Calsim-II

Hydrology Development for the Sacramento Valley

Andy Draper
MWH

CalSim III Development
October 08, 2004

Outline

- Overview
- Water Demands
- Water Supplies
- Groundwater
- ! Potential Issues

Overview

CalSim-II

Modeling Approach

Hydrology Development

Area Represented by Hydrology

Representation in CalSim II

CalSim-II

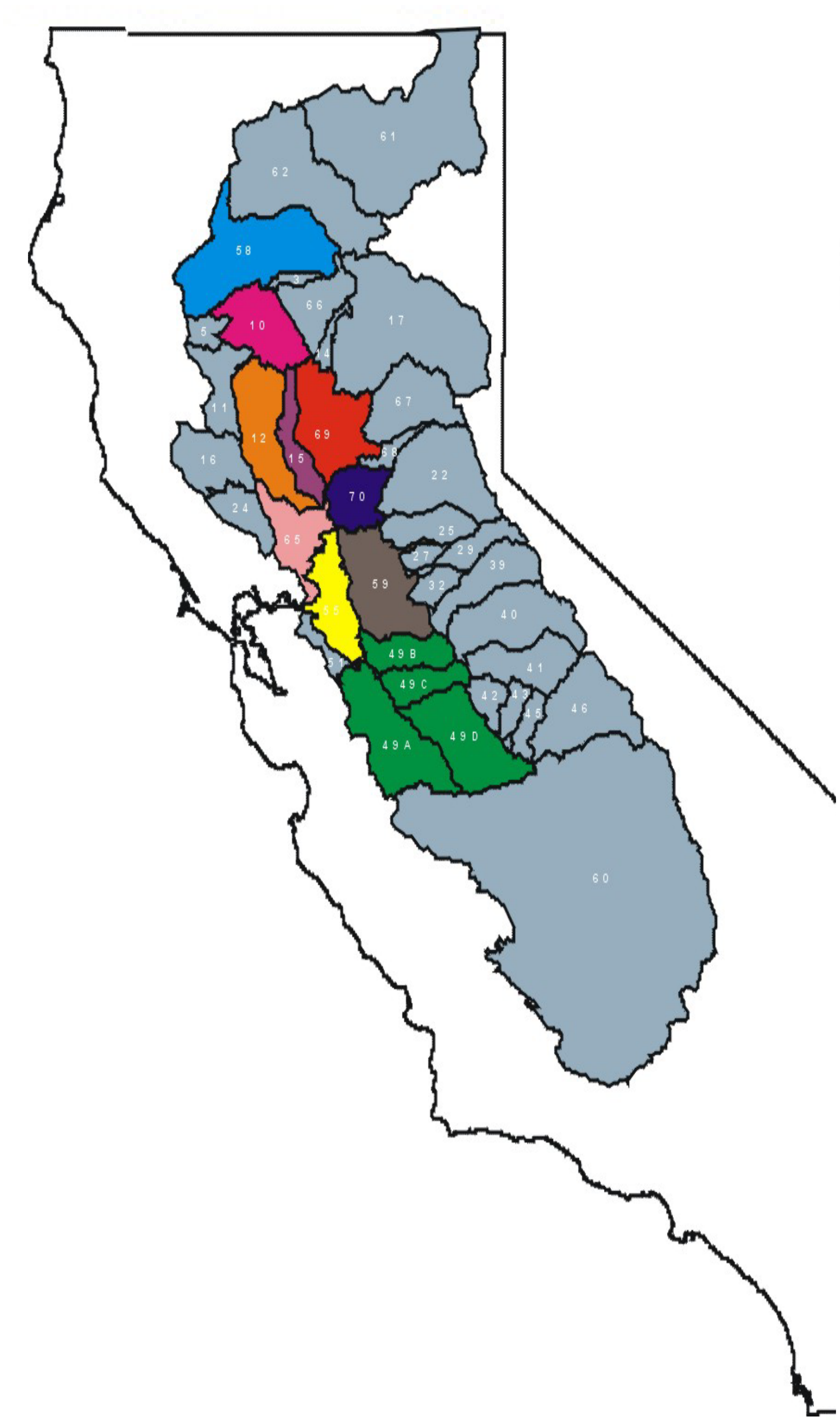
- Application of CalSim software to the CVP/SWP
- Represents the drainage basin of the Sacramento-San Joaquin Delta
- Primary purpose to estimate water supply reliability of the projects at a current or future level of development, with or without new facilities, regulations, or modes of operation.

Modeling Approach

- Use adjusted historical hydrology (based on historical period 1922-1994) to represent probable range of hydrologic conditions
- Assume temporal and spatial distribution of precipitation same as historical
- Modify historical stream flows for impacts of land use change and upstream flow regulation
- Assume static land use, fixed water supply contracts and regulatory requirements for each year of simulation

Hydrology Development

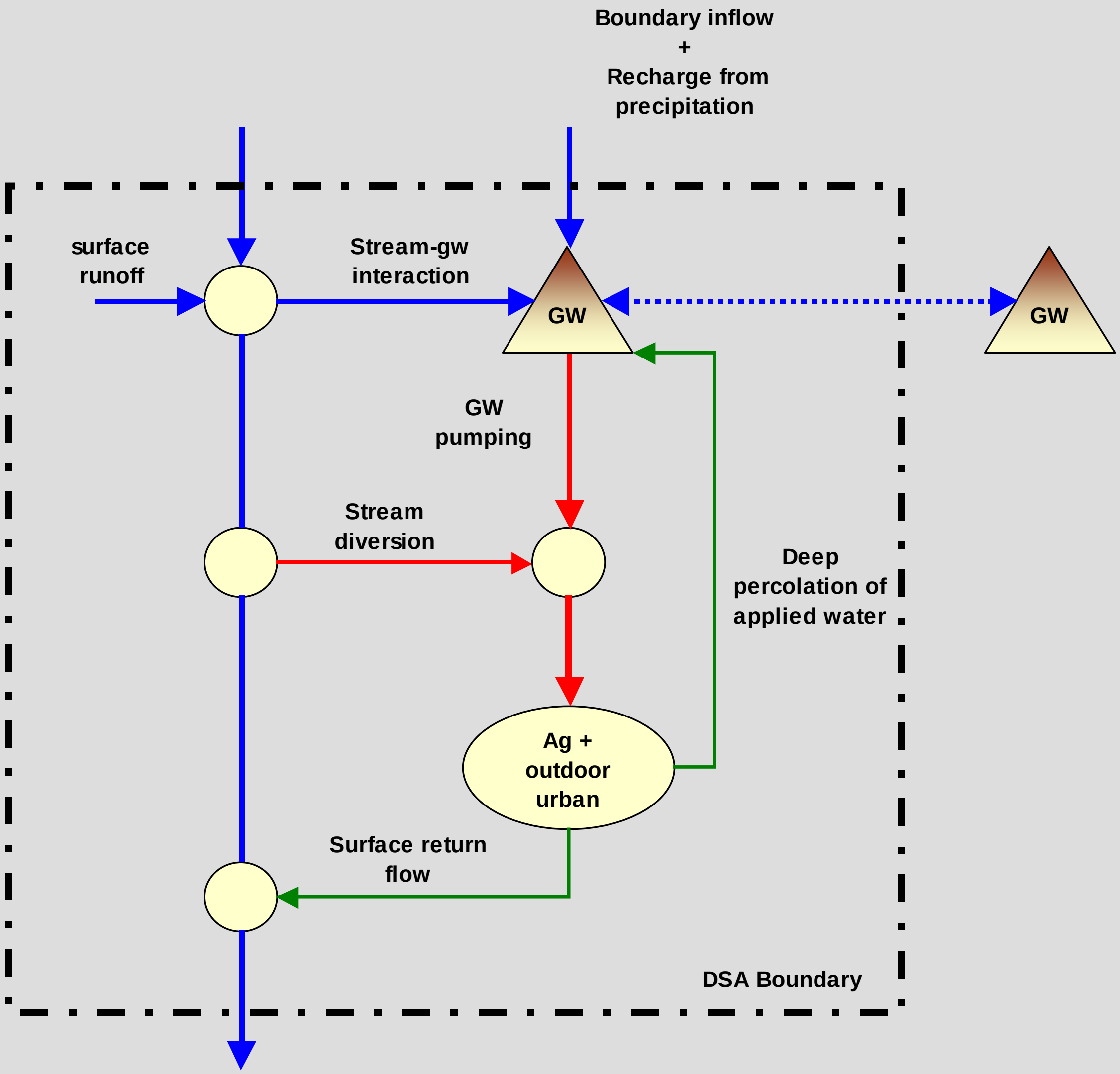
- Joint hydrology (DWR & Reclamation)
- No single common approach
- Land use based hydrology
  - Sacramento Valley
- Hydrology based on historical supplies, historical demands and contract amounts
  - San Joaquin Valley
  - South of Delta project demands



