Upcountry Maui Groundwater Nitrate Investigation

Presented by:
Hawaii Department of Health,
Safe Drinking Water Branch

Presented to:

The Upper Kula Community Association

February 21, 2018

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Overview

- Department of Health & Source Water Protection Program
- Description of terms
- Groundwater nitrate statewide
- Summary of DOH investigations and research
- The Upcountry Maui Nitrate Investigation
- Summary of findings
- Conclusions

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The Department of Health Mission and Goals

- The Department of Health (DOH):
  - Mission - to protect and improve health and environment
  - Goal - to prevent pollution and preserve a clean, healthy and natural environment
    - Protect and enhance air and water quality
- The Source Water Protection Program (SWPP)
  - Part of the DOH Safe Drinking Water Branch
  - Mission – to reduce or eliminate contamination risk to public drinking water sources

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Source Water Protection Program

- Evaluate the susceptibility to contamination of each drinking water source
- Work collaboratively with all parties to reduce the contamination threats and risks
- SWPP is a great planning and technical resource
- Funded by the Drinking Water State Revolving Fund
  - Provides assistance to water systems and other state programs
- SWPP is a voluntary program for contamination risk reduction

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SWPP Functions

- To Define zone of contribution to drinking water wells
  - Groundwater modeling is the primary vehicle for this effort
- Lend technical support to other programs
  - Red Hill fuel leak
  - Incidents high bacteria in South Kauai streams
  - Well siting assessments
- Works with Maui Department of Water Supply
  - Identify well locations with lowest contamination risk potential
  - Technical support for the proposed Wellhead Protection Ordinance

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Description of Terms

- Nitrate
  - Contaminant generally associated with fertilizers, wastewater, & livestock
  - In high enough concentrations can be fatal to infants
- Maximum contaminant level
  - A federal or state defined concentration a contaminant cannot exceed in public drinking water
- Onsite Sewage Disposal System or OSDS
  - Any wastewater system that discharges effluent within the parcel where it was generated
    - Cesspools
    - Septic systems
    - Aerobic treatment units
    - Advanced contaminant removal systems

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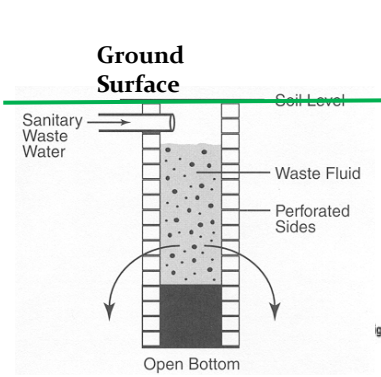
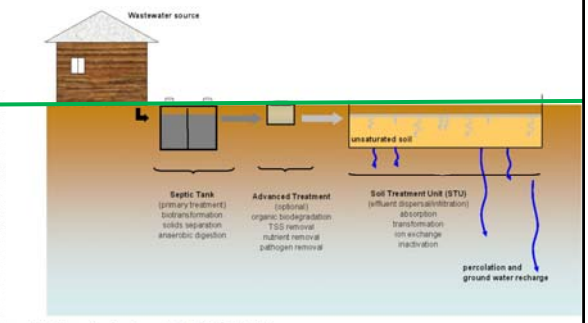
Major Onsite Sewage Disposal Systems Used in Hawaii





igure 1-1. Schematic of a Conventional OWTS with STU.

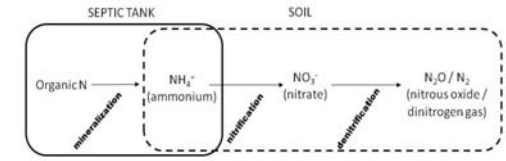


Figure 2-1. Main N Transformations in Septic Tanks and STUs (transformations are generalized, and may not be complete in field systems).

