Monitoring and Management of Water Resources Lahaina Aquifer Sector Area

John Helly [1, 2, 3], Amir Haroon [4]

[1]Member, Board of Water Supply, County of Maui
[2]San Diego Supercomputer Center
[3]Scripps Institution of Oceanography,
University of California, San Diego, La Jolla, California
[4]Hawaii Institute of Geophysics and Planetology,
University of Hawaii at Manoa, Honolulu, Hawaii

Outline

1. Problem Statement
2. Summary
3. Brief Review of Hydrology
4. Monitoring and Management Infrastructure
5. Expected Results
6. Projected Schedule and Budget
7. Summary (Slight Return)

Partnership Approach and Purpose

- Project realized through partnership of:
  - State (CWRM (?), University of Hawaii)
  - Counties (Maui MDWS)
  - NGOs (Kauai, 'Aina Ho'okupu o Kilauea (AHK))
  - Private Industry (Blue Rock LLC)
  - Federal: USGS (?)
- Funding Goes To
  - Collect critical data about Hawaiian aquifers
  - Expand current modeling capabilities (UH, USGS(?))
  - Establish training program for professional staff and students
  - Run Long-term operations providing decision-support to partners

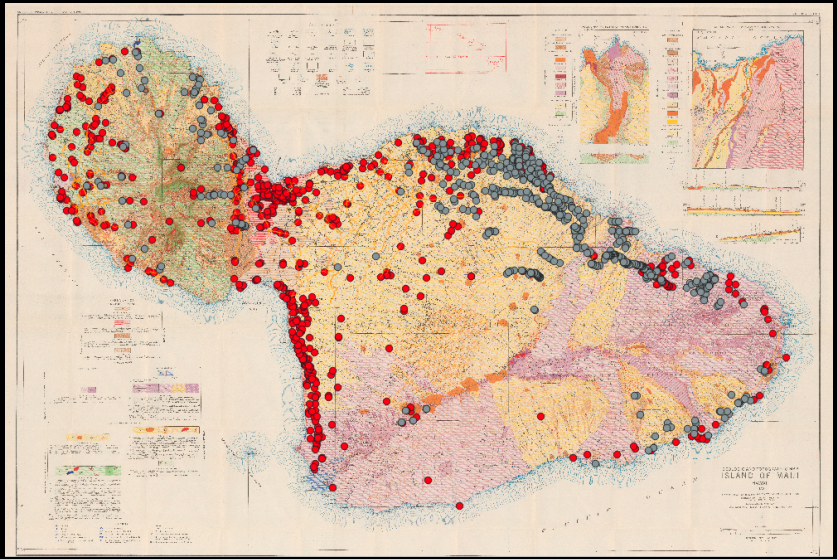
Problem Statement

- Declining ...
  - Water quantity
  - Water quality
  - Precipitation
- Population needs new housing; no housing without water
- There is no additional water without desalination (or more rain)
  - Re-allocation of existing use is only recourse in short-term
  - Management of groundwater resources is central to re-allocation and sustainability
- How to make re-allocation decisions without understanding aquifer conditions?

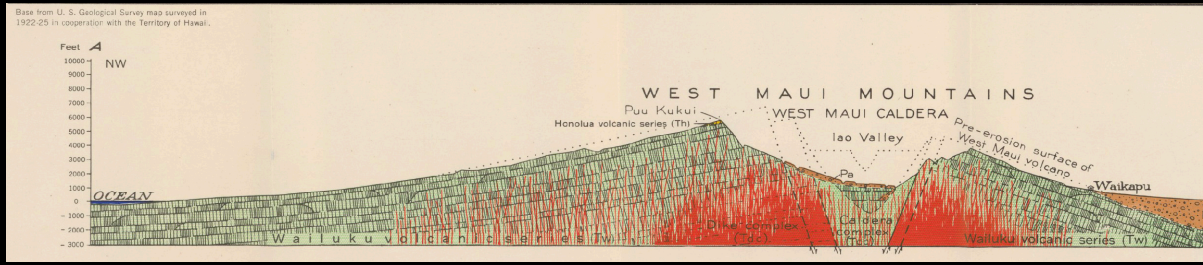
Maui Needs a Long-term Water Monitoring Program

