U.S. Army Corps
of Engineers
Seattle District

Final Environmental Assessment for July 2010 Interim Risk Reduction Measures Plan and Dam Safety Modification Project

Howard A. Hanson Dam
Green River, King County, Washington

October 2010

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Responsible Agency: The responsible agency for this work is the U.S. Army Corps of Engineers, Seattle District.

Summary: On 9 January 2009, a new high pool elevation of 1188.8 feet was reached at Howard A. Hanson Dam (HAHD), which is approximately six feet higher than the previous pool of record that occurred in February 1996. Three separate situations were observed during and immediately after the new high pool elevation was reached: (1) sediment was observed in the water from one of the drainage tunnel wells (TW 25); (2) a depression was formed on the upstream face of the right abutment as the flood pool was receding; and (3) increased readings in piezometers were observed. Interim risk reduction measures have been implemented and initiated. As a result of this flood event, the dam safety classification of the dam was revised, which initiated the U.S. Army Corps of Engineers (USACE) conducting a dam safety modification study (DSMS) for HAHD using the best available information and using a qualitative means of evaluation. The objective of the DSMS is to complete a baseline risk assessment of all significant and credible potential failure modes (PFMs) and pathways at HAHD; develop and evaluate risk management measures (RMMs) and range of dam safety modification alternatives; and recommend a preferred alternative. The intended outcome is to implement the preferred alternative that would completely remediate the individual failure modes that would support the ultimate goal of having an adequately safe dam. As required by the National Environmental Policy Act (NEPA), a final environmental assessment (EA) has been prepared to evaluate the potential environmental effects of the proposed action.

USACE determined the following four PFMs are credible and significant, and require remedial repairs for HAHD:

- Seepage and Piping through the Right Abutment (PFM 1)
- Spillway Flow Restriction (PFM 3)
- Spillway Stability (PFM 16)
- Left Embankment Erosion (PFM 17)

In accordance with draft ER 1110-2-1156, *Safety of Dams – Policy and Procedure* (30 April 2010), the following alternatives were evaluated:

- No Action
- Remove Dam
- Replace Dam
- Make 2009 IRRM Permanent
- Nonstructural
- Meet Risk Reduction Objectives/Achieve Only Tolerable Risk for Life Safety (Preferred Alternative)

The recommendation is to implement the identified risk management plan as part of a supplement to the IRRMP dated July 2010. The components of the preferred alternative are consistent with the interim risk reduction measures plan guidelines. The proposed action is briefly described below:

- Tunnel drainage improvements would address seepage and piping through the right abutment (PFM 1). This RMM would consist of installing approximately 38 new vertical drains, installing a new dewatering system in 12 of the new vertical drains, installing approximately 23 new horizontal drains from inside the drainage tunnel, abandoning 6 existing horizontal drains, abandoning an existing drain pipe beneath the floor of a drainage tunnel, converting 10 existing 6-inch vertical drains to piezometers, and installing 22 new piezometers along the dam embankment.
- Additionally a new tunnel spur would further address seepage and piping through the right abutment (PFM 1). This spur would connect approximately 240 feet from the existing drainage tunnel's outlet. The new tunnel would proceed south under the existing road entrance to the administration building and tie into the rock septum thus intercepting flow of water through overburden across a saddle of bedrock between the existing tunnel and the dam embankment/abutment interface.
- New debris booms and spillway gate alteration would address spillway flow restriction (PFM 3). The debris booms would involve providing two new floating debris booms with ground anchors at or above an elevation of 1,224 feet. The booms would be located in the reservoir gullet, approximately 3,000 feet upstream of the dam. The spillway gate alteration includes a mechanical alteration to the structure that would increase the bottom of the gate elevation by two feet and increase the spillway opening.
- Grouted rock anchors would address spillway stability (PFM 16). Prestressed grouted rock anchors would be installed at the spillway weir (elevation 1,176 feet) to resist the design net uplift forces acting on the base of the spillway weir.
- Resizing and replacement of slope protection would address left embankment erosion (PFM 17). This RMM would involve excavating the existing riprap and replacing with larger riprap.

Additionally, data collection activities to facilitate the Dam Safety Modification Study were taken in the winter of 2010. These activities, including four exploratory borings and the installation of eight piezometers, were previously addressed in a NEPA Categorical Exclusion.

This final EA meets USACE's requirements under the National Environmental Policy Act, consistent with USACE implementing regulations (ER 200-2-2).

THE OFFICIAL COMMENT PERIOD FOR THIS ENVIRONMENTAL ASSESSMENT WAS FROM 9 SEPTEMBER 2010 TO 12 OCTOBER 2010.

This document is available online under the project name "Howard A. Hanson Dam IRRMP and Safety Modification Project" at: http://www.nws.usace.army.mil/ers/doc_table.cfm.

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List of Acronyms

Abbreviation	Definition
AWSP	Additional Water Storage Project
BMP	best management practice
CFR	Code of Federal Regulations
cfs	cubic feet per second
dBA	A-weighted decibels
DPS	distinct population segment
DSAC	dam safety action classification
DSMS	dam safety modification study
EA	environmental assessment
Ecology	Washington State Department of Ecology
EIS	environmental impact statement
EM	Engineering Manual
EPA	U.S. Environmental Protection Agency
ER	Engineering Regulation
ESA	Endangered Species Act
ESU	evolutionarily significant unit
FOS	factor of safety
FRM	flood risk management
FY	fiscal year
HAHD	Howard A. Hanson Dam
GPM	gallons per minute
IDC	interest during construction
IRRM	interim risk reduction measure
IRRMP	interim risk reduction measures plan
KSI	kips per square inch
kV	kilovolt
kVA	kilovolt-ampere
LAAS	Larson Anthropological and Archaeological Services
M&I	municipal and industrial
NAAQS	National Ambient Air Quality Standards
NAVD 1929	North American Geodetic Vertical Datum of 1929
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRHP	National Register of Historic Places
NTU	nephelometric turbidity units
P&G	Principles and Guidelines
PCA	project cooperation agreement
PFM	potential failure mode
PMF	probable maximum flood
$PM_{2.5}$	particulates with an aerodynamic diameter of 2.5 micrometers or less

PM_{10}	particulates with an aerodynamic diameter of 10 micrometers or less
PSCAA	Puget Sound Clean Air Agency
Q2	2nd quarter of the fiscal year
RM	river mile
RMM	risk management measure
SR	State Route
TPU	Tacoma Public Utilities
TSP	total suspended particulates
USACE	U.S Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
WAC	Washington Administrative Code

1 INTRODUCTION

1.1 BACKGROUND

Howard A. Hanson Dam (HAHD) is a multipurpose project for flood risk management, low-flow augmentation, municipal and industrial (M&I) water supply, and ecosystem restoration. The project provides flood risk management benefits to the highly developed Green River Valley in King County, Washington. The net present value of economic impacts under a dam failure scenario is estimated at $17.3 billion.

During a storm event on 9 January 2009, HAHD reached a record high pool elevation of 1,188.8 feet. This is approximately six feet higher than the previous high pool record that occurred in February 1996. During and immediately after the 2009 record high flood pool, sediment was observed in the water from one of the drainage tunnel wells in the right abutment of the dam, and a depression formed on the upstream face of the right abutment of the dam at approximately elevation 1,191 feet. A second smaller depression was discovered at approximately elevation 1,174 feet on 2 February 2009.

The sediment movement combined with depression formation is an indication of potential piping. Piping is the movement of soil particles by percolating water leading to the development of a channel, and has been identified as a credible failure mode for the right abutment of the dam. Dam failure is not considered an imminent threat at this time. However, in response to these events, USACE modified the annual reservoir refill and drawdown strategy in 2009, installed several drainage wells, and constructed a grout curtain along approximately 475 feet of the right abutment of the dam, as an interim risk reduction measures plan (IRRMP).

USACE completed an Environmental Assessment (EA) in June 2009 to evaluate the 2009 activities. Subsequently, USACE conducted a similar reservoir refill and drawdown strategy for the 2010 which was evaluated in a Supplement to the June 2009 Final EA. The 2009 EA and 2010 Supplemental EA can be found at: http://www.nws.usace.army.mil/ers/doc_table.cfm under Howard Hanson Dam Right Abutment. Further analysis indicated the presence of four potential dam failure modes (PFMs) as further delineated in Chapter 2.1. USACE prepared an IRRMP supplement in July 2010 outlining remedies to address the four probable failure modes. Concurrently, USACE initiated the dam safety modification study to complete a baseline risk assessment of all significant and credible PFMs and pathways at HAHD, develop and evaluate risk management measures (RMM) and dam safety modification range of alternatives, and identify a preferred alternative. This EA evaluates the activities identified in the July 2010 IRRMP and dam safety modification study.

Data collection activities to facilitate the dam safety modification study were taken in winter 2010. These activities, including four exploratory borings and the installation of eight piezometers, were previously addressed in a NEPA Categorical Exclusion.

1.2 PURPOSE AND NEED

The purpose of this Federal action is to remediate all significant and credible failure modes in support of the USACE's ultimate goal of having an adequately safe dam that can meet all authorized project purposes which meet essential USACE guidelines and result in a tolerable total residual risk of dam

failure. The project need is created during the January 2009 event through observations that indicated HAHD may be at an unacceptable risk of failure during normal flood hazard reduction operations.

1.3 PROJECT LOCATION

HAHD is located on the Green River, in southeast King County near Palmer, Washington (Figure 1-1), approximately 35 miles southeast of Seattle at river mile (RM) 64.5 in Section 28, Township 21 North, Range 8 East, Willamette Meridian. The dam lies within the City of Tacoma municipal watershed, and access to much of the over 220 square miles of watershed upstream of HAHD 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 and eventually forms the Duwamish River at RM 12. The Duwamish River empties into Puget Sound at Elliott Bay.

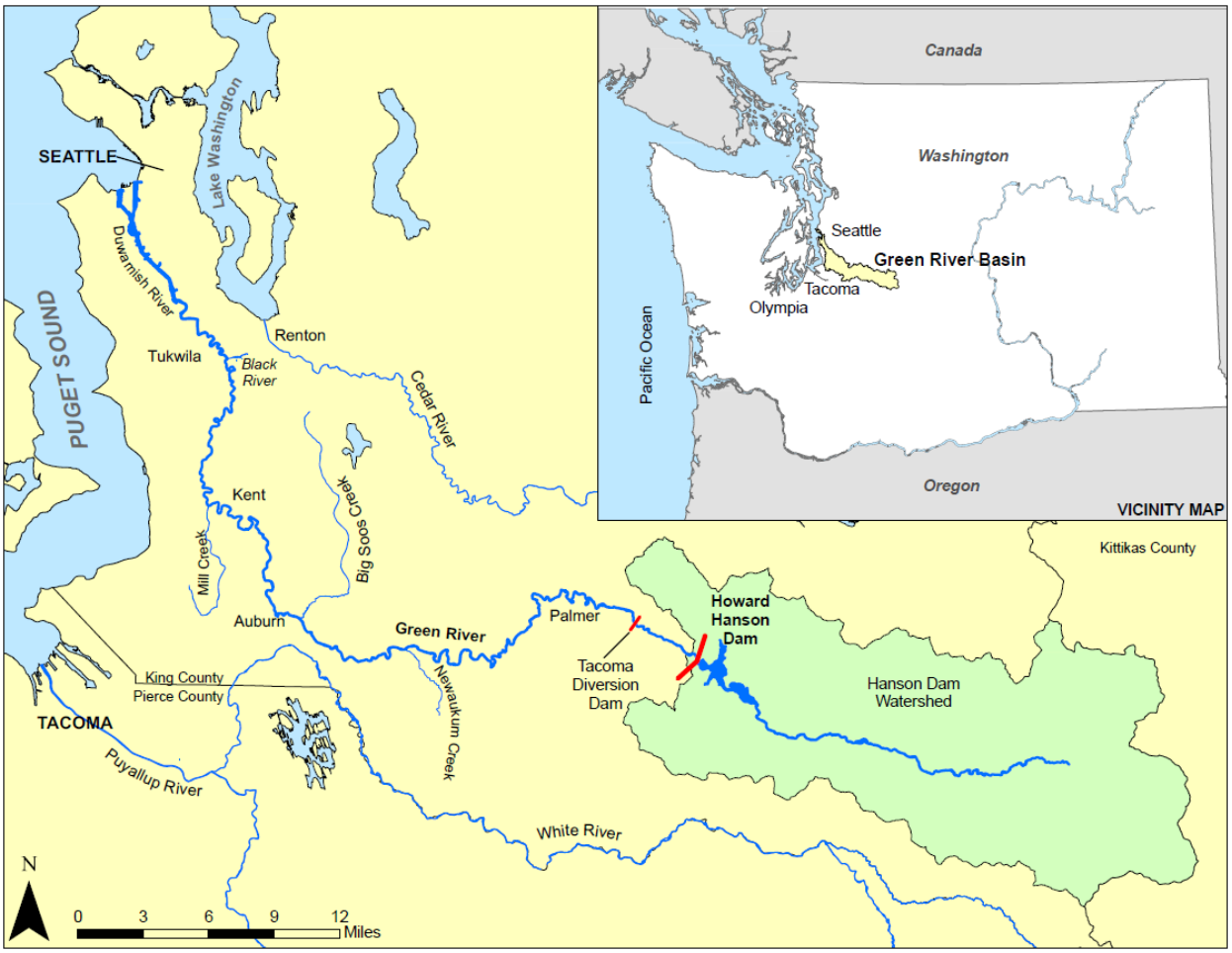

Figure 1-1. Location Map

1.4 PROJECT AUTHORIZATION

1.4.1 ORIGINAL AUTHORIZATION

Howard A. Hanson Dam, Washington, was originally authorized as Eagle Gorge Reservoir by Public Law 81-516, the Rivers and Harbor Act of 1950, 81st Congress, 2nd Session, for the principal purpose of flood control. Other project purposes listed in the chief's report (House Document 271), were low-flow augmentation, irrigation, and M&I water supply, with irrigation and M&I water supply to be implemented at an undetermined date. The total cost of the project was $39,048,060.56. House Document 271 recommended that the "local interests" contribute $2,000,000 in cash toward the cost of the project. Construction was completed in 1962.

1.4.2 SECTION 1135 FISH AND WILDLIFE RESTORATION PROJECT

Under authority of Section 1135 of the Water Resources Development Act of 1986, a study was initiated in 1996 to evaluate potential modifications to HAHD to improve fish and wildlife habitat within the reservoir and restore more natural river functions for fish habitat improvement. The study culminated in the authorization of an ecosystem restoration project in May 1997. The HAHD project modification included an additional 5,000 acre-feet of water for low-flow augmentation and fish and wildlife habitat features. The Section 1135 project changed the water control operating plan of the project to allow the conservation pool to be raised by six feet, from an elevation of 1,141 feet to 1,147 feet (based on the North American Geodetic Vertical Datum of 1929 [NAVD 1929]). USACE began to implement the higher pool level in 1996. In accordance with the project cooperation agreement (PCA), the sponsor contributed 25 percent of the total implementation costs of the project. Tacoma Public Utilities (TPU) is obligated to perform operation, maintenance, repair, and rehabilitation of all features of the Section 1135 project.

1.4.3 ADDITIONAL WATER STORAGE PROJECT

A significant modification to the original project was authorized in 1999 for water supply and ecosystem restoration. The HAHD Additional Water Storage Project (AWSP) was authorized in Section 101(b)(15) of the Water Resources Development Act of 1999 (Public Law 106-53, 17 August 1999).

Phase 1 of the AWSP provides an additional 20,000 acre-feet for M&I water supply for the City of Tacoma. Phase 1 of the AWSP raises the conservation pool to an elevation of 1,167 feet for M&I purposes. The PCA signed by the City of Tacoma stipulates that the City is responsible for 7.8 percent of the annual joint use repair, rehabilitation, or replacement of the existing project facilities during Phase 1 water storage. Phase 1 also includes the construction of features for ecosystem restoration and compliance with the Endangered Species Act (ESA), such as a new fish passage facility at the dam and various habitat improvement sites upstream and downstream of the dam. Water was first stored to an elevation of 1,167 feet for M&I purposes in 2007. All major design and construction that can be completed under the current authorization has been completed, including that associated with seepage control, ecosystem restoration, ESA compliance, and the design of the fish passage facility. The remaining Phase 1 construction is limited to the fish passage facility and cannot be advertised or awarded until the project is reauthorized.

Phase 2 of the AWSP would store an additional 12,000 acre-feet of water, which would be divided into 2,400 acre-feet for M&I water supply and 9,600 acre-feet for low-flow augmentation. Phase 2 would raise the conservation pool elevation to elevation 1,177 feet in the spring for release in the summer and

fall. Phase 2 cannot be completed until implementation of all features of the Phase 1 project are completed. The Phase 2 water supply includes habitat construction projects that are required to mitigate inundated habitat areas. The construction of Phase 2 could be several years in the future and will depend on adaptive management of the Phase 1 water supply and the concurrence of river stakeholders. The completion of Phases 1 and 2 depends on legislative reauthorization of the project because the current estimated costs exceed the authorized amount.

1.5 HOWARD A. HANSON DAM AND OPERATIONS

HAHD is an earth-filled structure composed of rolled rockfill, a sand and gravel core, and rock shell protection (Figure 1-2). The dam is 235 feet high, 675 feet long, 960 feet thick at the base, and 23 feet thick at the crest. The reservoir is approximately 4 miles long at its original authorized full conservation pool of 25,400 acre-feet, which corresponds to a water surface elevation of 1,141 feet. With water storage to 1,167 feet under Phase 1 of the AWSP, the reservoir is approximately 6 miles long and contains approximately 50,000 acre-feet. The right abutment of the dam is a pre-historic landslide deposit. Subsequent modifications of the dam structure were made after water seepage was discovered during a high water period that occurred in February 1965. The seepage was controlled by a gravel blanket supported by a crib wall. In 1968, a drainage tunnel was constructed within the downstream side of the right abutment at elevation 1,100 feet and extending 640 feet into the right abutment. Twelve relief wells were drilled and extend 20 feet below the tunnel floor. In addition, nine horizontal wells were installed. In 2002, a grout curtain was constructed along 300 feet of the right abutment. The top height of the grout curtain is at approximately elevation 1,207 feet; however, it is somewhat discontinuous along its length. In 2009, a grout curtain was constructed along 475 feet of the right abutment with a top height of approximately elevation 1,206 feet.

The drainage tunnel typically flows year-round responding both to rain and reservoir elevation. As the reservoir elevation increases during floods or spring refill, there is generally a corresponding increase in discharge from the drainage tunnel. According to the MODFLOW model, the total peak tunnel flow is 867 gallons per minute (gpm) at the conservation pool and 2,298 gpm at elevation 1,224 feet.

The dam's outlet structure consists of a gate tower and intake structure with two radial gates, a concrete horseshoe-shaped outlet tunnel, a gate-controlled bypass, and a stilling basin. A fish passage facility was not included in the original project design; it is part of the AWSP. Flows are regulated manually by adjusting the gate controls at the dam with direction from USACE Seattle District's Water Management Section acting in accordance with the Water Manual for HAHD.

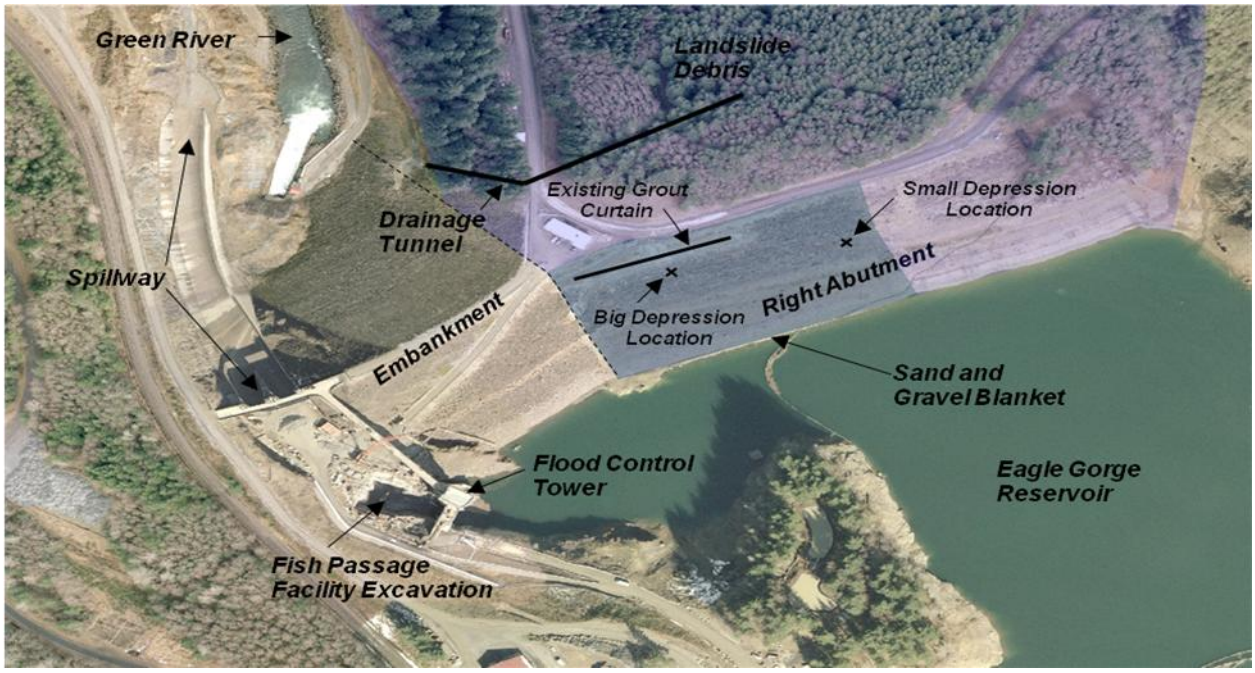

Figure 1-2. Key Identifying Features of Howard A. Hanson Dam

During winter months, when the flood threat is at a maximum, the reservoir is kept essentially empty (elevation 1,075 feet) and inflow into the reservoir is typically passed through the outlet tunnel in the dam's left abutment. The project is operated during flood control operations with the objective of managing river flow at the control point at Auburn, Washington to a maximum flow of 12,000 cfs to the extent possible. Reservoir inflows in excess of these releases are impounded in the reservoir and released through the outlet channel as fast as possible after the peak to provide storage space for subsequent floods. The cycle of impounding and releasing floodwater is repeated as often as storm conditions require. A fully functioning project (without pool restrictions) provides protection for events of approximately a 140-year recurrence interval, or an annual probability of 0.007. Typically beginning in late February, the pool is allowed to fill until the summer conservation and water supply pool elevation is reached in May or June. The pool storage is used through the summer and early fall to provide water for municipal needs and to augment river flows as necessary for the downstream fishery. Prior to implementation of the Section 1135 Fish and Wildlife Restoration Project in 1996, the summer conservation pool was refilled to elevation 1,141 feet. With the implementation of the Section 1135 Fish and Wildlife Restoration Project, the conservation pool was raised to elevation 1,147 feet for ecosystem restoration. Phase 1 of the AWSP, the water storage component of which was implemented in 2007, raised the pool elevation to 1,167 feet. Phase 2 of the AWSP would increase the conservation pool an additional 10 feet (to elevation 1,177 feet) for M&I water supply and additional low-flow augmentation.

A revised estimate of the Probable Maximum Flood (PMF) was developed in 1994 based upon an estimate of the probable maximum precipitation by utilizing Hydrometeorological Report 57 (HMR 57). A conservative assumption is made that the reservoir is full at the onset of the PMF as a result of a prior flood storage operation preceding the PMF. Peak inflow during the PMF is about 145,000 cfs. Peak outflow during the PMF is slightly less than 125,000 cfs, with a maximum spillway outflow of 108,000 cfs, 12,000 cfs through the outlet tunnel, and 4,400 cfs through the railroad notch adjacent to the left abutment at a maximum reservoir surcharge elevation of 1,223.9 feet.

2 ALTERNATIVES FORMULATION AND SELECTION

2.1 DAM SAFETY CONCERNS

On 9 January 2009, flood storage behind HAHD reached a new high pool elevation of 1,188.8 feet, approximately 6 feet higher than the previous pool record in February 1996. During this flood event, three piezometers located in the narrowest part of the right abutment recorded water levels that were anomalously high compared to recorded levels during previous flood pool elevations. On 12 January 2009, after the maximum flood pool elevation occurred, increased turbidity was noted in discharge from vertical drainage well No. 25. The turbidity readings exceeded the limits of the measurement equipment (i.e., 1,000 nephelometric turbidity units [NTUs]). The well outlet was plugged with an inflatable packer to prevent additional loss of fines through the well. In addition, the following were observed in response to the record pool: a large depression on the upstream face of the right abutment, unexpected piezometer responses, and rapid transmission of dye through the abutment. As a result of these findings and the results of numerous investigations including dye tracer tests, USACE Headquarters (HQUSACE) changed the dam safety action classification (DSAC) rating for HAHD from II (urgent) to I (urgent and compelling) on 16 March 2009. The change in the DSAC rating from II to I represents a heightened level of concern about dam safety. The change in DSAC classification triggered several actions, including the following:

- **Potential Failure Mode Analysis (PFMA).** A PFMA was completed in April 2009 by USACE, Seattle District, Risk Management Center staff and HQUSACE staff. Based on the 2009 PFMA, eight significant PFMs were identified.
- **Interim Risk Reduction Measures Plan (IRRMP).** An IRRMP was developed to address immediate risks and reduce the potential consequences of dam failure. Key structural measures implemented to date in accordance with the IRRMP include a 450-foot interim seepage barrier (grout curtain) and drainage tunnel improvements. Numerous investigations and nonstructural measures were also included in the IRRMP, as well as two subsequent supplements. The IRRMP is a living document that is modified in response to the findings from investigations completed in accordance with the plan. To date, 26 of the original 43 recommended actions have been completed. The most current IRRMP is dated July 2010.
- **Initiation of the Current DSMS.** USACE initiated the DSMS in August 2009 to determine the extent of the problem and evaluate alternatives for long-term solutions. The DSMS has been expedited to the extent practicable so that the recommended risk management plan can be approved, designed, and implemented in the shortest amount of time to reduce potential flood risk consequences downstream.
- **Pool Restrictions.** After the record flood pool in January 2009, the Seattle District engineer (DE) implemented temporary pool restrictions and reserved, for his authority alone, the decision to raise any flood pool to an elevation greater than 1,155 feet. After the implementation of several IRRMs in November 2009 and February 2010, the DE revised the maximum flood pool elevation to 1,170 feet for a period not to exceed 24 hours. USACE continues to be concerned about storing flood waters behind the dam if these flows potentially will cause the reservoir level to exceed the elevation at which the dramatic increase in seepage and turbidity have occurred in the past. This restriction was based on engineering analysis and information as of 2009. Operations for the 2010 - 2011 flood season are being reevaluated based on more recent information.

The probability of exceeding 12,000 cfs at Auburn in any year is only 1 in 140 for a fully functioning dam. On 5 November 2009, USACE stated that the probability of exceeding 12,000 cfs at the Auburn gage in any year is 1 in 25. The determination of the 1 in 25 probability was based on the level of confidence in the grout curtain, reservoir regulation studies and the advice from external and internal expert panels.

2.2 DSMS Risk Management Plan Formulation and Evaluation

Assessments of the safety of USACE dams are conducted using a risk assessment approach that provides input to risk-informed decision making. The approach combines the evaluation of dam safety in terms of USACE engineering guidelines and the evaluation of risk posed by USACE dams compared to tolerable risk guidelines. The former focuses on satisfying USACE essential guidelines for a wide range of engineering considerations (draft ER 1110-2-1156 30 April 2010, Appendix F). The latter involves identifying all credible and significant failure modes for a specific dam, quantifying their probabilities of occurrence and the associated consequences, and comparing the estimated risk of dam failure to the USACE tolerable risk guidelines. The tolerable risk guidelines address the probability of failure, risk to the public, economic risk, and environmental risk. For a particular USACE dam, the breadth of understanding gained from combining both evaluation approaches allows the formulation of well-reasoned recommendations for reducing risks to tolerable levels and meeting the USACE essential guidelines. Achieving and maintaining tolerably low risk levels for USACE dams requires structural measures in concert with an effective safety management regime, including staff training, O&M, monitoring and surveillance, and emergency action planning.

Because each USACE dam is a component of a large portfolio of dams, risk management decisions viewed from a national perspective are made centrally by HQUSACE. Therefore, the evaluation of dam safety for a particular dam must be made in a consistent manner such that the information obtained from these evaluations can be used to prioritize risk reduction actions across the portfolio of USACE dams. In addition, the DSAC system is designed and used to maintain the appropriate degree of urgency for addressing safety issues at individual dams. To appropriately manage the prioritization and urgency of risk reduction for each individual dam across the entire portfolio, opportunities for staging risk reduction actions using logically separable construction packages are considered in the DSMSs.

It is recognized that both the engineering guidelines approach and the risk-guidelines approach are subject to limitations based on the available information, an understanding of dam safety issues and failure modes, and limitations in the state-of-the-practice of dam safety engineering. Therefore, it is important that the degree of confidence in quantitative analyses be considered in both the engineering analyses and the risk assessments for each dam. Hence, USACE does not consider the tolerable risk guidelines to be strict criteria, and it does not rely solely on these guidelines to demonstrate adequate dam safety; rather USACE uses the entirety of the information available to support the recommendations to take a particular risk management action.

2.3 Qualitative Evaluation of Baseline Conditions

The evaluation of baseline conditions included a qualitative engineering assessment of all PFMs and pathways, including, but not limited to, those addressed previously. The evaluation included a description of how a dam breach or uncontrolled release of the pool could occur, as well as consideration of the available evidence to support or refute the risk claim. The evaluation also included the application of a qualitative decision tree, which described if and how the failure path might be initiated, whether it would continue and progress, what measures and/or time would be available for intervention, and finally

whether a breach or uncontrolled release of the reservoir could occur. Based on this qualitative analysis, four PFMs are credible and significant and require remedial repairs: The identified PFMs include: Seepage and Piping through the Right Abutment (PFM 1), Spillway Flow Constriction (PFM 3), and Spillway Stability (PFM 16) and Erosion of the Left Embankment (PFM 17)

2.3.1 BASELINE ASSESSMENT OF SEEPAGE AND PIPING THROUGH THE RIGHT ABUTMENT (PFM 1)

Seepage through the right abutment can lead to a breach of the dam by the following process. As the reservoir rises, seepage increases until the hydraulic gradient exceeds the critical gradient, movement of soil begins within the right abutment materials, backward erosion progresses until a sinkhole forms, gross enlargement continues until the abutment/embankment collapses, the dam is breached, and an uncontrolled release from the reservoir occurs, resulting in downstream consequences (Appendix E of the March 2010 draft baseline risk assessment).

Six seepage pathways along which piping, suffusion, and/or internal erosion could occur were identified for evaluation as a potential concern for the right abutment. The pathways, in order of estimated highest probability of failure, are as follows:

- Short path seepage between the dam embankment and the drainage tunnel
- Rock septum seepage along the interface of the landslide/fluvial/lacustrine deposits and the rock septum separating Eagle Gorge from the pre-landslide Green River Valley
- Seepage into the unfiltered drainage tunnel
- Seepage under the drainage tunnel
- Long path seepage in the upper aquifer around the drainage tunnel flow path through landslide materials around the east end of the drainage tunnel
- Lower aquifer seepage

Based on an evaluation of the evidence and sequence of initiation and progression, USACE determined three of the pathways for PFM 1 require remedial repairs. These include the short path seepage, rock septum seepage, and seepage into the unfiltered drainage tunnel. Seepage and piping under the tunnel, through the long path, and through the lower aquifer were not significant and/or not credible and do not require remedial repairs.

2.3.2 BASELINE ASSESSMENT OF SPILLWAY FLOW RESTRICTION (PFM 3)

Two pathways were identified for spillway flow restriction: debris blockage and flow impingement.

- **Debris Blockage.** During a PMF, the reservoir elevation is expected to rise to 1,224 feet. The existing logbooms are too low to contain debris during a PMF. For this scenario under existing conditions, it is possible that debris would accumulate in the reservoir, bypass a failed logboom, and block the spillway. As a result, overtopping of the embankment and railroad notch may cause uncontrolled releases and embankment failure. The spillway design flood occurs at an elevation of 1,206 feet, but the prediction of a large flood event can prompt the Seattle District Water Management Section to open the spillway gates at elevations less than 1,206 feet. Velocities at the downstream end of the reservoir pool during a PMF facilitate the migration of debris toward the spillway gates.
- **Flow Impingement.** When unobstructed by debris, the spillway gates are designed for weir flow when they are fully opened. However, during a PMF, the water surface elevation at the crest of the spillway would be higher than the bottom of the opened spillway gates, resulting in a flow

condition similar to that passing through an orifice rather than a weir. If the gates cannot pass the PMF in a free-flowing condition, the reservoir could continue to rise and eventually overtop/breach the embankment.

Based on an evaluation of the evidence and sequence of initiation and progression, USACE concluded that both pathways identified for PFM 3 are credible and significant and require remedial repairs.

2.3.3 BASELINE ASSESSMENT OF SPILLWAY STABILITY (PFM 16)

One pathway was identified for spillway stability: weir uplift and displacement. PFM 16 occurs during the PMF event when both spillway gates are fully open. The combined efficiency of the foundation drains and the grout curtain is assumed to be 50 percent, in accordance with Appendix C of Engineering Manual (EM) 1110-2-2100, *Stability Analysis of Concrete Structures*. At a PMF pool elevation of 1,224 feet, the existing Grade 40, No. 11 rock anchors (located only at the upstream side of the weir) are likely to become overstressed by high uplift loads. When an individual anchor fails, the uplift load that it was resisting is transferred to an adjacent anchor, causing progressive failure. Progressive failure of the anchors allows a crack to form between the weir and the rock foundation, causing an increase in uplift pressure under the weir. If the weir is displaced, it could lead to an uncontrolled release from the reservoir because the gate will not be able to be sealed as designed. Moreover, if the weir is displaced, there is also a risk of erosion of the exposed rock foundation by high-velocity flows.

