**CALVIN Input Hydrology Update: 2024**

**With comparison to previous modeling results**

**GitHub Repository:**

<https://github.com/msdogan/Update-CALVIN-data>

**Mustafa S. Dogan**

([msahindogan@aksaray.edu.tr](mailto:msahindogan@aksaray.edu.tr), [msdogan@ucdavis.edu](mailto:msdogan@ucdavis.edu))

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# **Summary**

This memo describes CALVIN hydrology and input data update and their data sources. As a part of the update process, CALVIN’s rim inflows, groundwater inflows, local inflows, reservoir evaporation rates, environmental flow requirements, including minimum instream flow requirements, wildlife refuge demands, and required Delta outflow, constrained flows (mostly weir flows), and allowable export capacities from the Delta via the California Aqueduct are updated. Mainly the CALSIM III model for surface hydrology and the C2VSim model for groundwater hydrology and their input or output databases are used as a data source. These updates extends CALVIN’s modeling horizon from 2003 to 2015, now covering 94 years of historical period from 1921. The old CALVIN covered 1921-2003 period. Then, the CALVIN model is run with the updated database, and comparison results are presented in the last section. These results include CALVIN’s total agricultural and urban water supply operations, surface reservoir storage and release, groundwater storage and pumping, water transfers from the Delta, and the surplus Delta outflow.

# **RIM Inflows**

CALVIN represents surface water supplies as a time series of monthly inflows. Rim flows represent streams that cross the boundary of the physical system being modeled. Typically they represent inflows to surface water reservoirs located in either the Sierra Nevada foothills or the Trinity/Cascade Mountain range. Hydrologic data for CALVIN have been extracted from other large-scale computer models that are in the public domain, mainly CALSIM III for surface water hydrology and C2VSim for groundwater hydrology.

Main data source for rim inflows in CALVIN is CALSIM III model. CALVIN’s rim inflows are mapped to CALSIM III’s rim inflows, representing unimpaired flows that enter to rim reservoirs, and are directly replaced. However, some CALVIN rim infows are not represented in CALSIM III (Tule, Kern, Kaweah, and Kings Rivers). For these remaining rim inflows, monthly inflows are gathered from the CDEC full natural flow dataset. Table 1 shows data sources of CALVIN’s updated rim inflows.

Red Bank Creek (inflow-d77) was represented in the CALSIM II and CALVIN models. However, it was not represented in CALSIM III. Therefore, Red Bank Creek monthly inflow time-series were removed (replaced with zeros). White River (inflow-c146) and New and Alamo Rivers (inflow-c148) are not available for water supply. Their monthly inflow time-series, therefore, extended with zeros.

**Table 1**. CALVIN rim inflows and data sources

|  |  |  |
| --- | --- | --- |
| **CALVIN Node** | **River Name** | **Data Source** |
|
| c2 | Cottonwood Creek | CALSIM III: I\_CWD018+I\_SCW008 |
| c38 | Dry Creek | CALSIM III: I\_DSC035 |
| d75 | Antelope, Mill, and Deer Creeks | CALSIM III: I\_ANT011+I\_MLC006+I\_DRC012 |
| d76b | Big Chico Creek | CALSIM III: I\_BCC014 |
| sr\_bul | North Fork Yuba River | CALSIM III: I\_NFY029+I\_SLT009+I\_NBLDB |
| c27 | Middle and South Fork Yuba River | CALSIM III: I\_OGN005+I\_MFY013+I\_SFY048 |
| d17 | North and Middle Fork American River | CALSIM III: I\_NFA054+I\_NNA013+I\_LKVLY+I\_CYN009+I\_NFA022+I\_NFA016+I\_FARMDW+I\_NMA003+I\_DCC010+I\_HHOLE+I\_MFA036+I\_NLC003+I\_MFA025+I\_MFA023+I\_LNG012 |
| sr\_fol | South Fork American River | CALSIM III: I\_SFA040+I\_FOLSM+I\_SLV006+I\_ALOHA+I\_ICEHS+I\_BSH003+I\_PYR001+I\_SFA066+I\_SFA076+I\_SFA040+I\_WBR001+I\_PLM001+I\_ALD002+I\_ALD004+I\_SLF009+I\_CAPLS+I\_SILVR+I\_LOONL+I\_LRB004+I\_RUB047+I\_SFR006+I\_STMPY+I\_PLC007+I\_UNVLY+I\_RCK001+I\_SLV015 |
| c28 | Deer Creek | CALSIM III: I\_DER001+I\_DER004+I\_SFD003 |
| c29 | French Dry Creek | CALSIM III: I\_MERLC+I\_LDC029 |
| sr\_cle | Trinity River | CALSIM III: I\_TRNTY |
| sr\_whi | Clear Creek | CALSIM III: I\_WKYTN |
| sr\_sha | Sacramento River | CALSIM III: I\_SHSTA |
| sr\_blb | Stony Creek | CALSIM III: I\_EPARK+I\_SGRGE+I\_BLKBT |
| c87 | Paynes and Sevenmile Creeks | CALSIM III: I\_PYN001 |
| c86 | Thomas and Elder Creeks | CALSIM III: I\_THM028+I\_ELD027 |
| c77 | Feather River | CALSIM III: I\_MFF019+I\_NFF027+I\_LGRSV+I\_OROVL+I\_WBF030+I\_WBF006+I\_WBF015+I\_RVPBH+I\_SFF008+I\_SFF011+I\_SLYCK |
| sr\_nhg | Calaveras River | CALSIM III: I\_NHGAN |
| c37 | Cosumnes River | CALSIM III: I\_CMP001+I\_CMP014+I\_CSM035+I\_JNKSN |
| c23 | Kelly Ridge Release | CALSIM III: R\_MNRRH\_FTR072 |
| sr\_nml | Stanislaus River | CALSIM III: I\_ANG017+I\_BEARD+I\_BVC007+I\_CFS001+I\_DONLL+I\_LYONS+I\_MFS047+I\_MFS022+I\_MFS013+I\_MIL003+I\_NFS033+I\_NFS009+I\_NFS005+I\_PCRST+I\_SFS033+I\_SFS30+I\_SPICE+I\_STS072 |
| sr\_mil | San Joaquin River | CALSIM III: I\_MLRTN+I\_SJR258 |
| sr\_mcr | Merced River | CALSIM III: I\_MCLRE |
| sr\_hid | Fresno River | CALSIM III: I\_HNSLY |
| sr\_buc | Chowchilla River | CALSIM III: I\_ESTMN |
| sr\_clk\_inv | Cache Creek | CALSIM III: I\_INDVL+I\_CLRLK |
| sr\_ber | Putah Creek | CALSIM III: I\_PTH070 |
| sr\_rll\_cmb | Bear River | CALSIM III: I\_RLLNS+I\_CMBIE |
| sr\_par | Mokelumne River | CALSIM III: I\_SLTSP+I\_UBEAR+I\_COL003+I\_TGC003+I\_NFM010+I\_MFM008+SFM005+I\_MOK079+I\_PARDE |
| sr\_scc | Tule River | CDEC: SCC |
| sr\_isb | Kern River | CDEC: KRI |
| sr\_trm | Kaweah River | CDEC: KWT |
| sr\_pnf | Kings River | CDEC: KGF |
| sr\_crw | Owens River | CDEC: OWL |
| sr\_gnt | Mono Basin Inflows | CDEC: Reg-WWR |
| c116 | Long Valley | CDEC: Reg-OWL |
| sr\_cr3 | Colorado River Aqueduct | Water Rights |
| sr\_dnp | Middle and South Fork Tuolumne | CALSIM III: I\_PEDRO+I\_TUO054+I\_DCT050 |
| sr\_hth | Tuolumne River | CALSIM III: I\_HTCHY |
| sr\_ll\_enr | Cherry and Eleanor Creeks | CALSIM III: I\_LLYOD+I\_ELENR |
| d74 | Cow and Battle Creeks | CALSIM III: I\_COW014+I\_BTL016 |
| d43a | Butte and Little Chico Creeks | CALSIM III: I\_BTC048+I\_LCC038+I\_BTC038+I\_LCC038 |
| d77 | Red Bank Creek | Not Represented in CALSIM III |
| sr\_scagg | Santa Clara Valley Inflow | WYT Extension |
| d94 | Lewiston Lake Inflow | CALSIM III: I\_LWSTN |
| sr\_lvq | Kellogg Creek | CALSIM III: I\_LOSVQ |
| c146 | White River | Not Available for Water Supply |
| c148 | New and Alamo Rivers | Not Available for Water Supply |