- Modeling (USGS) already used as management tool but ...
  - Currently, without sufficient data
  - Deep Monitor Wells (DMWs) essential to long-term management
  - Cannot build enough DMWs to be sufficient
  - AEM data provides missing structure and initial values
  - DMW data used long-term to validate model predictions
- Model projections can also be validated against pumping data for
  - Water levels
  - Chloride levels
  - Other contaminants
  - Regulatory decision-making
  - On-going pumping operations and compliance
  - Change detection and anticipation

Developed Water Supply on Island of Maui
Diversions and Wells

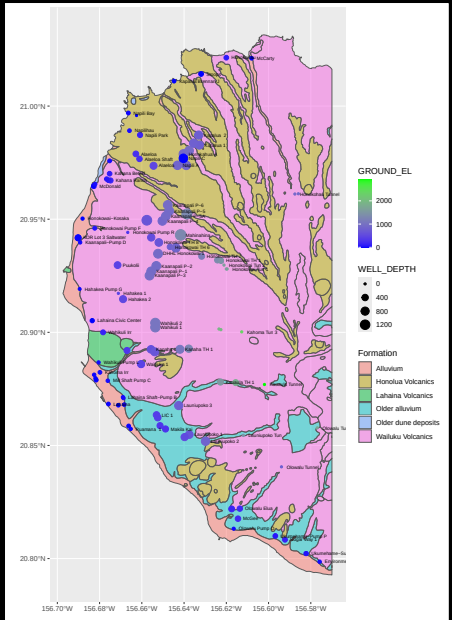


Cross-sectional Geologic Setting for LASEA
Limits of Present Knowledge



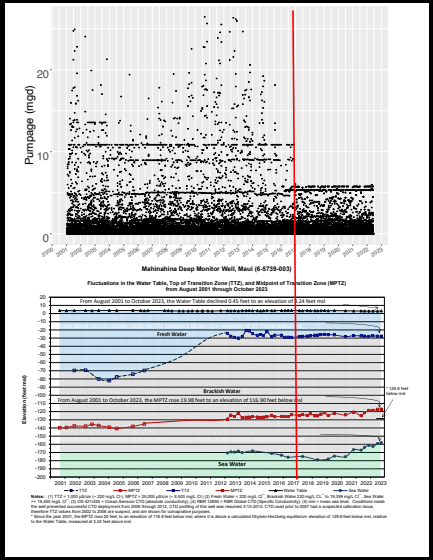
- Stearns and MacDonald (1942) is still the primary reference

Surficial Geological Setting for LASEA



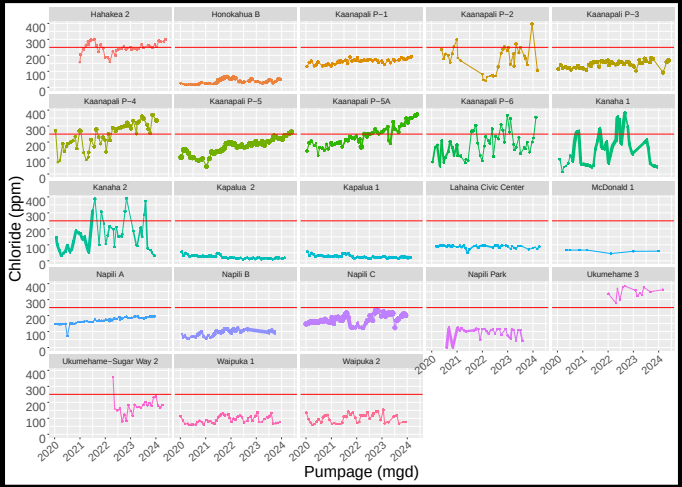
- Not geologically homogeneous
- Not geographically homogeneous in land or water use
- Numerous wells (MDWS and private)
- Two Water Treatment Facilities (surface water)

What Do We Know About Water Quantity and Quality?



