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March 14, 2017

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Mackay Dam: A Preventable Disaster

Dear Governor Otter, Mr. Spackman and Attorney General Wasden,

We are requesting that your offices take preventative action to protect the town of Mackay, Idaho from the collapse of Mackay Dam. Pursuant to Idaho Code Title 42 Chapters 1701-1721, we are requesting that an inspection and administrative enforcement action be commenced for Mackay Dam along with development of an emergency evacuation plan and publication to all residents that lie within the area of inundation.

The content of this letter is based on David McCoy's IDEQ DOE Permit Modification Request Appeal accessible with the link below.

http://environmental-defense-institute.org/publications/MackayDam2002.pdf

Mackay Dam is in poor condition, in an unsafe location and is a clear and present danger to the town of Mackay, Idaho. At risk are 600+ residents and their property that is in close down stream proximity to the dam. Mackay residents will have no advanced warning of an imminent dam collapse. [See attached Koslow Figure 7] Even with warning, evacuation could be difficult or impossible. See attached inundation map for the 100-year flood piping failure that clearly shows Alt. Rt. 93 north and south of the town Mackay (downstream of the dam) are in the flood zone; thus evacuation by vehicle may be blocked. At this time, there is no electronic or human warning system in place to allow evacuation.

Mackay Dam, should it not hold, threatens to send a 79 ft. wall of water towards the town of Mackay within 1 hour. [1] The downstream towns of Leslie (in the flood zone), Dartington, Moore and Arco (immediately adjacent flood zone) would also be affected. [See Reference Map 2] The current dam face is 75 ft. high and the reservoir covers 1392 acres with a storage capacity of approximately 45,000 acre feet of water. Flood water is "about 70 ft. at the dam, diminishing to 4 ft. at [INL Test Area North] TAN." [2]

Mackay Dam was built a century ago (1917) [3] without any thought given "to conform to seismic or hydrologic design criteria." [4] The Utah Construction Co. had no previous experience in reservoir construction. No one knows how safe the dam will be during the next earthquake or major flood or a peak maximum flood (PMF). Mackey Dam lies 11 miles from the Borah fault that caused a 7.3 earthquake (1983) and damage to Mackay Dam. [5]

The State of Idaho classifies Mackay Dam as a Category 1 "high hazard." The dam only receives safety inspections every two years. [6] IDWR Interim Director Gary Spackman letter to the Environmental Defense Institute stated: "Mackay Dam is rated as a high hazard structure because of the potential consequences to downstream life and property in the event of a catastrophic dam failure and sudden release of water." "Updating the emergency action plans includes the **compilation and publication** of current contact information for those individuals and organizations to be notified in the event of an emergency situation. In addition, IDWR will also **encourage** the District to produce an inundation map as a necessary component of their

[1] Koslow, K.N., Van Haaften, D.H., Flood Routing Analysis for a Failure of Mackay Dam, June 1986, EG&G Idaho Inc. Prepared for the U.S. Department of Energy, Idaho Operations Office, page 15 states: "The breach is assumed to develop over a 1-hr period ..." "The peak flow resulting from the PMF-Induced Overtopping Failure is 306,700 cfs in the reach immediately downstream of the dam (Table 7)." Hereinafter referred to as Koslow (1986).

[2] Koslow (1986) PG. 24.

[3] State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 3/27/13. Herein referred to IDWR 2013. "Beginning in 1917 a new contractor (Utah Construction Co.) resumed work on the project originally begun [1910] by Arnold Co..." pg.2.

[4] Koslow, K.N., Van Haaften, D.H., Flood Routing Analysis for a Failure of Mackay Dam, June 1986, EG&G Idaho Inc. Prepared for the U.S. Department of Energy, Idaho Operations Office, page 9. Hereinafter referred to as Koslow (1986).

[5] IDWR (12/4/13) "Photo 3 (10-17-85) – Compare against the 1955 photograph. As evidenced, the 1983 Mt. Borah earthquake and/or the subsequent blasting above the spillway (1984) apparently did indeed result in some displacement of the adjacent rock face; likely due to different response of the foundation materials (alluvium vs bedrock beneath the Tunnel and Tower. The 1985 construction was reported necessary to remove rocks obstructing Gates #1 & #5."

[6] ID Department of Water Resources, Dam Safety Record of Inspection, Mackay Dam, IDWR File No. 34-2225, 8/11/15, Inspector John Falk, Steve Bosworth. Herein referred to IDWR 2015.

emergency action plan. The inundation map depicts the spatial area of estimated downstream flooding for a catastrophic failure of the dam and associated release of water and will assist local emergency providers to plan accordingly for evacuation, supplies, and equipment. The dam owner must work with local governments and emergency personnel to implement and exercise the emergency action plan to help mitigate the risks associated with the presence of a large dam located immediately upstream from a population center." "Your point regarding the seismic activity of the area is well taken. One of the strongest earthquakes to occur in the continental U.S. was centered less than 25 miles from Mackay Dam in 1983. I understand that past performance is no guarantee for future behavior; therefore the age, size, physical condition, and the location of the dam to downstream development all are important reasons for continued close scrutiny of this structure. [7] [Emphasis added]

Despite IDWR Spackman's words above stating he encourages the Big Lost River Water District to "update the emergency action plans" that includes their "compilation and publication" and "produce an inundation map;" there is obviously no real concern for the importance of preventing a dam failure in avoiding loss of life or avoiding a serious radiological catastrophe at the INL .

