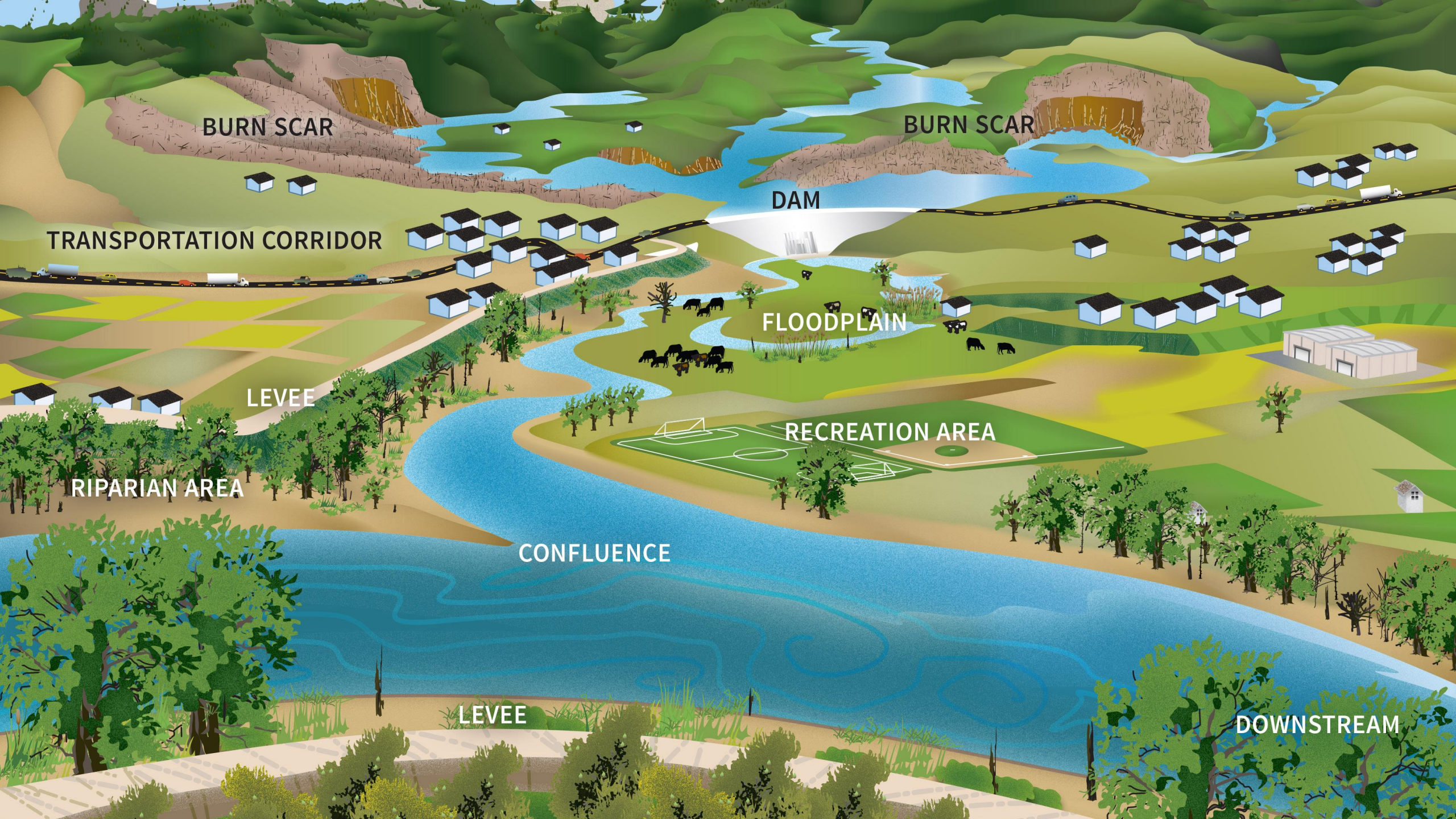


# Flood Safety Stakeholder Technical Workshop

Friday April 22, 2022



CALIFORNIA  
NATURAL  
RESOURCES  
AGENCY



BURN SCAR

BURN SCAR

DAM

TRANSPORTATION CORRIDOR

FLOODPLAIN

LEVEE

RECREATION AREA

RIPARIAN AREA

CONFLUENCE

LEVEE

DOWNSTREAM



Riceton

Palermo

Biggs

East Biggs

Vista Robles

Peachton

Gridley

East Gridley

Robinsons Corner

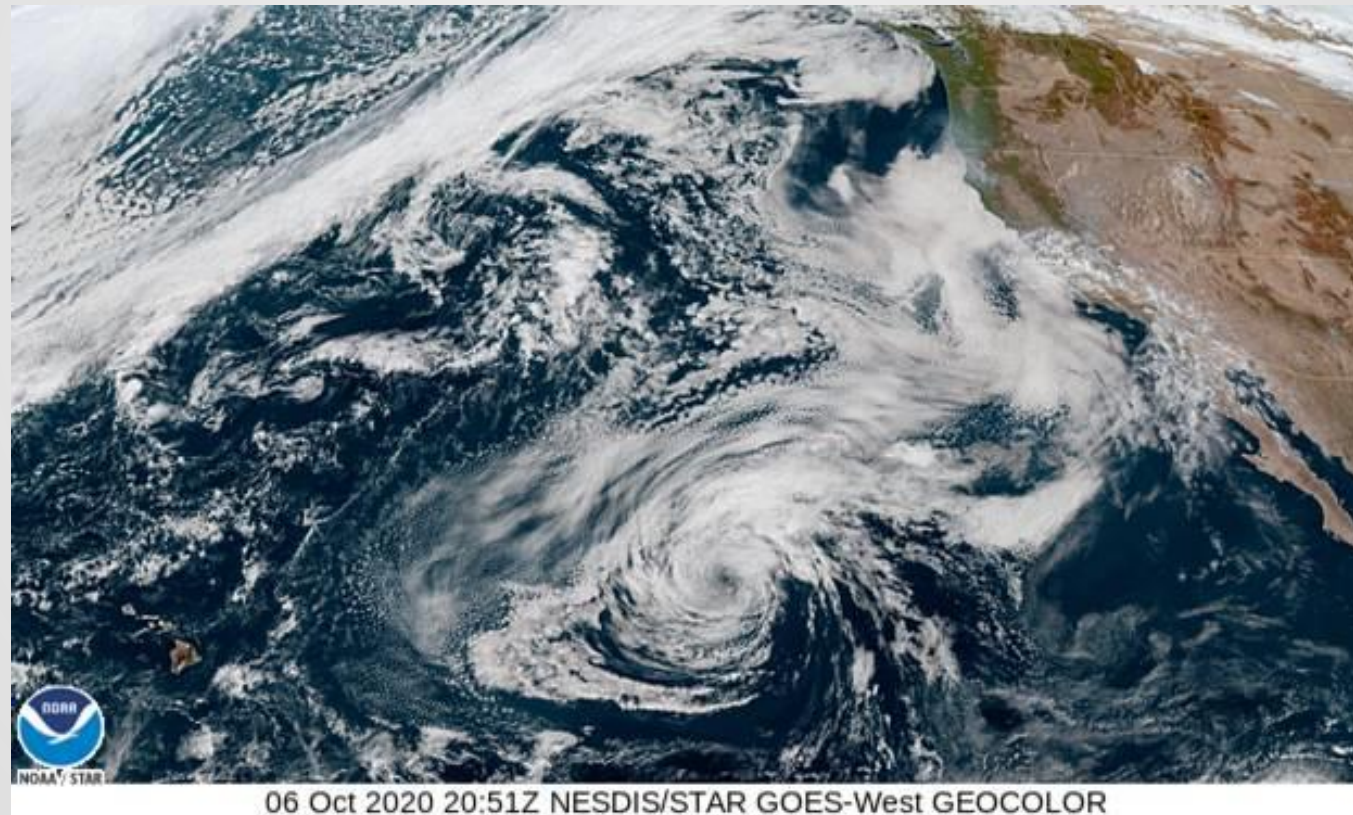
Fagan

Craig

# Meeting Facilitation

# Atmospheric Rivers, Major Flooding, and the 100-Year Flood Concept

OCAC Meeting, April 25, 2022



Dr. Michael L. Anderson, State Climatologist

# Talk Overview

- Atmospheric Rivers (ARs) and California Water
- Components of Major Floods from ARs to Snow to Runoff
- The 100-year Flood – Statistical Estimates



# Atmospheric Rivers (ARs)

- First identified in 1998 with new satellite technology
- Hundreds of miles wide; thousands of miles long; how 90% of the water vapor moves through atmosphere in 10% of the area
- Interact with winter storms to cause heavy rains/snow in California – key to water supply and flooding



# Characterizing an Atmospheric River

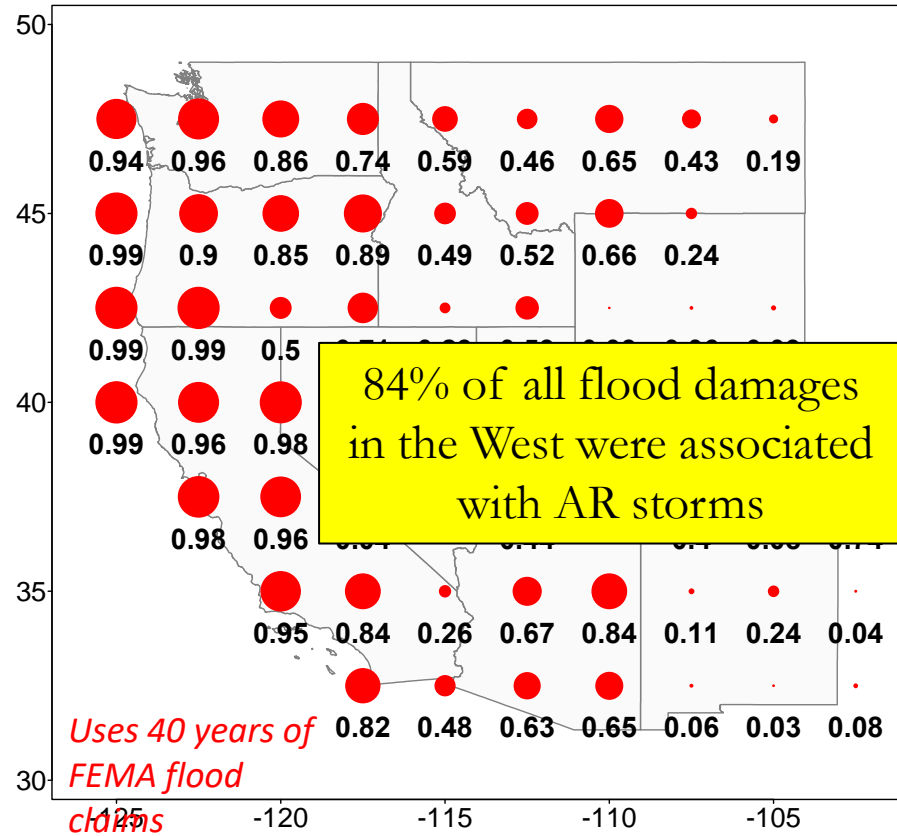
- How much water vapor moving in atmospheric river (Integrated Vapor Transport or IVT)
- Duration – how long is the atmospheric river overhead for a watershed
- Freezing Elevation – where rain turns to snow



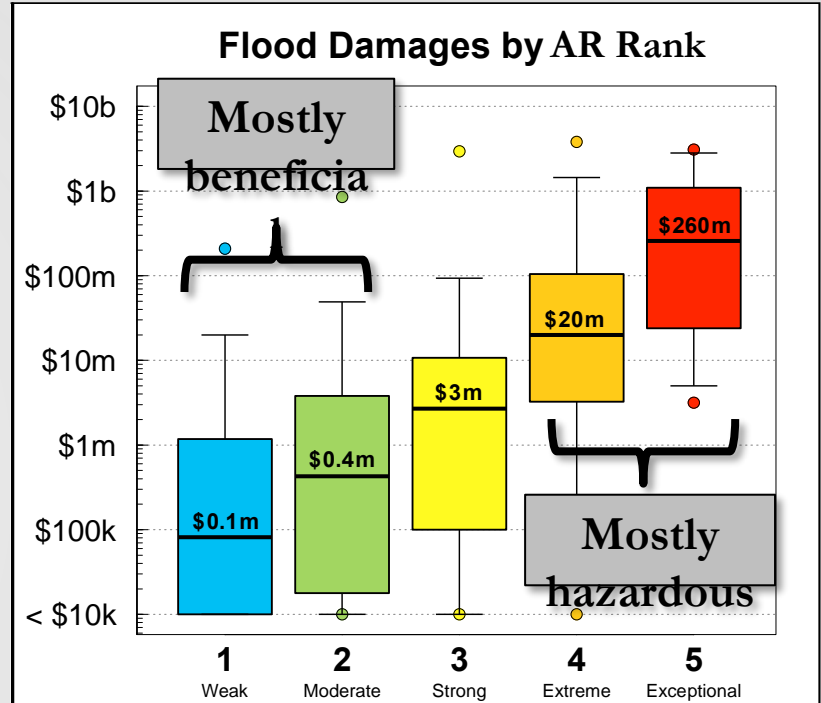
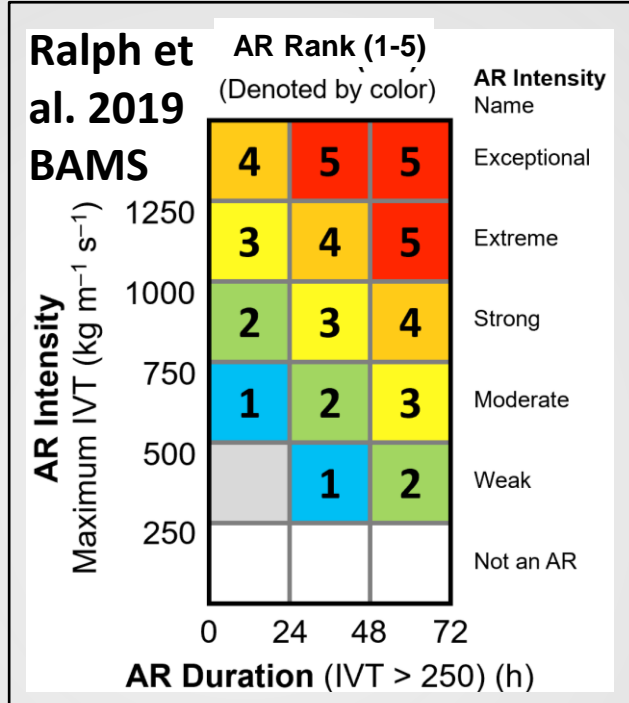


# ARs drive flood damages in the western U.S.

Proportion of Insured Losses Due to ARs



Corringham, Ralph, Gershunov, Cayan and Talbot, Sci. Advances (2019)



Corringham et al. 2019, Science Advances

## Flood damages increase exponentially with AR Category

# Components of a Major Flood

- Prior conditions in watershed including snow
- Large atmospheric river or multiple atmospheric rivers (called atmospheric river families)
- Timing, pace and scale of storms impact the timing pace and scale of runoff
- Observations and forecasts play key roles in managing flood response



# Sizing a Flood with Statistics

- The 100-year flood is really a flood that is estimated to have a 1% chance of being equaled or exceeded in any given year
- Sized based on the statistics of the largest independent flows in a given year for as many years as data is available



# The 100-Year Flood

- The 100-year flood is a flow peak or volume of water (a threshold) that has a 1% chance of being equaled or exceeded in any given year.
- It is a threshold based on historical events to guide engineering design
- Federal guidelines outline methodologies called Bulletin 17 (currently on Bulletin 17c)



# Scenarios and Systematic Evaluations

- Systematic Evaluations use statistical methods for different size floods to establish the threshold of performance of a system to determine a level of protection to meet regulatory or statutory requirements.
- Scenarios use a real or constructed event to evaluate how system and response functions handle that event. ARkStorm is a scenario.



# Summary – Key Points

- Atmospheric Rivers (ARs) are key to floods and water supply – timing, pace, and scale determine benefit versus hazard.
- Observations and forecasts key to maximizing benefits and minimizing hazard of AR driven floods.
- Flood evaluations use systematic evaluation of historical statistics (100-year flood) as well as scenario events (ARkStorm).



Q&A



## USACE AUTHORITY FOR FLOOD OPS

- Section 7 of the Flood Control Act of 1944 (58 Stat. 890, 33 U.S.C. 709)
- Prescribe flood control rules and regulations for all reservoirs where:  
Flood control is an authorized purpose  
Reservoir was constructed using Federal funds



[PUB. LAW 534.]

4

of the electric facilities of the projects) of the cost of producing and transmitting such electric energy, including the amortization of the capital investment allocated to power over a reasonable period of years. Preference in the sale of such power and energy shall be given to public bodies and cooperatives. The Secretary of the Interior is authorized, from funds to be appropriated by the Congress, to construct or acquire, by purchase or other agreement, only such transmission lines and related facilities as may be necessary in order to make the power and energy generated at said projects available in wholesale quantities for sale on fair and reasonable terms and conditions to facilities owned by the Federal Government, public bodies, cooperatives, and privately owned companies. All moneys received from such sales shall be deposited in the Treasury of the United States as miscellaneous receipts.

SEC. 6. That the Secretary of War is authorized to make contracts with States, municipalities, private concerns, or individuals, at such prices and on such terms as he may deem reasonable, for domestic and industrial uses for surplus water that may be available at any reservoir under the control of the War Department: Provided, That no contracts for such water shall adversely affect then existing lawful uses of such water. All moneys received from such contracts shall be deposited in the Treasury of the United States as miscellaneous receipts.

SEC. 7. Hereafter, it shall be the duty of the Secretary of War to prescribe regulations for the use of storage allocated for flood control or navigation at all reservoirs constructed wholly or in part with Federal funds provided on the basis of such purposes, and the operation of any such project shall be in accordance with such regulations: Provided, That this section shall not apply to the Tennessee Valley Authority, except that in case of danger from floods on the Lower Ohio and Mississippi Rivers the Tennessee Valley Authority is directed to regulate the release of water from the Tennessee River into the Ohio River in accordance with such instructions as may be issued by the War Department.





Photo By Hans Marsen

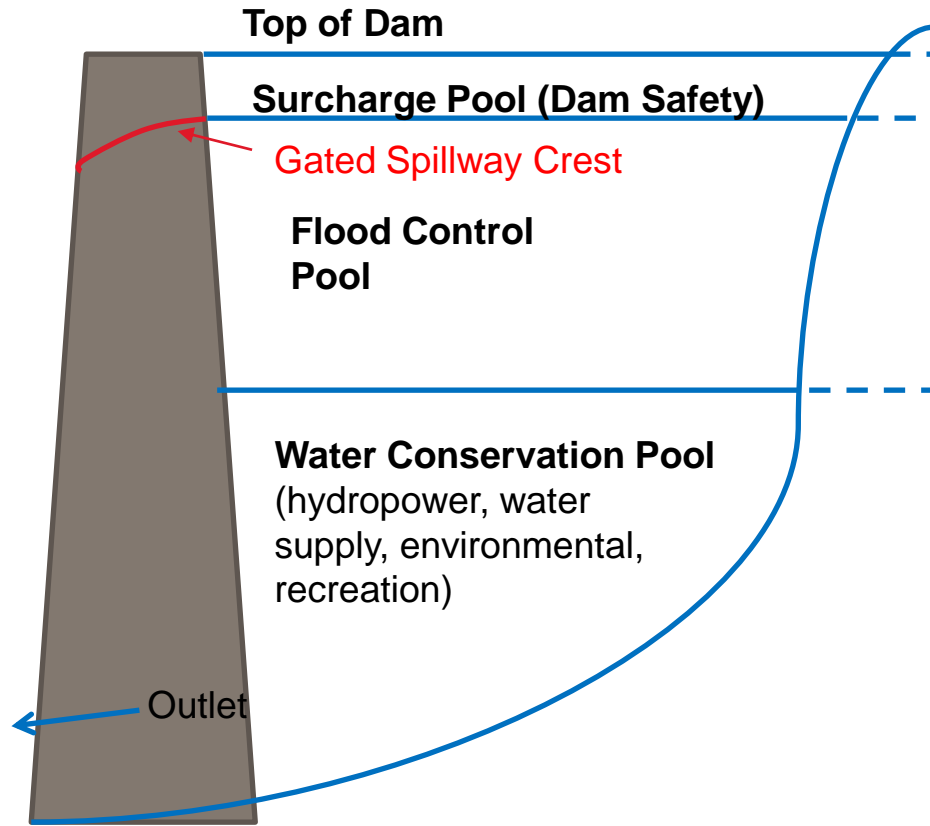
- Oversee flood operations
- Establish operating rules for flood control
- Update water control manuals
- Prepare deviation packages



