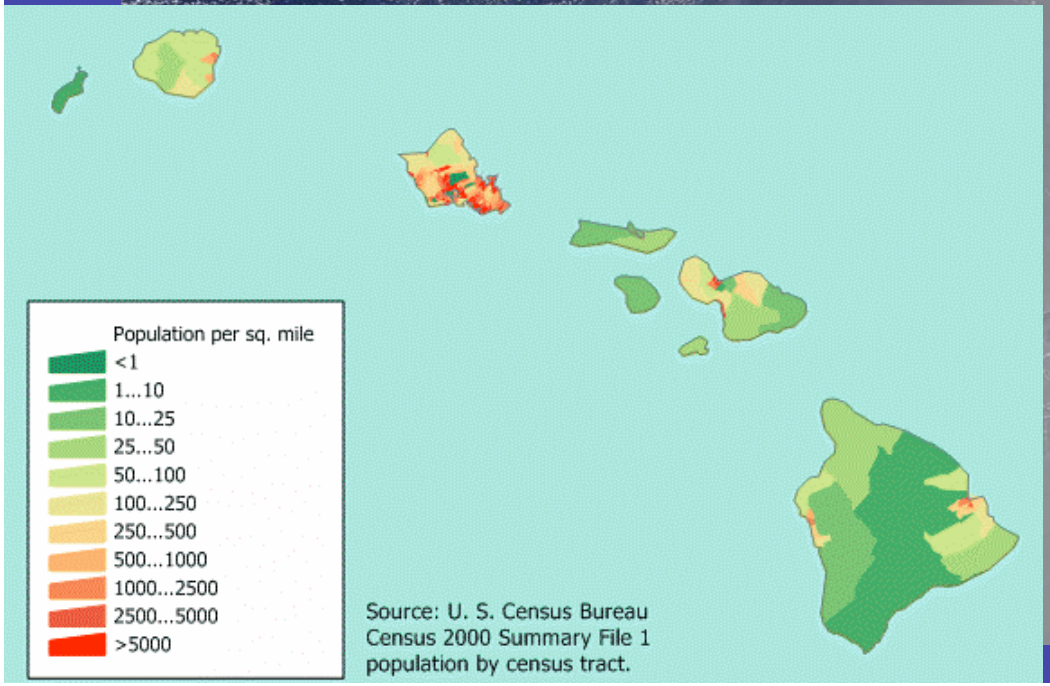
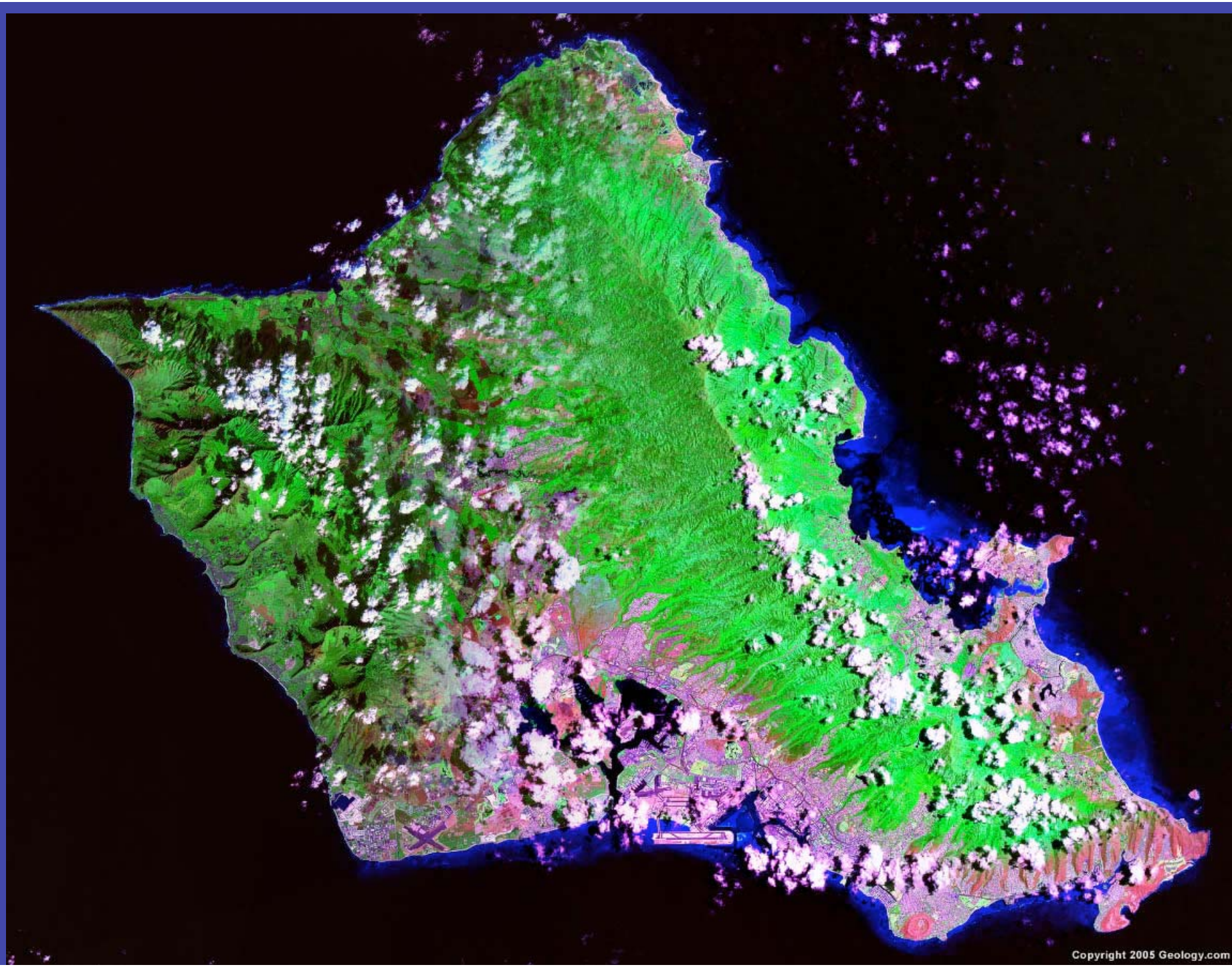
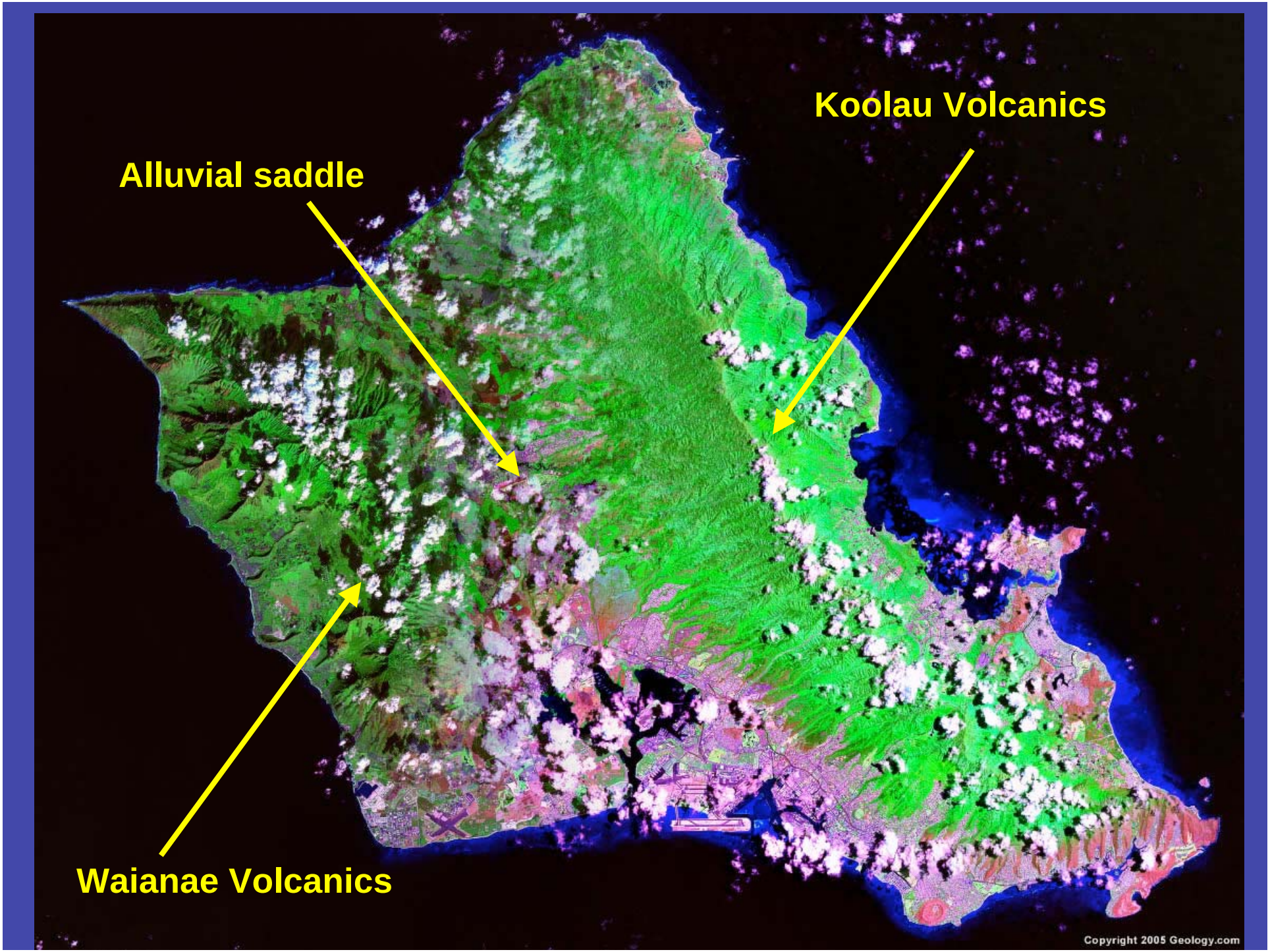
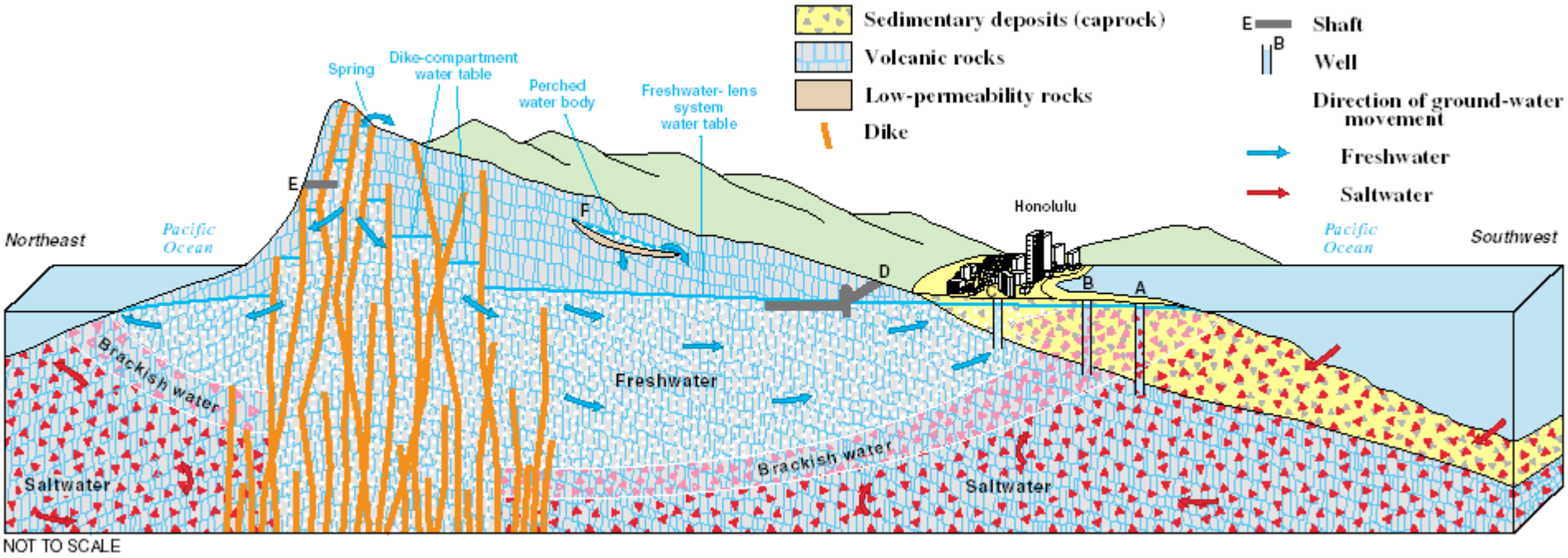
# Why is Oahu Hawaii's most densely populated island?




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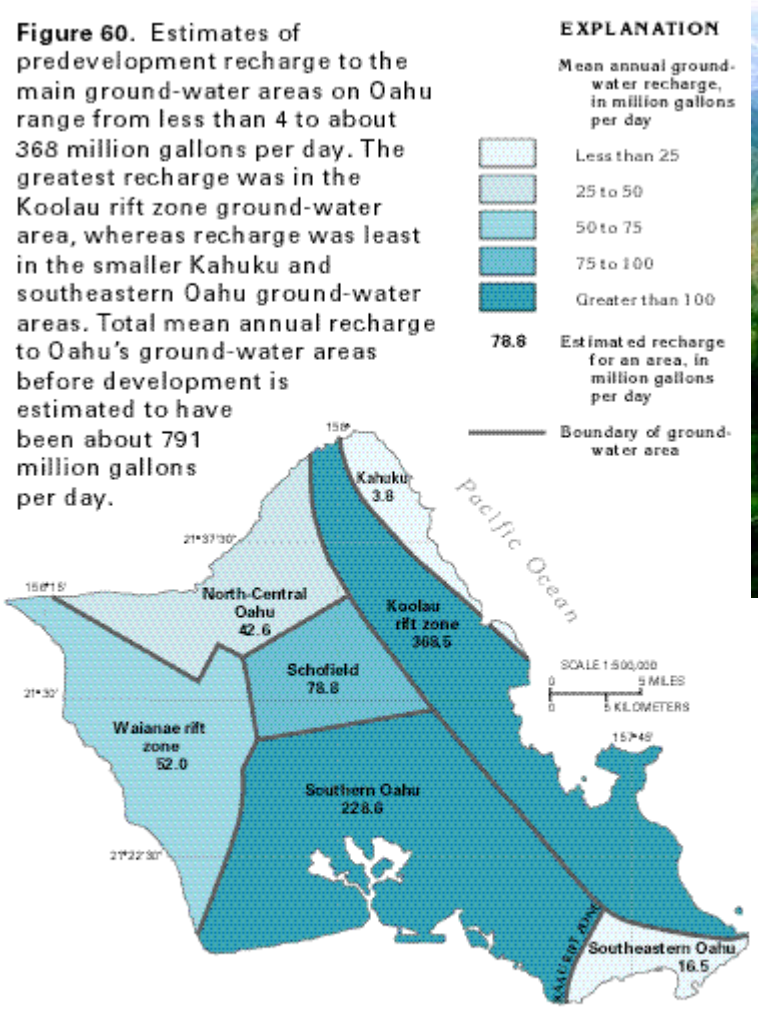

Koolau Volcanics
Alluvial saddle
Waianae Volcanics
Copyright 2005 Geology.com




1. Recharge – rainfall, fog drip, irrigation water
2. Porosity vs. permeability
3. Freshwater lens (Ghyben-Herzberg Principle 1:40)
4. Caprock
5. Brackish transition zone
6. Saltwater zone
7. Dike impounded system
8. Wells A-E

# What are the sources of Oahu's water?

**Figure 60.** Estimates of predevelopment recharge to the main ground-water areas on Oahu range from less than 4 to about 368 million gallons per day. The greatest recharge was in the Koolau rift zone ground-water area, whereas recharge was least in the smaller Kahuku and southeastern Oahu ground-water areas. Total mean annual recharge to Oahu's ground-water areas before development is estimated to have been about 791 million gallons per day.




