Mitman, Jeffrey

From: Khanna, Meena
Sent: Wednesday, December 22, 2010 12:57 PM
To: Mitman, Jeffrey
Subject: Re: OUO - Oconee Flooding Issue Presentation

Thx Jeff

From: Mitman, Jeffrey
To: Harper, Kevin; Cunningham, Mark; Skeen, David; Wilson, George; Khanna, Meena; Rodriguez, Veronica; Coleman, Neil; Wescott, Rex; Bartley, Jonathan; Rapp, Curtis; Rogers, Walt; Ferrante, Fernando; Persinko, Andrew; Stang, John; Kulesa, Gloria
Sent: Wed Dec 22 12:50:50 2010
Subject: OUO - Oconee Flooding Issue Presentation

All,

Attached is the presentation material that I plan to discuss during this afternoon's discussion. There is a lot of ground to cover, I want to cover all of the issues and therefore, many of the slides are supplied as background.

Thanks.

Jeff Mitman

E-25

U.S.NRC

United States Nuclear Regulatory Commission

Protecting People and the Environment

Concerns with Oconee Flooding Issue

Jeff Mitman

NRR/DRA

December 22, 2010

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overview: Adequate Protection Issue

- NRC letters questioned ONS's adequate protection from Jocassee Dam failure
  - NRC 50.54(f) (ML082750106) and follow-up (ML0905707790)
- Is Duke's inundation analysis bounding and/or conservative?
- What is consequence to Oconee of Jocassee Dam failure?
- Does Oconee (ONS) have defense-in-depth from Jocassee Dam failure?

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Does Oconee Have Adequate Protection?

- To answer this question NRC needs to know given Jocassee Dam failure:
  - What structures, systems and components (SSC) are damaged?
  - What SSCs survive?
- Need to know not only depth of water at SSF, but also
  - Velocity, duration and location of water across entire site
  - How water affects SSCs

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

State of Knowledge as of Sept. 2008

Per Duke letter (ML082750106) if Jocassee fails from Jocassee full pond level (1110 ft. msl):

- Water level at SSF ~815 ft. msl
- Offsite & onsite power loss
- ECCS fails
- BOP fails
- SSF fails
- 3 Units go to core damage in ~8 to 9 hours (CCDP = 1)
- 3 Units have containment failure in ~59 to 68 hours
- Loss of cooling to both spent fuel pools

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

State of Knowledge as of Sept. 2008 (cont.)

- Based on DRA estimation, CDF is: ~2E-4 per year
- This is about three times higher than all internal events combined
  - For other internal events (e.g., large LOCA) there is defense-in-depth and safety grade mitigation (ECCS) capability
- Oconee lacks defense for this hazard
- Oconee lacks defense-in-depth for this hazard
  - Memo DE to DORL ML102990064 dated 10-26-2010
  - I agree

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Definition of defense-in-depth

From Regulatory Guide 1.174

- Balance between prevention of core damage, prevention of containment failure, and consequence mitigation
- Avoid over-reliance on programmatic activities to compensate for weaknesses in plant design
- System redundancy, independence, and diversity are preserved commensurate with expected frequency, consequences of challenges to system, and uncertainties
- Defenses against potential common cause failures are preserved
- Independence of barriers is not degraded
- Defenses against human errors are preserved
- Intent of GDC in Appendix A is maintained

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Is Current Hydrology Analysis Bounding?

- Duke analysis to date:
  - ONS Jocassee-Keowee Dam Breach Model Report (March 2009): HEC-RAS 1-D
  - ONS Jocassee-Keowee Dam Breach Study, HEC-RAS 1-D (April 2010)
  - ONS, Jocassee 1-D Hydraulic Model Study (April 2010)
- Duke summarized analysis in letter dated August 2, 2010 (ML1021700060)
- Scope: sunny day failure assumed from piping

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Is Current Hydrology Analysis Bounding? (cont.)

- Peer review states (letter report to Duke dated 06-14-2010):

  "I want to emphasize that applications of complex hydraulic models is an art. The objective of ... modeling is to simplify an impossibly complex natural system so that it can be simulated ... Not all of the laws of physics are even represented in the extreme conditions such as those associated with a dam breach. The models cannot be calibrated using observed data because the regulated stream system has never exceeded full pond elevation."

- This speaks directly to issues of margin and uncertainty

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

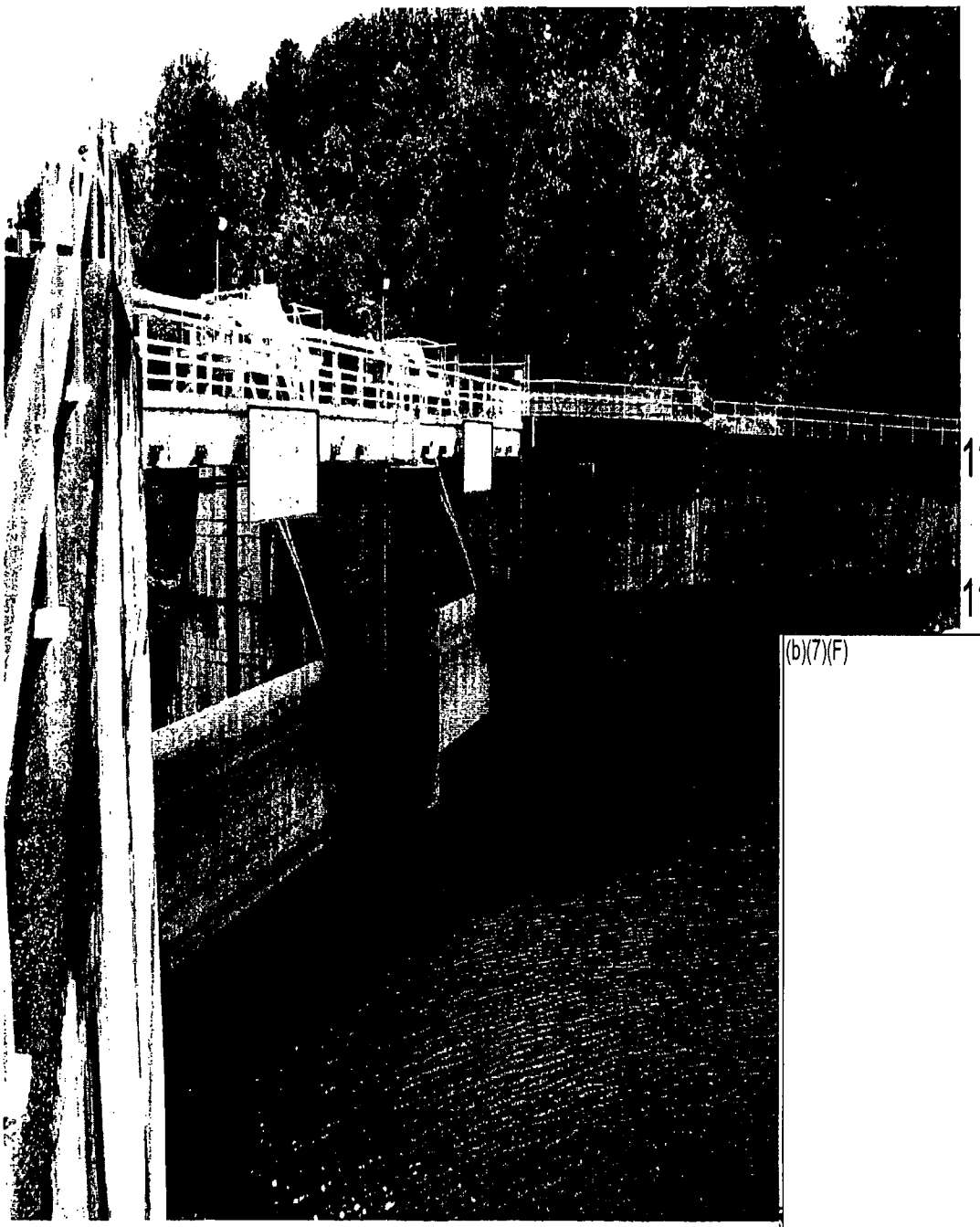
What is Basis for Max Level of 1110 ft. msl?