*Water Environmental Research Foundation

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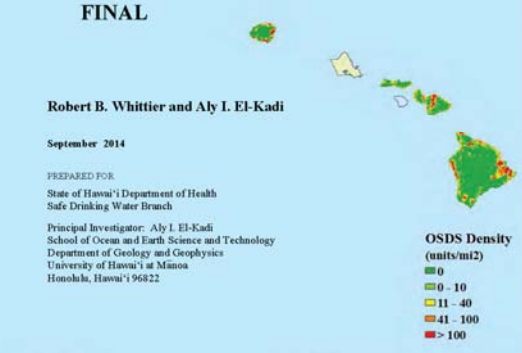

Onsite Sewage Disposal System (OSDS) Health and Environmental Risk Studies

- Study Objectives
  - Estimate the number of OSDS by type
    - Septic,
    - Aerobic treatment, and
    - cesspools
- Prioritize the risk to:
  - Human health
  - Streams
  - Coastal waters

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DOH OSDS Studies in Other Areas

- Kahalu`u
  - Collaborative effort with UH
  - Sample groundwater and coastal water for:
    - Nitrate and other nutrients
    - Isotopes of nitrate
    - General water chemistry
    - Pharmaceuticals
  - Measure groundwater discharge to coastal waters
    - Coastal water temperature
    - Measuring coast water radon concentrations
      - Radon occurs in groundwater, but is absent from seawater

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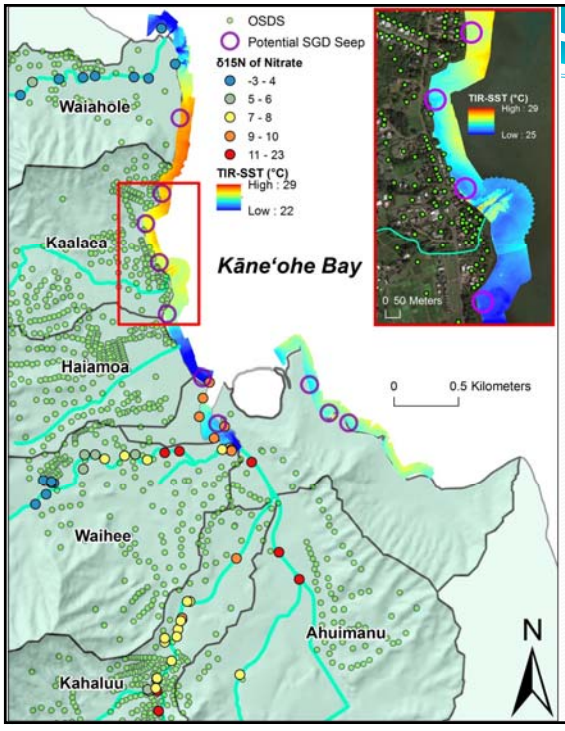
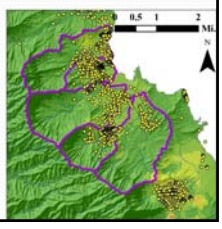


Kahalu`u, Oahu

- Priority 1 Area
  - 700 cesspools in this small group of watersheds
  - Very high concentrations of wastewater indicator bacteria
  - Incidents of serious skin infections



DOH OSDS Studies in Other Areas

- Hawaiian Paradise Park, Keeau, Hawaii Island
  - Risk to domestic wells
- Coastal discharge of nitrate contaminated groundwater
  - West Maui
  - West Hawaii
- Cost/benefit analysis of coastal nitrate reduction alternatives
- Partnering with
  - UH
  - NOAA
  - West Maui Reef to Ridge Project
  - And more

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Upcountry Maui Groundwater Nitrate Investigation

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Upcountry Maui Water Quality Investigation

- Problem: elevated nitrate concentrations in two wells
  - BRE-1 Well
    - Nitrate concentration up to 8.9 mg/L
    - Drilled as a drinking water source for a new development
  - Pukalani Golf Course Well
    - Nitrate concentration up to 6.8 mg/L
    - Sampled to evaluate water quality for a proposed development

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Nitrate - Groundwater Contaminant

- Regulated drinking water contaminant
- Maximum Contaminant Level of 10 mg/L
  - Concentration >12 mg/L can cause blue baby syndrome (methemoglobinemia) in infants
- Environmental risk
  - Essential nutrient in aquatic and marine systems - causes accelerated algae and plankton growth
- Sources of Nitrate
  - Natural (low concentrations) <0.5 mg/L
  - Agriculture (can result in high concentrations)
  - Livestock (can result in high concentrations)
  - Wastewater (can results in high concentrations)

