CalSim–CoSANA Integration for Sacramento Regional Water Bank (SRWB) Modeling

CWEMF 2024

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Presenters:

Stantec – Dr. Puneet Khatavkar

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Agenda

- Water Bank Analysis Framework *(Puneet)*
- Modeling Overview & Demand and Supply Assumptions *(Puneet/Jingnan)*
- CalSim-CoSANA Updates *(Puneet/Jingnan)*
- Groundwater Impacts and Metrics for Analysis *(Puneet/Jingnan)*

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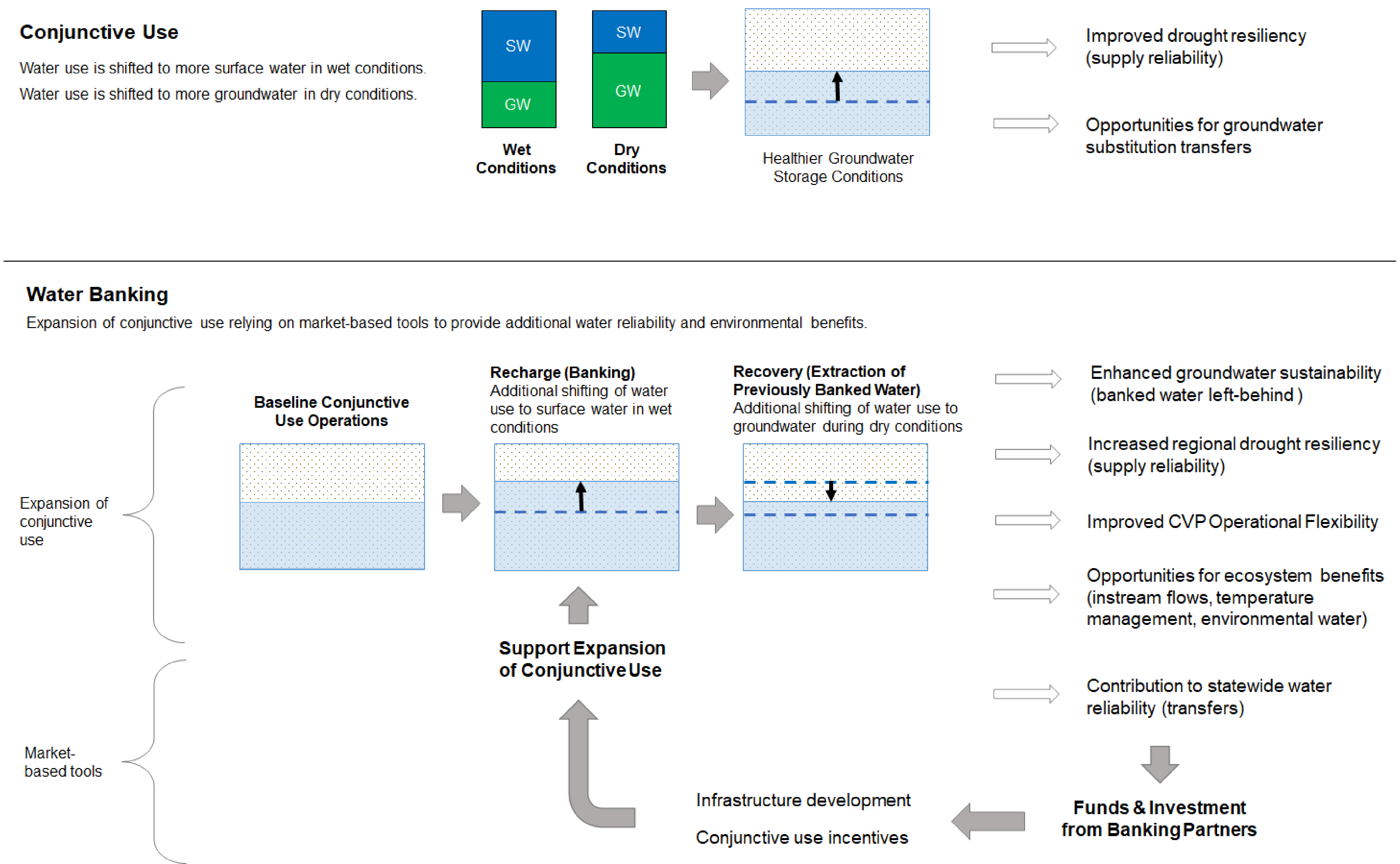
Water Bank Analysis Framework

The Big Story - The Water Bank is an Expansion of Conjunctive Use Operations



Modeling Overview & Demand and Supply Assumptions

CalSim 3 and CoSANA Key Modeling Assumptions

Item	CalSim 3 (Draft LTO 2024 Model)	CoSANA (GSPs Exiting Conditions with Extension to WY2023)
Simulation period	• 100-year (Oct 1921- Sep 2021)	• 54-year (WY 1970 – 2023)
Climate and Hydrology	• Historical adjusted hydrology, existing upstream flow regulations, and current sea levels reflecting sea level rise.	• 54-year Hydrology (Same as WY 1970 – 2023)
Land use	• Average irrigated crop area for 10-year period 2004-2013.	• 2015 Sacramento County survey
Urban Demands	• 2020 UWMPs • Single monthly pattern for all year types based on production data from DWR's PWSS database or UWMP data when available	• Existing Urban Demands per UWMP (2015)
Urban Water Supply Mix	• 2020 UWMPs • Stakeholder inputs for American River Basin	• 2015 UWMP
Agricultural Demands	• Land use based. • Developed using CalSimHydro (with built-in IWFM Demand Calculator)	• Estimated by Model based on current crop mix and irrigation practices and historical hydrology
Agricultural Supply Mix	• Agricultural Water Management Plans	• Agricultural Water Management Plans

Alignment of CalSim 3 and CoSANA Modeling Assumptions

- The simulation period is set to 50-year period from Oct 1969 to September 2021 to reflect the period of overlap between the simulation periods for the two models.
- Urban demand units in the North and South American groundwater subbasins are mapped between both models and as appropriate, aggregated or disaggregated, to align demand and water supply representations.
- A consistent set of urban demands are used in both models, including using a single repeating monthly demand pattern for each demand unit.
- Contribution from each water supply source to meet urban demands for each demand unit is determined in CalSim 3 and then passed to CoSANA.
- Representation of agricultural demands in the Study Area are unaltered in both models.
    - The effects of agricultural demands on surface water and groundwater budgets are simulated by CoSANA and are reflected in the streamflow accretions.
    - Agricultural demands are calculated using similar methodology for both models, with some differences in land use and crop information assumptions .
    - Because the focus of the Project is on M&I conjunctive use.

Agency-Specific Assumptions for Water Bank Operations

RWA Regional Water Authority — Building Alliances in Northern California

Sacramento Regional WATER BANK — A Sustainable Storage & Recovery Program

District	CoSANA District ID	CalSim Demand Units	Typical Water Use
Sac_Suburban_South	SSWDSOU	26N_NU4	SW-GW

Potential Water Bank Participation

Recharge:	Yes
Recovery:	No

Histroical Water Use (TAF)

Calendar Year	GW	SW	Total	GW%	SW%
2011	11.38	4.08	15.46	74%	26%
2012	9.83	6.46	16.30	60%	40%
2013	16.28	0.00	16.28	100%	0%
2014	13.77	0.00	13.77	100%	0%
2015	11.72	0.00	11.72	100%	0%
2016	12.19	0.42	12.61	97%	3%
2017	12.43	1.30	13.73	91%	9%
2018	13.34	0.00	13.34	100%	0%
2019	7.08	6.40	13.48	53%	47%
2020	14.11	0.39	14.50	97%	3%
2021	14.22	0.00	14.22	100%	0%
2022	13.72	0.00	13.72	100%	0%

Baseline Data

Actual 2019 - Wet Year Use (TAF)

GW	SW	Total	GW %	SW %
7.08	6.40	13.48	53%	47%

Actual 2022 - Dry Year Use (TAF)

GW	SW	Total	GW %	SW %
13.72	0.00	13.72	100%	0%

GSPs Current Conditions - Wet Year Use (TAF)

GW	SW	Total	GW %	SW %
10.68	3.36	14.04	76%	24%

GSPs Current Conditions - Dry Year Use (TAF)

GW	SW	Total	GW %	SW %
13.24	0.80	14.04	94%	6%

Agency WB Baseline - Wet Year Use (TAF)

GW	SW	Total	GW %	SW %
11.87	3.96	15.83	75%	25%

Agency WB Baseline - Dry Year Use (TAF)

GW	SW	Total	GW %	SW %
16.07	0.00	16.07	100%	0%

Water Bank - 65/55 Scenario

Wet Year - Recharge Action (TAF)

Additional SW Use	Required Improvements
11.6	Existing capacity
Source	Fairbairn/Sac River,

Dry Year - Recovery Action (TAF)

Additional GW Use	Required Improvements
0.0	Existing capacity
Source	

Agency Wet Year Use with WB Recharge (TAF)

GW	SW	Total	GW %	SW %
0.29	15.54	15.83	2%	98%

Agency Dry Year Use with WB Recovery (TAF)

GW	SW	Total	GW %	SW %
16.07	0.00	16.07	100%	0%

Water Bank - 95/95 Scenario

Wet Year - Recharge Action (TAF)

Additional SW Use	Required Improvements
7.6	NA
Source	Fairbaim/Sac River,

Dry Year - Recovery Action (TAF)

Additional GW Use	Required Improvements
0.00	NA
Source	

Agency Wet Year Use with WB Recharge (TAF)

GW	SW	Total	GW %	SW %
4.27	11.56	15.83	27%	73%

Agency Dry Year Use with WB Recovery (TAF)

GW	SW	Total	GW %	SW %
16.07	0.00	16.07	100%	0%

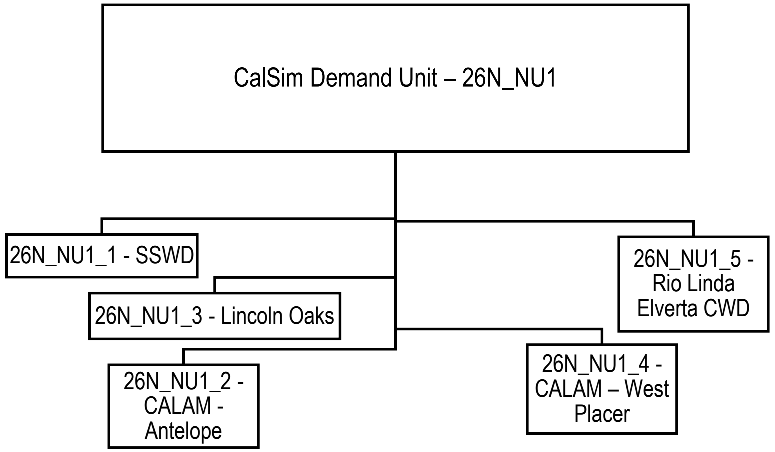
CalSim-CoSANA Updates

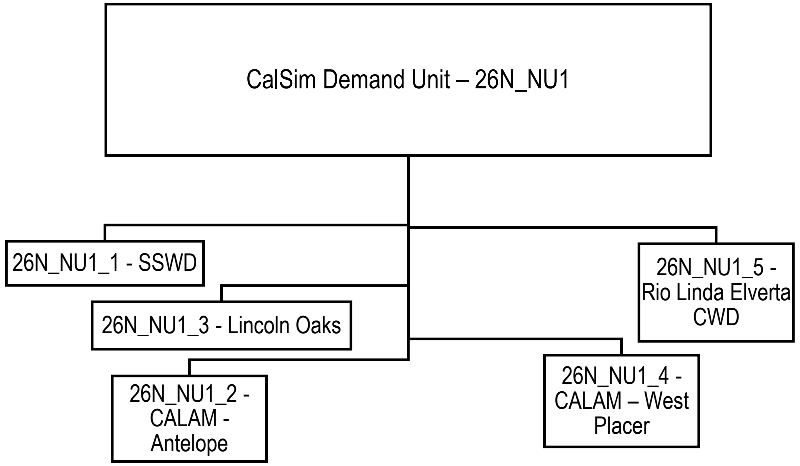
CalSim 3 Updates - Summary

- Baseline model based on LTO 2024 Draft CalSim 3 model
- Demands updated for American River basin
- Minimum and maximum groundwater pumping limits implemented to make model consistent with CoSANA and GSP assumptions and based inputs from Stakeholders
- Demand units in American River Basin disaggregated to match the CoSANA demand units
- Replaced C2VSim based GW DLL terms for seepage, SW runoff, and return flows to use CoSANA net accretions in Consumnes, American and Mokelumne River basins (CoSANA model domain).

