

Groundwater Educational Outreach Webinar Series

Webinar #3: Contaminant Transport in Groundwater

Presenters:

Dan Burnell, Ph.D. Tetra Tech

Lauren Cruz, Hawai'i DOH

Robert Whittier, Hawai'i DOH

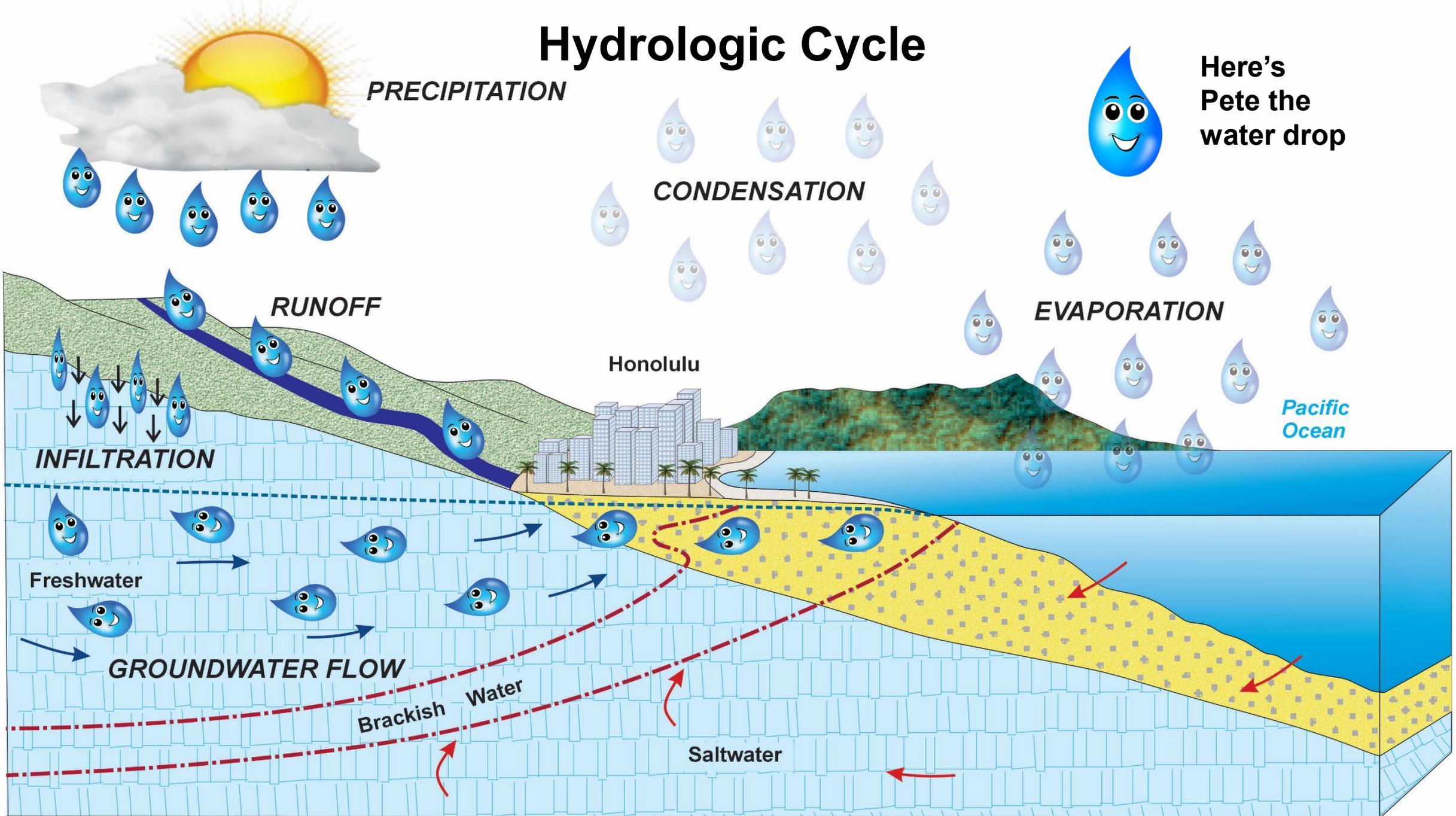
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June 20, 2025



KA 'OIHANA OLAKINO

Hydrologic Cycle



POTENTIAL GROUNDWATER CONTAMINATION SOURCES



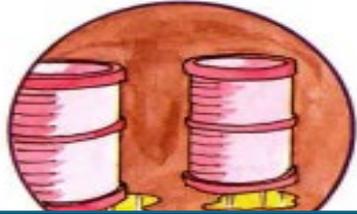
Excessive Application of Fertilizer



Dumping of Paint Solvents, Automotive Fluids, Wash Water, and other Household Hazardous Waste on the Ground



Leaks in Pipes Carrying Fuel



Spills or Release of Hazardous Materials and Waste



Improper Disposal of Livestock or Human Wastes in Unlined Collection Pits or Trenches or Cesspools

Pesticides, Fertilizers

Household Hazardous Waste

Petroleum Products

Toxic Hazardous Waste

Improper Disposal of Toxic and Hazardous Waste

Wastewater Treatment Plant and Injection Wells



Excessive Application of Pesticides

Excessive Pumping Lowers the Groundwater Level Around the Well and Can Pull Salty Water into the Fresh Water Layer

A Floating Plume Flows Near the Top of the Fresh Water Layer

Once a Contaminant Reaches Groundwater, it Flows with the Groundwater

A Sinking Plume Sinks Deeper into the Fresh Water Layer

Groundwater Protection and Planning in Hawai'i



State Groundwater Protection

Resource & Quality Assessment

Monitoring

Protection

Corrective Actions

Other Elements

- Data Management & Sharing
- Education & Outreach
- Integration with the Hawaii Water Plan
- Consultation with Stakeholders
- Gaps & Future Consideration

