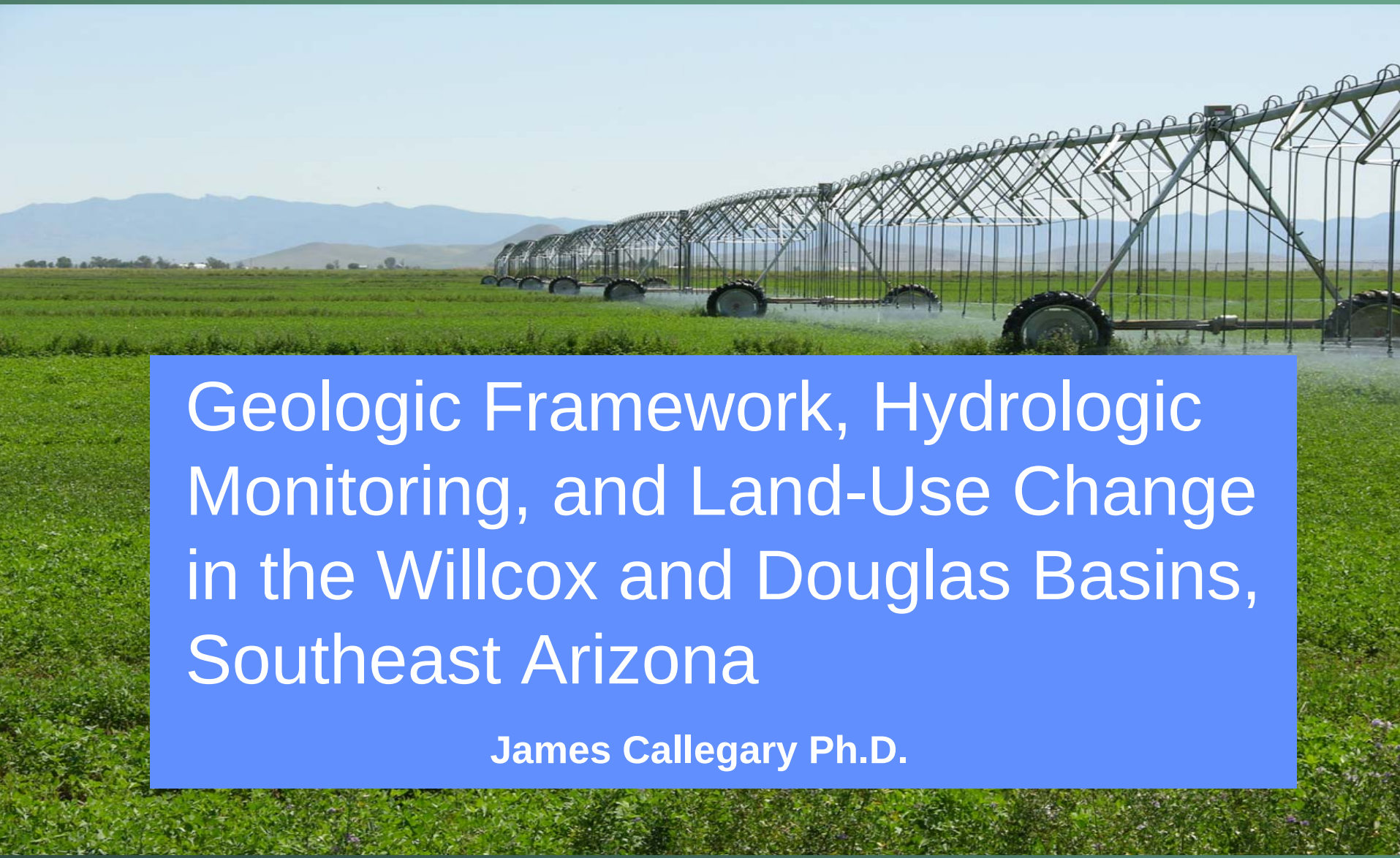


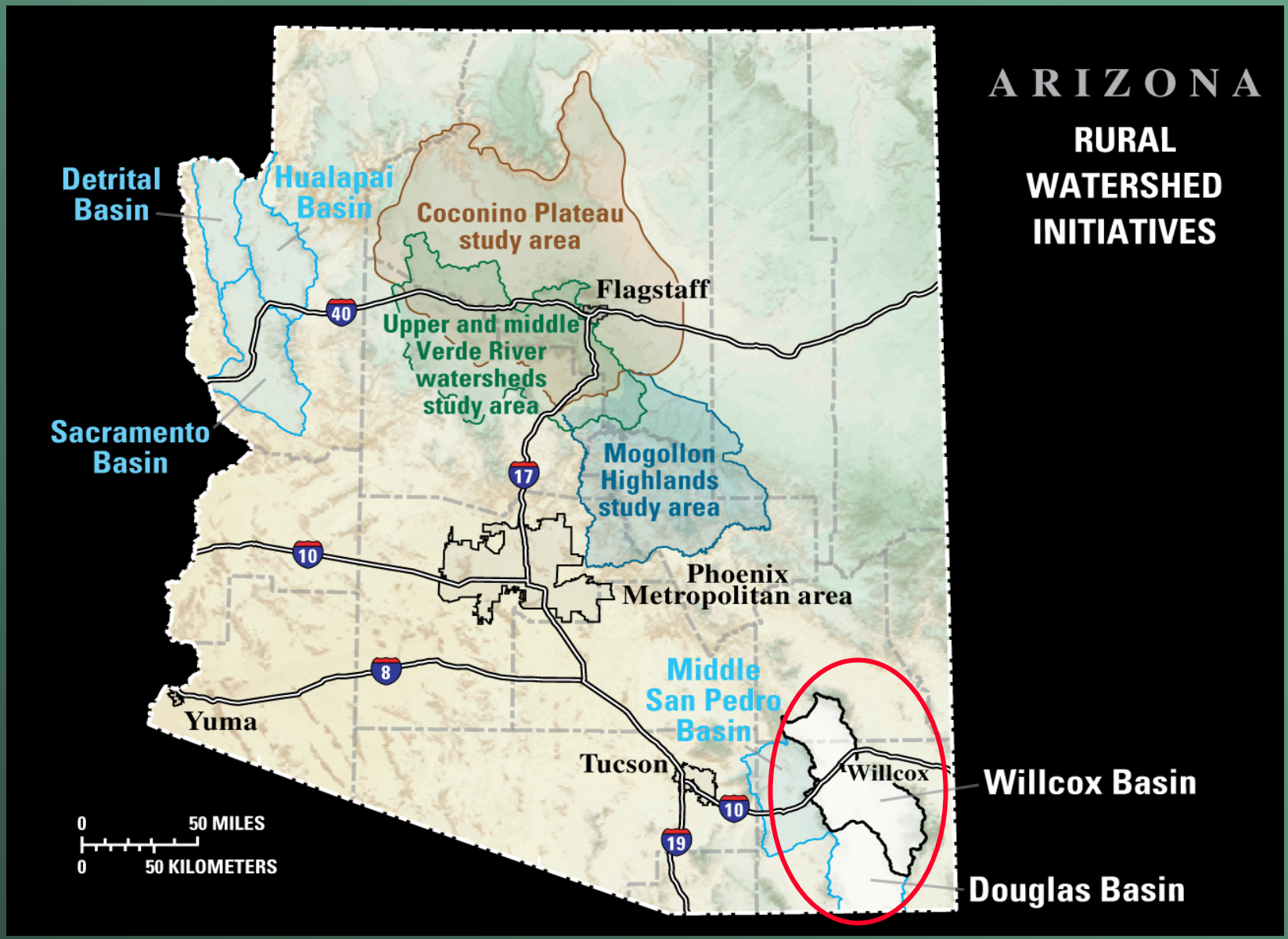
Geologic Framework, Hydrologic Monitoring, and Land-Use Change in the Willcox and Douglas Basins, Southeast Arizona

James Callegary Ph.D.

