Federal Energy Regulatory Commission

FERC Training Series: Part 12D Inspections and Reports

Presented in:

San Francisco, California

January 2015

Atlanta, Georgia

February 2015

Wausau, Wisconsin

May 2015

Background/Objective

- The FERC has noticed a decrease in the quality of Part 12D inspections and reports.
- Concern that the Part 12D process has become too lax and moving away from the intent of the process.
- There are a lot of new Independent Consultants not familiar with the Part 12D process.
- There are several new FERC initiatives added. We will explain how they play a role in the Part 12D process.

Background/Objective

- We will discuss FERC's expectations on the content and quality of each section of the Part 12D Report
- We will discuss FERC's expectations related to the thoroughness of the physical inspection
- We will discuss changes to the Risk-Informed Decision Making (RIDM) process and how Potential Failure Modes must be written this year and moving forward.
- We will discuss and present failures (case-studies) and successes from the Part 12D process

Background/Objective

Ultimate Goal?

PREVENTION!

Prevention!

Prevention!

Prevention!

Prevention!

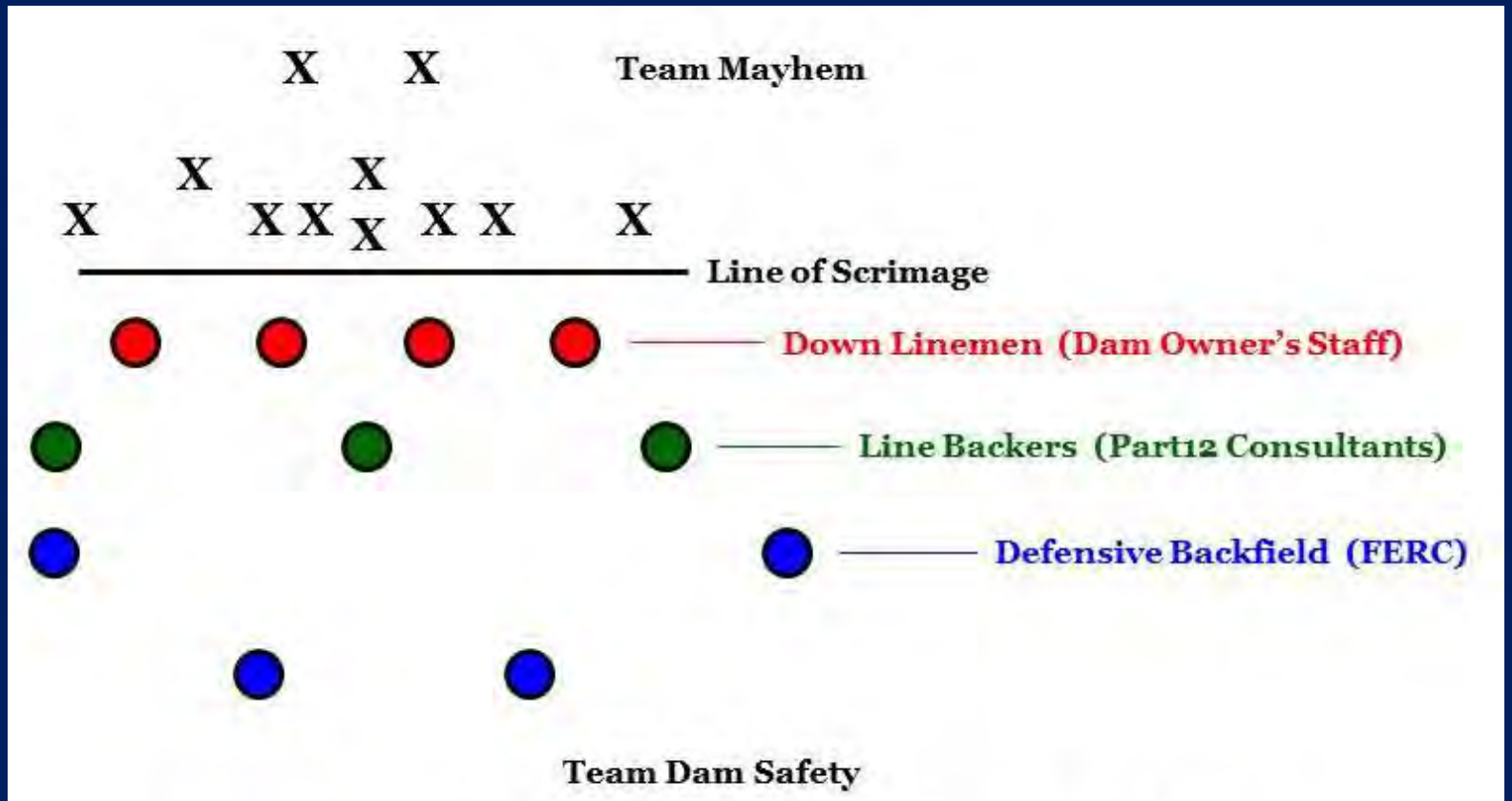
Prevention!

Prevention – Taum Sauk

Prevention – Toccoa Falls

Prevention – Silver Lake

Prevention - Delhi



If you're making all your tackles in the defensive Backfield, you're going to lose the game.

Agenda

- Objective
- **History**
- Purpose of the Part 12 process
- FERC expectations
- P-12 reminder letter
- Supporting Technical Information Document
- PFMA review process
- Review of analyses
- Engineering Guidelines
- Risk-based guidelines
- 18 CFR 12D requirements
- Report format
- Definitive statement required for each component of the dam
- Licensee responsibility
- Review the report prior to submitting to the FERC for review
- Question and Answer Time

The History of Part 12D

- The Rivers and Harbors Act of 1899 made it illegal to dam navigable streams without a license (or permit) .
- The Federal (Water) Power Act was enacted by Congress on June 10, 1920 to more effectively coordinate the development of hydroelectric projects in the U.S.
- The Act created the Federal Power Commission (FPC), .as the licensing authority for these projects.
- The Federal Energy Regulatory Commission was chartered as a result of the Department of Energy Organization Act of 1977, signed by President Carter on August 4, 1977 and established within the Department of Energy.

The History of Part 12D

- Original Part 12D inspection requirements were incorporated into the FPC Regulations by Order 315 issued December 1965. The Regulations required certain inspections and reports by Independent Consultants with respect to safety of structures of hydroelectric projects

- In 1981, Order No. 122 was issued superseding the 1965 regulations. The rule revoked existing dam inspection procedures in Part 12 of the Commission's rules and substituted new practices and procedures that encompassed reporting of safety-related incidents and preparation and implementation of emergency actions plans, and inspection by independent consultants

The History of Part 12D

- 1977 Dam Safety Memorandum to Heads of Certain Federal Agencies
- 1979 Implementation of the Federal Guidelines for Dam Safety

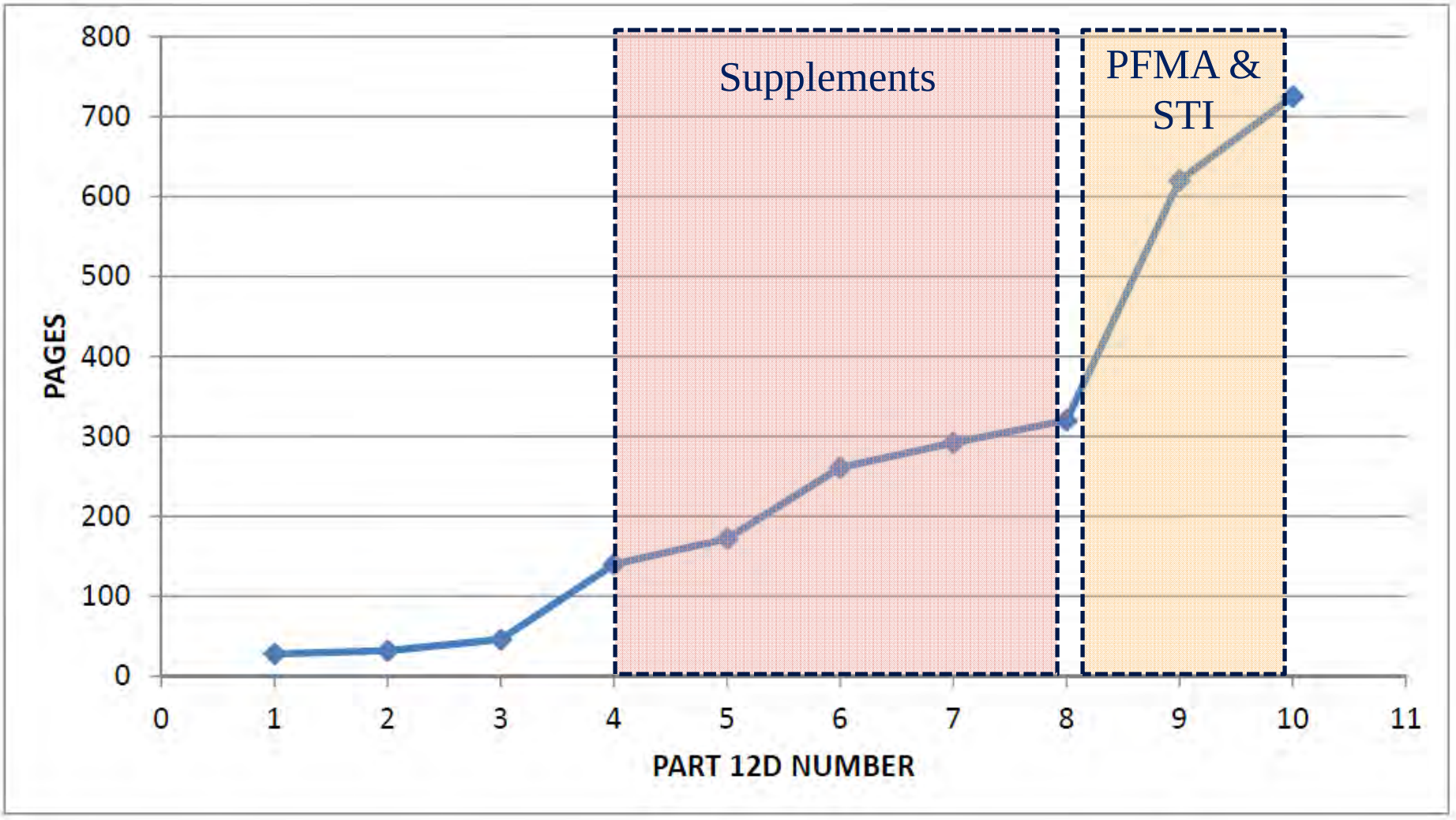
The History of Part 12D

- Order 122
  - Added “high” hazard potential dams to Part 12D in Section 12.30.
  - Allowed Independent Consultants to have worked on the project in the last 10 years (design, construction or maintenance) – just have “not been within two years of being retained to perform an inspection under this subpart, an employee or agent of the licensee or its affiliates” – Section 12.31
  - Independent Consultants may be part of a firm or acting alone – Section 12.32
  - Owners now have 60 days to provide a plan to address corrective measures, up from 30 – Section 12.39

The History of Part 12D

- Original Part 12D Reports were submitted to FERC in the 1960s and tended to be short and contain the original design basis.
- Subsequent reports would then reference earlier Part 12D analyses with phrases like “adequate analysis” but would not account for changing standards. This was not the intent of requiring subsequent reports.
  - Though, many reports did have a new date on the cover!
- As FERC scrutiny increased, so did the level of supporting information required in the reports!