Hawai'i Water Plan Components

Protection Policies

State Needs

Water Quality Plan

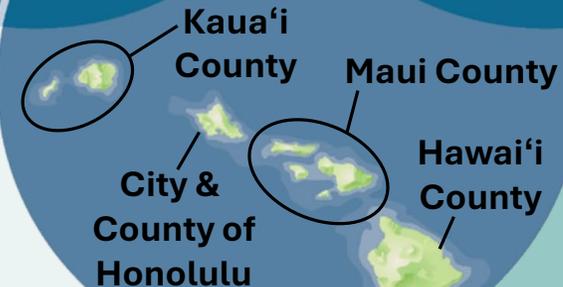
Agricultural Water Use and Development Plan

Water Resource Protection Plan

State Water Projects Plan

Sustainability

County Water Use & Development Plans

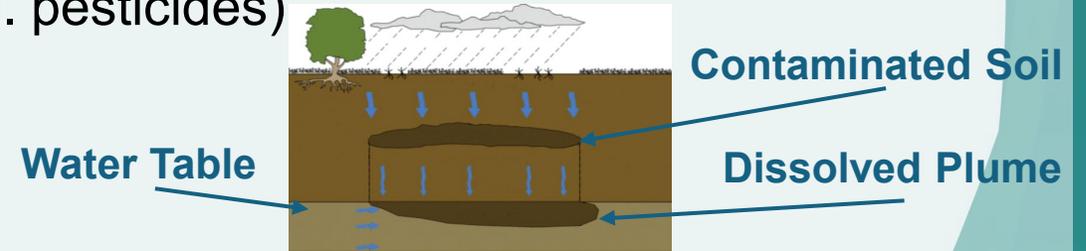


County Needs

Ways Contaminants Can Reach Groundwater in Hawai'i



1. Contaminant mixing with rainfall that migrates to water table and forming dissolved plume (e.g. pesticides)

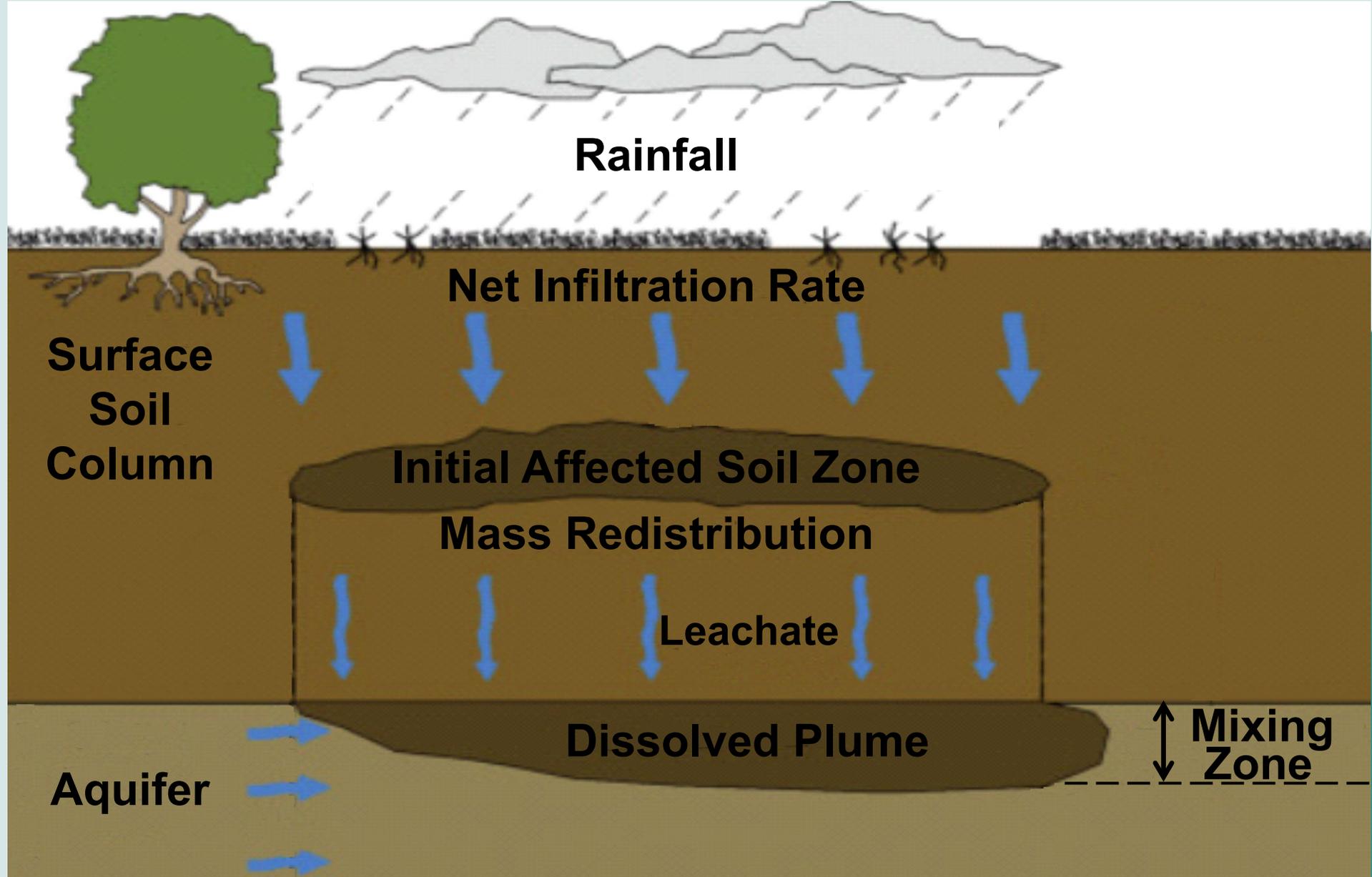


2. Light nonaqueous liquids (LNAPL) into groundwater and **float** on the water table (examples: oil, gasoline, diesel fuel)