Data from Shade, P.J., and Nichols, W.D., 1996, Water budget and the effects of land-use changes on ground-water recharge, Oahu, Hawaii: U.S. Geological Survey Professional Paper 1412–C, 38 p.
Base modified from U.S. Geological Survey digital data






# What are the sources of Oahu's water?







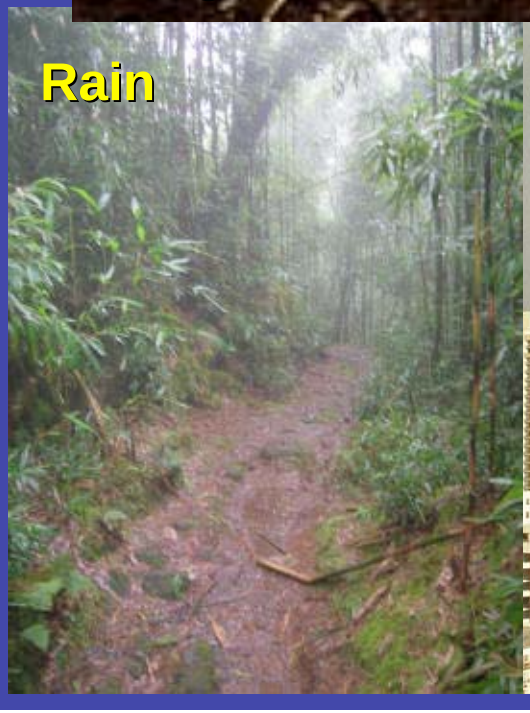


# What are the sources of Oahu's water?












# How much water actually stays in the ground?



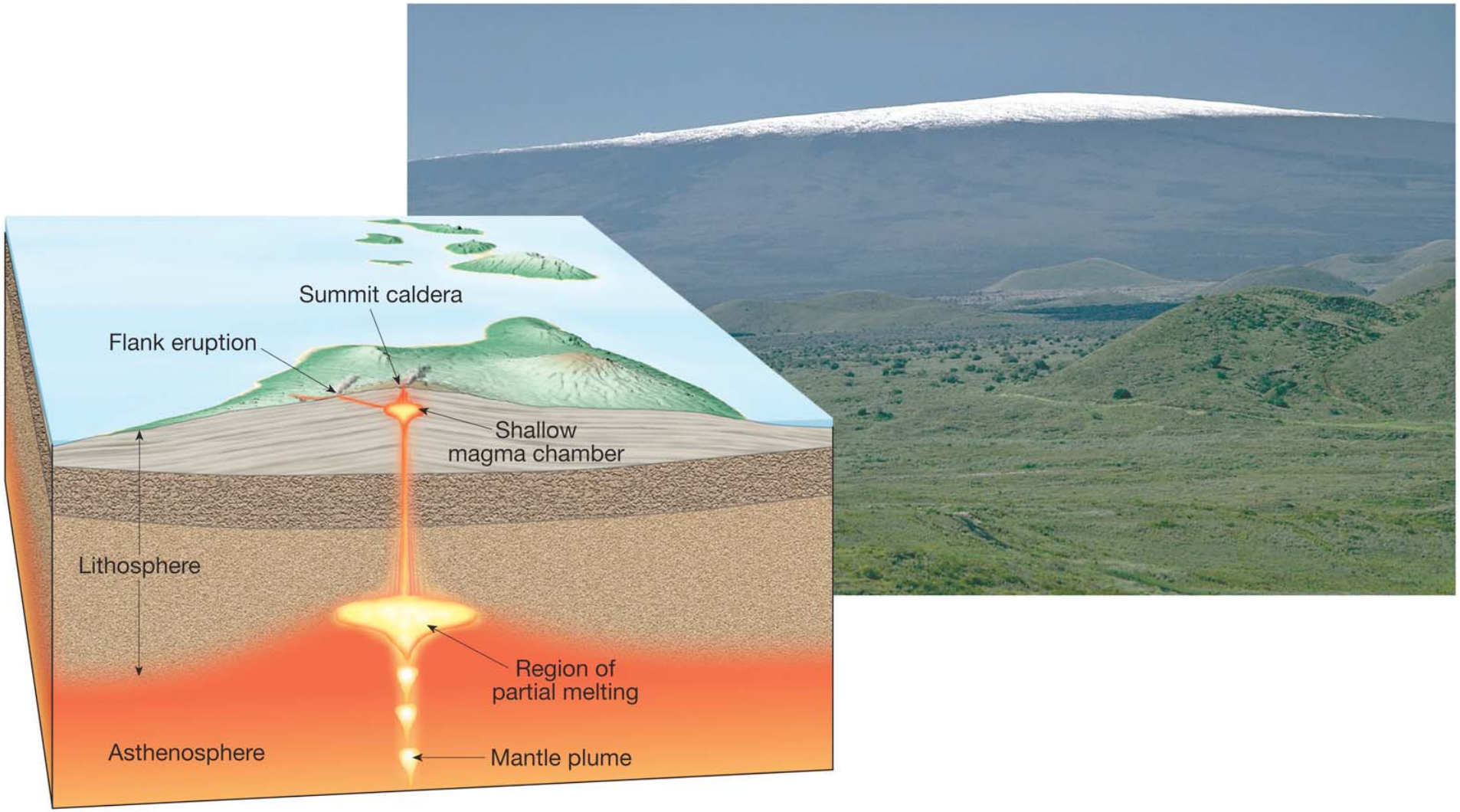


# How much water actually stays in the ground?





**Oahu RECHARGE = 10-50% of rainfall, fog drip, irrigation**



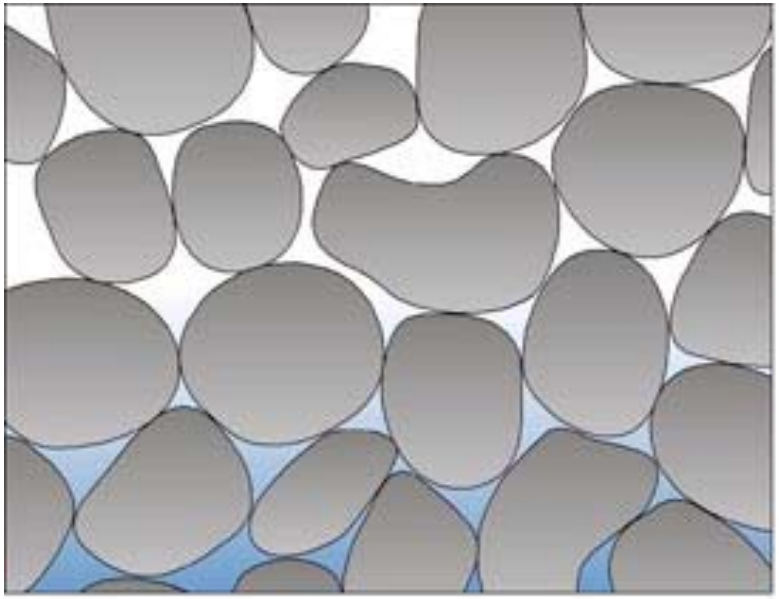

# Where does the groundwater go?

# Pahoehoe and Aa flows

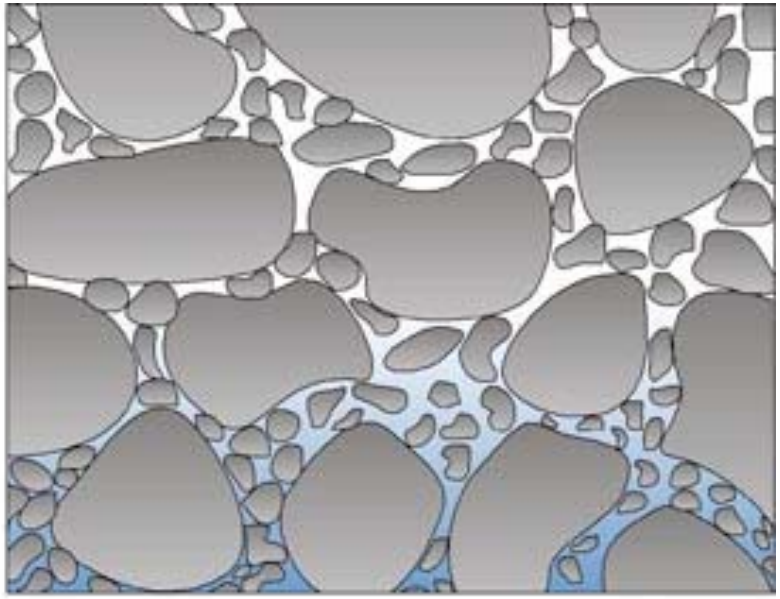




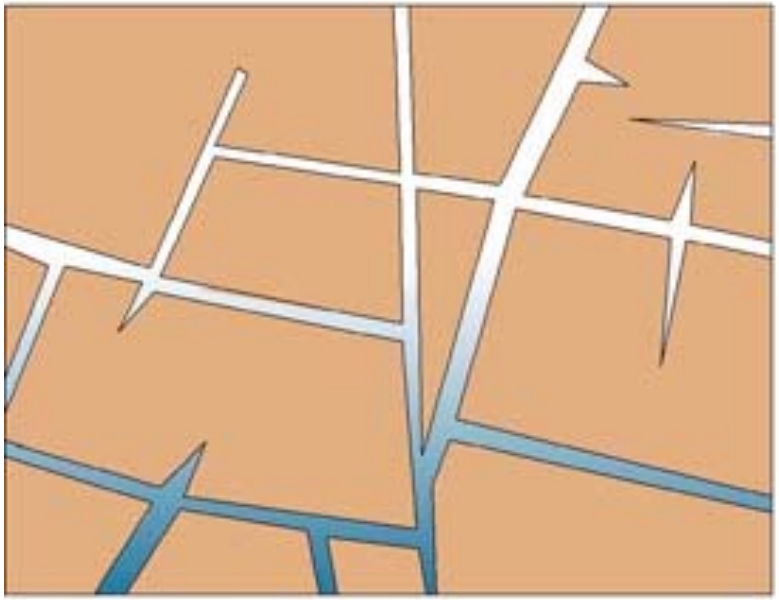




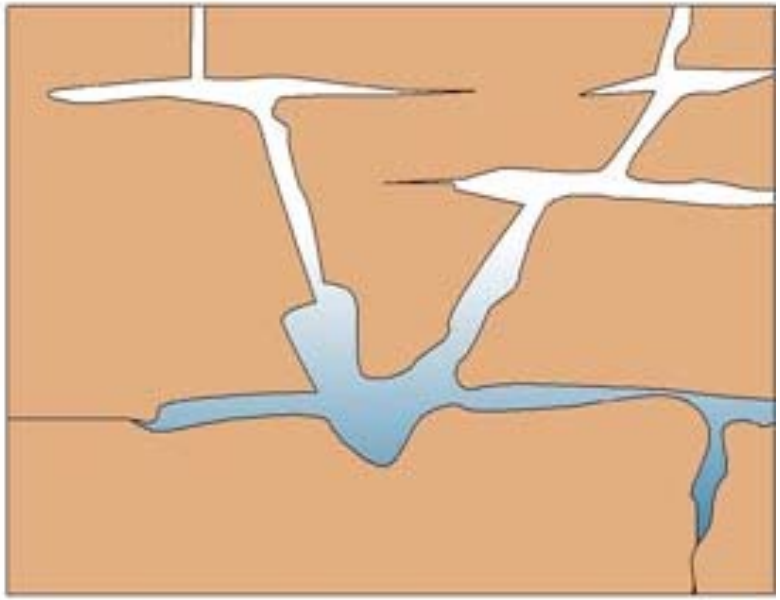
Well-sorted sedimentary material
(Alluvium of the South Platte River)



Poorly sorted sedimentary material
(Dawson, Denver, Arapahoe aquifers)



Fractured crystalline rocks
(Pikes Peak Granite)



Soluble rock-forming material
(Leadville Limestone)

## Porosity

% of the total volume of the rock that contains pore spaces

## Permeability

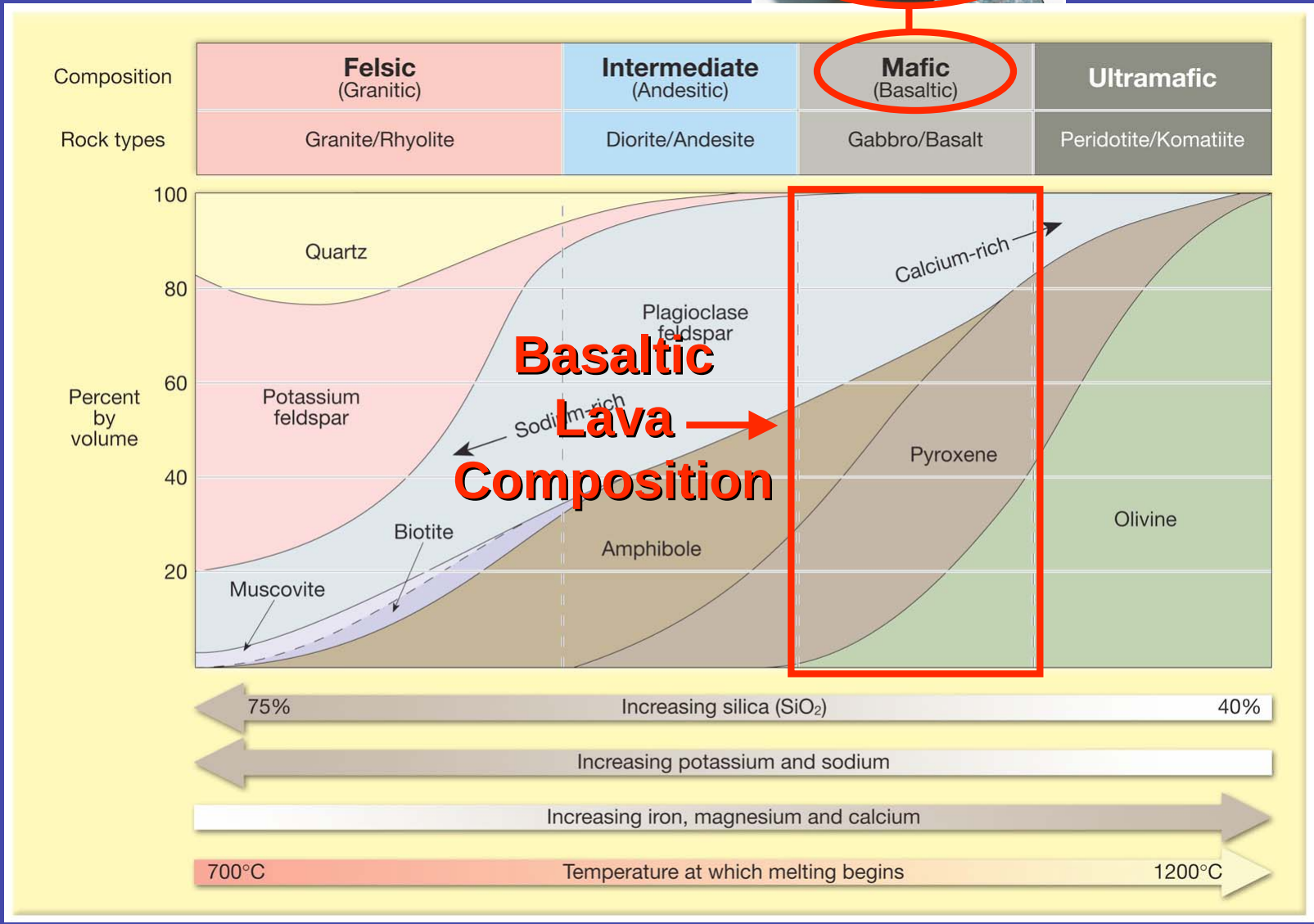
the ability of a material to transmit fluid

## Aquifer

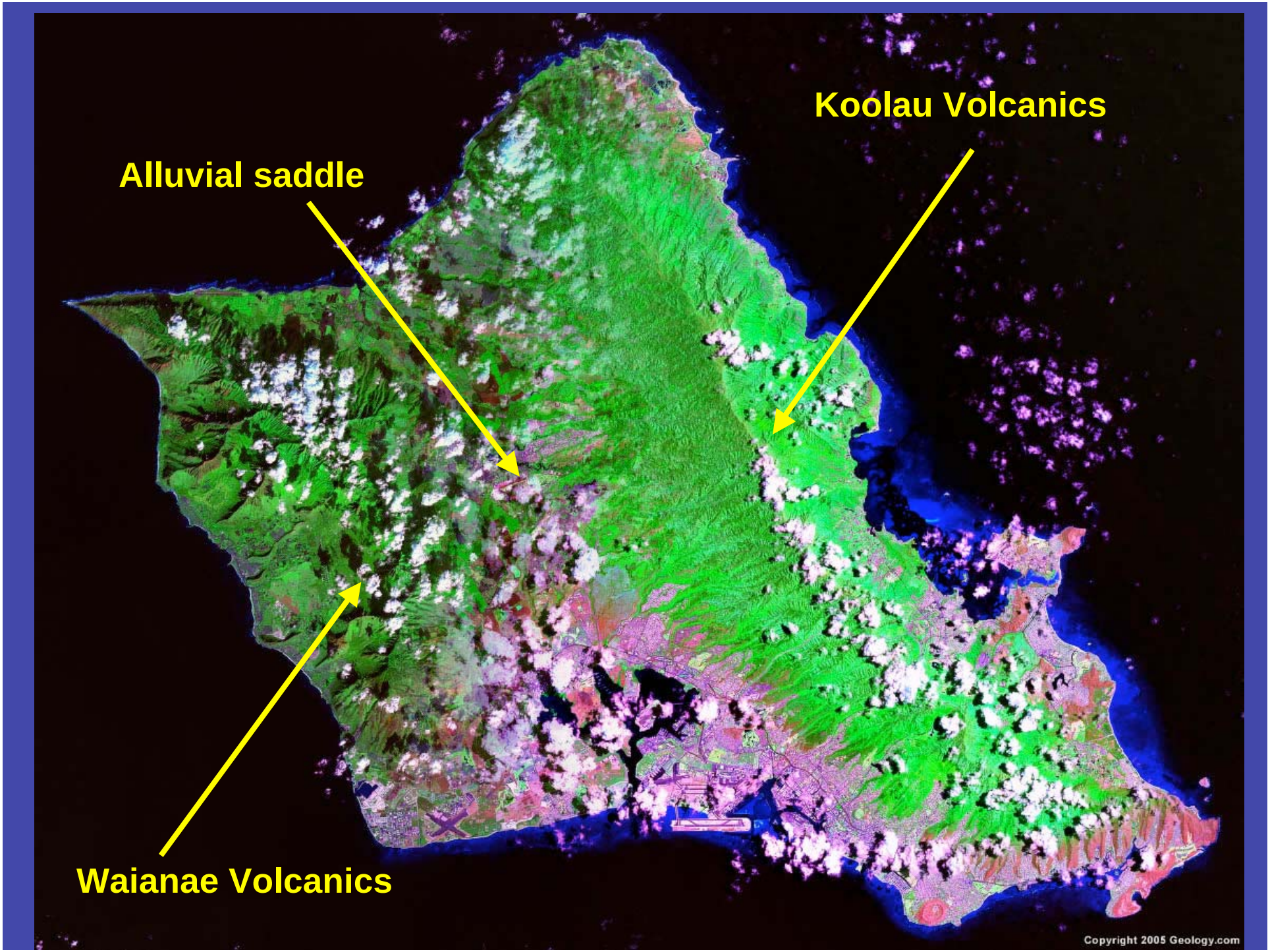
Permeable rock strata or sediments that transport groundwater

