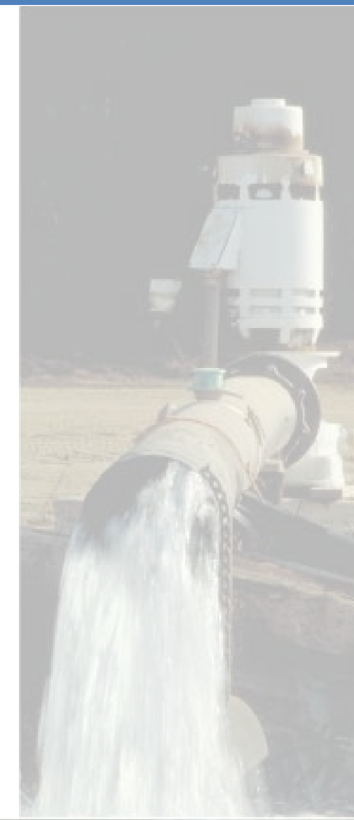

The California Central Valley Groundwater-Surface Water Simulation Model

Surface Water Processes

CWEMF C2VSim Workshop
January 23, 2013

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California Department of Water Resources, Sacramento, CA

Outline

IWFM Surface Water Process

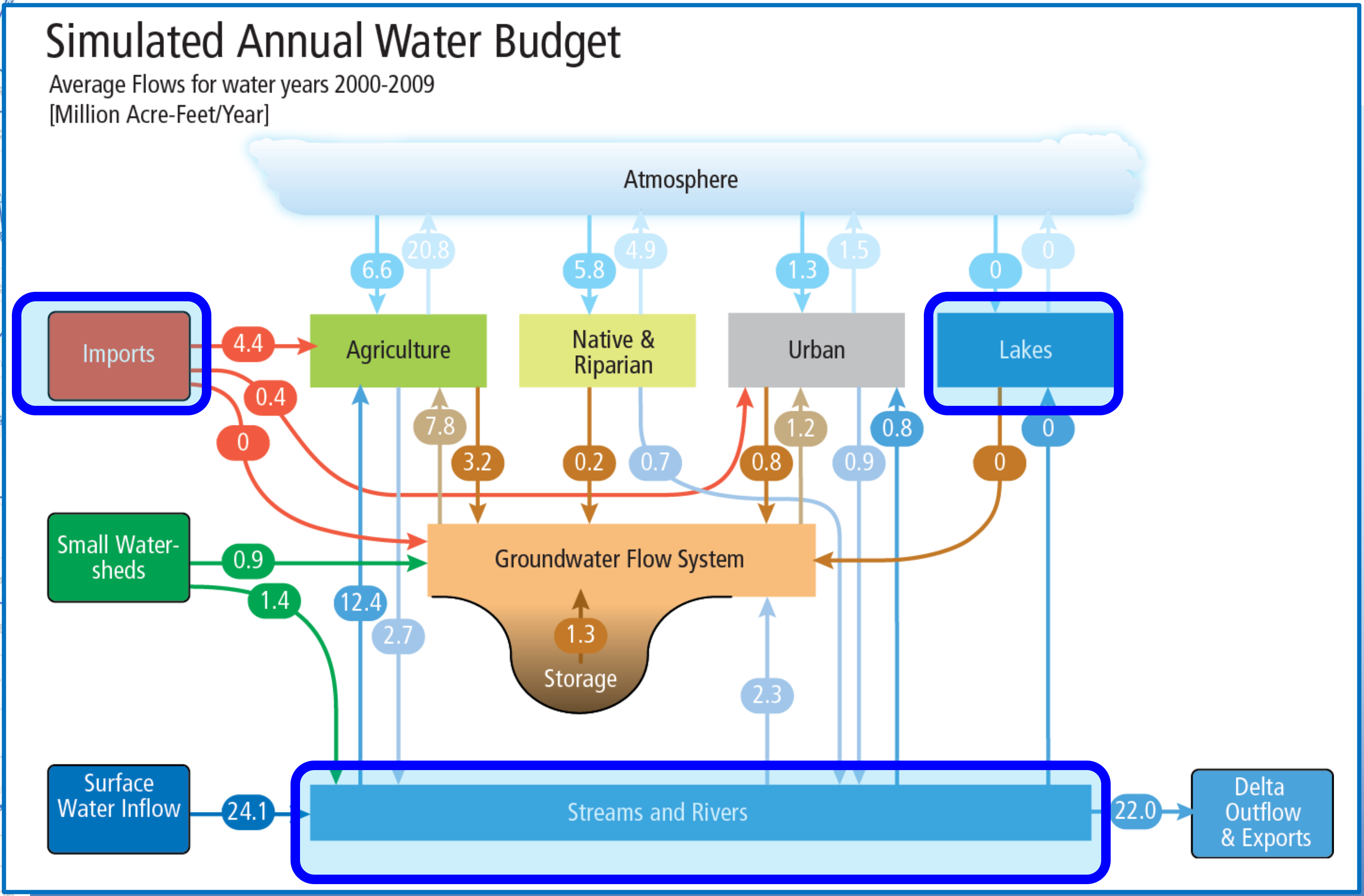
Stream Reach Budget

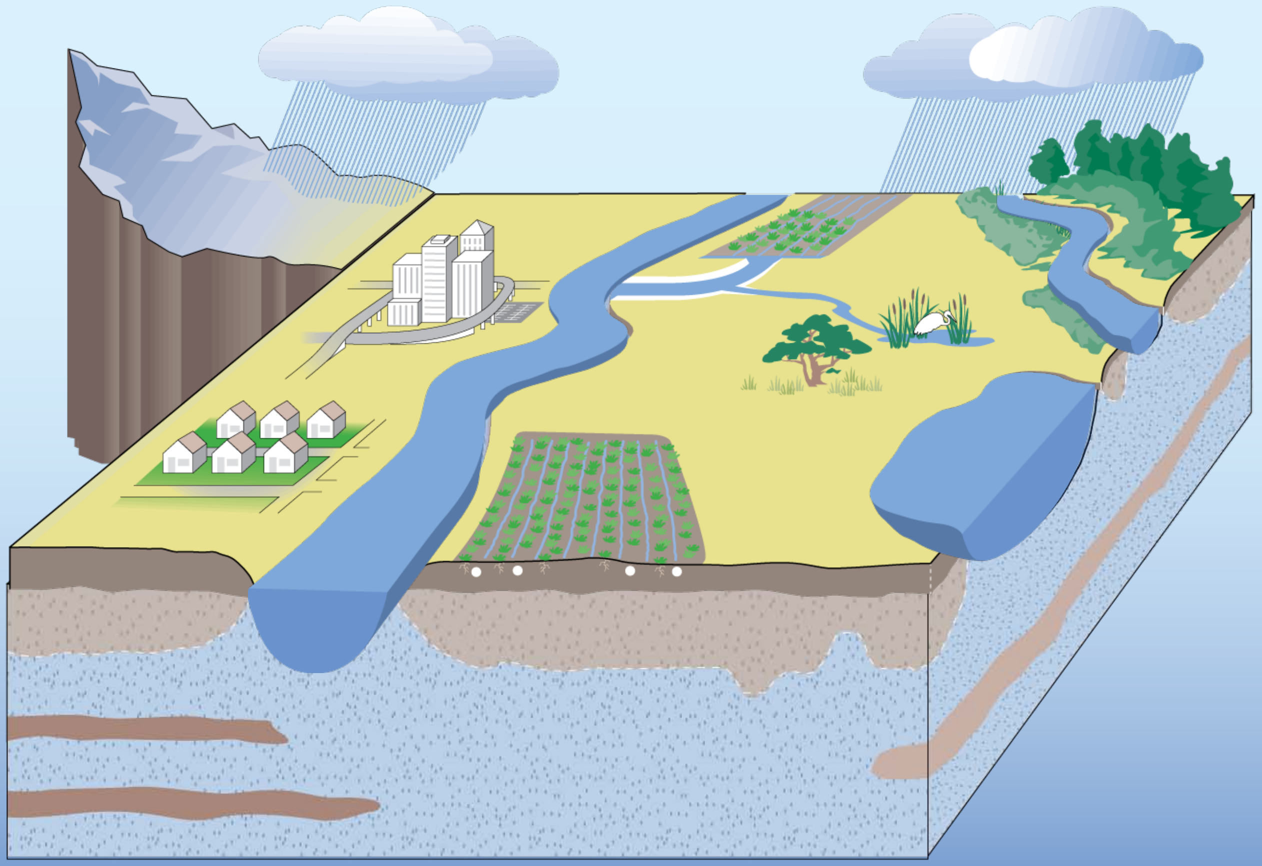
IWFM Small-Stream Watersheds Process

Small Watersheds Budget

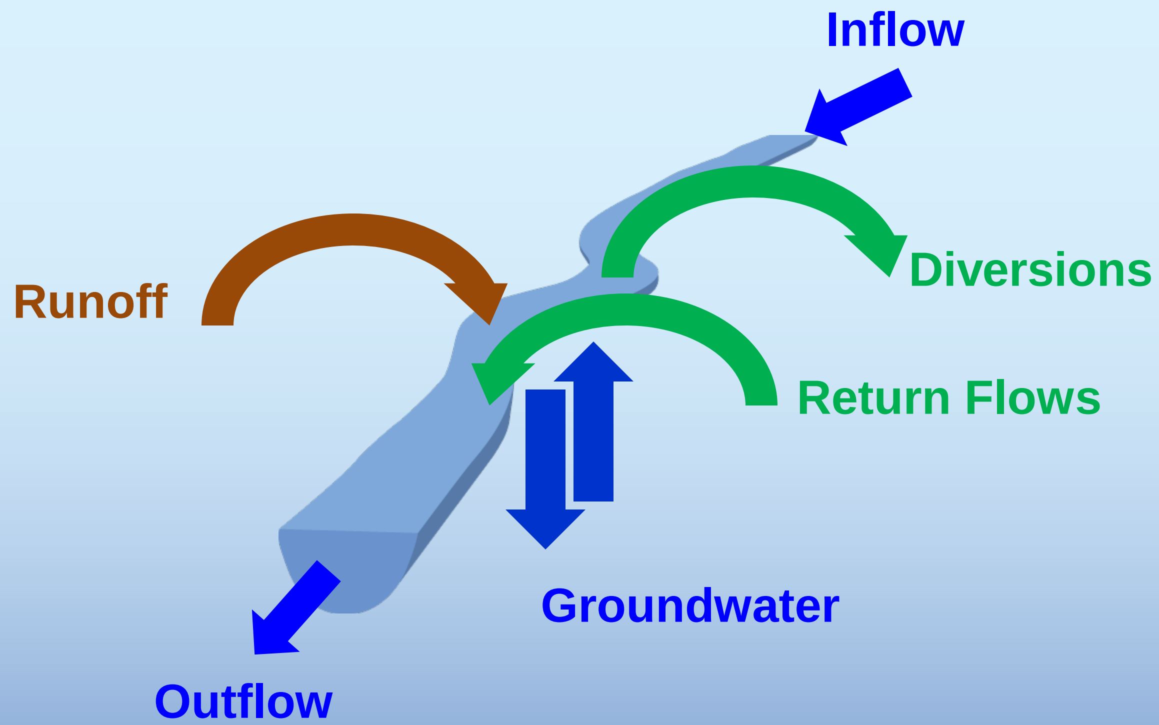
C2VSim Results

IWFM Surface Water Process

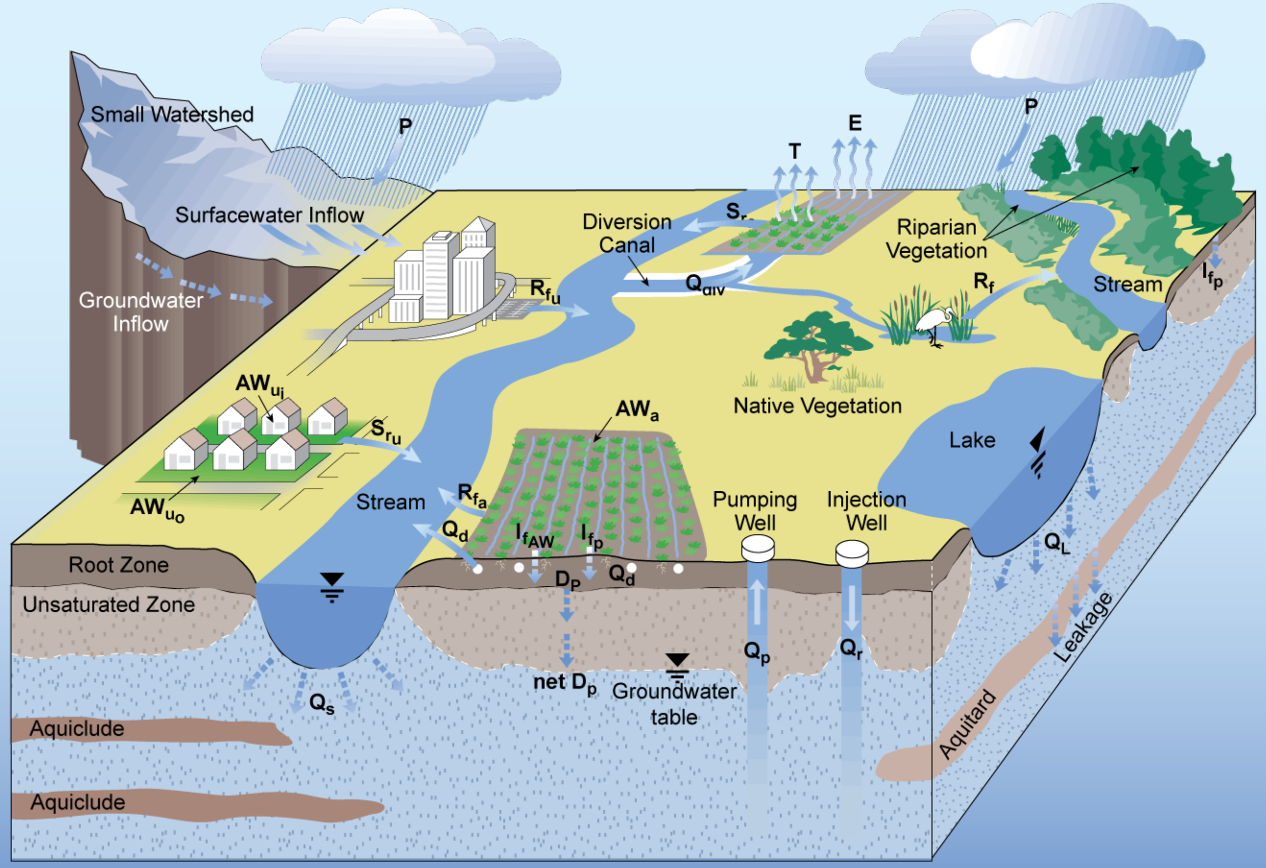




Surface Water Process

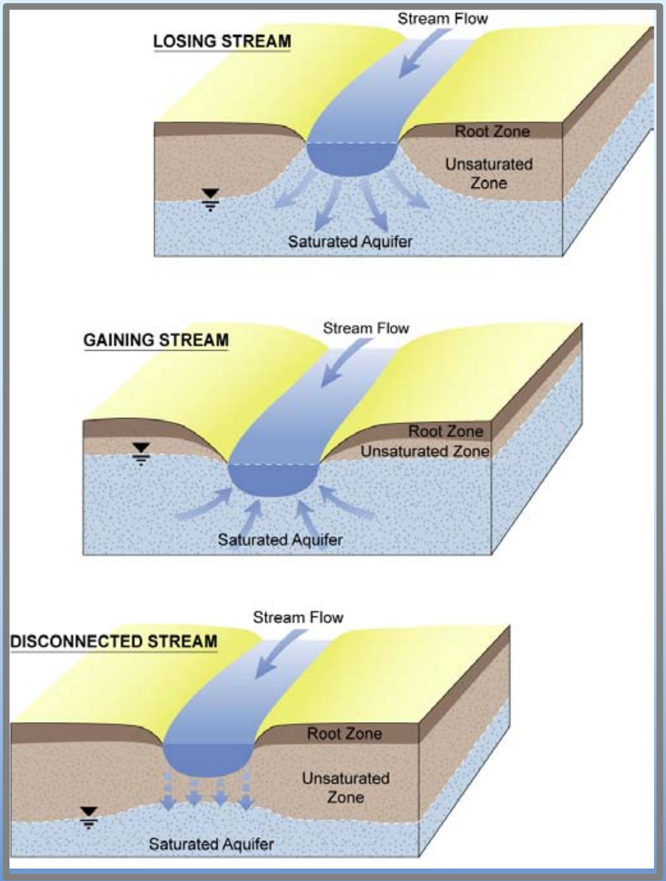


IWFM


Small Watershed
P
Surfacewater Inflow
Groundwater Inflow
R_{fu}
Diversion Canal
Q_{div}
T
E
P
Riparian Vegetation
R_f
Stream
I_{fp}
Native Vegetation
AW_{ui}
S_{ru}
AW_a
Lake
AW_{uo}
Stream
R_{fa}
Q_d
I_{fAW}
I_{fp}
D_p
Q_d
Pumping Well
Injection Well
Q_L
Root Zone
Unsaturated Zone
Q_p
Q_r
Leakage
net D_p
Groundwater table
Q_s
Aquiclude
Aquiclude
Aquitard

Stream Flow and Stream-Aquifer Interaction

- Assumption of zero storage at a stream node in computing stream flows; i.e. total inflow equals total outflow
- Fully coupled stream and groundwater conservation equations
- Simultaneous solution of stream and groundwater equations results in the computation of stream-aquifer interaction



Stream Flow

- Assumption of zero storage at a stream node

$$Q_s - Q_{sin} + Q_{sout} = 0$$

Q_s = stream flow, (L^3/T)

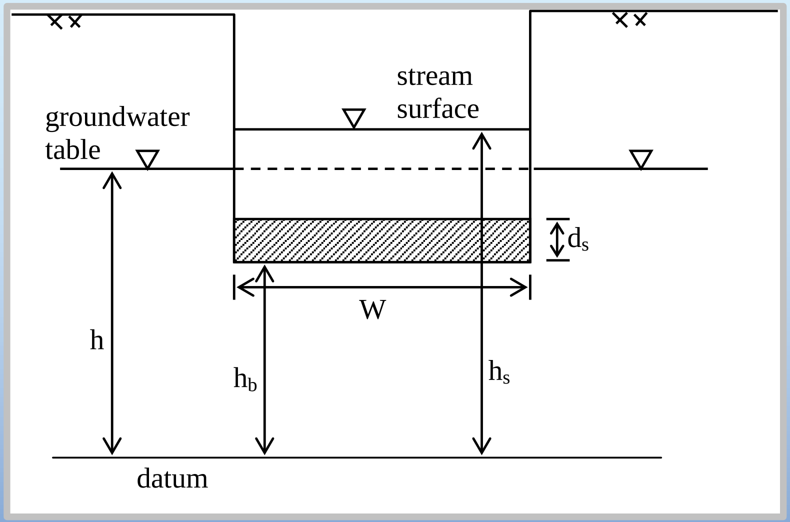
Q_{sin} = inflows into stream (flow from upstream nodes, return flow, rainfall runoff, tributary inflows, tile drain, lake outflow, bypass, user specified flows), (L^3/T)

Q_{sout} = outflows from stream (diversions, bypass flows, stream-aquifer interaction), (L^3/T)

