GLOBAL CHANGE IMPACTS ON AQUATIC ECOSYSTEM SERVICES OF THE SAN FRANCISCO BAY WATERSHED

The Stockholm Environment Institute, Boston, Massachusetts

The Natural Heritage Institute, Sacramento, California

The National Center for Atmospheric Research, Boulder, Colorado

Galbraith Environmental Sciences, Dummerston, Vermont

The Water Evaluation and Planning (WEAP) System

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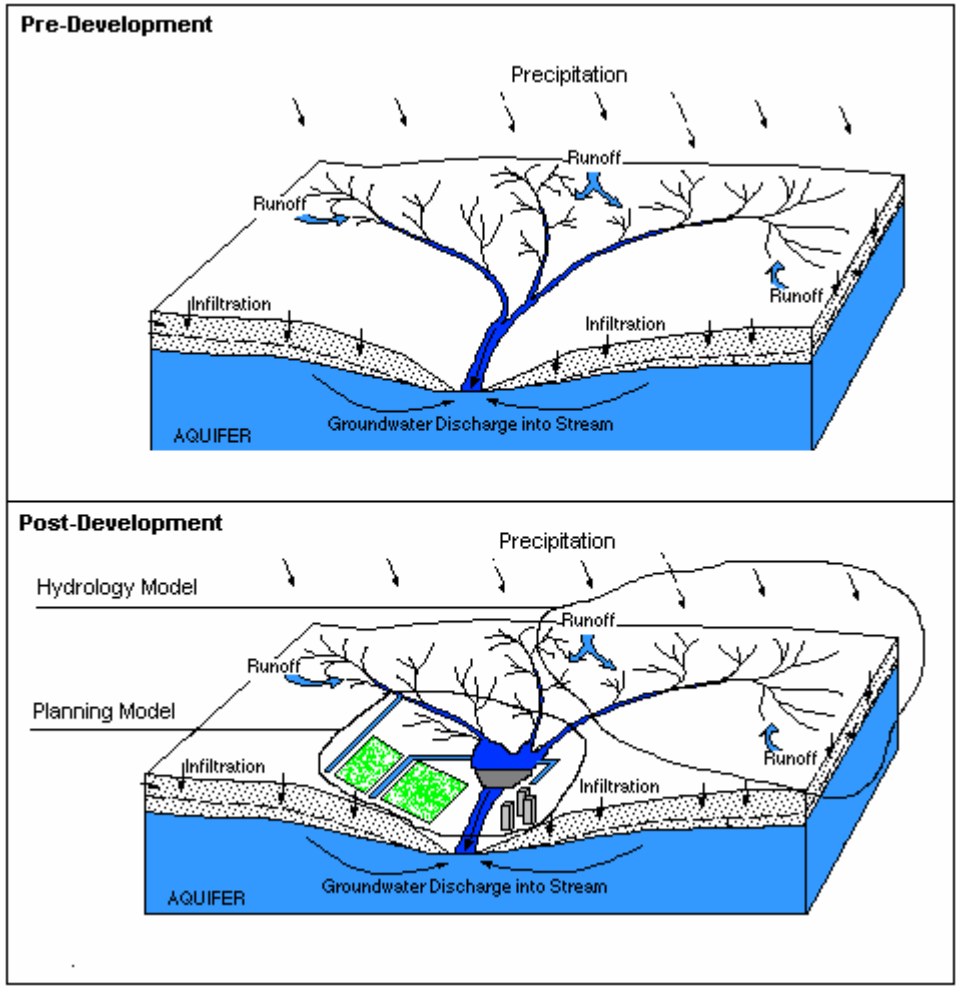
Senior Hydrologist
Natural Heritage Institute

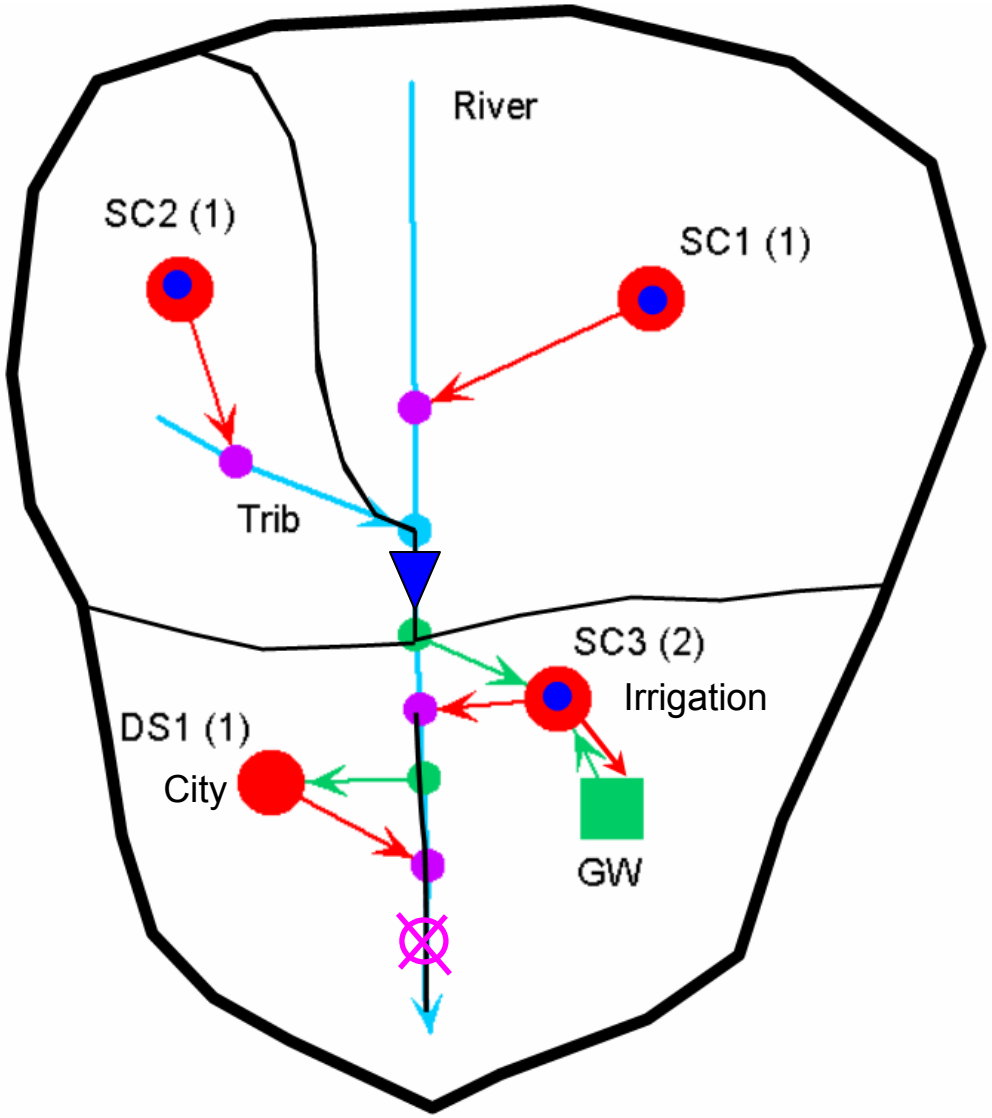
Proposal Outline

- Some Background on WEAP.
- The Sacramento River Basin Application.
- Portland, Oregon.
- Some Thoughts of the Utility of WEAP in the Context of California Water Planning

