



Subsidence, Drought, and Critical Water Infrastructure

Jeanine Jones, California Department of Water Resources

Outline

- Recent drought setting
- Subsidence monitoring triggered by 2014 drought emergency proclamation
- Impacts to critical water infrastructure in San Joaquin Valley

Where We've Been Prior to Water Year 2017

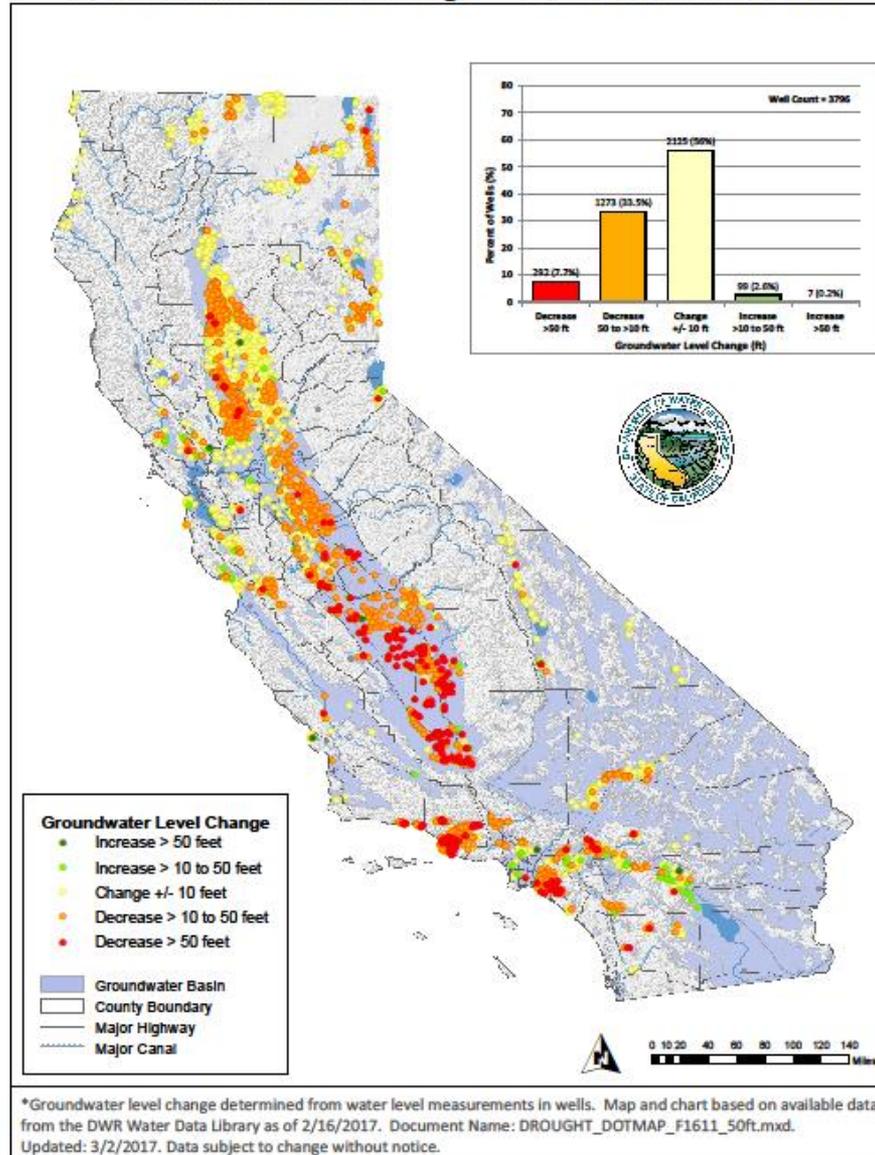
- 2007 – dry
- 2008 – dry
- 2009 – dry
- 2010 – normal
- 2011 – wet
- 2012 – dry
- 2013 – dry
- 2014 – dry
- 2015 – dry
- 2016 – dry to normal, location-specific



Comparison of Historical Water Project Allocations in Dry Years

	1991	2009	2014	2015	2016
SWP	30% & 0%	40%	5%	20%	60%
CVP N of Delta Ag	25%	40%	0	0	100%
CVP S of Delta Ag	25%	10%	0	0	5%
Friant	100%	100%	0	0	65%
CVP Sac water rights	75%	100%	75%	75%	100%
CVP SJ water rights	75%	100%	65%	75%	100%

