Summary of Alternative Approaches Considered

Formulation

Phase 2 of CVFPP development focused on identifying a comprehensive array of individual management actions to address one or more of the CVFPP goals. Management actions represent building blocks that can be combined in different ways to form systemwide solutions that collectively address all of the CVFPP goals while satisfying the planning principles. Some of the identified management actions are place-based or physical actions, such as new levees or floodwater storage. Others involve changes to policies, regulations, processes, or institutional arrangements. The comprehensive initial set of management actions identified by DWR and its partners and interested parties were iteratively refined, screened, and consolidated into 94 broad actions. The retained management actions generally fall into the following categories of actions:

- Additional floodplain and reservoir storage
- Storage operations
- Flood protection system modifications
- Operations and maintenance
- Ecosystem functions
- Floodplain management
- Disaster preparedness and flood warning
- Flood fighting, emergency response, and flood recovery
- Policy and regulations
- Permitting
- Finance and revenue

Given the large geographic scope and range of perspectives on solutions to flood management problems in the Central Valley, thousands of potential alternatives could have been formed from the combination of individual management actions. Consequently, a methodology was developed to reduce the number of alternatives to a manageable level while still representing the full range of approaches to resolving the problems and achieving the CVFPP goals. This methodology resulted in the identification of three, fundamentally different approaches for CVFPP implementation:

- Achieve SPFC Design Flow Capacities Approach
- Protect High Risk Communities Approach
- Enhance Flood System Capacity Approach

These preliminary systemwide approaches contribute to the CVFPP goals in different ways and to different degrees, both in magnitude and geographic scale. The systemwide approaches are not intended to be alternatives from which a single, superior alternative can be identified. Rather, the approaches bracket the range of potential actions that could be taken on a systemwide scale, and provide a means of exploring potential benefits, costs, and tradeoffs. The State

Systemwide Investment Approach will incorporate the most promising features and elements of each of the preliminary approaches to balance achievement of the CVFPP goals from a systemwide perspective, consistent with the planning principles (see **Figure 1**).

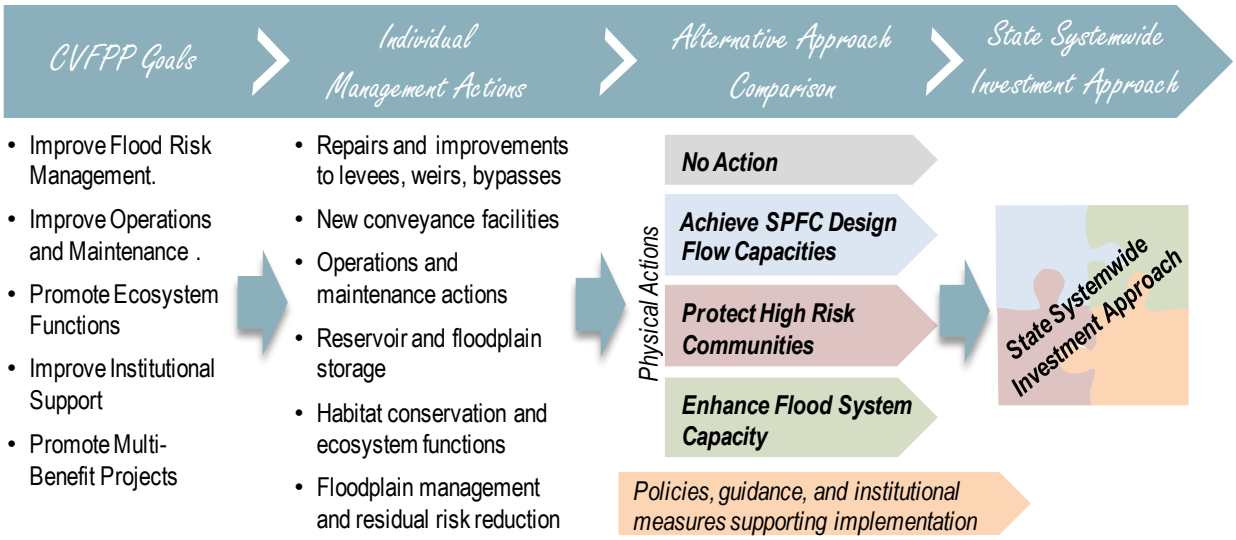


Figure 1– Formulation and Comparison of Alternative Approaches to Flood Management in the Central Valley

Achieve SPFC Design Flow Capacities Approach

Address capacity deficiencies and other conditions associated with existing SPFC facilities, without making major changes to the footprint or operation of those facilities

This approach would entail repairing SPFC facilities to address all levee conditions identified in the Flood Control System Status Report (under preparation by DWR), such that facilities could reliably accommodate the flows for which the existing projects were originally designed and constructed. A significant initial investment would be made to repair levees, correct design deficiencies, and restore (but not enhance) SPFC facilities, within their current facility footprints wherever feasible. Repairs would also be made to non-SPFC facilities that influence the successful operation of the State-federal flood management system. No changes would be made to reservoir operations, or to the operation of existing weirs, bypasses, or other control structures. There would be limited opportunities for ecosystem enhancement as part of facility repairs and structural improvements (waterside berms and incorporation of native vegetation in erosion prevention measures, where feasible).

The level of flood protection provided by facilities of the SPFC would not increase under this approach, but the likelihood of a system failure would be reduced through heavy investments in structural repairs. Long-term O&M costs would improve initially, based on the significant investment in improving facility reliability; however, O&M costs in the long-term would be as under existing conditions because the overall footprint of the system would remain fundamentally unchanged.

Protect High Risk Communities Approach

Focus on protecting populations at highest risk, including urban aeas and small communities

This approach would focus on reducing threats to human life and safety. These critical public safety threats are primarily present in dense urban areas and small communities with deep and/or rapid flooding. A minimum level of flood protection would be provided for existing urban areas (0.5% chance of occurrence) and existing small communities (1% chance of occurrence). Improvement actions would primarily include levee repairs and improvements (in-place), ring levees and floodwalls, and other physical actions. Improvements would focus on addressing flooding originating from the mainstems of the Sacramento and San Joaquin Rivers and their major tributaries (flooding from local sources would not be considered).

No changes would be made to reservoir operations, or to the operation of existing weirs, bypasses, or other control structures. No facility repairs or modifications would be made to increase the level of existing flood protection in areas where deficiencies do not pose immediate threats to public safety. In these areas, SPFC facilities would continue to be maintained and repaired as needed (similar to No Project). There would be limited opportunities for ecosystem enhancement as part of facility repairs and structural improvements (waterside berms and incorporation of native vegetation in erosion prevention measures, where feasible).

