Groundwater Management and Research in Hawaii

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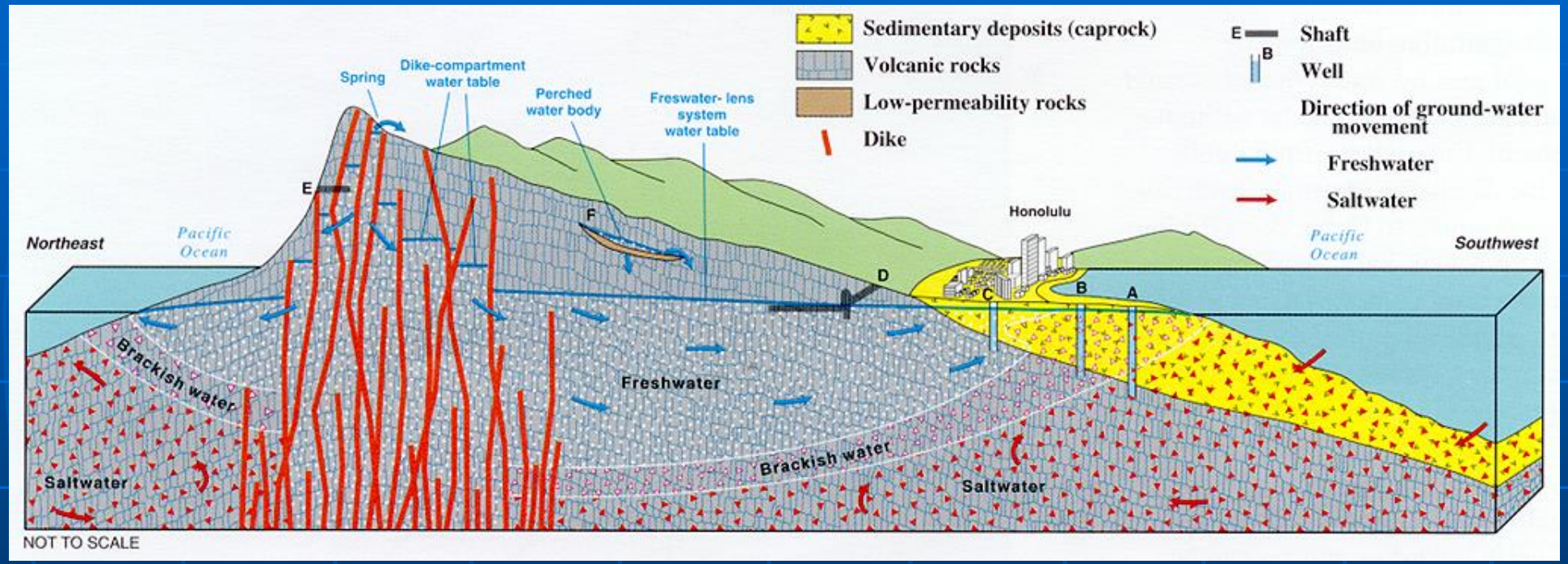
Outline

- Introduction
  - Groundwater value
  - Hawaii hydrogeology
  - Hawaii groundwater problems
- Modeling Studies
  - Water quantity
  - Water quality
  - Example case studies
- Needed research

Groundwater value

- On Oahu
  - 90% of drinking; 50% of agriculture
- Easier/cheaper to treat
- Less affected by rainfall variation
- Surface water use requires reservoir/diversion

