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Pacific Islands Water Science Center

Low-Flow Characteristics of Streams from Wailua to Hanapēpē, Kauaʻi, Hawaiʻi

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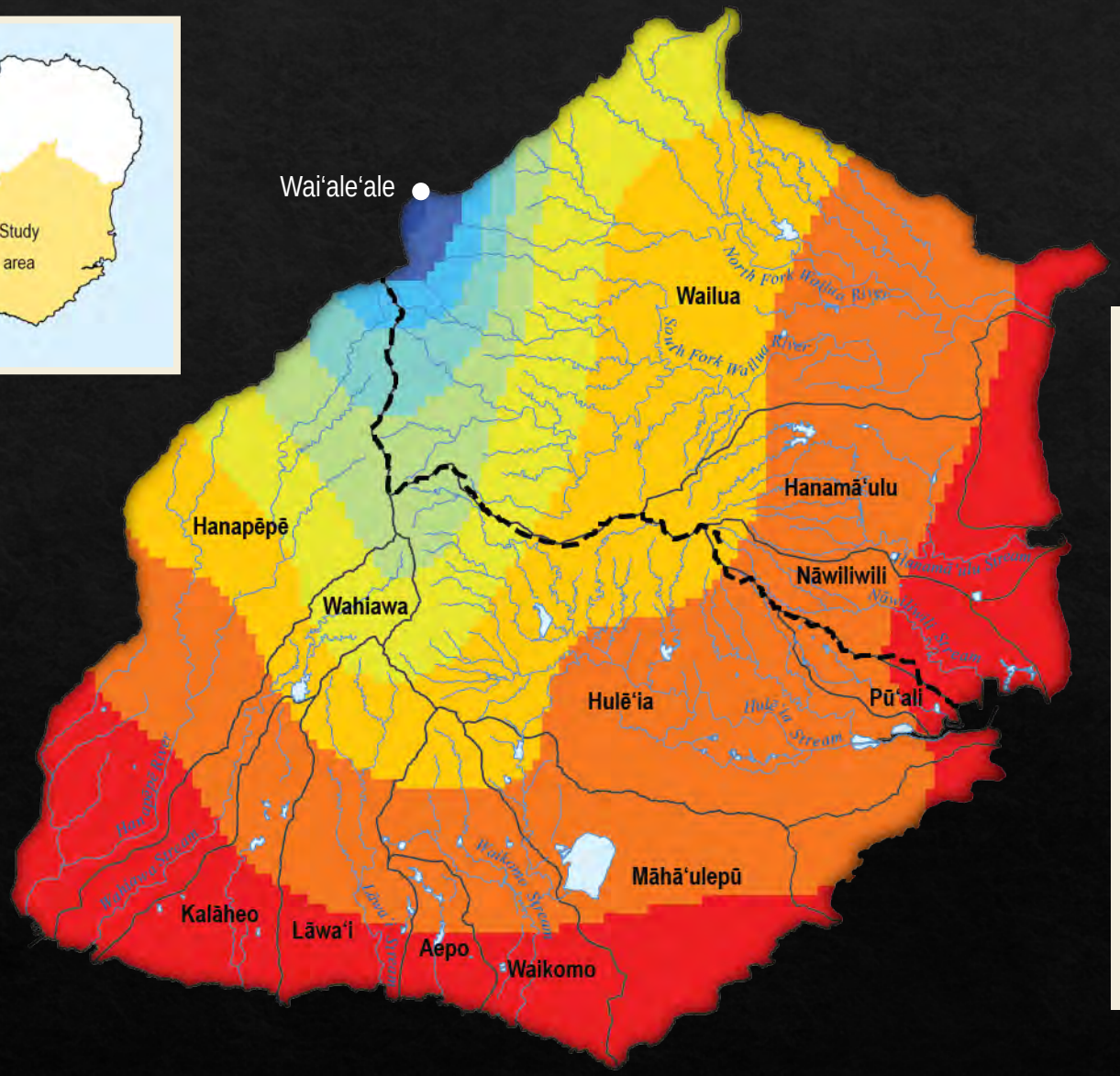
U.S. Department of the Interior
U.S. Geological Survey

Study Area



EXPLANATION

Mean annual rainfall, in inches—Modified from Giambelluca and others (2013)

394
350
300
250
200
160
120
80
50
17

Hydrologic-unit boundary

Windward-leeward area boundary—Modified from Yamanaga (1972)

Stream

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Surface-Water Use

Hydropower production

- Waiahi Stream

Diversified agriculture

- Wailua River
- Hanamā‘ulu Stream
- Hulē‘ia River
- Lāwa‘i Stream
- Wahiawa Stream
- Hanapēpē River

Taro cultivation

- Nāwiliwili Stream
- Hanapēpē River

Habitat for native species

- All streams

Waikoko Stream near ‘Ili‘ili‘ula-North-Wailua Ditch, Kaua‘i

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Questions Addressed by Study

- How much surface water is available?
- How does streamflow vary along the streams?
- Do the streams continuously flow mauka to makai?
- How can this information be used?