Figure 1 compares original CALVIN rim inflows for the October 1921 – September 2003 period and updated rim inflows for the October 1921 – September 2015 period. Only major rivers are shown in the figure.

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**Figure 1**. Original (1921-2003) and updated (1921-2015) rim inflows for major CALVIN rivers

# **Groundwater Inflows**

For the Central Valley groundwater basins (gw\_01 through gw\_21), groundwater inflows and beginning and ending storage values are gathered from C2VSim model. C2VSim postdrought baseline scenario coarse grid version is used. Beginning and ending storage values are boundary conditions and are predefined. Difference between beginning and ending storage is called overdraft. Beginning and ending storage values are calculated as follows (Zikalala 2013, <https://www.proquest.com/dissertations-theses/representing-groundwater-management-californias/docview/1413302653/se-2>). For each groundwater subbasin, September 2005 C2VSim storage is set as September 1921 CALVIN beginning period storage (Initial). Then overdraft amount is calculated and subtracted from beginning period storage to calculate September 2015 CALVIN ending period storage (Final). To calculate overdraft, first annual overdraft between 2015 and 1980 is calculated, and then integrated to 94 years. In a basecase historical CALVIN run, initial (beginning) and final (ending) groundwater storage values are used as hard constraints, setting lower bound and upper bound to the same value (initial or ending), However, postdrought C2VSim baseline simulation has too much water availability that causes infeasibilities (resulting in debug sink flows if run in debug mode). To prevent infeasibilities, initial storage is set as a hard constraint, but final storage is used as a soft constraint, setting the lower bound of final storage to the ending storage value but the upper bound to the infinity.With this representation, CALVIN can create historical defined overdraft or less than the defined overdraft. Less or negative overdraft are assumed to be positive for water management.

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| --- | --- |
|  | Equation 1 |
|  | Equation 2 |
|  | Equation 3 |

**Table 2**. Old and updated CALVIN groundwater basin beginning and ending period storage values (TAF)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Basin** | **Old CALVIN Beginning Storage (Oct 1921)** | **Updated CALVIN Beginning Storage (Oct 1921)** | **Old CALVIN Ending Storage (Sep 2003)** | **Updated CALVIN Ending Storage (Sep 2015)** |
| **gw\_01** | 38447 | 31774 | 39437 | 31480 |
| **gw\_02** | 136494 | 142310 | 136494 | 141212 |
| **gw\_03** | 132687 | 111911 | 131748 | 111460 |
| **gw\_04** | 60728 | 90886 | 60508 | 90264 |
| **gw\_05** | 91113 | 84675 | 90457 | 83199 |
| **gw\_06** | 174968 | 127733 | 175275 | 125758 |
| **gw\_07** | 56539 | 36239 | 51210 | 35063 |
| **gw\_08** | 190665 | 174703 | 182829 | 172612 |
| **gw\_09** | 139472 | 190789 | 139843 | 189798 |
| **gw\_10** | 90210 | 198852 | 87055 | 192059 |
| **gw\_11** | 58838 | 84701 | 58246 | 83280 |
| **gw\_12** | 42602 | 92355 | 40865 | 90713 |
| **gw\_13** | 138216 | 198654 | 128560 | 183173 |
| **gw\_14** | 178840 | 303244 | 172009 | 298017 |
| **gw\_15** | 309643 | 362094 | 306666 | 354078 |
| **gw\_16** | 64696 | 88674 | 64438 | 84666 |
| **gw\_17** | 97214 | 89487 | 93653 | 83366 |
| **gw\_18** | 321375 | 277190 | 321375 | 261975 |
| **gw\_19** | 141750 | 154496 | 128223 | 138698 |
| **gw\_20** | 137073 | 147688 | 125136 | 140780 |
| **gw\_21** | 341142 | 415614 | 324302 | 402317 |

CALVIN optimizes groundwater pumping based on agricultural and urban demands. CALVIN also calculates return flows to groundwater from agricultural and urban users. Since CALVIN is a water allocation optimization model (not a hydrological simulation model), groundwater inflows (net recharge), excluding pumping and return flows, must be defined. The C2VSim model is used to gather groundwater inflows. Using groundwater budget of the C2VSim model, following components are summed to calculate net groundwater inflows:

|  |  |
| --- | --- |
|  | Equation 4 |

Old CALVIN (1921-2003) and Updated CALVIN (C2VSim postdrought, 1921-2015) monthly groundwater inflows for the Central Valley groundwater basins are shown below. The Southern California groundwater basin’s inflows are extended with monthly average values.

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***Figure 2****. Original (1921-2003) and updated (1921-2015) groundwater inflows for the Central Valley groundwater basins*

# **Local Inflows**

Local water supplies represent surface water that originates within the boundary of the region being modeled, either from direct runoff or through surface water-groundwater interaction. In some models, these local water supplies are called gains or accretions and depletions. Local inflows can add water (inflow) to water supply system or remove water (sink) from the system. In CALVIN, local inflows are also used to represent local demands (fixed, no economic representation), aqueduct and canal losses, small streams and creeks, and local water supply sources.

CALVIN’s local inflows are mostly mapped to the CALSIM III model. So, monthly local inflow time-series were obtained from CALSIM III. However, Tulare Lake region and some parts of the Southern California are not represented in CALSIM III. For these locations, existing CALVIN local inflow time-series were extended to September 2015 with Water Year Type or monthly average methods. Water Year Type method maps year of interest (2003-2015) to a hydrologically similar year between 1921-2003 based on water year type and index. Then, monthly data value is copied from hydrologically similar year and month.

