Bureau of Reclamation
Mid-Pacific Region

California Department
of Water Resources

Upper San Joaquin River Basin Storage Investigation

Workshop 5

April 30, 2003

Workshop Purpose and Objectives

- Review comments on Draft Phase 1 In-Progress Report
- Provide status of technical studies
- Discuss alternatives development and evaluation

Workshop 5

Agenda

Welcome and Introductions

Investigation Overview

Conjunctive Use & Groundwater Storage

Surface Storage Options Screening

Alternatives Formulation and Feasibility Study Workplan

Next Steps

Participation Principles

- Participate – Attend the workshops
- Learn – Learn about resources, people, roles, and process
- Represent – Bring issues and interests forward from others whose interests you share
- Cooperate – Work with others in the workshops to share information and consider options
- Educate – Report back to others who share your interests

Workshop Ground Rules

- **Commit to being fully present**
  - No cell phones, pagers, voicemail, etc.
  - Ask for what you need from the meeting process and participants
- **Honor our time limits**
  - Keep comments and discussion concise
  - Stay focused on the topic – Use the parking lot for other issues
- **Respect each other**
  - Listen carefully to other participants
  - Respond to ideas and issues, not individuals
- **Support constructive discussion**
  - Suggest improvements and solutions
  - Build on others' ideas – Use "and" instead of "but"

Workshop 5

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Next Steps

Investigation Scope & Goals

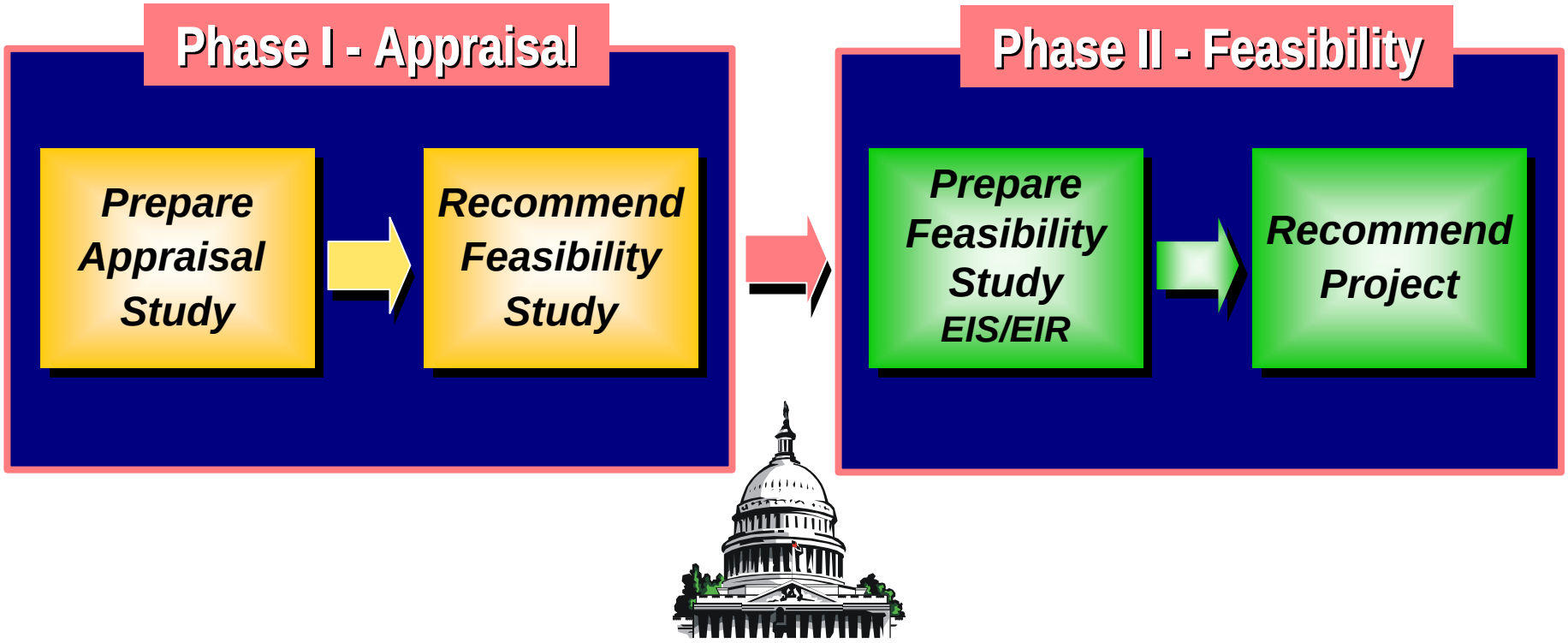
- **CALFED Goals for Upper San Joaquin River Basin Storage**
  - Contribute to restoration of San Joaquin River
  - Improve water quality in San Joaquin River
  - Facilitate conjunctive water management and water exchanges

- **CALFED Scope for Upper San Joaquin River Basin Storage**
  - An additional 250 - 750 TAF of storage in the upper San Joaquin River watershed through enlargement of Millerton Lake at Friant Dam or a functionally equivalent storage program

STUDY AREA

- **Upper San Joaquin River Basin**
  - Headwaters to the Merced River
- **Eastern San Joaquin Valley**
  - CVP Friant Division
  - Groundwater basin

Traditional Plan Development Approach



Objectives for Phase 1 Appraisal Study

- **Scope of investigation**
  - Problems and opportunities
  - Planning approach
- **Range of initial storage options**
  - Screen options and estimate costs
  - Describe potential project accomplishments
  - Define project objectives
- **Begin formulating alternatives**
- **Define scope of Feasibility Study**

Water Resources Problems and Opportunities

- **Problems**
  - San Joaquin river ecosystem
  - San Joaquin River water quality
  - Groundwater overdraft
  - Urban water quality

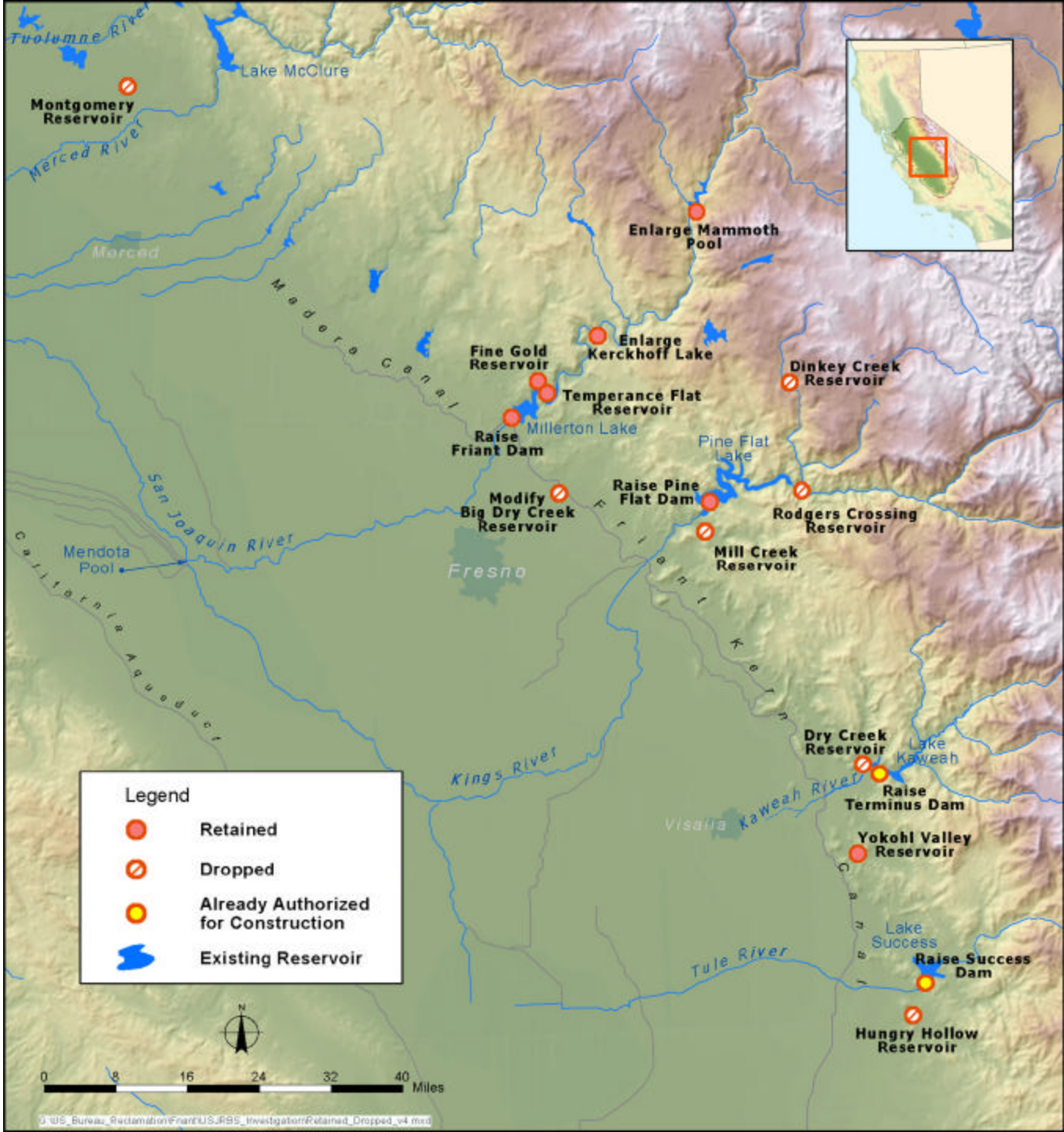
- **Opportunities**
  - Flood control
  - Hydropower
  - Recreation
  - Delta inflows

Planning Approach for Phase 1 Appraisal Study

Surface Storage Options

Initial Screening Results

- 16 sites identified
- 2 sites already authorized for construction
- 7 sites dropped
- 7 sites retained



Review and Comment Process

- **Review Process**
  - **Draft materials from team to participants**
  - **Workshop discussion and document review at key milestones**
    - Problems and Opportunities – Workshop #2
    - Surface Storage Options Screening – Workshop #3
    - In-Progress Phase 1 Report – Workshop #4
    - Alternatives Development – Currently
    - Draft Phase 1 Report -- Mid-2003
- **Roles**
  - **Participants provide oral and written comments to team**
  - **Team incorporates comments or provides rationale for alternate approach, strategy, or conclusion**

Phase 1 Information Available To Date

- **Workshop Summaries & Handouts**
- **Surface Storage Technical Memoranda**
- **Draft In-Progress Phase 1 Report**

- **All documents available on project website**

www.mp.usbr.gov/sccao/storage/index.html

Types of Comments on Phase 1 Report

- **Range of Phase 1 Issues**
  - Study process
  - Conjunctive use
  - Surface storage projects
- **Many Comments Related to a Feasibility Study**
  - Operational assumptions for baseline and alternatives
  - Incremental alternative development
  - Cost and benefit calculations
  - Quantified objectives and evaluation criteria

Comments on Study Process

- Consideration of water supply reliability
- Ecosystem restoration objectives
- Other project objectives

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Conjunctive Use & Groundwater Storage

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Next Steps

Comments Regarding Conjunctive Management and Groundwater Storage

- Overdraft conditions present an opportunity for groundwater storage
- Approach for integration of conjunctive management into Investigation is not clear
- Conjunctive management and groundwater storage should be considered for alternatives

Integration of Conjunctive Management to Upper San Joaquin River Basin Storage Investigation

- **Identify opportunities and specific projects**
  - Similar to CALFED ISI Conjunctive Management Program
- **Screen specific projects**
  - Similar to approach used to screen surface storage projects
- **Include specific projects in Investigation**

ISI Conjunctive Management Program

- **Goals**
  - Help local agencies improve regional water supply reliability by increasing the coordinated use of surface water and groundwater

- **Principles for project development**
  - Local planning and control
  - Voluntary implementation
  - Priority for in-basin water needs
  - Compensation for out-of-basin transfers
  - Basin-wide planning and monitoring

ISI Conjunctive Management Program

MOU
Between DWR and Local Entity

Phase I
Basin Assessment

- Guided by local advisory panel
- Establish basin objectives

Phase II
Project ID and Evaluation

- Project-specific feasibility study and environmental documentation
- Basin-wide modeling

Phase III
Project Implementation

- Local approval of feasible projects
- Subject to funding availability

Storage Investigation Conjunctive Use Approach

Step 1 Theoretical Opportunities

- Not project specific
- Based on available water supply
- Shows potential range

Step 2 Identify Specific Projects

- Consistent with CALFED Principles
- Similar to Identification component of ISI Phase II

Step 3 Evaluate Specific Projects

- Screen for inclusion in alternatives
- Similar to Evaluation component of ISI Phase II

Step 1
Theoretical Opportunities

Step 2
Identify Specific Projects

Step 3
Evaluate Specific Projects

- **Identify available flood flows**
  - Post-Process CALSIM output
- **Determine range of recharge capacity**
  - Apply series of “screens” that constrain opportunities
- **Apply to Benchmark and alternatives**
  - Indicate how additional surface storage could facilitate additional conjunctive use

Step 1
Theoretical Opportunities

Step 2
Identify Specific Projects

Step 3
Evaluate Specific Projects

- **CALFED Common Assumptions Inventory**
  - Grant applications for studies and projects
  - Previous project studies
  - WEF Survey

- **Coordination with stakeholders**
  - FWUA and member water districts
  - ISI Conjunctive Water Management Program

Step 1
Theoretical Opportunities

Step 2
Identify Specific Projects

Step 3
Evaluate Specific Projects

- Local project proponent
- Source and quantity of water
- Facilities and lands
- Operational assumptions and constraints
- Institutional and implementation issues
- Water developed at Friant Dam

Potential Findings from Project Evaluations

- **Projects that are fully defined**
  - Add to list of storage options
  - Add to Without-Project Condition
  - Do not include in Investigation

- **Projects that are not fully defined**
  - Continue to monitor project development
  - Coordinate with ISI Conjunctive Management Program
  - Reconsider for alternatives when better defined

CALSIM Baseline Simulation
Theoretical Groundwater Storage

- Total flood flows available
- Range of groundwater recharge capacity
- Recharge reduction based on basin wetness
- Hypothetical reoperation to pre-deliver water