Hawaii Hydrogeology

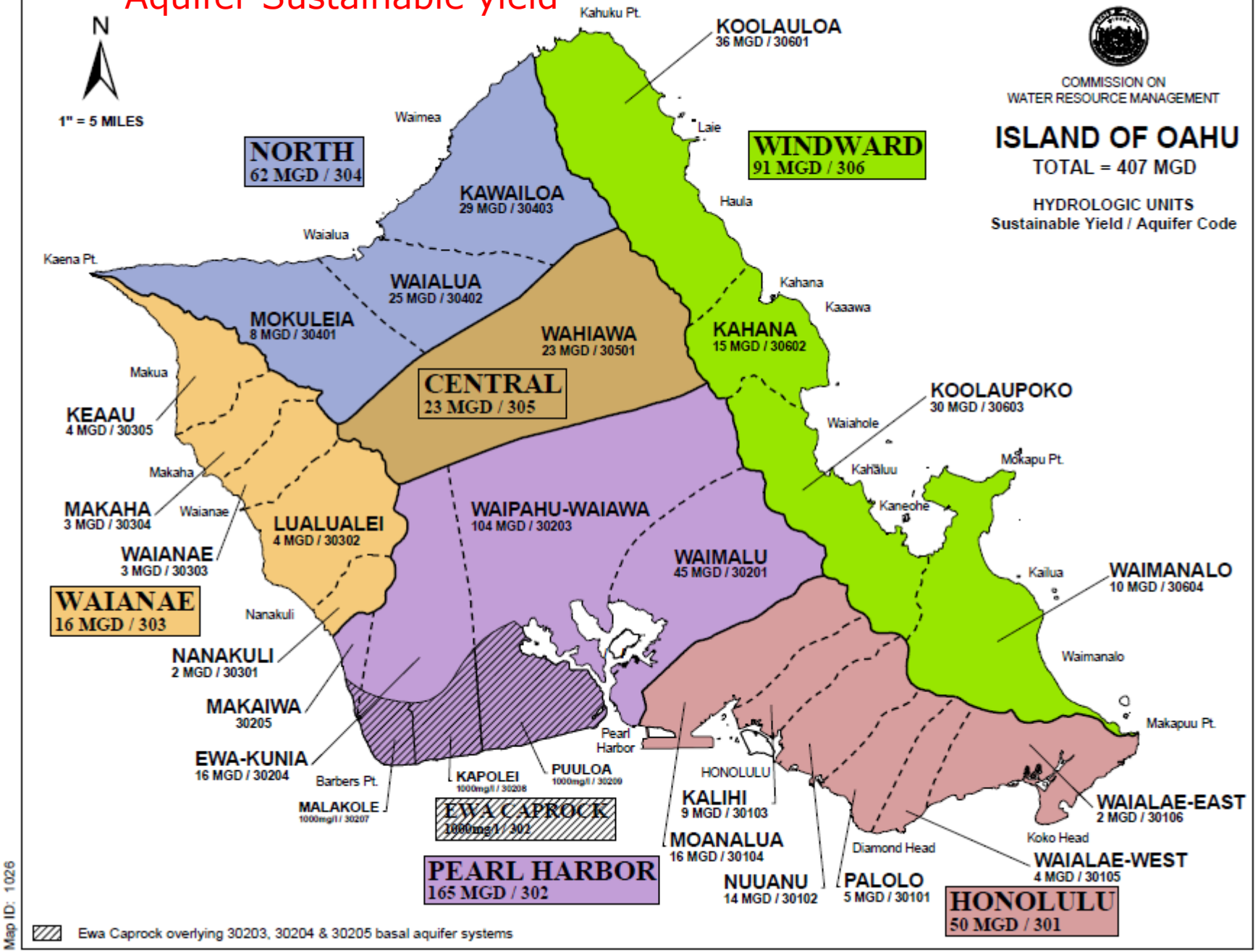


Schematic cross section of the island of Oahu showing various hydrogeological features and different water development installations (Gingerich and Oki, 2000).

Recharge

- Accurate assessment of recharge is an essential part of groundwater management, considering that uncertainties in recharge estimates can translate into inaccurate appraisal of aquifer sustainability.

Aquifer Sustainable yield



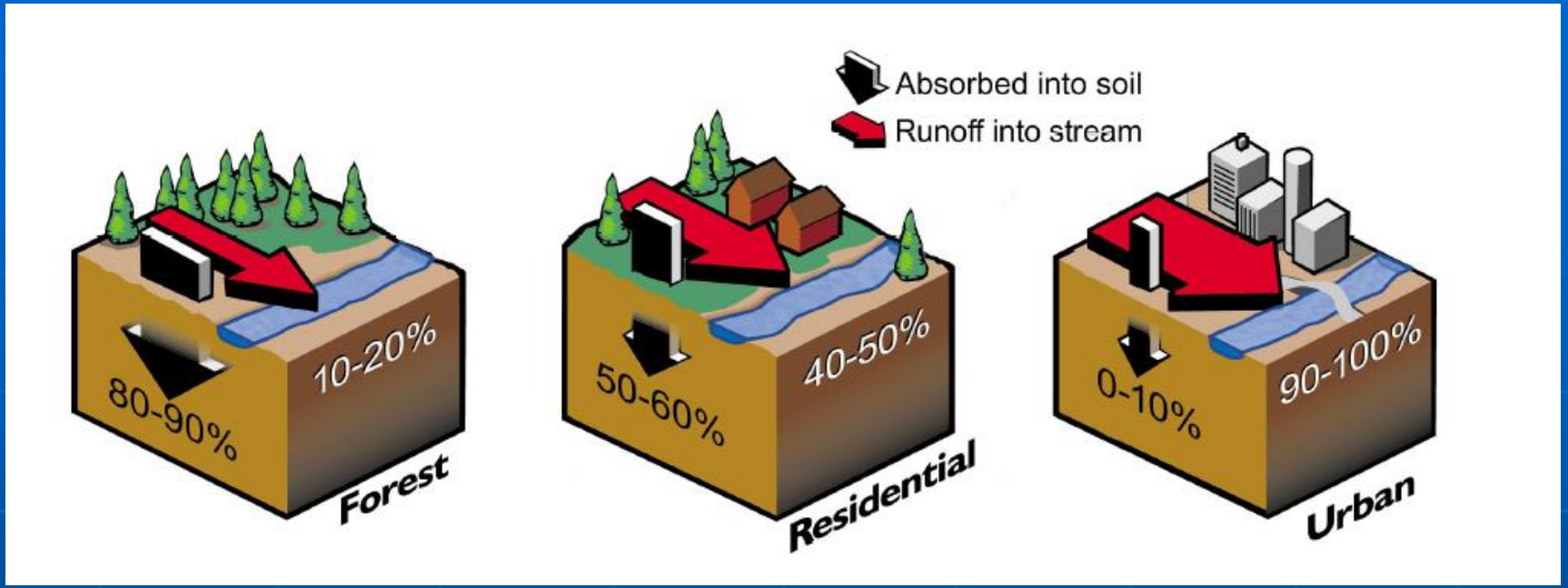
Rainfall and Recharge

- Rainfall less than 10 to more than 400 inches (annual)
- Average total rainfall 21 bgd (billion gallons per day)
- Total sustainable yield 3.6 bgd
- Actual pumped 0.5 bgd (1995)
- Recharge 10-50% of rainfall, irrigation, and fog drip
- Potential droughts/water degradation

Recharge

- Estimated from water budget elements:
  - rainfall
  - surface runoff
  - evapotranspiration
  - infiltration
  - soil moisture storage
  - fog drip

Partition between runoff and infiltration



Increased runoff:

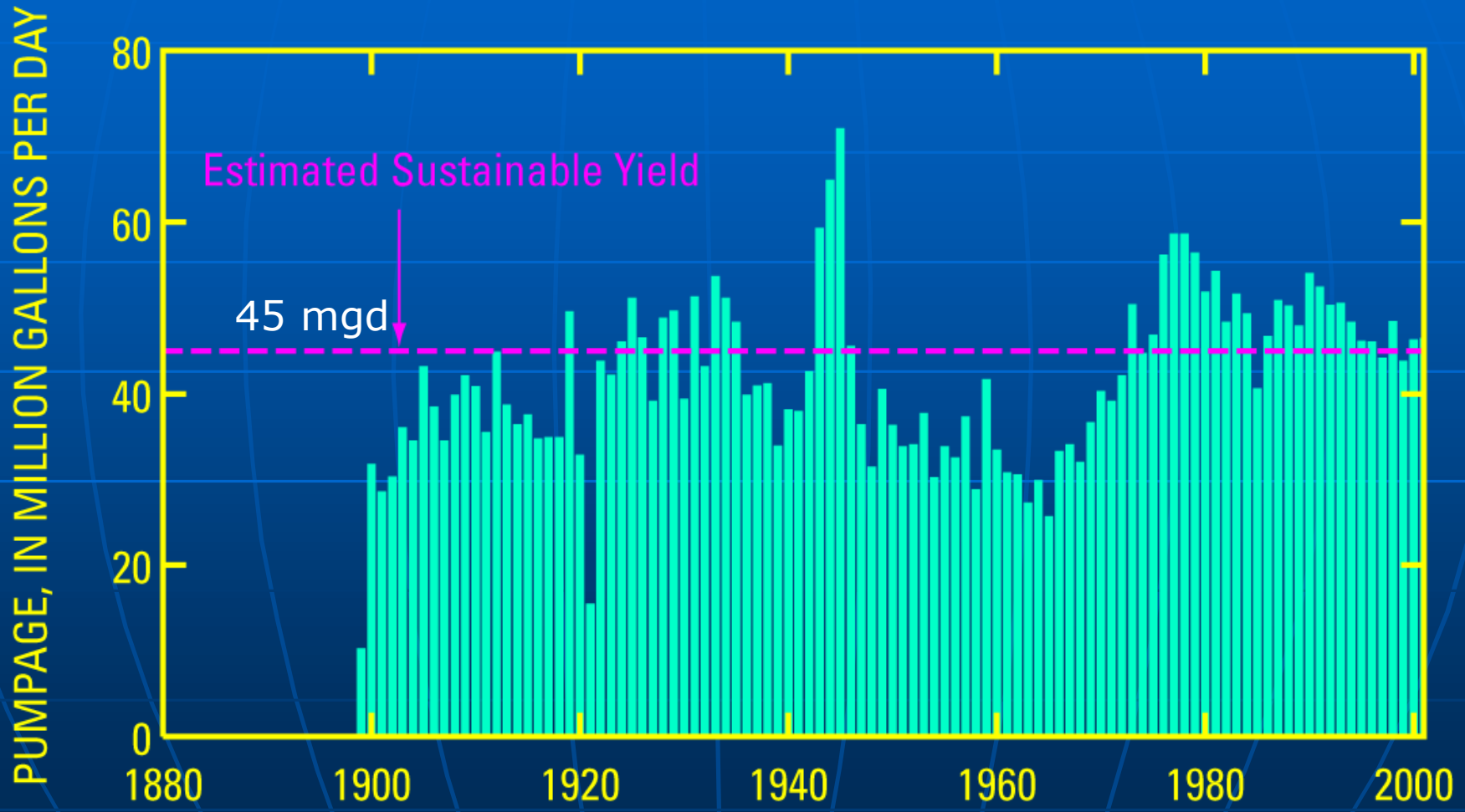
Clearing forests and grading

Urbanization

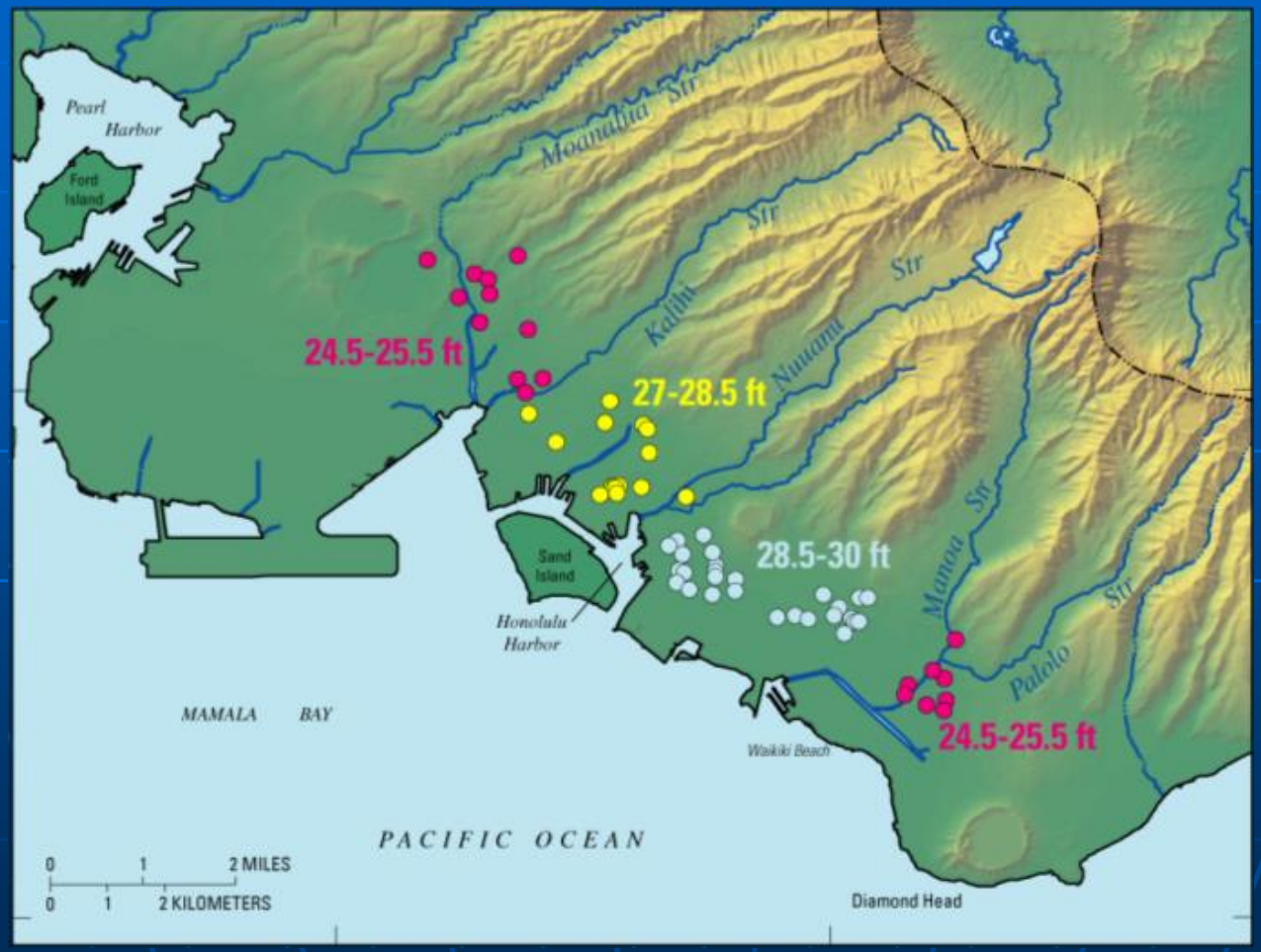
Hawaii Groundwater Problems

- Availability of potable freshwater
- Contamination due
