Cost effective actions to mitigate land-based sources of pollution in West Maui through decision models

4th Joint Government Water Conference

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110,000

of OSDS in HI in 2007
https://health.hawaii.gov/wastewater/files/2015/09/OSDS_NI.pdf
http://health.hawaii.gov/wastewater/cesspools/

70 million gallons per day (mgd) of minimally treated effluent to groundwater

Not all OSDS systems are created alike

OSDS Class	Individual Wastewater System and Disposal Type
Class I	Any system receiving soil treatment. This includes disposal types listed as bed, trench, and infiltration/chambers.
Class II	Septic systems discharging to a seepage pit. The effluent receives primary treatment only.
Class III	Aerobic units discharging to a seepage pit. The effluent receives primary and secondary treatment.
Class IV	All ***cesspools*** where the **effluent receives no treatment**.

80% of OSDS are Class IV

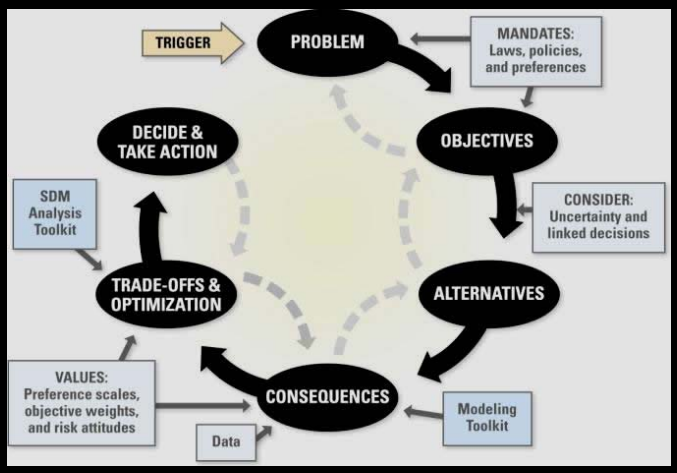
Policy response

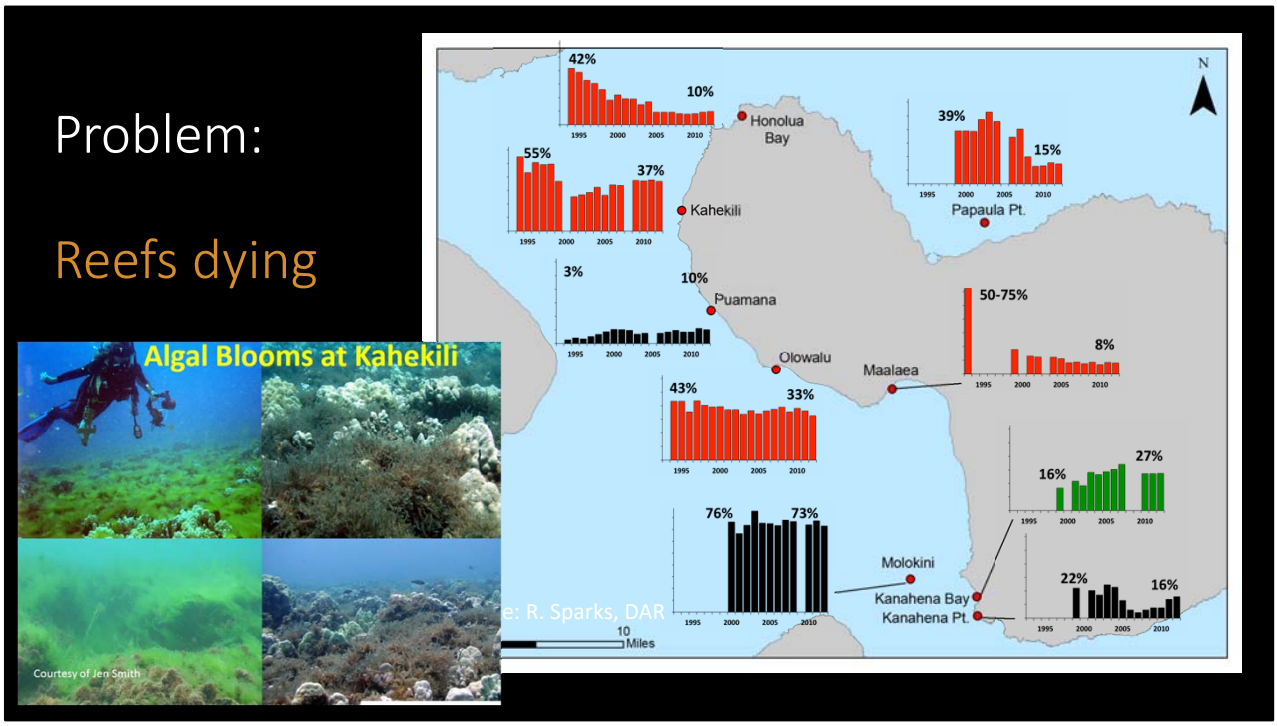
- Act 120 (2015): ban new cesspools; tax credit
- Act 125 (2017): expanded eligibility; 2050 upgrade deadline
- Act 132 (2018): Working Group

