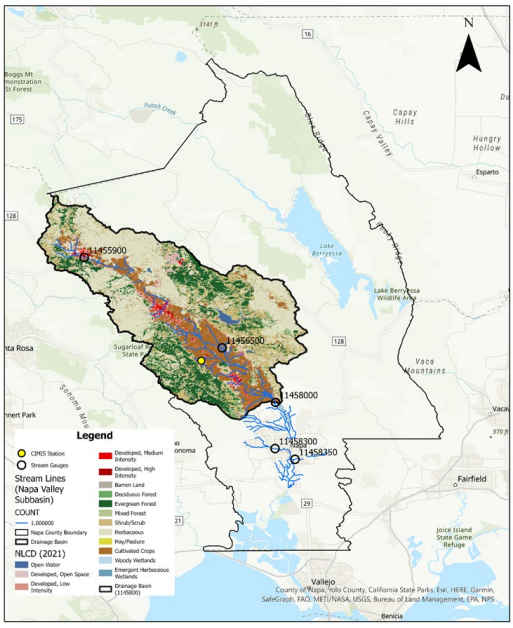
On the close relationship between precipitation and streamflow variations for Napa County

Compiling different datasets at Napa brings historical insights on water signatures.

A history of stream monitoring at Napa

The United State Geological Survey (USGS) has collected water-resources data (e.g., gage height, streamflow, water qualities) at around 1.5 million sites in and out of the conterminous United States (USGS, 2016). Within Napa Valley Subbasin, there are five USGS monitoring gauges, one currently in service (ID: 11458000), and four with historical records (IDs: 11458350, 11458300, 11456500, 11455900) before 2000.

Figure 1. Napa County Stream and Rainfall monitoring network



The gauge currently in service, which has a drainage area of 566.3 km^2, covers 28 % of the Napa County area (see Fig.1 as a comparison). Collecting data at a temporal resolution of 15-min, it provides rich information on streamflow response in a changing climate. The streamflow, as well as its baseflow component (delineated using the *grwat* package, R Core Team, 2023), were shown in figure 2.

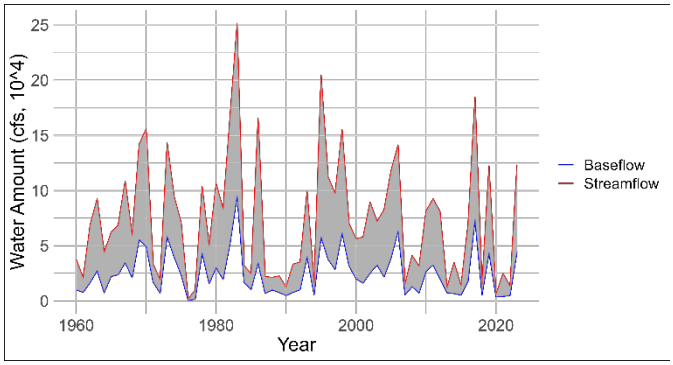


Figure 2. Streamflow and baseflow at Napa long-term stream gage site (USGS ID: 11458000)

CIMIS Station on weathering data

The California Irrigation Management Information System (CIMIS), overseen by the California Department of Water Resources (DWR), has a monitoring network of over 145 automated weather stations across California. At Napa County, the CIMIS station is located in between of the Walnut Dr and Oakville Grade Rd (station location is marked with a yellow circle in Fig.1), near the UC Davis Viticulture and Enology Department's Oakville

Station. The meteorological data at the CIMIS station dated back to 1989.

Precipitation vs. Stream?

In general, a wet year expects to bring more streamflow (r = 0.80) as well as baseflow (r = 0.71) at Napa (Fig.3). One may wonder, why more precipitation also brings more baseflow, which is more likely to be directly contributed by groundwater? Several mechanism could likely explain this: first, the recharge between stream and groundwater is bi-directional. During high-flow period, streamwater recharges the groundwater just as groundwater recharges streams during low-flow period. Second, as more precipitation infiltrates into the soil during storm events, it replenishes the belowground aquifer.

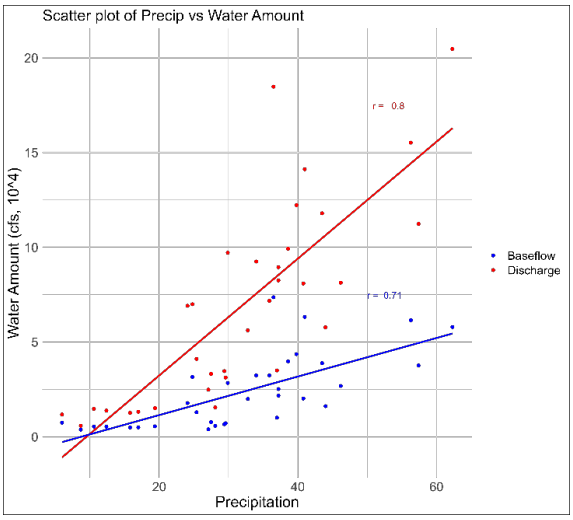


Figure 3. Scatter plots between precipitation, baseflow and discharge for selected drainage area.

To strengthen our conclusion, linear regression models were built and run on selected variables, all directly accessed from the CIMIS station. The most significant variable was still precipitation (p < 0.01). Other variables, such as evapotranspiration temperature, humidity, and wind speed, are not significant in predicting streamflow variabilities (p > 0.01).

The insights gained from this simple statistical analysis could be the bedrock for a series of future analysis. For example, what is the impact of land use change on streamflow generations? What is the response time of baseflow to a suddent, prolonged drought? A constant efforts of compiling and synthesizing different hydrologic datasets could provide invaluable insights into streamflow generation processes.

Implications for Napa Water Managers

Through a simple rainfall-runoff analysis on annual discharge and precipitation data, a direct evidence of precipitation on discharge and baseflow was found for the Napa Valley Subbasin over the past 32 years (1990 – 2022). As precipitation becoming more variable in the future, water managers should be prepared to cope with more dynamic streamflows, and consider the ecological impacts of stream dryness for in-stream habitats.

> *"Highly variable precipitation means highly variable streamflow in the future for Napa."*

References

U.S. Geological Survey, 2016, National Water Information System data available on the World Wide Web (USGS Water Data for the Nation), accessed [June 10, 2012], at URL [http://waterdata.usgs.gov/nwis/].

Claimers