- We know aquifer with *only* Deep Monitor Well shows disturbing trends and possibly unexpected behaviors

What Do We Know About Water Quantity and Quality? (cont.)

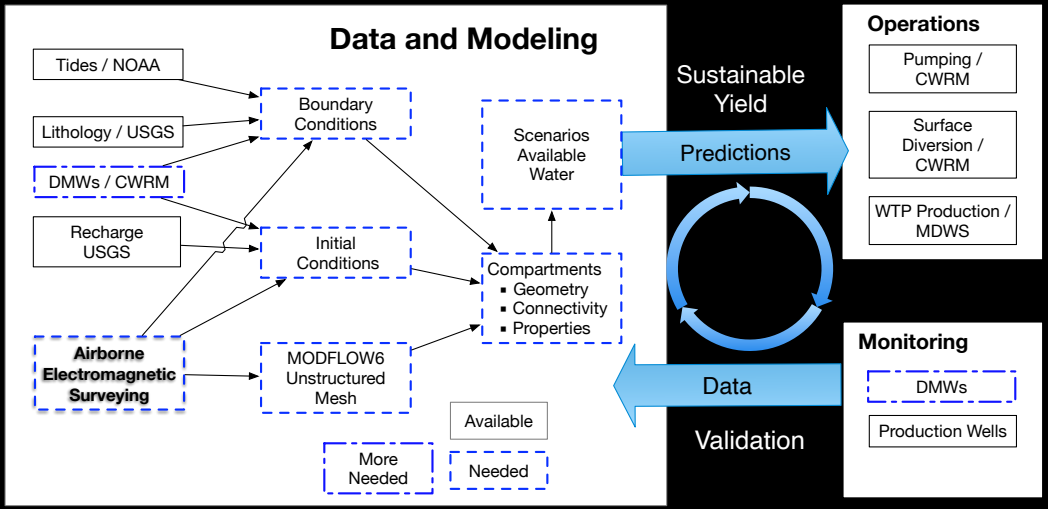


- We know wells over-pumped with increasingly frequent exceedances of potable water limits for salt (chloride)

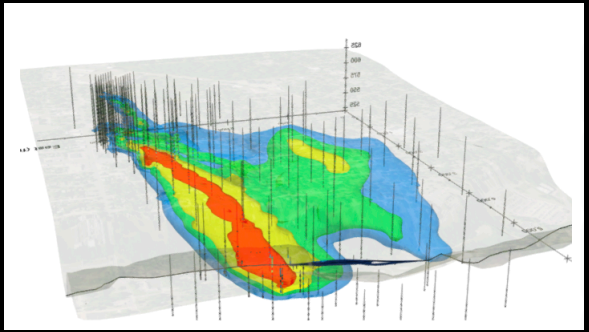
What can we do to improve this situation?

Operate pumping at sustainable levels

Requires Better Understanding of Aquifers



What Good Is A 3D Model of Groundwater?

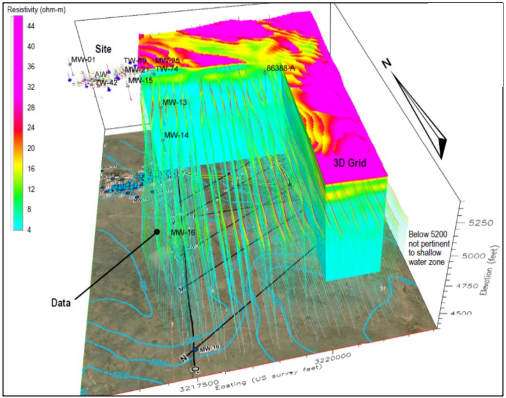


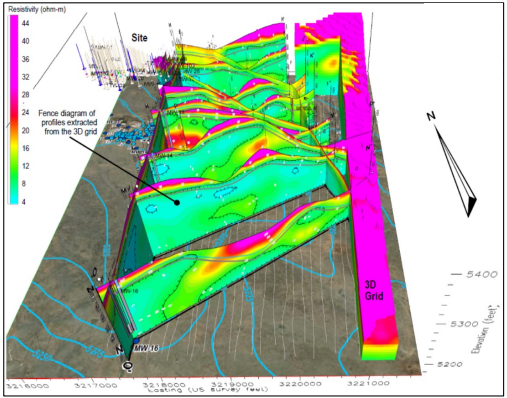
- Quantify volumes and distribution of groundwater horizontally and vertically
- Provide testable estimates of recharge; therefore sustainable yield
- Inform site selection for Deep Monitor Wells

