



United States Nuclear Regulatory Commission

Protecting People and the Environment

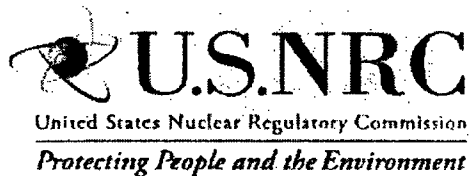
Flooding of Nuclear Power Plant Sites Following Upstream Dam Failure (GI-204):

Status and Outlook

July 10, 2012

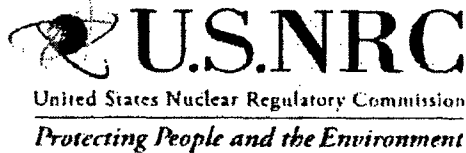
Christopher Cook

Division of Site Safety and Environmental Analysis
Office of New Reactors



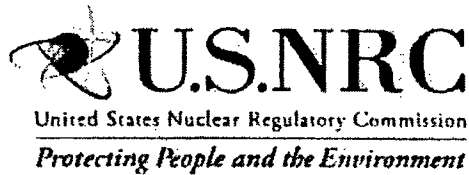
Background

- **GI-204**
 - **NRC Screening Study**
 - Performed by Perkins, Bensi, Philip, and Sancaktar
 - Completed in July 2011
 - GI approved by RES OD on Feb 29, 2012
- **Japan Near-Term Task Force (NTTF) Recommendations**
 - Issued July 2011
 - R2.1 "...reevaluate the seismic and flooding hazards at their sites against current NRC requirements and guidance, and if necessary, update the design basis and SSCs important to safety to protect against the updated hazards."



Background (con't)

- SECY-12-0025
 - Enclosure 7 contains draft 50.54(f) letters (not orders)
 - SRM-SECY-12-0025 issued on March 9, 2012
- Issuance details for the 50.54(f) letters
 - Letters sent on March 12, 2012
 - Addresses include all operating power reactor licensees
 - Flooding walkdowns are Letter Enclosure 4
 - Flooding reevaluations are Letter Enclosure 2
 - Walkdown results inform hazard reevaluation and follow-on assessments, if necessary



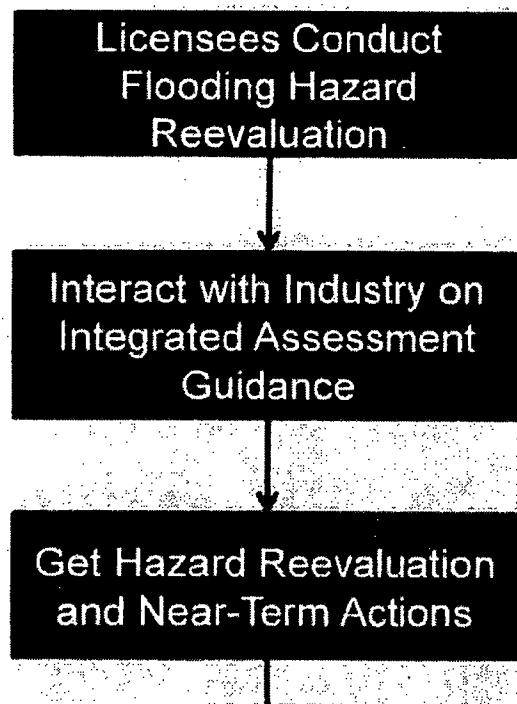
Implementation Approach

- GI-204 transferred under “Regulatory Office Implementation” per MD 6.4 in March 2012
- NRC team formed of staff from across the agency to address R2.1 with NRO/DSEA as the lead Division
- NRC teams
 - Extensive interactions with stakeholders (primarily NEI-lead industry group) in developing guidance
 - Review/issue guidance, as appropriate