Enhance Flood System Capacity Approach

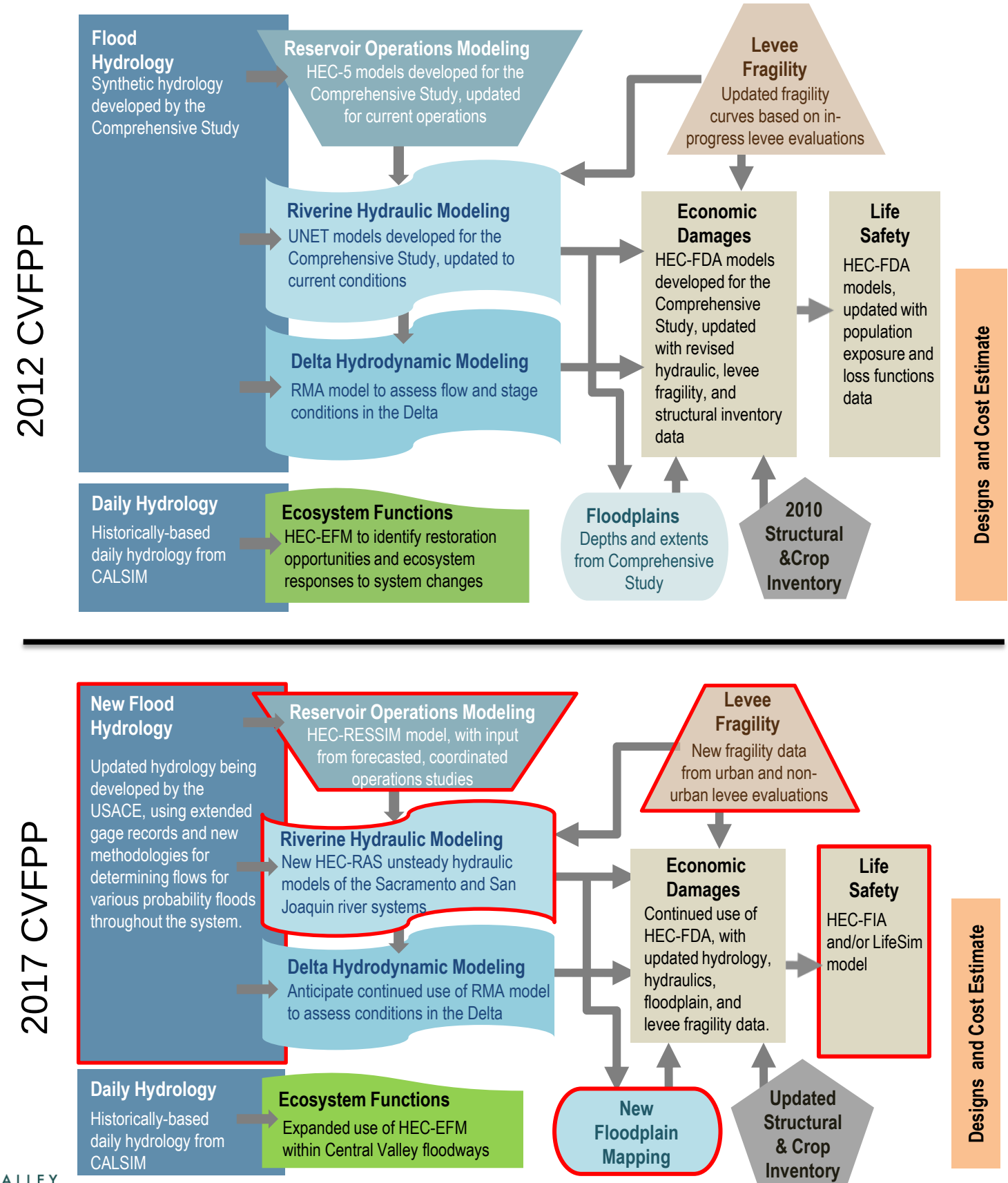
Seek opportunities to achieve multiple benefits through enhancing flood system storage and conveyance capacity

In contrast to the approaches described previously, which focus on improvements that can be implemented primarily within the existing footprint of the flood management system, this approach would include modifications to the footprint and function of the flood management system. These modifications would focus on enhancing the capacity of the flood management system by widening floodways, reconnecting floodplains, and increasing floodwater storage. Increased floodwater storage would be provided through a combination of operational changes to existing reservoirs, new reservoir storage, and modified or new floodplain storage. Enhancing flood system capacity would provide opportunities to achieve multiple benefits in addition to flood risk reduction, such as environmental restoration and related water resources benefits. For example, widening floodways could contribute to the restoration of ecosystem functions while also improving floodwater conveyance; similarly, the reconnection of floodplains could restore natural floodplain processes while also providing floodwater storage.

This approach would generally increase the level of flood protection provided by the system; however, levels of protection would vary widely from location to location. Compared with previous approaches, this approach would provide the greatest opportunities for the restoration of native habitats (including aquatic, riparian, and floodplain habitats) and provide opportunities to improve connectivity and ecosystem functions. It would also provide opportunities to improve water supply reliability through multipurpose reservoir storage projects, conjunctively management ground- and surface-water resources, and groundwater recharge within floodplain storage areas.

Handout 3

Technical Data, Tools, and Analysis Supporting CVFPP Development



2012 CVFPP:

Systemwide evaluations to support the 2012 CVFPP are based on existing available data and tools, with critical updates.

These data and tools are used primarily for evaluation of without-project conditions within the Central Valley flood management system, and the potential effects and benefits of alternative approaches and proposed systemwide investments.

2017 CVFPP and Beyond:

Ongoing multidisciplinary efforts are developing new data and tools for use in the 2017 CVFPP and future updates. New information and tools being developed for future CVFPP updates are depicted in the figure.

KEY:

CALSIM	= California Water Resources Simulation Model
Comprehensive Study	= Sacramento and San Joaquin River Basins Comprehensive Study
HEC	= USACE Hydrologic Engineering Center
HEC-5	= Reservoir Operations Simulation Model (predecessor to HEC-RESSIM)
HEC-EFM	= Ecosystem Functions Model
HEC-FDA	= Flood Damage Analysis Model
HEC-FIA	= Flood Impact Analysis Model
HEC-RAS	= River Analysis System Model
HEC-RESSIM	= Reservoir Operations Simulation Model
Fragility Curve	= Describes likelihood of levee breach at different flood stages
RMA model	= Model of Delta hydrodynamics
UNET	= One-Dimensional Unsteady Network Flow Model (predecessor to HEC-RAS)

CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

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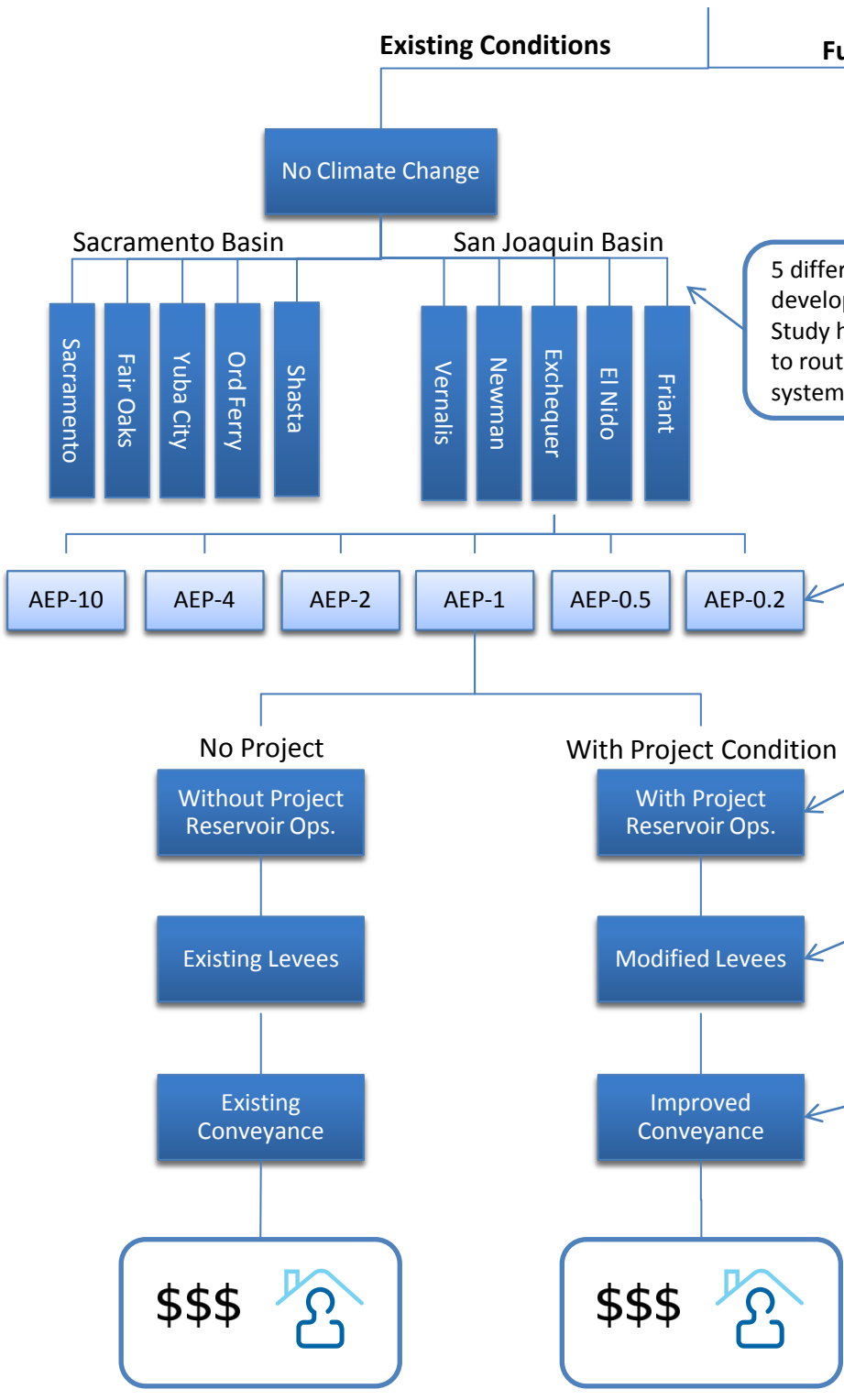
June 2011

PRELIMINARY DRAFT – Subject to Change

Handout 4

PRELIMINARY DRAFT – CVFPP Study Matrix

State Systemwide Investment Approach



A full Climate Change suite of scenarios was not developed. Instead a Climate Change Threshold Approach was developed to identify what future conditions could stress the existing flood management system.

5 different storm centerings developed in the Comp Study hydrology were used to route flow through the system.

Flood volumes for 6 different annual exceedence probabilities were run for each storm centering for a total of 30 loading scenarios for each basin.

Management actions in Implementation Phase III such as new storage facilities or reservoir operating rules could reduce peak flood flows.

Management actions in Implementation Phase I such as new or improved levees could reduce the probability of damaging flood waters impacting areas.

Management actions in Implementation Phases I, II, and III could improve system conveyance and transitory storage by adding system flexibility to further reduce the probability of damaging flood waters impacting areas.

Additional locally implemented residual risk management actions such as raising structures or implementing emergency response plans and actions could result in additional economic and life loss risk reductions.

Analysis Summary

Element	Tool	Level of Detail
Meteorological	Comp Study Storm Centerings	L
Hydrological / Runoff	Comp Study Synthetic Storm Centerings & Frequencies	L
Reservoirs Analysis	Updated HEC-5	M
System Performance Parameters	ULE / NULE Updated Levee Reliability / Fragility Data & Approach	M
Hydraulic Routing	Updated UNET	M
Estuary Hydrodynamics	RMA Delta Model	H
Floodplain Inundation	Updated FLO-2D Parcel / Channel Relationships	M
Economic Risk	HEC-FDA with updated 2010 Parcel /Structural Inventory Data	H
Life Loss Risk	2000 Census Population Data	M

CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

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Handout 4

PRELIMINARY DRAFT – CVFPP Study Matrix

Achieve SPFC Design Capacity Approach

Existing Conditions

No Climate Change

Sacramento Basin: Sacramento, Fair Oaks, Yuba City, Ord Ferry, Shasta

San Joaquin Basin: Vernalis, Newman, Exchequer, El Nido, Friant

5 different storm centerings developed in the Comp Study hydrology were used to route flow through the system.

AEP-10, AEP-4, AEP-2, AEP-1, AEP-0.5, AEP-0.2

Flood volumes for 6 different annual exceedence probabilities were run for each storm centering for a total of 30 loading scenarios for each basin.

No Project

Without Project Reservoir Ops.

Existing Levees

Existing Conveyance

$$$

With Project Condition

Without Project Reservoir Ops.

Modified Levees

Maintained Conveyance

$$$

This approach would not include management actions such as new storage facilities or modified reservoir operations rules.

Identified levee deficiencies would be addressed with management actions including structural repairs. Repairs would bring levees up to original 1955-1957 design standards.

This approach would not include improved conveyance, but would implement management actions such as bypass and weir rehabilitation or dredging to maintain conveyance to original 1955-1957 design standards.

Additional locally implemented residual risk management actions such as raising structures or implementing emergency response plans and actions could result in additional economic and life loss risk reductions.

Future Conditions

No Climate Change

A full Climate Change suite of scenarios was not developed. Instead a Climate Change Threshold Approach was developed to identify what future conditions could stress the existing flood management system.

Analysis Summary

Element	Tool	Level of Detail
Meteorological	Comp Study Storm Centerings	L
Hydrological / Runoff	Comp Study Synthetic Storm Centerings & Frequencies	L
Reservoirs Operations	Updated HEC-5	M
System Performance Parameters	ULE / NULE Updated Levee Reliability / Fragility Data & Approach	M
Hydraulic Routing	Updated UNET	M
Estuary Hydrodynamics	RMA Delta Model	H
Floodplain Inundation	Updated FLO-2D Parcel / Channel Relationships	M
Economic Risk	HEC-FDA with updated 2010 Parcel/ Structural Inventory Data	H
Life Loss Risk	2000 Census Population Data	M

CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

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Handout 4

PRELIMINARY DRAFT – CVFPP Study Matrix

Protect High Risk Communities Approach

Existing Conditions

No Climate Change

Sacramento Basin

Sacramento | Fair Oaks | Yuba City | Ord Ferry | Shasta

San Joaquin Basin

Vernalis | Newman | Exchequer | El Nido | Friant

5 different storm centerings developed in the Comp Study hydrology were used to route flow through the system.