  - organic or inorganic chemicals associated with land-use activities
  - saltwater intrusion

Waimalu Area Pumpage (Eastern Pearl Harbor) : From Oki (2005)

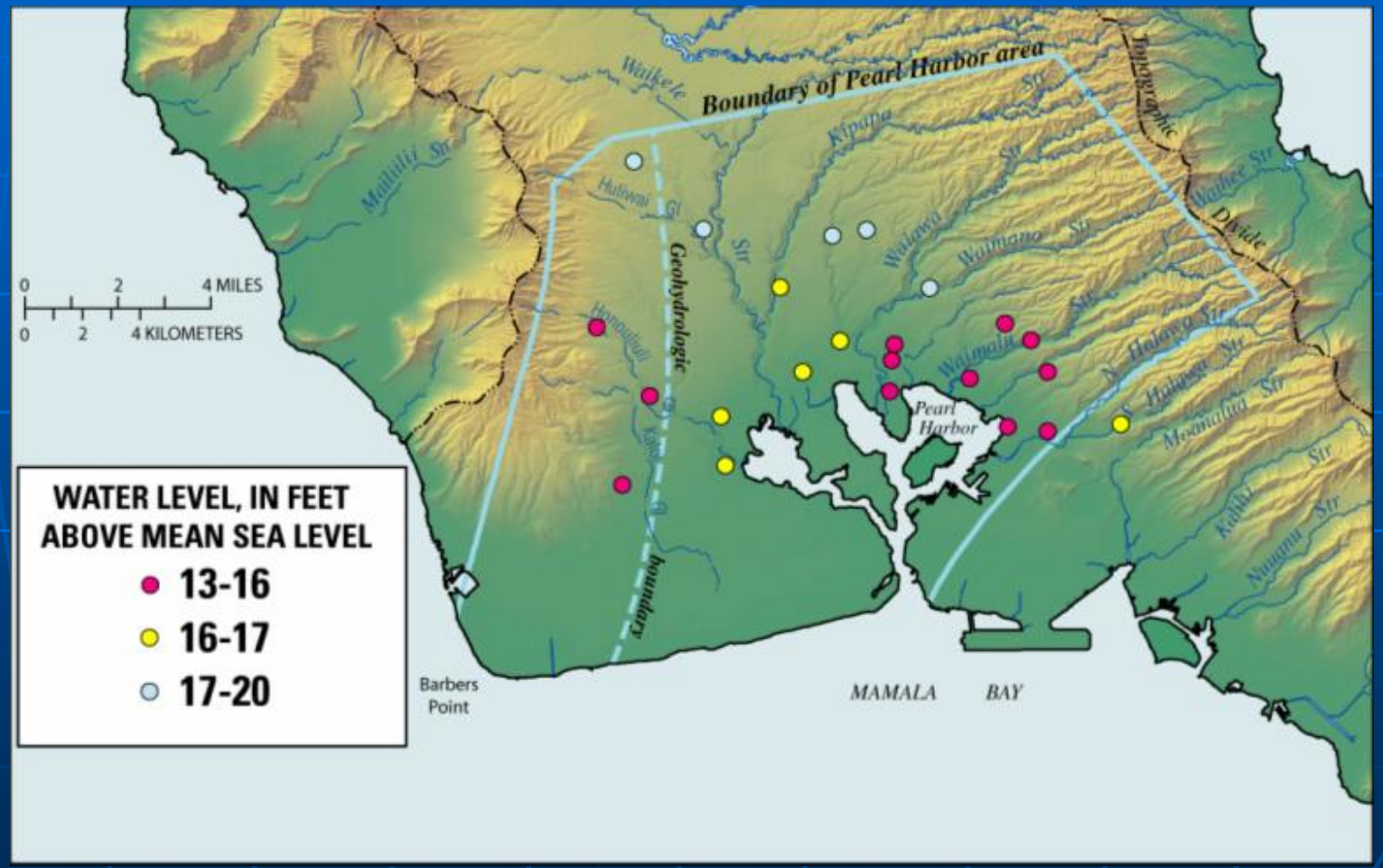


Honolulu Water Levels (May 1951) : From Oki (2005)