How can we best act to cost-effectively address OSDS pollution to minimize exposure to the risks associated with sewage?

Methods: Decision analysis

1. Define problem
2. Define objectives and metrics
3. Identify, cost and map feasible options (and constraints)
4. Develop alternatives
5. Estimate consequences (accounting for local preferences and values)
6. Evaluate trade-offs
7. Decide, act and monitor

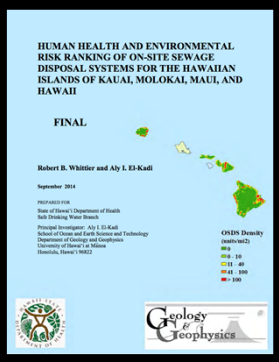




Per state data and watershed management plans, West Maui has hundreds of cesspools potentially contaminating valuable nearshore areas and drinking water sources.

Problem:

Cesspools


HUMAN HEALTH AND ENVIRONMENTAL RISK RANKING OF ON-SITE SEWAGE DISPOSAL SYSTEMS FOR THE HAWAIIAN ISLANDS OF KAUAI, MOLOKAI, MAUI, AND HAWAII

FINAL

Robert B. Whittier and Aly I. El-Kadi

September 2014

PREPARED FOR
State of Hawai'i Department of Health
Safe Drinking Water Branch

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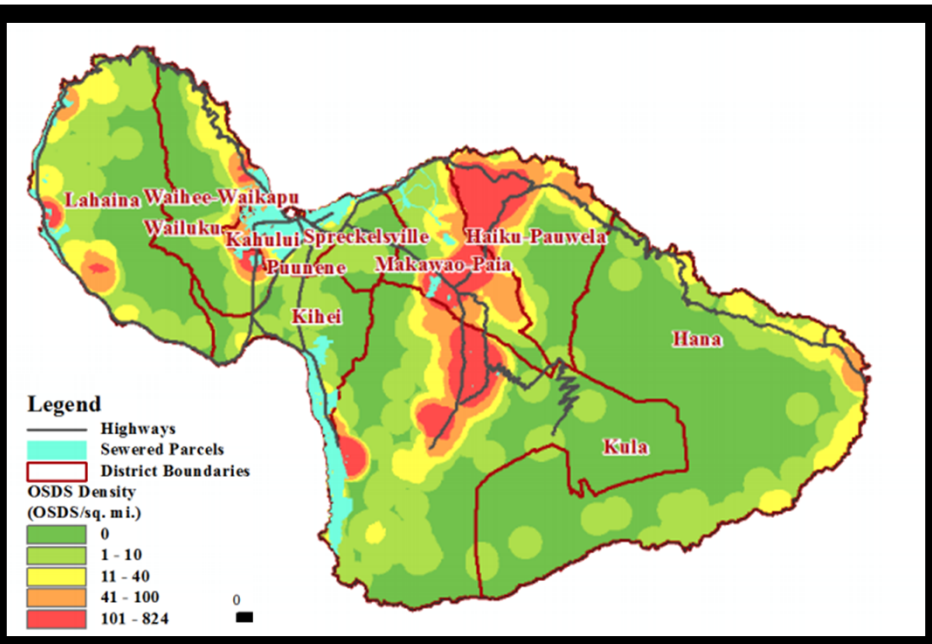
OSDS Density (units/sq2)
0
0 - 10
11 - 40
41 - 100
> 100



