Improved Representation of Stream Inflows and Surface water deliveries in C2VSimFG

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- Tracy Subbasin GSP team: Tracy subbasin data

Outline

Background

- Observed surface water data in C2VSimFG are foundational to building a good integrated SW-GW model
- Systematic approach and reproducible research in documentation and transparency (data science principle, GitHub, R and Python)
- Laborious work on data collection and QA/QC iterative processes

Stream inflows and Small Watersheds

- Watershed delineation tool
- Small watersheds and rim inflow delineation
- Time extension to WY2021
- Improved representation and bug fixes (double counting or underestimate of surface water inflows)

Surface water deliveries

- Time extension to WY2021
- Improved representation and bug fixes (diversion shortage, mismatch with water demand and delivery areas, Ag/urban surplus or shortage)

Stream Inflows and Small Watersheds

Watershed delineation tool is used to delineate drainage area above USGS stream gauges.

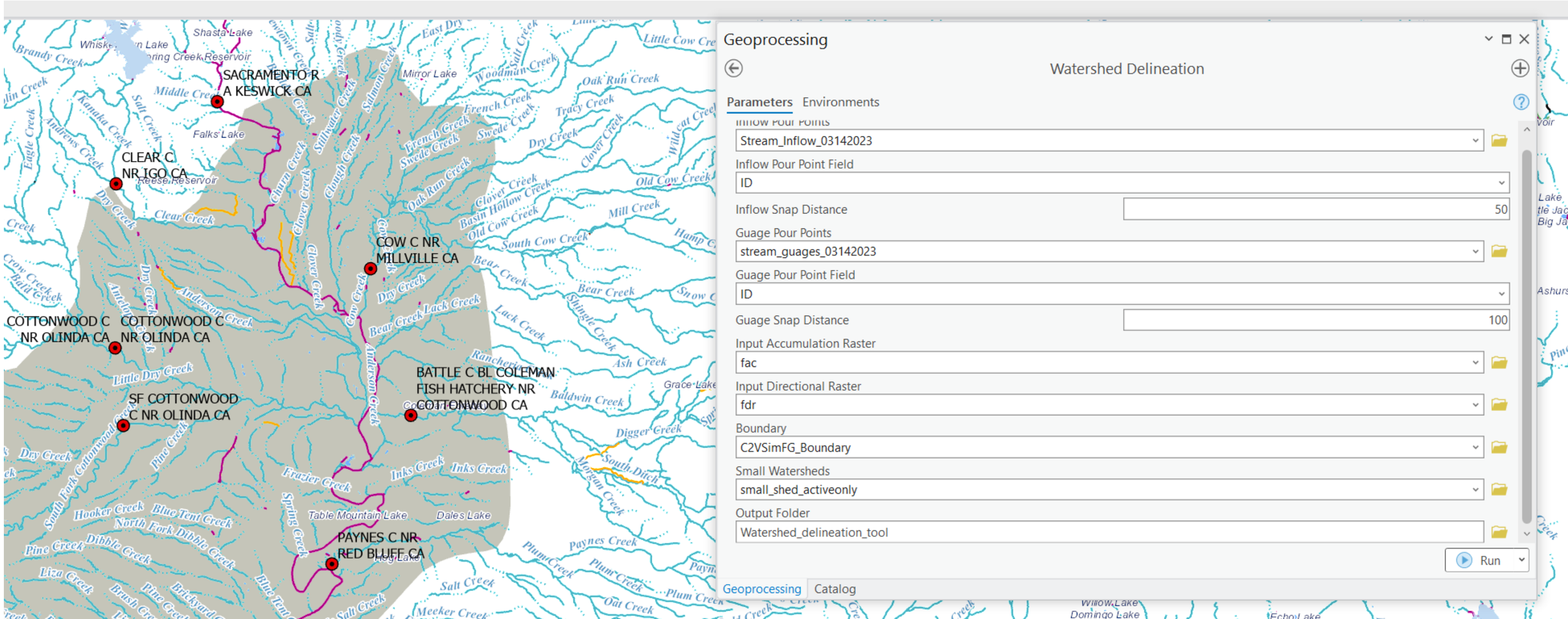
Automate delineation process and calculate scaling ratio	Guarantee to being seamless among boundaries	Reproducible and easy update for future model boundary

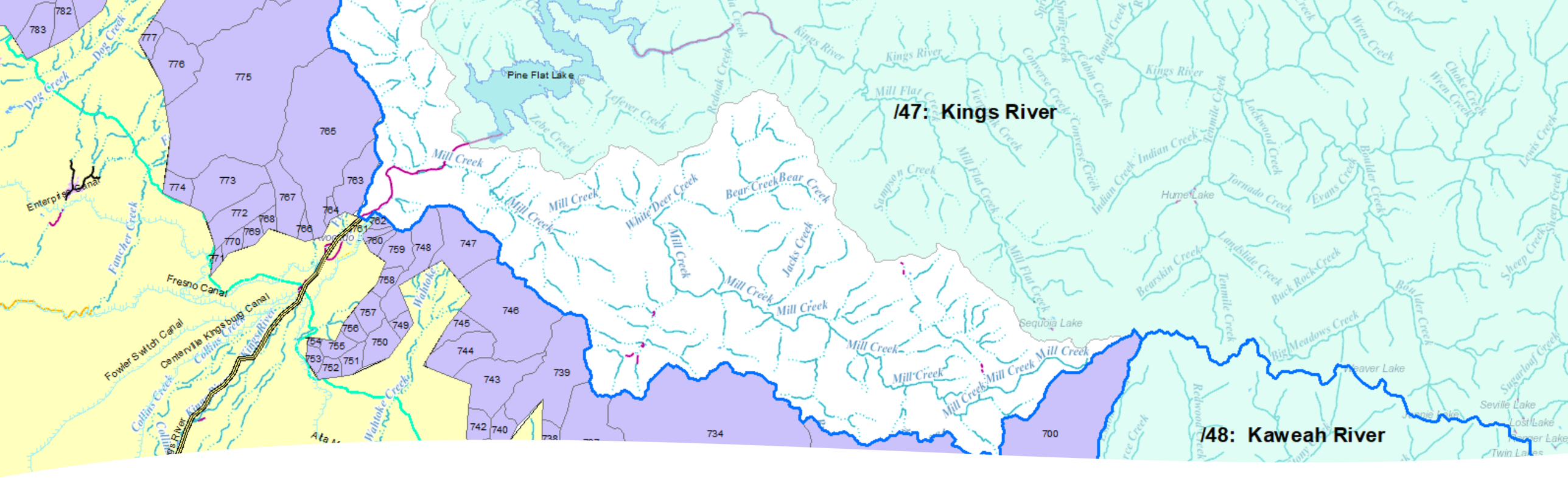
The Watershed Boundary Dataset (WBD) is intersected with C2VSimFG elements and the delineated gauged inflow watershed boundary to identify ungauged drainage.

Small watersheds: the ungauged area can be simplified at HUC10 level.

Watershed delineation tool

Arc GIS Pro 3.x Python based tool: watershed delineation using pour points, flow accumulation and directional raster.





Example: Stream Inflows – Kings River

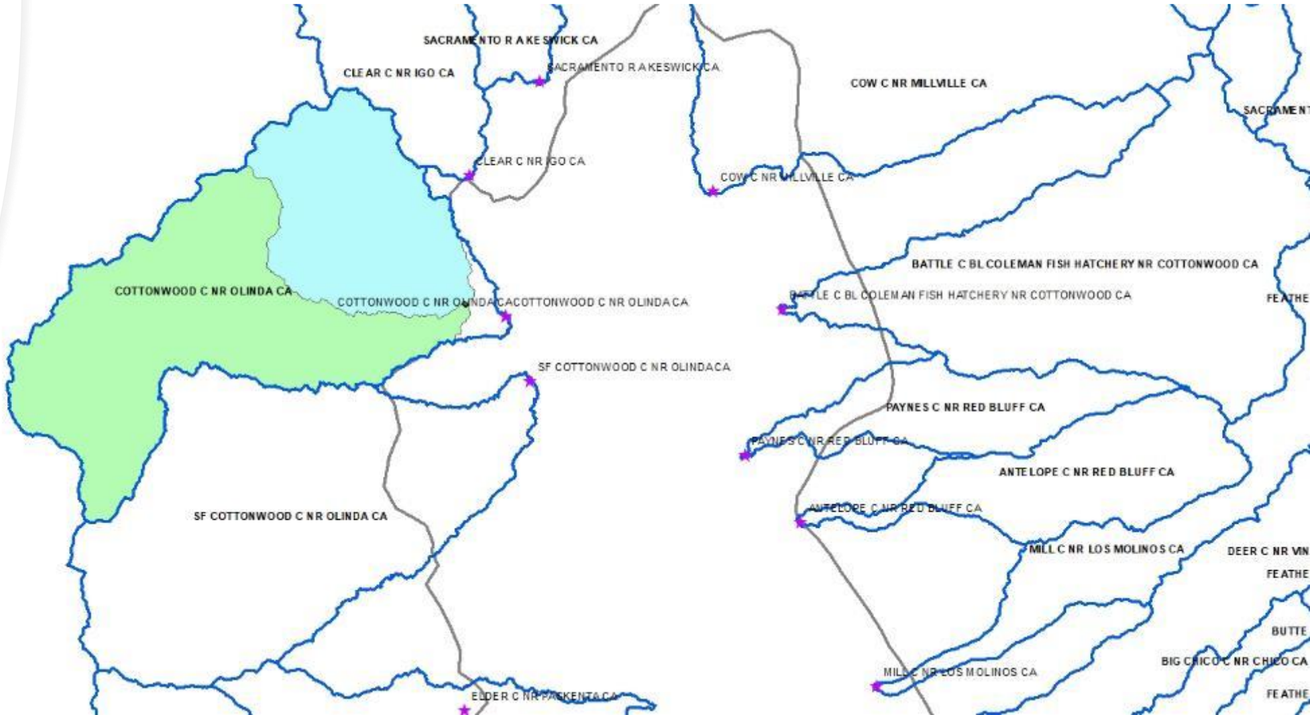
- Using Pine Flat Dam releases (USACE) means Mill Creek runoff is excluded.
- Calculated scale ratio: 1.10
- Because Mill Creek unimpaired runoff is different from regulated flows, separate estimation may be more accurate (limited USGS gaged flow data for Mill Creek and Kings River above Piedra discontinued by Sep 1959)

Start Date	End Date	Source
10/01/1921	09/30/1958	USGS gage 11222000 KINGS RIVER AT PIEDRA, CA
10/01/1958	09/30/1990	USGS gage 11221500 KINGS RIVER BELOW PINE FLAT DAM, CA
10/01/1990	09/30/2015	Pine Flat Dam releases (USACOE)

