

PIERCE COUNTY THREAT AND HAZARD IDENTIFICATION WORKSHOP:

MUD MOUNTAIN AND HOWARD A. HANSON DAMS

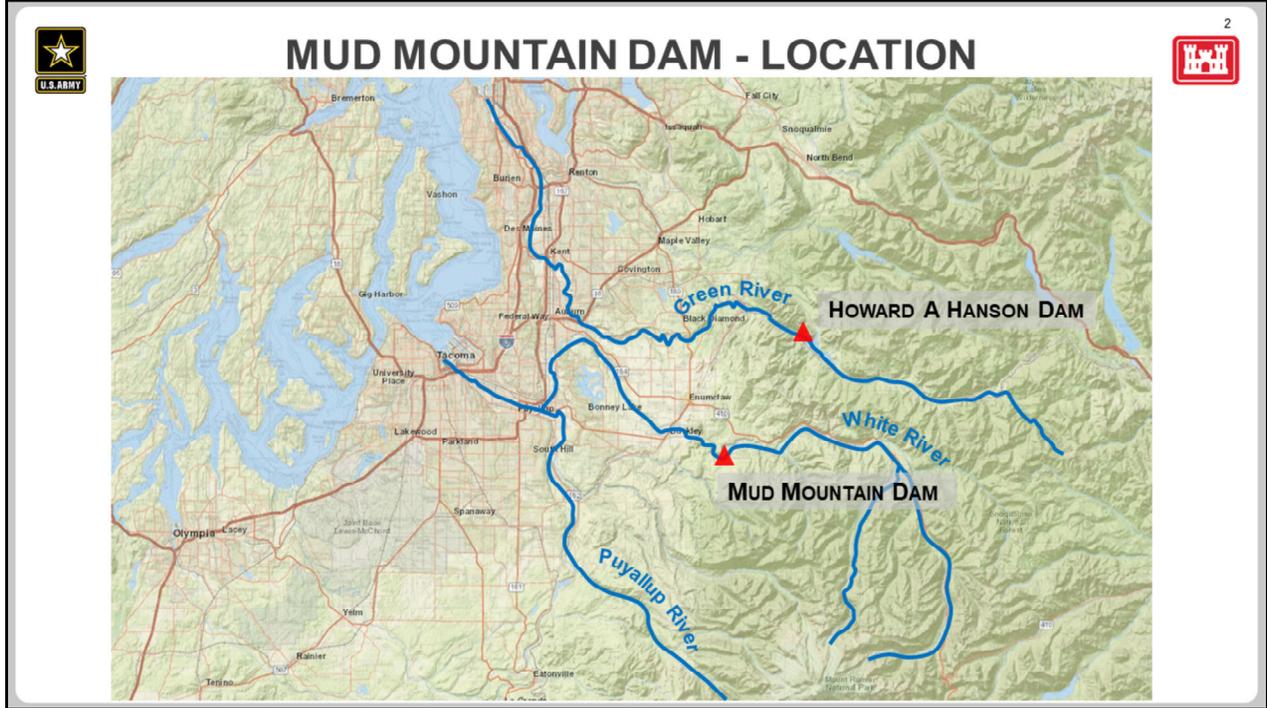
Richard E. Smith, PG
Dam Safety Program Manager
Northwestern Division/Seattle District
Date: 2 May 2019



Good Morning. My name is Richard Smith. I am the Dam Safety Program Manager for the United States Army Corps of Engineers, Seattle District. The Corps owns and operates two dams that impact or have the potential to impact Pierce County waterways.

The two dams are Mud Mountain Dam, near Buckley, Washington on the White River, and Howard A Hanson Dam near Palmer, WA on the Green River.

I shall give a brief introduction to each dam describing their location, features, history, purposes, river management operations and potential downstream impacts from a Dam Failure .



I shall talk about Mud Mountain Dam first because it has the greatest potential to impact locations in Pierce County.

Mud Mountain Dam is located here on the White river near the city of Buckley, WA.



MUD MOUNTAIN DAM - FEATURES



Project Features:

Looking at the upstream side of the dam, we have the 432 foot high earthen embankment.

We have our outlet works structure. This is what we use to regulate and pass the river under most flow conditions. There are two tunnels and three gate openings inside the tower. Two gates control the 23 foot diameter tunnel, and one controls the 9 foot tunnel.

We also have a spillway to pass flows in extreme flood events. This spillway has never been used to pass flow.



MUD MOUNTAIN DAM - FEATURES



Project Features

On this view from the downstream side, we have the embankment again for reference and the spillway.

Down in a very narrow canyon are located the exit portals for our outlet works tunnels.