U.S. Department of the Interior
U.S. Geological Survey

USGS science for a changing world

ARIZONA DEPARTMENT OF WATER RESOURCES



Location of Willcox and Douglas Basins

USGS

ARIZONA DEPARTMENT OF WATER RESOURCES

Issues

- Assuring an adequate supply of good quality water.
  - Basins have been in overdraft since the 1950's.
  - Water levels declining: in some areas greater than 80 feet between 1990 and 2005.
  - Irrigation in the Willcox Basin is on the rise.
  - Agua Prieta shares the border with Douglas: officially estimated population is 60,000 to 70,000. Unofficial estimates: between 100,000 and 200,000.
  - Salty water under the Willcox Playa could migrate toward pumping wells.
  - Exceedance of drinking water standards in over 120 wells since 1980.
    - Primarily arsenic and fluoride, but also nitrate, beryllium and antimony
    - Streams in Bisbee exceed for copper, cadmium and zinc.
- Subsidence and earth fissuring
  - Caused by falling water tables and drying of soils.
  - Extent to which each of these is responsible is unknown.

USGS

ARIZONA DEPARTMENT OF WATER RESOURCES

Key Study Area Characteristics

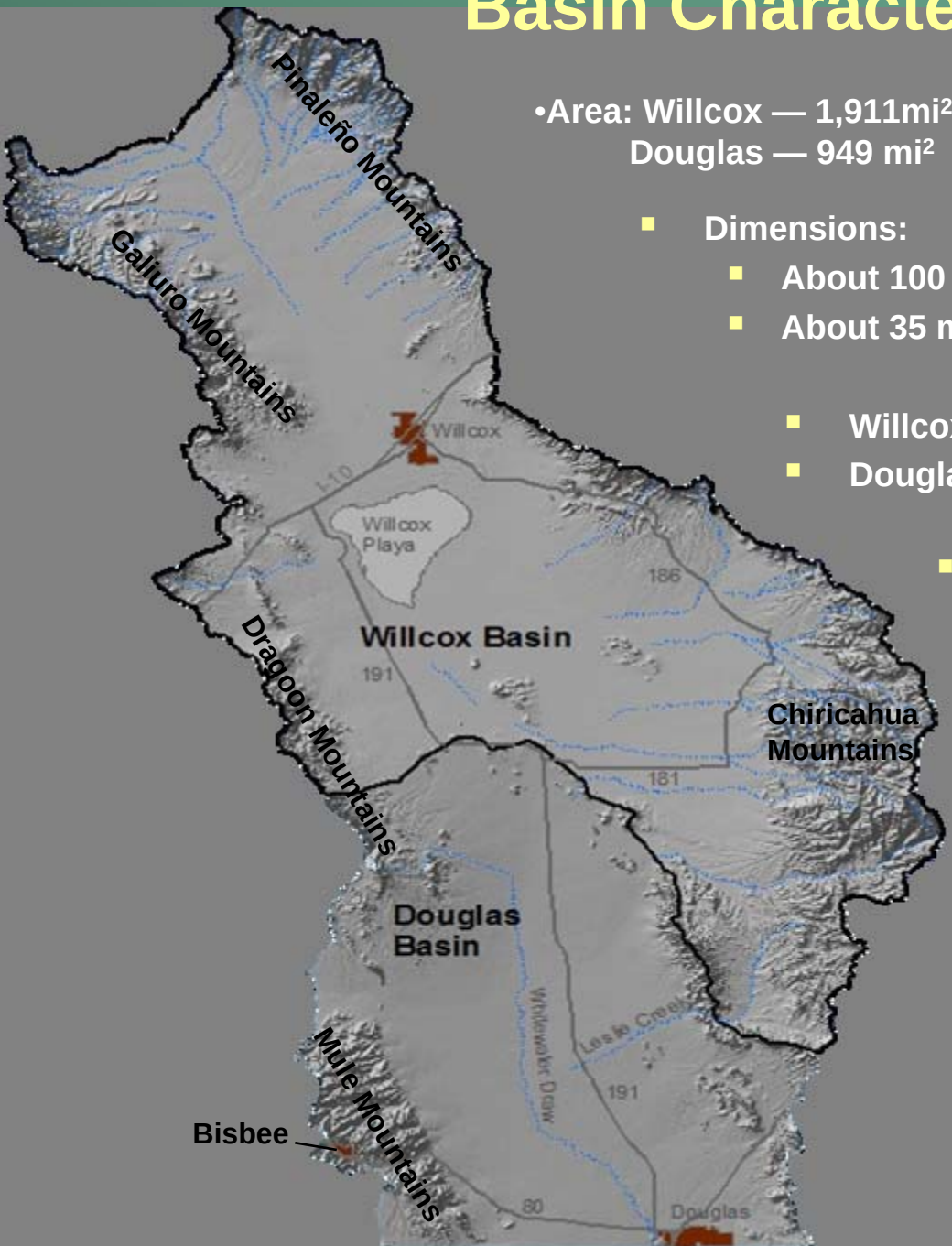
- Willcox is a primarily topographically closed basin.
- There is no perennial flow in streams and creeks except in the mountains and foothills bordering the basin.
- By law irrigation in the Douglas Basin cannot increase.
- Douglas Basin is continuous across the border with Mexico. Headwaters of the Yaqui River which flows to Gulf of California.
- Aquifers are alluvial.
- Land Ownership: > 50% private, about 25% State, and < 25% Federal


Leslie Canyon National Wildlife Refuge


Willcox Playa with Sandhill Cranes


San Bernardino National Wildlife Refuge

Basin Characteristics



- Area: Willcox — 1,911mi²
  Douglas — 949 mi²
- Dimensions:
  - About 100 mi North to South
  - About 35 mi East to West
- Willcox elevation range: 4,100 to 10,720 ft
- Douglas elevation range: 3990 to 7,185 ft
- Average Rainfall:
  - 12 in/yr on the basin floor
  - 35 in/yr in the mountains