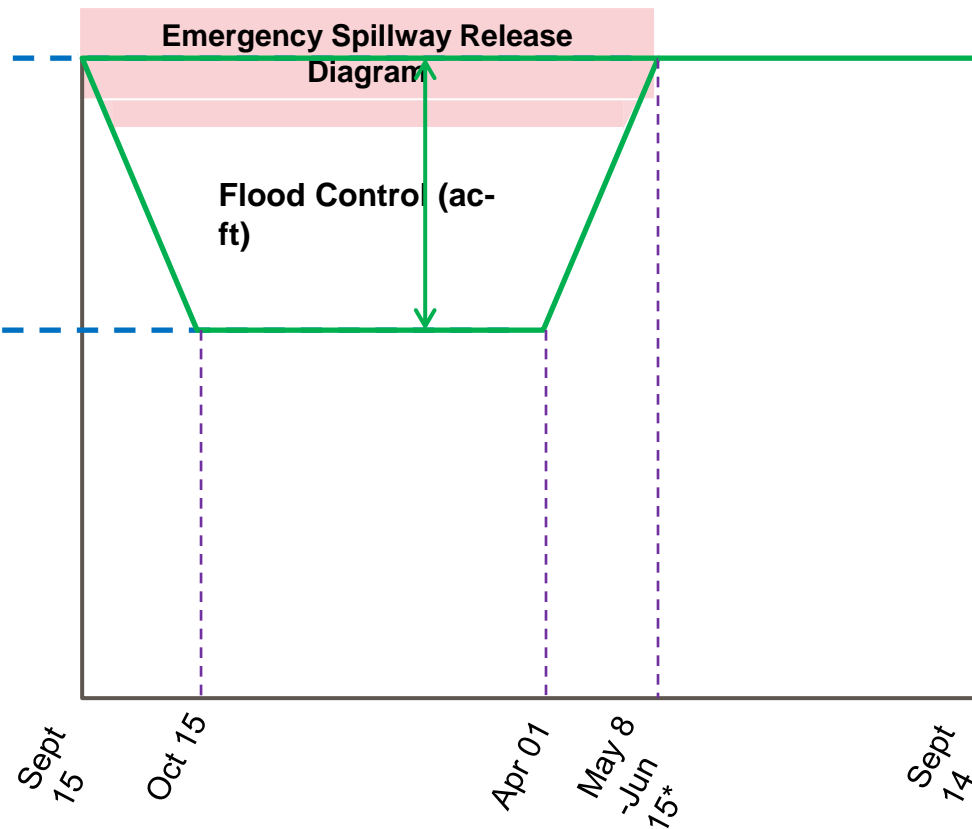
# RESERVOIR OPERATING ZONES



Simplified picture of Oroville Dam-Lake

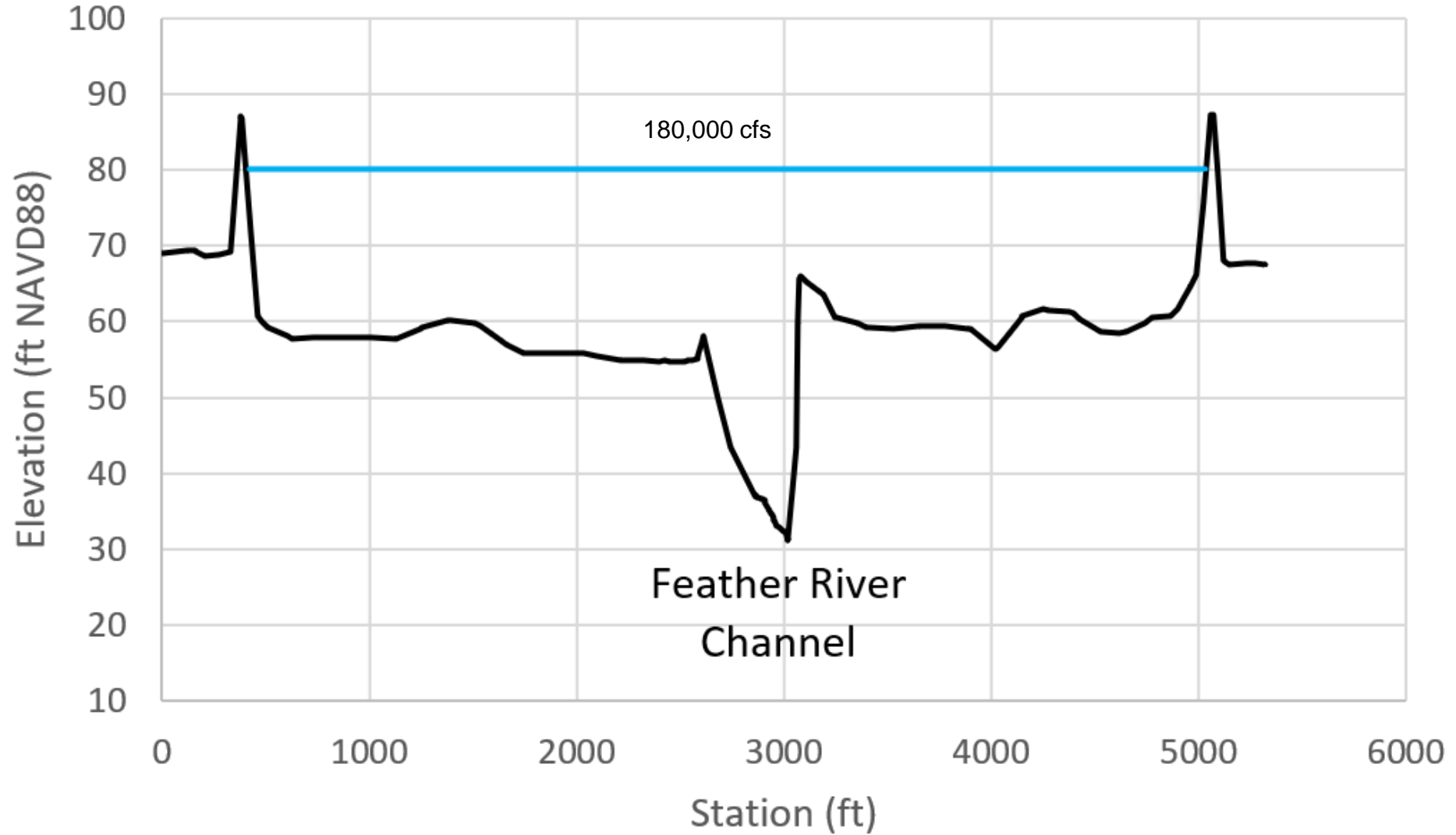


Simplified Water Control Diagram for Oroville Dam-Lake

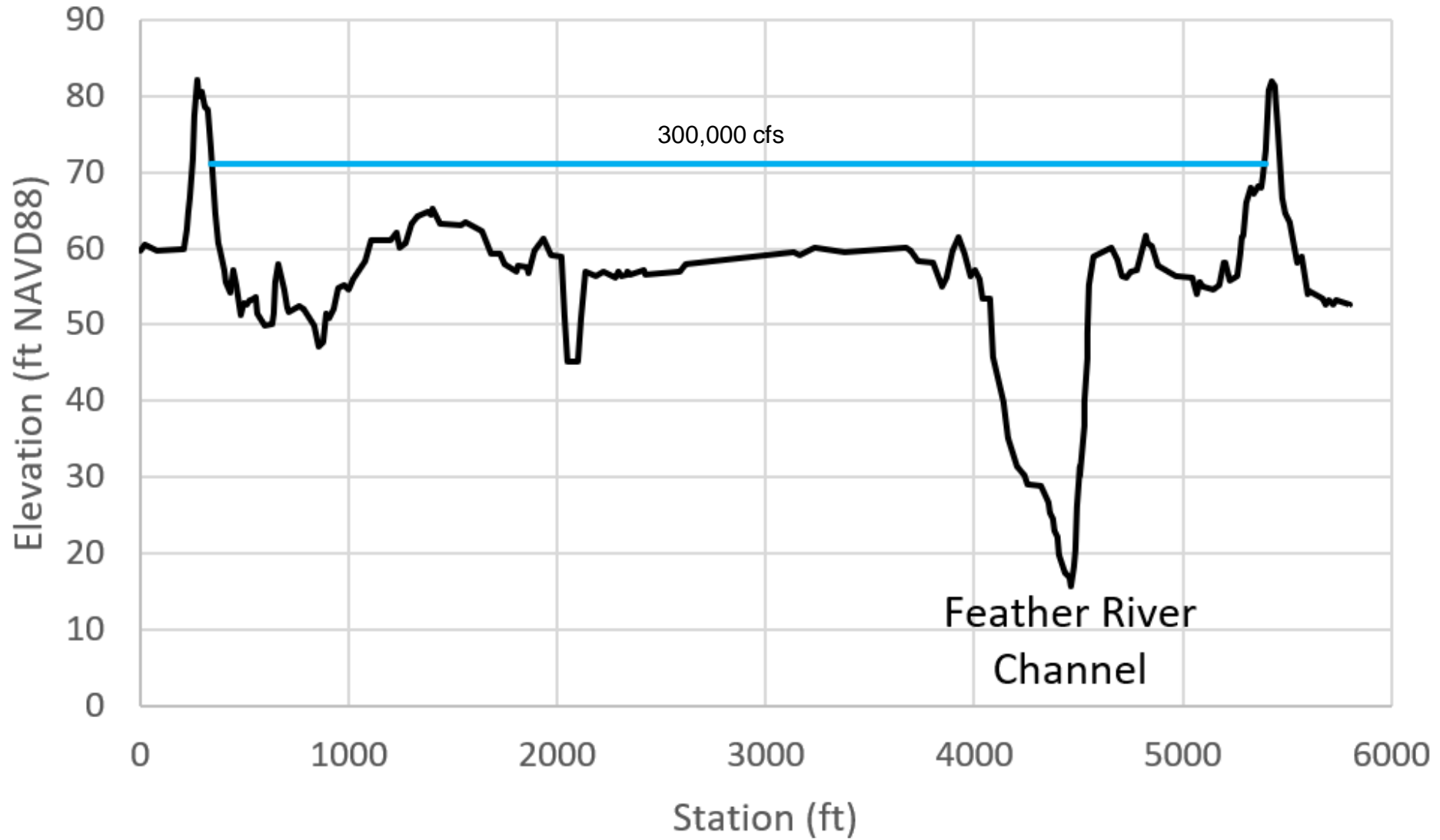


Note: NOT TO SCALE

\*Varies based on wetness parameter



Feather River between Honcut Creek and Yuba River confluence (RM 32.25)



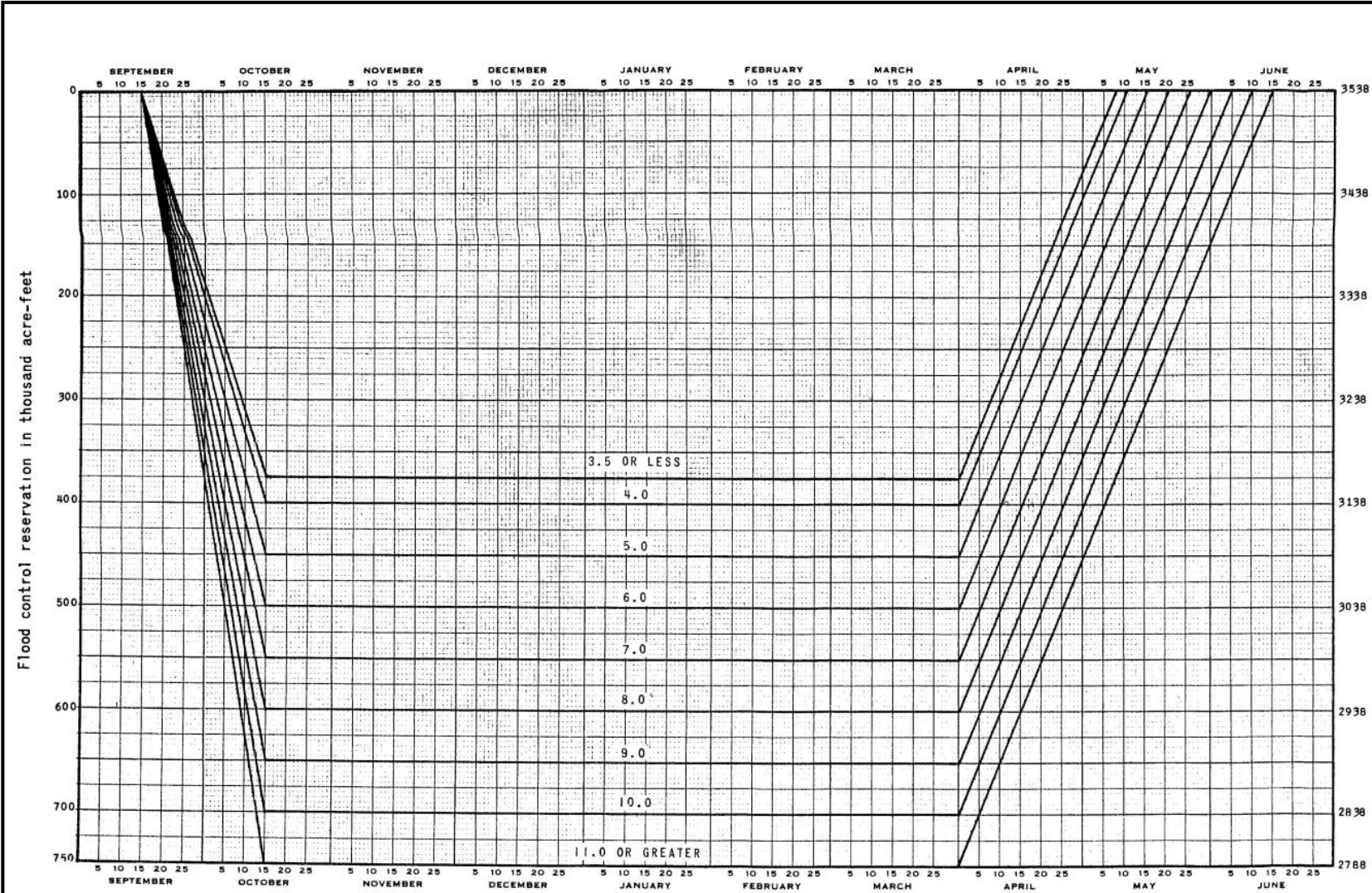
Feather River between Yuba River confluence and Bear River confluence (RM 25.0)



Oroville dam – d/s considerations



Source: California Department of Water Resources [State Plan of Flood Control Descriptive Document](#)



USE OF DIAGRAM

1. Parameters are computed daily from the weighted accumulation of seasonal basin mean precipitation by multiplying the preceding day's parameter by 0.97 and adding the current day's precipitation in inches.
2. Except when releases are governed by the emergency spillway release diagram currently in force (File No. 4-13-586), water stored in the flood control reservation, defined hereon, shall be released as rapidly as possible, subject to the following conditions:
  - a. That releases are made according to the release schedule hereon.
  - b. That flows in Feather River above Yuba River do not exceed 180,000 c.f.s.
  - c. That flows in Feather River below Yuba River do not exceed 300,000 c.f.s.
  - d. That flows in Feather River below Bear River do not exceed 320,000 c.f.s. insofar as possible.
  - e. That releases are not increased more than 10,000 c.f.s. or decreased more than 5,000 c.f.s. in any 2 hour period.

RELEASE SCHEDULE

ACTUAL OR FORECAST INFLOW (WHICHEVER IS GREATER) c.f.s.	FLOOD CONTROL SPACE USED ac-ft	REQUIRED RELEASES c.f.s.
0 - 15,000	0 - 5,000	Power Demand
0 - 15,000	Greater Than 5,000	Inflow
15,000 - 30,000	0 - 30,000	Lesser of 15,000 or maximum inflow
0 - 30,000	Greater Than 30,000	Maximum inflow for flood
30,000 - 120,000	-----	Lesser of maximum inflow or 60,000 c.f.s.
120,000 - 175,000	-----	Lesser of maximum inflow or 100,000 c.f.s.
Greater Than - 175,000	-----	Lesser of maximum inflow or 150,000 c.f.s.

OROVILLE DAM AND RESERVOIR  
FEATHER RIVER, CALIFORNIA

FLOOD CONTROL DIAGRAM

Prepared Pursuant to Flood Control Regulations  
For Oroville Dam and Reservoir

APPROVED: *f P Kovich*  
Major General, USA, Director of Civil Works

APPROVED: *W B Daniels*  
Director, Department of Water Resources

Q&A

# Role of Oroville Dam in Flood Management



*April 22, 2022*

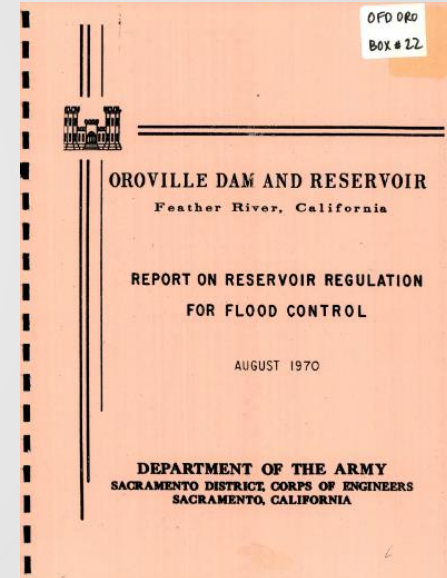
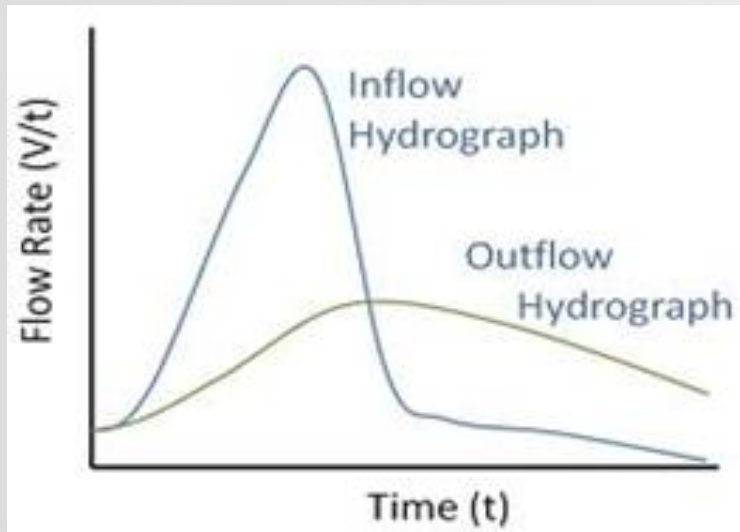
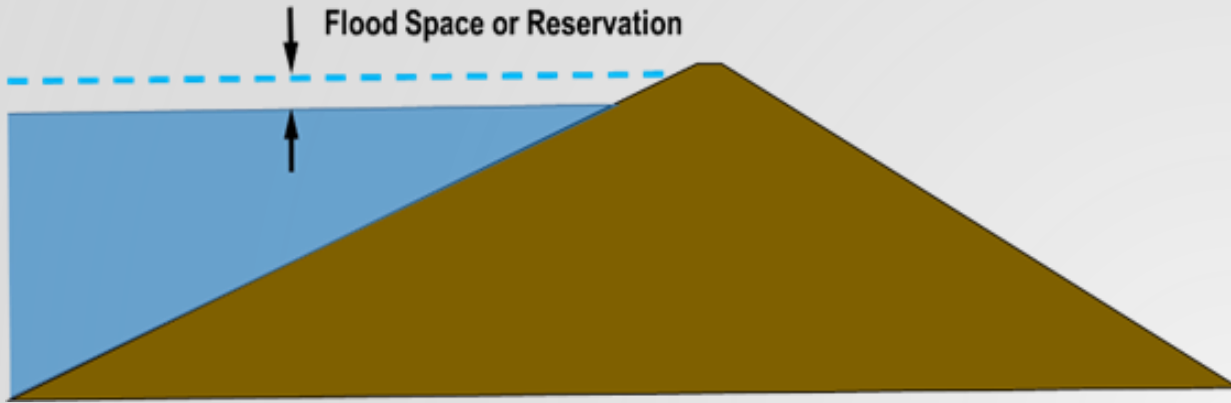
*John Yarbrough*

*Assistant Deputy Director- State Water Project*

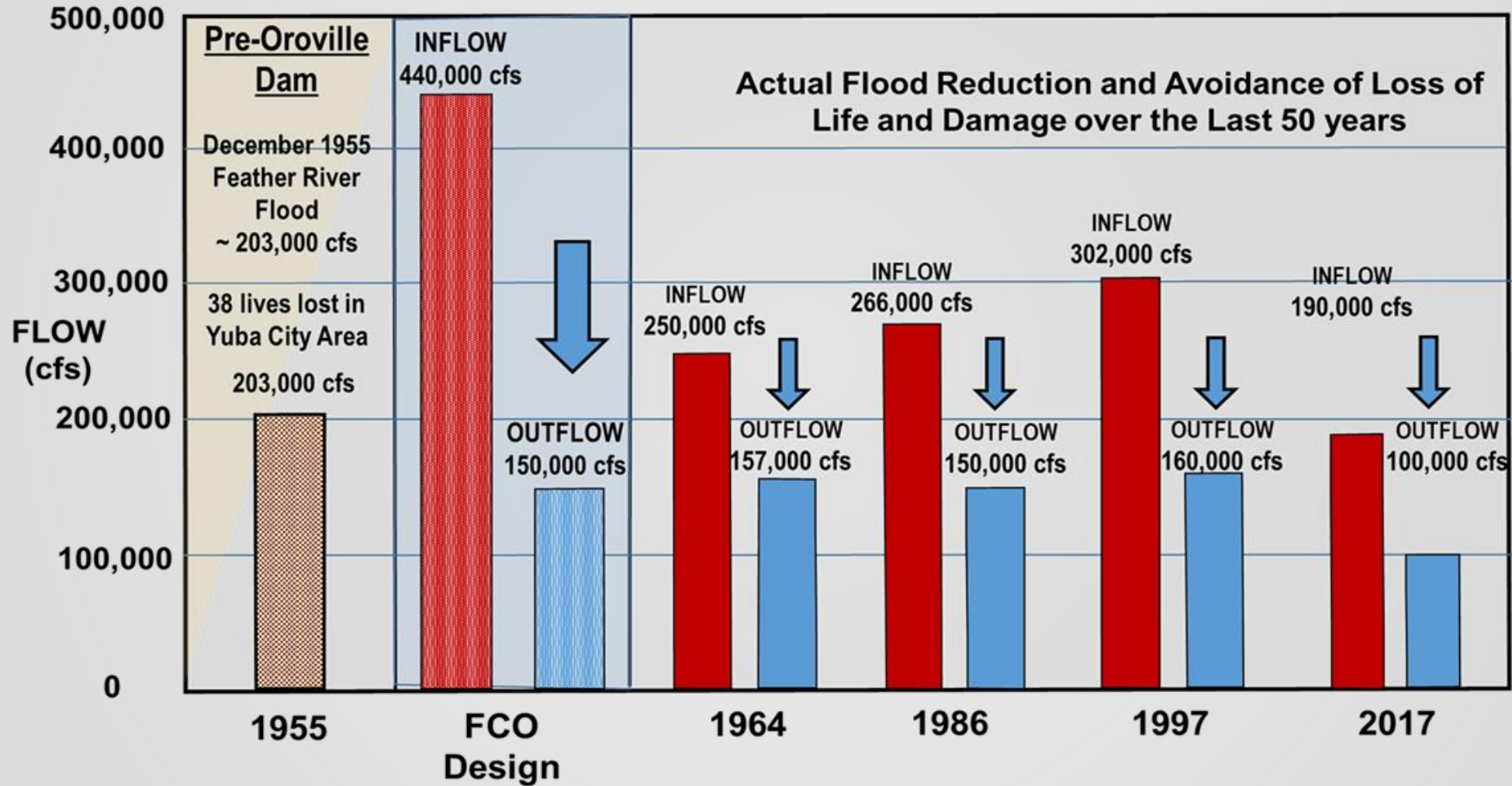




# Flood Management from Dams



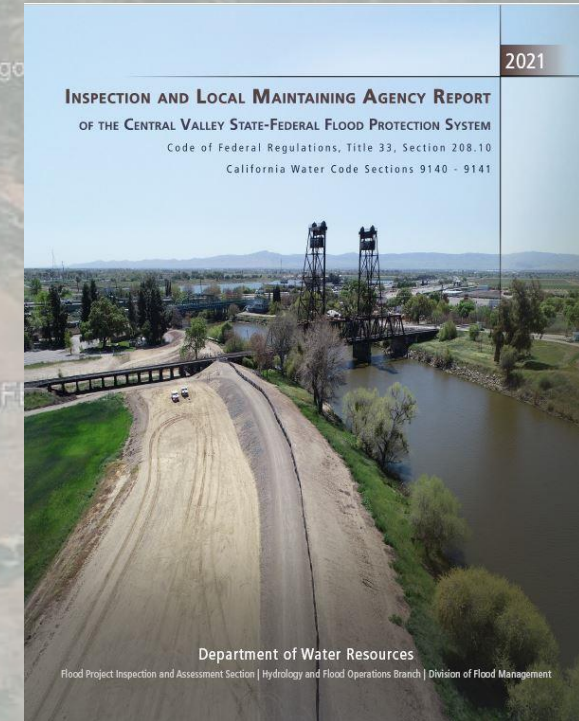
# Flood Operations at Oroville



Q&A

# DWR Inspections

- DWR Bi-annual Levee Inspections
- Annual Inspection of:
  - Structures, Pumping Plants, Channels
- Utility Inspections
- Annual Designated Floodway Inspection
- Flood Fight Training And Response
- High Water Staking