The public deserves to have IDWR take the need for emergency planning seriously. IDWR needs to have adequate Mackay Dam Operation/Emergency Plan and inundation maps. Currently IDWR acknowledges that these have not been "updated, verified as appropriate." Environmental Defense Institute submitted a Public Records request to IDWR for a copy of the current MacKay Dam Operation/Emergency Plan and was denied.

Another serious issue is that even if inundation maps and emergency plans are current state regulators won't necessarily take any action except during an emergency. As IDWR John Falk was quoted: "'But not all dam owners have updated emergency plans, Falk said. The state does not require them. In fact, state regulators don't have much statutory authority to force irrigation districts and other dam owners to take any action except during an emergency,' such as the one at California's Oroville." [See reference 17]

Recently, heavy rains caused the dam at Oroville, CA to overtop threatening catastrophic failure. Hundreds of thousands of downstream residents were forced to evacuate as a precaution. Such an action is prior to an emergency. Is Idaho prepared to take action prior to Mackay dam failure?

See photos of Mackay Dam Running Over Spillway on April 26 2010 and on June 26, 2011: http://mackayidaho1.blogspot.com/2010/04/mackay-dam-running-over-spillway-april_27.html Mackay Dam began going over the spillway today June 26 2011)

The Idaho Department of Water Resources (IDWR) 2009 [8] [9] recommendation of annual dam inspections by dam inspector has not been followed and is inconsistent with the severity of the

[7] State of Idaho Department of Water Resources, G. Spackman, Interim Director, September 29, 2011, letter to D. McCoy, C. Broscious, et. al. Mr. Speckman is now Director of IDWR.

[8] State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 8/6/09. Hereinafter IDWR (8/6/09)

hazard that the Mackay dam poses with regard to nuclear materials at the Idaho National Laboratory (INL).

Other IDWR recommendations have been ignored for years by the Mackey Dam owner, the Big Lost River Irrigation District. These include (but are not limited to) failure to:

- Maintain a record of the amount of flowing water through the waterworks of the dam;
- Inspect this dam annually;
- Issue storage authorization for one-year intervals;
- Update emergency action/operation plan to keep it "appropriate/current";
- Monitor all leaking water through the base of the dam, and to keep a comprehensive record of flow quantiles for future reference and evaluation;
- Install a log-boom or similar floating barrier at the entrance to the emergency spillway to help prevent boaters from accidental entry when reservoir is experiencing full-pool runoff conditions;
- Remove large trees and brush whose roots will further compromise dam structure that IDWR inspectors have warned about in their reports for years;
- All dam outlet gates must be "exercised annually" to insure operability.

The IDWR 2009 (8/6/09) dam inspection report states: "Much about this dam is not known due to poor documentation during initial construction and subsequent modifications. The amount of leakage observed at the right-center toe of the dam is cause for concern despite claims by the owner that 'it has always leaked like that'." [10] In the inspection, the flow of water from the dam's (downstream base middle) was leaking at a rate greater than 1 cu ft. per second (cfs) with a reservoir pool height (hydraulic ht.) of 58 ft. [11] This is enough water to fill a backyard swimming pool about every 30 minutes.

The IDWR 2011 (9/13/11) report states: "Significant leakage occurs at three locations (see photo 1-2). Total volume from east and middle springs is passed through a 'V' notch weir. Total discharge is est**. (1 cfs)."** [12] This represents a low pool level (also called hydraulic ht.) of 10.8 ft. that decreases seepage pressure. [13]

The IDWR 2013 (3/27/13) report states: "Seepage of the downstream toe was measured through the weir to **(~14 cfs)** …all seepage from downstream toe cannot be measured." [14] This was reported for a full dam (67 ft. hydraulic ht.).

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[9] IDWR website, Dam Safety Program: "The frequency between individual dam inspections depends on such items as the project's **physical condition, method of construction, maintenance record, age, hazard rating,** and size and storage capacity. However, all statutory sized dams must be inspected by IDWR no less than every five (5) years."

[10] IDWR (8/8/09)

[11] IDWR 2009 Inspection report, unlike other reports does no state pool hydraulic height, but does show dam height (67 ft.) – freeboard (8.2 ft.); so the derived hydraulic ht. is 58.8 ft.

[12] State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 9/13/11. Herein after IDWR 2011.

[13] IDWR inspection reports do not use a consistent terminology for dam water level. Some reports use "pool level; some reports use hydraulic ht; and some give dam height and "free board" (distance between dam top and water level).

[14] IDWR 2013

When comparing March 2013 seepage to August 2009, it's necessary to recognize that dams are typically fuller in March (spring) and thus the leakage from higher water level pressure in the dam would produce more seepage than when the level in the dam is lower.

The IDWR 2015 (8/11/15) report states: "Seepage: observed flowing water from areas noted historically. Volume from east and middle springs can be measured at the 'V' notch weir; but seepage from other sources does not report to the weir." "Current release rate reported to be ~347 cfs; flowing from the toe springs ~5-6 cfs. Seepage rate continues at historical levels." [15]
Dam seepage rates are not being monitored often enough or accurately enough to detect problems.

