Sustainable Groundwater Management Act and Groundwater Sustainability Plan for the Napa Valley Subbasin

Hydrologic Model Development

Nick Newcomb & Ryan Fulton

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Luhdorff & Scalmanini
Consulting Engineers

Outline

February – Model Introduction

Today – Model Development

1. Review Conceptual Model & Approach
2. Model Domain and Discretization
3. Geology and Model Layering
4. Surface Water
5. Farm Process
6. METRIC Analysis – Davids Engineering
7. Groundwater Pumping
8. Model Calibration

April – Water Budget Results

Conceptual Model and Approach

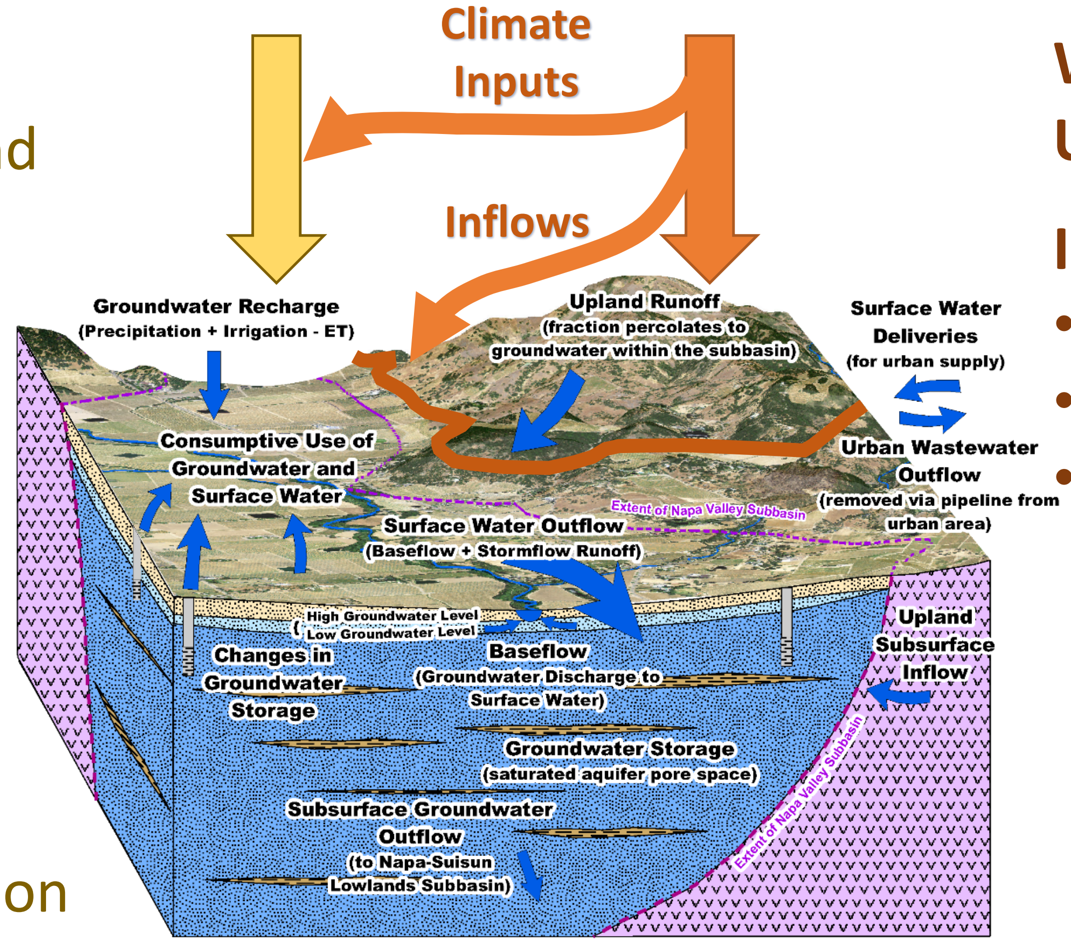
One-Water Hydrologic Model

Supply and Demand
- Ag/Urban Water Demand
- Irrigation & Imports
- Conjunctive Use

Streamflow
- Diversions and Runoff

Groundwater Hydraulics
- Recharge
- Pumping
- 3D Groundwater Flow
- Stream-Aquifer Interaction

One-Water **BCM**

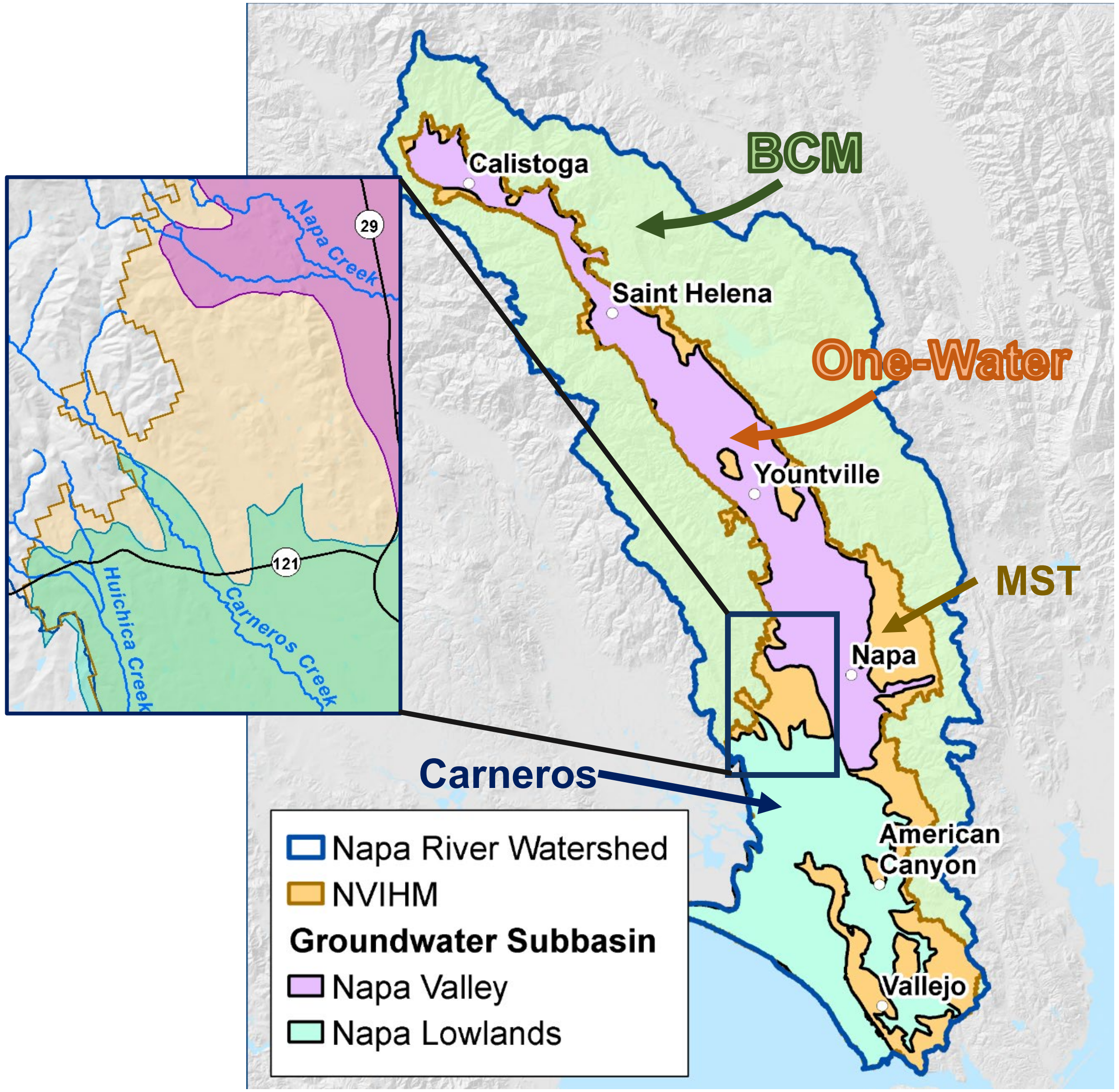


Basin Characterization Model

Watershed Response in Upper Watershed

Inputs to One-Water
- Tributary Inflows
- Mountain Block Recharge
- Climate Inputs
  - Reference ET
  - Precipitation

Model Boundaries and Discretization



Boundaries

- Napa Valley Groundwater Subbasin
- Napa Lowlands and MST
- Adjacent Uplands
- Lower and Upper Boundaries

