



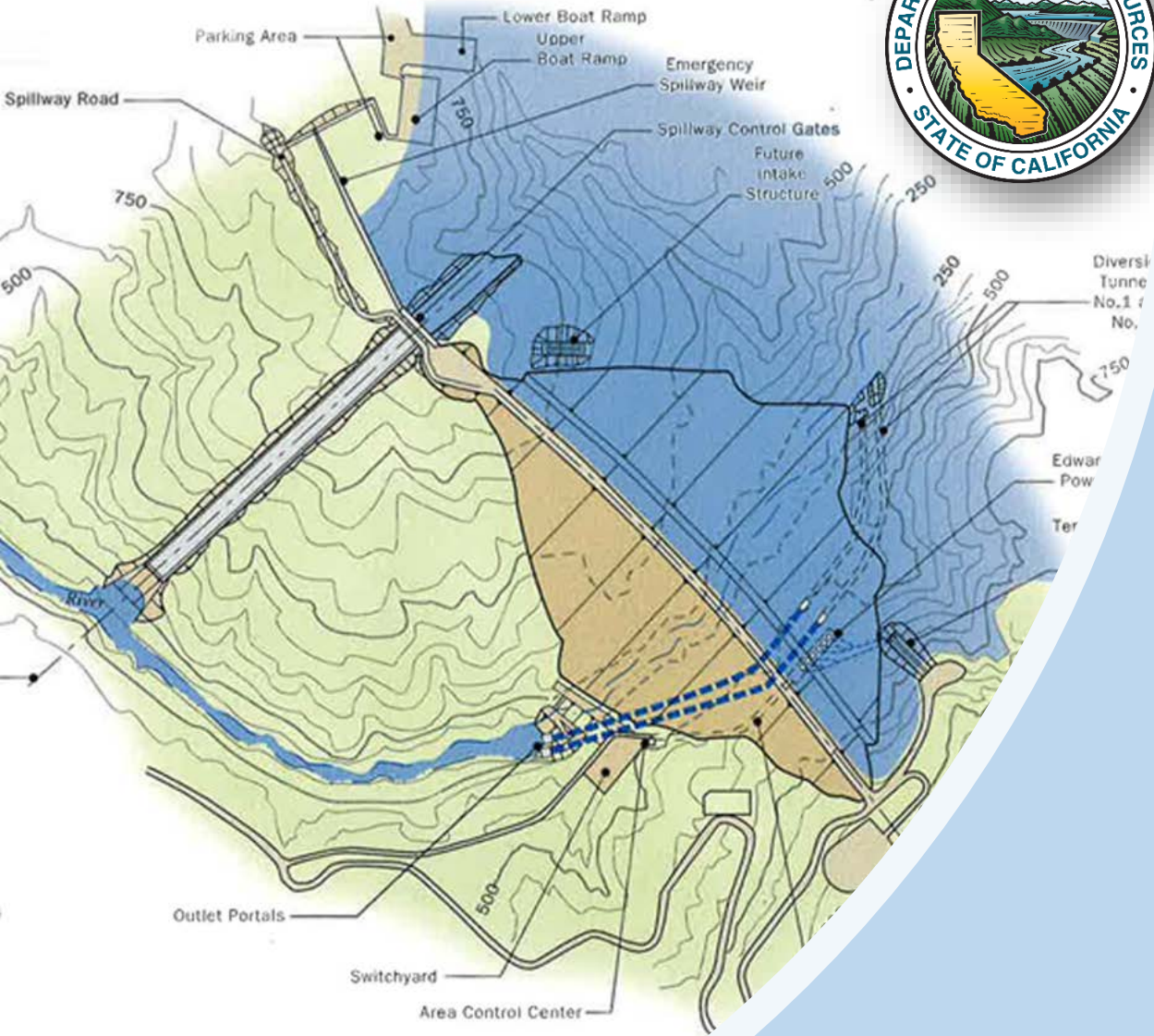
STATE OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
**OROVILLE DAM SAFETY
COMPREHENSIVE NEEDS ASSESSMENT**

Next Steps for DWR

Incorporating CNA Results into SWP Risk Management Framework

Ad Hoc Group Meeting No. 7

June 26, 2020





Next Steps for DWR

Incorporating CNA Results into SWP Risk Management Framework

January 12, 2018 DWR Letter to FERC

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY
DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

EDMUND G. BROWN JR., Governor



January 12, 2018

Mr. Frank L. Blackett, P.E.
Regional Engineer
Federal Energy Regulatory Commission
100 First Street, Suite 2300
San Francisco, California 94105-3084

FERC Project No. 2100 – Oroville Dam, Dam Safety
Comprehensive Needs Assessment Plan and Schedule

Dear Mr. Blackett:

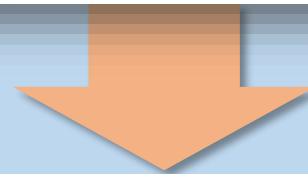
By letter dated June 28, 2017, the Department of Water Resources (DWR) informed the Federal Energy Regulatory Commission (FERC) of its intent to initiate a Comprehensive Needs Assessment (project) to identify measures to bolster the safety and reliability of Oroville Dam and the appurtenant structures. Over the past several months, DWR has identified the following six project tasks:

- Task 1 - Alternatives Evaluation to Restore Spillway Design Capacity to Pass the Probable Maximum Flood
- Task 2 - Operations Needs Assessment to Support Development of Alternative Reservoir Outflow Enhancements
- Task 3 - Flood Control Outlet Enhanced Reliability
- Task 4 - Alternatives Evaluation for Low-level Outlet
- Task 5 - Oroville Dam Embankment Reliability and Improvements
- Task 6 - Instrumentation and Monitoring for the Oroville Dam Complex

The project is scheduled to begin January 16, 2018 and conclude by December 31, 2019.

A list of prioritized dam safety and operational reliability needs will be produced through completion of the project. Those needs will then be evaluated by DWR management and scheduled as projects through normal practices and procedures. As the project progresses, the Project Manager may identify projects that provide significant public safety and risk reduction benefits. Such projects may be submitted to DWR management for early implementation. DWR will comply with FERC and other regulatory agencies' submittal, review, and approval processes as part of the implementation.

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SWP Risk Management Framework and Processes & Regulatory Processes



Next Steps – What are they and Why?