https://health.hawaii.gov/wastewater/files/2015/09/OSDS_NI.pdf

Problem

HAWAII STATE DEPARTMENT OF HEALTH

The legislature has allocated limited resources to implement change. DOH needs additional tools to identify which cesspools to upgrade within a given area.

Objectives

- **2050 policy** to eliminate cesspools: minimize degradation of sensitive waters (reefs, drinking water sources) and risk to humans

- **West Maui Ridge 2 Reef**: Restore and enhance the health and resiliency of West Maui coral reefs and near-shore waters through the reduction of land-based pollution threats

- Our objective: minimize pollution reaching nearshore ecosystems, particularly in high value areas (reefs, recreational use zones)

Objectives

WEST MAUI Ridge2Reef INITIATIVE

Manage land based sources of pollution

Restore & enhance health & resiliency of reef ecosystem

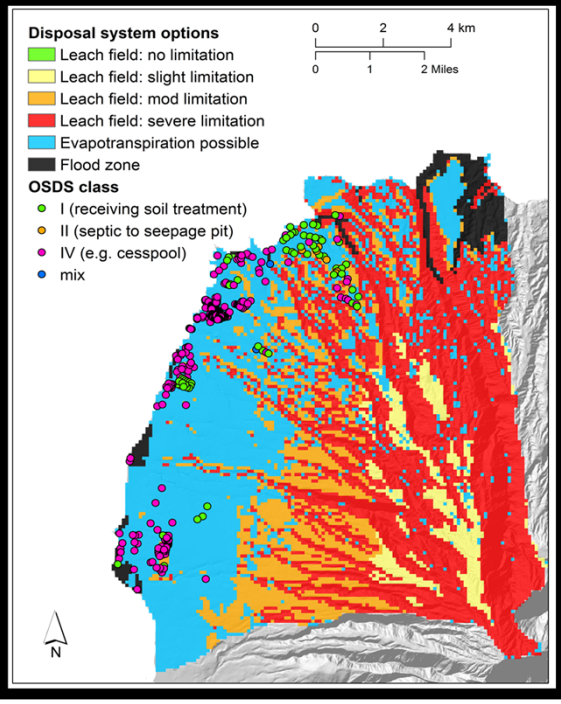
Maintain ES & Social benefits

Options

Site characteristics limit options

NR = Not Recommended, P = Possible, R = Recommended. ATU = Aerobic Treatment Unit

	Treatment			Disposal			
Site conditions	Septic	ATU NSF 40	Advanced Treatment NSF 40/245	Seepage pit / injection well	Leach Field / Infiltration chamber / beds / trenches	Drip Irrigation	Evapotran-spiration
High water table	P	R	R	NR	NR	R	P
Impermeable soil or rock formation	P	R	R	P	NR	R	R
Steep terrain	P	R	R	R	NR	R	NR
Flood zones	NR	NR	NR	NR	NR	NR	NR
Close to inland surface water (both streams and other bodies of water)	NR	R	R	NR	P	R	P
Close to coastal waters	P	R	R	P	P	R	P
High density of cesspools	P	R	R	NR	P	R	P
Protection of groundwater resources	P	R	R	P	P	R	R
Protection of drinking water	P	R	R	NR	NR	R	R
Hydrogeology	P	R	R	P	P	R	P



Every alternative, or management decision, has costs, benefits, and constraints that decisions may be based upon.