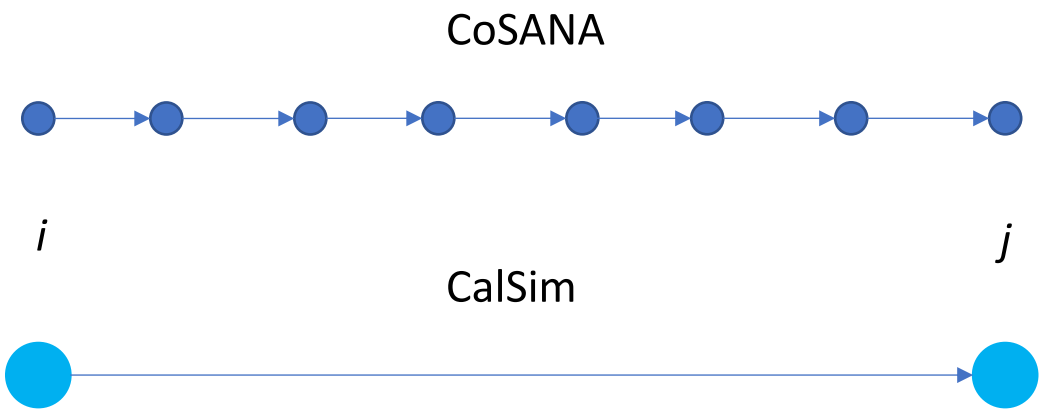
Refinements to CalSim Demand Units to match CoSANA

- Demand Units disaggregation
  - Certain CalSim Demand Units were disaggregated into sub-units to allow to match the demand units in CoSANA.
- Data Disaggregation
  - Demand data was disaggregated proportional to the annual demand for each user
  - Pattern is assumed to be same as the pattern for combined demand in CalSim LTO 2024 draft model.
- Operations/Diversion Disaggregation
  - Diversions were disaggregated for each of the sub-units in CalSim.
  - This included application of separate groundwater pumping limits and different water right/contract limit for each of the sub-units



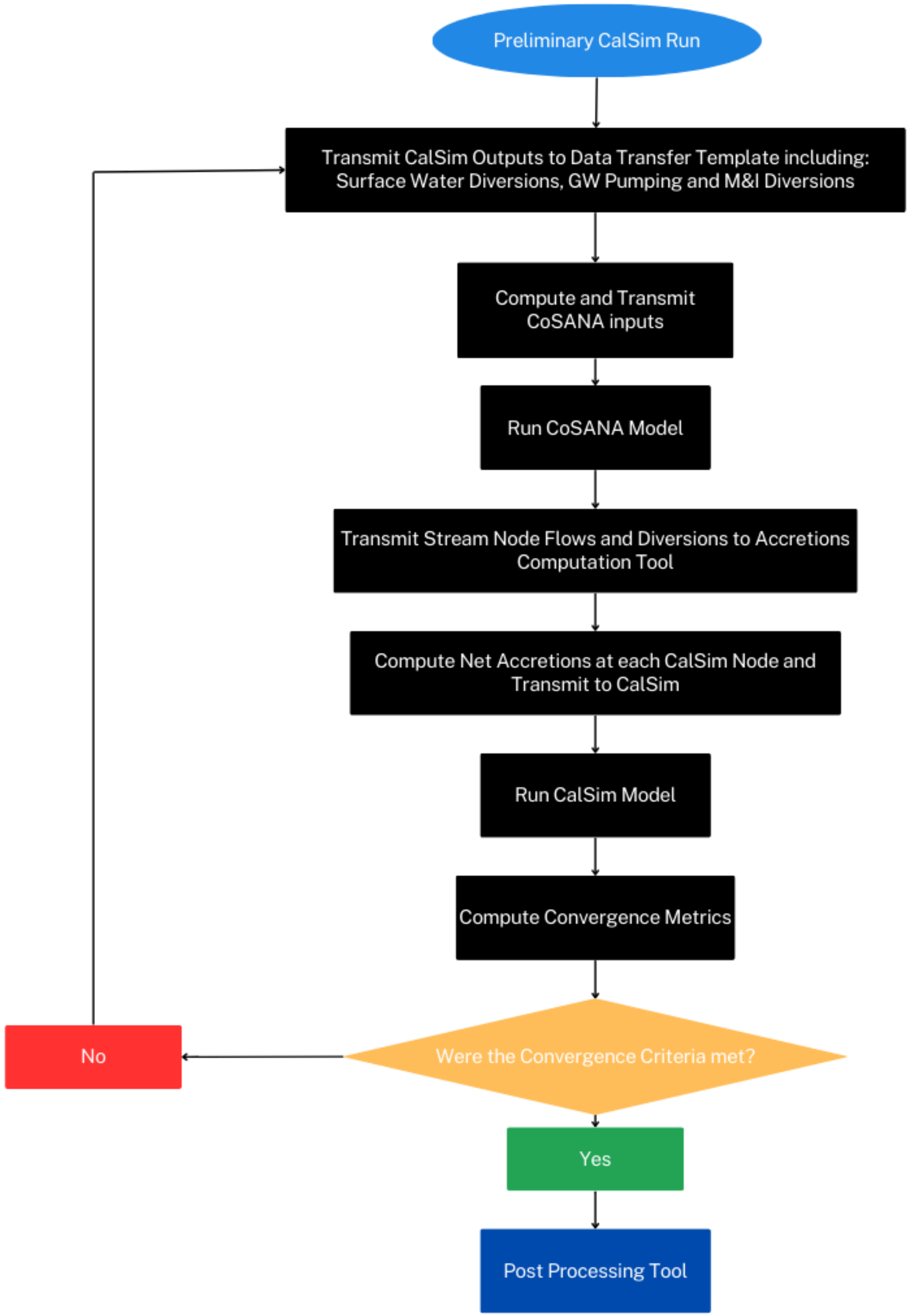


Accretions Computation



$$\text{Accretion}_j = Q_j - Q_i + \text{sum}(\mathrm{Div}_{i,j})$$

Q_i = Streamflow at node I
Div_i = Diversions between nodes i and j
Accretion_j = Accretion added at node j

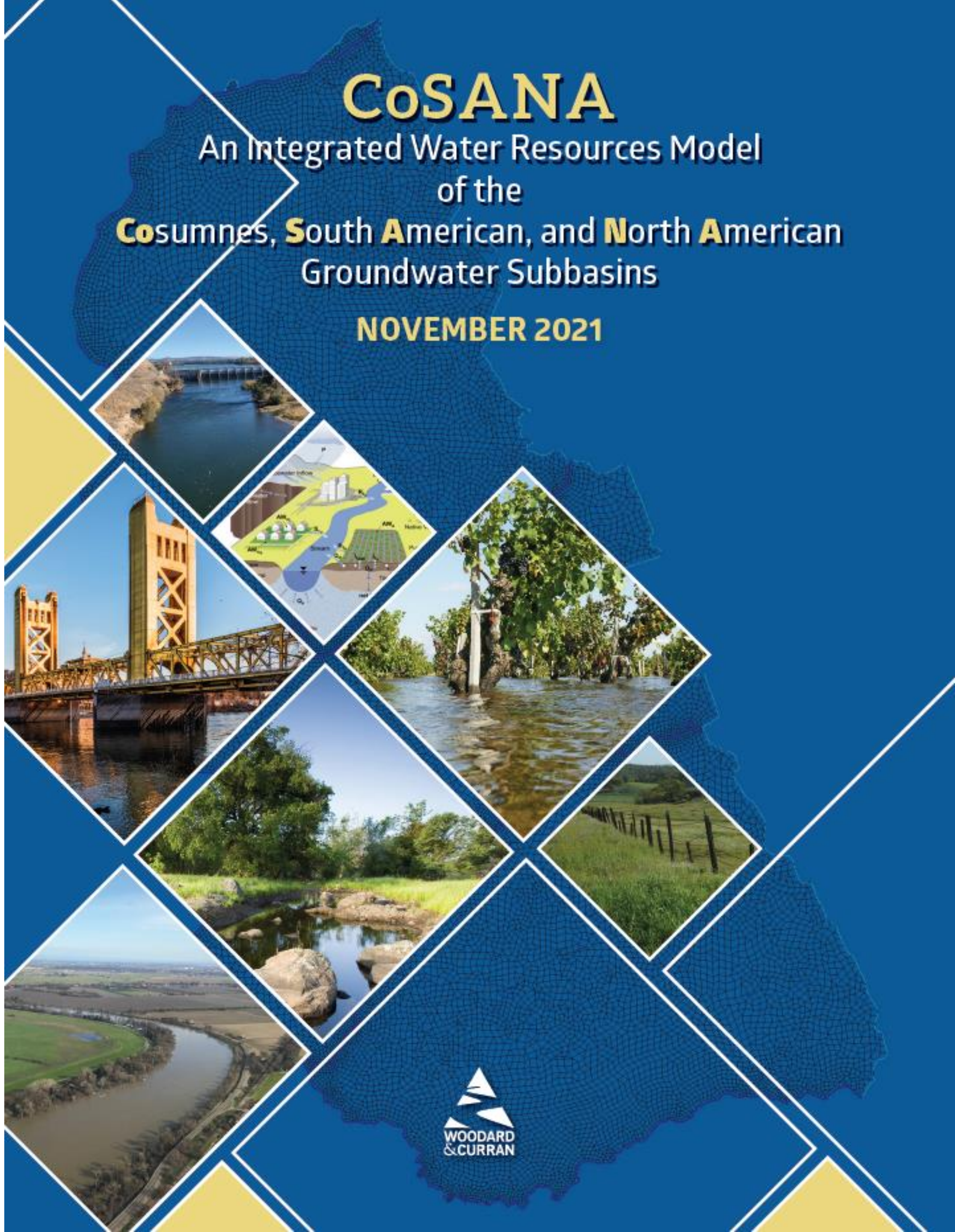


CalSim – CoSANA Integration

- Demand and Streamflow mapping
- Refinements to CalSim Demand Units to match CoSANA demand units
- Accretions Computation
- Tools for data inputs from CoSANA to CalSim

