Arizona Ground Water

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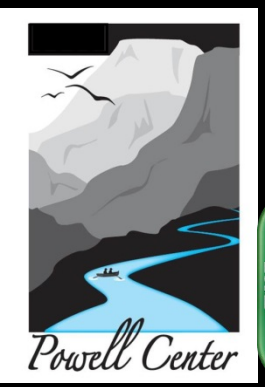
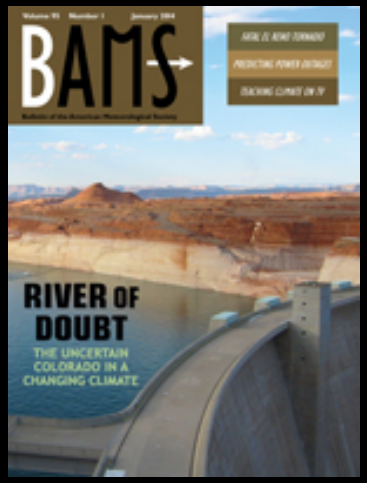
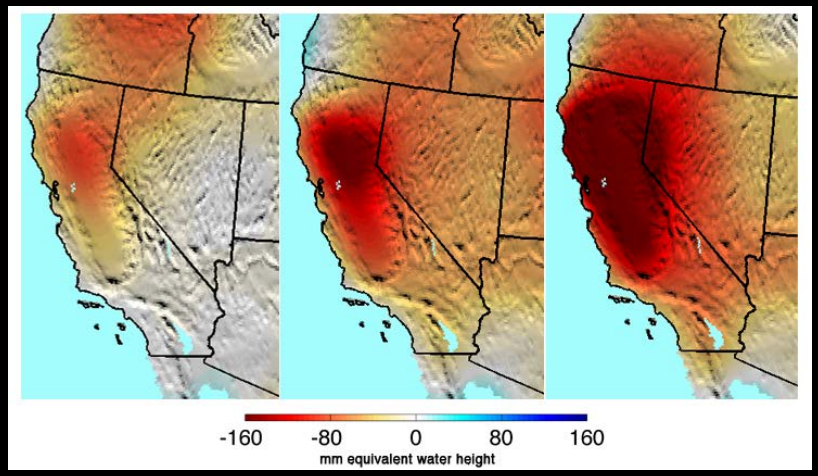


Rivers vs. Aquifers





Famiglietti 2014

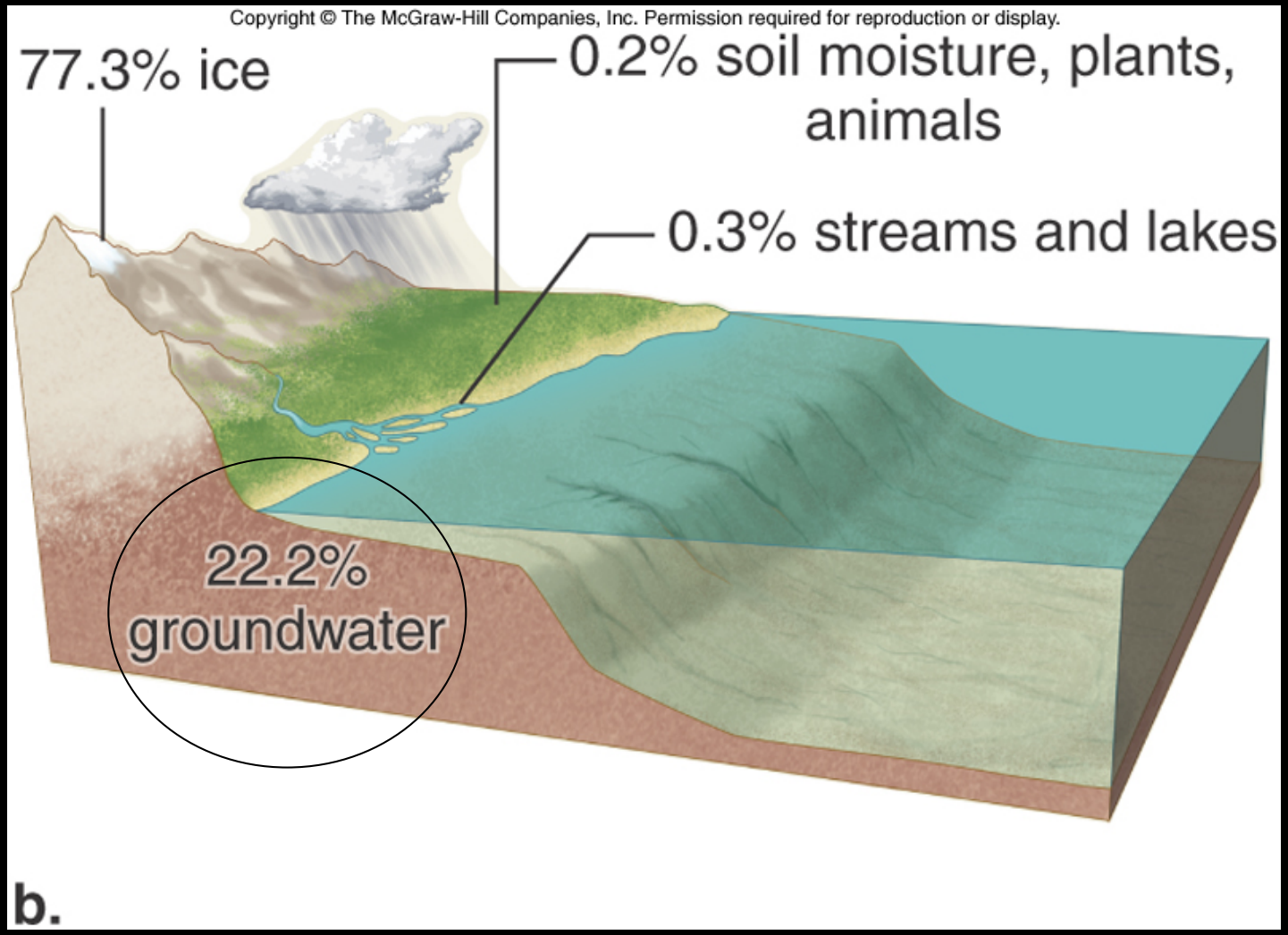
Regional trends in recharge impacts

- Local studies done
- Global theory described
- Changes in components of recharge

Arizona they provide ~40% of water
2.8 MAF
Critical for Arizona outside Sun Corridor

Vano et al. 2014

Water Distribution



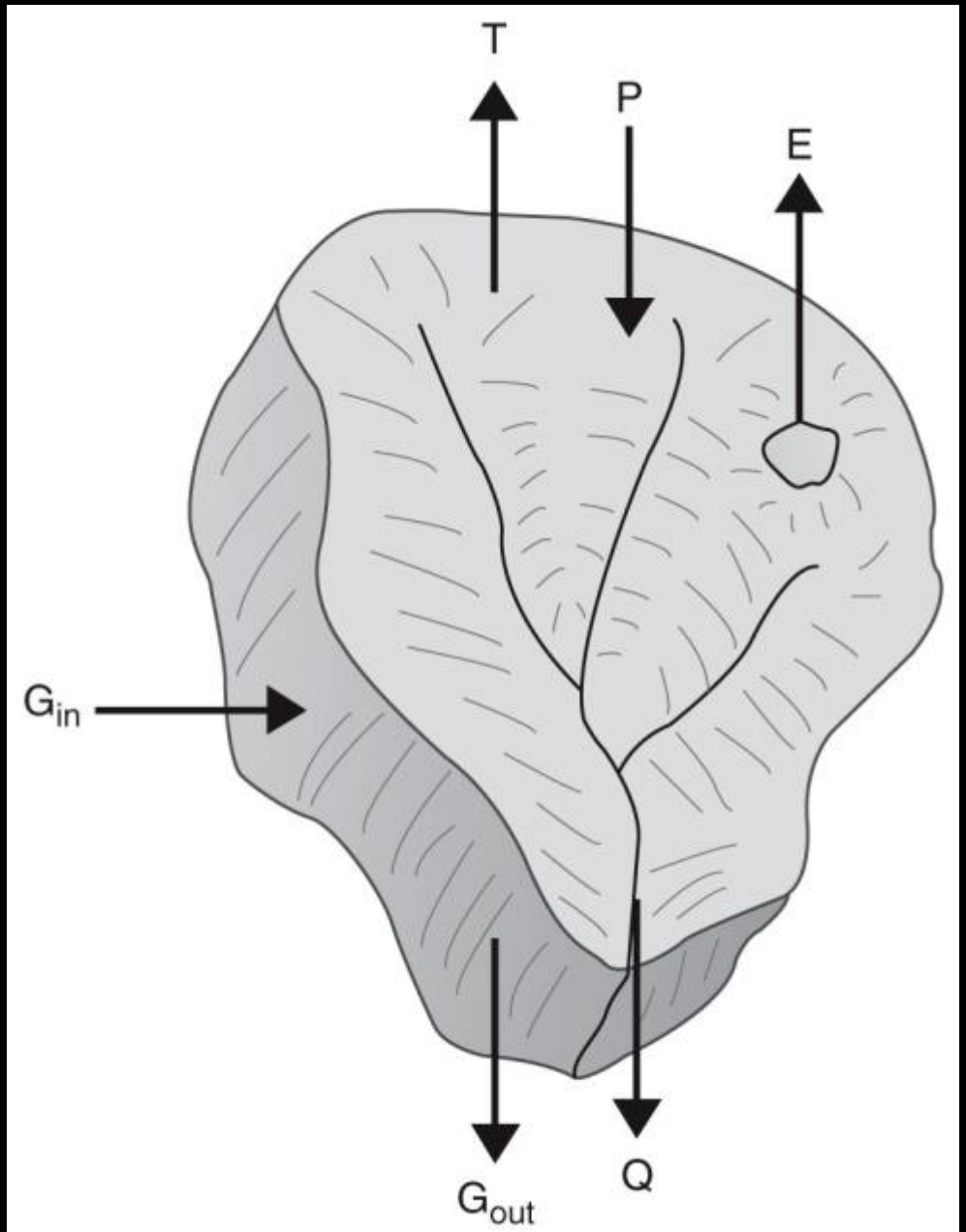
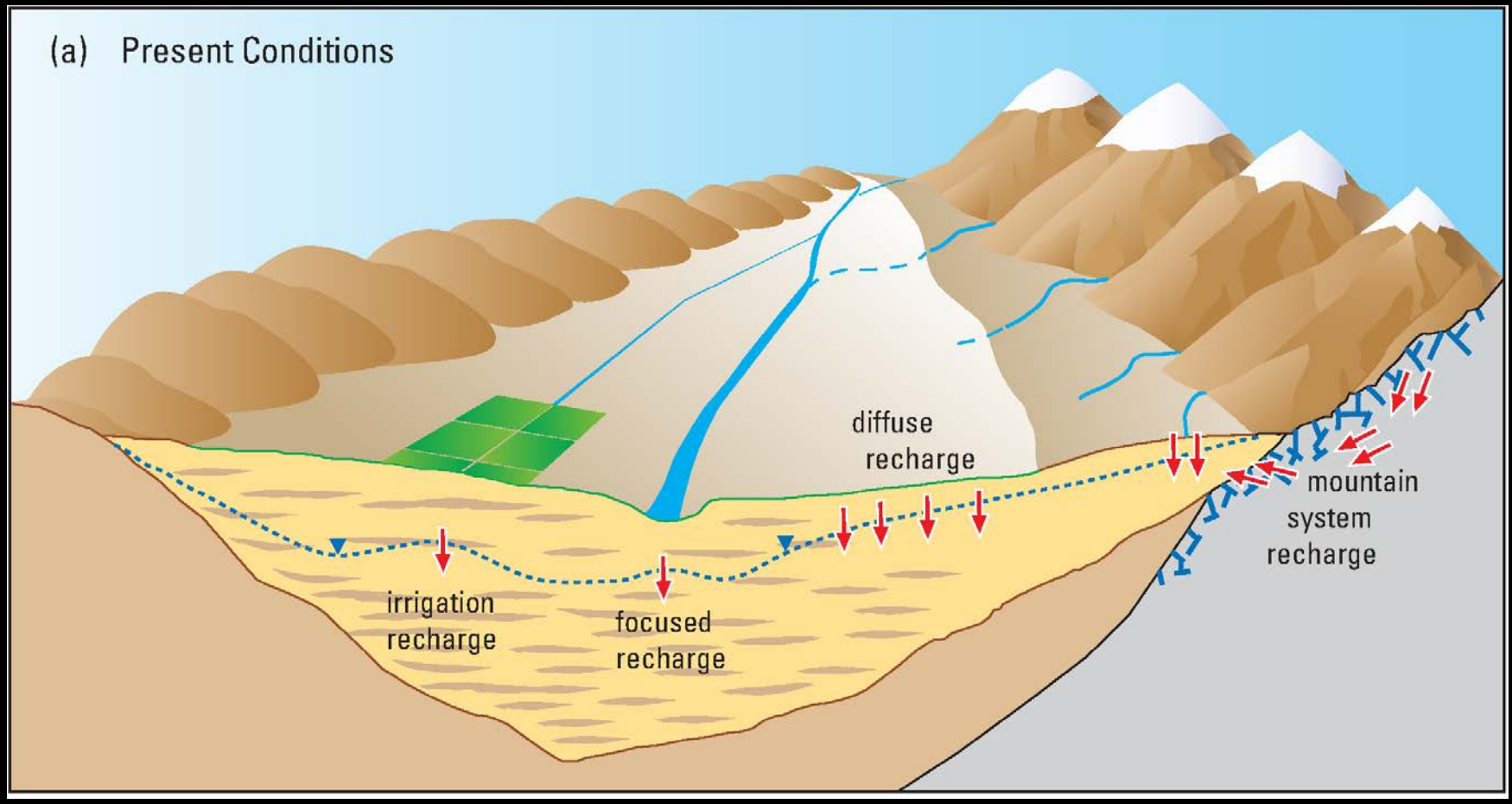
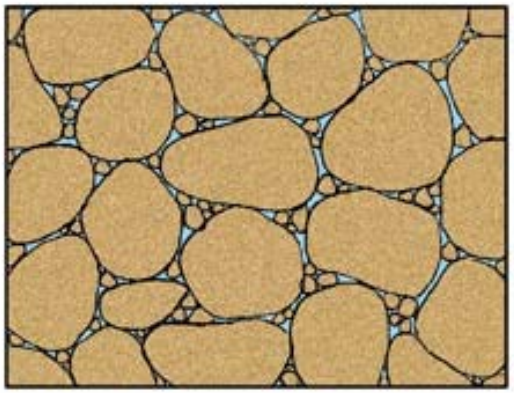