Costs

Costs vary across options

30 year NPV: Labor, material, equipment, mobilization, installation, overhead, contingency, operation and maintenance

Net Present Value discount rate: 2.8%

Disposal system		Treatment system: Cesspool	Septic	ATU NSF 40	Advanced Treatment NSF 40/245
		$5,083	**$14,933**	**$126,730**	**$50,864**
None	**$0**	$5,083			
Seepage Pits	**$10,664**		$25,598	$137,394	$61,528
Leach Field	**$41,560**		$56,493	$168,290	$92,424
Infiltration Chambers	**$17,000**		$31,933	$143,730	$67,864
Drip Irrigation + Standard	**$22,000**			$148,730	$72,864
Evapotranspiration	**$20,508**			$147,238	$71,373

NPV rate: 5%

		$3,780	**$13,630**	**$103,217**	**$42,440**
None	**$0**	$3,780			
Seepage Pits	**$10,471**		$24,101	$113,687	$52,911
Leach Field	**$33,094**		$46,725	$136,311	$75,534
Infiltration Chambers	**$17,000**		$30,630	$120,217	$59,440
Drip Irrigation + Standard	**$22,000**			$125,217	$64,440
Evapotranspiration	**$20,378**			$123,595	$62,818

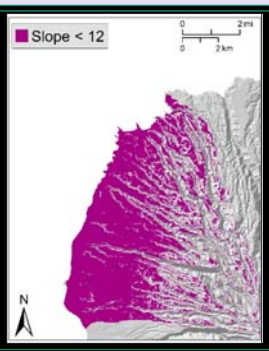
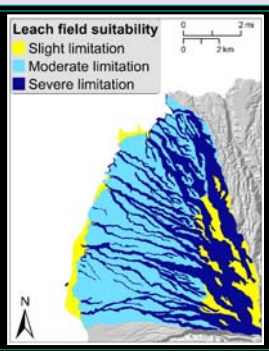
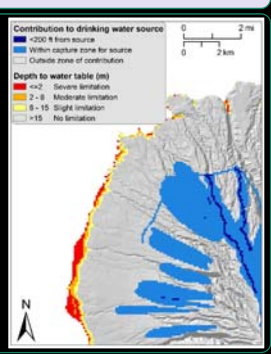
Benefit: Nitrogen removal

Nitrogen removal rates vary for different treatment - disposal combinations

		Cesspool	Septic	ATU NSF 40	Advanced Treatment NSF 40/245
		100	**66**	**57**	**47**
None	**100**	0			53
Seepage Pits	**100**		34	43	53
Leach Field	**59**		61	66	72
Infiltration Chambers	**59**		61	66	72
Drip Irrigation + Standard	**59**			66	72
Evapotranspiration	**59**			66	72

