CALIFORNIA DEPARTMENT OF WATER RESOURCES

CVSOM Development: Phase 1 (Central Valley System Operations Model)

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<u>Disclaimer</u>

The material presented represents ongoing Modeling Support Office (DWR) staff work to improve modeling of the Central Valley water resources system and operations. Results are based on the January 2022 deliverables (code and documentation) from consultants to DWR. The deliverables are still being QA/QC'd by DWR staff, and should be considered preliminary & subject to revision.

CVSOM: Central Valley System Operations Model

One of the latest efforts by Modeling Support Office staff to improve "CalSim" for modeling California's State Water Project and Central Valley Project (SWP/CVP) for planning studies

Improvements to "CalSim" over the last 35 years progressed along four paths:

1. Engine:
   - HEC-3 (version) for DWRSIM (1980's and 1990's)
   - WRIMS for CalSim I (1999) and CalSim II (2001) – MILP
   - WRIMS2 for Calsim_3 "CS3" (~2020) - MILP

2. Hydrology:
   Generically, the process of calculating projected land use level water demands, and the available surface water supplies to operate the reservoirs to meet the "unmet" demands through diversions and groundwater pumping.

Improvements to "CalSim" …. (continued)

2. Hydrology (cont.):

a. 1980's and 1990's (for DWRSIM and CalSim I)- Depletion Analysis approach

- The DA approach relied on three sequential phases:

i. Consumptive Use Model (root zone accounting) to calculate demands.

ii. Depletion Model: an accounting model that modifies historical (observed) stream flows to get "projected" stream flows (at Depletion Area outflow locations). Embedded within the DM is simplified 'put-and-take' groundwater operation.

iii. Accretion phase using a "COMP" model (FORTRAN based spreadsheet to manipulate timeseries tables, to calculate the future water supplies. Included in this phase is computation of the "Closure Terms"; timeseries to reflect differences between observed stream flows, and those computed by DA water budgets. This is an important supply (in addition to rainfall runoff) to meet demands.

Improvements to "CalSim" …. (continued)

2. Hydrology (cont.):
   b. 2001(for CalSim II)- Modified Depletion Analysis approach which allowed for including historical groundwater pumping from CVGSM (pre-C2VSIM).
   c. Circa 2015 (for CalSim 3) – Using CalSimHydro (including a version of IDC) and modifications to computing the "Closure Terms"

3. Groundwater:
   a. 1980's and 1990's (for DWRSIM and CalSim I)- "pre-operated" groundwater operations from Depletion Analysis process.
   b. 2002 (for CalSim II) – Use linearized Integrated Finite Difference equations embedded as constraints in the WRESL code (limited in number for computational reasons).
   c. Circa 2015 (for CalSim 3) – using Groundwater DLL (GWDLL) based on the groundwater module of C2VSIM.

4. Operating Rules:
   Inclusion of increasingly complex rules for reservoir operations to meet physical, allocation, and regulatory constraints

CVSOM: Central Valley System Operations Model

Recent Academic Work (2017*)

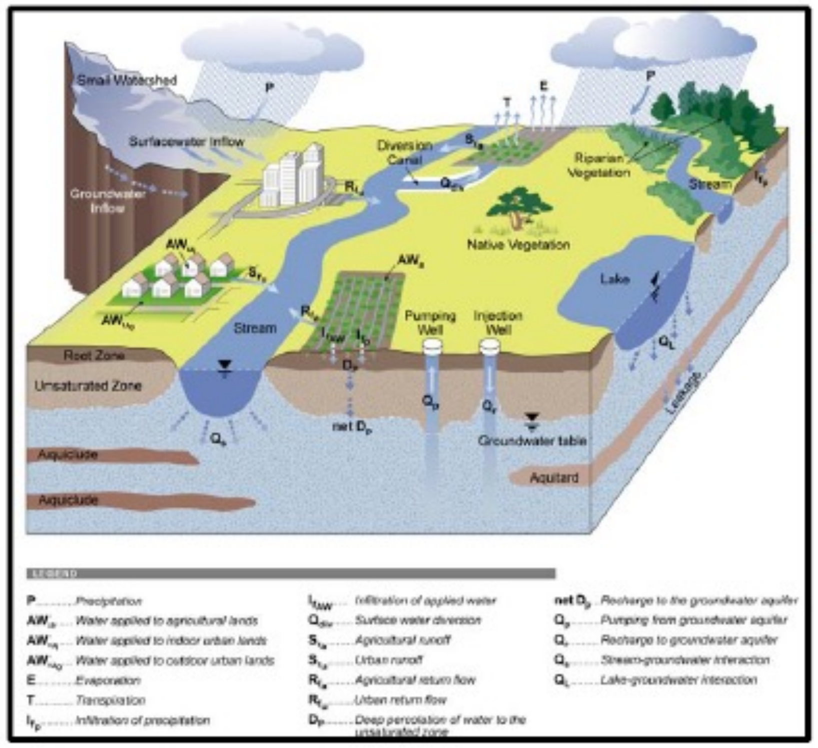


Figure 2-1: IWFM (DWR 2015a)

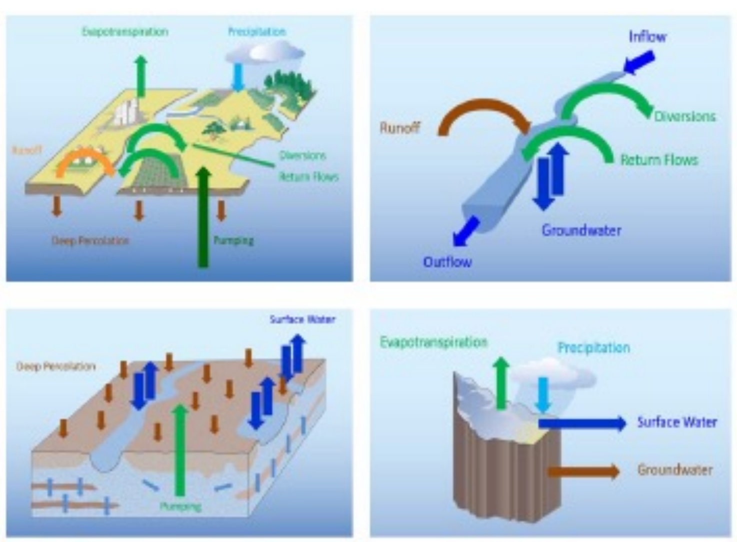


Figure 2-2: Major Hydrological Components Simulated in IWFM (CWEMF 2013)