MUD MOUNTAIN DAM - HISTORY

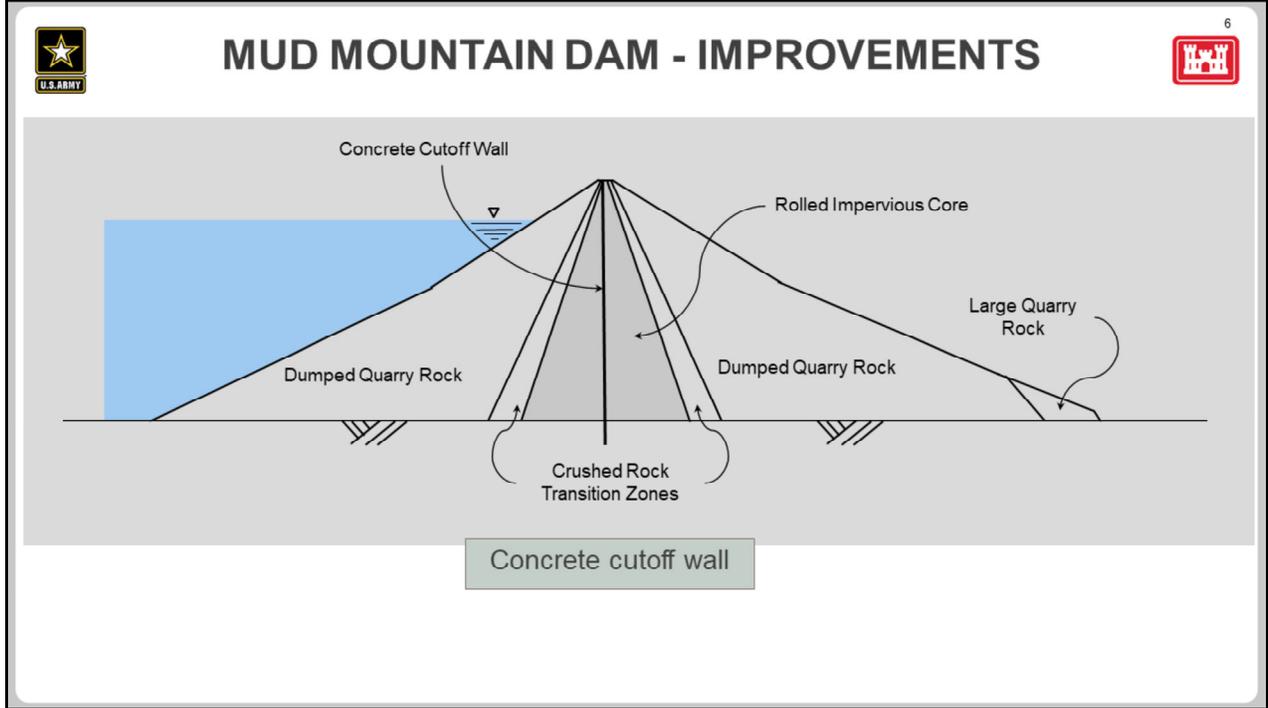


Project History:

Congress authorized construction of Mud Mountain Dam with the Flood Control Act of June 22, 1936, 74th Congress, Session II, Public Law 74-738. The sole authorized project purpose is flood risk management.

The Army Corps of Engineers designed the earthen embankment rolled rockfill dam, which was constructed by the Guy F. Atkinson Company of San Francisco using locally available materials, primarily regraded glacial till for the low permeable core and rock for the surrounding shells.

Construction began in 1939 and was completed in 1948 with a hiatus on construction during World War II.



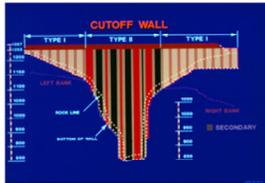
The Corps is a conscientious steward of our nation’s critical infrastructure and continuously monitors and maintains our dams to reduce the risk of failure.

During the 1980’s engineers monitoring the dam’s instrumentation became concerned that the central impervious core (shown in darker gray) of the dam was slowly eroding during flood storage events. Subsequent tests and investigations confirmed that loose zones, voids and cracks were present within the dam’s impermeable core and if left untreated had the potential to lead to dam failure. To mitigate these concerns, USACE designed a concrete cutoff wall to penetrate from the top of the dam, 432 feet through the dam and 15 feet into bedrock. The cutoff wall lessens seepage and prevents the development of a continuous erosion path through the dam.



MUD MOUNTAIN DAM - IMPROVEMENTS

7



Concrete cutoff wall

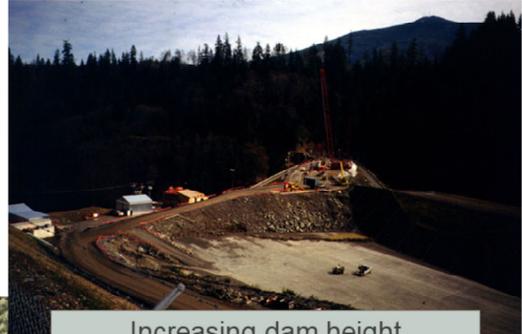
A contract was awarded to Soletanche Inc. (French company) who installed the cutoff wall using equipment called a hydrofraise in 1989 and 1990. The wall thickness varies from one foot thick to 40-inches thick depending on depth and location within the embankment. At the time of construction, it was the deepest such cutoff wall in any dam on earth.



MUD MOUNTAIN DAM - IMPROVEMENTS



Raising of spillway sidewalls



Increasing dam height



In the 1980s, the probable maximum flood (the most severe rain event that is considered possible for this basin) was revised. The dam was found to both have an inadequately sized spillway to pass the PMF and the dam was not tall enough to prevent overtopping during this extreme event.

The spillway sidewalls were raised to accommodate the PMF without overtopping the sidewalls and eroding the adjacent material.

During construction of the concrete cutoff wall, the top 10 feet of the dam were removed to provide a large enough working pad to accommodate the hydrofracture machinery. The dam was subsequently raised seven additional feet beyond its original height to accommodate the storage pool for the revised PMF.



MUD MOUNTAIN DAM - IMPROVEMENTS



Completed intake works



Construction of new intake works



Howell-Bunger Valves
on 23-foot tunnel

An earthquake study and reservoir debris evaluation, both completed in 1984, indicated that the 9-foot and 23-foot-diameter tunnel intake towers were likely to fail either during the Maximum Credible Earthquake (MCE) or the Project Design Flood, blocking the tunnels and causing the pool to rise with no means to subsequently evacuate the impounded water. To solve this problem, the two existing intake towers were replaced by a single intake tower capable of remaining operational during an earthquake or flood. The intake tower replacement was completed in 1995.

As part of this work, the original Howell –Bunger valve system that controlled flow through the 23-foot tunnel at the downstream end was replaced by an upstream radial gate.