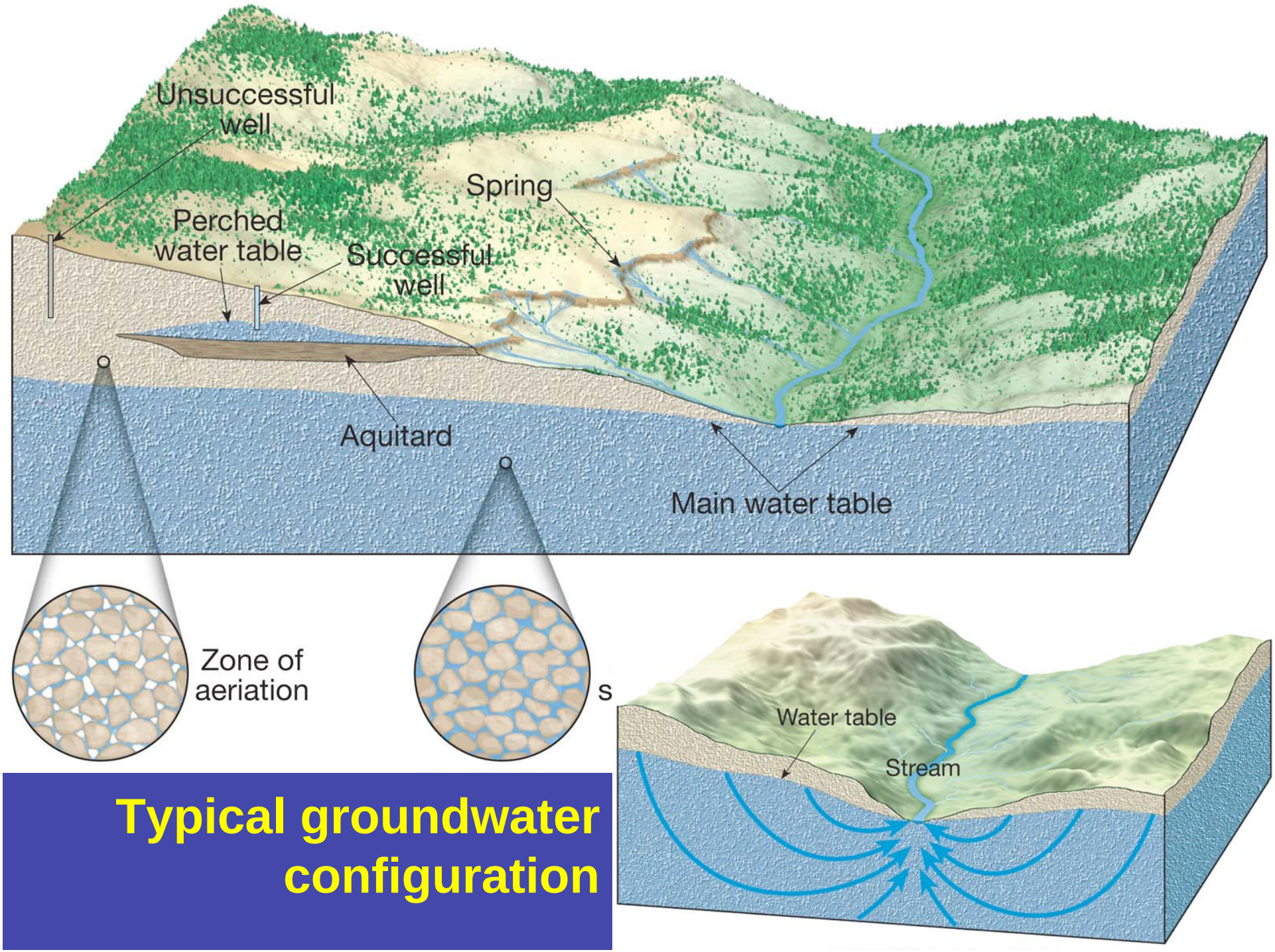
# What do you get when you weather basalt?





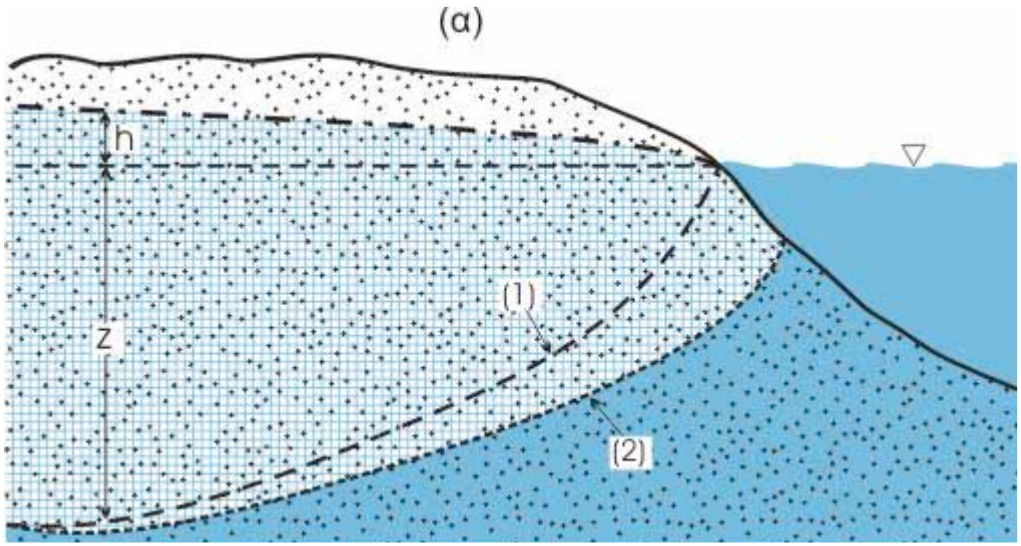

Hawaiian Red Dirt - “Saprolite”


Koolau Volcanics
Alluvial saddle
Waianae Volcanics
Copyright 2005 Geology.com




# Typical groundwater configuration

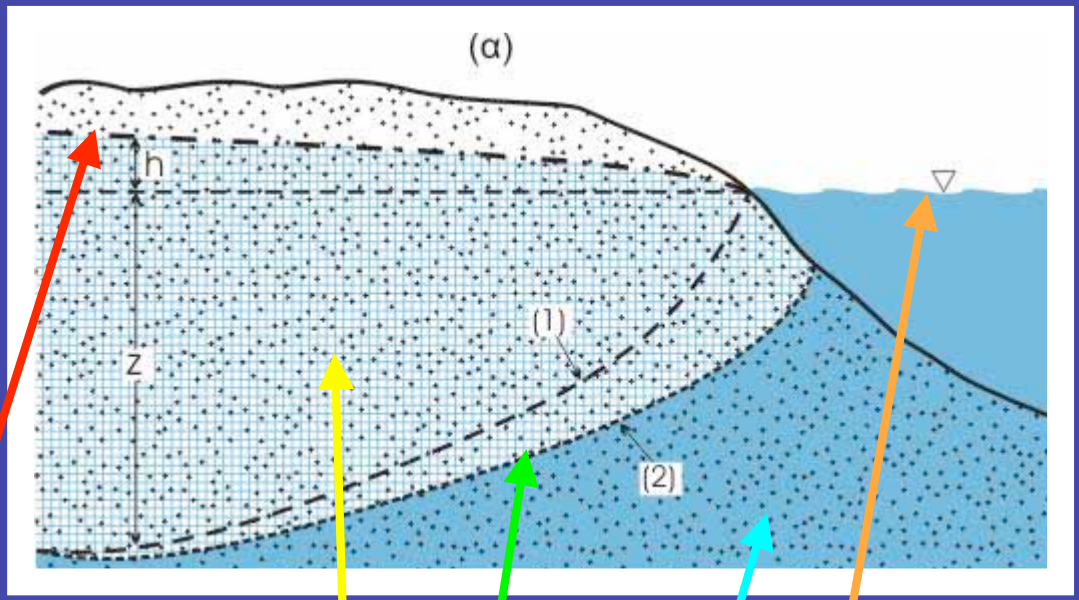
# Island aquifers are unique:
# Which is less dense, fresh or salt water?








# Island aquifers are unique:
# Fresh water floats on salt water




**Height of groundwater above sea level (water table)**

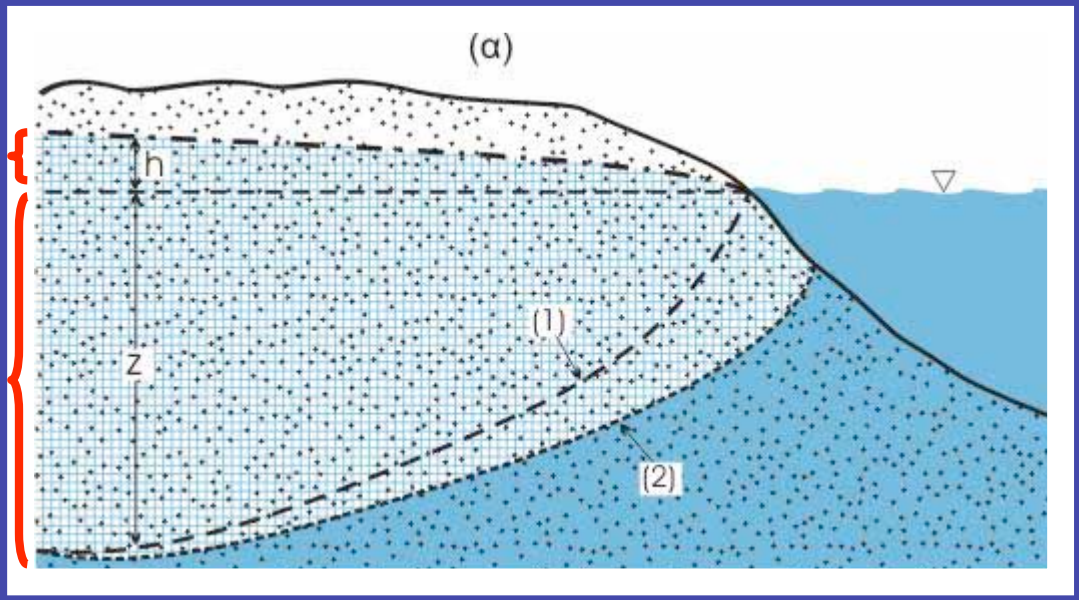
**Sea level (water table)**

**Freshwater lens**

**Brackish water transition zone**

**Salt water**

# Ghyben-Herzberg Principle

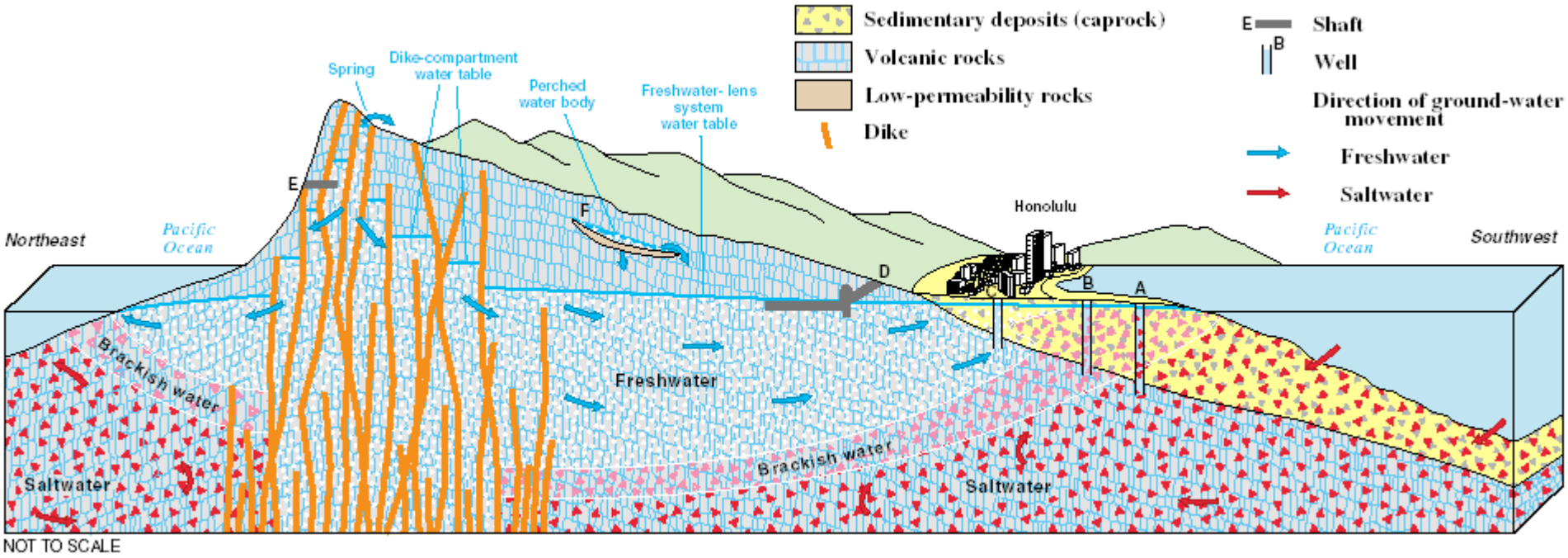



**Height of groundwater above sea level (water table) =**

**1/40th**

**Freshwater lens thickness**

***(Sea water 1/40$^{th}$ more dense than fresh water)***




**Porosity and permeability of volcanic material good**

**What impedes groundwater flow on Oahu?**



Shiprock, New Mexico



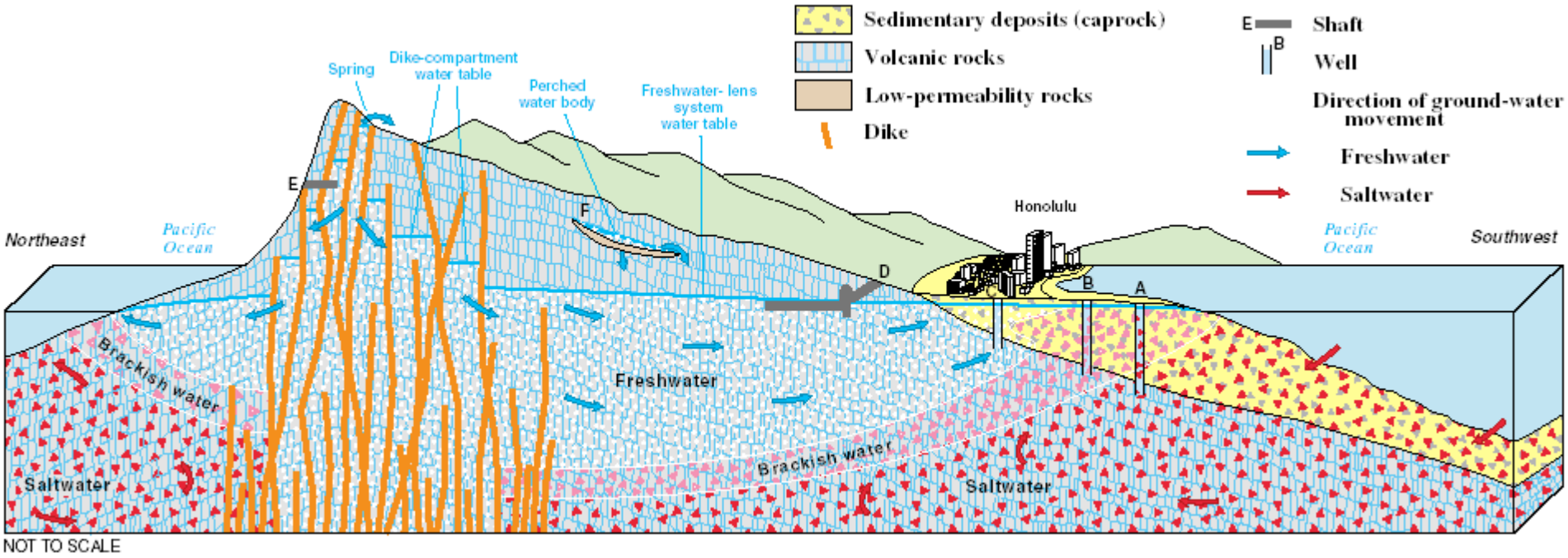
**Volcanic dikes create impermeable barriers**



# Limestone Caprock








**Volcanic dikes and the limestone caprock cause fresh water to pond in the island's interior**

# Geology controls aquifer locations

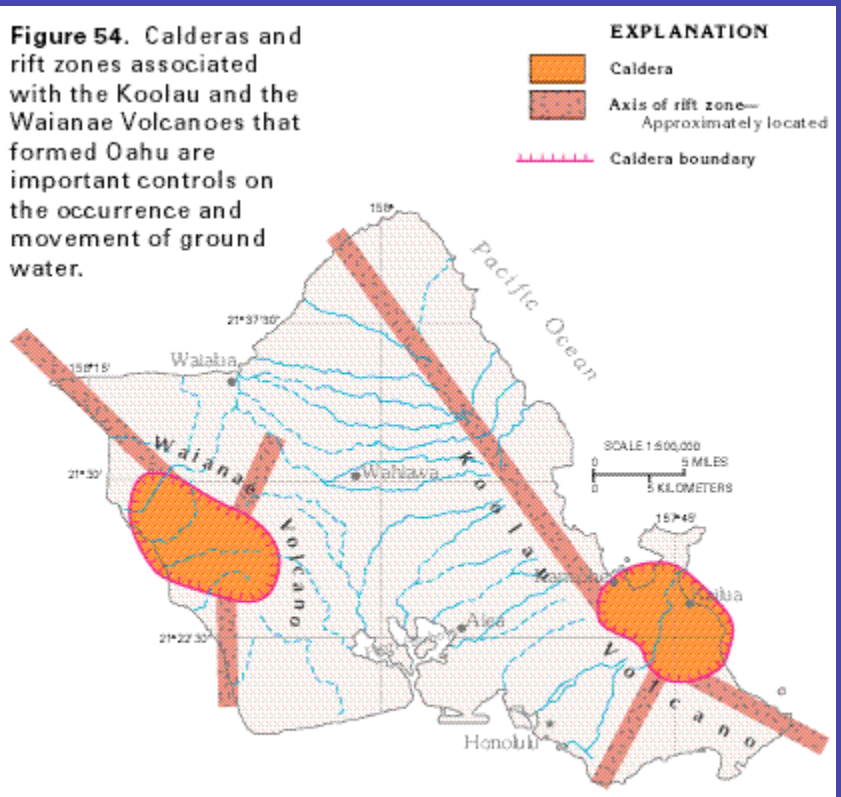



**Figure 54.** Calderas and rift zones associated with the Koolau and the Waianae Volcanoes that formed Oahu are important controls on the occurrence and movement of ground water.

