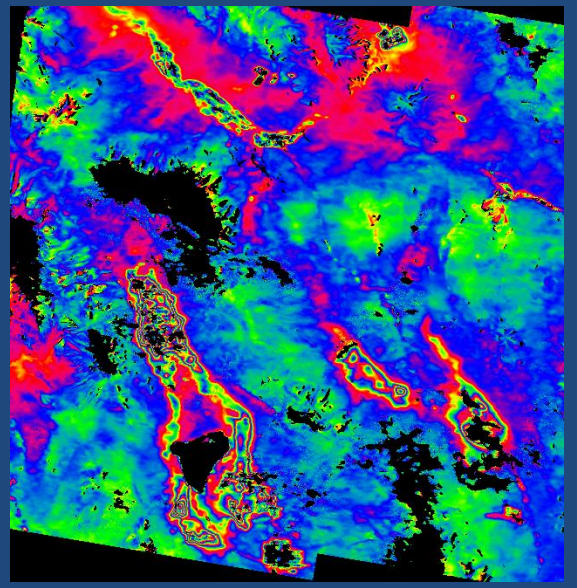
Arizona Department of Water Resources Land Subsidence Monitoring Program Using Interferometric Synthetic Aperture Radar (InSAR) Data



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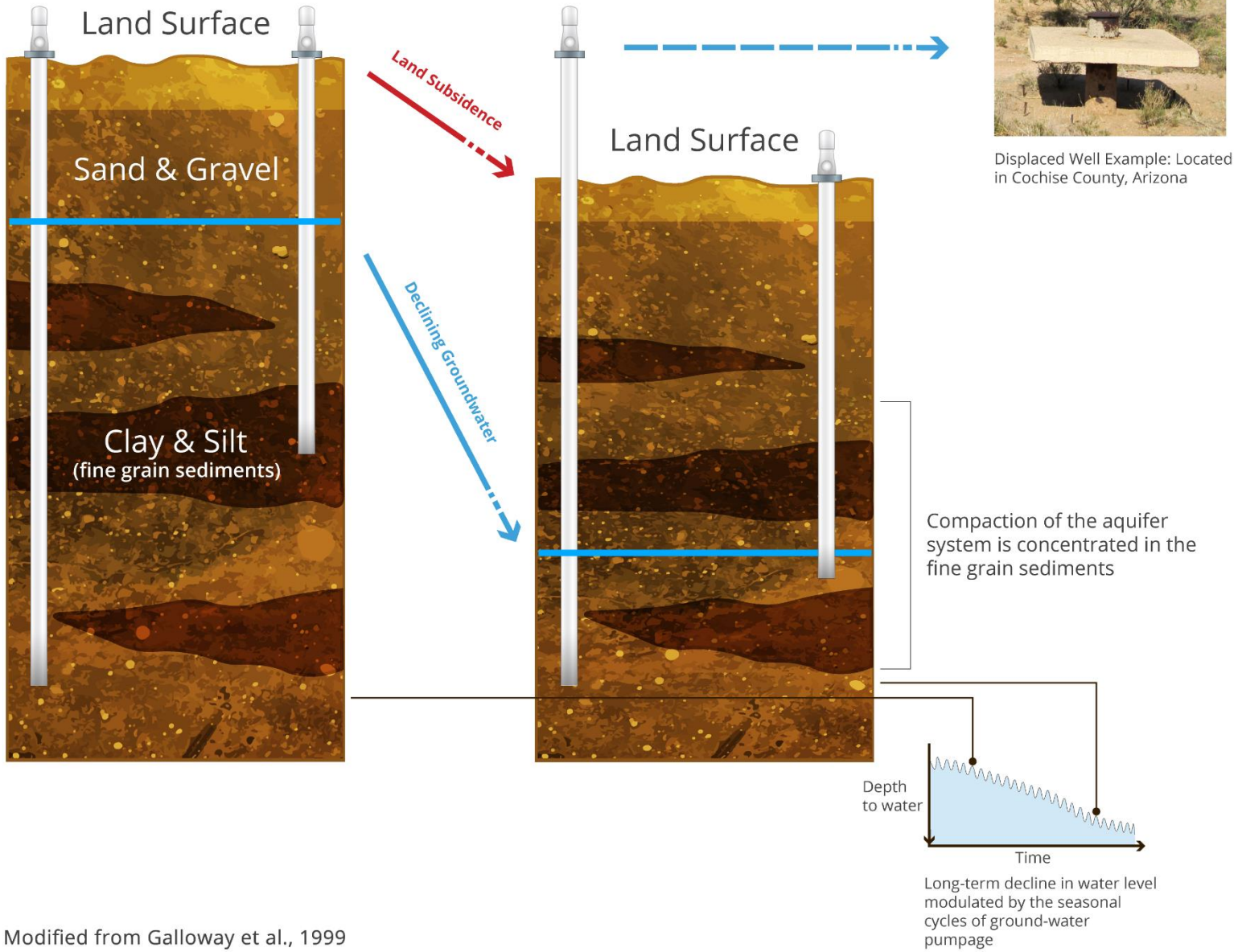
American Geosciences Institute
April 15, 2020

Protecting and enhancing Arizona's water supplies for future generations

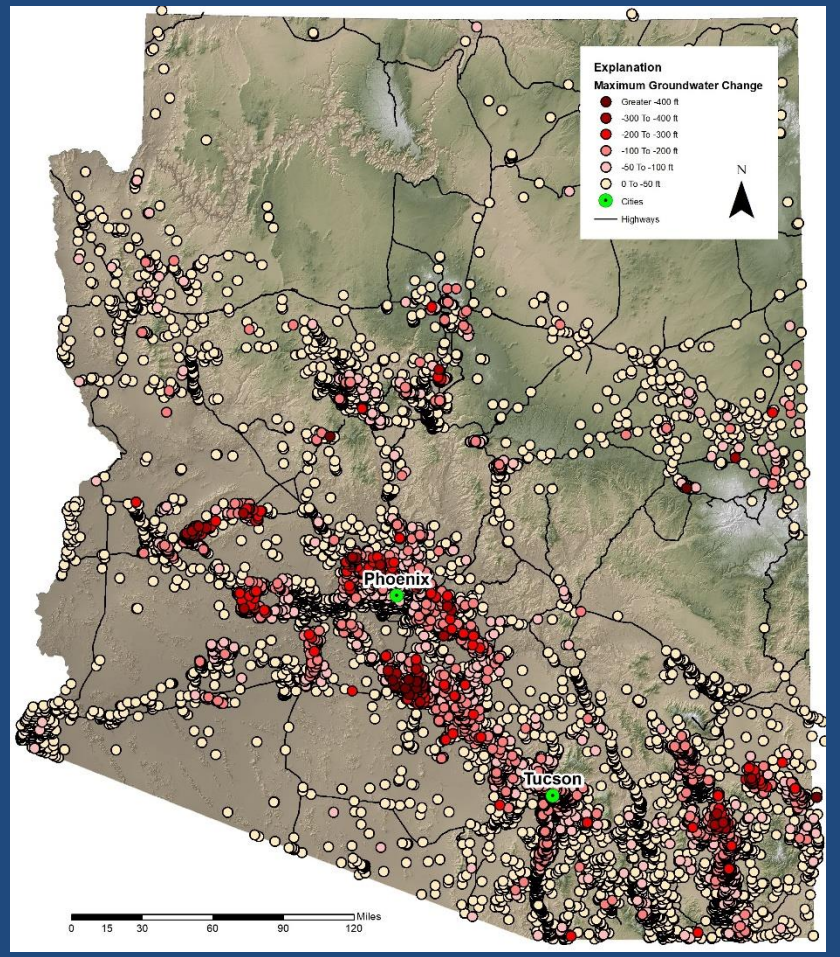

planetvids.com

What is Land Subsidence?



Modified from Galloway et al., 1999

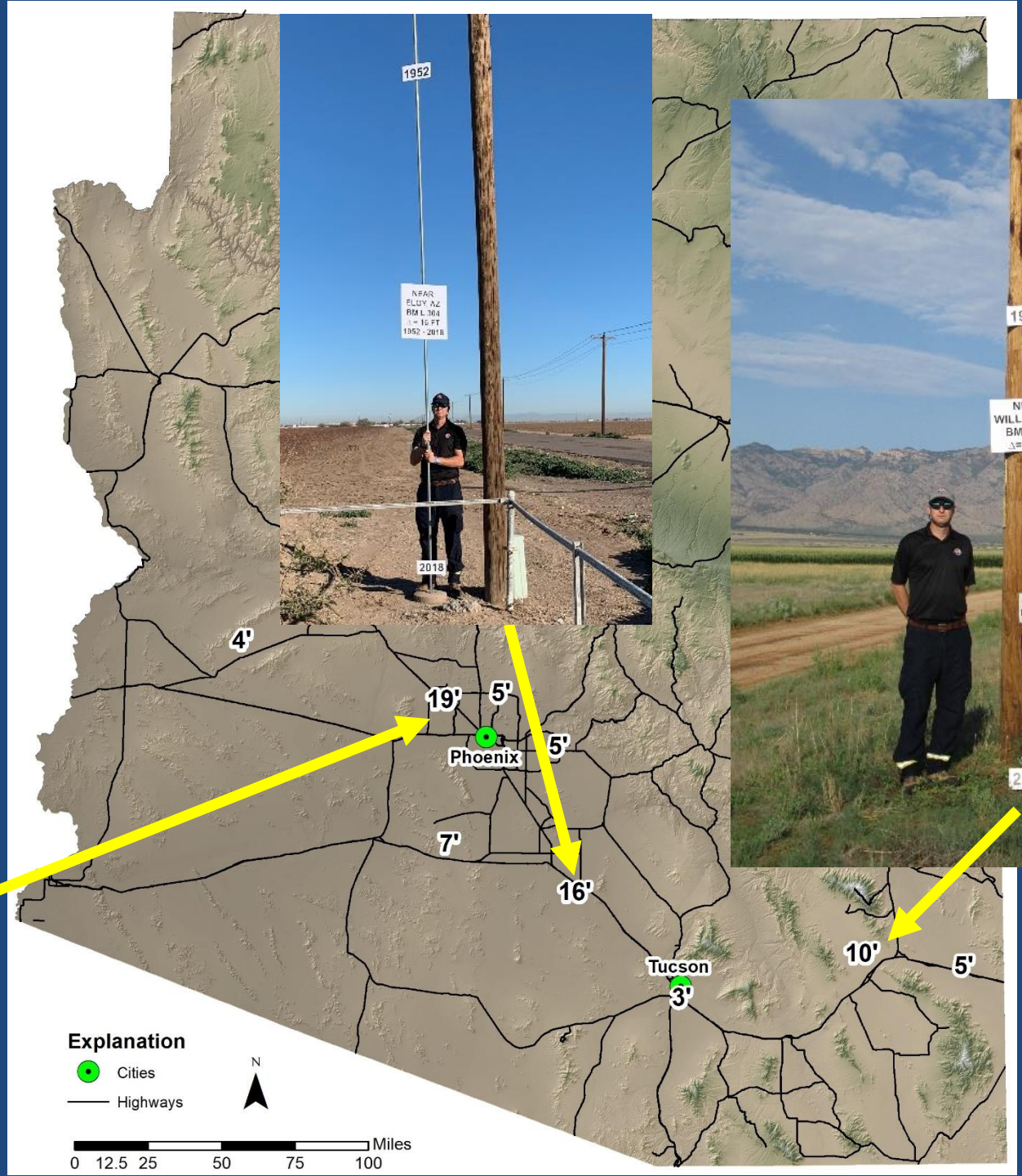
Displaced Well Example: Located in Cochise County, Arizona