Stream inflows time extension to WY2021

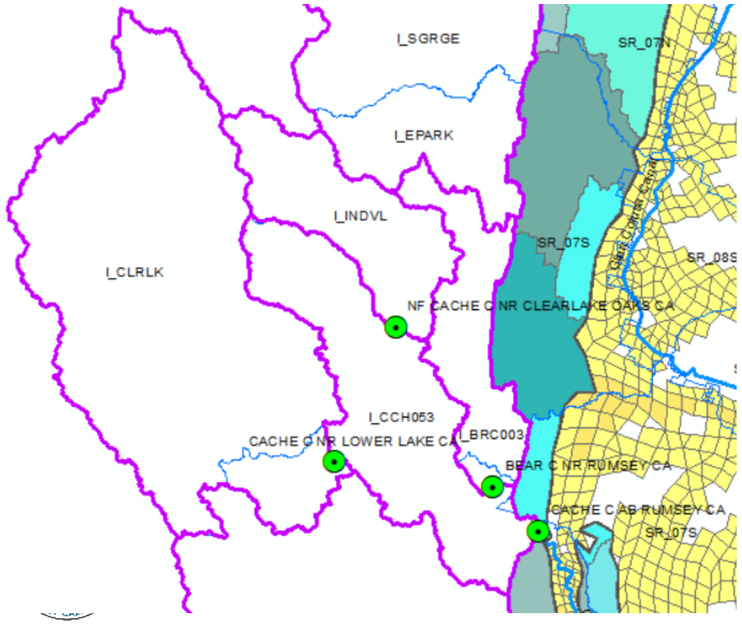
- Upstream reservoir releases: USGS gages or USACE operation data with drainage scaling ratio
- (e.g. Sacramento River at Keswick)
  - Unregulated streamflow: USGS gages (e.g. Cow Creek) or regression using adjacent gaged flow data. (e.g. SF, NF and MF Cottonwood Creeks)
  - Combined inflows from gaged flows and estimated unimpaired runoff (e.g. Cache Creek, Yuba River and Bear River)
  - New scale ratio values from watershed delineation
  - Python notebook and/or R script

	Node_Name	ScaleRatio	Note
2	/1: Sacramento River	1.00	One USGS gage
3	/2: Clear Creek	1.01	One USGS gage
4	/3: Cow Creek	0.86	One USGS gage
5	/4: Battle Creek	0.96	One USGS gage
7	/6: MF Cottonwood Creek	0.62	NF and MF share the same USGS gage
8	/7: SF Cottonwood Creek	0.83	One USGS gage
9	/8: Paynes and Sevenmile Creek	0.78	Sevenmile Creek within C2VSim model domain
10	/9: Antelope Creek Group	1.00	One USGS gage
11	/10: Mill Creek	0.99	One USGS gage
12	/11: Elder Creek	1.02	One USGS gage
13	/12: Thomes Creek	1.01	One USGS gage
14	/13: Deer Creek Group	1.00	One USGS gage
15	/14: Black Butte Release to Stoney Creek	0.94	USACE release data
16	/15: Stoney Creek North Fork	1.16	USACE Black Butte inflow data
17	/16: Stoney Creek South Fork	1.00	USACE Black Butte inflow data
18	/17: Big Chico Creek	1.00	One USGS gage
19	/18: Butte and Little Chico Creeks	1.00	Little Chico creek included in Small watershed
20	/19: Feather River	1.00	USGS gaged flows
21	/20: Honcut Creek North Fork	1.23	limited observed data
22	/21: Honcut Creek South Fork	2.19	limited observed data



Major changes and bug fixes for Stream inflows and small watersheds

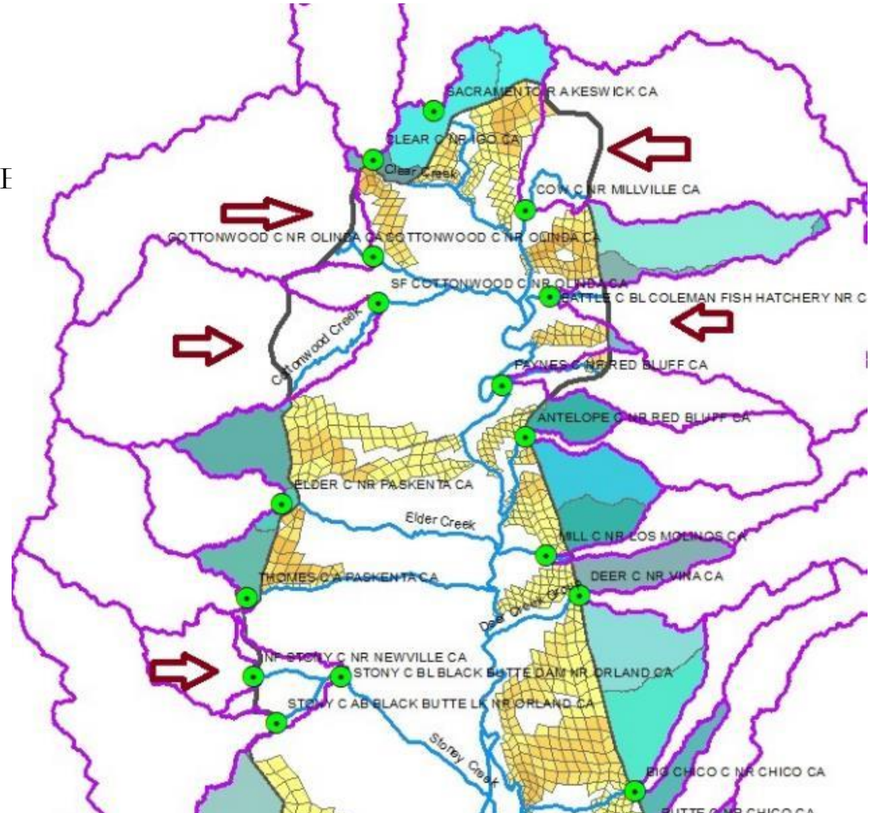
- Kern river: use CDEC station KRB in place of Isabella Dam releases (USACE). Remove overlapped small watesheds.
- Kings River: new scaling ratio (1.10) to include Mill Creek
- San Joaquin river: remove Small watershed 799 (I_SJR265, Cottonwood creek -San Joaquin)
- Little Panoche Creek removed (most drainage overlapped with small watersheds, lack of gage data)
- Avoid using CalSim unimpaired inflows for regulated inflows, apply new drainage area scaling ratio.
  - Cache creek: Indian valley reservoir outflow (CDEC) and USGS stream gages.
  - Stony Creek Black Butte inflows (USACE operation data)



Cache Creek above Rumsey in V1.01:
USGS gage 11451000 CACHE CREEK NEAR LOWER LAKE + CalSim 3 Cache Creek Local Inflow (I_CCH053) + CalSim 3 North Fork Cache Creek Inflow (I_INDVL) + CalSim 3 Bear Creek Inflow (I_BRC003)

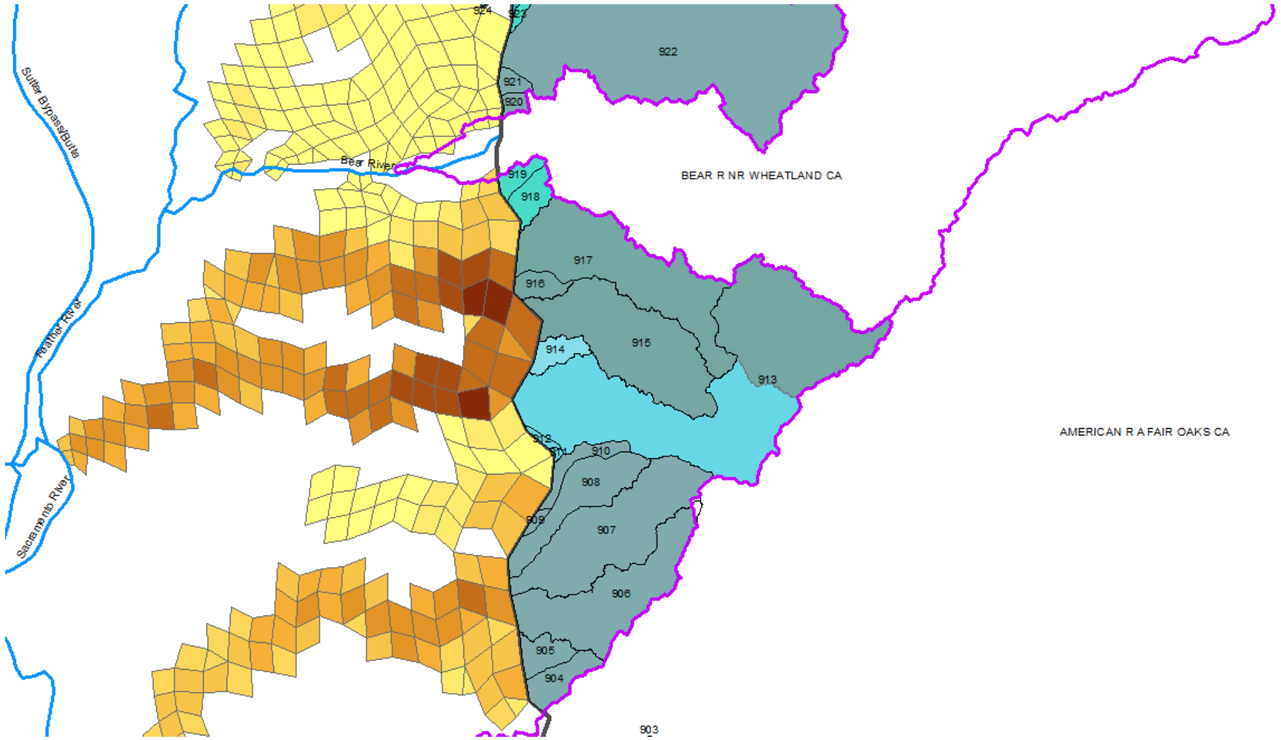
Small watersheds:

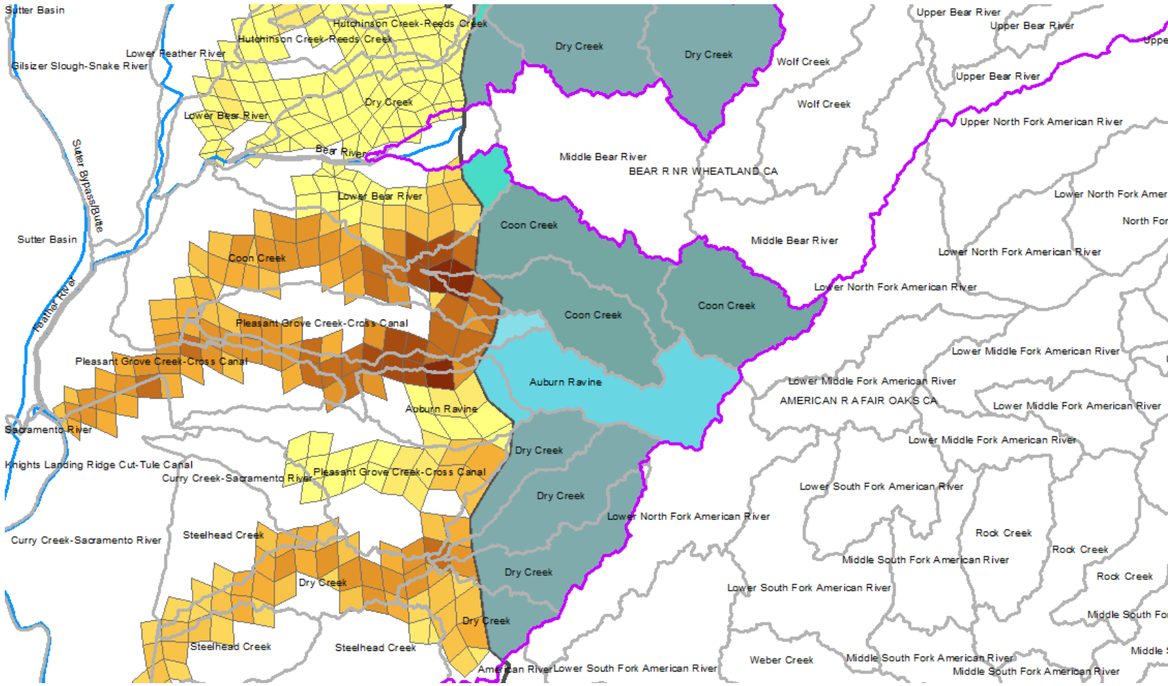
- Option 1: Keep current 1, 000 small watersheds
  - Small watershed boundary adjusted for spatial gaps(830, 1004, etc.)
  - Many small watersheds to be inactive for surface inflows due to double counting with gaged inflows.
- Option 2: Small watersheds simplified to about 300 in total.
- Open question: how to consistently consider subsurface boundary inflows (mountain front recharge)?



