

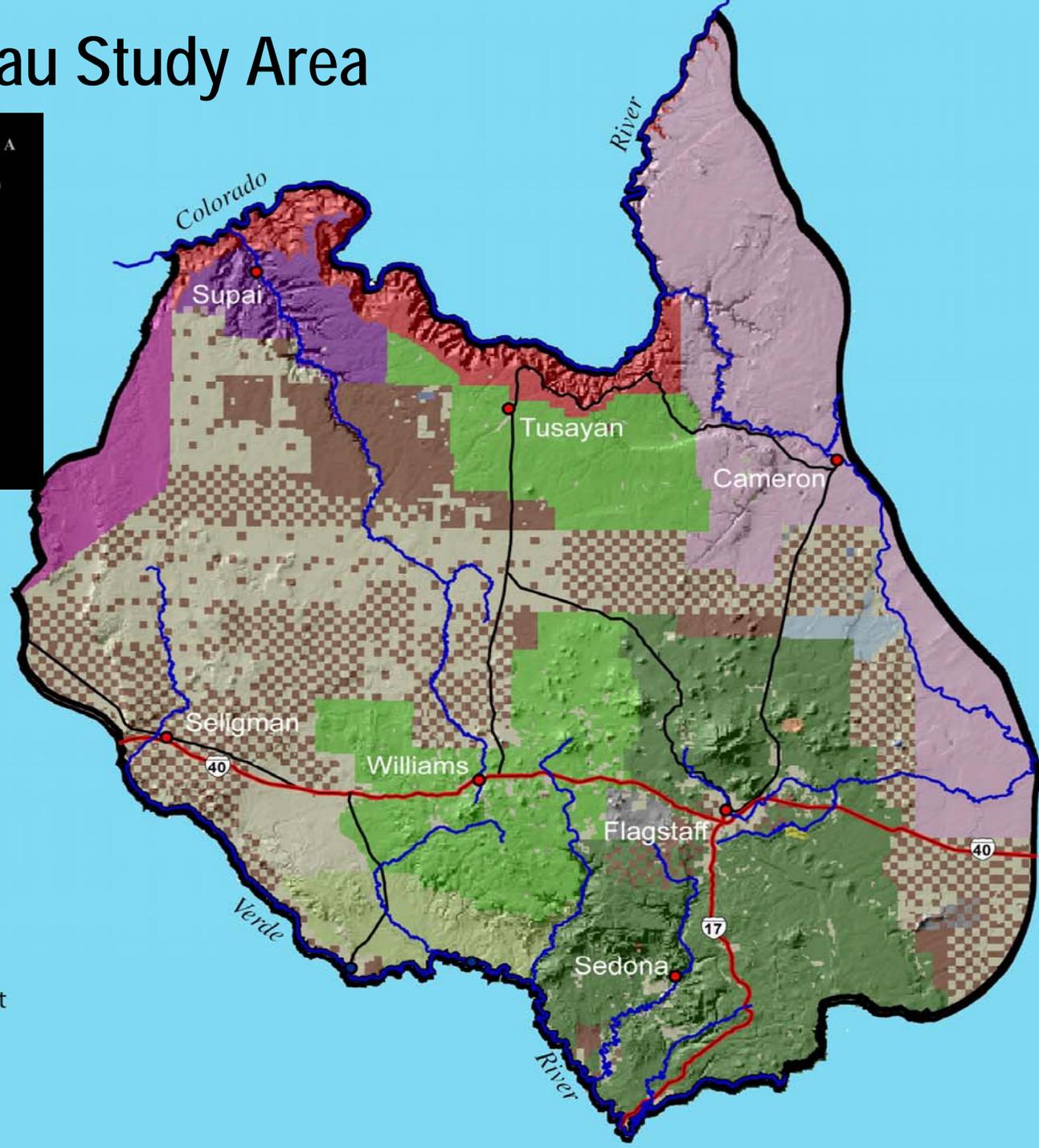
Hydrogeology Assessment of the Coconino Plateau and Adjacent Areas, Coconino and Yavapai Counties, Arizona

A Rural Watershed Initiative

By Donald J Bills, Marilyn E. Flynn, and Stephen A Monroe



Coconino Plateau Study Area



- Coconino National Forest
- Kaibab National Forest
- Prescott National Forest
- BLM
- State Trust
- Private
- Grand Canyon National Park
- Sunset National Monument
- Wupatki National Monument
- Walnut Canyon National Monument
- Havasupai Reservation
- Hualapai Reservation
- Navajo Reservation

Regional Water Issues

- Population growth
- Water demand, supply, and sustainability
- Ground-water development
- Riparian ecosystems
- Recreation and cultural uses

(2050 planning horizon, doubling of population and water use, un-meet water demand of about 15,000 acre-feet)





Program Goals and Objectives

- Create a regional database →
- Define a regional hydrogeologic framework →
- Develop a conceptual ground-water model →
- Develop a regional numerical model →

