Howard Hanson Dam

Programmatic Biological Assessment for Continued Operation & Maintenance and Phase I of the Additional Water Storage Project

US Army Corps
of Engineers
Seattle District

April 2000

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Prepared for

U.S. Army Corps of Engineers
Seattle District

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LIST OF ABBREVIATIONS/ACRONYMS

Term	**Abbreviation**
acre-feet	ac-ft
Additional Water Storage Project	AWSP
Area of Influence of the Dam	Action Area
Biological Assessment	BA
cubic feet per second	cfs
Distinct Population Segment	DPS
Draft Environmental Impact Statement	DEIS
Draft Feasibility Report	DFR
Dissolved Oxygen	DO
Engineered Log Jam	ELJ
Environmental Assessment	EA
Environmental Impact Report	EIR
Environmental Impact Statement	EIS
Environmental Protection Agency	EPA
Endangered Species Act	ESA
Evolutionarily Significant Unit	ESU
First Diversion Water Right Claim	FDWRC
Final Environmental Impact Statement	FEIS
Geographic Information Systems	GIS
Green River Flow Management Committee	GRFMC
Habitat Conservation Measure	HCM
Habitat Conservation Plan	HCP
Howard Hanson Dam	HHD
Incidental Take Permit	ITP
Large Woody Debris	LWD
Low-Flow Augmentation	LFA
Mean Sea Level	MSL
million gallons per day	mgd
Muckleshoot Indian Tribe	MIT
municipal and industrial water	M&I
National Environmental Policy Act	NEPA
National Marine Fisheries Service	NMFS
Nephelometric Turbidity Units	NTU
Operations and Maintenance	O&M
Programmatic Biological Assessment	PBA
Physical Habitat Simulation	PHABSIM

Term	**Abbreviation**
Pipeline No. 1	P1
Pipeline No. 5	P5
probable maximum flood	pmf
river mile	RM
Record of Decision	ROD
Region of Impact	ROI
Second Supply Project	SSP
Second Diversion Water Right	SDWR
Snowpack Telemetry	SNOTEL
Tacoma Water Supply Intake at RM 61.0	Headworks
Tacoma Water	Tacoma
Upland Management Areas	UMA
U. S. Army Corps of Engineers	Corps
U. S. Fish and Wildlife Service	USFWS
U.S. Forest Service	USFS
U.S. Geological Survey	USGS
Washington Department of Ecology	Ecology
Washington Department of Fish and Wildlife	WDFW
Washington Department of Natural Resources	WDNR
Washington State Forest Practice Board	WFPB
Water Resources Inventory Area	WRIA
Watershed Administrative Units	WAU
Western Washington Treaty Indian Tribes	WWTIT

CHAPTER 1.0
EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (Corps), as an agency of the federal government, is required under Section 7 of the Endangered Species Act of 1973 to ensure its actions do not jeopardize the continued existence of threatened or endangered species, or result in the destruction or adverse modification of critical habitat for listed species. If the Corps finds that a proposed action may affect a listed species or its critical habitat, it is obligated to consult with the National Marine Fisheries Service (NMFS) or the U.S. Fish and Wildlife Service (USFWS).

This Programmatic Biological Assessment (PBA) was prepared to facilitate formal consultation with the NMFS and the USFWS (collectively called the Services) to address impacts on selected listed species from Howard Hanson Dam (HHD) Continued Operation and Maintenance (O&M) and implementation of Phase I[1] of the Additional Water Storage Project (AWSP). Based on the information presented in this PBA, it is anticipated that the Services will prepare a Biological Opinion to assess whether the effects would result in jeopardy to the listed species or adverse modification of habitat, and issue an Incidental Take Statement (ITS) specifying the level of impact that would occur, the reasonable and prudent measures considered necessary to minimize the impact, and any other terms and conditions considered necessary by the Services.

This PBA covers two species of fish, three species of birds, and three species of mammals that are known to occur in the vicinity of HHD or could potentially occur there in the future. Six of the species are listed as *threatened*, one is listed as *endangered*, and one is proposed for listing as *threatened*. HHD Continued O&M has the potential to affect these listed species by altering flows in the Green River, interrupting natural ecosystem functions, and isolating critical habitat above HHD. Phase I of the AWSP would further influence flows in the Green River and increase the area of inundation behind the dam, thereby creating the potential for additional effects on listed species. This PBA does not address past effects on listed species (i.e., effects prior to the listing of a species under the ESA). Effects of HHD on chinook salmon prior to the date of their listing are considered part of the environmental baseline, against which proposed future effects are compared.

The determinations of effect on listed species are summarized in Table 1-1.

This PBA is organized into ten chapters as follows:

- Chapter 1 – Executive Summary.
- Chapter 2 – Background. Provides project location, project description (HHD and AWSP), a discussion on ESA consultation requirements, species covered in this PBA, and ITS activities.

[1] Phase II actions are not covered in this PBA. The acceptance of the Phase II storage by the MIT and resource agencies would be based on the successful performance of Phase I, as determined through the Phase I monitoring. The MIT and resource agencies would have the final determination on Phase II of the project. Further, all future references to the AWSP in this PBA are to Phase I only unless otherwise stated.

- Chapter 3 – Species and Habitat Information. A description of the life history requirements and status of all eight species covered in this PBA.
- Chapter 4 – Existing Conditions. Describes the existing physical, biological, and operational setting of the Green River basin to establish an "Environmental Baseline" for both HHD Continued O&M and the AWSP.
- Chapter 5 – Potential Impact of Howard Hanson Dam Continued Operation and Maintenance on Listed Species. Describes potential effects, proposed conservation measures, and the determinations of HHD Continued O&M on listed species.
- Chapter 6 – Potential Impacts of the Additional Water Storage Project on Listed Species. Describes the features of the AWSP (Phase I), potential effects, proposed conservation measures, and determinations of effect of the AWSP on listed species.
- Chapter 7 – Interrelated and Interdependent Effects. Addresses future interdependent/interrelated activities, protection measures, and their effects on listed species.
- Chapter 8 – Cumulative Effects. Addresses the effects on listed species of other non-federal activities not covered in Chapter 7.0.
- Chapter 9 – Summary Determination of Effect. Summarizes the determinations of effect from impact of HHD Continued O&M on listed species presented in Chapter 5 and impacts of the AWSP on listed species presented in Chapter 6.
- Chapter 10 – Literature Cited.

Table 1-1 Listed Species and Determinations of Effect for HHD Continued O&M and the AWSP					
Species Information		**HHD Continued O&M Determination of Effect**		**AWSP Determination of Effect**	
Common/Scientific Name	**Federal Status**	**Environmental Baseline**	**With Conservation Measures**	**Environmental Baseline**	**With Conservation Measures**
Chinook Salmon/ *Oncorhynchus tshawytscha*	Threatened	may affect, likely to adversely affect	may affect, **not** likely to adversely affect	may affect, likely to adversely affect	may affect, **not** likely to adversely affect
Bull Trout/ *Salvelinus confluentus*	Threatened	may affect, likely to adversely affect	may affect, **not** likely to adversely affect	may affect, likely to adversely affect	may affect, **not** likely to adversely affect
Bald Eagle/ *Haliaeetus leucocephalus*	Threatened	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect
Northern Spotted Owl/ *Strix occidentalis caurina*	Threatened	no effect	no effect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect
Marbled Murrelet/ *Brachyramphus marmoratus*	Threatened	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect
Grizzly Bear/ *Ursus arctos*	Threatened	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect
Gray Wolf/ *Canis lupus*	Endangered	no effect	no effect	may affect, **not** likely to adversely affect	may affect, **not** likely to adversely affect
Canada Lynx/ *Lynx canadensis*	Proposed Threatened	no effect	no effect	no effect	no effect

CHAPTER 2.0
BACKGROUND

2.1 PROJECT LOCATION

Howard Hanson Dam (HHD) was constructed by the U.S. Army Corps of Engineers (Corps) to provide flood protection and augment flows in the Green River basin within Water Resource Inventory Area (WRIA) 9. The project is located in southern King County, approximately 45 miles southeast of Seattle, Washington (Figure 2-1). The dam is located at River Mile (RM) 64.5 in Section 28, Township 21 North, Range 8 East, Willamette Meridian. The project site lies within the City of Tacoma (Tacoma) municipal watershed and access to much of the over 220 square miles of watershed above HHD is closed to the public. From RM 64.5, the Green River flows west and north from the Cascade Mountains to join with the Black River to form the Duwamish River. The Duwamish River then empties into Puget Sound 12 miles downstream at Elliott Bay.

2.2 PROJECT DESCRIPTION

2.2.1 Howard Hanson Dam

The Corps completed construction of HHD in 1962. The project is currently operated to provide winter and spring flood control and summer low-flow augmentation for fish resources. HHD is operated for flood control so that the sum of the dam release and local inflow downstream of the dam does not exceed a flow of 12,000 cfs as measured at the Auburn U.S. Geological Survey (USGS) gage (RM 32). The dam provides storage of 106,000 acre feet (ac-ft) for flood control from approximately October through March.

Operation of HHD during the winter is determined by flood control requirements. During the spring, the project switches from flood storage to its secondary role of conservation storage for low-flow augmentation. The existing reservoir provides for 25,400 ac-ft of summer/fall storage; 24,200 ac-ft is active storage available for enhancing instream flows below the project. During the switch from flood to conservation storage the amount of water released from HHD is reduced below the level of inflows, allowing the project to refill. Refill timing and release rates are based on target instream flows that are adjusted yearly in response to the existing weather conditions, snowpack, amount of forecasted precipitation, and input on biological conditions from agency and tribal resource managers (Corps 1998b).

Under the Section 1135 Project, an additional 5,000 ac-ft of water may be stored during selected years (e.g., initially during drought conditions expected in one out of five years) for a total active storage volume of 29,200 ac ft. Under the adaptive management provisions of the Section 1135 Project, the frequency of storage can be increased to an annual basis if shown to be beneficial to natural resources.

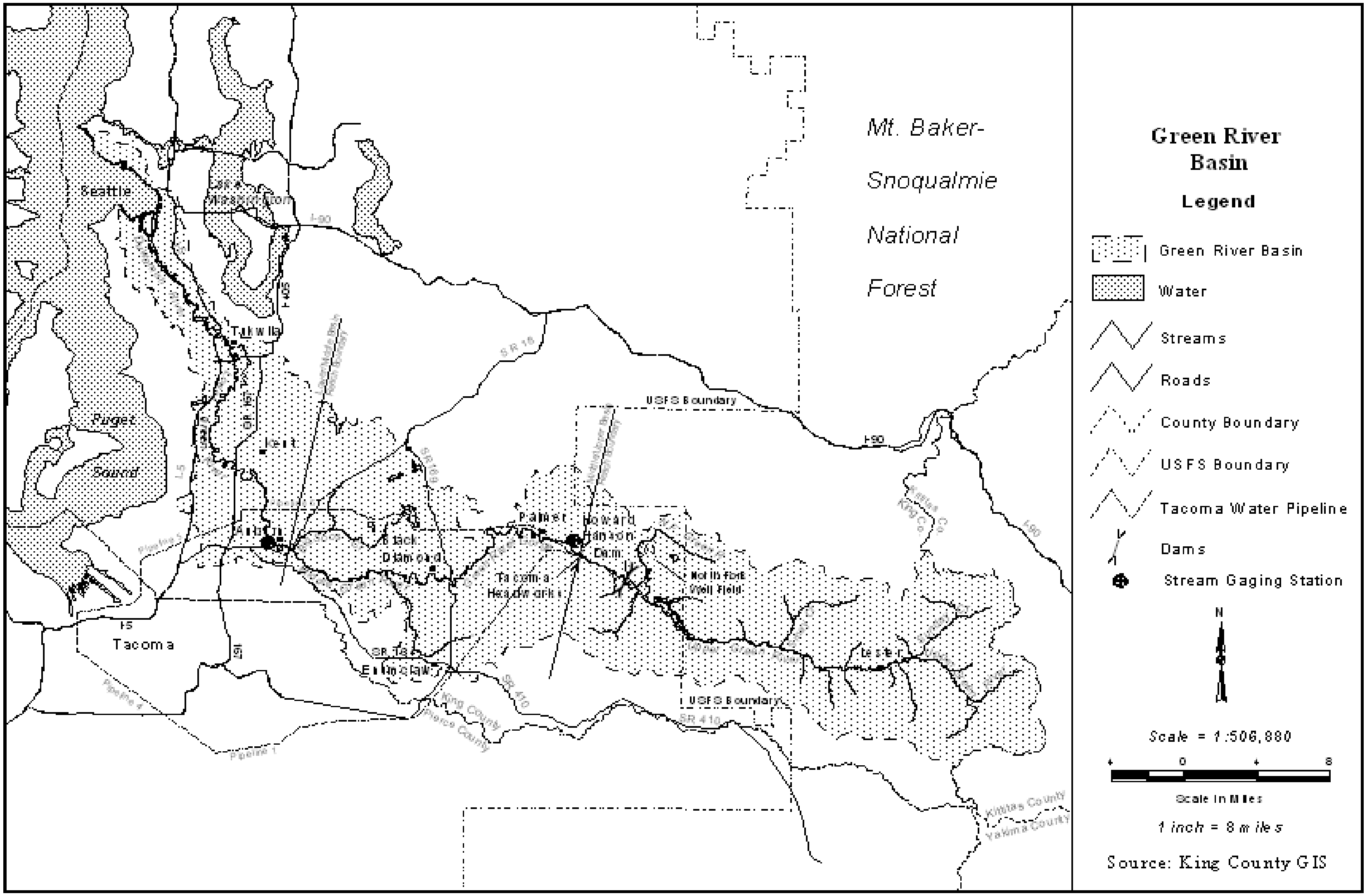

Figure 2-1. Green River Basin and Surrounding Area

2.2.2 Additional Water Storage Project (AWSP)

The full implementation of the proposed AWSP would provide up to an additional 32,000 ac-ft over existing storage in two phases by raising the existing summer conservation pool 30 feet (from 1,147 feet to 1,177 feet). In Phase I, the fish passage facility would be constructed at the dam and storage would be increased by up to 20,000 ac-ft for municipal water supply. Phase I would also include the option to store up to 5,000 ac-ft of water every year (Section 1135 Project water) for low-flow augmentation purposes to benefit downstream fishery resources. In Phase II, an additional 12,000 ac-ft (9,600 ac-ft available for flow augmentation for instream resource benefits, and 2,400 ac-ft for municipal and industrial [M&I] water supply) of storage would be added to the Phase I conditions (Table 2-1).

Table 2-1
Comparison of Howard Hanson Dam Summer Conservation Pool
Between the Existing Project and the AWSP Phase I and Phase II.

	Summer Conservation Pool			
Project Condition	**Conservation Storage (ac-ft)**	**M&I (ac-ft)**	**Total Volume (ac-ft)**	**Elevation (ft)**
Existing HHD Project	25,400	0	25,400 (normal year)	1,141
	30,400	0	30,400 (drought year)	1,147
AWSP Phase I	30,400	20,000	50,400	1,167
AWSP Phase II	40,000	22,400	62,400	1,177

The AWSP, a combined water supply and restoration project, was subjected to extensive agency review and a collaborative decision-making process involving the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), Washington Department of Ecology (Ecology), Washington Department of Fish and Wildlife (WDFW), the Muckleshoot Indian Tribe (MIT), Tacoma, and the Corps. This process resulted in the phased adaptive management plan that provides early outputs of water supply and restoration benefits with an opportunity to review and adjust the project as experience is gained. The key elements of the plan include experimentation, monitoring and analysis, followed by adjustment to the management and operation practices responsive to the monitoring information.

The acceptance of the Phase II storage by the MIT and resource agencies would be based on the successful performance of Phase I, as determined through the Phase I monitoring. The MIT and resource agencies would have the final determination on Phase II of the project. The storage of an additional 12,000 ac-ft in Phase II would raise the inundation pool at HHD from 1,167 feet to 1,177 feet. During the spring refill period, up to 32,000 ac-ft of water would be stored behind HHD; in addition, during this time up to 100 cfs (65 mgd) of water would be withdrawn through the Tacoma's proposed Second Supply Project (SSP), a 33.5 mile-long water supply project from the Tacoma Headworks to the City of Tacoma. This withdrawal of additional water would require additional water rights and would be subject to greater instream flow requirements.

The determination of adequacy of the proposed Phase II mitigation and restoration measures to mitigate Phase II actions is currently based on assumptions that would be verified by monitoring of Phase I mitigation and restoration measures. **Therefore, Phase II actions are not covered in this PBA. A separate ESA review of Phase II will be conducted after the Corps and Tacoma determine to proceed with implementation of Phase II, and after mitigation proposed for Phase I is determined to be adequate. Further, all future references to the AWSP in this PBA are to Phase I only unless otherwise stated.**

Up to 20,000 ac-ft of Phase I municipal and industrial water would be stored in the spring for release during the summer and fall to supply up to 100 cfs (65 mgd) for Tacoma's Second Diversion Water Right (SDWR). The water surface elevation of the HHD pool would be raised by 20 feet (from elevation 1,147 feet to 1,167 feet). Tacoma would exercise its SDWR when municipal water is being stored during spring reservoir refill. The stored water would then be released for immediate withdrawal during the summer and fall when there is a greater need for the water.

Phase I would include all structural features required to provide a downstream fish passage facility at HHD, as well as a number of habitat restoration and mitigation projects. As part of Tacoma's agreement with the Muckleshoot Indian Tribe regarding Tacoma's water rights, Tacoma will trap upstream migrating adult salmon and steelhead at Tacoma's Headworks and transport them upstream for release in or upstream of the HHD reservoir.

Goals for operation of HHD under Phase I are to meet springtime reservoir refill objectives while providing dam releases that mimic natural flow variation. Specific objectives include:

- maximize the survival of pre-smolts and smolts migrating through the HHD reservoir;
- maximize attraction and passage of outmigrating salmonids (fry, pre-smolts, smolts and steelhead kelts) at the surface intake of the HHD downstream fish passage facility;
- initiate efforts to re-establish runs of historical upper Green River anadromous fish stocks;
- evaluate benefits and potential risk of artificial freshets to downstream fisheries resources;
- establish flow management guidelines to optimize use of stored low-flow augmentation for downstream fishery benefits; and
- evaluate Phase I refill effects on lower Green River anadromous salmonid fish stocks through inventory and monitoring.

Habitat restoration and mitigation projects associated with Phase I would include:

- a downstream fish passage facility at HHD;
- re-establish sediment and woody debris transport processes below HHD;

- flow adjustments during spring refill to:
    - ▹ maximize outflow capacity of the fish passage facility by minimizing the reservoir refill rate during smolt outmigration and potential use of periodic artificial freshets that mimic natural freshets;
    - ▹ increase downstream survival of outmigrating salmonids by maintaining a target base flow and provide the option to release periodic freshets during peak outmigration;
    - ▹ partially mitigate downstream effects of storage by maintaining a target base flow that improves side channel and lateral mainstem rearing habitats;
    - ▹ provide adequate baseflows through the steelhead incubation period that protect eggs deposited during higher spawning flows;
    - ▹ annual storage of 5,000 ac-ft for low-flow augmentation;
- management of riparian forests to maintain forest succession on major streams above HHD (such management would occur in Tacoma's Natural, Conservation, and Commercial Forest Management zones);
- reconnection of approximately 3.4 acres of side-channel habitat to the mainstem lower Green River;
- habitat rehabilitation including large woody debris (LWD) placement and excavation or reconnection of off-channel habitats to selected streams between the elevations of 1,177 feet and 1,240 feet;
- return of the river to its historic channel between RM 83.0 and 84.0 using one or more debris jams/flow deflectors;
- maintenance of instream and riparian corridor habitat within the reservoir inundation zone (elevation 1,141 feet to 1,167 feet);
- maintenance of stream and riparian corridor habitat in lower Page Mill Creek, creation of a series of new, smaller ponds, and addition of woody debris to the ponds and stream channel;
- replacement of culverts that constitute barriers to upstream or downstream fish passage in tributaries to the Green River (locations to be identified from a culvert inventory);
- improvement of habitat in the mainstem Green River below HHD by constructing engineered log-jams[2] and limited excavation to recreate meanders or backwater habitats;
- wildlife habitat mitigation including: 1) creation of elk forage habitat; 2) upland forest management to promote late-successional and old-growth forest habitat conditions; and 3) wetland and riparian habitat improvements in the reservoir inundation zone (elevation 1,141 feet to 1,167 feet) including construction of two sub-impoundments and sedge plantings over 60 acres;

[2] Engineered log-jams are being considered as a replacement mitigation effort for the Lower Bear Creek improvement project described in the DFR/DEIS (Corps 1998).

- annual release of 3,900 cubic yards of gravel in the lower Green River; and
- transport and/or placement of woody debris (collected in HHD reservoir) in the lower Green River.

All Phase I restoration and mitigation projects would be monitored for at least 10 years, and some up to 50 years, after implementation depending on the project. Some of the activities also require pre-construction studies and monitoring, which are currently underway or planned. The Corps and Tacoma would cost-share fish passage project monitoring, and Tacoma would entirely fund monitoring and maintenance of the fish and wildlife mitigation and restoration projects. Responsibility for implementation of the monitoring efforts would be shared by Tacoma and the The Corps, with the work being conducted by either Tacoma staff, Corps staff, or contractors. All monitoring activities would be conducted in cooperation with the MIT and federal and state agencies.

2.3 PURPOSE AND NEED FOR CONSULTATION UNDER SECTION 7 OF THE ESA

The Corps, as an agency of the federal government, is required under Section 7 of the Endangered Species Act of 1973 (ESA) to ensure its actions do not jeopardize the continued existence of threatened or endangered species, or result in the destruction or adverse modification of critical habitat for listed species. If the Corps finds that a proposed action may affect a listed species or its critical habitat, it is obligated to consult on the action with the NMFS (for certain fish and marine mammals) or the USFWS (for other species). If the NMFS or the USFWS (collectively called the Services) finds the proposed action is not likely to adversely affect a listed species, they provide written concurrence to the Corps and the action is considered in compliance with Section 7. Conversely, if either of the Services finds the action may have an adverse effect on a listed species, they enter formal consultation and prepare a Biological Opinion (BO) to assess whether the effect would result in jeopardy to the listed species or adverse modification of critical habitat. If the Services find no jeopardy and no adverse modification of critical habitat, the action can proceed. In such cases, the Services provide the Corps with an Incidental Take Statement (ITS) specifying the level of impact that would occur, the reasonable and prudent measures considered necessary to minimize the impact, and any other terms and conditions considered necessary by the Services. If the action is found to cause jeopardy or result in the adverse modification of critical habitat, it cannot proceed without an exemption under Section 7(g) of the ESA.

This PBA was prepared by the Corps to facilitate formal consultation with the Services on the continued operation of the HHD and implementation of the AWSP. A number of listed fish and wildlife species are known to occur in the area influenced by HHD, or could occur there in the future (see Section 2.5 for a list of the potentially affected species). The NMFS designated the upper Green River watershed above HHD as critical habitat for Puget Sound chinook salmon effective March 17, 2000 (50 CFR 226). Ongoing operation of HHD has the potential to affect these listed species by altering flows in the Green River, interrupting natural ecosystem functions, and isolating critical habitat above HHD. The AWSP would further influence flows in the Green River and increase the area of inundation behind the dam, thereby creating the potential for additional effects on listed species. This PBA addresses potential effects of both HHD Continued O&M and the AWSP.

This PBA does not address past effects on listed species (i.e., effects prior to the listing of a species under the ESA). Effects of HHD on chinook salmon prior to the date their listing are considered part of the environmental baseline, against which proposed future effects are compared. In keeping with recent NMFS guidance on the implementation of Section 7 for listed salmon (NMFS 1999), those effects of an on-going federal action resulting from past unalterable resource commitments are included in the baseline condition, and those that would be caused by continuance of the proposed action are analyzed for determination of effects.

This PBA is based on the most current and best available scientific information about the affected species and their habitats, as well as the current understanding of the operation of HHD and its effects on the environment. Any Biological Opinion based on this PBA is valid only to the extent that there is no substantive change in the basic understanding of the covered species, the operation of HHD, and the overall effect of HHD on the covered species. The Corps and the Services would be required to reinitiate formal consultation under Section 7 if: a) the amount or extent of incidental take specified in the ITS is exceeded, b) new information reveals effects of HHD operation on listed species or critical habitat that were not previously considered, c) operation of HHD is modified in a manner that causes an effect on a listed species or critical habitat that was not previously considered, or d) a new species is listed and that species may be affected by operation of HHD.

2.4 RELATIONSHIP OF THIS PBA TO THE ACTIVITIES OF OTHERS IN THE GREEN RIVER BASIN

2.4.1 Tacoma Water

Tacoma Water (Tacoma) operates a municipal and industrial water supply project with an intake at RM 61.0 approximately 3.5 miles downstream of HHD. To protect the quality of water in the Green River, Tacoma also manages approximately 14,888 acres of the watershed above HHD. This PBA includes reference to Tacoma's activities on the Green River because the activities of the Corps and Tacoma are interrelated, particularly with respect to the AWSP and the Section 1135 Project. Tacoma would be the local sponsor for the AWSP, and the Corps would be storing water available to Tacoma under Tacoma's surface water rights on the Green River when it stores water under the AWSP. Tacoma would contribute funding for the AWSP and many of the project features, including the larger summer conservation pool area, would take place on Tacoma property in the upper watershed.

Tacoma recently submitted a Habitat Conservation Plan (HCP) to the Services in support of an application for an Incidental Take Permit (ITP) under Section 10 of the ESA. The Services have published the HCP and an accompanying Environmental Impact Statement (EIS) for public review and comment. The public comment period ended on March 31, 2000. The decision whether or not to issue the ITP would be made by the Services after review of the document and the comments received from the public.

All Corps activities under the AWSP with the potential to affect listed species are addressed in this PBA, even though many of the same activities are also discussed in Tacoma's HCP. The

ITP being requested by Tacoma under ESA Section 10 cannot provide incidental take coverage to the Corps. As a federal entity, the Corps must obtain incidental take coverage in the form of an Incidental Take Statement through Section 7. All on-going and proposed Corps activities with the potential to affect listed species must be addressed through the Section 7 process to receive incidental take coverage.

2.4.2 King County

King County was the local sponsor for the original construction and operation of HHD as a flood control structure. The county and several local municipalities also maintain a series of levees along the Green River that function in coordination with HHD to regulate floods and protect capital improvements in the lower watershed. Since the current operation of the levee system is entirely by non-federal entities, it is not subject to the requirements of Section 7 and is not covered by this PBA. It is, however, included in the discussion of cumulative effects in Chapter 8 of this document.

King County is the local sponsor of a joint Corps/County basin-wide ecosystem restoration study, termed the Green-Duwamish Basin General Investigation Study. The county, the Corps, and other interested parties are also involved in the State/County coordinated WRIA 9 salmon recovery process. One objective of the WRIA 9 recovery process is to identify and support the implementation of opportunities to improve or enhance habitat for fish and wildlife in the lower Green River. Some of these enhancement opportunities could involve modifications to the levee system to allow partial returns to “natural” flood patterns in areas where this would not conflict with other land uses. If implemented, the enhancement opportunities could be joint ventures between the Corps and the county, and could be at least partially funded by the Corps. A separate Section 7 consultation with the Services is underway to address the effects of the Green-Duwamish GI Study on listed species. The Green-Duwamish GI Study is further described in Chapter 7(Interrelated and Interdependent Effects).

2.4.3 Other Landowners in the Upper Green River Watershed

The Corps owns and manages only 407 acres (0.3%) of the upper Green River Watershed; most of which is immediately surrounding HHD and its associated support facilities. The majority of the upper watershed is owned by Plum Creek Timber Company (34.4%), the federal government (22.1%; administered by the U. S. Forest Service), the State of Washington (14.1%; administered by the Department of Natural Resources), Giustina Resources (10.4%), Tacoma (10.1%), Weyerhaeuser Company (5.7%), and a number of smaller interests (2.9%).

The activities of some of the major landowners in the upper watershed have previously been subjected to review under Section 7 or Section 10 of the ESA. The Northwest Forest Plan, which governs the management of U. S. Forest Service lands throughout the range of the northern spotted owl (*Strix occidentalis caurina*), was the subject of a Section 7 review in 1994. Plum Creek lands are covered by an ITP issued in 1996, and managed according to an HCP completed in support of the ITP. Washington DNR lands are similarly covered by an ITP and managed according to an HCP completed in 1996. As noted above, Tacoma lands in the upper watershed are the subject of a draft HCP currently under review by the Services. If the HCP is approved, Tacoma would receive an ITP for the continued operation of the water withdrawal facility and management of its lands in the watershed. None of the activities of these other parties in the upper watershed is covered by this PBA, but all pertinent activities are discussed under cumulative effects in Chapter 8 of this document.

2.5 SPECIES COVERED BY THIS PBA

This PBA covers two species of fish, three species of birds and three species of mammals (Table 2-2). Six of these species are listed as threatened, one is listed as endangered and one is proposed for listing as threatened. All eight species are known to occur in the vicinity of HHD, or could potentially occur there in the future.

The chinook salmon (*Oncorhynchus tshawytscha*) is present in the Green River below HHD, and historically used the upper watershed as well. This PBA addresses the effects of HHD, the AWSP, and associated conservation measures on chinook salmon spawning, incubation, rearing and migration (upstream and downstream) in the Green River.

Table 2-2
Species Covered by the Howard Hanson Dam PBA.

Common Name	Scientific Name	Federal Status
Chinook Salmon	*Oncorhynchus tshawytscha*	Threatened
Bull Trout	*Salvelinus confluentus*	Threatened
Bald Eagle	*Haliaeetus leucocephalus*	Threatened
Northern Spotted Owl	*Strix occidentalis caurina*	Threatened
Marbled Murrelet	*Brachyramphus marmoratus*	Threatened
Grizzly Bear	*Ursus arctos*	Threatened
Gray Wolf	*Canis lupus*	Endangered
Canada Lynx	*Lynx canadensis*	Proposed Threatened

The bull trout (*Salvelinus confluentus)*, and closely-related Dolly Varden (*S. malma*), are both quite rare or absent altogether in the upper Green River. The bull trout is covered in this PBA because of the possibility it may be present in the Green River and, thus, affected by operation of HHD. The PBA addresses the potential effects of HHD and the AWSP on bull trout spawning, incubation, rearing and migration. While the Dolly Varden is not listed as threatened or endangered, it is discussed in this document because it is virtually indistinguishable from the bull trout in the wild. The Dolly Varden would not, however, be covered by any Biological Opinion that results from this PBA.

The bald eagle (*Haliaeetus leucocephalus)* is known to occur in small numbers upstream and downstream of HHD at all times of the year. This species is proposed for delisting under the ESA, but it currently remains listed as threatened in Washington. This PBA addresses the effects of HHD and the AWSP on bald eagle nesting, foraging and winter roosting.

The northern spotted owl and marbled murrelet (*Brachyramphus marmoratus*) both utilize late-seral coniferous forest in the Green River watershed above HHD, where an increase in the size of the reservoir could displace future potential nesting habitat for both species. This PBA addresses the potential effects of HHD operation and AWSP on spotted owl nesting, roosting and foraging, and on marbled murrelet nesting.

The grizzly bear (*Ursus arctos*) and gray wolf (*Canis lupus*) are extremely rare in the Washington Cascades, but on-going efforts to recover both species creates the potential for either to make use of the upper Green River watershed at some time in the future. This PBA addresses the potential effects of HHD and the AWSP on grizzly bear and gray wolf denning and foraging. Similarly, the Canada lynx (*Lynx canadensis*) is a rare species on the west slope of the Cascades that is proposed for listing as threatened. Given the potential for the lynx also to be present in the upper watershed in the future, this PBA addresses the effects of HHD and the AWSP on denning and hunting by the species.

2.6 INCIDENTAL TAKE STATEMENT ACTIVITIES

Section 9 of the ESA prohibits unauthorized taking of listed species (16 U.S.C. §1538[a][1] 16 U.S.C. §1538[a][1][B]). The statute broadly defines "take" to include any activity that would or would attempt to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect a species covered by the ESA (16 U.S.C. §1532[19]). The Services' regulations define the take prohibition broadly to encompass both direct taking of the species (through wounding, killing, trapping, etc.) and indirect taking (through harm arising from habitat alteration or destruction or otherwise) (50 C.F.R. §17.3 [1993]).

Incidental take statements exempt action agencies and their permittees from the Act's Section 9 prohibitions if they comply with the reasonable and prudent measures and the implementing terms and conditions of incidental take statements. To be considered in an incidental take, any taking associated with an agency's action must meet the following three criteria (USFWS 1998a):

1) not be likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat,
2) result from an otherwise lawful activity, and
3) be incidental to the purpose of the action.

Table 2-3 lists the activities for incidental take described in Chapter 5 for HHD Continued O&M and in Chapter 6 for the AWSP Phase I. The HHD downstream fish passage facility is currently in the design phase, and details of the construction process have not been fully developed. The effects of construction of the downstream fish passage facility on listed species are not addressed in this PBA.

2.7 ACTION AREA

The Action Area consists of areas that would be either directly or indirectly affected by continued operations and maintenance of HHD and implementation of the AWSP. In general, this consists of the Green River watershed upstream of HHD, HHD and associated Corps facilities, and the mainstem Green River and associated floodplain areas downstream of HHD to the Duwamish estuary that are inundated by flows of up to 12,000 cfs. The following paragraphs describe specific areas within the action area that would be either directly or indirectly affected by the activities listed in Section 2.6. The Action Area will be the same for both HHD Continued O&M and the AWSP.

Table 2-3
Activities of the U.S. Army Corps of Engineers Associated with Howard Hanson Dam that Might Result in the Incidental Take of Species Listed Under the Endangered Species Act.

HHD Continued O&M	AWSP (Phase I)
Flood control (12,000 cfs at Auburn)	Flood control (12,000 cfs at Auburn)
Downstream flow releases	Downstream flow releases
Springtime storage of 24,200 ac-ft of water for low-flow augmentation	Springtime storage of 24,200 ac-ft of water for low-flow augmentation
Springtime storage of up to 5,000 ac-ft of water initially during drought years under Section 1135[(1)]	Springtime storage of 5,000 ac-ft of water expanded to every year
	Springtime storage of 20,000 ac-ft of water for Tacoma municipal and industrial use[(2)]
Release of 24,200 ac-ft to satisfy instream flow target of 110 cfs at Palmer	Release of 24,200 ac-ft to satisfy instream flow target of 110 cfs at Palmer
Release of up to 5,000 ac-ft initially during drought years to benefit downstream fisheries	Release of 5,000 ac-ft to benefit downstream fisheries
	Release of up to 20,000 ac-ft of water for downstream withdrawal by Tacoma[(2)]
Sediment management	Sediment management
Woody debris management	Woody debris management
Temperature regulation	Temperature regulation
Daily/Periodic O&M	Daily/Periodic O&M
Ecosystem restoration measures as described in Chapter 5 of this PBA	Ecosystem restoration measures as described in Chapter 6 of this PBA
	AWSP fish and wildlife mitigation measures as described in Chapter 6 of this document
Monitoring and adaptive management as described in Chapter 5 of this PBA	Monitoring and adaptive management as described in Chapter 6 of this PBA

(1) Storage of up to 5,000 ac-ft of water under the Section 1135 Project was initially considered for implementation only during drought years (1 in 5 years). Under the adaptive management provisions of the Section 1135 Project, the frequency of storage can be increased to an annual basis if shown to be beneficial to natural resources.
(2) The downstream effects of storage and release of up to 20,000 ac-ft of water are also considered activities to be covered under the City of Tacoma's Habitat Conservation Plan and Incidental Take Permit.

2.7.1 Direct Effects

Areas experiencing direct effects include the following:

- HHD site and project facilities would experience direct effects as a result of ongoing HHD operations and maintenance including activities associated with gate operations, collection of woody debris, maintenance of equipment and infrastructure associated with normal operations, and emergency operations. This area includes both the immediate dam site at RM 64.5, and lands used for the temporary storage and disposal of woody debris collected from the reservoir.
- Lands inundated by the HHD reservoir may experience short-term, direct effects up to a pool level of 1,206 feet MSL as a result of storage operations undertaken in support of flood control during the fall, winter, and early spring. During the spring, summer and early fall, ongoing low-flow augmentation, Section 1135 water storage, woody debris management and temperature control activities affect the reservoir up to a pool level of 1,147 feet MSL under existing conditions. Implementation of Phase I of the AWSP would extend these spring, summer and early fall impacts up to 1,167 MSL. In addition, lands inundated by the HHD reservoir would be directly affected by restoration activities associated with the Section 1135 Project (plantings, nest boxes and installation of floating islands) and by mitigation and restoration measures associated with the AWSP (wetland and riparian habitat measures, fish and water quality monitoring, and fish passage).
- Mainstem Green River and tributary channels upstream of HHD would be directly affected by habitat rehabilitation activities undertaken as mitigation and ecosystem restoration measures under the AWSP.
- Mainstem Green River channel and floodplain from below HHD downstream to the Duwamish estuary inundated by flows of up to 12,000 cfs would be directly affected by flood events, low-flow augmentation and drought flow releases. In addition, portions of these areas would experience direct effects as a result of large woody debris release or placement, gravel nourishment and side channel monitoring and improvements.
- Access routes to HHD and in the upper Green River watershed would be directly impacted by increased traffic required for mitigation, restoration and conservation measures associated with HHD operation and maintenance, the Section 1135 Project and the AWSP. Increased traffic would include use by trucks and heavy equipment required for construction of habitat rehabilitation measures around the reservoir perimeter, up to RM 83 on the mainstem Green River and at the woody debris and gravel release sites located downstream of HHD. Increased vehicular traffic between Tacoma's Headworks at RM 61.5 and an adult salmonid release site above HHD would occur as part of an upstream fish passage program.

2.7.2. Indirect Effects

Nearly the entire upper Green River watershed upstream of HHD would be indirectly affected by implementation of an upstream fish passage program. Adult fish passed upstream of HHD would be able to use stream channels up to impassible barriers. The effect of the influx of nutrients associated with salmon carcasses would extend beyond the wetted stream channels because scavengers would consume the carcasses and, thus, further distribute nutrients.

CHAPTER 3.0
SPECIES AND HABITAT INFORMATION

In order to evaluate the effects of activities on listed species, it is important to understand the life history requirements, population status, and distribution of species within the Green River Basin. A description of the life history requirements and status of all eight species covered by this PBA is contained in the following sections.

3.1 CHINOOK SALMON (*ONCORHYNCHUS TSHAWYTSCHA*)

3.1.1 Life History and Habitat Requirements

Chinook salmon present in the Green River are classified summer/fall run stocks (WDFW and Western Washington Treaty Indian Tribes 1994). Adult chinook salmon migrate upstream into the Green River from the Puget Sound from late June through November (Grette and Salo 1986). Owing to their body size, the presence of deep holding water and sufficient discharge are important to allow upstream passage through the lower and middle reach of the river. The upstream migration of chinook salmon in the lower Green River may be delayed by warm water temperatures and low dissolved oxygen concentrations in the late summer and early fall (Fujioka 1970; Williams et al. 1975), which are most likely to occur under low flow conditions.

Chinook salmon spawn in the Green River from early September through mid-November (Grette and Salo 1986). Caldwell and Hirschey (1989) report that chinook salmon in the Green River typically spawn in large gravels and cobbles at depths greater than 1 feet, and in water velocities ranging from about 2 to 3 feet per second (fps). The length of incubation in the Green River varies depending on location of redds and water temperature conditions, but is generally completed by the end of February. Chinook salmon fry usually emerge from gravels 2 to 3 weeks after hatching (Wydoski and Whitney 1979).

Most juvenile chinook salmon in the Green River have an ocean-type life history, meaning that they migrate to the ocean during the year they emerge from spawning gravels (Lister and Genoe 1970; Healey 1991). Consequently, the fry outmigration period for chinook salmon in the Green River extends from February through June. However, some chinook salmon juveniles in the Green River may migrate to the ocean later during the year (e.g., late summer and fall), or during the following spring following a 1-year period of freshwater residency. Ocean-type chinook salmon reside in estuaries for longer periods as fry than juveniles with stream-type life histories (Myers et al. 1998).

The peak movement of subyearling chinook planted in the upper watershed during 1991 into Howard Hanson Reservoir was observed in late May and early June (Dilley and Wunderlich 1992). The peak outmigration period for chinook smolts migrating out of the reservoir was between late April and early June, based upon studies conducted in 1992 (Dilley and Wunderlich 1993). The period of peak fry outmigration in the middle Green River was observed from April 7 through April 17 (Dunstan 1955). Recent juvenile surveys conducted in the middle Green River found that chinook salmon fry movement peaked in early April; chinook salmon fry were observed to be present in this section of the river from February 25 through June 25 (Jeanes and

Hilgert 1999). Age-1+ chinook were also captured during juvenile salmonid surveys in the middle Green River (Jeanes and Hilgert 1999). The origin of age-1+ chinook is unknown, but they may represent fish over-wintering in the Green River, or fish originating upstream from Howard Hanson Dam. Studies of downstream smolt movement using screw traps were initiated in 2000 as a Corps/State of Washington cooperative funding effort and will provide additional information on the timing of downstream smolt movement.

Studies performed in the Duwamish estuary indicate that peak juvenile chinook abundance in the Duwamish estuary occurs during mid to late May (Bostick 1955; Weitkamp and Campbell 1979; Warner and Fritz 1995). Myers et al. (1998) found the greatest abundance of juvenile chinook during early May, although chinook persisted in beach and purse seine catches through July. Warner and Fritz (1995) captured juvenile chinook in the estuary from mid-February through early September.

Most chinook salmon in the Puget Sound mature after 2 to 4 years of ocean residency, although the length of saltwater life can range from 1 to 6 years along the west coast (Myers et al. 1998). A small portion of males may mature early as "jacks" and return to fresh water after several months of ocean residency. Most chinook salmon originating from the Green River mature at age-4 (62%) and age-3 (26%), with a minority of fish maturing at age-2 (1%) and age-5 (11%) (WDFW et al. 1993).

3.1.2 Population Status

The Green River summer/fall chinook are part of the Puget Sound Evolutionary Significant Unit (ESU). Overall, abundance of chinook salmon in this ESU has declined substantially, and both long- and short-term abundance are predominantly downward. These factors have led to this ESU as listed as threatened under the ESA (63 FR 11482). Chinook salmon within the Duwamish/Green River basin originated from both native and hatchery fish (i.e., are of "mixed origin"). However, the hatchery stock of chinook salmon is currently believed to have descended from the wild run (Grette and Salo 1986). Escapement in the mainstem Green River averaged 7,600 from 1987 through 1992 with a trend toward increasing escapement (WDFW et al. 1994). In its review of the Puget Sound chinook ESU, NMFS classified the Green River stock as healthy based on high levels of escapement (Myers et al. 1998).

3.1.3 Known Occurrence in Project Vicinity

3.1.3.1 Lower Watershed

Preferred spawning areas for chinook salmon in the Green River include the main river channel and large side channels from Kent (RM 24.0) to the Tacoma Headworks diversion (RM 61.0). Spawning chinook salmon also utilize the lower portions of Newaukum and Big Soos Creeks (Williams et al. 1975; King County Planning Division 1978). Due to their ocean-type life history, most juvenile chinook salmon migrate out of the Green River as fry within a few months of emergence from gravels. The side channels present in the middle section of the Green River may provide important rearing habitat areas to chinook fry prior to their outmigration into the Puget Sound (Coccoli 1996; Jeanes and Hilgert 1999).

3.1.3.2 Upper Watershed

Juvenile chinook salmon may also be present in the upper Green River Watershed as a result of outplanting programs conducted by the Muckleshoot Indian Tribe (MIT) since 1987 (Corps 1998a, Appendix F1). When planted, these fish distribute in tributaries where they are released, as well as in the mainstem upper Green River. The NMFS designated the upper Green River watershed above HHD as critical habitat for Puget Sound chinook salmon effective March 17, 2000 (50 CFR 226).

3.2 BULL TROUT (*SALVELINUS CONFLUENTUS*) AND DOLLY VARDEN (*SALVETINUS MALMA)*

3.2.1 Life History and Habitat Requirements

There are two native char species present in western Washington: bull trout and Dolly Varden trout. Populations of both species can possess up to four different life history strategies: resident, fluvial, adfluvial, and anadromous (WDW 1992; WDFW 1998). Resident bull trout and Dolly Varden complete their life cycles in tributaries that possess cold water and relatively pristine habitat conditions (WDW 1992). Fluvial forms spawn and rear in small tributaries, but migrate to large rivers as adults. Adfluvial forms have a life history similar to fluvial fish, but migrate to lakes or reservoirs as adults. Finally, anadromous forms spawn and rear in freshwater rivers and streams, but migrate to the ocean as juveniles or adults. The anadromous form is the least understood and documented of these four life history forms (USFWS 1998b). Adult fish have been occasionally seen in lower sections of Puget Sound rivers and estuaries (including the Cedar, White, and Green Rivers), and are presumed to be anadromous forms (WDFW 1998). Anadromous native char migrate to sea in the spring and return in late summer and early fall (Wydoski and Whitney 1979).

Spawning in most native char populations occurs in September and October, although it may occur in August at elevations above 4,000 feet in the Cascades and as late as November in coastal streams (Goetz 1989; Craig 1997). Most anadromous populations spawn only every second year while resident char may spawn every year (Armstrong and Morrow 1980; U.S. Fish and Wildlife Service 1998b). Spawning sites are characterized by low-gradient, uniform flow and a gravel substrate between 0.25 to 2.0 inches in diameter (Wydoski and Whitney 1979; Fraley and Shepard 1989). Groundwater influence and proximity to cover are also reported as important factors in spawning site selection (Fraley and Shepard 1989). Studies conducted throughout the species' range indicate that spawning occurs in water from 0.75 to 2 feet deep (Wydoski and Whitney 1979; Fraley and Shepard 1989) and often occurs in reaches fed by streams, or near other sources of cold groundwater (Pratt 1992).

Bull trout/Dolly Varden require a long period of time from egg deposition until emergence. Embryos incubate for approximately 100 to 145 days, and hatch in late winter or early spring (Weaver and White 1985). Rieman and McIntyre (1993) indicate that optimum incubation temperatures are between 36°F (2°C) and 39°F (4°C). The alevins remain in the streambed, absorbing the yolk sac, for an additional 65 to 90 days (Pratt 1992). Emergence from the streambed occurs in late winter/early spring (Pratt 1992). High fine sediment levels in spawning substrates reduce embryo survival, but the extent to which they affect bull trout/Dolly Varden populations is not entirely known (Rieman and McIntyre 1993).

Fry are usually found in shallow, slow backwater side channels and eddies, in close proximity to instream cover (Pratt 1984; Goetz 1994). Young-of-the-year bull trout/Dolly Varden are found primarily in lateral stream habitats such as side channel areas and along stream margins, similar to that reported for other species of salmonids (Fraley and Shepard 1989; Goetz 1994). Juveniles are primarily bottom dwellers and are found among interstitial spaces in the substrate (Fraley and Shepard 1989; Pratt 1992). Sub-adults are often found in deeper stream pools or in lakes in deep water with temperatures less than 59°F (15°C) (Pratt 1992). Bull trout/Dolly Varden juveniles typically spend 2 to 3 years rearing in tributary streams before migrating downstream to mainstem river sections (fluvial forms), lakes (adfluvial forms), or the sea (anadromous forms)(Goetz 1989; Washington Department of Wildlife 1992; McPhail and Baxter 1996). Most fish become sexually mature between 4 and 6 years of age (Goetz 1989; Washington Department of Wildlife 1992).

Limiting factors to this species include warm water temperatures that exceed temperatures tolerated by spawning adults (about 50°F [10°C]) and rearing juveniles (about 59°F [15°C]), lack of spawning and rearing habitat, and a high percentage of fine sediment in spawning gravels (USFWS 1998b). Because of their close association with stream bottoms, native char are sensitive to changes in streambed conditions (Fraley and Shepard 1989; USFWS 1998b). Bull trout/Dolly Varden readily interbreed with non-native brook trout (*Salvelinus fontinalis*), which can seriously impact bull trout/Dolly Varden populations due to genetic introgression. Brook trout may also exclude bull trout/Dolly Varden from native habitats (USFWS 1998b). Native char are easily caught and are highly susceptible to fishing pressure; therefore, any increase in the accessibility of a population to fishing pressure may negatively impact a population (Fraley and Shepard 1989).

3.2.2 Population Status

Bull trout in the Coastal-Puget Sound distinct population segment (DPS) were listed as a threatened species by the USFWS on November 1, 1999 (64 FR 58910). Dolly Varden were not listed as part of this action. However, both bull trout and Dolly Varden are present in the Coastal-Puget Sound DPS, and have been found to coexist in a number of streams in this region (64 FR 58910). Bull trout and Dolly Varden are very difficult to distinguish based upon physical features, and have similar life history traits and habitat requirements (WDFW 1998; 64 FR 58910). Because these two species are closely related and have similar biological characteristics, the WDFW manages bull trout and Dolly Varden together as “native char” (WDFW 1998). Section 4(e) of the ESA provides for the listing of a non-threatened species if it closely resembles a listed species, and if the listing of this species provides a greater level of protection to the listed species. The USFWS stated that it will not list Dolly Varden under the similarity of appearance provision of the ESA at this time (64 FR 58910). The USFWS would consider listing Dolly Varden, however, if the WDFW departed from managing bull trout and Dolly Varden as the same species (64 FR 58910). For this report, bull trout and Dolly Varden will be referred to as “native char”.

3.2.3 Known Occurrence in Project Vicinity

3.2.3.1 Lower Watershed

Bull trout/Dolly Varden populations are located in the upper Cedar River and White River drainages, which are adjacent to the Green River Watershed (WDFW 1998). However, information on the presence and distribution of bull trout/Dolly Varden in the Green River is very limited (WDFW 1998). A single bull trout was reported in Soos Creek in 1956. No supporting information regarding this sighting is available (Beak Consultants Incorporated 1996). A single bull trout was also observed at the mouth of the Duwamish River in the spring of 1994 (Warner 1998). Native char have been captured in the Green River as far upstream as RM 40.0 (Watson and Toth 1995).

3.2.3.2 Upper Watershed

Bull trout/Dolly Varden have not been found in the Green River Watershed above Howard Hanson Dam (WDFW 1998). Access to the upper watershed for migratory native char (i.e., anadromous and fluvial forms) has been blocked by Tacoma's Headworks diversions since 1913, and by HHD since 1962.

3.3 BALD EAGLE *(HALIAEETUS LEUCOCEPHALUS)*

3.3.1 Life History and Habitat Requirements

Throughout the Pacific Northwest, bald eagles exhibit a close association with freshwater, estuarine, and marine ecosystems that provide abundant prey and suitable habitat for nesting and communal roosting (USFWS 1986; Watson et al. 1991). In Oregon, 84 percent of bald eagle nests were within 1.0 mile of water (Anthony and Isaacs 1989) while in western Washington, a sample of 218 bald eagle nests showed an average distance of 282 feet to water (Grubb 1980). Nests are often re-used year after year (60 FR 36000). Snags, trees with exposed lateral branches, or trees with dead tops are often present in nesting territories and are used as perches during nesting, hunting, feeding, resting, preening, mating, and behavioral displays (Stalmaster 1987).

