National Park Service
U.S. Department of the Interior

Natural Resource Science and Stewardship

DETERMINING GROUNDWATER SUSTAINABILITY – A PUBLIC-TRUST RESOURCE PERSPECTIVE

2015 Water Resource Sustainability Issues on Tropical Islands
Honolulu, Hawai‘i
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EXPERIENCE YOUR AMERICA™

The Water Budget Myth

The idea that the recharge is important in determining the magnitude of sustainable development is a myth.

(Bredehoeft 2002)

- The source of water derived from wells (Theis 1940)
- Safe yield (Lohman 1979)
- The water budget myth (Bredehoeft et al. 1982)
- Why “safe yield” is not sustainable (Sophocleous 1997)
- Safe yield and the water budget myth (Bredehoeft 1997)
- Sustainability of ground-water resources (Alley et al. 1999)
- The water budget myth revisited (Bredehoeft 2002)

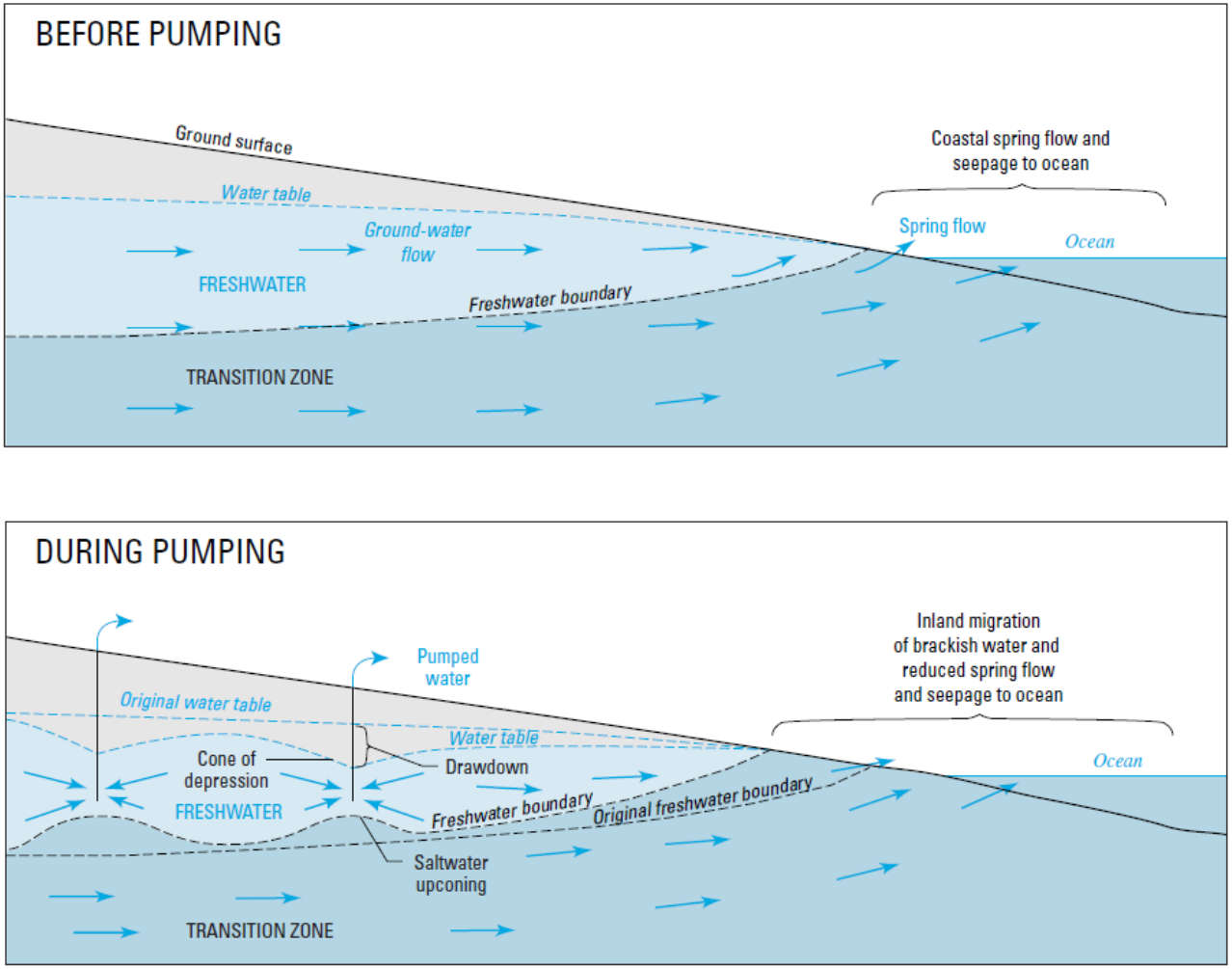
Source of Water Derived from Wells

All water discharged by wells is balanced by a loss of water somewhere.

(Theis 1940)

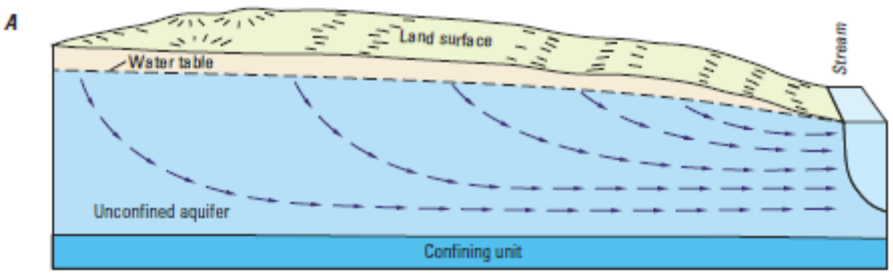
- Where are the losses?
- Are they acceptable?