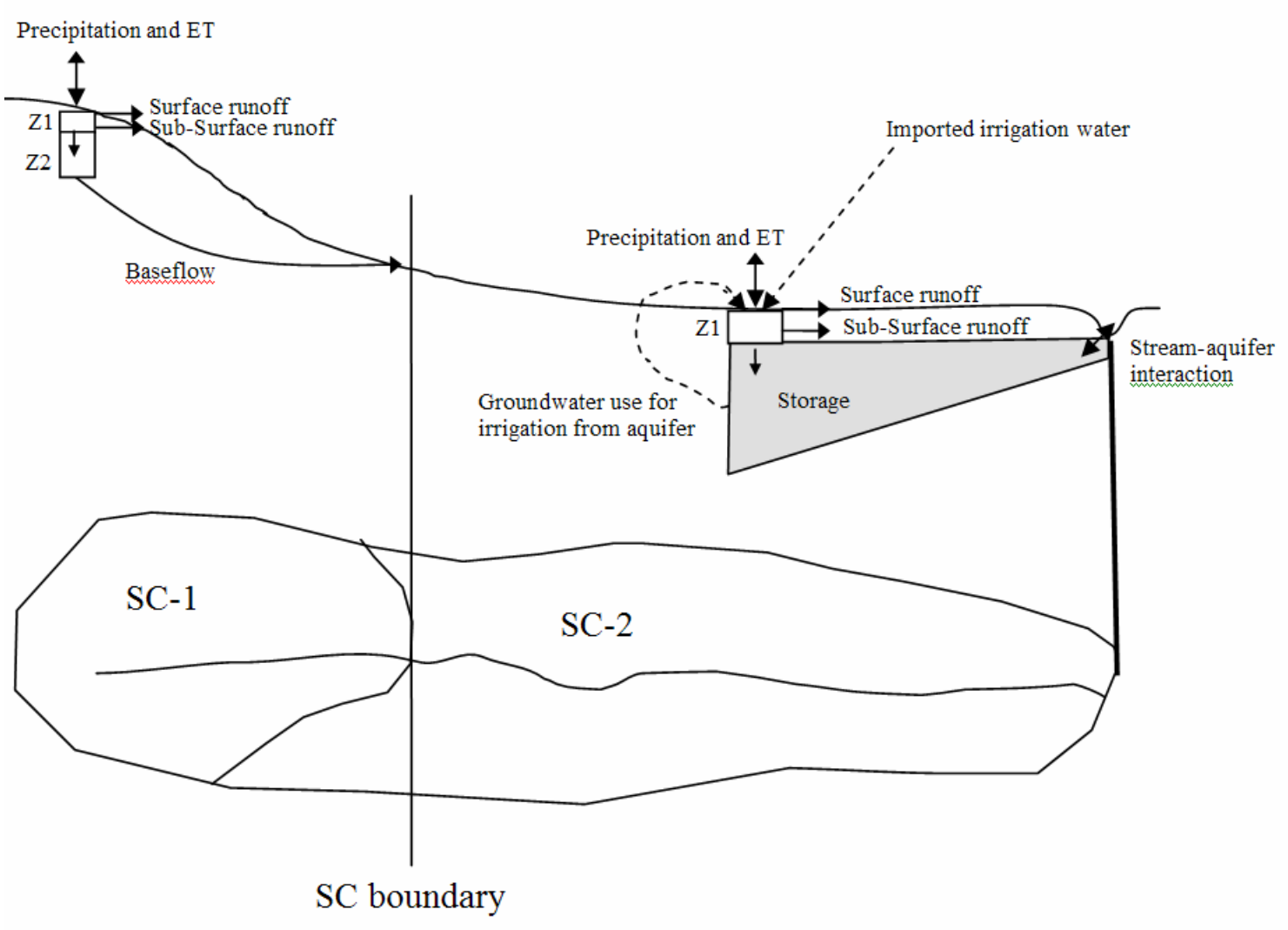
A Role for Models



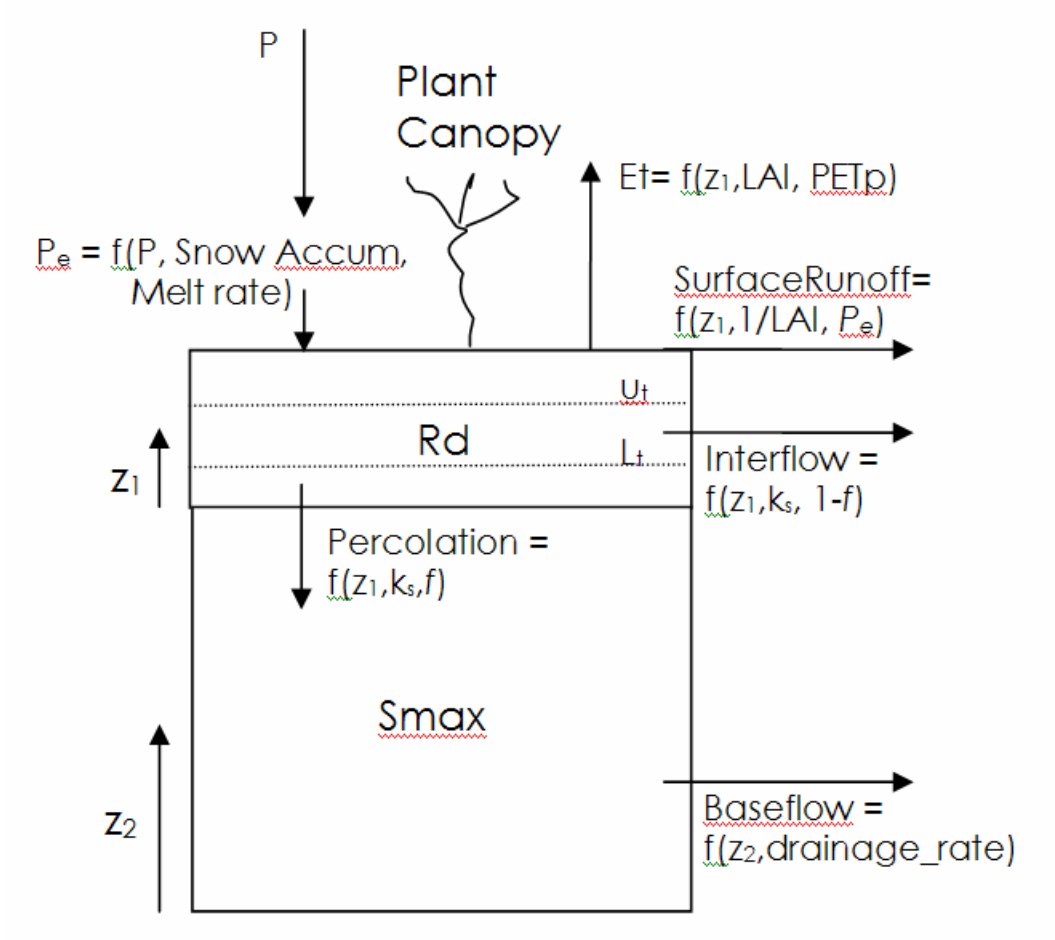
The Overall WEAP Approach



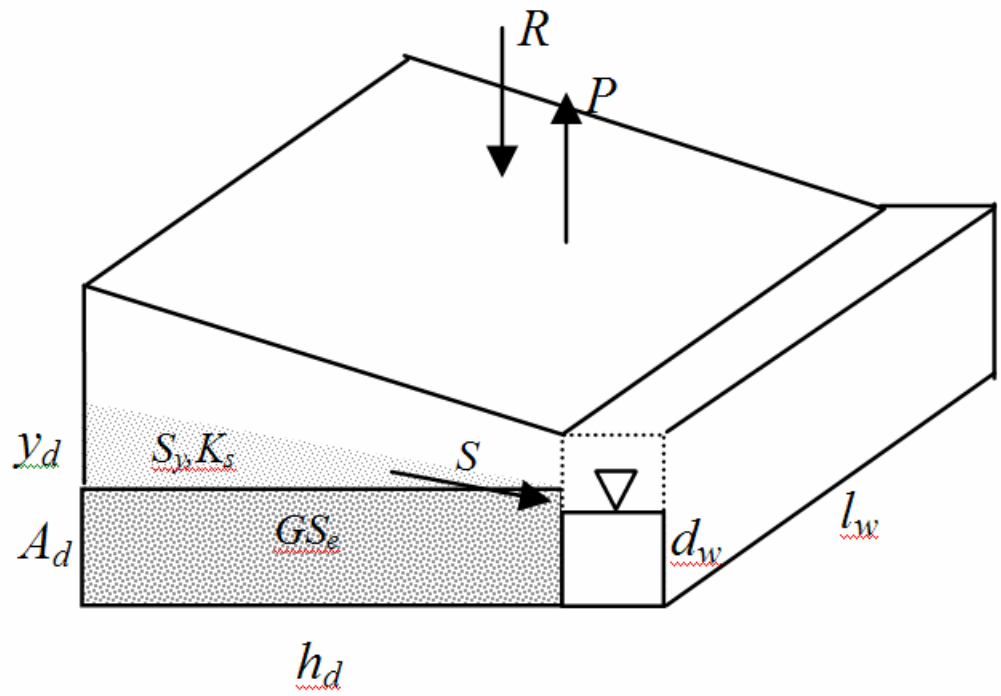
Climate Driven Aspects of WEAP



WEAP Hydrology



WEAP Stream-Aquifer Interactions



Non-Climate Driven Aspects of WEAP

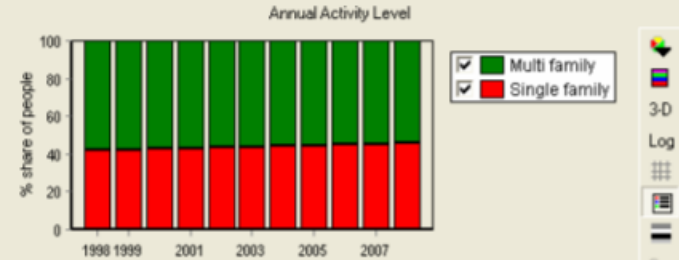
- Key Assumptions
- Demand Sites
  - South City
    - Single family
      - Showers
      - Toilets
      - Washing
      - Other
    - Multi family
      - Showers
      - Toilets
      - Washing
      - Other

Annual Activity Level | Annual Water Use Rate | Monthly Variation

Annual level of activity driving demand, such as agricultural area, population using water for domestic purposes, or industrial output. ? Help

Demand Site	1998	1999-2008	Scale	Unit	
South City	3.75	Growth(3%)	Million	person	
Single family	42	Interp(2020,50)	Percent	share	of people
Multi family	58	Interp(2020,50)	Percent	share	of people