- Assumption requires simulation time step to be large enough for stream flow to travel from upstream to downstream in a single time step

Stream-Groundwater Interaction

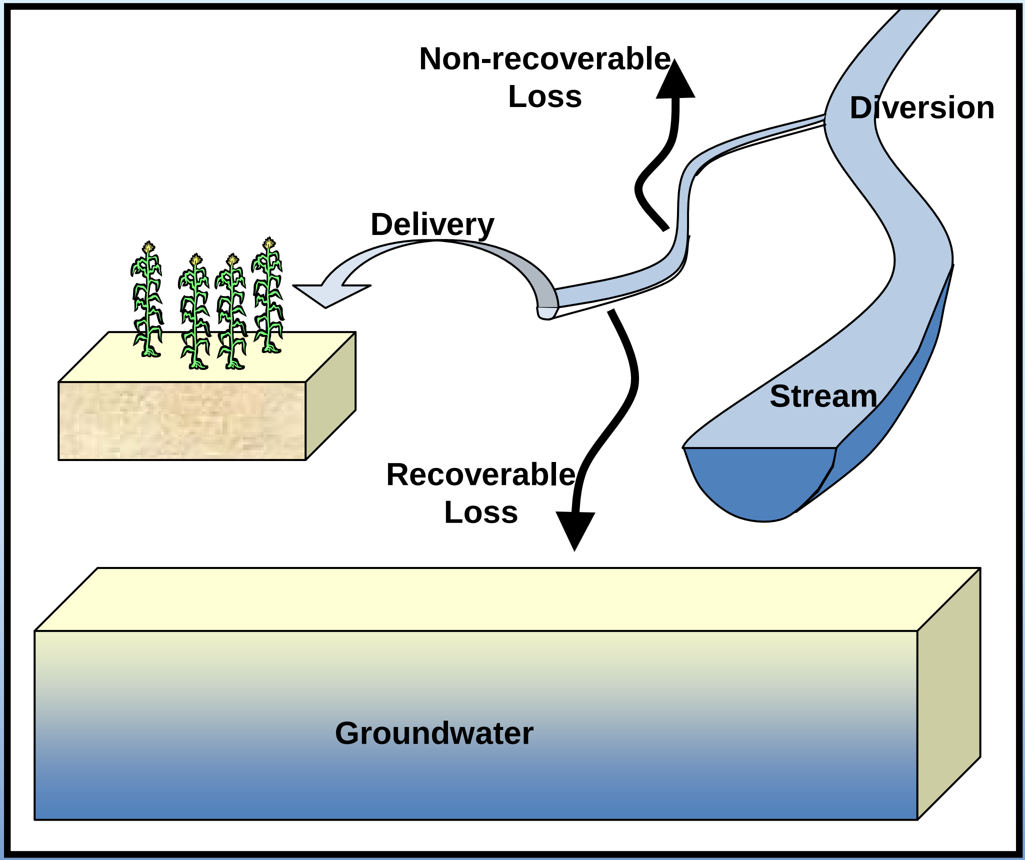
$$Q_{sint} = C_s \left[\max\left(h_s, h_b\right) - \max\left(h, h_b\right) \right] \quad ; \quad C_s = \frac{K_s}{d_s} LW$$



Q_{sint}	=	stream-aquifer interaction, (L^3/T)
h	=	groundwater head, (L)
h_s	=	stream surface elevation, (L)
h_b	=	stream bottom elevation, (L)
K_s	=	stream bed hydraulic conductivity, (L/T)
d_s	=	stream bed thickness, (L)
L	=	length of stream segment, (L)
W	=	channel width, (L)

Stream Diversions

- Used to meet agricultural and urban water demands
- User-specified fractions of diversion become recoverable (recharge to groundwater) and non-recoverable (evaporation) losses
- May be used to simulate spreading basins (100% recoverable and non-recoverable losses)



Lake-Groundwater Interaction

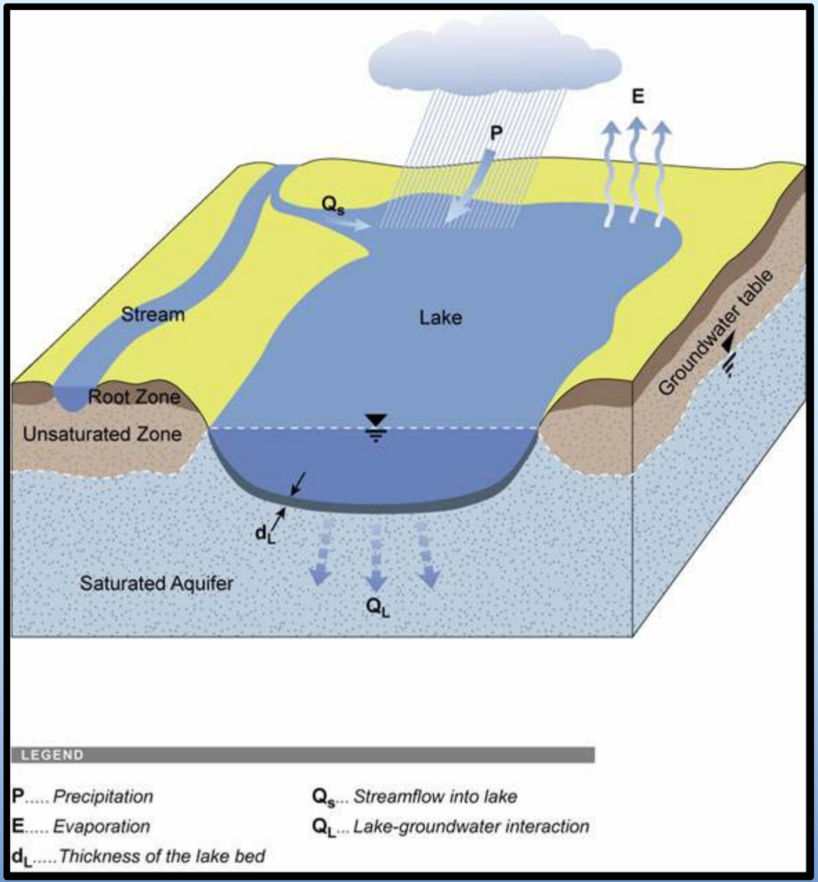
- One or more elements can be specified as lake elements
- Lakes are fully coupled with groundwater
- Lake storage is a function of precipitation, evaporation, inflows, lake-aquifer interaction and lake outflow

$$\frac{\Delta S_{lk}}{\Delta t} - Q_{lkin} + Q_{lkout} = 0$$

ΔS_{lk} = change in lake storage, (L^3)

Q_{lkin} = lake inflow (precipitation, inflows from streams and upstream lakes), (L^3/T)

Q_{lkout} = lake outflow (evaporation, lake spill, lake-aquifer interaction), (L^3/T)



Lake-Groundwater Interaction

$$Q_{lkint} = C_{lk}\left[\max\left(h_{lk}, h_{blk}\right) - \max\left(h, h_{blk}\right)\right] \;;\quad C_{lk} = \frac{K_{lk}}{d_{lk}} A_{lk}$$

Q_{lkint} = lake-aquifer interaction, (L^3/T)

h = groundwater head, (L)

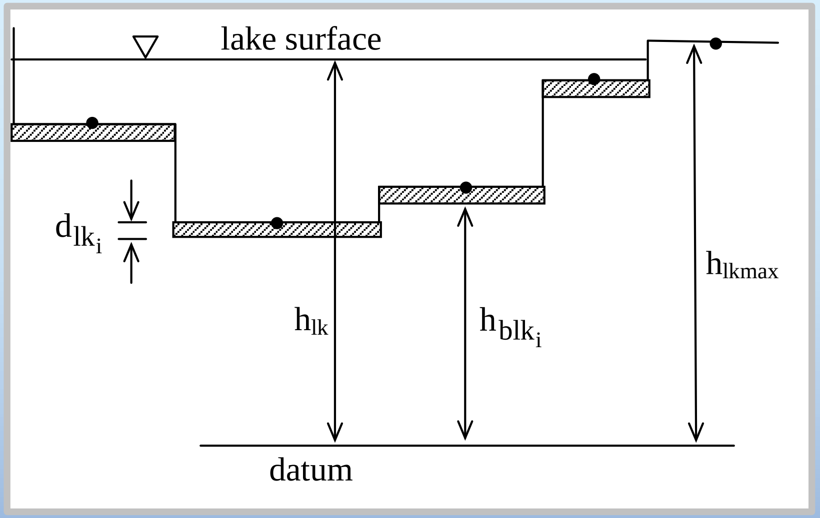
h_{lk} = lake surface elevation, (L)

h_{blk} = lake bottom elevation, (L)