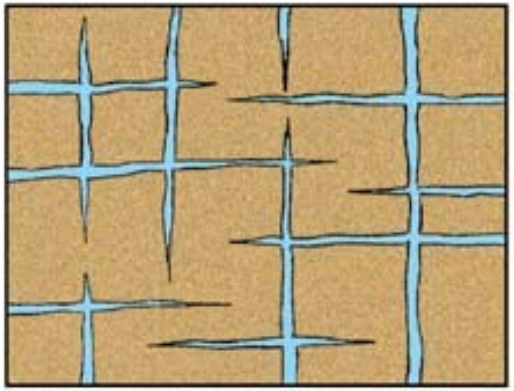
Figure 1.5.1


(a) Present Conditions
diffuse recharge
mountain system recharge
irrigation recharge
focused recharge

Porosity

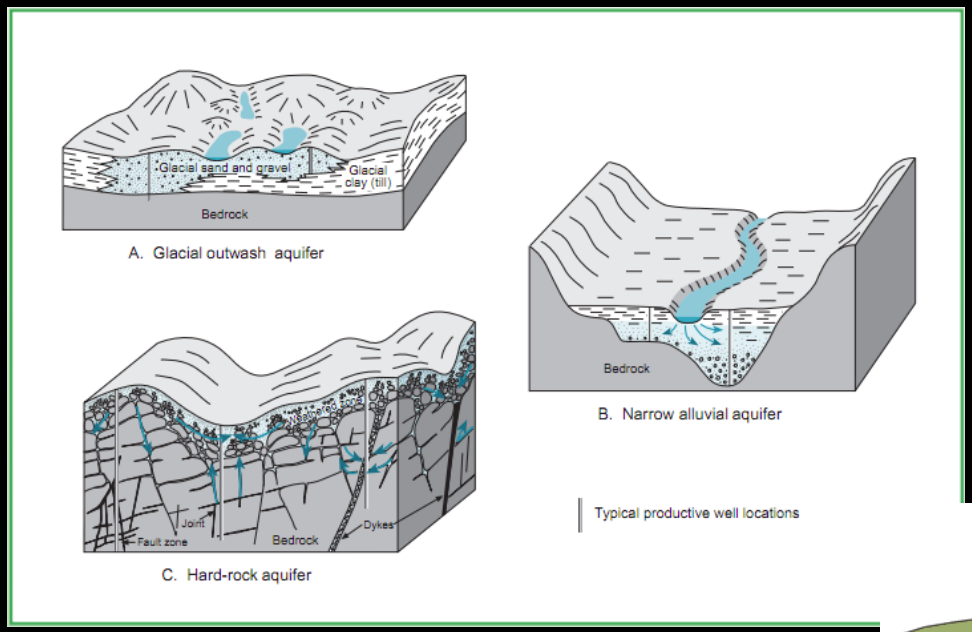


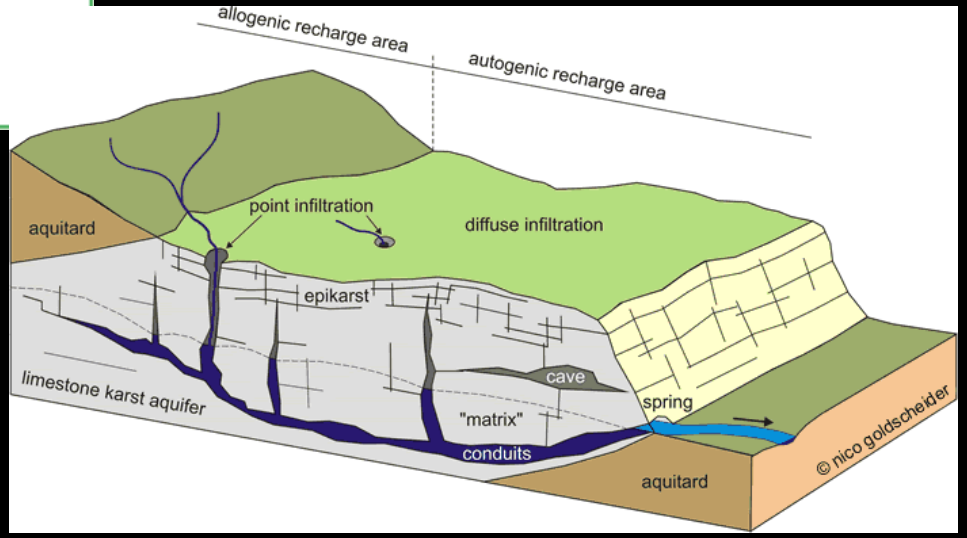
Sedimentary aquifer
Groundwater storage
between grains of sediment



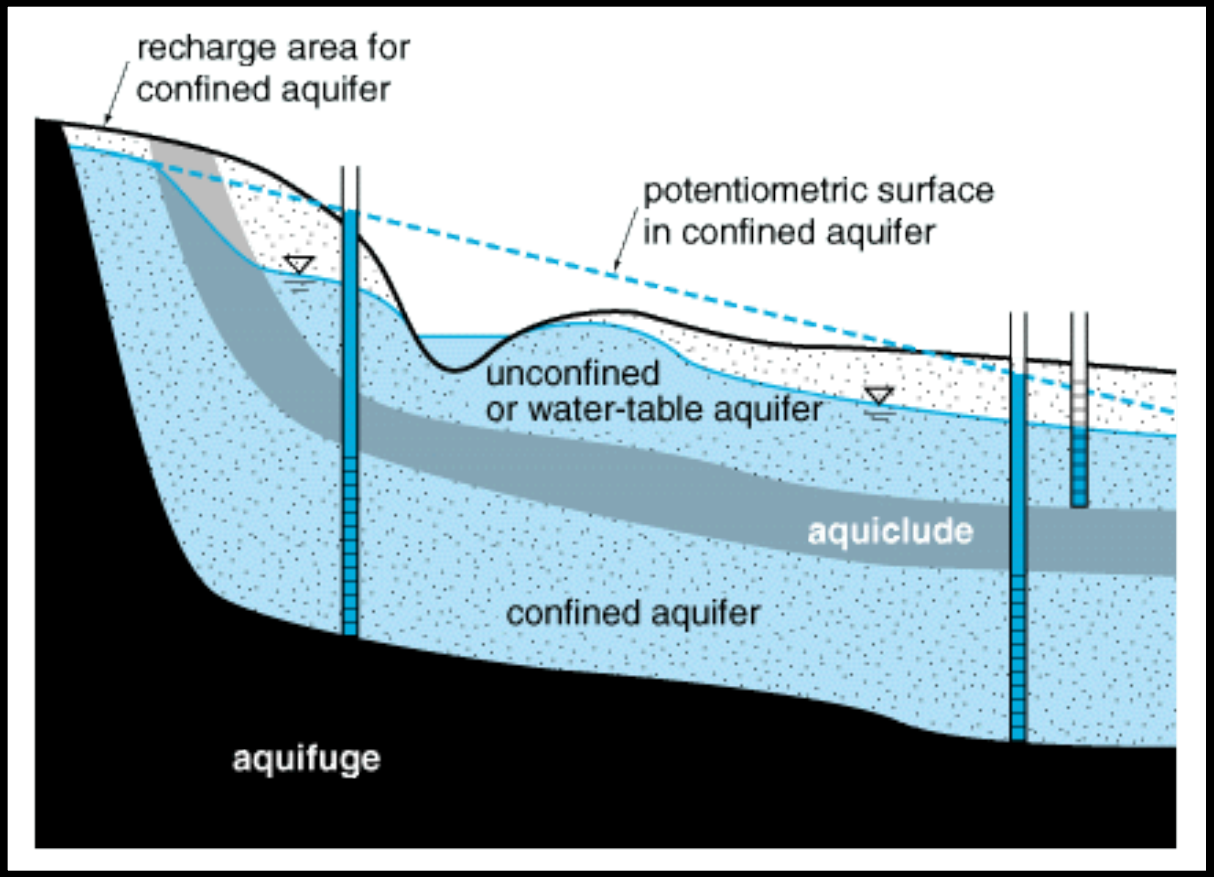
Sedimentary aquifer
Groundwater storage
in solution cavities