- Per Duke:
  - Per UFSAR PMP will not cause overtopping
  - Jocassee has never been operated above 1110 ft. msl
  - Dam operation procedures require maintaining level below 1110 using:
    - Turbine generators
    - Spillways: to be 100% open if water level reaches 1111 ft. msl
  - Therefore, 1110 is conservative
- My understanding
  - Jocassee Reservoir has been to 1110
  - UFSAR defines licensing/design basis
  - OFI has been categorized as adequate protection (see ML 0905707790)
  - Because UFSAR screens this out does not rule this beyond consideration in an adequate protection case

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Jocassee Spillway



1123.5 ft. msl

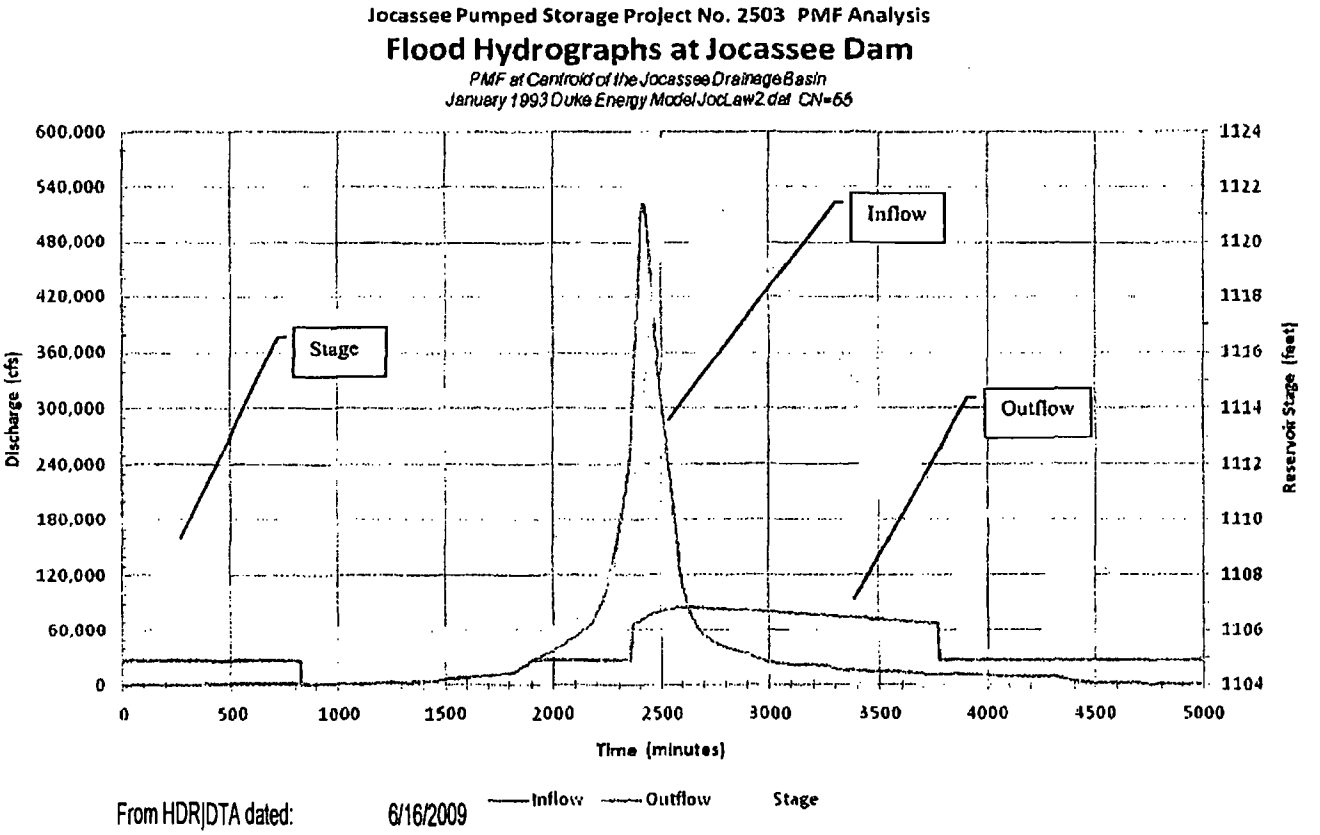
1110 ft. msl

(b)(7)(F)

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Duke/Law PMP Hydrograph



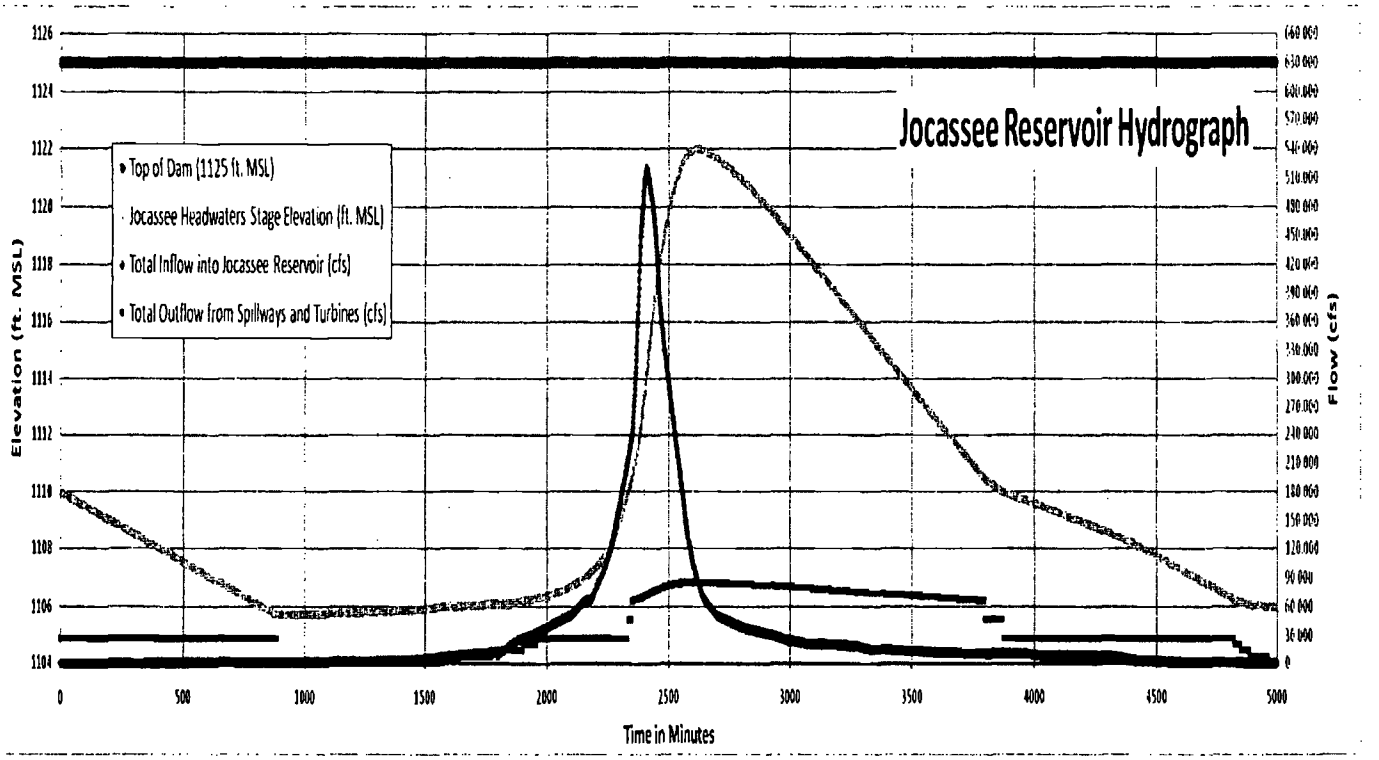
From HDR|DTA dated:	6/16/2009
Basin Drainage Area:	145 square miles
HMR Used:	HMR51/52
Basin Average PMP:	36.41 inches in 72 hours
Peak MPF Inflow:	522,734 cfs
Peak PMF Outflow:	85,405 cfs
Maximum Pool Level:	**1122.0 ft. msl**