Based on an evaluation of the evidence and sequence of initiation and progression, USACE concluded that weir uplift and displacement is a credible and significant pathway for PFM 16, and it requires remedial repairs.

2.3.4 BASELINE ASSESSMENT OF LEFT EMBANKMENT EROSION (PFM 17)

High velocities near the spillway gates during high flood pools can lead to erosion along the left embankment and could result in dam failure. The reservoir elevation during a PMF is expected to rise to 1,224 feet. The spillway gates may be opened at pool elevations less than 1,206 feet and will definitely be opened if the pool reaches 1,206 feet. High-velocity flow near the left embankment is initiated as the spillway gates open and the reservoir continues to rise. The high-velocity flow causes movement of riprap on the left embankment, leading to erosion of embankment material and subsequent dam failure. Hydraulic modeling studies show a maximum flow velocity of 18.4 feet per second at the left embankment. The corresponding pool elevation for the maximum velocity is approximately 1,210 feet. A flow velocity of this magnitude is expected to move the 12- to 24-inch-diameter rock that is protecting the left embankment.

Based on an evaluation of the evidence and sequence of initiation and progression, USACE concluded that the pathway identified for PFM 17 is credible and significant, and it requires remedial repairs.

2.4 EVALUATION OF ALTERNATIVE RISK MANAGEMENT PLANS

In accordance with draft ER 1110-2-1156, *Safety of Dams – Policy and Procedure* (30 April 2010), the following alternatives were evaluated:

- No Action
- Remove Dam
- Replace Dam

- Make 2009 IRRM Permanent
- Nonstructural
- Meet Risk Reduction Objectives
- Achieve Only Tolerable Risk for Life Safety

Distinction between the Meet Risk Reduction Objectives and Achieve Only Tolerable Risk for Life Safety alternatives is determined based on the results of a quantitative evaluation of risk. Because a quantitative analysis is not being performed for this DSMS, no distinction between these two alternatives will be made. As such, no separate plan was developed for the Achieve Only Tolerable Risks for Life Safety alternative. Consequently, the qualitative evaluation included only the Meet Risk Reduction Objective alternative in addition to the other five required alternatives. Each of the required alternatives was evaluated and compared to the criteria in the U.S. Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* (referred to as the Principles and Guidelines [P&G]): completeness, effectiveness, efficiency, and acceptability (Table 3-1).

Completeness is the extent to which an alternative risk management plan provides and accounts for all necessary investments or other DSM Findings and Recommendations to ensure the realization of the DSMS risk management objectives, including actions by other federal and non-federal entities. *Effectiveness* is the extent to which an alternative risk management plan contributes to achieving the objectives. *Efficiency* is the extent to which an alternative risk management plan is the most cost-effective means of achieving the objectives. *Acceptability* is the extent to which an alternative risk management plan is acceptable in terms of applicable laws, regulations, and public policies.

Table 2-1. Comparison of Alternatives to P&G Criteria

Required Alternatives	P&G Criteria			
	Completeness	Effectiveness	Efficiency	Acceptability
No Action	Not complete	No *Does not address PFMs*	No *Not efficient*	Not acceptable
Remove Dam	No *Does not address low-flow augmentation or water supply*	Partial *Resolves seepage*	No *Requires downstream levees*	No *Extensive economic and environmental impacts*
Replace Dam	Yes *No residual damages*	Yes *Resolves seepage and most effective solution*	No *More cost-effective options available*	No *Environmental impacts*
Make IRRM Permanent	No *Does not address all PFMs or provide protect from 1,206 to 1,230 feet*	Partial *Resolves seepage*	Partial *Low cost means to temporarily address seepage*	No *Not viewed as permanent solution*
Meet Risk Reduction Objectives for DSAC Class/Achieve Only Tolerable Risk Limit	Yes *Formulate a complete solution*	Yes *Formulate an effective solution*	Yes *Formulate a cost-effective solution*	Yes *Formulate a Acceptable plan*

2.4.1 NO ACTION ALTERNATIVE

NEPA requires that an evaluation of alternatives must include an analysis of the "no-action" alternative plan, against which other alternative plans can be compared. In this case, the No Action alternative would provide no long-term repairs to the dam. Implementation of the No Action alternative plan would require an acceptance of the current project risk, which is unacceptable according to the current USACE guidelines. Under the No Action alternative, the 2009 grout curtain would remain in place. Operational decisions including pool restrictions would continue to be at the discretion of the district commander based on ongoing dam safety evaluation and monitoring. Any possible changes in operations would likely be assessed at the beginning of the flood control season and again at the time of pool refill for low-flow augmentation in the spring.

The No Action alternative would not further reduce the risk of dam failure and other associated risks, such as loss of life, economic impacts, and environmental consequences. Expected annual flood damages with the project under current impaired conditions are estimated at $48 million. This figure is based on limiting the flood control pool to elevation 1,170 feet or less. This pool elevation corresponds to a 1 in 33 year event. Once the pool elevation exceeds this level, releases would be increased, and they would exceed the downstream levee capacity, initiating damages. Expected damages for a discharge of 15,200 cfs at Auburn, a 1 in 33 year event, have been estimated at $787.1 million. Flood damages for a larger flood event, such as the 100-year recurrence event (23,200 cfs), would result in an estimated $2 billion in damages based on limiting the flood control pool to elevation 1,170 feet.

In the event of a dam failure, all project purposes would be adversely affected. The consequences would include direct economic losses, lost project benefits, and dam reconstruction costs. It is assumed that in the case of dam failure, all damages would be repaired a year after the failure, and a new dam would be constructed in 5 years. Table 3-2 summarizes the economic impacts of dam failure, with a total net present value of $16.6 billion.

Table 2-2. Estimated Economic Impacts for Dam Failure over Assumed 5-year Repair Schedule

Q2 FY2010 Price Level, 4.375% Discount Rate, Rounded to Six Significant Digits								
	Lost Project Benefits ($millions)			**Reconstruction Costs ($millions)**			**Direct Economic Losses ($millions)**	**Total Losses by Project Year ($millions)**
Project Year	FRM	M&I	Total	Constr. Costs	IDC (to Midpoint)	Total Reconstruction	Dam Failure	Grand Total
1	$0	$3	$3	$218	$42	$260	$13,400	$13,663
2	$768	$3	$771	$218	$42	$260	$0	$1,031
3	$768	$3	$771	$218	$109	$327	$0	$1,098
4	$768	$3	$771	$218	$0	$218	$0	$989
5	$768	$3	$771	$218	$0	$218	$0	$989
Net present value @ 4.375%			**$2,659**			**$1,135**	**$12,838**	**$16,634**

IDC = interest during construction
FRM = flood risk management
M&I = municipal and industrial water supply

The No Action alternative does not address the identified PFMs, does not reduce risk from the current level, and therefore it does not meet the P&G criteria of completeness, effectiveness, efficiency, and acceptability. The No Action alternative does not meet the purpose and need of the Federal action. Nevertheless, this alternative was carried over for comparative consideration to the preferred alternative, in Chapter 5.

2.4.2 REMOVE DAM ALTERNATIVE

This alternative plan includes removing the entire earth and rockfill portions of the dam to allow the river to flow unregulated. The spillway, intake structure/outlet works, and drainage tunnel would be left in place to minimize demolition costs. The cost of removing the dam has been estimated at $165.1 million by USACE Cost Estimating. Without the structure in place, the current dam safety issues would be resolved. Given the significance of downstream development, this alternative would require increasing the downstream channel conveyance. The level of protection provided by HAHD (in a fully functioning condition) is the 140-year flood event; the downstream levees generally can accommodate outflows from HAHD up to a 140-year event when it is operating at unrestricted capacity. Assuming that the level of flood risk reduction needed after the dam removal is the same as the level that would exist under "with project" conditions, the levees would need to be raised. To contain the 140-year flood event (48,000 cfs), the height of the existing 96,430 lineal feet of levees in the Green River Valley would need to be increased by at least 10 feet. Based on the cost of a recent levee rehabilitation along the Green River at Tukwila provided by USACE Emergency Management, the estimated cost of raising the levees and purchasing the additional land associated with the setback required by the necessary larger footprint is estimated at $675 million. The length of time it would take to acquire the necessary real estate and implement such an extensive upgrade program has not been estimated but is expected to be a number of years and thus an excessive perpetuation of present risks. Low-flow augmentation to support ESA-listed salmon runs and other species would not be possible under this alternative. Water supply through storage at the reservoir would also not be possible.

This alternative is not acceptable because, in failure to provide low-flow augmentation or the currently authorized water supply, the dam's purposes beyond flood risk reduction are also compromised. It would

be effective at resolving the identified PFMs. It is not efficient because of its high costs and delay in completion, and it is not acceptable. This alternative was eliminated from further consideration.

2.4.3 REPLACE DAM ALTERNATIVE

This alternative plan includes replacing the existing dam with an equivalent rockfill dam and overflow nonregulated spillway. Replacing the structure would resolve all failure modes and result in the lowest failure risk of any of the alternatives because the structure could be built from rock wall to rock wall, approximately one mile downstream of the existing dam, requiring no abutment through landslide material. The estimated cost for a new structure is $1.1 billion. For USACE to be able to build a new dam, a new feasibility study would need to be conducted and new project-specific authorization and funding would be required. The feasibility study process alone, including securing necessary funding, could take 3 to 10 years. The NEPA environmental review process, including agency consultation related to impacts on threatened and endangered fish and wildlife species, would also be likely to take several years to complete. This alternative would be the most costly, would take the longest time to implement, would require new congressional authorization, and would likely result in significant environmental impacts.

This alternative was eliminated from further consideration because it would fail to alleviate risk of failure in the substantial interim period, and would be the most costly, would take the longest time to complete, would require a new congressional authorization, and would result in adverse environmental impacts. This alternative is complete and would be the most effective; however, it is not efficient or acceptable. This alternative was eliminated from further consideration.

2.4.4 MAKE 2009 IRRM PERMANENT ALTERNATIVE

This alternative plan includes maintaining the 2009 grout curtain and modifying the water control manual to include permanent pool restrictions. The 20-foot-thick, 450-foot-long grout curtain installed in late 2009 would be maintained. This alternative would also make the present water management regime permanent such that the following conditions are maintained:

a) During flood season, there is less than a 1 percent chance of exceeding a pool elevation of 1,180 feet.
b) The pool does not exceed elevation 1,170 feet for more than 24 hours.
c) The pool does not exceed elevation 1,165 feet for more than 7 days.

These pool restrictions were based on information available for the 2009-2010 flood season. Other interim measures are currently being considered for implementation under an IRRMP supplement – those proposed measures are not included in the Make 2009 IRRM Permanent alternative. This alternative only includes those measures currently in place described above.

The economic and environmental effects of the Make IRRM Permanent alternative would be similar to those of the No Action alternative. The 2009 grout curtain has helped to address short path seepage, and permanent pool restrictions would help reduce the risk of dam failure. However, given the substantial economic impacts under the impaired flood control operation, a 33-year level of flood protection for such an intensely developed and populated area is viewed as unacceptable. Expected annual economic damages with the project in its current impaired condition are estimated at $48 million. This figure is based on limiting the flood control pool to elevation 1,170 feet or less. Once the pool elevation exceeds this level, releases would be increased, and they would exceed the downstream levee capacity of 15,200 cfs, generating damages. Expected damages for a discharge of 15,200 cfs at Auburn, a 1 in 33 year event,

have been estimated at $787.1 million. Flood damages for a larger flood event, such as the 100-year recurrence event (23,200 cfs), would result in an estimated $2 billion in damages based on limiting the flood control pool to elevation 1,170 feet.

This alternative does not meet the project purpose and need because it does not fully address seepage and piping through the right abutment, and it does not address the other identified PFMs. This alternative would be partially effective and could be considered efficient in the short term. Because Phase 2 of the authorized AWSP could not be implemented, this alternative is viewed as unacceptable. This alternative was eliminated from further consideration.

2.4.5 NONSTRUCTURAL ALTERNATIVES

USACE has considered and implemented a multitude of nonstructural measures at HAHD with the intent to reduce the downstream consequences of dam failure. To date, 26 of the original 43 recommended risk management measures (RMMs) identified in the 2009 IRRMP have been completed. The other 17 RMMs are either in progress or require further analysis to determine whether they will be recommended for implementation.

Examples of nonstructural IRRMs that have been previously implemented are the following:

- Development of and updates to a communication plan, which would have no resultant reduction in failure probability but would increase awareness and allow advance preparation to reduce consequences.
- Development of a three dimensional groundwater model, which has increased understanding of failure probability. This measure has no resultant reduction in consequences.
- Increased monitoring/testing of the right abutment during 1,167-foot conservation pool and flood events, which could increase the probability of detecting the progression of the failure mode in time to prevent failure and allow for advanced warning to downstream communities, thereby reducing the consequences. This measure will have no adverse impacts.
- Conservation pool restrictions which will result in different reductions in failure probability, depending on the PFM.
- Implementation of flood pool restrictions.
- Conduct dam safety emergency exercises

No additional non-structural measures other than those previously initiated and those already under consideration for implementation under the IRRM plan have been identified. Thus, the USACE has concluded that implementation of additional practicable nonstructural measures, on their own, will not provide an effective reduction of risk addressing the identified PFMs. Given the degree of economic development in the watershed and the substantial population at risk, an alternative of additional nonstructural alternatives on its own would not meet the project purpose and need, and was eliminated from further consideration.

2.4.6 MEET RISK REDUCTION OBJECTIVES ALTERNATIVE (PREFERRED ALTERNATIVE)

The recommended alternative is the Meet Risk Reduction Objectives alternative. None of the other alternatives (No Action, Remove Dam, Replace Dam, Make IRRM Permanent, and nonstructural alternatives) adequately address each of the P&G criteria or fully meet project purpose and need. Although some of the alternatives address some of the criteria, none of them is complete, effective, efficient, and acceptable. Therefore, an alternative that addresses each of the four identified credible and significant PFMs was pursued. Plan formulation for a Meet Risk Reduction Objective alternative was

necessary to identify a complete, effective, efficient, and acceptable remedy for addressing the dam safety issues at HAHD. A detailed description of the recommended plan is provided in Chapter 3.

2.5 Development of Measures for Meet Risk Reduction Objectives Alternative

Plan formulation for the meet risk reduction alternative includes identifying and developing RMMs to address individual credible and significant failure modes and pathways. The measures are then combined to develop a complete alternative. Measures to address each PFM are summarized below. The intent was to identify a plan that will achieve a complete remediation of individual failure modes to support the ultimate goal of an adequately safe dam that meets the USACE essential guidelines (draft ER 1110-2-1156 30 April 2010, Appendix F) and for which the total residual risk is considered tolerable.

2.5.1 PFM 1 – Seepage and Piping through the Right Abutment

RMMs were identified to address three of the pathways of seepage and piping through the right abutment: short path seepage, rock septum seepage, and seepage into the unfiltered drainage tunnel. USACE determined that the other three pathways (seepage under the drainage tunnel, long path seepage, and lower aquifer seepage) require no remedial actions (see Section 2.3.1).

The identified RMMs involve five different methods for remediating seepage and piping through the right abutment:

- Grout curtain to aquitard
- Concrete cutoff wall to aquitard
- Upstream slope cover
- Downstream slope filter blanket
- Drainage tunnel improvements and tunnel spur

Each of the RMMs are described in the following subsections

2.5.1.1 Grout Curtain to Aquitard

This RMM includes a 1,270-lineal-foot grout curtain from a top elevation of 1,230 feet to a bottom elevation of 1,050 feet. The bottom elevation of 1,050 feet would terminate the grout curtain at the silt aquitard. A secant pile tie-in to the existing embankment would be required as part of this RMM.

2.5.1.2 Concrete Cutoff Wall to Aquitard

This RMM includes the construction of a 1,270-lineal-foot concrete cutoff wall with a top elevation of 1,230 feet and a bottom elevation of 1,050 feet (silt aquitard elevation).

2.5.1.3 Partial Slope Cover and Secant Cutoff Wall

This RMM includes the construction of (1) a low-permeability slope cover from a top elevation of 1,230 feet down to an elevation of 1,130 feet, (2) a secant cutoff wall from an elevation of 1,130 feet (bottom of the slope cover) down to an elevation of 1,050 feet (silt aquitard elevation), and (3) a vertical cutoff to bedrock at the embankment/abutment interface.

2.5.1.4 Full Slope Cover

This RMM consists of a low-permeability slope cover from a top elevation of 1,230 feet down to an elevation of 1,060 feet (tied into reservoir silts). The slope cover would be secured by an anchor trench at

the top of the slope. A vertical cutoff to bedrock would be constructed at the embankment/abutment interface.

2.5.1.5 EXTENSION OF 2009 GROUT CURTAIN

This RMM would extend the grout curtain constructed in 2009 approximately 750 lineal feet and add a third row of grouting to increase the longevity of the grout curtain. A 70-lineal-foot secant pile wall would be constructed from the grout curtain to the rock septum. The top of the existing grout curtain is at an elevation of 1,206 feet. Therefore, a partial slope cover from an elevation of 1,206 feet to an upper elevation of 1,230 feet would be constructed to provide the same level of seepage control as the other proposed RMMs. A vertical cutoff to bedrock would be constructed at the embankment/abutment interface.

2.5.1.6 DRAINAGE TUNNEL IMPROVEMENTS AND TUNNEL SPUR

This proposed RMM would consist of a series of improvements to the existing drainage tunnel to address the into the tunnel pathway identified for PFM 1; seepage and piping through the right abutment. In order to address the short path and rock septum pathways for PFM 1, the RMM would also include the addition of a 240 feet long tunnel spur.

The existing drainage tunnel has ten 6-inch-diameter wells that were drilled and installed on the upstream side of the drainage tunnel. The drains were cased with steel casing and perforated with 1/8- to ¼-inch wide torch and knife cut slots. No filter pack was placed around the drain casing, resulting in a potentially unfiltered drainage exit. Wood lagging from tunnel construction is still present along the outside of the tunnel's concrete lining. There are known voids between the tunnel liner and the surrounding sediments and bedrock formation. Under the tunnel is a gravel-filled drain layer with an 8-inch-diameter perforated tile pipe that has "T" connections on 15-foot centers for water to flow into the tunnel from beneath the floor. The drain layer is composed of sub-rounded, poorly graded gravel (3/8 to 1-inch) and may provide an unfiltered pathway for fines to enter the tunnel.

This RMM would consist of installing approximately 38 new vertical drains, installing a dewatering system in 12 of the new vertical drains, installing approximately 23 horizontal drains from inside the drainage tunnel, abandoning horizontal drains, abandoning a drain pipe beneath the floor of a drainage tunnel, converting 10 existing 6-inch vertical drains to piezometers, and installing 22 new piezometers along the dam embankment. The spur would extend approximately 240 feet from the bend in the existing drainage tunnel. The new tunnel would proceed south under the existing road entrance to the administration building and tie into the rock septum thus intercepting flow of water through overburden across a "saddle" of bedrock between the existing tunnel and the dam embankment/abutment interface.

2.5.1.7 DOWNSTREAM SLOPE FILTER BLANKET

The original dam construction photos and drawings indicate that the designed downstream filter system was not installed properly in the short path seepage area. To prevent piping/internal erosion, the native abutment material should have been overlain with Zone 3 material, then a layer of gravel drain, and finally capped with rock shell. This area is in the extreme right downstream side of the dam from approximately elevation 1,228 to 1,100 feet and approximately 150 feet wide. This RMM involves construction of a filter blanket in this area. Once the cover materials have been removed by excavation, a filter blanket (consisting of Zone 3, gravel drain, and rock shell materials) can be properly placed, starting at the bottom of the excavation and ending at the top.

2.5.2 PFM 3 – SPILLWAY FLOW RESTRICTION

The identified RMMs for addressing spillway flow restriction are the following:

- Construction of an overflow section at elevation 1,220 feet
- Increased spillway bridge capacity
- Armoring of the front, rear, and top of dam
- New debris booms
- Spillway gate alteration

Each of the RMMs are described in the following subsections

2.5.2.1 CONSTRUCTION OF AN OVERFLOW SECTION AT ELEVATION 1,220 FEET

This RMM includes cutting a 350 foot wide and 8 feet high notch at the dam crown to handle the spillway release of the PMF.

2.5.2.2 INCREASE SPILLWAY BRIDGE CAPACITY

This RMM involves replacing the 42-inch deep bridge deck with a 18-inch pre-stressed deck, which increases the clearance of the spillway by 24 inches.

2.5.2.3 ARMORING OF THE FRONT, REAR, AND TOP OF DAM

This RMM includes armoring the front, rear and top of the dam to provide protection to the embankment in the event that the spillway gates were blocked.

2.5.2.4 NEW DEBRIS BOOMS

This RMM involves providing two new floating debris booms with ground anchors at or above an elevation of 1,224 feet. The booms will be located in the reservoir "gullet", approximately 3,000 feet upstream of the dam.

2.5.2.5 SPILLWAY GATE ALTERATION

The spillway gate alteration includes a mechanical alteration to the structure that will increase the bottom of the gate elevation by two feet and increase the spillway opening to avert a potential overtopping of the embankment.

2.5.3 PFM 16 – SPILLWAY STABILITY

The identified RMM for addressing spillway stability is the installation of prestressed grouted rock anchors to resist the design net uplift forces acting on the base of the spillway weir.

2.5.4 PFM 17 – LEFT EMBANKMENT EROSION

The identified RMM for addressing left embankment erosion consists of resizing and replacement of the slope protection to resist erosion. A scour analysis and riprap calculation would be completed to resolve the sizing issue. The blanket thickness would be reevaluated as well.

2.6 EVALUATION, COMPARISON AND SELECTION OF MEASURES

Evaluation criteria were developed for each of the PFMs. The evaluation criteria for all of the identified PFMs included effectiveness, cost and environmental. Additional criteria were included for seepage and piping to help differentiate the identified RMMs.

2.6.1 SEEPAGE AND PIPING THROUGH THE RIGHT ABUTMENT (PFM 1)

USACE used the following criteria to evaluate the RMMs for seepage and piping through the right abutment:

- **Engineering/Effectiveness**. The effectiveness of each measure was based in part on the findings from groundwater modeling and also on the judgment of technical experts regarding the performance of each of the treatment approaches.
- **Cost.** The 10 percent design costs developed during the preliminary plan formulation were used to assess order of magnitude cost differences among the measures.
- **Constructability**. This criterion includes construction methods, complexity, and whether the proposed methods and technology are proven.
- **Environmental Effects**. This criterion includes potential impacts on the environment, the acreage of impacts, and requirements for NEPA and Clean Water Act processes.
- **Timeliness**. This criterion includes the time required to obtain the necessary permits and the estimated construction duration for the measure. It includes how quickly the measure could be implemented.
- **Do No Harm**. The intent of this criterion is to assess whether a particular measure could have an adverse or unknown effect on other pathways or failure modes.
- **Operational Considerations**. One of the aspects of this criterion is temporary effects on project operation resulting from construction. The other aspect is long-term impacts on the effectiveness of operation and the performance of the project for its intended purpose.

2.6.2 SPILLWAY FLOW RESTRICTION (PFM 3), SPILLWAY STABILITY (PFM 16), AND LEFT EMBANKMENT EROSION (PFM 17)

The following criteria were used to evaluate the RMMs for PFMs 3, 16, and 17:

- **Engineering/Effectiveness**. This criterion represents the effectiveness of the measure at addressing the PFM.
- **Cost.** This criterion represents the cost associated with implementing the measure.
- **Environmental Effects**. This criterion includes potential impacts of the measure on the environment.

2.6.3 SELECTED MEASURES

Based on an evaluation of each RMM in terms of the described criteria, a preferred RMM was selected to address each of the four PFMs.

2.6.3.1 PREFERRED RMM FOR SEEPAGE AND PIPING THROUGH THE RIGHT ABUTMENTS (PFM 1): DRAINAGE TUNNEL IMPROVEMENTS AND TUNNEL SPUR

To address seepage and piping through the right abutment, the preferred RMM consists of drainage tunnel improvements and a tunnel spur. In comparison to the other proposed RMMs for PFM 1, this RMM would have lower costs and less environmental concerns. In addition, this RMM would be highly effective and durable.

The concrete cutoff wall would present high costs, constructability concerns, excessive length of time to construct and environmental concerns, all weighing against this RMM. Other RMMs could address seepage and piping for lower costs and fewer constructability and environmental concerns. Based on the effectiveness and durability considerations, the grout curtain RMMs were eliminated from further consideration. Other RMMs are available that are more effective and durable.

Potential drawbacks to the slope cover RMM include the relatively high costs. More significantly, further investigations conducted between May and July 2010 have more accurately identified the specific areas of concern. The areas of concern for seepage and piping were narrowed to a more limited area which does not warrant such an extensive remedy. Other RMMs were more cost effective and efficient at addressing the identified issues.

Based on preliminary design work for the downstream filter blanket RMM, USACE determined removal of the filter/drain on the slope would be problematic and expose the dam to an unacceptable risk during construction. The downstream slope filter was eliminated from consideration.

2.6.3.2 PREFERRED RMM FOR SPILLWAY FLOW RESTRICTION (PFM 3) : DEBRIS BOOMS AND SPILLWAY GATE ALTERATION

To address spillway flow restrictions due to debris, the preferred RMM is the construction of new debris booms and alteration of the spillway gate. The primary and secondary debris booms are designed to catch debris up to the PMF pool elevation. This RMM would prevent the problem rather than resolving it after it has occurred. The flow impingement pathway includes a mechanical alteration to the structure that would increase the bottom of the gate elevation by two feet and increase the spillway opening. In comparison to the other proposed RMMs for PFM 3, this RMM would be easier to construct, have lower costs, and fewer environmental concerns. The spillway overflow section and spillway bridge clearance RMMs, both would fail to adequately pass the PMF and therefore would be technically deficient. In addition, the spillway overflow section and armor dam RMMs have constructability concerns. Furthermore, the armor dam RMM has the potential to cause irreversible damage due to uncontrolled flows.

2.6.3.3 PREFERRED RMM FOR SPILLWAY STABILITY (PFM 16) : GROUTED ROCK ANCHORS

To address concerns about spillway stability, the preferred RMM is the installation of grouted rock anchors. Prestressed grouted rock anchors are proposed to resist the design net uplift forces acting on the

base of the spillway weir. Although passive (non-prestressed) grouted anchors were used in the original construction of the dam, they are not recommended for this measure because prestressed anchors are more effective at preventing pressurization of the spillway foundation and more reliable than non-prestressed anchors because they are tensioned to a specified load after installation. The use of ASTM A722 all-thread anchors with a tensile strength of 150 kips per square inch (KSI) is proposed for this measure to reduce the number of required anchors compared to the number of lower-strength anchors that would be necessary.

2.6.3.4 PREFERRED RMM FOR LEFT EMBANKMENT EROSION (PFM 17) : LEFT EMBANKMENT SLOPE PROTECTION

To address erosion along the left embankment due to high velocities near the spillway, the preferred RMM consists of removal of the existing riprap to a depth of six feet from the upstream face of the dam for a distance of 160 feet north of the control tower bridge extending from the top of the dam to the decline road on the upstream dam face. New 48 inch diameter riprap would be placed in this area to provide appropriate slope protection.

3 PREFERRED ALTERNATIVE

On the basis of a qualitative assessment of probable failure modes and pathways, and evaluation of viable alternatives, the preferred alternative consists of the following RMMs (which are described in more detail below in Section 3.1 and shown on Figure 3-1):

- **Tunnel drainage improvements and new tunnel spur** to address seepage and piping through the right abutment;
- **New debris booms and spillway gate alteration** to address spillway flow restriction;
- **Grouted rock anchors** to address spillway stability; and
- **Resizing and replacement of slope protection** to address left embankment erosion.

This plan would be highly effective and durable, would address all the PFMs and pathways of concern, and could be implemented in an expeditious manner. The plan is efficient and would be cost-effective. Based on the design completed to date the plan is also acceptable. Delaying implementation of the preferred alternative would increase the risk of life loss and economic damage to the Green River Valley.

The recommendation is to implement the identified risk management plan as part of a supplement to the IRRMP dated July 2010. The components of the preferred alternative are consistent with the interim risk reduction measures plan guidelines.

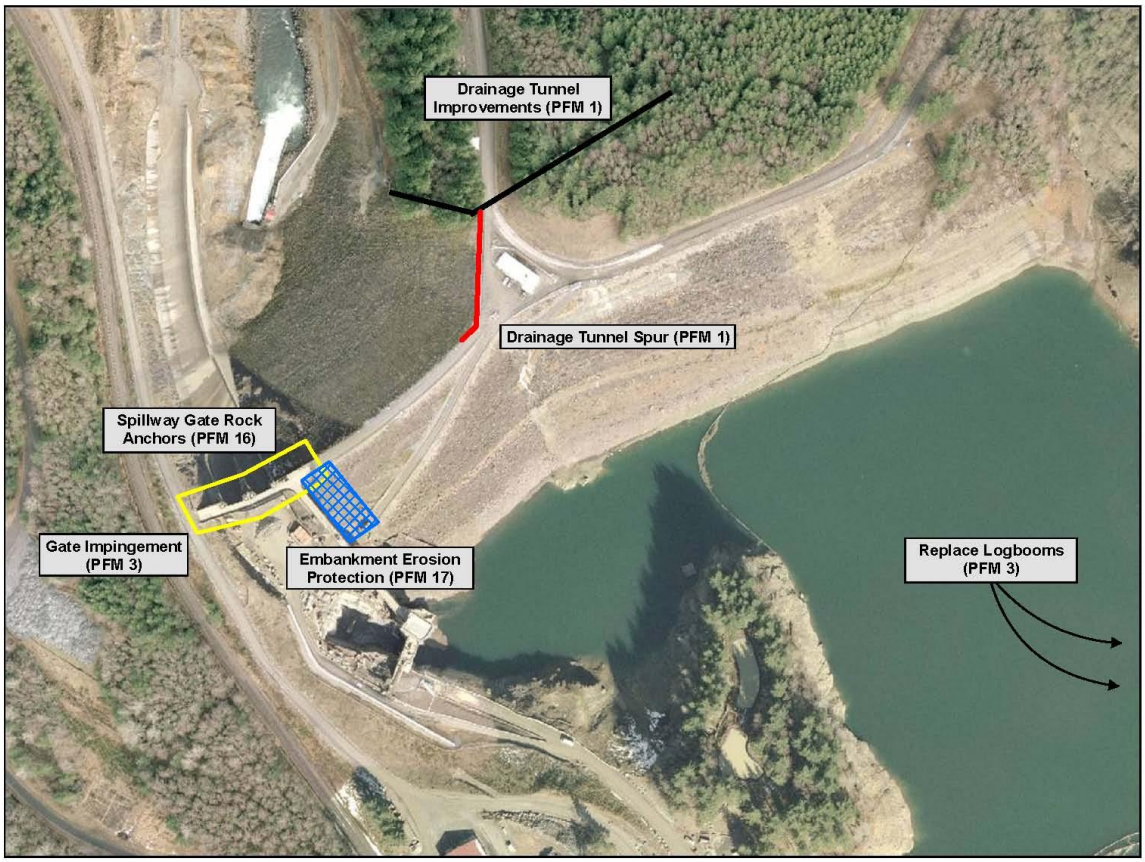

Figure 3-1. Features of the Preferred Alternative

3.1 PROJECT DESCRIPTION

3.1.1 PFM 1: DRAINAGE TUNNEL IMPROVEMENTS.

3.1.1.1 IMPROVEMENTS TO EXISTING TUNNEL

This RMM would consist of installing approximately 38 new vertical drains, installing a new dewatering system in 12 of the new vertical drains, installing approximately 23 new horizontal drains from inside the drainage tunnel, abandoning 6 existing horizontal drains, abandoning an existing drain pipe beneath the floor of a drainage tunnel, converting 10 existing 6-inch vertical drains to piezometers, and installing 22 new piezometers along the dam embankment (Figure 3-2). The new vertical drains would consist of 8-inch diameter stainless steel screens surrounded by sand filter pack in an 18-inch diameter bore hole. Twelve of the vertical drains would be installed from ground surface (elevation 1,230 feet) to elevation 1,080 feet to be connected to the tunnel spur once the spur is completed. These 12 drains would be incorporated into the dewatering system to be used during high flow events. The remaining 26 vertical drains would be drilled from the ground surface (elevation 1,300 feet) extending below the existing tunnel invert (elevation 1,100 feet) to a final elevation of 1,050 feet. The portion above and below the drainage tunnel would be completed as separate drains. The new horizontal drains would consist of 2 inch stainless steel pre-pack screens 50 feet in length. The existing horizontal drains and floor drain pipe would be abandoned with a chemical grout. The existing drains would be converted to standpipe piezometers with a gravel filter. The six new piezometers would consist of two-inch diameter PVC screen and casing surrounded by sand filter pack in a six-inch diameter bore hole. In addition, 15 new piezometers would be installed along the upstream and downstream face of the dam embankment and seven new piezometers would be installed along the alignment of the tunnel spur to monitor the effectiveness of the spur.

According to the MODFLOW model, the expected total peak tunnel flow including the tunnel spur is 888 gpm at the conservation pool which represents an increase in flow of approximately three percent from existing conditions and 2,642 gpm at elevation 1,224 feet, an increase in flow of approximately 15 percent.

The tunnel drainage system would consist of a flow measurement weir, collection and conveyance piping, and a riprap or gabion style outfall. Drainage would be collected at the existing tunnel portal. The drainage would pass through a weir box located near the portal to allow accurate measurement of flow. Discharge from the weir would be collected and conveyed along the edge of the existing tunnel access road, approximately 365 feet to a discharge located just downstream of the existing 36 inch dam bypass. The tunnel drainage system is designed for an anticipated maximum flow of 5,000 gallons per minute (gpm) or approximately 11.1 cubic feet per second (cfs). A riprap or gabion pad would be constructed at the drainage discharge point to eliminate erosion.

