

Operational Related Risks

Best Practices in Dam and Levee Risk Analysis

Part H – Other Risks

Chapter H-1

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Objectives

Understand

- The various ways improper or accidental operation can lead to failure
- How to construct and event tree to represent operational risks
- How to feed this information into other failure modes



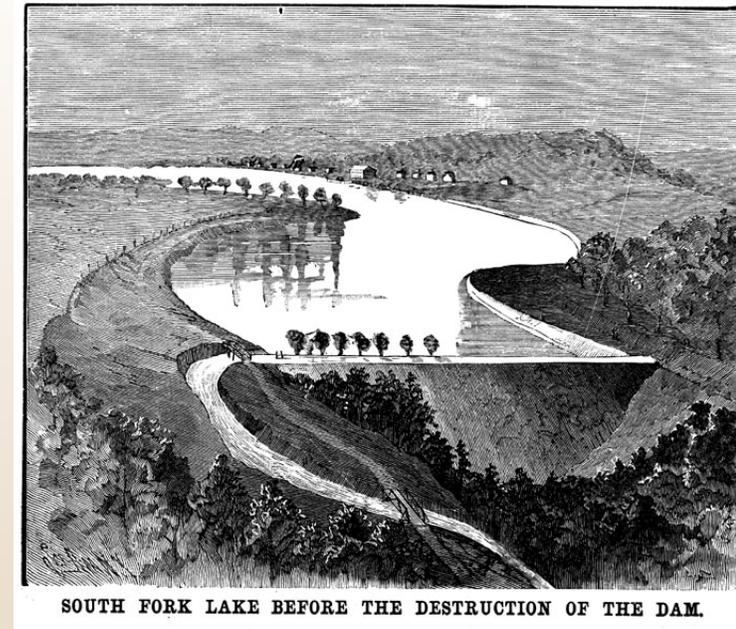
Key Concepts

- Operator error
- Inadvertent operation
- Gate misoperation or malfunction
- SCADA and remote operation
- Access
- Barge impact and towboat misadventures
- Water Control Plan
- Unique and require some creative thought
- Happen frequently
- Part of many risk assessments



South Fork Dam Modifications

- Failed in 1862 - collapse of stone outlet conduit, reconstructed but outlet filled in
- Spillway:
 - Ungated overflow
 - 99 feet wide
 - Bridge across spillway with supports at 6-1/2 foot spacing
 - Iron Screens were placed across the spillway to prevent fish from escaping reduced spillway capacity by 40%
- Dam crest lowered to widen roadway so that carriages could pass
- No camber, center portion of dam crest lower



SOUTH FORK LAKE BEFORE THE DESTRUCTION OF THE DAM.

South Fork Dam

- Heavy rains in May of 1889
- Inflow greater than spillway capacity and fish screens became plugged with debris
- Dam overtopped and failed



Failure Consequences, Johnstown, PA



- 2,209 Deaths
- 99 entire families died, including 396 children
- The greatest loss of life due to failure of a man-made structure for a single event in the history of the United States until 9/11.

Taum Sauk



- Concrete-faced earthfill “ring-dike” structure
- Upper reservoir of pumped-storage project
- Water routinely stored on 10-foot high parapet

Taum Sauk

- Membrane liner installed in 2004
- Reservoir level instrumentation could not be reinstalled properly due to liner warranty issues
- Instruments were loose and not reading reservoir level properly
- Resetting of reservoir sensors did not account for settlement of embankment
- Alarms wired so high level and high-high level sensors both needed to trigger for alarm
- Over-pumping was not detected and dam overtopped and failed



Taum Sauk



- 5 people in Ranger's house were miraculously thrown out of the way when the flood hit
- No one died