Bald eagles migrate to wintering ranges in Washington in late October. Large winter communal roosts are generally located close to feeding areas on large rivers, as well as along marine waters and in the Columbia Basin (USFWS 1986). Hansen et al. (1980) reported that winter roosts ranged from 0.16 to 1.5 miles from water, although eagles can travel up to 9 miles to feeding areas (Keister and Anthony 1983). Winter communal night roost are usually in old-growth or mature stands (Anthony et al. 1982; Keister and Anthony 1983; Stalmaster and Kaiser 1997) that provide thermal cover and wind protection (USFWS 1986).

3.3.2 Population Status

The bald eagle is currently listed as a threatened species under the federal ESA in the 48 conterminous states; however, the bald eagle is proposed for removal from the list of endangered and threatened species due to increased numbers of breeding pairs (64 FR 36454). The state of Washington also lists the bald eagle as a threatened species. The bald eagle is found only in North America and ranges over much of the continent, from the northern reaches of Alaska and Canada to northern Mexico.

3.3.3 Known Occurrence in Project Vicinity

The bald eagle has been sighted every month of the year near HHD. It is considered a year-round resident in the area, but the extent of use of the drainage above HHD is not well known. Surveys conducted in 1981, 1982, 1989, and 1993 detected adult bald eagles near HHD and along the Green River, Tacoma Creek, and Pioneer Creek (USFS 1996). A pair of bald eagles has been reported nesting at Eagle Lake, which is 1-mile northeast of HHD (USFS 1996). Resident fish and abundant waterfowl populations most likely provide foraging opportunities for bald eagles. Historically, anadromous salmonids probably provided an additional food source in the Green River watershed for bald eagles prior to construction of HHD. At least one account prior to construction of the dam indicates as many as 15 bald eagles at Eagle Gorge, which may have been the result of spawning salmon. Approximately 3,709 acres of potential nesting habitat and 5,582 acres of potential foraging habitat were identified within the USFS Green River Watershed Analysis Area (USFS 1996).

Below HHD there are five documented bald eagle nest sites (WDFW 1999). Two of these sites (WDFW Reference Nos. 903681 and 93627) are associated with tributaries to the Green River and their mapped territory boundaries are more than 2.0 miles from the Green River (WDFW 1999). The other three territories (WDFW Reference Nos. 901979, 903683, 902254) encompass at least a small portion of the Green River, and these resident eagles likely forage along the river at least seasonally. The Washington Priority Habitats and Species database does not contain any record of winter communal roosts along the Green River below HHD (WDFW 1999).

3.4 NORTHERN SPOTTED OWL (*STRIX OCCIDENTALIS CAURINA*)

3.4.1 Life History and Habitat Requirements

On the west slope of the Washington Cascades, the species can be found in forested areas below elevations of 4,200 feet. Preferred habitat is closed-canopy coniferous forests with multi-layered, multi-species canopies dominated by mature and/or old-growth trees (Thomas et al. 1990; Lujan et al. 1992). Nesting and roosting habitat are characterized by moderate to high canopy closure (60-80%), large (>30” dbh) overstory trees, substantial amounts of standing snags, other in-stand decadence (e.g., deformities, cavities, broken tops and dwarf mistletoe infections), and coarse woody debris of various sizes and decay classes on the ground (USFWS 1987, 1989, Thomas et al. 1990). Foraging occurs in nesting and roosting habitat, as well as in coniferous forest with smaller trees and less structural diversity if prey such as the northern flying squirrel (*Glaucomys sabrinus*) are present (Hanson et al. 1993).

Spotted owls do not build their own nests. Most nesting occurs within naturally formed cavities in live trees or snags, but abandoned platform nests of the northern goshawk (*Accipiter gentilis*) and common raven (*Corvus corax*) have also been used (Buchanan et al. 1993; Forsman and Giese 1997). Trees and snags supporting cavity nests are typically large (mean = 55.8 inches on the Olympic Peninsula; Forsman and Giese 1997), and this is often cited as one of the reasons spotted owls are strongly associated with mature and old growth forest. The principal prey of the northern spotted owl over much of its range (the northern flying squirrel) also dens in cavities within large trees, further strengthening the spotted owl's dependence on older forest. Where spotted owls have been found nesting in young forest, such occurrences have been attributed to the presence of large residual trees with cavities (Buchanan et al. 1998), climatic conditions conducive to the use of platform nests (Forsman and Giese 1997), and/or alternate sources of prey that do not rely on cavities for reproduction (Zabel et al. 1995).

At the landscape level, spotted owls select home ranges that emphasize old-growth (Carey et al. 1990). One study on the Olympic Peninsula reported that spotted owl pairs selected home ranges that contained an average of 44 percent old forest (Lemkuhl and Raphael 1993), while home ranges studied in Oregon had an average of 53 percent old forest (Carey et al. 1990, 1992). Using data from throughout the Pacific Northwest, Bart and Forsman (1992) documented that reproduction declined sharply in habitats with less than 40 percent old forest, and landscapes with less than 20 percent old forest rarely support nesting owls.

3.4.2 Population Status

The northern spotted owl was federally listed in July 1990 as threatened throughout its entire range in Washington, Oregon and Northern California. The principal cause for the listing was the on-going loss of habitat resulting from the harvest of old-growth forest and conversion to young forest or non-forest (55 FR 26114).

3.4.3 Known Occurrences in the Project Vicinity

Spotted owls do not occur within the Green River watershed downstream of HHD because of the general lack of suitable habitat. The upper Green River watershed supports 20 known spotted owl activity centers, representing 19 pairs (12 with confirmed reproduction) and one single spotted owl of unknown status. None of these activity centers lie within 1.8 miles of HHD or the reservoir, so owls occupying the activity centers are unlikely to use habitat influenced by the HHD project.

The entire upper Green River watershed has undergone extensive surveying over the past decade, and the 20 known spotted owl activity centers are thought to represent all the resident spotted owls (USFS 1996). Detections of single spotted owls in 1989 and 1990 in the Charley Creek drainage (approximately 1 mile from the reservoir) prompted the Washington Department of Natural Resources (DNR) to conduct formal spotted owl surveys according to U. S. Fish and Wildlife Service protocol (USFWS 1992) from 1992 through 1994. No spotted owls were detected during the 3 years of DNR surveys, and the site established in 1990 (WDFW Site/Detection No. 204-8759) was subsequently declared historic. The DNR survey not only resulted in no detections of spotted owls, but it also resulted in numerous detections of the barred owl (*Strix varia*), a species that successfully competes with the spotted owl in young and mid-age forests. The abundance of barred owls in the lower watershed suggests that forests in that area are not high quality spotted owl habitat.

Several thousand acres of federally designated critical habitat for the northern spotted owl occur in the upper Green River watershed, east of HHD and the reservoir (57 FR 1796). The spotted owl critical habitat closest to the project area is located on federal (USFS) lands approximately 7 miles east of the upper end of the reservoir in Township 20 North, Range 10 East.

3.5 MARBLED MURRELET *(BRACHYRAMPHUS MARMORATUS)*

3.5.1 Life History and Habitat Requirements

The marbled murrelet is a small seabird that spends most of its life cycle on marine waters, but is the only North American Alcid that nests in trees (Nelson and Hamer 1995). It is documented nesting in trees up to 39 miles inland in Washington (USFWS 1995a), although detections indicating stand occupancy (i.e., nesting) have been documented up to 52 miles inland (Ralph et al. 1994). Suitable nesting habitat is old-growth coniferous forest or mature coniferous forest with an old-growth component (Marshall 1988; Hamer and Cummins 1990; Interagency Interim Guidelines Committee 1991; Hamer 1995; Ralph et al. 1995). Murrelets typically require large coniferous trees greater than 32 inches in dbh, with large-diameter moss-covered limbs for nest sites (Singer et al. 1991; Ralph et al. 1994).

3.5.2 Population Status

The marbled murrelet was listed as threatened in Washington, Oregon and California in 1991 under the federal ESA. A variety of factors were presented as contributing to its decline, including over-fishing (of its prey), entanglement in fishing nets, oil spills and loss of nesting habitat (Marshall 1988; Ewins et al. 1993; Ralph et al. 1995; Carter and Kuletz 1995). The State of Washington also lists the marbled murrelet as threatened. Recent population estimates include 5,500 murrelets in Washington and a total population of about 300,000 birds in North America (Ralph et al. 1995). Modeling for the Pacific Northwest population indicates an annual decline of 2 to 12 percent in the at-sea population of marbled murrelets (Beissinger 1995).

3.5.3 Known Occurrence In Project Vicinity

In 1994, a survey was conducted in the reservoir area within three stands identified by Bill Ritchie (WDFW), Tim Bodurtha (USFWS), and Ken Brunner (Corps) as marginally suitable habitat. A 1-year survey was recommended as being sufficient by Bill Ritchie based on the observation that: 1) there was no other suitable murrelet nesting habitat within several miles of the three stands; 2) none of the stands are greater than 1 acre; 3) there are very few potential platforms on the three stands; and 4) no other murrelets had been detected in the Green River watershed, making these marginal sites even less likely to be occupied (Ritchie 1994). No marbled murrelets were detected during the survey.

Numerous other surveys for nesting murrelets have been conducted over several years in the upper Green River watershed, including surveys of a 5 to 10 acre stand near the Tacoma Diversion Headwork (Beak 1994a and 1995), but occupancy has only been detected in two sections on USFS land (Stebbins 2000). Both sections with occupancy are more than 7 miles east of the current reservoir. Marbled murrelets are not expected to occur adjacent to HHD or the reservoir, due to the absence of suitable habitat. The Washington Priority Habitat and Species database does not contain any record of occupied marbled murrelet habitat in the Green River basin below HHD.

Federally designated critical habitat for the marbled murrelet occurs in the Green River watershed, east of HHD and the reservoir (64 FR 26256). The closest critical habitat to the project area in the basin is located on federal lands designated as Late Successional Reserves in portions of Townships 20 and 21 North, Range 10 East. The occupied habitat mentioned above is located within this critical habitat.

3.6 GRIZZLY BEAR *(URSUS ARCTOS)*

3.6.1 Life History and Habitat Requirements

The grizzly bear is able to utilize a wide variety of habitat conditions, from open dry prairie to wet montane forest. Whitaker (1980) describes a general habitat condition of semi-open country, usually in mountainous areas. Population size and distribution have been limited by human intrusion (USFWS 1997b). Grizzly bears will avoid areas of human use, including areas containing roads and signs of timber cutting (USFWS 1997b).

The grizzly bear is a free-ranging animal that requires a large home range, with males having larger home ranges (200 to 500 square miles) than females (50 to 300 square miles) (USFWS 1995b). It is an opportunistic omnivore; however, 80 to 90 percent of the grizzly bears diet is green vegetation, wild fruits and berries, nuts, and bulbs or roots. The majority of the meat in its diet comes from carrion (USFWS 1995b). Grizzly bears may travel extensively to find suitable den locations, which are generally located on remote mountain slopes where snow will last until late spring. They usually move down to lower elevations after emerging from their dens in the spring.

3.6.2 Population Status

The grizzly bear is federally listed as threatened and state listed as endangered in Washington. The USFWS established six recovery zones within the conterminous 48 states, including the North Cascades Recovery Zone (north of Interstate Highway 90) (USFWS 1993). The grizzly bear population in the North Cascades ecosystem is estimated to number at least 10 to 20 bears (Johnson and Cassidy 1997).

3.6.3 Known Occurrence In Project Vicinity

The Washington Priority Habitats and Species database contains no records of grizzly bears in the Green River drainage (WDFW 1999). However, grizzly bears have been documented south of the Green River drainage in Kapowsin, Pierce County (Corps 1997) and near Snoqualmie Pass in or within 1 mile of the north parcel group of the I-90 land exchange (USFS 1998). Although the species is considered rare, it is possible that it inhabits the upper basin, but not downstream of HHD.

3.7 GRAY WOLF *(CANIS LUPUS)*

3.7.1 Life History and Habitat Requirements

Gray wolves are habitat generalists. The availability of prey may be the primary factor in determining habitat suitability (Stevens and Lofts 1988). Whitaker (1980) lists gray wolf habitat in North America as open tundra and forest. Human disturbance plays a roll in determining gray wolf distribution. In Alaska, Thurber et al. (1994) found that wolves avoided areas of human activity, including roads. In studying historic population changes of wolves in Wisconsin, Thiel (1985) found that wolf populations decreased when road densities exceeded 0.93 mile per square mile. Gray wolves often maintain very large home ranges; 40 to 47 square miles on Vancouver Island and 93 to 248 square miles in northern British Columbia (Scott 1979). Den sites are most commonly burrows in sandy soils, but can be located in a variety of settings, from downed logs and hollow trees to rock caves. Rendezvous sites tend to be near sources of open water in small meadows with limited visibility.

3.7.2 Population Status

The gray wolf is listed as endangered at both the federal and state levels in Washington. Gray wolves had apparently disappeared from Washington by 1920 (Ingles 1965). Although, between 1992 and 1997, two reliable sightings of wolves feeding pups were recorded in the North Cascades, the occurrence of the gray wolf in Washington remains questionable (Johnson and Cassidy 1997).

3.7.3 Known Occurrence In Project Vicinity

The Washington Priority Habitats and Species database contains no record of gray wolves in the Green River basin. However, the USFS reports one wolf sighting in 1992 in the Green River Watershed Analysis Area (USFS 1996). There are 13 other records of wolves in or within 1 mile of the I-90 Land Exchange parcel groups, including the I-90 North (1 record), Keechelus (1 record), and Big/Little Creek (2 records) (USFS 1998). Although the species is considered rare, it is possible that it inhabits the upper basin, but not the lower basin of the Green River.

3.8 CANADA LYNX *(LYNX CANADENSIS)*

3.8.1 Life History and Habitat Requirements

In Washington, lynx are known to occur above 4,000 feet in elevation (McKelvey et al. 1999; WDFW 1993). The Canada lynx requires a matrix of two important habitat types. For thermal and security cover and for denning it uses mature, closed-canopy, boreal forest that contains a high density of large logs and stumps and is near hunting habitat. For hunting, it uses early successional forest with high densities of snowshoe hare *(Lepus americanus)*. Additionally, lynx avoid large open spaces and tend not to cross openings greater than 330 feet (Koehler and Aubry 1994). The abundance of Canada lynx is correlated with the population cycle of its primary prey the snowshoe hare (Ingles 1965; Koehler and Aubry 1994; Johnson and Cassidy 1997).

3.8.2 Population Status

In Washington, where its population is estimated to be between 91 and 196 individuals, the Canada lynx is listed by the state as threatened (WDFW 1993). It has been proposed for federal listing as threatened throughout the lower 48 states (63 FR 36994). The listing proposal states that, "...the Canada lynx is threatened by human alteration of forests, low numbers as a result of past over-exploitation, expansion of the range of competitors (bobcats; *Felis rufus*) and coyotes (*Canis latrans*), and elevated levels of human access into lynx habitat," (63 FR 36994). The current projected range of the lynx in Washington does not extend west of the Cascade crest (WDFW 1993).

3.8.3 Known Occurrence In Project Vicinity

Range limits of the lynx predicted by gap analysis modeling do not include the Green River watershed (Johnson and Cassidy 1997), but one male was apparently observed in the USFS Green River Watershed Analysis Area in 1979 (USFS 1996). However, McKelvey et al. (1999) found no verifiable records of lynx from coastal areas west of the crest of the Cascade Mountains. No lynx have been documented in the I-90 Land Exchange parcel groups (USFS 1998). Although the species is considered rare, it is possible that it inhabits the upper Green River basin. It is not likely to occur in the lower basin near or below HHD.

CHAPTER 4.0
EXISTING CONDITIONS

This chapter describes the existing physical, biological, and operational setting of the Green River basin to establish an "Environmental Baseline" for both HHD Continued O&M and the AWSP. Specific differences in the "Environmental Baseline" for both major activities are identified in the introductions to Chapters 5 and 6.

4.1 ENVIRONMENTAL SETTING

4.1.1 Climate and Topography

The climate of the Green River basin is dominated by maritime influences of the Pacific Ocean and topographic effects of the Cascade Mountains. Regional climate is characterized by cool, wet winters and mild, dry summers. Precipitation is mostly derived from cyclonic storms generated in the Pacific Ocean and Gulf of Alaska that move inland in a southwest to northeast direction across western Washington. Over 80 percent of precipitation falls between the months of October and April. During summer months a regional high pressure system generally resides over most of the Pacific Northwest, which diverts storms and associated precipitation to the north.

This regional climatic pattern is modified by the presence of the Cascade Mountains, which rise to an elevation of approximately 5,000 feet at the eastern margin of the Green River basin. Moist, maritime air cools and condenses as it moves up in elevation from west to east through the basin, resulting in decreasing temperatures and increasing precipitation up this elevation gradient. Consequently, there is a considerable difference in both temperatures and precipitation from the lower to the higher elevations of the basin (Table 4-1). In addition, there is more snow in the upper portion of the basin. Melting of snow and the resulting surface runoff in spring is a major source of water to streams. The climatic pattern and topography interact to determine a runoff pattern that results in wet winters and dry summers. This runoff pattern affects the strategy of storing water for augmenting low summer instream flows and municipal water supplies.

Table 4-1
Temperatures and Precipitation in the Green River basin.

Location	Elevation (feet)	Period of Record	Mean July Max. Temperature (°F)	Mean Jan. Min. Temperature (°F)	Mean Annual Precipitation (inches)	Mean Annual Snowfall (inches)
Sea-Tac Airport	400	1931-1998	75	35	38	0
Palmer	900	1931-1998	75	31	91	43
Stampede Pass	3,300	1944-1998	65	20	88	442

Source: Western Regional Climate Center, 1998.

4.1.2 Geomorphology and Land Use

4.1.2.1 Geomorphology

Soils in the upper Green River basin, defined as the area above HHD, are largely derived from volcanic parent material and occur on mountainous slopes that become quite steep toward the crest of the Cascade Mountains. The upper basin also includes terraces in the underlying lava and bedrock created by glacial scouring and by wave action in large Pleistocene lakes that developed between the glacial lobe and the Cascade Mountains. Many locations of bedrock outcrop also exist. The upper Green River and its tributaries have relatively narrow to nonexistent floodplains that are confined by the steep valley sides.

The potential for erosion hazard is high or severe on many soils where the slopes are greater than 35 percent (USFS 1996). These soils often slump or slide in rainy periods after vegetation has been removed. Soil depths range from shallow soils associated with rock outslopes and talus slopes to very deep (>12 feet) valley bottom soils.

The lower Green River is defined as the reach below HHD extending downstream to the Puget Sound. In the lower Green River basin from Palmer to near Auburn, soils are largely derived from unconsolidated glacial material and occur on more gradual slopes characterizing the rolling topography in this area (SCS 1973). Soils in the Everett association, which are gravelly sandy loams formed in glacial outwash deposits, dominate the uplands surrounding the Green River floodplain. Floodplain soils in the middle basin are in the Oridia-Seattle-Woodinville association, which consists of somewhat poorly drained to very poorly drained silt loams, mucks, and peats. There are also strips of gravel and sand deposited along channels, which are typically quite narrow but average nearly 1,000 feet in width (nearly one-third of the floodplain) near the confluence of Newaukum Creek (Mullineaux 1970).

The floodplain of the lower Green River varies considerably in width. The Green River Gorge has virtually no floodplain, due to the rapid downcutting through relatively weak sandstones and mudstones. Downstream of the Gorge, the river has developed a broad floodplain in a valley that is typically about 0.5 mile in width.

In the lower Green River basin below the confluence of Soos Creek, soils are also in the Oridia-Seattle-Woodinville association developed from fine-textured alluvial material deposited by the Green, White, and Cedar rivers, with organic soils in depressional areas. Soils in this reach of the lower Green River basin have high agricultural potential, although urban development has now eliminated much of the previous agricultural land use in the area.

Prior to settlement by Euroamericans, the floodplain of what was once the lower White River probably covered most of the floor of what is now the Green River Valley north of Auburn, which averages about two miles in width. Due to the construction of levees, dredging of channels, and flood control by HHD, this floodplain is now essentially inactive.

4.1.2.2 Land Use

Most of the land (99 percent) in the upper Green River basin is managed as a water supply area for Tacoma and for commercial timber production. Ownership in the upper basin is divided among several private and public entities, including Plum Creek Timber Company (34 percent), USFS (22 percent), Washington State Department of Natural Resources (14 percent), and City of Tacoma (10 percent) (Tacoma 1998). The remaining 19 percent is mostly owned by other timber companies.

Tacoma owns 10 percent of the upper watershed, and has intentionally concentrated its holdings in lands adjacent to the Green River and the HHD reservoir. Tacoma manages these lands according to Tacoma's Green River Watershed Forest Land Management Plan to protect water quality and, where consistent, conduct commercial timber harvest.

Lands owned by other entities, such as the USFS and Plum Creek Timber Company, are also managed for timber production. USFS land is managed under the June 1990 Land and Resource Management Plan for the Mt. Baker-Snoqualmie National Forest as amended by the April 1994 Record of Decision for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl (i.e., the Northwest Forest Plan). Private and state timber lands are managed according to the Washington State Forest Practices Rules and Regulations (Title 222 WAC) and other management directives (i.e., Habitat Conservation Plans [HCP]) developed to comply with the federal Endangered Species Act (ESA) of 1973 as amended.

In the lower Green River basin, almost 80 percent of the land use is rural, forest production, and urban/residential. The middle Green River basin has one of the largest remaining agricultural communities in King County and is of increasing importance as an affordable area for suburban and rural residences and hobby farms.

The majority of the lower Green River basin below the Soos Creek confluence is urban residential, but there is also a substantial amount of rural and agricultural land use. Land use in the lower 11 miles of the basin is predominantly urban-residential, with heavy industrial use along the river. However, even in this urban/industrial setting, over 20 percent of the land is classified as rural.

4.1.3 Plant Communities

The upper Green River basin is within the Western Hemlock Forest Zone (Franklin and Dyrness 1987). The Western Hemlock Forest Zone is characterized by climax western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) forests and sub-climax Douglas-fir (*Pseudotsuga menziesii*) forests. Although western hemlock is the potential climax species in this zone, Douglas-fir forests cover large areas of the landscape. Douglas-fir-dominated forests develop following disturbance, such as fire and clearcut logging practices, and can persist for several centuries. Hardwood forests are commonly restricted to moist, early successional sites, where red alder (*Alnus rubra*) often dominates and big-leaf maple (*Acer macrophyllum*) is common. Topography, aspect, geology, soil, and available groundwater all influence plant community patterns at the local level, particularly for understory species. Common understory species include sword fern (*Polystichum munitum*) in moist sites, salal (*Gaultheria shallon*) in dry sites, and Oregon grape (*Berberis nervosa*) in sites with intermediate moisture status. Vine maple (*Acer circinatum*) is a common shrub in the middle understory.

Disturbance has had a major impact on forest patterns in the upper Green River basin due primarily to extensive timber harvest and past wild fires. Timber harvest activities have resulted in the predominance of second-growth, even-aged coniferous stands. There is also a large area of hardwood dominated by red alder with an understory of western hemlock and western red cedar present. The majority of the stands are 30 to 90 years old and, until about 30 years ago, regenerated naturally. More recent harvested areas have been planted with Douglas-fir. Deciduous forests comprised of red alder, big-leaf maple, and black cottonwood (*Populus balsamifera*) occur on wetter slopes.

4.1.4 Hydrology

The Green River originates in the high Cascades in central Washington state, and flows northwest for approximately 93 miles, draining an area of over 460 square miles before emptying into Puget Sound at Elliot Bay. Forty-eight tributaries enter the system above HHD, feeding both the mainstem and reservoir. Large headwater tributaries include the North Fork of the Green River, and Sunday, Smay, Charley, Gale, Twin Camp, Sawmill and Friday creeks. These tributaries lie within the snow zone and exhibit two distinct discharge peaks associated with fall rainstorms and spring snowmelt.

Below HHD, major tributaries include Newaukum and Soos creeks, which enter the middle Green River near RM 41 and RM 34, respectively. A number of flow-related problems have been associated with the increasing urban development in lower basin tributaries such as Soos Creek (King County 1989). With increasing impervious surface area, water runs off more quickly and less is captured and stored by wetlands or alluvial aquifers, reducing groundwater contributions that maintain summer low flows. Increased impervious area and ground water withdrawals were cited as the primary cause of recent declines in summer low flows in Soos and Newaukum Creeks (Culhane 1995). Channels become wider in response to the increased peak flows, and scour of spawning gravel may occur more frequently.

In addition to Corps measurements of reservoir levels behind HHD, the U.S. Geological Survey (USGS) maintains a series of stream gages in the Green River Basin. The most important gages from the standpoint of this PBA are located on the mainstem Green River at RM 60.3 near Palmer (12106700) and at RM 32 near Auburn (121130000). The Palmer gage is used as a flow contol target for the Corps low-flow augmentation. The Auburn gage is used as a target site for flood control operations and as a target site for instream flow requirements. The Auburn gage is just downstream of the majority of current anadromous salmonid spawning habitat, and upstream of the highest density urban areas. Analyses of the effects of HHD and the AWSP in this PBA use the Auburn gage as a control point to maintain consistency with documents produced earlier by the Corps and Tacoma Public Utilities (Corps 1998a; TPU 1999).

4.1.5 Water Quality

The Washington State Department of Ecology (Ecology) has established surface water quality standards pursuant to Chapter 90.48 RCW (Water Pollution Control Act) and Chapter 90.54 RCW (Water Resources Act of 1971) to protect uses of water beneficial to wildlife and humans. Water quality standards affected by forest practices are addressed by the Washington Forest Practices Board Manual, which states that “whereas Ecology is solely responsible for establishing water quality standards for waters of the state, both the Forest Practices Board and Ecology shall jointly regulate water quality issues related to silviculture in the State of Washington (RCW 90.48.420)." As a result, WAC 173-202, Washington Forest Practices Rules and Regulations to protect Water Quality, was jointly developed and adopted by the Forest Practices Board and Ecology so that compliance with Forest Practices Rules and Regulations would in turn achieve compliance with water pollution control laws.

Water Quality Standards for Surface Waters of the State of Washington (Chapter 173-201A WAC), classify the Green River as Class “AA” (extraordinary) upstream of RM 42.3 (Flaming Geyser State Park), Class “A” (excellent) between Flaming Geyser State Park and the Duwamish River confluence (RM 42.3 to 11.0), and Class “B” (good) within the Duwamish River (WAC 173-201A-130). These specific classifications are meant to define present and potential uses of these waters and do not necessarily define natural conditions. For example, WAC 173-201A-030 states that Class B waters shall meet or exceed the requirements for most uses (beneficial uses, as described in WAC 173-201A-030, include, but are not limited to: agricultural and industrial water supply; stock watering; fish and shellfish habitat; wildlife habitat; and secondary contact recreation). Class AA waters shall markedly and uniformly exceed the requirements for all or substantially all uses (identical to those listed for Class B waters, but in addition include domestic water supply and primary contact recreation). These classifications indicate that the Green River has sufficient water quality to support current uses of the river; however, several areas (primarily below Auburn) have been identified where water quality may be limiting to beneficial uses of the river during certain times of the year (Corps 1995; and discussed below).

In general, water quality problems that potentially contribute to the decline of salmonids in the Green River increase in severity as the water flows downstream. In the upper watershed, the primary factors affecting water quality and fish production are increased turbidity and fine-sediment loading associated with commercial forest management. Water quality in the lower watershed is influenced by a number of land and water uses and is degraded in the form of:

- Increased summer water temperatures due to removal of riparian vegetation, diversion of the White and Black rivers, and release of warmer water later in the summer from HHD storage. Water temperatures exceeding the state standard have been recorded frequently enough to warrant registering lower segments of the Green River on the state’s 303(d) lists; and
- Reduced DO due to elevated water temperatures and increased biochemical and chemical oxygen demand associated with high nutrient and pollutant inputs. DO levels that fail to comply with the state standard have also been recorded in the lower watershed during sustained low-flow periods. However, these failures have not been recorded frequently enough to warrant placement on the state’s 303[d] list).

Furthermore, disconnection of the floodplains by reduced flooding, plus the physical removal of wetlands (particularly in the lower basin) has reduced the natural capacity of the system to store and treat water entering and flowing through the river system. In addition to fisheries impacts, poor water quality has also influenced the aquatic macroinvertebrate community in the lower and middle basins.

In the 1980s, water quality and sediment monitoring identified pollution in the Duwamish River and Elliott Bay (Duwamish River and Elliott Bay Water Quality Assessment Team [WQAT] 1999). The pollution originated from a number of point and nonpoint sources. Recent improvements in wastewater and stormwater treatment facilities and processes (e.g., secondary treatment of wastewater, rerouting treatment plant effluent from the river to Puget Sound, sediment cleanup and capping of contaminated areas, and other measures [WQAT 1999]) have had a noticeable effect on improving water quality in the Duwamish River and Elliott Bay. Using water quality data collected weekly in 1996 and 1997 from 21 stations throughout the Duwamish Estuary, the WQAT concluded that there are currently minimal risks to aquatic life from chemicals in the water column. In particular, the WQAT found no risks to juvenile salmon from direct exposure to chemicals in the Duwamish River or Elliott Bay (WQAT 1999).

4.1.5.1 Water Temperature

Summer water temperatures in the Green River increase progressively as the water travels downstream. Based on data reported by the Corps (1995), water temperatures in the Green River above HHD are generally below 60°F (16°C). However, inflows into the HHD reservoir do exceed 60°F (16°C) during the summer in most years. Such periods are generally brief and do not appear to greatly affect reservoir temperatures. Temperatures in the lower levels of the reservoir during the summer are between 50° and 55°F (10 and 12.8°C), which is 15°F (9.4°C) below surface temperatures during the same time period. Surface temperatures fluctuate more than deeper layer temperatures, and reservoir stratification is generally weaker than in natural lakes (Corps 1998a). A more thorough assessment of temperature conditions in the Green River can be found in the Additional Water Storage Project (AWSP) DFR/DEIS, Appendix D3, Section 1 (Corps 1998a).

The HHD impoundment becomes thermally stratified in late spring or early summer, and remains in this condition through early fall. The stratification results in layers of water at elevated temperatures occurring at the surface and overlaying colder bottom waters. Mixing of the layers is prevented by density gradients. Because the release from the reservoir is achieved through low level outlets, downstream temperatures during the early summer period are colder than those that would have occurred without the project. Profile measurements made in the forebay over the 17-year time span June 21, 1967, through July 26, 1983, recorded a maximum surface temperature of 74°F (23.6°C) and a maximum bottom temperature of 62°F (16.5°C). Minimum recorded temperatures during this period were 41°F (5°C) at the surface and 40°F (4.5 °C) at the bottom of the pool (Corps 1998b).

Low-flow releases from HHD during the summer conservation period are made through a 48-inch bypass intake located about 35 feet above the bottom of the pool. The 48-inch bypass pipe is located below the level of typical reservoir stratification. As a result of drawing water from the lower, colder stratum, releases from HHD during the early summer are usually below expected natural temperatures. Later in the summer and in early fall, as cooler water is depleted and warmer water is released, temperatures are higher than would be expected under a natural, unimpounded flow regime (Corps 1998a). These artificially higher temperatures can adversely affect salmon spawning behavior and may accelerate maturation of developing salmon eggs.

High water temperatures in the lower Green River probably result from solar heating of the river during summer low-flow periods. The factors responsible for this warming include extensive paved areas in the lower Green River basin that reduce groundwater recharge and subsequent discharge of cool groundwater into the river, low summer flows, and lack of shade along the lower river (Corps 1998a).

Caldwell (1994) studied temperatures between HHD and the confluence with the Duwamish River. Between HHD and the Tacoma Headworks (3.5 river miles below the dam), summer water temperatures averaged 57 to 65°F (13.9 to 18.3°C). Caldwell found water temperatures at the Tacoma Headworks to be independent of HHD outfall temperatures.

Water temperatures above 60°F (15.5°C) are limiting for cold water-adapted fish, such as salmon and steelhead and also contribute to low DO, another potentially limiting water quality parameter. Elevated temperatures may also result in algae blooms, a particular concern in the lower Green River and in the Duwamish River. It is also thought that high water temperatures affect the movement of migrating adult salmonids, particularly during August and early September and may affect salmon egg viability and survival (Caldwell 1994).

4.1.5.2 Dissolved Oxygen

Measurement of 75 dissolved oxygen (DO) profiles in the dam forebay over an eleven-year period since the dam was completed have yielded a profile average of 9.52 mg/l. Extremes ranged from a maximum surface concentration of 12.5 mg/l to a lake bottom minimum of 4.4 mg/l. Outflows from the project, due to re-aeration in the tailrace, have generally ranged slightly higher than reservoir DO levels. Statistics of DO concentrations for the monitoring station below the dam indicate a mean of 10.69 mg/l with a maximum of 13.7 mg/l and a minimum of 7.95 mg/l. These figures indicate that DO is not a problem in release waters (Corps 1998b).

4.1.5.3 Saltwater Wedge (qualitative)

The lower several miles of the Duwamish River estuary (approximately downstream from the head of navigation) are comprised of a salt-water wedge overlain by a fresher-water layer. Stratification is strong during high freshwater inflows, which also push the wedge downstream relative to conditions during lower flows. Net circulation in the wedge is upstream due to entrainment of saltwater from the wedge to the overlying fresher-water. Net movement of the fresher-water is downstream. Circulation in the estuary and resultant water quality of the saltwater wedge are principally controlled by freshwater inflow rate, tidal action and estuary morphology.

Freshwater is principally supplied to the Duwamish estuary by the Green River. Flows in the Green River average 1,549 cfs (43.9 m^3/sec) at Tukwila with peak flows exceeding 12,000 cfs (343 m^3/sec) and minimum flows as low as 195 cfs (5.5 m^3/sec). Peak flows occur during winter months while low-flows occur during August and September. Flows have been regulated by the HHD since 1961, for flood control and during summer months to augment natural river flow (Harper-Owes 1981). Low-flows augmented by releases from HHD improve the circulation and water quality of the saltwater wedge.

4.1.5.4 Total Dissolved Gases

Although no measurements have been taken, Total Dissolved Gases (TDG) are not believed to be a concern due to the discharge design of HHD. The physical conditions of flow release and energy dissipation, which have caused supersaturation conditions at other dam projects, do not exist at HHD.

4.1.5.5 Turbidity

Turbidity is the only water quality parameter that has seasonally exceeded Class “AA” standards in the Green River above HHD (Corps 1995). Periods of high turbidity are generally associated with winter storms and snowmelt.

In the lower Green River, turbidity is not generally limiting to fish, though it may limit other uses such as water supply and recreation. Turbidity is of greatest concern during flood events and when HHD reservoir levels are low, both of which can result in river water at the Headworks being too turbid for use by Tacoma Water. When this occurs, Tacoma uses water from the North Fork Wells located in the upper North Fork Green River basin until turbidity levels fall to acceptable levels. A detailed discussion of turbidity effects from operation of the HHD can be found in Appendix D3, Section 2 of the AWSP DFR/DEIS (Corps 1998a) and in Section 4.3.4 Sediment Management.

Turbidity levels in the tailwater of HHD are currently the only known parameter to exceed the Department of Social and Health Services (DSHS) raw water quality standards. While turbidities were excessive during high flow conditions without the dam, because of stored water being released after flood regulation activity, the period of high turbidity is extended until the storage is evacuated or sufficiently diluted by cleaner inflows.

4.1.5.6 Contaminants

Analytical results indicate that waters impounded in HHD reservoir are of very good chemical quality and suitable for most purposes. The water is soft, has a low dissolved mineral content, only mildly buffered, and essentially neutral in pH. Low concentrations of dissolved nutrients and absence of algae blooms are indicative of an oligotrophic system, one that is low in primary productivity. Waters stored in the reservoir and released to the river meet the water quality criteria established by the State for class AA (extraordinary). Chemical analyses are performed annually by Tacoma to evaluate the chemical composition of the reservoir release. Past records indicate that the raw water quality conforms to State inorganic chemical criteria (Corps 1998b).

Ecology has measured levels of mercury, copper, lead, and zinc above state-established standards in the Duwamish River (Corps 1995). However, concentrations of most of these metals have not exceeded state standards frequently enough to warrant placement on the state's 303(d) list for 1998. The metal of most concern in the Green River is mercury. King County and Ecology have reported mercury at levels above state standards in the lower Green River. These sampling results have put the lower Green River (waterbody segment WA-09-1020) on the state's 303(d) list for mercury. One source of mercury was the Renton Treatment Plant, which discharged wastewater into the Black River/Springbrook Creek until 1987. An additional source of metals into the river may be leachate from the now closed Kent Highlands Landfill.

Toxic contaminants have been identified in bottom sediments and surface water in the lower Green River and especially in the Duwamish River (Corps 1995). Chemical testing of bottom sediments in the lower 5 miles of the Duwamish River revealed contamination by oil and grease, sulfides, pesticides, and polychlorinated biphenyls (PCB). More recently, Ecology cited excursions beyond criteria in sediment for polychlorinated biphenyls and polyaromatic hydrocarbons. Potential contamination sources are common along industrialized sections of the Duwamish River, which is currently being addressed as part of the EPA's *Elliott Bay Toxics Action Plan* as well as other programs addressing remediation and source control for toxic contaminants. Runoff from agricultural and other developed areas are also thought to be sources of toxic contaminants in the lower Green River.

4.1.6 Ecosystem Functions

Under natural conditions, aquatic ecosystems in the Pacific Northwest, including the Green River, are dynamic in both space and time. The behavior of fluvial systems in the Pacific Northwest ecoregion is driven by four components:

1) climate, which varies over time and causes floods and associated erosional events to be punctuated in time;
2) a complex topography that causes the supply of sediment and wood to streams to vary spatially;
3) a branching channel network that juxtaposes different sediment transport regimes and promotes the convergence of sediment pulses in larger rivers; and
4) basin history, which affects the timing, volume, and location of wood and sediment supplies (Benda et al. 1997).

The result is a mosaic of conditions within a basin at any time as a result of disturbances. Natural ecosystems have a large capacity to absorb change without being dramatically altered (Reeves et al. 1995). The following text describes current human activities governing the variability of important ecosystem processes including sediment transport, flooding, woody debris recruitment and low-flows in the Green River.

The partitioning of the Green River into the lower and upper basins reflects divisions of the system by both natural processes and human influences. Prior to construction of HHD and Tacoma's Headworks, the upper Green River basin was distinguished from below by natural geologic features (e.g., Eagle Gorge). With the exception of the impounded reservoir area, physical features of fish habitat in the upper Green River basin have been influenced primarily by timber harvest and railroad activities. However, the artificial geographic division imposed by water withdrawal and flood management facilities is approximately coincidental with the geologic division and, thus, is useful in the context of evaluating HHD activities. The biggest influence on fisheries in the upper basin by the HHD and the Headworks has been the disconnection of the upper basin from the lower Green River and the ocean; hence the significance of the provision of fish migration.

The lower Green River basin below Highway 18/Big Soos Creek confluence approximates the division between the lower gradient, depositional reaches in the lower basin and the intermediate gradient reaches upstream. The geographic division also roughly separates highly urbanized reaches downstream and lesser-developed reaches upstream. The lower basin includes the physically (and biologically) distinct canyon reach and a transition reach that is still adjusting to changes in flow and sediment supply caused by the construction of HHD and diversion of the White River. The fisheries in the lower basin have been influenced most by urban development, although construction of the Headworks and HHD has also affected fisheries in the lower basin. Specific aspects of fish habitat in the Green River system that have been influenced most adversely are summarized below.

Estuarine habitat is the component of fish habitat that has been the most severely compromised in the Green River system. Practically all of the original intertidal flats, wetlands, and swamps in the lower basin have been drained and lost to development, resulting in a severe loss of physical habitat space and biological productivity. Transport of the fine sediments responsible for forming and maintaining estuarine habitat has not been significantly influenced by construction of HHD and Tacoma's diversion, since the majority of this material may remain in suspension during even moderate flows. In fact, forest harvest activities in the upper watershed, and development in the lower watershed may actually have increased the fine sediment load of the Green River. However, fine material is systematically dredged from the Duwamish waterway to maintain the navigation corridor, and fine sediments in the bed of the present estuary and Elliot Bay are contaminated with toxic compounds transported on fine sediment originating in urban and industrial areas.

The natural ability of the estuarine system to counter water quality problems has been lost as a result of development and changes in flow. The extent of the saltwater influence has moved upstream to roughly the confluence with the Black River because of the diversion of the White and Cedar rivers. The loss of up to 50 percent of summer low-flows has also resulted in increased temperatures and a reduced ability to dilute pollutants. The loss of habitat and food production, coupled with poor water quality, has likely reduced survival of anadromous salmonids and other species that rely on estuarine habitat for at least part of their life history (Blomberg et al. 1988).

4.1.6.1 Flow Variations

The natural flow regime of a river varies on time scales of hours, days, seasons, years and longer. Hydrologists and aquatic ecologists have recently begun to realize that the full range of intra- and inter-annual variation in hydrologic regimes is necessary to sustain the native biodiversity and function of aquatic and riparian ecosystems (Richter et al. 1996; Poff et al. 1997). Richter et al. (1996) developed a means of characterizing and comparing variable hydrologic systems using "Indicators of Hydrologic Alteration (IHA)", a suite of flow statistics based on five fundamental characteristics of hydrologic regimes (magnitude, timing, frequency, duration, and rate of change). The IHA involves a comparison both of measures of central tendency (mean or median values) and dispersion (coefficient of variation). The coefficient of variation is equal to the mean divided by the standard deviation; larger numbers indicate greater variability.

A modified suite of IHA statistics is used in this PBA to assess the effect of covered activities and interrelated/interdependent activities (i.e. Tacoma HCP). The selected parameters, while by no means a complete set of all possible hydrologic statistics, represent all five groups identified by Richter et al. (1996) (magnitude, timing, frequency, duration and rate of change). The selected parameters are believed to represent aspects of the flow regime of importance to salmonid fishes and their habitats in the Green River (Table 4-2). For example, the magnitude of annual extreme events is important for floodplain recharge, sediment transport and channel formation (annual maximum) or for determining whether the upstream movement of certain species is impaired (annual 3-day low). The magnitude of monthly flows provides a measure of the availability of suitable habitat. The rate of change influences bank erosion, the connectivity of off-channel habitats, and may also affect the colonization and productivity of benthic habitats.

The timing of other important flow characteristics was evaluated by conducting the analysis on a seasonal basis (e.g. spring vs. fall pulses; summer vs. fall vs. winter rates of change). Since daily flows in the Green River vary widely throughout the year, the rate of change was calculated only for days on which the flow rose or fell more than 10 percent relative to the previous day.

A complete IHA analysis involves formal comparison of hydrologic attributes using "pre"-and "post" disturbance measured flow data, or "with" and "without" disturbance modeled flow data (Richter et al. 1996). Hypothesis testing may be used to evaluate the statistical significance of the change. Application of such tests requires a rigorous evaluation of variable distributions to ensure the appropriateness of the statistical approach used (e.g. parametric vs. non-parametric). No such evaluation was conducted for this analysis. Thus, data presented are provided only as a means of describing the various hydrologic regimes and estimating the magnitude of differences between them, rather than as a quantitative evaluation of the significance of change or the causal mechanism.

Table 4-2 **Modified IHA Flow Characteristics and** **Their Relevance to the Covered Species**		
Regime Characteristic	**Hydrologic Parameters**	**Examples of Ecological Importance**
Magnitude	Annual maximum	Floodplain recharge; channel forming flow; sediment transport
	Annual 3-day minimum	Fish passage; degree of drought induced stress
	Mean monthly Flow	Timing of key life-history stages
	Mean bi-weekly flow	Timing of key life-history stages
Timing	Julian date of annual minimum	Upstream migration
Frequency	Number of spring high pulses	Downstream migration; habitat connectivity
	Number of fall low pulses	Upstream migration; spawning success
	Number of events where flow increases or decreases by >10% over background	Downstream migration cues; Stranding/trapping; redd; dewatering
Duration	Average duration of spring high pulses	Time required for downstream migration
	Average duration of fall low pulses	Redd dewatering; migration delay
Rate of Change	Average rate of change in events where flow increases or decreases >10% over background	Downstream migration cues; upstream migration cues; stranding/trapping; redd dewatering

No record of daily flows is available to describe the "natural" flow regime prior to completion of Tacoma's Headworks at RM 61 in 1913. Therefore, natural flow conditions in the Green River were approximated using modeled data to estimate flows in the absence of both HHD and Tacoma's water withdrawals (CH2MHill 1997). The model was used to develop a 31-year record of daily flows by water year for the period between 1964 and 1995[3]. This period is believed to be representative of typical annual and seasonal flow variations in the Green River. The model does not incorporate information on potential variations in flows due to climatic

[3] An evaluation of IHA parameters requires daily flow records arrayed by water year. Previous evaluations of the Green River flow regime (e.g. Additional Water Storage Project EIS; Tacoma HCP) were based on a 32-year record of daily flows arrayed by calendar year. Slight variations in summary hydrologic statistics may result when different annual partitioning approaches are applied to the same data set.

conditions, forest harvest activities in the upper watershed, or other land-use activities, although these factors are known to have influenced the flow regime in major tributaries to the Green River both up and downstream of HHD (Culhane et al. 1995; Plum Creek 1997; Plum Creek 1996). Use of a consistent time period ensures that the effects of other potential sources of flow variations are constant across all scenarios analyzed and, thus, do not bias the conclusions of this PBA.

This PBA addresses the effects of continued operation and maintenance of HHD and the effects of the AWSP on species listed under the ESA. **Under the ESA, the total effects of past project operations form the environmental baseline for evaluating future direct and indirect impacts (USFWS 1998a). As such, the environmental baseline for this PBA includes HHD, Tacoma's Headworks, and the Section 1135 Project. A description of the natural flow regime is presented because it can serve as a guide for future adaptive management of the HHD.**

Natural Flows

Natural flow variations are an important determinant of ecosystem function, influencing the type and distribution of aquatic habitats provided by a river system. Annual high flows recharge alluvial aquifers, transport wood and sediment, and form and maintain gravel bars and side channel habitats. Seasonal freshets provide cues for certain salmonid life stages, for example the initiation of spawning, or the downstream migration of juvenile fish. Annual low flows may constrain productivity and influence water quality.

Modeled flow data indicate that the largest one-day maximum flow at the Auburn gage between 1964 and 1995 in the absence of both HHD and Tacoma's diversion would have been approximately 17,759 cfs. The mean three-day maximum flow was 7,659 cfs (Table 4-3). The highest 3-day maximum flow identified for the period between 1 February to 30 June under the natural flow regime would have been 10,111 cfs. An average of approximately 4 spring high flow pulses (defined as a single continuous flow event greater than the springtime 85% exceedence flow) would have occurred between the first of February and the end of May (Table 4-3).

Under the natural flow regime, flows are generally lowest in August and September. The model data suggests that the mean 3-day low flow at the Auburn gage under the natural flow regime is 249 cfs (Table 4-3). On average, the annual three-day low-flow would have occurred in the third week of September (Table 4-3). Flows in the Green River increase dramatically in response to the onset of fall rains (Figure 4-1).

Table 4-3
Selected IHA Parameters Based on Modeled Flows in the Green River at the USGS Gage at Auburn for Water Years 1964 through 1996 Under the Natural flow Regime and Existing Conditions.

	Natural		Existing	
	Mean	**Coefficient of Variation**	**Mean**	**Coefficient of Variation**
Annual mean daily flow (cfs)	1,386	0.23	1,265	0.25
Annual 3-day maximum (cfs)	7,659	0.57	7,539	0.34
Annual 3-day minimum (cfs)	249	0.18	213	0.16
Date of annual 3-day minimum	9/19	0.07	9/24	0.08
3-day low flow April 1-May 31 (cfs)	1,241	0.35	945	0.40
3-day low flow July 15-Sept 15 (cfs)[1]	275	0.2	235	0.16
Annual number of high pulses, Feb 1-June 30[2]	3.7	0.59	3.6	0.67
Average duration of high pulses, Feb 1-June 30 (days)	4	0.50	4	0.51
Average rate of change, Feb 1-June 30 (cfs/day)[3]	490	0.44	439	0.43
Number of changes, Feb 1-June 30	47	0.26	56	0.27
Average rate of change, July 1-Sept 30 (cfs/day)[3]	93	0.55	95	0.54
Number of changes, July 1-Sept 30	17	0.69	11	0.82
Average rate of change, Oct 1-Jan 30 (cfs/day)[3]	599	0.51	590	0.43
Number of changes, Oct 1-Jan 30	68	0.21	56	0.22
Average number of low pulses (<85% exceedence flow), Sept 1-Jan 30[5]	4	0.57	3	0.74
Average duration of low pulses, Sept 1-Jan 30 (days)	8	0.78	9	0.95
Average Monthly Flows (cfs)				
January	2,293	0.45	2,197	0.47
February	2,172	0.46	2,056	0.49
March	1,817	0.36	1,628	0.38
April	1,914	0.28	1,625	0.34
May	1,776	0.34	1,429	0.41
June	1,142	0.50	1,067	0.54
July	567	0.38	449	0.47
August	358	0.24	301	0.28
September	392	0.43	345	0.52
October	576	0.50	536	0.55
November	1,513	0.64	1,548	0.65
December	2,174	0.50	2,051	0.5

[1]One spring high pulse equals a series of continuous daily flows greater than the 10% exceedence flow occurring between 1 February and 30 June. 10% exceedence =2,860 cfs for Natural and 2,612 cfs for Existing.
[2]Change is defined as 2 consecutive days on which flow differs by > 10 percent. Rate of change equals average difference between days for the entire period. Direction of change can be either positive or negative.
[3]One fall low pulse equals a series of continuous daily flows less than the 85% exceedence flow occurring between 1 Oct 1 and Jan 31. 10% exceedence =335 cfs for Natural and 250 cfs for Existing.

[Insert figure 4-1]

Existing Flows

Existing conditions are represented by Tacoma's maximum potential water withdrawals under their FDWRC, HHD operations under the 1996 operational scenario, and the Section 1135 Project. HHD is operated primarily for flood control (prevent flows > 12,000 cfs at the Auburn gage) and secondarily to augment summer low flows. Summer flow augmentation and fall/winter flood control operations have generally been consistent since 1964; however, spring storage and refill operations have varied considerably since HHD was constructed. From 1964 to 1983, the start of refill was generally delayed until June, then nearly all of the flow except that required to satisfy instream flow targets was stored, in order to fill the reservoir pool as quickly as possible. From 1984 to 1992, refill was started as early as 19 April, but as before, all of the flow except that required to satisfy instream flow targets was stored until the reservoir reached full conservation pool. Since 1992, refill timing and release rates have been determined based on target instream flows that are adjusted annually in response to existing weather conditions, snowpack, and the amount of forecasted precipitation, based on input from other resource managers. For this reason, the 1996 operational scenario was selected as being most representative of "existing" conditions. Under 1996 operations, refill was conducted using a constant capture rate of 400 cfs regardless of inflow, until the pool elevation reached 1141 feet MSL.