K_{lk} = lake bed hydraulic conductivity, (L/T)

d_{lk} = lake bed thickness, (L)

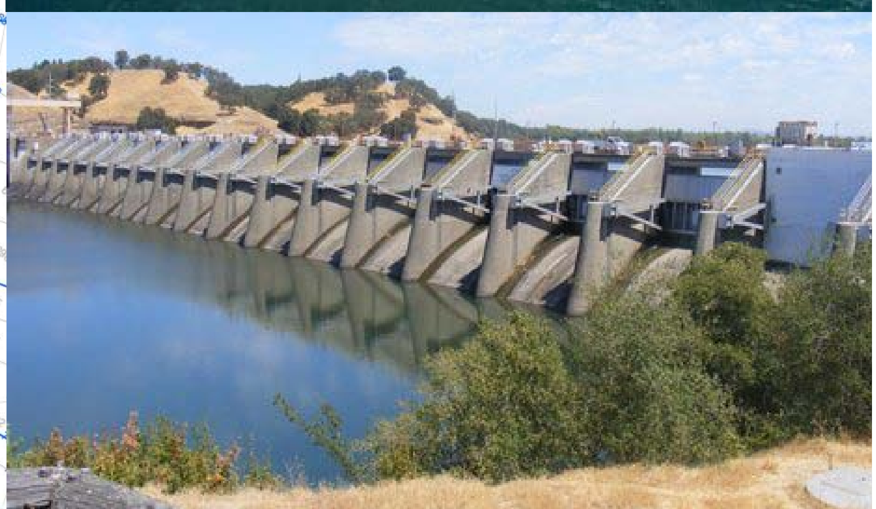
A_{lk} = area of lake, (L)

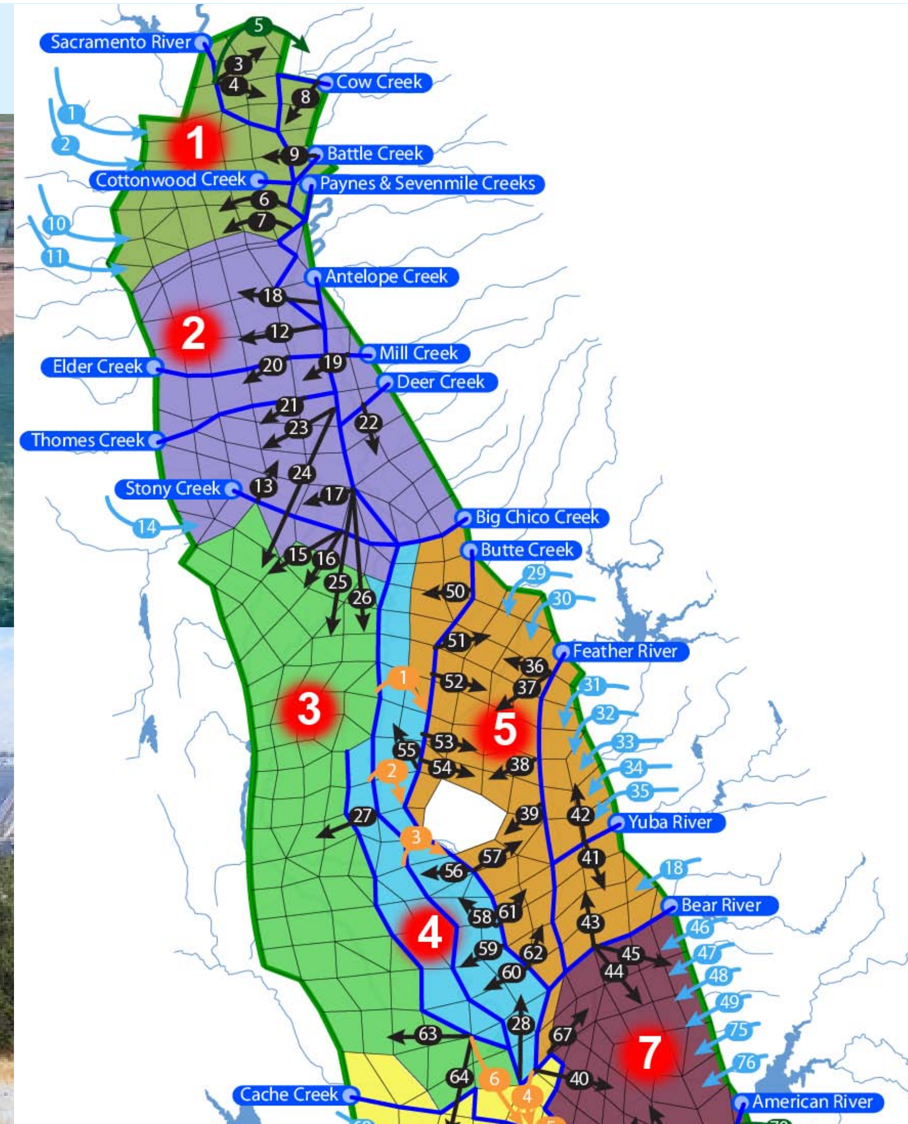


- Lake outflow is computed when lake surface elevation exceeds maximum lake elevation
- Lake outflow can be directed to a stream node or a downstream lake

Inflows

Monthly at 38 locations





Inflows File

```
C-------------------------------------------------------------------------------
C         VALUE                                        DESCRIPTION
C-------------------------------------------------------------------------------
          41                                           / NCOLSTRM
          43560000.0                                   / FACTSTRM  (TAF/mon --> ft^3/mon)
          1                                            / NSPSTRM
          0                                            / NFQSTRM
                                                       / DSSFL
C-------------------------------------------------------------------------------

C-------------------------------------------------------------------------------
C    IRST
C-------------------------------------------------------------------------------
     205                         / 1:     205   Sacramento River
     211                         / 2:     211   Cow Creek
     220                         / 3:     220   Battle Creek
     218                         / 4:     218   Cottonwood Creek
     225                         / 5:     225   Paynes and Sevenmile Creek
     233                         / 6:     233   Antelope Creek Group
     243                         / 7:     243   Mill Creek
     237                         / 8:     237   Elder Creek
     248                         / 9:     248   Thomes Creek
     256                         /10:     256   Deer Creek Group
     263                         /11:     263   Stony Creek
     269                         /12:     269   Big Chico Creek
     283                         /13:     283   Butte and Chico Creek
     341                         /14:     341   Feather River
     349                         /15:     349   Yuba River
     357                         /16:     357   Bear River
     390                         /17:     390   Cache Creek
     374                         /18:     374   American River
     400                         /19:     400   Putah Creek
     188                         /20:     188   Consumnes River
     182                         /21:     182   Dry Creek
     173                         /22:     173   Mokelumne River
     161                         /23:     161   Calaveras River
     146                         /24:     146   Stanislaus River
```

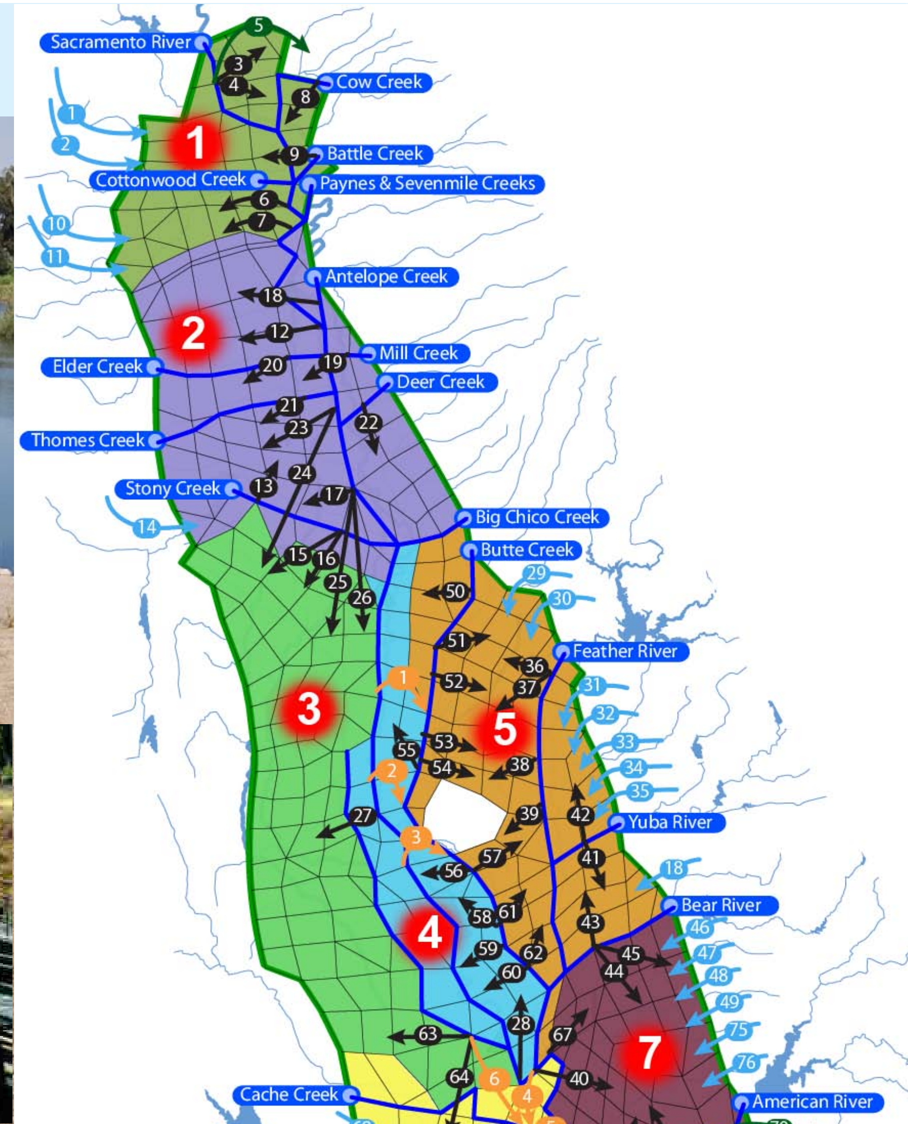
Inflows File

Sacramento River

```
C---------------------------------------------------------------------------------------------------
C   ITST      ASTRM(1)  ASTRM(2)  ASTRM(3) ...
C                     1       2       3       4       5       6       7       8       9       10      11      12      13      14      15
C---------------------------------------------------------------------------------------------------
10/31/1921_24:00      232.000 7.500   15.700  9.000   0.560   6.592   6.900   0.500   0.197   10.534  1.700   1.890   11.904  99.241  20.3
11/30/1921_24:00      237.000 22.500  19.500  17.900  1.030   6.180   6.400   1.000   1.077   11.626  1.000   2.640   11.904  97.051  27.0
12/31/1921_24:00      335.000 49.600  29.100  52.600  6.320   18.128  18.700  4.000   18.539  34.061  9.000   9.760   30.876  190.489 119.
01/31/1922_24:00      302.000 78.000  36.500  89.500  6.040   13.802  14.200  3.000   24.810  25.997  8.000   8.250   25.420  184.647 121.
02/28/1922_24:00      547.000 71.200  33.400  96.700  20.690  37.904  39.100  8.000   24.025  71.651  52.000  25.780  62.124  390.538 338.
03/31/1922_24:00      610.000 56.800  33.700  84.800  13.190  27.810  28.600  7.000   19.774  52.453  27.050  18.980  47.988  447.937 274.
04/30/1922_24:00      780.000 40.300  33.000  56.800  8.340   31.312  32.400  8.000   58.475  59.296  37.250  19.820  52.452  827.107 414.
05/31/1922_24:00      629.000 26.700  33.000  33.900  3.970   43.054  44.500  4.000   40.348  81.553  25.950  18.130  71.796  1469.554
06/30/1922_24:00      338.000 9.000   24.100  15.900  0.460   24.720  25.600  1.000   4.760   46.939  6.900   6.190   43.772  659.901 662.
07/31/1922_24:00      240.000 2.400   16.300  6.200   0.050   8.446   8.800   0.500   1.119   15.923  6.200   2.210   17.980  165.586 94.5
08/31/1922_24:00      214.000 1.600   13.000  4.700   0.040   5.974   6.100   0.500   0.118   11.411  5.200   1.670   11.532  106.558 31.7
09/30/1922_24:00      202.000 2.700   12.600  5.200   0.080   5.356   5.400   0.500   0.009   9.947   4.500   1.510   9.548   92.886  17.4
10/31/1922_24:00      232.000 6.100   12.700  7.300   0.410   7.210   6.200   0.500   1.119   10.370  2.050   1.790   10.912  101.455 22.1
11/30/1922_24:00      255.000 18.200  15.800  14.500  2.640   13.802  11.800  1.000   5.111   18.353  10.700  4.420   19.096  141.858 55.8
12/31/1922_24:00      336.000 40.100  23.500  42.600  15.350  44.702  38.300  4.000   28.856  63.273  36.000  19.500  56.792  383.129 308.
01/31/1923_24:00      399.000 63.100  29.500  72.400  7.940   24.308  20.700  4.000   28.383  34.265  32.000  11.070  33.976  310.205 172.
02/28/1923_24:00      312.000 57.600  27.000  78.200  3.170   13.802  11.800  3.000   15.395  19.379  15.000  5.780   21.452  201.433 113.
03/31/1923_24:00      333.000 46.000  27.300  68.600  1.810   13.802  11.800  3.000   10.207  19.546  9.050   5.840   21.452  303.257 144.
04/30/1923_24:00      590.000 32.600  26.700  45.900  1.970   29.664  25.300  5.000   35.369  41.644  27.750  8.420   39.308  563.802 407.
05/31/1923_24:00      357.000 21.600  26.700  27.400  0.310   14.832  12.600  2.000   11.228  20.700  6.550   2.510   23.932  385.773 411.
06/30/1923_24:00      267.000 7.300   19.500  12.800  0.110   9.064   7.800   1.000   5.724   11.023  5.500   1.260   16.492  181.547 200.
07/31/1923_24:00      214.000 1.900   13.100  5.100   0.030   6.180   5.200   0.500   0.563   8.594   5.850   1.030   10.416  115.966 72.4
08/31/1923_24:00      194.000 1.300   10.500  3.800   0.020   5.768   4.900   0.500   0.384   8.155   4.850   1.050   7.812   104.959 27.9
09/30/1923_24:00      196.000 2.200   10.200  4.200   0.060   6.592   5.700   0.500   0.248   8.524   3.800   1.140   8.556   94.433  23.7
10/31/1923_24:00      222.000 2.400   5.000   2.900   0.470   4.120   7.500   0.500   0.726   8.870   1.000   1.110   10.540  105.144 30.0
11/30/1923_24:00      206.000 7.200   6.200   5.700   1.030   3.502   6.400   0.500   0.976   8.218   1.000   1.450   9.052   96.516  21.1
12/31/1923_24:00      218.000 15.800  9.300   16.800  1.360   4.120   7.200   1.000   2.349   9.299   3.000   1.790   10.540  92.723  34.0
01/31/1924_24:00      226.000 24.900  11.700  28.600  1.800   4.326   7.900   2.000   3.671   10.084  3.000   2.110   12.028  100.655 40.3
02/29/1924_24:00      334.000 22.700  10.700  30.900  3.960   11.124  20.000  2.000   17.969  25.494  10.000  5.330   28.396  257.347 110.
03/31/1924_24:00      230.000 18.100  10.800  27.100  1.240   6.798   12.300  2.000   3.007   15.729  1.350   3.070   18.476  96.167  51.7
04/30/1924_24:00      210.000 12.900  10.500  18.100  0.460   5.562   9.900   1.000   2.696   12.535  2.400   1.740   16.988  127.696 95.8
05/31/1924_24:00      184.000 8.500   10.500  10.800  0.140   3.296   6.200   1.000   1.119   7.880   3.700   0.910   10.292  76.614  49.1
06/30/1924_24:00      169.000 2.900   7.700   5.100   0.060   2.884   5.100   0.500   0.084   6.529   2.000   0.520   6.448   55.000  11.3
07/31/1924_24:00      171.000 0.800   5.200   2.000   0.040   2.884   5.100   0.500   0.000   6.461   0.000   0.490   6.200   52.381  9.64
```