Dispute Over Mackay Dam Spillway Capacity to Prevent Overtopping

On the west side of the dam, the emergency spillway lies beneath a large mass of rock with continuous cracks from top to bottom. This area is susceptible to massive rock movement should an earthquake occur. The steep cliff above the spillway constantly sheds rock into the spillway channel and at the base of the waterworks tower gates inlet, piping, potentially reducing spillway and/or waterworks outlet capacity. There is no abutment on the east side of the dam. The 630 ft. concrete spillway channel is vulnerable throughout its length. [16]

The IDWR 2015 report states: "The emergency spillway consists of a formed concrete channel ~75 feet wide at the entrance. A five foot high concrete sill was added in 1956, but the entrance is **still** uncontrolled (no gate or stoplogs)." [Emphasis added] The dam owners [17] are negligent for not installing "stoplogs" [18] because any flood debris or ice could block the spillway entrance. Spillway blockage may cause dam overtopping in a PMF. "Channel concrete walls and bottom slab are broken, cracked and offset in some places but not appreciably changed since last inspection. The existing condition is appropriate given its age (1932); nonetheless, the high cliff that borders the west side of the spillway exhibits several long, continuous cracks and may present a rock fall hazard." See IDWR 2015 report photos.

The IDWR 2011 Mackay Dam inspection report states: "The estimated spillway capacity at the top of the dam (GH 75.2') is **7000 cfs**; the peak maximum flow flood (PMF) will overtop the dam." [19] ***Apparently the inspection report is including both spillway and waterworks capacity.*** [See Koslow below]

A USGS analysis of Big Lost River PMF states: "The flow of **11,600 cfs** represents the upper 95 percent confidence limit flow for the estimated 100-year peak flow." [20] It is a crucial figure not

[15] IDWR 2015
[16] IDWR 2015 photo # 6 and 7
[17] Big Lost River Irrigation District
[18] "Stoplogs" are crude connected/anchored log float designed to stop debris from entering dam spillway. More effective debris IDWR recommends is a fixed steel grate with sufficient depth to block floating debris but allow flood water to pass.
[19] State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 9/13/11.
[20] Estimated 100 Year Peak Flows and Flow Volumes in the Big Lost River and Birch Creek at the Idaho National Engineering Laboratory, U.S. Geological Survey, Water Resources Investigations Report 96-4163, page 6 &11

only that it is only the 100-year peak flow but not the 500-yr. peak flow compared to Mackay Dam spillway and outlet flow capacity under optimum operating conditions. Additionally, "climate change" has generated extreme weather conditions that must be considered. This was a factor in the Orville, CA where unusually heavy rains overtopped the dam in February 2017.

The Mackay Dam flooding study by Koslow (1986) (Reference 6) estimated peak flow from dam failure for outlet works piping failure and also for a Probable Maximum Flood (PMF) that included both heavy spring runoff and heavy precipitation. Dam failure is expected to occur if the dam spillway and outlet water works capacity is exceeded. Koslow states that the Mackay Dam spillway and outlet works capacities are 3,250 cfs and 2,900 cfs, respectively, totaling 6,150 cfs. [21]

It appears that at least some past safety studies for the INL nuclear facilities have inappropriately used a less severe flooding event, not commensurate with the radiological hazard. Recent safety studies of INL nuclear facilities have not been disclosed. A slow release 100-year "piping failure" and not the PMF scenario have been used. For instance, the PMF is used in the INEEL High-level Waste EIS; [22] which is appropriate, especially given the inadequacy of the Mackay dam design, the spillway limitations. See Reference 6 (Koslow, p. 14). "The spillway of Mackay Dam is not adequate to pass the PMF safely, therefore overtopping and subsequent breaching of the dam due to this PMF were analyzed." (Koslow, p. 16).

Significant flooding from the Mackay Dam may cause release of DOE Idaho National Laboratory (INL) radioactive waste stored or in process at the Radioactive Waste Management Complex (RWMC), may uncover above ground buried waste that is called Pad A, and will hasten the migration of radioactive and chemical contaminants to the aquifer below RWMC and other INL facilities. [23]

We point out that the flooding map may also affect RWMC, though not indicated in the inundation on attached Koslow Figure 6 map. Since the 1950s, the INL has experienced significant flooding events (localized and site-wide) in 1962, 1965, 1969, 1982 and 1984. [24]

Significant flooding from the Mackay Dam may compromise various nuclear facilities at INL/INTEC, including percolation pond, buried waste and in-soil contamination at areas such as the INTEC tank farm where liquid radioactive waste had leaked. And of great concern, flooding of underground high-level waste tanks at INTEC may cause release of radioactive material by shearing piping and cause extensive release of radioactive liquid over the aquifer or calcine

[21] Koslow (1986) pg. B-22-23.

[22] INEEL High-level Waste EIS pg. 1-8, DOE/EIS-02870. See reference #15. Hereinafter HLW EIS.

[23] Hydrological Modeling Study of the Potential Flooding of the Subsurface Disposal Area from a Hypothetical Breach of Dike 2 at the Idaho National Engineering Laboratory, Informal Report, EGG-WM-9502, December 1990. See reference 18.

[24] Koslow, pg. A-3, states: "When the ground is frozen, snowmelt flooding can be extensive. The **RWMC** has been flooded at least 3 times in recent years (1962, 1969, and 1982) by local runoff from rapid spring thaws. In 1969 there was also extensive snowmelt flooding Test Area North (TAN). These flooding events were the consequence of rapid snowmelt caused by heavy rain and warm winds."

waste over the aquifer and above ground. [25] INTEC CPP-666 holds significant spent nuclear fuel and SNF is also stored in dry storage in above ground casks and buried dry storage for Peach Bottom SNF. Adjacent to INTEC is the INL CERCLA Disposal Facility (ICDF) where all radioactive/hazardous cleanup waste is interred in landfill.