The seasonal flow distribution under existing HHD operations is typical of basins in the Pacific Northwest; flows are highest in the winter in response to fall rains, decline gradually during the spring while experiencing occasional freshets in response to spring rainstorms, and are lowest in the late summer and early fall (Figure 4-2). Floods in the Green River are generally the result of heavy rainstorms during the months of October to February, which may be substantially augmented by rain-on-snow events. Prior to the construction of HHD, the highest flow recorded at the Auburn gage was 28,100 cfs on 23 November 1959 (USGS 1996), and the two-year recurrence interval flow was approximately 12,000 cfs (Dunne and Dietrich 1978). Since construction of HHD in 1964, no flows greater than 12,000 cfs have occurred at the Auburn gage (Figure 4-2). The modeled average annual three-day maximum flow was 7,539 cfs. Although flows greater than 12,000 cfs are prevented, the duration of flows between 5,000 and 9,000 cfs has nearly doubled since regulation (Dunne and Dietrich 1978).

The modeled flow data indicate that under existing HHD operations, spring flows at the USGS Auburn gage during the period between 1964 and 1995 average less than 2,000 cf. However, the average three-day low-flow between 1 April and 31 May is much lower, averaging 945 cfs (Figure 4-2).

Under existing HHD operations, flows are generally lowest and least variable in August (Table 4-3). The model data suggests that the average three-day low-flow at the Auburn gage under existing operations is 213 cfs. On average, the annual three-day low-flow occurs in the third week of September; however, annual low flows are observed from as early as 29 July to as late as 1 November (Table 4-3). On average, there are three flow pulses less than 250 cfs each fall and (September 1 to January 30) (Table 4-3). The 85 percent exceedence flow between September 1 and January 31 is substantially lower (at least 51 cfs) than the average monthly flow during August.

[insert figure 4-2]

In the spring, daily flows are quite variable; changes greater than 10 percent as compared to the previous day occur an average of 56 times (Table 4-3). The average rate of change was approximately 439 cfs per day. In contrast, flows during the summer are less variable. Daily flows changed by more than 10 percent in an average of only 11 days, with an average rate of change of 95 cfs (Table 4-3). Flows become more variable with the onset of fall rains; daily flows changed by more than 10 percent on average 56 times as compared to 68 times (Table 4-3).

4.1.6.2 Gravel Transport

Coarse, gravel-sized sediment is transported downstream only during moderate to high flows, and is stored within the channel bed and banks during intervening low-flow periods. Construction of the Headworks and diversion of water by Tacoma did not seriously impair gravel movement from source areas in the headwaters to downstream alluvial reaches, since the Headworks facility has a negligible storage capacity and because Tacoma's withdrawal is small relative to the size of flows required to initiate coarse sediment transport. The construction of HHD, however, substantially reduced the supply of gravel to the Green River basin below RM 64.5, because coarse material drops out behind HHD during high flows, and free-flowing low-flows are inadequate to resume transport. Construction of HHD may be considered a "press" disturbance in terms of its effect on sediment transport.

Because gravels from the headwaters are trapped behind HHD, and there are few sources of resistant coarse sediment immediately below HHD, the availability of spawning habitat has been reduced downstream of the dam. Gravel stored in the channel downstream of HHD continues to move downstream during high flows, but since 1964 no sediment has been transported from upstream reaches to replenish it. In addition, the volume of sediment transported downstream each year may actually have increased, because flow regulation by HHD has increased the frequency of moderate flows (approximately 3,500 to 9,000 cfs) that are capable of mobilizing gravel in some reaches (Dunne and Dietrich 1978). Bank revetment construction may have also helped accelerate the loss of spawning gravel by straightening and confining the channel, thereby further increasing its sediment transport capacity. There is evidence that the effects of HHD and levee construction on gravel storage in the Green River extend downstream to Newaukum Creek (RM 41.2), which is now the most significant source of sediment to the lower Green River (Perkins 1993).

4.1.6.3 Fine Sediment Transport

Evaluation of fine sediment production in the Green River by O'Connor (1996) shows that sediment production increased from the period 1958-1967 to 1968-1978, but decreased from 1968-1978 to 1979-1995. O'Connor found that mass wasting was the largest source of fine sediment to the river. Timber harvest and road construction increased dramatically in several subwatersheds of the upper Green River in the late 1960s and early 1970s. Large runoff events in association with these management activities are a likely cause of higher sediment production in the 1968-1978 period. With recovery of vegetation and better forest management practices, sediment production in the Green River watershed has since been declining. Sediment inputs from the upper basin streams eventually enter the HHD reservoir.

Sediment from the watershed above HHD has been accumulating in the reservoir since the project began operation in 1962. As water is impounded behind the dam, the water velocity is greatly reduced and a large amount of coarse sediment drops out. A survey of the reservoir is currently underway, and upon receipt of the survey data, the Corps would assess the extent of sedimentation that has occurred since the beginning operation of HHD. The last survey was conducted in 1993. During the period from 1962 to 1993, approximately 1,769 acre-feet of sediment was deposited in the reservoir.

Most fine sediments eventually move past HHD, however, operation of the dam has essentially de-coupled fine sediment transport such that the majority of material is now moved past the dam on the declining limb of the hydrograph rather than at high flows. This results in the temporary deposition of fine sediment in the lower Green River, until flows sufficient to remobilize the material occur.

In addition, several large landslides have recently been reactivated, increasing the amount of fine sediment being input to the lower Green River. The largest of these, located near RM 42, is estimated to have delivered about 50,000 cubic yards of fine sediment to the lower Green River (Perkins 1999). The combined effect of the recent landslides and HHD operations has been to increase fine sediment levels in the lower Green River.

4.1.6.4 Woody Debris Transport

Woody debris is an important component of salmonid habitat because it provides habitat space (pools) and structure (cover), provides habitat and food for aquatic invertebrates, helps retain local deposits of spawning gravel in reaches where the sediment transport capacity exceeds the rate of supply, contributes to bank stability, and can be integral to channel migration processes in alluvial reaches. Removal of in-channel LWD has occurred throughout much of the Green River basin as a result of timber harvest practices prior to 1975, flood control, and clearing by private individuals to facilitate recreational boating.

Recruitment of new wood to the river throughout the basin has been reduced by management actions as well as human-induced changes in fluvial processes. Timber harvest in the riparian zone reduced the source of future LWD in the upper watershed. Land clearing for agriculture and development has had a similar affect on future LWD recruitment in the middle and lower Green River. Clearing and harvest of the riparian zone generally reduce bank stability, which then must be achieved artificially by constructing levees or revetments. Establishment of woody vegetation on re-enforced banks is often prevented because of flood control concerns, thereby removing shade and reducing inputs of organic detrital matter. Construction of HHD physically blocked the downstream transport of wood originating in the headwaters. Flood control operations at HHD, which prevent large channel altering flows, in combination with channelization and construction of levees and revetments, has reduced the rate of channel migration in the middle Green River, effectively stopping the movement of the channel into wooded areas that would provide material to the channel.

4.1.6.5 Channel Morphology

The channel morphology of the Green River determines the quality and distribution of aquatic habitat conditions in the Green River. With the exception of the Green River gorge (RM 45 to RM 58), the mainstem Green River is believed to have historically exhibited a pool-riffle channel morphology, with numerous associated side channels and an extensive floodplain. Channels in the upper Green River have become braided as a result of increased coarse sediments associated with commercial forestry and associated road-building activities. Since construction of HHD, the channel in the lower Green River was observed to become narrower, and formerly active gravel bars have stabilized due to encroachment of riparian vegetation (Perkins 1993; Perkins 1999). Pools and LWD below HHD are currently scarce based on criteria applied by the NMFS (FODS 1999).

4.1.6.6 Floodplain Connectivity

Rivers construct and maintain channels such that small and moderate-sized discharges (less than or equal to flows with a two year recurrence interval) are contained within the channel, while larger discharges that occur less frequently exceed the channel capacity and overflow onto the floodplain (Leopold 1994). Large floods are important sources of recharge to shallow alluvial aquifers that are an integral component of floodplain ecosystems (Naiman et al. 1992). During floods, water is stored in sloughs and side channels, or seeps into floodplain soils, recharging groundwater storage. This stored groundwater slowly drains back to the channel, providing a source of cool inflow during the summer (Naiman et al. 1992).

Low-gradient, unconfined channels migrate back and forth across their floodplains in a sinuous pattern in response to differential patterns of bank erosion and sediment deposition. Channel migration may occur as a result of slow, steady erosion of the outside of a meander bend accompanied by an approximately equivalent amount of deposition on the inside of the meander bend, or it may occur as a sudden, unexpected shift (avulsion) into an old channel or area that is lower in elevation than the existing channel. As a result of these processes, natural low gradient alluvial channels typically develop a complex consisting of a network of single thread low-flow channel containing numerous gravel bars, side channels that transmit water only during moderate to high flows and may support successional vegetation of varying ages, and abandoned oxbow lakes, sloughs or wetlands distributed across the floodplain. Such off channel habitats may historically have been an important component of juvenile rearing habitat within the lower Green River basin, providing rearing habitat and refuge from high flows.

The quantity and quality of off-channel habitat is currently limited due to flood control operation and due to spring reservoir refill for summer flow augmentation at HHD, Tacoma's regular diversion of water, and channelization and flood control measures. Historically, there were over 20 miles of side channel habitats associated with the Green River from HHD downstream to the confluence of Soos Creek (FODS 2000). As of 1992, only about 5 miles of this type of habitat was identified on maps and aerial photos of this reach of the Green River (FODS 2000).

Channelization and construction of levees, revetments and roads has disconnected many formerly accessible side channels. Approximately 12,340 linear feet of side channels were visible between RM 58 and RM 61 on aerial photos from 1953.The majority of side channel habitat identified consisted of two large abandoned meander bends. The large side channel on the south bank of the river near RM 59 (Signani Slough) had been separated from the river early in the century by construction of the Tacoma Headworks road and BNSF Railroad. Adult salmonids apparently were still able to access Signani Slough in 1953. Signani Slough was filled, channelized and disconnected by the Corps during construction of HHD and realignment of the Burlington Northern Railroad Line in 1960 and 1961 (Corps 1998a). During construction in 1960-61, over 1,000 adult salmon were trapped in the channel (L. Signani, Corps pers. comm., cited in Corps 1998a). Straightening this section of the Green River also caused another large meander north of the river at RM 58 (Brunner Slough) to be abandoned. There are also numerous relict side channels and meander downstream of the Green River gorge that have been separated from the mainstem by construction of levees (FODS 2000).

Floods larger than the former two-year return interval event have been prevented since the construction of HHD, effectively precluding the occurrence of large, channel altering flows responsible for creating new side channels and recharging the floodplain aquifer. The quality and connectivity of side channel habitats in the lower Green River may also have diminished because of changes in the Green River sediment transport regime, which may promote channel incision and disconnection of side channels from the mainstem at low-flows. Rearing habitat quantity and quality is particularly limited in the lower Green River due to extensive urbanization, channelization, and flood control measures.

4.2 STRUCTURAL SETTING

The two most obvious structural features that have been built on the Green River are the Howard Hanson Dam at RM 64.5 and the Tacoma Headworks at RM 61. Other structural features that affect the flow of water in the Green River include the Burlington Northern Santa Fe (BNSF) Railroad line in the upper basin and the levee system in the lower basin. These structural features are described in this section and the operational characteristics of the structural features are addressed in Section 4.3.

4.2.1 Howard Hanson Dam

Howard Hanson Dam is a subsidiary earth-filled structure composed of rolled rock fill, sand and gravel core, drain zones, and rock shell protection (Corps 1998b). A plan view of the dam is shown in Figure 4-3. The embankment is 235 feet high and 500 feet long and has an inclined core of sand and gravel material. The dam is 960 feet thick at the base decreasing to 23 feet thick at the crest. The total length of the dam is 675 feet. The intake structure also includes trashrack bars, a deck for debris removal, one tractor-type emergency gate, and gate hoist equipment located in the gate tower.

The outlet structure consists of a gate tower and intake structure with two tainter-type gates, a concrete horseshoe-shaped outlet tunnel, a gate-controlled bypass, and a stilling basin. No upstream or downstream fish passage facilities were included in the original project design.

The 900-foot-long, 19-foot-diameter flat bottom horseshoe-shaped outlet tunnel passes normal flow released for project regulation. The tunnel is controlled by two 10-foot-wide by 12-foot-high regulating tainter gates at the bottom of the reservoir pool (invert elevation 1035 feet) above mean sea level (MSL).[4] Low-flow releases during the summer conservation period are made through a 48-inch bypass intake located about 35 feet above the bottom of the pool. This outlet has a capacity of approximately 500 cfs at maximum conservation pool (elevation 1,141 feet). A cross-section of the dam with elevations of important features is shown in Figure 4-4.

The gate-controlled spillway is anchored in rock on the left abutment and in a concrete monolith adjacent to the embankment. The spillway is a concrete ogee overflow section with two 30-foot-high by 45-foot-wide tainter gates to control major flood flows and prevent overtopping of the dam. The lowest elevation of the gates is 1,176 feet. The downstream chute has a curved alignment and is paved for a distance of 712 feet downstream from the weir. The tainter gates permit storage to elevation 1,206 feet without spillway discharge. The reservoir provides 106,000 ac-ft of flood control storage at elevation 1,206 feet. The highest pool elevation attained was 1,183.5 feet in 1996. The maximum spillway discharge is 115,000 cfs at the spillway design flood pool elevation. Floating debris is collected during periods of high water by three stationary booms in the reservoir just upstream of the dam.

The dam and reservoir area includes various gravel-surfaced roads that provide access to the dam, stilling basin, intake structures, and the reservoir. An administration building is located in a fenced compound on the right dam abutment, and a fuel dispensing station and flammable materials storage building are located approximately 200 feet north of the administration building on Access Road A.

Subsequent modifications of the dam structure were made following the emergence of a spring during a highwater period (up to elevation 1,161 feet) that occurred in February 1965. The spring broke out about 350 feet downstream from the downstream right abutment toe. The spring was controlled by a gravel blanket supported by a crib wall. In 1968, a drainage tunnel was constructed at elevation 1,100 feet and extending 640 feet into the right abutment. Twelve relief wells were drilled to intersect and extend 20 feet below the tunnel floor. This system appears to have adequately controlled abutment leakage during the flood pools experienced to date.

[4] Elevations referenced in this document refer to a mean sea level datum.

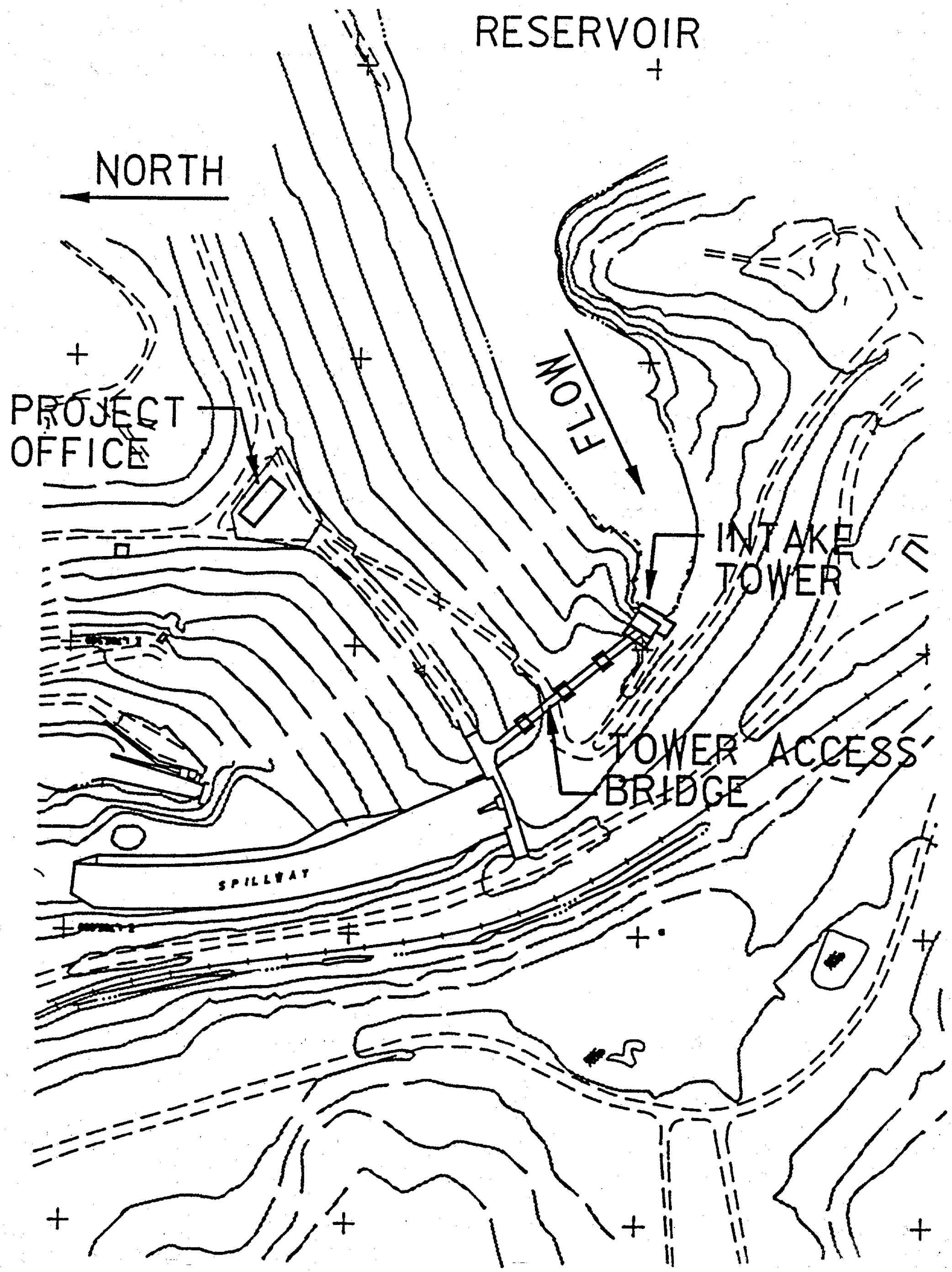

Figure 4-3. Plan view of Howard Hanson Dam and vicinity (Source: Corps 1998a).

4.2.2 Tacoma Headworks

Tacoma’s Headworks was completed in 1913 and is located at RM 61.0, which is 3.5 miles downstream of HHD. This diversion is the primary source of Tacoma’s First Diversion Water Right Claim (FDWRC). The diversion supplies water to a pipeline (Pipeline No. 1) that carries water from the diversion dam south and west to Tacoma (Figure 4-5). The pipeline has a capacity of 113 cfs (72 million gallons per day [mgd]). Tacoma is in the process of constructing another pipeline (Second Supply Project [SSP]) from the diversion toward Tacoma over a more northerly route by way of south King County and Federal Way. The new SSP would have a discharge capacity of 100 cfs (65 mgd) and carry Tacoma’s Second Diversion Water Right (SDWR) to Pipeline No. 4 near the Portland Avenue Reservoir in Tacoma. The operation of the SDWR diversion is subject to conditions specified in an agreement between Tacoma and the Muckleshoot Indian Tribe (MIT) (see Section 4.3.2). Tacoma’s current and future proposed activities at the Headworks are the subject of other ESA compliance documents and are not covered by this PBA. Tacoma’s activities are described here for reference only, due to their close association with operation of HHD and their effects on the fish and wildlife resources of the Green River.

The existing Headworks would be modified to allow diversion and transmission of water to the new pipeline and to improve fish passage and screening facilities. Construction activities proposed at the Headworks include: raising the existing diversion dam, realigning the existing intake and trashracks, constructing a new pipeline from the existing settling basin to the portal of Tunnel No. 2 (approximately 700 feet downstream of the diversion dam), adding fish/debris screening and bypass facilities (to include an adult fish ladder leading to a trap, holding, and transfer facility), and reshaping the river channel downstream of the dam to accommodate the fish bypass facilities. The existing building would be razed and replaced at the same location with an insulated equipment storage building approximately 25 feet by 20 feet in size.

The existing concrete gravity diversion dam is 17 feet high with a crest length of 155 feet. The dam is founded on bedrock and both abutments are keyed into rock. Proposed construction at the dam includes raising the crest and abutments 6.5 feet, removing part of the existing variable depth spillway apron and replacing it with a level apron. During construction of the dam, Tacoma's water supply would temporarily be collected and conveyed through a conduit running from the diversion dam to the settling basin about 70 feet away or, alternatively, by pumping water from the pool behind the diversion dam into the nearby North Fork pipeline.

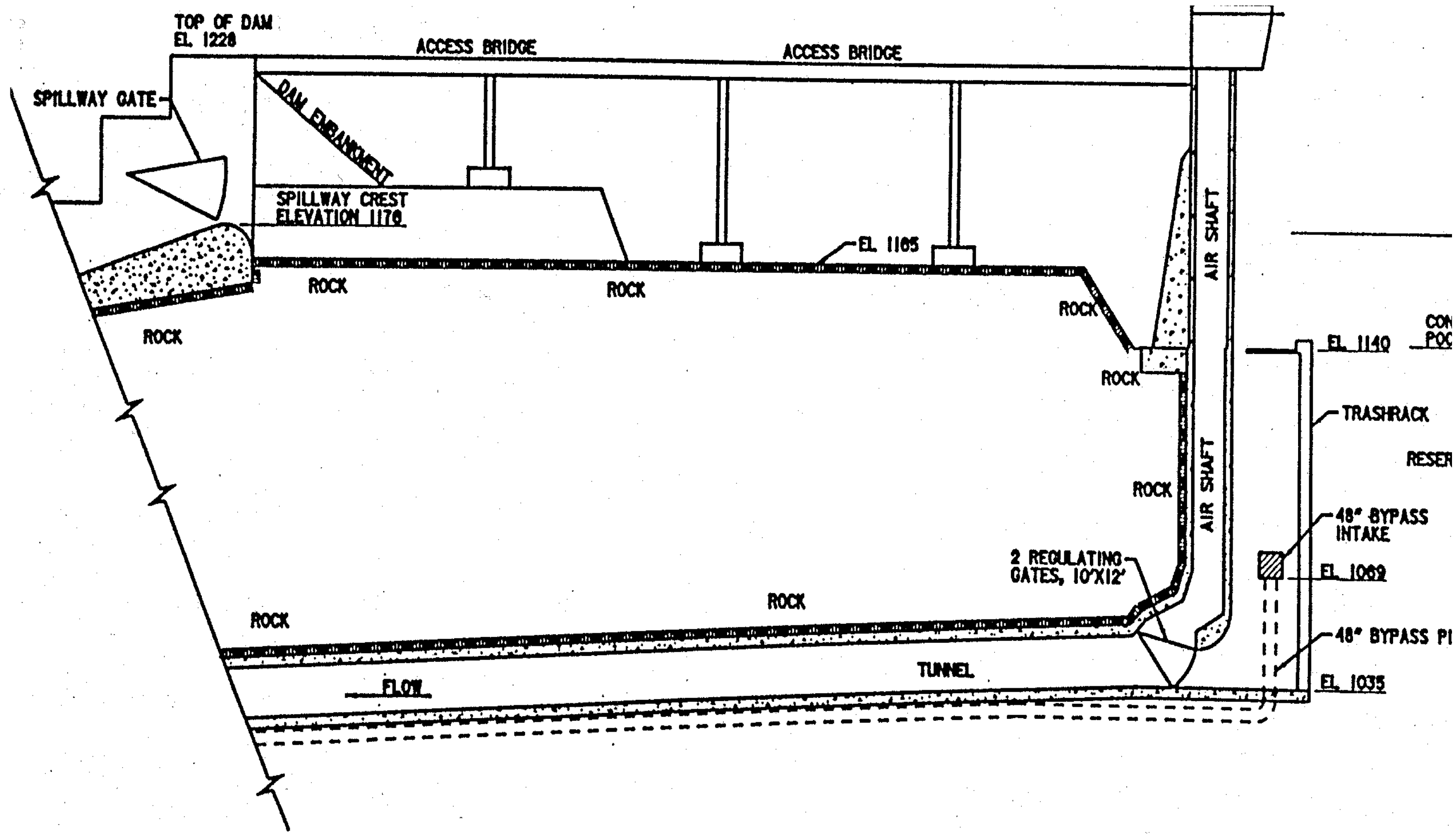

Figure 4-4. Cross-section of Howard Hanson Dam (Source: Corps 1998a).

The existing intake is 20 feet wide and located in the right abutment immediately upstream of the existing diversion dam. Proposed construction at the intake includes cofferdam construction, extending and raising the existing intake, new trashracks, trash raking equipment, stoplogs, and dual slide gates. The new top of the intake would be 6.5 feet higher than the existing intake structure to accommodate higher water surface elevations resulting from raising the dam crest.

The existing Headworks has minimal fish screening facilities. The modified Headworks would incorporate a nonrevolving screen design at the west end of the existing stilling basin and would involve the following construction activities: demolition and removal of the west end of the existing concrete settling basin structure; construction of a new automatically cleaned, vertical, wedgewire fish/debris screen structure approximately 100 feet long by 30 feet wide by 22 feet deep; and construction of a fish bypass that returns juvenile fish migrating downstream to a point below the dam in the Green River. The fish/debris screen surface area would be approximately 80 feet long and 13 feet high (1,040 square feet) and would be designed to meet the Washington State and federal screening criteria. Construction of the fish/debris screen structure would require removal of the existing north bank retaining wall.

The existing Headworks dam is currently impassable to upstream migrating fish. However, the proposed fish/debris screen bypass structure at the Headworks would incorporate provisions to allow future upstream fish passage. Instream work downstream of the dam would include filling and excavating to create a level spillway apron and excavating channels for fish attraction purposes. Under an Agreement between the Muckleshoot Indian Tribe and Tacoma, the existing Headworks would be modified by adding an adult fish ladder leading to a trap and holding facility.

Approximately 700 feet of existing 7-foot-diameter concrete pipe between the existing settling basin and the upstream portal of Tunnel No. 2 would be taken out of service and replaced with a new 8-foot-diameter steel pipe. The pipe would include a bypass section for use during construction or maintenance of the fish/debris screen structure.

The impacts of modifications to the Headworks and construction and operation of the SSP are assessed in separate documentation, not in this PBA.

4.2.3 Hydromodification

Channels in the lower and middle Green River basin channels have undergone extensive physical transformation to provide for navigation, flood control, and land development. The result has been straightening and confinement of the river to a single channel without riparian vegetation (important for both habitat and water quality) and instream habitat structure.

Removal of woody debris from the stream channel was first performed in the mid-1850s to facilitate navigation. Drainage of wetland areas began in the lower Green River basins circa 1858 to provide land for agriculture and settling. As the region's population grew, floodplain pumping was initiated; the Black River pumping station was installed in 1971 to pump stormwater from the floodplain into the Green River mainstem.

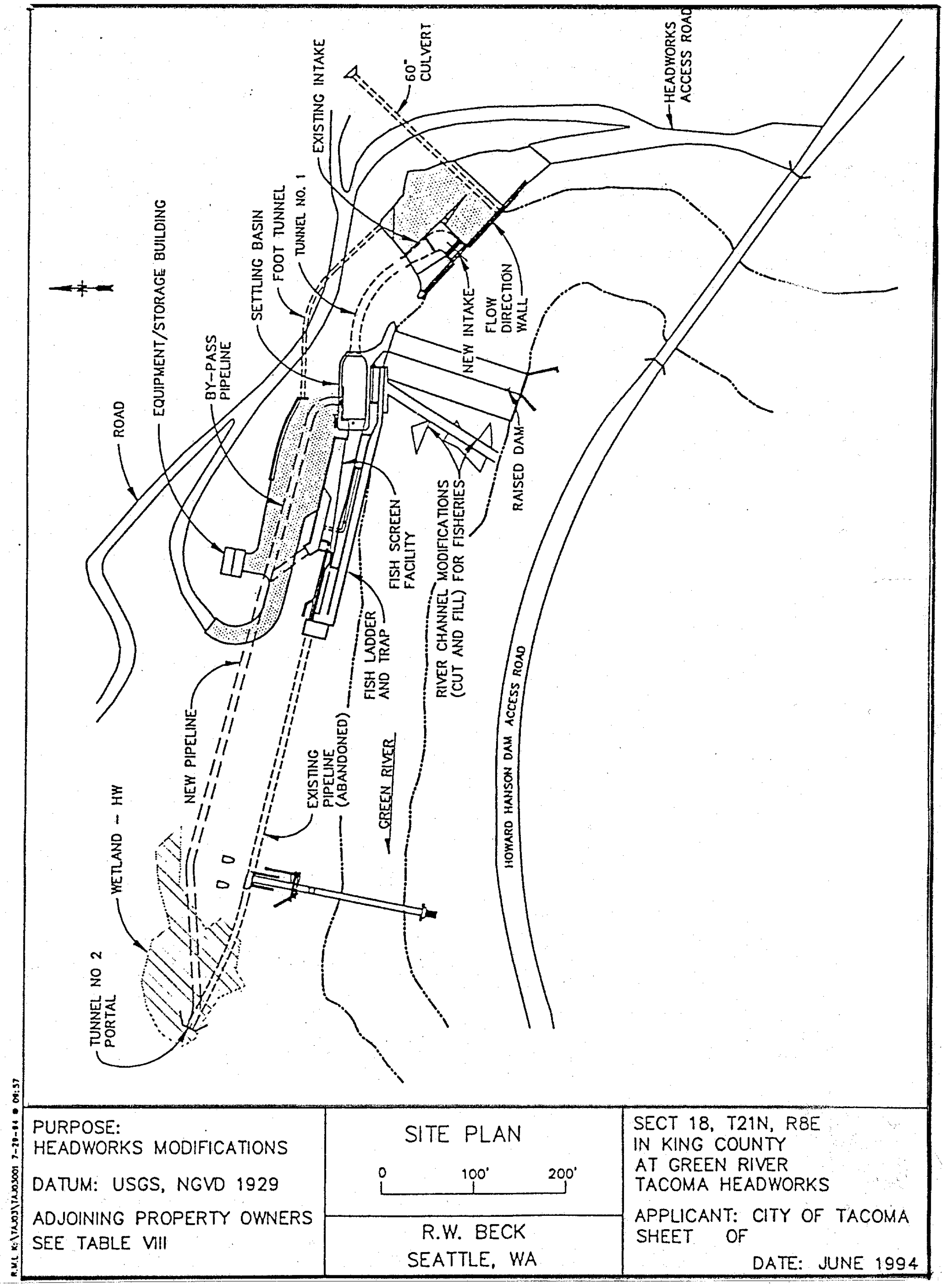

Figure 4-5. Site plan for modified Tacoma Headworks as designed for Second Supply Project (Source: Draft SEIS for SSP).

Large scale levees were built beginning in the early 1900s to help prevent the floodplains of the lower Green River from flooding. Periodic levee construction and maintenance activities continue to the present to protect higher density population areas and specific residential areas. Bank protection measures have resulted in restricting or preventing active channel meandering and migration across the floodplain. A recent survey of the Green River below Flaming Geyser State Park determined that levees and streambank revetments on one or both banks accounted for between 10 and 30 percent of the length of three contiguous reaches above about RM 38.0, and between 60 and 80 percent of the length of three contiguous reaches running between RM 25.0 and RM 38.0 (Perkins 1993; Tacoma 2000).

4.2.4 BNSF Railroad

The Burlington Northern Sante Fe (BNSF) Railroad parallels the upper Green River for much of its length. The line was built by the Northern Pacific Railroad in 1886-1887 (Corps 1998a). The rail line proceeds out of Auburn and follows the river in an easterly direction, gaining elevation to the top of Stampede Pass at about the 3,700-foot elevation and then proceeds down the east side of the Cascade range along the Yakima River to Cle Elum. In 1983 the line became inactive. Thirteen years later, as a result of a local increase in container traffic at the ports of Seattle and Tacoma, BNSF (the former Northern Pacific Railroad) spent over 130 million dollars to reactivate and upgrade the line. This upgrade included expanding the rail bed by placing additional rock in the Green River, and improvements of the tunnel and snow shed at the pass. The line was reopened in 1997, and it is anticipated that as many as eight trainloads of cars would be routed through the Stampede Pass line on a daily basis when it reaches full operation.

In many places along the upper Green River from HHD to Stampede Pass, the rail line is adjacent to the Green River channel and separates the main channel from much of its natural floodplain. Disruption of river bed migration, loss of access to side channels and tributaries, and localized impacts from instream filling with rock and ballast for the rail bed have affected the physical and biotic environment in these reaches.

4.3 OPERATIONAL SETTING

HHD is currently operated under Congressional legislation to provide flood control and low-flow augmentation. The Corps operates the project for flood control and maintains full storage capacity during the flood season, generally November through February. Outside of this window, the dam is used to provide a target minimum flow of 110 cfs to benefit fish. The operation of the dam has evolved substantially since it went into operation in 1962. The following sections describe the activities associated with HHD continued O&M that were listed in Table 2-3 and are evaluated for “take” in Chapter 5 of this PBA.

4.3.1 Flood Control

HHD provides storage of 106,000 ac-ft for flood control from approximately October through March. The transition months, October and March are evaluated during real-time conditions to determine the need for providing 100% of the flood control allocation. Flood control storage is not needed outside of the winter period because the river adequately handles runoff from snowmelt and groundwater. The objective is to control flows in the Green River at Auburn at, or below, 12,000 cfs.

The winter flood control period spans the period of approximately October through March. During the winter season, the reservoir elevation would be maintained at, or below, 1,070 feet to provide a minimum of 104,243 ac-ft of storage for the regulation of floods on the Green River. This storage provides the maximum possible effective reduction of the approved standard project flood for near Auburn. The project regulates only 55% of the total drainage area above the station near Auburn. Therefore, it is not possible to provide total control of all floods in the basin. Flood events that require flood control regulation are expected to have a 50% chance of occurrence each year (Corps 1998b).

During flood control regulation, releases must not cause the Green River discharge to exceed the maximum objective flow of 12,000 cfs as measured at the USGS streamgage, Green River near Auburn, Washington (Corps 1996b).

Flood control operations would make maximum beneficial use of available storage during each flood event and would be based upon a channel capacity that would safely carry a discharge of 12,000 cfs near Auburn. To provide a margin of safety against errors in forecasted local inflow, the project outflow would be regulated to control flows near Auburn to an objective flow of 10,000 cfs on a rising hydrograph. The objective flow would be increased during recession to evacuate storage as rapidly as practicable, the amount of increase to be based upon observed and forecasted precipitation and the shape of the recession hydrograph. Since the travel time between the dam and stream gage near Auburn is about 7 hours during high water, releases from the dam, plus forecast local inflow between dam and Auburn, must be combined to determine the Auburn discharge. On a flood recession the regulated discharge near Auburn may be increased to 12,000 cfs when conditions assure an accurate local inflow forecast.

The threat of flooding diminishes through the late winter and spring periods. Consistent with flood control requirements, spring refill may begin as early as February 15 (Corps 1998b).

Flows are released from HHD in three ways: (1) through a 48 in. “by-pass” (500 cfs capacity); (2) through the sluices and a 19’ flood control tunnel (12,000 cfs capacity); (3) and over the gated spillway (capacity 108,000 cfs.) Normal floods that do not require the spillway are passed through the sluices and flood control tunnel. To prevent the undesirable release of water surges, a Special Gate Regulation Schedule is used to determine the maximum release rate for large floods. The schedule specifies maximum releases in an orderly manner as the reservoir rises so the reservoir elevation does not exceed design conditions. When increasing the outflow, the sluices would normally be operated with full open gates before water is discharged over the spillway. The maximum spillway outflow is 108,000 cfs with 12,000 cfs through the sluices and 4,400 cfs through the railroad notch at a maximum reservoir surcharge elevation of 1,223.9 feet. When the reservoir begins to fall after using the Special Gate Regulation Schedule, the maximum gate openings of the sluices and spillway would be maintained until the reservoir recedes to elevation 1,206 feet and/or it is possible to control the Auburn discharge to an applicable objective flow. (Corps 1996)

4.3.2 Low-Flow Augmentation

The existing reservoir provides for 25,400 ac-ft of summer/fall storage; 24,200 ac-ft is active storage available for augmenting instream flows below the project. The Green River is the principal source of municipal and industrial water supply for Tacoma. During the summer-fall low-flow period, the minimum release from HHD reservoir is made up of the 110 cfs for the fishery plus 113 cfs or inflow, whichever is least, for Tacoma. This storage volume has a 98% refill reliability of maintaining a minimum instream of 110 cfs at the Palmer gage (6 miles downstream of HHD). This storage volume and use has been considered enhancement of instream resources (including fish), not restoration, as provided under existing project authority. Augmenting flows during the summer and early fall alters the flow regime from HHD (RM 64) to the estuary (RM 7) during the period when 1) juvenile salmonids are rearing in the river; 2) steelhead eggs are incubating and fry are emerging, 3) adult chinook and coho salmon are migrating upstream; and 4) chinook salmon are spawning in the river. The existing storage volume and minimum flows are barely sufficient to provide for instream passage of adult salmon during low-flow years and are insufficient to keep steelhead eggs watered. Since 1987, Tacoma has voluntarily reduced their water supply diversion during at least 3 years to supplement HHD releases to maintain higher flows.

4.3.2.1 Spring Reservoir Filling

The spring reservoir filling period spans the period of approximately April through July. Beginning in January, inflow volume forecasts is made in accordance with paragraph 6.03b of the Water Control Manual. Utilizing the runoff forecast as a starting point, the refill plan is formulated through consultation with the various resource agencies. In concept the plan, referred to as proportional capture, is to store a percentage of the runoff hydrograph so the shape of the reservoir discharge hydrograph is similar to the natural inflow hydrograph. Dam discharge always conform to the minimum discharge, rate-of-rise and rate-of-fall constraints.

The starting date of refill and percentage of runoff stored is determined by runoff simulation modeling utilizing historic runoff hydrographs as input to a Stella model of the Green River basin with an initial goal of filling to elevation 1,141 feet (25,400 ac-ft of storage) by June 1. The refill plan is updated approximately weekly, incorporating observed runoff and updated runoff forecasts, if available, to vary the percent of capture to assure refill. This iterative process plus the recognition that snowmelt runoff extends beyond June 1, provide approximately 98 percent chance that filling to elevation 1,141 feet would be achieved.

The original Design Memorandum for Howard A. Hanson Dam (1954) considered that the flood potential was greatly reduced after March 1. The accumulation of conservation storage was proposed to start on April 1. The maximum conservation pool of 1,141 feet would be achieved by June 1. Following is a flood statement that summarized studies for the design memorandum, "The storage space available above the 1,141 limit is more than adequate to control any probable flood during April and May . . . the amount of water that would be stored below this limit would be adequate to satisfy the fishery requirement of 110 second-feet at Palmer from June through November." Fishery benefits were estimated on the basis of the increased production of fish that would result from improvement in spawning conditions along the river as a direct effect of increasing the summer flows.

4.3.2.2 Conservation Flows

The summer conservation period spans the period of approximately July through September. The reservoir would be held at maximum summer conservation elevation 1,141 feet until storage is required to augment flow or, in the case of considerable summer rainfall, it is apparent full storage would not be required. Normally, drawdown of the reservoir to meet low-flow augmentation demands usually begins in July and continues through September. In the event of an exceptionally dry fall, if storage is available, augmentation would continue until winter precipitation increases river base flow to a level adequate to sustain discharge below the Tacoma diversion above the 110 cfs minimum instream flow requirement. As soon as conditions indicate conservation storage is no longer needed, the reservoir would be drafted to 1,070 feet, or below, for flood control.

During the summer-fall low-flow period, the minimum release would be made up of 110 cfs for fishery enhancement plus 113 cfs or inflow, whichever is least, for Tacoma (Corps 1998b).

After refill is complete in the spring, the Corps would pass inflow and maintain the full conservation pool until water is needed from storage. Minimum discharge would be 110 cfs plus 113 cfs or inflow, whichever is least. The quantity of 113 cfs is from inflow and is for water supply diversion at Tacoma’s intake. The quantity of 110 cfs is from storage and is for fishery enhancement below Tacoma’s diversion. During some periods in the fall, discharges may be greater than normal for several days to encourage the upstream migration of anadromous fish. Such operations come from coordination with resource agencies and are usually granted provided adequate water is available in storage (Corps 1996). Operations described for the summer conservation period would extend as long as low-flow conditions persist. In extreme conditions, this could be as late as early December. The summer low-flow season begins with the reservoir at its maximum conservation pool level (elevation 1,141 feet). The reservoir would be held at this maximum until storage is required to augment the river flow. When there is considerable rainfall during the summer, full storage may not be required and the reservoir could be drawn down along a schedule close to the guide curve. Normally, drawdown of the reservoir begins in July and continues through September. In the event of an dry fall, augmentation would continue if storage is available. As soon as conditions indicate that storage is no longer needed, the reservoir would be evacuated to prepare for flood control operations (Corps 1996).

Some deviation from normal operation and regulation can be expected during construction periods, either downstream of the project, or in the reservoir, during inspection of gates and other operational equipment, and during operations and testing for the fishery that may be performed from time to time by the Corps, or other interests. There have also been occasions in the past when special requests have been received from law enforcement agencies for reduced flows to search the river for drowning victims. These deviations would be considered on a case-by-case basis and any regulation coordinated between all parties concerned before being submitted to the Corps Northwest Division Office for approval (Corps 1998b).

Outflow would be passed through the 48-inch bypass as long as its discharge capacity is adequate. The discharge of the 48-inch bypass may be augmented by one of the sluices. However, very small openings of the sluice gates are avoided because of the potential for clogging by debris.

The 48-inch bypass affords the primary control of riverflow through the dam during the summer water conservation season when the reservoir pool elevation is 1,075 feet and above. During this season, the regulating gates are used only when the required discharge exceeds the capacity of the 48-inch bypass. (O&M 1972)

4.3.3 Section 1135 Water Storage

The HHD Section 1135 Project was initiated to increase the opportunity of flow augmentation to benefit downstream aquatic resources. In April 1997, approval was granted under Section 1135 of the 1986 Water Resources Development Act, as amended, to increase the volume of summer conservation storage contingent upon signing of the Local Cooperation Agreement (LCA) by the project sponsor, the City of Tacoma. As of March 2000, implementation is awaiting Tacoma's signature. The Section 1135 project provides for addition of up to 5,000 acre-feet of storage for flow augmentation. This will increase maximum storage level from elevation 1,141.0 to 1,147.1 and provide up to 29,200 acre-feet of conservation storage above the normal minimum pool elevation, 1,070.0. This water is currently targeted for drought year use (estimated at once every five years on average). Thus it provides minimal but critical restoration to supplement flows for benefit of downstream fisheries.

Prior to the Section 1135 Project, water was stored up to pool elevation 1,147 ft in some years to support debris collection operations within the reservoir. Once the debris collection was complete, the reservoir level was generally dropped to elevation 1,141 ft by releasing water over the next few weeks. Under the Section 1135 Project, during drought years, storage would be released during periods when reservoir inflow and conservation storage at HHD are not sufficient to maintain instream flows above 250 cfs at the Auburn gage. Under the adaptive management provision of the Section 1135 Project, the volume (up to 5,000 ac-ft), frequency of storage and pattern of release can be modified on an annual basis in coordination with natural resource agencies and the Muckleshoot Tribe.

4.3.4 Sediment Management

Sediment from the watershed above HHD has been accumulating in the reservoir since the project began operation in 1962. As water is impounded behind the dam, the water velocity is greatly reduced and a large amount of fine and coarse sediment drops out. A survey of the reservoir is currently underway, however the results were not available for inclusion in this PBA. Results of the last survey conducted in 1993 indicate that approximately 1,769 ac-ft of sediment were deposited in the reservoir (Corps 2000).

As the reservoir level is drawn down, water flow is channelized through the large sediment flats that have developed over time. As flow increases, erosion of accumulated sediment dramatically increases. This is accompanied by a sharp rise in turbidity of the reservoir discharge. The reservoir elevation at which significant erosion begins is known as the “turbidity pool” elevation.

The City of Tacoma has a diversion just downstream from HHD, and is required to blend river water with pumped water when the river turbidity exceeds 5 NTU. Typically, the Corps makes every attempt to maintain the water level behind HHD so that it is above the turbidity pool, thus avoiding negative turbidity impacts downstream (Corps 2000).

Periodically, and usually on an annual basis, the Corps seizes an opportunity to control the loss of reservoir storage space caused by sedimentation and the progressive rise in the turbidity pool. This is a special operation of the project whereby the reservoir is drafted in order to gently touch the turbidity pool while maintaining considerable project outflow. During this brief period of time, the water released from HHD is more turbid than usual and is closely monitored. With considerable project outflow (usually 2,000 cfs or more), the sediment from the turbidity pool largely remains suspended, and is transported to Puget Sound. This is considered to be a regular maintenance operation and is necessary to prevent a progressive increase in turbidity pool elevation. Without this operation, sediment would continue to accumulate and encroach into storage space that is required for flood control.

Preparation for turbidity pool operation begins about three days in advance, when inflow to HHD is forecast to be 2,000 cfs or greater. The ideal situation is for the reservoir to be a few feet above the turbidity pool about a day before the large inflows arrive. During the period when large inflows arrive, the reservoir is usually maintained at or near the turbidity pool elevation for as long as possible while an attempt is made to simply pass project inflow. After a few hours, the reservoir level generally begins to rise, and operation of HHD goes back to normal. On a few occasions, this operation has actually resulted in lowering of the turbidity pool, although the intent is simply to prevent it from growing.

The gate operations used for release of this flow would be similar to the operation for the flood flow releases.

4.3.5 Woody Debris Management

Winter floods bring floating debris, mostly in the form of wind-blown tree branches and entire trees, down from the upper reservoir area. The debris is held behind log booms until the temporary pool drops. During the spring, the debris floats again as the pool is raised for the low-flow augmentation season. The preferred storage area is used that requires a temporary pool raise elevation 1,141 feet to 1,147 feet.

During periods of high water, most of the floating debris is collected at three stationary log booms. Debris trapped by the booms is collected in sack booms and towed by barge to the temporary holding areas. Larger floating and sunken debris passing the booms may lodge against the intake structure trashrack bars and is removed periodically.

Debris that isn’t collected at the log booms or trash rack can pass through the outlet tunnel and on downstream.

When the conservation pool is at the maximum elevation, the debris is towed from the temporary holding areas to the holding and burning areas. When the pool level has been lowered and ground conditions permit operations in the burning areas, the sack booms and salvageable materials are removed and the unsalvageable materials sawed to convenient lengths and piled by bulldozers for burning. When the necessary burning permits have been obtained and local climatic conditions permit, the debris is burned (Corps 1998b).

4.3.6 Temperature Control

Water impounded in the reservoir becomes thermally stratified in early summer, a condition which continues through the fall, the onset and duration depending upon the amount of water in storage and hydroclimatological conditions. Selective withdrawal facilities are not available. Withdrawing water through either the sluices or 48-inch bypass at 1,069 feet or below, provides water temperatures below inflow conditions during the early summer. By early fall, the cool water in the bottom of the reservoir has been used up and releases begin to be warmer than inflow (Corps 1998b).

4.3.7 Daily/Periodic Operation and Maintenance

4.3.7.1 Normal Operation

Collecting, recording, and reporting data are routine functions required at all Corps projects, including HHD. Each normal workday, project personnel collect the maximum and minimum air temperature, snowfall and snow depth, and precipitation in the manual gage. This information, along with daily precipitation and turbidity readings obtained from Tacoma's headworks station, are reported to HHD. Project personnel collect inflow and outflow temperature and turbidity once per work day.

Additionally, Corps personnel are responsible for inspection and maintenance of all facilities associated with HHD (dam, equipment, painting, piezometers/wells, roads).

4.3.7.2 Emergency Operation

Some deviation from normal operation can be expected during construction periods, either downstream of the project or in the reservoir, during inspection of gates and other operational equipment, and during operations and testing for the fishery that may be performed from time to time by the Corps or other interests. There have also been occasions when special requests have been received from law enforcement agencies for reduced flows to search the river for drowning victims. The Corps coordinates special requests with resource agencies (MIT, WDFW, etc.) when possible.

4.3.7.3 Upper Basin Monitoring and Equipment Maintenance

Monitoring and equipment maintenance is conducted by HHD project personnel on a periodic basis as described below (Olson 2000).

Upstream Water Sampling

One Corps HHD project personnel conducts water sampling on a daily basis. They drive to the sampling site near Railroad Bridge 71, approximately 5 to 7 miles upstream of the dam.

Channel Inspections

One to two Corps HHD project personnel conduct channel inspections on a monthly basis. They inspect all incoming channels to the HHD reservoir as well as the outgoing channel downstream to the turbidity station (approximately one mile below HHD).

Real Estate Inspections

Real estate inspections are conducted annually by one to two HHD project personnel as well as one district representative. All project-owned properties are inspected for encroachments.

Road Inspection and Maintenance

One to two HHD project personnel conduct inspections and maintenance of the approximate five miles of project roads on a monthly basis. This activity consists of grading the roads and replacing lost gravel.

Lester Gage Maintenance

The Lester gage is located in a building owned by the USGS. Approximately once a calendar quarter, Corps HHD personnel are required to replace the batteries at the Lester gage.

Snowpack Monitoring and Measurements

Physical monitoring of the snowpack equipment, located on the north and south sides of the reservoir, occurs one to two times a year.

Dam Piezometers/Wells

Automated readings of the 39 piezometer wells occur on a daily basis and manual readings once a month. Weirs located on the right bank downstream of the dam near lower portal road are read weekly.

Equipment Maintenance

Construction equipment, graders, and boats require servicing and maintenance. Two 1,000 gallon tanks (one for gasoline and one for diesel) were upgraded four years ago with double-walled tanks and secondary containment.

CHAPTER 5.0
POTENTIAL IMPACTS OF HOWARD HANSON DAM CONTINUED OPERATION AND MAINTENANCE ON LISTED SPECIES

The activities associated with HHD Continued Operation and Maintenance (O&M) have a potential to affect listed species in the Action Area are listed in Table 2-3. In general, those activities include: flood control operations, low flow augmentation, Section 1135 storage, sediment management, woody debris management, temperature control, conservation measures, daily operations and maintenance, and monitoring and adaptive management. The analysis of the effects of HHD Continued O&M assumes that the AWSP does not proceed. In the absence of the AWSP, the funding source of conservation measures identified in this chapter is uncertain.

Sections 5.1 through 5.8 describe the effects of these activities and associated conservation measures designed to avoid take of species addressed by this PBA. The potential effects of the covered activities on ecosystem functions, water quality, fish passage, instream conditions, habitat alteration and/or species interactions are described first, followed by a description of the conservation measures to be implemented to address those potential effects. The overall effect of HHD Continued O&M on each issue is then summarized, and a determination of effect is made for each species. For the purposes of this analysis, the Action includes Continued O&M in support of Congressionally-authorized purposes plus associated conservation measures.

Analyses of the effects of HHD Continued O&M are based on consideration of the O&M Environmental Baseline conditions listed in Table 5-1. Future Green River flows under Continued O&M with proposed conservation measures were assumed to reflect the conditions in Table 5-2.

Under HHD Continued O&M, the Corps would modify operations based on input from the GRFMC, provided the recommended modifications did not compromise Congressionally-authorized project purposes. In addition, a suite of conservation measures and monitoring programs would be implemented to address potential affects on listed species associated with HHD Continued O&M. Conservation measures and monitoring to be implemented under HHD Continued O&M are summarized in Table 5-3.