Chart | Table | Notes

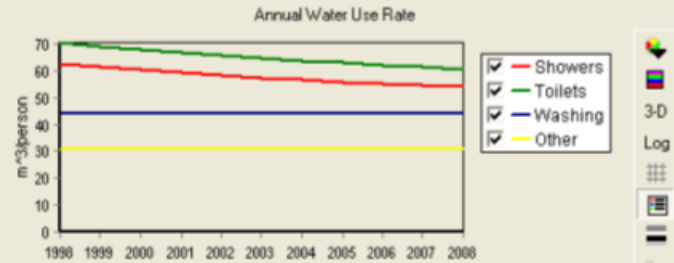


Annual Activity Level | Annual Water Use Rate | Monthly Variation

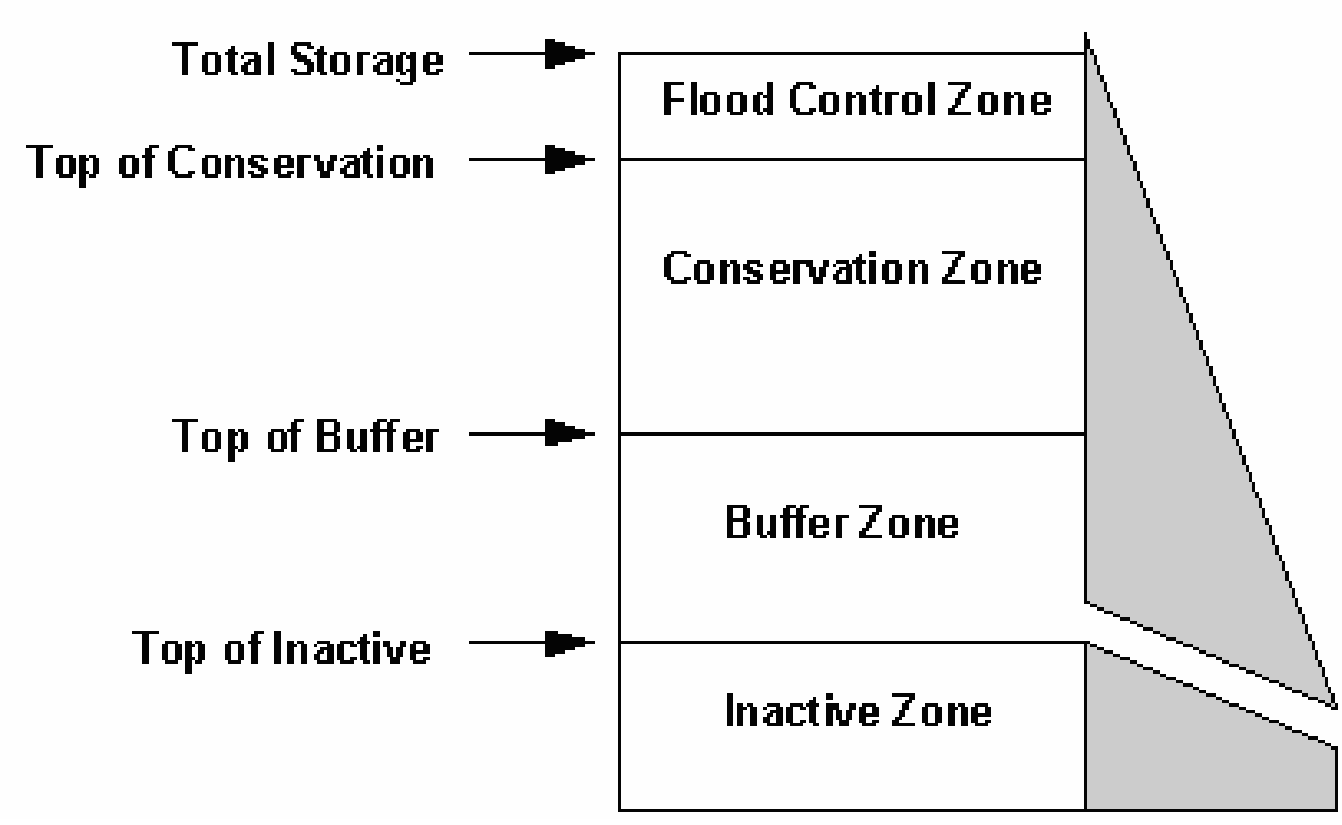
Annual water use rate per unit of activity ? Help

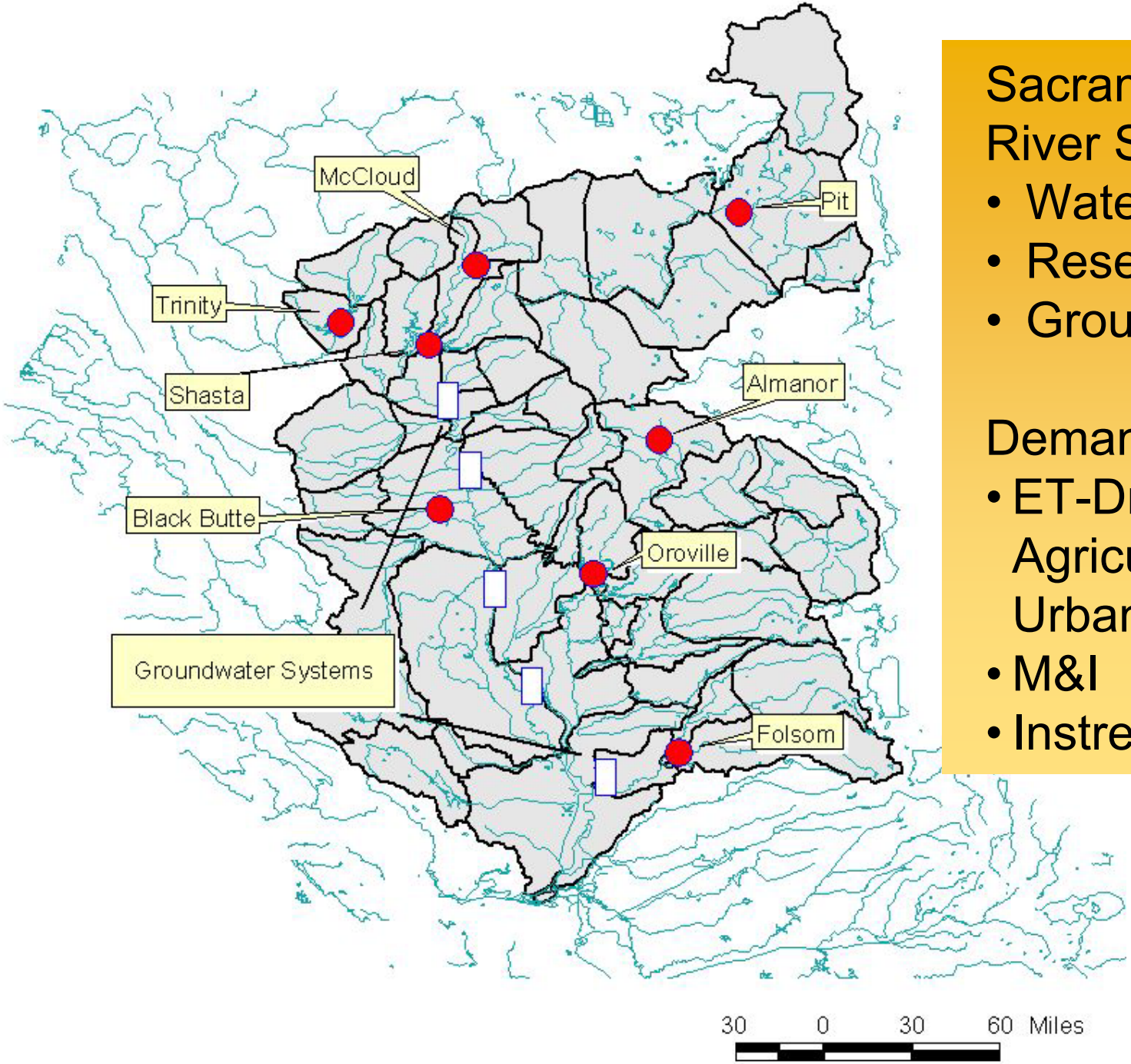
Single family	1998	1999-2008	Scale	Unit
Showers	62.62	GrowthAs(Key\Drivers\Technical Innovation,-0.25)		m^3
Toilets	70.5	GrowthAs(Key\Drivers\Technical Innovation,-0.25)		m^3
Washing	44.1	44.1		m^3

Chart | Table | Notes



Reservoir Operations in WEAP





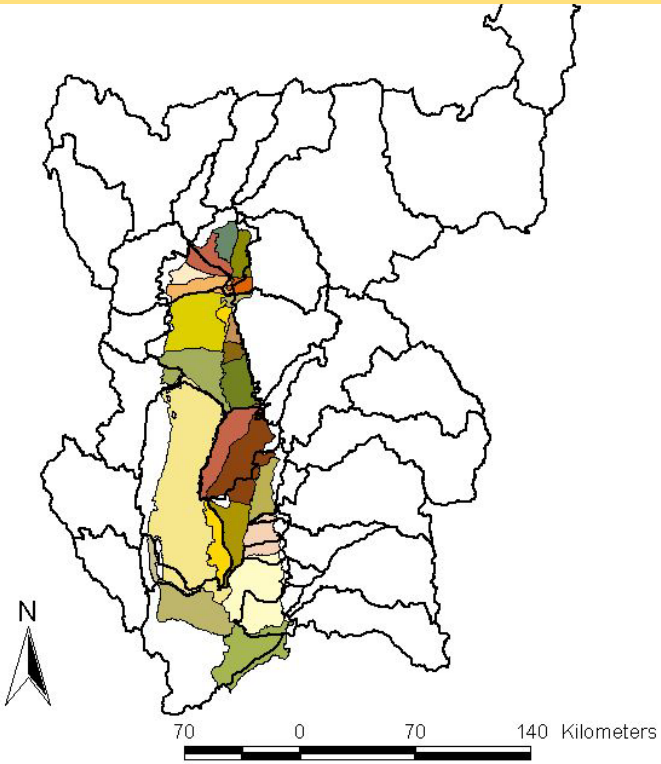
Sacramento River System:

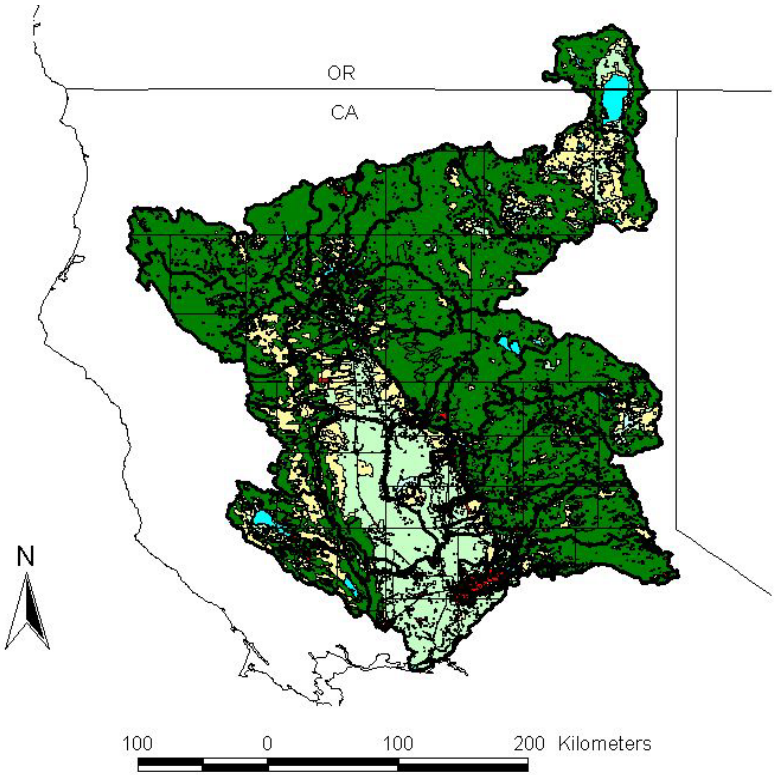
- Watersheds
- Reservoirs
- Groundwater

Demands:

- ET-Driven Agricultural & Urban
- M&I
- Instream Flows

Alluvial Aquifers and Land Use





Sacramento Basin HUCs

Sacremento Basin GW Sub-Basins

- ANDERSON
- ANTELOPE
- BEND
- BOWMAN
- CAPAY VALLEY
- CHILCOOT SUBBASIN
- COLUSA
- CORNING
- DYE CREEK
- EAST BUTTE
- EAST SUTTER
- ENTERPRISE
- LOS MOLINOS
- MILLVILLE
- NORTH AMERICAN
- NORTH YUBA
- RED BLUFF
- ROSEWOOD
- SOLANO
- SOUTH AMERICAN
- SOUTH BATTLE CREEK
- SOUTH FORK PITT RIVER
- SOUTH YUBA
- VINA
- WARM SPRINGS VALLEY
- WEST BUTTE
- WEST SUTTER
- YOLO