**Table 3**. CALVIN local inflows and data sources

|  |  |  |
| --- | --- | --- |
| **Link** | **Description** | **Data Source** |
| inflow-c5 | Surface water - gw interaction | CALSIM III: SVSG217\_SAC269+SVSG218\_CWD004\_35+SVSG219\_CWD003\_35+SVSG220\_BTL006\_36+SVSG221\_BTL006\_36+SVSG222\_SAC269\_37+SVSG223\_SAC265\_37+SVSG224\_SAC259\_37+SVSG225\_PYN001\_38+SVSG226\_PYN001\_38+SVSG227\_SAC259\_39+SVSG228\_SAC254\_39+SVSG229\_SAC250\_39+SVSG230\_SAC247\_39 |
| c5-sink | Surface water - gw interaction | CALSIM III: SVSG217\_SAC269+SVSG218\_CWD004\_35+SVSG219\_CWD003\_35+SVSG220\_BTL006\_36+SVSG221\_BTL006\_36+SVSG222\_SAC269\_37+SVSG223\_SAC265\_37+SVSG224\_SAC259\_37+SVSG225\_PYN001\_38+SVSG226\_PYN001\_38+SVSG227\_SAC259\_39+SVSG228\_SAC254\_39+SVSG229\_SAC250\_39+SVSG230\_SAC247\_39 |
| inflow-c304 | Colusa Basin Drain Local Inflow | CALSIM III: SVSG318\_CBD049\_55+SVSG319\_CBD044\_55+SVSG320\_CBD041\_55+SVSG321\_CBD037\_55+SVSG322\_CBD031\_55+SVSG323\_CBD031\_56+SVSG324\_CBD028\_56+SVSG325\_CBD023\_56+SVSG326\_CBD018\_56+SVSG327\_CBD012\_56+SVSG328\_CBD005\_56+SVSG329\_CBD000\_56 |
| inflow-d66 | Surface water - gw interaction | CALSIM III: SVSG262\_SAC196\_48+SVSG263\_STN026\_49+SVSG264\_STN021\_49+SVSG265\_STN014\_49+SVSG266\_STN009\_49+SVSG267\_STN004\_49+SVSG268\_STN004\_49+SVSG269\_BCC012\_50+SVSG270\_BCC006\_50+SVSG271\_BCC004\_50+SVSG272\_BCC004\_50+SVSG273\_SAC196\_51+SVSG274\_SAC193\_51+SVSG275\_SAC188\_51 (cfs) |
| d66-sink | Surface water - gw interaction | CALSIM III: SVSG262\_SAC196\_48+SVSG263\_STN026\_49+SVSG264\_STN021\_49+SVSG265\_STN014\_49+SVSG266\_STN009\_49+SVSG267\_STN004\_49+SVSG268\_STN004\_49+SVSG269\_BCC012\_50+SVSG270\_BCC006\_50+SVSG271\_BCC004\_50+SVSG272\_BCC004\_50+SVSG273\_SAC196\_51+SVSG274\_SAC193\_51+SVSG275\_SAC188\_51 (cfs) |
| inflow-n14 | Surface water - gw interaction | CALSIM III: SVSG276\_SAC182\_51+SVSG277\_SAC178\_51+SVSG278\_SAC174\_51+SVSG279\_SAC168\_51+SVSG280\_SAC162\_51+SVSG281\_SAC154\_51 |
| n14-sink | Surface water - gw interaction | CALSIM III: SVSG276\_SAC182\_51+SVSG277\_SAC178\_51+SVSG278\_SAC174\_51+SVSG279\_SAC168\_51+SVSG280\_SAC162\_51+SVSG281\_SAC154\_51 |
| c301-sink | Colusa Basin Drain Local Depletion | CALSIM III: SVSG318\_CBD049\_55+SVSG319\_CBD044\_55+SVSG320\_CBD041\_55+SVSG321\_CBD037\_55+SVSG322\_CBD031\_55+SVSG323\_CBD031\_56+SVSG324\_CBD028\_56+SVSG325\_CBD023\_56+SVSG326\_CBD018\_56+SVSG327\_CBD012\_56+SVSG328\_CBD005\_56+SVSG329\_CBD000\_56 |
| inflow-c35 | Yuba and America River net exports | CALSIM III: C\_BRR060 |
| c35-sink | Removing this demand because net exports are used | CALSIM III: D\_LBR002\_LBC001\_SV |
| inflow-c40 | Little Johns Creek | CALSIM III: I\_LJC022 |
| inflow-d9 | Local inflow to Lake Natomas | Not represented in CALSIM III |
| inflow-d64 | Local inflow at Sacramento River confluence | Not represented in CALSIM III |
| inflow-c308 | Local Inflow downstream Camp Far West Reservoir | CALSIM III: I\_DHC021 |
| inflow-c32 | Surface water - gw interaction | CALSIM III: SVSG341\_FTR068\_59+SVSG342\_FTR063\_59+SVSG343\_FTR059\_59+SVSG344\_FTR053\_59+SVSG345\_FTR048\_59+SVSG346\_FTR045\_59+SVSG347\_FTR036\_59+SVSG348\_FTR029\_59+SVSG349\_YUB011\_60+SVSG350\_YUB006\_60+SVSG351\_YUB002\_60+SVSG352\_FTR029\_61+SVSG353\_FTR025\_61+SVSG354\_FTR021\_61+SVSG355\_FTR016\_61+SVSG356\_FTR012\_61+SVSG362\_FTR012\_63+SVSG363\_FTR008\_63+SVSG364\_FTR008\_64+SVSG365\_FTR003\_64+SVSG366\_FTR003\_64 |
| c32-sink | Surface water - gw interaction | CALSIM III: SVSG341\_FTR068\_59+SVSG342\_FTR063\_59+SVSG343\_FTR059\_59+SVSG344\_FTR053\_59+SVSG345\_FTR048\_59+SVSG346\_FTR045\_59+SVSG347\_FTR036\_59+SVSG348\_FTR029\_59+SVSG349\_YUB011\_60+SVSG350\_YUB006\_60+SVSG351\_YUB002\_60+SVSG352\_FTR029\_61+SVSG353\_FTR025\_61+SVSG354\_FTR021\_61+SVSG355\_FTR016\_61+SVSG356\_FTR012\_61+SVSG362\_FTR012\_63+SVSG363\_FTR008\_63+SVSG364\_FTR008\_64+SVSG365\_FTR003\_64+SVSG366\_FTR003\_64 |
| inflow-c7 | Local inflow downstream Sacramento Weir | CALSIM III: C\_EMD001 |
| d517-sink | Delta accretion and depletion | CALSIM III: DA\_MOK\_MOK004\_DV+DD\_MOK004\_MOK |
| inflow-d517 | Delta accretion and depletion | CALSIM III: DA\_MOK\_MOK004\_DV+DD\_MOK004\_MOK |
| c150-sink | Local demand | CALSIM III: D\_CCH052\_20\_NA1+D\_CCH030\_20\_NA1 |
| c155-sink | Local demand | CALSIM III: D\_PTH024\_PSC003 |
| inflow-d509 | Marsh Creek | CALSIM III: I\_MSH015 |
| d509-sink | Marsh Creek | Climate change only |
| d848-sink | Coastal Aqueduct Deliveries to Castaic WA | CALSIM III: D868 |
| inflow-n1 | San Bernardino local inflow | Monthly average |
| inflow-c154 | East and West MWD local inflow | Monthly average |
| inflow-c161 | Central MWD local inflow | Monthly average |
| inflow-n8 | San Diego local inflow | Monthly average |
| inflow-hxcmwd | Central MWD urban local inflow | Monthly average |
| inflow-hxewmwd | East and West MWD urban local inflow | Monthly average |
| inflow-hxsd | San Diego urban local inflow | Monthly average |
| inflow-d73 | Surface water - gw interaction | CALSIM III: SVSG205\_SAC296\_32+SVSG206\_SAC294\_32+SVSG207\_SAC289\_32+SVSG208\_SAC287\_32+SVSG209\_SAC281\_32+SVSG210\_SAC277\_32+SVSG211\_COW014\_33+SVSG212\_COW007\_33+SVSG213\_COW003\_33+SVSG214\_COW003\_33+SVSG215\_SAC277\_34+SVSG216\_SAC275\_34 |
| d73-sink | Surface water - gw interaction | CALSIM III: SVSG205\_SAC296\_32+SVSG206\_SAC294\_32+SVSG207\_SAC289\_32+SVSG208\_SAC287\_32+SVSG209\_SAC281\_32+SVSG210\_SAC277\_32+SVSG211\_COW014\_33+SVSG212\_COW007\_33+SVSG213\_COW003\_33+SVSG214\_COW003\_33+SVSG215\_SAC277\_34+SVSG216\_SAC275\_34 |
| inflow-n13 | Surface water - gw interaction | SVSG231\_SAC240\_39+SVSG232\_SAC232\_39+SVSG233\_ANT010\_40+SVSG234\_ANT010\_40+SVSG235\_SAC232\_41+SVSG236\_SAC228\_41+SVSG237\_ELD027\_42+SVSG238\_ELD022\_42+SVSG239\_ELD017\_42+SVSG240\_ELD012\_42+SVSG241\_ELD005\_42+SVSG242\_ELD005\_42+SVSG243\_MLC006\_43+SVSG244\_MLC004\_43+SVSG245\_MLC004\_43+SVSG246\_SAC228\_44+SVSG247\_SAC224\_44+SVSG248\_THM026\_45+SVSG249\_THM021\_45+SVSG250\_THM017\_45+SVSG251\_THM012\_45+SVSG252\_THM005\_45+SVSG253\_THM005\_45+SVSG254\_SAC224\_46+SVSG255\_SAC218\_46+SVSG256\_DRC010\_47+SVSG257\_DRC005\_47+SVSG258\_DRC005\_47+SVSG259\_SAC218\_48+SVSG260\_SAC214\_48+SVSG261\_SAC207\_48 (cfs) |
| n13-sink | Surface water - gw interaction | SVSG231\_SAC240\_39+SVSG232\_SAC232\_39+SVSG233\_ANT010\_40+SVSG234\_ANT010\_40+SVSG235\_SAC232\_41+SVSG236\_SAC228\_41+SVSG237\_ELD027\_42+SVSG238\_ELD022\_42+SVSG239\_ELD017\_42+SVSG240\_ELD012\_42+SVSG241\_ELD005\_42+SVSG242\_ELD005\_42+SVSG243\_MLC006\_43+SVSG244\_MLC004\_43+SVSG245\_MLC004\_43+SVSG246\_SAC228\_44+SVSG247\_SAC224\_44+SVSG248\_THM026\_45+SVSG249\_THM021\_45+SVSG250\_THM017\_45+SVSG251\_THM012\_45+SVSG252\_THM005\_45+SVSG253\_THM005\_45+SVSG254\_SAC224\_46+SVSG255\_SAC218\_46+SVSG256\_DRC010\_47+SVSG257\_DRC005\_47+SVSG258\_DRC005\_47+SVSG259\_SAC218\_48+SVSG260\_SAC214\_48+SVSG261\_SAC207\_48 (cfs) |