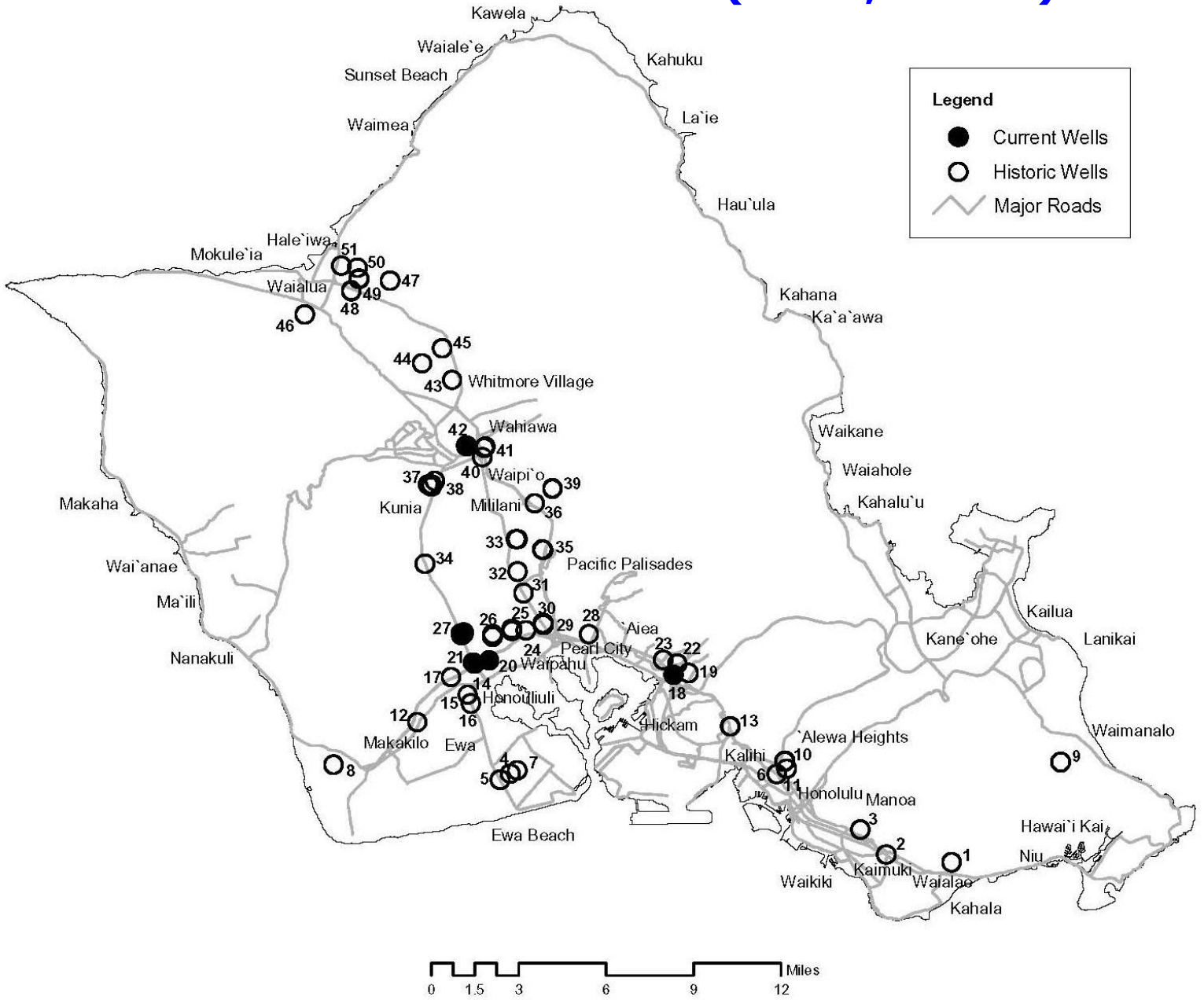


Source: BWS data

Pearl Harbor Water Levels (May 2003) : From Oki (2005)



Groundwater Contamination (2004; HDOH)



O`AHU 2004 Contamination Map						
Map #	Well #	Well Name	Use	Contaminant	Detected Level (ppb)	Date
1	1746-01	Ainakoa Well	DW	Dieldrin	0.03	07/28/03
2	1748-HS	Kaimuki Station Wells	DW	Dieldrin	0.03	10/06/04
2	1748-LS	Kaimuki Station Wells	DW	Dieldrin	0.02	10/06/04
2	1748-03-10	Kaimuki Station Wells	DW	PCE	0.03	4/23/85*
			*ND after this date. PCE detection levels raised from 0.01 ppb to 0.2 ppb.			
3	1849-14	Wilder Well 1	DW	Dieldrin	0.01	10/06/04
4	1900-01	OSCO Ewa Pump 20	Inactive	Ametryn	NQ <0.05	11/10/92
4	1900-01	OSCO Ewa Pump 20	Inactive	Atrazine	0.71	11/16/93
4	1900-01	OSCO Ewa Pump 20	Inactive	Diamino Atrazine	0.22	11/10/93
4	1900-01	OSCO Ewa Pump 20	Inactive	Desethyl Atrazine	1.20	11/16/93
4	1900-01	OSCO Ewa Pump 20	Inactive	Deisopropyl Atrazine	0.13	11/16/93
5	1901-01	OSCO Ewa Pump 24	Inactive	Ametryn	0.11	11/10/92
5	1901-01	OSCO Ewa Pump 24	Inactive	Atrazine	1.10	11/10/92
5	1901-01	OSCO Ewa Pump 24	Inactive	Diamino Atrazine	0.50	11/10/92
5	1901-01	OSCO Ewa Pump 24	Inactive	Desethyl Atrazine	1.59	11/10/92
5	1901-01	OSCO Ewa Pump 24	Inactive	Deisopropyl Atrazine	0.21	11/10/92
6	1952-HS	Kalihi Station Wells	DW	Dieldrin	0.02	10/06/04
7	2000-01	OSCO Ewa Pump 21	Inactive	Atrazine	0.77	11/16/93
7	2000-01	OSCO Ewa Pump 21	Inactive	Diamino Atrazine	0.25	11/16/93
7	2000-01	OSCO Ewa Pump 21	Inactive	Desethyl Atrazine	1.00	11/16/93
7	2000-01	OSCO Ewa Pump 21	Inactive	Deisopropyl Atrazine	0.13	11/16/93

Waimalu Area Chlorides (Halawa Shaft) :
From Oki (2005)

Source: BWS data from CWRM

Modeling

Use of simulation models to:

- Understand processes
- Identify data needs
- Manage resources: alone or combined with others (e.g., economic) models

Modeling: Water Quantity

Early Studies

- Sand box experiments
- Field assessment
- Analytical solutions
- Sharp interface models

Modeling: Water Quantity

More Recent Studies

- Two-dimensional modeling of mixing along saltwater–freshwater interface
- Areal sharp-interface models
- Three-dimensional models
  - Fixed density
  - Density dependent

Groundwater Modeling System (GMS)

- Interfaces to models, including:

- Flow: saturated zone
- Flow: saturated and unsaturated zone
- Transport
- Reactive transport
- Multi-phase reactive transport

Modeling: Water Quality

- Contaminants include agrochemicals, solvents, dry-cleaning agents, and insecticides.