Table 5-1 Assumptions Affecting Green River Flows Under Continued O&M Environmental Baseline Conditions Without Conservation Measures
▹ 1996[5] operations without AWSP; ▹ operation of HHD by the Corps to prevent flows at Auburn from exceeding 12,000 cfs; ▹ storage and release of 24,200 ac-ft of water by the Corps to satisfy a minimum flow of 110 cfs at Palmer when water is available in the conservation pool (i.e. not during the winter flood control season); ▹ storage of up to 5,000 ac-ft of water by the Corps on an annual basis (5,000 ac-ft of water would be stored every year. During drought years, the stored water would be gradually released to augment low summer flows. Water stored during average and wet years would be quickly released over the next few weeks once debris collection is completed.[6]); ▹ operation of HHD by the Corps using a 1996 refill scenario; reservoir refill starting on March 15, a constant refill rate of 200 cfs March 15 to April 15 and a 400 cfs refill rate from April 16 to May 31; ▹ withdrawals of up to 113 cfs under the FDWRC on a daily basis; ▹ no downstream fish passage facility; and ▹ limited ability to regulate the temperature of flow releases due to the lack of a multi-level outlet to control water temperatures.

Table 5-2 Assumptions Affecting Green River Flows Under Continued O&M With Proposed Conservation Measures
▹ HHD operations without AWSP; ▹ operation of HHD by the Corps to prevent flows at Auburn from exceeding 12,000 cfs; ▹ storage and release of 24,200 ac-ft of water by the Corps to satisfy a minimum flow of 110 cfs at Palmer when water is available in the conservation pool (i.e. not during the winter flood control season); ▹ storage of up to 5,000 ac-ft of water by the Corps on an annual basis; (5,000 ac-ft of water would be stored every year. During drought years, the stored water would be gradually released to augment low summer flows. Water stored during average and wet years would be quickly released over the next few weeks once debris collection is completed.[6]); ▹ operation of HHD by the Corps using a proportional capture guideline in response to input from GRFMC[7] with reservoir refill starting as early as February 15; ▹ withdrawals of up to 113 cfs by Tacoma under the FDWRC on a daily basis; ▹ construction and operation of a downstream fish passage facility; and ▹ increased ability to regulate the temperature of flow releases through construction of a multi-level intake as part of the downstream fish passage facility.

[5] Operation of HHD during 1996 was used to maintain consistency with the AWSP Environmental Impact Statement (Corps 1998a).

[6] Under the adaptive management provisions of the Section 1135 Project, the frequency, volume and duration of storage of up to 5,000 ac-ft of water can be modified on an annual basis.

[7] Recommendations on the storage and release of water from HHD will be developed through the Corps' coordination with the Green River Flow Management Committee (GRFMC). The GRFMC consists of representatives of tribal and natural resource agencies convened by the Corps to recommend adaptions in the water storage and release regime of HHD. Responsibility for operation of HHD lies with the Corps. The Corps, in turn, must comply with project purposes as identified by congressional authorization and must abide by NMFS and USFWS direction through Section 7 consultation under the ESA. The GRFMC consists of representatives from the Corps, NMFS, USFWS, MIT, WDFW, Ecology, King County DNR, and Tacoma Public Utilities (Tacoma Water). Representatives from other groups, such as Trout Unlimited and Friends of the Green River, have participated in past meetings of the GRFMC. It is up to the NMFS and USFWS to determine the degree of influence of each member of the GRFMC.

Table 5-3
Chinook Salmon Conservation Measures and Monitoring to be Implemented by the Corps Under HHD Continued O&M

Issue	Measure	Monitoring
Ecosystem Functions		
Flow Variations	HHD non-dedicated storage and flow management strategy provides opportunity to manage water storage and release at HHD to minimize impacts to salmonids	Install up to three snow pillows in the upper Green River basin to monitor snowpack and precipitation and improve flow forecasting as described in Tacoma (1999).
	Modular Inclined Screen (MIS) capacity provides increased flow management flexibility	Install and operate a rotary screw trap at RM 34 to monitor downstream migration of juvenile salmonids.
Gravel Transport	Place up to 8,000 cubic yards of gravel downstream of HHD	Use periodic aerial photo surveys to monitor the area of gravel bars between placement sites and Highway 18 bridge (RM 34). Monitor changes in bed elevation, channel capacity and substrate size at selected cross-sections.
	Implement Sediment Management Plan	See Appendix A.
Fine Sediment Transport	Implement Sediment Management Plan	See Appendix A.
Wood Transport	Implement woody debris management plan as described in TPU HCP (Tacoma 1999)	Survey the Green River from Tacoma Headworks to Highway 18 (RM 34) to identify the distribution and frequency of LWD.
		Monitor stability and effectiveness of designed placement of LWD (ELJ).
Channel Morphology	See gravel and wood transport	See gravel and wood transport.
Floodplain Connectivity	See flow variations	Monitor physical side channel connectivity and habitat quality, and salmonid use of lateral habitats.
Water Quality		
Temperature	Construct new intake to allow selective withdrawal from various reservoir levels	Monitor temperature up and downstream of HHD.
Dissolved Oxygen	None needed	None needed.
Saltwater Wedge	None needed	None needed.
Total Dissolved Gas	Verify that existing condition is functioning properly	Measure TDG content of outflow.
Turbidity	See fine sediment	See fine sediment.
Contaminants	None needed	None needed.
Fish Passage		
Upstream Fish Passage	Construct/Operate fish collection facility and trap and haul program from top of TPU Headworks to HHD	Confirm adults find and enter facility.
		Monitor mortality in trap/transit.
		Monitor daily number and species transported and release sites.
		Conduct spawner surveys in upper watershed.
Downstream Fish Passage	Construct/operate downstream fish passage facility at HHD to elevation 1147 ft MSL	Monitor movement of juvenile fish into reservoir by seasonal installation of a fyke net in the upper mainstem.

Table 5-3 Chinook Salmon Conservation Measures and Monitoring to be Implemented by the Corps Under HHD Continued O&M		
Issue	**Measure**	**Monitoring**
		Monitor reservoir passage and survival, fish passage facility survival and fish collection efficiency.
		Monitor condition of fish passing through fish passage facility.
		Deploy fixed hydroacoustics in forebay, fish passage facility horn and wetwell; conduct mobile hydroacoustic surveys and gillnetting in reservoir; place transducers in passage facility.
		Mark and recapture juvenile salmonids to quantify capture efficiency of sampling station.
Instream Conditions		
Spawning/Incubation	See wood and gravel transport	See wood and gravel transport.
Rearing	See wood transport	See wood transport.
Instream Adult Migration	See upstream migration and flow variations	See upstream migration and flow variations.
Instream Juvenile Migration	See downstream migration	See downstream migration.
	See flow variations	Install and operate a rotary screw trap at RM 34 to monitor downstream migration of juvenile salmonids.
Stranding and Trapping	None needed	None needed.
Species Interactions		
Competition	None needed	None needed.
Predation	Implement predator abatement program (if necessary)	Monitor concentrations of predatory fish at migratory transition areas above and below HHD.

5.1 CHINOOK

5.1.1 Potential Effects of HHD Continued O&M Environmental Baseline and Proposed Conservation Measures on Chinook Salmon

The effects of HHD Continued O&M on chinook salmon were evaluated assuming an Environmental Baseline as described in Table 5-1. The effects of the conservation measures of Continued O&M were evaluated assuming the conditions in Table 5-2.

5.1.1.1 Ecosystem Functions

As described in Chapter 4, the Green River basin, like other watersheds in the Pacific Northwest, is a highly dynamic ecosystem where aquatic habitat conditions vary over both space and time in response to both natural and anthropogenic disturbances. Under natural conditions, climate, landform, and wildfire help drive these variations. In the Green River, however, many of the geomorphic processes responsible for maintaining aquatic habitats have been forced out of the normal range of variability by activities such as flood control, urban development, flow diversion and forest harvest (Section 4.1). Analysis of the effects of HHD Continued O&M must consider current processes as they exist under the modified geomorphic regime as well as the ability to restore natural processes given existing social, economic and scientific limitations.

Flow Variation

Potential Effects. Under the O&M Environmental Baseline hydrologic regime as measured at the USGS gage at Auburn, peak flows of up to 12,000 cfs occur during the fall and winter (November through February). Springtime flows average around 1,625 cfs in March and April, declining to around 1,000 cfs by June. The 10 percent exceedence flow between February 1 and June 30 is 2,612 cfs, and freshets greater than this flow occur on average between three and four times per year, and generally last about four days. Flows are lowest during the late summer, averaging approximately 300 cfs in August; the minimum three-day flow between July 15 and September 15 averages only 235 cfs. Flows in the Green River are currently considered to be functioning at risk due to diversion of the White and Black River, flood control operations, water withdrawal and changes in the flow regime resulting from urbanization and forest management.

HHD Continued O&M would continue to control flood flows and reduce flows during spring refill operations. Improvements could be implemented to mimic natural spring and summer flow variations under the existing HHD flow management regime.

Conservation Measures. Continued operation of Howard Hanson Dam would be conducted in a manner that more closely mimics natural flow variations. Spring refill operations of HHD will consider following a proportional capture strategy instead of a constant capture rate. Utilizing a proportional capture scenario will ensure that both large and small freshets are passed downstream of HHD. From July through the onset of fall rains in November, releases from HHD would maintain at least a minimum flow (110 cfs at Palmer) at all times. When inflow exceeds 110 cfs at Palmer, and sufficient water is stored in the reservoir to ensure baseflows can continue to be met, the Corps will consider available opportunities to manage HHD releases to mimic natural flow variations. As a result of these operational changes, the timing and frequency of spring, summer and early fall flows will become more similar to the natural flow regime than under O&M Environmental Baseline conditions.

In addition, the Green River Flow Management Committee (GRFMC) would be formalized and would provide recommendations to the Corps regarding adjustments to spring refill and summer through early fall low flow augmentation. Decisions by the committee cannot compromise the Corps's ability to comply with project purposes as identified by congressional authorization, but otherwise will allow resource managers to play a more active role in adaptively managing discretionary activities such as the spring refill strategy and the release schedule of water stored for low flow augmentation. This is expected to improve coordination between agencies responsible for management of fish and fish habitat in the Green River basin, and will therefore increase the likelihood that rehabilitation efforts implemented under the auspices of various federal, state and local programs are successful.

The overall result of this Action will be to improve flow variation as compared to O&M Environmental Baseline conditions. Complete restoration is not possible given the need to meet congressionally authorized flood control and conservation storage requirements via operation of HHD.

Gravel Transport

Potential Effects. Construction of HHD interrupted the transport of coarse sediment in the mainstem Green River. Geological analysis indicates that the upper watershed was formerly the primary source of gravel delivered to the Green River downstream of HHD (Mullineaux 1970; Dunne and Dietrich 1978) thus the interrupted sediment supply substantially alters natural sediment transport processes.

Under the Environmental Baseline, HHD Continued O&M would continue to prevent coarse sediment from being transported past the dam. The interrupted transport of coarse sediment is believed to have resulted in channel armoring and possibly bed degradation in the reach between Palmer and the Green River gorge (RM 57 to RM 61) (Corps 1998a; Perkins 1999). In the absence of other sources of bedload sediments, the continued interruption in sediment supply by HHD would be expected to result in a similar response in the reach downstream of Flaming Geyser Park once the supply of sediment stored within the channel upstream has been exhausted (Perkins 1999). Since a supply of gravel-sized sediment is critical to chinook salmon reproduction, the interruption of gravel transport at HHD under the Environmental Baseline is considered to be functioning at an unacceptable risk.

Conservation Measures. Under HHD Continued O&M, the Corps will place an average of 8,000 cubic yards of gravel (approximately 13,000 tons) downstream of HHD on an annual basis. This volume is designed to replace the quantity of gravel-sized sediment estimated to be annually blocked from downstream movement by operation of HHD (Corps 1998a). This amount may be adjusted based on monitoring efforts to confirm the amount of gravel transported into HHD and the effect of gravel nourishment on downstream reaches.

Under the Green/Duwamish Ecosystem Restoration Project, an additional 4,000 cubic yards of gravel may be placed at Flaming Geyser Park (RM 43) for a period of 50 years, resulting in placement of a total of approximately 12,000 cubic yards of gravel annually. Gravels placed under the Ecosystem Restoration Project are designed to replenish gravels lost by past operation of HHD. If gravel were not placed under the Ecosystem Restoration Project, the Corps would not be responsible under Section 7 of the ESA for placement of more than the quantity intercepted by future operation of HHD.

The effect of gravel placement will be monitored using a combination of remote sensing analysis and field surveys. Low level air photos of the river between the Tacoma headworks and the Highway 18 bridge (near RM 34) will be flown in years 2, 5 and 10 following gravel placement. The photos will be examined to determine changes in the area and location of gravel bars, helping to identify areas that may be aggrading. A series of cross-sections will be surveyed each year photos are taken to assess patterns of scour and deposition. Pebble counts will be conducted at each cross-section site to track gross changes in substrate size. Monitoring data will be used to guide adaptation of the program such as changes in the method or location of placement sites. If monitoring indicates that additional gravel replacement is necessary to replace gravel trapped behind HHD, the Corps would be responsible for supplying the additional gravel under Section 7 of the ESA. Reductions in the amount of gravel placed would occur only at the direct request of the Services.

Addition of this increment of gravel is expected to prevent further bed degradation and armoring in the reach immediately below HHD, and potentially increase the rate of channel migration, initiating the formation of new side channels (Perkins 1999). Aggradation is expected to occur in the immediate vicinity of the gravel placement sites, and could also occur at sites where the increased supply of bedload exceeds the transport capacity, including at the upstream end of Flaming Geyser Park (RM 44-RM 45) and near the O'Grady Park site (RM 41.5) (Perkins 1999).

The overall result of this Action would be to restore gravel transport processes to levels considered to be functioning appropriately given HHD Continued O&M.

Fine Sediment Transport

Potential Effects. O'Connor (1996) found that mass wasting was the largest source of fine sediment to the upper Green River. Timber harvest and road construction increased dramatically in several subwatersheds of the upper Green River in the late 1960s and early 1970s. Large runoff events in association with these management activities are a likely cause of higher sediment production. With recovery of vegetation and better forest management practices, sediment production in the Green River watershed has since been declining (O'Connor 1996).

Fine sediments accumulate behind HHD when floodwaters are impounded behind the dam. As the reservoir is drawn down, the river flows through large sediment flats that have developed in the reservoir area over time. Thus, fine sediments deposited during flood events may become resuspended on the falling limb of the hydrograph, or by bank erosion when the reservoir pool is drawn down, resulting in increased turbidity at lower flows.

Under normal operations, the Corps attempts to maintain the water level behind HHD so that it is above the turbidity pool (elevation 1,070 feet). However, the continued build-up of sediments creates the need for special operations that are conducted to periodically remove fine sediment to control the loss of reservoir storage space. To do this, the pool elevation is lowered to slightly less than the turbidity pool elevation while maintaining considerable reservoir outflow (usually 2,000 cfs or more). Special operations to control the level of the turbidity pool (below 1,070 feet) are usually conducted in the fall and early winter, when moderate to high rainfall events are forecast. During the special operations, water released from HHD is more turbid than usual, but because flows are high, most sediment from the turbidity pool remains suspended and is transported to Puget Sound. If the forecasted flow increases do not occur, the special operation is called off.

As a result of increased sediment yield in the upper watershed, the de-coupling of sediment transport caused by HHD, and high sediment inputs from several large landslides in the lower Green River, fine sediment transport is currently considered to be functioning at risk in the Green

River. Fine sediment input to the Green River during chinook salmon incubation can smother eggs and cause increased egg mortaility. Under HHD Continued O&M, fine sediment would continue to accumulate behind the dam during flood control operations, resulting in the potential for increased fine sediment transport at low flows.

Conservation Measures. Potential impacts to fine sediment transport in the lower Green River resulting from continued O&M would be mitigated by implementation of a sediment management plan as described in Appendix A. It is expected that implementation of the sediment management plan would improve fine sediment transport function as compared to the existing O&M Environmental Baseline. However, flood control operations at HHD will continue to shift downstream transport of fine sediments from the rising to the falling limb of the hydrograph. In addition, increased sediment inputs from landslides located up and downstream of HHD are expected to continue at least in the near future, thus it is expected that fine sediment transport in the Green River will improve, but will continue to function at risk.

Woody Debris Transport

Potential Effects. HHD currently blocks the downstream transport of wood from the upper Green River watershed. In combination with historic channel clearing to facilitate flood control, and conversion of streamside forests to urban and rural/agricultural land uses in much of the lower basin, the blockage of wood transport has contributed to reduced levels of woody debris downstream of HHD. Woody debris interacts with other natural processes (e.g., climate, hydrology, sediment transport) to create food, cover, and microclimates suitable for virtually all species of juvenile salmonids at some point in their maturation. The deposition of key woody debris pieces initiates pool formation, promotes bar and side channel formation, stores sediment, and retains organic matter (Tacoma 1999). Given the current blockage of woody debris transport by HHD, LWD transport is currently considered to be functioning at an unacceptable risk in the lower Green River. Future operation and maintenance of HHD would continue to interrupt the downstream transport of wood.

Conservation Measures. A woody debris management program would be implemented to restore downstream transport of wood past HHD. At least 50 percent of the wood collected from the reservoir each year would be passed downstream of HHD, including up to 5 truckloads of small woody debris per year. Ensuring that at least some wood passes HHD will improve LWD function in the lower Green River. The effects of the LWD placement program will be evaluated by conducting surveys of functional LWD, key pieces and jams at five-year intervals for the first 15 years following initiation of the transport program. Changes in the method of LWD placement or reductions in the amount of LWD placed would be initiated only at the direct request of the Services.

The number and quality of pools associated with LWD should increase, and jams that contribute to side channel formation could become more frequent, thus the overall effect of this Action is expected to be an improvement in LWD function in the lower Green River. However, this conservation measure replaces only 50 percent of the LWD transported to HHD, and recruitment from downstream riparian stands will continue to be suppressed as a result of flood control and land use activities. For these reasons, it is expected that LWD transport will improve over Environmental Baseline conditions, but will continue to function at risk in the lower Green River.

Channel Morphology

Potential Effects. Changes in the channel morphology of the Green River affect the quality and distribution of aquatic habitat conditions in the Green River. Above the HHD reservoir, channels in the upper Green River have become braided as a result of increased coarse sediment inputs associated with forest management activities. In the HHD reservoir, approximately 4.6 miles of former riverine habitat is seasonally transformed into lacustrine habitat as a result of flood control and conservation storage operation at HHD.

Operation of HHD has altered the hydrologic regime of the Green River by preventing flows greater than 12,000 cfs at Auburn. The reduction in peak flows reduces the peak sediment transport capacity of the river, and could be considered to benefit salmon incubation by reducing peak sediment scour events. Peak flood events scour gravels to a deeper depth than smaller flow events and the reduction in peak flood events may be particularly beneficial to salmon laying eggs deep in the gravel substrate.

While flood control may reduce peak scour events, operation of HHD has increased the frequency of 3,000 to 9,000 cfs flow events (Corps 1998a). Since gravel transport in the Flaming Geyser reach of the Green River increases as flows increase over 2,900 cfs (Corps 1998a), flood control may cause a net increase in annual gravel scour and transport. Shallow salmon redds are particularly susceptible to scour events and the increased frequency 3,000 to 9,000 cfs events may cause a net decrease in the survival of incubating salmon eggs.

Since construction of HHD in 1964, the channel in the lower Green River was observed to become narrower, and formerly active gravel bars have stabilized due to encroachment of riparian vegetation (Perkins 1993; Perkins 1999). These changes are attributed primarily to the reduction in flood flows (Perkins 1999). Construction and maintenance of dikes and levees by King County and other municipalities also reduced the width of the lower Green River channel. Degradation of the channel in response to the decreased supply of coarse sediment is also hypothesized to have occurred in the reach between Tacoma's Headworks and Palmer (RM 61 to RM 58). Narrow channels will increase the rate of sediment transport at a given flow compared to wider channels and increase the likelihood of redd damage associated with gravel scour. For these reasons, channel morphology is considered to be functioning at risk in the Green River.

Continued operation and maintenance would not affect channels upstream of HHD as compared to existing conditions. Future changes in channel width immediately downstream of the dam are unlikely, as terrestrial vegetation is already well established on formerly active bar surfaces, and the magnitude of high flows would not change. Lack of wood input from upstream reaches would continue to reduce the channel complexity downstream of the Green River gorge. In addition, continued interruption of coarse sediment transport at HHD could lead to isolation of existing side channels in the lower Green River downstream of the Green River gorge.

Conservation Measures. Channel morphology would be maintained or would become more complex under the wood and sediment management programs. Increases in LWD and sediment are expected to increase the number and complexity of pools and the amount of spawning gravel, particularly in reaches that currently lack adequate sediment storage sites. Additional side channels could form in response to the increased wood and sediment load. The connectivity of existing side channels would be maintained or enhanced. The overall effect of this Action is expected to be an improvement in channel morphology. However, continued flood control by HHD and maintenance of levees and revetments in the lower Green River will prevent full restoration of channel morphology.

Floodplain Connectivity

Potential Effects. Flows greater than 12,000 cfs have been prevented since construction of HHD. Construction of levees and flood control structures downstream of the dam has reduced the area inundated by floods, and has cut off a number of formerly active side channels. As a result of these activities, floodplain connectivity downstream of HHD is currently considered to be functioning at risk.

Floods greater than 12,000 cfs would continue to be prevented under ongoing operation of HHD, thus floodplain recharge will be the same as under existing operations. As described above, connectivity of side channels downstream of the Green River gorge could begin to decline as gravel storage sites within the gorge are depleted and downstream transport of coarse sediment continues to be interrupted. Reduced side channel connectivity would further impair floodplain functions such as groundwater recharge and could result in a loss of wetlands and off-channel habitat over the long-term.

Conservation Measures. Increasing bedload sediments to levels more representative of natural conditions will ensure that existing side channels do not become perched under future HHD operations and will enhance the formation of active gravel surfaces that represent favored regeneration sites for some riparian species. Localized aggradation and increased LWD loads could result in local increases in flood levels at locations where the gravel is placed. Overall this Action is expected to improve or maintain floodplain connectivity and function; however, continued flood control by HHD, maintenance of levees and revetments along the lower Green river, and agricultural and rural development of former floodplain surfaces will continue to prevent full restoration of floodplain function.

5.1.1.2 Water Quality

Current water quality problems in the Green River include warm water temperatures during the summer and fall, low dissolved oxygen (DO) levels, nutrient enrichment, and a variety of pollutants. Dissolved oxygen problems are related to both elevated water temperatures and nutrients and are most severe in the lower Duwamish within the tidal zone (up to RM 11.0). Such conditions can stress fish and render them more susceptible to the effects of other pollutants. Water quality problems identified by Ecology in the Green River downstream of HHD include: 1) the Green River between RM 11 and 42.3 (waterbody segment WA-09-1020), listed as limited for mercury, fecal coliform bacteria, and temperature; and 2) the Green River between RM 42.3 and 64.5 (waterbody segment WA-09-1030), listed as limited for temperature (Ecology 1998).

Water Temperature

Potential Effects. Numerous exceedences of the Washington State temperature criteria for Class A Waters have been recorded in the lower Green River (Ecology 1998). Based upon the results of a study by Caldwell (1994), it appears that warm water temperatures in the lower and middle Green River during summer low flow periods largely result from heat exchange with warm air and solar heating. Temperatures at the Headworks were largely unchanged from temperatures recorded at the HHD outfall, averaging 57 to 65°F (13 to 18.3°C); however, between the downstream end of the Green River Gorge and Tukwila, maximum temperatures in July and August ranged from 72.5 and 75.2°F (22.5 to 24°C). The factors responsible for the high temperatures include extensive paved areas in the lower Green River basin that reduce groundwater recharge and subsequent discharge of cool groundwater into the river, low flows which increase the susceptibility of water to heating on warm days, and lack of shade along the lower river (Corps 1998a).

Warm water temperature in the lower Green River has several potentially adverse impacts on chinook salmon. Warm water temperatures and resulting low DO concentrations have been found to result in delayed upstream passage of chinook salmon in the lower Green River and Duwamish estuary during the late summer and fall (Fujioka 1970). Water temperatures exceeding 60°F (15.5°C) become progressively more limiting to the growth and survival of juvenile salmon and trout. Although most chinook salmon migrate out of the Green River as fry, some of these fish may reside in the Duwamish estuary during the summer where they would be potentially exposed to poor water quality conditions. Finally, warm water temperature during the fall could reduce the viability and survival of eggs deposited in river gravels by chinook salmon. For these reasons, water temperatures downstream of HHD are currently considered to be functioning at risk.

Under the HHD Continued O&M Environmental Baseline, the temperature of water released from the dam during the early to mid-summer would continue to be cooler than expected natural (pre-impoundment) temperatures due to the withdrawal of cold water from the lower stratum of the reservoir. Water temperatures in the lower stratum of the reservoir typically range from 50 and 55°F (10 and 12.8°C)°F during the summer. In contrast, seasonal heat accumulation of water stored in the reservoir and depletion of cold water in the lower stratum of the reservoir would cause late summer releases to be warmer than inflow water temperatures (Corps 1998a). Dam releases affect temperatures up to six miles downstream (Caldwell 1994).

Conservation Measures. Under HHD Continued O&M, a new tower would be constructed to support the Modular Inclined Fish Screen and would facilitate selective water withdrawal, allowing the Corps to withdraw water throughout the water column. Selective withdrawal would minimize the potential for withdrawing warm waters from the reservoir during the late summer and fall. Improved flow regulation due to the new intake is expected to improve the temperature of releases.

The benefits to chinook salmon provided by cooler temperatures of water released from HHD would extend several miles downstream of HHD, based upon the results of Caldwell's (1994) temperature study. However, because high temperatures in the lower river are largely a function of activities unrelated to HHD Continued O&M, the temperature regime of the lower Green River is expected to continue to function at risk.

Dissolved Oxygen

Potential Effects. Levels of DO in the reservoir are excellent including the hypolimnion. Levels of DO in the lower Green River are generally satisfactory to support fisheries resources. Samples collected by Metro in the lower Green River show a few occasions where DO levels were measured below the state Class "A" criterion (Corps 1995). These violations of the state criterion were not frequent enough to warrant listing the lower Green River as water quality-limited for dissolved oxygen. However, portions of the Duwamish Waterway and River were placed on the State 303(d) list in 1996 and in 1998 (Ecology 1998). Low DO can impair successful migration by fish and may affect reproductive success, especially during periods when eggs and hatchlings are within the gravel strata. Low DO levels, along with warm water temperatures, have been found to delay the upstream migration of chinook salmon in the Duwamish/lower Green River during low flow periods in the summer and early fall (Fujioka 1970). For these reasons, DO is currently considered to be functioning at risk in the lower Green River.

Conservation Measures. Improved flow management provided at the direction of the GRFMC could result in slight improvements in DO conditions in the Duwamish and lower Green River during late summer and early fall if additional water was allocated to summer low augmentation. However, the ability to store water for summer low flow augmentation would continue to be limited, thus overall effect this Action is expected to maintain existing levels of DO.

Saltwater Wedge

Potential Effects. The position of the saltwater wedge in the lower Green River has been substantially shifted by the loss of inflows from the White River, which were cut-off from the Green River in 1917 to protect agricultural lands from erosion. The White River historically contributed a large portion of the flow in the Duwamish/Lower Green River, resulting in a saltwater wedge which occurred farther downstream than under current conditions. The saltwater wedge currently migrates upstream as far as RM 11 under low flow conditions. The position and size of the saltwater wedge in the lower Green River is not expected to change under the HHD Continued O&M Environmental Baseline compared to existing conditions. The saltwater wedge is considered to be functioning at risk under O&M Environmental Baseline conditions.

Conservation Measures. The position of the saltwater wedge could potentially be shifted downstream under low flow conditions by the provisional release of water stored behind HHD, if this was determined to be beneficial to chinook salmon by the GRFMC. This would result in an improvement over the existing O&M Environmental Baseline.

Total Dissolved Gases

Potential Effects. The supersaturation of total dissolved gases (TDG) can be caused by the operation of spillways at large dams (Corps 1996a). High concentration of TDG can result in the injury and mortality to fish and other aquatic organisms in rivers downstream of dams. TDG supersaturation is caused by entrainment of air by water passed over the spillways of dams into deep plunge pools and stilling basins (Corps 1996a). TDG problems are unlikely to occur below HHD because the spillway of this dam has never been used. Instead, water is passed from the reservoir via a submerged intake, and travels through a tunnel where it is released into the river below the dam. High concentrations of TDG are unlikely to occur under HHD Continued O&M Environmental Baseline conditions because no air is entrained in water passing through the dam, as would be the case if it was alternatively released via the spillway. TDG impacts under HHD Continued O&M would be likely to be limited only to periods of spills occurring under extreme flood events. TDG levels in the Green River are currently unknown, but are very unlikely to be greater than 100% saturation. Consequently, TDG is assumed to be functioning appropriately; this assumption will be confirmed by monitoring.

Conservation Measures. Total dissolved gas concentrations are unlikely to reach levels injurious to chinook salmon and other aquatic organisms under HHD Continued O&M. No conservation measures have been proposed for TDG concentrations other than monitoring to confirm TDG levels. Total dissolved gas concentrations are assumed to function appropriately under HHD Continued O&M.

Turbidity

Potential Effects. Turbidity is the only water quality parameter that has seasonally exceeded Class "AA" standards in the Green River above HHD (Corps 1995). Turbidity is of greatest concern during flood events and when HHD reservoir levels are low. Because turbidity increases are generally of short duration, turbidity is not likely to be limiting to fish in the lower Green River, though it may limit other uses such as Tacoma's water supply and recreation. As described for fine sediment, both natural and management related increases in fine sediment result in turbidity currently being considered to function at risk in the Green River.

The frequency and magnitude of flood events that transport fine sediment into and through HHD reservoir would not change under HHD Continued O&M, thus there is the potential that HHD operations could continue to result in short-term increases in turbidity.

Conservation Measures. Potential turbidity impacts resulted from shoreline and stream channel erosion under HHD Continued O&M would be mitigated by implementation of the sediment management plan (Appendix A). However, flood control operations at HHD will continue to shift downstream transport of fine sediments from the rising to the falling limb of the hydrograph, thus turbidity is expected to continue to function at risk.

Contaminants

Potential Effects. Contaminants that have been observed to exceed State Water Quality Standards in the Green River include fecal coliform, metals and toxic chemicals. Ecology has measured levels of mercury, copper, lead, and zinc above state-established standards in the Duwamish River (Corps 1995). Toxic contaminants have been identified in bottom sediments and surface water in the lower Green River and especially in the Duwamish River (Corps 1995). Chemical testing of bottom sediments in the lower 5 miles of the Duwamish River revealed contamination by oil and grease, sulfides, pesticides, and polychlorinated biphenyls (PCB). More recently, Ecology (1998) cited excursions beyond criteria in sediment for polychlorinated biphenyls and polyaromatic hydrocarbons. No contaminant exceedences have been observed upstream of HHD.

High levels of contaminants are currently adversely impacting chinook salmon in the Green River. Contaminants can bioaccumulate in juvenile chinook feeding on macrobenthos in the lower Green River. For this reason, contaminant levels are currently considered to be functioning at risk in the lower Green River.

HHD Continued O&M would not change the concentration of toxic contaminants in the lower Green River compared to that occurring under existing conditions. The magnitude and duration of flood events that mobilize toxic contaminants in the lower river would remain the same.

Conservation Measures. HHD Continued O&M is not expected to alter the level of contaminants in the lower Green River, thus no conservation measures were developed to address this issue. The overall result of the Action would be to maintain contaminant levels at current levels.

5.1.1.3 Fish Passage

Upstream Fish Passage

Potential Effects. The upper Green River watershed historically supported naturally reproducing populations of anadromous fish, including steelhead, chinook and coho salmon. In 1913, completion of Tacoma's Headworks Diversion Dam at RM 61.0 blocked adult anadromous fish access to the upper Green River watershed. The completion of HHD at RM 64.5 in 1962 created an additional barrier to the upstream passage of anadromous fish. There are approximately 220 square miles of watershed above Howard Hanson Dam representing about 45 percent of the total Green River watershed.

Various authors have estimated that over 30,000 adult salmon and steelhead could be produced in the watershed above the dams (Corps 1998a). From 1911-1914, a weir and egg take station was used to capture broodstock and establish hatchery runs of steelhead, coho and chinook salmon to compensate for the loss of spawning habitat above the Diversion Dam, with trap counts maintained for coho and steelhead. The average return for coho during those years was 5600 adults while steelhead was 1600 adults. Grette and Salo (1986) reported that historical production ranged from 9,000-25,000 for coho, 500-5200 for steelhead, and from 150 to 300 for chinook. Analysis of Washington Department of Game records suggests that harvest and seasonal blockages below the trap could have resulted in underestimates of total returns (Corps 1998). Most of the streams in the upper watershed are unconstrained by levees or dikes and substantial anadromous fish habitat could be restored to production if upstream and downstream fish passage were provided past the dams.

Since 1992, the MIT, Tacoma, WDFW, and Trout Unlimited have cooperatively administered a temporary fish ladder and trap-and-haul program. As a pilot program, between 7 and 133 adult steelhead have been captured at Tacoma's Headworks fish trap and either released above HHD for natural spawning or used as broodstock to produce fry for outplanting in the upper Green River watershed. The Tacoma Headworks diversion dam is 17-ft high. Upstream fish passage over the Headworks structure can be easily accomplished via a fish ladder. If the AWSP does not proceed, it is reasonable to expect that Tacoma will provide upstream fish passage over the Headworks diversion dam as part of their compliance with the ESA. Assuming Tacoma provides upstream fish passage over their Headworks dam, upstream migrating fish will still be blocked from accessing the upper watershed by the 235-ft high Howard Hanson Dam. The lack of upstream fish passage facilities at HHD under the Environmental Baseline isolates critical chinook habitat in the upper Green River watershed and creates an unacceptable risk.

Conservation Measures. If the AWSP does not proceed, it is assumed that both Tacoma and the Corps will be required to provide upstream fish passage facilities to allow chinook salmon access to historical habitat in the upper Green River watershed. Assuming Tacoma provides upstream fish passage by installing a fish ladder at their Headworks facility, the Corps would provide upstream fish passage over HHD by constructing a trap-and-haul facility at Tacoma's Headworks.

Upstream migrating adult chinook would enter the Tacoma fish ladder and pass upstream to the top of the Headworks diversion. Although the fish ladder at Tacoma's Headworks would have the physical capability to allow chinook to be released into the mainstem channel immediately above the Headworks, the Corps proposes to collect fish at the top of the Headworks diversion for passage around HHD. There is about 3.5 miles of mainstem Green River habitat between Tacoma’s Headworks and HHD. If fish were passed into mainstem reach above Tacoma’s Headworks, another fish passage barrier dam would have to be constructed between the Headworks and HHD to direct the fish into the entrance to the HHD upstream fish passage facility. The barrier would have to be at least 12 feet high to ensure upstream migrants are directed into the entrance of the passage facility. The additional passage barrier would also have to be located far enough downstream to avoid backwatering HHD outlets. Howard Hanson Dam could not be used as a fish passage barrier because the outlet area is used to dissipate energy and fish would have difficulty finding the entrance to the fish passage facility.

Construction of a fish ladder at the Tacoma Headworks combined with a second fishway leading to a trap-and-haul facility to pass fish around HHD would impose higher stress and increases the risk of delay to upstream migrants than a trap-and-haul constructed at Tacoma’s Headworks. A separate upstream passage facility at HHD would require adult fish to locate and enter a second fishway leading to a trap, crowder and loading facility. Given the configuration of the river and outlet works at HHD, it is likely that a second upstream fish passage facility would need to be located well downstream of HHD; thus reducing the benefits of allowing salmonids access to the reach between Tacoma's Headworks and HHD. Since successfully attracting fish to a fishway entrance is often the most challenging design feature of a fish passage facility, requiring an additional fish upstream of Tacoma's Headworks would increase the risk of delaying upstream migrants.

Instead of constructing a second fishway between Tacoma's Headworks and HHD, the Corps would construct a trap and crowder facility to load the fish from the Tacoma Headworks fish ladder into a tank truck for transport around HHD. Adult fish would be collected at Tacoma Headworks at RM 61.0 and released near the downstream end of the reservoir in the vicinity of RM 65.5. Upstream migrating adult chinook could also be released into the reach between the Headworks and HHD if deemed beneficial by MIT and WDFW in coordination with the Services.

The Corps trap-and-haul facility at Tacoma's Headworks was selected in favor of other passage alternatives such as a very long fish ladder or a fish lock. There are serious concerns regarding the applicability of conventional fish ladder technology to HHD. The overall height of the HHD (235-feet) would require a ladder with a length of at least one-mile. Adult chinook attempting to ascend a ladder of this length and height would be exposed to stress and potential water quality deterioration.

Another limitation to installing a fish ladder at HHD is the large fluctuation in the reservoir level. Since HHD provides a major flood control function, the water level behind the dam can vary by more than 150 feet during times when adult salmon and steelhead are migrating upstream. During times when the water level is low, the fish that ascended the 235 foot high ladder would then need to be lowered (as much as 150 feet) to the level of the reservoir pool behind the dam. This would require that the adults either be returned in a high velocity slide/chute to the pool level or via some type of mechanical elevator. In either case, the fish would experience additional stress associated with the passage facilities. Since the HHD reservoir pool must be drained prior to the flood control season, returning fish to the river in the vicinity of the dam would greatly increase the rate of adult fallback (movement downstream past the dam). As an alternative to returning the fish to the lower pool level, the fish ladder could be extended to the upper end of the reservoir; however, this would entail extending the fish ladder approximately 4.6 miles upstream of the dam. While an upstream fish ladder of this length is theoretically feasible, the risk of failure is much higher than a trap-and-haul facility. There are at least four trap-and-haul facilities currently used in western Washington to pass fish around barriers more than 150-ft high. There are no fish ladders in use in Washington State to pass fish over barriers of this height.

Assuming natural production of coho, steelhead, and chinook is successfully re-established in the upper watershed, up to approximately 10,000 adult salmonids may be transported upstream around HHD on an annual basis. The trap-and-haul will be operated on a near continuous basis, with only brief periods of shutdown for required maintenance. Operational details of the proposed trap-and-haul facility to pass fish above HHD have not been developed as of January 2000. A design of the fish ladder leading to a trap and crowder facility at Tacoma's Headworks is available from Tacoma Water. Operational details of the upstream fish passage facilities will be developed prior to construction. The Corps currently operates a trap-and-haul facility on the White River in western Washington. The following description of anticipated trap-and-haul operations on the Green River is based on the Corps practices employed on the White River.

The capacity of the Green River fish transport truck is expected to be approximately 100 to 150 adult salmonids depending on the size of fish. Based on operational experience at the White River trap-and-haul, the average number of fish per haul is expected to be much less. Haul trips on the White River are conducted Monday, Wednesday and Friday, except during periods of peak migration when trips are more frequent. During 1990, the Corps made 175 round-trips, hauling 6,789 adult salmonids from the Puget Sound Energy Diversion at RM 23.5 on the White River to a right bank release site above Mud Mountain Dam at RM 33.8 (Table 5-4). The peak fish-hauling season on the Green River is expected to be September and October during the coho run, but transport trips may occur every month of the year.

Table 5-4
White River Fish Transport Trips[1]

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
No. trips	3	5	16	17	13	11	9	14	47	29	10	1

[1]Timing of 175 truck transport trips conducted by the Corps to haul 6,789 adult salmonids from RM 24.3 on the White River at Puget Sound Energy's diversion dam below Mud Mountain Dam to RM 33.8 above Mud Mountain Dam during calendar year 1990 (Hilgert 1992).

The proposed conservation measure affords adult salmonids upstream passage around HHD and restores adult chinook salmon access to the upper watershed. The need for continued human intervention at the trap-and-haul program causes upstream fish passage to function at some risk to chinook salmon. Combining a trap-and-haul facility with Tacoma Headworks fish ladder provides safe passage around both the Headworks and HHD without imposing additional delays and stress to the fish. The Corps will monitor the number, species and condition of fish transported around HHD, and a weekly tally of the number of fish released above HHD will be posted on a Corps web site or equivalent public information access medium. The distribution and spawning success of adult chinook following release above HHD will also be monitored to ensure accessible habitats are being fully utilized.

Downstream Fish Passage

Reservoir Passage.
Potential Effects. One of the primary purposes of the Howard Hanson Dam project is to reduce the magnitude of flooding in the lower Green-Duwamish valley. From November through February the project is operated solely for flood control purposes. Up to 106,000 ac-ft of flood storage at elevation 1206 feet MSL is available behind Howard Hanson Dam during the winter months. During the spring, the reservoir is allowed to fill to elevation 1147-ft to store water for later release to augment instream flows below HHD. Beginning in mid-March, the reservoir is filled at a constant refill rate of 200 cfs March 15 to April 15, and a 400 cfs refill rate from April 16 to May 31 or until the summer conservation pool of 30,400 ac-ft at elevation 1147-ft is reached. During the summer, the stored water is released to satisfy an instream flow target of 110 cfs measured at the USGS gage at Palmer. By late November, the reservoir is emptied to

provide for the full flood control capacity of 106,000 acre-feet. In response to winter flood control operations, the reservoir is allowed to fill during periods of high inflow and is subsequently drained to provide flood control storage for the next storm event. Releases from HHD are regulated to limit the river flow measured at the USGS gage at Auburn to a maximum of 12,000 cfs.

Since 1962, the Corps has modified springtime reservoir refill strategies in an effort to protect fisheries resources while meeting their conservation pool storage requirements. Because of the lack of a downstream fish passage facility and other operational and physical constraints, none of the strategies have provided adequate fishery protection. Up until the early 1980s, the Corps delayed the start of reservoir refill until late April and May so that smolts outmigrating from the upper basin in March and April are not forced to sound to great depths to exit through the large radial gates at the base of HHD. While this strategy benefited upper basin migrants, higher refill rates in May caused adverse impacts to spawning steelhead and reduced instream flows during the peak of the lower river juvenile salmonid outmigration period. During the late 1990s, in response to input from fishery resource agencies, the Corps has started refill earlier to avoid impacting fish resources in the lower river.

Juvenile chinook moving downstream during their spring outmigration must pass through the Howard Hanson reservoir before reaching the dam. When the reservoir is held below elevation 1070-ft elevation, the reservoir has a surface area of less than 100 acres and outmigrants are assumed to pass quickly and safely through the pool. As the reservoir level rises, downstream migrating fish must pass through an increasingly larger slack-water area. Juvenile salmonids migrating through the larger reservoir pool may be delayed which can affect smolt survival, timing of ocean transition and thermal imprinting. As a general rule, juvenile outmigrant fish appear to cue into changes in water velocity, and except when holding for resting or feeding, move towards areas of higher velocities.

Conservation Measures. The size of a reservoir impoundment can affect the outmigration of juvenile salmonids by causing residualization, extending the duration of travel and decreasing survival. During the winter flood control season, the reservoir behind HHD is held essentially empty below elevation 1,070-ft MSL, except when floodwaters are retained and subsequently released to provide downstream flood protection. At the summer conservation pool of 1,147-ft, the surface area of the impoundment is 871 acres, with a volume of 30,400 acre-feet. The reservoir is approximately 4.6 miles long at this pool level and has a perimeter of 13 miles. Staff from the Corps have calculated that at the summer conservation pool of elevation 1,147-ft, it would take approximately 294 hours for a water particle to enter the reservoir and be flushed downstream at a flow of 1,250 cfs.

In the absence of the AWSP, the Corps proposes to retrofit HHD with a downstream fish passage facility that has an intake capacity that approximates the median daily inflow to the reservoir during the peak smolt outmigration period (April and May). Providing a large capacity, surface-oriented intake is expected to reduce reservoir travel-time and improve the survival of downstream migrating chinook.

Chinook smolt survival may also benefit in light of additional measures such as 1) leave all trees along the new reservoir shoreline; 2) use of woody debris in streams above, within, and below the reservoir, 3) mimicry of natural flow fluctuations with natural or artificial freshets; and 4) selective removal of predatory fish if monitoring suggests this is necessary.

Dam Passage.

Potential Effects. In 1913, the City of Tacoma blocked adult anadromous fish access to the upper Green River watershed to avoid potential impacts to use of the upper Green River as a source of municipal water supply. Since 1982, juvenile salmonids have been planted into the upper watershed by state and tribal fisheries agencies to make use of available rearing habitats. Juvenile salmonids migrating downstream from the upper watershed must pass through one of two HHD outlets (the flood control tunnel or a 48-inch-diameter bypass pipe). The flood control tunnel (elevation 1,035 feet) is regulated by two large radial gates with a capacity of up to 12,000 cfs per gate. Any fish moving downstream from the upper watershed when the reservoir pool is low (less than 1,070 feet elevation) pass through the radial gates. When the reservoir pool is filled and release flows are less than 500 cfs, the 48-inch bypass pipe at elevation 1069-feet is used. Under O&M baseline conditions, refill of the project begins mid-March when the pool is filled from low pool to the summer conservation pool of 1,147 feet. Reservoir refill during the spring coincides with the main outmigration period of juvenile salmonids.

During winter and early spring when the dam is operated as a run-of-river facility, any fish moving downstream from the upper watershed pass safely through the radial gates. As the radial gates are submerged during spring refill, estimated survival of juvenile outmigrants passing through HHD outlets drops to 5 to 25 percent based on a fish passage model and on-site monitoring data (Dilley and Wunderlich 1992, 1993). The low survival rate is primarily a function of two factors: the spring refill of the reservoir submerging the dam outlets and the low survival of juveniles as they pass through the outlets. Juvenile fish require a near surface-outlet (typically 5 to 20 feet deep) with a high discharge capacity outlet (exact volumes depend on site conditions). Therefore, at a time when fish need high flows and a shallow outlet, the project is reducing outflow (refill) and creating a deeper outlet (from 35 to 112 feet deep). During outmigration, juvenile salmonids may not find or be willing to use outlets that are deeply submerged. Fish that are delayed or entrapped beyond their normal outmigration period may become resident and not contribute to the returning adult population. Fish that sound (dive) to reach the bypass outlet pipe experience high mortality from impacts at sharp bends or turns within the bypass pipe.

Conservation Measures. Once juvenile chinook pass through the reservoir, they must be able to find the entrance to the downstream fish passage facility and safely pass Howard Hanson Dam and pass downstream to the mainstem river. In the absence of the AWSP, the proposed downstream fish passage facility consists of: (1) a new intake tower; (2) a floating fish collector that supports a modular-inclined screen; (3) a fish lock for temporary holding and passage downstream; and (4) a fish transport conduit for routing fish to the mainstem channel below HHD. The intake will be designed to function at reservoir levels of 1,080-ft to 1,147-ft with an intake capacity of up to 1,250 cfs. The downstream passage facility will be similar, but built to a lower elevation, than that described in Section 6.1.

Based on studies conducted at other high-velocity fish passage facilities, fish protection criteria have been developed to guide the design of the HHD facility. The modular-inclined screen will be designed to function at flows of less than 1,250 cfs. At flows of 1,250 cfs, the approach velocity at the face of the screen is approximately 6.0 feet per second (fps), which is the upper limit of velocities shown to minimize injuries at other installations. At flows between 1,250 cfs and 1,600 cfs, the collector and modular inclined screen could be operated to pass fish downstream, but the approach velocity would exceed design criteria established by a work group of state, federal and private fisheries engineers and biologists. Operation at flows that exceed design criteria of 6.0 fps would be contingent on the results of monitoring and evaluation of fish passing through the facility. Flows in excess of those passed through the modular inclined screen would be passed through the unscreened radial gate outlets at the base of the dam.

In addition to construction and operation of the downstream fish passage facility, a monitoring station will be constructed at the downstream fish transport pipe. Fish behavior approaching the collector and within the lock will be observed using hydro-acoustics for at least the first ten years of project operations. Monitoring measures during at least the first ten years of operation would be similar to those described in the Daft Feasibility Report for the AWSP (Corps 1998a).

Under HHD Continued O&M Environmental Baseline conditions, the lack of downstream fish passage facilities represents an unacceptable risk for critical chinook habitat in the upper watershed (Table 5-5). While juvenile chinook may safely pass the HHD reservoir and dam when the reservoir pool is low, storing up to 30,400 ac-ft of water during the spring creates a large, slow-velocity reservoir pool, which hinders the downstream movement of chinook fry. As the depth of the reservoir pool increases with spring storage, downstream migrating chinook are unwilling to use, or unable to find, the existing radial gate outlets. These conditions effectively prevent use of the upper watershed by chinook salmon.

If the downstream passage facility is implemented as described, downstream fish passage will be restored which provides the opportunity to restore chinook salmon production to the upper watershed. Given that the proposed downstream fish passage facility is an experimental design and will require ongoing human intervention to operate successfully, downstream fish passage will continue to function at risk in the Green River (Table 5-5).

5.1.1.4 Instream Conditions

Spawning and Incubation Habitat

Upper Watershed.

Potential Effects. Spawning and incubation habitat in the upper Green River is currently rated as being in fair to poor condition by watershed analyses conducted for the Upper Green/Sunday and Lester WAUs (Fox 1996; Fox and Watson 1997). The upstream migration of chinook salmon is currently blocked by Tacoma's Headworks diversion dam at RM 61.0, and by HHD at RM 64.5. For these reasons, spawning and incubation habitat in the upper Green River watershed are considered to be functioning at risk (Table 5-5).

insert table 5-5

Tacoma's Headworks and HHD would remain in place under the HHD Continued O&M, and would thus continue to represent a barrier to potential chinook spawning habitat above HHD.

Conservation Measures. It is assumed that upstream passage of fish will be provided at both the Tacoma's Headworks and HHD (Section 5.1.2.3). Fall chinook adult spawning capacity estimates developed by the WDFW for Olympic Peninsula streams vary according to gradient and elevation, and using these data the Corps estimated there are 24 miles of mainstem and large tributary chinook spawning habitat in the upper Green River watershed (Corps 1998). This will increase the total chinook spawning and incubation habitat in the Green/Duwamish Basin by approximately 28 percent.

The quality of spawning habitat in the upper watershed will not be affected by HHD Continued O&M. Substrate in the mainstem Green River is currently too coarse for optimal spawning in much of the upper Green River watershed as a result of increased sediment inputs from logging-related landslides (Fox 1996; Fox and Watson 1997), thus spawning and incubation in the upper Green River watershed will continue to function at risk until conservation actions recently implemented or proposed for the upper watershed by other landowners take effect.

Lower Watershed.

Potential Effects. Chinook spawning and incubation habitat in the lower Green River watershed is currently considered to be functioning at risk. Interruption of the coarse sediment supply has reduced the availability of chinook spawning habitat between Tacoma's Headworks and the Green River gorge, and has the potential to further reduce spawning habitat quality and availability downstream of the gorge. Increased fine sediment inputs associated with several recent large landslides in the lower Green River have substantially increased the amount of fine sediment in spawning gravels in some sections of the river. Low flows may limit the availability of spawning habitat. Prolonged high temperatures in the fall can delay chinook from reaching spawning areas and can reduce incubation success.

No additional water would be available for low flow augmentation during the late summer and fall under continued O&M, thus low flows would continue to have the potential to limit chinook spawning. Downstream transport of fine sediment on the falling limb of the hydrograph could further degrade spawning gravels in the lower Green River. The incubation period of chinook salmon in the Green River is generally completed by mid-February. Consequently, the earlier refill (starting February 15 instead of March 15) would not affect chinook salmon incubation.