Groundwater declines of more than 100 feet were occurring by the 1970's. Some areas declined more than 500 feet

Land Subsidence

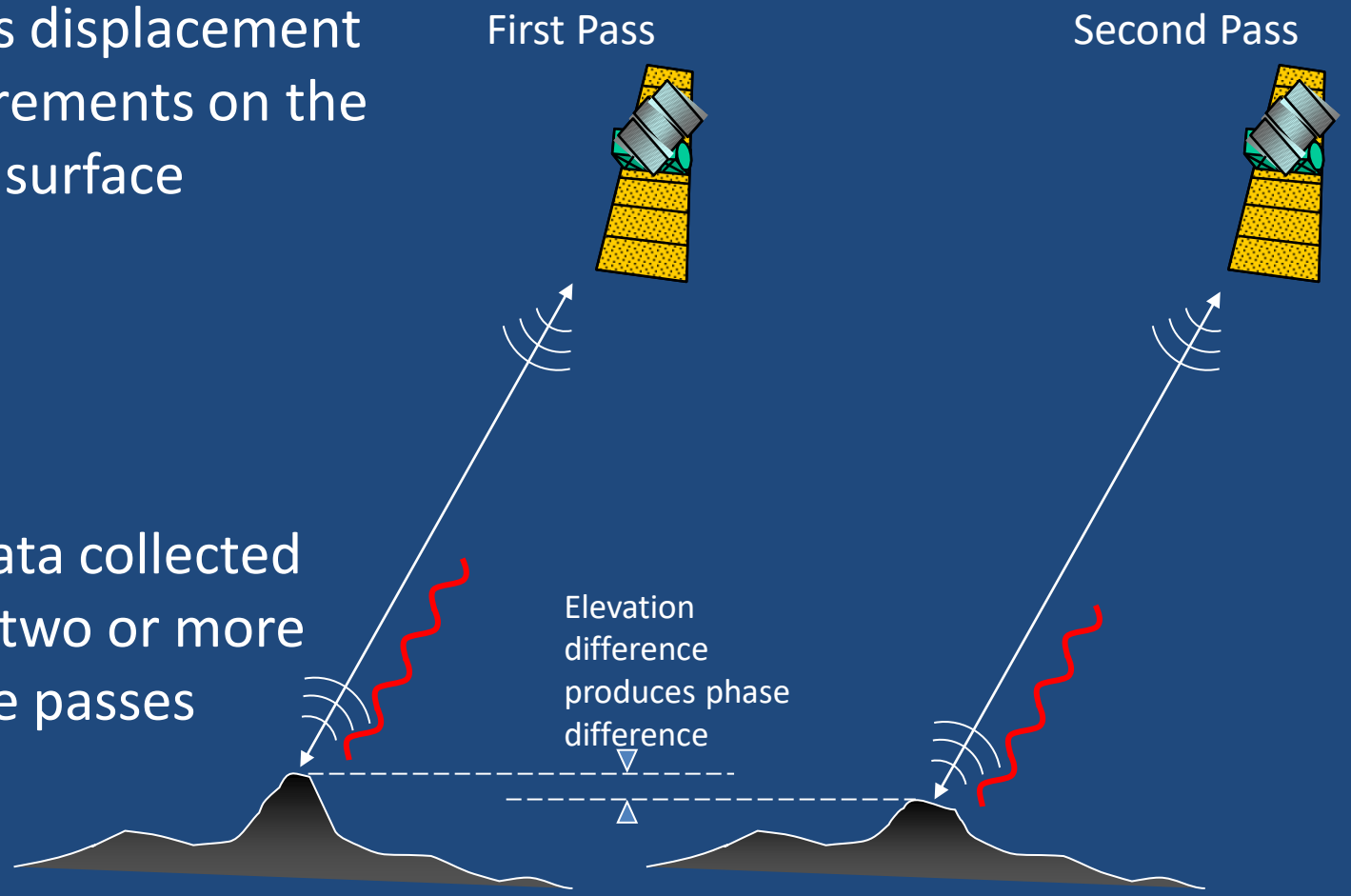
- Repeat leveling/GNSS surveys revealed land subsidence up to 19 feet



Synthetic Aperture Radar Interferometry (InSAR)

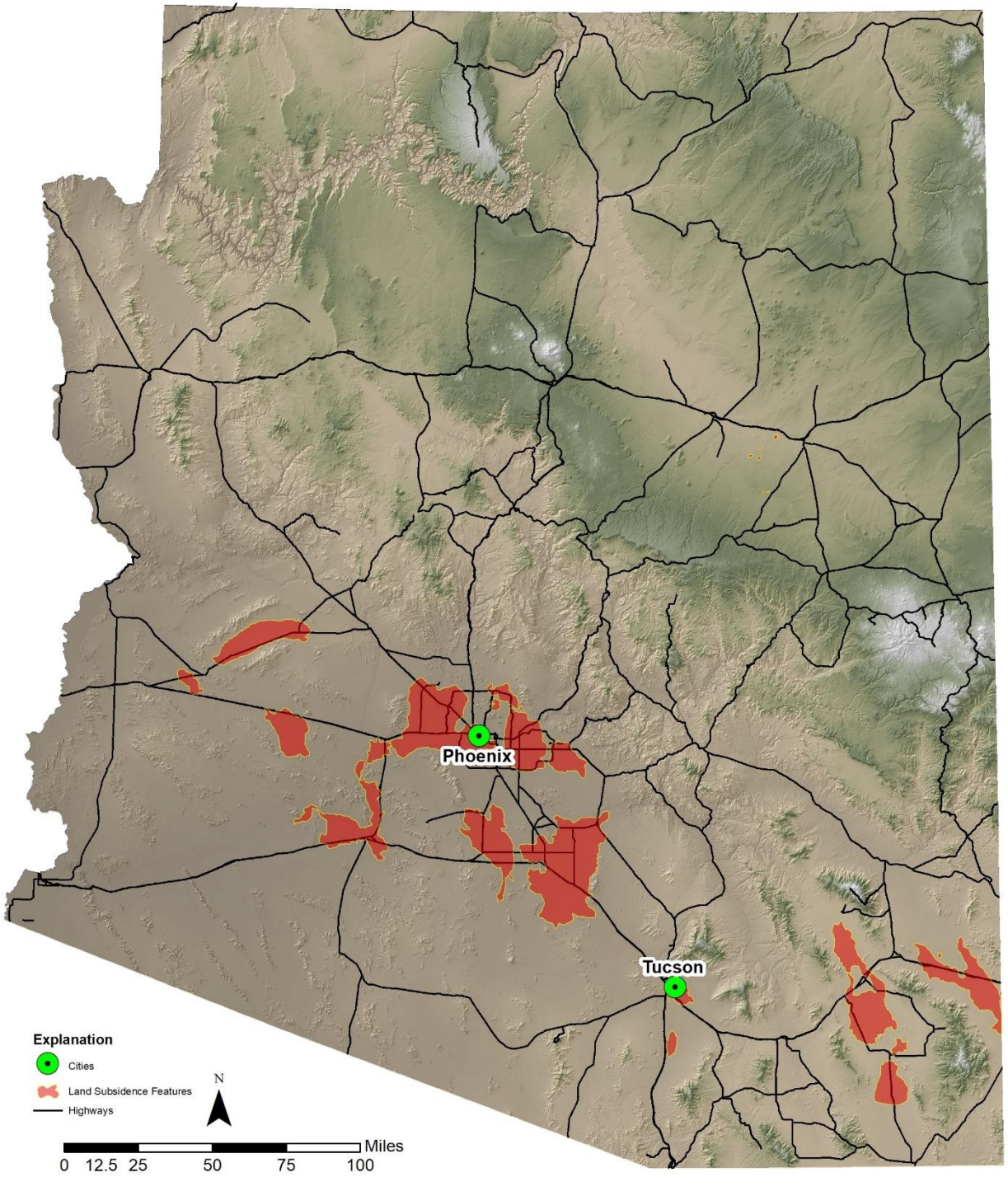
Enables displacement measurements on the Earth's surface

Uses data collected during two or more satellite passes



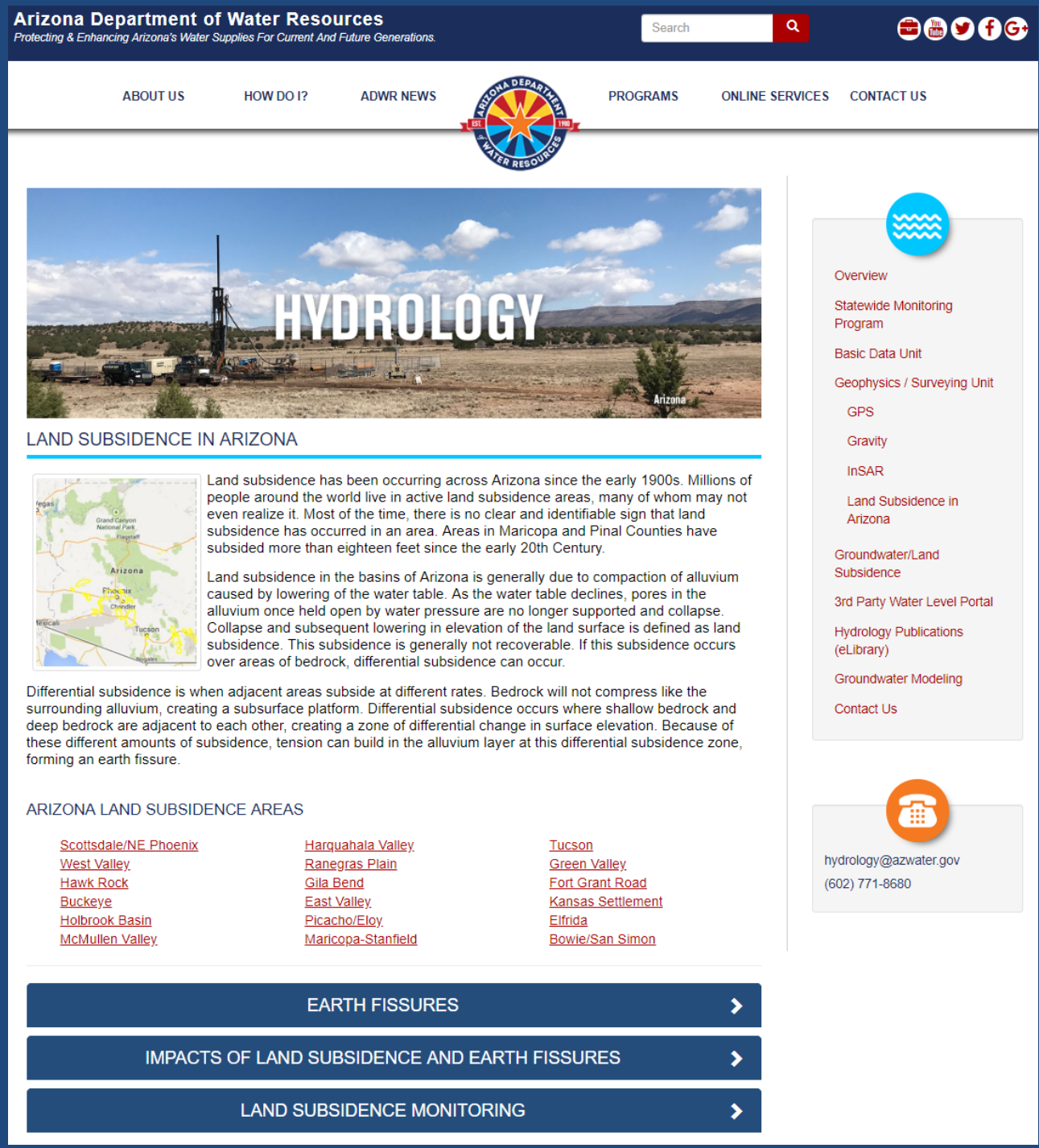
ADWR'S InSAR Program

- Started in 2002 after the award of a $1.3 million NASA grant
- By 2020, identified 27 individual land subsidence features covering an area greater than 3,400 square miles
- ADWR cooperates with fourteen different federal, state, county, and local agencies and private water companies to help fund the InSAR program
- Statewide InSAR monitoring program