Small watershed figures: HUC12 vs. HUC10

- Figures show element subsurface inflows, small watersheds in V1.01 and proposed HUC10 simplification.





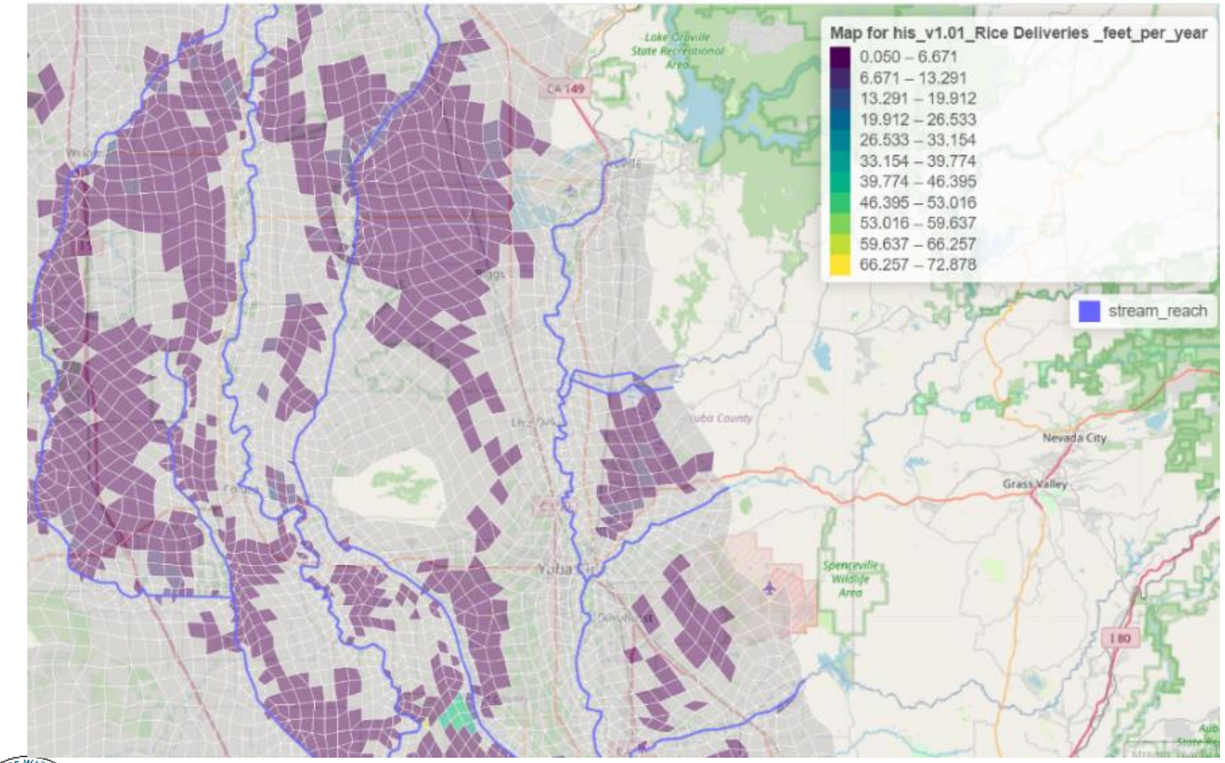
Surface Water Deliveries

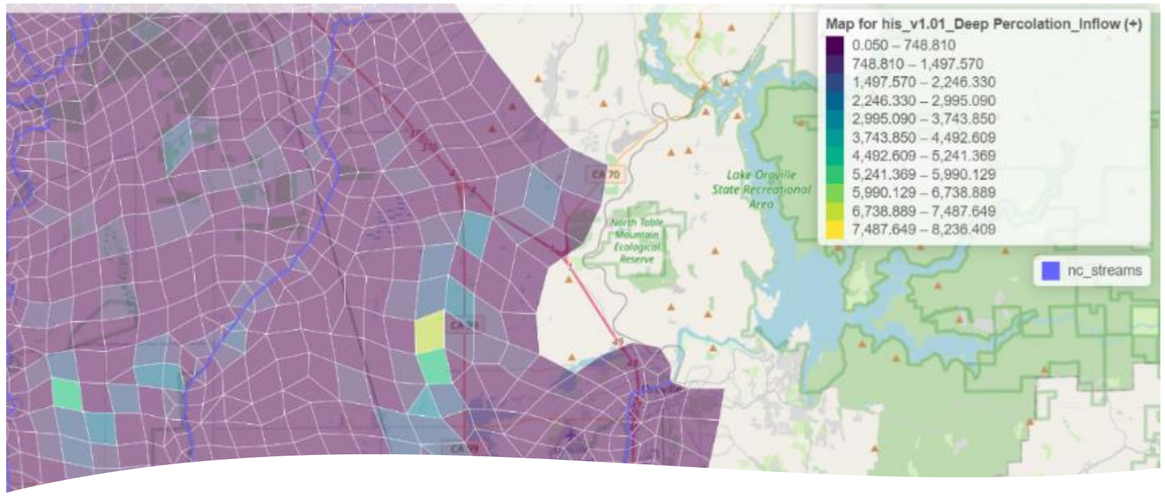
Time series data extension to WY2021.

Improved representation and bug fixes

Role of Surface water deliveries in C2VSimFG water budget

- **In IWFM, groundwater pumping** is estimated from (water demand – surface water supply). Ag and urban supply requirements are estimated from land use and evapotranspiration.
- Stream water budget (e.g. **stream-aquifer interaction**) is impacted by in-stream surface water diversion.
- Groundwater budget: deep percolation of applied water, recoverable loss





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Overview of C2VSimFG V1.01 diversion data

C2VSimFG_DiversionSpec.DAT: diversion specification

C2VSimFG_Diversions.DAT: time series data

Overview of C2VSimFG V1.01 diversion data

C2VSimFG_DiversionSpec.DAT: diversion specification

1. 465 diversion specifications in total

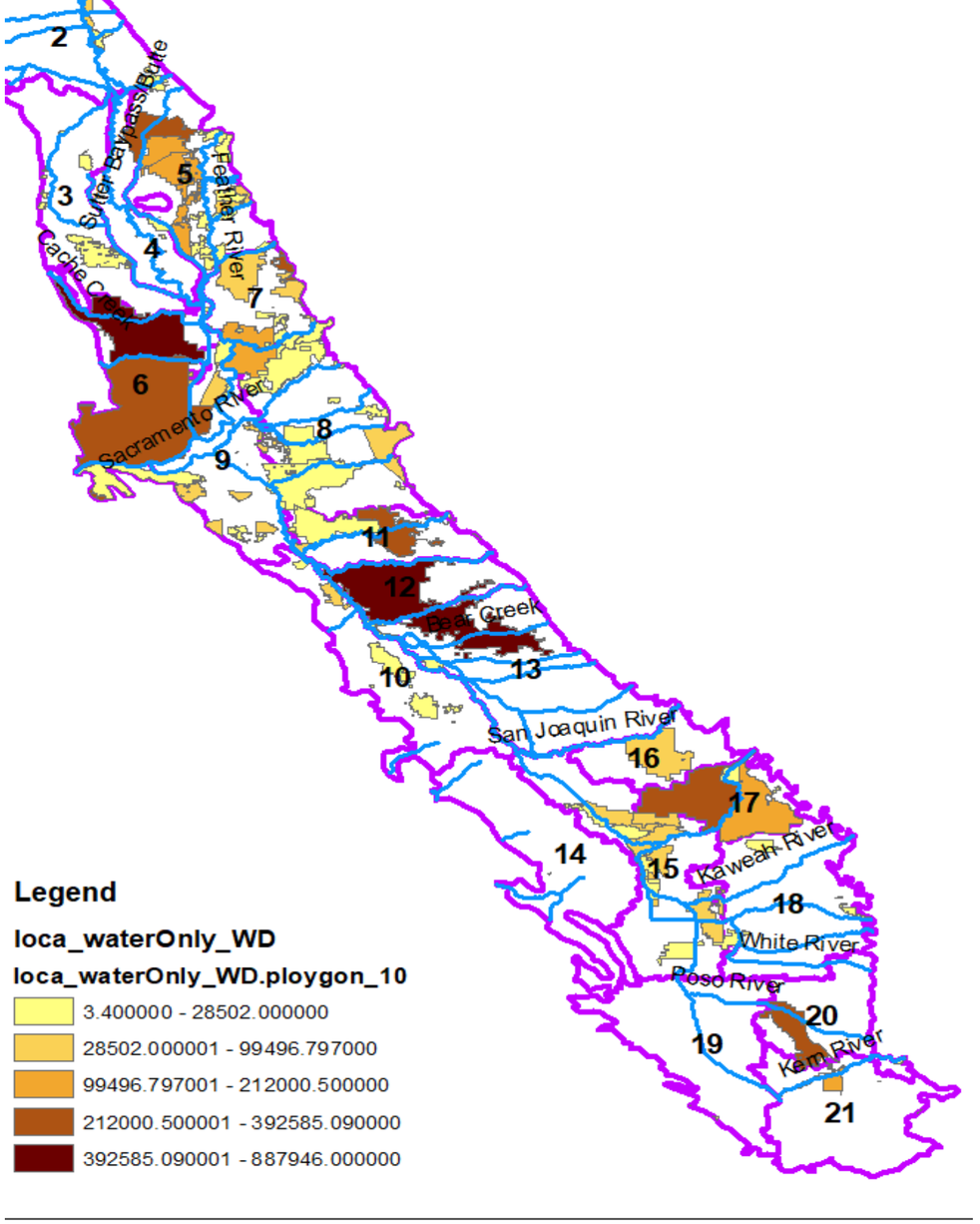
2. 424 surface water diversions (ID# 1 - 424).