https://sketchfab.com/3d-models/groundwater-plume-example-13-r-priority-e2d54ec8511c49969cfd0c1a3ea8e7e2

3D Model Mesh from Airborne Electromagnetic (AEM) Data

3D Model from Resistivity Data





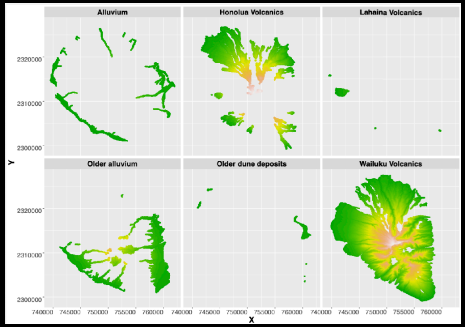
Post-Oasis Montaj Processing

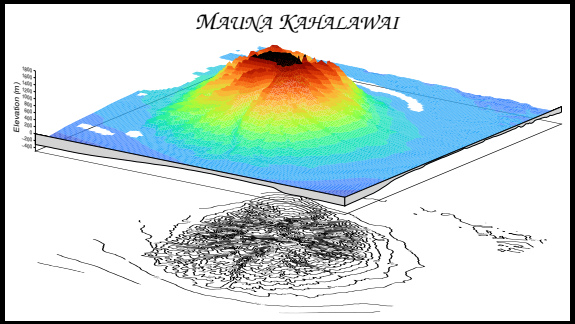
- The 3D grid-interpolation was performed using a minimum tension splining algorithm within the EarthVision 3D geologic modeling suite (Dynamic Graphics, 2023)
- Calibrated (updated) the resistivity model to corroborate with existing 'onsite' boreholes (lithology, saturated zone, etc.)
- Extracted onsite and offsite profiles from the 3D grid to construct this 'Fence Diagram'

What Are Benefits of Airborne Electromagnetic Surveys for Reliable 3D Modeling?

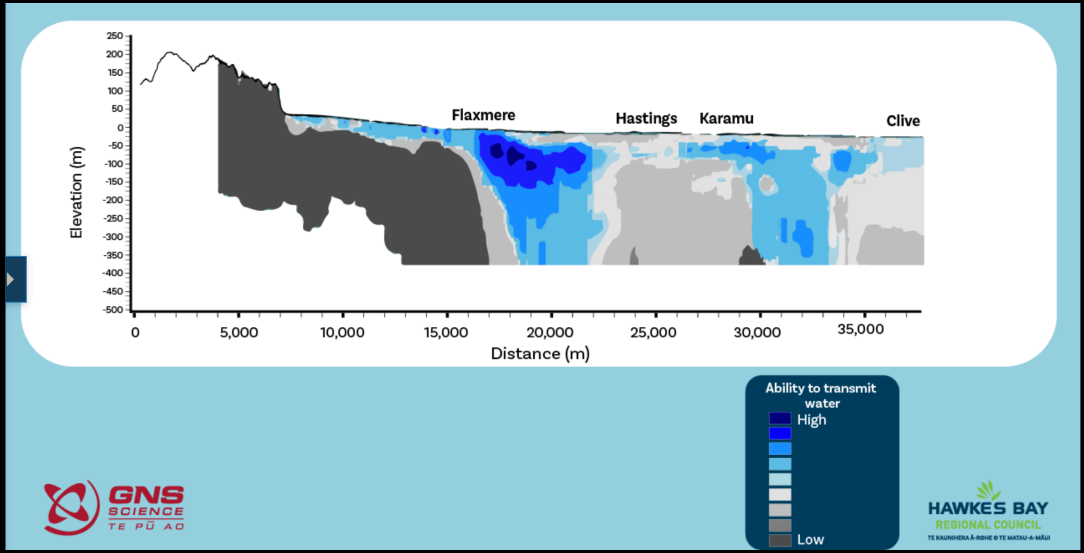
- Large area characterization of aquifer structure at fine spatial resolution
- Point-in-time estimate of water volume and distribution within the ground
- Relationship of existing wells to available and compromised water including ocean intrusion
- Model projections can be compared to wells (i.e., monitor and production) for on-going management, change detection, regulatory decision-making

