby land uses. The effectiveness of riparian buffers generally increases with buffer width and presence of streamside conifers. Generally, riparian corridors need to be as wide as the streamside trees are tall; maximum height of trees in the Basin is 150 feet, and resource agencies recommend 150-foot buffer width.

Riparian function in the upper areas of all the watersheds is severely impaired. When the upper watersheds were cleared for pasture, riparian vegetation did not reestablish in either large or contiguous corridors. Cattle and other livestock probably cropped the sapling trees, except in areas where livestock were excluded.

In addition, riparian vegetation was removed when ditch channels were dug for stormwater flow conveyance improvements to solve local flooding problems. The upper watersheds contain many ditch channels. Homeowners along the creeks have encroached on riparian buffers by clearing vegetation to the edge of the creek and planting lawns. The sparse, patchy, narrow, or absent riparian vegetation has a wide range of adverse effects on salmonid communities.

The loss of trees and other streamside vegetation affects the recruitment of large woody debris and the frequency of pools in streams. Large woody debris and pools in streams are important to salmonid habitat. The general lack of streamside tree cover and shade also limits terrestrial insect and leaf litter inputs to the food chain.

The canyon reaches of the tributaries generally have good riparian characteristics. The canyon reaches extend up to: 64th Street East for Swan Creek; 58th Street East for Squally Creek; 72nd Street East for Clear, Rody, and Diru Creeks; 84th Street East for Woodland Creek; and 96th Street East for Clarks Creek. Woodland Creek does not have much of a canyon reach or a contiguous riparian area associated with it. Despite the generally good riparian buffer width in the canyon reaches of the streams, many of the desirable benefits of riparian growth are absent. Shade is generally good, but the trees are too young to contribute much LWD to the channels.

Channel down cutting is another factor diminishing the benefit of riparian function in the canyon reaches. Any large woody debris that falls into the creeks is swept downstream by high peak flows. Streambank erosion contributes to this problem by creating smooth-walled channels that are unable to hold trees in place.

Deciduous trees dominate the forest community in canyon reaches. In streamside areas, conifer trees typically provide a higher benefit to habitat than deciduous trees because conifers provide more durable, longer lasting wood when submerged in streams. Conifers are more resistant to rot compared to deciduous trees. Conifers LWD can last up to 50 to 80 years in wet conditions whereas deciduous LWD may last no more than 20 years. Some conifers, such as cedars, can last up to 100 years or more. Deciduous trees provide leaf litter, but it comes as one big dump in the fall. Conifers provide leaf litter year-round. Conifer trees also provide year-round shade, which is helpful in shading out undesirable or invasive understory vegetation, such as Himalayan blackberries, purple nightshade, and reed canary grass.

The floodplain reaches of all the streams have been adversely affected by practices that have removed the native riparian cover. This has allowed invasive species such as Himalayan blackberry, elodea, and reed canary grass to encroach on the streams. Nearly all of the creeks in this area have been channelized (straightened and rerouted from their original courses). Stream channelization limits the complexity of the riparian community and eliminates fish refuge areas by removing meander bends and disconnecting the stream from the floodplain.