The History of Part 12D



The History of Part 12D

- In late 2002, FERC, in cooperation with dam owners and ICs, developed and circulated guidance for carrying out a Potential Failure Mode Analysis (PFMA).
- The PFMA process introduced the concept of a STID (Supporting Technical Information Document) which included critical project information from earlier Reports that had been lost over time.
- Part 12D Reports were revised to focus on Potential Failure Modes, necessitating a more focused review of previous analyses and initiating new analyses.
- Present Part 12D Reports are again tending to accept prior methods, results and conclusions without critical review. Additionally, PFMs are poorly worded and unclear.

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Purpose

"The purpose of the Part 12D inspection is not to only inspect for those conditions that may develop as described in the PFMA but to document the actual condition of the project structures." (Chapter 14).

A detailed review of the design, construction, performance, and current condition assessment of the ***ENTIRE*** project.

Purpose

WHAT IT IS NOT: A bureaucratic exercise to simply comply with FERC's minimum requirements. No "check the box" mentality!

WHAT IT IS: A comprehensive assessment of the current health and long-term safety of the dam, much like a detailed physical examination by your physician.

Purpose

- See what is out there:

the IC is to include a complete evaluation of each component of the project, both from an analytical and a physical inspection point of view.

- See what is in there:

each project must be analyzed in accordance with the Engineering Guidelines for all loading conditions – normal, seismic, and hydrologic loading conditions.

- Includes PFMA process!

Purpose

- Review what others have seen: give due consideration to pertinent inspections and the reports prepared by or under the direction of any Federal or State agencies. Includes PFMA review!

- Ring the alarm: if "*an Independent Consultant discovers any condition for which emergency corrective measures are advisable, they must immediately notify the licensee and the licensee must immediately report that condition to the Regional Engineer.*" Includes findings from PFMA review.

Weir readings are holding steady at 900 gallons per minute.

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FERC Expectations: Owner

Preparation…include coordination of attendance by FERC engineer

- Once the Independent Consultant (IC) has been approved, it is the Licensee's responsibility to provide the IC with all project documentation, including, but not limited to:
  - STID
  - DSSMRs/DSSMP (5 years worth)
  - H&H analyses
  - Stability analyses
  - Construction information
  - Operational data
    - Flood SOP (ex. Stanchions, flashboards, gate operations)
    - Normal operation

FERC Expectations: Owner

Preparation (continued):

- Three (3) past Part 12D Reports
- Any ongoing studies (with comment letters – when applicable)
- Any FERC correspondence since the last Part 12D
- Last FERC Dam Safety Inspection Report (DSIR) (5)
- FERC Part 12D reminder letter

Essentially provide all documentation required for the IC to gain a complete understanding of the design, construction, and performance of the project.

FERC Expectations: Owner

Physical Preparation

- The owner must clear vegetation to allow for visual observation of the project
  - This means that it at least gets done once each year!

Clear View of the Project

FERC Expectations: Owner

Physical Preparation

- The owner must provide safe access to every nook and cranny of the project. For difficult access areas, such as gates or underwater features, it may be necessary to hire a specialized contractor to perform these tasks, and provide a report to the IC for review.
- Confined space entry and testing and recovery equipment.

- Provide or ensure that the inspection team has the appropriate equipment to perform their inspection.

Safe Access

FERC Expectations: IC

IC Preparation – BEFORE the inspection

- Review everything that was provided:
  - Review the existing PFMs to make sure that they are fully developed (from initiation to uncontrolled loss of the reservoir)
  - Consider new PFMs and prepare for PFMA Review
  - If other staff reviews and prepares summary, staff must attend inspection
- Review the physical requirements to inspect the entire project (**caution to ICs with physical restrictions**)
- Suggest eLibrary search

FERC Expectations: IC

Inspection

- Photo document all critical dam sections
- The inspection should keep PFMs and prior Part 12D findings in mind
- Open a spillway gate at least one foot (standby power if available):
  - May require notice/coordination to downstream owners
  - May require notice to operational staff (standby power)
- At completion of the inspection:
  - Recap PFM adequacy, including RRMs
  - Add new PFMs as necessary and assign an appropriate category

FERC Expectations: IC and Licensee

Inspection

- Pre-arrange access to all works with Owner
- Bring appropriate gear and paperwork (Confined Space, boat PFD, etc.) after consulting owner
- Pre-arrange water craft use (delivery and pickup)
- Lead a pre-inspection discussion of the PFMs (PFMA review session), P12 findings, FERC DSIR findings, DSSMR findings and other outstanding items.
- Access the spillway toe for scour (need to work with Owner on safe access and reduced flows) and spillway chute.

FERC Expectations: IC

Preparation

- Permit-required “confined space”
- Slip-and-fall conditions
- Steep / vertical slopes
- Low light levels
- Standing water
- Tight corridors
- Inadequate support/team

FERC Expectations :IC

Spillway looks great! I think.

Spillway chute also looks great! I think.

Upstream Face Looks Great!

Maybe not??

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FERC Expectations: Owner

Changes in letter this year

- To assist many of you in your planning, we intend to send the **reminder letter out 18 months** prior to the due date. However, this does not eliminate your need to track the due date of your next inspection and plan appropriately for your organizational time frames.

- Two phone calls:
  - After receipt of the reminder letter – Licensee and FERC RO

    Review of what the FERC expects so the Scope of Work for the RFP can be as accurate as possible.

  - 90 days prior to the inspection/PFMA review – Licensee, IC, and FERC RO

Part 12D Reminder Letter

- Letter Addresses:
  1. Potential Failure Mode Analysis (PFMA) -Review /Update Requirements
  2. Project Features - to be addressed in the report
  3. Independent Consultant Approval
  4. Report
  5. Report Recommendations Follow-up
  6. Enclosures (changes, responsibilities, report outline, 90 day pre-meeting conference call agenda)

Part 12D Reminder Letter

- Letter
  - All portions of the project associated with the Part 12 need to be inspected including:
    - All water retaining structures (dams, canals, penstocks, powerhouses)
    - Other features that may contribute to an uncontrolled release of the reservoir (abutments, low reservoir rim, potential landslides into reservoir, etc.)
  - Additional works and/or outstanding issues related to the project needing close attention will be identified.
  - Less frequent inspection activities should be coordinated with and evaluated in the Part 12 D inspection report:
    - Penstock inspections
    - Detailed Tainter gate inspections
    - Dive inspections (tail race, spillway toe)
    - Tunnel inspections

Part 12D Reminder Letter

- IC Approval

  Sixty days prior to inspection

  Three copies of requesting letter

  - Resume complying with 18 CFR Section 12.31

    Licensed Professional Engineer

    - At least 10 years experience and expertise in dam design and construction and in the investigation of the safety of existing dams; and
    - Is independent from the Licensee and has been for at least two years.

Part 12D Reminder Letter

IC Approval

List of approved IC's :

http://www.ferc.gov/industries/hydropower/safety/guidelines/dspmp/consultants.asp

Part 12D Reminder Letter

- At least 60 days prior to the inspection we request that owners coordinate their IC's field inspection and PFMA review with the Regional Office so that we may attend both.
- In order to allow the IC adequate time to adequately prepare for and inspect a project, and complete the Report, we strongly encourage the request letter and resume at least **six** months before the Report is due.
- The annual FERC dam safety inspection will be in conjunction with the IC's field inspection, if possible.

Part 12D Reminder Letter

- Important Reminder:
  - If you do not hear from us within **30 days** after submitting your IC letter, please contact us.
  - FERC HQ prioritizes the response to these letters.
  - If you **eFile** these letters, they on rare occasions get lost in the system. An email to the FERC project engineer notifying them the submittal will allow us to follow-up with HQ for a timely response.

Part 12D Reminder Letter

- The First Report for new constructed projects or projects where a major dam safety remediation has recently been completed may be done by the design engineer or an engineer from the design engineer's firm.
- The next Report must be completed by a different engineer not associated with either the design nor the construction firm.
- Subsequent Reports may be completed by an engineer associated with the design, construction, or remediation work.

Part 12D Reminder Letter

2015 Letter –

- The IC must provide a clear and comprehensive statement of concurrence or non-concurrence with the methodology, assumptions, and conclusions of previous reports and studies summarized in the STI
- The statement of concurrence must be **specific to each item** and include a thorough justification, not merely a repetitive general statement.
- Reasons for non-concurrence must be explained in detail and may require a independent analysis by the IC to clarify the effects on factors of safety of the structures.

Part 12D Reminder Letter

2015 Letter

- If there are no definitive statements, or the report does not meet other requirements....

- The report will be returned to the Licensee for the IC to revise and resubmit.

Part 12D Reminder Letter

2015 Letter

- IC report recommendations: 18 CFR Section 12.39 requires within 60 days of the date the IC report is filed, the licensee submit a plan of action and schedule to satisfy these recommendations.

- The Licensee needs to **confirm their agreement** with the IC's recommendations to continue any ongoing measures specifically identified in the Report.

Part 12D Reminder Letter

2015 Letter

The Licensee does not have to agree with the IC

- An owner's plan of action may include any proposal, including taking no action, considered as a preferable alternative to any corrective measures recommended by the IC in the Report.

Part 12D Reminder Letter

2015 Letter

- However, all original dam safety related recommendations by the IC should **remain in the Part 12 report** and any proposed alternative or dissenting opinion of the Licensee must be supported by complete justification and detailed analysis and evaluation in support of that alternative.

Part 12D Reminder Letter

Keep in mind:

Although the report is a FERC requirement, it has the greatest value to the dam owner.

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Supporting Technical Information Document

"The **purpose** of the Supporting Technical Information document (STI) is to **summarize** those project elements and details that do not change significantly between quinquennial FERC Part 12D Independent Consultant Safety Inspection Reports. **The Licensee is responsible** for compiling the "Supporting Technical Information" (STI) document and will create and maintain this document for use by themselves, the Part 12D Consultant and the FERC."