Aquifer Types

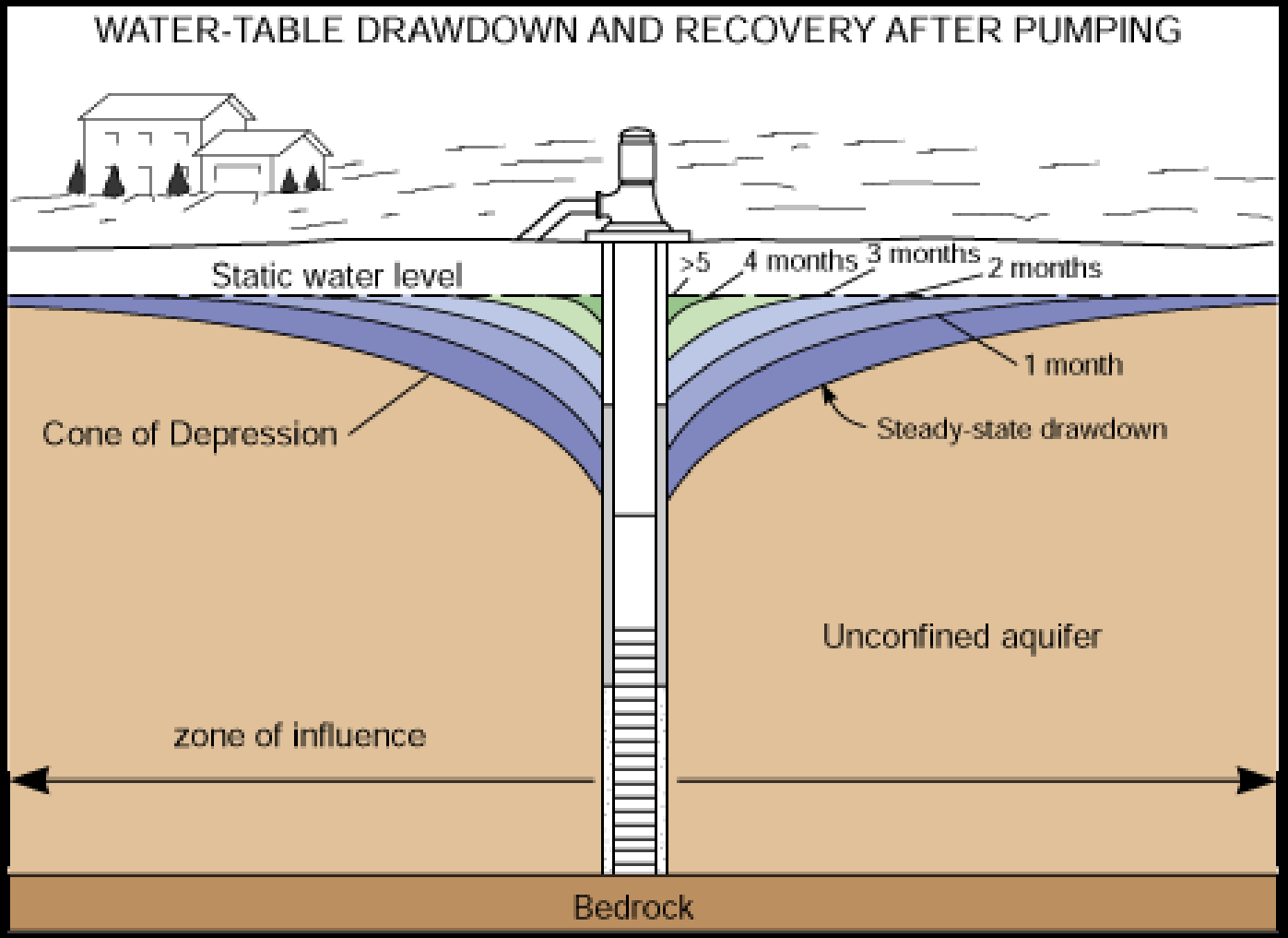


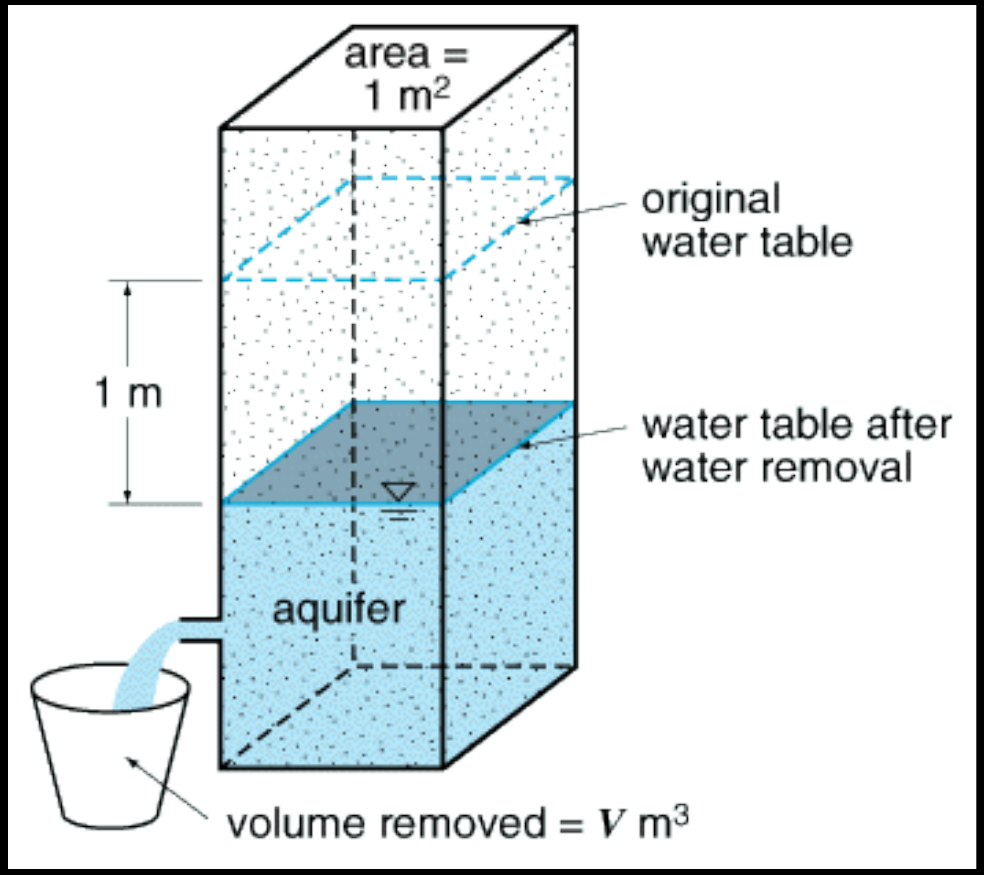


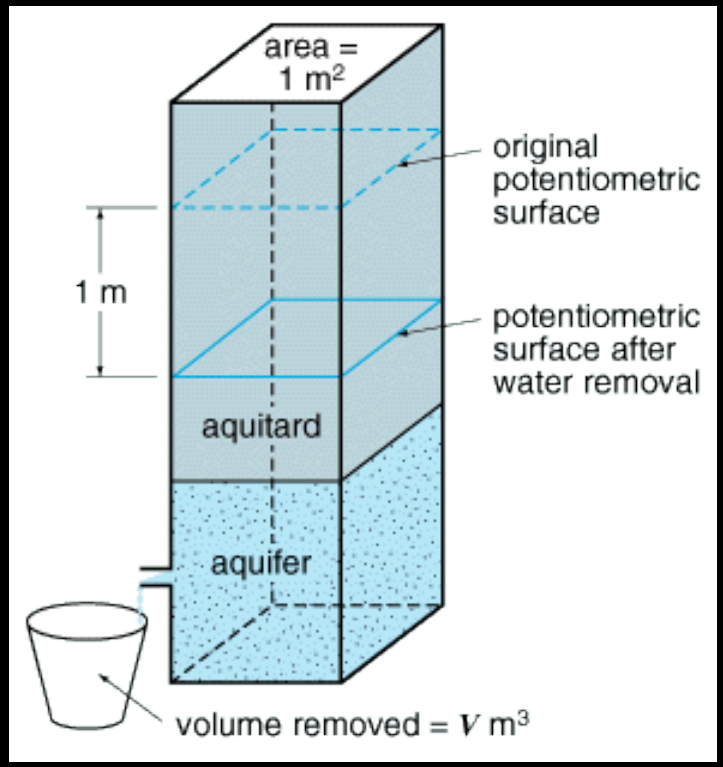
Aquifers


recharge area for
confined aquifer
potentiometric surface
in confined aquifer
unconfined
or water-table aquifer
aquiclude
confined aquifer
aquifuge

Wells


WATER-TABLE DRAWDOWN AND RECOVERY AFTER PUMPING
Static water level
>5
4 months
3 months
2 months
1 month
Cone of Depression
Steady-state drawdown
Unconfined aquifer
zone of influence
Bedrock


area =
1 m²
original
water table
1 m
water table after
water removal
aquifer
volume removed = V m³


area =
1 m²
original
potentiometric
surface
1 m
potentiometric
surface after
water removal
aquitard
aquifer
volume removed = V m³

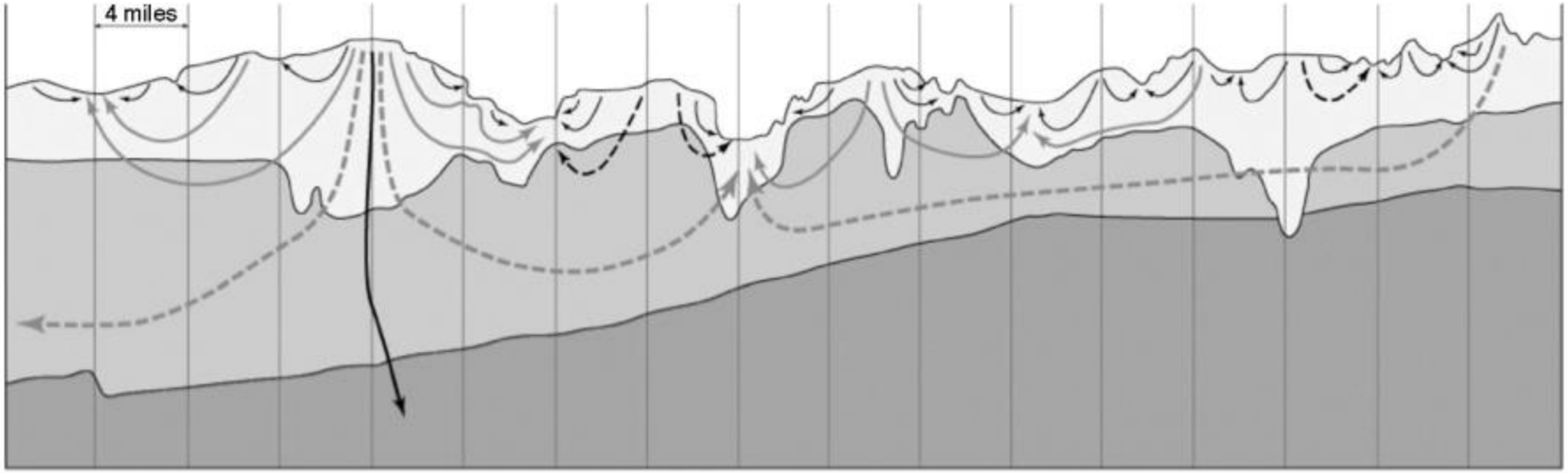
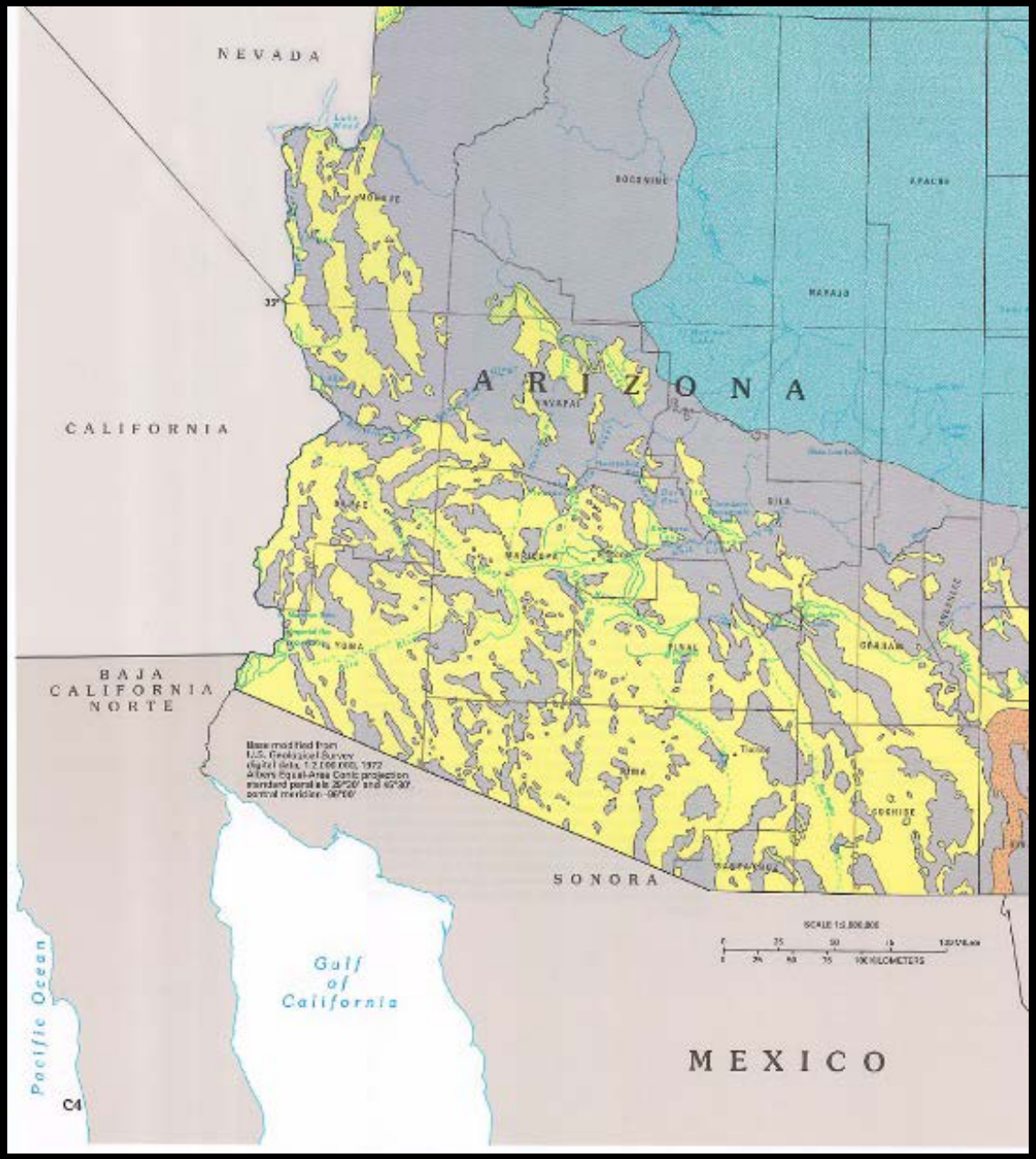


Figure 1.1.5

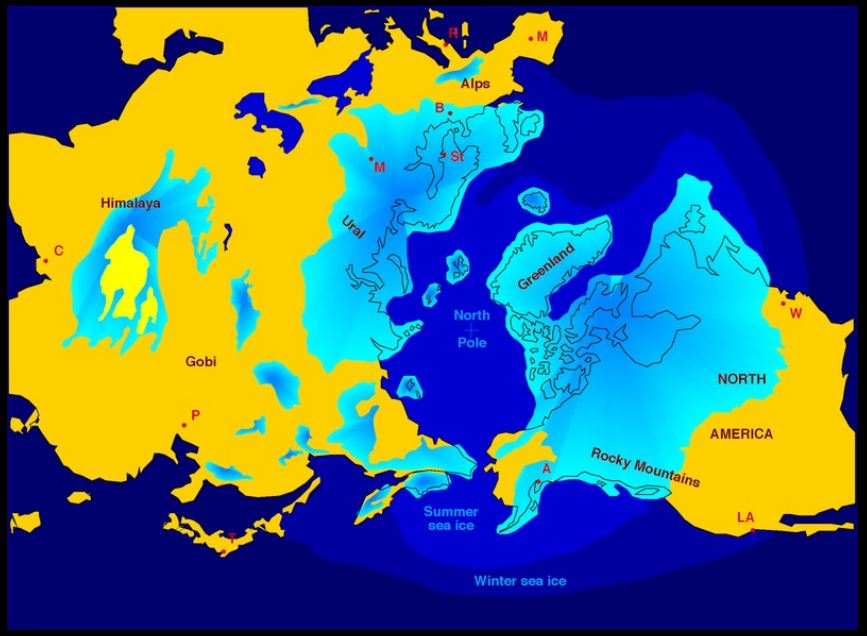
Arizona Geologic Provinces

Major Aquifers of Arizona



- During the last ice age, the Tucson Basin was in a far more temperate basin and the aquifers filled.

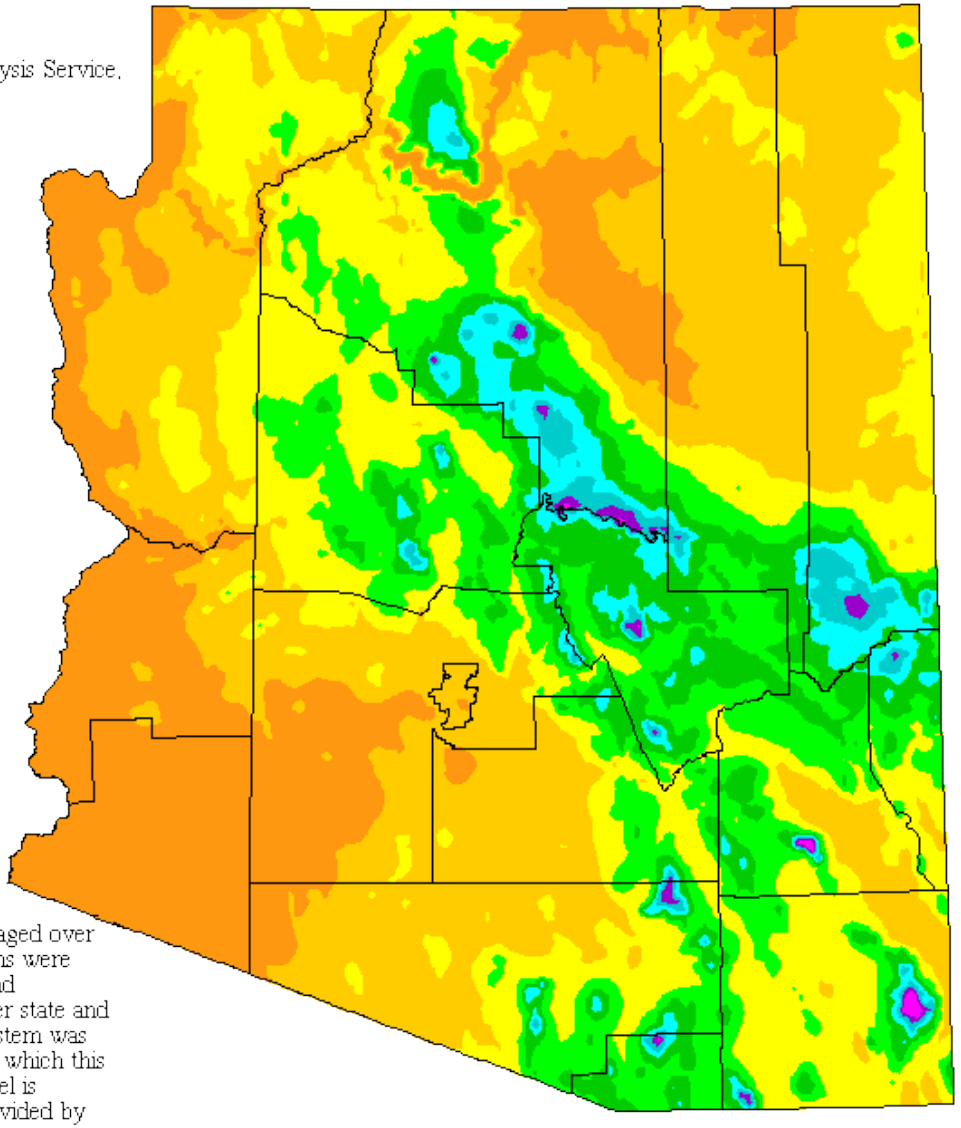
  Deeper waters in the Tucson Basin date back to 10,000 to 12,000 years.