MUD MOUNTAIN DAM – RIVER OPERATIONS

10

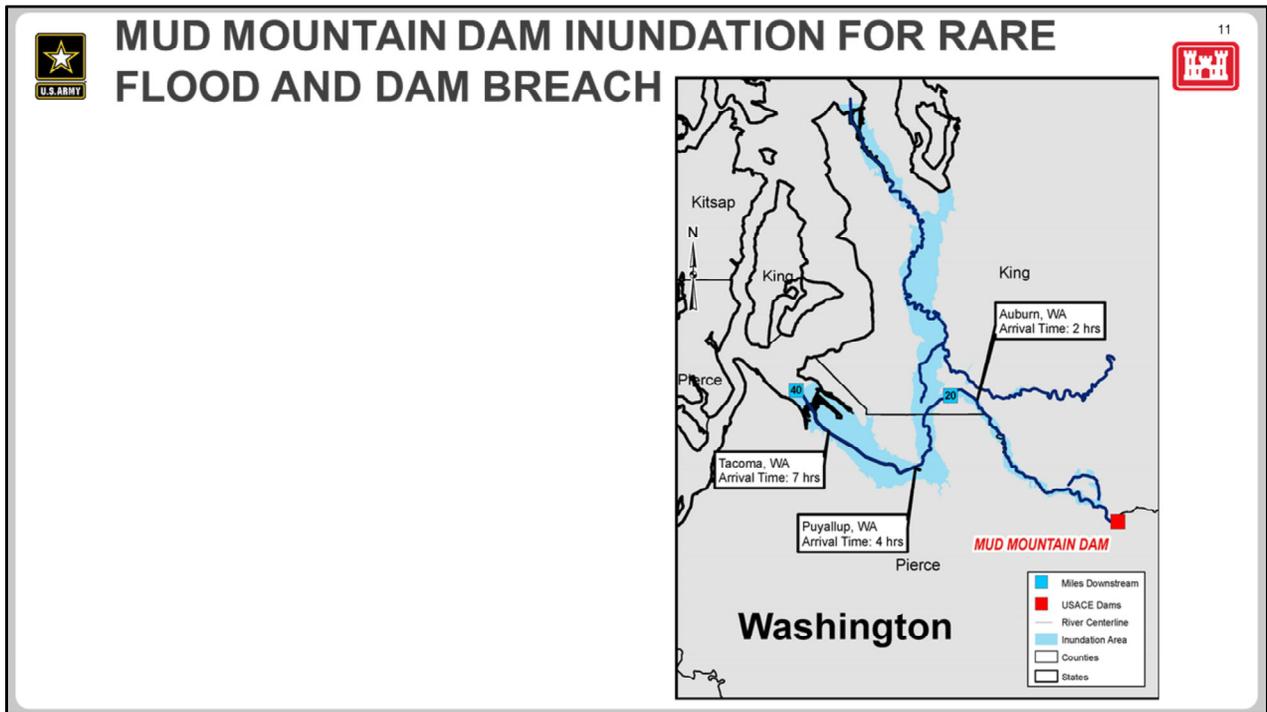


Pool of Record
– February 1996
– Elevation 1,199.5 feet
NAVD 88
– 19 feet below spillway
crest



River operations

The dam has never experienced its full pool. The primary purpose of Mud Mountain Dam is to provide a storage basin in which excessive runoff from the White River drainage area can be temporarily retained, thus preventing damaging floods in the lower Puyallup Valley. During winter months, when the flood threat is at a maximum, the reservoir is kept essentially empty. Normal river flow at this time is passed through the 9-foot outlet tunnel in the dam's right abutment. When the river flow exceeds the 9-foot tunnel capacity, flow is passed through the 23-foot tunnel and regulated to limit releases for downstream flood risk management. Currently the two flood control objectives are to maintain releases as low as possible to protect flood prone areas in the City of Pacific, and to maintain a total flow less than 50,000 cfs at the city of Puyallup, below the confluence of the Puyallup and White Rivers. Floodwater in excess of these releases is impounded in the reservoir. After the peak of the storm, these releases are maintained to empty the reservoir as fast as possible to provide storage space for subsequent floods.



This level of detail can be released to the public.

This map shows that a failure of Mud Mountain dam during an extreme flood event has the potential for flooding in both Pierce and King Counties.

Based upon the most recent risk assessment of Mud Mountain Dam in 2018, USACE considers Mud Mountain Dam to be a moderate risk dam among its more than 700 dams because the consequences associated with a dam failure are very high. Dam safety risk is primarily driven by the potential for embankment erosion from Lower Cascade Creek during a rare flood event and subsequent overtopping and failure of the dam.



MMD INUNDATION MAPS

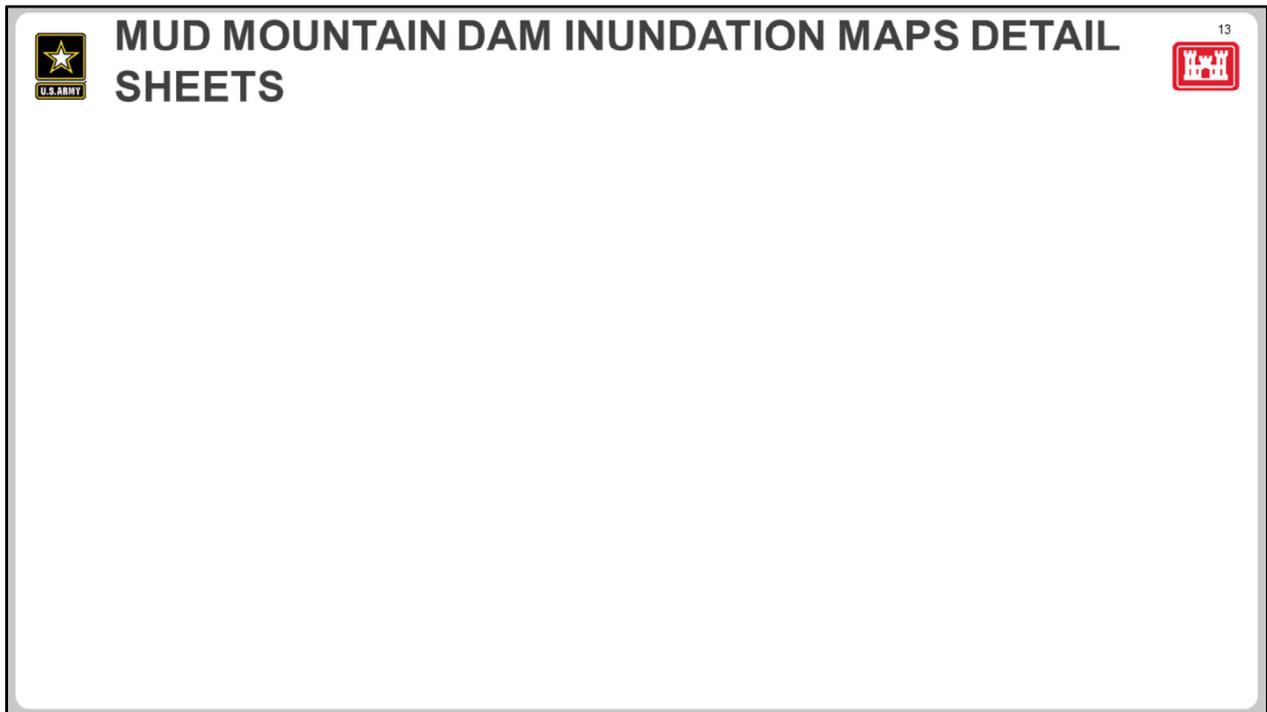
12



The inundation maps that we provide to downstream emergency responders and planners are not releasable to the general public. This document is considered FOUO.

Note that the flooding event shown in this overview in pink combines a dam failure with the Probable Maximum Flood. This is a worst case event.

