

ADWR's Land Subsidence Monitoring Program and the Arizona Continuously Operating Reference Station Network (AZCORS)



Brian D. Conway
Hydrogeologist Principal/Supervisor
Geophysics-Surveying Unit

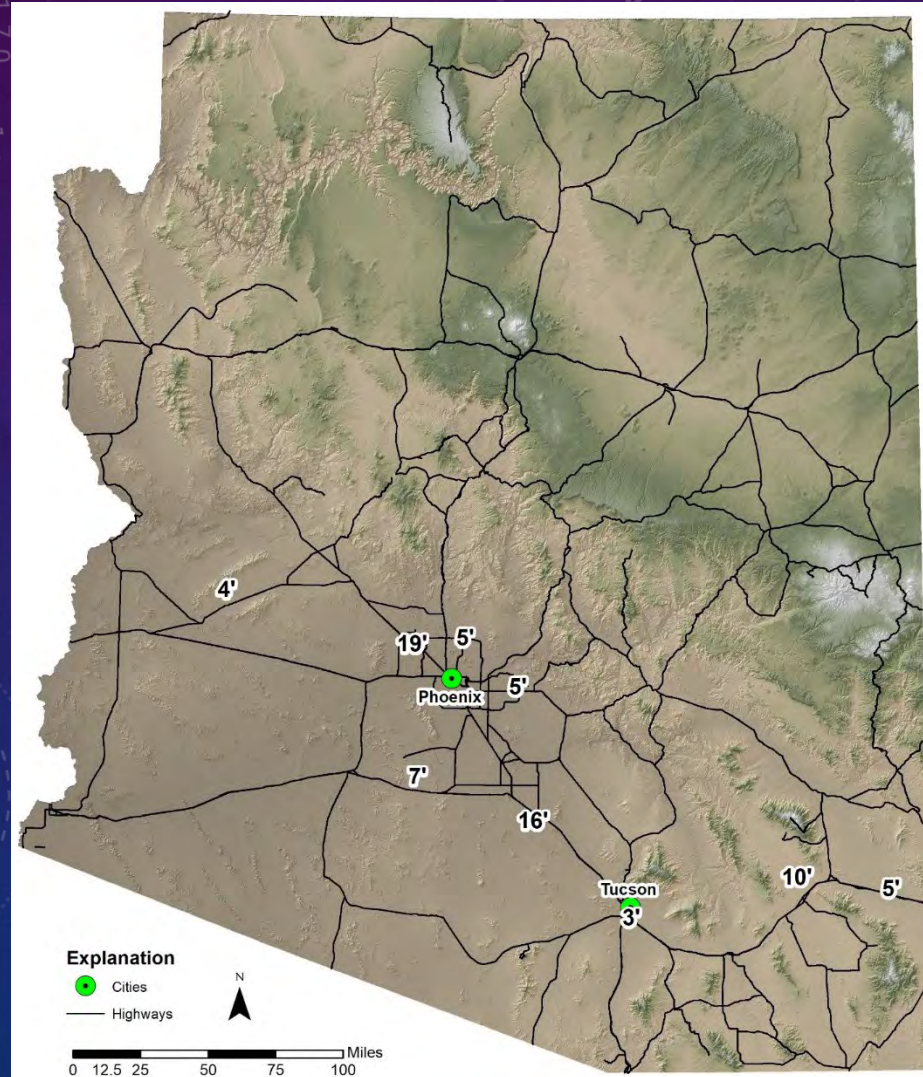
CSRC CC Meeting
May 15, 2025



Protecting Arizona's Water Supplies
For Its Next Century

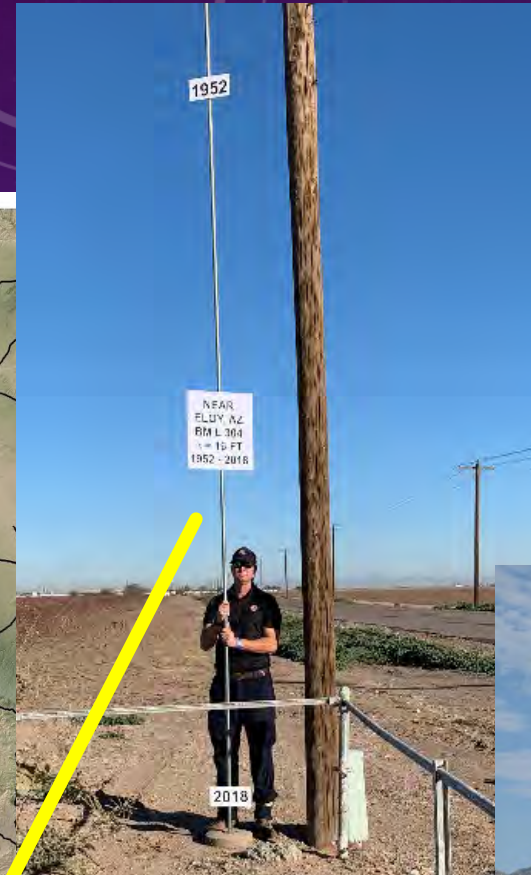
ADWR's Land Subsidence Monitoring Program