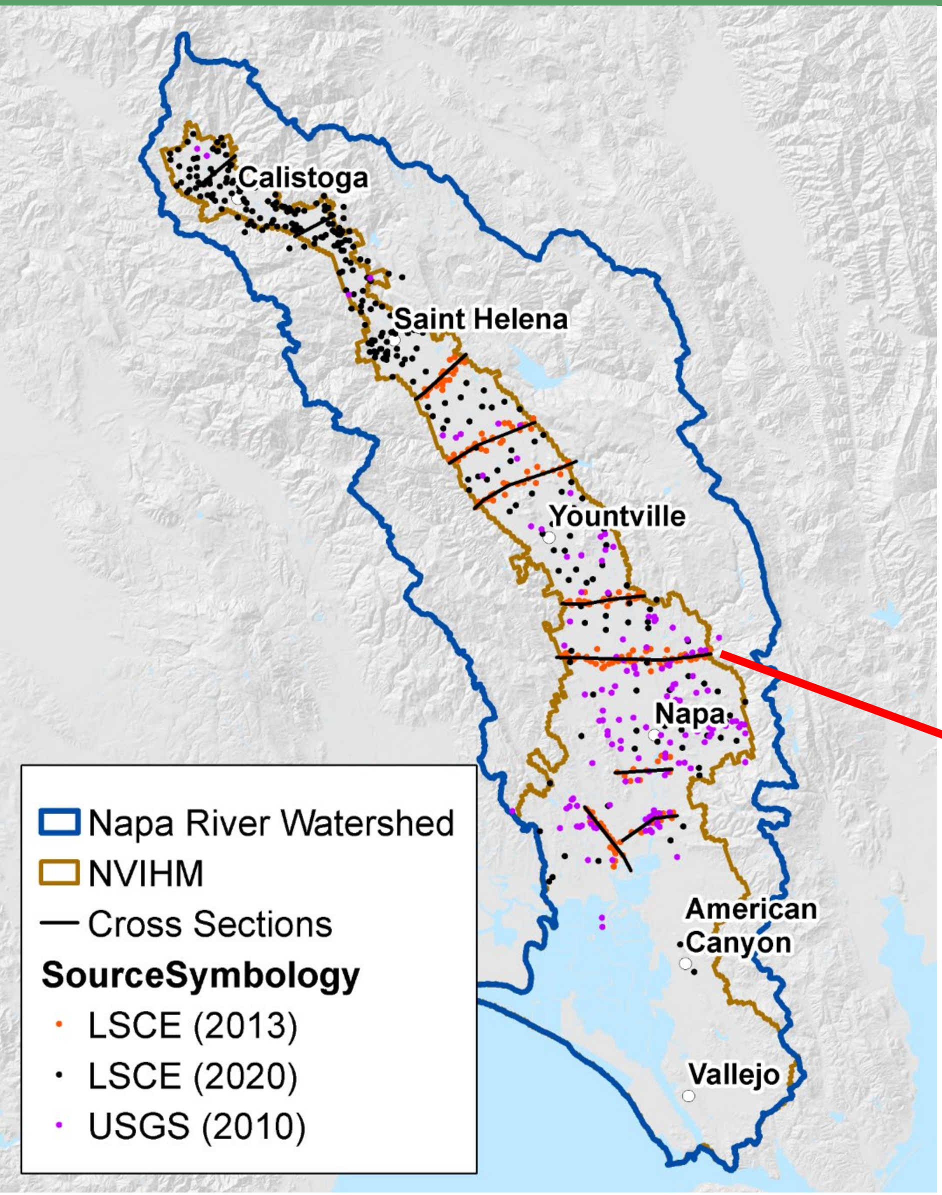
Spatial Discretization

- Horizontal: 500 x 500 feet (~6 acres)
- Vertical 10 Layers

Temporal Discretization

- Monthly Stress Periods
- Model Initialization: 1984 - 1987
- Historical Water Budget Analysis: 1988 – 2018
- Current Water Budget Year: 2019

Geology and Model Layering (Data)

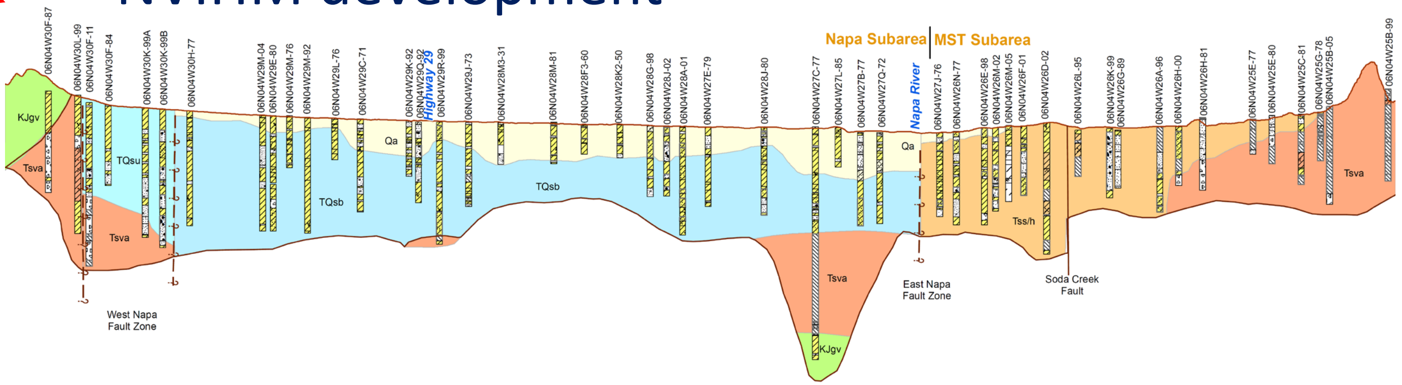


Studies

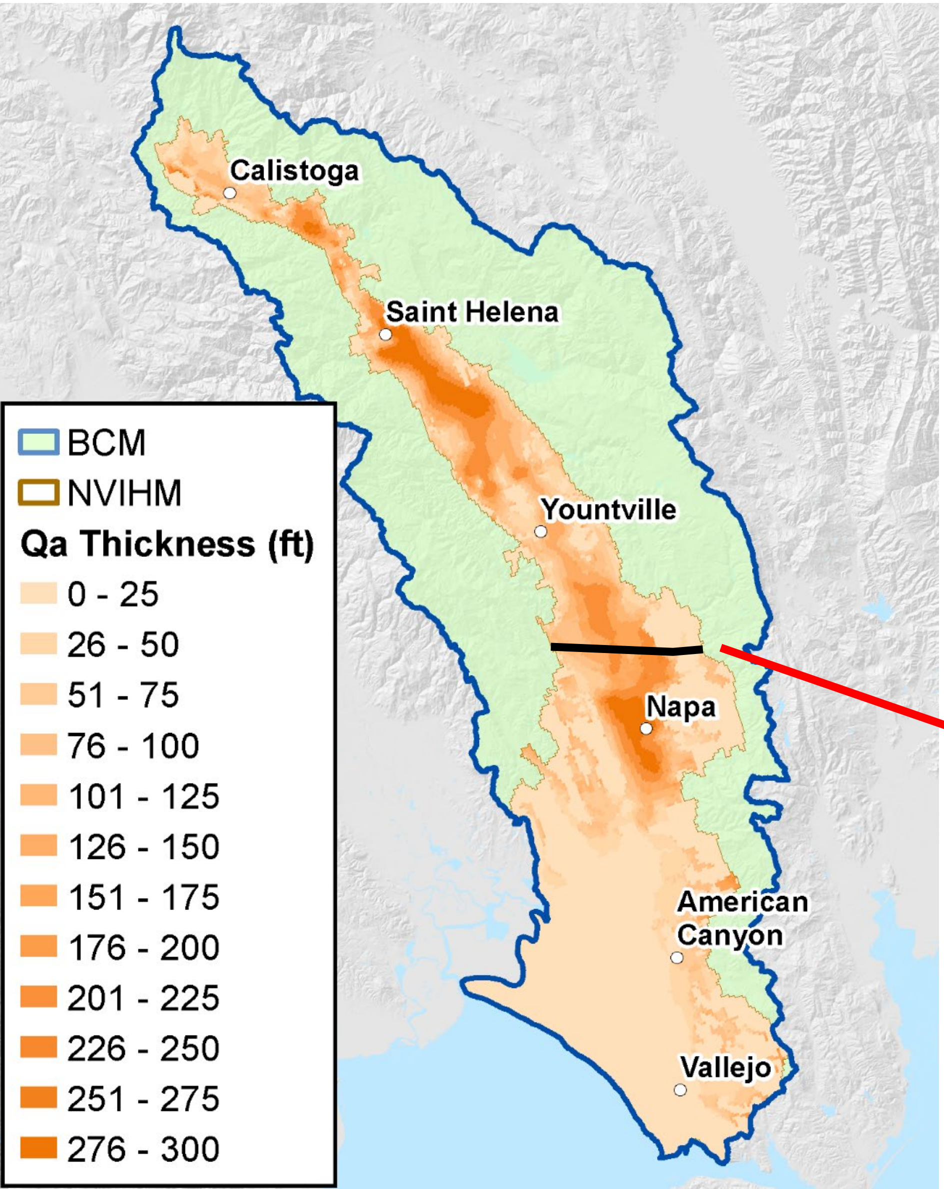
- Graymer (2002, 2007), Kunkle & Upson (1960), Sweetkind & Taylor (2010), Farrar & Metzger (2003)
- Hydrogeologic Conceptualization (LSCE, 2013)

Borehole Data

- 375 wells digitized for previous efforts (LSCE, Sweetkind & Taylor)
- 295 additional well completion reports digitized for NVIHM development



Geology and Model Layering

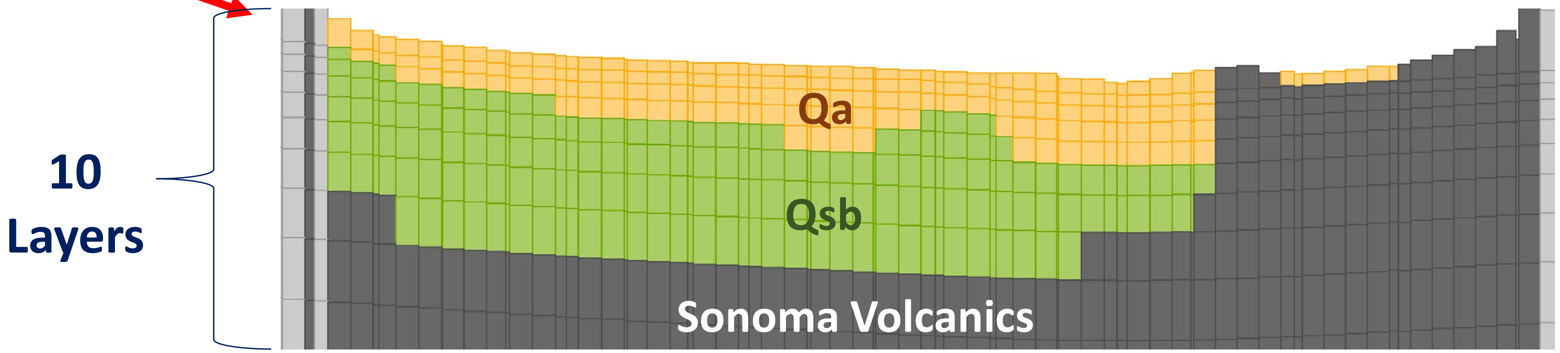


Geologic Units

- Thickness and distribution of 3 primary geologic units
- Texture distribution in quaternary alluvium (Qa) explicitly incorporated