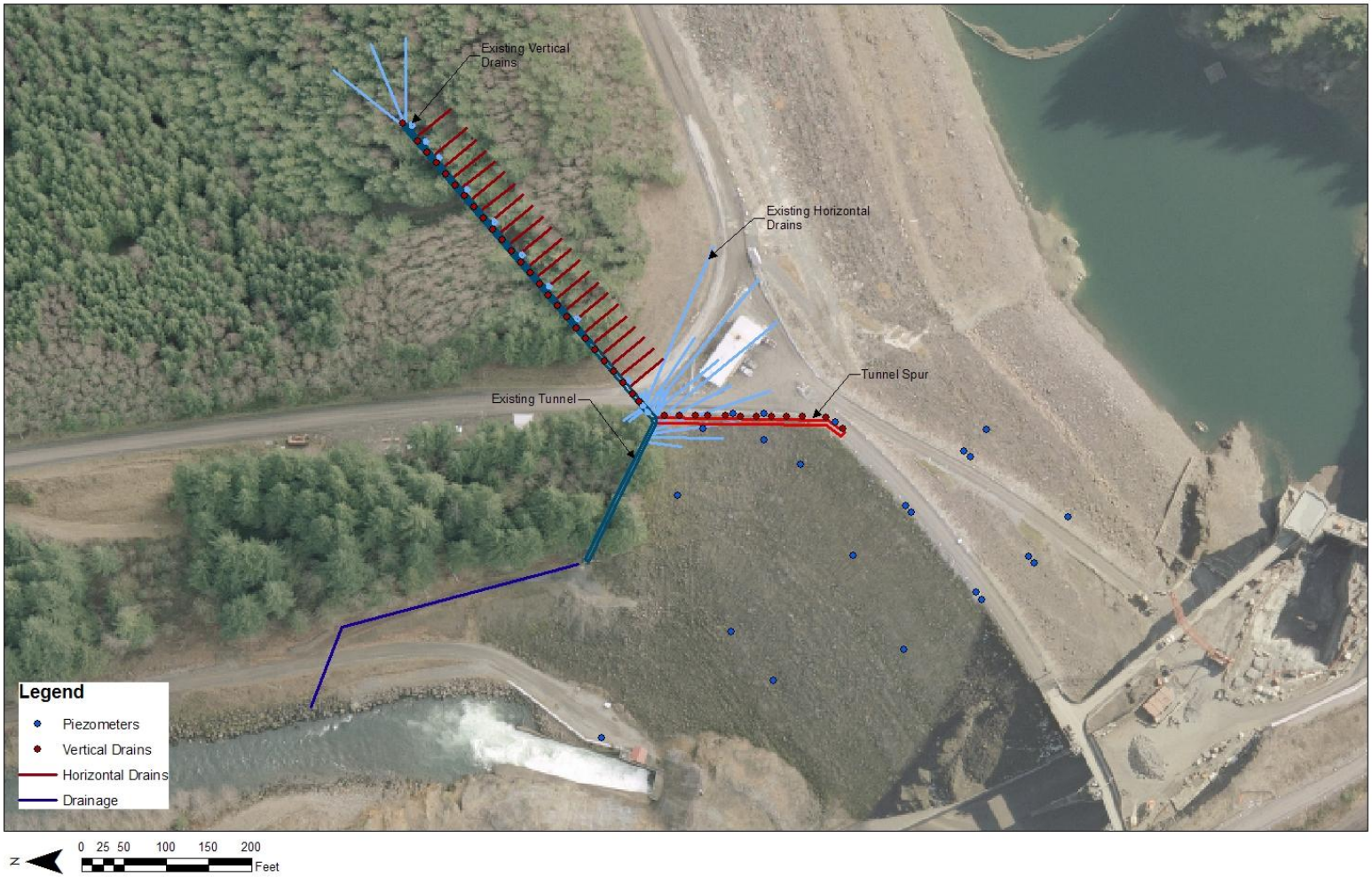

Figure 3-2. Plan View of Improvements to Existing Tunnel

3.1.1.2 TUNNEL SPUR

The tunnel spur portal would be located at the bend in the existing drainage tunnel. From the portal, the tunnel spur would extend south approximately 240 feet (Figure 3-3) and tie into the rock septum. This configuration intercepts the flow of water through the overburden located above the bedrock "saddle" between the existing tunnel and the dam embankment/abutment interface. The spur would have a modified horseshoe, reinforced concrete final lining with a finished interior of approximately six feet wide by nine feet tall. Approximately 1,200 cy of material would be excavated and disposed of at an appropriate offsite location. A floor drain would be installed in the short path area to intercept seepage from continuing to the downstream slope. The proposed 12 vertical drains (see Section 3.1.1.1) immediately adjacent to the new tunnel spur would be connected to the new tunnel spur. The drains would outlet into the new drainage tunnel and the floor drain would outlet into the existing tunnel. The drains and floor drain would be properly filtered to prevent piping/internal erosion from initiating. The wells and tunnel would be designed to maintain a groundwater table along the tunnel alignment of approximately elevation 1,100 feet for up to the 1,224 flood pool elevation. The drainage system is designed as a free draining passive system, but the option to pump for additional control would be retained. The staging area would be limited to the 3.5 mile area (south of the intersection of the main access road and the drainage tunnel access road).

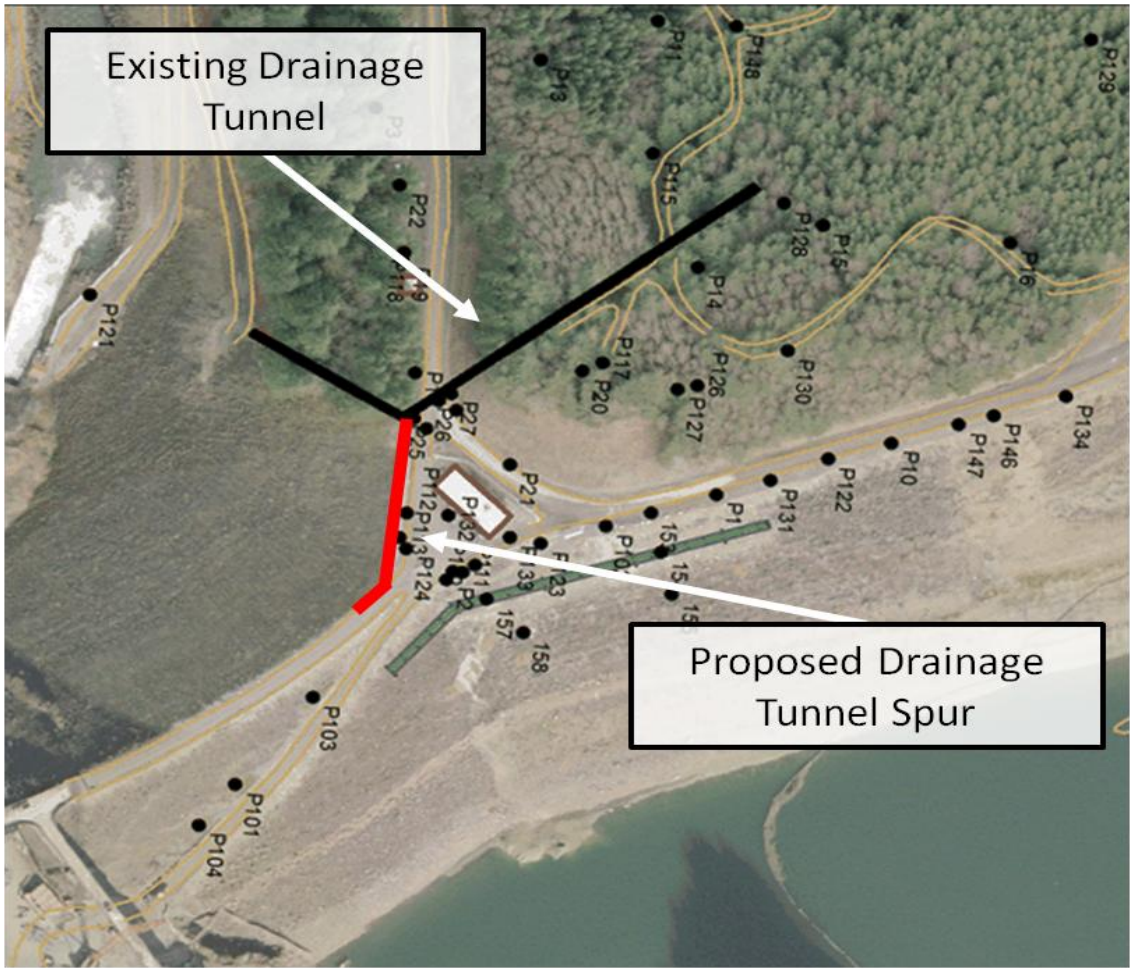

Figure 3-3. Plan View of Tunnel Spur

3.1.1.3 CONSTRUCTION SEQUENCING FOR DRAINAGE TUNNEL IMPROVEMENTS

Construction of the 12 new vertical drains and dewatering system, as well as the horizontal drains are the highest priority and would be started first. The construction of the 12 new vertical drains and associated dewatering system would be constructed simultaneously with the horizontal drains. As new horizontal drains are completed in sections of the tunnel, abandonment of the existing floor drain pipe and construction of the new vertical drains may begin in the completed section. As construction of the new vertical drains is completed, adjacent existing drains will be converted to piezometers. A temporary access road would be constructed to access the hillside. The temporary road would be hydroseeded and replanted on completion of the tunnel improvements. No pool restriction would be necessary during or after construction.

The anticipated construction period for the 12 vertical wells and associated dewatering system is 12 weeks. The anticipated construction period for the horizontal drains and the 26 vertical drains installed through the existing drainage tunnel is 26 weeks assuming that construction of the vertical drains may begin 2 weeks after the start of the horizontal drains. In addition, it is anticipated that 2 weeks would be required for site preparation. All remaining work to include conversion of existing drains to piezometers and installation of new piezometers would be completed within 2 weeks after completions of the drains. The total anticipated construction period is 40 weeks.

The construction of the tunnel spur with connections to the 12 vertical drains would follow immediately after completion of the drainage tunnel improvements and is expected to take one year. The contact grouting within the bedrock portion of the existing drainage tunnel would be done with the tunnel spur construction work.

3.1.1.4 DATA COLLECTION

In order to properly evaluate all alternatives for the DSMS, the study gathered additional information on the overburden materials and depth to bedrock at the right abutment. The work involved completing four borings into bedrock at approximately elevation 1,090 feet and installing eight piezometers in 2010.

The drilling technology for the four borings at elevation 1,090 feet used a self-contained non-truck mounted rig system. Two rigs were placed by helicopter at elevation 1,090 feet. The drilling began on 18 February 2010 and concluded on 5 March 2010, and refill of the reservoir began. The drilling involved recovering a core from each hole to a depth of 70 feet below top of bedrock. The deepest hole was 254 feet below ground surface. All holes were backfilled with a cement based grout (approximately 10 cubic yards total). The drilling muds or cuttings were collected in barrels onsite and disposed of at an appropriate onsite facility. Water and drilling fluid such as Con Det and EZ Mud were the only fluid used during the drilling process.

The installation of eight piezometers (Nos. 141-148) were within existing roadway of several roads on the right abutment. The work involved with the installation of the piezometers and borings included: finding the depth of the bedrock, and types of material above the bedrock; permeability tests; and eventually monitoring how much water is in the new holes. This data was used in the study to analyze the range of alternatives.

This work was the subject of a distinct Categorical Exclusion under NEPA, prepared in accordance with 33 CFR 230.9(b), as a routine repair or rehabilitation activity at a completed USACE civil works project that carries out the authorized project purposes (refer to Appendix D).

3.1.2 PFM 3: DEBRIS BOOMS AND SPILLWAY GATE ALTERATION

3.1.2.1 DEBRIS BOOMS

The debris booms would involve providing two new floating debris booms with ground anchors at or above an elevation of 1,224 feet. The booms would be located in the reservoir "gullet", approximately 3,000 feet upstream of the dam (see Figure 3-4). Up to and during a PMF event, the booms would trap any buoyant debris which has accumulated along the reservoir rim and upstream tributaries within the 1,224 feet inundation area. The westerly (secondary) boom would collect any debris that passes by the easterly (primary) boom, and also would provide redundancy should the easterly boom fail. Removable linkages would be provided at every sixth boom segment to allow operational access through the boom. Boom sections are of steel pipe construction, approximately 2 feet in diameter and 30 feet long, with foam billet inserts. Total lengths of the easterly and westerly booms would be 1,175 feet and 1,425 feet, respectively. Construction activities would include site clearing and grubbing, as required to allow for clear and free operation of booms from run of river operation (elevation 1,070 feet) to PMF conditions; building a temporary access road; and installing boom anchors.

Limited clearing and grading would be required for the construction of the access roads (approximately 0.35 acres). Additional tree clearing would be required around each of the boom anchor locations, referred to as vegetation management areas, to provide free movement of the debris booms in response to changes in pool elevation and wind direction. These vegetation management areas would need continuing maintenance program to keep the area clear of trees. The fallen trees would be left onsite with the trunks and root balls remaining in place. For the northern anchor location, the vegetation management area would be approximately 0.90 acre. For the southern anchor location, the vegetation management area would be approximately 0.66 acre.

Proposed access alignments are shown on Figure 3-4, but may be modified to fit actual field conditions and to minimize habitat and vegetation impacts. Access road design requirements would be driven by the type of anchor and the type of equipment necessary for construction of the anchors. The 1961 concrete pedestal and anchor could be constructed with minimal equipment access, whereas the “pile” type anchor would require drill rig access. The 1961 concrete pedestal and anchor consisted of two large concrete blocks; a pedestal and an anchor. The pedestal has a base of about 10 feet x 10 feet and sits on the surface. The anchor is buried approximately 8 feet below and 15 feet behind the pedestal. A 2.5 inch diameter steel rod is attached to the anchor and extends to the surface. A 2.5 inch diameter cable attaches to the rod and drapes over the top of the pedestal and down to the log boom. The proposed "pile" type anchor would be an 18 inch diameter drilled, concrete-filled pile. An 18 inch diameter steel casing would be advanced to a minimum embedment depth of 35 feet. The casing would extend approximately two feet above the surface and be finished with a conical shaped steel cap to protect the exposed concrete top. A 1.25 inch diameter cable will be looped over the top of the anchor pile and extend down slope to its connection with the log boom. Materials required for temporary access construction would be dependent on soil conditions at time of construction. A summer/fall construction could require little to no surfacing materials. Spring or winter construction may require quarry spall or other surfacing to stabilize the road surface and prevent erosion. Construction is planned for summer/fall. Upon completion of construction, the road would be abandoned by stripping the surface materials off, hydroseeding the roadway, and allowing the area to reconvert to the natural condition. Temporary erosion and sedimentation control measures would remain in place until vegetation is established and soils stabilized.

The location of the boom anchors is shown on Figure 3-4. Soil types and spatial limitations govern the suitability of anchor block designs. In cases where bedrock depth is deep below ground surface and no construction space limitations exist, the basic block and buried deadman anchor is appropriate. In cases where bedrock depth is shallow, an alternative anchor design that places the deadman firmly into the

bedrock is appropriate. This design is conducive to more stringent spatial limitations as the magnitude of the deadman depth and distance from the pedestal is not as great. Finally, in cases where construction space is a limiting factor, a “pile” type anchor is appropriate regardless of the soil profile. At this time, no specific data exists on the soil types at the proposed anchor sites. Site specific geotechnical information will be accumulated through site investigations, excavation, and laboratory testing for the 65% design report.

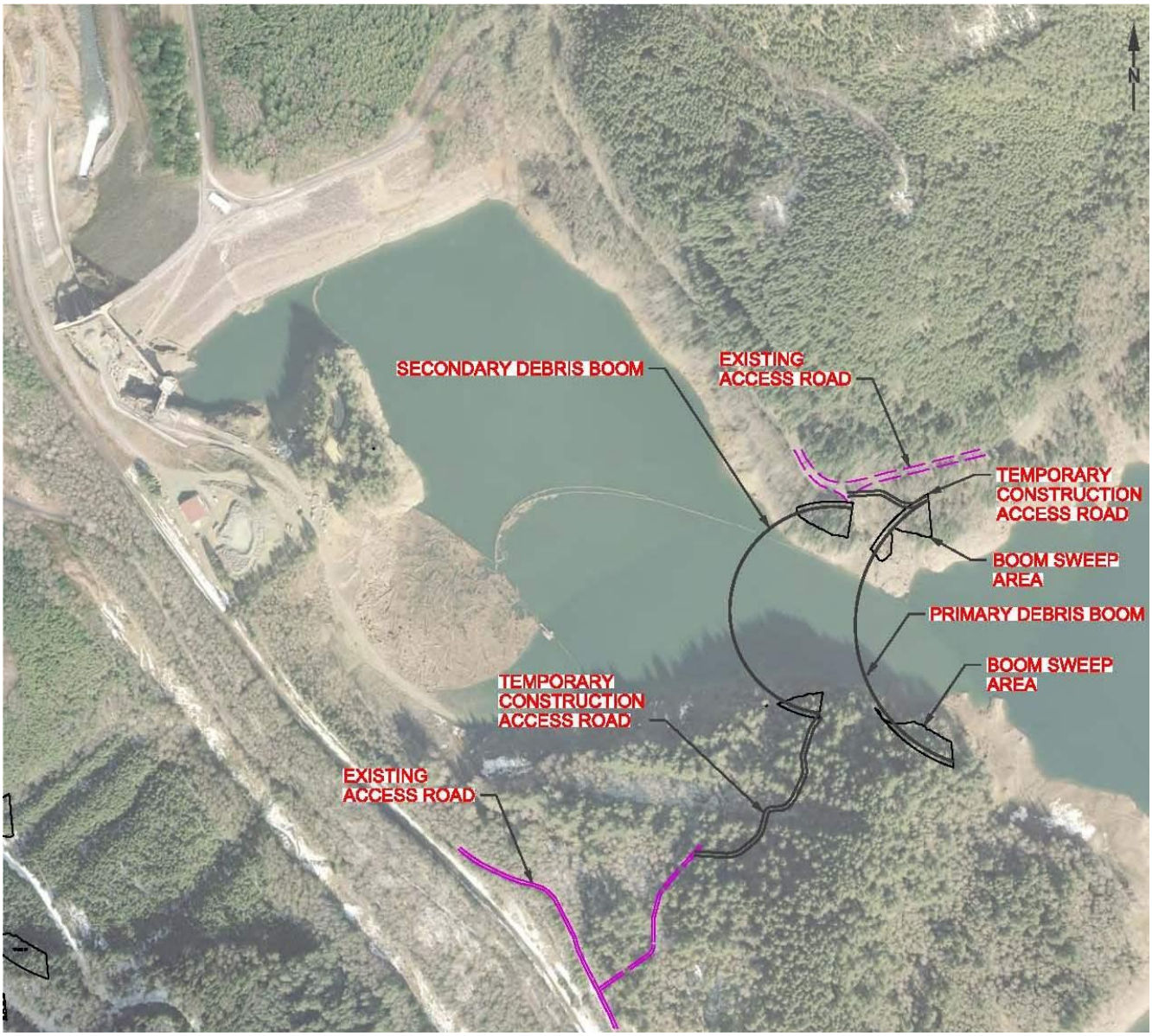

Figure 3-4. Plan View of Debris Booms

3.1.2.2 SPILLWAY GATE ALTERATION

This RMM would include a mechanical alteration to the structure that would increase the bottom elevation of the gate by two feet and increase the spillway opening. The hoist gate rope position would align itself to nearly vertical when the gate achieves its original design open position (bottom of gate at elevation 1,212 feet).

This alteration would entail minimal risk to the structural integrity of the spillway gate. With an added 2.5 feet of gate elevation, the rope angle of inclination at the gate connection changes (approximately 9 degrees). The change in tension on the 10 hoist gate ropes versus angle of inclination off the gate connection due to this additional 2.5 feet does not appear significant. In fact the rope tension is at a maximum when the gate is fully closed. Opening the gate wider by hoisting an additional two and a half feet of rope increases the load on the ropes by approximately 7%, compared to the original design, due in part to the shift in the estimated center of gravity (i.e. the trunnion takes on proportionally more of the gate's mass than before).

The effects of vibration on the gates due to water or wind are not expected to change substantially from those acting on the gate at original design conditions. Hence gate vibration was not studied. Similarly, debris loading on the gate lip (in the unlikely case of floating debris caught on the gate lip at elevation 1,214.5 feet) was considered beyond the scope of this study. This gate adjustment would appear to have an acceptable effect on the spillway gate ropes, hoisting mechanisms, and the gates themselves.

3.1.3 PFM 16: SPILLWAY WEIR ROCK ANCHOR

Prestressed grouted rock anchors would be installed at the spillway weir (elevation 1,176 feet) to resist the design net uplift forces acting on the base of the spillway weir. ASTM A722 all-thread anchors (64) with a 150-KSI tensile strength would be used for this measure to reduce the number of anchors required compared to the number of lower strength anchors that would be necessary. The rock anchors would be drilled down into bedrock and grouted into place.

3.1.4 PFM 17: UPSTREAM SLOPE PROTECTION

This RMM would involve excavating the existing riprap and replacing with larger riprap. The existing riprap would be removed to a depth of 6 feet below surface using two 400 series excavators. Excavation work would start at the top of the slope and progress to the toe of the slope. A 1V:1H slope would be left adjacent to the upstream side of the gravel access road to provide temporary support. The excavators would compact the surface of this slope using the backs of the buckets to improve the slope strength. It is assumed the materials encountered during excavation would be riprap or loose rock, which should maintain a slope of 1V:1H. All excavated material would be disposed of at an appropriate offsite disposal site. Prior to the start of excavation, temporary traffic plates and precast concrete barriers would be placed on the gravel access road at the top of the dam. These barriers are required for safety to prevent personnel and vehicles from accidentally traveling over the edge of the road into the excavation or upstream face of the dam north of the work area. The plates and barriers would remain in place until the end of construction. The concrete traffic barriers would be transported to an approved storage area for future reuse.

An Eco-block retaining wall is present at the toe of the riprap slope in the work area and supports a former drilling platform next to the decline road on the upstream face of the dam. The majority of the wall would be dismantled by the removing the blocks with a lift crane and stored at HAHD. The lower

two blocks of the wall would be left in place, as the removal of these blocks could result in damage to the decline road. The remaining blocks would provide lateral support for the new riprap at the toe of the slope. The surface of bedrock to the south of the work area is locally covered with loose rock clasts and boulders. This loose debris would be removed.

A 6 feet thick layer of new 48 inch diameter riprap would be placed on the slope to backfill the excavation. Placement would start at the toe and progress in lifts no greater than 5 feet to the top of the slope using two 400 series excavators. The riprap would not be placed by end dump from a dump truck. Each large stone would be tightly fitted into a dense rock mat with minimal void space. Voids not filled with rock clasts or small stones would be filled with 2 inch minus gravel during the placement of the larger stones. The new riprap slope should reduce gradually from at 1V:2H at the toe of the excavation to the base of the 1V:1H temporary slope at the top of the excavation. The thickness of the riprap would thin toward the top of the surface slope and would have a final surface slope of 1V:1.5H.

Work activities would rut the existing gravel roads. These roads would be repaired at the completion of work. The area for road work would be on the gravel access road on the top of the dam from the north end of the concrete pavement of the control tower bridge to the south entrance to the administration building parking lot. The upstream decline road would be surfaced with crushed course gravel (1 ¼ inch minus) from the south end of the administration building parking lot to the middle bridge pier of the control tower access bridge.

A shallow swale would be bladed along the downstream side of the decline road from the north end of the remaining eco-block wall to the existing storm water catch basin at the south end of the wall. Sediment would be cleaned from the catch basin to improve drainage.

4 AFFECTED ENVIRONMENT

This chapter describes the resources in the project area. The following resources: land use/basin characteristics, geology/soils, and traffic/transportation are presented to add to the overall understanding of the study area, but are not affected by the preferred alternative.

4.1 LAND USE AND BASIN CHARACTERISTICS

Most of the land (99 percent) in the upper Green River watershed upstream of HAHD is managed as a water supply area for Tacoma and for commercial timber production. Ownership in the upper watershed is divided among private timber companies, the U.S. Forest Service, the Washington State Department of Natural Resources, and the City of Tacoma (Tacoma 1998). Tacoma has intentionally concentrated its holdings in lands adjacent to the Green River and the Eagle Gorge Reservoir. Tacoma manages these lands according to its habitat conservation plan (Tacoma 2001) and the Green River Watershed Forest Land Management Plan (Ryan 1996) to protect water quality and, where consistent with these plans, conduct commercial timber harvest. Private and state timber lands are managed according to the Washington State Forest Practices Rules and Regulations (Washington Administrative Code, WAC, Title 222) and other management directives, such as habitat conservation plans developed to comply with the Federal ESA.

In the Green River watershed downstream of HAHD, almost 80 percent of the land use is rural, forest production, and urban/residential. The middle Green River watershed 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. Most of the lower Green River watershed downstream of 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 watershed 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.

Before settlement by Euro-Americans, 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 2 miles in width. Due to the construction of levees, dredging of channels, and flood control by HAHD, this floodplain is now essentially inactive except under extraordinary flow conditions.

4.2 GEOLOGY AND SOILS

HAHD is located in Eagle Gorge canyon. The canyon was carved in volcanic bedrock (andesite) of the 20 to 40 million year old Ohanapecosh Formation as a result of the burial of the adjacent ancestral valley by a rockslide that diverted the river. The pre-landslide ancestral channel is currently buried under fluvial, glacial, lacustrine, and rockslide deposits that make up the right abutment of HAHD (Figure 4-1). Interbedded fluvial and glacial outwash deposits overlie bedrock at the center of the ancestral valley and suggest a history of erosion and deposition common to these environments. Lacustrine deposits, which overlay the fluvial and glacial outwash sediments, were deposited during glacial period(s) when ice and debris dammed the Green River and created glacial lake(s).

During subsequent interglacial periods, the Green River cut its channel through these glacial, fluvial, and lacustrine deposits, resulting in oversteepened side slopes and the subsequent collapse of the northeastern valley side. It is likely that the rockslide dammed the Green River for a period of time after this event.

The main channel of the Green River eventually overtopped the rockslide debris, began flowing against the south valley side, and cut a narrow, steep-walled canyon in bedrock where the present-day Eagle Gorge is located.

Today, the rockslide is a significant landform that creates part of the right abutment of HAHD. Lacustrine silt deposits, where present, act as a confining layer between the upper glaciofluvial sediments and rockslide unit and the lower glaciofluvial unit. These upper and lower stratigraphic units represent two separate aquifers and have been historically called the upper and lower aquifer. It is likely that these aquifers are connected in places within the right abutment. The upper aquifer has been interpreted as the area of concern in terms of seepage-related problems along the right abutment of HAHD. Tertiary-age volcanic rocks characterize the bedrock at the dam site. Locally, these rocks are known as the Eagle Gorge andesite, and regionally, they correlate with the Ohanepechosh Formation of early Miocene age. Regional dip of the bedrock is roughly 35 degrees southeast. In the vicinity of the new fish passage facility, where extensive bedrock exploration has occurred, the bedrock is composed of andesite and basaltic andesite flows, pyroclastic flows, tuffs, and breccias with acidic dikes and sills. Few structural and stratigraphic patterns exist in this vicinity due to the depositional environment of the volcanic rocks and subsequent intense faulting, shearing, and hydrothermal alteration of the bedrock. On the right abutment, no detailed geologic exploration of the bedrock has occurred, and little detail is known about its composition, fracture patterns, hydrogeology, or other physical properties.

The portion of the right abutment within about 100 to 200 feet of the dam embankment is referred to as the “short path seepage area”. It is the area of greatest concern for piping/internal erosion due to the nature of the materials (silt, sand, and gravel layers in contact with very high permeability fractured bedrock and landslide debris), high groundwater gradients, and the short distance from the upstream to the downstream face in this area.

During dam construction, the upstream face of the right abutment was cleared and grubbed, graded, and a sand and gravel blanket of dam embankment fill material was placed over the first 500 feet of the face of the right abutment and the rest of the cleared face of the abutment was covered with random fill. The entire face of the right abutment was covered with a rock shell composed of angular volcanic boulders up to 4 feet in diameter.

Soils in the upper Green River watershed 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 watershed 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 lower Green River is defined as the reach downstream of HAHD that extends to Puget Sound. In the lower Green River watershed, 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 watershed 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 with Newaukum Creek (Mullineaux 1970).

The width of the floodplain of the lower Green River varies considerably. The Green River Gorge has virtually no floodplain, because of 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 wide. In the lower Green River watershed below the confluence with 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.

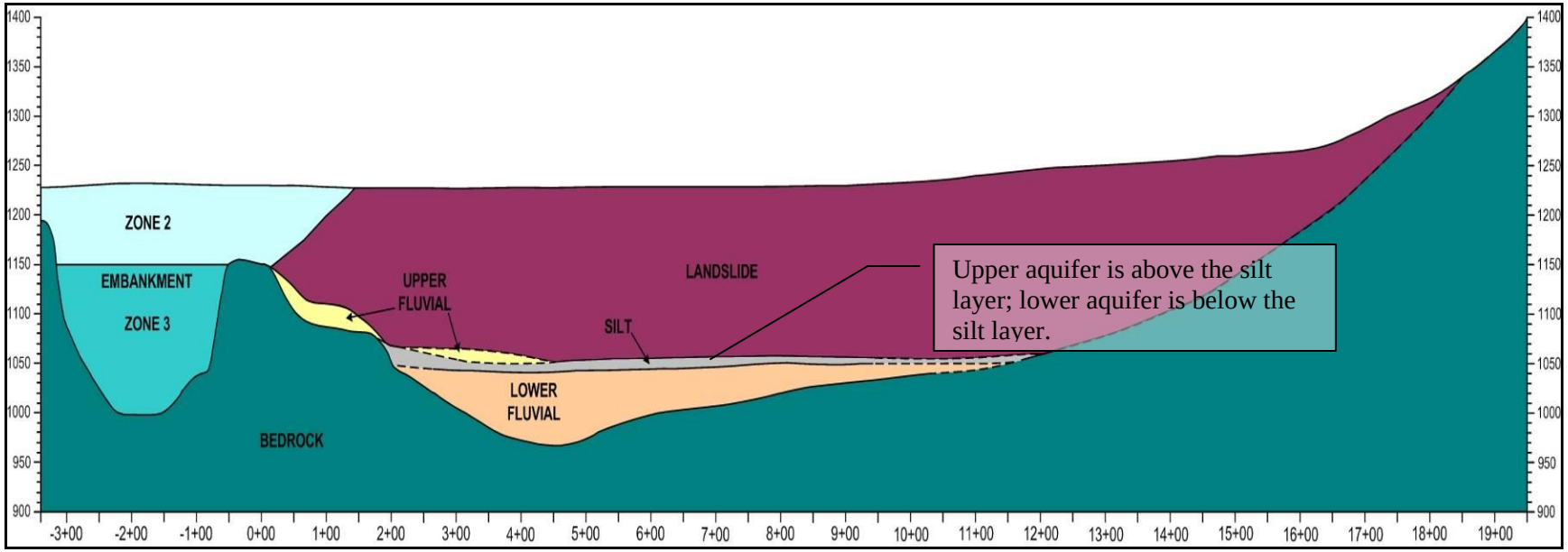

Figure 4-1. Cross Section of the Right Abutment

4.3 CLIMATE

The climate of the Green River watershed is dominated by the maritime influences of the Pacific Ocean and the 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 the 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 the 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 watershed. Moist, maritime air cools and condenses as it moves up in elevation from west to east through the watershed, resulting in decreasing temperatures and increasing precipitation up this elevation gradient. Consequently, there is a considerable difference in both temperature and precipitation from the lower to the higher elevations of the watershed. In addition, there is more snow in the upper portion of the watershed. Melting of snow and the resulting surface runoff in spring is a major source of water to streams.

Climate change discussion is in Section 4.13 – Air Quality, Climate Change, and Noise.

4.4 HYDROLOGY

The Green River originates in the high Cascades in central Washington and flows northwest for approximately 93 miles before emptying into Puget Sound at Elliott Bay. The Green River watershed is about 460 square miles. Forty-eight tributaries enter the system above HAHD, feeding both the mainstem and the reservoir. Large headwater tributaries include the North Fork 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 HAHD, 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 the vicinity of the lower watershed 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 groundwater withdrawals were cited as the primary cause of recent declines in summer low flows in Soos and Newaukum creeks (Culhane, Kelly, and Liszak 1995).

Large flood events are most likely to occur from November to March. Highest flows generally occur in December or January, declining through March with a subsequent snowmelt peak in April or May (USACE 1997). Since construction of HAHD, flood events that inundate the adjacent floodplain have not occurred and large channel-altering flows have an extremely low probability of occurrence (USACE 1997). However, localized flooding does still occur.

Low summer flows are most often associated with low precipitation during summer. Minimum stream flows in the river occur between July and November and are most frequent in August and September. Before construction of HAHD, flows at the Tacoma Diversion Dam (RM 61) were less than 150 cfs every other year on average and less than 100 cfs every 9 years on average. The HAHD low-flow augmentation

regime has reduced the frequency of flows that are less than 150 cfs to approximately one in every 6 years on average and flows that are less than 100 cfs to less than one every 50 years (USACE 1997).

Downstream of the confluence with Soos Creek, the river has been channeled and straightened, increasing the velocity of flows through the lower watershed due to reduced overbank storage. Overbank storage was historically provided by wetlands and floodplains associated with the river and helped regulate flows, minimizing peak flows and maximizing low flows. A large percentage of impermeable surfaces reduces the rate and quantity of infiltration and increases the rate and quantity of surface runoff during storms. Therefore, compared to an undeveloped watershed, a large percentage of impermeable surface can cause the river to reach a peak flow more quickly and cause the peak to be higher in a watershed that has undergone urbanization and industrialization (USACE 1997).