- Repeat surveys revealed land subsidence up to 19 feet



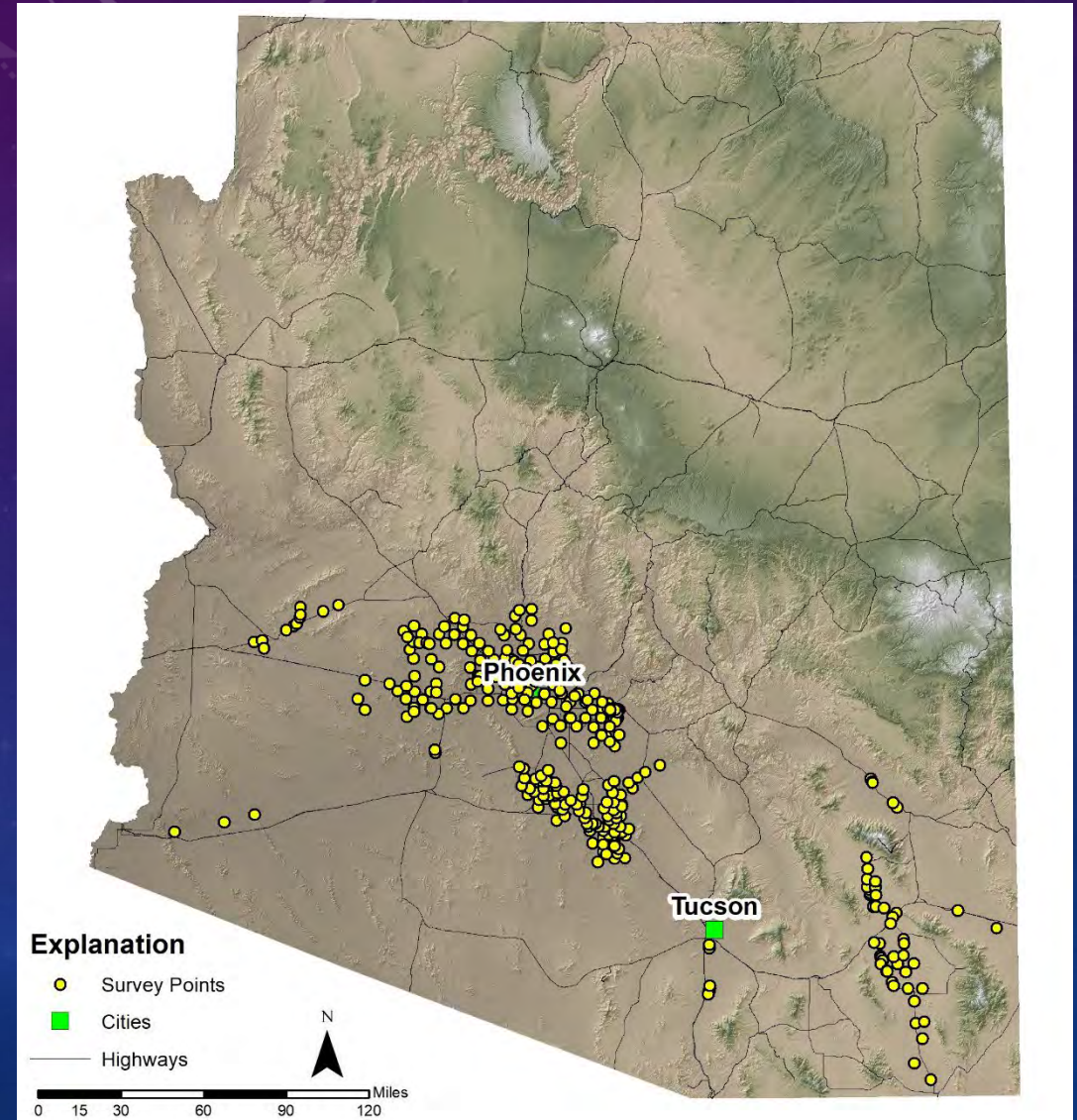
ADWR's Land Subsidence Monitoring Program