8.3.4 Instream Habitat

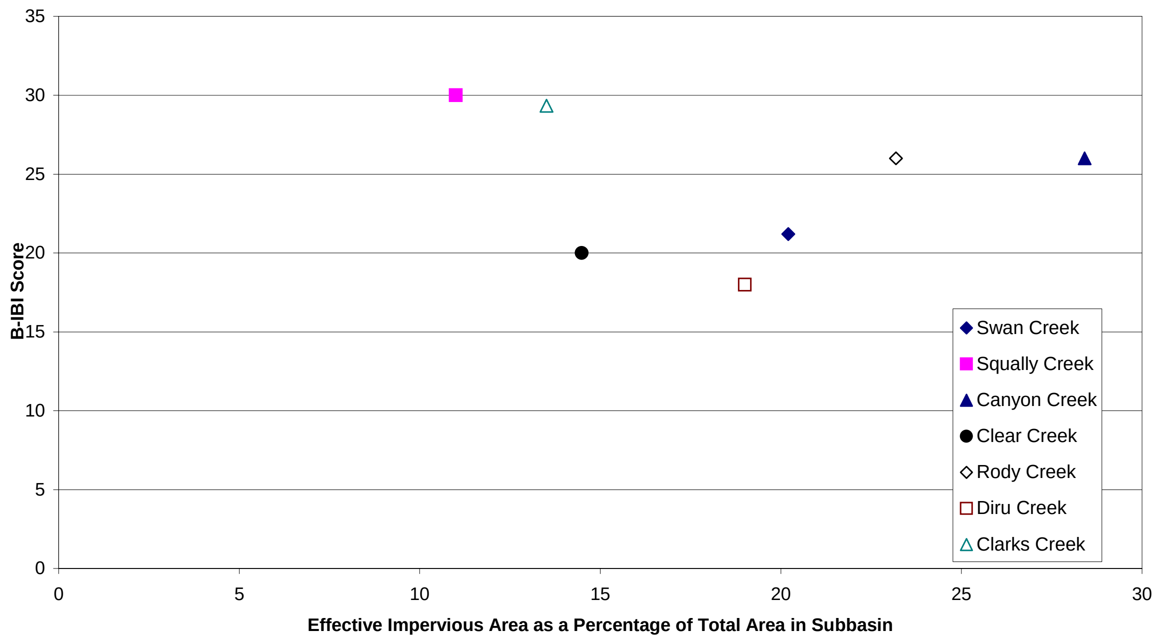
The diversity and abundance of aquatic insects that live in or near the stream bottom is a good indicator of the overall ability of the stream to support healthy salmon populations. Factors, such as water quality, sedimentation and bed load movement, affect the benthic[1] community and salmon production in a similar manner.

The Benthic Index of Biotic Integrity (B-IBI) was assessed for Swan, Squally, Clear, Canyon, Rody, Diru and Clarks Creeks. B-IBI is a measure of the degree to which the quality of stream habitat deviates from that expected at a relatively undisturbed site. It is based upon the numbers and diversity of species of benthic invertebrates obtained from samples taken from the stream substrate. Based on this assessment, the condition of the benthic community in the creeks was rated “Fair” for all but Swan Creek, which was rated “Poor”.

Increasing urbanization has been correlated to a rapid decline in stream biological health (May, 1997). Total impervious area as low as 10% of the total basin area has been linked to degradation of the instream habitat. *Figure 8-2* plots the B-IBI scores and the existing effective impervious area (EIA). The figure shows that streams in the Clear/Clarks Creek Basin generally follow expected relationships with the highest B-IBI scores occurring in the subbasins with the lowest EIA. Conversely, subbasins with the lowest scores contain the highest percentage EIA.

[1] Benthic means organisms living in or on bottom substrates in aquatic habitats

FIGURE 8-2
B-IBI Scores and EIA for Clear/Clarks Creek Streams
Source: Habitat investigation, see Section 4.4.2 and Appendix "E"



8.3.5 Stream Bank Erosion & Instability

Normal bank erosion processes are necessary for the maintenance of productive salmon habitat. Bank erosion introduces large woody debris for pool creation and sediment retention, and provides gravel used for spawning. However, erosion at high levels can be detrimental to a stream system by degrading fish habitat and water quality, increasing the frequency of overbank flooding, and inducing mass wasting (land slides). Fine sediments entering the stream negatively affect habitat by burying spawning gravels. Excessive scouring and downcutting can disturb salmon spawning nests and causes salmon eggs to wash out of spawning nests.

Habitat field evaluation identified unstable and eroding streambanks in the canyon and floodplain reaches of nearly all streams within the Basin. Erosion problems in canyon reaches are generally characterized by unstable banks cut by high peak streamflow rates. Channel widening and downcutting (as described in the previous section) were observed throughout the stream systems. Channel widening due to sedimentation is the main erosion problem in the floodplain reaches. High stream flows in the canyons transport eroded sediments downstream into the floodplain reaches, where sediments settle out in low-gradient backwater reaches. Typically, a depositional channel will widen in order to re-establish the conveyance capacity of the stream.