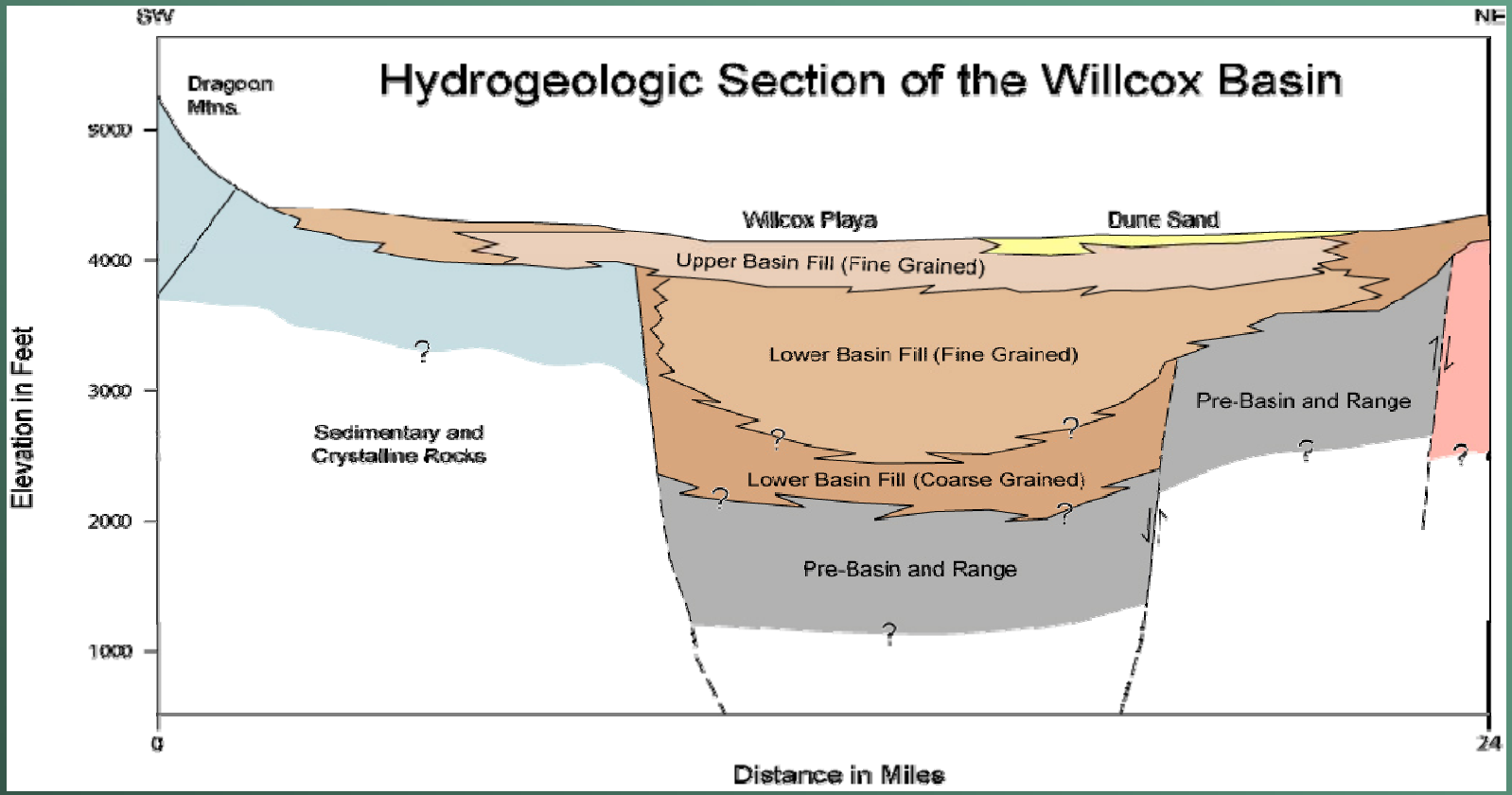
Objectives

- **Water Availability**
  - Improve understanding of the boundaries and properties of aquifers.
  - Assess (a) the current state of knowledge of the ground-water flow systems, (b) existing water-level data collection networks and needs for improvement.
  - Establish a microgravity monitoring network to assess temporal changes in aquifer storage.
  - Evaluate historical and current estimates of ground-water withdrawal for agricultural use.
- **Subsidence and earth fissuring**
  - Use satellite data (InSAR)
  - High-precision GPS surveys
  - Evaluate sites for installation of extensometers
- Write proposal for future work based on the evaluation phase

USGS

Objective: Understanding boundaries and properties of aquifers

Method: Review previous hydrogeologic and modeling studies



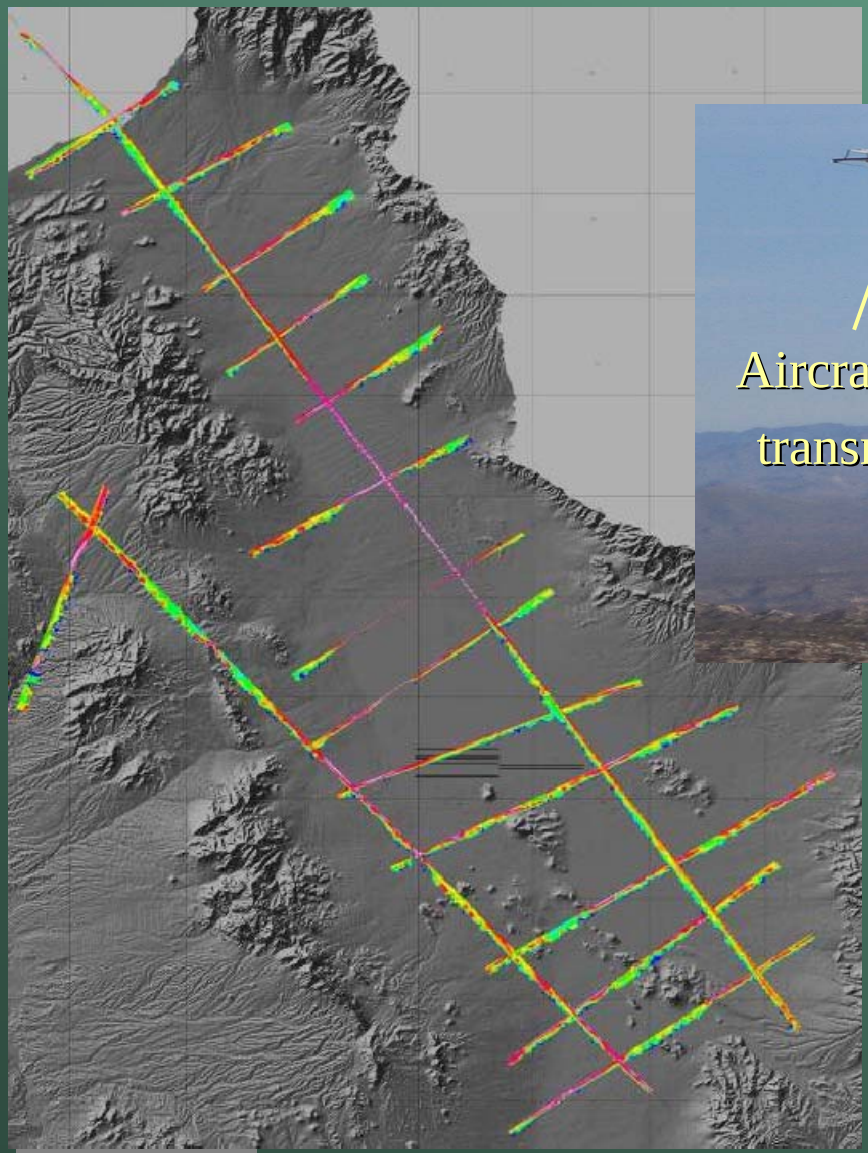
- Basin and Range structure
- Sediment thickness – up to 4,000 ft
- Less permeable at depth and toward the center