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Nitrate as a Groundwater Contaminant

- Nitrate does not degrade in water with dissolved oxygen
  - Hawaii's aquifers have abundant oxygen
  - So nitrate continues to accumulate along the flow path to a well or to the ocean
- Normal concentration in Hawaii aquifers is less than 3 mg/L
- Concentrations greater than 5 mg/L trigger increased drinking water monitoring of this contaminant

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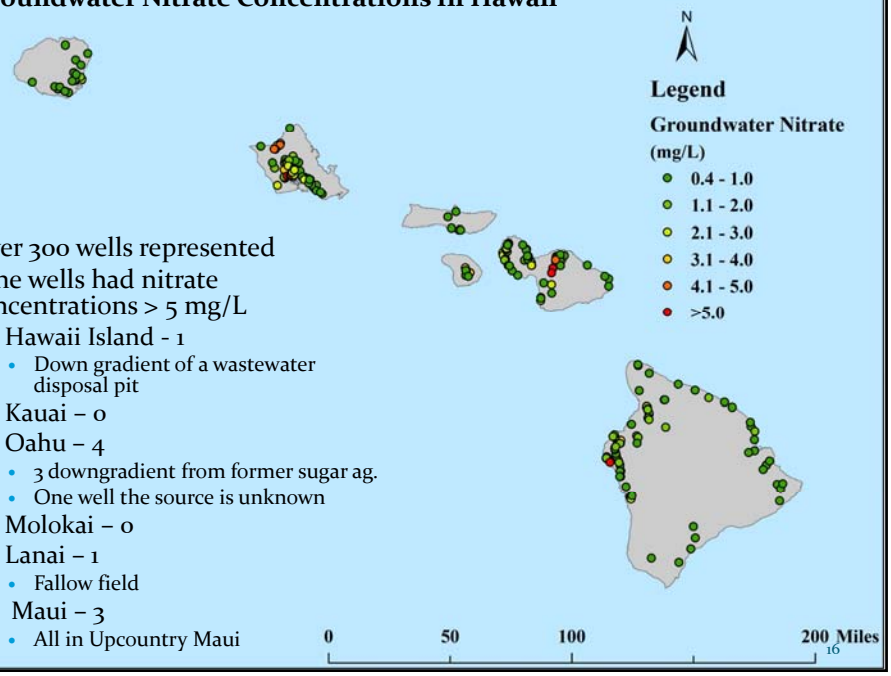
Groundwater Nitrate Concentrations In Hawaii



- Over 300 wells represented
- Nine wells had nitrate concentrations > 5 mg/L
  - Hawaii Island - 1
    - Down gradient of a wastewater disposal pit
  - Kauai – 0
  - Oahu – 4
    - 3 downgradient from former sugar ag.
    - One well the source is unknown
  - Molokai – 0
  - Lanai – 1
    - Fallow field
  - Maui – 3
    - All in Upcountry Maui

