GAGE GAP

Stream gages provide essential information about one of California's most precious resources - water. Gaps in the stream gage network make it difficult to ensure that both people and nature are getting water when and where they need it. This report highlights the major gage gaps and ways to fill them.

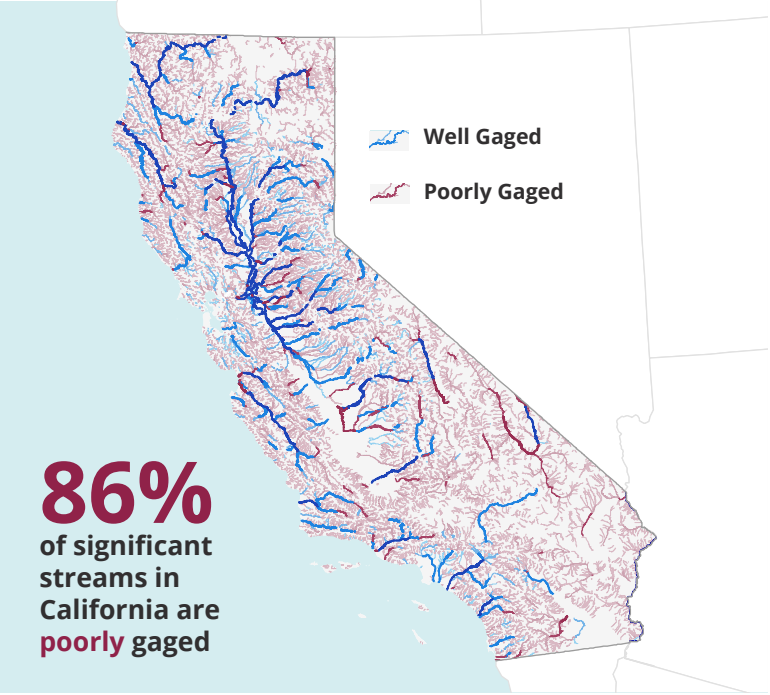
The Nature Conservancy

bit.ly/gage_gap

TRACING WATER PATTERNS

Following a difficult five-year drought, California just had one of the wettest winters on record. The state is famous for its highly engineered water system, which moves millions of gallons of water from north to south and east to west. Thirty-nine million people and our $47 billion agricultural industry[1] rely on that water, not to mention wildlife from the Sierra to the sea.

And yet we have surprisingly little data about how much water is moving through our streams at any given time. There are over 3,600 locations in California where stream gages have been active at *some point*, but only 54% have been active recently[2]. And even fewer of those provide the kind of rich, real-time reporting needed to manage what is arguably our state's most precious and contentious resource.



WHY GAGES?

The recent Oroville dam incident highlighted a surprising gap. The nation's tallest dam serving the most populous state is served by a gage network that can take months to publish data on water flow and levels, long after the flood danger to hundreds of thousands of people has passed.

Coyote Creek in San Jose was also caught off guard by recent flooding. Local residents were not promptly notified of potential flooding. Many only became aware of the danger after seeing the water rise outside their living room windows. Not only were additional gages needed, real-time reporting, if available to the public, would have provided an opportunity for more notification as well as citizen-driven awareness of the situation.

"It's pretty bleak when you look at the number of watersheds with listed species that have no gage and very active diversions."

Of course, danger to people is not the only need when it comes to stream gages. Across the state, countless sensitive species and unique habitats depend on adequate streamflows. But without data, it's impossible to know if those important landscapes are getting the water they need. "It's pretty bleak when you look at the number of watersheds with listed species that have no gage and very active diversions," said Erin Ragazzi of the State Water Resources Control Board.