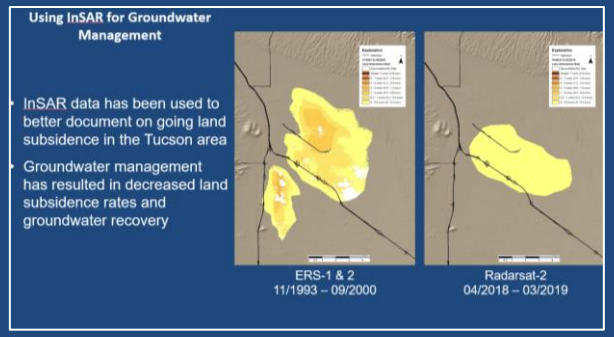


ADWR'S InSAR Program

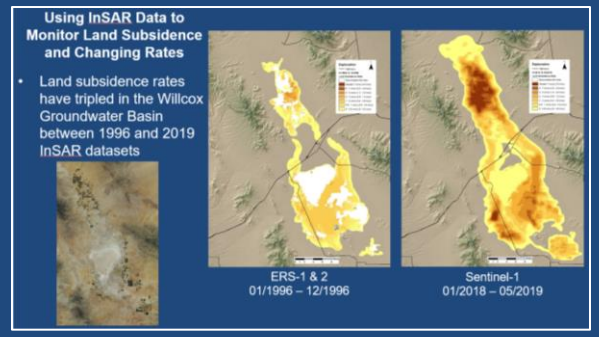
- InSAR data is processed and analyzed by ADWR
- ADWR's website has a dedicated land subsidence section
- Each land subsidence features has it's own dedicated webpage
- A total of 496 land subsidence maps are available for download
- The maps cover various periods of time between 1992 and 2000, 2004 to 2010, and 2010 to present



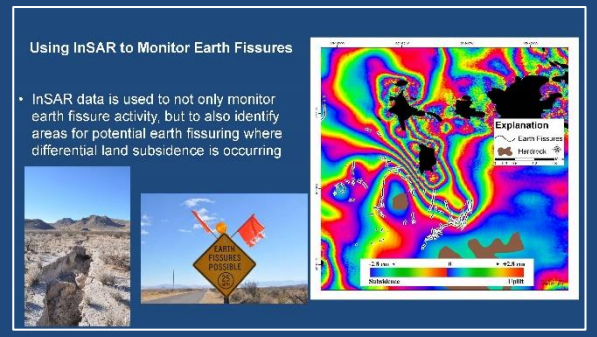
Applications of InSAR in Arizona



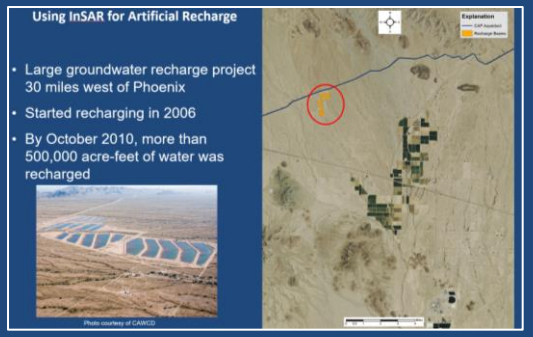
Groundwater Management



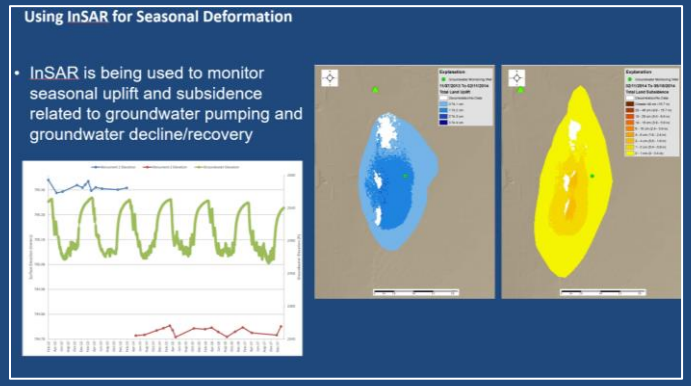
Land Subsidence Rates



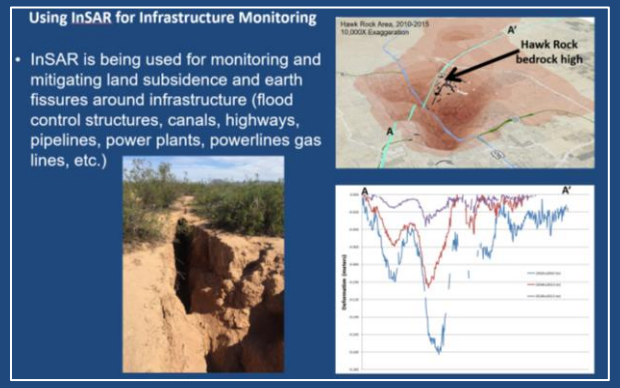
Earth Fissures



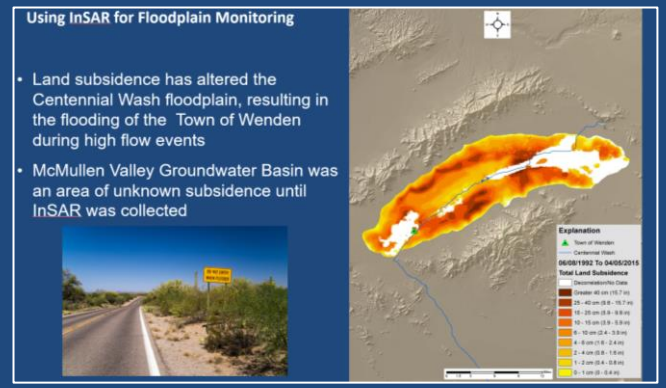
Recharge



Seasonal Subsidence



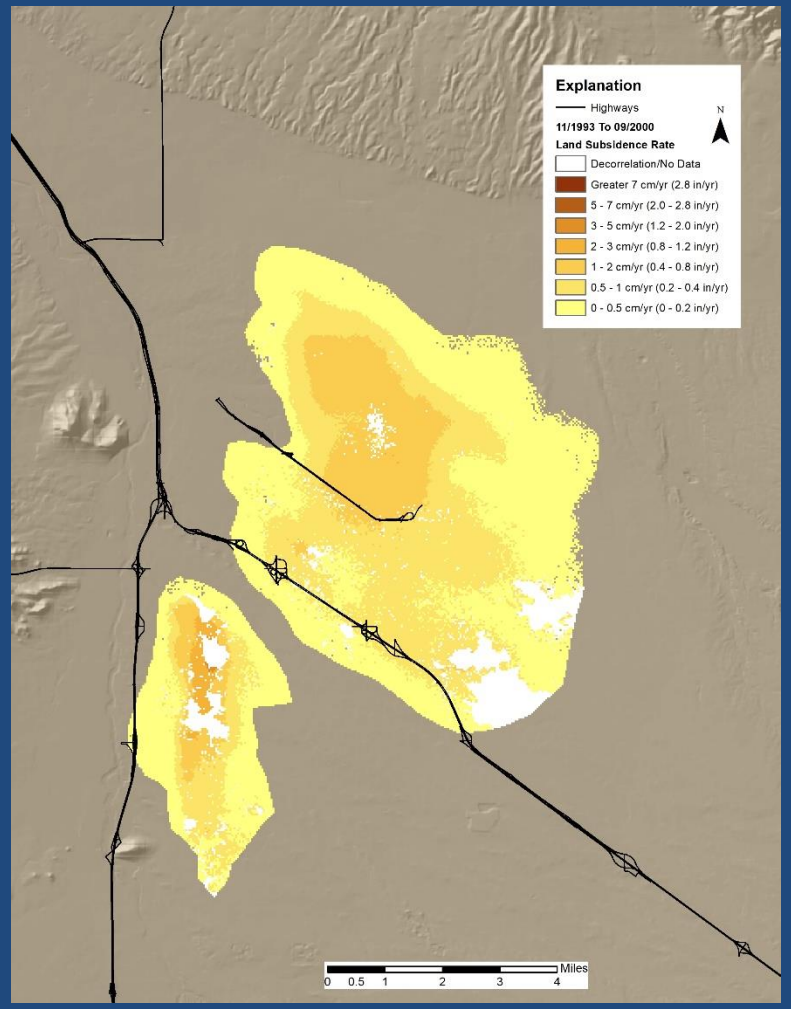
Infrastructure



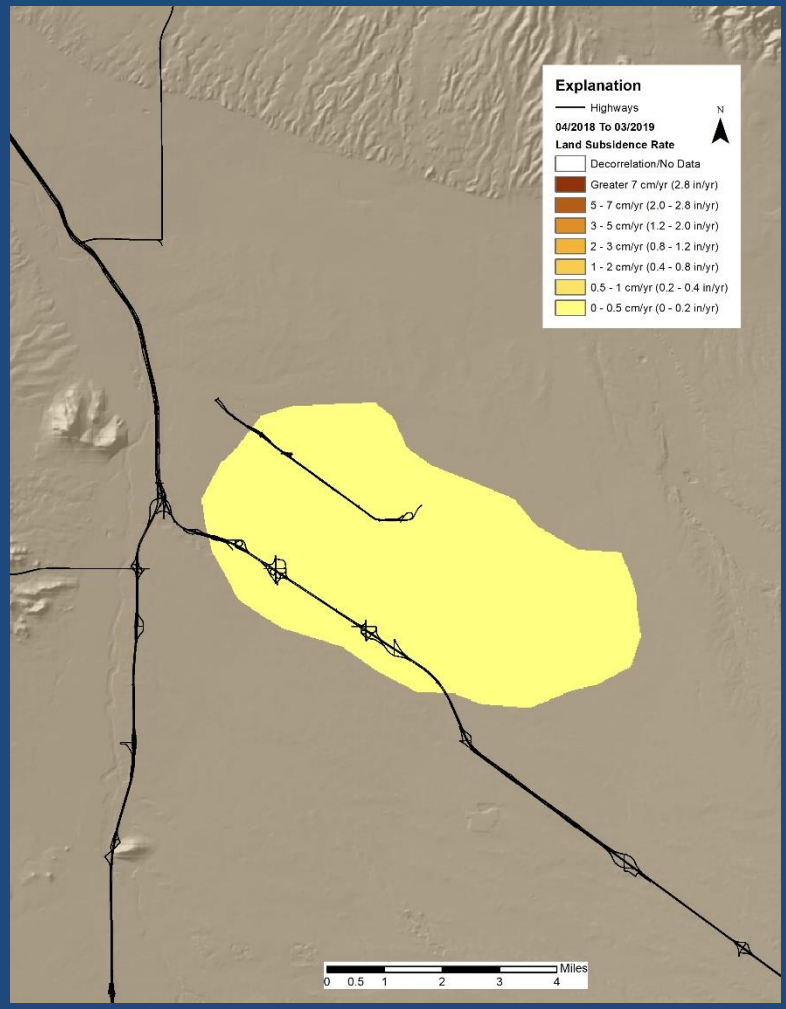
Floodplains

Using InSAR for Groundwater Management

- InSAR data has been used to better document ongoing land subsidence in the Tucson area
- Groundwater management has resulted in decreased land subsidence rates and groundwater recovery