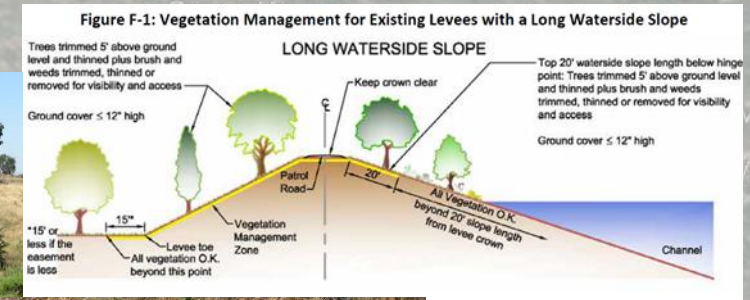
# Bi-Annual Levee Inspections

- Levee Inspections Performed Spring And Fall

- Inspected For:

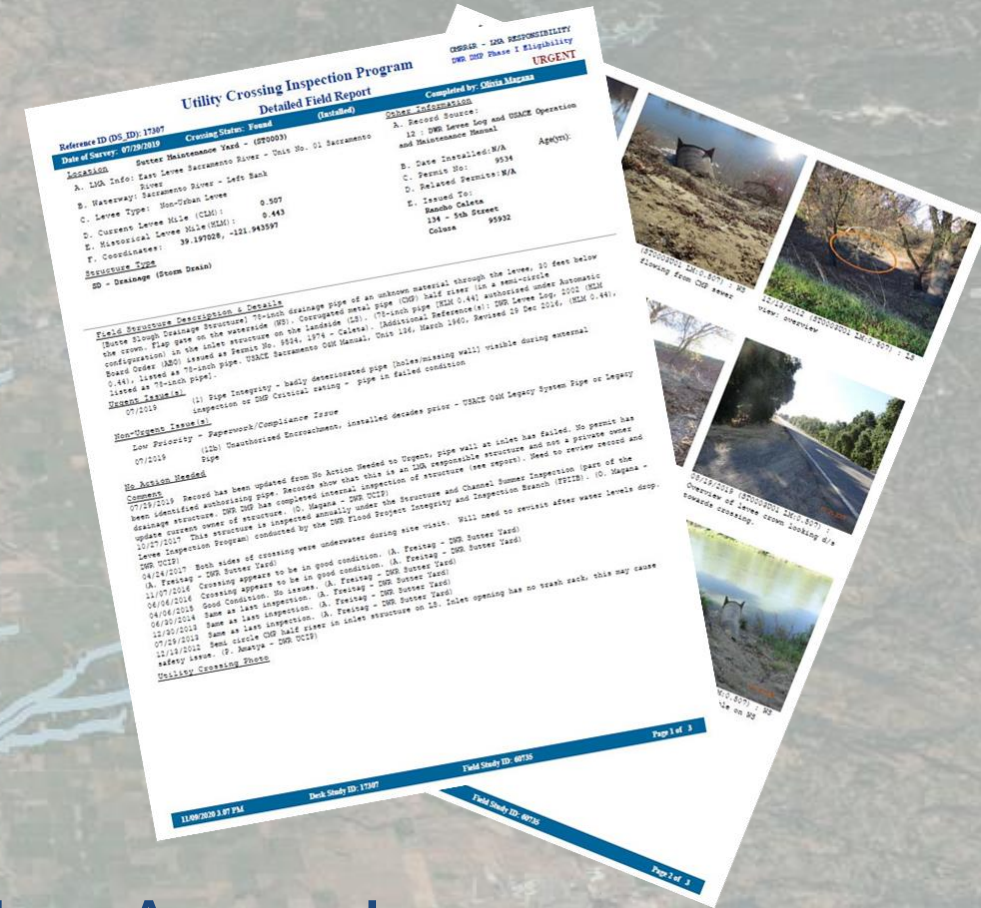
- Erosion
- Cracking
- Animal Burrowing Activity
- Sloughing Or Instability
- Trash And Debris
- Vegetation, Etc.

- Reports Provided To Local Maintaining Agencies, The CVFPB And The USACE



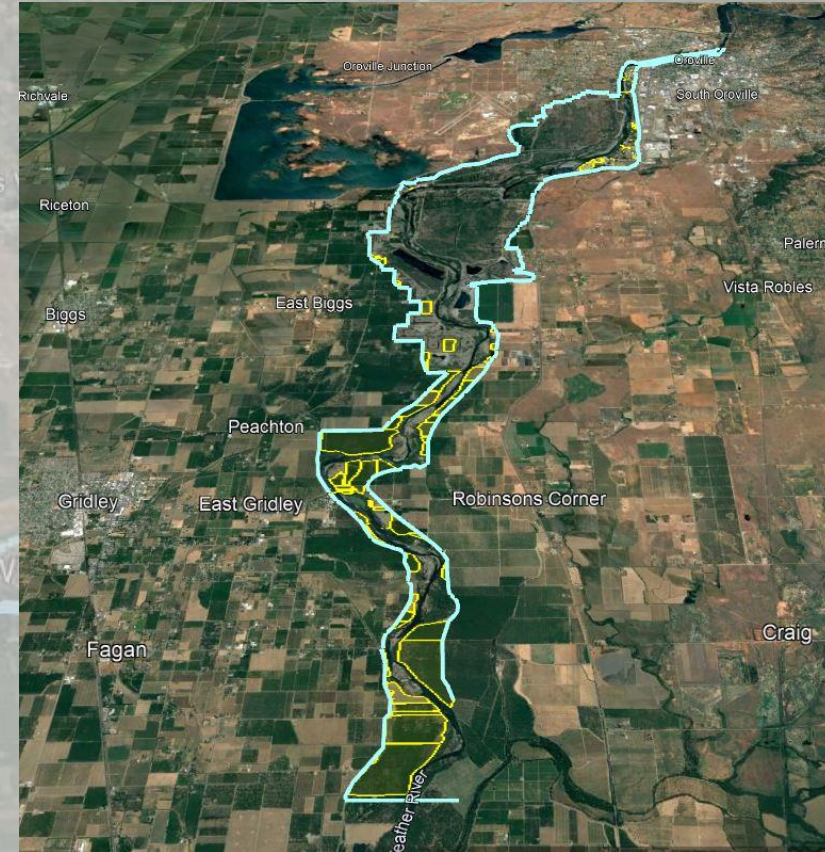
# Utility Inspections

- Pipes Through The Levees
- Every 5-years
- External Inspections
  - Identify And Report
    - Broken
    - Severely Corroded
    - Missing/Broken Closure Devices
    - Leaks Causing Erosion
- Reports Provided To Local Maintaining Agencies, The CVFPB And The USACE



# Designated Floodway Inspections

- Aerial Imagery Review Of Delineated Sections Of Floodways
- Identifies Unauthorized Encroachments
- Reported To The CVFPB
- Helps To Reduce Impact To Capacity Of The Floodway



# Flood Fight Training And Response

- Inspectors Teach Flood Fight Skills And Techniques
- Classes Provided Upon Request
- During A Flood Fight, Our Specialists Provide Technical Support When Requested
- Advanced Flood Fight measures





# High Water Staking

- Survey Of High-water Marks Throughout The Affected River
- Can Be Used To Update Existing Models Or Validate New Models
- FPIAS Can Perform High Water Staking Upon Request
- Feather River High Water Surveyed after 2017



# Q&A

# Oroville Dam Citizens Advisory Commission: Flood Safety Workshop – April 22, 2022

## FEMA Floodplain Mapping

- Risk MAP Discovery and Resiliency Planning
- Acquisition of New Topographic Data
- New Hazard Studies & Flood Map Revisions
- Questions & Answers

<https://msc.fema.gov/nfhl> (National Flood Hazard Layer)

FEMA Mapping & Insurance eXchange (FMIX)

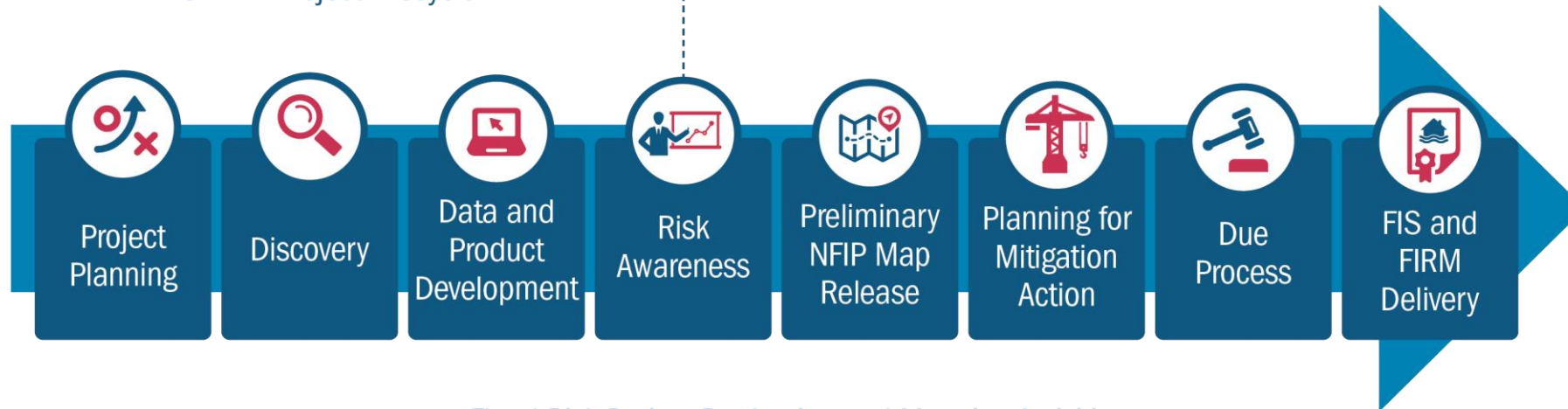
[FEMA-FMIX@fema.dhs.gov](mailto:FEMA-FMIX@fema.dhs.gov)

1-877-336-2627 or live chat (6am to 2pm PT)

# FEMA Steps & Engagement Process



RiskMAP Project Lifecycle



Flood Risk Project Production and Mapping Activities

# Q&A

# Considerations for Safe and Reliable Flood Management in face of Climate Change

*Dr. R. Storesund, PE., GE,*

*Executive Director, UC Berkeley's Center for Catastrophic Risk Management*

April 22 2022

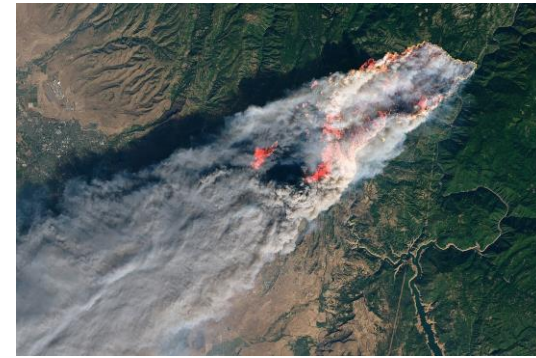
# About Rune

- Dual Degree Program UC Santa Cruz/UC Berkeley
  - BA Anthropology (UC Santa Cruz)
  - BS Civil Engineering (UC Berkeley)
- Masters in Geotechnical Engineering (UC Berkeley)
- Doctorate in Civil Systems (UC Berkeley)
  
- Executive Director, UC Berkeley's Center for Catastrophic Risk Management
- Consulting Engineer, Storesund Consulting
- President & CEO, NextGen Mapping, Inc. (Software Development)
- President & CEO, Storesund Construction, Inc. (Class A, B, C-57)
- President & Director, SafeR<sup>3</sup> (Non-Profit)
- Adjunct Professor, Memorial University of Newfoundland



# My Disaster Research

- 1986 NASA Challenger
- 2003 NASA Columbia
- 2005 Hurricane Katrina
- 2010 San Bruno PGE Explosion
- 2010 Deepwater Horizon
- 2014 Oso Landslide (WA State)
- 2015 Aliso Canyon Gas Leak
- 2017 Oroville Dam Spillway Failure
- 2017 US Navy Ship Collisions
- 2018 California Wildfires (Butte County)
- 2019 Brumadinho Landslide
- 2019 Boeing 737 MAX
- 2020 Michigan Dam Failures
- 2021 Surfside Condo Collapse
- 2018 to ??? Millennium Tower (ongoing)





# Intriguing Terms

- Extreme Event – period of record; confidence interval?
- Risk – what is the Pf? and Cf? we're talking about?
- Residual Risk – what have we/have we not looked at?

My research finds there is no shared understanding or communication of these terms...mean different things to different people.

For infrastructure, my first question is always “what was it supposed to do?” Turns out, systems are rarely ‘overwhelmed’....

They tend to fail in ‘under-whelming’  
conditions

# What is “Safe”?



# High Reliability Organizations (HROs)

- Have a clear and explicit concept of “reliability” that is shared consistently across the organization
- Highly integrated reliability and safety-minded organizational culture (widely held assumptions, attitudes, values, and practices)
- Recognize and utilize “uncertainty” as a formal resource
- Use ‘precursor conditions’ as proactive risk-reduction approaches
- Embrace and support “Reliability Professionals”
- Exhibit a strategic degree of organizational flexibility
- Are constantly on the lookout for errors

# Deepwater Horizon

## Organizational Safety Culture Traits

- Inquiring attitude
- Hazard identification and risk management
- Leadership commitment to safety values and actions
- Effective safety and environmental communication
- Respectful work environment
- Environment of raising concerns
- Personal accountability
- Work processes
- Continuous improvement

Strengthening the Safety Culture  
of the  
Offshore Oil and Gas Industry



*The National Academies of*  
SCIENCES • ENGINEERING • MEDICINE



EPA

# Risk Management Frameworks



# Event Types

	Knowable	Unknowable
Preventable	<p><b>“Probabilities”</b> <b>“Possibilities”</b></p> <p><b>Today’s Focus!!</b></p>	<p><b>“Prevention Through People”</b></p>
Unpreventable	<p><b>Risk Transfer</b> <b>Risk Acceptance</b></p>	<p><b>Mindfulness</b></p>

# Risk Management and Socio-Technical Systems

*Risk Management in systems designed, operated, and managed by people.*

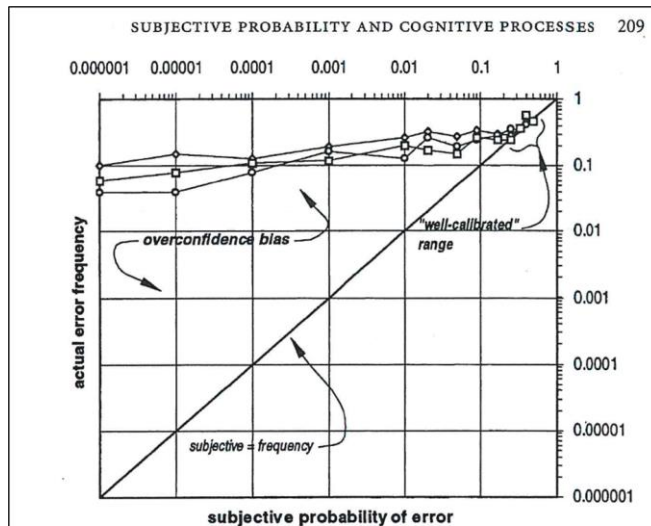
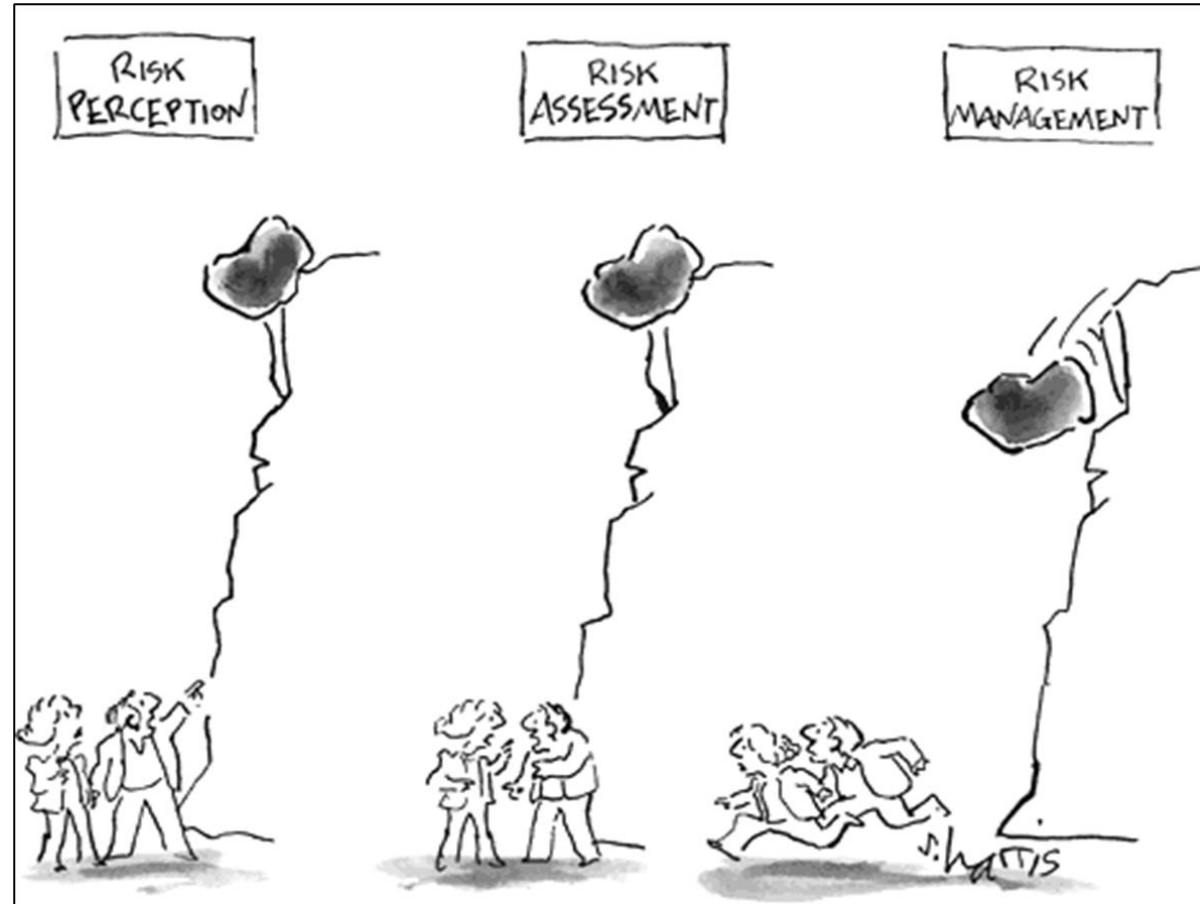
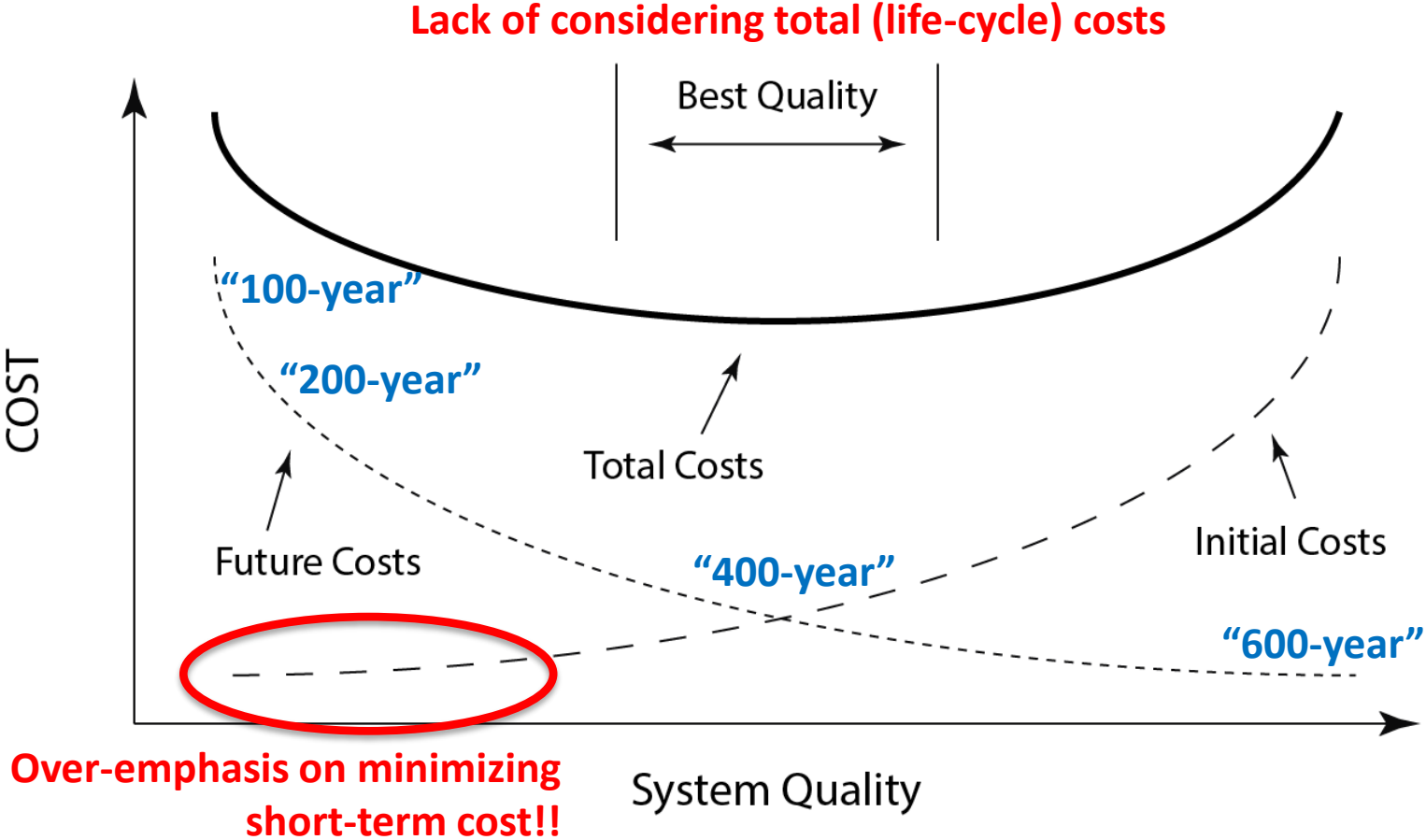


FIGURE 5-3. Overconfidence bias and calibration.  
Source: Experimental data from Fischhoff, et al., 1977.