[1] California Department of Food and Agriculture, 2016 Crop Year Report, www.cdfa.ca.gov/statistics/
[2] Active gages on NHD streams with a drainage area >= 5km^2, excludes reservoirs, lakes, and artificial waterways

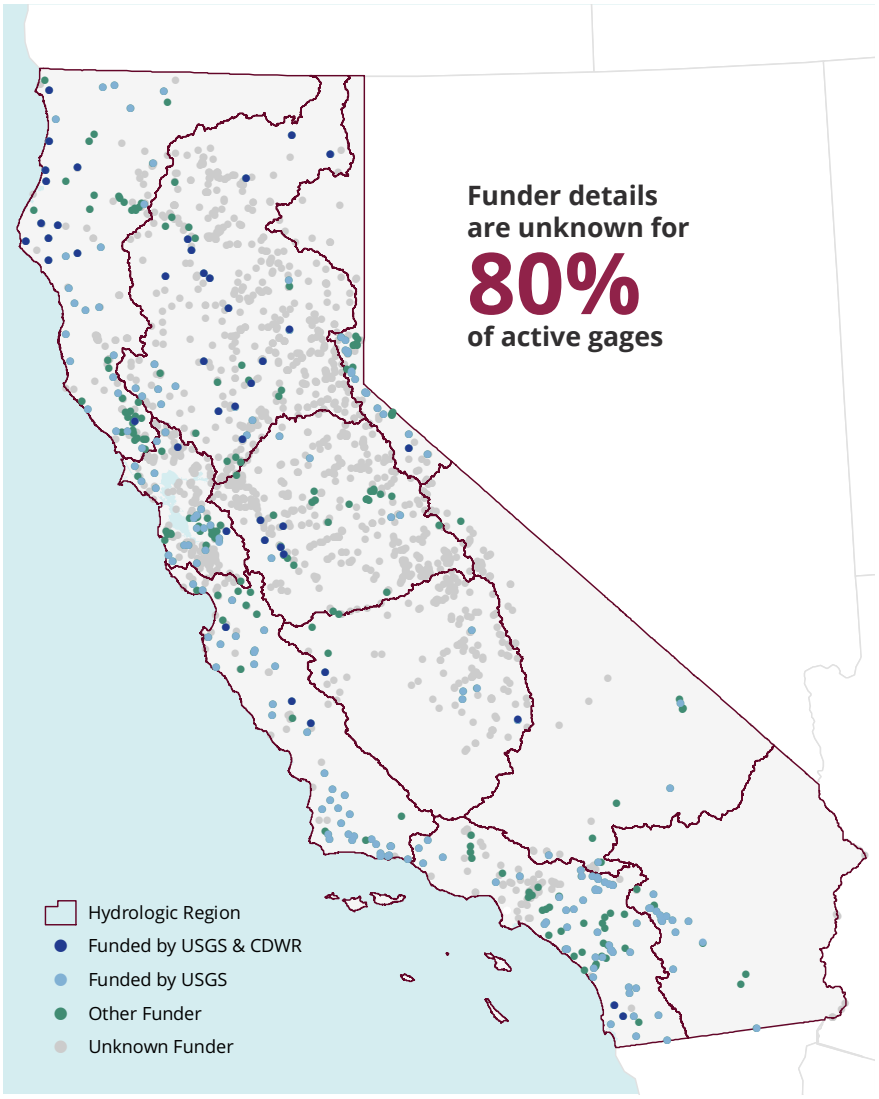
DATA NEEDS AND LIMITATIONS

Comprehensive data on gages does not exist in California. Despite the various efforts to assemble gage data, there is no single authoritative database on gage locations. So although there is a large quantity of data available about gages in California, that data is challenging to harmonize and analyze if one wants a complete survey of California's gage network.

Most of the available data sources include similar key attributes, such as active/inactive, flow in cubic feet per second (CFS), temperature, and gage owner/manager. But the formats and standards for those values are disparate, and many gages are present in multiple data sources. Duplication of gages and heterogeneity of gage attribute data make it very difficult to combine existing data into a comprehensive database for analysis.

And that's only to assess gages on their own. To assess the quality of a stream gage network, we need to know which gages are on which stream reaches, which then allows us to define gaps in the network. Unfortunately, gage locations are approximate in most data sets, and stream networks are rather complex. Small errors in latitude/longitude coordinates can lead to gages' being assigned to the wrong stream reach. While such errors are unlikely to be a problem for consumers of data from a small number of known gages, location inaccuracy and lack of confidence in the association between gage locations and stream reaches become a bigger problem as we attempt to analyze larger sections of the overall network.