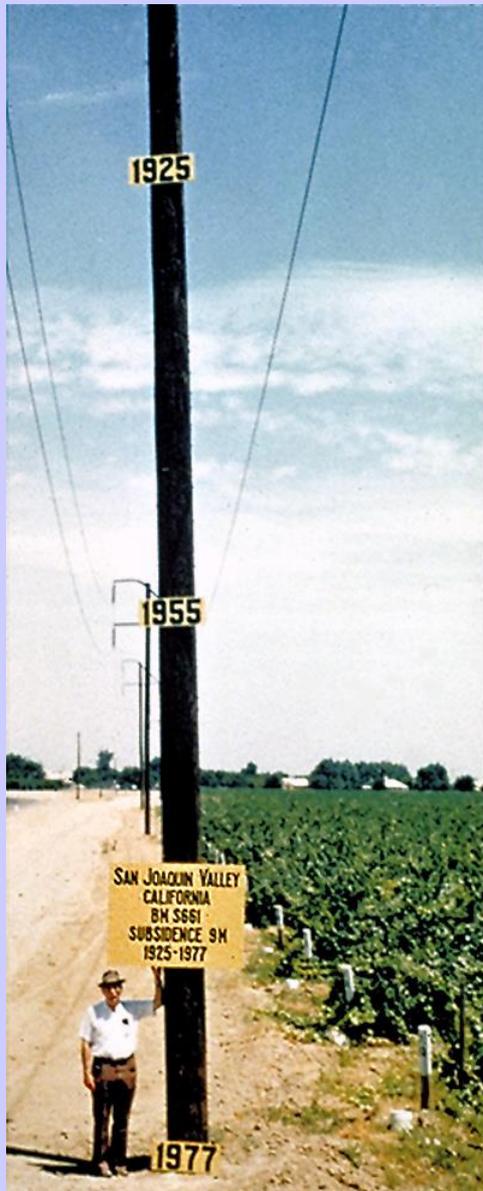
Groundwater Level Change* - Fall 2011 to Fall 2016



Expected Impacts of Multi-Year Drought

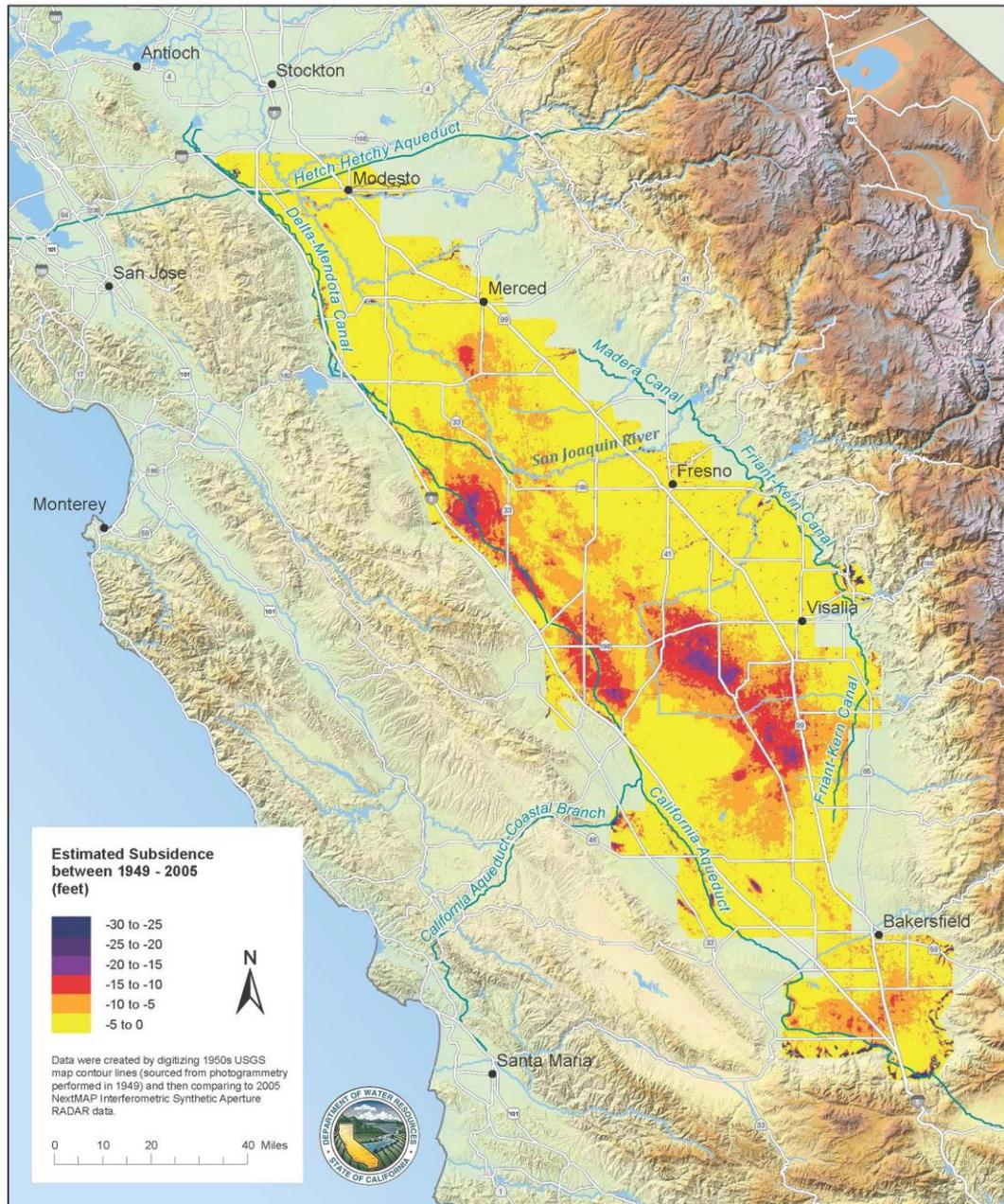
- **Unmanaged systems**
 - Risk of catastrophic wildfire (health & safety, economic)
 - Non-irrigated agriculture (livestock grazing)
 - Fish & wildlife (e.g., salmonids)
- **Managed systems**
 - Small water systems (health & safety)
 - Irrigated agriculture
 - Green industry (urban water supplies)
 - Fish & wildlife (e.g., wildlife refuges, salmonids)
 - Other environmental (e.g., **land subsidence**)