Difficulties in modeling

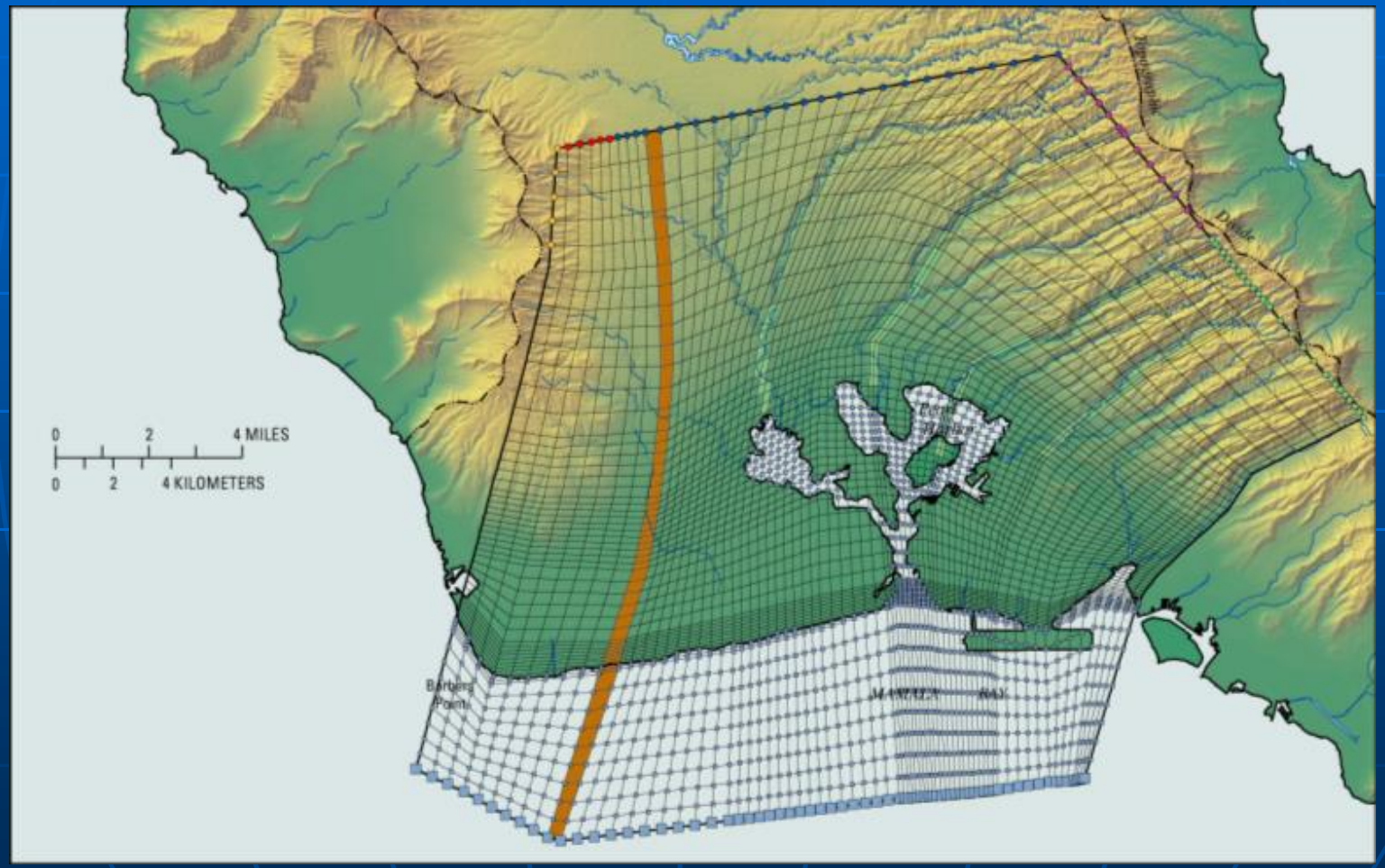
- Thickness of unsaturated zone
- Great variability of subsurface characteristics, such as hydraulic conductivity
- Assessment of chemical transformations and dispersion parameters.
- Potential preferential flow in unsaturated zone

Example Modeling Study

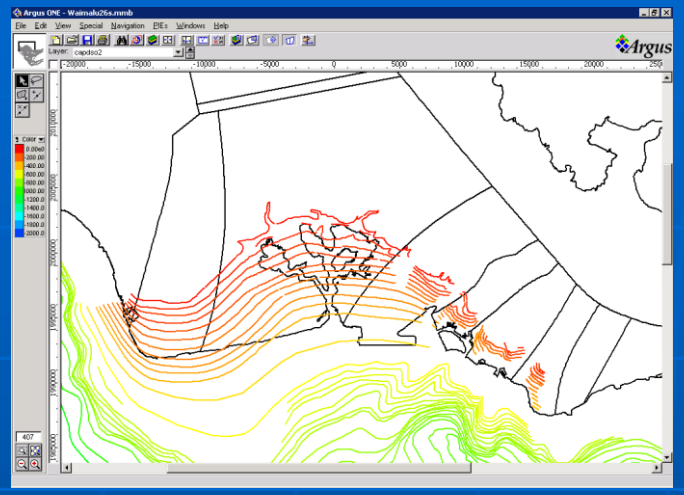
Modeling Valley Fill Influence on Flow Patterns in the Pearl Harbor Aquifer

Oki, D.S. 2005. Numerical simulation of the effects of low-permeability valley-fill barriers and the redistribution of ground-water withdrawals in the Pearl Harbor area, Oahu, Hawaii.