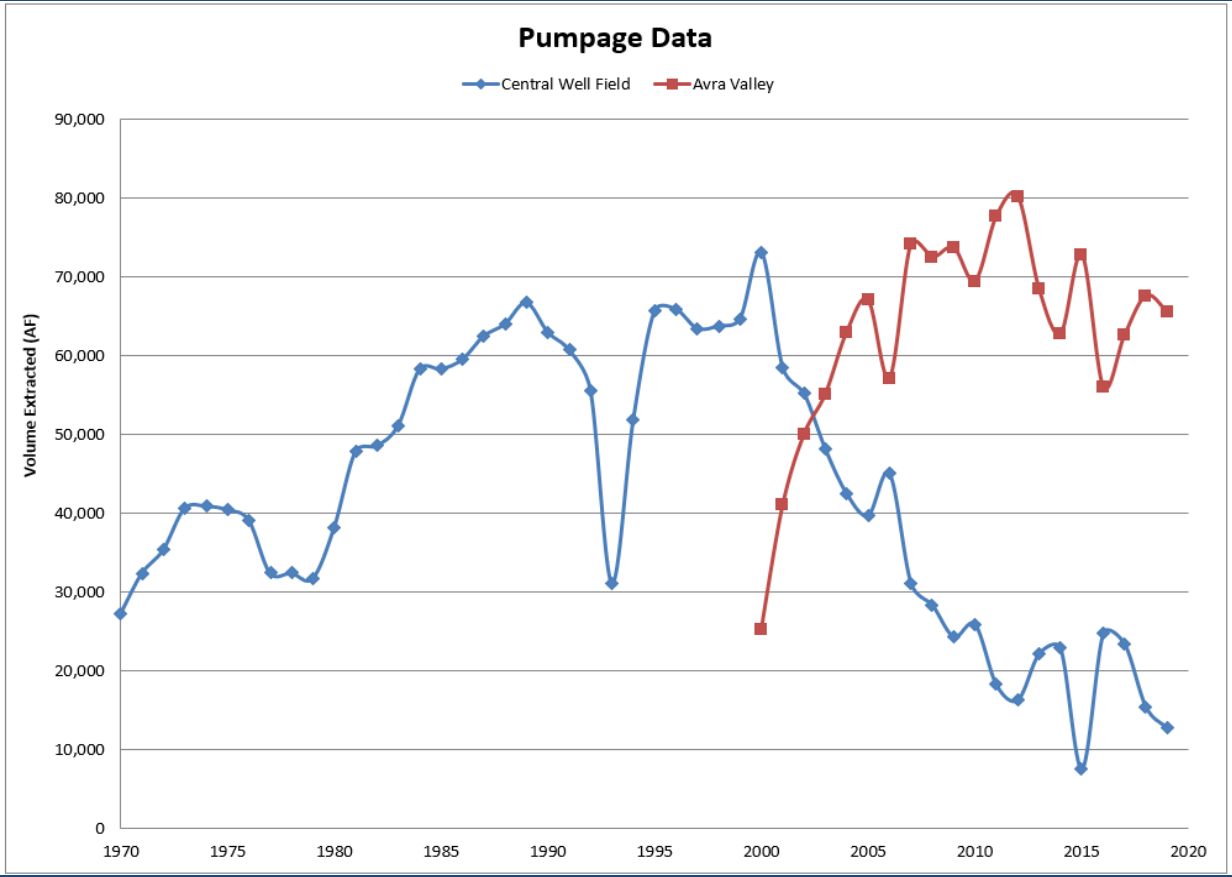
ERS-1 & 2
11/1993 – 09/2000

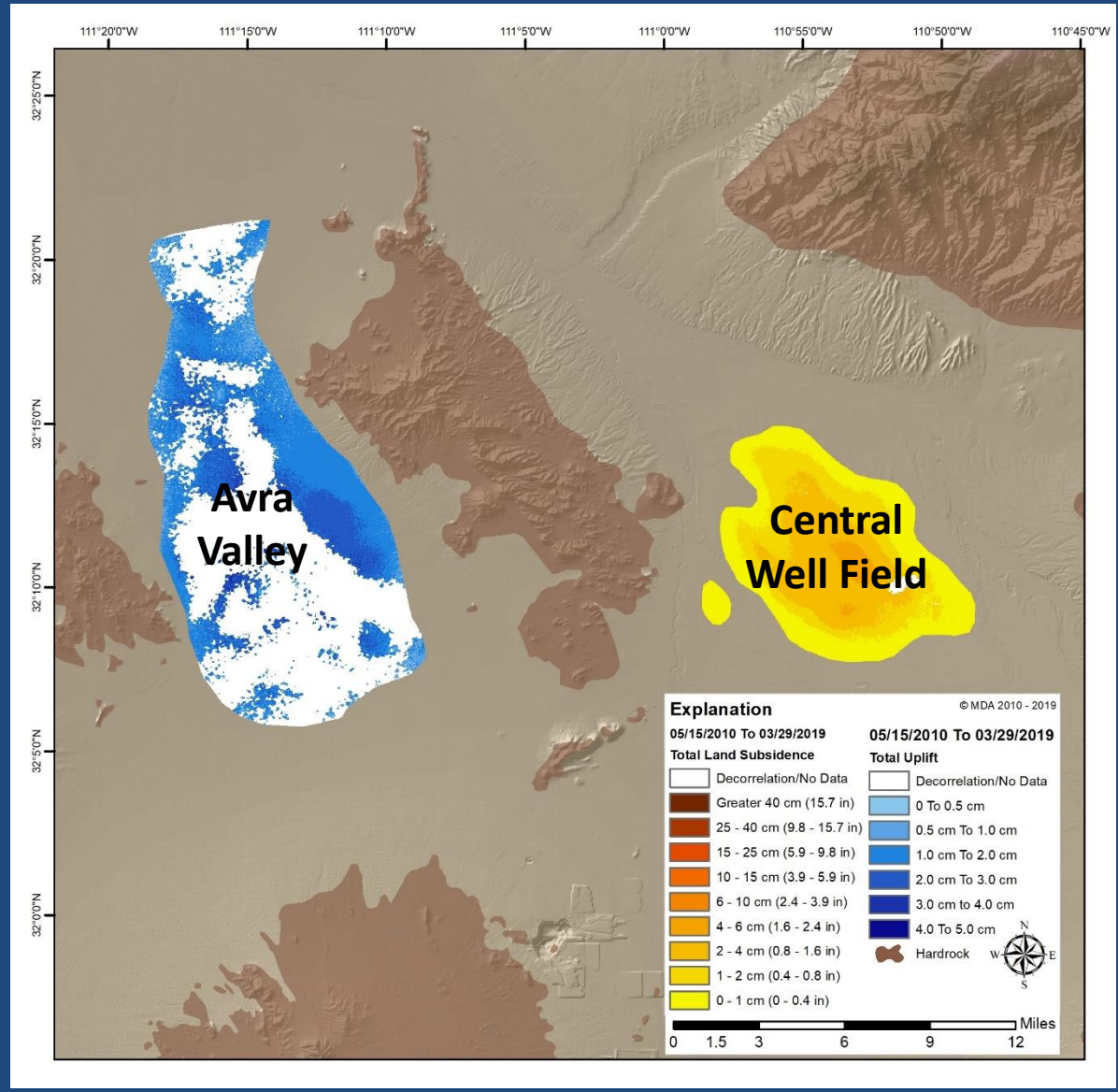


Radarsat-2
04/2018 – 03/2019

Using InSAR for Groundwater Management

- Groundwater recharge results in uplift in Avra Valley
- Recovery of groundwater levels in the central well field, mitigating land subsidence

