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UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

Water Resources Division
1201 Pacific Avenue - Suite 600
Tacoma, Washington 98402

May 12, 1983

Mr. Ronald L. Ballard, Chief
Environmental & Hydrologic Engineering Branch
Office of Nuclear Reactor Regulation
U.S Nuclear Regulatory Commission
Washington, D.C. 20555

Dear Mr. Ballard:

Reference our meeting of May 11, 1983, at the Corps of Engineers office in Portland, Oregon relative to determination of flood elevations at the Trojan Nuclear Powerplant resulting from a breach of the debris barrier at Spirit Lake, Washington. The principal attendees at that meeting were Bill Mayer, Federal Emergency Management Agency; Colonel Friedenwald, U.S. Army Corps of Engineers; Leslie B. Laird and Edward Bolke, U.S. Geological Survey; and Ron Ballard, Nuclear Regulatory Commission.

As requested by the Nuclear Regulatory Commission, the U.S. Geological Survey is prepared to conduct a two-phase analysis of flood levels occurring at the Trojan plant due to the mudflow as described in our previous analysis for the Federal Emergency Management Agency. The mudflow is described in U.S. Geological Survey Investigations 82-4125 entitled, "Mudflow Hazards Along the Toutle and Cowlitz Rivers from a Hypothetical Failure of Spirit Lake Blockage."

The first phase of this study will assume that the discharge of the Cowlitz River is clear water. A kinematic model will be used to route this flow effect upstream past the Trojan plant. The sediment content of the upstream flow will then be estimated and the model programmed to deposit the sediment in time-incremental steps. If the flood elevation at the plant is equal to or less than 45 feet, the analysis will be considered complete. If the flood elevation exceeds the 45-foot level, the second phase of the study will be initiated. During the second phase, the major assumptions made for the mudflow and Columbia River routing models will be reviewed for reasonableness. Reevaluation of the flood level will then be made progressively, as appropriate.

The analysis will be completed six weeks or less after initiation of the study. Results of the study will be published in a brief report which will not be released until approved by our Director. We hope to obtain that approval within the given time frames.

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The cost for Phases I and II will be $60,000. If the study is completed at the end of Phase I, the cost will be appreciably less.

We will intitiate the Phase I study as soon as we receive written authorization from the Nuclear Regulatory Commission. If authorization documents are processed by the National Headquarters Office, please provide us a copy of same.

Sincerely yours,

for L. B. Laird
District Chief

For your information:

Our telecopy # is 390-6514
verify # is 390-6510

K. Gonzales
P-314

DEPARTMENT OF THE ARMY
PORTLAND DISTRICT, CORPS OF ENGINEERS
P. O. BOX 2946
PORTLAND, OREGON 97208

JUN 05 1984

Planning Division (PL-NR-EQ)

To All Interested Parties:

Enclosed for your information is a copy of the Record of Decision (ROD) for a permanent outlet for Spirit Lake, near Mount St. Helens, Washington. The ROD has been prepared pursuant to Council on Environmental Quality Regulations for implementing the procedural provisions of the National Environmental Policy Act (40 CFR 1505.2).

Copies of the ROD are being provided to concerned agencies, organizations, and members of the public known to have an interest in the project.

Sincerely,

for David Katin, LTC
R. L. Friedenwald
Colonel, Corps of Engineers
District Engineer

Enclosure

Copies to: Messrs. Steele, Orser, Yundt, Trammell,
TNP:GEN ENGR 7:FSAR Section 2.4

RECORD OF DECISION
SPIRIT LAKE PERMANENT OUTLET
SKAMANIA COUNTY, WASHINGTON

I have reviewed and evaluated, considering the overall public interest, the Corps of Engineers alternative strategies for a permanent outlet for Spirit Lake, near Mount St. Helens, Washington. The environmental effects of the alternative outlets have been identified and described in a Final Environmental Impact Statement (EIS), prepared in compliance with the National Environmental Policy Act. The views of interested agencies and the concerned public have been obtained through public meetings held in the affected communities and through public review of the Draft and Final EIS.

The Corps of Engineers has determined that the outlet to Spirit Lake should consist of a tunnel through rock to South Coldwater Creek, which drains into the North Fork Toutle River through Coldwater Lake. This determination is based on considerations of engineering, geology, cost and environmental factors, and public concerns and preferences.