Model Layering

- 10 model layers
- Thinner near the land surface
- Increase in thickness with depth



Tributary Inflows

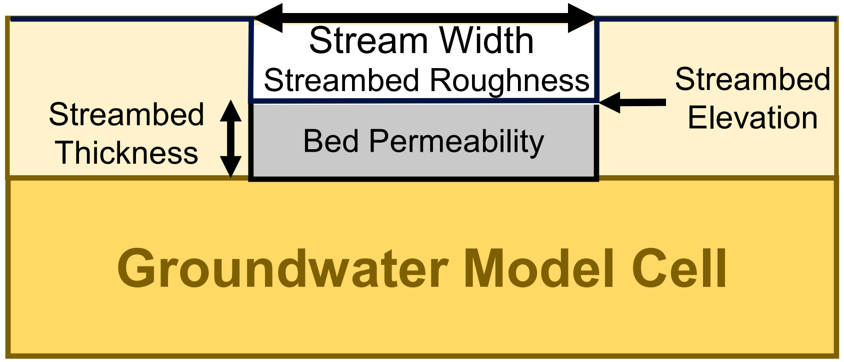
- BCM provides raw tributary recharge & runoff
- Post-processing algorithm to estimate streamflow and mountain block recharge

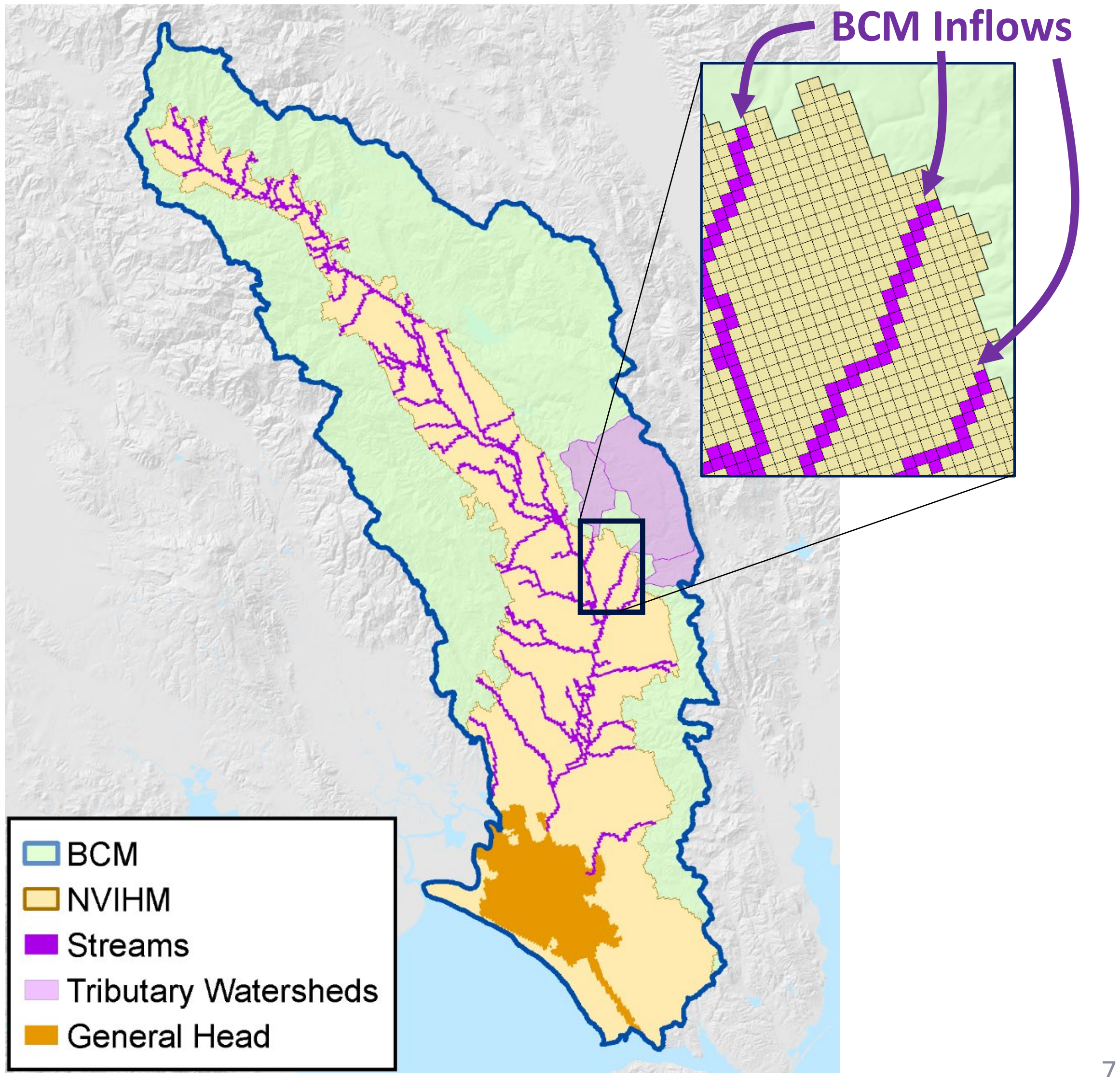
Flow

- Calculated internally from Manning's Equation
- Diversions and runoff & returns from Farm Process

Stream Properties

- Channel elevation (LIDAR)
- Channel width estimated using areal imagery





Farm Process (Water Sources)

Sources of Water

Surface Water Imports

- Municipalities

Stream Diversions

- eWRIMS (State Board records)

Recycled Water

- Napa Sanitary, Municipalities

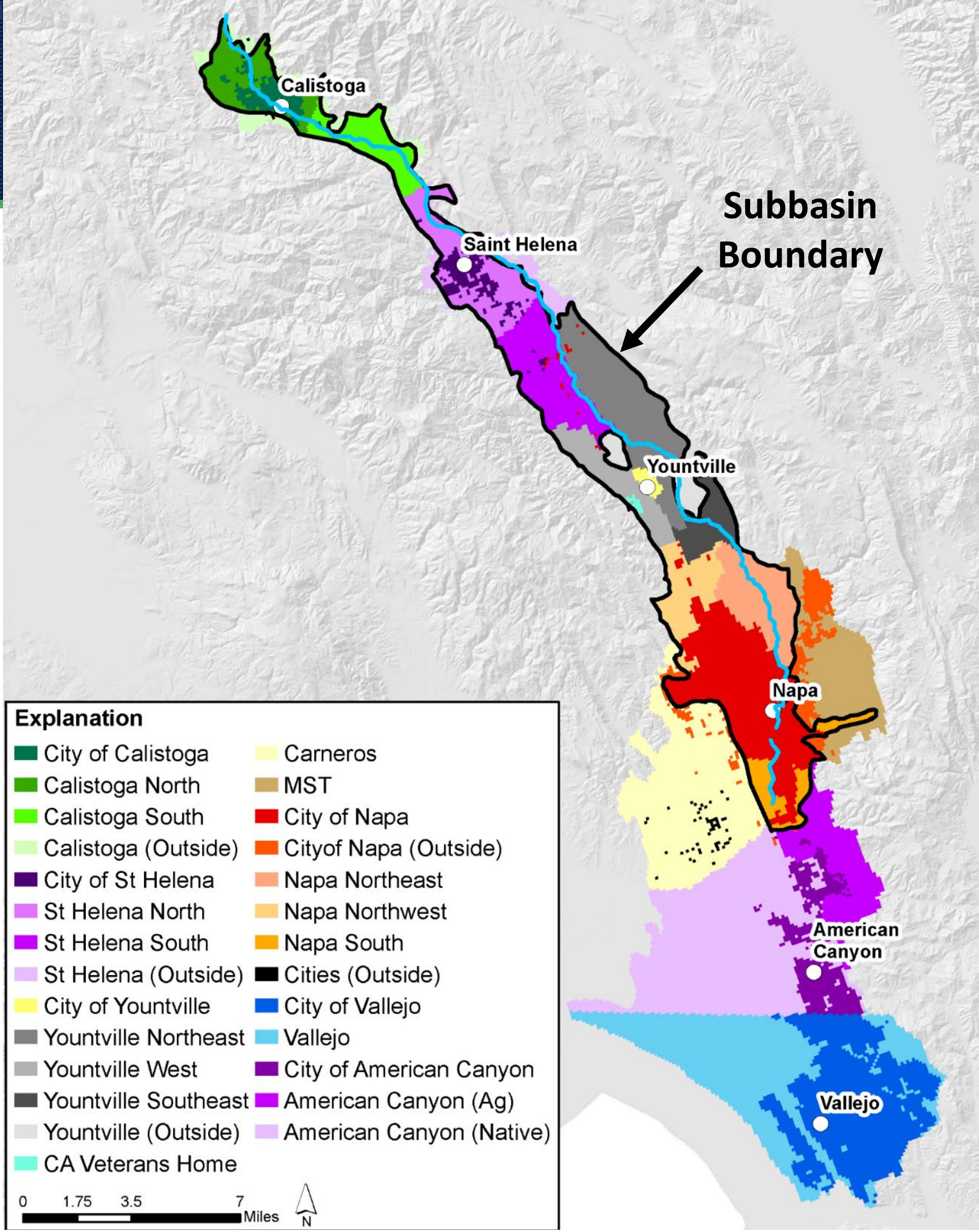
On-Farm Storage

- Growers, Farm Bureau

Drains & Stored Return Flows

- Farm Bureau

Groundwater Pumping



Farm Process (Climate)