Conservation Measures. The gravel nourishment conservation measure will improve spawning habitat conditions in the middle Green River by replacing gravel recruitment lost from the upper watershed due to the presence of HHD. Placement of LWD in the mainstem is also expected to improve available spawning habitat by enhancing the complexity of the channel in reaches where LWD is currently scarce, increasing sediment storage particularly in steep reaches such as the Palmer reach (RM 58 to RM 61) and the Green River gorge, where gravel is otherwise rapidly transported throughout the system. Low-flow augmentation could be selectively increased through adaptive use of the Section 1135 water. However, low flows and high temperatures will continue to influence spawning and incubation success in the lower Green River, thus spawning and will continue to function at risk.

Rearing Habitat

Upper Watershed.
Potential Effects. Juvenile chinook salmon are presently planted in the upper Green River Watershed by the MIT. Rearing habitat in the upper Green River is currently considered to be in fair to poor condition as a result of high management related-coarse sediment inputs and lack of LWD and shade in some reaches (Fox 1996; Fox and Watson 1997). Flood control operations and conservation storage by HHD seasonally inundate approximately 4.5 miles of potential chinook rearing habitat. For these reasons, rearing habitat in the upper Green River is currently considered to be functioning at risk.

Continued operation and maintenance of HHD would not alter the flow regime or amount of seasonally inundated habitat in the upper Green River Watershed as compared to existing conditions, thus future O&M are not expected to effect juvenile chinook rearing in the upper watershed.

Conservation Measures. HHD Continued O&M will not affect rearing habitat in the upper watershed, thus no conservation measures will be implemented to address this issue. Rearing habitat function in the upper watershed will be maintained, but will continue to function at risk until conservation actions recently implemented or proposed for the upper watershed by other landowners take effect.

Lower Watershed.
Potential Effects. Juvenile chinook rearing habitat in the lower Green River is currently considered to be functioning at risk because of changes in the natural flow regime, lack of LWD and loss of side channel habitats. Continued operation and maintenance of HHD could affect chinook salmon juvenile rearing habitat by starting refill in mid-February instead of mid March, reducing flows at a time when juvenile chinook are emerging and beginning to migrate downstream.

Conservation Measures. Increasing LWD recruitment by passing LWD downstream of HHD, and designed placement of ELJs, is expected to improve the complexity and quality of rearing habitat in the middle Green River. Gravel nourishment will ensure that existing side channels remain connected. In addition, benefits could also be realized for several miles of the Green River immediately below HHD by improving (decreasing) water temperatures for rearing chinook salmon which are may be present in the river during the summer and early fall.

Although refill will commence earlier in the season, refinements to the refill strategy are expected improve habitat conditions for juvenile chinook rearing by more closely mimicking the natural flow regime. Low-flow augmentation could be selectively increased through adaptive use of the Section 1135 water.

Overall the effect of this Action will be to improve rearing habitat in the lower Green River. However, because of high temperature concerns and the continued suppression of LWD recruitment and side channel formation caused by flood control activities, juvenile rearing habitat in the lower Green River is expected to continue to function at risk.

Adult Upstream Migration

Upper Watershed.
Potential Effects. Under existing conditions, the Tacoma Headworks diversion structure prevents the upstream migration of adult chinook salmon above RM 61.0. Additionally, HHD at RM 64.5 has been a barrier to the upstream migration of chinook salmon into the upper Green River watershed since its construction in the early 1960s, blocking access to approximately 24 miles of potential chinook spawning habitat. Howard Hanson Dam was originally authorized and built by the Corps without fish passage facilities.

Upstream migration of adult salmonids above HHD may currently be delayed in some locations by streamflow that goes subsurface. Holding pools are scarce in some reaches due to aggradation and lack of LWD, but are present in confined portions of the mainstem where bedrock outcrops form deep pools (Fox 1996; Fox and Watson 1997). Because of the lack of passage facilities and generally poor holding habitat conditions in much of the river, adult upstream migration above HHD is currently considered to be functioning at risk.

Tacoma's Headworks and HHD would remain in place, blocking upstream migration of adult chinook into the upper watershed under continued O&M. Continued O&M would not alter flow or habitat conditions in the upper watershed, and thus would not affect upstream migration of adult chinook above HHD.

Lower Watershed.
Potential Effects. Upstream migration of adult chinook may be delayed in some years by low flows and high temperatures. Deep pools suitable for adult holding are generally scarce between RM 34 and RM 47 (Fuerstenberg et al. 1996). For these reasons, adult upstream migration in the lower Green River is currently considered to be functioning at risk. Under continued O&M, low flows, high temperatures and the scarcity of pool habitats would continue to be a concern in the late summer.

Conservation Measures. Refinements in the flow release schedule developed by the GRFMC could be targeted to augment flows or provide a freshet in the late summer or early fall when adult chinook salmon are holding in the lower Green/Duwamish River prior to upstream migration. If such actions are implemented they could improve adult upstream migration in the lower river.

The overall effect of this Action would be to improve upstream migration of adult chinook. However, it is expected that upstream migration would continue to function at risk due to low flows and high temperatures throughout the watershed.

Juvenile Downstream Migration

Potential Effects. The survival of outmigrating juvenile salmon downstream of Tacoma's Headworks is assumed to be affected by the timing and quantity of instream flows. Although the relationship between flow and migration survival is poorly understood, survival is assumed to increase as flows increase (Wetherall 1971). Spring refill of the Howard Hanson Dam Conservation pool reduces flows during the time when juvenile chinook are migrating downstream, thus juvenile downstream migration is currently considered to be functioning at risk. Under continued O&M, refill would begin as early as February 15, which could affect early chinook outmigrants.

Conservation Measures. Beginning spring refill in February could affect early downstream migrating chinook. Refinements in the refill strategy developed by the GRFMC are expected to result in a pattern of spring flows that more closely mimics natural conditions, resulting in an overall improvement in downstream migration of juvenile chinook.

Stranding

Potential Effects. Rapid fluctuations in flows can strand or trap juvenile chinook salmon or incubating redds. Under existing conditions, HHD operations generally do not alter flows during the period when chinook redds are incubating. However, spring refill operations can reduce flows during the spring, trapping juvenile chinook in side channel habitats that become disconnected from the mainstem. For this reason, stranding and trapping are currently considered to be functioning at risk in the lower Green River.

Even with earlier refill, continued O&M would not alter flows during the chinook incubation period as compared to existing conditions, and thus are not expected to affect the stranding of chinook redds. Chinook salmon fry will continue to be susceptible to stranding in gravel bars and potholes situated along the mainstem river channel, as well as in the side channel located along the middle Green River during periods of rapid flow reductions.

Conservation Measures. Increased flow variability resulting from refinements in the spring refill regime developed by the GRFMC are expected to increase the frequency at which off-channel habitats are connected to the mainstem reducing the risk that juvenile chinook become trapped in such areas during prolonged flow reductions associated with refill activities.

5.1.1.5 Species Interactions

Competition

Potential Effects. Competition is not likely to be a factor limiting the distribution and abundance of chinook salmon adults and juveniles in the Green River. Most juveniles migrate out as fry to the ocean, and consequently do not compete for space or food in the Green River. Due to the scarcity of gravels caused by HHD under existing conditions, competition for spawning gravels may occur among chinook salmon in some reaches of the Green River. Chinook salmon are fall spawners, and would not compete for spawning areas with other salmonid species with the exception of bull trout, which are seldom observed in the Green River. Competition is considered to be functioning properly in the Green River under the environmental baseline condition, and no conservation measures have been proposed for this biotic process.

Conservation Measures. Competition is considered to be functioning properly in the Green River under environmental baseline condition, and no conservation measures have been proposed for this biotic process.

Predation

Potential Effects. HHD Continued O&M would not be expected to alter the risk of predation to chinook salmon. Predation is considered to be functioning at risk in the Green River due to sportfishing pressure, tribal harvest, and poaching. The HHD Continued O&M actions will not affect that level of function.

Conservation Measures. Restoration of anadromous fish production to the upper Green River watershed may increase the concentration of predators in the vicinity of the downstream fish passage facility. Juvenile chinook will be released from the fish lock into the mainstem river below HHD in higher concentrations than typically occur under natural conditions. The density of juvenile chinook in fish lock release flows may attract predators such as concentrations of resident cutthroat trout. If concentrations of predators increase under operation of the downstream fish passage facility, a predatory abatement program (i.e. selective hook-and-line removal of predatory fish as described in Corps (1998a)) will be implemented. The intent of the predatory abatement program is to maintain the density of predators to O&M baseline conditions. No other conservation measures have been proposed to reduce the impacts of predation under the proposed action.

5.1.2. Determination of Effect of HHD Continued O&M on Chinook Salmon

Under the Environmental Baseline (without conservation measures), HHD Continued O&M **may affect, and is likely to adversely affect** critical habitat for Puget Sound chinook salmon. The upper Green River watershed, above HHD, was listed as critical habitat for chinook salmon by the NMFS in March 2000. In the absence of upstream fish passage facilities, HHD Continued O&M will prevent adult chinook salmon from accessing historic habitat above HHD. Even if adult chinook salmon were transported above HHD, the lack of downstream fish passage facilities would cause the majority of juvenile outmigrants to be injured or killed during their passage through the HHD project. The lack of fish passage facilities at HHD effectively isolates critical habitat in the upper watershed, and the lack of gravel and woody debris transport past HHD adversely affects critical chinook habitat in the Green River below HHD.

If the proposed conservation and monitoring measures are implemented as described in this PBA, HHD Continued O&M is **not likely to adversely affect** chinook salmon. Ecosystem functions will be improved or restored. Water quality will be maintained or slightly improved. Instream habitat conditions and interactions between species will be improved or maintained.

Assuming Tacoma constructs a fish ladder to the top of their Headworks diversion dam at RM 61.0, construction and operation of a trap-and-haul facility from Tacoma's Headworks to above HHD by the Corps will restore adult fish access to the upper Green River watershed and re-connect habitat historically used by chinook salmon. Tallying the number of fish released and monitoring their distribution and spawning success will ensure that continued operation of HHD will restore properly functioning upstream fish passage at HHD (Table 5-5).

The Howard Hanson reservoir pool up to elevation 1147 feet MSL presents a slack-water area that may hinder the downstream passage of juvenile chinook. The proposed large capacity, surface-oriented fish collector and fish lock will compensate for changes in reservoir level, and the high rate of injury and residualization observed with early reservoir refill will be minimized. Although the design of the fish passage facility will undergo intense review by state and federal fisheries agencies, the actual rate of successful fish passage at the HHD project is difficult to predict. The rate of successful project passage is expected to increase dramatically over O&M baseline conditions, but the project will still present a risk to downstream migration of juvenile chinook (Table 5-5).

5.2 Bull Trout and Dolly Varden

5.2.1. Potential Effects of HHD Continued O&M Environmental Baseline and Proposed Conservation Measures on Bull Trout and Dolly Varden

The effects of HHD Continued O&M on bull trout were evaluated assuming an Environmental Baseline as described in Table 5-1. The effects of the conservation measures of Continued O&M were evaluated assuming the conditions in Table 5-2. The conservation measures and monitoring to be implemented by the Corps for bull trout and Dolly Varden will be the same as those listed in Table 5-3 and described in detail in the following sections.

5.2.1.1 Ecosystem Functions

Potential Effects

The effects of HHD Continued O&M on ecosystem functions will be the same as those described for chinook in Section 5.1.1. HHD Continued O& M will not alter the flow regime in the upper watershed. Downstream of HHD, floods greater than 12,000 cfs will continue to be prevented. Flows in the lower Green River will generally be the same as under the O&M Environmental Baseline except during the spring and fall when refinements by the GRFMC may alter the refill strategy or release remaining in storage to augment fall flows. Fine sediment will continue to accumulate behind HHD, and downstream transport of coarse sediment and LWD will continue to be blocked. Interruption of the supply of sediment and LWD could lead to a coarsening of the bed, isolation of side channels and continued constraint of the river’s ability to form new side channels in the lower Green River below HHD. Floodplain connectivity could be impaired by the increasing isolation of side channels.

Conservation Measures

The effects of conservation measures on ecosystem functions will be the same as those described in described for chinook in Section 5.1.1.1. The GRFMC may recommend changes to the spring refill or fall flow release strategies that could improve conditions for bull trout; however, operational flexibility in the fall would remain limited by the lack of storage. Placement of LWD and gravel downstream of HHD will improve or restore LWD and gravel transport processes, facilitating the retention of spawning gravel, increasing the number and complexity of large pools, and improving existing side channel connectivity and floodplain function. The overall effect of conservation measures proposed under HHD Continued O&M will be to improve ecosystem functions as compared to O&M Environmental Baseline conditions, although some processes will continue to function at risk due to impacts unrelated to HHD Continued O&M.

The overall effect of the Action of ecosystem functions will improve or restore ecosystem function in the lower Green River. However, these improvements may provide only limited benefits to bull trout, temperature conditions are expected to continue to limit use of the lower watershed by bull trout.

5.2.1.2 Water Quality

Potential Effects

The presence of a reproducing, self-sustaining population of native char is unlikely in the Green River below HHD due to warm water temperatures and extensive habitat degradation (i.e., urbanization, roads, logging). Water temperatures in the middle and lower Green River frequently exceed 18ºC during the summer, and often exceed 20ºC (Caldwell 1994). Water temperatures in the Green River at Auburn were found to exceed 18ºC during 46 percent of total hours monitored in August 1992. Water temperatures above 15ºC are believed to limit the distribution of juvenile bull trout (Goetz 1989; Rieman and McIntyre 1993; McPhail and Baxter 1996). Water temperatures in the lower and middle Green River are also likely too warm during the fall and early winter for incubating eggs of native char.

The effects on HHD Continued O&M on water quality will be the same as those described in Section 5.1.2. Water temperatures in the lower watershed are expected to remain high. Dissolved oxygen levels in the middle and lower Green River will continue to be generally satisfactory except in the Duwamish Waterway. HHD Continued O&M is unlikely to effect the saltwater wedge or contaminant levels in the lower Green River, and will not result in increases in TDGs at the HHD outfall. Turbidity could continue to experience periodic increases as a result of HHD flood control or land-use-related inputs.

Low DO levels in the Duwamish waterway and high temperatures throughout the lower river could potentially impair the upstream migration of native char in the Duwamish / lower Green River. Turbidity increases are not expected to impact native char downstream of HHD because of their generally short duration.

Changes in water quality will be similar to those described for chinook in Section 5.1.2.2. Modifications of the intake tower will allow the Corps to withdraw water from cooler portions of HHD reservoir, and the benefits of decreased HHD outflow temperatures would extend several miles downstream of HHD, based upon the results of Caldwell's (1994) temperature study. Increased fall flows resulting from changes in the flow release schedule recommended by the GRFMC could benefit bull trout if they are present in the lower Green River by slightly reducing temperature or DO levels; however improvements will continue to be limited by the lack of storage. Changes in flows are not expected to be substantial enough to alter the location of the saltwater wedge. Potential turbidity impacts resulting from HHD Continued O&M would be mitigated by implementation of the sediment management plan (Appendix A). Continued HHD Continued O&M is not expected to alter the level of contaminants in the lower Green River. The overall effect of the Action would be to maintain water quality parameters that are currently functioning appropriately (TDG), and to maintain or slightly improve water quality parameters that are currently functioning at risk (temperature, DO, saltwater wedge, turbidity and contaminants)

5.2.1.3 Fish Passage

Upstream Fish Passage

Potential Effects. Prior to 1906, the glacially fed White River flowed into what is now called the Green River channel. Native char were commonly observed in the White River, and even after the White River was diverted into the Puyallup River channel, native char continued to be observed in the White River. After the diversion of the White River from the Green however, observations of native char in the Green River became much more infrequent. There is no evidence of a reproducing native char population in the mainstem Green River below HHD at present; observations are limited to solitary adults sighted in the lower river. Despite fisheries surveys conducted by the USFS (USFS 1996), Plum Creek Timber Company (Watson and Toth 1995; Wunderlich and Toal 1992), and City of Tacoma (Hatfield 1986), no native char have been sighted above HHD. Small numbers of native char could be present in cold, spring-fed tributaries of the middle watershed, and since native char distribution is often spotty, there could be small populations in upper watershed tributaries. The lack of upstream fish passage facilities at Tacoma's Headworks diversion and HHD prevents the interaction of native char populations if they are present, and prevents the colonization of upper tributary habitat from populations originating in other basins.

Conservation Measures. The upstream fish passage facilities described in Chapter 5.1.2.3 will provide access to upper watershed habitats for any anadromous salmonids that migrate up the Green River to Tacoma's Headworks. Any native char captured in the trap facility will be transported and released into the upper watershed above HHD.

Downstream Fish Passage

Potential Effects. If native char currently exist in upper headwater tributaries, under O&M baseline conditions their interaction with other populations is hindered by the lack of downstream fish passage facilities at HHD. Any native char moving downstream from upper tributaries during the spring must exit the reservoir prior to mid-March or risk being blocked from project passage by the rising reservoir level. The absence of downstream fish passage facilities contributes to the isolation of populations.

Conservation Measures. The behavior of downstream migrating native char smolts is not well-known, but the proposed downstream fish passage facility described in Chapter 5.1.2.3 is assumed to provide successful passage should native char move downstream through the reservoir and dam. The proposed fish passage monitoring station and associated monitoring efforts will increase the likelihood that native char, if present, will be observed and provide additional information to manage native char populations.

5.2.1.4 Instream Conditions

Potential Effects

Bull trout are able to colonize higher gradient streams than most salmonids (Rieman and McIntyre 1993) and, if present, will likely be able to spawn in all tributaries in the upper Green River which do not have passage barriers. Based upon this assumption, native char could potentially utilize up to 106 miles of mainstem and tributary habitat in the upper Green River. Like chinook, bull trout are fall spawners, however juvenile bull trout generally rear in the river system for at least two years, and may complete their entire life cycle there. It is likely that bull trout would preferentially occupy habitat located in the headwaters of the Green River where temperatures are naturally likely to be coldest. However, anadromous forms of bull trout would be expected to utilize the entire river system during up and downstream migration.

The effects of HHD Continued O&M on bull trout habitat will be the same as those described for chinook in Section 5.1.1.4. Continued O&M will not alter habitat upstream of HHD, where the majority of bull trout spawning and rearing is expected to occur as compared to the O&M environmental baseline. The upstream migration of native would continue to be blocked by Tacoma's Headworks diversion dam and RM 61.0, and by HHD at RM 64.5, and could be adversely impact by high temperatures and DO downstream of HHD that are unrelated to HHD Continued O&M. If native char are present in the Green River, then changes in the spring flow regime could affect the survival of outmigrating juveniles (anadromous forms) in the Green River. Incubating eggs (redds) and rearing fry are unlikely to be present in the lower watershed due to unsuitable temperature and habitat conditions, thus the potential for stranding of fry or redds as a result of alterations in the springtime flow regime is not expected to affect this species.

Conservation Measures

The effects of the Action on instream conditions will generally be the same as those described for chinook in Section 5.2.4. It is assumed that upstream passage of fish will be provided at both the Tacoma's Headworks and HHD (Section 5.1.2.3). Bull trout are able to colonize higher gradient streams than most salmonids (Rieman and McIntyre 1993) and, if present, will likely be able to spawn in all tributaries in the upper Green River which do not have passage barriers. Based upon this assumption, native char could potentially utilize up to 106 miles of mainstem and tributary habitat in the upper Green River, thus adult upstream migration will improve.

The quality of spawning and rearing habitat in the upper watershed not be affected by continued HHD Continued O&M. The quality of spawning and rearing habitat in the lower watershed is expected to improve as a result of LWD and gravel placement; however, bull trout are unlikely to utilize habitat downstream of the Green River gorge for spawning or rearing due to ongoing temperature concerns unrelated to HHD Continued O&M.

Refinements in the refill strategy developed by the GRFMC are expected to result in a pattern of spring flows that more closely mimics natural conditions, resulting in an overall improvement in downstream migration of juvenile bull trout. Implementation of the AWSP is not expected to affect stranding of bull trout redds or fry in the Green River, since none are expected to be present downstream of HHD.

5.2.1.5 Species Interactions

Competition

Potential Effects. Native char are rarely observed in the Green River below HHD. Competition is assumed to be functioning properly (i.e., competitive impacts are minimal) for native char under environmental baseline conditions. The proposed HHD maintenance and operations action would not be expected to change this status.

Conservation Measures. Competition is considered to be functioning properly in the Green River under environmental baseline condition, and no conservation measures have been proposed for this biotic process.

Predation

Potential Effects. Predation is assumed to be functioning at risk for native char due to incidental harvest mortality and poaching. HHD Continued O&M would not be expected to alter this status.

Conservation Measures. No conservation measures are proposed to reduce the impacts of human predation on this native char. Native char, which are a potential predator of juvenile salmon and steelhead, could be captured as part of predator abatement programs (i.e. selective hook-and-line removal of predatory fish) proposed for the section of the Green River between HHD and Tacoma's Headworks. All native char will be immediately released since the numbers captured, if any, will be too low to present risk to overall survival of juvenile salmon and steelhead.

5.2.2 Determination of Effect of HHD Continued O&M on Bull Trout

Under the Environmental Baseline (without conservation measures), HHD Continued O&M **may affect, and is likely to adversely affect** critical habitat for bull trout. In the absence of upstream fish passage facilities, HHD Continued O&M will prevent adult bull trout from accessing habitat above HHD. Although it is unclear whether anadromous bull trout historically used the upper watershed, HHD prevents the extension of their range and expansion of sub-populations. The lack of fish passage facilities at HHD effectively isolates habitat in the upper watershed, and the lack of gravel and woody debris transport past HHD adversely affects bull trout habitat in the Green River below HHD.

If the proposed conservation and monitoring measures are implemented as described in this PBA, HHD Continued O&M is **not likely to adversely affect** bull trout. Ecosystem processes in the lower Green River will be improved or restored. Water quality will be improved or maintained. Instream habitat conditions and interactions between species will be improved or maintained.

The provision of upstream fish passage around HHD will restore the opportunity for colonization of upper watershed habitats by native char from other river systems (Table 5-6). Upstream fish passage also provides for potential interaction of populations in the Green River basin. Transport and release of native char above HHD could establish an anadromous run in the upper Green River above HHD; however, this is unlikely because of the few sightings of native char in the lower river. The proposed downstream fish passage facility at HHD restores potential extension and interaction of native char populations within the Puget Sound area. While the migration characteristics of juvenile native char are assumed to be similar to other salmonids, there remains some risk that behavioral requirements specific to native char may not be met by the design of the proposed facility, or that the facilities may not perform as expected (Table 5-6).

5.3 BALD EAGLE

5.3.1 Potential Effects of HHD Continued O&M Environmental Baseline and Conservation Measures on Bald Eagle

5.3.1.1 Potential Effects of Habitat Alteration

Bald eagles currently perch along the reservoir and feed on fish and waterfowl in the reservoir. They also nest and winter along the Green River below HHD. Bald eagles do not presently roost or nest around the reservoir, but nesting could occur in the future when the existing trees reach sufficient size to support nests. Communal night roosting adjacent to the reservoir is not likely, however, because the area is too open and exposed to wind to provide sufficient thermal cover.

HHD Continued O&M will result in no physical alteration of bald eagle habitat upstream or downstream. There will be no alteration of existing nesting, perching and foraging habitat, and no interference with the development of trees adjacent to the reservoir that could provide nesting habitat in the future. There will be no short-term or long-term effects of habitat alteration on bald eagles under HHD Continued O&M.

5.3.1.2 Potential Effects of Alteration in Prey Availability

The diet of the bald eagle in Western Washington is composed largely of fish and waterfowl. Both types of prey are taken year-round, but adult salmon become particularly important during the winter when eagles congregate along rivers that support anadromous runs. In the Green

River watershed, adult salmon (coho, chinook and chum) and steelhead are available seasonally below Tacoma Water's headworks facility (RM 61.0), while waterfowl are present in limited numbers year-round above and below HHD. The availability of waterfowl in the watershed probably peaks during the winter on the HHD reservoir, where up to 200 ducks have been reported. Resident fish are also available above and below HHD, and probably contribute to the diet of nesting bald eagles in the watershed.

HHD Continued O&M will influence the abundance of anadromous fish in the Green River watershed, and have resulting effects on bald eagles. Fish abundance will be affected by efforts to reintroduce anadromous runs above the dam, and the construction of a downstream fish passage facility at HHD. The four anadromous fish species are addressed separately in the following discussion.

Coho Salmon

The coho salmon is the most abundant anadromous fish species in the Green/Duwamish basin (King County Planning Division 1978). Adult coho spawn in the Green River from September through January, generally in tributaries and side channels. Fry emerge from March through June and rear in side channels and pools of the mainstem and its tributaries for one year before migrating down to the Duwamish estuary and out to Puget Sound.

The coho run in the mainstem Green River and Soos Creek averaged 14,950 fish from 1982 to 1991, with an estimated average escapement of 2,970, indicating stable escapement and production levels (WDFW et al. 1994). In contrast, the Newaukum Creek stock has been classified as depressed because of short-term declines in escapement (WDFW et al. 1994). Hatchery fingerlings have been planted above HHD since 1983, but fry-to smolt survival rates for these planted fish have been lower than other watersheds (Dilley and Wunderlich 1993). The lower survival of the planted fish is probably a result of high stocking and low survival (25% or less) among smolts migrating through HHD and the reservoir (Corps 1998a).

The coho salmon is a federal species of concern in Washington. A preliminary stock status review concluded that listing was not warranted (WDFW 1997a), but listing could occur in the future if overall population declines continue.

Trapping and hauling of adult coho salmon under conservation measures proposed for HHD Continued O&M would provide access to suitable spawning habitat in the upper watershed. The net effect will be an opportunity to increase the number of adult coho salmon throughout the Green River during the spawning season (September through January), particularly in the upper watershed which is currently in accessible to adult coho.

Chinook Salmon

Adult chinook spawn in the Green River from August through November, with peak spawning in September and October. Spawning generally occurs in the mainstem from RM 28 to the Tacoma Water headworks, and in the larger tributaries along that reach. Chinook fry emerge from January through March and rear in side channels and pools of the mainstem for days to months

Insert Table 5-6

before migrating down to the Duwamish estuary and out to Puget Sound. Peak emigration occurs from March to June.

Adult chinook salmon returns to the Green River and its tributaries averaged 7,600 from 1987 to 1992, with an increasing trend (WDFW et al. 1994). The runs have met escapement goals (5,800 fish) in the recent past, but harvest has been severely curtailed due to lower than expected smolt-to-adult survival rates. Stock status is rated healthy. Since 1983, hatchery fingerlings have been planted above HHD. Fry-to smolt survival rates for these planted fish have been lower than other watersheds (Dilley and Wunderlich 1993). The lower fry-to-smolt survival rates are probably a result of high stocking rates and low survival rates of smolts migrating through HHD and the reservoir. Historically, an unknown number of chinook salmon spawned in the upper watershed. An estimated 100 to 400 adult chinook were captured at the Tacoma Water headworks after its completion from 1911 to 1913 (Grette and Salo 1986). Currently, there is no established escapement goal for the upper Green River. The Puget Sound, Lower Columbia River and Upper Willamette River chinook salmon stocks were listed by NMFS as threatened on March 24, 1999 (64 FR 14308).

Trapping and hauling of adult chinook salmon under continued O&M will provide access to suitable spawning habitat in the upper watershed. The net effect will be an opportunity to increase the number of adult chinook salmon throughout the Green River during the spawning season (August through November), particularly in the upper watershed which is currently in accessible to adult chinook salmon.

Chum Salmon

Adult chum salmon migrate up the Green River from early November to the first week of December. Spawning occurs from mid-November through December in the mainstem Green River between Burns Creek and Crisp Creek (WDFW et al. 1994). Recent surveys have found spawners up to RM 45 in side channels of Flaming Geyser State Park. Muckleshoot Tribal biologists surveyed the Green River during 1996 and reported significant chum spawning in side channels in the middle and lower Green River reaches. Chum fry emerge from mid-February to July and rear from days to weeks in side-channel and mainstem backwater habitats. Peak downstream migration of chum salmon fry occurs from late March through May.

Puget Sound chum salmon are a federal species of concern under the ESA. A preliminary stock status review determined that listing was not warranted for Puget Sound fall/summer/winter chum salmon (WDFW 1997a). Two chum stocks are recognized in the Green River system (WDFW et al. 1994). The Crisp (Keta) Creek fall chum stock originated from releases of Quilcene and Hood Canal stocks from the Keta Creek hatchery in the early 1980's. This stock is considered healthy. The Duwamish/Green stock has been considered a remnant native stock, but their status is unknown.

Chum salmon will not be targeted for transport above HHD, so continued O&M of the project will not affect chum salmon use of habitat in the upper watershed. Conservation measures, such as gravel nourishment and woody debris transport below HHD, are expected to improve the quality and availability of chum salmon spawning habitat in the lower Green River.

Winter Steelhead

Steelhead are differentiated into two types, winter and summer. They share common juvenile behavior patterns, but are distinguished by the timing of adult returns. Winter steelhead adults return to the Green River from November through early June, while summer adults return from April through November (Caldwell 1994). Winter steelhead are native to the Green River, but summer steelhead are of Skamania River origin and are primarily maintained by hatchery plants. Winter steelhead spawn from January through June, with the peak in spawning in April and May. Spawner escapements for wild winter steelhead have been close to or exceeded goals (2,000 fish) in most years, and the status of the stock is healthy. A limited number of summer steelhead spawn in the Green River, usually from mid-January to early April. Many of these fish spawn below the Palmer rearing ponds at RM 56. A significant difference between steelhead and Pacific salmon is that not all steelhead die after spawning, and those that do not die are capable of repeat spawning. Repeat spawning in Washington ranges from of 4.4 to 14.0 percent of total spawning runs (Wydoski and Whitney 1979).

Both winter and summer juvenile steelhead rear in freshwater for one to two years (mostly two) before migrating to the ocean. Juvenile downstream migration occurs from April through July, with peak migration in mid-April. Since 1982, hatchery fingerlings have been planted above HHD. Fry-to smolt survival rates for these planted fish have not been estimated, but probably follow the trend for coho and chinook salmon, which have been lower than other watersheds (Dilley and Wunderlich 1993). The lower fry-to-smolt survival rates are probably a result of high stocking rates and low survival rates (<25%) of smolts migrating through HHD and the reservoir. An estimated 500 to 5,200 adult steelhead were captured at the Tacoma Water headworks after its completion from 1911 to 1913 (Grette and Salo 1986). Since 1991, a temporary fish trap has been operated at the headworks. These fish are either released above HHD for natural spawning, or a select few are used to rear fry for outplanting in the upper watershed. Currently, there is no established escapement goal for the upper Green River.

Puget Sound steelhead are a federal species of concern under the ESA. A stock status review concluded that Puget Sound steelhead presently are not warranted for listing.

Trapping and hauling of adult steelhead under continued O&M will provide continued access to suitable spawning habitat in the upper watershed. Construction of a downstream fish passage facility at HHD will increase outmigrant survival from 9 percent to an estimated 90 percent. The net effect will be an increase in the number of adult steelhead throughout the Green River during the spawning season (January through June), particularly in the upper watershed where the species is presently absent.

The net effect of increasing fish numbers in the Green River watershed will be increased food supply for bald eagles, particularly during the winter. In the short term, salmon from the proposed Muckleshoot Tribal Fish Restoration Facility may be released into the upper watershed to facilitate reestablishment of a natural run. In the long term, efforts to reintroduce salmon and steelhead to the upper watershed could support increased adult spawner escapements. These adult fish will be available to wintering bald eagles and other scavengers, and those that are not consumed directly will provide nutrients to the upper watershed that may improve the productivity of resident fisheries. Nesting bald eagles above and below HHD may also feed on adult salmon, but they are more likely to benefit indirectly through increased productivity of the resident fishery, since the timing of the salmon runs excludes a key portion of the nesting season (late spring and early summer). Increased numbers of salmon in the upper watershed could eventually result in increases in the population of both nesting and wintering bald eagles above and below HHD.

5.3.1.3 Potential Effects of Human Activity and Disturbance

Human activity associated with continued O&M will have no effect on individual bald eagles or on the Western Washington population of bald eagles. Construction of the downstream fish passage facility will be several miles from the nearest bald eagle nest, and it will affect no known winter roosts or foraging perches. Construction-related blasting, the use of heavy equipment, vehicle traffic and human presence will have no effect on resident or wintering bald eagles.

Future human activity under HHD Continued O&M will be limited to daytime use of the reservoir and the roads in the upper watershed. Bald eagles may be briefly encountered perching along the reservoir or adjacent to streams where salmon are present, but the frequency and duration of human activity associated with the project will not be sufficient to cause more than occasional and brief flushing by the birds. No areas of important use (i.e., nests, winter roosts or key foraging areas) will be affected.

5.3.1.4 Conservation Measures

There will be no conservation measures under HHD Continued O&M specifically to benefit bald eagles.

5.3.2 Determination of Effect of HHD Continued O&M on Bald Eagle

The HHD Continued O&M is **not likely to adversely affect** the bald eagle. Increases in the number of adult salmon in the upper watershed during the winter will increase the food source for wintering bald eagles, with resulting benefits to individual bald eagles inhabiting the watershed as well as to the overall population in Western Washington.

5.4 NORTHERN SPOTTED OWL

5.4.1 Potential Effects of HHD Continued O&M Environmental Baseline and Conservation Measures on Northern Spotted Owl

5.4.1.1 Potential Effects of Habitat Alteration

HHD Continued O&M will cause no alteration of suitable spotted owl habitat. There will be no habitat associated short-term or long-term effect on individual spotted owls, or on the overall population of spotted owls in the Western Washington Cascades.

5.4.1.2 Potential Effects of Human Activity and Disturbance

Human activity in the Upper Green River Watershed associated with the HHD Continued O&M will have no effect on individual spotted owls or on the Western Washington Cascades population of spotted owls in the short term or long term. Construction of the downstream fish passage facility will occur within the next decade (prior to 2010), during which time spotted owls are unlikely to nest any closer than 7 miles from HHD because of the absence of suitable habitat. Construction-related blasting, the use of heavy equipment, vehicle traffic and human presence will have no effect on resident spotted owls at that distance. Future human activity associated with the project will be limited to daytime use of the reservoir and the roads in the upper watershed. Spotted owls are unlikely to nest or roost adjacent to the reservoir or along roads, so daytime activity in these areas will have no effect on the species.

5.4.1.3 Conservation Measures

No conservation measures will be implemented to directly benefit spotted owls under the HHD Continued O&M.

5.4.2 Determination of Effect of HHD Continued O&M on Northern Spotted Owl

The HHD Continued O&M will have **no effect** on the northern spotted owl. The project will not alter suitable spotted owl habitat, and it will not result in human activity in or around nesting or roosting habitat.

5.5 MARBLED MURRELET

5.5.1 Potential Effects of HHD Continued O&M Environmental Baseline and Conservation Measures on Marbled Murrelet

5.5.1.1 Potential Effects

HHD Continued O&M will cause no short-term or long-term impact to marbled murrelets, marbled murrelet nesting habitat, or the population of marbled murrelets in Recover Zone 1. No suitable marbled murrelet habitat will be removed or modified as a result of HHD Continued O&M.

From the limited information that is available concerning disturbance to nesting marbled murrelets, it appears that human activities do not adversely impact nesting murrelets unless they produce a sudden loud noise or are conducted close to a nest. Operation and maintenance of HHD primarily involve human activity around the dam (including vehicle traffic, human presence, and operation of power equipment) and boat operation on the reservoir. These activities do not produce sudden loud noises that would be expected to disturb nesting murrelets. Normal O&M activities are not conducted within forest stands or close to murrelet nests.

5.5.1.2 Conservation Measures

Since there will be no modification of suitable marbled murrelet habitat or disturbance to nesting murrelets, no conservation measures are proposed to protect marbled murrelets.

5.5.2 Determination of Effect of HHD Continued O&M on Marbled Murrelet

HHD Continued O&M is **not likely to adversely affect** the marbled murrelet.

5.6 GRIZZLY BEAR

5.6.1 Potential Effects of HHD Continued O&M Environmental Baseline and Conservation Measures on Grizzly Bear

5.6.1.1 Potential Effects

HHD Continued O&M may have a positive impact on the grizzly bear by increasing the seasonal food supply in the upper watershed. The Tacoma Water headworks dam currently blocks access by anadromous fish to the upper Green River watershed. Steelhead are currently trapped at the headworks and hauled around HHD, but salmon are not. As described in detail in Section 5.3.1.2 of this PBA, the Corps and Tacoma Water will trap and haul coho salmon and chinook salmon in addition to steelhead in the future, thereby making the upper watershed accessible to salmon first time in several decades. The Corps also will construct a downstream fish passage facility at HHD to improve survival of outmigrants and increase the long-term productivity of salmon runs in the upper watershed. The net result will be increased numbers of adult salmon in streams of the upper watershed during the spawning season, when they can be eaten by the bears.

Human disturbance from O&M will not have any short-term impact on individual grizzly bear or the grizzly population in the Washington Cascades. Currently, no grizzly bears are known to use the Green River watershed, and the estimated population for the North Cascades ecosystem is very low (10 to 20 animals) (section 3.7). Grizzly bear have large home ranges (50 to 500 square miles depending on sex).

The dam and reservoir lie south of Interstate 90 and the North Cascades Recovery Zone for grizzly bear, where recovery efforts will be concentrated. If recovery efforts are successful, grizzly bears may expand outside the recovery zone and use the upper Green River watershed in the future. If this occurs, the low level of human activity associated with the HHD Continued O&M could result in potential grizzly bear disturbance over the long term. Most of the O&M activity is conducted in close association with the HHD facility. The HHD facility is closely associated with mainline roads, both north and south of the river, that carry most of the traffic in the basin and a railroad line. The majority of the traffic along the roads and railroad are not associated with HHD, and extend further throughout the basin that the O&M activities. Disturbance from HHD Continued O&M will be negligible in comparison to the more dispersed disturbance from road and rail traffic.

Activities on the reservoir are the second most significant sources of grizzly bear disturbance. Periodic use of boats on the reservoir to manage woody debris and monitoring could disturb grizzly bear in the early spring, when they may be expected to forage in the vicinity of the reservoir. Later in the year grizzly bears will move to higher elevations, away form the reservoir. The density of roads and road use around the reservoir would reduce the likelihood that grizzly bear would use the are and thus be disturbed by activities on the reservoir.

5.6.1.2 Conservation Measures

There are no conservation measures designed to benefit grizzly bear habitat or to protect grizzly bear from disturbance, since grizzly bear are not known to occur in the Green River basin, and HHD is so closely associated with other human activities. However, it is reasonable to assume that the continued HHD Continued O&M will require restoration of anadromous fish runs in the upper basin. Up to approximately 10,100 adult salmon and steelhead will be released above HHD (Section 5.1.2.3) and will provide improved potential foraging opportunities for grizzly bear.

5.6.2 Determination of Effect of HHD Continued O&M on Grizzly Bear

HHD Continued O&M is **not likely to adversely affect** the grizzly bear.

5.7 GRAY WOLF

5.7.1 Potential Effects of HHD Continued O&M Environmental Baseline and and Conservation Measures on Gray Wolf

5.7.1.1 Potential Effects

HHD Continued O&M will have no short-term or long-term impacts on gray wolves or their habitat. There are no known gray wolves in the Green River watershed, and HHD Continued O&M will not adversely impact terrestrial habitat. If gray wolves are found in the Green River watershed in the future, HHD Continued O&M will not disturb gray wolves at den or rendezvous sites. Human activity in the vicinity of HHD and the reservoir (e.g., forest management, road traffic, railroad traffic) that is not related to the project will likely prevent gray wolves from establishing dens or rendezvous sites in the vicinity of the project.

5.7.1.2 Conservation Measures

There are no conservation measures designed to benefit gray wolf habitat or to protect gray wolves from disturbance, since gray wolves are not known to occur in the Green River basin and HHD is so closely associated with other human activities.

5.7.2 Determination of Effect of HHD Continued O&M on Gray Wolf

HHD Continued O&M will have **no affect** the gray wolf.

5.8 CANADA LYNX

5.8.1 Potential Effects of HHD Continued O&M Environmental Baseline and Conservation Measures on Canada Lynx

5.8.1.1 Potential Effects

The current geographic range of the Canada lynx does not include the Green River watershed, even though individuals may occasionally travel through the area (Section 3.8). Activities associated with HHD Continued O&M are well below the elevation of known lynx occurrence, and are not expected to have any short-term or long-term impacts to individual lynx, lynx habitat, or the lynx population in the Washington Cascades.

5.8.1.2 Conservation Measures

Since habitat known to be occupied by lynx will not be impacted by continued O&M activities, no conservation measures are provided to benefit the Canada lynx.

5.8.2 Determination of Effect of HHD Continued O&M on Canada Lynx

HHD Continued O&M will have **no effect** on the Canada lynx.

CHAPTER 6.0
POTENTIAL IMPACTS OF THE ADDITIONAL WATER STORAGE PROJECT ON LISTED SPECIES

6.1 DESCRIPTION OF THE ADDITIONAL WATER STORAGE PROJECT (AWSP)

The HHD AWSP was initiated by the Corps in response to a request from Tacoma in August 1989 to address the water supply needs of Pierce and King County residents; it was expanded in 1994 to include environmental (ecosystem) restoration objectives. The AWSP has completed the Environmental Impact Statement process and the Record of Decision will be filed when the Section 7 process is completed. (Corps 1999). Phase I of its implementation is being assumed for purposes of this PBA. The primary structural change to be made in Phase I will be the addition of a downstream fish passage facility. Other modifications proposed in the AWSP include: remediation of right abutment drainage; new access bridge and access road; and new buildings or additions to existing buildings including an administration, a maintenance, a monitoring facility, and a generator building.

The proposed fish passage facility (Figure 6-1) would be a new structure that is intended to pass migrating juvenile fish and steelhead kelts downstream through HHD. It is not intended to pass migrating adult fish upstream through the dam. Adult fish would be trapped downstream of HHD at the Headworks and transported for release above HHD via a proposed trap-and-haul operation. Currently, the entire Green River flow must pass through the existing outlet works intake structure. Upon completion of the new fish passage facility, which will be located adjacent to the existing outlet works, flows will pass through either the existing intake structure or the new fish passage facility. The new fish passage facility is designed to pass the median daily flow for the period March through May ($\underset{\sim}{}$1,250 cfs).

The main features of the fish passage facility are:

- new intake tower;
- wet-well;
- fish collector;
- fish lock;
- discharge conduit; and
- fish transport pipeline.

Prior to the AWSP, reservoir refill began in March, refilling to a maximum pool elevation of 1,147 feet, assuming 5,000 ac-ft of water stored for debris removal operations or low-flow augmentation. At this conservation pool level, the reservoir impounded 25,400 ac-ft and covered about 850 acres. Under the AWSP Phase I, the reservoir will begin to fill on February 15 to a maximum pool elevation of 1,167 feet to provide summer and early fall low-flow augmentation and M&I water supply. At full conservation pool level, the summer/fall reservoir will impound a total of 50,400 ac-ft (25,400 ac-ft under previous operation and under AWSP Phase I, 20,000 ac-ft for M&I water supply and 5,000 ac-ft for low-flow augmentation).

Insert Figure 6-1

Implementation of the AWSP would result in the additional inundation of about 300 acres of terrestrial and wetland habitats (including 79 acres of riparian and 11.5 acres of stream habitat). Most plants in the inundation zones would die during the first season of inundation, although a few species of plants that are more tolerant of inundation would survive for a longer period. As currently planned, trees will be left in the new inundation zone. In addition, to ensure that suitable perches will be maintained for raptors, dead snags would be retained and allowed to fall as they rot.

Two adverse impacts to anadromous fish were identified under the AWSP feasibility study resulting from storing 20,000 ac-ft of the SDWR during the winter and spring. These impacts within the project boundary from increased pool size are: 1) potential decreased survival of a proportion of juvenile salmon and steelhead migrating through the larger pool, and 2) stream and riparian habitat inundated by the pool raise. The AWSP presumes there will be no impacts to the lower watershed during spring refill since storage uses water (SDWR) that Tacoma would have otherwise diverted from the mainstem river between February and June. Tacoma addressed the impacts associated with spring time exercise of the SDWR in an HCP submitted to the Services in January 2000.

The AWSP includes Ecosystem Restoration as a project purpose. A series of aquatic habitat limiting factors have been identified in the Green/Duwamish Basin that the AWSP could address. These include: 1) reconnection of the Upper and Lower Green River with fish passage over and/or through the Tacoma Diversion Dam and HHD; 2) low flows during summer and fall; 3) water temperatures that exceed state water quality standards; 4) lack of large woody debris in tributary and mainstem areas; and 5) reduction of peak flows with reduced sediment transport. The AWSP includes a series of restoration projects (habitat improvement authorized as project components) that address part(s) of each of these limiting factors:

- <u>Downstream Fish Passage.</u> A new intake tower with new fish collection and transport facility (capable of passing up to 1250 cfs within NMFS screening criteria) would be built including: a wet-well, a fish collector, a fish lock, a discharge conduit, a fish transport pipeline, monitoring station and equipment. The facility will be adaptively managed based on project monitoring and evaluation. A 10-year reservoir and dam monitoring program is proposed. Upstream fish passage will be provided by Tacoma with a trap-and-haul facility at the diversion dam beginning as early as 2003 (Corps 1998a).
- <u>Low-Flow Augmentation.</u> The AWSP provides for yearly storage of the 5,000 ac-ft under the HHD Section 1135 project. The 5,000 ac-ft is currently planned for use during drought conditions which occur approximately once every five years.
- <u>High Water Temperatures.</u> The new fish passage facility provides for withdrawal of water at selected depths near the thermocline which will ameliorate existing high temperatures resulting from dam discharges from deep water depths. Outflow releases will track the natural ambient rise and fall of seasonal temperature change. In the lower river, LFA can provide increased flow volume and velocities that can improve near-shore temperatures and intergravel flow.
- <u>Lack of Large Woody Debris</u>. Habitat improvements above HHD include addition of large woody debris to mainstem and large tributaries of the Green River above HHD. Below HHD the Corps is proposing to truck and release, at RM 59, an underdetermined number of pieces

of large wood collected out of HHD Reservoir. Lastly, a ¾ mile long side-channel will be restored and reconnected to the mainstem between RM 58-59. Several hundred pieces of large woody debris would be added to this off-channel habitat.

- Sediment Transport. Since construction of HHD, peak flows have been reduced from 30,000 cfs to a maximum 12,000 cfs with a concurrent reduction of coarse sediment transport due to storage of larger particles behind HHD at a rate of 3,900-11,700 cu yd/year. This reduction in sediment transport has already degraded spawning habitat from HHD to Flaming Geyser and is continuing to degrade spawning habitat (through bed armoring) in the lower Green River (RM 40-46) at a rate of 700-1,000 lineal feet of mainstem habitat per year (Fuerstenberg et al. 1996). Annual placement of 3,900 cubic yards would occur below Tacoma's Diversion Dam to reinitiate sediment transport in the Palmer area.[8]

Analyses of the effects of the proposed AWSP were conducted by comparing the Green River flow regime under two scenarios: Environmental Baseline conditions and the flow regime under the proposed AWSP. The Environmental Baseline condition used to evaluate effects of the AWSP differs from existing conditions as described in Chapter 4 in order to isolate impacts that result solely as a result of actions undertaken by the Corps.

Environmental Baseline conditions for the AWSP consist of Green River flows without AWSP based on 1996 operations, but with Tacoma Water withdrawals under the FDWRC and SDWR and storage under the Section 1135 Project only during drought years. Green River flows under the AWSP Environmental Baseline were modeled assuming the conditions listed in Table 6-1.

Under the AWSP Environmental Baseline scenario, any water stored behind HHD is used for low flow augmentation and no water is stored for municipal use. A separate Section 7 consultation has been completed for the HHD Section 1135 Fish and Wildlife Restoration Project which authorizes storage of an additional 5,000 ac-ft of water for low flow augmentation initially during drought years, thus this activity is considered a baseline condition for the AWSP. It is also assumed that Tacoma will withdraw 113 cfs under the FDWRC on a daily basis and up to 100 cfs under the SDWR at the Headworks. The amount of water available under the SDWR is constrained by minimum flow levels specified in the MIT/TPU Agreement. TPU was granted a permit, under Section 404 of the Clean Water Act, to construct Pipeline No. 5, which will carry Tacoma's SDWR. Construction is scheduled to be complete by 2003, before the HHD AWSP is scheduled to be implemented, thus this activity is considered part of the AWSP baseline. Impacts resulting from Tacoma's exercise of their FDWRC and SDWR have already been mitigated for, or are being considered for ESA compliance through a Habitat Conservation Plan (HCP) that Tacoma is currently pursuing. The effect of these actions will be further addressed in the discussion of cumulative effects.

[8] If the Green-Duwamish GI Study does not provide 4,000 cubic yards at Flaming Geyser, then the Corps and Tacoma may elect to move their planned gravel placement to that location.

Table 6-1
Assumptions Affecting Green River Flows Under
Howard Hanson Dam – Additional Water Storage Project
Environmental Baseline Conditions (Without Conservation Measures)

– 1996 HHD operations without the AWSP(1);
– Operation of HHD by the Corps to prevent flows at Auburn from exceeding 12,000 cfs;
– Storage and release of 24,200 ac-ft of water by the Corps to satisfy a minimum flow of 110 cfs at Palmer when water is available in the conservation pool (i.e., not during the winter flood control season);
– Storage of up to 5,000 ac-ft of water by the Corps on an annual basis (Modeling runs for the AWSP Environmental Baseline assumed that up to 5,000 ac-ft of water would be stored every year. During drought years, the stored water would be gradually released to augment low summer flows. Water stored during average and wet years would be quickly released over the next few weeks, once debris collection is completed.(2));
– Operation of HHD by the Corps using a 1996 refill scenario; reservoir refill starting on March 15, a constant refill rate of 200 cfs March 15 to April 15 and a 400 cfs refill rate from April 16 to May 31;
– Withdrawals by Tacoma of up to 113 cfs at their Headworks under the FDWRC on a daily basis (as constrained by MIT/TPU Agreement);
– Withdrawals by Tacoma of up to 100 cfs at their Headworks under the SDWR when flows permit (as constrained by MIT/TPU Agreement);
– No downstream fish passage facility; and
– Limited ability to regulate the temperature of flow releases due to the lack of a multi-level outlet to control water temperatures.

Notes:
(1) Operation of HHD during 1996 is used to maintain consistency with the AWSP Environmental Impact Statement (Corps 1998a).
(2) Under the adaptive management provisions of the Section 1135 Project, the frequency, volume (up to 5,000 ac-ft), and duration of storage can be modified on an annual basis.

The flow regime under the proposed AWSP was developed assuming all facilities of the AWSP were constructed and operating. Under the proposed AWSP, the Green River flow regime was assumed to reflect the conditions listed in Table 6-2.

