UCANR MAKING A DIFFERENCE

Land, Air, and Water Resources

Understanding our Groundwater Resources

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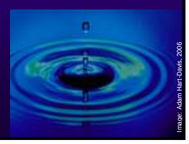
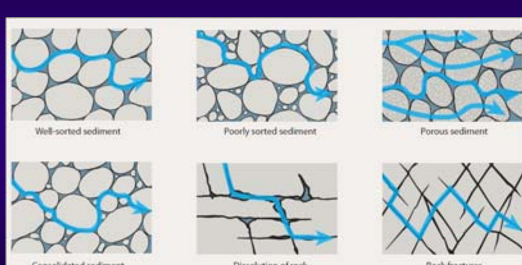


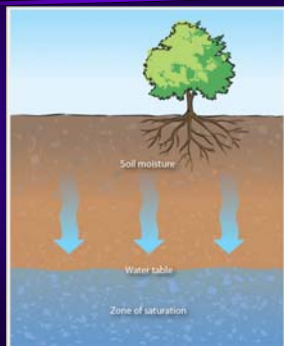
Outline

- Groundwater: how does it work
- Wells: the magic tap
- Aquifer Testing (as opposed to well testing)
- Groundwater Modeling

What is Groundwater?



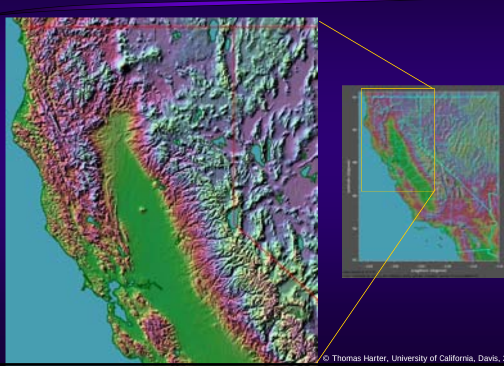
What is Groundwater?



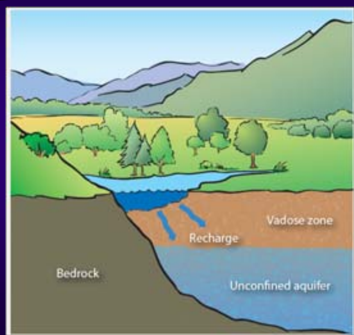
What is Groundwater?

Classification	Particle size (inch)
medium gravel	0.5
coarse sand	0.05
very fine sand	0.005
silt	0.001
clay	0.0001