1. Complete CNA Early Implementation Projects
2. Initiate design of efficient CNA risk reduction measures
 - FCO gate backup power/starter
 - Line Palermo Canal
 - Raise Parish Camp Saddle Dam
3. Implement pre-CNA \$224 million planned capital investment
4. Plan and Schedule investigations, studies, and surveillance enhancements (CNA and Part 12D recommendations)
5. Integrate select CNA measures into SWP Risk Framework and processes

All of these steps work to reduce risk to the Oroville facilities

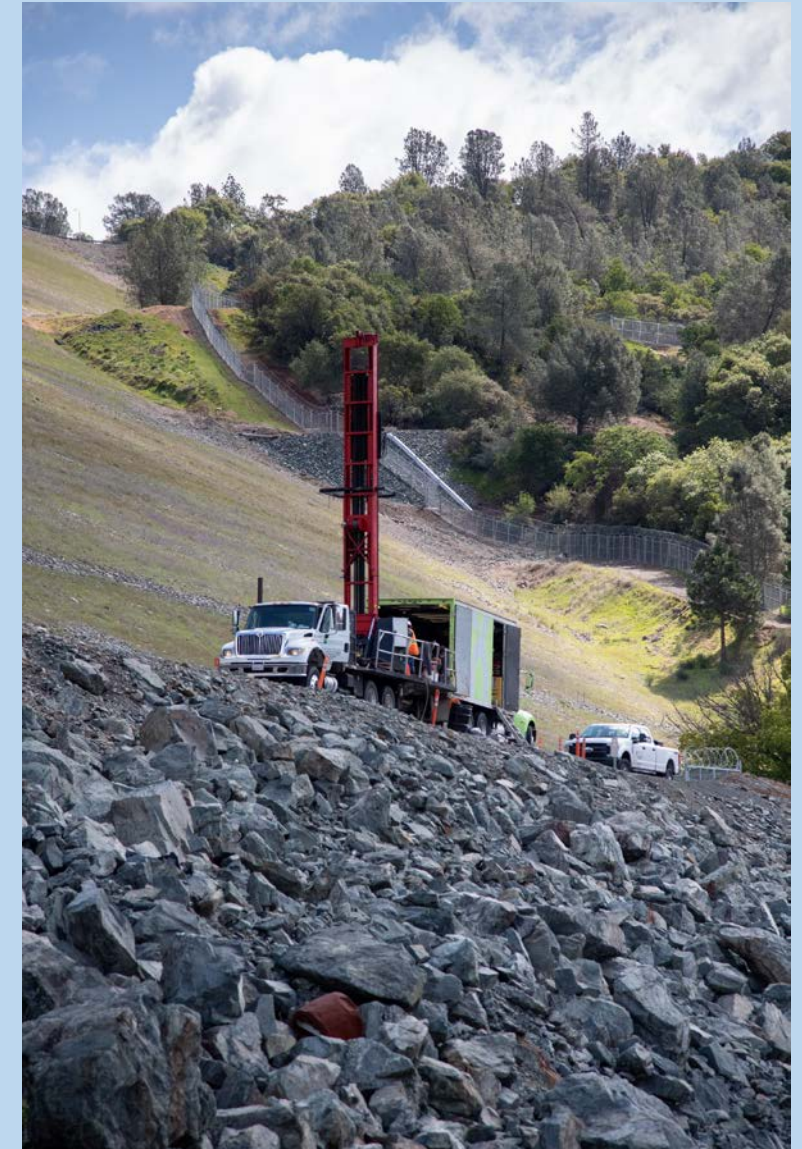
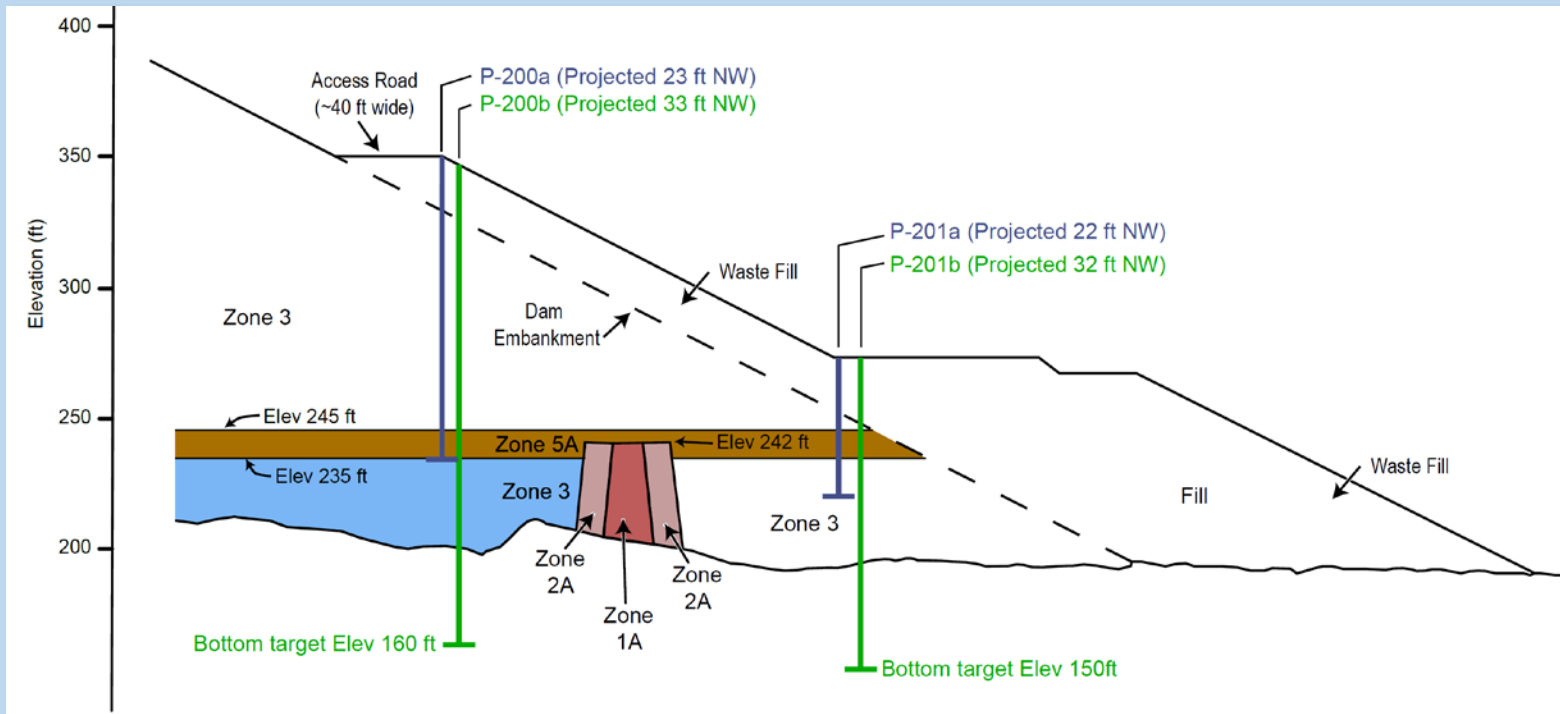
1. Complete CNA Early Implementation Projects

What: Installation of new piezometers at:

- **Oroville Main Dam at downstream toe**

Why: Enhance surveillance for internal erosion-related PFMs, and inform on-going seepage analyses and modeling.