Stream bank and stream bed erosion is a serious problem in all watersheds in the Clear/Clarks Creek Basin. For example, Swan Creek has sections where the channel has downcut as much as 12-feet with vertical banks. There was one area of serious slumping located on Swan Creek about 1,500 feet below 64th Street East.

The tremendous hydraulic power of peak flows and the associated bedload movement of cobble and gravel are demonstrated by the condition of a recent bed stabilization project in the 0.5-mile-long reach below 64th Street East. A series of log "V" weirs were installed in the mid-1990s. When observed in 2001, about half of these weirs had washed away (they were sequentially numbered and marked) and the other half were not functioning. Most of the remaining weirs were almost completely buried with gravel on both the upstream and downstream side of the weir. This reach was dry in July 2001.

The significance of high peak flows and the associated erosion and bedload movement, is that pools cannot be maintained and spawning success can be greatly diminished. Salmonid eggs in spawning nests (redds) might be lost if the scour depth extends into the spawning depth. It is almost certain that this occurs, but the extent to which it happens is not known. LWD is washed downstream where it is piled up against road culverts and, thus, is not available to create and maintain pools.

Lack of pools is a serious limiting factor in all watersheds. Excessive sands and fine particles, which are part of the till soil being eroded upstream, fill in the void spaces between spawning gravels and limit water irrigation over developing eggs. The loss of water movement around salmonid eggs can lead to death of the developing embryos.

In Clear Creek, altered hydrology from impervious surfaces in the upper watershed has led to an erosion and bedload situation similar to that in Swan Creek, albeit less serious. In Clear Creek, the channel has down cut as much as 10-feet with vertical exposed banks below the 72nd Avenue East culvert. The most severe erosion observed in the Clear Creek Basin was below this culvert, with exposed banks continuous on both sides of the creek for 150-feet downstream of the culvert. A private homeowner, interviewed on 72nd Avenue East, described how his backyard fence has required rebuilding due to the slumping land below. Exposed banks and slides of shorter length were also observed between the 45th Street East cul-de-sac and Pioneer Way East on Clear Creek.

In Canyon, Rody, and Woodland Creeks, channel down cutting is common. The most severe down cutting occurs in Woodland Creek, above and below the 84th Street East crossing. Along Woodland Creek, the exposed soil layers appear to have a higher clay content, and have subsequently resisted sloughing and slumping. However, down cutting in Woodland Creek was observed at depths of as much as eight feet, often in places with a channel width of only two or three feet. In Canyon and Rody Creeks, down cut banks were present, but were not as severe as those in Woodland Creek. Exposed banks of up to three-feet were encountered only occasionally.

Serious erosion was not observed in Clarks Creek. This was because the short canyon reach in Clarks Creek within the City of Puyallup was not surveyed. Stream bed substrate in the reach of Clarks Creek adjacent to DeCoursey Park is composed almost entirely of sand and organic muck, which suggests that there is a significant sediment source somewhere upstream. According to a local resident, sediment deposition in Clarks Creek near Puyallup has raised the bottom of the channel three feet in the past 30 years.

8.3.6 Channel Morphology

As described in Chapter Four, channel morphology in all streams (except Clarks Creek) differs dramatically above and below Pioneer Way East. In Clarks Creek, the change occurs at Meeker Ditch. Downstream of Pioneer Way East (downstream of Meeker Ditch in the case of Clarks Creek), the stream channels have been straightened into ditch-like conveyance channels. The nearly flat topography, tidal backwatering, flooding from the Puyallup River, and manmade excavation are all influences that have shaped channel morphology in this area. Additionally, the Puyallup River levee system effectively disconnects the lowland, floodplain area of the Clear/Clarks Creek drainage from the Puyallup River.

The low-gradient channelized reaches serve as depositional areas due to low stream energy and high bed load and fine sediment inputs from upper reaches. The mouths of the channels additionally experience sediment deposition from the Puyallup River. Several channels appear to have been rerouted from their original course and have been reformed as channelized, uniform drainage ditches with little, or no habitat complexity.