USGS

ARIZONA DEPARTMENT OF WATER RESOURCES

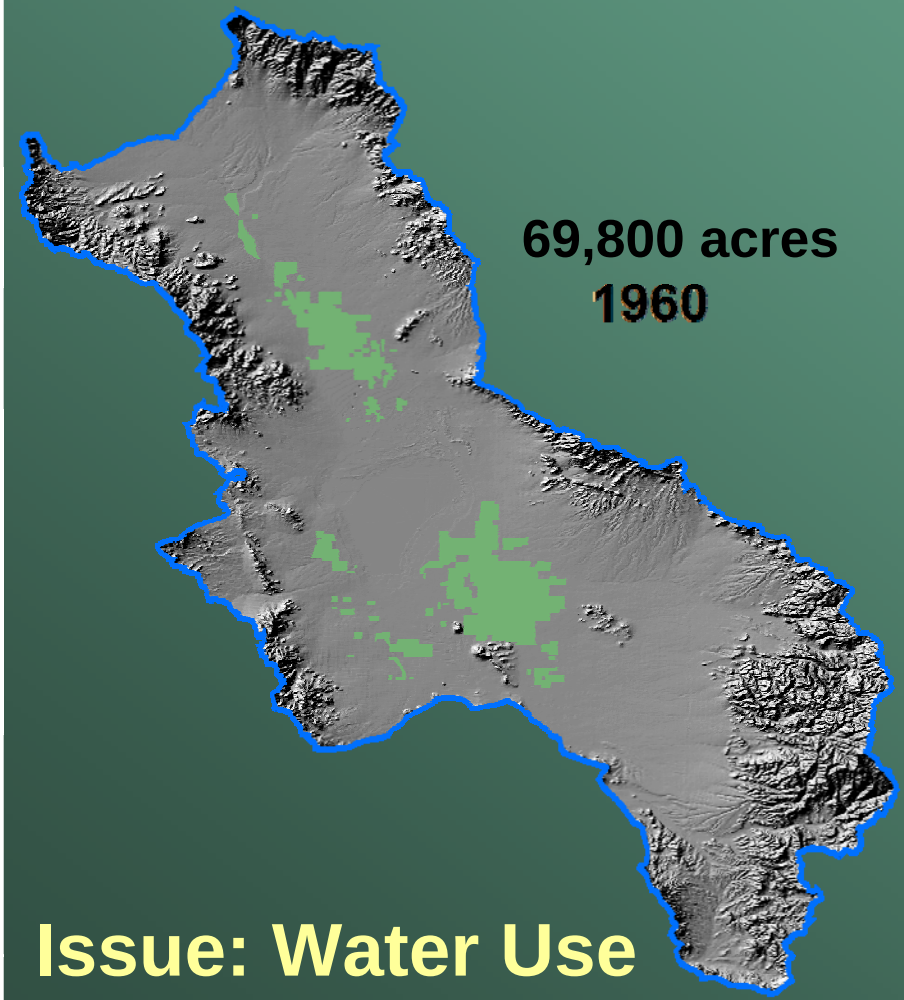
Objective: Understanding boundaries and properties of aquifers

Method: Aerial Electromagnetic Surveys

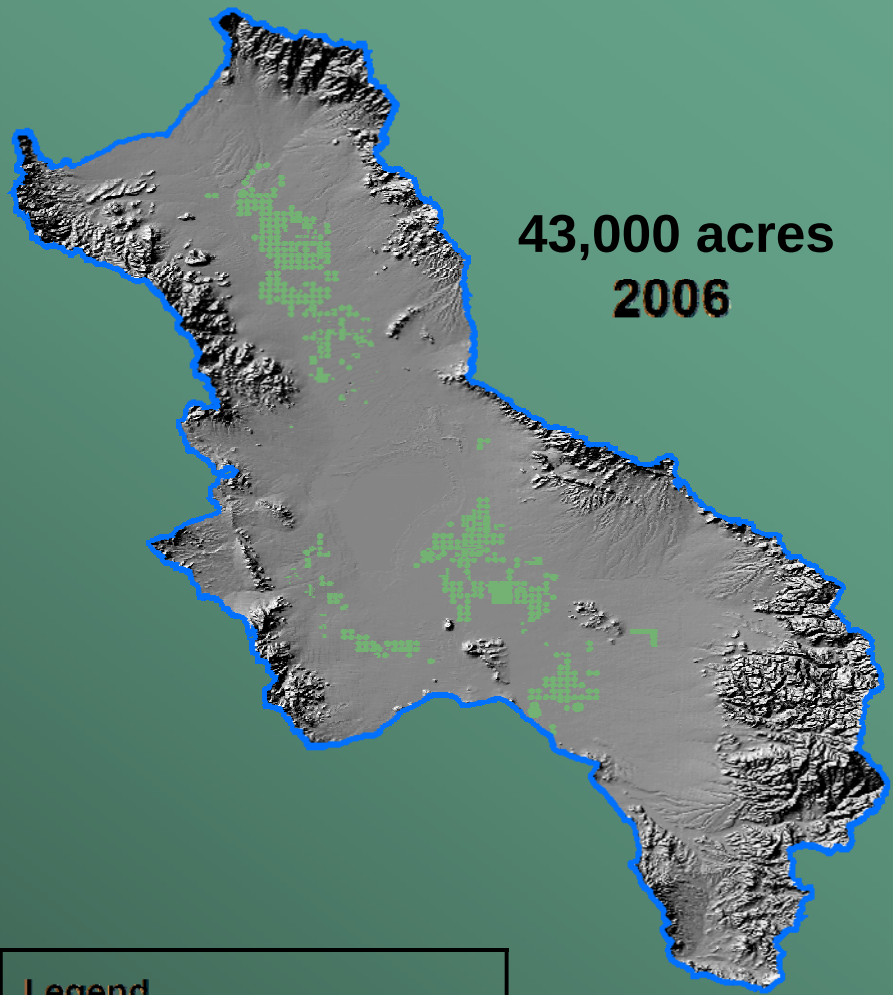


- Map subsurface properties such as:
  - Extent and thickness of silt and clay beds
  - Depth to bedrock