Significant flooding also poses nuclear reactor accident risks at the Advanced Test Reactor and will affect various chemical and radiological above ground facilities including spent nuclear fuel pools, ponds, in-soil waste contamination from past percolation pond and facility waste water leakage to soil (and aquifer). Adjacent to ATR is/or will be the Remote-handled Waste Disposition Project. [26] Naval Reactors Facility (NRF) holds spent nuclear fuel inventory at the Expended Core Facility. Test Area North (TAN) has extensive in-soil contamination, in-aquifer contamination as well as nuclear facilities. This is not an exhaustive list of INL nuclear facilities, but only highlights some of the nuclear facilities and hazards.

Even if the flooding does not result in a catastrophic above ground radiological release from one or several INL nuclear facilities, the flooding will hasten the migration of contaminants to the aquifer, contaminants that flow downgradient to communities south of the INL. [See attached Koslow Figure 6 PMF flood map that shows flood reaching NRF and TAN]

Damaged Concrete Outlet Tower and Control Gates

IDWR 2015 report states: "Observe the concrete outlet tower for new cracks, breakage, or other deterioration." "The gates have been prone to sticking in times past; care should be taken to avoid overstressing when opening or closing to avoid damage to stem guides and or the stems themselves. The concrete gate tower appears to be cracked and broken; with an obvious horizontal off-set between construction joints (see photos). These should be carefully watched for any new displacement and/or new cracks or breaks that would indicate renewed movement." See IDWR "Close-up view [photo 4b) of same [concrete Gate tower] showing the concrete lift line and apparent offset between the top and bottom intervals (yellow arrow). On the opposite side of the shaft note the bent stem bracket…" [27] In short, the control gate electric mechanisms and/or questionably accessible manual mechanisms during a PMF are problematic to reduce the dam water when needed during high water and emergency overtopping scenario.

The State of Idaho has a history of ignoring potential disasters. In 1976, the earthen Teton Dam began eroding due to a leak at its base, then burst, resulting in 11 deaths and over a billion dollars in property damage. Teton Dam, built during the same era and of similar design, was only 125 miles away from Mackay Dam.

[25] The HLW/EIS [pg. 4-54] states that "... in the event of a design basis flood with sufficient magnitude and duration, it may be possible that one or more buried [high-level] 300,000 gallon waste tanks could float." Another potential effect could be the failure of high-level waste calcine bin sets. Shearing of service lines and the release of radioactive liquids is another potential hazard in addition to lack of access to tanks needed to receive flood waters pumped from inundated waste facilities.

[26] The new Replacement Remote-handled Low Level Waste facility is not in use yet but could be under construction, and will intern transuranic and Greater–than- Class C low-level radioactive waste that is now dumped at the RWMC.

[27] IDWR 2015

Dam failures can result from any one, or a combination, of the following causes:

- Earthquakes, which typically cause longitudinal cracks at the tops of the embankments, leading to structural failure.
- High water shed snow-pack followed by warm weather, prolonged periods of rainfall and flooding, cause most failures;
- Inadequate spillway capacity, resulting in excess overtopping of the earthen embankment;
- Internal erosion caused by embankment or foundation leakage or piping;
- Improper maintenance, including failure to remove trees, repair internal seepage problems, or maintain gates, valves, and other operational components;
- Improper design or use of improper construction materials;
- Landslides into reservoirs, which cause surges that result in overtopping or block outlet gates;
- Freezing and thawing causing changes in soil density and shrinkage of embankments in contact with bedrock abutments that might adversely affect the safety of earth dams;
- High winds during heavy rains, which can cause significant wave action and result in substantial erosion; and,
- Destructive acts of terrorists; (NOTE: In the spring of 1933, during a drought, farmers desperate for water to irrigate their crops, dynamited the head house tower at Mackay dam releasing all impounded waters, and destroyed diversion equipment at the Blaine Diversion. A week later they also blew up the diversion gates at Darlington. More threats of dynamiting caused the Utah Construction Co. to considerably reduce the asking price for its interest.)

All of the above causes for potential dam failure exist at Mackay Dam.

Can a similar occurrence be prevented? Recommendations to consider are:

- Install an electronic warning system and 24 hour monitoring,
- Create and publish an emergency plan for evacuation,
- Make annual inspections and an action plan to correct deficiencies,
- Repair leakage,
- Spillway repairs to include debris blocking mechanisms,
- The federal government should take over ownership of Mackay Dam due to national security issues,
- The current owner must carry adequate liability insurance for loss of life and property damage,
- Access to the dam should be blocked to prevent sabotage.

In addition to the potential loss of life and property in the towns of Mackay, Leslie, Dartington, Moore and Arco, a failure of the Mackay dam poses the potential for radiological catastrophe from one or several nuclear facilities at the Idaho National Laboratory, many of which may be under several feet of flood water. The hazards from flooding the INL facilities range from above ground airborne release of radioactive material from release of stored materials or reactor severe

accident, release of underground stored radioactive waste including calcine, to accelerated migration of radioactive contamination in-soil and buried at the INL. Remediation of many of these radiological releases likely will not be possible.

With a failure of the Mackay dam, which may occur rapidly from overtopping, earthquake, etc., there may be too little time for evacuation. Currently, it will rely on happenstance to know that the dam is failing. For these reasons, more frequent inspection, dam surveillance of its condition, limitation of water levels as well as emergency planning should all be considered.