3. 27 special specifications for stream evaporation (ID# 439-465)

4. 14 Place holder for future use (ID# 425-438)

Overview of C2VSimFG V1.01 diversion time series data

- Total 460 columns of time series data
  - **424 columns for surface water deliveries**
  - 16 for flow bypasses
  - One stream evaporation
  - Others as place holder



Credit: Based on Hagerty (2022)

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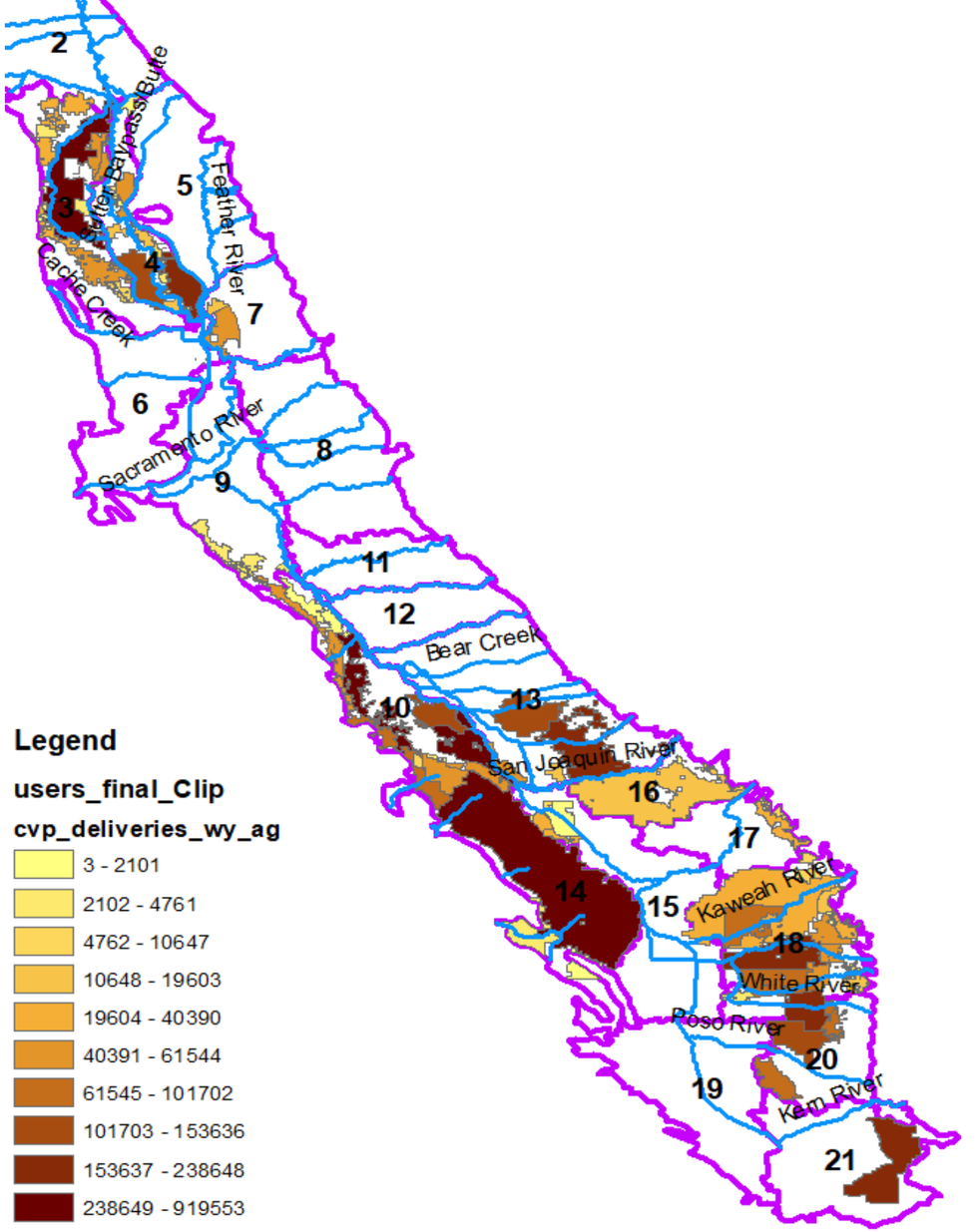
Overview of C2VSimFG V1.01 diversion time series data

- Total 460 columns of time series data
  - **424 columns for surface water deliveries**
  - 16 for flow bypasses
  - One stream evaporation
  - Others as place holder
- Surface water supply source: CVP, SWP, local streams, water transfer and others.
- Surface water use: Ag, managed wetland, urban and groundwater recharge.



Credit: Based on Hagerty (2022)
https://github.com/hagertynw/data-surface-water

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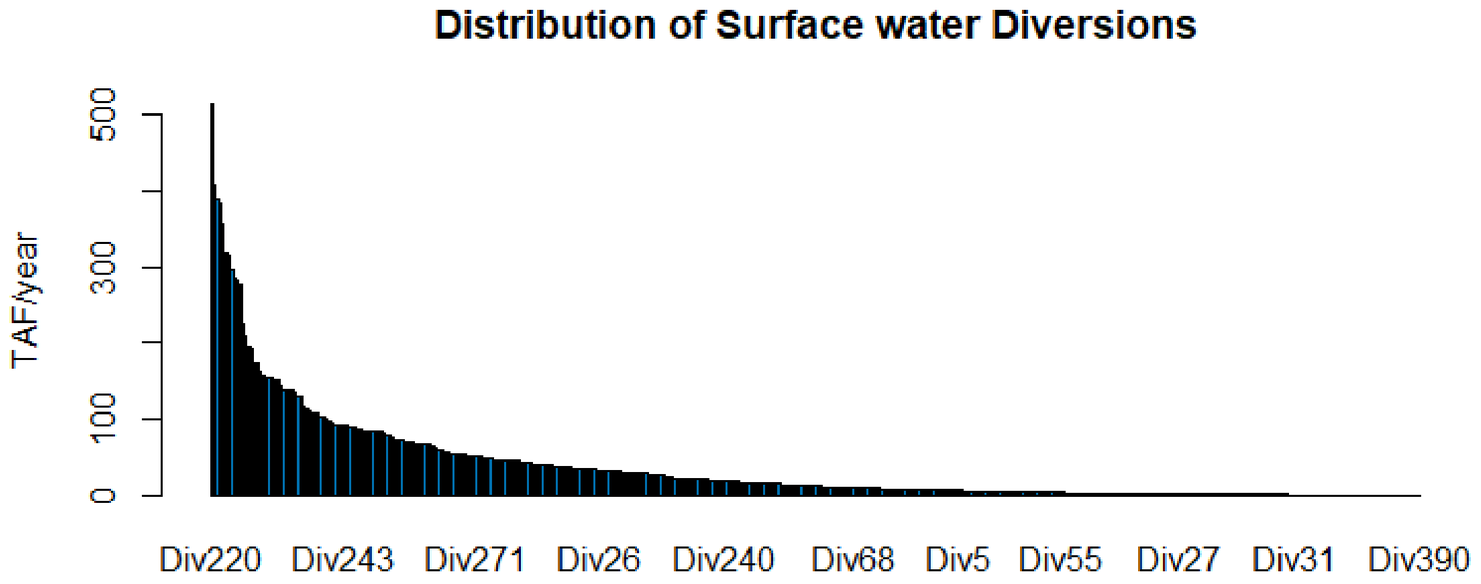
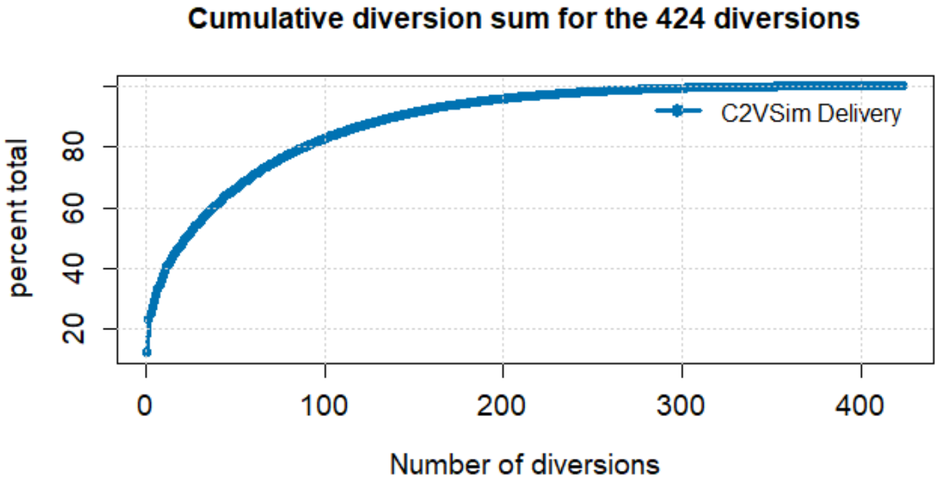
Statistics on C2VSimFG V1.01 diversion data (WY1996-WY2015)

out of 424 deliveries, excluding CVP and SWP Delta exports, number of diversions have annual mean deliveries :

1. > 100 TAF/yr., 47
2. > 50 TAF/yr., 98
3. > 30 TAF/yr., 143
4. <= 5.0 TAF/yr., 145
5. <=0.1 TAF/yr., 20+
6. SWP and CVP Delta exports > 2,000 TAF/yr.



