C2VSimFG

Model Data Development and Tools

Presented By:

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CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER MANAGEMENT PROGRAM

Woodard & Curran

California Central Valley Groundwater-Surface Water Simulation Model – Fine Grid (C2VSimFG)

Survey Questions and Introduction

On your phone or laptop, go to:
MENTI.COM

And type in code:
16 18 45 7

Woodard & Curran

Outline

- Status of C2VSimFG
- Collection of Data Processing and Visualization Tools
  - Excel-based Tools
  - Python-based Tools
  - R-based Tools
  - GIS and Web-based Tools
- Conclusions and Next Steps

Status of C2VSimFG

C2VSimFG v1.0

- Released December 2020
- First calibrated version

C2VSimFG v1.01

- Released April 2021
- Minor bug fixes

C2VSimFG Baseline

- Pending release summer 2022

C2VSimFG v1.02 or v2.0

- Simulation period and data extension (adding WY2016-2021)
- Bug fixes
- Re-calibration

C2VSimFG Data Format

Name	Type	Size
C2VSimFG_GW_Budget.bud	BUD File	2,662 KB
C2VSimFG_GW_Budget.hdf	HDF File	2,015 KB
C2VSimFG_GW_FinalCond.out	OUT File	2,418 KB
C2VSimFG_GW_FinalCond_2011.out	OUT File	2,418 KB
C2VSimFG_GW_HeadAll.out	OUT File	714,796 KB
C2VSimFG_GW_Hydrographs.out	OUT File	325,361 KB
C2VSimFG_GW_ZBudget.hdf	HDF File	5,288,565 KB
C2VSimFG_L&WU_Budget.bud	BUD File	2,673 KB
C2VSimFG_L&WU_Budget.hdf	HDF File	2,106 KB
C2VSimFG_L&WU_ZBudget.hdf	HDF File	3,725,231 KB
C2VSimFG_Pumping.out	OUT File	460,443 KB
C2VSimFG_RZ_Budget.bud	BUD File	8,548 KB
C2VSimFG_RZ_Budget.hdf	HDF File	5,040 KB
C2VSimFG_RZ_FinalCond.out	OUT File	18,305 KB
C2VSimFG_RZ_ZBudget.hdf	HDF File	8,984,873 KB
C2VSimFG_Stream_Budget.bud	BUD File	10,978 KB
C2VSimFG_Stream_Budget.hdf	HDF File	9,114 KB
C2VSimFG_Stream_Diversions.bud	BUD File	23,678 KB
C2VSimFG_Stream_Diversions.hdf	HDF File	26,405 KB
C2VSimFG_Stream_Hydrographs.out	OUT File	483 KB
C2VSimFG_Stream_NodeBudget.hdf	HDF File	383,117 KB
C2VSimFG_Subsidence.out	OUT File	3,642 KB
C2VSimFG_SWatersheds_Budget.bud	BUD File	149,071 KB
C2VSimFG_SWatersheds_Budget.hdf	HDF File	98,773 KB
C2VSimFG_SWatersheds_FinalCond.out	OUT File	30 KB
C2VSimFG_Unsat_Budget.bud	BUD File	968 KB
C2VSimFG_Unsat_Budget.hdf	HDF File	1,038 KB
C2VSimFG_Unsat_FinalCond.out	OUT File	1,081 KB
C2VSimFG_Unsat_ZBudget.hdf	HDF File	1,030,425 KB

```
C-------------------------------------------------------------------------------
C   ITDV        ADIVS)  ADIVS2  ADIVS3 ...
C   Column       1   2   3   4   5   6   7   8   9   10  11  12  13  14  15  16  17  18  19  20  21  22  23
C            (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)   (TAF)
C-------------------------------------------------------------------------------
10/31/1921_24:00     0.000   0.000   0.000   0.025   0.025   8.276   0.000   0.000   0.000   0.000   0.026
11/30/1921_24:00     0.000   0.000   0.000   0.022   0.022   0.000   0.000   0.000   0.000   0.000   0.000
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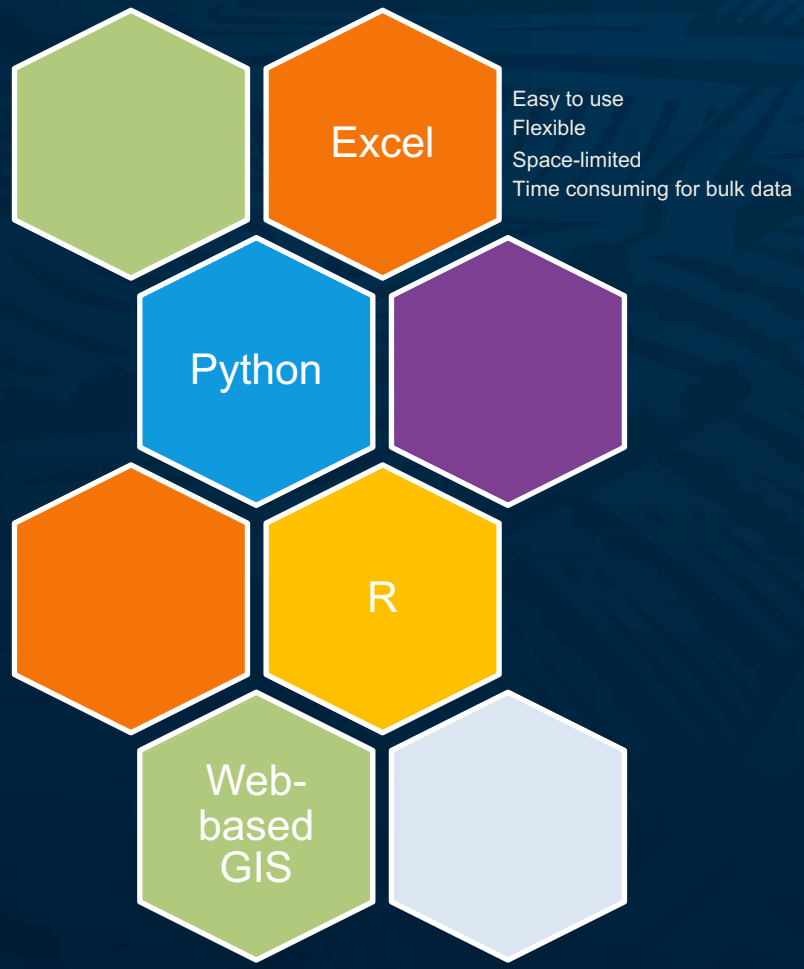
02/28/1922_24:00     0.000   0.000   0.000   0.020   0.020   0.000   0.000   0.000   0.000   0.000   0.000
03/31/1922_24:00     0.000   0.000   0.000   0.023   0.023   0.000   0.000   0.000   0.000   0.000   0.000
04/30/1922_24:00     0.000   0.000   0.000   0.029   0.029   6.640   0.000   0.000   0.000   0.000   0.031
05/31/1922_24:00     0.000   0.000   0.000   0.049   0.049   15.228  0.000   0.000   0.000   0.000   0.086
06/30/1922_24:00     0.000   0.000   0.000   0.046   0.046   19.210  0.000   0.000   0.000   0.000   0.230
07/31/1922_24:00     0.000   0.000   0.000   0.074   0.074   23.346  0.000   0.000   0.000   0.000   0.269
08/31/1922_24:00     0.000   0.000   0.000   0.079   0.079   23.431  0.000   0.000   0.000   0.000   0.238
09/30/1922_24:00     0.000   0.000   0.000   0.000   0.000   16.101  0.000   0.000   0.000   0.000   0.150
10/31/1922_24:00     0.000   0.000   0.000   0.025   0.025   8.276   0.000   0.000   0.000   0.000   0.026
11/30/1922_24:00     0.000   0.000   0.000   0.022   0.022   0.000   0.000   0.000   0.000   0.000   0.000
12/31/1922_24:00     0.000   0.000   0.000   0.026   0.026   0.000   0.000   0.000   0.000   0.000   0.000
01/31/1923_24:00     0.000   0.000   0.000   0.023   0.023   0.000   0.000   0.000   0.000   0.000   0.000
02/28/1923_24:00     0.000   0.000   0.000   0.020   0.020   0.000   0.000   0.000   0.000   0.000   0.000
03/31/1923_24:00     0.000   0.000   0.000   0.023   0.023   0.000   0.000   0.000   0.000   0.000   0.000
04/30/1923_24:00     0.000   0.000   0.000   0.030   0.030   6.640   0.000   0.000   0.000   0.000   0.031
05/31/1923_24:00     0.000   0.000   0.000   0.049   0.049   15.228  0.000   0.000   0.000   0.000   0.086
06/30/1923_24:00     0.000   0.000   0.000   0.047   0.047   19.210  0.000   0.000   0.000   0.000   0.230
```

```
*                                    ****************************************
*                                    *    GROUNDWATER HEAD AT ALL NODES     *
*                                    *           (UNIT=FEET)                *
*                                    ****************************************
*                          NODE
*        TIME                1          2          3          4          5          6          7
09/30/1973_24:00         480.4700   640.5000   672.4800   672.4400   793.8700   649.0100   572.2400
                         369.4100   364.0600   360.0000   366.0000   368.0000   363.7000   352.0700
                         357.8100   353.4300   344.4600   339.2100   336.8900   343.6400   344.4200
                         357.8100   353.4300   344.4600   339.2100   336.8900   343.6400   344.4200
10/31/1973_24:00         481.4614   522.4720   551.8461   559.8443   648.2787   530.7204   492.3849
                         383.5756   471.1704   450.2778   434.3271   461.6966   443.4695   394.6369
                         385.6995   471.1247   443.0254   421.4017   436.2917   432.3549   391.1892
                         386.3639   471.1643   442.9849   421.4942   436.1749   432.4485   391.3431
11/30/1973_24:00         481.5170   514.5721   514.4617   526.2417   578.7042   495.3833   471.0456
                         398.5440   510.4996   482.3038   463.5839   515.9783   473.5639   408.8443
                         400.7459   510.4412   482.3919   464.1122   514.8356   474.1472   409.6279
                         401.4083   510.4190   482.4075   464.2715   514.4593   474.3307   409.8945
12/31/1973_24:00         481.4979   517.8602   503.0088   516.3725   572.4340   489.5560   465.3849
                         412.0930   517.5941   492.6379   475.4214   567.0945   486.8155   414.2415
                         413.9618   517.4218   492.7632   476.1091   565.0357   487.3355   415.0659
                         414.5254   517.3703   492.7989   476.3313   564.4109   487.5118   415.3491
01/31/1974_24:00         481.4784   520.6472   499.5125   513.4852   567.7978   491.6695   463.8853
                         424.2992   520.2715   496.3619   481.7800   563.8486   492.3090   417.2578
                         425.8724   520.0334   496.4971   482.4044   562.2986   492.7113   418.0682
                         426.3480   519.9621   496.5381   482.6079   561.8478   492.8515   418.3468
02/28/1974_24:00         481.4626   522.9632   498.7575   512.6414   563.6279   493.4999   463.4857
                         435.2658   522.4779   498.2668   486.3413   560.0282   494.0592   419.5819
```