Diversions

Monthly at 246 locations



Surface Water Diversions

- Diversions and imports
  - "Diversions" means water taken from a simulated river node, subject to availability
  - "Imports" generally means water taken from a source that is not modeled
    - Reservoirs outside the model area serving canals
    - Reservoirs inside the model area that are not modeled (for example Black Butte and Camanche)
    - Complex delivery systems (California Aqueduct)

Surface Water Imports

- Friant-Kern Canal
  - Release water from Millerton Lake to canal
  - Deliveries to contractors along canal
  - Wasteway flows to river beds for delivery to down-stream customers
  - Flows to Kern River

Surface Water Imports

- Friant-Kern Canal deliveries simulated as:
  - Imports to individual subregions
  - Separate diversions for
    - Agricultural
    - Urban
    - Refuges
    - Spreading (Aquifer Storage)
  - Diversions to some districts via river channels
    - Inflow "FKC Wasteway Deliveries to Tule River"
    - Diversion from river

Surface Water Exports & Imports

- California Aqueduct
  - Pump water from Delta to San Luis Reservoir (outside model area)
  - Release water from San Luis Reservoir for use inside model area
  - Release water from San Luis Reservoir for use outside model area
- Simulated as exports and imports
  - Too complex to incorporate in a regional model

Diversion Specification

Diversion source and destination

```
C   NRDV;    Number of surface water diversions included in the model.
C-------------------------------------------------------------------------------
C   VALUE                        DESCRIPTION
C-------------------------------------------------------------------------------
    246                          / NRDV
C-------------------------------------------------------------------------------
C
C   The following lists the specifications for each surface water diversion
C   (skip if no diversions are modeled, i.e. NRDV = 0)
C
C   ID      ; Surface water diversion identification number
C   IRDV    ; Stream node from where the diversion takes place. Enter '0' if the stream node is outside the model area.
C   ICDVMAX ; Maximum diversion amount - this number corresponds to the  appropriate data column in the diversion data file Unit 26
C   FDVMAX  ; Fraction of data value specified in column ICDVMAX to be used as maximum diversion amount
C   ICOLRL  ; Recoverable loss -  this number corresponds to the appropriate data column in the diversion data file Unit 26
C   FRACRL  ; Relative proportion of the data value that is specified by ICOLRL to be used as recoverable loss
C   ICOLNL  ; Non-recoverable loss - this number corresponds to the appropriate data column in the diversion data file Unit 26
C   FRACNL  ; Relative proportion of the data value that is specified by ICOLNL to be used as non-recoverable loss
C   NDLDV   ; Number  of sub-regions to which diverted surface water is delivered
C   IRGDL   ; Sub-region number to which the delivery is made (1...NDLDV)
C   ICOLDL  ; Delivery to sub-region IRGDL - this number corresponds to the appropriate data column in the diversion data file Unit 26
C   FRACDL  ; Relative proportion of the data value that is specified by ICOLDL to be used as delivery to subregion IRGDL
C   ICFSIRIG; Fraction of the delivery that is used for irrigation purposes - this number corresponds to the appropriate data column in the
C              irrigation fraction data file Unit 27 (remaining amount will be used to supply the user specified urban demand)
C   ICADJ   ; Supply adjustment specification - this number corresponds to the appropriate data column in the supply adjustment
C              specifications data file Unit 12
C
C-----------------------------------------------------------------------------------------------------------------------
C Description
C ID    IRDV    ICDVMAX FDVMAX  ICOLRL  FRACRL  ICOLNL  FRACNL  NDLDV   IRGDL   ICOLDL  FRACDL  ICFSIRIG        ICADJ
C-----------------------------------------------------------------------------------------------------------------------
C
C  Whiskeytown and Shasta imports for SR1 Ag
C
1      0      265     1       1       0.03    1       0.01    1       1       1       0.96    23      1
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Whiskeytown and Shasta imports for SR1 M&I
C
2      0      265     1       2       0.03    2       0.01    1       1       2       0.96    22      2
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 Ag
C
3      206    265     1       3       0.03    3       0.02    1       1       3       0.95    23      3
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 M&I
C
4      206    265     1       4       0.03    4       0.01    1       1       4       0.96    22      4
C
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for Export
```

Source River Node (0 = import)

Allocation to losses and delivery

Destination subregion

Land use (23 = Ag, 22 = urban)

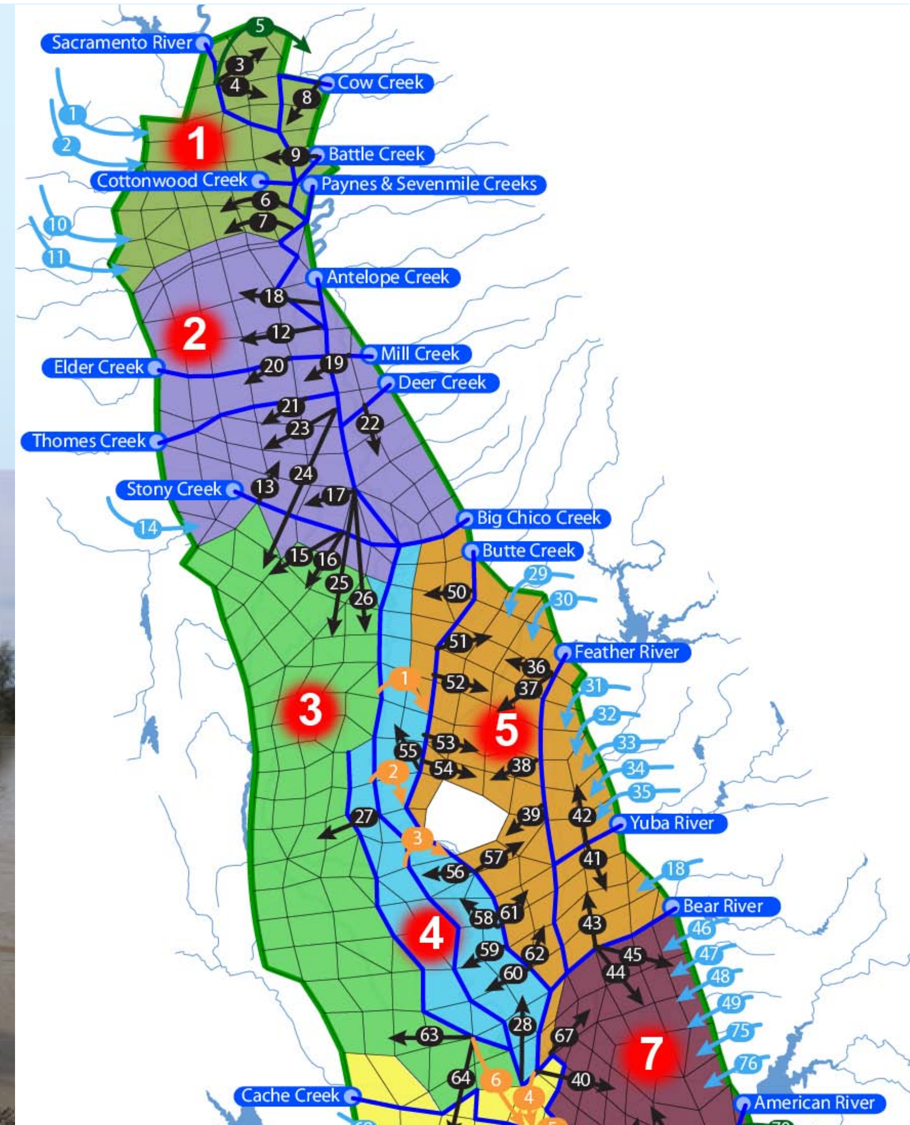
Diversion Specification

Recharge area for recoverable losses

```
C===========================================================================================================================
C
C                  Recharge zone for each diversion point
C        (Skip if no diversions are being modeled, i.e. NRDV = 0)
C
C   ID    ;  Recharge zone identification number (*Note* Recharge zone ID's should match river diversion ID numbers)
C   NERELS;  Total number of elements through which recharge occurs
C   IERELS;  Element number through which recharge occurs
C   FERELS;  Relative proportion of the recoverable loss to be applied to
C               element IERELS as recharge
C
C-------------------------------------------------------------------------------
C    ID         NERELS      IERELS      FERELS
C-------------------------------------------------------------------------------
C
C  Whiskeytown and Shasta imports for SR1 Ag
C
     1            1           12        1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Whiskeytown and Shasta imports for SR1 M&I
C
     2            1           12        1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 Ag
C
     3            2           2         1
                              3         1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for SR1 M&I
C
     4            2           2         1
                              3         1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River to Bella Vista conduit for Export
C
     5            2           5         1
                              8         1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River Keswick to Red Bluff for SR1 Ag
C
     6            9           5         1
                              8         1
                              13        1
                              14        1
                              15        1
                              19        1
                              20        1
                              26        1
                              27        1
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C  Sacramento River Keswick to Red Bluff for SR1 M&I
C
     7            9           5         1
```

Bypasses

- Flood control
- Kings River bifurcation
- ASR programs



Bypass Specification

Source and destination river nodes

```
C*******************************************************************************
C
C                 Bypass Configuration Specifications
C
C   NDIVS;  Number of bypasses
C   FACTX;  Conversion factor for DIVX - It is used to convert only the spatial component of the unit;
C   TUNITX; Time unit of stream flow.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C   FACTY;  Conversion factor for DIVY - It is used to convert only the spatial component of the unit;
C   TUNITX; Time unit of diversion.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C
C-------------------------------------------------------------------------------
C   VALUE                       DESCRIPTION
C-------------------------------------------------------------------------------
     12                         / NDIVS
     60                         / FACTX       values in CFS * 60 -> CFM
     1min                       / TUNITX
     60                         / FACTY       values in CFS * 60 -> CFM
     1min                       / TUNITY
C-------------------------------------------------------------------------------------------------------------
C
C   ID   ;  Bypass identification number
C   IA   ;  Stream node number where bypass is exported
C   IDIVT;  Stream node number where bypass is imported
C   IDIVC;  If positive, IDIVC is the column number in the diversion data file Unit 26 for bypass flow
C           If negative, IDIVC is the number of points in the diversion rating table
C   DIVRL;  Fraction of the diversion assigned as recoverable loss
C   DIVNL;  Fraction of the diversion assigned as non-recoverable loss
C   DIVX ;  Stream flow available at stream node IA; [L^3/T]
C   DIVY ;  Diversion amount corresponding to DIVX; [L^3/T]
C
C  ID   IA  IDIVT   IDIVC   DIVRL  DIVNL
C                           DIVX   DIVY ( this rating table should follow if IDIVC < 0 )
C-------------------------------------------------------------------------------------------------------------
C Bypass 1 - Moulton Weir spill to Butte Basin
C
   1   280    290   251      0.        0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 2 - Colusa Weir spill to Butte Basin
C
   2   282    291   252      0.        0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 3 - Tisdale Weir near Grimes
C
   3   297    337   253      0.        0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 4 - Freemont Weir spill to Yolo Bypass
C
   4   367    396   254      0.        0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 5 - Sacramento Weir spill to Yolo Bypass
C
   5   372    397   255      0.        0.
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
```