4.5 WATER QUALITY

The Washington State Department of Ecology (Ecology) is responsible for setting water quality standards based on water use and water quality criteria. For aquatic life uses, the Green River is classified as core summer salmonid habitat from the headwaters to about RM 24.5 (Table 4-1), spawning and rearing downstream to RM 11, and rearing/migration only downstream to the mouth. For recreational uses, the Green River is classified as extraordinary primary contact from the headwaters to Flaming Geyser State Park (RM 43), primary contact downstream to RM 11, and secondary contact downstream to the mouth. For water supply uses, it is classified as domestic water upstream of RM 11. The entire river is classified as suitable for miscellaneous uses (WAC 173-201A-602). In general, water quality in the upper Green River is better than the water quality at the downstream stations. Although the Green River maintains a relatively high water quality rating, it appears on Ecology's 303(d) list of impaired waters for various contaminants and temperature. For HAHD, the elevation of the summer conversation pool (currently 1,167 feet) is considered the ordinary high water (OHW) mark. Downstream of the dam near the stilling basin, the OHW mark is approximately elevation 1,011 feet.

Table 4-1. Aquatic Life Uses Criteria for Core Summer Salmonid Habitat

Temperature (7-DADMax)	60.8°F
Dissolved oxygen (lowest 1-day minimum)	9.5 mg/L
Turbidity (NTU)	• No more than 5 NTU over background when the background is 50 NTU or less; or • No more than a 10% increase in turbidity when the background turbidity is more than 50 NTU
Total dissolved gas (percent saturation)	No more than 110% saturation at any point of sample collection
pH (standard pH units)	From 6.5 to 8.5, with a human caused variation within the above range of less than 0.2 units

Notes:
°F = degrees Fahrenheit
7-DADMax = arithmetic average of seven consecutive daily maximum temperature measurements
mg/L = milligrams per liter
NTU = nephelometric turbidity units

4.6 VEGETATION AND HABITAT

The upper Green River watershed is located within the Western Hemlock Forest Zone (Franklin and Dyrness 1988), which is characterized by forests of climax western hemlock (*Tsuga heterophylla*) and western red cedar (*Thuja plicata*) and forests of subclimax Douglas-fir (*Pseudotsuga menziesii*). Although western hemlock is the potential climax species in this zone, Douglas-fir forests cover large areas of the landscape. 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. 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 watershed 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 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, they regenerated naturally. More recent harvested areas have been planted with Douglas-fir. Deciduous forests consisting of red alder, big-leaf maple, and black cottonwood (*Populus balsamifera*) occur on wetter slopes.

The lower Green River watershed is dominated by second-growth Douglas-fir on the forested slopes near the river. The forested habitats of the lower watershed are similar in composition to the forested habitats in the upper watershed. Virtually no late successional forest exists in the lower watershed. Pasture and cropland are the dominant cover types in the agricultural areas farther downstream. Because the topography is flatter and the river fluctuations are not as severe in the lower watershed, riparian and wetland habitats are more common than they are in the upper watershed. Riparian deciduous forest is common adjacent to the river. Wetland habitat is most prevalent in the lower segments where the river is flanked by floodplain.

The lower Green River watershed is characterized by rapid development and urbanization. In general, human activity and land use intensity increase in the downstream direction. Much of the forest land has been cleared by logging or for agriculture and development. With the construction of HAHD and the levee system, much of the remaining riparian vegetation was removed. The vegetation that now exists in the riparian zone is patchy and narrow and is often dominated by nonnative, invasive species. This decrease in riparian vegetation has reduced the function of the riparian zone for wildlife and plants and its connectivity to upland seed sources. The decreased vegetation in the riparian zone has limited the amount of large wood available in the riparian system (Fuerstenberg, Nelson, and Blomquest 1996).

The face of the dam and adjacent portion of the right abutment generally consists of a rock shell composed of angular volcanic boulders up to 4 feet in diameter. Upslope of the main access road along the right abutment is comprised primarily of conifers, deciduous trees, and common understory. The slope of the right abutment nearest to the administration building is adjacent to the main access road to the dam and is subject to traffic including logging trucks, and thus a highly disturbed area. At the debris boom installation, the southwest site generally consists of Douglas-firs and an understory of sword ferns, vine maple, and salmonberry (*Rubus spectabilis*) and is located within the natural zone defined in Tacoma's habitat conservation plan (HCP) pursuant to Section 10 of the ESA (Tacoma 2001). The natural zone is an area managed without timber harvest for the preservation of healthy vegetative cover to reduce erosion and provide fish and wildlife habitat. The northeast site of the debris boom installation is

located on federally owned land and was previously disturbed in 1960s and 70s; this area consists of conifers, deciduous trees, and common understory.

4.7 FISHERY RESOURCES

Over 30 fish species have been documented in the Green-Duwamish River. The salmonid species include both resident and anadromous stocks. Resident fish are present in the lower river and the upper river, including the reservoir area. Anadromous stocks are limited to the river system below the Tacoma Diversion Dam, except where they are stocked or released in the upper watershed.

Five major anadromous salmonid runs use the lower and middle watershed to complete their life cycles: Chinook salmon (*Oncorhynchus tshawytscha*), coho salmon (*O. kisutch*), chum salmon (*O. keta*), pink salmon (*O. gorbuscha*), and steelhead trout (*O. mykiss*). Most of the salmonid spawning occurs upstream of RM 29.6. Although limited spawning occurs downstream of this point, spawning gravels are limited. Small numbers of sea-run cutthroat trout (*O. clarki*) may also use the middle Green River. Additionally there are three hatcheries operating in the middle Green River, two run by the Washington State Department of Fish and Wildlife and one by the Muckleshoot Indian Tribe, which supplement the Chinook, coho, chum, and steelhead runs. Resident fish populations may include rainbow trout, cutthroat trout, and mountain whitefish (*Prosopium williamsoni*). Other native fish species are present, including lampreys (*Lampetra* spp.), northern pikeminnows (*Ptychocheilus oregonensis)*, three-spined stickleback (*Gasterosteus aculeatus*), daces (*Rhinichthys* spp.), sculpins (*Cottus* spp.), and suckers (*Catastomus* spp.).

Returning anadromous salmonids have no access to the river above the Tacoma Diversion Dam; however City of Tacoma has constructed an upstream fish passage facility for this dam and will commence operation of the facility, once the USACE's fish passage facility at HAHD is operational. As mentioned in USACE's 1998 final environmental impact statement (EIS) for the HAHD AWSP, various surveys by USFWS, the U.S. Forest Service, and other public and private landowners have investigated use of the reservoir and upper watershed by resident fish. The documented fish include resident rainbow trout, cutthroat trout, mountain whitefish, and sculpins. USACE conducted a predator study that documented rainbow trout, cutthroat trout, and mountain white fish in the reservoir (USACE 2008). Brook trout (*Salvelinus fontinalis*) were identified in Page Creek, a tributary of the North Fork Green River. Resident trout populations are composed of stream-rearing and possibly lake- and reservoir-dwelling strains. Stream-rearing fish live out their entire life cycle in the small tributary streams of the upper watershed. Lake-rearing fish reside primarily in isolated alpine lakes, whereas reservoir-rearing fish use the mainstem and reservoir area, spawning in larger tributary streams (USACE 1998).

4.8 WILDLIFE RESOURCES

Wildlife present in the vicinity of the upper Green River watershed includes common species associated with the lowland coniferous and deciduous forests of western Washington. Because the upland forests in the project area consist primarily of younger stands, wildlife primarily associated with late successional forests is expected to be uncommon or absent from the area. A variety of forest-dwelling mammals, including herbivores, carnivores, rodents, lagomorphs (rabbits and hares), and insectivores, occur. The most visible mammals include elk (*Cervus elaphus*) and black-tailed deer (*Odocoileus hemionus*). Cougars (*Felis concolor*) are numerous. Common amphibians and reptiles associated with the forests, wetlands, and riparian areas of western Washington live in the upper watershed.

Passerines (perching birds), raptors (birds of prey), waterfowl, upland gamebirds, and shorebirds occupy the various habitats of the upper watershed. Raptors occurring in the watershed include bald eagles (*Haliaeetus leucocephalus*), red-tailed hawks (*Buteo jamaicensis*), Cooper's hawks (*Accipiter cooperii*), sharp-shinned hawks (*Accipiter striatus*), northern goshawk (*Accipiter gentilis*), ospreys (*Pandion haliaetus*), great-horned owls (*Bubo virginianus*), and western screech-owls (*Otus kennicottii*). Waterfowl species that may nest near the reservoir include great blue herons (*Ardea herodias*), Canada geese (*Branta canadensis*), mallards (*Anas platyrhynchos*), green-winged teals (*Anas crecca*), wood ducks (*Aix sponsa*), harlequin ducks (*Histrionicus histrionicus*), hooded mergansers (*Lophodytes cucullatus*), and common mergansers (*Mergus merganser*). Common loons (*Gavia immer*) have been observed nested on the reservoir since the early 1990s. During the winter, the reservoir is used by common goldeneyes (*Bucephala clangula*), ring-necked ducks (*Aythya collaris*), and buffleheads (*Bucephala albeola*).

Because of the migratory tendencies of many birds, their populations in any given location typically fluctuate throughout the year. The upper watershed is no exception. Passerines are typically more common during the nesting season in spring and early summer. Waterfowl populations are highest in winter when up to 200 ducks have been observed on the reservoir at a time.

Wildlife occurrence in the upstream portion of the lower watershed is similar to that of the upper watershed. However, because of an increase in human activity below the restricted access portion of the watershed, populations of wildlife most sensitive to human disturbance, such as elk and cougars, are generally lower. Farther downstream where forest habitat decreases and agricultural land dominates, the wildlife composition shifts to a predominance of species associated with agricultural and edge habitat. Because of the increase in human activity and predominance of disturbed habitats in the downstream areas, wildlife inhabiting these areas is typically adaptable to a variety of habitats and has more tolerance to disturbance.

Bird diversity remains high in the middle watershed but diminishes somewhat downstream in the lower watershed where urban density is higher. Many small mammals (e.g., foxes [*Vulpes* spp.], skunks [*Mephitis* spp.], weasels [*Mustela* spp.], and squirrels [*Sciurus* spp.]) use the dense understories of some of the forested stands. Small streams and sloughs meander through the pasture and upland areas, providing habitat for many species of insects and amphibians, including red-legged frogs (*Rana aurora*), Pacific tree frogs (*Pseudacris regilla*), salamanders (*Plethodon* spp. and *Rhyacotriton* spp), and toads (*Bufo* spp.). Reptilian fauna is not diverse, but several species of snakes and lizards occur in the watershed as well (USACE 1997).

Elk, bald eagles, northern goshawks, osprey, harlequin ducks, and common loons are all on Washington Department of Fish and Wildlife (WDFW) priority species list and occur in the vicinity of reservoir (WDFW 2010). Washington State law provides priority species with protective measures for their survival due to their population status, sensitivity to habitat alteration, and/or recreational, commercial, or tribal importance. Priority species include State Endangered, Threatened, Sensitive, and Candidate species; animal aggregations (e.g., heron colonies, bat colonies) considered vulnerable; and species of recreational, commercial, or tribal importance that are vulnerable. (WDFW 2008a)

Although bald eagle was delisted in 2007, bald eagles are still protected under the Bald and Golden Eagle Protection Act, and Federal agencies must still assure that their actions do not adversely affect nesting bald eagles. Bald eagles are frequently sighted near HAHD and are considered a year-round resident in the area. The project area is outside the range for golden eagles. No bald eagle nests have been documented within a half mile of the project area. The location or frequency of the observed bald eagles does not appear to be affected by regular operations and maintenance activities at HAHD, and to the fish passage facility construction that began in early 2004, which involves heavy machinery, cranes, blasting,

and excavation noises and USACE believes that bald eagles in the area are acclimated to such construction activity.

4.9 THREATENED AND ENDANGERED SPECIES

Eight animal and fish species on the federal list of threatened and endangered species may occur in the Green River watershed, all are threatened with the exception of the gray wolf which is endangered:

- Northern spotted owl (*Strix occidentalis caurina*)
- Marbled murrelet (*Brachyramphus marmoratus*)
- Grizzly bear (*Ursus arctos horribilis*)
- Gray wolf (*Canis lupus*)
- Canada lynx (*Lynx canadensis*)
- Puget Sound evolutionarily significant unit (ESU) of Chinook salmon (*Oncorhynchus tshawytscha*)
- Coastal–Puget Sound distinct population segment (DPS) of bull trout (*Salvelinus confluentus*)
- Puget Sound DPS of steelhead (*Oncorhynchus mykiss*)

None of these species is found in the vicinity of the reservoir (WDFW 2010).

4.9.1 NORTHERN SPOTTED OWL

The northern spotted owl is a forest bird that inhabits old-growth or late successional coniferous and mixed conifer-hardwood forest and can be found throughout the west slope of the Cascade Range in areas with habitat characteristics of moderate to high canopy closure, large overstory trees, substantial amounts of standing snags, in-stand decadence, and coarse woody debris of various sizes and decay classes scattered on the forest floor (USFWS 2010).

The upper Green River watershed supports 20 known spotted owl activity centers, none of which is located closer than 1.8 miles of HAHD. A 3-year survey (1992–1994) by the Washington State Department of Natural Resources resulted in no detections of spotted owls but did result in numerous detections of the barred owl (*Strix varia*). Barred owls are known to compete successfully with spotted owls in young and mid-aged forest, so the abundance of barred owls suggests that the forest in this area is not high-quality habitat for spotted owls.

4.9.2 MARBLED MURRELET

Marbled murrelets are small seabirds that feed on fish and invertebrates usually within two miles of shore and nest in stands of mature and old growth forest. The marbled murrelet typically forages for prey in sheltered marine waters during the day and visits its nest site at dawn or dusk (USFWS 1997a). The loss of old growth forests to logging and development has contributed to the decline of this species.

A 1994 survey team identified three forested stands in the reservoir area as marginally suitable habitat; however, no murrelets were detected in the Green River watershed during that survey, making these stands unlikely to be occupied (USACE 2000). One of these stands is approximately three-quarters of a mile from the project area. In other surveys, two stands with murrelet occupancy were detected more than 7 miles east of the reservoir (Stebbins 2000).

4.9.3 GRIZZLY BEAR

The grizzly bear population in the North Cascades ecosystem is estimated at 10 to 20 bears (Johnson and Cassidy 1997); however, the Washington Priority Habitats and Species database contains no records of

grizzly bears in the Green River watershed (WDFW 2005c). Grizzly bears will avoid areas of human use, including areas with roads and signs of timber cutting (USFWS 1997b).

4.9.4 GRAY WOLF

While a small number of sightings have been reported in the North Cascades, the occurrence of the gray wolf in western Washington remains questionable (Johnson and Cassidy 1997).

4.9.5 CANADA LYNX

The Canada lynx requires a matrix of two important habitat types: boreal forest with a high density of large logs and stumps for denning and early successional forest with high densities of snowshoe hare (*Lepus americanus*). In Washington, lynx are known to occur at elevations higher than 4,000 feet (McKelvey, Aubrey, and Ortega. 1999). The current projected range of the lynx in Washington does not extend west of the Cascade crest, so lynx presence in the project area is highly unlikely.

4.9.6 PUGET SOUND CHINOOK SALMON ESU

Chinook salmon present in the Green River are classified as summer-/fall-run stocks (WDFW and Western Washington Treaty Indian Tribes 1994). As of 2002, the status of Green-Duwamish Chinook stock was healthy (WDFW 2002a). Adult Chinook salmon migrate from Puget Sound upstream to the Green River from late June through November (Grette and Salo 1986). 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). The general timing of Chinook salmon outmigration is shown in Figure 4-2, extending from January until July. Preferred spawning areas for Chinook salmon in the Green River include the main river channel and large side channels upstream of RM 30.0 to the Tacoma Diversion Dam (RM 61.0). The Green River both upstream and downstream of HAHD has been designated as critical habitat for Chinook salmon.

4.9.7 PUGET SOUND STEELHEAD DPS

Steelhead are known to be present in the Green-Duwamish River year-round. Steelhead are anadromous and can spend several years in fresh water before they smolt and migrate to salt water. The majority of steelhead found in the Green River remain in the river for 2 years and in the ocean for 2 years (Pautzke and Meigs 1940). The Green River system supports both winter and summer stocks. As of 2002, the status of the winter stock was healthy, and the status of the summer stock was depressed (WDFW 2002a). The winter return of adult wild steelhead in the Green-Duwamish begins in February but occurs predominantly in March and April. Critical habitat for Puget Sound steelhead has not yet been proposed.

4.9.8 COASTAL-PUGET SOUND BULL TROUT DPS

Bull trout have historically been recorded in the Green River (Suckley 1859), and a bull trout was captured near the mouth of Newaukum Creek in 2000. There is ample evidence from captures that anadromous bull trout regularly use the lower Duwamish River downstream of RM 5.8, especially in the spring. These fish are believed to be migratory visitors from other watersheds that entered the Duwamish from Puget Sound perhaps to forage on emigrating smolts. No bull trout have been found in surveys of the upper watershed upstream of HAHD, and no bull trout stock is currently recognized as existing in the Green River (WDFW 1998). The Green River downstream of the Tacoma Diversion Dam has been designated as critical habitat for bull trout.

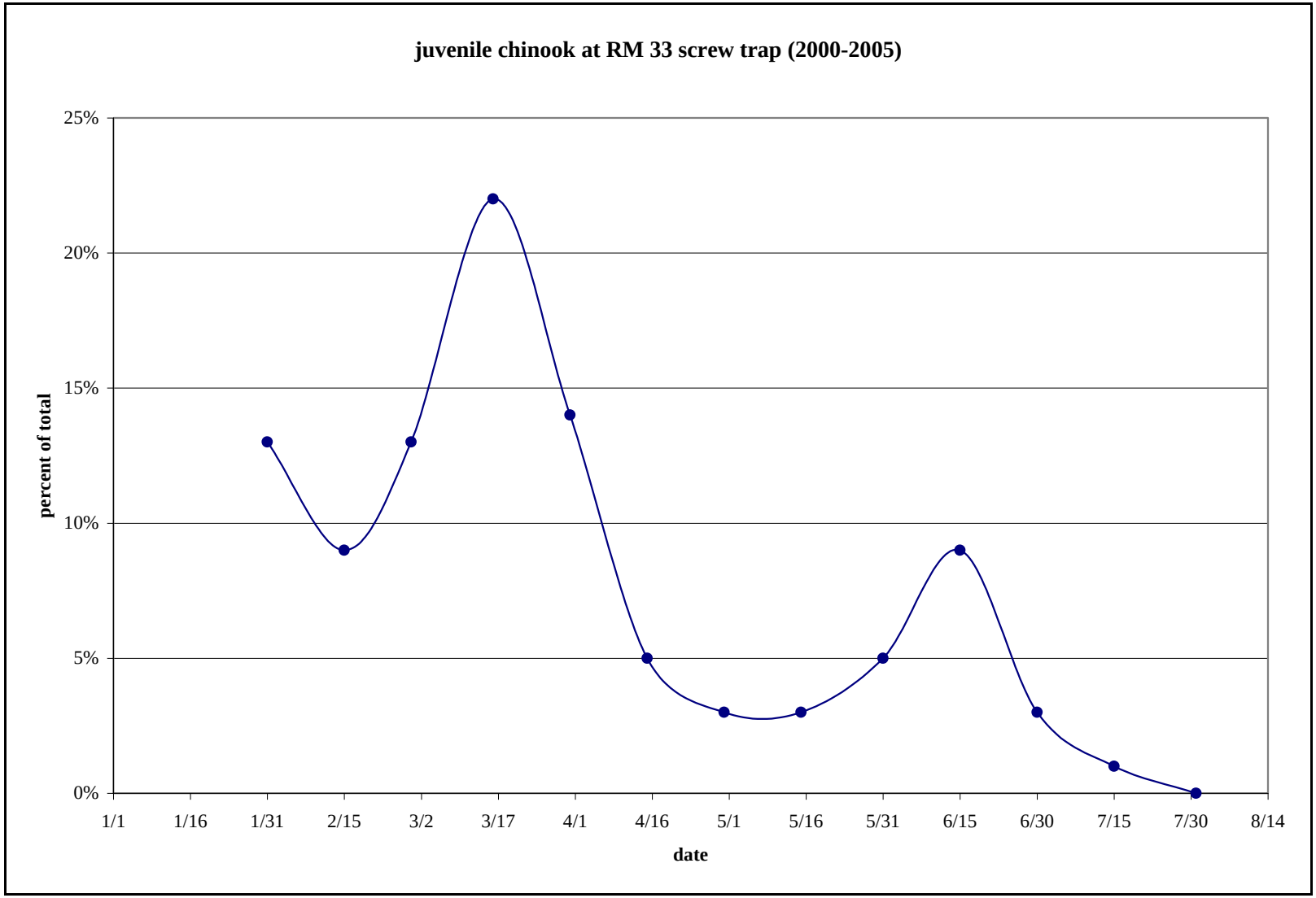

Figure 4-2. Juvenile Chinook Salmon Outmigration Timing
Sources: WDFW 2002b, 2004a, 2004b, 2005a, 2005b, and 2006.

4.10 HISTORIC PROPERTIES AND CULTURAL RESOURCES

Cultural resources are locations of past human activities on the landscape. The term generally includes any material remains that are at least 50 years old and are of archaeological interest. Examples include archaeological sites such as lithic scatters, villages, procurement areas, resource extraction sites, rock shelters, rock art, shell middens; and historic era sites such as trash scatters, homesteads, railroads, ranches, and any structures that are over 50 years old. Under the National Historic Preservation Act (as amended in 2006), Federal agencies must consider the effects of federally regulated undertakings on cultural resources that are eligible for listing in the National Register of Historic Places (NRHP). Cultural resources that are eligible for listing in the NRHP are referred to as historic properties.

The National Park Service has established three main standards that a resource must meet to qualify for listing on the NRHP (Code of Federal Regulations, Title 36, Part 60 [36 CFR 60]): age, integrity, and significance. To meet the age criterion, a resource generally must be at least 50 years old. To meet the integrity criterion, a resource must possess integrity of location, design, setting, materials, workmanship, feeling, and association. Finally, a resource must be significant in terms of one or more of the following criteria:

> (a) Be associated with events that have made a significant contribution to the broad patterns of our history
>
> (b) Be associated with the lives of persons significant in our past
>
> (c) Embody the distinctive characteristics of a type, period, or method of construction, or represent the work of a master, or possess high artistic values, or represent a significant and distinguishable entity whose components may lack individual distinction
>
> (d) Have yielded, or may be likely to yield, information important in prehistory or history

Several cultural resource inventories have been performed in and around the project area. In June 1985 and July 1986, Evans-Hamilton, Inc., undertook a cultural resource inventory of high-probability areas within the HAHD drawdown zone between the elevations of 1,100 and 1,141 feet and portions of the permitted flood control elevations between 1,141 and 1,205 feet (Benson and Moura 1986). The field procedures included a pedestrian survey at 30-meter (98.43-foot) intervals and some shovel tests. A total of 13 prehistoric sites, three historic sites, and one mixed component site were located during the inventory. However, none of these sites is located within one-quarter mile of the area of the currently proposed work.

In 1995 and 1996, USACE contracted with Larson Anthropological and Archaeological Services (LAAS) to conduct a survey for the AWSP pool raise that included the 900-acre impact zone between 1,141 and 1,206 feet (Lewarch, Forsman, and Larson 1996). All of the previously recorded sites were relocated, but no additional sites were recorded.

In winter 2009, USACE's architectural historian recorded the structures associated with HAHD (McCroskey and Storey 2009). HAHD is eligible for NRHP listing under criterion (a), due to its pronounced and measureable effects on the economic development of the lower Green River Valley.

A project-specific inventory was completed for the dam safety modification study (Storey 2010). The inventory included a pedestrian inventory of the debris boom anchor locations at 5-meter (16.4-foot)

intervals, the possible road reroute, and the grout curtain extension location. No historic properties were identified during the inventory.

4.11 RECREATION AND AESTHETICS

HAHD is within the boundary of the Tacoma municipal watershed. Public access is restricted by the City of Tacoma for the protection of water quality. As a result, there is no recreation around HAHD. Downstream of HAHD and the municipal watershed boundary, the Green River is a popular boating river. Kayaks and rafts frequent the middle Green River, in particular the Green River Gorge (Oasis 2008). Downstream of the gorge, small boats are common during fishing seasons. Fishing is also common from the river banks throughout the river downstream of HAHD. The visual quality of the lower Green River watershed varies with its diverse land use and development. Visual quality decreases downstream as development increases.

4.12 TRAFFIC AND TRANSPORTATION

Within the upper watershed, including at HAHD, the primary existing transportation network consists of logging roads. In addition Burlington Northern Santa Fe Railroad (BNSF) has an active rail line that provides access to points east via Stampede Pass. State Routes (SR) 18, 165, and 410 are located north, west, and south, respectively, of HAHD. According to the Washington Department of Transportation, average daily traffic volumes at the intersection of SR 169 and Kent Kangley Road were 16,000-19,000 vehicles per day from 2006 to 2009 (WSDOT 2009).

4.13 AIR QUALITY, CLIMATE CHANGE, AND NOISE

4.13.1 AIR QUALITY

In accordance with the Clean Air Act and its amendments, National Ambient Air Quality Standards (NAAQS) have been established by the U.S. Environmental Protection Agency (EPA) for several criteria pollutants: lead, ozone, carbon monoxide, sulfur dioxide, nitrogen dioxide, total suspended particulates (TSP), and particulates with aerodynamic diameters of 10 micrometers or less (PM_{10}) and 2.5 micrometers or less ($PM_{2.5}$). Three agencies have jurisdiction over air quality in the project area: the EPA, Ecology, and the Puget Sound Clean Air Agency (PSCAA). These agencies establish regulations that govern both the concentrations of pollutants in the outdoor air and the contaminant emissions from air pollution sources. Although their regulations are similar in stringency, each agency has established its own standards. Unless the state or local jurisdiction has adopted more stringent standards, the EPA standards apply. The lower Green River valley is classified as an attainment area for all criteria pollutants except carbon monoxide, ozone, and PM_{10}. For carbon monoxide, ozone, and PM_{10}, the region is classified as a maintenance area, which is a provisional attainment status that must be maintained for several years before the area can be reclassified as full attainment. The project area is classified as an attainment area for all criteria pollutants except carbon monoxide and ozone for which the area is classified as a maintenance area.

In the lower watershed, a high density of industrial sources and vehicles has caused air quality problems. Motor vehicles are the largest source of air pollutants in King County. General periods of drought in mid-summer can result in localized problems related to dust and particulates from vehicles on unpaved roads,

which contribute to high particulate levels. In the winter months, temperature inversions can occur as a result of low solar heating. During these occasions, high concentrations of pollutants associated with wood burning (stoves and fireplaces) and transportation sources can occur. This condition is intensified by the topography of the valley walls.

4.13.2 CLIMATE CHANGE

Indications are that average atmospheric temperatures are trending upward over the previous several decades, and are correlated to increased atmospheric carbon dioxide levels (IPCC 2001). Internal combustion engines emit carbon dioxide (CO_2) as one byproduct of efficient burning of fuel (gasoline or diesel). International efforts are being directed at reducing carbon release into the atmosphere. The University of Washington Climate Impact Group (UWCIG 2008) predicts warmer, wetter winters for western Washington as one manifestation of global climate change.

4.13.3 NOISE

State, county, and local noise regulations specify standards that restrict both the level and duration of noise measured at any given point within a receiving property. The maximum permissible environmental noise levels depend on the land use of the property that contains the noise source (e.g., industrial, commercial, or residential) and the land use of the property receiving that noise. The King County noise standards are shown in Table 4-2. The King County rural noise standards would be applicable in the project area.

Table 4-2. King County Environmental Noise Limits

King County Environmental Noise Limits (dBA)

	District of Receiving Property			
District of Noise Source	Rural Day/Night	Residential Day/Night	Commercial	Industrial
Rural	49/39	52/42	55	57
Residential	52/42	55/45	57	60
Commercial	55/45	57/47	60	65
Industrial	57/47	60/50	65	70

Source: King County Code Chapter 12.88.

Note: dBA = A-weighted decibels

4.14 SOCIOECONOMICS

HAHD is located within King County. King County has a population of approximately 1.8 million people with a per capita income of $39,237. Approximately 9.5% of King County's population lives below the poverty level. The county's demographic is comprised of 73.0% white, 13.0% Asian, 7.4% Hispanic, 5.7% African American, and 0.9% American Indian, Alaska Native, Native Hawaiian, and other Pacific Islander. Approximately 18% of the county has graduated from high school, approximately 28% have a bachelor degree, and 16% have a graduate or professional degree. (US Census Bureau 2010).

HAHD provides flood risk management benefits to over $19 billion in infrastructure located in the lower Green River Valley, which includes the cities of Kent, Auburn, Renton, and Tukwila. Industrial,

commercial, and residential development is located throughout the Green River Valley, as well as significant infrastructure of highways, roads, utilities, and water treatment and sewer treatment facilities. Over 300,000 people live in, work in, and travel through the Green River Valley. The Green River Valley is the third largest contiguous warehousing district in the United States. The estimated flood damages prevented by the operation of HAHD during the January 2009 flood were approximately $3.9 billion.

Since 2007, 20,000 acre-feet of both M&I water supply for City of Tacoma and low-flow augmentation water have been stored behind HAHD during the spring for use in the summer and early fall. This is the result of the AWSP currently being implemented by Tacoma and USACE.

5 ENVIRONMENTAL EFFECTS

This chapter analyzes the environmental effects of each risk reduction measure of the preferred alternative. The preferred alternative would result in no impacts to the following resources: land use/basin characteristics, geology/soils, and traffic/transportation.

The No Action alternative plan would provide no long-term repairs to the dam and could ultimately result in a dam failure. In the event of a dam failure, all authorized dam purposes would be adversely affected; those purposes are to provide low-flow augmentation, water supply, and flood risk reduction. Implementation of the No Action alternative would require an acceptance of the current project risk and would thus not meet the Federal action purpose and need, which is to remediate all significant and credible failure modes in support of the USACE's ultimate goal of having an adequately safe dam that can meet all authorized project purposes. Accordingly, the No Action alternative is unacceptable according to the current USACE guidelines. The No Action alternative is, therefore, carried forward for analysis for the sole purpose of providing the baseline for evaluating the effects of the preferred alternative.

5.1 HYDROLOGY

5.1.1 PFM 1: DRAINAGE TUNNEL IMPROVEMENTS

As discussed in Chapter 1.4, the drainage tunnel typically flows year-round responding both to rain and reservoir elevation. As the reservoir elevation increases during floods or spring refill, there is generally a corresponding increase in discharge from the drainage tunnel. According to the MODFLOW model for the conservation pool, the expected total quantity of water flowing from the new tunnel improvements and tunnel spur would not be substantially different from the flows under the No Action alternative. This is in part due to the 2009 grout curtain. With the addition of the 2009 grout curtain, seepage through this part of the right abutment has decreased.

All the work associated with the drainage tunnel improvements would be done in the existing tunnel and the right abutment. None of the construction activities would be near or in the reservoir or river; therefore, construction activities themselves would not result in a change to the management of reservoir levels or flows from HAHD.

The construction activities associated with the tunnel spur would not occur near or in the reservoir or river. All the work would be conducted within the existing tunnel and access road. No effects to the hydrology, therefore, would occur.

USACE made the decision to wait until completion of the exploration drilling (5 March 2010) to begin refill. This is within the USACE operational flexibility and refill commencing on 6 March 2010 has no more than a minimal effect on downstream flows. The downstream flows between March and June were within the typical range for those months and associated impacts were well within natural variation.

5.1.2 PFM 3: REPLACE AND IMPROVE RESERVOIR DEBRIS BOOMS

The debris boom anchors would be located up the reservoir slope at approximately elevation 1,224 feet (Figure 3-4) and therefore, would not affect the hydrology of the reservoir. New debris booms would be installed; however debris booms have been used at this location in the past. No impacts, therefore, would occur to hydrology.

5.1.3 PFMs 3, 16 & 17: Spillway Gate Alteration, Installation of Spillway Anchors Bolts, & Replace Upstream Slope Protection

The installation of rock anchors and replacement of the slope protection are within the dam structure and above OHW; therefore, these RMMs would not affect the hydrology of the reservoir or the river. When the spillway gate is opened during a high water event, the effect of flow would be slightly higher velocities and discharge from the spillway; thus would have a minimal effect of hydrology.

5.2 Water Quality

5.2.1 PFM 1: Drainage Tunnel Improvements

As a result of construction-related activities of tunnel improvements and the tunnel spur, a short-term increase in turbidity in the river could occur from the drilling and tunnel excavation activities; however all applicable best management practices (BMPs) would be implemented to ensure water quality standards would be met. All drilling cuttings and water would be controlled on site and disposed of at a permitted disposal sites. The water from the tunnel would be collected at the existing tunnel portal into a weir box and conveyed along the access road, exiting onto a riprap or gabion pad structure that would flow eventually into the river. The riprap or gabion pad structure would be above OHW. Drainage water from the tunnel would be the same or better quality than ambient conditions in the river. The effects to water quality from construction and operation of the tunnel improvements and the tunnel spur would be short term in nature and would be extremely minimal.

The exploration drilling for the four borings was conducted at elevation 1,090 feet. The drilling rig mobilized to the site on 17 February 2010 and the drilling concluded by 5 March 2010. This action required waiting to begin refill of the reservoir until 6 March 2010. The drilling involved recovering a core from each hole to a depth of 70 feet below top of bedrock. All holes were backfilled with a cement based grout (approximately 10 cubic yards total). Any drilling muds or cuttings were collected in barrels onsite and disposed of at an appropriate onsite facility. Water and drilling fluids such as Con Det and EZ Mud were the only fluids used during the drilling process. Plastic was laid down under the drill rig to contain any potential spills. Accordingly, the exploratory drilling did not affect water quality.