Area Represented by Hydrology

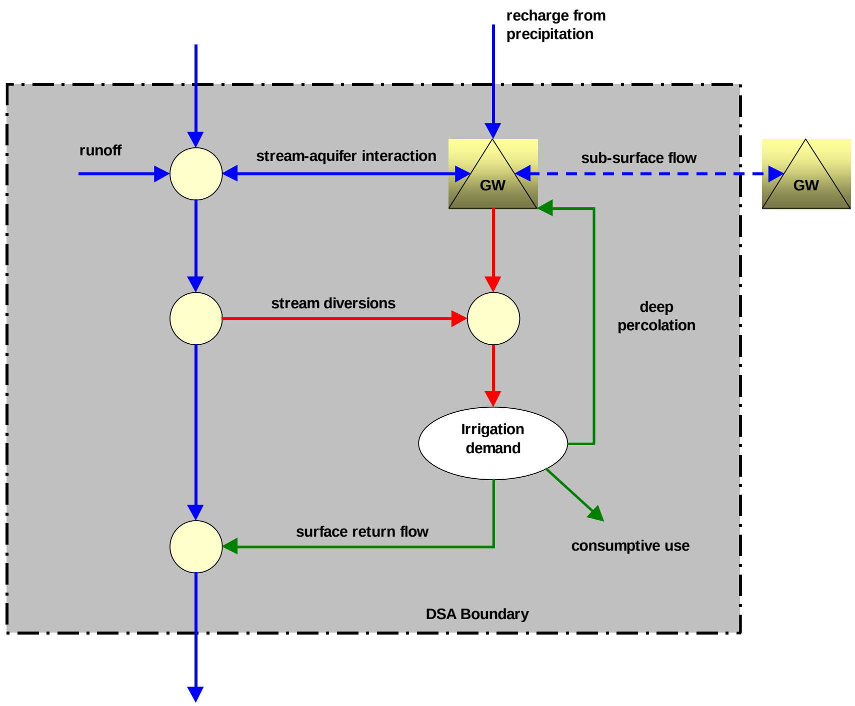
- Rim DSAs (in gray)
  - represented indirectly
  - preprocessed inflow to CalSim II
- Valley floor DSAs (in color)
  - represented directly by series of nodes and arcs
  - Dynamically simulated
- ! DSA represents spatial resolution of the model

Representation of Sacramento Valley in CalSim II

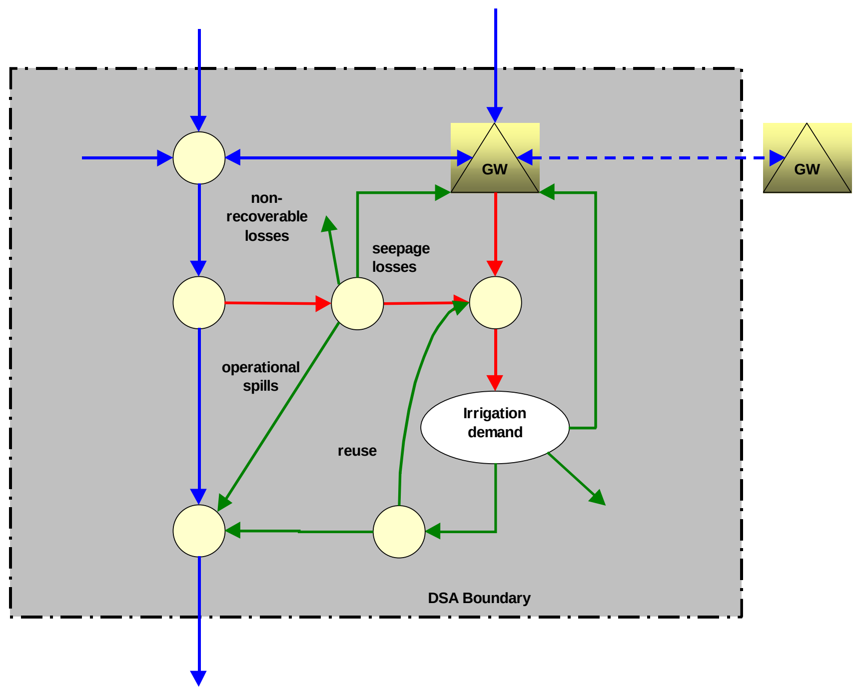


Explicit Representation of Flow Paths

Existing



Proposed



Land-Use Based Demands

Demand Sectors
Consumptive Use Model
CU Model Input and Output
CU Model Assumptions
CU Model Issues
Components of Demand
Efficiencies
Project vs Non-Project