AEP-10 | AEP-4 | AEP-2 | AEP-1 | AEP-0.5 | AEP-0.2

Flood volumes for 6 different annual exceedence probabilities were run for each storm centering for a total of 30 loading scenarios for each basin.

No Project

Without Project Reservoir Ops.

Existing Levees

Existing Conveyance

$$$

With Project Condition

Without Project Reservoir Ops.

Modified Levees

Existing Conveyance

$$$

Performance of the Protect High Risk Communities approach was post-processed and qualitatively assessed using the No Project and Maintain SPFC Design Capacity approach simulation results.

This approach would not include management actions such as new storage facilities or modified reservoir operations rules.

Management actions including structural repairs or new levees would provide small communities with a 100-year level of protection and urban communities with a 200-year level of protection.

This approach would not include management actions such as bypass and weir rehabilitation or dredging to maintain conveyance.

Additional locally implemented residual risk management actions such as raising structures or implementing emergency response plans and actions could result in additional economic and life loss risk reductions.

Future Conditions

No Climate Change

A full Climate Change suite of scenarios was not developed. Instead a Climate Change Threshold Approach was developed to identify what future conditions could stress the existing flood management system.

Analysis Summary

Element	Tool	Level of Detail
Meteorological	Comp Study Storm Centerings	L
Hydrological / Runoff	Comp Study Synthetic Storm Centerings & Frequencies	L
Reservoirs Operations	Updated HEC-5	M
System Performance Parameters	ULE / NULE Updated Levee Reliability / Fragility Data & Approach	M
Hydraulic Routing	Updated UNET	M
Estuary Hydrodynamics	RMA Delta Model	H
Floodplain Inundation	Updated FLO-2D Parcel / Channel Relationships	M
Economic Risk	HEC-FDA with updated 2010 Parcel/ Structural Inventory Data	H
Life Loss Risk	2000 Census Population Data	M

CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Handout 4

PRELIMINARY DRAFT – CVFPP Study Matrix

Enhance Flood System Capacity Approach

Existing Conditions

No Climate Change

Sacramento Basin: Sacramento, Fair Oaks, Yuba City, Ord Ferry, Shasta

San Joaquin Basin: Vernalis, Newman, Exchequer, El Nido, Friant

5 different storm centerings developed in the Comp Study hydrology were used to route flow through the system.

AEP-10, AEP-4, AEP-2, AEP-1, AEP-0.5, AEP-0.2

Flood volumes for 6 different annual exceedence probabilities were run for each storm centering for a total of 30 loading scenarios for each basin.

Future Conditions

No Climate Change

A full Climate Change suite of scenarios was not developed. Instead a Climate Change Threshold Approach was developed to identify what future conditions could stress the existing flood management system.

No Project

Without Project Reservoir Ops. → Existing Levees → Existing Conveyance → $$$

With Project Condition

With Project Reservoir Ops. → Modified Levees → Improved Conveyance → $$$

Management actions in Implementation Phase III such as new storage facilities or reservoir operating rules could reduce peak flood flows. Evaluations included 17 scenarios for the Sacramento Basin and 33 scenarios for the San Joaquin Basin.

Management actions in Implementation Phase I such as new or improved levees could reduce the probability of damaging flood waters impacting areas.

Management actions in Implementation Phases I, II, and III could improve system conveyance and transitory storage by adding system flexibility. Evaluations included 19 scenarios for the Sacramento Basin and 8 scenarios for the San Joaquin Basin.

Additional locally implemented residual risk management actions such as raising structures or implementing emergency response plans and actions could result in additional economic and life loss risk reductions.

Individual elements of the Enhance Flood System Capacity approach were evaluated with modeling scenarios, however performance of the entire approach was post-processed and qualitatively assessed using the No Project condition and Maintain SPFC Design Capacity approach simulation results.