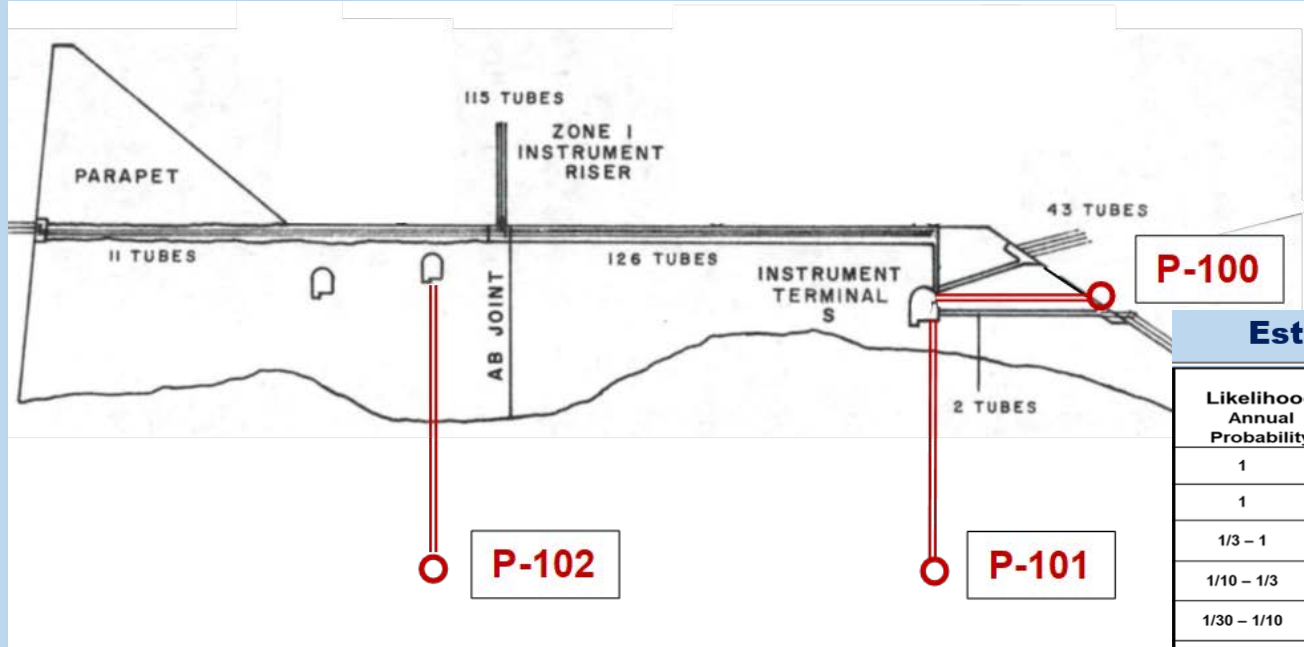
-Originated as Measure T5-O24, and handed off to Task 6.



1. CNA Early Implementation Projects

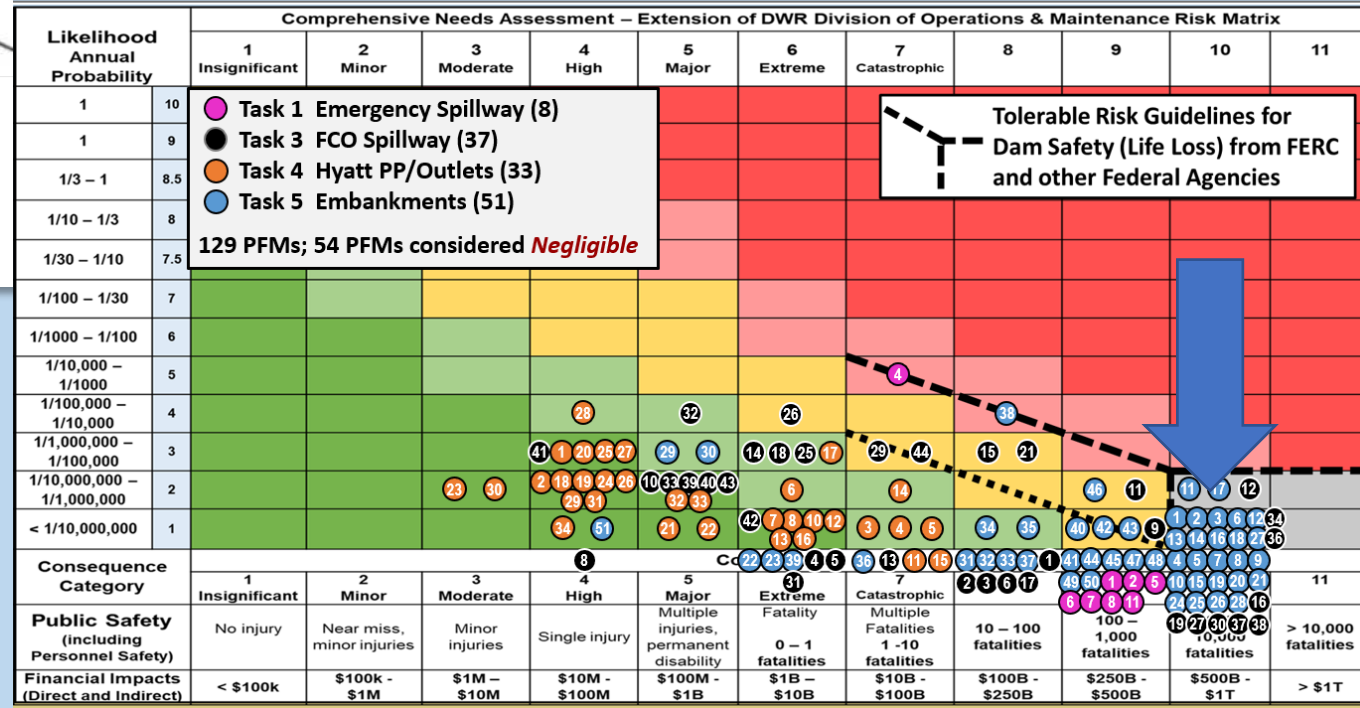
What?: Installation of new piezometers at **Oroville Main Dam in grout and core block galleries**

Why?: Replace original instrumentation, enhance monitoring of internal erosion-related PFMs.