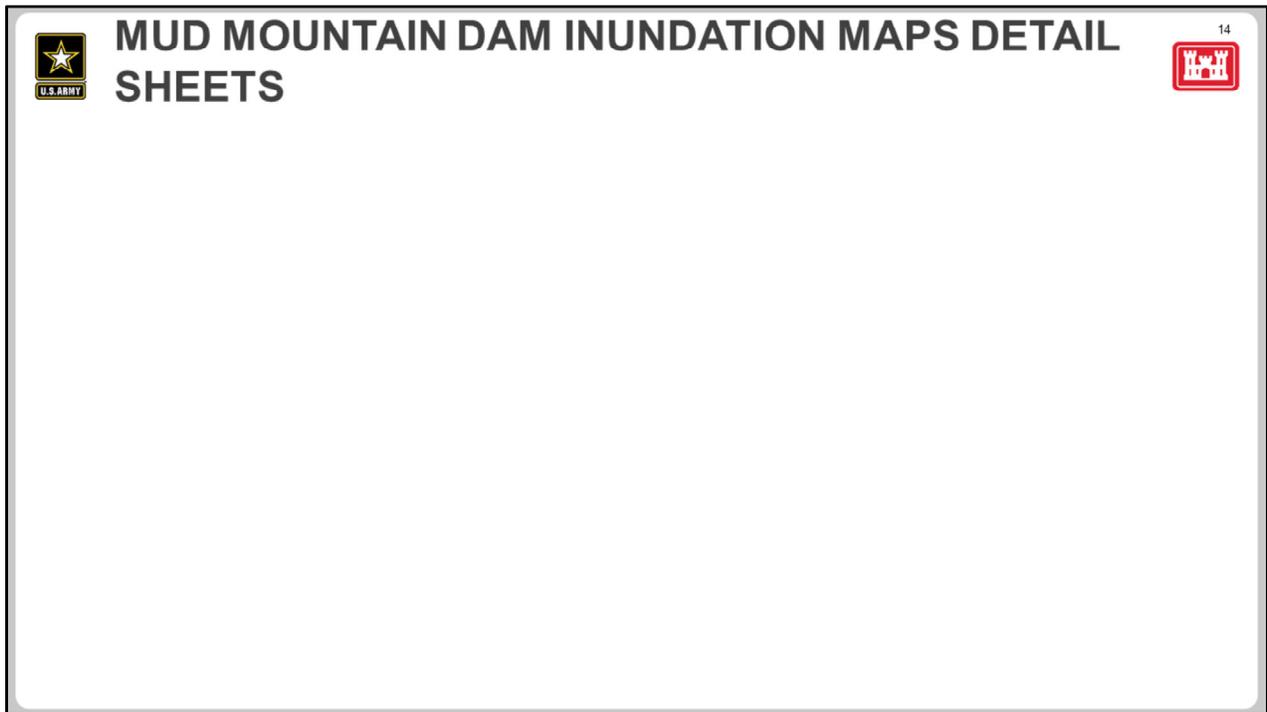
A breach of the dam under these conditions has the potential to cause widespread flooding in King County, due to the relatively low watershed divide between the White and Green Rivers.



Detail inundation maps are FOUO and cannot be released to the public.

Detail sheets show inundation (blue diagonal striped region) from a 10% chance exceedance flood pool elevation with dam failure. This is a standard mapping product that is not particularly useful for this dam since the pool is empty more than 90% of the time. Notice that this particular flood generally stays within the river channel.

The PMF with dam breach scenario shows the maximum extent of possible flooding.

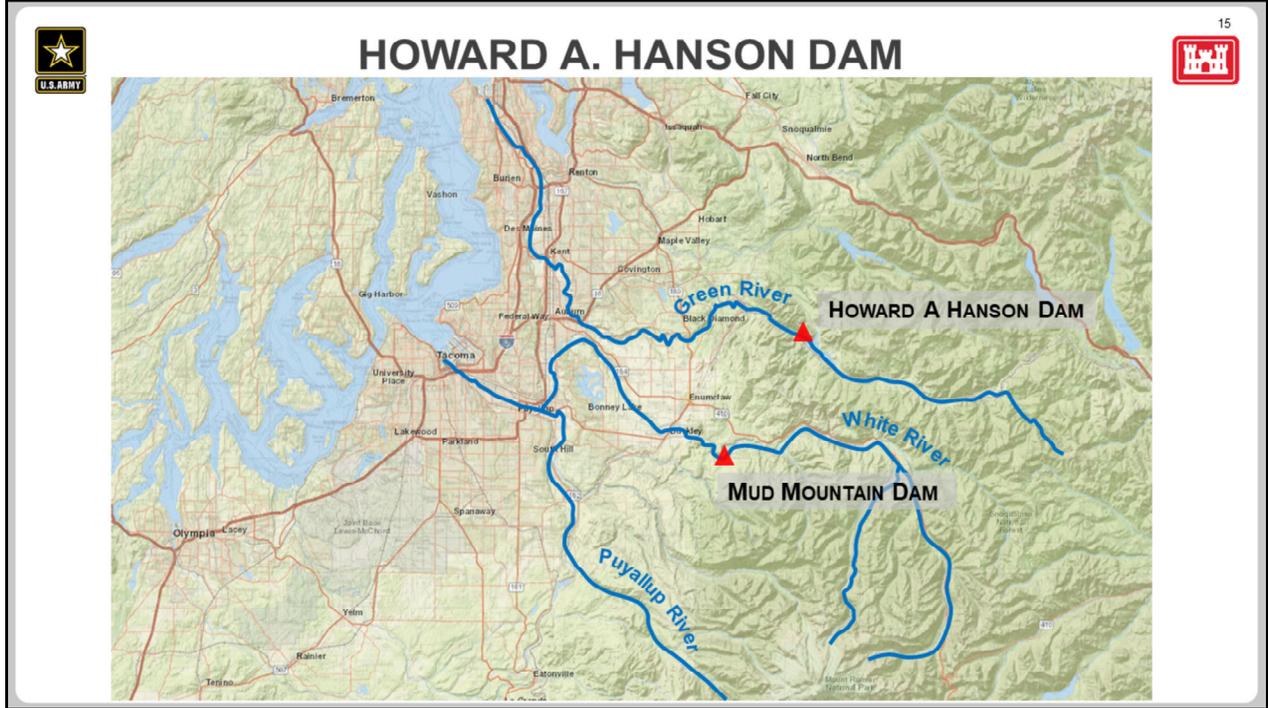


Detail inundation maps are FOUO and cannot be released to the public.

This section view along the river shows inundation depths compared to initial flow at dam break (gray) for various times after dam break and includes representations of buildings (black dots) and critical infrastructure elements (symbols).

Both failure scenarios discussed previously are shown. On top is the 10% pool elevation exceedance flood with dam break (no impact). On the bottom is the probable maximum flood inundation level at the modeled dam break (gray) with the additional inundation caused by the dam break in colors by hour post dam break.