Duke's only analysis of record shows that level can go above 1110

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

DRA Comparison PMP Analysis



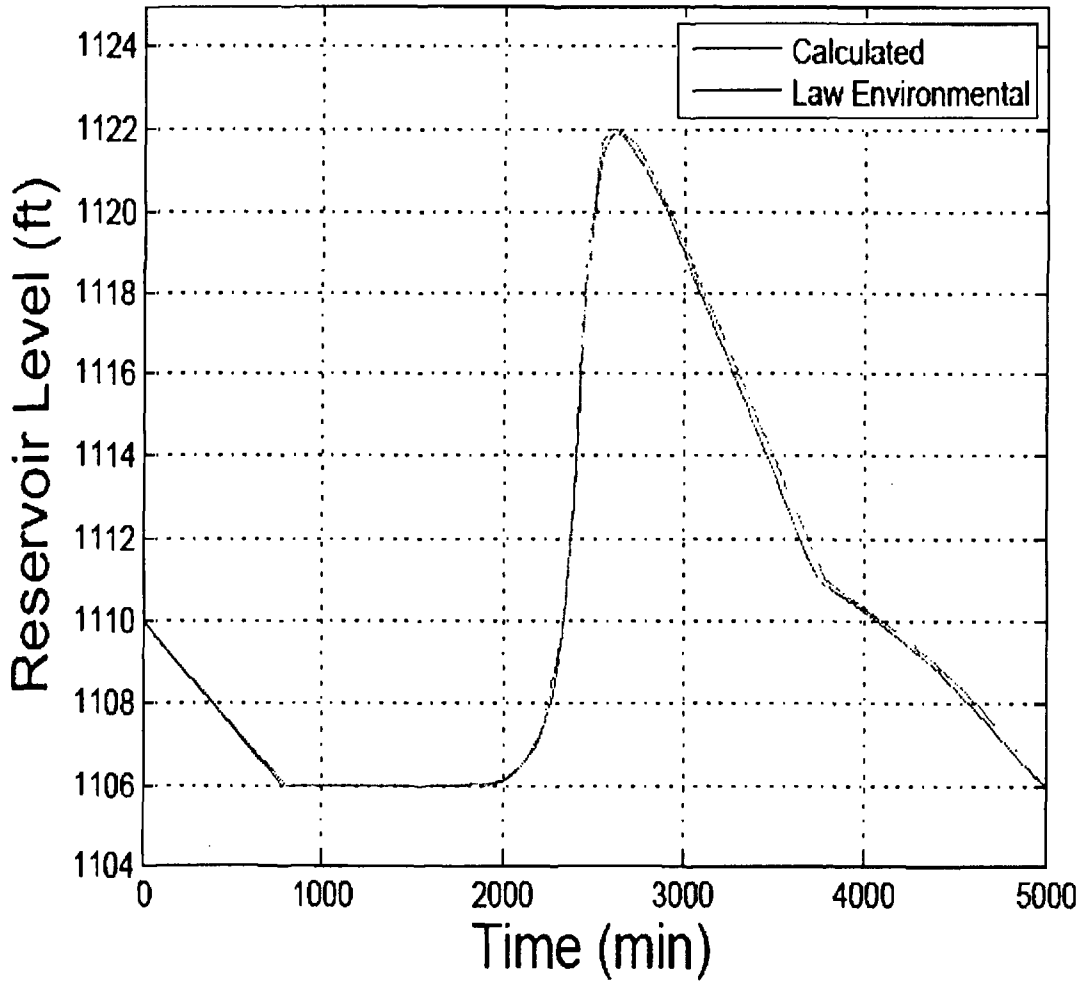
Calculated in both Matlab and Excel

- Turbines available
- Spillways available
- DRA predicts max water level = 1121.99