5.2.2 PFM 3: Replace and Improve Reservoir Debris Booms

The debris boom anchors would be located up the slope from the reservoir at or above elevation 1,224 feet and therefore construction activities associated with the installation of the anchors would occur well above OHW. The swing path for each anchor would involve clearing trees as shown on Figure 3-4; however the understory would remain. Construction of the temporary access road would involve clearing vegetation; hydroseeding with native seed mix; and allowing the recolonization of the vegetation to minimize any potential erosion. Trees would be removed along approximately 515 linear feet of the shoreline to accommodate the swing path. The entire reservoir has 96,693 linear feet of shoreline with trees. The loss of trees from this measure would constitute 0.5 percent loss of trees from the shoreline; which could result in a negligible increase in water temperature of the reservoir. The removal of trees is not expected to have the potential to affect water quality parameters other than temperature. Debris booms have been previously strung across the reservoir at this general location. Effects to water quality would, therefore, be minimal for replacing and improving the debris booms.

5.2.3 PFMs 3, 16 & 17: Spillway Gate Alteration, Installation of Spillway Anchors Bolts, & Replace Upstream Slope Protection

Impacts associated with altering the spillway gate, installing the rock anchors and replacing the slope protection includes short-term and temporary increases in construction run-off adjacent to the worksites. All construction activities are above OHW. Waters of the U.S. would not be impacted due to construction activities as these proposed RRMs would not involve any work in the wetted area of the HAHD reservoir, the Green River, or in wetlands. Work would follow guidance on BMPs for minimizing impacts to water quality and erosion.

5.3 Vegetation and Habitat

5.3.1 PFM 1: Drainage Tunnel Improvements

With the exception of three new vertical wells located on the hillside northeast of the administration building, all the tunnel improvement's construction activities would occur on existing staging areas, access roads and the tunnel itself. To install those three vertical wells, a temporary access road is needed on the hillside which is on Federally-owned property. Approximately 0.25 acre of mainly conifers would be removed to accommodate the temporary access road. Upon completion of this RMM, the road would be removed; the disturbed area would be hydroseeded with a native seed mix and replanted with conifers. Because the vegetation and habitat disturbance is minimal in relation to the entire watershed and the replanting of vegetation, the effects to vegetation or habitat would be minimal.

The construction activities including mobilization for the tunnel spur would not require any vegetation removal or modification to any habitat. All work areas are already highly disturbed. No effects to vegetation or habitat, therefore, would occur.

Exploration drilling did not remove any vegetation or affect habitat. The installation of piezometers occurred with the existing roadways and the exploration drilling was conducted on the face of the right abutment which is riprap and gravel.

5.3.2 PFM 3: Replace and Improve Reservoir Debris Booms

Approximately 0.90 acres of forested habitat for the north location and approximately 1.0 acre of forested habitat for the south location would be disturbed to construct the debris boom anchors including the vegetation management area (approximately 0.66 acre) to facilitate the booms ability to swing freely, and a temporary access road (approximately 0.35 acre) (Figure 3-4). There is a concern that the debris booms could become entangled in trees. The vegetation management area would be allowed to recolonize with understory vegetation that could accommodate the debris booms.

For the south location, the area that would be affected by the vegetation management area and temporary access road does not appear to provide habitat for any threatened or endangered species. However, this area is located within the natural zone as defined in Tacoma Water's Green River HCP pursuant to Section 10 of the ESA. Lands affected include the Forest Management Zone and Natural Zone. The Forest Management Zones are lands managed to provide maintenance of water quality and protection of fish and wildlife habitat. The Natural Zone is an area managed without timber harvest for preservation of healthy vegetative cover to reduce erosion and provide fish and wildlife habitat. The trees cleared in the vegetation management area would be left onsite to provide wildlife habitat or possibly instream habitat. The rootballs would remain in the ground to provide erosion control. The temporary access road to the southwest anchor location would disturb upland habitat. Upon completion of the construction, the

temporary access road would be removed and hydroseeded; and vegetation would be allowed to recolonize this area.

Tacoma Water's Green River HCP covers 32 species of fish and wildlife that are known to either use, or have the potential to use, the Green River watershed (Tacoma 2001). The proposed work would likely impact two HCP requirements – Habitat Conservation Measure (HCM) 3-01A, and Forest Management Zone; HCM 3-01B, Natural Zone. Tacoma Water is responsible for maintaining compliance with their HCP. They are coordinating with U.S. Fish and Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS) to determine if the loss of trees would require any mitigation. USACE is cooperating with Tacoma Water to ensure that the proposed action is consistent with the HCP. Work would follow the HCP guidance on best management practices for minimizing impacts to water quality and erosion. No logging activities or permanent roads construction would occur. In addition, the vegetation and habitat disturbance is minimal in relation to the entire watershed. Therefore, effects to vegetation and habitat would be less than significant.

5.3.3 PFMs 3, 16 & 17: Spillway Gate Alteration, Installation of Spillway Anchors Bolts, & Replace Upstream Slope Protection

No vegetation would be disturbed or removed; all construction activities would occur on the dam structure where no vegetation occurs. No effects to vegetation or habitat would occur from the spillway gate alteration, installation of rock anchors or replacement of the slope protection.

5.4 Fishery Resources

5.4.1 PFM 1: Drainage Tunnel Improvements

Tunnel improvement and the tunnel spur construction would not require in-water work; all construction activities would be contained to the drainage tunnel and adjacent access road. In addition, all applicable BMPs would be implemented to control any construction-related runoff. Therefore no long-term or short-term impacts to fisheries would occur. The proposed work would not affect management of HAHD operations, so reservoir levels and downstream flows would remain within the current operating pool levels and resulting effects on fishery resources would not change from the No Action alternative.

USACE decided to wait until 10 March 2010 to begin refill, in order to first conduct the exploration drilling. This is within the USACE operational water management flexibility and refill commencing on 10 March has no more than a minimal effect on downstream flows. The downstream flows between March and June 2010 were within the typical range for those months and associated impacts were well within natural variation. The actual drilling did not occur where there was habitat for fisheries. Therefore, this action did not affect any species of fish.

5.4.2 PFM 3: Replace and Improve Reservoir Debris Booms

The log boom anchors would be located up the slope from the reservoir at or above elevation 1,224 feet and therefore construction activities associated with the installation of the anchors would have minimal effects on fisheries. As discussed above in Section 5.2 – Water Quality, the loss of trees associated the vegetation management area could result in a negligible increase in water temperature of the reservoir which could have a minimal effect on fisheries. Debris booms have been previously strung across the reservoir at this general location.

5.4.3 PFMs 3, 16 & 17: Spillway Gate Alteration, Installation of Spillway Anchors Bolts, & Replace Upstream Slope Protection

The spillway gate alteration, installation of rock anchors, and replacement of slope protection would not require any in water work; all construction activities would be contained to the spillway and adjacent dam face and all applicable BMPs would be implemented to minimize construction-related runoff. Therefore no long-term or short-term effects to fisheries would occur.

5.5 Wildlife Resources

The following effects analysis for WDFW priority species would apply to all the RMMs. None of the WDFW priority species in the vicinity of the reservoir are found within a half mile of the project area (2010). In addition, the species that are both on the federal ESA and WDFW priority species lists do not occur in the vicinity of the reservoir (WDFW 2010). The short-term presence of humans and heavy equipment at the right abutment, at the debris boom anchor area, and along the left bank and spillway would not affect bald eagles as the activity is located along the right abutment away from the nearest nest and feeding area, and thus would not disrupt feeding behavior. As discussed in Section 4.8 (Wildlife Resources), no bald eagle nests have been documented within a half mile of the project area. Nonetheless, prior to ground disturbance a site visit will be conducted by a qualified wildlife biologist to determine no new nests have been constructed (Lucas, R., pers. comm. 2010). If eagle nests are found during this site visit, avoidance measures and BMPs will be implemented consistent with the Bald and Golden Eagle Protection Act. Therefore, the project is expected to have no effect on WDFW priority species and bald eagles.

5.5.1 PFM 1: Drainage Tunnel Improvements

As mentioned in Section 5.3 (Vegetation and Habitat), the installation of three vertical wells would require a temporary access road, which would result in disturbance of approximately 0.25 acre. Wildlife species that utilize this area would be temporarily displaced during construction; however there is similar habitat in the nearby area of the watershed that is easily available for wildlife use during the short term. Effects to wildlife, therefore, would be less than significant.

All construction-related activities for the tunnel spur would be confined to the drainage tunnel, staging area, and existing access road. No habitat would be lost or disturbed; therefore effects on wildlife would be negligible.

Exploration drilling did not remove any vegetation or affect habitat. The installation of piezometers occurred with the existing roadways and the exploration drilling was conducted on the face of the right abutment which is riprap and gravel. Wildlife resources, therefore, were not affected by the piezometers or exploration drilling.

5.5.2 PFM 3: Replace and Improve Reservoir Debris Booms

As mentioned in Section 5.3 – Vegetation and Habitat, approximately 0.90 acres and 1.0 acres of forested habitat for the north and south locations, respectively, would be cut down to construct the log boom anchors and vegetation management areas. Wildlife species that utilize these areas would be displaced during construction. The birds and other species that utilize the trees in the vegetation management area would be permanently displaced; however there is abundant similar habitat nearby and around the reservoir and upper watershed for the bird and other species to relocate to. In addition, the clearing of

trees would occur in the fall to not effect nesting birds in the area. Therefore, effects to wildlife would be less than significant as compared to the No Action alternative.

5.5.3 PFMs 3, 16 & 17: Spillway Gate Alteration, Installation of Spillway Anchors Bolts, & Replace Upstream Slope Protection

All construction activities would occur on the dam structure where no wildlife habitat occurs. The dam is primarily engineered rock fill with concrete structures. In addition, the construction materials associated with rock anchors installation and slope protection replacement are consistent the materials currently at the spillway and adjacent to the spillway. Therefore, no effects to wildlife would occur.

5.6 Threatened and Endangered Species

The following effects analysis for threatened and endangered species would apply to all the RMMs. None of these species is found in the vicinity of the reservoir (WDFW 2010).

5.6.1 Spotted owl

Spotted owl would be unlikely to be present at the project area, mainly due to absence of suitable habitat and the presence of human activity associated with the operation of the dam and ongoing construction activities. The habitat in the vicinity of the debris booms anchors has been previously logged or disturbed by human activity. The temporary and localized noise and presence of humans at the project is expected to have no effect on spotted owls.

5.6.2 Marbled murrelet

Similar to the spotted owl, marbled murrelet would be unlikely to be present at project area, mainly due to absence of suitable habitat and the presence of human activity associated with the operation of the dam and ongoing construction activities. The habitat in the vicinity of the debris booms anchors has been previously logged or disturbed by human activity. Marbled murrelets are not expected to occur adjacent to HAHD or the reservoir, due to the absence of suitable habitat; therefore, the project is expected to have no effect on marbled murrelets.

5.6.3 Grizzly bear

As mentioned in Chapter 4.9.3, grizzly bears will avoid areas of human use, including areas containing roads and signs of timber cutting (USFWS 1997). Because of the low probability of grizzly bear presence in the Green River watershed, the project is expected to have no effect on grizzly bears.

5.6.4 Gray wolf

Gray wolves likely do not occur in the central Cascades. In the event that a wolf or wolves moved into the area, gray wolves typically avoid human activity and roads so the likelihood of their occurrence in the vicinity of HAHD is low. The project is expected to have no effect on gray wolves.

5.6.5 CANADA LYNX

The action area for the project is at an elevation of approximately 1,200 feet and does not include the prerequisite abundance of snowshoe hares for lynx to be present, so this project is expected to have no effect on Canada lynx.

5.6.6 PUGET SOUND CHINOOK SALMON ESU

Chinook do not spawn above the headworks dam, as adults are not transported to the upper watershed. There would be no in-water work and very little or no materials would enter the reservoir because the project site is either within or on the dam, and above the reservoir, and there would be no changes to the shoreline as none of the bank will be altered below the normal summer pool level at elevation 1,167 feet. Approximately 2.25 acres of vegetation would be disturbed as a result of the project, of which approximately 0.25 acre would be replanted immediately following project completion. Construction is expected to be completed in 2012. No change to water management operations occurred as a result of the drilling for data collection or piezometer installation, or would occur once the recommended actions are complete. This project would have no effect on hydrology, water quality, substrate, or fish habitat. Therefore, the project would have no effect on Puget Sound Chinook salmon or their critical habitat.

5.6.7 PUGET SOUND STEELHEAD DPS

Similar to Chinook salmon, steelhead do not have access above the headwork dam. In addition, there would be no in-water work, and no changes to the shoreline as none of the bank will be altered below the high pool level at elevation 1,167 feet. This project would have no effect on hydrology, water quality, substrate, or fish habitat. The project would, therefore, have no effect on steelhead. Critical habitat for steelhead has not yet been designated.

5.6.8 COASTAL-PUGET SOUND BULL TROUT DPS

Bull trout have not been found in the Green River above HAHD, and information on bull trout stock status for the rest of the river is unknown (WDFW 1998). Access to the upper watershed for migratory native char has been blocked by TPU's headworks diversion since 1913 and by HAHD since 1962. Bull trout spawning is not known to occur in the vicinity of the project. There would be no in-water work, and no changes to the shoreline as none of the bank will be altered below the high pool level at elevation 1,167 feet. This project would have no effect on hydrology, water quality, substrate, or fish habitat. Therefore, the project would have no effect on bull trout or their critical habitat.

5.7 HISTORIC PROPERTIES AND CULTURAL RESOURCES

5.7.1 PFMS 1, 3, 16 & 17: TUNNEL IMPROVEMENTS, SPILLWAY GATE ALTERATION, INSTALLATION OF ROCK ANCHORS & SLOPE PROTECTION

The proposed tunnel improvements, tunnel spur, spillway gate alteration, rock anchors and slope protection constitute an effect to the HAHD. The Corps determined that the dam was eligible for the National Register under criterion (a) due to its pronounced and measurable effects on the economic development of the lower Green River Valley (McCroskey and Storey 2010). The Department of Archaeology and Historic Preservation (DAHP) has concurred with this determination.

The Corps must take into consideration the impact that RMMs would have on the qualities that make the dam eligible for the National Register. In this case, the dam is eligible because of its significant role in the development of the watershed, not for its architectural qualities. The dam was not found to be eligible

under criterion (c). Actions that could adversely affect the Dam's eligibility would be significant alterations to the dam's character defining features, major impacts to the surrounding viewshed, or major changes to the dam's operation or function.

By necessity, the dam is a dynamic resource that has seen a variety of modifications over the years in order to remain functional. Changes to the dam have included: constructing a 650 foot drainage tunnel with vertical drains in 1969; adding a tapered, triple box to the outtake tower in 1994; installing ten additional horizontal wells and a 300 foot grout curtain in the right abutment in 2001; installing a 475 foot grout curtain and 13 new horizontal wells in 2009; and constructing the fish passage facility (project work ongoing). The proposed remedies for the right abutment are minor in scope and do not adversely affect the historic significance of the dam or any of its character defining features. The tunnel improvements and spur would occur below ground within the right abutment. Similarly, the spillway gate alteration, replacement of rock anchors within the spillway and increasing the size of the riprap for the slope protection are incredibly minor changes and mostly hidden from view. USACE has determined and State Historic Preservation Office (SHPO) has concurred that the proposed project would not result in an adverse affect to any historic properties (Appendix B).

5.7.2 PFM 3: Replace and Improve Reservoir Debris Booms

A cultural resource inventory was completed for the proposed boom anchor locations and access roads. The inventory consisted of a pedestrian survey with less than 5 meter transect spacing. No historic properties were located during the inventory. The Corps has determined and the SH PO has concurred that this undertaking will not affect any eligible cultural resources. A report detailing the results of the inventory entitled "A Cultural Resource Inventory of the Howard A. Hanson Dam Safety Modification" (Storey 2010) is on file with the SHPO and at the USACE Seattle District Office.

5.8 Recreation and Aesthetics

The project area is within the Tacoma municipal watershed that is closed to the public. No recreation, therefore, occurs at the dam. The proposed project would not change the access to the reservoir.

The characteristics of the right abutment including the administration building would remain unchanged with the drainage tunnel improvements. Both the northeast and southwest locations of debris boom anchors has been previously disturbed by logging activity and have had previous debris boom anchors. The spillway gate alteration, installation of the rock anchors and replacement of the slope protection are both within the existing dam prism and would not change the material of the dam. Overall, the general character of HAHD would not change substantially and thus, have no effect on aesthetics. The characteristics of the Green River valley downstream of the dam would remain unchanged; the proposed project would not affect the aesthetics downstream.

5.9 Air Quality, Climate Change, and Noise

Equipment such as dump trucks, excavators and dozers would have mufflers and exhaust systems in accordance with State and Federal standards. Any effects to air quality will be short term; only during construction. The project is exempted from the conformity requirements of the CAA because actions taken to repair and maintain existing facilities are specifically excluded from the CAA conformity requirements where the action, as here, would result in an increase in emissions that is clearly *de minimis* (40 CFR § 93.153(c)(2)(iv)). There would be a temporary increase in noise during construction; however

construction noise levels would be consistent with current noise levels of ongoing construction at the dam. Following construction, there will be no change in air quality, noise or light parameters. Impacts to air quality and noise would be less than significant.

Diesel fuel consumption by heavy machinery required for construction and repair and gasoline consumption for travel to the sites for all USACE projects, including dam repairs, are a part of world-wide cumulative contributions to change in climate by way of increases in greenhouse gas emission. Climate change models in the Pacific Northwest are predicting warmer, wetter winters and drier summers which may trigger more flooding (UWCIG 2008). It is notable that the eliminated alternatives which would have had more heavy equipment, more earthwork, and longer construction schedules would nevertheless have resulted in minuscule contribution of CO_2 emissions to the overall global emissions. The small scope of the proposed project would generate an incremental contribution to global climate change that is considered less than significant.

5.10 SOCIOECONOMICS

It is anticipated that all water storage projects, including M&I storage, would be successfully implemented for the long term upon completion of proposed project. In addition, the dam would be able to be operated to its full flood capacity. The proposed project, therefore, would not result in impacts to socioeconomics.

5.11 CUMULATIVE IMPACTS

NEPA defines cumulative impacts as the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR §1508.7).

Future and current activities in and around HAHD include several large construction projects including construction of a fish passage facility, and ongoing dam operations described in Chapter 1.5. Multiple habitat restoration type activities associated with the AWSP and Tacoma HCP are ongoing or planned. Timber harvesting in the upper Green River watershed will continue. In the lower Green River, several levee rehabilitation projects were constructed in 2008. Several additional levee repair projects are planned for 2009. These activities are likely to continue as local municipalities manage flood risks such as temporarily raising the levee height with “super sacks”, and large sand bags.

The 2009 interim repair, including a grout curtain, was constructed along the right abutment and was completed November 2009. The proposed drainage tunnel improvements would overlap the construction footprint for the 2009 interim repair and areas previously disturbed by the original dam construction. The proposed debris booms and their anchors are located in areas that in the past had booms and anchors. The rock anchors and slope protection are within the dam footprint. The cumulative impact of the proposed project is negligible.

The activities described in this document evaluate and maintain the existing authorized functions of HAHD. This includes flood control and the various water storage activities. The incremental effects of the proposed project, combined with other past, present, and future actions described above are not expected to result in significant environmental impacts.

5.12 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENT OF RESOURCES

The irreversible and irretrievable commitment of resources is the use of materials, resources, or land during implementation of an alternative that makes these resources unavailable for other uses, given known technology and reasonable economics. No Federal resources would be irreversibly and irretrievably committed to the proposed action until this environmental assessment is finalized and a "Finding of No Significant Impact" has been signed. The data collection efforts did not represent an irretrievable commitment of resources and did not limit the election of a reasonable range of alternatives.

6 COMPLIANCE WITH APPLICABLE LAWS, POLICIES AND PLANS FOR THE PREFERRED ALTERATIVE

6.1 NATIONAL ENVIRONMENTAL POLICY ACT

National Environmental Policy Act (NEPA) (42 U.S.C. 4321 et seq.) requires that Federal agencies consider the environmental effects of their actions. It requires that an EIS be included in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The EIS must provide detailed information regarding the proposed action and alternatives, the environmental impacts of the alternatives, appropriate mitigation measures, and any adverse environmental impacts that cannot be avoided if the proposal is implemented. Agencies are required to demonstrate that these factors have been considered by decision makers prior to undertaking actions. Major Federal actions determined not to have a significant effect on the quality of the human environment are evaluated through an EA.

The data collection work that consisted of four exploratory borings and the installation of eight piezometers was the subject of a Categorical Exclusion, under 33 CFR 230.9(b), as a routine repair and rehabilitation activity at a completed USACE civil works project that carries out the authorized project purposes of flood risk reduction, water supply, and ecosystem restoration. The Categorical Exclusion was executed on 12 February 2010. These activities were urgently required at that time to inform the DSMS. Furthermore, at that time it was unknown what, if any, further dam safety modification measures would prove to be necessary at the conclusion of the study. Those data collection activities did not represent an irretrievable commitment of resources and did not limit the election of a reasonable range of alternatives. Now that a recommended course of action for dam safety modification activities has been developed, and in recognition of the fact that the data collection activities are integrally related to the recommended construction actions, the environmental impacts of those prior activities are considered in conjunction with the recommended actions.

A draft EA was posted for a 33-day comment period that began 9 September 2010 and ended 12 October 2010; one comment letter was received. This comment letter was received from WDFW dated 12 October 2010 and can be found in Appendix F along with USACE response. The signed Finding of No Significant Impact (FONSI) is included in Appendix A. This Final EA and signed FONSI satisfy the documentation requirements of NEPA.

6.2 ENDANGERED SPECIES ACT

The Endangered Species Act (ESA) (16 U.S.C. 1531-1544), amended in 1988, establishes a national program for the conservation of threatened and endangered species of fish, wildlife, and plants and the habitat upon which they depend. Section 7(a) of the ESA requires that Federal agencies consult with the USFWS and NOAA Fisheries, as appropriate, to ensure that their actions are not likely to jeopardize the continued existence of endangered or threatened species or to adversely modify or destroy their critical habitats. Under Section 7 regulation, if USACE determines the proposed action will have no effect on ESA-listed species and designated critical habitat, it is not required to consult with the Services.

As summarized in Section 5.6, USACE has determined the preferred alternative would have no effect on ESA-listed species or designated critical habitat. A Memorandum for Record (MFR) detailing the analysis of ESA compliance (Appendix E) has been prepared and filed.

6.3 MAGNUSON-STEVENS FISHERY CONSERVATION AND MANAGEMENT ACT

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), (16 U.S.C. 1801 et. seq.) requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The objective of an EFH assessment is to determine whether the proposed action(s) "may adversely affect" designated EFH for relevant commercial, federally-managed fisheries species within the proposed action area. The assessment describes conservation measures proposed to avoid, minimize, or otherwise offset potential adverse effects to designated EFH resulting from the proposed action.

The EFH mandate applies to all species managed under a Fishery Management Plan (FMP). In the state of Washington, three FMPs are in effect, which cover groundfish, coastal pelagic species, and Pacific salmon. All work for this project would occur in the dry above the Ordinary High Water Mark and have no impact on water quality in the Green River or reservoir. No substrate would be disturbed and no spawning or rearing areas will be altered by construction or dam operations during construction. The project would have no effect on EFH, either during construction or as a result of the completed project. Analysis of EFH effects is included in the MFR on ESA compliance (Appendix E).

6.4 CLEAN WATER ACT

Under Section 401 of the Clean Water Act (CWA), State Water Quality Certification is required for discharges that may impact water quality. The certification ensures that the discharge will comply with the applicable provisions of Sections 301, 302, 303, 306 and 307 of the CWA. Under Section 404 of the CWA, a Department of the Army permit is required for the discharge of dredged or fill material into waters of the United States, including wetlands. The work associated with the preferred alternative will not occur below OHW and will not result in a discharge of fill material into waters of the United States and therefore does not require a Section 401 water quality certification or a 404(b)(1) evaluation.

Section 402(p) of the CWA provides that stormwater discharges associated with industrial activity that discharge to waters of the United States must be authorized by an National Pollutant Discharge Elimination System (NPDES) permit when construction footprints exceed one acre. The term "discharge" when used in the context of the NPDES program means the discharge of pollutants (40 CFR §122.2). The RMMs associated with the preferred alternative will require a NPDES permit for the construction activities.

Based on discussions with the Environmental Protection Agency (EPA), a NPDES permit is not required for discharge of water pumped from the twelve dewatering wells along the spur alignment during a high flood event (Olson 2010). Turbidity and dissolved oxygen will be monitored.

As an integral element of the repair of HAHD, any discharge associated with the exploration drilling activities, even though they may have occurred below the ordinary high water mark, is excluded from Section 404 jurisdiction, under CWA Section 404(f)(1)(B). Because there was no 404 jurisdictional activity being conducted, no 404(b)(1) evaluation is required and no 401 water quality certification is required. Because there is less than one acre of ground disturbance and no discharge of drilling muds or cuttings, no Section 402 permitting was required for the data collection activities.

6.5 RIVERS AND HARBORS ACT

Section 10 of the Rivers and Harbors Act of 1899 prohibits the unauthorized obstruction or alteration of any navigable water of the United States. Activities that involve the construction of dams, bridges, dikes etc. across any navigable water, or placing obstructions to navigation outside established Federal lines and excavating from or depositing material in such waters, require permits from USACE. The proposed activities will not obstruct navigation in the Green River.

6.6 COASTAL ZONE MANAGEMENT ACT

The Coastal Zone Management Act of 1972, as amended, requires Federal agencies to carry out their activities in a manner that is consistent to the maximum extent practicable with the enforceable policies of a state's approved Coastal Zone Management (CZM) Program. The Shoreline Management Act (SMA) of 1972 (RCW 90.58) is the core of authority of Washington's CZM Program. Primary responsibility for the implementation of the SMA is assigned to local government. In the case of HAHD and the Green River, the local jurisdiction is King County. A portion of the recommended plan involves construction that extends beyond the boundary of Federal lands. Planning, construction, modification, or removal of public works, facilities, or other structures requires a Department of Ecology concurrence with the USACE consistency determination.

The King County Shoreline Management Plan (SMP) designates area around the dam as conservancy, excluding Federal lands. Conservancy areas are intended to maintain their existing character. This designation is designed to protect, conserve, and manage existing natural resources and valuable historic and cultural areas. The preferred uses are those nonconsumptive of the physical and biological resources of the area. The project has been evaluated against the King County Shoreline Management Master Program (Appendix C). The recommended plan is consistent to the maximum extent practicable with the enforceable policies of the Washington Coastal Zone Management Program. Ecology has concurred with the USACE consistency determination.

6.7 NATIONAL HISTORIC PRESERVATION ACT

Section 106 of the National Historic Preservation Act (NHPA) requires that Federal agencies identify, evaluate and assess the effects of undertakings on sites, buildings, structures, or objects listed in or eligible for listing in the National Register of Historic Places (NRHP). Eligible properties must generally be at least 50 years old, possess integrity of physical characteristics, and meet at least one of four criteria for significance. Regulations implementing Section 106 (36 CFR Part 800) encourage maximum coordination with the environmental review process required by NEPA and with other statutes. Recently-amended Washington state laws also apply on non-Federal lands, including the Archaeological Sites and Resources Act (RCW 27.53), Indian Graves and Records Act (27.44 RCW) and the Abandoned and Historic Cemeteries and Historic Graves Act (68.60 RCW).

In order to comply with Section 106, USACE conducted a cultural resource inventory. No cultural resources were encountered during the inventory. Previously the HAHD has been recorded and found to be eligible for the National Register under criterion (a). USACE has determined and the SHPO has concurred that the proposed project will not adversely affect the dam (Appendix B).

If, during construction activities, the Contractor observes items that might have historical or archeological value, such observations shall be reported immediately to the Contracting Officer, or, if present, USACE's Construction Supervisor so that the appropriate authorities may be notified and a determination can be made as to their significance and what, if any, special disposition of the finds should be made. The Contractor shall cease all activities that may result in the destruction of these resources and shall prevent his employees from trespassing on, removing, or otherwise damaging such resources.

6.8 NATIVE AMERICAN GRAVES PROTECTION AND REPATRIATION ACT

The Native American Graves Protection and Repatriation Act (NAGPRA) (25 U.S.C. 3001) addresses processes and requirements for Federal agencies regarding the discovery, identification, treatment, and repatriation of Native American and Native Hawaiian human remains and cultural items (associated funerary objects, unassociated funerary objects, sacred objects, and objects of cultural patrimony). Consistent with procedures set forth in applicable Federal laws, regulations, and policies, USACE will proactively work to preserve and protect natural and cultural resources, and establish NAGPRA protocols and procedures.

6.9 CLEAN AIR ACT

The Clean Air Act (CAA) (42 U.S.C. 7401 et seq.), amended in 1977 and 1990, was established "to protect and enhance the quality of the nation's air resources so as to promote public health and welfare and the productive capacity of its population." The CAA authorizes the EPA to establish the National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. The CAA establishes emission standards for stationary sources, volatile organic compound emissions, hazardous air pollutants, and vehicles and other mobile sources.

The CAA requires the states to develop implementation plans, called State Implementation Plans (SIP), for eliminating or reducing the severity and number of violations of the NAAQS, while achieving expeditious attainment of the NAAQS. The Act requires Federal actions to conform to the appropriate SIP. An action that conforms with a SIP is defined as an action that will not: (1) cause or contribute to any new violation of any standard in any area; (2) increase the frequency or severity of any existing violation of any standard in any area; or (3) delay timely attainment of any standard or any required interim emission reductions or other milestones in any area.

The project site is in a maintenance area, provisional attainment status. Emissions of pollutants from the construction equipment would be negligible. The project is exempted from the conformity requirements of the CAA because actions taken to repair and maintain existing facilities are specifically excluded from the CAA conformity requirements where the action, as here, would result in an increase in emissions that is clearly *de minimis* (40 CFR § 93.153(c)(2)(iv)).

6.10 MIGRATORY BIRD TREATY ACT

The Migratory Bird Treaty Act of 1918 (MBTA) (16 U.S.C. 703-712), as amended, establishes a Federal prohibition, unless permitted by regulations, to "pursue, hunt, take, capture, kill, attempt to take, capture or kill, possess, offer for sale, sell, offer to purchase, purchase, deliver for shipment, ship, cause to be shipped, deliver for transportation, transport, cause to be transported, carry, or cause to be carried by any

means whatever, receive for shipment, transportation or carriage, or export, at any time, or in any manner, any migratory bird, included in the terms of this Convention . . . for the protection of migratory birds . . . or any part, nest, or egg of any such bird."

The proposed actions will not affect migratory birds that nest in the debris boom project area because tree clearing will be conducted in the fall when nesting season is over. Because no direct harm to any migratory birds is anticipated, a take permit under the MBTA is not required.

6.11 EXECUTIVE ORDER 12898: ENVIRONMENTAL JUSTICE

Executive Order 12898 directs every Federal agency to identify and address disproportionately high and adverse human health or environmental effects of agency programs and activities on minority and low-income populations. HAHD is in an area that is closed to the public, and the downstream flow effects are not expected to have more than negligible effects on the human population. Therefore no disproportionate adverse effects on minority or low income populations will occur as a result of the proposal.

6.12 EXECUTIVE ORDER 11990: PROTECTION OF WETLANDS

This executive order encourages federal agencies to take actions to minimize the destruction, loss, or degradation of wetlands and to preserve and enhance the natural and beneficial values of wetlands when undertaking Federal activities and programs. No wetlands would be affected by the proposed actions.

6.13 EXECUTIVE ORDER 11988: FLOODPLAIN MANAGEMENT GUIDELINES

This executive order requires Federal agencies to evaluate the potential effects of actions on floodplains and to avoid undertaking actions that directly or indirectly induce growth in the floodplain or adversely affect natural floodplain values. The proposed actions include an evaluation and repair of HAHD, the purpose of which is to restore the dam to its original functionality. This would not result in further development of the Green River floodplain beyond that which had existed prior to the January 2009 flood.

6.14 TRIBAL TREATY RIGHTS

In the mid-1850's, the United States entered into treaties with a number of Native American tribes in Washington. These treaties guaranteed the signatory tribes the right to "take fish at usual and accustomed grounds and stations…in common with all citizens of the territory" [U.S. v. Washington, 384 F. Supp. 312 at 332 (WDWA 1974)]. In U.S. v. Washington, 384 F. Supp. 312 at 343 - 344, the court also found that the Treaty tribes had the right to take up to 50 percent of the harvestable anadromous fish runs passing through those grounds, as needed to provide them with a moderate standard of living (Fair Share). Over the years, the courts have held that this right comprehends certain subsidiary rights, such as access to their "usual and accustomed" fishing grounds. More than de minimis impacts to access to usual and accustomed fishing area violates this treaty right [Northwest Sea Farms v. Wynn, 931 F. Supp. 1515 at 1522 (W.D. WA 1996)].

Project activities will occur within the usual and accustomed fishing grounds of the Muckleshoot Tribe. No effects to tribal treaty rights are expected since the work will not take place in areas that are use, or are potentially used, for tribal fishing and effects of the proposed work on fishery resources in the Green River are expected to be negligible.

7 COORDINATION

The following agencies and entities have been involved with the coordination of this project:

- National Marine Fisheries Service (NMFS)
- U.S. Fish and Wildlife Service (USFWS)
- Washington Department of Fish and Wildlife (WDFW)
- Washington Department of Ecology (WDOE)
- Washington State Historic Preservation Officer (SHPO)
- Washington State Department of Archaeology and Historic Preservation (DAHP)
- City of Tacoma
- The Muckleshoot Tribe of Indians

Coordination with the above listed agencies and tribes consisted of phone conversations, letter correspondences, and e-mail exchanges. Topics discussed during this coordination include project design, project construction timing, effects to listed species, and other environmental concerns.