Monitor for numerous internal erosion-related PFMs (blue) that plot in Grey Zone

Estimated Risks for CNA Potential Failure Modes – Existing Conditions



2. Initiate Design of Effective CNA Measures

What: Initiate design of:

- Back-up power/local starter (Measure T3-BH.2)
- Line Palermo Canal (Measure T4-U)
- Raise Parish Camp Saddle Dam (Measure T5-P2)

Recommended Measures		PLAN 1	PLAN 2	PLAN 3	PLAN 4	PLAN 5	PLAN 6	PLAN 10	PLAN 7	PLAN 8	PLAN 9
T1-A	Minimally improved pilot channel					X			X	X	
T1-C	New Full length RCC chute				X						
T1-E	New FCO gated reinforced concrete chute	X	X	X			X	X			
T1-P	Hyatt Powerplant discharge portal bulkheads	X	X	X	X	X	X	X		X	X
T1-Z	Secant Pile Wall buttress					X			X	X	
T1-AW	Partial extension of RCC apron w/ minimally imp. Ch.										
T3-AJ	Upstream bulkhead gates*	X	X	X							
T3-I	Structural upgrades/retrofit*	X	X	X							
T3-BH.2	Backup power, local starter, etc.*	X	X	X	X	X	X	X	X	X	X
T3-	Debris control structures/devices	X	X	X	X	X		X			
T4-N	Rock bolts in Hyatt Powerplant	X	X								
T4-W	Palermo Intake landslide stabilization	X	X								
T4-O	Barrier around ACC and switchyard landslide stabl	X	X								
T4-U	Palermo Canal Lining	X	X	X	X	X					
T4-C	New High-Level Outlet @ EI 775 ft	X									
T4-E	New Low-Level Outlet @ EI 435 ft		X	X	X	X	X		X		
T4-G	New Low-Level Outlet @ EI 340 ft	X									
T5-02	Modify portion of dam that wraps around Mon. 31*	X	X	X	X	X	X	X	X	X	X
T5-03	Modify the upper 40 ft of Main Dam	X	X	X							
T5-05	Raise Main Dam by 3 ft	X	X	X							
T5-B2	Raise Bidwell Bar Saddle Dam (BBCSD) by 3 ft	X	X	X							
T5-P2	Raise Parish Camp Saddle Dam (PCSD) by 3 ft	X	X	X	X	X	X	X	X	X	X

FCO Radial Gate Backup Power, Starter (CNA Measure T3-BH.2)

Line Palermo Canal (CNA Measure T4-U)

Raise Parish Camp Saddle Dam (CNA Measure T5-P2)

2. Initiate Design of Effective CNA Measures

Why?: These CNA measures:

- Are common across most of the Plan formulations.
- IRB Recommendation: Small to moderate investments that do not need further study or investigation to understand the issue nor the risk reduction/benefit they provide.

Estimated Risks for CNA Potential Failure Modes – Existing Conditions

Likelihood Annual Probability		Comprehensive Needs Assessment – Extension of DWR Division of Operations & Maintenance Risk Matrix																		
		1 Insignificant	2 Minor	3 Moderate	4 High	5 Major	6 Extreme	7 Catastrophic	8	9	10	11								
1	10	● Task 1 Emergency Spillway (8)																		
1	9	● Task 3 FCO Spillway (37)																		
1/3 – 1	8.5	● Task 4 Hyatt PP/Outlets (33)																		
1/10 – 1/3	8	● Task 5 Embankments (51)																		
1/30 – 1/10	7.5	129 PFMs; 54 PFMs considered <i>Negligible</i>																		
1/100 – 1/30	7																			
1/1000 – 1/100	6																			
1/10,000 – 1/1000	5																			
1/100,000 – 1/10,000	4				28	32	26													
1/1,000,000 – 1/100,000	3			41	1	20	25	27	29	30	14	18	25	17	29	44	15	21		
1/10,000,000 – 1/1,000,000	2			23	30	2	18	19	24	26	10	33	39	40	43	6	14	46	11	
< 1/10,000,000	1																			
Consequence Category		8																		
Public Safety (including Personnel Safety)		1 Insignificant	2 Minor	3 Moderate	4 High	5 Major	6 Extreme	7 Catastrophic	8	9	10	11								
Financial Impacts (Direct and Indirect)		< \$100k	\$100k - \$1M	\$1M - \$10M	\$10M - \$100M	\$100M - \$1B	\$1B - \$10B	\$10B - \$100B	\$100B - \$250B	\$250B - \$500B	\$500B - \$1T	> \$1T								

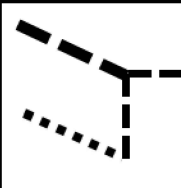
Tolerable Risk Guidelines for Dam Safety (Life Loss) from FERC and other Federal Agencies

Raise Parish Camp Saddle Dam (CNA Measure T5-P2). Addresses extreme flood and internal erosion-related PFMs 33, 34, 37, and 38)

Line Palermo Canal (CNA Measure T4-U) Addresses PFMs 14 & 15

FCO Radial Gate Backup Power, Starter (CNA Measure T3-BH.2) Addresses power related PFMs (36, 37, 38)

PFM Risk Reductions with Interim Implementation Project (3 Measures) (06-06-20)

Likelihood Annual Probability		Comprehensive Needs Assessment – Extension of DWR Division of Operations & Maintenance Asset Management Risk Matrix																			
		1 Insignificant	2 Minor	3 Moderate	4 High	5 Major	6 Extreme	7 Catastrophic	8	9	10	11									
Likely to occur 10 times a year	10	3 PFMs Addressed by Interim Implementation Project ● Task 3 FCO Spillway (PFM T3-36/Measure T3-BH.2) ● Task 4 Hyatt PP/Outlets (PFM T4-14/Measure T4-U) ● Task 5 Embankments (PFM T5-38/Measure T5-P2) <i>Circular symbols (3) denote Life Loss as dominant consequence,</i>						 Tolerable Risk Guidelines for Dam Safety (Life Loss) from FERC and other Federal Agencies													
Likely to occur within 1 year	9																				
Likely to occur within 3 years	8.5																				
1/10 – 1/3	8																				
1/30 – 1/10	7.5																				
1/100 – 1/30	7																				
1/1,000 – 1/100	6																				
1/10,000 – 1/1,000	5																				
1/100,000 – 1/10,000	4																				
1/1,000,000 – 1/100,000	3																				
1/10,000,000 – 1/1,000,000	2																				
1/100,000,000 – 1/10,000,000	1																				
Negligible < 1/100,000,000																					
Consequence Category	Consequence Level																				
	1 Insignificant	2 Minor	3 Moderate	4 High	5 Major	6 Extreme	7 Catastrophic	8	9	10	11										
Public Safety (including Personnel Safety)	No injury	Near miss, minor injuries	Minor injuries	Single injury	Multiple injuries, perm. disability	0 – 1 fatalities	1 -10 fatalities	10 – 100 fatalities	100 – 1,000 fatalities	1,000 – 10,000 fatalities	> 10,000 fatalities										
Financial Impacts (Direct and Indirect)	< \$100k	\$100k - \$1M	\$1M - \$10M	\$10M-\$100M	\$100M - \$1B	\$1B - \$10B	\$10B - 100B	\$100B - \$250B	\$250B - \$500B	\$500B - \$1T	> \$1T										