Improve the understanding of the regional ground-water system

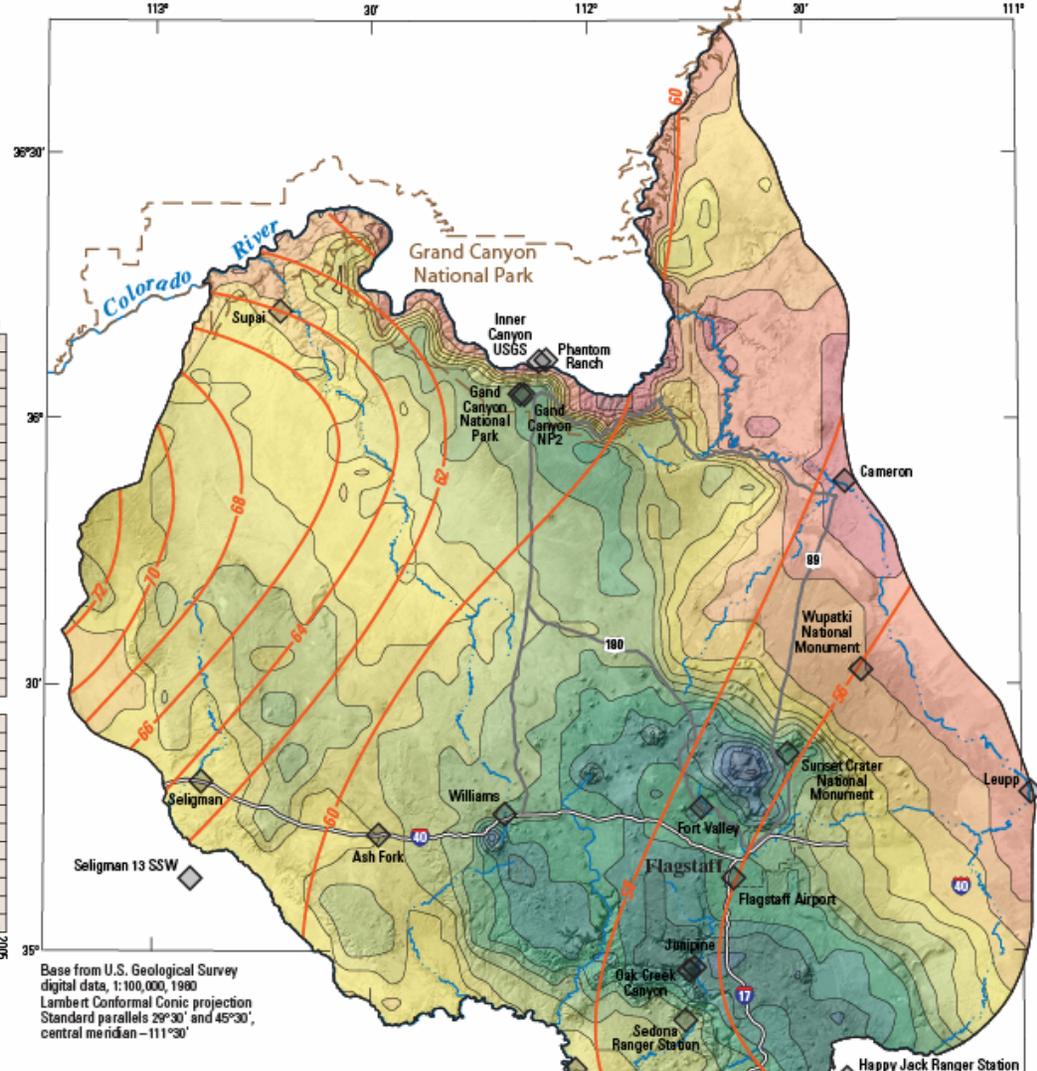
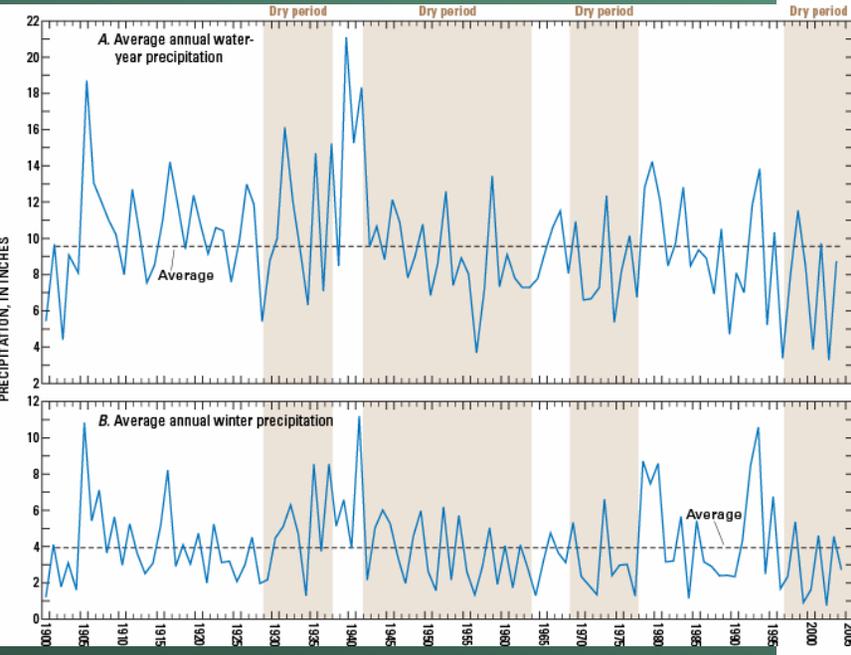
Coconino Plateau Study Area

EXPLANATION

-  Topographically closed basin
 -  Confined
 -  Unconfined
 -  Dry
- Approximate boundary between confined and unconfined conditions in the Redwall-Muav aquifer
- Approximate areal extent of the C aquifer



Where does the water come from?



EXPLANATION

MEAN ANNUAL PRECIPITATION 1971-2000, IN INCHES PER YEAR:

3-5	15-17	27-29
5-7	17-19	29-31
7-9	19-21	31-33
9-11	21-23	33-35
11-13	23-25	Greater than 35
13-15	25-27	

— 60 — LINE OF EQUAL AVERAGE ANNUAL EVAPORATION, IN INCHES PER YEAR—Contour interval 2 inches

◆ WEATHER STATION AND STATION NAME

Ash Fork

0 20 MILES
0 20 KILOMETERS

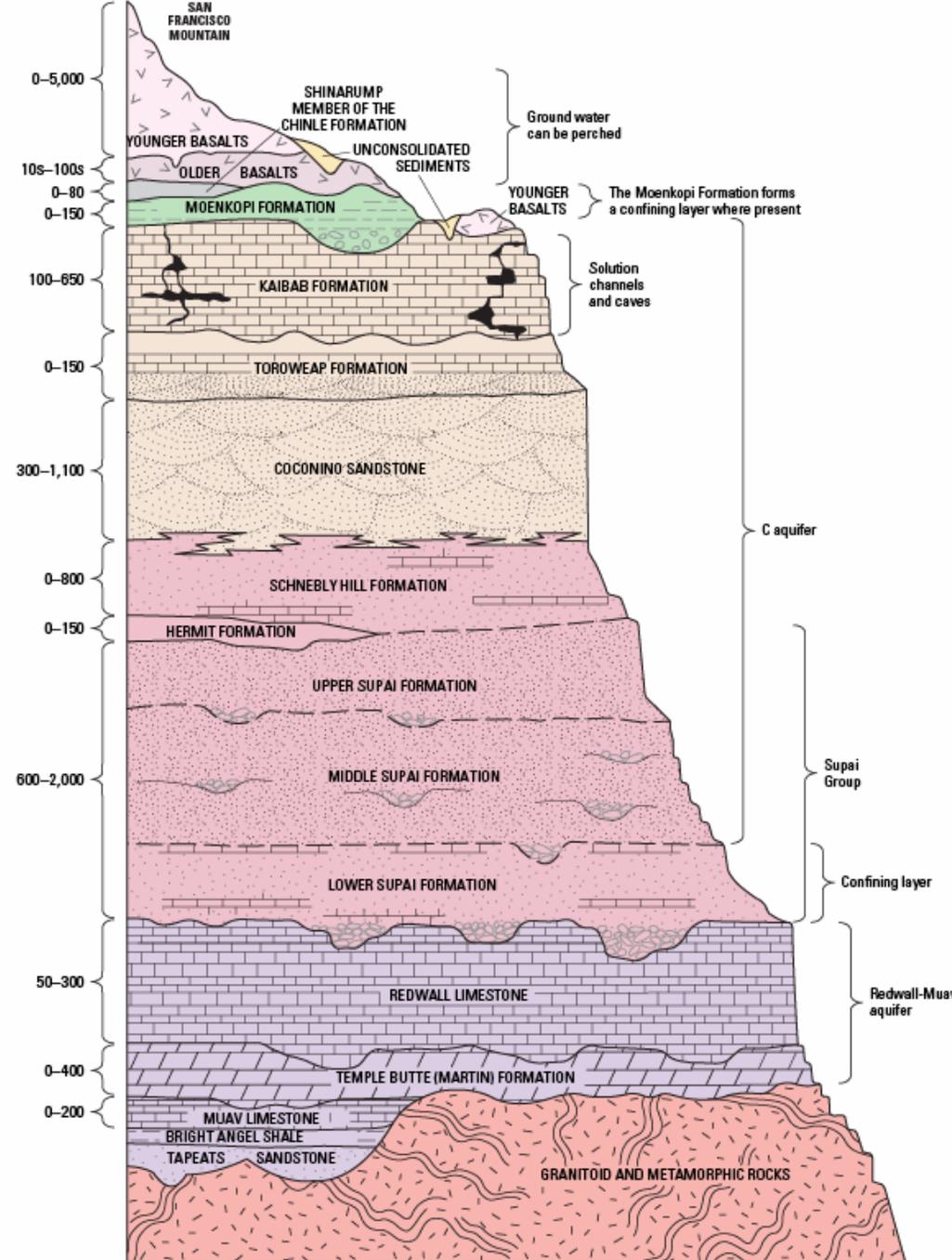
Precipitation source:
Spatial Climate Analysis Service,
Created February 4, 2004,
Spatial Climate Analysis Service,
Oregon State University,
<http://www.oc.s.oregonstate.edu/prism>