~~OUO - Sensitive Information - Do Not Disclose~~

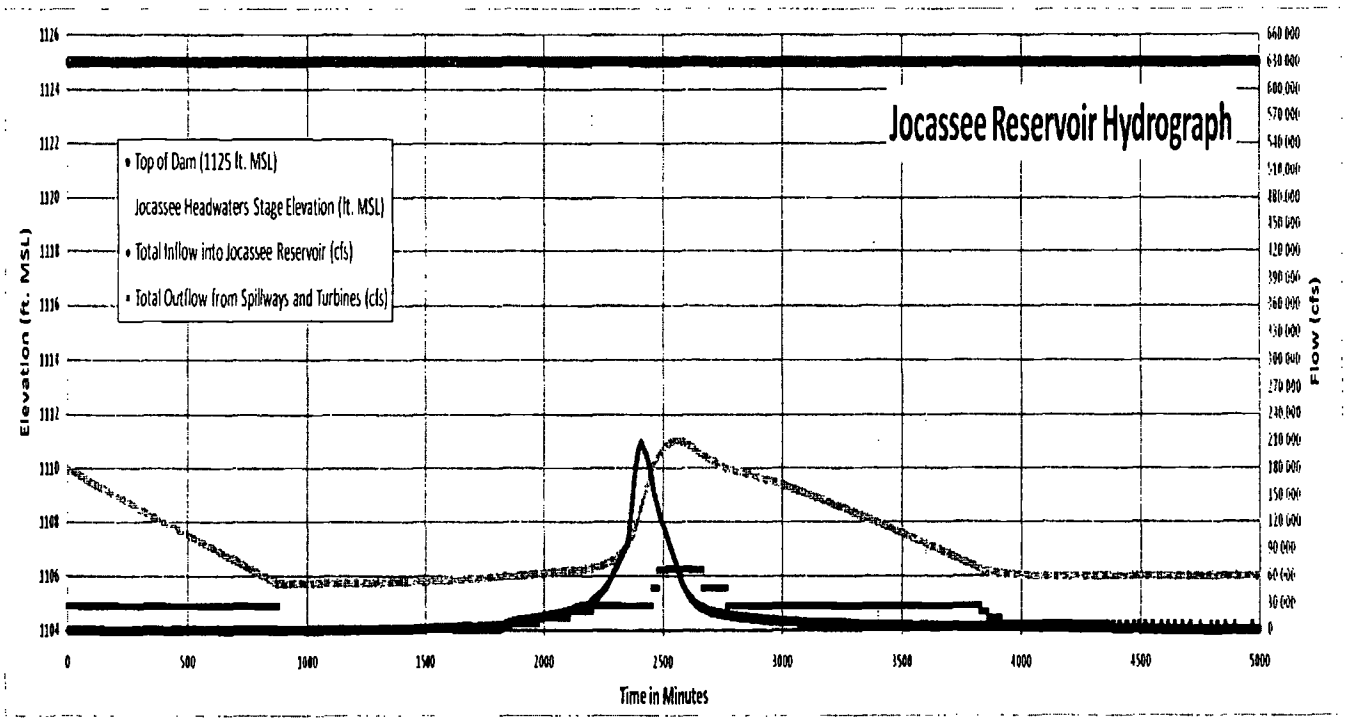
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Comparison of Law to DRA PMP Hydrographs Using MATLAB



U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

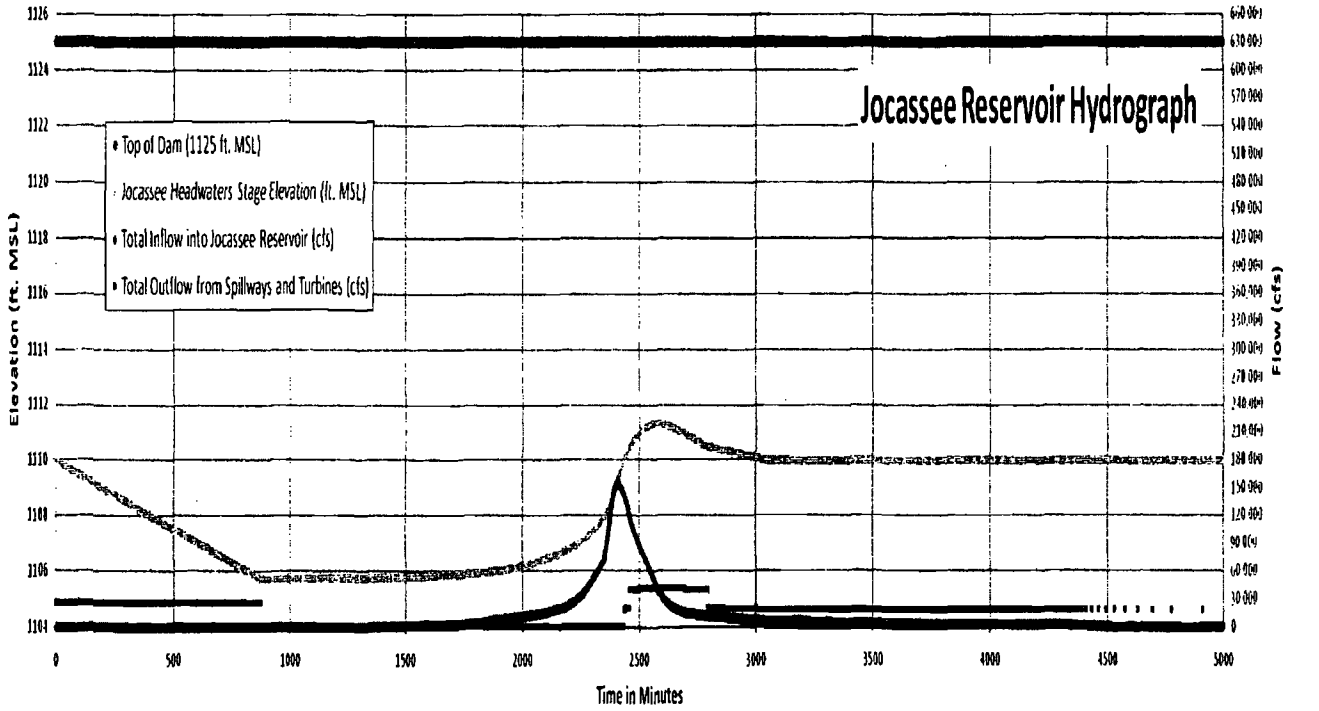
DRA Analysis of 40% of PMP Storm



- Turbines available and credited
- Spillways available and credited
- Max water level = 1111 ft. msl
- Any storm greater than 40% of PMP will have water levels above 1110 ft. msl