2. Initiate Design of Effective CNA Measures

- Multiple power sources already exist.
- An enhancement could include installation of quick connections for a portable generator.
- Consistent with ALARP principles (As Low As Reasonably Practical)



Radial Gate Backup Power/Starter (CNA Measure T3-BH.2)



2. Initiate Design of Effective CNA Measures

- Several PFMs with significant uncertainty pertain to Palermo Canal failing and flooding the Switchyard.
- Address the PFMs directly with a simple, common, and efficient measure - lining improvements.



**Line Palermo Canal
(CNA Measure T4-U)**

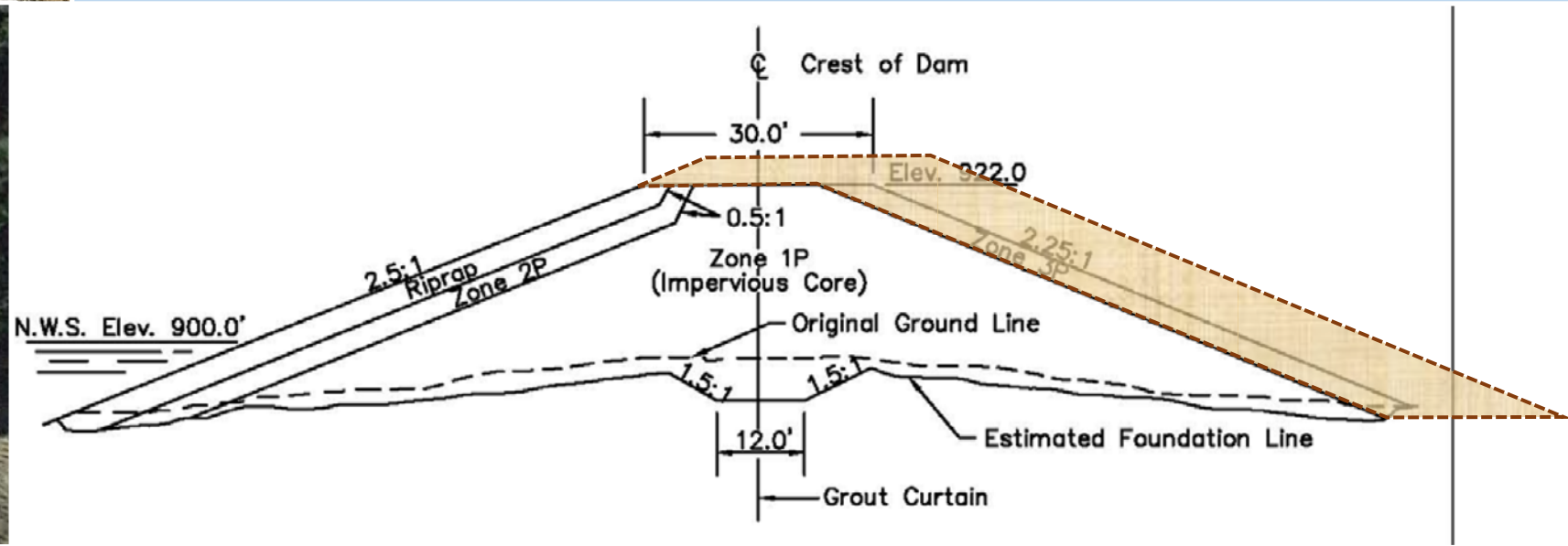


2. Initiate Design of Effective CNA Measures

- Small dam with that rarely impounds water – Toe at Elevation 890 feet.
- One of the highest risks (T5-38) – Overtopping during an Extreme Flood (beyond the PMF), as well as other internal erosion PFMs in the Amber and Grey zones.
- Raising and incorporating a downstream filter can drive down risk associated with all of its PFMs.



Raise Parish Camp Saddle Dam (CNA Measure T5-P2)





3. Pre-CNA \$224 Million Planned Capital Investment

- Maintains recently reduced level of risk as well as driving down pre-CNA and newly identified PFMs.
- Improves reliability of key dam appurtenances and critical equipment.

Approximate Estimated Expenditures Currently Planned for Oroville Dam Complex by Calendar Year

**Total
2020-2025**

2020	2021	2022	2023	2024	2025	\$ 224 Million
\$ 41 Million	\$29 Million	\$49 Million	\$55 Million	\$24 Million	\$26 Million	



3. Pre-CNA \$224 Million Planned Capital Investments

Over 40 Projects, Including:

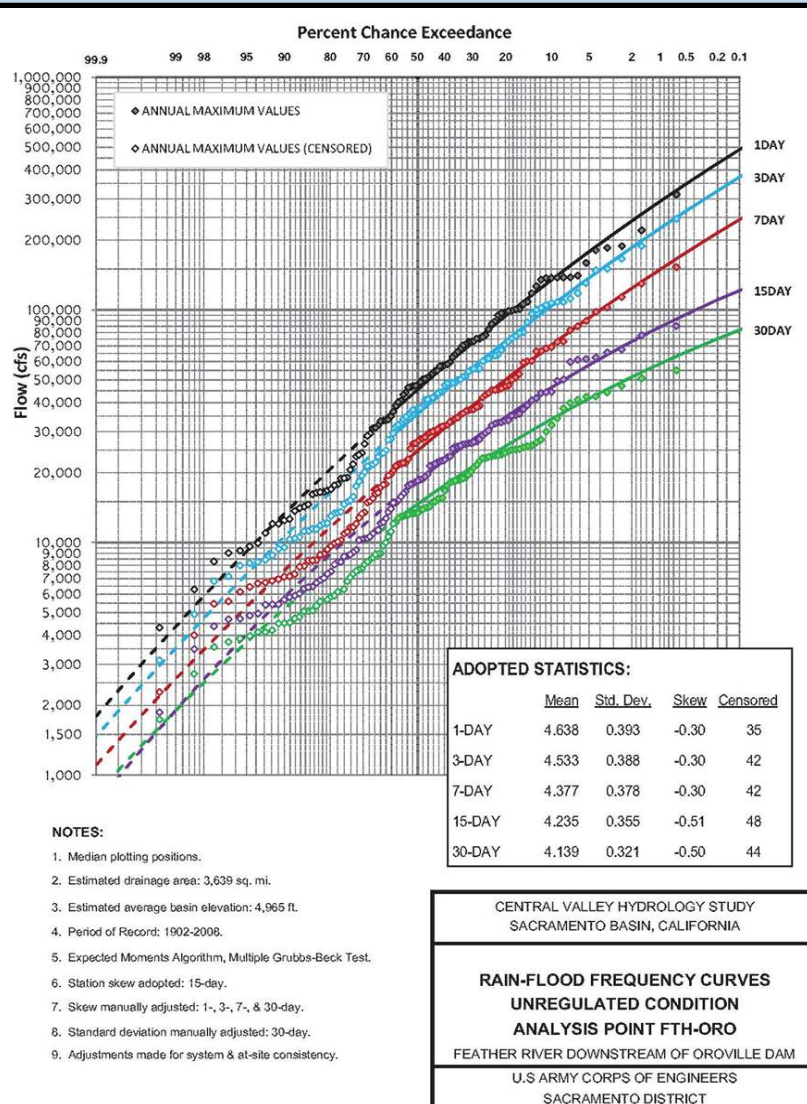
- Hyatt Powerplant Intake Gate Refurbishment
- Hyatt Powerplant Penstock Inspection and Repair
- Hyatt Powerplant Turbine Shutoff Valves Refurbishment
- River Valve Outlet System Upgrades
- Palermo Tunnel Bulkhead Emergency Closure Improvements
- Flood Control Outlet Radial Gate Trunnion Pin Inspections/Refurbishment
- Flood Control Outlet Radial Gate Maintenance and Repair
- Core Block Drain Hole Inspections and Cleaning
- 230 KV Power Line Refurbishment
- Oroville Physical Security Improvements
- Hyatt Powerplant New Turbine Runners
- Bidwell Bar Bridge Seismic Retrofit
- Hyatt PP Fire Detection System Upgrade
- Seismic Monitoring Upgrades
- Oroville Lakeside Access Road
- Oroville SEG Replacement
- Hyatt Powerplant Tap Guard Valve Replacement

4. Plan and Schedule Investigations, Studies, and Surveillance Enhancements

Why: Reduce Uncertainty, Rule-out hypotheticals, Verify Conditions, Inform analyses and decision-making.

What:

- Continue study of forecast-informed reservoir operations.
- Stochastic Flood Modeling with improved inputs from regional precipitation and paleohydrology analyses.
- Investigate feasibility for sampling and testing of Main Dam Zone 1 Core for erodibility.
- Trenching investigations at interface of Main Dam embankment and FCO Monolith 31.

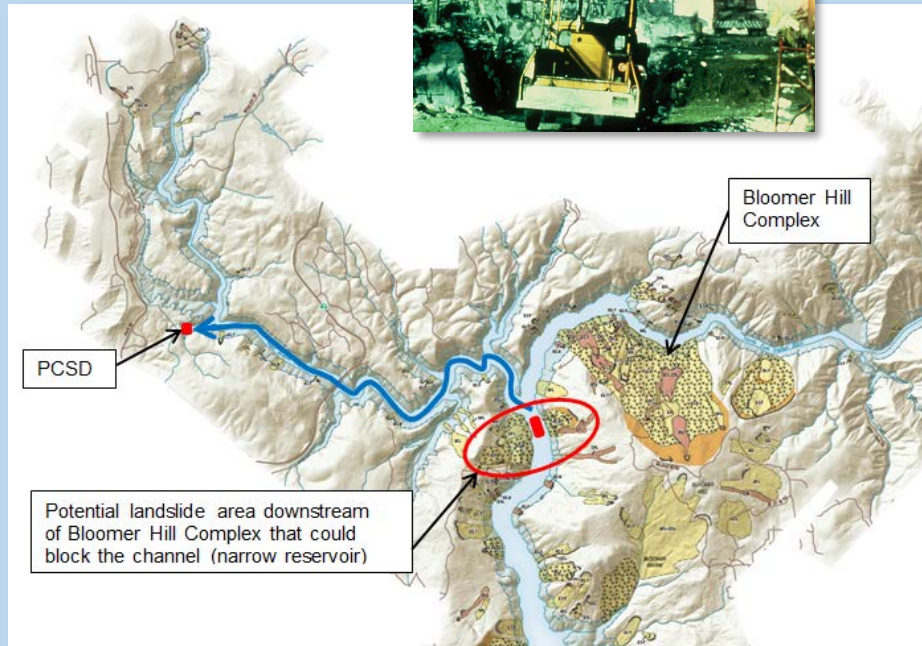


4. Plan and Schedule Investigations, Studies, and Surveillance Enhancements



Investigations/Studies (continued)

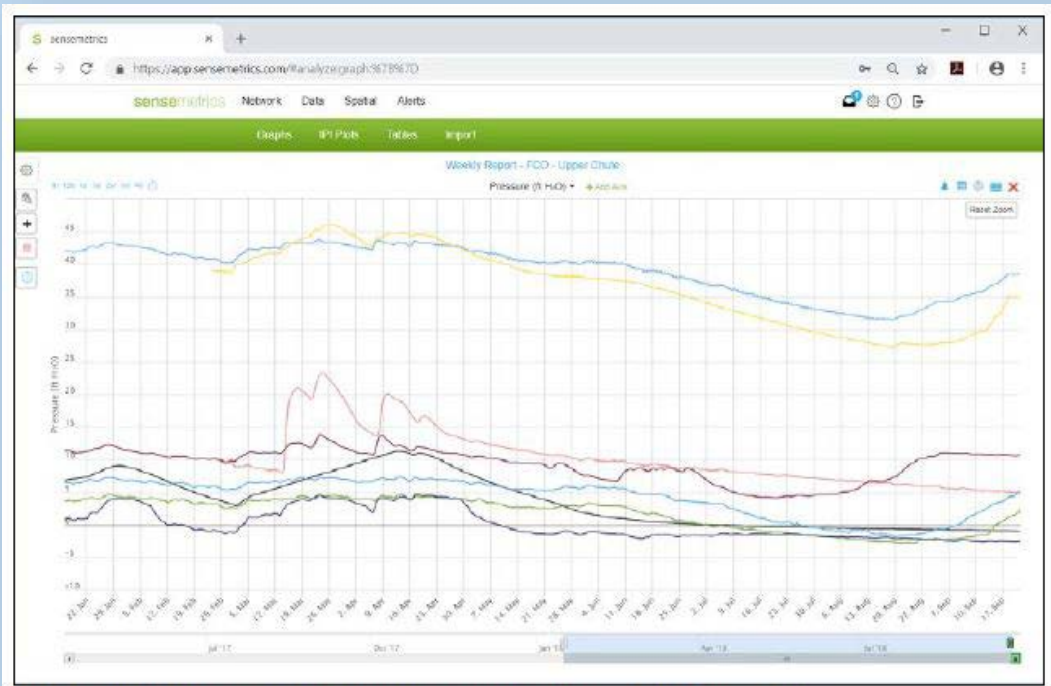
- Updated evaluations of seismic loadings on FCO Radial Gate trunnion anchorages/plans to address aging.
- Detailed reliability assessments (FCO Gate System, Hyatt PP equipment, Hyatt Intake equipment).
- Inspection of rock bolts and shotcrete in crown of Hyatt PP.
- Landslide hazard assessment on downstream left abutment of Main Dam above ACC.
- Potential for reactivation of existing landslides and the potential for new landslides along the reservoir rim.