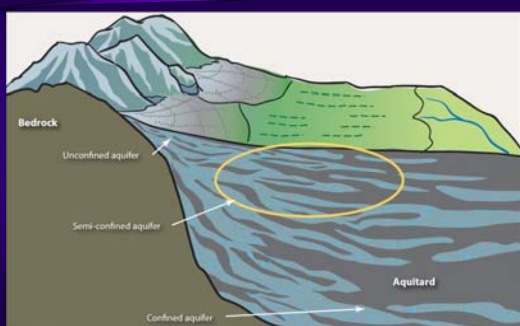
California Groundwater



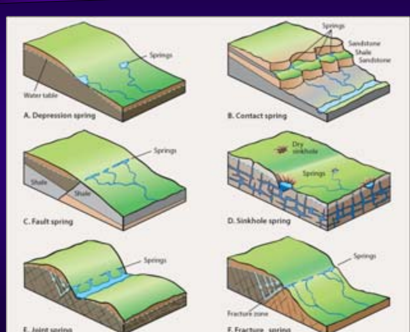
Unconfined Aquifer



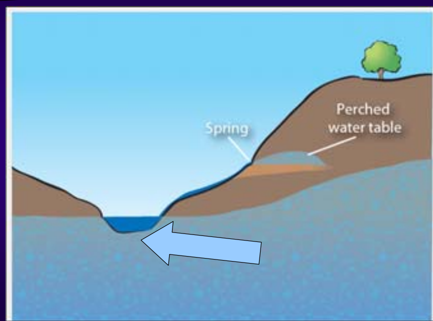
Confined Aquifer



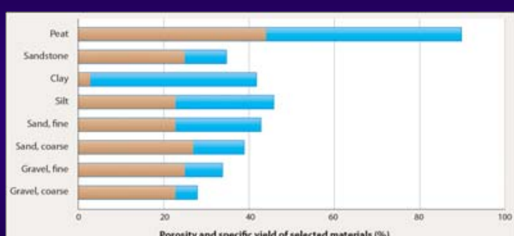
Springs



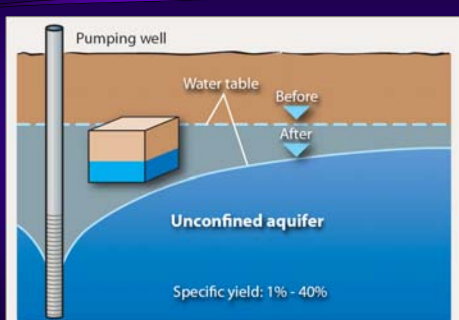
Gaining Stream

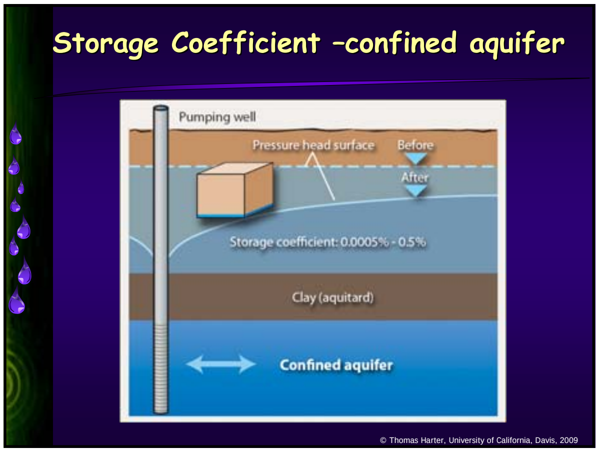


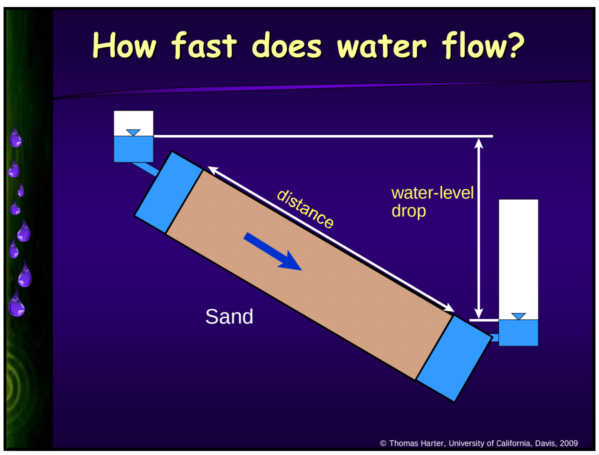
How Much Water is in the Ground?



Specific Yield - Unconfined Aquifer




Storage Coefficient –confined aquifer
Pumping well
Pressure head surface
Before
After
Storage coefficient: 0.0005% - 0.5%
Clay (aquitard)
Confined aquifer
© Thomas Harter, University of California, Davis, 2009


How fast does water flow?
distance
water-level
drop
Sand
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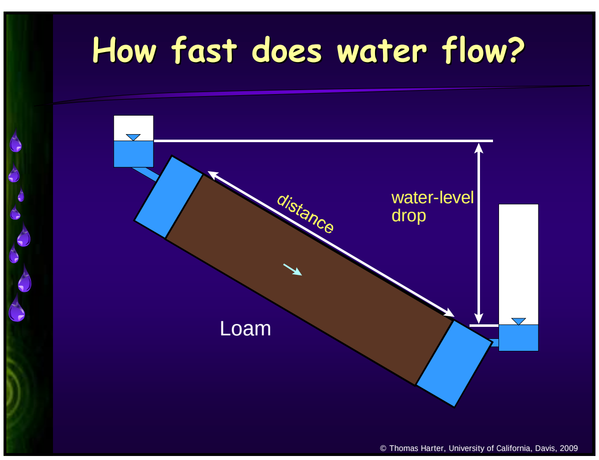
How fast does water flow?
distance
water-level
drop
Loam
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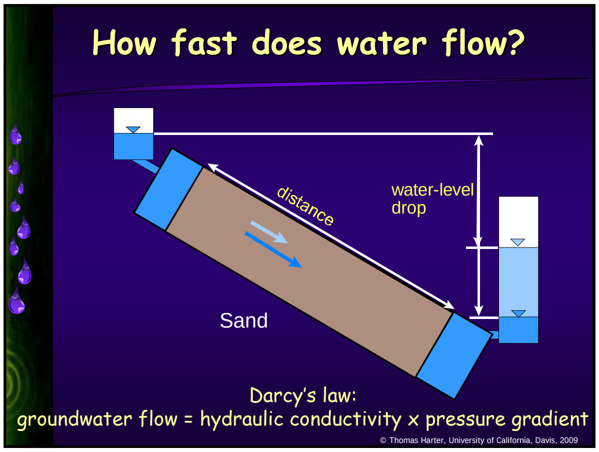