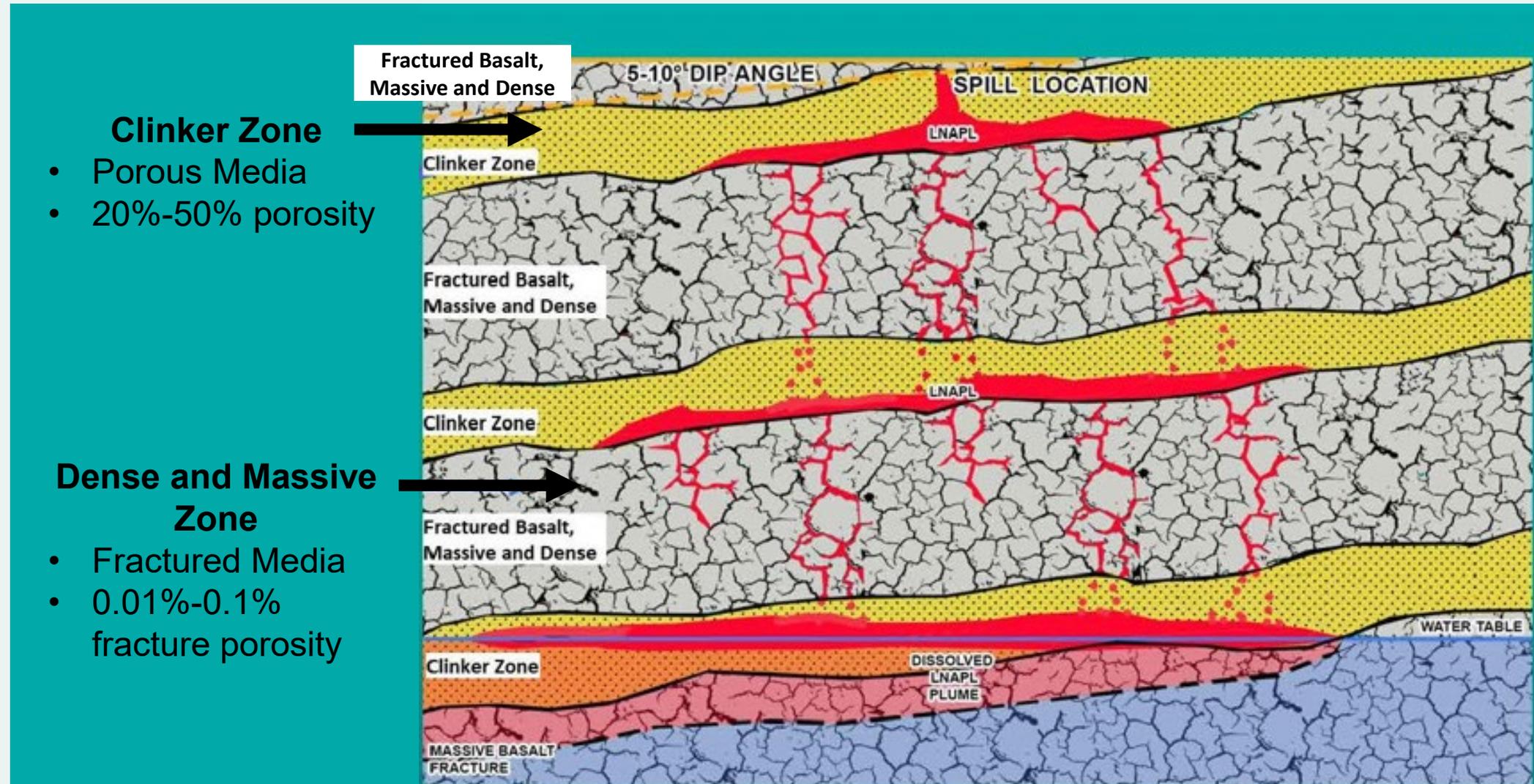


3. Downward migration of dense aqueous phase liquids (DNAPL) that can **sink** to bottom of aquifer (dry cleaning solvents)