Chapter 14 Engineering Guidelines

Supporting Technical Information Document

The STI should include sufficient information to understand the design and current engineering analyses for the project such as:

- A **complete copy** of the Potential Failure Mode Analysis report
- A **detailed description** of the project and project works
- A **summary** of the construction history of the project
- A **summary** of Standard Operating Procedures
- A **description** of geologic conditions affecting the project works
- A **summary** of hydrologic and hydraulic information
- **Summaries** of instrumentation and surveillance for the project and collected data
- **Summaries** of stability and stress analyses for the project works
- Pertinent correspondence from the FERC and state dam safety organizations related to dam safety

Chapter 14 Engineering Guidelines

Supporting Technical Information Document

Table of Contents

Supporting Technical Information Document

The STID:

- What it is:
  - An Executive Summary with electronic copy of detailed analyses and associated files attached.
- What it Is NOT:
  - A “kitchen sink” to throw a hard copy of everything you can find into it without summarizing the important points related to each section of the STID

Supporting Technical Information Document

Qualifying Statement: **(even we can do these!)**

The following section of this presentation is not intended to represent a complete and all-inclusive list that an Independent Consultant should use to ensure completeness of every section of the Supporting Technical Information (STI) Document. It is the responsibility of the IC **and** the Licensee/Exemptee to be familiar with all the FERC requirements for what is to be included in the STI and the FERC will determine the adequacy of the submittal for acceptance or rejections.

Supporting Technical Information Document

All Licensees and IC's are strongly encouraged to review **Chapter 14 Appendix I for** what is to be contained in each section as well as an example STID

The FERC –CRO is reasonable and flexible to a point, provided the spirit of the STID is met.

Supporting Technical Information Document

- 1. PFMA report(s).
  - Have the PFM's been completely developed?
  - Has each PFM been appropriately classified?
  - Have all PFMs been considered – do any need to be added?
  - Are the risk reduction measures appropriate / sufficient, including the surveillance monitoring, operational changes, physical improvements and studies?
- 2. Description of the Project.
  - Is the description up to date?
  - Carefully review the description and update if required?

Supporting Technical Information Document

- 3. Construction History
  - Is the project history current?
  - Update description if required and thoroughly document problems observed and treated during construction. These can be very important in understanding subsequent behavior of project features.

    Eg. "Seepage (in 1956) from the right abutment made construction access difficult and drain pipes had to be added to the construction access road"

    "Groundwater (in 1939) was difficult to control due to the highly fractured rock in the left contact area"

    "Rip-rap below the spillway (in 1910) had to be replaced several times due to high flows"

Supporting Technical Information Document

4. Standard Operating Procedures

- Purpose of Project – run of river, irrigation, pumped storage, etc.
- Reservoir Operating Rule Curves by season
- Standard Gate Operating Procedures
    - Critical elevations
    - Location of equipment, controls, and warning system
    - Access to equipment/controls
    - Gate operations at different flow regimes (EAP)

Supporting Technical Information Document

- Flood Flow Operating Procedures
  - Gate operations
  - Sequencing of gate openings
  - Auxillary /Emergency spillway operations
  - EAP Activation
  - Mitigation of negative response times
    - Detection
    - Verification
    - Notification
    - Response time (Owner)
    - Response time (EMA)

Supporting Technical Information Document

- 5. Geology and Seismicity
  - Landslide potential.
  - Potential for sinkholes and subsidence.
  - Weak rocks seams.
  - Artesian sources.
  - Liquefaction Potential

  - Peak Ground Acceleration (PGA)

  Seismicity generally only a concern in Ohio and Mississippi River basins.

Supporting Technical Information Document

Geology/Hydrogeology

Foundation Material

Bedrock foundation – rock types, lithology, degree of weathering, structure (bedding, jointing, faulting),

Soil foundation – stratigraphy, soil types, depositional environment, depth to bedrock

Groundwater conditions – aquifers, confining layers, perched water tables

Aquifer characteristics - transmissivity, storativity

Supporting Technical Information Document

- 6. Hydrology and Hydraulics
  - Project must be designed either to withstand overtopping or the loading condition that would occur during flooding up to the PMF/IDF or that would endanger project structures.
  - The PMP must be estimated to be able to assess if the design is adequate
  - Was one of the HMR's used to estimate the PMP. Is that HMR current or is a site or an area (eg. state wide) specific study required. (May affect the ability of existing spillway to pass the PMF/IDF),

Supporting Technical Information Document

Hydrology and Hydraulics

Provide supporting documentation for new PMP.

- Magnitude
- Centering
- Duration
- Rain on Snow
- Orographics

Supporting Technical Information Document

- 6. Hydrology and Hydraulics
  - Is there adequate back-up for hydrology:

    Drainage area (confirm with latest GIS technology or use StreamStats)

    Antecedent soil moisture conditions (AMC I, II or III)

    Rainfall / runoff transform

    Flood of Record (FOR) used for calibration of model.

    Recent unit hydrograph (UH) studies in watershed

Supporting Technical Information Document

- 6. Hydrology and Hydraulics
  - Is there adequate back-up for dam hydraulics:

    Spillway rating curve:
    - Discharge coefficients
    - Gate and flashboard assumptions – consistent with SOP
    - Effective crest length vs. total crest length
    - Fuse plug, low rim, and levee overtopping assumptions
    - Debris blockage
    - Cavitation potential

Supporting Technical Information Document

- 6. Hydrology and Hydraulics
  - Dam hydraulics:

    Spillway tailwater rating curve.
    - Impact on stability analyses
    - Impact spillway performance (gates, outlets)
    - Downstream control structure causing restricted flow and affect tailwater depth.
    - spillway – submerged tailwater
    - Jetting - increase tailwater levels

Supporting Technical Information Document

Supporting Technical Information Document

Supporting Technical Information Document

- 6. Hydrology and Hydraulics
  - Check back-up for dam hydraulics:

    Normal and IDF freeboard?

    Spillway capacity at zero freeboard?

    Design basis of IDF
    - Suspect if it is just equals the existing spillway capacity
    - Common knowledge Operating rule curve frequently outdated and of minimal use.-
    - Have downstream conditions changed such that the hazard potential classification will change?

    Stilling basin or plunge pool design?

    Scouring

Supporting Technical Information Document

I looked at the IDF backup, seems fine

Supporting Technical Information Document

- 6. Hydrology and Hydraulics
  - Water hammer – transient analysis

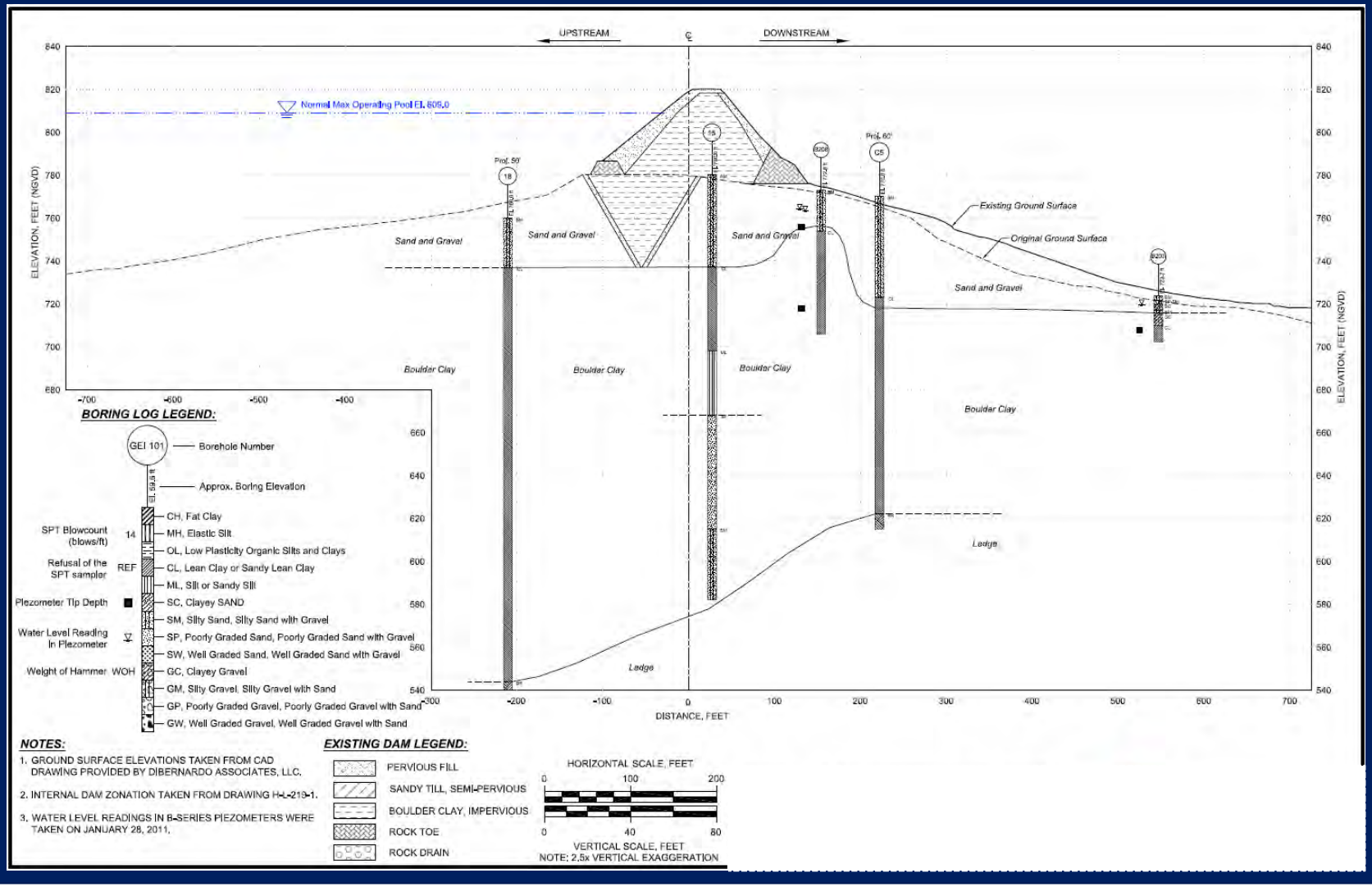
Supporting Technical Information Document

- 7. Surveillance and Monitoring Program (DSSMP)
  - Include location map of active instruments
  - Headwater/tailwater instruments (staff gages, pressure transducers, etc.)
  - Horizontal and vertical survey monuments
  - Piezometers/Observation wells
  - Seepage weirs
  - Slope Indicators
  - Extensometers
  - Crack monitors
  - Siesmic Instrumentation

Supporting Technical Information Document

- Piezometers:
- Include section view:
  - Stationing / offset of location of borings
  - Blow counts
  - Soil types / stratigraphy
  - Critical details of instrumentation installation (Casing/screen diameter, screen location, vibrating wire/pneumatic piezo location, observation well, etc.)
  - Elevations (standard datum) of all key features (normal pool, crest, screens locations, top of casings, etc.)