Figure 2-3a: C2VSIM Extent in the Central Valley

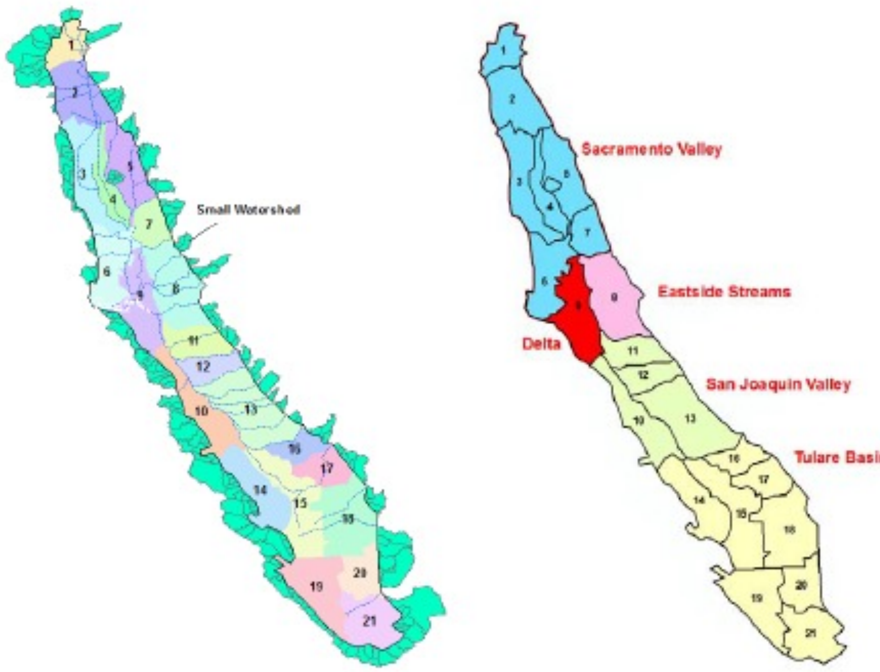


Figure 2-3b: C2VSIM Sub-regions –left- (black numbers), Major Streams, Small Watersheds, and Hydrologic Basins -right (red labels)

(*) Coupled Reservoir Operation and Integrated Hydrologic Simulation Modeling of the SWP and CVP Systems in California with Dynamic Hydrology Adjustment (Ph.D., UC Davis, 2017)

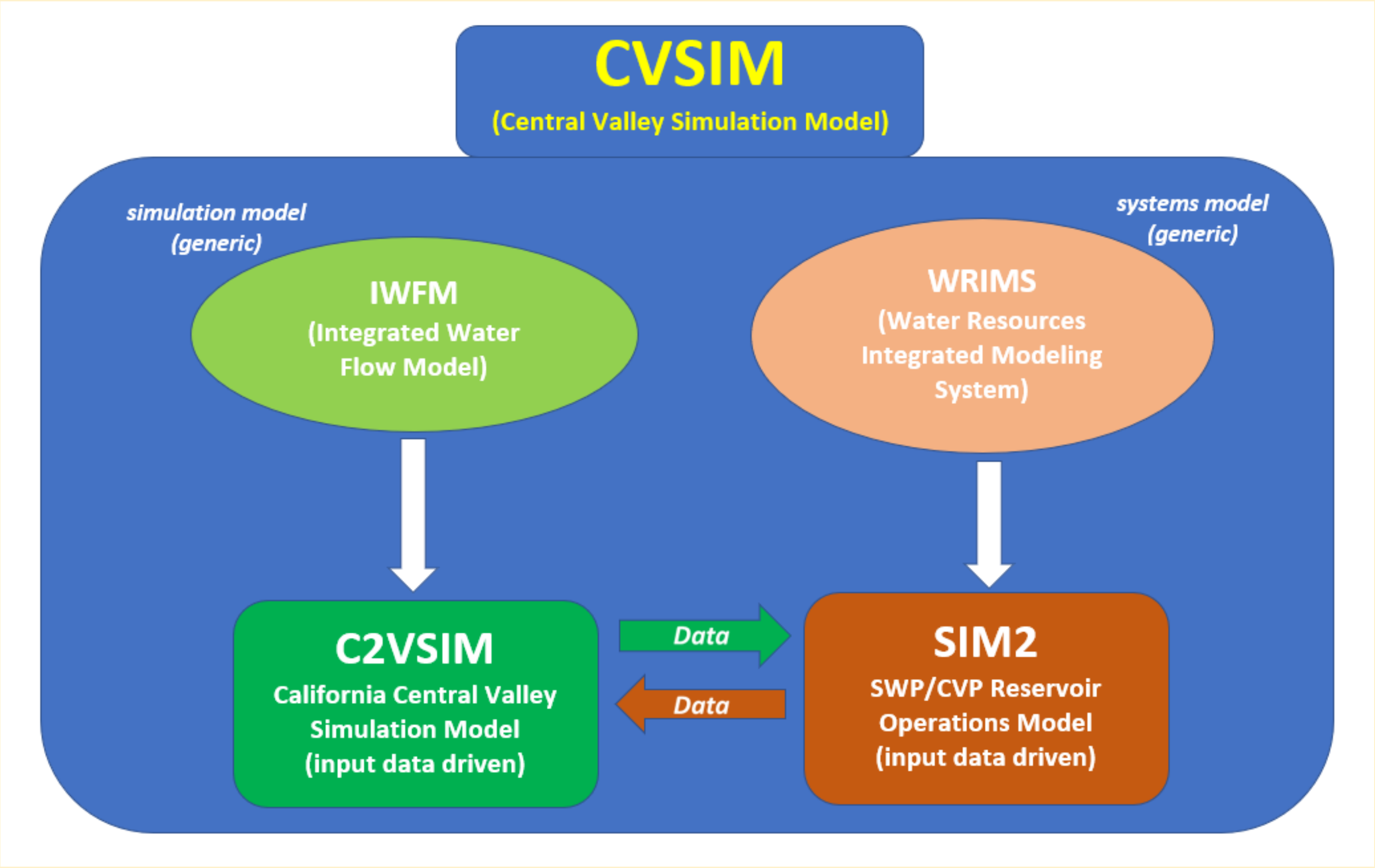
Motivation:

Let C2VSIM be the template for representing physical system, calculating demands , hydrology components, and routing, AND build a corresponding reservoir operations (systems) model based on WRIMS to do the allocation, subject to meeting physical, operational, and regulatory constraints

C2VSim computes the hydrology including water demands and adjusted supplies, precipitation runoff, steam-aquifer interaction (seepage), bypass flows (including weir flows), and passes on to the systems model SIM2 to compute reservoir releases, surface water diversions, ground water pumping, while imposed constraints.

Important:

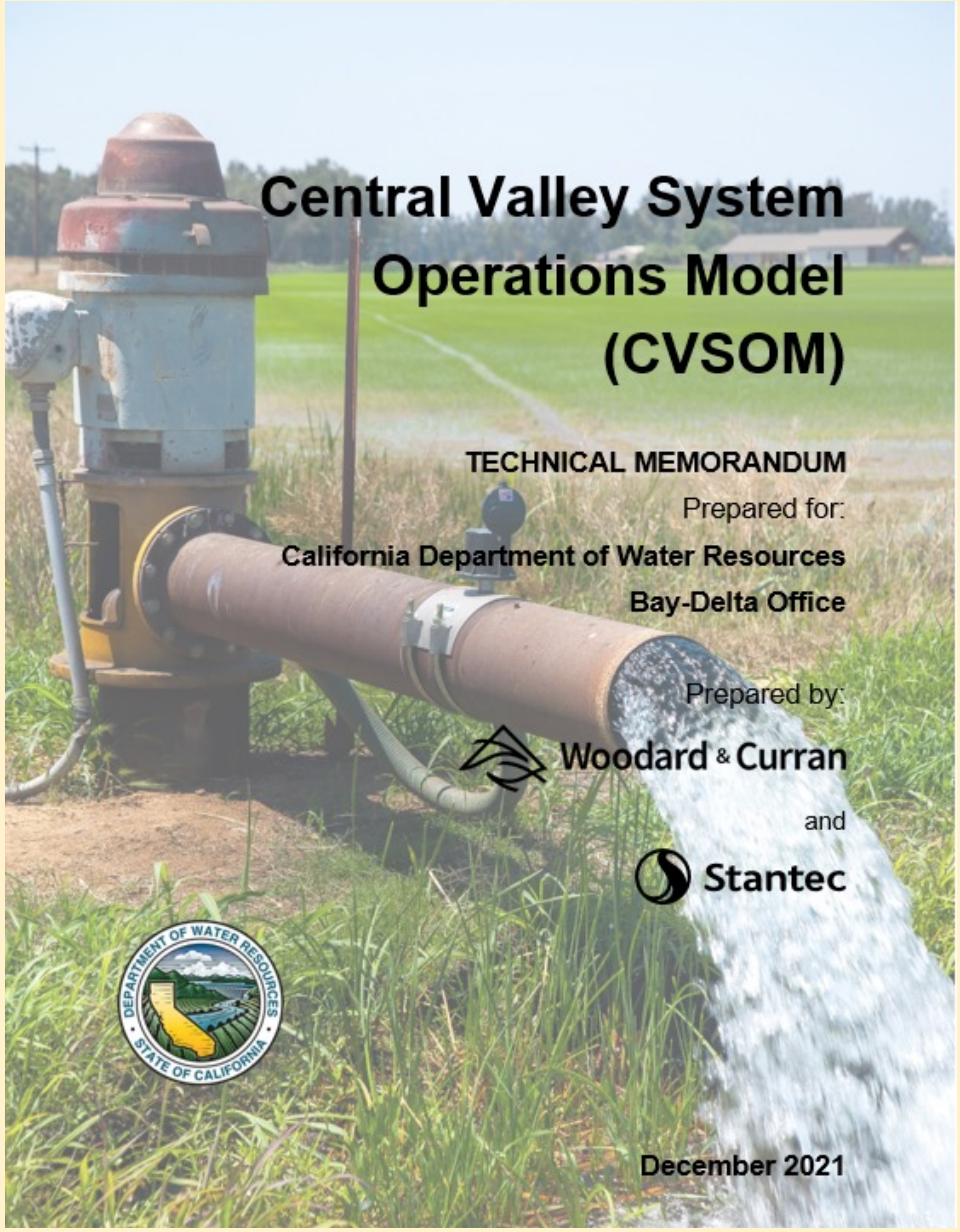
Closure Terms (or Water Supply Adjustments) Computed dynamically using ANN’s.