Bypass Specification

Recharge area for recoverable losses

```
C==========================================================================================================================
C
C               Seepage locations for bypass canals
C
C      The following information specifies the recharge zone for each bypass.
C      (Skip if no bypass is being modeled, i.e. NDIVS = 0)
C
C   ID    ;  Recharge zone identification number (*Note* Recharge zone ID's should match bypass ID numbers)
C   NERELS;  Total number of elements through which recharge occurs
C   IERELS;  Element number through which recharge occurs
C              (If bypass to lake elements, provide negative sequential lake number, as in the LAKE input data file)
C   FERELS;  Relative proportion of the recoverable loss to be applied to element IERELS as recharge.
C
C-------------------------------------------------------------------------------
C    ID          NERELS      IERELS     FERELS
C-------------------------------------------------------------------------------
C Bypass 1 - Moulton Weir spill to Butte Basin
C            All losses go outside the model (losses = 0)
C
   1              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 2 - Colusa Weir spill to Butte Basin
C            All losses go outside the model (losses = 0)
C
   2              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 3 - Tisdale Weir to Yolo Bypass
C            All losses go outside the model (losses = 0)
C
   3              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 4 - Freemont Weir to Yolo Bypass
C            All losses go outside the model (losses = 0)
C
   4              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 5 - Sacramento Weir to Yolo Bypass
C            All losses go outside the model (losses = 0)
C
   5              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 6 - Knights Landing Ridge Cut flood flow to Yolo Bypass
C            All losses go outside the model (losses = 0)
C
   6              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 7 - Kings River to Fresno Slough
C            All losses go outside the model (losses = 0)
C
   7              0             0         0
C - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
C Bypass 8 - End of Kaweah River to be spread in Kaweah River Fan as recharge
C -- Aquifer Storage Program - no observed flow past this stream node
```

River Parameters

```
C*****************************************************************************************************************
C                        STREAM BED PARAMETERS
C
C      The following lists the parameters to model streams.
C      *Note* Skip data input if no streams are modeled
C
C    FACTK ;   Conversion factor for stream bed conductivity - It is used to convert only the spatial component of the unit;
C    TUNITK;   Time unit of conductivity.  This should be one of the units
C               recognized by HEC-DSS that are listed in the Main Control File.
C    FACTL ;   Conversion factor for stream bed thickness and wetted perimeter
C    IR    ;   Stream node number
C    CSTRM ;   Hydraulic conductivity of stream bed; [L/T]
C    DSTRM ;   Thickness of stream bed; [L]
C    WETPR ;   Wetted perimeter; [L]
C
C-------------------------------------------------------------------------------
C    VALUE                      DESCRIPTION
C-------------------------------------------------------------------------------
     1.0                        / FACTK
     1mon                       / TUNITK
     1.0                        / FACTL
C-------------------------------------------------------------------------------
C     IR        CSTRM          DSTRM         WETPR          River Name (Optional)
C-------------------------------------------------------------------------------
      1      3.91109000    1.          300.0       REACH  1   -    KERN RIVER
      2      7.64316000    1.          300.0
      3      4.27314000    1.          300.0
      4      14.6494000    1.          300.0
      5      3.44887000    1.          300.0
      6      2.01865000    1.          300.0
      7      1.63871000    1.          300.0
      8      2.23515000    1.          300.0
      9      .920359000    1.          300.0
     10      1.84849000    1.          420.0       REACH  6   -    TULE RIVER
     11      14.1967000    1.          420.0
     12      2.54948000    1.          420.0
     13      1.44002000    1.          420.0
     14      .928433000    1.          420.0
     15      1.47745000    1.          420.0
     16      1.23984000    1.          420.0
     17      1.04805000    1.          420.0
     18      6.85300E-4    1.          420.0       REACH  6a   -    TULE RIVER(ZERO)
     19      8.68300E-4    1.          420.0
     20      8.39200E-4    1.          420.0
     21      8.15800E-4    1.          420.0
     22      8.14200E-4    1.          420.0
     23      .673012000    1.          475.0       REACH  2   -    KINGS RIVER
     24      .542923000    1.          475.0
     25      .478602000    1.          475.0
     26      .376210000    1.          475.0
     27      .337160000    1.          475.0
     28      .473797000    1.          475.0
     29      .644172000    1.          475.0
```

Lake Parameters

```
C*******************************************************************************
C                            LAKE PARAMETERS
C
C     The parameters required to model lakes are listed below.
C     *Note* Skip data input if no lakes are modeled
C
C   FACTK  :   Conversion factor for lake bed hydraulic conductivity
C   TUNITK :   Time unit of hydraulic conductivity.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C   FACTL  :   Conversion factor for thickness of lake bed
C   IL     :   Lake number
C   CLAKE  :   Hydraulic conductivity of the lake bed; [L/T]
C   DLAKE  :   Thickness of the lake bed; [L]
C   ICHLMAX:   Column of max-lake file that gives maximum lake elevation
C
C-------------------------------------------------------------------------------
C   VALUE                 DESCRIPTION
C-------------------------------------------------------------------------------
    1.0                   / FACTK
    1mon                  / TUNITK
    1.0                   / FACTL
C-------------------------------------------------------------------------------
C   IL       CLAKE      DLAKE     ICHLMAX    Lake Name (Optional)
C--------------------------------------------------------------------------------
    1        20.0       1.00000    1         Buena Vista Lake Bed
    2        20.0       1.00000    2         Tulare Lake Bed
C*******************************************************************************
```

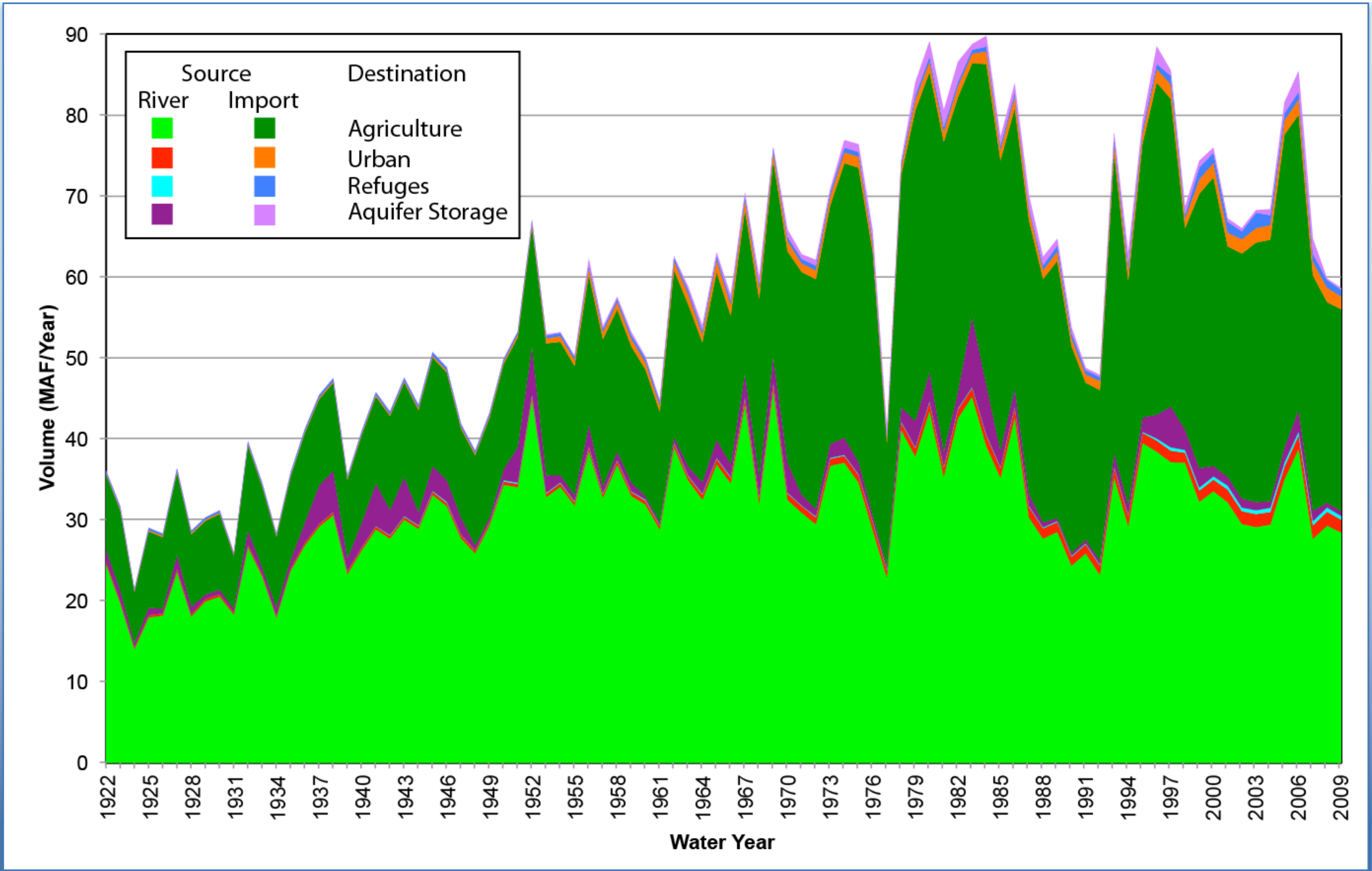
Stream Reach Budget

Column	Flow	08/31/2004	Process
Upstream Inflow (+)	IN	2,944	
Downstream Outflow (-)	OUT	781	
Tributary Inflow (+)	IN	0	SWS
Tile Drain (+)	IN	0	GW
Runoff (+)	IN	0	LS
Return Flow (+)	IN	2	LS
Gain from Groundwater (+)	+/-	-1,593	GW
Gain from Lake (+)	+/-	0	
Diversion (-)	OUT	0	LS
By-pass Flow (-)	OUT	573	
Discrepancy (=)		0.00	
Diversion Shortage		0	

