—HIDOH / USGS Cooperative Program—

Wastewater and Nutrient Source Tracking – Results of Reconnaissance Chemical Mapping at Kualoa and Kahana, Oahu

Chip Hunt, USGS

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Partner / Program Linkages

- Hawaii Department of Health (HIDOH)
  - Clean Water Branch—Beach monitoring
  - TMDL tie-in?
- USEPA program links
  - Clean Water Act
  - Beach Act
  - TMDL program?

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Problem

- **Beach Monitoring of Recreational Waters**
  - **High fecal indicator bacteria at fixed sites**
  - **Sources uncertain, ambiguous**
  - **Although septic wastewater is suspected …**

    … we lack a convincing "picture" to sway decision makers, stakeholders
- **TMDL**
  - **Would like nutrient "source attribution"**

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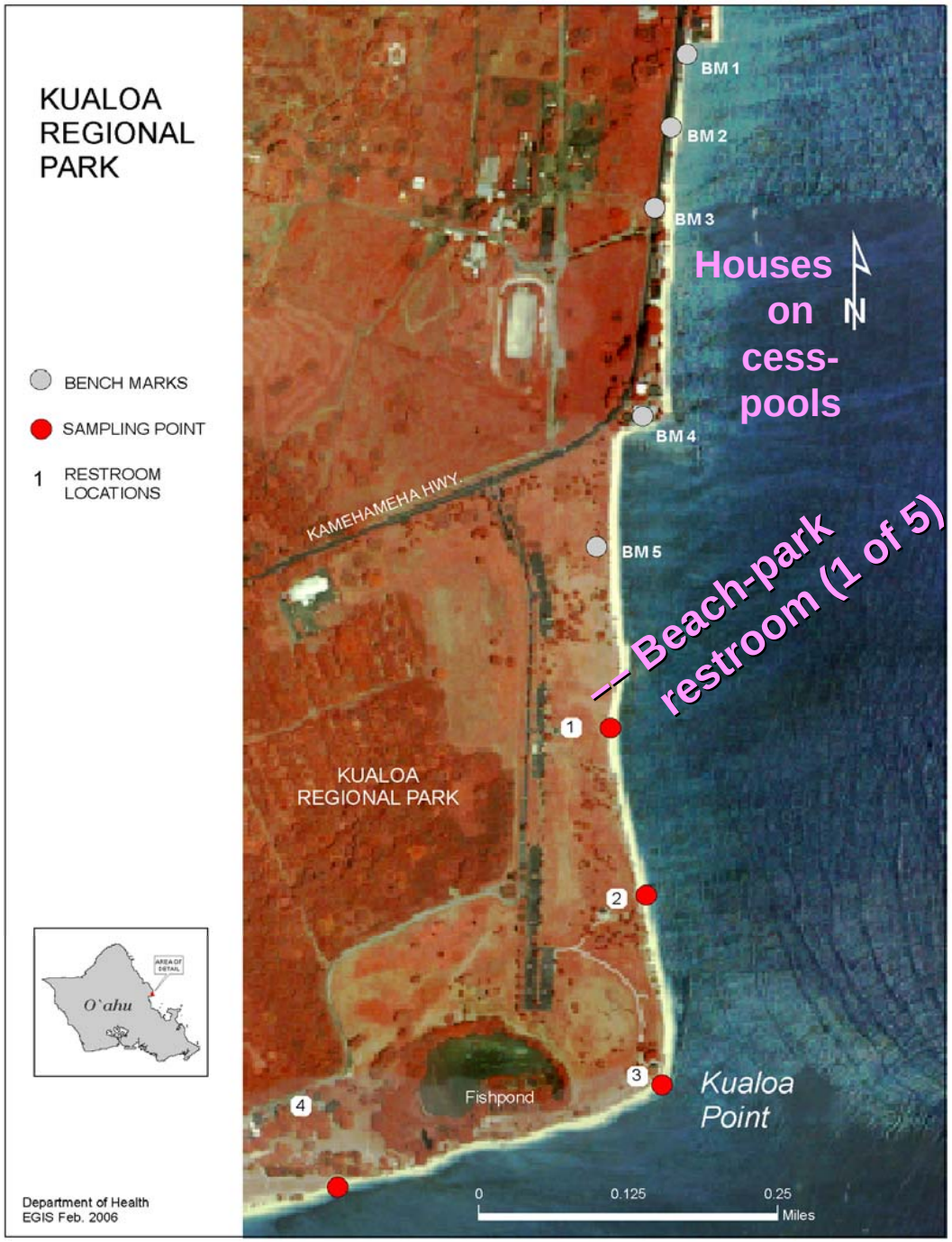
Kualoa

High bacterial counts at DOH fixed monitoring sites



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Kahana Bay
<– what causes these slicks?
… and high bacteria counts near the beach?
24
13
14
15
12
11
22
10
23
9
7
8
6
5
4
3
2
1
17

Beach Closure – Kualoa, Oahu

Photo: Jeff Widener, The Honolulu Advertiser

Malfunctioning beach-park septic systems may be a cause

Kualoa contamination nets city $300,000 fine

The release of sewage into the sea prompts the state's penalty

Honolulu Star-Bulletin

Feb 10, 2007

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But There Are Non-Human Sources, Too

Photo: Jeff Widener, The Honolulu Advertiser

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… the lighter side

Turtles key suspects in UFO* debate

* Unidentified Floating Object

Charles Memminger,
Honolulu Lite
Honolulu Star-Bulletin
Feb 19, 2006

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Objectives and Approach

- Provide the “picture” or context via continuous mapping to aid interpretation of fixed-site data
- In-house DOH method for rapid reconnaissance
- Conduct proof-of-concept surveys, evaluate success, identify needed refinements
- Tiered approach - cheap mapping first, expensive lab analyses later
- Multi-tracer approach

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Case-Study Surveys

Completed:

- Kualoa Beach, Oahu—Beach monitoring
  - Shoreline wading surveys (2)
  - Beach porewater transect (25 samples)
- Kahana Bay, Oahu—Beach monitoring
  - Beach porewater transect (25 samples)

Future:

- Hanalei, Kauai—Beach monitoring, TMDL
- Kaelepulu Pond, Oahu—TMDL

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Conclusions

Overall

- **Wading & porewater methods have proven out → interpretable maps**

Kualoa Beach

Restrooms

- **No** strong multi-tracer wastewater signature; slight indication NO_3 & PO_4

North cove and farther

- Probable animal / human waste signature; enhanced GW discharge

Kahana Bay

Punaluu Beach Park

- **Strong** multi-tracer wastewater signature; good septic endmember

NW cove

- **No** strong multi-tracer wastewater signature; enhanced GW discharge, denitrification (of natural N?)

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Multiple Tracers

Tracer	Possible Indicator of:
Salinity	Freshwater discharge (stream, GW)
NO_3, NH_4, PO_4	Animal / human waste, fertilizers
^{15}N, ^{18}O of NO_3	Animal vs plant NO_3, denitrification
^{2}H, ^{18}O of H_2O	Water origin, evaporation, mixing
^{11}B	Laundry detergents (low 11B)
Fluorescence	Fabric brighteners in detergents
Pharmaceuticals	Household wastewater
WW compounds	Household wastewater

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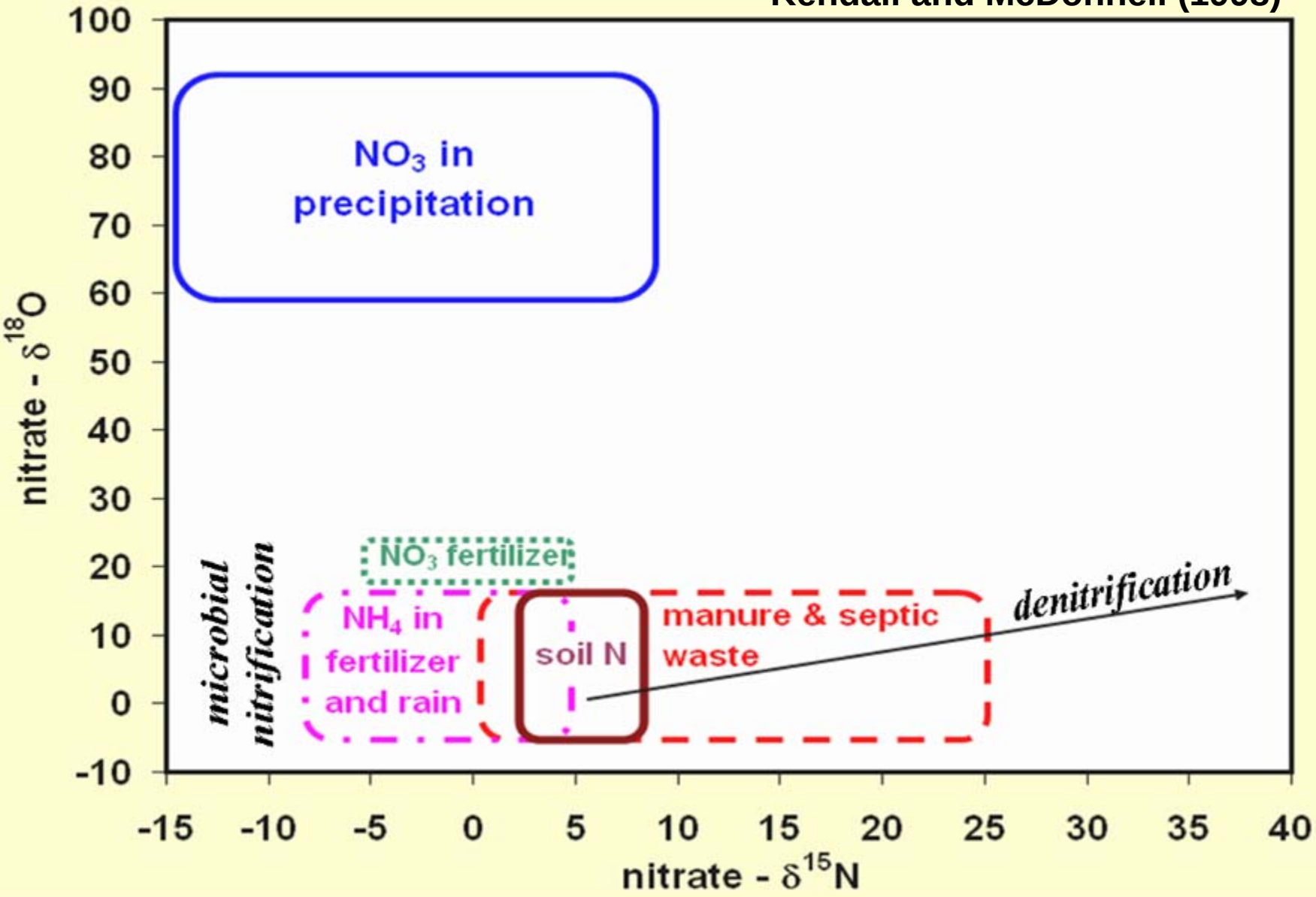
Example Tracer - ^{15}N of Nitrate Sources

Kendall and McDonnell (1998)



Mapping, Transecting Methods

- Wading instrument surveys (continuous)
  - GPS “trackline” fixes at 30-sec intervals
  - Multiparameter—Salinity, DO, chlorophyll, etc
  - Coming soon—fabric-brightener fluorescence
- Wading dip samples (fewer discrete points)
  - Fabric-brightener fluorescence, handheld meter
  - GPS “waypoint” fixes
- Beach porewater transects (discrete sites)
  - Lab analyses for various tracers

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Wading survey, initializing instrument & GPS

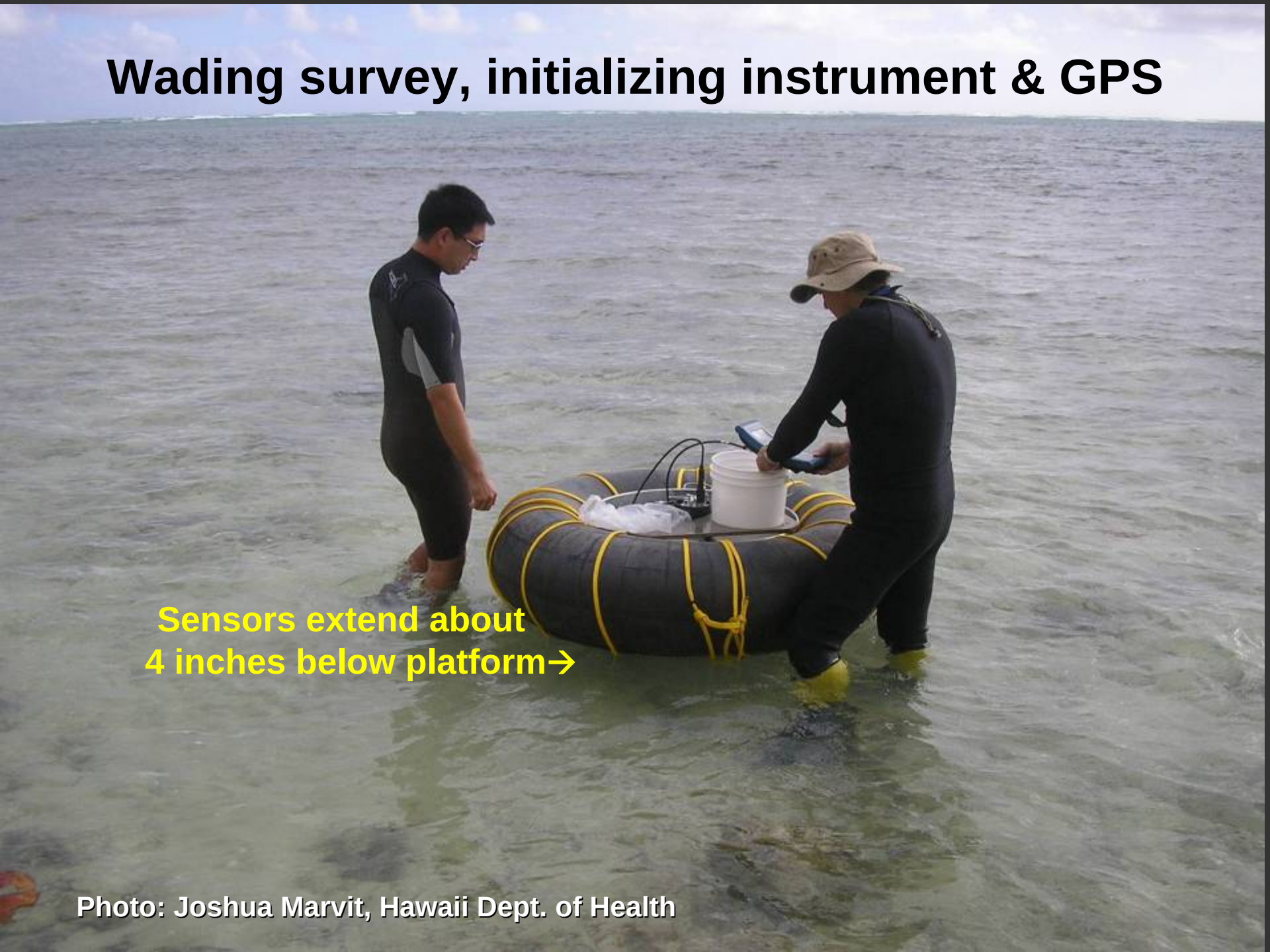

Photo: Joshua Marvit, Hawaii Dept. of Health

DOH Wading Platform

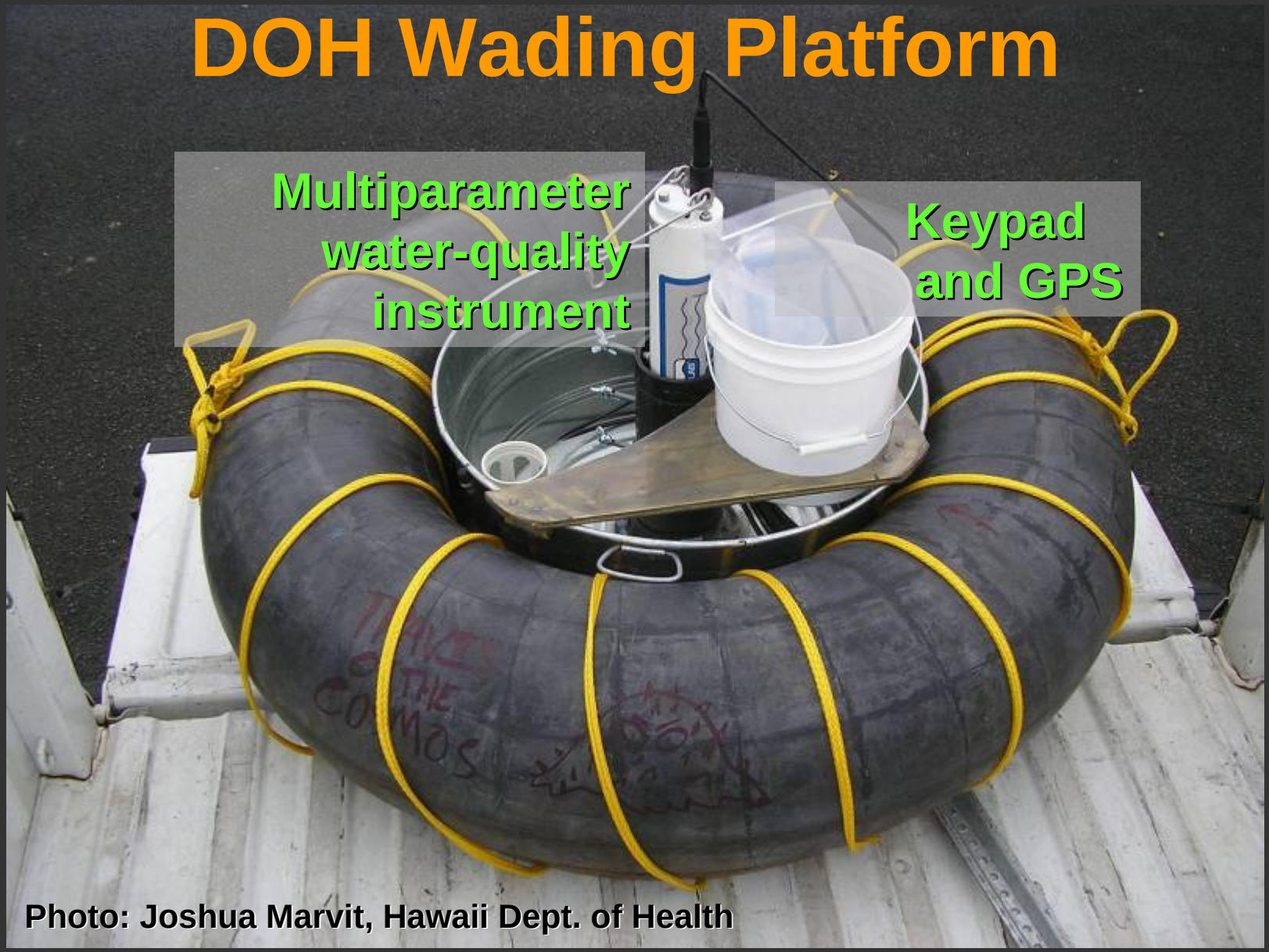

Photo: Joshua Marvit, Hawaii Dept. of Health

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Wading survey just off the beach