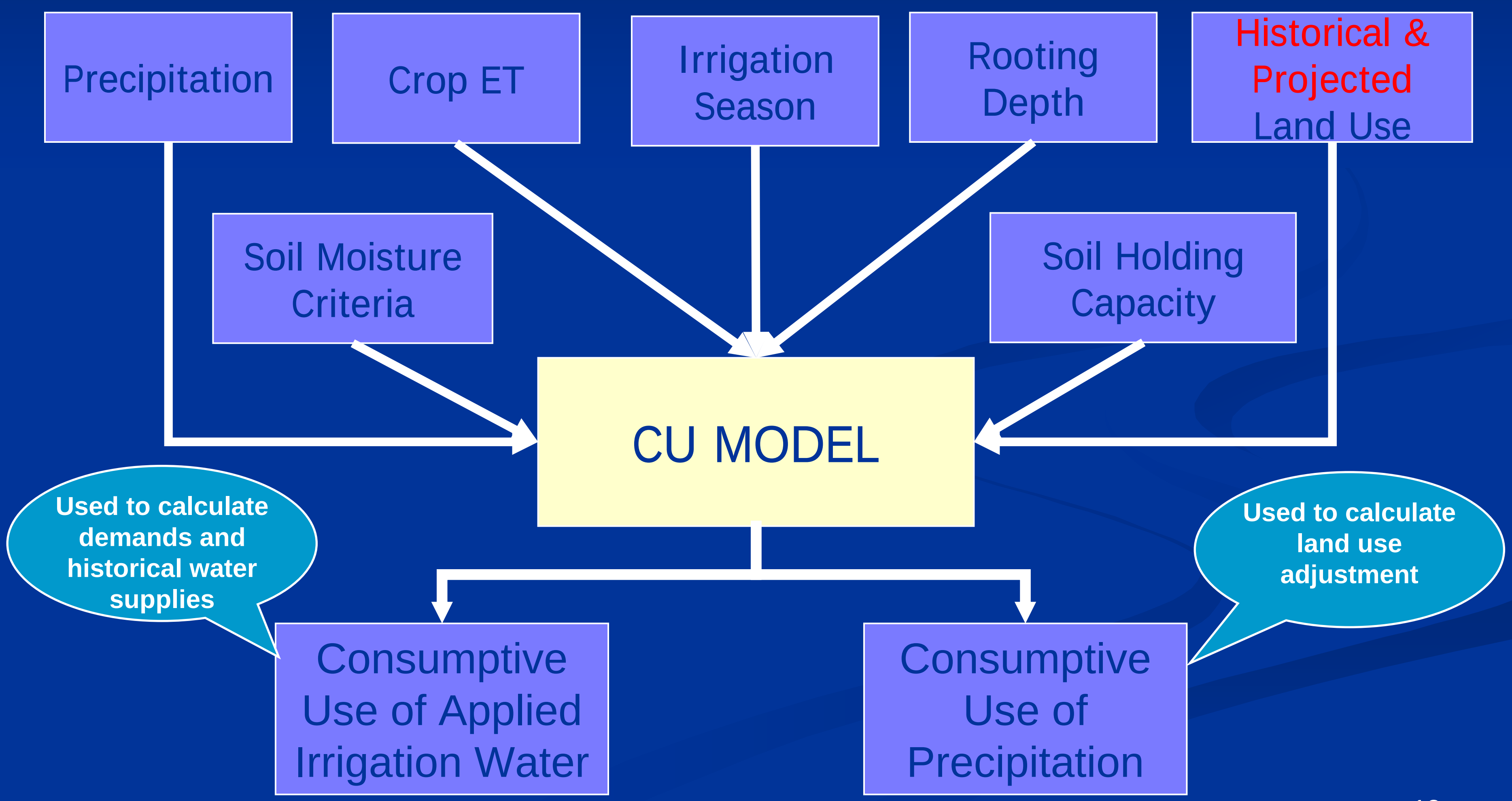
Demand Sectors

- Sectors
  - Irrigated agriculture
  - Outdoor urban (irrigated landscape)
  - Indoor urban (residential, commercial, industrial)
  - Wildlife refuges
  - Environment (min. instream flow requirements)
- ! Outdoor urban aggregated with agriculture
- ! Indoor urban generally not modeled

Consumptive Use Model

- Used to calculate historical and projected monthly water use
- Considers four land use classifications
  - Irrigated agricultural (13 crop types)
  - Urban (lawns, vacant lots, hard top)
  - Native vegetation
  - Riparian vegetation

CU Model Input & Output



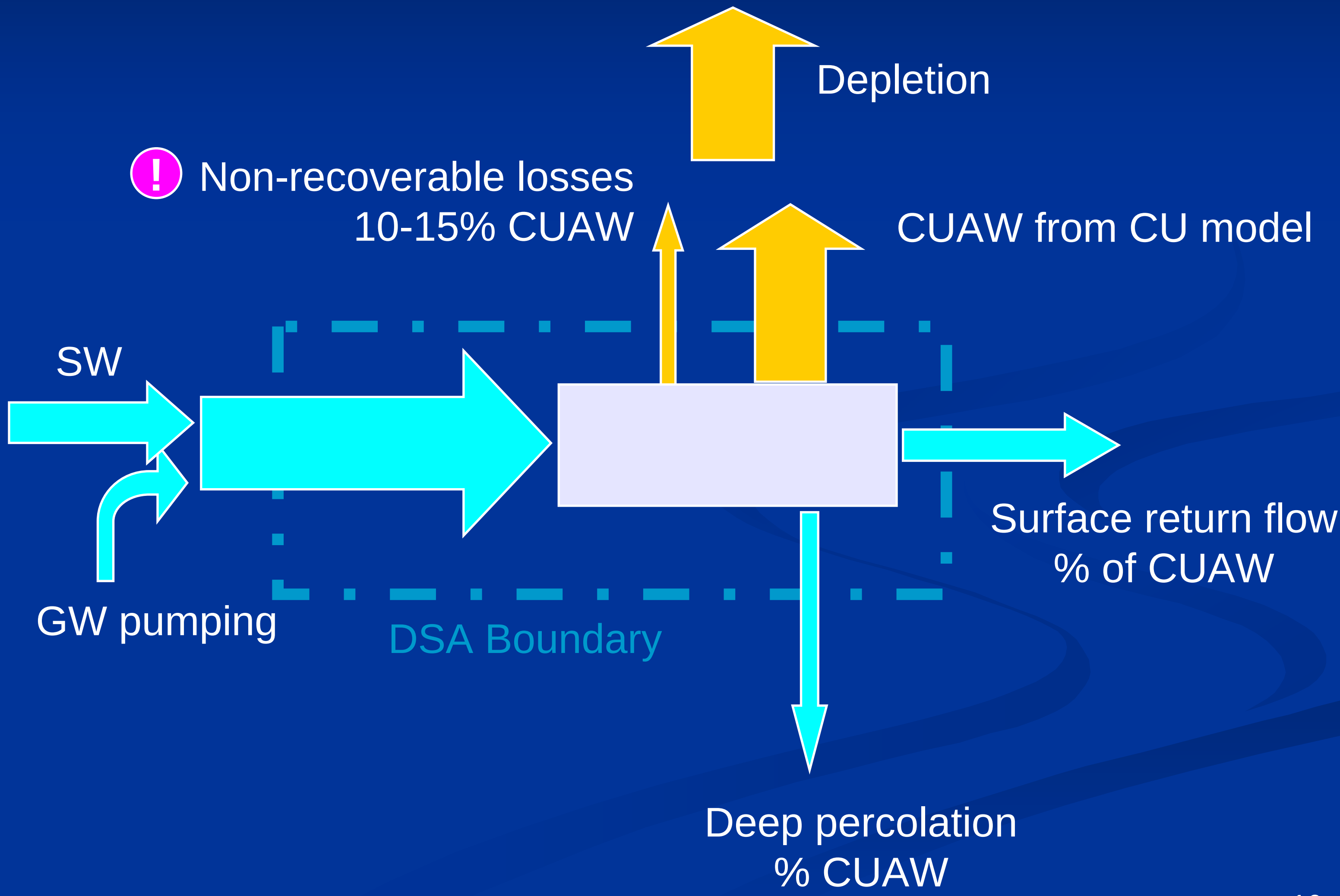
CU Model Assumptions

- No inter-annual variation in crop ET.
- No inter-annual variation of crop agronomic factors or growing season
- Available soil moisture storage capacity is 1.5 inches of water per foot of rooting depth.
- During a non-irrigation month, if precipitation and soil moisture do not meet soil ET, then the demand is unsatisfied.
- Crops are not subject to water stress or deficit irrigation.
- No runoff or deep percolation occurs unless the soil profile is at the upper limit (i.e., field capacity).
- Consumptive use of applied water does not include other beneficial uses of water (e.g., leaching requirements).

CU Model Issues

- Uses monthly not daily time step
- Crop ET not calculated explicitly from staged planting dates, growth stages, crop coefficients and reference crop ET
- No explicit surface runoff routine
- No differentiation between runoff and deep percolation
- Based on 1970s data
- Not consistent with models used by DPLA
- Limited number of crop categories

Components of Demand



Basin Efficiencies

- Basin efficiency used to translate crop consumptive use (CUAW) into demand at DSA level (stream diversions and groundwater pumping)
- Calculated from field measurements and water use budgets (1960/70s)

DSA	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
58	65	65	65	65	65	65	65	65	65	65	65	65
10	70	70	70	70	70	70	70	70	70	70	70	70
15	70	70	70	70	70	70	79	65	75	78	65	35
12	70	70	70	70	70	70	79	65	75	78	65	35
69	40	70	70	70	70	70	70	65	75	80	75	30

Efficiencies cont'd

- Hydrology ***not*** calibrated to diversions so that Calsim-II may not accurately mimic historical diversions and return flows
- Efficiencies not related to on-farm water use
- No explicit representation of conveyance loss, operational spills, reuse
- Efficiency not dependent on source
- Demands for Delta represented as a mass balance between precipitation and gross consumptive use

