MODFLOW-OWHM Hydrologic Budgets and Case Studies

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Outline

- SGMA overview
- Types of hydrologic budgets generated by MF-OHWM
- Examples from case studies scattered within
  - CVHM (Claudia Faunt)
  - SJJRPGW (Jon Traum)
  - MERSTAN (Steve Philips)
  - SBFTM (Scott Paulinski)
  - PVHM (Randy Hanson)
  - Example Problems (Scott Boyce)

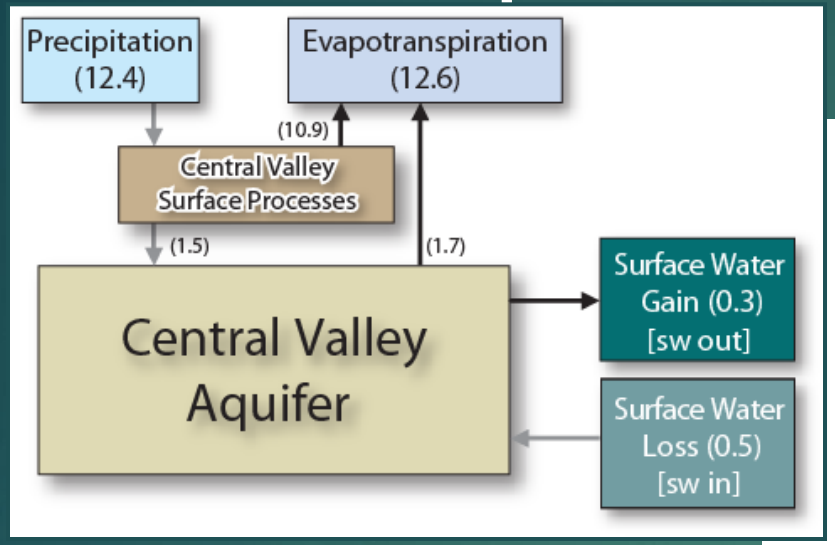
SGMA Undesirable Results

- Lowering of groundwater levels
- Reduction of groundwater storage
- Degraded water quality
- Seawater intrusion
- Land subsidence
- Depletions of interconnected surface water

Hydrologic Budgets

- SGMA definition of hydrologic budget
  - Total groundwater and surface water entering and leaving a basin
- MF-OWHM Budgets
  - Groundwater budget
  - Water use budget
  - Streamflow budget
  - MNW2 budget
  - UZF budget

Pre-development

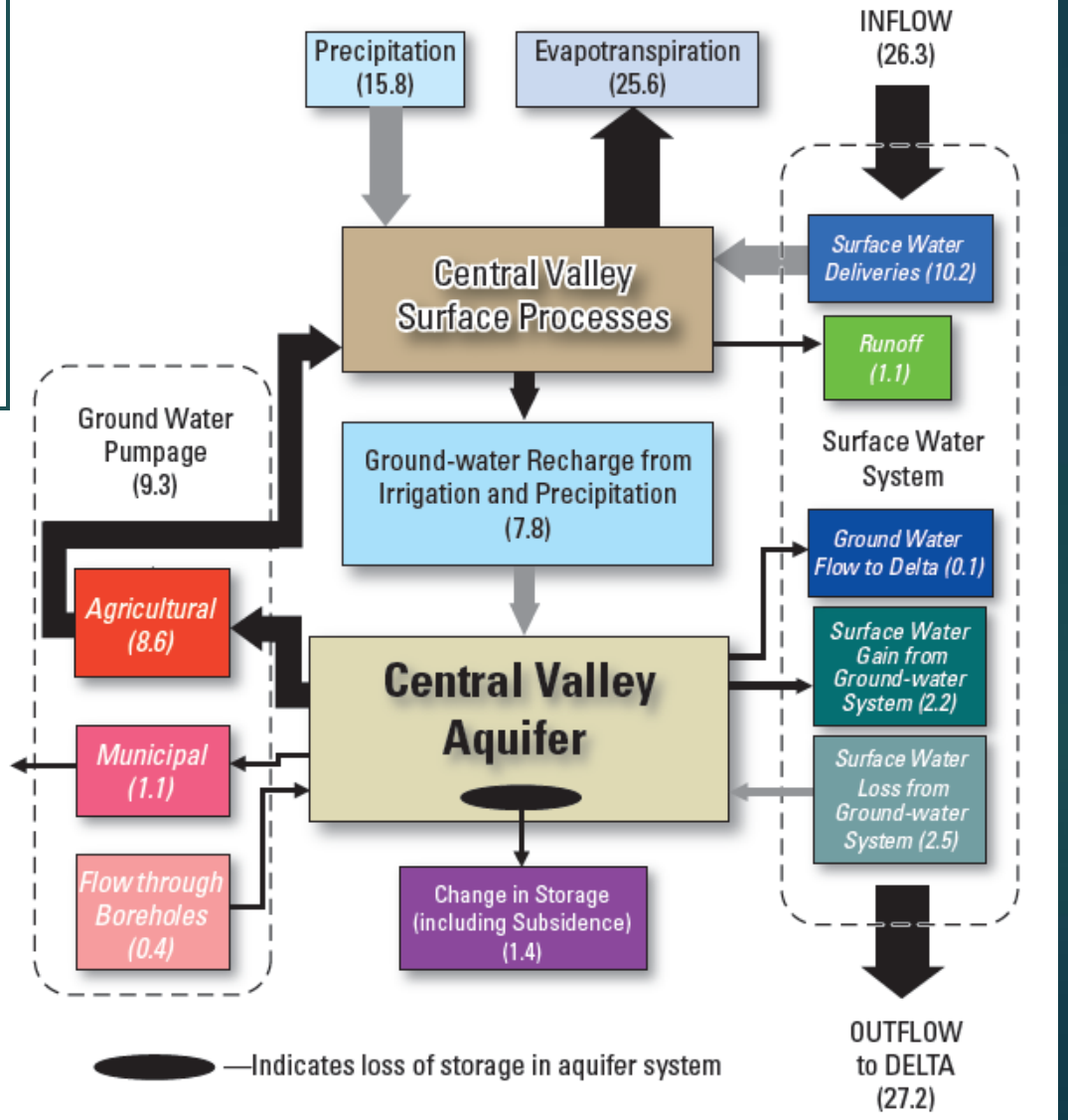


Natural → **Engineered**

Simple → **Complex**

2 million acre-feet/year recharge /discharge → **12 million** acre-feet/year recharge /discharge

1962-2003/Engineered



USGS

Processing Budgets

- Many different ways to temporally or spatially aggregate budget
  - Available for every model time step
  - Available at detailed spatial scales (GW Budget by cell, SW Budget by stream reach)
  - Some stored in binary format
- Tools to help
  - Zone Budget: subregional aggregation
  - ModelMuse: visualization
  - GW_Chart: convert to text

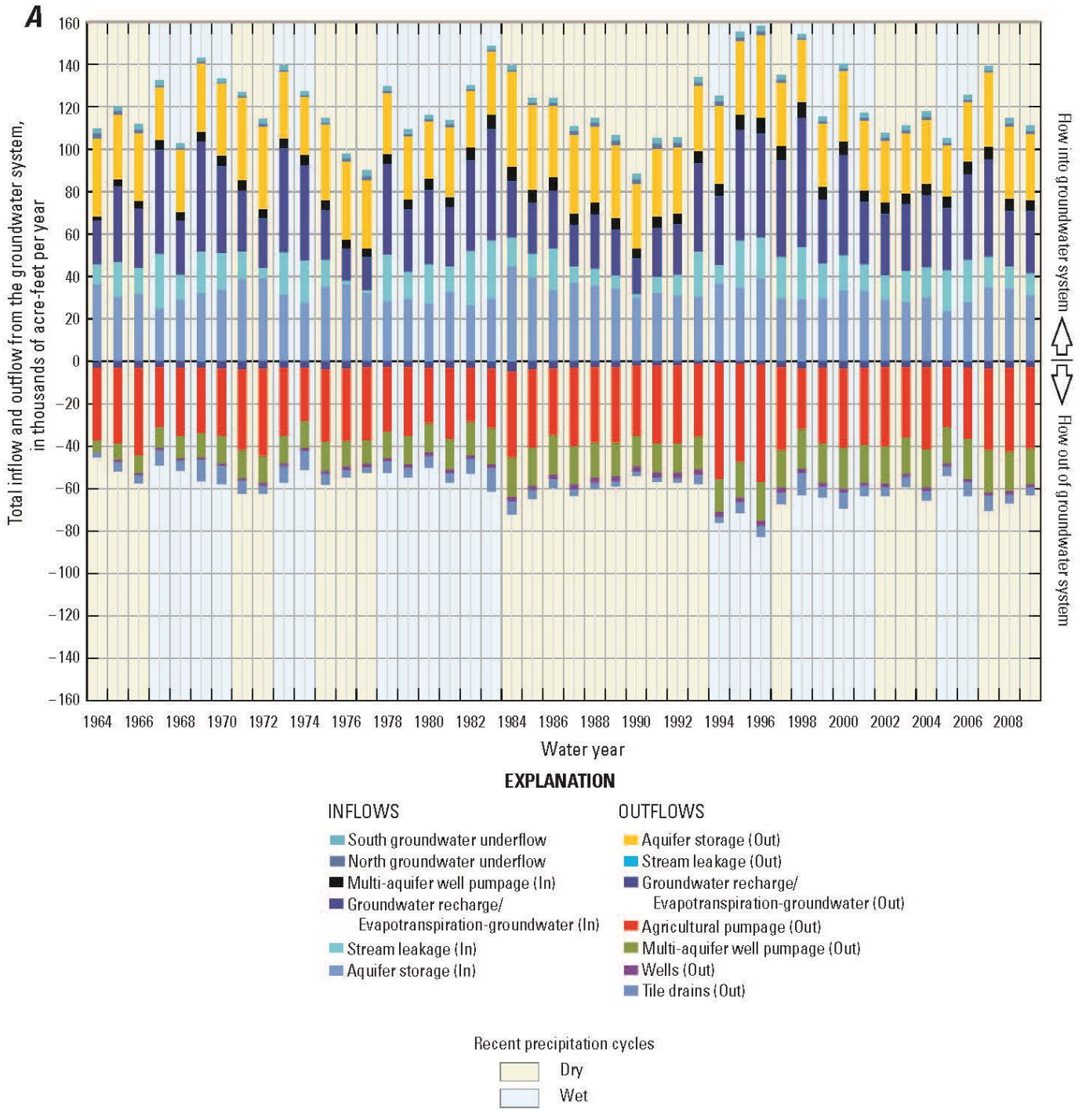
Groundwater Budget

- Used to determine reduction of groundwater storage
- Provides the flows into and out of each model cell in binary format
- Also called cell-by-cell budget

