Integrated Water Flow Model (IWFM): A Tool for Effective Water Budgeting in Support of SGMA

CWEMF Annual Meeting

Folsom, California

April 11 – 13, 2016

Can Dogrul

California Department of Water Resources

SGMA Draft GSP Emergency Regulations (February 18, 2016)

§ 354.18. Water Budget

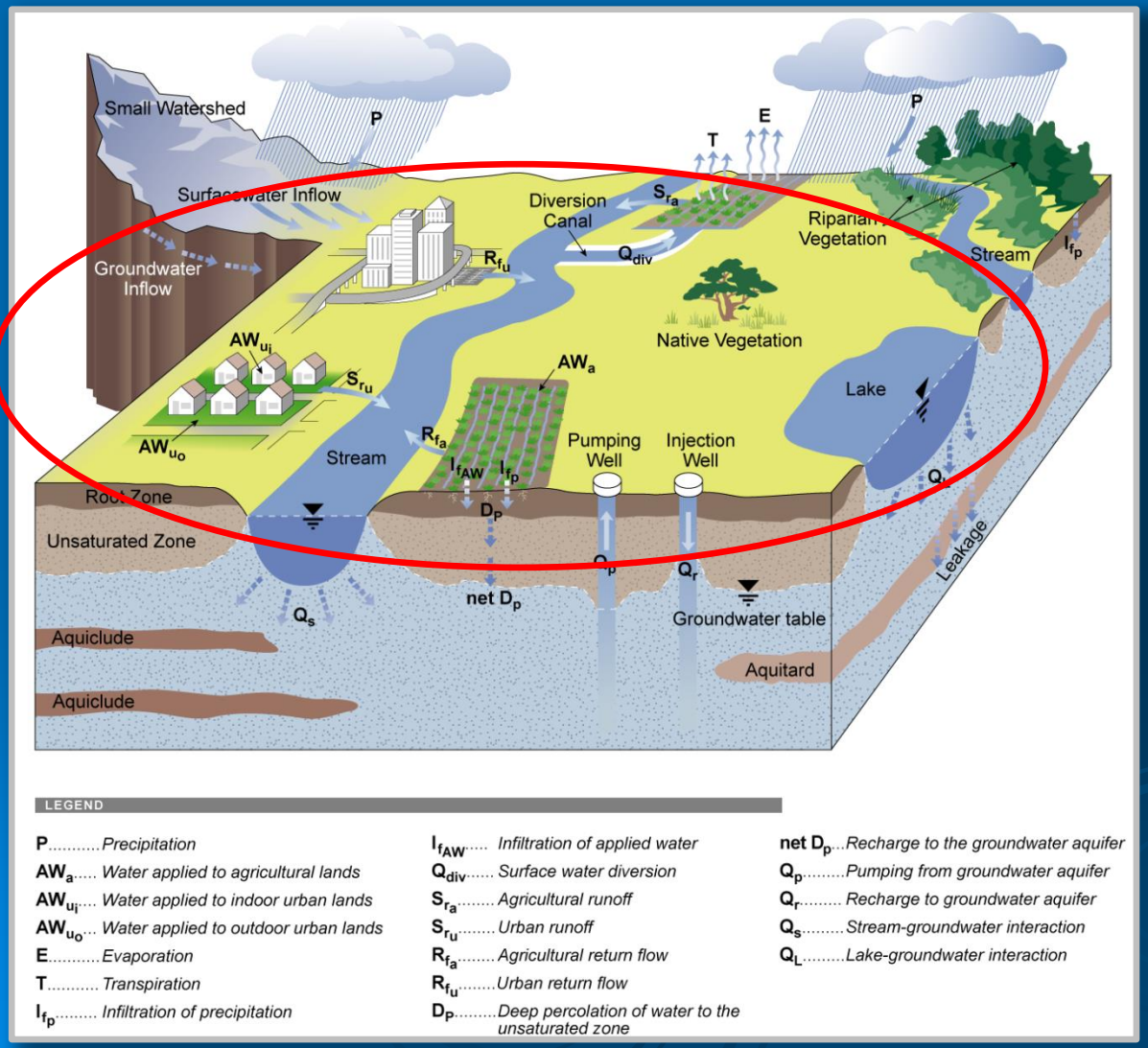
- "*The Plan shall include a water budget for the basin … annual amount of groundwater and surface water entering and leaving the basin, including historical, current and projected water budget conditions …*"

- *" … water budget shall quantify …"*
  - ✓ All inflows (infiltration of precipitation, infiltration of applied water and from surface water system; subsurface groundwater inflow, etc.)
  - ✓ All outflows (ET, groundwater extraction, losses to streams, subsurface groundwater outflow, etc.)
  - ✓ Change in annual volume of groundwater storage

Undesirable Results in SGMA

- Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply
- Significant and unreasonable reduction of groundwater storage
- Significant and unreasonable seawater intrusion
- Significant and unreasonable degraded water quality
- Significant and unreasonable land subsidence
- Surface water depletions that have significant and unreasonable adverse impacts on beneficial uses of the surface water

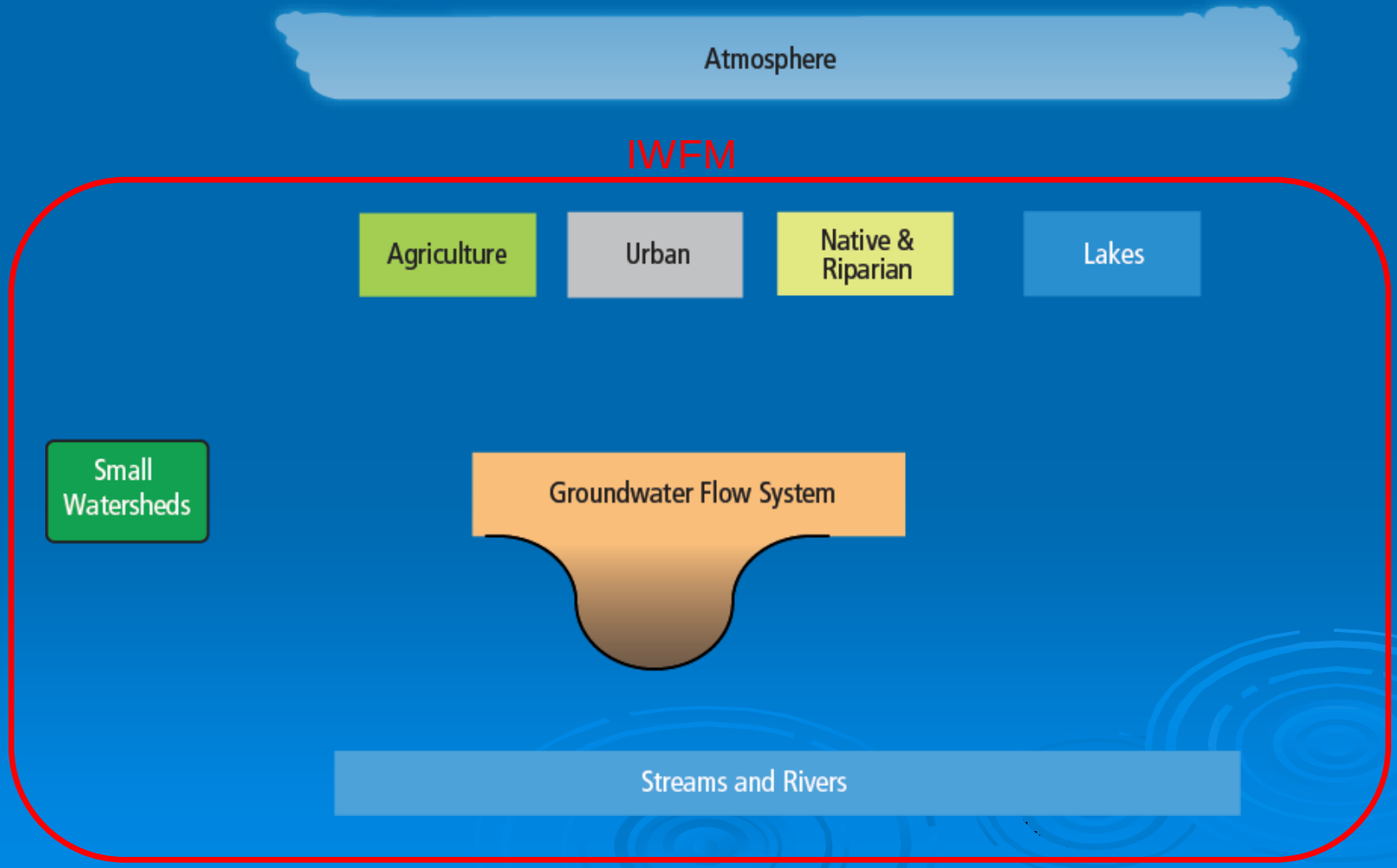
Integrated Water Flow Model (IWFM)