Project Description

The Spirit Lake tunnel will be 8,463 feet long, between 11 and 14 feet in diameter, and either circular or horseshoe shaped, depending upon whether construction is accomplished by drill and blast or by tunnel boring machine. The excavated material consisting of finely broken basalt and tuff rock will be placed in a disposal site along the south side of South Coldwater Valley and underwater in Spirit Lake. The quantity of material to be excavated is approximately 73,500 cubic yards. The tunnel inlet will be a 100-foot long, 50-foot wide channel cut in hard rock. The tunnel outlet will direct the outflow directly into the creek channel. Channel stablilization in the form of revetment or groins will be required at the junction of the South Coldwater Creek with the North Fork Toutle Valley. This is to direct the flow into Coldwater Lake, from which it will flow out through the Coldwater Lake rock cut outlet channel into the North Fork Toutle River.

Background

The May 18, 1980 eruption of Mount St. Helens caused a landslide which blocked the natural outlet of Spirit Lake, located about 4 miles northeast of the volcano. With no outlet, the water level in the lake will rise until the blockage is breached by seepage or overtopping. A breach will cause severe damage from mudflow and flooding in downstream communities on the lower Toutle and Cowlitz Rivers, with a high potential for loss of human life. As a temporary measure to prevent the water from rising to dangerous levels, pumps have been installed at Spirit Lake to stabilize the water level. These pumps, however, are not capable of lowering the lake surface to an elevation which could assure long term safety. A permanent outlet for Spirit Lake is needed through which the water level can be lowered and maintained permanently at a safe elevation.

To determine a permanent safe lake elevation a number of factors were considered. The effects of erosion, blockage stability, piping potential (internal erosion of material due to seepage), downstream flood hazards posed by different lake water levels, impact on water surface levels from flood events, and impacts of volcanic and earthquake events were evaluated. Based on these studies, the safe lake level was determined to be elevation 3,440 feet, which allows for temporary raises in lake level due to volcanic and flood events.

Alternatives Considered

A number of alternatives were evaluated for establishing a permanent outlet for Spirit Lake. Each of these alternatives, except the "no action" alternative, would be capable of maintaining Spirit Lake at elevation 3440. These alternatives are:

1. No action

2. A buried conduit in the debris blockage

3. An open channel excavated through the debris blockage

4. A tunnel through rock to Smith Creek, in the Lewis River drainage (Alinement B_1)

5. A tunnel through rock to the North Fork Toutle River (Alinement G)

6. A tunnel through rock to South Coldwater Creek, which drains into the North Fork Toutle River through Coldwater Lake (Alinement F)

7. A permanent pumping facility on Spirit Lake

Comparison of Alternatives

These alternatives were analyzed and compared considering several major factors: cost, risk, impact on the National Volcanic Monument, and impact on downstream areas. The conclusions of these analyses were:

° Cost: Estimated total initial costs ranged from $10.2 million (tunnel Alinement B_1) to $17.8 million (tunnel Alinement G).

° Risk: Tunnel Alinement B_1 would have the least risk because both the inlet and outlet would be sheltered from the volcano. Tunnel alinement F would have somewhat more risk because its inlet would be more exposed to potential volcanic events. Tunnel alinement G would have greater risk with its outlet adjacent to the debris blockage. The buried conduit, open channel and permanent pumping facilities would have the highest risk because each is located within the debris blockage which may be in the path of future mudflows or pyroclastic flows caused by volcanic events.

° Impacts on the National Volcanic Monument (NVM): Each of the alternative outlets would be constructed within the NVM and would disturb a portion of this protected area. Spirit Lake itself would be reduced in size from 2,860 surface acres to 2,580 acres. Construction of the buried conduit or open channel would require excavation in the debris avalanche. The permanent pumping facility would also require excavation, as well as construction of an overhead powerline and electrical substation. The tunnel alternatives would require construction of intake and outlet portals but would have the least effect on the NVM. Each alternative would require disposal of excavated materials, with the open channel producing the largest quantity of material. All of these features would have negative visual effects for visitors to the NVM and would detract from recreational and interpretive uses. Scientific research within the NVM could be adversely affected by increased streamflows, erosion, and lake drawdown.