Excluding Div184 and 185 for SWP and CVP Delta exports

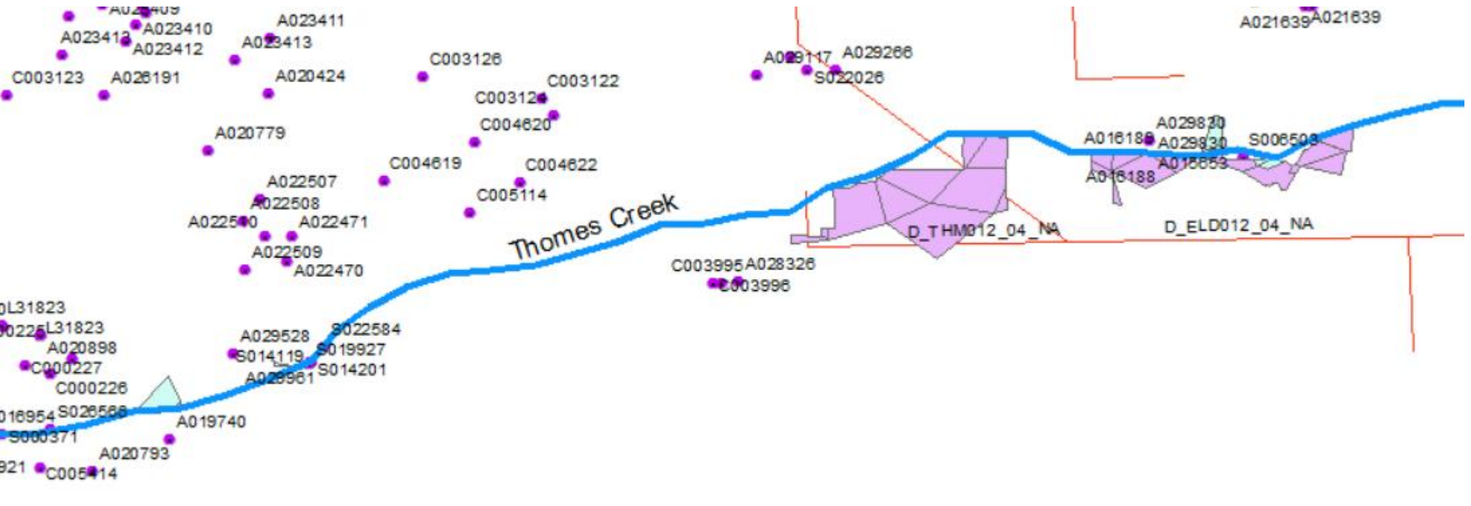


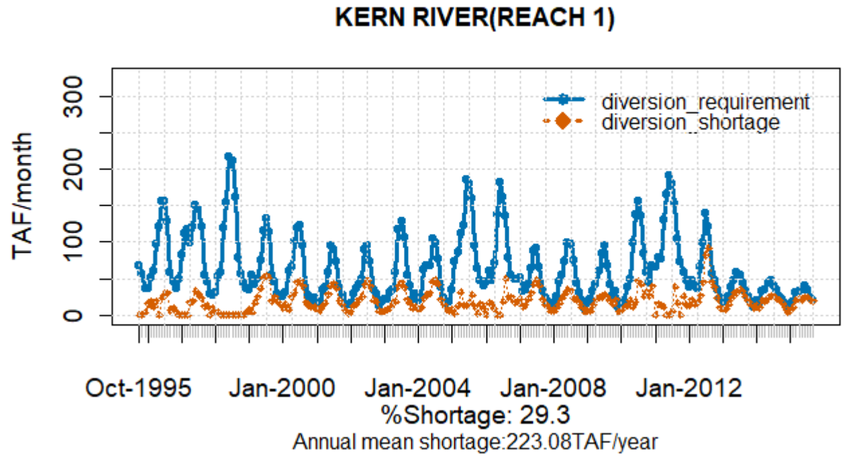
Diversion shortage and Ag. shortage or surplus in C2VSimFG V1.01

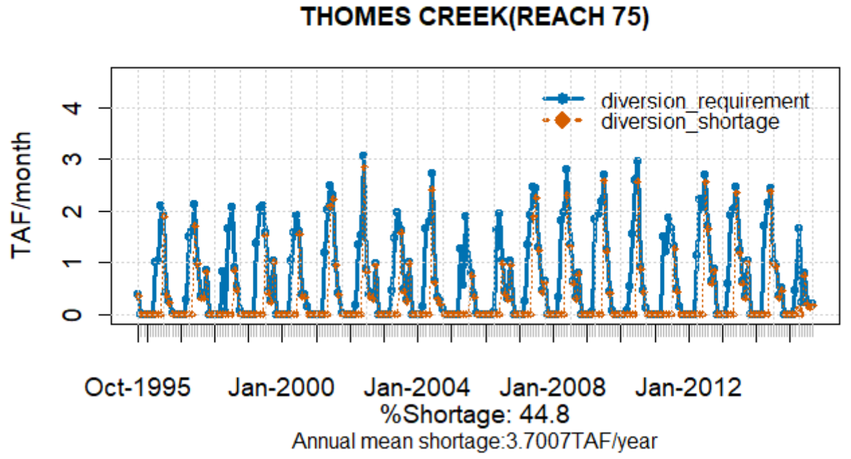
- 33 Stream reaches have diversion shortage
- Major shortage reaches: Kern, South fork King, Colusa drain, Fresno Slough

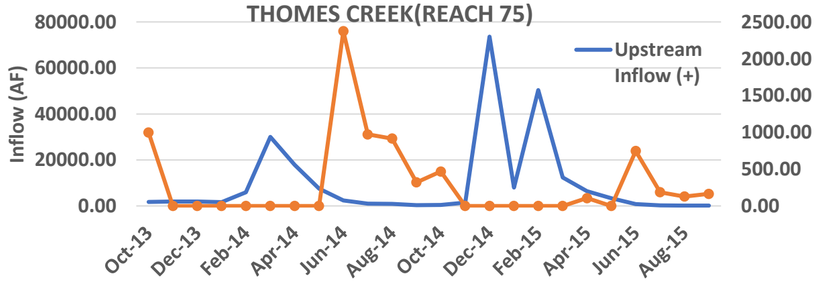
What cause diversion shortage:

1. Stream inflows (e.g. Colusa drain, Kern river)
2. Diversion input (Kern river AEWSD wrong water source - CVP and others)
3. Applied demand based estimate for riparian diversions – CalSim 3.0. (e.g. several creeks, is closure term overestimated?, eWRIMS check)
4. Combined delivery areas (e.g. Delivery to Kern and White Wolf)









Source data for C2VSim Surface water delivery time extension

- CalSim 3.0 **historical** diversion data (mainly in Sacramento Valley)
  - Most C2VSimFG diversions have corresponding CalSim diversion arc.
  - Many data overlapped with other data sources (e.g. CVP and SWP)
  - C2VSimFG baseline planning model makes use of CalSim simulated diversions (fixed LOD land use)

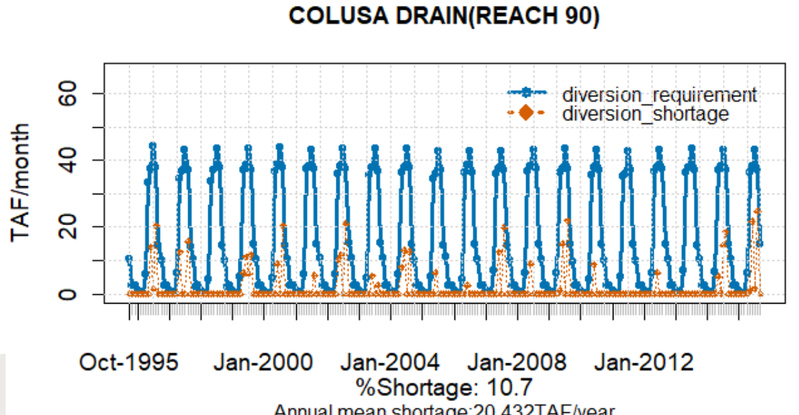
- SWRCB EWRIMS database
  - Water rights
  - **Water use report (self-reporting, need QA)**
- CVP delivery data, USBR CVO tables 21-28
- SWP delivery data, DWR SWPAO, Bulletin 132.
- Limited Available CDEC, USGS stations and USACE reservoir operations.
- AWMP, **farm gate reporting (self-reporting, need QA)**
- local water districts/agencies
- GSPs and **GSP annual reports**
- UWMP for urban water use
- Academic publications: Goodrich, Cayan and Pierce (2020); Hagerty (2022)

Table 11-16. Historical and Simulated Agricultural Deliveries

Agricultural Water Users	Applied Water Demand	Full Contract Amount	Average Annual Deliveries[1]			
			Historical		Simulated	
			SW	GW[2]	SW	GW
	(TAF/year)					
SWP Feather River Service Area[3]	954	989	1,048		1,085	131
CVP Settlement Contractors[4]	2,040	2,071	1,760		2,009	132
CVP Water Service Contractors[5]	725	434	343		345	333
Other Reclamation Projects[6]	280	346	228		233	103
Non-Project: Large Water Districts	895	N/A	651		682	364
Non-Project: Minor Diverters	2,128	N/A	333		489	1,571
Total	**7,021**	**3,840**	**4,364**		**4,841**	**2,616**

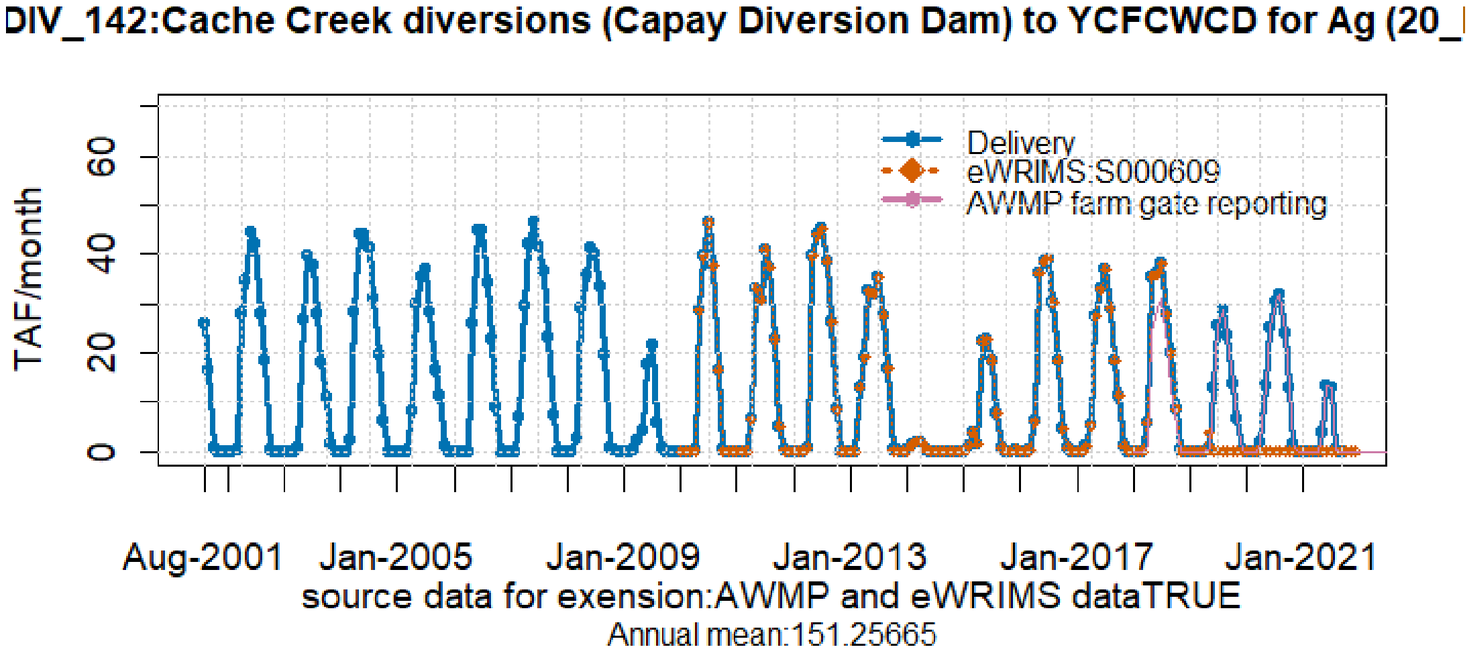
Notes:
[1] Average annual deliveries are based on water years 1996 – 2015.
[2] No reliable data exist for historical groundwater pumping.
[3] Contract amount for the Feather River Service Area includes both settlement and water right water. It excludes 27.5 TAF of Table A water for Butte County and 9.6 TAF for the City of Yuba City. Historical diversions are from USGS measurements at the outlets from Thermalito Afterbay and include water delivered to the Upper Butte Wildlife Area, Gray Lodge Wildlife Area, and the Butte Sink duck clubs. This amount does not include CVP contract for Feather WD.
[4] Deliveries to CVP Settlement Contractors includes diversions of non-CVP water from sources other than the Sacramento River, but excludes water diverted outside of the April through October irrigation season. Contract amount excludes 21.0 TAF for the City of Redding and 0.75 TAF for Sacramento County Water Agency.