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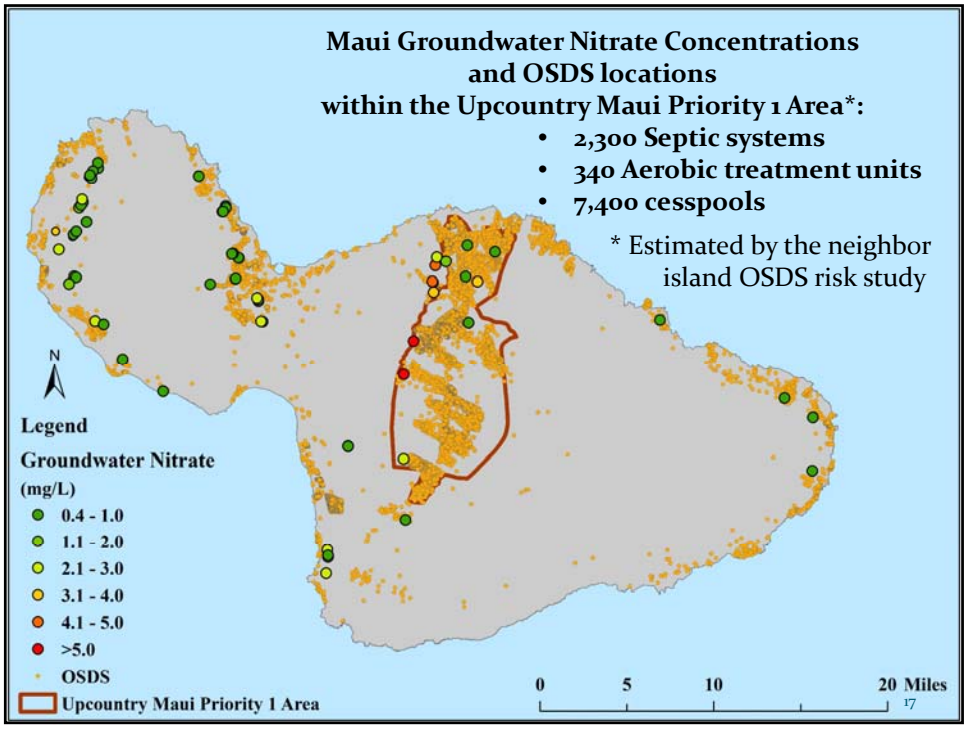

Upcountry Maui Groundwater Nitrate Investigation

- Sampled available wells for:
  - Nitrate, phosphate, and other nutrients
    - Compared results with nitrate contamination source locations
  - General groundwater chemistry
  - Isotopes of nitrate (described later)
  - Pharmaceuticals and Personal Care Products
- Developed a computer model of Upcountry Maui groundwater flow system
  - Further evaluate the source of the nitrate contamination

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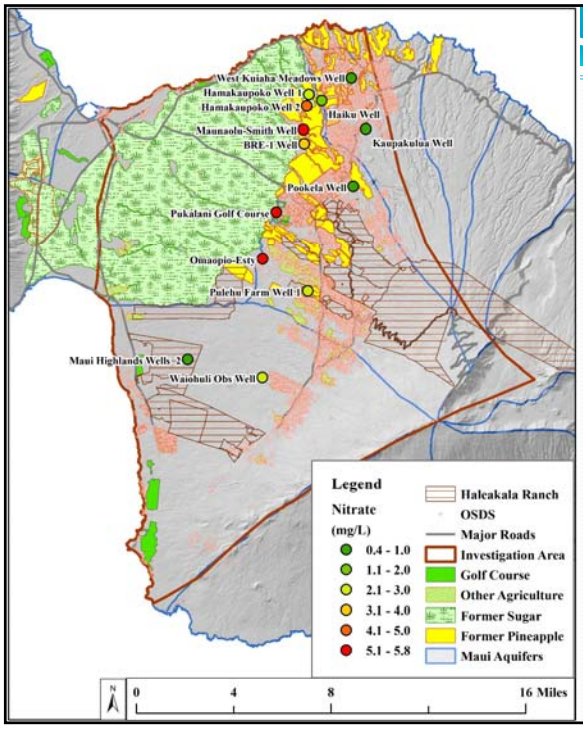

GW Nitrate vs Nitrate Sources

- Nitrate results
  - Low in the northeast
  - Concentrations increase going south
  - Low again in the south
- Potential nitrate sources
  - Former pineapple ag.
  - Former sugar ag.
  - OSDS (>70% cesspools)
  - Livestock operations

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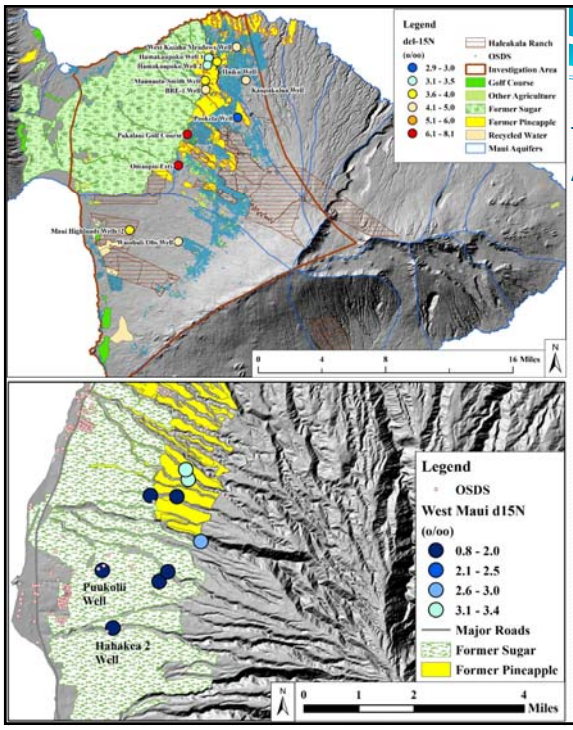