To conduct the Gage Gap analysis, we developed a database of gages, rivers, and their relationships. While the individual data points may have some inaccuracies and omissions, on a regional and statewide scale, the data support meaningful analysis and needs assessment.



Existing Stream Gage Databases:

- California Data Exchange Center (Department of Water Resources)
- USGS Gages II
- USGS Web Service / API
- National Streamflow Information Program
- National Water Information System
- National Oceanic and Atmospheric Administration

DEFINING A WELL-GAGED STREAM NETWORK

California must prepare for increases in both droughts and floods, and for more effective water management across all year types to maximize the benefits of its limited water supply. Understanding the state of our stream flows is critical to such preparedness, but our current gage network is inadequate to address this challenge.

IN THIS REPORT

Significant stream = drainage area of 5km^2 or more.

Well-gaged stream = a significant stream with a gage close enough on the same stream network to estimate the flows.

CALIFORNIA'S CURRENT GAGE NETWORK	WELL-GAGED NETWORK
14% of the state's significant stream segments are well-gaged.	**100%** of significant stream segments are well-gaged.
Only gages run by large agencies provide readily available data to the public.	Delivers **publicly** available data from all gages.
Only a **subset** of gages report data in real-time.	**All** gages report data in real-time.
Is poorly funded and even **finding data on groups currently funding gages is difficult.**	Is **adequately funded** for installation, maintenance and repair to ensure **long-term** data collection.
Too often **fails to report key variables:** flow, temperature, drainage.	Collects and **reports key variables** in a standardized format on an established schedule.
Only a **subset** of gages provide easy access to historical data.	Provides **historical data** for the majority of gages.

IMPORTANT NOTES

Though some inactive gages have been abandoned for good reason (poor siting or subsequent changes in the stream network), most gages that go offline do so for a single reason: lack of funding.

When a gage goes offline, we lose not only the current data, but also the ability to compare current trends to historical data points from the same site. That historical data is a key need as climate extremes become more frequent and damaging.

CURRENT DAY, A DECLINING SYSTEM

With federal and state dollars stretched thin, funding continues to be uncertain. Over the past 50 years, despite advances in technology, the status of California's stream gage system has varied widely and experienced an overall decline[3]. California is a leader in technology and the most populous state—yet gages and the data they should be reporting lag behind, with nearly half of gages once installed now silent.