Collection of Data Processing and Visualization Tools

- Pre- and post-processes and visualizes model inputs and results
- Supports model data QA/QC
- Generic for any C2VSimFG versions or even any IWFM models
- Reproducible and well-documented

Collection of Data Processing and Visualization Tools



Easy to use
Flexible
Space-limited
Time consuming for bulk data

Collection of Data Processing and Visualization Tools

Excel

Easy to use
Flexible
Space-limited
Time consuming for bulk data

Python

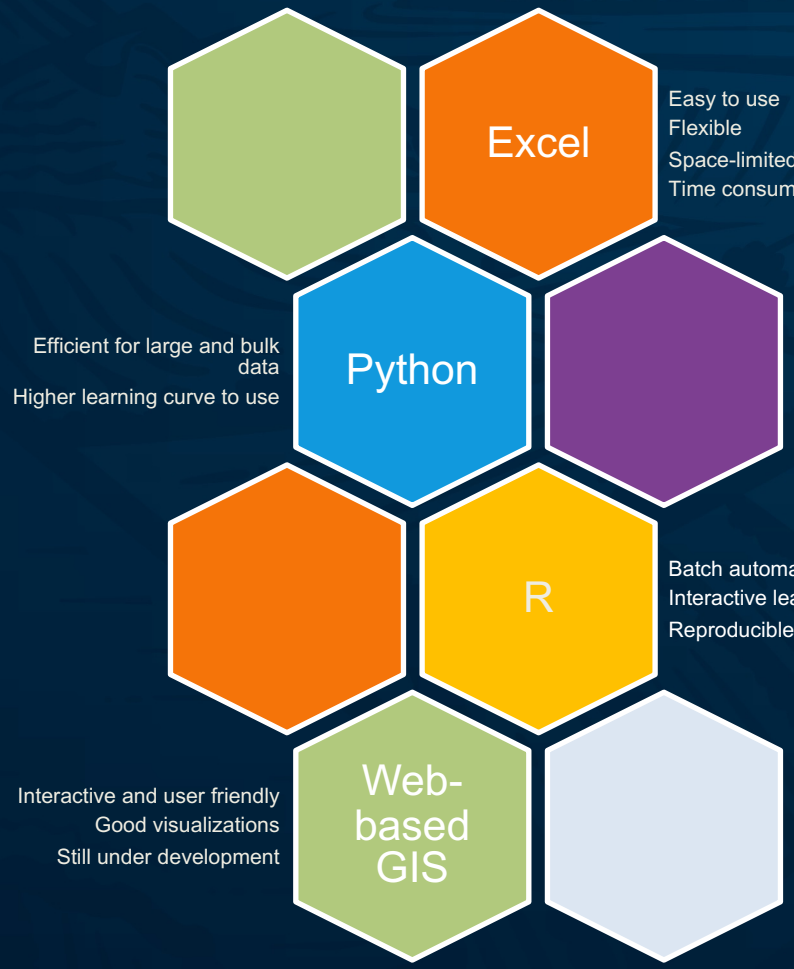
Efficient for large and bulk data
Higher learning curve to use

R

Batch automation
Interactive leaflet maps
Reproducible

Web-based GIS

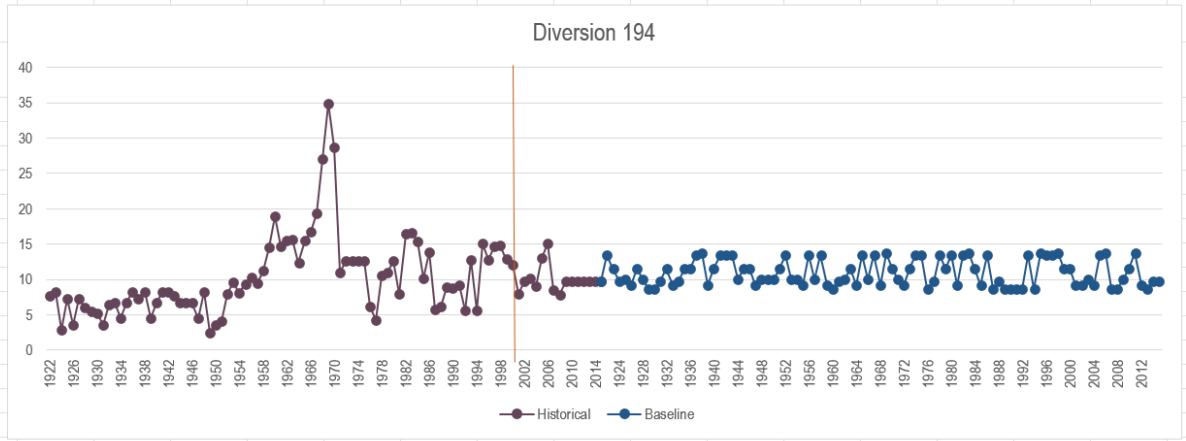
Collection of Data Processing and Visualization Tools