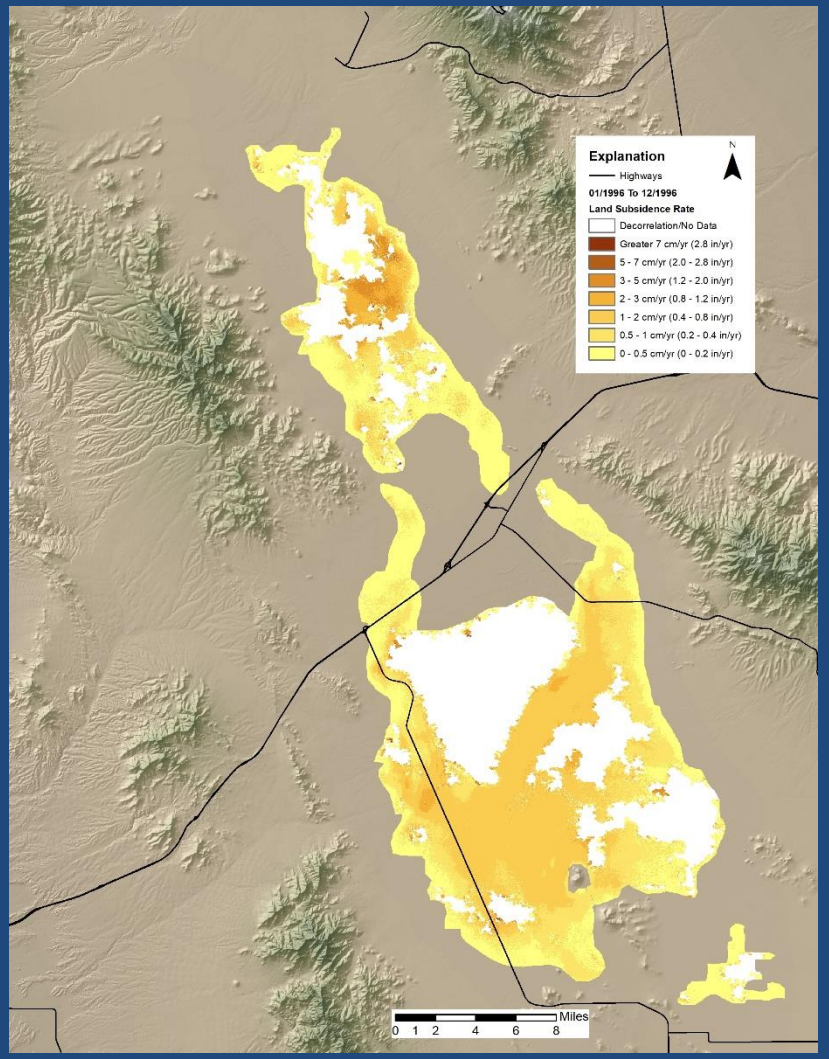




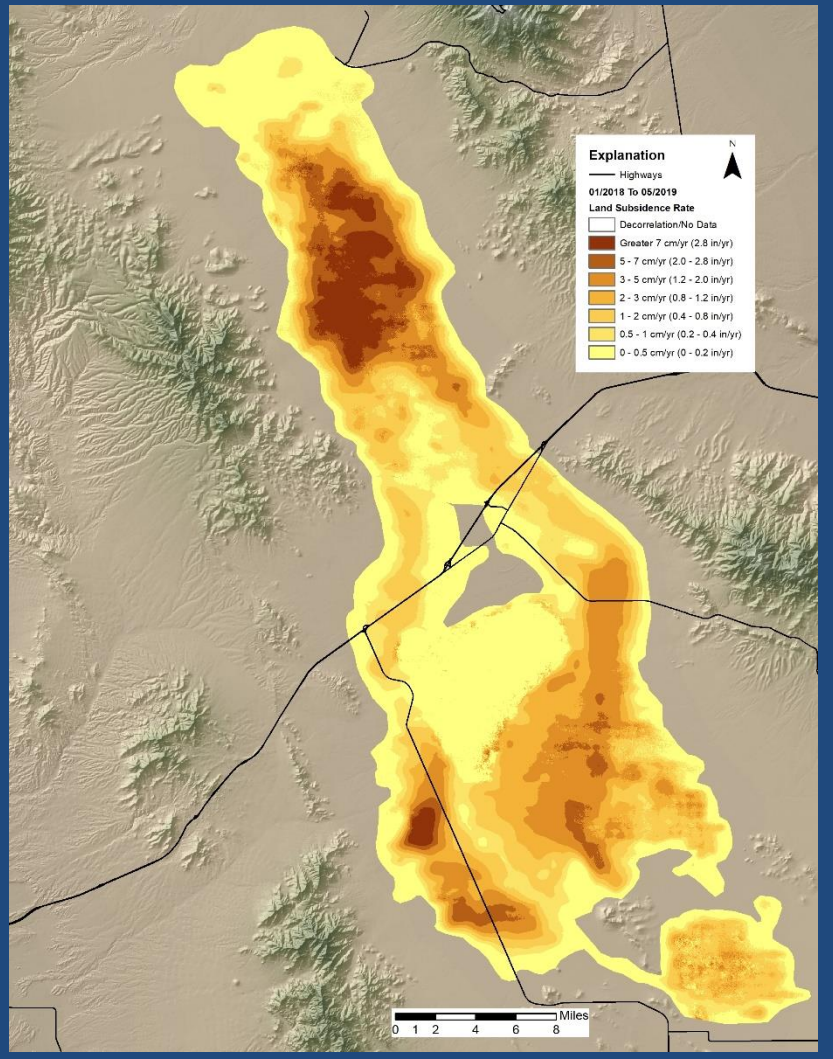
Radarsat-2
05/2010 – 03/2019

Using InSAR Data to Monitor Land Subsidence and Changing Rates

- Land subsidence rates have tripled in the Willcox Groundwater Basin between 1996 and 2019 InSAR datasets



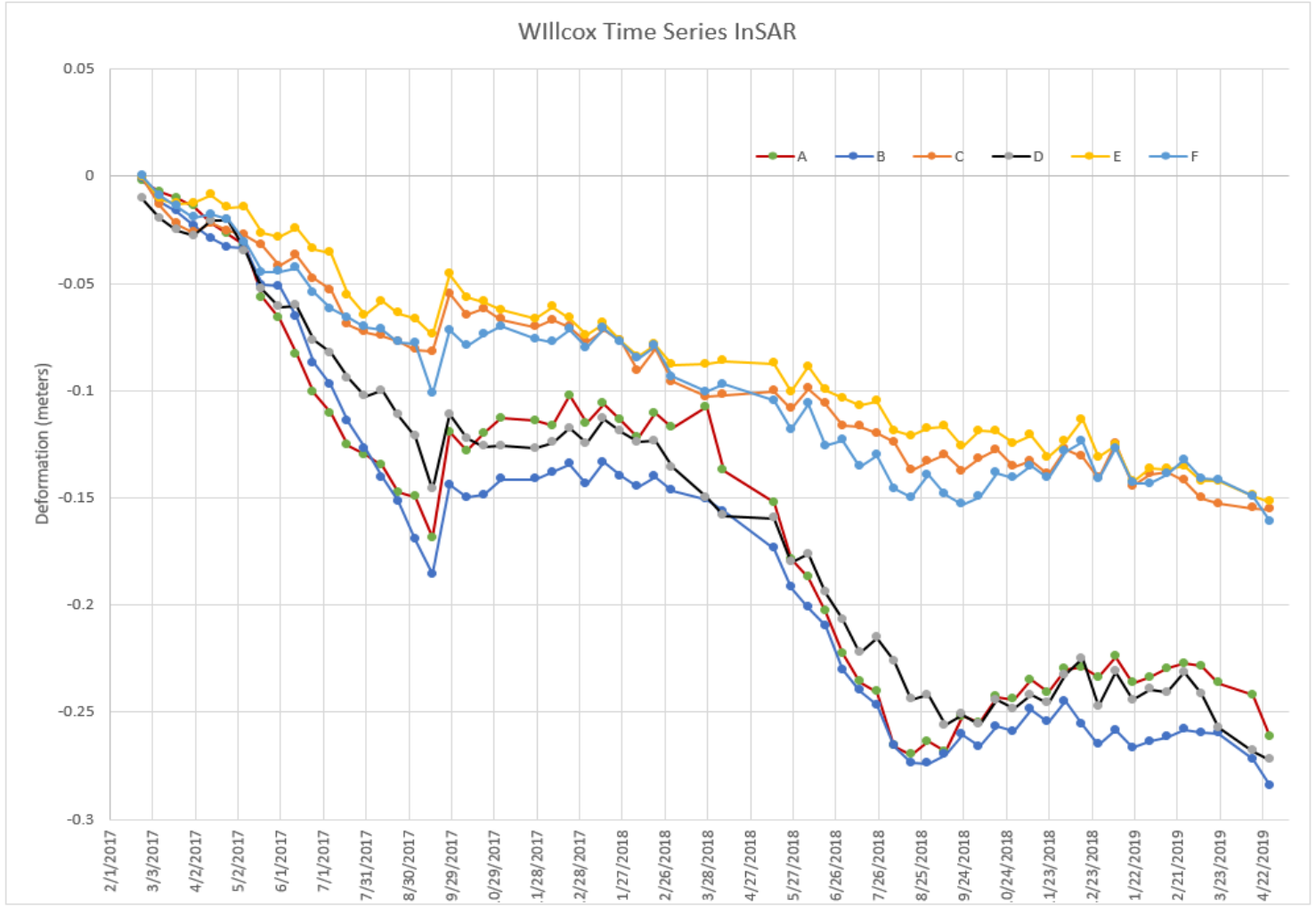
ERS-1 & 2
01/1996 – 12/1996

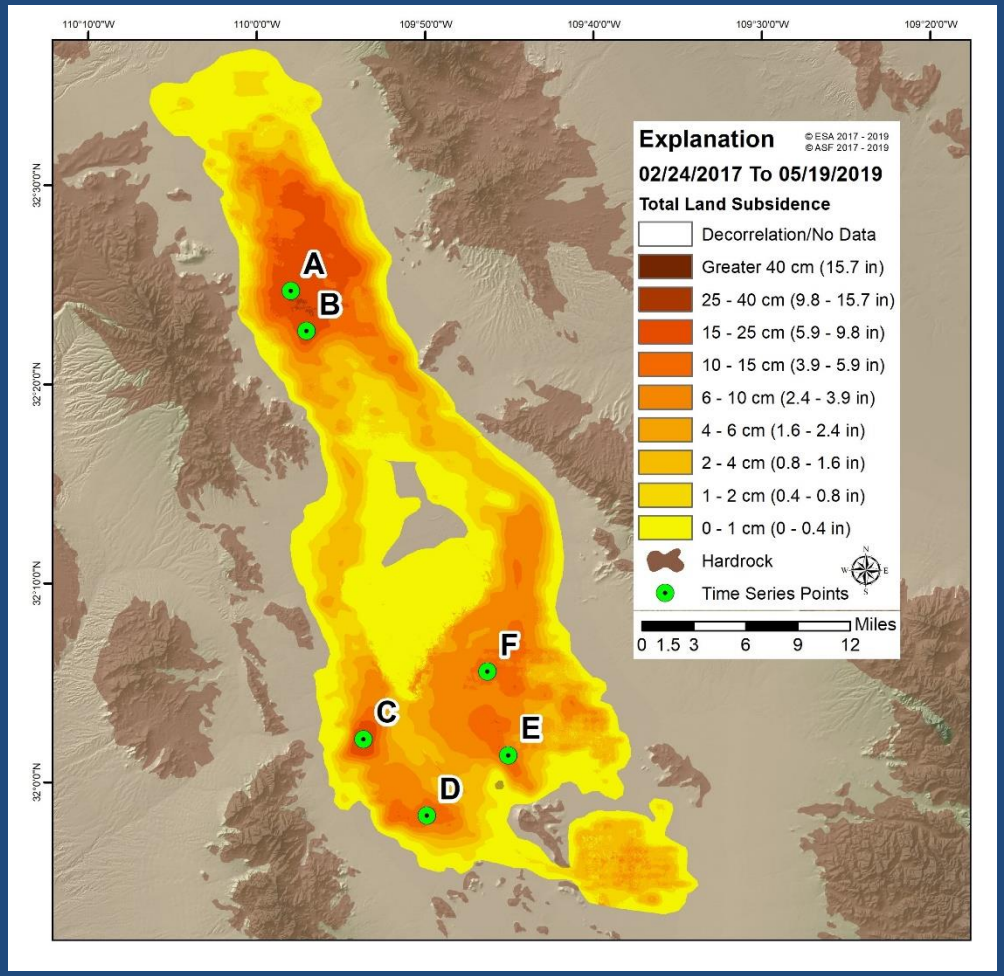


Sentinel-1
01/2018 – 05/2019

Using InSAR to Monitor Seasonal Deformation

- Able to leverage large data stacks (62 collects of Sentinel-1) to evaluate seasonal deformation and annual land subsidence