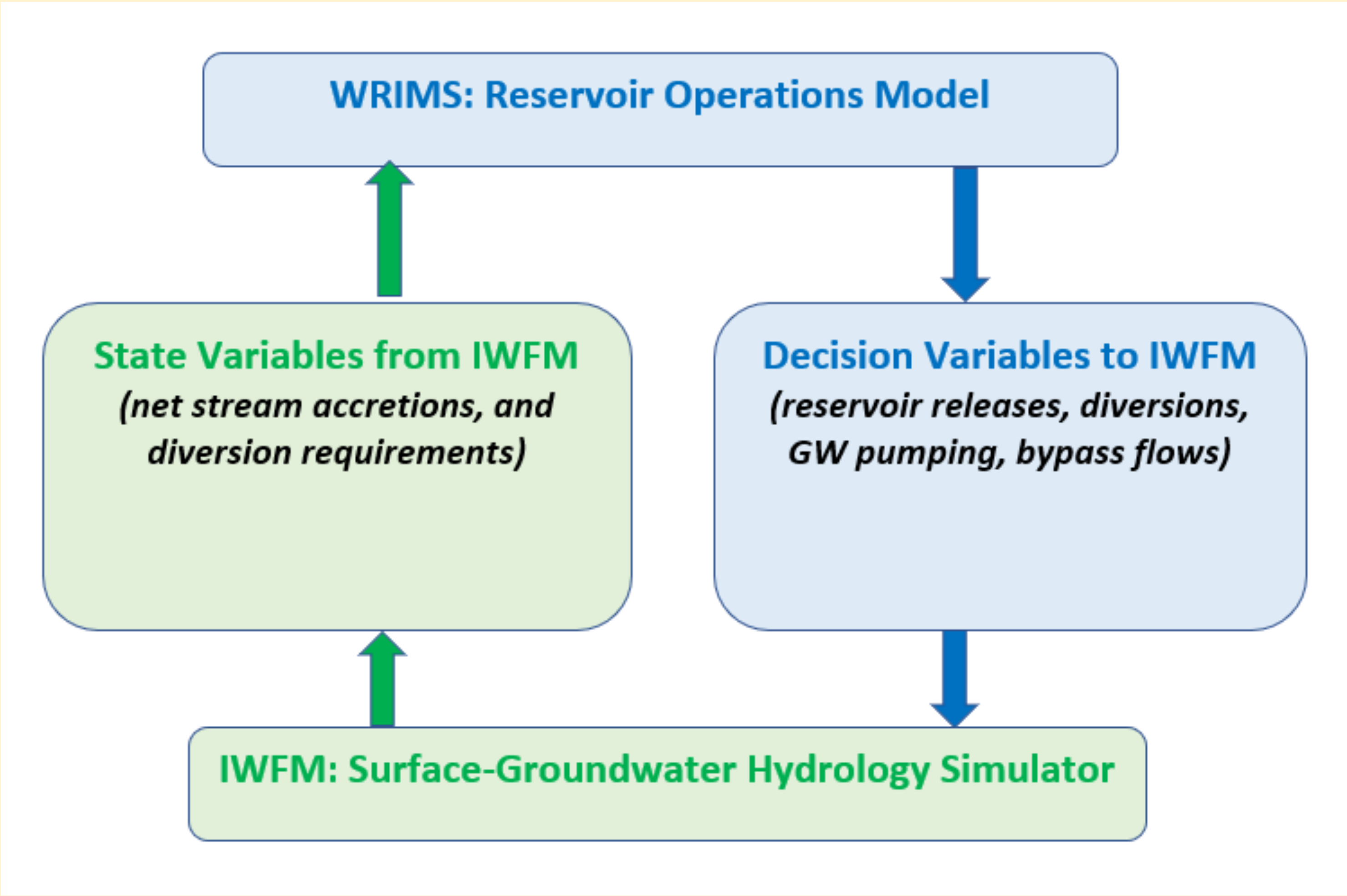


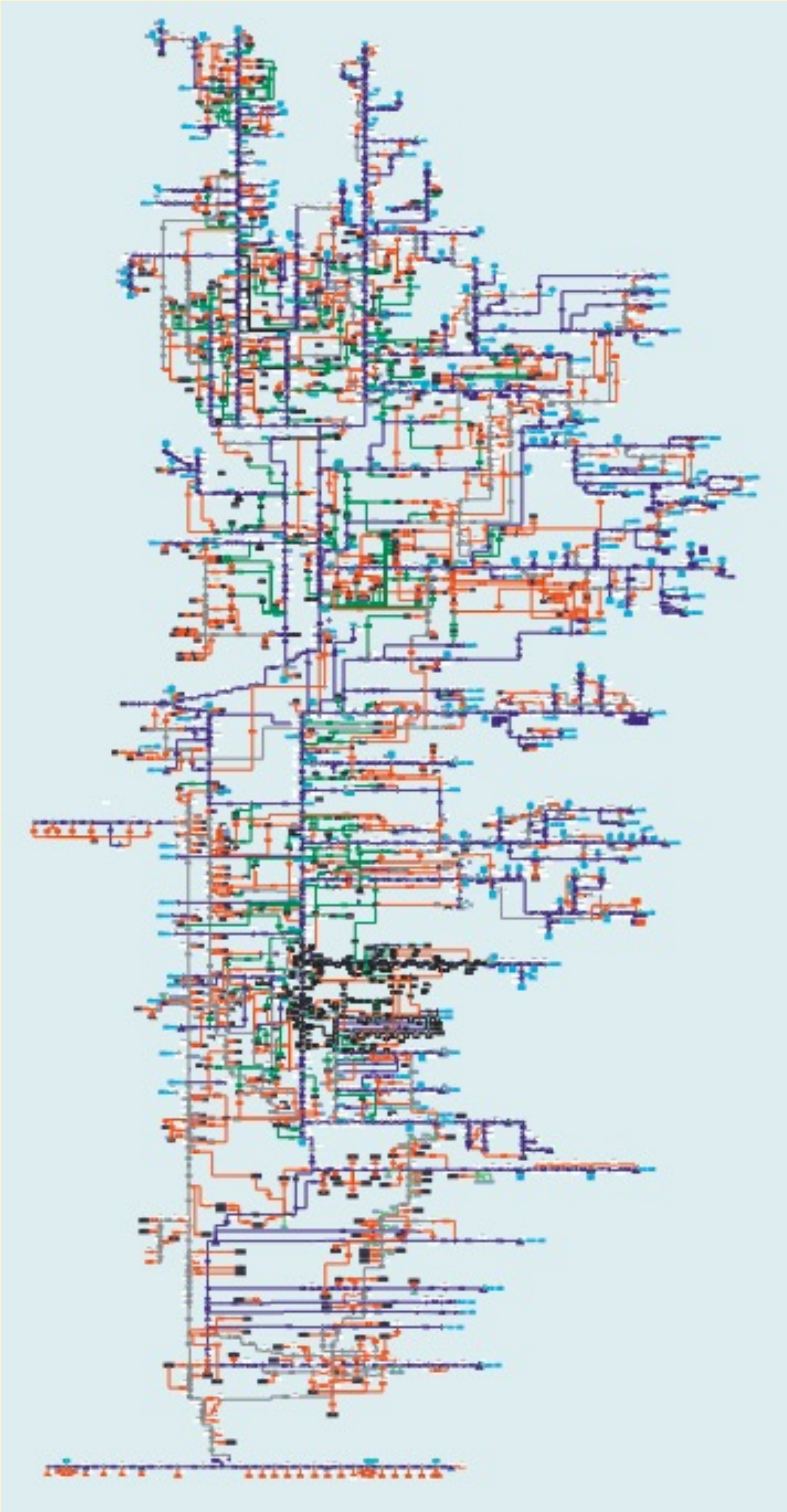
DWR (MSO) 2019-2020

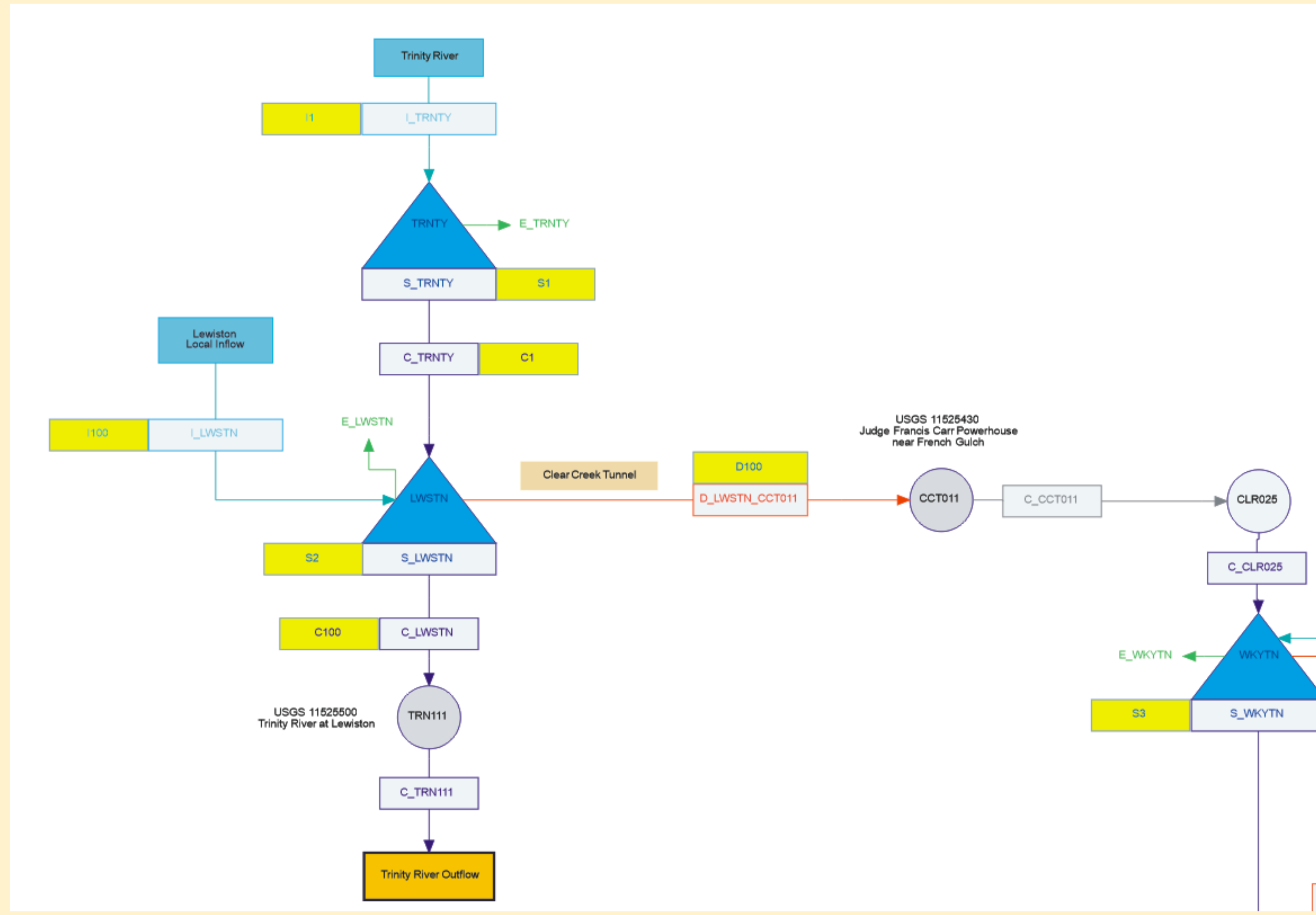
- IWFM 2015
- Updated C2VSIM
- IWFM-Ops wrapper
- Balancing Supply and Demand by Element Group
- Communications between IWFM & WRIMS2 on a monthly time step
- More reservoirs simulated (Sacramento and SJ Valleys, and more operation rules)
- Adding more physical features including California Aqueduct, DMC, and FKC

Consultants to DWR 2021









Trinity River
I1
I_TRNTY
TRNTY
E_TRNTY
S_TRNTY
S1
C_TRNTY
C1
Lewiston Local Inflow
I100
I_LWSTN
E_LWSTN
LWSTN
S2
S_LWSTN
Clear Creek Tunnel
D100
D_LWSTN_CCT011
USGS 11525430
Judge Francis Carr Powerhouse
near French Gulch
CCT011
C_CCT011
CLR025
C_CLR025
E_WKYTN
WKYTN
S3
S_WKYTN
C100
C_LWSTN
USGS 11525500
Trinity River at Lewiston
TRN111
C_TRN111
Trinity River Outflow