Precipitation and Reference ET

- BCM provides monthly gridded estimates on a 270-meter (900 feet) resolution
- Interpolated onto 500-foot NVIHM grid

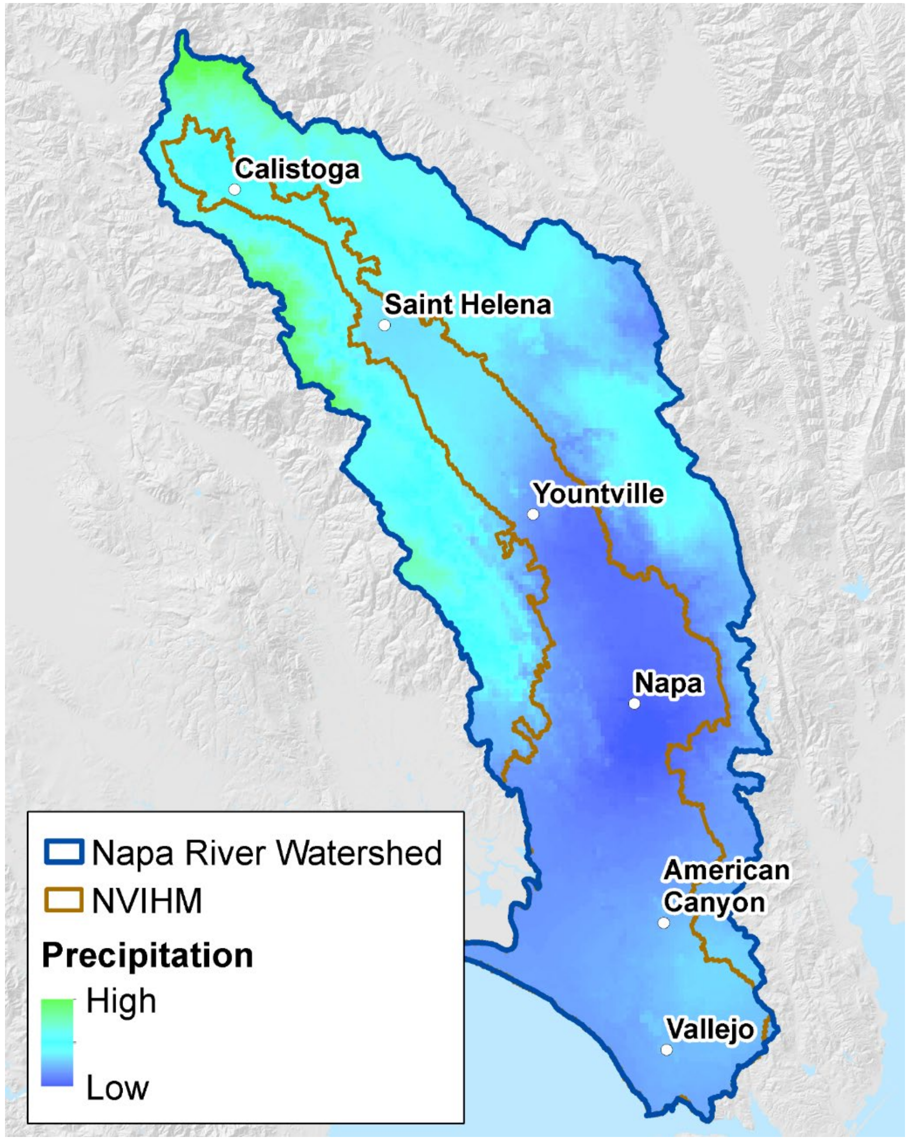
Reference ET

$$ET_c = ET_o Kc$$

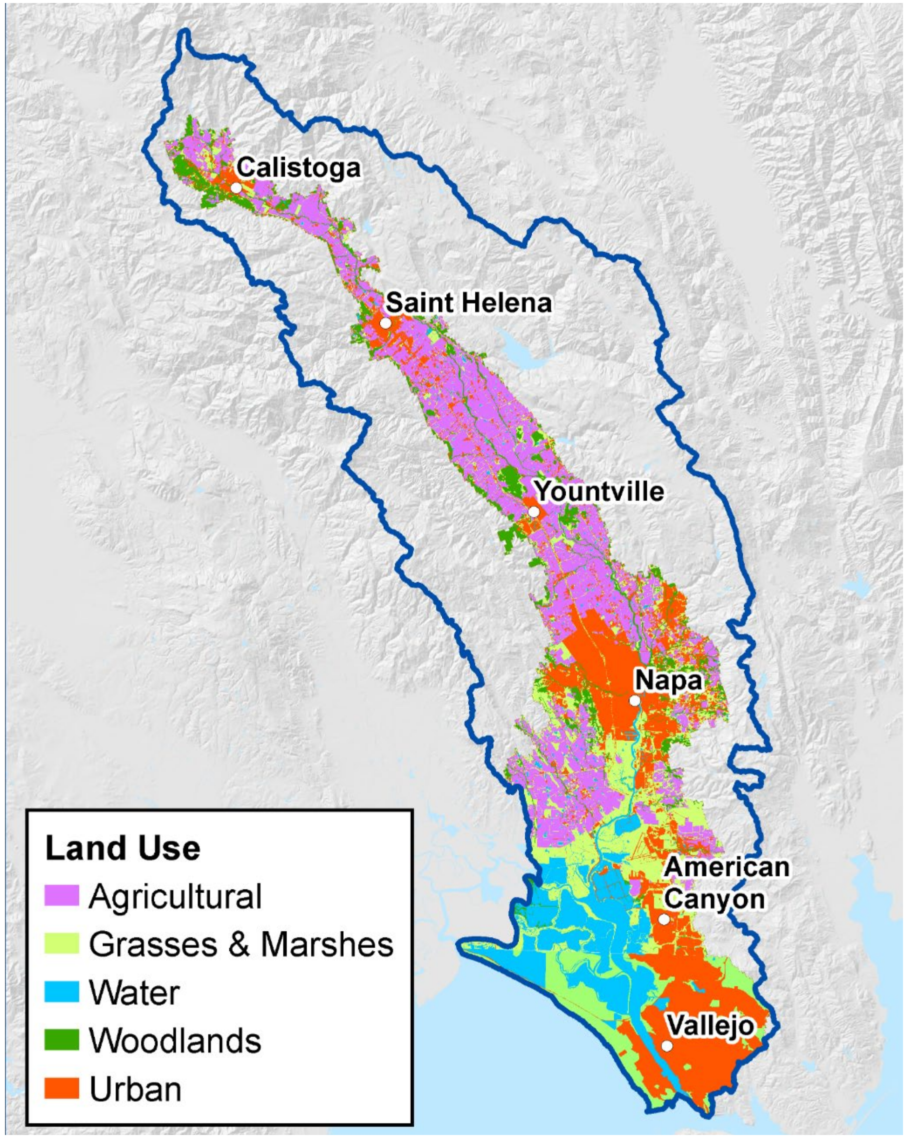
- Derived using Priestley-Taylor Equation
- Scaled to observations at CIMIS stations

Precipitation

- PRISM (Oregon State Climate Group)



Farm Process (Land Use)



Land Use Classes (17)

- Native land use classes (7)
- Urban land use classes (4)
- Agricultural land use classes (6)

Datasets

- DWR Napa County mapping (1987, 1999, 2011)
- DWR Solano County mapping (1994, 2003)
- DWR Statewide (LandIQ) mapping (2014, 2016)
- UC Davis (ICE) native vegetation mapping (2005)
- County agricultural mapping (1993, 2002, 2005, 2010, 2014, 2016)
- Areal imagery

Farm Process (Crop Parameters)

Crop Parameters Assigned by Land Use

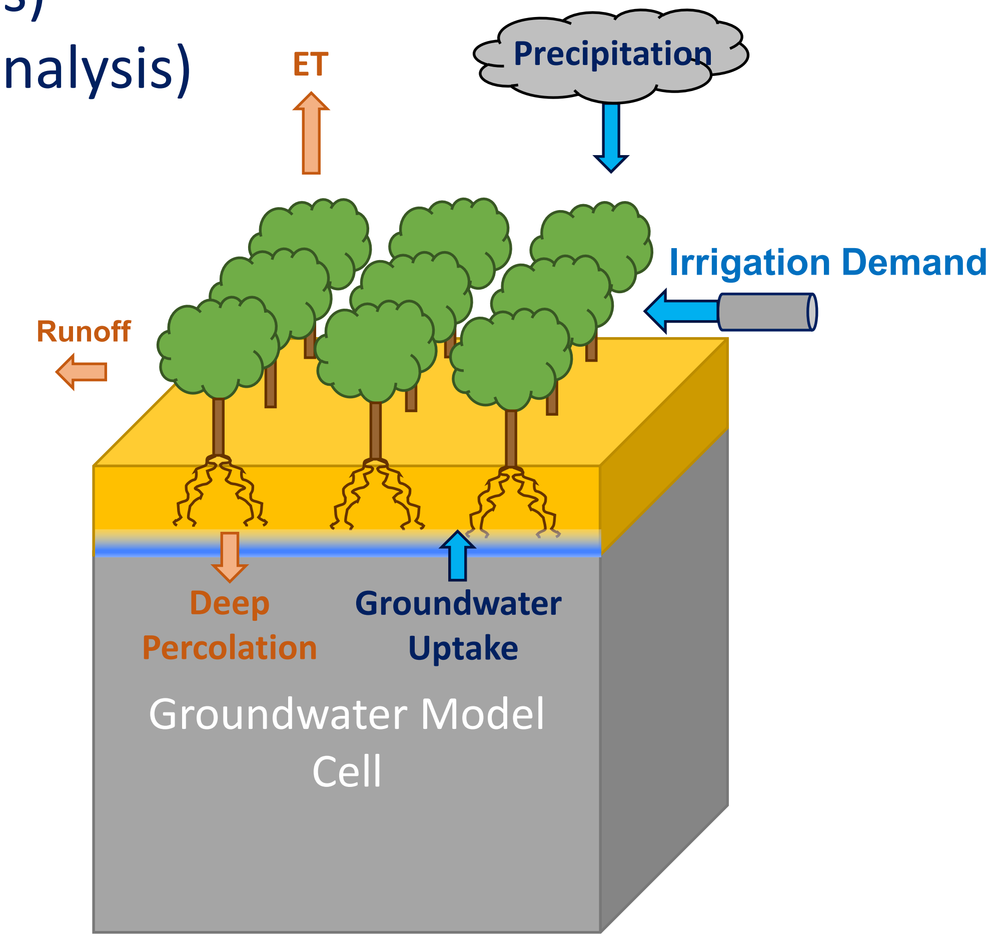
- Crop coefficient (supplied by METRIC analysis)
- Transpiration fraction (supplied by METRIC analysis)
- Rooting depth
- Runoff fractions