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

DRA Analysis of 30% PMP without Turbines

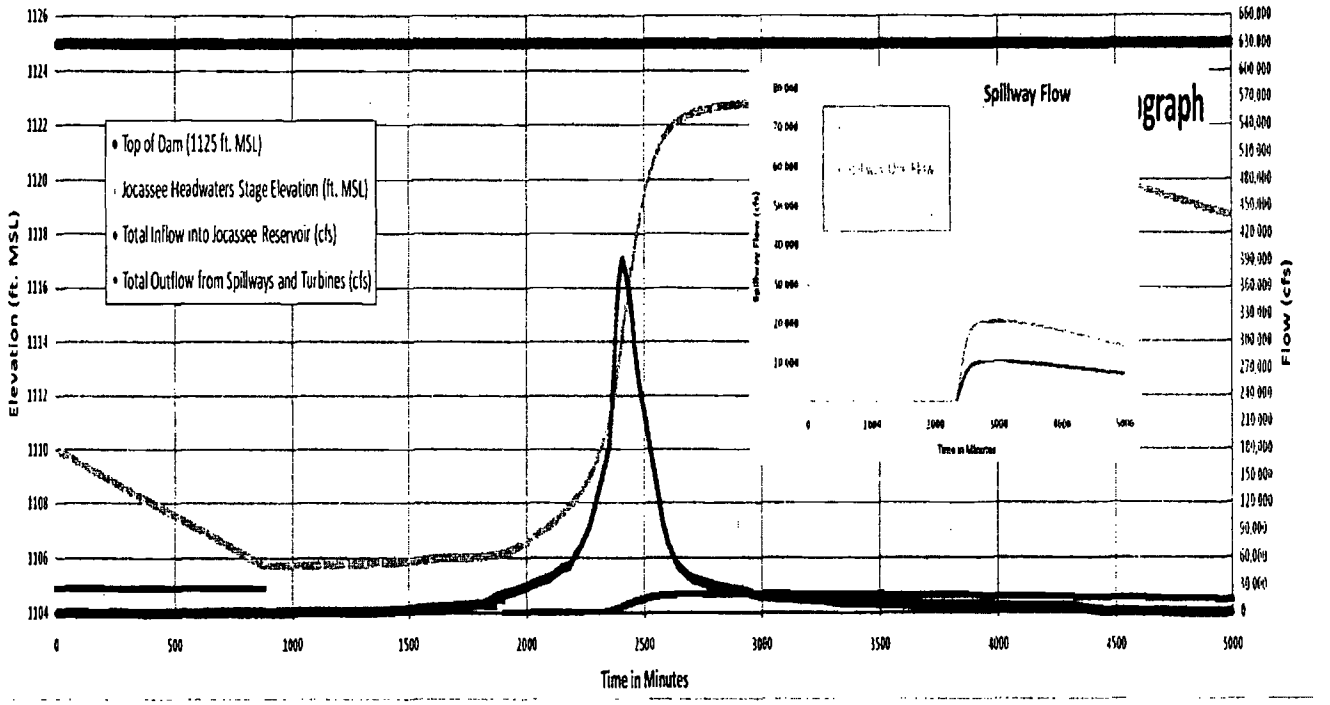


- Turbine available early
- Turbines assumed to fail as storm intensifies
  - Typical turbines cannot be run unloaded
  - Requires generator available
  - Generator requires grid available
  - Availability of grid during a PMP is questionable
- Spillways available and credited
- Max water level = 1111 ft. msl

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

75% PMP without Turbines or Spillways



- Turbine available early
- Turbines assumed to fail as storm intensifies
  - Typical turbines cannot be run unloaded
  - Requires generator available
  - Generator requires grid available
  - Availability of grid during very large storm is questionable
- Spillways assumed to fail: not expected to be rare during large storm
- Max water level = 1122.8 ft. msl

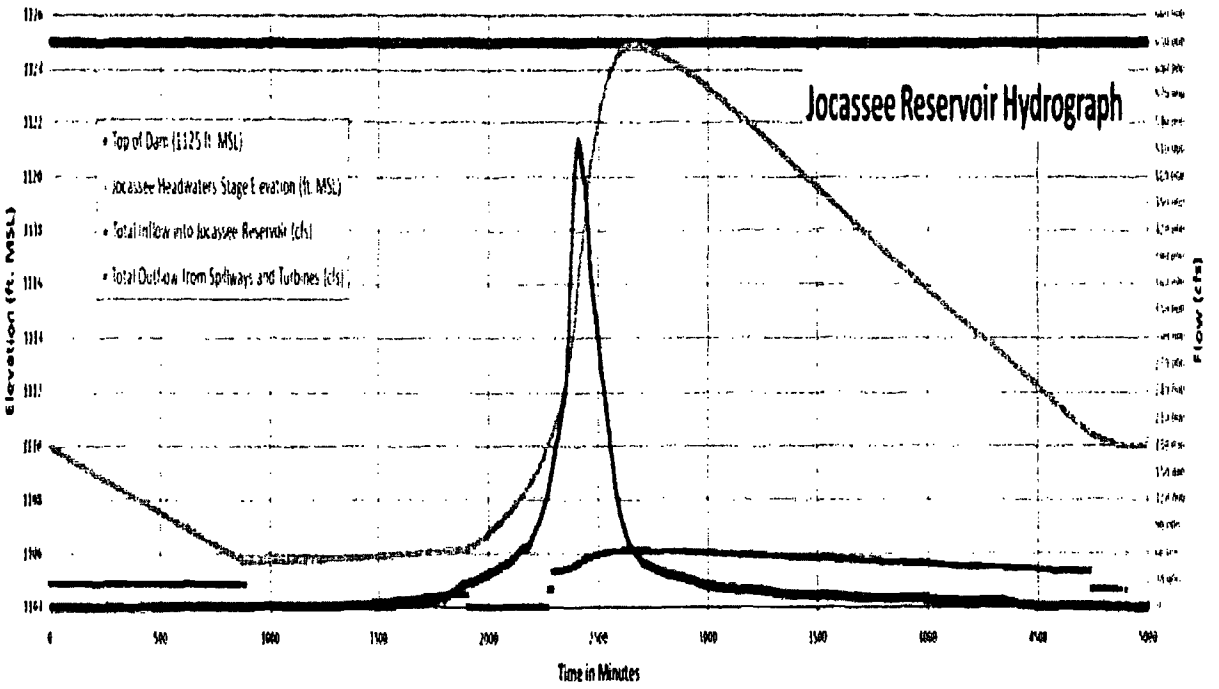
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Conclusion 1110 is not bounding

- Duke's PMP analysis of record clearly indicates that water level can exceed 1110
- Comparatively "small" storm (40% of PMP) indicates level will exceed 1110 with max outflow from turbines and spillways
- In my opinion this demonstrates that 1110 is not conservative and not bounding value
- Note: these are <u>not</u> "sunny day" failures

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

DRA Analysis of PMP without Turbines

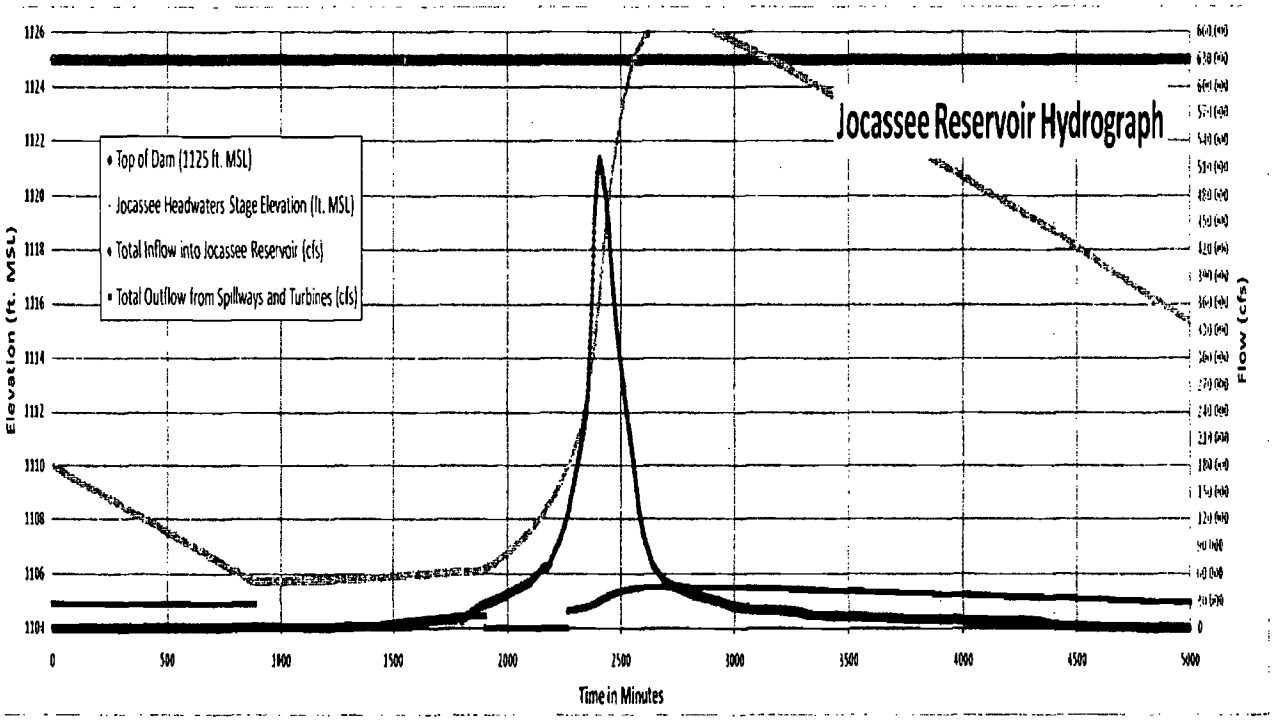


- Turbines available early
- Turbines assumed to fail as storm intensifies – this is highly likely scenario
  - Typical turbines cannot be run unloaded
  - Requires generator available
  - Generator requires grid available
  - Availability of grid during a PMP is questionable
- Both spillways available
- Max water level = 1124.9 ft. msl
- **No margin for uncertainty**