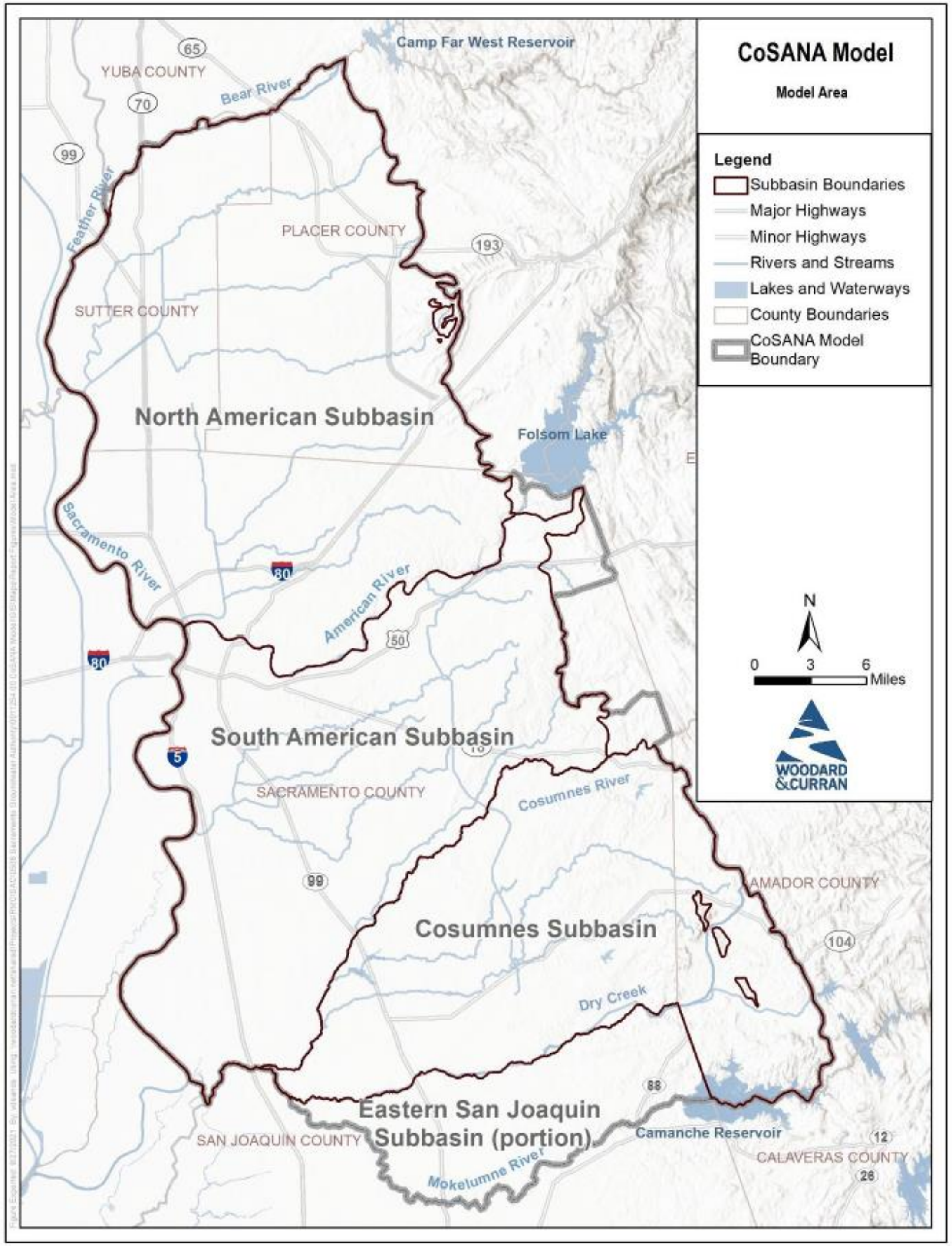
CoSANA Overview

- Regional integrated water resources model developed as an upgrade and enhancement of the existing SacIWRM
- Built on Integrated Water Flow Model (IWFM) framework



CoSANA Overview

- Model area
  - North American, South American, and Cosumnes Groundwater Subbasins
- Layering
  - 5 layers
- Elements
  - 24,171 elements with an average element area of 37 acres
- Stream system
  - 27 simulated streams with 51 reaches
- Land Use
  - 24 land use types, including 20 agricultural crops
- Water Supply
  - Surface water, groundwater, and recycled water supply to agricultural and urban water purveyors
- Remediation Pumping
  - Groundwater extraction and cleanup at 4 remediation sites
- Hydrologic period
  - Water Years 1970-2019 on a monthly time step

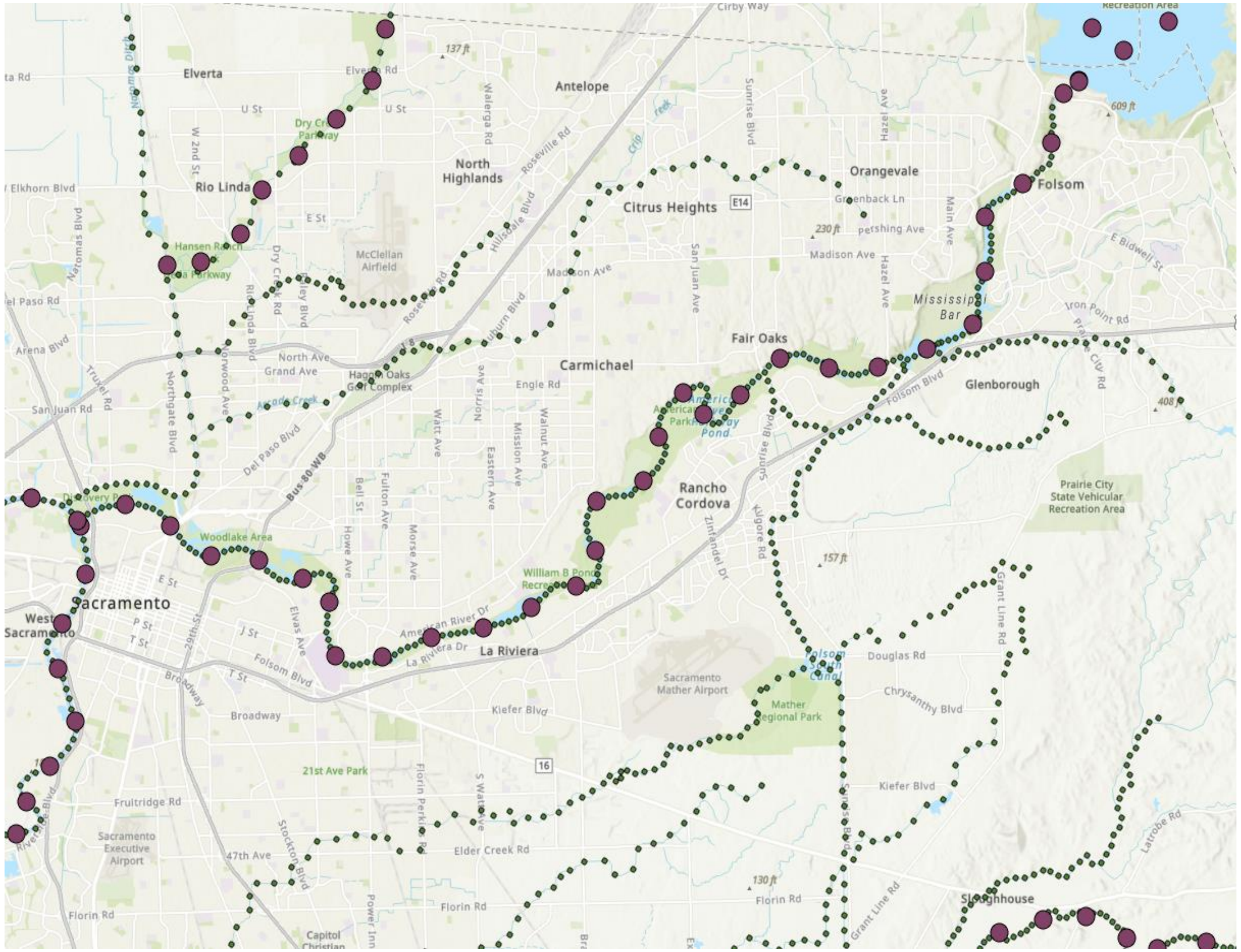


What are the advantages of CoSANA over GW DLL?

- Finer resolution compared with C2VSIM (GW-DLL) provides ability to model SW-GW interactions at each stream reach in CalSim.

- Stream losses are better represented

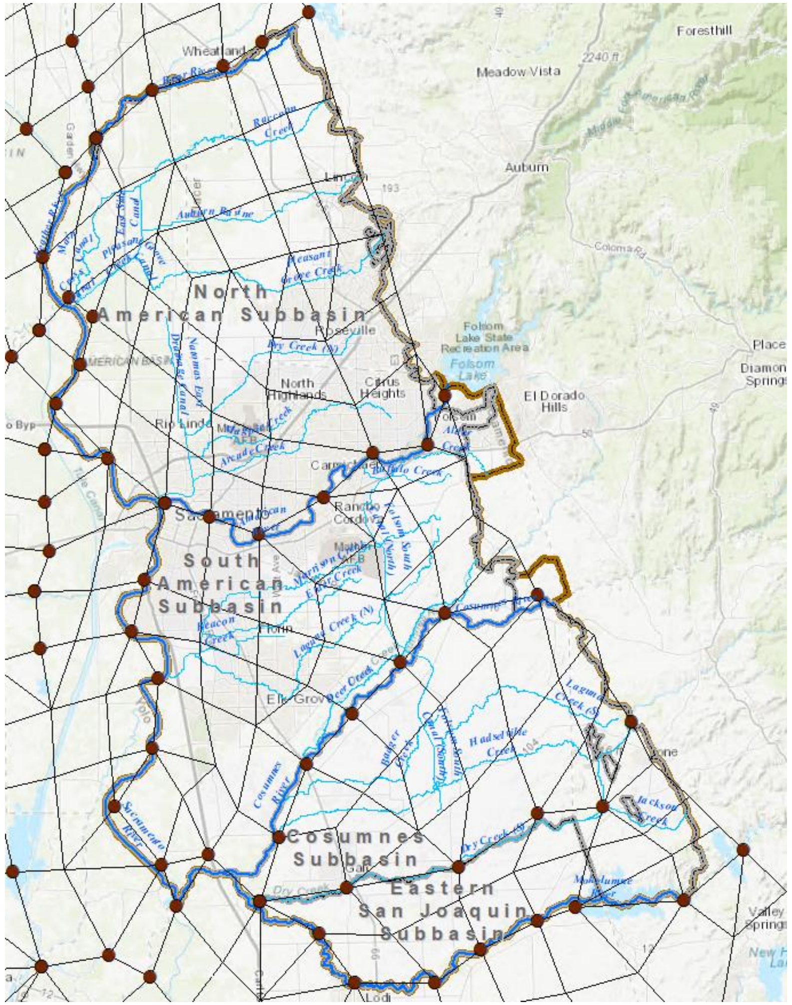
- Capability to model recharge and recovery at well level for modeling water bank operations



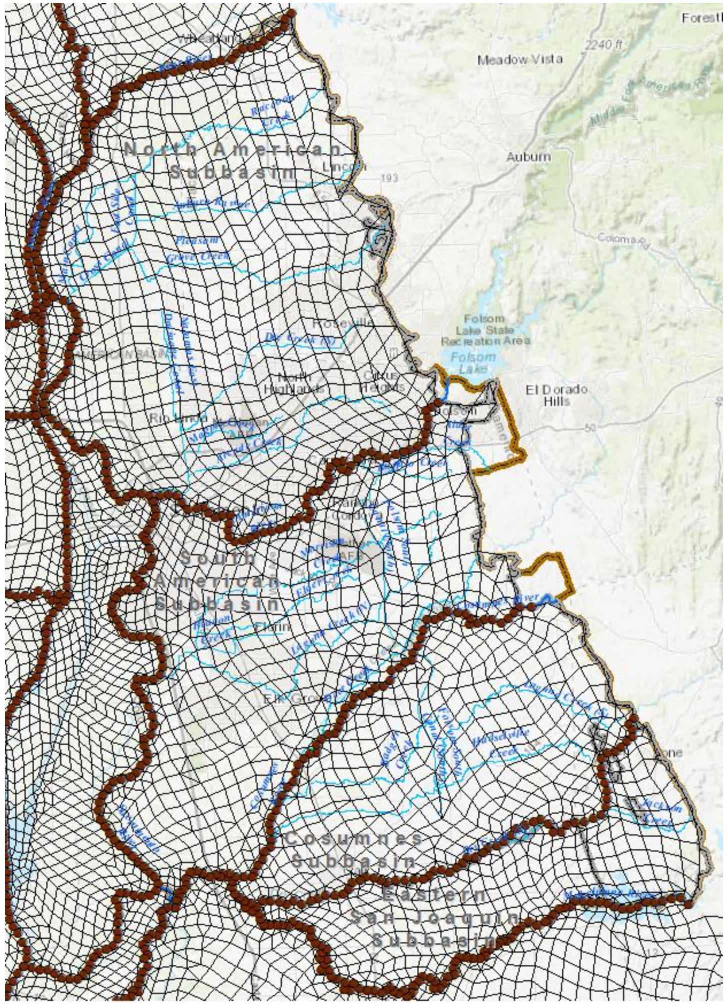
American River – CoSANA Stream Nodes vs. CalSim Stream Nodes

What are the advantages of CoSANA over GW DLL?