Evaporation source:
Farnsworth and others, 1982



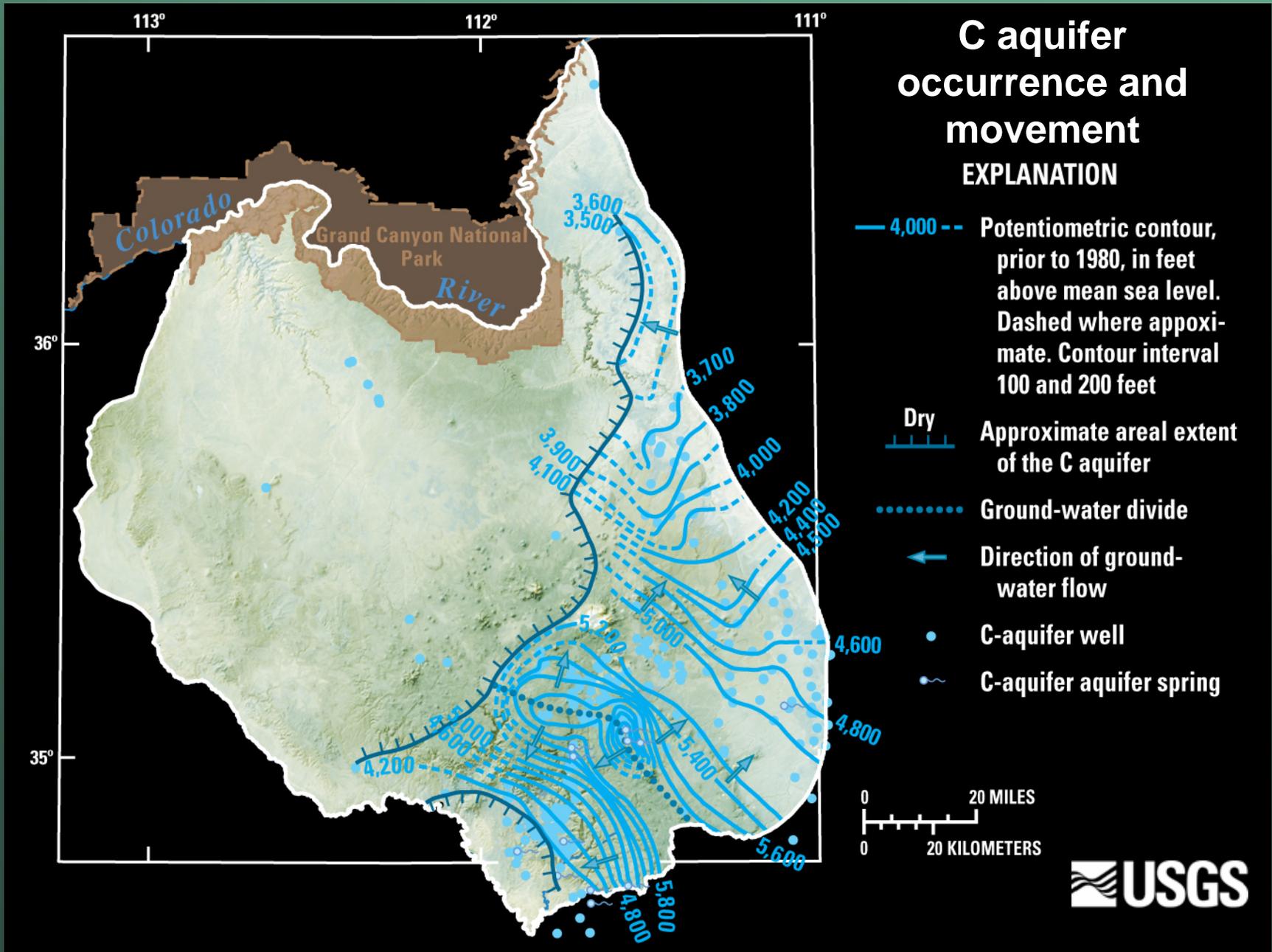
Where does the water go?

- Evapotranspiration
- Runoff
- Ground-water recharge
 - Perched water-bearing zones
 - **C aquifer**
 - **Redwall-Muav aquifer**



Modified from Bills and others, 2000

Goals and Objectives, Regional data base leads to improved understanding of the hydrogeology



Redwall-Muav aquifer occurrence and movement

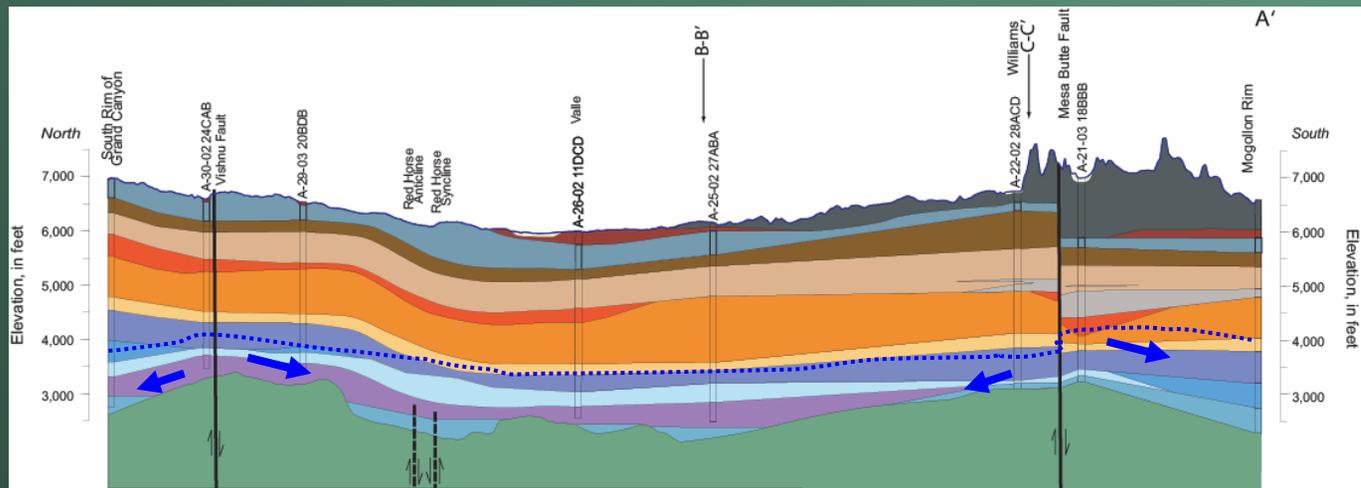
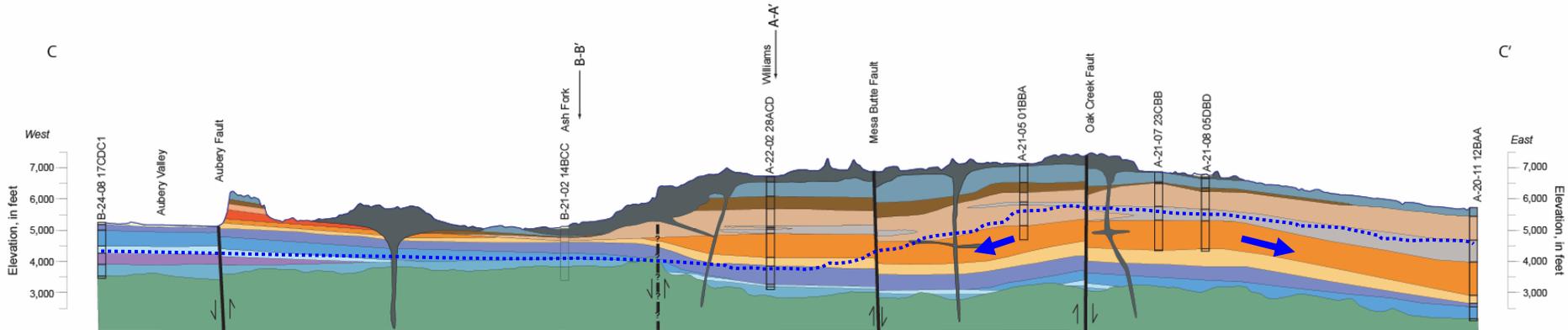