The stream channels below Pioneer Way East are currently confined to the minimum channel width required for base flows, presumably to maximize agricultural acreage. Channel sizing of this type promotes flooding problems during high-flow events. Widening the channels would allow for sufficient containment during high-flows and could allow normal channel morphology to develop.

Above Pioneer Way East in all creeks except Clarks Creek and Woodland Creek, channel morphology is dramatically different. All the streams surveyed contained reaches with steep, confined, and erosional channels with long high-gradient riffles and very few pools. In Clarks and Woodland Creeks, these reaches did not begin for several hundred yards upstream of Pioneer Way East. For Swan, Squally, Clear, Canyon, Rody, and Diru Creeks the channel processes transition between floodplain and alluvial fan at Pioneer Way East. The low pool/riffle ratio found in the stream reaches above and below Pioneer Way is unfavorable for salmonids other than chum salmon. Chum salmon do not need pool habitat because juveniles move downstream to the estuary shortly after emergence from the nests.

8.4 Future Habitat Conditions

8.4.1 Fish Passage Barriers

Several factors will probably improve fish passage over time. Creation of new fish passage barriers is not likely due to the ESA listings of Puget Sound chinook salmon and bull trout (Dolly Varden).

A Hydraulic Project Approval (HPA) permit is required for projects with construction activity in, or near state waters (RCW 75.20.100-160) that affect the bed or flow of a stream. Fish passage and protection will be a condition of new HPA permits or permits issued by the Army Corp of Engineers. As existing culverts or other manmade barriers are repaired or replaced, removal of the barriers to fish passage will probably be required.

Three recommended CIP projects involve removing a barrier to fish passage: one on Canyon Creek; and two on Woodland Creek.

8.4.2 Stream Flows and Stream Bank Erosion

Hydrologic analysis predicted a significant increase in peak stream flow rates under future land use conditions in Swan and Woodland Creeks, with the largest increases occurring for the more frequent storm events. The analysis predicted that flow durations above the two-year peak flow rate (channel shaping flow) will increase in Swan and Woodland Creeks and in the upland reaches of Canyon Creek. Because streamflow rates in excess of the two-year peak flow rate most heavily influence channel shaping processes, higher peak flows of longer duration increase erosion rates and will further degrade habitat in these streams unless mitigation measures (such as stormwater detention) are constructed.

Current County stormwater standards require stormwater detention or infiltration for all new developments to mitigate peak flows. Current detention standards are effective in controlling peak flows from large storm events, but extend the flow duration for intermediate levels and provide little benefit for smaller storms (CH2M HILL, 2001). Data on stream flow are presented in Chapter Six.

The County is updating its stormwater regulations to be equivalent to recent flow control standards published in the updated Stormwater Management Manual for Western Washington (Ecology, 2001). The new Ecology standard requires peak flows from a building site to match those of forested conditions, with an optional flow duration standard. Adopting the new Ecology flow control standard in its entirety would minimize future flow impacts and help to prevent an increase in erosion.

A significant number of residential subdivisions in the Clear/Clarks Creek Basin were approved before adoption of the current stormwater regulations. Because previous stormwater control regulations were much less stringent than the current standards, peak flows will increase as these projects are built.

8.4.3 Riparian, Instream Habitat, and Channel Morphology

The condition of riparian areas will likely remain at current levels. As described earlier, much of the riparian function in the upper reaches and floodplain areas of the watershed is seriously impaired. Much of the intact riparian area in the canyon reaches will likely remain intact, due to either the inaccessibility of the ravines or because these reaches flow through public property.

The increase in stream bank erosion rates described in the previous section will probably result in continued impairment of instream habitat. Future development in the basin is forecast to further degrade instream habitat and degrade water quality. More significant levels of instream habitat degradation are expected in Swan Creek and Woodland Creek than in the other streams because of higher levels of future development in these basins.