There are an infinite number of possible flood scenarios based upon the magnitude of a particular flood event and the nature of a compounding dam failure. At present, the two cases given here are the only cases for which the Corps has developed inundation maps for Mud Mountain Dam.



HAHD is located on the Green River, in southeast King County, near Palmer, Washington 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. The dam is located approximately 35 miles southeast of Seattle and 25 miles east of Tacoma, at river mile (RM) 64.5. From RM 64.5, the Green River flows west and north from the Cascade Mountains to eventually form the Duwamish River at RM 12. The Duwamish River empties into Puget Sound 12 miles downstream at Elliott Bay in downtown Seattle, Washington.



HOWARD A. HANSON DAM - FEATURES

16



Project Features:

Howard A Hanson Dam is an earth embankment dam with:



HOWARD A. HANSON DAM - FEATURES

17



A flood control spillway

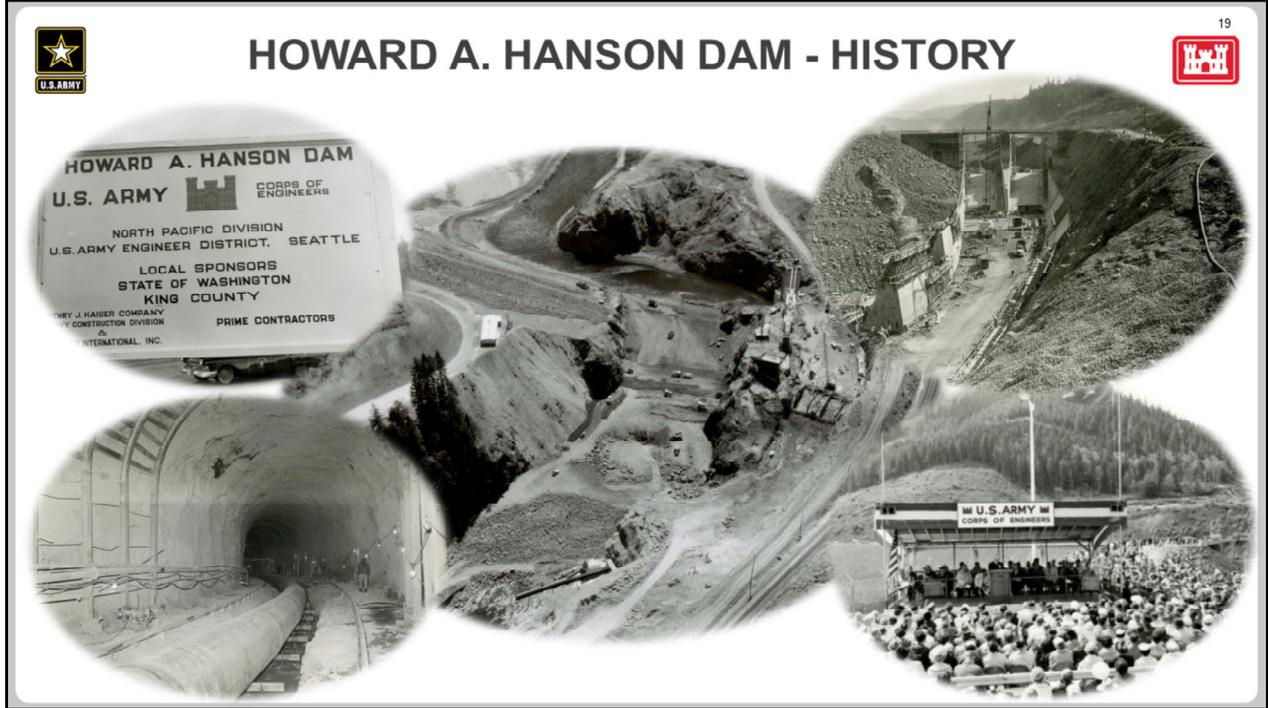


HOWARD A. HANSON DAM - FEATURES

18



And an intake tower with connecting tunnel in bedrock to the outlet works and stilling basin.



Project History:

Howard A. Hanson Dam, Washington, was originally authorized as the Eagle Gorge Reservoir by Public Law 81- 516, the Rivers and Harbors Act of 1950, 81st Congress, 2nd Session, for the principal purpose of flood control. The Chief's Report, House Document 271, 81st Congress, also listed low-flow augmentation, irrigation, and M&I water supply as project purposes, with irrigation and M&I water supply to be implemented at an undetermined date. A significant modification to the original project was authorized in 1999 to support water supply and ecosystem restoration.

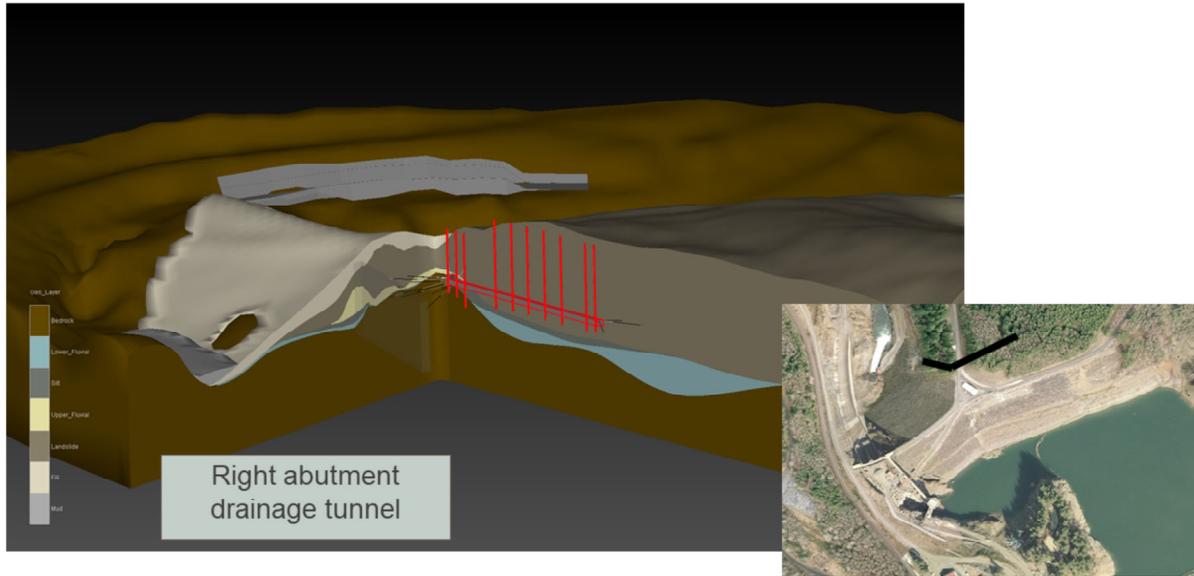
The dam as designed by the Seattle District US Army Corps of Engineers and constructed by the Henry J Kaiser Company and Raymond International Inc. with construction completed in 1962.