Supporting Technical Information Document



Supporting Technical Information Document

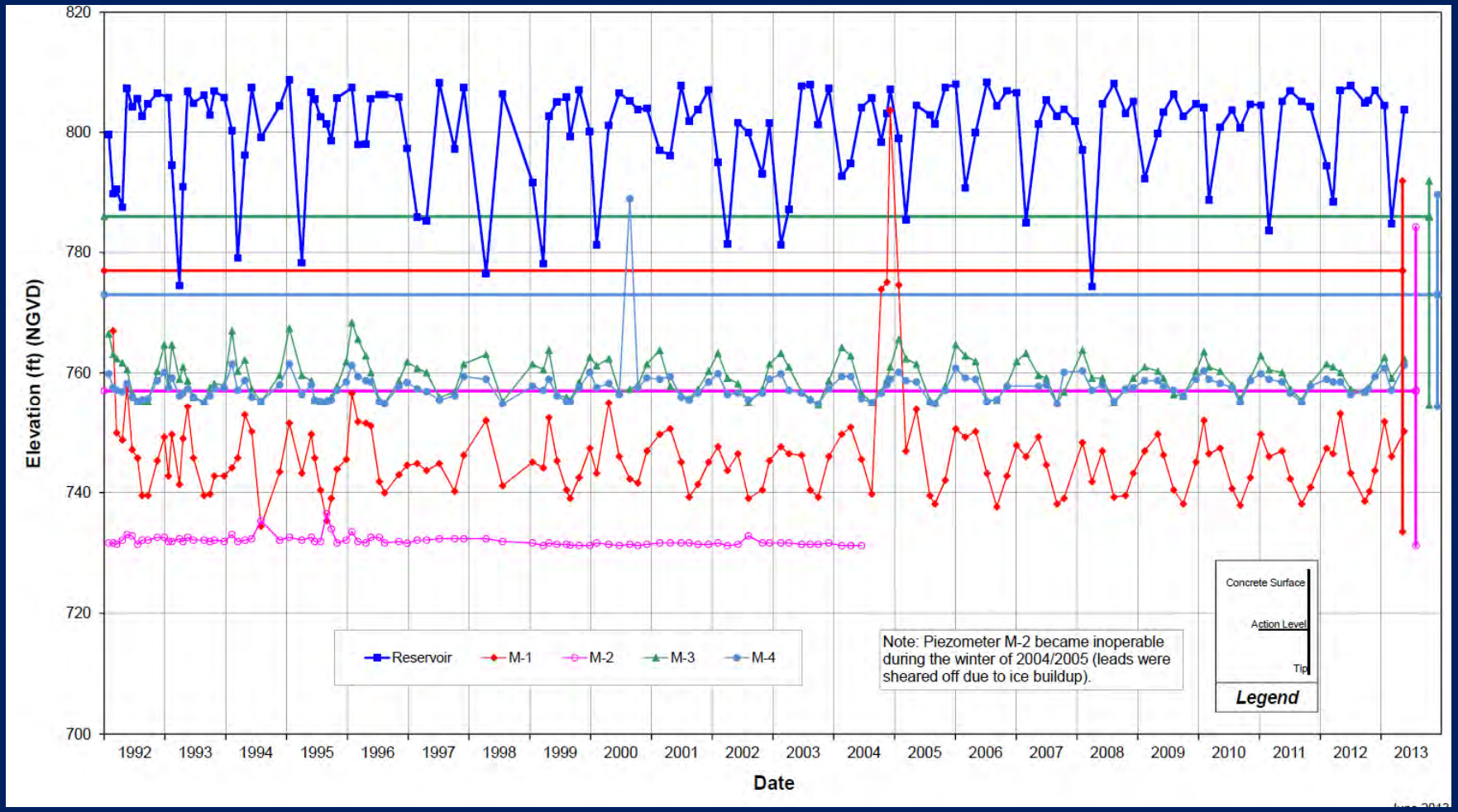
- 7. DSSMP/DSSMR – Con'd
  - Discuss frequency of readings:

    Need to establish a baseline that can be separated from extreme conditions (heavy rainfall, high reservoir, etc.)
  - Discuss spurious readings:

    Readings outside of the acceptable range (i.e. Action Level) must be carefully explained and monitoring must continue to confirm reading or determine if reading was inaccurate.

    Must include a trend analysis with other data plotted (eg. reservoir level, tailwater level, etc.)
  - Provide historical plots, and data since last Part 12D (five years)

Supporting Technical Information Document



Supporting Technical Information Document

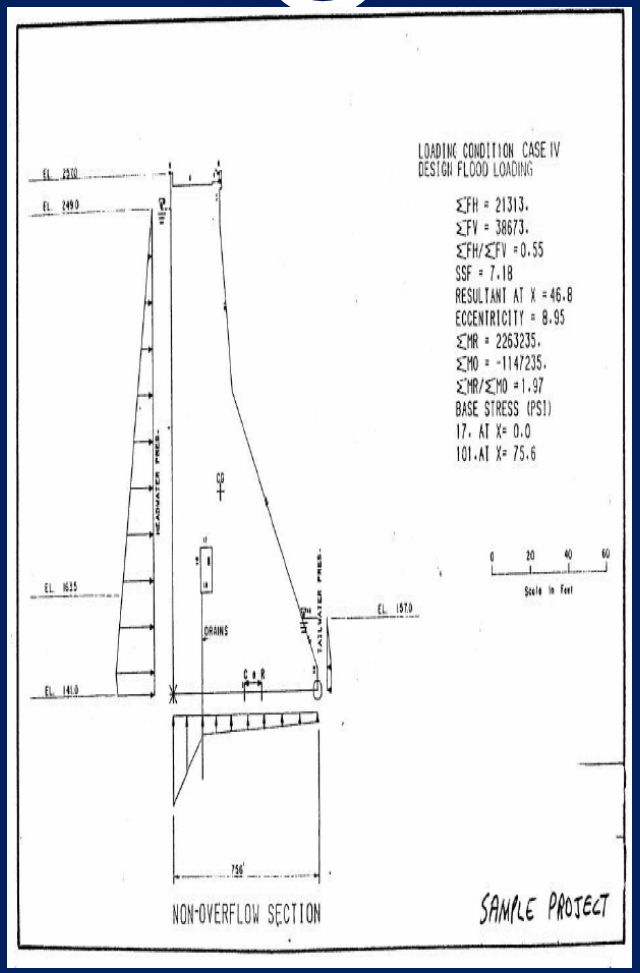
- 7. DSSMP/DSSMR – Con'd
  - Discuss the threshold and action levels (upper and lower).
    - Basis – historical, related to stability FS
    - Are these levels reasonable ?
  - Historic range of readings for each instrument
  - Discuss any readings outside expected range.
  - Critically review number and location of instrumentation and recommend elimination, addition, new locations.
  - Is the DSSMP adequate?
  - DSSMP needs to be updated as required.

Supporting Technical Information Document

- 8. Stability and Stress Analyses of Project Structures
  - List the credible load cases analyzed
  - Discuss selection of strength parameters for structures
  - Discuss factors of safety required and minimum for each load condition
  - For embankment, gravity and arch structures: Include freebody diagrams with loads, dead weight, uplift, silt line, headwater and tailwater elevation and other loads (ice) assumed for each loading condition (include a vertical datum).

    (Spillways: consider negative crest pressure (if appropriate) and tailwater conditions).

Free Body Diagram



Supporting Technical Information Document

- 8. Stability and Stress Analyses of Project Structures
  - Earthen Embankment Structures:
    - Provide a detailed cross-section referenced to a vertical datum
    - Deformation/Settlement
    - Drainage System – (Holland-Ackerman-Holland)
    - Soil strength parameters and physical characteristics
    - Liquefaction

Supporting Technical Information Document

- Gravity Dam Structures

  Provide a detailed cross-section referenced to a vertical datum

  Key trench

  Horizontal Lift Joints

  Vertical Construction Joints

  Foundation Drains/Grout Curtain

  Drain efficiency (uplift assumptions confirmed by instrumentation)

  Nappe forces can be significant at high discharge rates

  Tailwater effects

  Ice Loading – bubbler, de-icing system

  Post-tensioned anchors – corrosion protection

  Gravity analysis versus Finite Element – distribution of shear stress along failure plane, structure/foundation interaction, complex geometry.

  Passive Pressures versus weight of wedge

Supporting Technical Information Document

- For each arch dam load case:
  - Finite element mesh
  - Nodal displacements/element stresses
  - Stress contours
  - Principal Stress Vector diagrams
  - Thrust block stability (site characterization, structural geology)
  - Pulsating load potential, etc.

Supporting Technical Information Document

- 9. Spillway Gates
  - Annual gate operations and certifications
  - Detailed gate inspections
  - Review gate stress analysis
  - Discuss any operational concerns

Supporting Technical Information Document

- 10. Pertinent Correspondence Related to Safety of Project Works
- 11. Status of Studies in Process and Outstanding Issues
- 12. References
- 13. Conclusions

Supporting Technical Information Document

- In summary – include everything that is required to summarize the project sufficiently to use as a reference if you had only one document to pull during an emergency to get a general overview of the project.

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Federal Energy Regulatory Commission

Part 12D Refresher Training Potential Failure Modes Analysis (PFMA)

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frank.blackett@ferc.gov
Federal Energy Regulatory Commission
Division of Dam Safety and Inspections
San Francisco Regional Office
Wausau, WI May 5, 2015

Potential Failure Modes Soapbox

- Potential Failure Modes (PFMs) are like Geotechnical Engineers, and…..
- We all get "**no respect!**"
- Without a thorough geotechnical investigation for a dam, your dam has a high risk of problems and possibly **failure** – unless you get lucky
- Without a detailed PFM, your risk-informed decision will be **flawed** – unless you get lucky

Potential Failure Modes

- **Common Mistakes**
  - ***By far the biggest mistake made is rushing through a PFMA!***

Potential Failure Modes

- **Other Common Mistakes**
  - Confusing "**valid**" PFM with a "**credible**" PFM
    - "Valid" can be "hand of God" or meteorite impact – something typically considered physically impossible or extremely remote
    - Credible is something physically possible, regardless of liklihood
  - **Do NOT** consider likely/unlikely factors when developing PFM
  - **Do NOT** say, it's always been this way so it must be ok!
  - Inadequate documentation of PFMA

Potential Failure Modes

- Key Points to remember about PFMs and PFMAs
  - If it's not **documented**, it was not discussed.
  - Multiple PFMs can result by **changing a word** or two in a single PFM – but all must be separated into individual PFMs.
  - **Develop** each PFM to failure even if you realize that it's very remote while developing it.
  - Detailed **step-by-step** description of initiation to failure.
  - **Negative thinking** is encouraged to think of every possible way the dam can fail.

Potential Failure Modes

- Key Points to remember about PFMs and PFMAs
  - To the FERC, a failure is an **uncontrolled release** of water.
  - Operation of an emergency spillway is not an uncontrolled release of water.
  - Is such a thing as a restricted uncontrolled release – outlet works, turbine, etc… Still considered a failure.

- Licensee Concerns
  - **Unacceptable performance** could be a failure to Licensee
  - A Licensee may consider the loss of a turbine a PFM even without a release of water. The FERC is concerned but it is not a dam safety concern

Example - Wanapum Dam

Potential Failure Modes

- As mentioned, not all dams will undergo a formal risk analysis in the near future, (if ever) but…
  - PFMA review will be performed during **ALL** Part 12 inspections and should provide PFMs ready for use in a risk analysis.
  - PFMA is a crucial for evaluating **dam safety**.
  - You will likely **learn** a lot more about your dam.
  - Bound to be some **"Ah-ha"** moments and very possibly some **"#%*&?"** moments… especially for some CEOs once they understand the downstream **consequences** and **risk** posed by their dams!

