R. Gonzales
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UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D. C. 20555

MAY 11 1984

Docket No. 50-344

MEMORANDUM FOR: Gus C. Lainas, Assistant Director
for Operating Reactors, DL

FROM: William V. Johnston, Assistant Director
Materials, Chemical & Environmental Technology, DE

SUBJECT: HYDROLOGIC ENGINEERING REPORT AND RECOMMENDATIONS CONCERNING SPIRIT LAKE AND THE TROJAN PLANT

Attached is a Hydrologic Engineering report that addresses potential flooding of the Trojan Plant due to a postulated breakout of Spirit Lake. In this report, we are recommending several conditions to assure the continued safe operation of the Trojan Plant should there be a breakout of the Lake. These recommendations are made on the basis of preliminary information and are subject to change should additional information become available.

The U.S. Geological Survey, in response to a request from the Federal Emergency Management Agency, is currently conducting a detailed study of the impacts of a breakout of Spirit Lake on the Columbia River. A preliminary report on this study is scheduled for completion later this month. We will review the USGS report at that time and notify you if there is any new information that would affect the recommendations of this report.

We recently received the final version of the Trojan Plant/Spirit Lake study that USGS did for NRC together with a comparison of the assumptions and

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results of this study with the independent study done by the licensee. Copies of these are attached.

William V. Johnston

William V. Johnston, Assistant Director
Materials, Chemical & Environmental
Technology
Division of Engineering

Attachment:
1. Hydrologic Engineering Report
2. USGS Study done for NRC-WRI Report
   83-4197
3. Study comparisons by USGS,
   Tacoma, Washington

cc: w/attachment no. 1
H. Denton
R. Vollmer
D. Eisenhut

w/attachment nos. 1, 2, & 3
W. Johnston
R. Ballard
J. Miller
C. Trammell
M. Fliegel
R. Gonzales

HYDROLOGIC ENGINEERING REPORT AND RECOMMENDATIONS CONCERNING A POSTULATED BREAKOUT OF SPIRIT LAKE AND ITS IMPACTS ON THE TROJAN PLANT

Purpose

On May 18, 1980, Mount St. Helens erupted and caused a massive mudflow flood that deposited a large amount of sediment in the Columbia River near the mouth of the Cowlitz River. The Trojan Nuclear Plant which is located on the west bank of the Columbia River about 4.5 miles upstream of the mouth of the Cowlitz River (See figure 1) was not directly affected by the sediment deposited in the Columbia River, although large deposits were measured near the intake structure. However, there now exists a potential for a more severe mudflow than the one that followed the May 1980 eruption because the outlet channel of Spirit Lake is blocked with debris deposited by the 1980 eruption. The debris-blockage which is a massive and unstable deposit, has caused a dramatic increase in the volume of water stored in Spirit Lake. Because of the unstable nature of the debris blockage, Spirit Lake could breach the blockage and cause a mudflow flood that could possibly affect the safe operation of the Trojan Plant. This report addresses the potential effects of how such a mudflow flood at the Trojan Plant and recommends several conditions to assure the safe operation of the plant.

Background

The 1980 eruption of Mount St. Helens caused a failure of the north flank of the volcano. The resultant avalanche of rock, mud and ice swept down the slopes of Mount St. Helens, moving at high velocity into Spirit Lake and the Upper Toutle River Valley. As the debris avalanche slid into Spirit Lake, it displaced the lake level upward by more than 200 feet. The avalanche also deposited an estimated 3.9 billion cubic yards (bcy) of sediment in the upper 17 miles of the North Fork Toutle River Valley and buried the outlet channel of Spirit Lake with debris ranging in depth to 500 feet. Before the eruption, the volume of water in Spirit Lake was about 123,000 acre-feet. By December 1982, it had increased to 275,000 acre-feet due to the blockage of the outlet channel.

Mudflows associated with the May 1980 eruption moved down the Toutle River and carried more than 50 million cubic yards (mcy) of material into the Cowlitz River and its overbank areas. An additional 45 mcy were deposited in the Columbia River, mostly in a nine mile reach of the river extending from about 5 miles downstream of the mouth of the Cowlitz River to 4 miles upstream.