- Repeat surveys revealed land subsidence up to 19 feet



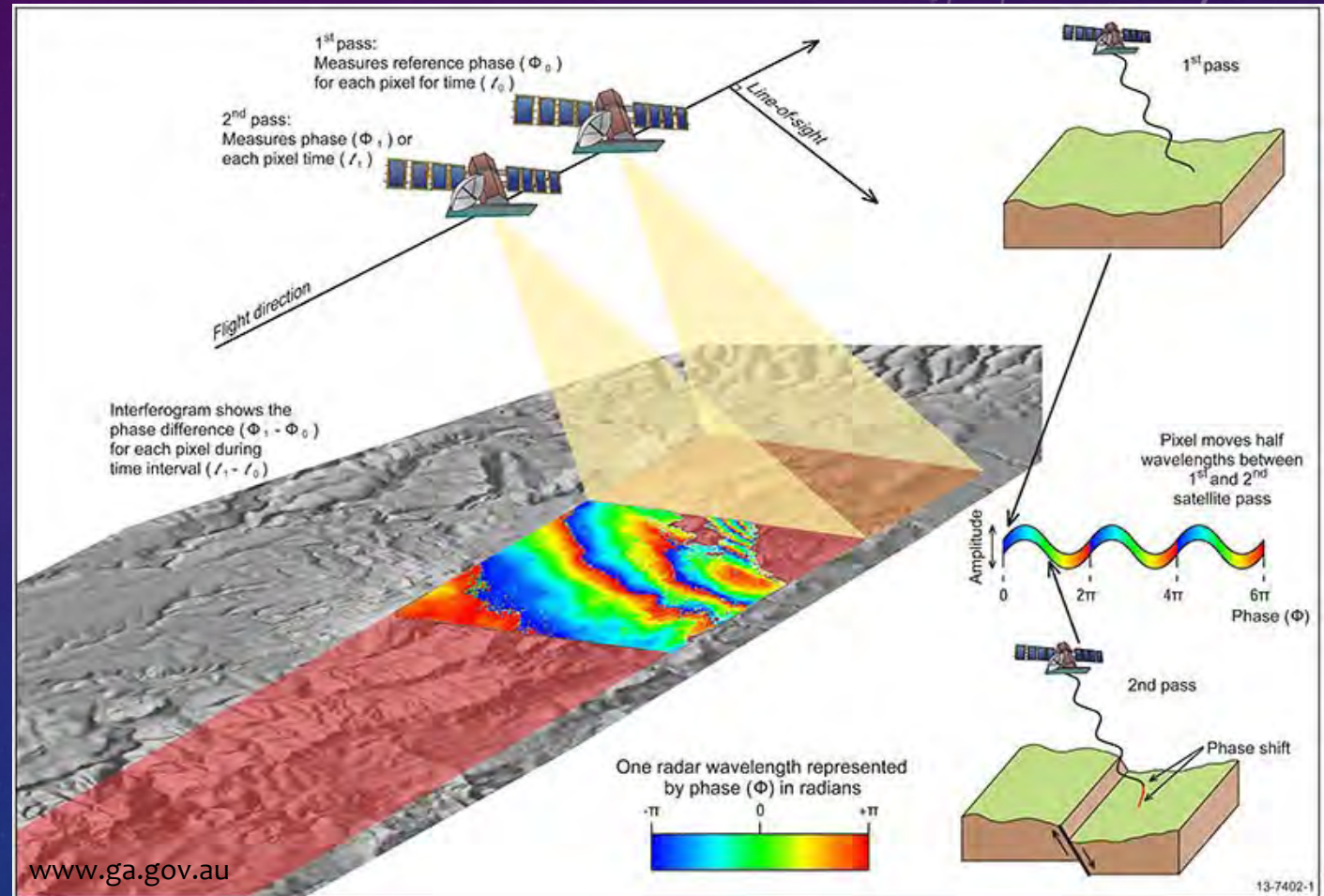
ADWR's InSAR Land Subsidence Monitoring Program

- Have been completing GNSS surveys since 1998
- Data is processed using Trimble Software, NGS OPUS, OPUS-Share, and OPUS Projects
- Networks have been expanded to improve monitoring
- Surveys vary from monthly, seasonally, and annually



Synthetic Aperture Radar Interferometry (InSAR)

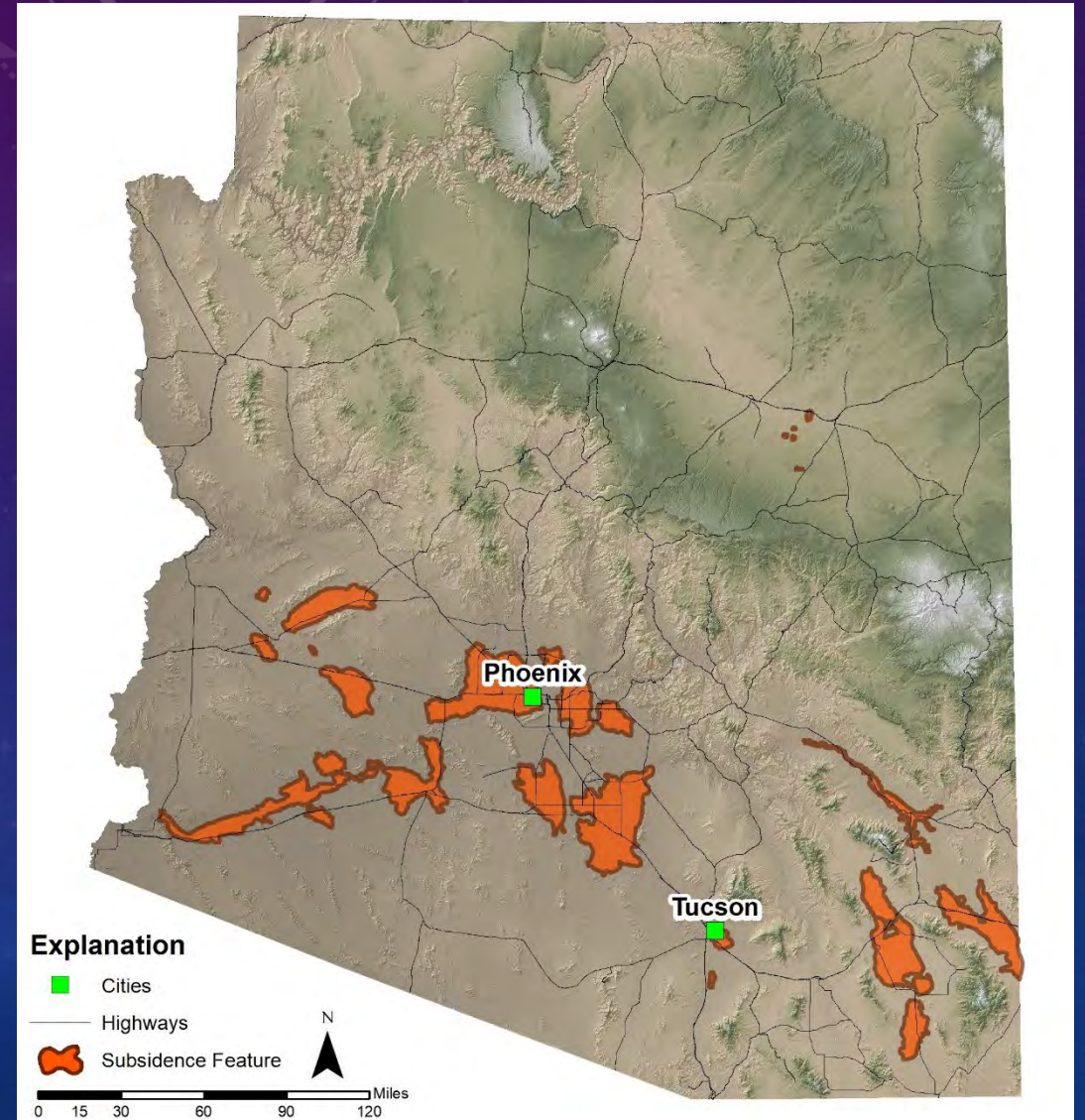
- Interferometric Synthetic Aperture Radar (InSAR) is a geodetic technique that can identify movements of the Earth's surface.
- Observations of surface movement made using InSAR can be used to detect, measure, and monitor crustal changes associated with geophysical processes.
- InSAR can identify surface movements with high spatial resolution on a millimeter to centimeter scale.
- Subsidence and uplift induced by anthropogenic activities such as groundwater extraction or injection.