# Investment Decisions





# NOAA ATLAS 14 POINT PRECIPITATION FREQUENCY ESTIMATES: CA

## Data description

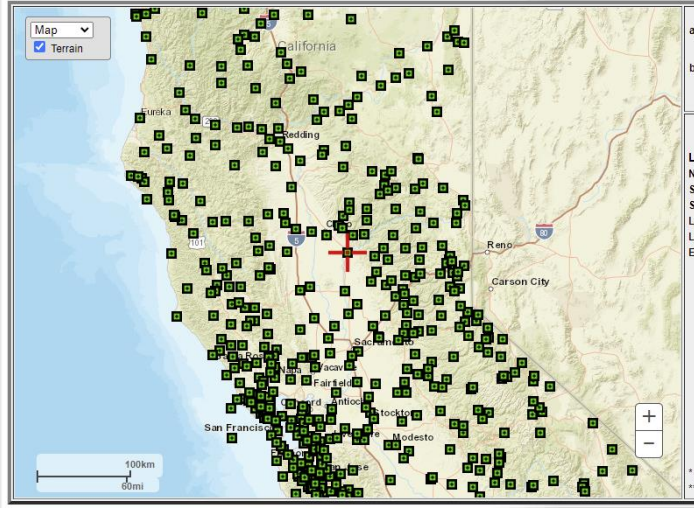
Data type: Precipitation depth Units: English Time series type: Partial duration

## Select location

### 1) Manually:

- a) By location (decimal degrees, use "-" for S and W): Latitude:  Longitude:
- b) By station (list of CA stations): OROVILLE (04-6521)
- c) By address

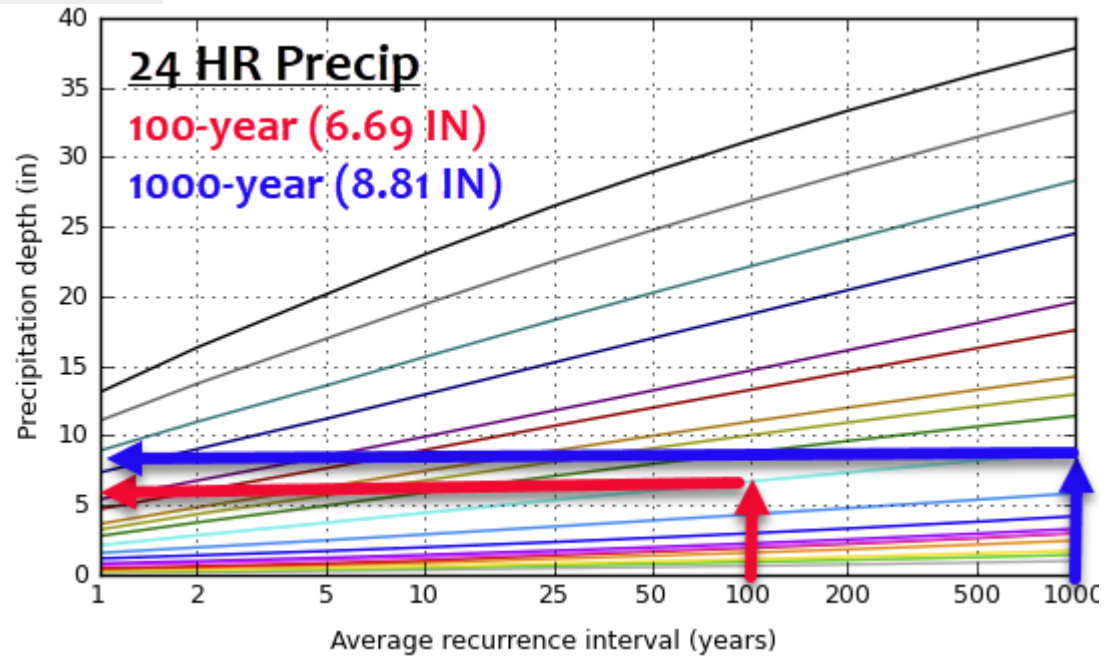
### 2) Use map (if ESRI interactive map is not loading, try adding the host: <https://js.arcgis.com/> to the firewall, or contact us at [hdsc.questions@noaa.gov](mailto:hdsc.questions@noaa.gov)):



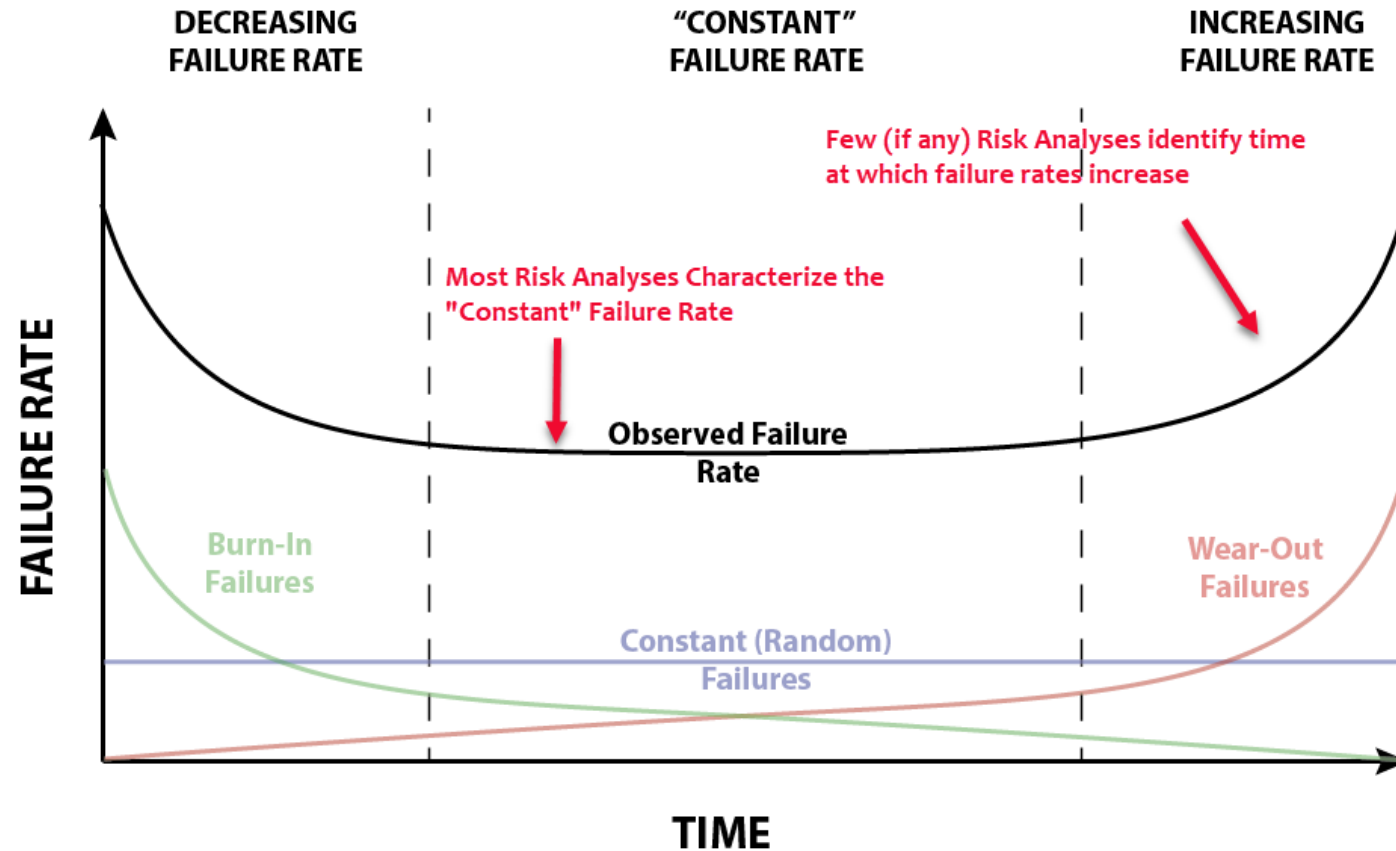
- a) Select location  
Move crosshair or double click
- b) Click on station icon  
 Show stations on map

**Location information:**  
Name: Oroville, California, USA\*  
Station name: OROVILLE  
Site ID: 04-6521  
Latitude: 39.5178°  
Longitude: -121.5531°  
Elevation: 171 ft

Duration	
5-min	2-day
10-min	3-day
15-min	4-day
30-min	7-day
60-min	10-day
2-hr	20-day
3-hr	30-day
6-hr	45-day
12-hr	60-day
24-hr	



# Failure is Time-Dependent



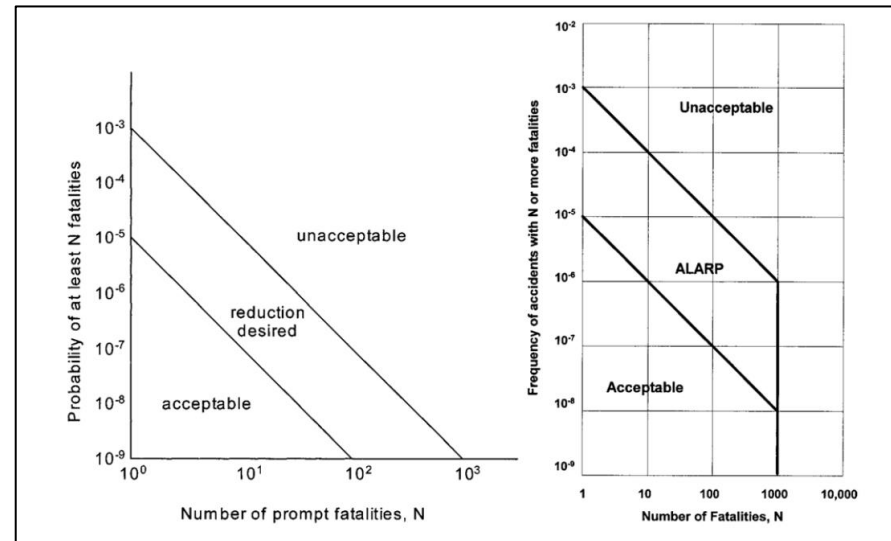
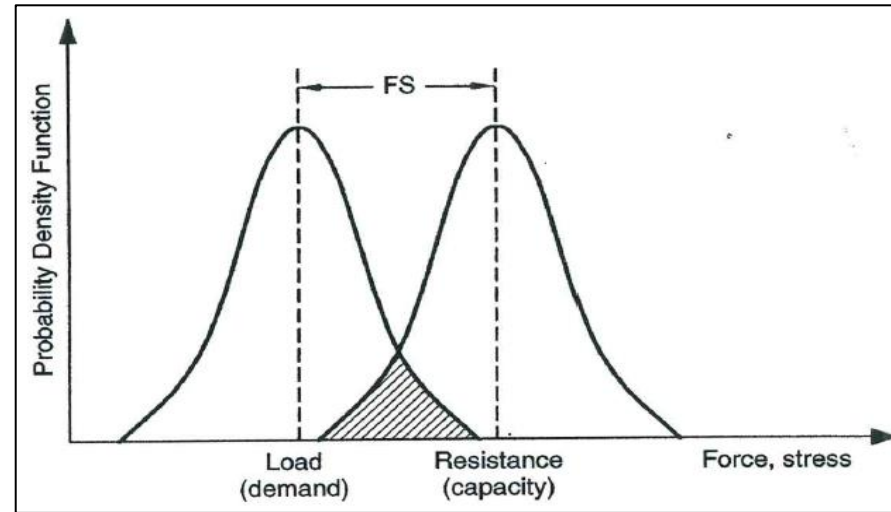
# Traditional Risk Analysis (TRA)

$$\text{RISK} = P_f \times C_f$$

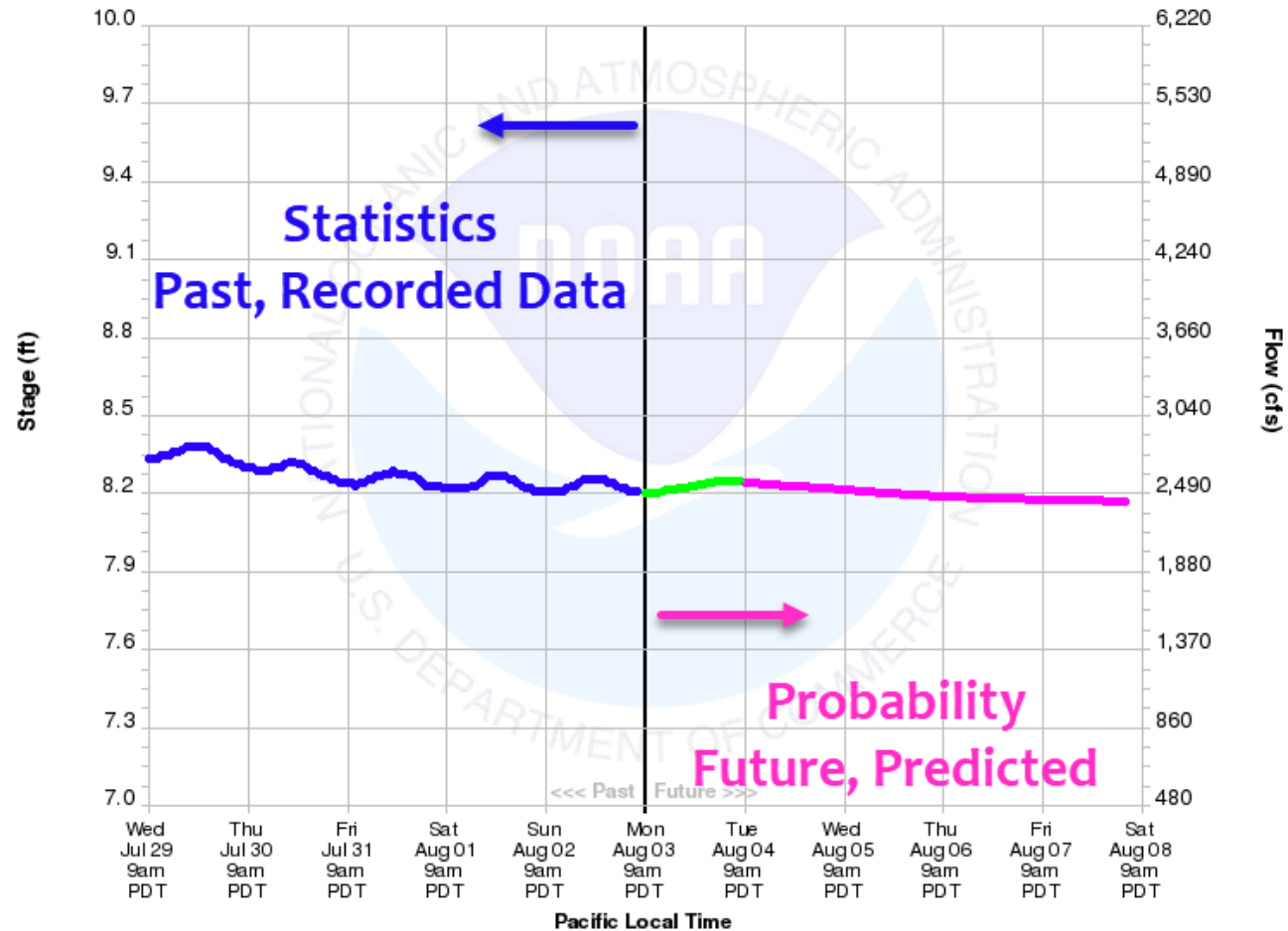
$P_f$  = Probability of Failure

$C_f$  = Consequence of Failure

**Frequently, 'Demand' and 'Capacity' distributions are 'imagined' by "Subject Matter Experts" rather than by data or actual system configuration**



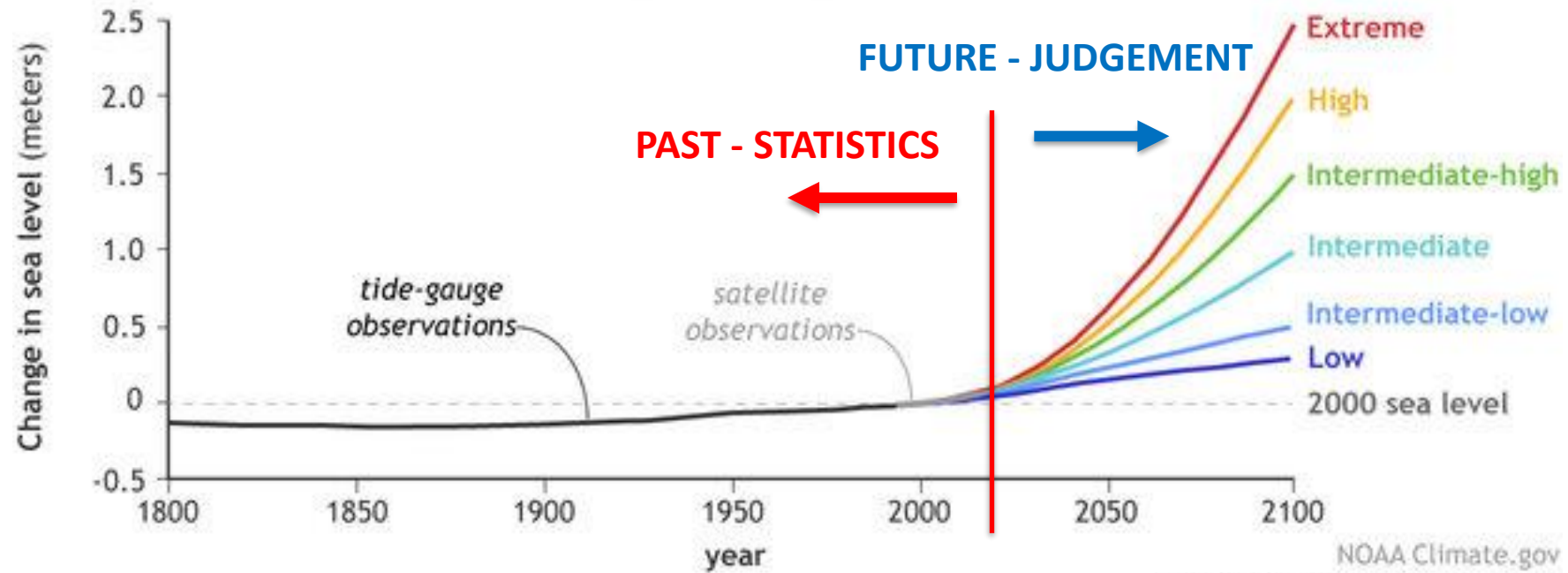
# Statistics vs. Probability



Observed • Forecast • Guidance • Probability  
 Created: 08/03/2020 at 9:16 AM PDT (KLMC1 Forecast Run Time = 1441Z)

California Department of Water Resources  
 NOAA / NWS / California Nevada River Forecast Center