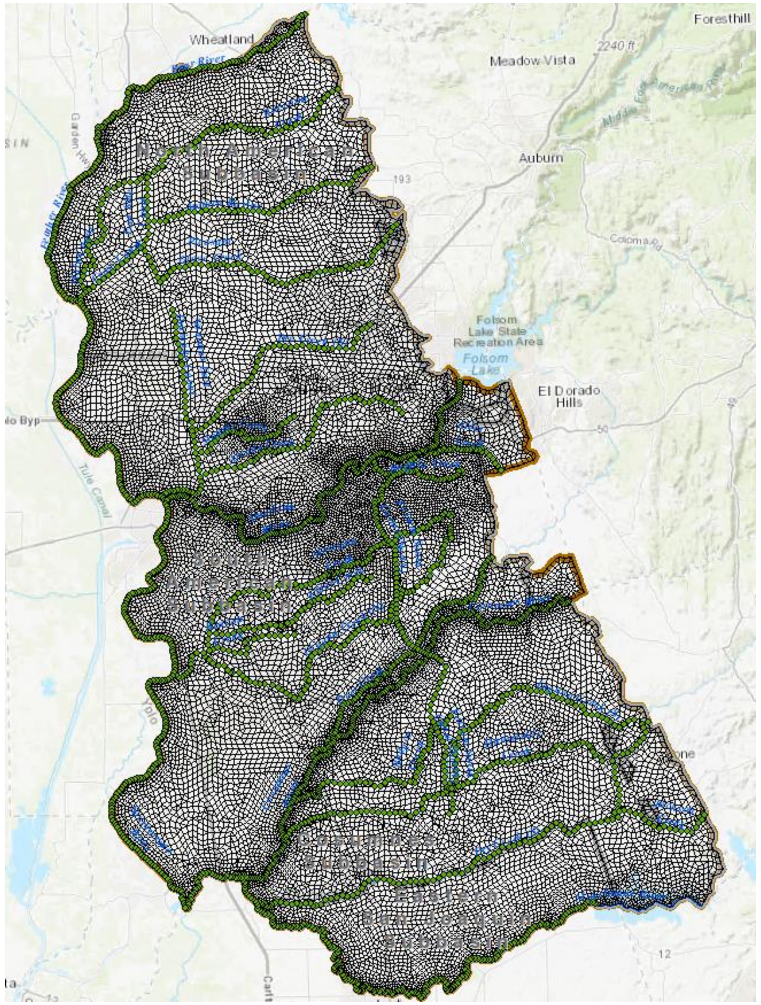
- Finer resolution compared with C2VSim (GW-DLL) provides ability to model SW-GW interactions at each stream reach in CalSim.



C2VSim CG Model Grid

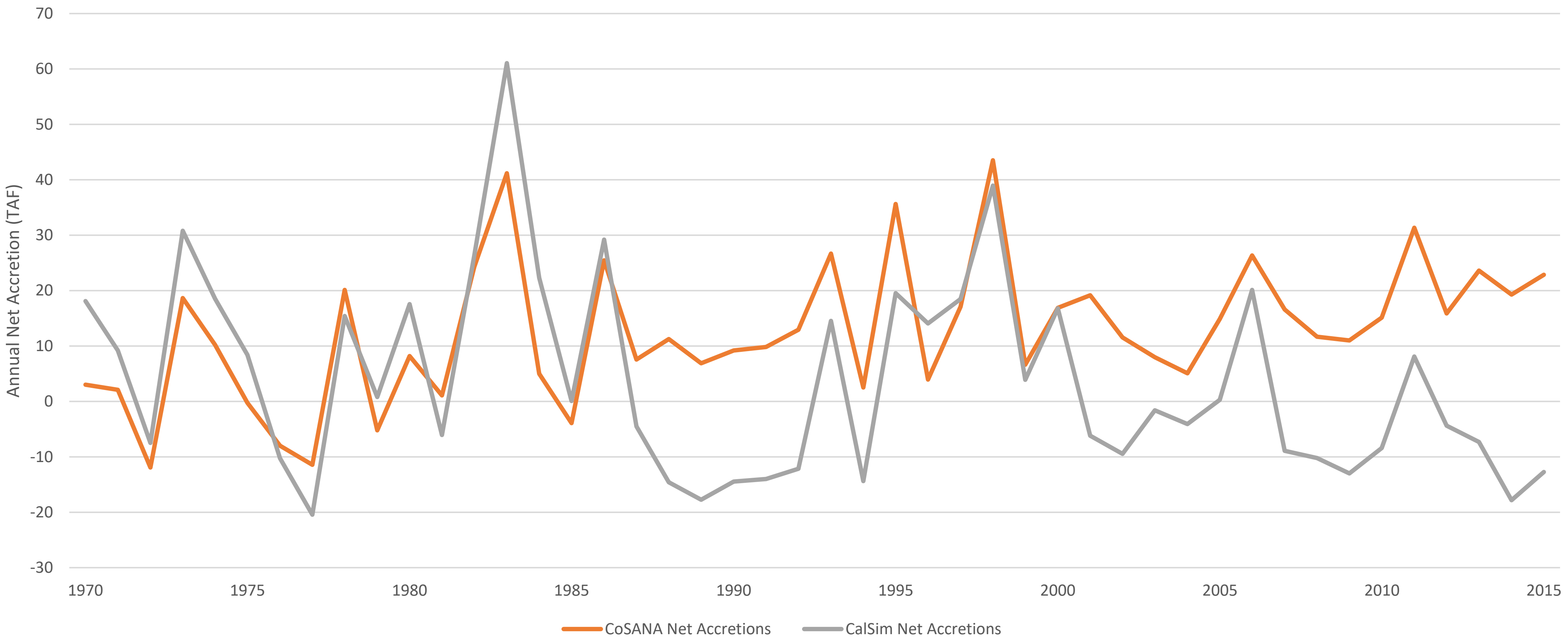


C2VSim FG Model Grid



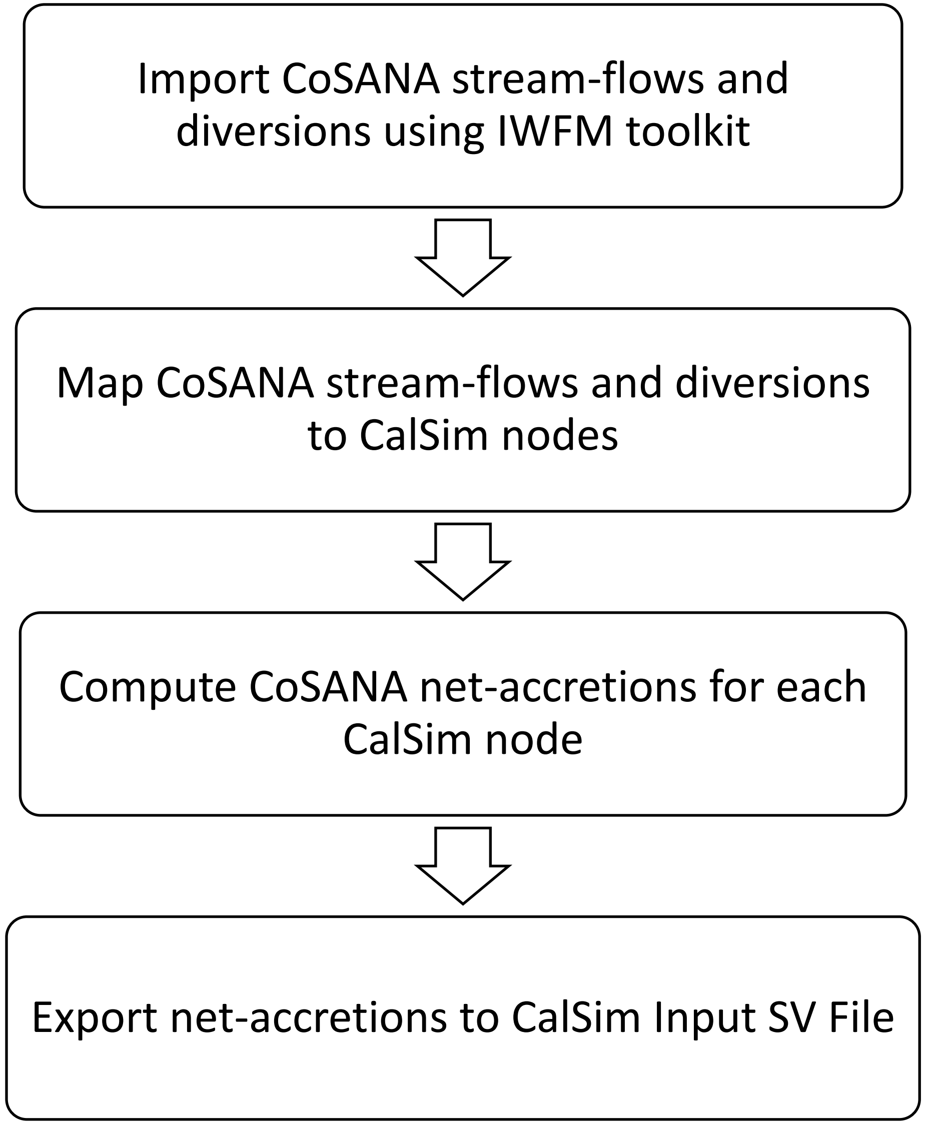
CoSANA Model Grid

Net Accretions



Tools Developed

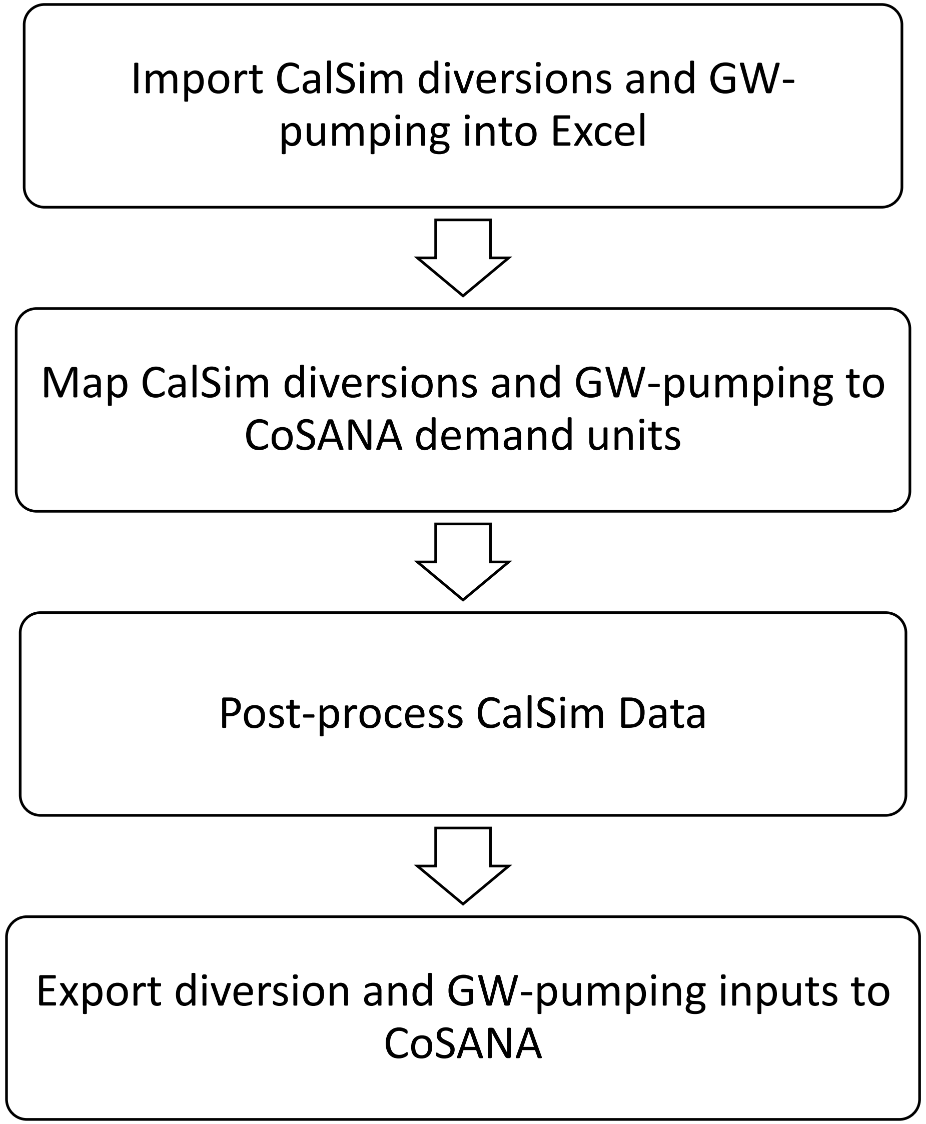
1. CoSANA postprocessor and Net accretions calculator
    - Imports stream-flows and diversions from CoSANA budget files
    - Maps CoSANA stream-flows to appropriate CalSim nodes
    - Computes net accretions for each CalSim node within CoSANA model domain