The dam was constructed with materials (sand, gravel, and cobbles) obtained from local borrow sources within the watershed



HOWARD A. HANSON DAM - IMPROVEMENTS

20

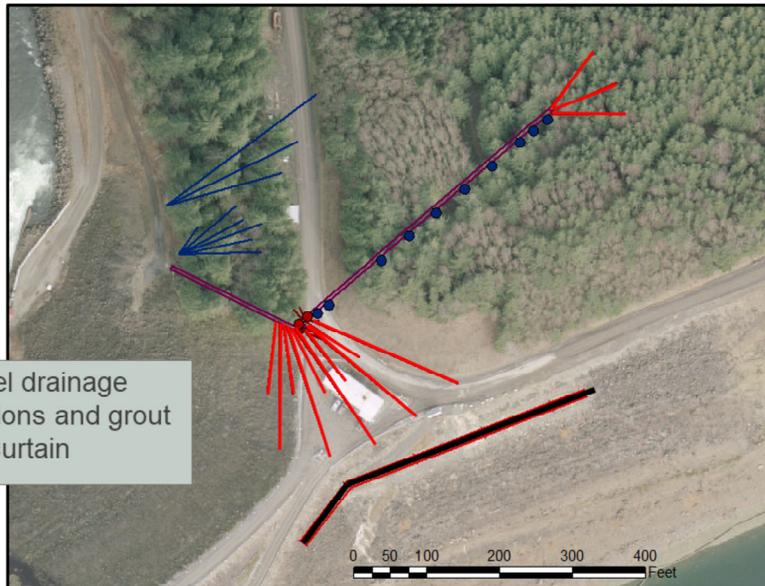


In 1965, the first flood pool was held above an elevation of 1160.0 feet. At a reservoir elevation of 1161.8 feet, leakage appeared on the downstream right abutment at an elevation of 1134.0 feet. An estimated flow of 80 to 100 gpm was observed when the pool was at 1140.0 feet and dropping. The leakage saturated the loose slope wash on the steep hillside and caused local sloughing of the surface material. The water flow caused further minor erosion of underlying compact till. An inspection found the emergence to be coming from the slide material at the contact with the underlying glacial till. The seepage was clear, and the till did not appear to be eroding appreciably. Other springs were intermittently spaced and seepage was observed flowing from the bank at elevations as high as 1120.0 feet. There was no evidence of water discoloration or surface erosion. A crib wall with drainage was designed and installed to provide slope stability. The need for increased seepage control and downstream stability of the right abutment led to the installation of the drainage tunnel in 1969, with a gravel floor drain and vertical drains. Additional horizontal drains were installed downstream of the tunnel, and piezometers were installed within the right abutment to stabilize and monitor the right abutment.



HOWARD A. HANSON DAM - IMPROVEMENTS

21



Tunnel drainage modifications and grout curtain

Negative performance observed during the 2009 flood pool of record led to modifications of the right abutment drainage tunnel. Vertical drain 25, a source of turbid water during the record pool event, was constructed within a silty material with blade cut slotted steel casing and no filter material between the slots and the surrounding formation. Drain 25 was replaced by two new nearby vertical drains with properly designed filter material and wire wrapped screens. Thirteen new horizontal drains with properly graded filters and screens were installed from within the tunnel (shown as red lines). Three of these drains were installed from the terminus of the tunnel, and ten were installed from the area where the tunnel bends and turbidity has been noted in the past.

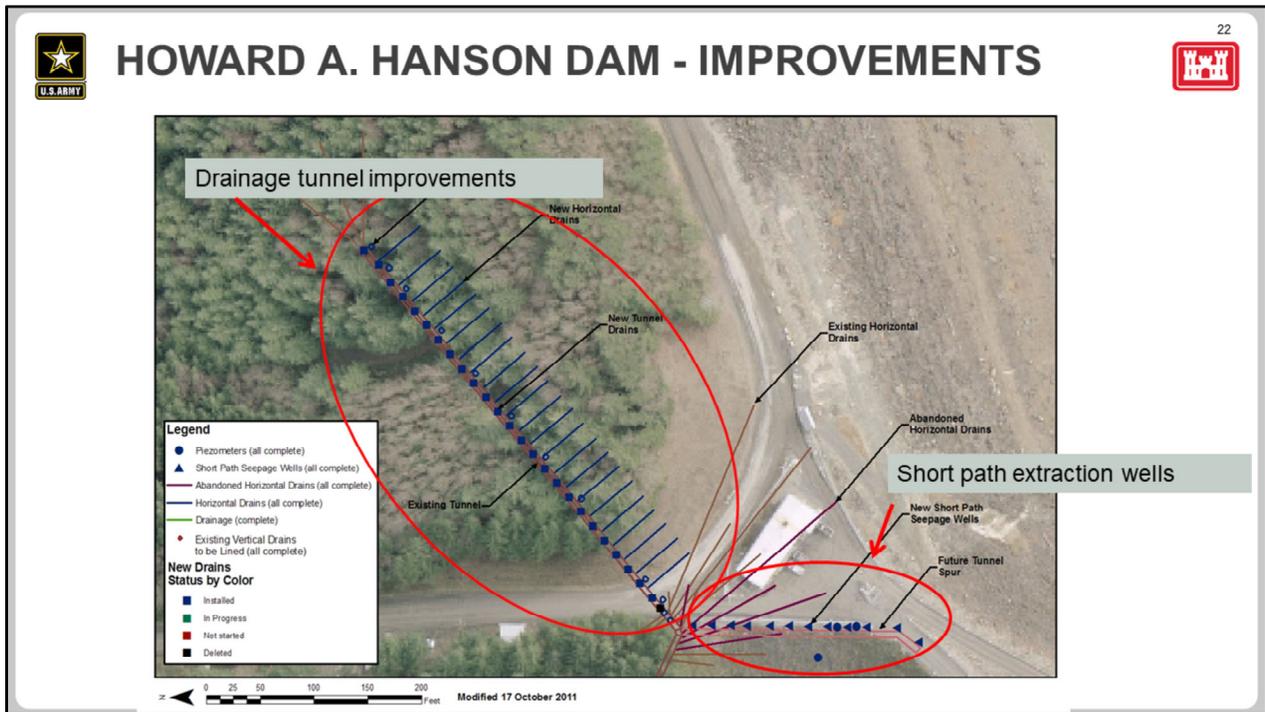
A grout curtain was installed on the upstream face of the dam to intercept and impede the flow of water through the abutment and the contact of the embankment with the abutment. The combination of these features were very effective in controlling seepage through this region.