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

PMP without Turbines and 1 Spillway



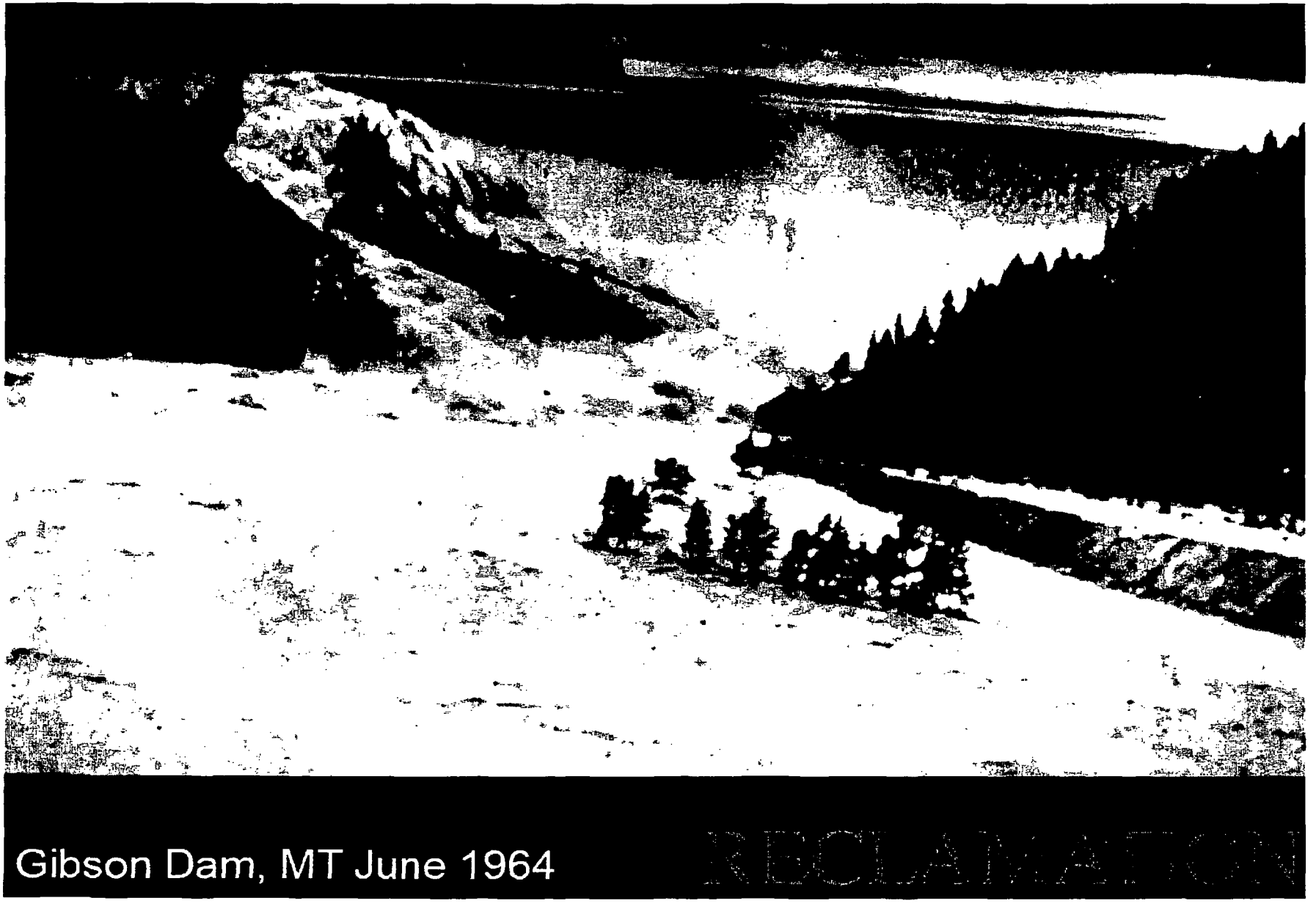
- Turbines available early
- Turbines assumed to fail as storm intensifies
- One spillway fails (probability of spillway failure during normal times is between 0.1 and 0.01 per demand)
- Max water level exceeds 1125 for hours

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Gibson Dam Overtopping Case Study

- Gibson is concrete dam
- June 6-8, 1964 record regional rainstorm in northern Montana
- Spillway radial gates not fully open controls inaccessible
  - 2 gates completely open
  - 2 gates completely closed
  - 2 gates partially open
- Overtopping about 3 feet over parapet for 20 hours
- Dam did not fail



Gibson Dam, MT June 1964

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Overtopping Conclusion

- Duke's PMP analysis of record indicates that water level reaches 1122
  - There is significant uncertainty
  - Duke's assumption that spillway and turbines work during very large storm is optimistic
- DRA analysis indicates that if optimistic assumptions on spillways and turbines is wrong Jocassee will overtop
- This issue raised previously:
  - April 2009 non-concurrence
  - US Bureau of Reclamation TLR to NRC dated 7-6-2009
- In my opinion: 1110 ft. msl is not conservative

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Why is Jocassee Level Important

- Higher levels at Jocassee mean more water behind dam and at ONS
- Higher water levels increase Jocassee Dam failure probability
  - Because Jocassee has never been above 1110, if it does go above 1110 Jocassee may behave as a juvenile dam
- Higher water levels mean faster failure and less warning
- Level sensitivity analysis was requested in NRC 50.54(f) follow-up letter dated 4/30/2009
  - "The sensitivity analyses should include varying key parameters that can affect the on-site flood height (e.g., breach size, **reservoir levels**, and time to dam failure) individually and in combination over a sufficient range to provide an understanding of how changes impact the flood height estimates."
- Duke did not vary reservoir levels in their analysis
- Duke committed to submit Jocassee Dam PRA by ~1/2010: this has not been submitted

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Relationship of Level to Failure Probability

"The possibility of failure must not be lost sight of. To Sum up in a concrete manner, it is my judgment that the chance of failure with the water at varying elevations will be substantially as follows:

	Elevation	Chances
	3795	1 in 5000
	3800	1 in 2000
LIKELYHOOD	3805	1 in 500
	3810	1 in 100
	3815	1 in 10"

Thaddeous Merriman, New York, February 21, 1912

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

What Are Consequences of Jocassee Dam Failure?