Potential Failure Modes

- **Communication to those unfamiliar**
  - They are ***POTENTIAL*** failure modes and not failure modes
    - Those unfamiliar with dam safety and the PFMA process may think the dam is going to fail in the procedure identified.

PFMA *Review*

vs

***New* PFMA**

and….

RIDM

vs

Part 12D

PFMA Review vs New PFMA

- **Why this is important?**
  - **Not** "just" another FERC initiative
  - The FERC found a large percentage of **inadequate** PFMs for both dam safety and RIDM.
  - Without good PFMs and a complete PFMA, dam safety issues could be **overlooked**.
  - Major improvement in **understanding** of the safety of your dam.

PFMA Review vs New PFMA

Что , черт возьми RIDM???

There seems to be a lot of confusion regarding the application of RIDM to the PFMA review process!

PFMA Review vs New PFMA

- **RIDM Confusion**
  - At this stage, RIDM ***does not impact*** your PFMA or project, ***HOWEVER***, a PFMA serves the future of RIDM!
  - ***Dam safety*** relies exclusively on a **complete PFMA**.
  - **RIDM** relies heavily upon a ***complete PFMA.***
  - Without **complete PFMs**, a PFMA ***does not serve*** the **dam safety** of your project appropriately.
  - Without ***complete PFMs***, a PFMA **does not serve** your **risk analysis**.

- Should a:

PFMA Review < New PFMA

or

PFMA Review = New PFMA?

PFMA Review vs New PFMA

- **New or First-time PFMA**
  - Requires experts in all fields of study (structural, H&H, geotech, etc..), operators, and anyone with expertise about the project.
  - A facilitator experienced in facilitating PFMAs.

PFMA Review vs New PFMA

- **PFMA Review – Evaluate existing PFMA**
  - Evaluate the adequacy of your **existing** PFMs?
  - Any **new** conditions observed?
  - Any **changes** in operational procedures?
  - Any new **documentation** discovered?
  - Have there been any **modifications** to the project?
  - **Summary**: any changes in operation, information, observations, etc… since original PFMA needs to be discussed during PFMA review.

PFMA Review vs New PFMA

- **PFMA Review – Evaluate existing PFMA**
  - **May** require experts in all fields of study (structural, H&H, geotech, etc..), operators, etc… depending upon the quality of the initial PFMA.
  - **May** be conducted by the IC, unless extensive rework required and should be facilitated as a first-time PFMA.

PFMA Review vs New PFMA

- **PFMA Review - Procedure**
  - Detailed review of **ALL existing** PFMs to determine if they are fully developed… ***including*** Category IV and "other considerations!"
    - If not fully developed, they must be developed into complete PFMs
  - Any PFM **not fully developed** must be refined
  - Review all "**other considerations**" taking any new information into consideration.
  - Review the **category** of each PFM.

PFMA Review vs New PFMA

- **PFMA Review - Procedure**
  - If you find that your PFMA is:
    - poorly documented
    - requires extensive revisions
    - Requires the addition of numerous PFMs…..
  - You may need to consider writing an entirely new report!

Conducting a New PFMA

OR

PFMA Review / Supplemental PFMA

PFMA Preparation

- Supplemental PFMA may include:
  - a PFMA review
  - a construction PFMA
  - a new design PFMA

- A focused PFMA could focus only at a specific portion of the project, which should then be incorporated into the next PFMA review.

PFMA Preparation

- A lot of similarities between both
- Do your homework
  - Review project information
  - Review existing PFMs
  - Do your own brainstorming for new PFMs prior to the actual PFMA team effort
  - Have documents available for reference at the PFMA

Facilitating PFMA

Facilitating a PFMA

- Multiple ways to perform a PFMA
  - Assign team homework to develop PFMs prior to PFMA and start by reviewing these PFMs
  - Jump in with both feet developing the first PFM that comes to mind
  - Brainstorm the entire project before fully developing any PFM

Facilitating a PFMA

- Thank you for asking MY recommendation!
  - (One advantage of having a captive audience!)

- Brainstorming
  - Discuss entire project before heading into the weeds!

PFMA Brainstorming

- Discuss one loading condition or one pathway at a time for each portion of the project and complete brainstorming before moving on.
  - Normal (static) loading
  - Seismic loading
  - Hydrologic loading
  - Internal erosion through embankment
  - Internal erosion through foundation
  - Internal erosion from embankment into foundation
  - Etc…

PFMA Brainstorming

- For each loading condition discuss:
  - Original Design
  - Construction
  - Performance since construction
  - Focus on any problem areas, but…
    - Don't get sidetracked away from looking at entire project

PFM Categories

PFM Categories - Review

- The FERC is trying to clarify the confusion surrounding PFM Categories.
  - Our intent is to get our nationwide program all on the same page!
- If you do not fully develop a PFM, you cannot categorize it.

PFM Categories - Review

- Great confusion about categories
  - Do not consider risk when selecting categories
  - Do not confuse deterministic with probabilistic thinking
  - PFM is developed with understanding that each preceding event does occur.

- Remember “credible” vs “viable” PFM definition
  - Do NOT consider likelihood when developing PFM
  - DO consider likelihood of PFM happening when determining category

PFM Categories - Review

- Category I
  - ***Highlighted Potential Failure Modes*** - Those potential failure modes of greatest significance considering *need for awareness*, potential for occurrence, magnitude of consequence and likelihood of adverse response (physical possibility is evident, fundamental flaw or weakness is identified and conditions and events leading to failure seemed reasonable and credible) are *highlighted*.

PFM Categories - Review

- Category I
- What it is!
  - **Highlighted PFM** that is ***critical to dam safety*** and requires frequent monitoring
    - Must be Included in Dam Safety Surveillance and Monitoring Plan (DSSMP)
    - Instrumentation may be limited to visual observation
- **What it is not!**
  - An **automatic** identification of a dam safety deficiency
  - An **automatic** requirement to spend $$$$$$$$ to mitigate a dam safety deficiency

Category I – Example

- At the normal reservoir elevation of 2,348 feet, seepage begins to exit the left groin at elevation 2,290. The seepage increases until it begins to erode soil from the downstream face of the embankment. Backward erosion continues between the abutment and embankment soils forming a roof that allows a pipe to develop through the embankment The pipe progresses until reaching the reservoir allowing the full reservoir head to begin flowing through the developed pipe. The pipe enlarges to the point where the embankment collapses into the pipe allowing the embankment to breach resulting in a catastrophic release of the reservoir.

Category I – Example

- Why is this a Category I? (Likely and Unlikely)
  - Seepage begins to exit the left abutment when the reservoir reaches elevation 2,348 feet.
  - There is evidence that seepage flows have resulted in the erosion of embankment soils.

- Risk Reduction Measures
  - Restrict reservoir to an elevation below 2,348 feet
  - Increase visual monitoring of left groin when reservoir reaches elevation 2,348 feet and above

PFM Categories - Review

- Category II
  - ***Potential Failure Modes Considered but not Highlighted*** - These are judged to be of *lesser significance and likelihood (than Cat I)*. Note that even though these potential failure modes are considered less significant than Category I they are all also described and included with reasons for and against the occurrence of the potential failure mode. The reason for the lesser significance is noted and summarized in the documentation report or notes.

PFM Categories - Review

- Category II
- What it is!
  - PFM that is very **important to dam safety** to keep monitoring on a regular basis
    - Must be Included in Dam Safety Surveillance and Monitoring Plan (DSSMP)
    - Visual monitoring
    - Instrumentation
- **What it is not!**
  - A PFM that can be totally ignored in your DSSMP

Category II – Example

- At the normal reservoir elevation of 2,348 feet, seepage begins to exit the left groin at elevation 2,290. The seepage increases until it begins to erode soil from the downstream face of the embankment. Backward erosion continues between the abutment and foundation soils and a roof begins to form allowing a pipe to develop. The pipe progresses until reaching the reservoir allowing the full reservoir head to begin flowing through the developed pipe. The pipe enlarges to the point where the embankment collapses into the pipe allowing the embankment to breach resulting in a catastrophic release of the reservoir.

Category II – Example

- You note that these are identical PFMs
- What is the difference?
  - **Category 1** because monitoring program notes seepage develops when the reservoir reaches elevation 2,348 vs **Category II** because no seepage ever noted in left groin, but data indicates a change in construction that causes some concern. You must *always monitor seepage at embankment dams*.
- Risk Reduction Measures
  - Increase frequency of visual monitoring of left groin when reservoir reaches elevation 2,348 feet

PFM Categories - Review

- Category III

  – ***More Information or Analyses are Needed in order to Classify.*** These potential failure modes to some degree ***lacked information*** to allow a confident judgment of significance and thus a dam safety investigative action or analyses can be recommended. Because action is required before resolution the need for this action may also be highlighted.

PFM Categories - Review

- Category III
- What it is!
  - A PFM that you has **insufficient** information to classify at the time of the PFMA.
- **What it is not!**
  - A way to delay a decision about a possible dam safety issue.

Category III – Example

- During a seismic event, the cross-canyon motions cause the spillway piers to fail allowing the spillway gates to become detached from the piers. The loss of the gates result in an uncontrolled release of water and loss of 60-percent of the reservoir volume.
  - Unknowns:
    - No design Peak Ground Accelerations developed for the project
    - No structural analysis of the spillway piers addressing cross-canyon shaking.

Category III – Example

- Important note!
- The FERC will require a plan and schedule to address the missing information in any Category III PFM in order to make a final determination of the PFM category (I, II, or IV)

PFM Categories - Review

- Category IV
  - ***Potential Failure Mode Ruled Out*** Potential failure modes may be ruled out because the *physical possibility does not exist*, information came to light which eliminated the concern that had generated the development of the potential failure mode, ***or*** the potential failure mode is clearly *so remote* a possibility as to be non-credible or not reasonable to postulate.

PFM Categories - Review

- Category IV
- What it is!
  - The most **misinterpreted** category of PFM
  - The category that results in a lot of confusion and wasted discussion time
  - PFMs fully developed but found to be non-credible ***or*** physically impossible.
- **What it is not!**
  - A category to be confused with Category II
  - Does not require incorporation into the DSSMP
  - An appropriate category for any seepage PFM

Category IV – Example

- During the PMF, flows of 235,590 cfs overtop the concrete gravity dam by four feet for 5 hours. The flows erode the bedrock at the right abutment resulting in the loss of support of the right abutment of the dam. The flood load causes the right side of the dam to slide downstream sufficiently to allow a catastrophic release of the reservoir.