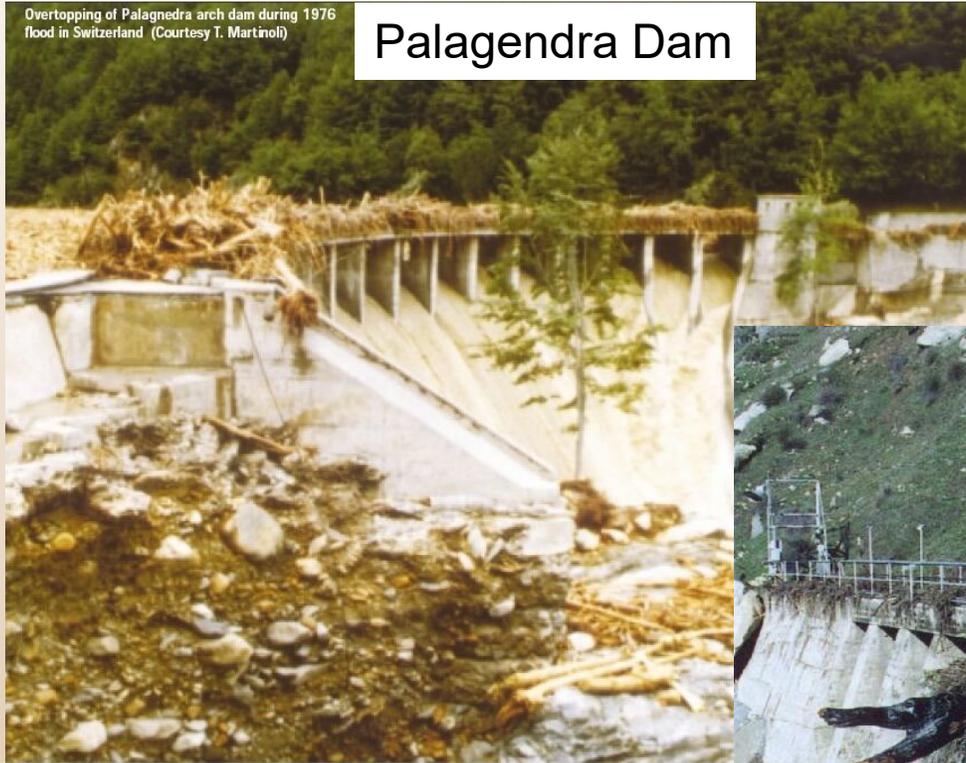


- Winter – campground not occupied
- No one died

Dams with Debris

Overtopping of Palagnedra arch dam during 1976 flood in Switzerland (Courtesy T. Martinoli)