Subsidence Not a New Issue in San Joaquin Valley



1997 California Aqueduct Lining Raise

Estimated Subsidence in the San Joaquin Valley between 1949 – 2005



Subsidence & DWR Drought Preparedness

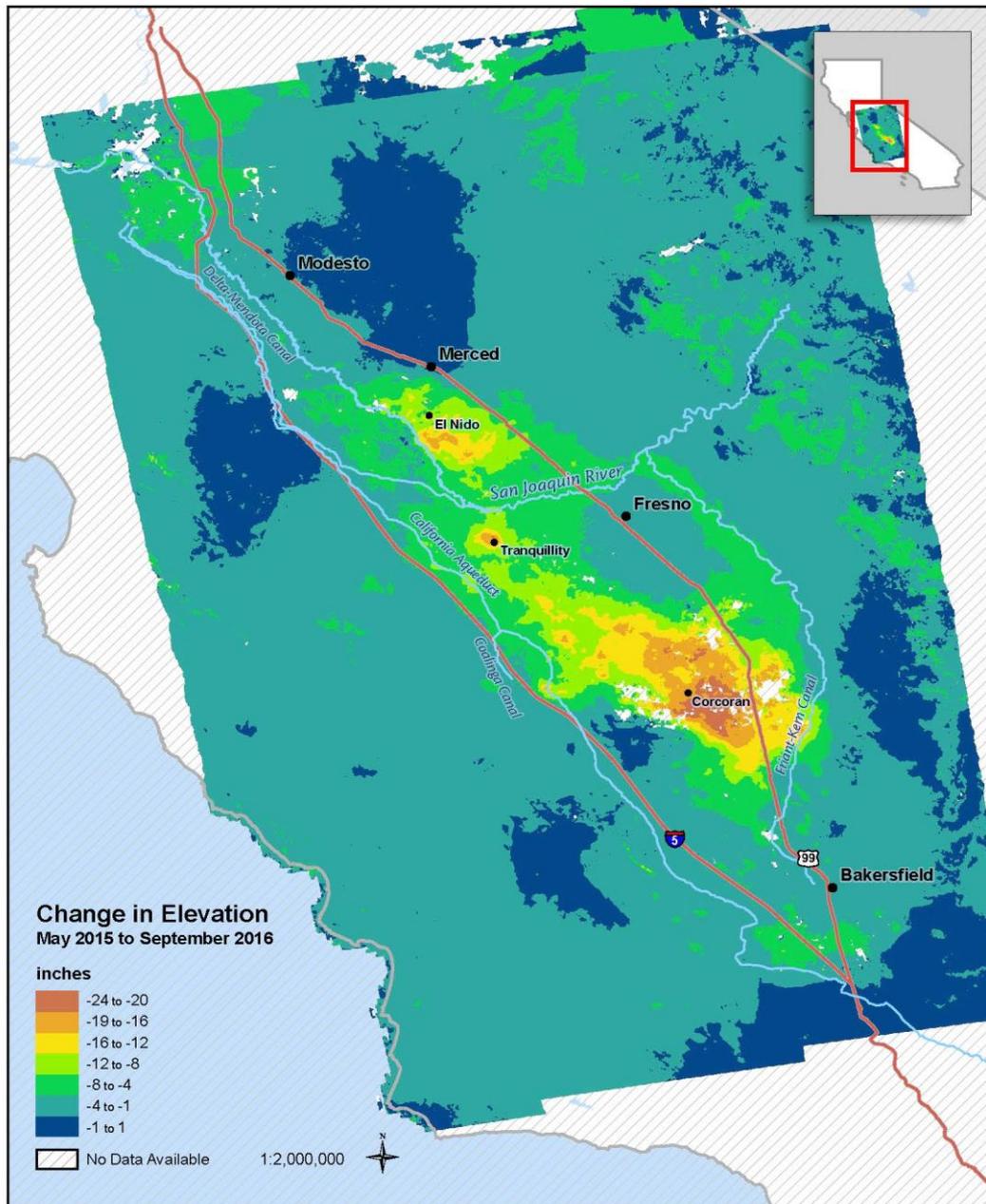
- Began discussions with NASA as part of NASA's California ARRA project in 2010-11
- Governor's drought emergency proclamation in 2014 supported DWR funding for NASA InSAR monitoring
- Focus of monitoring -- Where are the subsidence hot spots? **How is critical water infrastructure being affected?**