Manawaiopuna Falls on Hanapēpē River, Kauaʻi

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How much surface water is available?

Approach

Streamflow characteristics

- Natural (unregulated) flow
- At and below median flow (low flows)

Data-collection sites

- Long-term continuous stations
- Short-term continuous low-flow stations
- Partial-record sites

Flow-duration statistics

- Index-streamgage approach
- 59-year base period of 1961–2019

‘Ili‘ili‘ula Stream, Wailua River basin, Kaua‘i

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How much surface water is available?

Data-collection sites

- 2 active continuous stations (monitor natural flow)
- 2 continuous low-flow stations
- 18 partial-record sites

EXPLANATION

- Hydrologic-unit boundary
- Stream
- Streamflow-measurement location—Each measurement location is labeled with station number or map identifier.
- ▲ Stream-gaging station—In operation during base period from 1961 to 2019
- ▲ Stream-gaging station—Station established for this study and monitors natural low-flow conditions only
- ● Partial-record measurement site

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Continuous Low-Flow Station

Waiahi Stream, Wailua River Basin

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How much surface water is available?

Natural discharge at median-flow conditions (Q_{50})

EXPLANATION

Hydrologic-unit boundary

Stream

Streamflow-measurement location—The number at each measurement location indicates natural discharge, in cubic feet per second, equaled or exceeded 50 percent of the time. The size of the symbol indicates the magnitude of discharge.

- < 2.0
- ≥ 2.0 and < 10
- ≥ 10

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How much surface water is available?

Natural discharge equaled or exceeded 70 percent of the time (Q_{70})

EXPLANATION

Hydrologic-unit boundary

Stream

Streamflow-measurement location—The number at each measurement location indicates natural discharge, in cubic feet per second, equaled or exceeded 70 percent of the time. The size of the symbol indicates the magnitude of discharge.

- < 2.0
- ≥ 2.0 and < 10
- ≥ 10

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How much surface water is available?

Natural discharge equaled or exceeded 90 percent of the time (Q_{90})

EXPLANATION

Hydrologic-unit boundary

Stream

Streamflow-measurement location—The number at each measurement location indicates natural discharge, in cubic feet per second, equaled or exceeded 90 percent of the time. The size of the symbol indicates the magnitude of discharge.

- < 1.0
- ≥ 1.0 and < 10
- ≥ 10

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Accuracy of the Estimates (at non-index sites only)

- Correlation coefficient (*r*)

  Measures the strength of the linear relation between concurrent discharges at the index station and measurement site

- Modified Nash-Sutcliff coefficient of efficiency (*E*)

  Determines the accuracy to which the statistical relation predicts low-flow duration discharges at the measurement sites from the low-flow duration discharges at the index station

Performance metric	Range of values	Acceptable values	Values in study
Correlation coefficient (*r*)	-1 to 1	≥ 0.80	0.88 to 0.94
Modified Nash-Sutcliff coefficient of efficiency (*E*)	-∞ to 1	≥ 0.50	0.51 to 0.64

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How does streamflow vary along the streams?

Approach

Seepage run

- Consists of several streamflow measurements collected on the same day at specific sites along a stream under stable-flow conditions
- Used to determine the magnitude of streamflow gain (groundwater discharge into stream) or loss (stream discharge into groundwater) in each measured stream reach, and to identify flowing and dry reaches
- Targeted flow conditions different from those of previous seepage runs