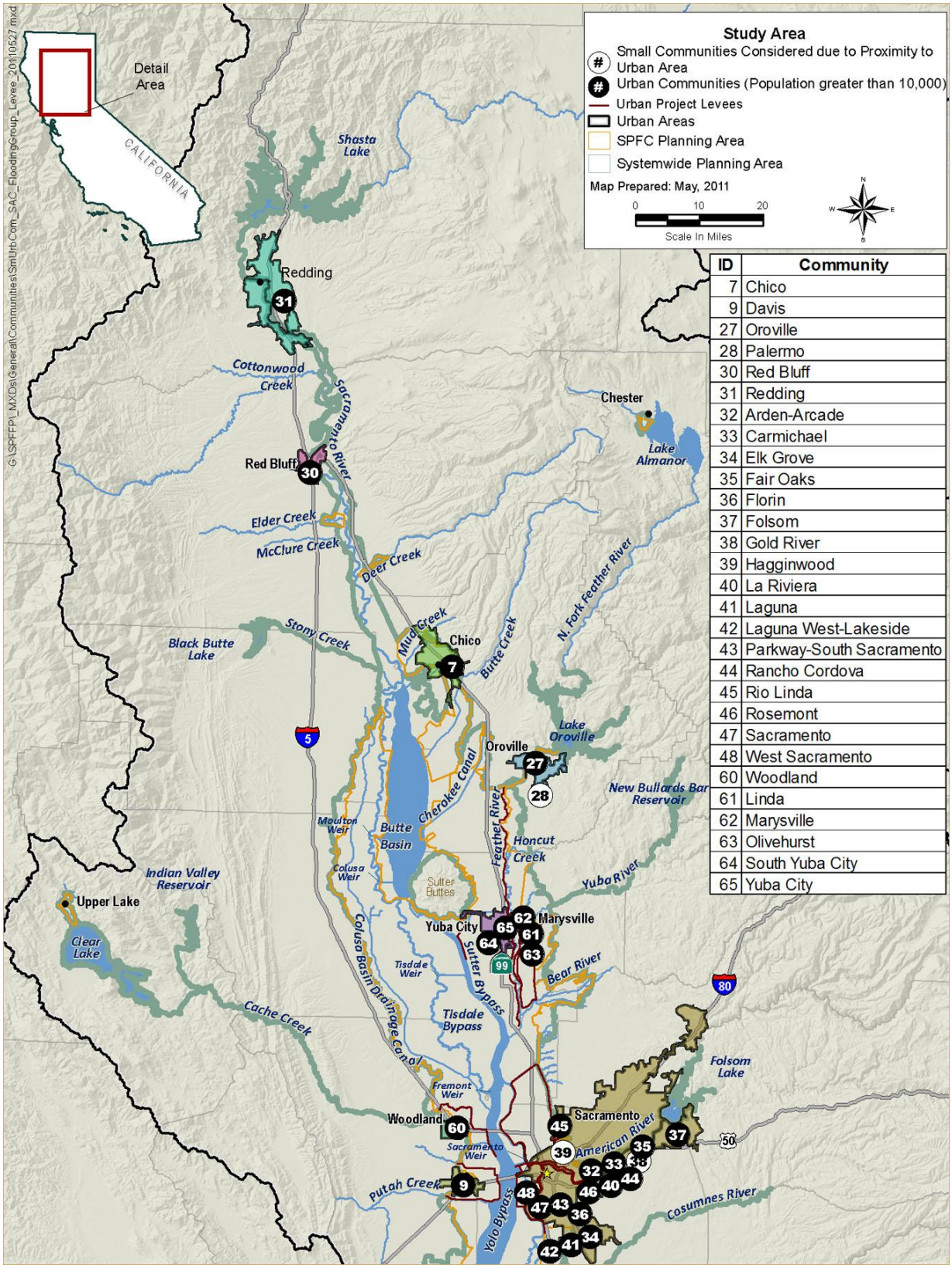
CENTRAL VALLEY FLOOD MANAGEMENT PLANNING PROGRAM

FloodSAFE CALIFORNIA

Analysis Summary

Element	Tool	Level of Detail
Meteorological	Comp Study Storm Centerings	L
Hydrological / Runoff	Comp Study Synthetic Storm Centerings & Frequencies	L
Reservoirs Operations	Updated HEC-5	M
System Performance Parameters	ULE / NULE Updated Levee Reliability / Fragility Data & Approach	M
Hydraulic Routing	Updated UNET	M
Estuary Hydrodynamics	RMA Delta Model	H
Floodplain Inundation	Updated FLO-2D Parcel / Channel Relationships	M
Economic Risk	HEC-FDA with updated 2010 Parcel/ Structural Inventory Data	H
Life Loss Risk	2000 Census Population Data	M

Handout 5

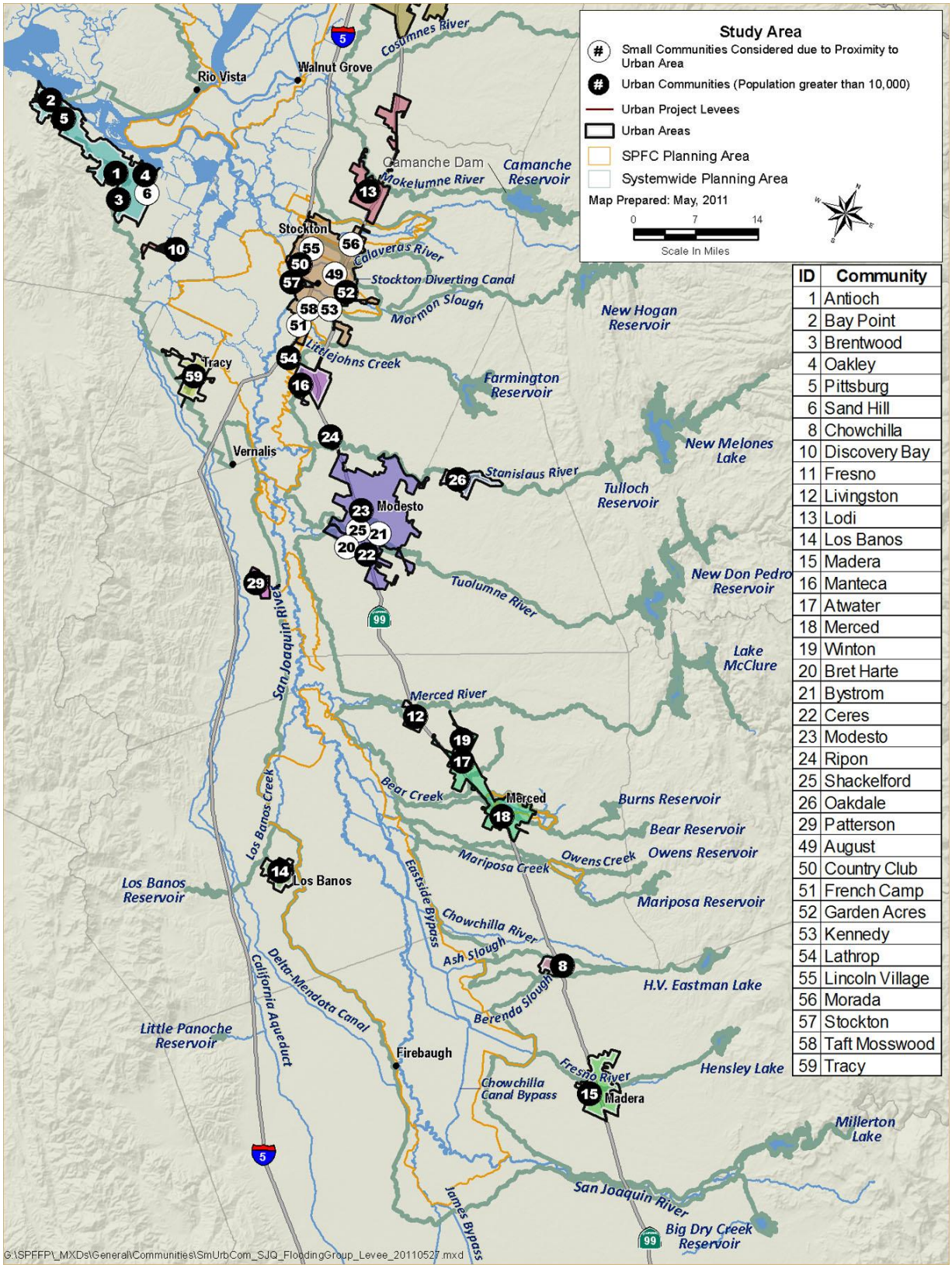


ID	Community
7	Chico
9	Davis
27	Oroville
28	Palermo
30	Red Bluff
31	Redding
32	Arden-Arcade
33	Carmichael
34	Elk Grove
35	Fair Oaks
36	Florin
37	Folsom
38	Gold River
39	Hagginwood
40	La Riviera
41	Laguna
42	Laguna West-Lakeside
43	Parkway-South Sacramento
44	Rancho Cordova
45	Rio Linda
46	Rosemont
47	Sacramento
48	West Sacramento
60	Woodland
61	Linda
62	Marysville
63	Olivehurst
64	South Yuba City
65	Yuba City