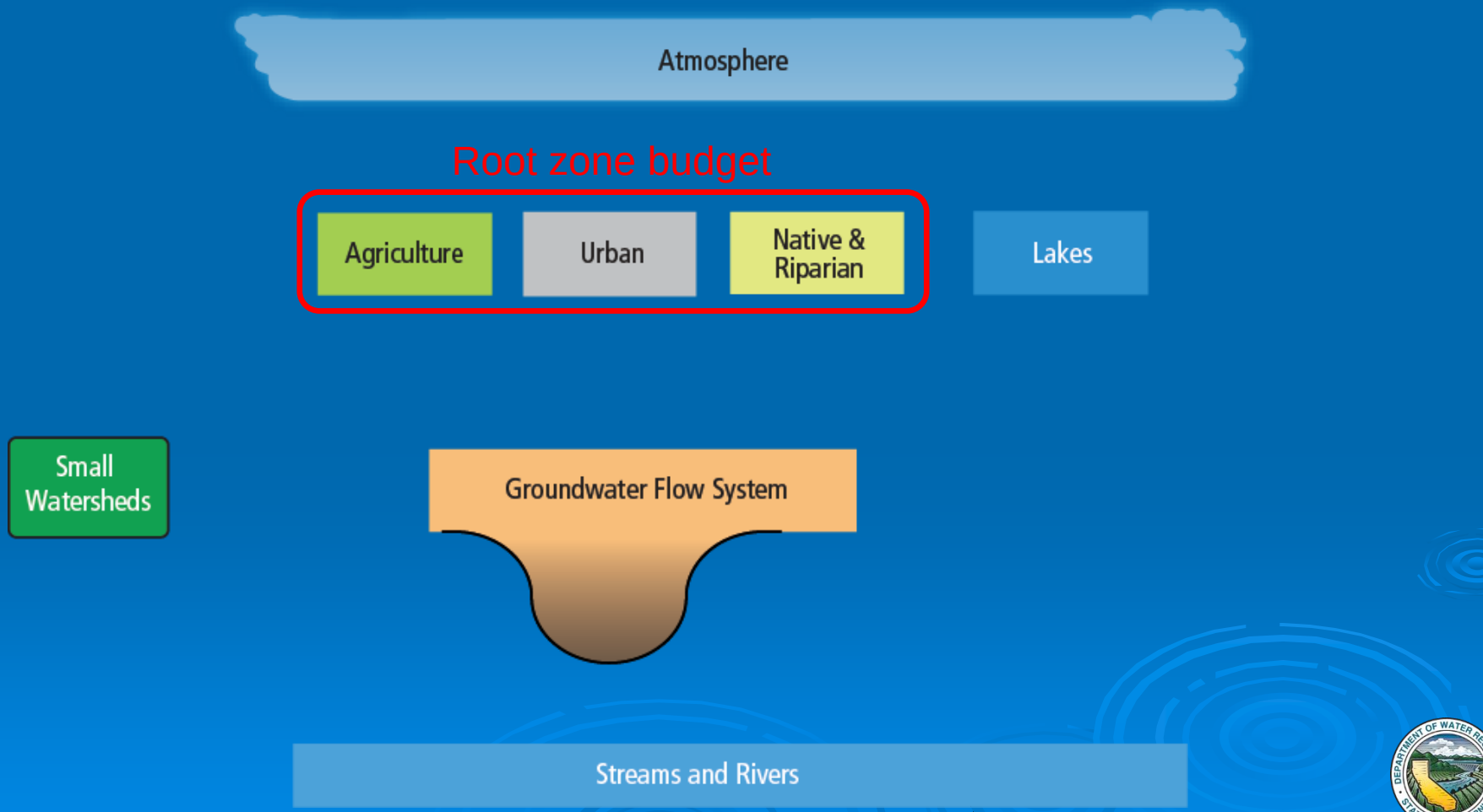
Budget Files Generated by IWFM

- Extensive water budget output for all simulated hydrologic components:
  - Groundwater budget
  - Stream flow budget
  - Root zone budget
  - Land and water use budget (comparison of water demand and supply)
  - Unsaturated zone budget
  - Lake budget
  - Small watershed budget (ungauged watersheds contributing surface and subsurface boundary inflows)