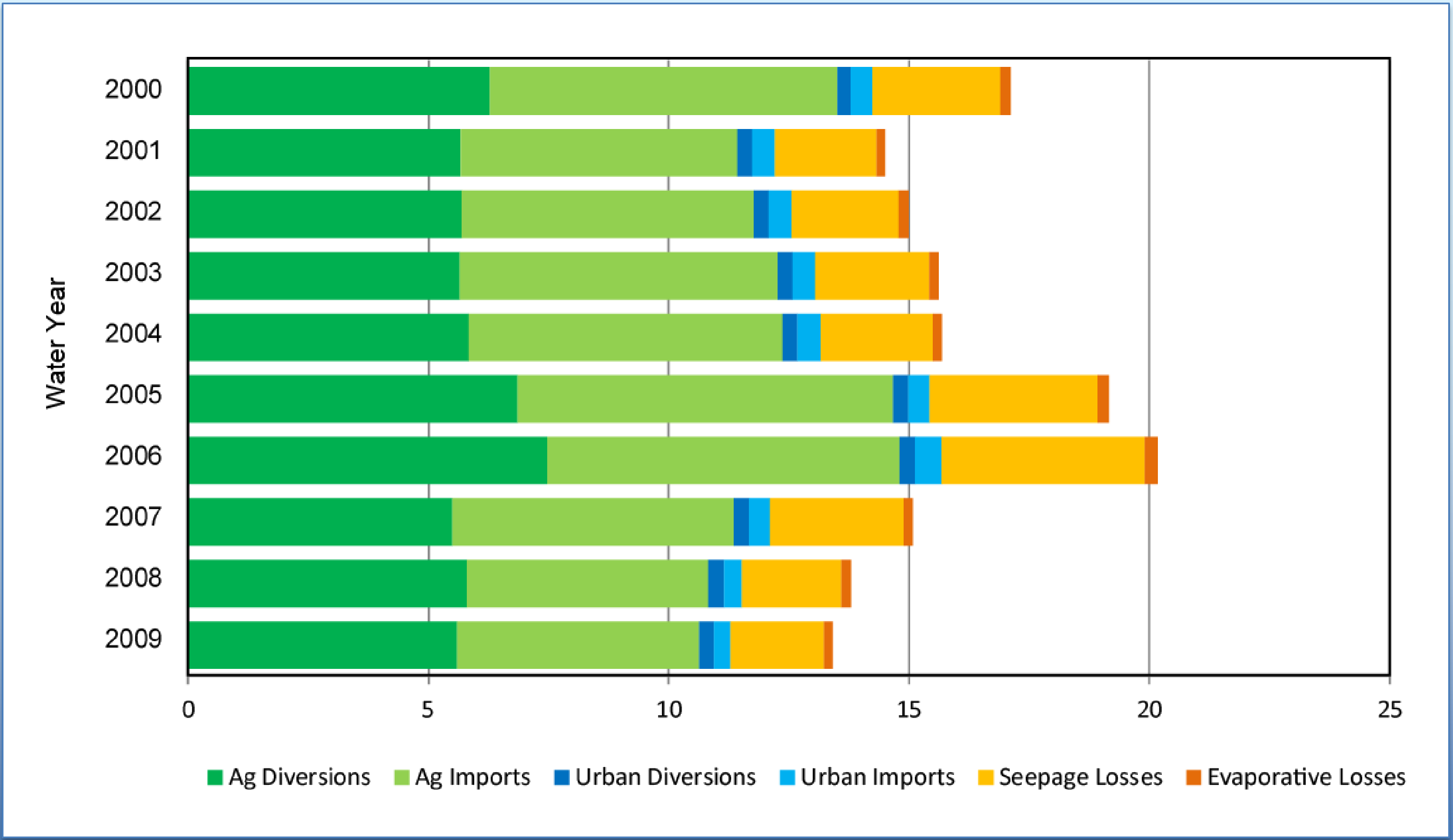
Lake Budget

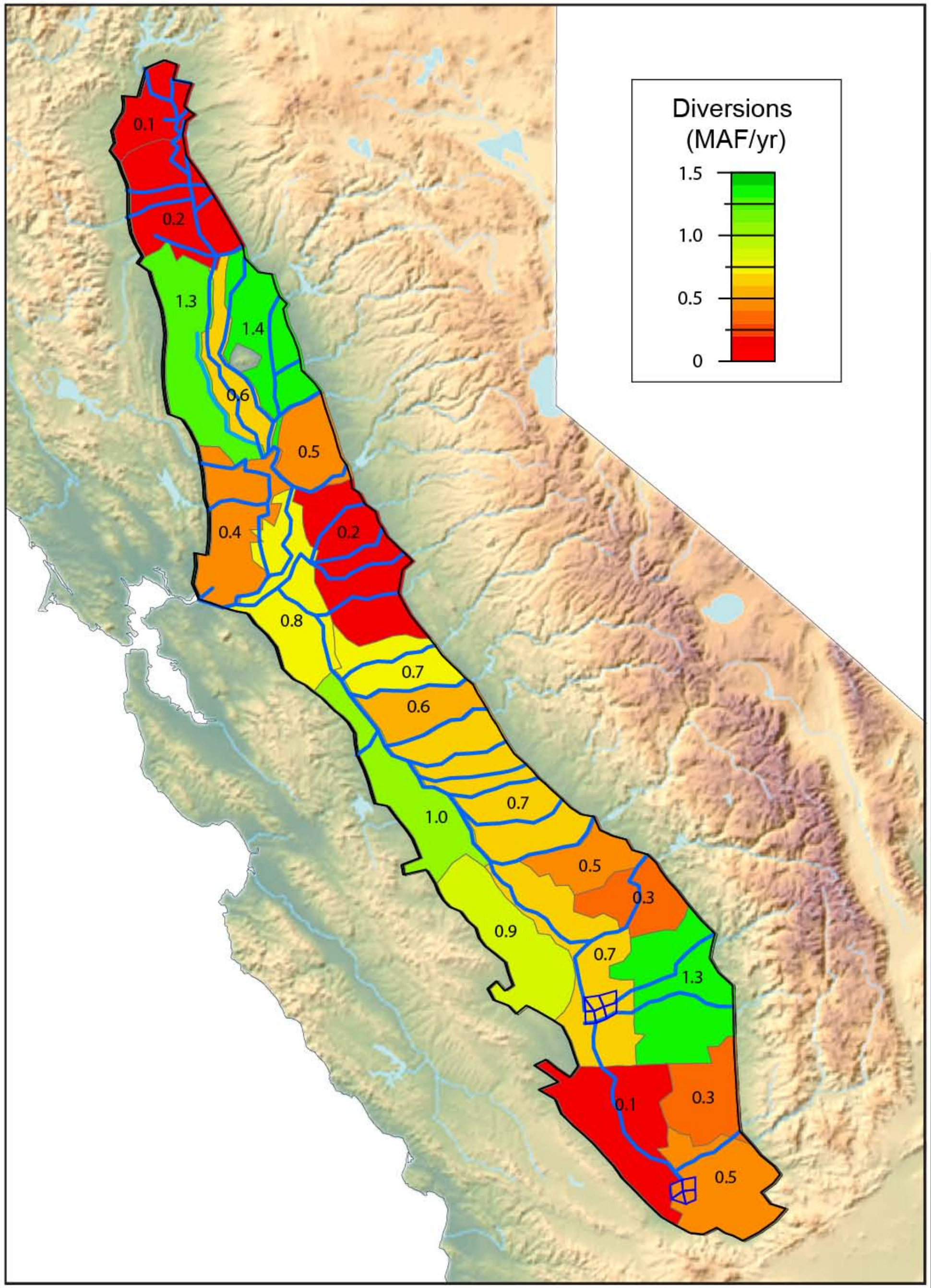
Column	Flow	08/31/2004	Process
Beginning Storage (+)		63,418	
Ending Storage (-)		51,052	
Flow from Upstream Lake (+)	IN	0	
Flow from By-passes (+)	IN	799	
Precipitation (+)	IN	0	
Gain from Groundwater (+)	+/-	1,939	GW
Lake Evaporation (-)	OUT	15,104	
Lake Outflow (-)	OUT	0	
Discrepancy (=)		0.30	
Lake Surface Elevation (FEET)		185	

Diversions & Imports



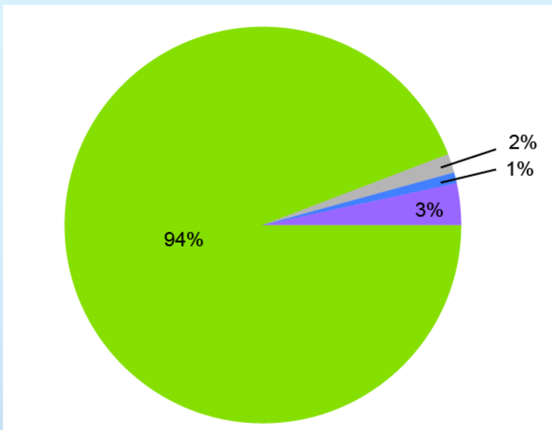
Surface Water Destinations



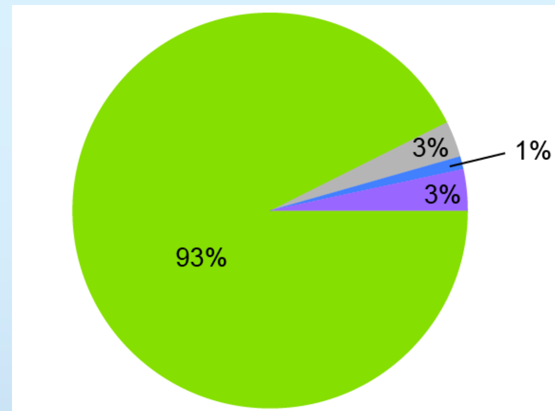

Diversions
(MAF/yr)
1.5
1.0
0.5
0
0.1
0.2
1.3
1.4
0.6
0.5
0.4
0.2
0.8
0.7
0.6
0.7
1.0
0.5
0.3
0.9
0.7
1.3
0.1
0.3
0.5