From Duke 2-D analysis results reported in 8-2-2010 letter

- Keowee headwater elevations above 817 ft msl at 2.1 hours after Jocassee Dam fails
- ONS intake canal elevations above 817 at 2.9 hrs. after Jocassee Dam fails
- SSF max water level at 815 3.7 hrs.

Questions:

- When will onsite and offsite power be lost?
- When will water enter turbine building basement and cause failure of BOP, ECCS and require operation SSF?
- When does water level overtop SSF walls?
- Low pressure Hale (B.5.b) pumps will require that secondary and primary be depressurized for this mitigating strategy to be successful. Can this be accomplished before SSF fails?
- These issues speak directly to probability of success of mitigation actions

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Example Consequences from High Level

- ONS USFAR Rev. 18 in Section 3.4.1.1.1 discusses internal flooding
- Wall separating Turbine and Aux. buildings ("N" line) has been analyzed up to flood depth of 20 ft. (775 + 20 = 795 ft. msl)
- Potential height per 2-D analysis is 815 or 40 ft.
- Some walls in Aux. Bldg. are block
- Will this wall survive?
- If it fails what are impacts to mitigation/recovery?
- Are there other structures (e.g., walls, ingress points, etc.) that could be impacted?

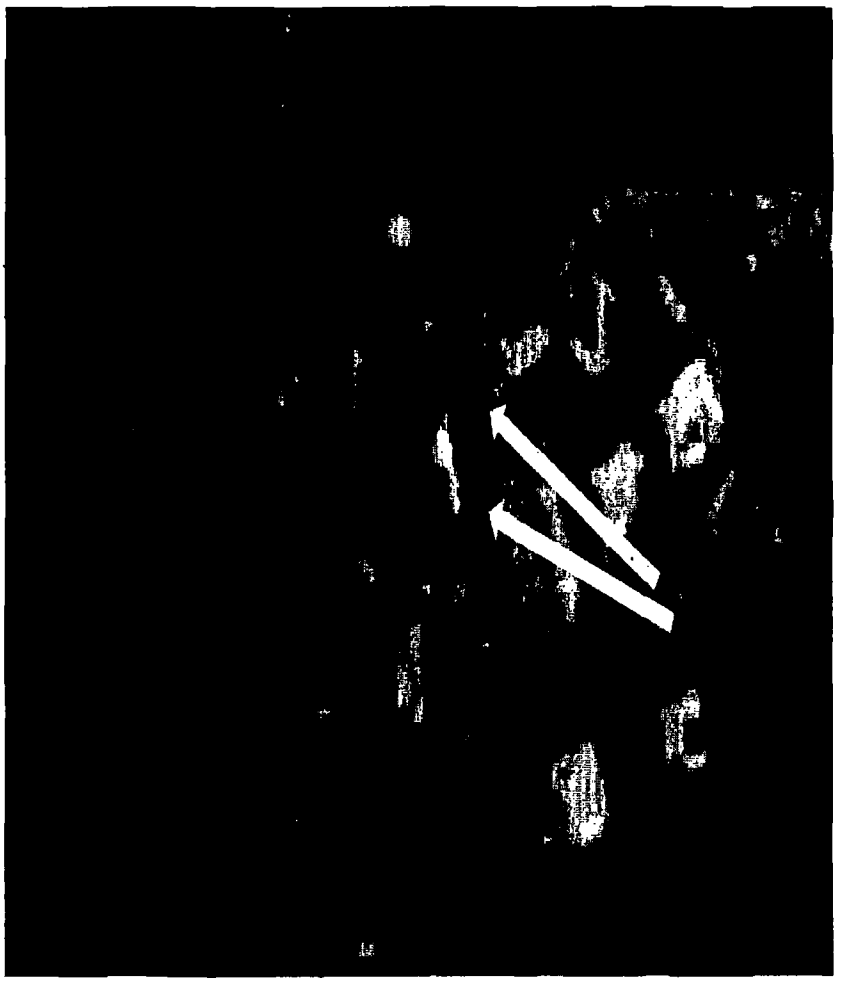
U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Flow Consequences

- Duke's 1-D analysis from 3-2009 indicates:
  - Peak flow across Keowee dam is ~3.2 million cfs
  - Peak flow across ONS Intake structure is ~0.5 million cfs
  - As reference comparison: average flow in Mississippi River at New Orleans is 0.6 million cfs
- What are velocities of this water as it crosses ONS and what damage will it do?
- Duke's hydrology analysis indicates that scouring is not considered. What damage will this scouring do to SSC in yards and buildings?
- What deposition of material from flood waters will occur and what damage can this cause?

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Supercritical Flow Areas Near Power Block