Lāwaʻi Stream, Kauaʻi

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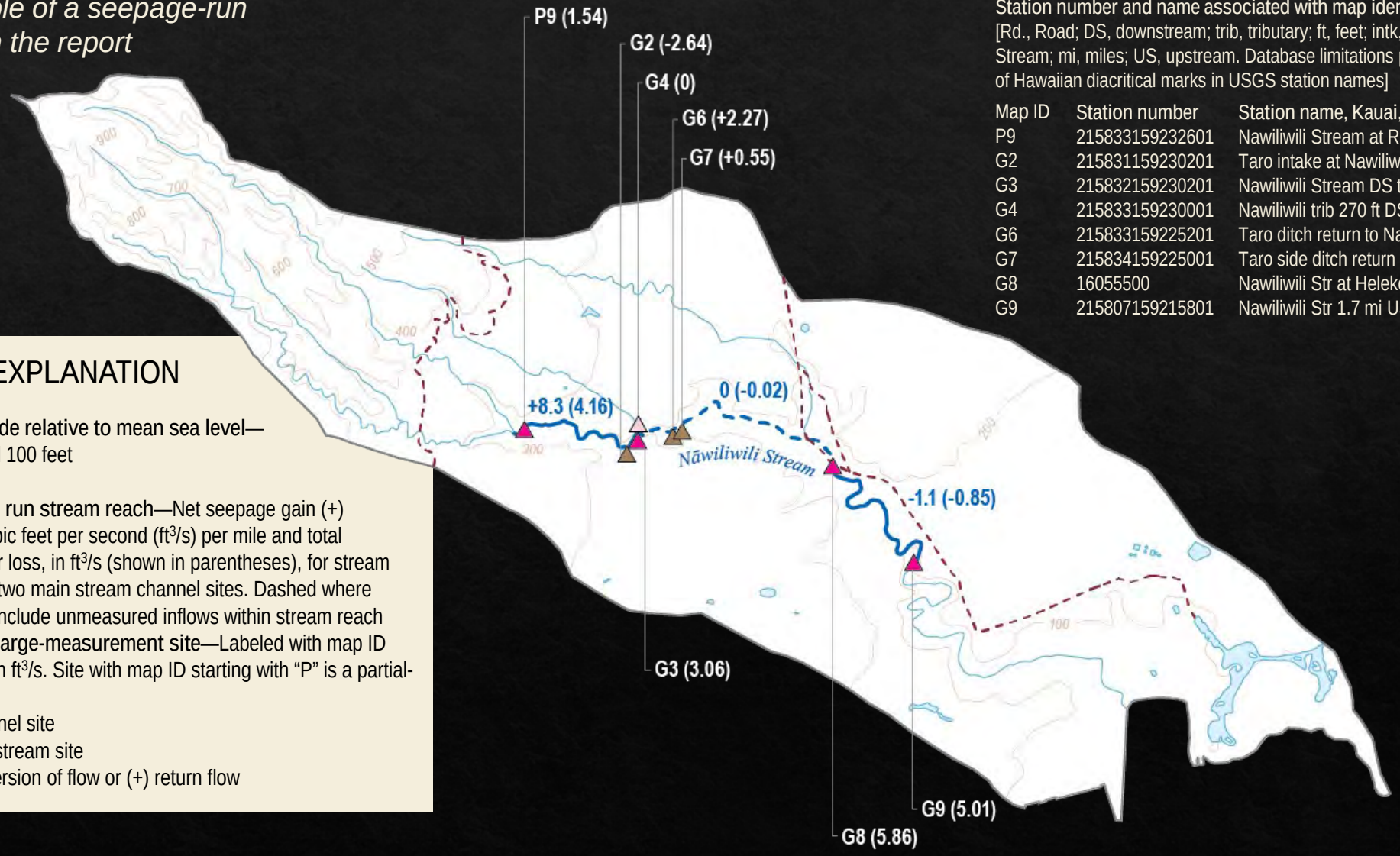
Nāwiliwili Stream Seepage Run (9/12/2019)

This is an example of a seepage-run figure included in the report



Station number and name associated with map identifier (ID)
[Rd., Road; DS, downstream; trib, tributary; ft, feet; intk, intake; Str, Stream; mi, miles; US, upstream. Database limitations preclude the use of Hawaiian diacritical marks in USGS station names]

Map ID	Station number	Station name, Kauai, HI
P9	215833159232601	Nawiliwili Stream at Rapoza Rd.
G2	215831159230201	Taro intake at Nawiliwili Stream
G3	215832159230201	Nawiliwili Stream DS taro intake
G4	215833159230001	Nawiliwili trib 270 ft DS taro intk
G6	215833159225201	Taro ditch return to Nawiliwili Str
G7	215834159225001	Taro side ditch return Nawiliwili Str
G8	16055500	Nawiliwili Str at Heleko Road at Lihue
G9	215807159215801	Nawiliwili Str 1.7 mi US mouth

EXPLANATION

—100— Line of equal altitude relative to mean sea level—Contour interval 100 feet

– – – Diversion system

+8.3 (4.16) Measured seepage run stream reach—Net seepage gain (+) or loss (-) in cubic feet per second (ft^3/s) per mile and total seepage gain or loss, in ft^3/s (shown in parentheses), for stream reach between two main stream channel sites. Dashed where seepage rates include unmeasured inflows within stream reach

Seepage-run discharge-measurement site—Labeled with map ID and discharge in ft^3/s. Site with map ID starting with "P" is a partial-record site

▲ Main stream channel site

△ Tributary to main stream site

▲ Ditch site—(-) diversion of flow or (+) return flow

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How does streamflow vary along the streams?