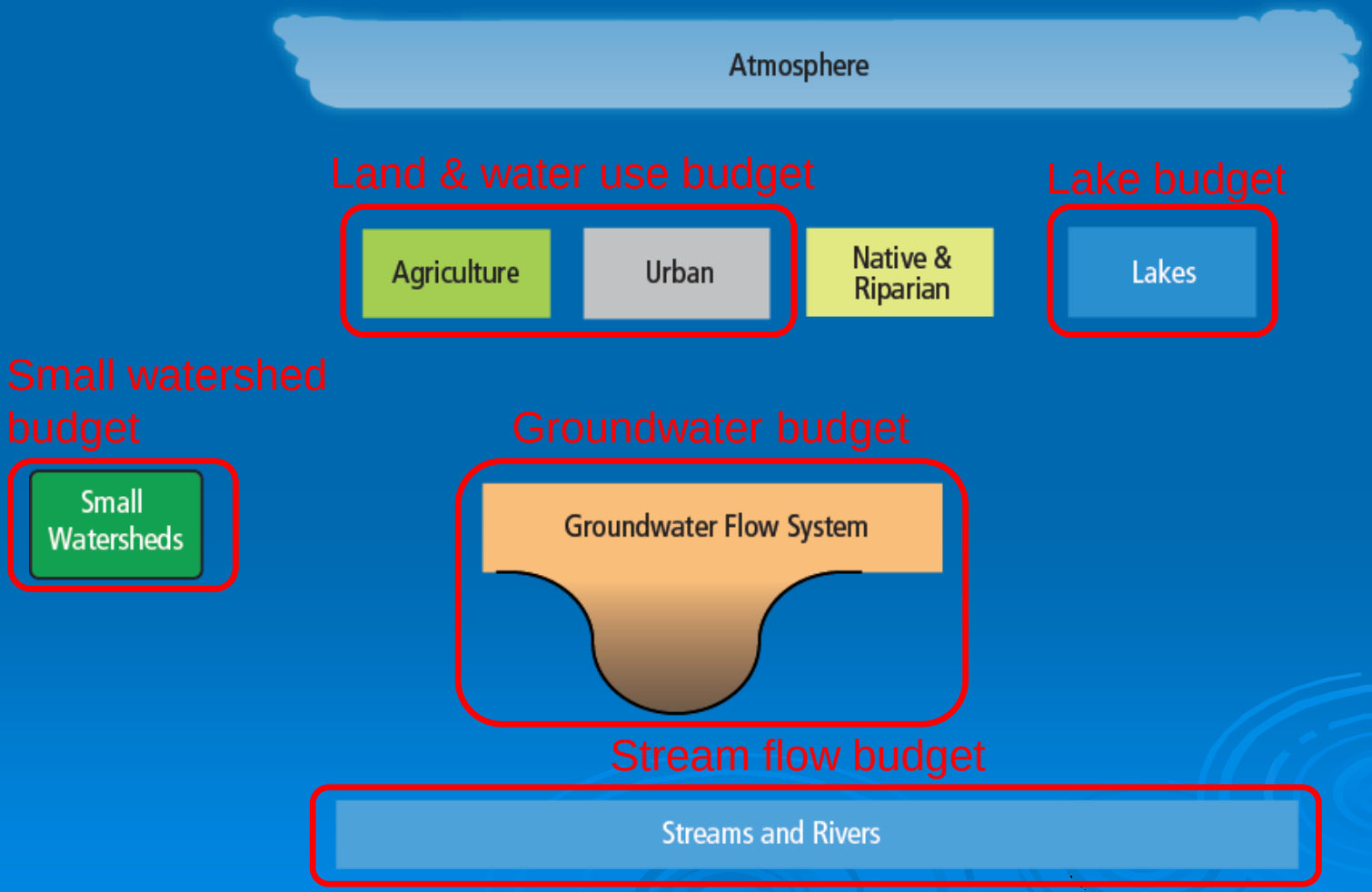
Water Budgets in IWFM



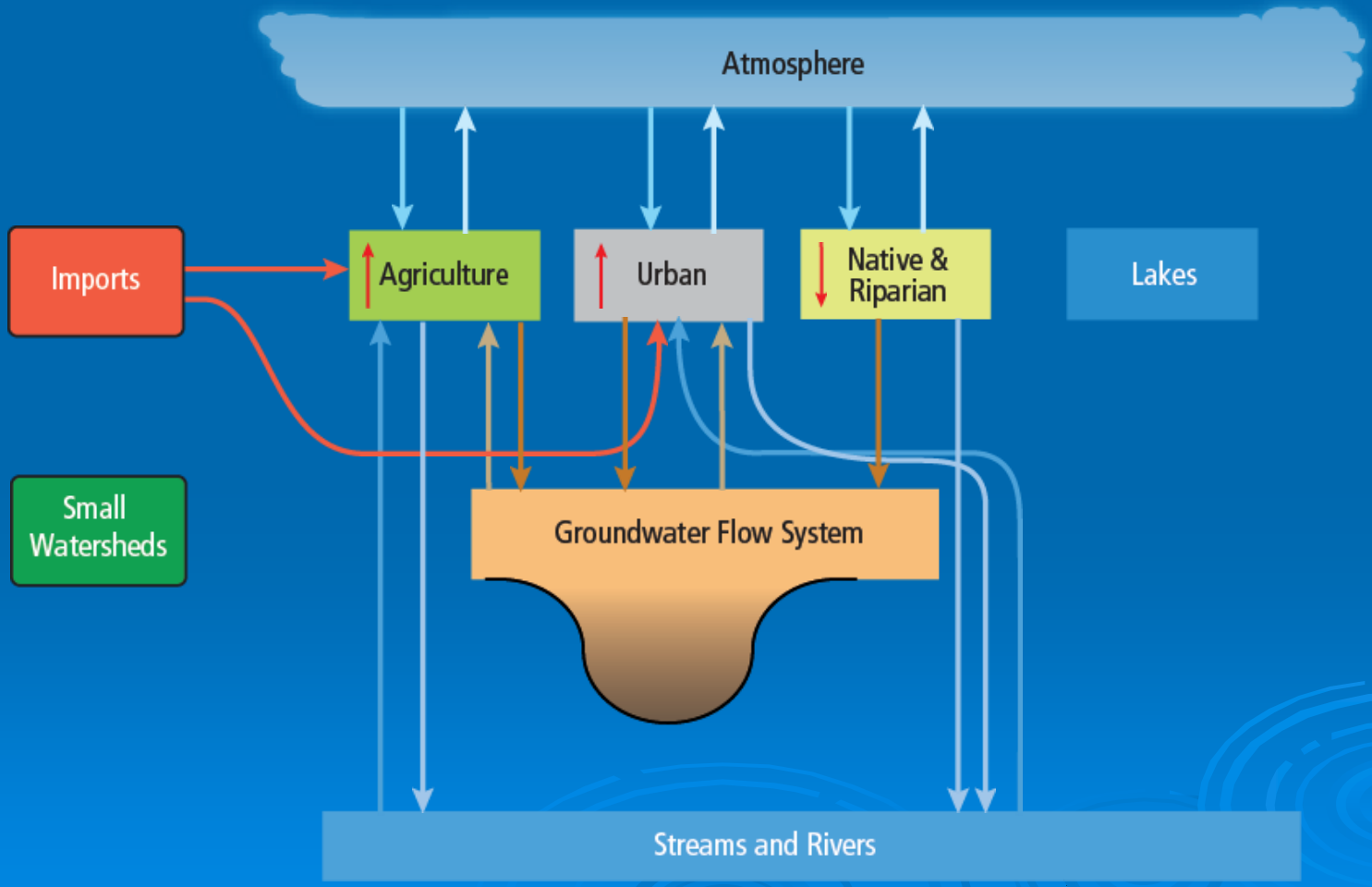
Water Budgets in IWFM



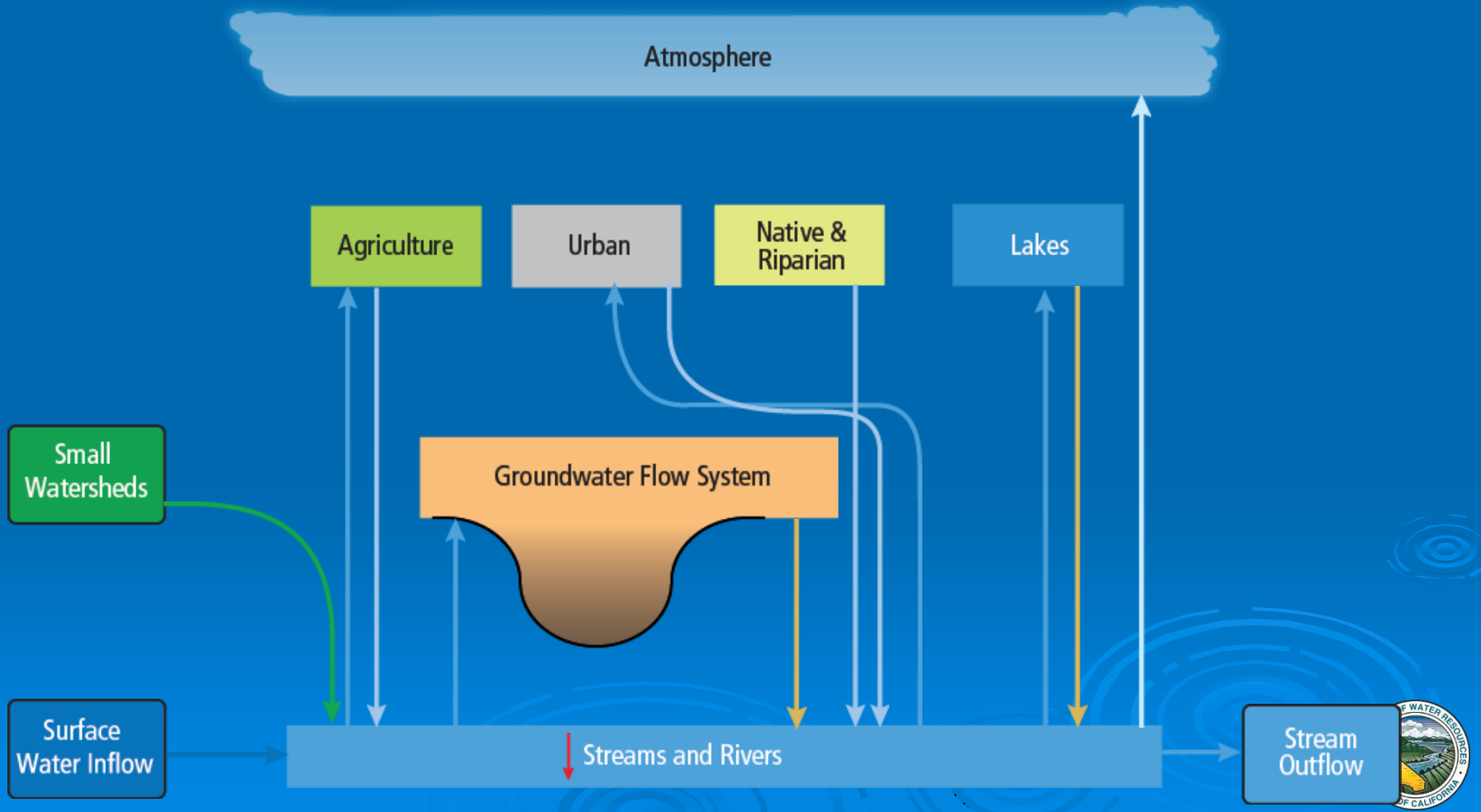