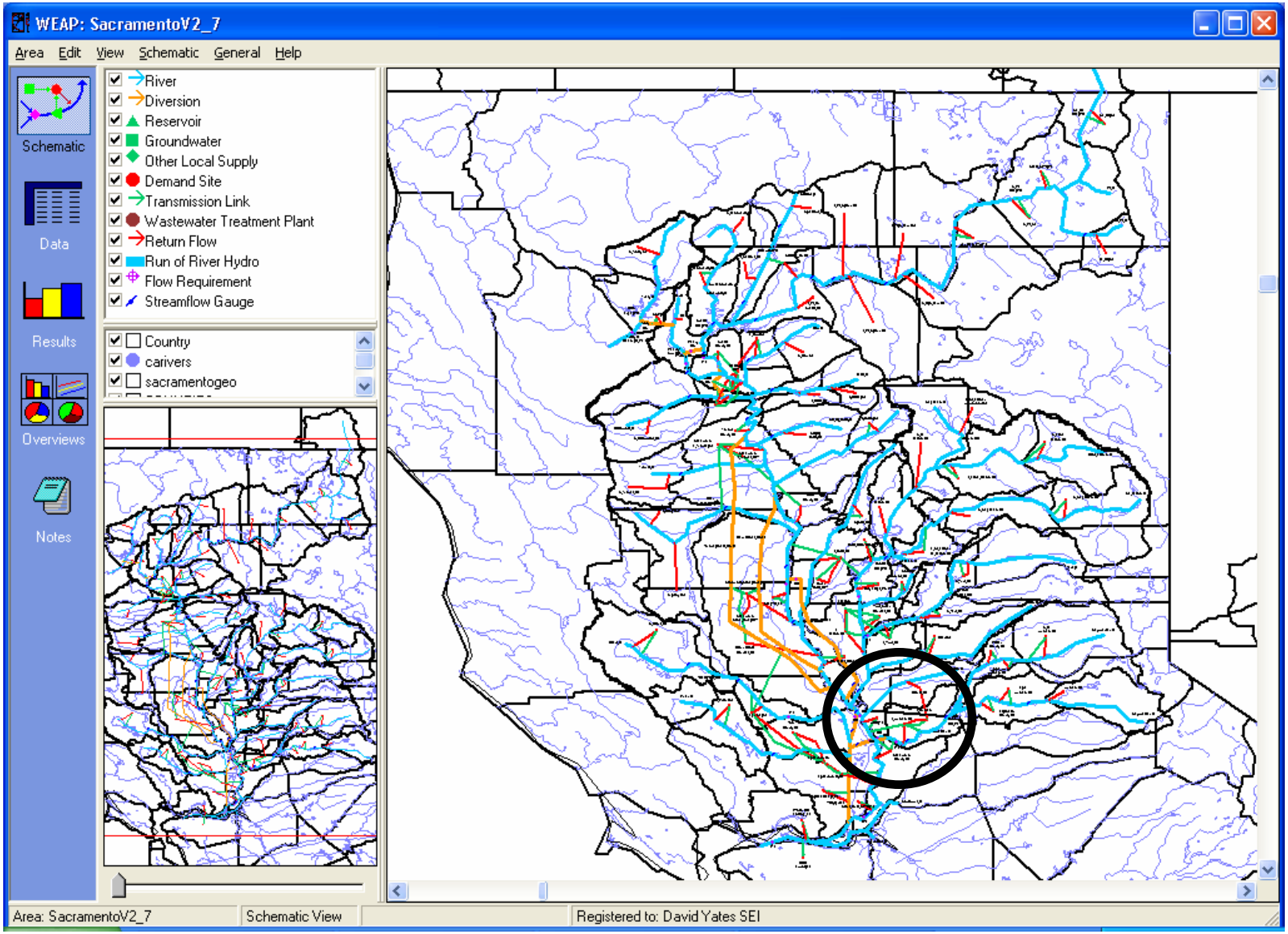
Legend

Hydrologic Units

Land Use/Land Cover

- AGRICULTURAL LAND
- BARE GROUND
- FOREST
- OPEN WATER
- RANGELAND
- URBAN
- WETLAND

WEAP Schematic of Sacramento Watershed



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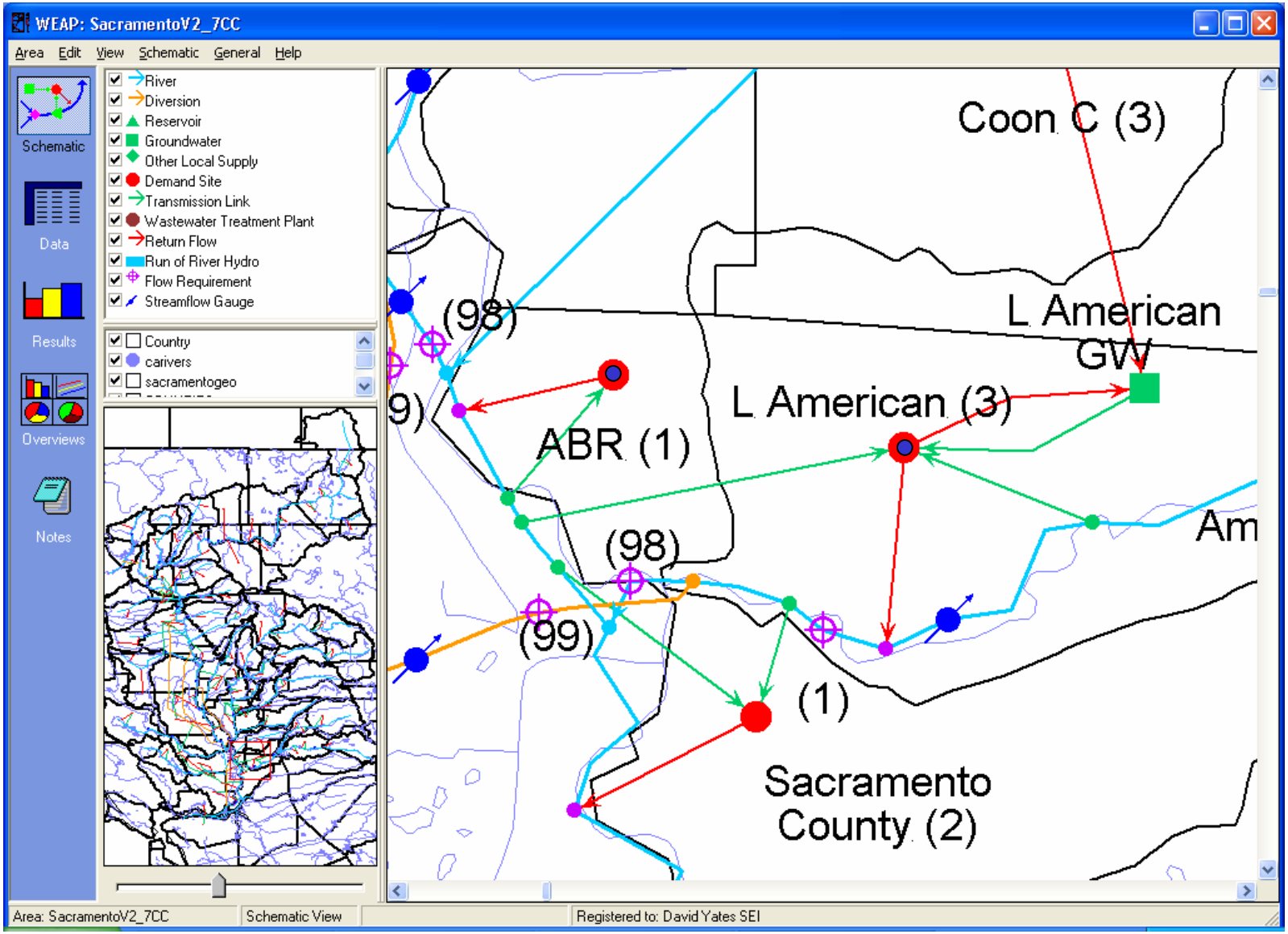
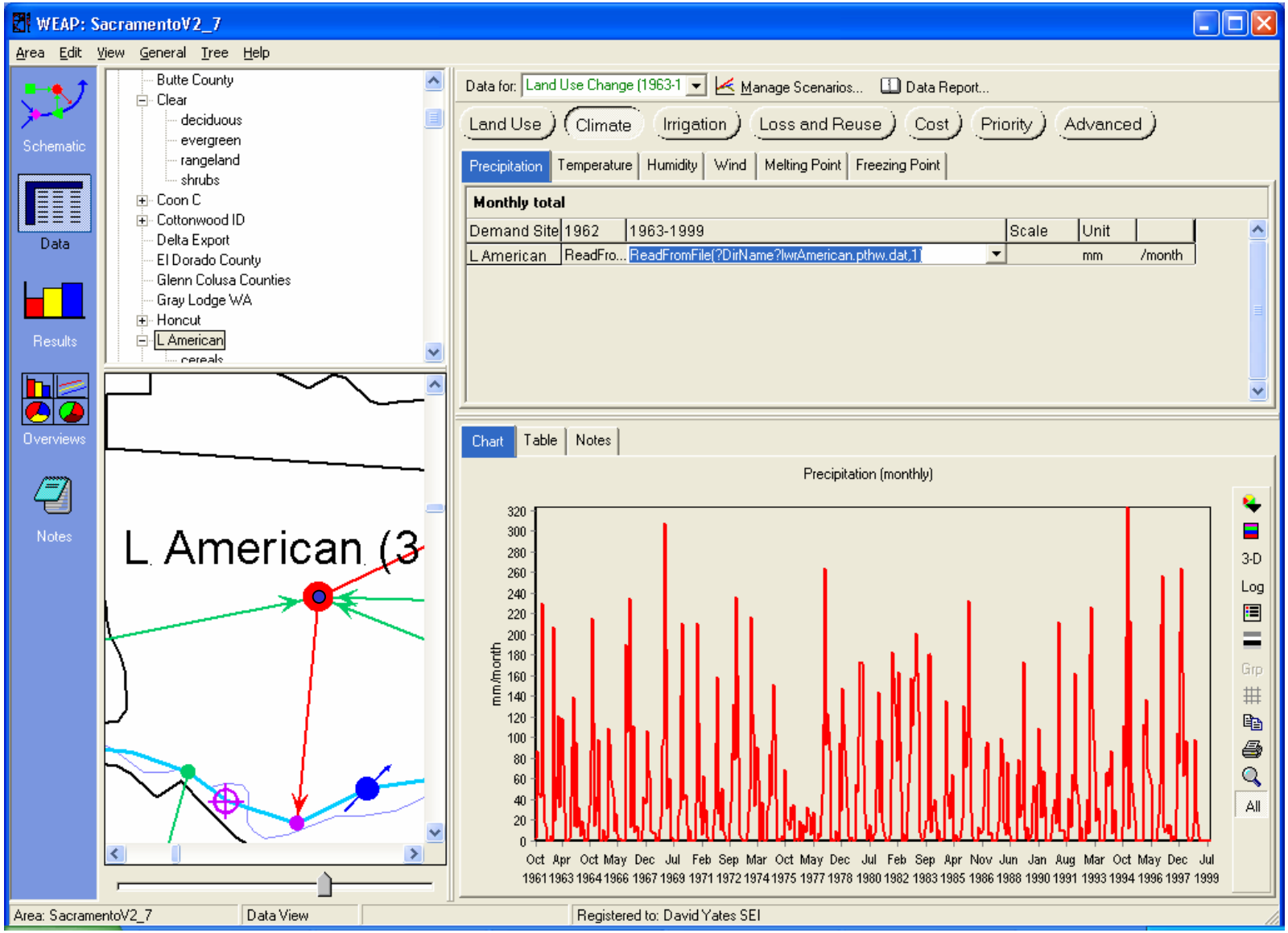


WEAP Schematic of Sacramento Watershed



WEAP Schematic of Sacramento Watershed

Watershed Divided into Irregular Polygons (HUCS)

Sub-Divided by % Cover

- Land Use Type
- Soil Type
- Land Use and Soil Type
- Others

cereals	1%
deciduous	1%
evergreen	2%
oilcrops	5%
pasture	1%
rangeland	18%
rice	1%