8.5 Potential Solutions

Because the aquatic habitat problems have multiple causes, the solutions will have to involve a range of activities; from non-structural programmatic actions to structural solutions. The capital improvement program (CIP) projects developed to solve habitat problems are a mix of:

- Structural solutions
- Wetland and riparian habitat restoration
- Floodplain preservation through property acquisition

Structural solutions consist primarily of the replacement of culverts to remove fish passage barriers. Typically, these projects replace culverts with channel-spanning bridges or large embedded culverts. Structural solutions also include channel stabilization projects to prevent erosion and sediment transport. Detention and infiltration facilities are structural solutions that also play important roles in reducing peak flows.

The field habitat investigation and the PCD identified numerous culverts as actual or potential fish passage barriers above the canyon reaches of the creeks. No projects were developed for these culverts because the low-flow condition described in Section 8.3 would limit the usefulness of these structures. Should suitable low-flow mitigation measures be developed then these structures should be replaced.

Habitat restoration projects restore wetlands, stream habitat and/or riparian areas generally in floodplains. Many restoration projects also benefit water quality because they reduce erosion (turbidity) and provide shade (temperature).

CIP projects involving riparian or wetland revegetation/restoration will require substantial maintenance during the first two to five years after planting. Irrigation may be required for the first year or two to establish some of the tree and brush species. In addition, annual weed removal or suppression will be needed until plants are well established. This is particularly critical in areas where reed canary grass is being eliminated.

Programmatic solutions can benefit existing aquatic habitat and prevent future degradation. For instance, programs can identify and preserve high quality habitat areas, enhancement programs can prioritize and facilitate habitat restoration, and monitoring programs can track water quality, erosion and channel incision, and other measures of the health of natural systems.

8.5.1 Special Considerations in Solution Development

Channel Stabilization and Enhancement

The erosion sites listed in Chapter Five, *Tables 5-1* and *5-2* were evaluated using the streambank protection process described in the Integrated Streambank Protection Guidelines (ISPG) developed by the Washington Department of Fish and Wildlife (WDFW, 2003).

The ISPG methodology provides three screening matrices that help to select the appropriate stream bank protection technique. Screening is based on an assessment of site conditions (mechanism of failure), reach conditions (cause of failure), habitat considerations and a risk analysis.

The ISPG analysis was applied to each of the four failure mechanisms (cause pairings) described in *Appendix "E"* to identify appropriate streambank protection techniques. The analysis only considered protection measures rated "Fair" or "Good" and did not consider protection measures rated "Poor" or "Inappropriate." The results of this analysis are shown in *Appendix "E."*

The highest ranked streambank protection techniques should be considered first when selecting techniques for CIP projects. There may be cases where unique site conditions prevent the use of the highest ranked technique. In that case, CIP projects should consider using the next highest ranked technique.

Stormwater Retention/Detention

Many of the erosion problems described in the previous section are caused primarily by an increase in peak flow rates resulting from land development in the basin. Additional stormwater detention to control peak flow rates in the basin will help to prevent failure of stream bank protection techniques presented.

Previous stream bank stabilization efforts in Swan Creek have been only partially successful due to design and construction problems, and no corresponding means to control peak flow rates and duration. Peak flow reduction is also needed to reduce or eliminate stream bank erosion in the future.

Detention volume estimates in this Plan are based on the need to obtain 50% reduction of the 2-year peak flood (channel shaping flow) under future landuse conditions. The 50% reduction target is based on an assumption that peak flood events in a stream increase by a factor of two or more as a basin develops (Hollis, 1975). The type of stream bank stabilization measures downstream should be a factor when establishing the target release rate.

8.5.2 Problems Resolved or Not Addressed in the Basin Plan

Three culverts identified by the Pierce Conservation District as having unknown barrier status were found to meet fish passage design criteria for adult chum salmon. Nine habitat problems were located outside the authority of the Pierce County Public Works and Utilities.

Tables 8-5 and *8-6* list aquatic habitat problems not addressed by the recommendations forwarded to Chapter Nine. *Figures 5-1* and *5-2* in Chapter Five show the problem locations referred to in these tables.