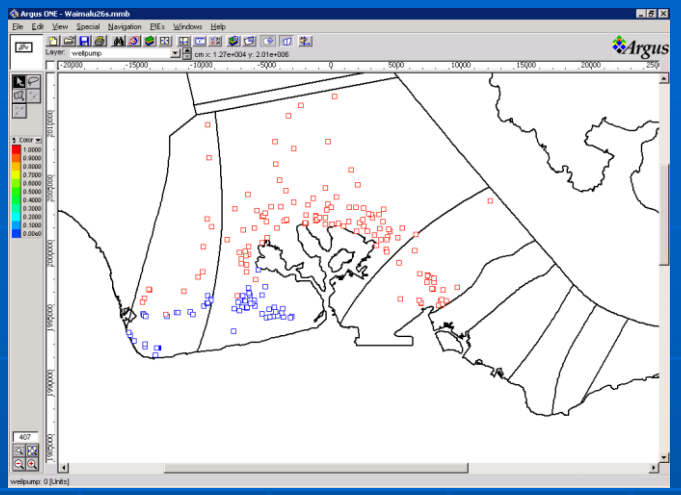
Model Mesh (306,432 nodes) : From Oki (2005)



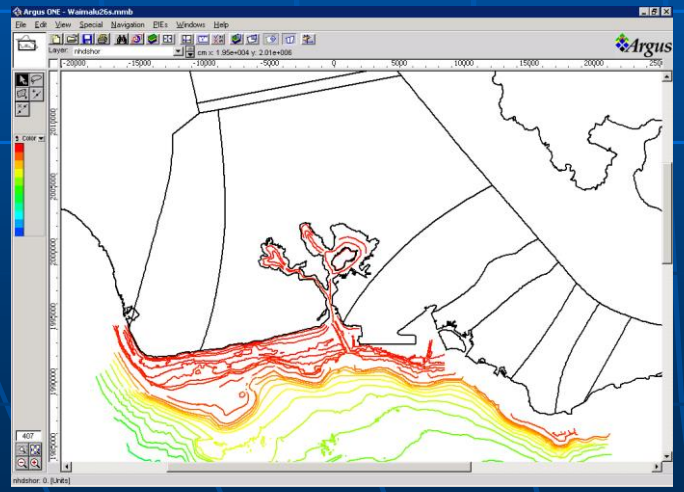
Model Construction: From Oki (2005)



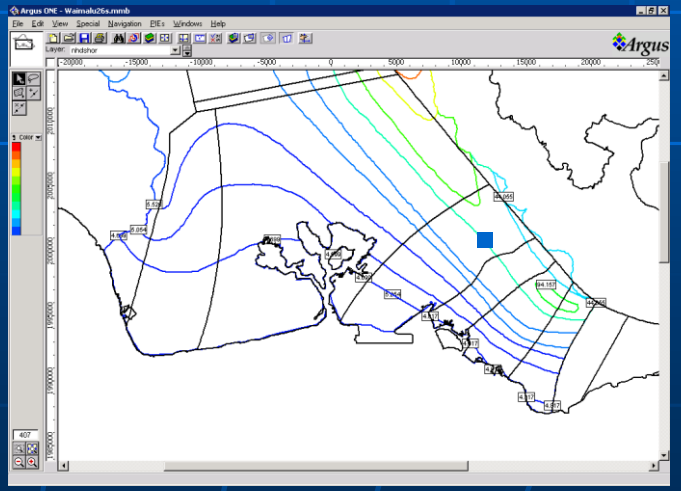
Caprock



Pumped Wells (basalt and caprock)