° Impacts on Downstream Areas: All of the potential alinements were studied to determine impacts to receiving watersheds from the Spirit Lake outflow. Erosion downstream of the outflow would be caused by the increased flow and resulting increase in sediment transport capability of the affected stream. For each alinement, the effects of the outflow are greatest in the vicinity of the outfall and diminish in the downstream direction as the Spirit Lake contribution to total watershed discharge lessens proportionally. For each alinement, downstream impacts are increased by project outflow and lessened by minimizing peak outflows from the Spirit Lake watershed.

The alinements with outflows down the debris avalanche would produce the most erosion. Of these, the F alinement through South Coldwater Creek would cause the least erosion on the North Fork Toutle River. After passing through Coldwater Lake, which would act as a sink for suspended sediment, Spirit Lake flows would enter the North Fork Toutle approximately five miles downstream of the outlets for tunnel G and the alternatives crossing the debris blockage.

The B_1 alinement through Smith Creek into the Lewis River drainage would cause no erosion of the debris avalanche. However, Spirit Lake outflows would increase the sediment yields from Smith Creek into the Muddy River, Lewis River, and Swift Reservoir.

° Other factors considered were the effects of the alternatives on fish and wildlife, water quality social and economic factors, cultural resources and geologic conditions.

° Fisheries in the receiving waters could be temporarily adversely affected by increased turbidity levels during initial drawdown of the lake. Outlet alternatives which would release water into the North Fork Toutle River would benefit fish habitat in that stream, which is slowly recovering from the destruction caused by the eruption. Diversion of Spirit Lake water into Smith Creek would deprive the Toutle fishery of that water source. If no action were taken, the lake would breach the avalanche and massive mudflows would inundate newly recovering fish habitat in the Toutle River, block

the Cowlitz River migration channel, and adversely affect aquatic resources in the Columbia River by high turbidity and habitat loss.

° Wildlife habitat could be adversely affected by erosion of those downstream riparian areas which were affected by the eruption and are now slowly recovering. If no action were taken, mudflows would destroy wildlife habitat along the rivers. Dredging to reestablish channel capacity in the Columbia River would result in the significant loss of riparian and upland wildlife habitat in areas used for dredged material disposal.

° Water quality in Spirit Lake has improved since the post-eruption conditions observed in 1980. The release of Spirit Lake water is not expected to create a health hazard if discharged to either the Toutle or Lewis River Systems.

° Social and economic systems in the lower Toutle and Cowlitz valleys would benefit from any alternative which would reduce the threat of a catastrophic release of Spirit Lake.

° Cultural resources would not be affected by the alternatives considered. There are no known historical or archeological sites in the areas which would be affected by any of the alternative outlets.

° Geologic conditions favored tunneling and portal construction according to the following priority; a tunnel to Smith Creek, a tunnel to South Coldwater Creek and a tunnel to the North Fork of the Toutle River.

Compliance with Environmental Requirements

A Section 404 water quality evaluation for the recommended plan has been prepared and a water quality certification has been issued by Washington Department of Ecology in compliance with the Clean Water Act. Coordination has been completed with the U. S. Fish and Wildlife Service, the State Historic Preservation Officer, and Federal, state, and local agencies, and interested individuals and organizations. The recommended plan is in compliance with the requirements of the Endangered Species Act of 1973, as amended.

All practicable means to avoid or minimize environmental harm from the recommended plan have been adopted. The U. S. Forest Service has been consulted for advice on minimizing adverse effects on the National Volcanic Monument, and this coordination will continue through project construction. The Forest Service has assisted the Corps of Engineers in locating sites for disposal of excavated material and construction of access roads and staging areas which will cause the least damage to the NVM. Erosion control work to protect the Coldwater Lake blockage has been included in the recommended plan.

During lake drawdown release flows will be monitored to minimize downstream erosion and to observe water quality effects in the receiving waters.

Conclusion

In conclusion, I find that the selection of the recommended plan to construct an outlet to Spirit Lake by tunneling through rock to South Coldwater Creek is based on a thorough analysis and evaluation of various factors of public interest, that reasonable alternatives have been discussed, that the work will comply with established Federal, state, and local laws, regulations and codes, and that all practicable means have been incorporated into the project plans to avoid or minimize environmental harm.