Modified from Nichols, W.D., Shade, P.J., and Hunt, C.D., Jr., 1996, Summary of the Oahu, Hawaii, regional aquifer-system analysis: U.S. Geological Survey Professional Paper 1412–A, 61 p.
Base modified from U.S. Geological Survey digital data

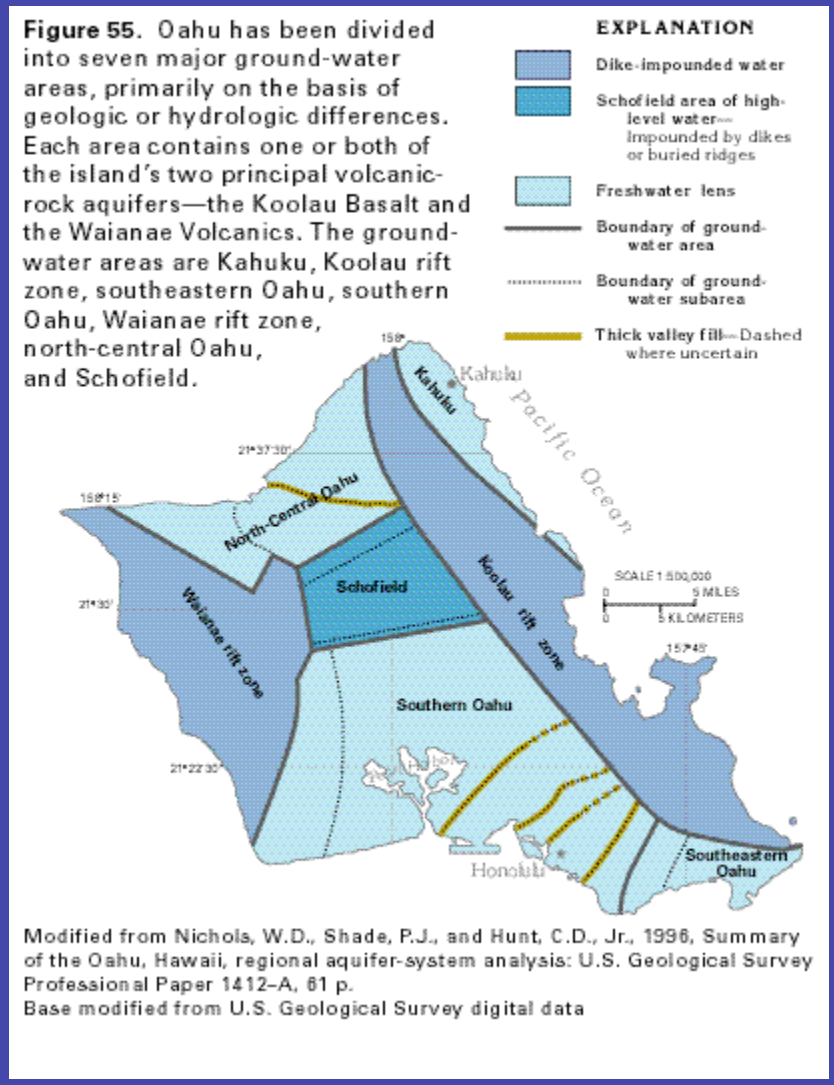
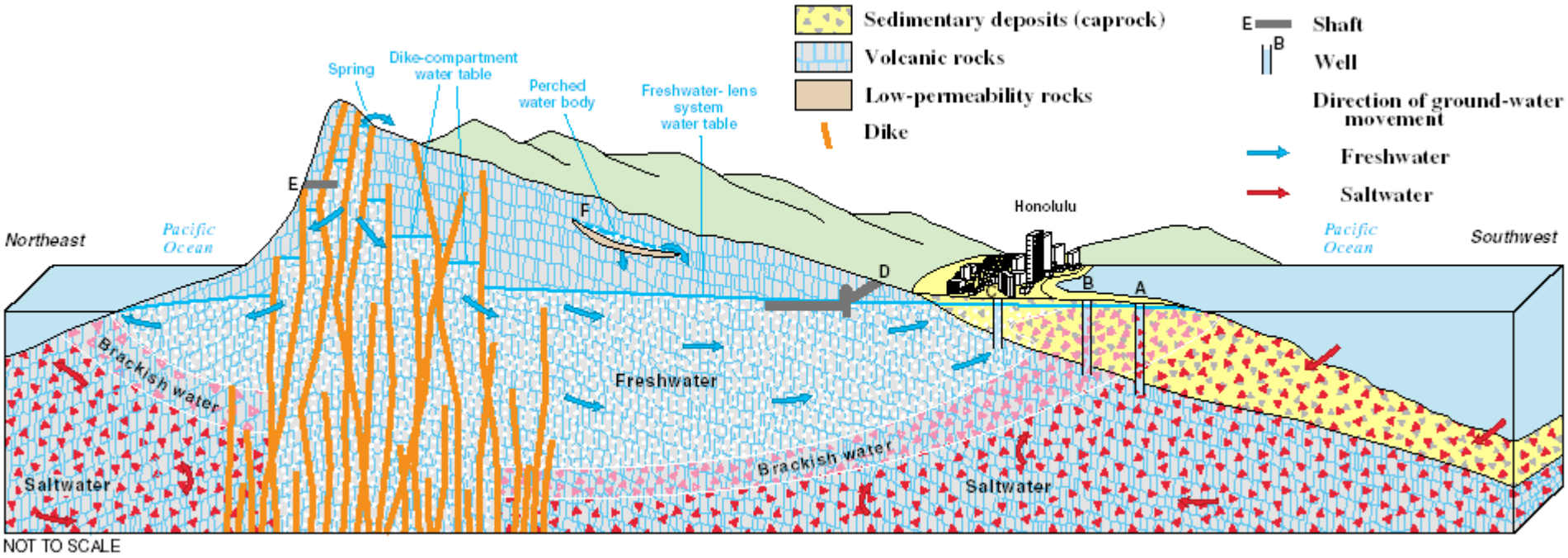



**Figure 55.** Oahu has been divided into seven major ground-water areas, primarily on the basis of geologic or hydrologic differences. Each area contains one or both of the island's two principal volcanic-rock aquifers—the Koolau Basalt and the Waianae Volcanics. The ground-water areas are Kahuku, Koolau rift zone, southeastern Oahu, southern Oahu, Waianae rift zone, north-central Oahu, and Schofield.

Modified from Nichols, W.D., Shade, P.J., and Hunt, C.D., Jr., 1996, Summary of the Oahu, Hawaii, regional aquifer-system analysis: U.S. Geological Survey Professional Paper 1412–A, 61 p.
Base modified from U.S. Geological Survey digital data

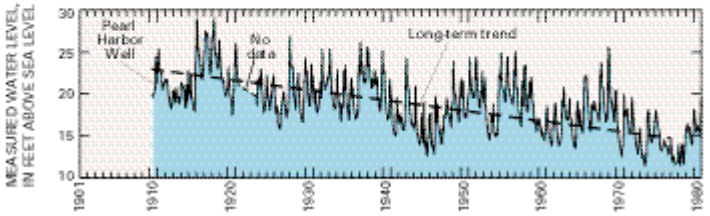



## How do we access these aquifers?

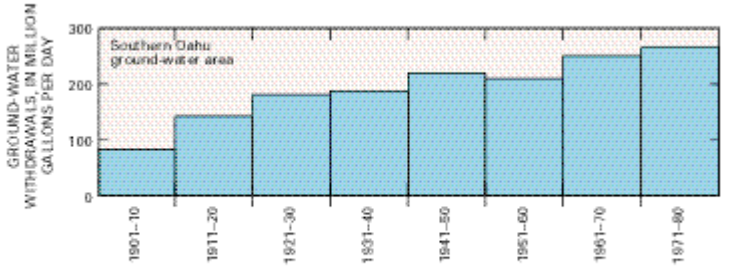
# How do pumping rates affect aquifers?

**Figure 59.** Large ground-water withdrawals from 1901 through 1980 in southern Oahu have caused water levels in the volcanic-rock aquifer in the Pearl Harbor area to decline.



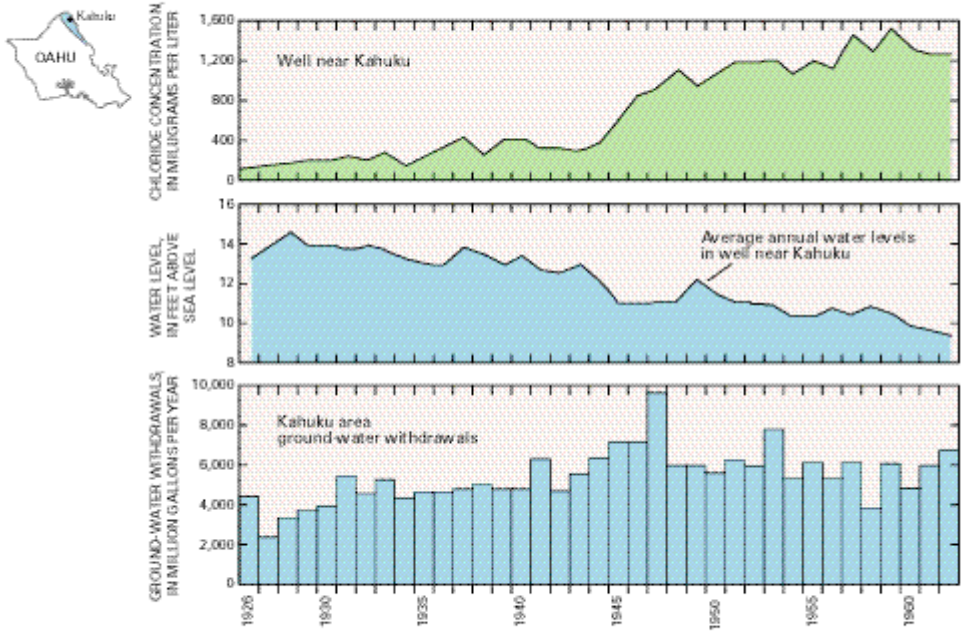




Modified from Oki, D.S., 1998, Geohydrology of the central Oahu, Hawaii, ground-water flow system and numerical simulation of the effects of additional pumping: U.S. Geological Survey Water-Resources Investigations Report 97–4276, 132 p.




Modified from Hunt, C.D., Jr., 1996, Geohydrology of the island of Oahu, Hawaii: U.S. Geological Survey Professional Paper 1412–B, 54 p.

**Figure 64.** Large, sustained ground-water withdrawals near Kahuku caused water levels to decline in a nearby well. The decline in water level permitted saltwater to intrude the freshwater aquifer, as indicated by an increase in the concentration of chloride in water from another nearby well.

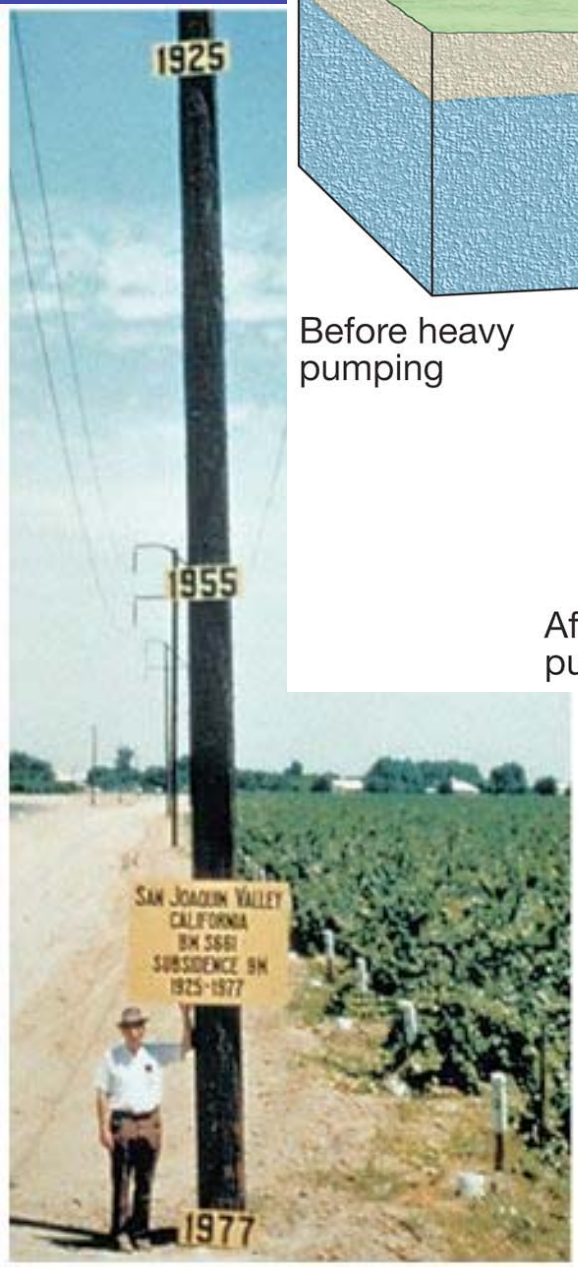


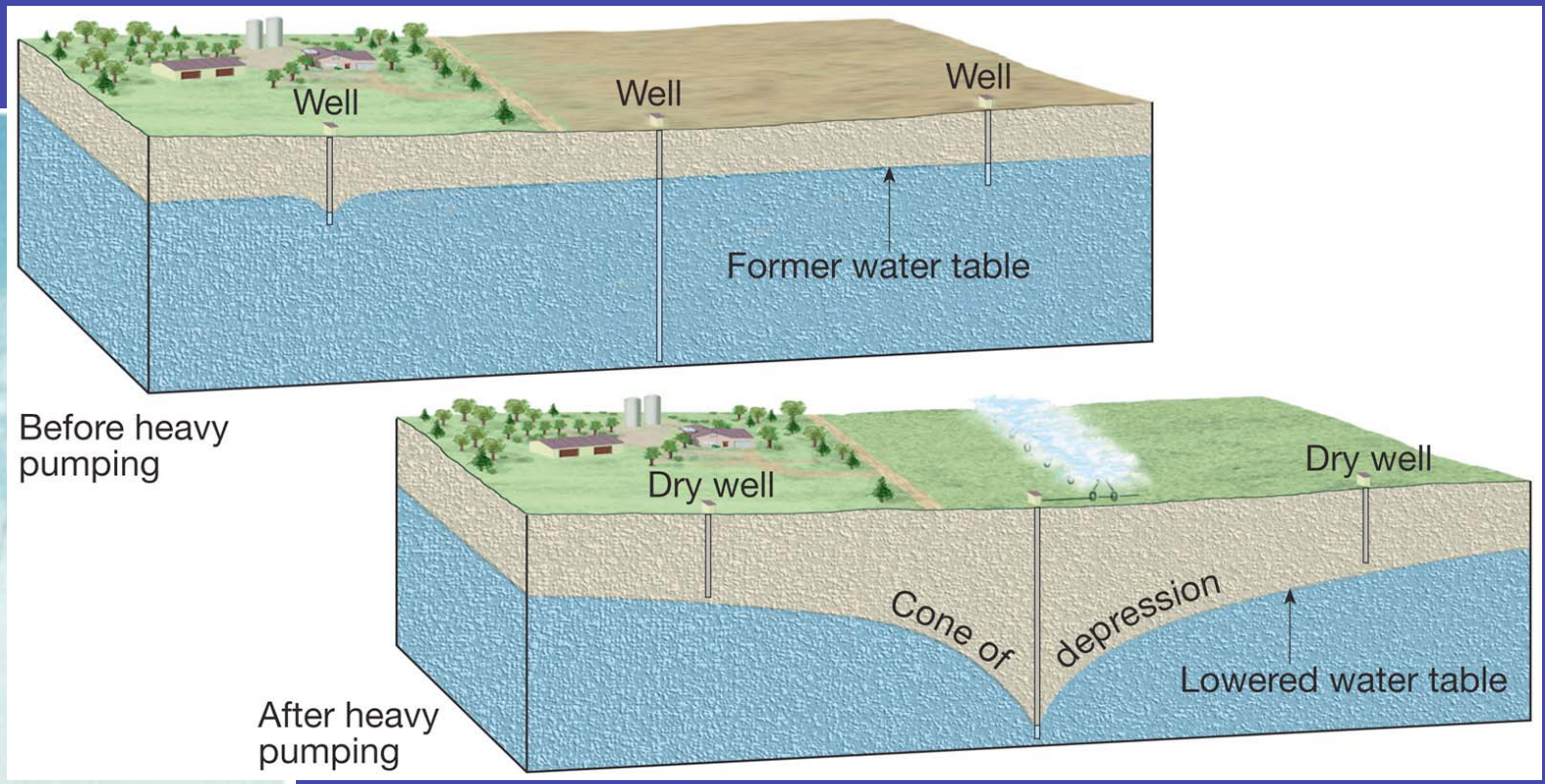

Modified from Takasaki, K.J., and Valenciano, Santos, 1969, Water in the Kahuku area, Oahu, Hawaii: U.S. Geological Survey Water-Supply Paper 1874, 59 p.