Even as late as 2,000 years ago, the foothills of the Tucson Basin were covered with pine and juniper (pack rat middens).

Average Annual Precipitation

Arizona



Legend (in inches)

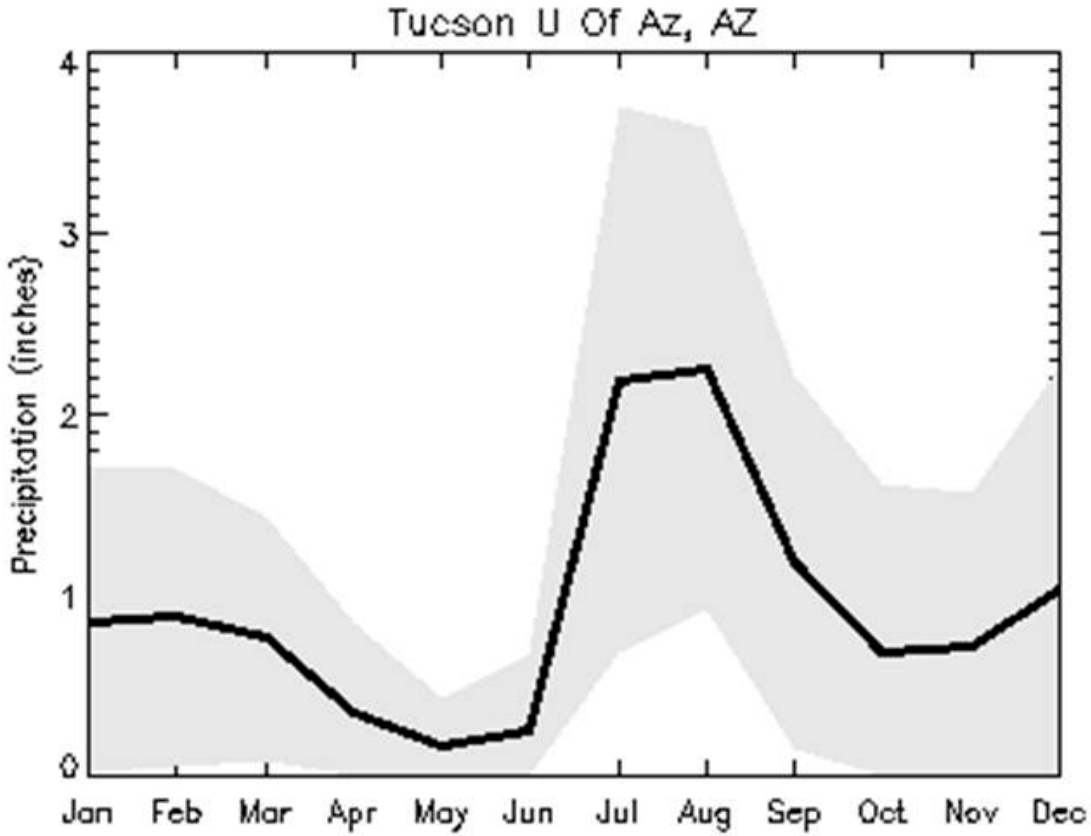
Under 8	24 to 28
8 to 12	28 to 32
12 to 16	32 to 36
16 to 20	Above 36
20 to 24	

For information on the PRISM modeling system, visit the SCAS web site at http://www.ocs.orst.edu/prism

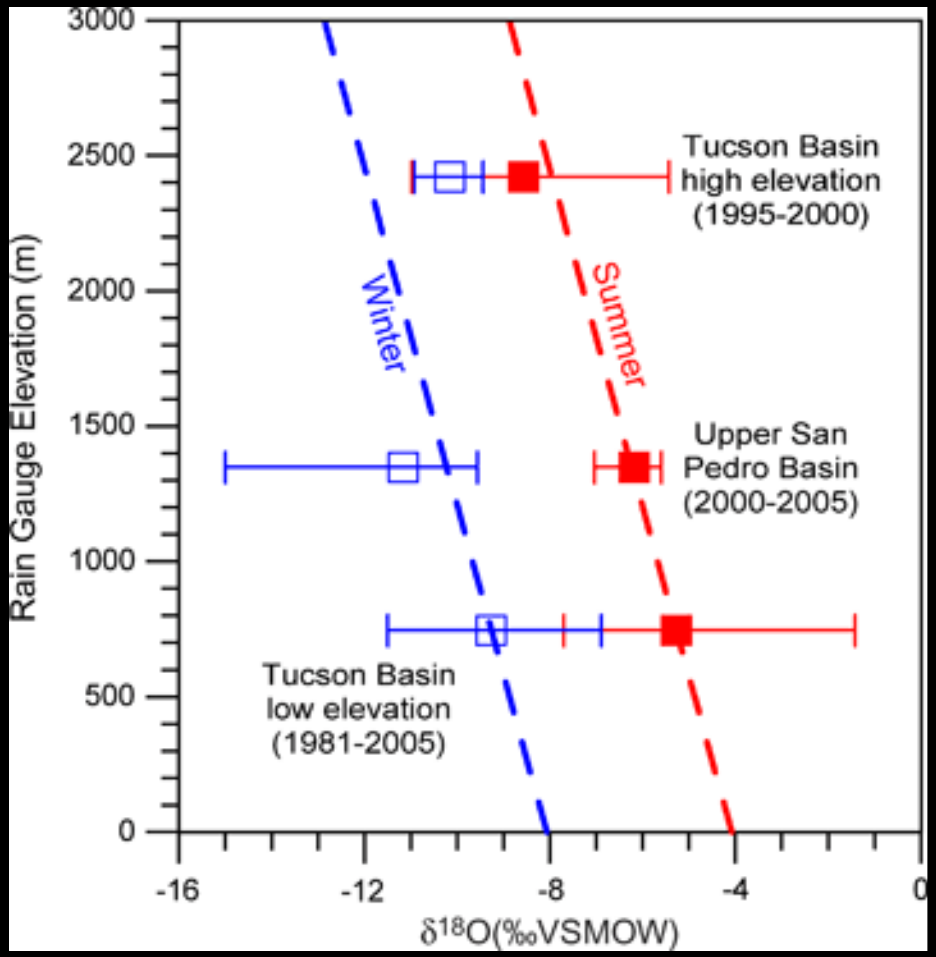
The latest PRISM digital data sets created by the SCAS can be obtained from the Climate Source at http://www.climatesource.com

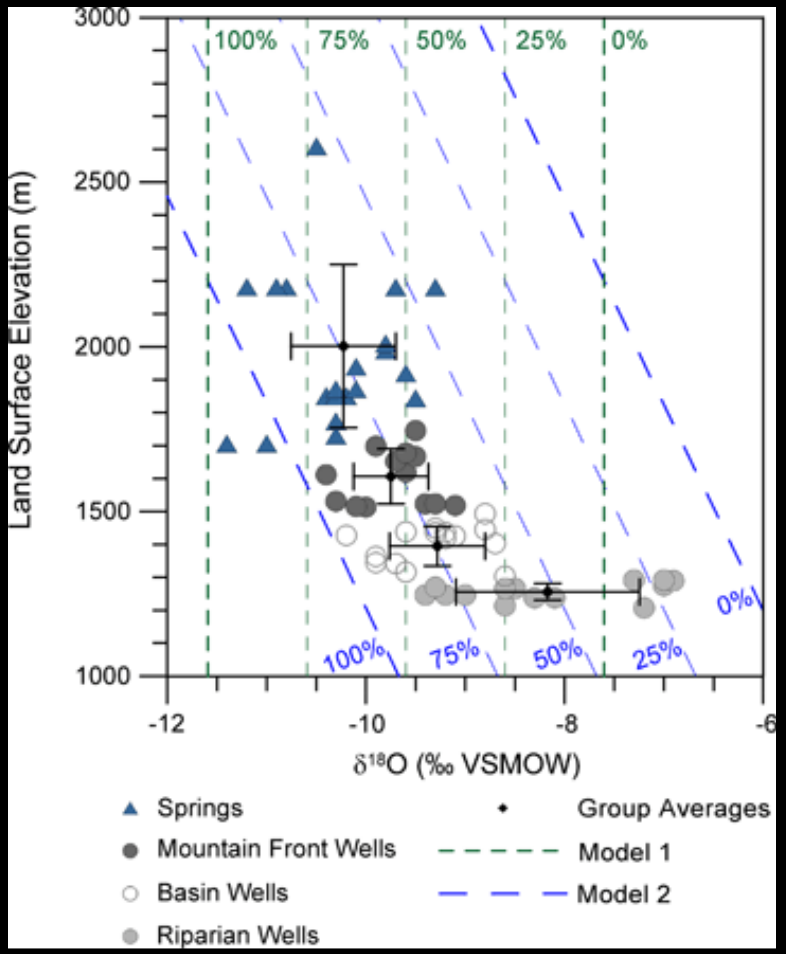
This is a map of annual precipitation averaged over the period 1961-1990. Station observations were collected from the NOAA Cooperative and USDA-NRCS SnoTel networks, plus other state and local networks. The PRISM modeling system was used to create the gridded estimates from which this map was made. The size of each grid pixel is approximately 4x4 km. Support was provided by the NRCS Water and Climate Center.