Possible future sea levels for different greenhouse gas pathways

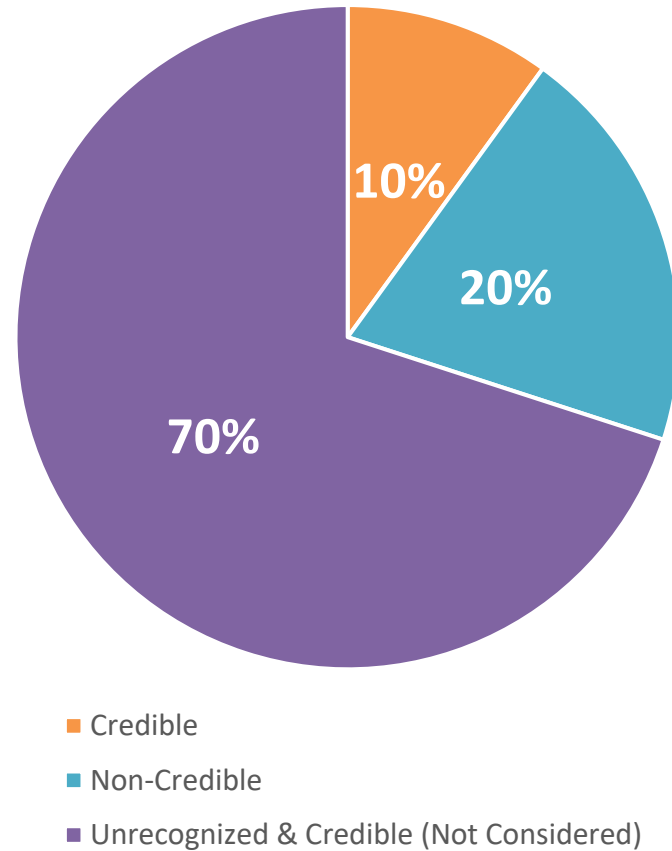


NOAA Climate.gov  
Adapted from Sweet et al., 2017

**IN THIS CASE, THE PAST IS LIKELY NOT A PERFECT PREDICTOR OF THE FUTURE**

# Limited “Imagination” for Scenarios

Failure Scenarios



## Consequences of Failure (Cf)

		Less Uncertainty	More Uncertainty
Probability of Failure (Pf)	Less Uncertainty	<p><b>Traditional Quantitative Risk Analysis</b></p> <p><b>PROBABILITIES</b></p> <p><i>Well-Structured</i> <i>Well-Defined</i> <i>Bounded</i></p> <p>BOX 1</p>	<p><b>Unfolding Events</b></p> <p><b>CRISIS</b></p> <p>BOX 2</p>
	More Uncertainty	<p>BOX 3</p> <p><b>Anticipated Events</b></p> <p><i>"Earthquakes"</i></p> <p><i>"1,000 year storm"</i></p> <p><b>POSSIBILITIES</b></p>	<p>BOX 4</p> <p><b>Unanticipated Unfolding Events</b></p> <p><b>SURPRISES</b></p> <p><i>Ill-Structured</i> <i>Un-Defined</i> <i>Un-Bounded</i></p>

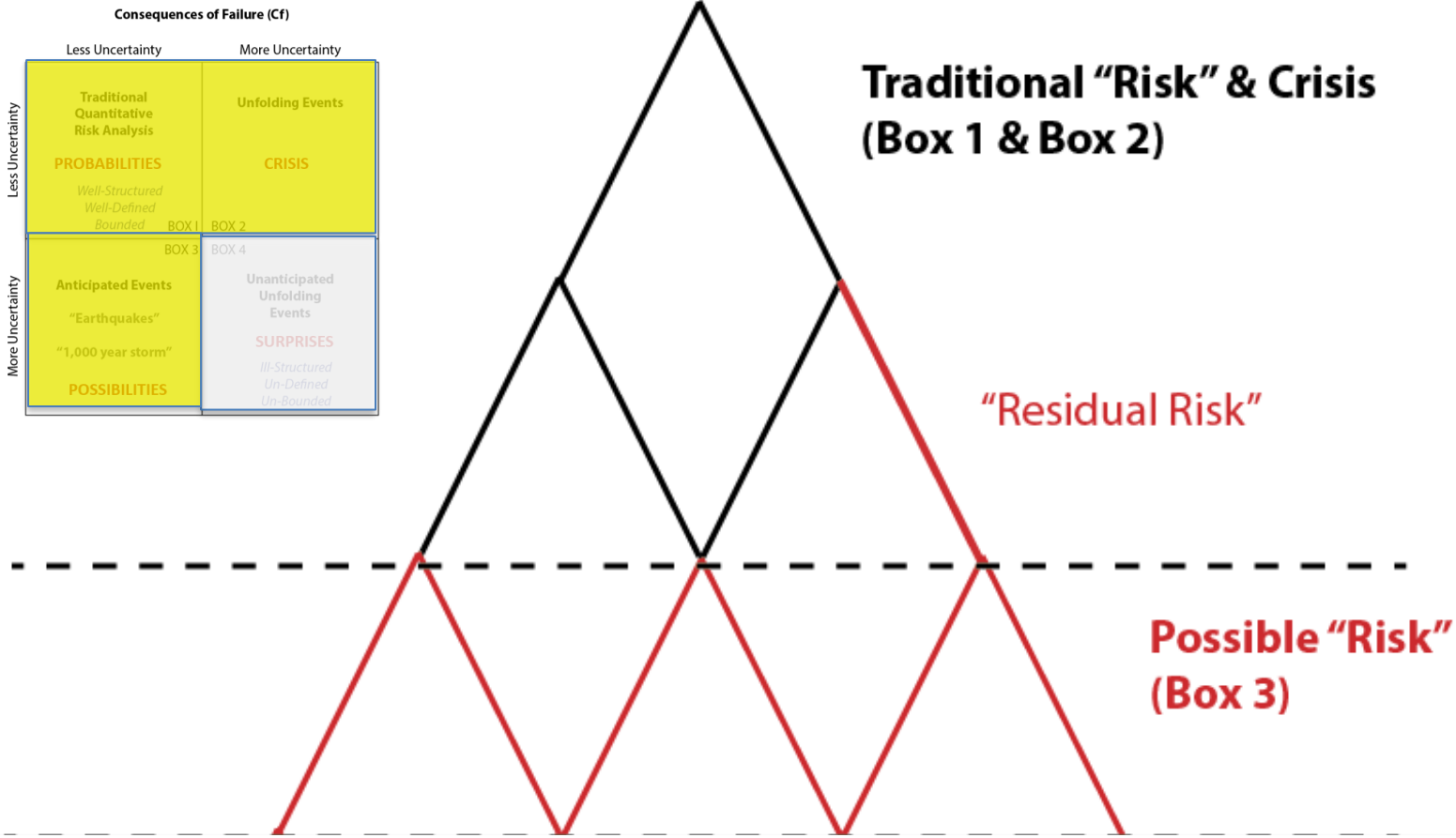
**NEED DIFFERENT TOOLS/METHODS/ STRATEGIES FOR EACH REGION!**

Rune Storesund, D.Eng., P.E., G.E., August 2016

**NOTE, THESE REGIONS ARE NOT DISCRETE, BUT VERY FLUID AND TIME-DEPENDENT!!**

		Consequences of Failure (Cf)	
		Less Uncertainty	More Uncertainty
Probability of Failure (Pf)	Less Uncertainty	Traditional Quantitative Risk Analysis <b>PROBABILITIES</b> <i>Well-Structured Well-Defined Bounded</i>	Unfolding Events <b>CRISIS</b>
	More Uncertainty	Anticipated Events "Earthquakes" "1,000 year storm" <b>POSSIBILITIES</b>	Unanticipated Unfolding Events <b>SURPRISES</b> <i>Ill-Structured Un-Defined Un-Bounded</i>
		BOX 1	BOX 2
		BOX 3	BOX 4

## Traditional "Risk" & Crisis (Box 1 & Box 2)





# Uncertainties

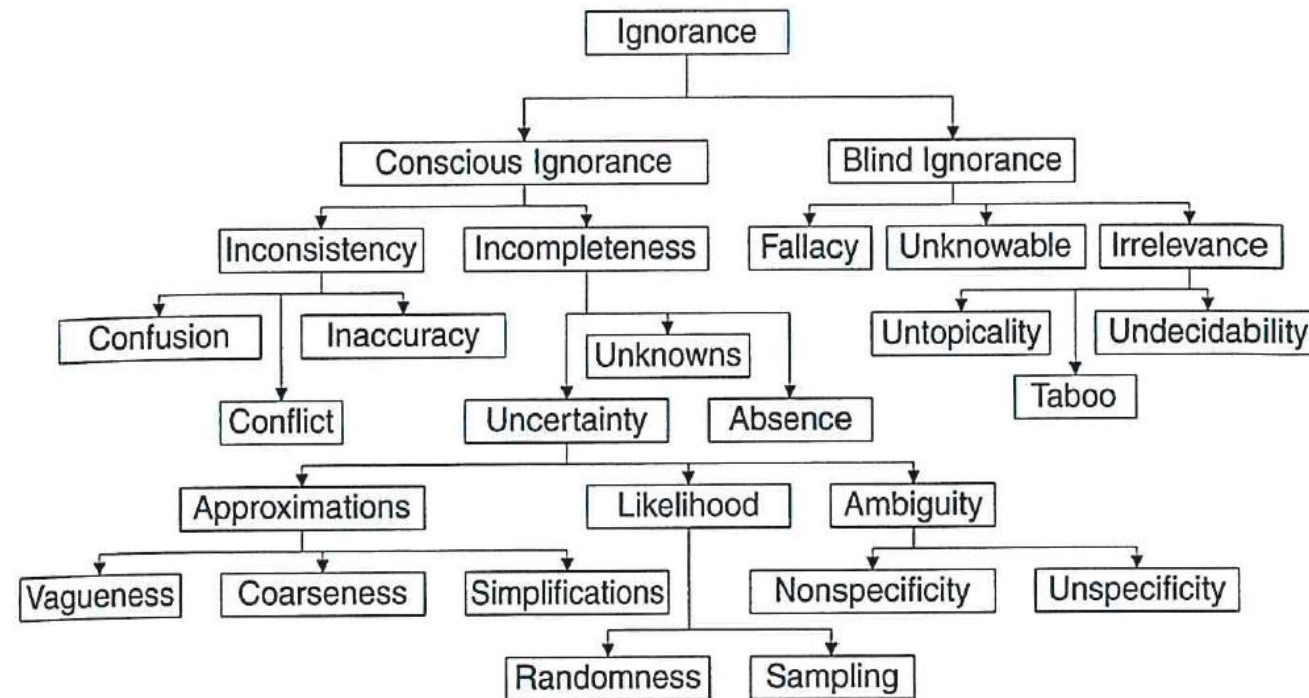


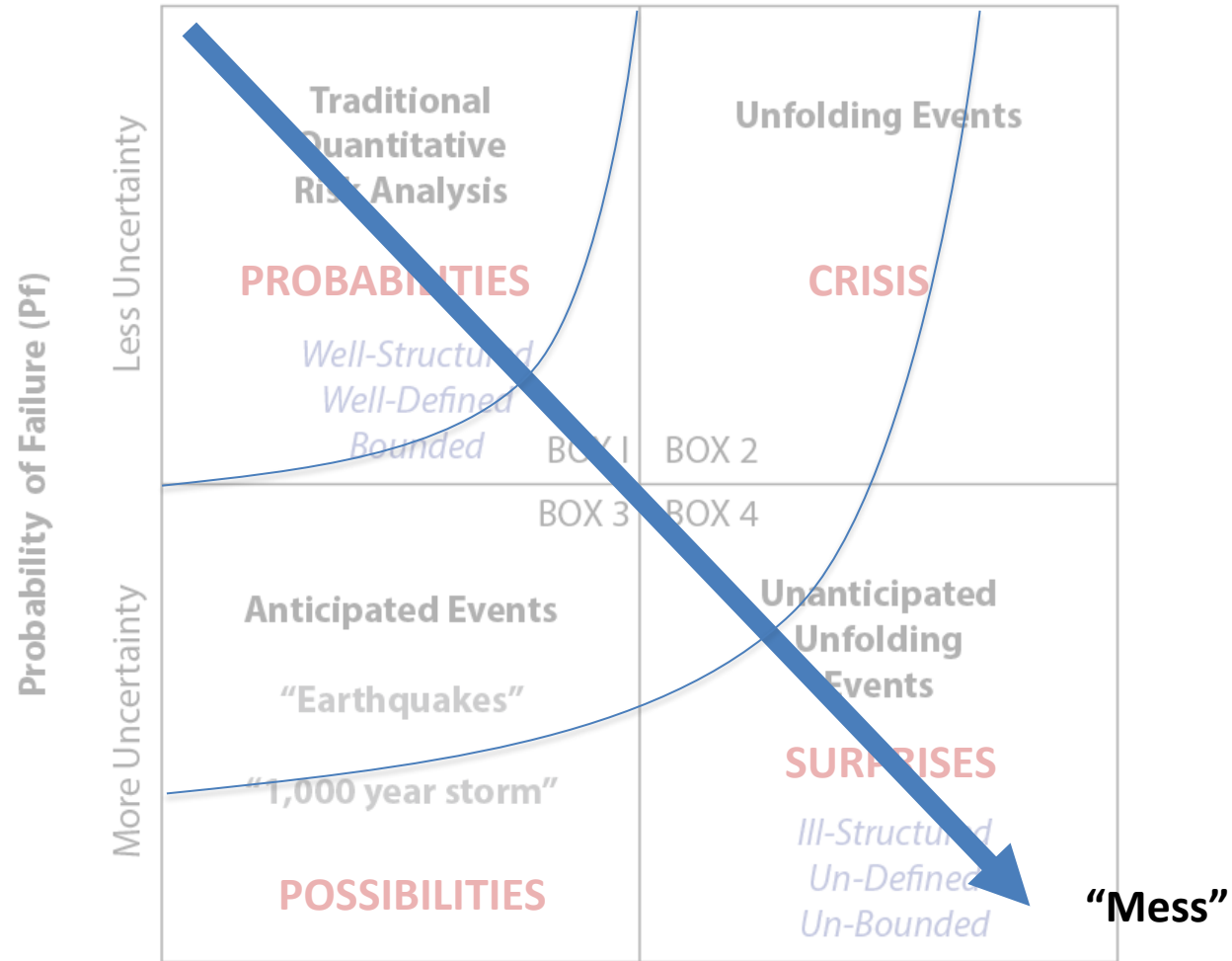
FIGURE 1-2 Ignorance types.

# Consequences of Failure (Cf)

**Crisp/EXERCISE**

Less Uncertainty

More Uncertainty



Rune Storesund, D.Eng., P.E., G.E., August 2016

# Problem “Crispness”

Crisp

“Messy”

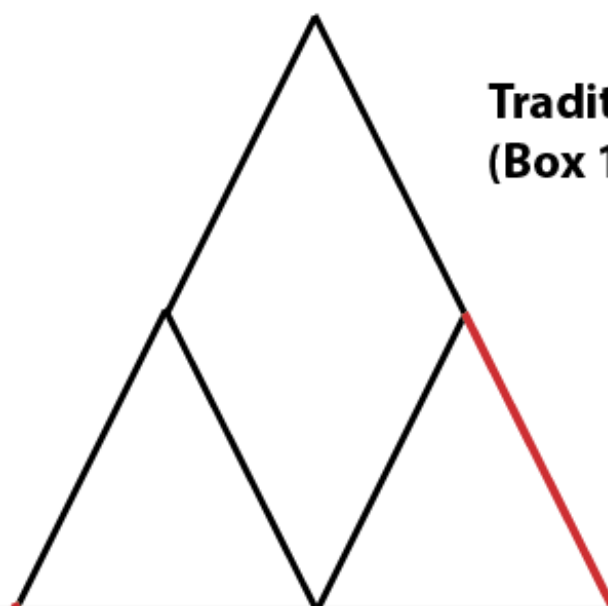


EXERCISES		PROBLEMS	MESSES
<ul style="list-style-type: none"> <li>*Bounded</li> <li>*Structured</li> <li>*Well-Defined</li> <li>*Existing Algorithms</li> <li>*Established "Rules"</li> <li>*All stakeholders in strong agreement</li> </ul>		<ul style="list-style-type: none"> <li>*Establish base assumptions</li> <li>*Questions to be answered</li> <li>*Abstracted from messes</li> <li>*Well-Specified</li> <li>*Identify plausible "Rules"</li> <li>*Requires Effective Communication</li> </ul>	<ul style="list-style-type: none"> <li>*Unbounded</li> <li>*Unstructured</li> <li>*Ill-Defined</li> <li>*Heuristics (judgment)</li> <li>*No established "Rules"</li> <li>*Strong Stakeholder Disagreement</li> <li>*Ineffective Communication</li> </ul>
Quantitative		Qualitative	Ill-defined
Type I-Analytic	Type II-Crisis	Type III-"Possibilities" Type IV-"Unexpected"	

**Consequences of Failure (Cf)**

		Less Uncertainty	More Uncertainty
Probability of Failure (Pf)	Less Uncertainty	Traditional Quantitative Risk Analysis <b>PROBABILITIES</b> <i>Well-Structured Well-Defined Bounded</i>	Unfolding Events <b>CRISIS</b>
	More Uncertainty	Anticipated Events "Earthquakes" "1,000 year storm" <b>POSSIBILITIES</b>	Unanticipated Unfolding Events <b>SURPRISES</b> <i>Ill-Structured Un-Defined Un-Bounded</i>
		BOX 1	BOX 2
		BOX 3	BOX 4

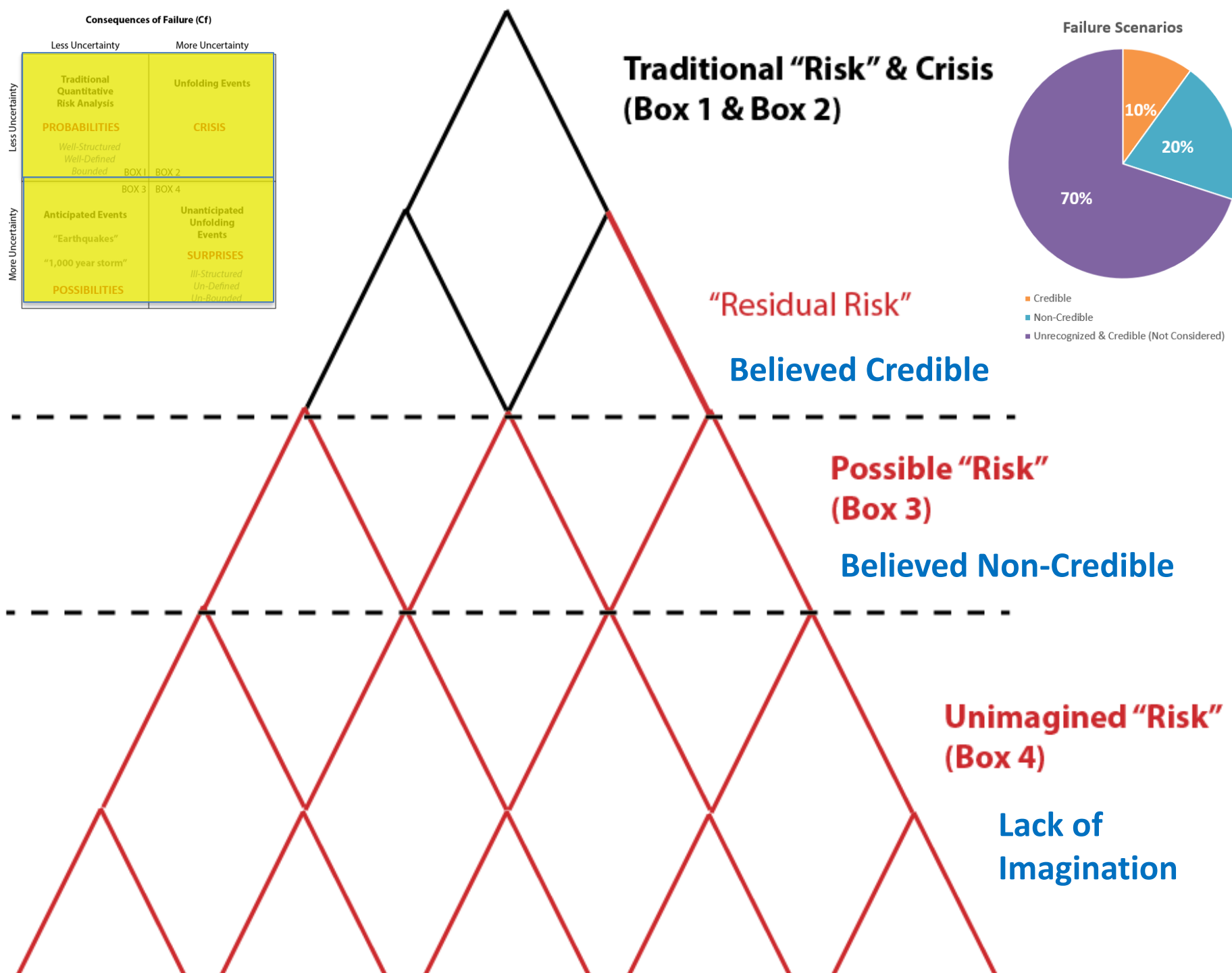
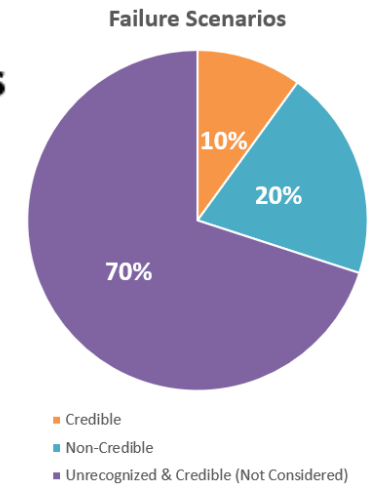
## Traditional "Risk" & Crisis (Box 1 & Box 2)



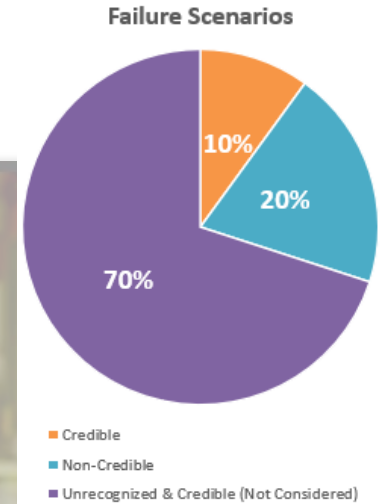
"Residual Risk"