4. Plan and Schedule Investigations, Studies, and Surveillance Enhancements

Inspections, Instrumentation, and Monitoring

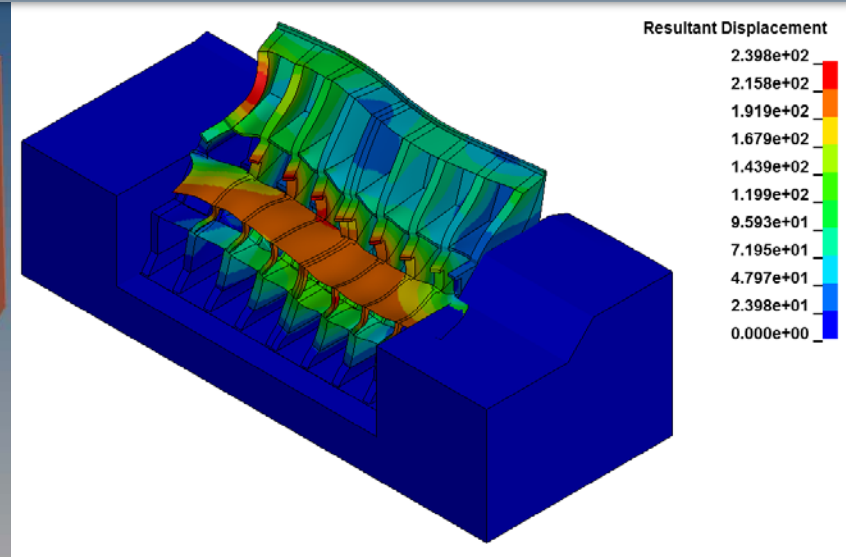
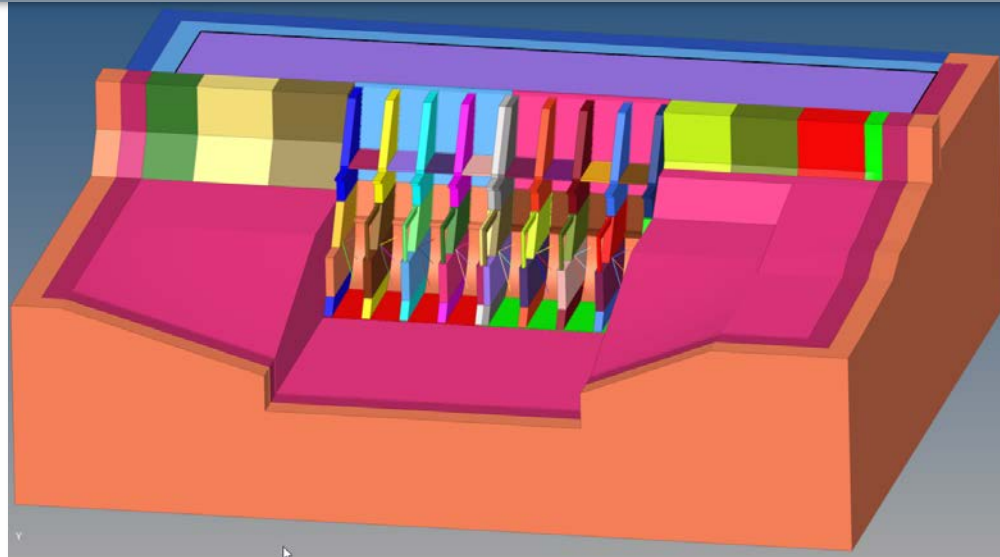
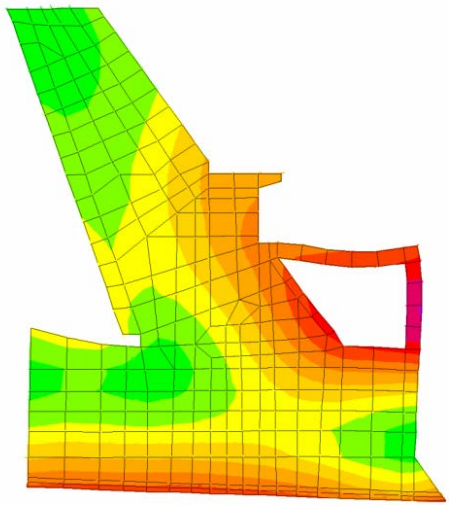
- Perform new high-density surveys of the embankments and bathymetric surveys.
- Install a new accelerometer on the FCO crest.
- Inspect the 24-inch air intake that accommodates displaced air from Penstock Nos. 1 and 2.
- Continue implementing automated real-time dam safety instrumentation.



4. Plan and Schedule Investigations, Studies, and Surveillance Enhancements

Potential Implementation of CNA Measure T3-J Structural Upgrades and Seismic Retrofit – *As Needed*

Efforts Include Ongoing 2D and 3D FEM Seismic Stability Re-evaluation of FCO Headworks Structure



5. Integrate CNA measures into O&M Risk Management Framework and processes

Why Integration?

- No dam safety deficiencies or issues identified that require immediate action.
- Need to complete studies (technical or planning-level)
- Seeking to drive down risk across the entire SWP portfolio of assets, addressing the highest public safety risks first.
- The O&M Risk Management Framework provides a structured approach to risk management that contributes to consistent and comparable results.



5. Integrate CNA measures into O&M Risk Management Framework and processes

What is the process? CNA has followed the process....