Table 6-2 Assumptions Affecting Green River Flows Under Howard Hanson Dam – Additional Water Storage Project With Proposed Conservation Measures
– Operation of HHD by the Corps to prevent flows at Auburn from exceeding 12,000 cfs; – Storage and release of 24,200 ac-ft of water by the Corps to satisfy a minimum flow of 110 cfs at Palmer when water is available in the conservation pool (i.e., not during the winter flood control season); – Storage of up to 5,000 ac-ft of water by the Corps on an annual basis[(1)]; – Operation of HHD by the Corps modeled using a refill scenario involving reservoir refill starting on February 15, a constant refill rate of 180 cfs February 15 to February 28, 400 cfs March 1 to March 31, 300 cfs April 1 to April 30, and 200 cfs refill rate from May 1 to June 30 or until conservation pool is achieved; – Operation of HHD by the Corps using management of dedicated and non-dedicated blocks of water and storage to provide the opportunity to store water using a proportional capture guideline in response to input from the GRFMC; – Withdrawals by Tacoma of up to 113 cfs at their Headworks under the FDWRC on a daily basis (as constrained by MIT/TPU Agreement); – Storage of up to 20,000 ac-ft of SDWR water behind HHD by the Corps between February 15 and June 30 at a rate of up to 100 cfs a day when flows permit; – Withdrawals of up to 100 cfs of SDWR water by Tacoma at their Headworks when flows permit (as constrained by MIT/TPU Agreement) and SDWR water is not being stored or released at HHD; – Withdrawals of up to 100 cfs a day by Tacoma at their Headworks when stored M&I water available under the SDWR is released from HHD; – Operation of a downstream fish passage facility at HHD; and – Increased ability to regulate the temperature of flow releases through construction of a multi-level intake as part of the downstream fish passage facility.
Note: (1) Under the AWSP, water stored during drought, average and wet years is available for downstream fisheries benefits such as augmenting flows during late June and July to protect steelhead incubation, or fall flow augmentation for chinook salmon spawning.

Table 2-3 of this PBA identified the activities associated with the AWSP that are being evaluated for "take." Those activities are described below and the effects on listed species are discussed in Sections 6.2 through 6.9, inclusive. In addition, a suite of conservation measures and monitoring programs to be implemented to address potential effects associated with the AWSP are summarized in Table 6-3.

Table 6-3 Chinook Salmon Conservation Measures and Monitoring to be Implemented by the Corps Under the AWSP		
Issue	**Measure**	**Monitoring**
Ecosystem Functions		
Flow Variations	HHD non-dedicated storage and flow management strategy provides opportunity to manage water storage and release at HHD to minimize impacts to salmonids.	Install up to three snow pillows in the upper Green River basin to monitor snowpack and precipitation and improve flow forecasting
	Modular Inclined Screen (MIS) capacity provides increased flow management flexibility	Install and operate a rotary screw trap at RM 34 to monitor downstream migration of juvenile salmonids
Gravel Transport	Place 3,900 cubic yards of gravel downstream of HHD	Use periodic aerial photo surveys to monitor the area of gravel bars between placement sites and RM 34
		Monitor changes in bed elevation, channel capacity and substrate size at selected cross-sections
	Place up to 4,100 cubic yards of gravel downstream of HHD under Section 7[(1)]	As above
	Implement Sediment Management Plan (to be developed)	To be developed
Fine Sediment Transport	Implement Sediment Management Plan (to be developed)	To be developed
	Reservoir slope stability	Install inclinometers in headwall of Charley Creek landslide to assess the effect of the increased reservoir pool elevation on the stability of a known deep-seated landslide
Wood Transport	Implement woody debris management plan as described in TPU HCP (Tacoma 1999)	Survey the Green River from Tacoma Headworks to Highway 18 (RM 34) to identify the distribution and frequency of LWD
		Monitor stability and effectiveness of anchored LWD (if applicable)
Channel Morphology	See gravel and wood transport	See gravel and wood transport
Floodplain Connectivity	See flow variations	Monitor physical side channel connectivity and habitat quality, and salmonid use of lateral habitats
Water Quality		
Temperature	Construct intake to allow selective withdrawal from various reservoir levels	Monitor temperature up and downstream of HHD
Dissolved Oxygen	None needed	None needed
Saltwater Wedge	None needed	None needed
Total Dissolved Gas	Verify that existing condition is functioning properly	Measure TDG of outflow
Turbidity	See fine sediment	See fine sediment
Contaminants	None needed	None needed

Table 6-3 Chinook Salmon Conservation Measures and Monitoring to be Implemented by the Corps Under the AWSP		
Issue	**Measure**	**Monitoring**
Fish Passage		
Upstream Fish Passage	Adult salmon trap and haul program from below Tacoma Headworks to above HHD provided by City of Tacoma.	Compliance $; confirm adults find and enter facility
		Monitor mortality in trap/transit
		Monitor daily number and species transported and release sites
		Conduct spawner surveys in upper watershed
Downstream Fish Passage	Construct/operate downstream fish passage facility at HHD to elevation 1177 ft MSL(2). MIS capacity designed for median springtime smolt migration flow	Monitor movement of juvenile fish into reservoir by seasonal installation of a trap and/or net in the upper mainstem Green River and tributaries above HHD
		Monitor reservoir passage and survival, fish passage facility survival and fish collection efficiency
		Conduct paired PIT tag release and detection study to monitor reservoir passage and survival, fish passage facility survival and fish collection efficiency
		Monitor condition of fish passing through fish passage facility
		Deploy fixed hydroacoustics in forebay, fish passage facility horn and wetwell; conduct mobile hydroacoustic surveys and gillnetting in reservoir; place transducers in passage facility.
		Mark and recapture juvenile salmonids to quantify capture efficiency of sampling station
		Monitor water quality and zooplankton in HHD reservoir
Instream Conditions		
Spawning/Incubation	See gravel transport	See gravel transport
	See upstream fish passage	Conduct spawner surveys in upper watershed
	See flow variation	Lower Watershed - Conduct spawning surveys in lateral habitats and restoration sites in lower watershed
Rearing	See wood transport	See wood transport
	Re-connect and rehabilitate 3.4 acres of off-channel habitat in Signani Slough (RM 60)	Monitor structural stability, habitat quality and utilization

Table 6-3 Chinook Salmon Conservation Measures and Monitoring to be Implemented by the Corps Under the AWSP		
Issue	**Measure**	**Monitoring**
	Rehabilitate fish and wildlife habitat in the reservoir inundation zone, riparian areas upstream and downstream of HHD	Monitor structural stability, habitat quality and utilization
	Rehabilitate habitat in mainstem Green River and selected larger tributaries	Monitor structural stability, habitat quality and utilization
Instream Adult Migration	See upstream migration and flow variations	See upstream migration and flow variations
Instream Juvenile Migration	See downstream migration	See downstream migration
	See flow variations	Install and operate a rotary screw trap at RM 34 to monitor downstream migration of juvenile salmonids
Stranding and Trapping	None needed	None needed
Species Interactions		
Competition	None needed	None needed
Predation	Implement predator abatement program (if necessary)	Monitor concentrations of predatory fish at migratory transition areas

Notes:
(1) If the Green-Duwamish GI does not place gravel at Flaming Geyser, AWSP gravel would be used at Flaming Geyser, and Corps Section 7 responsibility under the ESA would be increased to 8,000 cubic yards.
(2) The AWSP was staged to allow Phase I (storage to 1,167 ft) to proceed while the potential environmental effects of Phase II (storage up to 1,177 ft) are identified through monitoring. Although only Phase I of the AWSP will be implemented at this time, the HHD structure will be modified to provide downstream fish passage at pool elevations up to 1,177 ft.

6.2 CHINOOK SALMON

6.2.1 Potential Effects of the AWSP Environmental Baseline and Proposed Conservation Measures on Chinook Salmon

The effects of the HHD-AWSP on chinook salmon were evaluated assuming Environmental Baseline conditions and Green River flows as described in Table 6-1. Conservation measures proposed to offset environmental impacts associated with AWSP Environmental Baseline operations involve structural and operational changes to HHD, and Green River flows resulting from these conservation measures were modeled as described in Table 6-2. The effects of the Environmental Baseline and proposed conservation measures (Table 6-3) on chinook salmon vary by ecosystem function and by specific life history stage and are described in the following sections.

6.2.1.1 Ecosystem Functions

Flow Variation

Potential Effects. The seasonal distribution of flows in the Green River under the AWSP Environmental Baseline is typical of other western Washington basins, with high flows in the fall and winter, and low flows in the late summer and early fall (Figure 6-2). The Index of Hydrologic Alteration (IHA) parameters discussed in Section 4 were generated for both AWSP baseline and for the AWSP and are presented in Table 6-4. Under the AWSP baseline, flows greater than 12,000 cfs at the Auburn USGS gage are prevented. The modeled average annual three-day maximum flow is 7,237 cfs. Average daily flows by month range from 2,108 cfs in January to 331 cfs in August. Under baseline conditions, spring flows at the USGS Auburn (February through June) declined steadily, from 1,964 cfs in February to 989 cfs in June. The average 3-day low flow during the latter portion of this period (1 April and 31 May) is 870 cfs. Three or four high flow pulses greater than 2,512 cfs occur annually, generally lasting for about four days. Monthly flows are generally lowest in August (331 cfs), although the annual three-day minimum generally occurs in the first week of September, and averages 287 cfs. There is generally at least one period of flows less than 300 cfs each fall (September 1 to January 30). Flows in the Green River under the AWSP Environmental Baseline are considered to be functioning at risk (Table 6-5) due to diversion of the White and Black rivers, flood control operations, water withdrawals and changes in the flow regime resulting from urbanization and forest management.

Conservation Measures. Implementation of the AWSP will provide increased operational flexibility to manage flows such that they more closely match the natural flow regime, or provide benefits to specific aquatic species or life stages. As described for continued operations and maintenance, water in non-dedicated storage would be managed in response to input from the GRFMC. This water could be used to adjust the flow regime in a variety of ways, including:

- augmenting releases during short term low flow periods in March, April and May;
- increasing outflows in late May and June to protect incubating steelhead;
- suspending storage during selected high flow events to allow natural freshets to pass;
- providing a short-term release of high flows during the springtime if natural freshets are not anticipated to occur;
- augmenting low flows after September 15 when minimum flow requirements for Tacoma's FDWRC stipulated in the MIT/TPU Agreement expire.

Under the AWSP, flows greater than 12,000 cfs at the Auburn USGS gage continue to be prevented. The modeled average annual three-day maximum flow was 7,470 cfs, more than 200 cfs greater than under AWSP baseline conditions. Average daily flows by month are generally similar to those experienced under AWSP baseline conditions, ranging from 2,108 cfs in January to 332 cfs in August (Table 6-2). The primary difference occurs in the springtime; average daily flows are approximately 200 cfs lower in March as refill gets underway, and approximately 250 cfs higher in May (Table 6-2, Figure 6-2). The average 3-day low flow between 1 April and 31 May is 999 cfs, approximately 130 cfs greater than under baseline conditions. The number and duration of spring high flow pulses is approximately the same; however, the intra-annual variability in the number of pulses is reduced (coefficient of variation drops from 0.77 to 0.61) as release of artificial freshets assumed for modeling purposes results in pulses occurring more consistently regardless of climatic conditions. As modeled, flows in the summer and late fall are the same as under the AWSP baseline.

Table 6-4
Selected IHA Parameters Based on Modeled Flows in the Green River at the USGS Gage at Auburn for Water Years 1964 through 1996 Under the Baseline Conditions and With the Proposed AWSP

	Environmental Baseline		AWSP	
	Mean	Coefficient of Variation	Mean	Coefficient of Variation
Annual mean daily flow	1,209	0.26	1,210	0.26
Annual 3-day maximum (cfs)	7,237	0.41	7,470	0.41
Annual 3-day minimum (cfs)	272	0.13	272	0.13
Date of annual 3-day minimum	9/5	0.13	9/5	0.13
3-day low flow April 1-May 31 (cfs)[1]	870	0.40	999	0.45
3-day low flow July 15- Sept 15 (cfs)	287	0.15	287	0.15
Annual number of high pulses, Feb 1-June 30[2]	3.6	0.77	3.7	0.61
Average duration of high pulses, Feb 1-June 30 (days)	4	0.61	4	0.55
Average rate of change, Feb 1-June 30 (cfs)[3]	425	0.42	465	0.39
Number of changes	58	0.23	58	0.24
Average rate of change, July 1-Sept 30 (cfs)[4]	92	0.77	91	0.74
Number of changes, July 1-Sept 30	8	0.61	8	0.63
Average rate of change, Oct 1 1-Jan 30 (cfs)[3]	625	0.24	627	0.24
Number of changes, Oct 1-Jan 30	50	0.46	50	0.46
Average number of low pulses (<85% exceedence flow), Sept 1-Jan 30[4]	1	1.22	1	1.22
Average duration of low pulses, Sept 1-Jan 30 (days)	22	0.97	22	0.97
Average Monthly Flows				
January	2,108	0.48	2,108	0.48
February	1,964	0.51	1,951	0.52
March	1,530	0.40	1,331	0.46
April	1,533	0.35	1,551	0.34
May	1,339	0.43	1,585	0.39
June	989	0.57	939	0.58
July	443	0.36	443	0.36
August	331	0.18	332	0.18
September	364	0.39	364	0.39
October	533	0.52	534	0.52
November	1,471	0.67	1,471	0.67
December	1,960	0.52	1,960	0.52

[1]Under both the baseline and AWSP/HCP scenarios, the annual 3-day low flow occurred during the winter (1/05) in at least one of the modeled flow years.
[2]One spring high pulse equals a series of continuous daily flows greater than the 10% exceedence flow occurring between 1 February and 30 June. 10% exceedence =2,512 cfs for Baseline and 2,557 cfs for AWSP/HCP.
[3]Change is defined as two consecutive days on which flow differs by > 10 percent. Rate of change equals average difference between days for the entire period. Direction of change can be either positive or negative.
[4]One fall low pulse equals a series of continuous daily flows less than the 85% exceedence flow occurring between Oct 1 and Jan 31. 10% exceedence = 300 cfs for both the AWSP baseline and AWSP/HCP scenarios.

HHD operations under the AWSP would continue to limit flows to less than 12,000 cfs at Auburn. Changes in flow storage and release operations during non-flood control periods will be improved and more closely mimic variations in inflow compared to AWSP Environmental Baseline conditions; however, flow variability would continue to function at risk (Table 6-5).

Gravel Transport

Potential Effects. Under the AWSP Environmental Baseline, potential effects on gravel transport would be the same as those described for Operations and Maintenance in Section 5.1.1.1. Gravel transport would continue to be interrupted and the continued interruption in sediment supply would be expected to result in bed armoring and possibly degradation downstream of Flaming Geyser Park once the supply of sediment stored within the channel upstream has been exhausted (Perkins 1999). A supply of gravel-sized sediment is critical to chinook spawning and incubation, and the continued interception of gravels by operation of HHD is considered to be an unacceptable risk.

Conservation Measures. Under the AWSP, up to 3,900 cubic yards of gravel will be placed downstream of HHD on an annual basis. Since about 8,000 cubic yards of gravel are estimated to be transported annually in the Green River, the Corps proposes to place up to an additional 4,100 cubic yards of gravel below HHD to replace that portion intercepted by HHD. The 4,100 cubic yards of would be placed to avoid potential take of chinook salmon and would be in response to Section 7 responsibilities under the ESA. Under the Green/Duwamish Ecosystem Restoration Project, approximately 4,000 cubic yards of gravel may also be placed near Flaming Geyser at RM 43. The Green/Duwamish Restoration gravel nourishment measure is meant to stop the downstream extension of bed armoring caused by past operation of HHD since 1961. Addition of up to 12,000 cubic yards of gravel under AWSP, the Corps Section 7, and Green-Duwamish Restoration efforts is expected to prevent further bed degradation and armoring, and potentially increase the rate of channel migration, initiating the formation of new side channels (Perkins 1999). Aggradation is expected to occur in the immediate vicinity of the gravel placement sites, and could also occur at sites where the increased supply of bedload exceeds the transport capacity, including at the upstream end of Flaming Geyser Park (RM 44 to RM45) and near the O'Grady Park site (RM 41.5) (Perkins 1999). Addition of gravel to the Middle Green River is not expected to affect the reach downstream of RM 41, because the river is already transport limited there, thus gravel added upstream can not be carried through this reach (Perkins 1999). The physical effects of gravel placement will be monitored as described for continued operations and maintenance in Section 5.1.1.2. The overall effect of implementing the AWSP will be to restore gravel transport and change the function of gravel transport from "unacceptable" to "at risk." Gravel nourishment activities may require several years to develop proper seeding rates and locations and may have unanticipated effects.

Fine Sediment Transport

Potential Effects. Fine sediments will continue to accumulate behind HHD under the AWSP, and the potential effects are similar to those described for continued Operations and Maintenance in Section 5.1.1.1.

Insert Table 6-5

Conservation Measures. Will be provided.

Woody Debris Transport

Potential Effects. Howard Hanson Dam will continue to block the downstream transport of wood under the AWSP. The potential effects are expected to be similar to those described for continued operations and maintenance: a persistent suppression of wood recruitment to the lower Green River. Woody debris interact with other natural processes (i.e., climate, hydrology, sediment transport) to create food, cover and microclimates suitable for virtually all species of juvenile salmonids at some point in their maturation. The deposition of large woody debris pieces also initiates pool formation, promotes bar and side channel formation, stores sediment, and retains organic matter. Given the current blockage of woody debris transport by HHD, woody debris transport is considered to be functioning at unacceptable risk to chinook salmon.

Conservation Measures. The woody debris management program implemented under the AWSP would be the same as described for continued operations and maintenance. At least 50 percent of the remaining wood collected from the reservoir would be passed downstream of HHD, including up to five truckloads of small woody debris per year. Ensuring that at least some wood passes HHD will increase the channel complexity in the middle Green River. The number and quality of pools associated with LWD should increase and jams that contribute to side channel formation could become more frequent.

In addition, a number of mitigation and restoration measures implemented under the AWSP will increase LWD loadings in selected reaches. As a replacement to the Bear Creek Project (described in Corps 1998a), the current plan is to provide two or more engineered log-jams immediately below Tacoma's Diversion Dam. Under the AWSP, LWD will be added to: 1) the mainstem Green River, North Fork Green River, Page Mill Pond and Page Creek, and other tributary channels within the AWSP inundation zone (elevation 1,147 to 1,167); and 2) North Fork; Gale Creek, and mainstem above elevation 1,240 feet. Large woody debris will be added to these sites at a rate of approximately two pieces per channel width. Large woody debris will be added to approximately 2.7 miles of the mainstem Green River, North Fork Green River and other tributary streams between elevation 1,177 and 1,240 feet MSL as part of the Howard Hanson Reservoir restoration package. Finally, the mainstem Green River between RM 83 and RM 84 will be re-routed back into its former channel and out of a channel cut through erosion of a stream adjacent road and landing strip in 1996. This will be accomplished through construction of a series of engineered log-jams.

Overall, implementation of the AWSP and associated mitigation and restoration projects are expected to increase woody debris transport in the upper and lower Green River. The proposed conservation measures only replace half of the LWD that enters the HHD reservoir, and recruitment from downstream riparian stands will continue to be suppressed as a result of flood control and land use activities. For these reasons, the ecosystem function of woody debris transport will change from unacceptable to "at risk."

Channel Morphology

Potential Effects. Potential downstream effects on channel morphology under the AWSP will generally be the same as those described for continued operations and maintenance in Section 5.1.1.1. The continued interruption of wood recruitment and coarse sediment transport could lead to isolation of existing side channels in the Middle Green River downstream of the Green River gorge. Operation of HHD under the AWSP Environmental Baseline will continue to constrain the rivers ability to form new side channel habitats causing the ecosystem function to be considered at risk (Table 6-5).

Conservation Measures. Implementation of the AWSP would influence channel morphology in the upper watershed. In Phase I, a total of 1.9 miles will be seasonally inundated of which 0.8 miles is mainstem and 1.1 miles is tributary habitat. Channel gradient and valley topography suggest that the mainstem Green River and larger tributaries such as the North Fork Green River, Page Creek, Charley Creek, and Gale Creek currently exhibit a predominantly pool-riffle morphology, with meandering channels and predominantly gravel to cobble size substrate. Small tributaries such as Cottonwood Creek, Piling Creek and several unnamed streams are steeper, with coarser substrates composed of cobble to small boulder size material (Wunderlich and Toal 1992). These channels most likely currently exhibit a plane-bed or step-pool morphology, depending on the recent disturbance history and amount of in channel LWD. Following implementation of the AWSP, inundated mainstem and tributary reaches will be characterized by lacustrine conditions during the late spring and summer. Even following drawdown, channel conditions are likely to be altered by transformation of existing arboreal riparian communities to inundation-tolerant wetland species, a reduction in bank stability, and an increase in fines in the bed, as has been observed in channels within the exiting inundation zone (Wunderlich and Toal 1992).

In addition to placement of LWD, restoration and mitigation projects include provisions to excavate new side and off-channel habitats in the inundation zone and reconnect side channels just above the inundation zone on the mainstem. These activities will help maintain or re-establish the typical pool-riffle channel morphology with abundant side channels that would be expected in these channels under natural conditions.

As described for continued operations and maintenance in Section 5.1.1.2, channel morphology would be maintained or would become more complex under the wood and sediment management projects. Increases in in-channel wood and sediment are expected to increase the number and complexity of pools and the amount of spawning gravel, particularly in reaches that currently lack adequate sediment storage sites. Additionally, one major side channel downstream of HHD would be reconnected and rehabilitated. The reach between Tacoma’s Headworks and Palmer (RM 61.5 to RM 58) formerly meandered widely across its floodplain. By 1953, the channel had been straightened, and by 1964 the two former meander bends, which had continued to function as side channels, had both been cut off from the river. One of these relict side channels (Signani Slough) will be reconnected to the mainstem Green River. Overall, side channel rehabilitation and the wood and sediment management programs will improve channel morphology in the Green River but it will still function at risk (Table 6-5).

Floodplain Connectivity

Potential Effects. Potential downstream effects on channel morphology under the AWSP will generally be the same as those described for continued operations and maintenance in Section 5.1.1.1. Floods greater than 12,000 cfs will continue to be prevented thus hydrologic connectivity and recharge of the floodplain will be as described under HHD Continued O&M. Side channel connectivity downstream of the Green River Gorge could begin to decline as gravel storage sites within the gorge are depleted and downstream transport of coarse sediment continues to be interrupted. Reduced side channel connectivity will impair floodplain functions such as groundwater recharge causing the ecosystem function to be considered at risk (Table 6-5).

Increasing the summer conservation pool elevation from 1147 to 1167 feet in Phase I of the AWSP will influence floodplain function upstream of HHD along approximately 0.8 miles of the mainstem, and less than a half-mile of the North Fork Green River. Other tributary streams do not have well-developed floodplains, thus changes in floodplain functions are expected to be minimal. Increasing the summer conservation pool elevation will exacerbate sediment deposition on floodplain surfaces beyond that occurring during flood control storage, and could fill existing side channels and wetlands that serve as groundwater recharge areas. The length of time that floodplain soils are saturated will increase, and saturated conditions will occur in a season when soil and groundwater storage are usually beginning to contribute to baseflows. Prolonged inundation during the growing season is likely to result in a change in floodplain vegetation communities. Altered floodplain vegetation, increased saturation during the summer, and filling of lateral environments that currently contribute to groundwater recharge, are likely to alter the subsurface hydrology of affected areas.

Conservation Measures. Under the AWSP, floodplain connectivity is expected to improve as a result of the sediment and wood management programs and mitigation and restoration projects implemented under the AWSP. Increasing bedload sediments to levels more representative of natural conditions will ensure that existing side channels do not become perched under future HHD operations. Aggradation and increased LWD loads will result in local increases in flood levels and will enhance the formation of active gravel surfaces that represent favored regeneration sites for some riparian species. Reconnection of existing side channels will improve their ability to store water during flood flows and recharge alluvial aquifers, but continued flood control and water withdrawals for water supply will cause the ecosystem function to remain at risk.

6.2.1.2 Water Quality

Current water quality problems in the Green River include warm water temperatures during the summer and fall, low dissolved oxygen (DO) levels, nutrient enrichment, and a variety of pollutants. Dissolved oxygen problems are related to both elevated water temperatures and nutrients and are most severe in the lower Duwamish within the tidal zone (up to RM 11.0). Such conditions can stress fish and render them more susceptible to the effects of other pollutants. Water quality problems identified by Ecology in the Green River downstream of HHD include: 1) the Green River between RM 11 and 42.3 (waterbody segment WA-09-1020), listed as limited for mercury, fecal coliform bacteria, and temperature; and 2) the Green River between RM 42.3 and 64.5 (waterbody segment WA-09-1030), listed as limited for temperature (Ecology 1998). Under baseline conditions for the AWSP, water quality concerns are expected to be approximately the same or slightly improved as compared to existing conditions as a result of low flow constraints implemented by TPU under the MIT settlement. On average, the model indicated that low flows would be approximately 20 cfs greater between July 15 and October 15, and would be approximately 40 cfs greater from June 15 to November 30 in the driest year on record compared to flows under existing conditions.

Water Temperature

Potential Effects. Under baseline conditions, the temperature of water released from the dam during the early to mid-summer is expected to continue to be cooler than expected natural (pre-impoundment) temperatures due to the withdrawal of cold water from the lower stratum of the reservoir. Water temperatures in the lower stratum of the reservoir typically range from 50 and 55°F (10 and 12.8°C)°F during the summer. In contrast, as under existing conditions, temperatures will continue higher than would be expected under natural conditions during the late summer and fall due to seasonal heat accumulation of water stored in the reservoir, and from the depletion of cold water in the lower stratum of the reservoir (Corps 1998a).

Based upon the results of a study by Caldwell (1994), it appears that warm water temperatures in the lower Green River during summer low flow periods largely result from heat exchange with warm air and solar heating. Temperatures at the Headworks were largely unchanged from temperatures recorded at the HHD outfall, averaging 57 to 65°F (13 to 18.3°C); however, between the downstream end of the Green River Gorge and Tukwila, maximum temperatures in July and August ranged from 72.5 and 75.2°F (22.5 to 24°C). The factors responsible for the high temperatures include extensive paved areas in the lower Green River basin that reduce groundwater recharge and subsequent discharge of cool groundwater into the river, low flows which increase the susceptibility of water to heating on warm days, and lack of shade along the lower river (Corps 1998a). Slight increases in low flow as compared to existing conditions are not expected to substantially reduce temperatures in the lower river under the AWSP baseline.

Warm water temperature in the lower Green River have a number of potentially adverse impacts on chinook salmon. Warm water temperatures and resulting low DO concentrations have been found to result in delayed upstream passage of chinook salmon in the lower Green River and Duwamish estuary during the late summer and fall (Fujioka 1970). Water temperatures exceeding 60°F (15.5°C) become progressively more limiting to the growth and survival of juvenile salmon and trout. Although most chinook salmon migrate out of the Green River as fry, some of these fish may reside in the Duwamish Estuary during the summer where they would be potentially exposed to poor water quality conditions. Finally, warm water temperature during the fall could reduce the viability and survival of eggs deposited in river gravels by chinook salmon. For these reasons, water temperature is considered to be functioning at risk (Table 6-5).

Conservation Measures. Compared to AWSP Environmental Baseline, the AWSP would result in decreased flows in the lower Green River during from February 15 through April 15, and would result in higher sustained baseflows from April 16 through June 1. The modifications in flow by the AWSP during this period would be expected to result in slight changes to the thermal regime of the lower Green River. The potential for increased water temperatures in the Green River during the reservoir filling period (February 15 through April 15) is small because air temperatures are typically cold and flows relatively high during the late winter and spring.

Water temperatures would decrease in several miles of the Green River downstream of HHD during the summer. Under the AWSP, construction of the new tower would facilitate selective water withdrawal, allowing the Corps to withdraw water throughout the water column. Selective withdrawal would reduce but not eliminate the potential for withdrawing warm waters from the reservoir during the late summer and fall, which occurs under AWSP Baseline conditions. The additional storage of 20,000 ac-ft for Tacoma's SDWR would provide additional cooling benefits during summer by increasing the total volume of cold water stored in the reservoir. The new fish passage facility provides for withdrawal of water at selected depths near the thermocline which will ameliorate existing high temperatures resulting from dam discharges from deep water depths. Outflow releases will track the natural ambient rise and fall of seasonal temperature change.

To evaluate the potential for changes in the temperature regime, a model was developed for HHD and the lower Green River basins (Valentine 1996; Corps 1998a). Analyses compared the proposed AWSP (new tower with a selective water withdrawal) with use of the existing tower with no modification. Temperature modeling results indicated that the natural inflows to HHD exceed the state Class "AA" temperature standard of 16.0°C in most years for a few to several days. Modeling results for the AWSP indicated that water releases from HHD will exceed this temperature in only one of 33 years. The preferred fish passage alternative, therefore, has a reliability of 97 percent for maintaining HHD release temperatures below the state standard. The benefits to chinook salmon provided by cooler temperatures would extend several miles downstream of HHD, based upon the results of Caldwell's (1994) temperature study. Water temperature would improve under the AWSP but is considered to remain at risk due to potential effects of warm HHD releases during the late summer.

Dissolved Oxygen

Potential Effects. Levels of DO in the reservoir are excellent, including the hypolimnion. Levels of DO in the lower Green River are generally satisfactory to support fisheries resources. However, samples collected by Metro in the lower Green River show a few occasions where DO levels were measured below the state Class "A" criterion (Corps 1995). However, these violations of the state criterion were not frequent enough to warrant listing the lower Green River as water quality-limited for dissolved oxygen. Low DO can impair successful migration by fish and may affect reproductive success, especially during periods when eggs and hatchlings are within the gravel strata. For this reason, DO was considered to be functioning at risk under AWSP Environmental Baseline conditions.

Conservation Measures. DO concentrations would not be expected to change in the Duwamish/ lower Green River under the AWSP compared to AWSP Baseline conditions. The AWSP would result in modified flows over those occurring under Baseline conditions from February 15 to June 1. Flows are relatively high and water temperatures in the river are cold during this period.

These conditions result in high DO levels throughout the middle and lower Green River. Zones possessing low DO values are most likely to form in the Duwamish / lower Green River in the late summer and fall when water temperatures are warm and flows are low. Flow releases under the AWSP during this time are equal to or greater than the baseline.

Water stored in the reservoir under the Section 1135 project could be used to increase flows in the Green River during the late summer and fall in average and wet years as well as during drought years. Despite the increased ability to augment summer low flow releases, which could improve DO conditions by increasing water velocities and decrease the formation of stagnant areas in the Duwamish and lower Green River during these periods, this function will remain at risk.

Saltwater Wedge

Potential Effects. Under the AWSP Environmental Baseline, potential effects on the saltwater wedge will be similar to those described under HHD Continued O&M.

Conservation Measures. The position of the saltwater wedge could potentially be shifted downstream under low flow conditions by the provisional release of water stored behind HHD, if this was determined to be beneficial to chinook salmon by the GRFMC. This would result in an improvement over the AWSP Environmental Baseline.

Total Dissolved Gases

Potential Effects. The AWSP is assumed to have no discernible effect on total dissolved gases; this assumption will be confirmed by monitoring.

Conservation Measures. Total dissolved gas concentrations are assumed to function appropriately under the AWSP.

Turbidity

Potential Effects. Turbidity is the only water quality parameter that has seasonally exceeded Class "AA" standards in the Green River above HHD (Corps 1995). Periods of high turbidity are generally associated with winter storms and snowmelt. Evaluation of fine sediment production in the Green River by O'Connor (1996) shows that sediment production increased from the period 1958-1967 to 1968-1978 but decreased in the period 1979-1995. O'Connor found that mass wasting was the largest source of fine sediment to the river. Timber harvest and road construction increased dramatically in several subwatersheds of the upper Green River in the late 1960s and early 1970s. Large runoff events in association with these management activities are a likely cause of higher sediment production in the 1968-1978 period. With recovery of vegetation and better forest management practices, sediment production in the Green River watershed has since been declining.

Suspended sediments in upper basin streams eventually enter the HHD reservoir. According to the Corps, studies have shown a small net accretion of fine sediment in the reservoir. It is likely that large, heavy particles settle in the reservoir while small particles are carried downstream of the dam (Corps 1998a). Turbidity is of greatest concern during flood events and when HHD reservoir levels are low. Based on these concerns, this indicator is considered to be at risk. A detailed discussion of turbidity effects from operation of the HHD can be found in Appendix D3, Section 2 of the AWSP DFR/DEIS (Corps 1998a).

Conservation Measures. In the lower Green River, turbidity is not likely to be limiting to fish, though it may limit other uses such as Tacoma's water supply and recreation. The pool raise associated with the AWSP could result in increased turbidity levels on a periodic basis due to increased shoreline erosion. The total shoreline area of the project will increase as a consequence of the raised reservoir pool under the AWSP. In addition, sections of streams and the mainstem river inundated by the raised pool may be susceptible to increased erosion during drawdown periods.

Potential turbidity impacts resulted from stream channel erosion under the AWSP would be minimized by the placement of boulders and LWD within the stream corridors inundated by the raised pool. Shoreline erosion impacts will be minimized by the leave of trees and plantings of inundation tolerant plants. This measure will be used to stabilize banks, as well as provide habitat benefits to juvenile salmonids. With these measures, the AWSP would not be expected to result in changes in the frequency and magnitude of high turbidity events in the Green River below HHD compared to those occurring under AWSP Baseline conditions; as such, this indicator would remain at risk.

Contaminants

Potential Effects. Contaminants that have been observed to exceed State Water Quality Standards in the Green River include fecal coliform, metals and toxic chemicals. Ecology has measured levels of mercury, copper, lead, and zinc above state-established standards in the Duwamish River (Corps 1995). Toxic contaminants have been identified in bottom sediments and surface water in the lower Green River and especially in the Duwamish River (Corps 1995). Chemical testing of bottom sediments in the lower 5 miles of the Duwamish River revealed contamination by oil and grease, sulfides, pesticides, and polychlorinated biphenyls (PCB). More recently, Ecology (1998) cited excursions beyond criteria in sediment for polychlorinated biphenyls and polyaromatic hydrocarbons. For these reasons, contaminants are considered to be at risk under the AWSP Environmental Baseline. No contaminant exceedences have been observed upstream of HHD.

Conservation Measures. The AWSP would not affect the concentration of toxic contaminants in the lower Green River compared to that occurring under AWSP Baseline conditions. The magnitude and duration of flood events that mobilize toxic contaminants in the lower river would not substantially change under the AWSP compared to the AWSP baseline. Flow augmentation during low flow periods in the summer and fall by water stored under the 1135 project could result in small improvements to water quality in the lower Green River in average and wet years by diluting the concentrations of toxicants in the water column. Concentrations of contaminants in the water column would be the same under AWSP and AWSP Baseline conditions during drought years, since the storage of 1135 project water for fish and wildlife habitat is provided under the AWSP baseline during drought years; as such, this indicator would remain at risk.

6.2.1.3 Fish Passage

Upstream Fish Passage

Potential Effects. Under AWSP baseline conditions, upstream fish passage is not provided at Tacoma's Headworks diversion or HHD. The upper Green River watershed historically supported production of anadromous fish, including steelhead, coho and chinook. In 1913, completion of Tacoma's Headworks Diversion Dam at RM 61.0 blocked adult anadromous fish access to the upper Green River watershed. The completion of HHD at RM 64.5 in 1962 created an additional barrier to the upstream passage of anadromous fish. There are approximately 220 square miles of watershed above Howard Hanson Dam representing about 45 percent of the total Green River watershed. Most of the streams in the upper watershed are unconstrained by levees or dikes and substantial anadromous fish habitat could be restored to production if upstream and downstream fish passage were provided past the dams. The lack of upstream fish passage facilities at HHD under the AWSP Environmental Baseline isolates critical chinook habitat in the upper Green River watershed and is considered to be functioning at unacceptable risk (Table 6-5).

Conservation Measures. Under the AWSP, the Corps will not provide upstream fish passage at HHD, since fish passage around both Tacoma's Headworks diversion and HHD will be provided by the City of Tacoma. If the AWSP proceeds, Tacoma has committed to constructing a fish ladder at their Headworks combined with a trap-and-haul to pass fish upstream of HHD as part of their Settlement Agreement with the Muckleshoot Indian Tribe. The Settlement Agreement addressed the effects of water withdrawals under Tacoma's FDWRC and SDWR. Transport of adult salmonids above HHD is also identified as a Tacoma commitment under their Green River Habitat Conservation Plan (Tacoma 1999). Tacoma's construction and operation of an upstream fish passage facility from below their Headworks to above HHD will restore adult chinook salmon access to the upper watershed. The need for continued human intervention with the trap-and-haul program causes upstream fish passage to continue to function at risk for chinook salmon.

In their Habitat Conservation Plan, Tacoma committed to tallying the number, species and condition of fish transported above HHD. Under their HCP, Tacoma did not commit to monitoring the fate of adult salmonids released into the upper watershed. The Corps proposes to monitor the distribution of adult salmonids released above HHD to ensure accessible habitats are being fully utilized.

Downstream Fish Passage

Reservoir Passage.
Potential Effects. Prior to the start of the spring smolt outmigration season, the reservoir behind HHD is held essentially empty below elevation 1,070 feet MSL. Under the AWSP environmental baseline, the HHD summer conservation pool is held at 1,147 feet elevation and

impounds up to 30,400-acre-feet of water. At the summer conservation pool of 1147 feet, the reservoir pool is approximately 4.6 miles long and has a surface area of about 850 acres. The AWSP baseline condition assumes the Section 1135 Project provides for the storage of up to 5,000 ac-ft of water that is initially held during drought years for later release to augment flows below HHD for fisheries purposes. During average and wet years, the 30,400 acre-feet of water includes the short-term storage of up to 5,000 ac-ft of water for debris maintenance operations. During average and wet years, the water held for debris maintenance operations is released during the first two weeks in June, consistent with past project operations.

Under the proposed AWSP action, the summer conservation pool will be increased to elevation 1,167 feet and will impound up to 50,400 acre-feet of water. At the summer conservation pool of 1,167 feet, the reservoir pool is approximately 5.4 miles long and has a surface area of 1,100 acres. Staff from the Corps have calculated that at elevation 1,167 feet, it would take approximately 493 hours for a water particle to enter the reservoir and be flushed downstream at a flow of 1,250 cfs compared to an estimated 294 hours under the AWSP Environmental Baseline pool elevation of 1,147 feet. There are no studies of comparable reservoirs that will allow the accurate prediction of the effects of an enlarged reservoir on chinook outmigrant survival (Corps 1998). Under the AWSP action, reservoir refill will be started in mid-February and will impound up to 50,400 ac-ft of water by late May. Because it is unknown how well juvenile chinook will pass through the reservoir, this pathway is considered to be at risk.

<u>Conservation Measures</u>. Under the AWSP, a large capacity, surface-oriented collector will be part of a downstream fish passage facility at HHD. The capacity of the collector and screen facility is the maximum practical volume available using one modular-inclined screen and the current 6.0 fps maximum screening criteria. The large capacity intake and screen will contribute to the surface attraction of the facility and should minimize smolt delay mortality in the reservoir. A combination of flow management and monitoring will also be used to "optimize" operation of the project so survival of smolts through the project can be maximized. Flow management strategies include minimizing the storage of water during the peak outmigration period and providing facilities that enhance operation of HHD to provide outflows that mimic inflow, and thereby provide properly functioning reservoir passage. Monitoring of smolt outmigration and predator abundance/distribution will be implemented so adaptive measures can be employed to maintain or improve smolt survival. Chinook smolt survival may also benefit in light of additional measures such as 1) leave all trees along the new reservoir shoreline; 2) use of woody debris in streams above, within, and below the reservoir; 3) mimicry of natural flow fluctuations with natural or artificial freshets; and 4) selective removal of predatory fish if monitoring suggests this is necessary.

Dam Passage.

<u>Potential Effects</u>. Under the AWSP, springtime reservoir refill will be started in mid-February to impound up to 50,400 acre-feet of water by late May. Starting the reservoir refill in mid-February will cause the radial gates at the base of HHD to be deeply submerged during the majority of the chinook outmigration period. The lack of a large capacity, surface-oriented outlet will prevent most chinook from safely moving downstream past HHD during the spring. As most anadromous salmonid populations in the Pacific Northwest evolved to migrate to the

saltwater environment during the spring and early summer, it is highly likely that significant delay will have substantial negative effects on survival of the stock.

Conservation Measures. Under the AWSP, a downstream fish passage facility will be constructed similar to that described in Chapter 5.1.2.3. The significant difference between the facilities is that the downstream fish passage facility will be constructed to operate to pool elevation 1,177 feet (instead of elevation 1,147 feet). The difference in cost between the two fish passage facilities consists of a difference in stoplogs and wet well wall costs, electrical work, and construction mobilization and demobilization and access roads. Compared to the fish passage facility constructed to elevation 1147-ft, the stop logs and exterior wet well wall would be increased by 30 feet and some of the electrical work would be increased. Per the project designer, the tower under both scenarios would still be constructed to elevation 1254-ft. All other fish passage costs would be the same for the two facilities.

Under the Environmental Baseline condition of the AWSP, the lack of downstream fish passage facilities presents an unacceptable risk for critical chinook habitat in the upper watershed (Table 6-5). While juvenile chinook may safely pass the HHD reservoir and dam when the reservoir pool is low, storing up to 49,400 ac-ft of water during the spring creates a large, slow-velocity reservoir pool, which hinders the downstream movement of chinook fry. As the depth of the reservoir pool increases with spring storage, downstream migrating chinook are unwilling to use, or unable to fund, the existing radial gate outlets. These conditions effectively prevent use of the upper watershed by chinook salmon.

If the downstream passage facility is implemented as described, it will provide the opportunity to restore chinook salmon production to the upper watershed. Given that the proposed downstream fish passage facility is an experimental design and will require ongoing human intervention to operate successfully, downstream fish passage will continue to function at risk in the Green River (Table 6-5).

6.2.1.4 Instream Conditions

Spawning and Incubation Habitat

Upper Watershed.
Potential Effects. Under the AWSP Environmental Baseline, the upstream migration of chinook salmon is currently blocked by Tacoma's Headworks diversion dam at RM 61.0, and by HHD at RM 64.5. These structures will remain in place under the proposed AWSP, and will thus continue to represent a barrier to potential chinook spawning habitat above HHD.

Conservation Measures. It is assumed that upstream passage of fish will be provided at both the Tacoma Headworks and HHD (Section 5.1.2.3). Fall chinook adult spawning capacity estimates developed by the WDFW for Olympic Peninsula streams vary according to gradient and elevation, and using these data, the Corps estimated there are 24 miles of mainstem and large tributary chinook spawning habitat in the upper Green River watershed (Corps 1998a). This will increase the total chinook spawning and incubation habitat in the Green/Duwamish Basin by approximately 28 percent.

The quality of spawning habitat in the upper watershed will not be affected by the AWSP. Substrate in the mainstem Green River is currently too coarse for optimal spawning in much of the upper Green River watershed as a result of increased sediment inputs from logging-related landslides (Fox 1996; Fox and Watson 1997), thus spawning and incubation in the upper Green River watershed will continue to function at risk until conservation actions recently implemented or proposed for the upper watershed by other landowners take effect.

Lower Watershed.
Potential Effects. The AWSP would not affect chinook salmon spawning and incubation habitat in the mainstem and side channels of the Green River below HHD compared to the AWSP Baseline. Changes in flows under the AWSP differ from flows under Baseline conditions only between February 15 and June 1 (Figure 6-2). Chinook salmon are fall spawners, and therefore would not be affected by flow modifications occurring under the AWSP. The incubation period of chinook salmon in the Green River is generally completed by mid-February. Consequently, flows during the peak incubation period for chinook salmon would not be changed by the AWSP. During some years, chinook fry incubation may extend into late February. The rate of water storage during late February is governed by over-riding responsibility to maintain a low pool level to provide flood control. Water storage during late February will be held to less than 180 cfs per day which will limit the effects of water storage on chinook fry incubation.

Conservation Measures. The 5,000 cfs storage provided under the Section 1135 Project could optionally be used to improve flows during the fall spawning period in average and wet years. For example, water could be released from Section 1135 Project reservoir storage to provide higher sustained baseflows during the fall or used for artificial freshets. This could reduce the impacts of short-term low flow events on chinook salmon spawning conditions in the middle and lower Green River. Effects of the Section 1135 Project would be the same under the AWSP and AWSP Environmental Baseline during drought years.

The gravel nourishment conservation measure will also benefit spawning habitat conditions in the middle Green River by replacing gravel recruitment lost from the upper watershed due to the presence HHD. Placement of LWD in the mainstem is also expected to improve available spawning habitat by enhancing the complexity of the channel in reaches where LWD is currently scarce, increasing sediment storage particularly in steep reaches such as the Palmer reach (RM 58 to RM 61) and the Green River gorge, where gravel is otherwise rapidly transported throughout the system. In addition, specific restoration and mitigation projects will improve spawning habitat by placing 2 or more engineered log jams in the mainstem and reconnecting Signani Slough.

Rearing Habitat

Upper Watershed.
Potential Effects. Juvenile chinook salmon are presently planted in the upper Green River Watershed by the MIT. The pool raise associated with Phase I of the AWS project will replace free-flowing streams with a slack-water reservoir pool. The additional storage would inundate

[insert figure 6-2]

1.9 miles (11.5 acres) of total stream habitat, including 0.8 miles of mainstem channel length (Corps 1998a, Appendix F1).

Conservation Measures. The loss of rearing habitat in the inundated stream areas may be partially offset by the larger HHD pool. USFWS studies of HHD reservoir (Dilley and Wunderlich, 1992, 1993; Dilley 1994) found tremendous growth rates for chinook juveniles in lower and upper reservoir areas. The physical loss of stream habitat resulting from the AWSP pool raise will be mitigated through a series of habitat improvements implemented in the inundation zone, reservoir perimeter, and mainstem channel and tributaries. These actions, which include placement of LWD in 11.5 miles of mainstem and 2.4 miles of tributary habitat in the inundation zone and channels upstream of the reservoir, will provide additional benefits for juvenile salmonid rearing. An additional 1.1 acres of off-channel habitat (beaded ponds, side channels, and dendrites) will be created, and boulders and LWD will be used to stabilize the banks and maintain the existing channel configuration in the new seasonally inundated reaches.

Lower Watershed.

Potential Effects. The AWSP could affect chinook salmon juvenile rearing habitat by decreasing flows in the Green River below the Headworks in late February and March, and increasing flows in late April and May as compared to the AWSP Baseline Conditions (Figure 6-2). Chinook salmon fry begin emerging in the Green River in January and some migrate seaward immediately after yolk absorption. Prior studies conducted in the Green River and general reviews of the life history of fall chinook salmon suggest that most chinook fry outmigrate in April to June (see Chapter 3). Surveys of side channel habitats in the middle Green River in 1998 support the assumption that a large portion of the chinook fry population in the Green River system migrate downstream 30 to 90 days after emergence (Jeanes and Hilgert 1998). The assumption is also supported by sampling efforts by MIT biologists in the Duwamish estuary; however, some chinook juveniles are thought to move seaward as fingerlings in the late summer of their first year, while others overwinter and migrate as yearling fish. The proportion of fingerling and yearling migrants may vary from year to year.

The potential effects of AWSP were evaluated using potential habitat area and flow functions developed by Ecology for juvenile chinook salmon in the Green River. Potential mainstem habitat area for juvenile chinook salmon was predicted to increase by an average of 1.8 percent in the lower river, and an average of 2.1 percent in the middle river. The increase in habitat resulted from reductions in high flows from Feb. 15 to April 15 (i.e., reservoir refill period), and higher sustained baseflows following April 15. Flows in the lower and middle Green River during the winter and spring frequently exceed the flows considered to be optimal for juvenile chinook salmon by Ecology's instream flow study (Caldwell and Hirschey 1989). The Ecology study did not develop potential habitat and flow functions for chinook fry, but since chinook fry are weaker swimmers than the larger juveniles modeled in the Ecology study, chinook fry should benefit even more than juveniles from the benefits of lower velocities in the mainstem channel during periods of high flow.

The potential effects of the AWSP on chinook fry rearing habitat in the side channels of the middle Green River were evaluated using wetted side channel area versus discharge relationships developed by the Corps (Corps 1998a, Appendix F1, Section 7). The results of the modeling effort identified a slight reduction in the average area of side channel rearing habitat under the AWSP compared to the AWSP Baseline.

Conservation Measures. Conservation measures designed to improve juvenile chinook salmon habitat in the lower Green River include reconnecting and restoring the Signani Slough side channel, placement of 2 or more engineered log jams, and placement of LWD in the river channel. Up to 50 percent of the wood currently intercepted by HHD would be placed or anchored downstream of the Headworks. Adding LWD will increase the complexity and quality of habitat in the middle Green River. The reconnection of Signani Slough with mainstem flow will improve juvenile chinook salmon habitat by providing up to 3.4 acres of additional off-channel habitat, which is important for overwintering, and by increasing the structural complexity of main channel habitats.

Adult Upstream Migration

Upper Watershed.
Potential Effects. Under the AWSP Baseline, the Tacoma Headworks diversion structure prevents the upstream migration of adult chinook salmon above RM 61.0. Additionally, HHD at RM 64.5 has been a barrier to the upstream migration of chinook salmon into the upper Green River watershed since its construction in the early 1960s. Howard Hanson Dam was originally authorized and built by the Corps without fish passage facilities. These structures would remain in place and would continue to block migration of adult chinook into the upper watershed. Chinook are typically mainstem river spawners, and likely would not use the HHD reservoir or the upper reaches of smaller tributaries for spawning. Nevertheless, based on gradient and elevation, there are approximately 24 miles of mainstem Green River available in the upper watershed (above the reservoir) suitable for chinook spawning (Corps 1998a). Implementation of the AWSP would not affect streamflows in the upper watershed, and thus would not alter instream-flow conditions during the time adult chinook would be migrating upstream.

Conservation Measures. The AWSP would not affect streamflows in the upper watershed during the time chinook would be migrating upstream, thus no conservation measures specifically designed to maintain or improve adult migration in the upper watershed would be implemented. Re-routing the river back into its original channel between RM 83 and 84 will improve upstream migration for adult chinook, as flows currently go subsurface in this area during the late summer, and could delay upstream migrating fish (Goetz 2000). Placement of large woody debris in the mainstem within and upstream of the new inundation zone could also increase the number and complexity of deep pools, improving holding habitat for adult chinook.

Lower Watershed.
Potential Effects. Flows under the AWSP would not affect the upstream migration of adult chinook salmon in the lower and middle Green River. Upstream migration of spawning chinook salmon in the Green River occurs during the late summer and fall. The AWSP would only affect flows in the Green River below HHD between Feb. 15th and June 1st, prior to the migration period of chinook salmon.

Conservation Measures. The AWSP includes a provision for the optional annual storage of up to 5,000 ac-ft of water to be used for fisheries protection purposes. Some of this storage could be targeted to augment flows or provide a freshet in the late summer or early fall when adult chinook salmon are holding in the lower Green/Duwamish rivers prior to upstream migration. During drought years, no additional benefits would be yielded to chinook salmon spawning by the Section 1135 Project under the AWSP compared to the AWSP Baseline. Fish protection flows under the Section 1135 Project would be implemented under both the AWSP and AWSP Baseline during drought years.