Location and Extent of Agricultural Fields



69,800 acres
1960



43,000 acres
2006

Issue: Water Use

Legend

- Boundary of Groundwater Basin
- Agriculture

N

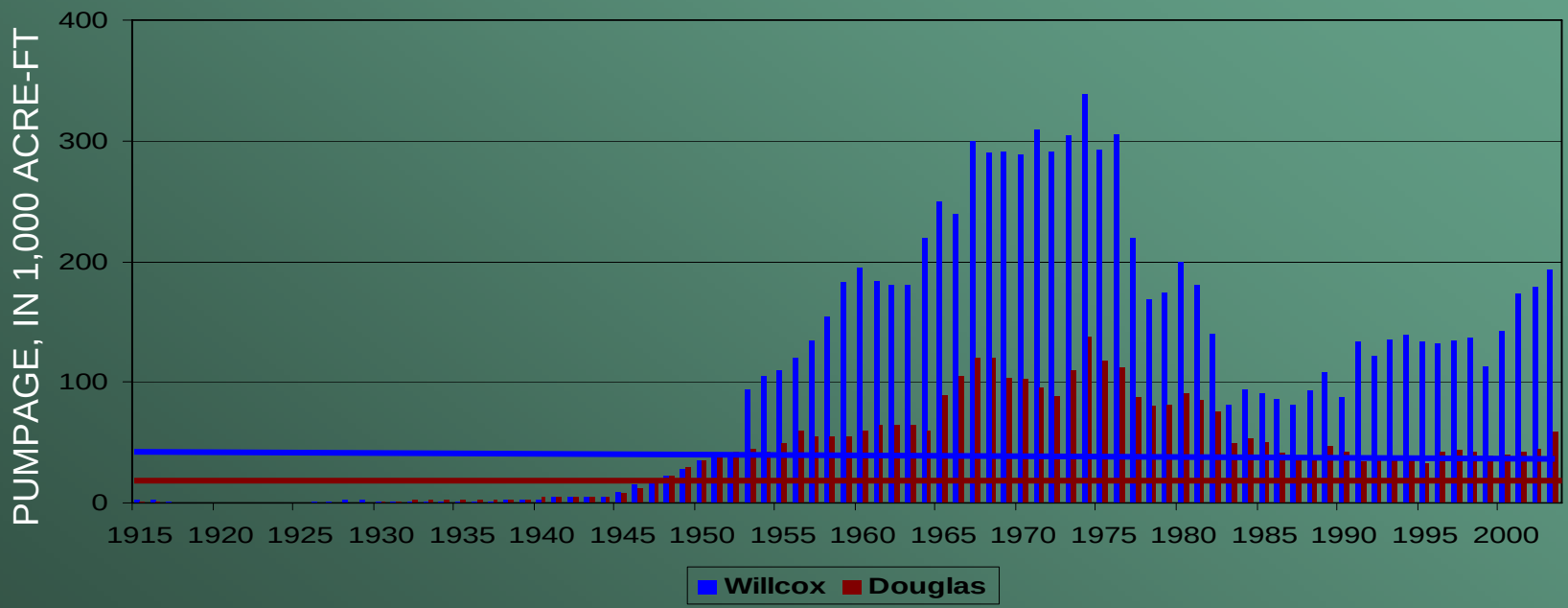
ARIZONA DEPARTMENT OF WATER RESOURCES

USGS science for a changing world

Issue: Recharge and ground-water pumpage in Willcox and Douglas Basins

Recharge Estimates:

Willcox – 47,000 Douglas – 22,000



Maximum in 1974

Willcox – 339,000 Douglas – 138,000

In 2003

Willcox – 193,000 Douglas – 59,000

USGS

ARIZONA DEPARTMENT OF WATER RESOURCES

Objective: Evaluate historical and current estimates of ground-water withdrawal for agricultural use

Method: Estimate ground-water pumpage for crop irrigation

- **Crop type**
- **Irrigated acreage**
- **Irrigation system**
- **Seasonal crops**

- **Estimate of water use:**

$$W = (A \times C) / E$$

W – Irrigation withdrawal
A – Planted acreage
C – Consumptive use
E – Irrigation efficiency