Irrigation

- Irrigated/non-irrigated
- Irrigation method
- Irrigation efficiency

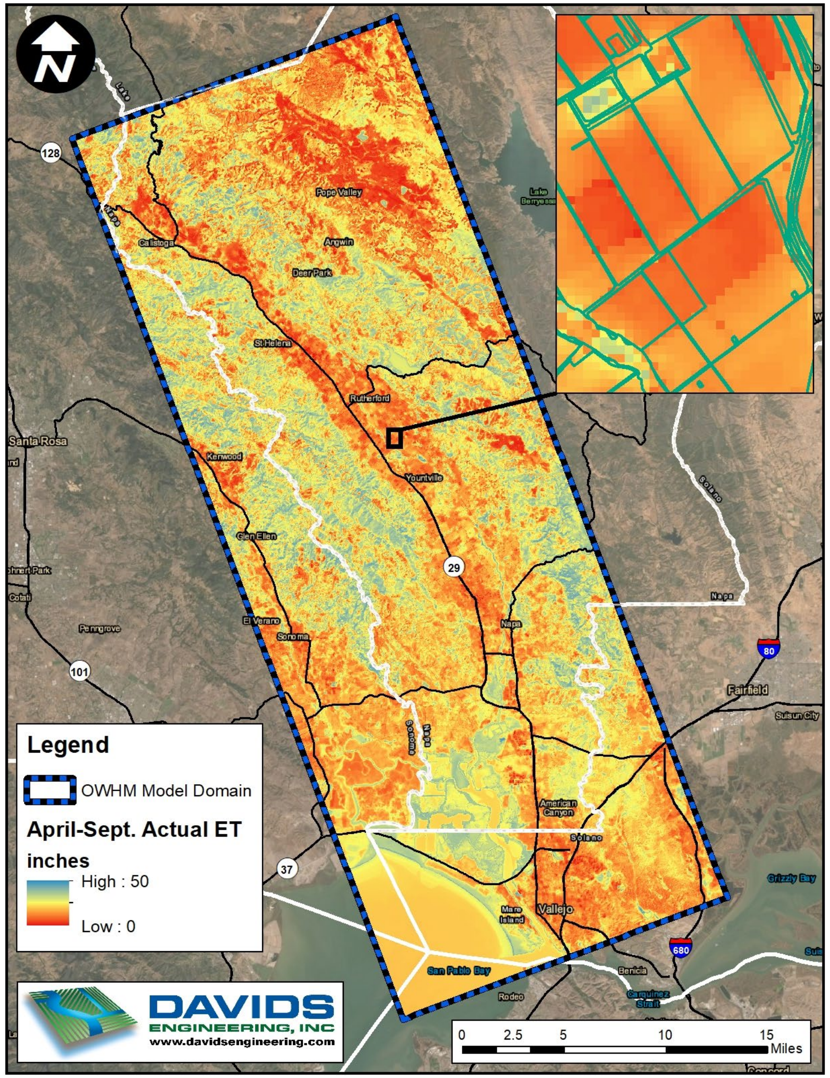
Soils

- Five primary soil types
- Capillary fringe
- Drains



METRIC

- **M**apping **E**vapo**T**ranspiration at high **R**esolution with **I**nternalized **C**alibration (**METRIC**)
  - Originally developed based on **S**urface **E**nergy **B**alance **A**lgorithm for **L**and (**SEBAL**)
  - Widely applied satellite energy balance method to estimate consumptive use
- Benefits
  - Applicable over large areas at high resolution
  - Limited need for ground-based instrumentation
- Challenges/Limitations
  - Available imagery
  - Estimation of ET between image dates
  - Complex surfaces

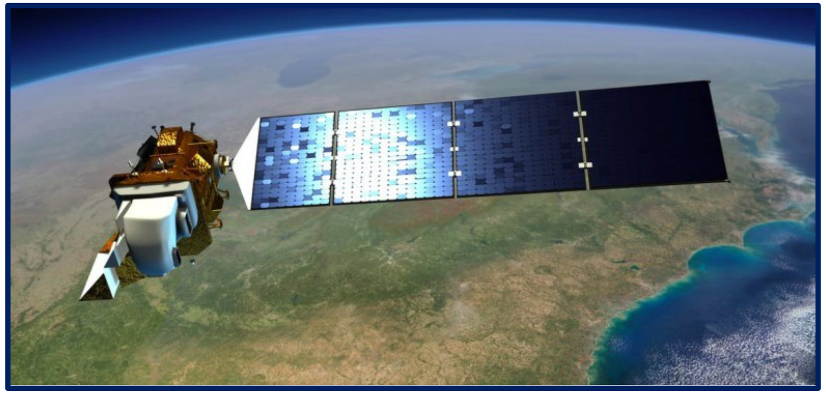


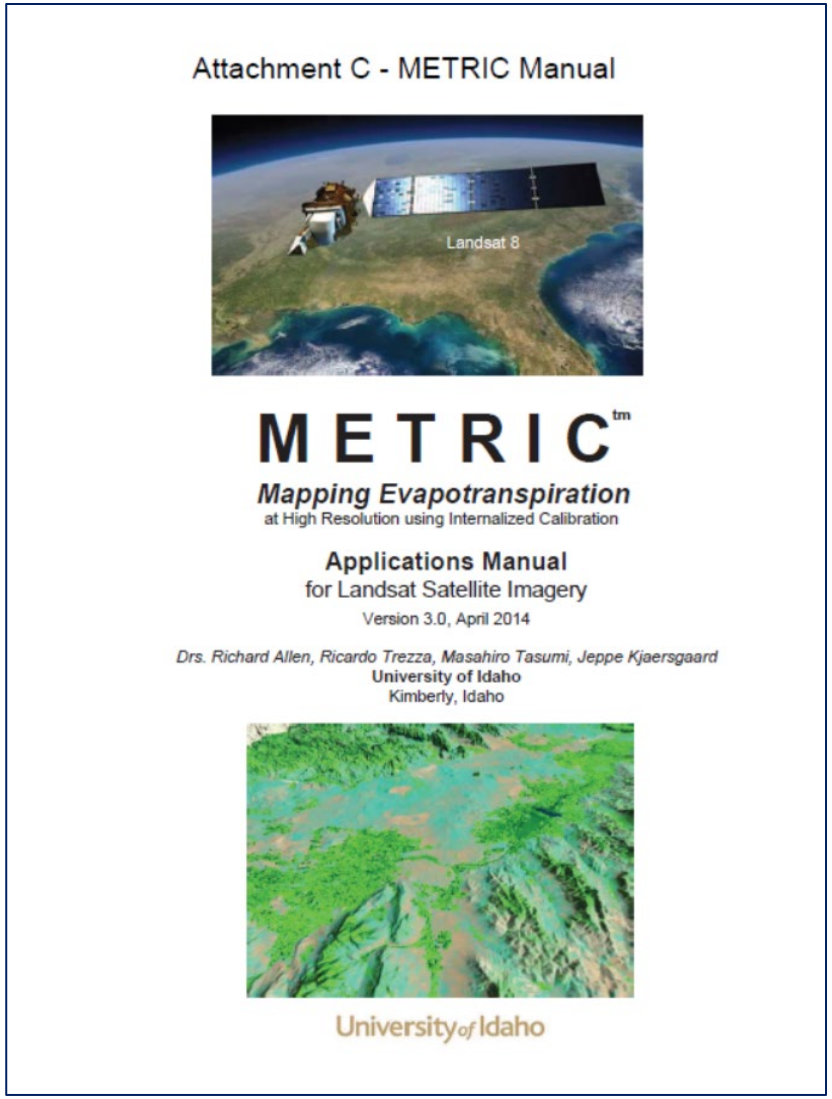
For More information: DWR Draft Handbook for Water Budget Development with or without Models. 2020. https://water.ca.gov/-/media/DWR-Website/Web-Pages/Programs/Groundwater-Management/Data-and-Tools/Files/Water-Budget-Handbook.pdf?la=en&hash=30AD0DFD02468603F21C1038E6CC6BFE32381233

METRIC (continued)

- Analysis by Davids Engineering
- Support and Review by Dr. Rick Allen (METRIC developer and principal investigator)
- Level 3 METRIC Code
- Landsat 8 Imagery (13 Images)
- Combination of CIMIS and Local Weather Data