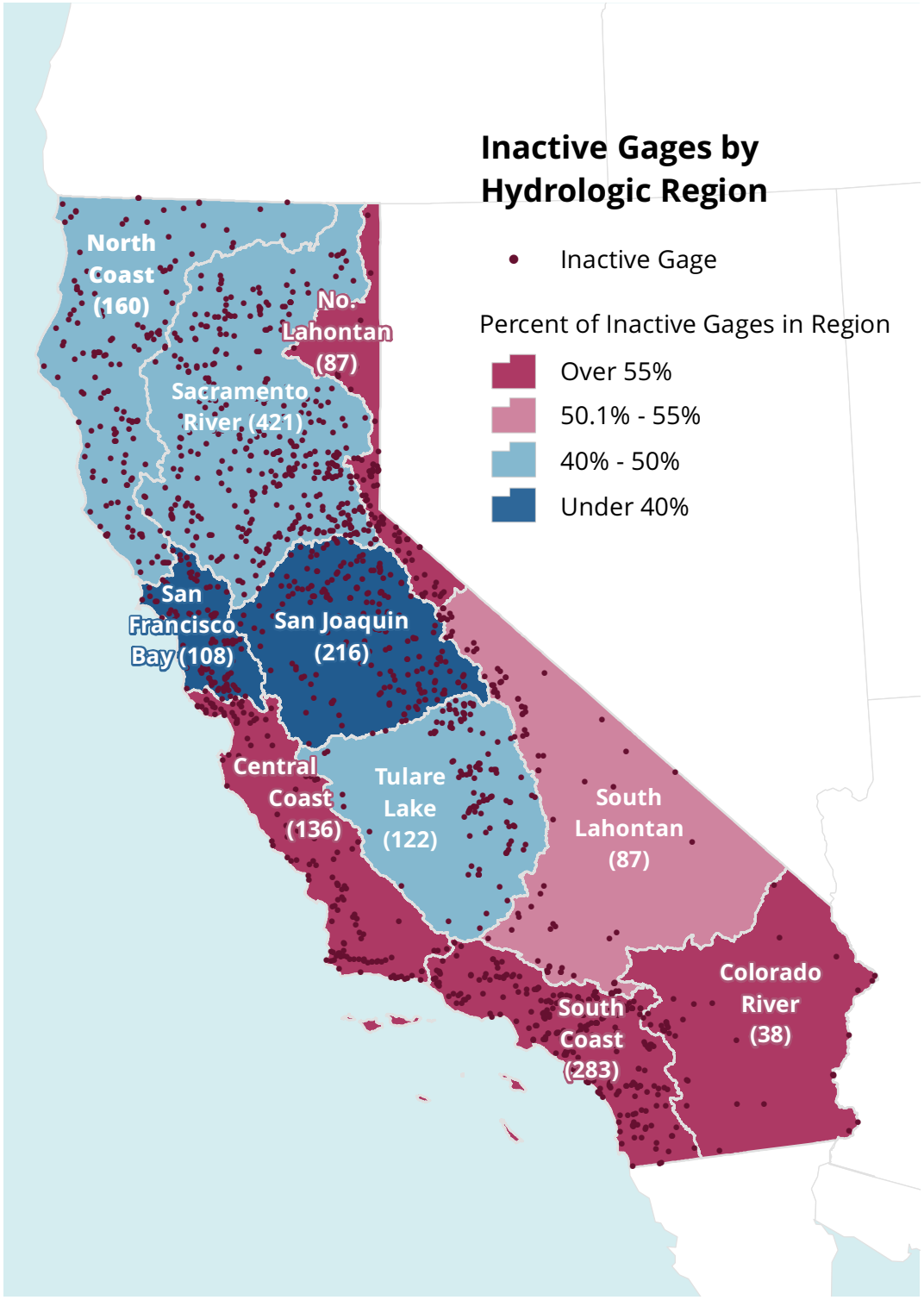
46%
of **gages** in California are **inactive**

↓

86%
of the stream kilometers in the state are **poorly gaged**

THE NATIONAL PICTURE

Across the nation USGS gages are also in decline – though the percentage of gages reporting in real-time from active gages has increased. From Water Year 2008 to Water Year 2009 the total number of USGS stream gages fell to 7,825. The number of losses of long-record stream gages has risen steeply in the past few years from Water Year 2005 to Water Year 2009 384 long-record stream gages were discontinued[4].



[3] The Gage Gap database identified 3,628 gages of which 1,658 were inactive.
[4] USGS National Streamflow Information Program (NSIP), Trends in the Size of the USGS Streamgaging Network 2014, water.usgs.gov/nsip/trends9.html

WHAT DOES IT COST?

For a gage to be effective in helping inform water management during climate extremes and highly variable flows, it should record quality data, report key variables (such as flow and temperature), and make its data accessible to the public promptly. Robust gages that meet these standards average $25,000 to install and $15,000–$20,000 per year to maintain. Such gages are often referred to as "gold-standard gages."

Gold-standard gages

- Record quality data
- Report key variables (such as flow and temperature)
- Provide real-time publicly accessible data