Today

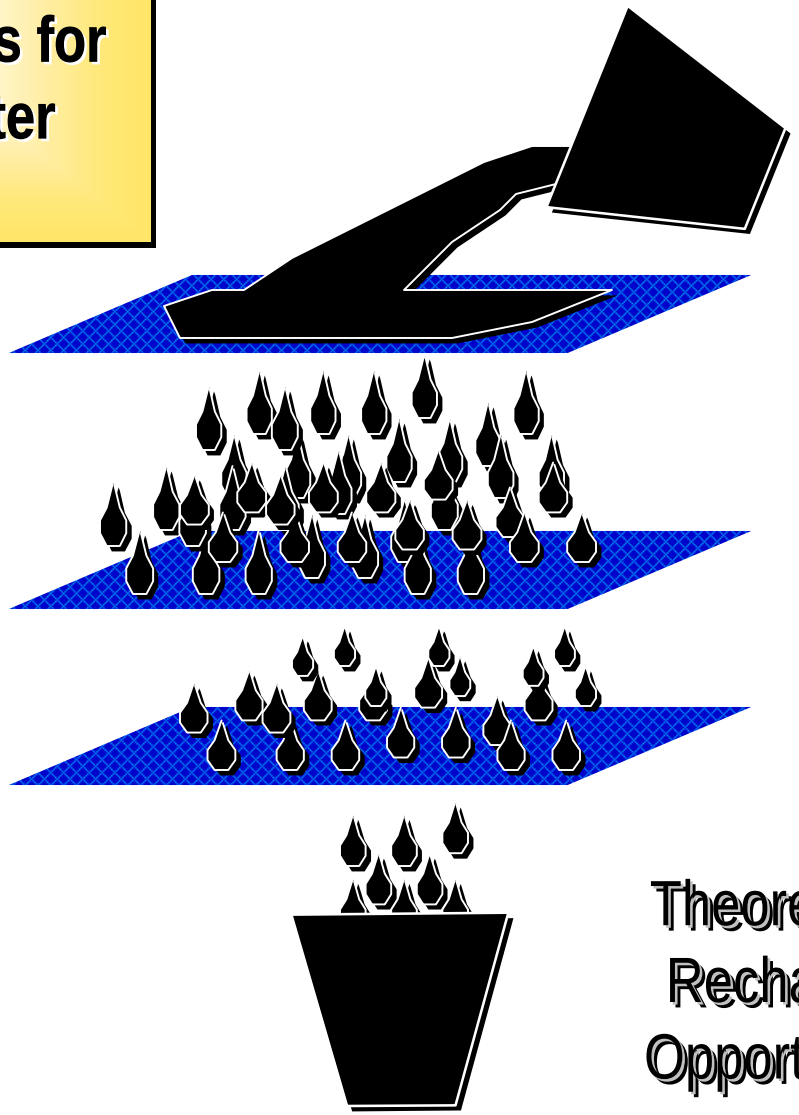
Theoretical Groundwater Recharge Opportunity

- Potential specific projects to recharge groundwater
- Potential recovery of stored water

Future

Groundwater Storage Options for Evaluation

Step 1 Theoretical Opportunities for Groundwater Storage



Flood Flows

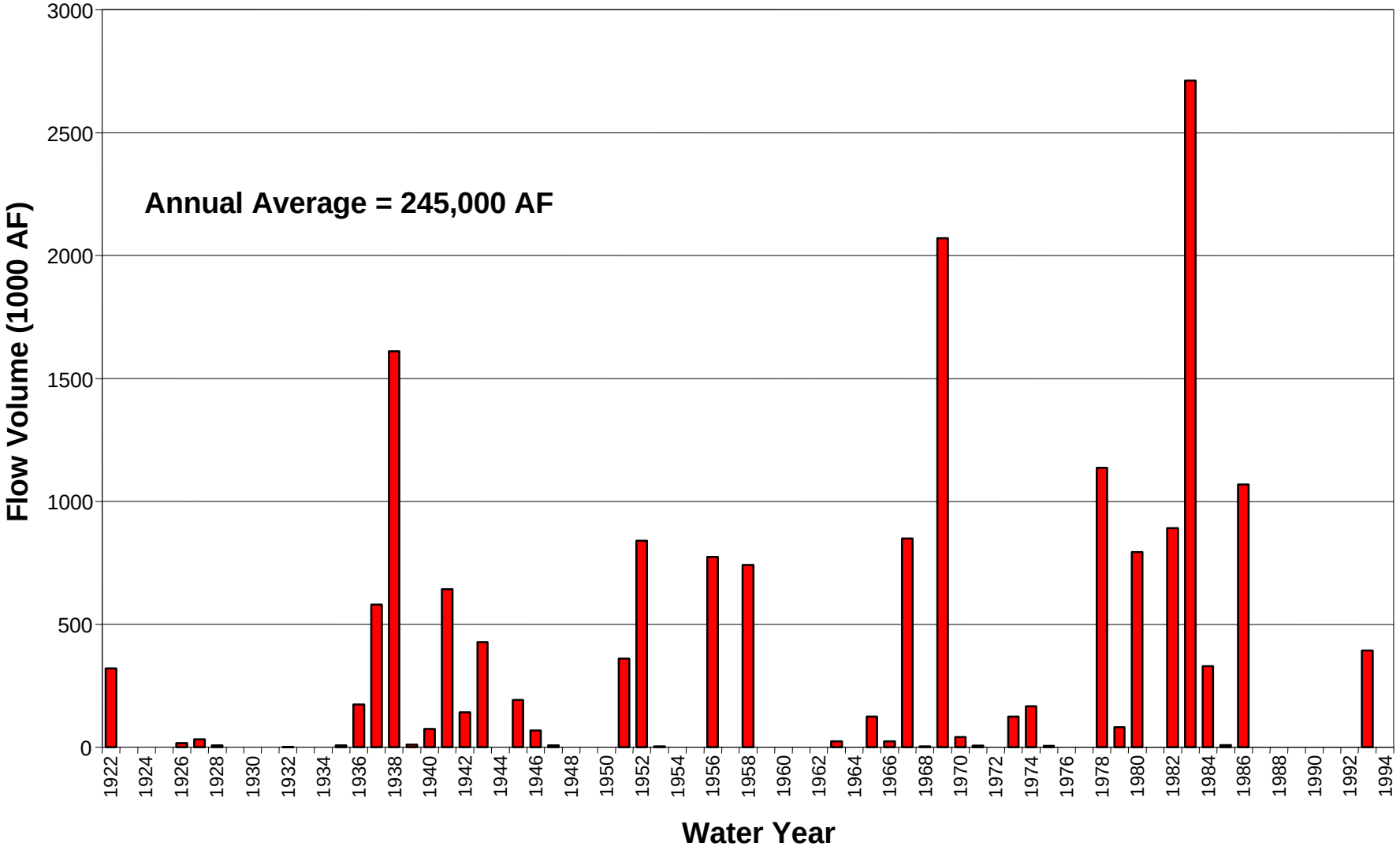
Conveyance Capacity

Recharge Capacity

Basin Wetness Index

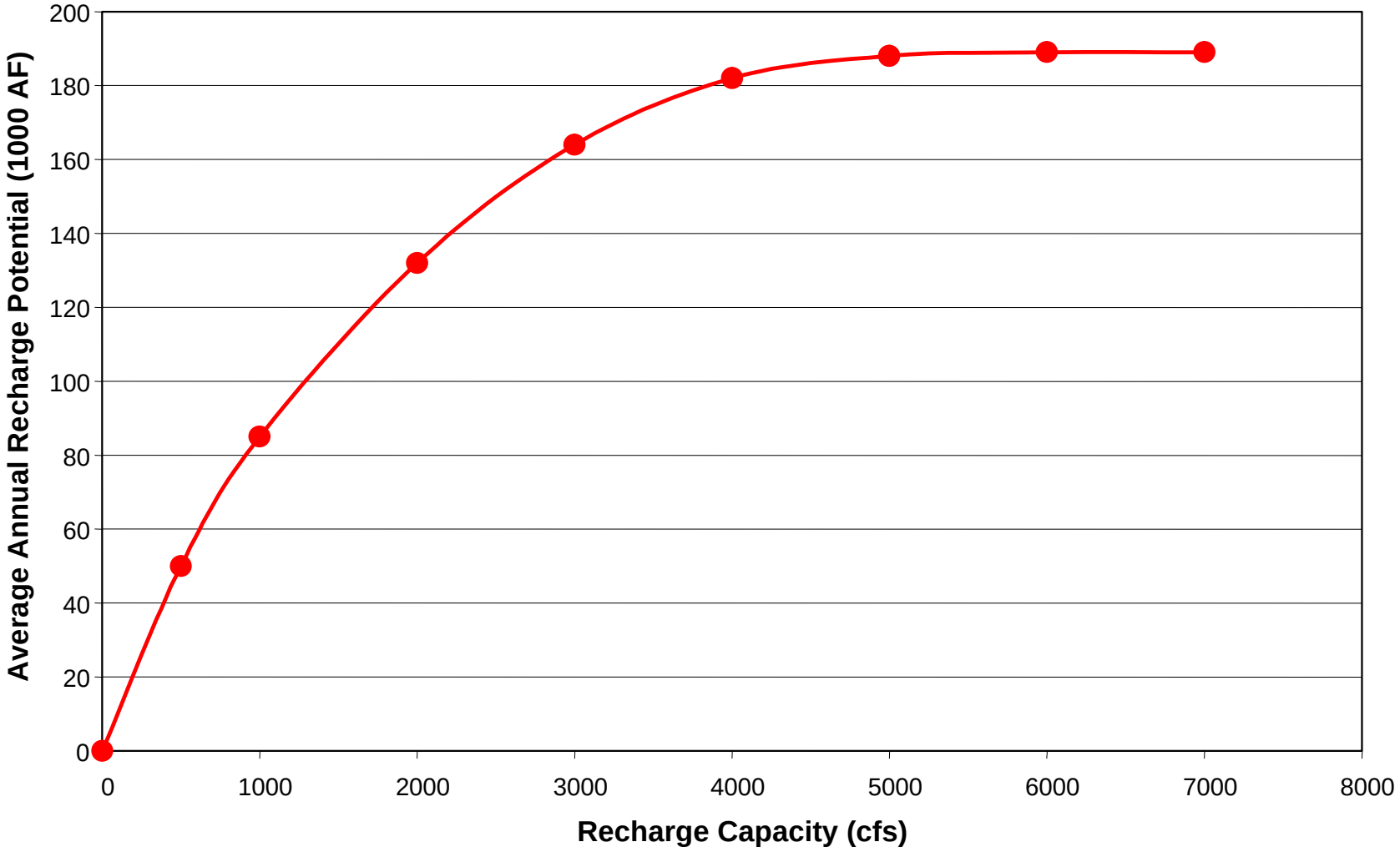
Theoretical Recharge Opportunity

Flood Flows Released from Friant Dam



Additional Groundwater Recharge Potential

Based on Available Flow and Potential Available Recharge Capacity

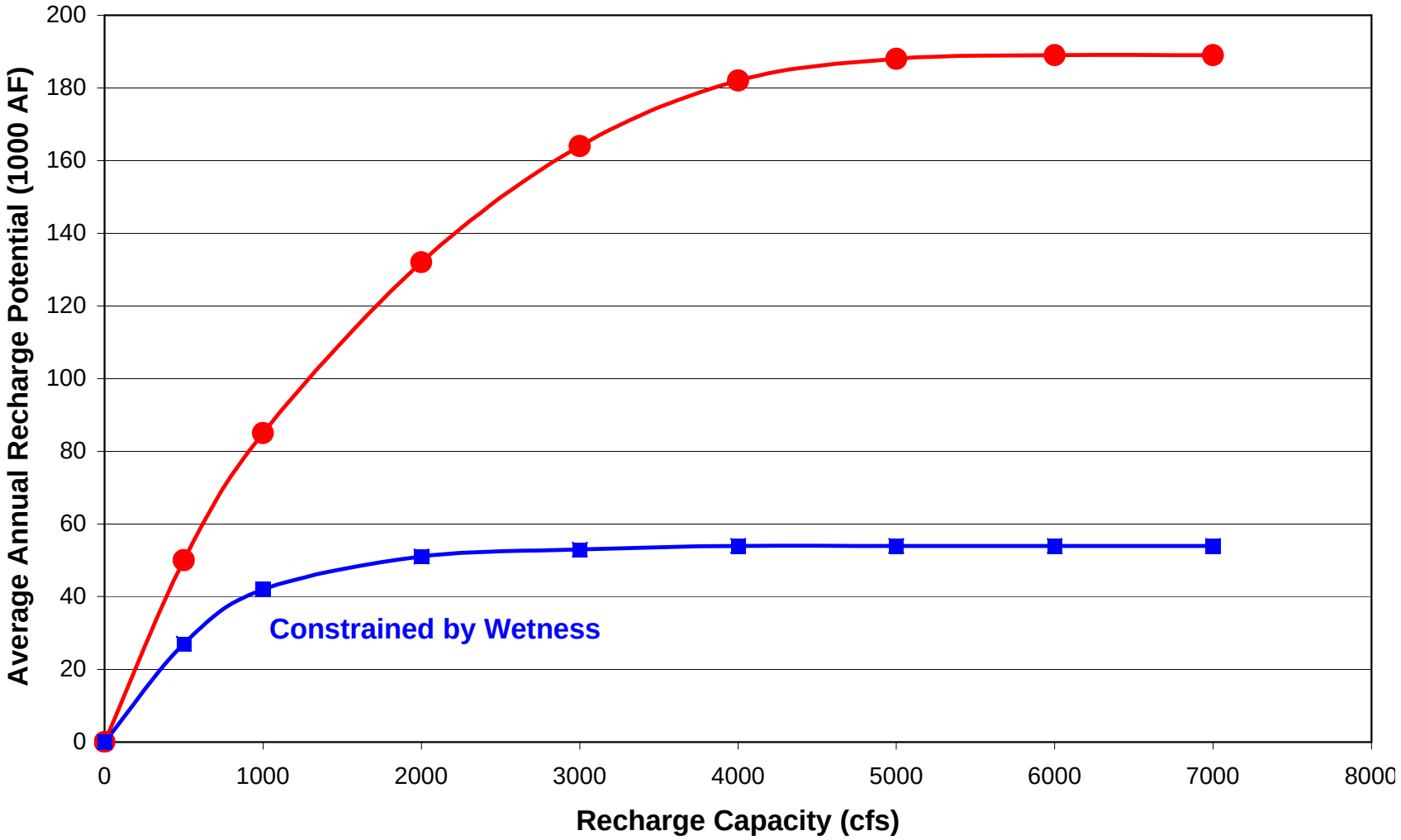


Wetness Index in CALSIM Baseline Simulation

- **Friant-Kern Canal Class 2 delivery is reduced based on Tulare Basin wetness**
  - Natural Flow of Tule River is used as wetness indicator
- **215 water (or Surplus Delivery) is not allocated when delivery is reduced due to basin wetness**
- **Assume ability to accept water for recharge would be limited based on wetness index**