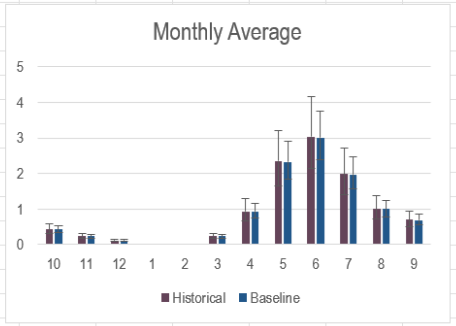


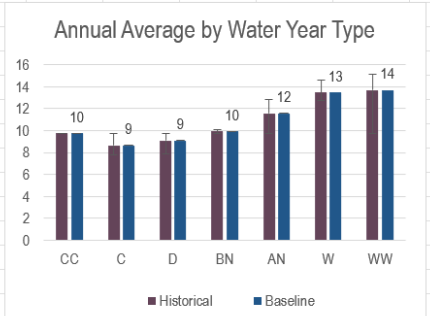
Excel-based Tools

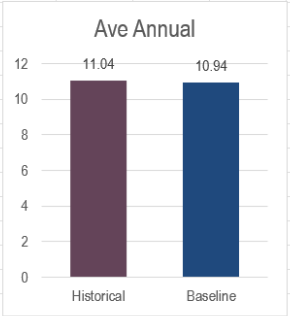
Lower Limit	Upper Limit	Range	Count	%	1	2	3	4	5	6	7	8	9	10	11	12	13
-300	-280	-300 - -280	69	0%													
-280	-260	-280 - -260	110	0%													
-260	-240	-260 - -240	234	0%													
-240	-220	-240 - -220	211	0%													
-220	-200	-220 - -200	244	0%													
-200	-180	-200 - -180	411	0%													
-180	-160	-180 - -160	504	0%													
-160	-140	-160 - -140	693	1%													
-140	-120	-140 - -120	1103	1%													
-120	-100	-120 - -100	1137	1%													
-100	-80	-100 - -80	1905	2%													
-80	-60	-80 - -60	3168	3%													
-60	-40	-60 - -40	4743	5%													
-40	-20	-40 - -20	8332	8%													
-20	0	-20 - 0	31129	30%													
0	20	0 - 20	32058	31%													
20	40	20 - 40	12059	12%													
40	60	40 - 60	5771	6%													
60	80	60 - 80	2989	3%													
80	100	80 - 100	1671	2%													
100	120	100 - 120	1065	1%													

	N	O	P	Q	R	S	T	U	V	W
1	Diversion	Export	Diversion Modified	Delivery Area Modified	Sac/SJ	Source	Adjustment		Units: TAF	
2	194	*No*			*SJ*	*Ave Hist*	*Adj - ag*			
3	**Cosumnes River Riparian diversions**									
4										
5		1995	1922						WY	
6		2015	2015			Historical	Baseline		1922	7.7
7					Ave Annual	11.04	10.94		1923	8.2
8	Ave	Historical	Baseline						1924	2.8
9	10	0.434476	0.430738		CC	9.762	9.762		1925	7.2
10	11	0.235095	0.233078		C	8.676	8.676		1926	3.5
11	12	0.117524	0.1165		D	9.117	9.117		1927	7.2
12	1	0	0		BN	9.940	9.940		1928	6
13	2	0	0		AN	11.560	11.560		1929	5.5
14	3	0.235095	0.233078		W	13.476	13.476		1930	5.2
15	4	0.939952	0.931911		WW	13.701	13.701		1931	3.5
16	5	2.35	2.329875						1932	6.4
17	6	3.032762	3.006791		Max				1933	6.7
18	7	1.991	1.97398		CC	0.000	0.000		1934	4.5
19	8	1.006476	0.99786		C	1.086	0.000		1935	6.7
20	9	0.69619	0.69022		D	0.665	0.000		1936	8.2
21					BN	0.178	0.000		1937	7.2
22	Max				AN	1.301	0.000		1938	8.2
23	10	0.161524	0.108762		W	1.166	0.000		1939	4.5
24	11	0.086905	0.058672		WW	1.432	0.000		1940	6.7
25	12	0.043476	0.0295						1941	8.2
26	1	0	0		Min				1942	8.2
27	2	0	0		CC	0.000	0.000		1943	7.7
28	3	0.086905	0.058672		C	0.876	0.000		1944	6.7
29	4	0.349048	0.234839		D	1.239	0.000		1945	6.7
30	5	0.872	0.586875		BN	0.178	0.000		1946	6.7
31	6	1.125238	0.757459		AN	1.798	0.000		1947	4.5









