Estimated Groundwater Recharge for Mid-Century and End-of-Century, Kauaʻi, Oʻahu, Molokaʻi, Lānaʻi, Maui, and Hawaiʻi

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State of Hawaiʻi
Commission on Water Resource Management Virtual Meeting
January 18, 2022

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Projected Island-Wide Rainfall Anomalies
Mid- and End-of-Century Climate Projections

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Projected Island-Wide Rainfall Anomalies Water-Budget Model Scenarios

Island-wide mean annual rainfall anomaly expressed as a fraction of the 1978–2007 mean

Climate Projection
- SD RCP8.5 2041–71
- SD RCP8.5 2071–99
- HRCM2 RCP4.5 2080–99
- HRCM2 RCP8.5 2080–99
- HRCM1 A1B 2080–99

Kauaʻi | Oʻahu | Molokaʻi | Lānaʻi | Maui | Hawaiʻi

SD = Statistical Downscaling from Elison Timm and others (2015)
RCP = Representative Concentration Pathway
HRCM1 = Hawaiʻi Regional Climate Model from Zhang and others (2016a,b)
HRCM2 = Hawaiʻi Regional Climate Model from Zhang and others (2017)
A1B = A1B global emission scenario

PRELIMINARY INFORMATION
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**Water-Budget Model Scenarios**

<table>
<thead>
<tr>
<th>Study-defined climate scenario(^a)</th>
<th>Selected climate condition or projection</th>
<th>Kaua‘i</th>
<th>O‘ahu</th>
<th>Moloka‘i</th>
<th>Lāna‘i</th>
<th>Maui</th>
<th>Hawai‘i</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference climate</td>
<td>1978–2007</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>Mid-century climate</td>
<td>SD RCP8.5 2041–71</td>
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<td>✔</td>
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<tr>
<td>Dry climate(^b)</td>
<td>SD RCP8.5 2071–99</td>
<td>✔</td>
<td>✔</td>
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<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>Wet climate(^c)</td>
<td>HRCM1 A1B 2080–99</td>
<td>-</td>
<td>-</td>
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<td>✔</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Wet climate(^c)</td>
<td>HRCM2 RCP4.5 2080–99</td>
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<td>-</td>
<td>-</td>
<td>✔</td>
<td>-</td>
<td>✔</td>
</tr>
<tr>
<td>Wet climate(^c)</td>
<td>HRCM2 RCP8.5 2080–99</td>
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<td>✔</td>
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<tr>
<td>Drought</td>
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<td>-</td>
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<td>-</td>
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</tr>
</tbody>
</table>

\(^a\) All scenarios use 2020 land-cover conditions  
\(^b\) Driest scenario relative to available set of projections  
\(^c\) Wettest scenario relative to available set of projections
Projected Island-Wide Recharge Anomalies

Water-Budget Model Scenarios

Study-defined climate scenario
- Mid-century climate
- Dry climate
- Wet climate

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Lānaʻi

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5 2080–99

Dry climate
SD RCP8.5 2071–99

Drought
1998–2002
Mean Annual Groundwater Recharge

Reference climate 1978–2007

EXPLANATION
Mean annual groundwater recharge during 1978–2007, in inches


Boundary of aquifer system (State of Hawai‘i, 2014)
Lānaʻi

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99

Change in Groundwater Recharge

Dry climate
SD RCP8.5 2071–99

Drought
1998–2002
Lānaʻi

Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM2 RCP4.5
2080–99

Dry climate
SD RCP8.5 2071–99

Drought
1998–2002
Change in Aquifer System Recharge

Mid-century climate
SD RCP8.5 2041–71

Dry climate
SD RCP8.5 2071–99

Wet climate
HRCM2 RCP4.5 2080–99

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Pearl Harbor Aquifer Sector and Moanalua Aquifer System, O‘ahu

Dry climate
SD RCP8.5 2071–99

-79% (-0.7)
-71% (-7.8)
-19% (-16)
-17% (-10)

Wet climate
HRCM2 RCP8.5 2080–99

8.4% (0.9)
14% (0.1)
0.8% (0.7)
2.6% (0.5)