Impacts of Groundwater Withdrawals



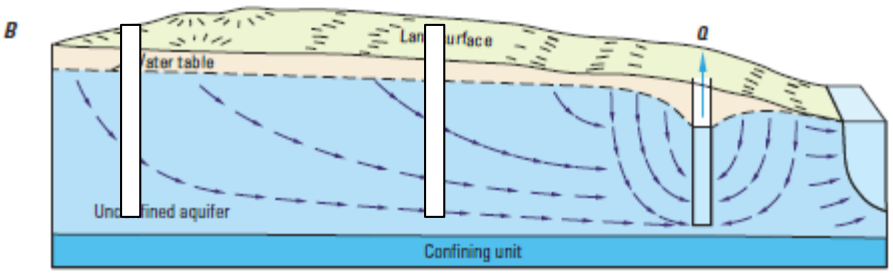
(Curruth 2003)

Pre-Development



(Barlow & Leake 2012)

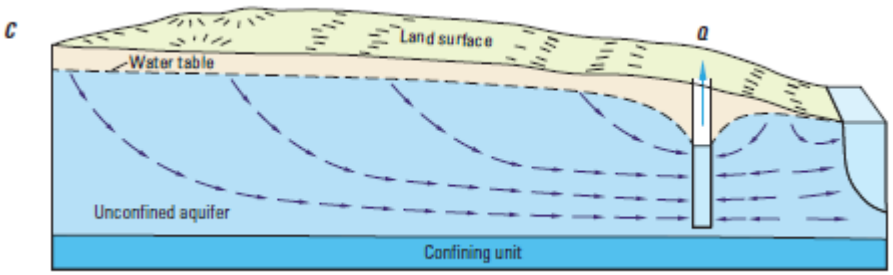
Removal of Water from Storage



(Barlow & Leake 2012)

- lowered water levels
- rising saltwater

Captured Groundwater Discharge



(Barlow & Leake 2012)

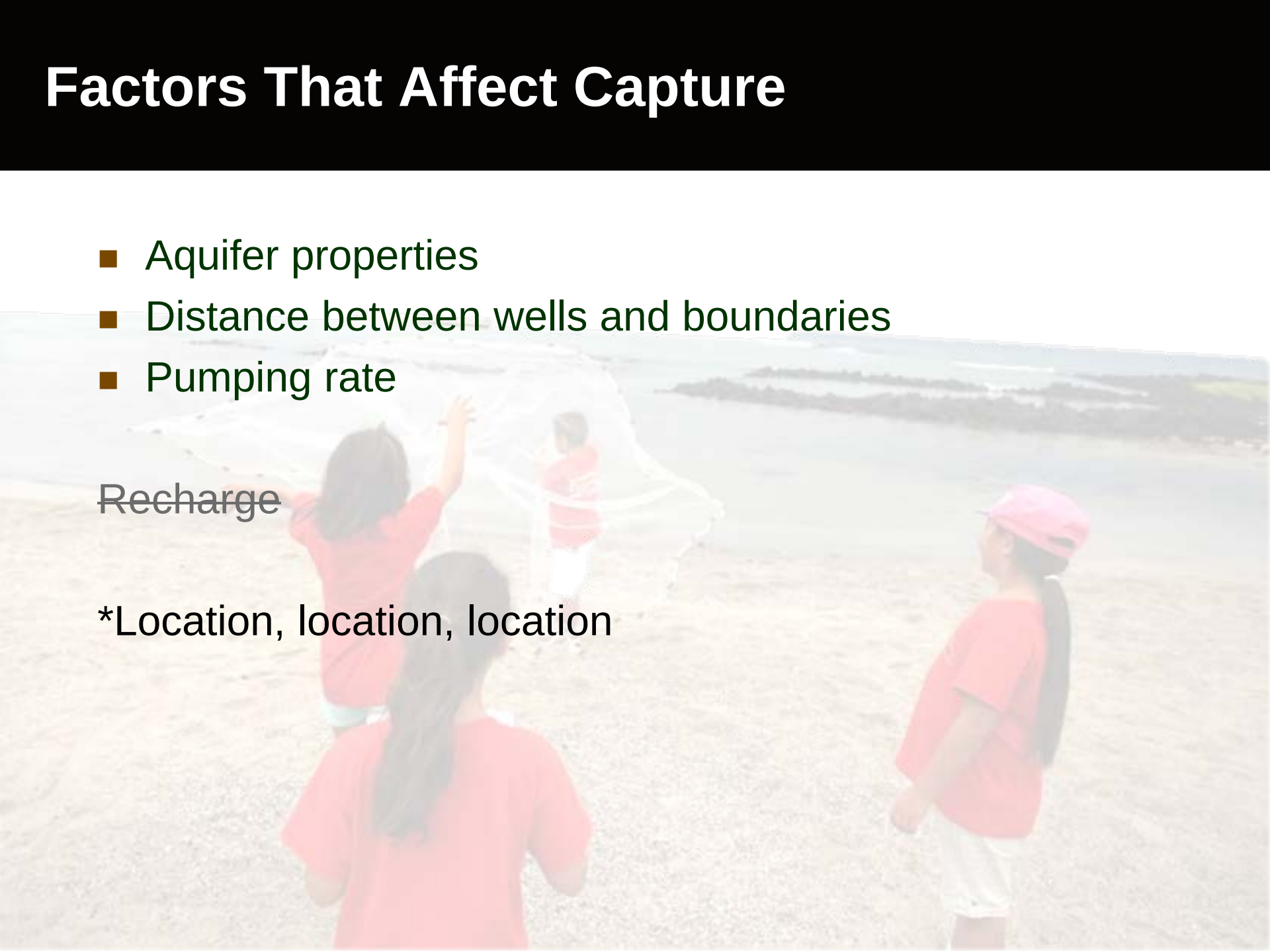
- streamflow depletion
- less freshwater discharge
- saltwater intrusion