A Public Notice was distributed to public agencies, tribes, government offices and members of the public in King County; a draft EA was made available for public review on 9 September 2010 via posting of the document on the public USACE, Seattle District website. One comment letter was received during the 33-day public notice period; no requests for an extension of the review period were received. This comment letter was received from WDFW dated 12 October 2010 and can be found in Appendix F along with USACE response to the WDFW comment.

8 CONCLUSION

In conclusion, potential environmental impacts of the preferred alternative, as compared with the environmental baseline reflected in the No Action alternative include vegetation and habitat disturbance due to construction of temporary access roads for the drainage tunnel improvements and debris booms. The drainage tunnel improvements including the spur would occur on existing staging areas, access roads and the tunnel itself, with the exception of a temporary access road to install three vertical wells on the slope; this area would be hydroseeded with a native seed mix and replanted with conifers. The installation of the debris boom anchors would disturb forested habitat for the north location and south location. The trees cleared in the vegetation management area would be left onsite to provide wildlife habitat or possibly instream habitat. The rootballs would remain in the ground to provide erosion control. Upon completion, the temporary access road would be removed and hydroseeded; and vegetation would be allowed to recolonize this area. USACE is cooperating with Tacoma Water to ensure that the proposed action is consistent with the HCP. Because the vegetation and habitat disturbance is minimal in relation to the entire watershed and disturbed area would be hydroseeded and/or replanted of vegetation, the effects to vegetation or habitat would be less than significant. Wildlife species would be temporarily displaced during construction related to the drainage tunnel improvements and debris booms; however similar habitat exists in the nearby area of the watershed. Effects to wildlife, therefore, would be less than significant.

The work associated with the preferred alternative would not occur below ordinary high water and would not result in a discharge of fill material into waters of the United States and therefore does not require a

Section 401 water quality certification or a 404(b)(1) evaluation. The work has been analyzed pursuant to the Coastal Zone Management Act. The proposed plan is consistent to the maximum extent practicable with the enforceable policies of the Washington Coastal Zone Management Program. USACE has determined the preferred alternative would have no effect on ESA-listed species. A Memorandum for Record has been prepared and filed. Under Section 7 regulations, if USACE determines the proposed action would have no effect on ESA-listed species, it is not required to consult with the Services.

Based on this assessment, the proposed actions are not expected to result in significant adverse environmental impacts. The proposed actions are not considered major Federal actions having a significant impact on the quality of the human environment and do not require preparation of an environmental impact statement.

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10 APPENDICES

Appendix A.

Finding of No Significant Impact

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Environmental Resources Branch

Howard A. Hanson Dam
July 2010 Interim Risk Reduction Measures Plan and Safety Modification Project, King County, Washington

FINDING OF NO SIGNIFICANT IMPACT

1. Background. On 9 January 2009, a new high pool elevation of 1188.8 feet was reached at HAHD, which is approximately six feet higher than the previous pool of record that occurred in February 1996. Three separate situations were observed during and immediately after the new high pool elevation was reached: (1) sediment was observed in the water from one of the drainage tunnel wells (TW 25); (2) a depression was formed on the upstream face of the right abutment as the flood pool was receding; and (3) increased readings in piezometers were observed. Interim risk reduction measures have been implemented and initiated. As a result of this flood event, the dam safety classification of the dam was revised, which initiated the U.S. Army Corps of Engineers (USACE) conducting a dam safety modification study for HAHD using the best available information and using a qualitative means of evaluation. The objective of the DSMS is to complete a baseline risk assessment of all significant and credible potential failure modes (PFMs) and pathways at HAHD, develop and evaluate risk management measures (RMM) and alternatives, and identify a preferred alternative. The intent is to identify the preferred alternative which will achieve a complete remediation of those individual failure modes and thereby, reduce dam safety concerns to an acceptable level and meet USACE tolerable risk guidelines. USACE determined the following four PFMs are credible and significant, and require remedial repairs for HAHD:

- Seepage and Piping through the Right Abutment (PFM 1)
- Spillway Flow Restriction (PFM 3)
- Spillway Stability (PFM 16)
- Left Embankment Erosion (PFM 17)

The recommendation is to implement the identified risk management plan as part of a supplement to the IRRMP dated July 2010. The components of the preferred alternative are consistent with the interim risk reduction measures plan guidelines.

2. Purpose and Need. The purpose of this Federal action is to remediate all significant and credible failure modes in support of the USACE's ultimate goal of having an adequately safe dam that can meet all authorized project purposes which meets essential USACE guidelines and results in a tolerable total residual risk of dam failure. The project need is created by observations of the January 2009 pool that indicate that HAHD may be at an unacceptable risk of failure during normal flood hazard reduction operations.

3. Proposed Action. Tunnel drainage improvements will address seepage and piping through the right abutment. This RMM will consist of installing approximately 38 new vertical drains, installing a dewatering system in 12 of the new vertical drains, installing approximately 23 horizontal drains from inside the drainage tunnel, abandoning 6 horizontal drains, abandoning a drain pipe beneath the floor of a drainage tunnel, converting 10 existing 6-inch vertical drains to piezometers, and installing 22 new piezometers along the dam embankment.

A new tunnel spur will also address right abutment seepage and piping. The tunnel spur portal will be located at the bend in the existing drainage tunnel. From the portal, the tunnel spur will extend south approximately 240 feet and tie into the rock septum. This configuration intercepts the flow of water through the overburden located above the bedrock “saddle” between the existing tunnel and the dam embankment/abutment interface. The spur will have a modified horseshoe, reinforced concrete final lining with a finished interior of approximately 6 feet wide by 9 feet tall. Approximately 1,200 cy of material will be excavated and disposed of at an appropriate offsite location. A floor drain will be installed in the short path area to intercept seepage from continuing to the downstream slope.

New debris booms and spillway gate alteration will address spillway flow restriction. The debris booms will involve providing two new floating debris booms with ground anchors at or above an elevation of 1224 feet. The booms will be located in the reservoir "gullet", approximately 3000 feet upstream of the dam. During a probable maximum flood event, the booms will trap any buoyant debris that has accumulated along the reservoir rim and upstream tributaries within the 1,224-foot elevation inundation area. The spillway gate alteration includes a mechanical alteration to the structure that will increase the bottom of the gate elevation by two feet and increase the spillway opening to avert a potential overtopping of the embankment.

Grouted rock anchors will address spillway stability. Prestressed grouted rock anchors will be installed at the spillway weir (elevation 1176 feet) to resist the design net uplift forces acting on the base of the spillway weir.

Resizing and replacement of slope protection will address left embankment erosion resulting from high velocities near the spillway gates during high flood pools. This RMM will involve excavating the existing rip rap and replacing with larger rip rap.

Data collection efforts, consisting of four exploratory borings at elevation 1,090 feet and the installation of eight piezometers, were the subject of a NEPA Categorical Exclusion, prepared in accordance with 33 CFR 230.9(b), as a routine repair or rehabilitation activity at a completed Corps civil works project that carries out the authorized project purposes. Now that a recommended course of action for dam safety modification activities has been developed, and in recognition of the fact that the data collection activities are integrally related to the recommended construction actions, the environmental impacts of those prior activities are considered in conjunction with the recommended actions.

4. Summary of Impacts. Pursuant to the National Environmental Policy Act, the attached Environmental Assessment (EA) has been prepared. The EA provides an evaluation of the potential environmental impact of the proposed work which is briefly summarized below.

Potential environmental impacts of the preferred alternative include vegetation and habitat disturbance due to construction of temporary access roads for the drainage tunnel improvements and debris booms. The drainage tunnel improvements including the spur will occur on existing staging areas, access roads and the tunnel itself, with the exception of a temporary access road to install three vertical wells on the

slope; this area will be hydroseeded with a native seed mix and replanted with conifers. The installation of the debris boom anchors will disturb forested habitat for the north location and south location. The trees cleared in the vegetation management area will be left onsite to provide wildlife habitat or possibly instream habitat. The rootballs will remain in the ground to provide erosion control. Upon completion, the temporary access road will be removed and hydroseeded; and vegetation will be allowed to recolonize this area. USACE is cooperating with Tacoma Water to ensure that the proposed action is consistent with the HCP. Because the vegetation and habitat disturbance is minimal in relation to the entire watershed and disturbed area will be hydroseeded and/or replanted of vegetation, the effects to vegetation or habitat will be less than significant. Wildlife species will be temporarily displaced during construction related to the drainage tunnel improvements and debris booms; however similar habitat exists in the nearby area of the watershed. Effects to wildlife, therefore, will be less than significant.

The work associated with the preferred alternative will not occur below ordinary high water and will not result in a discharge of fill material into waters of the United States and therefore does not require a Section 401 water quality certification or a 404(b)(1) evaluation. The work has been analyzed pursuant to the Coastal Zone Management Act. The proposed plan is consistent to the maximum extent practicable with the enforceable policies of the Washington Coastal Zone Management Program. USACE has determined the preferred alternative will have no effect on ESA-listed species. A Memorandum for Record has been prepared and filed. Under Section 7 regulations, if USACE determines the proposed action will have no effect on ESA-listed species, it is not required to consult with the Services.

5. Finding. For the reasons described above, I have determined that the proposed actions will not result in significant adverse environmental impacts. The project will not constitute a major Federal action with significant impacts on the quality of the human environment and, therefore, does not require an environmental impact statement.

26 OCT 2010
Date

Anthony O. Wright
Colonel, Corps of Engineers
District Commander

Appendix B.

SHPO and Tribal Correspondences

USACE letters to SHPO and MIT

dated 13 August 2010

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 3755
SEATTLE, WASHINGTON 98124-3755

REPLY TO
ATTENTION OF

Environmental Resources Section

AUG 13 2010

Allyson Brooks, Ph.D.
State Historic Preservation Officer
Department of Archaeology and Historic Preservation
Post Office Box 48343
Olympia, Washington 98504-8343

SUBJECT: Howard A. Hanson Dam Safety Modification Project request for concurrence with no historic properties adversely affected

Dear Dr. Brooks:

In the winter of 2009, the U.S. Army Corps of Engineers (Corps) discovered sediment in the water from one of the drainage tunnel wells in the right abutment of the Howard A. Hanson Dam (HAHD) as well as two depressions along the upstream face of the abutment. The HAHD is located along the Green River at river mile 64.5, approximately 25 miles east of Tacoma in the Cascade Mountain Range. The sediment movement and depressions are both indicators that soil particles could be working their way through either the constructed right abutment or within underlying fluvial materials via water. This process, often referred to as piping, could erode an internal channel and result in a breach along the right abutment.

The Corps is proposing to address seepage issues at the dam by extending and improving the existing underground tunnel through the right abutment, installing additional logbooms, increasing the size of the rip rap on the upstream face of the left embankment, and replacing the rock anchors in the spillway

The majority of the work would occur on the dam itself or in areas previously disturbed by the dam's construction in the late 1950s thru 1962. The Corps has defined the area of potential effect (APE) as the HAHD, existing drainage tunnel, access roads, staging areas, and logboom anchor locations. A cultural resource inventory was conducted along the logboom anchor locations and access roads and along a road reroute which was subsequently dropped from the proposed project. No cultural resources were encountered during the inventory.

The HAHD was recorded in 2010 by the Corps' architectural historian, Lauren McCroskey. The dam and its associated features were determined to be eligible for the National Register under Criterion A because of its vital role in the development of the Green River Valley.

By necessity, the dam is a dynamic resource that has seen a variety of modifications over the years in order to remain functional. Changes to the dam have included: constructing a 650 foot drainage tunnel with vertical drains in 1969; adding a tapered triple box to the outtake tower

in 1994; installing ten additional horizontal wells and a 300 foot grout curtain in the right abutment in 2001; and constructing the fish passage facility (project work ongoing).

The proposed remedies for the right abutment are minor in scope and do not adversely affect the historic significance of the dam or any of its character defining features. The tunnel improvements and extension would occur below ground within the right abutment. Similarly, the replacement of rock anchors along the spillway and increasing the size of the riprap along the left embankment are minor changes that do not alter the function of the dam and are mostly hidden from view.

The Corps has determined that the proposed project would not result in an adverse affect to any historic properties. The Corps is consulting with the Muckleshoot Tribe of Indians concurrently with this letter. Copies of the cultural resource report and the Corps' correspondence to the tribes have been enclosed for your perusal. We invite you to concur with our determination. If you have any questions or need additional information, please contact Danielle Storey of my staff at (206) 746 4466 or by email at Danielle.L.Storey@usace.army.mil

Sincerely,

Evan Lewis, Acting Chief
Environmental Resources Section

Enclosures

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 3755
SEATTLE, WASHINGTON 98124-3755

REPLY TO
ATTENTION OF

Environmental Resources Section

Melissa Calvert
Assistant Tribal Operations Manager
The Muckleshoot Tribe of Indians
Philip Starr Building
39015 172nd Ave SE
Auburn, WA 98092

AUG 13 2010

SUBJECT: Request for knowledge of, or concerns with, historic properties within or near the proposed Howard A. Hanson Dam Safety Modification Project

Dear Ms. Calvert:

In the winter of 2009, the U.S. Army Corps of Engineers (Corps) discovered sediment in the water from one of the drainage tunnel wells in the right abutment of the Howard A. Hanson Dam (HAHD) as well as two depressions along the upstream face of the abutment. The HAHD is located along the Green River at river mile 64.5, approximately 25 miles east of Tacoma in the Cascade Mountain Range. The sediment movement and depressions are both indicators that soil particles could be working their way through either the constructed right abutment or within underlying fluvial materials via water. This process, often referred to as piping, could erode an internal channel and result in a breach along the right abutment.

The Corps is proposing to address seepage issues at the dam by extending and improving the existing underground tunnel through the right abutment, installing additional logbooms, increasing the size of the rip rap on the upstream face of the left embankment, and replacing the rock anchors in the spillway

The majority of the work would occur on the dam itself or in areas previously disturbed by the dam's construction in the late 1950s thru 1962. The Corps has defined the area of potential effect (APE) as the HAHD, existing drainage tunnel, access roads, staging areas, and logboom anchor locations. A cultural resource inventory was conducted along the logboom anchor locations and access roads and along a road reroute which was subsequently dropped from the proposed project. No cultural resources were encountered during the inventory.

The HAHD was recorded in 2010 by the Corps' architectural historian, Lauren McCroskey. The dam and its associated features were determined to be eligible for the National Register under Criterion A because of its vital role in the development of the Green River Valley.

By necessity, the dam is a dynamic resource that has seen a variety of modifications over the years in order to remain functional. Changes to the dam have included: constructing a 650 foot drainage tunnel with vertical drains in 1969; adding a tapered triple box to the outtake tower in 1994; installing ten additional horizontal wells and a 300 foot grout curtain in the right abutment in 2001; and constructing the fish passage facility (project work ongoing).

The proposed remedies for the right abutment are minor in scope and do not adversely affect the historic significance of the dam or any of its character defining features. The tunnel improvements and

extension would occur below ground within the right abutment. Similarly, the replacement of rock anchors along the spillway and increasing the size of the riprap along the left embankment are minor changes that do not alter the function of the dam and are mostly hidden from view. The Corps has determined that the proposed project would not result in an adverse affect to any historic properties.

To further identify historic properties, Section 106 of the National Historic Preservation Act (NHPA or the Act) of 1966, as amended (36 CFR 800.4[a] [3]), requires Federal agencies to seek information from tribes likely to have knowledge of, or concerns with, historic properties within the project's APE. We are specifically seeking assistance in identifying properties that may be of religious or cultural significance and may be eligible for listing in the National Register of Historic Places (NRHP), including Traditional Cultural Properties (TCP). Specific guidance concerning the Corps' obligation to contact your tribe regarding this issue is found at 36 CFR 800.4(a) (4), which states that the agency official shall:

> (4) Gather information from any Indian tribe or Native Hawaiian organization identified pursuant to Sec. 800.3(f) to assist in identifying properties, including those located off tribal lands, which may be of religious and cultural significance to them and may be eligible for the National Register, recognizing that an Indian tribe or Native Hawaiian organization may be reluctant to divulge specific information regarding the location, nature, and activities associated with such sites. The agency official should address concerns raised about confidentiality pursuant to Sec. 800.11(c).

We appreciate any assistance you can provide us in our efforts to comply with Section 106 of the National Historic Preservation Act. Please be assured that the Corps will treat any information you decide to share with us with the degree of confidentiality that is required in Section 800.11(c) of the Act, or with any other special restrictions you may require. In order to fulfill these obligations we request that you provide comments at your earliest convenience.

If you have any questions, please feel free to contact me at (206) 746-4466 or by e-mail. My e-mail address is Danielle.L.Storey@usace.army.mil.

Sincerely,

Danielle, Storey
Environmental Resources Section

Enclosures

Cc: (with enclosures)
Laura Murphy, Archaeologist
The Muckleshoot Tribe of Indians
Preservation Department
39015 172nd Ave SE
Auburn, WA 98092

SHPO concurrence letter

dated 31 August 2010

STATE OF WASHINGTON

DEPARTMENT OF ARCHAEOLOGY & HISTORIC PRESERVATION

1063 S. Capitol Way, Suite 106 • Olympia, Washington 98501
Mailing address: PO Box 48343 • Olympia, Washington 98504-8343
(360) 586-3065 • Fax Number (360) 586-3067 • Website: www.dahp.wa.gov

August 31, 2010

Mr. Chris Jenkins
Regulatory Branch
Seattle District, Corps of Engineers
PO Box 3755
Seattle, Washington 98124-3755

Re: Howard A. Hanson Dam Safety Modification Project
Log No: 032910-24-COE-S

Dear Mr. Jenkins:

Thank you for contacting our department. We have reviewed the professional archaeological survey report you provided for the proposed Howard A. Hanson Dam Safety Modification Project, King County, Washington.

We concur with your Determination of No Adverse Effect.

We would appreciate receiving any correspondence or comments from concerned tribes or other parties that you receive as you consult under the requirements of 36CFR800.4(a)(4).

In the event that archaeological or historic materials are discovered during project activities, work in the immediate vicinity must stop, the area secured, and the concerned tribes and this department notified.

These comments are based on the information available at the time of this review and on the behalf of the State Historic Preservation Officer in conformance with Section 106 of the National Historic Preservation Act and its implementing regulations 36CFR800. Should additional information become available, our assessment may be revised. Thank you for the opportunity to comment and a copy of these comments should be included in subsequent environmental documents.

Sincerely,

Robert G. Whitlam, Ph.D.
State Archaeologist
(360) 586-3080
email: rob.whitlam@dahp.wa.gov

DEPARTMENT OF ARCHAEOLOGY & HISTORIC PRESERVATION
Protect the Past, Shape the Future

USACE letter to SHPO regarding National Register eligibility

dated 15 March 2010

DEPARTMENT OF THE ARMY
SEATTLE DISTRICT, CORPS OF ENGINEERS
P.O. BOX 3755
SEATTLE, WASHINGTON 98124-2255

REPLY TO
ATTENTION OF

MAR 15 2010

Environmental Resources Section

Allyson Brooks, Ph.D.
State Historic Preservation Officer
Department of Archaeology & Historic Preservation
1063 South Capitol Way, Suite 106
Olympia Washington 98501

SUBJECT: Section 110 and Section 106 Compliance Regarding the National Register Eligibility of the Howard A. Hanson Dam, King County

Dear Dr. Brooks:

In an effort to fulfill its Section 110 responsibilities, and in anticipation of actions that may be subject to Section 106 consultation, the U.S. Army Corps of Engineers (Corps) is hereby forwarding its evaluation of National Register eligibility for the Howard Hanson Dam. We are including both an electronic historic properties inventory form, as well as a larger historic context evaluation.

At this time, the Corps is seeking alternatives for both interim and permanent solutions to address safety and performance concerns at the dam. Some of these solutions pose little or no effect to the dam's character defining features and will require no further Section 106 consideration. One alternative may require removal of the current administrative building. However, the context document here, to include photographs, as well as the existence of drawings for the dam and all buildings, should provide sufficient mitigation of any adverse effects, should this building be demolished.

As stated, we believe that the dam is eligible for listing in the National Register of Historic Places because of the measurable effects it has had on downstream commerce and development since beginning operation. The dam structure, though completed in 1962 and not yet fifty years of age, meets the criterion of exception for these historical associations.

Please note that this evaluation concerns the historic property known as the dam, but does not address archaeological concerns. Separate consultation and reporting for archaeological investigations in and around areas that may be affected by proposed safety modifications, to include tribal notifications, will be submitted shortly.

Enclosed is an historic properties inventory and historic context statement. The CD includes both the HPIF electronic data as well as a pdf version of the evaluation document.

At this time, the Corps invites your comment regarding the eligibility of the dam and associated components. If you have any questions or require additional information, please feel free to contact Lauren McCroskey at (206) 764-3538.

Sincerely,

Evan Lewis, Acting Chief
Environmental Resources Section

Enclosures

SHPO concurrence regarding National Register eligibility

dated 29 March 2010

STATE OF WASHINGTON

DEPARTMENT OF ARCHAEOLOGY & HISTORIC PRESERVATION

1063 S. Capitol Way, Suite 106 • Olympia, Washington 98501
Mailing address: PO Box 48343 • Olympia, Washington 98504-8343
(360) 586-3065 • Fax Number (360) 586-3067 • Website: www.dahp.wa.gov

March 29, 2010

Ms. Lauren McCroskey
Corps Of Engineers, Seattle District
BOX 3755
Seattle, WA 98124-3755

In future correspondence please refer to:
Log: 032910-24-COE-S
Property: Howard Hanson Dam
Re: Determined Eligible

Dear Ms. McCroskey:

Evan Lewis of your office recently contacted the Department of Archaeology and Historic Preservation (DAHP) concerning the eligibility of the Howard Hanson Dam. I have reviewed the materials provided to us and we concur with your professional opinion that the historic property is eligible to the National Register of Historic Places. I look forward to further consultation regarding your determination of effect to the dam, and the administration building as well as consultation on any archaeological concerns the US Army Corps may have.

I would appreciate receiving any correspondence or comments from concerned tribes or other parties that you receive as you consult under the requirements of 36CFR800.4(a)(4) and the survey report when it is available. These comments are based on the information available at the time of this review and on behalf of the State Historic Preservation Officer pursuant to Section 106 of the National Historic Preservation Act and its implementing regulations 36CFR800.

Please note that DAHP requires that all historic property inventory and archaeological site forms be provided to our office in PDF format on a labeled CD along with an unbound paper copy. For further information please go to http://www.dahp.wa.gov/documents/CR_ReportPDF_Requirement.pdf.

Thank you for the opportunity to review and comment. Should you have any questions, contact me.

Sincerely,

Russell Holter
Project Compliance Reviewer
(360) 586-3533
russell.holter@dahp.wa.gov

DEPARTMENT OF ARCHAEOLOGY & HISTORIC PRESERVATION
Protect the Past, Shape the Future

Appendix C

COASTAL ZONE MANAGEMENT ACT

Consistency Determination

and

Ecology's Concurrence

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COASTAL ZONE MANAGEMENT ACT
CONSISTENCY DETERMINATION

Howard A. Hanson Dam
Safety Modification Project

The proposed risk reduction measures at Howard A. Hanson Dam (HAHD) are activities undertaken by the U.S. Army Corps of Engineers, a Federal agency. The following constitutes a Federal consistency determination with the enforceable provisions of the Washington State Coastal Zone Management Program.

1. INTRODUCTION

This consistency determination is applicable to the Howard A. Hanson Dam (HAHD) July 2010 Interim Risk Reduction Measures Plan and Safety Modification Project. The U.S. Army Corps of Engineers (USACE) has conducted a dam safety modification study for HAHD using the best available information and using a qualitative means of evaluation. The objective of the DSMS is to complete a baseline risk assessment of all significant and credible potential failure modes (PFMs) and pathways at HAHD, develop and evaluate risk management measures (RMM) and alternatives and identify a preferred alternative that supports the expeditious and cost effective reduction of risks associated with HAHD. The intent is to identify the preferred alternative which will achieve a complete remediation of those individual failure modes and thereby, reduce dam safety concerns to an acceptable level and meet USACE tolerable risk guidelines. As required by the National Environmental Policy Act (NEPA), a draft environmental assessment (EA) has been prepared to evaluate the potential environmental effects of the preferred alternative.

USACE determined the following four PFMs are credible and significant, and require remedial repairs for HAHD:

- Seepage and Piping through the Right Abutment (PFM 1)
- Spillway Flow Restriction (PFM 3)
- Spillway Stability (PFM 16)
- Left Embankment Erosion (PFM 17)

Following a qualitative assessment of viable alternatives, USACE recommends the following preferred alternative to support the ultimate goal of having an adequately safe dam. The preferred alternative is briefly described below and is shown graphically in Figure 1:

- Tunnel drainage improvements would address seepage and piping through the right abutment. This RMM would consist of installing approximately 38 new vertical drains, installing a dewatering system in 12 of the new vertical drains, installing approximately 23 horizontal drains from inside the drainage tunnel, abandoning horizontal drains, abandoning a drain pipe beneath the floor of a drainage tunnel, converting 10 existing 6-inch vertical drains to piezometers, and installing 22 new piezometers along the dam embankment.
- New tunnel spur would address seepage and piping through the right abutment. This spur would connect approximately 240 feet from the existing drainage tunnel's outlet. The new tunnel would proceed south under the existing road entrance to the administration building and tie into the rock septum thus intercepting flow of water through overburden across a "saddle" of bedrock between the existing tunnel and the dam embankment/abutment interface.
- New debris booms and spillway gate alteration would address spillway flow restriction. The debris booms would involve providing two new floating debris booms with ground anchors at or

above an elevation of 1224 feet. The booms would be located in the reservoir "gullet", approximately 3000 feet upstream of the dam. The spillway gate alteration includes a mechanical alteration to the structure that would increase the bottom of the gate elevation by two feet and increase the spillway opening.

- Grouted rock anchors would address spillway stability. Prestressed grouted rock anchors would be installed at the spillway weir (elevation 1176 feet) to resist the design net uplift forces acting on the base of the spillway weir.
- Resizing and replacement of slope protection would address left embankment erosion. This RMM would involve excavating the existing rip rap and replacing with larger rip rap.
- Data collection activities to facilitate the Dam Safety Modification Study were taken in the winter of 2010. These activities, including four exploratory borings and the installation of eight piezometers, were previously addressed in a NEPA Categorical Exclusion. Viewed in isolation, these activities were conducted outside the Washington coastal zone, and did not involve a development project. The relevant parameters of the data collection activities were functionally analogous to conditions that would fall under USACE Nationwide Permit 18 (Minor Discharges), for which the State of Washington has provided a general concurrence of CZMP consistency.

More detail regarding these RRMs can be found in the draft Environmental Assessment dated September 2010. This determination of consistency with the Washington Coastal Zone Management Act is based on review of applicable sections of the State of Washington Shoreline Management Program and policies and standards of the King County Shoreline Management Plan.

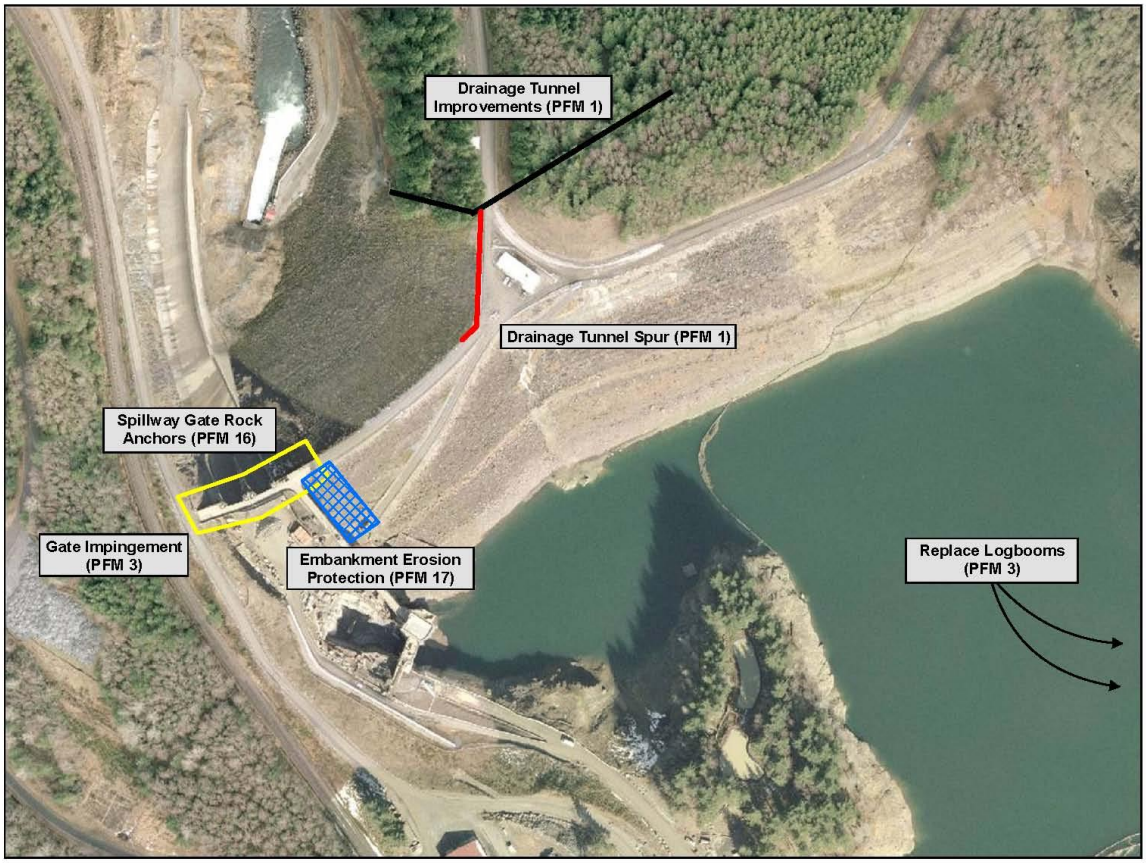

Figure 1 Features of the Preferred Alternative

2. STATE OF WASHINGTON SHORELINE MANAGEMENT PROGRAM

The Coastal Zone Management Act of 1972, as amended, requires Federal agencies to carry out their activities in a manner which is consistent to the maximum extent practicable with the enforceable policies of the approved state Coastal Zone Management (CZM) Programs. The Shoreline Management Act of 1971 (SMA) (RCW 90.58) is the core authority of Washington's CZM Program. Primary responsibility for the implementation of the SMA is assigned to local governments. In the case of Howard Hanson Dam and the Green River, the local government is King County. King County implements the SMA through the King County Shoreline Master Program (SMP) adopted in 1978 (KCC Title 25).

3. KING COUNTY SHORELINE MANAGEMENT PROGRAM

The King County SMP designates the area around HAHD as conservancy, excluding Federal lands. The drainage tunnel improvements and debris booms measures primarily do not occur on Federal lands. The spillway gate alteration, installation of rock anchors, replacement of slope protection, and data collection occur primarily on Federal lands. The majority of land comprising the reservoir is not Federally owned and is designated conservancy under the SMP. This includes the land where the drainage tunnel work is planned. Lands along the Green River downstream of the HAHD Federal boundary are designated either conservancy, rural, natural, or urban. As stated above, the SMP specifically excludes Federal lands from regulation under the SMP. The Corps has determined that a portion of the project constitutes development activity outside Federal

property and thus within the coastal zone, and that other elements of the project will occur outside the coastal zone but are nevertheless expected to have reasonably foreseeable effects on coastal uses and resources. The analysis below therefore evaluates the project effects to SMP covered lands upstream and downstream of the Federal reservation.

Applicable portions of the King County SMP are presented below with an explanation of consistency indicated in *italics***.**

Project consistency upstream and in the immediate vicinity of Howard A. Hanson Dam.

Land designation: conservancy.

25.24.010 Purpose. Conservancy areas are intended to maintain their existing character. This designation is designed to protect, conserve, and manage existing natural resources and valuable historic and cultural areas. The preferred uses are those nonconsumptive of the physical and biological resources of the area.

Project is consistent. The proposed drainage tunnel improvements and tunnel spur work will be conducted on existing staging areas, access roads and the tunnel itself, with the exception of three new vertical wells located on the hillside northeast of the administration building. To install these three vertical wells, a temporary access road will disturb approximately 0.25 acre of mainly conifers. Upon completion of this RMM, the road would be removed; the disturbed area will be hydroseeded with a native seed mix and replanted with conifers. The installation of the debris boom anchors will disturb approximately 0.90 acres of forested habitat for the north location and approximately 1.0 acre of forested habitat for the south location including the vegetation management area (approximately 0.66 acre) to facilitate the boom's ability to swing freely and a temporary access road (approximately 0.35 acre). The trees cleared in the vegetation management area will be left onsite to provide wildlife habitat or possibly instream habitat. The rootballs will remain in the ground to provide erosion control. The temporary access road to the southwest anchor location will disturb upland habitat. Upon completion of the construction, the temporary access road will be removed and hydroseeded; and vegetation will be allowed to recolonize this area. In addition, the project will not adversely affect the historic significance of the dam or any of its character defining features. The preferred alternative is designed to be nonconsumptive of the area resources.

25.24.030 General requirements.

A. Nonwater related, water related and residential development shall not be permitted waterward of the ordinary high water mark.

B. Except in those cases when the height requirements of the underlying zone are more restrictive, no structure except agricultural structures may exceed a height of thirty-five feet above average grade level.

C. All development shall be required to comply with K.C.C. chapter 9.04 to control runoff and to provide adequate surface water and erosion and sediment control during the construction period.