Key Features of January 2022 version of CVSOM

- Simulation of major reservoirs in the Sacramento Valley (more operating rules)
- Simulation of major reservoirs in the San Joaquin Valley (more operating rules)
- Simulation of water management facilities within the Tulare (Lake) Basin
- Simulation of Delta regulatory requirements, including State Water Resources Control Board water quality standards, using an Artificial Neural Network (ANN)

General

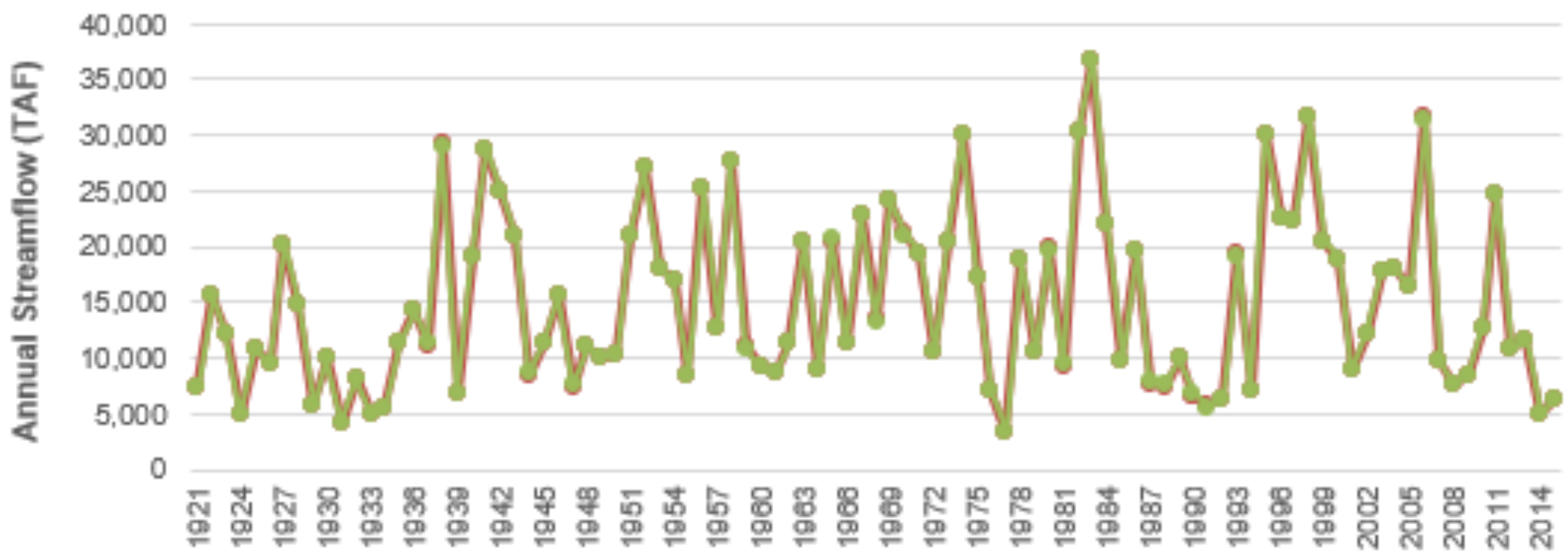
- Simulation period: WY1922-2015
- Monthly time steps
- Historical weather sequence (for precipitation and ET) and current land use, facilities, and regulatory environment
- Closure Terms from CalSim 3
- Comparison of CVSOM results to:
    - CalSim "Limited"
    - Recent historical