Palagnedra Dam



Kerckhoff Dam



Rock Fall Damages Spillway Gates



Project Access



Limit Switch Failure



Spillway Operating Deck and Generator Floods

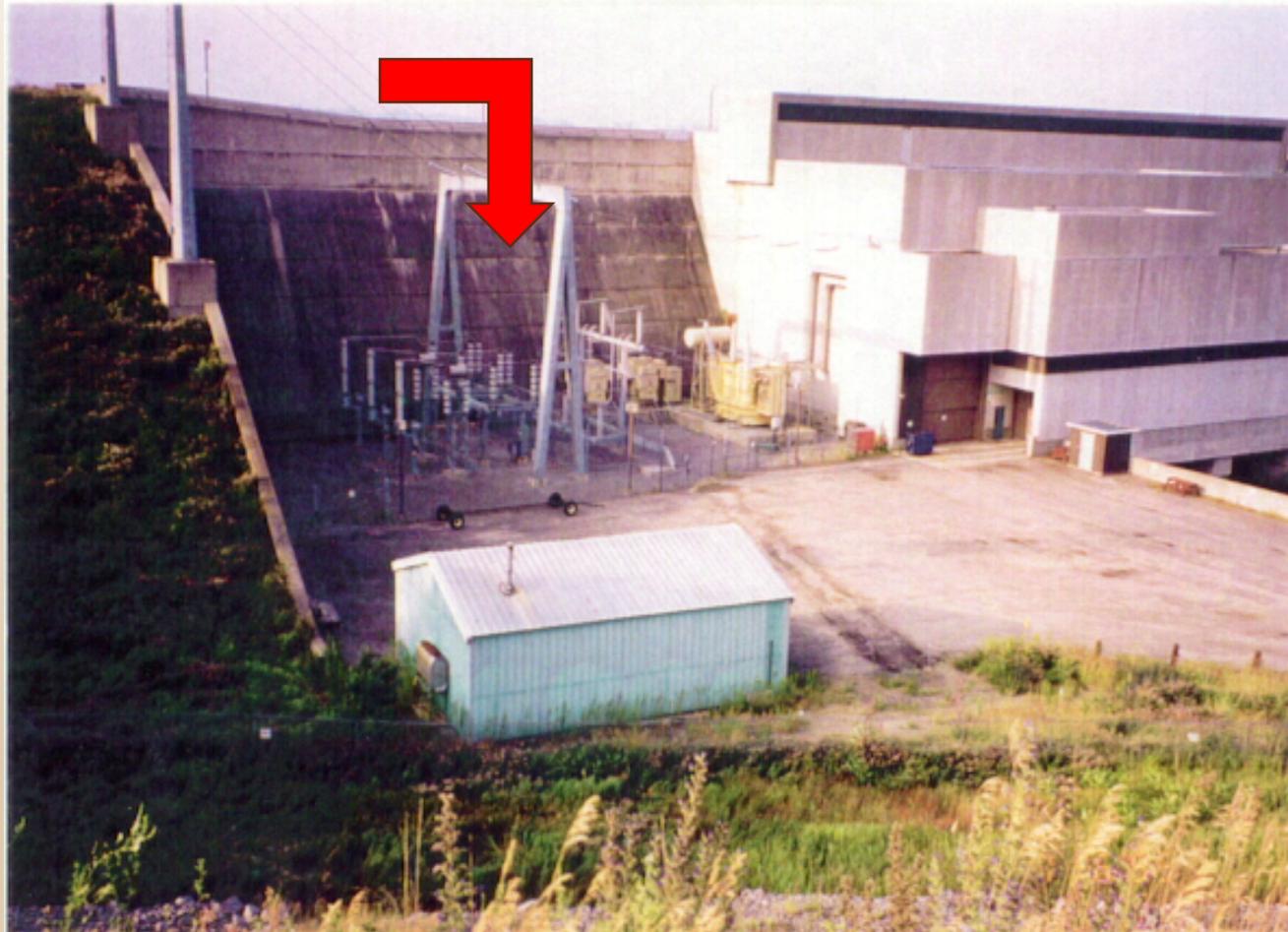


Emergency generator room
same elevation as catwalk.



Catwalk almost inundated
during flood – gates must be
operated from catwalk

Switchyard Floods – Loss of Power Release Capacity



Other Mechanical/Electrical Related Failure Examples

- Valve failure



- Control valve left in open position leading to fully opened gate
 - Control valve not equipped with spring loaded lever
- Software error in SCADA syst. causes gate to open unexpectedly

Insufficient Pump Capacity Inundates Leveed Area



Backflow Through Interior Drainage Culvert Due to Failure to Close Gate

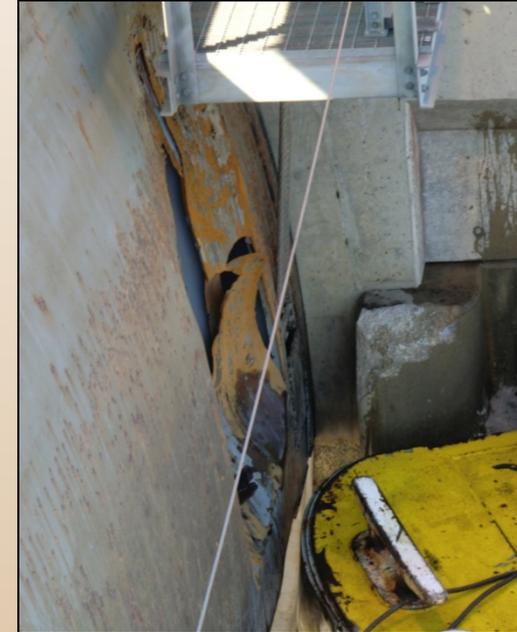


Brookport Levee System

Marseilles L&D, IL Incident 18-19 April, 2013



Marseilles L&D, IL Tainter Gate Damage



Marseilles Damage Summary

- Main Dam
 - Six barges break free and three sink.
 - Gates 2 through 6 impacted by barges leaving Gates 2 and 3 inoperable
 - Pier 2 trunnion anchorage destroyed
 - Decreased spillway capacity led to erosion at dam around boiler house
- Earth Dike (Note: this structure is upstream of the main dam)
 - Erosion of earth section
 - Widespread residential flooding



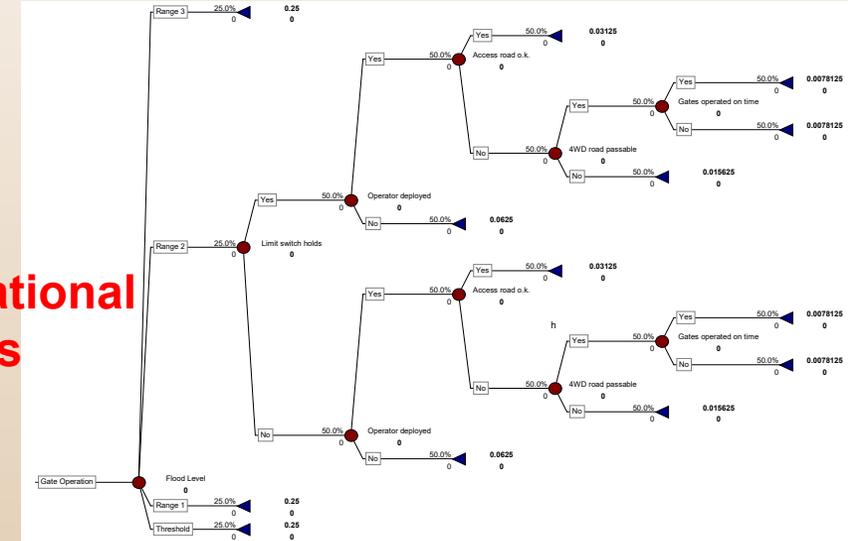
Data on Spillway (Lack of) Release Incidents