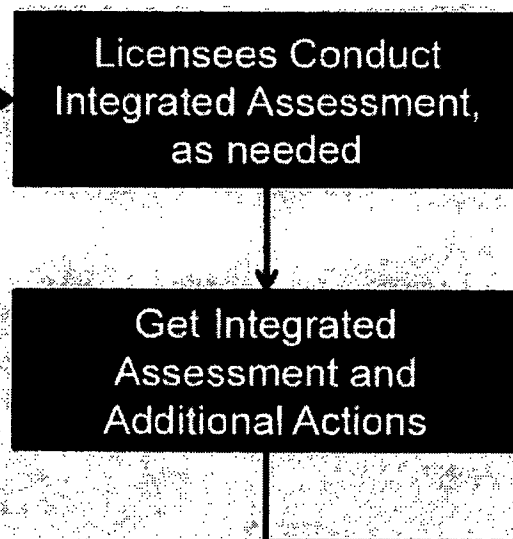
R2.1 Flooding Evaluation

PHASE 1

STAGE 1



STAGE 2



PHASE 2

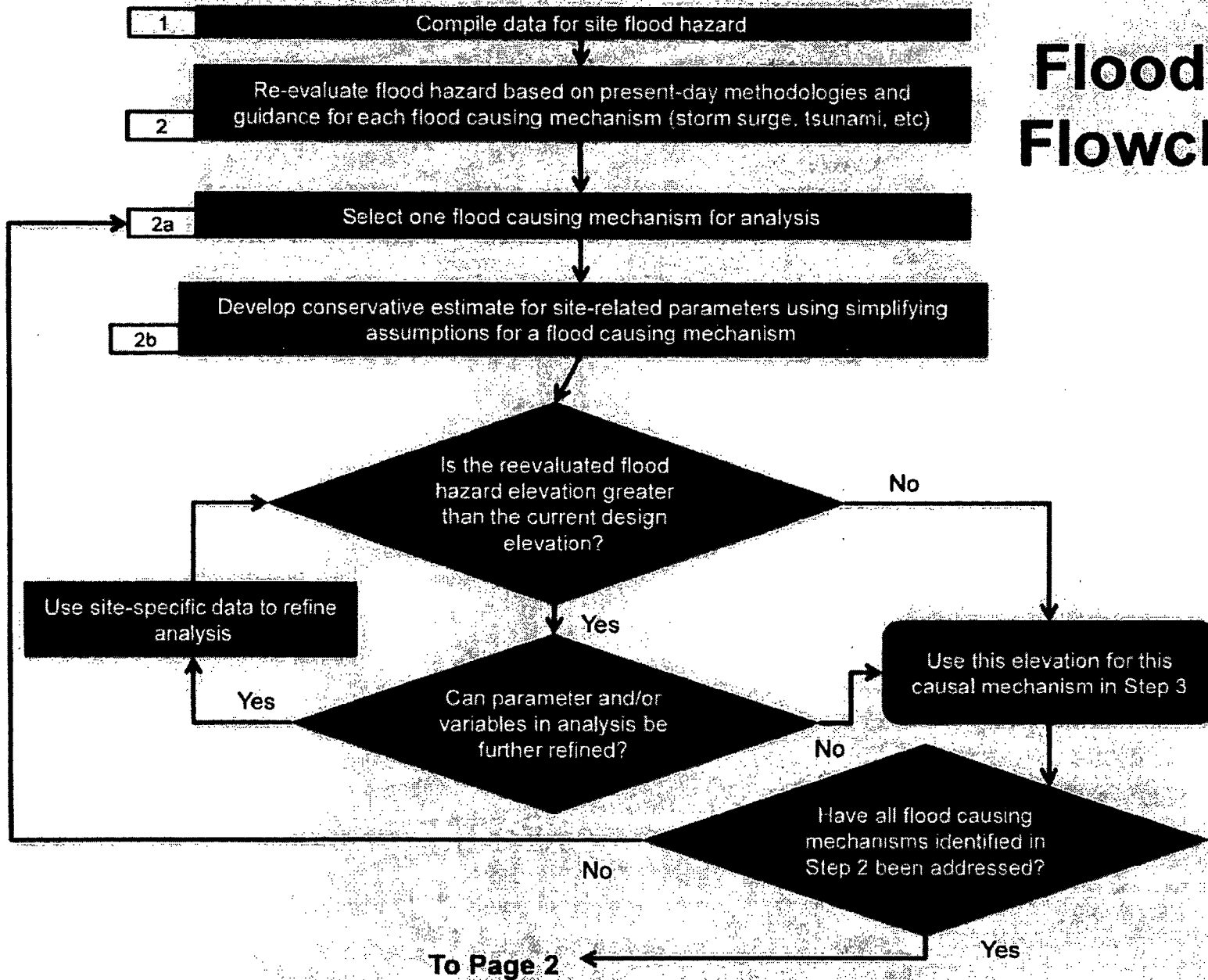




R2.1 Timeline

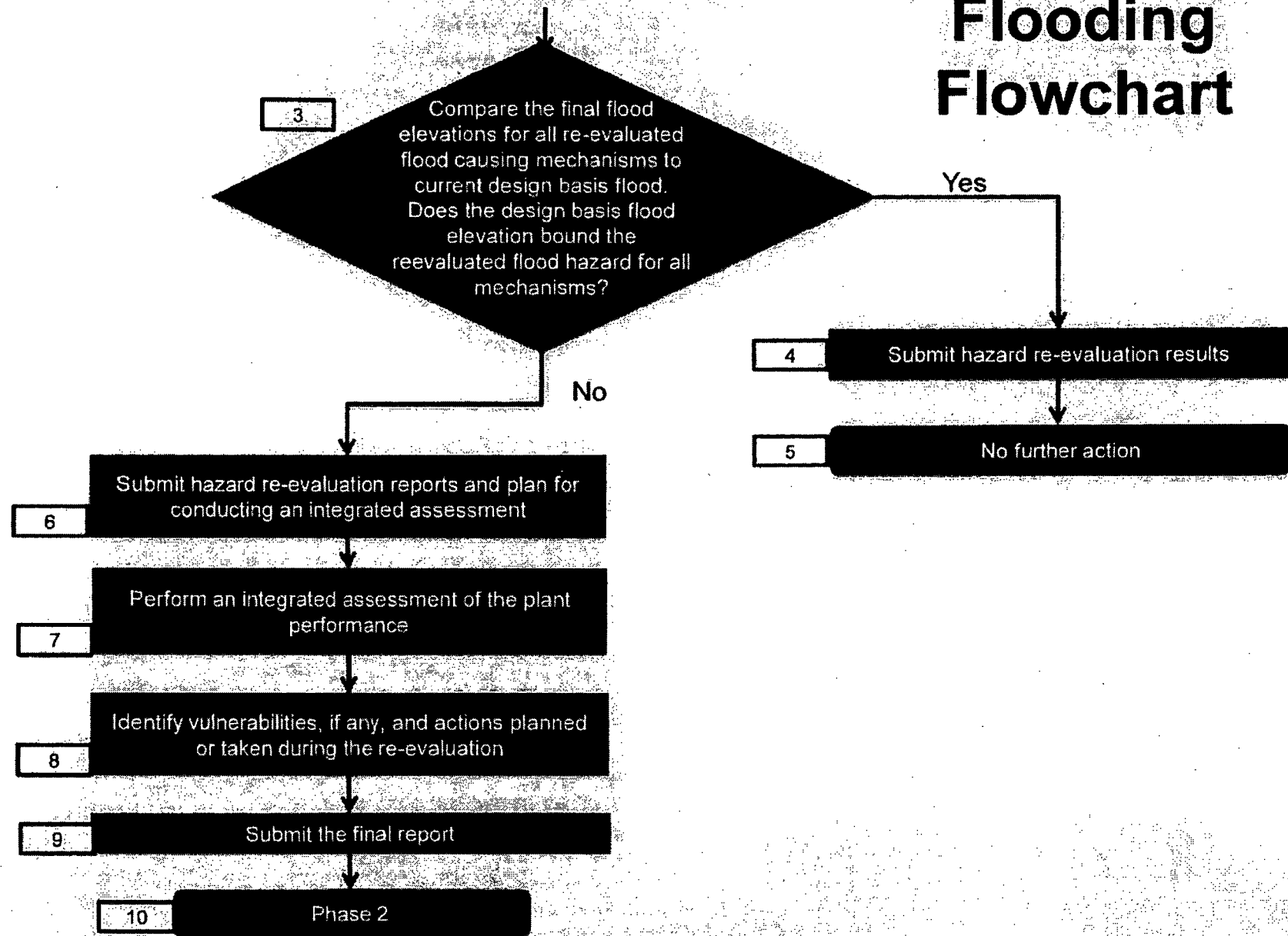
Deliverable	50.54(f) Required Response
Flooding - NRC Prioritizes Sites	60 days (May 11, 2012; Complete)
Interact Risk/Integrated Assessment	180 days (Nov 30, 2012)
Flood Hazard Reevaluation Report Submittals	Within 3 years (March 2013, 2014 or 2015) depending on priority
Flooding - Integrated Assessment	2 years after the hazard (March 2015, 2016, or 2017)

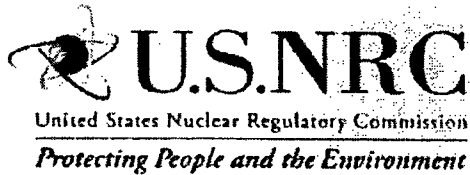
Flooding Flowchart



From Page 1

Flooding Flowchart





Flood Hazard Reevaluation

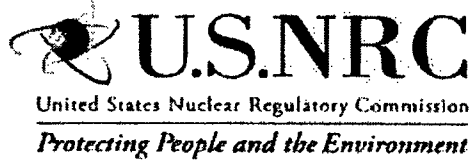
- Application of methodologies used for ESP and COL Reviews
 - NUREG-0800 (SRP; Mar 2007)
 - NUREG/CR-7046 (Nov 2011)
- Includes all flood causing mechanisms at site, including plausible combined events
- Dam Failure Evaluation: Expect White Paper from Industry Group (July?)
 - NRC R2.1 team to review and evaluate

Progress to Date

Flood Hazard Reevaluation Prioritization

- List issued on May 11, 2012
- Three criteria used to sort all NPP sites into one of three due-date categories
 - Potential for integrated assessment (insights; includes GI-204 screening report)
 - Complexity of hazard review
 - Resource allocation (Industry & NRC staff)
- Due dates are March 2013, 2014 or 2015

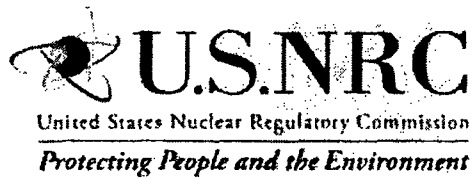
ADAMS Accession: ML12097A510



Other Progress to Date

Flood Protection Walkdowns (R2.3)

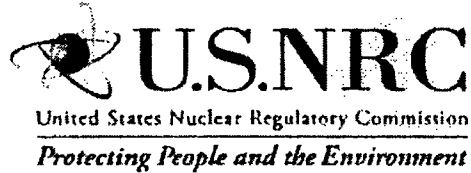
- Purpose: Walkdowns are to gather information in the interim period until longer term actions (R2.1) are completed to update the design basis for external events
- Walkdown methodology and acceptance criteria developed by Industry.
- Discussed over numerous public meetings with NRC team.



Other Progress to Date

Flood Protection Walkdowns (R2.3) con't

- NEI issued final guidance May 2012
 - NEI 12-07 “Guidelines for Performing Verification of Plant Flood Protection Features”
 - NRC endorsed guidance on May 31, 2012
 - ADAMS Accession: ML12173A215
- NRC issued Inspection Manual Temporary Instruction to verify walkdowns conducted according to endorsed methodology
 - TI 2515/187
 - ADAMS Accession: ML12129A108



Summary

- GI-204 was subsumed by Recommendation 2.1 activities in March 2012.
- R2.1 flood hazard reevaluations (including dam failure, as appropriate) are underway at all operating reactor sites.
- White Paper from Industry Group (NEI) on Dam Failure Evaluations is underway.
- R2.1 reevaluations expected in March 2013, 2014, or 2015 based on issued prioritization list.
- Flood protection walkdowns are ongoing. Results from all sites due by end-Nov 2012.

From: Barr, Jonathan
Sent: Thursday, October 04, 2012 12:20 PM
To: Criscione, Lawrence
Cc: Schaperow, Jason; Chang, Richard
Subject: RE: RES Seminar 108

Hi Larry,

Please submit your request here and I think our IT staff will get you a copy.

<http://www.internal.nrc.gov/RES/communication/Seminar/SeminarDVD-Req.cfm>

Jon

From: Chang, Richard
Sent: Thursday, October 04, 2012 10:33 AM
To: Criscione, Lawrence
Cc: Barr, Jonathan; Schaperow, Jason
Subject: RE: RES Seminar 108

Larry,

There should be a DVD of the seminar, and I believe Jon Barr (cc'd on this e-mail) should have the final copies of them.

Thanks,
Richard Chang

From: Schaperow, Jason
Sent: Thursday, October 04, 2012 8:24 AM
To: Criscione, Lawrence
Cc: Barr, Jonathan; Chang, Richard
Subject: RE: RES Seminar 108

Hi Larry,

The slides from the SOARCA seminar of 6/4/12 are attached. I am not aware of any DVDs from this seminar. I am including Jon Barr and Richard Chang on this email in case they know anything about a DVD.