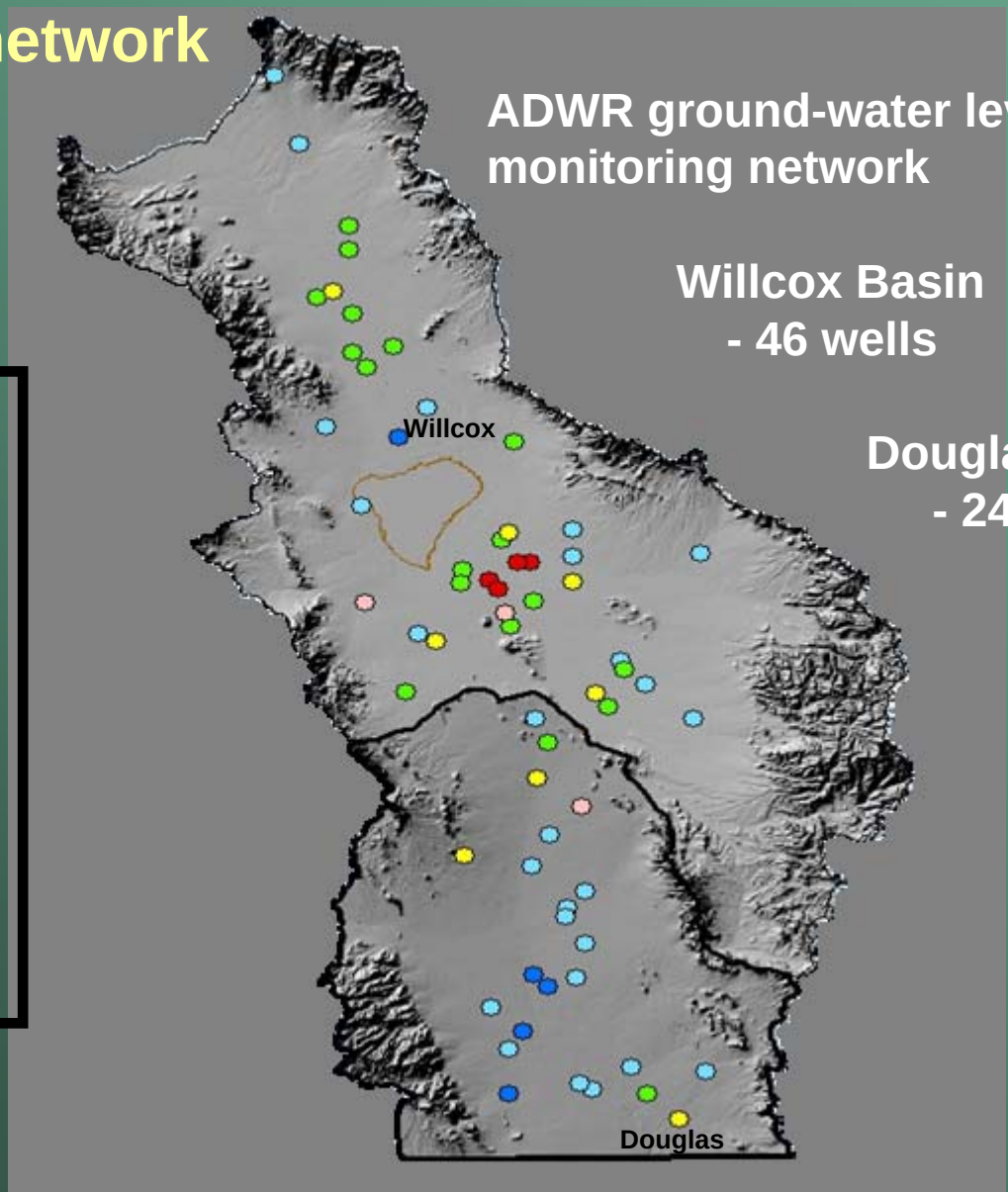
Field Verification

USGS

ARIZONA DEPARTMENT OF WATER RESOURCES

Objective: Assess Water Availability

Method: Review and update the ground-water level monitoring network

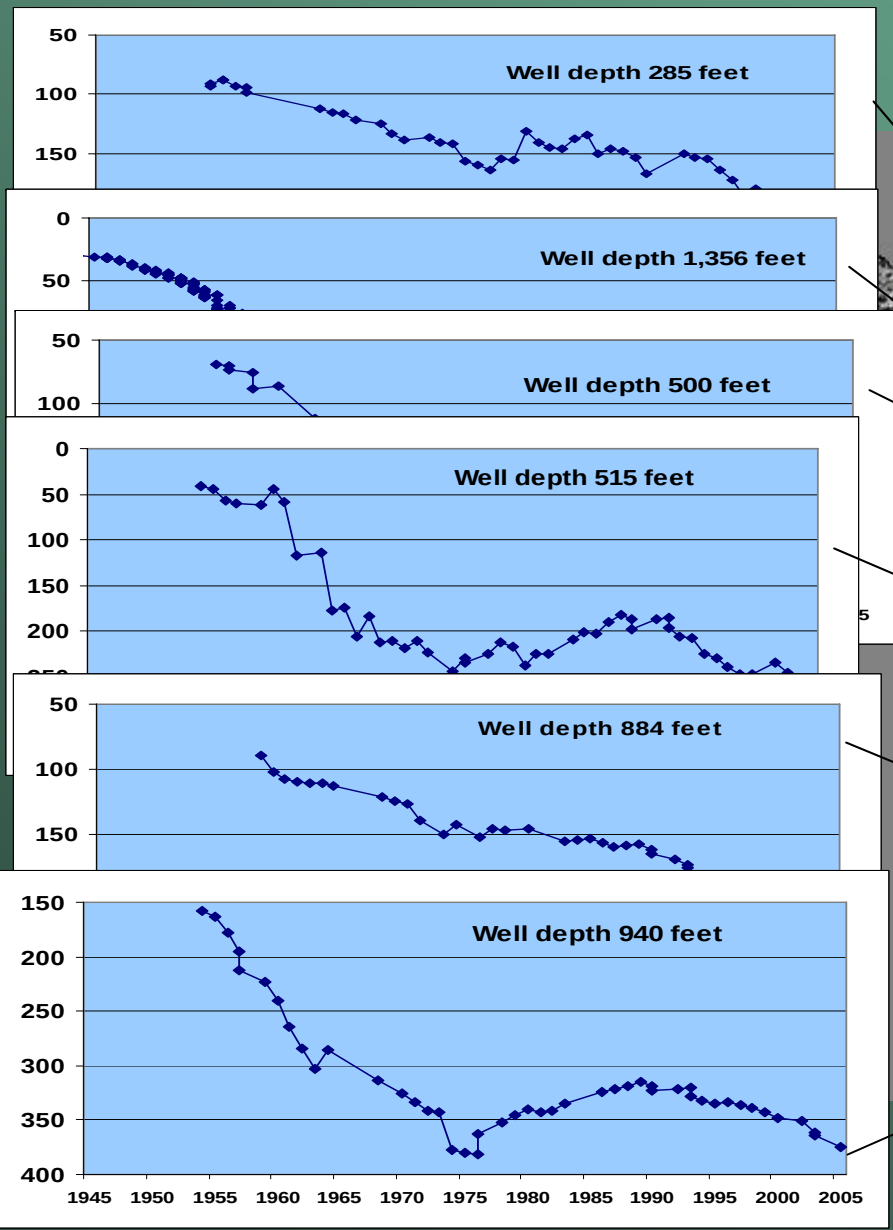


USGS

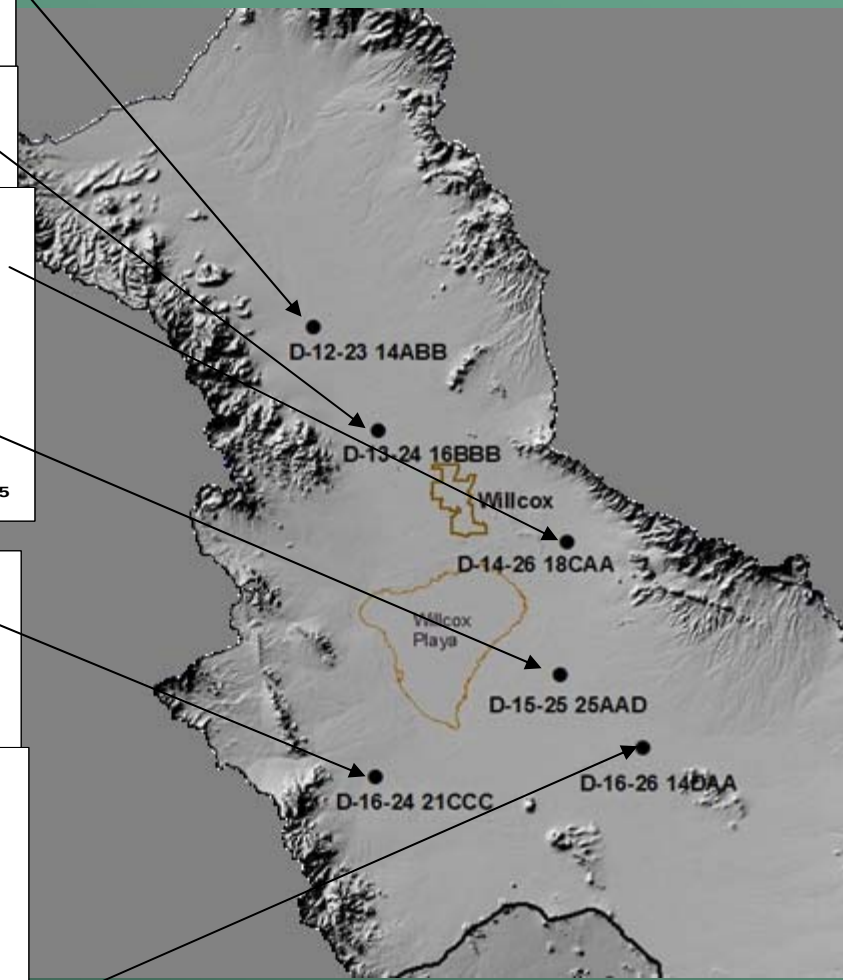
ARIZONA DEPARTMENT OF WATER RESOURCES

Objective: Water Storage

Method: monitor long term change in water levels

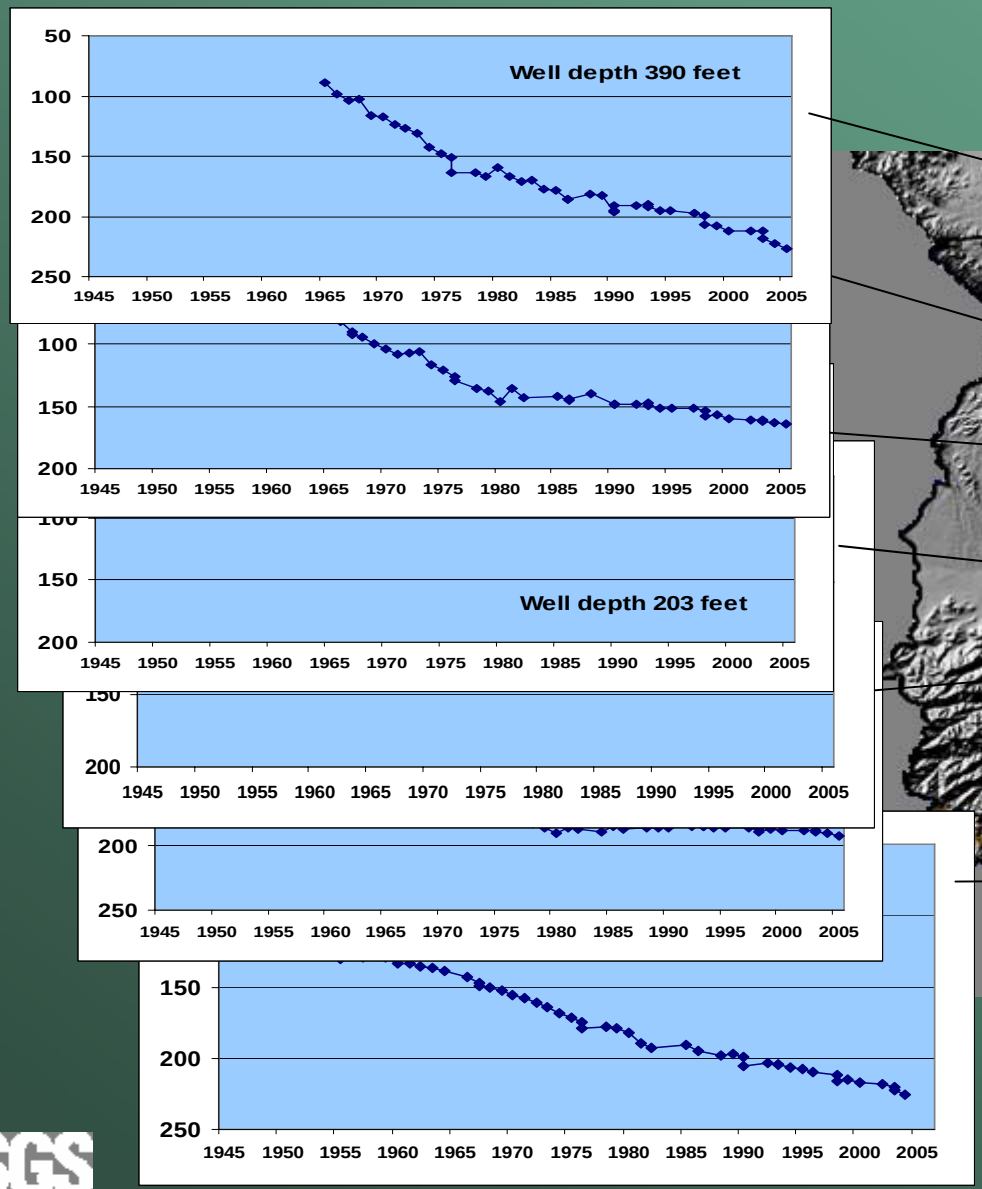


Willcox Basin