Acquisition Date	Days Since Last Image
12/28/2013	N/A
1/13/2014	16
3/18/2014	64
4/19/2014	32
5/21/2014	32
6/6/2014	16
6/22/2014	16
7/24/2014	32
8/9/2014	16
9/10/2014	32
10/12/2014	32
10/28/2014	16
12/31/2014	64




Attachment C - METRIC Manual

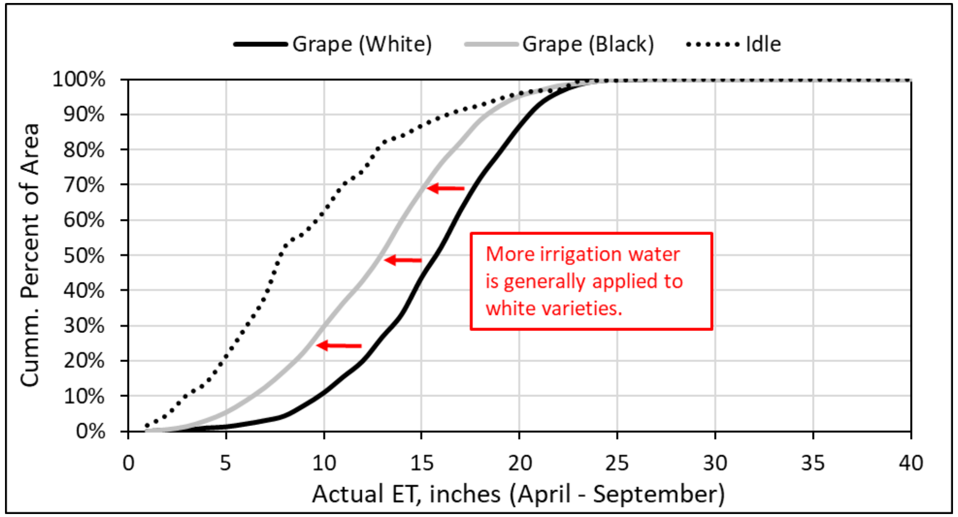
METRIC tm
Mapping Evapotranspiration
at High Resolution using Internalized Calibration

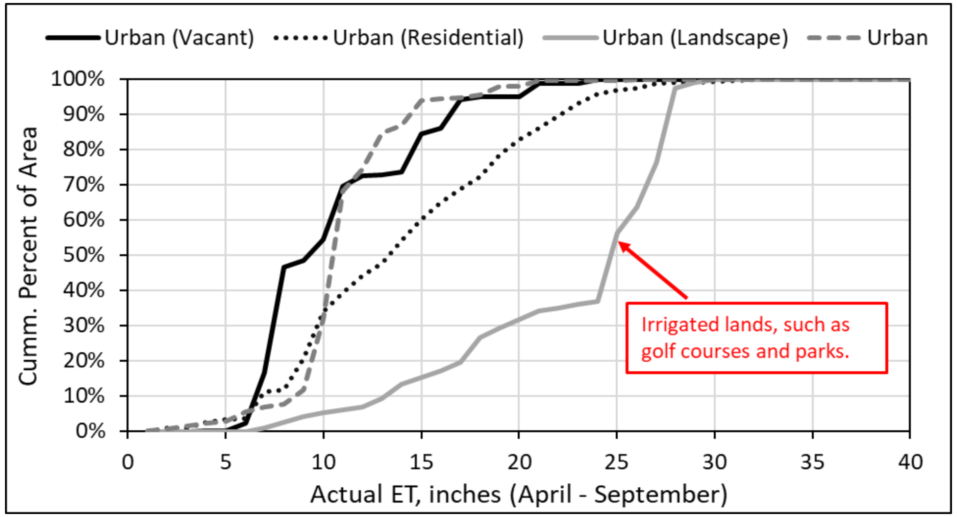
Applications Manual
for Landsat Satellite Imagery
Version 3.0, April 2014

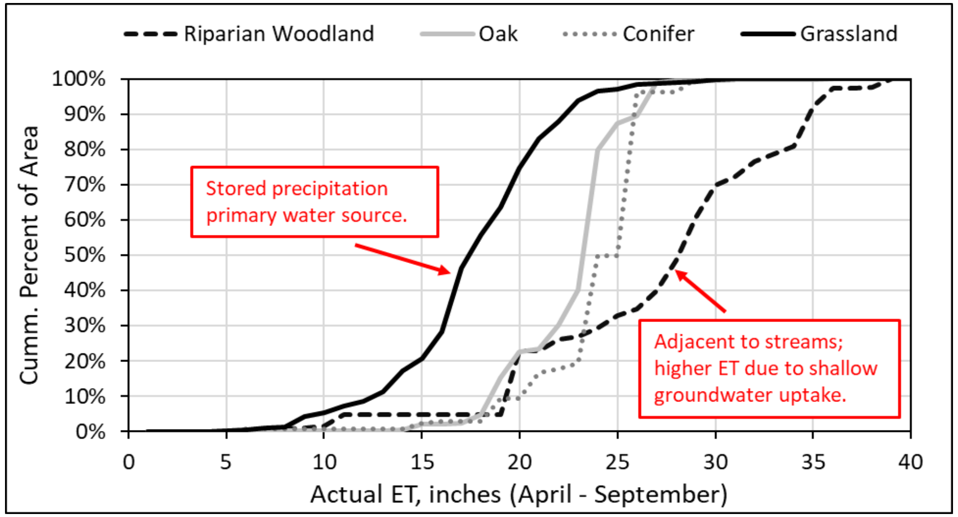
Drs. Richard Allen, Ricardo Trezza, Masahiro Tasumi, Jeppe Kjaersgaard
University of Idaho
Kimberly, Idaho

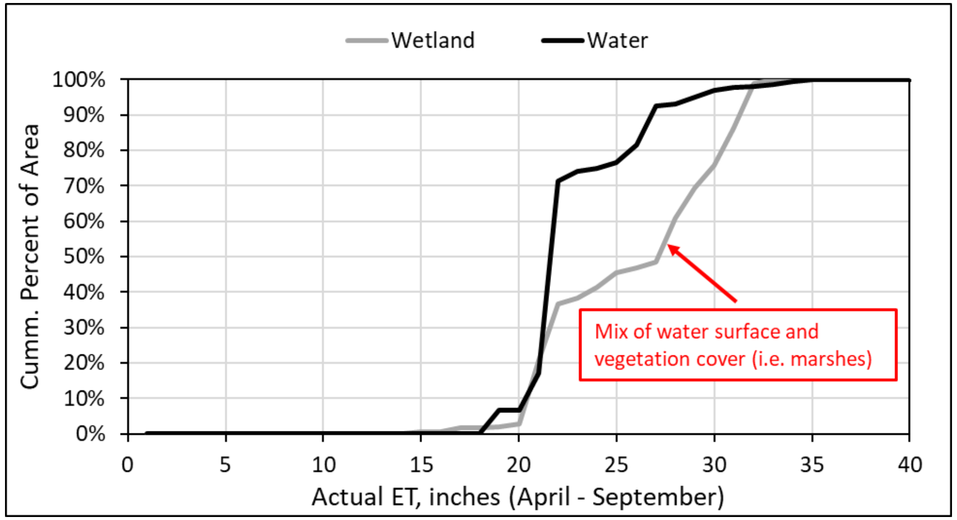
University of Idaho

Actual Evapotranspiration (2014)









	ETa, inches*	
Land Use Category	Annual**	April-Sept
Conifer	35.1	25.4
Oak	34.7	24.6
Riparian Woodland	41.7	30.1
Grassland	28.2	19.2
Wetland	40.4	29.6
Shrubland	41.0	30.2
Water	35.6	26.3
Urban	21.1	12.8
Urban Residential	25.1	15.9
Urban Landscape	37.1	25.3
Urban Vacant	20.0	12.2
Orchard	26.2	16.5
Semi Ag	24.9	15.8
Field Crop	23.6	15.6
Idle	18.3	9.6
Grape (White)	26.3	17.2
Grape (Black)	23.4	14.1