http://www.worldatlas.com/

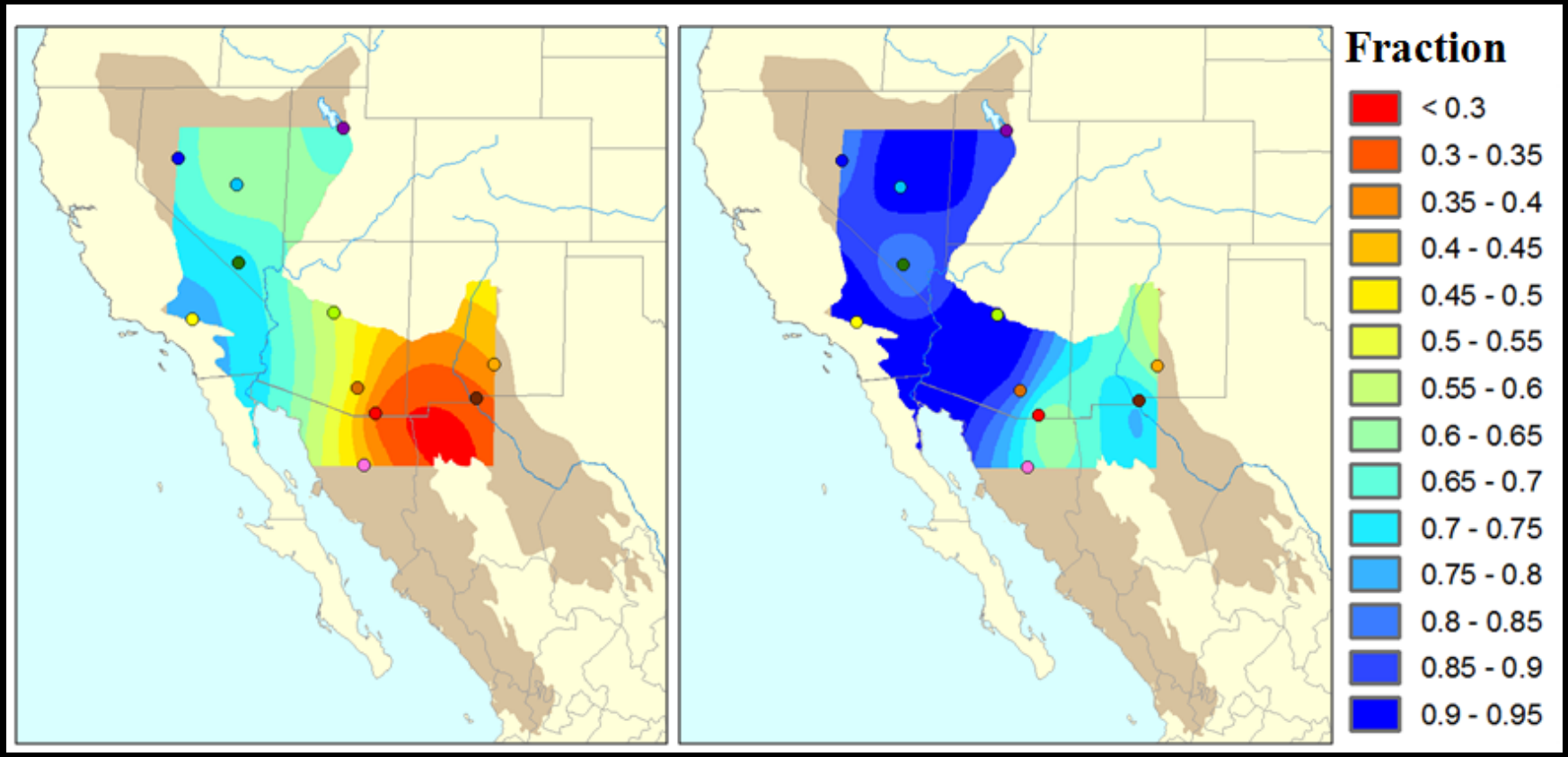


http://atmoz.org/blog/2008/06/24/monthly-precipitation-around-the-united-states/

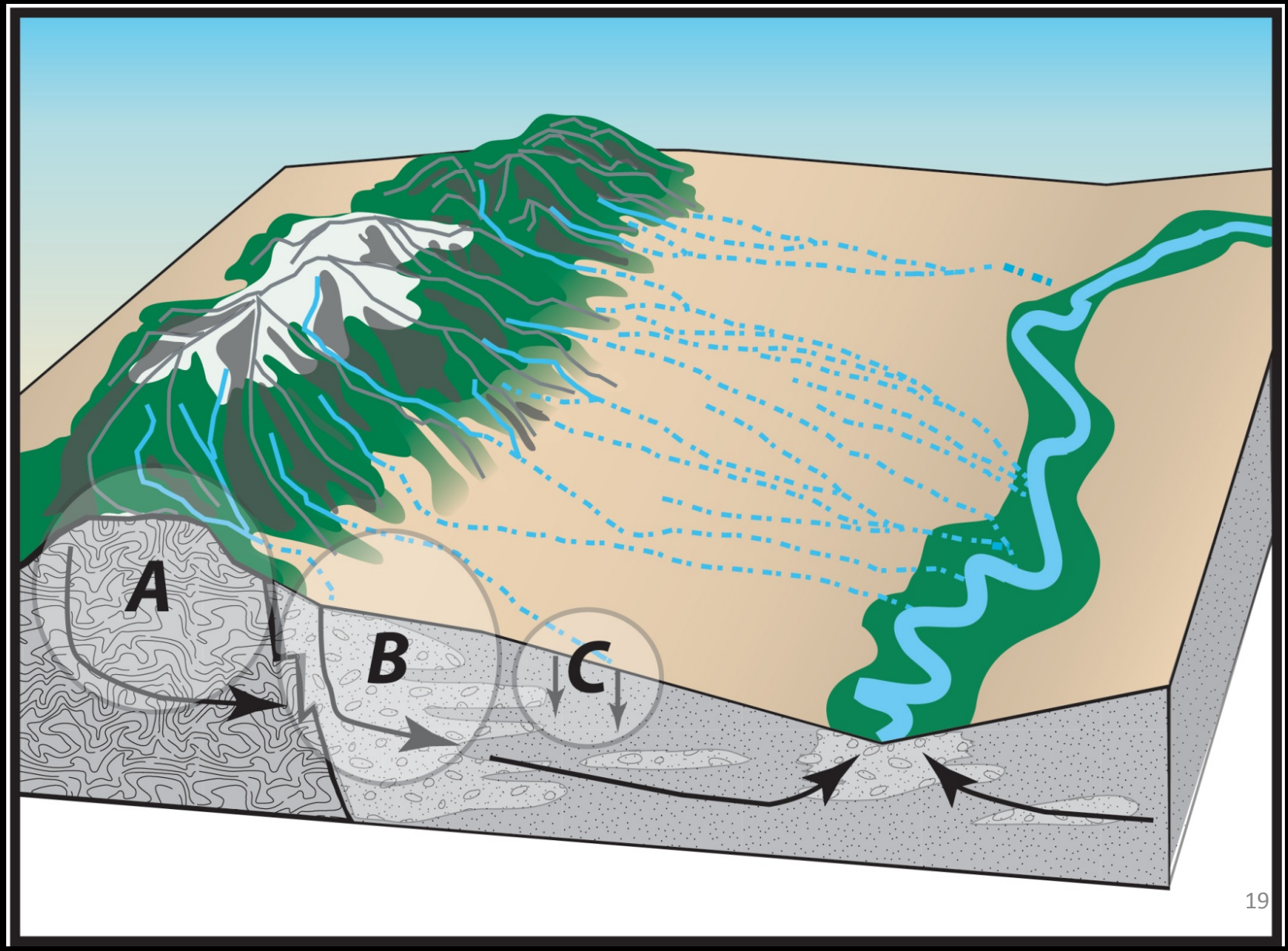

Rain Gauge Elevation (m)
3000
2500
2000
1500
1000
500
0
-16
-12
-8
-4
0
δ18O(‰VSMOW)
Winter
Summer
Tucson Basin
high elevation
(1995-2000)
Upper San
Pedro Basin
(2000-2005)
Tucson Basin
low elevation
(1981-2005)


Land Surface Elevation (m)
3000
2500
2000
1500
1000
-12
-10
-8
δ18O (‰ VSMOW)
100%
75%
50%
25%
0%
Springs
Mountain Front Wells
Basin Wells
Riparian Wells
Group Averages
Model 1
Model 2

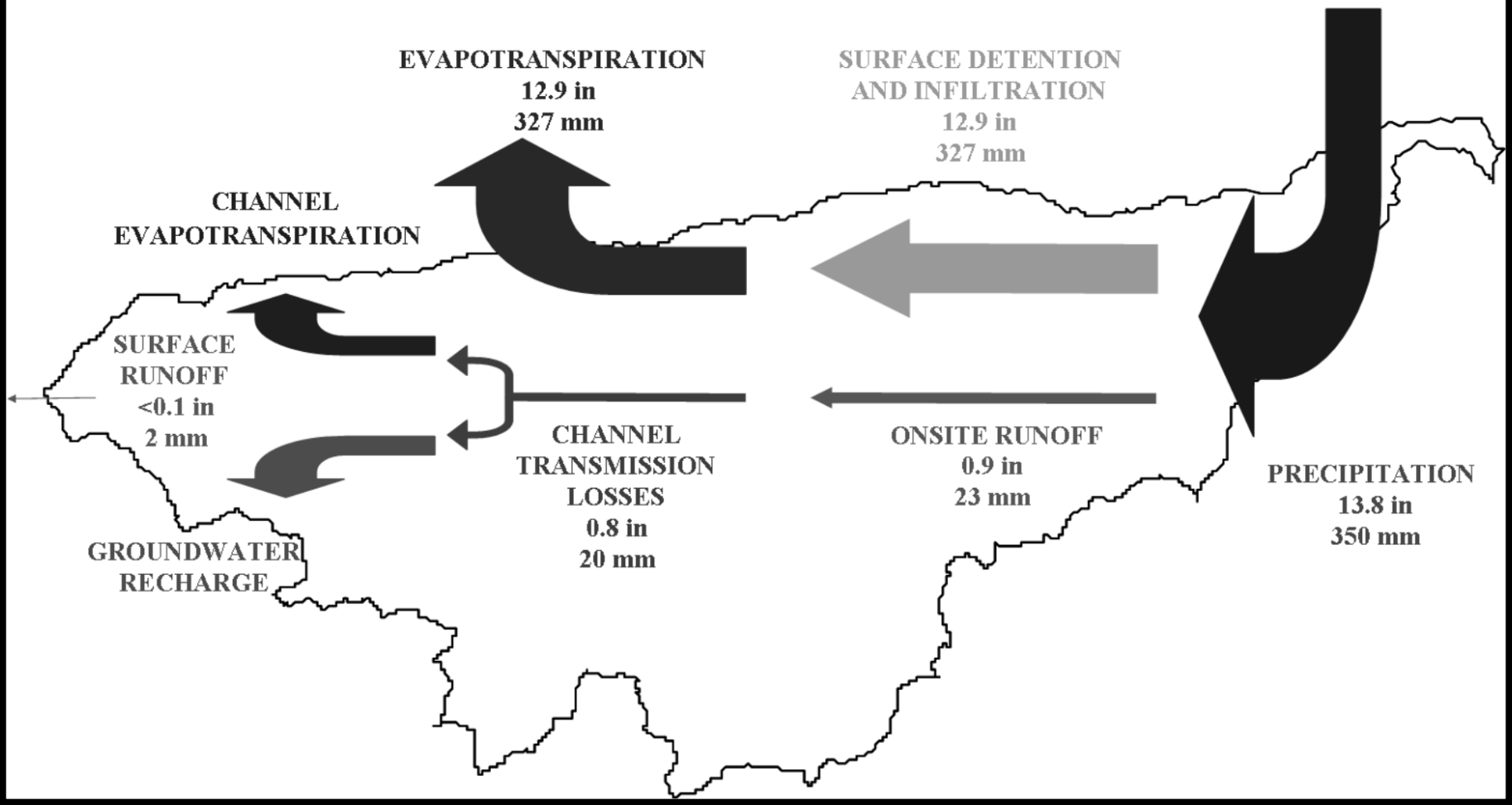
Winter Precipitation & Recharge

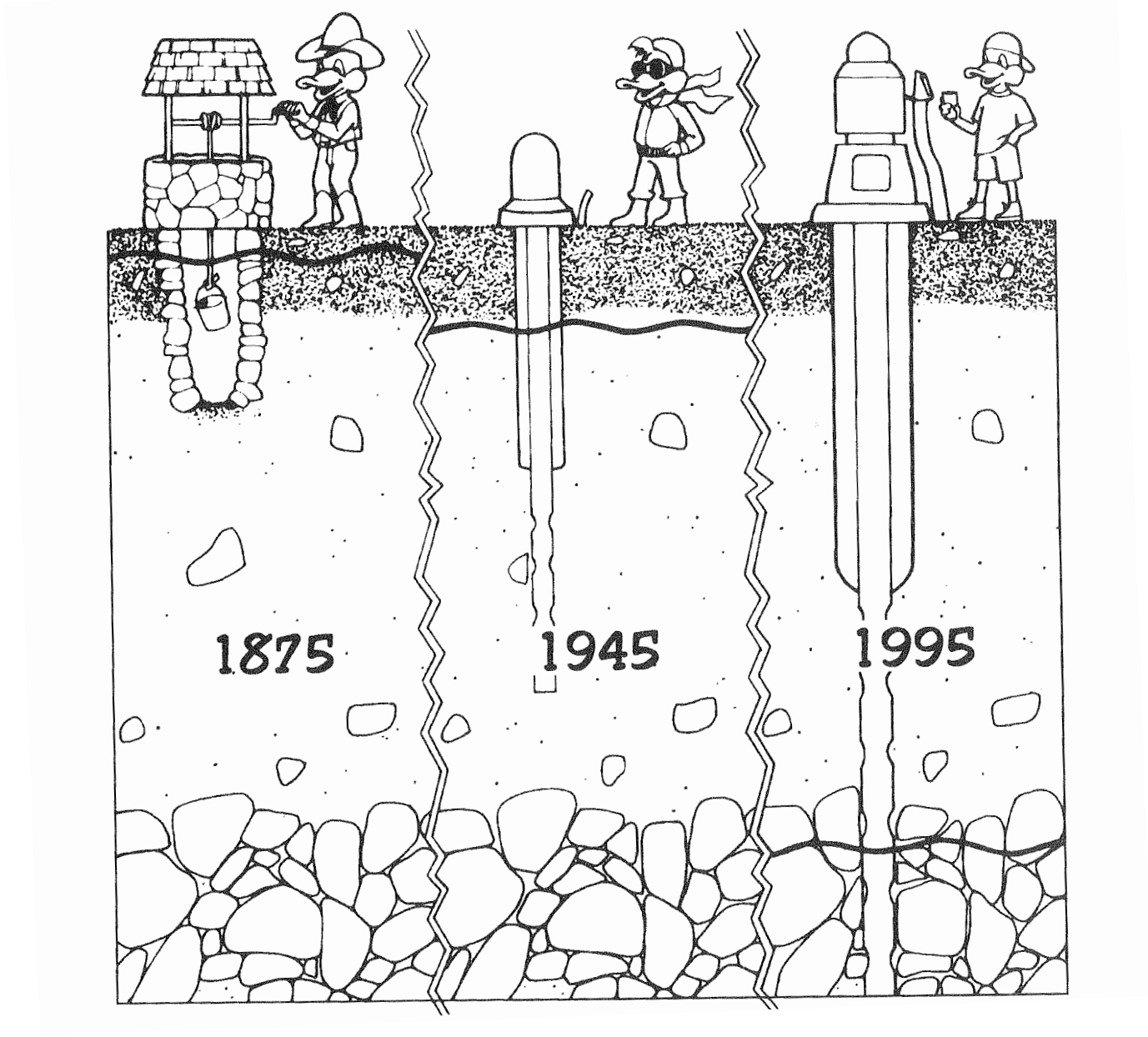


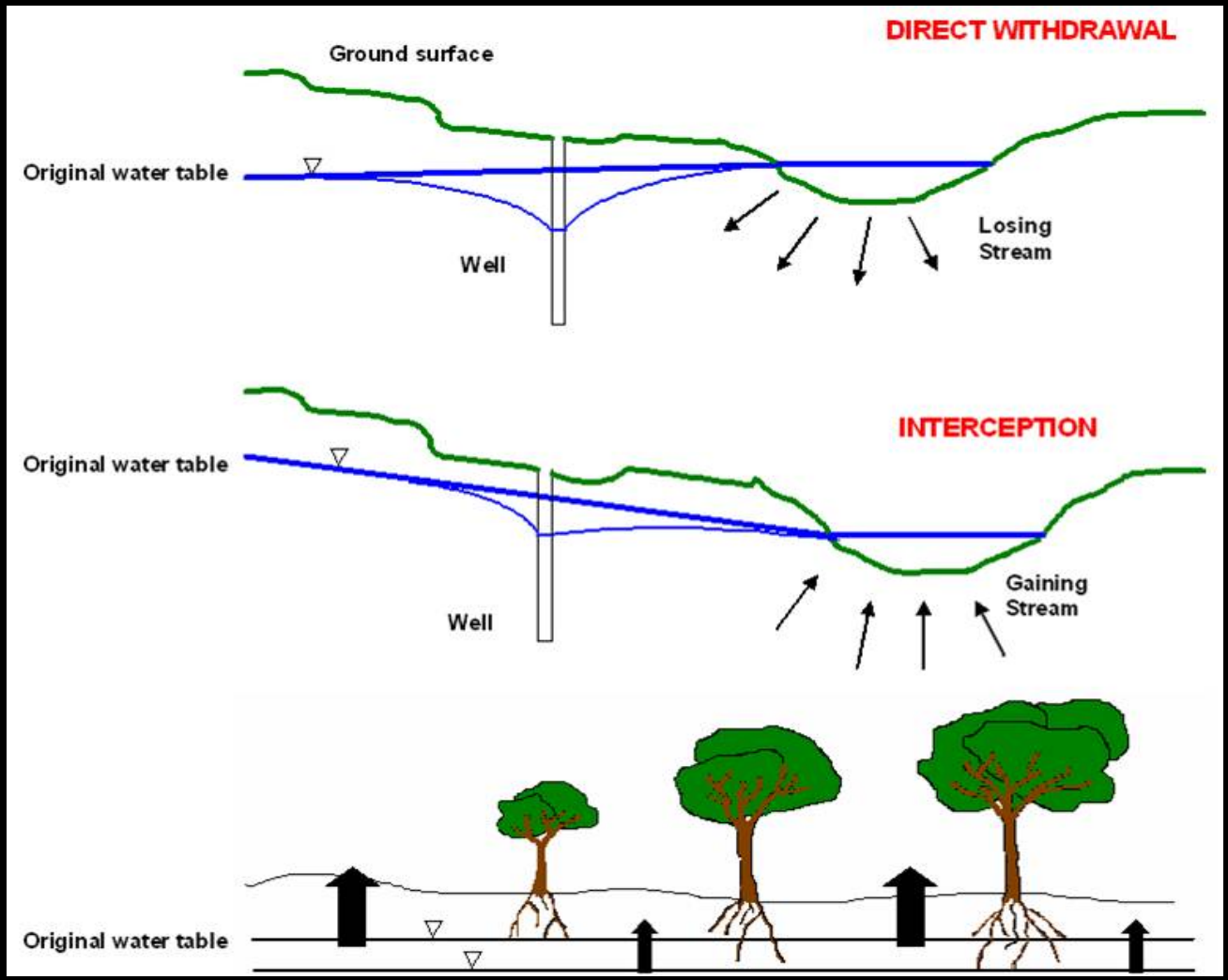
Mountain Systems



WALNUT GULCH EXPERIMENTAL WATERSHED
ANNUAL WATER BALANCE




1875
1945
1995


DIRECT WITHDRAWAL
Ground surface
Original water table
Well
Losing
Stream
INTERCEPTION
Original water table
Well
Gaining
Stream
Original water table

Riparian Habitat Loss

The Santa Cruz River riparian area near Silverlake in the 1940s.