Photo: Joshua Marvit, Hawaii Dept. of Health

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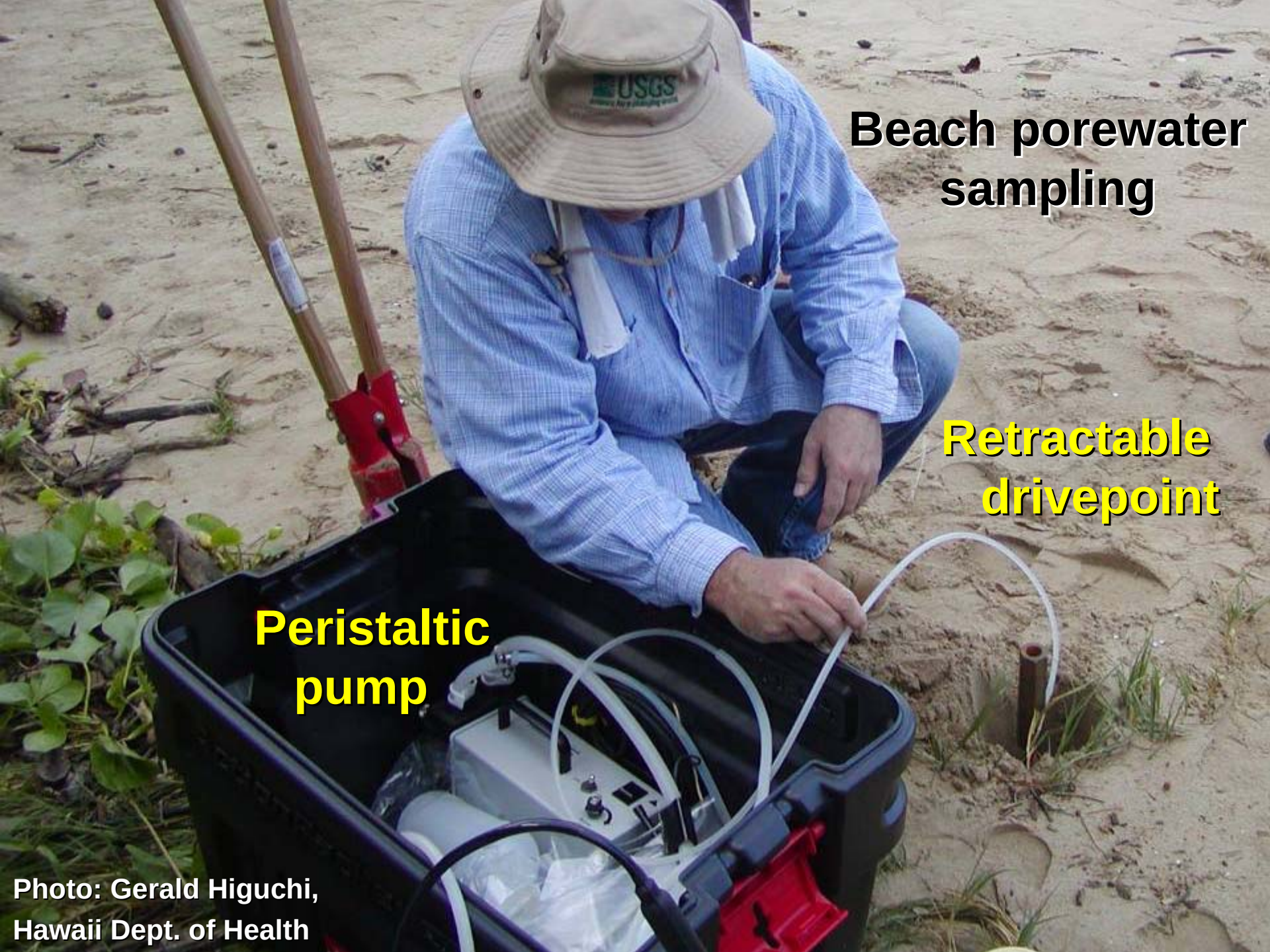
Beach Porewater Sampling

Photo: Gerald Higuchi, Hawaii Dept. of Health



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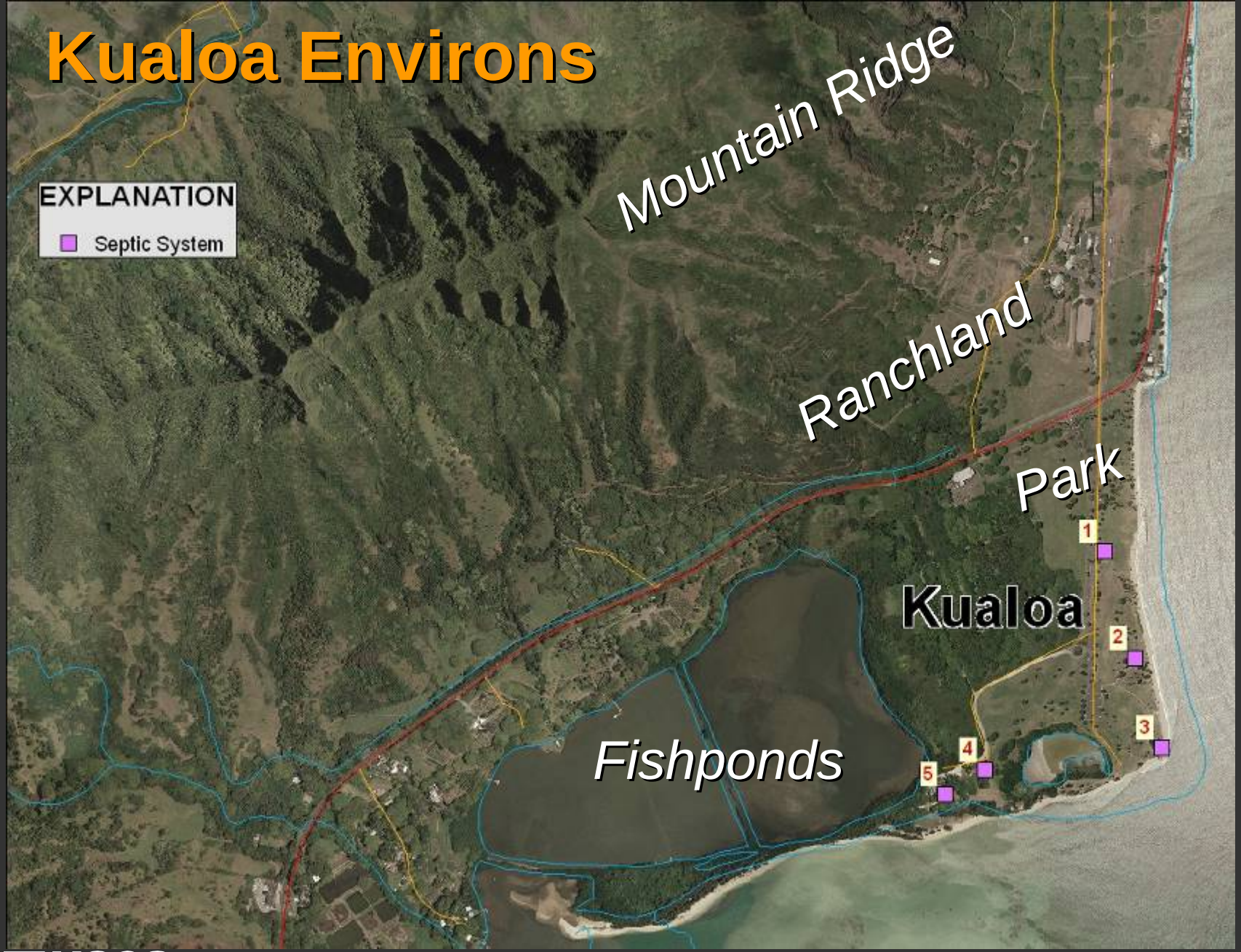

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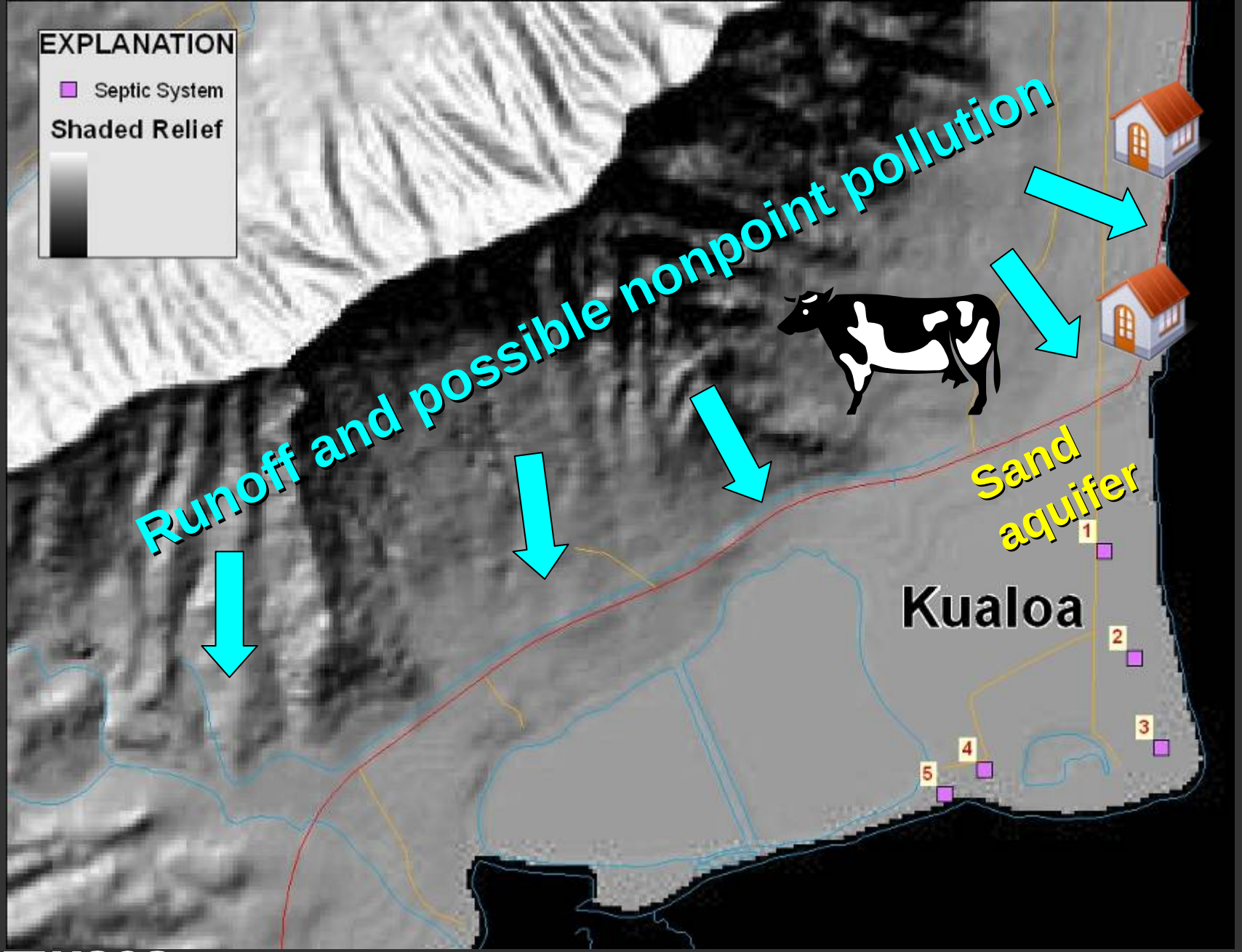

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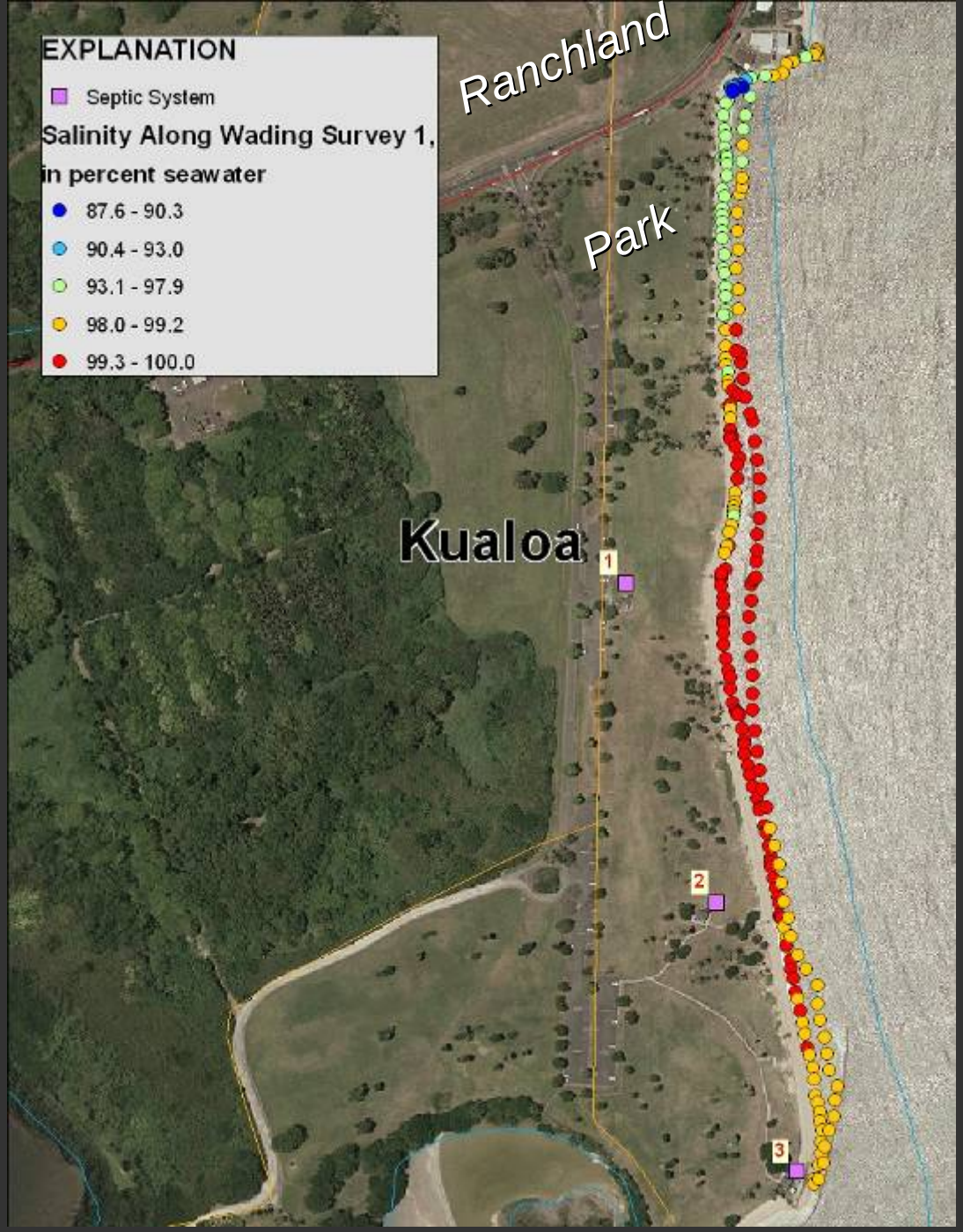