Surface Water Destinations

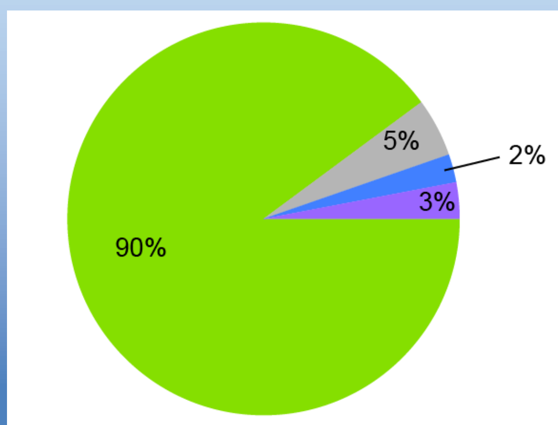
1922-1929

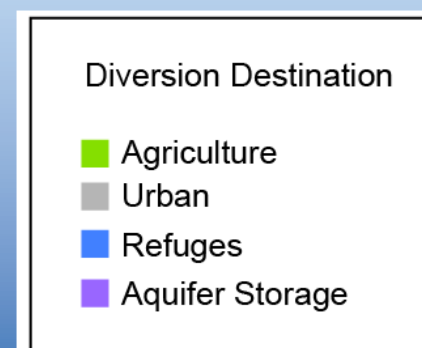


1960-1969

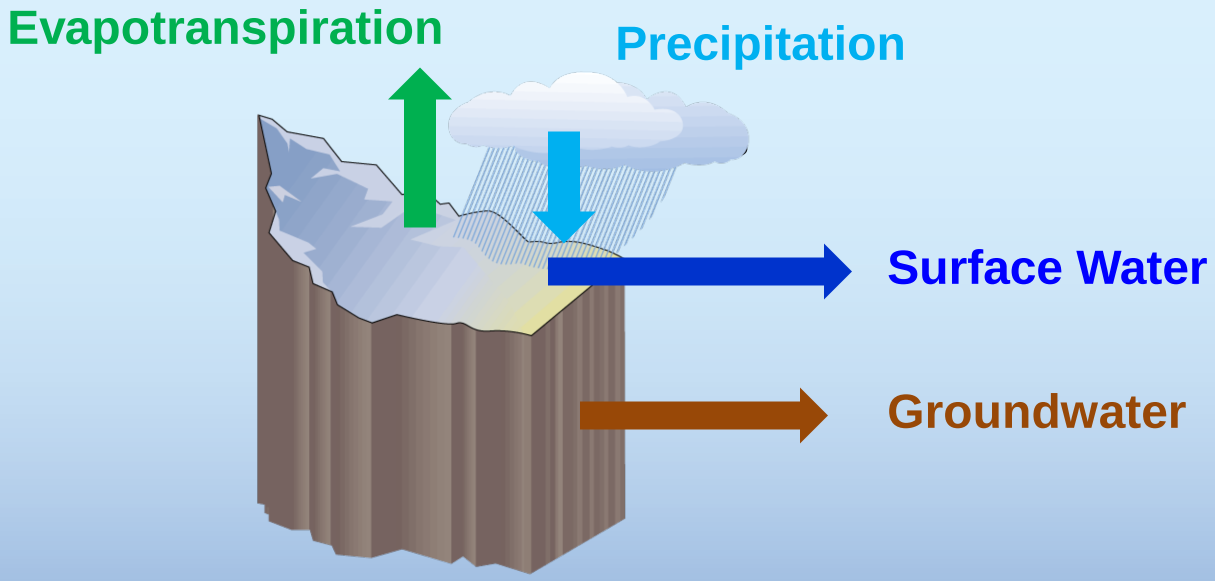


2000-2009





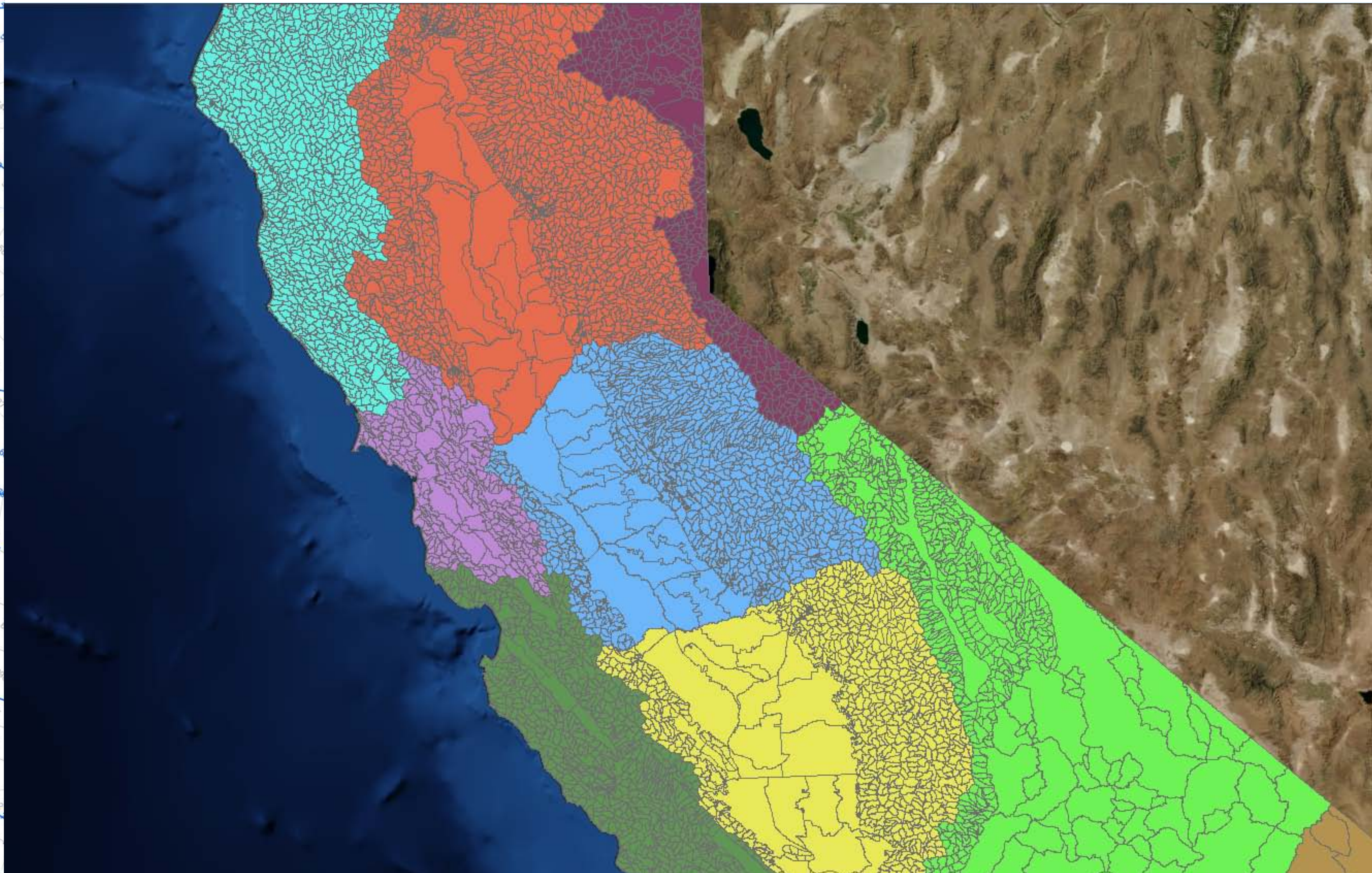
IWFM Small Watersheds



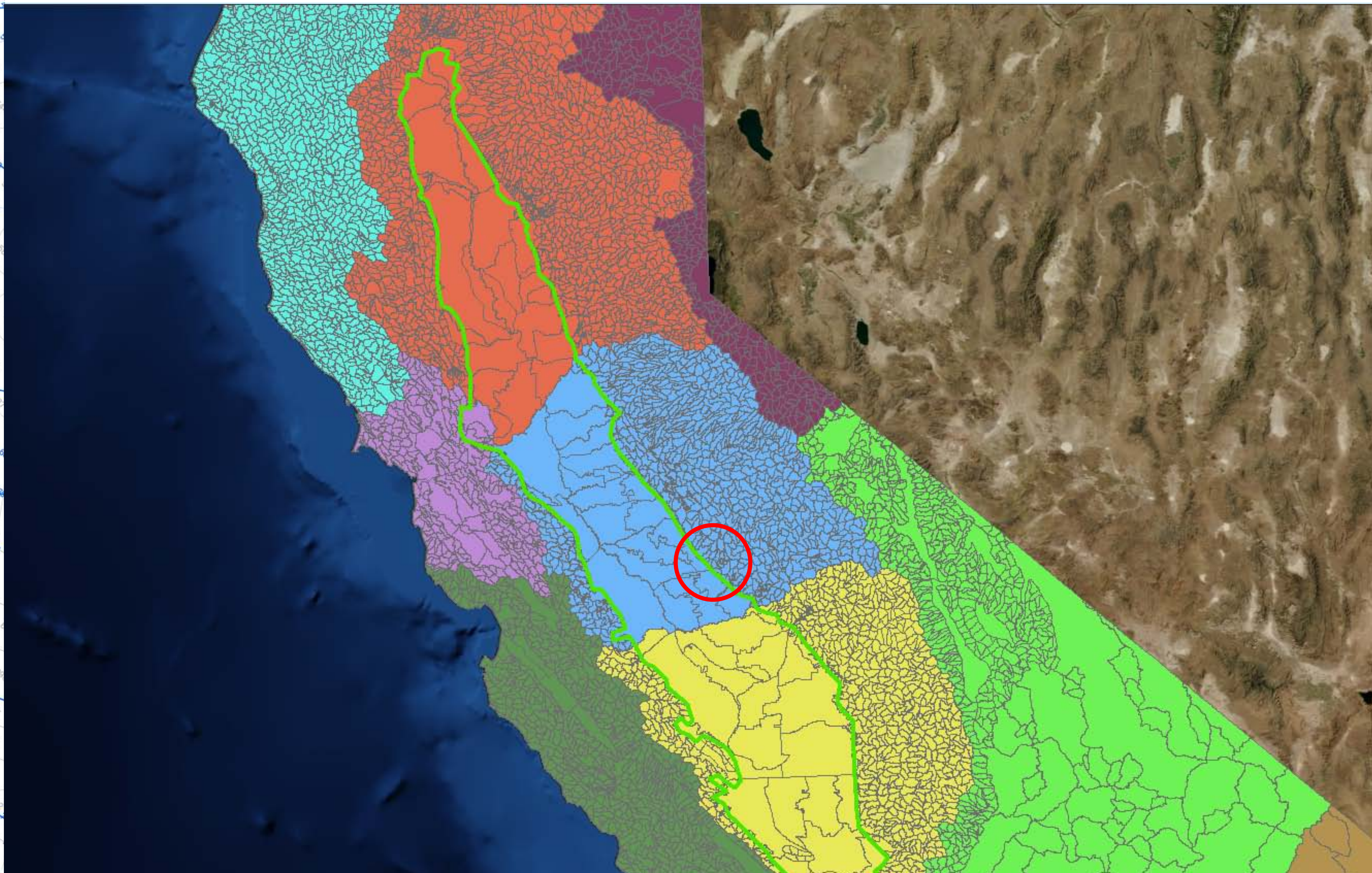
Small-Stream Watersheds

- Calculate monthly ungaged surface water inflows and groundwater inflows
- Areas and flow channels from CalWater watershed coverage
- Grouped with nearest boundary node
- Resulted in 210 small-stream watersheds
- Approximately 5% of surface water inflow