Two SAR images of the same area are acquired at different times. If the surface moves between the two acquisitions a phase shift is recorded. An interferogram maps this phase shift spatially.

ADWR's InSAR Land Subsidence Monitoring Program

- Started in 2002 from a NASA grant
- Have an extensive InSAR library, data between 1992 and present
- By 2025, identified 30 individual land subsidence features covering an area greater than 4,300 square miles
- Cost of the InSAR data has exceeded \$2.2 million dollars



ADWR's Land Subsidence Website

- ADWR's website has a dedicated land subsidence section
- Each land subsidence feature has a dedicated webpage
- A total of 811 land subsidence maps are available for download
- The InSAR-derived maps cover various periods of time between 1992 and 2000, 2004 to 2010, and 2010 to present



Land Subsidence In Arizona



Land subsidence has been occurring across Arizona since the early 1900s. Millions of people around the world live in active land subsidence areas, many of whom may not even realize it. Most of the time, there is no clear and identifiable sign that land subsidence has occurred in an area. Areas in Maricopa and Pinal Counties have subsided more than eighteen feet since the early 20th Century.

Land subsidence in the basins of Arizona is generally due to compaction of alluvium caused by lowering of the water table. As the water table declines, pores in the alluvium once held open by water pressure are no longer supported and collapse. Collapse and subsequent lowering in elevation of the land surface is defined as land subsidence. This subsidence is generally not recoverable. If this subsidence occurs over areas of bedrock, differential subsidence can occur.

Differential subsidence is when adjacent areas subside at different rates. Bedrock will not compress like the surrounding alluvium, creating a subsurface platform. Differential subsidence occurs where shallow bedrock and deep bedrock are adjacent to each other, creating a zone of differential change in surface elevation. Because of these different amounts of subsidence, tension can build in the alluvium layer at this differential subsidence zone, forming an earth fissure.

Arizona Land Subsidence Areas

Avra Valley Land Subsidence Feature	Bowie/San Simon Land Subsidence Feature	Butler Valley Land Subsidence Feature
East Valley Land Subsidence Feature	Elfrida Land Subsidence Feature	Fort Grant Road Land Subsidence Feature
Gila Bend Land Subsidence Feature	Green Valley Land Subsidence Feature	Harquahala Valley Land Subsidence Feature
Hawk Rock Land Subsidence Feature	Holbrook Basin Land Subsidence Feature	Kansas Settlement Land Subsidence Feature
Lower Gila Land Subsidence Feature	Maricopa-Stanfield Land Subsidence Feature	McMullen Valley Land Subsidence Feature
Piocho-Eloy Land Subsidence Feature	Ranegras Land Subsidence Feature	Scottsdale and Northeast Phoenix Land Subsidence Feature
Tucson Land Subsidence Feature	Upper Gila Land Subsidence Feature	West Valley Land Subsidence Feature

Groundwater Modeling	▼
Field Services	▼
AZCORS	
Depth to Water Statistics	
Groundwater Information	
Groundwater Level Changes	
Hydrology Publications and Data	
Land Subsidence in Arizona	
Statewide Monitoring Program	
Third Party Water Level Portal	
Hydrology Contact Us	

Contact Form
hydrology@azwater.gov
(602) 771-8535

Applications of InSAR in Arizona

Using InSAR for Groundwater Management

- InSAR data has been used to better document on going 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 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 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

Areas of differential land subsidence and shallow bedrock

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 CARRCO

Groundwater Management

Land Subsidence

Earth Fissures

Recharge

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 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.)