How fast does water flow?
distance
water-level drop
Sand
Darcy's law:
groundwater flow = hydraulic conductivity x pressure gradient
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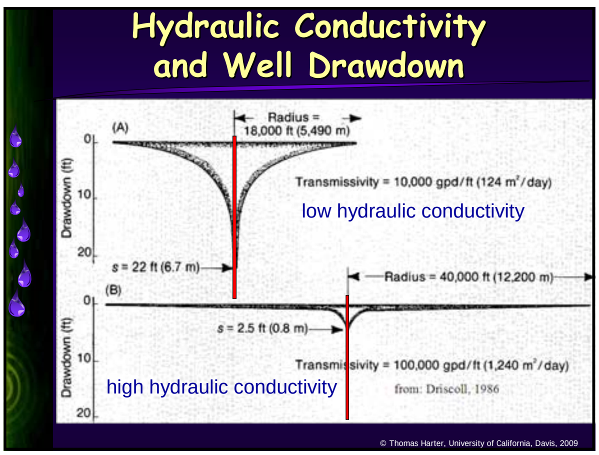
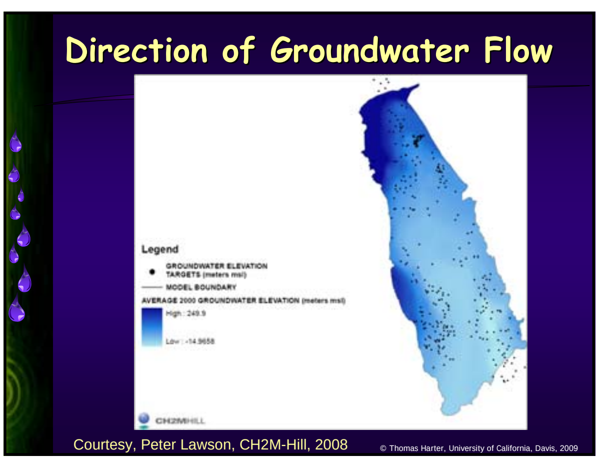


Hydraulic Conductivity and Well Drawdown
(A)
Radius = 18,000 ft (5,490 m)
Transmissivity = 10,000 gpd/ft (124 m²/day)
low hydraulic conductivity
Drawdown (ft)
s = 22 ft (6.7 m)
(B)
Radius = 40,000 ft (12,200 m)
s = 2.5 ft (0.8 m)
Transmissivity = 100,000 gpd/ft (1,240 m²/day)
high hydraulic conductivity
from: Driscoll, 1986
© Thomas Harter, University of California, Davis, 2009



Direction of Groundwater Flow
Legend
GROUNDWATER ELEVATION TARGETS (meters msl)
MODEL BOUNDARY
AVERAGE 2000 GROUNDWATER ELEVATION (meters msl)
Courtesy, Peter Lawson, CH2M-Hill, 2008
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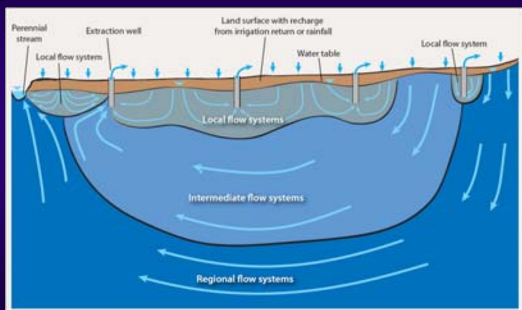
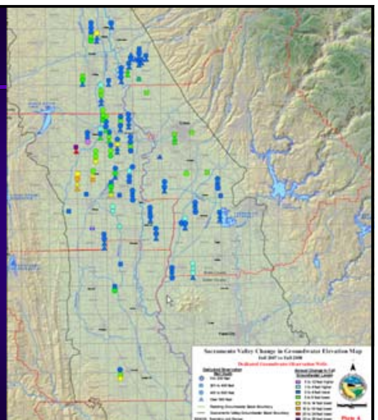
Local & Regional Groundwater Flow



