Assessing Groundwater Availability in Hawaiʻi’s Diverse Hydrogeologic Settings

Scot Izuka
U.S. Geological Survey
Pacific Islands Water Science Center

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Groundwater Availability — a Definition

Availability of fresh groundwater
What Limits Groundwater Availability?

Quantity

Consequences
In Hawai‘i, Pumping is Less Than Recharge

Water budget, in million gallons per day

Recharge: 661
Wells: 209 (32%)
Streams, Submarine GW discharge: 452

O‘AHU

Fresh groundwater
Dikes
Ocean
Saltwater
Consequences of Pumping

- Recharge
- Inflow
- Wells
- Outflow
- New Storage Volume
- Water-table decline
- Reduced discharge
- Streams
- Submarine GW discharge
- Saltwater rise
Consequences and Availability

• Any amount of groundwater withdrawal has consequences

• Availability of groundwater depends on what consequences are deemed acceptable

• Type and magnitude of the consequences depend on
  - How much water is withdrawn
  - Hydrogeologic setting
Hawaiʻi’s Diverse Hydrogeologic Settings

- High-perm. lava flows
- Low-perm. lava flows
- Caprock
- Low-perm. dikes
- Perched?
High-Permeability Lava Flows, no Caprock

Submarine discharge

Ocean

Freshwater lens

Brackish transition zone

Saltwater

Water table
Pumping from Thin Freshwater Lens

Reduced discharge

Water-table decline

Well

Saltwater rise & encroachment
Freshwater Lens with Caprock

- Freshwater lens
- Discharge to streams/springs
- Caprock
- Discharge to ocean
- Water table
- Freshwater lens
- Saltwater

USGS
Pumping from Freshwater Lens with Caprock

Reduced discharge to streams & ocean

Water-table decline

Well

Saltwater rise & encroachment
Freshwater Lens in Low-Permeability Aquifer

Discharge to streams

Discharge to ocean

Thick freshwater lens

Saltwater

Water table
Pumping from Low-Permeability Aquifer

Reduced discharge to streams

Reduced discharge to ocean
Dike-Impounded Groundwater

Discharge to ocean

Freshwater lens

Saltwater

Water table
Dike-Impounded Groundwater

Discharge to ocean

Discharge to springs & streams

Saltwater
Withdrawing Dike-Impounded Groundwater

- Reduced discharge to streams
- Reduced discharge to ocean
- Loss of spring discharge
Approaches to Quantifying Consequences
Acceptable Consequence

- Salinity 1% that of seawater or better

Approach

- Numerical groundwater model
- Solute-transport capable
## Wailuku, Maui—Freshwater Lens

(Gingerich, 2008, USGS SIR 2008-5236)

<table>
<thead>
<tr>
<th>Pumping rate (Mgal/d)</th>
<th>Number of well fields</th>
<th>Percentage of yield meeting acceptable criterion</th>
</tr>
</thead>
<tbody>
<tr>
<td>20.1</td>
<td>4</td>
<td>23%</td>
</tr>
<tr>
<td>27.1</td>
<td>14</td>
<td>89%</td>
</tr>
</tbody>
</table>
Līhuʻe, Kauaʻi—Thick Lens, Low Permeability
(Izuka and Oki, 2002, USGS WRI 01-4200)

Acceptable Consequence
- Not specified

Approach
- Numerical groundwater model
- Capable of assessing streamflow depletion

Reduced discharge to streams
Effects of Pumping Additional 1.2 Mgal/d from Līhuʻe

Decrease in GW discharge to streams = 1.1 Mgal/d
USGS Groundwater-Availability Assessments
USGS Groundwater Availability Study in Hawaiʻi
Numerical Models

Kauaʻi
Oʻahu
Maui
Summary

• Groundwater availability limited by consequences community is willing to accept

• Hawai‘i—diverse hydrogeologic settings, each with its own set of pumping-related consequences

• Assessing groundwater availability in Hawai‘i requires:
  
  Identifying hydrogeologic setting and associated consequences of groundwater withdrawal
  
  Setting acceptable limits for those consequences
  
  Using approaches that quantify consequences for the desired pumping