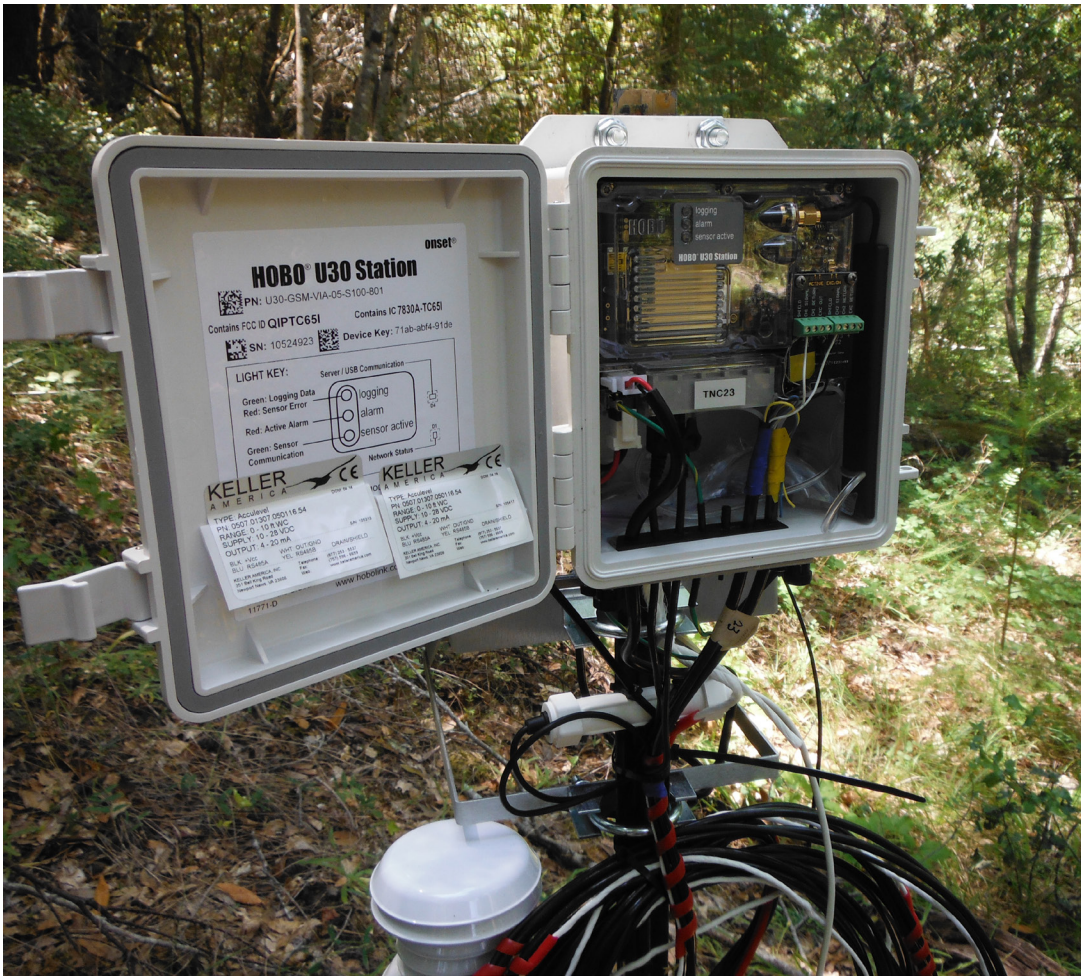
As technology and hardware generally have become more affordable, with the last decade's supercomputers now in our pockets, it's a common misconception that gold-standard gages should also fall in price.

However, much of the cost in such a gage is not in the hardware but in the expertise to manage and adjust both hardware and raw data to account for the highly changeable conditions in an active streambed.

The annual investment in gold-standard gages is really an investment not just in hardware but also in the expertise to maintain and interpret real-time data from dynamic natural systems.

In interviews with experienced gage operators, we heard statements like this more than once:

"If you have someone learning how to do stream gages, all the data they collect for the first few years is essentially worthless. You have to prove to someone that the data is good. The documentation and the training is where people fall flat."