Evaluate Isotope Data Using the "Paired Aquifer" Approach

- Upcountry Maui
  - Leeward slope
  - Former sugar and pineapple agriculture
  - High density of OSDS
  - Livestock operations
- West Maui
  - Leeward slope
  - Former sugar and pineapple agriculture
  - Very few OSDS
  - No livestock
- The Isotope values narrowed the nitrate sources to:
  - Wastewater, and
  - livestock

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Livestock or Wastewater Nitrate?

- We looked at:
  - Pharmaceuticals in samples from the high nitrate wells
  - Used a computer model to show the nitrate distribution if the sources are:
    - Former sugar cultivation
    - Former pineapple cultivation
    - OSDS
  - Looked elsewhere in Hawaii to evaluate livestock impact on groundwater

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Pharmaceutical Sampling

PPCP	Reporting Limit (ng/L)	Pukalani Golf Course Well (ng/L)	Omaopio-Esty Well (ng/L)	Description
Bromacil	5	<5	13	Herbicide commonly used to control perennial grasses
Chloridazon	5	13	11	widely used organochlorine herbicide
4-nonylphenol	100	460	460	Component of non-ionic surfactants used in detergents
Amoxicillin	20	300	72	Common anti-biotic to treat infections
Sulfameth – oxazole*	5	11	<5	Antibiotic for treating infections
Sulfathiazole*	5	30	6.2	Organosulfur compound used as a short acting sulfa-drug
Acesulfame-K	20	30	<20	Non-calorie sugar substitute

* - Indicates analyzed for by an EPA dairy farm groundwater impact study
ng/L = nanogram per Liter

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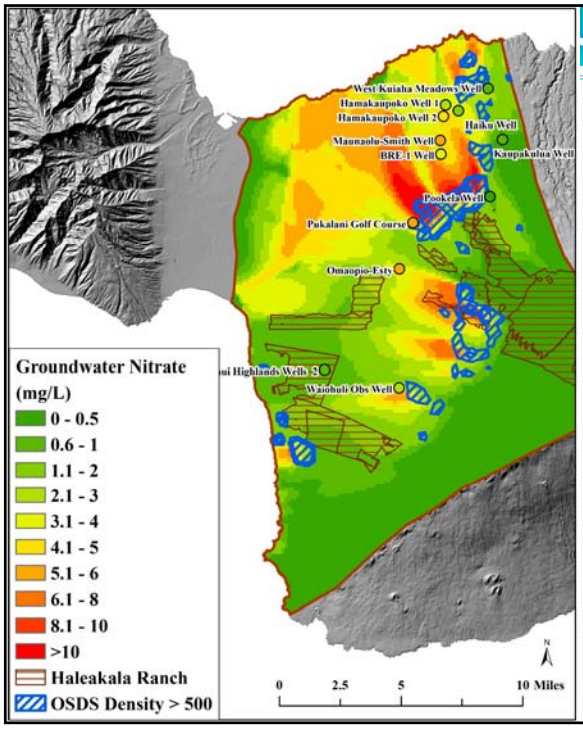

Groundwater Nitrate Computer Model

- Background – computed simulated nitrate
- Symbols measured nitrate
- Color scheme is the same for both
- Generally good agreement
- Computer modeled sources of nitrate:
  - Former sugar cane,
  - Former pineapple, and
  - OSDS
- The computer model nitrate closely matches that measured
  - The computer model captures the major sources of nitrate