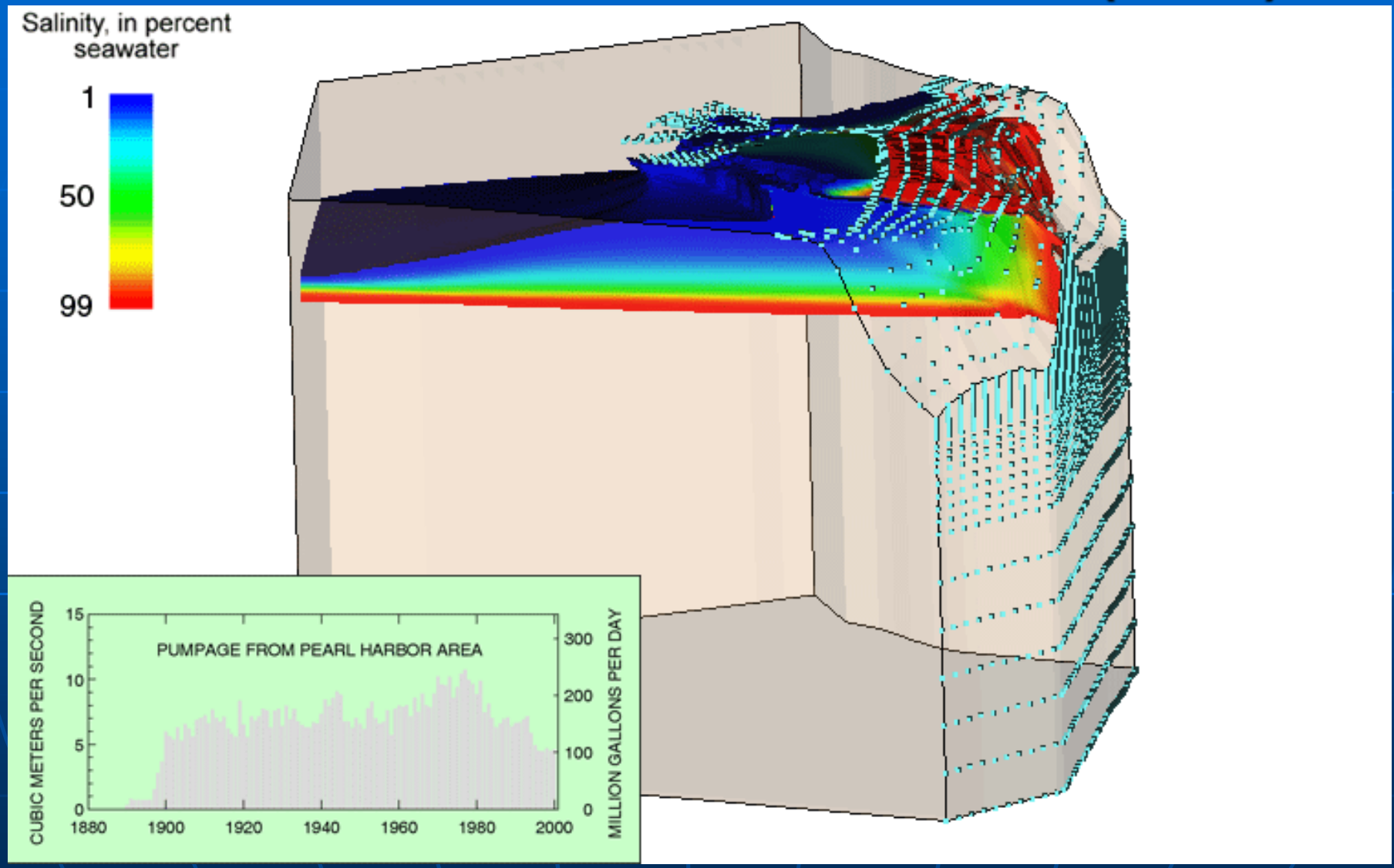


Bathymetry



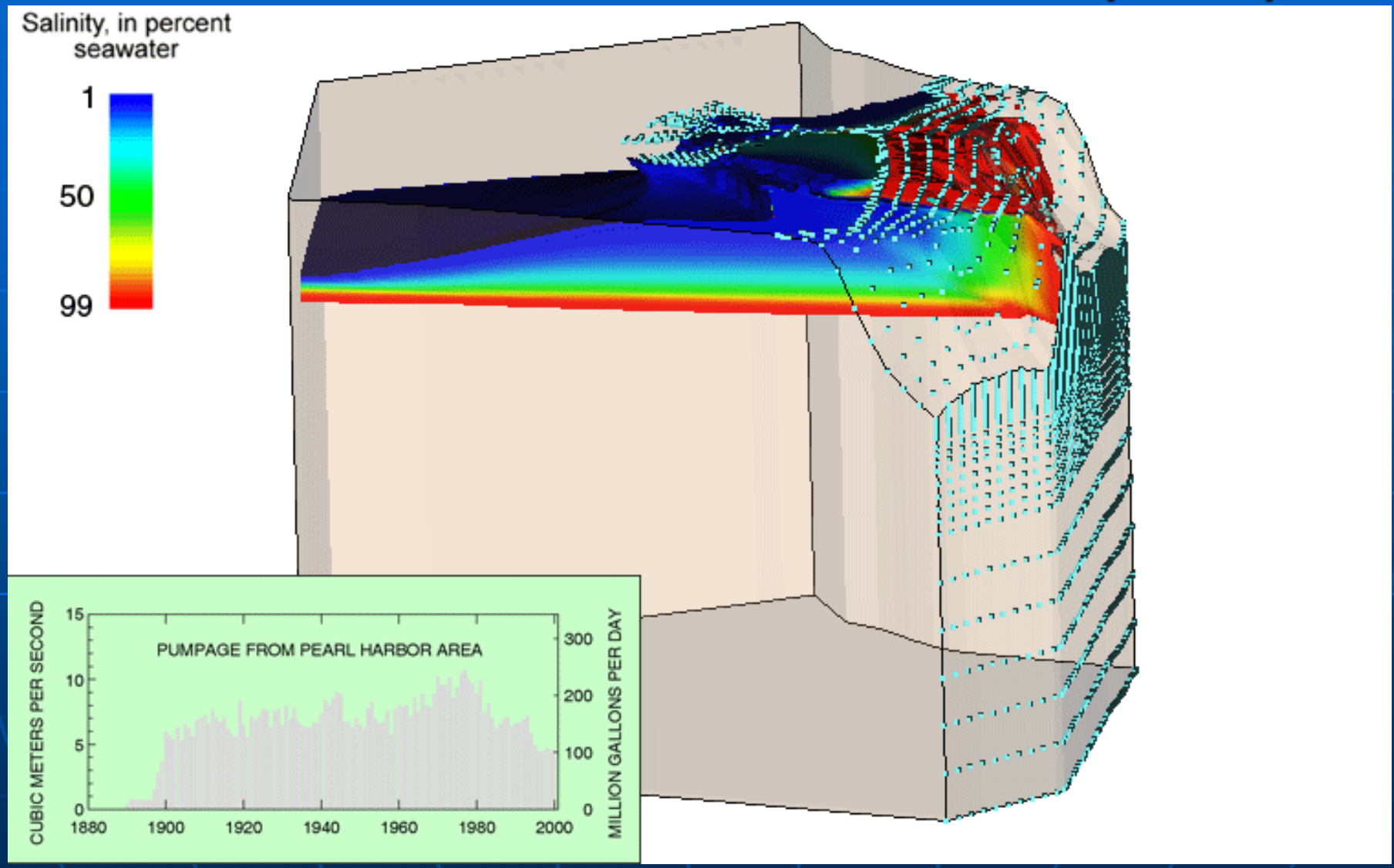
Recharge

1880-2000 Simulation: From Oki (2005)



Courtesy: Delwyn Oki (USGS)

1880-2000 Simulation: From Oki (2005)



Courtesy: Delwyn Oki (USGS)

Needed Research

- Hawaii hydrogeology is complex
- new methodologies and application of existing ones for parameter estimation
- develop integrated approach for resource management
- develop geophysical methods for identifying new water sources through exploitation of low-conductivity zones

- develop new geophysical methods to explore new water-supply aquifers
- study hydrogeochemically heterogeneous aquifers
- develop exploration methods to describe spatial variability of unsaturated zone
- develop methods and models to describe the effects of aquifer variability on different scales of dispersion
- study organic contamination persistence in the source area