Factors That Affect Capture

- Aquifer properties
- Distance between wells and boundaries
- Pumping rate

~~Recharge~~

*Location, location, location



Submarine Groundwater Discharge

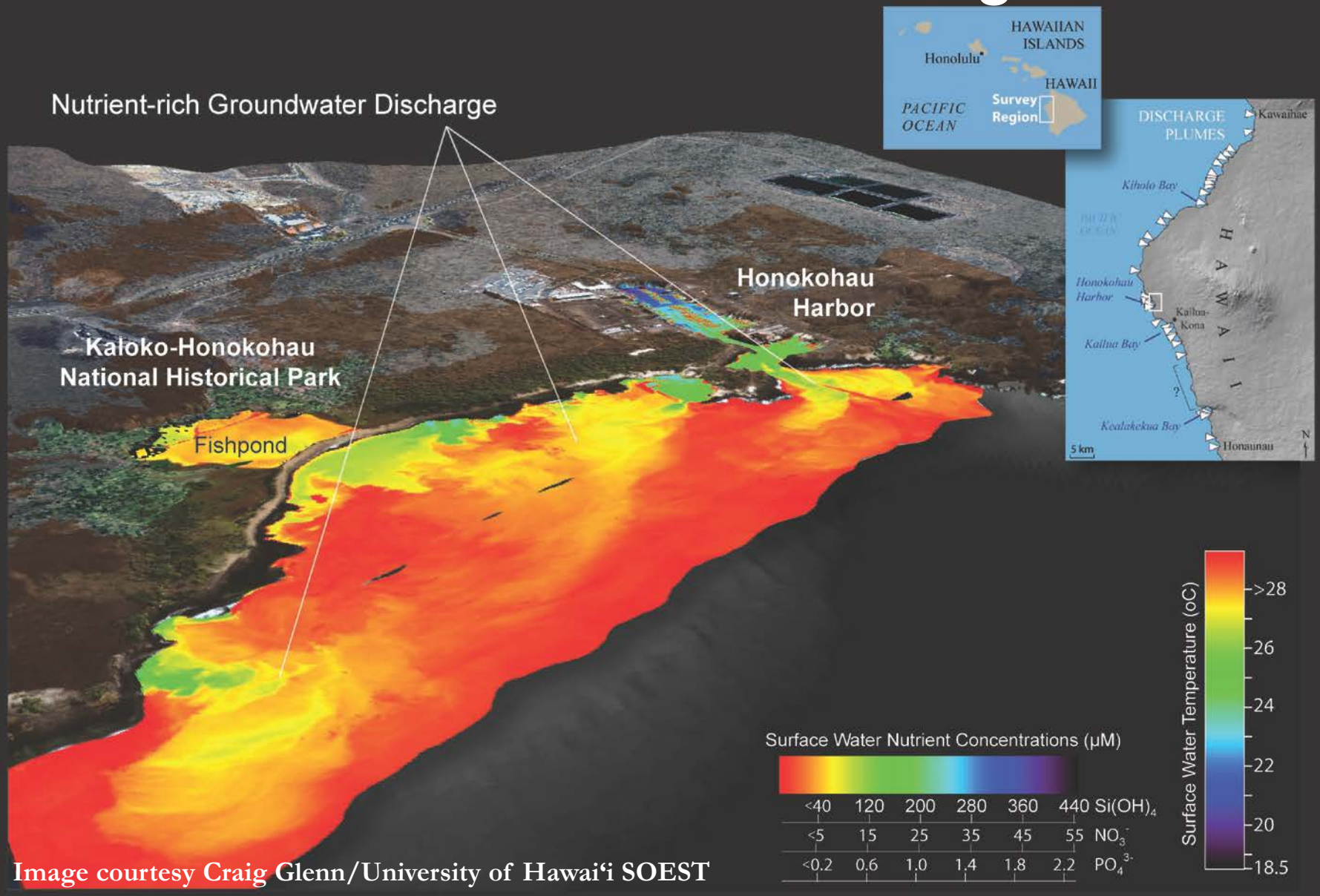


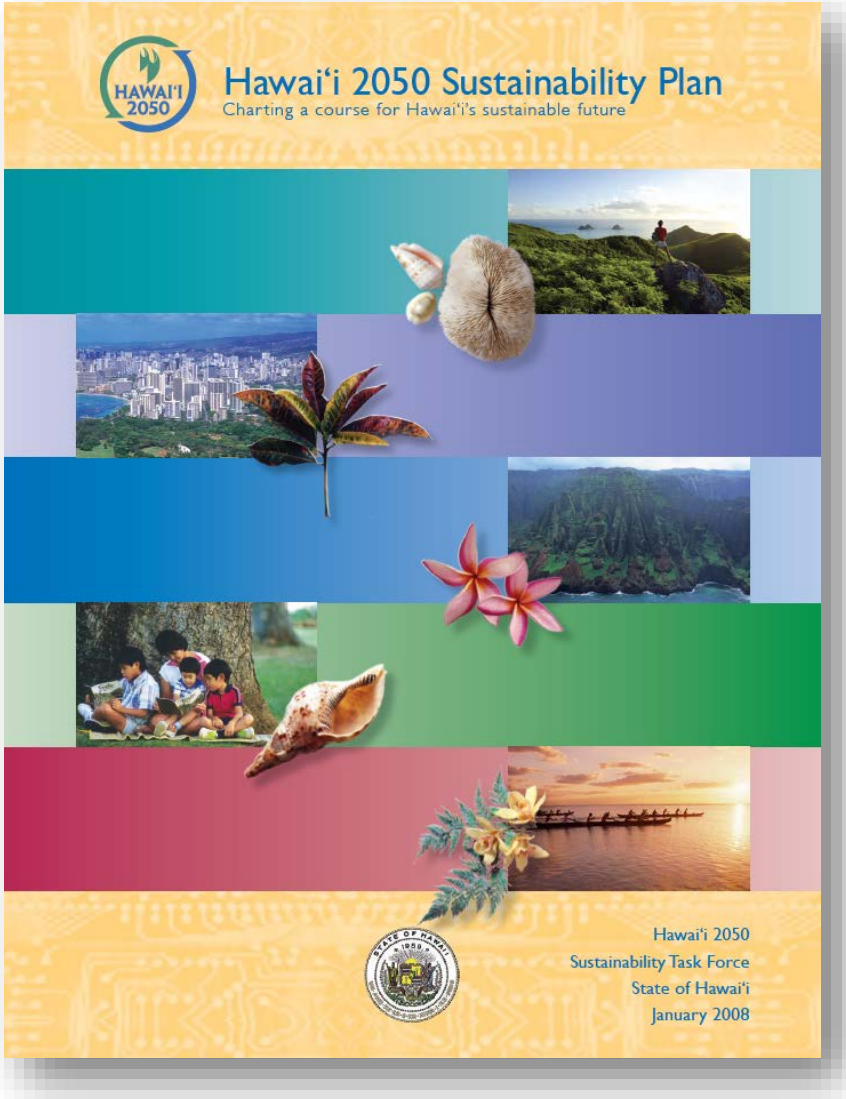
Image courtesy Craig Glenn/University of Hawai'i SOEST

Kaloko-Honokōhau National Historical Park

What Is Groundwater Sustainability?

The State's first definition of sustainability:

- Respects the culture of communities
- Balances economic, community, and environmental priorities
- Meets needs of the present without compromising the ability of future generations to meet their own needs



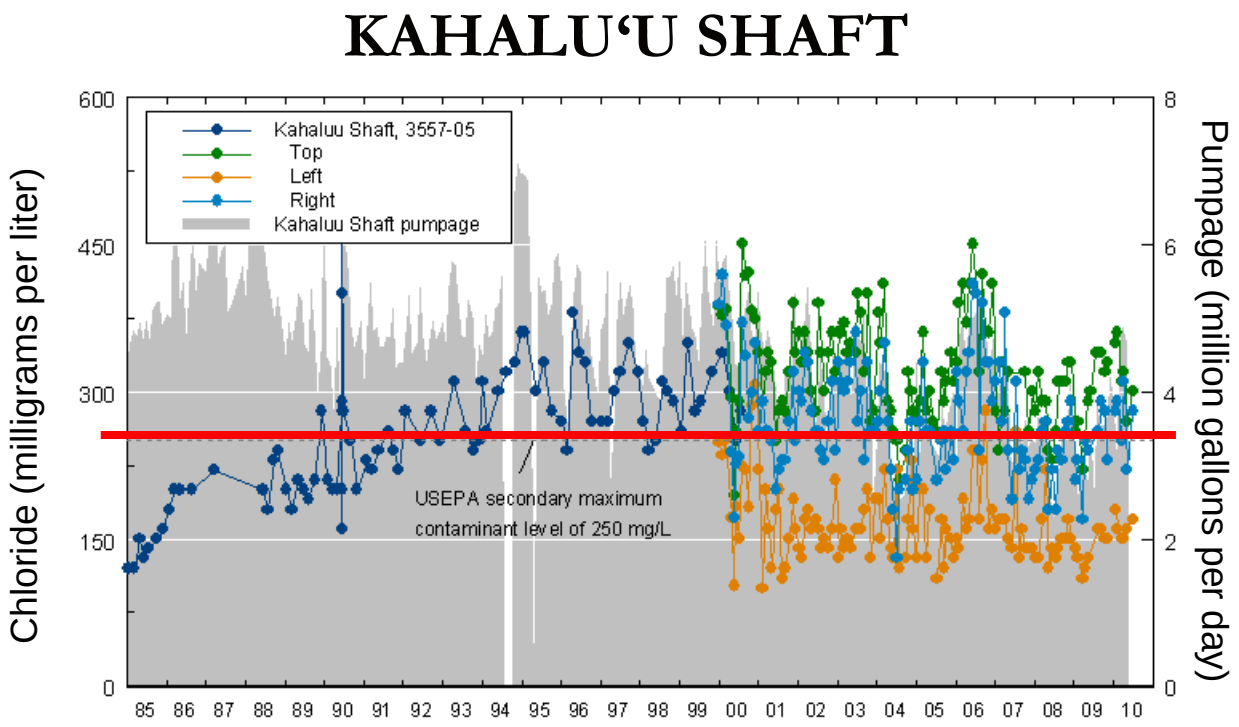
Sustainable Yield

"**Sustainable yield**" means the maximum rate at which water may be withdrawn from a water source without impairing the utility or quality of the water source as determined by the commission.