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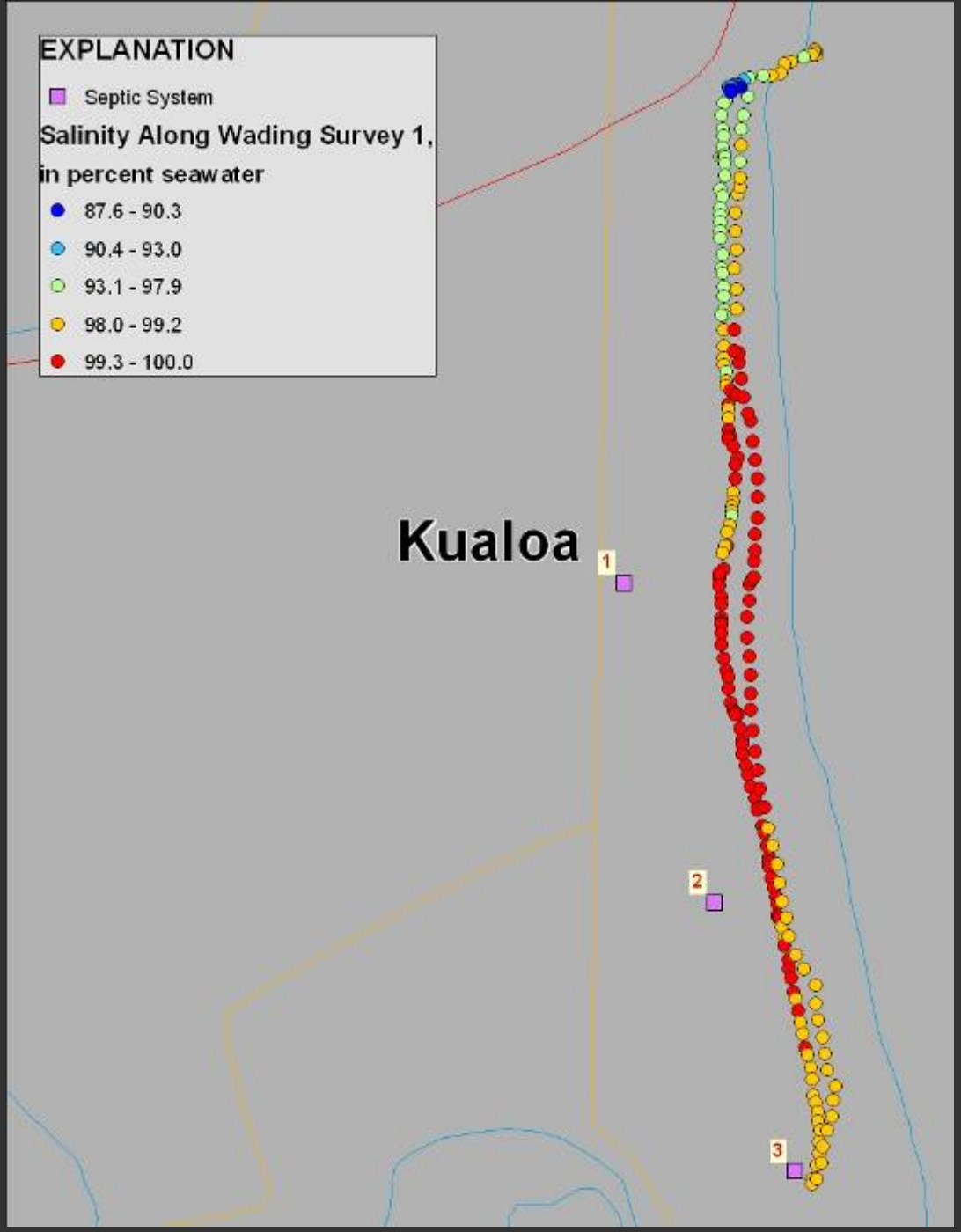

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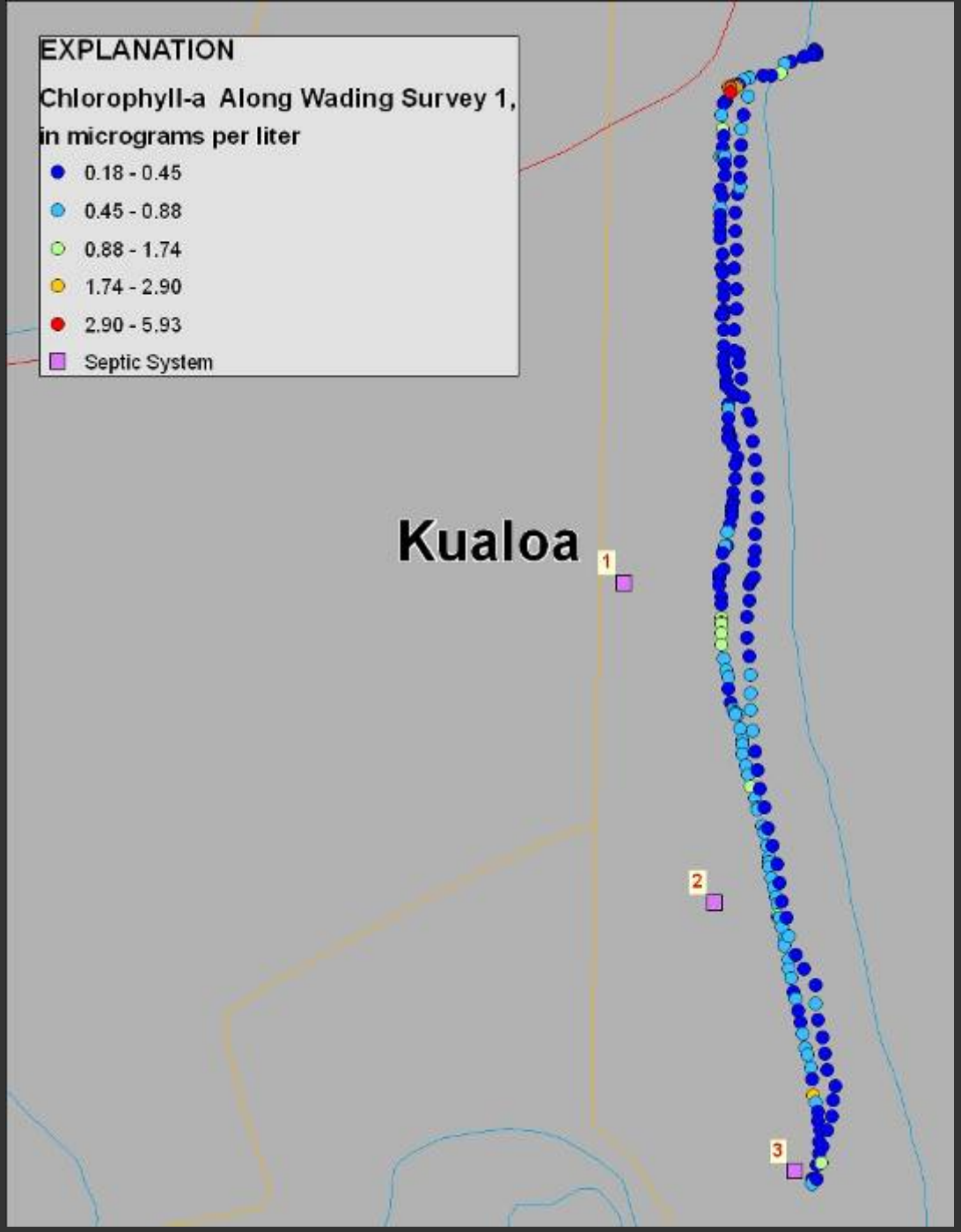

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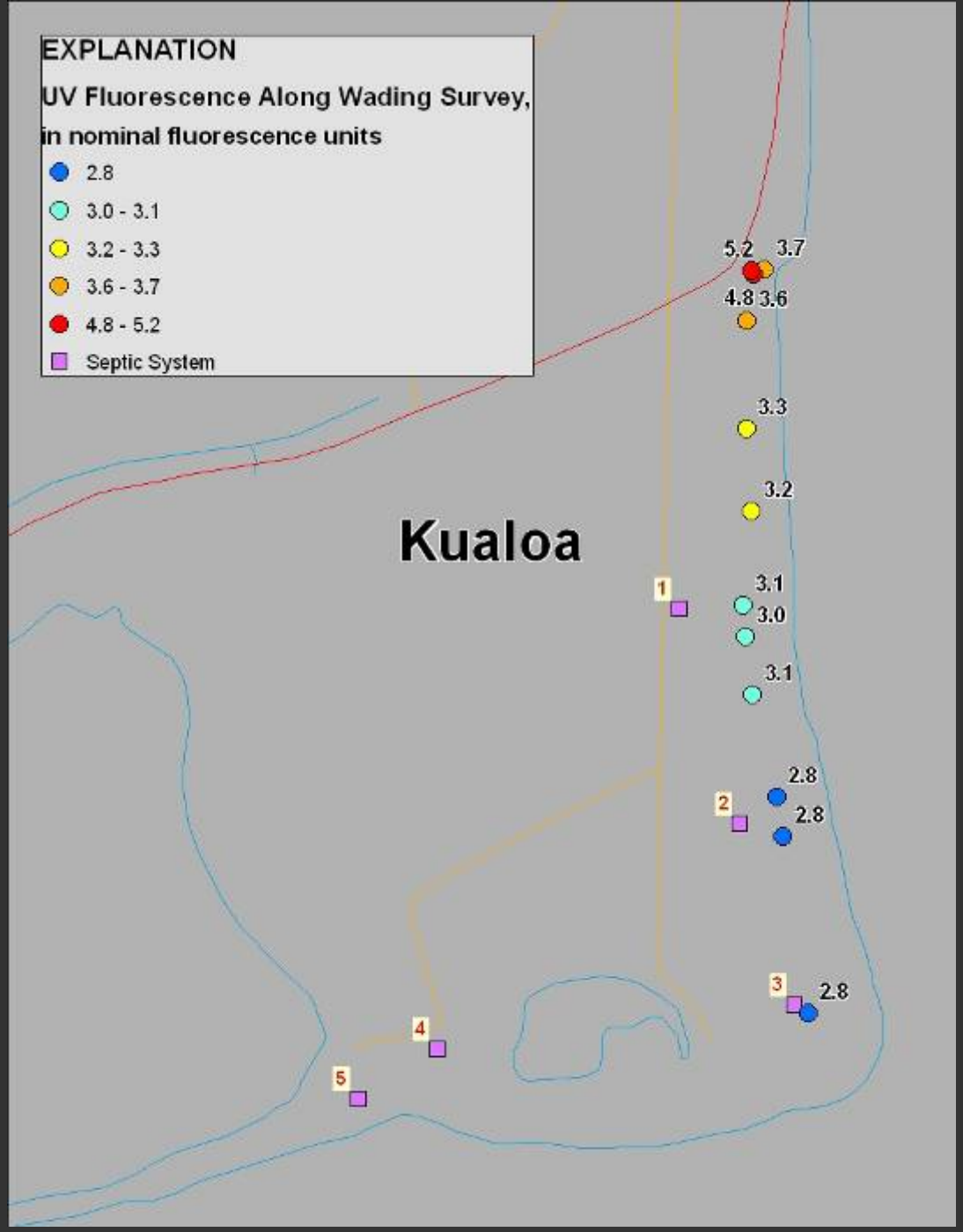

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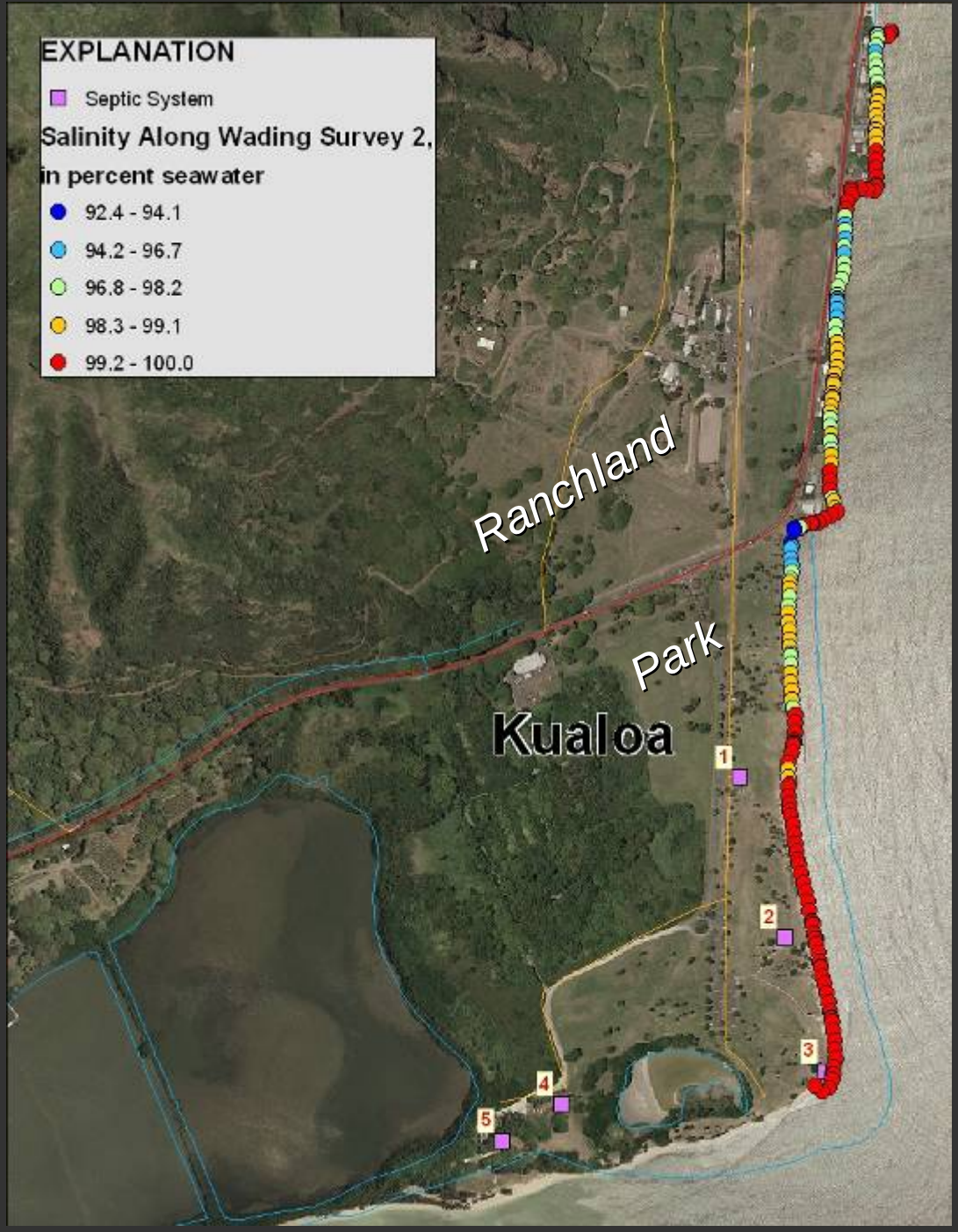

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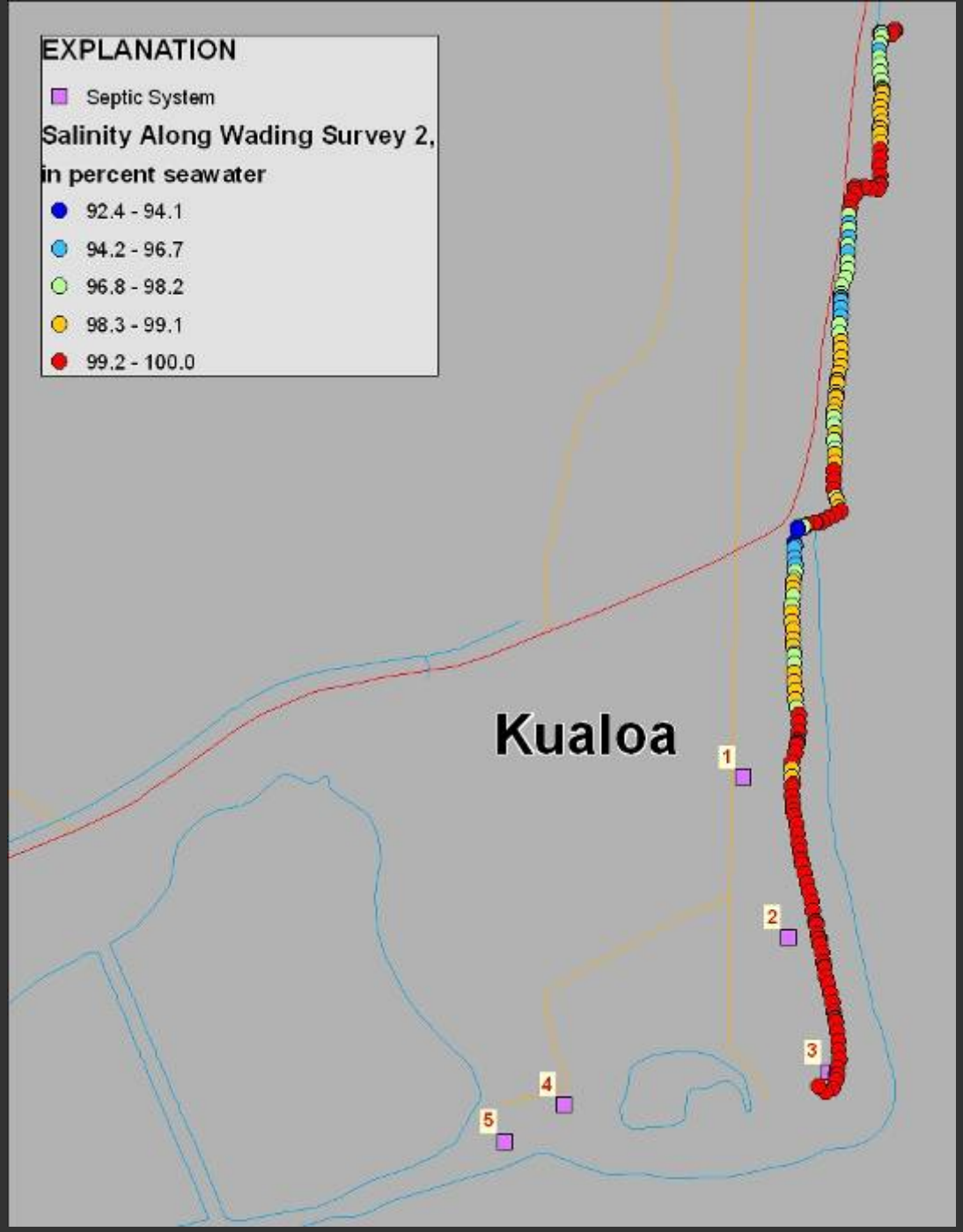