1. Rainfall Infiltration and Leaching from Impacted Soil



2. Release of Light Nonaqueous Phase Liquid (LNAPL)



Clinker Zone

- Porous Media
- 20%-50% porosity

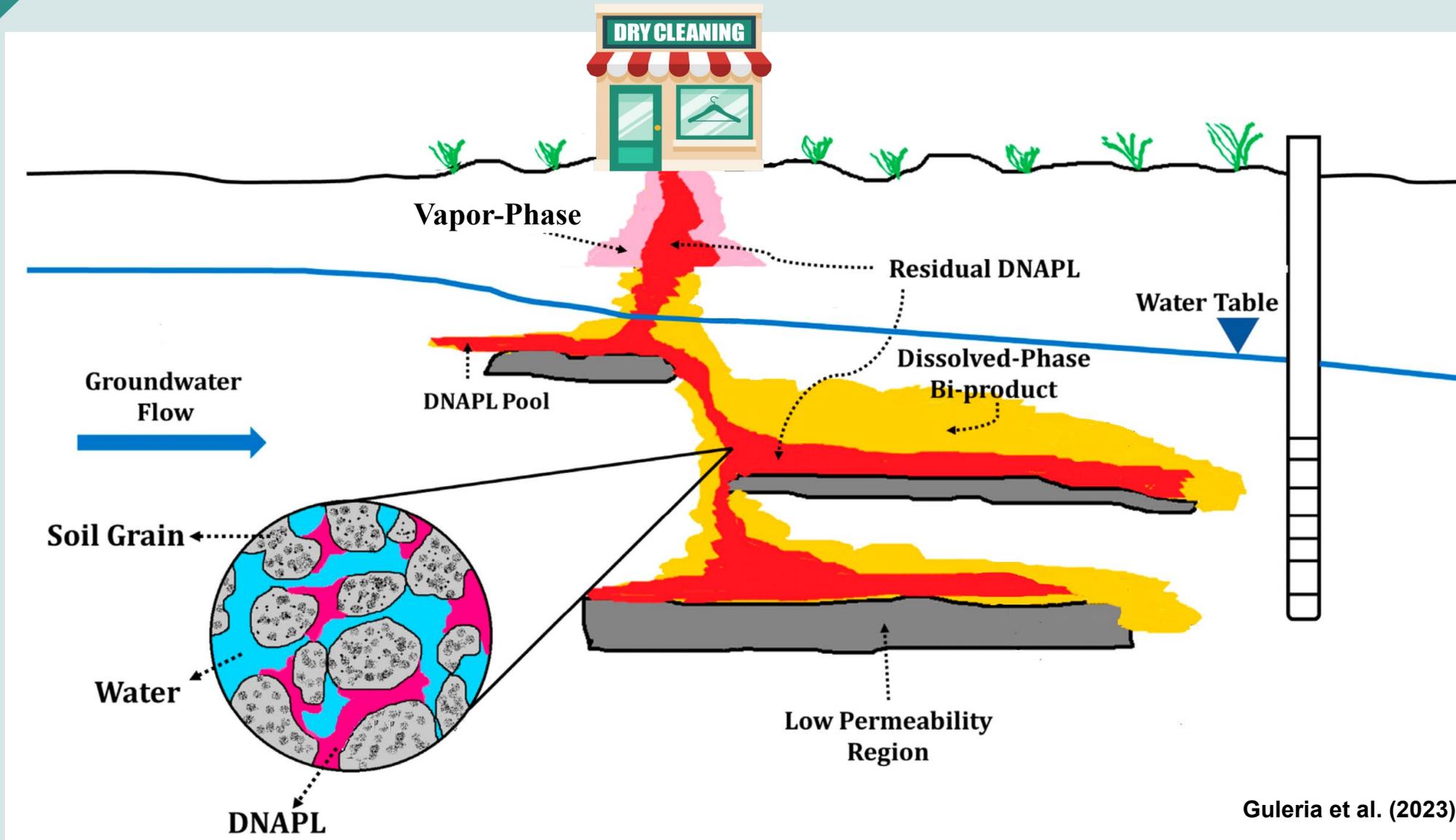
Dense and Massive Zone

- Fractured Media
- 0.01%-0.1% fracture porosity

LNAPL
“floater”



3. Release of Dense Nonaqueous Phase Liquid (DNAPL)



DNAPL
"sinker"



Guleria et al. (2023)

Possible Types of Contaminants in Groundwater

1. Organic Contaminants

- Dry cleaning/degreasing solvents (TCE)
- Petroleum Compounds (Benzene)
- Pesticides and Herbicides (Atrazine)



2. Inorganic Contaminants

- Metals (e.g., lead, arsenic)
- Nitrates and nitrites
- Salts

3. Microbial Contaminants

- Bacteria, Viruses, Protozoa

4. Radioactive Contaminants

- Radon and Uranium

5. Emerging Chemicals

- 1,4 dioxane and PFAS



Note:

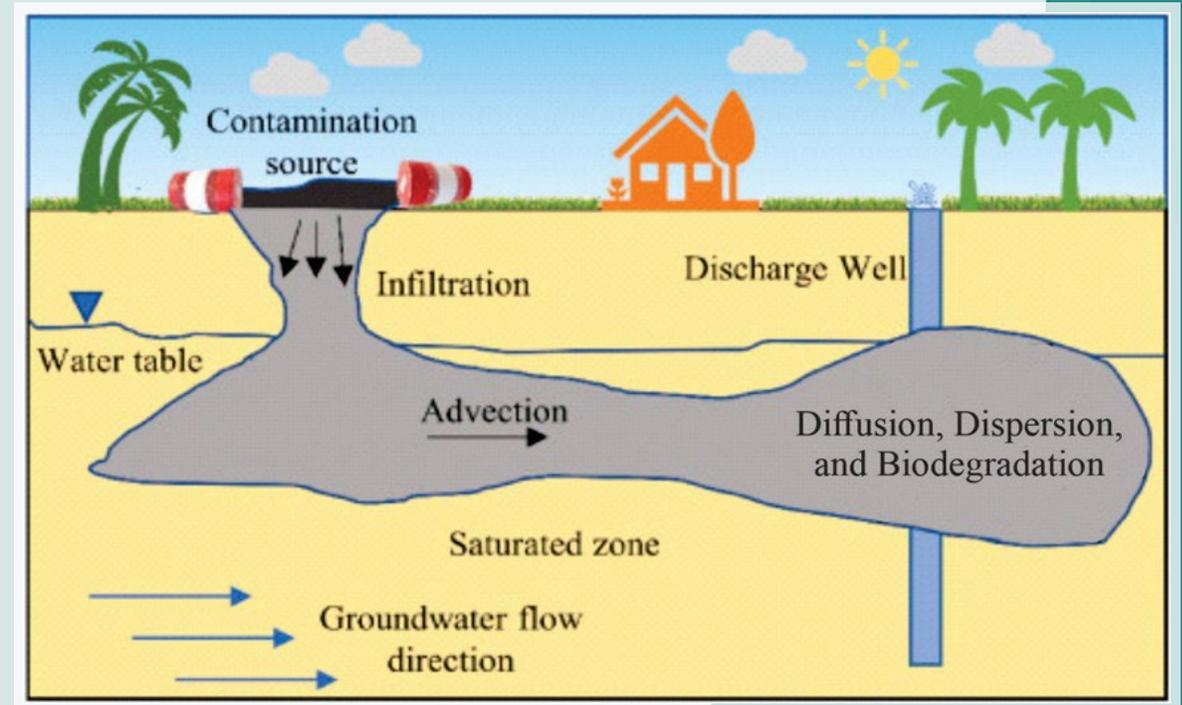
Type of possible contaminants in groundwater vary depending on location.