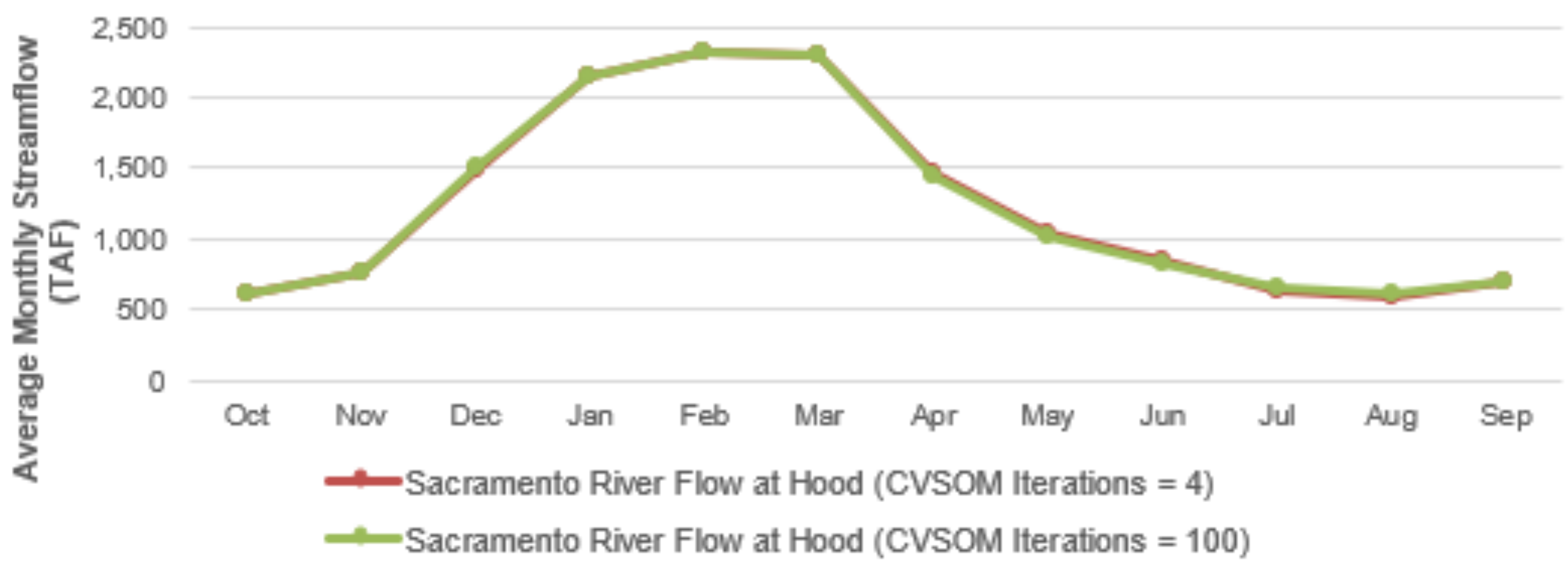
CalSim 3 Limited vs. CalSim 3

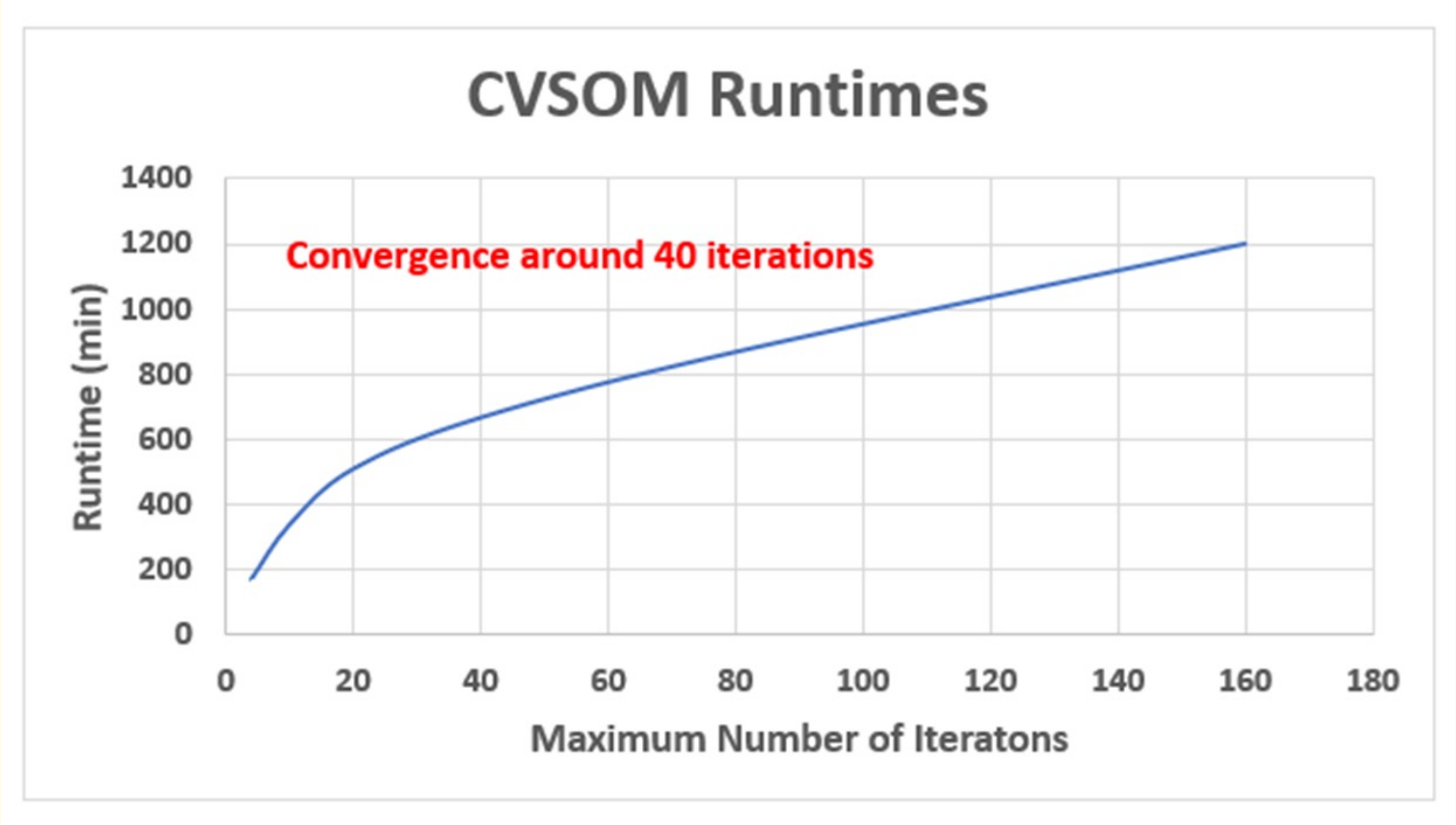
- A simplified or "limited" version of CalSim 3 to validate CVSOM results
- Simulates all the in initial cycles of the full CalSim 3 (public release July 30, 2021), **including**:
    - Forecast cycles
    - Upper watershed cycles
    - SJ Valley cycle
    - First Sacramento Valley cycle
    - **Does not** include (at this time) regulations for:
        - Free wheeling
        - Water transfers
        - Joint Point of Diversion
        - Refined COA sharing formula
        - SWP Incidental Take Permit (ITP)