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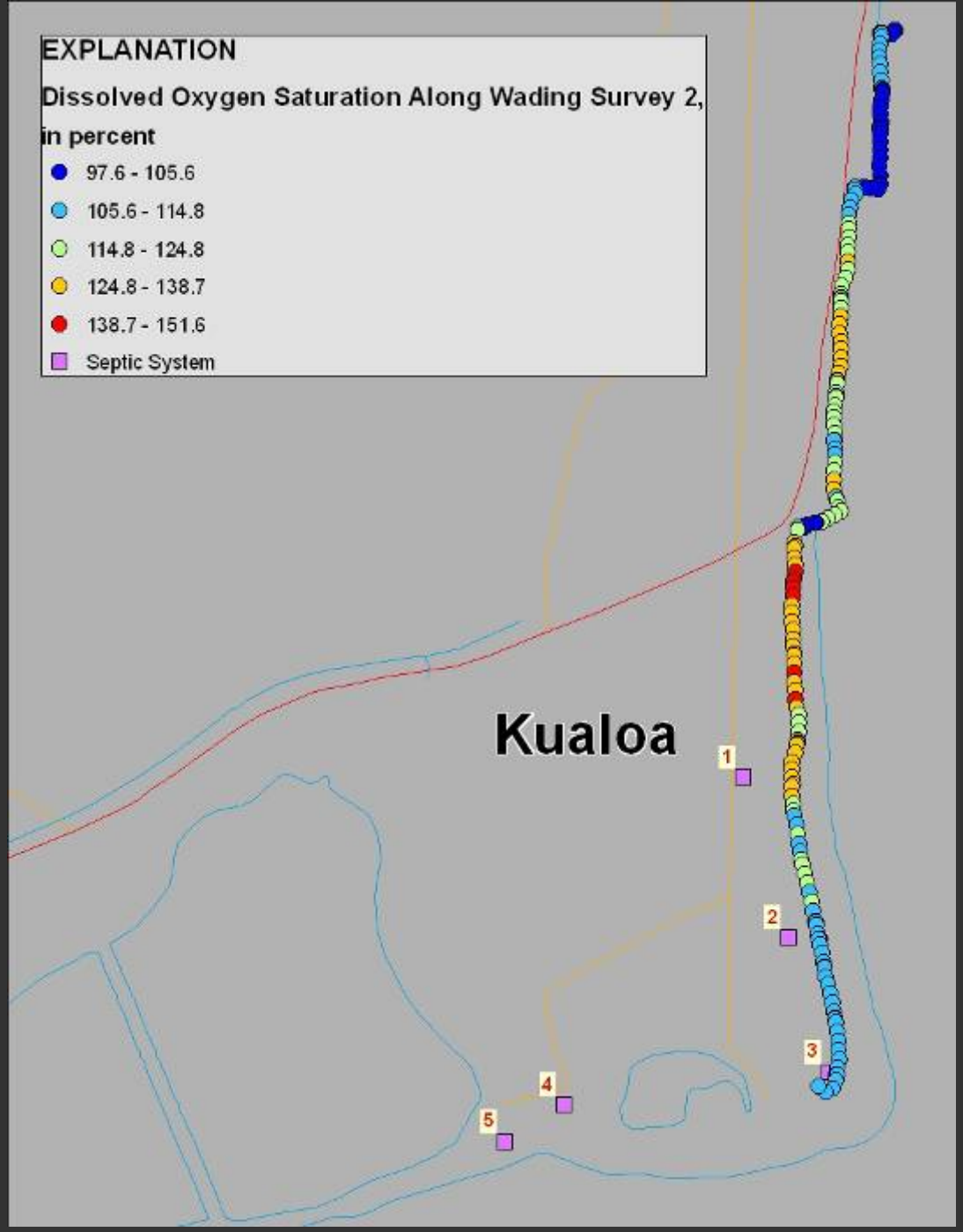

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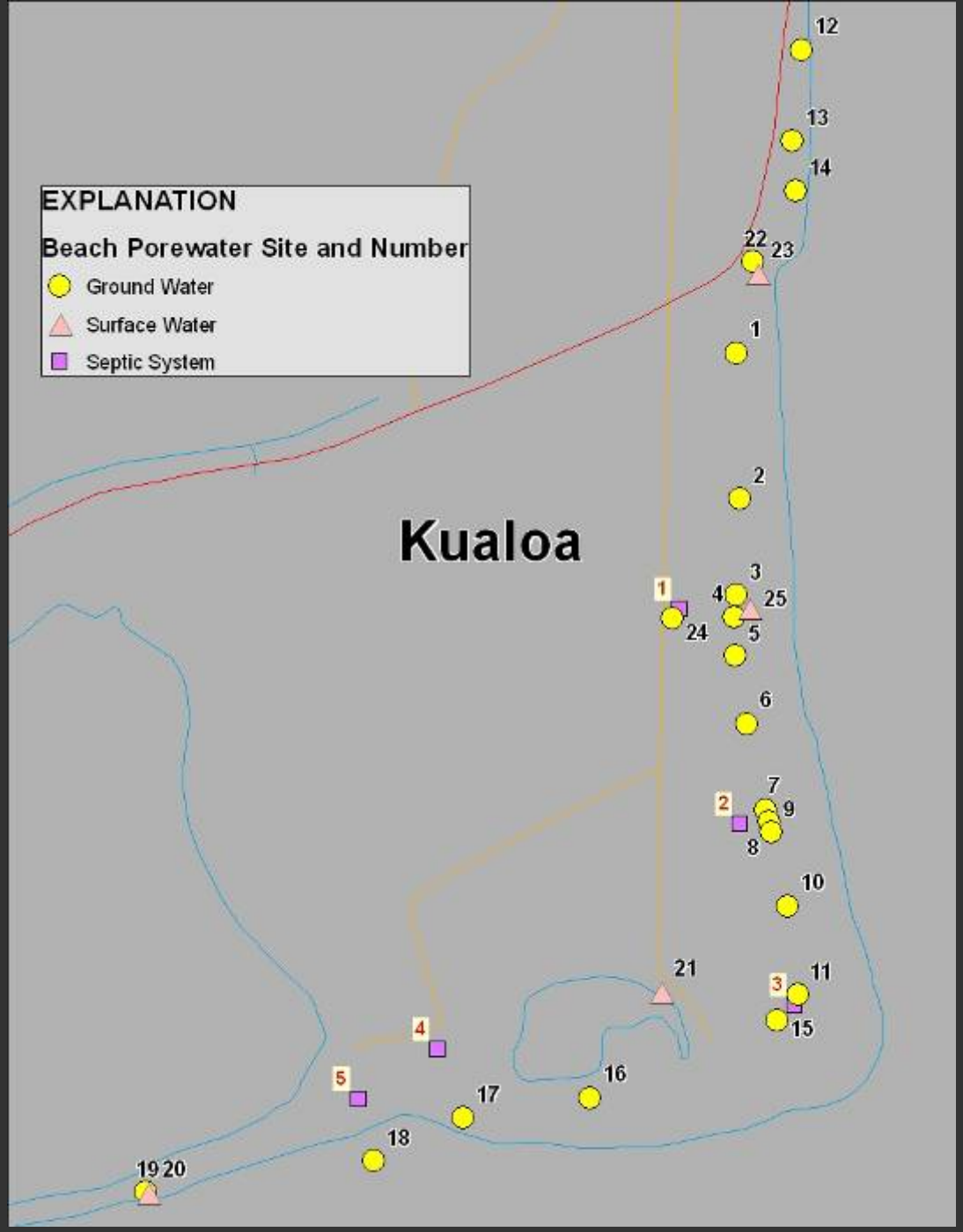

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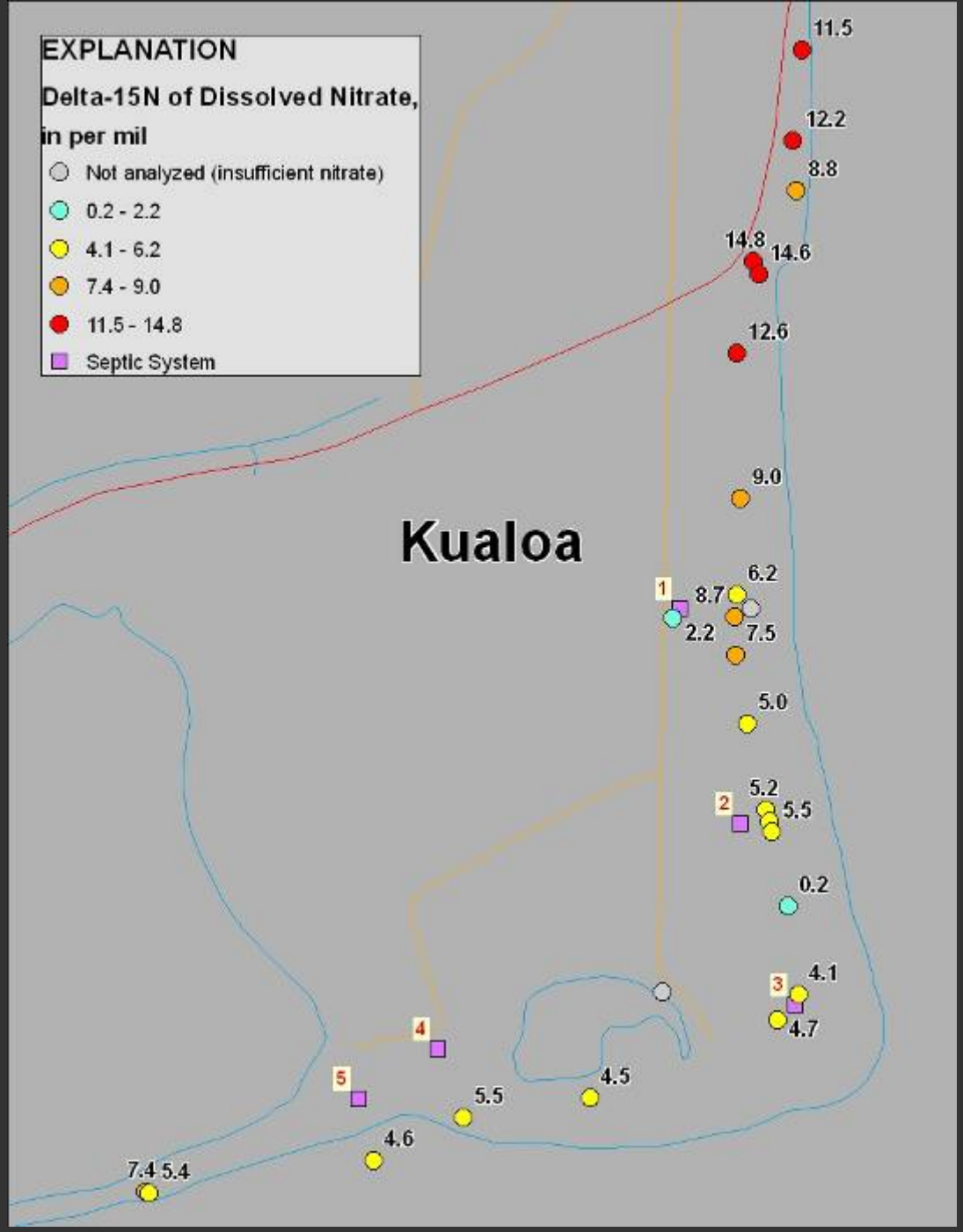

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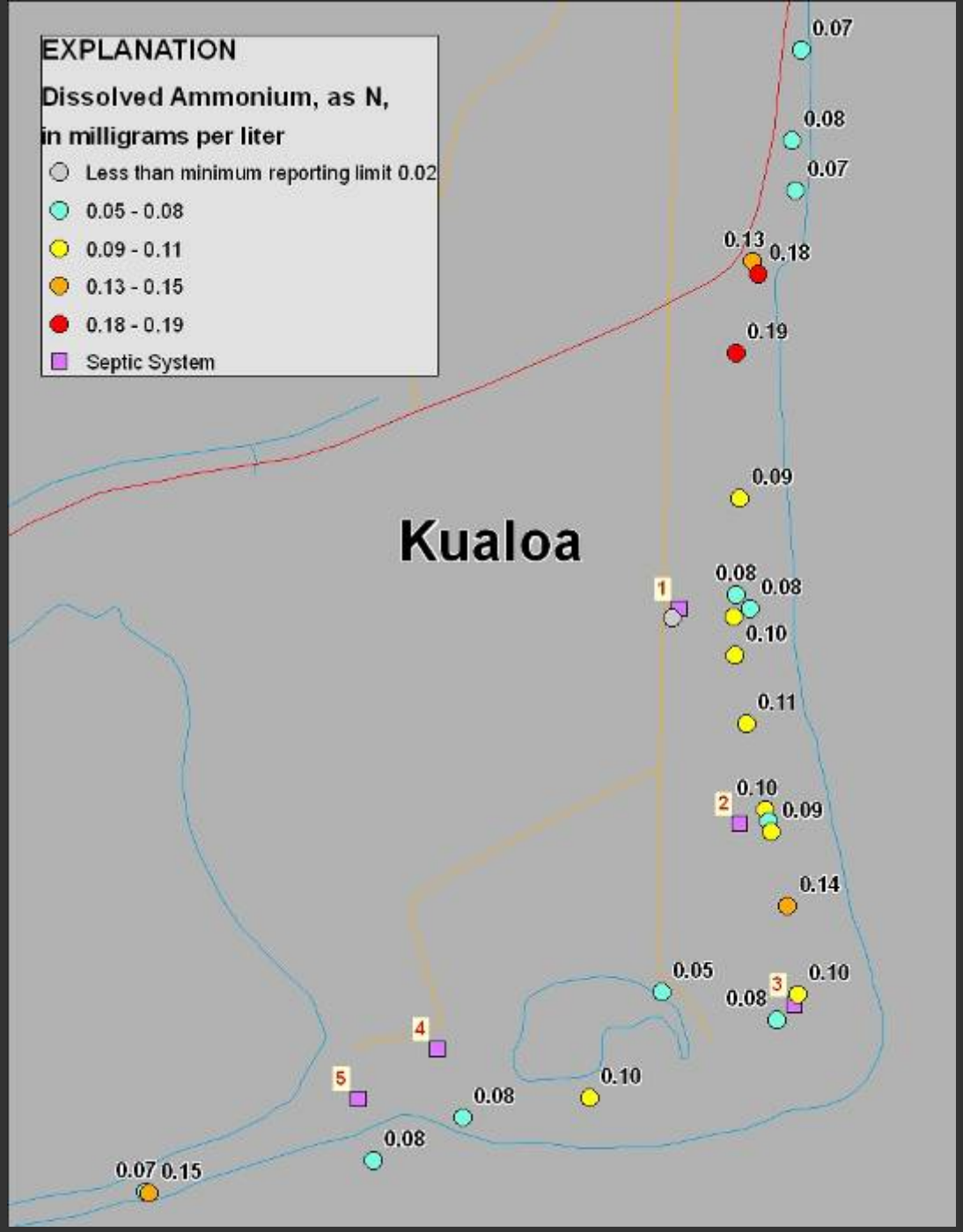