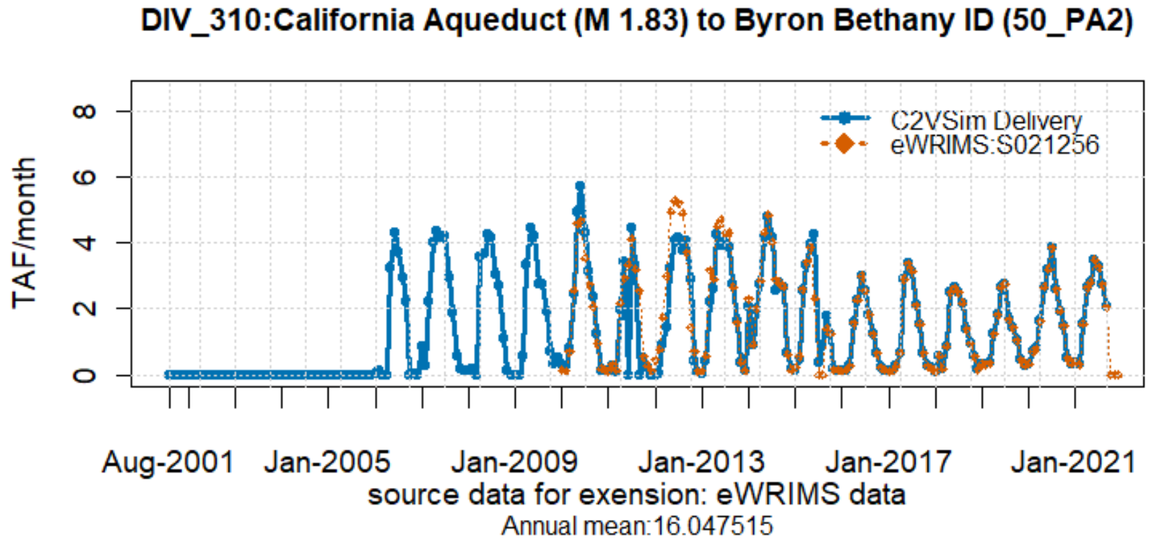
Source: DWR(2022) CalSim 3.0 Report



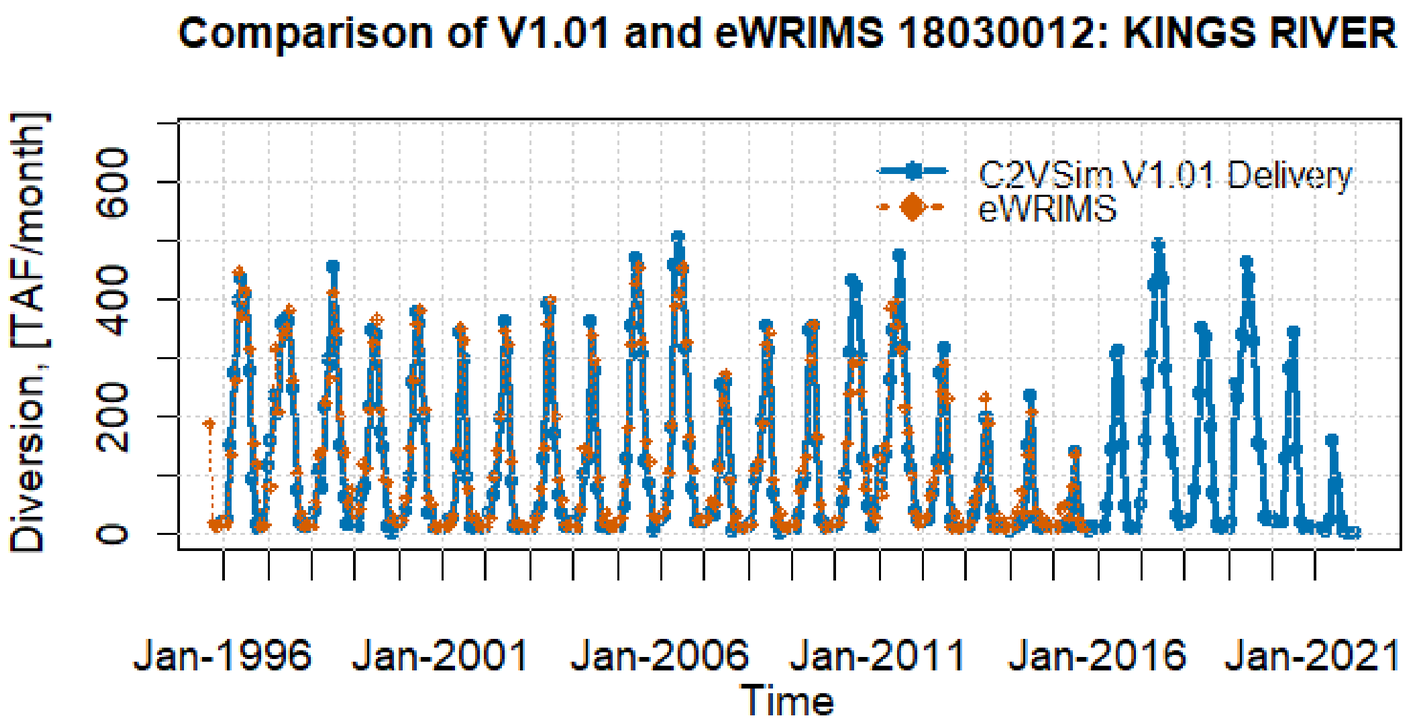
SWRCB eWRIMS data

- Water rights information for all streams
- R script used for batch processing the state wide dataset available(CSV) from open data (by HUC8, primary WR users or river names).
- Example: Cache Creek, BBID, and Kings River diversions



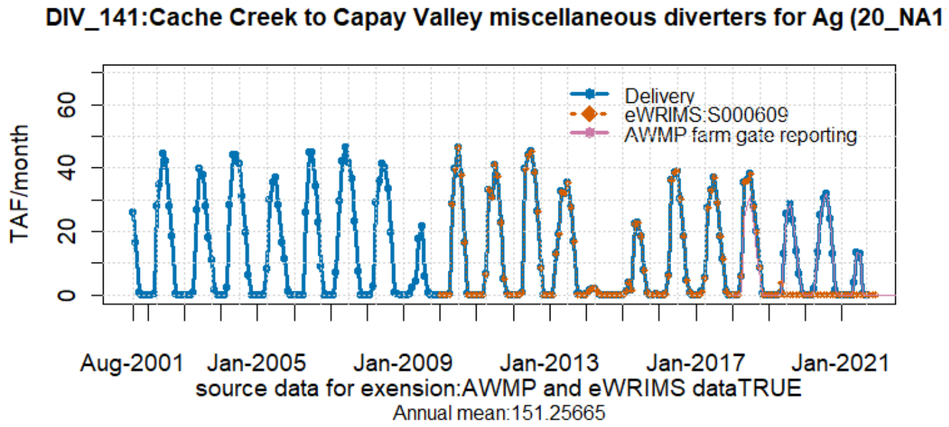


Kings River HUC8 total diversions match C2VSimFG v1.01 estimated Kings total diversions (after 2003) quite well.

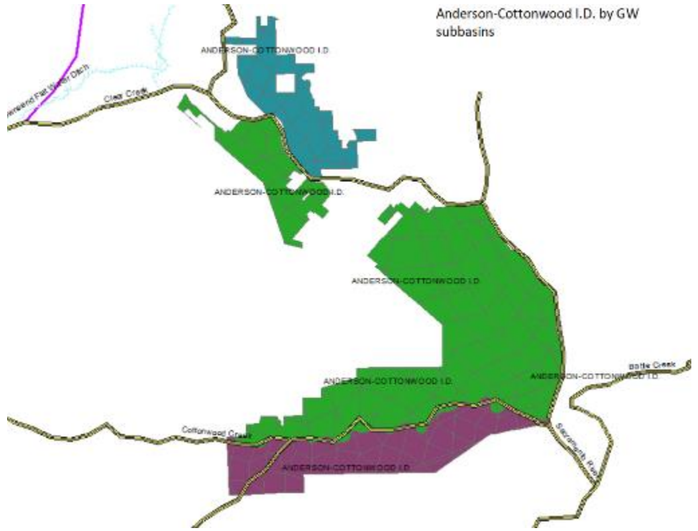


Div260	**Kings River to Fresno ID for Ag**
Div261	**Kings River to Fresno ID for Spreading**
Div262	**Kings River to Consolidated ID for Ag**
Div263	**Kings River to Consolidated ID for Spreading**
Div264	**Kings River to Alta ID for Ag**
Div265	**Kings River to Alta ID for Spreading**
Div266	**Kings River Main Stem for Ag**
Div267	**Kings River South Fork for Ag**
Div268	**Kings River North Fork for Ag**
Div269	**Kings River Fresno Slough for Ag**

AWMP (Agricultural Water Management Plan) reports and data
- farm gate reporting data



- Available for major irrigation districts, self-reporting, need QA/QC (https://wuedata.water.ca.gov/ag_farm_plans)
- Provide farm delivery distribution by Groundwater subbasins (e.g. ACID (88% for right bank -Div06, assumed 85% from CalSim), AEWSD – Kern and White Wolf)
- Limited availability: incomplete coverage from 2013 to 2022.
- Groundwater recharge, water transfer, etc. not included.
- Example: Cache creek; Putah Creek; Kings River diversions – Fresno ID, Alta ID.