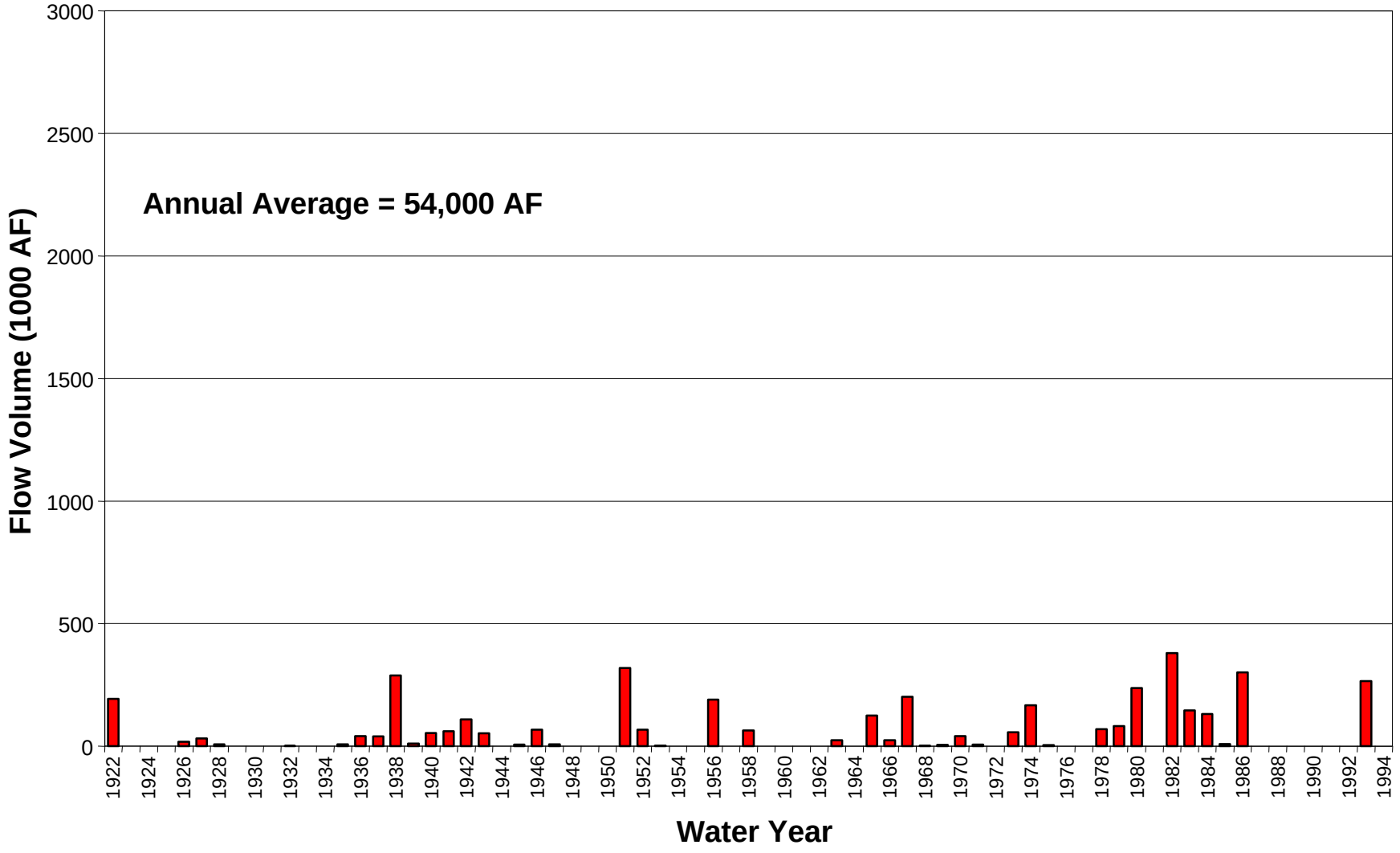
Additional Groundwater Recharge Potential

Based on Available Flow and Available Capacity

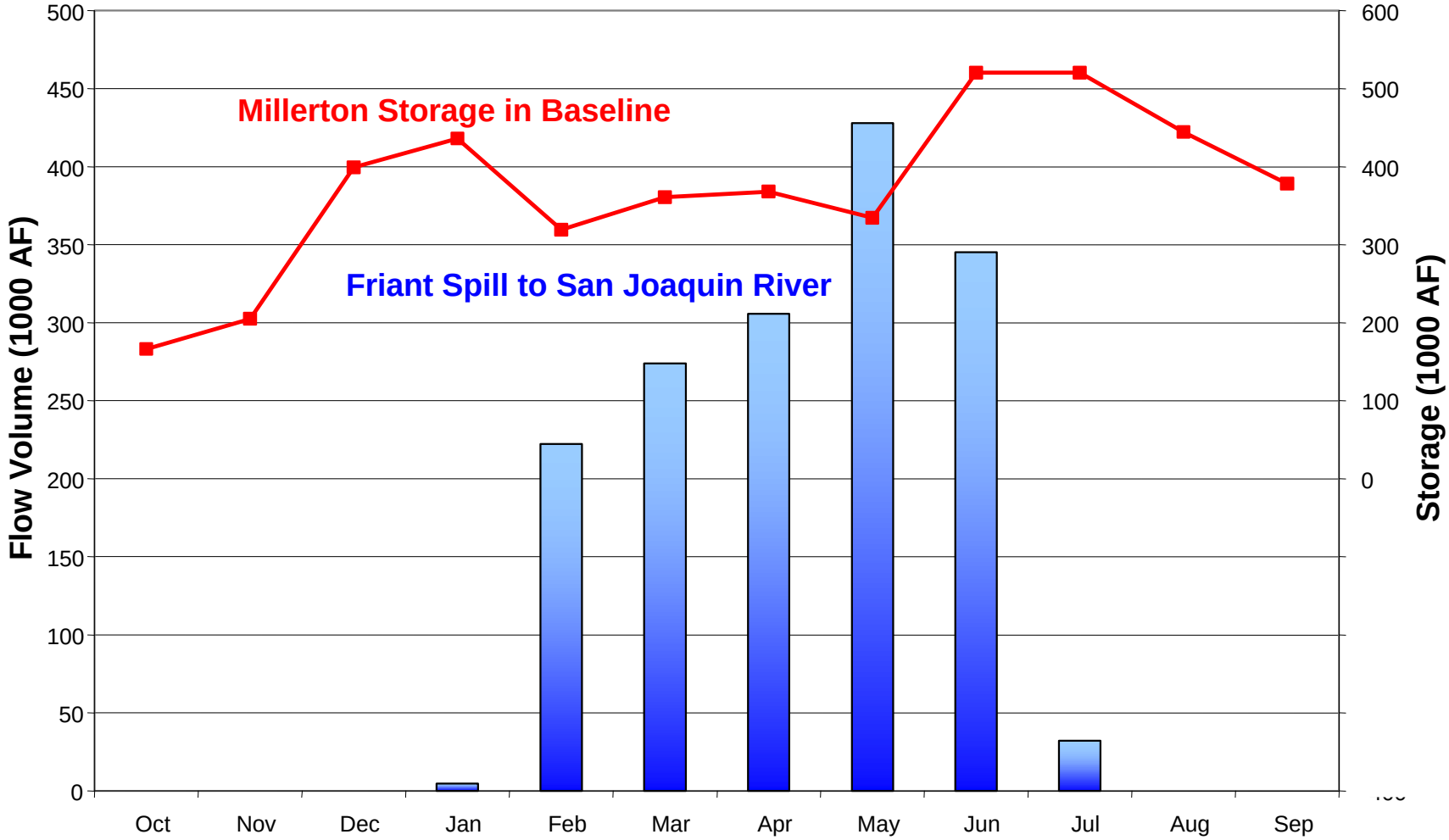


Annual Water Available for Recharge

Based on Available Flow, Available Capacity, and Wetness Index



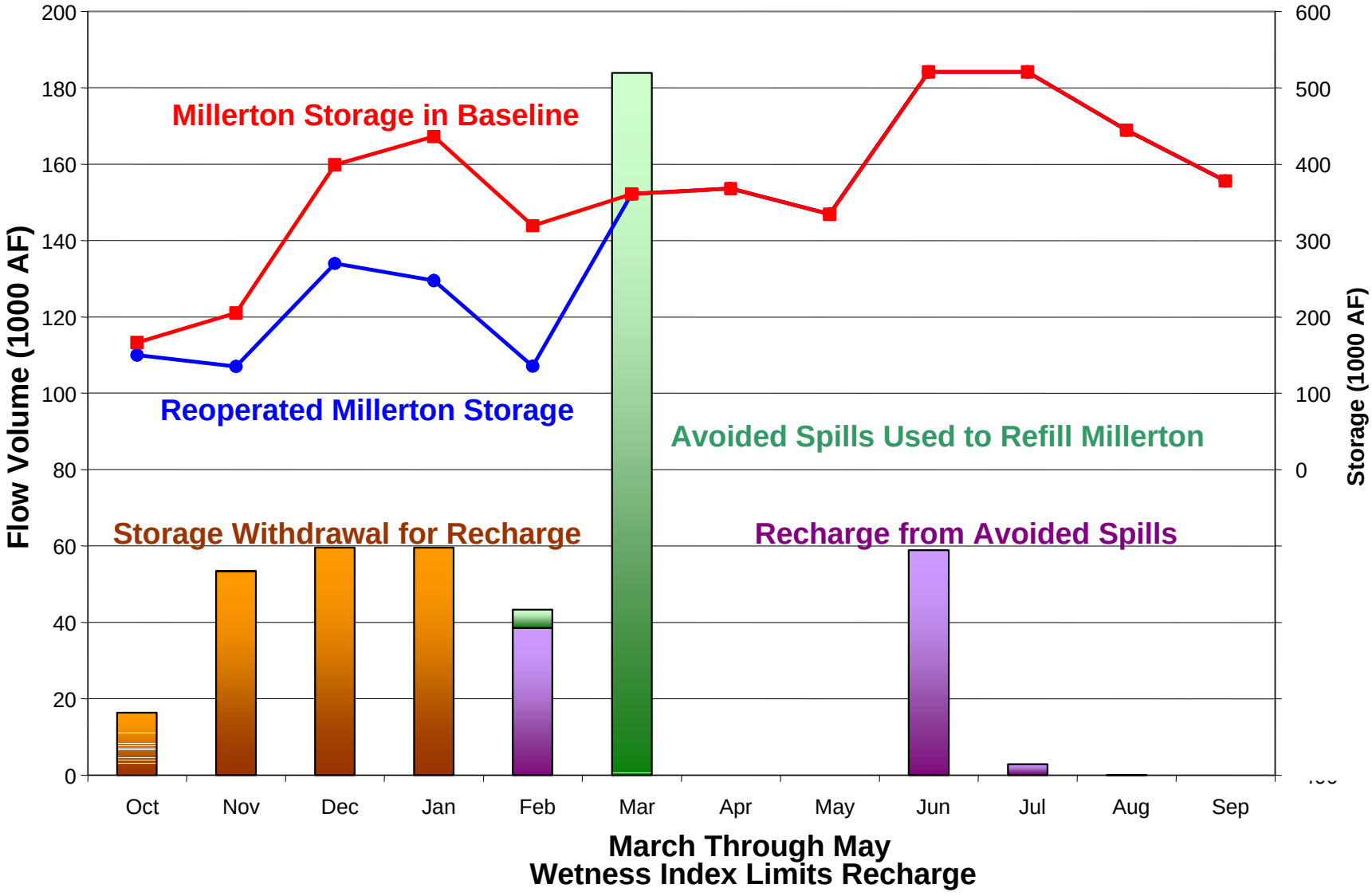
Monthly Operation of Millerton Reservoir
Example for (Wet) Water Year 1938



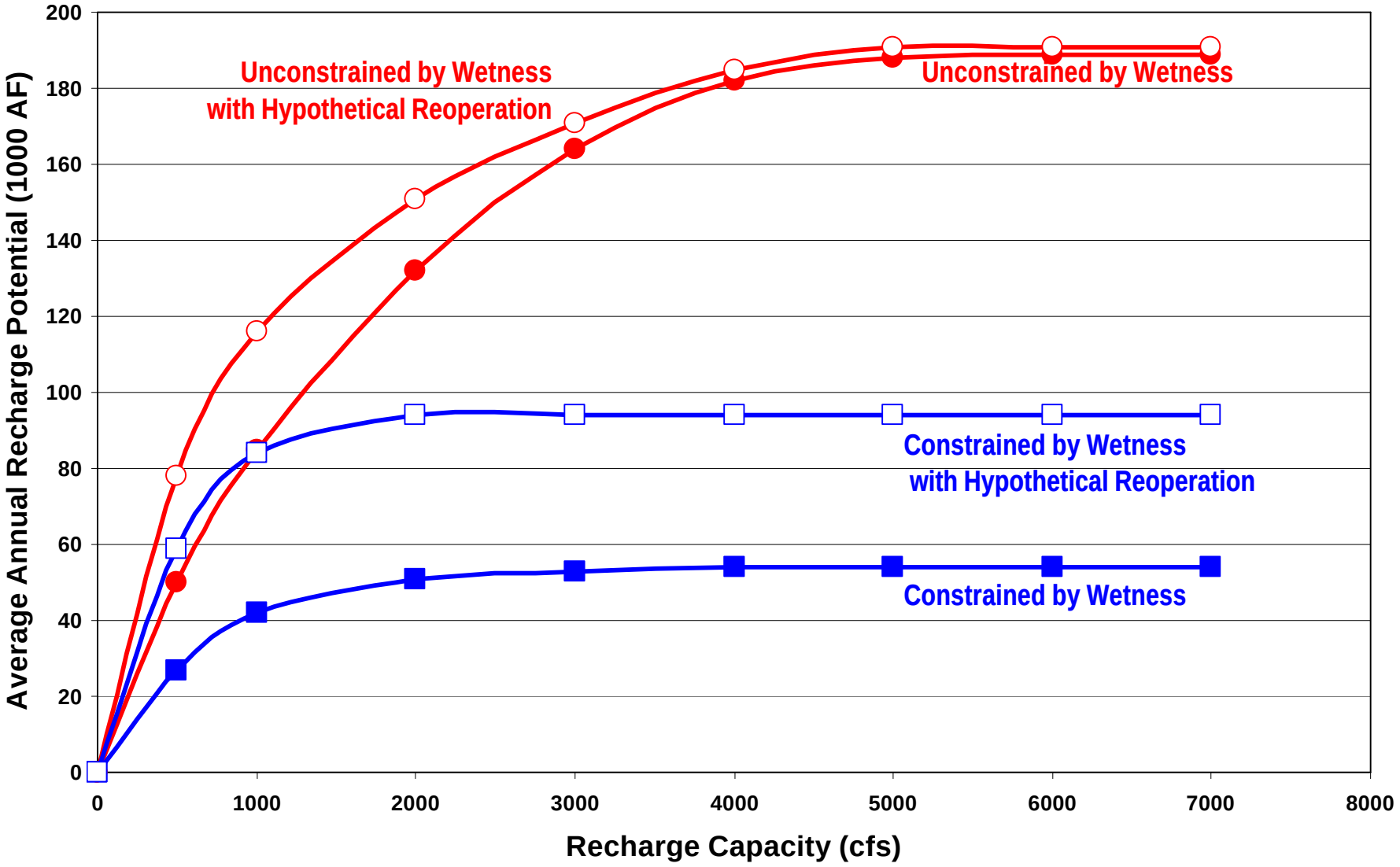
CALSIM Baseline Simulation
Adjustment Based on Hypothetical Reoperation

- **Draw down reservoir at the end of the year**
  - Pre-deliver water to recharge basins October through January
- **Refill reservoir with winter flows**
  - Reduces flood spills
  - Wetness index limits recharge in this period
- **Use excess water that would have spilled in the spring**
  - Recharge when wetness allows

Example of Hypothetical Reoperation for (Wet) Water Year 1938



Theoretical Groundwater Recharge Potential



Theoretical Recharge Analysis Findings

- **Theoretical recharge capacity is not significantly limited by canal conveyance capacity**
  - Canal capacity would limit recharge only at very high recharge rates
  - Results would be similar at any recharge location
- **Specific project details are needed for additional evaluation**
  - Each project will have additional operational criteria and constraints

Workshop 5

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Surface Storage Options Screening