Alternatives

1. High
2. Medium
3. Low
4. Max feasible

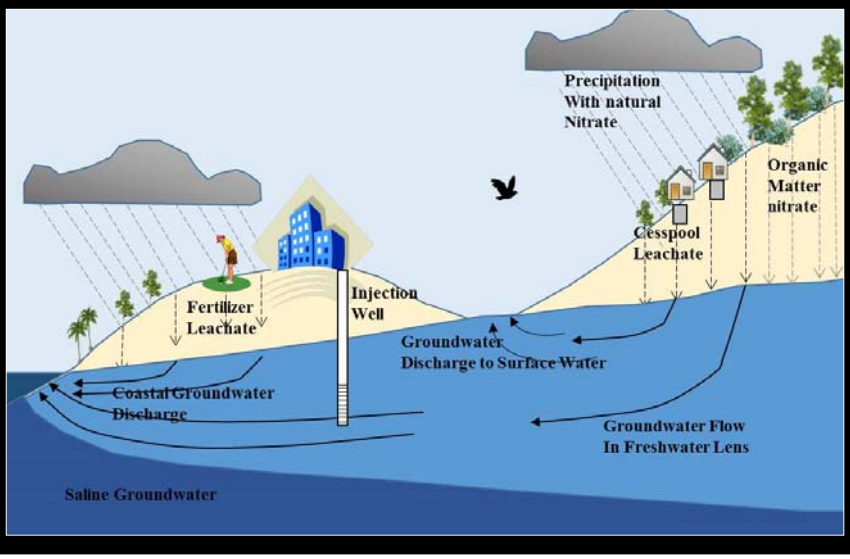
Focal strategies	**High** Advanced ATU + evapotranspiration	**Medium** Septic tank + leach field	**Low** Septic tank + seepage pit
Constraints	• OSDS Class IV system • Within 3 km of coastline • Slope < 12	• OSDS Class IV system • Within 3 km of coastline • Leach field suitability ≠ "severe limitation"*	• OSDS Class IV system • Within 3 km of coastline • Protection of drinking water • Water table > 2 m depth
Area to which it applies			

**constraint by leach field suitability limitation, defined by Whittier & El-Kadi 2014*

High treatment: All feasible systems upgraded to an advanced Aerobic Treatment Unit (ATU) with evapotranspiration (ET) disposal system.
Medium treatment: All feasible systems upgraded to a septic system with leach field disposal.
Low treatment: All feasible systems upgraded to a septic system with seepage pit disposal.
Maximum Feasible Reduction: Each unit is upgraded to the unit with the best nutrient reduction that is feasible.