Sacramento Valley, Fall 2007 – Fall 2008 Water Level Decline

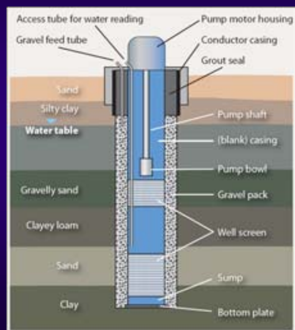


Northern California DWR, 2008
http://www.nd.water.ca.gov/PPAs/GroundwaterBasins/GroundwaterLevel

How do we measure hydraulic conductivity?

- Estimate based on sediment type (gravel, sand, silt, clay, fractured rock)
- Measure on sediment/rock cores in laboratory
- Estimate from specific capacity of wells
- Measure using an aquifer test
- Estimate from groundwater models

A Groundwater Well



Well Screen (stainless steel wire-wrap)

Well Testing: Specific Capacity of a Well

Specific capacity of a well =

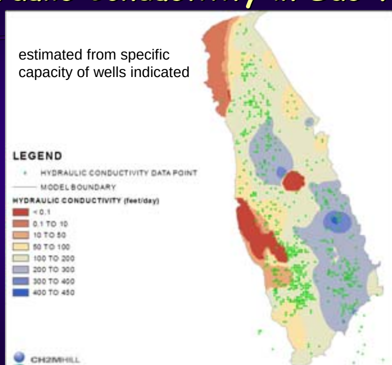
Rate of pumping per foot of drawdown.
(measured as gpm/ft)

well test usually done by pumping
for 1 hr – 24 hrs

Well Testing for Specific Capacity

- very low: 1 gpm/ft; very high: 100 gpm/ft
- decreases with time during pumping test
- decreases with increased pumping rate
- decreases with lower water level in a well
- larger in a properly designed and developed well
- affected by land subsidence
- approximately proportional to hydraulic conductivity