Date: 30 May 84

JAMES W. VAN LOBEN SELS
Brigadier General, U. S. Army
Division Engineer

SIMONS & LI REPORTS

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

February 27, 1984

Memorandum

To: The record
From: Bill Sikonia, USGS, WRD, Tacoma, WA
Subject: Meeting with Nuclear Regulatory Commission, Simons and Li Associates, and Portland General Electric regarding the impact of a potential Spirit Lake outburst on the Trojan Nuclear Plant.

The following is intended to distinguish some of the differences in assumptions between the USGS reports on the subject (Swift and Kresch, Kresch and Laenen, and Kresch), and that of Simons and Li. The main differences are that Simons and Li assumed that less sediment would be entrained in a smaller total volume of water during a hypothetical outburst, and that deposition along the North Fork Toutle, Toutle, and Cowlitz Rivers would reduce the total volume of sediment transported to the Columbia River.

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It is a little difficult to make a direct comparison without some careful reading of the papers, so in the interests of having everyone comparing the same quantities, the following sediment and water volumes may be helpful. To clarify the conversion of in-situ volumes to flow volumes at the debris dam, we have the following comparison:

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USGS (Debris porosity = 32%, and degree of saturation = 50%).

Bulk debris

2.4 bcy	x (1. - 0.32)	= 1.63 bcy	solids from debris
2.4 bcy	x 0.32 x 0.50	= 0.38 bcy	water from debris
2.4 bcy	x 0.32 x 0.50	= 0.38 bcy	air from debris
		0.51 bcy	water from Spirit Lake
		2.52 bcy	total sediment plus water

The sediment concentration at the debris avalanche is 65% by volume.

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Simons & Li (Debris porosity = 31%, and degree of saturation = 30%, approximately).

Bulk debris

0.45 to 1.28 bcy x (1. - 0.31)	= 0.31 to 0.88 bcy	solids from debris
0.45 to 1.28 bcy x 0.31 x 0.30	= 0.04 to 0.12 bcy	water from debris *
0.45 to 1.28 bcy x 0.31 x 0.70	= 0.10 to 0.28 bcy	air from debris *
	0.50 bcy	water from Spirit Lake
	0.81 to 1.38 bcy	total sediment plus water

* Water in the debris was actually ignored. The Simons and Li analysis proposed that incomplete draining of Spirit Lake would keep water from that source to less than 0.50 bcy, perhaps by 0.04 to 0.12 bcy, so that the total water volume from lake and debris would be 0.50 bcy. The initial sediment concentrations at the debris avalanche, under this assumption of total water volume restricted to 0.50 bcy, range from 38% to 64% by volume.

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The corresponding volumes at the confluence of the Cowlitz and Columbia Rivers were as follows:

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USGS

Full sediment and water hydrographs were routed from the debris dam. The flow into the Columbia was assumed to still be 65% sediment by volume.

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                1.63 bcy solids
0.38 + 0.51 = 0.89 bcy water
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                2.52 bcy total sediment plus water
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Peak discharge was obtained by routing a sharply-peaked hydrograph with 65 percent sediment by volume from Camp Baker.

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  705,000 cfs sediment
  385,000 cfs water
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1,090,000 cfs total
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Simons and Li

0.12 to 0.40 bcy solids (0.19 to 0.48 bcy having been deposited in the Toutle and Cowlitz Rivers)
0.50 bcy water

0.62 to 0.90 bcy total sediment plus water

Peak discharge was obtained by assuming triangular water and sediment hydrographs of duration 35.4 hours and peaks so that the assumed total volumes are obtained, which yields

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 53,000 to 173,900 cfs sediment
          212,100 cfs water
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265,100 to 386,000 cfs total
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Deposition of larger sized sediment particles was assumed to occur before arrival of the flood at the Columbia. The resulting sediment concentrations ranged from 19% to 44%.