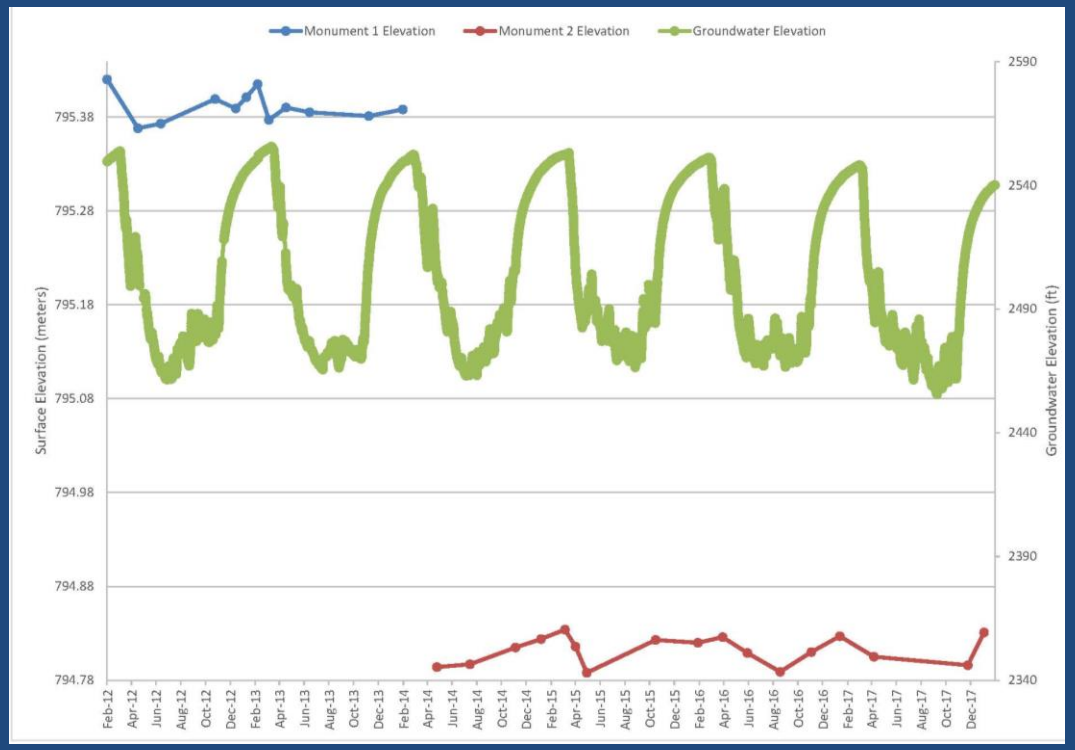


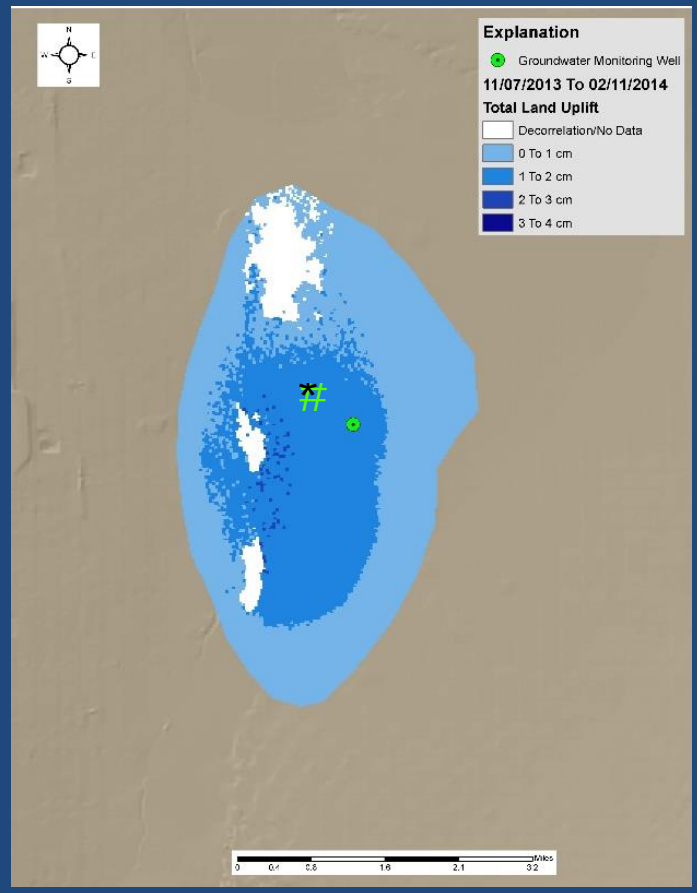


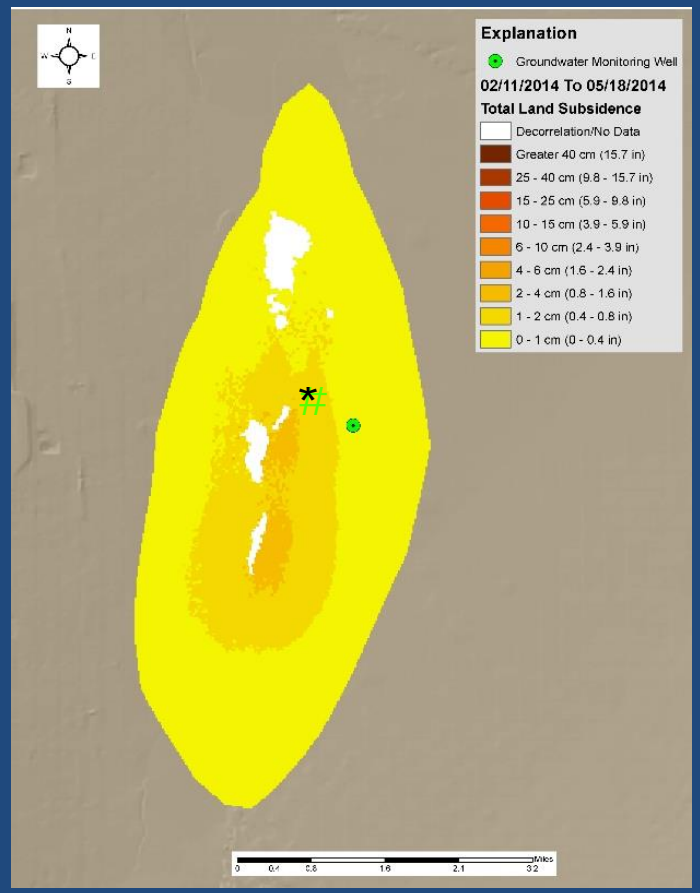
Sentinel-1
04/2017 – 05/2019

Using InSAR for Seasonal Deformation

- InSAR is being used to monitor seasonal uplift and subsidence related to groundwater pumping and groundwater decline/recovery

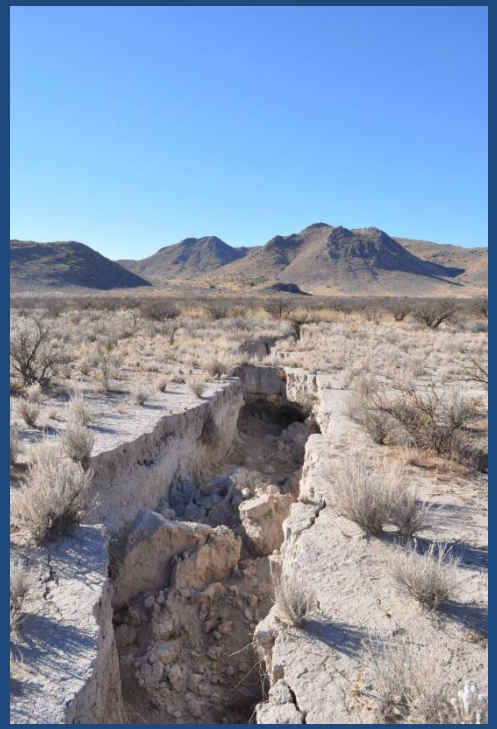


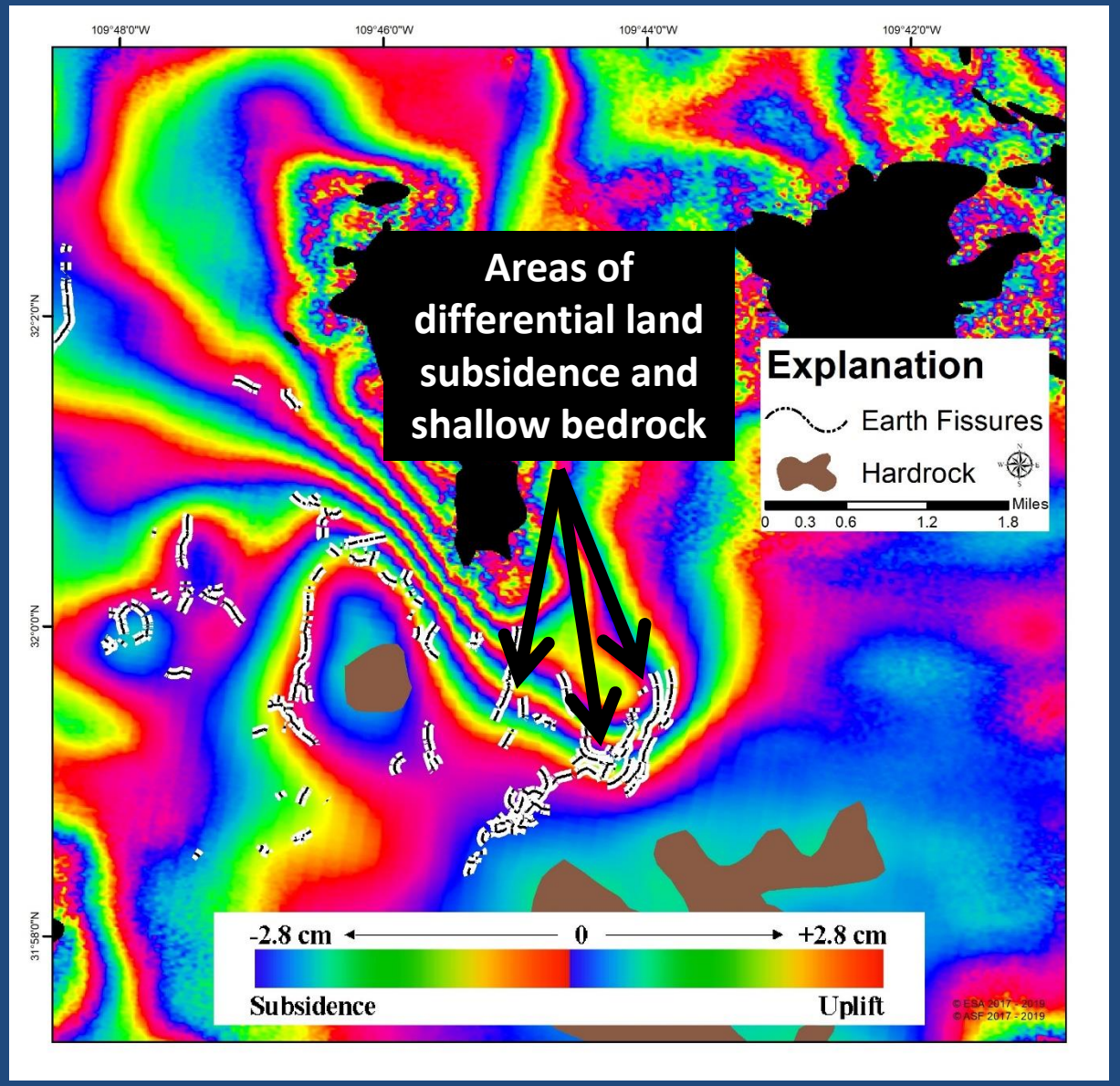




Using InSAR to Monitor Earth Fissures

- InSAR data is used to not only monitor earth fissure activity, but to also identify areas for potential earth fissuring where differential land subsidence is occurring