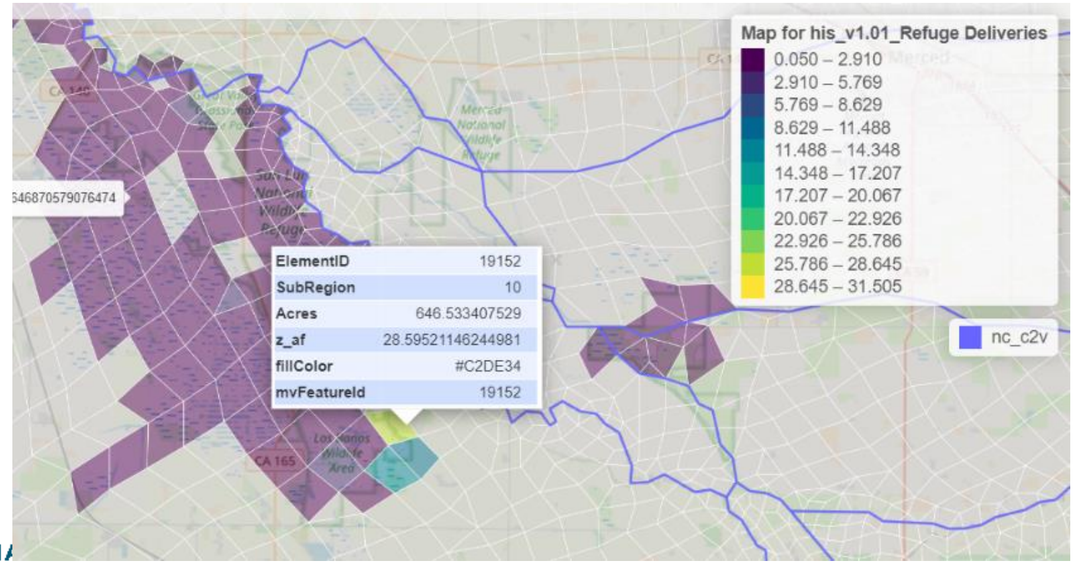
Anderson-Cottonwood I.D.2020 (Farm gate reporting in AF)

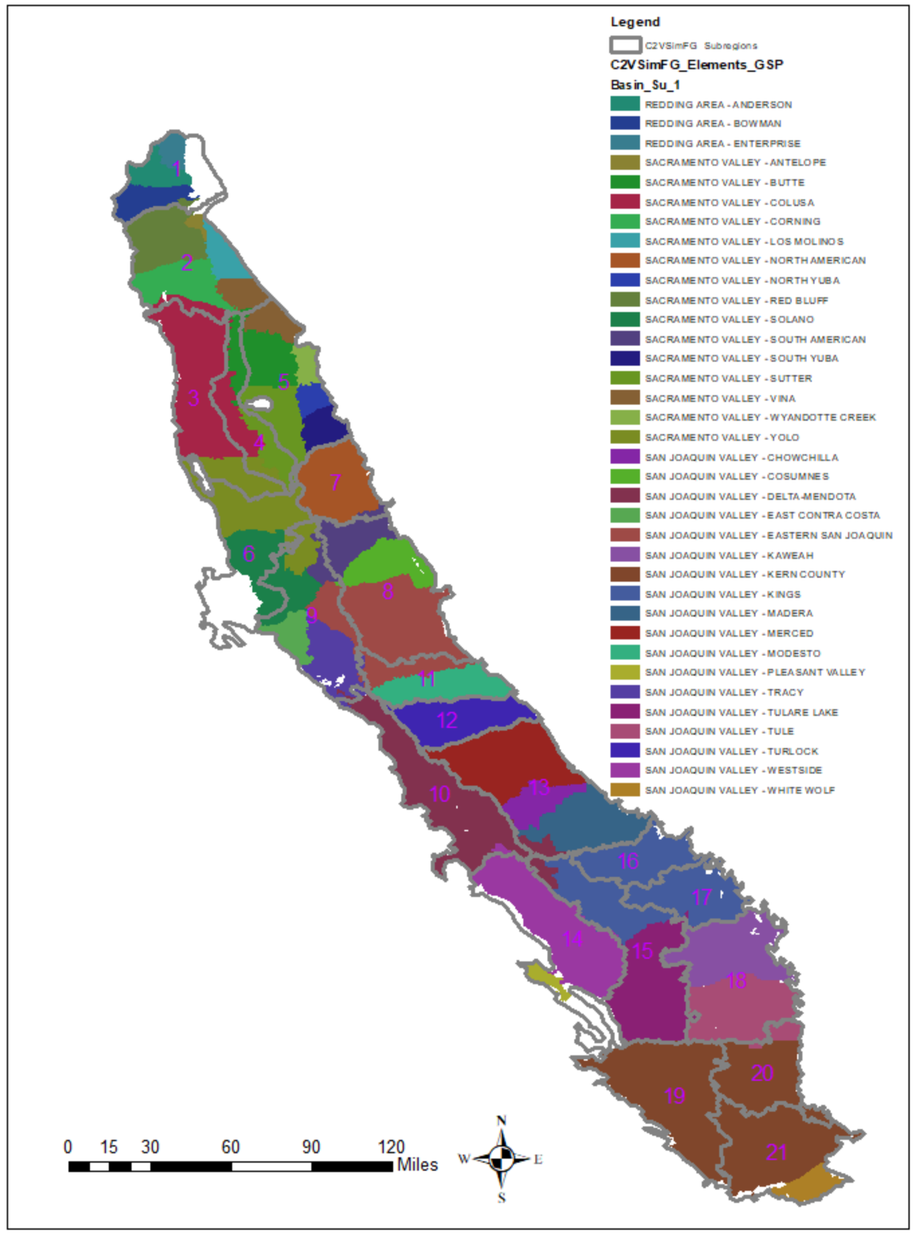
GW Basin/Subbasin #	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
5-006.01 Bowman				1107	2447	2876	2222	2774	2281	2180			15887
5-006.03 Anderson				2353	5199	6111	4722	5894	4846	4632			33757
5-006.04 Enterprise				340	884	1427	1001	1076	1091	824			6643

Surface water delivery Map
- Delivery element groups

- 32537 C2VSimFG elements
- 21 Subregions for water balance
- 105 DAU county for urban
- 36 Groundwater Subbasins – GSP data
- Water Districts and CalSim demand units
- Inaccurate water delivery destination can lead to

Abnormal results (example at Element 19152,
6 overlapped DMC diversions total 28 ft/year, Div304-309).





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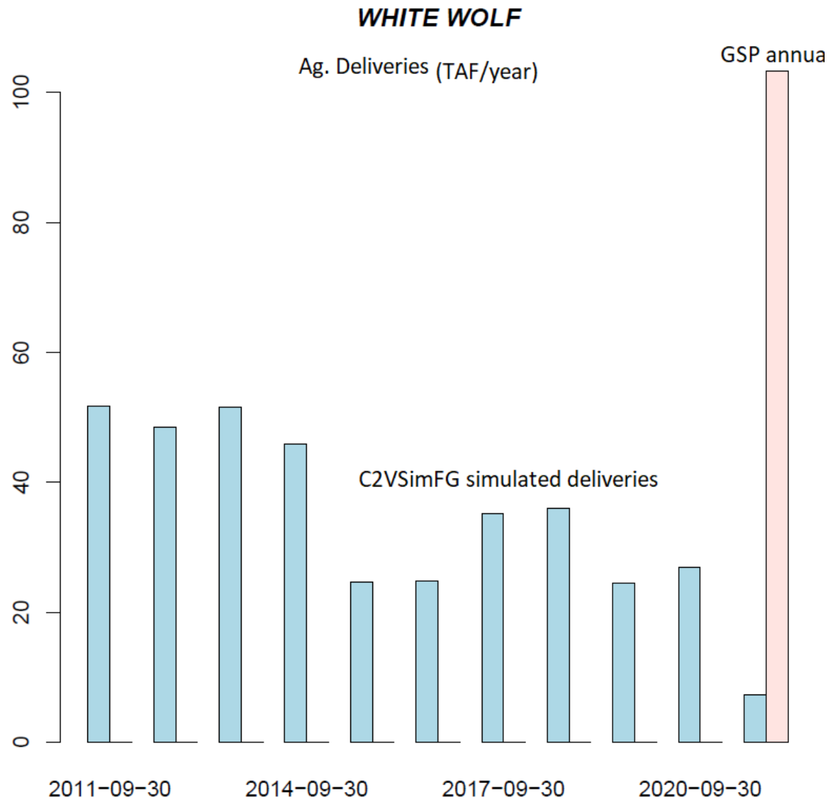
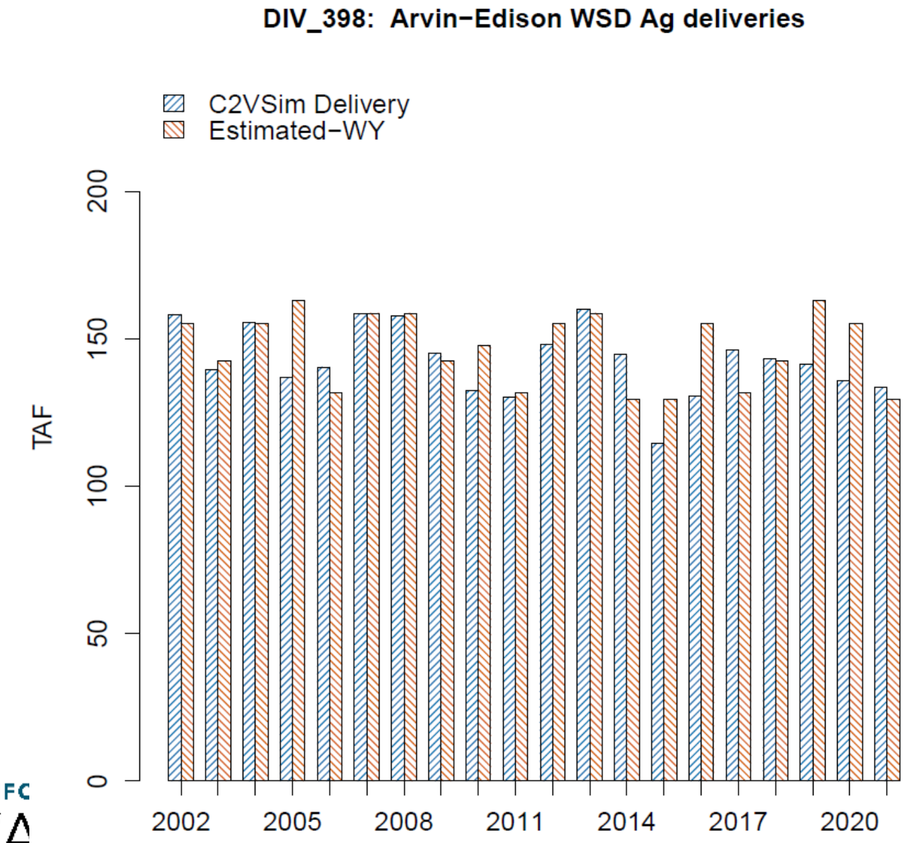
Put it all together: Arvin-Edison WSD – Ag. deliveries