Two things to note:

- The SOARCA seminar (and all of the RES seminars) are internal seminars. The slides have not been previously distributed outside of the NRC.
- I now work in NRO, and Richard Chang now works in NSIR. Jon Barr is currently the SOARCA PM.

Thanks,
Jason

From: Criscione, Lawrence
Sent: Tuesday, October 02, 2012 3:29 PM
To: Schaperow, Jason
Subject: RES Seminar 108

Jason,

Can I get the slides and DVD from the SOARCA RES Seminar (#108)?

Thanks,
Larry Criscione

From: McGee, Jim (HSGAC) [mailto:Jim_McGee@hsgac.senate.gov]
Sent: Tuesday, October 02, 2012 9:50 AM
To: Criscione, Lawrence
Subject: RE: GI 199 and Mineral, VA earthquake

Thanks. I couldn't get any of these links to work. I highlighted the topics that appear germane. Will try to track down those slides or DVD's, unless you have them.

Jim McGee
Professional Staff/Investigations
Senate Committee on Homeland Security and Governmental Affairs
202-224-2627

From: Criscione, Lawrence [mailto:Lawrence.Criscione@nrc.gov]
Sent: Monday, October 01, 2012 8:00 PM
To: McGee, Jim (HSGAC)
Subject: FW: GI 199 and Mineral, VA earthquake

Jim,

I meant to send this to you a couple of weeks ago, but accidentally sent it to Jon Ake, Marty Stutzke and Ben Beasley (I had "temporarily" put their names in the "To" line to copy down their email addresses).

Anyways, at the very bottom of this email is a list of RES seminars. You might find #99, #102 and #112 interesting pertaining to dam failures, earthquakes and paleofloods.

Larry Criscione

From: Criscione, Lawrence
Sent: Friday, September 21, 2012 2:38 PM
To: Ake, Jon; Beasley, Benjamin; Stutzke, Martin
Subject: GI 199 and Mineral, VA earthquake

Jim,

Below is a list of Seminars given to the Office of Research.

One of them was on the Mineral, VA Earthquake of August 23, 2011. It was given by Dr. Leith of the USGS. The NRC contact was Jon.Ake@nrc.gov, 301-251-7626. He could probably send you the seminar material.

Marty Stutzke (martin.stutzke@nrc.gov, 301-251-7614) was one of the chief scientists on GI 199 (the earthquake Generic Issue) if you have any questions about what was looked at and what the conclusions were. Ben Beasley (Benjamin.Beasley@nrc.gov, 301-251-7676) should be able to either tell you what the status of it is or direct you to a contact in the office assigned to implement it.




Larry

From: Perkins, Richard
Sent: Friday, September 21, 2012 2:19 PM
To: Criscione, Lawrence
Subject: RE: Info









I found this, but there are no slides available. It was recorded.

12/14/10
Success and Failure: A Paradoxical Relationship
Prof. Henry Petroski
Duke University
Nathan Siu
DRA




Here's a copy of the RES Seminar Table through 2009 (if you can read this)

Seminar #114	09/19/12	Long-Term Research Program Overview	Robert Tregoning, Ph.D. Michael B. Rubin, LTRP PM David W. Stroup, P.E. Jacob Philip, P.E	
Seminar #113	08/08/12	The NRC and Social Media - What We're Doing, Why We're Doing It, and How You Can Get Involved [View Poster]	Holly Harrington - Office of Public Affairs	No DVD available for this seminar
Seminar #112	07/10/12	Dam Failure, Nuclear Power Plant Flooding, and the Outlook for Generic Issue 204 [View Slide 1] [View Slide 2] [View Slide 3]	Richard Perkins & Jacob Philip RES/DRA	
Seminar # 111	06/19/12	Training Range Environmental Evaluation and Characterization System (TREECS) Applications - [View Slide]	Billy E. Johnson, U.S. Army Corps of Engineers; Mark S. Dortch, MSD Inc., and Boris Faybishenko, Lawrence Berkeley National Laboratory Sponsored by Tom Nicholson, DRA/RES	No DVD available for this seminar
Seminar # 110	06/07/12	ASR Degradation of Concrete affecting Nuclear Power Plant Structures - [View Slide] [Presentation 1][Presentation 2]	Jason Weiss, Purdue University; Kenneth Snyder, NIST; and Fahim Sadek, NIST Sponsored by Jacob Philip, ETB/DRA/RES	No DVD available for this seminar
Seminar # 109	06/06/12	Live webcast of Zirconium Fire Experiment on PWR Spent Fuel Pool Complete Loss of Coolant Accident	Ghani Zigh, RES/DSA	No DVD available for this seminar
Seminar #108	6/4/2012	State-of-the-Art Reactor Consequence Analyses (SOCRCA) RES Seminar - [View Slides]	Richard Chang, Jonathan Barr & Jason Schaperow (SOARCA Team)	
Seminar #107	5/21/2012	Health Physics Brown Bag 2012 Series: US Federal Agency Response to Fukushima Incident	Dr. Luis Benevides from NAVY, sponsored by Gladys Figueroa, RES/DSA/RPB	

Seminar #106	4/17/2012	Multi-Scale Assessment of Prediction Uncertainty in Coupled Reactive Transport Models <u>Curtis Flyer Announcement</u>	Gary P. Curtis(USGS) Ming Ye(FSU) Philip D. Meyer(PNNL) Steve Yabusaki(PNNL)	No DVD available for this seminar
Seminar #105	3/27/2012	Development of the Extremely Low Probability of Rupture (xLPR) Assessment Tool <u>View Slides</u>	Dave Rudland, RES/DE	DVD
Seminar #104	2/13/12	The NRC's Simulator-based Human Performance Testing Program -- Advancing Model Validity with Data	Amy D'Agostino & James Chang, RES/DRA	DVD
Seminar #103	1/25/12	Computational Fluid Dynamics for Nuclear Safety Analysis	Christopher Boyd RES/DSA	DVD
Seminar #102	12/13/11	The Mineral, VA Earthquake of August 23, 2011 <u>View poster</u> <u>View presentation</u>	Dr. William Leith, U.S. Geological Survey / Jon Ake, RES/DE/SGSEB	No DVD available for this seminar
Seminar #101	11/01/11	Lessons Learned from Investigations of Oil and Chemical Industry Events <u>View Presentation</u>	Mark Griffon Board Member U.S. Chemical Safety and Hazard Investigation Board	DVD
Seminar #100	10/05/11	Investigations of Zirconium Fires during Spent Fuel Pool Loss of Coolant Accidents	Ghani Zigh RES/DSA	DVD
Seminar #99	08/23/11	The Value of Paleoflood Information when Estimating Flood Risk [Slides] <u>Background Info 1</u> <u>Background Info 2</u>	Dr. Timothy Cohn, U.S. Geological Survey Thomas Nicholson DRA	DVD
Seminar #98	07/11/11	Research Topics and Experiences on Safety Assessment Methods of Radioactive Materials (RAM) Containers German Federal Institute for Materials Research and Testing (BAM) Berlin, Germany	Dr. Frank Wille, "Requirements for Transport Packages after Interim Storage" Dr. Karsten Muller, "Recent Activities on Experimental Package and Component Testing at BAM" Mr. Gernar Eisenacher "Impact Limiter Modeling - An Approach for a Finite Element Material Model for Wood" Dr. Jose Pires, RES/DE/SGSEB	DVD
Seminar #97	06/21/11	Assuring Durable Concrete: Chemical Degradation Processes and Modeling Service Life - <u>View Slides</u>	Dr. Kenneth A. Snyder National Institute of Standards and Technology Jacob Philip, DRA/ETB	DVD
Seminar #96	04/26/11	Chernobyl 25th Anniversary <u>1. Mike Weber's Introduction</u> <u>2. Dr. Brian Sheron's Presentation</u> <u>3. Dr. Frank Congel's Presentation</u> <u>4. Dr. John Boice's Presentation</u>	Dr. Brian Sheron, RES Frank Congel, Former NRC Employee Dr. John Boice, IEI	DVD