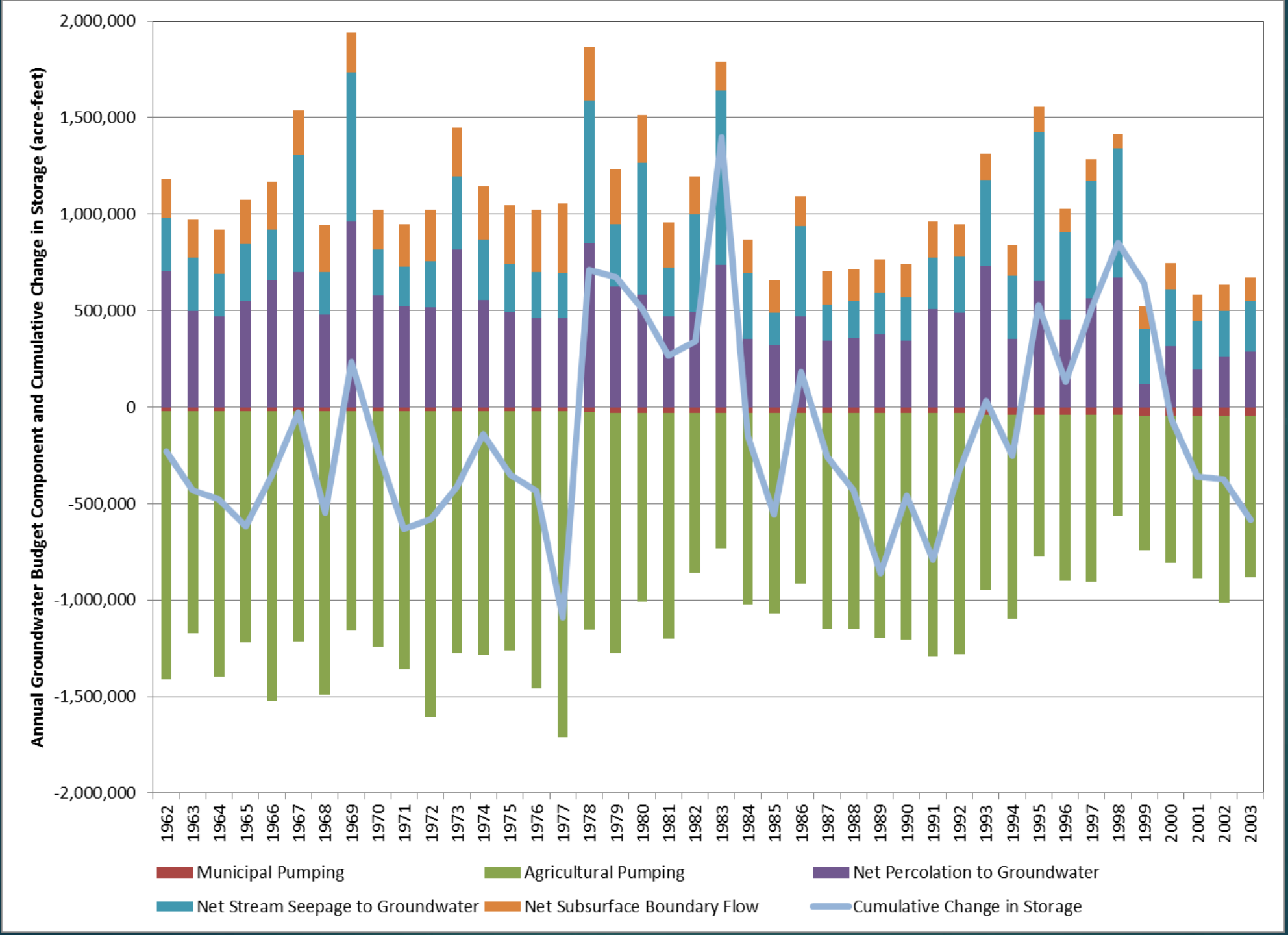
[Values in acre-feet; totals may not sum because of rounding]

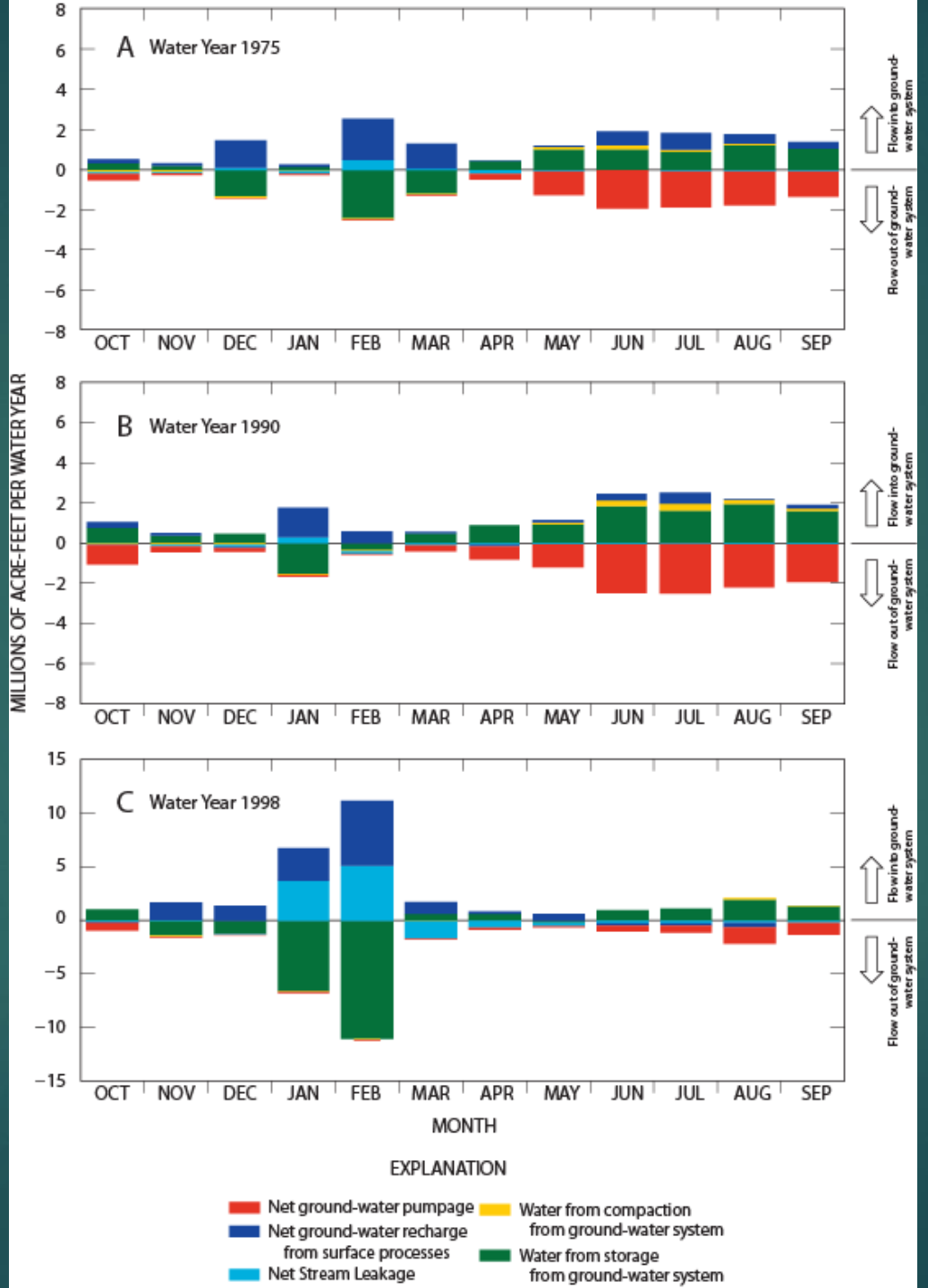
Water-balance subregion	Area (square miles)	Net storage from specific yield and compressibility of water[1]	Net elastic and inelastic storage[1]	Net stream leakage[2]	Net pumpage	Net recharge from landscape[3]	Precipitation	Evapotranspiration	Surface-water deliveries
1	611	36,000	13,000	–144,000	45,000	453,000	1,063,000	547,000	46,000
2	1,163	–17,000	23,000	–294,000	557,000	768,000	1,496,000	1,269,000	129,000
3	1,112	–39,000	3,000	–212,000	49,000	508,000	1,125,000	1,300,000	717,000
4	560	–34,000	0	–494,000	6,000	–19,000	562,000	635,000	78,000
5	957	–34,000	–1,000	–200,000	65,000	466,000	1,200,000	1,101,000	439,000
6	1,044	–47,000	10,000	34,000	506,000	522,000	1,137,000	1,315,000	329,000
7	534	2,000	4,000	–38,000	186,000	222,000	590,000	512,000	172,000
Sacramento Valley	**5,981**	**–99,000**	**52,000**	**1,348,000**	**1,414,000**	**2,920,000**	**7,173,000**	**6,6799,000**	**1,910,000**
Eastside Streams (8)	**1,362**	**–26,000**	**7,000**	**95,000**	**850,000**	**721,000**	**1,365,000**	**1,444,000**	**205,000**
Delta (9)	**1,026**	**–218,000**	**3,000**	**705,000**	**467,000**	**–200,000**	**975,000**	**1,603,000**	**64,000**
10	1,083	–36,000	29,000	64,000	60,000	89,000	588,000	1,465,000	983,000
11	664	–21,000	0	–98,000	85,000	251,000	509,000	901,000	643,000
12	540	–56,000	1,000	39,000	45,000	131,000	384,000	702,000	440,000
13	1,648	43,000	67,000	163,000	754,000	474,000	1,092,000	2,233,000	936,000
San Joaquin Basin	**3,935**	**–70,000**	**97,000**	**168,000**	**944,000**	**945,000**	**2,573,000**	**5,301,000**	**3,002,000**
14	1,071	179,000	165,000	6,000	934,000	418,000	432,000	1,631,000	716,000
15	1,423	26,000	146,000	239,000	1,603,000	708,000	607,000	2,225,000	757,000
16	478	89,000	35,000	33,000	202,000	212,000	299,000	518,000	358,000
17	569	54,000	28,000	170,000	445,000	348,000	358,000	852,000	442,000
18	1,358	158,000	198,000	104,000	1,135,000	710,000	715,000	2,237,000	821,000
19	1,365	85,000	133,000	0	754,000	334,000	494,000	1,275,000	367,000
20	705	74,000	92,000	19,000	252,000	240,000	295,000	892,000	610,000
21	1,105	83,000	81,000	130,000	324,000	272,000	414,000	1,333,000	1,096,000
Tulare Basin	**8,074**	**748,000**	**878,000**	**701,000**	**5,649,000**	**3,188,000**	**3,614,000**	**10,963,000**	**5,167,000**
Total	**20,378**	**300,000**	**1,000,000**	**300,000**	**9,300,000**	**7,600,000**	**15,700,000**	**25,900,000**	**10,300,000**