| inflow-d31 | Surface water - gw interaction | CALSIM III: SVSG282\_SAC148\_51+SVSG293\_SAC148\_53+SVSG294\_SAC141\_53+SVSG295\_SAC134\_53+SVSG296\_SAC129\_53+SVSG297\_SAC122\_53+SVSG298\_SAC115\_53+SVSG299\_SAC106\_53+SVSG300\_SAC097\_53+SVSG301\_SAC092\_53+SVSG330\_SAC092\_57+SVSG331\_SAC085\_57 |
| d31-sink | Surface water - gw interaction | CALSIM III: SVSG282\_SAC148\_51+SVSG293\_SAC148\_53+SVSG294\_SAC141\_53+SVSG295\_SAC134\_53+SVSG296\_SAC129\_53+SVSG297\_SAC122\_53+SVSG298\_SAC115\_53+SVSG299\_SAC106\_53+SVSG300\_SAC097\_53+SVSG301\_SAC092\_53+SVSG330\_SAC092\_57+SVSG331\_SAC085\_57 |
| d85-sink | Surface water - gw interaction | CALSIM III: SVSG375\_NTOMA\_66+SVSG376\_AMR020\_66+SVSG377\_AMR015\_66+SVSG378\_AMR009\_66+SVSG379\_AMR004\_66 |
| inflow-d85 | Surface water - gw interaction | CALSIM III: SVSG375\_NTOMA\_66+SVSG376\_AMR020\_66+SVSG377\_AMR015\_66+SVSG378\_AMR009\_66+SVSG379\_AMR004\_66 |
| inflow-d37 | Surface water - gw interaction | CALSIM III: SVSG358\_BRR017\_62+SVSG359\_BRR011\_62+SVSG360\_BRR004\_62+SVSG361\_BRR004\_62 |
| d37-sink | Surface water - gw interaction | CALSIM III: SVSG358\_BRR017\_62+SVSG359\_BRR011\_62+SVSG360\_BRR004\_62+SVSG361\_BRR004\_62 |
| c83-sink | Lower Yuba River ag diversions | WYT Extension |
| inflow-c51 | Surface water - gw interaction | WYT Extension |
| inflow-c89 | Surface water - gw interaction | WYT Extension |
| c56-sink | Surface water - gw interaction | WYT Extension |
| c58-sink | Surface water - gw interaction | WYT Extension |
| inflow-c65 | Surface water - gw interaction | WYT Extension |
| c97-sink | Surface water - gw interaction | WYT Extension |
| c52-sink | Surface water - gw interaction | WYT Extension |
| inflow-c52 | Surface water - gw interaction | WYT Extension |
| c53-sink | Surface water - gw interaction | WYT Extension |
| inflow-c57 | Surface water - gw interaction | WYT Extension |
| inflow-c54 | Surface water - gw interaction. Fresno Slogh | CALSIM III: SVSG51\_FSL012\_4+SVSG52\_FSL005\_4+SVSG53\_FSL005\_4 |
| c54-sink | Surface water - gw interaction. Fresno Slogh | CALSIM III: SVSG51\_FSL012\_4+SVSG52\_FSL005\_4+SVSG53\_FSL005\_4 |
| c49-sink | Friant-Kern Canal loss | CALSIM III: L910 |
| c76-sink | Friant-Kern Canal loss | CALSIM III: L920 |
| c688-sink | Friant-Kern Canal loss | CALSIM III: L930 |
| c62-sink | Friant-Kern Canal loss | CALSIM III: L933 |
| c64-sink | Friant-Kern Canal loss | CALSIM III: L935 |
| c689-sink | Friant-Kern Canal loss | CALSIM III: L950 |
| d861-sink | California Aqueduct loss | CALSIM III: D862 |
| d853-sink | California Aqueduct loss | CALSIM III: D854 |
| d751-sink | California Aqueduct loss | CALSIM III: D829 |
| d870-sink | East Branch Aqueduct loss | CALSIM III: D880 |
| d872-sink | East Branch Aqueduct loss | CALSIM III: D882 |
| c131-sink | East Branch Aqueduct loss | CALSIM III: D889 |
| d885-sink | West Branch Aqueduct loss | CALSIM III: D891 |
| d886-sink | West Branch Aqueduct loss | CALSIM III: D893 |
| d887-sink | West Branch Aqueduct loss | CALSIM III: D894 |
| inflow-d889 | Coastal Aqueduct deliveries to Castaic WA | CALSIM III: D868 |
| inflow-wtp205 | Local inflow to Napa-Solano | Monthly average |
| inflow-n7 | Antelope Valley local inflow | Monthly average |
| inflow-c106 | Ventura local inflow | Monthly average |
| inflow-wtp503 | Castaic urban local inflow | Monthly average |
| inflow-sr\_tul | Local inflow to Tulloch Reservoir | CALSIM III: I\_TULOC |
| inflow-d616 | Del Puerto Creek | CALSIM III: I\_DPC008 |
| inflow-d612 | Ingram Creek | CALSIM III: I\_ING008 |
| inflow-d692 | Eastside Streams | CALSIM III: I\_COT033+I\_DBC024+I\_DED044+I\_MPS038+I\_OWN040+I\_BCK040+I\_BUR005 |
| inflow-d691 | Mud and Salt Slough local inflow | CALSIM III: I614 |
| inflow-d653b | Surface water - gw interaction | CALSIM III: SVSG146\_STS058\_23+SVSG147\_STS053\_23+SVSG148\_STS050\_23+SVSG149\_STS043\_23+SVSG150\_STS036\_23+SVSG151\_STS030\_23+SVSG152\_STS020\_23+SVSG153\_STS011\_23+SVSG154\_STS011\_23 |
| d653b-sink | Surface water - gw interaction | CALSIM III: SVSG146\_STS058\_23+SVSG147\_STS053\_23+SVSG148\_STS050\_23+SVSG149\_STS043\_23+SVSG150\_STS036\_23+SVSG151\_STS030\_23+SVSG152\_STS020\_23+SVSG153\_STS011\_23+SVSG154\_STS011\_23 |
| inflow-d663 | Surface water - gw interaction | CALSIM III: SVSG135\_TUO053\_21+SVSG136\_TUO047\_21+SVSG137\_TUO043\_21+SVSG138\_TUO036\_21+SVSG139\_TUO030\_21+SVSG140\_TUO022\_21+SVSG141\_TUO015\_21+SVSG142\_TUO010\_21+SVSG143\_TUO003\_21 |
| d664-sink | Surface water - gw interaction | CALSIM III: SVSG135\_TUO053\_21+SVSG136\_TUO047\_21+SVSG137\_TUO043\_21+SVSG138\_TUO036\_21+SVSG139\_TUO030\_21+SVSG140\_TUO022\_21+SVSG141\_TUO015\_21+SVSG142\_TUO010\_21+SVSG143\_TUO003\_21 |
| inflow-d642 | Surface water - gw interaction | CALSIM III: SVSG120\_MCD028\_17+SVSG121\_MCD021\_17+SVSG122\_MCD014\_17+SVSG123\_MCD009\_17+SVSG124\_MCD002\_17 |
| d643-sink | Surface water - gw interaction | CALSIM III: SVSG120\_MCD028\_17+SVSG121\_MCD021\_17+SVSG122\_MCD014\_17+SVSG123\_MCD009\_17+SVSG124\_MCD002\_17 |
| inflow-d646 | Surface water - gw interaction | CALSIM III: SVSG116\_MCD052\_17+SVSG117\_MCD048\_17+SVSG118\_MCD042\_17+SVSG119\_MCD036\_17 |
| d647-sink | Surface water - gw interaction | CALSIM III: SVSG116\_MCD052\_17+SVSG117\_MCD048\_17+SVSG118\_MCD042\_17+SVSG119\_MCD036\_17 |
| d897-sink | South Bay Aqueduct loss | CALSIM III: D816 |
| d703-sink | Delta Mendota Canal loss | CALSIM III: D702 |
| d804-sink | California Aqueduct loss | CALSIM III: D803 |
| d743-sink | California Aqueduct loss | CALSIM III: D824+D834 |
| d744a-sink | California Aqueduct loss | CALSIM III: D826+D838 |
| d745-sink | California Aqueduct loss | CALSIM III: D840+D827 |
| d749-sink | California Aqueduct loss | CALSIM III: D842+D828 |
| inflow-d98 | Local accretion | Climate change only |
| inflow-d606 | Local accretion | Climate change only |
| c20-sink | Local depletion | Climate change only |
| d699-sink | Local depletion | Climate change only |
| d605-sink | Local depletion | Climate change only |
| inflow-sr\_cfw | Local inflow to Camp Far West Reservoir | CALSIM III: I\_CMPFW |
| inflow-n202 | Local inflow upstream Camp Far West Reservoir | CALSIM III: I\_BRR023 |
| n202-sink | Local demand | CALSIM III: SVSG357\_CMPFW\_62 |
| inflow-n201 | Local inflow downstream Lake Combie | CALSIM III: I\_WLF013 |
| n201-sink | Canal diversions | CALSIM III: D\_BRR050\_BEC000\_SV+D\_CMBIE\_CBC000\_SV |