Category IV – Example

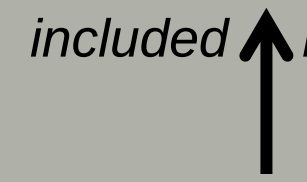
- Why is this a Category IV
  - The dam overtops for only 5 hours
  - A scour analysis of the bedrock indicates that it would not erode under the PMF overtopping conditions
  - The stability analysis indicates that the dam is stable with most of the bedrock gone.

- Risk Reduction Measures***
  - None

*** Note: if there are risk reduction measures it should not be a Category IV

PFM Categories - Review

- "Other Considerations"
  - *Sometimes an item or issue brought up relates to dam safety, surveillance and monitoring or is of **general concern** but is recognized by all as something that **does not or would not result in failure of the dam** or other water retaining structure at the project and is thus not a candidate potential failure mode. However, such items **still need to be included in the documentation to illustrate that they were identified**, considered and were left to be addressed (potential identification of action) by the Part 12D consultant and or the owner. Such items are referred to as **"Additional Monitoring or Performance Related Items Discussed"** and are to be included in the report in a section under that heading.*



Section Title in PFMA Report.

PFM Categories - Review

- Other Considerations

- What it is!
  - **Documentation** of all brainstormed PFMs discussed but not fully developed.
  - PFMs **not fully developed** because they were determined by the team to be much less likely than other similar PFMs
  - PFMs that may or may not require incorporation into the DSSMP

PFM Categories - Review

- Other Considerations

- What it is not!
  - A “catch all” category to put everything that you don’t want to develop into a full PFM
  - An automatic “out-of-sight out-of-mind” PFM with regards to your DSSMP

Other Considerations – Example

- *Seepage from the left abutment into the embankment during normal reservoir conditions at elevation 2,348.*

- During the development of PFM #(on next slide), the team discussed the possibility of seepage from the abutment into the embankment. This PFM was ruled out from full development because the abutment is hard, lightly fractured/jointed bedrock that would not erode and provide full access to the reservoir. The team also concluded that seepage would either be filtered by the properly compacted filter or saturation of the downstream shell would not result in a slope failure sufficient to release the reservoir.

Other Considerations – Example

- At the normal reservoir elevation of 2,348 feet, seepage begins to exit the left groin at elevation 2,290. The seepage increases until it begins to erode soil from the downstream face of the embankment. Backward erosion continues between the abutment and foundation soils and a roof begins to form allowing a pipe to develop. The pipe progresses until reaching the reservoir allowing the full reservoir head to begin flowing through the developed pipe. The pipe enlarges to the point where the embankment collapses into the pipe allowing the embankment to breach resulting in a catastrophic release of the reservoir.

Other Considerations – Example

- You note that these could be developed into near-identical PFMs
- What is the difference?
  - The team determined the most likely path was along the abutment/embankment contact and not into the abutment and warranted full development
- Risk Reduction Measures
  - Visually monitor the left groin for the development of seepage.

Category – General Notes

- **IMPORTANT NOTE:**
  - **All internal erosion and piping PFMs should be included in your visual monitoring program regardless of classification. They could develop at any time and you must be diligent in monitoring for changes in seepage.**
  - **The IC or facilitator (Review vs new PFMA) must make the final determination of the Category and not simply list the votes of the PFMA Team.**

PFM Categories - Review

- Miscellaneous considerations
  - No dual Categorization
    - PFMs should be a single Category since there are clear distinctions between each Category.
  - Preferred numbering
    - 1,2,3,4,5,etc…
  - Be clear when using possible confusing numbering
    - 1, 1A, 1B

Risk Reduction Measures

PFMA – Risk Reduction Measures

- Another critical part of the process
  - Measures to lessen the likelihood of the PFM from developing:
    - Actions
      - Lower the reservoir?
      - Minor modification?
      - Major modification?
      - Install more instrumentation?
      - Automation? – with caution and a good understanding
    - Monitoring
      - More frequent
      - Enhance monitoring by automation or adding vertical monitoring to concrete dam survey monuments.

Correlation of Instrumentation to PFMs ?

PFMA – Instrumentation

- A recent FERC initiative required the submittal of a table in the Dam Safety Surveillance and Monitoring Report (DSSMR) that correlates instrumentation with PFM beginning with 2014 DSSMR submittals.

- Consider adding this discussion to the PFMA process to aid in the understanding of the PFMs.

PFMA – Instrumentation Table

NEWLY IDENTIFIED PFMs (Follow Procedure in Chapter 14, Section 14.3.6 for Updating PFM's)

PFM – Number/Title(s)	Monitoring Effort	Result
Sliding of the non-overflow under normal loading conditions (candidate PFM identified during evaluation of deformation survey results)	Deformation Surveys	Differential movement detected and further evaluation of stability is needed
	Daily operator inspections	New cracks found on 9/18
	Monthly supervisor inspection	No adverse findings
	Annual engineer inspection	No adverse findings
Failure of Penstock No. 1 due to corrosion under normal loading (candidate PFM identified during review of STID)	Daily operator inspections	No visual changes to corrosion or leakage detected
	Monthly supervisor inspection	No visual changes to corrosion or leakage detected
	Annual engineer inspection	No visual changes to corrosion or leakage detected
	Ultrasonic thickness measurements	Section loss detected, see evaluation on page 19

INSTRUMENTATION NOT ASSOCIATED WITH A PFM: (General Health of Dam)

Monitoring Effort	Result
PZ-5	No adverse trends, no thresholds exceeded
Surveillance Camera at Weir	No visual changes or seepage with soil fines
Deformation Surveys	No adverse trends, no thresholds exceeded
Daily operator inspections	No adverse findings
Monthly supervisor inspection	No adverse findings
Annual engineer inspection	No adverse findings

What is an Appropriate Number of PFMs for a Dam?

PFMA – Risk Reduction Measures

- What's the minimum number of PFMs that should be developed?
  - Answer: As many as you need!
  - There should be a minimum of one fully developed PFM per loading condition and/or dam feature
    - Each type of internal erosion
    - Spillway structure/chute
    - Spillway gates
    - Concrete structures
    - Seismicity
    - Flooding

But as in all things FERC, there are always exceptions. Use good judgement!

Examples of fully developed Potential Failure Modes

Potential Failure Mode Description

- Step-by-step progression
- “Connect-the-dots” process
- Verbal description enabling someone to visualize the progression from initiation to failure
- A process, where if one step does not occur, neither with an uncontrolled release of water.

Potential Failure Mode Description

- **Internal Erosion process, but similar for all PFMs**

↳Reservoir loading condition

↳Flaw exists – Continuous crack, high permeability zone, etc.

↳Initiation – Particle detachment (erosion starts)

↳Continuation – Unfiltered or inadequately filtered exit exists

↳Progression – Continuous stable roof and/or sidewalls

↳Progression – Constriction or upstream zone fails to limit flows

↳Progression – No self-healing by upstream zone

↳Unsuccessful detection and intervention

↳ Dam breaches (uncontrolled release of reservoir)

Potential Failure Mode Description

- Remember this example? Paragraph format:
- At the normal reservoir elevation of 2,348 feet, seepage begins to exit the left groin at elevation 2,290. The seepage increases until it begins to erode soil from the downstream face of the embankment. Backward erosion continues between the abutment and foundation soils and a roof begins to form allowing a pipe to develop. The pipe progresses until reaching the reservoir allowing the full reservoir head to begin flowing through the developed pipe. The pipe enlarges to the point where the embankment collapses into the pipe allowing the embankment to breach resulting in a catastrophic release of the reservoir.

Potential Failure Mode Description

- Bullet example (often easier to create an event tree)

- At the normal reservoir elevation of 2,348 feet,
- Seepage begins to exit the left groin at elevation 2,290
- Seepage increases until it begins to erode soil from the downstream face of the embankment.
- Backward erosion continues between the abutment and foundation soils
- A roof begins to form allowing a pipe to develop.
- The pipe progresses until reaching the reservoir
- Full reservoir head to begin flowing through the developed pipe.
- Pipe enlarges to the point where the embankment collapses into the pipe
- The embankment breaches leads to a catastrophic release of the reservoir.

Potential Failure Mode Description

- **<u>PFM Frequently Developed:</u>**
  - Sliding of the concrete dam on the foundation.
- **<u>More Appropriate PFM:</u>**
  - During a period of normal high reservoir level at elevation 1,155 feet, and a continuing increase in uplift pressure on the shale layer slide plane, or a decrease in shearing resistance due to gradual creep on the slide plane, sliding of the buttresses initiates. Major differential movement between two buttresses takes place causing the deck slabs to become unseated from their simply supported condition on the corbels. Two bays quickly fail followed by the failure of adjacent buttresses due to lateral water load resulting in an uncontrolled release of the reservoir.
  - Or is this actually correct?

Potential Failure Mode Description

- This are actually two separate and distinct PFMs – Do not combine different loading conditions or failure mechanisms into one PFM.

Potential Failure Mode Description

- PFM 1:
  - During a period of normal high reservoir level at elevation 1,155 feet and ***a continuing increase in uplift pressure on the shale layer slide plane*** initiates sliding of the buttresses. Major differential movement between two buttresses takes place causing the deck slabs to become unseated from their simply supported condition on the corbels. Two bays quickly fail followed by the failure of adjacent buttresses due to lateral water load resulting in an uncontrolled release of the reservoir.
  - (Piezometers used to monitor uplift)

- PFM 2:
  - During a period of normal high reservoir level at elevation 1,155 feet and *a* ***decrease in shearing resistance due to gradual creep on the slide plane initiates*** sliding of the buttresses. Major differential movement between two buttresses takes place causing the deck slabs to become unseated from their simply supported condition on the corbels. Two bays quickly fail followed by the failure of adjacent buttresses due to lateral water load resulting in an uncontrolled release of the reservoir.

    (Survey monuments to monitor movement of dam)

Potential Failure Mode Description

- **PFM Frequently Developed:**
  - Dam overtopping due to gate operation failure.
- **More Appropriate PFM:**
  - During a 250-year flood, flows in excess of 12,000 cfs are requited to pass through a remotely controlled gate. The limit switch on the automated gate fails to prevent releasing flows that will wash out the only access road fails (occurred in 1994) due to a loss in communications equipment. The gate fully opens wiping out the access road. An operator is deployed to the site, but cannot make it to the dam. The release capacity of the single automated gate is insufficient and the dam overtops, eroding the embankment resulting in an uncontrolled release of the reservoir.

PFMA Report

Potential Failure Mode Report

- Original PFMA Report should never be altered
- **PFM Review:**
  - Appendix attached to original PFMA Report
- **New PFM Report**
  - If the existing PFMA Report is found to require a very significant rewrite, produce a new report and attach the original report as an Appendix to the new report.