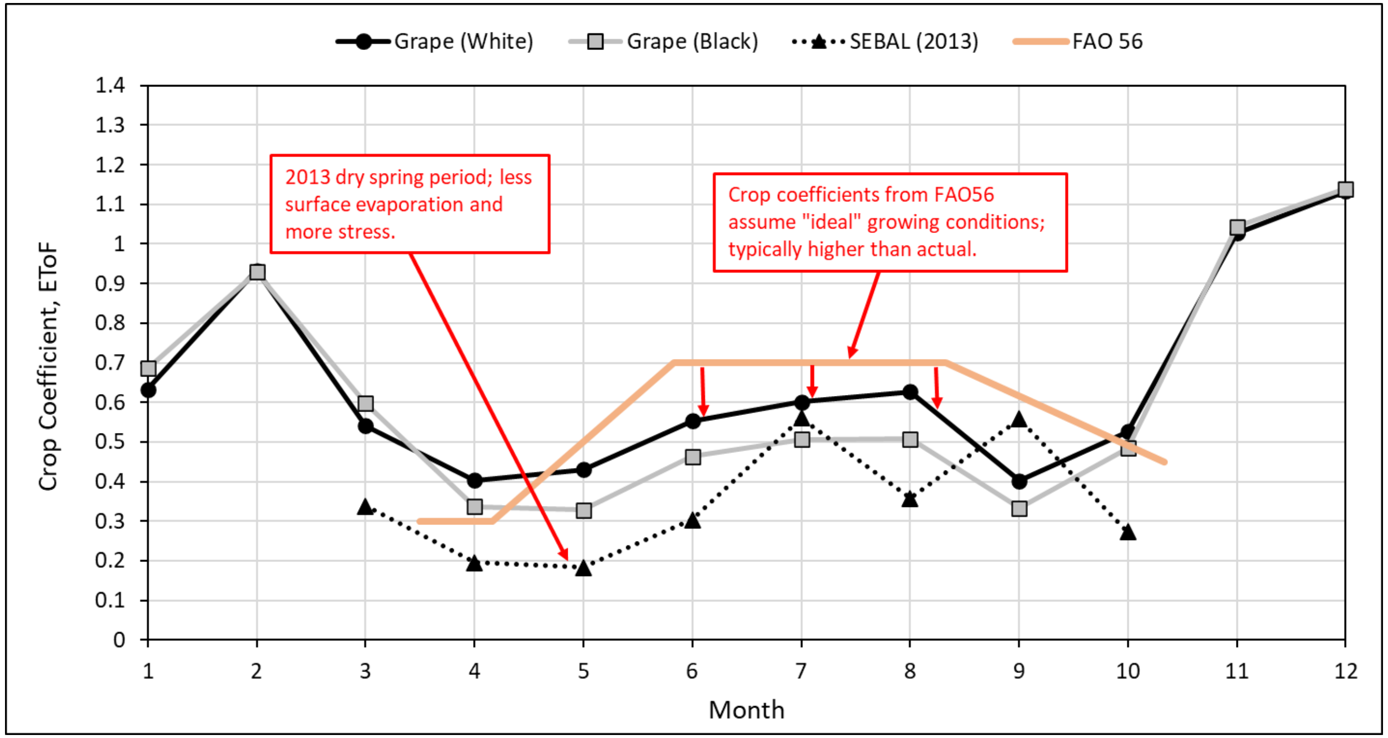
*ETa estimated as the area weighted average across all fields.
**2014 was a 'typical' rainfall year.

Note: October thru March ETa depends heavily on rainfall amount and pattern.

Vineyard Crop Coefficients

Actual ET = Crop Coefficient (EToF) * Reference ET (ETo)

- Reference ET (ETo) = rate of ET for a green, well-watered grass of uniform height with full ground cover
- Crop Coefficient (EToF) = a crop specific scaling factor (typically ranges from 0 to ~1.2); dependent upon plant characteristics and water status, irrigation method, precipitation, etc.

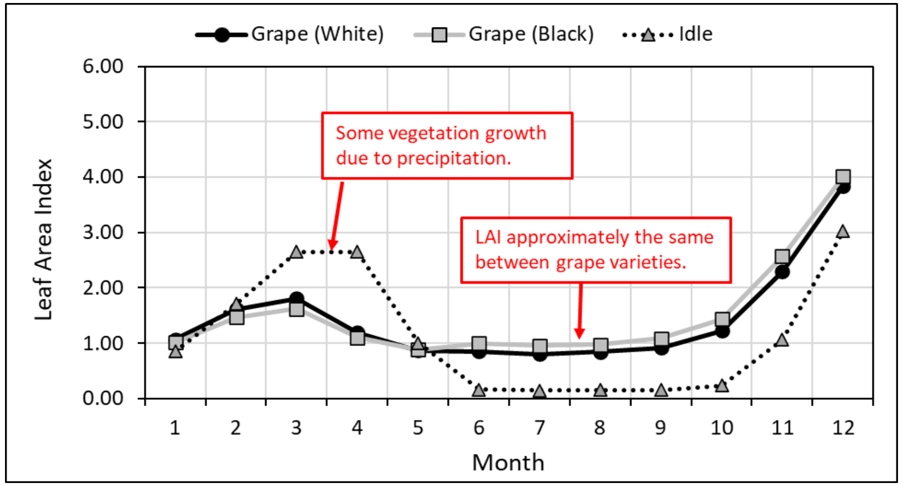


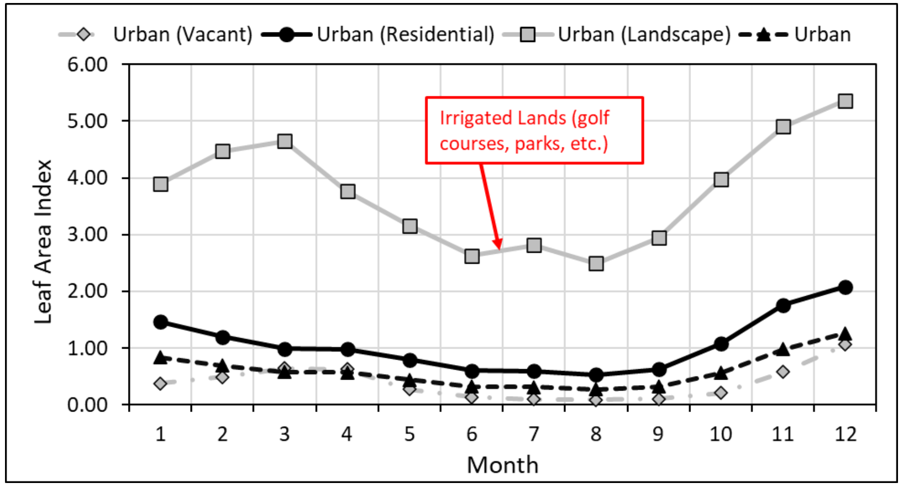
Month	Precipitation, inches	
	2013 (Dry)	2014 (Typical)
1	0.9	0.1
2	0.4	11.1
3	1.0	3.2
4	1.2	2.5
5	0.2	0.0
6	0.9	0.0
7	0.0	0.0
8	0.0	0.0
9	0.7	0.5
10	0.0	0.7
11	1.0	3.0
12	0.6	15.6
Annual	6.8	36.8
Mar. – May (Spring)	2.3	5.8

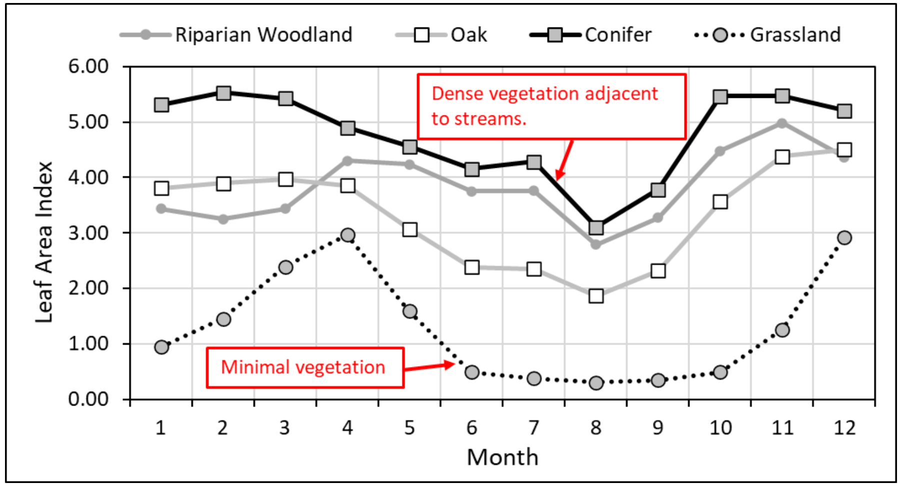
Source: Allen, R. G., L. S. Pereira, D. Raes, and M. Smith (1998), Crop Evapotranspiration: Guidelines for Computing Crop Water Requirements (FAO Irrigation and Drainage Paper No. 56), 328 pp., FAO—Food and Agric. Organ. of the U. N., Rome.

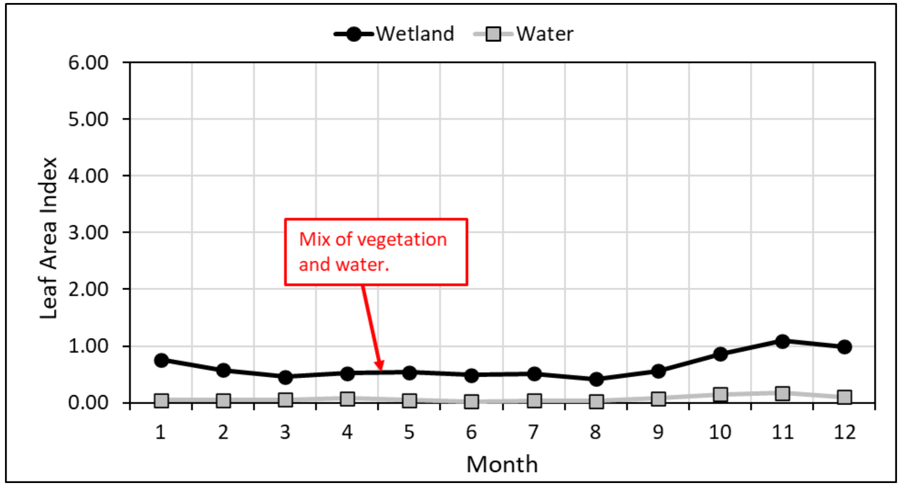
Leaf Area Index (LAI)

Leaf Area Index defined as the area of one side of plant leaves per land area including areas between plants and rows (values range from 0 to 6)