TABLE 8-4
Resolved Aquatic Habitat Issues

Problem ID[a]	Problem Description	Problem Resolution
Clear Creek		
CL-30	Unknown fish passage barrier status at Pioneer Way E	Hydraulic analysis showed this culvert is not a barrier to fish passage.
CL-32	Unknown fish passage barrier status at Gay Road E	Hydraulic analysis showed this culvert is not a barrier to fish passage.
Rody Creek		
RY-20	Unknown fish passage barrier status at Pioneer Way E	Hydraulic analysis showed this culvert is not a barrier to fish passage.

[a] See Figures 5-1 and 5-2 for site locations.

TABLE 8-5
Aquatic Habitat Issues Referred to Other Parties

Problem ID[a]	Problem Description	Jurisdiction/ Responsible Party
Swan Creek		
SW-3	72nd Street E culvert is a barrier to fish passage	City of Tacoma
SW-31	Pipeline Road culvert is a barrier to fish passage.	City of Tacoma
Squally Creek		
SQ-7	Fish passage barrier at railroad culvert	BNSF RR
Clarks Creek		
CK-5	Poor habitat and water quality in Clarks Creek north of 15th Avenue SW.	City of Puyallup
CK-17	Meeker Ditch at 11th Street SW (City of Puyallup) culvert is a possible barrier to fish passage	City of Puyallup
CK-18	Roadside ditch tributary to Meeker Ditch - 11th Street SW (City of Puyallup) culvert is a barrier to fish passage	City of Puyallup
CK-19	Unnamed tributary to Meeker Ditch – 12th Avenue SW (City of Puyallup) culvert is a possible barrier to fish passage	City of Puyallup
CK-20	WDFW Fish Hatchery dam is a barrier to fish passage.	WDFW

[a] See Figure 5-1 and 5-2 for problem locations

8.5.3 Small Works Projects, Maintenance, and Enforcement Issues

One habitat-related drainage problem (RY-18) identified in the basin characterization qualifies as a small works project. Rather than including the project in the list of CIP projects, the Basin Plan refers the low cost aquatic habitat related project to the Facilities Maintenance section of Water Programs for implementation.

Rody Creek Weir

RY-18 is located on Rody Creek upstream of Pioneer Way East. An instream weir is installed across the channel that is a barrier to fish passage. The weir needs to be redesigned and constructed in a manner that removes the barrier.

8.5.4 Capital Improvement Program Projects

Thirty-four CIP projects were developed to help solve the aquatic habitat problems related to storm drainage. The projects are a mix of projects to stabilize stream banks, floodplain (aquatic habitat) restoration projects, and projects to improve fish passage. In addition, nine regional detention projects are recommended to reduce peak streamflow rates and corresponding erosion of stream banks. The detention projects extend the effective life of the stream bank protection measures. Regional detention projects also protect against flooding when located upstream of areas prone to flooding (see Chapters Five and Six).

Chapter Nine describes each of the projects listed in *Table 8-6* in detail. *Figures 9-1* through *9-3* identify CIP project locations.

TABLE 8-6
Aquatic Habitat CIP Projects

ID Number	Project Name	Solves Problem
Swan Creek Sub-Basin		
CIP03-SW-DP01	Swan Creek Regional Detention Project: 80 acre-feet of storage to reduce peak stormwater flows upstream of 72nd Street East	SW-22 SW-23 SW-25 SW-26
CIP03-SW-SBS01[a]	Stream Bank Stabilization at 72nd Street East Outfall	SW-3
CIP03-SW-SBS02	Stream Bank Stabilization from 72nd Street East to 64th Street East: roughened rock toes, porous weirs and drop structures direct energy away from stream banks	SW-22
CIP03-SW-SBS03[a]	64th Street East Culvert Outfall Repair Project: repair culvert headwall & install boulder clusters at the mouth of the culvert to dissipate energy	SW-23
CIP03-SW-SBS04	Stream Bank Stabilization Downstream of 64th Street East:	SW-24
Squally Creek Sub-Basin		
CIP03-SQ-VC01	Pioneer Way East Riparian Area Enhancement and Restoration: remove invasive vegetation and replant to provide shade	SQ-6
Clear Creek Sub-Basin		
CIP03-CL-RST01	Clear Creek Stream Restoration Project	CL-1 CL-17 CL–18 CL-24
CIP03-CL-SBS01	Stream bank Stabilization on West Fork Downstream of 72nd Street East	CL-19
CIP03-CL-SBS02	Stream bank Stabilization on East Fork Downstream of 72nd Street East	CL-20
CIP03-CL-SBS03	Stream bank Stabilization in vicinity of 49th Street East	CL-21
CIP03-CL-SBS04	Stream bank Stabilization on West Fork Downstream of 64th Street East	CL-22
CIP03-CL-SBS05	Stream bank Stabilization 5000 Block of Vickery Avenue East	CL-33
CIP03-CL-DP01	West Fork Clear Creek Regional Detention Project	CL-17 CL-19 CL–21 CL-22
CIP03-CL-DP02	East Fork Clear Creek Regional Detention Project	CL-17 CL-20 CL–21 CL-22