EXPLANATION

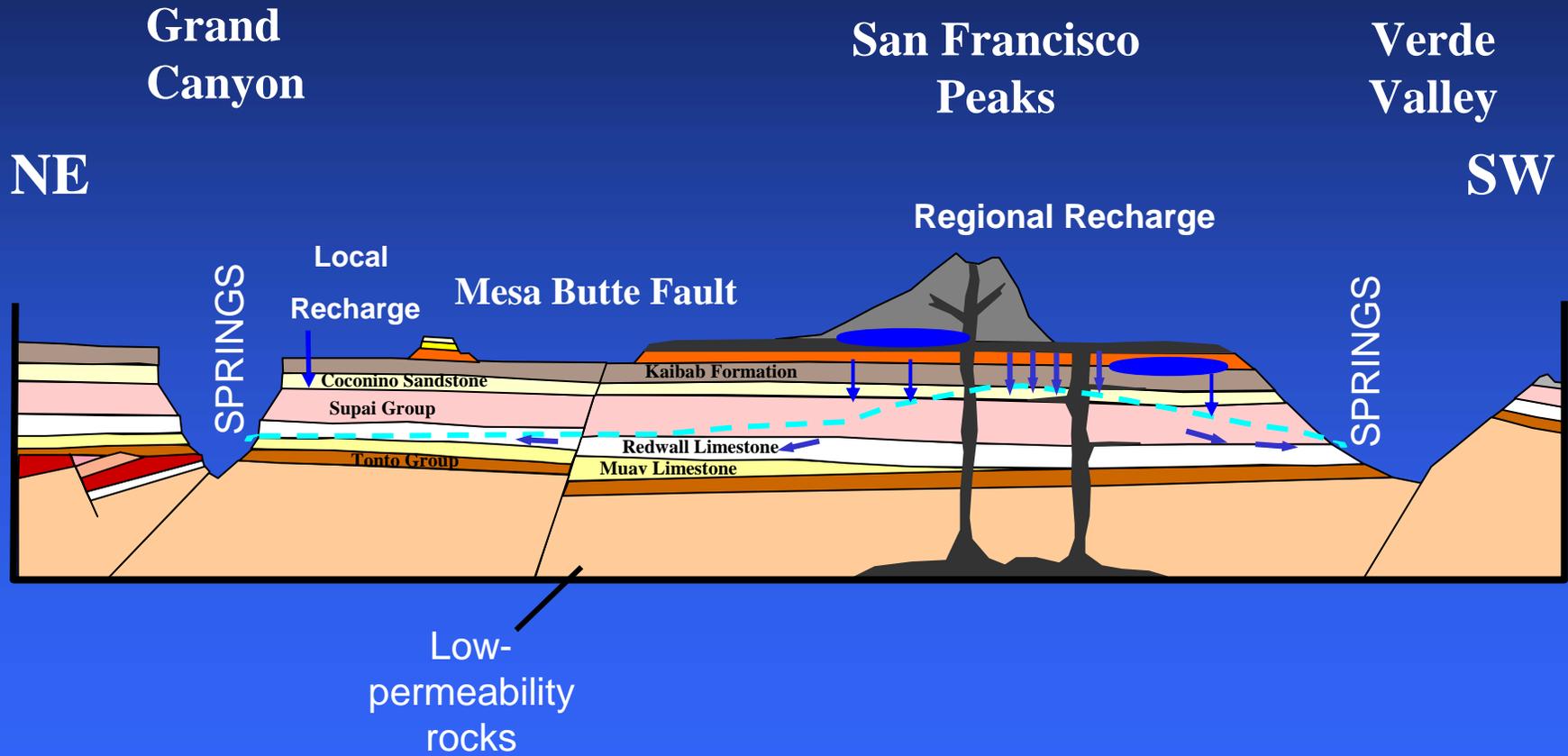
- 4,000 -- Potentiometric contour, prior to 1990, in feet above mean sea level. Dashed where approximate. Contour interval 100 and 200 feet
- Ground-water divide
- ← Direction of ground-water flow
- Redwall-Mauv aquifer well
- Redwall-Mauv aquifer spring



Improved geologic and structural information leads to a better understanding of the hydrogeologic framework



Flow system conceptual model: Coconino Plateau



How much water is there?

Conceptual Model, water budget components

A. Pre-1975

$$\text{Watershed budget} - P - ET_{ws} - R_o = R + / - \Delta S$$
$$\text{Ground-water budget} - R + GW_i - GW_o - ET_{gw} = \Delta S$$