Python-based Tools

```
*                                    ************************************
*                                    *    GROUNDWATER HEAD AT ALL NODES    *
*                                    *           (UNIT=FEET)               *
*                                    ************************************
*                          NODE
*        TIME                1          2          3          4          5          6          7
09/30/1973_24:00        480.4700   640.5000   672.4800   672.4400   793.8700   649.0100   572.2400
                        369.4100   364.0600   360.0000   366.0000   368.0000   363.7000   352.0700
                        357.8100   353.4300   344.4600   339.2100   336.8900   343.6400   344.4200
                        357.8100   353.4300   344.4600   339.2100   336.8900   343.6400   344.4200
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                        383.5756   471.1704   450.2778   434.3271   461.6966   443.4695   394.6369
                        385.6995   471.1247   443.0254   421.4017   436.2917   432.3549   391.1892
                        386.3639   471.1643   442.9849   421.4942   436.1749   432.4485   391.3431
11/30/1973_24:00        481.5170   514.5721   514.4617   526.2417   578.7042   495.3833   471.0456
                        398.5440   510.4996   482.3038   463.5839   515.9783   473.5639   408.8443
                        400.7459   510.4412   482.3919   464.1122   514.8356   474.1472   409.6279
                        401.4083   510.4190   482.4075   464.2715   514.4593   474.3307   409.8945
12/31/1973_24:00        481.4979   517.8602   503.0088   516.3725   572.4340   489.5560   465.3849
                        412.0930   517.5941   492.6379   475.4214   567.0945   486.8155   414.2415
                        413.9618   517.4218   492.7632   476.1091   565.0357   487.3355   415.0659
                        414.5254   517.3703   492.7989   476.3313   564.4109   487.5118   415.3491
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                        424.2992   520.2715   496.3619   481.7800   563.8486   492.3090   417.2578
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                        426.3480   519.9621   496.5381   482.6079   561.8478   492.8515   418.3468
02/28/1974_24:00        481.4626   522.9632   498.7575   512.6414   563.6279   493.4999   463.4857
                        435.2658   522.4779   498.2668   486.3413   560.0282   494.0592   419.5819
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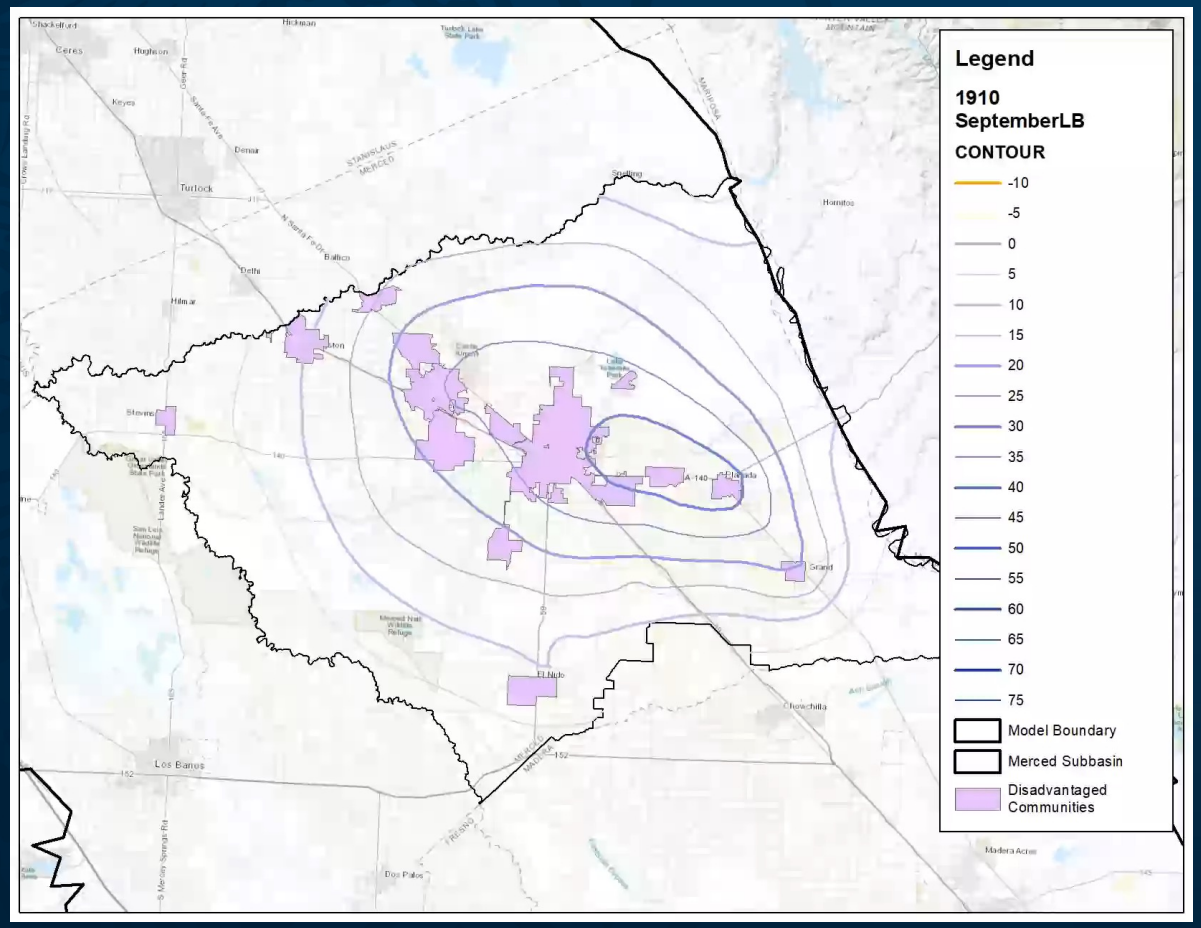
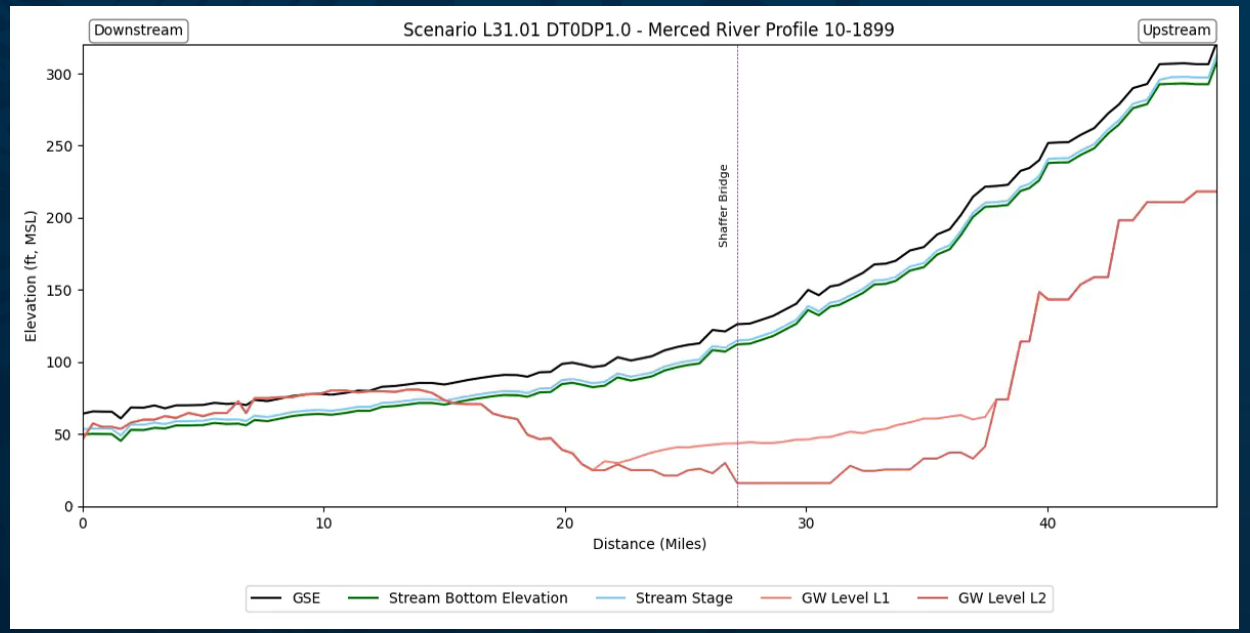


Head All Groundwater Levels → Spatial and Temporal Contours

Python-based Tools