Tools Developed

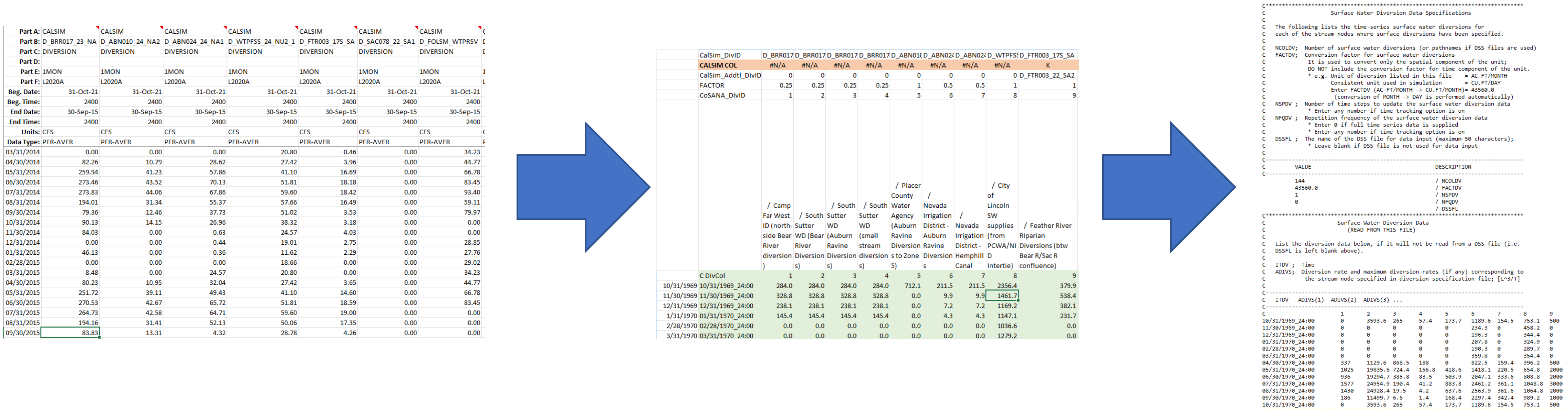
2. CalSim-CoSANA Data transfer template

- Imports diversions and groundwater pumping from CalSim
- Maps CalSim diversions and GW pumping to appropriate CoSANA demand units
- Post processes CalSim data for CoSANA and converts into CoSANA input format

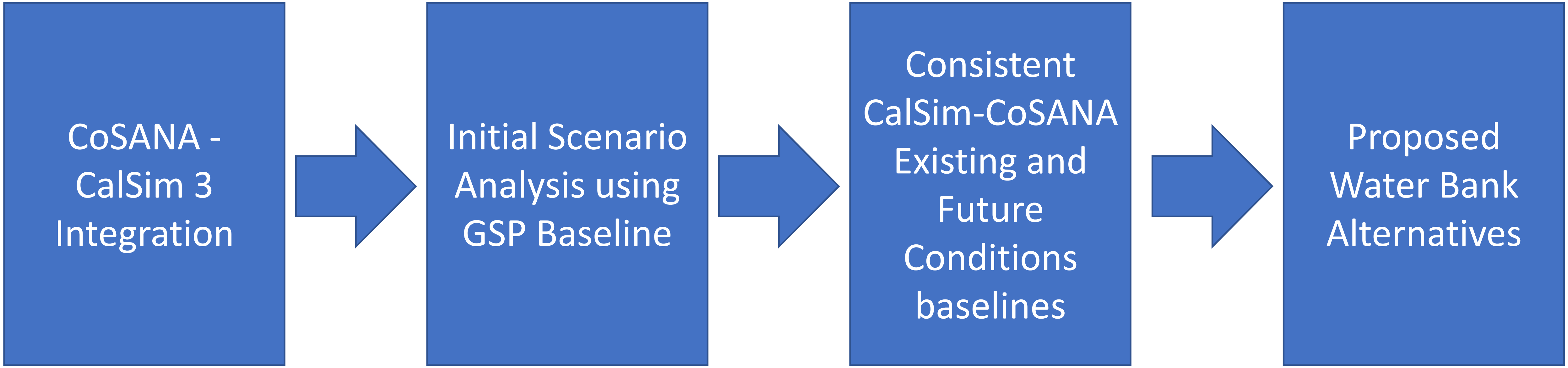


CoSANA-CalSim Integration

- Developed template that takes single-page of CalSim data and disaggregates to CoSANA input files
- Templates are complete for updating supply mix



Phases of Water Bank Analysis



Water Bank Baselines and Scenarios

- Baselines
  - Existing Conditions Baseline
  - Future Conditions Baseline with Climate Change
  - Cumulative Conditions Baseline with Climate Change
- Scenarios
  - Water Bank Scenario under Existing Conditions
  - Water Bank Scenario under Future Conditions
  - Water Bank Scenario under Cumulative Conditions

Groundwater Impacts and Metrics for Analysis

CalSim Results

- CalSim Results for Sacramento Water Bank Baseline Run compared with DCR 2021
- These results represent 2 iterations between CalSim and CoSANA models
- Net accretions changes were negligible after 2 iterations

Evaluation/Convergence Metrics

	Iteration		1	1	1	2	2	2		3	3	3	
Type	Metric	Unit	Min	Max	Avg	Min	Max	Avg	Diff %	Min	Max	Avg	Diff %
	Sacramento River at Keswick (C_KSWCK)	CFS	2,768.65	57641.53	8818.568	2,768.65	57641.53	8818.742	0.00%	2,768.65	57641.53	8818.731	0.00%
	Feather River at Thermalito (C_FTR059)	CFS	710.44	46552.74	4332.758	710.44	46552.98	4332.71	0.00%	710.44	46552.75	4332.738	0.00%
	American River at Nimbus (C_NTOMA)	CFS	1.59	32701.04	3597.335	500.00	32701.01	3597.301	0.00%	500.00	32700.69	3597.051	0.01%
	Sacramento River at Freeport (C_SAC049)	CFS	4,957.33	86427.04	22059.89	4,960.29	86426.82	22060.59	0.00%	4,960.29	86426.89	22060.34	0.00%
	Yolo Bypass at Lisbon Weir (C_YBP016)	CFS	35.67	167751.7	4802.34	35.68	167751.9	4801.574	0.02%	35.50	167751.4	4801.32	0.01%
	San Joaquin River at Vernalis (C_SJR070)	CFS	321.16	51606.7	4088.333	321.15	51605.35	4086.455	0.05%	321.07	51607.06	4088.328	0.05%
	Sacramento River Downstream of North Delta Diversion (C_SAC041)	CFS	5,005.53	88095.04	22295.76	5,007.43	88094.56	22296.41	0.00%	5,007.43	88094.63	22296.16	0.00%
	Net Delta Outflow Index (NDOI)	CFS	3,000.00	312924.8	24117.7	3,000.00	312924.8	24116.72	0.00%	3,000.00	312924.5	24117.38	0.00%
	X2 Position (X2_PRV)	KM	49.02	94.28667	75.7386	49.02	94.28667	75.74153	0.00%	49.02	94.28667	75.74129	0.00%
	Combined Old and Middle River (C_OMR014)	CFS	-11,988.93	24366.99	-4776.9	-11,990.58	24366.98	-4777.44	0.01%	-11,982.98	24367.03	-4777.34	0.00%
	Total Delta Exports (C_CAA003 + C_DMC000)	CFS	900.00	13847.2	3574.32	900.00	13847.2	3573.858	0.01%	900.00	13847.2	3574.335	0.01%
	SWP Exports (C_CAA003_SWP + C_CAA003_WTS)	CFS	9.83	9247.2	3449.195	9.83	9247.2	3448.242	0.03%	9.83	9247.2	3449.279	0.03%
Systemwide Flows	CVP Exports (C_CAA003_CVP + C_DMC000)	CFS	586.77	7722.131	101.4572	586.77	7721.289	101.9752	0.51%	586.77	7724.227	101.3873	0.58%
	Emmaton Salinity (EM_EC_Month)	UMHOS/CM	159.63	2303.627	717.2254	159.62	2303.449	717.4577	0.03%	159.63	2304.484	717.3419	0.02%
	Jersey Point Salinity (JP_EC_Month)	UMHOS/CM	159.63	2303.627	717.2254	159.62	2303.449	717.4577	0.03%	159.63	2304.484	717.3419	0.02%
	Rock Slough Salinity (RS_EC_Month)	UMHOS/CM	103.00	1129.822	424.4682	102.99	1130.086	424.5793	0.03%	102.99	1130.218	424.5262	0.01%
Salinity	Collinsville Salinity (CO_EC_Month)	UMHOS/CM	195.65	12762.58	3651.496	195.65	12760.32	3652.766	0.03%	195.65	12773.81	3652.55	0.01%
	End of September Storage in Shasta (S_SHSTA)	TAF	602.11	3400	2960.911	602.98	3400	2959.963	0.03%	602.38	3400	2959.904	0.00%
	End of September Storage in Trinity (S_TRNTY)	TAF	455.15	1975	1454.12	455.36	1975	1453.917	0.01%	455.23	1975	1453.928	0.00%
	End of September Storage in Folsom (S_FOLSM)	TAF	254.49	752	589.3549	254.53	752	588.9437	0.07%	254.44	752	588.8368	0.02%
	End of September Storage in Oroville (S_OROVL)	TAF	186.86	3351	1960.848	186.67	3351	1960.751	0.00%	186.08	3351	1960.773	0.00%
	End of May Storage in Shasta (S_SHSTA)	TAF	1,742.47	4552.1	4097.136	1,743.48	4552.1	4095.833	0.03%	1,742.46	4552.1	4095.793	0.00%
	End of May Storage in Trinity (S_TRNTY)	TAF	776.11	2420	1892.546	776.11	2420	1892.276	0.01%	776.00	2420	1892.289	0.00%
	End of May Storage in Folsom (S_FOLSM)	TAF	338.27	967	829.9347	338.34	967	829.9107	0.00%	338.25	967	829.9087	0.00%
	End of May Storage in Oroville (S_OROVL)	TAF	797.55	3538	2910.248	797.36	3538	2910.572	0.01%	796.76	3538	2910.471	0.00%
	Average Storage in Shasta (S_SHSTA)	TAF	550.00	4552.1	3400.278	550.00	4552.1	3399.426	0.03%	550.00	4552.1	3399.413	0.00%
	Average Storage in Trinity (S_TRNTY)	TAF	441.89	2447.65	1635.672	442.09	2447.65	1635.424	0.02%	441.96	2447.65	1635.439	0.00%
	Average Storage in Folsom (S_FOLSM)	TAF	90.00	967	639.4872	90.00	967	638.912	0.09%	90.00	967	638.9866	0.01%
Storage	Average Storage in Oroville (S_OROVL)	TAF	39.84	3538	2312.334	39.16	3538	2312.444	0.00%	37.72	3538	2312.331	0.00%
	Total Accretions	TAF	-883.78	443.90	47.29	-884.44	444.14	47.26	0.06%	-884.44	444.14	47.26	0.00%
	Bear River Accretions	TAF	-1.06	2.17	0.69	-1.09	2.16	0.68	1.34%	-1.09	2.16	0.68	0.00%
	Feather River Accretions	TAF	-6.98	574.61	0.68	-6.98	574.61	0.68	0.05%	-6.98	574.61	0.68	0.00%
	Sacramento River Accretions	TAF	-1,431.95	138.98	17.66	-1,431.95	139.25	17.65	0.06%	-1,431.95	139.25	17.65	0.00%
	American River Accretions	TAF	-1.71	23.77	3.62	-1.81	23.63	3.62	0.09%	-1.81	23.63	3.62	0.00%
	Consumnes River Accretions	TAF	-1.59	125.64	10.27	-1.59	125.64	10.27	0.00%	-1.59	125.64	10.27	0.00%
CoSANA Accretions	Mokelumne River Accretions	TAF	-31.18	100.03	7.53	-31.18	100.04	7.53	0.01%	-31.18	100.04	7.53	0.00%

Water Bank operations metrics

Water Bank Storage	Timeseries of WB storage - NASb - SASb - Project area (M&I boundaries)
Leave-behind	• Cumulative leave-behind • Long-term increase in basin storage less the WB storage • Hydrograph of selected wells.
Net stream seepage (potential losses)	Change in seepage water budget component as long-term average and by year type - American river - Sac River - Cosumnes, Bear, and Feather
Net Boundary flow (potential losses)	Change as long-term average and by year type - between NASb and SASb - Adjacent subbasins