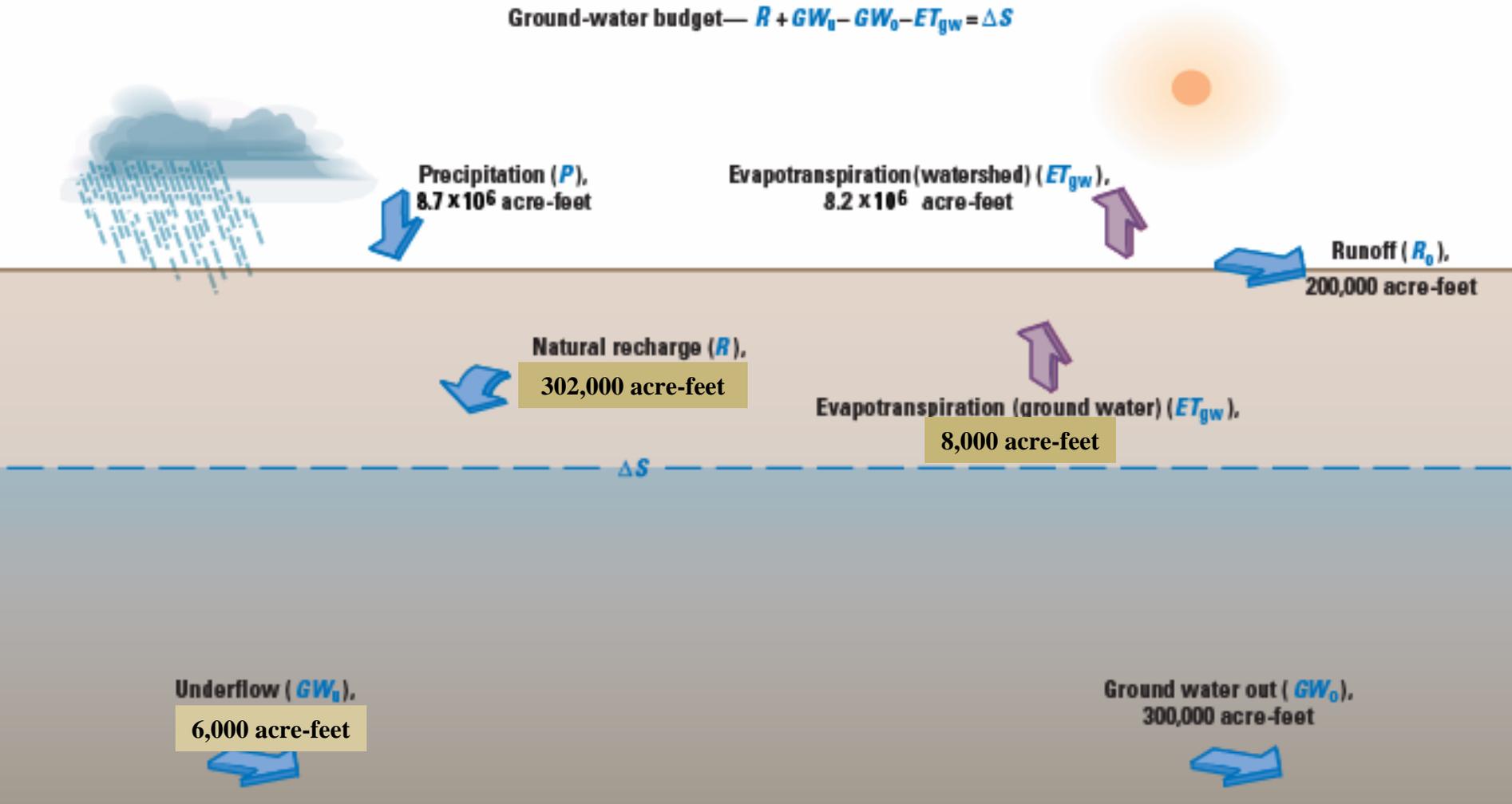
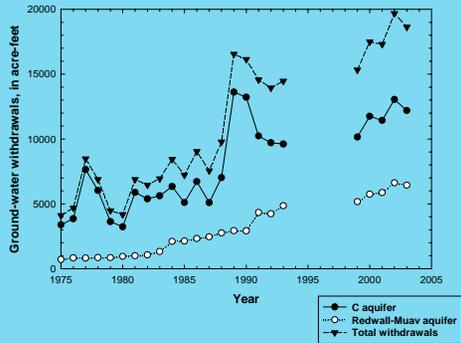
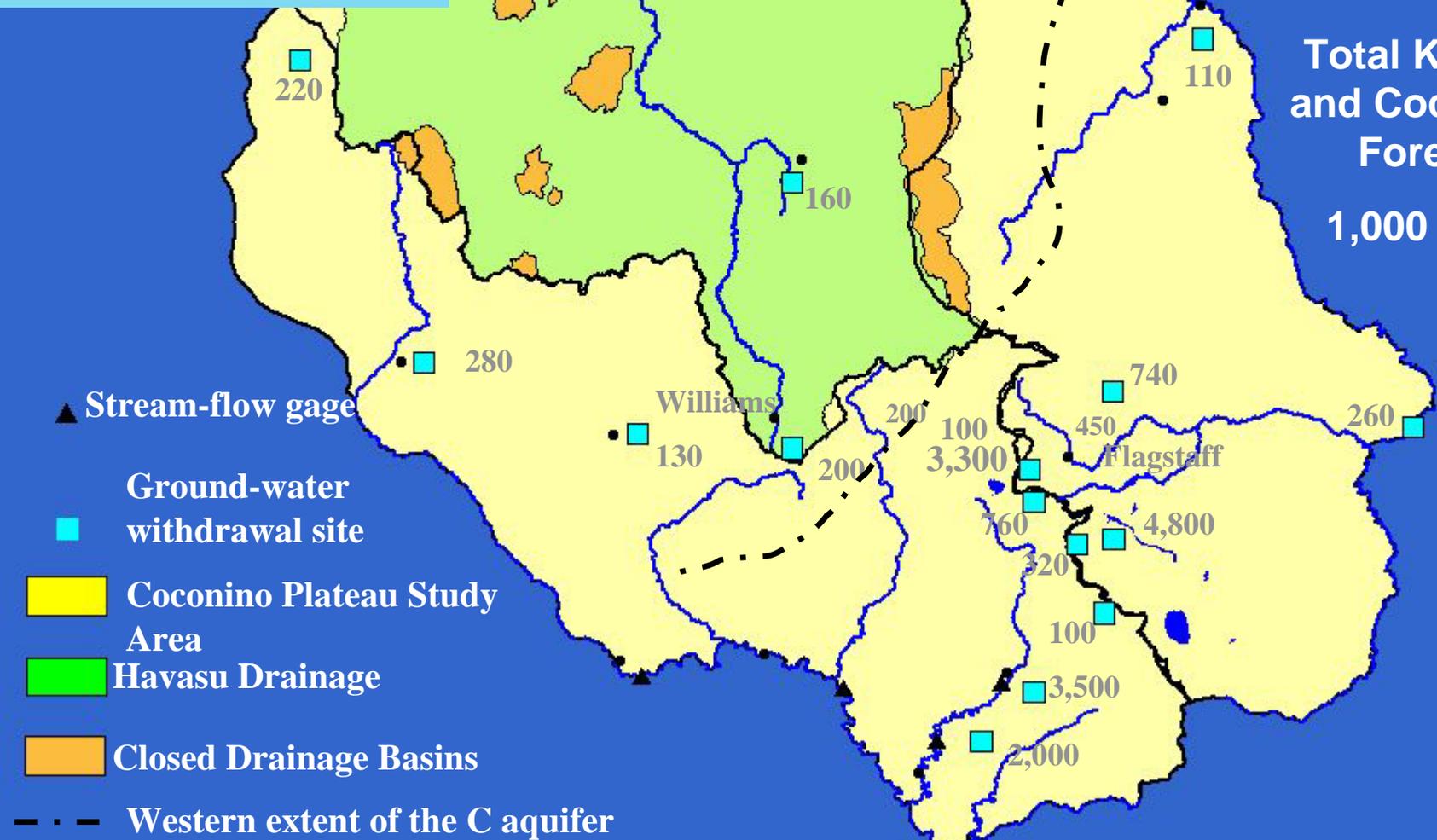


Figure 8. Total ground-water withdrawals from the C aquifer and the Redwall-Muav aquifer on the Coconino Plateau, Arizona, 1975-2003