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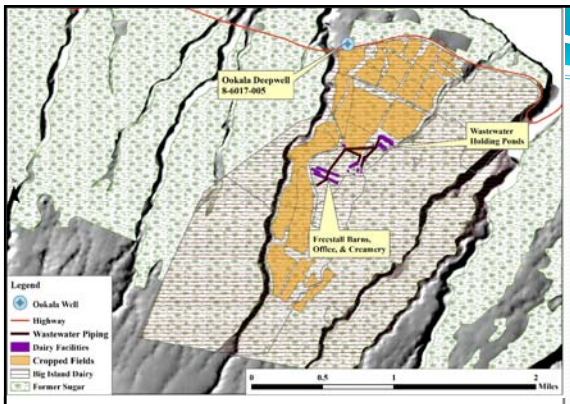

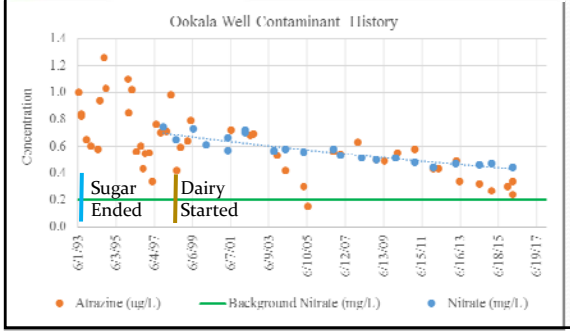

Big Island Dairy

- Former sugar cane area
- Confined animal feeding operation >2,000 head
- No apparent impact on the groundwater after 20 years
  - No elevated nitrate has been seen from Hamakua dairy operations
    - ~20 years of dairy operations
- The available evidence discounts the ranching operations as a source of elevated groundwater nitrate
  - Groundwater modeling results
  - Pharmaceutical results

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Baldwin Ranch Estates Well

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BRE-1 Well Sample History

Date	Nitrate (mg/L)	Method	Comments
7/14/15	8.7	Pump	Initial Sample
9/4/15	<0.1	Grab	Top Water
9/4/15	8.9	Grab	Bottom Water
9/24/15	8.8	Pump	Confirmatory Sample
7/19/17	4.0	Grab - composite	Upcountry Maui Nitrate Investigation

- Sampled as part of the drinking water system approval process
  - Initial sample had high NO_3
- Two small volume samples (grab) from different depths
  - Top - low NO_3
  - Bottom - high NO_3
- Confirmatory sample had high NO_3
- Our mixed sample mid-range NO_3
- It is expected when the well goes into product for the nitrate levels to be high

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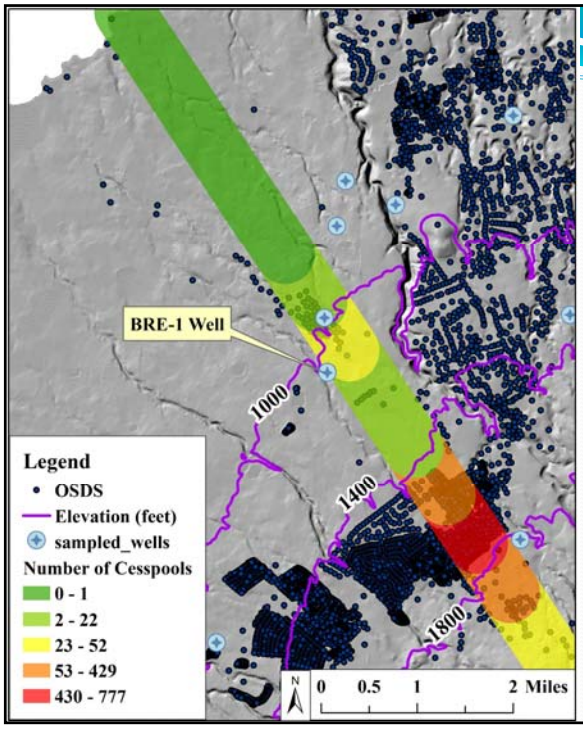

BRE-1 Well & OSDS

- BRE-1 Elev. about 1,100 ft
- About 1.5 – 2.4 mi. down gradient from OSDS
  - Very high density of OSDS
  - Elevation varies from 1,400 to 1,800 ft
  - Nitrate does not degrade in groundwater
- <u>The 2050 Cesspool ban & the BRE-1 Well are independent of each other</u>