STATE WATER CODE

Chapter 174C of the Hawai‘i Revised Statutes

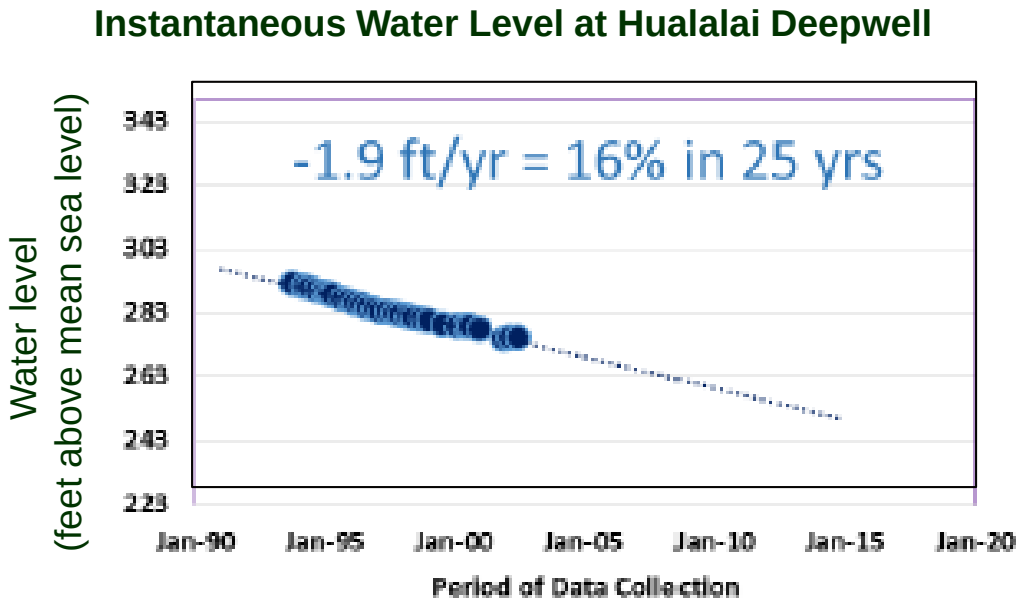
Saltwater Intrusion



http://hi.water.usgs.gov/recent/westhawaii/chloride.html

Keauhou Aquifer System Sustainable Yield = 38 million gallons per day
Kahaluʻu Shaft Pumpage = 4 million gallons per day

Declining Water Levels

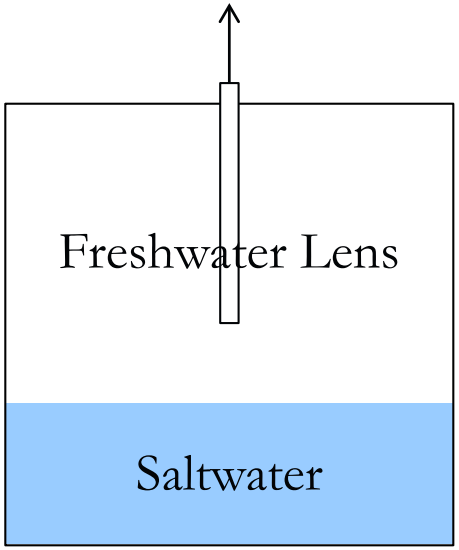


(Commission on Water Resource Management 2014)

Keauhou Aquifer System Sustainable Yield = 38 million gallons per day
Keauhou Aquifer System pumpage = 15 million gallons per day
Hualalai Deepwell Pumpage = 0.84 million gallons per day

1980 Robust Analytical Model (RAM)

- Freshwater-lens system
- Recharge & wells evenly distributed
- Sharp interface



$$SY = Recharge \times \left[1 - \left(\frac{Postdevelopment\ water\ level}{Predevelopment\ water\ level}\right)^2\right]$$