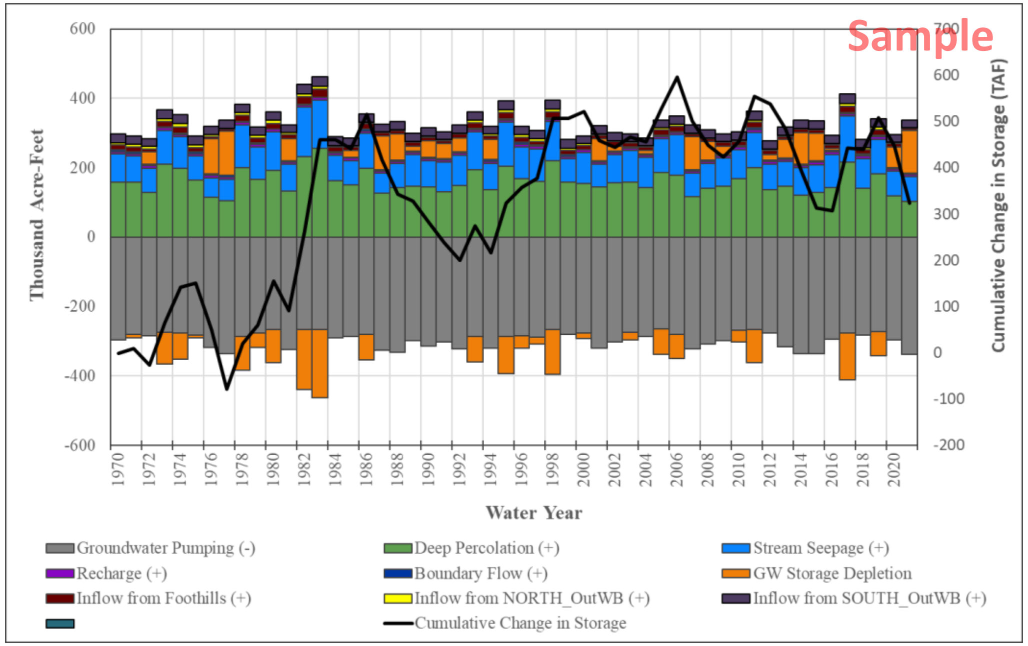
GSPs Compliance Metrics (CoSANA)

Chronic Lowering of Groundwater Levels	Change in # of exceedance of MTs by year type. Change in # of exceedance of MOs by year type.
Reduction of Storage	Change in storage by year type - NASb - SASb - Project area (M&I boundaries)
Stream Depletions due to GW pumping	Change in stream flows by year type and by month, exceedance charts - American river - Sac River - Cosumnes, Bear, and Feather
Degraded GW quality	Qualitative
Land subsidence	Qualitative

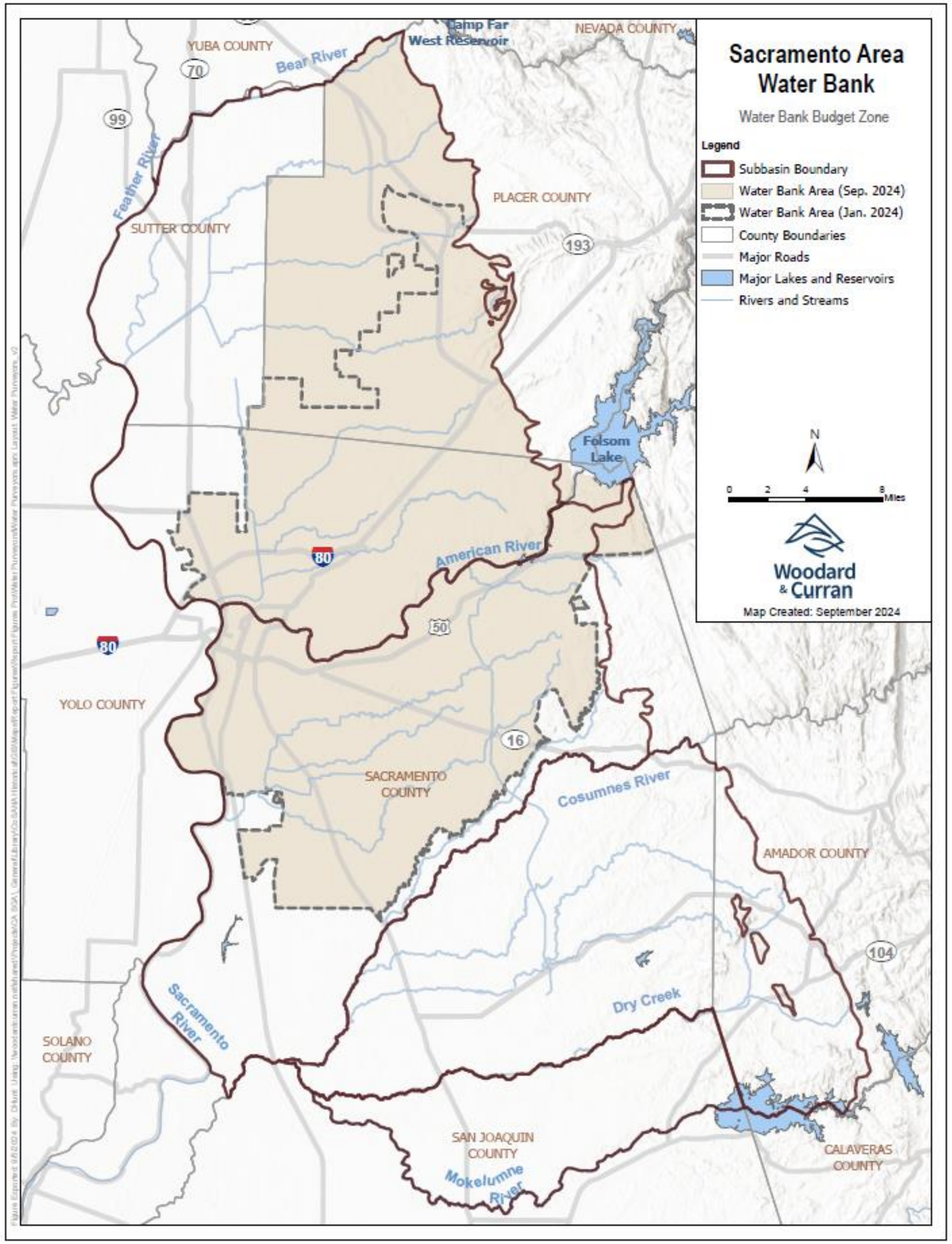
- GSP Indicators:
    - NASb: >20% of wells exceed MTs for two consecutive fall measurements
    - SASb: >25% of wells exceed MTs for three consecutive years
- Adopt the approach used for the City of Sacramento EIR:
    - hydrographs showing GWL averages by WY-types
    - tabulated exceedance violations to show consistency with the GSPs

Groundwater Budget Comparison

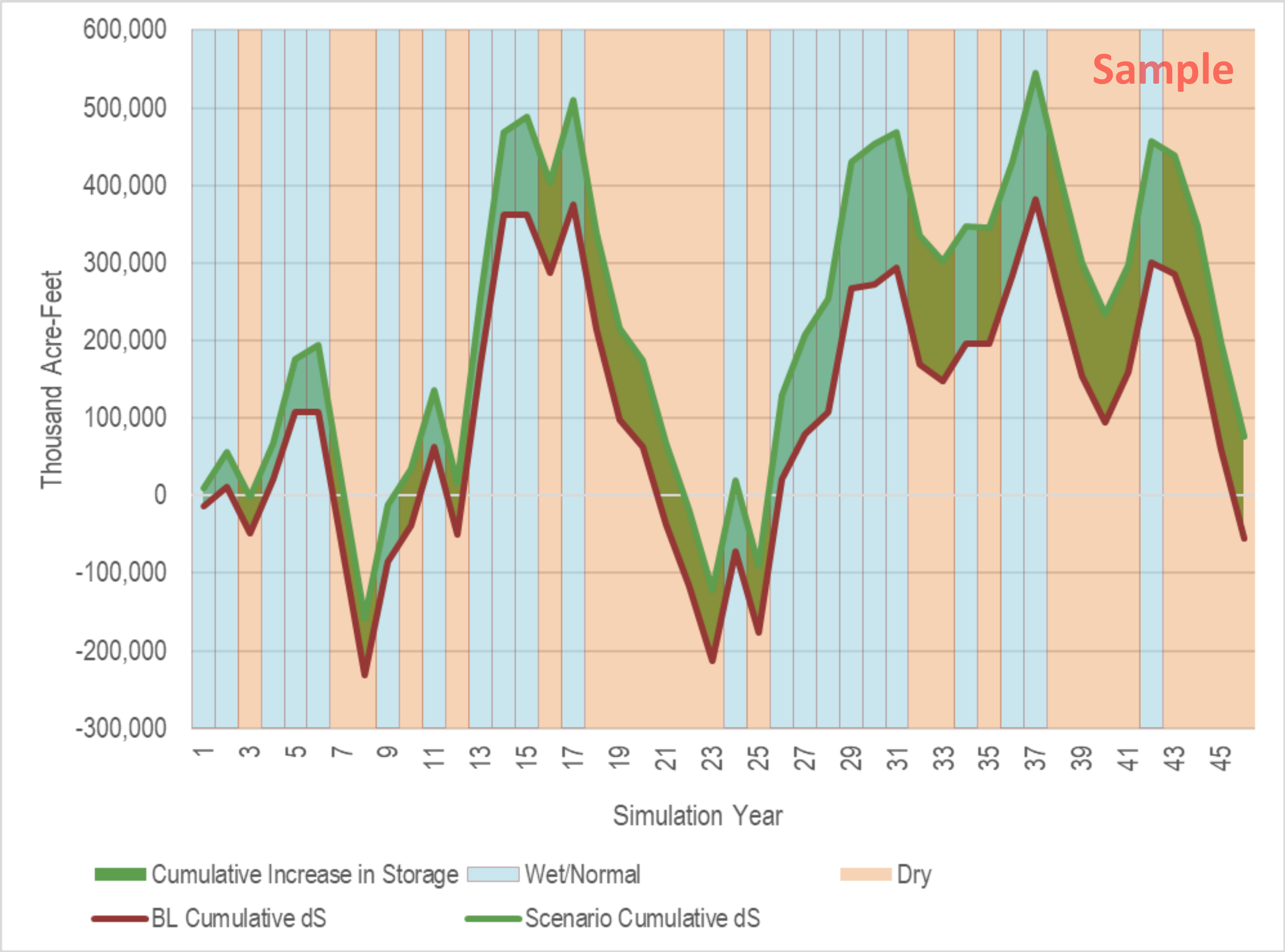
- NASb
- SASb
- Project area (M&I boundaries)