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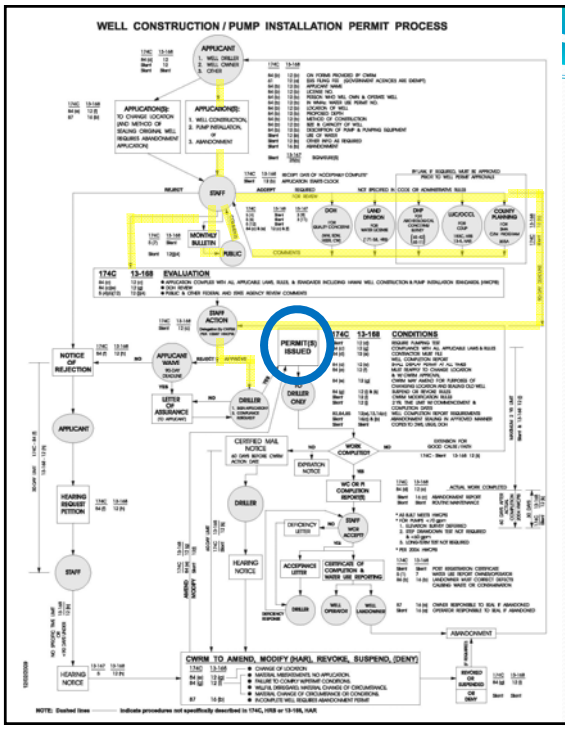

Well Permitting Process

- DLNR Commission on Water Resources Management – Lead agency
- Other agencies review and comment
  - DOH -> SWAP assessment required after well installation
  - DLNR Land Division
  - DLNR State Historic Preservation Division
  - Land Use Commission
  - County Planning
- Public review and comment
- Flow chart:
  - http://files.hawaii.gov/dlnr/cwrm/forms/dgwcpip.pdf

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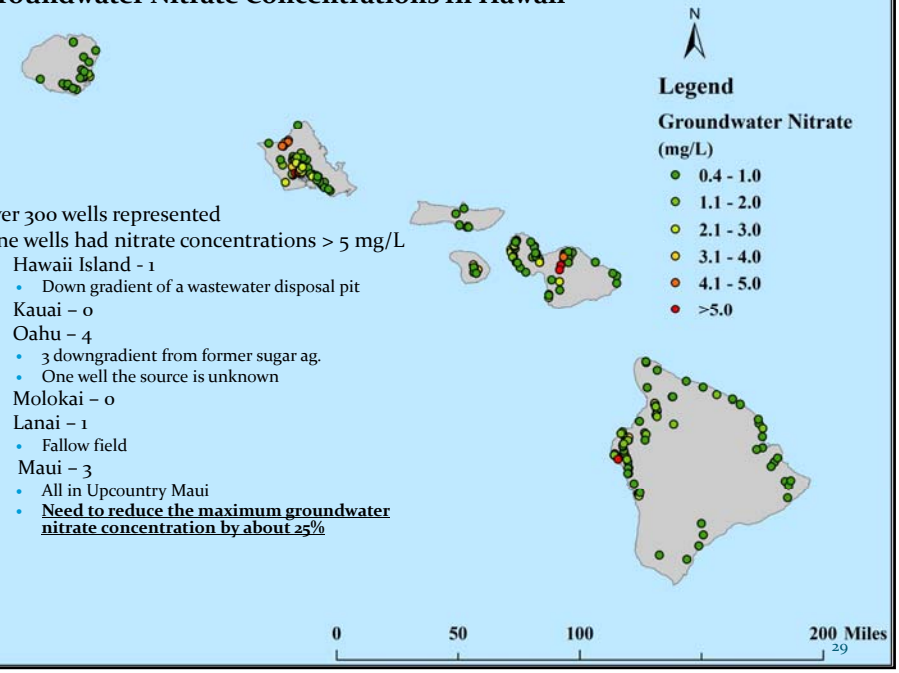
Groundwater Nitrate Concentrations In Hawaii