shrubs	1%
urban_imp	48%
urban_per	21%
water	1%
wetlands	1%

Calibration and Validation

Model is Demand Driven, Period is 1961-1999

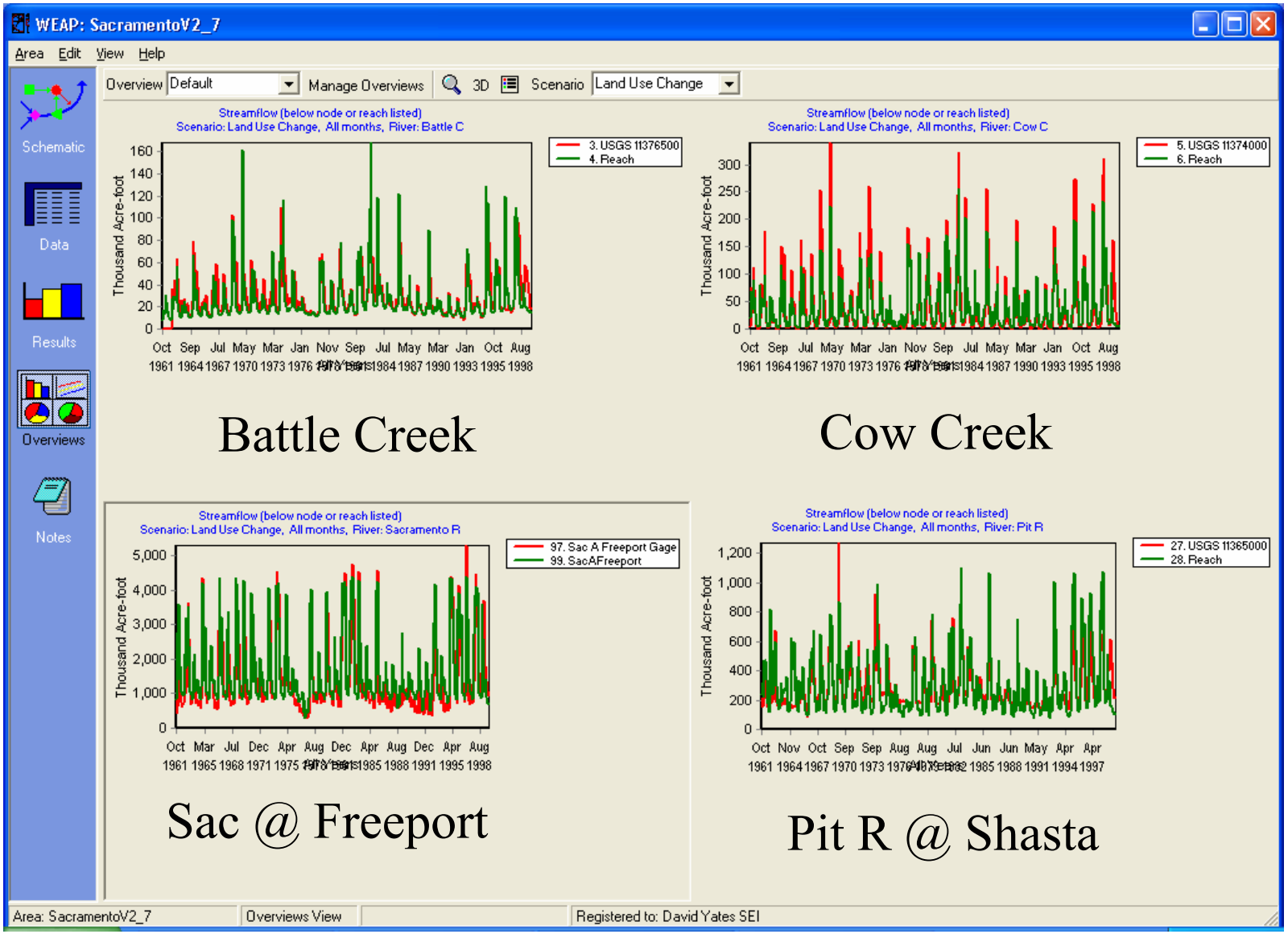
- Timestep is Monthly (can be sub-monthly)
- Stylized Reservoir Operating Rules
- In-stream Flow Requirements
- Delta Exports are Exogenous
- Irrigated Agricultural Requirements (acreage and ET)
- Allocation Algorithm is Solved as a Linear Program currently minimizes unmet demand

Calibration and Validation

Calibration Criterion:

1. Flows Along Mainstem and Tributaries
2. Reservoir Storage
3. Agricultural Water Demand
4. Groundwater Storage Trends
5. Yolo Bypass Flood Inundation