1980 Robust Analytical Model (RAM)

- Freshwater-lens system
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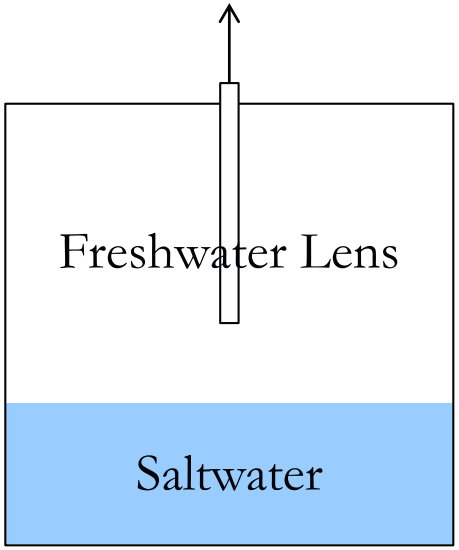
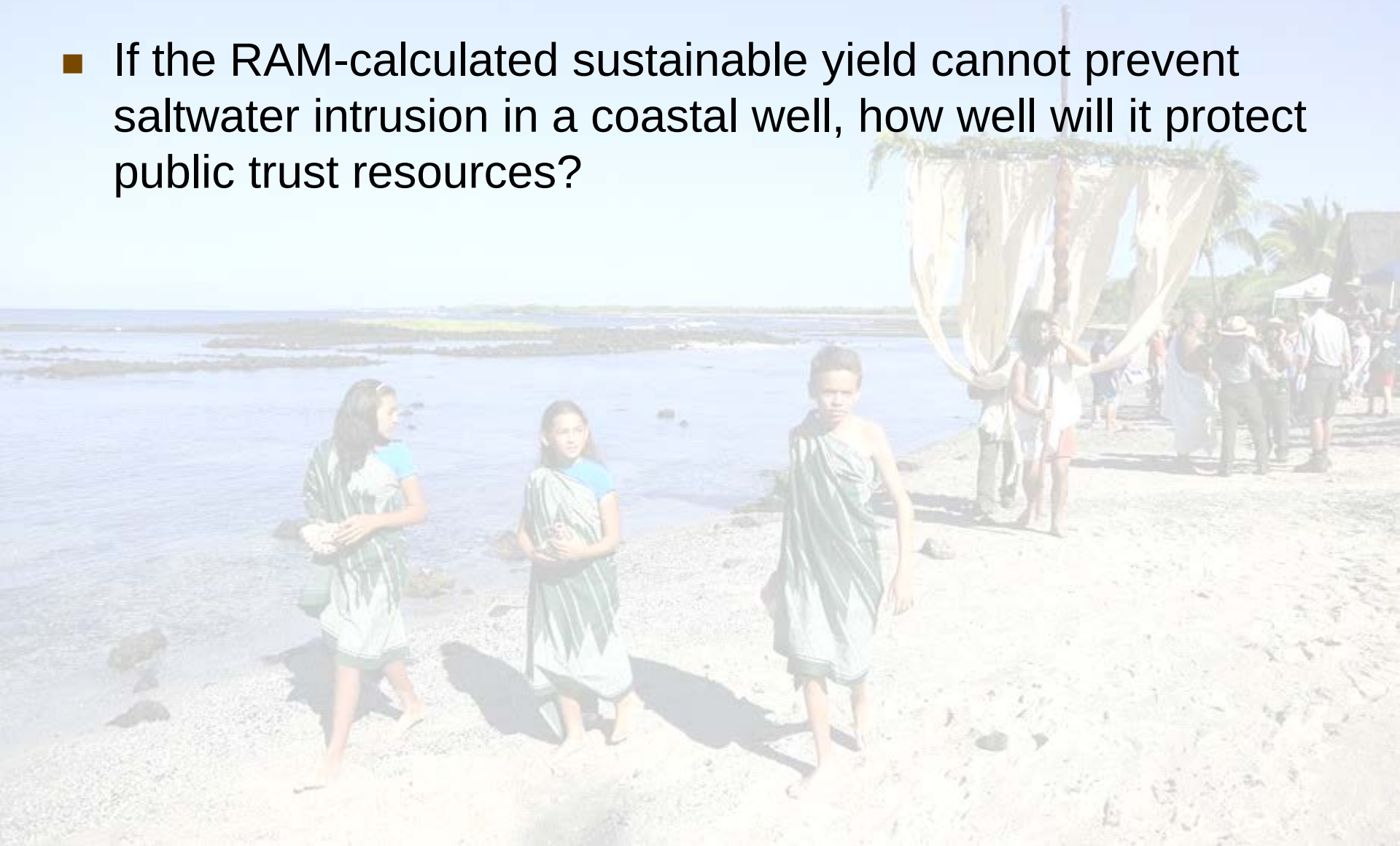


In view of the above limitations, the sustainable yield estimates should be used as a guide in planning rather than an inflexible constraint.

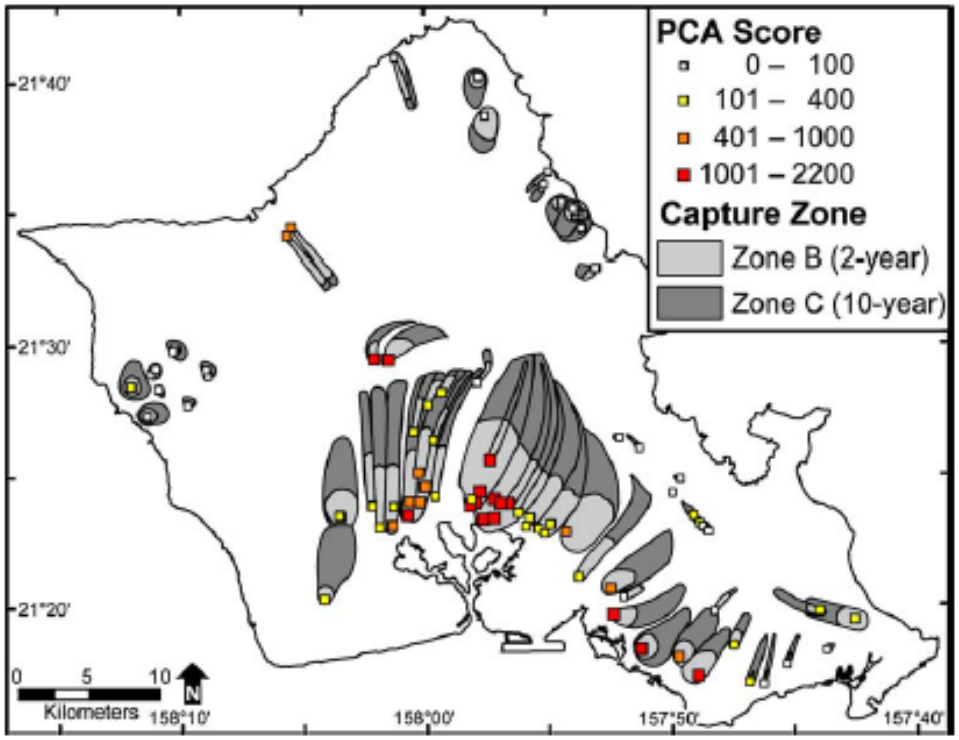
(1990 Water Resources Protection Plan)

Public Trust Resources

- If the RAM-calculated sustainable yield cannot prevent saltwater intrusion in a coastal well, how well will it protect public trust resources?