In the fall of 1981, a task force organized by the U.S. National Forest Service determined that the effective crest of the debris blocking the Spirit Lake outlet would deteriorate from elevation 3490 ft msl to 3475 ft msl during the winter of 1982-83 because of subsidence and erosion. It was estimated that Spirit Lake would fill to elevation 3475 ft msl (314,000 acre-feet) sometime in March 1983 assuming that no action was taken to reduce the level and volume of the lake and that the annual inflow was average. Were this to happen, there would be a very high potential for failure of the blockage and catastrophic flooding downstream. To reduce the potential for failure, the Corps of Engineers, as an interim measure, constructed a pumping facility at Spirit Lake. Pumping began on November 5, 1982, and is expected to continue until a permanent solution to the Spirit Lake flooding potential is in place. With normal inflow, the goal of the pumping operation is to stabilize the lake level at an elevation of about 3,462 ft. msl which corresponds to a lake volume of about 275,000 acre-feet. However, greater-than-normal rainfall, failure or disruption of the pumping system and/or addition of debris into Spirit Lake from a subsequent eruption could cause the lake level to rise excessively. In an extreme case the debris blockage could fail.

Because of the potential public safety hazard associated with a breakout of Spirit Lake, the U.S. Geological Survey (USGS) in cooperation with the Federal Emergency Management Agency (FEMA) conducted a study (Water Resources Investigations 82-4125) to determine the extent of inundation that might result downstream in the Toutle and Cowlitz Rivers should a breakout generate a catastrophic mudflow flood. The results of the USGS study were published in early 1983 and the NRC received a copy of the USGS report in March 1983. In its study, the USGS concluded that the level of mudflow flooding at the confluence of the Cowlitz and Columbia Rivers due to a postulated Spirit Lake breakout would be of significantly greater magnitude than the mudflow that followed the May 1980 eruption of Mount St. Helens. The USGS did not assess the effects of the mudflow on the Columbia River. However, in reviewing the report, it appeared to the NRC staff that the predicted mudflow level at the mouth of the Cowlitz, estimated to reach an elevation of about 40-50 feet msl, could potentially result in some flooding of the Trojan plant which is located on the west bank of the Columbia River about 4.5 miles upstream of the mouth of the Cowlitz River. FEMA also expressed concern about the impact on the Columbia River so they requested that USGS conduct additional mudflow studies to include effects on the Columbia River.

One of the problems encountered by the USGS is the lack of a verified computer model to handle transport of a mudflow. The models that are available do not handle transport in an upstream direction at river confluences. The mudflow that followed the May 1980 eruption moved mud and debris upstream in several tributary streams. This was significant in the Cowlitz River

above the mouth of the Toutle River and in the Columbia River above the mouth of the Cowlitz River. It is expected that a mudflow resulting from a failure of the Spirit Lake debris-blockage would also result in significant sediment movement at river confluences. The USGS thus decided to develop a new computer model before assessing the effects on the Columbia River. This effort was expected to take about a year to complete.

NRC Concerns

Because of immediate safety concerns, the NRC contracted with the USGS to furnish in the shortest time possible, a conservative estimate of the flows and elevations in the Columbia River at the Trojan Plant that would result from a Spirit Lake breakout. To expedite this analysis, the NRC instructed the USGS to use the mudflow hydrograph which had been generated in the USGS-FEMA Report (Water Resources Investigation 82-4125) as the inflow into the Columbia River. Using this mudflow hydrograph, the USGS considered two scenarios: (1) the coincident occurrence of a mudflow and a Columbia River flood and (2) the occurrence of a mudflow depositing sediment in the Columbia River during a low flow period and then being followed by a Columbia River flood flow.

In the first of these scenarios, a hypothetical mudflow with a peak discharge of 1.1×10^6 cfs at the mouth of the Cowlitz River was postulated to occur coincident with a high flow in the Columbia River. The hydraulic properties of the combined Cowlitz River mudflow/Columbia River flood flow, could be those for either a clear-water flow or a mudflow. Therefore, the USGS computed flood elevations in the Columbia River at the Trojan Plant for both clear-water and mudflow assumptions. It was also assumed that very little, if any, sediment would be deposited in the Columbia River upstream of the Cowlitz River during this assumed high flow. For a coincident flow of about 690,000 cfs in the Columbia River, the water level at the Trojan plant would rise as high as the plant grade elevation of 45 ft msl assuming combined mudflow conditions. With clear water assumptions, a coincident Columbia River flow as high as the 850,000 cfs resulted in a flood elevation of only 32 ft. msl at the Trojan Plant.

In the second scenario, it was assumed that the mudflow would occur coincident with a low flow in the Columbia River. The low flow would not transport the sediment downstream so it would deposit and aggrade the Columbia River channel. This event by itself would not impact on the safe operation of the Trojan Plant unless it was followed by a high flow in the Columbia River. It was determined that if the Columbia became blocked to the extent estimated by the USGS during low flow conditions, a subsequent flow of about 430,000 cfs or greater would result in a flood level at Trojan at or above plant grade elevation of 45 ft msl.