D. Development shall maintain the first fifty feet of property abutting a natural environment as required open space.

E. Parking facilities except parking facilities associated with detached single-family and agricultural development shall maintain a shoreline setback of one hundred feet from the ordinary high water mark and retain existing vegetation or be planted in conformance with the landscape standards enumerated in the general requirements (K.C.C. 25.16.030) of the urban environment.

F. Water quality treatment in compliance with K.C.C. chapter 9.04 shall be required where stormwater runoff would materially degrade or add to the pollution of recipient waters or adjacent properties.

G. The regulations of this chapter have been categorized in a number of sections; regardless of the categorization of the various regulations, all development must comply with all applicable regulations.

H. Development proposed in shorelines of the state shall maintain setbacks, provide easements or otherwise develop the site to permit a trail to be constructed or public access to continue where:
1. There is a proposed trail in the King County trail system; or
2. Part of the site is presently being used and has historically been used for public access.
I. Along shorelines of the state on Lake Sammamish, no building shall be placed on lands below thirty-two and one-half feet mean sea level.
J. The regulations of this chapter are in addition to other adopted ordinances and rules. Where conflicts exist, that which provides more protection to a sensitive area shall apply; provided except that water dependent uses shall adhere to the applicable regulations and policies of the King County Shoreline Master Program and shall comply with other ordinances and rules to the greatest extent feasible.

Project is consistent. As discussed above, the proposed drainage tunnel improvements and tunnel spur work will be conducted on existing staging areas, access roads and the tunnel itself, with the exception of three new vertical wells located on the hillside northeast of the administration building. To install these three vertical wells, a temporary access road will disturb approximately 0.25 acre of mainly conifers; this area will be hydroseeded with a native seed mix and replanted with conifers. The installation of the debris boom anchors will disturb forested habitat for the north location and south location. The trees cleared in the vegetation management area will be left onsite to provide wildlife habitat or possibly instream habitat. The rootballs will remain in the ground to provide erosion control. Upon completion, the temporary access road will be removed and hydroseeded; and vegetation will be allowed to recolonize this area. All applicable best management practices will be implemented to ensure water quality standards are met. All stormwater will be controlled as necessary per applicable regulations. All tunnel work will be above ordinary high water mark.

As drilling for data collection purposes, the borings were not a development project under the CZMA. Furthermore, the data collection activities met the parameters of USACE's Nationwide Permit (NWP) 18 (Minor Discharges), for which the State has provided a general CZMA consistency concurrence determination where, as here, CWA Section 401 certification is not required for the activity. The State's general concurrence under NWP 6 (Survey Activities) similarly applied. The regional conditions of NWP 18 require that temporary devices must be removed within 30 days of project completion, and the drilling was completed in 15 days and drill rigs removed from the site.
25.24.040 Agricultural practices. Agricultural practices may be permitted in the conservancy environment subject to the agricultural provisions (Section 25.16.040) of the urban environment.

Project is consistent. There are no agricultural practices proposed.

25.24.050 Aquatic resource practices. Aquatic resource practices may be permitted in the conservancy environment subject to the aquatic resource provisions (Section 25.16.050) of the urban environment, except that mechanical harvesting of shellfish shall not be permitted.

Project is consistent. There are no aquatic resource practices proposed.

25.24.060 Forest management practices. Forest management practices may be permitted in the conservancy environment subject to the forest management practices provisions (Section 25.20.060) of the rural environment.

Project is consistent. There are no forest management practices proposed.

25.24.070 Commercial development. Commercial development shall not be permitted in the conservancy environment.

Project is consistent. There is no commercial development proposed.

25.24.080 Signs. Signs, except educational signs of not more than twenty-five square feet erected within recreational developments and signs as permitted for single detached residences by K.C.C. 21A.20.080, are not permitted in the conservancy environment.

Project is consistent. Temporary construction signs may be placed at the intersection of Kanaskat-Palmer road and the Green River Headworks Road. This is a location that currently and has in the past contained similar signs including a sign for the Tacoma Headworks and signs for other construction projects.

25.24.090 Residential development. A. Multifamily development is prohibited in the conservancy environment, except that the clustering of dwelling units into multifamily development may be permitted to avoid development of sensitive or hazardous areas such as marshes, swamps, bogs, flood plains, or steep or unstable slopes; provided, that the density standards enumerated in K.C.C. 25.24.100 shall not be exceeded. This provision is not intended to promote intensive development in the conservancy environment. The intent of this provision is to permit development which would have less adverse impact on sensitive or hazardous areas than traditional lot by lot development.
B. Single-family residential development may be permitted in the conservancy environment subject to the general requirements of this chapter and the single-family provisions K.C.C. 25.16.090 through 25.16.140 of the urban environment. Single-family residential development shall maintain a minimum setback of fifty feet from the ordinary high water mark, except that:
1. If the minimum setback from the ordinary high water mark of a river or stream falls within the floodway, the development shall be required to be located past the upland edge of the floodway,
2. If development is proposed on shorelines, including one or more sensitive areas, as defined in K.C.C. 21A.06, such development shall be done in accordance with regulations and procedures set forth in K.C.C. 21A.24.
3. A farmhouse permitted under the reasonable use exception provisions of K.C.C. 21A.24 shall be exempt from the setback requirements of this section.
C. Any pier, moorage, float or launching facility permitted accessory to single-family development or common use facility accessory to subdivision, short subdivision or planned unit development in the conservancy environment shall be subject to the pier, moorage, float and launching facility provisions K.C.C. 25.16.090 through 25.16.140 of the urban environment; provided, no such authorized structure shall be located within two hundred feet of any other such structure.

Project is consistent. There is no residential development proposed.

25.24.110 Utilities. Utility facilities may be permitted in the conservancy environment subject to the general requirements (K.C.C. 25.24.030) of this chapter and the utility provisions (K.C.C. 25.16.160) of the urban environment.

Project is consistent. The vertical wells could be considered utilities. The work should have a negligible effect on fish and wildlife habitat. No trees or vegetation is expected to be removed since the tunnel improvements footprint is already cleared or is along existing roads, with the exception of 0.25 acre for a temporary access road. This area will be hydroseeded with a native seed mix and replanted with conifers.

25.24.120 Industrial development. Industrial development shall not be permitted in the conservancy environment.

Project is consistent. There is no industrial development proposed.

25.24.130 Shoreline protection. A. Shoreline protection may be permitted in the conservancy environment, subject to the shoreline protection provisions (K.C.C. 25.16.180) of the urban environment.
B. Breakwaters shall not be permitted.

Project is consistent. No shoreline protection is proposed.

25.24.140 Excavation, dredging and filling. Excavation, dredging and filling may be permitted in the conservancy environment, subject to the excavation, dredging and filling provisions in K.C.C. 25.16.190 of the urban environment, provided:
A. Excavation, dredging or filling below the ordinary high water mark shall be permitted only as follows:
1. To mitigate conditions which endanger public safety or fisheries resources; or
2. As part of and necessary to roadside or agricultural ditch maintenance that is performed consistent with best management practices promulgated through administrative rules pursuant to the sensitive areas provisions of K.C.C. chapter 21A.24 and if:
a. the maintenance does not involve any expansion of the ditch beyond its previously excavated size. This limitation shall not restrict the county's ability to require mitigation, pursuant to K.C.C. chapter 21A.24, or other applicable laws;
b. the ditch was not constructed or created in violation of law;
c. the maintenance is accomplished with the least amount of disturbance to the stream or ditch as possible;
d. the maintenance occurs during the summer low flow period and is timed to avoid disturbance to the stream or ditch during periods critical to salmonids; and
e. the maintenance complies with standards designed to protect salmonids and salmonid habitat, consistent with K.C.C. chapter 21A.24;
B. Channelizing, straightening or relocating rivers or streams shall not be permitted;
C. Excavation or dredging of marshes, swamps or bogs shall not be permitted, except for water transmission pipelines within existing utilized transmission pipeline corridors, provided that no practicable alternatives exist, impacts are minimized, and appropriate compensatory mitigation is provided consistent with K.C.C. 21A.24.

Project is consistent. Earthwork in the conservancy zone is limited to the drainage tunnel improvements and spur. Earthwork associated with the drainage tunnel improvements and spur includes drilling. This work is above the ordinary high water and will not affect any wetlands. The wells are designed to drain the higher ground water levels that result when HAHD reservoir contains a large volume of water. Even though the exploratory borings for the data collection were excavation, they were however conducted to mitigate public safety conditions and were subject to a general consistency concurrence through NWP 18, as explained in the USACE's explanation for Section 25.24.030.

25.24.150 Recreation. Recreational development may be permitted in the conservancy environment subject to the general requirements of this chapter (Section 25.24.030) and the recreation provisions (Section 25.16.200) of the urban environment provided:
A. The recreational development will not require any significant filling, excavating or regarding involving more than twenty-five percent of that portion of the site within the shorelines of the state.
B. The construction of indoor swimming pools, gyms and other indoor recreational facilities is prohibited.
C. Piers, moorages, floats or launching facilities constructed in conjunction with recreational development shall not be:
1. Longer than one hundred twenty feet; or
2. Larger than 1350 square feet in surface area.

Project is consistent. No recreational development is proposed.

Project consistency downstream of Howard A. Hanson Dam.

Land designation: natural, conservancy, rural, urban. For the purposes of this evaluation, the most restrictive designation, natural, was evaluated for consistency.

25.28.010 Purpose. The purpose of designating the natural environment is to preserve and restore those natural resource systems existing relatively free of human influence. These systems require severe restrictions of intensities and types of uses permitted so as to maintain the integrity of the natural environment.

Project is consistent. The preferred alternative will not have any effects downstream of HAHD.

25.28.030 General requirements. A. Nonwater related, water related and residential development shall not be permitted waterward of the ordinary high water mark.
B. No structure shall exceed a height of thirty feet.
C. All development shall be required to comply with K.C.C. chapter 9.04 to control runoff and to provide adequate surface water and erosion and sediment control during the construction period.
D. Water quality treatment in compliance with K.C.C. chapter 9.04 shall be required where stormwater runoff would materially degrade or add to the pollution of recipient waters or adjacent properties.
E. Parking areas must maintain a shoreline setback of two hundred feet from the ordinary high water mark and retain existing vegetation or be planted to conform to the landscape standards enumerated in the general requirements (K.C.C. 25.16.030) of the urban environment.

Project is consistent. No development or construction will occur downstream of HAHD.

25.28.040 Agricultural practices. Agricultural practices shall not be permitted in the natural environment.

Project is consistent. There are no agricultural practices proposed.

25.28.050 Aquatic resources practices. Aquatic resource practices may be permitted in the natural environment of the Green River at Icy Creek subject to a public hearing and the general requirements set forth in Section 25.28.030 and provided;
A. The aquatic resources practices shall be limited to natural hatcheries;
B. The development and operation of the natural hatchery shall be within state and federal guidelines for the quality of surface water and groundwater;
C. All facilities shall be installed with a minimum disturbance to shoreline banks and existing channels;
D. Benefits of the natural hatchery will significantly outweigh the impacts;
E. That the benefits cannot be achieved at another location on the Green River not designated as a natural environment.

Project is consistent. There are no aquatic resource practices proposed.

25.28.060 Forest management practices. Forest management practices shall not be permitted in the natural environment.

Project is consistent. There are no forest management practices proposed.

25.28.070 Commercial development. Commercial development shall not be permitted in the natural environment.

Project is consistent. No commercial development is proposed downstream of HAHD.

25.28.080 Signs. Signs, except educational signs of no more than twenty-five square feet within recreational developments and signs which are permitted for single detached residences by K.C.C. 21A.20.080 are not permitted in the natural environment.

Project is consistent. Temporary construction signs may be placed at the intersection of Kanaskat-Palmer road and the Green River Headworks Road. This is a location that currently and has in the past contained similar signs including a sign for the Tacoma Headworks and signs for other construction projects.

25.28.090 Residential development. A. Multifamily and accessory development is prohibited in the natural environment.
B. Single-family residential development may be permitted in the natural environment subject to the general requirements of K.C.C. 25.28.030 and the single-family provisions 25.16.090 through 25.16.140 of the urban environment; provided, single-family residential development shall maintain a minimum setback of one-hundred feet from the ordinary high water mark, except that:
1. If the minimum setback from the ordinary high water mark of a river or stream falls within the floodway, the development shall be required to locate past the upland edge of the floodway.
2. If development is proposed on shorelines, including one or more sensitive areas, as defined in K.C.C. 21A.06, such development shall be done in accordance with regulations and procedures set forth in K.C.C. 21A.24.
C. Piers, moorages, floats or launching facilities accessory to single-family development shall not be permitted in the natural environment.

Project is consistent. There is no residential development proposed.

25.28.110 Utilities. Utility facilities may be permitted in the natural environment subject to the general requirements (Section 25.28.030) of this chapter and the utility requirements (Section 25.16.160) of the urban environment.

Project is consistent. No utilities are proposed downstream of HAHD.

25.28.120 Industrial development. Industrial development shall not be permitted in the natural environment.

Project is consistent. No industrial development is proposed downstream of HAHD.

25.28.130 Shoreline protection. Shoreline protection shall not be permitted in the natural environment.

Project is consistent. No shoreline protection is proposed downstream of HAHD.

25.28.140 Excavation, dredging and filling. Excavation, dredging, and filling may be permitted in the natural environment subject to the provisions K.C.C. 25.16.190 of the urban environment, provided:
A. Excavation, dredging, or filling below the ordinary high water mark shall be permitted only to mitigate conditions which endanger public safety or fisheries resources;
B. Fill or excavation above the ordinary high water mark shall be permitted only to the extent permitted and necessary to construct development allowed in the natural environment;
C. Channelizing, straightening or relocating rivers or streams shall not be permitted;
D. Excavation or dredging of marshes, swamps or bogs shall not be permitted.

Project is consistent. No excavation, dredging, or filling will occur downstream of HAHD.

25.28.150 Recreation. Recreational development may be permitted in the natural environment subject to the general requirements (Section 25.28.030) of this chapter, provided:
A. The recreational development will not require any significant filling, excavation or regarding involving more than fifteen percent of that portion of the site within the shorelines of the state.
B. The construction of indoor swimming pools, gyms and other indoor recreational facilities is prohibited.
C. Piers, moorages, floats or launching facilities constructed in conjunction with recreational development shall not be permitted, except that floating walkways or other similar over water pedestrian structures facilitating access to observation points or viewing areas may be permitted.

Project is consistent. No recreational development will occur.

STATEMENT OF CONSISTENCY
Based on the above evaluation, the Corps has determined that the proposed project at Howard A. Hanson Dam complies with the enforceable policies, general conditions, and activities as specified in the King County Shoreline Management Plan. The proposed action is thus considered to be consistent to the maximum extent practicable with the State of Washington Shoreline Management Program and the Coastal Zone Management Act of 1972.

Ecology Concurrence Letter
dated 22 October 2010

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STATE OF WASHINGTON
DEPARTMENT OF ECOLOGY
PO Box 47600 • Olympia, WA 98504-7600 • 360-407-6000
711 for Washington Relay Service • Persons with a speech disability can call 877-833-6341

October 22, 2010

U.S. Army Corps of Engineers
Environmental Resources Branch
Attn: Hannah Hadley
Post Office Box 3755
Seattle, Washington 98124-3755

RE: Federal Consistency – Howard Hanson Dam Safety Modification Project

Dear Ms. Hadley:

The Department of Ecology, Shorelands and Environmental Assistance Program received your letter for a Coastal Zone Consistency Determination regarding the proposed risk reduction measures at Howard A. Hanson Dam on the Green River, near Palmer, King County, Washington.

Upon review of the *Draft Environmental Assessment for July 2010 Interim Risk Reduction Measures Plan and Dam Safety Modification Project* and the *CZMA Consistency Determination*, Ecology agrees with your determination that the proposed changes are consistent to the maximum extent practicable with the enforceable policies of Washington's Coastal Zone Management Program and will not result in any significant impacts to the State's coastal resources.

If you have any questions regarding this letter please contact Jessica Moore at (360) 407-7421.

Sincerely,

Brenden McFarland, Section Manager
Environmental Review and Transportation Section
Shorelands and Environmental Assistance Program

cc: Jessica Moore, Ecology

Appendix D.

Categorical Exclusion of Exploratory Borings and Installation of Piezometers

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CENWS-PM-PL-ER 12 February 2010

MEMORANDUM FOR RECORD

SUBJECT: Environmental evaluation for installation of piezometers and borings on the right abutment at Howard A. Hanson Dam, King County, Washington.

PROJECT BACKGROUND: The US Army Corps of Engineers, Seattle District (Corps), is conducting a dam safety modification study (DSMS) at Howard A. Hanson Dam (HAHD) to address long term plans to repair potential failure modes, thereby reducing the overall risk of dam failure. On 9 January 2009, a new high pool elevation of 1188.8 feet, a new record, was reached at HAHD, which is approximately six feet higher than the previous pool of record that occurred in February 1996. Three separate situations were observed during and immediately after the new high pool elevation was reached: (1) sediment was observed in the water from one of the drainage tunnel wells (TW 25); (2) a depression formed on the upstream face of the right abutment as the flood pool was receding; and (3) unexpectedly high piezometer readings were observed. Interim risk reduction measures have been implemented and initiated.

PROJECT LOCATION: The project takes place at HAHD which is a multipurpose project on the Green River, located in King County, Washington. The project is about twenty miles east of Tacoma, Washington. The borings and piezometers are to be installed along the right abutment.

PROJECT DESCRIPTION: In order to properly evaluate all alternatives for the DSMS, the study needs to gather additional information on the overburden materials and depth to bedrock at the right abutment. The work involves completing four borings into bedrock at approximately elevation 1090 (see Figure 1; #149 - 152) and installing eight piezometers (see Figure 2, #141-148).

The drilling technology for the four borings at elevation 1090 will use a HWP casing advancer system with HQ-coring in the bedrock (all the same rig). This is a non-truck mounted rig system. Two rigs will be placed by helicopter at elevation 1090. The drilling is anticipated to mobilize to the site on 17 February and the drilling will be concluded by 10 March. This action requires waiting to begin refill of the reservoir until 10 March. The drilling will involve recovering a core from each hole to a depth of 70 feet below top of bedrock. The deepest hole may be as deep at 220 feet below ground surface. All holes will be backfilled with a cement based grout (approximately 10 cubic yards total). Any drilling muds or cuttings will be collected in barrels onsite and disposed of at an appropriate onsite facility. Water will be the only fluid used during the drilling process.

The installation of eight piezometers (# 141-148) will be within existing roadway of several roads on the right abutment (see Figure 2). No vegetation would be removed. The work involved with the installation of the piezometers and borings will include: finding the depth of the bedrock, and types of material above the bedrock; permeability tests; and eventually monitoring how much water is in the new holes. This data will be used in the study analyze to the range of alternatives.

ENVIRONMENTAL COMPLIANCE:

NEPA: The effects of this proposed project are anticipated to be extremely minor, discountable and/or insignificant. For these reasons, and in accordance with paragraph 9.a., ER 200.2.2 (activities at completed Corps projects which carry out the authorized Corps purpose) and 33 CFR 230.9(b), this action is categorically excluded from NEPA documentation because it does not have significant effects on the quality of the human environment when considered individually and cumulatively, and no extraordinary or extenuating conditions exist which would require an environmental assessment or environmental impact statement.

ESA: Waiting until March 10 to begin refill is within the Corps operational flexibility and has a minor effect on downstream flows. The flows between March and June would be slightly reduced (1.25% to 2.2% reduction of flow) and associated impacts are anticipated to be well within natural variation. The actual work will take place in areas that do not provide habitat for listed species. Therefore, this action will not affect any threatened or endangered species of fish, wildlife, or plants or destroy or adversely modify designated critical habitat.

NATIONAL HISTORIC PRESERVATION ACT: The eight proposed piezometer locations are limited to areas of previous ground disturbance with little to no potential to contain cultural resources. The remaining four borings would be placed along the engineered structure. The nature of the undertaking would not affect the qualities that make the HAHD eligible for the listing on the National Register.

CLEAN WATER ACT: As an integral element of the maintenance/repair of HAHD, the discharge associated with the survey activities, even though they will occur below the ordinary high water mark, is excluded from Section 404 jurisdiction, under 404(f)(1)(B). Because there is no 404 jurisdictional activity being conducted, no 404(B)(1) evaluation is required and no 401 water quality certification is required. Because there is less than one acre of ground disturbance and no discharge of drilling muds or cuttings, no Section 402 permitting is required.

COASTAL ZONE MANAGEMENT ACT: This action is being conducted outside the State's coastal zone. The Corps has determined that this action is functionally analogous to conditions that would fall under Corps Nationwide Permit (NWP) 18 (Minor Discharges).The Corps Nationwide Permit (NWP) 18 (Minor Discharges) regional conditions state that temporary devices must be removed within 30 day of project completion and the State has made a CZMA consistency concurrence determination. The drilling would be completed in 22 days and drill rigs removed from the site, thus this action complies with the regional condition and State concurrence with the Corps' determination of consistency with the State's CZMP can be presumed.

CONCLUSION: All environmental statutes and regulatory requirements associated with this project have been fulfilled.

2/12/2010
Date

Evan Lewis, Acting Chief
ERS

Figure 1: Location of Boring at elevation 1090

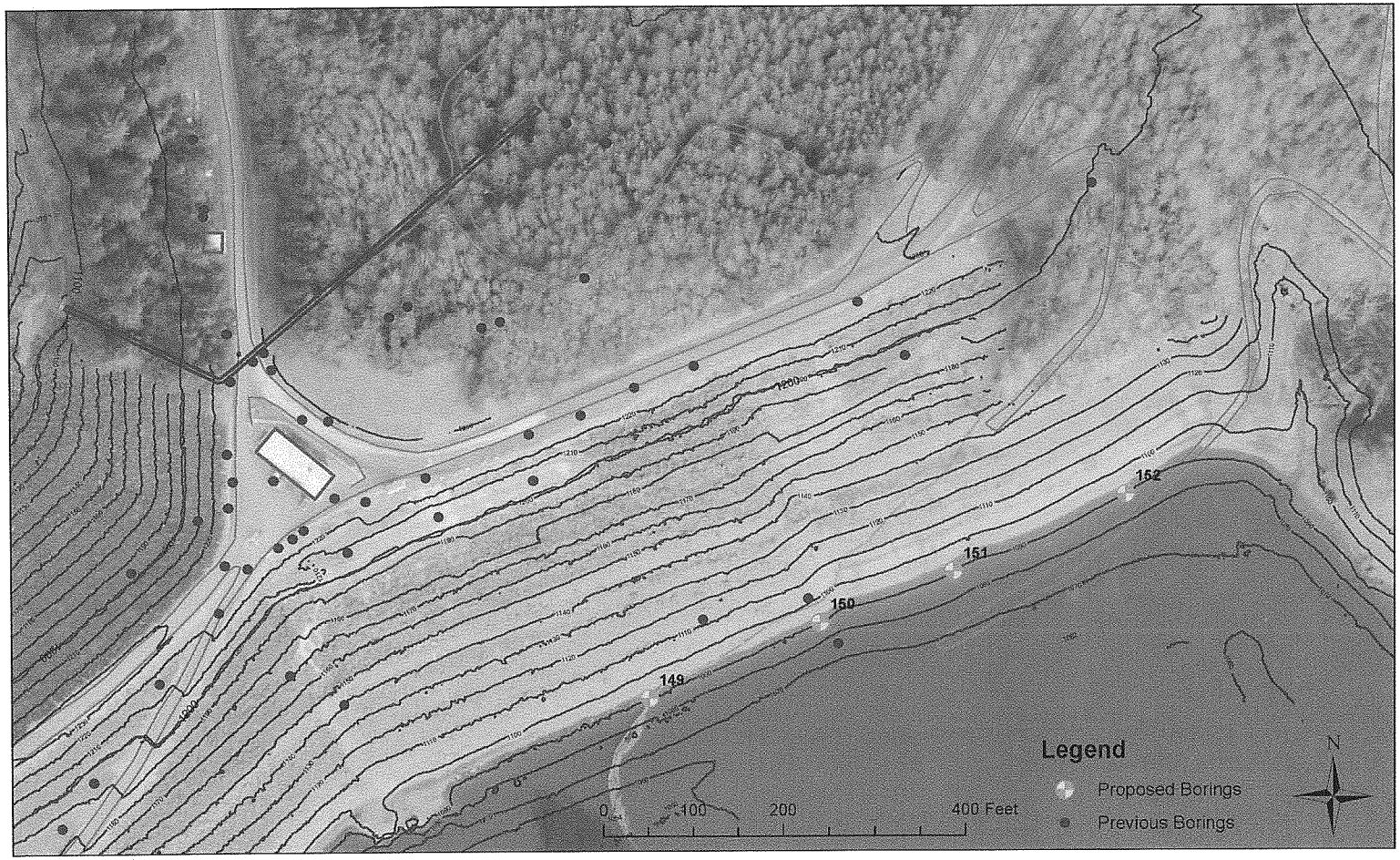
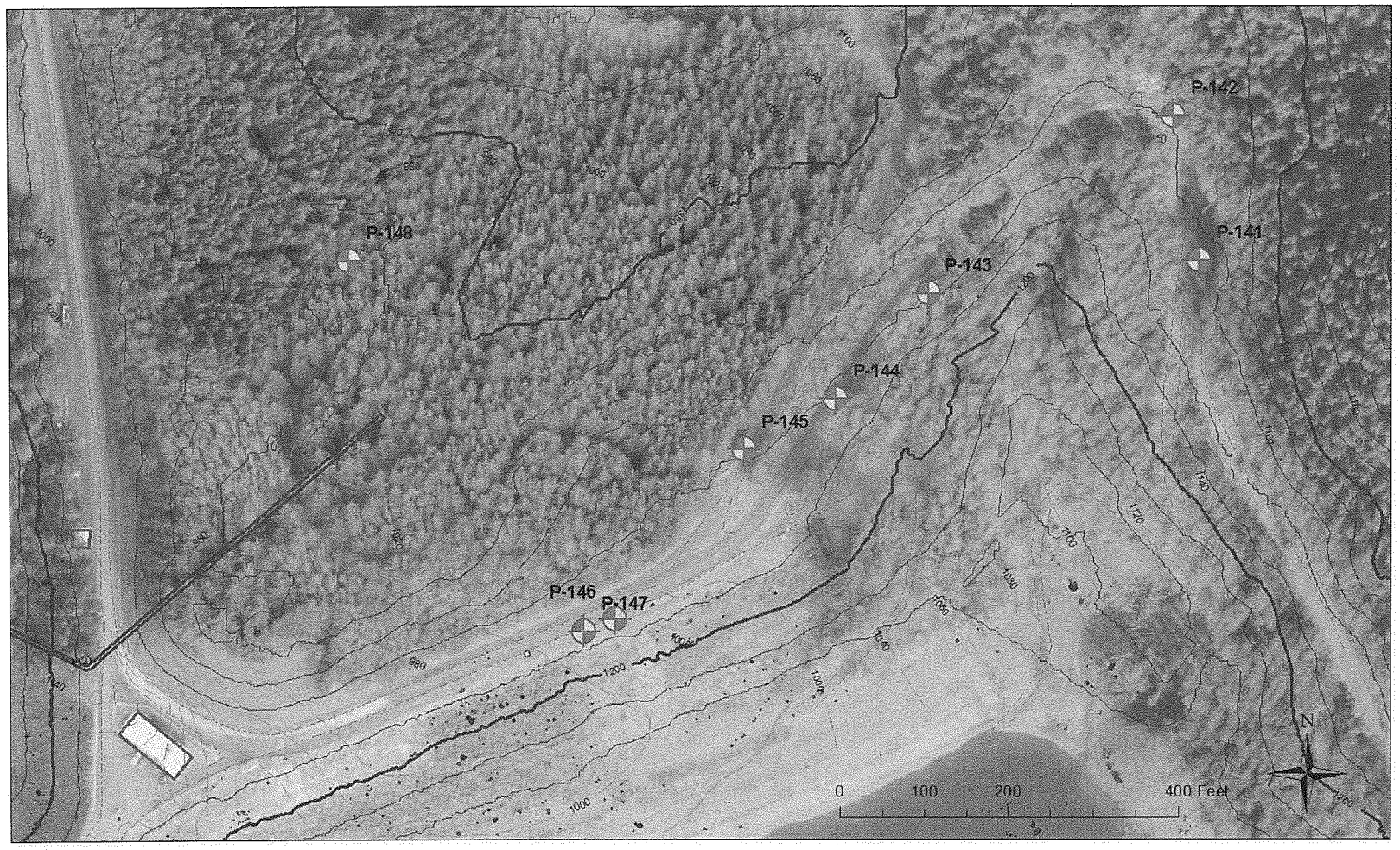


Figure 2: Location of Borings on Existing Roads



Appendix E.

Memorandum for Record

Determination of No Effect on Listed Species under the Endangered Species Act

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HOWARD HANSON DAM
Dam Safety Modification Project
KING COUNTY, WASHINGTON
Determination of No Effect on Listed Species under the Endangered Species Act
September 2010

1. Introduction

During the January, 2009, Western Washington flood event, Howard Hanson Dam was operated to provide flood damage reduction on the Green River. Water was stored in the reservoir to a record elevation of 1189 feet. Two separate situations were observed during and immediately after the flood pool: 1) sediment was observed in the water from one of the drainage tunnel wells and 2) a depression was formed on the upstream face of the right abutment as the flood pool was receding. A second, smaller depression on the upstream face of the right abutment was discovered on 2 Feb 2009. The damage to the right abutment raised concerns about structural integrity of the dam and specifically that a flow path through the right abutment could develop and ultimately lead to dam failure. Several actions are planned as part of the Interim Risk Reduction Measures Plan to address the flow path concern and remediation efforts to protect the dam. These measures are designed to prevent dam failure under the highest significant probable failure mode. This document evaluates the possible effects of the proposed actions on species found in the project area, as required by the Endangered Species Act of 1973.

Howard Hanson Dam (HHD) is located in southeastern King County on the Green River at river mile 64.5 (Figure 1). Figure 2 shows key project features and action areas of the dam, including the right abutment which is the most significant concern. Figures 3 and 4 show specific locations for the actions.

2. Project Purpose and Description

The purpose of this Federal action is to address and remediate all four significant and credible failure modes to support the ultimate goal of having an adequately safe dam which meets essential USACE guidelines, and where the total residual risk for the dam is considered tolerable. The need for this project is to increase public safety in the Green River Valley. The project is a study to develop and evaluate risk management measures and alternatives, and to implement the recommended alternative to reduce the risk of dam failure through a repair of the right abutment and associated dam features. The specific actions or risk management measures (RMMs) to address probable dam failure modes include drainage tunnel improvements (Right Abutment Seepage and Piping), replacement and improvement of reservoir debris booms (Spillway Debris Blockage), installation of spillway anchors (External Spillway Stability), and repair of upslope erosion control near the spillway (Left Embankment Erosion Control).

Right Abutment Seepage and Piping. Extensive research has shown the right abutment has a potential for piping and seepage through a short path seepage area or along the rock septum interface. Groundwater modeling results indicate that for an extreme flood event materials in this area will become saturated potentially leading to erosion into the dams toe and rock shell. This may result in the initiation of piping or internal erosion that could progress to a breach of the dam. Currently there is limited instrumentation in this area and the rock shell prevents observations of any seepage that would detect if the movement of soil material has begun. The project area is shown in Figure 3.

Improvements to Existing Tunnel

This RMM would consist of installing approximately 38 new vertical drains, installing a dewatering system in 12 of the new vertical drains, installing approximately 23 horizontal drains from inside the drainage tunnel, abandoning horizontal drains, abandoning a drain pipe beneath the floor of a drainage tunnel, converting 10 existing 6-inch vertical drains to piezometers, and installing 22 new piezometers along the dam embankment (Figure 3-2). The new vertical drains would consist of 8-inch diameter stainless steel screens surrounded by sand filter pack in an 18-inch diameter bore hole. Twelve of the vertical drains will be installed from ground surface (elevation 1,230 feet) to elevation 1080 feet to be connected to the tunnel spur once the spur is completed. These 12 drains would be incorporated into the dewatering system to be used during high flow events. The remaining 26 vertical drains would be drilled from the ground surface (elevation 1,300 feet) extending below the existing tunnel invert (elevation 1,100 feet) to a final elevation of 1,050 feet. The portion above and below the drainage tunnel would be completed as separate drains. The new horizontal drains would consist of 2x4 inch stainless steel pre-pack screens 50 feet in length. The horizontal drains and floor drain pipe would be abandoned with a chemical grout. The existing drains would be converted to standpipe piezometers with a gravel filter. The 6 new piezometers would consist of 2-inch diameter PVC screen and casing surrounded by sand filter pack in a 6-inch diameter bore hole. In addition, 15 new piezometers would be installed along the upstream and downstream face of the dam embankment and 7 new piezometers would be installed along the alignment of the tunnel spur to monitor the effectiveness of the spur.

Construction of the 12 new vertical drains and dewatering system, as well as the horizontal drains are the highest priority and shall be started first. The construction of the 12 new vertical drains and associated dewatering system will be constructed simultaneously with the horizontal drains. As horizontal drains are completed in sections of the tunnel, abandonment of the floor drain pipe and construction of the vertical drains may begin in the completed section. As construction of the vertical drains is completed, adjacent existing drains will be converted to piezometers. A temporary access road would be constructed to access the hillside. The temporary road would be hydro seeded and replanted on completion of the tunnel improvements. No pool restriction would be necessary during or after construction.

The anticipated construction period for the 12 vertical wells and associated dewatering system is 12 weeks. The anticipated construction period for the horizontal drains and the 26 vertical drains installed through the existing drainage tunnel is 26 weeks assuming that construction of

the vertical drains may begin 2 weeks after the start of the horizontal drains. In addition, it is anticipated that 2 weeks will be required for site preparation. All remaining work to include conversion of existing drains to piezometers and installation of new piezometers will be completed within 2 weeks after completions of the drains. The total anticipated construction period is 30 weeks.