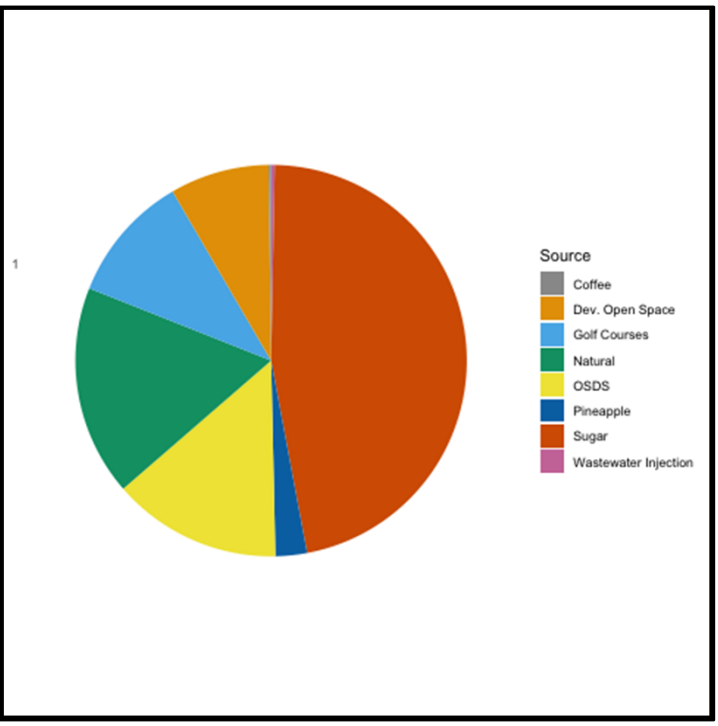
Consequences: Nitrogen

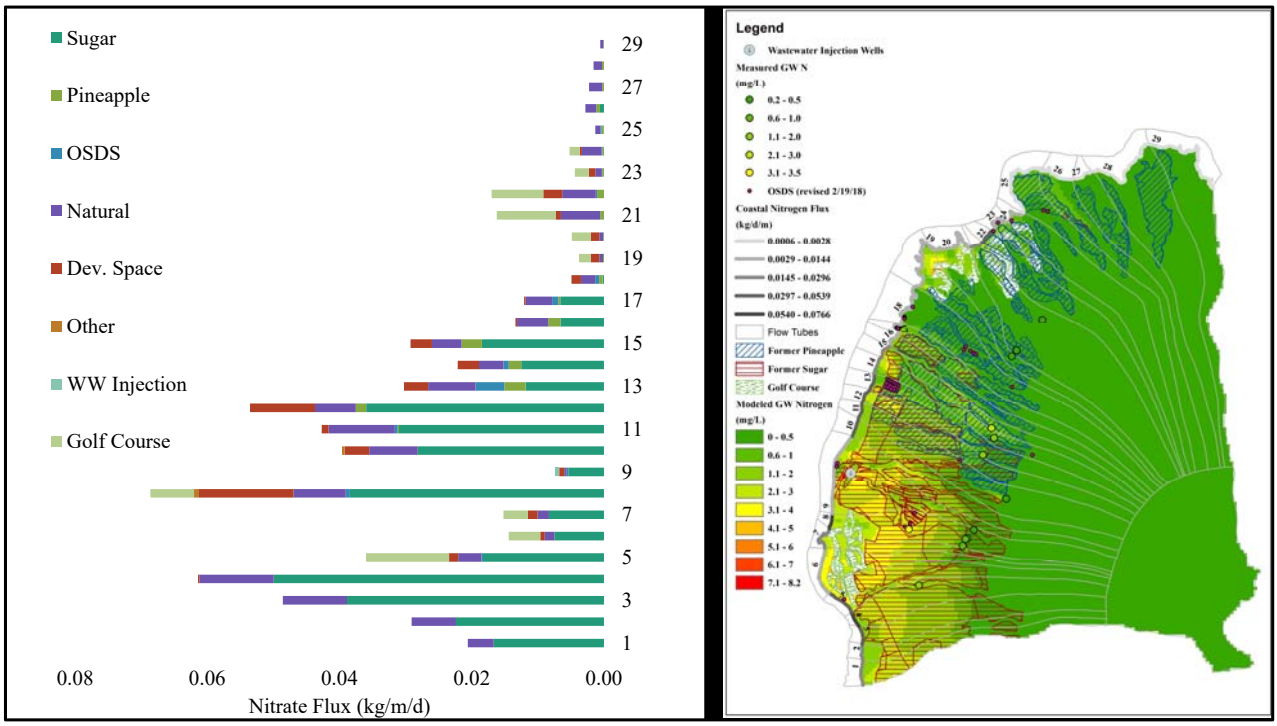
Groundwater model



Consequences:
Baseline

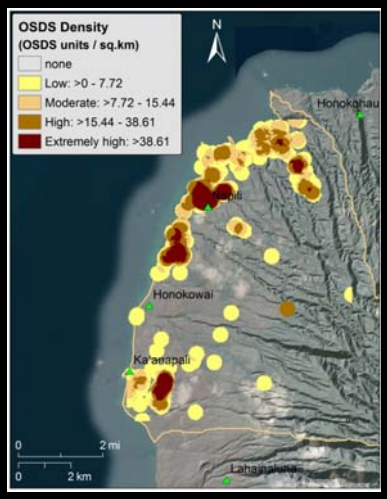
Most current nitrogen at the coast is a legacy of past ag





We estimate that these improvements have resulted in an 84% reduction in N flux (corresponding to a load reduction of 55.36 g/m/d) across the study area