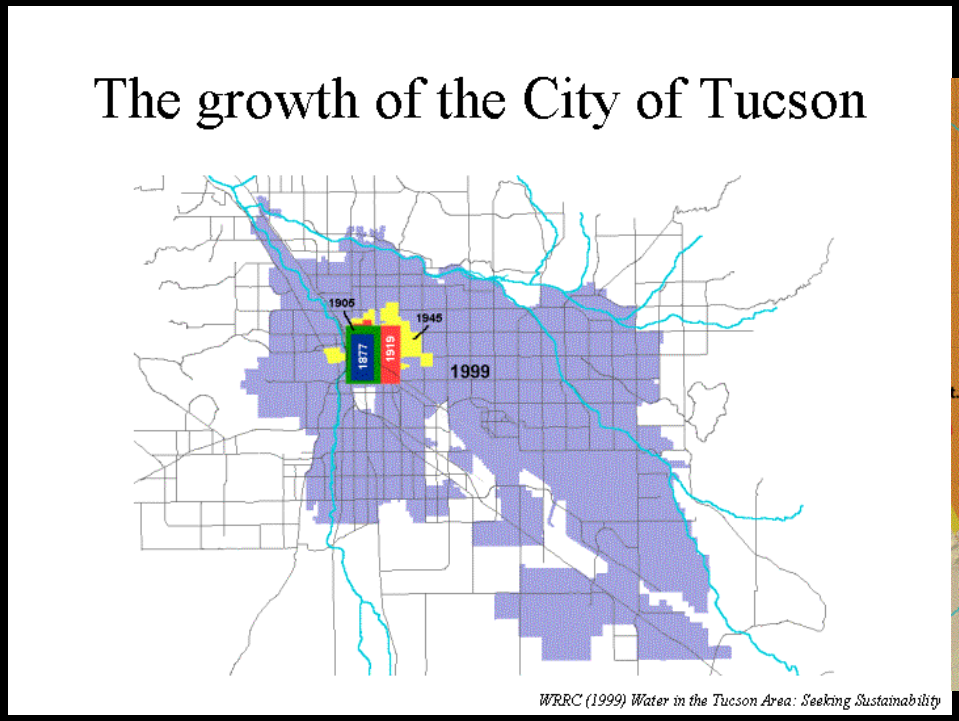
The Santa Cruz River riparian area near Silverlake in the 1980s.

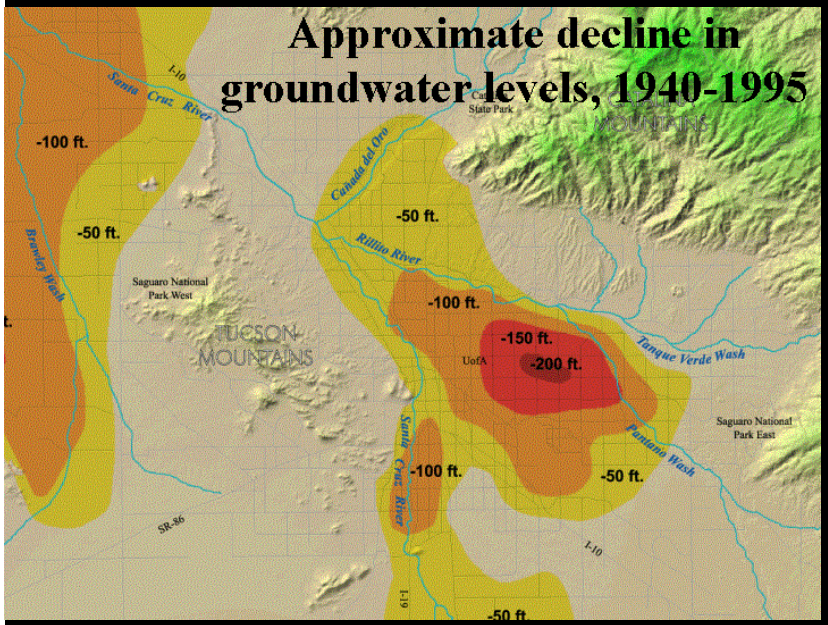
Silverlake

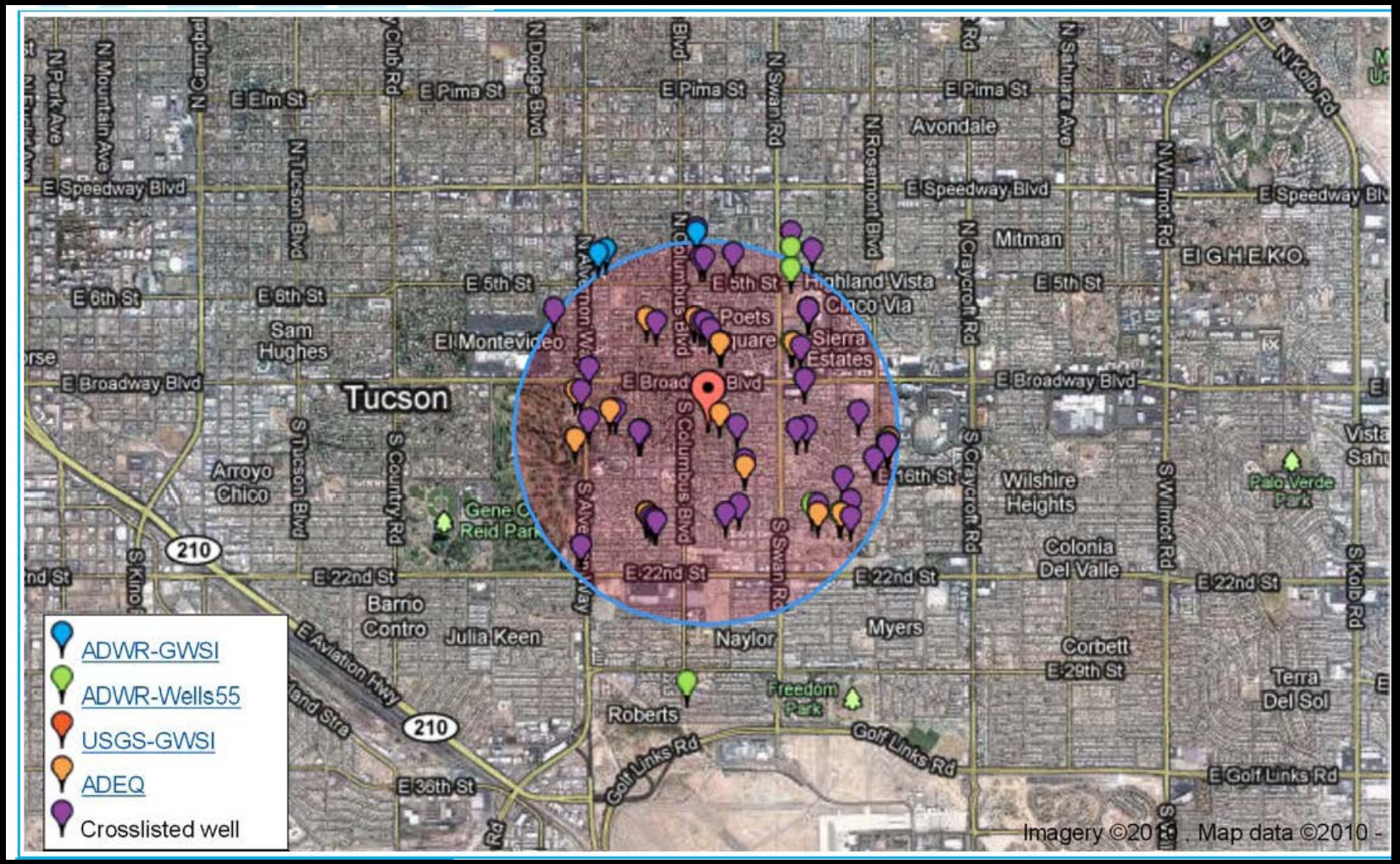
Tucson's Growth and Pumping Affects

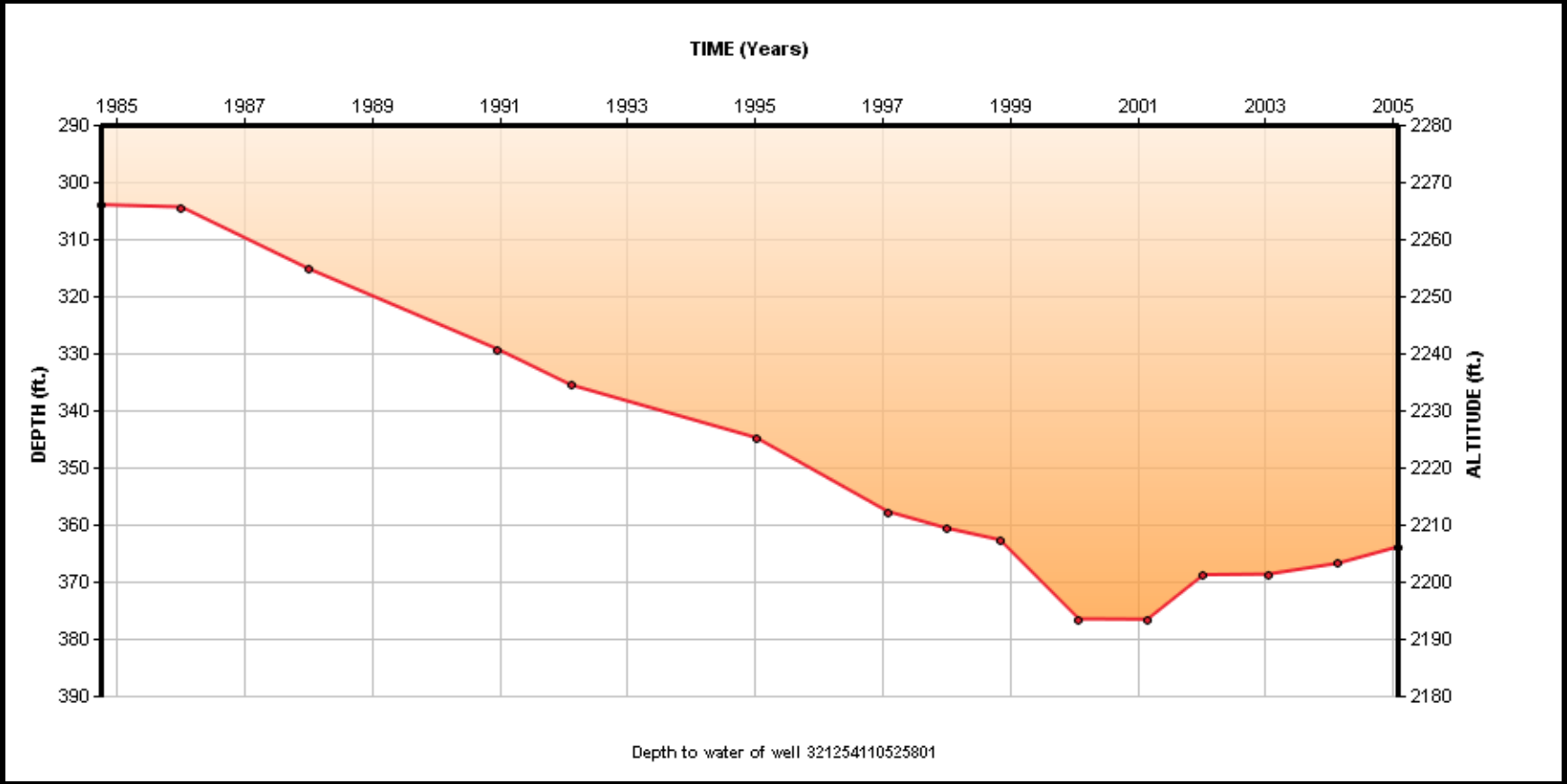
The 2009 Census Bureau estimate puts the city's population at 543,910, with a metropolitan area population at 1,020,200.

With this growth, the Tucson aquifer cannot recharge to keep up. As a result of this, the water level of the aquifer under the city of Tucson is dropping rapidly.