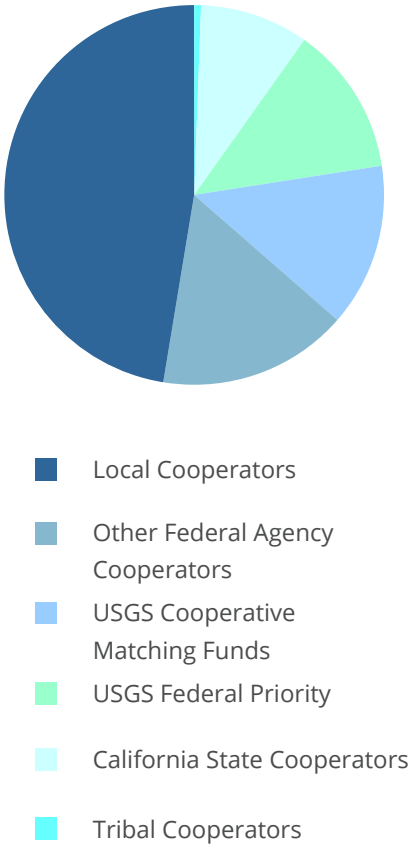


LOCAL AGENCIES PROVIDE MOST GAGE FUNDING

Although the largest individual sponsor of gold-standard gages in California is the **USGS**, it works largely in partnership with other agencies that provide funding to support gages. **At least 57% of USGS funded gages are also funded by a local agency**[5].

USGS'S CALIFORNIA GAGE BUDGET FY2017

LEVEL	TYPE	AMOUNT[6]	% TOTAL
Local	**Local Cooperators**	**$4.1M**	**47.4%**
Federal	Other Federal Agency Cooperators	$1.4M	16.2%
Federal	USGS Cooperative Matching Funds	$1.2M	13.9%
Federal	USGS Federal Priority	$1.1M	12.7%
State	CA State Cooperators	$0.8M	9.2%
Tribe	Tribal Cooperators	$0.05M	0.6%
Total		**$8.65M**	



The table above gives us an overall sense of the funding landscape. But to better understand the gage landscape in California, it's critical to know which specific agencies are already funding particular gages. Such data is available for **only 20% of active gages in California.**

The information we do have demonstrates that a diverse array of local agencies are the most promising source for increased funding of new gages.

That in turn means that regional outreach is the most likely approach to increasing the network of gold-standard gages. The Gage Gap data and web mapping tool provides an excellent starting point to find out who is already funding in certain areas and where the most important opportunities lie in re-activating inactive gages.

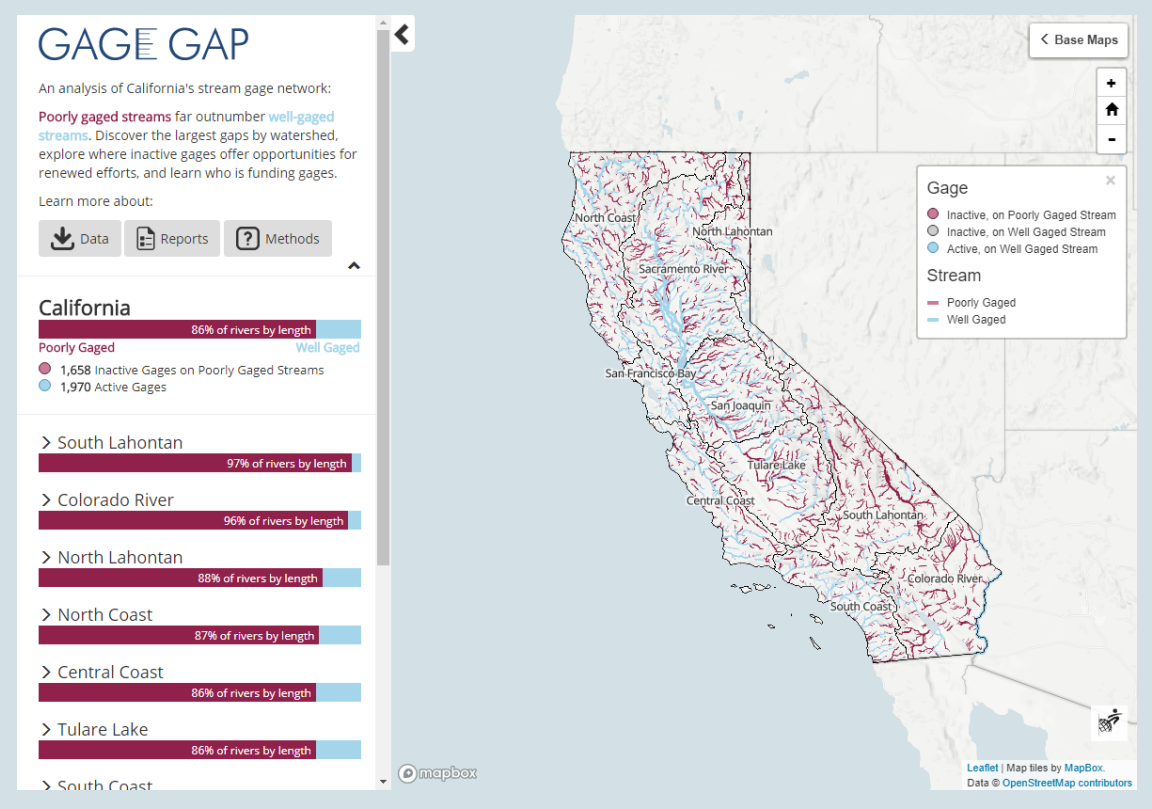
[5] USGS funds 219 gages in California, of which 125 are in partnership with a local agency.
[6] Based on correspondence with D. Crilley of USGS and G. Smith of DWR. Funding estimates were generated from internal data designed for a different purpose, data omissions or errors are possible.