River and Tributary Flows



Battle Creek

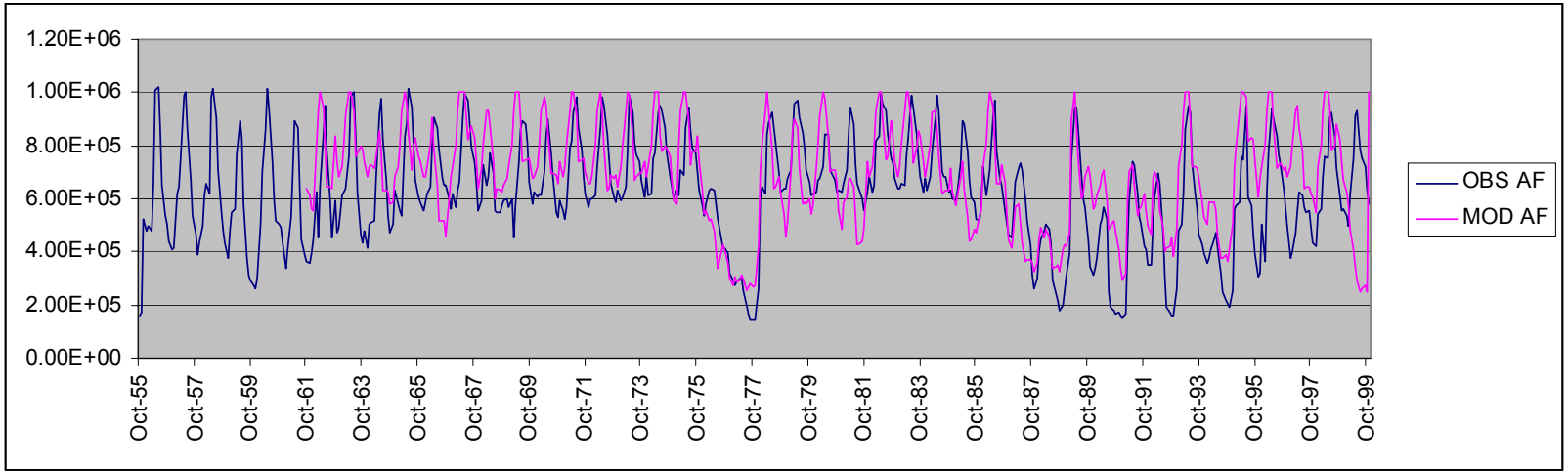
Cow Creek

Sac @ Freeport

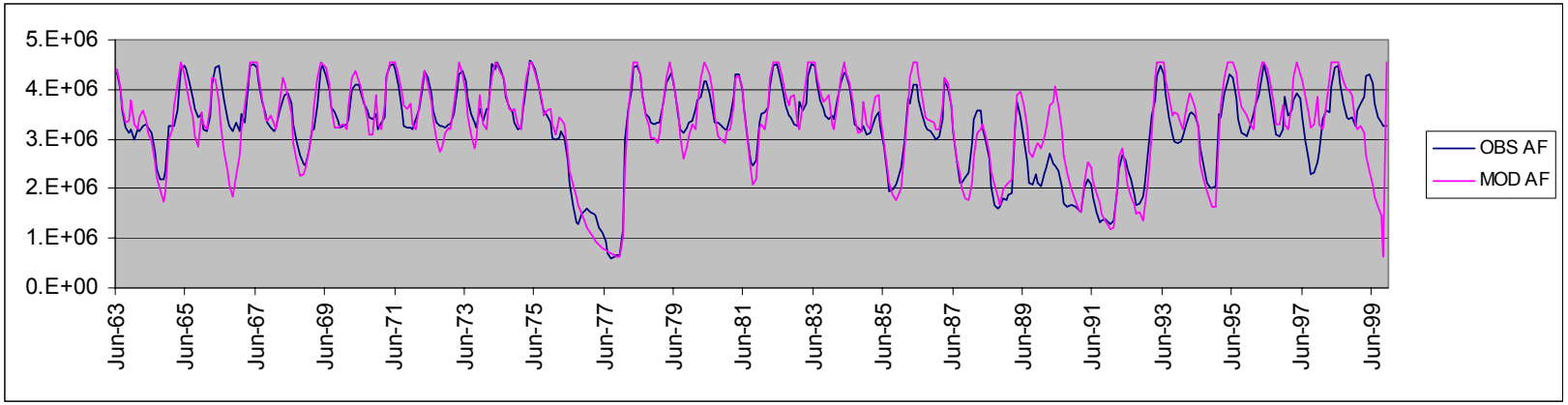
Pit R @ Shasta

Reservoir Storage

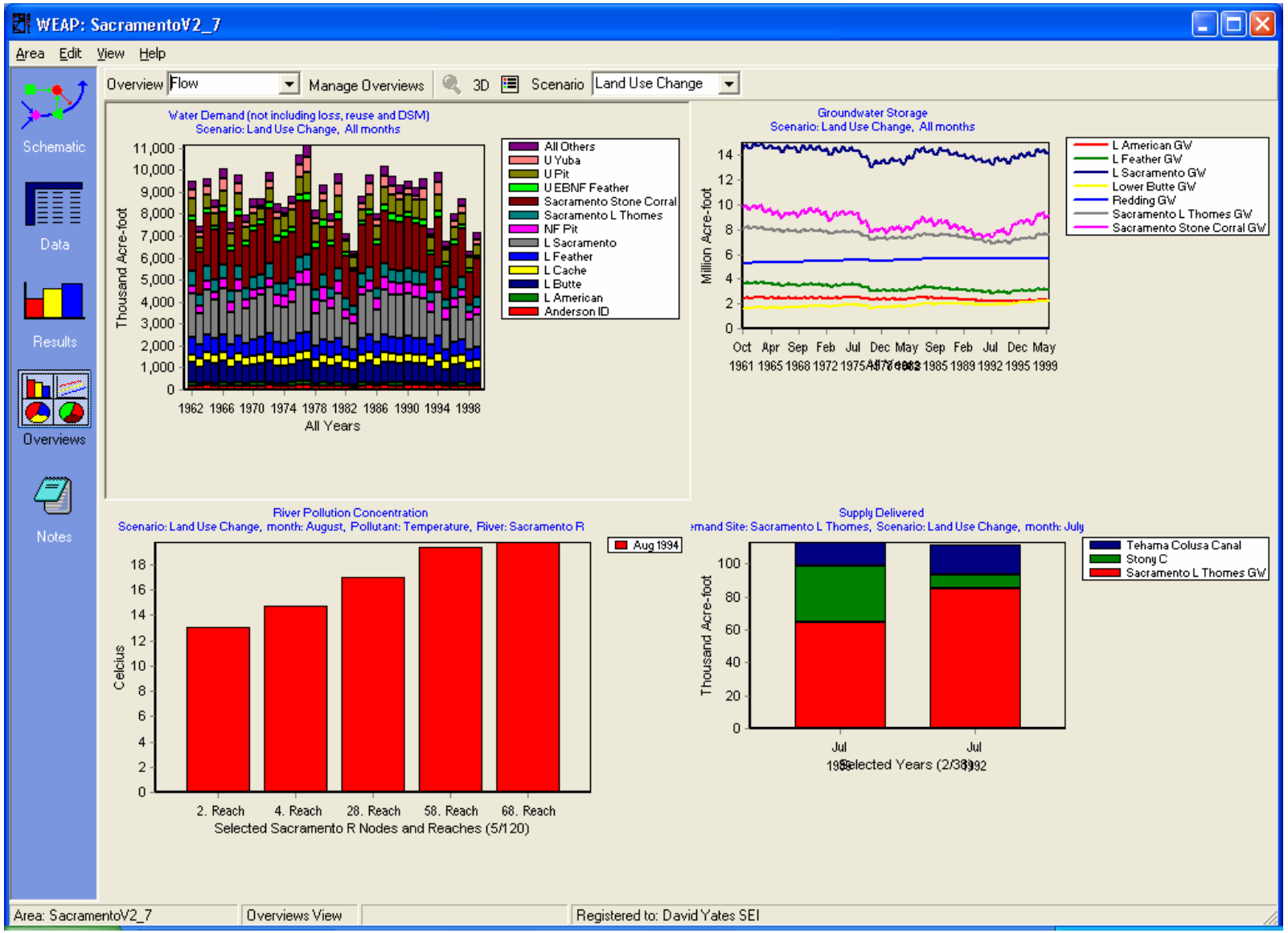
FOLSOM



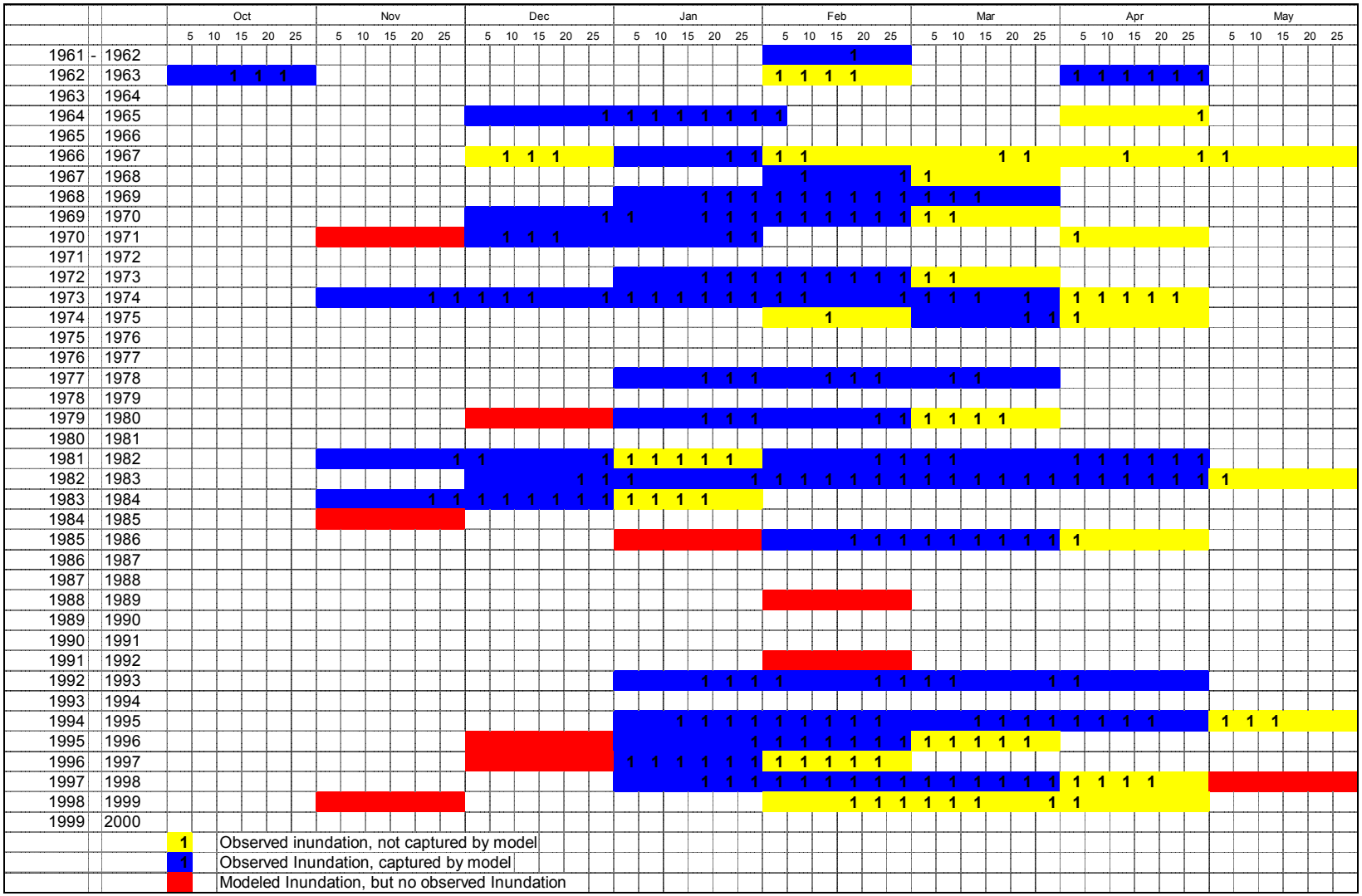
SHASTA



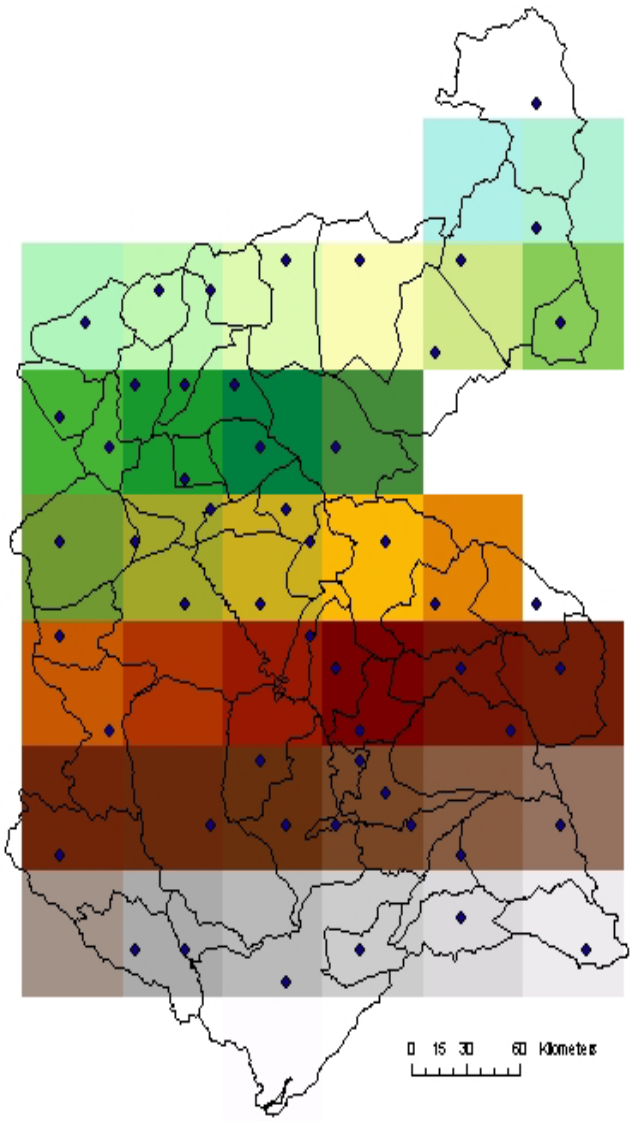
Agricultural Demand, Groundwater Levels



Yolo Bypass Inundation



Climate Change Scenarios



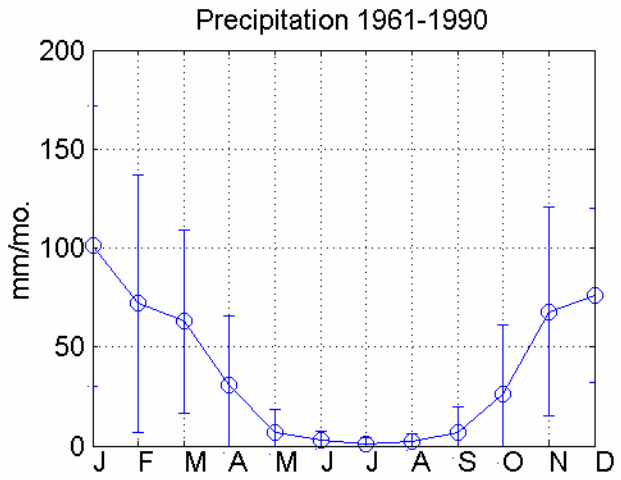
IPCC Hadley A2, B2 GCM based scenarios.