```
1  *                                    ************************************
2  *                                    *          STREAM HYDROGRAPH         *
3  *                                    *            (UNIT=AC-FT)            *
4  *                                    ************************************
5  *       HYDROGRAPH ID             1          2          3          4          5
6  *               NODES          2741       2780       2829       2854       2880
7  *        TIME
8  10/31/1973_24:00           15115.02    2055.97     995.30     914.29    7246.29
9  11/30/1973_24:00          134813.73   54840.77   36421.32  106912.00   50286.12
10 12/31/1973_24:00          149567.96   88470.63   60009.10  174614.67   54486.45
11 01/31/1974_24:00          238270.73  182957.51  122634.58  333675.86  104727.39
12 02/28/1974_24:00           70414.25   41320.09   23908.69   70611.59   35384.59
13 03/31/1974_24:00          169263.46  111180.81   77173.39  215982.34   76672.91
14 04/30/1974_24:00           83628.91   91845.92   45221.88  142694.18   61484.21
15 05/31/1974_24:00           34707.70   24151.48   12995.65   37814.35   45999.79
16 06/30/1974_24:00           17315.46    8218.55    4878.90   13048.17   36972.85
17 07/31/1974_24:00           10245.65    5202.71    1347.32    7180.83   30593.33
18 08/31/1974_24:00            6777.00    2544.75     191.40    2934.28   21843.60
19 09/30/1974_24:00            5609.73    1145.07      94.85    1538.23   19011.25
20 10/31/1974_24:00            7503.28    1641.79     382.67    2797.96   22010.79
21 11/30/1974_24:00           10821.87    3025.48    1256.23    5143.60   23245.20
```

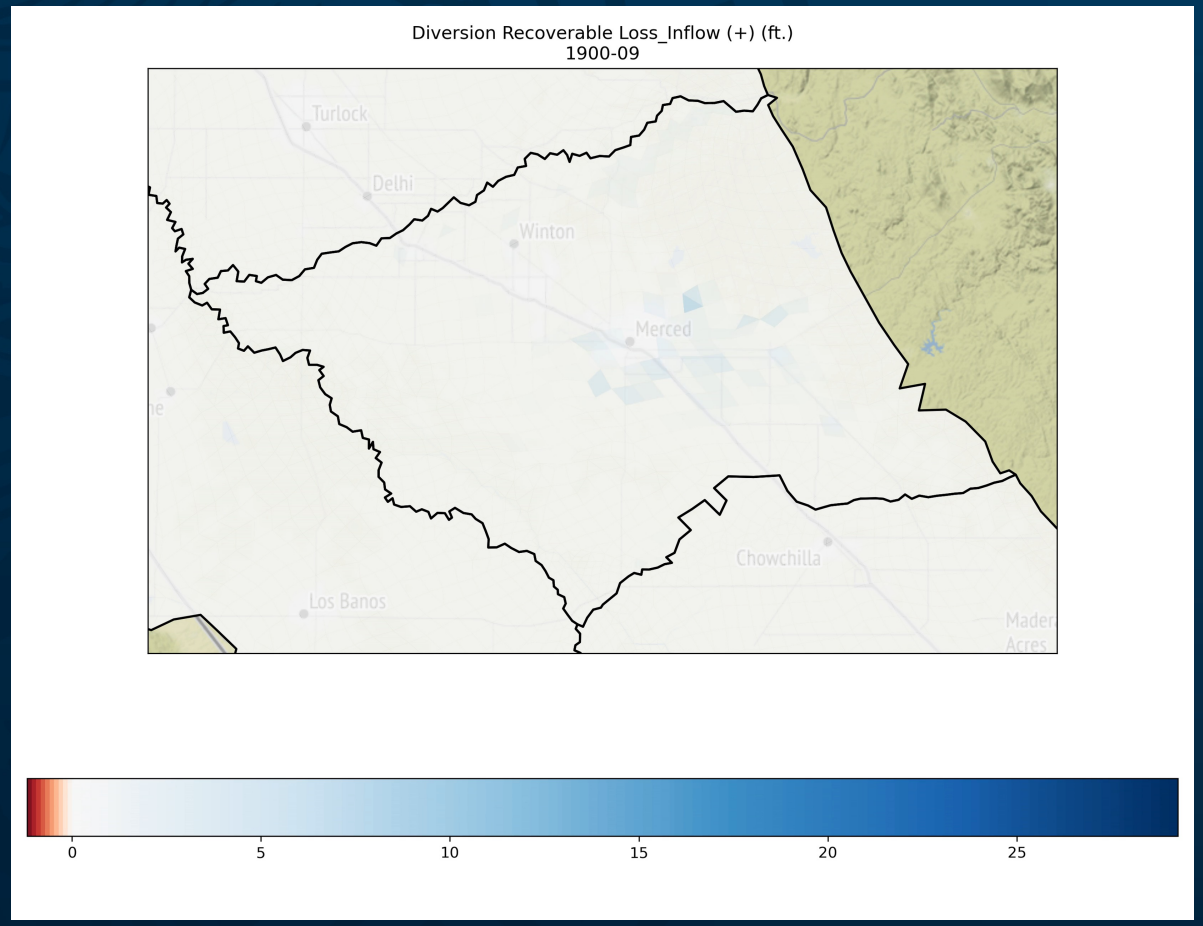
```
C*************************************************************************
C                        Stratigraphy Data
C
C  *The stratigraphy data represents the geology that deals with the origin,
C   composition, distribution and succession of groundwater layers.
C
C  *Each groundwater layer is specified as an aquifer and aquiclude or aquitard.