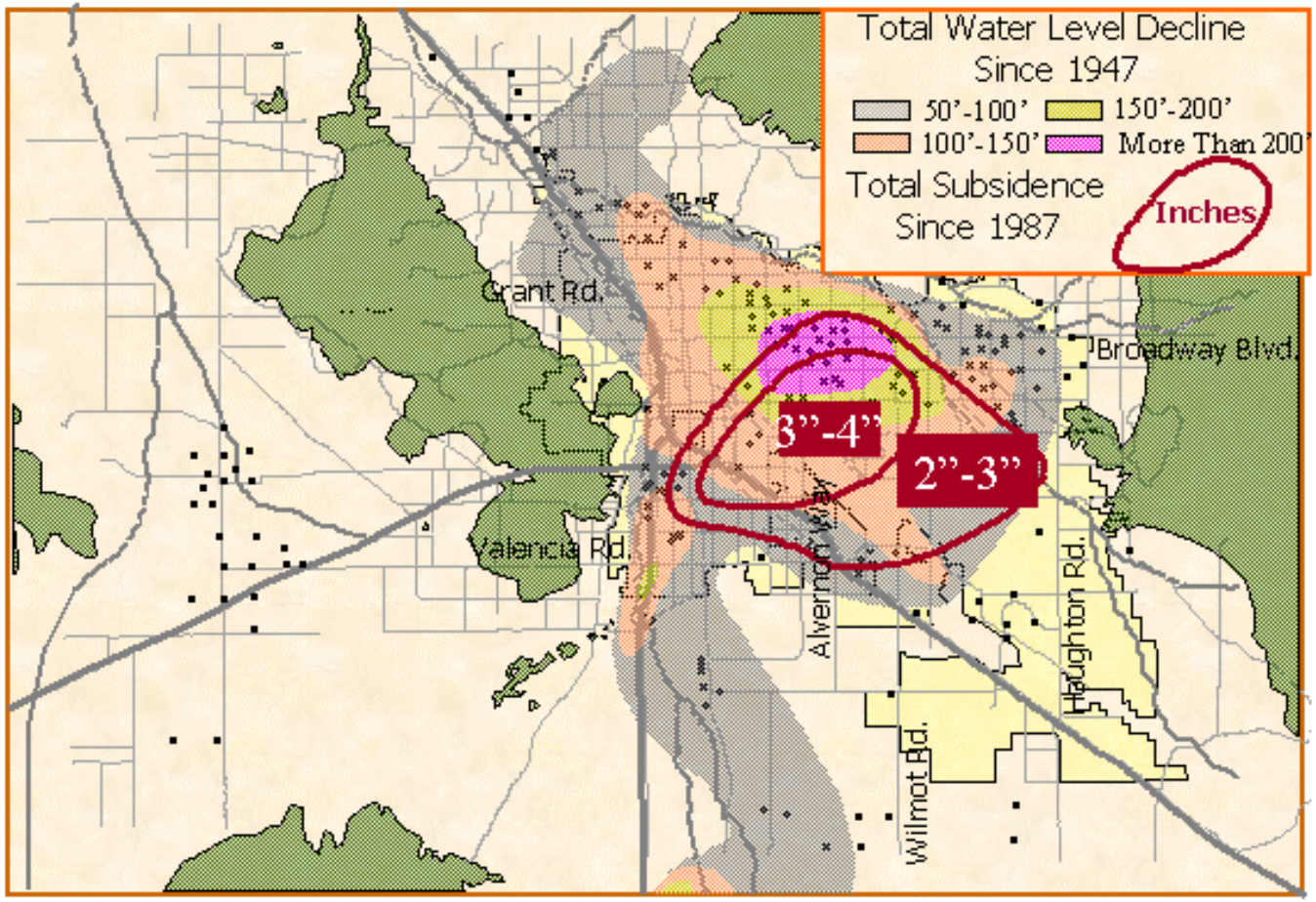





ADWR-GWSI
ADWR-Wells55
USGS-GWSI
ADEQ
Crosslisted well
Tucson
Avondale
El Ghekko
Mitman
Sam Hughes
El Montevideo
Poets Square
Highland Vista
Chico Via
Sierra Estates
Arroyo Chico
Barrio Contro
Julia Keen
Naylor
Myers
Corbett
Wilshire Heights
Colonia Del Valle
Terra Del Sol
Roberts
Freedom Park
Gene C. Reid Park
Palo Verde Park
E Broadway Blvd
E 22nd St
E 16th St
E 5th St
E 6th St
E Speedway Blvd
E Pima St
E Elm St
E 29th St
E 35th St
E Golf Links Rd
Golf Links Rd
N Swan Rd
N Rosemont Blvd
N Craycroft Rd
N Wilmot Rd
N Kolb Rd
N Dodge Blvd
N Tucson Blvd
N Park Ave
N Mountain Ave
N Campbell Ave
N Sahuara Ave
N Columbus Blvd
S Columbus Blvd
S Swan Rd
S Craycroft Rd
S Wilmot Rd
S Kolb Rd
S Tucson Blvd
S Country Club Rd
S Kino
S Avenue
E Aviation Hwy
210
Imagery ©2010 . Map data ©2010 -


TIME (Years)
1985
1987
1989
1991
1993
1995
1997
1999
2001
2003
2005
DEPTH (ft.)
290
300
310
320
330
340
350
360
370
380
390
ALTITUDE (ft.)
2280
2270
2260
2250
2240
2230
2220
2210
2200
2190
2180
Depth to water of well 321254110525801

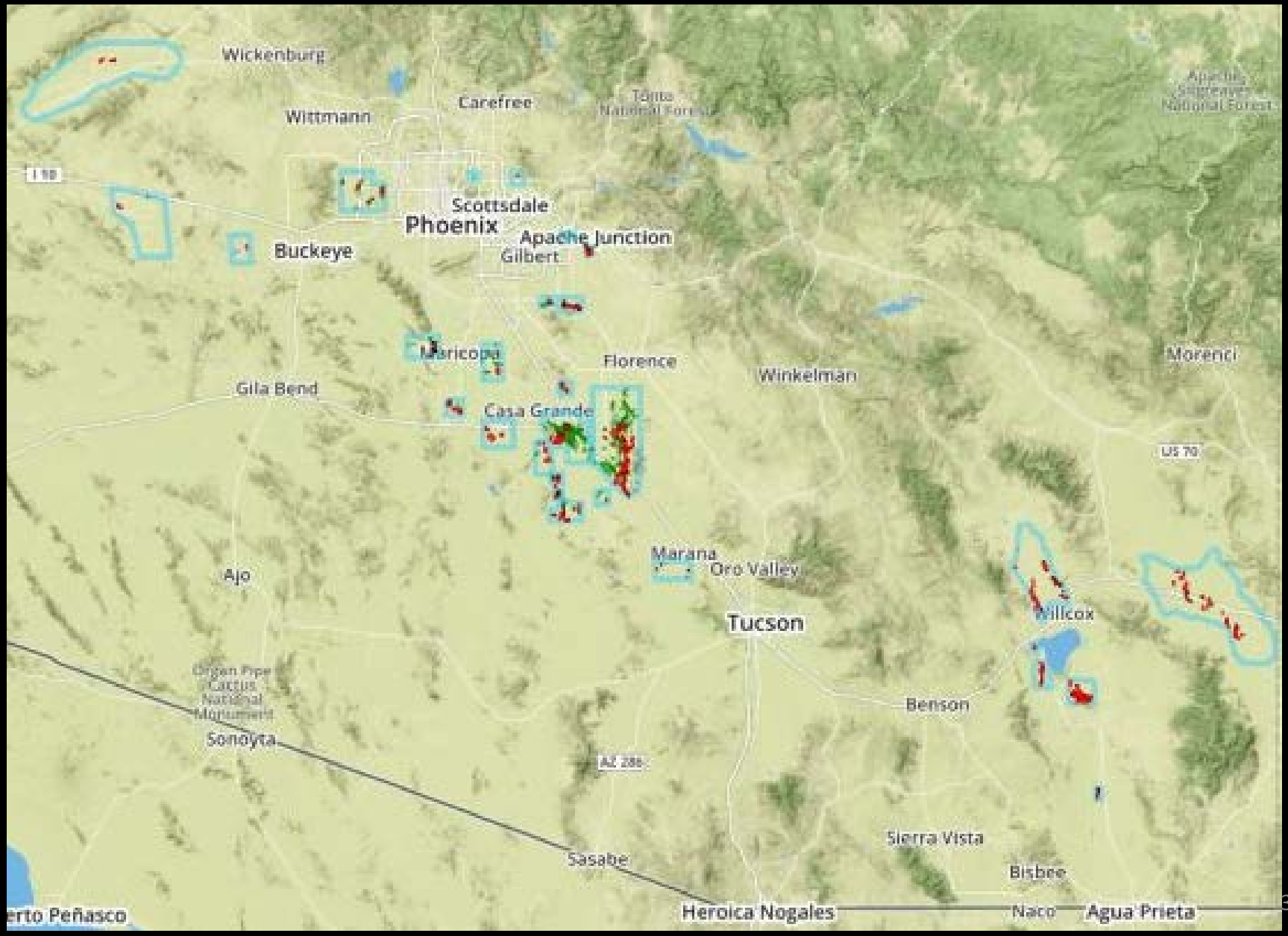
Subsidence in the Tucson Basin



Tucson Water

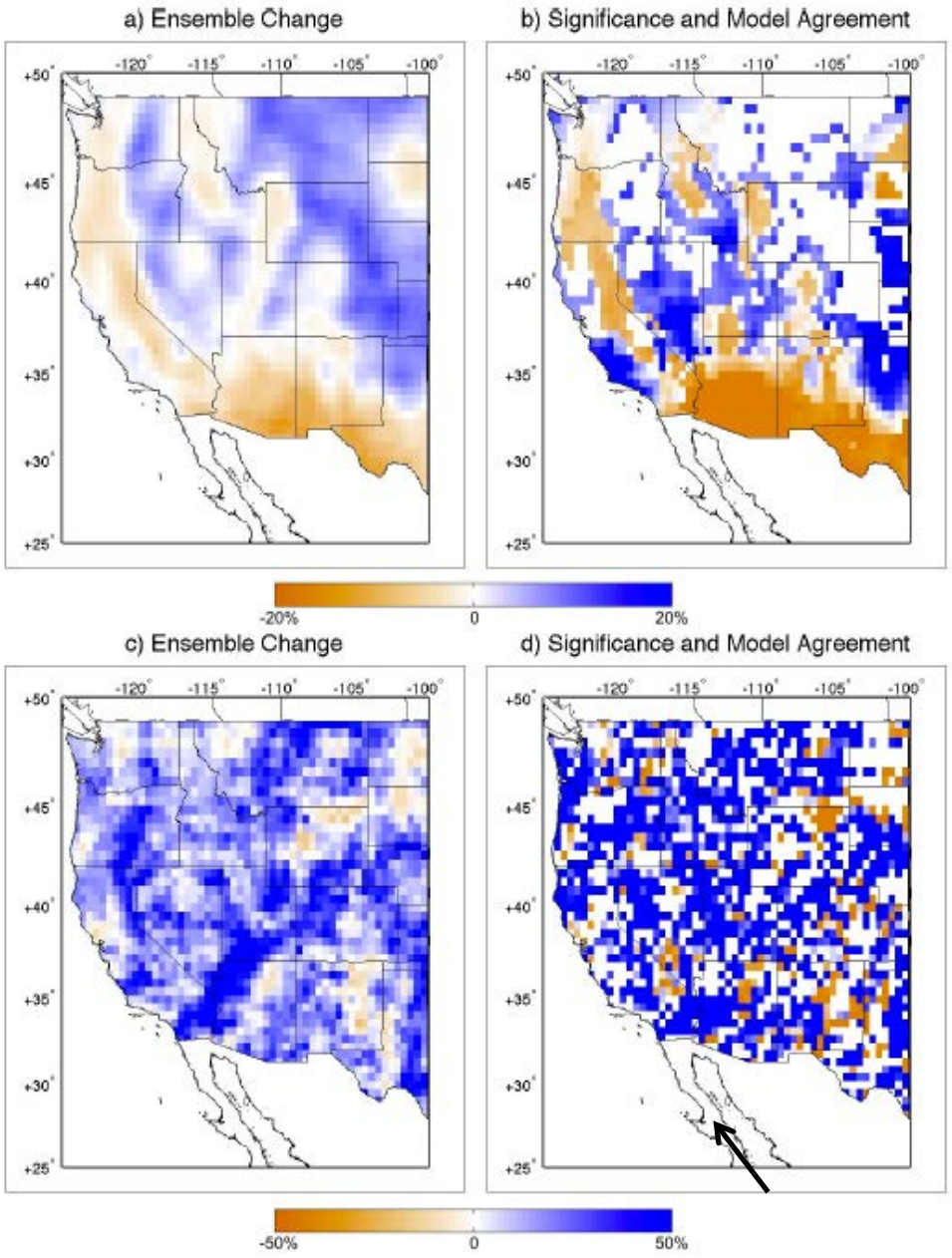

SUBSIDENCE
AREA

Earth Fissures



Mean Winter Precipitation

50-yr Return Period Winter Precipitation

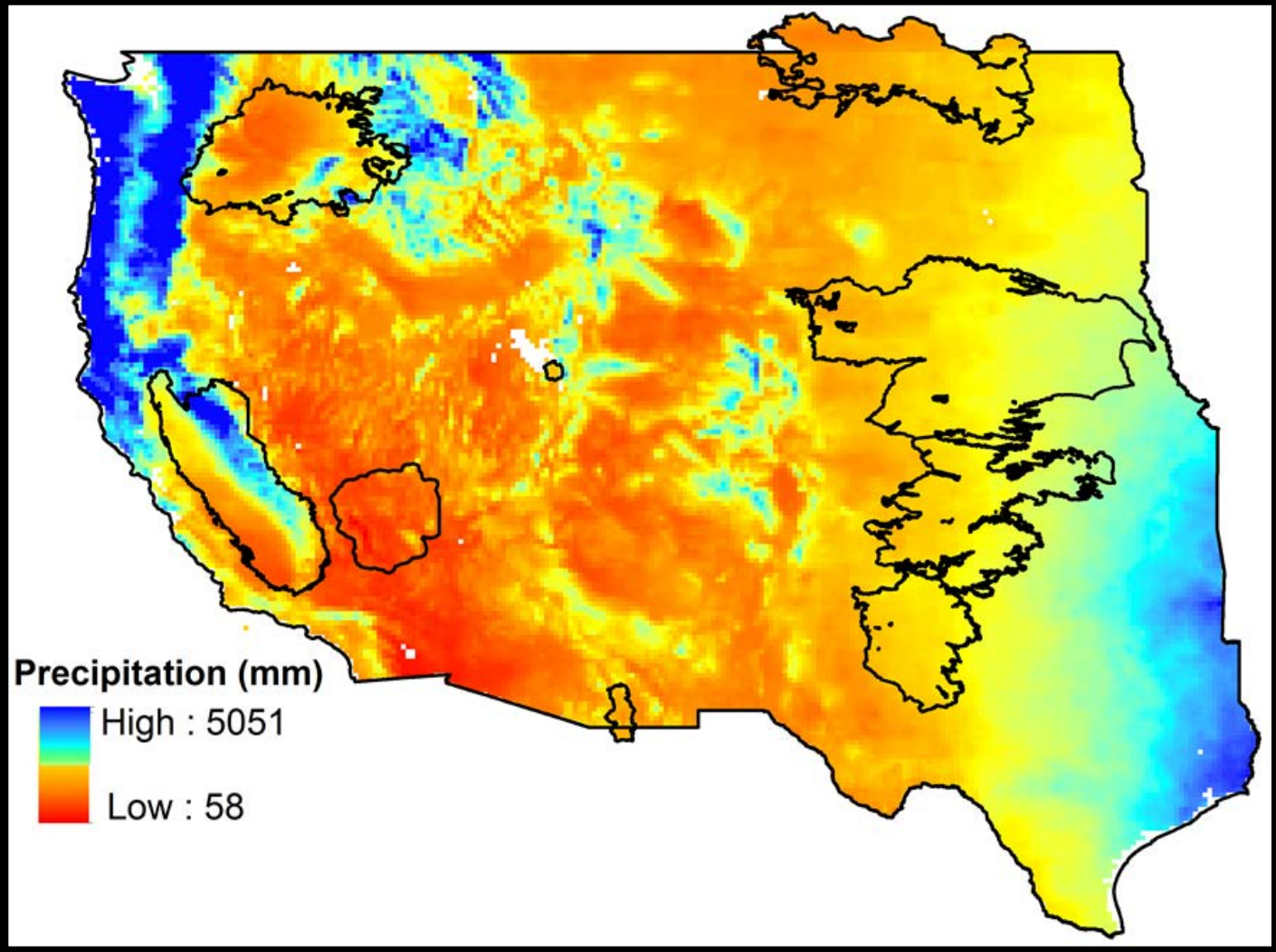


Mean winter precipitation is projected to increase in the north and decrease in the south and west.