TABLE 2

Flood elevations in the Columbia River at the Trojan Nuclear Plant

Columbia River Discharge	Licensee's Analyses	USGS Analysis		
		Scenario No. 1		Scenario No. 2
		Mudflow Conditions	Clear-Water Conditions	
125,000 cfs	31 ft msl			
250,000 cfs				39 ft msl
400,000 cfs	35 ft msl			
430,000 cfs		38 ft msl	25 ft msl	45 ft msl
640,000 cfs		34 ft msl	28 ft msl	49 ft msl
*690,000 cfs		*45 ft msl		
790,000 cfs		47 ft msl	30 ft msl	52 ft msl
800,000 cfs	39 ft msl			
850,000 cfs		48 ft msl	32 ft msl	

* 690,000 cfs flow in the Columbia River was not considered by either the USGS or the Licensee. This flow was extrapolated by the NRC staff to correspond to a water level at the Trojan Plant of 45 ft msl which is the plant grade elevation.

TABLE 1

	Licensee's Analyses	USGS ANALYSIS Scenario No. 1 Mudflow Conditions	USGS ANALYSIS Scenario No. 1 Clear-Water Conditions	USGS ANALYSIS Scenario No. 2
Spirit Lake volume/elevation at time of breakout	310,000 ac-ft/ ---	314,000 ac-ft/ 3,475 ft	314,000 ac-ft/ 3,475 ft	314,000 ac-ft/ 3,475
Sediment concentration in percent by volume entrained from debris blockage	65%	65%	65%	65%
Sediment concentration in percent by volume in mudflow at the mouth of the Cowlitz River	45%	65%	65%	65%
Peak of mudflow into Columbia River	$3.86X10^5$cfs	$1.1X10^6$cfs	$1.1X10^6$cfs	$1.1X10^6$cfs
Sediment volume deposited in Columbia River	$0.28X10^9$yd	0	0	$0.50X10^9$yd^3
Slope of sediment deposited in Columbia River upstream of Cowlitz River	-7.5 ft/mi	NA	NA	-2.5 ft/mi
Assumed tide level in Columbia River at downstream end of reach	7.5ft	9.0 ft	9.0 ft	9.0 ft
Assumed hydraulic properties of flow in Columbia River downstream of Cowlitz River	clear water	mudflow	clear water	clear water

The licensee, in an independent study, also addressed the potential impact of a Spirit Lake breakout on the Trojan Plant. The licensee, however, did not use the mudflow hydrograph from the USGS-FEMA report. Instead they developed their own inflow hydrograph to the Columbia River based on their analysis of the effects of a Spirit Lake breakout in the Toutle-Cowlitz system. Their resulting inflow hydrograph to the Columbia River was less severe than that used by the USGS. In analyzing the effect of a mudflow on the Trojan Plant, the licensee conservatively assumed that during a coincident high flow in the Columbia River, there would be sediment deposition of the mudflow in the Columbia River.

The worse case considered by the licensee was based on a flow of 800,000 cfs in the Columbia River occurring coincident with a mudflow in the Cowlitz River. For this case, a flood elevation of 39 ft msl was estimated for the Columbia River at the Trojan Plant. This elevation is lower than the Trojan Plant grade elevation which is 45 ft msl. This analysis is comparable to the USGS scenario no. 1 except that the licensee conservatively assumed that sediment would deposit in the Columbia River upstream of the mouth of the Cowlitz River while the USGS assumed no deposition.

Initially, the licensee did not consider a case similar to the USGS's second scenario which analyzed a mudflow occurring during a period of low flows in the Columbia River with consequent high sediment deposition to be followed by a high flow in the Columbia River. However, in response to a staff question concerning this scenario, the applicant stated that it considered this scenario to be of negligible probability. Additionally their analysis included the assumption of sediment deposition in the Columbia during high flows so there was no need to assume a low Columbia flow during the mudflow followed by a high Columbia flow. They reported that if a flow of 1,000,000 cfs was to occur instead of the 800,000 cfs previously considered, the flood elevation in the Columbia River at the Trojan Plant would be 42.1 ft msl which is lower than the grade level of the plant.

In analyzing how a breakout of Spirit Lake would affect flood levels in the Columbia River at the Trojan Plant, both the USGS and the licensee had to make many assumptions. Table 1 compares some of the assumptions made. Table 2 is a tabulation of the flows assumed in the Columbia River coincident with a mudflow from the Cowlitz River and the resultant flood elevations at Trojan.