We think an emergency plan in the case Mackay Dam would (at minimum) include an early warning to evacuate when for example the dam looks like it's going to overtop. Problem with Mackay Dam is there could be coincidence of several factors—flooding, dam full, overtopping and an earthquake. That's why frequent inspection and maintenance is so important. Specifically, spring inspections to see maximum high water seepage and fall to see dam at low water level when infrastructure is observable. Brings up the question of who has authority to even order evacuation if necessary. Thus, an emergency plan for an aged dam should be public and available or the public should know they are not safe.

Summary

The State of Idaho's leadership must recognize lessons learned from the Teton Dam tragedy and implement legislative remedies to the current non-enforcement of known "high hazard" dam risks that present an unacceptable public hazard. Basically, IDWR recognizes an issue and remains useless as an "enforcement agency" to protect the public when that is their duty to do so because of a reported "lack of authority."

Remedies must include, but not be limited to, annual or more frequent dam inspections, rigorous dam monitoring and maintenance, willingness to invoke management of the dam to reduce the harm of a failure of the dam, and also address the role of preventing a Mackay Dam failure to avoid serious radiological issues caused by severe flooding at INL.

We are requesting that your offices take preventative action to protect the towns of Mackay and Leslie, Idaho from the collapse of Mackay Dam. Pursuant to Idaho Code Title 42 Chapters 1701-1721, we are requesting that an inspection and administrative enforcement action be commenced for Mackay Dam along with development of an emergency evacuation plan plans that includes an inundation map and publication to all residents that lie within the area of inundation. Given the State of Idaho's ineffective measures thus far, the loss of life and a nuclear catastrophe at the INL appears inevitable.

We would like to acknowledge technical contribution and review by Tami Thatcher.

Respectfully submitted,

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Primary Reference:
Before the Director of the Idaho Department of Environmental Quality, In the Matter of the Hazardous Waste Treatment, Order Granting Limited and Storage Partial Review of Permit, Docket No 10HW-0109, Permit for Units at INEEL Bldgs. CPP-659/1659, IDAPA 58.05.013 [40 CFR SS 124.19], David B. McCoy, (PETITIONER) Appellant Brief, 1/11/02.

Attachments:
1. Flood Routing Analysis for a Failure of Mackay Dam, K. N. Koslow, et. al., June 1986, EG&G Idaho, prepared for U.S. Department of Energy, EGG-EP-7184, DE86 013458, Table 7 Results of PMF-Induced Overtopping Failure shows Peak Water Flow at Mackay dam 306,700 cfs. We need to point out that the 306,700 cfs is much more unlikely than a 100-yr or 500-yr peak flood flow. But you also would need to point out that the flood depths (peak water surface elevation) on Table 7 are vastly underestimated because more modern analysis of the flow depths from much lower flooding flow rates yielded higher flood depths at INL facilities in 1998 analyses. Hereinafter referred to as Koslow (1986).

2. Koslow (1986) Figure 6 Inundation map for 100-year flood piping failure that shows flood extending from Mackay Dam to INL Test Area North. This map also the shows the evacuation roads inundated from the dam to Arco. We point out that flooding may also affect RWMC, though not indicated in the inundation map because Koslow gave significant credit to INL Diversion Dam.

3. USGS aerial photo of INL flooding in the vicinity of Radioactive Waste Management Complex with Big South Butte perspective.

4. DOE photo of Radioactive Waste Management Complex flooding of waste trench with Big South Butte perspective, (1962 and 1969).

5. DOE photo of Radioactive Waste Management Complex Pit-9 flooding of waste trench with Big South Butte perspective, (1962 and 1969).

6. DOE photo of Radioactive Waste Management Complex Pit-9 flooding of waste trenched with Big South Butte perspective, (1962 and 1969).

Additional References:

1. State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 8/6/09.
2. State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 9/13/11.
3. State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 3/27/13.
4. Dam Safety Section, Trip Report, To: Kade Raymond, From: John Falk, PE. 12/4/13, IDWR File: 34-2225, Mackay Dam Outlet Inspection.
5. State of Idaho Department of Water Resources, Record of Inspection, Mackay Dam, File No. 34-2225, Date 8/11/15.
6. Flood Routing Analysis for a Failure of Mackay Dam, K. N. Koslow, et. al., June 1986, EG&G Idaho, prepared for U.S. Department of Energy, EGG-EP-7184, DE86 013458, page 9, 15, 16, A-6 & Table 7. Pg. 12 states: "During a PMF the water surface at the dam would rise to a level exceeding 6,077 ft. [mean sea level] msl, overtopping the crest of the dam by more than 1 ft. Four cases have been included in this analysis. 1. Seismic failure of the dam, coincident with the 25-year recurrence interval flood; 2. Hydraulic (piping) failure of the dam, with the 100-year recurrence interval flood; 3. Hydraulic (piping failure), with the 500-year recurrence interval flood; and 4. Overtopping failure caused by the probable maximum flood (PMF)." [pg. 12]

   Scenario 4 is used in the HLW/EIS). Scenarios 1, 2 and 3 assumed a failure time of over one hour. This is a significant factor related to flood elevations downstream from the dam due to longer release duration of the Mackay Dam backwaters. The fourth Mackay Dam failure assumes a near immediate Mackay Dam failure due to overtopping, and a trapezoid opening of the dam. "The PMF represents the hypothetical flood that is considered to be the most severe flood event reasonably possible, based on hydrologic factors." "The PMF is based on the maximum potential for critical hydrometerological [sic] conditions to occur, not on probabilities or historical flood frequencies." (Koslow, p.14).