Project vs Non-Project

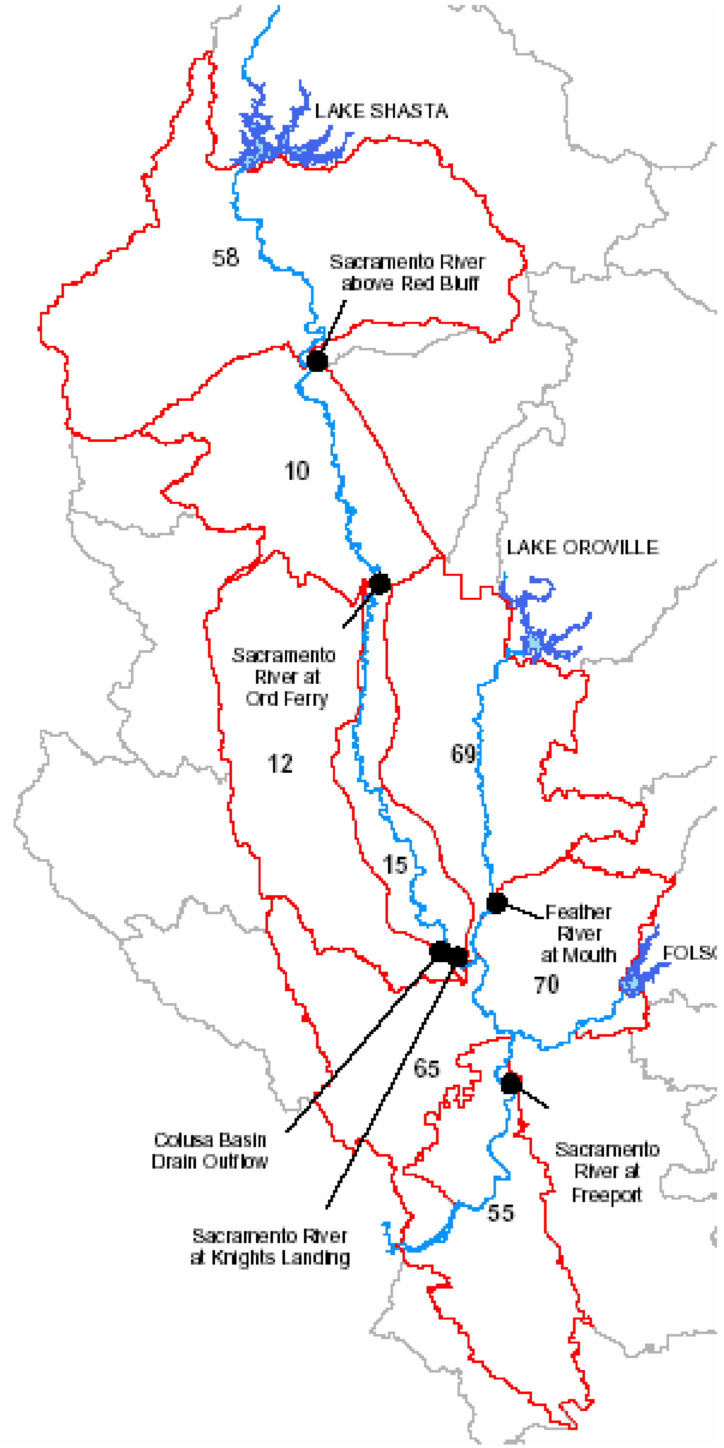
- Demand calculated for each DSA based on current or projected crop acreage
- DSA demand subsequently split into project and non-project
- Project Demands
  - Entitled to releases from project storage
  - Deliveries constrained to lower of land use based demand or contract allocation
- Non-Project Demands
  - Diversions constrained to lower of land use based demand or unimpaired river flow
  - Not entitled to releases from project storage

Water Supplies

Rim Flows vs Local Water Supplies
Rim Flows
Average Annual Inflow from Rim DSAs
Local Water Supplies
Hydrologic Mass Balance
Water Supply as a Calibration Term
Historical Flow Components
Average Annual Local Water Supply
Rainfall-Runoff Adjustment

Water Supplies

- Inflows to major reservoirs
- Time series of inflows to each of the seven Valley floor DSAs
  - Represent direct runoff from precipitation and inflow from minor streams
  - Calculated as closure term in hydrologic mass balance on each DSA



Rim Flows

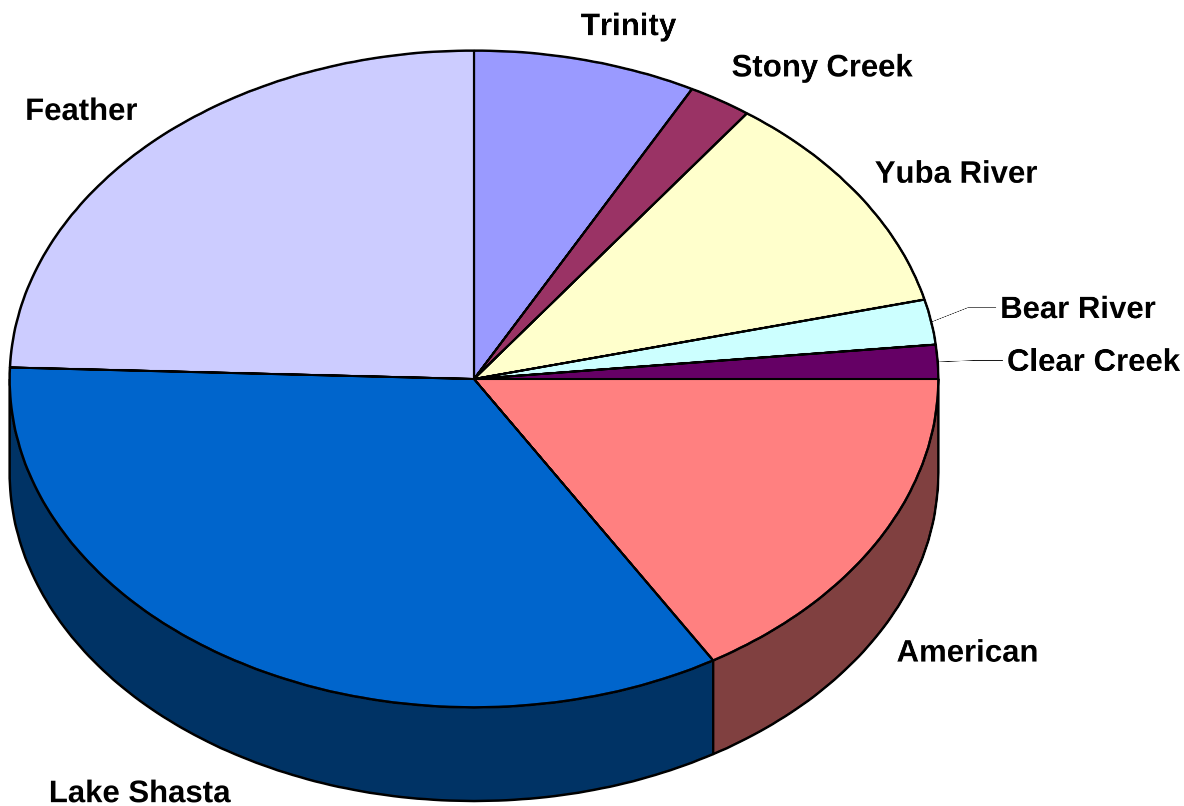
- Generally developed using a ***depletion analysis***
- Depletion refers to loss of water (precipitation, stream flow, groundwater) through evaporative means

Projected flow = Historical flow
- historical storage withdrawals / increases
+ projected storage withdrawals / increases
+ historical depletion of irrigation water
- projected depletion of irrigation water
+ rainfall-runoff land-use adjustment