Hawk Rock Area, 2010-2015
10,000X, Exaggerated

Hawk Rock bedrock high

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

Explanation:
Town of Wenden
Centennial Wash
08/01/1992 To 04/08/2015
Total Land Subsidence
Displacement (in Feet)

Greater 40 cm (16.7 in)
30 - 40 cm (11.8 - 16.7 in)
20 - 30 cm (7.9 - 11.8 in)
10 - 20 cm (3.9 - 7.9 in)
5 - 10 cm (2.0 - 3.9 in)
4 - 5 cm (1.6 - 2.4 in)
2 - 4 cm (0.8 - 1.6 in)
1 - 2 cm (0.4 - 0.8 in)
1 - 1 cm (0.4 - 0.8 in)

Seasonal Deformation

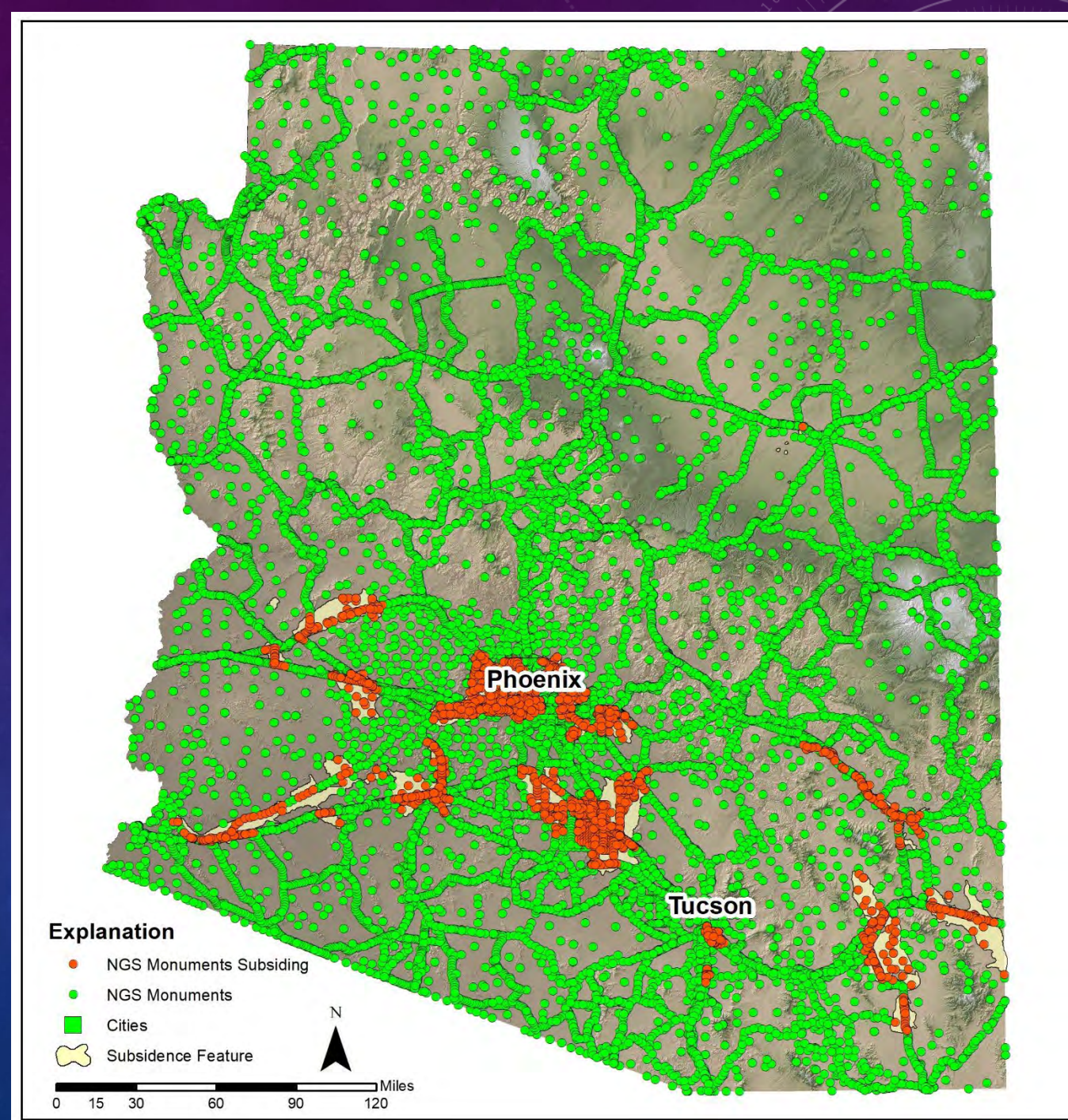
Infrastructure

Floodplains

Surveying

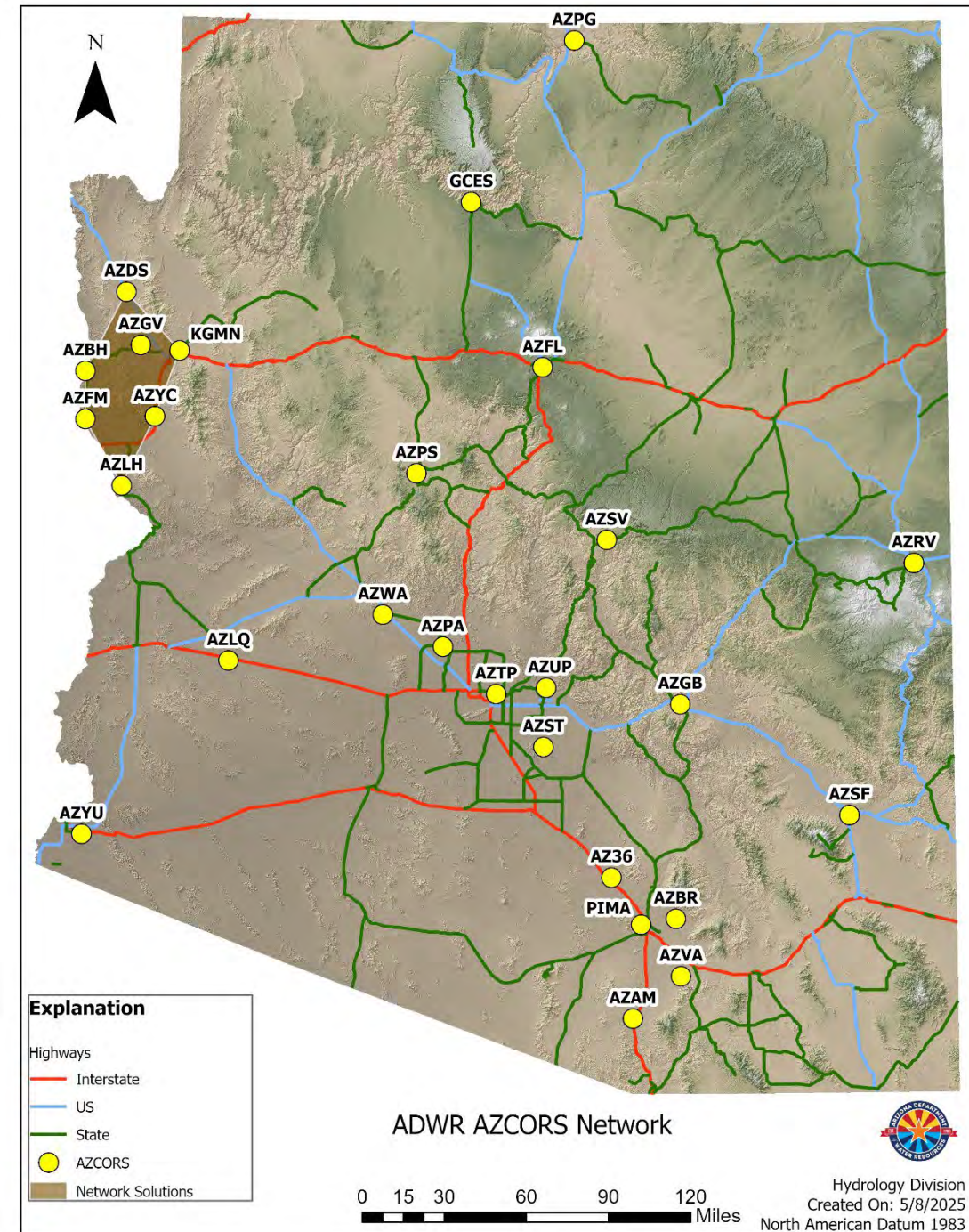
- Land subsidence is compromising vertical surveying control monuments
- Surveying control should be verified