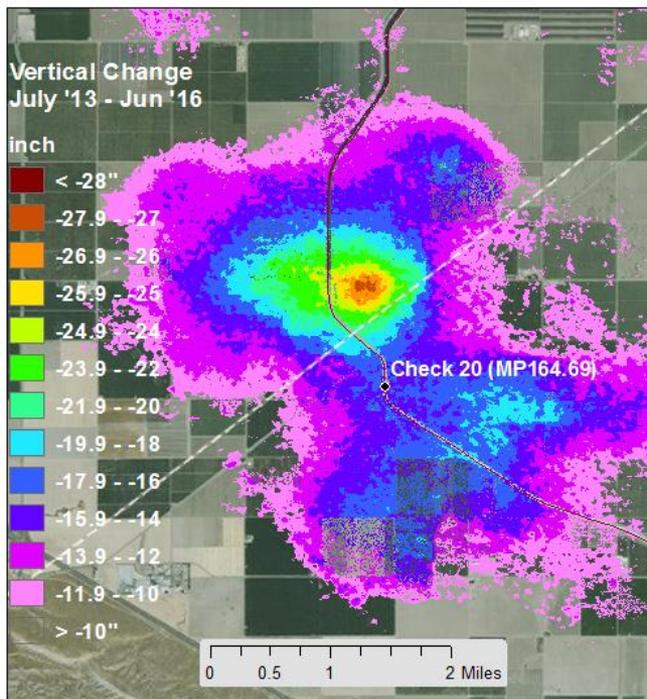
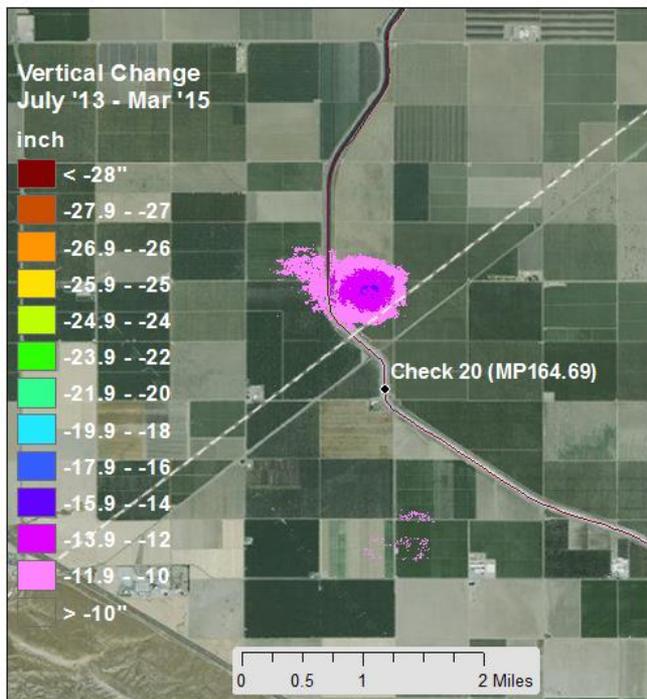
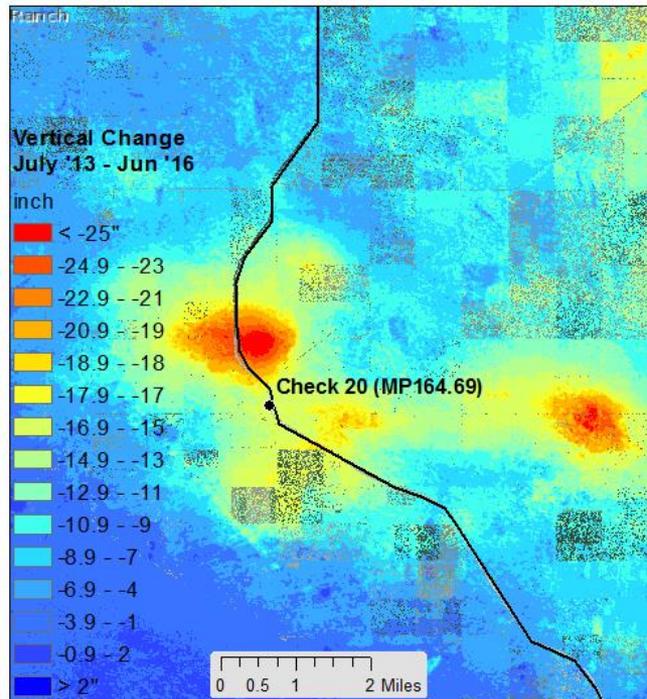
DWR-NASA Project Timeline