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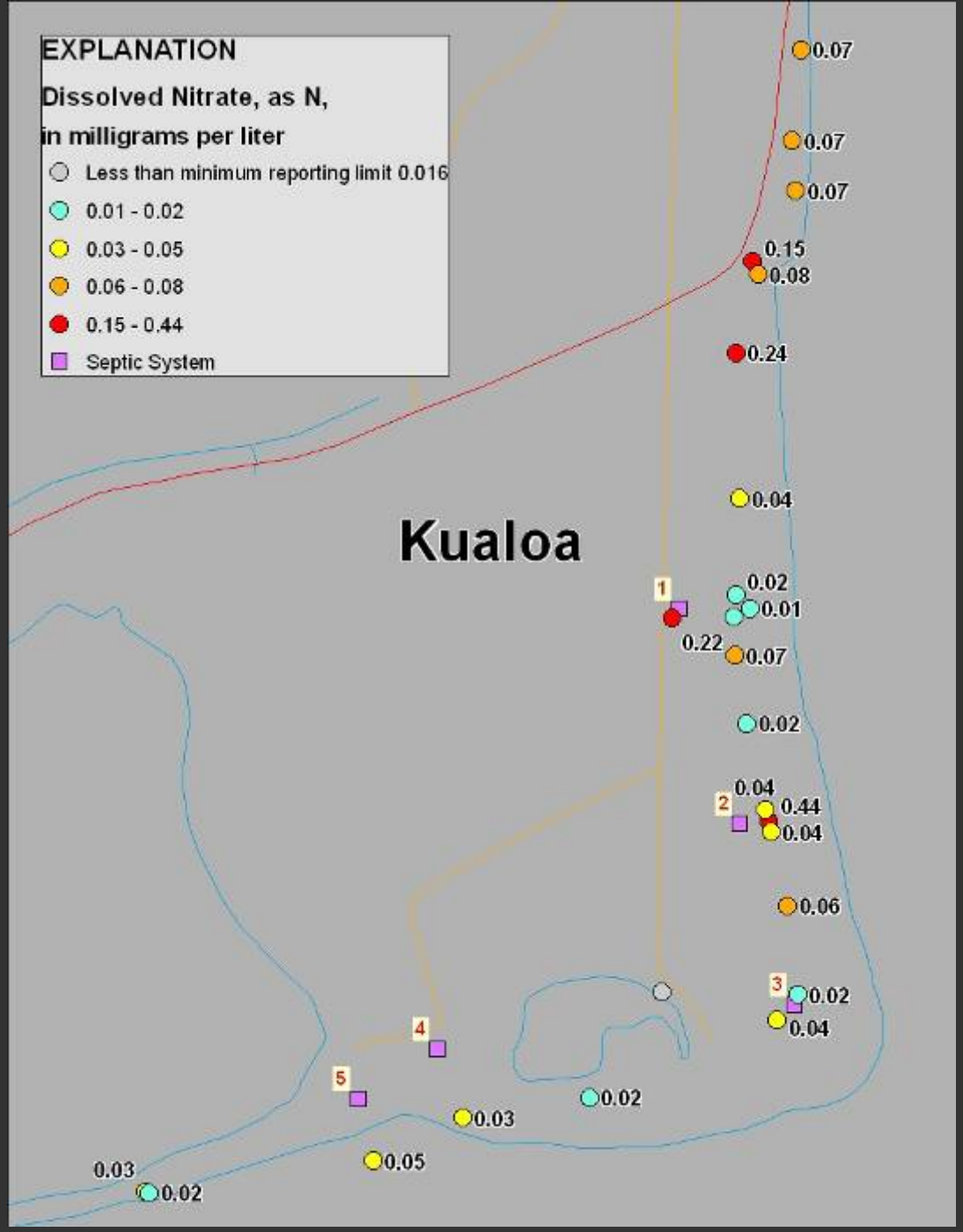

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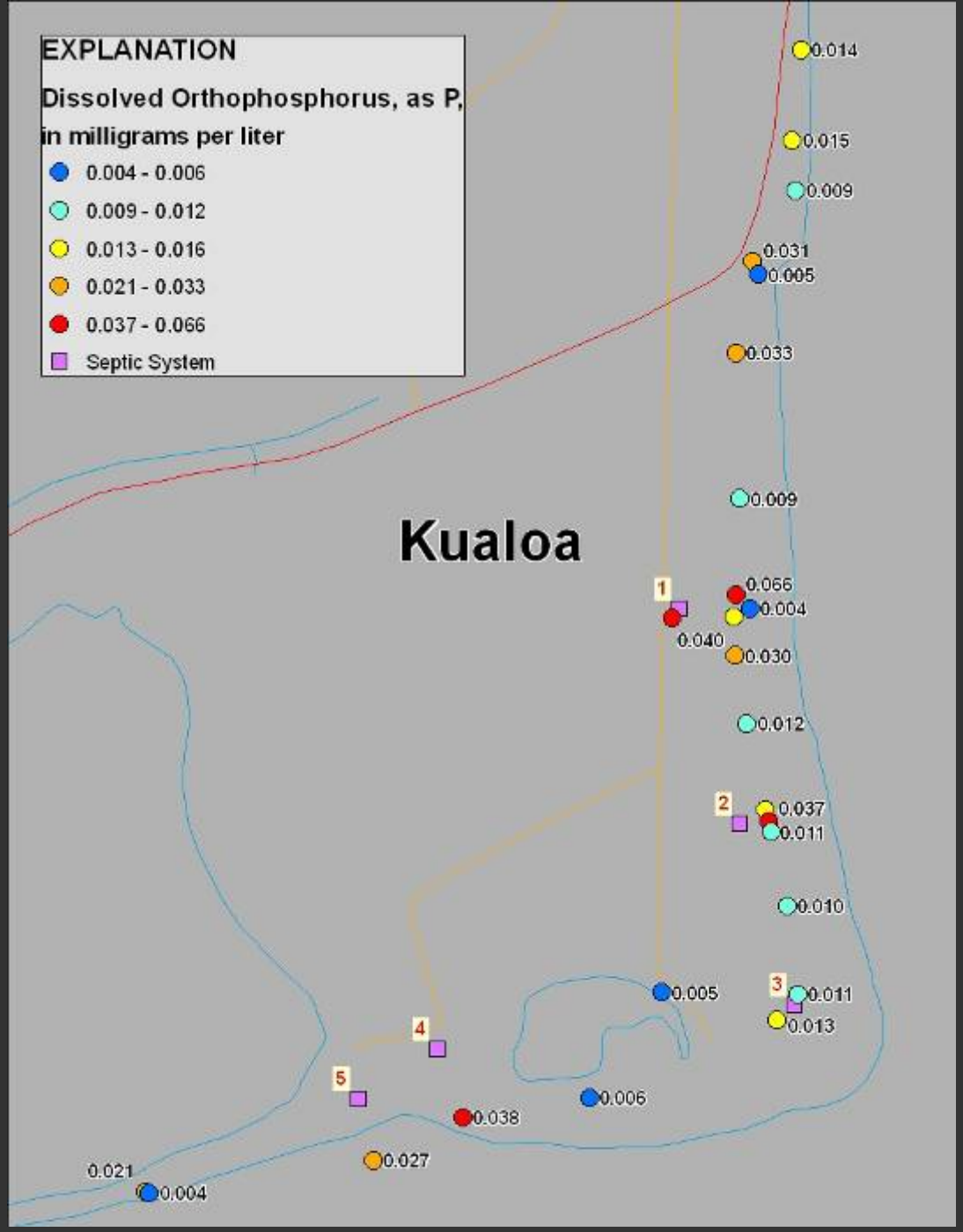

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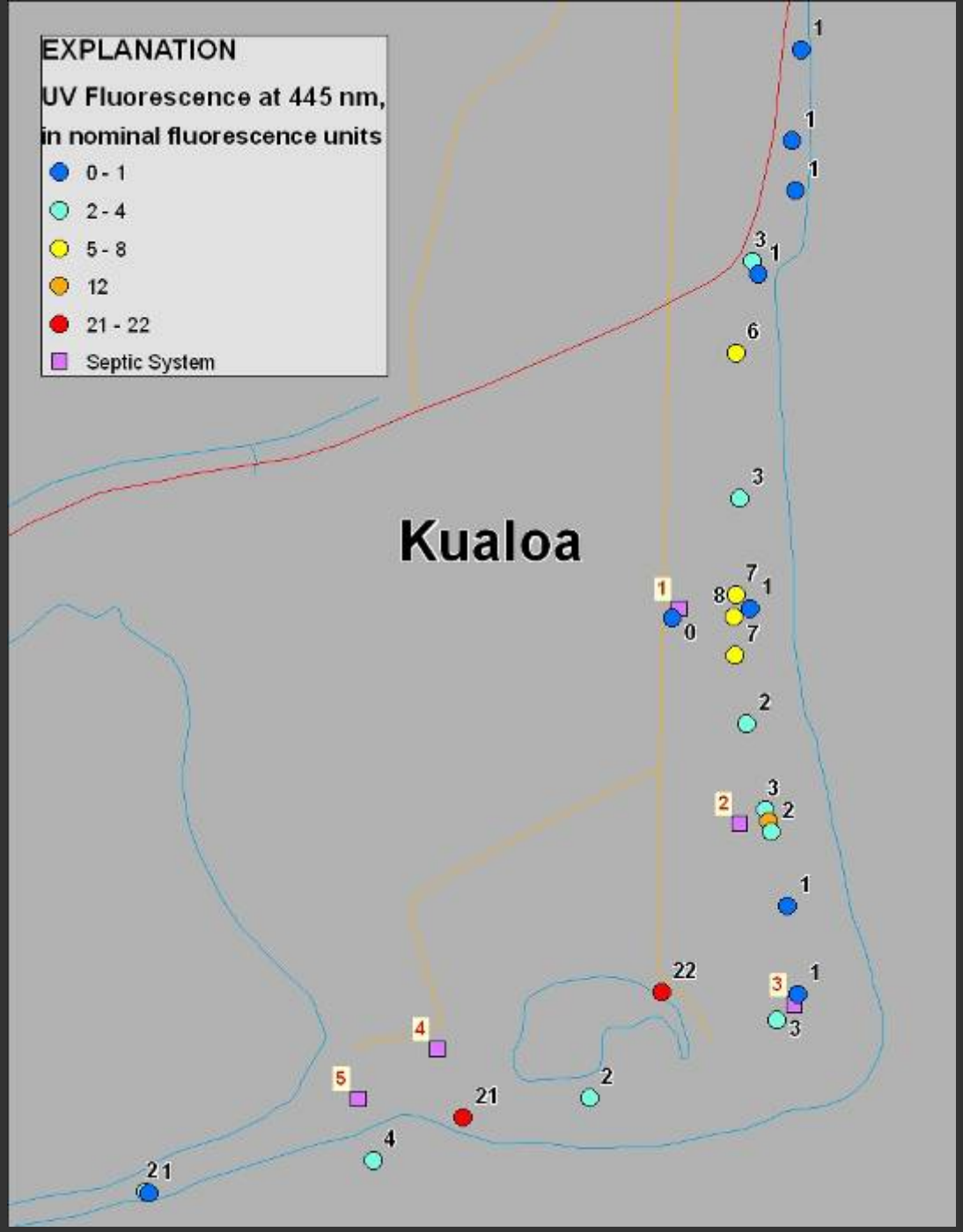

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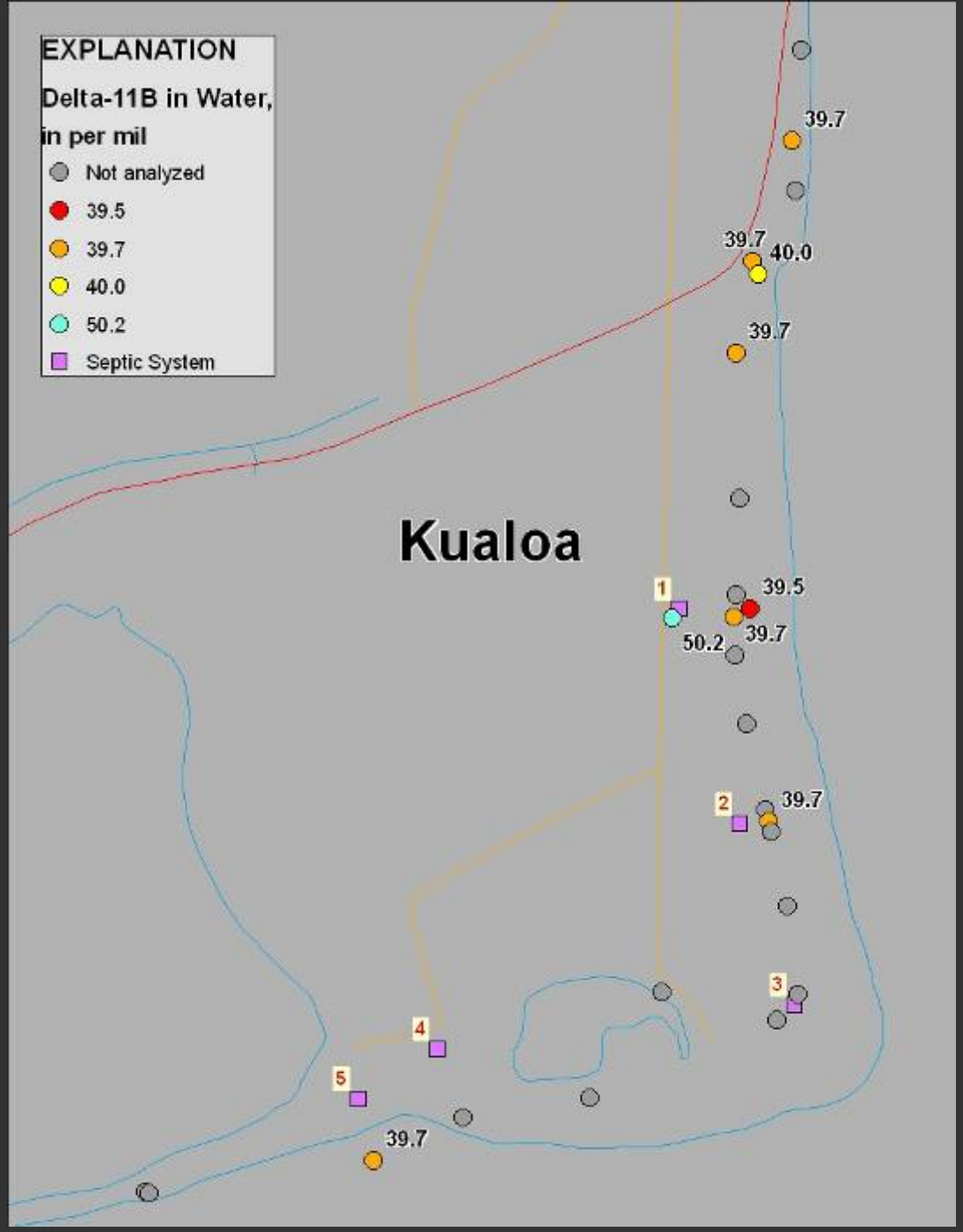

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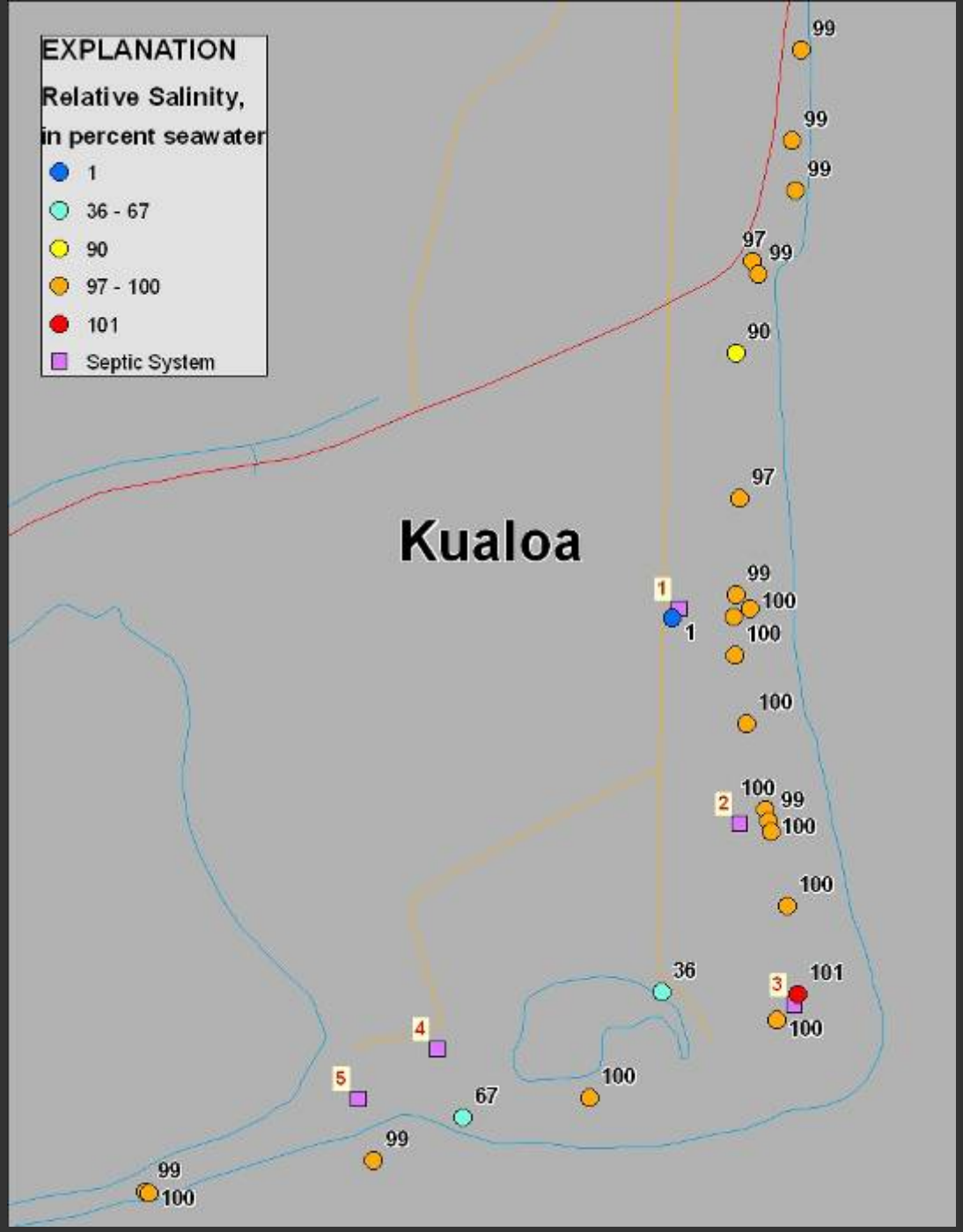