Annual totals

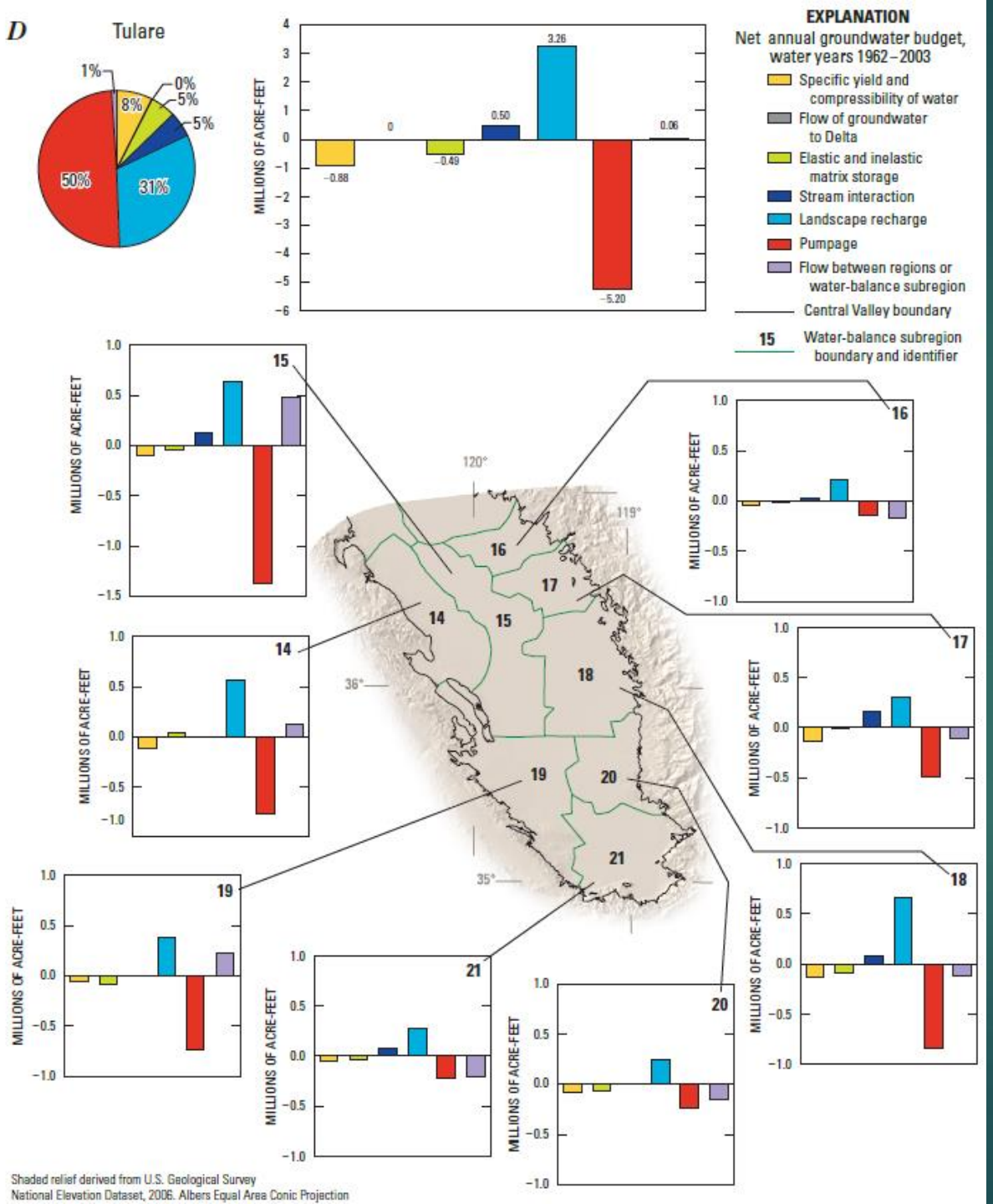


Annual totals





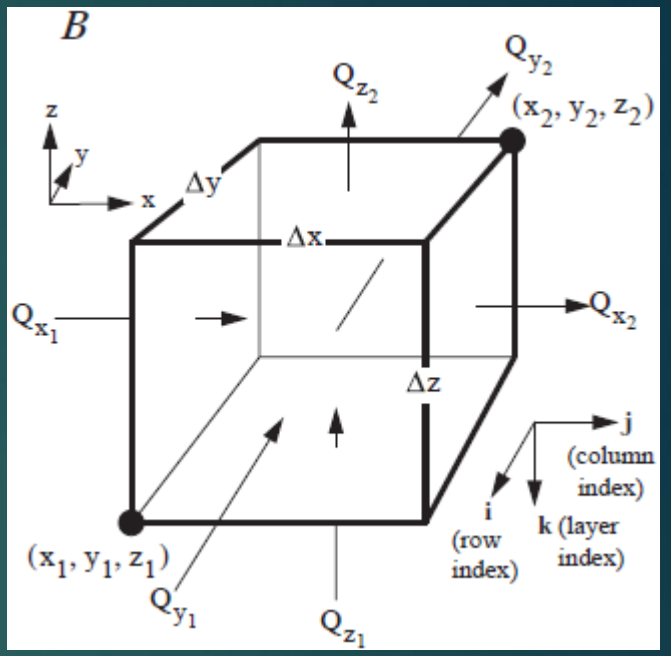
Monthly for selected year types

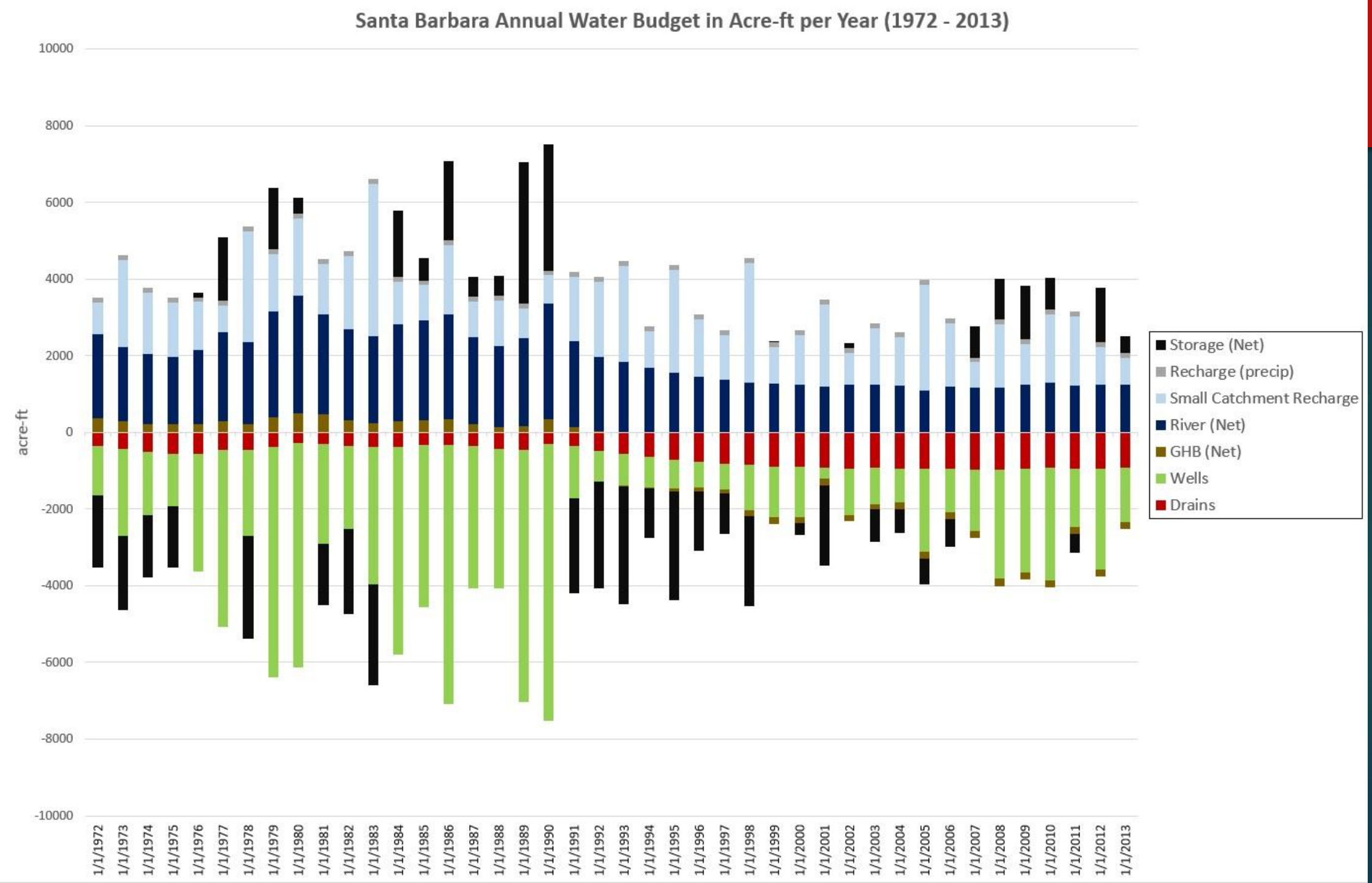


Average annual totals by subregion

Groundwater Flow Paths

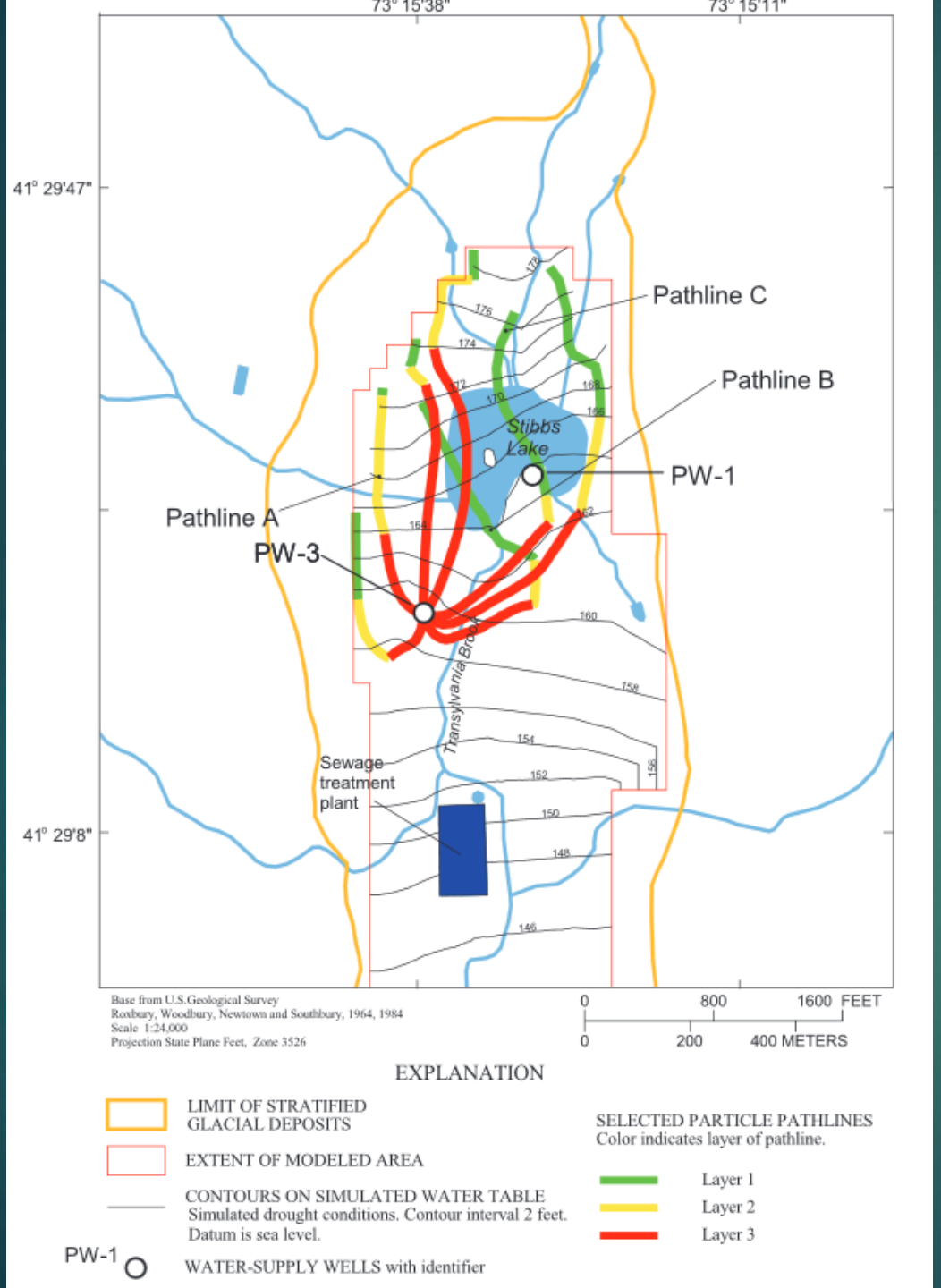
- Cell to cell flow (also called subsurface flow) is a key component of the groundwater budget
- Used to analyze water quality issues including seawater intrusion
- MODPATH post-processor to estimate groundwater flow paths from cell-by-cell output
- MODPATH-OBS post-processor for MODPATH to get concentrations
- MT3DMS and SEAWAT