Juvenile Downstream Migration

Potential Effects. The survival of outmigrating juvenile salmon in the middle and lower Green River below the Headworks is assumed to be affected by the timing and quantity of instream flows. For the lower Green River, although the relationship between flow and migration survival is poorly understood, survival is assumed to increase as flows increase (Wetherall 1971). Under the AWSP, flows in late February and March would be somewhat lower than under Baseline conditions, which could impact early outmigrants. Flow augmentation in the late spring (April and May) resulting from implementation of the AWSP is expected to improve outmigration survival conditions for the majority of juvenile chinook salmon in the Green River below HHD compared to the AWSP Baseline.

Conservation Measures. As described in Section 6.2.1.4, Flow augmentation in the late spring (April and May) resulting from implementation of the AWSP is expected to improve outmigration survival conditions for the majority of juvenile chinook salmon in the Green River below HHD compared to the AWSP Baseline. The improvement results from the slight reductions in flows between Feb. 15 to April 15 (i.e., reservoir refill period), when flows frequently exceed levels considered to be optimal for juvenile chinook salmon (Caldwell and Hirschey 1989). In addition to this benefit, the AWSP includes the provision for two 2,500 cfs freshets that would be released during the spring to help initiate movement of chinook salmon fry from the middle and lower Green River into the Duwamish Estuary. This conservation measure would be expected to increase the survival of outmigrating fry in the Green River.

Stranding

Potential Effects. Incubating eggs (redds) of chinook salmon can be stranded (dewatered) during low flow events which follow the spawning period. The AWSP would not alter flows during the chinook incubation period as compared to the AWSP Baseline, and thus is expected to have no affect on the stranding of chinook redds.

Conservation Measures. Storage in HHD is evacuated by November 1 for flood protection purposes as required by Congressional authorization. Consequently, storage under the Section 1135 Project could not be used to protect redds from dewatering during the fall incubation period of chinook salmon.

In spring, chinook salmon fry are also susceptible to stranding in gravel bars and potholes situated along the mainstem river channel, as well as in the side channel located along the middle

Green River, during periods of rapid flow reductions. The AWSP would reduce the susceptibility of chinook salmon fry to stranding compared to the AWSP Baseline by providing higher sustained baseflows from mid-April through June.

The fry stranding impacts of the two 2,500 cfs freshets proposed as conservation measures under the AWSP would be small compared to natural flow fluctuations occurring under both the AWSP and the AWSP Baseline. The increased downstream survival of outmigrating fry would likely outweigh the risks to these fry from stranding.

6.2.1.5 Species Interactions

Competition

Potential Effects. Competition is not likely to be a factor limiting the distribution and abundance of chinook salmon adults and juveniles in the Green River. Most juveniles migrate out as fry to the ocean, and consequently do not compete for space or food in the Green River. Due to the scarcity of gravels caused by HHD under existing conditions, competition for spawning gravels may occur among chinook salmon in some reaches of the Green River. Chinook salmon are fall spawners, and would not compete for spawning areas with other salmonid species with the exception of bull trout, which are seldom observed in the Green River. Competition is considered to be functioning properly in the Green River under the environmental baseline condition, and no conservation measures have been proposed for this biotic process.

Conservation Measures. Competition is considered to be functioning properly in the Green River under environmental baseline condition, and no conservation measures have been proposed for this biotic process.

Predation

Potential Effects. The AWSP would not be expected to alter the risk of predation to chinook salmon. Predation is considered to be functioning at risk in the Green River due to sportfishing pressure, tribal harvest, and poaching. The AWSP actions will not affect that level of function.

Conservation Measures. Restoration of anadromous fish production to the upper Green River watershed may increase the concentration of predators in the vicinity of the downstream fish passage facility. Juvenile chinook salmon will be released from the fish lock into the mainstem river below HHD in higher concentrations than typically occur under natural conditions. The density of juvenile chinook in fish lock release flows may attract predators such as concentrations of resident cutthroat trout. If concentrations of predators increase under operation of the downstream fish passage facility, a predatory abatement program (i.e., selective hook-and-line removal of predatory fish as described in Corps (1998a)) will be implemented. The intent of the predatory abatement program is to maintain the density of predators to baseline conditions. No other conservation measures have been proposed to reduce the impacts of predation under the proposed action.

6.2.2. Determination of Effect of AWSP on Chinook Salmon

Under the Environmental Baseline (without conservation measures), the AWSP Environmental Baseline conditions **may affect, and is likely to adversely affect** Puget Sound chinook salmon. The upper Green River watershed, above HHD, was listed as critical habitat for chinook salmon by the NMFS in March 2000. In the absence of upstream fish passage facilities, the AWSP Environmental Baseline will prevent adult chinook salmon from accessing historic habitat above HHD. Even if adult chinook salmon were transported above HHD, the lack of downstream fish passage facilities would cause the majority of juvenile outmigrants to be injured or killed during their passage through the HHD Project. The lack of fish passage facilities at HHD effectively isolates critical habitat in the upper watershed, and the lack of gravel and woody debris transport past HHD adversely affects critical chinook habitat in the Green River below HHD.

With implementation of the conservation and monitoring measures as described in this PBA, the AWSP is **not likely to adversely affect** chinook salmon. The downstream transport of LWD and sediment will be improved or restored. The ability to manipulate the flow regime to better mimic natural flow variations or to improve habitat conditions to alleviate specific concerns (i.e. release of spring-freshets; augmentation of flows in late summer and fall) will improve; however the necessity to provide for municipal water supply and continued flood protection prevents total restoration. Together, improvements in these processes are expected to improve channel morphology and floodplain connectivity.
Water quality will be improved or maintained. Instream habitat conditions and interactions between species will be improved or maintained

The City of Tacoma, as described in their Green River Habitat Conservation Plan (Tacoma 1999) will provide passage of adult salmonids upstream around both Tacoma's Headworks diversion and HHD. Tacoma's provision of the upstream fish passage facilities and the Corps' monitoring of the distribution of released fish will ensure that the AWSP will restore upstream passage of chinook salmon to the upper Green River watershed. Under the AWSP, the proposed downstream fish passage facility will restore the opportunity for juvenile chinook to pass downstream of HHD even when the radial gates at the base of HHD have been deeply submerged. The proposed downstream fish passage facility will be constructed to operate between reservoir elevation 1,080 feet and 1,177 feet, and estimated smolt survival through the reservoir and dam should approach 65 percent. Project passage of juvenile chinook under AWSP baseline conditions was estimated at less than 25 percent (Corps 1988). The estimated 65 percent survival of juvenile chinook passing HHD could enable restoration of self-sustaining runs, but there is greater uncertainty with this species relative to coho and steelhead. Achievement of self-sustaining runs will be dependent on continuing refinement of fish passage facility and reservoir operations, implementation of the habitat improvement projects, and possibly on harvest management during the initial years following completion of the project.

6.3 Bull Trout and Dolly Varden

6.3.1. Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Bull Trout and Dolly Varden

The effects of the AWSP on bull trout were evaluated assuming an Environmental Baseline that does not include upstream or downstream fish passage at HHD and assumes that Tacoma is withdrawing water from the Green River under their FDWRC and SDWR (Table 6-1). The effects of AWSP activities and conservation measures on bull trout were evaluated assuming flow conditions as described in Table 6-2. The conservation measures and proposed monitoring activities to be implemented are described in Table 6-3 and are described in greater detail in the following sections.

Within western Washington, bull trout occur sympatrically within the range of Dolly Varden. Both species closely resemble each other in physical appearance. Because Dolly Varden and bull trout are difficult to differentiate visually, and both are members of the char family, the WDFW currently manages both species together under the auspices of “native char.” Although Dolly Varden are not presently listed under the ESA, the ESA authorizes that species may be listed based on similarity of appearance (Section 4(e)) if they “closely resemble in appearance an endangered or threatened species.” Should Dolly Varden and bull trout begin to be managed as separate species by WDFW, the USFWS has reserved the right to list Dolly Varden under the ESA using the similarity of appearance clause. No effort has been made in this document to distinguish between the two species, and discussion of project effects on bull trout will be assumed to be similar for Dolly Varden.

6.3.1.1 Ecosystem Functions

Potential Effects

Ecosystem functions under the AWSP Environmental Baseline will have effects on bull trout similar to those described for chinook in Section 6.2. Floods greater than 12,000 cfs will continue to be prevented. Flows will be the same as under the AWSP Environmental Baseline except during the spring, when flows will be somewhat lower from February to April 15, and somewhat higher from April 15 to June 1 (Figure 6-2). The ability to utilize 5000 acre-feet of water stored under the Section 1135 project in average and wet years could result in slightly higher flows in the early fall (after September 15) and maintain flows beyond the period TPU is required to restrict flows under the MIT/TPU agreement. Fine sediment will continue to accumulate behind HHD, and downstream transport of coarse sediment and LWD will continue to be blocked. The increased reservoir pool level will seasonally inundate approximately 0.8 miles of the mainstem and 1.1 miles of tributary streams, transforming arboreal riparian communities to low growing, inundation tolerant vegetation, reducing bank stability and the area and complexity of pools, and increasing levels of fine sediment in the bed and banks. Interruption of the supply of sediment and LWD could lead to a coarsening of the bed, isolation of side channels and continued constraint of the river’s ability to form new side channels in the lower Green River below HHD. Floodplain connectivity could be impaired by the increasing isolation of side channels.

Under the AWSP Environmental Baseline, ecosystem functions are considered to be functioning at risk to bull trout (Table 6-4). Operation of HHD would continue to control flood flows affecting channel morphology and floodplain connectivity. The interception of sediment and woody debris transport under the AWSP Environmental Baseline are considered to be functioning at unacceptable risk due to the continued degradation of potential spawning and rearing habitats downstream of HHD.

Conservation Measures

The effects of conservation measures on ecosystem functions will be the similar to those described in Section 6.2.1.1. Implementation of the AWSP will provide increased operational flexibility to manage flows so that they more closely match the natural flow regime or to provide benefits to specific species or life-stages, including bull trout. Placement of LWD and gravel downstream of HHD is expected to facilitate retention of spawning gravel, increase the number and complexity of large pools, and maintain existing side channel connectivity and floodplain function.

The overall effect of implementing the AWSP will be to improve ecosystem functions compared to Environmental Baseline conditions, although processes will continue to function at risk primarily due to impacts unrelated to HHD operations or the AWSP. Gravel placement will restore transport processes to levels considered to be functioning appropriately given the continued operation of HHD. Woody debris transport will be restored but since only about 50 percent of the woody debris entering HHD will be transported downstream, woody debris transport will function at risk to potential bull trout habitats in the lower river (Table 6-4).

6.3.1.2 Water Quality

Water Temperature

Potential Effects. The presence of a reproducing, self-sustaining population of native char is unlikely in the Green River below HHD due to warm water temperatures and extensive habitat degradation (i.e., urbanization, roads, logging). Water temperatures in the lower Green River frequently exceed 18ºC during the summer, and often exceed 20ºC (Caldwell 1994). Water temperatures in the Green River at Auburn were found to exceed 18ºC during 46 percent of total hours monitored in August 1992. Water temperatures above 15ºC are believed to limit the distribution of juvenile bull trout (Goetz 1989; Rieman and McIntyre 1993; McPhail and Baxter 1996). In the South Cascade Geomorphic Province, bull trout spawning areas are found at elevations greater than 1,530 feet. As the lower Green River falls below 1,000 feet, it is unlikely spawning habitat exists below the Tacoma Dam (Goetz 1994). Although a reproducing population of bull trout have not been observed in the Green River in recent years, it is possible that bull trout may use localized areas of groundwater inflow or use the lower river during winter and spring months. Under the AWSP Environmental Baseline, water temperature in the Green River is considered to be functioning at risk to bull trout.

Conservation Measures. Changes in water quality will be similar to those described for chinook in Section 6.2.1.2. Facility modifications undertaken as part of the AWSP have a reliability of 97 percent for maintaining HHD release temperatures below the state standard. The benefits to bull trout provided by cooler temperatures would extend several miles downstream of HHD, based upon the results of Caldwell's (1994) temperature study. Increased summer and fall low flows resulting from storage and release of Section 1135 water in average and wet years could benefit bull trout if they are present in the lower Green River. Water temperatures will improve under the AWSP but will continue to function at risk to bull trout.

Dissolved Oxygen

Potential Effects. Dissolved oxygen levels in the middle and lower Green River are generally satisfactory to support fisheries resources. However, samples collected by Metro in the lower Green River show a few occasions where DO levels were measured below the state Class "A" criterion (Corps 1995). However, these violations of the state criterion were not frequent enough to warrant listing the lower Green River as water quality-limited for dissolved oxygen. These low DO levels could potentially impair the upstream migration of native char in the Duwamish/ lower Green River. Native char are fall spawners, and generally spawn from September through November in western Washington (WDFW 1998). Low DO levels in the lower Green River, which typically occur in conjunction with warm water temperatures during the summer and fall, may affect the reproductive success of native char in this system by lower survival of incubating eggs and embryos.

Conservation Measures. Water stored in the reservoir under the Section 1135 Project could be provisionally used to increase flows in the Green River during the late summer and fall. These flow releases could improve DO conditions in the Duwamish and lower Green River, thereby benefiting bull trout if they are present. Dissolved oxygen may marginally improve under the AWSP, but will continue to function at risk to bull trout in the Green River.

Salt Water Wedge

Potential Effects. As described in Section 6.2, the position of the saltwater wedge in the lower Green River has been affected by the loss of inflow from the White River and by water withdrawals from Tacoma. The saltwater wedge currently migrates upstream as far as RM 11 under low flow conditions and is considered to be functioning at risk to bull trout.

Conservation Measures. The position of the saltwater wedge would only be marginally affected by the AWSP. Operation of HHD using the proposed downstream fish passage facility could shift water storage from May to March compared to Environmental Baseline conditions and reduce the effects of HHD on the saltwater wedge during late spring months. The affects of the conservation measures would not substantially change the ecosystem functions of the saltwater wedge and it would continue to function at risk to bull trout.

Total Dissolved Gases

Potential Effects. High concentrations of total dissolved gases are unlikely to occur under AWSP Environmental Baseline conditions as described in Section 6.2. Total dissolved gas levels in the Green River below HHD are currently unknown. The level of total dissolved gases are assumed to be functioning appropriately (Table 6-4); however, this assumption will be confirmed by monitoring.

Conservation Measures. Total dissolved gas concentrations in the Green River are unlikely to reach levels injurious to bull trout under the AWSP. Monitoring is proposed to confirm TDG levels levels, which will improve our information base but is not expected to lead to the need for any conservation measures.

Turbidity

Potential Effects. Turbidity is the only water quality parameter that has seasonally exceeded Class “AA” standards in the Green River above HHD (Corps 1995). Turbidity is of greatest concern during flood events and when HHD reservoir levels are low. Because turbidity increases are generally of short duration, turbidity is not likely to be limiting to bull trout in the lower Green River, though it may limit other uses such as Tacoma’s water supply and recreation. As described for fine sediment, both natural and management related increases in fine sediment result in turbidity currently being considered to function at risk in the Green River.

Conservation Measures. Potential turbidity impacts resulting from shoreline and stream channel erosion under the AWSP would be mitigated by implementation of the sediment management plan (Appendix A). However, flood control operations at HHD will continue to shift downstream transport of fine sediments from the rising to the falling limb of the hydrograph, thus turbidity is expected to continue to function at risk.

Contaminants

Potential Effects. Contaminants that have been observed to exceed State Water Quality Standards in the Green River include fecal coliform, metals and toxic chemicals. Ecology has measured levels of mercury, copper, lead, and zinc above state-established standards in the Duwamish River (Corps 1995). Toxic contaminants have been identified in bottom sediments and surface water in the lower Green River and especially in the Duwamish River (Corps 1995). Chemical testing of bottom sediments in the lower 5 miles of the Duwamish River revealed contamination by oil and grease, sulfides, pesticides, and polychlorinated biphenyls (PCB). More recently, Ecology (1998) cited excursions beyond criteria in sediment for polychlorinated biphenyls and polyaromatic hydrocarbons. No contaminant exceedences have been observed upstream of HHD.

It is unknown whether high levels of contaminants are currently adversely impacting bull trout in the Green River. However, contaminants could bioaccumulate in juvenile bull trout, if present, feeding on macrobenthos in the lower Green River. For this reason, contaminant levels are currently considered to be functioning at risk in the lower Green River.

Conservation Measures. The AWSP would be expected to have little or no effect on the concentration of toxic contaminants in the middle and lower Green River compared to that occurring under the AWSP Baseline. The magnitude and duration of flood events, which mobilize toxic contaminants in the lower river, would not change under the AWSP as compared to the AWSP Environmental Baseline. The AWSP would not affect flows in the lower Green River during the summer and fall compared the AWSP Environmental Baseline except for possible flow augmentation by the 1135 Project during average and wet years. Consequently, no conservation measures are proposed to address contaminants and changes in concentrations of toxic contaminants would not be expected to occur during the summer and fall low flow periods.

6.3.1.3 Fish Passage

Upstream Fish Passage

Potential Effects. Under the AWSP Environmental Baseline condition, upstream fish passage facilities are not available at either Tacoma's Headworks at RM 61.0 or HHD at RM 64.5. Although native char have not been observed in the upper Green River watershed, the lack of upstream fish passage facilities prevents the interaction of native char populations if they are present, and prevents native char populations originating in other basins from colonizing tributary habitat in the upper Green River watershed. The lack of upstream fish passage facilities at HHD is considered an unacceptable risk to bull trout.

Conservation Measures. The upstream fish passage facilities described in Section 6.2 will provide access to upper watershed habitats for any anadromous salmonids that migrate up the Green River to Tacoma's Headworks. Under the proposed AWSP, the City of Tacoma will provide upstream fish passage around both Tacoma's Headworks and HHD as part of their commitments to the Muckleshoot Indian Tribe related to Tacoma's water withdrawals from the Green River. Any native char captured in the trap facility will be transported and released into the upper watershed above HHD. The proposed upstream fish passage facilities will restore adult bull trout access to the upper Green River watershed; however, the need for continued human intervention at the trap-and-haul program causes upstream fish passage to function at some risk to bull trout.

Downstream Fish Passage

Potential Effects. If native char currently exist in upper headwater tributaries, under AWSP baseline conditions their interaction with other populations is hindered by the lack of downstream fish passage facilities at HHD. Any native char moving downstream from upper tributaries during the spring must exit the reservoir prior to mid-March or risk being blocked from project passage by the rising reservoir level. Further, passage through the existing tunnels presents a high risk of mortality to fish attempting passage. If present in the upper watershed, the absence of downstream fish passage facilities may contribute to the isolation of native char populations.

Conservation Measures. The behavior of downstream migrating native char smolts is not well-known, but the proposed downstream fish passage facility described in Chapter 6.2 is assumed to provide successful passage should native char move downstream through the reservoir and dam. Under the AWSP, the summer conservation pool will be increased to elevation 1,167 feet to provide storage for water supply and low flow augmentation. The increased size and volume of the storage will require the downstream fish passage facility to operate over a range of pool elevations from 1,080 feet to 1,167 feet. The proposed facility is designed to provide the opportunity to closely match inflow and outflow and minimize potential delay. The proposed fish passage monitoring station and associated monitoring efforts will increase the likelihood that native char, if present, will be observed and provide additional information to manage native char populations.

If downstream fish passage facilities are implemented as described in Section 6.2 and the AWSP FEIS (Corps 1998a), downstream fish passage from the upper Green River watershed will be restored. Given that the proposed downstream fish passage facility is an experimental design and will require human intervention to operate successfully, downstream fish passage will continue to function at risk (Table 6-4).

6.3.1.4 Instream Conditions

Potential Effects. Bull trout are able to colonize higher gradient streams than most salmonids (Rieman and McIntyre 1993) and, if present, would be able to spawn in suitable tributaries in the upper Green River which do not have passage barriers. Like chinook, bull trout are fall spawners, however juvenile bull trout generally rear in the river system for at least two years, and may complete their entire life cycle in the upper watershed. It is likely that bull trout would preferentially occupy habitat located in the headwaters of the Green River, or localized areas of groundwater inflow where temperatures are naturally cold. Anadromous forms of bull trout may utilize the entire river system during their upstream and downstream migration and if present, are affected by environmental baseline flows as described in Table 6-1. Due to warm water temperatures, bull trout are not likely to use the lower river on a year-round basis, therefore, instream conditions are considered to be functioning at risk to bull trout under AWSP Environmental Baseline conditions (Table 6-4).

Conservation Measures. As proposed, upstream fish passage will be provided at both Tacoma's Headworks and HHD allowing bull trout access to habitat in the upper watershed. After completion of the AWSP, the quality of spawning and rearing habitat for bull trout in the upper watershed will not be degraded by operation of HHD. Habitat conditions in the upper watershed are expected to improve as protection measures associated with Habitat Conservation Plans implemented by other upper watershed landowners begin to show results. Improved habitat conditions in the upper watershed will complement improved bull trout access by the adult trap-and-haul program.

The effects of the AWSP on bull trout instream conditions in the lower watershed will be similar to those described for chinook in Section 6.2. The quality of spawning and rearing habitat in the lower watershed is expected to improve as a result of woody debris and gravel placement. Improvements in flow control provided by the new intake tower and refinements in the refill strategy in association with the GRFMC are expected to improve the pattern of spring flows to more closely mimic natural conditions. If bull trout juvenile outmigrants are observed in the lower Green River, then shifting much of the water storage period from May to March will likely improve the survival of outmigrating juveniles compared to Environmental Baseline conditions. The AWSP flow measures are expected to improve downstream survival of steelhead smolts (Corps 1998a), which like anadromous bull trout, outmigrate in the spring after two to three years of freshwater residency. Bull trout populations are not expected to fully utilize improved stream conditions in the lower watershed since, in recent years, only solitary adults have been found in the lower river. High water temperatures unrelated to the AWSP appear to limit year-round use of the lower river by bull trout.

Little is known about the susceptibility of bull trout fry to stranding, however, because habitat in the lower Green River is not considered adequate to support bull trout rearing, stranding associated with spring time water storage is expected to have no affect on bull trout.

6.3.1.5 Species Interactions

Competition

Potential Effects. Native char are rarely observed in the Green River below HHD. Competition is assumed to be functioning properly (i.e., competitive impacts are minimal) for native char under AWSP Environmental Baseline conditions.

Conservation Measures. Adult chinook salmon reintroduced into the upper watershed could conceivably compete with bull trout for spawning areas, or disturb bull trout redds, since these two species spawn during the early fall. However, adult chinook salmon are predicted to use the lower mainstem sections of the river and tributaries (i.e., total of 24 miles of spawning), whereas bull trout could potentially spawn in any accessible tributary (i.e., up to 106 miles of habitat).

Juvenile coho salmon and steelhead occurring in the upper watershed as a result of the trap-and-haul program may potentially compete with bull trout for habitat space. Bull trout, if present, are likely to be found in the upper reaches of tributaries since they prefer cold water temperatures. Consequently, the impacts of competition from juvenile coho salmon and steelhead on bull trout are likely to be minor because these coho and steelhead juveniles inhabit mainly lower and middle gradient reaches of the Green River above HHD.

Competition is considered to be functioning properly in the Green River and no conservation measures have been proposed for this biotic process under the AWSP.

Predation

Potential Effects. Predation is assumed to be functioning at risk for native char due to incidental harvest mortality.

Conservation Measures. The re-introduction of chinook salmon, coho salmon, and steelhead into the upper Green River would have both positive and negative effects on bull trout if they inhabit the watershed. Bull trout adults and larger juveniles are piscivorous (Goetz 1989; McPhail and Baxter 1996), and have been known to feed upon chinook salmon fry (Brown 1995). Bull trout will likely feed on coho salmon and steelhead juveniles as well. The addition of a high quality food supply through the re-introduction of salmon and steelhead to the upper watershed would be beneficial to bull trout.

Implementation of the AWSP is not expected to alter the risk of predation for bull trout in the Green River, thus no conservation measures addressing this issue have been developed. The risk of predation for bull trout in the Green River, if present, is considered to be functioning at risk due to incidental harvest mortality, and the proposed AWSP will not affect that level of function.

6.3.2. Determination of Effect of AWSP on Bull Trout

Under the Environmental Baseline (without conservation measures), the AWSP **may affect, and is likely to adversely affect** critical habitat for bull trout. In the absence of upstream fish passage facilities, the AWSP will prevent adult bull trout from accessing habitat above HHD. Although it is unclear whether anadromous bull trout historically used the upper watershed, HHD prevents the extension of their range and expansions of sub-populations. The lack of fish passage facilities at HHD effectively isolates habitat in the upper watershed, and the lack of gravel and woody debris transport past HHD adversely affects bull trout habitat in the Green River below HHD.

The anticipated effects of the AWSP on bull trout in the Action Area with conservation measures are summarized in Table 6-6. The proposed project is **not likely to adversely affect** bull trout. The downstream transport of LWD and sediment will be restored, however, woody debris will continue to function at risk due to the continued interception of some of the woody debris at HHD. The ability to manipulate the flow regime to better mimic natural flow variations or to improve habitat conditions to alleviate specific concerns (i.e. release of spring-freshets; augmentation of flows in late summer and fall) will improve; however the necessity to provide for municipal water supply and continued flood protection prevents total restoration. Together, improvements in these processes are expected to improve channel morphology and floodplain connectivity. Water quality will be improved or maintained and instream habitat conditions and interactions between species will be improved or maintained

Under the AWSP, Tacoma will provide upstream fish passage around HHD that will restore the opportunity for colonization of upper watershed habitats by native char from other river systems (Table 6-6). Upstream fish passage also provides for potential interaction of populations in the Green River basin. Transport and release of native char above HHD could establish an anadromous run in the upper Green River above HHD; however, this is unlikely because of the few sightings of native char in the lower river. The increased storage under the AWSP presents additional risk that downstream migrating native char may be unable to pass through the reservoir or may be unable to find the entrance to the fish passage facility. The large capacity, surface-oriented collector is expected to minimize potential reservoir delay and residualization.

Insert Table 6-6

6.4 BALD EAGLE

6.4.1 Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Bald Eagle

6.4.1.1 Potential Effects of Habitat Alteration

The AWSP will increase the area of the reservoir by about 300 acres at full pool, and consequently widen the area of exposed reservoir at low pool (i.e., the area between the water and the surrounding forest) by 50 to 800 feet, depending on slope. Fourteen of the approximately 300 acres that will be inundated are currently mature coniferous forest, and 216 acres support young coniferous forest, deciduous forest and mixed forest (Corps 1998a). The 14 acres of mature coniferous forest currently include trees large enough to serve as bald eagle perches, while the 216 acres of young coniferous forest have the potential to develop the appropriate structural characteristics to be used by perching and/or nesting bald eagles at some time in the future. None of the 230 acres of coniferous forest is located appropriately to serve as bald eagle roost habitat now or in the future, as it is too exposed to provide the type of protection from wind sought by roosting eagles during the winter (Stalmaster 1987). In addition to the 230 acres of coniferous forest that will be inundated by the AWSP, another 3.6 acres of mature coniferous forest and 12 acres of young forest will be cleared and converted to elk foraging habitat (grasses and forbs) under the AWSP. These areas will be located some distance from the reservoir, where they could potentially function as nest or roost habitat in the future if trees of sufficient size are present.

In the short-term, the reduction of currently suitable and potential future nesting and roosting habitat, and the associated increase in the size of the reservoir under the AWSP will have no effect on individual bald eagles or on the overall population of bald eagles in Western Washington. No bald eagles currently nest or roost in the area immediately adjacent to the reservoir, and none will be displaced or otherwise affected by the reduction of habitat.

The reduction of 14 acres in the amount of currently suitable perch habitat around the reservoir, and the increased distance from the shoreline forest to the winter reservoir pool, will have short-term effects on bald eagles that use the area in the winter. Bald eagles forage primarily by perching in the vicinity of prospective prey and awaiting opportunities to kill live individuals or scavenge dead ones (Stalmaster 1987). In the Upper Green River watershed, prospective winter prey are primarily waterfowl on the reservoir. By effectively moving the winter pool as much as 800 feet away from perch trees, the AWSP will reduce the foraging opportunities for wintering bald eagles on the reservoir. Winter foraging in the reservoir will not be eliminated altogether, though, because bald eagles are known to forage for waterfowl over large open areas without perches (Stalmaster 1987). Summer foraging by bald eagles will not be affected because the reservoir will be at the new full pool (1,167 feet) from mid-May through late summer.

In the long term, the amount of potential nesting habitat in the watershed will be reduced by up to 245.6 acres (all forest affected by the AWSP), the amount of potential roosting habitat will be reduced by up to 15.6 acres (affected forest away from the reservoir), and the amount of potential winter perch habitat will be reduced by up to 230 acres (affected forest along the shoreline). It is not known how many acres of nesting, roosting and perch habitat exist for bald eagles in the 147,523-acre upper Green River watershed, but the amount to be affected by the AWSP likely represents a small percentage of the total available.

The long-term effects of a reduction in winter perch habitat adjacent to the reservoir could be greater because it will occur along the entire shoreline and effectively reduce bald eagle foraging over the entire reservoir. Management of upland forest beyond the reservoir shoreline by the Corps and others will not offset the loss of perch habitat at the shoreline.

6.4.1.2 Potential Effects of Alteration in Prey Availability

The diet of the bald eagle in Western Washington is composed largely of fish and waterfowl. Both types of prey are taken year-round, but adult salmon become particularly important during the winter when eagles congregate along rivers that support anadromous runs. In the Green River watershed, adult salmon (coho, chinook and chum) are available seasonally below Tacoma's Headworks facility (RM 61.0), while waterfowl are present in limited numbers year-round above and below HHD. The availability of waterfowl in the watershed probably peaks during the winter on the HHD reservoir, where up to 200 ducks have been reported. Resident fish are also available above and below HHD, and probably contribute to the diet of nesting bald eagles in the watershed.

The AWSP will influence the abundance of both anadromous fish and waterfowl in the Green River watershed, and have resulting effects on bald eagles. Fish abundance will be affected by: a) changes in the release of water from HHD that will improve habitat conditions for some fish species in the Green River below the dam; b) improvement of fish habitat above and below the dam (LWD placement, deposition of spawning gravel and reconnection of side channels); and b) efforts to reintroduce anadromous runs above the dam. Waterfowl populations will be influenced by: a) changes in flow regime along the lower Green River during the nesting season, and b) wetland mitigation measures in the upper watershed above the reservoir that could increase winter waterfowl populations. Effects to fish and waterfowl populations are addressed separately.

Coho Salmon

The coho salmon is the most abundant anadromous fish species in the Green/Duwamish basin (King County Planning Division 1978). Adult coho spawn in the Green River from September through January, generally in tributaries and side channels. Fry emerge from March through June and rear in side channels and pools of the mainstem and its tributaries for one year before migrating down to the Duwamish estuary and out to Puget Sound.

The coho run in the mainstem Green River and Soos Creek averaged 14,950 fish from 1982 to 1991, with an estimated average escapement of 2,970, indicating stable escapement and production levels (WDFW et al. 1994). In contrast, the Newaukum Creek stock has been classified as depressed because of short-term declines in escapement (WDFW et al. 1994). Historically, an estimated 9,000 to 27,000 coho salmon spawned in the watershed above the Tacoma Diversion headworks (Grette and Salo 1986), but currently there is no established escapement goal for the upper Green River. Hatchery fingerlings have been planted above HHD since 1983, but fry-to smolt survival rates for these planted fish have been lower than other watersheds (Dilley and Wunderlich 1993). The lower survival of the planted fish is probably a result of high stocking and low survival (25% or less) among smolts migrating through HHD and the reservoir (Corps 1998a).

The coho salmon is a federal species of concern in Washington. A preliminary stock status review concluded that listing was not warranted (WDFW 1997), but listing could occur in the future if overall population declines continue.

The AWSP will improve habitat conditions for coho salmon by:

- providing access to 49 miles of suitable spawning habitat in the upper watershed;

- improving juvenile rearing conditions in the upper watershed by placing LWD in 15.5 miles of mainstem and 3.5 acres of side channel habitat;

- increasing outmigrant survival by constructing a new downstream fish passage facility at HHD; and

- increasing spawning habitat below HHD by opening 3.4 acres of side channel habitat and placing spawning gravel and woody debris in the mainstem.

The expected effect of these habitat improvements is an increase in the number of adult coho salmon throughout the Green River during the spawning season (September through January), particularly in the upper watershed where the species is presently absent.

Chinook Salmon

Adult chinook spawn in the Green River from August through November, with peak spawning in September and October. Spawning generally occurs in the mainstem from RM 28 to the Tacoma Water headworks, and in the larger tributaries along that reach. Chinook fry emerge from January through March and rear in side channels and pools of the mainstem for days to months before migrating down to the Duwamish estuary and out to Puget Sound. Peak emigration occurs from March to June.

Adult chinook salmon returns to the Green River and its tributaries averaged 7,600 from 1987 to 1992, with an increasing trend (WDFW et al. 1994). The runs have met escapement goals (5,800 fish) in the recent past, but harvest has been severely curtailed due to lower than expected smolt-to-adult survival rates. Stock status is rated healthy. Since 1983, hatchery fingerlings have been planted above HHD. Fry-to smolt survival rates for these planted fish have been lower than other watersheds (Dilley and Wunderlich 1993). The lower fry-to-smolt survival rates are probably a result of high stocking rates and low survival rates of smolts migrating through HHD and the reservoir. Historically, an unknown number of chinook salmon spawned in the upper watershed. An estimated 100 to 400 adult chinook were captured at the Tacoma Water headworks after its completion from 1911 to 1913 (Grette and Salo 1986). Currently, there is no established escapement goal for the upper Green River. The Puget Sound, Lower Columbia River and Upper Willamette River chinook salmon stocks were listed by NMFS as threatened on March 24, 1999 (64 FR 14308).

The AWSP will improve habitat conditions for chinook salmon by:

- providing access to 24 miles of suitable spawning habitat in the upper watershed;
- improving juvenile rearing conditions in the upper watershed by placing LWD in 15.5 miles of mainstem and 3.5 acres of side channel habitat;
- increasing outmigrant survival by constructing a new downstream fish passage facility at HHD; and
- increasing spawning habitat below HHD by opening 3.4 acres of side channel habitat and placing spawning gravel and woody debris in the mainstem.

The expected effect of these habitat improvements is an increase in the number of adult chinook salmon throughout the Green River during the spawning season (August through November), particularly in the upper watershed where the species is presently absent.

Chum Salmon

Adult chum salmon migrate up the Green River from early November to the first week of December. Spawning occurs from mid-November through December in the mainstem Green River between Burns Creek and Crisp Creek (WDFW et al. 1994). Recent surveys have found spawners up to RM 45 in side channels of Flaming Geyser State Park. Muckleshoot Tribal biologists surveyed the Green River during 1996 and reported significant chum spawning in side channels in the middle and lower Green River reaches. Chum fry emerge from mid-February to July and rear from days to weeks in side-channel and mainstem backwater habitats. Peak downstream migration of chum salmon fry occurs from late March through May.

Puget Sound chum salmon are a federal species of concern under the ESA. A preliminary stock status review determined that listing was not warranted for Puget Sound fall/summer/winter chum salmon (WDFW 1997). Two chum stocks are recognized in the Green River system (WDFW et al. 1994). The Crisp (Keta) Creek fall chum stock originated from releases of Quilcene and Hood Canal stocks from the Keta Creek hatchery in the early 1980's. This stock is considered healthy. The Duwamish/Green stock has been considered a remnant native stock, but their status is unknown.

The AWSP will alter habitat conditions for chum salmon by:

- decreasing outmigrant survival an estimated 0.3 percent by decreasing flows in the lower river (below HHD) from late March through May; and

- increasing spawning habitat below HHD by placing spawning gravel and woody debris in the mainstem.

Overall the AWSP will have little effect on the number, distribution or timing of adult chum salmon in the Green River.

Winter Steelhead

Steelhead are differentiated into two types, winter and summer. They share common juvenile behavior patterns, but are distinguished by the timing of adult returns. Winter steelhead adults return to the Green River from November through early June, while summer adults return from April through November (Caldwell 1994). Winter steelhead are native to the Green River, but summer steelhead are of Skamania River origin and are primarily maintained by hatchery plants. Winter steelhead spawn from January through June, with the peak in spawning in April and May. Spawner escapements for wild winter steelhead have been close to or exceeded goals (2,000 fish) in most years, and the status of the stock is healthy. A limited number of summer steelhead spawn in the Green River, usually from mid-January to early April. Many of these fish spawn below the Palmer rearing ponds at RM 56. A significant difference between steelhead and Pacific salmon is that not all steelhead die after spawning, and those that do not die are capable of repeat spawning. Repeat spawning in Washington ranges from of 4.4 to 14.0 percent of total spawning runs (Wydoski and Whitney 1979).

Both winter and summer juvenile steelhead rear in freshwater for one to two years (mostly two) before migrating to the ocean. Juvenile downstream migration occurs from April through July, with peak migration in mid-April. Since 1982, hatchery fingerlings have been planted above HHD. Fry-to smolt survival rates for these planted fish have not been estimated, but probably follow the trend for coho and chinook salmon, which have been lower than other watersheds (Dilley and Wunderlich 1993). The lower fry-to-smolt survival rates are probably a result of high stocking rates and low survival rates (<25%) of smolts migrating through HHD and the reservoir. An estimated 500 to 5,200 adult steelhead were captured at the Tacoma Water headworks after its completion from 1911 to 1913 (Grette and Salo 1986). Since 1991, a temporary fish trap has been operated at the headworks. These fish are either released above HHD for natural spawning, or a select few are used to rear fry for outplanting in the upper watershed in an to attempt to maintain the small run. Currently, there is no established escapement goal for the upper Green River.

Puget Sound steelhead are a federal species of concern under the ESA. A stock status review concluded that Puget Sound steelhead presently are not warranted for listing.

The AWSP will improve habitat conditions for steelhead by:

- improving access to 66 miles of suitable spawning habitat in the upper watershed;

- improving juvenile rearing conditions in the upper watershed by placing LWD in 15.5 miles of mainstem and 3.5 acres of side channel habitat;

- increasing outmigrant survival by constructing a new downstream fish passage facility at HHD; and

- improving spawning habitat below HHD by placing spawning gravel and woody debris in the mainstem.

The expected effect of these habitat improvements is an increase in the number of adult chinook salmon throughout the Green River during the spawning season (January through June), particularly in the upper watershed where the species presently occurs in low numbers.

The net effect of fisheries improvements in the Green River watershed under the AWSP will be increased food supply for bald eagles, particularly during the winter. In the short term, adult salmon may be released into the upper watershed to facilitate reestablishment of a natural run. In the long term, efforts to reintroduce salmon and steelhead to the upper watershed could support adult spawner escapements of up to 6,500 coho, 1,300 winter steelhead and 2,300 chinook (Corps 1998a). These adult fish will be available to wintering bald eagles and other scavengers, and those that are not consumed directly will provide nutrients to the upper watershed that may improve the productivity of resident fisheries. Nesting bald eagles above and below HHD may also feed on adult salmon, but they are more likely to benefit indirectly through increased productivity of the resident fishery, since the timing of the salmon runs excludes a key portion of the nesting season (late spring and early summer). Increased numbers of salmon in the upper watershed could eventually result in increases in the population of both nesting and wintering bald eagles above and below HHD.

Waterfowl

Ducks and geese are present in the Green River above and below HHD year-round, and a small population of loons also breeds on the reservoir. Waterfowl using the Green River below HHD likely will not be affected by the changes in flow that will occur under the AWSP, so there will be no short-term or long-term effect on bald eagles along the lower river in winter or summer.

Waterfowl wintering on the reservoir may be influenced by the AWSP if widening of the area between the winter pool and the surrounding forest increases wind speeds in portions of the reservoir and result in shifts in where the waterfowl congregate and feed. Concentrating waterfowl in certain areas of the reservoir, if it occurs, will not likely effect bald eagles, although it may increase the opportunities for these opportunistic predators to capture waterfowl prey.

Waterfowl nesting on the reservoir may be negatively affected by the increase in the reservoir pool under the AWSP, because annual filling of the reservoir will occur during the spring when ducks and geese are establishing nests and laying eggs. Waterfowl nests that are established in the exposed area adjacent to the winter pool will be flooded as the pool rises. Increasing the size of the seasonal fluctuation zone will increase the potential for flooding of established waterfowl nests. The establishment of sedge meadows and provision of bird nest islands (as proposed for AWSP mitigation) in the seasonal fluctuation zone will further encourage waterfowl to nest there, where they will be vulnerable to flooding. Overall, the potential for flooding of waterfowl nests will increase under the AWSP.

Increasing the size of the summer pool may also alter the location of use by waterfowl. Nesting birds will favor sheltered portions of the reservoir where wind speeds are less, particularly after young have hatched. The locations of protected bays and arms will change as the reservoir level increases, with unpredictable effects on nesting waterfowl.

Counteracting the negative effects of the AWSP on waterfowl will be possible increases in food for ducks and geese. In the short-term, productivity of the reservoir may increase temporarily as a result of a nutrient pulse from the new inundation area. This could benefit both herbivorous and carnivorous waterfowl. In the long term, herbivorous birds like geese will find increased food supply in the sedge meadows, wetlands and elk forage plots that will be established in and near the reservoir as part of the AWSP. Predatory birds such as loons will find an increased abundance of salmon and steelhead fry and juveniles if efforts to increase anadromy above HHD are successful. Overall, the number of nesting waterfowl on the reservoir may increase, but the increase will not likely be large.

6.4.1.3 Potential Effects of Human Activity and Disturbance

Human activity associated with the AWSP will have no effect on individual bald eagles or on the Western Washington population of bald eagles. Construction of the downstream fish passage facility will be several miles from the nearest bald eagle nest, and it will effect no known winter roosts or foraging perches. Construction-related blasting, the use of heavy equipment, vehicle traffic and human presence will have no effect on resident or wintering bald eagles.

Future human activity under the AWSP will be limited to daytime use of the reservoir and the roads in the upper watershed, maintenance of unforested elk forage plots, and silvicultural enhancement of coniferous forest. Bald eagles may be briefly encountered perching along the reservoir or adjacent to streams where salmon are present, but the frequency and duration of human activity associated with the AWSP will not be sufficient to cause more than occasional and brief flushing by the birds. No areas of important use (i.e., nests, winter roosts or key foraging areas) will be affected.

6.4.1.4 Conservation Measures Associated with AWSP to Benefit Bald Eagles

Short-term negative effects on bald eagles will be reduced by retaining all suitable perch trees in the new inundation area. If operational constraints preclude the retention of adequate perch trees in portions of the new inundation area, artificial perches will be erected.

In the long-term, bald eagles will benefit from measures to accelerate the development of late-seral coniferous forest near the reservoir. An estimated 143 acres of young coniferous, mixed and deciduous forest on Tacoma Water lands adjacent to the reservoir will be managed by combinations of thinning and planting to accelerate the natural development of mature coniferous forest conditions. The benefits of this effort will vary, depending on the initial age and species composition of the forest and local site conditions. Dry and mesic sites currently supporting young or mature coniferous forest are likely to be the most successful at achieving conditions suitable for bald eagle nesting within the next 50 years. Forested wetlands and frequently disturbed sites dominated by deciduous tree species may take longer to develop trees of sufficient size for nests.

6.4.2 Determination of Effect of AWSP on Bald Eagles

The AWSP, with or without proposed conservation measures, is **not likely to adversely affect** the bald eagle. A small amount of potential perching habitat adjacent to the reservoir will be lost in the short-term, but long-term increases in the amount of perch, nest and roost habitat will offset the short-term loss. The most pronounced effect of the AWSP in both the short- and the long-term will be an increase in the number of adult salmon in the upper watershed during the winter. The food source for wintering bald eagles will be substantially increased, with resulting benefits to individual bald eagles inhabiting the watershed as well as to the overall population in Western Washington.

6.5 NORTHERN SPOTTED OWL

6.5.1 Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Spotted Owls

6.5.1.1 Potential Effects of Habitat Alteration

The AWSP will increase the area of the reservoir by approximately 300 acres, widen the reservoir by several hundred feet (at the widest point), and lengthen the reservoir 4,230 feet. Of the 300 acres that will be inundated, 14 acres currently support mature coniferous forest and 216 acres support young coniferous, deciduous and mixed forest (Corps 1998a). Only the 14 acres of mature coniferous forest are currently considered suitable for foraging, roosting, and occasional nesting by spotted owls (currently suitable habitat). The 216 acres of young forest currently are not suitable for spotted owls, although they have the potential to develop the appropriate structural characteristics to be used by spotted owls at some time in the future (potential future habitat). In addition to the area that will be inundated by the AWSP, another 3.6 acres of mature coniferous forest (currently suitable habitat) and 12 acres of young forest (potential future habitat) will be cleared and converted to elk foraging habitat (grasses and forbs) as mitigation for the AWSP. This will bring the total area of forest inundated or otherwise affected by the AWSP to 17.6 acres of currently suitable spotted owl habitat and 228 acres of potential future spotted owl habitat.

The reduction of currently suitable and potential future spotted owl habitat and the increase in the size of the reservoir under the AWSP will have no short-term effect on individual spotted owls, or on the overall population of spotted owls in the Western Washington Cascades. No spotted owls currently inhabit the area surrounding the reservoir, and none will be displaced or otherwise affected by the reduction of habitat. The area of the reservoir has not been identified as important to the recovery of the northern spotted owl (Lujan et al. 1992), so a 17.6-acre reduction in habitat in the short term will have no effect on recovery efforts.

The inundation of currently suitable and potential future habitat will have no long-term effect on individual spotted owls, but it may have a minor long-term effect on the population of spotted owls. Although spotted owls do not currently use the area surrounding the reservoir, habitat conditions could improve over time due to the Washington DNR HCP (DNR 1997), the Plum Creek HCP (Plum Creek 1996), the Tacoma Water HCP (Tacoma Water 1999), and the Northwest Forest Plan (USFS and BLM 1994). If these management plans achieve their collective goals, spotted owls could be found nesting, roosting and foraging directly adjacent to the reservoir and dispersing across the reservoir within the next 50 to 100 years.

Individual spotted owls will not be affected by habitat reduction under the AWSP in the long term because the actual reduction of habitat (i. e., raising of the reservoir pool under the AWSP) will occur well before any individual spotted owls inhabit the area. Of the 14,888 acres of Tacoma Water land surrounding the reservoir, only 12 percent support coniferous forest over 80 years old, while 23 percent support forest less than 40 years old (Ryan 1999). The amount of suitable habitat will not increase directly adjacent to the reservoir for several decades, while the pool raise and subsequent reduction in the amount of currently suitable and potential future habitat will occur within the first decade.

The distribution of the inundated habitat also will prevent the habitat reduction from affecting individual spotted owls over the long term. The habitat that will be inundated by the AWSP occurs in a dispersed, linear distribution around the existing reservoir. The absence of this habitat in the future will not be concentrated in any one area where it will have a discernable effect on the local availability of habitat. If spotted owls make use of the forest surrounding the reservoir in the future, the area inundated by the AWSP will be adjacent to several potential owl home ranges and will not represent a significant reduction in the ability of any given area to support spotted owls.

Increasing the size of the reservoir will have no long-term effects on individual spotted owls. While spotted owls are generally associated with mature coniferous forest, they have been reported to cross large forest openings in the course of foraging and dispersing (Forsman et al. 1984). The reservoir occupies roughly 10 percent of the length of the Green River in the upper watershed; the remainder of the river is free flowing and within its natural channel. Resident spotted owls probably do not cross the reservoir routinely while foraging, but it is unlikely that the reservoir represents a significant barrier to juvenile dispersal or the seasonal movements of adults. Dispersing spotted owls are capable of flying around or across the reservoir, and increasing the width by a maximum of several hundred feet will have no effect on spotted owl movements in the watershed.

The population of spotted owls in the Western Washington Cascades may be affected in the long term by the reduction of 245.6 acres in the amount of currently suitable and potential future habitat adjacent to the reservoir. This effect will be minor, and probably immeasurable. The Upper Green River watershed is roughly 147,523 acres, and a substantial amount of this area is likely to be suitable spotted owl habitat in the future. This is particularly true for Tacoma lands surrounding the reservoir, where the City will manage approximately 7,800 acres of forested uplands to develop and maintain spotted owl habitat (Tacoma Water 1999). A reduction of 245.6 acres due to AWSP inundation amounts to roughly 3 percent of the habitat that will be available on Tacoma lands directly adjacent to the reservoir, and less than 0.2 percent of the entire watershed. It also represents approximately 7 percent of the median amount of suitable forest habitat within the home ranges of individual pairs of spotted owls on the west slope of the Washington Cascades (3,281 acres) (Thomas et al. 1990). A habitat reduction of this size will not appreciably decrease the overall ability of the watershed to support spotted owls, or measurably alter the ability of the watershed to contribute to the overall population in the Western Washington Cascades.

Increasing the size of the reservoir will have no effect on the Western Washington Cascades population of spotted owls. As noted above, the enlarged reservoir will not present an obstacle to spotted owl dispersal in the watershed, and therefore will not interrupt the process of juvenile dispersal that is essential to long-term population viability.

6.5.1.2 Potential Effects of Human Activity and Disturbance

Human activity in the Upper Green River Watershed associated with the AWSP will have no effect on individual spotted owls or on the Western Washington Cascades population of spotted owls in the short term or long term. Construction of the downstream fish passage facility will occur within the next decade (prior to 2010), during which time spotted owls are unlikely to nest any closer than 7 miles from HHD because of the absence of suitable habitat. Construction-related blasting, the use of heavy equipment, vehicle traffic and human presence will have no effect on resident spotted owls at that distance. Future human activity under the AWSP will be limited to daytime use of the reservoir and the roads in the upper watershed, maintenance of unforested elk forage plots, and silvicultural enhancement of coniferous forest. Spotted owls are unlikely to nest or roost adjacent to the reservoir, along roads, or adjacent to forage plots, so daytime activity in these areas will have no effect on the species. Silvicultural enhancement will occur in cooperation with Tacoma Water, and will be subject to Habitat Conservation Measures in Tacoma Water's HCP that limit forest management activities near active spotted owl nests during the nesting season.

6.5.1.3 Conservation Measures Associated with AWSP to Benefit Spotted Owls

No conservation measures will be implemented to directly benefit spotted owls in the short term, but measures to accelerate the development of late-seral coniferous forest near the reservoir will have long-term benefits to individual spotted owls and to the Western Washington Cascades population as a whole. An estimated 143 acres of young coniferous, mixed and deciduous forest on Tacoma Water lands adjacent to the reservoir will be managed by combinations of thinning and planting to accelerate the natural development of mature coniferous forest conditions. The benefits of this effort will vary, depending on the initial age and species composition of the forest and local site conditions. Dry and mesic sites currently supporting young or mature coniferous forest are likely to be the most successful at achieving conditions suitable for spotted owls within the next 50 years. Forested wetlands and frequently disturbed sites dominated by deciduous tree species may take longer to reach target habitat conditions for spotted owls.

6.5.2 Determination of Effect of AWSP on Spotted Owls

The AWSP, without conservation measures, is **not likely to adversely affect** the northern spotted owl. The project will have no effect on individuals or populations of the species in the short term without conservation measures because the species does not presently inhabit the project area. Long-term effects of the AWSP, with conservation measures, on spotted owls are likely to be immeasurable, as the loss of up to 245.6 acres of currently suitable and potential future habitat will be offset by the creation/enhancement of 143 acres of suitable habitat in the immediate vicinity. Human presence and activity associated with the AWSP will have no effect on the spotted owl.