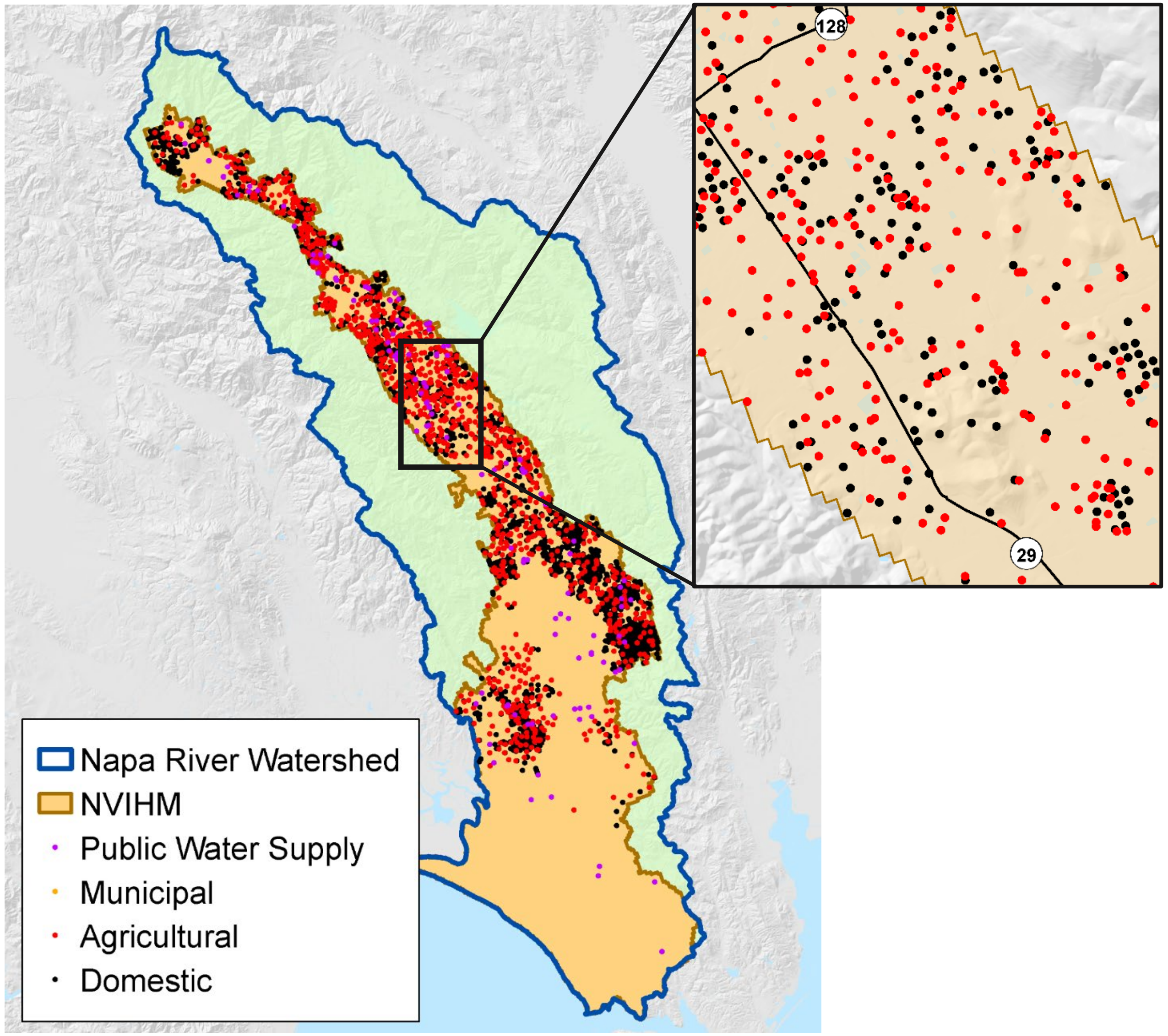
Wells & Groundwater Pumping

Measured/Specified Pumping

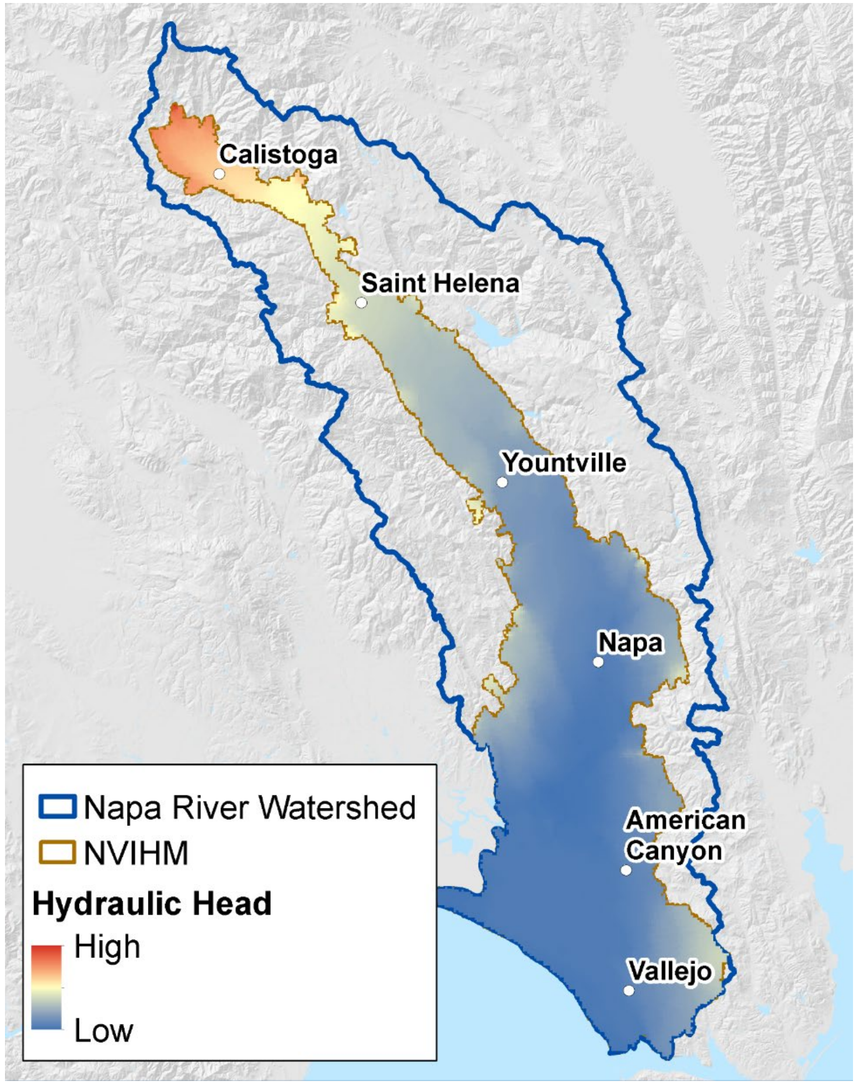
- **Municipal Pumping**
  - City of St Helena, City of Calistoga (historical) & Town of Yountville (future?)
- **Rural Domestic Pumping**
  - Based on population estimates (indoor uses)
- **Public Water Supply Pumping**
  - SWRCB Reporting
- **Winery Pumping**
  - Based on wine production

Computed Pumping (by Model from unmet irrigation demand)

- Agricultural Pumping
- Residential landscaping



Model Calibration – Testing the Model



Quantitative Data

- Groundwater levels
- Streamflow
- Evapotranspiration
- Applied water estimates

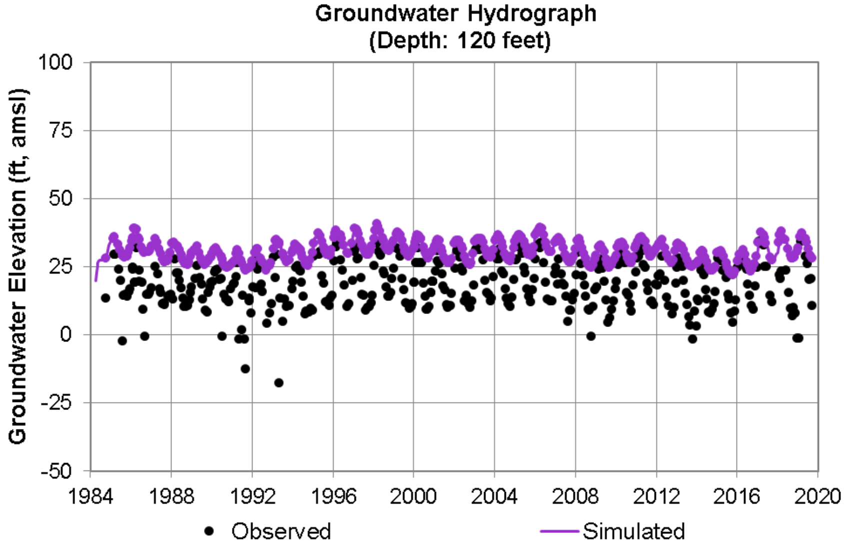
Qualitative Data

- Hydraulic head maps
- Potential GDE mapping

Calibration

- Manual
- Parameter estimation
- Parameter sensitivity analysis

Example: Uncalibrated Output



Next Steps

Calibration

- Update model parameters to better fit observed data
- Continued coordination with stakeholders and agencies
- Parameter sensitivity analysis

SGMA

- Summarize historical and current water budgets

Future Conditions

- Develop predictive scenarios
- Evaluate climate change
- Incorporate and test projects and management actions
- Simulate basin conditions relative to Sustainable Management Criteria

Agency Contacts

Napa County Groundwater Sustainability Agency

1195 Third Street
Suite 310
Napa, CA 94559

Minh Tran, ***Executive Officer***
Napa County Groundwater Sustainability Agency
1195 Third Street
Suite 310
Napa, CA 94559
minh.tran@countyofnapa.org

David Morrison, ***Director***
Planning, Building, and Environmental Services Department
1195 Third Street
Suite 210
Napa, CA 94559
david.morrison@countyofnapa.org

Jeff Sharp, ***Principal Planner***
Planning, Building, and Environmental Services Department
1195 Third Street
Suite 210
Napa, CA 94559
jeff.sharp@countyofnapa.org

Thank You

Nick Newcomb
nnewcomb@lsce.com
(530) 661-0109

Ryan Fulton
Davids Engineering
ryan@davidsengineering.com
(530) 757-6107

Luhdorff & Scalmanini
Consulting Engineers