Executive summary

# Overview

Ephemeral streams lack surface flow for most of the year and are common features of hydrologic networks in arid regions of Southern California. These streams drain large areas of watersheds and can greatly influence the quantity and quality of downstream waters. However, ephemeral streams are generally excluded from regional assessment programs due to lack of assessment tools. For example, there are no reliable maps that show where ephemeral, intermittent, or perennial streams occur in Southern California. The assessment of non-perennial streams, in addition to traditional monitoring of perennial waters, is critical for developing a complete picture of watershed health.

Identifying the locations and extents of ephemeral streams is the first step towards more comprehensive assessments. Existing maps do not adequately represent which streams are ephemeral vs. those with longer flow durations. Knowing the extent and locations of these streams is important to evaluating the ability of existing assessment tools to characterize hydrologic and ecological conditions and to support development of new assessment tools.

Stream maps that are currently available are insufficient to describe the extent and location of ephemeral streams. Existing map products are typically created by manual photointerpretation or based on estimates of flow accumulation with elevation changes. Maps produced using both methods will under-represent ephemeral streams or provide inaccurate locations. Streams may not be visually identified with photointerpretation or maps based on elevation layers may have poor sensitivity in low gradient environments.

The Santa Ana Regional Water Quality Control Board (RWQCB) has recently investigated the use of stream periodicity models to map and describe ephemeral streams in Southern California. These models improve on traditional mapping methods by estimating the likelihood of perennial vs. ephemeral flow at every stream reach in the drainage network. Building on earlier efforts in the San Diego region, this report summarizes efforts to develop and apply stream periodicity models in four watersheds of the Santa Ana region, plus the adjacent San Gabriel watershed. The objective of this application is to better characterize non-perennial streams in this highly developed watershed, in addition to understanding the abilities of existing tools to characterize flow conditions in different watersheds.

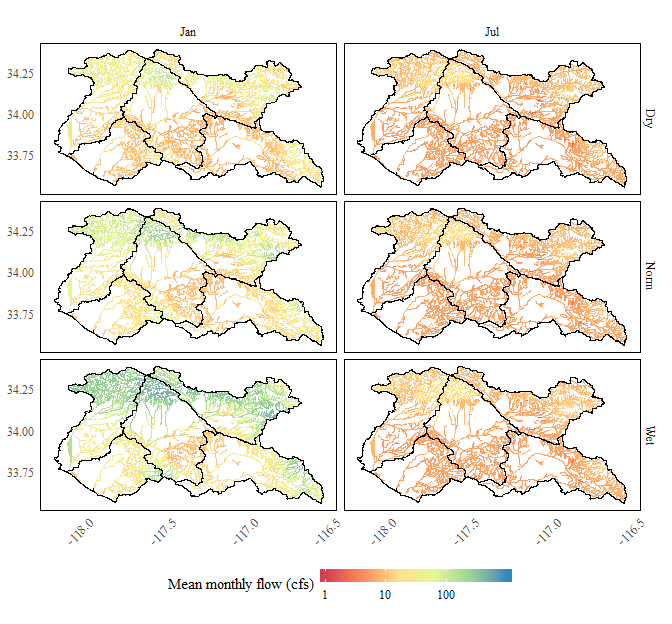
# Key findings and products

Historic (pre-developed) flows were estimated by modeling stream discharge at 58 reference gauges from arid regions of southern and central California. This model predicts mean monthly flow under wet, normal, and dry conditions, based on watershed characteristics (such as area and geology) and climate data. Because the model was calibrated with reference gauges, predictions reflect undisturbed conditions at catchments that have undergone conversion to urban or agricultural uses. A second model was then developed to estimate likelihood of change from historic conditions (i.e., inflated or diminished flows) based on land cover. Both models were applied to all stream segments in the Santa Ana region, providing maps showing historic and present-day hydrologic conditions.

**Ephemeral streams are likely to change from year to year**

Estimates of stream flow vary considerably both throughout the year, and across climate conditions. Static classes of flow duration (e.g., "perennial", "nonperennial") are unlikely to characterize a stream accurately. A probabilistic approach (e.g., "likelihood of flow") may provide a more meaningful way to characterize flow duration .

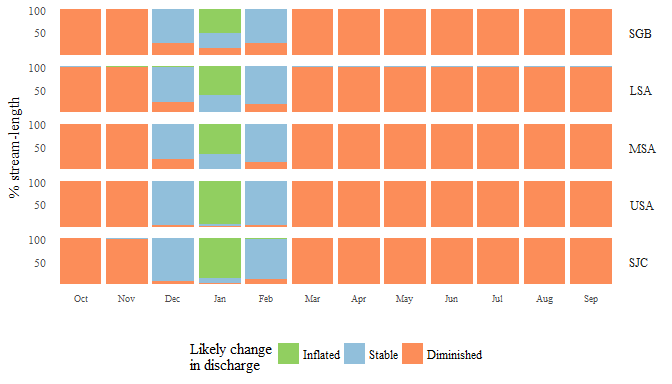
The predictive models were able to produce maps of the relative likelihood of short vs. long flow duration. Somewhat higher estimates of flow were predicted than is typically encountered in undeveloped portions of the region—particularly during low-flow conditions. However, the relative patterns were correct, indicating that the maps and models are most useful for estimating relative extents within the Santa Ana region.