WB ECBL – Water Bank Area



Cumulative Change in Storage Comparison

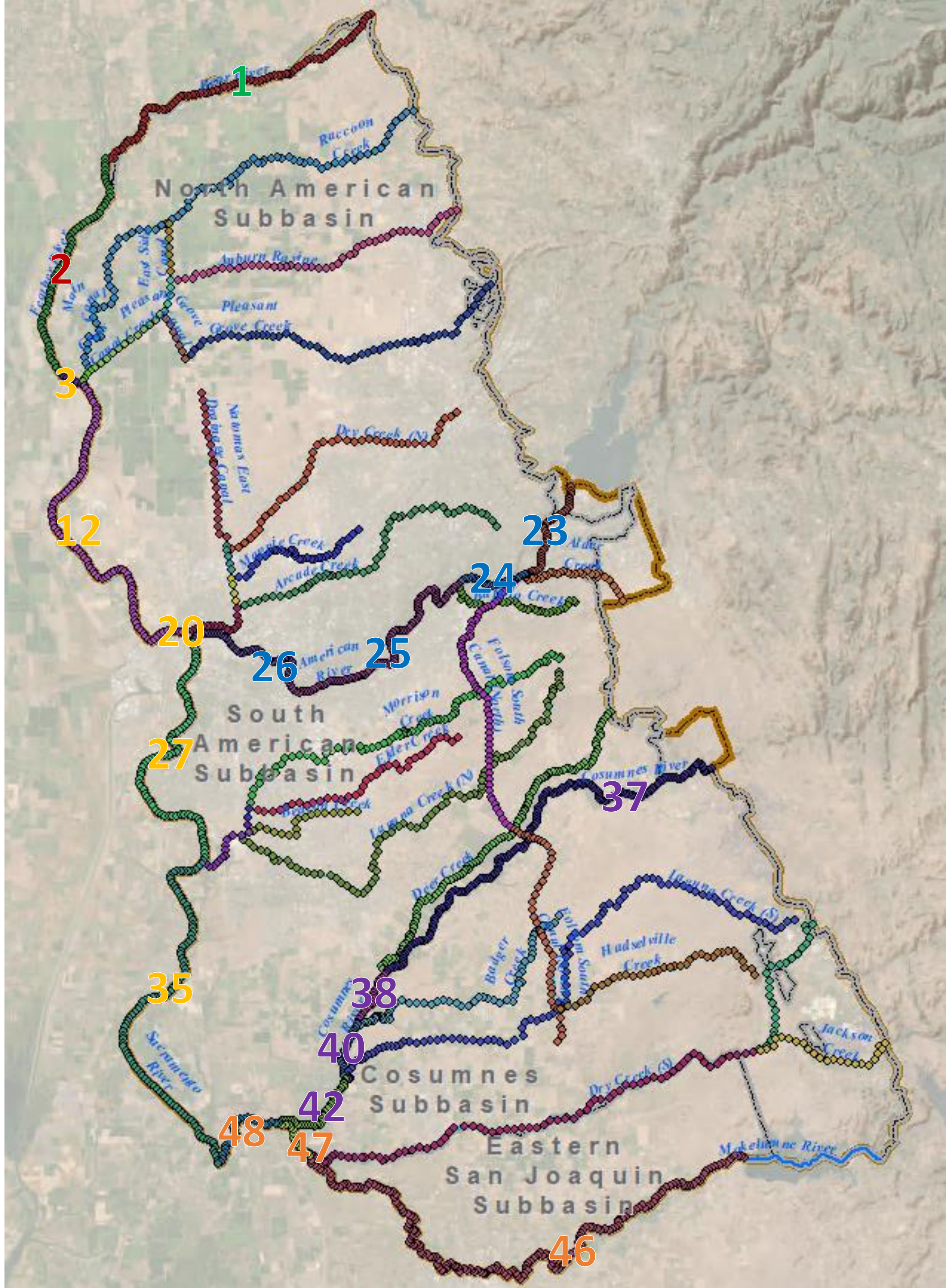


Stream Budget Comparison

- American River
  - Upstream (Reaches 23, 24)
  - Midstream (Reach 25)
  - Downstream (Reach 26)
- Sacramento River
  - Above American River (Reaches 3, 12, 20)
  - Below American River (Reaches 27,35)
- Cosumnes River (Reaches 37, 38, 40, 42)
- Bear River (Reach 1)
- Feather River (Reach 2)
- Mokelumne River (Reaches 46, 47, 48)

Sample

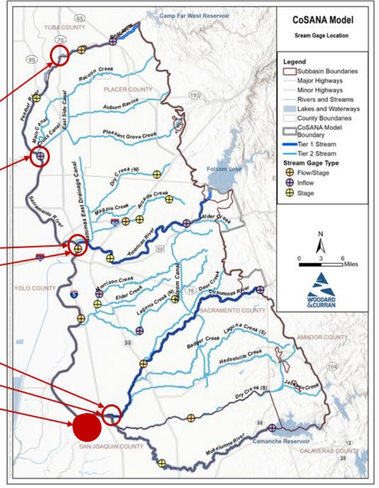
Stream Budget Average Annual (AFY)		ECBL_Iter2				
Stream	Reach Number	Stream Inflow ("+" = stream gain; "-" = stream loss)	Stream Outflow	Return Flow (+)	Diversions (+)	Seepage (Gain from GW)
American River	23, 24, 25, 26	10,481,069	10,401,121	0	60,829	-19,120
Upstream	23, 24	5,224,642	5,225,837	0	0	1,195
Midstream	25	2,677,950	2,578,478	0	60,829	-38,643
Downstream	26	2,578,478	2,596,806	0	0	18,328
Sacramento River	3, 12, 20, 27, 35	73,902,470	73,914,471	52,563	112,022	-40,459
Above American River	3, 12, 20	40,977,263	40,956,170	8,350	89,265	27,851
Below American River	27, 35	32,925,207	32,958,302	44,213	22,758	-68,310
Cosumnes River	37, 38, 40, 42	1,973,764	1,987,932	7,378	9,461	-29,961
Bear River	1	365,836	401,270	3,667	0	16,749
Feather River	2	5,696,064	5,659,037	0	11,000	-26,027
Mokelumne River	46, 47, 48	2,307,473	2,280,784	1,341	42	-33,135



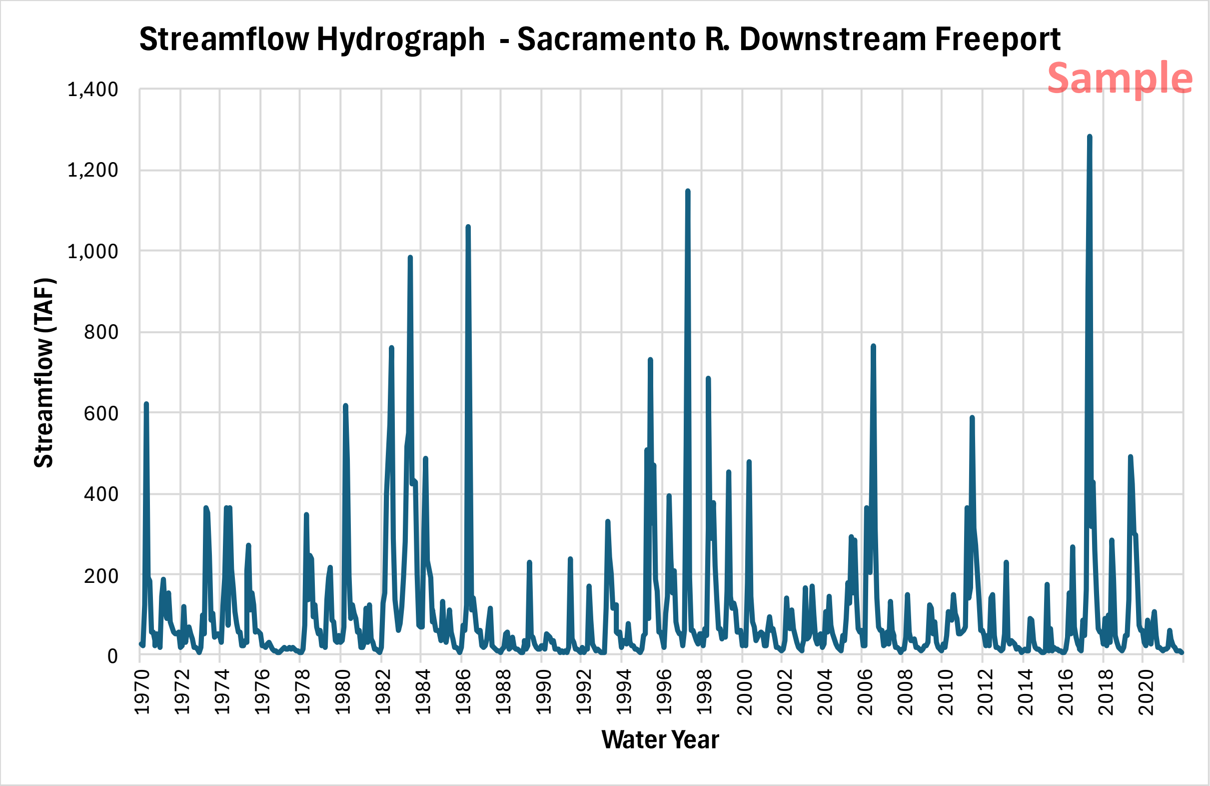
Stream Hydrograph & Exceedance Chart

Stream Flow Reporting Points
(CalSim 3 & CoSANA)

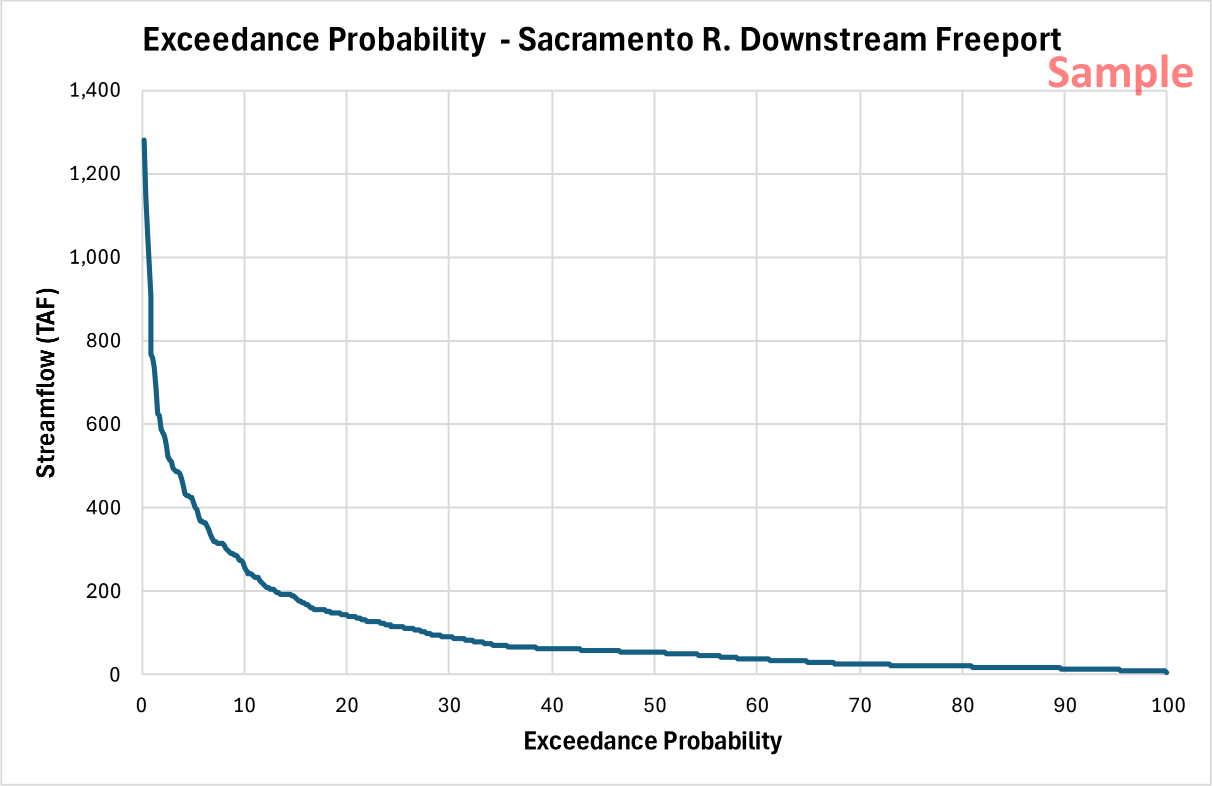
Bear R. at Feather R. confluence
Sacramento R. at Verona
Sacramento R. at American R. confluence
American R. at Sacramento R. confluence
Cosumnes R at Mokelumne R. confluence
Mokelumne R. at Cosumnes R. confluence
Sacramento R downstream Freeport (CoSANA outflow)