- DWR initial contract with NASA covered 2007-2010 (PALSAR satellite) & 2014-15 (Radarsat 2 satellite) in San Joaquin Valley & small portion of Sacramento Valley, plus UAVSAR (aircraft) in 2013-15 along California Aqueduct
- Subsequent contract amendment covered 2015-16, newly available imagery from Sentinel satellite beginning in 2015 greatly expanded spatial coverage
- New contract amendment for 2017-18 coverage

San Joaquin Valley Land Subsidence, May 2015 – September 2016

InSAR Data from Sentinel Satellite Mission, Processed by NASA JPL





Monitoring Results

- The good news -- InSAR monitoring did a great job of providing cost-effective synoptic coverage over a large geographic area
- Goal of hotspot detection and monitoring was met
- The bad news – observed subsidence rates were high
- Critical water infrastructure is located in high subsidence areas



CALIFORNIA DEPARTMENT OF WATER RESOURCES

NEWS FOR IMMEDIATE RELEASE

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Contact:

Jeanine Jones, DWR Interstate Resources Manager
(916) 653-8126 | Jeanine.Jones@water.ca.gov

Alan Buis, NASA Jet Propulsion Laboratory
(818) 354-0474 | Alan.Buis@jpl.nasa.gov

NASA Report: San Joaquin Valley Land Continues to Sink *Groundwater Pumping Causes Subsidence, Damages Water Infrastructure*

SACRAMENTO – New NASA radar satellite maps prepared for the California Department of Water Resources (DWR) show that land continues to sink rapidly in certain areas of the San Joaquin Valley, putting state and federal aqueducts and flood control structures at risk of damage.

“The rates of San Joaquin Valley subsidence documented since 2014 by NASA are troubling and unsustainable,” said DWR Director William Croyle. “Subsidence has long plagued certain regions of California. But the current rates jeopardize infrastructure serving millions of people. Groundwater pumping now puts at risk the very system that brings water to the San Joaquin Valley. The situation is untenable.”

A prior August 2015 NASA report prepared for DWR documented record rates of subsidence in the San Joaquin Valley, particularly near Chowchilla and Corcoran, as farmers pumped groundwater in the midst of historic drought. [The report released today](#) shows that two main subsidence bowls covering hundreds of square miles grew wider and deeper between spring 2015 and fall 2016. Subsidence also intensified at a third area, near Tranquillity in Fresno County, where the land surface has settled up to 20 inches in an area that extends seven miles.