Urban Area Within the Sacramento River Basin

PRELIMINARY DRAFT – Subject to Change

Handout 5

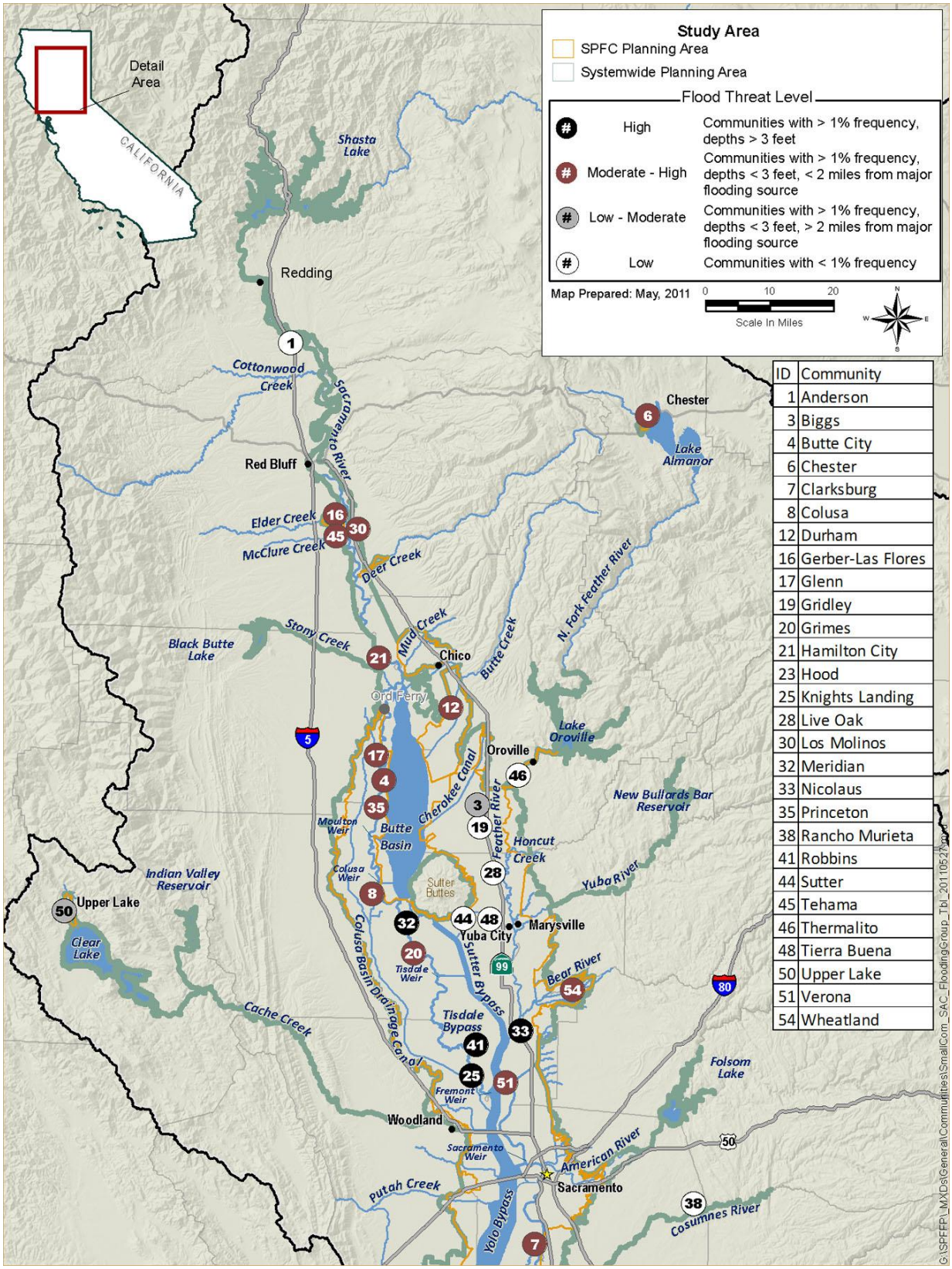


ID	Community
1	Antioch
2	Bay Point
3	Brentwood
4	Oakley
5	Pittsburg
6	Sand Hill
8	Chowchilla
10	Discovery Bay
11	Fresno
12	Livingston
13	Lodi
14	Los Banos
15	Madera
16	Manteca
17	Atwater
18	Merced
19	Winton
20	Bret Harte
21	Bystrom
22	Ceres
23	Modesto
24	Ripon
25	Shackelford
26	Oakdale
29	Patterson
49	August
50	Country Club
51	French Camp
52	Garden Acres
53	Kennedy
54	Lathrop
55	Lincoln Village
56	Morada
57	Stockton
58	Taft Mosswood
59	Tracy