C   If there is no aquiclude or aquitard within the layer, specify a thickness
C   of zero
C
C  *The stratigraphy data includes the ground surface elevation, as well as the
C   thickness of the aquifer, aquitard, or aquiclude at each groundwater node
C
C   ID;      Groundwater node
C   ELV;     Ground surface elevation with respect to a common datum; [L]
C   W(1);    Thickness of aquiclude in Layer 1; [L]
C   W(2);    Thickness of aquifer in Layer 1; [L]
C   W(3);    Thickness of aquiclude in Layer 2; [L]
C   W(4);    Thickness of aquifer in Layer 2; [L]
C   W(5);    Thickness of aquiclude in Layer 3; [L]
C   W(6);    Thickness of aquifer in Layer 3; [L]
C
C-------------------------------------------------------------------------
C     NodeID    GSE          A1          L1          A2          L2          A3          L3          A4
C-------------------------------------------------------------------------
       1       616.86      0.00      136.39      0.00      122.35      0.00      124.57      0.00
       2       682.02      0.00      200.44      0.00      127.51      0.00      104.08      0.00
       3       701.69      0.00      203.87      0.00      137.82      0.00       82.27      0.00
```



Stream Hydrographs, Stratigraphy, and GWL Head All → Stream Stage relative to GWLs

Python-based Tools

575	C----------																		
576	C ITDV	ADIVS)	ADIVS2	ADIVS3 ...															
577	C Column	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
578	C	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)	(TAF)
579	C----------																		
580	10/31/1921_24:00	0.000	0.000	0.000	0.025	0.025	8.276	0.000	0.000	0.000	0.000	0.026							
581	11/30/1921_24:00	0.000	0.000	0.000	0.022	0.022	0.000	0.000	0.000	0.000	0.000	0.000							
582	12/31/1921_24:00	0.000	0.000	0.000	0.025	0.025	0.000	0.000	0.000	0.000	0.000	0.000							
583	01/31/1922_24:00	0.000	0.000	0.000	0.023	0.023	0.000	0.000	0.000	0.000	0.000	0.000							
584	02/28/1922_24:00	0.000	0.000	0.000	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000							