The staff has reviewed both the USGS and the applicant's analyses. All of the cases considered contain both conservative assumptions and assumptions which may be too optimistic. For example, the licensee's assumptions with respect to sediment concentration, peak discharge of the mudflow into the Columbia, hydraulic properties of flow in the Columbia, and tide level are

more optimistic than USGS's. However, their assumption of sediment deposition in the Columbia during an assumed concurrent flood is more conservative than the USGS's analysis which assumed no deposition. Because of the uncertainty of the applicability of the computer models used and of the many assumptions that necessarily have to be made, the staff concludes that the results of the more conservative USGS analyses should be used as a basis for establishing limiting conditions for the operation of the Trojan Plant.

Both the licensee and USGS studies indicate that the elevation to which the Columbia River water level would rise in the vicinity of the Trojan Plant following a failure of the debris-blockage and a breakout of Spirit Lake, is directly dependent on the stage of the Columbia River at the time the mudflow flood would discharge into the Columbia River. In the USGS's first scenario, a discharge in the Columbia River of about 690,000 cfs would result in a flood level at the Trojan Plant equal to the plant grade elevation of 45 ft msl, assuming that a catastrophic mudflow flood moves into the Columbia River at the same time. In their second scenario, a Columbia River flow of 430,000 cfs, following a mudflow during a low Columbia River flow, result in water at plant grade.

The possibility of sediment from a mudflow blocking the intake structure and affecting the service water system which provides safety-related cooling water, has been addressed by the licensee. In the event that the intake to the service water system is lost, the licensee is required by existing Technical Specifications to shut down the plant. In lieu of the service water system, adequate cooling can be provided for a minimum of 165 hours by the circulating water system and the cooling tower basin, assuming no makeup to the system. This cooling capacity can be maintained in the event of concurrent loss of off-site power by use of the cooling tower make-up pumps which can be connected to an emergency electrical bus supplied by the diesel generators by closing an electrical breaker. If the water in the cooling tower should be exausted by evaporative losses before the intake to the service water is restored, additional water can be pumped into the cooling tower by temporary pumping systems or fire pumpers. Water could probably be taken from the Columbia River. An alternative source of water could be from the on-site Reflecting Lake or Recreation Lake. The combined water volume of these lakes is approximately 100 million gallons. Assuming that only 70 percent of this volume is available and no inflow to the lakes, make-up water for the cooling tower basin is available for about 97 days.

Recommendations

Based on the above, we recommend that during the estimated 2-3 year time interval until the Corps of Engineers installs permanent facilities to control the level of Spirit Lake, the following measures be taken while the Trojan Plant is operating.

1) Monitor and record the discharge of the Columbia River in the plant vicinity once every 24 hours.

2) Whenever the Columbia River discharge is in excess of 500,000 cfs, the following will be implemented:

   (a) On a daily basis, confirm with the appropriate authorities that the early warning system installed to signal an uncontrolled release from Spirit Lake is operational.

   (b) Procedures designed to implement emergency measures in the event of a Spirit Lake breakout will be reviewed to confirm that the necessary actions can be successfully implemented.

3) In the event of a failure of the Spirit Lake debris-blockage, the Trojan Plant will be shut down immediately regardless of the flow in the Columbia River.

References

(1) U.S. Army Corps of Engineers, Portland District, "Mount St. Helens Eruption, The Challenge to Restore and Protect", October 1981.

(2) U.S. Geological Survey, "Mudflow Hazards Along the Cowlitz River from a Hypothetical Failure of Spirit Lake Blockage", Water Resources Investigation 82-4125, Tacoma, Washington, 1983.

(3) U.S. Geological Survey, "Preliminary Estimate of Possible Flood Elevations in the Columbia River at Trojan Nuclear Power Plant Due to Failure of Debris Dam Blocking Spirit Lake, Washington", Water Resources Investigation 83-4197, Tacoma, Washington, 1984.

RECORD OF TELEPHONE CONVERSATION

DATE: JULY 11, 1984 PROJECT: TROJAN NPP/ MT. ST. HELENS

RECORDED BY: Raymond Gonzales

TALKED WITH: Bill SiKonia OF the USGS · Tacoma, Wash.
FTS 8-390-6510

MAIN SUBJECT OF CALL: status of report that USGS has prepared for FEMA addressing the question of flood levels in the Columia River due to a postulated failure of the Spirit Lake blockage.

In a previous conversation with Mr. SiKonia, on May 8, 1984, he informed me that the report was finished and under review. Today I called to find out if the review process had been completed yet.

The report is still being reviewed. To date Mr SiKonia has received comments from only one of three reviewers. He is currently responding to these comments. Once he receives comments from the other two reviewers, he will respond to those, and make changes to the report, if required, before he sends it to the USGS regional office for further review. After that comes review by the USGS national office before the report is ready for publication. Mr. SiKonia estimates that it will be at least two months before the report is ready for publication.

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