TABLE 8-6
Aquatic Habitat CIP Projects

ID Number	Project Name	Solves Problem
Canyon Creek Sub-Basin		
CIP03-CY-SBS01	Stream bank Stabilization on Reach Downstream of 80th Street East	CL-18
CIP03-CY-SBS02	Stream bank Stabilization on Reach Downstream of 72nd Street East	CY-22
CIP03-CY-SBS03	Stream bank Stabilization on Reach Upstream of Second Canyon Road Crossing	CY-20
CIP03-CY-SBC04	Stream bank Stabilization Downstream of Second Canyon Road Crossing	CY-21
CIP03-CY-RST01	Canyon Creek Stream Restoration Project	CY-23 CY-25 CY–26
CIP03-CY-FP01	Private Driveway Culvert Replacement Project	CY-28
CIP03-CY-DP01	Canyon Creek Regional Detention	CY-18 CY-20 CY–22 CY-23
Rody Creek Sub-Basin		
CIP03-RY-SBS01	Stream bank Stabilization Project at 72nd Street East	RY-14
CIP03-RY-SBS02[a]	Stream bank Stabilization Project at 80th Street East	RY-3
CIP03-RY-RST01	Rody Creek Stream Restoration Project	RY-16
CIP03-RY-DP01	Rody Creek Regional Detention Facility Expansion	RY-14
Diru Creek Sub-Basin		
CIP03-DU-RST01	Diru Creek Stream Restoration Project Downstream of Pioneer Way East	DU-10 DU–13 DU-14
CIP03-DU-SBS01	Stream bank stabilization at 72nd St East	DU-11
CIP03-DU-DP01	Diru Creek Regional Detention	DU-11
Woodland Creek Sub-Basin		
CIP03-WO-RST01	Woodland Creek Stream Restoration Project	WO-27
CIP03-WO-CR02[a]	80th Street East Culvert Replacement Project	WO-8
CIP03-WO-SBS01	84th Street East High Flow Bypass Pipeline Project	WO-24 WO–25 WO-26
CIP03-WO-SBS02	Stream bank Stabilization at 80th Street East	WO-27

TABLE 8-6
Aquatic Habitat CIP Projects

ID Number	Project Name	Solves Problem
Clarks Creek Sub-Basin		
CIP03-CK-RST01	Clarks Creek Stream Restoration Project	CK-1 CK-13 CK–14 CK-16
CIP03-CK-SP01	State Hatchery Sedimentation Basin Retrofit Project	CK-14
Potholes Sub-Basin		
No aquatic habitat projects at this time		
Roosevelt Ditch Sub-Basin		
No aquatic habitat projects at this time		

a Also listed as an Flooding and Drainage CIP project (See Table 6-12)

8.5.5 Problems Requiring More Detailed Data or Analysis

One study is recommended to fill information gaps as described below:

ST03-02 Identify Significant Sediment Sources in the Basin

Perform a comprehensive survey of basin creeks to identify additional locations of eroding stream banks and other significant sources of fine sediment. The stream survey performed to support the habitat analysis did not cover every reach in the stream system; therefore, it is unlikely that all significant sources of fine sediment were identified during the development of this plan. The study should provide an estimate of the amount of sediment, identify alternatives to solve the problems and recommend control measures.