Seminar #95	04/19/11	A Probabilistic Risk Assessment View of Consequential Steam Generator Tube Rupture [View Slides]	Selim Sancaktar, RES/DRA/PRAB	No DVD available for this seminar
Seminar #94	02/22/11	Radiation Epidemiology Past Studies and Future Opportunities [View Poster]	Dr. John Boice, Medicine at Vanderbilt University School of Medicine and Scientific Director of the International Epidemiology Institute (IEI) / Stephanie Bush- Goddard, RES/DSA/HEB	
Seminar #93	02/15/11	American Society of Mechanical Engineers [View Slides]	Rick Swayne, ASME Carol Moyer, RES/DE/CMB	
Seminar #92	01/20/11	Weather and Hydrologic Extremes in a Non-stationary Climate with Implications for Managing Critical Infrastructures and Key Resources Presentation Slides	Dr. Auroop Ganguly(ORNL) Joe Kanney (RES/DRA/ETB) Tom Nicholson (RES/DRA)	
Seminar #91	01/12/11	Field and Modeling Studies to Assess Radionuclide Transport in the Subsurface	Dr. Andy Ward, Senior Research Scientist, Pacific Northwest National Laboratory Tom Nicholson (RES/DRA)	
Seminar #90	12/14/10	Success and Failure: A Paradoxical Relationship	Prof. Henry Petroski Duke University Nathan Siu DRA	
Seminar #89	11/10/2010	Zirconium in the Nuclear Industry - [View Slides]	Patrick Raynaud DSA / FSTB	
Seminar #88	10/20/2010	ASME Codes and Standards: History, Content, Development, and Endorsement	Carol Moyer & Gary Stevens, RES/DE	No DVD available for this seminar
Seminar #87	09/23/2010	Seismic-related Generic Issue (GI-199) Safety /Risk Assessment Methods and Results - [Detail] [view Slides]	Marty Stutzke (RES/DRA) Jon Ake (RES/DE/SGSEB) Lauren Killian (RES/DRA/OEGIB)	
Seminar #86	07/23/2010	Risk and Uncertainty in Dam Safety [View Detail 1] [View Detail 2] [View Detail 3]	Professor Gregory B. Baecher University of Maryland, College Park/ Thomas Nicholson, RES/DRA	No DVD available for this seminar
Seminar #85	07/19/2010	The Evolution of Radiation Protection: From Erythema to Genetic Risks to Risks of Cancer [View Slides]	Charles Meinhold / Terry Brock, RES/DSA/HEB	
Seminar #84	07/12/2010	Advanced Control Room Human Factors [View Slides]	Jing Xing & Stephen Flegen RES/ DRA/HFRB	No DVD available for this seminar

Seminar #83	06/17/2010	Severe Accident Response for Steam Generator Tubing [View Slides]	Saurin Majumdar, ANL	No DVD available for this seminar
Seminar #82	06/17/2010	Lean Six Sigma on Internal Contracting	Mary Muesale, PMDA	No DVD available for this seminar
Seminar #81	05/13/2010	Overview of the Electric, Power Research Institute Organizational and Program Structure and its Relationship to the Industry's Materials Initiative	David Modeen / hosted by DE, David Rudland	DVD
Seminar #80	04/29/2010	Lessons Learned in Detecting, Monitoring, Modeling, and Remediating Radioactive Groundwater Contamination at Brookhaven National Laboratory; [Handout]	Dr. William Gunther, Dr. Mike Hauptmann, and Dr. Terry Sullivan / hosted by DRA Thomas Nicholson	DVD
Seminar #79	04/15/2010	Human-Rating of Space Systems - [View Slides]	Mr. Bryan O'Connor, Chief, Office of Safety and Mission Assurance, NASA	No DVD available for this seminar
Seminar #78	03/26/2010	Browns Ferry Seminar	Jack Lewis & Felix Gonzalez, ORA Dr.	DVD
Seminar #77	03/25/2010	Fundamentals of Structural Dynamics - [View Slides]	Dr. Abhinav Gupta	No DVD available for this seminar
Seminar #76	02/23/2010	Recent United States Geological Survey (USGS) Research on Seismic Hazards and Ground Motions in the Eastern U.S.	Dr. Paul Spudich, USGS colleagues & Jon Ake, DE	DVD
Seminar #75	01/21/2010	Improving the State-of-the-Art in Severe Accident Analysis [View Slides]	Richard Lee	No DVD available for this seminar
Seminar #74	01/05/2010	State of the Practice of Seismic Hazard Analysis: From the Good to the Bad	Dr. Norman Abrahamson	DVD
Seminar #73	12/10/2009	Experimental Basis for Modification of Cladding Embrittlement Criteria	Michelle Flanagan	DVD
Seminar #72	11/30/2009	Pressurized Thermal Shock	Mark Kirk	DVD
Seminar #71	10/26/2009	Health Effects as a Function of Dose Rate Delivered [View Slides]	Dr. Jacquelyn Yanch, MIT	No DVD available for this seminar
Seminar #70	09/11/2009	THE COLLAPSE OF WORLD TRADE CENTER 7- THE FORGOTTEN BUILDING OF 9/11	Dr. Therese McAllister, National Institute of Standards and Technology (NIST)	DVD
Seminar #69	09/08/2009	Geophysical Surveys Supporting Analysis of Contaminant Transport through Fractures [View Slides]	Dr. John Williams, USGS [View Bio]	DVD
Seminar #68	08/24/2009	Safety and Regulatory Perspectives on Protective Coatings for Nuclear Facilities [View Slides]	Bruce Lin, RES/DE/MEEB	DVD
Seminar #67	07/21/2009	Performance of Engineered Covers for Waste Disposal with Implications for PA [View Slides]	Professor Craig Benson, University of Wisconsin [View Bio]	DVD
Seminar #66	05/11/2009	The Spent Nuclear Fuel Burnup Credit Research	John Wagner, ORNL	DVD
Seminar #65	05/07/2009	2009 William B. Joyner Memorial Lecture, entitled "Earthquakes, Seismic Hazard, and Performance-Based Design"	Dr. Robin McGuire	DVD
Seminar #64	04/24/2009	Modeling Uranium Behavior during In-Situ Bioremediation	Steven Yabusaki, Pacific Northwest National Laboratory	No DVD available for this seminar

Seminar #63	04/22/2009	Screening Methods for Estimating Storm-Surge Levels and Severity	Dr. Donald Resio US Army Corps of Engineers	
Seminar #62	03/25/2009	The Accident at Three Mile Island - 30th Anniversary A Look Back: Preserving the Institutional Memory March 26, 2009 [Details] - [Poster] - [View Presentations]	Brian Sheron Edward Frederick Harold Denton Gary Holahan	Please Contact Amy Bonaccorso
Seminar #61	02/10/2009	Perspectives on HTGR Safety and Design Considerations [View Slides]	Dr. Kenneth Stroh (VP, Sentech Inc. and Retired Guest Scientist, LANL)	
Seminar #60	01/21/2009	Modeling of the Dynamics of the Nucleation and Growth of Cracks Initiated due to Stress in Materials	Dr. Appajosula Rao, Material Engineer, DE/CMB	

From: Criscione, Lawrence
Sent: Friday, September 21, 2012 3:09 PM
To: Perkins, Richard
Subject: RE: Info

It was really about how engineering lessons learned are forgotten over time, but the guy giving it used bridge design as his basis. It was in 2010 or 2011. I'm not certain it was a RES seminar. It was in the same auditorium as our seminars and I know I went to it with Kauffman so I assume it was a seminar. Do other offices do seminars?

From: Perkins, Richard
Sent: Friday, September 21, 2012 1:53 PM
To: Criscione, Lawrence
Subject: Info