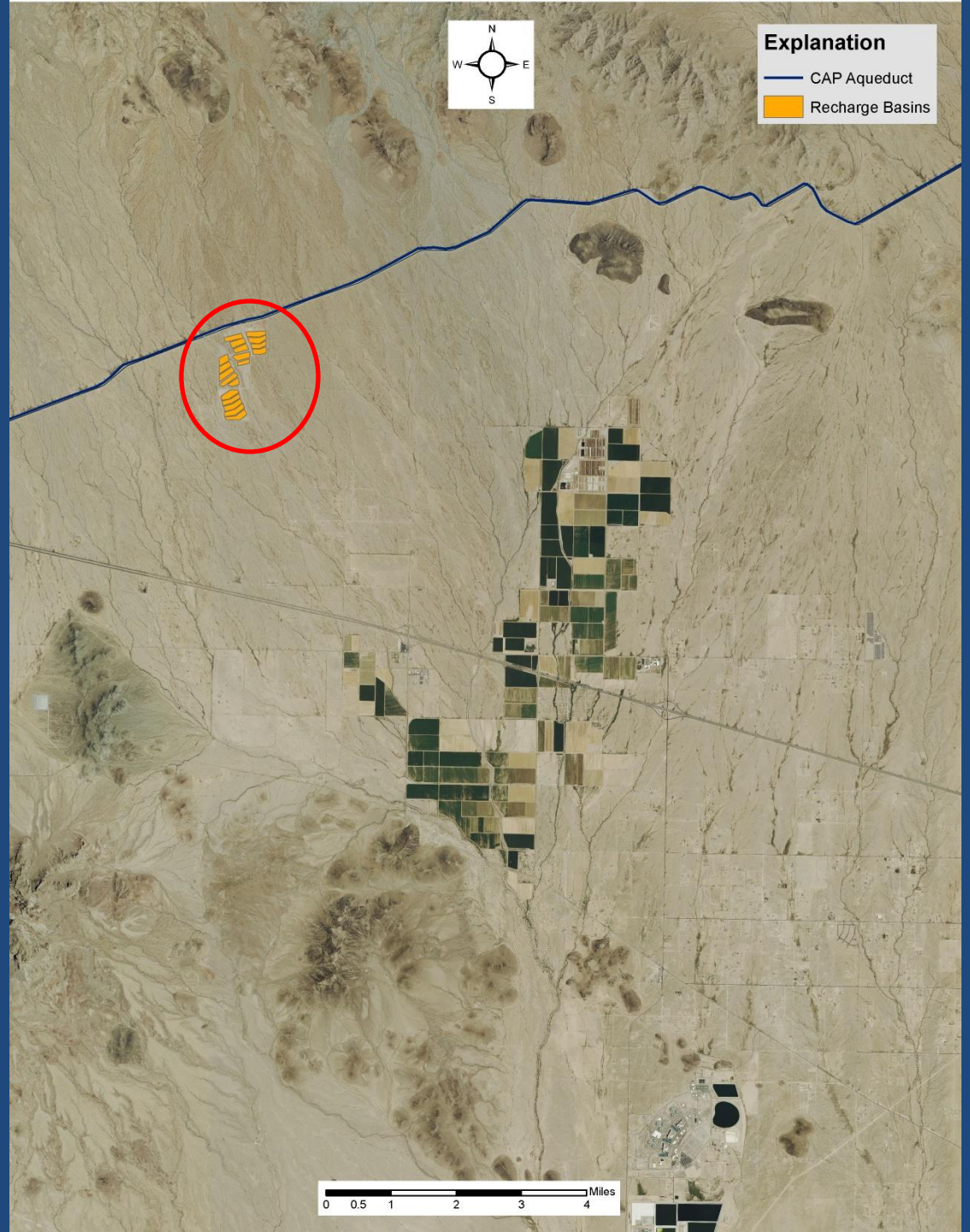




Using InSAR for Artificial Recharge

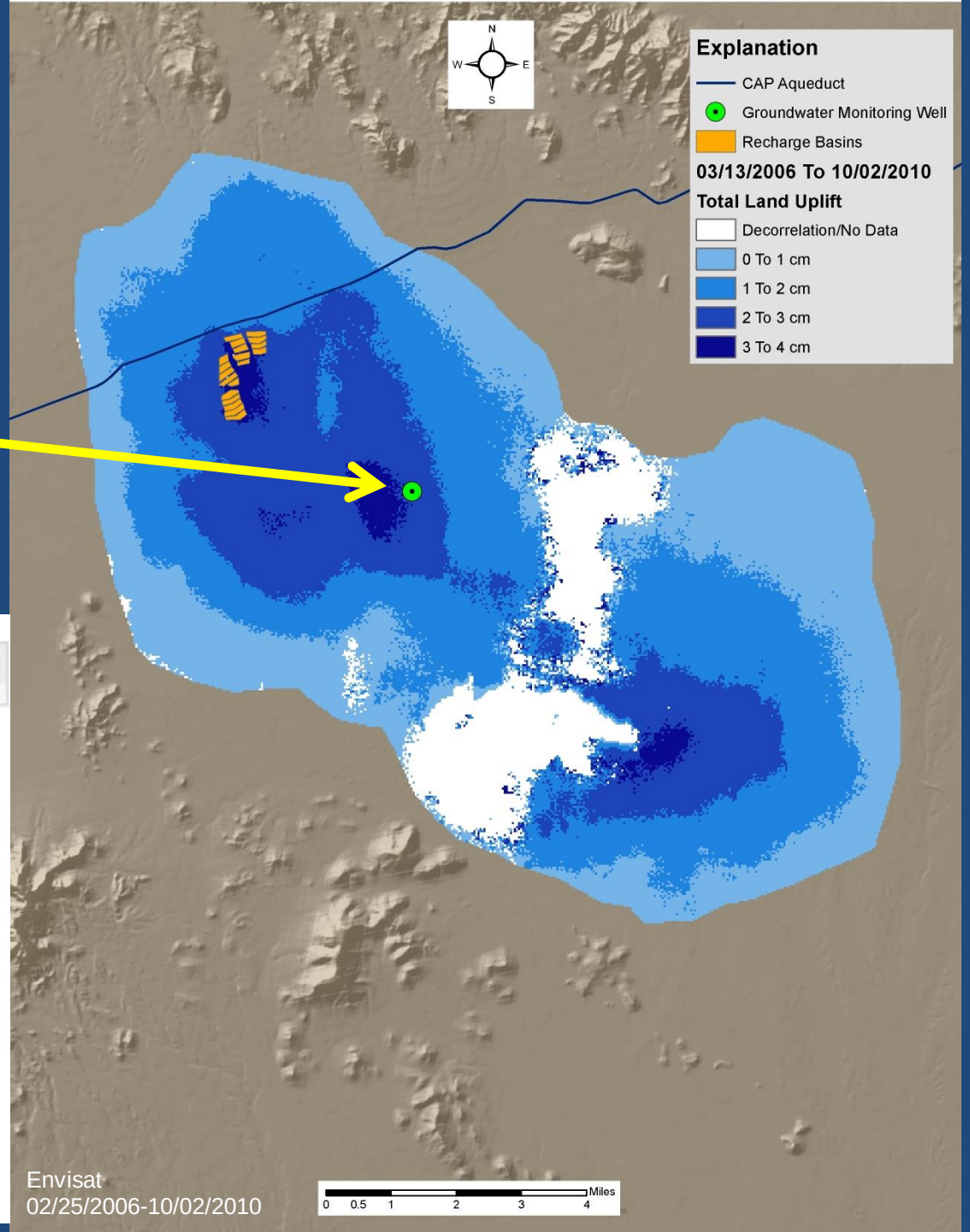
- Large groundwater recharge project 30 miles west of Phoenix
- Started recharging in 2006
- By October 2010, more than 500,000 acre-feet of water was recharged

Photo courtesy of CAWCD



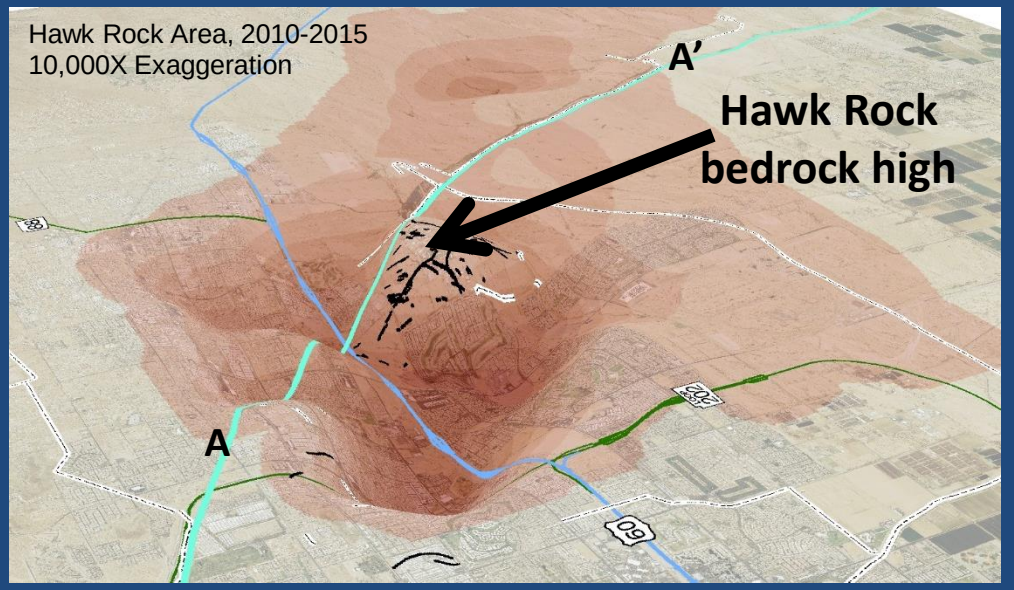
Using InSAR for Artificial Recharge

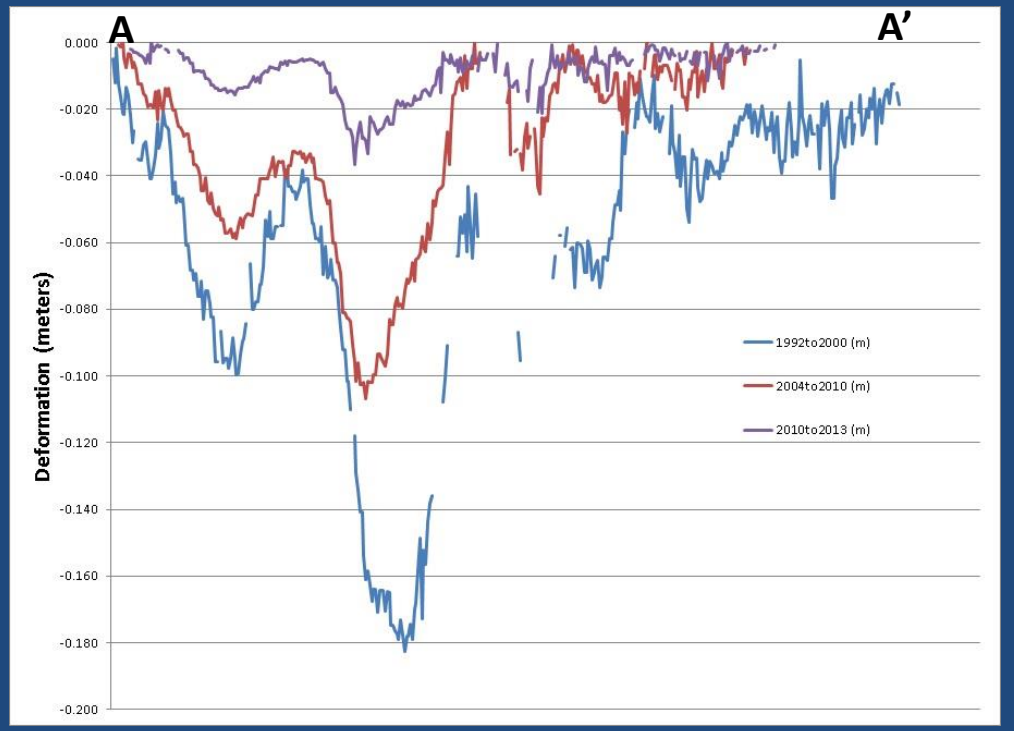
- Uplift up to 3.2 cm is measured
- Uplift covers 50 square miles
- Groundwater level monitoring well showed a groundwater rise of 200 feet due to the recharge