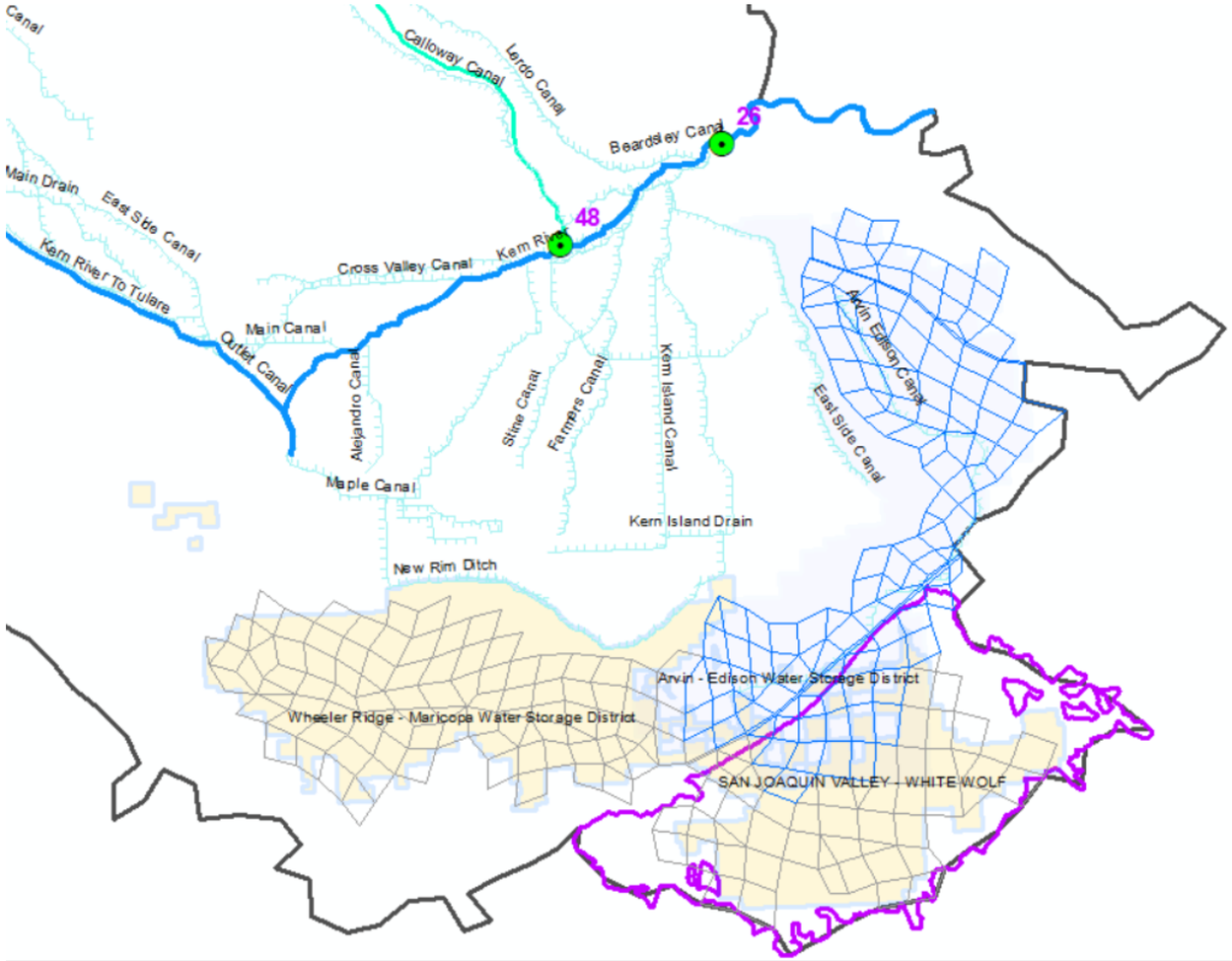
- Arvin-Edison WSD deliveries for Ag
  - Source data: C2VSim-Kern model; CVP, AWMP and GSP reports
  - Water source: CVP-FKC, SWP, Kern river, water transfer
  - Delivery area: Kern subbasin (Kern Div389) and White Wolf Subbasin (Kern Div 390)
  - Bug fix: Diversion 398 diverts from Kern river at 2nd point, only about 29% can be delivered (diversion shortage). It should be total Ag. deliveries from all surface water sources (as imports).
  - Correction and time extension: modify Div398 as import and split into two diversions like Kern model.



Arvin-Edison WSD Ag. Deliveries

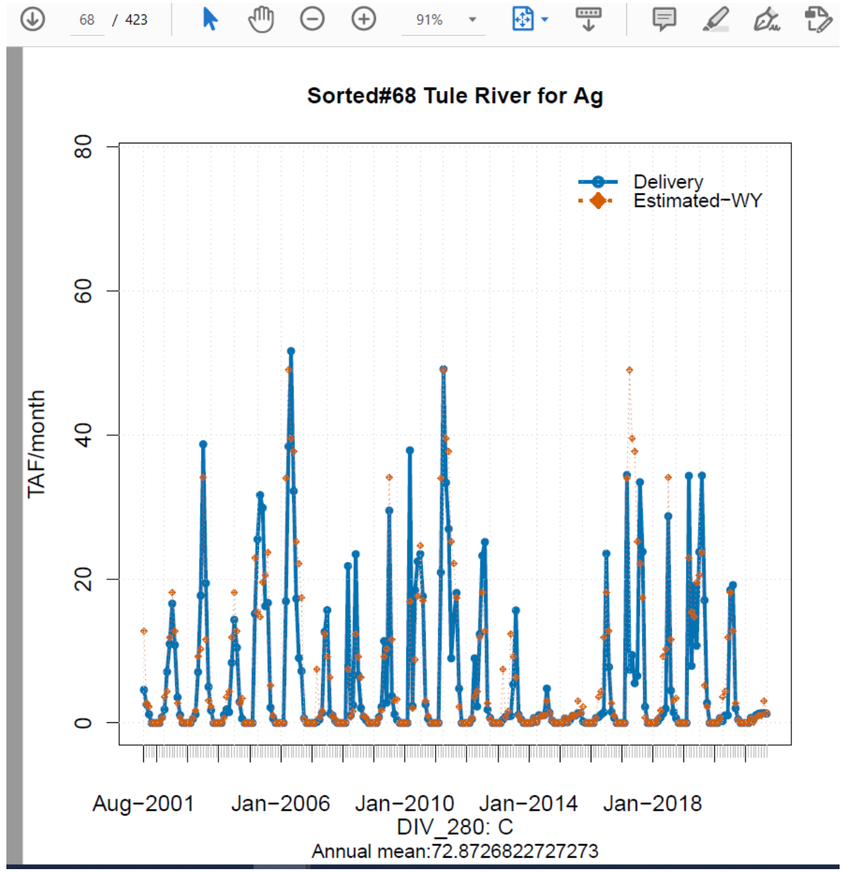
- AWMP water supply source partition (CVP 61%, Kern river 9%, CVC 22%, SWP 9%)
- Wheeler Ridge-Maricopa W.S.D. Also has White Wolf delivery.





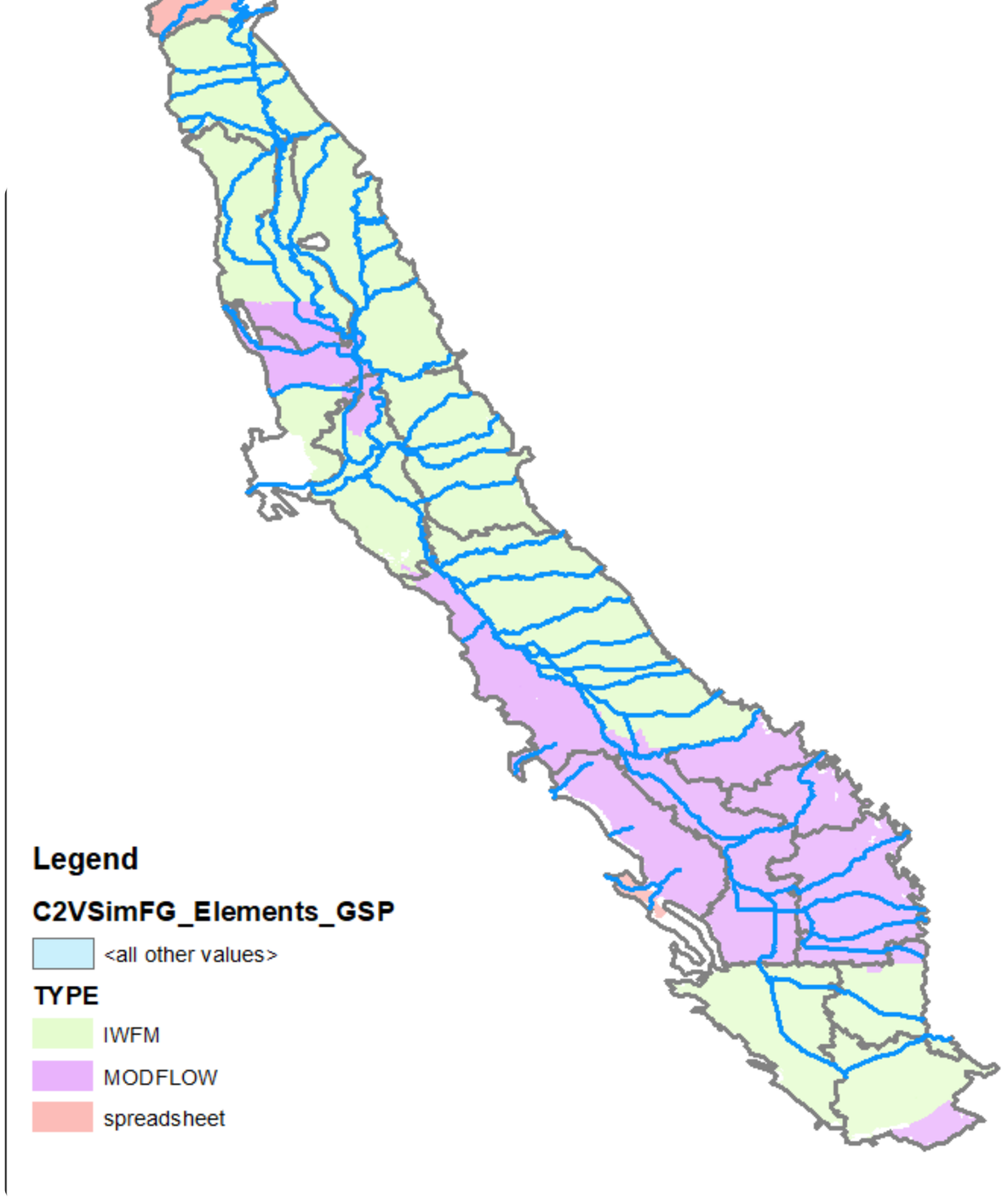
Diversion data time extension from WY2016 to WY2021

- Sacramento Valley
  - Colusa drain basin, Cache Creek (Yolo Subbasin) and Putah Creek (Solano Subbasin): eWRIMS and AWMP
  - Many other diversions are available from CVP/SWP and CalSim 3.0 time extension
- San Joaquin Valley
  - Westside of San Joaquin river is mostly CVP water.
  - Eastside: ESJWRM, CVP-Friant-Kern, USGS and limited CalSim 3.0 data matching.
- Tulare Lake basin
  - Kern County: C2VSim Kern model.
  - Kings River, Kaweah and Tule Rivers: eWRIMS and AWMP; GSP annual reports
- Data gaps filled with demand-based calculation (Delta) or water year types.



GSPs and Local groundwater models: potential data source and validation

- Twenty four(24) out of 36 GSPs within C2VSimFG model domain are using IWFM based models, many of them derived from C2VSim/SVSim.
- Model data sharing with us for time extension: C2VSim-Kern, ESJWRM and Tracy Subbasin.
- GSP annual reports requirement is different from modeling input data need but can be a potential source for data sharing.



Take home message and next step

- Watershed delineation tool improves stream inflows and small watersheds.
- C2VSimFG time extension to WY2021 reveals a lot about data source and existing issues and needed bug fixes in C2VSimFG V1.01 surface water representation.
- Many improvement and Bug fixes are to be made in the C2VSimFG model next release.
- Continued collaboration and data sharing with DWR-USBR CalSim team (new CalSim – Tulare?).
- Outreach on data sharing from local agencies.