# **Reservoir Evaporation**

CALVIN uses net evaporation rates (ft/month) to calculate monthly evaporation losses. Monthly time-series of evaporation rates, obtained from CALSIM III, is multiplied with lake area to calculate evaporation volume. Lake areas are calculated with area capacity factors, shown in **Table 3**. Multiplying reservoir volume with an area capacity factor yields reservoir lake area. Using amplitude parameter, evaporation losses are subtracted from reservoir volume mass balance.

**Table 4**. Area capacity factors of CALVIN reservoirs

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Area Capacity Factor** |
| SR-CLE | Clair Engle Lake (Trinity) | 0.0061350 |
| SR-WHI | Whiskeytown Lake | 0.0124850 |
| SR-SHA | Shasta Lake | 0.0064700 |
| SR-ORO | Lake Oroville | 0.0040650 |
| SR-TAB | Thermalito Afterbay | 0.0700000 |
| SR-FOL | Folsom Lake | 0.0111700 |
| SR-BLB | Black Butte Lake | 0.0185263 |
| SR-CFW | Camp Far West Reservoir | 0.0026020 |
| SR-CLK-INV | Clear Lake & Indian Valley Reservoir | 0.0325582 |
| SR-CMN | Camanche Reservoir | 0.0056040 |
| SR-EBMUD | EBMUD Aggregate | 0.0107392 |
| SR-ENG | Englebright Lake | 0.0101960 |
| SR-BER | Lake Berryessa | 0.0097464 |
| SR-LVQ | Los Vaqueros Reservoir | 0.0101394 |
| SR-BUL | New Bullards Bar Reservoir | 0.0050660 |
| SR-NHG | New Hogan Lake | 0.0111820 |
| SR-PAR | Pardee Reservoir | 0.0072920 |
| SR-NML | New Melones Reservoir | 0.0046270 |
| SR-SNL | San Luis Reservoir | 0.0099700 |
| SR-DLV | Lake Del Valle | 0.0122030 |
| SR-MIL | Millerton Lake | 0.0087520 |
| SR-MCR | Lake McClure | 0.0063800 |
| SR-SLW | Silverwood Lake | 0.0055800 |
| SR-PRR | Lake Perris | 0.0183000 |
| SR-PYM | Pyramid Lake | 0.0072500 |
| SR-CAS | Castaic Lake | 0.0079800 |
| SR-HID | Hensley Lake | 0.0134050 |
| SR-BUC | Eastman Lake | 0.0087450 |
| SR-DNP | New Don Pedro Reservoir | 0.0057720 |
| SR-SFAGG | SF aggregate | 0.0191240 |
| SR-BVLB | Buena Vista Lake Bed | 0 |
| SR-DMV | Diamond Valley Lake (Eastside reservoir) | 0.0050800 |
| SR-GNT | Grant Lake | 0.0224610 |
| SR-HTH | Hetch Hetchy Reservoir | 0.0054325 |
| SR-LA | LAA Storage | 0.0316500 |
| SR-CRW | Long Valley Reservoir (Lake Crowley) | 0.0243000 |
| SR-ISB | Lake Isabella | 0.0114120 |
| SR-TRM | Lake Kaweah | 0.0059120 |
| SR-LL-ENR | Lake Lloyd/Lake Eleanor | 0.0082410 |
| SR-MHW | Lake Mathews | 0.0175000 |
| SR-SCC | Lake Success | 0.0223700 |
| SR-SKN | Lake Skinner | 0.0279000 |
| SR-ML | Mono Lake | 0.0140000 |
| SR-PNF | Pine Flat Reservoir | 0.0037780 |
| SR-SCAGG | Santa Clara Aggregate | 0.0204070 |
| SR-SS | Salton Sea | 0.0170000 |
| SR-TL | Tulare Lake Bed | 0 |
| SR-TUL | Tulloch Reservoir | 0.0192250 |