		Consequences of Failure (Cf)	
		Less Uncertainty	More Uncertainty
Probability of Failure (Pf)	Less Uncertainty	Traditional Quantitative Risk Analysis <b>PROBABILITIES</b> <i>Well-Structured Well-Defined Bounded</i>	Unfolding Events <b>CRISIS</b>
	More Uncertainty	Anticipated Events "Earthquakes" "1,000 year storm" <b>POSSIBILITIES</b>	Unanticipated Unfolding Events <b>SURPRISES</b> <i>Ill-Structured Un-Defined Un-Bounded</i>
		BOX 1	BOX 2
		BOX 3	BOX 4

## Traditional "Risk" & Crisis (Box 1 & Box 2)



# Gov. Newsom (April 19, 2022)

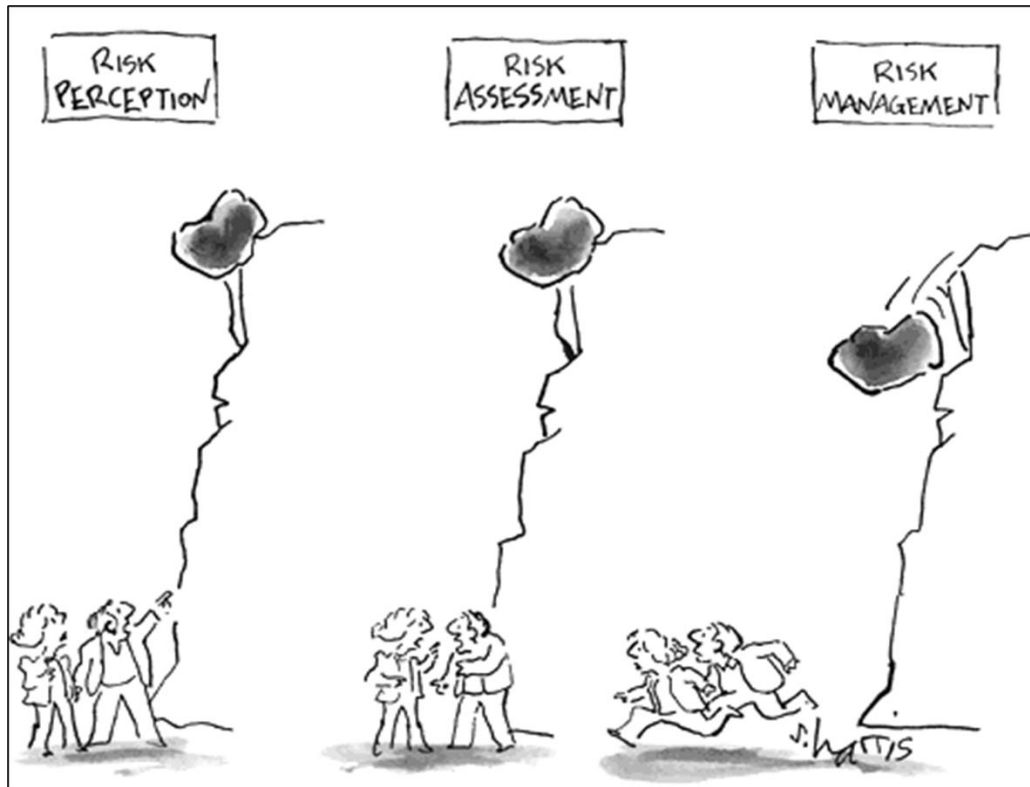


...to address the weather whiplash that we're now experiencing. To address the extremes that we're experiencing for the first time in our lives. The fact that this facility shutdown last August, that never happened before, just never happened before, **it was imagined, but we never thought it would be realized in our lifetime.** It happened and the prospect that will happen again or very real particularly because we had the driest January the driest February and driest March in California history...

8:44 / 26:30

<https://youtu.be/8Yolbq0xKHI?t=507>

# Confronting Belief



## Strategies/Tools

- Integrity Management
- Prevention Through People
- Enhanced Regulation
- Uncertainty as a Resource
- Safety Culture Principles
- HRO Principles
- Life-Cycle Management
- Total Cost Analysis
- Embracing 'extreme' thinking
- Crisp Communication (Safe = ???)

Consequences of Failure (Cf)

CONVENTIONAL

		Less Uncertainty	More Uncertainty
Probability of Failure (Pf)	Less Uncertainty	<p><b>A</b> Traditional</p> <p><b>B</b> Quantitative Risk Analysis</p> <p><b>C</b> "Probabilities"</p> <p><b>D</b> Well-Structured Well-Defined Bounded</p> <p>BOX 1</p> <p><b>E</b></p> <p><b>F</b></p> <p><b>G</b></p>	<p><b>A</b> Unfolding Events</p> <p><b>B</b></p> <p><b>C</b> CRISIS</p> <p><b>D</b> G</p> <p>BOX 2</p> <p><b>E</b></p> <p><b>F</b></p> <p><b>G</b></p>
	More Uncertainty	<p>BOX 3</p> <p><b>A</b> Anticipated Events</p> <p><b>B</b> "Earthquakes"</p> <p><b>C</b> ,000 year storm"</p> <p><b>D</b> "Possibilities"</p> <p><b>E</b></p> <p><b>F</b></p> <p><b>G</b></p>	<p>BOX 4</p> <p><b>A</b> Unanticipated Unfolding Events</p> <p><b>B</b></p> <p><b>C</b> CRISIS</p> <p><b>D</b> Ill-Structured Un-Defined Un-Bounded</p> <p><b>E</b></p> <p><b>F</b></p> <p><b>G</b></p>

Rune Storesund, D.Eng., P.E., G.E., August 2016

LEVERAGE PEOPLE (HRO) & BUILD ORGANIZATIONAL CAPABILITIES ACROSS

UNCERTAINTY DOMAINS (BOXES 1-4)

- A. Have a clear and explicit concept of "reliability" that is shared consistently across the organization
- B. Highly integrated reliability and safety-minded organizational culture (widely held assumptions, attitudes, values, and practices)
- C. Recognize and utilize "uncertainty" as a formal resource
- D. Use 'precursor conditions' as proactive risk-reduction approaches
- E. Embrace and support "Reliability Professionals"
- F. Exhibit a strategic degree of organizational flexibility
- G. Are constantly on the lookout for errors





# SCRaM – Crowdsource Tool

## Create Scenario

### Step 1

Allow sharing for this scenario?

Scenario Name

### Step 2

What type of disruption are you going to experience?

Select Type

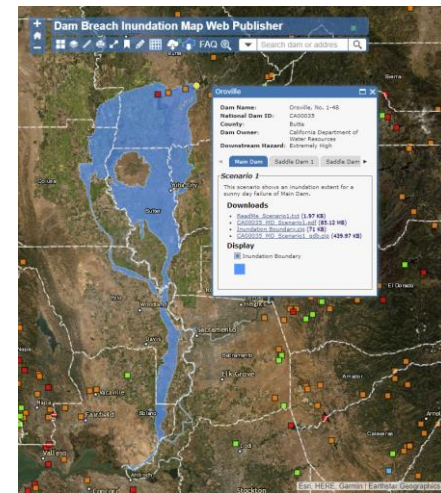
### Step 3

Select boxes in the chart below to represent your range of consequences and likelihoods.

Consequence (Exposure)

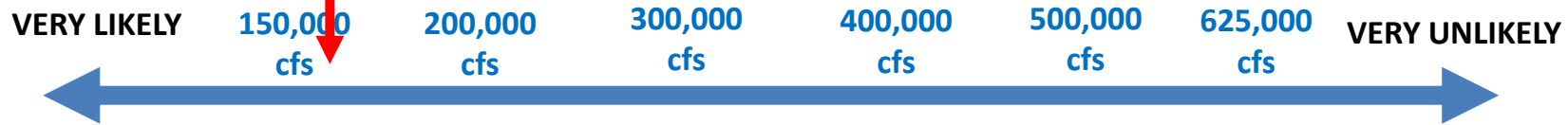
	None	Minor	Moderate	Serious	Catastrophic
Expected					
Very Likely					
Likely					
Medium Likely					
Unlikely					
Very Unlikely					
Unexpected					

# Elevated Releases Study



1997 Oroville Evacuation  
@ ~165,000 cfs

## ELEVATED OROVILLE DAM RELEASES



Drought/Water Shortage  
Floods (Localized  
Stormwater)  
Severe Weather  
Extreme Heat  
Freeze/Winter Storm  
Wildfires



Preventable

Earthquake > Mw 7.0  
Full Dam Failure  
Volcano  
"Ark Storm"

	Knowable	Unknowable
Preventable	<p>"Probabilities" "Possibilities"</p> <p><b>Today's Focus!!</b></p>	<p>"Prevention Through People"</p>
Unpreventable	<p>Risk Transfer Risk Acceptance</p>	<p>Mindfulness</p>

# 32 years ago, 300,000 people flattened the Golden Gate Bridge



Eric Ting, SFGATE

May 25, 2019 | Updated: May 25, 2019 12:34 p.m.



**ANTICIPATED**  
**80,000**

**ACTUAL**  
**800,000**

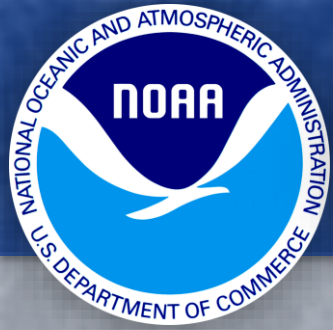
Dr. Rune Storesund, D.E.ng. P.E., G.E.

Executive Director

Center for Catastrophic Risk Management (CCRM)

University of California, Berkeley

# Q&A



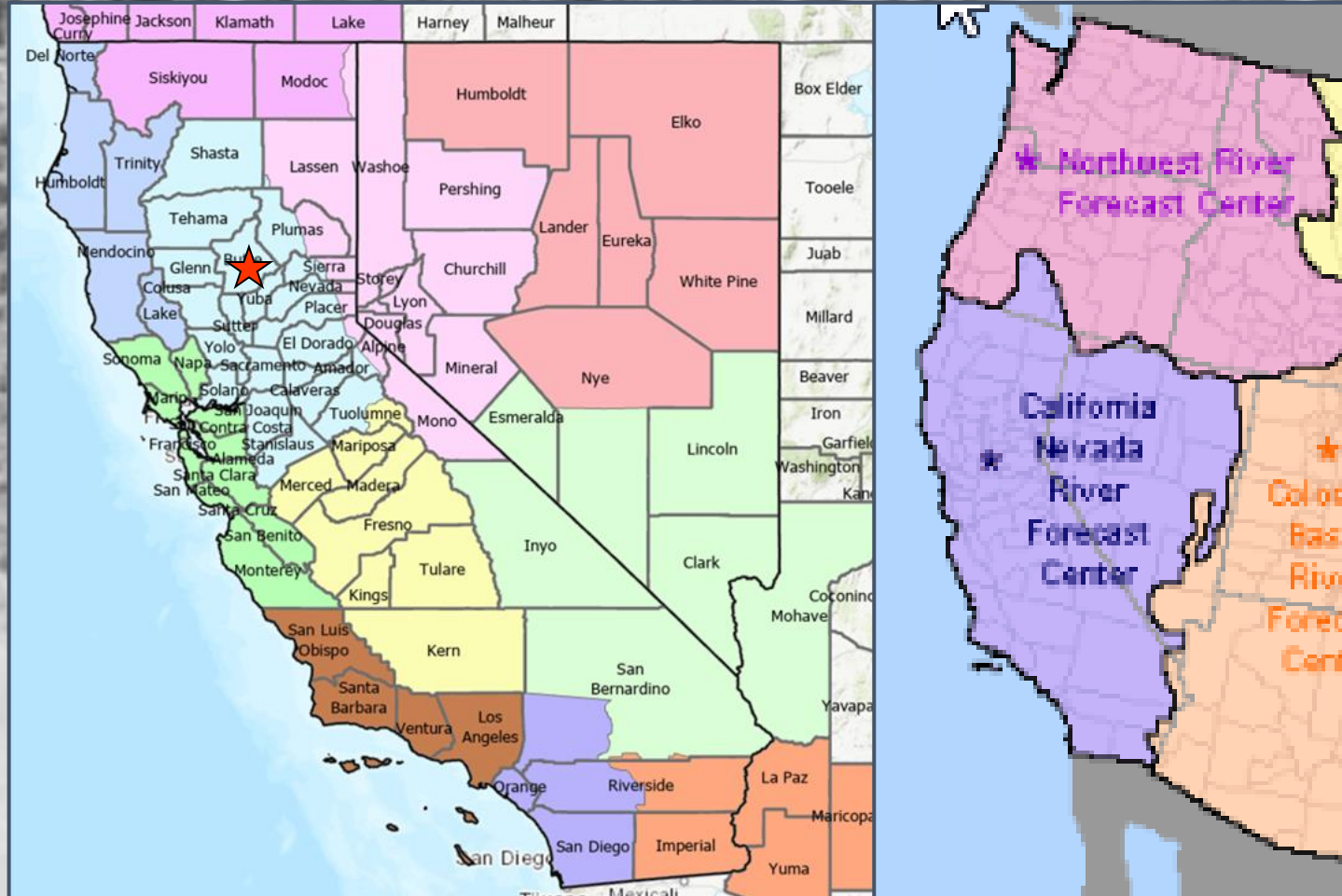
# NWS/CNRFC Forecasting and Notification

Weather Forecast Office  
Sacramento, CA

Friday, April 22

Presenter : Cindy Matthews

Senior Service Hydrologist



## 10 NWS Offices - (NWS Sacramento)

- Watch Warning Program
- Multiple Aspects of Weather
- EM Interface
- Public Interface
- 24 x 7

## CA-NV River Forecast Center

- Hydrologic expertise
- Mainstem Rivers
- Reservoirs
- Snowpack/water supply

*...the protection of life and property...*

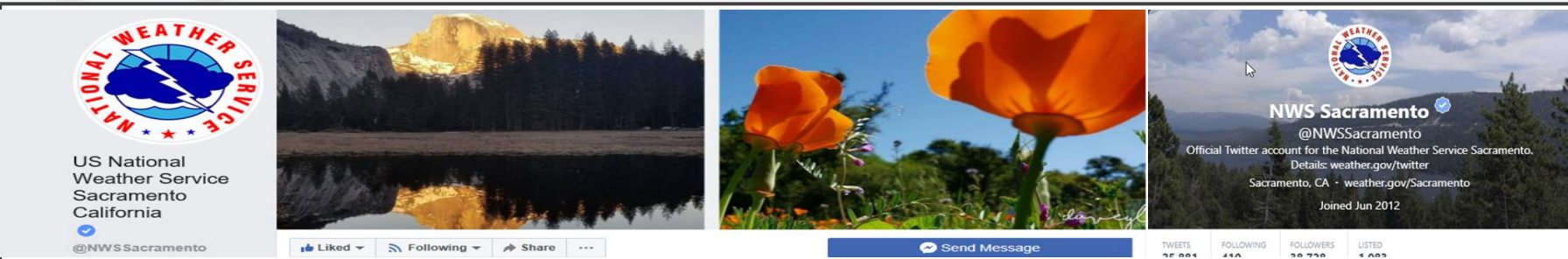


- **Partner Email** – 3-5 days out – approaching impactful weather
- **Watch** - Strong possibility of event to occur in next 12 - 48 hours. Occurrence, location, and /or timing is still uncertain
- **Warning** –Imminent or Occurring – Life threatening
  - Serious, Long or Short Duration Events
  - EAS and WEA messages
- **Advisory** – Non life threatening, significant weather events
  - May become life threatening if precautions are not taken
- **Statements** - Follow up/continuation products



# Distribution Services

Weather Forecast Office  
Sacramento, CA  
Friday, April 22



## Social Media

Facebook: [NWSSacramento](#)  
Twitter: [@NWSSacramento](#)

**NATIONAL WEATHER SERVICE**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME FORECAST PAST WEATHER SAFETY INFORMATION EDUCATION NEWS SEARCH ABOUT

Local forecast by "City, ST" or ZIP code  
Enter location:  Go

**News Headlines**  
• [Winter 2022 NorCal Climate Summary](#)

**NWS Forecast Office Sacramento, CA**  
Weather.gov > Sacramento, CA

Current Hazards Current Conditions Radar Forecasts Rivers and Lakes Climate and Past Weather Local Programs

Unsettled Late Week Tuesday Highs

**VALLEY AND FOOTHILLS**

- Widespread showers possible
- Uncertainty on timing and amounts

**NWS Sacramento**  
**RAIN AND SNOW MID TO LATE WEEK**  
Late Wednesday April 13 - Saturday April 16, 2022

**MOUNTAINS**

- Snow showers with several inches of snow possible
- Lighter snow possible Friday
- Snow levels 3500-5000 ft

EAS  
&  
WEA

**National Weather Service**  
National Oceanic and Atmospheric Administration

Weather Forecast Office  
Sacramento  
Friday, Oct 22, 2021

**Significant Rain and Snow this Weekend into Early Next Week**

**KEY POINTS**

- Periods of moderate to locally heavy rain could cause small stream and urban flooding
- Possible debris and ash flows on recently burned areas
- Breezy winds Sunday
- Winter Storm Watch in effect Sunday evening into Tuesday

**CHANGES FROM PREVIOUS BRIEFING**

- Winter Storm Watch issued for Sunday night into early Tuesday
- Flood Watch in effect from Late Saturday night through Sunday

**WEATHER RISK OUTLOOK**

Risk levels incorporate potential impacts from weather hazards and likelihood of occurrence.

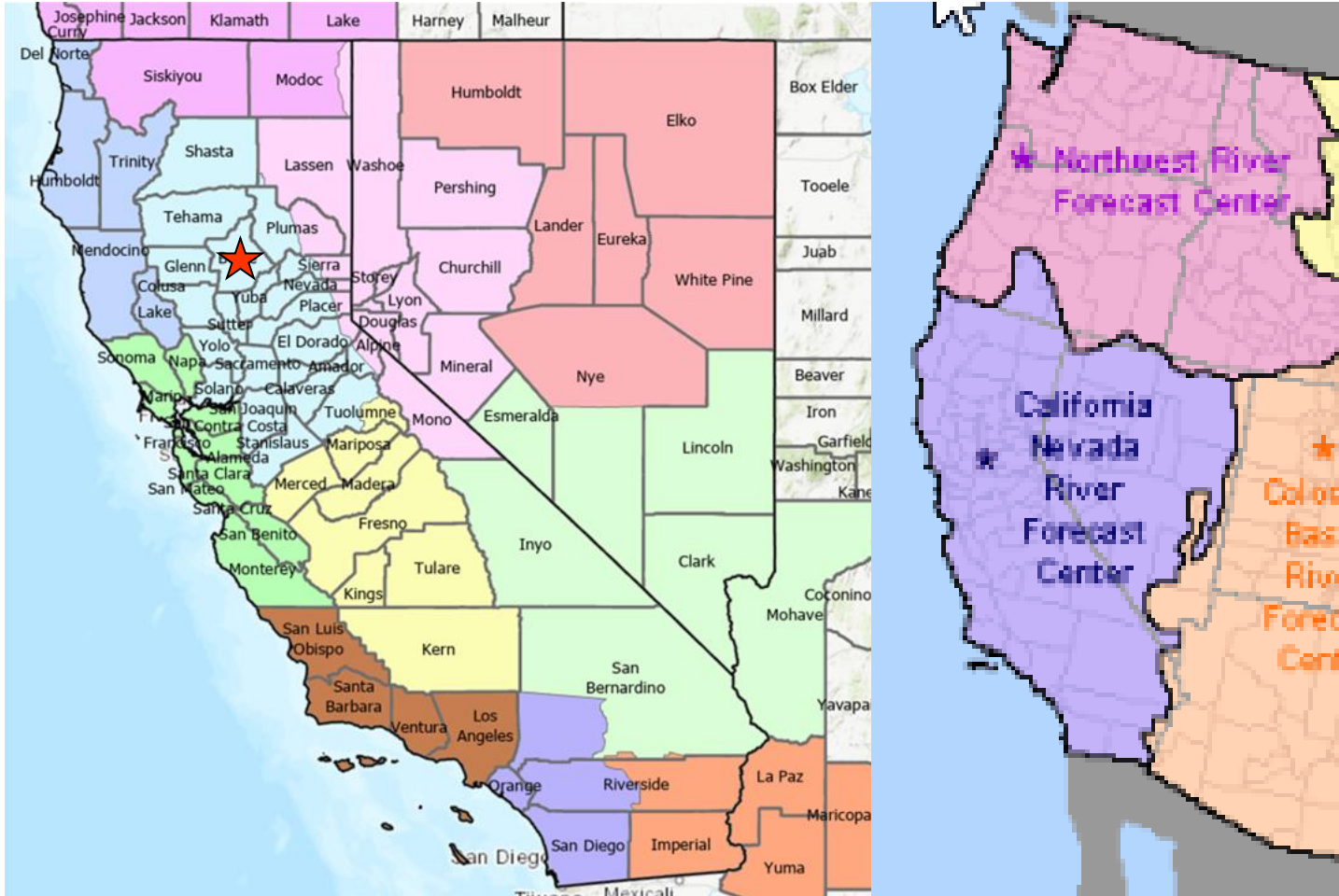
	Fri 10/22	Sat 10/23	Sun 10/24	Mon 10/25	Tue 10/26	Wed 10/27	Thu 10/28
<b>Valley</b>	Rain	Rain	Rain/Wind	Rain	Rain	Rain	
<b>Foothills</b>	Rain/Debris Flows	Rain	Rain/Wind/Debris Flows	Rain	Rain	Rain	
<b>Mountains</b>	Rain/Debris Flows	Rain	Rain/Wind/Debris Flows	Snow	Snow	Rain	

Webpage  
[weather.gov/sacramento](http://weather.gov/sacramento)