**2,669 Monuments Affected
by Land Subsidence**



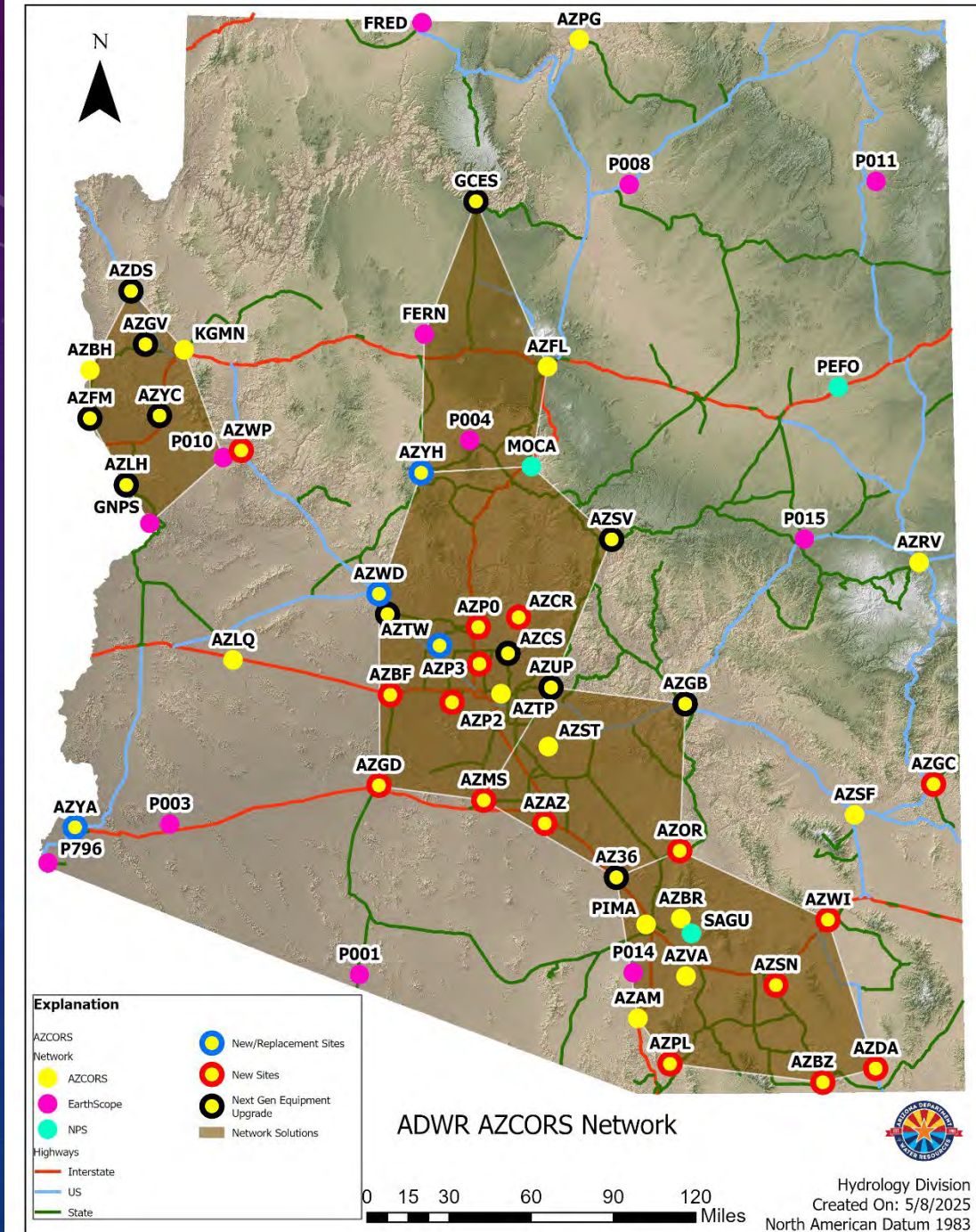
ADWR AZCORS Program

- Took over management and operation of AZCORS from ADOT in March 2023
 - 27 CORS sites
 - 1 Network Solution in Mohave County
 - 2 Network Servers