Different chemicals have unique mobility in groundwater.

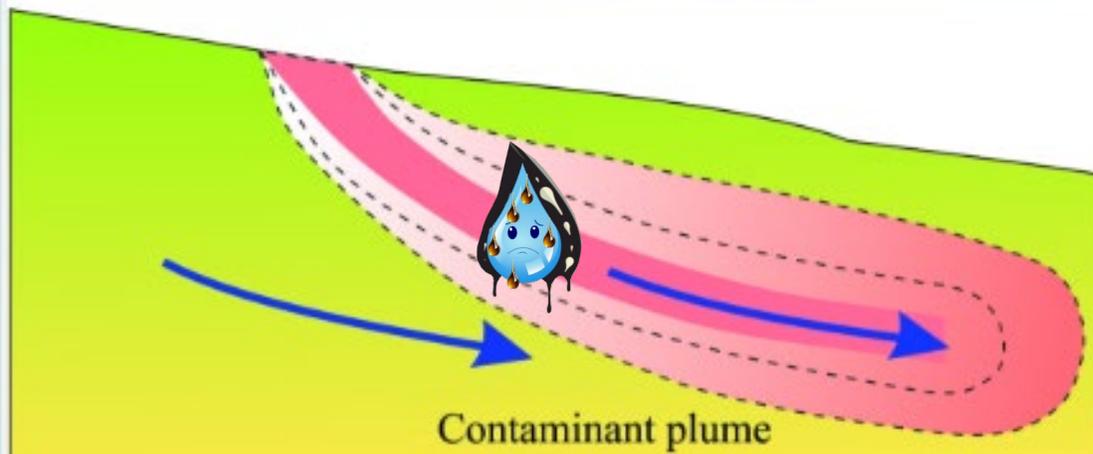
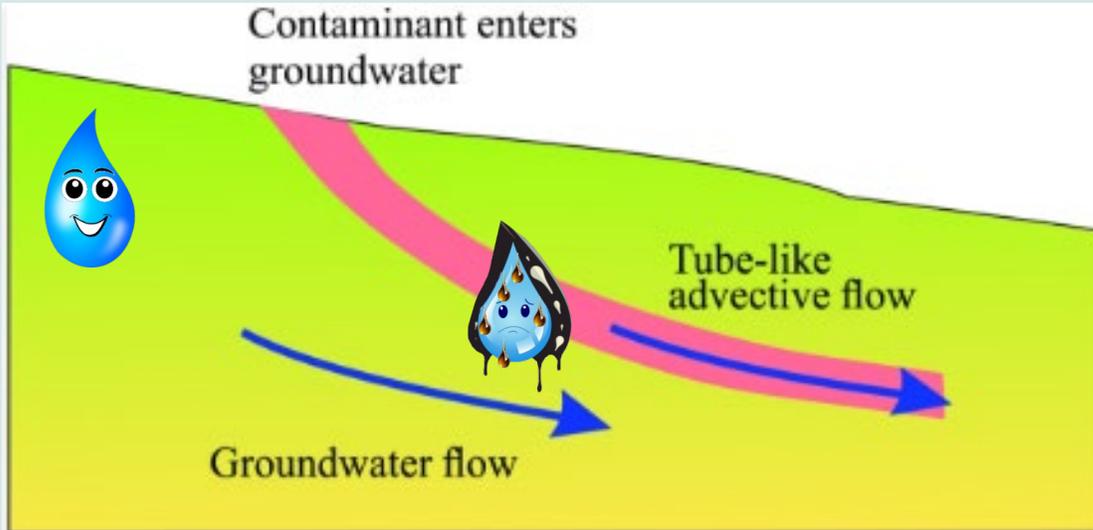
Some chemicals biodegrade and others are more persistent.

Movement and Fate of Contaminants in the Subsurface

- Spills and downward transport
- Dissolved phase vs. floating/sinking transport
- Contaminant plume migration
 - Carried by groundwater (advection)
 - Spreading and mixing (dispersion and diffusion)
- Plume break-down by natural bacteria (biodegradation)
- Not all contaminants biodegrade rapidly



Contaminant Migration Via Advection (Moving with Groundwater)



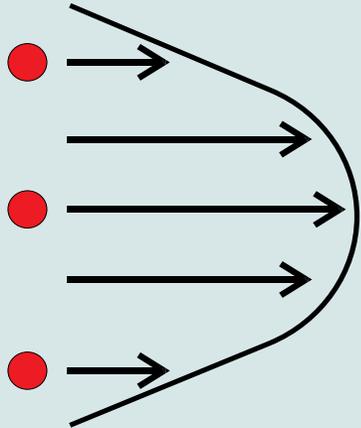
During advection, contaminants are carried along piggy-back with moving groundwater

Mixing (dispersion) at different rates with groundwater causes a larger contaminant plume