! No distinction between surface water and groundwater use

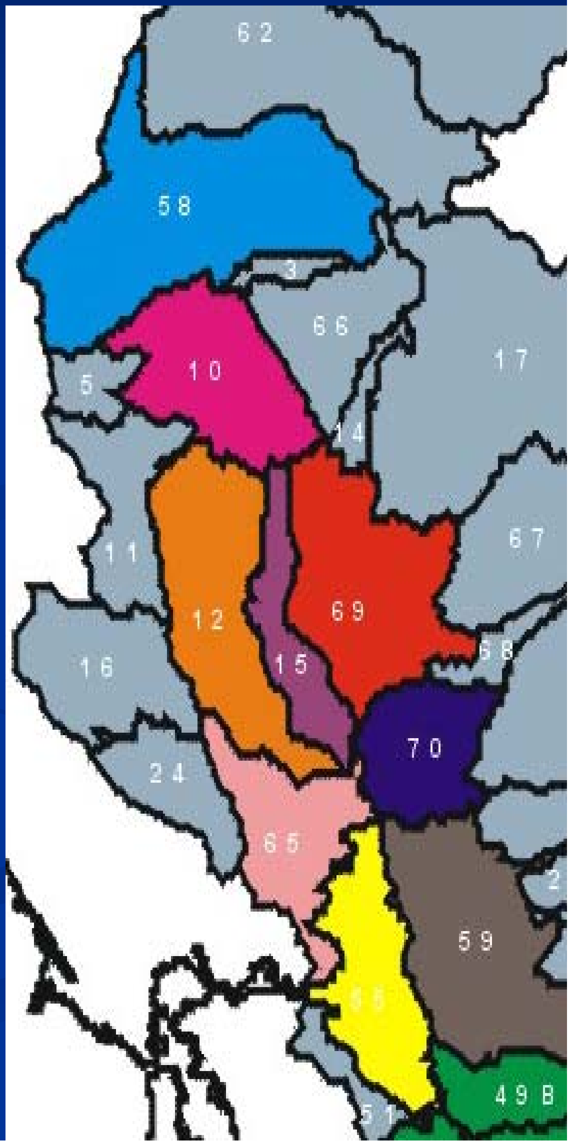
Average Annual Rim Flow

Average Annual Regulated Inflow = 16,150 taf/yr



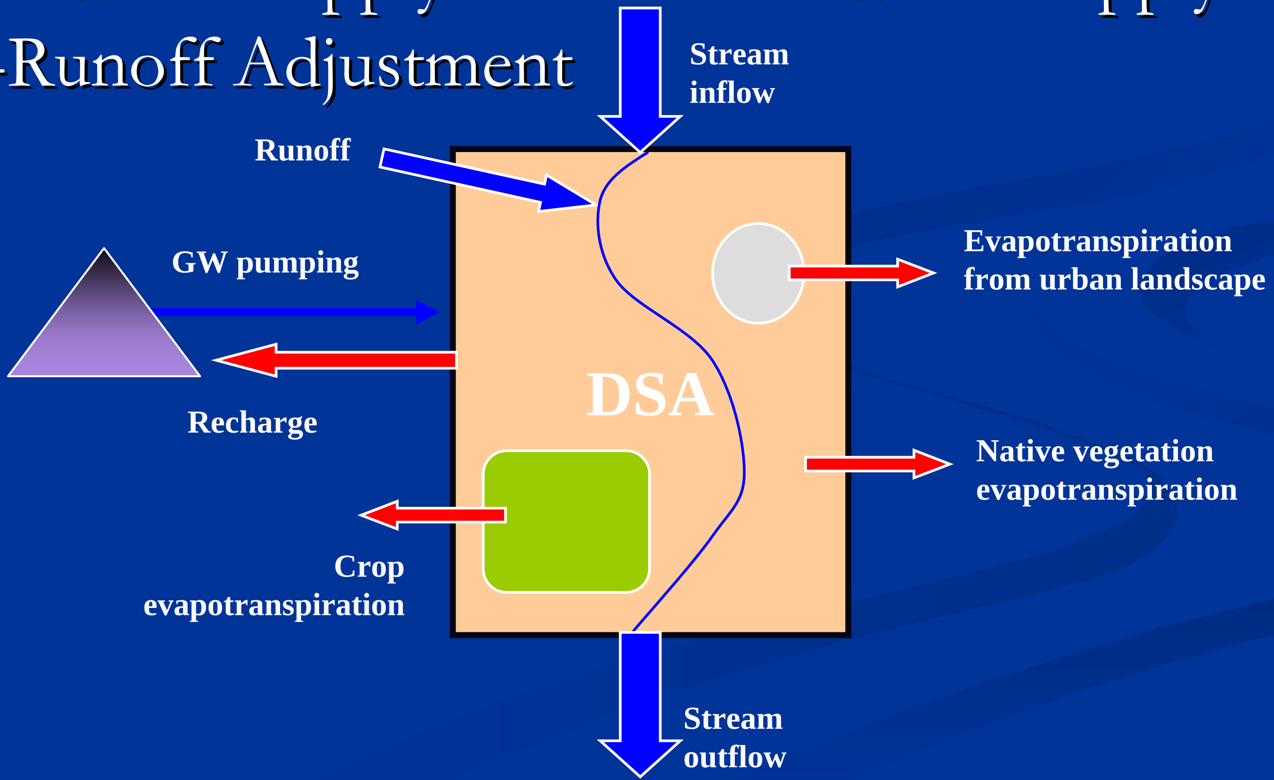
Local Water Supplies

- Time series of inflows to each of the seven Valley floor DSAs
- Calculated as closure term in hydrologic mass balance on each DSA
- Represents direct runoff from precipitation
- Includes all error terms



Hydrologic Mass Balance

- Historical water supply = Historical Outflow - Historical Inflow
- Projected Water Supply = Historical Water Supply + Rainfall-Runoff Adjustment



Local Water Supplies

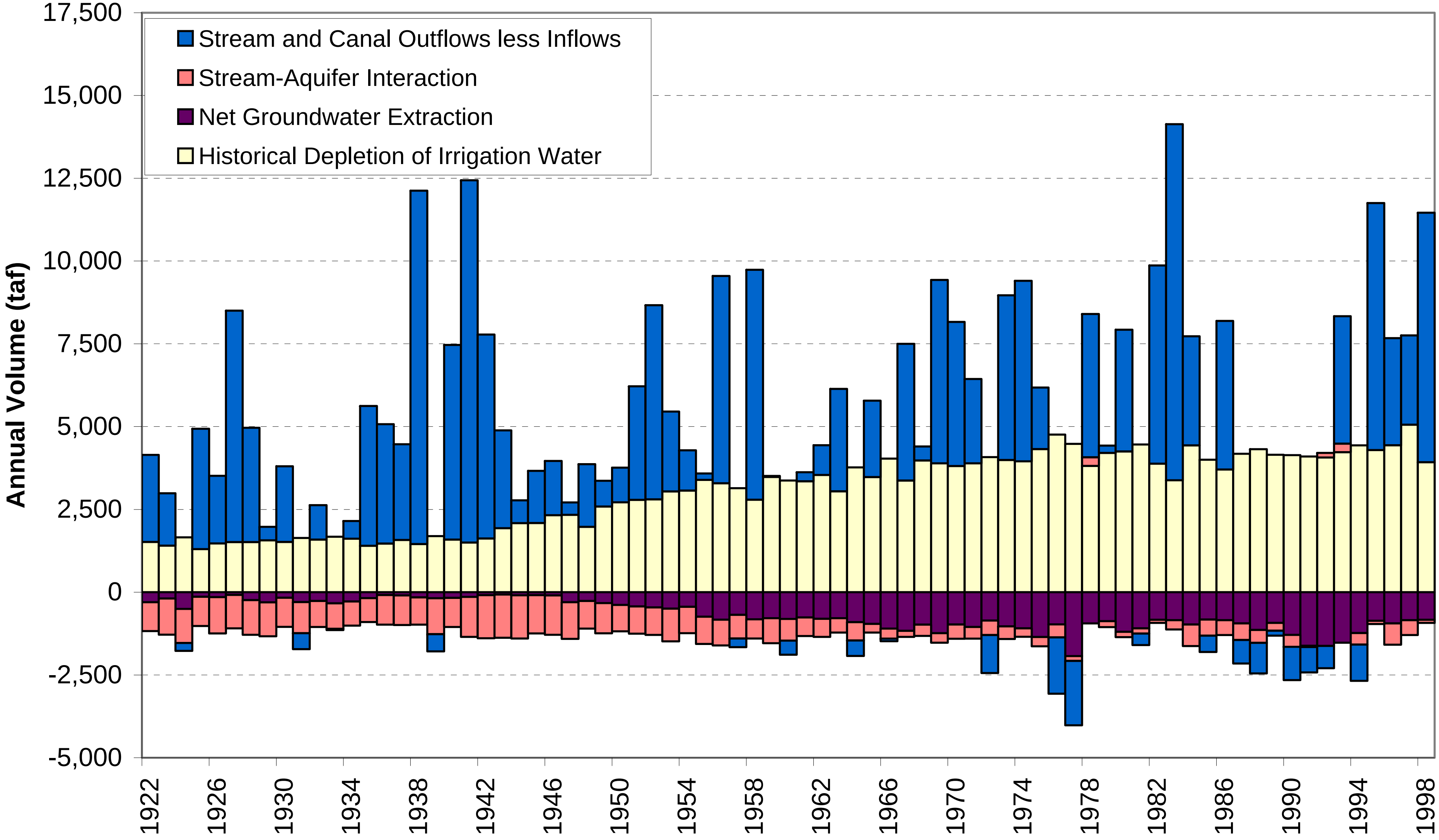
Projected supply = Historical outflows (stream outflow, canal exports)
- historical inflows (stream inflow, canal imports)
+ historical depletion of irrigation water
+ historical deep percolation from irrigation
- historical groundwater pumping
+ historical stream seepage to groundwater
- historical stream gains from groundwater
- historical storage withdrawals
+ historical storage increase
+ rainfall-runoff adjustment