**What is relationship between:**

1. **Pumping rate**
2. **Well water level**
3. **Chloride content (salt intrusion)**

**???**

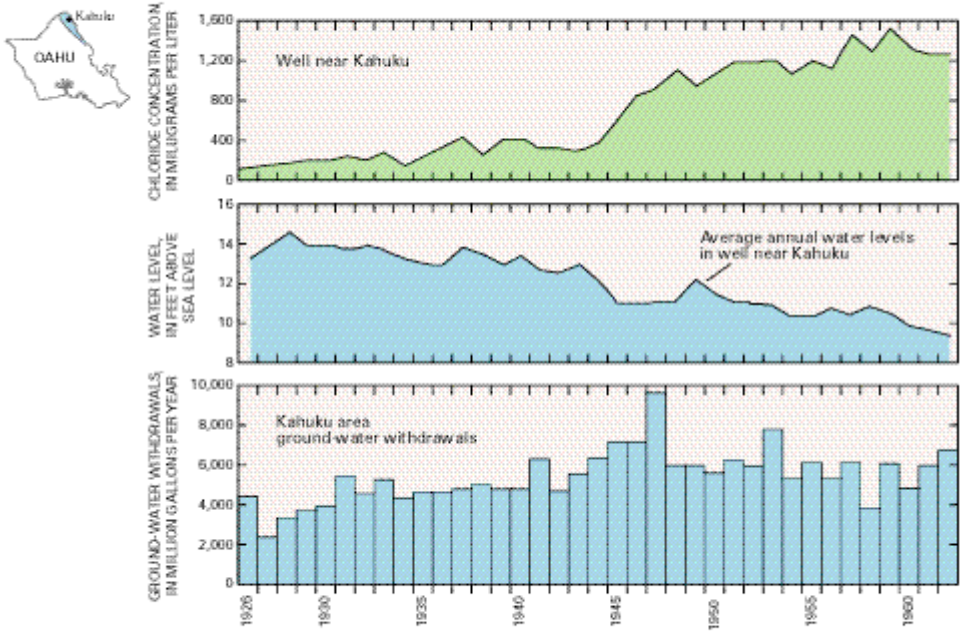



**Over-pumping can:**

1) **Lower water table**
2) **Cause ground subsidence**

**Figure 64.** Large, sustained ground-water withdrawals near Kahuku caused water levels to decline in a nearby well. The decline in water level permitted saltwater to intrude the freshwater aquifer, as indicated by an increase in the concentration of chloride in water from another nearby well.




Modified from Takasaki, K.J., and Valenciano, Santos, 1969, Water in the Kahuku area, Oahu, Hawaii: U.S. Geological Survey Water-Supply Paper 1874, 59 p.

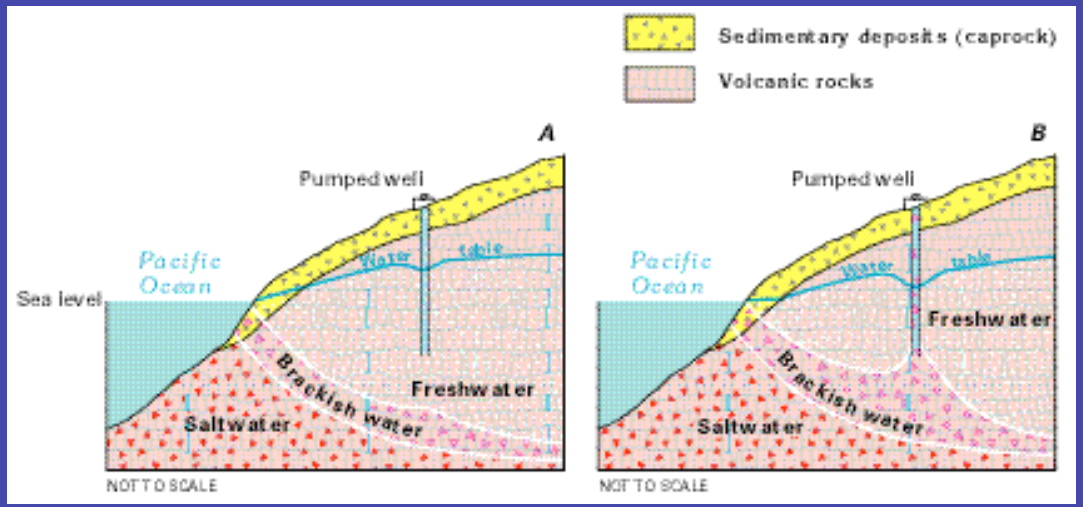
▲ **Chloride content**

▼ **Well water level**

▲ **Pumping rate**

**1) Water table is Lowering**

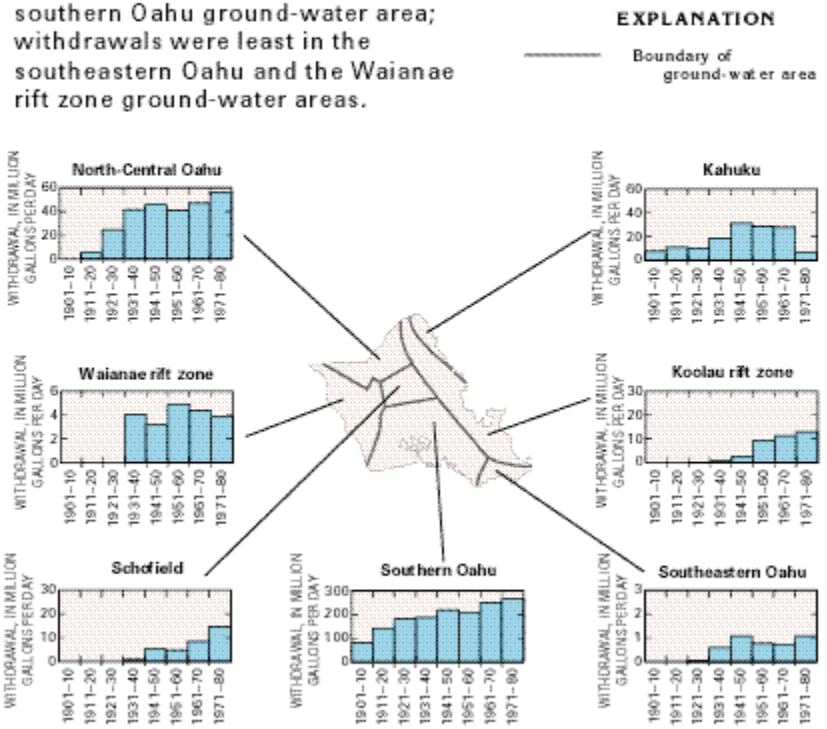
**2) Saltwater is intruding**



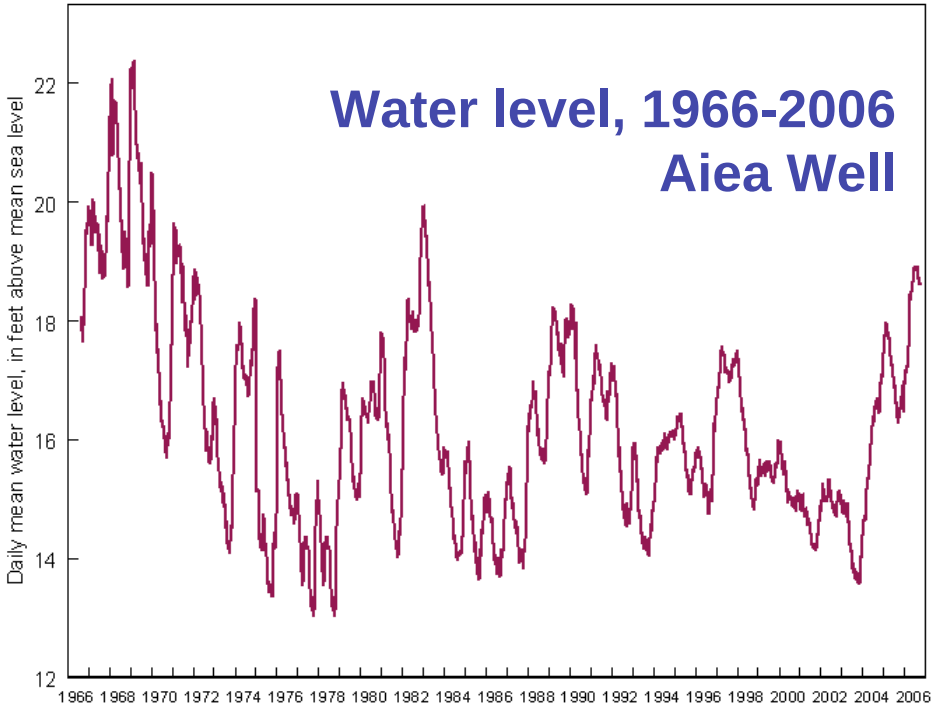
# Excessive pumping thins fresh water lens

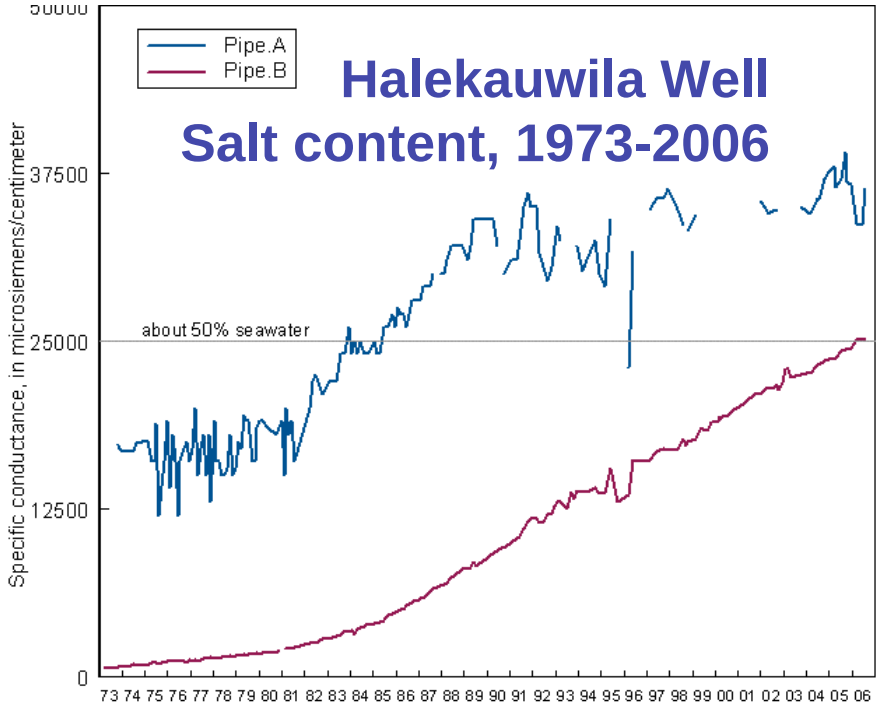
**Figure 61.** Estimates of ground-water withdrawals for each ground-water area range from less than 5 million to more than 200 million gallons per day during the decades from 1901 to 1980. The greatest withdrawals were in the southern Oahu ground-water area; withdrawals were least in the southeastern Oahu and the Waianae rift zone ground-water areas.

**Pumping rates 1901-1980**

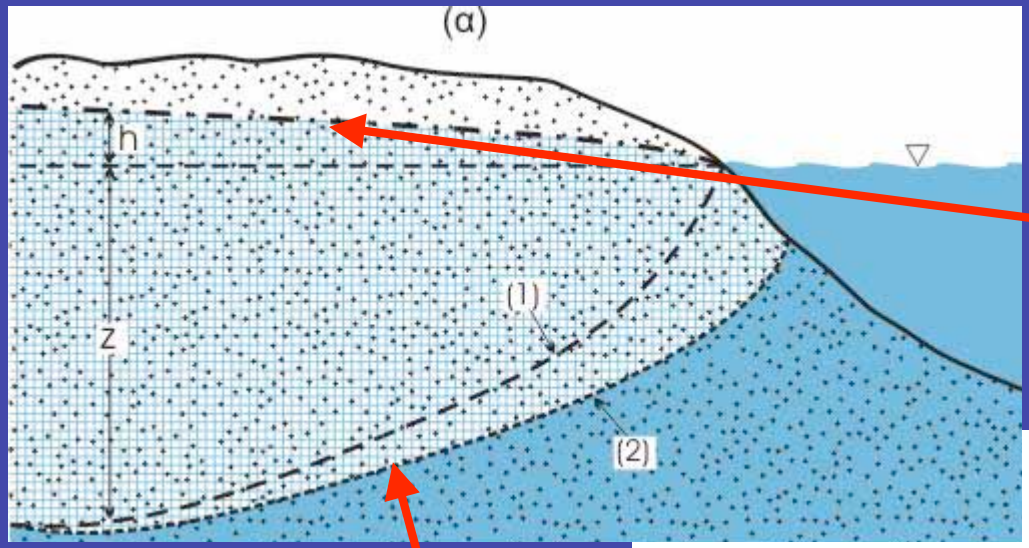



Modified from Hunt, C.D., Jr., 1996, Geohydrology of the island of Oahu, Hawaii: U.S. Geological Survey Professional Paper 1412–B, 54 p.