These were considered temporary measures to deal with right abutment seepage until studies and designs to install a permanent solution were completed.



HOWARD A. HANSON DAM - IMPROVEMENTS

22

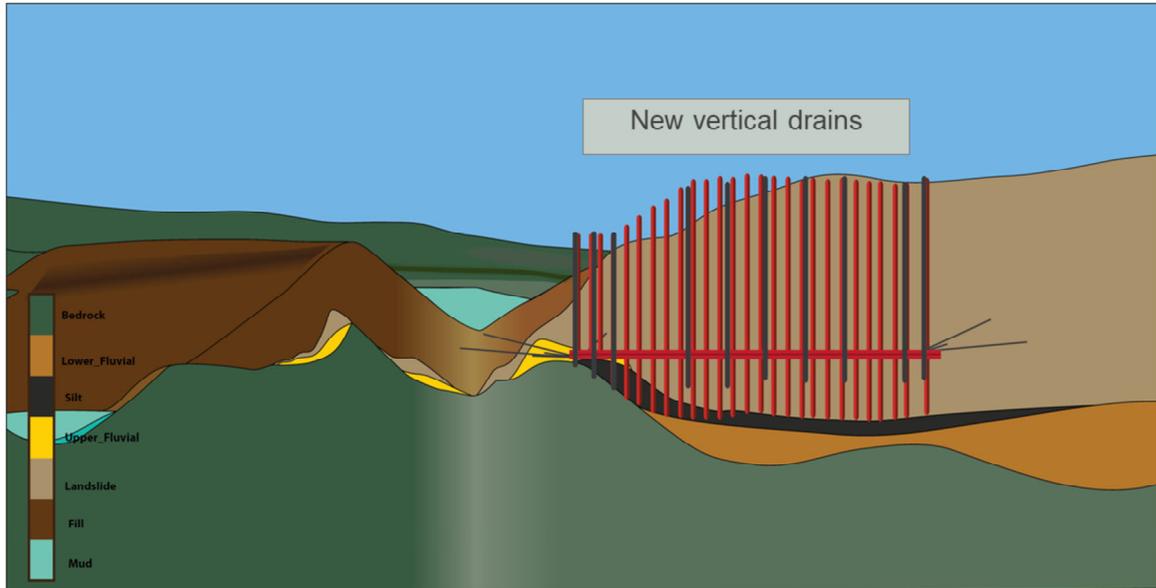


The final repair completed in 2012 consisted of installing new vertical drains in the existing tunnel, relining the existing vertical drains with properly filtered drains, installing new horizontal drains on the upstream side of the tunnel, and installing a series of extraction wells to remove seepage water that might penetrate through the short path seepage area during an extreme flood event and initiate internal erosion of the abutment/embankment contact.



HOWARD A. HANSON DAM - IMPROVEMENTS

23

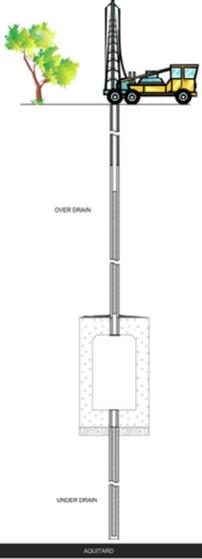


New vertical drains shown in red. Note that new drains fully penetrate the landslide material that forms the upper aquifer and is responsible for seepage of concern.



HOWARD A. HANSON DAM - IMPROVEMENTS

24



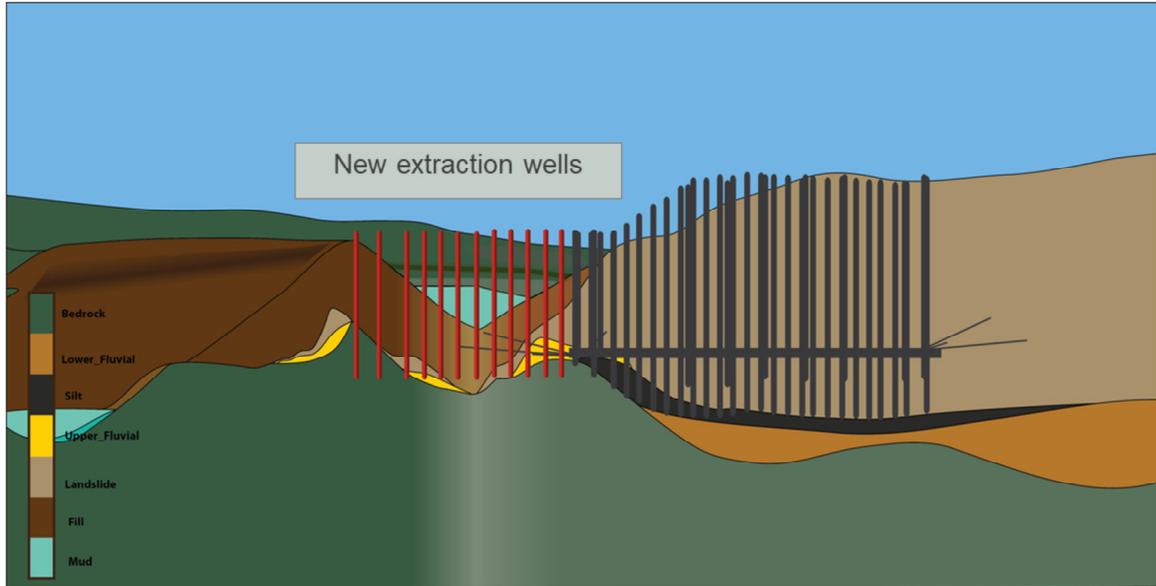
New vertical drains

It was challenging to target a tunnel so far underground.