! Historical groundwater pumping, recharge and stream-aquifer interaction from historical run of CVGSM

Water Supply as a Calibration Term

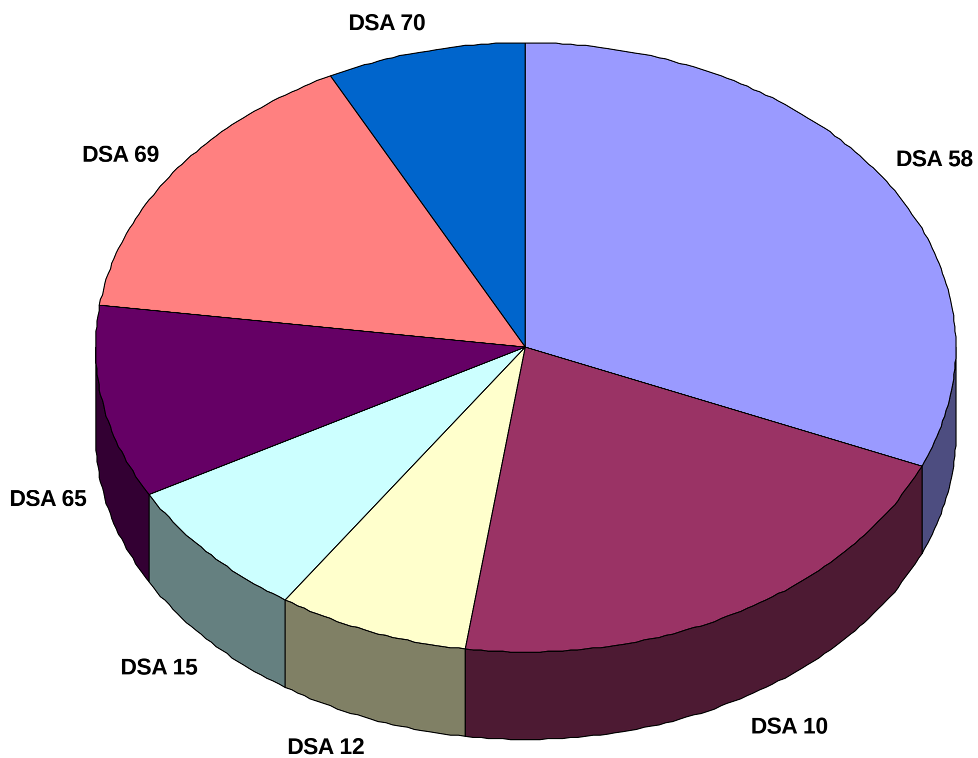
- Water supply term contains all errors in mass balance
- Accounts for errors in:
  - stream flow record
  - estimated crop consumptive use of applied water
  - historical groundwater use
- For a historical land use Calsim II will exactly match historical stream flow if reservoir releases are fixed at their historical level and groundwater pumping and stream-aquifer interaction are fixed at their assumed historical level.