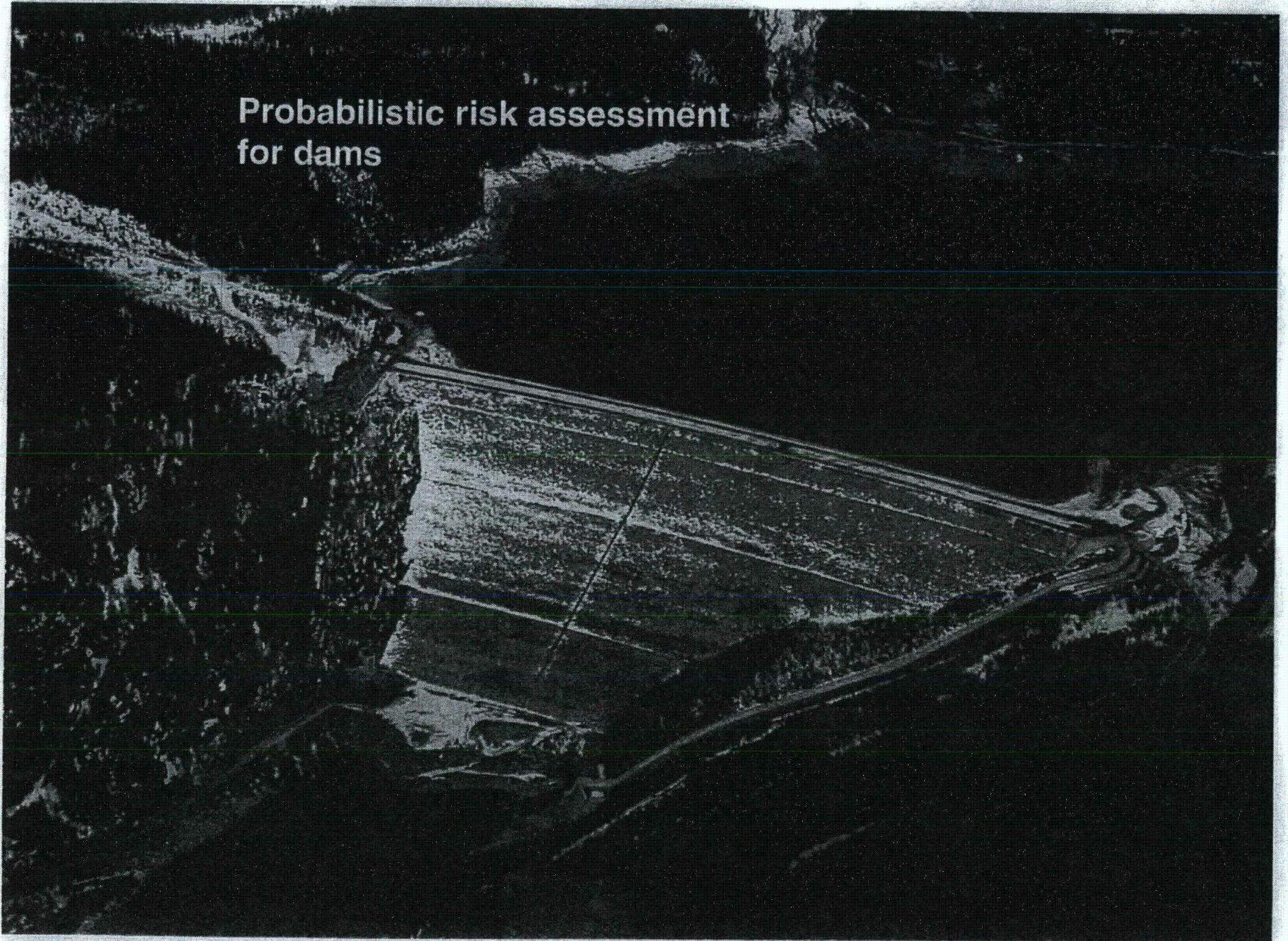
Energy Daily did a front page story today on FERC standing up a new office. You should take a look at that if you haven't.

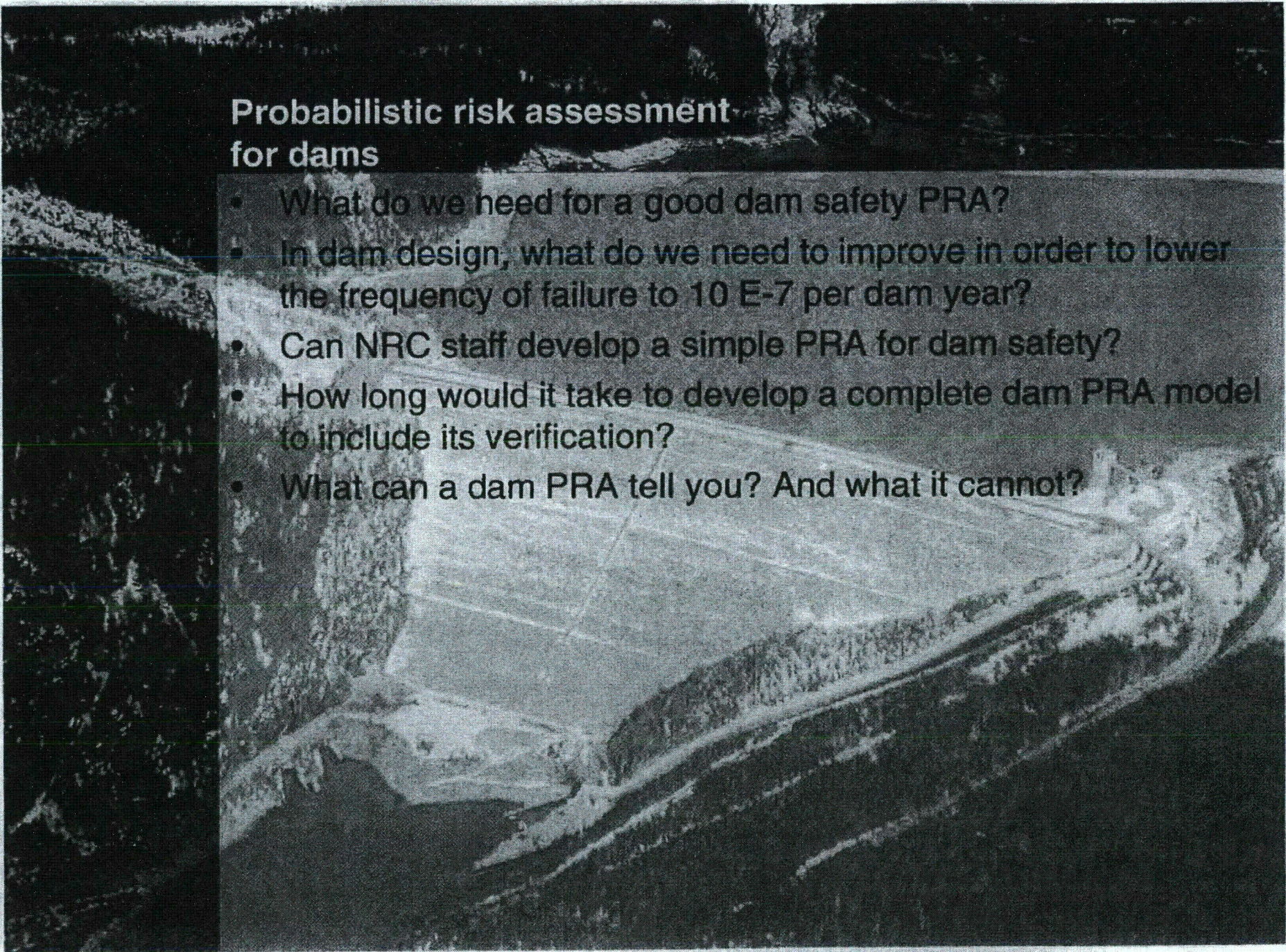
I just sent the info on paleofloods (previous e-mail). Let me know if you don't get it.

I don't recall the brief about bridge failure. Anything to help me find it? Didn't see it in the RES seminar list (or I didn't recognize it as bridge failure related).

Richard H. Perkins, P.E.
Nuclear Regulatory Commission
Office of Nuclear Regulatory Research
Division of Risk Analysis
Operating Experience and Generic Issues Branch
Phone - 301/251-7479

Probabilistic risk assessment
for dams



An aerial photograph of a large dam and its reservoir. The dam is a long, straight structure across the middle of the image. The reservoir is a large body of water on the left side. The surrounding landscape is rugged and mountainous.

Probabilistic risk assessment for dams

- What do we need for a good dam safety PRA?
- In dam design, what do we need to improve in order to lower the frequency of failure to 10 E-7 per dam year?
- Can NRC staff develop a simple PRA for dam safety?
- How long would it take to develop a complete dam PRA model to include its verification?
- What can a dam PRA tell you? And what it cannot?

PRA for dams

Webster says, a dam is,

"a barrier built across a waterway to control the flow or raise the level of the water.

The Federal Guidelines for Dam Safety says,

"Any artificial barrier, including appurtenant works, which impounds or diverts water, and which

(1) Is 25 feet or more in height from the natural bed of the stream or watercourse measured at the downstream toe of the barrier or from the lowest elevation of the outside limit of the barrier if it is not across a stream channel or watercourse, to the maximum water storage elevation; or

(2) Has an impounding capacity at maximum water storage elevation of 50 acre feet or more.

These guidelines do not apply to any such barrier which is not in excess of 6 feet in height regardless of storage capacity, or which has storage capacity at maximum water storage elevation not in excess of 15 acre-feet regardless of height. This lower size limitation should be waived if there is potentially significant downstream hazard.