Using InSAR for Infrastructure Monitoring

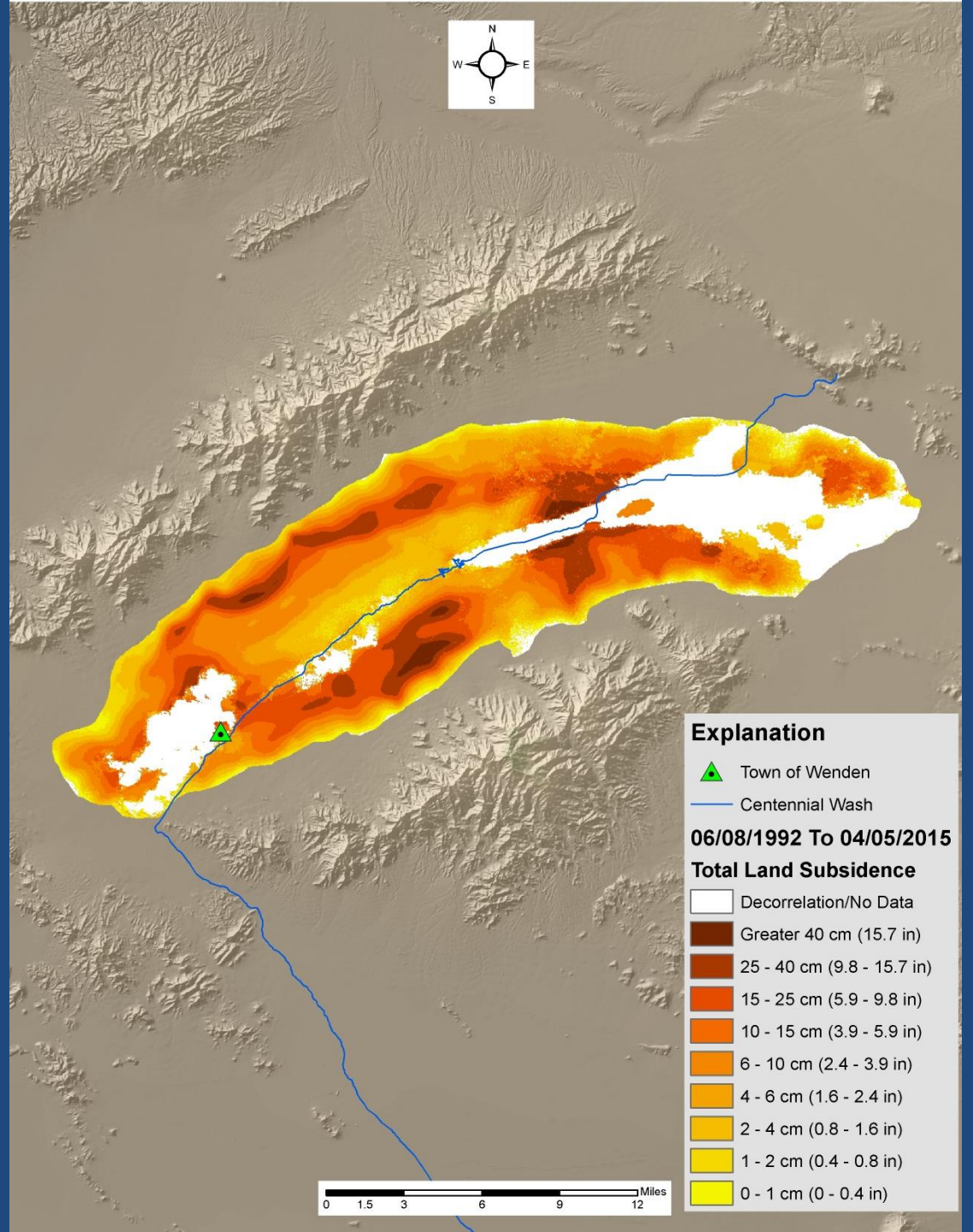
- InSAR is being used for monitoring and mitigating land subsidence and earth fissures around infrastructure (flood control structures, canals, highways, pipelines, power plants, powerlines gas lines, etc.)





Using InSAR for Floodplain Monitoring

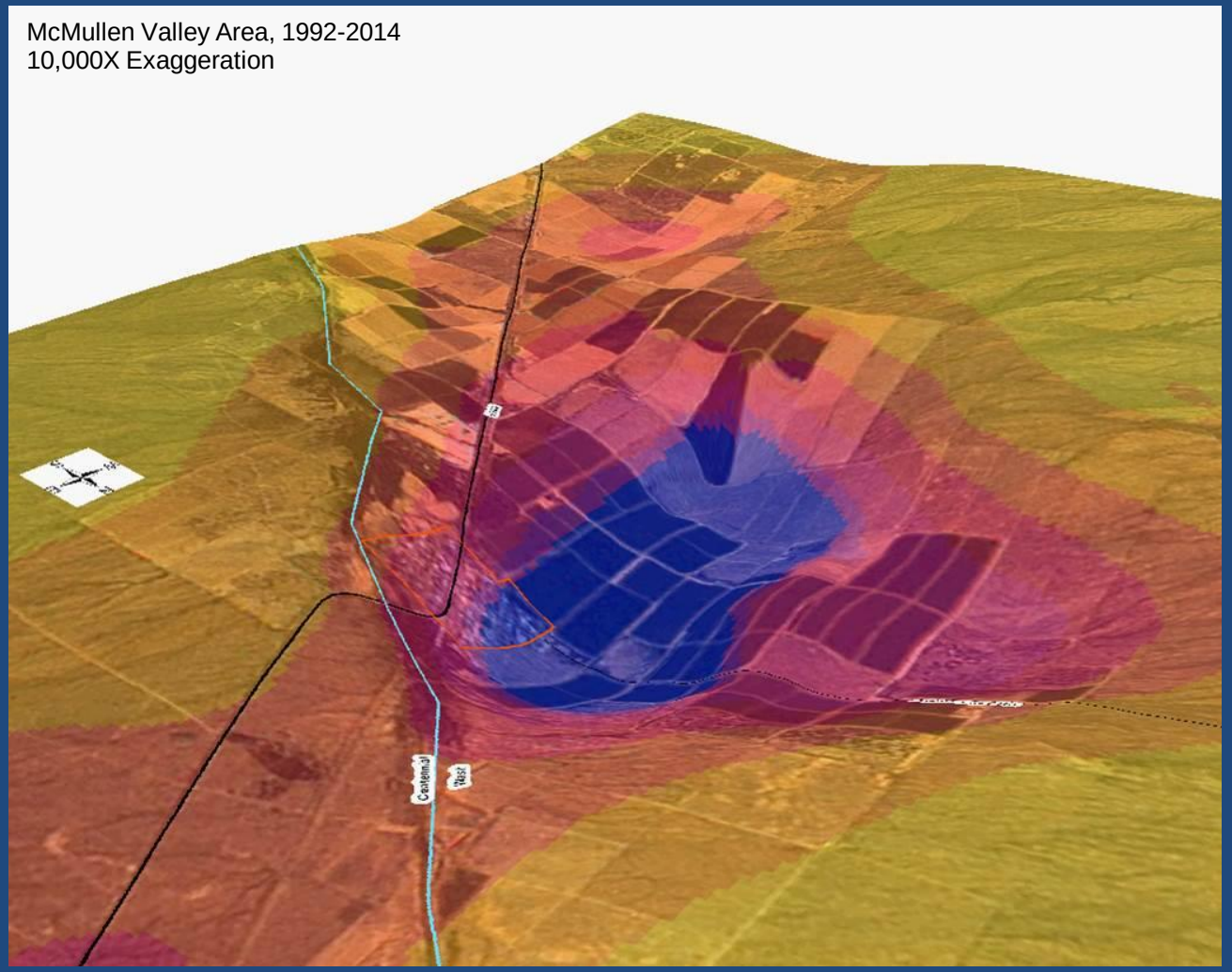
- Land subsidence has altered the Centennial Wash floodplain, resulting in the flooding of the Town of Wenden during high flow events
- McMullen Valley Groundwater Basin was an area of unknown subsidence until InSAR was collected



Using InSAR for Floodplain Monitoring

- Town of Wenden is located on the side of a subsidence bowl and has flooded several times in the past 15 years

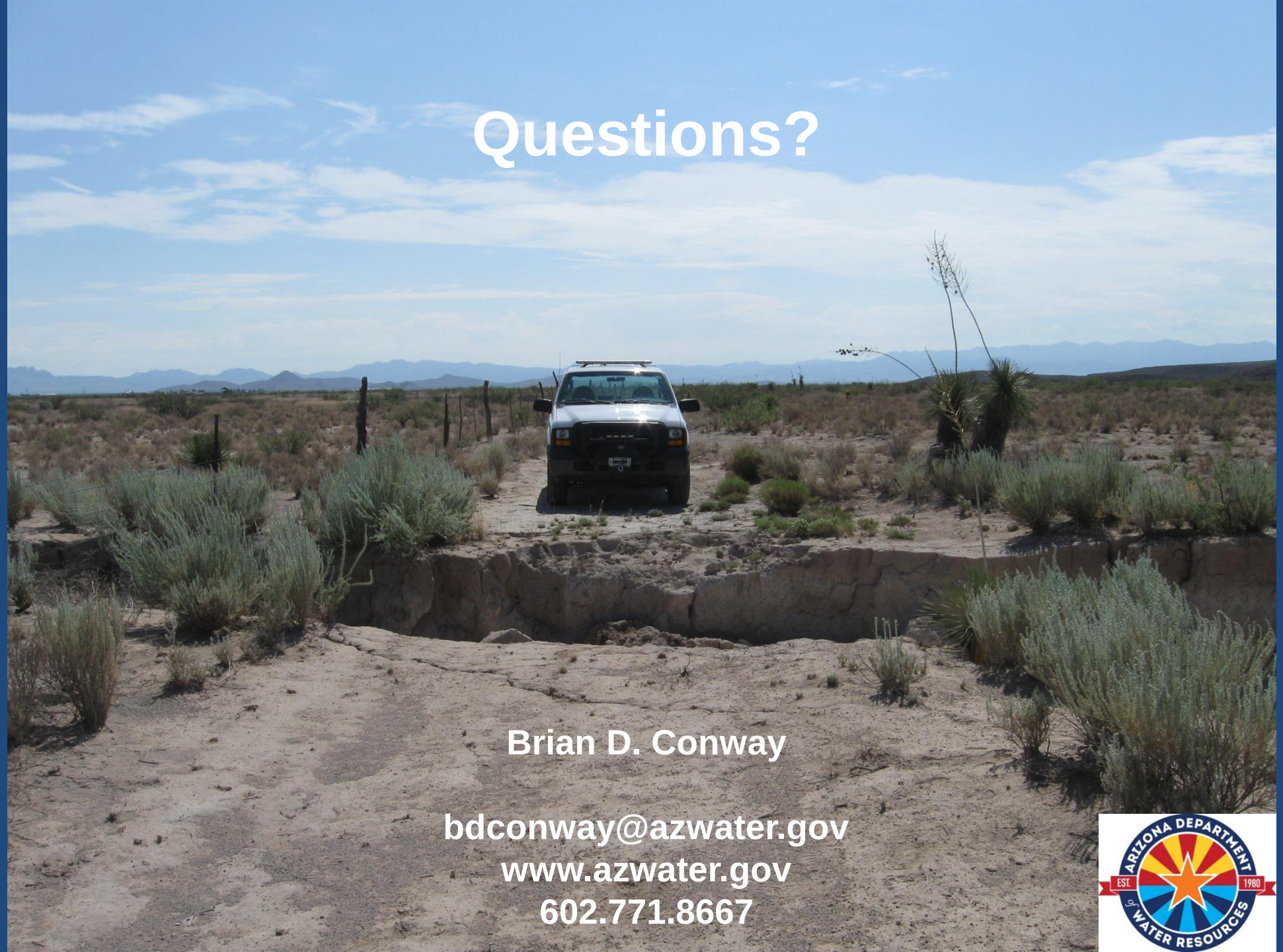
Town of Wenden Flooding 2010,
Photo courtesy of La Paz County



Benefits From InSAR in Arizona

- Greatly improved land subsidence monitoring efforts across Arizona
- Developed important partnerships with other federal, state, county, and local agencies providing land subsidence data for their monitoring efforts
- Developed and published land subsidence maps and GIS-ready deformation data for the State of Arizona
- Greatly improved awareness of land subsidence and the potential problems caused by land subsidence
- Able to have a data synergy between InSAR data and other critical datasets (groundwater pumping, groundwater levels, earth fissures), all of which are made freely available and accessibility through ADWR's website and are used for decision making, project planning, mitigation, and groundwater management

Questions?



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