The tunnel drainage system would consist of a flow measurement weir, collection and conveyance piping, and a rip-rap or gabion style outfall. Drainage would be collected at the existing tunnel portal. The drainage would pass through a weir box located near the portal to allow accurate measurement of flow. Discharge from the weir would be collected and conveyed along the edge of the existing tunnel access road, approximately 365 feet to a discharge located just downstream of the existing 36 inch dam bypass. The tunnel drainage system is designed for an anticipated maximum flow of 5,000 gallons per minute (gpm) or approximately 11.1 cubic feet per second (cfs). A rip rap or gabion pad would be constructed at the drainage discharge point to eliminate erosion.

Tunnel Spur

This spur would connect approximately 240 feet from the existing drainage tunnel's outlet. The new tunnel would proceed south under the existing road entrance to the administration building (Figure 3-3) and tie into the rock septum thus intercepting flow of water through overburden across a "saddle" of bedrock between the existing tunnel and the dam embankment/abutment interface. The spur would have a modified horseshoe final lining with a finished interior of approximately 6 feet wide by 9 feet tall, would be constructed of concrete with steel reinforcement and would have a gravel under-floor drain. Approximately 1,200 cy of material would be excavated and disposed of at an appropriate offsite location. Vertical wells and a floor drain would be installed in the short path area to intercept seepage from continuing to the downstream slope. The wells would outlet into the new drainage tunnel and the floor drain would outlet into the existing tunnel. The wells and floor drain would be properly filtered to prevent piping/internal erosion from initiating. The wells and tunnel would be designed to maintain a phreatic surface along the tunnel alignment of approximately elevation 1,100 feet for up to the 1,224 flood pool elevation. The drainage system is designed as a free draining passive system, but the option to pump for additional control would be retained. The 12 existing vertical drains immediately adjacent to the new tunnel spur would be connected to the new tunnel spur. The staging area would be limited to the 3.5 mile area (south of the intersection of the main access road and the drainage tunnel access road).

DATA COLLECTION

In order to properly evaluate all alternatives for the DSMS, the study gathered additional information on the overburden materials and depth to bedrock at the right abutment. The work involved completing four borings into bedrock at approximately elevation 1,090 feet and installing eight piezometers.

The drilling technology for the four borings at elevation 1,090 feet used a HWP casing advancer system with HQ-coring in the bedrock (all the same rig). This is a non-truck mounted rig

system. Two rigs were placed by helicopter at elevation 1,090 feet. The drilling began on 18 February 2010 and concluded on 5 March 2010. This action required waiting to begin refill of the reservoir until 10 March. The drilling involved recovering a core from each hole to a depth of 70 feet below top of bedrock. The deepest hole was 254 feet below ground surface. All holes were backfilled with a cement based grout (approximately 10 cubic yards total). The drilling muds or cuttings were collected in barrels onsite and disposed of at an appropriate onsite facility. Water and drilling fluid such as Con Det and EZ Mud were the only fluid used during the drilling process.

The installation of eight piezometers (# 141-148) were within existing roadway of several roads on the right abutment. The work involved with the installation of the piezometers and borings included: finding the depth of the bedrock, and types of material above the bedrock; permeability tests; and eventually monitoring how much water is in the new holes. This data was used in the study analyze to the range of alternatives.

Spillway Debris Blockage. During major flood events large amounts of woody debris from the upstream watershed are delivered to the reservoir pool. Debris fields in excess of 15-20 feet in thickness have been observed covering acres of the pool. The geometry of the spillway gates and approach channel are susceptible to plugging by this large mass of debris. The existing log booms located at the project are anchored at Elevation 1206. During major flood events when the spillway gates must be opened these log booms will be ineffective since they cannot restrict debris at higher pool elevations. To prevent blockage of the spillway, two additional log booms are to be installed that will provide protection during an extreme event. These new log booms will be designed to function under varying pool elevation and maximum loading conditions. Anchors for the log booms will be placed at elevation 1224-1234 ft on north and south slopes of the reservoir (see Figure 3). Small areas of vegetation will be cleared (root balls of trees remain) and managed for anchor installation and for log boom placement.

Debris Booms

The debris booms would involve providing two new floating debris booms with ground anchors at or above an elevation of 1,224 feet. The booms would be located in the reservoir "gullet", approximately 3,000 feet upstream of the dam (Figure 4). During a PMF (probable maximum flood) event, the booms would trap any buoyant debris which has accumulated along the reservoir rim and upstream tributaries within the 1,224 feet inundation area. The westerly (secondary) boom would collect any debris that passes by the easterly (primary) boom, and also would provide redundancy should the easterly boom fail. Removable linkages would be provided at every sixth boom for operational access. Boom sections are of steel pipe construction, approximately 2 feet in diameter and 30 feet long, with foam billet inserts. Total lengths of the easterly and westerly booms would be 1,175 feet and 1,425 feet, respectively. Construction activities would include site clearing and grubbing, as required to allow for clear and free operation of booms from run of river operation (elevation 1,070 feet) to PMF conditions; building a temporary access road; and installing boom anchors.

Limited clearing and grading would be required for the construction of the access roads (approximately 0.35 acres). Additional tree clearing (root balls of trees to remain) would be required around each of the boom anchor locations to provide free movement of the debris booms in response to changes in pool elevation and wind direction. For the northern anchor location, the vegetation management area would be approximately 0.90 acre. For the southern anchor location, the vegetation management area would be approximately 0.66 acre.

Proposed access alignments may be modified to fit actual field conditions and to minimize habitat and vegetation impacts. Access road design requirements would be driven by the type of anchor and the type of equipment necessary for construction of the anchors. The 1961 concrete pedestal and anchor could be constructed with minimal equipment access, whereas the "pile" type anchor would require drill rig access. Materials required for temporary access construction would be dependent on soil conditions at time of construction. A summer/fall construction could require little to no surfacing materials. Spring or winter construction may require quarry spall or other surfacing to stabilize the road surface and prevent erosion. Upon completion of construction, the road would be abandoned by stripping the surface materials off, hydro seeding the roadway, and allowing the area to reconvert to the natural condition. Temporary erosion and sedimentation control measures would remain in place until vegetation is established and soils stabilized.

Soil types and spatial limitations govern the suitability of anchor block designs. In cases where bedrock depth is deep below ground surface and no construction space limitations exist, the basic block and buried deadman anchor is appropriate. In cases where bedrock depth is shallow, an alternative anchor design that places the deadman firmly into the bedrock is appropriate. This design is conducive to more stringent spatial limitations as the magnitude of the deadman depth and distance from the pedestal is not as great. Finally, in cases where construction space is a limiting factor, a "pile" type anchor is appropriate regardless of the soil profile. At this time, no specific data exists on the soil types at the proposed anchor sites. Site specific geotechnical information will be accumulated through site investigations, excavation, and laboratory testing for the 65% design report

External Spillway Stability. The dam spillway is subject to high uplift pressures that may result in failure. At the PFM pool elevation of 1224 feet, the existing rock anchors are likely to become overstressed by the high uplift loads. Progressive failure of the anchors allows a crack to form between the weir and the rock foundation, eventually displacing the weir rendering the spillway gates inoperable. As flows increase, erosion of the exposed rock foundation begins resulting in an uncontrollable release from the reservoir. To prevent this failure mode from initiating, the spillway gate will be modified and rock anchors will be designed to prevent uplift and after installation will be loaded tested to ensure the required strength is met (Figure 3).

Spillway Gate Alteration

This RMM would include a mechanical alteration to the structure that would increase the bottom of the gate elevation by two feet and increase the spillway opening. The hoist gate

rope position would align itself to nearly vertical when the gate achieves its original design open position (bottom of gate at elevation 1,212 feet).

This alteration would entail minimal risk to the structural integrity of the spillway gate. With an added 2.5 feet of gate elevation, the rope angle of inclination at the gate connection changes (approximately 9 degrees). The change in tension on the 10 hoist gate ropes versus angle of inclination off the gate connection due to this additional 2.5 feet does not appear significant. In fact the rope tension is at a maximum when the gate is fully closed. Opening the gate wider by hoisting an additional two and a half feet of rope increases the load on the ropes by approximately 7%, compared to the original design, due in part to the shift in the estimated center of gravity (i.e. the trunnion takes on proportionally more of the gate's mass than before).

The effects of vibration on the gates due to water or wind are not expected to change substantially from those acting on the gate at original design conditions. Hence gate vibration was not studied. Similarly, debris loading on the gate lip (in the unlikely case of floating debris caught on the gate lip at elevation 1,214.5 feet) was considered beyond the scope of this study.

Spillway Weir Rock Anchor

Prestressed grouted rock anchors would be installed at the spillway weir (elevation 1,176 feet) to resist the design net uplift forces acting on the base of the spillway weir. Passive (non-prestressed) grouted anchors were used in the original construction of the dam but are not recommended for this measure because of the significant advantages of prestressed anchors. Prestressed anchors are more effective at preventing pressurization of the spillway foundation and are more reliable than non-prestressed anchors because they are tensioned to a specified load after installation. ASTM A722 all-thread anchors (64) with a 150-KSI tensile strength would be used for this measure to reduce the number of anchors required compared to the number of lower strength anchors that would be necessary. The rock anchors would be drilled down into bedrock and grouted into place.

<u>Left Embankment Erosion Control</u>. Existing rock riprap on the right side of the spillway and under the intake tower (1167 ft elevation and above) is highly weathered and fragmented and this area is prone to potential failure during flood events. During these high flow conditions, high velocities occur and the small diameter rock will be displaced downstream leaving the embankment material susceptible to erosion. This erosion could progress until the dam is breached leading to an uncontrolled release of the reservoir pool. To prevent this failure mode, larger sized riprap will be installed in these areas of high velocity flow and properly designed and installed slope protection will prevent erosion of the embankment from initiating (Figure 3).

Upstream Slope Protection

This RMM would involve excavating the existing rip rap and replacing with larger rip rap. The existing rip rap would be removed to a depth of 6 feet below surface using two 400 series excavators. Excavation work would start at the top of the slope and progress to the toe of the

slope. A 1V:1H slope would be left adjacent to the upstream side of the gravel access road to provide temporary support. The excavators would compact the surface of this slope using the backs of the buckets to improve the slope strength. It is assumed the materials encountered would be rip rap or loose rock, which should maintain a slope of 1V:1H. All excavated material would be disposed of at an appropriate offsite disposal site. Prior to the start of excavation, temporary traffic plates and precast concrete barriers would be placed on the gravel access road at the top of the dam. These barriers are required for safety to prevent personnel and vehicles from accidentally traveling over the edge of the road into the excavation or upstream face of the dam north of the work area. The plates and barriers would remain in place until the end of construction. The concrete traffic barriers would be transported to an approved storage area for future reuse.

An Eco-block retaining wall is present at the toe of the rip rap slope in the work area and supports a former drilling platform next to the decline road on the upstream face of the dam. The majority of the wall would be dismantled by the removing the blocks with a lift crane and stored at HAHD. The lower two blocks of the wall would be left in place, as the removal of these blocks could result in damage to the decline road. The remaining blocks would provide lateral support for the new rip rap at the toe of the slope. The surface of bedrock to the south of the work area is locally covered with loose rock clasts and boulders. This loose debris would be removed.

A 6 feet thick layer of new 48 inch diameter rip rap would be placed on the slope to backfill the excavation. Placement would start at the toe and progress in lifts no greater than 5 feet to the top of the slope using two 400 series excavators. The rip rap would not be placed by end dump from a dump truck. Each large stone must be tightly fitted into a dense rock mat with minimal void space. Voids not filled with rock clasts or small stones would be filled with 2 inch minus gravel during the placement of the larger stones. The new rip rap slope should reduce gradually from 1V:2H at the toe of the excavation to the base of the 1V:1H temporary slope at the top of the excavation. The thickness of the rip rap would thin toward the top of the surface slope and would have a final surface slope of 1V:1.5H.

Work activities would rut the existing gravel roads. These roads would be repaired at the completion of work. The area for road work would be on the gravel access road on the top of the dam from the north end of the concrete pavement of the control tower bridge to the south entrance to the administration building parking lot. The upstream decline road would be surfaced from the south end of the administration building parking lot to the middle bridge pier of the control tower access bridge. A shallow swale would be bladed along the downstream side of the decline road from the north end of the remaining eco-block wall to the existing storm water catch basin at the south end of the wall. Sediment would be cleaned from the catch basin to improve drainage.

Best Management Practices:

a. Equipment that will be used near the water will be cleaned prior to construction.
b. Refueling will occur away from the riverbank/reservoir.

c. Construction equipment will be regularly checked for drips or leaks.
d. At least one fuel spill kit with absorbent pads will be onsite at all times.
e. Sediment Control : There will be no rock lost down the face of the dam in to the water. Silt fences may be required around the excavated material from the depressions depending on time of exposure. Bare earth along road rehabs will be hydro seeded.
f. Pollution Control: There are no adverse substances being used only rock.
g. Construction spoils handling: Material cuttings will be hauled off-site. Staging will be done on all previous disturbed areas, i.e. area at 3.5 mile road.
h. Construction site will be managed to be safe, efficient and provide for the least amount of environmental disturbance as the project will allow.
i. The Construction Lead is responsible for implementing sediment control measures as needed per relevant and applicable Washington State requirements. As site conditions change (i.e. rain) implementation of other sediment devices may be necessary.

3. <u>Action Area and Project Area</u>
The project area includes Headworks road from TPU's watershed gate up to the North Fork spur, the upper and lower portions of the right abutment adjacent to the dam, the spillway and adjacent upland on the dam, and upland areas on the north and south shores of the reservoir approximately 0.5 mile upstream of the dam. For this project, the action area is the same as the project area.

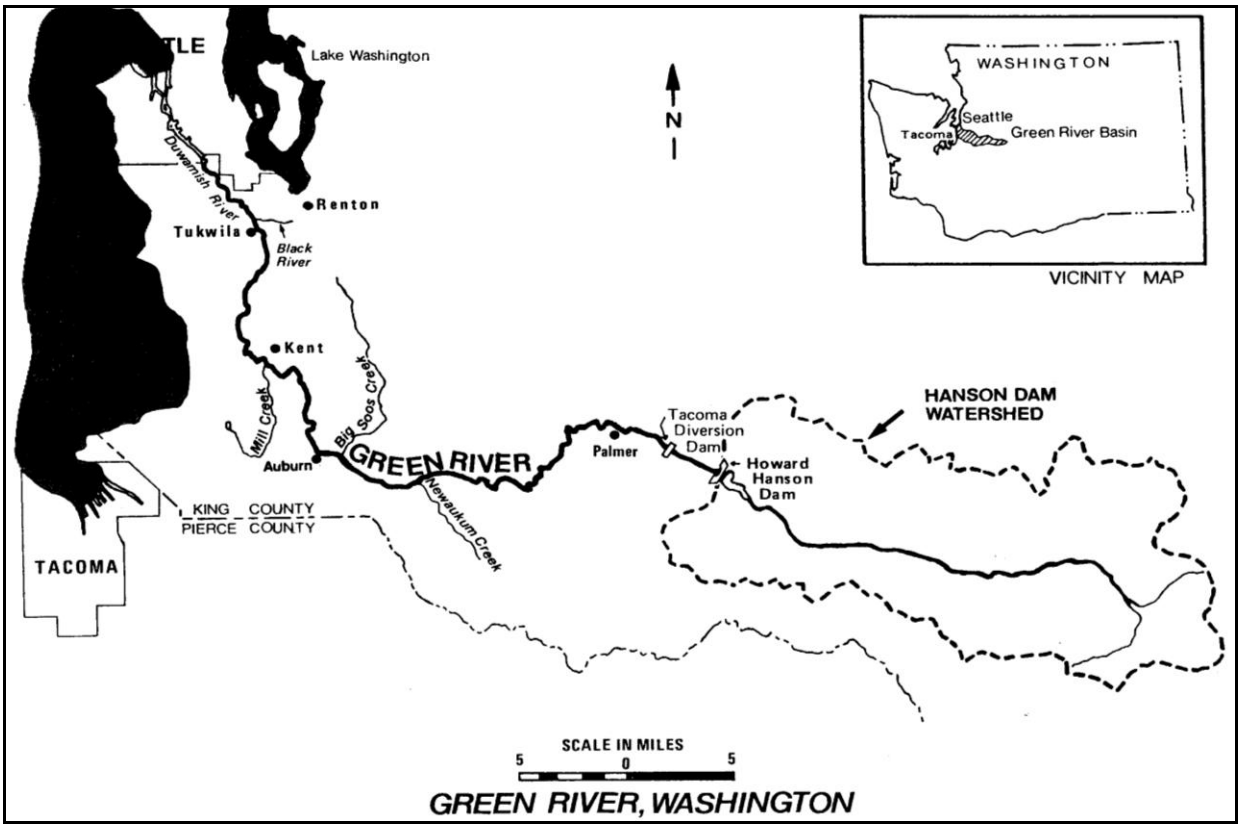

Figure 1. Location and vicinity map of the Green River watershed including Howard Hanson Dam.

Figure 2. Primary features of Howard Hanson Dam.

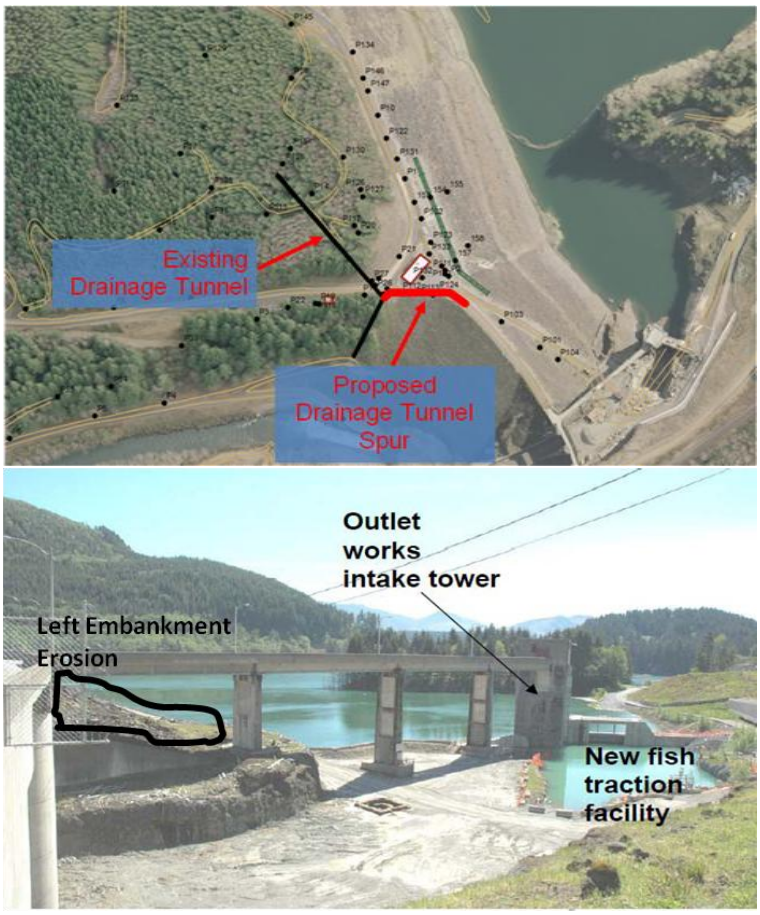

Figure 3. Drainage tunnel improvement area (top) and left embankment erosion control area next to spillway (bottom).

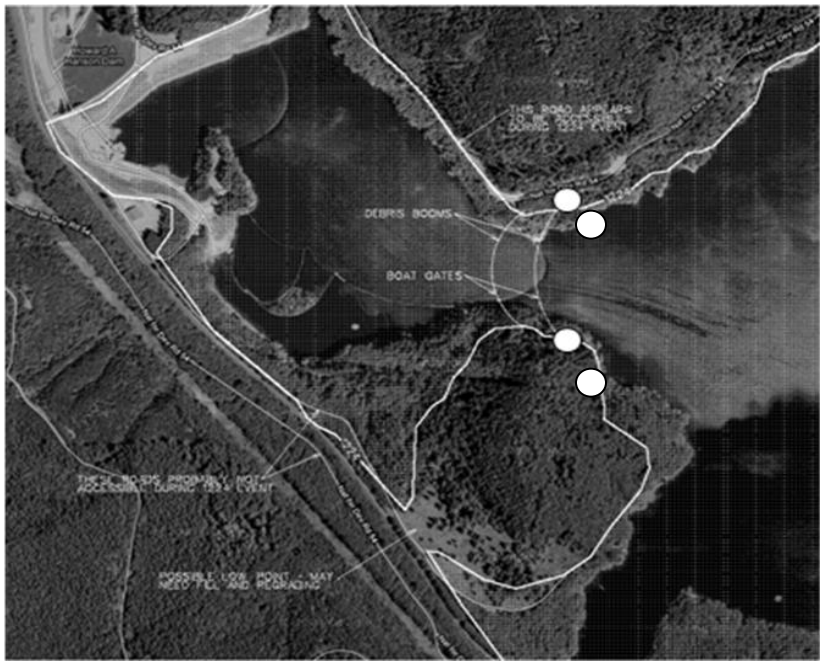

Figure 4. Log boom improvement locations (white dots showing upland area), north area is USACE land and south area is Tacoma, at 1224 ft elevation.

4. Discussion of Effects

a. Direct Effects

The area receiving direct effects of this project includes Green River Headworks road up to the North Fork spur, and the surrounding hillside of the lower and upper abutments, which includes potential staging areas, the spillway and adjacent upland on the dam, and upland areas on the north and south shores of the reservoir approximately 0.5 mile upstream of the dam. Direct effects include human presence and activity surrounding the abutment, and noise from two excavators, two D-6 bulldozers, and up to six 14-ton dump trucks. Work will be done in 20 hr days. Machinery noise may be slightly disruptive to wildlife for the approximately three-week duration of the work. However, cofferdam construction and excavation have been going on in the vicinity for approximately three years, so the additional noise of equipment is not anticipated to be a significant increase to ambient noise from other construction. Noise and air quality effects would be temporary and localized, and would only be a minuscule increase over the noise and air pollution impact from the nearby construction site. The result of this interim risk reduction measures plan is to enable analysis of possible seepage issues and reduce the risk of dam failure. As the abutment is unvegetated, no vegetation will be removed to facilitate construction in this area. The log boom replacement area (vegetation management area) includes 0.9 acres north (including access road) and 1 acre south including any temporary roads. All work for this project will occur in the dry above the Ordinary High Water Mark and have no impact on water quality in the Green River or reservoir.

The drainage tunnel improvement would not require in water work; all construction activities would be contained to the drainage tunnel and adjacent access road. Therefore no impacts to fisheries would occur. Therefore, this action did not affect any species of fish.

The log boom anchors would be located upstream from the dam at or above elevation 1224 ft and therefore construction activities associated with the installation of the anchors would have minimal effects on in-reservoir fisheries and no effect on anadromous fish located 5 or more miles downstream of the dam. The loss of trees associated with the vegetation management area could result in a negligible increase in water temperature of the reservoir which would have a minimal effect on in-reservoir fish and no effect on anadromous fish in the lower Green River. Log booms have been previously strung across the reservoir at this general location.

The installation of rock anchors and replacement of slope protection would not require any in water work; all construction activities would be contained to the spillway and adjacent dam face and all applicable BMPs would be implemented to minimize construction-related runoff. Therefore minimal impacts to fisheries would occur.

b. Indirect Effects

Human presence and noise will temporarily intensify for a 2-year period of construction at the project site, but this is not expected to change the normal behavior of any of the listed species addressed in this analysis.

c. Interrelated and Interdependent Effects

The risk reduction measures plan is required in order to provide additional information and improve the structural integrity of the right abutment to enable analysis of possible seepage issues and reduce the risk of dam failure. These actions will have minimal impact on the environment and listed species.

d. Cumulative Effects

No cumulative effects are expected to occur as a result of this project—the Corps is not aware on any non-Federal activities that are reasonably certain to occur in this vicinity.

5. Species Information

Effects Determination: Based on the above analysis and rationale, and the following species analyses, the interim risk reduction measures plan project Howard Hanson Dam will have no effect on any federally listed species.

a. Chinook salmon (*Oncorhynchus tshawytscha*)

Chinook salmon present in the Green River are classified as summer/fall run stocks (WDFW and WWTIT 1994). Adult Chinook migrate upstream into the Green River from Puget Sound from late June through November (Grette and Salo 1986). Because access to the upper watershed is blocked by the TPU headworks dam and HHD, the Muckleshoot Indian Tribe has been planting juvenile Chinook above HHD since 1987 for fisheries enhancement. The peak outmigration period for Chinook smolts is believed to be between late April and early June (Dilley and Wunderlich 1993). The Green River Chinook population is part of the Puget Sound Evolutionarily Significant Unit (ESU). While overall abundance of this ESU has declined substantially, the National Marine Fisheries Service has classified the Green River stock as healthy based on high levels of escapement (Myers et al. 1998).

Chinook do not spawn above the headworks dam, as adults are not transported to the upper watershed. There will be no in-water work and very little earth materials would fall into the reservoir because the project site is either within or on the dam, and above the reservoir, and there would be no changes to the shoreline as none of the bank will be altered below the high pool level at elevation 1167 feet. Less than 2.25 acres of vegetation would be removed as a result of this work of which 0.25 acres will be replanted immediately following project completion with all disturbed areas hydro seeded immediately after construction. Construction is expected to be completed in 2012. This project will have no effect on water quality, substrate, or fish habitat.

Therefore, the Corps has determined the project will have "no effect" on Puget Sound Chinook salmon.

b. Steelhead (*Oncorhynchus mykiss*)

Steelhead are known to be present in the Green-Duwamish River year-round. Steelhead are anadromous and can spend several years in fresh water before they smolt and migrate to salt water. The majority of steelhead found in the Green River remain in the river for 2 years and in the ocean for 2 years. The Green River system supports both winter and summer stocks. As of 2002, the status of the winter stock was healthy, and the status of the summer stock was depressed. The winter return of adult wild steelhead in the Green-Duwamish begins in February but occurs predominantly in March and April. Critical habitat for Puget Sound steelhead has not yet been proposed.

Steelhead do not spawn above the headworks dam, as adults are not transported to the upper watershed: there is a population of rainbow trout above the dam which has genetic traits that can lead to anadromy, however there are not managed as part of the steelhead stock. There will be no in-water work and very little earth materials would fall into the reservoir because the project site is either within or on the dam, and above the reservoir, and there would be no changes to the shoreline as none of the bank will be altered below the high pool level at elevation 1167 feet. Less than 2 acres of vegetation would be removed as a result of this work of which 0.25 acres will be replanted immediately following project completion with all disturbed areas hydro seeded immediately after construction. Construction is expected to be completed in 2012. This project will have no effect on water quality, substrate, or fish habitat. Therefore, the Corps has determined the project will have "no effect" on Puget Sound Steelhead.

c. Bull trout (*Salvelinus confluentus*)

Bull trout have not been found in the Green River above HHD, and information on bull trout stock status for the rest of the river is unknown (WDFW 1998). Access to the upper watershed for migratory native char has been blocked by TPU's headworks diversion since 1913 and by HHD since 1962. Bull trout spawning is not known to occur in the vicinity of the project. There will be no in-water work, and no changes to the shoreline as none of the bank will be altered below the high pool level at elevation 1167 feet. This project will have no effect on water quality, substrate, or fish habitat. The Corps determined the project will have "no effect" on bull trout.

d. Bald eagle (*Haliaeetus leucocephalus*)

Although bald eagle was delisted in 2007, bald eagles are still protected under the Bald and Golden Eagle Protection Act, and Federal agencies must still assure that their actions do not adversely affect nesting bald eagles. Bald eagles are frequently sighted near HHD and are considered a year-round resident in the area. The nearest nest site to the project area is located in Eagle Gorge, more than one mile northeast of HHD (USFS 1996). Bald eagles seen in the area are assumed to be acclimated to regular operations and maintenance activities at HHD, and to the large construction project that began in

early 2004, which involves heavy machinery, cranes, blasting, and excavation noises. The short-term presence of humans and excavators at the right abutment during daylight hours only, and limited time at the log boom anchor area, will not affect bald eagles as the activity is located along right abutment far away from the nearest nest and feeding area, and thus would not disrupt feeding behavior. Therefore, the project is expected to have "no effect" on bald eagles.

e. Spotted owl (*Strix occidentalis caurina*)

The upper Green River watershed supports 20 known spotted owl activity centers; none of these, however, are located within 1.8 miles of HHD, so owls occupying the activity centers are unlikely to utilize habitat near the right abutment or the log boom anchor area. Three years of Washington Department of Natural Resources surveys (1992 – 1994) resulted in no detections of spotted owls, but did result in numerous detections of the barred owl (*Strix varia*). Barred owls are known to compete successfully with spotted owls in young and mid-aged forest, so the abundance of barred owls suggests that the forest in this area is not high quality spotted owl habitat. The temporary and localized noise and presence of humans at the right abutment is expected to have "no effect" on spotted owls.

f. Marbled murrelet (*Brachyramphus marmoratus*)

A 1994 survey team identified three stands in the reservoir area as marginally suitable habitat; however, no murrelets had been detected in the Green River watershed during that survey, making these stands unlikely to be occupied (USACE 2000). One of these stands is about ¾ mile from the project area. In other surveys, two stands with murrelet occupancy were detected more than seven miles east of the reservoir. Marbled murrelets are not expected to occur adjacent to HHD or the reservoir, due to the absence of suitable habitat; therefore, the interim risk reduction measures plan is expected to have "no effect" on marbled murrelets.

g. Grizzly bear (*Ursus arctos*)

The grizzly bear population in the North Cascades ecosystem is estimated at 10 – 20 bears (Johnson and Cassidy 1997); however, the Washington Priority Habitats and Species database contains no records of grizzly bears in the Green River basin (WDFW as cited in USACE 2000). Grizzly bears will avoid areas of human use, including areas containing roads and signs of timber cutting (USFWS 1997). Because of the low probability of grizzly bear presence in the Green River watershed, the interim risk reduction measures plan is expected to have "no effect" on grizzly bears.

h. Gray wolf (*Canis lupus*)

The gray wolf is listed as endangered at both the federal and state levels in Washington. While a small number of sightings have been reported in the North Cascades, the occurrence of the gray wolf in Washington remains questionable (Johnson and Cassidy 1997). Gray wolves typically avoid human activity and roads so the likelihood of their

occurrence in the vicinity of HHD is low. The interim risk reduction measures plan is expected has been determined to have "no effect" on gray wolves.

i. Canada lynx (*Lynx canadensis*)

Canada lynx require a matrix of two important habitat types, which are boreal forest with a high density of large logs and stumps for denning, and early successional forest with high densities of snowshoe hare (*Lepus americanus*). In Washington, lynx are known to occur above 4,000 feet in elevation (McKelvey et al. 1999). The current projected range of the lynx in Washington does not extend west of the Cascade crest, so lynx presence in the action area is highly unlikely. The action area for the interim risk reduction measures plan is at an elevation of approximately 1200 feet and does not include the prerequisite abundance of snowshoe hares for lynx to be present, so this project is determined to have "no effect" on Canada lynx.

6. Critical Habitat

Table 1. Analysis of effects of road repair project on critical habitat of listed species in upper Green River watershed.

Species	Critical Habitat ruling	Critical habitat designation	Effects determination
Chinook salmon	65 FR 7764	Includes all marine, estuarine, and river reaches accessible to listed Chinook salmon in Puget Sound	All work will be completed in the dry and will have no effect on Chinook habitat.
Bull trout	64 FR 58927	No critical habitat designated in the Upper Green River watershed	All work will be completed in the dry and will have no effect on bull trout habitat.
Steelhead		None designated	All work will be completed in the dry and will have no effect on Chinook habitat.
Bald eagle		None designated	
Spotted owl	56 FR 20816	Critical habitat is located in the upper Green River watershed, but not in the project area. The nearest site is about 10 miles from the project area.	Short term, localized disturbance 10 miles away will have no effect on spotted owl habitat.
Marbled murrelet	61 FR 26258 71 FR 53838	Critical habitat is located in the upper Green River watershed, but not in the project area. The nearest site is about 10 miles from the project area.	Short term, localized disturbance 10 miles away will have no effect on murrelet habitat.

Grizzly bear		None designated.	
Gray wolf	43 FR 9607	No critical habitat designated in the Upper Green River watershed	
Canada lynx	74 FR 8616	No critical habitat designated in the Upper Green River watershed	

7. Essential Fish Habitat

The Magnuson-Stevens Fishery Conservation and Management Act (MSA), as amended by the Sustainable Fisheries Act of 1996 (Public Law 104-267) requires Federal agencies to consult with NMFS on activities that may adversely affect Essential Fish Habitat (EFH). The EFH mandate applies to all species managed under a Fishery Management Plan (FMP). In the state of Washington, three FMPs are in effect, which cover groundfish, coastal pelagic species, and Pacific salmon. All work for this project will occur in the dry above the Ordinary High Water Mark and have no impact on water quality in the Green River or reservoir. No substrate will be disturbed and no spawning or rearing areas will be altered by construction. The project will have no effect on EFH, either during construction or as a result of the completed project.

8. References

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Appendix F.

Comments on Draft EA and USACE Responses

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Comment received from Peggy Miller, Biologist, Washington Department of Fish and Wildlife; received by letter dated 12 October 2010:

WDFW recognizes that trees would be removed to prevent the debris booms from becoming entangled, resulting in a loss and/or change of fish and wildlife habitat. It is stated in the draft EA that Tacoma Water is coordinating with US Fish and Wildlife Service and National Marine Fisheries Service, and USACE will participate with Tacoma Water to provide compensatory mitigation if deemed necessary. With this process in place WDFW feels the issue of the lost habitat is being addressed in a satisfactory manor.

WDFW found no other issues that merited comments.

USACE Response: As reflected in Section 5.3.2 of the EA, USACE is working with the Services and the City of Tacoma to ensure that the vegetation management actions at the debris boom anchor sites are consistent with the existing HCP.