Alternatives Formulation and Feasibility Study Workplan

Next Steps

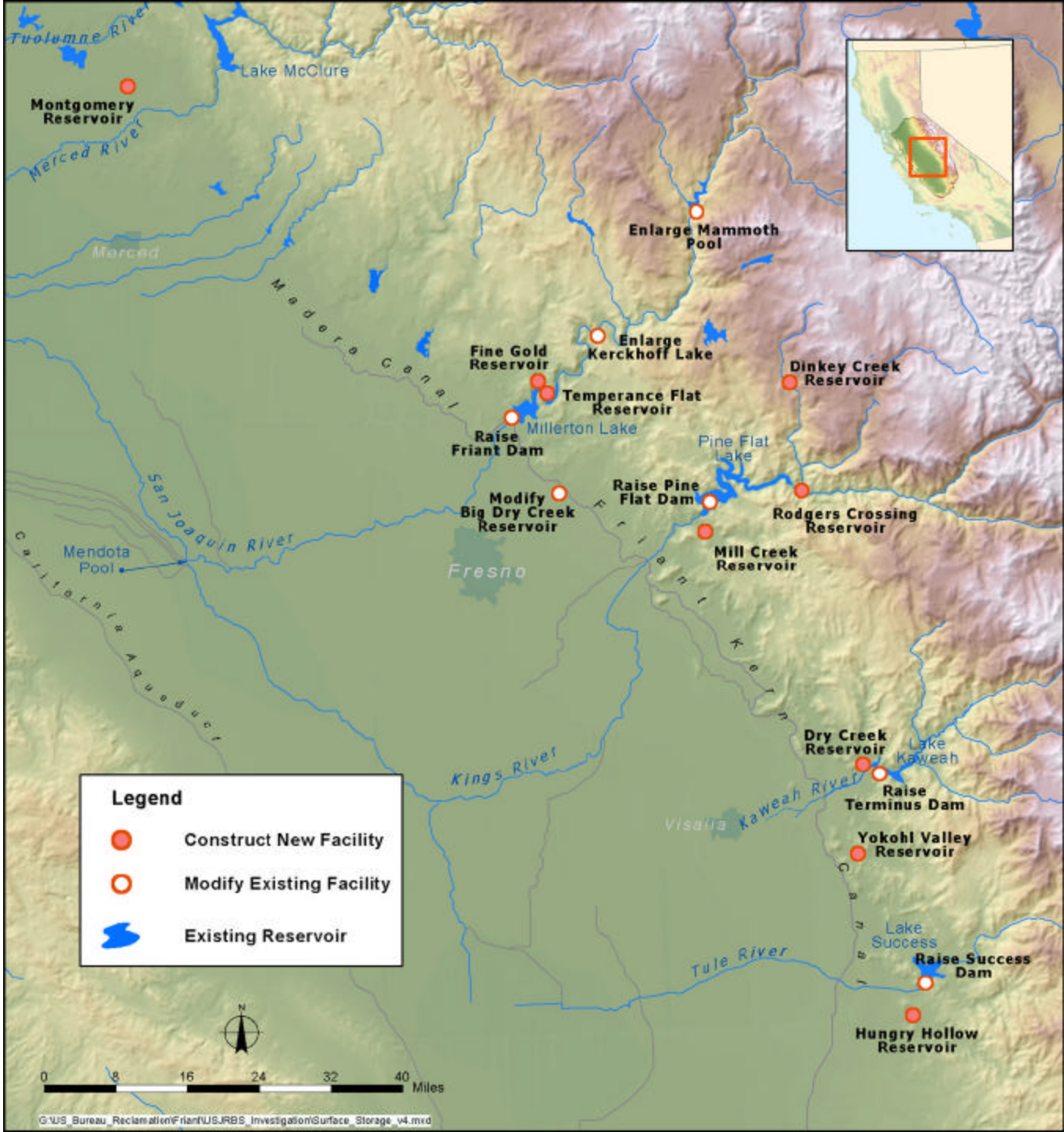
Types of Surface Storage Options

- **San Joaquin River Upstream of Friant Dam**
  - Similar to expansion of Millerton Lake
  - Includes pump-back storage above Millerton Lake
- **Exchange with Millerton Lake Water**
  - Pre-deliver water from Millerton Lake
  - Storage in another watershed to replace Millerton deliveries
- **Off-Canal Storage**
  - Gravity or pumped storage from Friant -Kern Canal

Surface Storage Options

Initial Sites Considered

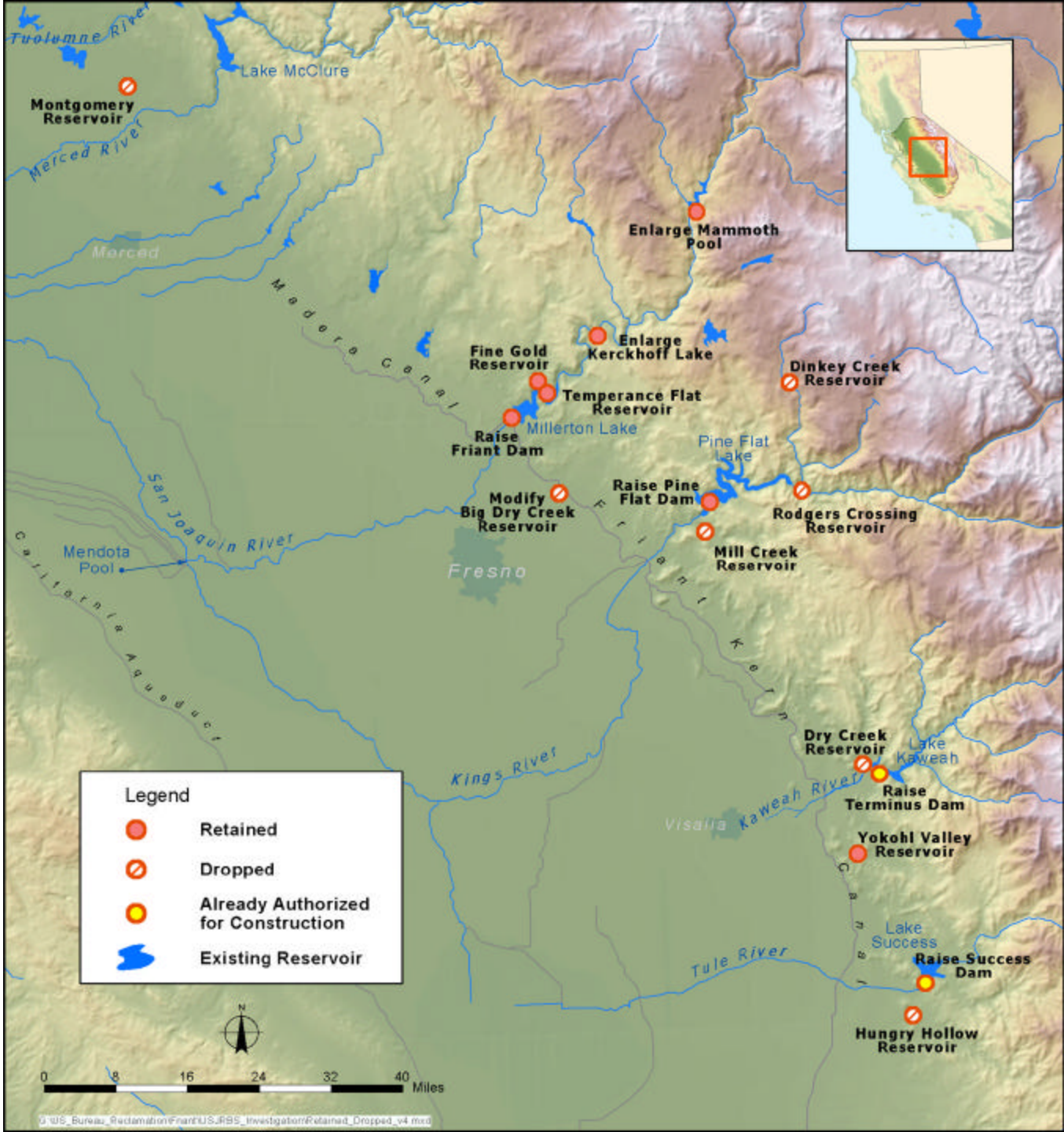
- **Reviewed previous studies**
  - USBR
  - DWR
  - Local Agencies
  - NRDC/FWUA



Surface Storage Options

Initial Screening Results

- 16 sites identified
- 2 sites already authorized for construction
- 7 sites dropped
- 7 sites retained



Status of Surface Storage Site Screening

SAN JOAQUIN RIVER

◆ Enlarge Friant	Retained
◆ Fine Gold	Retained
◆ Temperance Flat	Retained - multiple dam sites
◆ Enlarge Kerckhoff	Include with Temperance Flat
◆ Enlarge Mammoth Pool	Monitor progress by FWUA/SCE

EXCHANGE

◆ Enlarge Pine Flat	Dropped

OFF-CANAL

◆ Yokohl	Retained

Surface Storage Options

Estimated First Costs

- **Costs include**
  - **Listed items**
  - **Unlisted items (10%)**
  - **Contingencies (25%)**
  - **Mitigation (5%)**
  - **Investigations, design, construction mgt. (15%)**
- **Lands and easements costs not yet estimated**
  - **Exception: Yokohl**

Surface Storage Options

Estimated First Costs

Site	Storage Option	Max Surface Elevation (ft, msl)	New Storage (TAF)	Est. First Cost ($M)
Friant	Raise 25 Ft	603	132	$113
	Raise 60 Ft	638	340	$266
	Raise 140 Ft	718	870	$662
Temperance Flat (RM279)	New Reservoir (RCC Dam)	900	451	$435
	New Reservoir (RCC Dam)	1100	1,273	$771
Mammoth Pool	Enlarge Reservoir	3355	30	
Fine Gold	New Reservoir (RCC Dam)	900	133	$161
	New Reservoir (RCC Dam)	1100	780	$428
Yokohl Valley	New Reservoir (F-K Canal source	791	450	$294

Modeling Summary From Workshop #4

- **Developed Benchmark**
  - Friant operations logic in CALSIM II model
  - Logic developed from review of historical operations
  - Appropriate as Benchmark for comparison

- **Single-purpose analyses for surface storage options**
  - San Joaquin River restoration
  - San Joaquin River water quality
  - Water supply reliability

Single Purpose Analyses Assumptions

- Annual reservoir operation
- Existing flood space rules
- New supply used for one purpose only
- Benchmark average deliveries for each year type maintained in restoration and water quality analyses

Summary of Single Purpose Analysis Results

Storage Options	Size	Additional Single-Purpose Release from Friant Dam		
		WS	RF	WQ
Friant Enlargement	700	134	140	134
	450	98		
	340	73		
	250	56		
	125	27		
Mammoth Pool	35	8		
Temperance Flat	1,273	163	171	181
	2,100	189	210	222
Fine Gold	800	117	124	124
	400	69		
	350	54		
	133	36		
Yokohl Creek	800	115	127	121
	400	74	76	69
Pine Flat	124	23		

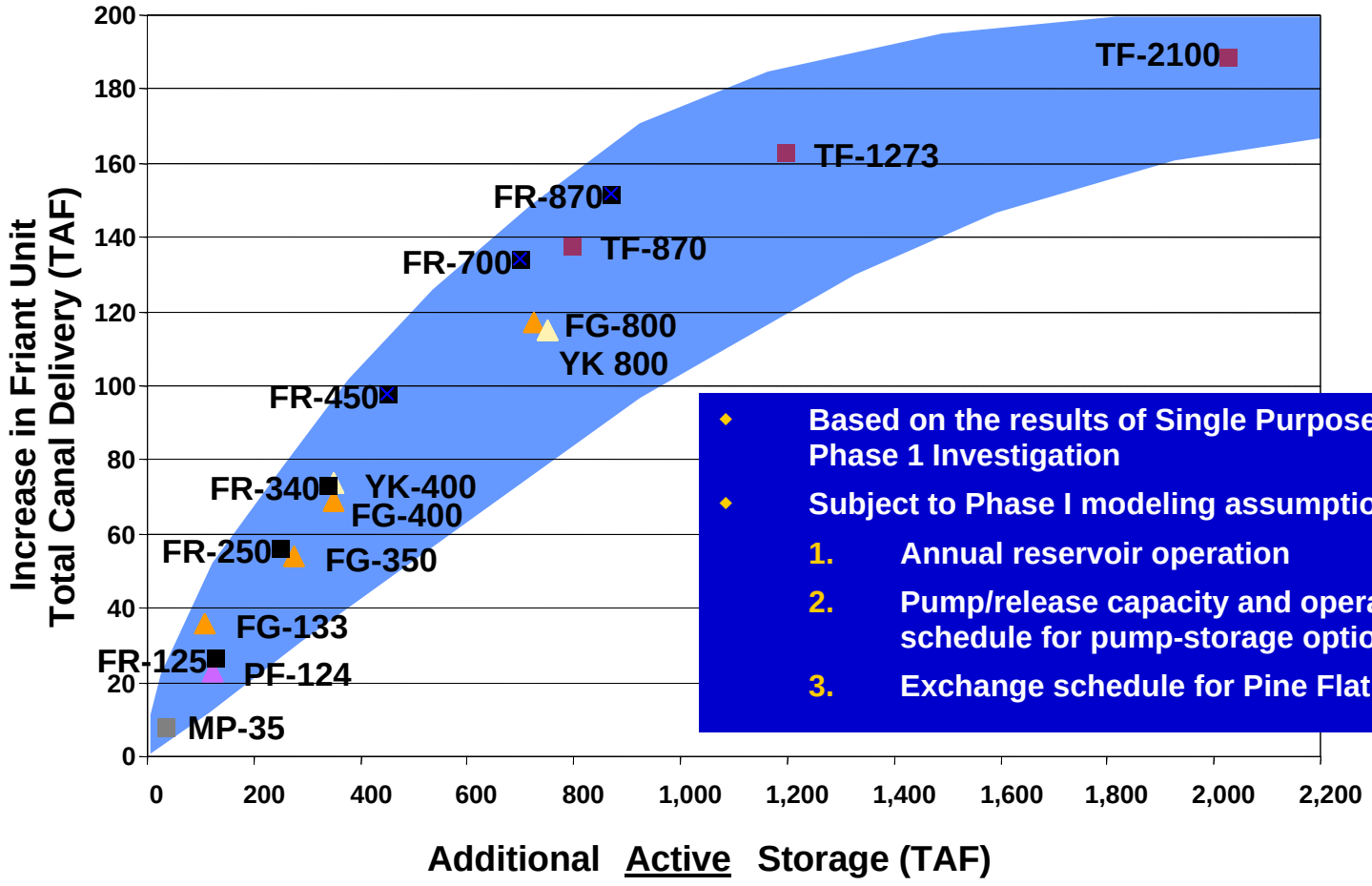
Expected long-term average similar to WS

Expected long-term average similar to WS

Expected long-term average similar to WS

Long-term average of WS, RF, and WQ are similar

Single Purpose Analysis Results



- Based on the results of Single Purpose - WS for Phase 1 Investigation
- Subject to Phase I modeling assumptions:
  1. Annual reservoir operation
  2. Pump/release capacity and operating schedule for pump-storage options
  3. Exchange schedule for Pine Flat option

Single Purpose Analyses Findings

- **Additional storage increases Class 2 water allocation and reduces available temporary flood water**
- **Additional water supply at Friant Dam is similar in all three single purpose evaluations**
- **Difficult to support new river demands in critical years**
- **Potential system impacts**
  - Flood damage reduction
  - Same delivery to Mendota Pool, but different source mix