Historical Flow Components
Used in Calculation of Local Water Supply

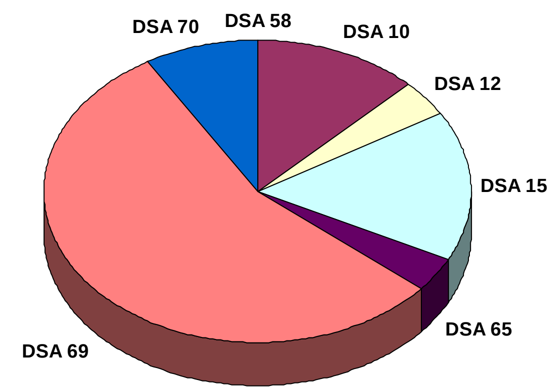


Average Annual Local Water Supply

Average of Positive Values = 6,420 taf/yr



Average of Negative Values = 626 taf/yr

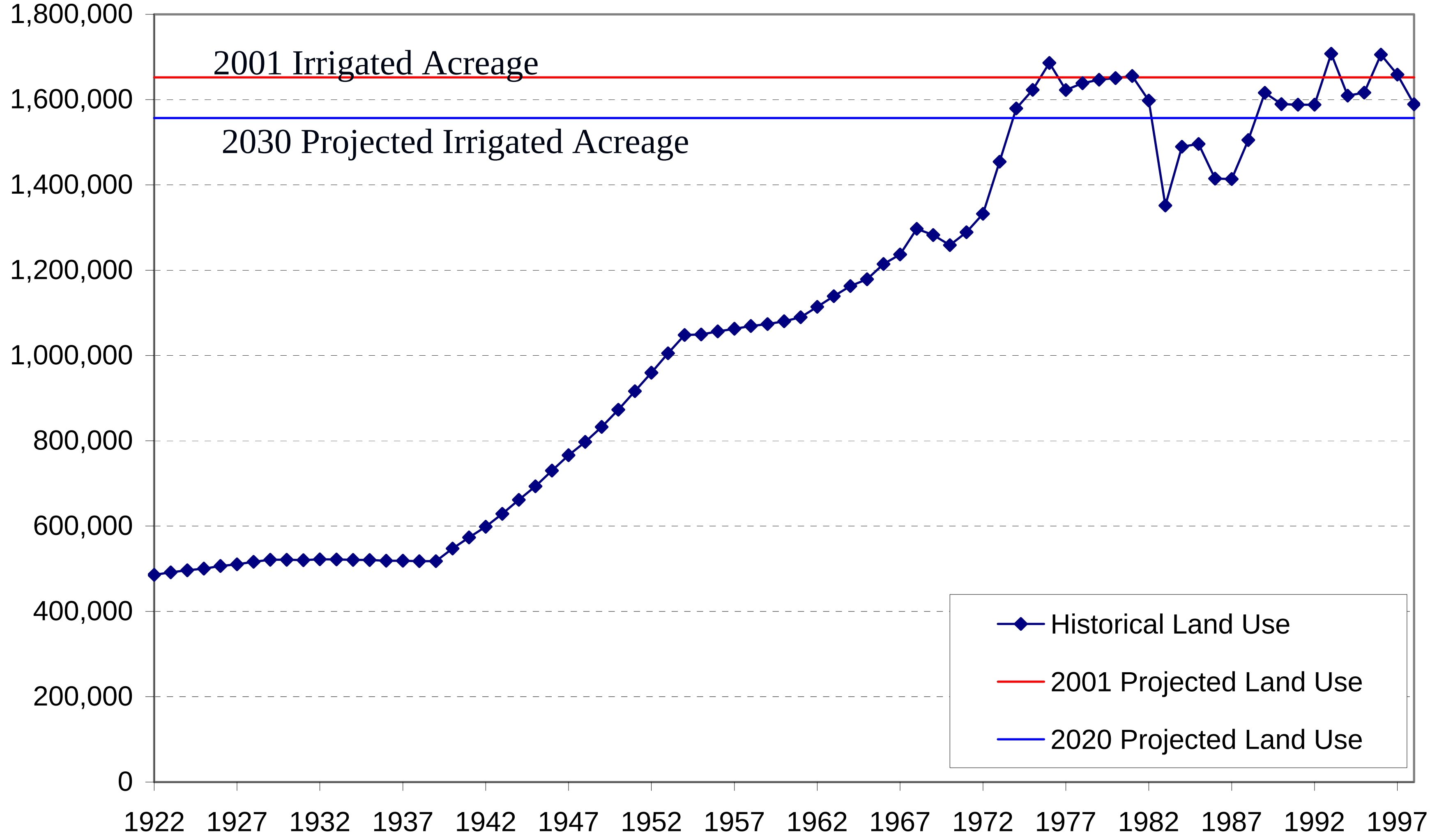


Rainfall-Runoff Adjustment

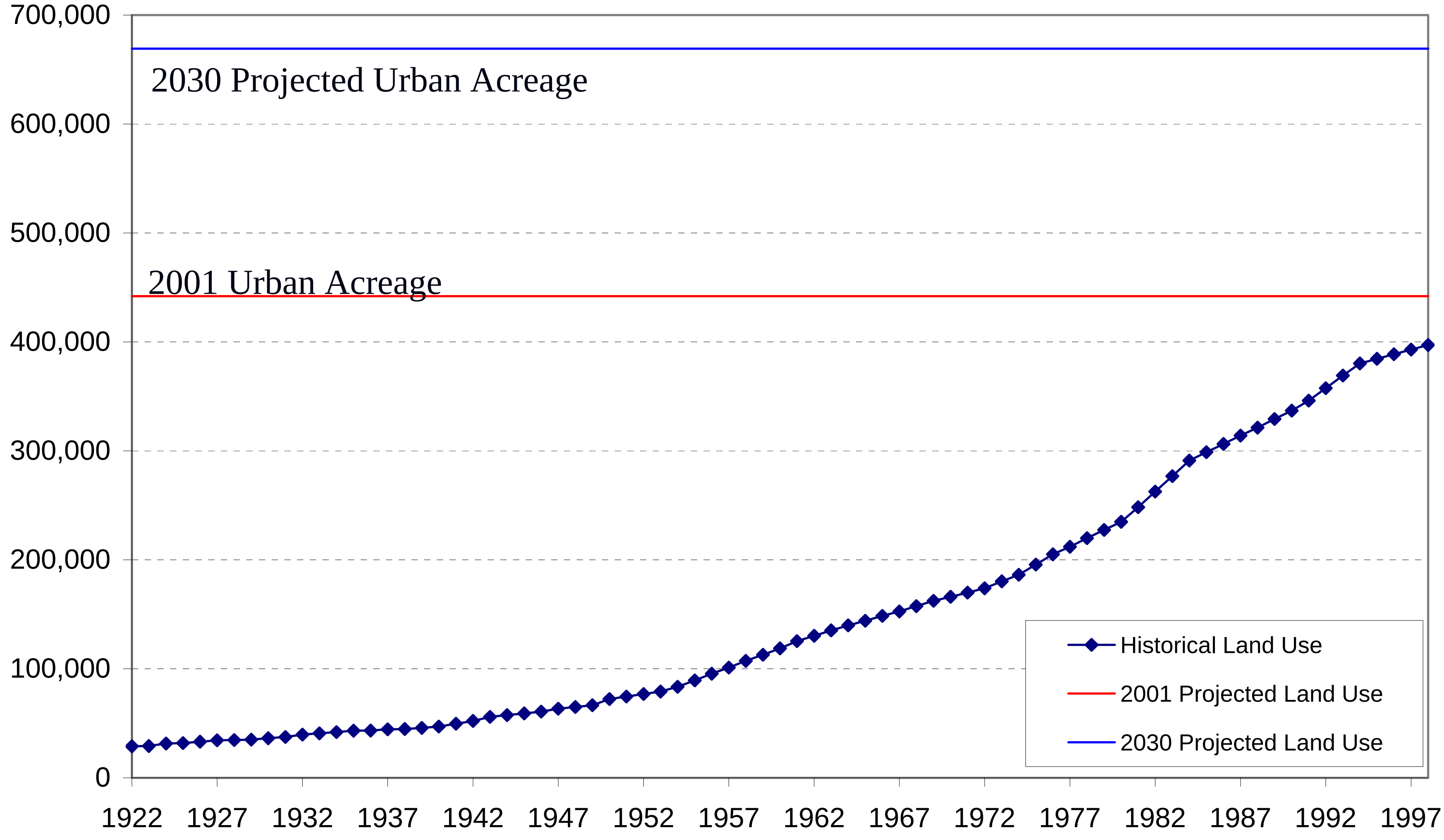
- Land use affects direct runoff and groundwater recharge from precipitation
- Land use adjustment determined using the CU model
- ! Assume no change in groundwater recharge from precipitation

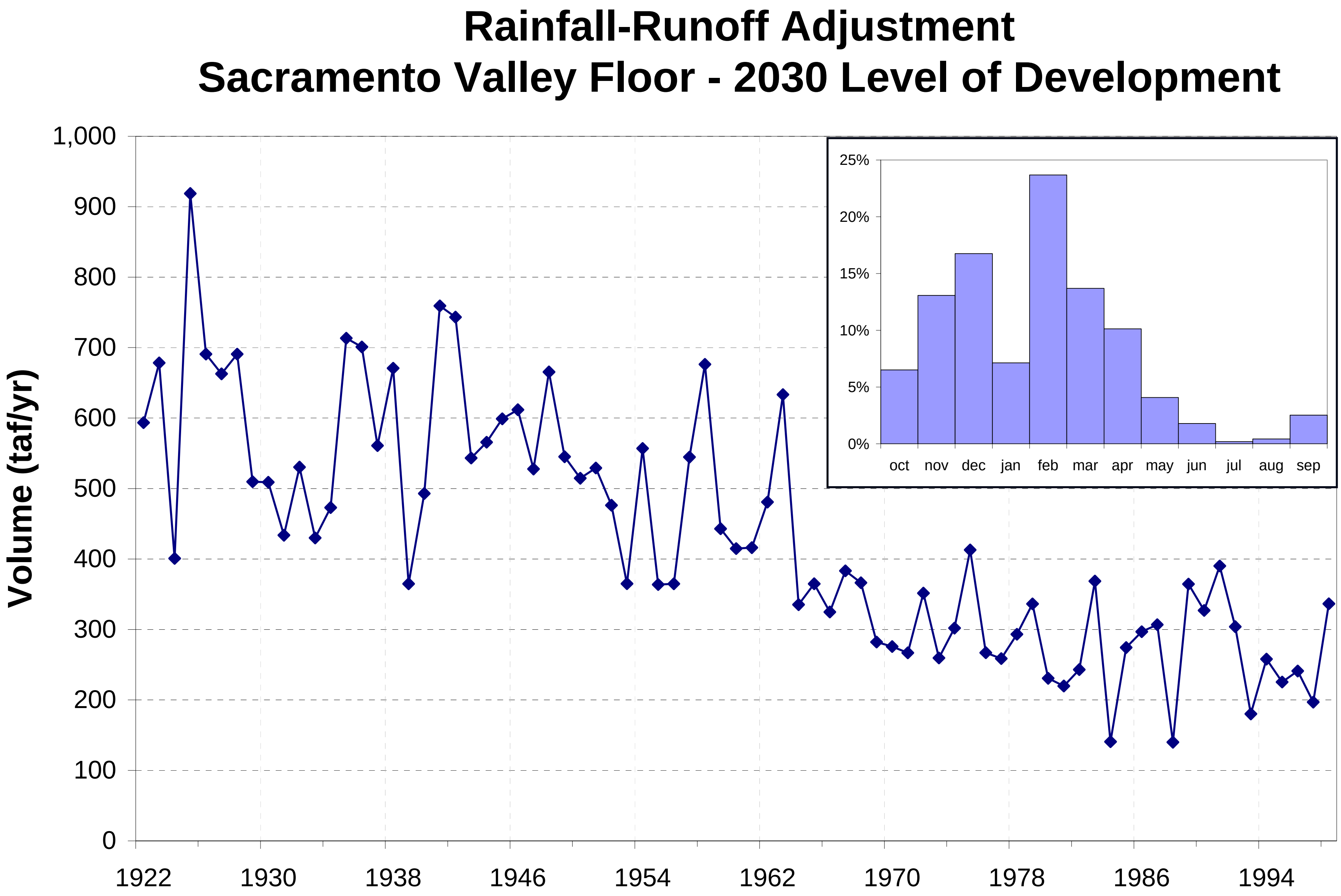
- Additional flow = historical depletion of precipitation
  - projected depletion of precipitation