585	03/31/1922_24:00	0.000	0.000	0.000	0.023	0.023	0.000	0.000	0.000	0.000	0.000	0.000							
586	04/30/1922_24:00	0.000	0.000	0.000	0.029	0.029	6.640	0.000	0.000	0.000	0.000	0.031							
587	05/31/1922_24:00	0.000	0.000	0.000	0.049	0.049	15.228	0.000	0.000	0.000	0.000	0.086							
588	06/30/1922_24:00	0.000	0.000	0.000	0.046	0.046	19.210	0.000	0.000	0.000	0.000	0.230							
589	07/31/1922_24:00	0.000	0.000	0.000	0.074	0.074	23.346	0.000	0.000	0.000	0.000	0.269							
590	08/31/1922_24:00	0.000	0.000	0.000	0.079	0.079	23.431	0.000	0.000	0.000	0.000	0.238							
591	09/30/1922_24:00	0.000	0.000	0.000	0.000	0.000	16.101	0.000	0.000	0.000	0.000	0.150							
592	10/31/1922_24:00	0.000	0.000	0.000	0.025	0.025	8.276	0.000	0.000	0.000	0.000	0.026							
593	11/30/1922_24:00	0.000	0.000	0.000	0.022	0.022	0.000	0.000	0.000	0.000	0.000	0.000							
594	12/31/1922_24:00	0.000	0.000	0.000	0.026	0.026	0.000	0.000	0.000	0.000	0.000	0.000							
595	01/31/1923_24:00	0.000	0.000	0.000	0.023	0.023	0.000	0.000	0.000	0.000	0.000	0.000							
596	02/28/1923_24:00	0.000	0.000	0.000	0.020	0.020	0.000	0.000	0.000	0.000	0.000	0.000							
597	03/31/1923_24:00	0.000	0.000	0.000	0.023	0.023	0.000	0.000	0.000	0.000	0.000	0.000							
598	04/30/1923_24:00	0.000	0.000	0.000	0.030	0.030	6.640	0.000	0.000	0.000	0.000	0.031							
599	05/31/1923_24:00	0.000	0.000	0.000	0.049	0.049	15.228	0.000	0.000	0.000	0.000	0.086							
600	06/30/1923_24:00	0.000	0.000	0.000	0.047	0.047	19.210	0.000	0.000	0.000	0.000	0.230							



Any component of GW, RZ, or LWU Zbudget → Spatial and Temporal Visualization

Python Library Accessing IWFM DLL

CALIFORNIA DEPARTMENT OF WATER RESOURCES
SUSTAINABLE GROUNDWATER MANAGEMENT OFFICE

Installation Tutorial API Reference

Search the docs ...

PyWFM Documentation

pywfm is a python package that exposes the functionality of the IWFM DLL

On this page

Overview

The pywfm library includes 3 main classes:

- IWFMModel
- IWFMBudget
- IWFMZBudget

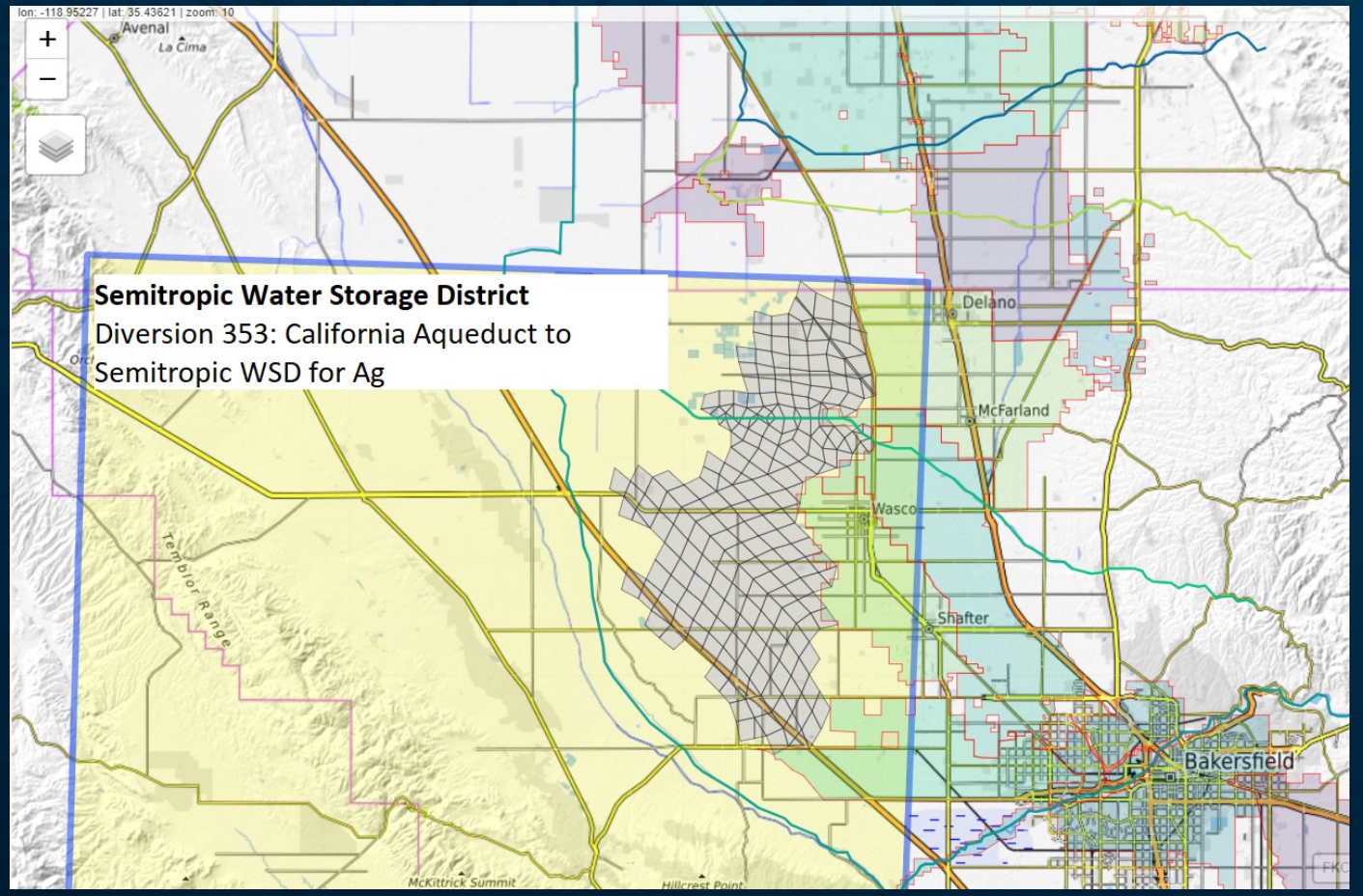