6.6 MARBLED MURRELET

6.6.1 Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Marbled Murrelet

6.6.1.1 Potential Effects of Habitat Alteration

The AWSP will result in the inundation of approximately 300 acres of stream channels, wetlands, and terrestrial habitats. Associated habitat management measures will result in the maintenance of 79 acres of habitat in an early-successional condition for elk. A habitat review conducted in the vicinity of the reservoir by the WDFW, USFWS, and the Corps found no old-growth forest; and only a few trees with suitable nest-site characteristics in the area to be inundated. In particular, within the new inundation area there is one small, isolated stand with about 1 acre of suitable nest trees. No other potential nesting habitat is within the new inundation area. The loss of this habitat will have no short-term or long-term impact on individual marbled murrelets, their habitat, or the population within Recovery Zone 1, as described in the Marbled Murrelet Recovery Plan (USFWS 1997).

Based on the surveys conducted around the reservoir in 1994 and near the Tacoma Water headworks in 1994 and 1995, no marbled murrelets occur within the vicinity of HHD or the reservoir (subsection 3.4). Due to the relatively young age of most of the trees in the reservoir vicinity (60 to 80 years), murrelets are not likely to nest in there in the next 10 years. However, given the AWSP conservation measures aimed at advancing the succession of eight forest stands (143 acres) near the reservoir, and Tacoma Water’s plan to manage the forest around the reservoir as late-successional coniferous forest (Natural and Conservation zones), marbled murrelets may nest in the project vicinity in the future. The loss of forested habitat under the AWSP in the short term is not expected to adversely affect marbled murrelets. To assure that associated management of coniferous forest near the reservoir does not adversely impact suitable murrelet habitat in the long-term, no management will be initiated on stands that are known to be occupied by marbled murrelets, and active management will cease once a stand develops suitable murrelet nesting structures.

6.6.1.2 Potential Effects of Human Activity and Disturbance

Construction of the downstream fish passage facility under the AWSP will take place in the short term (i. e., within the next 10 years). Construction activity will not impact nesting marbled murrelets because there is no known occupied murrelet habitat in the immediate vicinity. Human activity in the upper watershed will increase in the long term as a result of fisheries and wildlife enhancement under the AWSP, but the increased activity is not expected to impact nesting murrelets. The AWSP will result in a small increase in vehicle traffic along existing roads as adult salmon and steelhead are trucked to streams and released. The limited information available on marbled murrelet disturbance indicates that passing vehicles do not disturb the birds (Long and Ralph 1998). Management of elk pastures will require the annual use of farm equipment at five sites. Available information also indicates that prolonged loud noises do not disturbed nesting murrelets if activities are not visible from the nest (Long and Ralph 1998). These activities could potentially be visible from a relatively small amount of future murrelet nesting habitat, but they are not expected to impact murrelets.

6.6.1.3 Conservation Measures Associated with AWSP to Benefit Marbled Murrelet

There are no conservation measures specifically designed to benefit marbled murrelets. However, conservation measures implemented to facilitate the development of mature forest conditions in second-growth stands could benefit the marbled murrelets by increasing the local availability of potential nesting habitat.

The late successional forest conservation measure for the AWSP will use harvest management to facilitate the development of mature forest conditions on 143 acres in eight stands. Human activities and the use of power equipment within an occupied stand could disrupt murrelet nesting. To avoid disturbing nesting murrelets, management activities will not be initiated in any stand that is known to be occupied by murrelets and will be concluded when the stand exhibits suitable murrelet nesting habitat characteristics.

6.6.2 Determination of Effect of AWSP on Marbled Murrelet

The AWSP, with or without conservation measures, is **not likely to adversely affect** the marbled murrelet.

6.7 GRIZZLY BEAR

6.7.1 Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Grizzly Bear

6.7.1.1 Potential Effects of Habitat Alteration

The AWSP will inundate approximately 300 acres of stream channels, wetlands, and terrestrial habitats that could potentially provide forage and foraging habitat for grizzly bears. The loss of this habitat will have no short-term or long-term impacts on individual grizzly bears or the grizzly population in the Washington Cascades. Currently, no grizzly bears are known to use the Green River watershed, and the estimated population for the North Cascades ecosystem is very low (10 to 20 animals) (subsection 3.7). Grizzly bears have large home ranges (50 to 500 square miles depending on sex). The inundation of 300 acres of habitat would impact an estimated 1 percent or less of an individual grizzly bear home range. This level of impact would not be expected to reduce the number of grizzly bears in the Washington Cascades.

Grizzly bears avoid areas of consistent human activity and are, therefore, not expected to occur below the HHD in the future. Changes in flow regimes that result from the AWSP will not directly impact grizzly bears, but could assist in the reestablishment of anadromy in the upper watershed.

6.7.1.2 Potential Effects of Human Activity and Disturbance

Construction of the downstream fish passage facility under the AWSP will take fewer than 10 years and is not expected to impact individual grizzly bears, since there are no known grizzly bear in the project area and the current grizzly population in the North Cascade ecosystem is low.

The project areas lie south of Interstate 90 and the North Cascades Recovery Zone for grizzly bear, where recovery efforts will be concentrated. If recovery efforts are successful, grizzly bears may expand outside the recovery zone and use the upper Green River watershed in the future. If this occurs, the small increase in human activity associated with the AWSP could result in potential grizzly bear disturbance. Transporting adult salmonids above HHD will increase vehicle traffic along existing roads in the upper watershed, which are currently used for forest management and other activities unrelated to the AWSP. Details of the proposed upstream fish passage have not been finalized, as of January 2000. However, it is expected to be similar to the trap-and-haul operation run by the Corps on the White River in western Washington (Hilgert 2000). Fish transport will be conducted year-round, with the peak hauling expected in September and October. To re-establish anadromous runs, as many as 260 trips (less than one per day on average) may be required to transport adult fish above HHD. This increase is expected to have a negligible impact on grizzly bears in the future, given traffic will be on or adjacent to existing roads that already receives human use.

In addition to fish transportation, the AWSP includes measures to create and maintain elk pasture at five sites adjacent to the reservoir. Maintenance of these sites will require annual mowing and/or disking and seeding. Four of the sites are within and adjacent to existing powerline rights-of ways that are currently maintained for grass and shrub habitat, while the fifth site is adjacent to a natural meadow (Baldi field). All of the sites are near the reservoir and existing roads. Maintaining these pastures is not expected to adversely increase human activity in the reservoir area or the future human disturbance to grizzly bears. Both the fish transportation and the elk pasture maintenance will potentially maintain or increase foraging opportunities for grizzly bear in the upper watershed by maintaining the elk population and reestablishing anadromous fish runs.

6.7.1.3 Conservation Measures Associated with AWSP to Benefit Grizzly Bear

There are no conservation measures designed to benefit grizzly bear habitat or to protect grizzly bears from disturbance. However, the AWSP will attempt to restore anadromous fish runs and improve winter forage and cover for elk and deer in the upper basin. Approximately 79 acres of elk pasture will be maintained to support wintering elk. The adult salmon and healthy elk populations will provide potential foraging opportunities for grizzly bear.

6.7.2 Determination of Effect of AWSP on Grizzly Bear

The AWSP, with or without conservation measures, is **not likely to adversely affect** the grizzly bear.

6.8 GRAY WOLF

6.8.1 Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Gray Wolf

6.8.1.1 Potential Effects of Habitat Alteration

The AWSP will inundate approximately 300 acres of habitat, including stream channels, wetlands, and terrestrial habitat that could potentially provide denning, foraging, and rendezvous habitat for gray wolves. The loss of this habitat is not expected to have a short- or long-term impact on individual wolves or the gray wolf population in the Washington Cascades. Currently, there are no resident gray wolves known to use the watershed, and there are only a few confirmed wolf sightings within 10 miles of the project area (subsection 3.6). Gray wolves have large home ranges (from 40 to 248 square miles in British Columbia). The habitat to be inundated is estimated to represent 1.3 percent or less of an individual wolf home range. The inundated habitat would not likely be used for den or rendezvous sites, since the habitat is in close proximity to existing roads and railroad line, and wolves are particularly sensitive to human disturbance near these sites. The modification of approximately 300 acres of potential foraging habitat is not expected to impact the size or suitability of an individual gray wolf's home range, or alter the number of wolves in the Washington Cascades.

6.8.1.2 Potential Effects of Human Activity and Disturbance

Construction of the downstream fish passage facility under the AWSP will take fewer than 10 years and is not expected to impact individual gray wolves, since there are no known wolves in the project area and the wolf is so rare in the Washington Cascades. If the gray wolf population in the Washington Cascades increases, gray wolves may occupy the upper watershed in the future. Increased human activity in the upper watershed that results from the AWSP could potentially disturb gray wolves.

Increased human activity in the upper watershed will result from measures to reestablish anadromy above HHD, provide elk pastures for winter forage, and develop mature and late-successional forest. These activities could include the use of mechanized equipment associated with forestry, road maintenance, and farming. However, these activities will be conducted in areas that are closely associated with existing roads and human activity. Gray wolves would not be likely to use these areas for den or rendezvous sites with the current level of human activity. The increased activity resulting from the AWSP management measures will not significantly add to this disturbance.

Gray wolf foraging areas will be determined by the location of suitable prey species. Elk and deer generally move out of an area with human activity. If elk and deer are disturbed by human activity, they will still be available as prey to gray wolves. A small increase in human activity is not expected to impact foraging gray wolves.

6.8.1.3 Conservation Measures Associated with AWSP to Benefit Gray Wolf

There are no conservation measures designed to benefit gray wolf habitat or to protect gray wolves from disturbance. However, habitat management measures under the AWSP will create and maintain pasture habitat for deer and elk foraging, and mature forest conditions for deer and elk thermal and escape cover. Maintaining healthy ungulate populations will benefit gray wolves.

6.8.2 Determination of Effect of AWSP on Gray Wolf

The AWSP, with or without conservation measures, is **not likely to adversely affect** the gray wolf.

6.9 CANADA LYNX

6.9.1 Potential Effects of AWSP Environmental Baseline and Proposed Conservation Measures on Canada Lynx

6.9.1.1 Potential Effects

The current range limits for the Canada lynx do not include the Green River watershed, even though individuals may occasionally travel through the area (subsection 3.8). The AWSP will raise the reservoir elevation 1,167 feet, well below the elevation of known lynx occurrence. Since lynx are known to forage and den above 4,000 feet in Washington, the AWSP is not expected to have any short- or long-term impacts to individual lynx, lynx habitat, or the lynx population in the Washington Cascades.

6.9.1.2 Conservation Measures

Since habitat known to be occupied by lynx will not be impacted by the project, no conservation measures are provided to benefit Canada lynx.

6.9.2 Determination of Effect of AWSP on Canada Lynx

The AWSP will have **no effect** on the Canada lynx.

CHAPTER 7.0
INTERRELATED AND INTERDEPENDENT EFFECTS

For the purposes of this PBA, interdependent actions are those which have no independent utility apart from the action being considered. Interrelated actions are activities that are part of the larger action and depend on the larger action for their justification. This chapter addresses future interdependent/interrelated activities, protection measures, and their effects on listed species.

7.1 FUTURE ACTIVITIES

7.1.1 Tacoma FDWRC and SDWR

Under its First Diversion Water Right Claim (FDWRC), Tacoma has withdrawn up to 113 cfs of water from the headworks diversion facility at RM 61.0 since 1913. Withdrawal of 113 cfs from the Green River is based on historic water right claims dating from 1906 and 1908. Use of water under the FDRWC would continue even in the absence of HHD Continued O&M and the AWSP, thus this action is not considered interrelated or interdependent.

Tacoma is authorized to divert an additional 100 cfs of M&I water under its Second Diversion Water Right (SDWR), for a total of 213 cfs. This 100 cfs of SDWR is conditioned by the Tacoma Public Utilities/Muckleshoot Indian Tribe Agreement (1995), which establishes minimum instream flows for the Green River through each calendar year. These flows exceed the current state established minimum flows. A new pipeline (Pipeline No. 5) will carry the additional 100 cfs from the Green River to the Tacoma Regional Water Supply Area, including south King County, to meet future water needs. Pipeline No. 5 will consist of two primary features: 1) improvements to the existing headworks on the Green River; and 2) construction of a new 33.5-mile-long pipeline. Tacoma's ability to exercise their SDWR and implement the MIT/TPU Agreement would be jeopardized without the AWSP, thus this action is considered interdependent. In addition, Seattle Public Utilities will be using up to 30% of the water stored under the AWSP through their agreement on the SDWR with Tacoma. Thus, Seattle's ability to withdraw water from the SSP is interdependent on implementation of the AWSP.

7.1.2 King County Floodplain Management

The systematic construction of flood control facilities along the lower Green River has led to large-scale, long-term alteration of natural riverine environments and processes. Construction of an extensive system of levees and revetments, in combination with flood control by HHD, allowed development of the former floodplain. Land uses such as agriculture, urban and residential development, and construction of infrastructure (roads, bridges, drainage systems) have permanently altered the valley landscape. The operation and maintenance of existing flood control facilities is dependent on flood control operations by HHD.

The King County River Section is currently responsible for flood control programs and projects along the lower Green River. The King County Flood Hazard Reduction Plan (KCFHRP), adopted in 1993 provides policy guidance for projects and programs implemented by the River Section. Adoption of the KCFHRP resulted in significant changes in the way King County conducted flood hazard reduction projects. New initiatives include home relocation and elevation projects, use of design standards that protect and enhance fish and wildlife habitat, and setback of levees where possible (King County 2000). Other programs implemented under the KCFHRP include structural capital improvements (CIPs), floodplain land acquisitions, and flood protection facility maintenance. In recent years, flood control CIPs have been limited to small bank stabilization projects that protect one or more homes.

Existing levees and revetments are maintained in accordance with the "Guidelines for Bank Stabilization" (Johnson and Stypula 1993). Maintenance of existing levees and revetments historically included the systematic removal of vegetation. The current guidelines feature methods that incorporate soil, vegetation and LWD to enhance fish and wildlife habitat (King County 2000). Where possible, repair projects include levee setbacks and slope reconfiguration (Schaefer 2000). Land acquisitions that allow removal of some flood control facilities are considered the most effective and desirable means of returning river channels to their natural functions and processes, although available funding often limits this approach (King County 2000).

7.2 FUTURE PROTECTION MEASURES

7.2.1 Muckleshoot Indian Tribe/Tacoma Public Utilities Agreement

The Muckleshoot Indian Tribe (MIT) is involved on many levels in the Green River Basin. The MIT also has co-management responsibilities with the State of Washington for the fisheries resources within its usual and accustomed fishing areas, which include Lake Washington, the Green, Cedar, and upper Puyallup/White River basins. The Muckleshoot Indian reservation also encompasses a portion of the Green River. Fishing, hunting, gathering of native plant material, and access to the river, wetlands, and forests of the Green River basin above and below HHD provide essential economic and spiritual sustenance to the Muckleshoot people (Corps 1998).

As co-managers of anadromous fish resources, the Muckleshoot Tribe provides input to the Corps operation of the existing HHD Project. Technical staff represents the Tribe each year during pre-season forecasting, seasonal refill, and summer flow augmentation coordination of reservoir operations. Their input, along with the WDFW, has dramatically altered the form of refill and release operations. In addition to input to project operations, the Muckleshoot Tribe influences fisheries management in the Upper Green River by stocking hatchery reared juvenile salmonids above HHD.

The Muckleshoot Indian Tribe and the City of Tacoma signed the Muckleshoot Indian Tribe/Tacoma Public Utilities Settlement Agreement (MIT/TPU Agreement) in 1995. The MIT/TPU Agreement settles all claims by the Muckleshoot people relating to Tacoma's water supply operation on the Green/Duwamish River System, except for the AWSP, through a combination of financial and natural resource remedies. Included in this Agreement are several planned provisions important to restoration of anadromous fish to the Upper Green River. These provisions include: 1) a fish restoration facility–a "naturalized" rearing facility for reestablishing salmon and steelhead; 2) a fish ladder and adult collection and transport facility to provide adult fish passage above Tacoma's Headworks; and 3) higher, guaranteed minimum flows to protect instream resources (MIT/TPU 1995).

7.2.2 Green/Duwamish River Basin GI Ecosystem Restoration Study

The Corps/King County Ecosystem Restoration feasibility study has begun on the Green River and identifies potential ecological limiting factors in the river (Fuestenberg et al 1996). One major factor identified by the study is the low level of summer and fall flows. These low flows, in addition to limiting freshwater fish habitat, can be associated with other water quality concerns. Decreased low flows during summer and fall can influence 1) the amount of available freshwater habitat in the Duwamish estuary; 2) available dissolved oxygen in the river; and 3) dilution of nutrients and introduced pollutants in the river.

A series of restoration strategies have been identified to return the Green River to a more natural condition (Corps 1997). Some of the strategies include:

- *Improve connections between the mainstem river and floodplain/estuary habitats.* Less than 10% of the floodplain and 3% of the estuary wetlands are connected to the river. Actions being considered include removal or setback of levees, lower the elevation of side channel inlets[9], or addition of large wood[9] to increase the mainstem water surface.
- *Change river sediment loads and transport.* Almost 50% of the watershed is above HHD and the dam traps a large sediment load. Up to 1,000 linear feet of lower river mainstem spawning habitat is losing gravel substrates each year. Actions being considered are limited but could include placement of gravel in selected sediment deficient areas[9].
- *Change river flows.* Peak flows have been reduced to a maximum of 12,000 cfs at Auburn, water withdrawals have reduced minimum flows in major tributaries, and refill of HHD has altered the natural flow regime in the spring. Actions include altering HHD refill to mimic natural flow regime, altering timing of refill, and additional storage for flow augmentation.[9]
- *Improve instream habitat complexity and structure.* Large wood is scarce from construction of HHD and loss of the riparian zone; levees constrain much of the lower 35 miles. Actions include addition of large wood[9] and removal or setback of levees.
- *Reduce water temperatures in the mainstem.* Loss of nearshore forests and lower flows have resulted in higher summer water temperatures, often near lethal limits for cold-water fish. Actions include provision of water control at HHD outlet, flow augmentation, improvement of riparian areas, setback or removal of levees.[9]
- *Increase natural nutrient loading levels*. A reduction in natural spawners (and their carcasses) throughout the watershed has reduced critical inputs of marine-origin nitrogen. Limited amounts of nitrogen reduces productivity of the entire aquatic food chain. The Upper Green River is severely deficient in natural inputs of nitrogen.

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[9] This strategy is also included as part of this PBA.

7.3 ANALYSIS OF EFFECTS ON LISTED SPECIES

7.3.1 Chinook

Implementation of the AWSP, in conjunction with the TPU/MIT Agreement, Green/Duwamish GI project and KCFHRP will substantially improve habitat conditions for chinook in the Green River. Under the AWSP, the flow regime downstream of HHD can be managed to mimic natural flow variations or to provide specific benefits to target species (e.g. increased fall flows to improve conditions for upstream migrating chinook). The MIT/TPU Agreement will increase minimum flows during the summer and early fall.

Passage of chinook to and from the upper watershed will be restored by construction of downstream passage facilities at HHD and Tacoma's Headworks, and implementation of an adult trap and haul program. Under the MIT/TPU Agreement, a naturalized fish reproduction facility may be funded to help re-establish chinook production in the upper watershed.

Habitat rehabilitation activities undertaken as part of the AWSP, Green/Duwamish GI project and KCFHRP will improve habitat conditions in the near-term for chinook salmon in both the upper and lower watershed. The combined gravel nourishment and LWD management programs are expected to restore coarse sediment transport downstream of HHD to properly functioning conditions, improving spawning habitat for adult chinook. Addition of LWD as part of site-specific rehabilitation projects under the AWSP and KCFHRP is expected to increase the number and complexity of pools and improve the quality of stream margins used by rearing chinook. Side channel restoration projects under the AWSP and Green Duwamish GI will increase the amount of available side channel habitat by over 20,000 feet (Table SWM-T5).

7.3.2 Bull Trout

The effects of interrelated and interdependent activities on bull trout will be similar to those described for chinook. Passage to and from the upper watershed will be restored and habitat will improve as a result of increased minimum flows and habitat rehabilitation projects implemented throughout the upper and lower Green River watershed.

7.3.3 Bald Eagle

The SSP will have little or no effect on the bald eagle. The SSP was the subject of a previous Biological Assessment (Beak Consultants Incorporated 1996), which noted the presence of a bald eagle nest near Lake Sawyer, approximately 2,000 feet from the route of the SSP. It was determined in that BA that construction of the new pipeline would not disturb or alter bald eagle habitat, and construction activity would likely not be detectable above the high background levels of human activity in the vicinity of the nest. As a precaution against disturbing nesting bald eagles, Tacoma will restrict construction activity within 2,640 feet of the Lake Sawyer nest during most of the nesting season (January 1 through July 15). Additional bald eagle nests exist in the lower Green River valley, but none is within 1 mile of the SSP construction or mitigation sites, and none would be affected by the project.

Tacoma's withdrawal of the AWSP water in late summer will have no effect on the bald eagle. The water will be stored behind HHD in the spring and released by the Corps in late summer under the AWSP. Tacoma's subsequent withdrawal of the released water 3.5 miles downstream of HHD (at the Tacoma headworks) will result in no net change in Green River flows from those described and analyzed in Chapter 6 of this PBA. It will have no additional effect on bald eagles in the upper or lower Green River watersheds.

King County floodplain management and the Green/Duwamish GI ecosystem restoration activities will have no effect on bald eagles because any such activities would need to comply with state and federal laws protecting bald eagles and their nests. No potentially impacting activities would occur without prior preparation and approval of a nest site protection plan.

The MIT fish restoration facility is not likely to have a negative effect on the bald eagle, and it may have a positive effect. The facility will not displace or disturb nesting bald eagles, but it will help to maintain and enhance salmon runs in the Green River that could increase the food supply for local bald eagles. Bald eagles may be attracted to the restoration facility during periods when returning adult salmon are present in the Green River, and efforts to protect salmon from foraging eagles could occasionally involve flushing of the birds from the vicinity of the facility. This temporary and intermittent negative effect would be more than offset by the overall positive of salmon restoration in the watershed.

7.3.4 Northern Spotted Owl

Construction of the SSP will have no effect on the northern spotted owl, as it will result in no alteration of suitable spotted owl habitat or disturbance of nesting spotted owls. No suitable spotted owl habitat exists in the vicinity of any of the SSP construction areas. Tacoma's withdrawal and use of Green River flows under the AWSP and the SSP also will have no effect on spotted owl habitat or individual spotted owls, as these activities will occur in areas highly unlikely to support spotted owls now or in the future.

King County floodplain management and the Green/Duwamish GI ecosystem restoration activities will have no effect on the northern spotted owl because no spotted owl nesting habitat is present in the areas where these activities might occur.

The Muckleshoot fisheries enhancement facility will have no effect on the spotted owl. Construction of the facility will not alter or disturb suitable habitat, and operation of the facility will not disturb nesting spotted owls.

7.3.5 Marbled Murrelet

The SSP will have little or no effect on the marbled murrelet. The SSP was the subject of a previous Biological Assessment (Beak Consultants Incorporated 1996), which noted the presence of potentially suitable marbled murrelet nesting habitat near the Tacoma headworks. It was determined in that BA that construction at the headworks will not disturb or alter the potentially suitable habitat, and construction-related noise levels will not exceed existing noise levels on the adjacent Mainline Road created by log trucks and other vehicle traffic.

Tacoma's withdrawal and use of Green River flows under the AWSP and the SSP will have no effect on marbled murrelet habitat or individual marbled murrelets, as these activities will occur in areas highly unlikely to support murrelets now or in the future (Beak Consultants Incorporated 1996).

King County floodplain management and the Green/Duwamish GI ecosystem restoration activities will have no effect on the marbled murrelet because no marbled murrelet nesting habitat is present in the areas where these activities might occur.

The Muckleshoot fisheries enhancement facility will have no effect on the marbled murrelet. Construction of the facility will not alter or disturb suitable habitat, and operation of the facility will not disturb nesting murrelets.

7.3.6 Grizzly Bear

None of the activities that are interrelated with or interdependent on the operation and maintenance of HHD or the AWSP will effect the grizzly bear. These activities will occur in the Green River watershed below HHD, where the grizzly bear does not occur and is not likely to occur in the foreseeable future. No grizzly bear habitat will be altered, and no individual grizzly bears will be disturbed or prevented from using otherwise suitable habitats by the occurrence of these activities.

7.3.7 Gray Wolf

None of the activities that are interrelated with or interdependent on the operation and maintenance of HHD or the AWSP will effect the gray wolf. These activities will occur in the Green River watershed below HHD, where the gray wolf does not occur and is not likely to occur in the foreseeable future. No gray wolf habitat will be altered, and no individual gray wolves will be disturbed or prevented from using otherwise suitable habitats by the occurrence of these activities.

7.3.8 Canada Lynx

None of the activities that are interrelated with or interdependent on the operation and maintenance of HHD or the AWSP will effect the Canada lynx. These activities will occur in the Green River watershed below HHD, where the Canada lynx does not occur and is not likely to occur in the foreseeable future. No Canada lynx habitat will be altered, and no individual Canada lynxes will be disturbed or prevented from using otherwise suitable habitats by the occurrence of these activities.

CHAPTER 8.0
CUMULATIVE EFFECTS

This chapter addresses the effects of non-federal activities that were not previously addressed in Chapter 7.0 and not related to HHD Continued O&M or the HHD AWSP.

8.1 FUTURE STATE, LOCAL AND PRIVATE ACTIVITIES

8.1.1 Forest Management in the Upper Green Watershed

8.1.1.1 Washington Department of Natural Resources (WDNR)

The WDNR manages 20,752 acres (14.1% of the upper watershed) of state trust lands for economic return and environmental quality according to the WDNR Habitat Conservation Plan. WDNR lands in the Green River watershed play a very small role in the overall effort to conserve late-seral coniferous species, and very few of the WDNR lands in the watershed are targeted for spotted owl or marbled murrelet habitat. Primary emphasis for WDNR lands in the Green River watershed is on commercial timber production. WDNR timber management must be in compliance with the Forest Practices Act and ESA per their own HCP.

8.1.1.2 Plum Creek Timber Company

The Plum Creek Timber Company owns and manages 50,751 acres (34.4% of the upper watershed) according to its Habitat Conservation Plan. This largest landowner in the upper watershed manages for commercial timber production, while maintaining and enhancing habitat for spotted owls and riparian/aquatic species.

8.1.1.3 Giustina Resources

Giustina Resources owns and manages 15,312 acres (10.4% of the upper watershed) for commercial timber production in compliance with Washington Forest Practices Rules and the federal ESA. Giustina, however, does not conduct any special practices for fish or wildlife.

8.1.1.4 Tacoma Water

Tacoma owns and manages 15,116 acres (10.1% of the upper watershed) for water quality, fish and wildlife habitat and commercial timber production according to its Forest Management Plan. The majority of Tacoma lands lie directly adjacent to the HHD reservoir, the upper Green River, and its major tributaries. Roughly 75% of the Tacoma lands are managed without clearcut harvest to protect water quality and maintain or enhance habitat for fish and wildlife. The remaining 25% of Tacoma lands are managed for commercial timber production and habitat on an extended harvest rotation of 70 years. Future management of Tacoma’s land is expected to be conducted to measures implemented according to the draft Tacoma Water Habitat Conservation Plan (TPU 1999), which includes measures designed to provide increased protection of riparian zones, unstable landforms and roads as well as species specific conservation measures. Approximately 450 acres of Tacoma's lands will be managed for wildlife as mitigation for the AWSP.

8.1.1.5 Weyerhaeuser Company

Weyerhaeuser Company owns and manages 8,365 acres (5.7% of the upper watershed) for timber production according the Washington Forest Practices Rules and in compliance with the federal ESA.

8.1.1.6 Other Private Timber Companies

Other private timber companies own and manage 226 acres (0.2% of the upper watershed) for timber production according the Washington Forest Practices Rules and in compliance with the federal ESA.

8.1.2 Burlington Northern Santa Fe Railroad (BNSF)

The BNSF owns 1,387 acres (0.9% of the upper watershed) which is maintained as railroad right-of-way and associated support facilities. This is an active rail line that handles daily freight traffic. The rail line is maintained by mechanical clearing, herbicides, and riprap of existing levees.

8.1.3 Puget Sound Energy (PSE)

PSE maintains an electrical power transmission line that runs the length of the upper watershed. The line is accessed, as needed, for maintenance and repair. The vegetation on the right-of-way is kept in grasses and shrubs through the use of mechanical and limited chemical methods.

8.1.4 Continued Growth and Development in the Lower Watershed

HHD provides flood damage reduction in the Green River valley and an increased level of flood protection to landowners and local governments. Following dam construction in 1963, the valley continued to transform from agricultural to major industrial, commercial, and residential uses. In the mid-1960s, industrial expansion in the Green River valley included development of two major Boeing facilities in Kent and Auburn. By the late 1960s, the land use in the valley had shifted from a dominance of agricultural to a wide variety of industrial and commercial uses. By the 1970s, farming in the valley was substantially reduced and much of the land was left vacant or converted to industrial/commercial use. During the 1980s, land use in the valley further diversified to include not only industrial, manufacturing, and warehouse uses, but service industries and commercial offices. Today the Green River valley is primarily classified as industrial with some residential, commercial, and farmland areas (Corps 1998a).

8.1.5 Recreational Activities on the Green River

The area below HHD is a recreational resource of value with several park locations allowing access to the river for activities such as fishing, floating, canoeing, kayaking, white water rafting and hiking. The upper watershed above the Tacoma Headworks is basically undeveloped and closed to fishing within the City of Tacoma's watershed. Some recreational hunting is permitted annually.

There is intense public interest in use of HHD to enhance white water recreational opportunities. In recent years the Corps has placed reduced emphasis on these needs while still considerating them in water management decisions (Corps 1998a).

8.2 FUTURE STATE, LOCAL AND PRIVATE PROTECTION MEASURES

8.2.1 State Plans and Policies

8.2.1.1 Wild Salmonid Policy

In response to the ESA listing, the State of Washington has implemented or is in the processes of implementing a number of programs designed to support a chinook recovery plan developed by the NMFS. A Joint Natural Resources Cabinet and Salmon Recovery Office have been established to develop a statewide strategy to address the listing of chinook and other salmonid species. A draft Wild Salmonid Policy was developed in cooperation with the western Washington Treaty Tribes, and adopted on December 5, 1997. The goal of the Wild Salmonid Policy is to protect, restore and enhance the productivity, production, and diversity of wild salmonids and their ecosystems to sustain ceremonial, subsistence, commercial and recreational fisheries (WDFW 1997). Enforcement of laws against poaching, habitat destruction, water pollution and withdrawing water without a permit will be intensified by hiring additional staff. Water quality and quantity problems will be addressed by: 1) setting TMDLs for water bodies that do not meet federal Clean Water Act standards; 2) installing additional stream gages to monitor flows and regulate water use; 3) making decisions on water rights; and 4) purchasing existing water rights to return water to streams.

8.2.1.2 Wild Stock Restoration Initiative

The Washington Department of Fish and Wildlife and Western Washington Treaty Tribes created the Wild Stock Restoration Initiative in 1991 in response to concerns about wild salmon and steelhead. A general approach to assess wild stock status and recovery was developed, beginning with a statewide inventory of all salmon and steelhead stocks and their habitat, the Salmon and Steelhead Stock Inventory [SASSI] (Washington Department of Fish and Wildlife and Western Washington Treaty Tribes 1994). Following completion of these efforts, management strategies will be reviewed, recovery and management plans developed, and a monitoring and evaluation program implemented.

8.2.1.3 Washington Department of Fish & Wildlife Priority Habitats and Species Program

The Washington Department of Wildlife has developed statewide riparian management recommendations to protect aquatic habitats and priority fish species (Knutsen and Naef 1997). These recommendations cover major land use activities commonly conducted within or adjacent to stream channels including agriculture, chemical treatments, grazing, watershed management, roads, stream crossings, recreation, forest practices, urbanization and habitat restoration and enhancement.

8.2.1.4 Hatchery/Harvest

The State of Washington and Washington Treaty Tribes have co-management responsibilities for fisheries resources. Under the 1997 Wild Salmonid Policy, fisheries will be managed to 1) maintain or increase genetic diversity within and among stocks; 2) maintain wild salmonid stocks at levels that naturally sustain ecosystem processes and diverse indigenous species; 3) meet the spawning escapement policy; 4) protect, rehabilitate and re-establish naturally spawning populations using integrated principals of genetic conservation, ecology, hatchery production and fish management; and 5) use programs of stable, cost-effective artificial production to provide significant fishery benefits while having no significant adverse impacts on the long-term productivity of natural salmonids (WDFW 1997).

8.2.1.5 Shorelines Management Act

The State Shoreline Management Act protects and regulates management that could impact Shorelines of the State. Shorelines of the State include streams with a mean annual flow of more than 20 cfs and lakes larger than 20 acres. Associated shorelines includes lands within 200 feet of the ordinary high water mark and wetlands or river deltas associated with the streams. Activities proposed within Shorelines of the State must comply with permitting and development requirements set forth in the Shoreline Master Program and Shoreline Regulations. Policies and regulations governing Shorelines of the State are currently under review, and are expected to be revised in the near future to increase the protection afforded these areas.

8.2.1.6 Growth Management Act

The Washington State Legislature passed the Growth Management Act (GMA) as a way to protect the unique Pacific Northwest quality of life. The GMA directs the state's most populous and fastest growing counties and their cities to prepare comprehensive land use plans that anticipate growth and impact for a 20-year horizon.

King County and cities within its boundaries developed the King County Countywide Planning Policies to meet the GMA requirements and to coordinate planning among all of its jurisdictions. These policies establish an urban growth area within the western one-third of King County where most growth and development is projected to occur. The policies' goals include reducing urban sprawl, protecting rural areas, and more efficiently providing roads, parks and other services (King County 2000).

8.2.2 King County Salmon Recovery Efforts

The NMFS is responsible for establishing 4(d) Rules for Puget Sound chinook salmon listed under the ESA. The rules, when finalized by NMFS, will prohibit activities that will harm salmon and their habitat - also known as "take." The rules will govern all aspects of land use affecting their habitat, including logging, development, fishing, hatcheries and agriculture. NMFS intends to defer, when possible, to local and state recovery plans instead of implementing broad federal regulations through the 4(d) rules.

A Tri-County ESA group was formed in early 1998 when King, Snohomish, and Pierce counties brought together cities, tribes, businesses, the environmental community, utilities and other community groups to address recovery of the salmon and revitalization of the watersheds. The executives of each county head the Tri-County ESA group that has been working to develop a recovery plan since the chinook salmon was named a threatened species. Their work has been aimed at adoption of a special draft rule, which would allow salmon recovery to continue while the cities and counties, and the businesses that operate within their boundaries, can continue to operate by using environmentally sensitive business practices.

The "Tri-County Initiative to Recover the Puget Sound Chinook" includes the conservation plan of each county and the cities within its boundaries. This multi-jurisdictional initiative for salmon restoration is the largest cooperative effort ever undertaken in the region's history. Through the Tri-County partnership, a strategy has been developed to conserve salmon, sustain economy – and control the region's destiny.

The King County contribution to the "Tri-County Initiative," entitled "Return of the Kings – Strategies for the long-term conservation and recovery of the chinook salmon," illustrates both immediate and longer-term commitments to salmon recovery through a description of past, continuing and early conservation actions. King County intends to undertake a comprehensive review of regulations relating to salmon and habitat through the watershed conservation planning process. For example, King County's Sensitive Areas Ordinance applies stringent standards across the entire unincorporated area, and is a fundamental element of stream protection in King County. In order to improve protections for salmon-bearing streams, King County is proposing to update the ordinances, increase enforcement of the regulations, and initiate an enhanced monitoring program to evaluate compliance and performance. As sponsor of the Green Duwamish GI Study, King County will implement many recovery and restoration activities through partnering with the Corps.

In the interim, King County will evaluate its use of State Environmental Protection Act (SEPA) authority to impose additional conditions and mitigation on development proposals to further protect salmon habitat. This use of SEPA substantive authority is consistent with existing County policies, does not require changes to the state SEPA law, and can be accomplished within the general framework of permit review already in place.

8.2.3 Wastewater Treatment Plant Section 10 Coverage

King County's Wastewater Treatment Division (WTD), Environmental Compliance Unit, is preparing an HCP as described in Section 10 of the ESA, as part of King County's response to the listing of the chinook salmon and other species under the ESA by the Services. The focus of the HCP is to obtain an Incidental Take Permit for the present and future activities of the Wastewater Treatment Division and to guide King County in addressing its impact on threatened and endangered species.

The HCP will be developed in phases with the first phase covering the existing WTD operations and the siting of a new third treatment plant and marine outfall, pending approval by the Metropolitan King County Council, or other major near-term capital improvements in the Council-adopted Regional Wastewater Services Plan (RWSP). The proposed plant is part of the King County Executive's preferred plan in the RWSP.

8.3 ANALYSIS OF CUMULATIVE EFFECTS ON LISTED SPECIES

8.3.1 Chinook

As described in Chapter 7, HHD O&M and the AWSP are complemented by the Green Duwamish GI project sponsored by King County and by the fisheries measures contained in the 1995 MIT/TPU Settlement Agreement. New State programs and policies, King County Salmon Recovery efforts, and the federal Section 4(d) rules will contribute to the overall improvements in aquatic habitat in the lower Green River. As described in Chapter 7, the net result of these actions will be increased shade and LWD recruitment and improved spawning habitat. In addition, development-related peak flow increases will be stabilized and potentially partially reversed, poaching pressure will decrease and the connectivity and function of floodplain habitat will improve.

Together, implementation of the AWSP and the Wastewater Treatment Plant HCP will improve water quality in the Green River. Implementation of the AWSP will reduce summer temperatures immediately downstream of HHD, while increased minimum flows and implementation of King County's Wasterwater Treatment Plant HCP are expected to reduce temperatures and increase DO levels in the lower Green River. Improved protection of riparian zones should also help reduce temperatures throughout the Green River over the long term.

The overall effect of increased protection provided by the Plum Creek HCP, Tacoma Water HCP, WDNR HCP and more stringent Washington Forest Practice regulations will be to improve shade and LWD recruitment and reduce sediment inputs in the upper watershed. These actions will result in improved riverine habitats over the long-term, which will benefit chinook salmon. Habitat rehabilitation projects conducted as part of the AWSP, and Green Duwamish GI project would provide immediate benefits to a number of stream reaches. Mitigation measures in association with the BNSF rail line reopening will have similar immediate benefits. The presence and continued operation of the BNSF railroad line and adjacent roads would prevent full realization of increased shade and LWD recruitment in portions of streams in the upper watershed. The original construction of roads and railroads disrupted channel migration, prevented access to tributary channels, removed shade, and has resulted in localized inputs of rock and ballast from the railroad bed. These effects will continue into the future as long as the roads and rail line are maintained. However, these reaches represent only a small portion of the total habitat in the upper watershed.

8.3.2 Bull Trout

The cumulative effect of the actions described above and in Chapter 7 on bull trout will be similar to those described for chinook. Passage to and from the upper watershed will be restored, and habitat and water quality will improve throughout the watershed. Reductions in temperature resulting from increased shade, higher minimum flows and improved temperature regulation at HHD will be especially beneficial to bull trout.

8.3.3 Bald Eagle

The cumulative effect of HHD O&M, the AWSP, and non-federal activities in the Green River watershed will be positive on the bald eagle, particularly with respect to food supply. The storage of water behind HHD, the subsequent release of stored water, and the withdrawal of water by Tacoma will continue to be coordinated with NMFS, USFWS, WDFW, the Muckleshoot Indian Tribe, King County and others to maintain or improve instream conditions for fish, particularly anadromous salmonids. It is anticipated that fisheries in the Green River will benefit from the combined effects of coordinated flow management, re-establishment of upstream and downstream fish passage, mainstem habitat improvements (LWD and gravel placement), and headwaters habitat improvements under current and future forest management. The result will be increased food supply for bald eagles.

Habitat conditions for bald eagles also will improve in the upper watershed. Requirements of forestland owners to maintain and enhance late-seral riparian forest conditions in the upper watershed (under Washington Forest Practices Rules, existing HCPs and/or AWSP mitigation) will increase the availability of nesting, perching and winter roosting habitat for bald eagles. Habitat conditions for bald eagles in the lower Green River watershed will be unaffected, although other activities not addressed in this PBA (e. g., recent salmon listings) will likely lead to increased protection of streamside habitat in the lower watershed used by nesting and foraging bald eagles.

Disturbance-related effects on bald eagles may increase in the lower Green River watershed over time if the number of eagles increases. Specific efforts to improve fisheries and general efforts to recover the bald eagle are both likely to increase the number of nesting and wintering bald eagles along the lower Green River. Continued use of the river for recreation (e.g., boating and fishing) may increase the incidence of bald eagles being flushed from feeding areas and perches (Knight 1984), or precluded from using otherwise suitable nesting habitat. Similar disturbance effects are not anticipated in the upper watershed because of restrictions on human access.

8.3.4 Northern Spotted Owl

Like the marbled murrelet, the northern spotted owl is highly unlikely to occur downstream of HHD, so there will be no cumulative effects on the species in the lower Green River watershed. Upstream of HHD, the cumulative effects of HHD O&M, the AWSP and non-federal activities will be mixed. The principal non-federal landowners in the upper watershed (Plum Creek and the DNR) will manage their lands under approved HCPs that allow the short-term harvest of existing spotted owl nesting-roosting-foraging (NRF) habitat, but require the long-term maintenance of target levels of spotted owl dispersal habitat. Plum Creek also will retain some of the existing NRF habitat in the "checkerboard" landscape of intermixed federal and non-federal ownership at the eastern end of watershed. The proposed Tacoma HCP will follow a similar strategy, although the amount of NRF habitat on Tacoma lands will increase in the future along with the amount of dispersal habitat. It is not likely the increase in NRF habitat on Tacoma lands will offset the decrease on other non-federal lands, so the net effect will likely be an overall reduction in NRF habitat on non-federal lands outside the checkerboard landscape of the upper watershed. This overall management of the upper watershed is consistent with the Final Draft Recovery Plan for the Northern Spotted Owl (Lujan et al. 1992).

8.3.5 Marbled Murrelet

The marbled murrelet is highly unlikely to occur downstream of HHD, so there will be no cumulative effects on the species in the lower Green River watershed. Upstream of HHD, the cumulative effects of HHD O&M, the AWSP and non-federal activities will be positive. Existing marbled murrelet nesting habitat in the upper watershed will be protected by take prohibitions under Section 9 of the ESA, as well as by Washington Forest Practices Rules that restrict timber harvest in and near "occupied" nesting habitat. New marbled murrelet nesting habitat eventually will develop on Tacoma lands managed under their proposed HCP, as well as in larger riparian areas on other ownerships that will be protected under current Forest Practices Rules. The marbled murrelet population in the upper Green River watershed may increase over the long-term.

8.3.6 Grizzly Bear

The grizzly bear does not occur in the lower Green River watershed, and it will not occur there in the future due to the amount of human activity in the area. The grizzly bear is presently absent from the upper Green River watershed as well, but it could inhabit the area in the future if the range of the species expands beyond the North Cascades. On-going and planned activities in the upper watershed associated with HHD O&M, the AWSP, and non-federal activities will not reduce the suitability of the area for grizzly bears, or interfere with any range expansion that might occur. Measures in the Plum Creek HCP and Tacoma HCP will help to minimize impacts to grizzly bears if the species uses the upper watershed in the future. The cumulative effects of these activities on the grizzly bear will be negligible.

8.3.7 Gray Wolf

The gray wolf does not occur in the lower Green River watershed, and it will not occur there in the future due to the extent to which the environment has been altered by human activity and development. The gray wolf is presently absent from the upper Green River watershed as well, but it could inhabit the area in the future if the range of the species expands beyond the North Cascades. On-going and planned activities in the upper watershed associated with HHD O&M, the AWSP, and non-federal activities will not reduce the suitability of the area for wolves, or interfere with any range expansion that might occur. The cumulative effects of these activities on the gray wolf will be negligible.

8.3.8 Canada Lynx

The lower Green River watershed is beyond the historic range of the Canada lynx, and the lack of suitable habitat in the area makes it unlikely the species will ever be found there. The upper Green River watershed is beyond the current range of the Canada lynx, but the species could find marginal habitat there in the future, particularly at higher elevations on Plum Creek and federal (USFS) lands. The future occurrence of the Canada lynx in the Green River watershed will be largely dependent on the management of Plum Creek and federal lands, and on the success of management of the population overall in the Washington Cascades. Other activities by non-federal entities in the Green River watershed will have little or no influence on the presence of the Canada lynx in the future, and will not affect any lynx that inhabit the watershed.

CHAPTER 9.0
SUMMARY DETERMINATION OF EFFECT

This chapter summarizes the determinations of effect from impacts of Howard Hanson Dam (HHD) Continued Operations and Maintenance (O&M) on listed species. As described in Chapter 5, the determinations of effect were evaluated both without and with conservation measures. Determinations of effect were also identified for the HHD Additional Water Storage Project (AWSP), and as presented in Chapter 6, determinations were evaluated both without and with conservation measures.

The effect of the proposed actions on listed species was characterized under four alternate determinations. The following description of possible conclusions was adapted from a guide to Biological Assessments prepared by the NMFS (NMFS 1999):

No effect – this category is used when the proposed action will not affect listed species or critical habitat.

May affect, not likely to adversely affect – this conclusion describes effects on listed species or critical habitat that are expected to be beneficial, discountable or insignificant. Beneficial effects have positive effects without any adverse effects on the species or habitat. Insignificant effects relate to the size of the impacts and should never reach the scale where take occurs. Discountable effects are those extremely unlikely to occur.

May affect, likely to adversely affect – this conclusion is used when the proposed action is expected to have an adverse effect to listed species or critical habitat. Adverse effects may occur as a direct or indirect result of the proposed action or its interrelated or interdependent actions.

Likely to adversely jeopardize proposed species or adversely modify proposed critical habitat – this conclusion is used when the proposed action is likely to jeopardize the proposed species or adversely modify proposed critical habitat.

9.1 HHD CONTINUED O&M

Table 9-1 summarizes the determinations of effect of HHD Continued O&M based on evaluations of potential effects both without and with conservation measures as described in Chapter 5. In the absence of the proposed conservation measures and monitoring, HHD Continued O&M would likely adversely affect listed salmonid species in the Green River. Although the HHD structure is considered an existing condition under the HHD Continued O&M Environmental Baseline, operations will continue to block upstream migrating fish from accessing critical habitat in the upper Green River watershed above HHD. Operations at HHD will also continue to intercept woody debris and gravel entering the reservoir and affect natural ecosystem functions required to maintain healthy, resilient habitats below HHD. Provided upstream and downstream fish passage facilities are implemented as described in Chapter 5, HHD Continued O&M will restore adult salmonid access to the upper watershed. In addition to restoring access to critical chinook habitat above HHD, proposed conservation measures, including sediment and woody debris transport, will partially restore ecosystem functions to the

Green River. Monitoring measures, coupled with provisions for adaptive management, will help ensure that continued O&M will not likely adversely affect listed salmonid species.

In addition to two listed salmonids, there are three listed avian species and three listed mammals in the HHD Action Area. In general, HHD Continued O&M activities are expected to have no effect or are not likely to adversely affect listed avian and mammalian species in the Green River Basin. Operation of HHD directly affects lower elevation habitats in the upper watershed and species such as the Canada lynx would be expected only at high elevations far above the HHD project. As summarized in Table 9-1, some of these species will not be affected by HHD Continued O&M activities. Grey wolves and Canada lynx are not known to occur in the Green River basin and project activities without or with conservation measures would not affect individuals of those species who might travel through the area. Proposed conservation measures under HHD Continued O&M offer the potential to increase the range of anadromous salmonids into the upper watershed. Since adult salmonids are an important food source for both bald eagle and grizzly bear, the effects of HHD Continued O&M conservation measures are expected to be beneficial through providing increased foraging opportunities

Table 9-1
Summary Determination of Effect
for HHD Continued O&M

Species Name	**Determination**	
	Environmental Baseline (without conservation measures)	**With Conservation Measures**
Chinook Salmon	may affect, likely to adversely affect	may affect, ***not*** likely to adversely affect
Bull Trout	may affect, likely to adversely affect	may affect, ***not*** likely to adversely affect
Bald Eagle	may effect, ***not*** likely to adversely affect	may effect, ***not*** likely to adversely affect
Northern Spotted Owl	no effect	no effect
Marbled Murrelet	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Grizzly Bear	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Gray Wolf	no effect	no effect
Canada Lynx	no effect	no effect

9.2 AWSP

Table 9-2 summarizes the determinations of effect of the AWSP based on evaluations of potential effects both without and with conservation measures as described in Chapter 6. The Environmental Baseline of the AWSP assumes there are no upstream or downstream fish passage facilities at HHD and woody debris and gravel-sized sediments continue to be intercepted by HHD. Although the upper Green River watershed is listed as critical habitat for Puget Sound chinook by the NMFS, the lack of fish passage facilities isolates the habitat from adult chinook in the lower river. Further, the baseline condition of the AWSP is that woody debris and gravel will continue to be intercepted by HHD with no measures implemented to restore those functions. The combination of these impacts leads to a determination of likely to adversely affect for Puget Sound chinook and bull trout.

One objective of AWSP is to provide storage of up to additional 20,000 acre-feet of water storage during the spring and summer to meet municipal water needs. The increased storage will raise the reservoir pool level during the spring and summer and will increase the duration of inundation of some stream reaches. Downstream migrating salmonids will have to pass through the larger pool and may experience delay or mortality, but the proposed downstream fish passage facility is designed to maximize opportunities to pass fish through the HHD reservoir and project. With the implementation of conservation and monitoring measures as described in Chapter 6, the proposed AWSP will restore the opportunity for naturally spawning, anadromous fish populations to use critical habitats above HHD. Conservation and monitoring measures are also proposed to partially restore ecosystem functions that affect salmonid habitats in the lower river. Implementation of those restoration measures leads to a determination of not likely to adversely affect for salmonid species.

Table 9-2
Summary Determination of Effect
for the AWSP

Species Name	**Determination**	
	Environmental Baseline (without conservation measures)	**With Conservation Measures**
Chinook Salmon	may affect, likely to adversely affect	may affect, ***not*** likely to adversely affect
Bull Trout	may affect, likely to adversely affect	may affect, ***not*** likely to adversely affect
Bald Eagle	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Northern Spotted Owl	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Marbled Murrelet	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Grizzly Bear	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Gray Wolf	may affect, ***not*** likely to adversely affect	may affect, ***not*** likely to adversely affect
Canada Lynx	no effect	no effect

The listed avian and mammalian listed species may also be affected by the increased reservoir storage for municipal water supply. The AWSP will inundate about approximately 300 surface acres of habitat, affecting areas that have been inundated during past fall and winter flood control operations. Mitigation measures proposed as part of the AWSP will offset the effects of increased inundation and the opportunity to restore naturally spawning, anadromous fish populations will improve foraging opportunities for bald eagle and grizzly bear.

CHAPTER 10.0
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APPENDIX A
SEDIMENT MANAGEMENT PLAN

To be provided at a later date.