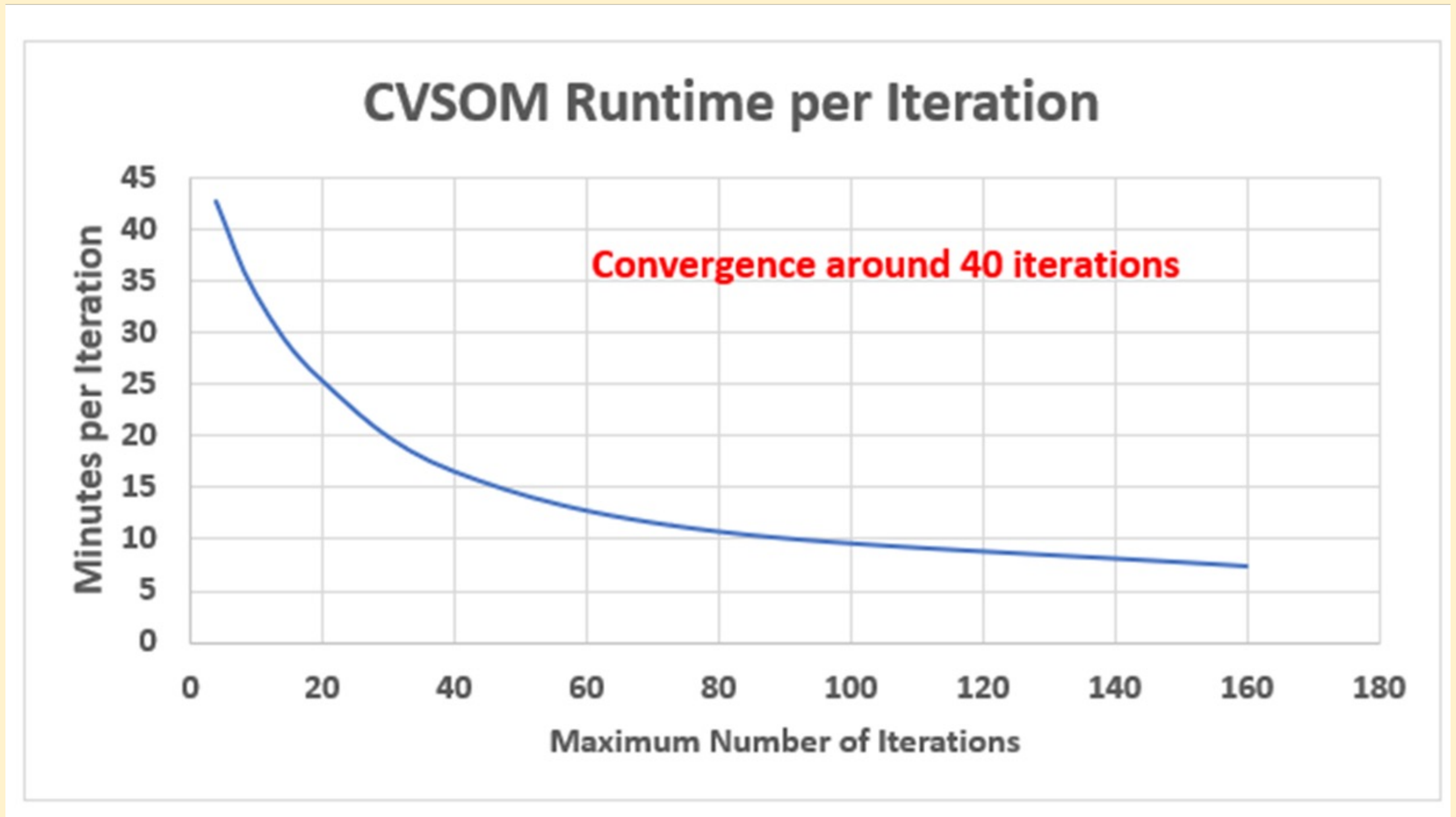
Runtimes

Max Number of Iterations	Water Years	Run Time (Hours)
5	1922-2015	03:14:30
10	1922-2015	05:17:32
20	1922-2015	07:33:49
30	1922-2015	10:07:23
40	1922-2015	10:58:48
50	1922-2015	11:47:44
100	1922-2015	12:41:46
200	1922-2015	14:17:58






CVSOM Runtimes
Convergence around 40 iterations
Runtime (min)
1400
1200
1000
800
600
400
200
0
0
20
40
60
80
100
120
140
160
180
Maximum Number of Iteratons


CVSOM Runtime per Iteration
Convergence around 40 iterations
Minutes per Iteration
45
40
35
30
25
20
15
10
5
0
0
20
40
60
80
100
120
140
160
180
Maximum Number of Iterations

CVSOM - Long Term Average Flows for Sacramento River at Freeport (C_SAC049) in cfs

	WY1922-2015	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Total
Max-iter = 4	Avg.	10031	12844	24536	35124	41783	37858	24657	16900	14232	10531	9781	11893	250169
	Max	28464	60690	91200	107235	122998	119810	85493	63091	57088	24164	16169	20955	622887
	Min	4181	3488	5417	6673	7348	7137	4005	3432	2657	2677	3070	4169	57717
Max-iter = 10	Avg.	10035	12904	24521	35081	41764	37841	24636	16861	14135	10495	10089	11861	250223
	Max	29157	60631	91126	107245	122999	119812	85059	63105	57064	24188	16174	20962	622855
	Min	4091	3493	5132	6738	7338	7255	3867	3423	2607	2636	3100	4224	57922
Max-iter = 20	Avg.	10063	12900	24599	35127	41751	37829	24629	16843	14119	10548	9868	11909	250184
	Max	29158	60676	91126	107245	122999	119817	85059	63105	57065	24188	16175	20963	622855
	Min	4092	3485	5204	6733	7327	7263	3868	3426	2607	2639	3102	4226	57943
Max-iter = 40	Avg.	10086	12910	24593	35127	41731	37819	24626	16849	14137	10551	9872	11899	250201
	Max	29138	60609	91125	107245	122998	119819	85060	63106	57064	24188	16174	20962	622888
	Min	4092	3493	5195	6727	7326	7263	3868	3425	2607	2638	3102	4226	57945
Max-iter = 80	Avg.	10086	12919	24574	35120	41722	37826	24628	16847	14138	10563	9882	11913	250218
	Max	29038	60608	91125	107245	123003	119819	85059	63105	57063	24187	16174	20962	622851
	Min	4092	3485	5206	6735	7328	7263	3867	3425	2607	2639	3102	4226	57940
Max-iter = 160	Avg.	10079	12913	24597	35105	41722	37827	24630	16840	14139	10571	9873	11903	250199
	Max	29038	60606	91123	107245	122999	119819	85059	63105	57064	24188	16174	20963	622854
	Min	4092	3485	5206	6736	7328	7263	3866	3426	2607	2639	3102	4226	57934

Runs by TKadir using CVSOM_clean

Conclusions

- Robust proof of concept of IWFMF-Ops (using IWFM and WRIMS2)

- Provides a reasonable approximate simulation of federal, state, and local agency facilities across the Central Valley and resulting surface water and groundwater flows and storage

Future Work

- Continue QA/QC, especially groundwater

- Improve IWFM-Ops to reduce runtimes

- Develop ANN's to dynamically computer water supply adjustments (closure terms)

Thank You

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