Measured and Estimated Ground-Water Withdrawals, in Acre Feet, 2002

Total Kaibab and Coconino Forest, 1,000 ac-ft



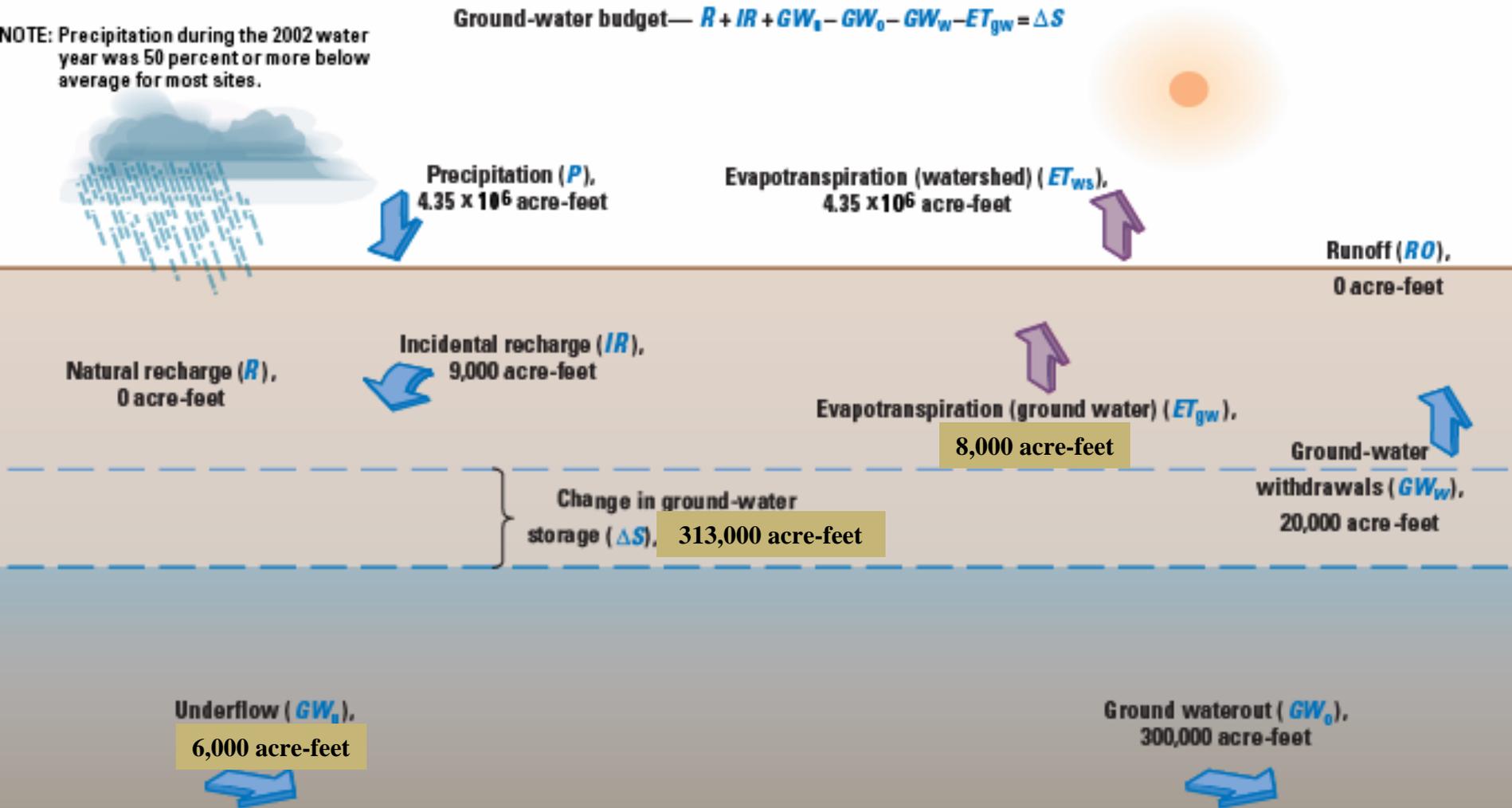
- ▲ Stream-flow gage
- Ground-water withdrawal site
- Coconino Plateau Study Area
- Havasu Drainage
- Closed Drainage Basins
- - - Western extent of the C aquifer

B. Transient, 2002 water year

NOTE: Precipitation during the 2002 water year was 50 percent or more below average for most sites.

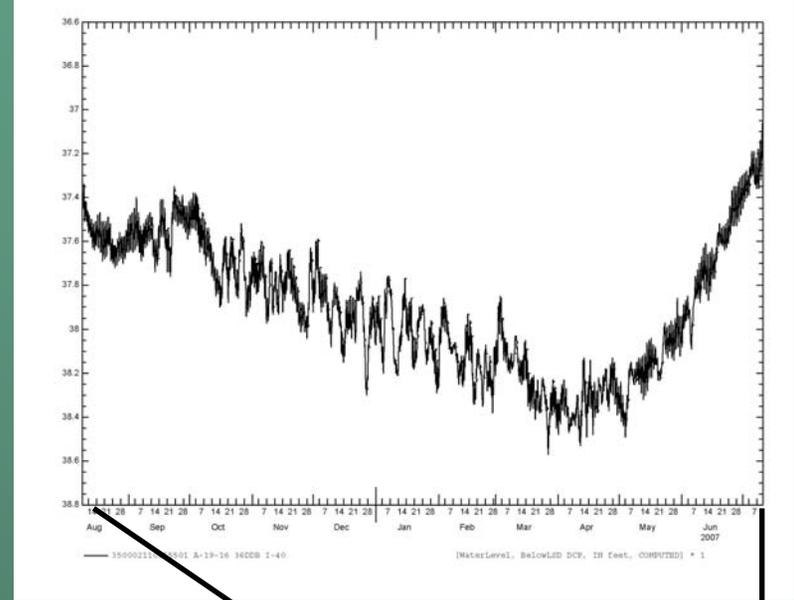
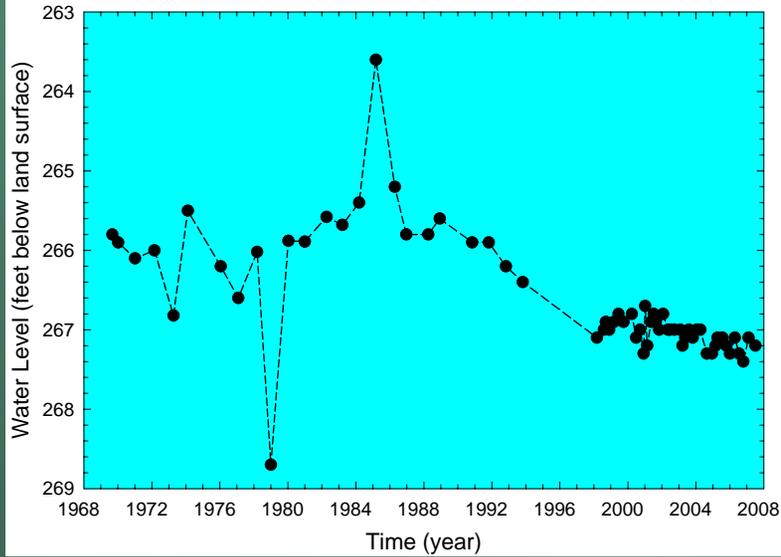
$$\text{Watershed budget} — P - ET_{ws} - R_o = R + / - \Delta S$$

$$\text{Ground-water budget} — R + IR + GW_s - GW_o - GW_w - ET_{gw} = \Delta S$$