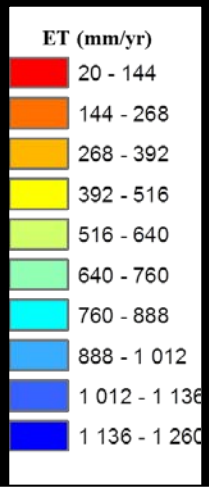
Extreme precipitation is projected to increase throughout the domain.

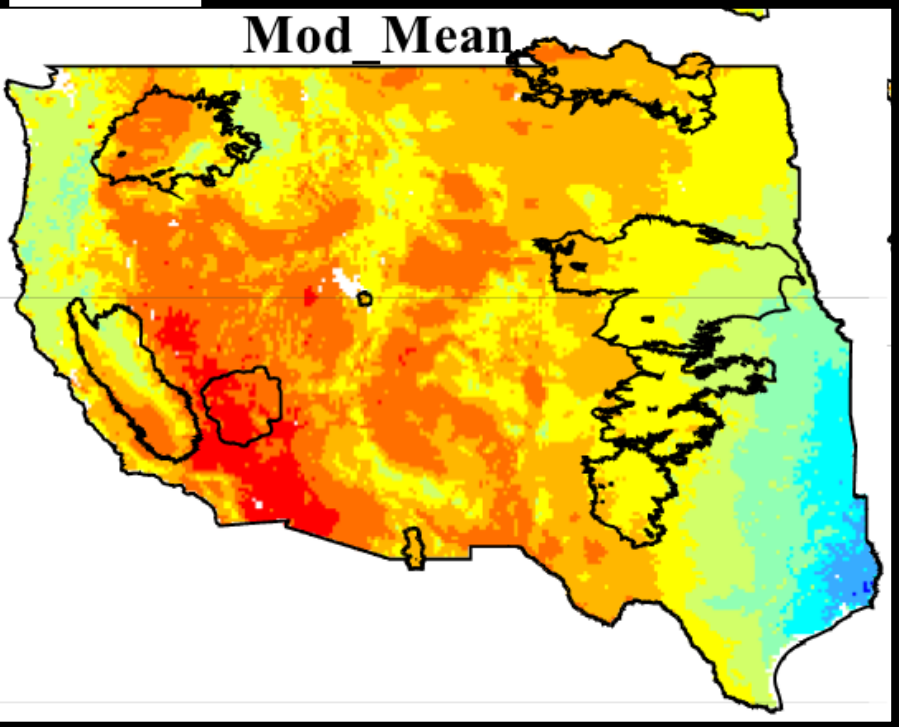
Dominguez et al., 2012. *Geophys. Res. Lett.*

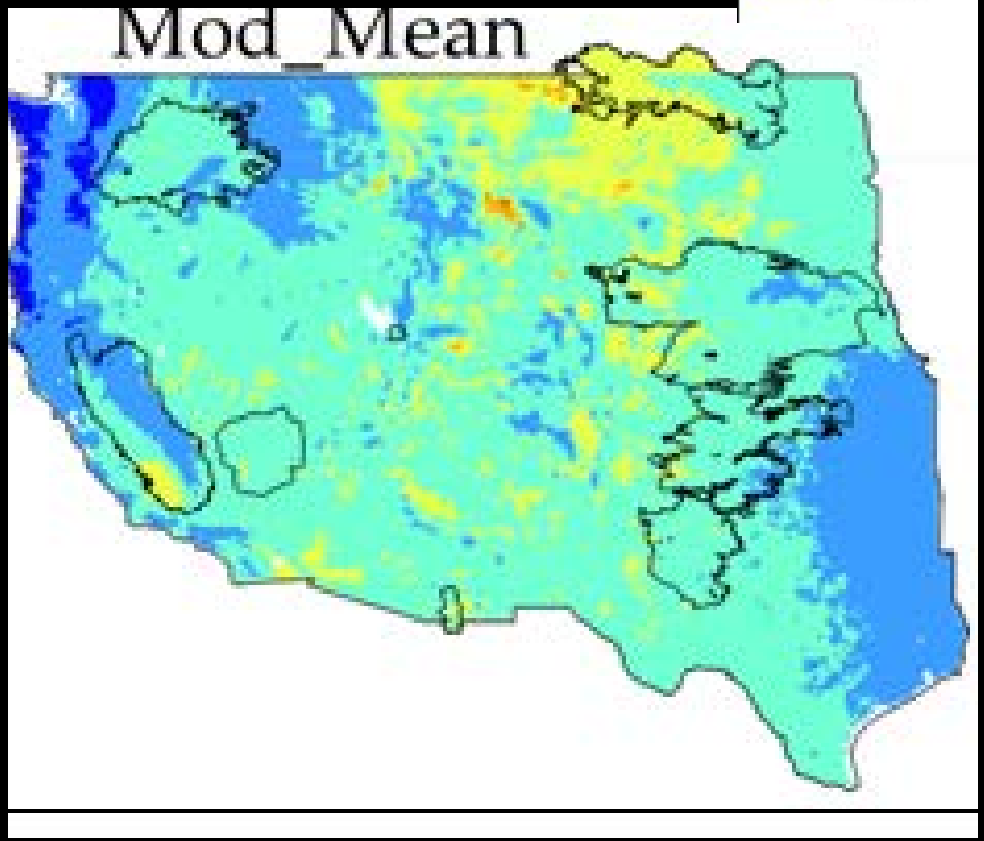
Precipitation



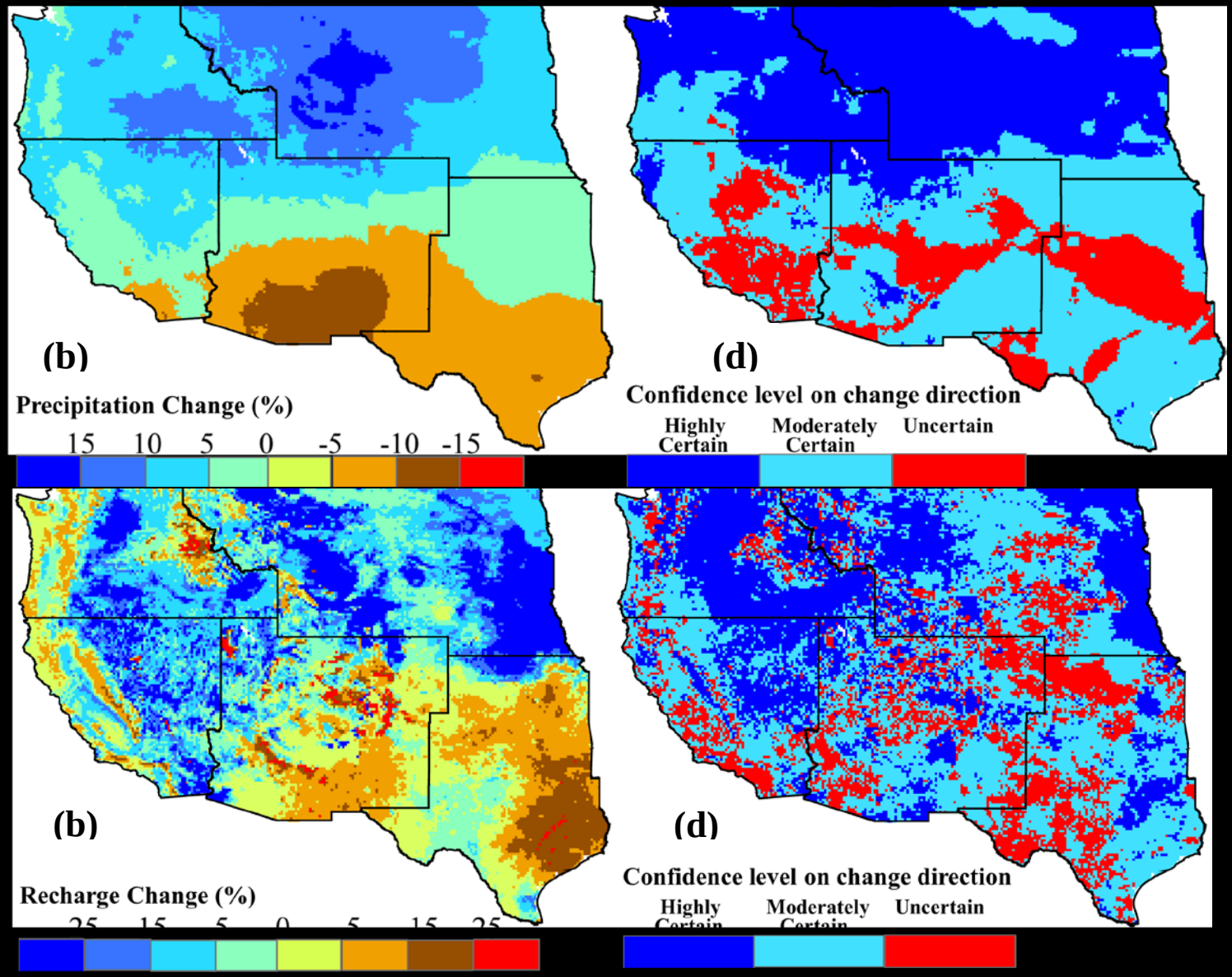
ET and Recharge

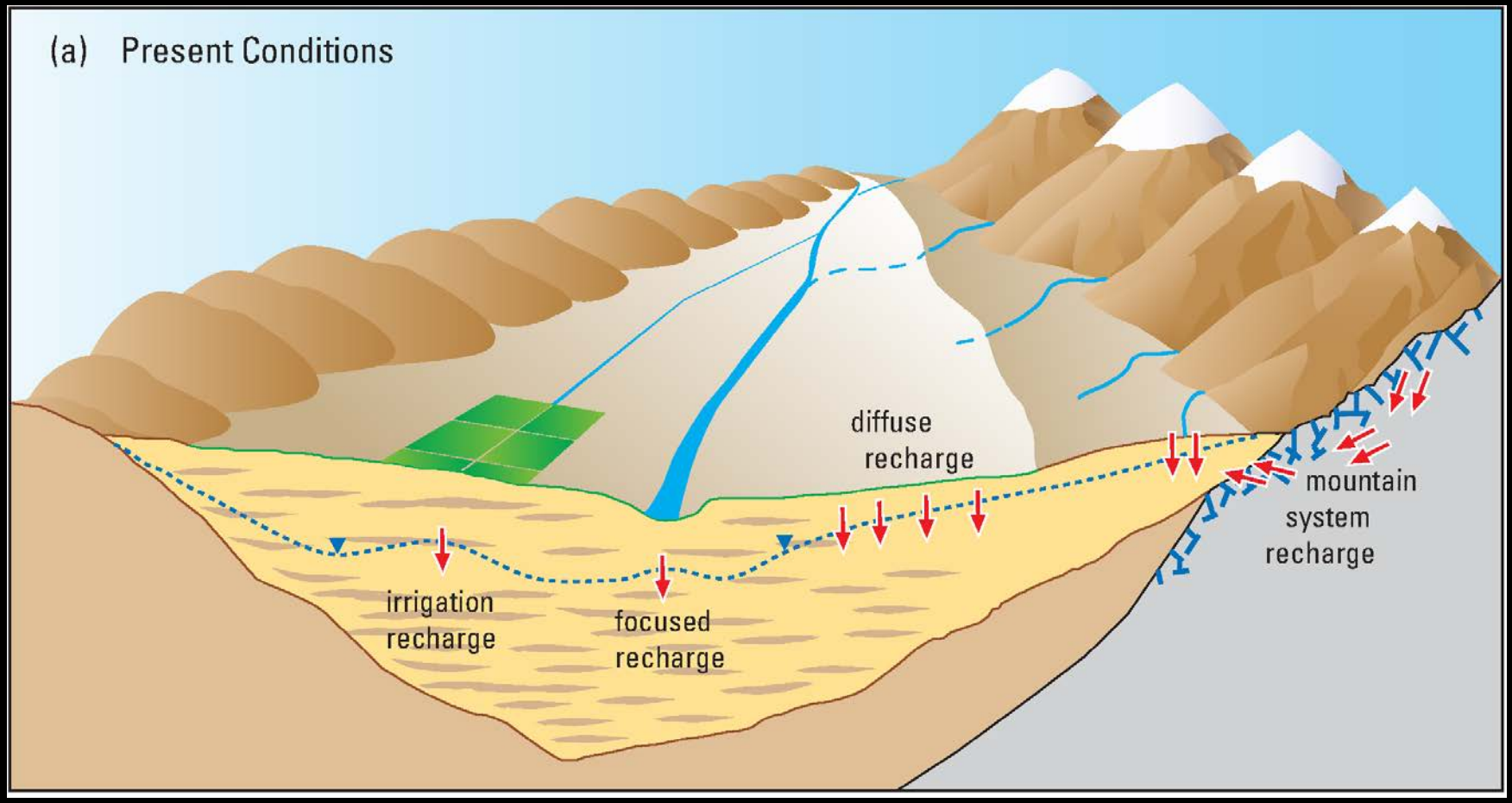






P and Recharge Changes




(a) Present Conditions
diffuse recharge
mountain system recharge
irrigation recharge
focused recharge

Summary

- Groundwater is unseen
- Three major aquifer regimes in Arizona
- Basin and Range systems critical
- Past and future climate change
  - Exacerbate over extraction
  - Unsustainable
  - Subsidence

Mountain Systems