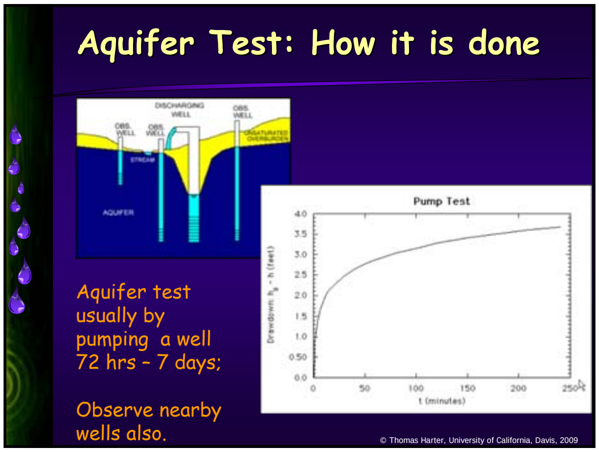
Hydraulic Conductivity in Sac Valley



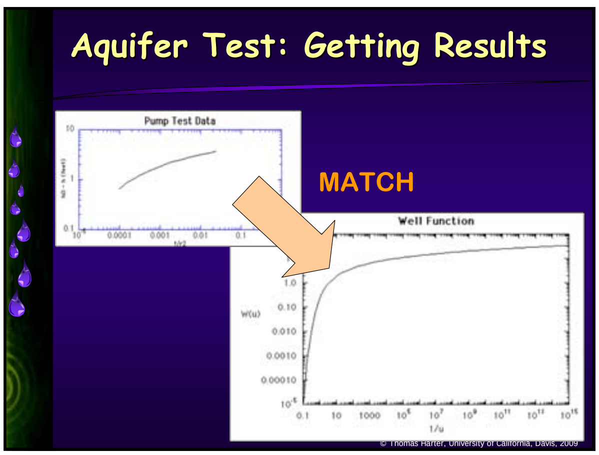
Courtesy, Peter Lawson, CH2M Hill, 2008

Aquifer Test

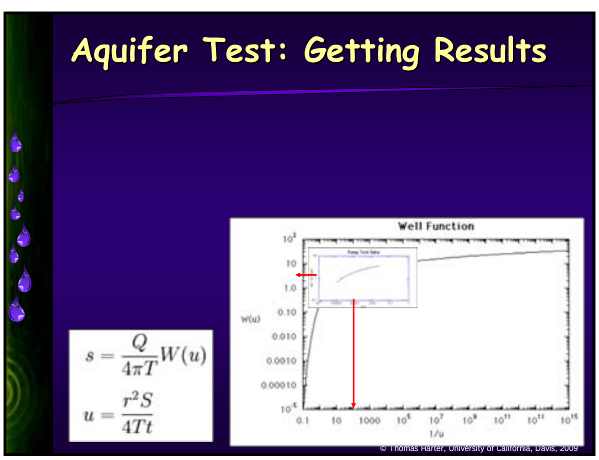
- Determine aquifer hydraulic properties
  - hydraulic conductivity, *K*, or transmissivity, *T*
  - specific yield, *Sy*, or storage coefficient, *S*
  - leakage through confining units
- Based on matching real world data to the solution of the groundwater flow equation
- The groundwater flow equation is based on two physical principles:
  - mass balance: change in volume = inflow –outflow
  - Darcy's law: q = K i



Aquifer Test: How it is done
DISCHARGING WELL
OBS. WELL
STREAM
AQUIFER
UNSATURATED OVERBURDEN
Aquifer test usually by pumping a well 72 hrs – 7 days;
Observe nearby wells also.
Pump Test
t (minutes)
© Thomas Harter, University of California, Davis, 2009



Aquifer Test: Getting Results
Pump Test Data
MATCH
Well Function
W(u)
1/u
© Thomas Harter, University of California, Davis, 2009



Aquifer Test: Getting Results
$s = \frac{Q}{4\pi T} W(u)$
$u = \frac{r^2 S}{4Tt}$
Well Function
W(u)
1/u
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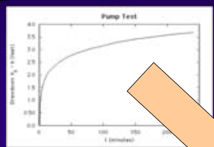
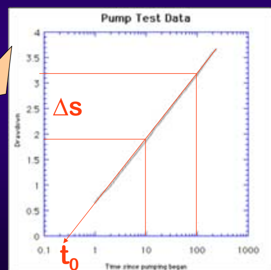
Aquifer Test: A simple procedure



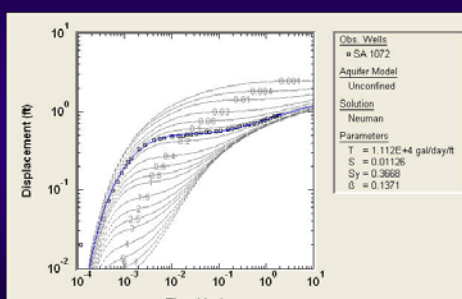
PLOT ON SEMI-LOG PAPER



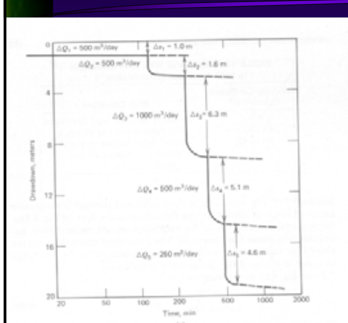
$$T = \frac{2.3Q}{4\pi \Delta s_{\text{per log cycle}}}$$

$$S = \frac{2.25 T t_0}{r^2}$$

Aquifer Tests: many "Type Curves" to choose from

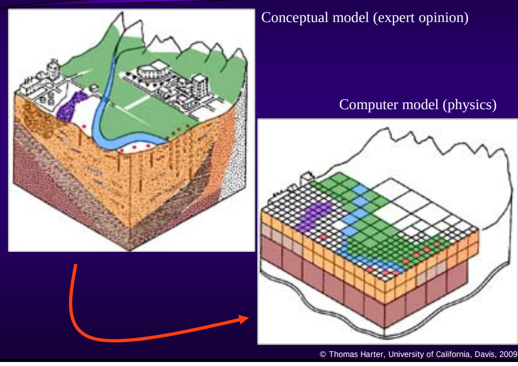


Multistep Test

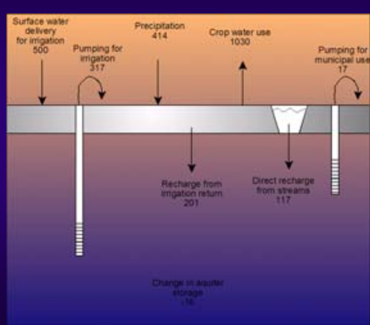


- multistep pump test w/ continuous water level monitoring
- comparison to drawdown in nearby wells (of limited value)
- pump for 1 hour: if water level recovers by 90% within 5 minutes => worst case, unacceptable well losses