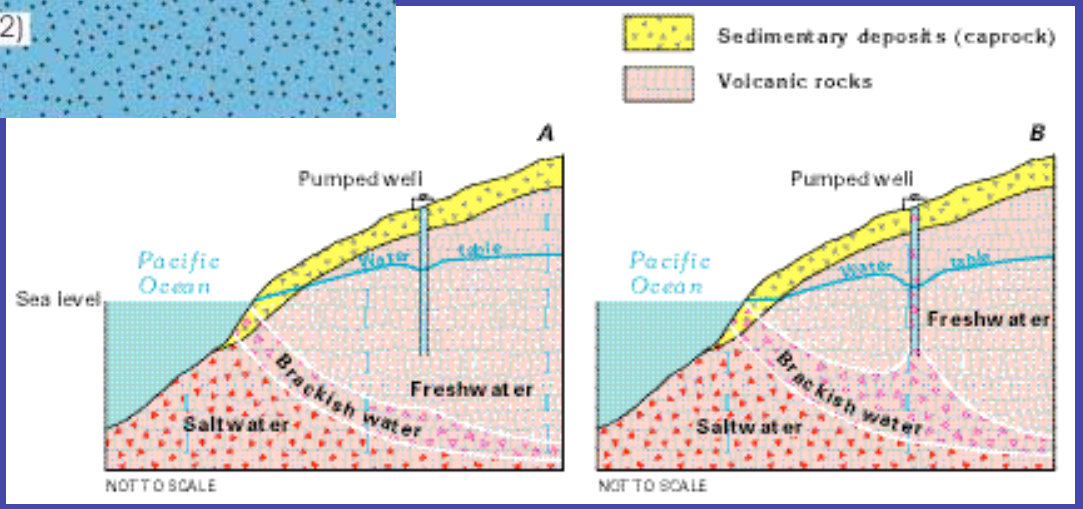



**Oahu's fresh water lens, the source of our drinking water, is <u>thinning</u>**




**Depth to water table increasing**

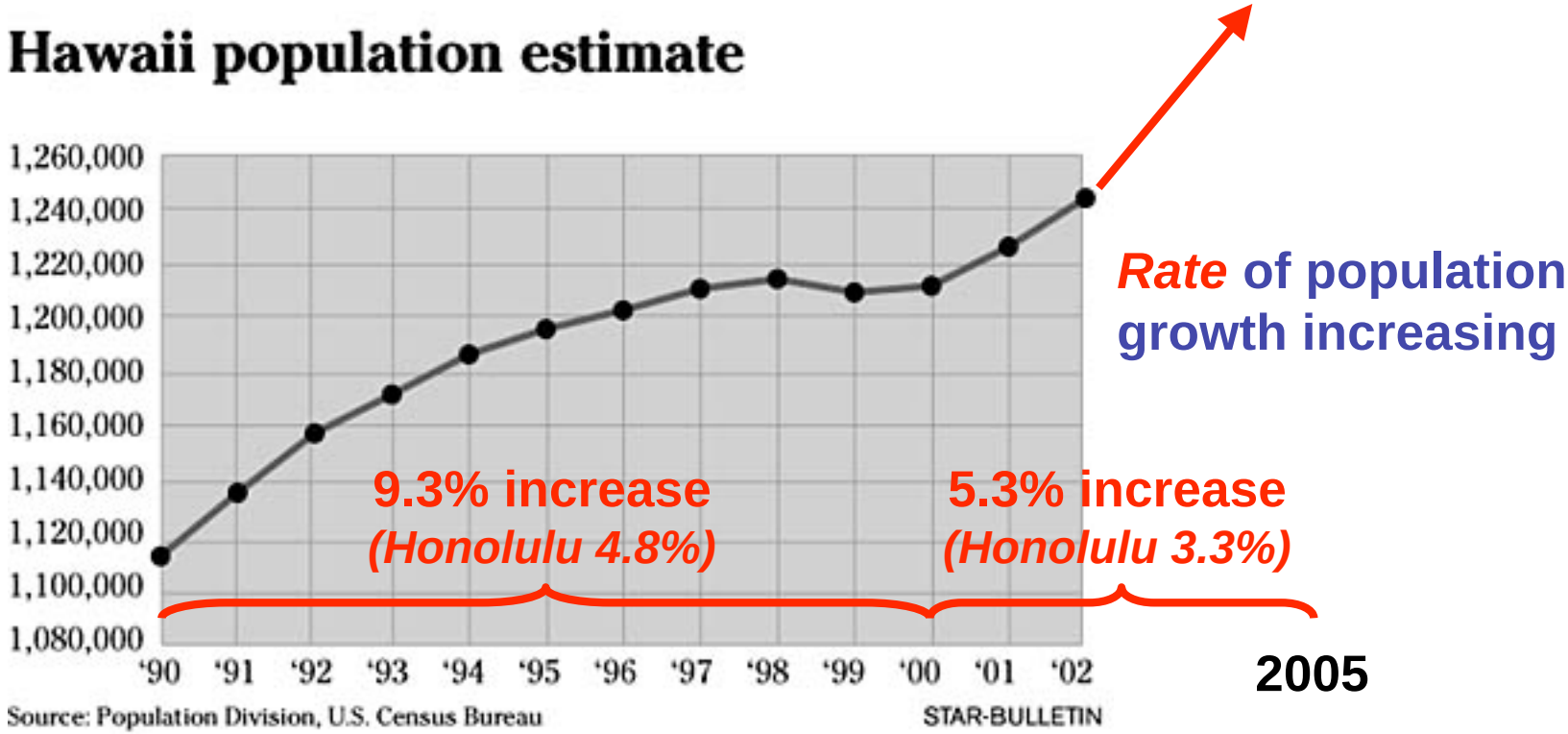
**Depth to salt water decreasing**




**water table – top surface of water-saturated zone**

# What’s happening to Hawaii’s population?

# What's happening to Hawaii's population?




***Rate*** **of population growth increasing**

# Where is growth happening?



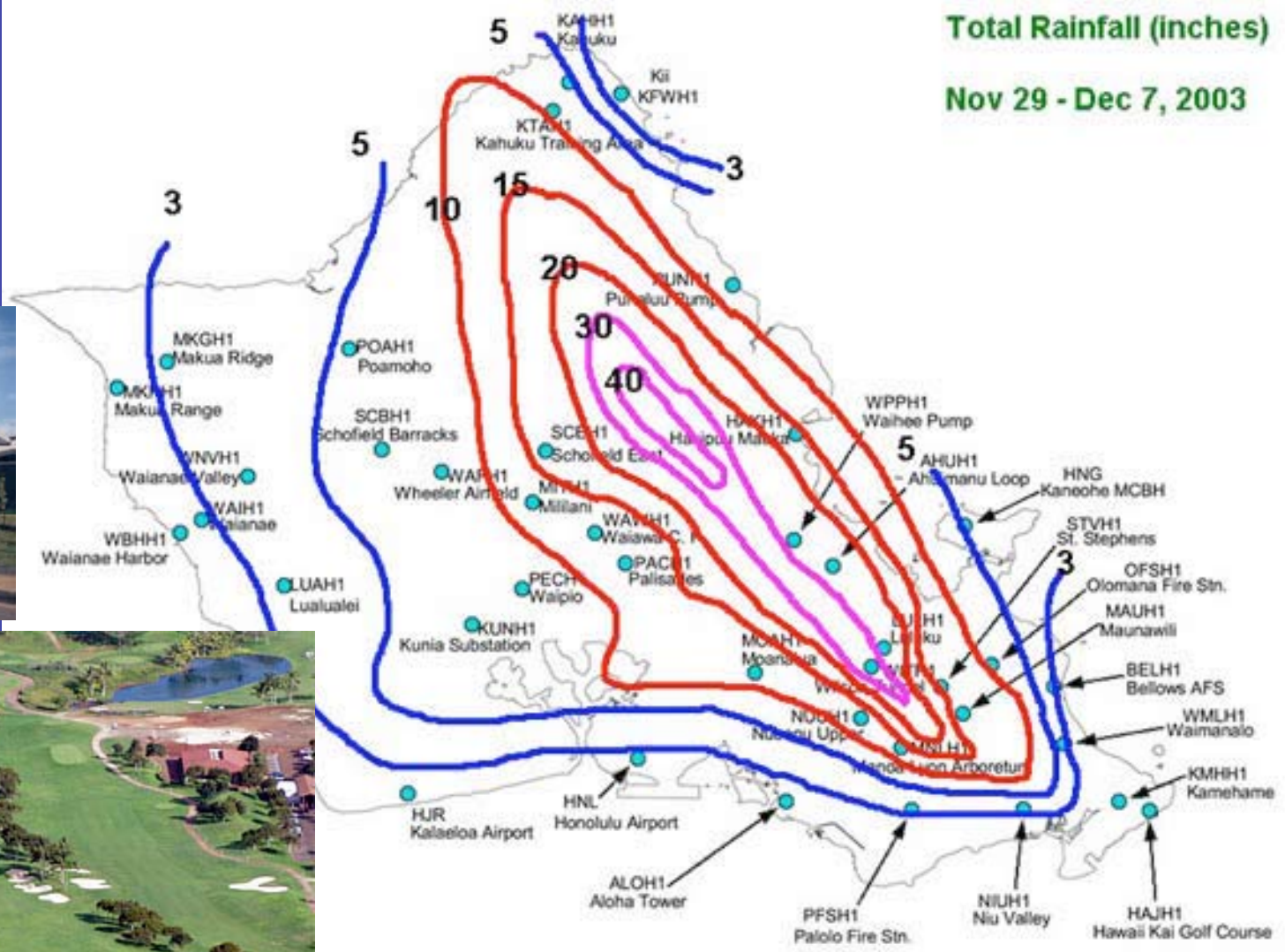



**Population and Employment Growth by Development Plan Area**

# Oahu Population Growth







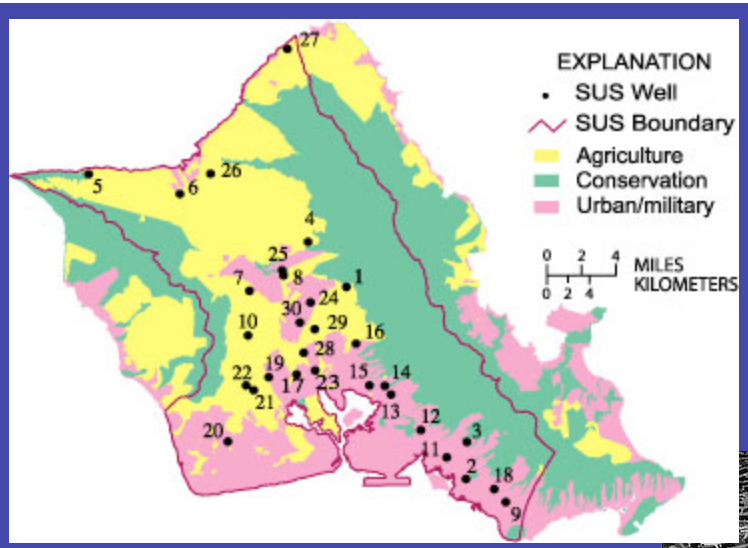

**How will the expected population growth affect groundwater resources ???**

1. Growing population

2. Increasing groundwater withdrawal

3. Thinning fresh water lens

What else do we have to protect our groundwater from?


EXPLANATION
SUS Well
SUS Boundary
Agriculture
Conservation
Urban/military
0 2 4
MILES
0 2 4
KILOMETERS
27
26
5
6
4
25
8
1
7
24
30
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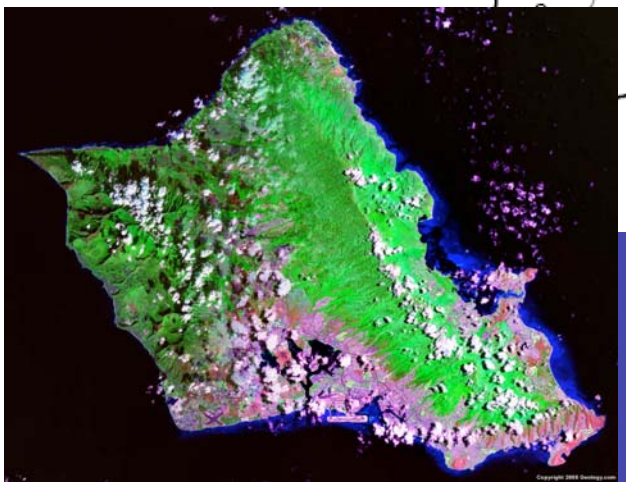












## *Sample contaminants*

**TCE – metal/dry cleaning fluid**
**DBCP – pesticide**
**EDB – pesticide/fumigant**
**TCP – soil fumigant**
**Dieldrin – insecticide**
**Chlordane – insecticide**
**Carbon tetrachloride – propellant/pesticide**
**Atrazine - pesticide**

Hau`ula
Hale`iwa
Mokule`ia
Waialua
Wahiawa
Makaha
Kunia
Wai`anae
Ma`ili
Nanakuli
Pacific Palisades
Aiea
Kane`ohe
Kailua
Lanikai
Waimanalo
Hickam
Kalihi
Ewa
Ewa Beach
Honolulu
Waikiki
Wai`alae
Kahala
Hawai`i Kai
Nui

**Contaminated drinking water wells on Oahu results from 1995-2005**


Dole
PLANTATION
DOLE






Del Monte
Quality
Del Monte Fresh Produce (Hawaii) Inc.
PRIVATE PROPERTY
NO TRESPASSING

# Pesticides









**DBCP (1,2-dibromo-3-chloropropane)**

Carcinogen
Reproductive toxicant
Developmental toxicant
Endocrine toxicant
Gastrointestinal/liver toxicant
Neurotoxicant
Respiratory toxicant
Skin toxicant
Top 10% most hazardous compounds





**Dieldrin**

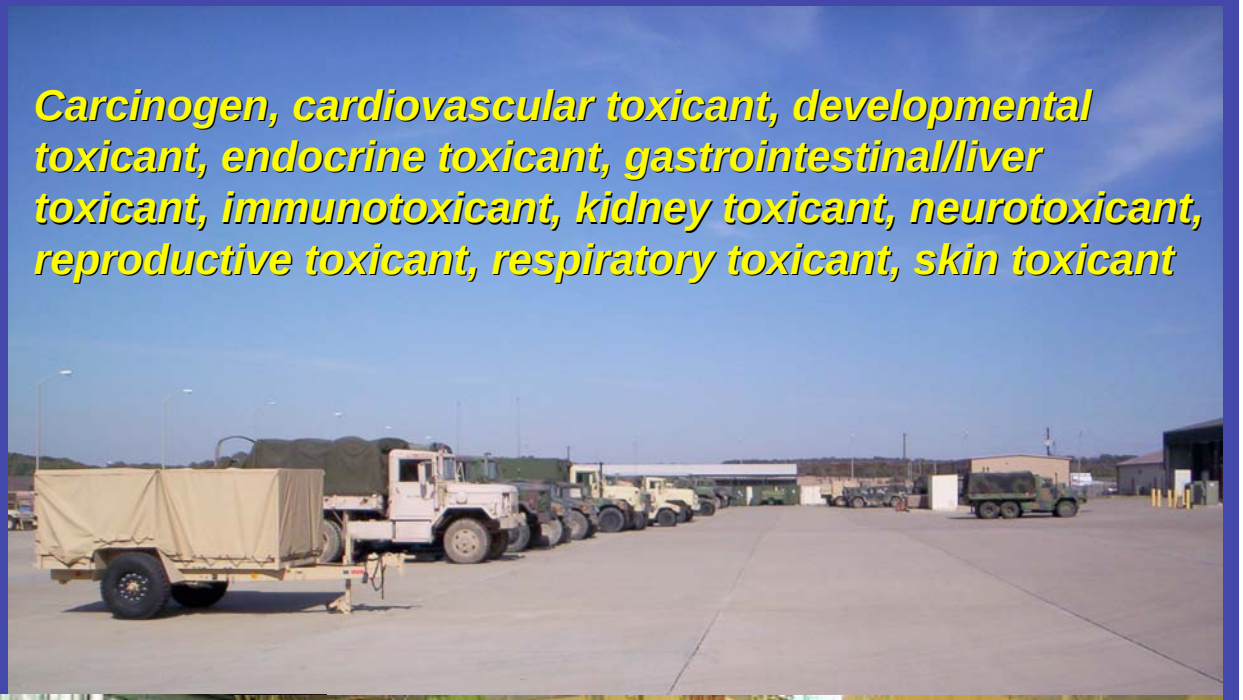
Carcinogen
Cardiovascular toxicant
Endocrine toxicant
Gastrointestinal/liver toxicant
Immunotoxicant
Kidney toxicant
Neurotoxicant
Reproductive toxicant
Respiratory toxicant
Top 10% most hazardous compounds

## Industrial Solvents:

**Trichlorethene (TCE)**

- **Removes grease from vehicle parts, paint remover**

**Found in Schofield wells in 1985**








U.S. Environmental Prote

# Region 9 Superfund

Serving Arizona, California, ~~Hawaii~~, Nevada, the Pacific Islands, and over 140 Tribal Nations

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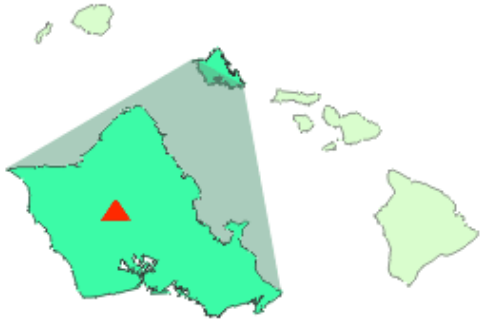
EPA Home > Region 9 > Cleanup > Superfund > Site Overviews by Site Name > SCHOFIELD BARRACKS

- Region 9 Home
- Region 9 Cleanup Home
- R9 Superfund Home
- Site Overviews
- Administrative Records
- Fact Sheets
- Records of Decision
- Images
- Maps
- Legal Documents

# SCHOFIELD BARRACKS

## HAWAII

**EPA ID# HI7210090026**



Click here for interactive site area map

**EPA Region 9**
**City: Wahiawa, Oahu**
**County: Oahu**
**Other Names:**

## Table of Contents

Click on a category below or scroll down the page.

- Site Description and History
  - Maps
  - Images
- Threats and Contaminants
  - Description
  - Environmental Data
- Cleanup Approach
  - Response Action Status
- Environmental Progress
- Potentially Responsible Parties
- Site Documents and Reports
- Community Involvement: Public Meetings, Newsletters, and Fact Sheets
- Site Repositories/Library Sources
- Contacts
- Miscellaneous Information

**Drinking water wells serving 25,000 military and 55,000 civilians contaminated with TCE.**

# Hawaii Superfund Sites

**NPL Sites in Hawaii** by County
To access the fact sheet for each site, select the site name.
For the NPL Site Narrative, select the CERCLIS ID.
Federal Register notices can be accessed by selecting the date of each action listed.