Urban Areas Within the San Joaquin River Basin

PRELIMINARY DRAFT – Subject to Change

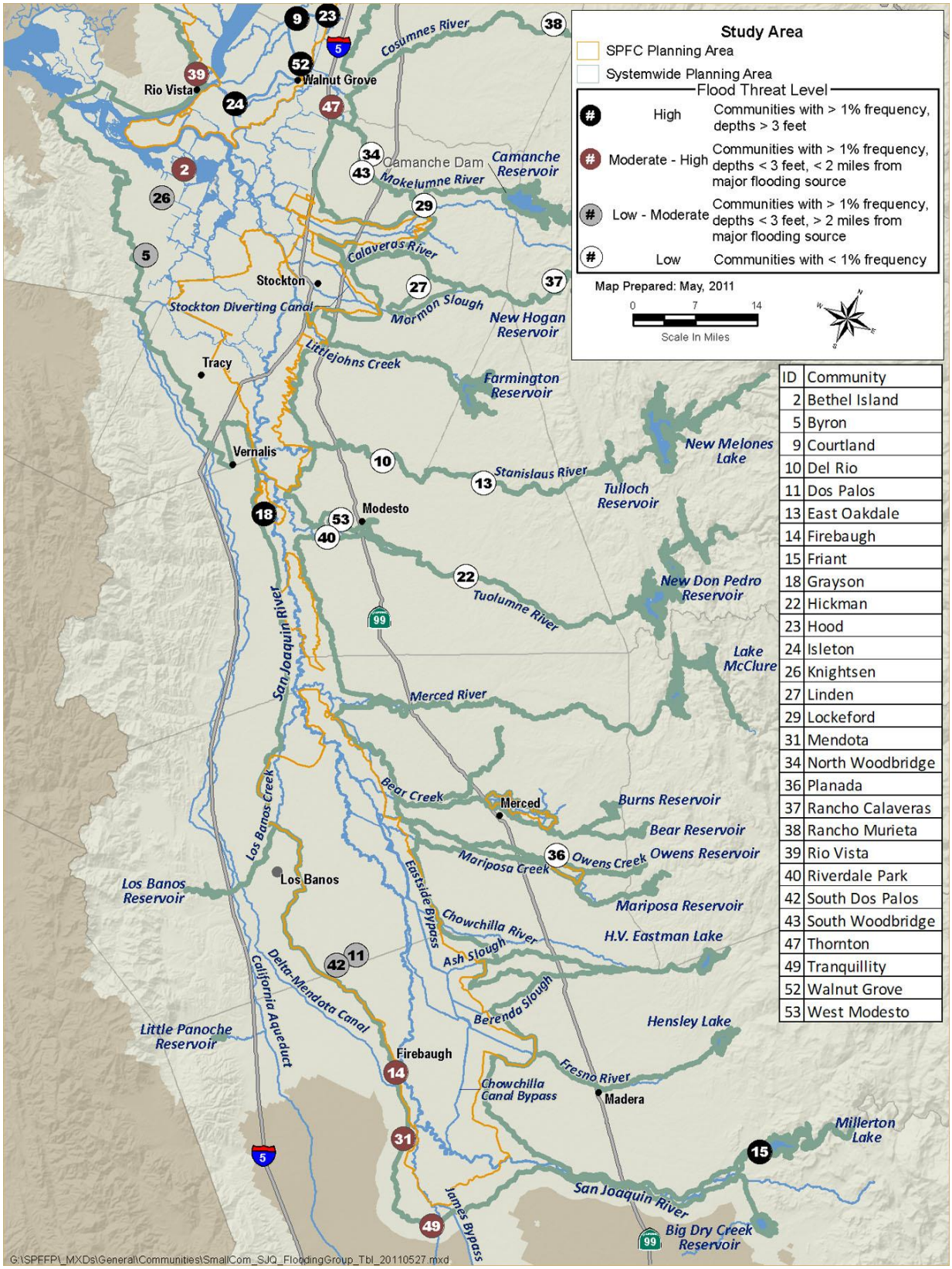
Handout 5



Small Communities Within the Sacramento River Basin

PRELIMINARY DRAFT – Subject to Change

Handout 5



Small Communities Within the San Joaquin River Basin

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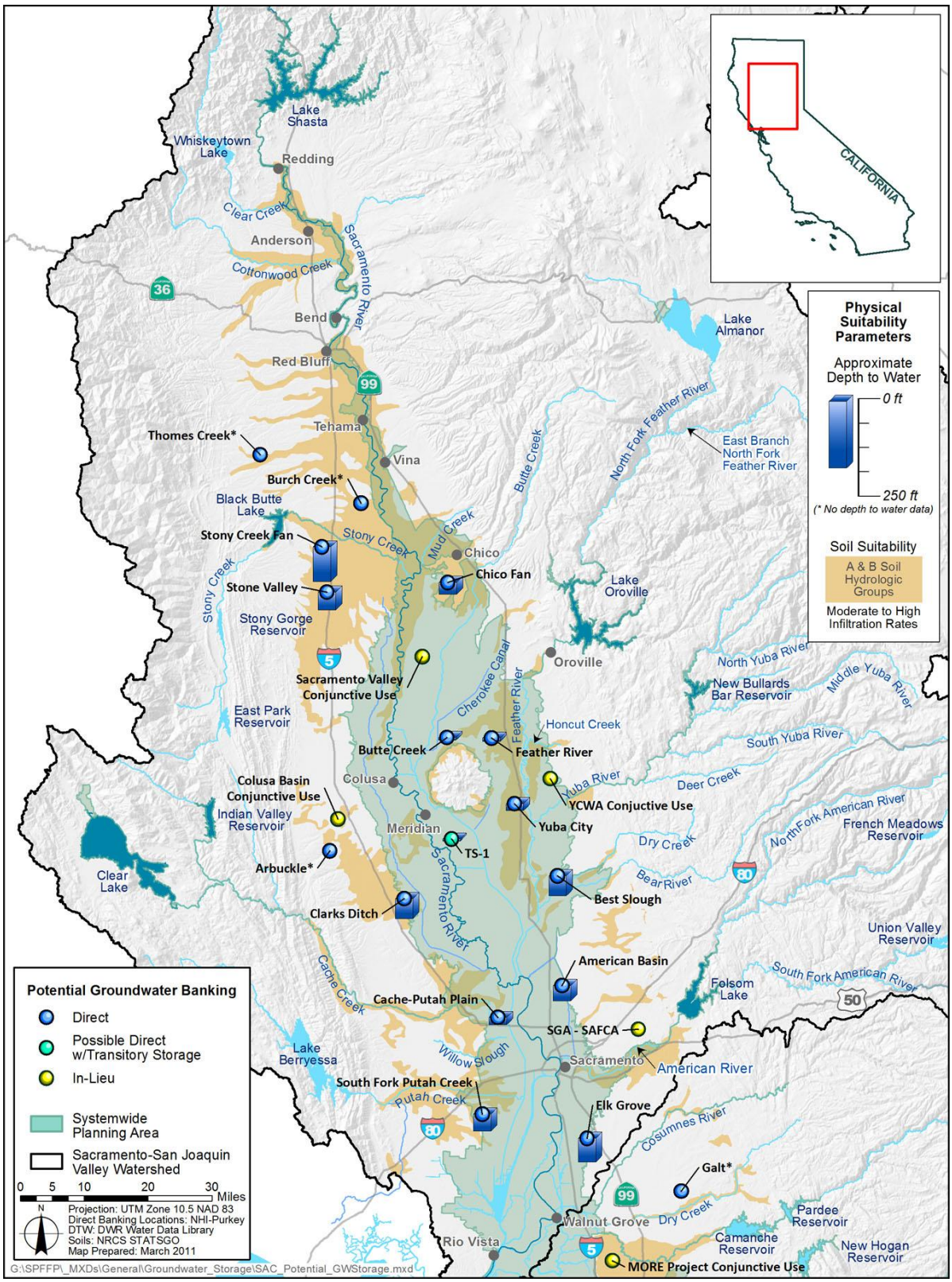
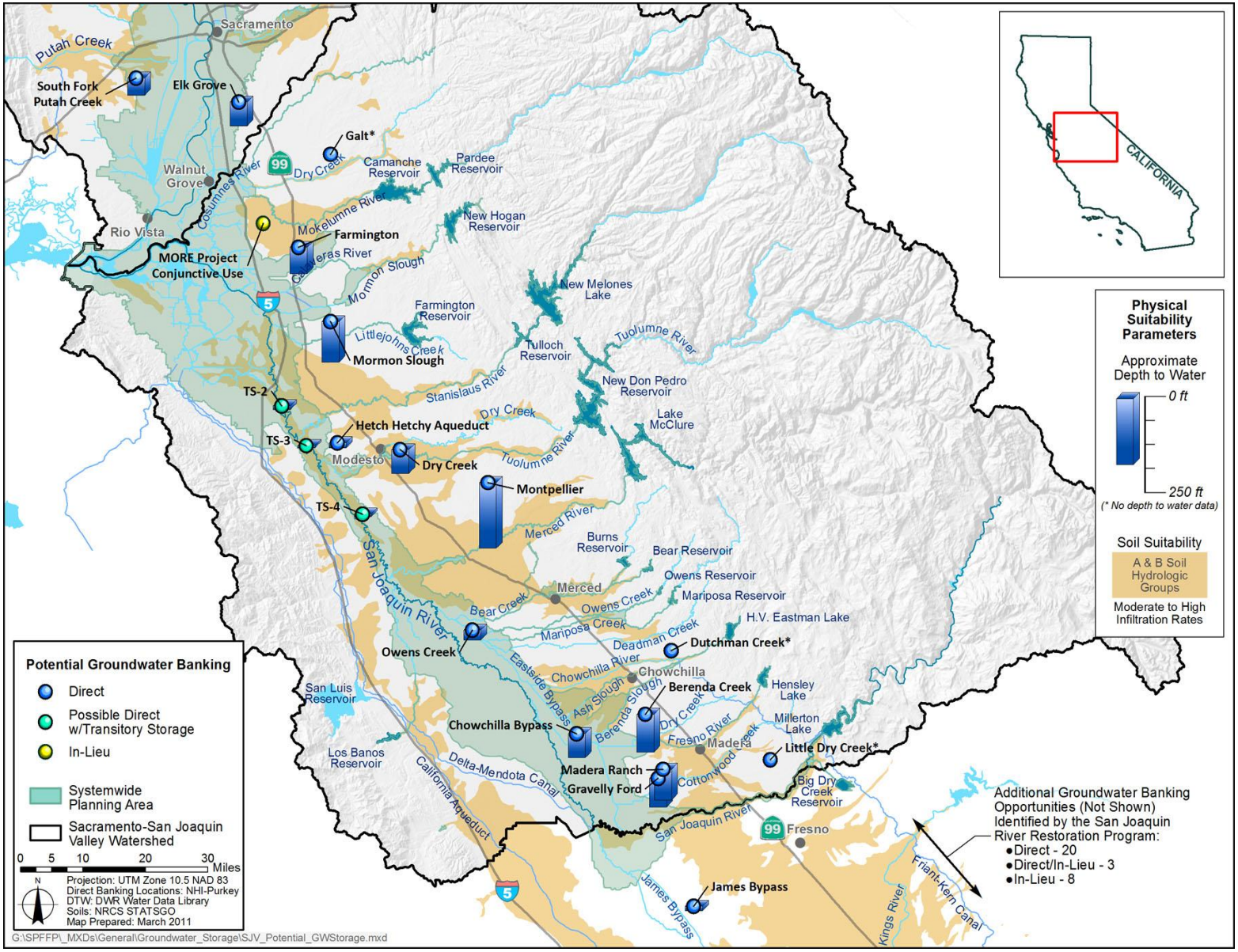