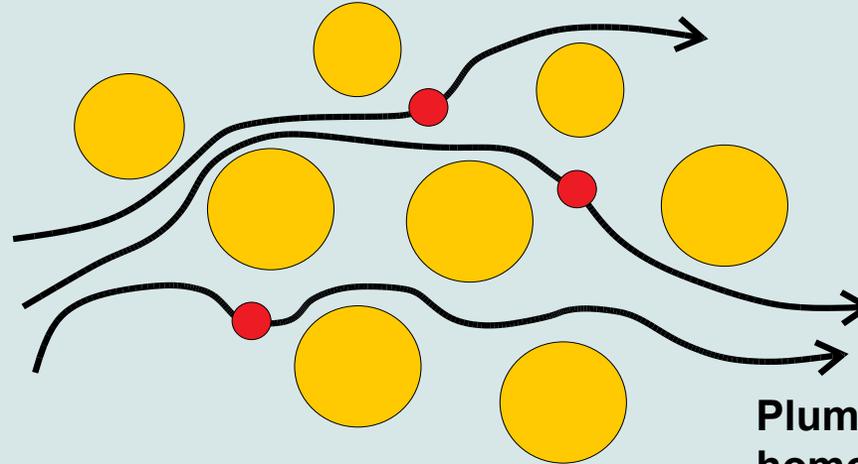
Contaminant Spreading from Hydrodynamic Dispersion



1. Variations in Flow Velocity

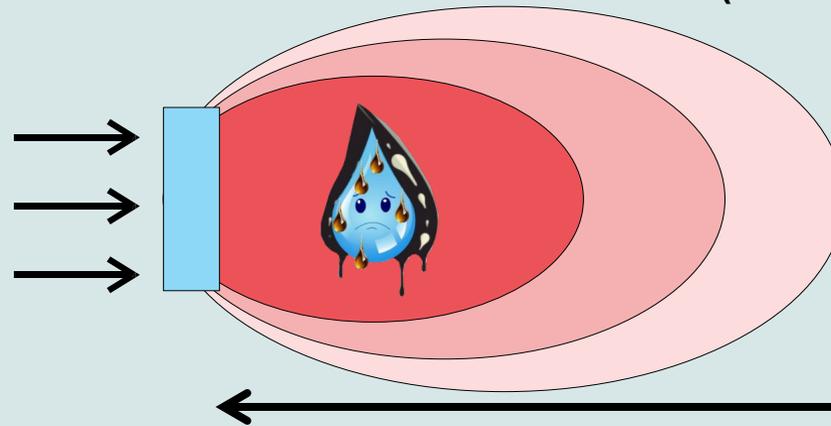


2. Different Solute Flow Paths



Plume for relatively homogeneous aquifer (beach sand)

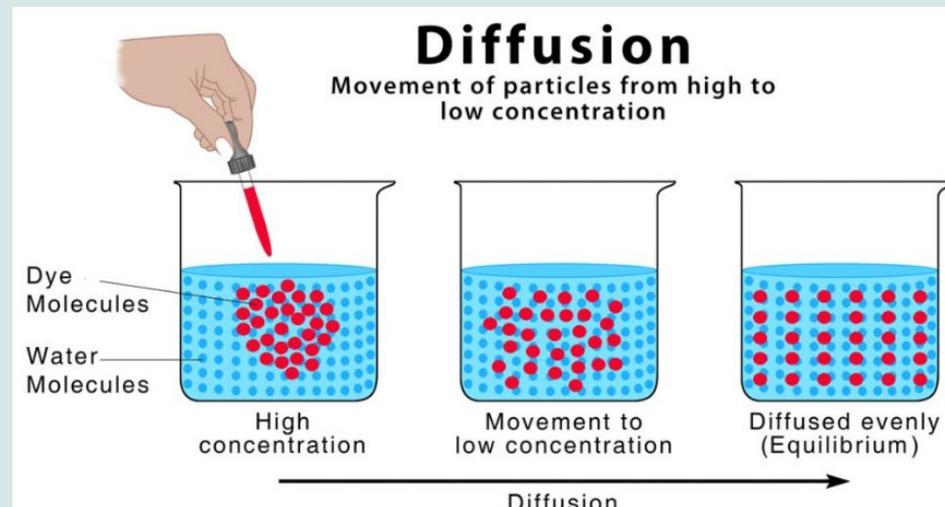
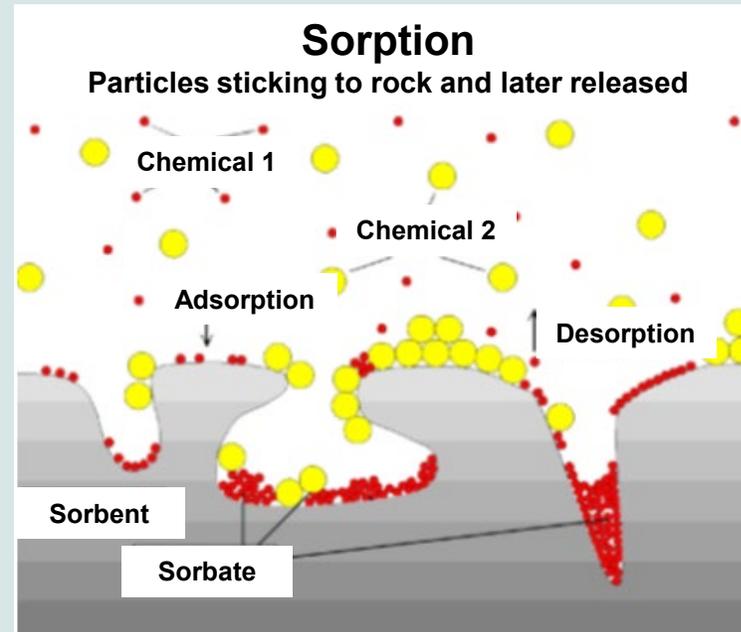
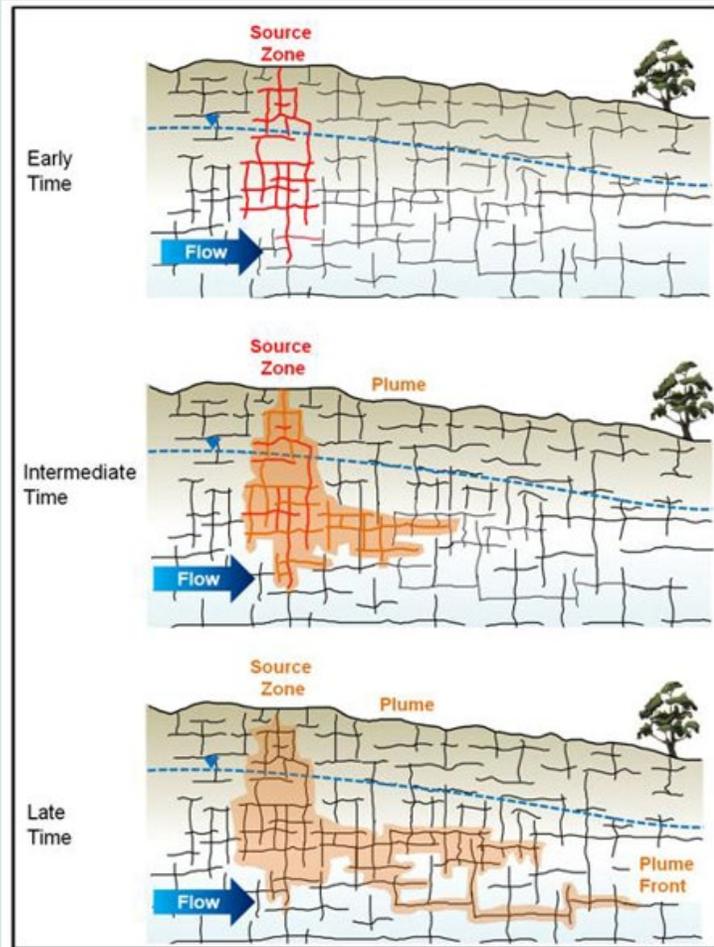
3. Causes the Plume to Spread