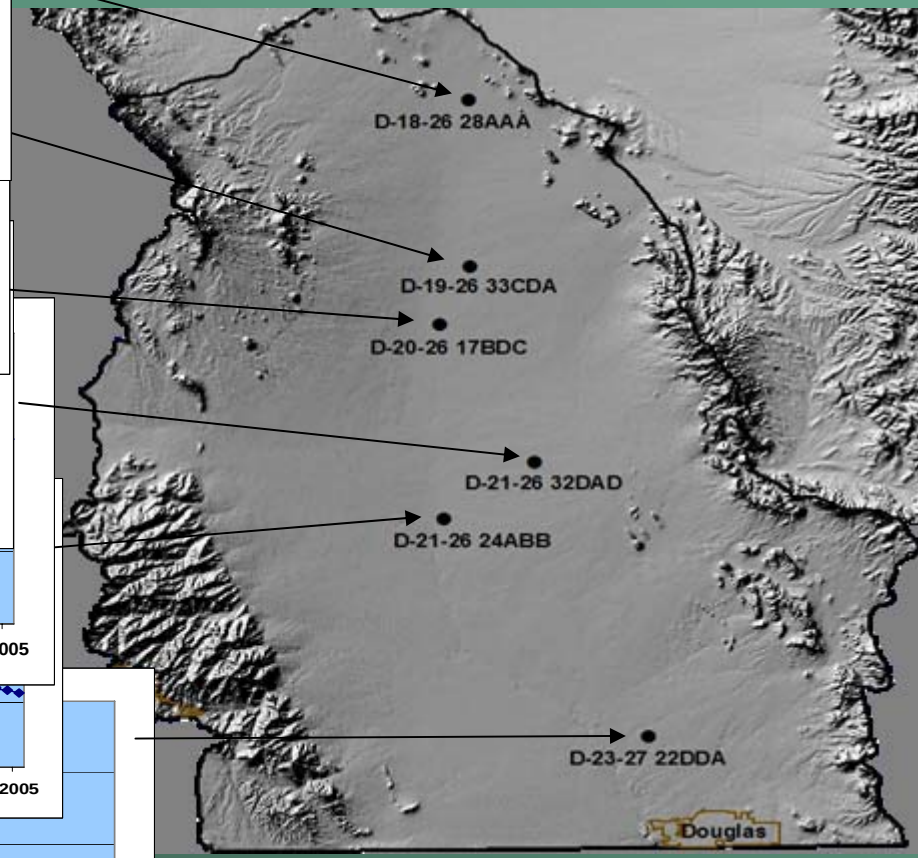


ARIZONA DEPARTMENT OF WATER RESOURCES

Change in Well Water Levels over Time



Douglas Basin



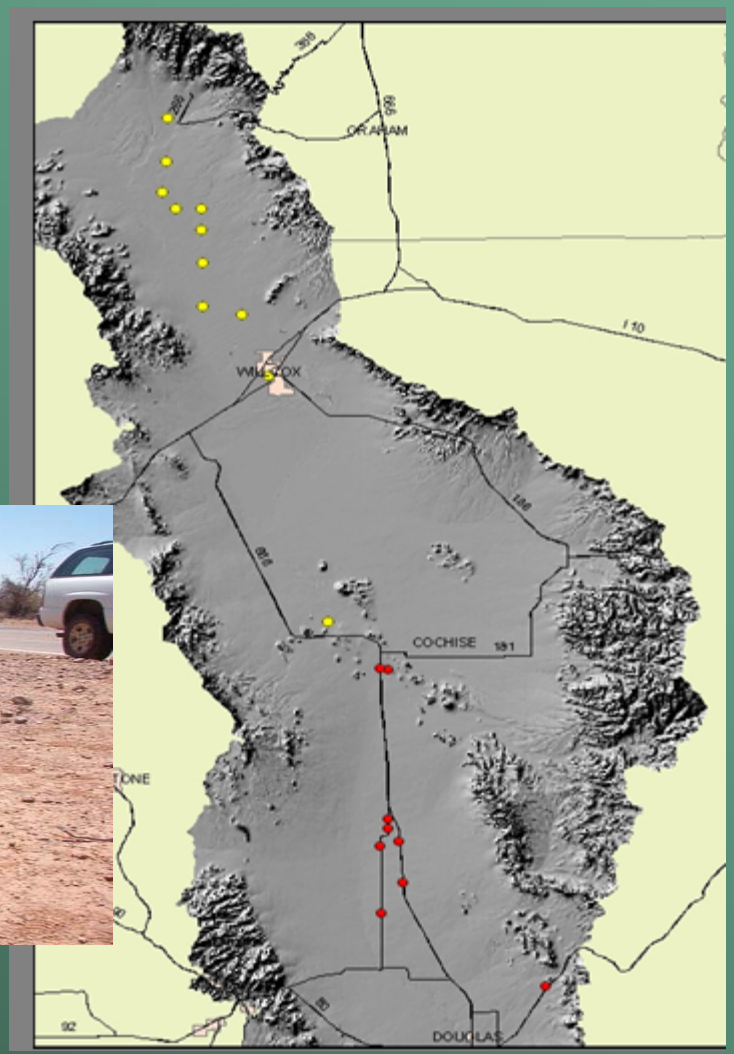
USGS

ARIZONA DEPARTMENT OF WATER RESOURCES

Objective: long-term monitoring of ground-water storage

Method: Develop microgravity ground-water storage change network

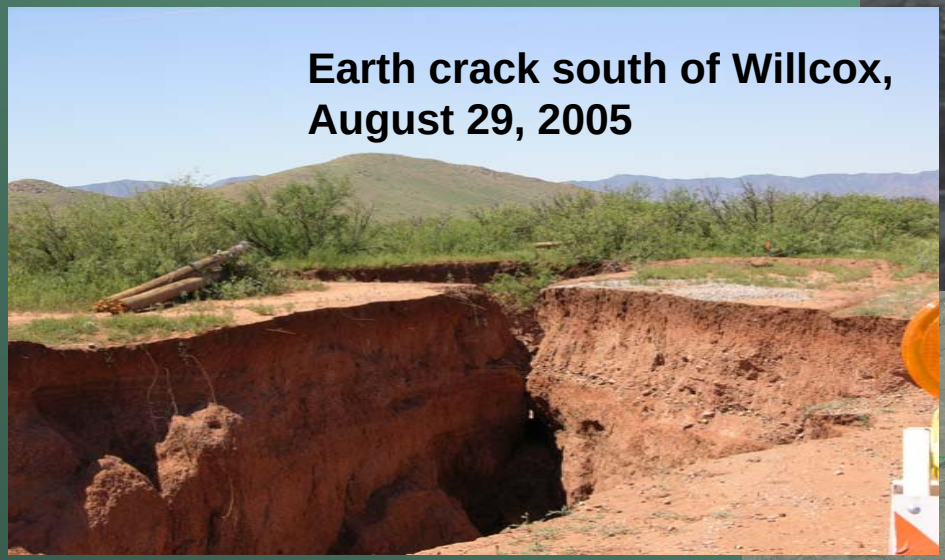
- Noninvasive
- Independent of other hydrologic measurements
- Provide a direct measure of the change in aquifer storage