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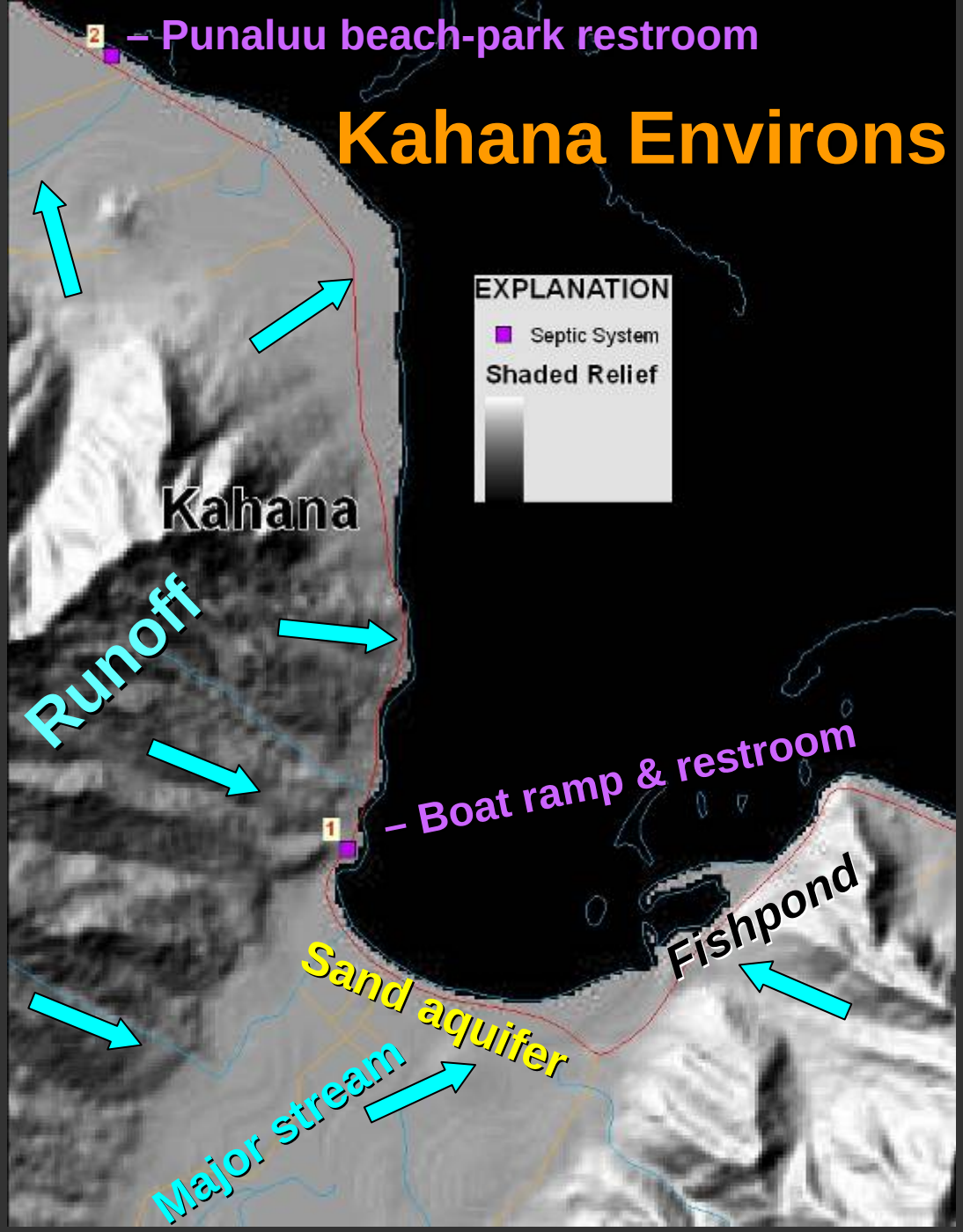

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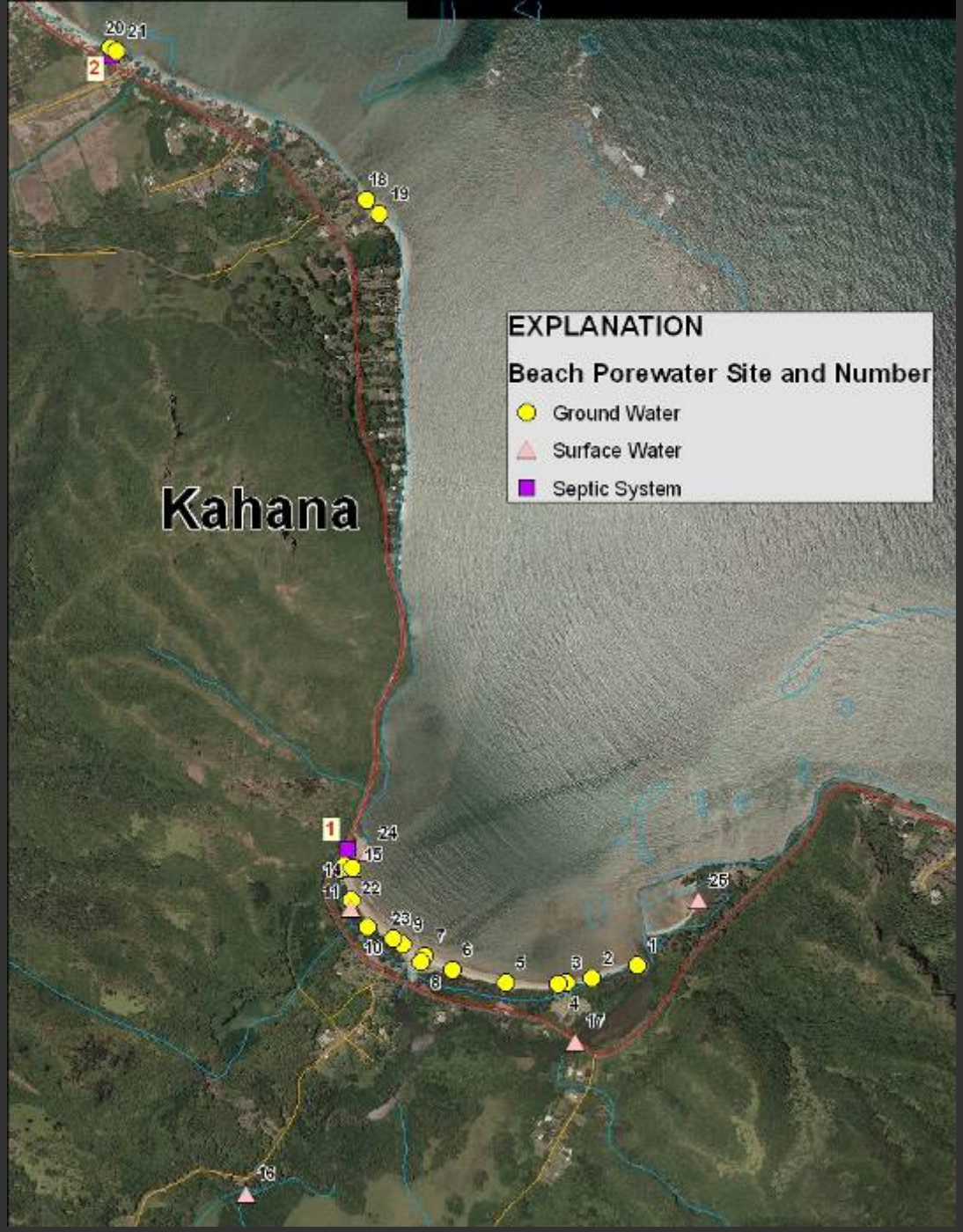

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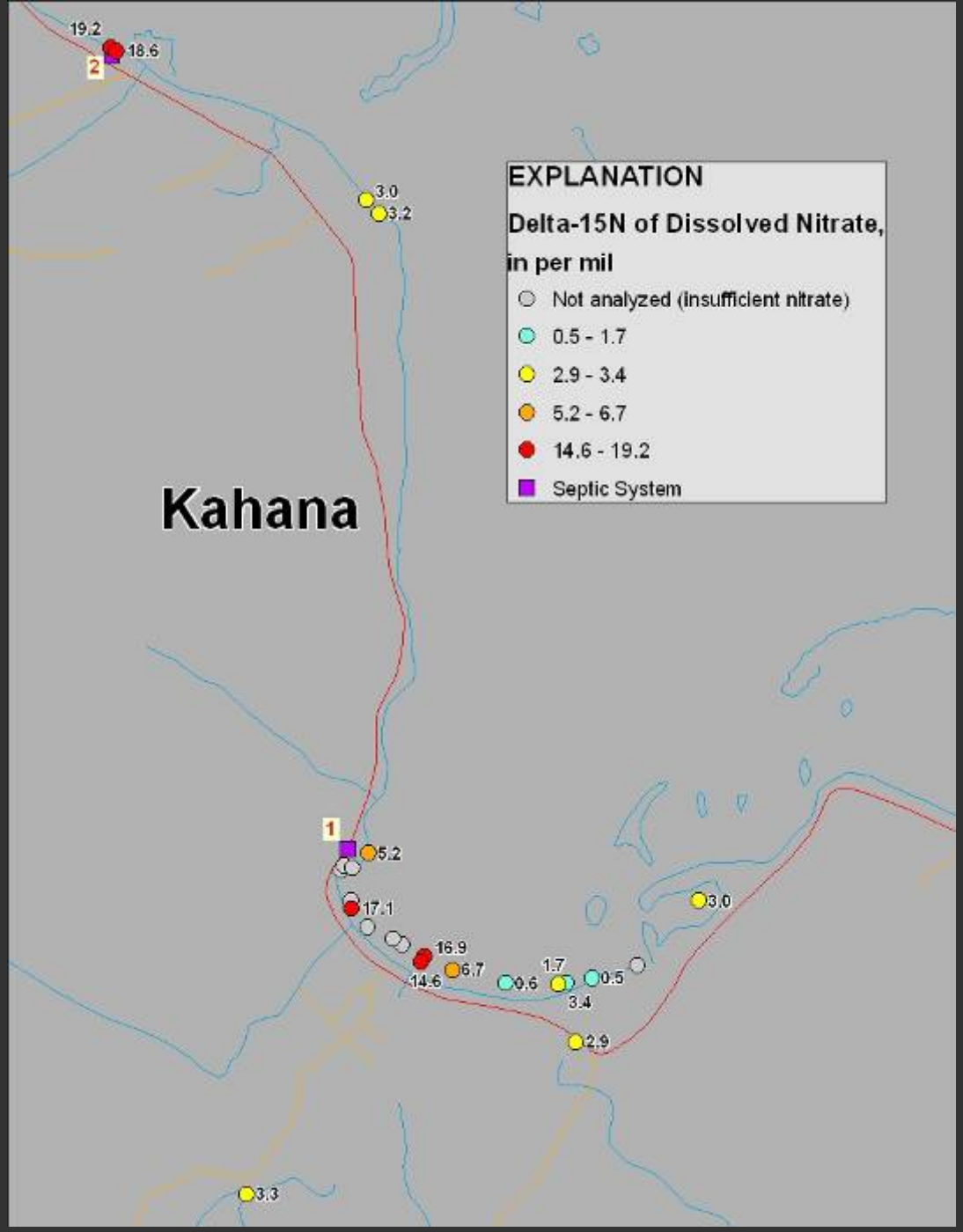

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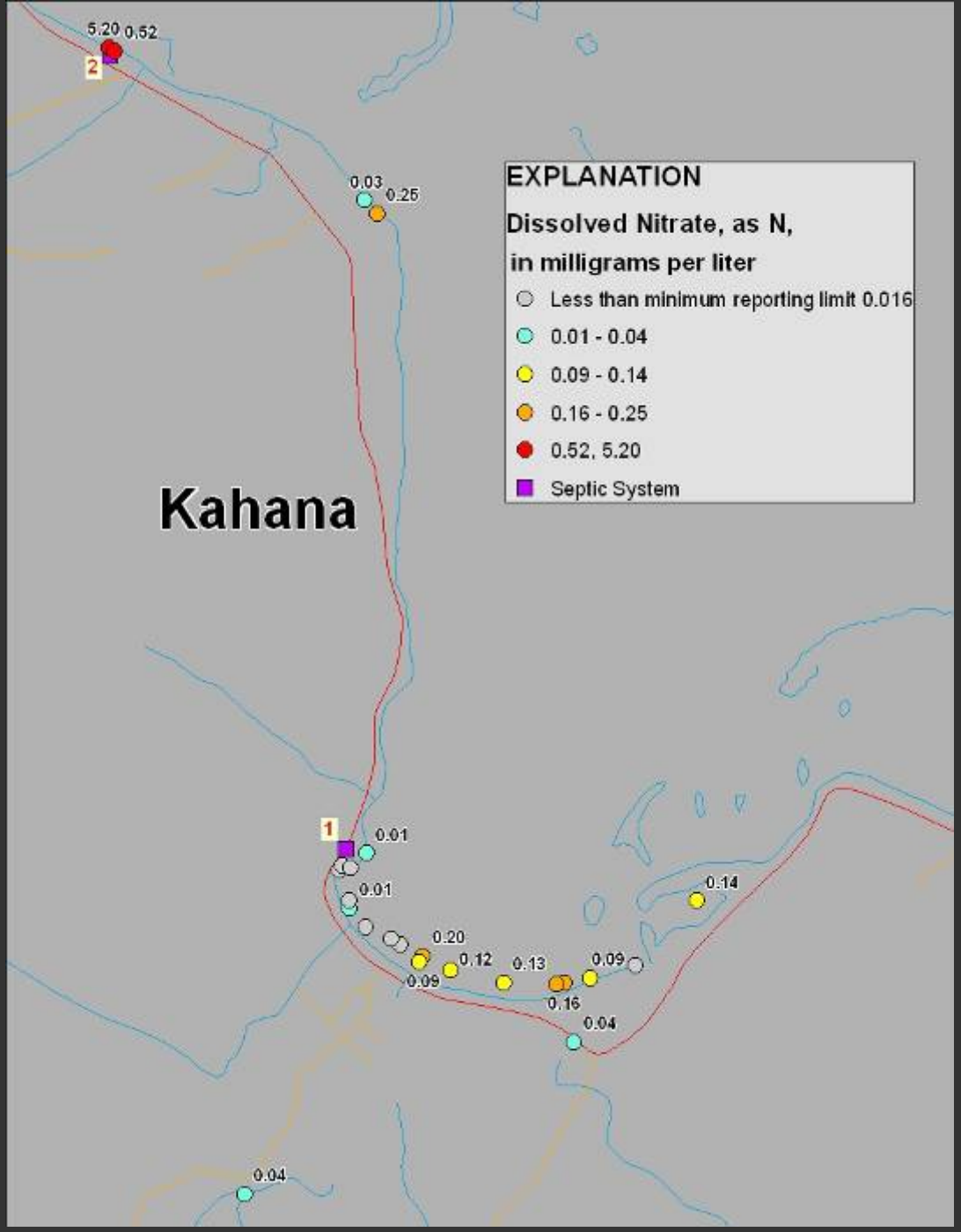