   Considering that the HLW/EIS and the EDF both are using the USGS, 1986 Koslow, and Bureau of Reclamation (BOR) studies for their calculations which result in different conclusions, these are major discrepancies which could affect the accuracy of other calculations presented in the EDF with respect to hydrodynamic and hydrostatic forces expected to result as a consequence of the probable maximum flood. The prevention of washout at the CPP-659 could likewise be affected by the calculations.
7. Preliminary Water-Surface Elevations and Boundary of the 100 Year Peak Flow in the Big Lost River at the Idaho National Engineering and Environmental Laboratory, Idaho, US Geological Survey, Water-Resources Investigations Report 98-4065, DOE/ID-22148, pages 6, 8, 9 and 11.

8. Final Record of Decision, Idaho Nuclear Technology and Engineering Center, Operable Unit 3-13, October 1999, DOE/ID-10660, page 5-2. Figure 5-1: 100-year floodplain at INTEC (USGS 1998).
9. Charles E. Berenbrock, U.S. Geological Survey Hydrologist, March 25, 1999 email to Chuck Broscious
10. Estimated 100 Year Peak Flows and Flow Volumes in the Big Lost River and Birch Creek at the Idaho National Engineering Laboratory, U.S. Geological Survey, Water Resources Investigations Report 96-4163, page 11 shows flow rates for 5-year, 10-year, 100-year, and 500-year floods.
11. Capacity of the Diversion Channel Below the Flood Control Dam on the Big Lost River at the Idaho National Engineering Laboratory, US. Geological Survey Water Resources Investigations Report 86-4204, C. M. Bennet, page 1 and 25.
12. Hydrology of the Solid Waste Burial Ground, as Related to the Potential Migration of Radionuclides, Idaho National Engineering Laboratory, U.S. Geological Survey, Open File Report 76-471, J. Barraclough, August 1976, page 8
13. Probability of Exceeding Capacity of Flood-Control System at the National Reactor Testing Station, Idaho, U.S. Geological Survey Water Resources Division, P. Carrigan, JR., 1972, page 4.
14. Moriarty, T. P., Feasibility of Locating Dry Storage of Spent Nuclear Fuel on Idaho National Engineering Laboratory Land at a Site That Does Not Overlie the Snake River Aquifer, November 1995.
15. Idaho High-Level Waste & Facilities Disposition Draft Environmental Impact Statement, December 1999, DOE/EIS-02870. The HLW/EIS flood analysis is based on the overtopping of Mackay Dam coupled with the Probable Maximum Flood (PMF). HLW/EIS states that "... in the event of a design basis flood with sufficient magnitude and duration, it may be possible that one or more buried [INTEC high-level] 300,000 gallon waste tanks could float." [Pg. 4-54] Another potential effect could be the failure of calcine bin sets. Shearing of service lines and the release of radioactive liquids is another potential hazard in addition to lack of access to tanks needed to receive flood waters pumped from INTEC waste facilities. The INTEC tank farm pipe penetrates the inner cell structure. There is no specificity as to what flood protection devices are designed to route water to a sump in the valve cubicle. If one or more 300,000 gallon tanks are floated, as the HLW/EIS states as a possible effect of the 100-year flood, what is the potential impact of such an event on the HLW Integral Waste Treatment Facility and other waste facilities?
16. Idaho Department of Environmental Quality, IDEQ/INEEL Quarterly Meeting June 8, 2000 Neil C. Hutten). The twenty-five year floodplain analyses which have been performed for INL facilities that have containers, tanks and waste piles "need to be evaluated to determine ... whether they need to be updated for current conditions." (There is no apparent indication that IDEQ considered that the waste facilities, tanks and containers may not have been assessed from the perspective of the 100 year flood.
17. "*Dam threat places spotlight on aging Idaho dams*," Posted: February 15, 2017 5:08 p.m. By Rocky Barker, *Idaho Statesman*. Article states; "But even with the threat of an 80- foot wall of water just six minutes away from the 600 residents of Mackay, people there don't worry. Not even as they watch news reports of the evacuation of 200,000 people this week from below the Oroville Dam in California."

"Federal dams, such as Lucky Peak east of Boise owned by the U.S. Army Corps of Engineers, and Arrowrock, farther up the Boise River and owned by the U.S. Bureau of Reclamation, go through a tougher, federal inspection regimen, said Michael Coffey, public affairs officer for the Bureau of Reclamation's Northwest Region office in Boise.

"Idaho tragedy

"The bureau's dam-safety program was forced to become stronger after its Teton Dam failed on June 5, 1976, killing 11 people and 13,000 livestock, and causing an estimated $2 billion in damages in Idaho Falls, Rexburg and other communities.

"On Feb. 10, Falk sent a letter to the owners of all of the high-hazard dams in Idaho, recommending they begin releasing water gradually to make sure they have enough space for all of the runoff in their watershed this spring. He also told them to make sure that their spillways are clear of obstructions and that they have reviewed and updated their emergency plans.

"But not all dam owners have updated emergency plans, Falk said. The state does not require them. In fact, state regulators don't have much statutory authority to force irrigation districts and other dam owners to take any action except during an emergency — such as the one at California's Oroville.

"The state does have power, however, to restrict how much water dam owners may store in their reservoirs. In 2004, the state forced the irrigation company that owned the Fish Creek Dam near Carey to restrict its pool by half. The irrigators explored the cost of rebuilding the dam to allow them to store all their water again. The estimate was from $11 million to $20 million, Falk said, and the pool has remained restricted.

"If you mortgaged all the land under irrigation, you still wouldn't have enough collateral for the bank to build the dam," Falk said."