HOWARD A. HANSON DAM - IMPROVEMENTS

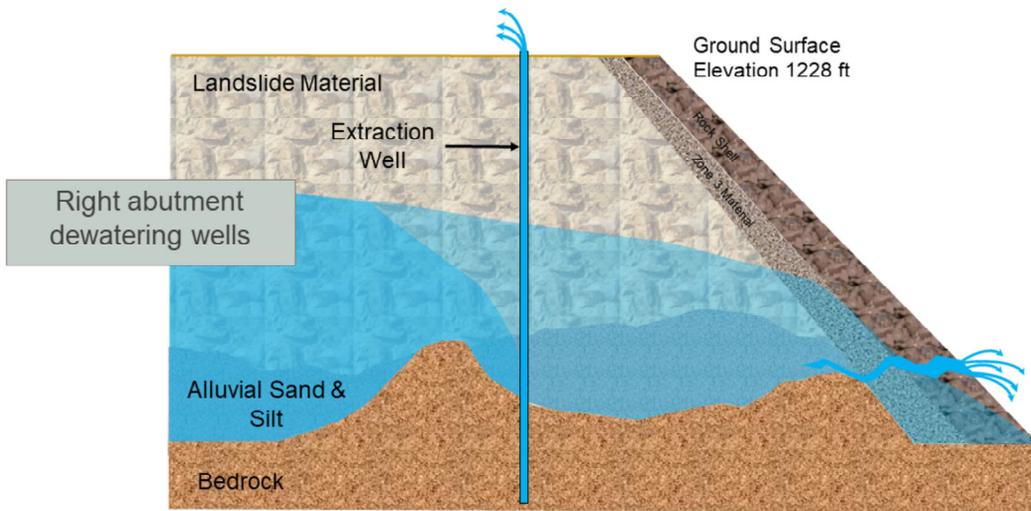
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HOWARD A. HANSON DAM - IMPROVEMENTS

26



Animation shows how seepage through the abutment materials could create saturated conditions from the pool to the downstream contact with the embankment. Because the embankment materials are filter incompatible with the rock shell and the abutment, this could lead to internal erosion. The extraction wells are designed to intercept this water and prevent it from reaching the critical contact between the abutment and the embankment materials, thus eliminating the pathway for internal erosion.



HOWARD A. HANSON DAM - IMPROVEMENTS

27

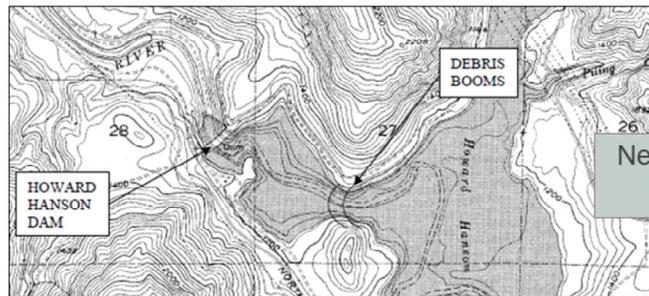


A portion of the upstream embankment was re-armored to prevent erosion during a spillway use event. The old armor stone had degraded with time until it was broken down into sizes that were too small to remain in place given the model generated velocities expected across the embankment face during a spillway use event.



HOWARD A. HANSON DAM - IMPROVEMENTS

28



New log booms for woody debris management

The spillway gate openings are relatively narrow in comparison to the length of woody debris that can accumulate in the reservoir during a major flood. If the spillway were to become obstructed, overtopping and breach of the dam could occur. A new log boom system was installed to ensure that floating debris are captured upstream of the spillway.



HOWARD A. HANSON DAM – RIVER OPERATIONS

29



Pool of Record
– January 2009
– Elevation 1188.8 feet
NGVD 29
– 17.2 feet below top of
spillway gates



River operations

The dam has never experienced its full pool and the spillway has never been used to pass flow. Howard Hanson Dam provides flood risk management benefits to over \$25 billion in infrastructure located in the lower Green River valley, which includes the cities of Kent, Auburn, Renton and Tukwila.

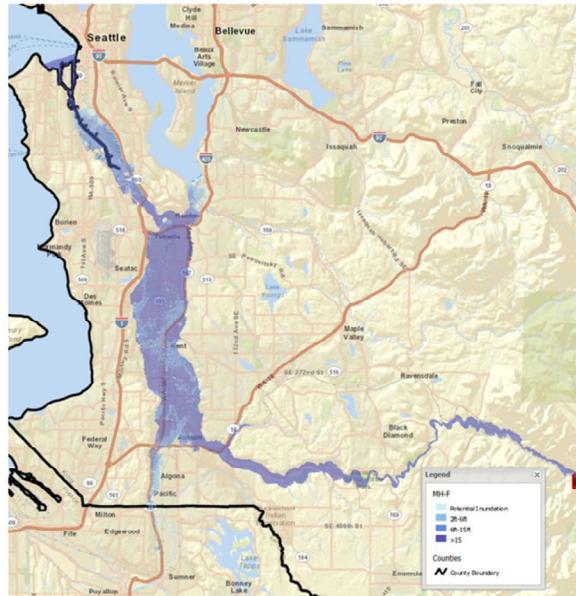
It is operated for multiple purposes in the winter, spring, summer, and fall. Flows are regulated manually by adjusting the tower gate controls at the dam (located at the base of outlet tower) with direction from the NWS Water Management Section. During winter months (October through February), when the flood threat is at a maximum, the reservoir is kept essentially empty. Normal river flow at this time is passed through the outlet tunnel in the dam's left abutment. When the river flow reaches flood stage, control gates in the outlet tunnel are regulated to manage river flow at the control point at Auburn, Washington, to 12,000 cubic feet per second (cfs) or less, as feasible. The normal historical summer conservation pool was initially set at an elevation of 1141.0 feet. With the implementation of the Section 1135 Fish and Wildlife Restoration Project in 1996, the conservation pool was raised

to an elevation of 1147.0 feet for ecosystem restoration. The pool raise to 1167.0 for Phase 1 of the AWSP, was implemented in 2007.



HOWARD A. HANSON DAM INUNDATION FOR RARE FLOOD AND DAM BREACH

30



This level of detail can be released to the public.

Based upon the most recent risk assessment in 2014, USACE considers this dam to be a low risk dam among its more than 700 dams because of the recent repairs completed to reduce risk associated with embankment abutment seepage and piping, embankment erosion during spillway use, and spillway debris blockage.



HOWARD A. HANSON INUNDATION MAPS

31



The inundation maps that we provide to downstream emergency responders and planners are not releasable to the general public. This document is considered FOUO.

Note that the flooding event shown in this overview in pink combines a dam failure with the Probable Maximum Flood. This is a worst case event.

A breach of the dam under these conditions has the potential to cause minor flooding in Pierce County, also due to relatively low watershed divide between the White and Green Rivers.



HOWARD A. HANSON DAM INUNDATION MAPS DETAIL SHEETS



Detail inundation maps are FOUO and cannot be released to the public.

Only the PMF with dam breach scenario shows inundation in Peirce County limits.