PFMA – Instrumentation

PFM SUMMARY TABLE*

PFM #	Potential Failure Mode Description
CATEGORY I	
1	Continued corrosion of the steel plug in the future penstock section of the dam results in a failure of the plug and uncontrolled release of the reservoir.
7	Internal erosion and piping of the core along the left wall of the spillway exits unfiltered into the downstream rockfill shell.
8	The left abutment experiences slope instability due to increased hydrostatic pressures resulting from clogging of the horizontal drains in the rock slope. A loss of support the slope provided to the concrete dam is removed, resulting in a stability failure of the concrete dam.
CATEGORY II	
2	Continued movement of the intake/powerhouse section results in the sliding failure of that section of the dam.
3	A large landslide into the reservoir creates a downstream wave that overtops the dam. This leads to sufficient erosion of the embankment dam, resulting in a breach of the dam and uncontrolled release of the reservoir.
4	Internal erosion and piping of the core along the poorly compacted left abutment contact with bedrock into the downstream rockfill.
CATEGORY III	
6	Liquefaction of the foundation of the right embankment during the design earthquake (PGA of 0.75g).
CATEGORY IV	
5	Sliding failure of the gravity section of the dam resulting from loading during the PMF event.
9	Liquefaction of the upstream face of the right embankment during the design earthquake (PGA of 0.75g).
10	Structural failure of the spillway piers due to cross-canyon loading during the design earthquake (PGA of 0.75g).
11	Overtopping failure of the right embankment during the PFM event.

* This table contains brief summary descriptions of the current PFMs. Refer to the PFMA report for the fully developed PFM descriptions.

Potential Failure Modes

- More detailed PFM presentation and information on our web site

FERC.gov

Federal Energy Regulatory Commission

Part 12D Refresher Training
Potential Failure Modes Analysis (PFMA)
Questions? Discussion?

Agenda

- Objective
- History
- Purpose of the Part 12 process
- FERC expectations
- P-12 reminder letter
- Supporting Technical Information Document
- PFMA review process
- **Review of analyses**
- Engineering Guidelines
- Risk-based guidelines
- 18 CFR 12D requirements
- Report format
- Case studies
- Definitive statement required for each component of the dam
- Licensee responsibility
- Review the report prior to submitting to the FERC for review
- Question and Answer Time

Review of Analyses

- As stated earlier, Chapter 14 (and 18 CFR 12) require that the IC , where appropriate, make a clear statement that they have:
  - Reviewed the pertinent analyses and evaluations along with the underlying assumptions
  - Concluded that the assumptions and methods of analysis or evaluation were appropriate for the structure, were applied correctly and are appropriate given current guidelines and the state of dam safety practice.
- Our expectation is ownership, not the assumption of liability for the original designer.

Review of Analyses

- Chapter 14, Appendix H, Section 7 states:

- *"The purpose of this section is for the Part 12D Independent Consultant to assess the contents of the "Supporting Technical Information" document compiled by the licensee. The STI document should include information needed to understand and confirm the underlying assumptions and the conclusions of the analyses of record supporting the assessment of the safety of the Project.*
- *In each section, where appropriate, **the Independent Consultant shall make a clear statement** that they have reviewed the pertinent analyses and evaluations along with the underlying assumptions and that they have concluded that the assumptions and methods of analysis or evaluation were appropriate for the structure, were applied correctly and are appropriate given current guidelines and the state of dam safety practice."*

Review of Analyses

- The review of the STID is the best opportunity to carefully review the prior analyses as necessary to attest as to the overall safety of the project.
- Recently discovered deficiencies, during review of Ninth and Tenth Part 12D reports include:
  - Wrong hazard potential classification
  - No basis for the IDF
  - Insufficient stability factors of safety (all loading conditions)
  - Insufficient freeboard (potential for overtopping)
  - Incorrect rating curve
  - Numerous exceedances of the Action Levels without comment

Review of Analyses

A statement that an analysis is sufficient because FERC previously accepted it is not adequate, it could be cause for rejection of the report. Nor is a similar statement referencing back to the prior PFMA

Agenda

- Objective
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Engineering Guidelines / Format

- The FERC Engineering Guidelines should be taken as “guidelines” allowing for some flexibility to meet specific projects.
- Chapter 14 includes a sample Part 12D, PFMA, DSSMR, DSSMP and STI layout.
- The Chapter 14 Table of Contents examples should be followed to ease FERCs review and provide a consistent guidance document where key information can be quickly located

Engineering Guidelines / Format

- The quality and thoroughness of analyses should be compared to the specific Chapter of the Engineering Guidelines governing such analyses:
  - Chapter 2 - Selecting and Accommodating Inflow Design Floods for Dams
  - Chapter 3 - Gravity Dams
  - Chapter 4 - Embankment Dams
  - Chapter 5 - Geotechnical Investigations and Studies
  - Chapter 8 - Determination of the Probable Maximum Flood
  - Chapter 9 - Instrumentation and Monitoring
  - Chapter 10 - Other Dams
  - Chapter 11 - Arch Dams
  - Chapter 13 - Evaluation of Seismic Hazards
  - Chapter 14 - Dam Safety Performance Monitoring Program

Engineering Guidelines / Format

- The Guidelines are available for download here:

  https://www.ferc.gov/industries/hydropower/safety/guidelines/eng-guide.asp

- A major warning (spoiler alert) is that the Guidelines have not all been updated to match most recent software. They should be used for methodologies only, and not software advice. For example:
  - *"The most widely used and recommended method for dam break analysis is the unsteady flow and dynamic routing method used in the National Weather Service DAMBRK model."*
  - *"FLOODWAV is also recommended as a preferred model for dambreak analysis."*

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Risk-Based Guidelines

- The posted Engineering Guidelines for RIDM are draft versions. They were developed by technical committees consisting of dam owners, engineering consultants, and FERC staff:

  http://www.ferc.gov/industries/hydropower/safety/initiatives/risk-informed-decision-making/eng-guide-ridm.asp

- They include:
  - Chapter RI – Introduction to Risk Informed Decision Making
  - Chapter R5 – Concrete Dams
  - Chapter R10 – Internal Erosion
  - Chapter R19 – Probabilistic Flood Hazard Analysis
  - Chapter R20 – Probabilistic Seismic Hazard Analysis
  - Chapter R21 – Dam Breach
  - Chapter R22 – Estimation of Life Safety Consequences

Risk-Based Guidelines

- Although the FERC has developed draft RIDM Guidelines, the existing deterministic guidelines will remain in place for the foreseeable future.
- Use of the draft RIDM guidelines in the near term will be on an exception basis.
- The FERC is now prepared to begin implementing RIDM on a trial basis. Over the next few years a limited number of projects will be selected, in consultation with the dam owners, to undergo a risk-informed process.
- Owners may contact the FERC if they believe their project is a candidate for the RIDM trials.

Risk-Based Guidelines

Any Projects that use the RIDM process will be required to meet the following conditions:

- Attendance at FERC sponsored RIDM training programs.
- Selection of an experienced risk analysis facilitator approved by the FERC.
- FERC staff participation in working and formal RIDM meetings.
- Selection and use of appropriate technical consultants with experience in risk analysis and/or probabilistic hazard analyses.
- Completion of appropriate data collection for use in a comprehensive RIDM analysis.
- Perform an External Peer Review by an engineer with experience in RIDM related to dams.
- Preparation of a RIDM report signed and stamped by a Registered Professional Engineer.

Risk-Based Guidelines

- The first informal steps of RIDM include:
  - Improving your PFMs
  - Identifying missing PFMs
  - Considering a full range of potential consequences
  - Explicit accounting of both life loss and economic consequences
  - Explicit accounting of the probability of failure across the full range of PFMs
  - Explicit accounting for uncertainty in the analyses
  - Identifying critical systems and components
  - Estimating the probability of failure for each PFM

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18 CFR 12 Part D Requirements

- § 12.30 — Applicability
- § 12.31 — Definitions
- § 12.32 — General inspection requirement
- § 12.33 — Exemption
- § 12.34 — Approval of independent consultant
- § 12.35 — Specific inspection requirements
- § 12.36 — Emergency corrective measures
- § 12.37 — Report of the independent consultant
- § 12.38 — Time for inspections and reports
- § 12.39 — Taking corrective measures after the report

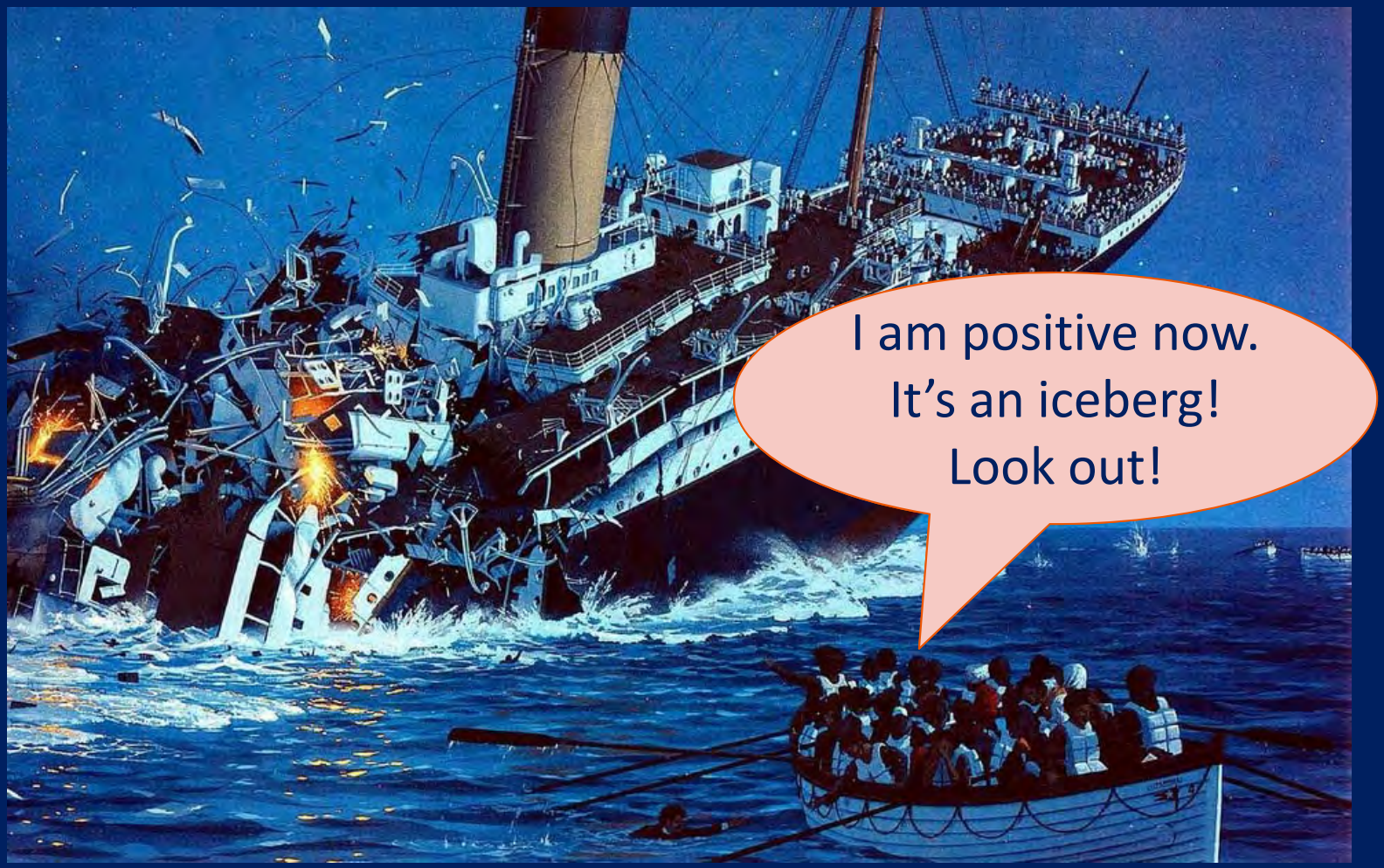
18 CFR 12 Part D Requirements

- While discussed elsewhere, there are a few points not yet highlighted in this presentation.
- § 12.33 Exemption :
  - (a) Upon written request from the licensee, the Director of the Office of Energy Projects Licensing may grant an exemption from the requirements of this subpart in extraordinary circumstances that clearly establish good cause for exemption.
  - (b) Good cause for exemption may include the finding that the development in question has no dam except dams that meet the criteria for low hazard potential as defined by the Corps of Engineers in 33 CFR part 222.