CALVIN reservoirs are mapped to CALSIM III reservoirs and net reservoir evaporation rates are gathered from the CALSIM III model. If a CALVIN reservoir does not exist in CALSIM III (such as Tulare Lake region and the Southern California reservoirs), then monthly average reservoir evaporation rates are used to extend CALVIN evaporation rate time-series. **Table 4** shows CALVIN reservoirs and their evaporation rate data sources.

**Table 5**. CALVIN reservoirs and net reservoir evaporation rate data sources

|  |  |  |
| --- | --- | --- |
| **CALVIN Node** | **Reservoir Name** | **Data Source** |
|  |
| sr\_mhw | Lake Mathews | Monthly pattern |  |
| sr\_ll\_enr | Lake Lloyd and Eleanor | CALSIM III: ER\_LLOYD+ER\_ELENR |  |
| sr\_trm | Lake Kaweah | Monthly pattern |  |
| sr\_isb | Lake Isabella | Monthly pattern |  |
| sr\_crw | Lake Crowley | Monthly pattern |  |
| sr\_la | Los Angeles Aqueduct Storage | Monthly pattern |  |
| sr\_hth | Hetch Hetchy Reservoir | CALSIM III: ER\_HTCHY |  |
| sr\_gnt | Grant Lake | Monthly pattern |  |
| sr\_dmv | Diamond Valley Lake | Monthly pattern |  |
| sr\_bvlb | Buena Vista Lake Bed | Monthly pattern |  |
| sr\_sfagg | San Francisco Aggregate Reservoirs | Monthly pattern |  |
| sr\_dnp | New Don Pedro Reservoir | CALSIM III: ER\_PEDRO |  |
| sr\_buc | Eastman Lake | CALSIM III: ER\_ESTMN |  |
| sr\_hid | Hensley Lake | CALSIM III: ER\_HNSLY |  |
| sr\_cas | Castaic Lake | CALSIM III: ER\_S29 |  |
| sr\_pym | Pyramid Lake | CALSIM III: ER\_S28 |  |
| sr\_prr | Lake Perris | CALSIM III: ER\_S27 |  |
| sr\_slw | Silverwood Lake | CALSIM III: ER\_S25 |  |
| sr\_mcr | Lake McClure | CALSIM III: ER\_MCLRE |  |
| sr\_mil | Millerton Lake | CALSIM III: ER\_MLRTN |  |
| sr\_dlv | Lake Del Valle | CALSIM III: ER\_S15 |  |
| sr\_snl | San Luis Reservoir | CALSIM III: ER\_SLUIS |  |
| sr\_nml | New Melones Reservoir | CALSIM III: ER\_MELON |  |
| sr\_par | Pardee Reservoir | CALSIM III: ER\_PARDE |  |
| sr\_nhg | New Hogans Lake | CALSIM III: ER\_NHGAN |  |
| sr\_bul | New Bullards Bar Reservoir | CALSIM III: ER\_NBLDB |  |
| sr\_lvq | Los Vaqueros Reservoir | CALSIM III: ER\_LOSVQ |  |
| sr\_ber | Lake Berryessa | CALSIM III: ER\_BRYSA |  |
| sr\_eng | Englebright Lake | CALSIM III: ER\_ENGLB |  |
| sr\_ebmud | EBMUD Aggregate Reservoirs | Monthly pattern |  |
| sr\_cmn | Camanche Reservoir | CALSIM III: ER\_CMCHE |  |
| sr\_clk\_inv | Clear Lake and Indian Valley Lake | CALSIM III:ER\_CLRLK+ER\_INDVL |  |
| sr\_cfw | Camp Far West Reservoir | CALSIM III: ER\_CMPFW |  |
| sr\_blb | Black Butte Lake | CALSIM III: ER\_BLKBT |  |
| sr\_fol | Folsom Lake | CALSIM III: ER\_FOLSM |  |
| sr\_tab | Thermalito Afterbay | CALSIM III: ER\_THRMA |  |
| sr\_oro | Oroville Lake | CALSIM III: ER\_OROVL |  |
| sr\_sha | Shasta Lake | CALSIM III: ER\_SHSTA |  |
| sr\_whi | Whiskeytown Lake | CALSIM III: ER\_WKYTN |  |
| sr\_cle | Clair Engle Lake | CALSIM III: ER\_TRNTY |  |
| sr\_scc | Lake Success | Monthly pattern |  |
| sr\_skn | Lake Skinner | Monthly pattern |  |
| sr\_ml | Mono Lake | Monthly pattern |  |
| sr\_pnf | Pine Flat Reservoir | Monthly pattern |  |
| sr\_scagg | Santa Clara Aggregate Reservoirs | Monthly pattern |  |
| sr\_ss | Salton Sea | Monthly pattern |  |
| sr\_tl | Tulare Lake Bed | Monthly pattern |  |
| sr\_tul | Tulloch Reservoir | CALSIM III: ER\_TULOC |  |
| sr\_rll\_cmb | Rollins Reservoir and Lake Combie | CALSIM III: ER\_RLLNS+ER\_CMBIE |  |

The following figure compares original CALVIN net reservoir evaporation rates for the October 1921 – September 2003 period and updated evaporation rates for the October 1921 – September 2015 period. Only major reservoirs are shown in the figure. When precipitation is greater than evaporation, net reservoir evaporation rates become negative.

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**Figure 3**. Original (1921-2003) and updated (1921-2015) net reservoir evaporation rates for major CALVIN reservoirs

# **Environmental Flow Requirements**

Agicultural and urban demands have economic representation in CALVIN. Environmental demand, however, is modeled with constraints, meaning environmental demand must be fulfilled before fulfilling any other demand. The environmental demand in CALVIN is represented in three forms: minimum instream flow requirements, minimum reservoir storage requirements, and wildlife refuge demands. Minimum instream flow and storage requirements are represented on lower bounds in a given CALVIN link, where flow or storage must be equal or greater than the requirement. Wildlife refuge demands are represented as fixed flows, with return flows to mostly surface water after their consumptive use. Delta outflow is represented in two parts: required and surplus Delta outflow. Required Delta outflow is modeled as a fixed monthly time-series with data obtained from CALSIM III.

## **Minimum Instream Flow Requirements**

Updated minimum instream flow requirements are gathered from the CALSIM III model. The only exception is Mono Lake inflow requirements, whose minimum flow time-series were extended using Water Year Type method. Three reservoirs have minimum stroage requirements: Trinity, Shasta, and Folsom. Level 2 storage requirements from the CALSIM III are used in CALVIN.