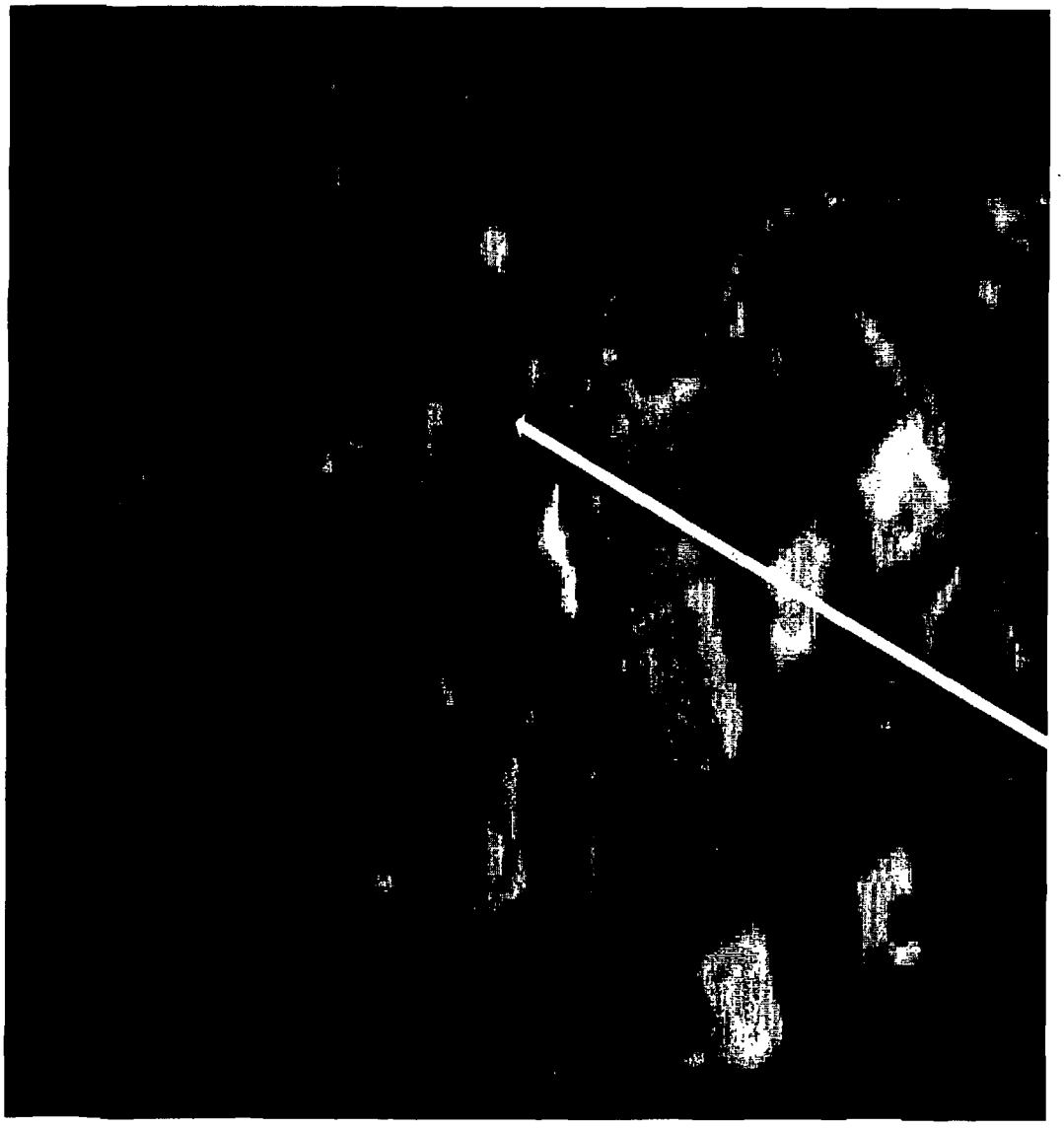


- From Duke RAI responses dated October 12, 2010: Fig. 4, T = 3.33 hours
- Red and green areas indicate supercritical flow conditions which are likely to cause significant erosion

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Supercritical Flows Near Retention Ponds?



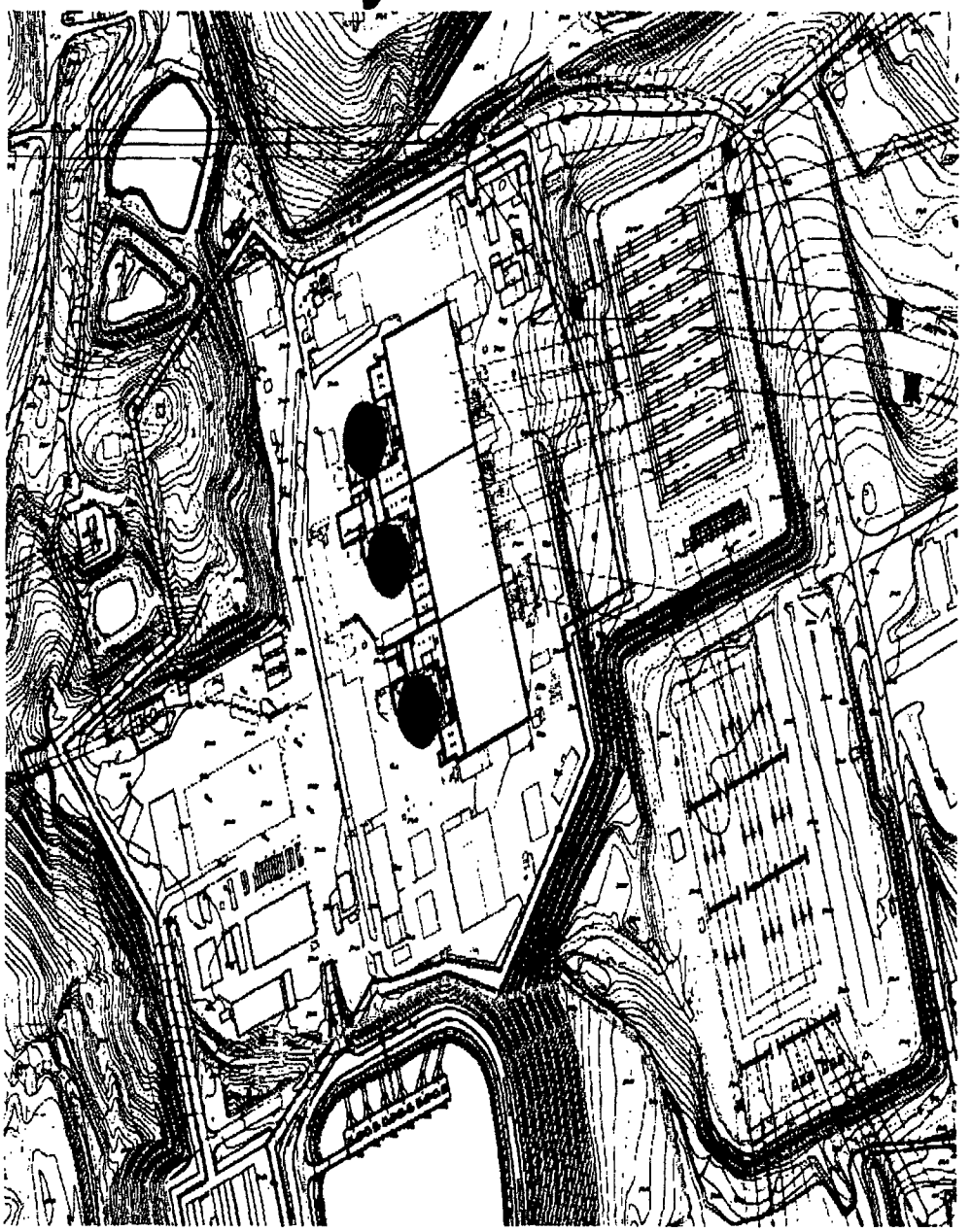
Retention Ponds are Source for "Hale" pumps

From Duke RAI responses dated October 12, 2010: Fig. 3, T = 2.58 hours

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Power Block and Yard Layout



~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Other Consequences

- There are three roads into ONS, all either cross bridges and/or dams. None are expected to survive.
- Will scouring damage buried piping relied on by mitigating strategies?
- With large volumes of water crossing site, to what degree will yards be unusable once water recedes?

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Status as of December 2010

Per Duke letter (ML1021700060) if Jocassee fails from Jocassee full pond level (1110 ft. msl):

- 2D (Case 2) analysis indicates level at SSF 815 ft. msl
- Offsite & onsite power loss
- ECCS fails
- BOP fails
- SSF fails
- ICMs in place (ML1016100830 & ML1017303290)
  - Additional mitigating procedures/guidance using "B.5.b pumps"
  - Additional Jocassee Dam inspection and monitoring
  - Table top exercises
  - Additional means to operate spillway
  - Second B.5.b pump

~~OUO - Sensitive Information - Do Not Disclose~~

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Status 2010 (cont.)

- Additional inspection may lower initiating event frequency
- B.5.b pumps are a line of defense supplying mitigation capability
- CDF may be somewhat less than 2E-4 per year
- Oconee has single non-safety related, non-tested line of defense for this hazard
- In my opinion Oconee lacks defense-in-depth for this hazard

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

Conclusions

- Current hydrology analysis is not bounding
- Consequences of flood to site, reactor and containment not fully understood
- Does ONS have defense-in-depth currently?
- Will ONS have defense-in-depth once proposed changes completed?
  - Flood diversion wall on intake canal dike completed
  - New SSF electrical supply – will SSF failure probability substantially increase above current Duke estimate of 2.7E-1
  - Enhanced SSF flood protection
  - Makeup capability to spent fuel pools
- Many of questions are not hydrology issues they are civil and systems issues
- Has adequate protection issue been fully addressed?