ADWR AZCORS Program

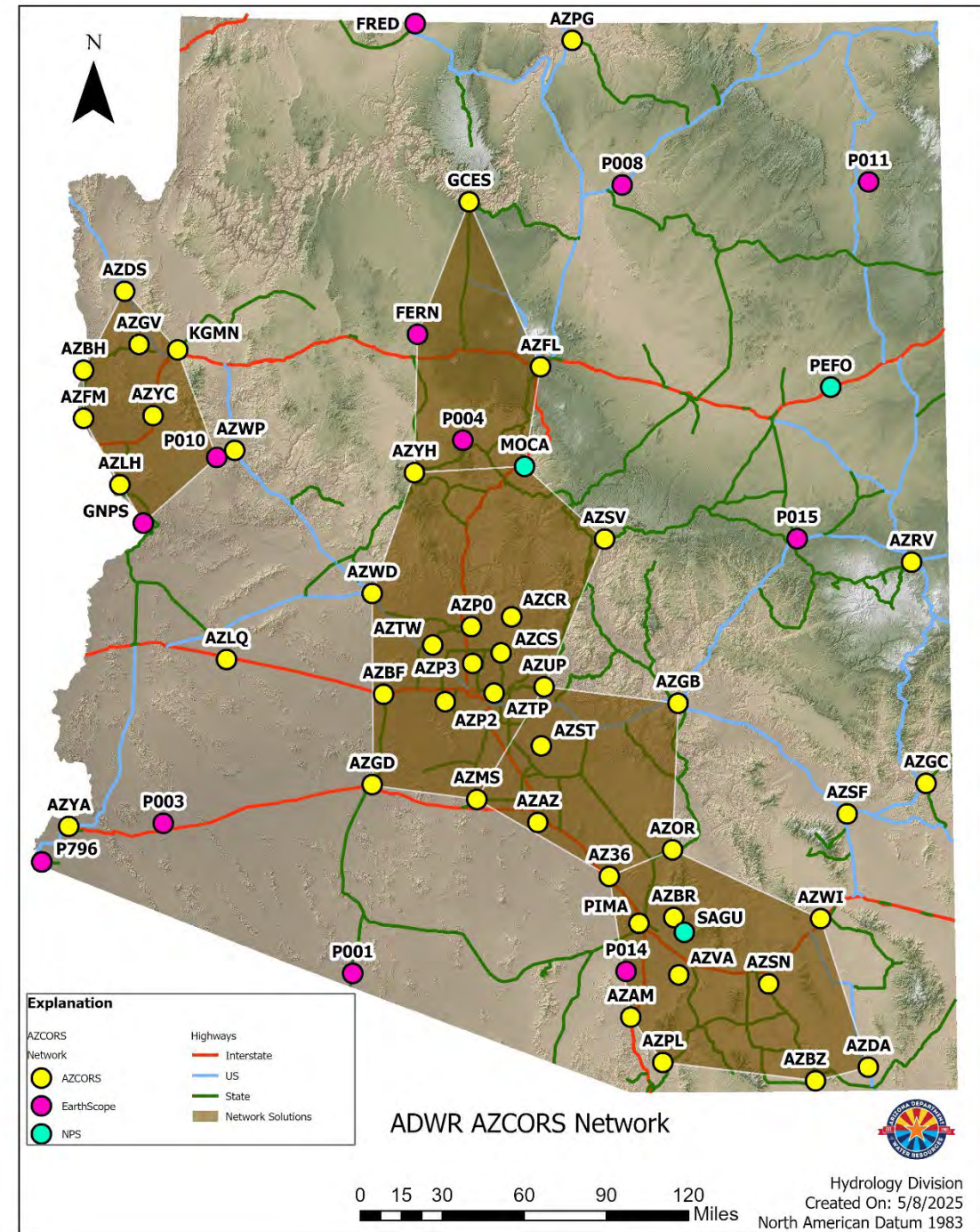
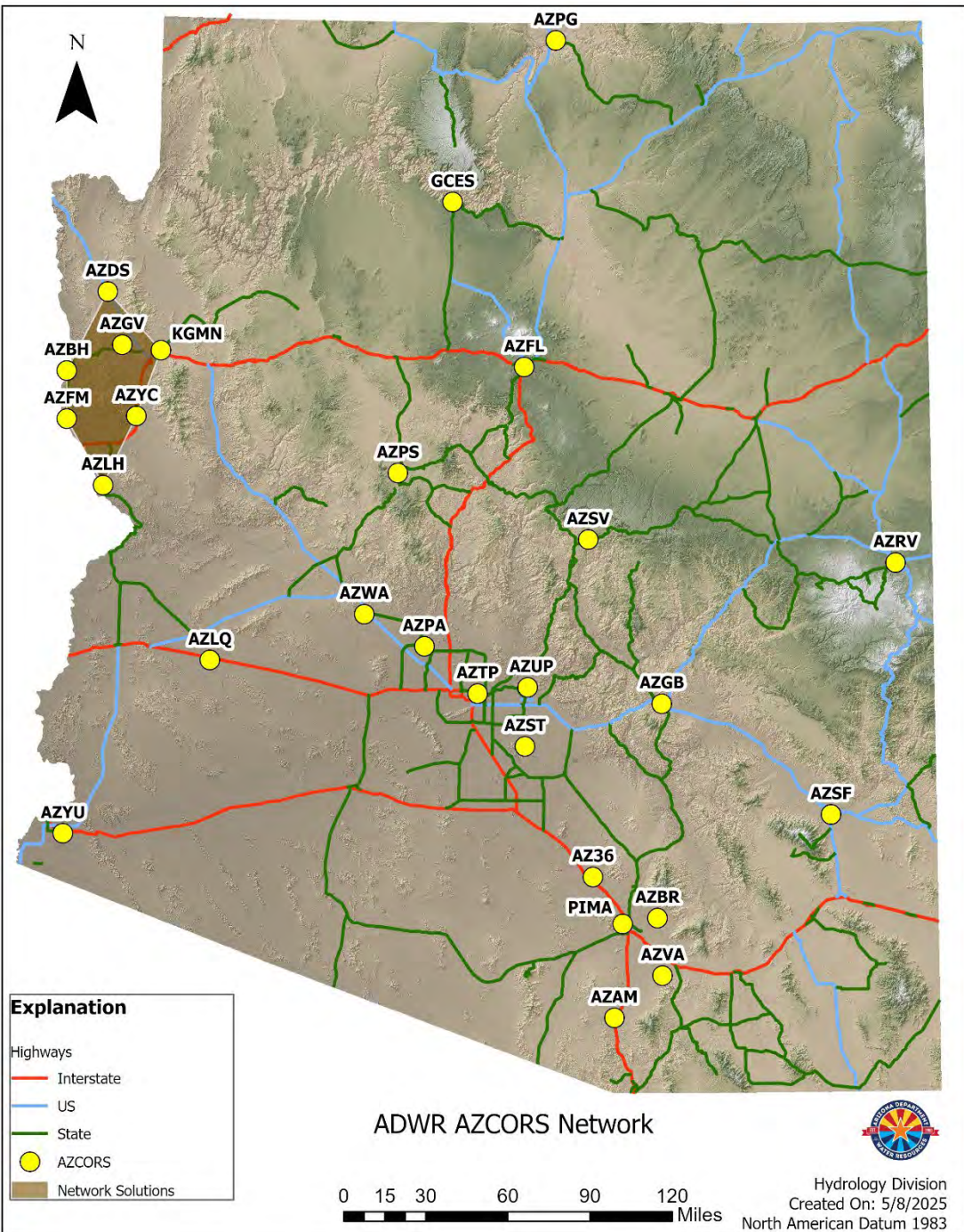
- Replaced/upgraded legacy equipment
- 20 braced monuments built
 - 4 replacement sites, 16 new sites
- Created 4 new Network Solutions
- Ingest data from NPS and EarthScope
- New servers and website
 - azcors.azwater.gov (open data policy)
- 59 total CORS sites (44 AZCORS, 12 EarthScope and 3 NPS)



ADWR AZCORS Program

Braced Monument Construction





Thank you

Brian D. Conway

bdconway@azwater.gov

www.azwater.gov

602.771.8667