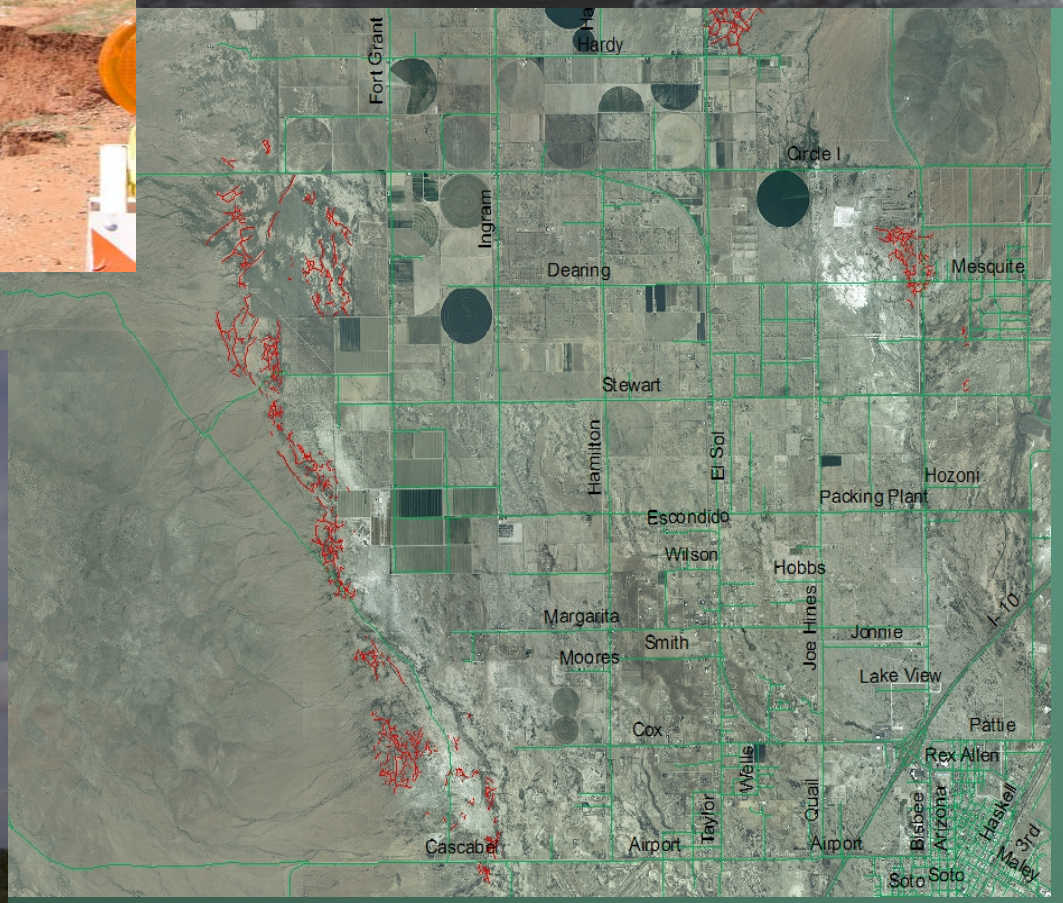
ARIZONA DEPARTMENT OF WATER RESOURCES

Issue: Subsidence

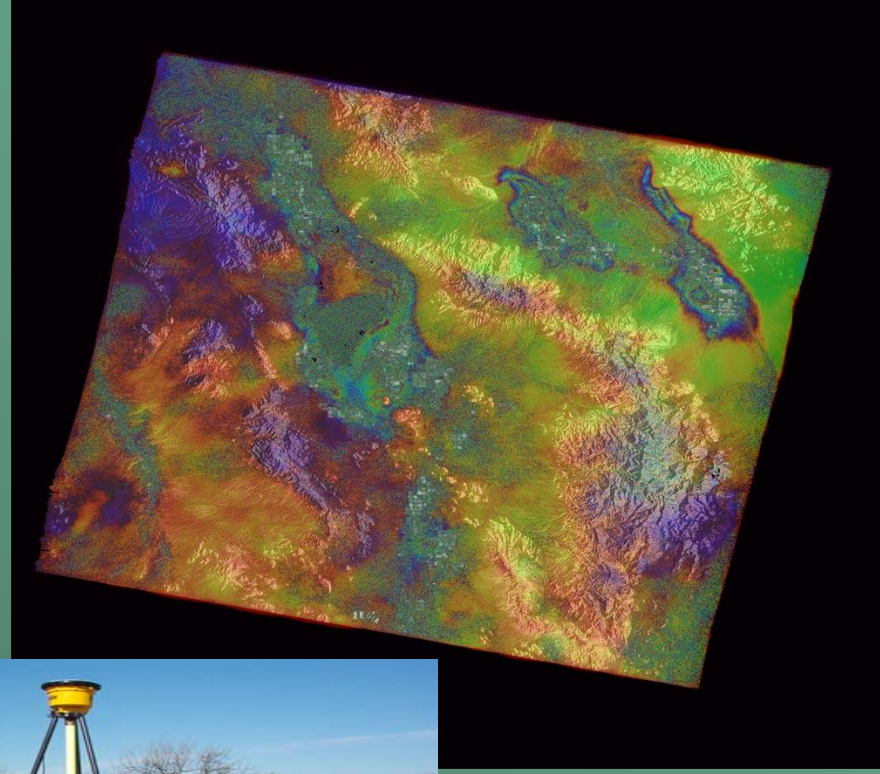
Earth fissure near Square Mountain, January 1952



Earth crack south of Willcox, August 29, 2005



Objective: monitoring subsidence



Method:

- Use satellite data (InSAR)
  - Annual high-precision GPS surveys
  - Evaluate sites for installation of extensometers

Questions?

USGS

ARIZONA DEPARTMENT OF WATER RESOURCES