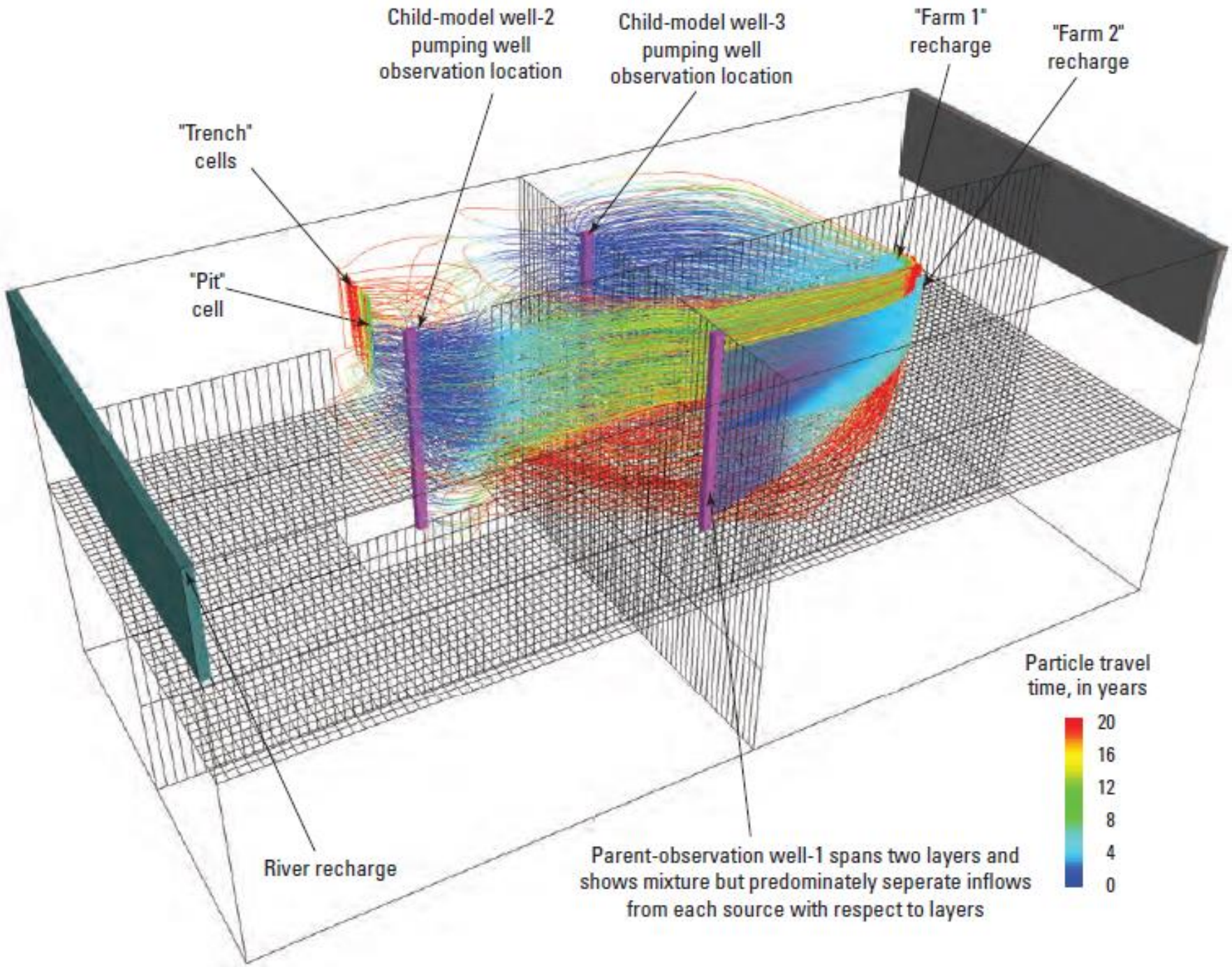


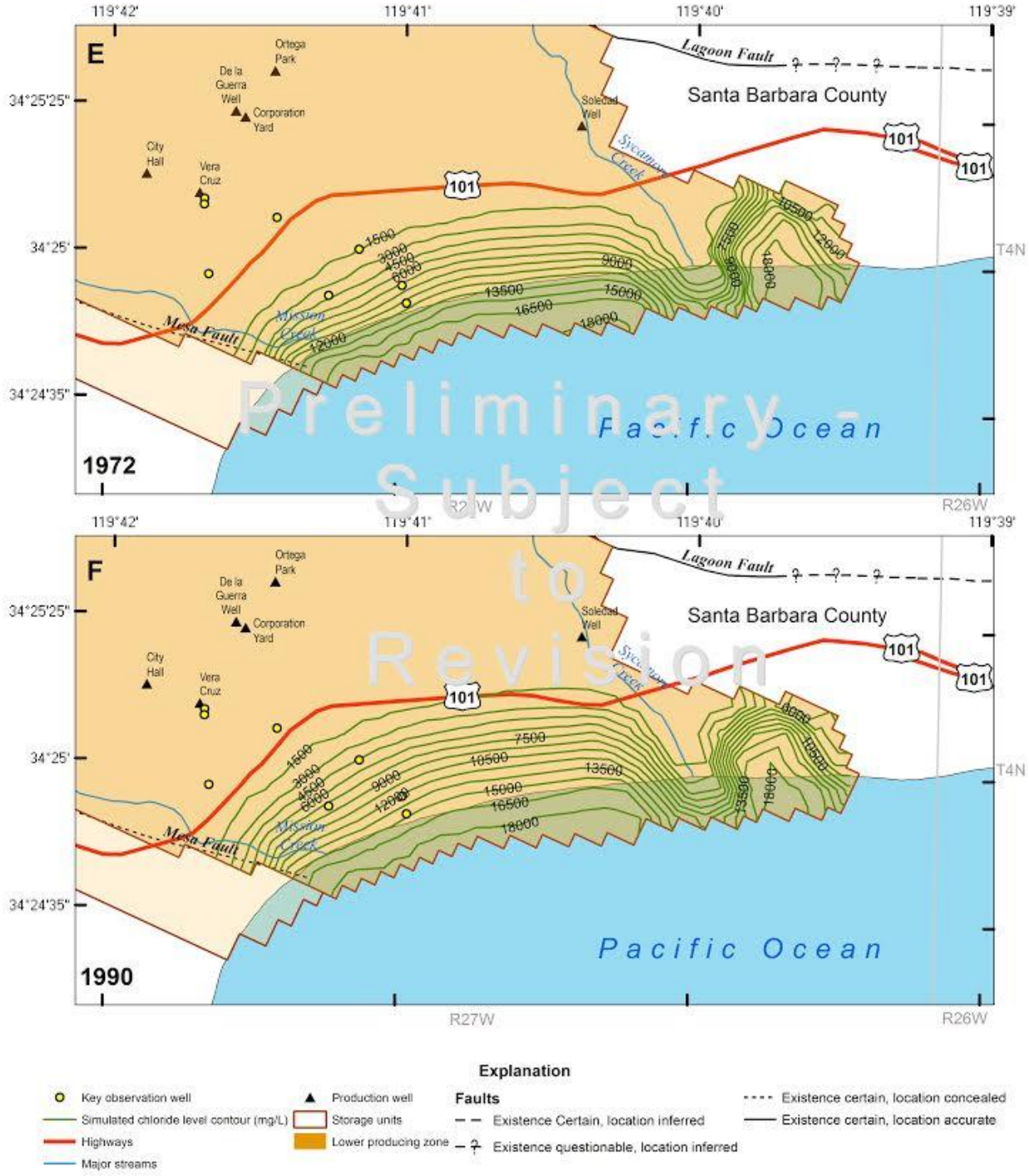
Annual totals

Simulated flow paths



Simulated travel times

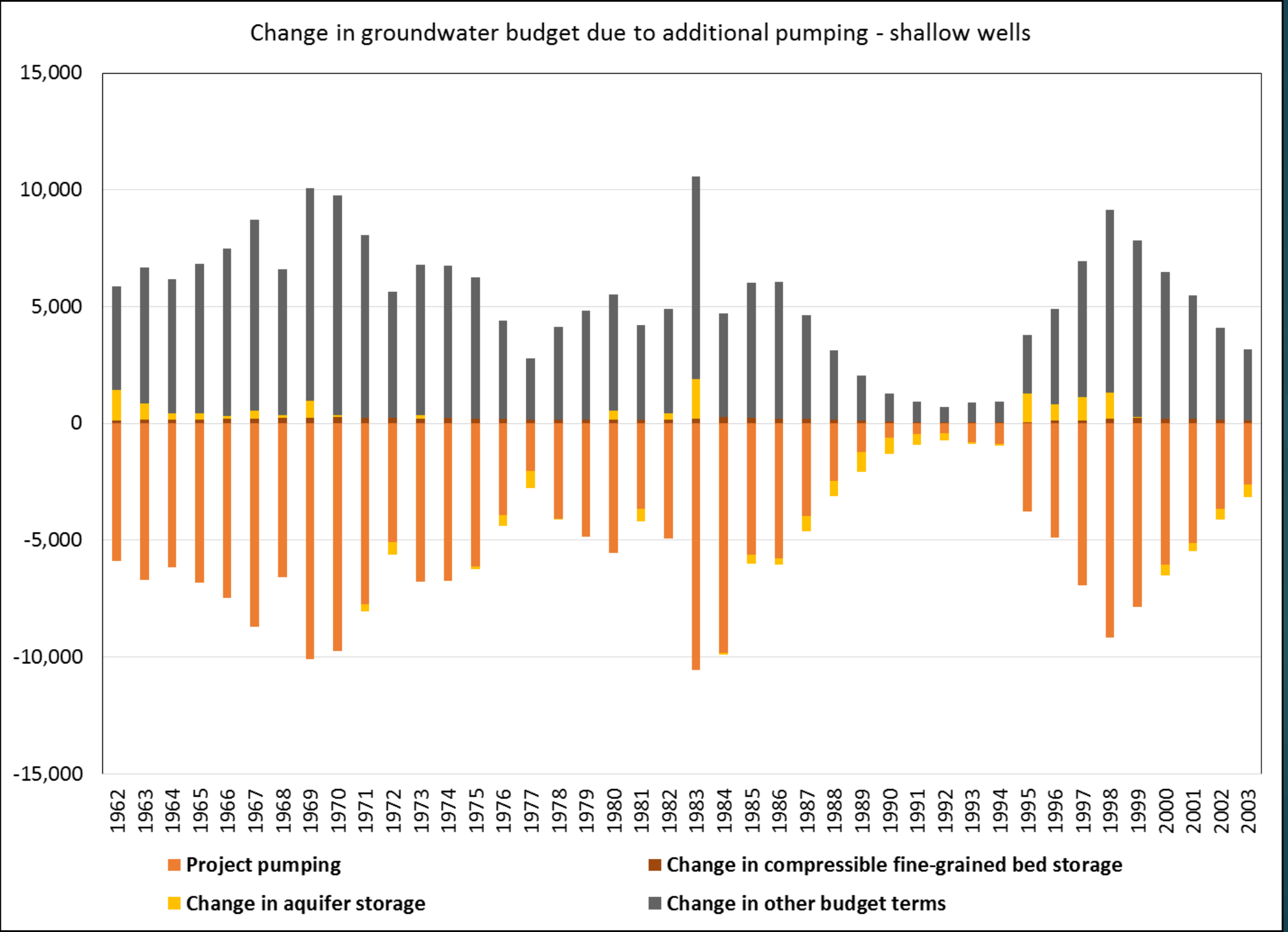




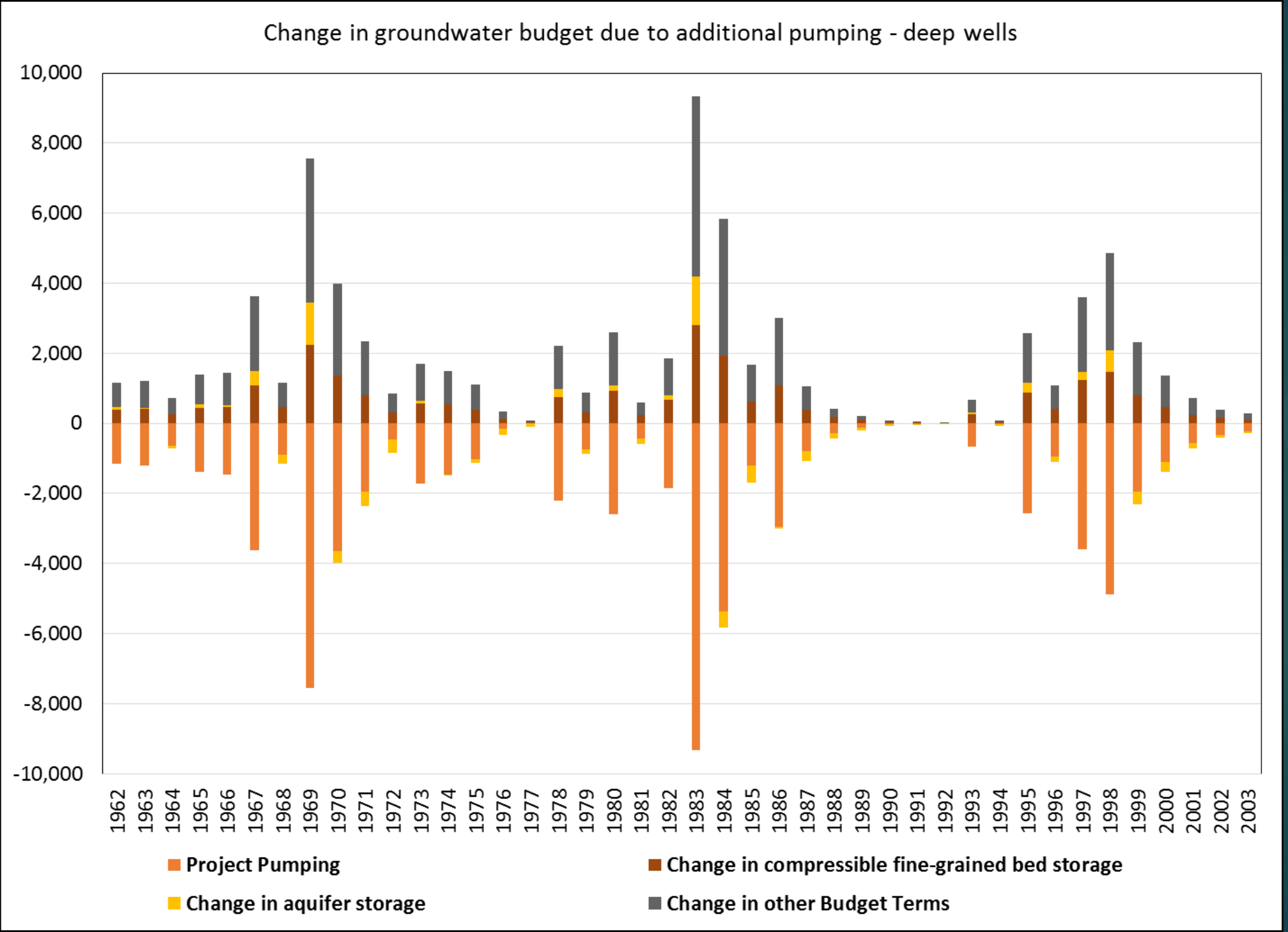
Simulated chloride concentrations

Subsidence Term in Groundwater Budget

- Subsidographs are used to determine location and magnitude of subsidence