18. Hydrological Modeling Study of the Potential Flooding of the Subsurface Disposal Area from a Hypothetical Breach of Dike 2 at the Idaho National Engineering Laboratory, Informal Report, EGG-WM-9502, December 1990 that states: "This investigation shows that the SDA berm is in danger of being overtopped by a breach flood under the most extreme case investigated." "A Mackay Dam failure is considered to be the practical limit of water available to discharge in the Big Lost River Drainage Basin. To simulate maximum inflow into Spreading Area A, the peak flow at the INEL Diversion Dam due to a Mackay Dam failure must coincide with the peak flow recorded in the 1965 flood. For the model, the failure of the dam occurs at 480 hours into the simulation." [Executive Summary pg. iii]
19. *Another Teton Dam Disaster More Plausible Than You Think*, Editorial, Aug 21, 2011, Magic Valley News.com. "For a decade, environmental activists David McCoy and Chuck Broscious have told anyone who will listen that 93-year Mackay Dam on the Big Lost River in eastern Idaho is a disaster waiting to happen.

"The earth- and rock-filled structure leaks like a sieve, they say — 1 cubic foot per second, or enough to fill a backyard swimming pool in 30 minutes. It's also located close to the fault line that caused the destructive 1983 Borah Peak Earthquake.

"Downstream is the town of Mackay, and beyond that Idaho National Laboratory — and more than a dozen 300,000-gallon underground storage tanks filled with high-level nuclear waste. Theoretically, a big enough flood could release radiation.

"The Idaho Department of Water Resources knows all about Mackay Dam — the agency rates it "high hazard," or its top risk, but is hard-pressed to do much about it. Because of budget cuts, IDWR now has a dam safety staff of three, none of whom is based in eastern Idaho.

"That's because the agency — which in addition to monitoring to dam safety is vital to south-central Idaho's irrigation-based economy — has had its budget cut 30 percent in three years.

"So on this, the 35th anniversary of the spectacular collapse of the Teton Dam in eastern Idaho, it's time to decide IDWR's cuts can't go any deeper. Dam safety is a minor part of IDWR's responsibility, but if something goes wrong the consequences will outweigh anything that's happened in the agency's 116-year history. Idaho has 134 dams, seven of which are classified "high hazard" or "significant hazard."

"In 2007, the Association of Dam Safety Officials — a national organization — named Fish Creek one of four high-hazard dams in Idaho due to structural deficiencies and the threat to human life if it failed.

"But the dam had problems before that. In 2002, IDWR required the Fish Creek Reservoir Co. to install a dam-failure warning system, and in 2005 the agency ordered a larger spillway be cut into the dam to prevent water from rising too high.

"One of the most fragile is in south-central Idaho. Eighty-eight-year-old Fish Creek Dam, located 11 miles northeast of Carey, is so troublesome that Fish Creek Reservoir can never be filled more than 80 percent.

"McCoy wants a dam-failure warning system installed and 24-hour monitoring begun at Mackay Dam — but it's unclear who would pay for it. What is clear is that a state agency with a single inspector and a dam-safety budget of less than $300,000 can't adequately protect Idahoans.

"The Legislature has a lot of backfilling to do at Water Resources. It must start with dam safety in eastern Idaho is a disaster waiting to happen."

20. *Expert: "significant risk" of dam issues in east Idaho*, By: Chris Oswalt Posted: Feb 16, 2017. "IDAHO FALLS, Idaho (KIFI/KIDK) – "The state of Idaho's Dam Safety Program, run by the Idaho Department of Water Resources, is responsible for the inspection of nearly 450 dams across the state. Many of the dams across the Gem State are extremely old, which plays a factor into its stability.

"The older the dam, the more problems it experiences based on age," Dam Safety Program Manager John Falk said.

The age of the dams holding back thousands of gallons of water in east Idaho is a concern for those responsible for making sure they are up to code. Falk says that a number of the dams in east Idaho are seeing problems and are at risk of failure.

"Earthen dams require a lot closer scrutiny," Falk said. "They are less resistant to over-topping. Once they start to erode, and water starts to pass through them or over them, they can disappear pretty quickly."

The dam of biggest concern for Falk and his team is upstream from the town of Mackay. Falk says the dam, last inspected in 2014, is leaking near the toe.

"It leaks more than you might expect from an earthen dam," said Falk.

"While there is no deterioration at the Mackay dam, Falk worries that a quick snow melt could cause the water to rise face, causing the dam to give way, recreating a scene like we saw 41 years ago when the Teton Dam broke.

'If it were to fail quickly, similar to what Teton Dam experienced, there would be loss of life,' said Falk."

[**This Local News 8 includes a video of the most at risk Idaho dams like Mackay and Oakley**]. http://www.localnews8.com/news/idaho/expert-significant-risk-of-dam-issues-in-east-idaho/338452411

21. *Dam Disasters* (click on Teton Dam at top for pictures taken during the Idaho catastrophe. https://www.bing.com/images/search?q=dam+disasters+in+the+us&qpvt=dam+disasters+in+the+US&qpvt=dam+disasters+in+the+US&qpvt=dam+disasters+in+the+US&FORM=IGRE

We haven't yet seen a dam that spilled onto a nuclear waste facility after wiping out an entire town and its population when the environmental regulators knew it was all possible.

22. https://www.fema.gov/why-dams-fail

"Dams can fail for one or a combination of the following reasons:

* Overtopping caused by floods that exceed the capacity of the dam
* Deliberate acts of sabotage
* Structural failure of materials used in dam construction
* Movement and/or failure of the foundation supporting the dam
* Settlement and cracking of concrete or embankment dams
* Piping and internal erosion of soil in embankment dams.
* Inadequate maintenance and upkeep."