Sensitivity Analyses Suggested at Workshop #4

- **On Benchmark**
  - Modeling time step (monthly vs. daily)
- **On Single Purpose Analyses**
  - Off-stream storage pumping / release capacity
  - Demand pattern for river restoration
  - Carryover storage operation to provide water for river releases in critical years

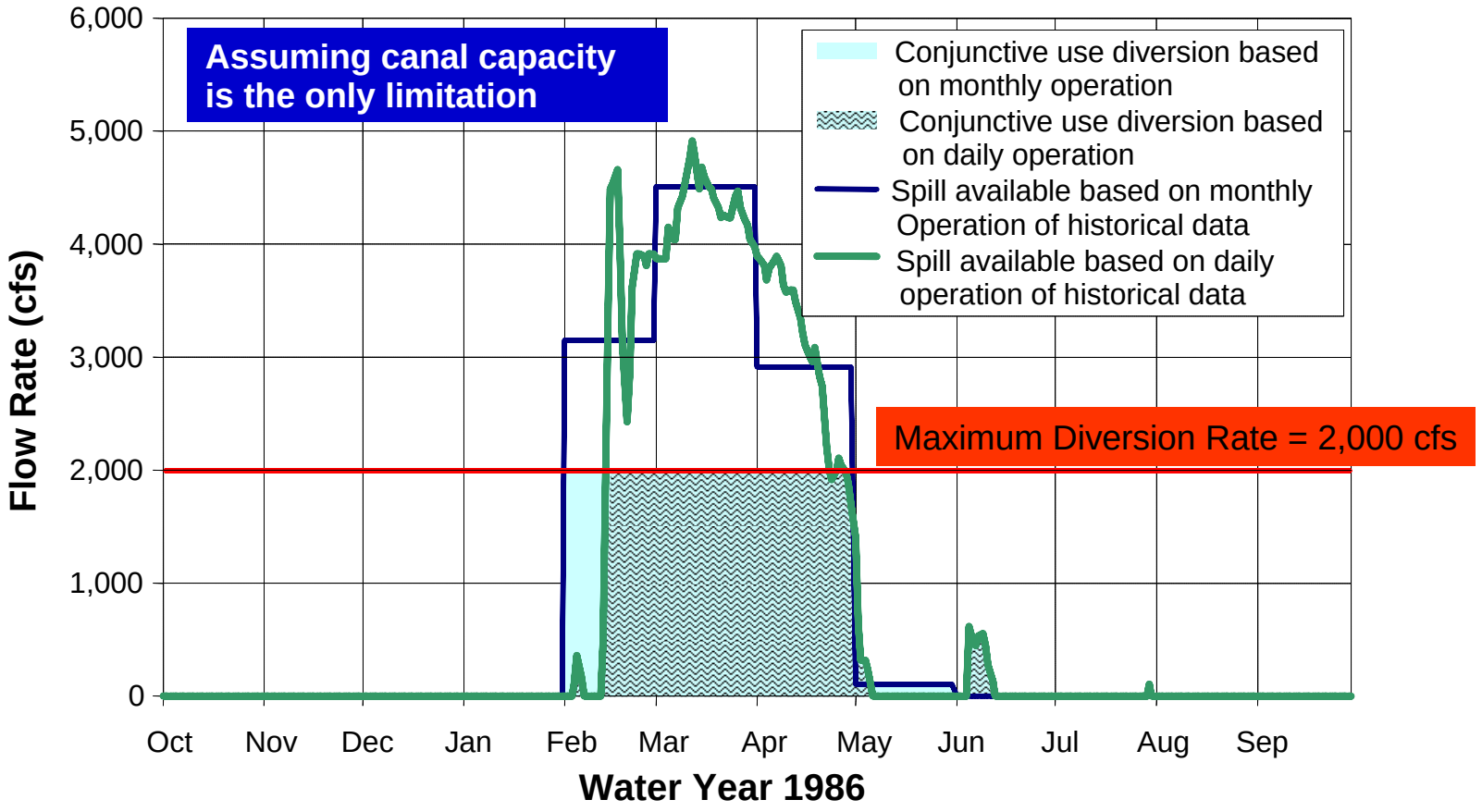
Sensitivity Analyses on Time Step

Monthly vs. Daily Operation

- **Issues**
  - Flood operation requires daily or hourly simulation
  - Representation of flood release as monthly volume
  - Options subject to results of flood operation may be sensitive to the modeling time-step
  - Examples include conjunctive use and off-stream storage along the Friant-Kern Canal
- **Approach in Sensitivity Analysis**
  - Historical monthly vs. daily
  - CALSIM results vs. historical monthly

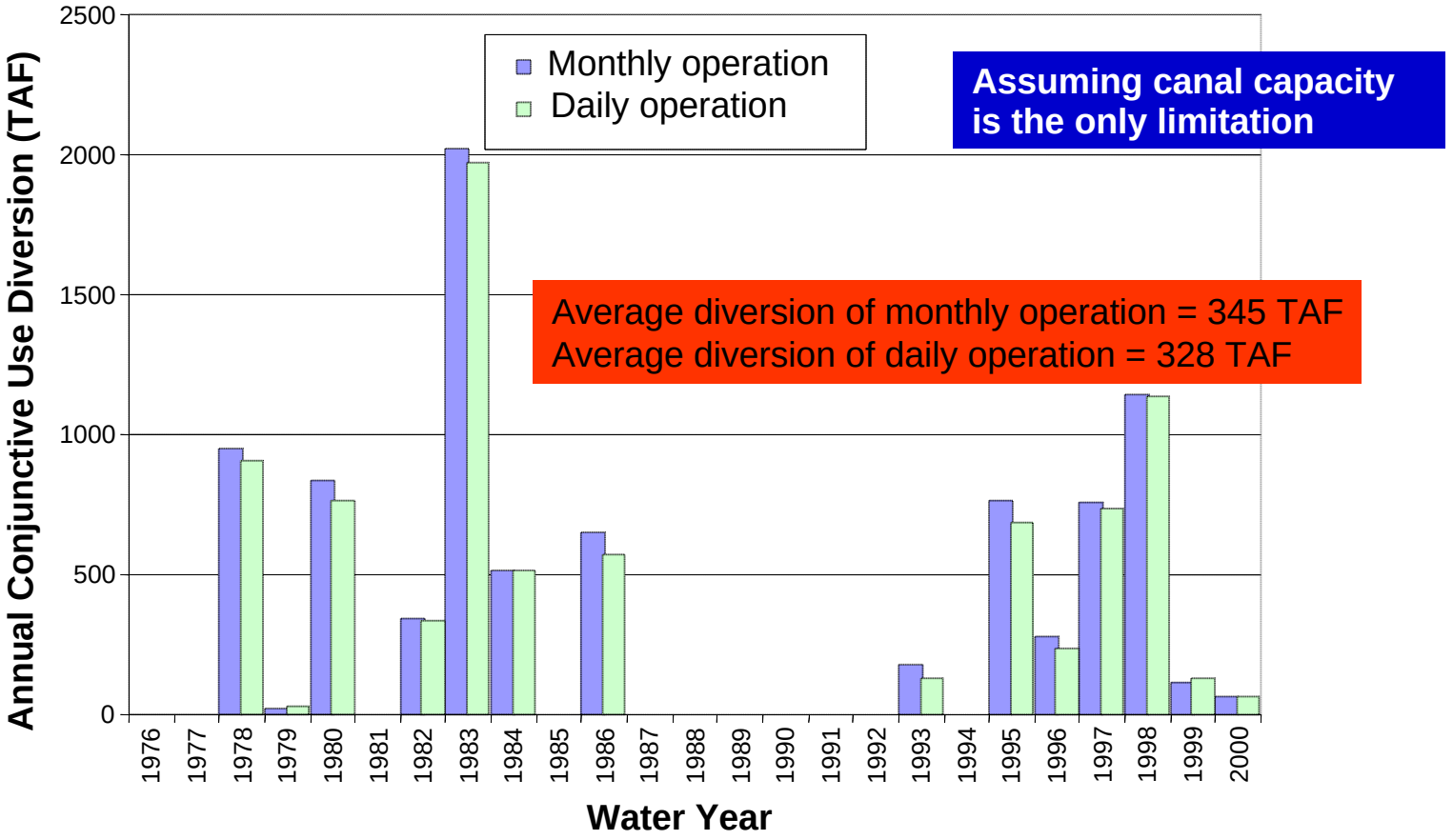
Sensitivity Analyses on Time Step

Example - Potential water supply for conjunctive use



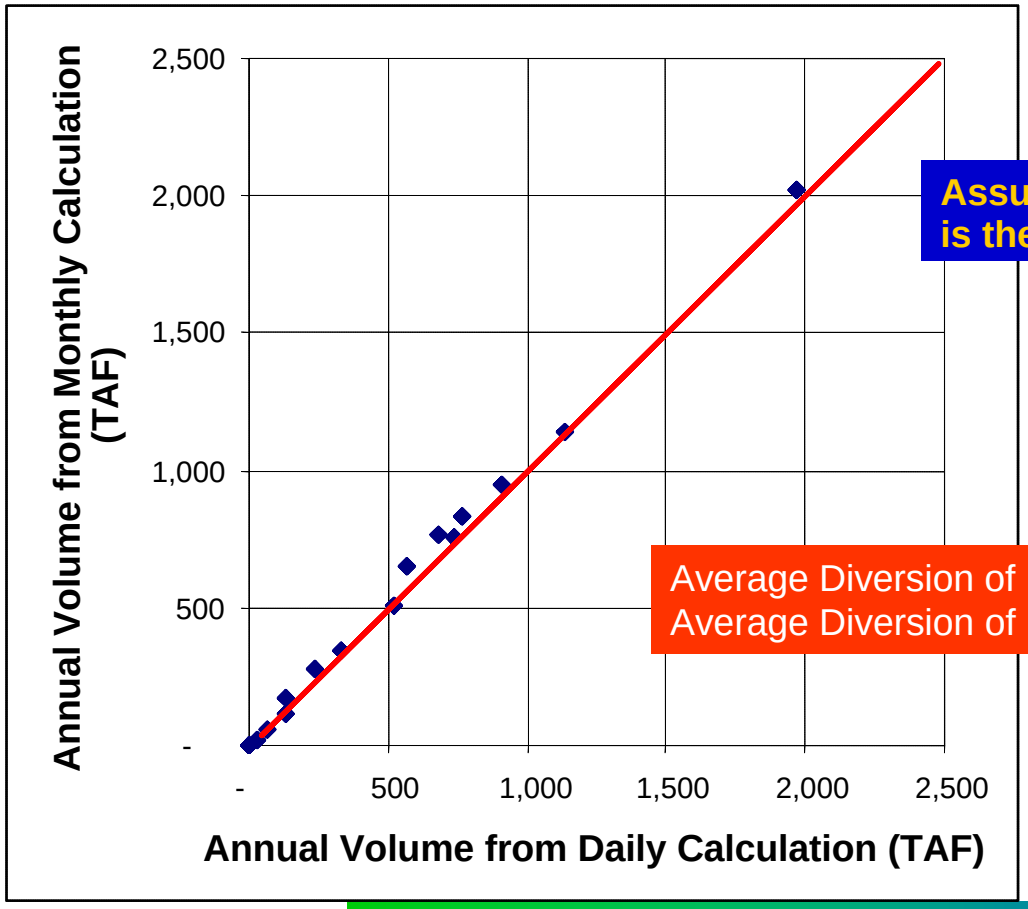
Sensitivity Analyses on Time Step

Example - Potential water supply for conjunctive use



Sensitivity Analyses on Time Step

Example - Potential water supply for conjunctive use



Assuming canal capacity is the only limitation

Average Diversion of Monthly Operation = 345 TAF
Average Diversion of Daily Operation = 328 TAF

1976 through 2000

Findings from Time Step Sensitivity Analysis

- **Use of monthly volume may overestimate available supply for canal diversions**
  - Conjunctive use opportunities
  - Off-canal storage
- **Difference is not significant for appraisal-level study**
- **Feasibility Study modeling needs**
  - Shorter time steps for flood control and hydropower
  - Refine operational assumptions

Sensitivity Analyses Suggested at Workshop #4

- **On Benchmark**
  - Modeling time step (monthly vs. daily)

- **On Single Purpose Analyses**
  - **Off-stream storage pumping / release capacity**
  - Demand pattern for river restoration
  - Carryover storage operation to provide water for river releases in critical years

Sensitivity Analyses on SPA Evaluations

Summary of Simulated Options

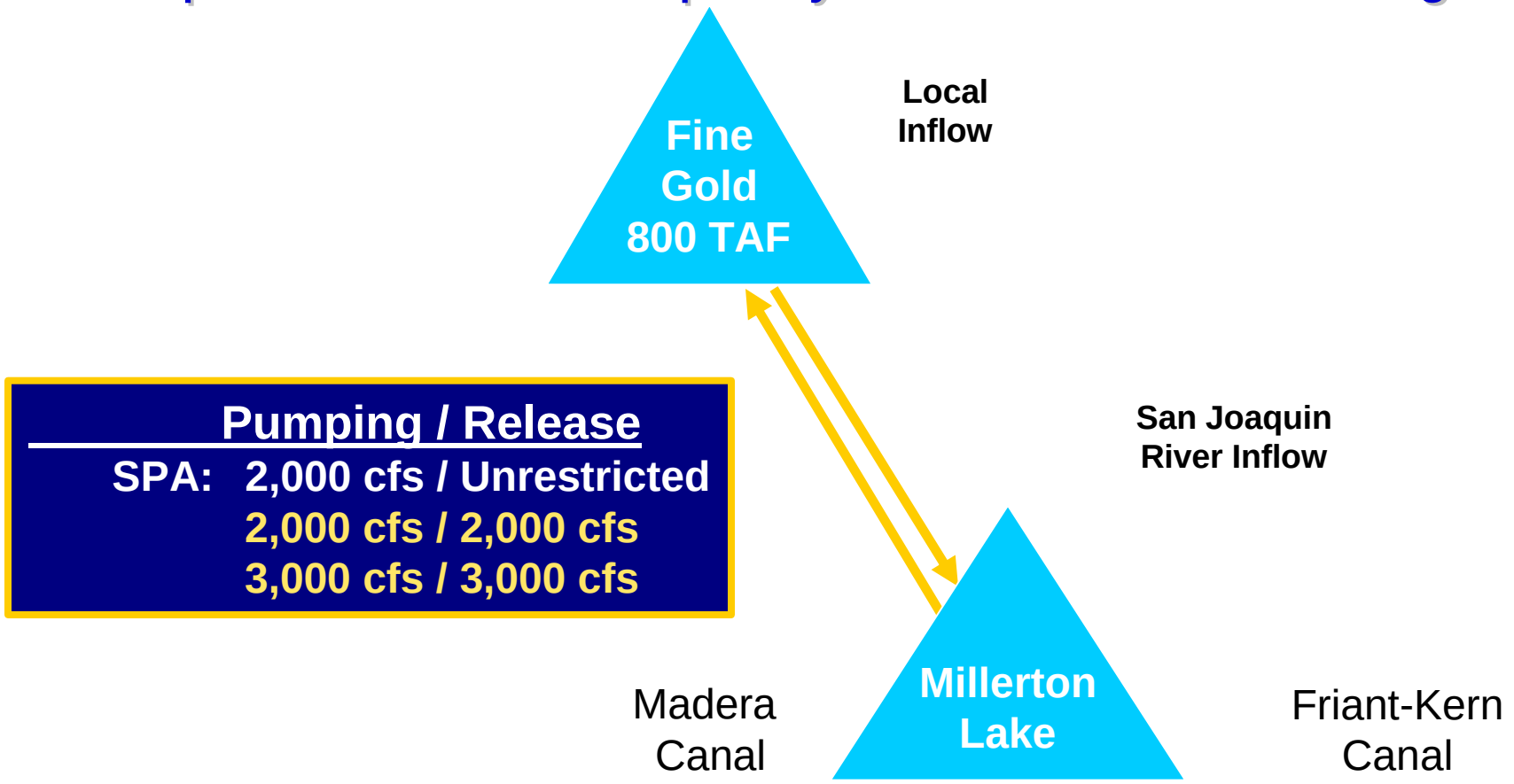
Storage Options	Size	
Friant Enlargement	700	
	450	
	340	
	250	
	125	
Mammoth Pool	35	
Temperance Flat	1,273	
	2,100	
Fine Gold	800	
	400	
	350	
	133	
Yokohl Creek	800	
	400	
Pine Flat	124	