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The routing of the sediment size distribution from the debris avalanche to the lower Columbia river proceeded as follows:

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USGS

Gravel and Cobbles (>5 mm) -- on to Columbia River,
40% of debris 40% deposited at confluence

Sands (0.0625 to 5 mm) -- on to Columbia River,
40% of debris 30% deposited at confluence
10% carried beyond confluence

Silt and Clay (<0.0625 mm) -- on to Columbia River,
20% of debris 20% carried beyond confluence

The total bulked volume of the sediment deposit at the confluence of the Columbia River and the Cowlitz is

2.4 bcy x (0.40 + 0.30) = 1.68 bcy -- 0.50 bcy upstream (30%)
1.18 bcy downstream (70%)

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Simons & Li

Gravel and cobbles (>5 mm) -- 40% deposited in Toutle
40% of debris

Sands (0.0625 to 5 mm) -- 22 to 15% deposited in Cowlitz
40% of debris 18 to 25% deposited at confluence * **

Silt and clay (<0.0625 mm) -- 20% carried beyond confluence
20% of debris

* Table 3.6 has a slight variation in percentage deposited in the Cowlitz, but a 50%/50% split sand/silt-clay was actually used in the computer runs of appendix B.

** The computer runs of appendix B show about 98% (minimun 94%) of the sand load entering the confluence is deposited there.

The bulked volume of the sediment deposit at the confluence of the Columbia River and Cowlitz river is

[(0.45 x 0.18) to (1.28 x 0.25)] x 0.98
= 0.08 to 0.31 bcy -- 0.06 to 0.25 bcy upstream (80%) ***
0.02 to 0.06 bcy downstream (20%)

*** The upstream/downstream split was estimated by scaling profiles in figure 3.5.

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Other assumptions about the physical processes involved are as follows:

1. With regard to the material subject to entrainment at the debris dam, Simons and Li restricted the volume below the breach elevation of 3475 feet to something less than 1.28 bcy, whereas the USGS said that the volume available is as much as 2.6 bcy.

2. With regard to the sediment deposit in the Columbia River at the confluence of the Cowlitz, Simons and Li used a slope on the upstream side of the deposit of about 7 feet per mile, whereas the USGS used 2.5 feet per mile. The different upstream slopes resulted from interpretation of different streambed profiles for the May 1980 deposit in the Columbia River, one profile from USGS and the other, used by Simons and Li, from the Corps of Engineers. Simons and Li had roughly 80% of the eventually deposited material upstream of the confluence, whereas the USGS had 30% upstream under minimum (10,000 cfs) flow conditions on the Columbia River. Neither USGS nor Simons and Li analyzed the deposit on the basis of the physical processes that govern the shape, upstream slope, height, and location of the deposit.

3. The Simons and Li analysis did not include pore water from the debris, about 0.04 to 0.12 bcy assuming 30% degree of saturation. The USGS analysis assumed a degree of saturation of 50%, for a pore water volume of 0.38 bcy, and included this volume in the analysis. Recent measurements made since both the Simons and Li, and USGS reports were published indicate the water level in wells on the debris avalanche is at 82% of the thickness; that is, 82% of the thickness is saturated. Assuming 50% saturation above the water table, this gives an average degree of saturation of 91% at present. For a bulked debris volume of 2.4 bcy at 32% porosity, this represents 0.70 bcy of water, or 140% of the water volume in Spirit Lake.

4. Simons and Li assumed deposition of sediment in the Toutle and Cowlitz rivers that would reduce the sediment concentration from an initial 38% to 64% by volume on the debris avalanche to 19% to 44% at the Columbia River. The USGS assumed a full 65% by volume concentration for the entire routing. The Simons and Li analysis envisions that that a hyperconcentrated sediment-in-water flow (lower sediment concentrations than in a mudflow) will start developing in the Toutle and Cowlitz rivers, with associated deposition of larger grain sizes. The USGS, while admitting that deposition should be considered along these rivers, envisions a flow that may still be a mudflow, with higher sediment concentrations and poor sorting by size, lower in the Toutle and Cowlitz valleys.

References

Kresch, D. L., Analysis of a hypothetical failure of Spirit Lake blockage and resultant mudflow along the Toutle and Cowlitz Rivers, Washington, U.S. Geological Survey Professional Paper ____, (in preparation).

Kresch, D. L. and Laenen, Ant ius, 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, U.S. Geological Survey Water-Resources Investigations Report 83-4197, 11 p.

Simons and Li Associates, Inc., 1983, Analysis of flood level at Trojan nuclear power plant associated with hypothetical failure of Spirit Lake blockage, 48 p.

Swift III, C. H., and Kresch, D. L., 1983, Mudflow hazards along the Toutle and Cowlitz Rivers from a hypothetical failure of Spirit Lake blockage: U.S. Geological Survey Water-Resources Investigations Report 82-4124, 10 p.