**Table 6**. CALVIN minimum instream flow and storage requirements and data sources

|  |  |  |  |
| --- | --- | --- | --- |
| **CALVIN Node** | **River** | **Location** | **Data Source** |
|
| sr\_cmn-c38 | Mokelumne | Downstream Camanche Reservoir | CALSIM III: C\_CMCHE\_MIF |
| d662-d663 | Tuolumne | Downstream LaGrange Dam | CALSIM III: C\_TUO054\_MIF |
| d609-d608 | San Joaquin | San Joaquin River upstream Mendota Pool | CALSIM III: C605A\_VAMPDO |
| c33-c308 | Bear | Bear River at Wheatland | CALSIM III: C\_BRR017\_MIF |
| n201-n202 | Bear | Downstream Combie and Bear River Canal diversions | CALSIM III: C\_CMBIE\_MIF |
| c35-sr\_rll\_cmb | Bear | Downstream Boardman Canal diversion | CALSIM III: C\_BRR061\_MIF |
| d616-c42 | San Joaquin | San Joaquin River at Vernalis | CALSIM III: C639\_VAMPDO |
| sr\_gnt-sr\_ml | Mono Basin | Mono Lake inflow | WYT Extension |
| c37-c38 | Cosumnes | Mokelumne River confluence | CALSIM III: I\_CMP001 + I\_CMP014 + I\_CSM035 + I\_JNKSN |
| sr\_dnp-d662 | Tuolumne | Downstream New Don Pedro reservoir | CALSIM III: C81VAMP |
| c41-c42 | Calaveras | San Joaquin River confluence | CALSIM III: C508\_VAMPDO |
| c83-c31 | Yuba | Feather River confluence | CALSIM III: MF\_YUB006DV |
| sr\_eng-c28 | Yuba | Downstream Englebright Lake | CALSIM III: MF\_YUB024DV |
| d624-c48 | Fresno | Chowchilla Bypass confluence | CALSIM III: C\_FRS036\_MIF |
| d649-d695 | Merced | San Joaquin River confluence | CALSIM III: C\_MCD033\_MIF |
| d645-d646 | Merced | Downstream Crocker-Huffman Diversion Dam | CALSIM III: C\_MCD052\_MIF |
| d672-d675 | Stanislaus | Downstream Goodwin Dam | CALSIM III: C\_STS059\_MIF |
| c25-c31 | Feather | Yuba River confluence | CALSIM III: C\_FTR059\_MIF |
| d42-d43 | Feather | Sacramento River confluence | CALSIM III: C\_FTR003\_MIF |
| c23-c25 | Feather | Downstream Thermalito diversion | CALSIM III: C\_FTR068\_MIF |
| c9-c12 | Stony | Downstream ag diversions | CALSIM III: C\_STN014\_MIF |
| sr\_blb-c9 | Stony | Downstream Black Butte Lake | CALSIM III: C\_BLKBT\_MIF |
| d507-d509 | Sacramento | Sacramento River at Rio Vista | CALSIM III: C\_SAC017\_MIF |
| d503-d511 | Sacramento | Sacramento River at Hood | CALSIM III: C\_SAC041\_MIF |
| d61-c301 | Sacramento | Downstream Tisdale Weir | CALSIM III: C\_SAC120\_MIF |
| d77-d75 | Sacramento | Downstream Tehama-Colusa Canal | CALSIM III: C\_SAC240\_MIF |
| d5-d73 | Sacramento | Downstream Keswick Reservoir | CALSIM III: C\_KSWCK\_MIF |
| d94-sink | Trinity | Downstream Lewiston Lake | CALSIM III: C\_LWSTN\_MIF |
| sr\_whi-d73 | Clear Creek | Downstream Whiskeytown Lake | CALSIM III: C\_WKYTN\_MIF |
| d9-d85 | American | Downstream Folsom South Canal diversion | CALSIM III: C\_NTOMA\_MIF |
| d64-c8 | American | Sacramento River confluence | CALSIM III: C\_AMR004\_MIF |
| sr\_cle | Lake Trinity | Lake Trinity minimum storage | CALSIM III: S\_TRNTYLEVEL2 |
| sr\_sha | Lake Shasta | Lake Shasta minimum storage | CALSIM III: S\_SHSTALEVEL2 |
| sr\_fol | Lake Folsom | Lake Folsom minimum storage | CALSIM III: S\_FOLSMLEVEL2 |

Minimum flow and storage requirements for selected locations are shown below. Minimum storage requirements did not exist previously in CALVIN’s Folsom lake. 2024 CALVIN Hydrology update introduced Folsom Lake minimum storage requirements.

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**Figure 4**. Original (1921-2003) and updated (1921-2015) minimum flow and storage requirements for major locations

## **Wildlife Refuge Demand**

CALVIN represents wildlife refuge demands in eight aggregated wildlife refure locations. These demads were updated based on CALSIM III wildlife refuge deliveries. Water Year Type extension method is used to extend Kern and Pixley NWR constrained demands. Data sources are shown below.

**Table 7**. CALVIN wildlife refuge deliveries and data sources

|  |  |  |
| --- | --- | --- |
| **CALVIN Link** | **Description** | **Data Source** |
| hsur101-r\_srw | Sacramento, Delevan, and Colusa NWR delivery | CALSIM III: D\_GCC027\_08N\_PR1+D\_GCC039\_08N\_PR2+D\_GCC056\_08S\_PR+D\_CBD041\_08S\_SA2 |
| hsur201-r\_gld | Gray Lodge NWR delivery | CALSIM III: D\_BGD000\_17N\_PR+D\_JBC002\_17N\_PR |
| hsur202-r\_sut | Sutter NWR delivery | CALSIM III: D\_SBP028\_17S\_PR+D\_SEC009\_17S\_PR |
| hsur301-r\_sje | Merced and San Luis (East Bear Creek Unit) NWR delivery | CALSIM III: D\_DED010\_63\_PR2+D\_EBP048\_63\_PR3 |
| hsur302-r\_sjw | Volta WA, Los Banos WA and Grasslands WA, Grassland WD, San Luis (Kesterson, Freitas, San Luis, West Bear Creek Units) NWR delivery | CALSIM III: D\_VLW008\_72\_PR1+D\_ARY010\_72\_PR4+D\_XCC033\_72\_PR4+D\_VLW008\_72\_PR5+D\_XCC054\_72\_PR5+D\_ARY010\_72\_PR6+D\_XCC025\_72\_PR6+D\_XCC033\_72\_PR2+D\_ARY010\_72\_PR3 |
| hsur303-r\_mdt | Mendota WA delivery | CALSIM III: D\_MDOTA\_91\_PR |
| hsur401-r\_ker | Kern NWR delivery | WYT Extension |
| hsur402-r\_pix | Pixley NWR delivery | WYT Extension |

Original and updated wildlife refuge monthly time-series are shown below.

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**Figure 5**. Original (1921-2003) and updated (1921-2015) wildlife refuge demands

## **Required Delta Outflow**

CALVIN separates Delta Outflow into two parts: Required Delta Outflow and Surplus Delta Outflow. Required Delta Outflow is a constrained monthly flow time-series obtained from CALSIM III. Surplus Delta Outflow is unbounded.

**Table 8**. CALVIN required Delta outflow data source

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| **CALVIN Link** | **Description** | **Data Source** |
| d541-req\_delta | Required Delta outflow | CALSIM III: D407 |

Original and updated required Delta outflow monthly time-series and data comparison are shown below.