Sensitivity Analysis

- **Pump / release capacity for off-stream storage**
- **River restoration demand pattern**
- **Carry over storage for new river demand**

Sensitivity Analysis

Pump and Release Capacity for Off-Stream Storage



Pump and Release Capacity Sensitivity Analysis

Findings from Fine Gold 800 TAF Simulations

- **Results for all three single purpose analyses are similar**
- **Sensitivity to changes in pump / release capacity is small**
- **Similar results expected for off-canal storage (Yokohl)**

Annual Average Release at Friant Dam for SPA (TAF)

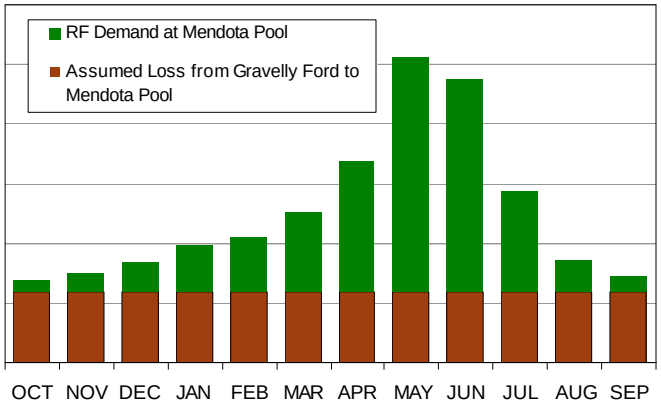
FG-800	Pumping / Release Capacity (cfs)		
	2,000 / Unrestricted	2,000 / 2,000	3,000 / 3,000
WS	117	117	125
WQ	124	124	137
RF	124	124	133

Sensitivity Analyses Suggested at Workshop #4

- **On Benchmark**
  - Modeling time step (monthly vs. daily)
- **On Single Purpose Analyses**
  - Off-stream storage pumping / release capacity
  - **Demand pattern for river restoration**
  - Carryover storage operation to provide water for river releases in critical years

Sensitivity Analysis

Restoration Pattern

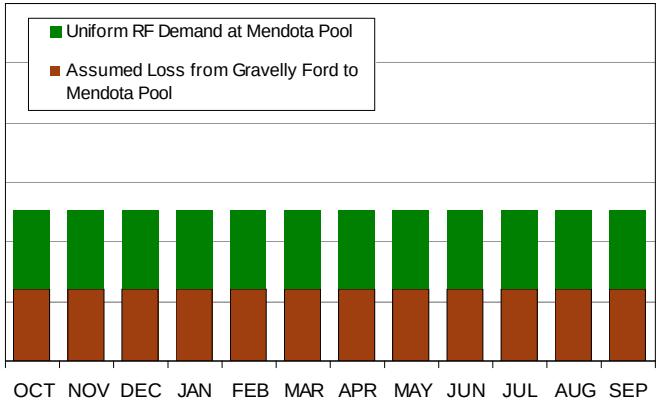


Single Purpose Analysis:
SJR unimpaired flow distribution

Assumed constant loss rate (6 TAF per month) for all year types

Year-type varying demand

Uniform distribution



Restoration Pattern Sensitivity Analysis

Findings from Three Simulations

- **Single Purpose Analysis results are not sensitive to changes in monthly restoration flow distribution**

Annual Average Restoration Release at Friant Dam (TAF)

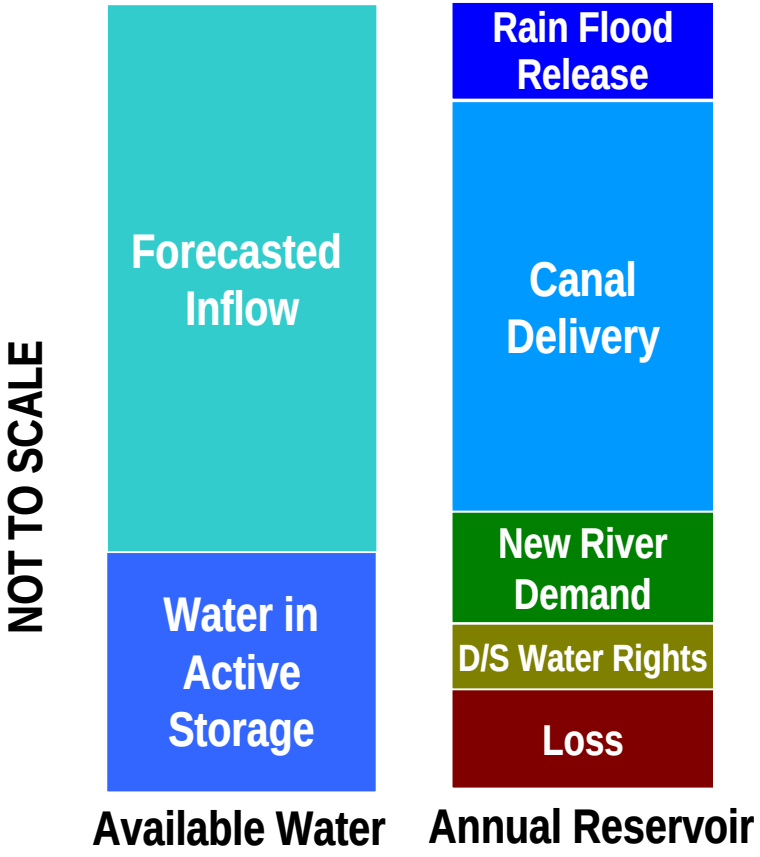
Options	Restoration Flow Pattern	
	SJR Unimpaired Flow Distribution	Uniform Distribution
FR-700	142	141
TF-1273	171	173
FG-800	124	120

Sensitivity Analyses Suggested at Workshop #4

- **On Benchmark**
  - Modeling time step (monthly vs. daily)
- **On Single Purpose Analyses**
  - Off-stream storage pumping / release capacity
  - Demand pattern for river restoration
  - **Carryover storage operation to provide water for river releases in critical years**

Carryover Storage Sensitivity Analysis

Water Allocation for Annual Reservoir



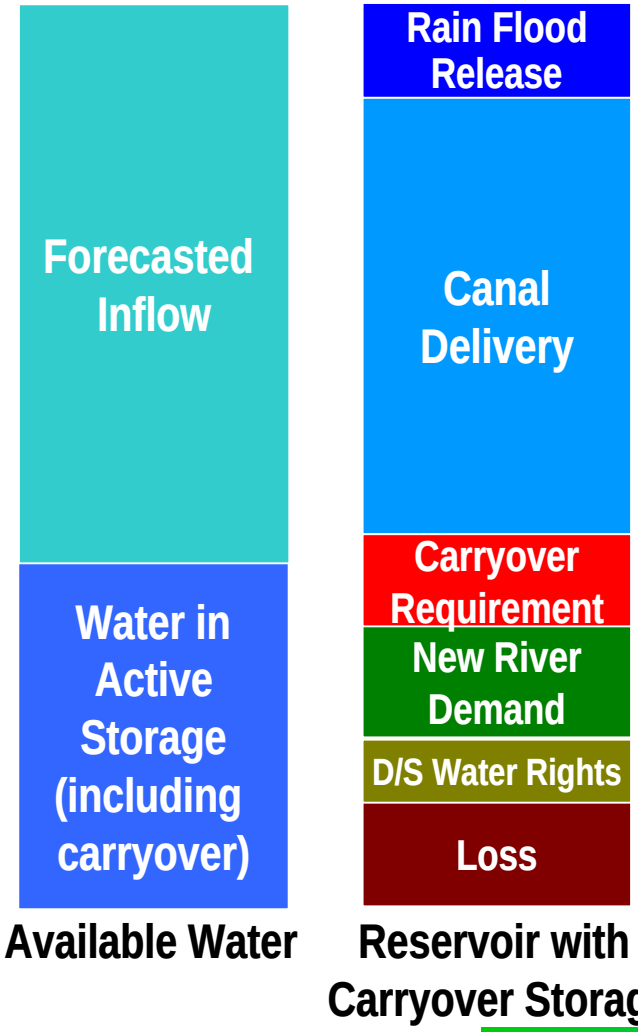
- Dynamic allocation
- Based on hydrologic conditions and reservoir storage

- Prescribed for water quality or restoration flow purpose
- Based on a year-type-varying demand patterns

Carryover Storage Sensitivity Analysis

Water Allocation with Carryover Requirement

NOT TO SCALE



- Dynamic allocation
- Based on hydrologic conditions and reservoir storage

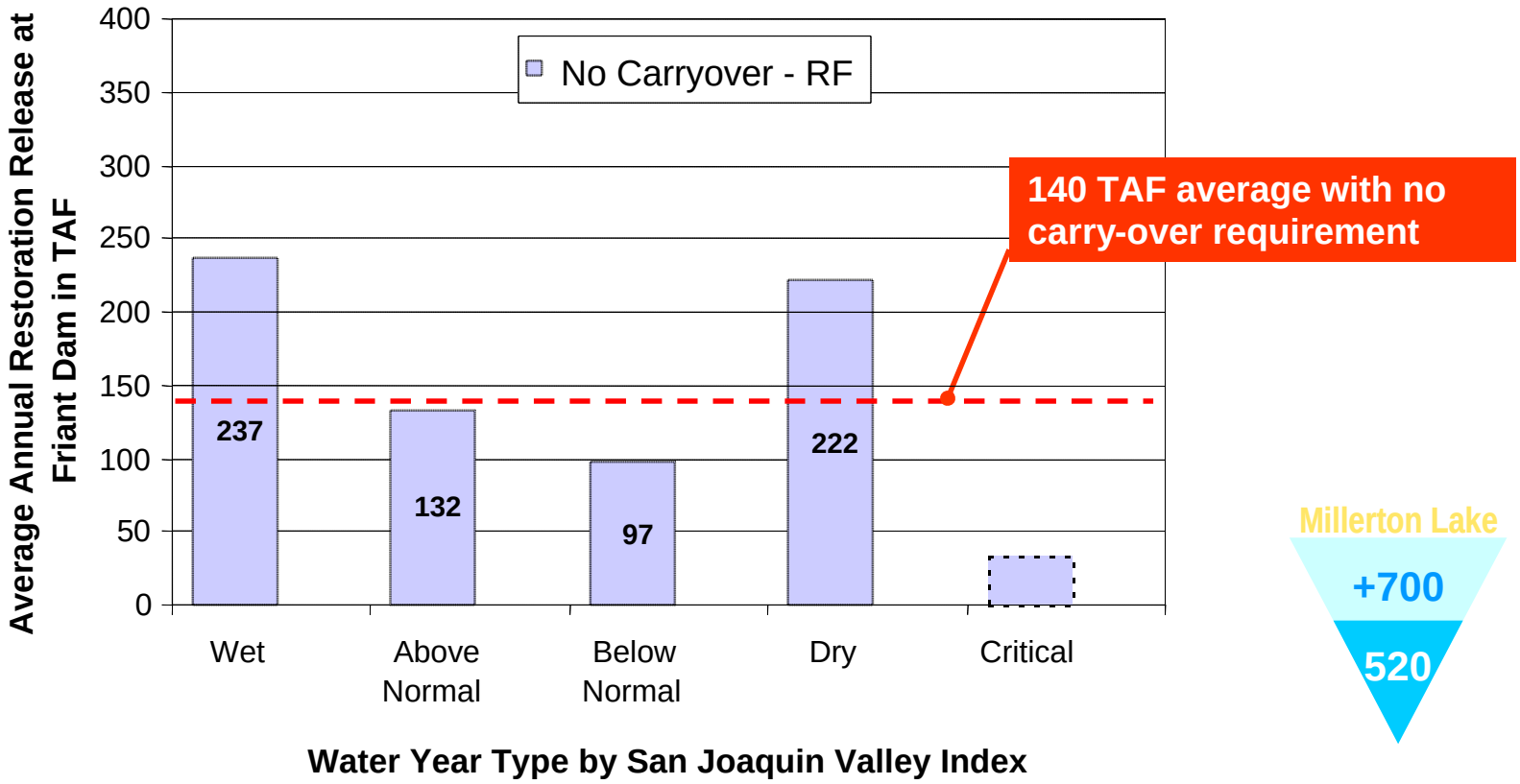
- Dynamic allocation
- Based on hydrologic conditions and other considerations

- Prescribed for water quality or restoration flow purpose
- Based on a year-type-varying demand patterns