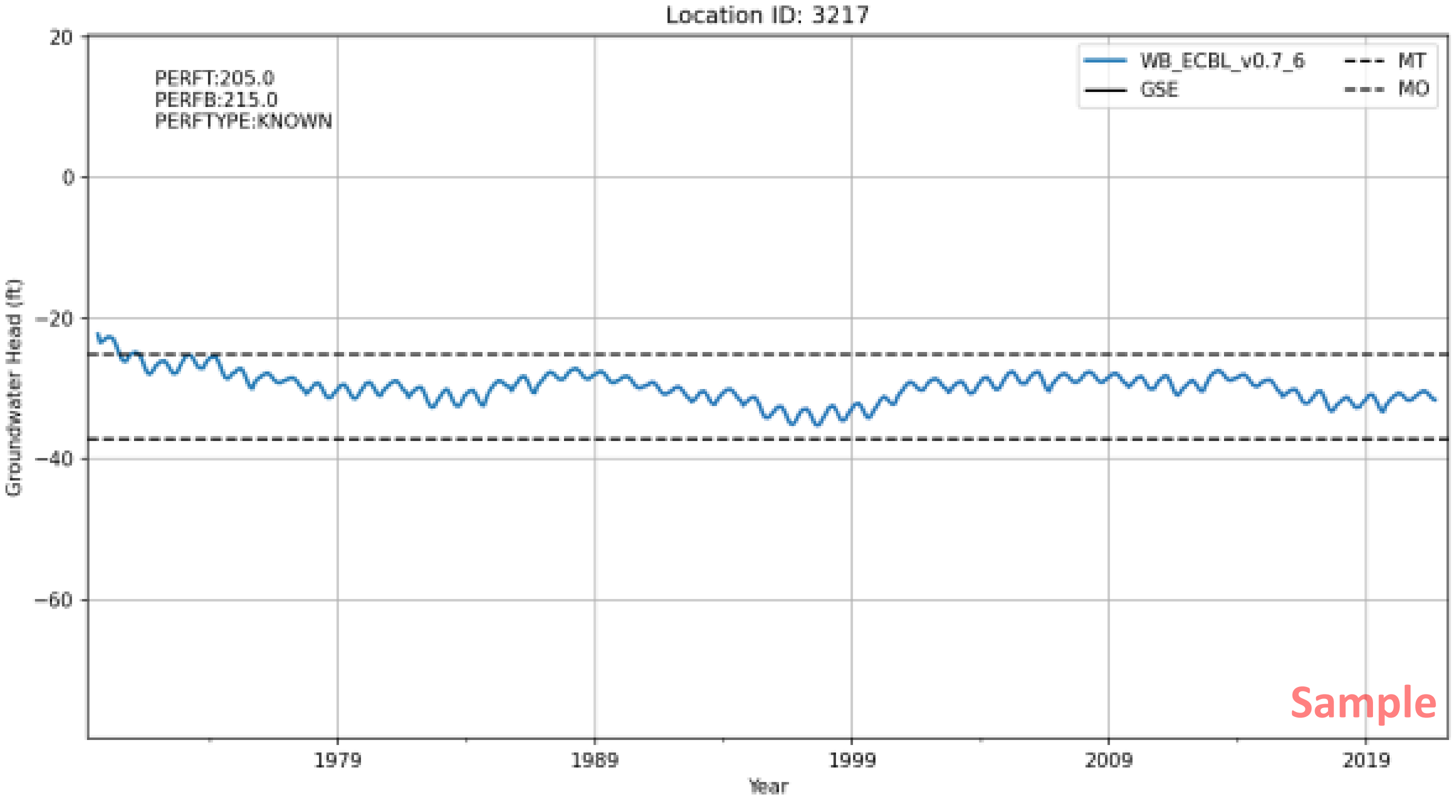
WB ECBL

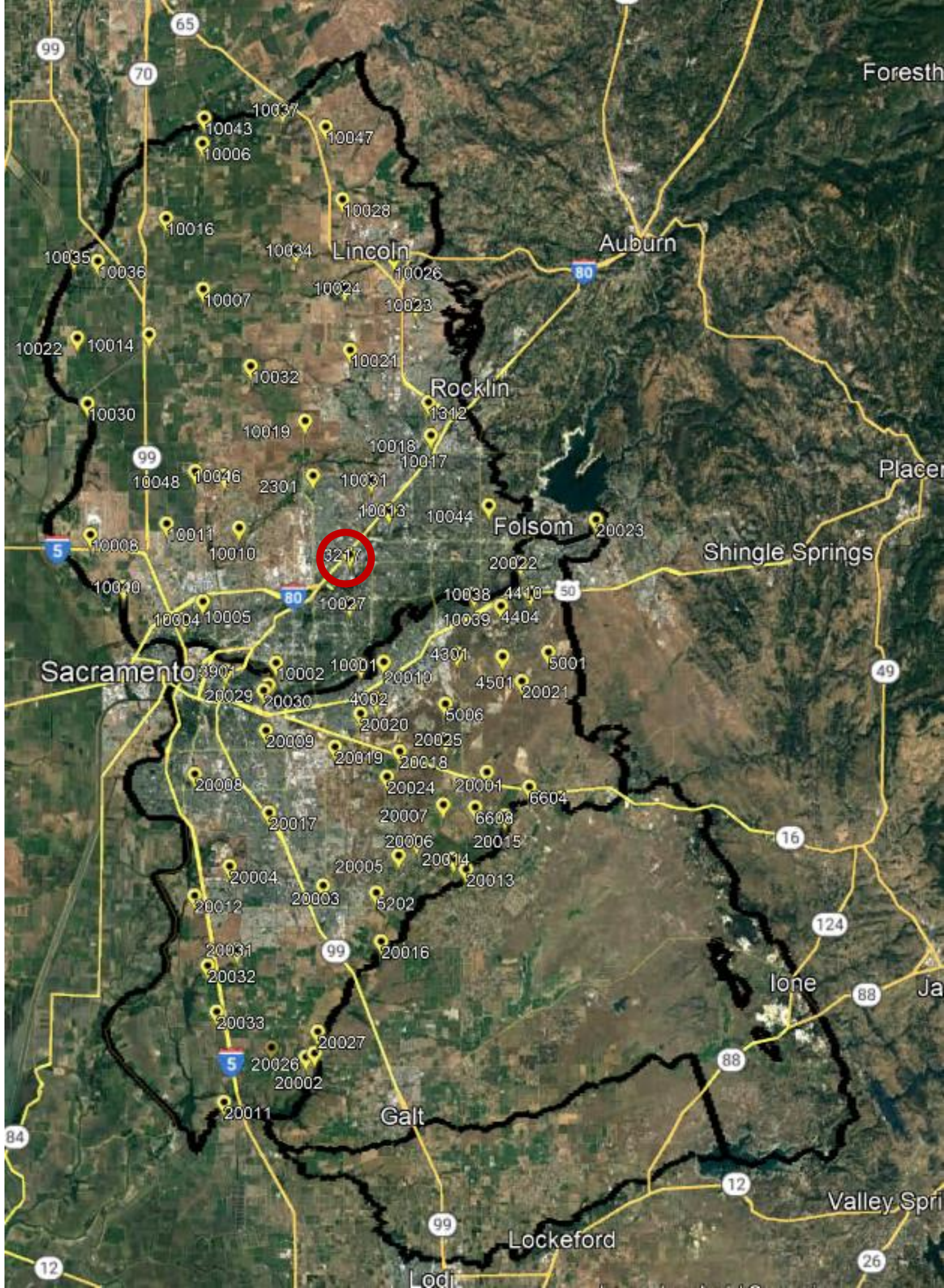


WB ECBL



Hydrograph

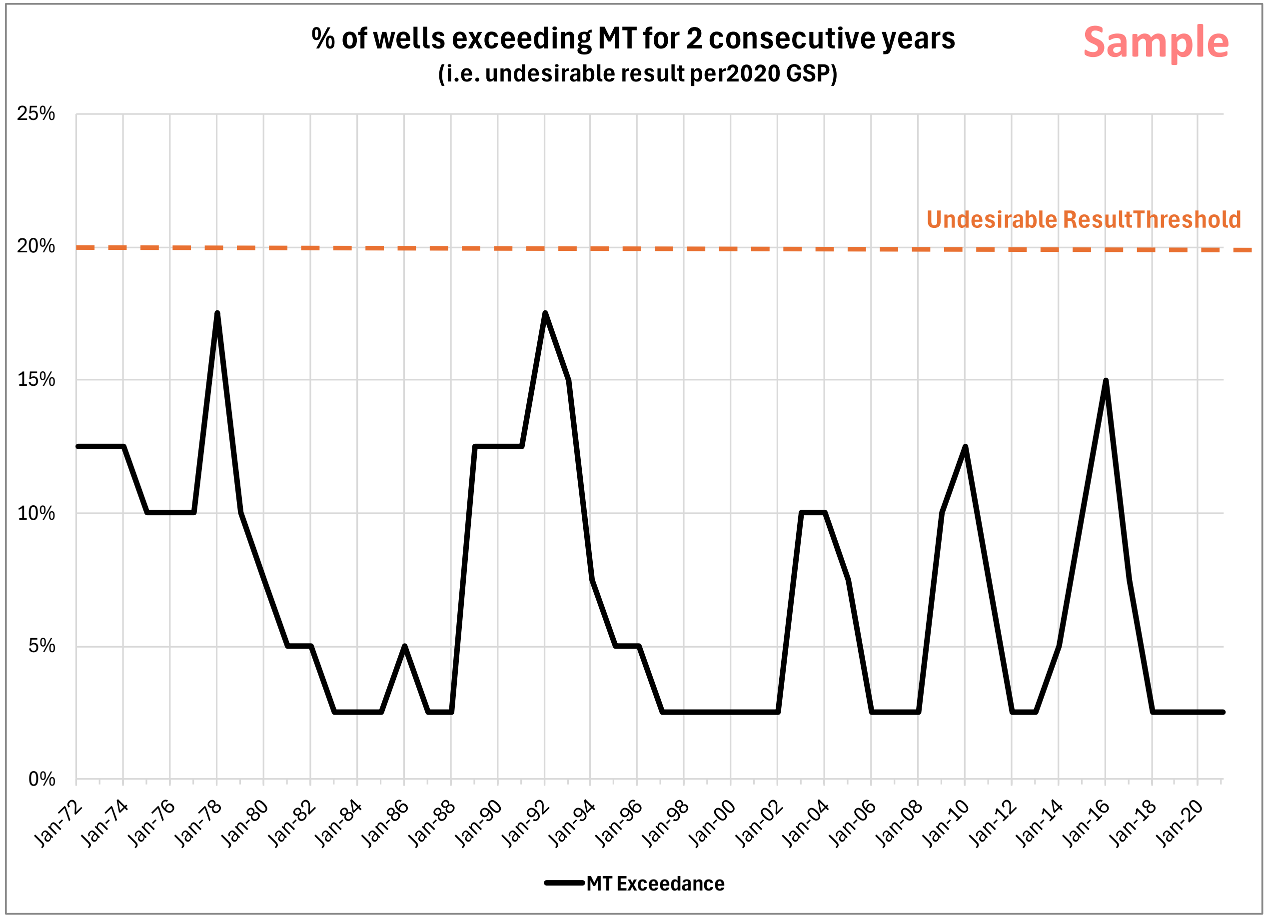

Location ID: 3217
PERFT:205.0
PERFB:215.0
PERFTYPE:KNOWN
WB_ECBL_v0.7_6
GSE
MT
MO
Groundwater Head (ft)
Year
20
0
−20
−40
−60
1979
1989
1999
2009
2019
Sample


Lincoln
Auburn
Rocklin
Folsom
Shingle Springs
Sacramento
Galt
Ione
Lockeford
3217

GSPs Compliance Metrics (CoSANA)

- GSP Indicators:
  - NASb: >20% of wells exceed MTs for two consecutive fall measurements
  - SASb: >25% of wells exceed MTs for three consecutive years

WB ECBL – NASb



Loss Factor Analysis*

- The concept of **"loss"** refers to the physical movement of water out of the basin, which the Water Bank will analyze using scientific methods.
- Loss is determined by monitoring and accounting for water that migrates underground, potentially moving between basin boundaries, and as water that may seep into river systems, or may include reduced recharge due to recharged water.
- By doing so, the Water Bank aims to effectively account for these losses so that when banked water is later extracted, Water Bank managers will know more precisely the actual volume of water that remains and may be available for beneficial uses.

* Engagement – Sacramento Regional Water Bank (sacwaterbank.com)

Leave Behind Amount for Water Bank*

- **“Leave behind”** refers to the intentional policy decision of dedicating a volume of recharged water in the aquifer to help ensure long-term sustainability.
- For example, the Water Bank plans to implement a leave-behind policy for agencies storing water with the intent of transferring it out of the basin after local needs are met. This policy mandates that a portion of the stored water remains in the basin and is never extracted as part of Water Bank operations. The primary goal of a “leave behind” is to build a reserve of groundwater that contributes to the long-term stability and resilience of the region’s water supply.

* Engagement – Sacramento Regional Water Bank (sacwaterbank.com)

Summary

- The modeling approach for Sacramento Area Water Bank is unique.
- The approach employs integrating Statewide operations model with local integrated hydrologic model and/or groundwater model.
- The modeling approach is currently used to support significant policy decisions and environmental permitting process for the Water Bank.
- This approach can be used in other similar conditions in the state, where groundwater banking opportunities are considered.

Discussions/Questions?

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