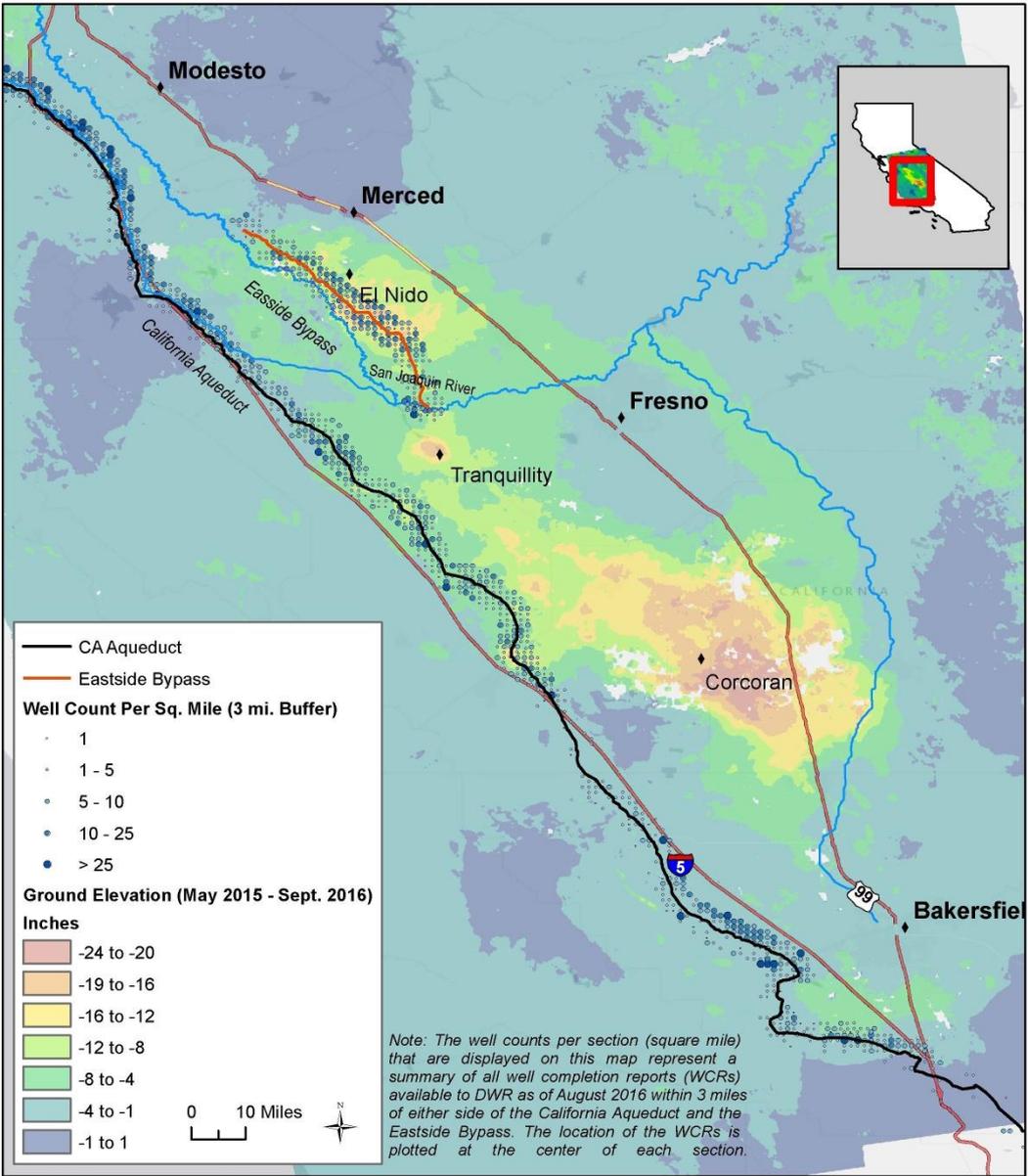
Additional aircraft-based NASA radar mapping was focused on the California Aqueduct, the main artery of the State Water Project, which supplies 25 million Californians and nearly 1 million acres of farmland. The report shows that subsidence caused by groundwater pumping near Avenal in Kings County has caused the Aqueduct to drop more than two feet. As a result of the sinking, the Aqueduct at this stretch can carry a flow of only 6,650 cubic feet per second (cfs) – 20 percent less than its design capacity of 8,350 cfs. To avoid overtopping the concrete banks of the Aqueduct in those sections that have sunk due to subsidence, water project operators must reduce flows.

The California Department of Water Resources (DWR), which operates the State Water Project, is analyzing whether the subsidence-created dip in the Aqueduct will affect deliveries to Kern County and Southern California water districts. If the State Water Project allocation is 85 percent or greater, delivery may be impaired this year due to the cumulative impacts of subsidence in the Avenal-Kettleman City area.

The NASA analysis also found subsidence of up to 22 inches along the Delta-Mendota Canal, a major artery of the Central Valley Project (CVP), operated by the U.S. Bureau of Reclamation. The CVP supplies water to approximately three million acres of farmland and more than two million Californians.