Carryover Storage Sensitivity Analysis

Criteria for Carryover Objective

- Results show difficulty in supplying river demand in critical years



Carryover Storage Sensitivity Analysis

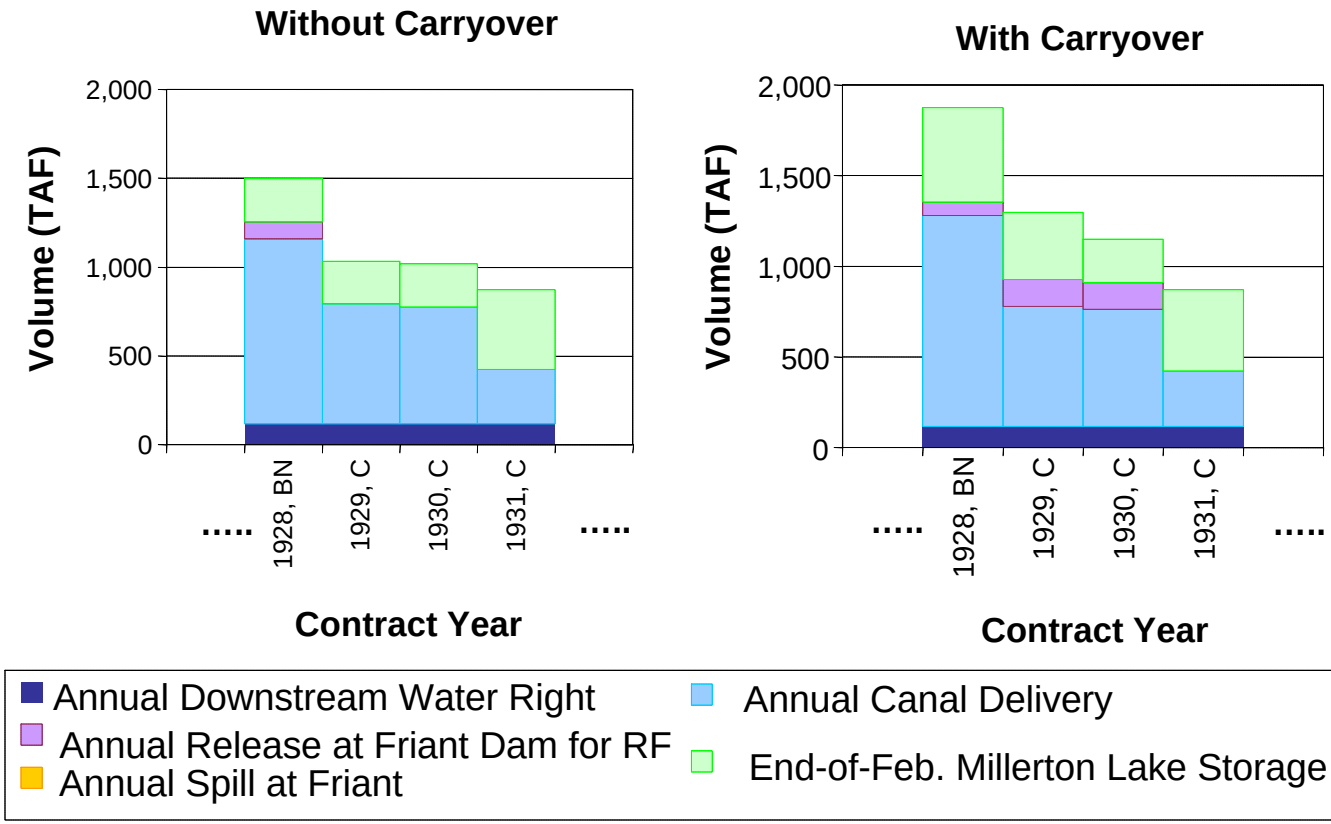
Criteria for Carryover Objective

Water Year	Year Type by San Joaquin Valley Index	Carryover Amount Units	Carryover Amount (TAF)	
⋮	⋮	⋮	⋮	
1927	Above Normal	2	280	**2 carryover units target**
1928	Below Normal	2	280	
1929	Critical	1	140	**Beginning of drought, 1 carryover unit**
1930	Critical	0	0	**Into drought, no carryover**
1931	Critical	0	0	
1932	Above Normal	1	140	**Out of drought, 1 carryover unit**
1933	Dry	0	0	**Into drought, no carryover**
1934	Critical	0	0	
1935	Above Normal	1	140	**Out of drought, 1 carryover unit**
1936	Above Normal	2	280	**2 carryover units target**
1937	Wet	2	280	
⋮	⋮	⋮	⋮	

One-year carryover objective set at 140 TAF

Carryover Storage Sensitivity Analysis

Example Carryover Operation



Millerton Lake

+700

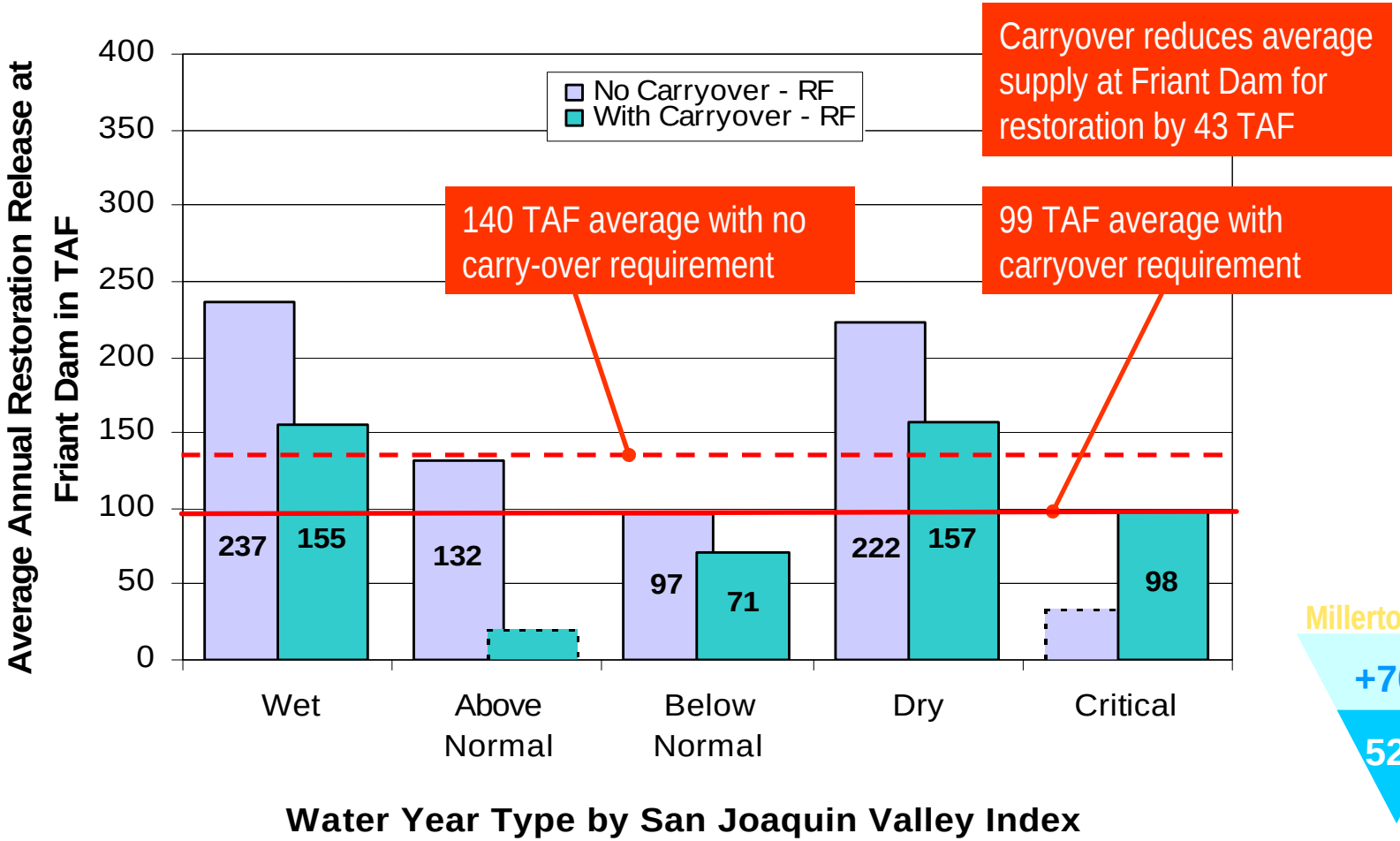
520

Carryover Storage Sensitivity Analysis Findings

- **Total water available for river demand is decreased**
  - Long-term annual average amount reduced about 30%
- **Ability to make river releases is shifted by year type**
  - Objective of carryover was to provide water in critical years
  - Problem shifted to above normal or below normal years

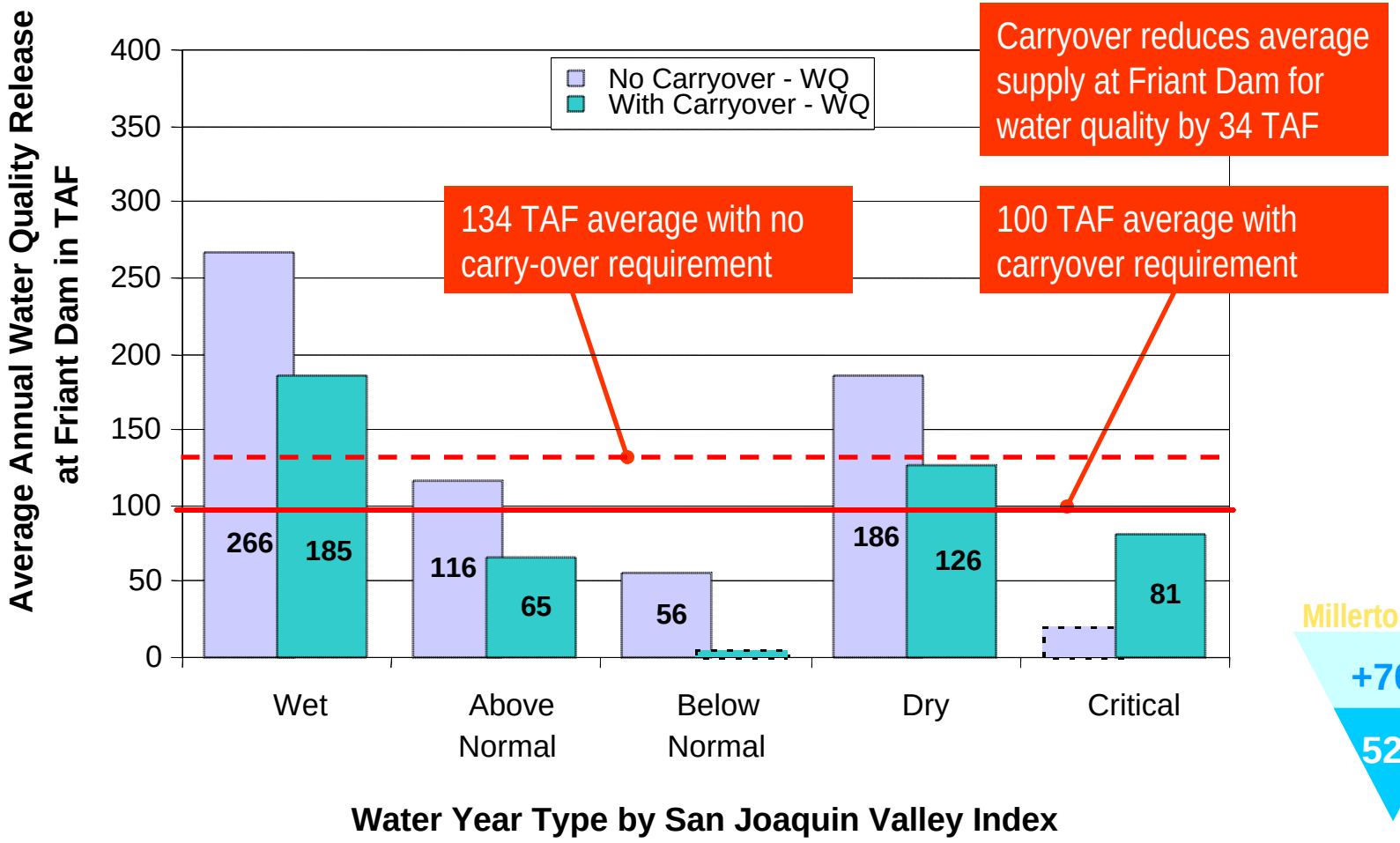
Carryover Storage Sensitivity Analysis Findings

Effect on Restoration Releases



Carryover Storage Sensitivity Analysis Findings

Effect on Water Quality Releases



Sensitivity Analyses Conclusions

- **Sensitivity Analysis Findings**
  - Time step - minor, limited to specific analyses
  - Off-stream pump / release rates - minimal
  - Restoration pattern - insignificant
  - Carry-over operations - very significant

- **Operational Assumptions will be Important in Alternatives**
  - Preservation of Benchmark deliveries
  - Basis for carry-over requirements - risk-based analysis
  - Flood control rules

Workshop 5

Agenda

Welcome and Introductions

Investigation Overview

Conjunctive Use & Groundwater Storage

Surface Storage Options Screening

Alternatives Formulation and Feasibility Study Workplan

Next Steps

Range of Comments on Options and Alternatives

- **Alternatives formulation**
  - Functional equivalence
  - Baseline assumptions
- **Environmental impacts**
- **Economics**
  - Project cost
  - Incremental analysis
  - Beneficiaries pay

What does “Functional Equivalence” mean?

- **Anything that provides water?**
  - Other CALFED Programs address non-storage actions
- **Storage options only?**
  - Surface Storage
  - Groundwater Storage
- **Similar accomplishments to a specific project?**
  - Friant Enlargement 250 - 700 TAF
  - Increase additional supply at Friant Dam

Functional Equivalents

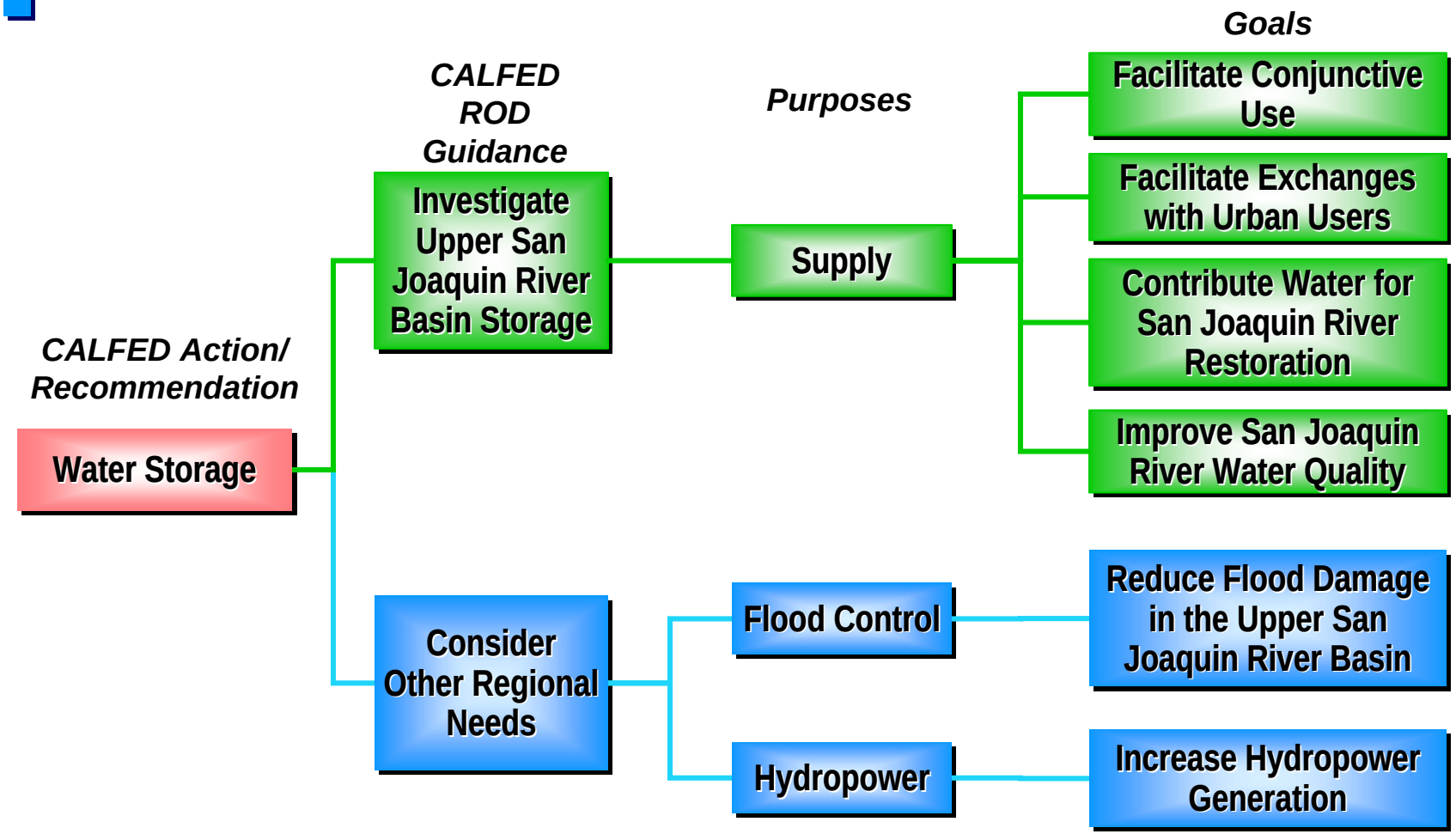
Storage options that provide additional water supply at Friant Dam to support CALFED objectives for Upper San Joaquin Storage