- However, budget can be helpful for determining if subsidence is “significant and unreasonable”



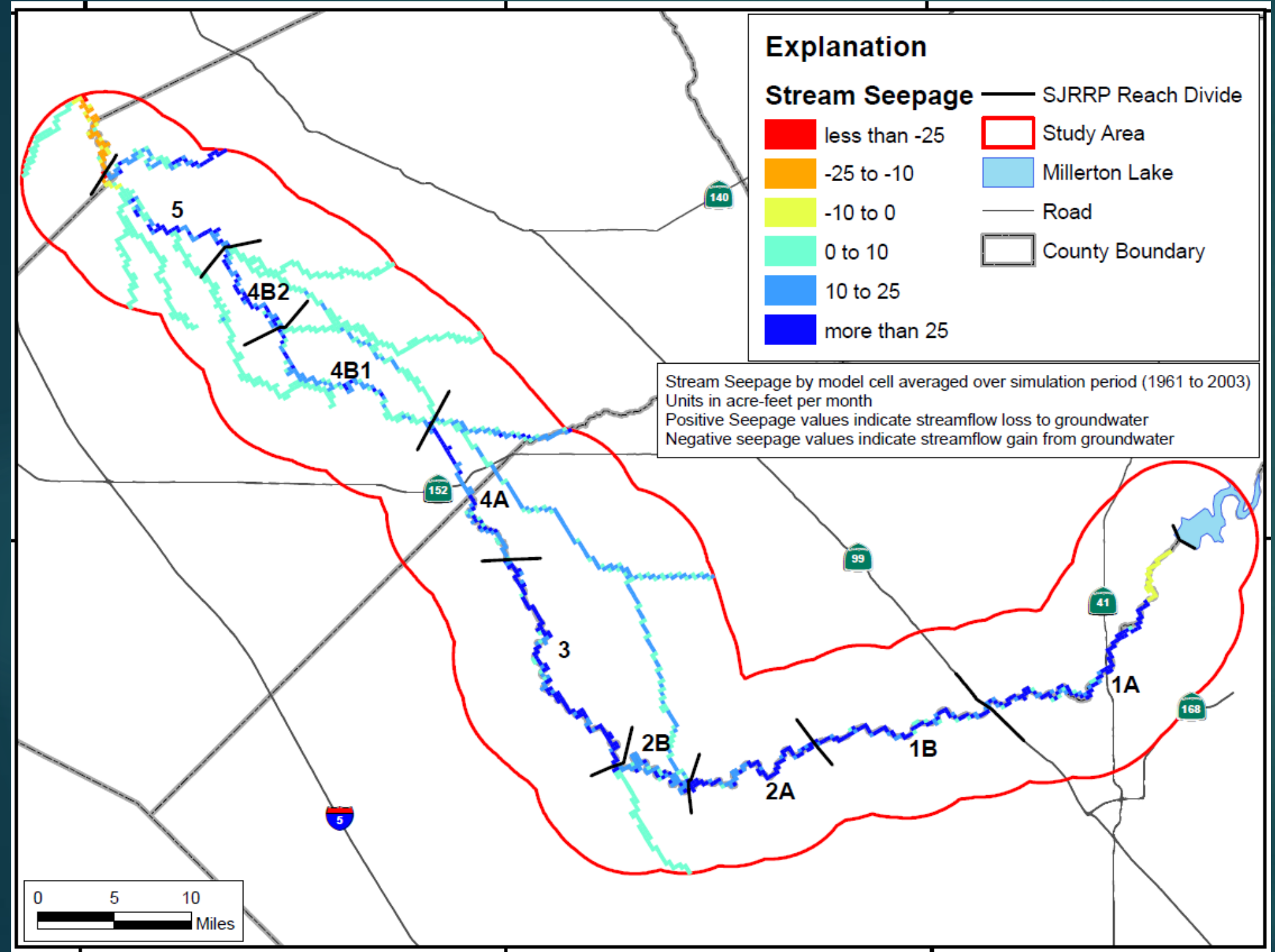
Change in storage due to pumping shallow wells



Change in storage due to pumping deep wells

Streamflow Budget

- Provides the inflows and outflows to the stream network by stream reach
- Can be used to determine depletion of interconnected surface water