PRA for dams

- 1. Inventory**
- 2. Modes of failure**
- 3. Actors, owners, regulators**
- 4. Risk analysis**
- 5. Downstream consequences**
- 6. Tolerable risk**

National Inventory of Dams

•Based on the 2007 National Inventory of Dams ~ 83,000 Dams >25 ft w/ 15ac-ft capacity or >6ft w/ 50ac-ft capacity



Hazard

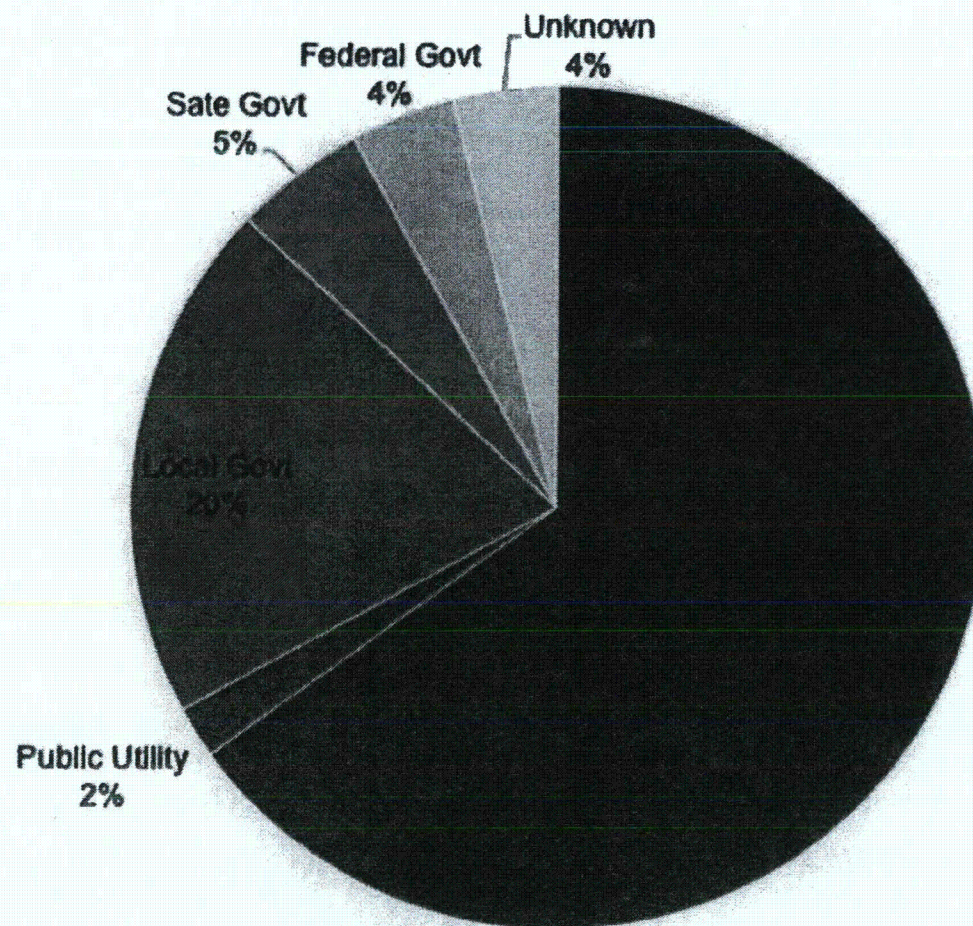
Classifications

~ 12,000 High Hazard

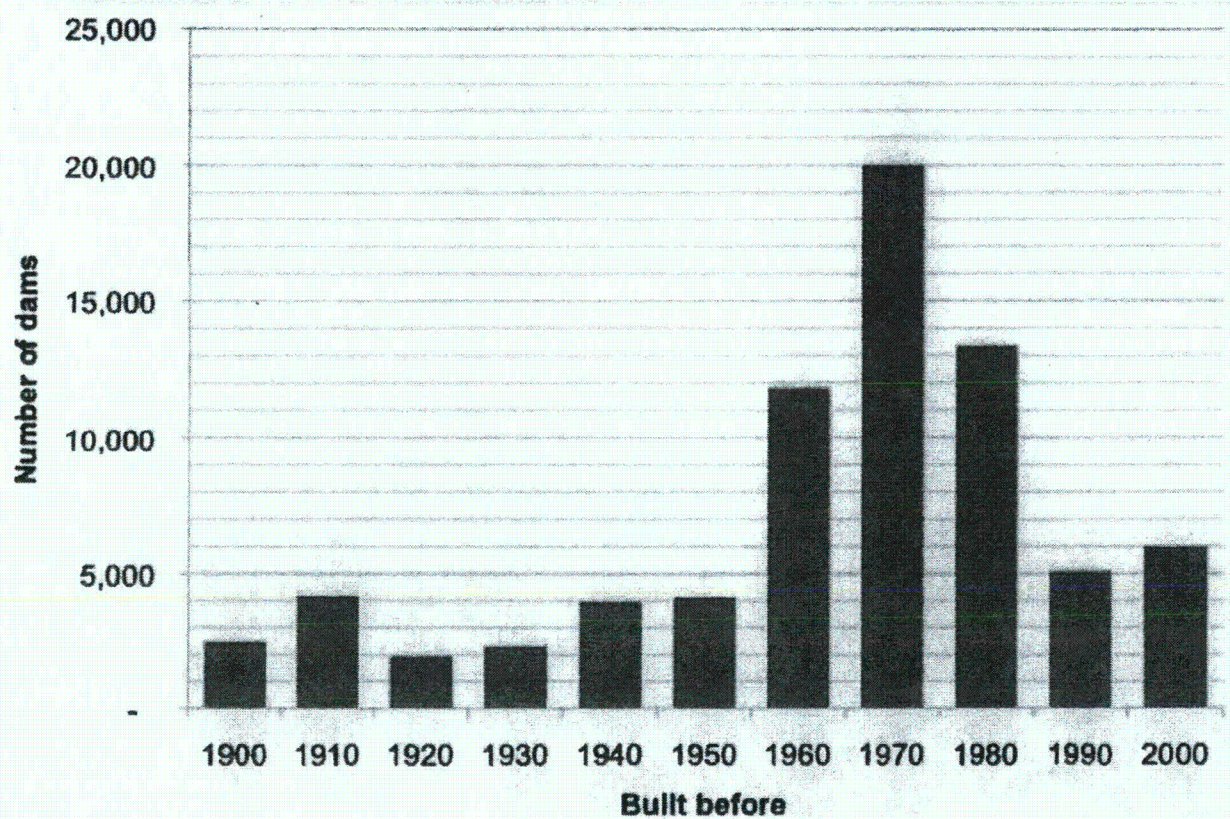
~ 14,000 Significant Hazard

~ 57,000 Low Hazard

Inventory of US dams



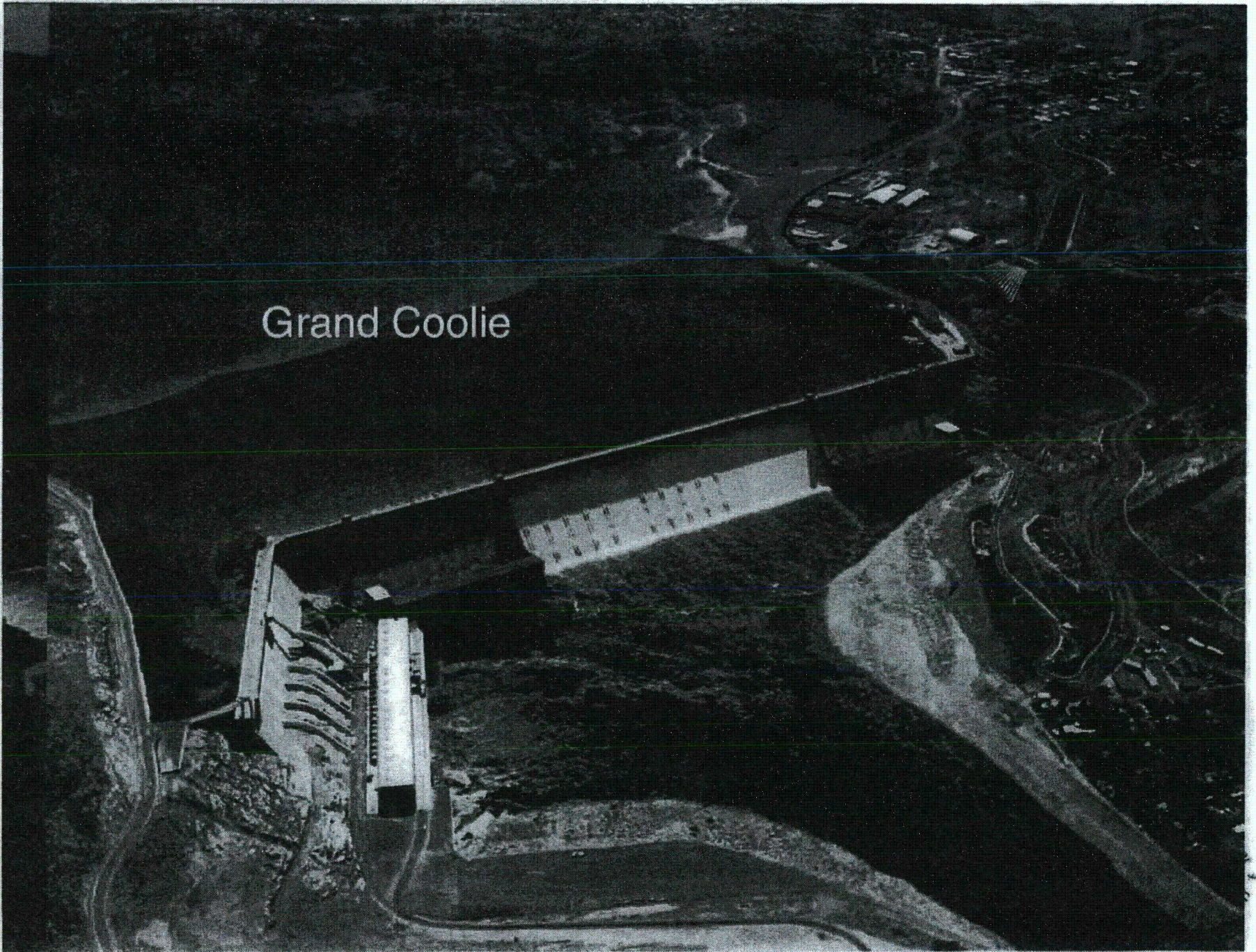
Inventory of US dams



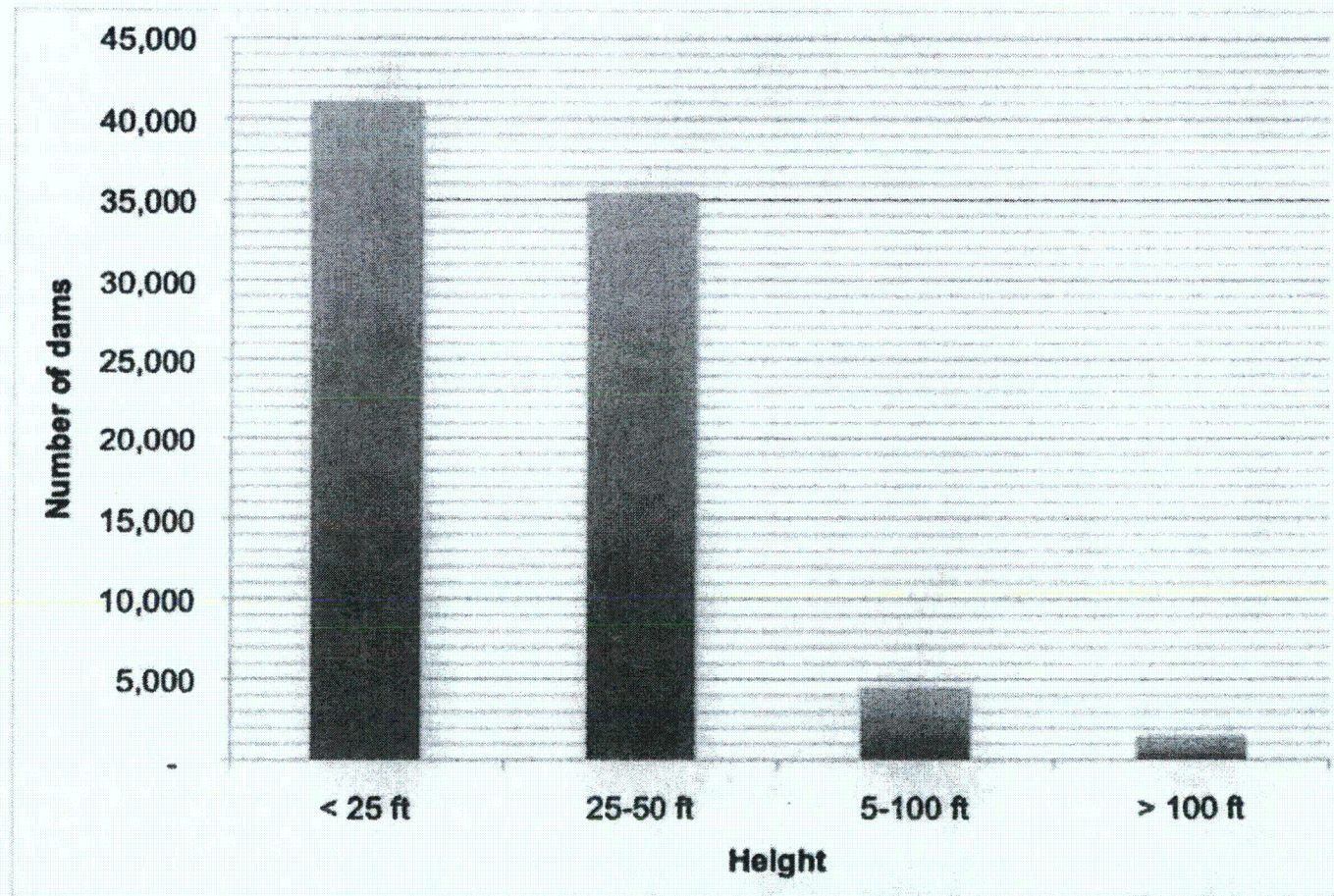