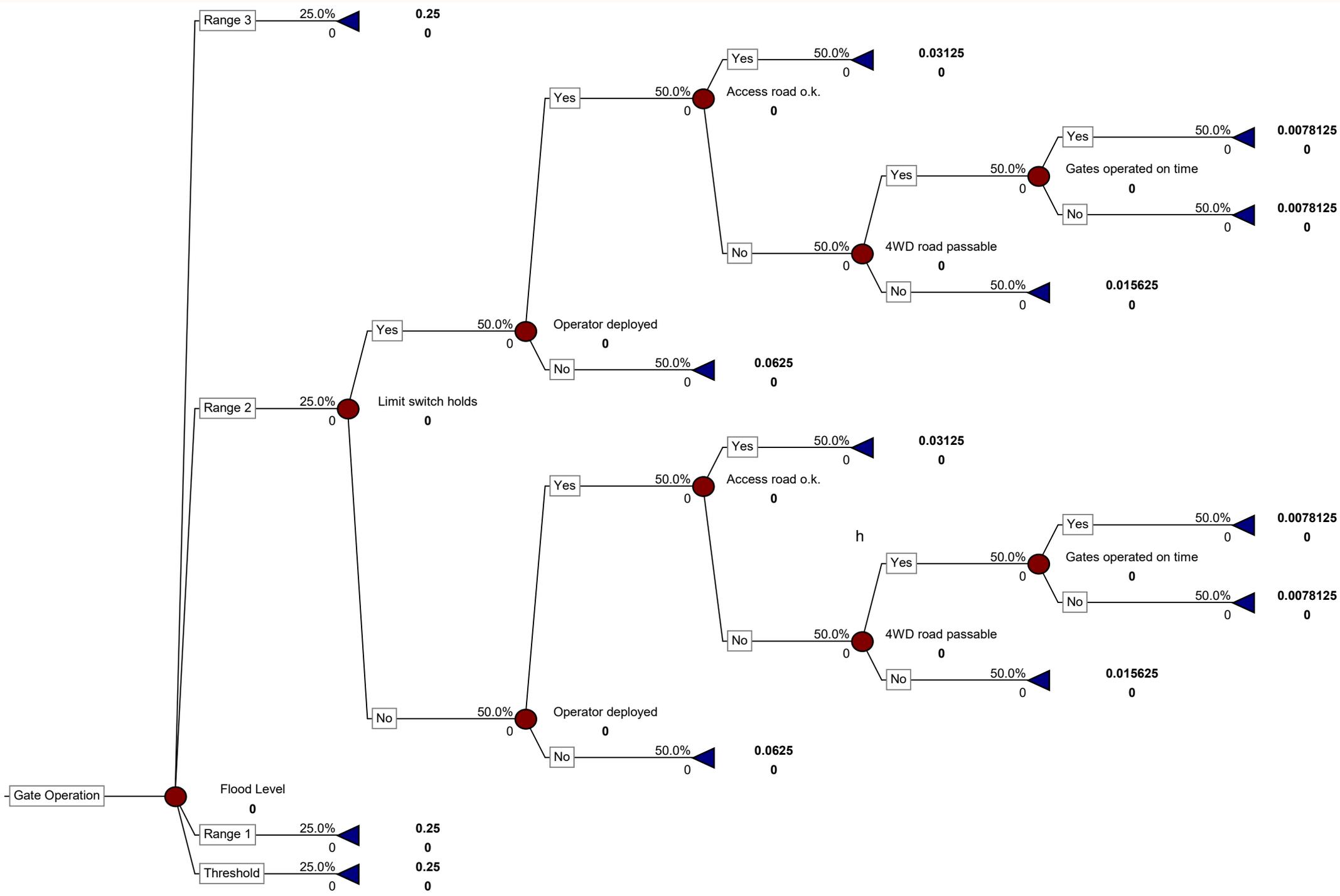
- National Performance of Dams Database
 - 24 incidents related to debris plugging
 - 19 incidents related to structural failure
 - 25 incidents related to misoperation
- FERC Incident database
 - 6 incidents related to debris plugging



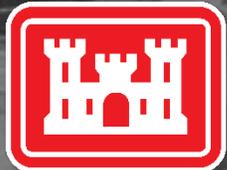
Typical Portion of Event Tree

- ↳ Reservoir loading (partition)
 - ↳ Initiation - Limit Switch Fails
 - ↳ Operator Deployed
 - ↳ Main Access Road Impassable
 - ↳ Secondary (4WD) Road Impassable
 - ↳ Gates Not Operated on Time
 - ↳ Embankment Dam overtops
 - ↳ Erosion Initiates
 - ↳ Crest breaches
 - ↳ Dam breaches (uncontrolled release of reservoir)





Questions



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