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    - All in Upcountry Maui
    - **<u>Need to reduce the maximum groundwater nitrate concentration by about 25%</u>**

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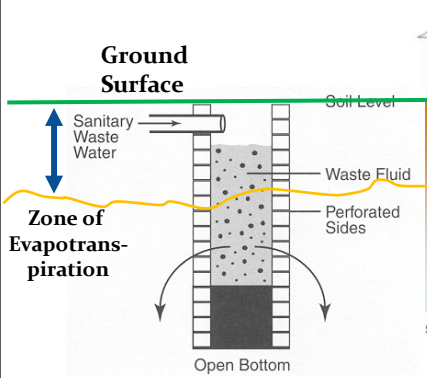
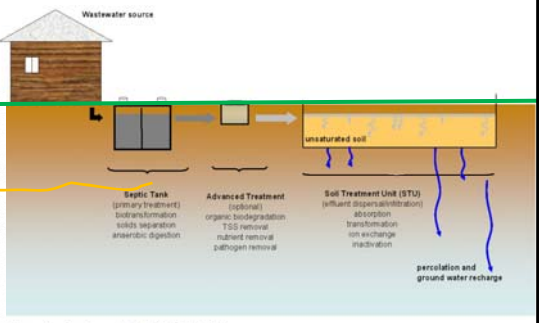
Disposal and Treatment of Domestic Wastewater



Cesspool N Removal; Based on groundwater data appears to be minimal



Schematic of a Conventional OWTS with STU.

About 30% N Removal*

~25-60% N Removal*

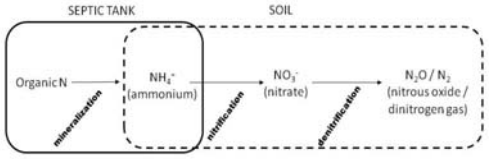


Figure 2-1. Main N Transformations in Septic Tanks and STUs (transformations are generalized, and may not be complete in field systems).

*Water Environmental Research Foundation

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Peer Review of Study

- The methods used in this study are standard for this type of investigation
  - DOH has great confidence in the conclusions of this study
- A peer review is desired
  - Increase the confidence of the public, planners, and elected officials in the value of this study
  - Expand the scientific depth of this study so the results can be more broadly applied
- Working with the University of Hawaii to develop a process for scientific review

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Public Review of Study

- The Draft Upcountry Report and Appendices are available online at:
  - http://health.hawaii.gov/wastewater/files/2018/02/Upcountry_report.pdf (2.7MB, 62 pages)
  - http://health.hawaii.gov/wastewater/files/2018/02/Upcountry_appendices.pdf (18MB, 465 pages)
- Copies are available to review at the District Health Offices in Hilo, Kona, Wailuku, and Lihue.
- All comments must be transmitted in writing, no later than Friday, March 30, 2018, to Joanna L. Seto, P.E., of the Safe Drinking Water Branch at sdwb@doh.Hawaii.gov or to 2385 Waimano Home Rd., Uluakupu Bldg. 4, Pearl City, HI 96782-1400.

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Summary

- The purpose was to present the logic and evidence that went into our conclusions about the sources of the significantly elevated nitrate concentrations in the Upcountry Maui groundwater
- Presentation summary
  - DOH and SWPP mission and goals
  - Past and current DOH investigations dealing with onsite disposal of wastewater
  - The investigation methods employed including:
    - Groundwater sampling for nutrients, general chemistry, stable isotopes, and pharmaceuticals
    - Sampling results were compared to model predictions
  - The sources of nitrate to the Upcountry Maui groundwater
  - Expected nitrogen reduction from septic systems with a leach field

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Conclusions

- Nitrate captured by the wells in Upcountry Maui is a combination of natural, fertilizer, and wastewater sources
- Nitrate in the wells in the northern part of the study area is primarily from natural and fertilizer sources
- OSDS leachate significantly elevates the nitrate concentrations in the south-central study area wells
- Replacing cesspools with other forms of treatment can reduce the groundwater nitrate concentration to well below drinking water limits
- Pre-siting contaminant risk assessments are very beneficial for good drinking water resource planning

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Thank You!