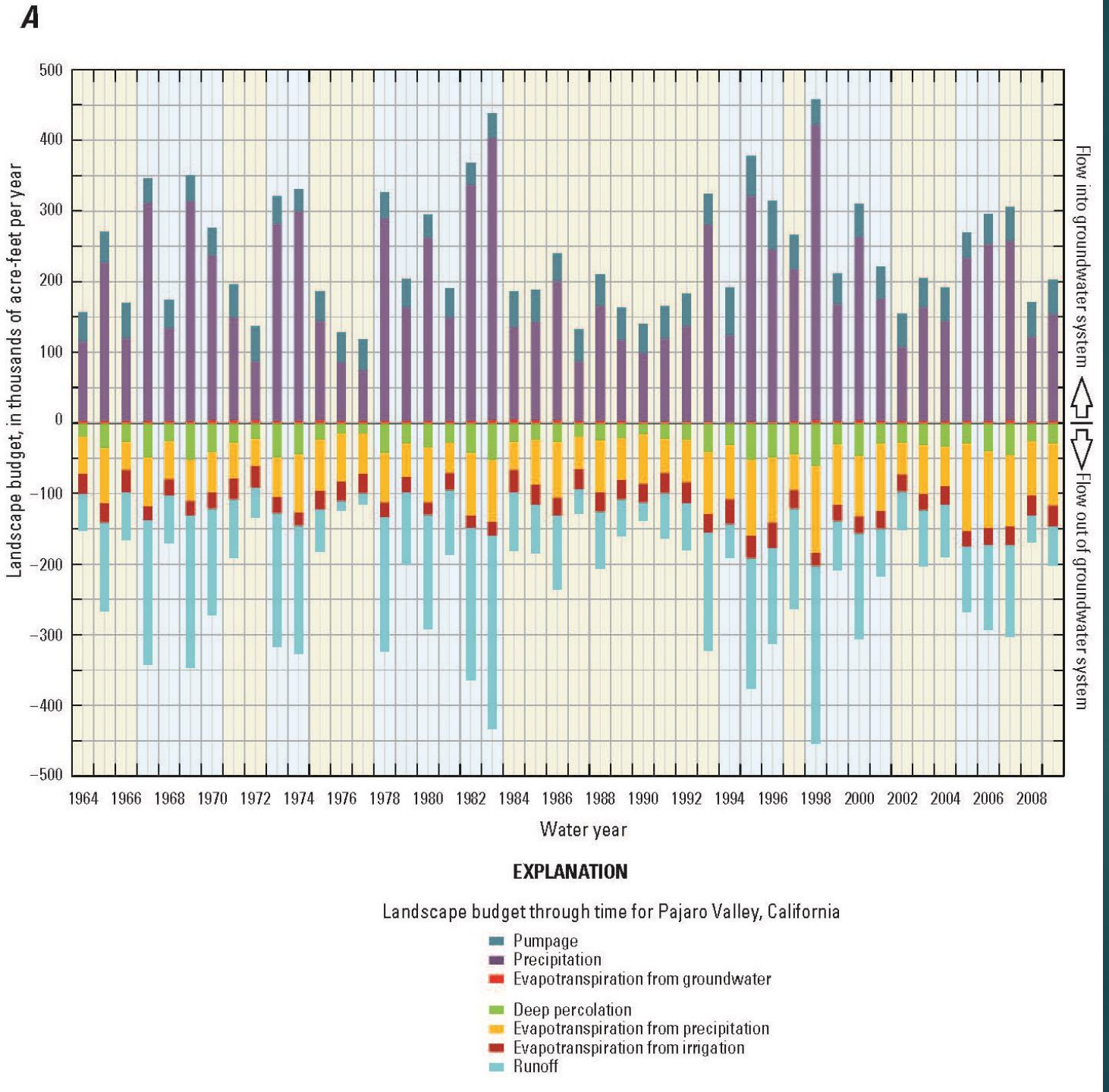


Annual Average groundwater and surface water exchange

Water Use Budget

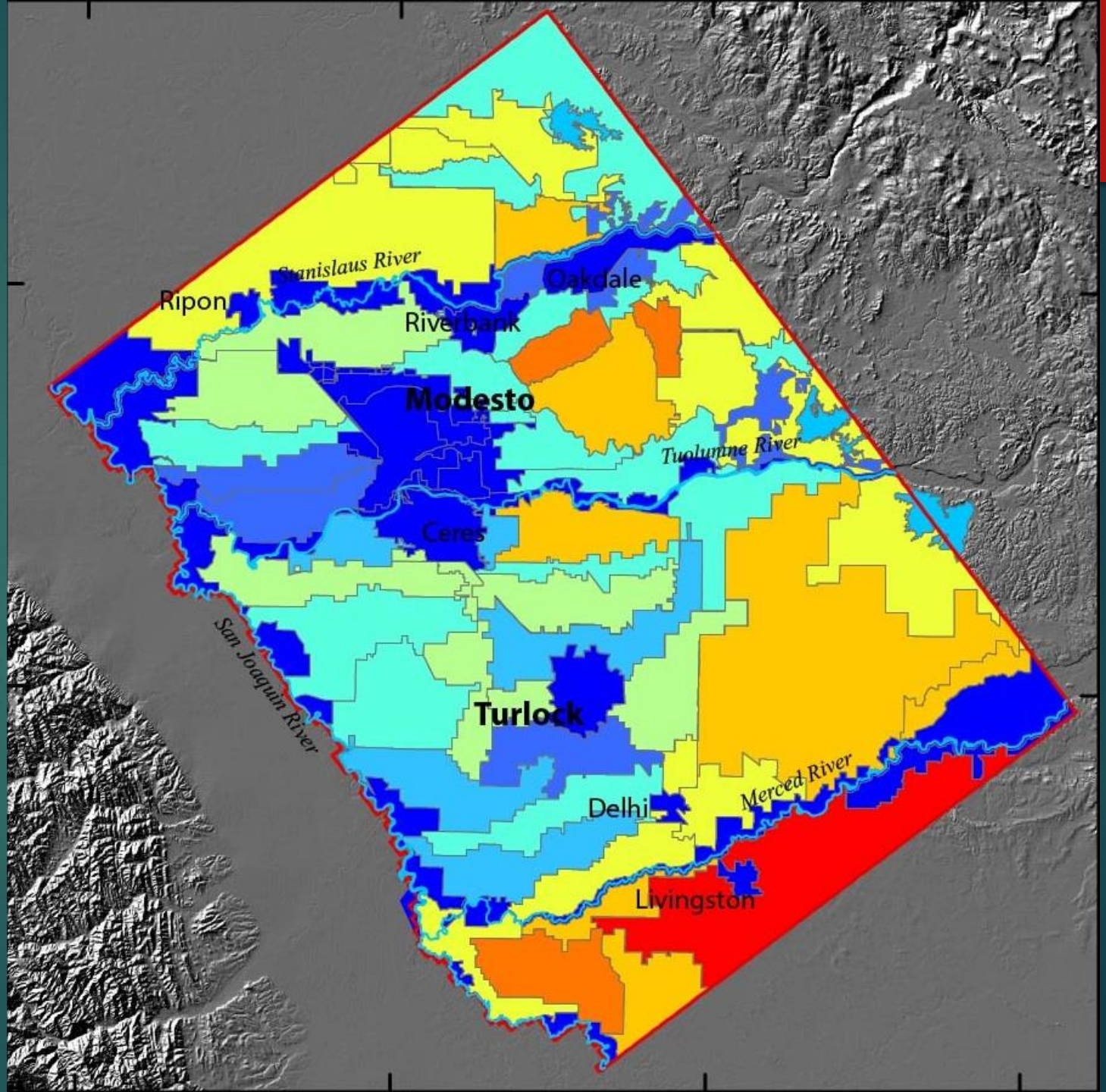
- Provides the flow components related to the supply and demand of crops and other plants for each water balance subregion
- Also called landscape budget, supply and demand budget, or farm budget
- Includes groundwater pumping and recharge which are significant components of the groundwater budget
- Includes the atmospheric budget components of precipitation and evapotranspiration