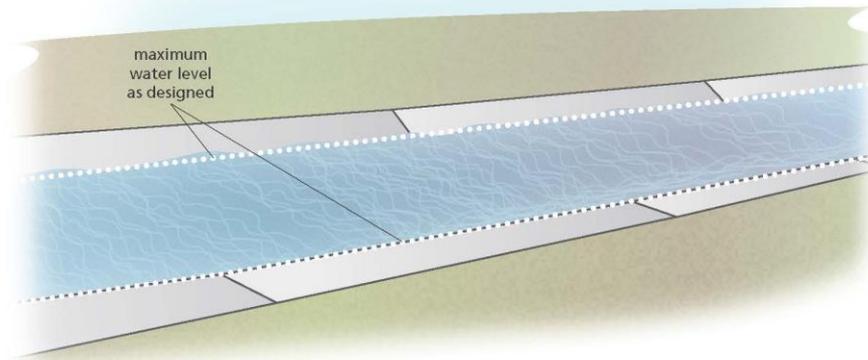
Also of concern is the Eastside Bypass, a system designed to carry flood flow off the San Joaquin River in Fresno County. The Bypass runs through an area of subsidence where the land surface has fallen between 16

San Joaquin Valley Land Subsidence, May 2015 – Sept. 2016 InSAR Data
 With Select Water Infrastructure and Well Completion Reports

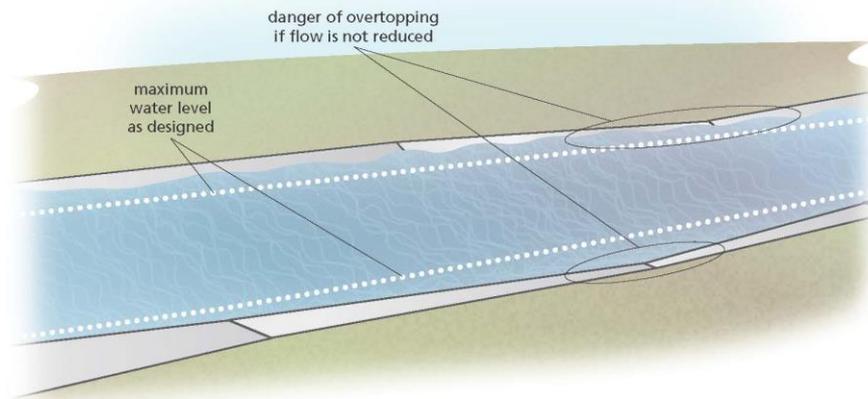


Subsidence Impacts to Flow in Canals & Flood Channels

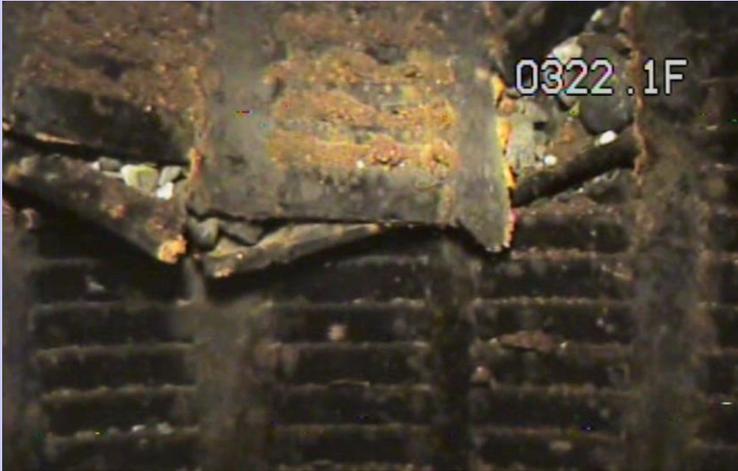
Aqueduct Before Subsidence:



Aqueduct After Subsidence:



Damage to Water Supply Facilities



And to Flood Conveyance Capacity

Merced Sun-Star

Sinking ground near El Nido could impact flood fighting

BY BRIANNA CALIX

MARCH 03, 2017 5:12 PM



Hanford Sentinel:

Fearing flood, Corcoran raises levee

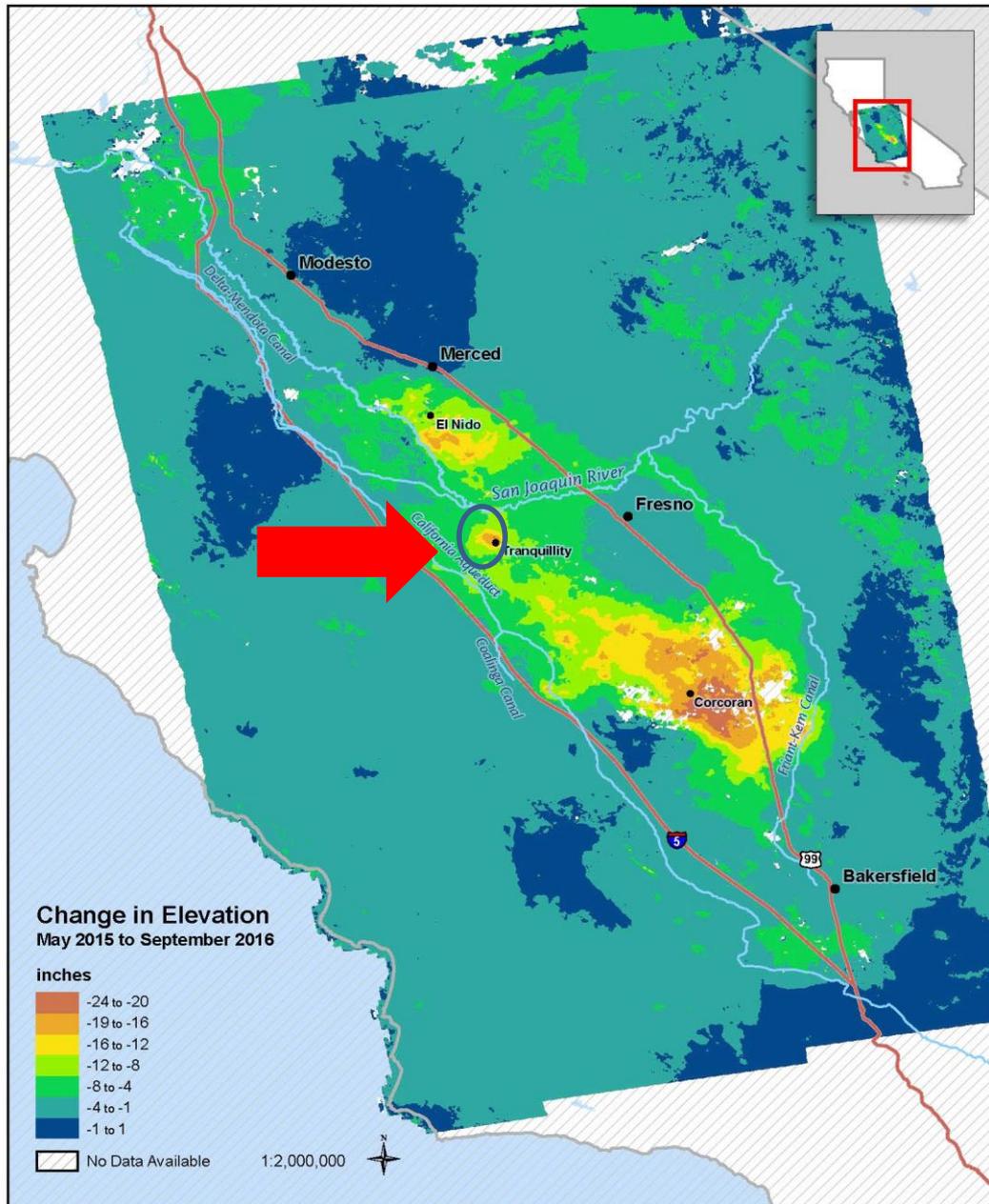
[Seth Nidever Staff Reporter](#)

Mar 10, 2017

- ▶ 14 miles of levee raise on Cross Creek & Tule River near Corcoran by Cross Creek Flood Control District
- ▶ \$14 million project, 4-foot raise
- ▶ Levees last raised in 2015, reported subsidence of 2 feet since October 2015

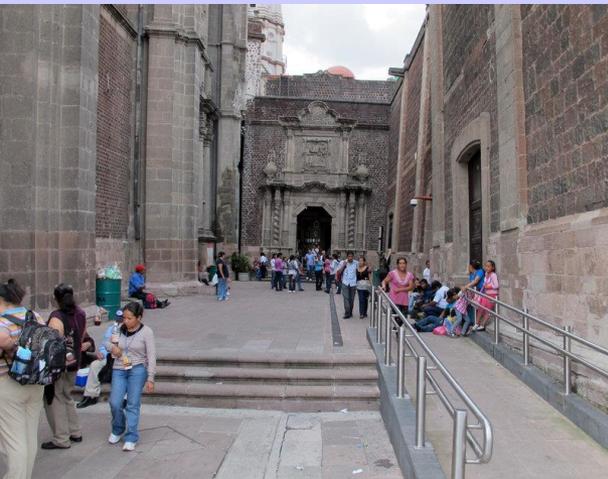
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InSAR Data from Sentinel Satellite Mission, Processed by NASA JPL



Need for Monitoring

- In developed urban areas, subsidence impacts can be relatively apparent
- In rural areas damages less obviously visible – damaged water well casings, impacts to flow capacity in canals and flood control channels



Data Gaps in High Subsidence Areas