The Water Collaborative at Maryland



Grand Coolie



Inventory of US dams



The Water Collaborative at Maryland

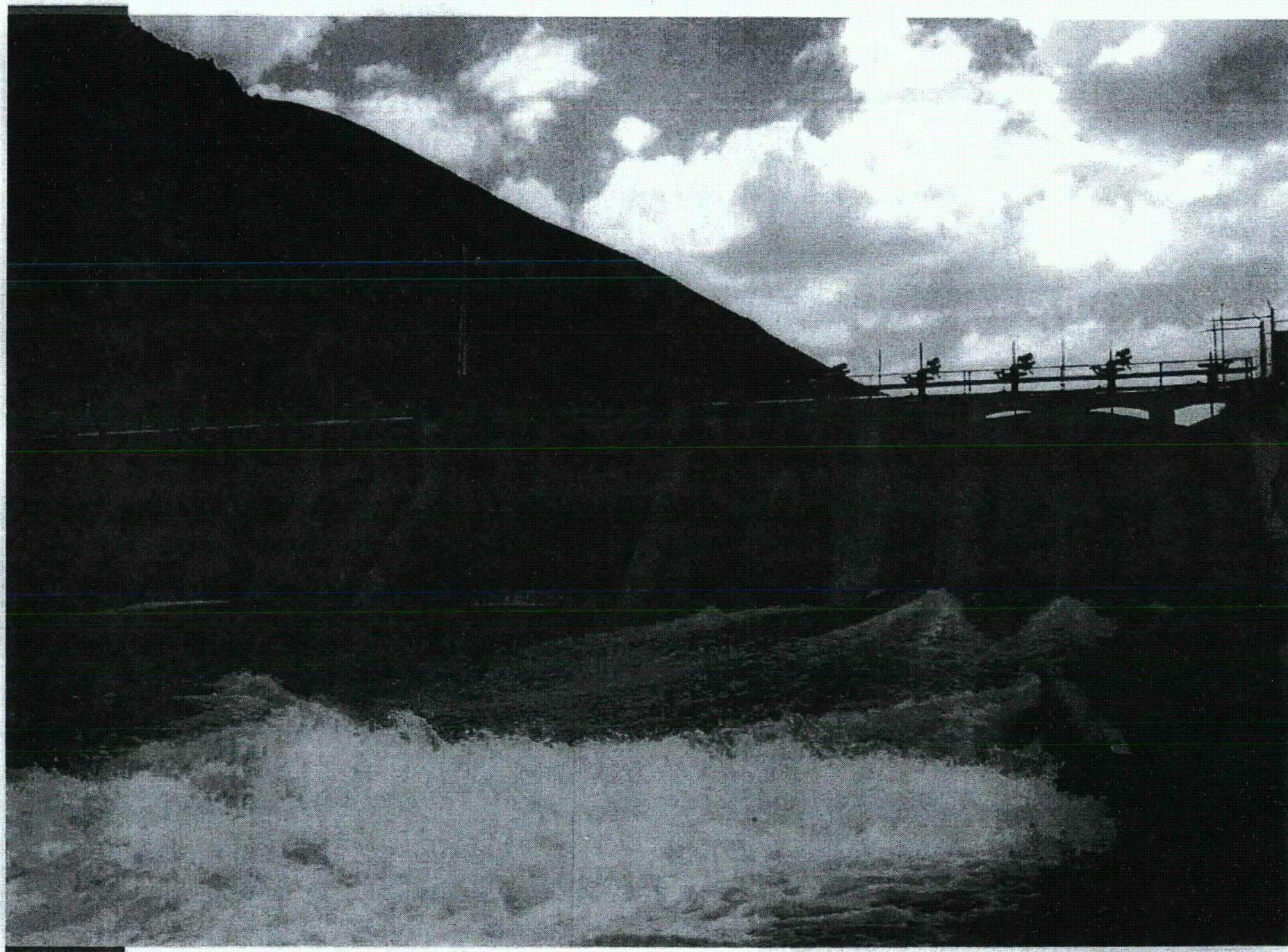






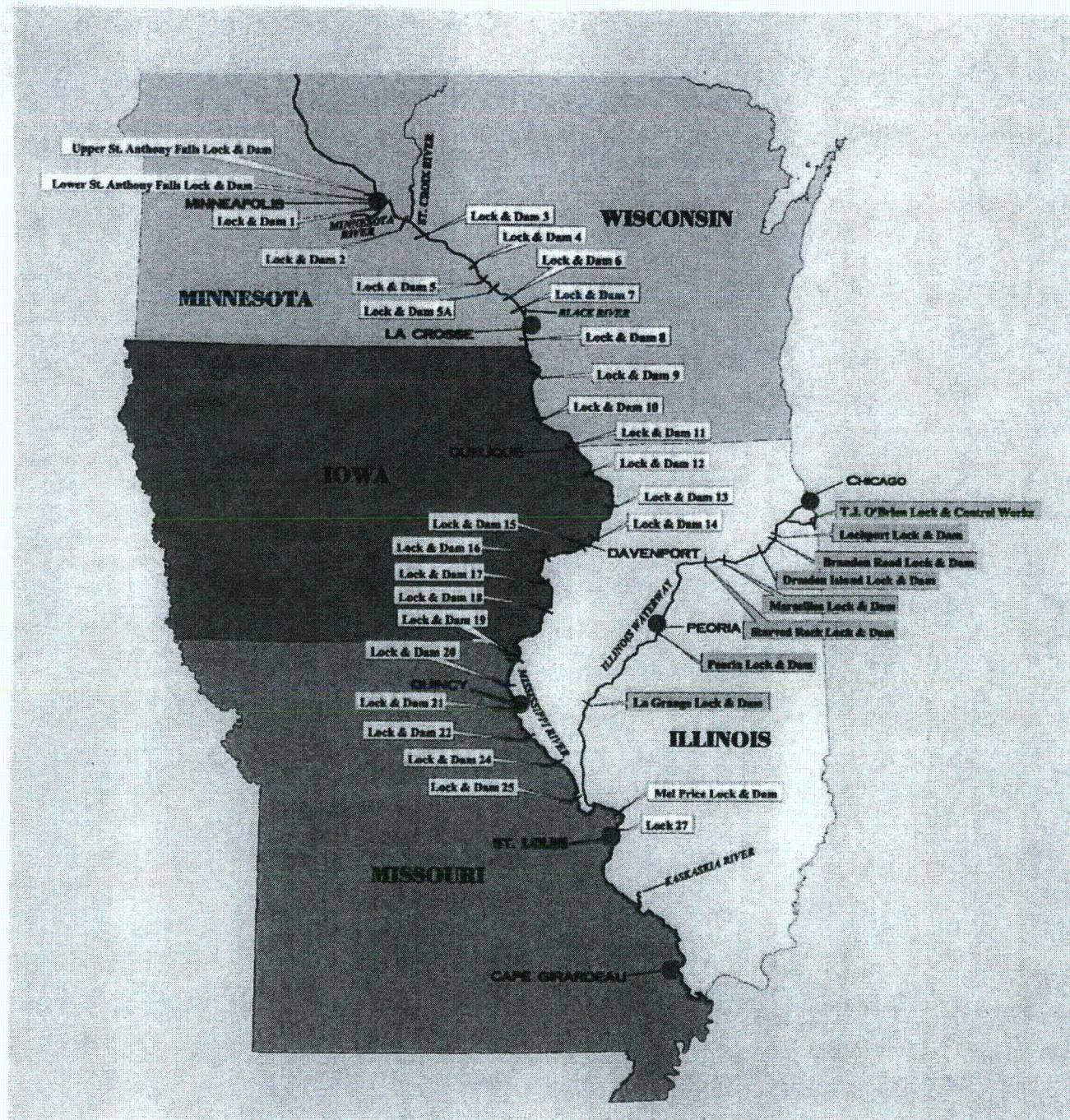
Collaborative at Maryland

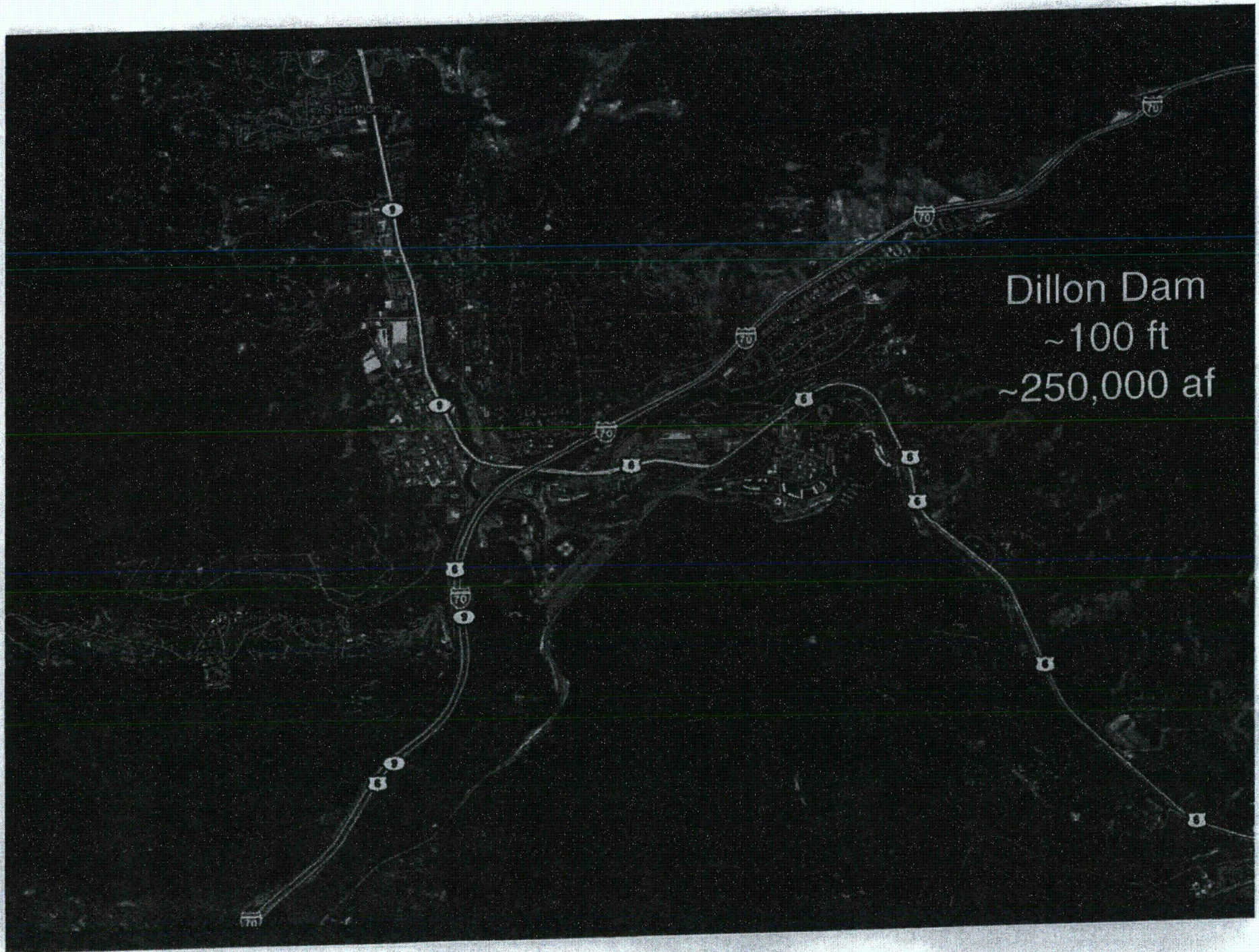












Dillon Dam
~100 ft
~250,000 af

Watts Bar Dam, TVA