Partner Emails



# California NWS Offices - The CNRFC!



## 10 NWS Offices - (NWS Sacramento)

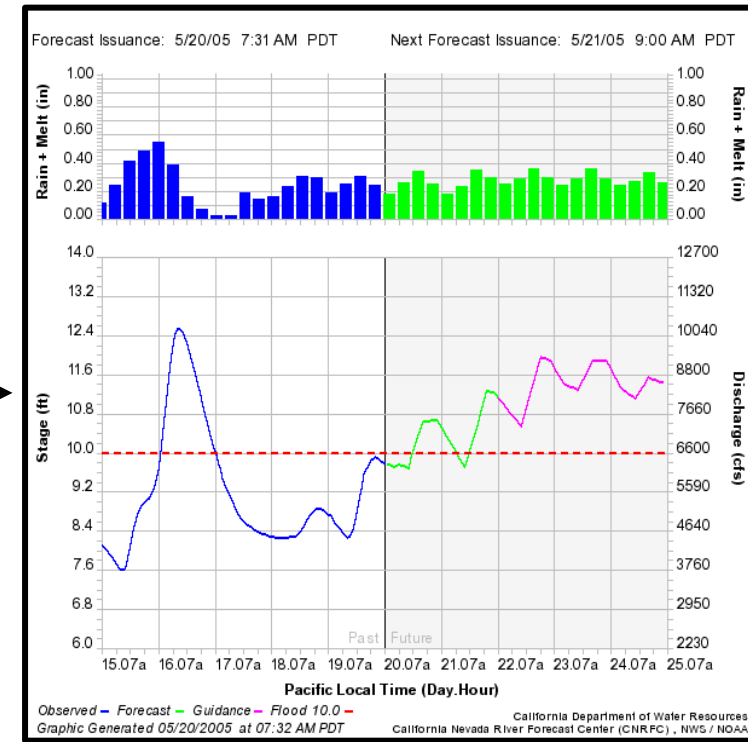
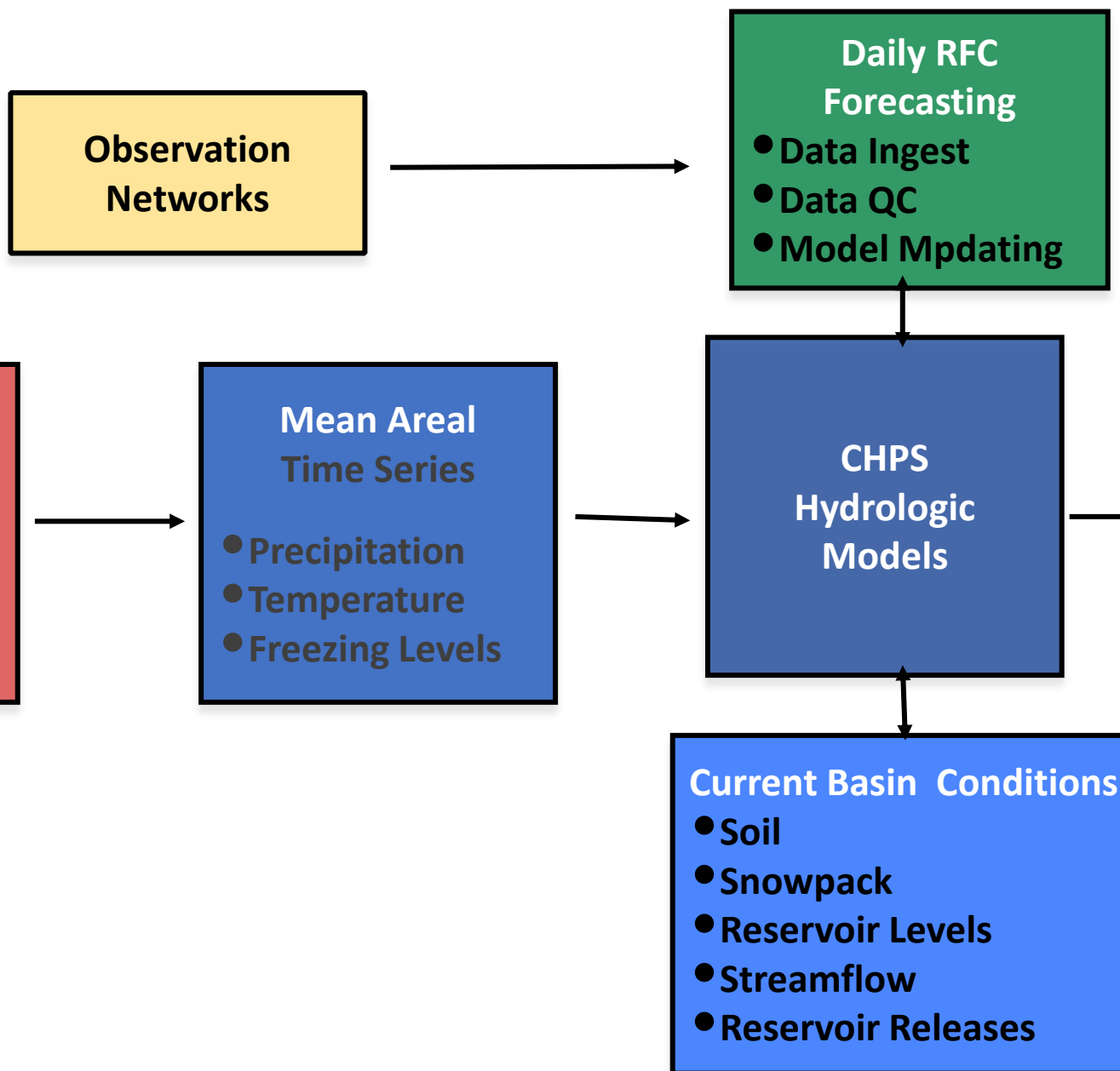
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- Multiple Aspects of Weather
- EM Interface
- Public Interface
- 24 x 7

## CA-NV River Forecast Center

- Hydrologic expertise
- Mainstem Rivers
- Reservoirs
- Snowpack/water supply

*...the protection of life and property...*







# River Forecast Distribution

Weather Forecast Office  
Sacramento, CA  
Friday, April 22

**NATIONAL WEATHER SERVICE**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME FORECAST PAST WEATHER SAFETY INFORMATION EDUCATION NEWS SEARCH

Local forecast by "City, St" or ZIP code  
Enter location ... Go  
[Location Help](#)

**NWS Forecast Office Sacramento, CA**  
Weather.gov > Sacramento, CA

Click a location below for detailed forecast.

Watches, Warnings & Advisories  
 Winter Weather Advisory  
 Small Craft Advisory  
 Special Weather Statement  
 Hazardous Weather Outlook

weather.gov/sacramento

**CALIFORNIA NEVADA RIVER FORECAST CENTER**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME HYDROLOGY WEATHER CLIMATE RESEARCH / OUTREACH LINKS SEARCH ABOUT US

Local forecast by "City, St" or ZIP Code  
Enter location ... Go  
[Location Help](#)

NOAA / NWS News and Local CNRFC Information  
 2022 Tide Tables Available - The 2022 tide tables are now available on our river forecast page.  
 CNRFC Daily Briefing - View a graphical summary of current & forecast weather & hydrologic conditions. Updated by 10 AM PT.

**NORMAL** All River Guidance (Flood Forecast) Points Are Currently and Forecast to Remain Below Critical Stages **NORMAL**

Recently-Issued CNRFC Text Products: Text Product Description ( ID ) Date/Time Issued to Web

Home Page Version: Interactive Map | Legacy  
 Download PNG Show Data Table Enlarge Map PERMALINK Map Search Go

Geographic CNRFC Boundary States Basins Counties Lakes WFOS  
 Rivers Nat'l Parks Burn Areas 2021 2020 2019 2018

**Rivers/Reservoirs**

**Deterministic Forecasts**  
 Show only critical stages (focst pts only)  
 Data updated: Tue Apr 12 2022 10:12 AM PDT  
 Forecast Points  Other Points

**Ensemble Forecasts**  
 Data updated: Tue Apr 12 2022 07:35 AM PDT  
 Ensemble Points

**Peak Exceedance Probabilities\***  
 Data updated: Tue Apr 12 2022 08:27 AM PDT  
 10% 25% 50% 75% 90%

5-Day Peak  
 10-Day Peak

\*Exceedance probabilities are only available for selected forecast points.

**Observed Data**  
 Data updated: Tue Apr 12 2022 09:58 AM PDT  
 Show only critical stages (applies to focst pts only)  
 Latest 1 Hr 2 Hrs 3 Hrs  
 Hour Ago Ago Ago

Forecast Points  
 Other Points  
 Reservoirs

**Deterministic Forecast + Observed Data**  
 Focst data updated: Tue Apr 12 2022 10:12 AM PDT  
 Obs data updated: Tue Apr 12 2022 09:58 AM PDT  
 Forecast Points Show only critical stages  
 Link to  observed  forecast  
 Latest Hour 1 Hr Ago 2 Hrs Ago 3 Hrs Ago

**Significant River Flood Outlook**  
 Data updated: Mon Apr 11 2022 11:00 AM PDT  
 Valid: 04/11/2022 - 04/16/2022  
 Latest Flood Outlook Product (updated daily)  
[National Significant River Flood Outlook](#)

Water Resources  
 Snow Data

Legend:  
 No Monitor or Flood Stage Available  
 100 Normal Conditions  
 Above Monitor Stage  
 Above Flood Stage  
 Above Danger Stage

The number inside each circle above represents the number of gages with forecast conditions inside that category.

CNRFC.noaa.gov

**CA.GOV** Department of Water Resources  
CALIFORNIA DATA EXCHANGE CENTER

HOME QUERY TOOLS PRECIPITATION RIVER FORECAST RIVER STAGES RESERVOIRS SNOW STATIONS WEATHER

River Forecast

California Data Exchange Center - River Forecast

**RIVER FORECAST BULLETINS**

- Delta Tide Forecast Bulletin
- Upper Sacramento River System
- Lower Sacramento River System
- San Joaquin River System
- North Coast River System
- Russian/Napa River System
- Central Coast River System
- Southern California River System

**RIVER FORECAST GUIDANCE**

- River Stage Guidance Plots
- NWS California-Nevada River Forecast Center
- River Guidance Points Forecast Specified Stage Definitions

**TIDE FORECASTS**

- Sacramento River Tide Table: Latest Yr 2022 (PDF: 341KB) | Previous **UPDATED**
- San Joaquin River Tide Table: Latest Yr 2022 (PDF: ...)

MOST POPULAR PAGES  
 RELATED PAGES

SAVE OUR WATER  
 STAY CONNECTED

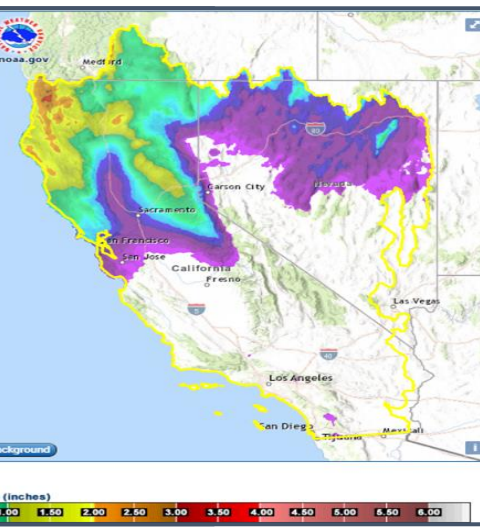
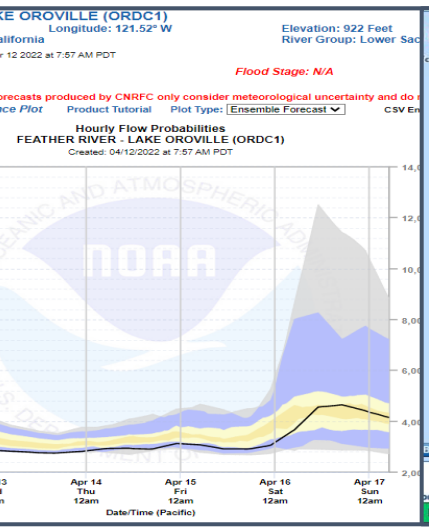
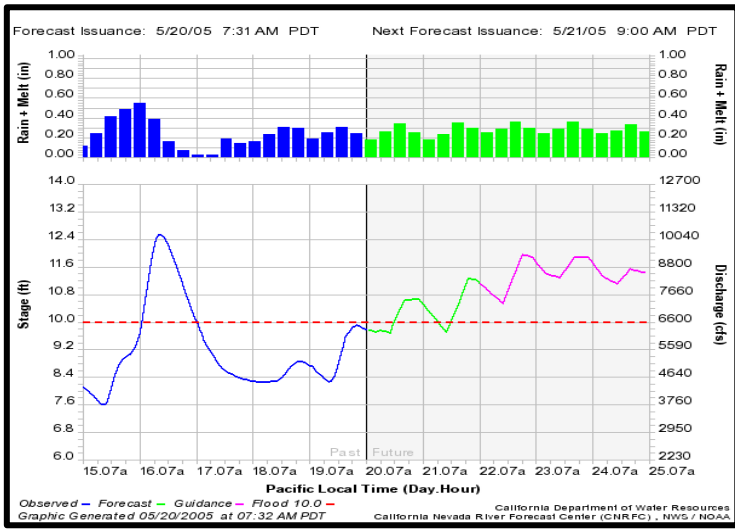
DEPARTMENT OF WATER RESOURCES  
 STATE OF CALIFORNIA

cdec.water.ca.gov

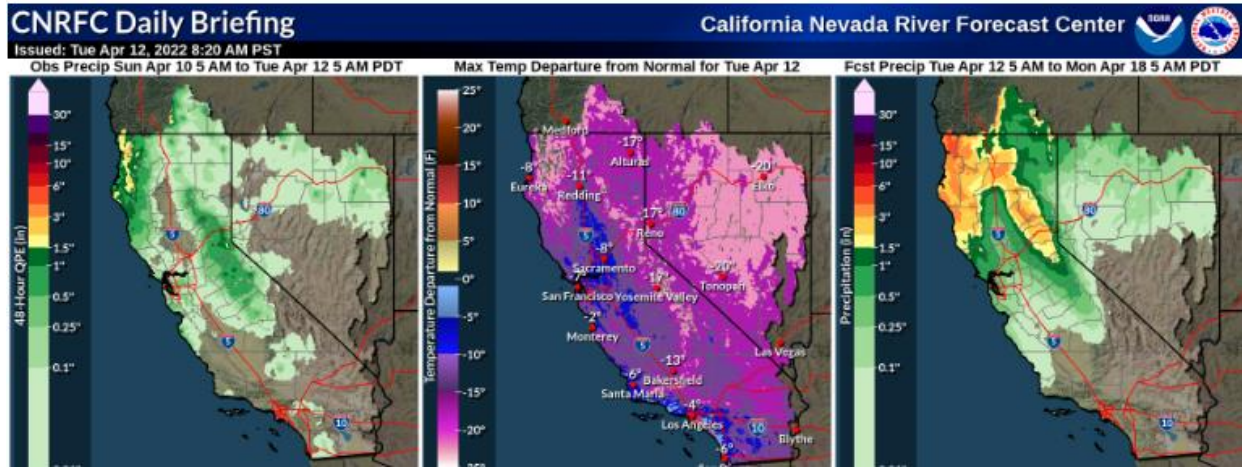


PERMALINK

- ▶ Rivers/Reservoirs
- ▶ Water Resources
- ▶ Snow Data
- ▶ Observed Precipitation (QPE)
- ▶ Forecast Precipitation (QPF)
- ▶ Observed Temperatures
- ▶ Forecast Temperatures
- ▶ Freezing Levels
- ▶ Flash Flood Guidance/Debris Flow
- ▶ Water Temperatures
- ▶ Climate/Drought
- ▶ QPF Verification
- ▶ Watches/Warnings/Advisories




[CNRFC Daily Briefing](#)  
Last issued: Tue Apr 12, 2022 at 08:21 AM PST (updated daily by 10 AM Pacific Time).  
Click image for full-resolution version.



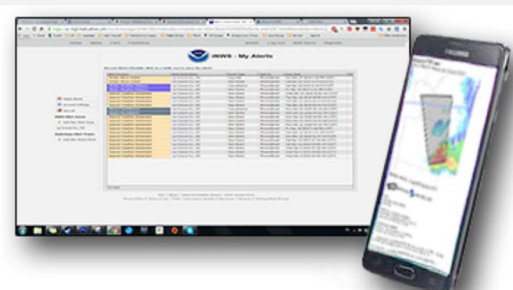
**NEW!!! CNRFC Daily Briefing**

- Emergency Management Contacts
  - Hourly / Daily / Weekly
- Phone, CalWAS, text, video, etc
- iNWS
- CalOES SOC
- County EOC Deployments
- State and Local briefings
- 24x7 NWS Operations access
  - Response
  - Recovery
  - Mitigation
  - Preparedness





**iNWS - Interactive NWS**  
National Weather Service Mobile Decision Support Services (MDSS)

**iNWS MOBILE ALERTING**  
Receive customized text message and e-mail alerts for National Weather Service products that you care about.



**Welcome**  
InteractiveNWS (iNWS) is the home of...  
Service. This application suite allows...  
new and innovative ways, such as...  
our mission of protecting life and pro...

**Significant Storm with Potential for Flooding & Heavy Snow**  
October 23-26, 2021  
Video Briefing

**National Weather Service**  
Sacramento, California  
October 22, 2021



# Questions?

Weather Forecast Office  
Sacramento, CA  
Friday, April 22

If you have questions please contact:

NWS SACRAMENTO

[cindy.matthews@noaa.gov](mailto:cindy.matthews@noaa.gov)

916-979-3064



nws.sacramento@noaa.gov



(916) 979-3045



weather.gov/sacramento



# Q&A

# 5 Minute Break

# State-Federal Flood Operations Center

*Oroville Dam Citizens Advisory Commission  
Technical Workshop*





# FOC Responds to...

High water / flooding

Large and/or intense storms

Earthquakes / tsunamis

Dam incidents

## FOC's Role

---

Coordinate DWR's response to flooding statewide



# FOC Coordination

## *Provides:*

- Situational awareness
- Technical and direct assistance
- Conduit for federal assistance under Public Law 84-99

## *Does NOT:*

- Declare emergencies
- Order evacuations
- Repair levees



# Situational Awareness

Provide year-round daily forecasts of

- Reservoir inflows
- River flows and water levels
- For CA and parts of OR & NV

Users

- Flood Operations Center
- Cooperating Agencies
- State and County Offices of Emergency Services
- Public and media

**CALIFORNIA NEVADA RIVER FORECAST CENTER**  
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME HYDROLOGY WEATHER CLIMATE RESEARCH / OUTREACH LINKS SEARCH ABOUT US

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Recently-Issued CNRFC Text Products:  ( ID ) Date/Time Issued to Web

Home Page Version: Interactive Map | Legacy [Download PNG](#) [Show Data Table](#) [Enlarge Map](#) [PERMLINK](#)  Map Search

**Geographic Overlays**  
 CNRFC Boundary  States  Counties  Lakes  Rivers  
 Drainage Basins  National Parks  Burn Areas 2020 2019 2018

Markers: 100

**Rivers/Reservoirs**

**Deterministic Forecasts**  
Show only critical stages (focst pts only)   
Data updated: Wed Aug 11 2021 08:31 AM PDT  
 Forecast Points  Other Points

**Ensemble Forecasts**  
Data updated: Wed Aug 11 2021 07:01 AM PDT  
 Ensemble Points

**Peak Exceedance Probabilities\***  
Data updated: Wed Aug 11 2021 08:03 AM PDT  
10% 25% 50% 75% 90%  
5-Day Peak       
10-Day Peak       
\*Exceedance probabilities are only available for selected forecast points.

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Data updated: Wed Aug 11 2021 08:26 AM PDT  
Show only critical stages (applies to focst pts only)   
Forecast Points      
Other Points      
Reservoirs

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Valid: 08/10/2021 - 08/15/2021  
 Latest Flood Outlook Product (updated daily)  
[National Significant River Flood Outlook](#)

**Water Resources**  
**Snow Data**  
**Observed Precipitation (QPE)**

**Change Map Background**

No Monitor or Flood Stage Available  100 Normal Conditions  0 Above Monitor Stage  0 Above Flood Stage  0 Above Danger Stage

The number inside each circle above represents the number of gages with forecast conditions inside that category.