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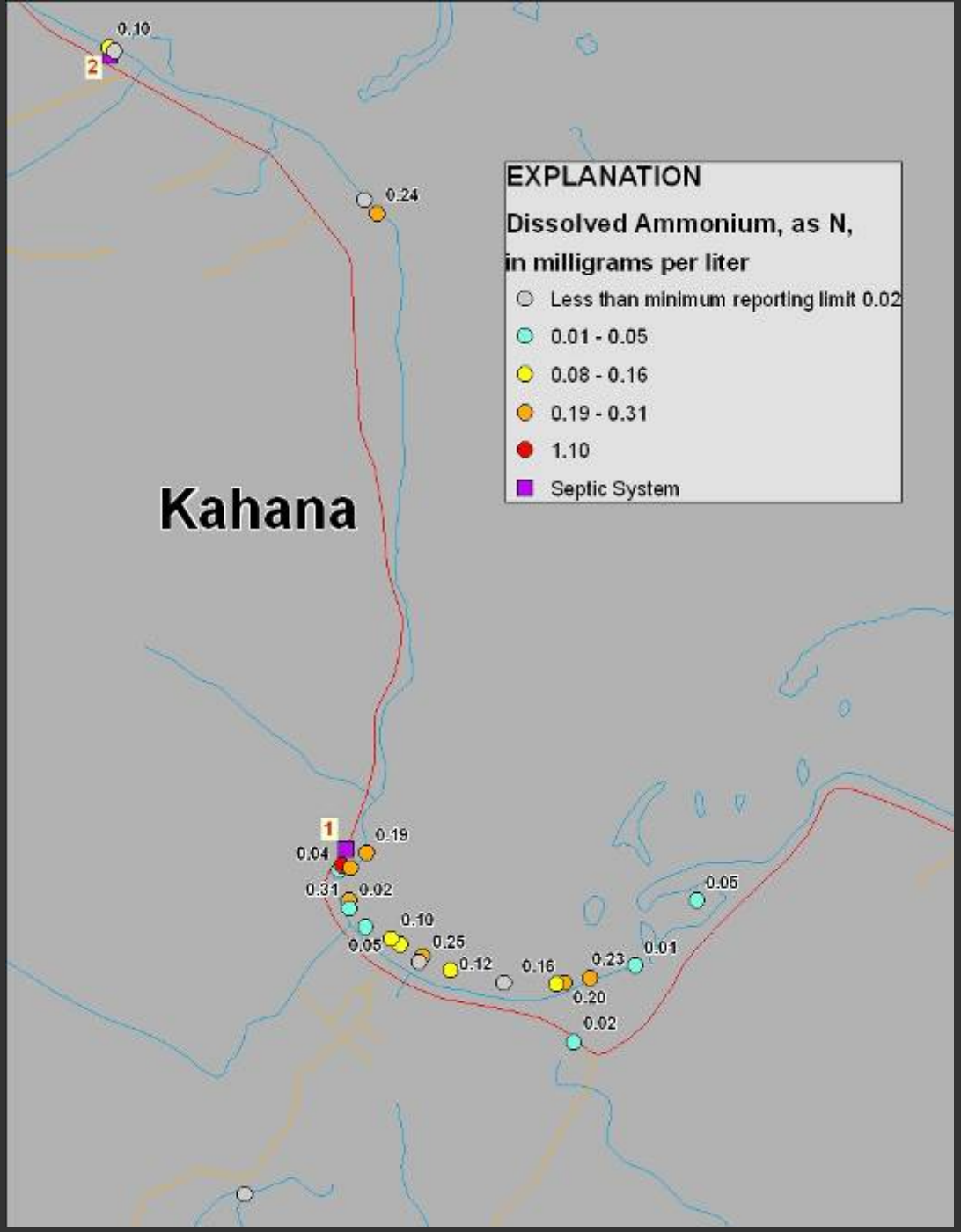

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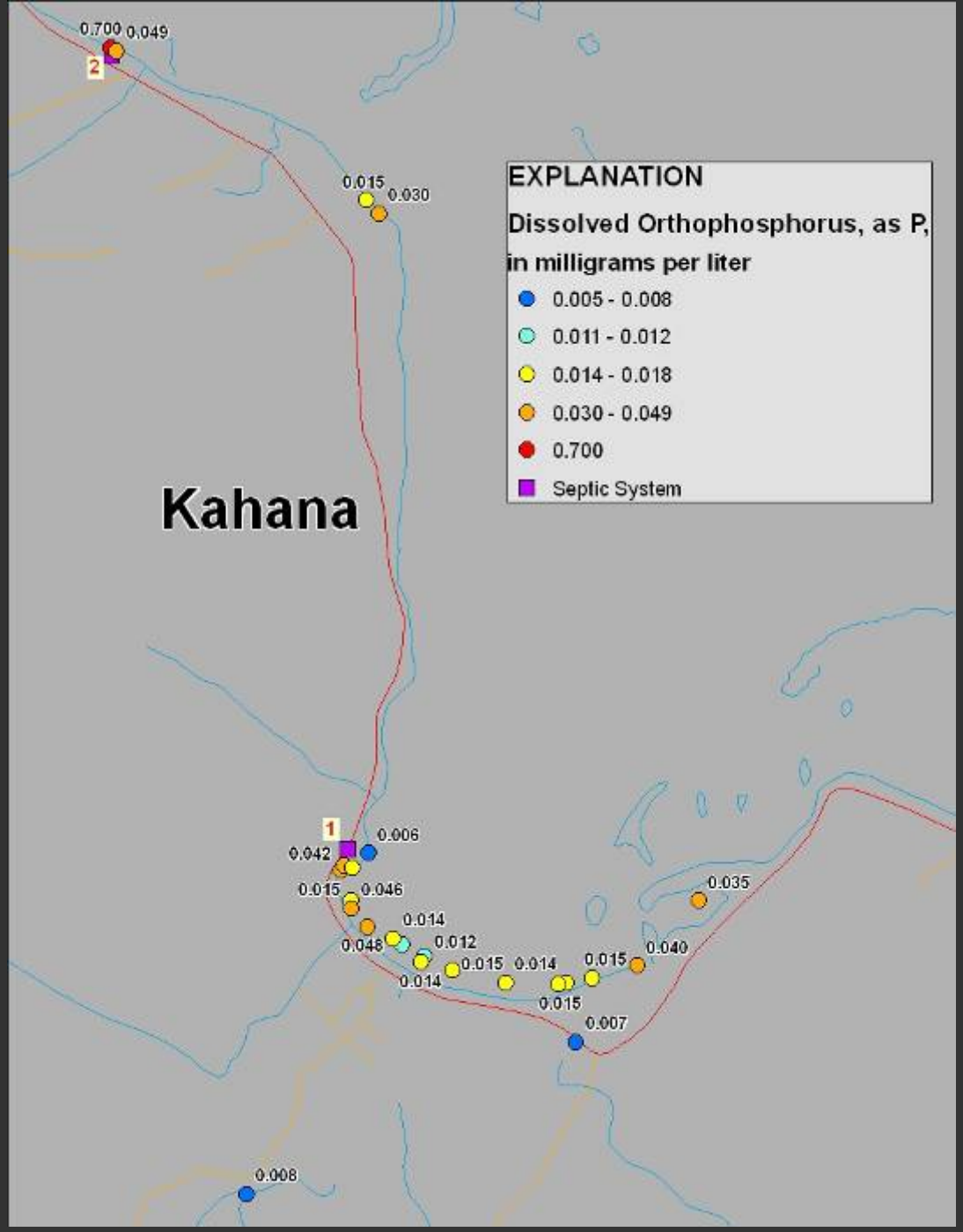

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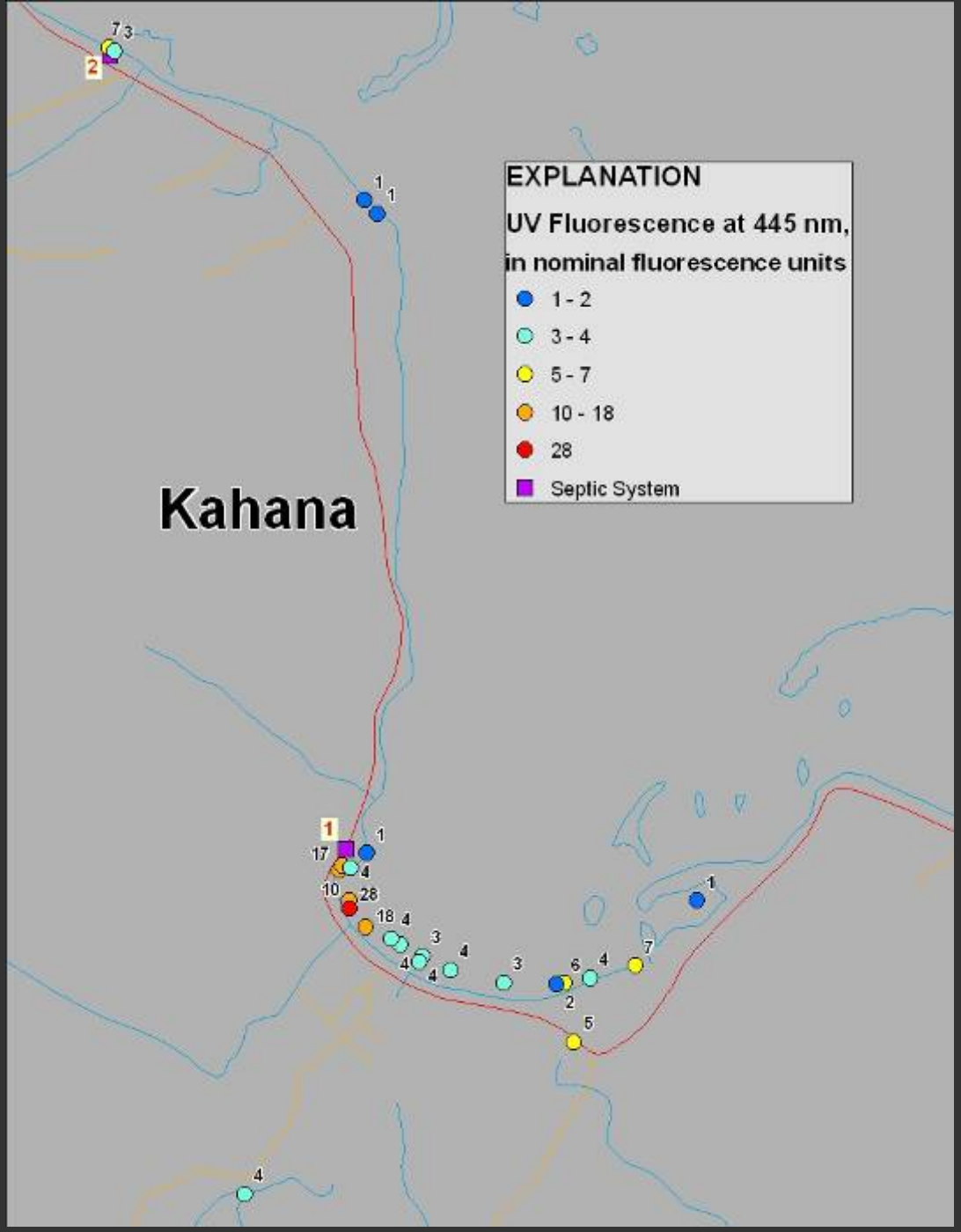

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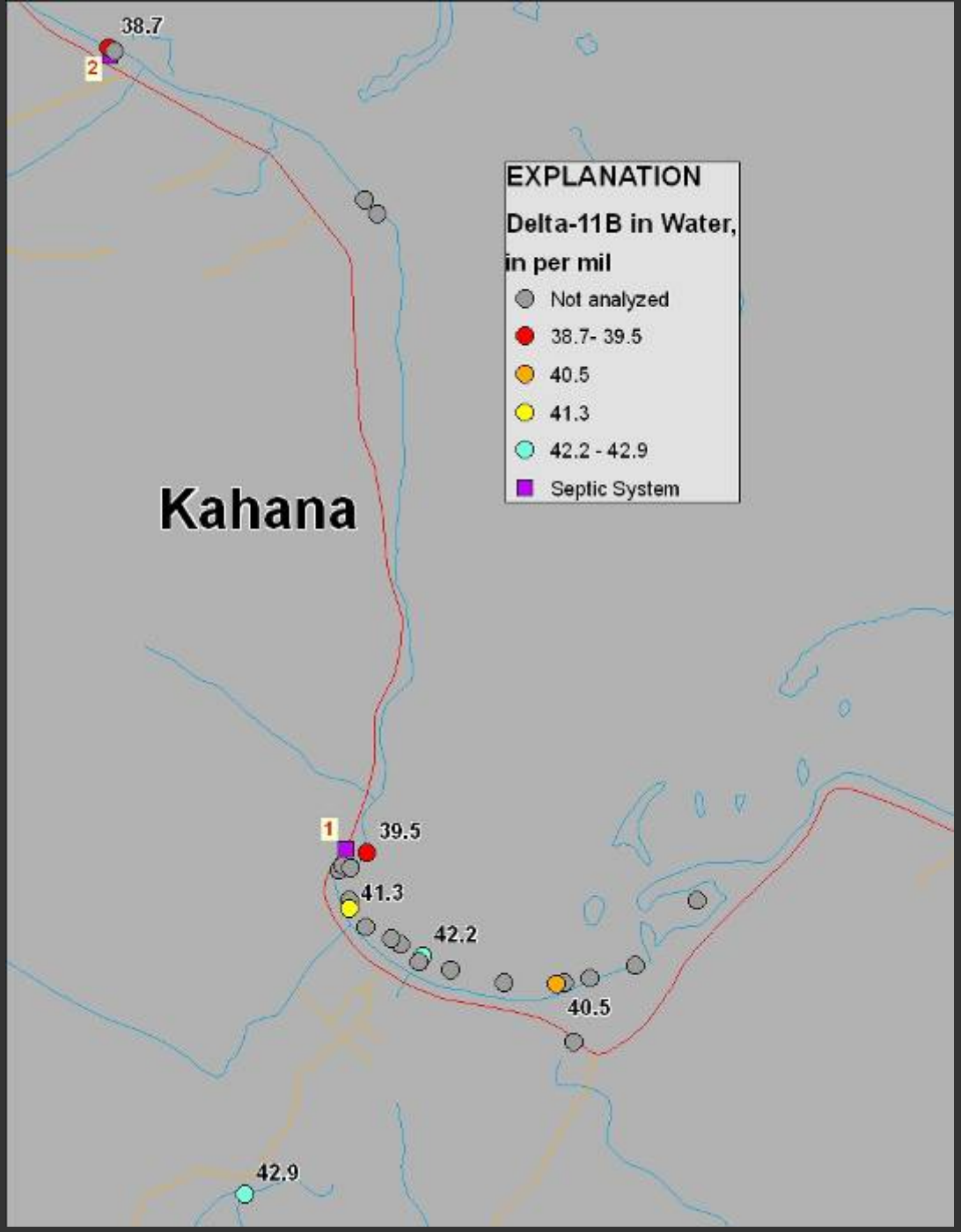

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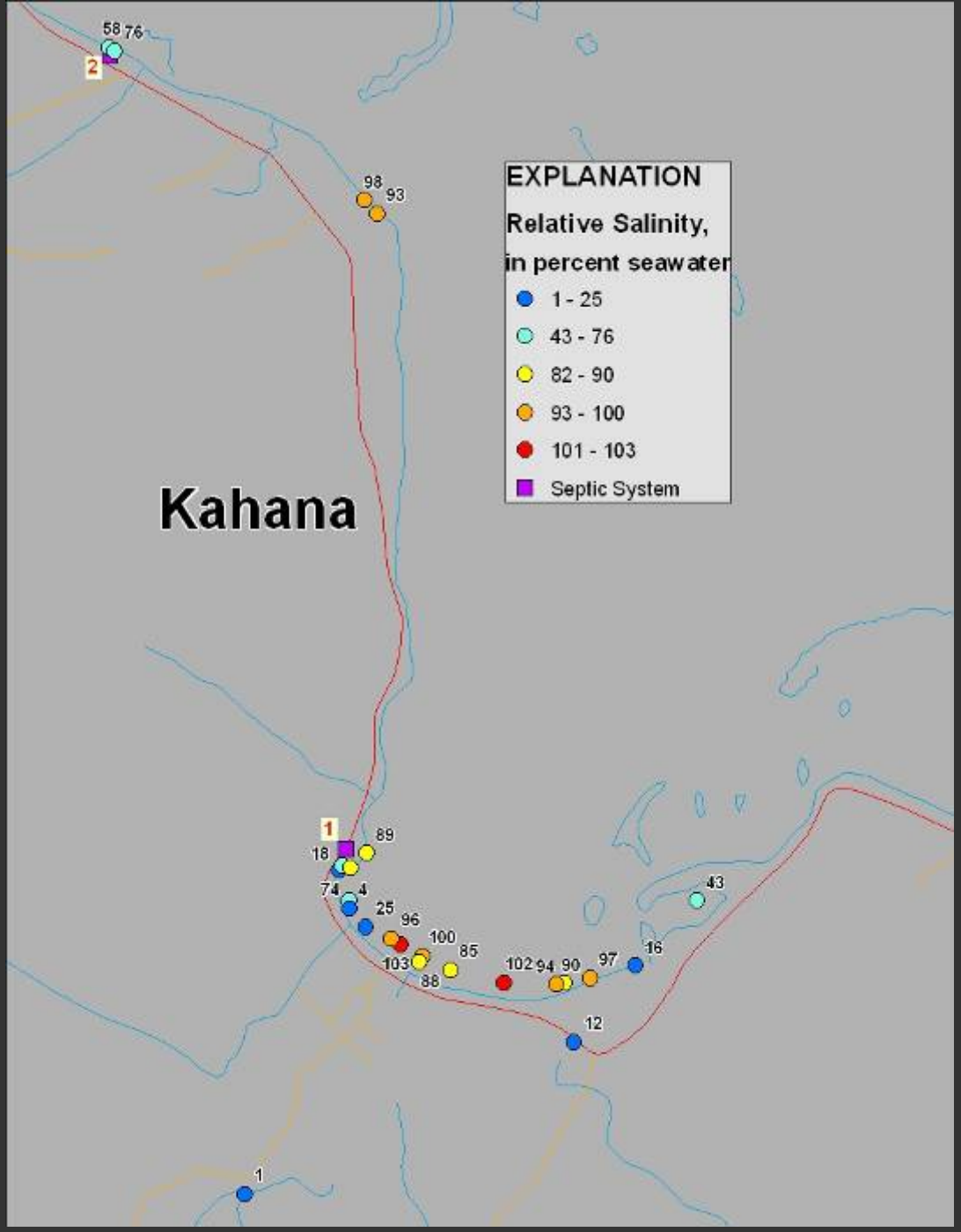