Water Budgets in IWFM



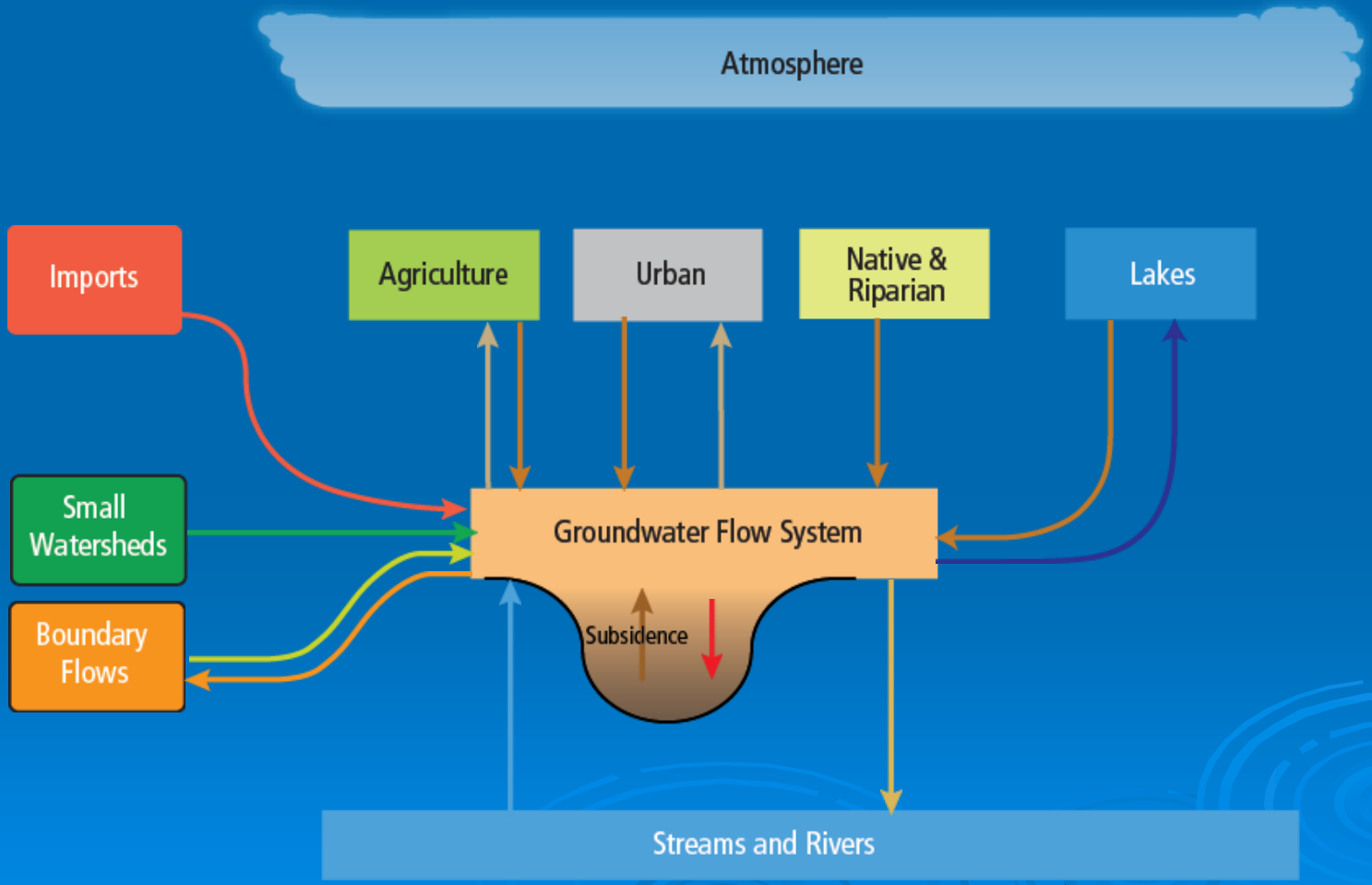
Root Zone Budget



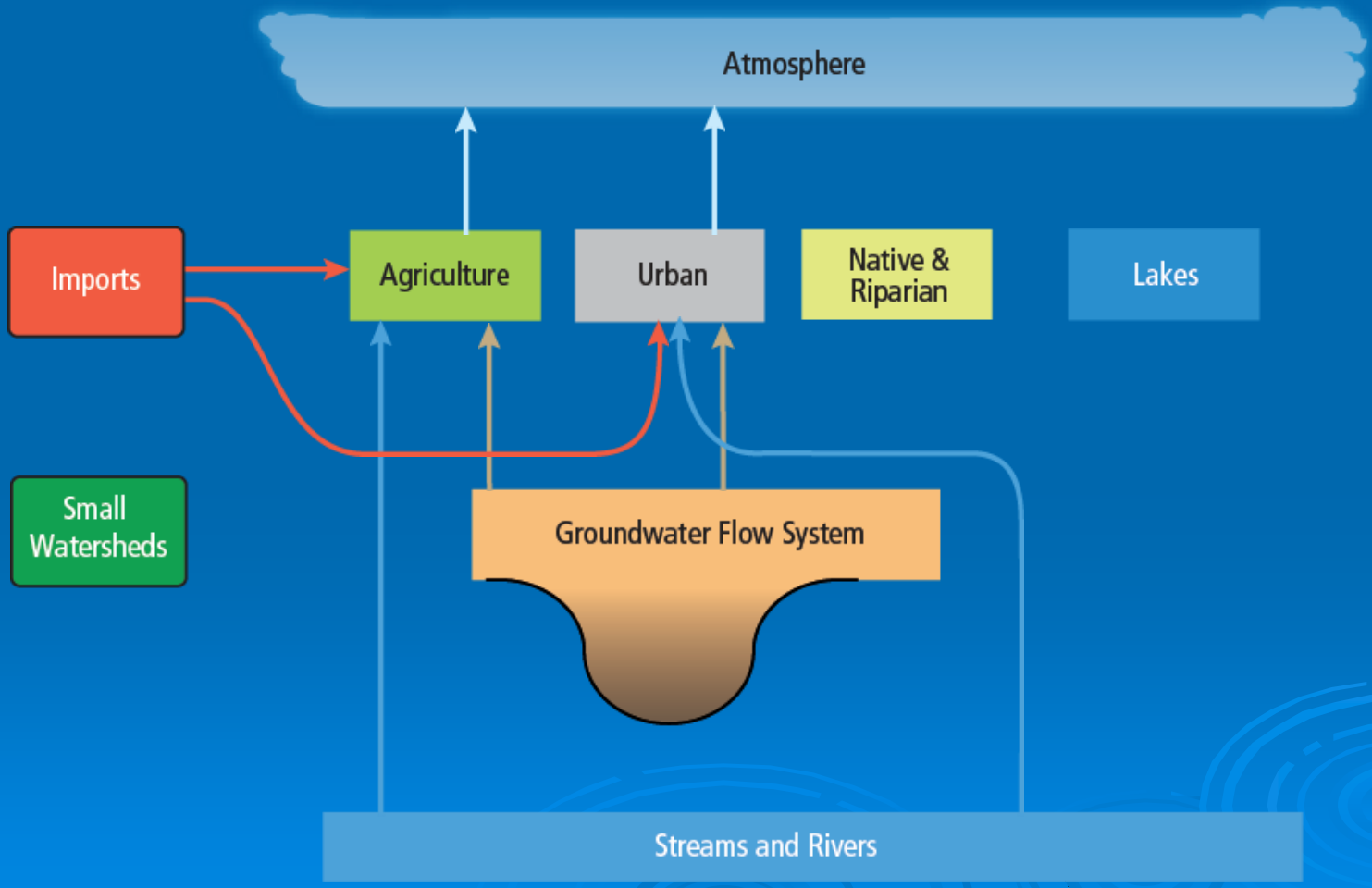
Stream Flow Budget