Each of these inherits from the IWFMMiscellaneous base class. Many of the methods in the IWFMMiscellaneous base class cannot be used on their own because the IWFMMiscellaneous class was designed without direct access to the IWFM DLL. Users can access all of this functionality from within the IWFMModel, IWFMBudget, and IWFMZBudget classes.

Design

The pywfm library wraps each of the IWFM DLL functions so that the user does not have to deal with the IWFM DLL syntax directly. Instead, users familiar with python can work with standard python objects such as strings, ints, floats, lists, and numpy arrays.

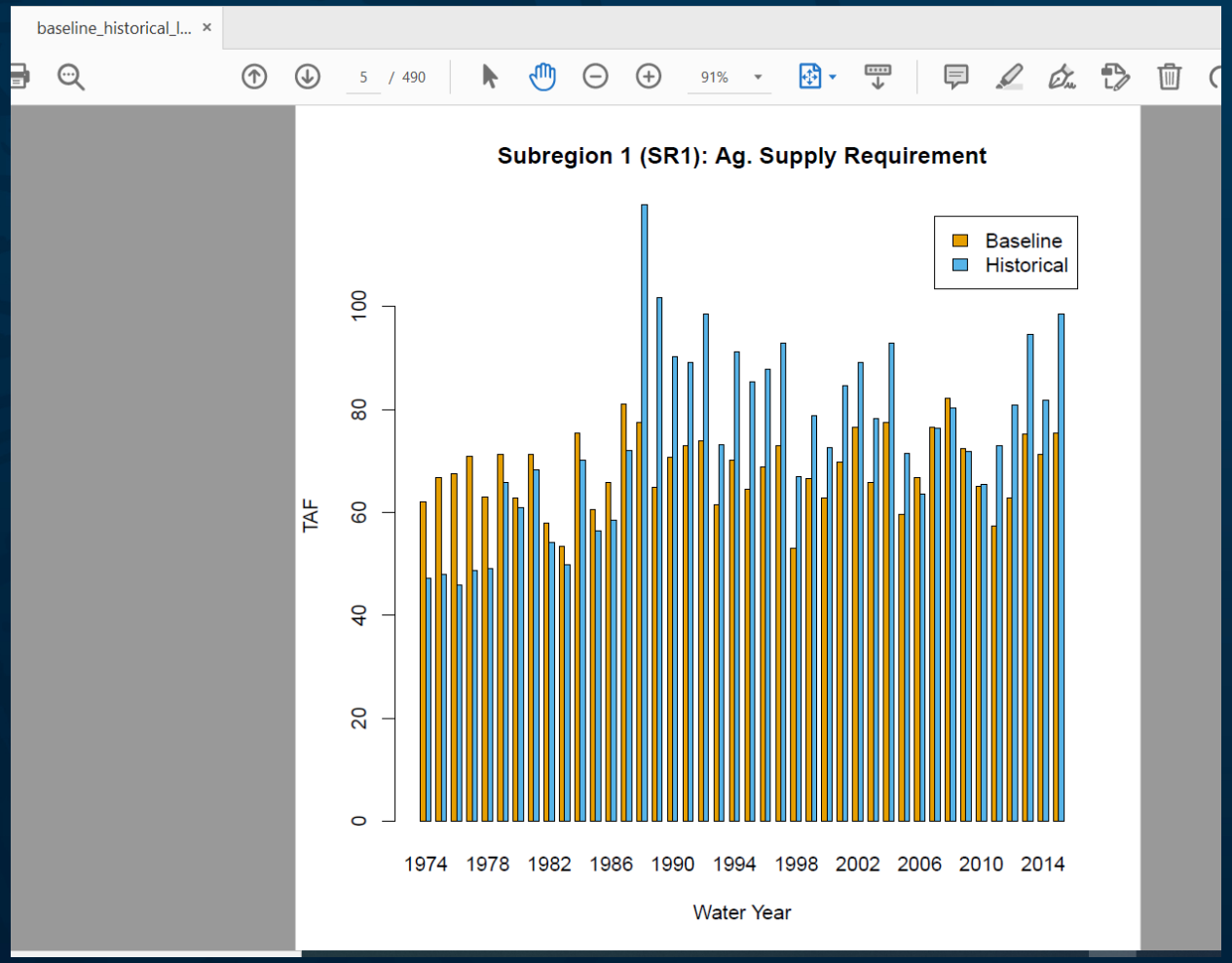
R-based Tools

- Calling PYWFM to read water budget and zonal water budget HDF files
- **Leaflet dynamic maps**



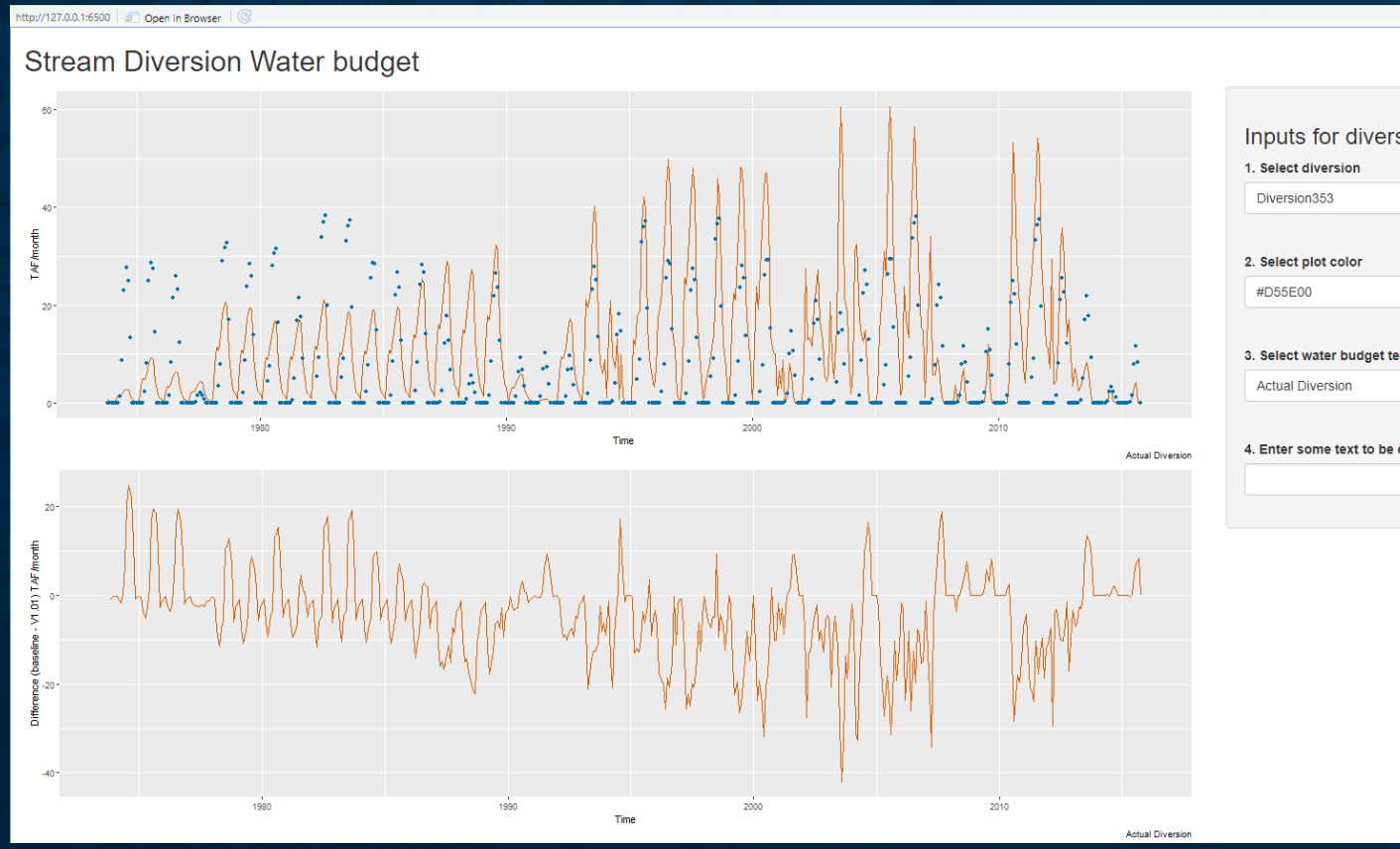
R-based Tools

- **Calling PYWFM to read water budget and zonal water budget HDF files**
  - R interface to Python package “reticulate”
  - R scripting for easy data import and visualization (creating hundreds of figures in PDF or PNG)



R-based Tools

- Calling PYWFM to read water budget and zonal water budget HDF files
  - R Shiny for Web-based interaction (see diversion comparison for historical and baseline scenarios example)

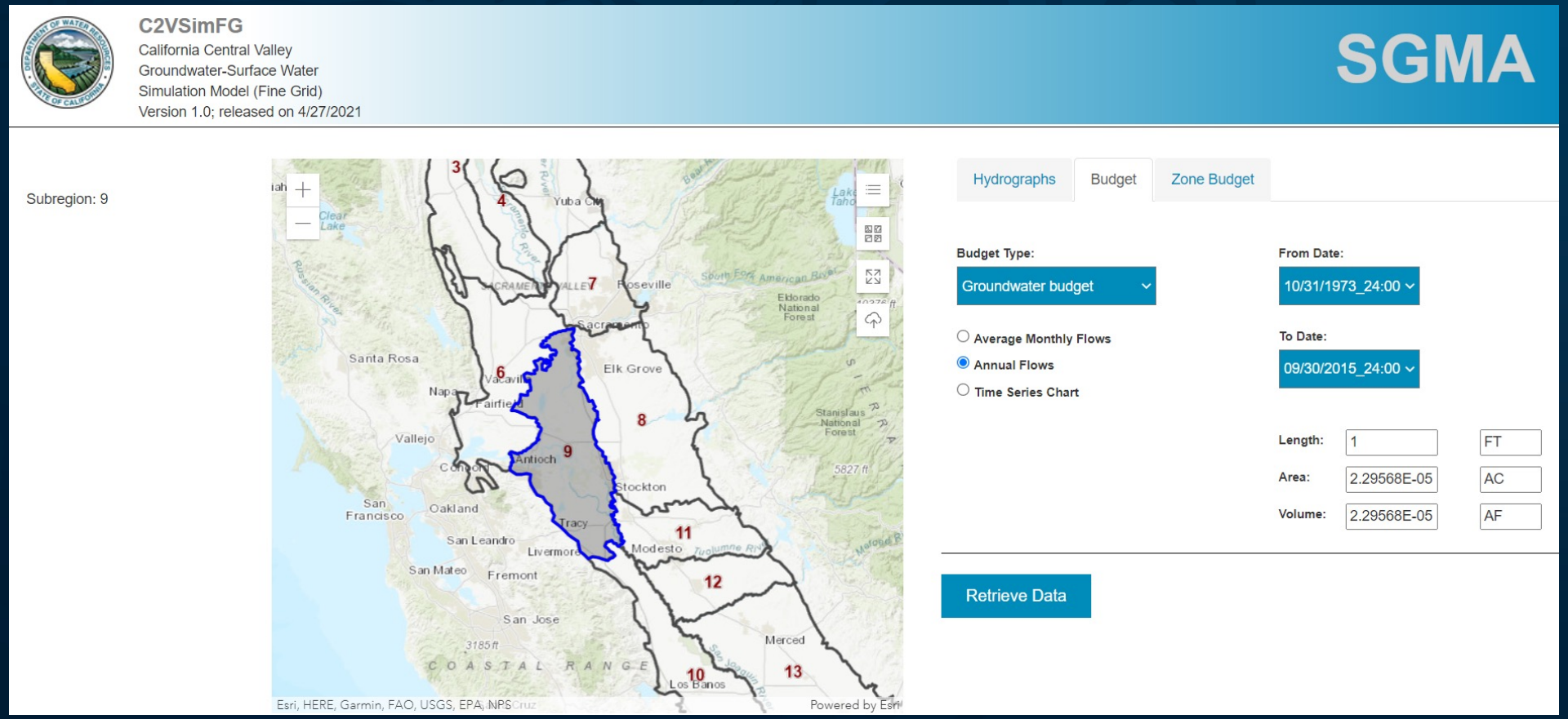


GIS and Web-based Tools

- C2VSimFG Web application
- New Watershed delineation tool
- IWFM soil builder

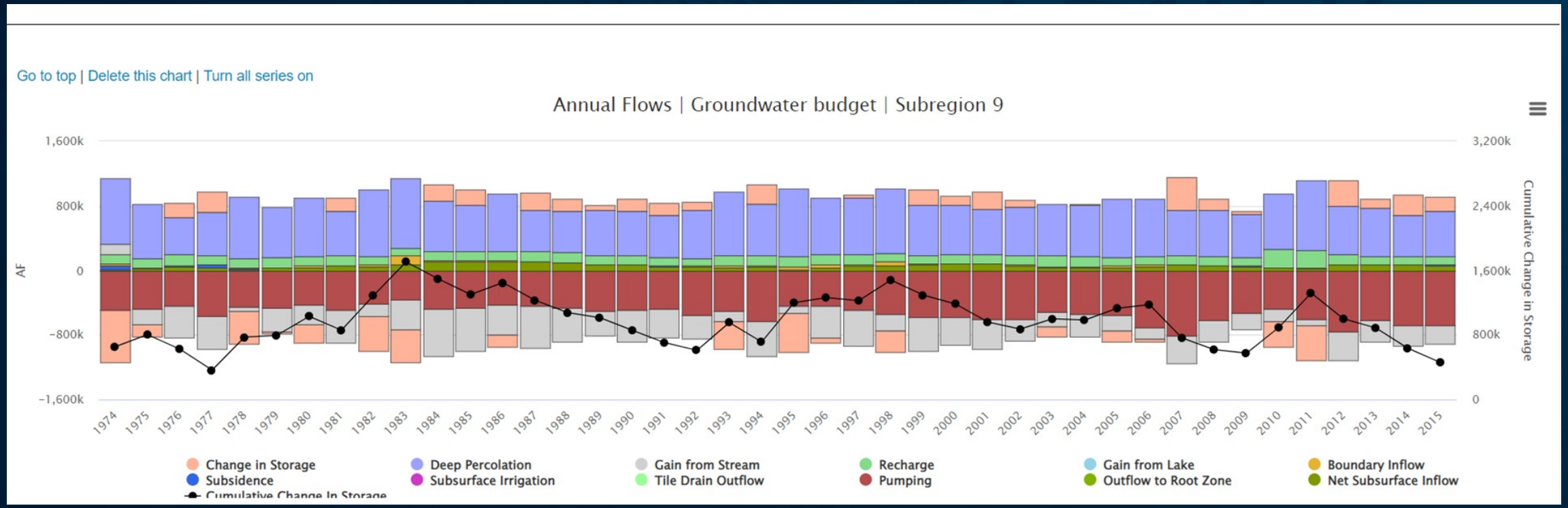
GIS and Web-based Tools

- Nearly ready to public release
- Zonal budget with uploaded user shape file



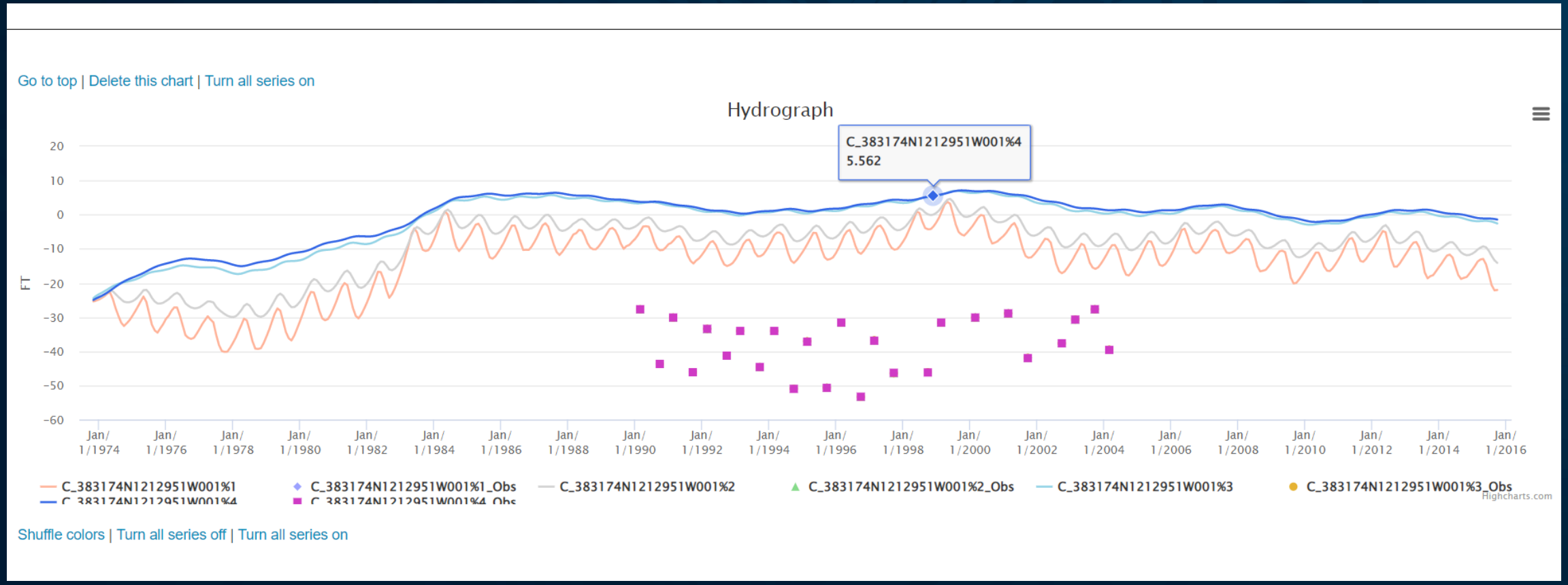
C2VSimFG Web application

- Retrieve and visualize model output data



C2VSimFG Web application

- Retrieve and visualize model output data



Conclusions and Next Steps

- DWR and Woodard & Curran are developing a collection of tools for C2VSimFG / IWFM data processing and visualization
- Tools use multiple platforms for different purposes and user abilities
- Public release and documentation pending

California Central Valley Groundwater-Surface Water Simulation Model – Fine Grid (C2VSimFG)

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