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**Figure 6**. Original (1921-2003) and updated (1921-2015) required Delta outflow

# **Constrained Flows**

Constrained flows include fixed urban deliveries (no economic representation), weir spills, the Kern River Intertie, and the Delta Cross Channel flows. Urban demands are extended with monthly average values. Bypass (weir) flows are updated with data from CALSIM III.

**Table 9**. CALVIN constrained flows and data sources

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| **CALVIN Link** | **Description** | **Data Source** |
| u102-ext\_cvpm02 | Urban constrained demand | Monthly average |
| u102-int\_cvpm02 | Urban constrained demand | Monthly average |
| u103-ext\_cvpm03 | Urban constrained demand | Monthly average |
| u103-int\_cvpm03 | Urban constrained demand | Monthly average |
| u104-ext\_cvpm04 | Urban constrained demand | Monthly average |
| u104-int\_cvpm04 | Urban constrained demand | Monthly average |
| u206-ext\_cvpm09 | Urban constrained demand | Monthly average |
| u206-int\_cvpm09 | Urban constrained demand | Monthly average |
| u202-ext\_cvpm05 | Urban constrained demand | Monthly average |
| u202-int\_cvpm05 | Urban constrained demand | Monthly average |
| hxi203-ext\_cvpm06 | Urban constrained demand | Monthly average |
| u203-int\_cvpm06 | Urban constrained demand | Monthly average |
| u404-ext\_cvpm15 | Urban constrained demand | Monthly average |
| hxi402-ext\_cvpm14 | Urban constrained demand | Monthly average |
| u402-int\_cvpm14 | Urban constrained demand | Monthly average |
| u408-ext\_cvpm19 | Urban constrained demand | Monthly average |
| u404-int\_cvpm15 | Urban constrained demand | Monthly average |
| u408-int\_cvpm19 | Urban constrained demand | Monthly average |
| u409-ext\_cvpm21 | Urban constrained demand | Monthly average |
| u409-int\_cvpm21 | Urban constrained demand | Monthly average |
| u303-ext\_cvpm10 | Urban constrained demand | Monthly average |
| u303-int\_cvpm10 | Urban constrained demand | Monthly average |
| hu500-ags\_owens | Ag constrained demand | Monthly average |
| d30-n203 | Moultan and Colusa Weir spills | CALSIM III: SP\_SAC159\_BTC003 + SP\_SAC148\_BTC003 |
| d61-d61b | Tisdale Weir spills | CALSIM III: SP\_SAC122\_SBP021 |
| d43-c306 | Fremont Weir spills | CALSIM III: SP\_SAC083\_YBP037 |
| c7-c20 | Sacramento Weir spills | CALSIM III: SP\_SAC066\_YBP020 |
| c73-d859 | Kern River Intertine | CALSIM III: I860 |
| d66a-n203 | Sutter bypass near Ord Ferry spills | CALSIM III: SP\_SAC193\_BTC003 + SP\_SAC188\_BTC003 |
| d511-d513 | Delta Cross Channel flows | CALSIM III: D\_SAC030\_MOK014 + C\_SAC029B |

Original and updated Kern River Intertie and the Delta Cross Channel monthly time-series and data comparison are shown below.

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**Figure 7**. Original (1921-2003) and updated (1921-2015) Kern River Intertie and the Delta Cross Channel constrained flows

# **Delta Allowable Export Capacity**

The water is exported from the Delta via the Delta-Mendota Canal and the California Aqueduct. Tracy Pumping Plant pumps water into the Delta Mendota Canal, and Banks Pumping Plant pumps water into the California Aqueduct. Tracy Pumping Plant has a constant upper bound (allowable) capacity of 4600 cfs. However, allowable pumping capacities of the Banks Pumping Plant changes depending on the Delta’s environmental regulations. Banks Pumping Plant allowable pumping capacity data is gathered from the CALSIM III model.

**Table 10**. Banks allowable pumping capacity and data source

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| **CALVIN Link** | **Description** | **Data Source** |
| pmp\_banks-d800 | Banks pumping capacity | CALSIM III: BANKSALLOWOUT |

Original and updated Banks allowable pumping capacity monthly time-series and data comparison are shown below.

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**Figure 8**. Original (1921-2003) and updated (1921-2015) Banks allowable pumping capacities

# **Comparison to Previous Modeling Results**

This section compares CALVIN results with updated hydrology, covering 1921-2015 period, to previous CALVIN model with 82 years of data, covering 1921-2003 period.

## **Agricultural Deliveries**

Groundwater pumping and surface water diversions are two available water supply sources to agricultural users. Most agricultural demand is supplied from surface sources, while groundwater supplies increase in drought years and surface water supplies increase in wet years, as a result of conjunctive use in CALVIN. Agricultural water operations of old (82year) and updated (94year) CALVIN model are shown below. Overall, total agricultural deliveries are similar in both models. However, there are additional small scarcities on large demands (above 4 MAF in total) in the updated model, occurring mostly in drought years. Even though magnitude of scarcities increase in the updated model, on average (corresponding to 50% of exceedence), scarcities are slightly lower in this model. Deliveries from groundwater increase in the updated model, while peak deliveries decrease. Surface water deliveries are similar in both models, while on average the updated model’s surface deliveries are lower.

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**Figure 9**. Total agricultural deliveries, supplies from groundwater and surface water, scarcities, and their delivery-reliabilities

## **Urban Deliveries**

Urban users have much higher willingness-to-pay than agricultural users, while their total demand is less. Thus, their demands are mostly met. Both old and updated CALVIN models meet the urban demands, even though there are some small scarcities in the updated model. Groundwater and surface water are two main water supply sources for urban users, but desalination and recycled wastewater reuse are also available for some urban users. Overall, surface and groundwater deliveries to urban users do not significantly change in both models. However, due to updates on Delta exports allowable capacity (from Banks PP), there are some large urban deliveries from surface sources in the updated model. Also, as a result of conjunctive use in CALVIN, groundwater deliveries increase and surface water deliveries decrease in drought years.

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**Figure 10**. Total urban deliveries, supplies from groundwater and surface water, and their delivery-reliabilities

## **Reservoir Storage and Release**

Surface reservoirs are used to meet agricultural, urban, and environmental demands. CALVIN’s objective is to maximize hydropower generation revenue while meeting these demands. Total surface reservoir storage and release follow similar patterns in both old and updated models, increasing in wet years and decreasing in dry years. Average reservoir storage, corresponding to 50% of exceedende (or duration) do not change in both models. However, storage variability increase in the updated model.

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**Figure 11**. Total CALVIN surface reservoir storage, release, and reliabilities

## **Groundwater Storage and Pumping**

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**Figure 12**. Total CALVIN groundwater storage, pumping, and reliabilities

## **Delta Exports and Surplus Delta Outflow**

2024 CALVIN updates significantly changed Delta export operations due to updated allowable pumping capacities from Banks Pumping Plant (the California Aqueduct). Tracy Pumping Plant’s (the Delta-Mendota Canal) allowable pumping capacity remains the same (4600 cfs). With the updated CALVIN model, overall monthly average Delta exports decrease, while peak exports increase (mostly in wet years).Surplus Delta outflow follows a similar pattern in both old and updated CALVIN models, but the magnitude of the outflow peaks decrease in the updated model, due to increased allowable export capacity in this model.

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**Figure 13**. Total Delta exports from the California Aqueduct and the Delta-Mendota Canal, surplus Delta outflow, and reliabilities