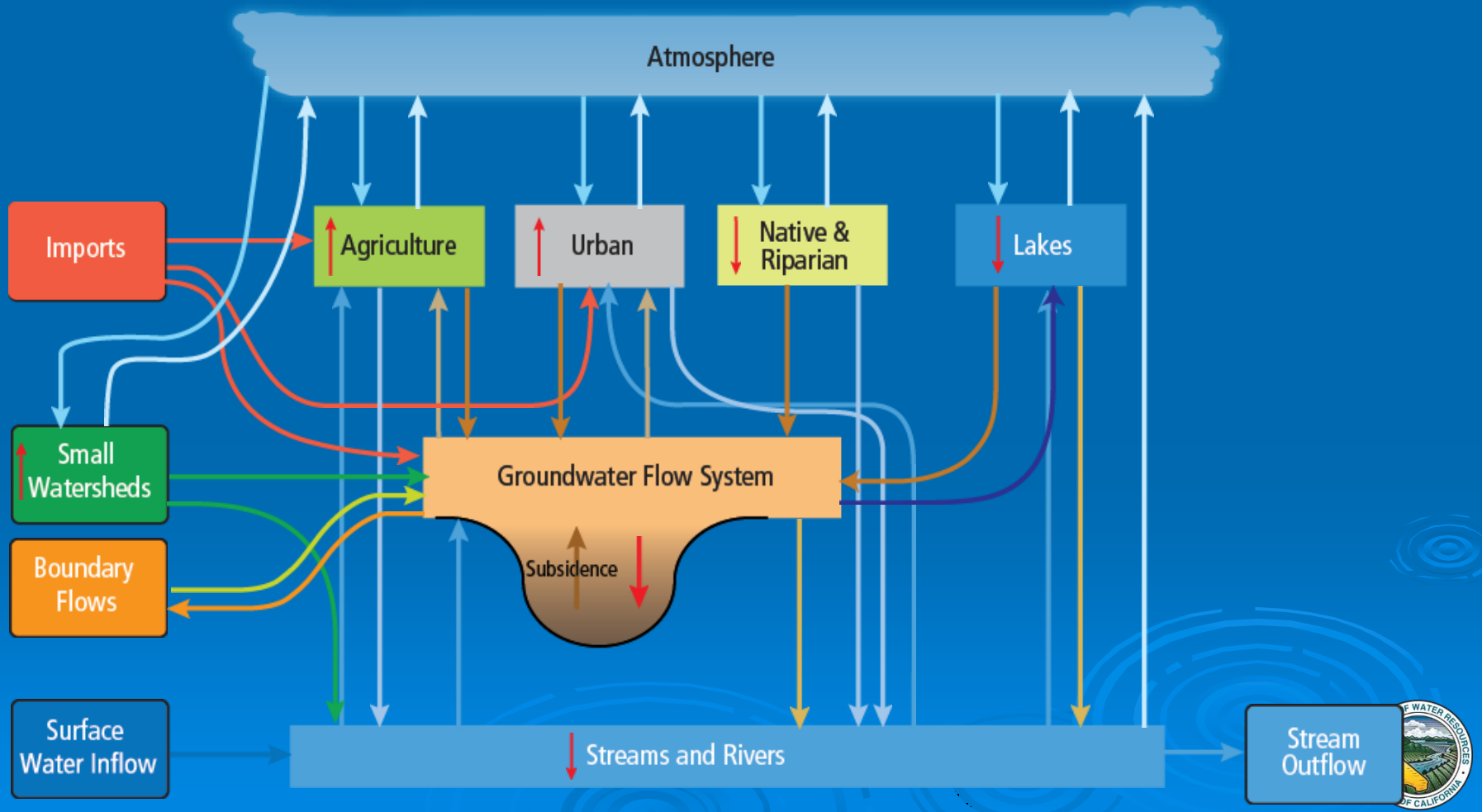
Groundwater Budget



Land & Water Use Budget

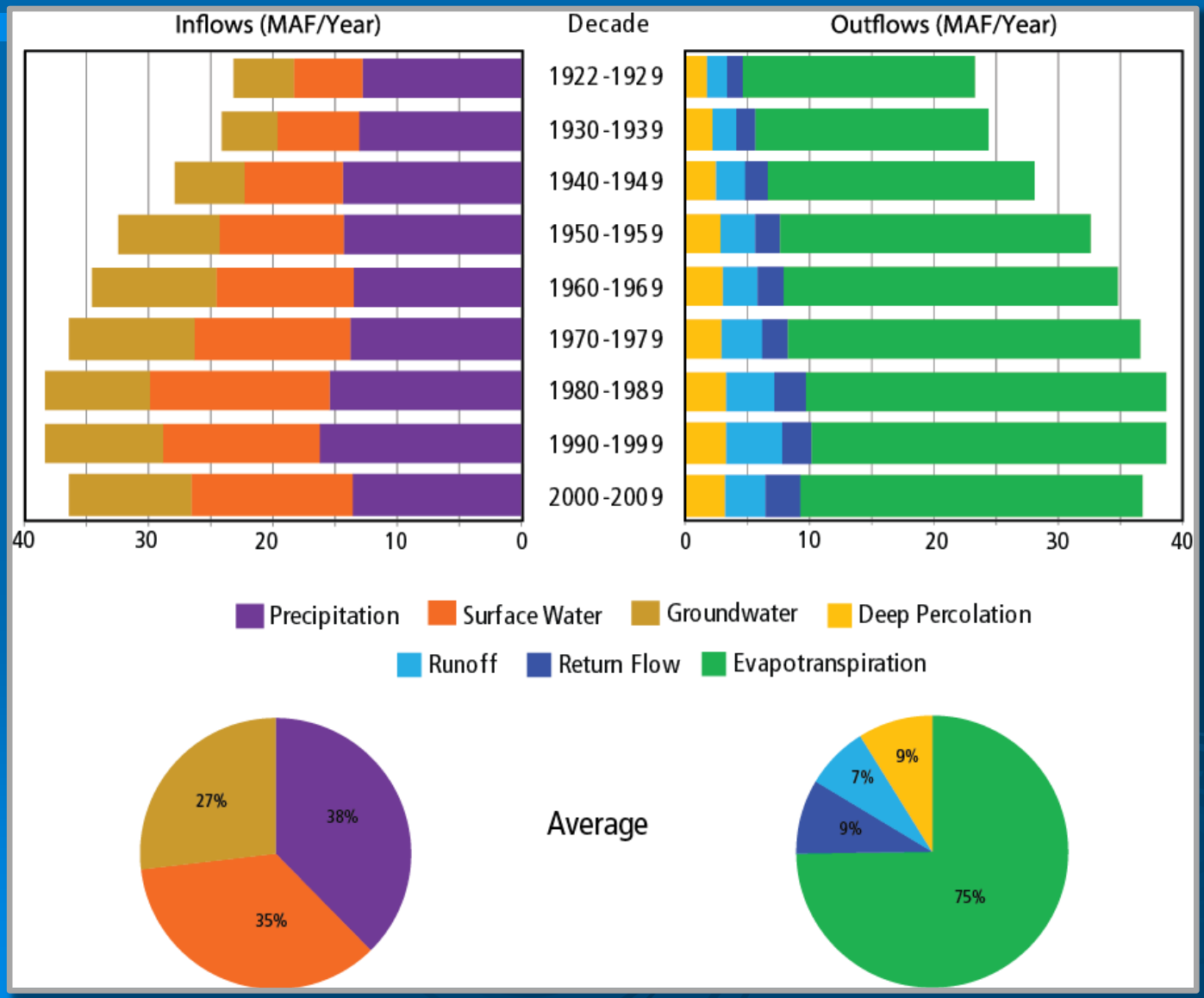


Water Budgets in IWFM



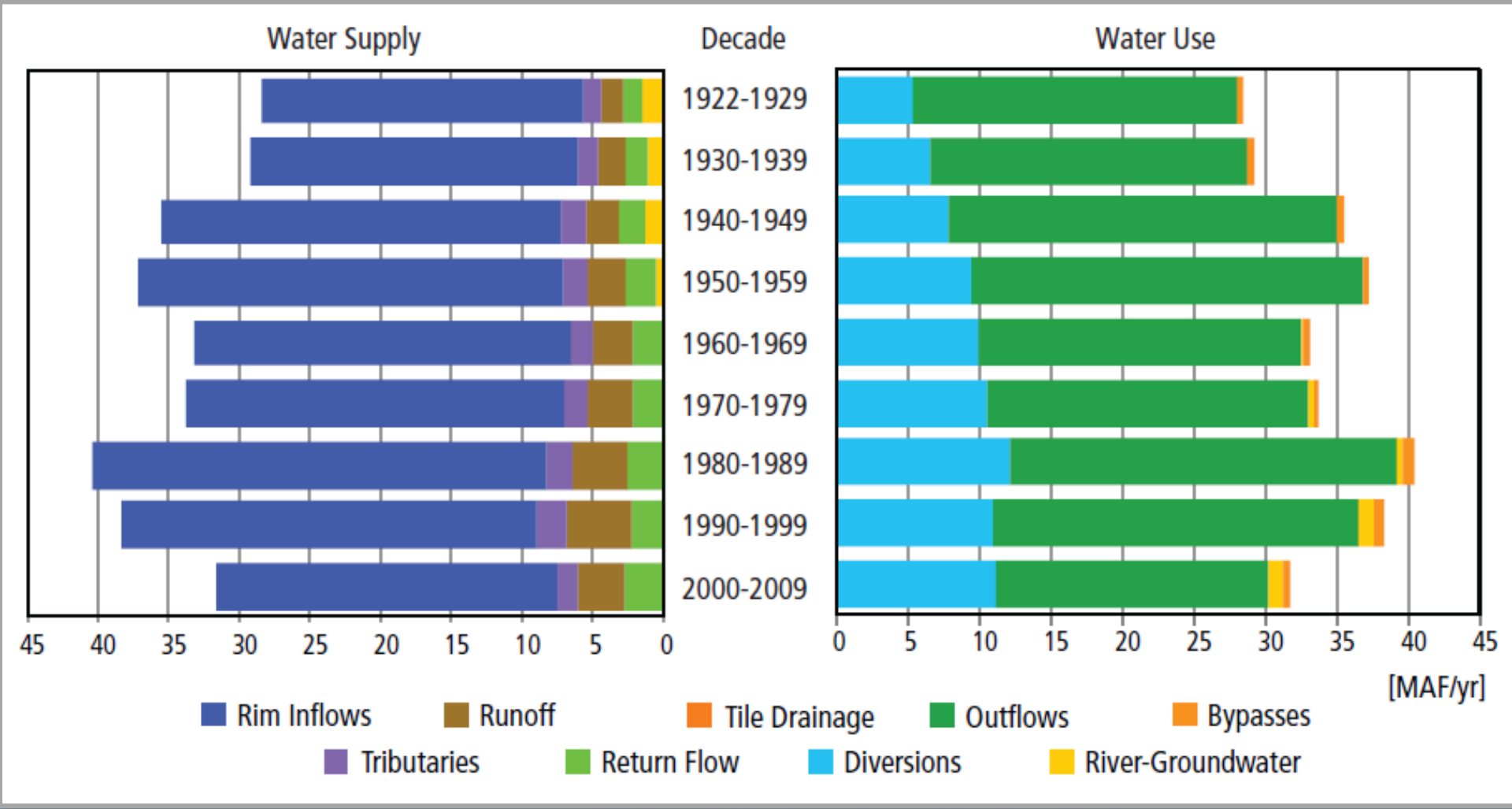
Example: Root Zone Budget

(*Source: DWR C2VSim Technical Memorandum*)



Example: Stream Flow Budget

(*Source: DWR C2VSim Technical Memorandum*)