TABLE 7. RESULTS OF PMF-INDUCED OVERTOPPING FAILURE

Location (Approximate Elevation, ft msl)	Streambed Elevation (ft msl)	Peak Water Surface Elevation (ft msl)	Peak Flood Flow (cfs)	Peak Water Velocity (ft/sec)	Time of Wave Arrival (hr)
Mackay Dam (6076)	5997	6078	306,700	8.5	0.0
Arco (5310-5410)	5309	5319	147,720	5.6	6.7
INEL Diversion (5065)	5043	5073	71,850	1.0	10.0
CFA (4928-4940)	4935	4942	67,830	3.4	12.8
TRA (4920-4925)	4919	4924	67,170	2.8	13.2
CPP (4914-4930)	4911	4917	66,830	2.7	13.5
NRF (4845-4850)	4846	4851	61,620	1.9	16.4
TAN/LOFT (4780-4795)	4778	4786	34,810	1.1	34.5

Total Flow to INEL Diversion Area: 27,460 ac-ft

Total Reservoir Release: 142,330 ac-ft

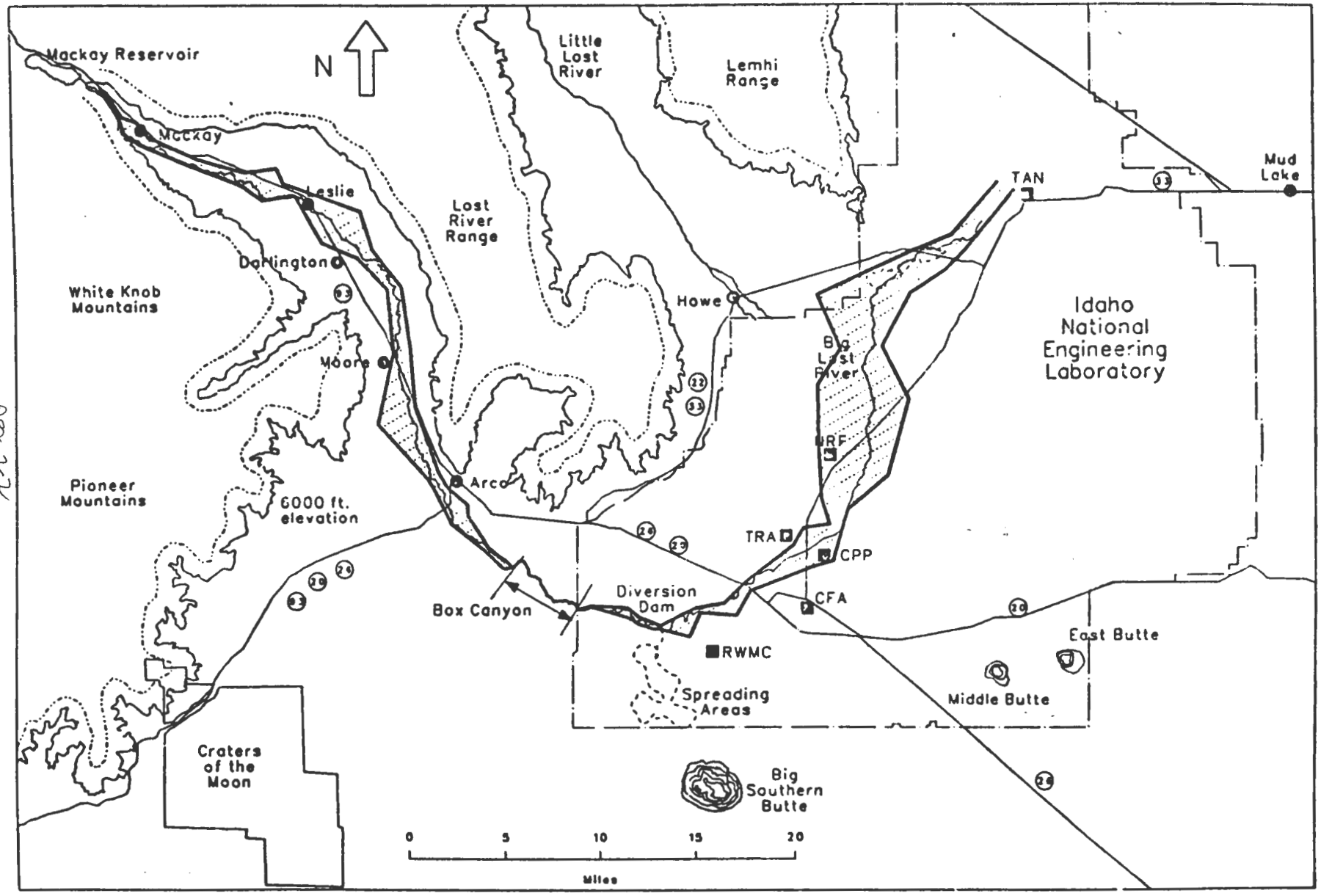

Figure 6. Inundation map for the 100-year flood piping failure.

Flood Routing Analysis for a Failure of Mackay Dam
EGG-EP-7184, DE86 013458, June 1986, pg 22

RWMC Pit-9 1962-1969 flood of waste trench, Big Southern Butte in upper right

1962-1969 RWMC-Pit-9 flood of waste trench, Big Southern Butte in upper right

RWMC Pit-9 1962-1969 flood of waste trench, Big Southern Butte in upper right