Functional Equivalence Framework

Performance Measures for Phase 1 Evaluation

- **Derived from CALFED objectives for Upper San Joaquin Storage**
- **Method to organize results of operational studies**
- **Compare options and develop alternatives**

Functional Equivalence Framework



Alternatives Formulation Approach

- **Identify increments for storage options**
  - Enlarge Friant — 125 to 870 TAF
  - Fine Gold — 125 to 800 TAF
  - Temperance Flat — 425 to 2,100 TAF
  - Yokohl — 400 to 800 TAF
  - Conjunctive use projects — As defined
- **Calculate cost and yield for each increment**
  - Some options will require additional cost information

Alternatives Formulation Approach

- **Initial alternatives based on major options**
  - Surface storage options
  - Conjunctive use projects
- **Incremental analysis**
  - Add reasonable project increments
  - Identify economic breakpoints

Workshop 5

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Next Steps

Next Steps

- Temperance flat options review
- Hydropower evaluation
- Conjunctive use project identification
- Draft phase 1 report
- Feasibility Study Work Plan

Temperance Flat Options

- **Options addressed in In-Progress Report**
  - 274, 279, 280 Sites described
  - 279 Site representative - considered construction issues
  - 280 Site dropped - similar to but less effective than 279

- **Additional options to be considered in Phase 1**
  - 274 and 286 Sites
  - Construction, environmental, hydropower issues

Hydropower Evaluation

- **Impacts to existing power facilities**
  - Generation loss
  - Potential mitigation actions

- **Potential use and generation for new facilities**
  - Power plant opportunities
  - Estimated pumping for off-stream storage sites
  - Estimated generation at all sites

Conjunctive Use Project Identification

- **Review CALFED Common Assumptions Inventory**
- **Stakeholder coordination**
  - Clarify project details
- **Identify operations assumptions**
- **Determine whether project should be included**
  - Without Project Condition
  - Alternatives

Phase 1 Report Summary

- **Problems and opportunities**
- **Identify and screen storage options**
  - Surface storage sites
  - Conjunctive use approach
- **Costs and initial benefits of retained options**
- **Describe initial alternatives**
- **Provide focus for Feasibility Study**

Feasibility Study Work Plan

- **Describe initial range of alternatives**
- **Technical studies**
  - Model development and application
  - Field activities
- **Methodologies to identify costs and benefits**
  - Water supply
  - Ecosystem
  - Water quality
  - Flood control
  - Hydropower

Feasibility Study Activities

- Issue NOI/NOP
- Formulate and evaluate alternatives
- Identify recommended plan
- Draft FS Report and EIS/EIR
- Final FS Report and EIS/EIR

Bureau of Reclamation
Mid-Pacific Region

California Department
of Water Resources

Upper San Joaquin River Basin Storage Investigation

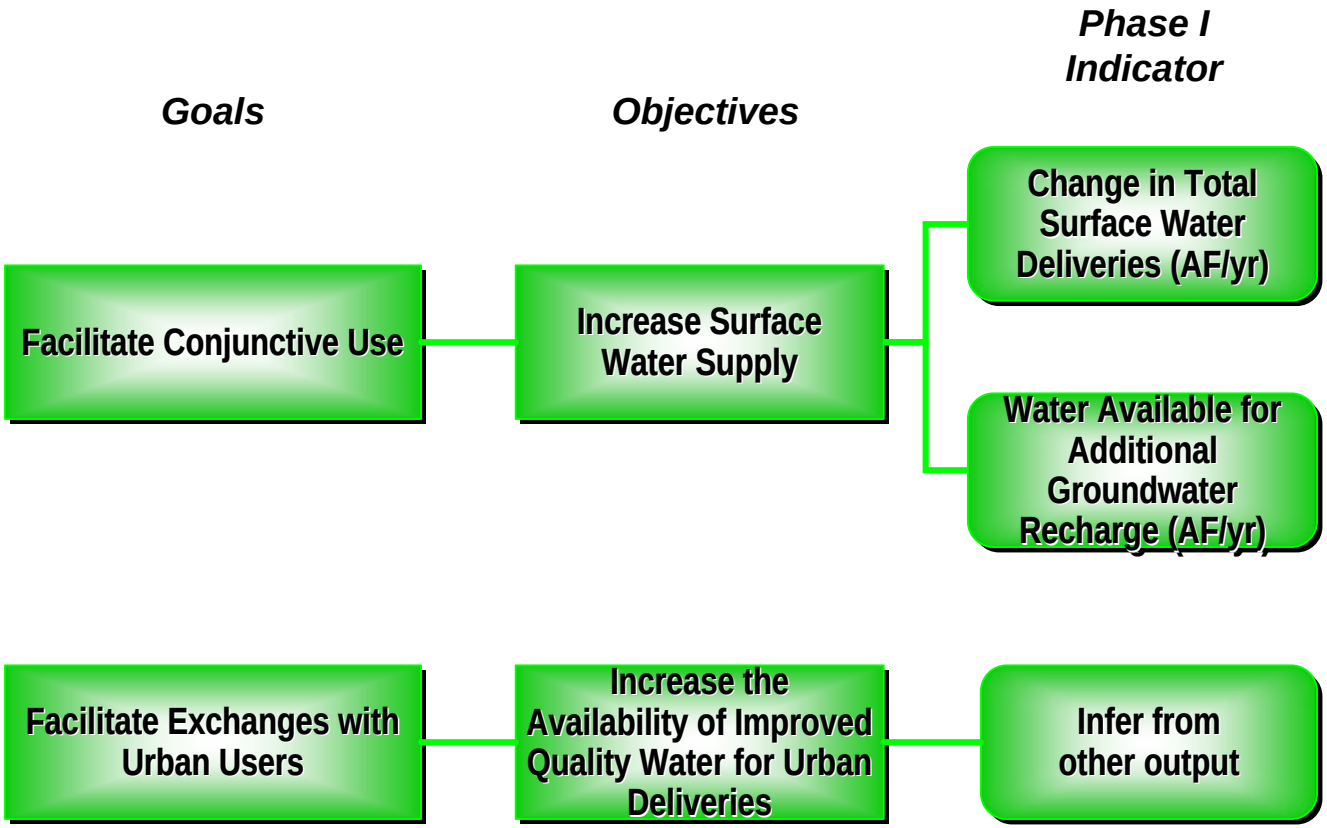
Workshop 5

April 30, 2003

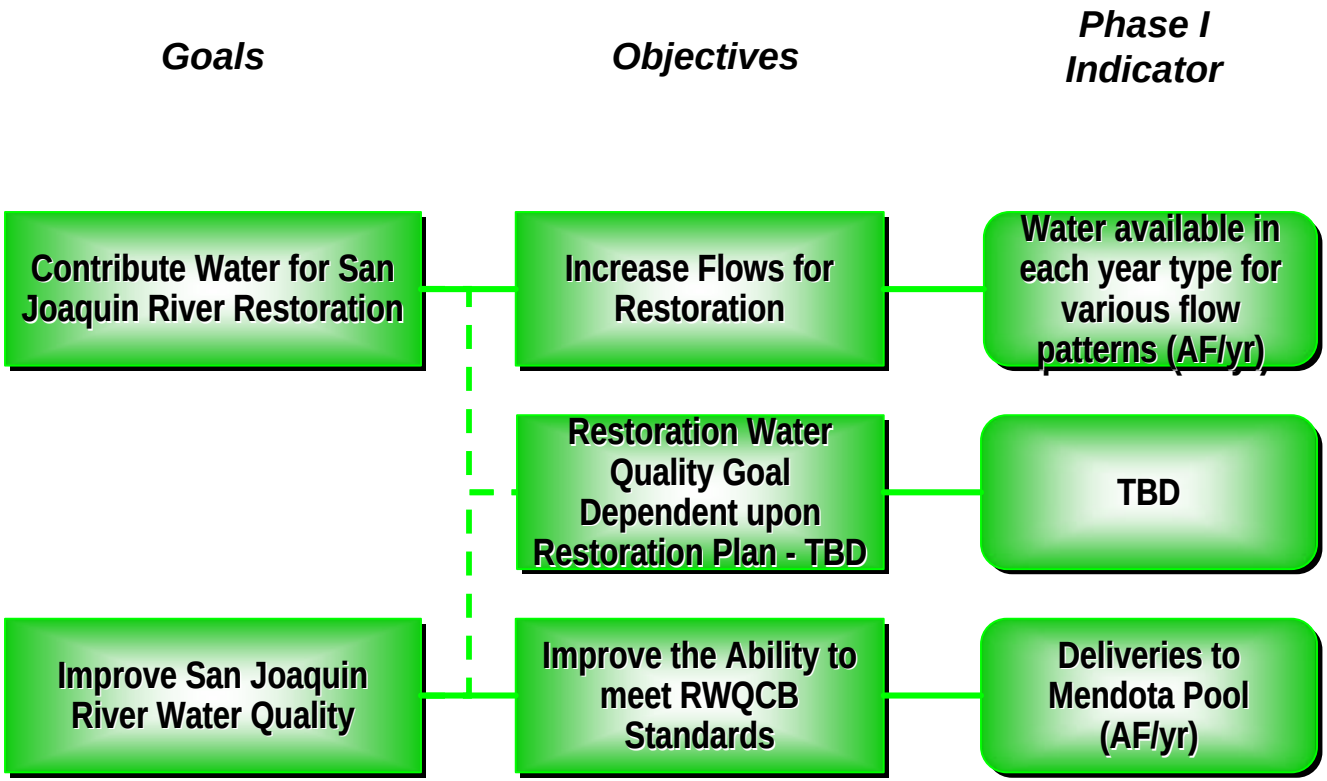
ISI Conjunctive Management Program

- **MOU Between DWR and Local Entity**
- **Phase I - Basin Assessment**
  - Local advisory panel
  - Establish basin objectives
- **Phase II - Project Identification and Evaluation**
  - Basin-wide modeling
  - Feasibility studies and environmental documentation
- **Phase III - Project Implementation**
  - Local approval of feasible projects
  - Subject to funding availability

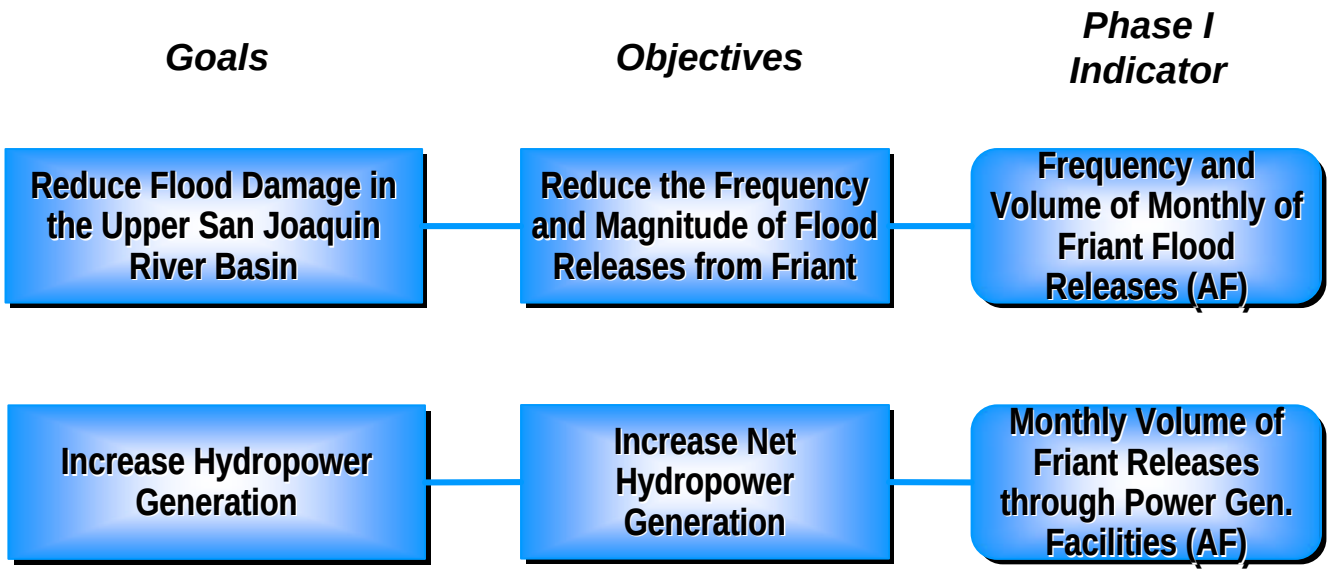
Measuring Functional Equivalence



Measuring Functional Equivalence (continued)



Measuring Functional Equivalence (continued)



Carryover Storage Sensitivity Analysis Findings

Total water available for river demand is decreased

Annual Average Release at Friant Dam in SPA (TAF)

Options	No Carryover WQ	With Carryover WQ	No Carryover RF	With Carryover RF
FR-700	134	100	142	99
TF-1273	181	153	171	154
FG-800	124	93	124	98

Average End-of-September Friant Unit Total Storage (TAF)

Options	No Carryover WQ	With Carryover WQ	No Carryover RF	With Carryover RF
FR-700	398	547	464	626
TF-1273	589	790	672	848
FG-800	464	611	532	664

Carryover Storage Sensitivity Analysis Findings

Ability to make river releases is shifted by year type

Percentage of Time with Release at Friant Dam in SPA

FR-700

San Joaquin Valley Index	No Carryover WQ	With Carryover WQ	No Carryover RF	With Carryover RF
Wet	100%	90%	100%	90%
Above Normal	100%	86%	100%	0%
Below Normal	100%	0%	100%	92%
Dry	100%	100%	100%	100%
Critical	0%	67%	0%	67%

TF-1273

San Joaquin Valley Index	No Carryover WQ	With Carryover WQ	No Carryover RF	With Carryover RF
Wet	100%	90%	100%	90%
Above Normal	100%	86%	100%	86%
Below Normal	100%	92%	100%	92%
Dry	100%	100%	100%	100%
Critical	100%	67%	100%	67%

FG-800

San Joaquin Valley Index	No Carryover WQ	With Carryover WQ	No Carryover RF	With Carryover RF
Wet	100%	90%	100%	90%
Above Normal	100%	86%	100%	0%
Below Normal	100%	92%	100%	92%
Dry	100%	100%	100%	100%
Critical	0%	67%	0%	67%