Example: Groundwater Budget

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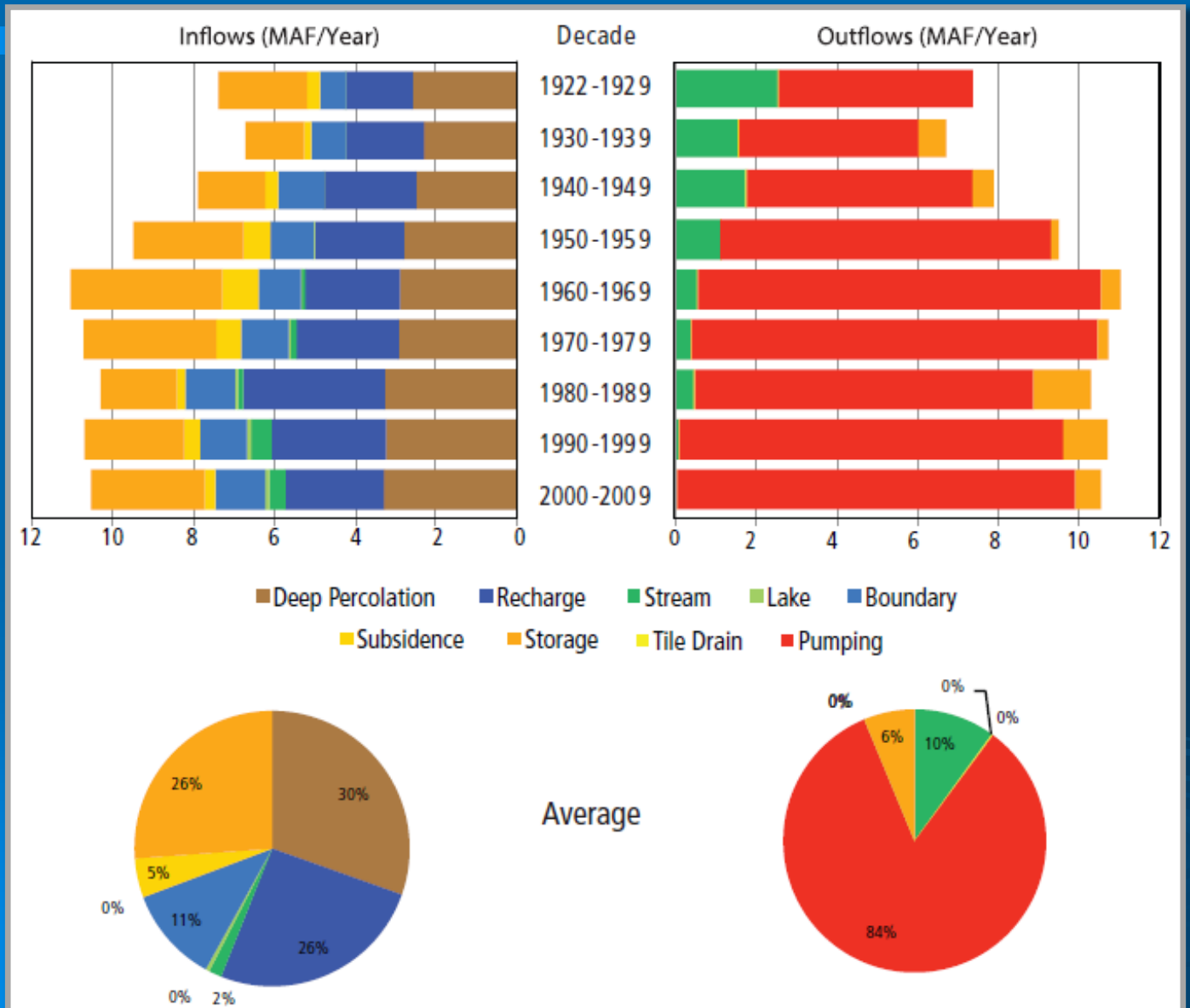
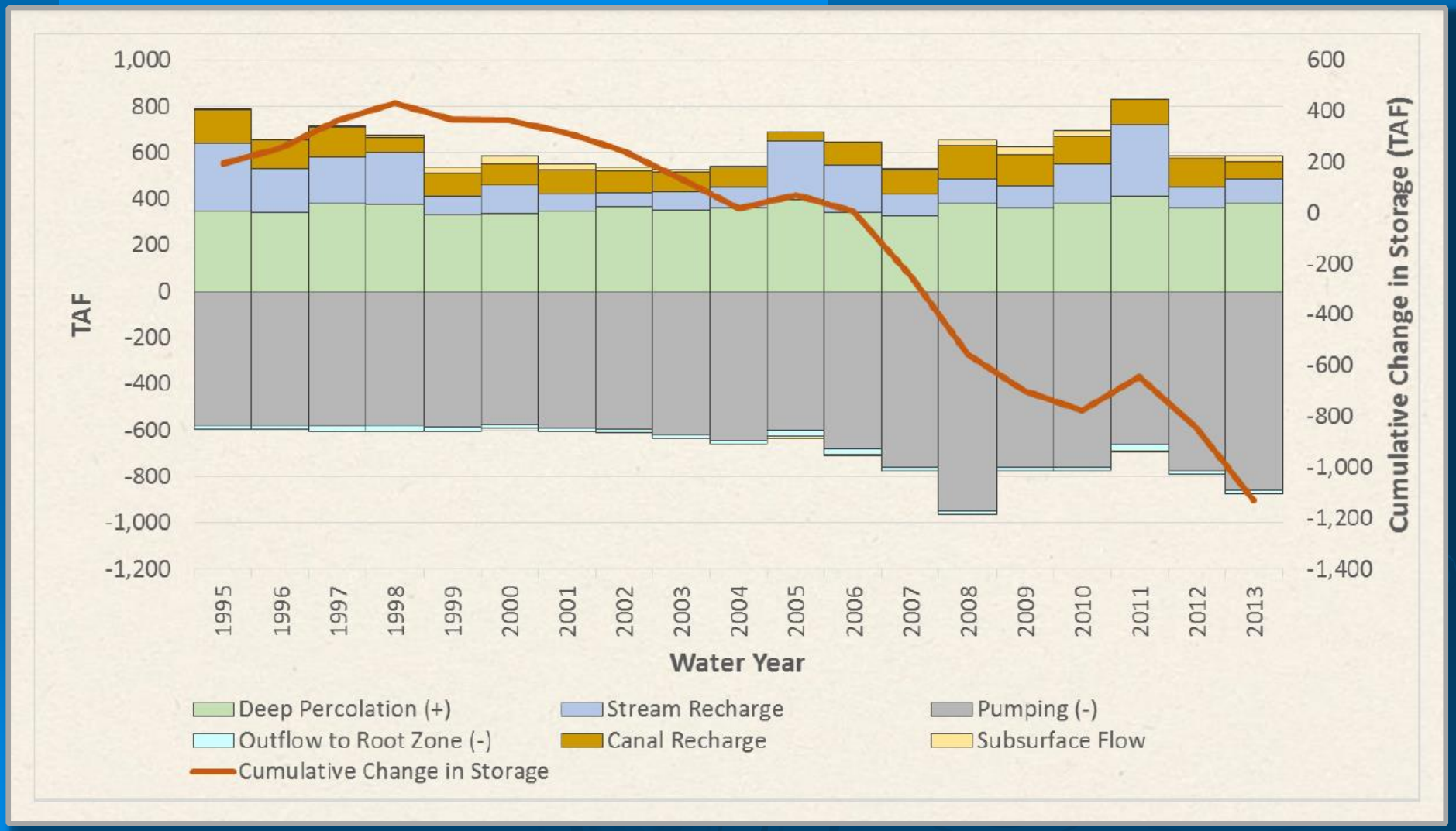


Example: Groundwater Budget

(*Source: Draft MAGPI Model; courtesy of RMC Water and Environment*)