HELP CLOSE THE GAGE GAP

gagegap.codefornature.org/

The **Gage Gap** application provides an immediate statewide view of the gage network, as well as information and summaries at state, regional, and local levels. Statewide views can help frame policy discussions and frame overall need. But that need across the whole state is so large — 86% of rivers by length are poorly gaged — that it's challenging to consider funding solutions that are comprehensive and realistic within the near- or medium-term.

That's why we made sure that Gage Gap is flexible for multiple scales. That helps gage funding discussions focus at the right level for particular policy decisions. Most importantly, Gage Gap allows local funders to look closely at the specific local region where they are working, to assess local need, greatest **impact**, and **potential funding partners**.



Key features Gage Gap offers to help support local collaboration on gage funding:

- Use the tool to view **gage gaps by watershed**. Quickly see which watersheds cover the largest drainage areas and have the largest gage gaps.
- Find **inactive gages on poorly gaged streams**. Gage experts agree that existing inactive gage sites should be a priority for new gages, especially because historical data is available at those sites. Use Gage Gap to find inactive gages on significant streams and consider how restoring them would improve the network.
- And finally discover **which funding groups support which gages** in your area of interest to identify groups you might be able to collaborate with to fund new gages. This allows highly detailed opportunity analysis at the level of single inactive gage sites tied to specific stream reaches draining areas of known size.

By spanning scales from the whole state to hydrological region to individual watershed, Gage Gap helps frame gage funding needs at the statewide, regional, and local scales. The tool ties inactive gage sites to stream reaches and calculates priority by drainage area, which in turn allows those seeking gage funding to quickly find those inactive gages with the greatest drainage area impact, and then find nearby funders who might help support that gage site.

LOOKING AHEAD

Improvements in the stream gage network are vital to California's social, environmental, and economic well-being. With increased funding for installation, maintenance, and data tracking, California can have a robust stream gage network that:

- Keeps Californians safe
- Monitors vital water resources
- Informs research, policy, and planning

With **Gage Gap, the full array** of potential funders and supporters of stream gages can find the specific areas and partners where resources can meet the greatest needs for the least expense.

Choose from Gage Gap's 10 hydrological regions in the list or the map to begin exploring the gage gaps in your area:

Summary reports are available for each region:

- Central Coast
- Colorado River
- North Coast
- North Lahontan
- Sacramento River
- San Francisco Bay
- San Joaquin River
- South Coast
- South Lahontan
- Tulare Lake

DATA QUALITY AND PROCESSING

As discussed in the data section, comprehensive data on gages in California is not readily available. For this report a composite database was created from major agency and compiled data published by: CDEC, USGS, NOAA, NWIS, NSIP, and LADWP. The figures in this report are based on a resulting database after the removal of duplicate gages between data sets were reviewed for active reporting on flow.
Agency data was available from USGS and CDEC, but is largely incomplete.
The statistics related to funding are best estimates and subject to revision should more information become available.

Contacts: Kirk Klausmeyer kklausmeyer@tnc.org
Amanda Recinos amanda@greeninfo.org

GreenInfo Network