**HONOLULU COUNTY**

| Site Name<br>CERCLIS ID | Proposed Listing | Final Listing | Construction Completion | Partial Deletion | Deletion |
|---|---|---|---|---|---|
| Del Monte Corp. (Oahu Plantation) | | | | | |
| HID980637631 | 5/10/93 | 12/16/94 | N/A | 1/13/04 | N/A |
| Naval Computer & Telecommunications Area | | | | | |
| HI0170090054 | 1/18/94 | 5/31/94 | N/A | N/A | N/A |
| Pearl Harbor Naval Complex | | | | | |
| HI4170090076 | 7/29/91 | 10/14/92 | N/A | N/A | N/A |
| Schofield Barracks (USARMY) | | | | | |
| HI7210090026 | 7/14/89 | 8/30/90 | 9/23/98 | N/A | 8/10/00 |

## Contaminants

**Fumigants: EDB, DBCP, DCP**

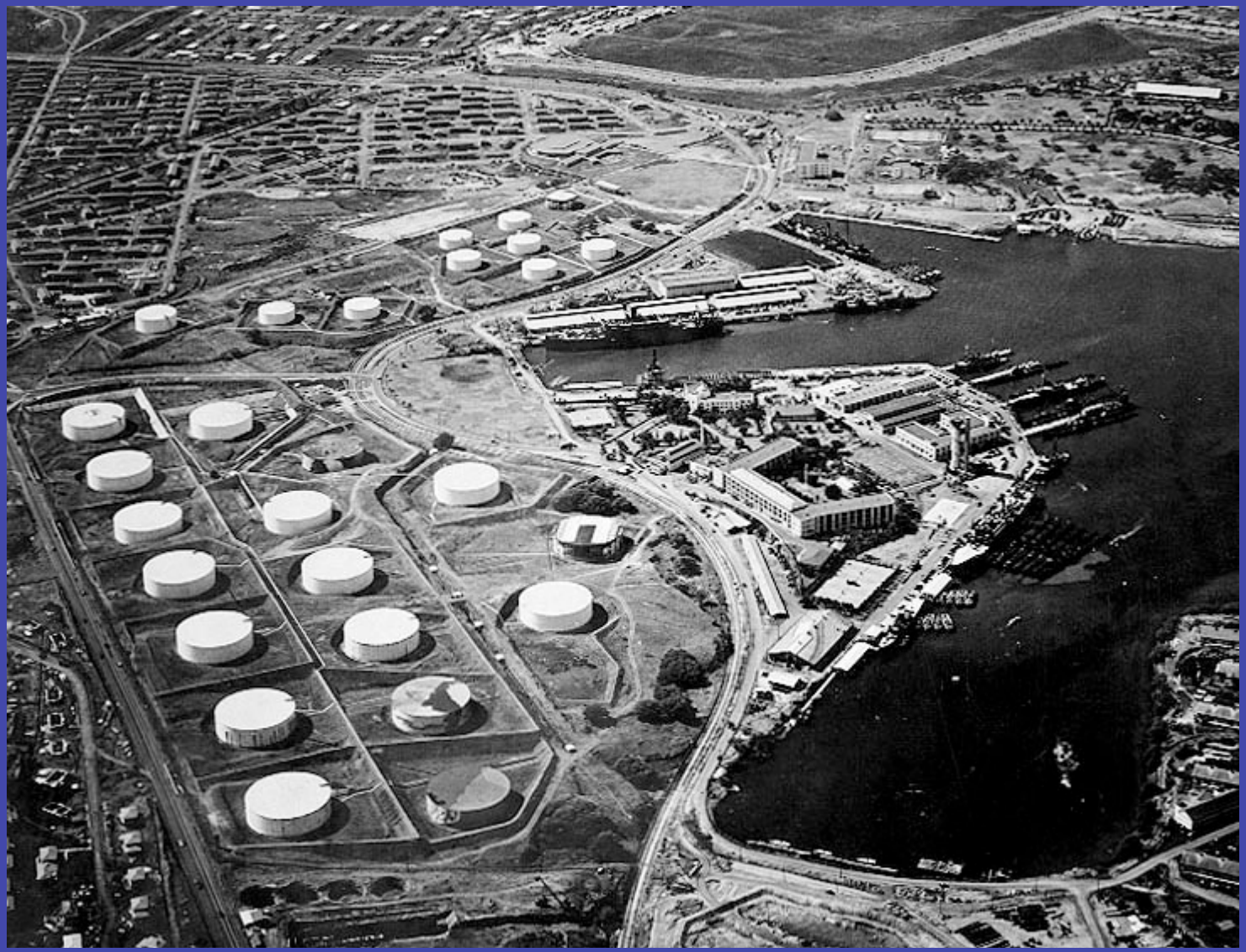
**PCBs, volatile organics, semi-volatile organics, metals**

**Metals, organic compounds, petroleum hydrocarbons**

**Industrial solvent: TCE**

# Pearl Harbor Superfund Site

**Soil, *groundwater*, sediment contaminated with metals, organic compounds, petroleum hydrocarbons**



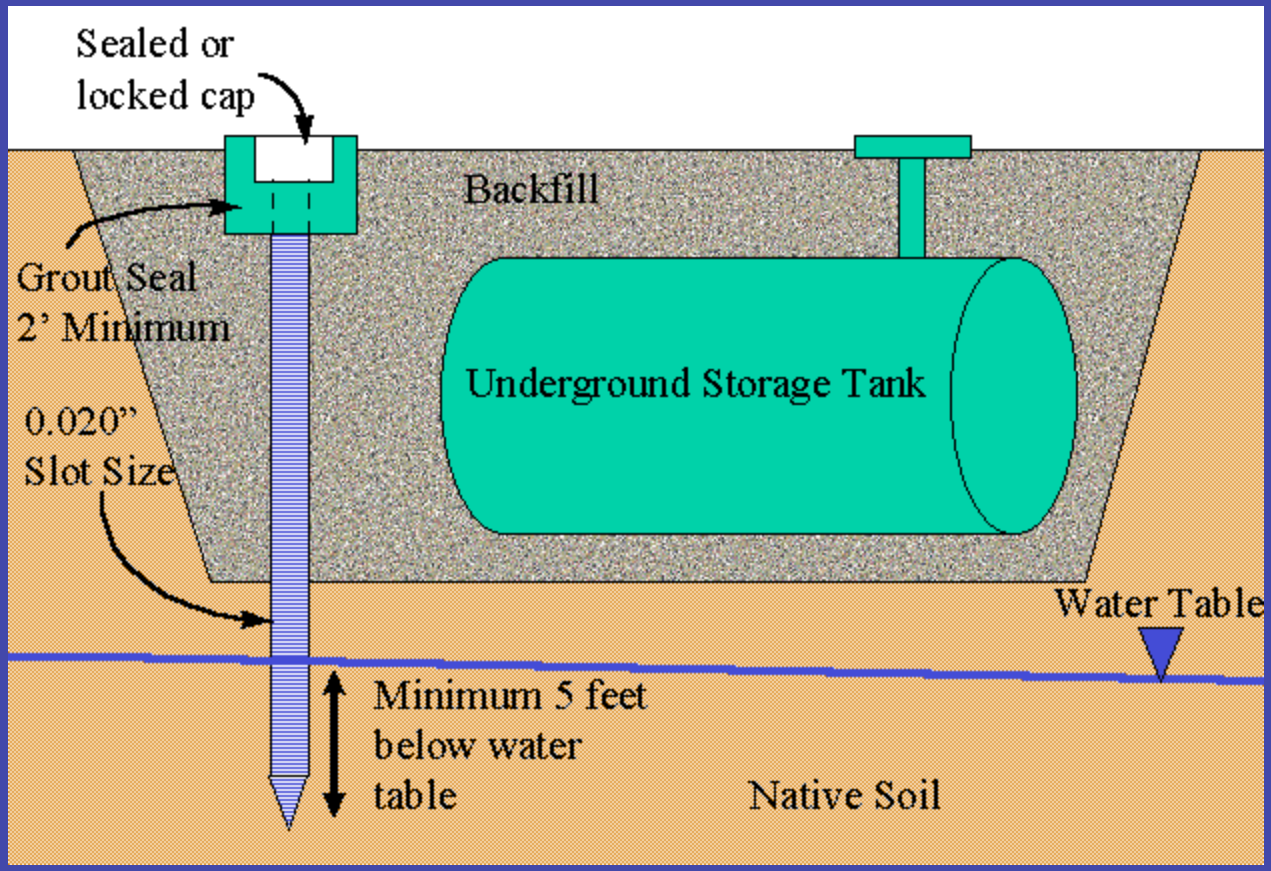
# Fuel Additives






MTBE – fuel efficiency enhancer, possible carcinogen, nervous system effects, liver & kidney damage, etc.

# Where is water table on Oahu?













**Leaking Underground Storage Tanks**



*Irritability, excess salivation, labored breathing, tremors, convulsions, deep depression, anemia, leukemia, damage to liver, kidney, lungs, heart, spleen, adrenal glands; cancer, death*



**<u>Chlordane: pesticide</u>**
**Illegal since 1988**
**Prior to that 3.6 million lbs/year used in U.S.**



# Waimanalo (?) Gulch Landfill

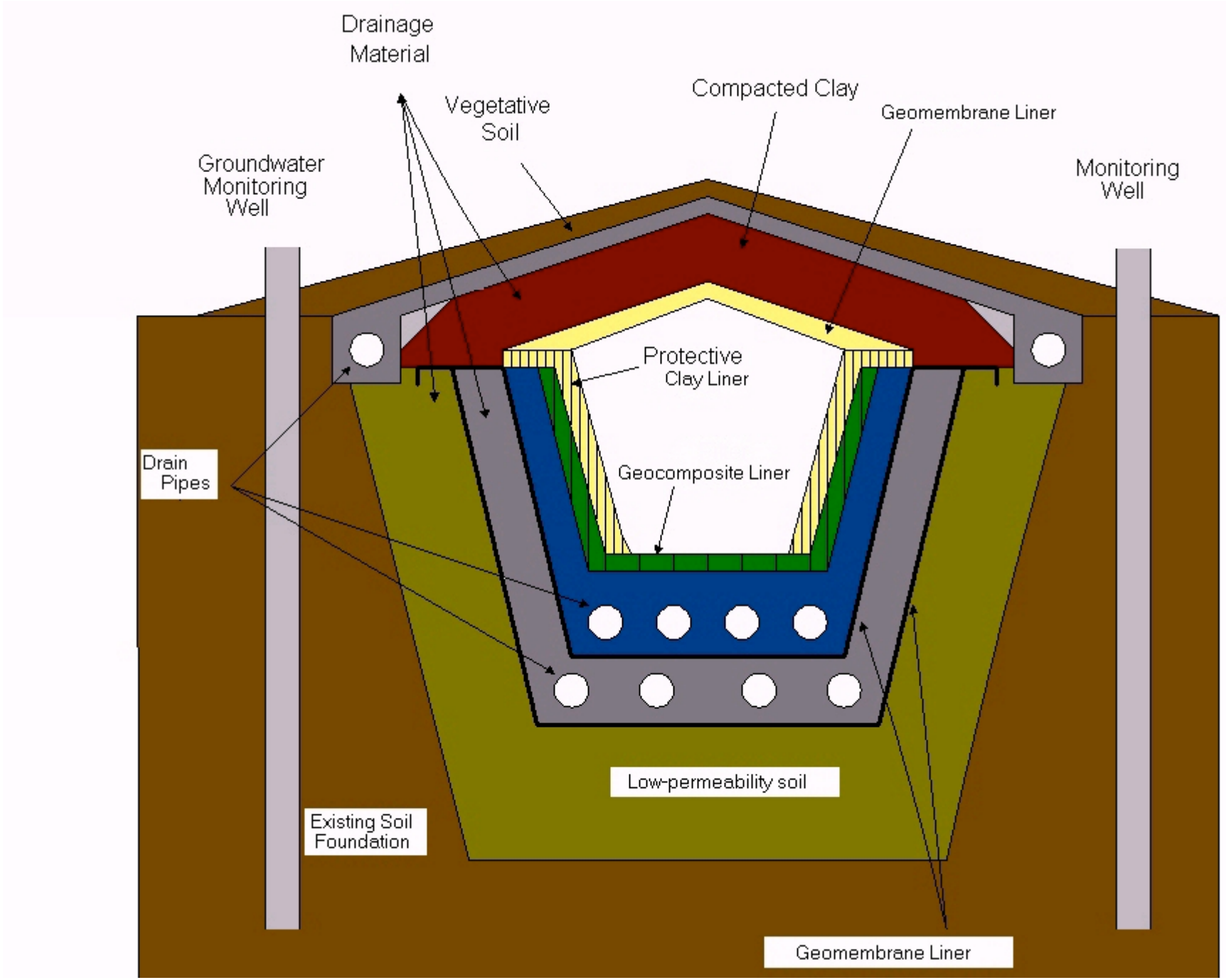
**Ma'ili 200 acres 15 years**
**Nanakuli B 432 acres 15.6 years**
**Makaiwa Gulch 338 acres 25 years**
**Ameron Quarry 391 acres 15 years**

**80 abandoned landfills on Oahu**





**decorating products (paints, stains, varnish, paint thinners), garden products (pesticides, fungicides, herbicides), vehicle products (engine oil, brake fluid, antifreeze, car batteries), household cleaners (bleach, disinfectant, air fresheners), toiletries (cosmetics, old medicines), batteries from watches, radios, mobile phones, etc. may contain heavy metals like mercury, nickel, cadmium**


Drainage Material
Vegetative Soil
Compacted Clay
Geomembrane Liner
Groundwater Monitoring Well
Monitoring Well
Protective Clay Liner
Geocomposite Liner
Drain Pipes
Low-permeability soil
Existing Soil Foundation
Geomembrane Liner

**Golfing in paradise…**
**14% of tourists**
**lots of locals**



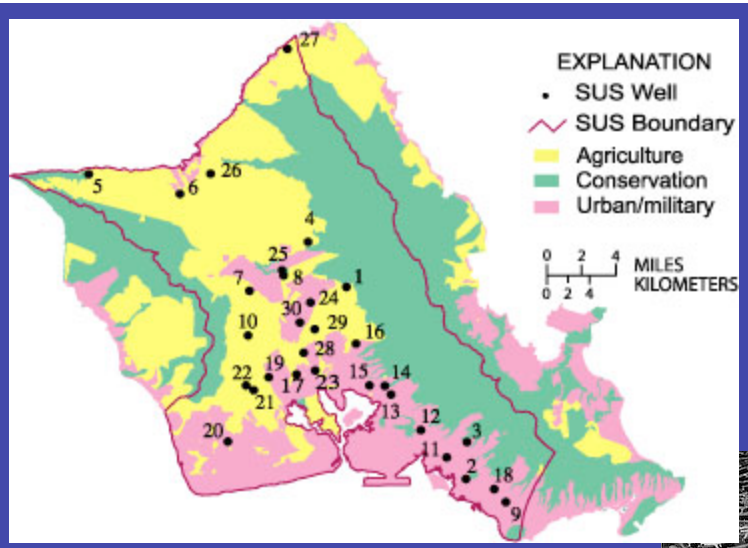
**Oahu Golf Courses**

1) Ala Wai Golf Course
2) Barbers Point Golf Course
3) Bayview Golf Links
4) Coral Creek GC
5) New Ewa Beach GC
6) Ewa Villages Golf Course
7) Ford Island Golf Course
8) Hawaii Country Club
9) Hawaii Kai Golf Courses
10) Hawaii Prince Golf Club
11) Hickam Mamala Bay
12) Honolulu Country Club
13) Kahuku Golf Course
14) Kalakaua Golf Course
15) Kaneohe Klipper GC
16) Kapolei Golf Course
17) Ko Olina Golf Club
18) Koolau Golf Course
19) Leileihua Golf Course
20) Luanna Hills
21) Makaha Valley CC
22) Makaha Resort GC
23) Mid Pacific CC
24) Mililani Golf Club
25) Moanalua Golf Club
26) Navy-Marine Golf Course
27) Oahu Country Club
28) Olomana Golf Links
29) Pali Golf Course
30) Pearl Country Club
31) Ted Makalena Golf Course
32) Turtle Bay Resort Golf Club
33) Waialae Country Club
34) Waikele Golf Club
35) Walter Nagorski Golf Course
36) West Loch Golf Course



**Average 1000 lbs chemical pesticides per year**

**…also fertilizers, herbicides…**


EXPLANATION
SUS Well
SUS Boundary
Agriculture
Conservation
Urban/military
0 2 4
MILES
0 2 4
KILOMETERS
27
26
5
6
4
25
8
1
7
24
30
10
29
16
28
22
19
15
14
17
23
21
13
12
3
20
11
2
18
9











# Non-point source pollution



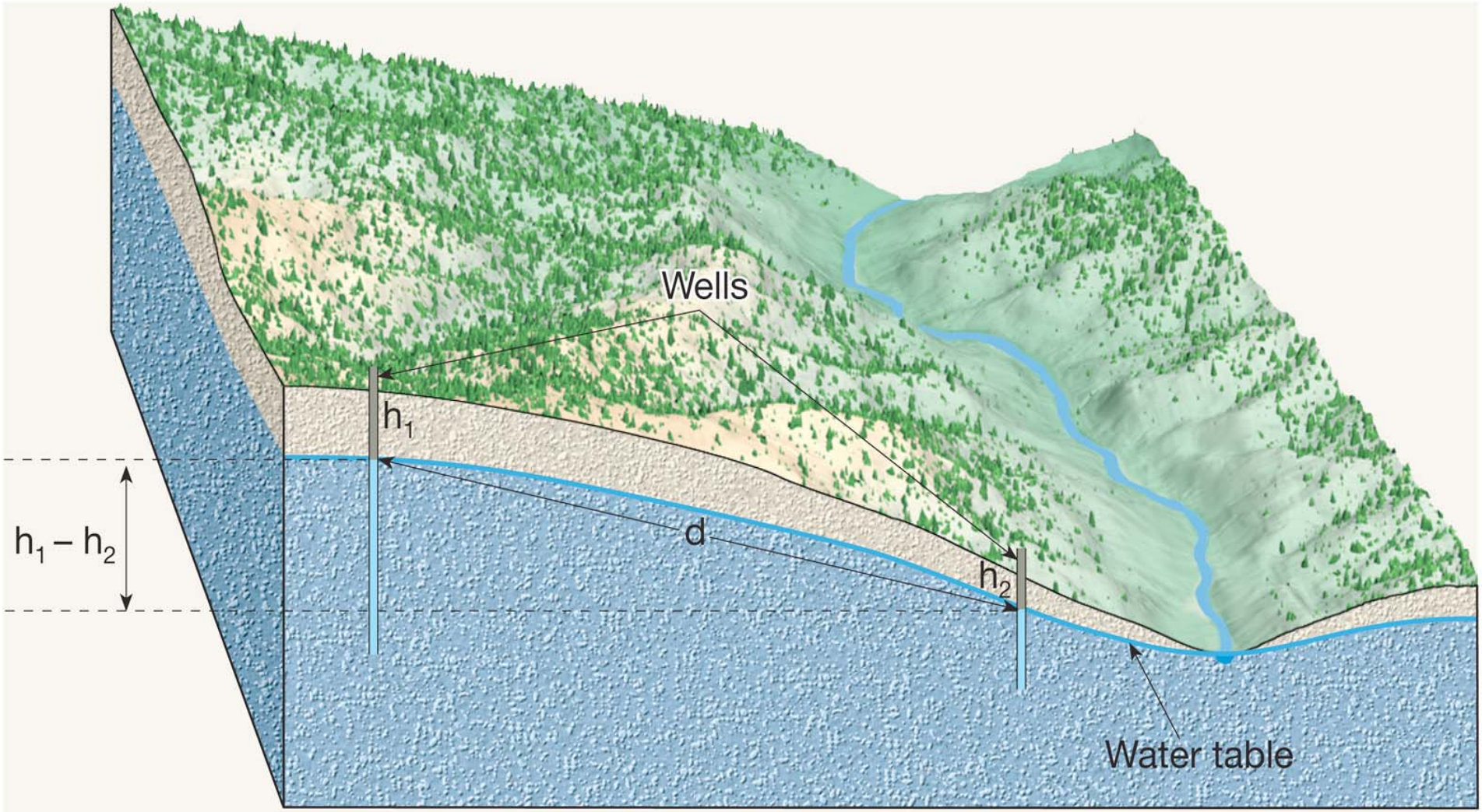




# Now that the pollution is there, what can we do?

## Now that the pollution is there, what can we do?

1. Stop polluting




**Discharge =**

$$\text{Hydraulic gradient} = \frac{h_1 - h_2}{d}$$

**the volume of water that flows through an aquifer in a specified time**

**permeability, hydraulic gradient**

**Now that the pollution is there, what can we do?**

1. **Stop polluting ($)**

   **Military $5.6 billion in Hawaii in 2005; 125,000 jobs**
   **Hawaii pineapple industry worth $135 million annually**
   **Pest control, petroleum industry, golfing…$$$**