Small-Stream Watersheds

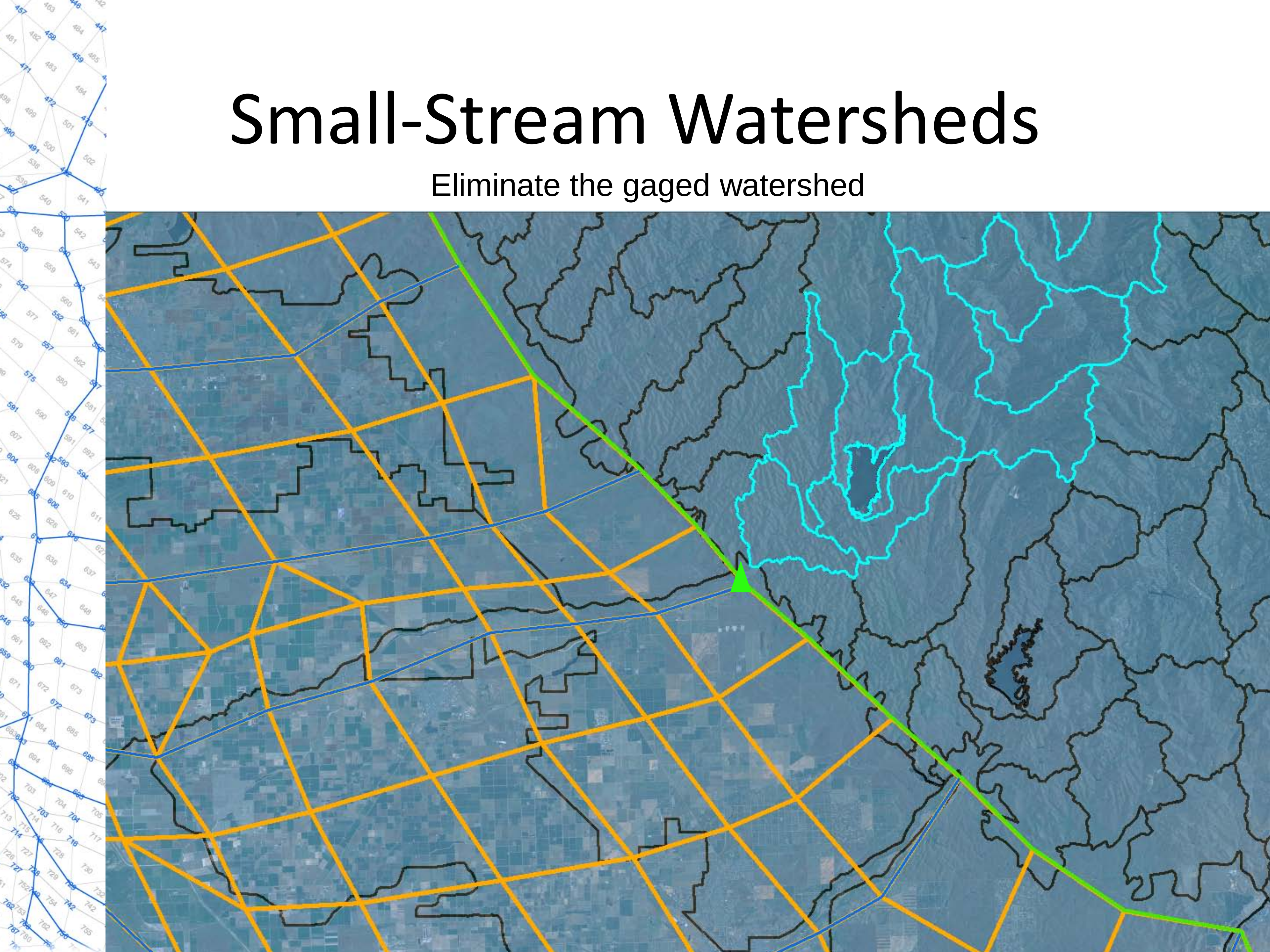


Small-Stream Watersheds



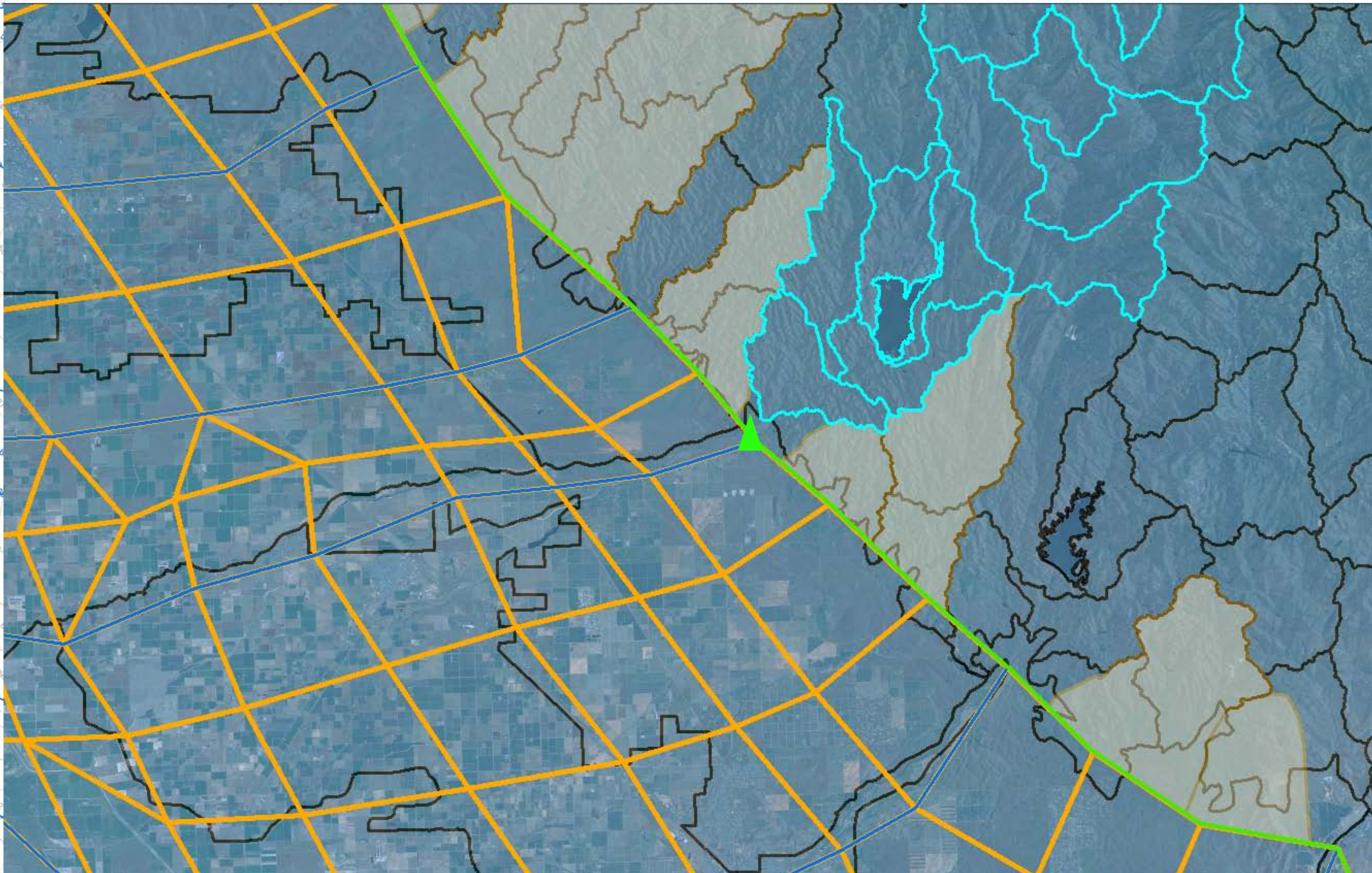
Small-Stream Watersheds

Eliminate the gaged watershed



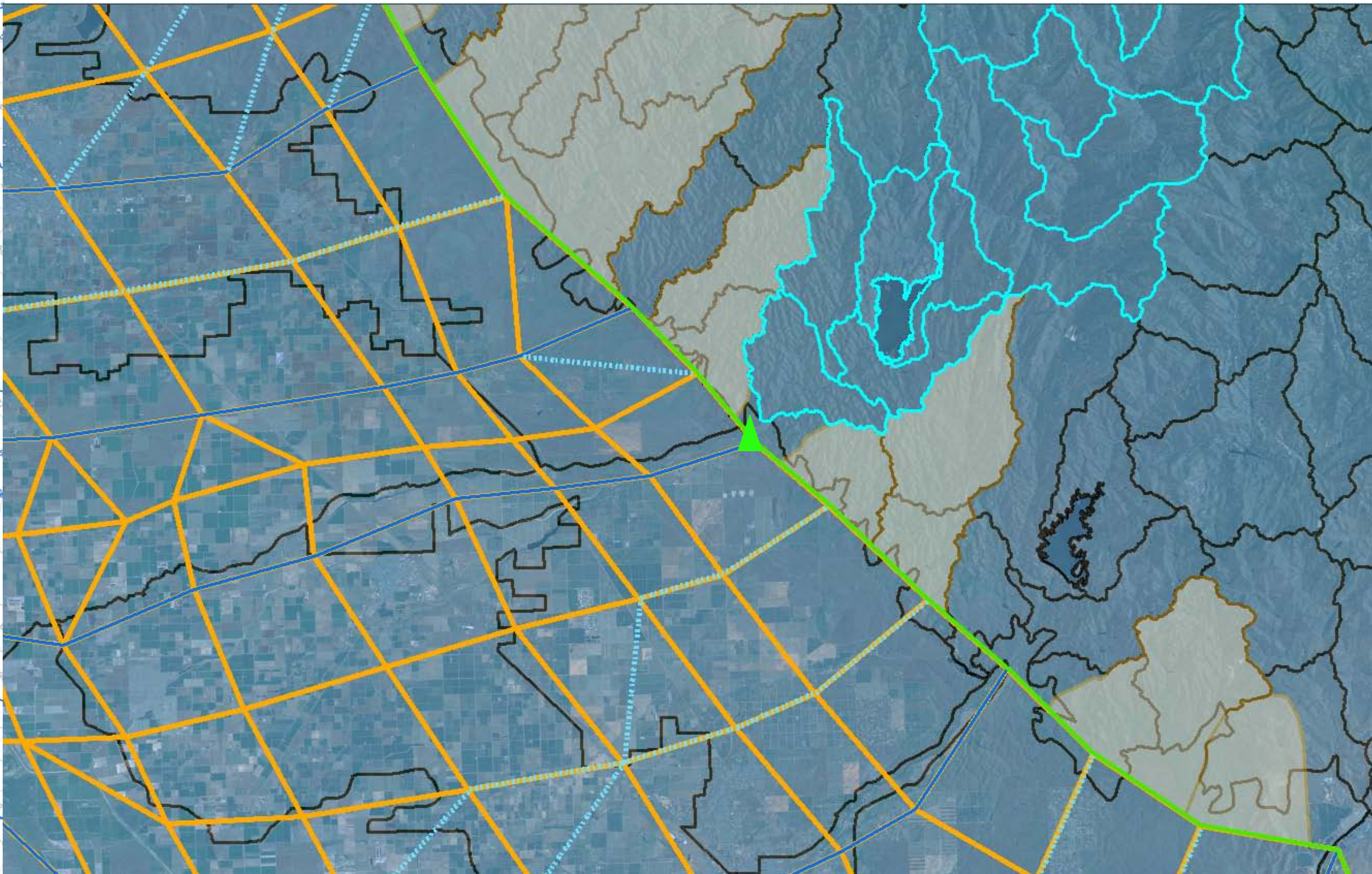
Small-Stream Watersheds

These are the ungaged watersheds



Small-Stream Watersheds

Overland flow paths



Small Watersheds

```
C*******************************************************************************
C
C          Boundary Conditions for Small Watershed Inflow Computation
C
C    NTWB  ; Number of small watersheds where inflows will be computed and specified as boundary flux
C    FACTA ; Conversion factor for small watershed drainage area
C    FACTQ ; Conversion factor for maximum recharge rate - It is used to convert only the spatial component of the unit;
C    TUNIT ; Time unit of max. recharge rate.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C
C-------------------------------------------------------------------------------
C       VALUE                       DESCRIPTION
C-------------------------------------------------------------------------------
        210                         / NTWB
        43560.0                     / FACTA  (ac --> ft^2)
        43560.0                     / FACTQ  (ac.ft/mon --> cu.ft./mon)
        1mon                        / TUNIT
C------------------------------------------------------------------------------
C    ID    ; Small watershed identification number
C    IWBS  ; Watershed group number corresponding to the watershed parameter groups specified in the parameter data file Unit 7
C    AREAS ; Drainage area of the small watershed; [L^2]
C    IWBTS ; Stream node that receives the surface runoff from the small watershed
C    NWB   ; Number of groundwater nodes that receive the base flow and the percolation of surface flow from the small watershed
C    IWB   ; Groundwater node number small watershed baseflow is routed through
C    QMAXWB; Maximum recharge rate for each node; [L^3/T]
C           (Enter -1 to specify which groundwater node(s) receive baseflow from the small watersheds)
C
C      ID    IWBS     AREAS   IWBTS     NWB     IWB        QMAXWB
C------------------------------------------------------------------------------
        1       1     48887     434       3    1371            -1
                                               1369      200.0000
                                               1370      200.0000
        2       2     30177     434       3    1368            -1
                                               1369      200.0000
                                               1370      200.0000
        3       3     22140     434       3    1360            -1
                                               1361      200.0000
                                               1362      200.0000
        4       4     20783     434       3    1349            -1
                                               1350      200.0000
                                               1351      200.0000
        5       5      9992     434       3    1339            -1
                                               1340      200.0000
                                               1341      200.0000
        6       6     14459     434       4    1329            -1
                                               1330      200.0000
                                               1340      200.0000
                                               1341      200.0000
        7       7     11979     434       5    1318            -1
                                               1319      200.0000
                                               1320      200.0000
                                               1321      200.0000
                                               1341      200.0000
        8       8     13309     440       3    1305            -1
```

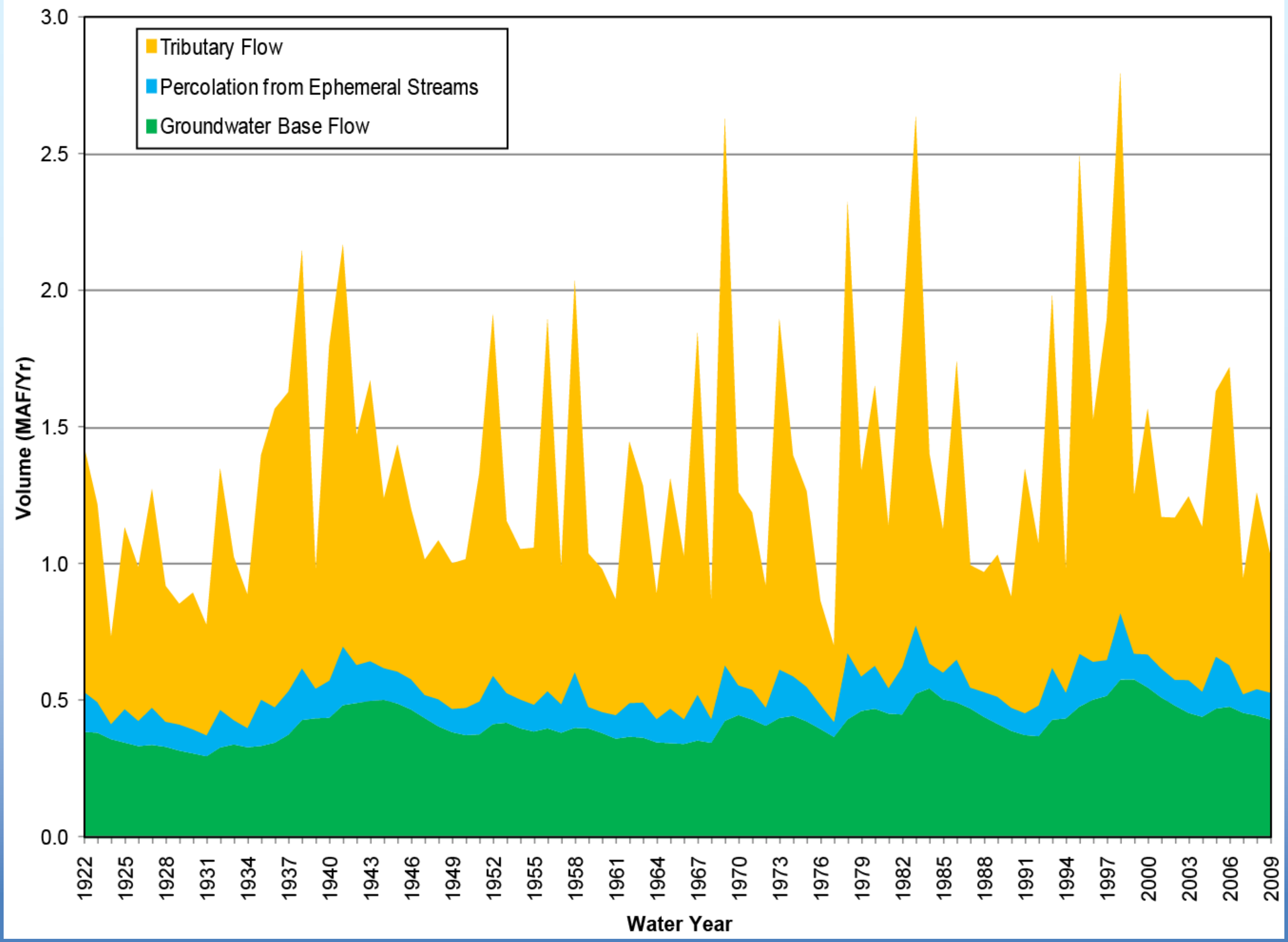
Small Watershed Parameters

```
C****************************************************************************
C                         SMALL STREAM WATERSHED DATA
C
C   The following  lists the small watershed parameters that are used in the computation of runoff from the tributary watersheds outside the model boundary.
C
C   NSW   ;   Number of small watershed groups
C   FACTL ;   Conversion factor for root zone depth and groundwater threshold value
C   FACTK ;   Conversion factor for hydraulic conductivity
C   TUNITK;   Time unit of hydraulic conductivity.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C   FACTT ;   Conversion factor for recession coefficients
C   TUNITT;   Time unit of recession coefficients.  This should be one of the units recognized by HEC-DSS that are listed in the Main Control File.
C
C-----------------------------------------------------------------------------
C   VALUE                      DESCRIPTION
C-----------------------------------------------------------------------------
    210                    / NSW
    1.00000                / FACTL
    1.00000                / FACTK
    1day                   / TUNITK
    1.00000                / FACTT
    1mon                   / TUNITT
C-----------------------------------------------------------------------------------------------------------------
C   IS    ;   Small watershed group identification number
C   IRNS  ;   Rainfall station number associated with the small watershed
C   FRNS  ;   Rainfall weighting factor for the small watershed
C   FLDCAS;   Field capacity; [L/L]
C   TPOROS;   Total porosity; [L/L]
C   CROOT ;   Root zone depth of native vegetation in the small watershed; [L]
C   SOILKS;   Hydraulic conductivity of the root zone; [L/T]
C   CN    ;   Curve number for small watershed area
C             (Reference: USDA, 1985)
C   GWSOS ;   Threshold value of groundwater depth above which groundwater
C                storage of small watershed contributes to surface runoff; [L]
C   SWKS  ;   Recession coefficient for surface outflow; [1/T]
C   GWKS  ;   Recession coefficient for base flow; [1/T]
C
C IS     IRNS     FRNS     FLDCAS   TPOROS   CROOT    SOILKS   CN       GWSOS    SWKS     GWKS
C----------------------------------------------------------------------------------------------------------------------------------------------
1        1393     1        0.109    0.235    6.2      6.43     65.0     9.99     0.1000   0.01044
2        1394     1        0.073    0.236    6.2      2.75     72.0     9.99     0.1000   0.01044
3        1395     1        0.006    0.139    4.0      7.51     97.7     10.00    0.1000   0.01000
4        1396     1        0.022    0.150    4.0      7.85     97.7     10.00    0.1000   0.01000
5        1397     1        0.043    0.173    4.0      7.82     98.9     10.00    0.1000   0.01000
6        1398     1        0.102    0.231    4.0      7.29     97.7     10.00    0.1000   0.01000
7        1399     1        0.153    0.273    4.0      4.20     94.0     10.00    0.1000   0.01000
8        1400     1        0.202    0.309    4.0      2.47     84.1     10.00    0.1000   0.01000
9        1401     1        0.214    0.333    4.0      2.83     86.6     10.00    0.1000   0.01000
10       1402     1        0.250    0.383    4.0      3.03     94.0     10.00    0.1000   0.01000
11       1403     1        0.217    0.351    4.0      4.45     94.0     10.00    0.1000   0.01000
12       1404     1        0.283    0.427    4.0      2.72     92.8     10.00    0.1000   0.01000
13       1405     1        0.291    0.440    4.0      2.66     79.2     10.00    0.1000   0.01000
```

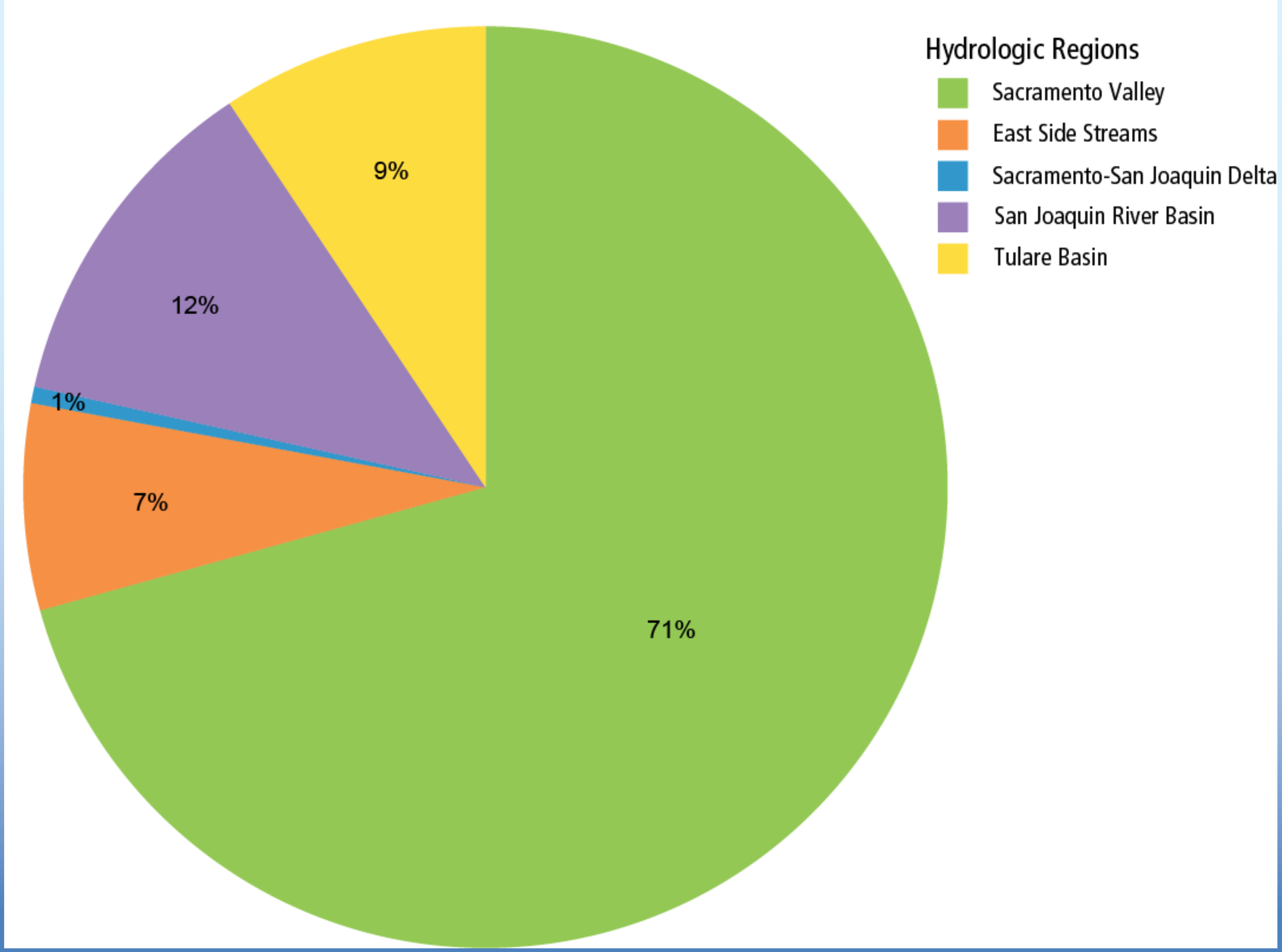
Small Watershed Budget

Column	Flow	08/31/2004	Process
Total SW Outflow	OUT	6,049	
GW Base Outflow	OUT	90,386	
Base Flow + Surface Percolation	OUT	90,456	
Net Surface Outflow to Streams	OUT	5,979	

Small-Watershed Inflows



Small Watershed Inflows



END