FLOOD: 2017 Winter Storm Flooding

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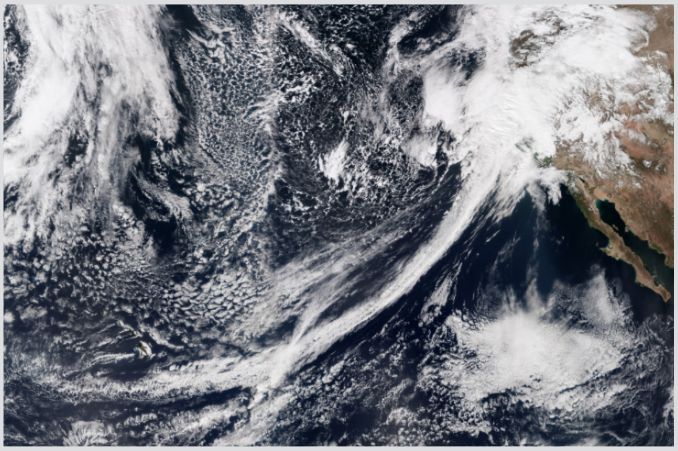
Water year 2017 was a tale of two extremes. After five years of drought conditions, California received historic amounts of precipitation and flooding in 2017.

Atmospheric Rivers Cause California Flooding

Beginning in 2010, California experienced a *drought* that lasted six years. The *drought* ended when winter storms came in 2017. These storms brought more rain than had been recorded in over 100 years and all in one winter season. The rainfall in some parts of the state was more than four times above normal! The weather system that caused most of the flooding during that time is called an "*Atmospheric River*," or a more commonly used term is "Pineapple Express." An *atmospheric river* is moisture in the sky that builds up in the tropical Pacific around Hawaii where it forms a "river" in the sky. Strong winds bring the *atmospheric river* across the Pacific. The "river" can dump as much as five inches of rain on California in one day. *Atmospheric rivers* can wallop the U.S. and Canada's West Coasts with heavy rainfall and snow. About 17 *atmospheric rivers* hit California that winter.

In 2017 much of the flooding that occurred was due to intense ground river flooding. Days of persistent rain began overflowing rivers that spilled over into flatlands. The year ranked as the wettest year ever for rain in Northern California at a record 94.7 inches. This is almost twice as much rain that the region usually gets in one year. The rain that fell in January and February caused some rivers to rise to their highest levels ever. These storms caused flooding across most of California. The flooding caused damage to *levees*, tested dams, and thousands of people had to be *evacuated* to escape rising water.



NASA satellite image of the *atmospheric river*. https://www.nbclosangeles.com/news/local/california-storm-winter-weather-flooding-landslides-snow/11800/ (accessed March 9, 2020).

Oroville Dam Tested

By February, heavy rainfall and peak inflows of water filled Lake Oroville, located in Butte County, California, to capacity. The lake was so full of water that as more rainwater entered the lake, it began to spill over the concrete flood control *spillway*, part of the rim of the dam that was designed to let water out and to protect the dam. This was the first time in history that floodwaters spilled over the flood control *spillway*. In the process of releasing water from the lake, the *spillway* was damaged, hampering more releases and causing the lake (*reservoir*) to fill. These water releases caused *erosion* of the hillside below the *spillway*.

Ruins of the main *spillway* at Oroville Dam reveal badly eroded areas of rock beneath the concrete structure. (CA Department of Water Resources) https://www.kqed.org/news/11608745/oroville-dam-spillway-ferc-safety-review-2014-ruled-out-spillway-failure (accessed March 9, 2020)

Oroville Dam emergency *spillway* on Sunday, Feb. 12, 2017, the day officials warned that the *spillway* was in danger of failing. https://www.mercurynews.com/2017/02/13/oroville-dam-how-did-we-get-to-this-point/ (accessed March 9, 2020).

Due to the uncertainty of the weather, the damaged *spillway*, and the potential of *downstream* flooding should something happen to the dam, local authorities decided to *evacuate* 188,000 people from their communities *downstream* of the Oroville Dam. This evacuation was one of the largest evacuations ever in California.

Why *Evacuate* Citizens?

If the dam were to fail and release all the lake water at one time, scientists and engineers predicted that the wall of water could be up to 30 feet high! They believed that this wall of water would cause significant damage to property in the Feather River *watershed* and endanger the lives of thousands of people living *downstream* from the dam. There was widespread flooding throughout California during the winter storms of 2017; however, the events that happened at Lake Oroville were considered to be the most dangerous. Authorities, including local public safety officials, decided to *evacuate* people living where they thought the wall of water would go. Over 188,000 people were *evacuated* to higher ground from 3 counties and 9 different cities including Oroville, Gridley, Live Oak, and Marysville.

Additional Floods of 2017

- **Maxwell, CA:** In the early morning on February 18, flooding on Stone Corral Creek flooded the town of Maxwell in Colusa County. More than 100 residents had to be *evacuated* by boat after water filled the streets.
- **Russian River:** In early January, the Russian River flooded about 500 houses. Over 3,000 people were *evacuated*. Flooding in the Russian River Valley caused millions of dollars in damage.
- **Anderson Dam:** The Anderson *Reservoir* overflowed in February. The resulting flooding led to the *evacuation* of 14,000 people and caused millions of dollars in damage.
- **Manteca *Levee* Breach:** On February 20, a *levee* broke, and 500 people were *evacuated*.
- **Big Sur Mudslides:** Multiple mudslides led to a long stretch of the Pacific Coast Highway closing. The highway took over a year to repair and cost about $40 million. Mudslides are not considered a flood yet can occur with heavy rains in hilly or mountainous areas.
- **Southern California:** February storms were the strongest in at least 10 years. Five people died in the Los Angeles area as heavy rain flooded roads and cut power to 110,000 homes.

Types of Floods

According to the National Severe Storms Laboratory, a National Oceanic & Atmospheric Administration division, there are five types of floods, which include:

A San Jose, CA, neighborhood floods on February 22, 2017 (California Department of Water Resources).

1. **River (Fluvial) Flooding** occurs when water levels rise over the top of river banks due to excessive rain from tropical systems making landfall, persistent thunderstorms over the same area for extended periods of time, combined rainfall and snowmelt, or an ice jam.
2. **Coastal Flooding**, or the inundation of land areas along the coast, is caused by higher than average high tide and worsened by heavy rainfall and onshore winds (i.e., wind blowing landward from the ocean).
3. **Storm Surge Flooding** is an abnormal rise in water level in coastal areas, over and above the regular ocean tide cycle, caused by forces generated from a severe storm's wind, waves, and low atmospheric pressures.

4. **Inland Flooding** occurs when moderate precipitation accumulates over several days, intense precipitation falls over a short period, or a river overflows because of an ice or *debris* jam or dam or *levee* failure.

5. **Flash Flooding** is caused by heavy or excessive rainfall in a short period of time, generally less than six hours. Flash floods are usually characterized by raging torrents after heavy rains that rip through river beds, urban streets, or mountain canyons.

Flooding Hazard Risk in California

Flooding is the second most destructive hazard in the state of California. Floods can occur in various ways to include river and stream overflows, sea level rise and coastal flooding, tsunamis, and even *levee* or dam failures. Since 1950, floods have accounted for the second highest combined losses and the largest number of deaths. Every county experiences some level of flooding, and every flood poses some threat to the community.