Other Data Needed for 3D-Model Development Already Exist

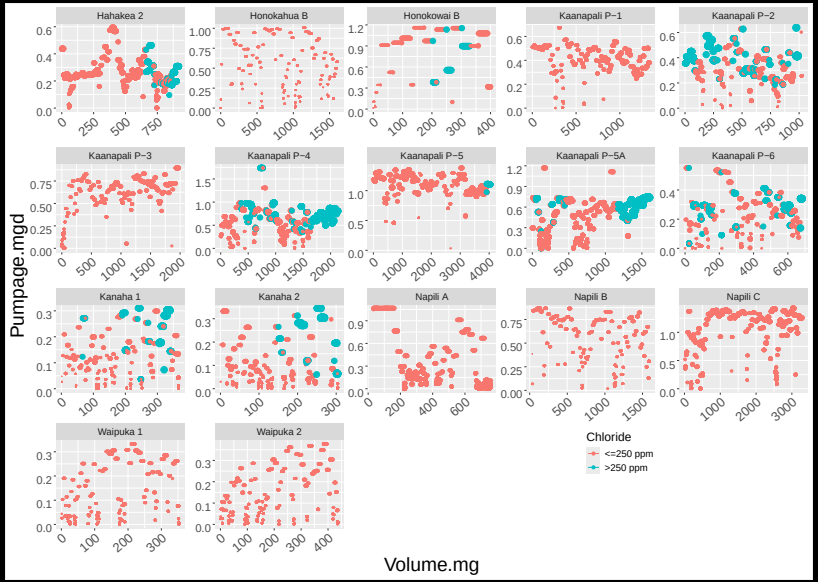




Example Results: Hawkes Bay New Zealand (2022)



Expected Results: Pumping Limits Within Well-defined Aquifers



Preliminary Schedule & Budget

Status	Year		Y1				Y2				Y3				Y4				Non-Recurring Cost ($M)	Recurring Cost ($M)	Non-Recurring Cost ($M)
	Quarter		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	West Maui		8 x Area
	Component	Item																			
CWRM	Monitoring	DMW.Mahinahina.1	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
New	Monitoring	DMW.Mahinahina.2								X	X	X	X	X	X	X	X	X	1.1	0.1	
New	Monitoring	DMW.Launiopoko.1								X	X	X	X	X	X	X	X	X	1.1		
CWRM	Monitoring	CWRM.WellData	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			
New	Modeling	AEM Data Acquisition					X												0.5		1.5
New	Modeling	AEM Data Analysis						X	X	X											
New	Modeling	Development	X	X	X	X	X	X	X	X	X	X	X						1.5		
New	Modeling	Verification & Validation					X	X	X	X	X	X	X						0.8		
New	Modeling	Maintenance													X	X	X	X		0.2	
New	Operations	Long-term									X	X	X	X	X	X	X	X	0.1	0.5	
																		Totals	2.9	0.8	1.5

Schedule and Budget (cont.)

- Project realized through partnership of:
  - State (CWRM (?), University of Hawaii)
  - Counties (Maui MDWS)
  - NGOs (Kauai, 'Aina Ho'okupu o Kilauea (AHK))
  - Private Industry (Blue Rock LLC)
  - Federal: USGS (?)
- Funding Goes To
  - Collect data
  - Expand current modeling capabilities (UH, USGS(?))
  - Establish training program for professional staff and students
  - Run Long-term operations providing decision-support to partners