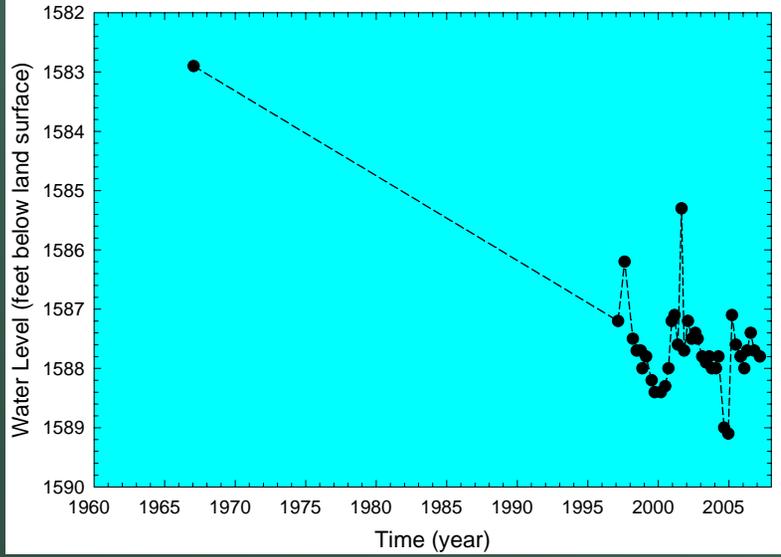


Well Hydrographs

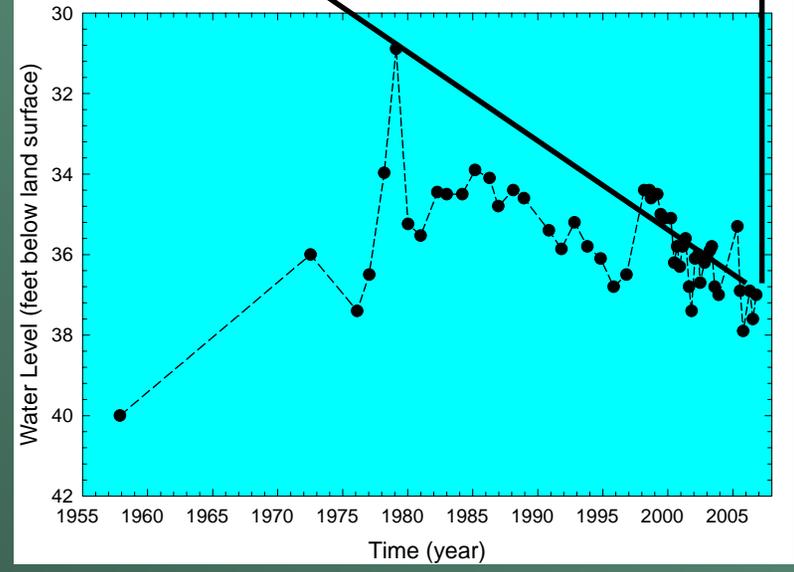
Winslow T Observation Well (A-18-15) 28AAD



NPS-Wupatki, Citadel Well (A-25-09) 06CCD

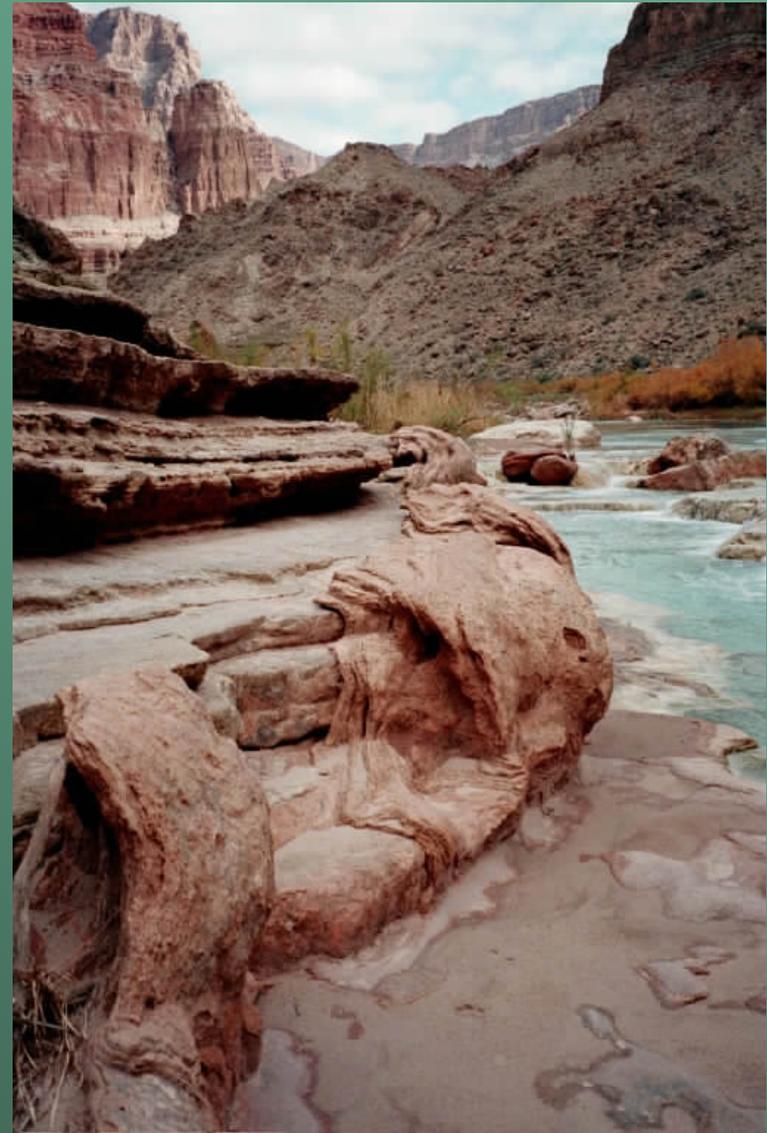


Winslow I-40 Observation Well (A-19-16) 36DBB



Significant results, hydrogeology of the Coconino Plateau

- Two regional flow systems dominated by fracture flow
 - C Aquifer
 - Redwall-Muav Aquifer
- Major fault systems act as both barriers and conduits to flow
- Both regional flow systems in transient state owing to drought, increasing withdrawals; Water level declined 10's to over 200 ft
- Water chemistry verifies conceptual model and provides a range of water age from modern to about 20,000 years



Products, Coconino Plateau ground-water study

Completed:

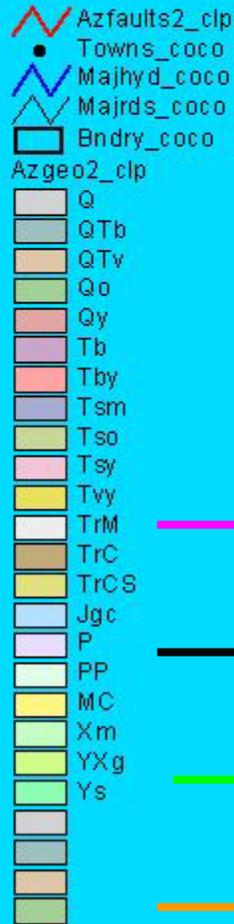
- Database
- Hydrogeologic Framework
- Geologic mapping
- Water budget
- Interactive web site
- Reports
 - **OFR 02-265** (Data Report Coconino Plateau)
 - **FS 113-02** (Fact Sheet Coconino Plateau)
 - **FS 096-02** (Fact Sheet Upper and Middle Verde)
 - **WRIR 02-4026** (C aquifer, LCR Basin)
 - **SIR 2004-5146** (Grand Canyon Springs)
 - Numerous abstracts



In progress:

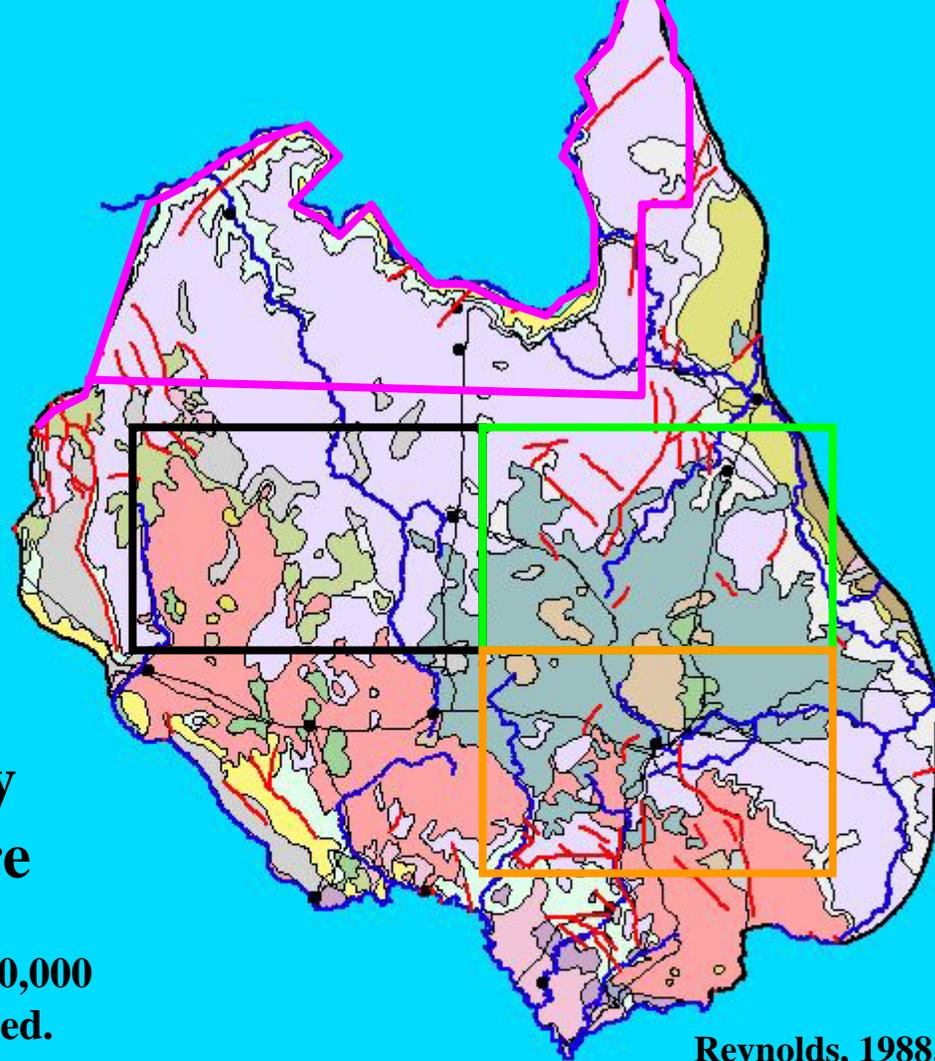
- **SIR 2005-5222** (in press)
- Geologic mapping
- Interpretive Model

Surface Geology and Geologic Structure



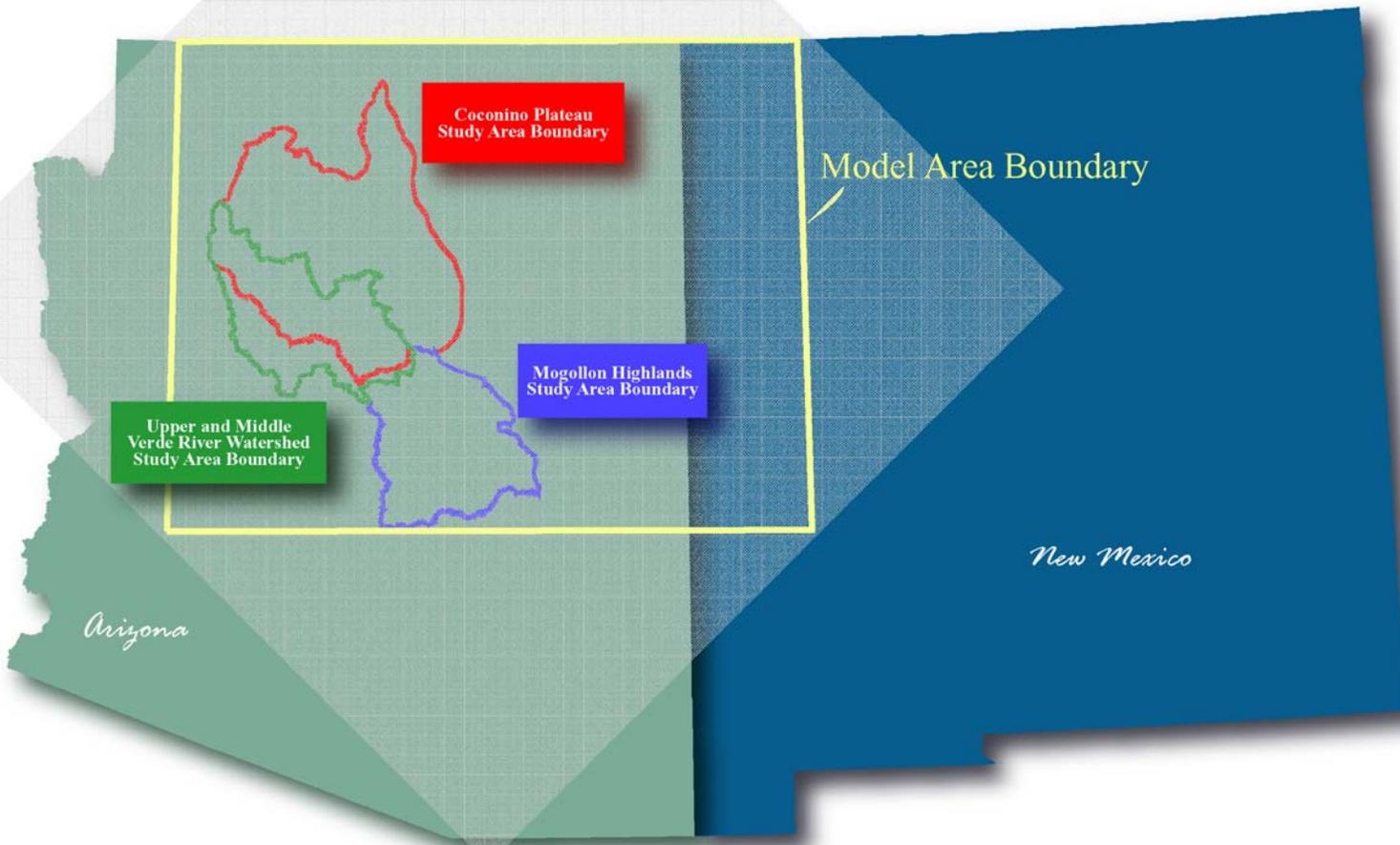
New geology and structure

- •Grand Canyon, 1:100,000 completed and digitized.
- •Valle 2 degree sheet, completed, digitized.
- •Cameron 2 degree sheet, Done, in press in progress.
- •Flagstaff 2 degree sheet, Digitizing in progress complete.



Reynolds, 1988, 1:1,000,000

Model Grid
Grid Size: 1 mile x 1 mile
Rotation: N45W





Additional data needs, monitoring



Comments, questions, contact info

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<http://az.water.usgs.gov/projects/C1D01.html>