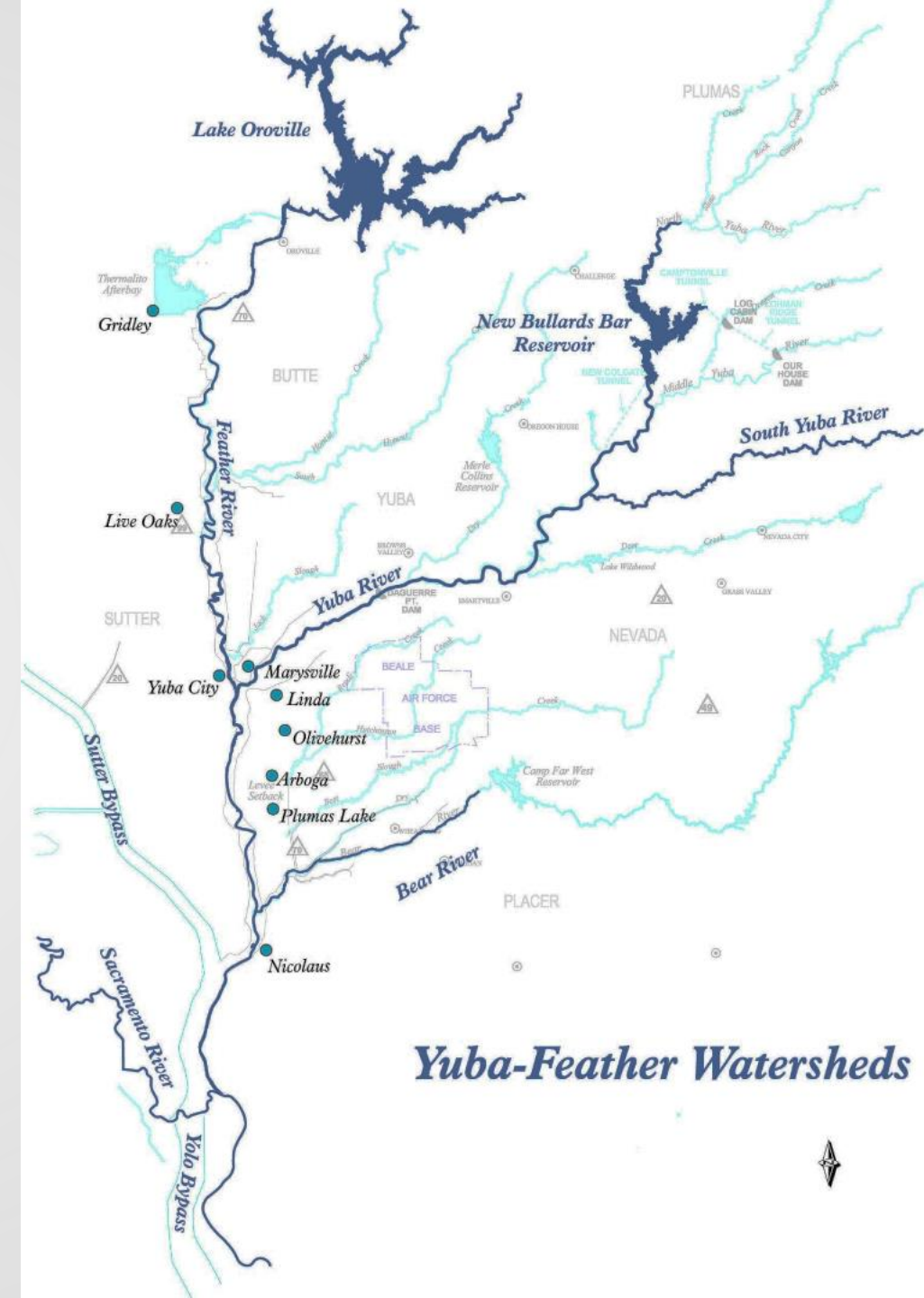
CALIFORNIA DEPARTMENT OF  
WATER RESOURCES

# High Water Notifications

Based on river forecasts  
Notifications and updates provided to  
downstream agencies potentially impacted  
by high river flows and stages

Local, city, county, state & federal partners

These are *not* evacuation orders



# FOC's Relationship to Oroville Dam

Notifications and updates provided to downstream agencies potentially impacted by high flows or failure scenario

LMAs, cities, counties, state & federal partners

Built-in redundancy

These are *not* evacuation orders

Participate in annual meetings and exercises



# Contact Information

---

## FLOOD OPERATIONS CENTER

 (916) 574-2619       [flood\\_center@water.ca.gov](mailto:flood_center@water.ca.gov)

## Resources

---

California Data Exchange Center (CDEC)

<http://cdec.water.ca.gov>

CA-NV River Forecast Center (CNRFC)

<http://www.cnrfc.noaa.gov/>

# Q&A



**Cal OES**  
GOVERNOR'S OFFICE  
OF EMERGENCY SERVICES

# Dam Safety Planning Division

**Emergency Action Plans**





# Water Code Sections 6160 and 6161

---

- Owners of state-regulated, jurisdictional dams must submit an Emergency Action Plan (EAP) to Cal OES and DWR if classified as EH, H, or S
- EAP must include a DWR-approved inundation map
- Includes deadlines for submissions
- Cal OES review timelines are given
- Owners must update the EAP, including the map, at a minimum every 10 years



# Government Code Section 8589.5

- EAP must be developed in consultation with local public safety agencies
- EAP must adhere to FEMA's Guidelines
  - 6 Elements of an EAP

**Emergency Notification Flowcharts**

**Responsibilities**

**Preparedness Activities**

**Inundation Maps**

**Response Process**

**Additional Info in Appendices**

- Dam owner must conduct an EAP notification exercise with local public safety agencies once a year



# Emergency Action Plans

---

## What is an EAP?

- Identifies potential emergency conditions at a dam
- Specifies actions to be followed to minimize property damage or loss of life
- Based on approved inundation maps, which show critical areas of evacuation in case of a dam emergency



# Dam Owner Outreach to Public Safety Agencies

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## Who

- Those impacted by dam incident
  - Local: law enforcement, fire, OES,
  - State/Fed: NWS, DWR (DSOD, FOC), Cal OES

## How

- Meetings, phone calls, etc.

## When

- Earlier is better
- Have something to show those groups



# Incorporating Outreach into Plan

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## Methods to Meet Statutory Requirement:

- Signature Page
- Narrative explaining which agencies were consulted during development of the plan and what the contributions were
- Agenda, sign-in roster, and minutes from EAP development meeting(s)
- Include the agencies' roles within the EAP



# Notification Flowcharts

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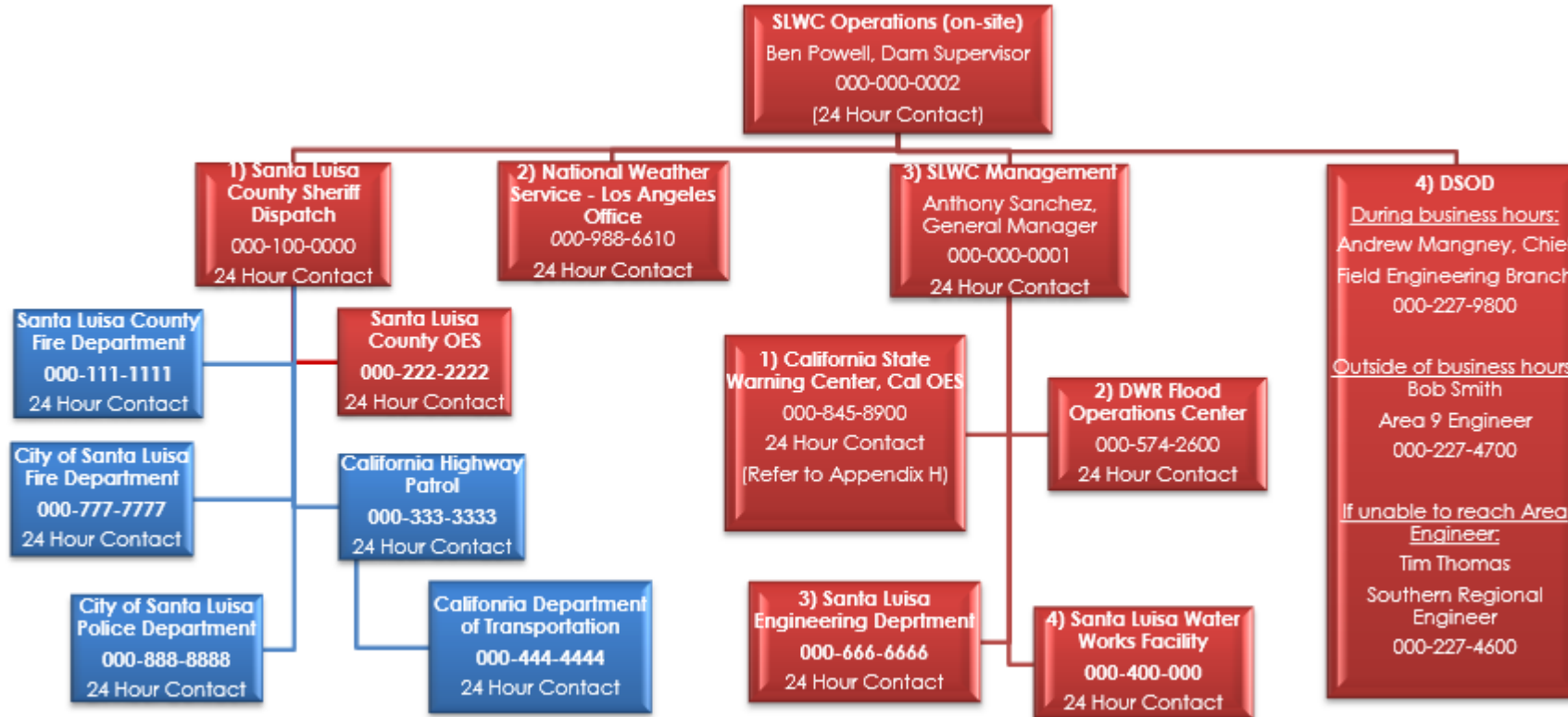
## Flowcharts

- Identifies who is to be notified of a dam safety incident, by whom, and in what order
- One chart or a set of charts may be needed depending on the complexity on the hazards associated with the dam and affected downstream areas
- Should include emergency level, individuals who will conduct notifications, prioritization of notifications, individuals who will be notified



# Notification Flowcharts

**Notification Flowchart for High Flow, Non-Failure, Potential and Imminent Failure**





# Questions?

**Casey Meredith**  
**Dam Safety Planning**  
**Cal OES**



# Q&A

# Making Investments to “Buy Down” Flood Risk

Oroville Citizens Advisory Commission  
Flood Management Stakeholder Workshop  
April 22, 2022



Michael Mierzwa, P.E., State Floodplain Manager  
CA Dept. of Water Resources, Division of Flood Management



CALIFORNIA DEPARTMENT OF  
WATER RESOURCES

# Outline of Today's Topics

- “Buying Down Risk Concept”
- Central Valley Flood Protection Plan (CVFPP) Overview
- Using the CVFPP to Guide Future Investment Need
- Example of a Risk Assessment from the CVFPP



# “Buying Down” Risk



Many of today’s other presentations have focused on understanding flood risk through better understanding of flood hazards, mapping, inspections, forecasting, and sharing information.



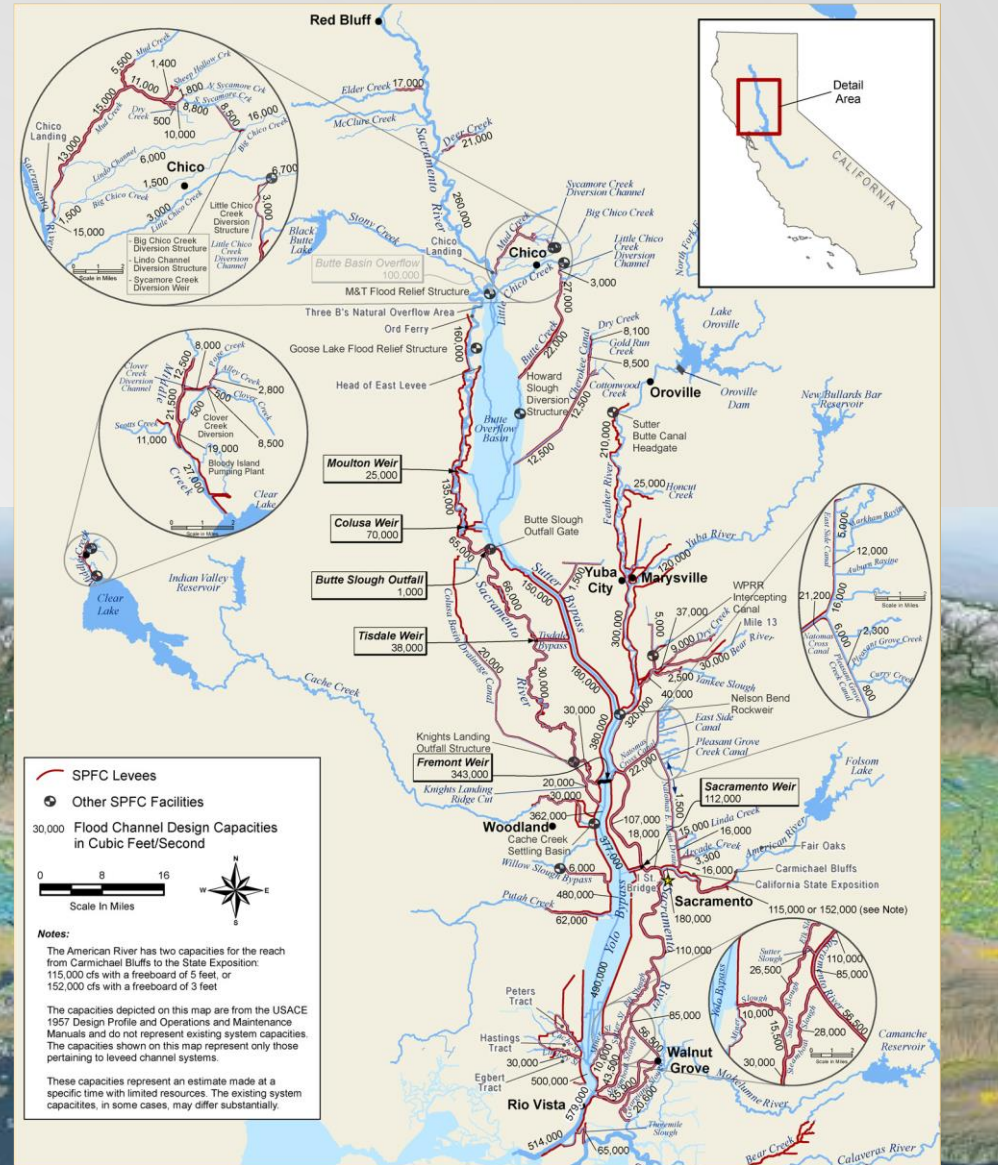
OCAC has previously featured presentations on reservoir storage operations.



# Central Valley Flood Protection Plan


## Key Features (as of 2017):

- Land area size of State of Florida
- Highest net agricultural production region in United States
- 1,600 miles of Federal-State levees
- Extensive system of bypasses & floodways
- 2 completely different river basins, each w/ over 5 major rivers
- Over 1.3 million people living in floodplains
- +\$80B property / assets at risk




# Recommended 2017 CVFPP Update Investment

**C V F P P** **\$17 to 21 billion** Investment over 30 years

 **ONGOING INVESTMENTS** \$M/Y

Annual funding for routine activities:  
**\$250–310 M/year**

+

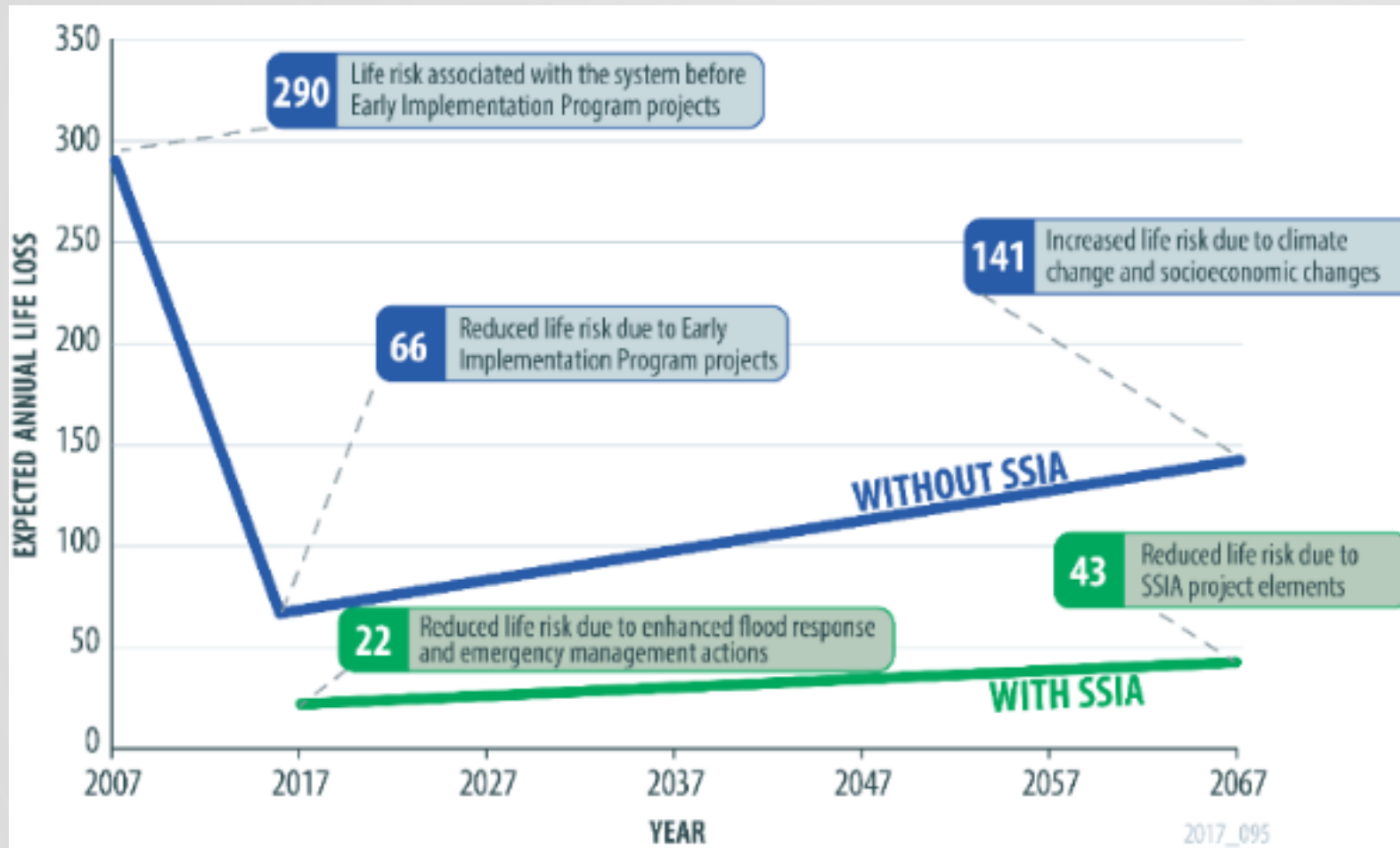
 **CAPITAL INVESTMENTS** \$\$\$

One-time funding for construction or improvements:  
**\$12–16.2 B**

ISTM\_047



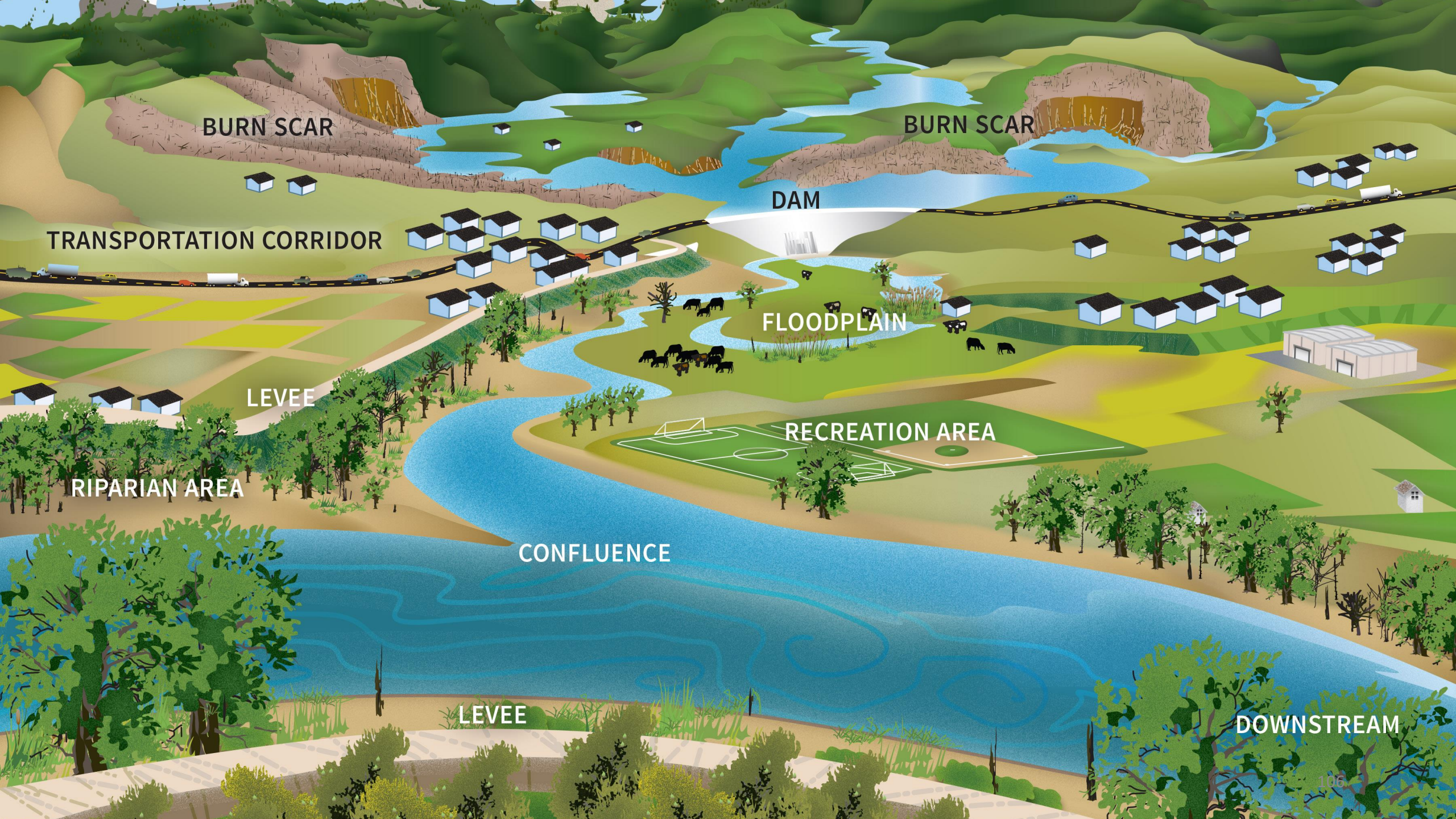
# Example of a Risk Assessment



# Q&A



# Public Comment



BURN SCAR

BURN SCAR

DAM

TRANSPORTATION CORRIDOR

FLOODPLAIN

LEVEE

RECREATION AREA

RIPARIAN AREA

CONFLUENCE

LEVEE

DOWNSTREAM

Thank You