Lateral and vertical dispersion

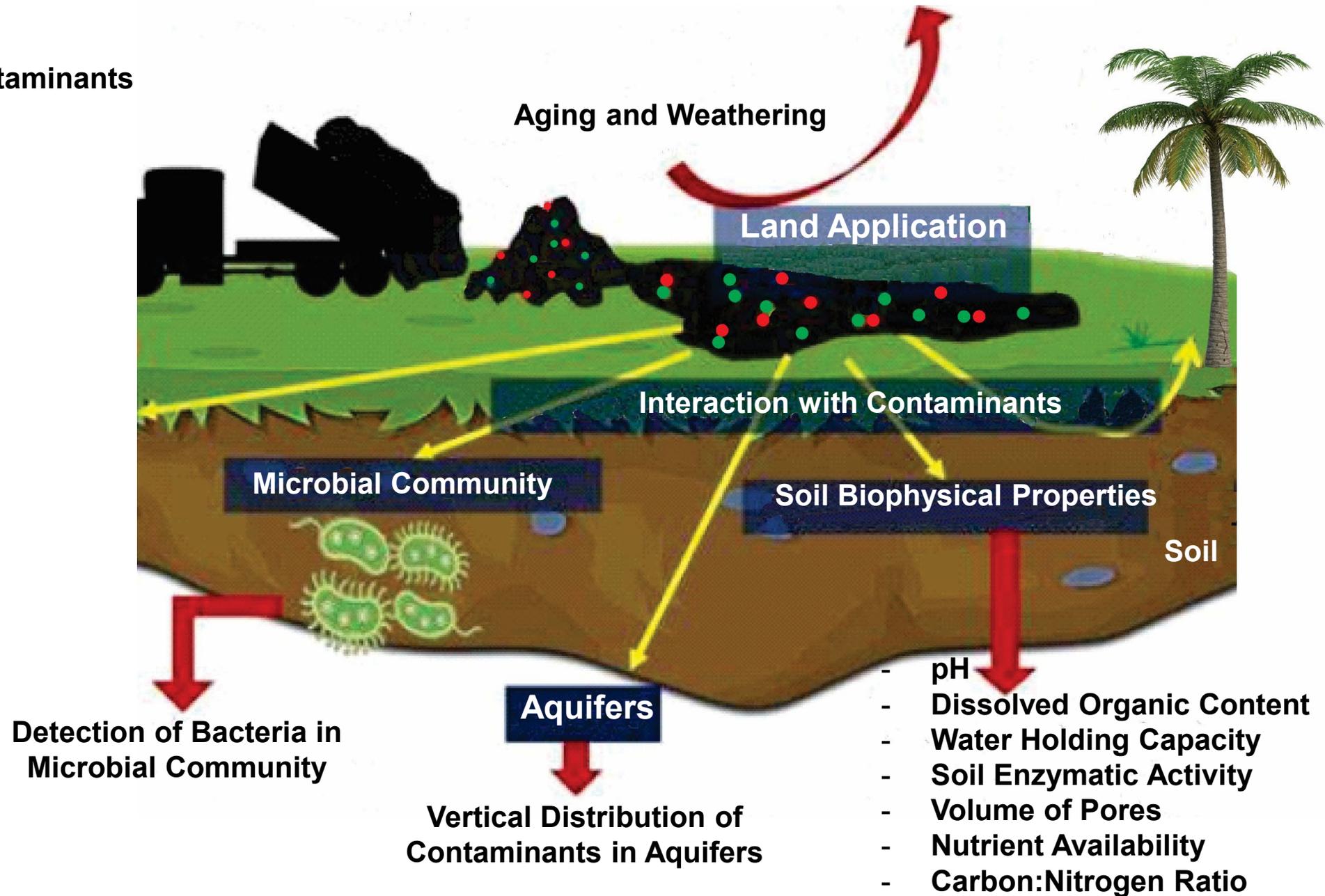
Longitudinal dispersion (along flow direction)

Advection, Sorption, and Diffusion Plume Migration Over Time



Contaminant Biodegradation

● ● Contaminants



Potential Impacts of Contaminants in Groundwater



Health Risks: Exposure to contaminants like pesticides, volatile organic chemicals (VOCs), and heavy metals can lead to health issues.