Example: Groundwater Flows between Regions

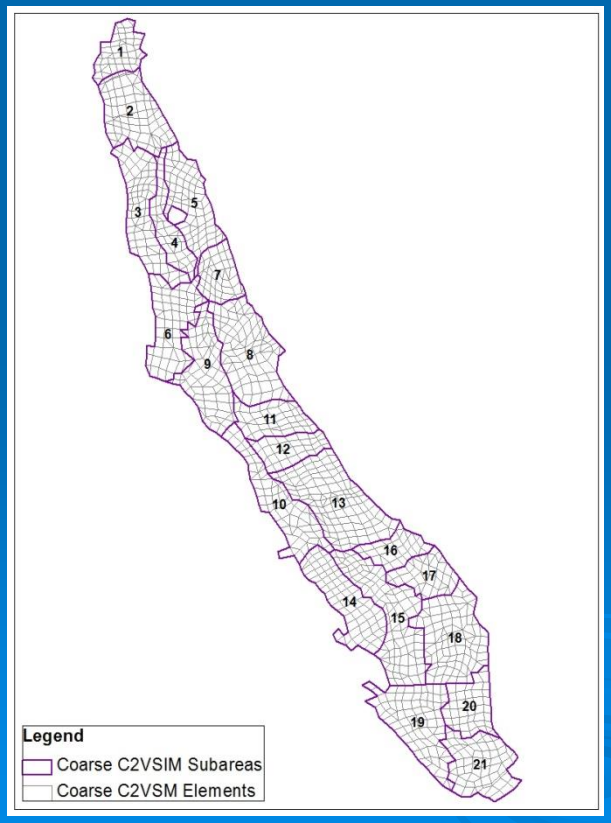
Water Budgets in IWFM

- Use of clear terminology
- Consistent terminology among budget tables
- Consistent units among budget tables
- Inflows to and outflows from a hydrologic component are clearly designated using “+” (inflows) and “–” (outflows)
- Easy to traverse between budget tables to track water within the system
- Post-processing tools available to import budget tables into Excel for effective analysis and visualization

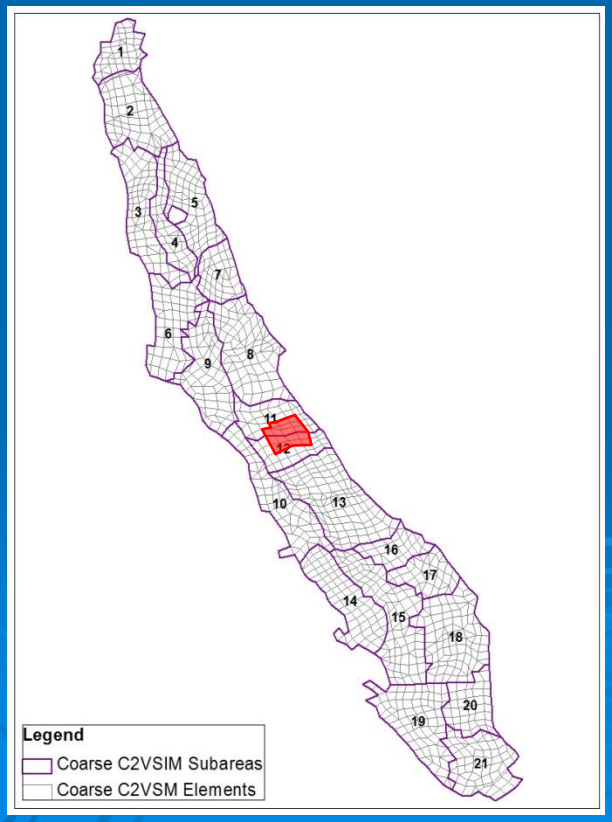
Planned Updates for Water Budgets

- Implement Z-Budget outputs for hydrologic processes other than groundwater

Budget
(for pre-defined subregions)



Z-Budget
(for arbitrary cell collections)



Thank You!

IWFM ROOT ZONE PACKAGE (v3.02.0096)

ROOT ZONE MOISTURE BUDGET IN ac.ft. FOR DSA 58 (SR1)

SUBREGION AREA: 328274.82 ac.

Agricultural Area

Beginning Storage (+)	Net Gain from Land Expansion (+)	Infiltration (+)	Other Inflow (+)	Actual ET (-)	Deep Percolation (-)	Ending Storage (-)	Discrepancy (=)
2900.7	0.0	4461.5	0.0	4353.9	126.4	2881.8	0.0
2881.8	0.0	1428.7	0.0	2118.5	32.2	2159.9	-0.0
2159.9	0.0	1500.0	0.0	1390.5	69.4	2200.0	0.0
2200.0	0.0	1661.8	0.0	1293.8	144.5	2423.5	0.0
2423.5	0.0	1606.4	0.0	1981.2	53.4	1995.3	0.0
1995.3	0.0	4271.1	0.0	3593.0	165.0	2508.5	0.0
2508.5	0.0	16211.4	0.0	5150.7	8985.1	4584.0	0.0
4584.0	0.0	17560.9	0.0	6656.6	10814.8	4673.5	0.0
4673.5	0.0	16513.2	0.0	8553.0	8098.0	4535.8	-0.0
4535.8	0.0	18395.8	0.0	9166.6	9170.7	4594.4	-0.0
4594.4	0.0	17032.0	0.0	7713.3	9311.2	4601.8	-0.0
4601.8	0.0	16713.8	0.0	6004.8	10645.2	4665.6	-0.0
4665.6	23.6	7811.1	0.0	4662.1	3288.1	4550.2	-0.0
4550.2	0.0	1291.7	0.0	2268.4	215.8	3357.6	-0.0
3357.6	0.0	1495.7	0.0	1516.4	176.9	3160.0	0.0
3160.0	0.0	1601.4	0.0	1391.1	212.8	3157.5	0.0
3157.5	0.0	1393.1	0.0	2208.0	29.7	2312.8	-0.0
2312.8	0.0	4573.6	0.0	3936.4	157.4	2792.6	0.0
2792.6	0.0	6108.5	0.0	5568.4	234.9	3097.8	-0.0
3097.8	0.0	16593.9	0.0	7045.2	7679.7	4966.7	0.0
4966.7	0.0	18102.6	0.0	9148.5	8877.4	5043.4	0.0
5043.4	0.0	18862.6	0.0	9771.8	9079.3	5054.8	-0.0
5054.8	0.0	18996.1	0.0	8233.9	10676.6	5140.3	0.0
5140.3	0.0	16781.2	0.0	6380.3	10413.8	5127.5	-0.0
5127.5	-330.0	13379.1	0.0	4362.0	8992.0	4822.6	-0.0
4822.6	0.0	792.8	0.0	2122.4	221.4	3271.5	0.0
3271.5	0.0	1341.4	0.0	1418.8	151.9	3042.2	0.0

Root Zone Budget

Agricultural Area

Beginning Storage (+)	Net Gain from Land Expansion (+)	Infiltration (+)	Other Inflow (+)	Actual ET (-)	Deep Percolation (-)	Ending Storage (-)

Unsaturated Zone Budget

IWFM (v2015.0.0432)
UNSATURATED ZONE BUDGET IN ac.ft. FOR DSA 58 (SR1)
SUBREGION AREA: 328274.82 ac.

Time	Beginning Storage (+)	Ending Storage (-)	Deep Percolation (+)	Net Deep Percolation (-)	Discrepancy (=)

Groundwater Budget

IWFM (v2015.0.0432
GROUNDWATER BUDGET IN ac.ft. FO
SUBREGION AREA: 328274.

Beginning Storage (+)	Ending Storage (-)	Net Deep Percolation (+)	Gain from Stream (+)	Recharge (+)	Gain from Lake (+)	Boundary Inflow (+)

Stream Flow Budget

IWFM STREAM PACKAGE (v4.0.0075)
STREAM FLOW BUDGET IN ac.ft FOR REACH 1

Tributary Inflow (+)	Tile Drain (+)	Runoff (+)	Return Flow (+)	Gain from Groundwater (+)	Gain from Lake (+)	Riparian ET (-)