Estimates of stream flow under reference conditions vary by month, as well as climatic conditions.

**Developed land use leads to reduced stream flow in most years**

Models estimated widespread changes in streamflow from historic conditions. Flows may be reduced at most streams for most of the year, although some streams may have inflated flows in winter months. These changes are typical of urbanization, where impervious surfaces increase peak flows and decrease baseflows, leading to a flashier hydrograph. Conditions in wet years may be somewhat more stable than normal or dry years.



In all watersheds, stream-flow reduction (red) from historic levels may be pervasive for most months of the year. Stable conditions (blue) may be more common in winter months, while inflated flows (green) only occur during the winter. SGB: San Gabriel; LSA: Lower Santa Ana; MSA: Middle Santa Ana; USA: Upper Santa Ana; and SJC: San Jacinto.

# How can these data support management decisions?

Maps and models of stream flow dynamics can support a number of management decisions. For example:

* *Prioritize streams for monitoring of hydromodification impacts.* Maps can identify areas where modification has likely been altered, which can be verified with follow-up hydrologic or habitat monitoring.
* *Set targets for flow management*. In some cases, historic flows may be an appropriate target to restore biological condition or other beneficial uses.
* *Provide evidence on causes of impairment related to flow alteration*. Maps and models can be used in streamlined causal assessments to determine if flow alteration is a supported cause of poor biological condition.
* *Select assessment tools appropriate for local flow conditions*. Certain assessment tools (e.g., benthic macroinvertebrates, algae) are best suited for perennial or intermittent streams, while ephemeral streams are best evaluated with other tools (e.g., riparian plants). Maps will let monitoring programs know which tools will be best for the task at hand, prior to any site visits.
* *Forecast the impacts of climate change or land use conversion*. Models allow predictions of changes to stream flow under different climatic regimes or impervious cover. These predictions can prioritize areas requiring protection or mitigation. Similarly, these tools could help evaluate the impacts of changes in water management, such as increased stormwater capture or water recycling.

Because models are spatially explicit, all these decisions can be made on a site-specific basis—without the costs typically associated with developing site-specific hydrologic models.

# Recommendations

The development of flow predictions under different land use and climate scenarios for the Santa Ana region is a first step towards more holistic stream assessment in Southern California. Additional steps can be taken that focus on key components of this work to expand applications beyond the Santa Ana region:

* *Improved predictions of low flows*. Low flows were likely over-estimated in much of the region, and relatively insensitive to climatic variability. This outcome is likely a consequence of the scarcity of intermittent and ephemeral streams in the calibration data. Incorporation of new data sources (e.g., water-level loggers) from these stream-types are likely to improve predictions of low flows.
* *Improve estimates of altered flow*. Models estimated the likelihood of flow alteration, but not the severity. The finding that alteration was widespread begs questions about the magnitude of change, and whether these alterations are having a likely impact on aquatic life or other beneficial uses. Incorporation of data about diversions, dam management, and other activities that affect flow could improve models.
* *Integrate with other stream flow assessment methods*. Maps could be used in tandem with other stream flow classification methods, such as those based on field indicators. Stream-flow maps are likely to enhance these methods for applications where classifications are needed (e.g., Federal jurisdictional determinations). The integration of multiple methods warrants further investigation.
* *Support use of data products*. The impact of this work could be extended if additional tools are developed that improve the communication of results. In particular, interactive applications could be developed that allow users to better visualize projected impacts within the regions. These tools could include online map applications or specific software tools that allow a more comprehensive evaluation of the results.

# Products

Data products and metadata will be uploaded to a repository for open data. Documentation describing the origin, version, data types, and anticipated uses will be provided.

**Statistical models**

Two statistical models (as R objects) to predict 1) historic (reference) stream flows and 2) likelihood of inflated or diminished flow under present-day conditions.

**Geodatabase of model predictions**

Two geodatabases that represent predictions for every stream segment in the Santa Ana region were created for 1) historic (reference) stream flows and 2) likelihood of inflated or diminished flow under present-day conditions:

* Flow estimates under reference conditions in each month for dry, stable, or wet conditions
* Likelihood of stream flow inflating or diminishing under anthropogenic conditions for each month under dry, stable, or wet conditions.