18 CFR 12 Part D Requirements

- § 12.36 Emergency corrective measures:
  - If, in the course of an inspection, an IC discovers any condition for which emergency corrective measures are advisable, the independent consultant must **immediately notify** the licensee and the licensee must report that condition to the Regional Engineer pursuant to § 12.10(a) of this part.

Timely warnings



18 CFR 12 Part D Requirements

- § 12.37 Report of the IC
  - (5) Dissenting views. If the inspection and report were conducted and prepared by **more than one independent consultant**, the report must clearly indicate any dissenting views concerning the analyses or recommendations of the report that might be held by any individual consultant.
  - (6) List of participants. The report must identify all professional personnel who have participated in the inspection of the project or in preparation of the report and the independent consultant who directed those activities.
  - (7) Statement of independence. The independent consultant must declare that all conclusions and recommendations in the report are made independently of the licensee, its employees, and its representatives.
  - (8) Signature. The report must be signed by each independent consultant responsible for the report.

18 CFR 12 Part D Requirements

- § 12.39 Taking corrective measures after the report.
  - (a) Corrective plan and schedule.

    (1) **Not later than 60 days** after the report of the independent consultant is filed with the Regional Engineer, the licensee must submit to the Regional Engineer three copies of a plan and schedule for designing and carrying out any corrective measures that the licensee proposes.

    (2) The plan and schedule may include any proposal, including taking no action, that the licensee considers a preferable alternative to any corrective measure recommended in the report of the independent consultant. Any proposed alternative must be accompanied by the licensee's complete justification and detailed analysis and evaluation in support of that alternative.
  - (b) Carrying out the plan. The licensee must complete all corrective measures in accordance with the plan and schedule submitted to, and approved or modified by, the Regional Engineer.
  - (c) Extension of time. For good cause shown, the Regional Engineer may extend the time for filing the plan and schedule required by this section.

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Report Format

- Report contents are summarized in 18 CFR 12.35
- And are repeated in the P-12 Reminder Letter
- Incomplete reports will be rejected

Report Format

- Our expectation is ***not*** for you to assume professional liability for the original designer
- Chapter 14, Appendix H, Section 7 states:

- *The purpose of this section is for the Part 12D Independent Consultant to **assess the contents** of the "Supporting Technical Information" document compiled by the licensee. The STI document should include information needed to understand and confirm the underlying assumptions and the conclusions of the analyses of record supporting the assessment of the safety of the Project.*

- *In each section, where appropriate, the Independent Consultant shall make a clear statement that they have reviewed the pertinent analyses and evaluations along with the underlying assumptions and that they have concluded that the assumptions and methods of analysis or evaluation were appropriate for the structure, were applied correctly and are appropriate given current guidelines and the state of dam safety practice.*

Report Format

- The report will be returned to the Licensee for the IC to revise and resubmit.

Report Format

- Failure to provide a clear review statement is unacceptable to the FERC and **should be unacceptable to any dam owner** with an appreciation of their responsibility and liability
- Chapter 7 of the Part 12D is “Assessment of the Supporting Technical Information Document”
- The STI document should include information needed to understand and confirm the underlying assumptions and the conclusions of the analyses of record supporting the assessment of the safety of the Project.

Report Format

Table of Contents

Report Format

List of Tables (with location)
List of Figures (with location)
List of References

Appendices for Part 12D Inspection Report
A. FERC Letter Requiring Part 12D Inspection
B. FERC Letter Approving Part 12D Consultant
C. Project Figures
D. Instrumentation Monitoring Data Plots
E. Inspection Photographs
F. Inspection Checklists and/or Field Notes (Optional)
G. Operation and Maintenance Documentation (If required)

Report Format

- Section 7 of the Part 12 Report is the Section that is the most misunderstood
  - Must make definitive statement in each of the sections individually
  - Generic, general statement is not acceptable

Report Format

- 7.1 PFMA report(s).
- 7.2 Description of the Project.
- 7.3 Construction History
- 7.4 Standard Operating Procedures
- 7.5 Geology and Seismicity

Report Format

- 7.6 Hydrology and Hydraulics
- 7.7 Surveillance and Monitoring Program (DSSMP)
- 7.8 Stability and Stress Analyses of Project Structures

Report Format

- 7.9 Spillway Gates
- 7.10 Pertinent Correspondence Related to Safety of Project Works
- 7.11 Status of Studies in Process and Outstanding Issues
- 7.12 References
- 7.13 Conclusions

Report Format

Report – cause for rejection

- "You are reminded that failure to conform to the requirements of the Part 12D process will result in rejection of the report." – 2015 Part 12D Reminder Letter
- Each PFM must have a specific loading condition, mode of failure, defined consequence to public safety, and category.
- Prior analyses (and supplements) are to be scrutinized:
  - No back-up or sources documents means that an analysis **must** be revisited.
- Instrumentation and instrumentation data must be reviewed.

Report Format

Reminder:

- If there are no definitive statements, or the report does not meet other requirements....

- The report will be returned to the Licensee for the IC to revise and resubmit.

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Case Histories

Case Studies were presented but are not included for public distribution.

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Definitive Statements

- As discussed before, the IC must provide a ***clear and comprehensive statement*** of concurrence or non-concurrence with the methodology, assumptions, and conclusions of previous reports and studies summarized in Section 8 of the STI.
- One general statement is not acceptable.
- The Report should indicate in each section that this review and concurrence has been completed.

Definitive Statements

- Please ensure that the Report fulfills this requirement, as unresponsive Reports received by the D2SI will likely be returned for resubmittal, **and many across the nation have been returned recently.**

- When a Consultant justifies the adequateness of a section in the Supporting Technical Information document by stating that the FERC previously accepted a report submitted by the licensee, the Consultant is, in essence, attempting to delegate their responsibility to the FERC.

Definitive Statements

- The definitive statements are intended to fulfill the requirement in 18CFR12.37 ... “Analyze the safety of the project works and the maintenance and methods of operation of the development fully in light of the independent consultant's reviews, field inspections, assessments, and evaluations described in §12.35”.

Definitive Statements

- Adjust appropriately to match the section you are discussing.
- Individual statements are required in each section to ensure that the IC has paid necessary attention to each section.

Section 7.1 Example

- Positive: The PFMA was reviewed for completeness during a PFMA review conducted in conjunction with the Part 12 inspection. I/we reviewed the following items (itemize here) and as a result, consider the PFMs to be well written, well documented, and complete relative to the project information.

- Negative: I/we reviewed the following items (itemize here) . PFM Number XX was not fully developed and a recommended revision is included in the recommendation section of this report. After review and concurrence by FERC the revised PFM should be adopted. The other PFMs are considered to be well written, well documented, and complete relative to the project information.

Section 7.2 Example

- Positive: The description of the project is correct and adequately summarizes the major components of the project and provides a good executive review level discussion about the project.

- Negative: It is recommended that the description of the project included in the STID be revised to include a better description of the spillway gate operators as noted in the recommendation section of this report.

Definitive Statement Examples

- Section 7.3. The construction history is adequately described, including significant construction issues encountered during the construction which include (list here) that could potentially impact the operation and performance of the project features.

- Section 7.4. The Standard Operating Procedures are adequately summarized in the STI and include (list here) that are of specific interest regarding the continued safe operation of the project.

Section 7.5 Example

- The geology and seismology of the project are adequately summarized and highlights specific issues that could impact the operation and performance of the project and include (list here).

- Our/my review of the seismicity indicates that site seismicity was developed using the most current data and approach available. The assumptions, methods, and use of the data and its application to this project meet the current guidelines and the state of dam safety practice.

Section 7.6 Example

- 7.6 The hydrology of the project is adequately described in the STI. My/our assessment of the hydrology included a review/analysis of (list here). The key assumptions and parameters include (list here) and are considered appropriate to the current methodologies, data, and state of dam safety practice for evaluating the hydrologic safety of a dam. The PMF inflow of xxxx cfs is appropriate for this project, and the project spillway(s)/outlets can pass this flood with xx feet of freeboard on the dam.

- The hydraulics of the project are adequately described in the STI. The spillway rating curve(s) is correct and adequately represents the current spillway hydraulics.

Part 12D Reminder Letter

Reminder – One last time?

- If there are no definitive statements, or the report does not meet other requirements....

- The report will be returned to the Licensee for the IC to revise and resubmit.

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Licensee Responsibility

- Two phone calls:
  - After receipt of the reminder letter – Licensee and FERC RO
  - 90 days prior to the inspection/PFMA review – Licensee, IC and FERC
- Prepare for inspection by clearing vegetation, provide safe access and ensure proper safety and training is met.
- Submit the IC's Report to the FERC and ensure that the Report meets the requirements of the Commission.

Licensee Responsibility

- Additional relevant responsibilities under 18 CFR 12:
  - § 12.5 Responsibilities of licensee or applicant. Use sound and prudent engineering practices in any action relating to the design, construction, operation, maintenance, use, repair, or modification of a water power project or project works.
  - § 12.12 Maintenance of records. The owner must maintain as permanent project records engineering and geological data, instrumentation data, and the operational and maintenance history of the project.

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Licensee Review

- It is the Licensee's responsibility to review and concur with the IC report
  - If there are **differing opinions** about recommendations and/or conclusions, the IC must remain steadfast in their decisions if it is a dam safety concern.
  - If the **Licensee disagrees** with conclusions/recommendations, they should **remain in the Part 12 report** with the Licensee making a case why they disagree.
  - D2SI will review both cases and provide comments regarding which case they determine to be most appropriate.

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- **Question and Answer Time**

Presenters

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William Allerton
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William Brown
Kevin Griebenow
Eric Gross
Douglas Johnson
Wayne King
Edward Perez
Olaf Weeks
John Zygaj

Thank you

Any Questions?