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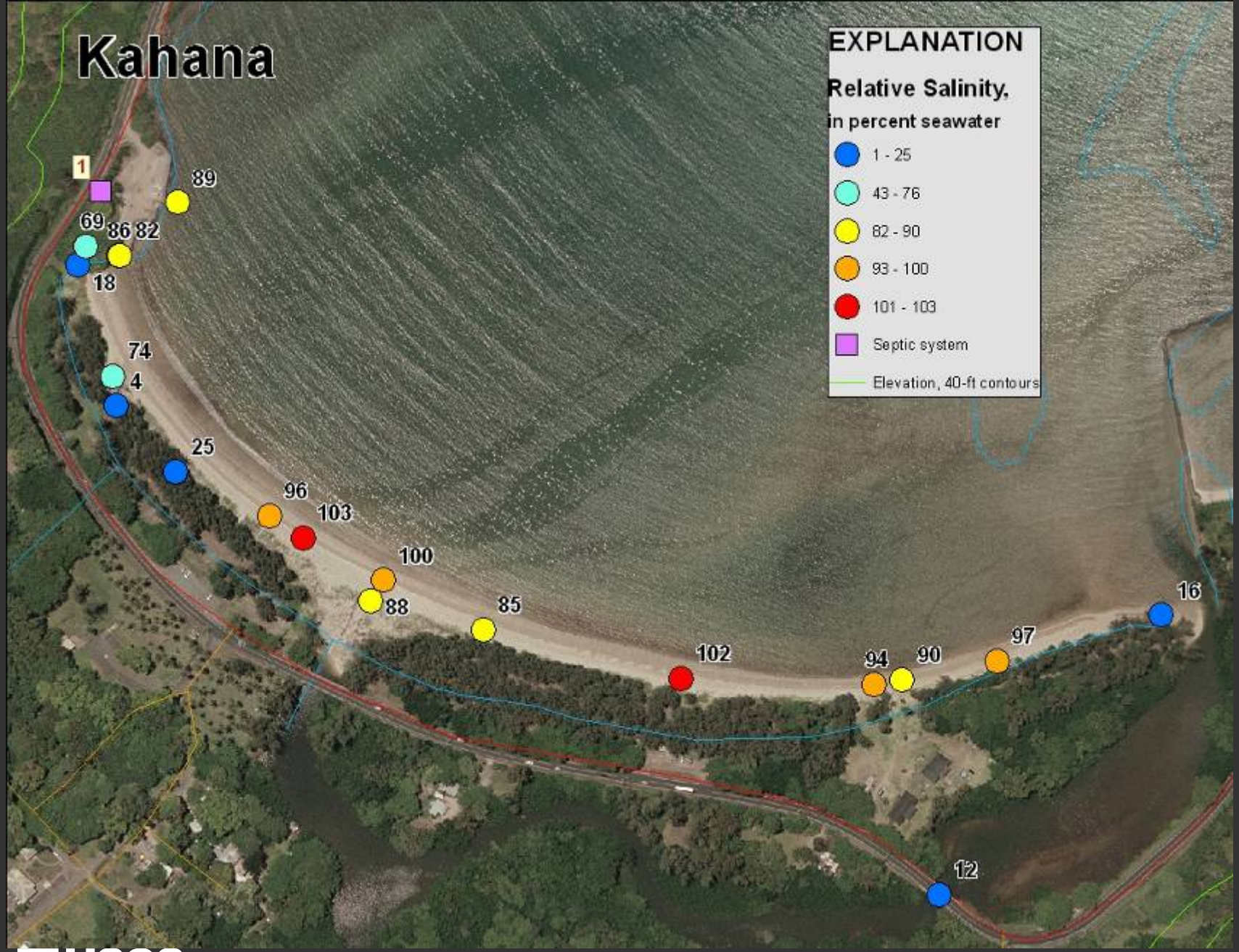

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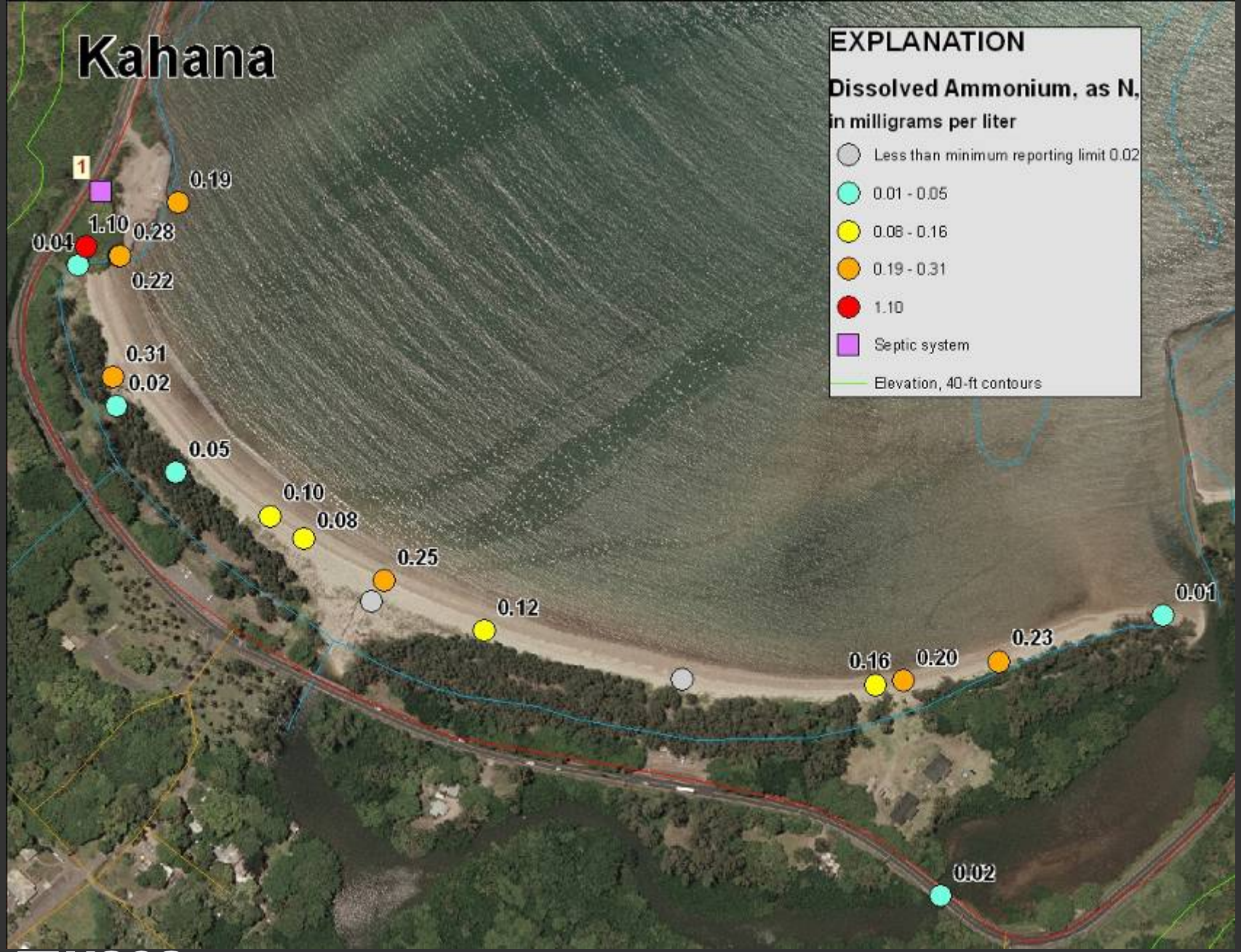

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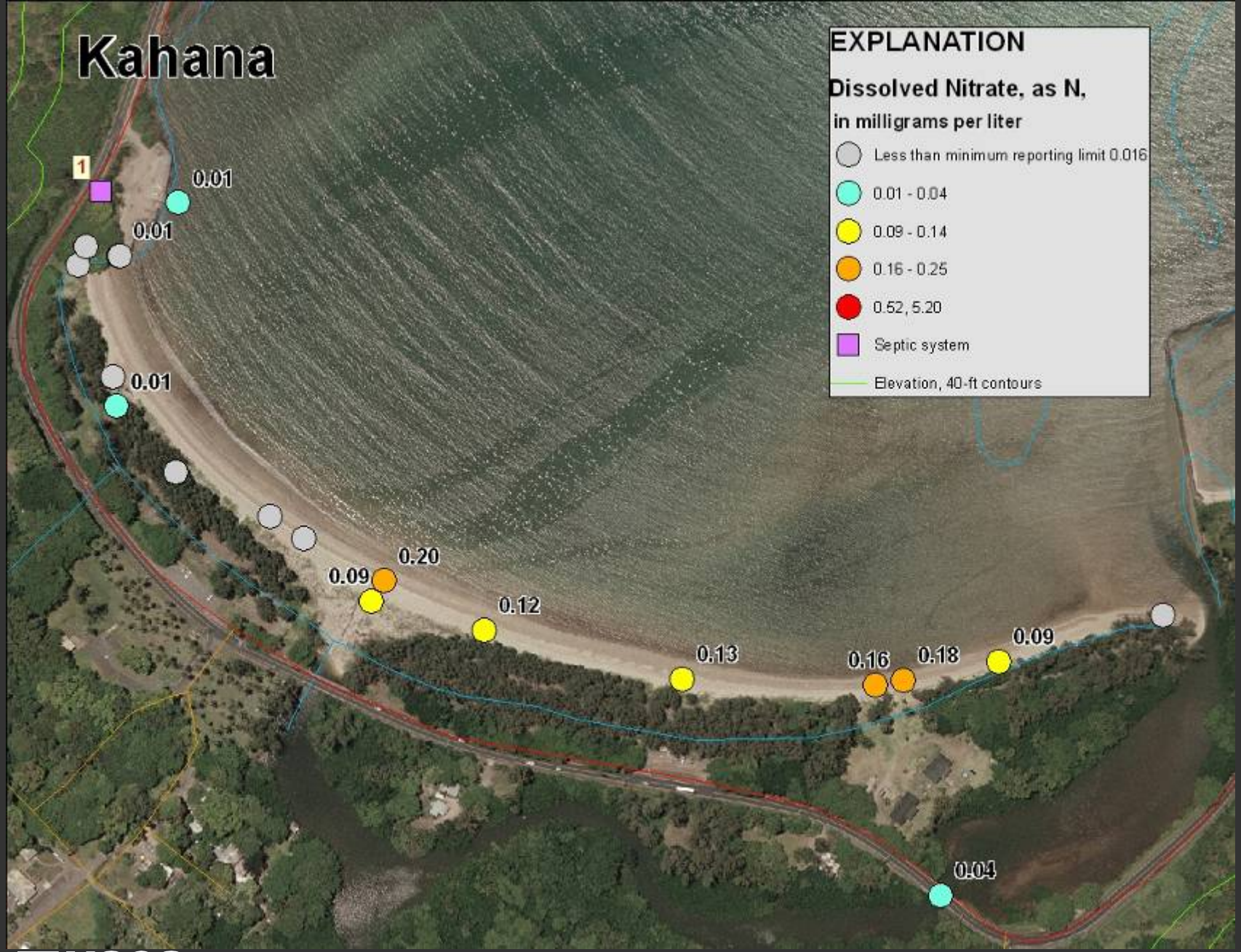

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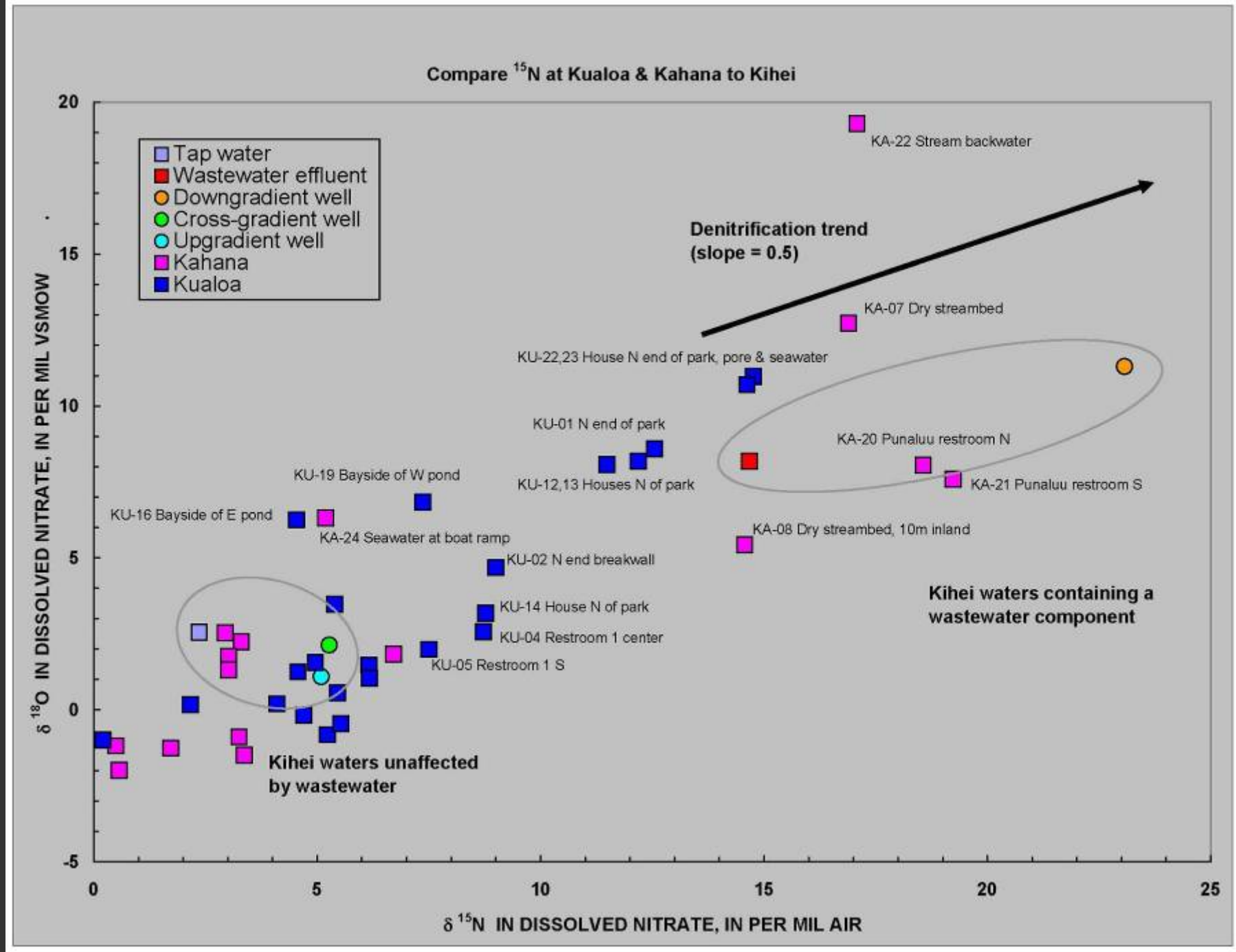
Compare 15N at Kualoa & Kahana to Kihei
Tap water
Wastewater effluent
Downgradient well
Cross-gradient well
Upgradient well
Kahana
Kualoa
Denitrification trend
(slope = 0.5)
KA-22 Stream backwater
KA-07 Dry streambed
KU-22,23 House N end of park, pore & seawater
KU-01 N end of park
KU-12,13 Houses N of park
KA-20 Punaluu restroom N
KA-21 Punaluu restroom S
KA-08 Dry streambed, 10m inland
KU-19 Bayside of W pond
KU-16 Bayside of E pond
KA-24 Seawater at boat ramp
KU-02 N end breakwall
KU-14 House N of park
KU-04 Restroom 1 center
KU-05 Restroom 1 S
Kihei waters containing a wastewater component
Kihei waters unaffected by wastewater
δ 18O IN DISSOLVED NITRATE, IN PER MIL VSMOW
δ 15N IN DISSOLVED NITRATE, IN PER MIL AIR
20
15
10
5
0
-5
0
5
10
15
20
25

Conclusions

Overall

- **Wading & porewater methods have proven out → interpretable maps**

Kualoa Beach

Restrooms

- **No** strong multi-tracer wastewater signature; slight indication NO_3 & PO_4

North cove and farther

- Probable animal / human waste signature; enhanced GW discharge

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NW cove

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Refinements & Further Work

- Retrospective bacteria vs rainfall time-series
  – wet or dry problem? (can do *now* with existing data)
- Begin to evaluate overland runoff sources
- Fluorescence sensor on multiparameter probe
- Conduct bacterial transects *with* wading surveys
- Denser beach porewater transects to make sure we're not missing possible restroom "plumes"
- Targeted sampling for pharmaceuticals, wastewater indicator compounds, major ions
- Closer attention to redox conditions
- Ultimately – Bacterial source-tracking methods?

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Wet or Dry Problem?

Friday Jan 12, 2007

(most recent beach closure)

Kualoa closed to swimmers because of bacteria count

Honolulu Advertiser

Jan 12, 2007

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Other Relevant USGS Studies

- Bacterial contamination, Huntington Beach
- Sources of microbial contamination at public beaches, Santa Barbara
- Enterococcus surface protein indicator of human fecal pollution, Russian River
- Pathogen Exposure through Recreational Water
  http://health.usgs.gov/pathogens/
  - Microbial Source Tracking page
  - Lots of Great Lakes work

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Future?- Hanalei Beach Park & River

Photos: HawaiiWeb, Inc.

Future?- Kaelepulu Pond, Kailua (TMDL)