Annual totals



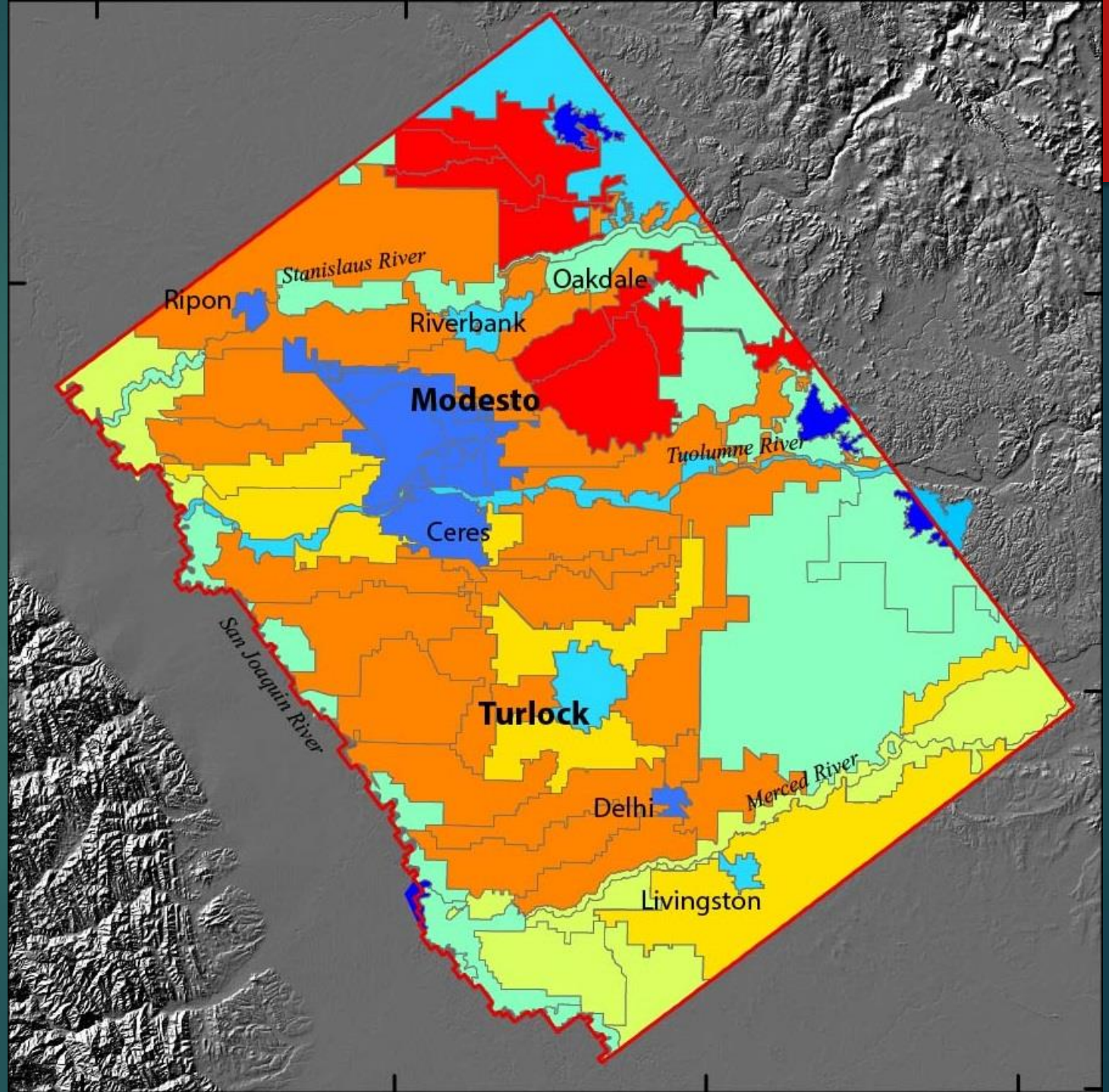
Simulated agricultural pumping

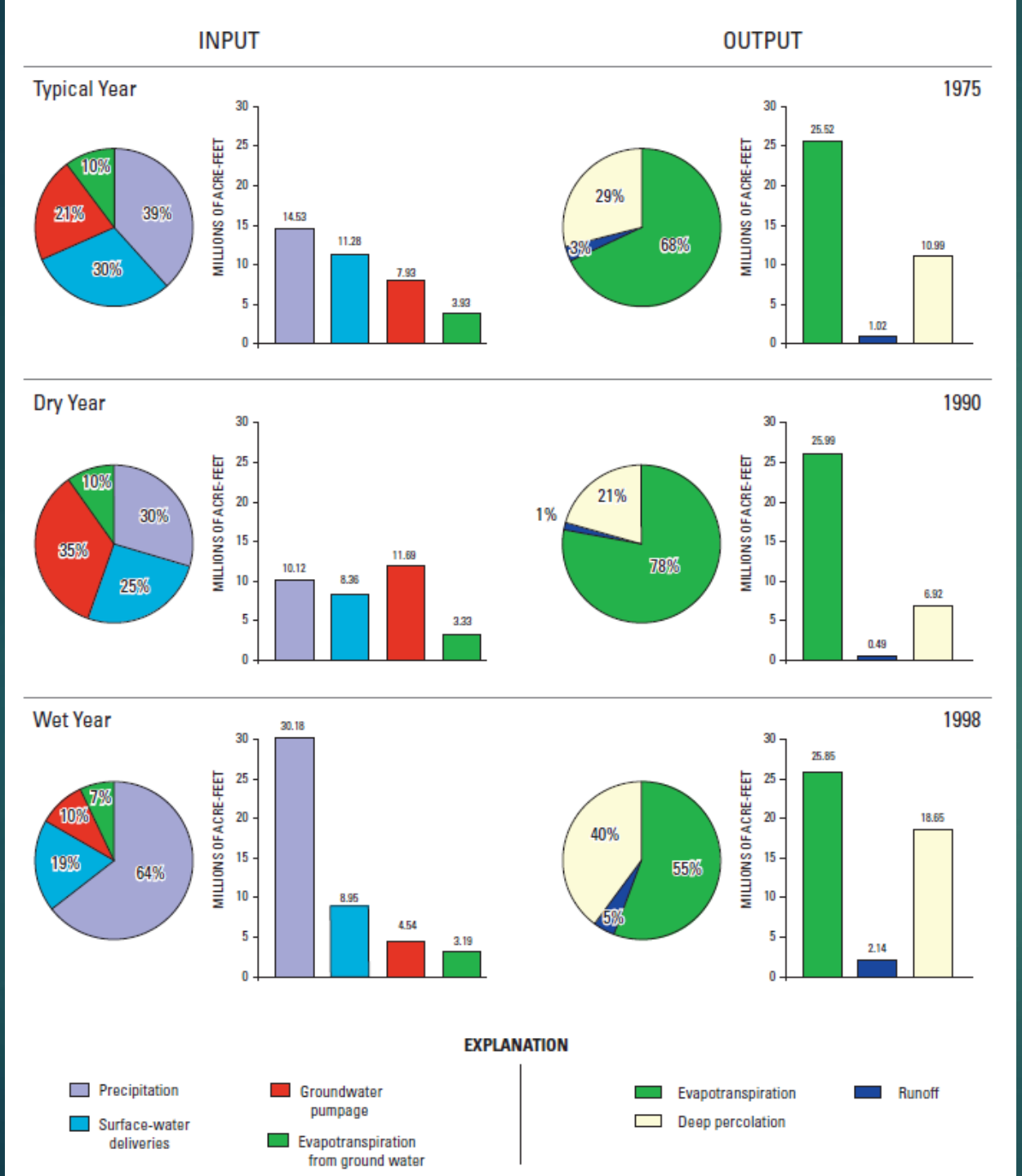
Hotter color = more Ag pumping



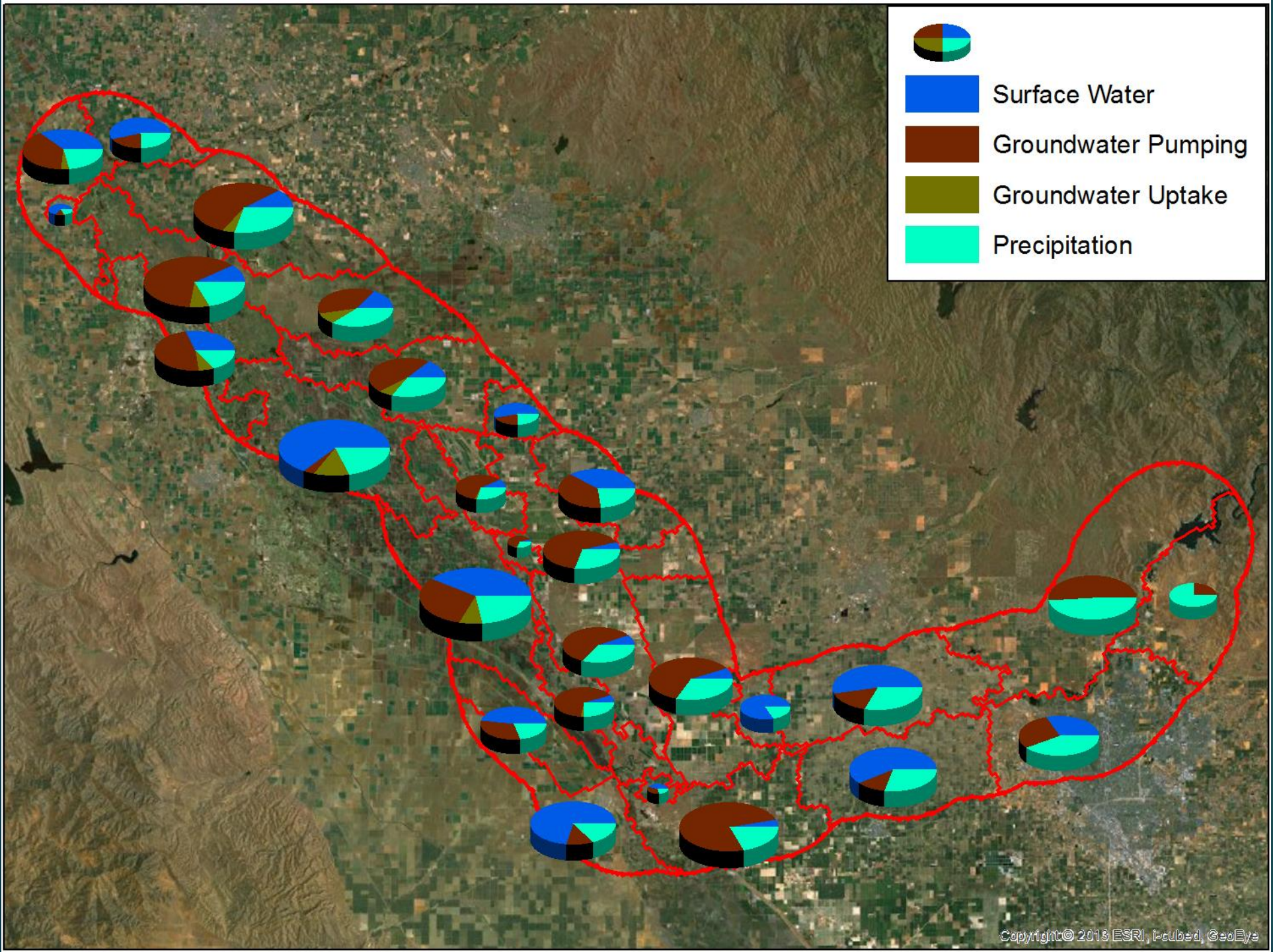
Simulated areal recharge

Hotter color = more recharge

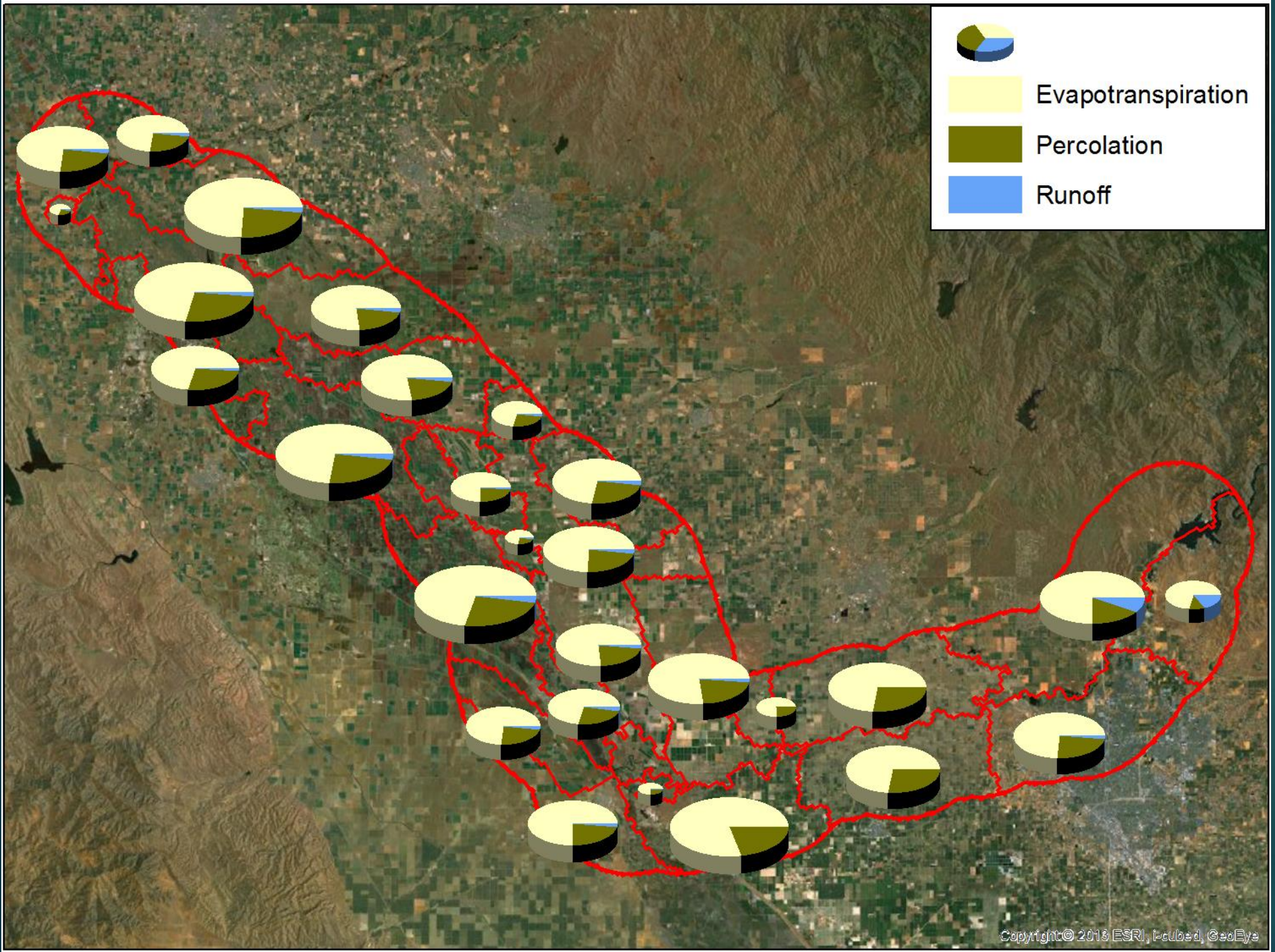




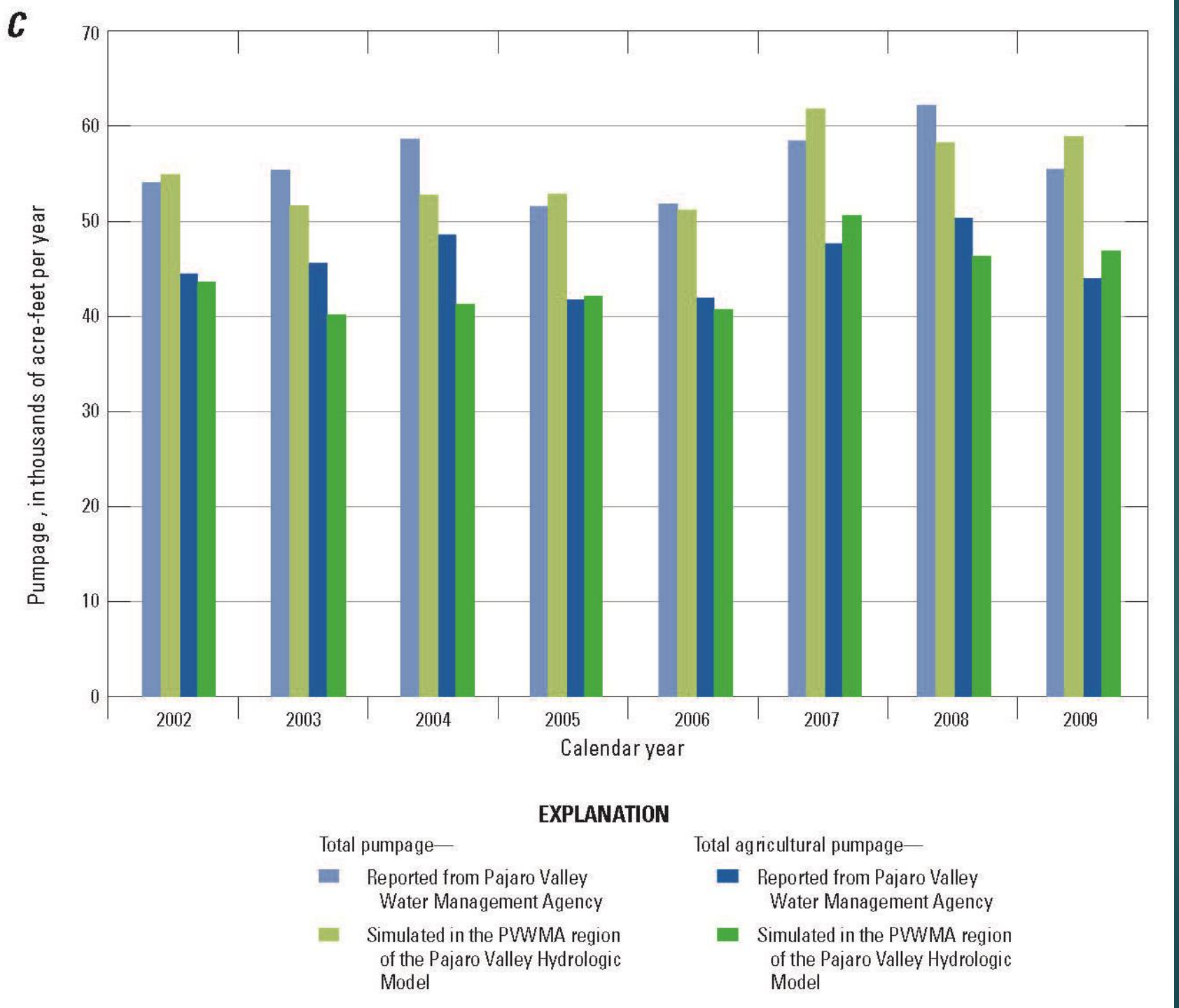
For hydrologic year types