Groundwater Recharge Opportunities Identified in the Sacramento River Basin

Handout 6



Groundwater Recharge Opportunities Identified in the San Joaquin River Basin

PRELIMINARY DRAFT – Subject to Change

Handout 7

Comparison of Preliminary Systemwide Approach Contributions to CVFPP Goals

Goal or Measurement	Preliminary Systemwide Approaches		
	Achieve SPFC Design Capacity	**Protect High Risk Communities**	**Enhance Flood System Capacity**
Contributions to Primary Goal - Improve Flood Risk Management			
– Level of Flood Protection	**Varies throughout system** • SPFC reliably passes design flow capacities • Levels of flood protection associated with SPFC design flow capacities vary throughout the system	**High in urban areas and small communities, varies elsewhere** • Urban areas achieve protection from a 0.5%-annual-chance flood • Small communities achieve protection from a 1%-annual-chance flood • No change in level of flood protection in other areas of the system	**Overall higher protection, but varies throughout system** • Overall increased levels of flood protection throughout system reflecting improved capacity to manage flood peaks through enhanced storage and conveyance
– Life Safety (focused on populations at risk)	**Some Improvement** • Minimal improvement in urban areas • Improvement in some small communities protected by SPFC	**Highest Improvement** • Substantial improvement in urban areas • Improvement in all small communities	**Improvement Varies** • Improvement in urban areas • Some improvement in small communities, but magnitude varies
– Economic Damages	**Reduction in Rural Area Damages** • Minimal reduction in economic damages because most improvements would benefit rural areas	**Reduction in Urban and Small Community Damages** • Substantial reduction due to focus on protecting urban areas and small communities	**Reduction in Urban and Rural Area Damages** • Overall reduction due to increased storage and conveyance, but varies throughout system
Contributions to Supporting Goals			
Improve Operations and Maintenance	• **Initial decrease in O&M costs** due to investments in SPFC reconstruction (addresses deferred maintenance) • Long-term O&M costs remain high	• **No significant change** in long-term costs for existing SPFC facilities • Potential cost increase due to the construction of new facilities to protect small communities	• **Decrease in long-term costs** due to modifications that make system more compatible with natural geomorphic processes and facilitate vegetation management, and removal of facilities
Promote Ecosystem Functions	• **Limited opportunities** to integrate ecosystem restoration into in-place repairs to SPFC facilities	• **Some opportunities** to integrate restoration into in-place repairs in urban areas, and new facilities protecting small communities	• **Substantial opportunities to** improve ecosystem functions, fish passage, and the quantity, quality, and diversity of habitats
Improve Institutional Support	Policy and institutional management actions were not evaluated as part of the preliminary systemwide approaches		
Promote Multi-Benefit Projects	• **Very limited opportunities** to integrate other benefits into repairs to SPFC facilities	• **Limited opportunities** to integrate other benefits into repairs, improvements, and new levees	• **Opportunities** to integrate water quality, groundwater recharge, recreation, power, and other benefits

Key: O&M = Operations and maintenance SPFC = State Plan of Flood Control

Comparison of Preliminary Systemwide Efficiency and Sustainability

	Achieve SPFC Design Capacity	Protect High Risk Communities	Enhance Flood System Capacity
Efficiency (Cost and Timeframe to Achieve Benefits and Meet Legislated Objectives)			
Capital Cost	**Very High** due to magnitude of levee reconstruction throughout system $$-$$$ TBD	**High** due to magnitude of improvements in urban areas and small communities $-$$ TBD	**Very High** due to magnitude of flood system modifications (storage and conveyance expansion) $$$-$$$ TBD
Annual Costs	**High** Initial decrease in O&M costs due to investments in SPFC reconstruction, but long-term costs remain high	**High** Some reduction in urban areas, but O&M costs for the system remain similar to existing conditions	**Low-Moderate** Flood system capacity expansion and facilities removal would reduce erosion/sedimentation and other chronic O&M challenges
Estimated Implementation Timeframe	**15-20 years**	**10-15 years**	**20+ years**
Ability to Meet Objectives in Flood Legislation	**Partially meets** Limited contributions to environmental & water supply objectives; does not achieve high level of urban flood protection	**Partially meets** Limited contributions to environmental and water supply objectives	**Mostly Meets** Contributes to all objectives, but at highest cost and with substantial impacts to existing land uses (potentially low acceptability)
Sustainability (Financial, Environmental, and Social)			
Overall Sustainability	**Low**	**Low**	**Medium**
– Financial	• Very high upfront and high long-term costs	• High upfront and long-term costs	• Very high upfront and lower long-term costs
– Environmental	• Some opportunities to improve habitat connectivity, quality, quantity, and bio-diversity	• Limited opportunities to improve habitat connectivity, quality, quantity, and bio-diversity	• Highest opportunities to improve habitat connectivity, quality, quantity, and bio-diversity
– Social	• Potential to encourage new development in floodplains due to extensive levee improvements in non-urban areas • Some land use impacts due to acquisition / easements to accommodate SPFC reconstruction • Does not improve flood system resiliency (ability to adapt)	• Some potential to encourage new development in floodplains within and adjacent to urban and small community improvements • Some land use impacts due to acquisition / easements for new or improved facilities • Does not improve flood system resiliency (ability to adapt to climate change)	• Considerable impacts to existing land uses due to floodway expansion and facility removal • Some potential to encourage new development in floodplains due to improved level of flood protection • Improves flood system resiliency (ability to adapt to climate change)

Key: O&M = Operations and maintenance SPFC = State Plan of Flood Control