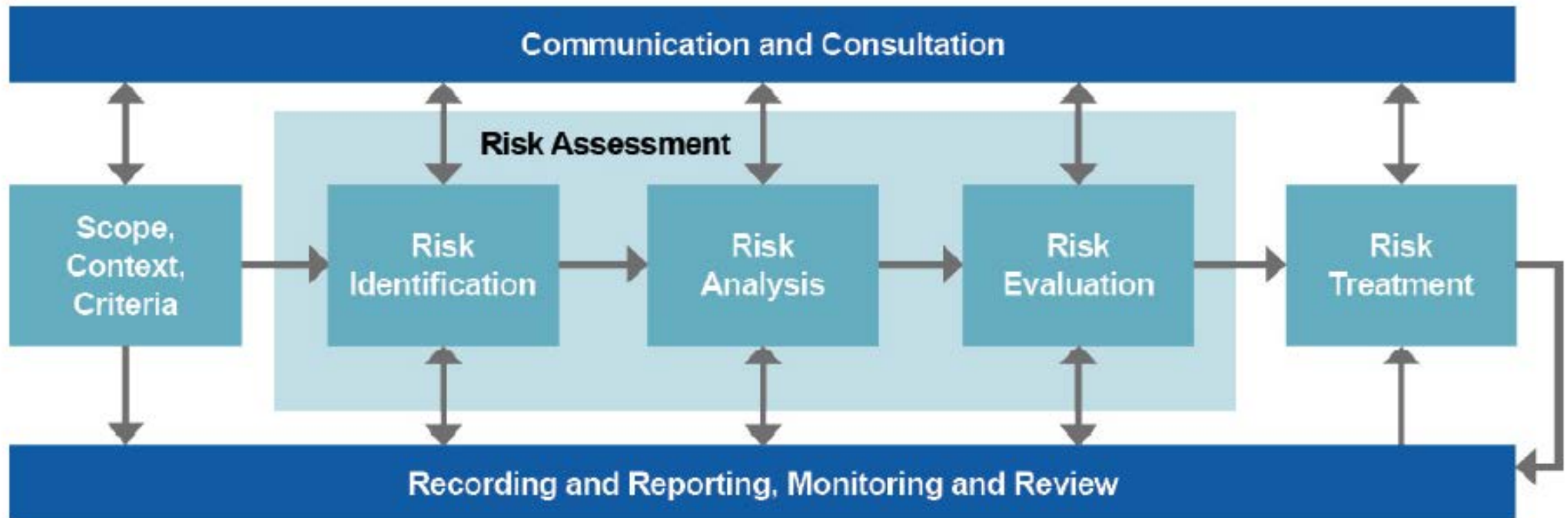
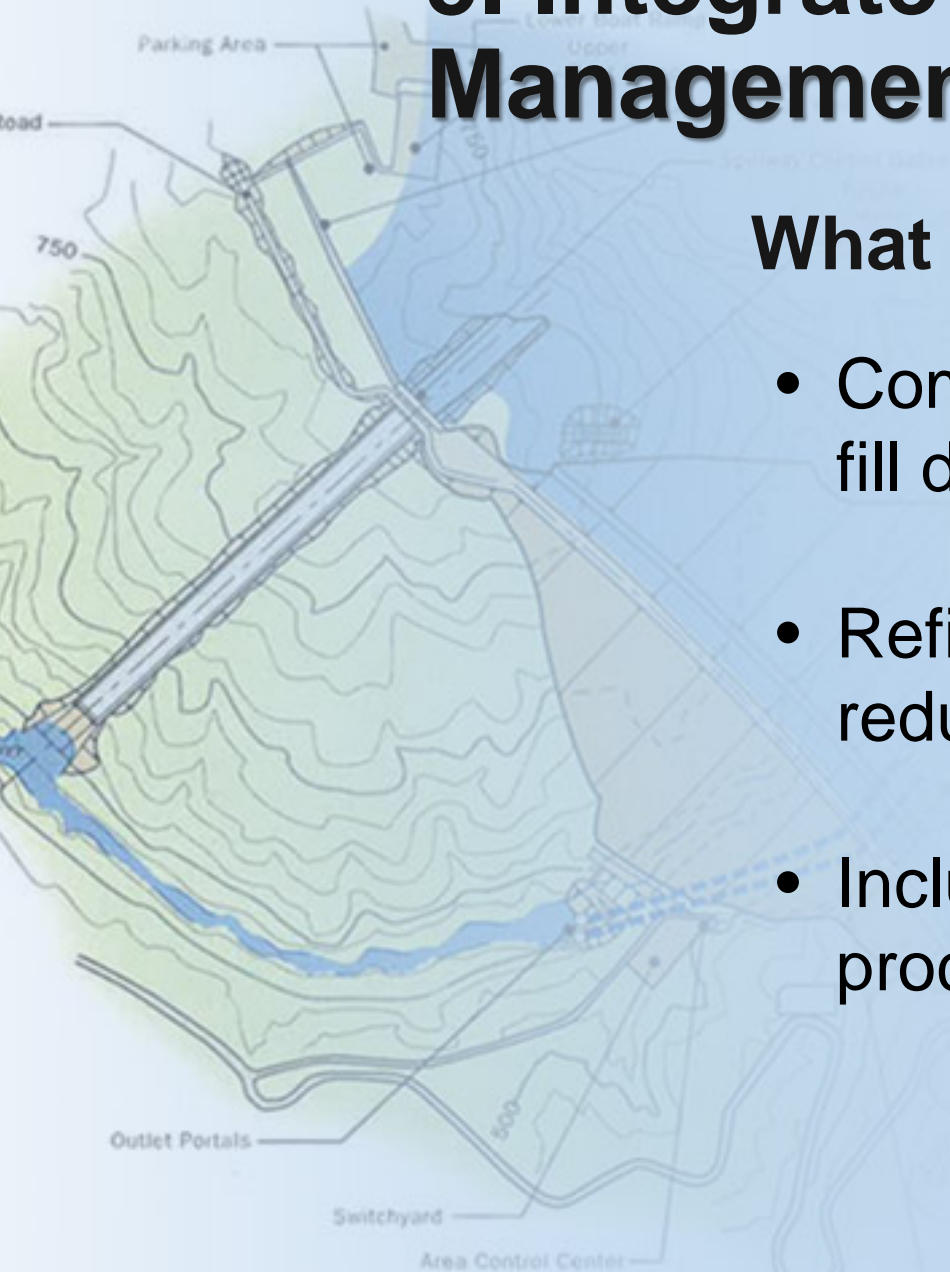


Figure 4 Risk Management Process

5. Integrate CNA measures into O&M Risk Management Framework and processes

What is going to happen to the other Measures?

- Complete the necessary studies and investigations to fill data gaps and reduce uncertainty.
- Refine the risks and treatment measures. Verify risk reduction achieved.
- Include the measure(s) into the SWP risk management process/register for planning and design.





Moving Forward

- DWR will report the progress of these efforts at future meetings of the Oroville Citizen's Advisory Commission.