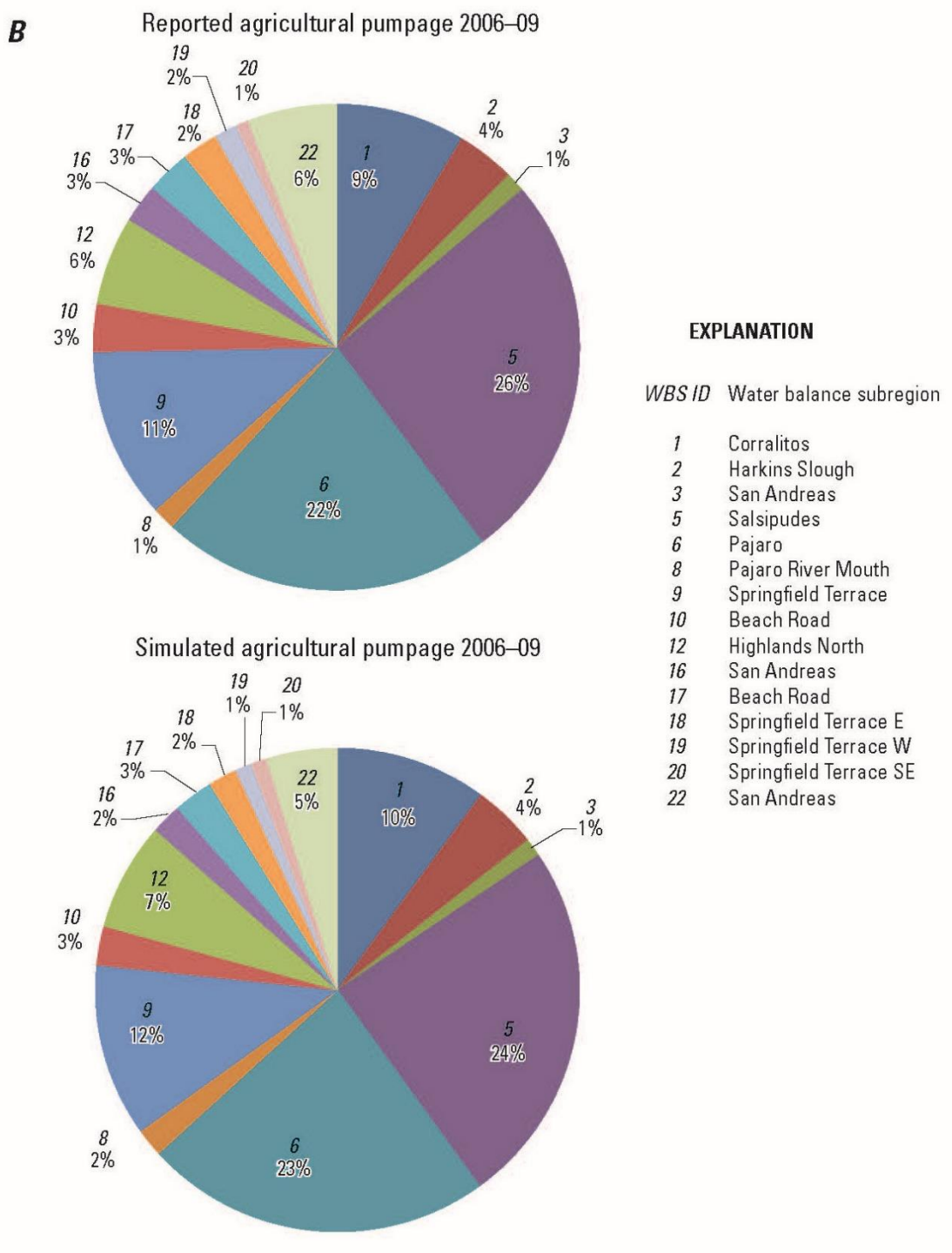
Simulated water supply



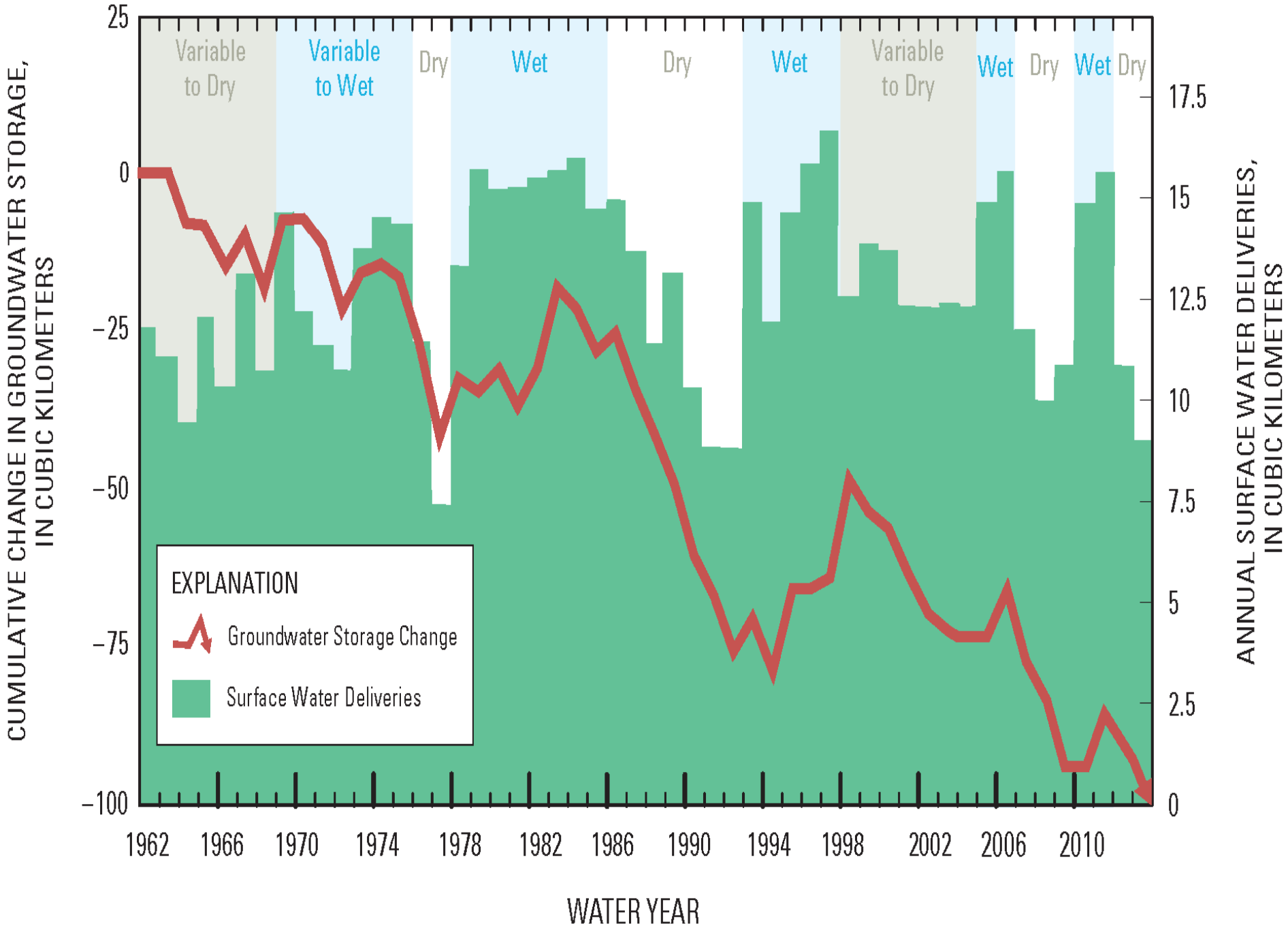
Simulated water demand



Comparing simulated and reported pumping – annual totals



Comparing simulated and reported pumping – by subregion



Combining budget types can help understand effects

References – MODFLOW and Tools

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