Mid-century climate
SD RCP8.5 2041–71

WAIPAHU-WAIAWA
-14% (-12)

‘EWA-KUNIA
-56% (-6.2)

WAIMALU
-13% (-7.4)

MAKĀIWA
-64% (-0.6)

MOANALUA

WAIMALU
-9.7% (-1.8)

Values in parentheses represent change in million gallons per day

EXPLANATION
Projected change in mean annual groundwater recharge, in percent

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Molokaʻi

Mid-century climate
SD RCP8.5 2041–71

Dry climate
SD RCP8.5 2071–99

Wet climate
HRCM2 RCP8.5
2080–99

Change in Aquifer System Recharge

Projected change in mean annual groundwater recharge, in percent

EXPLANATION

Notes
(1) Values in parentheses represent change in million gallons per day


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Mid-century climate
SD RCP8.5 2041–71

Wet climate
HRCM1 A1B 2080–99

Dry climate
SD RCP8.5 2071–99

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Lahaina Aquifer Sector, Maui

Mid-century climate
SD RCP8.5 2041–71

Dry climate
SD RCP8.5 2071–99

Wet climate
HRCM1 A1B 2080–99

HONOKŌHAU
-11% (-2.2)

HONOKŌWAI
-16% (-5.3)

LAUNIUPOKO
-21% (-8.1)

OLOWALU
-35% (-4)

UKUMEHAME
-51% (-5.9)

Values in parentheses represent change in million gallons per day

EXPLANATION
Projected change in mean annual groundwater recharge, in percent
-25 -20 -15 -10 -5 0 5 10 15 20 25

Boundary of aquifer system (State of Hawai‘i, 2014)

Preliminary Information-Subject to Revision. Not for Citation or Distribution.
Hawai‘i

Mid-century climate SD RCP8.5 2041–71

Wet climate HRCM2 RCP4.5 2080–99

Dry climate SD RCP8.5 2071–99
Keauhou Aquifer System, Hawai‘i

Mid-century climate
SD RCP8.5 2041–71
-38%
(-39)

Dry climate
SD RCP8.5 2071–99
-53%
(-53)

Wet climate
HRCM2 RCP4.5 2080–99
-33%
(-33)

Values in parentheses represent change in million gallons per day

EXPLANATION
Projected change in mean annual groundwater recharge, in percent

- Boundary of aquifer system
(State of Hawai‘i, 2014)

Preliminary Information—Subject to Revision. Not for Citation or Distribution.
Testing of Selected Model Input Parameters for HRCM Scenarios

Differences due to projected changes in atmospheric carbon dioxide (CO₂)

Preliminary Information - Subject to Revision. Not for Citation or Distribution.
Summary

• Projected decreases in island-wide recharge for the mid-century and dry-climate scenarios on all 6 islands

• Mixture of decreases and increases in aquifer-system recharge projected for the wet-climate scenario on all 6 islands

• Projected decreases in island-wide recharge due to projected warming are largely offset by enhanced recharge due to projected increases in mean atmospheric CO$_2$ concentrations
Limitations

• Dissimilar simulation periods between the climate projections requires adjustment to a common reference period

• Greater uncertainty in recharge estimates in areas with low rain-gage and stream-gage densities

• Limited information on projected changes to cloud-water interception rates, cloud-zone altitudes, and evapotranspiration rates

• Differences in the evapotranspiration rates of native and non-native forests are not well known for all important species and settings

• Recharge rates from reservoirs are not well known and assigned constant values based on limited data

• Taro irrigation and cultivation rates on each island are not well known and assigned constant values based on limited data
Next Steps

• Publish results for recent conditions, and mid-century climate and end-of-century scenarios in a USGS report and data release

• Assess potential effects of drought on soil moisture and recharge for recent and future-climate conditions

• Assess capacity of cloud-water interception to mitigate the hydrologic effects of drought on recharge
References


Mahalo to Our Cooperators!

Cooperators

• State of Hawai‘i Commission on Water Resource Management

• USGS Pacific Islands Climate Adaptation Science Center

• Pūlama Lānaʻi