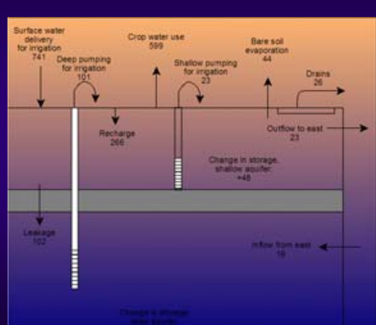
Computer Groundwater Model



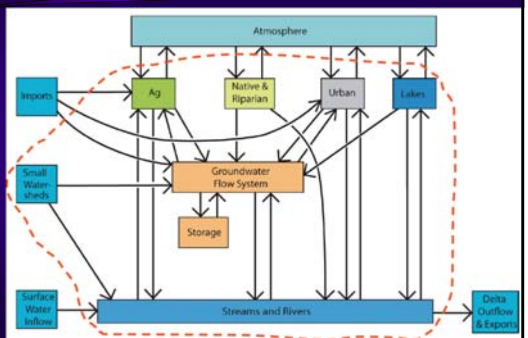
Water Budget (Tulare County)



Water Budget (Westside SJV)

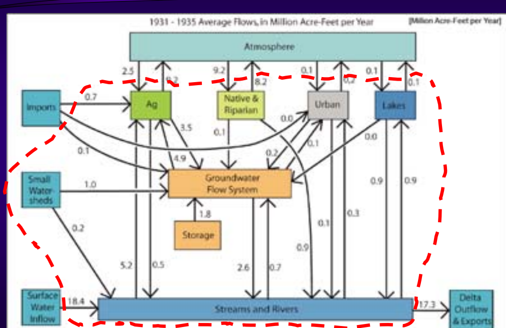


Elements of an Integrated Water Model

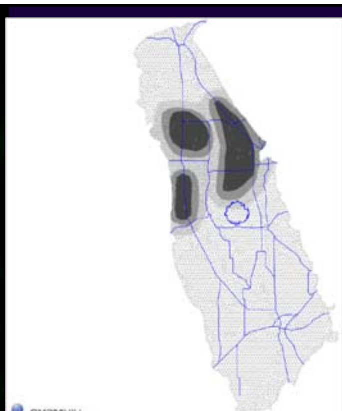


Courtesy, Charlie Brush, Ca. DWR, 2008

Water Budget, Central Valley



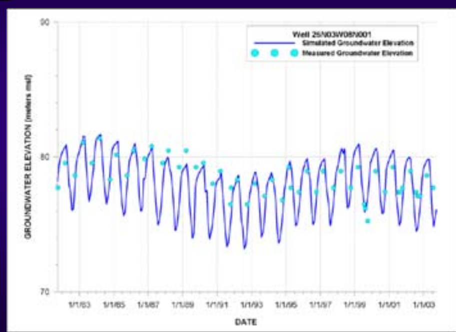
Courtesy, Charlie Brush, Ca. DWR, 2008



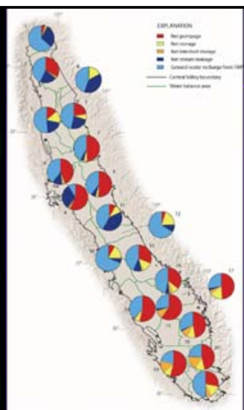
Example of a Sac Valley Model

Courtesy, Peter Lawson, CH2M Hill, 2008

Making sure the model works



Courtesy, Peter Lawson, CH2M Hill, 2008



Some Useful Model Results

Courtesy, Claudia Fawn, USGS, 2008

Conclusion

- Groundwater flow = hydraulic conductivity x pressure gradient
- Aquifer tests: measure hydraulic conductivity
- Water level data: measure pressure gradients across region
- Groundwater models: put everything together we know about the groundwater system (including aquifer test data)
- Compare groundwater models to measured water levels => if ok, use for:
  - Prediction
  - Scenario analysis
  - Identifying additional data needs