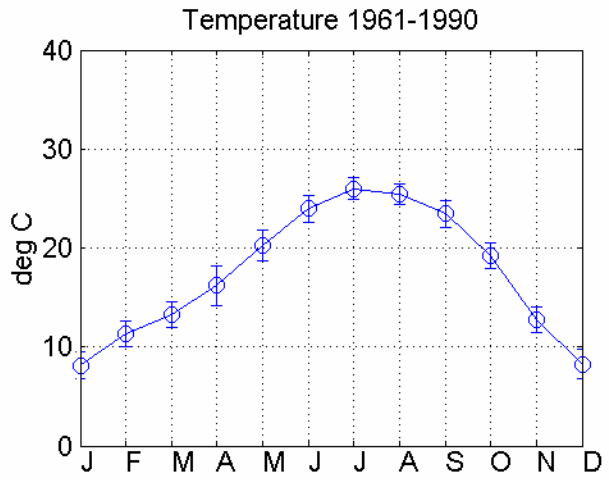
1st Downscaled to 0.5x0.5

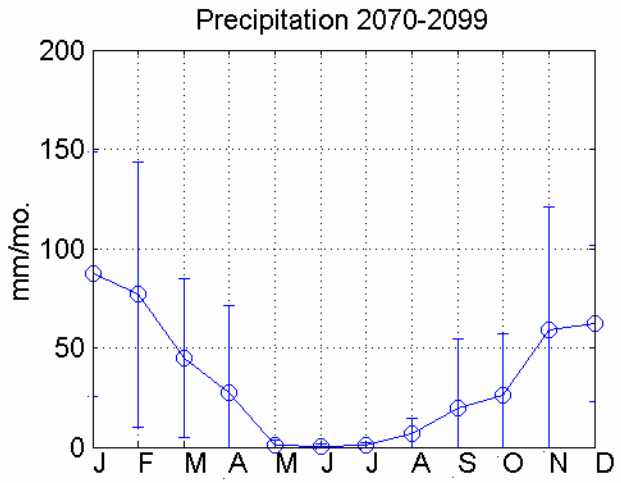
2nd Scaled against Historic Climate

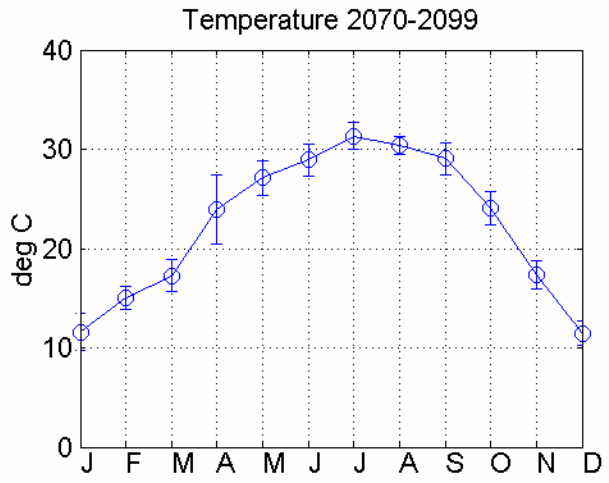
3rd Mapped to Individual HUCs

Climate Change Scenarios



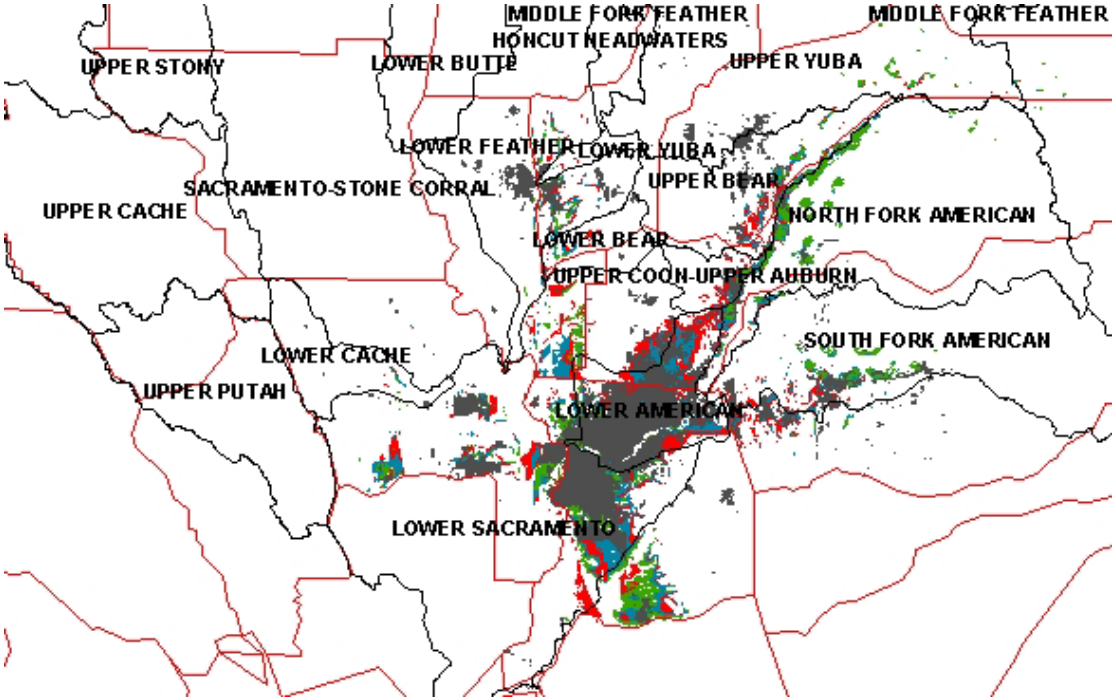






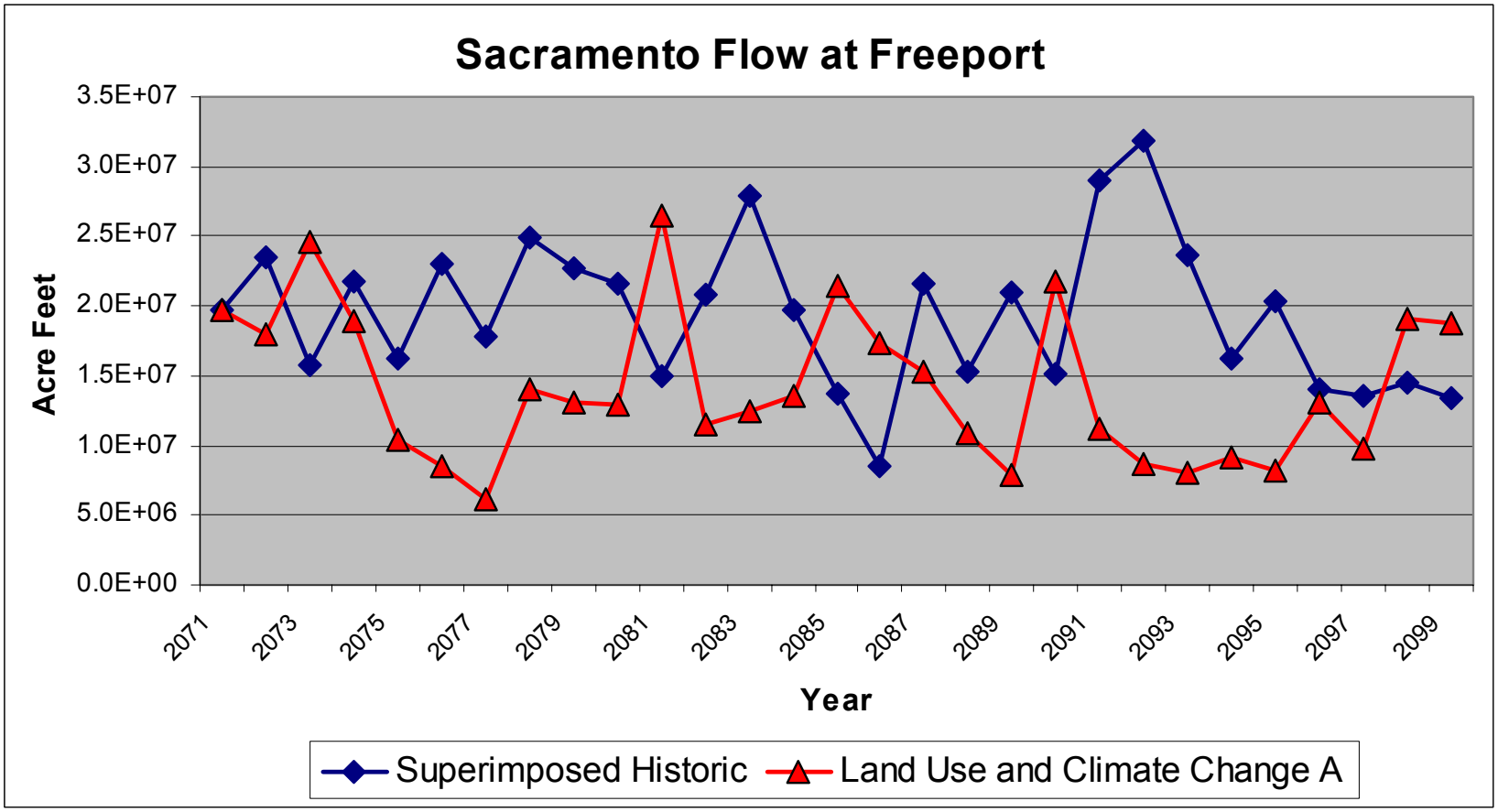
Sacramento

Land Use Projections

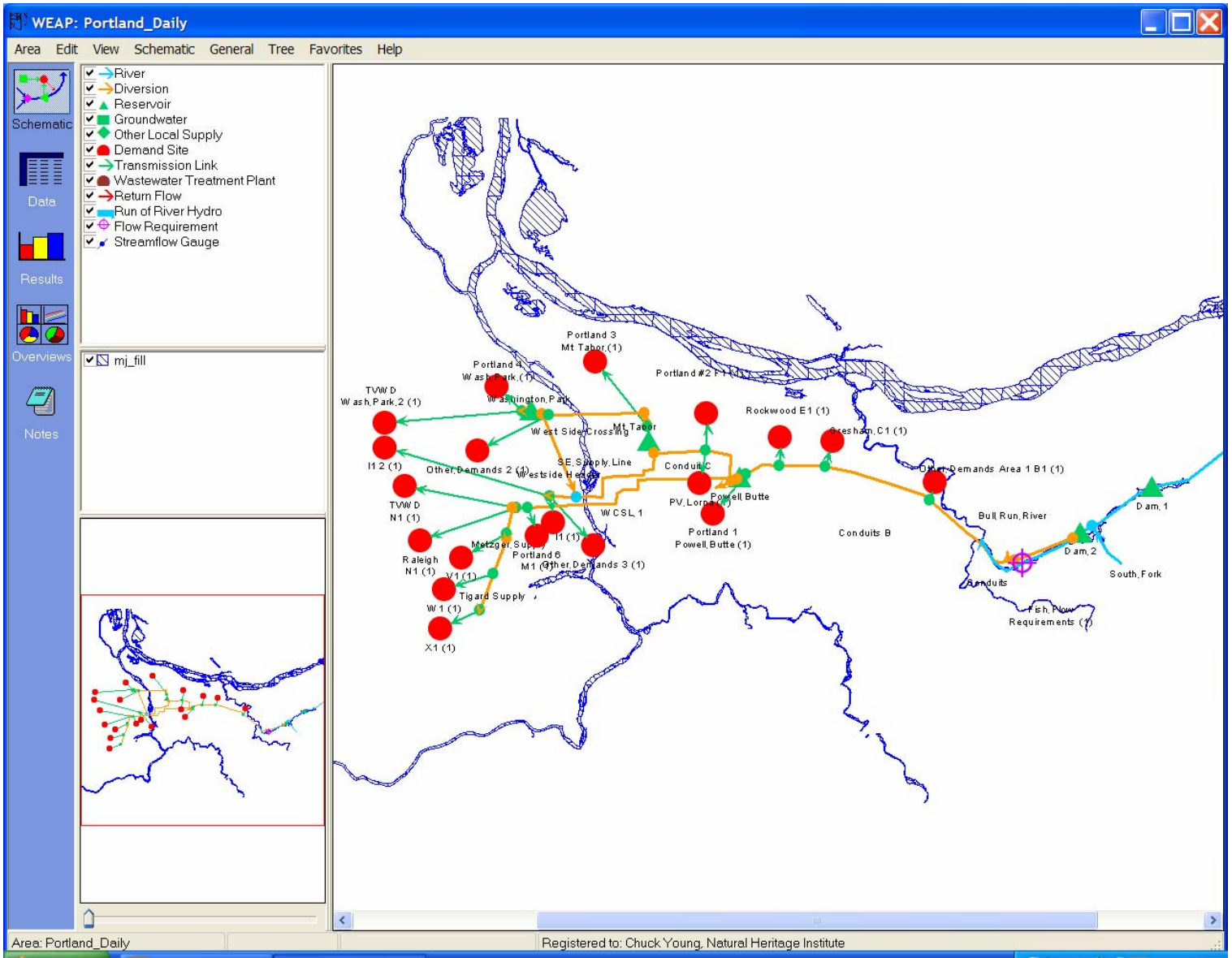


Land Use Projections
Current 1998 (gray); 2020 (green); 2050 (blue); 2100 (red)
(source: Landis and Reilly, 2003)

Sacramento Flow under A2 Scenario



Another Application: Portland, Oregon



Advantages of WEAP for DWR Planning

- Flexible and Transparent.
- Designed Specifically to Handle Multiple What If Scenarios.
- Allows for Continual Change Over the Course of a Simulation.
- Internatizes Climate and Land-Use Scenarios.
- Powerful Demand-Side Module.
- Use an Allocation Algorithm Similar to CALSIM II.
- Sacramento River System Already Constucted.
- Rich Internal Graphics Capability.