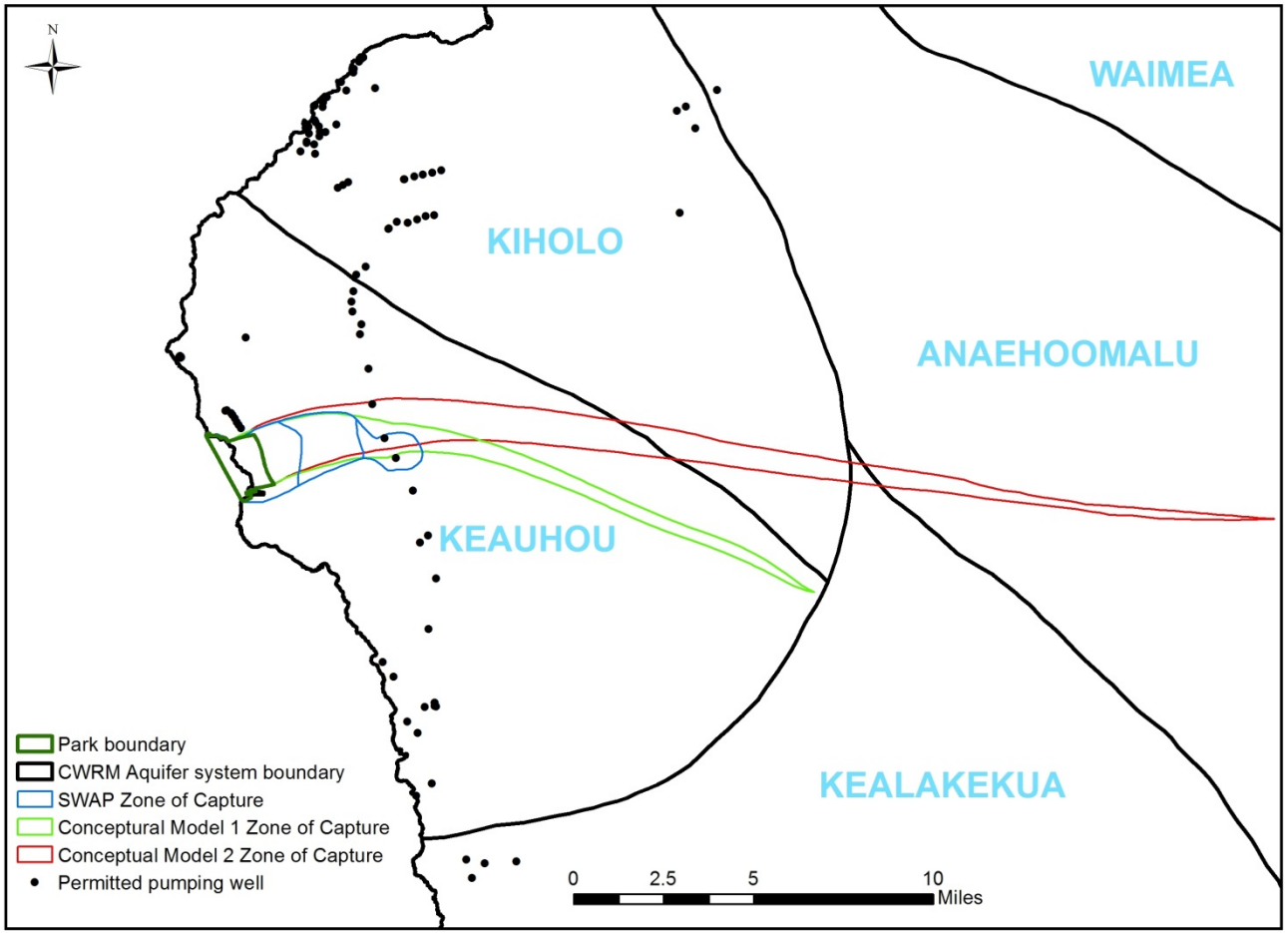


Capture Zone Delineation



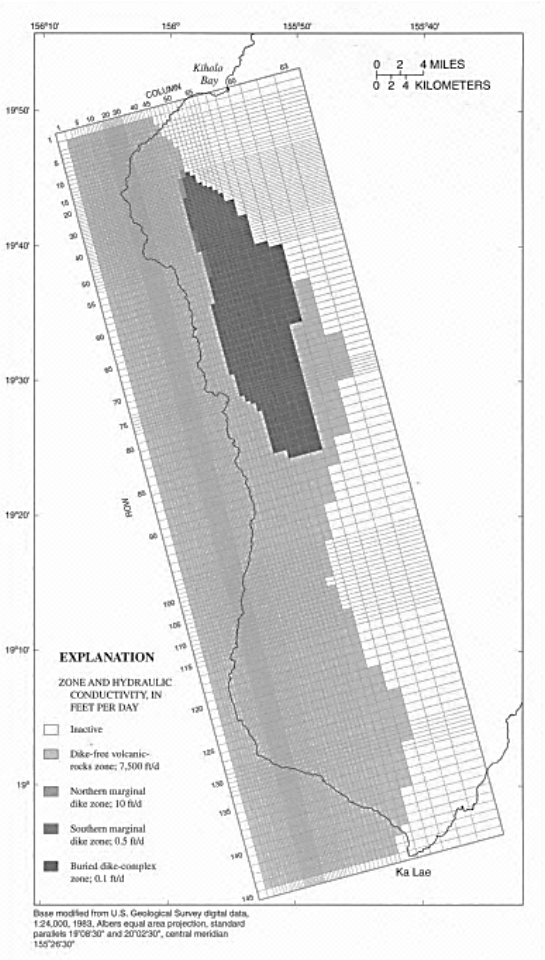
(Whittier et al. 2010)