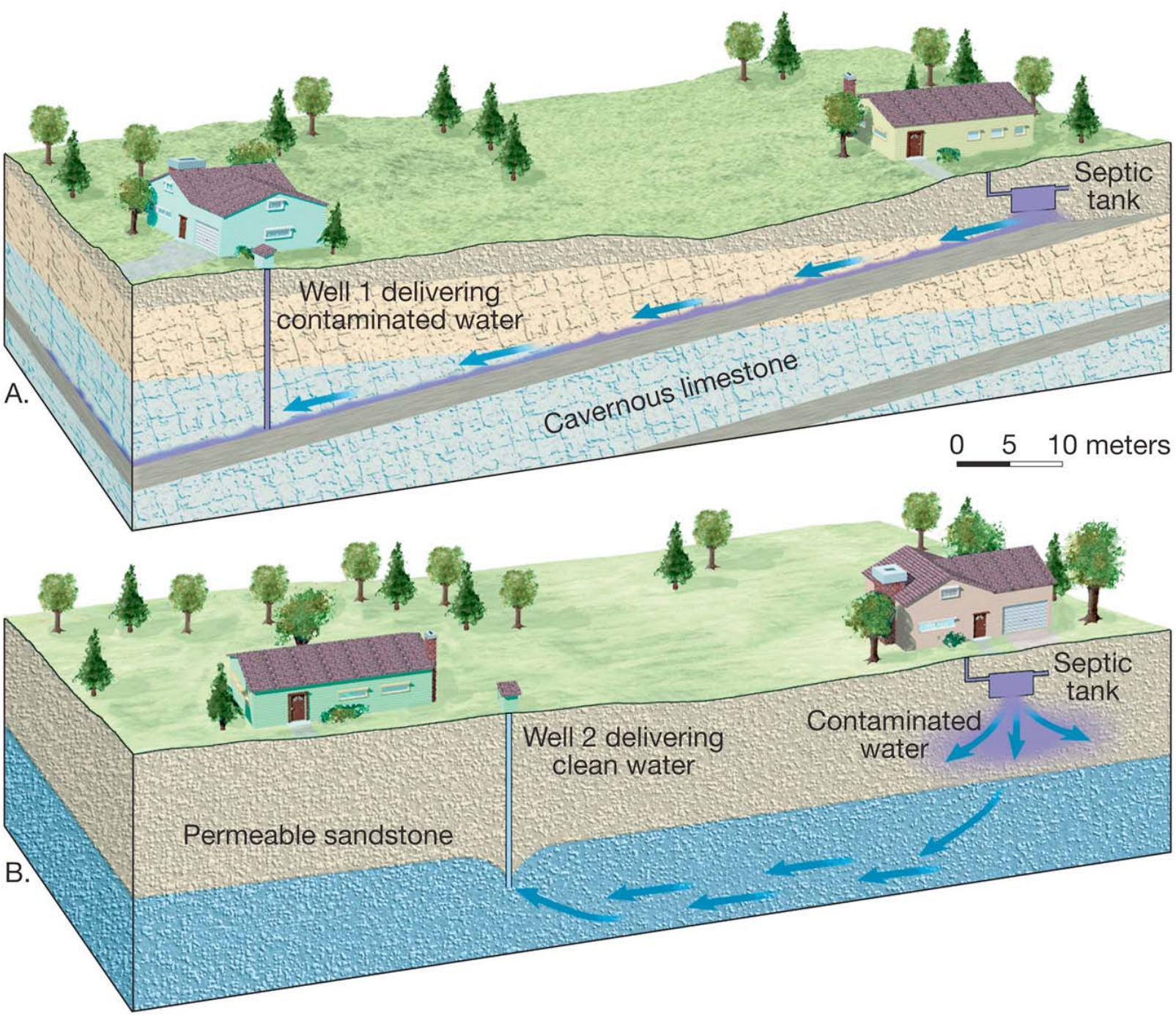
2. **?**

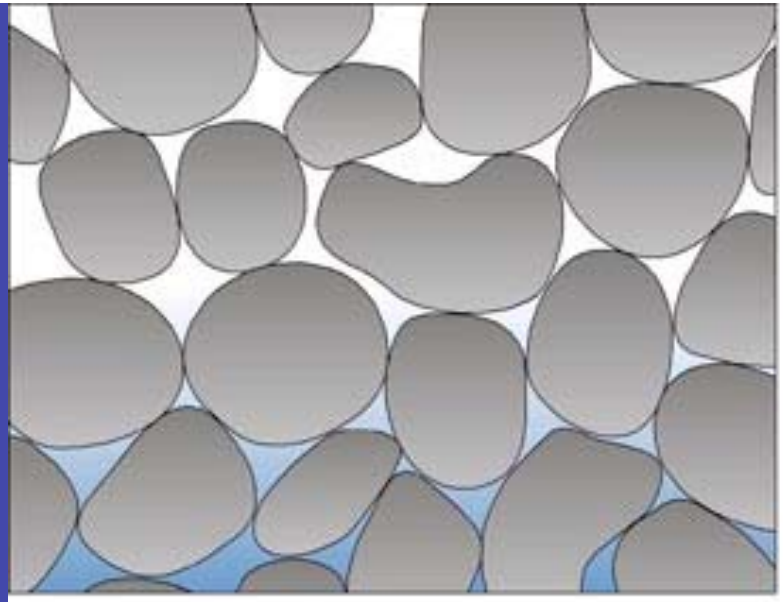
**Now that the pollution is there, what can we do?**

1. **Stop polluting ($)**

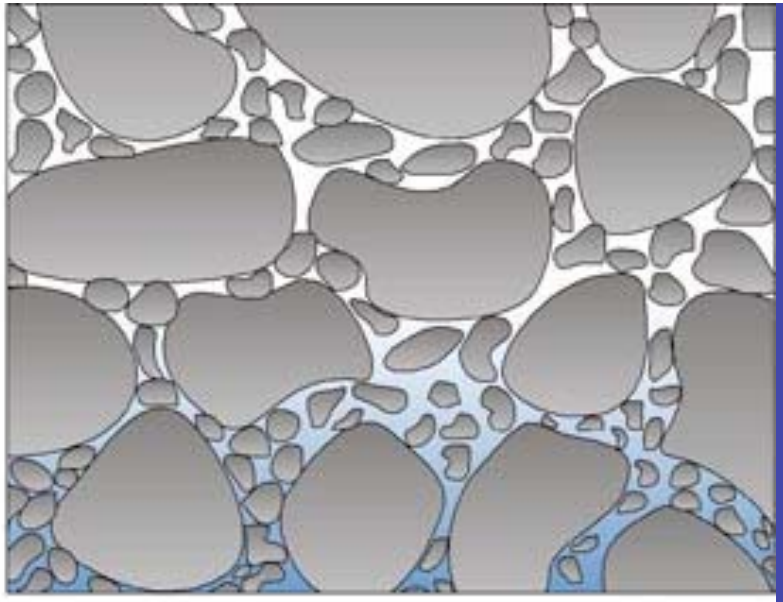
   **Military $5.6 billion in Hawaii in 2005; 125,000 jobs**
   **Hawaii pineapple industry worth $135 million annually**
   **Pest control, petroleum industry, golfing…$$$**

2. **Filtration**

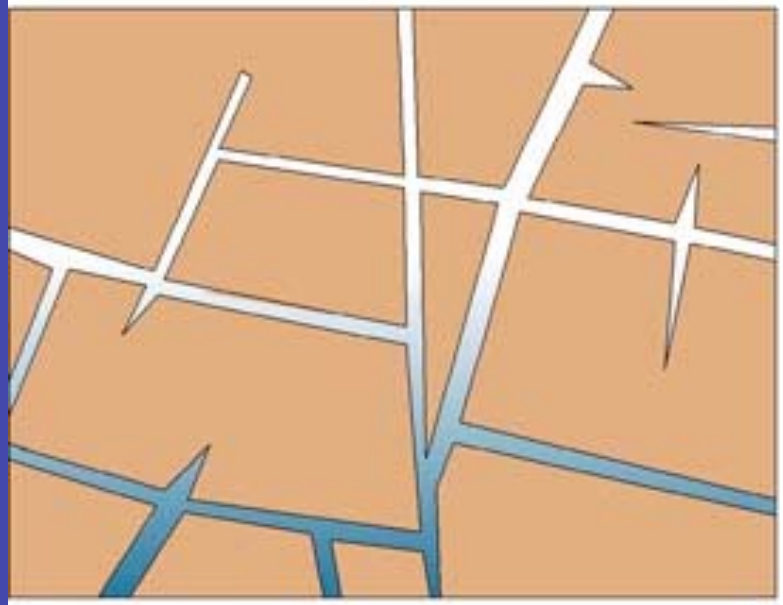

Septic tank
Well 1 delivering contaminated water
Cavernous limestone
A.
0 5 10 meters
Septic tank
Contaminated water
Well 2 delivering clean water
Permeable sandstone
B.



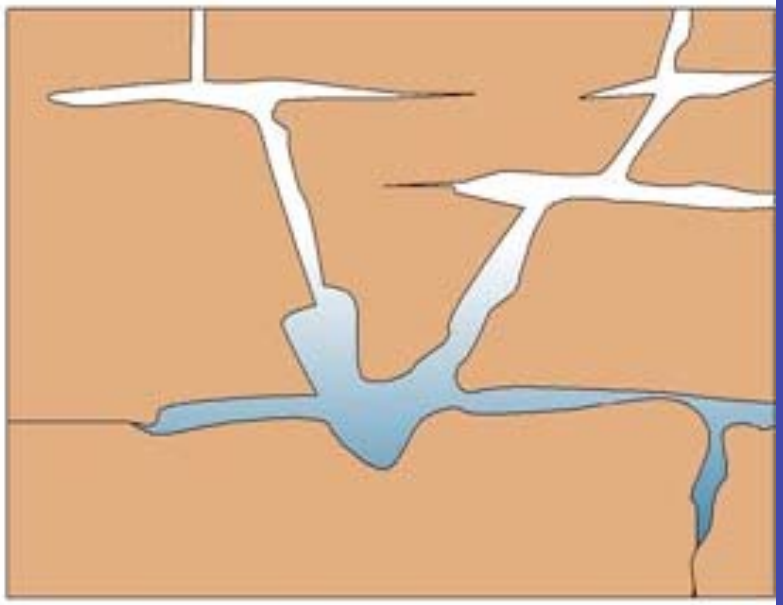
Well-sorted sedimentary material
(Alluvium of the South Platte River)



Poorly sorted sedimentary material
(Dawson, Denver, Arapahoe aquifers)



Fractured crystalline rocks
(Pikes Peak Granite)



Soluble rock-forming material
(Leadville Limestone)

**Now that the pollution is there, what can we do?**

**1. Stop polluting ($)**

**Military $5.6 billion in Hawaii in 2005; 125,000 jobs**
**Hawaii pineapple industry worth $135 million annually**
**Pest control, petroleum industry, golfing…$$$**

**2. Install filtration systems ($)**

**$895-$8,000+ / household, municipal???**

**3. ?**

- Safe Drinking Water
- Water Quality Report
- Our Drinking Water
- What You Can Do

PRINT THIS PAGE

**CONSERVATION TIP**

Remember, whatever you place on the ground may someday end up in our island water supply. It's up to all of us to do our part to make sure that our groundwater resources are protected for present and future generations.

SITE MAP | FAQ | CONTACT US

Enter Keywords GO!

HOME : WATER QUALITY : WATER QUALITY REPORT

# Water Quality Report




The BWS Water Quality Report - also known as the "Consumer Confidence Report" (CCR) - is sent to all customers each summer. The CCR contains a wealth of information about your water quality.

- Click to download the 2006 Water Quality Report (PDF)
- Click to download the Water Quality Report for your specific area

This report does several things:

- Identifies the source which supplies water for your address
- Reports detected contaminants or elements in the water and ensures that your drinking water meets all safe drinking water standards
- Describes any treatment process used, if necessary, to make your water safe to drink
- Explains terms used in the regulation of drinking water
- Tells you where to go for additional information



What we all do and the habits that we practice every day will determine both the quality of our water and the quantity available for our use. Monitoring the quality of our water won't matter if we don't take care of our environment as individuals and as a community.

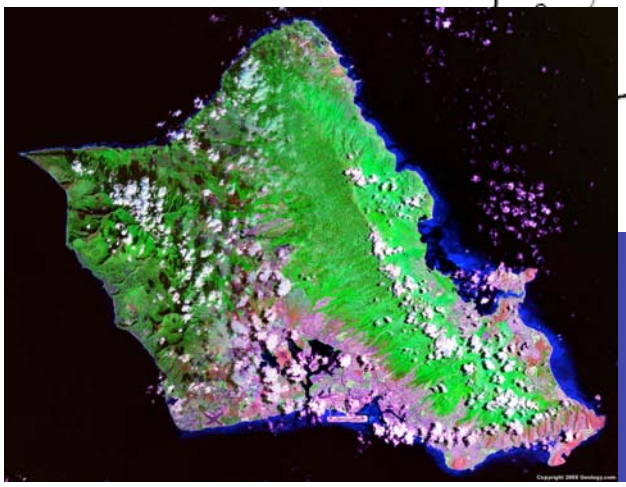
Oahu is blessed with water that is among the best quality in the world. At the Board of Water Supply (BWS), our job is to make sure it's also the safest.

That is why water from each of our sources is regularly tested. We must ensure that Oahu's water supply not only meets the Safe Drinking Water Act requirements, but also exceeds the most demanding regulations governing the quality of our drinking water.

As mandated under Federal and State law, the State Department of Health and the Board of Water Supply regularly test Oahu's drinking water for more than 100 different kinds of chemical "contaminants". At BWS, over 18,500 tests are conducted by our Chemical Laboratory.

# Groundwater contaminants

| | |
|---|---|
| **REGULATED** | |
| Alpha emitters<br>Beta/photon emitters<br>Radium 228 | radioactive particles (naturally-occurring) |
| Nitrate | fertilizer |
| Barium | metal – drilling mud |
| Chromium | metal – making steel, dyes & pigments, chrome plating, leather tanning, wood preserving |
| 1,2,3-Trichloropropane | industrial solvent, paint and varnish remover, cleaning and degreasing agent |
| Fluoride | dental health additive |
| **UNREGULATED** | |
| Sulfate | mineral (naturally-occurring) |
| Dieldrin | pesticide |



## *Sample contaminants*

**TCE – metal/dry cleaning fluid**
**DBCP – pesticide**
**EDB – pesticide/fumigant**
**TCP – soil fumigant**
**Dieldrin – insecticide**
**Chlordane – insecticide**
**Carbon tetrachloride – propellant/pesticide**
**Atrazine - pesticide**

Hau`ula
Hale`iwa
Mokule`ia
Waialua
Wahiawa
Makaha
Kunia
Wai`anae
Ma`ili
Nanakuli
Pacific Palisades
Aiea
Kane`ohe
Kailua
Lanikai
Waimanalo
Hickam
Kalihi
Ewa
Ewa Beach
Honolulu
Waikiki
Wai`alae
Kahala
Hawai`i Kai
Nui

**Contaminated drinking water wells on Oahu results from 1995-2005**

## Now that the pollution is there, what can we do?

## 1. Stop polluting ($)

Military $5.6 billion in Hawaii in 2005; 125,000 jobs
Hawaii pineapple industry worth $135 million annually
Pest control, petroleum industry, golfing…$$$

## 2. Install filtration systems ($)

$895-$8,000+ / household, municipal???

## 3. Monitor water quality ($)

Hawaii Department of Health Environmental Monitoring
Budget FY2007 - $243,953,098 ($201/person/year)