- Generally gaining streams
- Measured seepage-gain rates that considered all inflows and outflows ranged from 0.03 to 24.3 ft^3/s per mile of stream reach

EXPLANATION

Hydrologic-unit boundary—From State of Hawai'i

Stream reaches illustrating results of seepage runs conducted in 2017—2020

*Results for Hanamā'ulu Stream from 1996

Gaining reach

Losing reach

No gain or loss

Not surveyed

Aquifer system

Anahola (partly shown)

Wailua

Hanamā'ulu

Koloa

Hanapēpē

Makaweli (partly shown)

Hydrogeologic setting—From Izuka and others (2018)

Dike-impounded groundwater

Thickly saturated

Freshwater lens

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Do the streams continuously flow mauka to makai?

- Under natural-flow conditions and flow conditions of the seepage runs, a majority of the streams flow continuously from mauka (immediately upstream of uppermost diversion) to makai.
- Waikomo Stream: A seepage run conducted under lower flow conditions—when flow contributions from Waita Reservoir are reduced—is needed to determine flow continuity.
- Hanamāʻulu and Wahiawa Streams: A dry reach may occur immediately downstream from the reservoir to the point of seepage gain or return flow.

North Fork Wailua River, Kauaʻi

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Summary

How much surface water is available?

- Q_{50}: 0.19 to 69 cubic feet per second
- Q_{70}: 0.19 to 50 cubic feet per second
- Q_{90}: 0.047 to 43 cubic feet per second

How does streamflow vary along the streams?

- Generally gaining streams except lower reaches of North Fork Wailua River, Nāwiliwili Stream, Waikomo Stream, and Hanapēpē River

Do the streams continuously flow mauka to makai?

- Under natural-flow conditions and flow conditions of the seepage runs, a majority of the streams flow continuously from immediately upstream of uppermost diversion to the ocean

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How can this information be used?

Information on natural flows is needed to

- establish interim instream-flow standards
- quantify surface-water availability for downstream use
- determine flows for aquatic biota and cultural uses
- help with appurtenant water-rights decisions
- estimate groundwater recharge from streams
- prioritize areas for further study

Waiahi Stream, Kauaʻi

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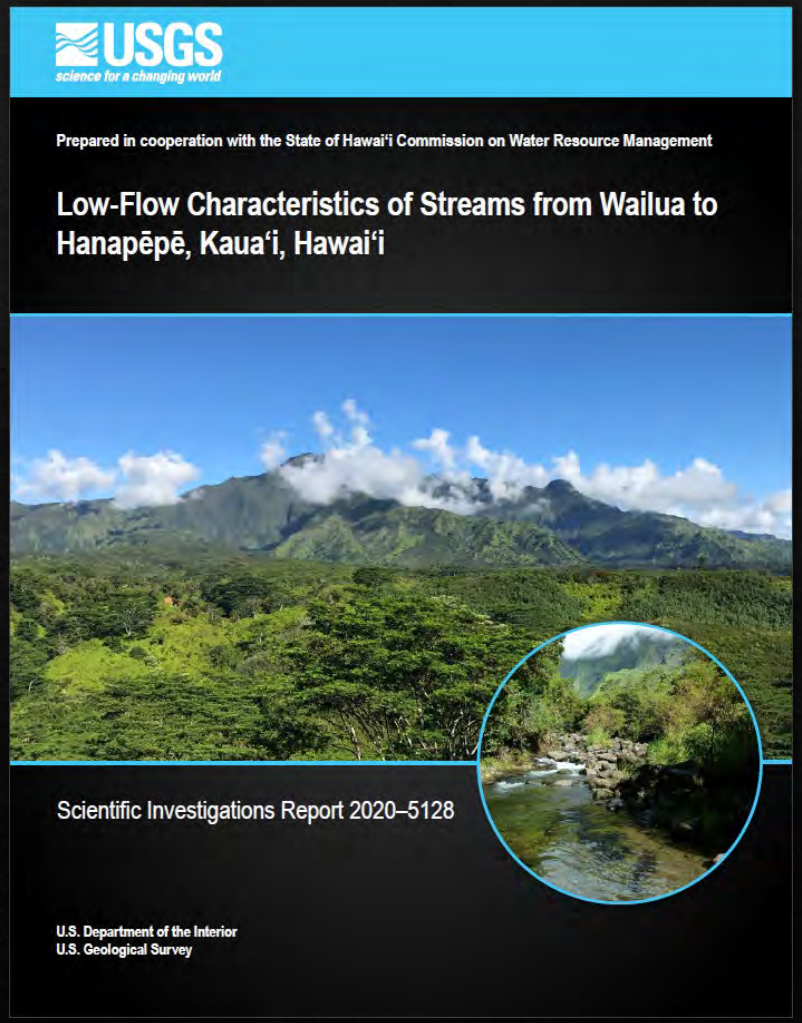

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