Historical and Projected Irrigated Acreage in the Sacramento Valley Floor



Historical and Projected Urban Acreage in the Sacramento Valley Floor



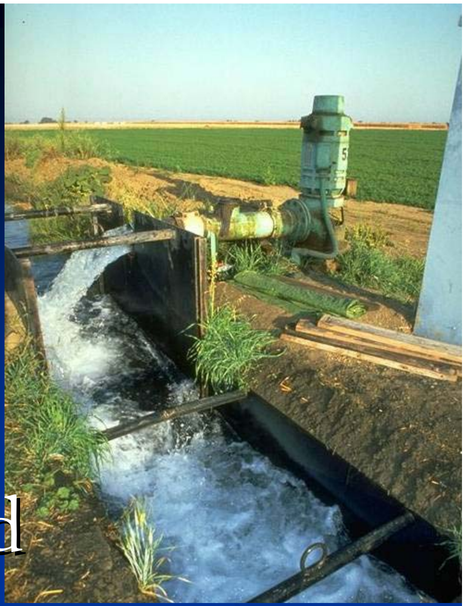


Rainfall-Runoff Adjustment
Sacramento Valley Floor - 2030 Level of Development
Volume (taf/yr)
1,000
900
800
700
600
500
400
300
200
100
0
1922
1930
1938
1946
1954
1962
1970
1978
1986
1994
25%
20%
15%
10%
5%
0%
oct
nov
dec
jan
feb
mar
apr
may
jun
jul
aug
sep

Groundwater in CalSim II

Groundwater Pumping
Groundwater Recharge
Stream-Aquifer Interaction
Groundwater Storage

Groundwater Pumping



- Dynamically calculated
- Supply priorities for meeting demand
  - Minimum groundwater pumping
  - Surface water
    - up to the contract amount for project demand
    - and up to its availability for riparian demands.
  - ❗ Additional groundwater pumping for any unmet demand
- Minimum pumping volumes based on CVGSM output

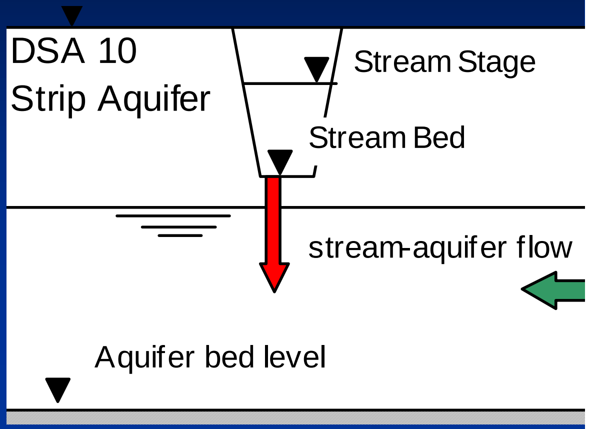
Groundwater Recharge

- Recharge from precipitation
  - Pre-processed
  - Based on CVGSM soil moisture budget

- Recharge from irrigation
  - Modeled dynamically
  - Calculated as fixed percentage of CUAW

end

Stream-Aquifer Interaction

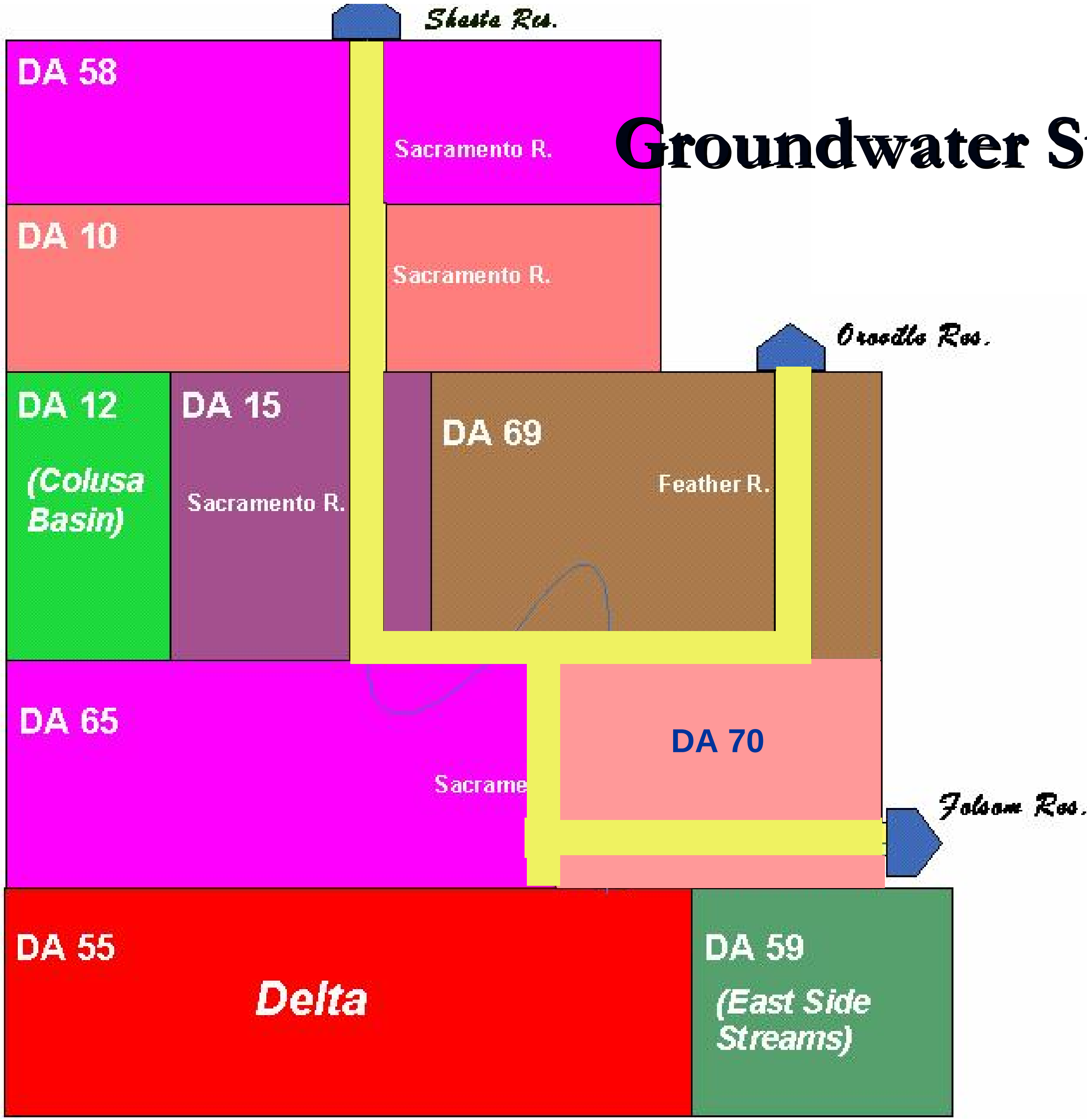


- Represented by five arcs
  - 3 for the Sacramento River
  - 1 for the American River
  - 1 for the Feather River
- Dynamically calculated, function of:
  - Stream stage (previous time step)
  - Groundwater average head (previous time step)
  - Streambed conductance
- For losing streams the difference in head driving stream seepage is limited to the stream depth

Groundwater Storage

- Purpose: to simulate groundwater elevations in the vicinity of the major streams for the calculation of stream gains and losses
- Multi-cell groundwater model: set of interlinked lumped parameter groundwater basins
  - Seven cells (‘main aquifers’) for seven DSAs north of Delta
  - Additional five cells (‘strip aquifers’) to represent groundwater adjacent to the major streams

Groundwater Storage



Groundwater Storage

- Characterization of the multiple-cell model based on CVGSM (Run 5.0)
- 41 parameters: specific yields, hydraulic conductivities, and conductance
- Calibration to fix the value of parameters so that multi-cell model has similar response to stress
- Calibration period 1981-1993

Questions?