Capture Zone Delineation (Preliminary)

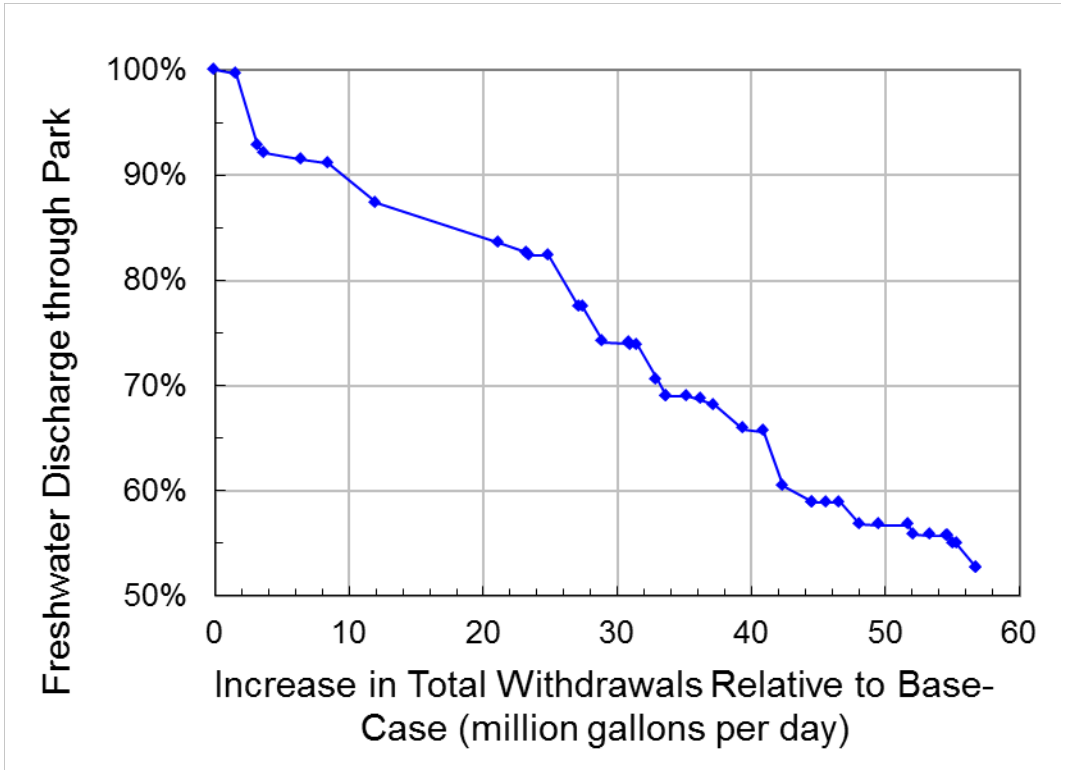


(Data courtesy Robert Whittier/State of Hawai‘i Department of Health)

1999 USGS Numerical Model



(Oki et al. 1999)

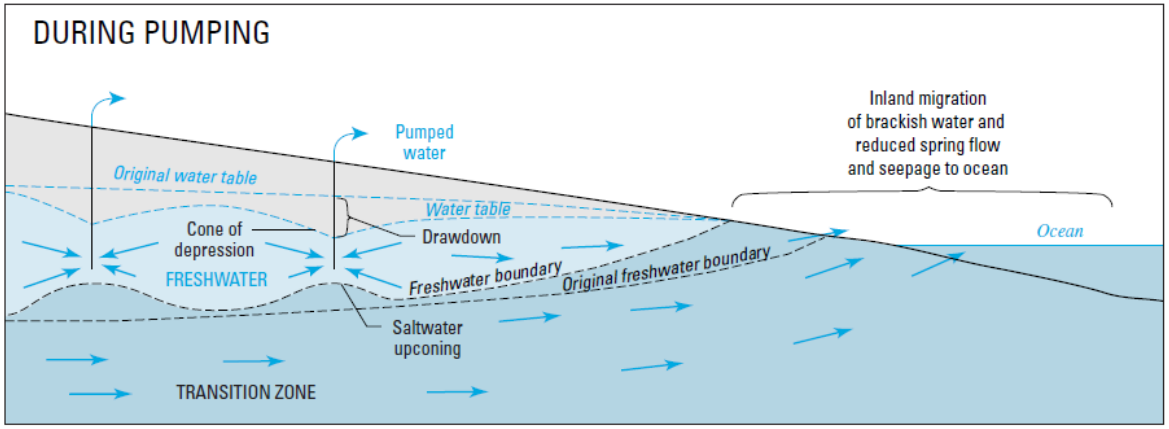


(Modified from Oki et al. 1999)

Capture = 3 million gallons per day in park

Summary

- Capture a function of well location (not recharge)
- Numerical models can estimate where capture occurs
- Sustainability guided by estimates of capture
  - Where will capture occur?
  - How much is acceptable for public trust resources?



(Curruth 2003)

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http://www.nature.nps.gov/water/index.cfm

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