Environmental Risks: Contaminated groundwater can harm ecosystems, affecting plants, animals, and aquatic life.



Economic Impact: Costs associated with cleaning up contaminated groundwater and providing alternative water sources can be significant.

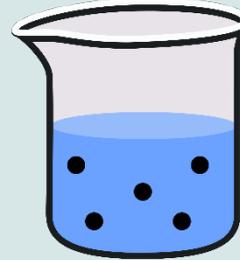


Community Impact: Communities relying on groundwater for drinking water may need water conservation (use restrictions)

When Contaminants Require Action



Groundwater is shaped by the environment it moves through.



Risk depends on concentration, not just presence.



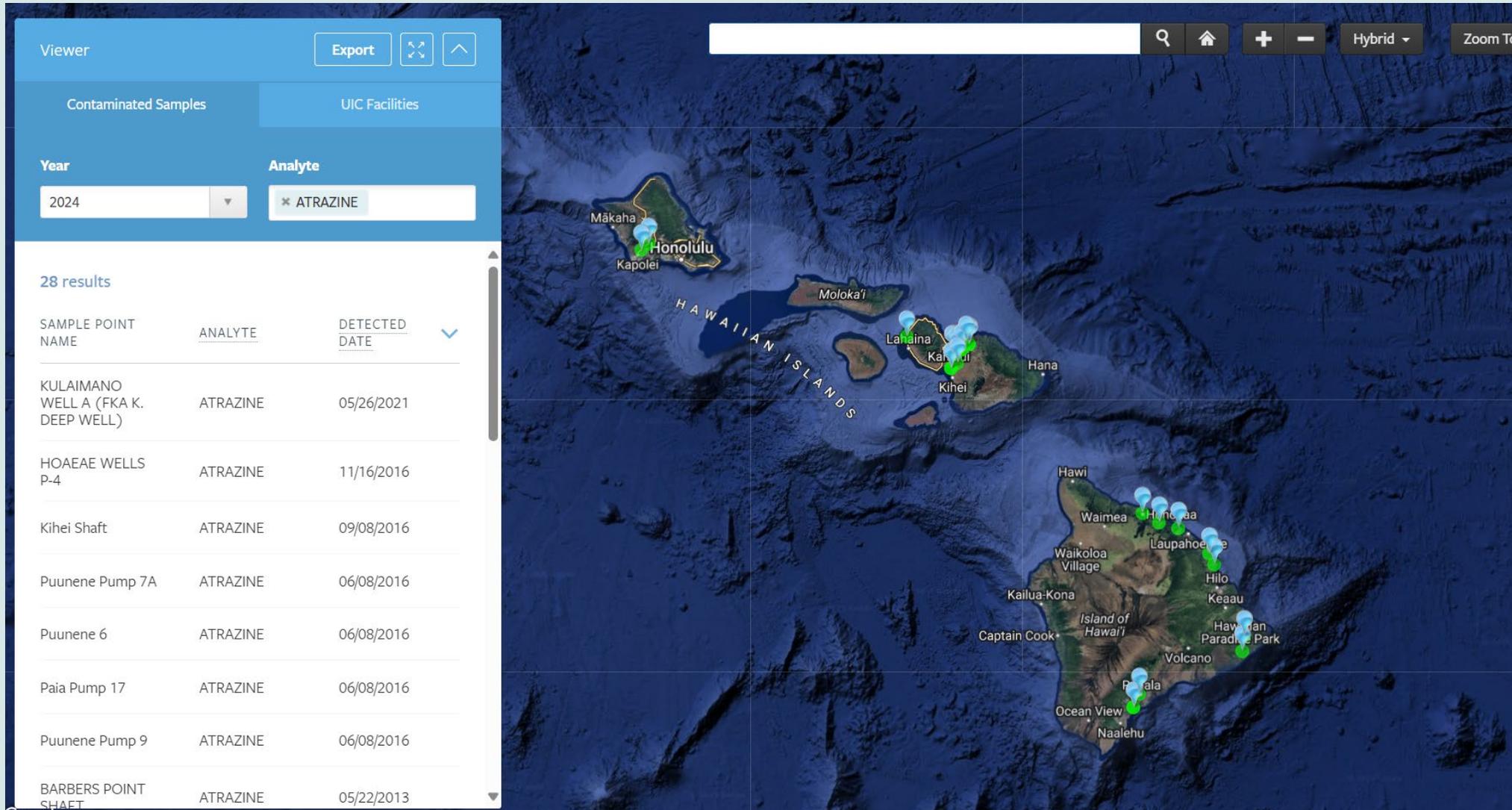
Strict standards protect people and the environment.

- EPA Maximum Contaminant Levels
- DOH Environmental Action Levels



Exceedances require investigation and/or cleanup.

DOH Map of Historical Drinking Water Well Testing in Hawai'i



<https://eha-cloud.doh.hawaii.gov/sdwb/#!/viewer>

Next Webinar: Contaminant Plume and Aquifer Cleanup

If you have further questions or would like more information
on a specific topic, please send us an email at:

curtis.pruder@doh.hawaii.gov



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