Consequences: Past upgrades



2007 → 2017

442 total OSDS in study area

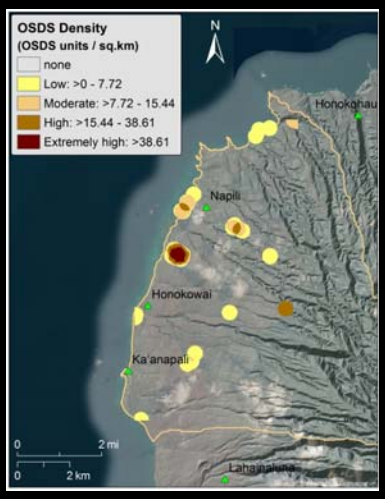
433 within 3km of coast

336 within 1km of coast

362 Class IV (cesspool)

57 Class IV

50 within 3km of coast

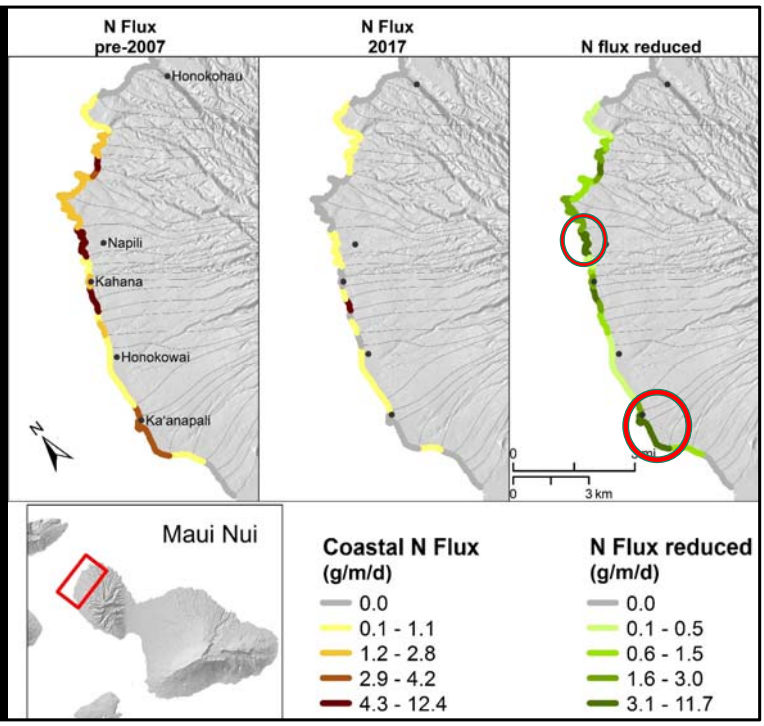


442 total OSDS in study area
433 within 3km of coast
336 within 1km of coast
362 Class IV (cesspool)

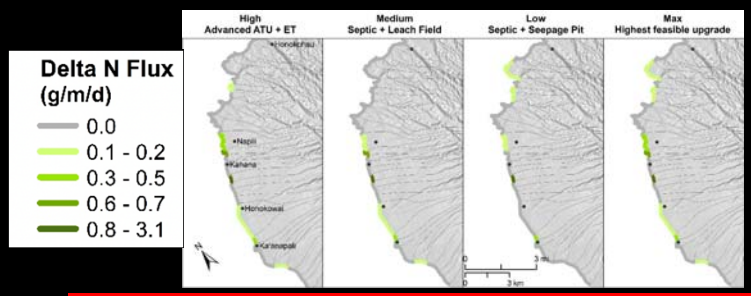
- 57 Class IV.
- 50 within 3km of coast

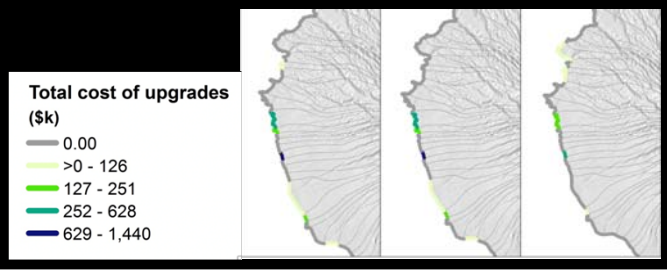
Consequences:
Nitrogen reduction of sewering

Reduced OSDS-derived nitrogen by 84%



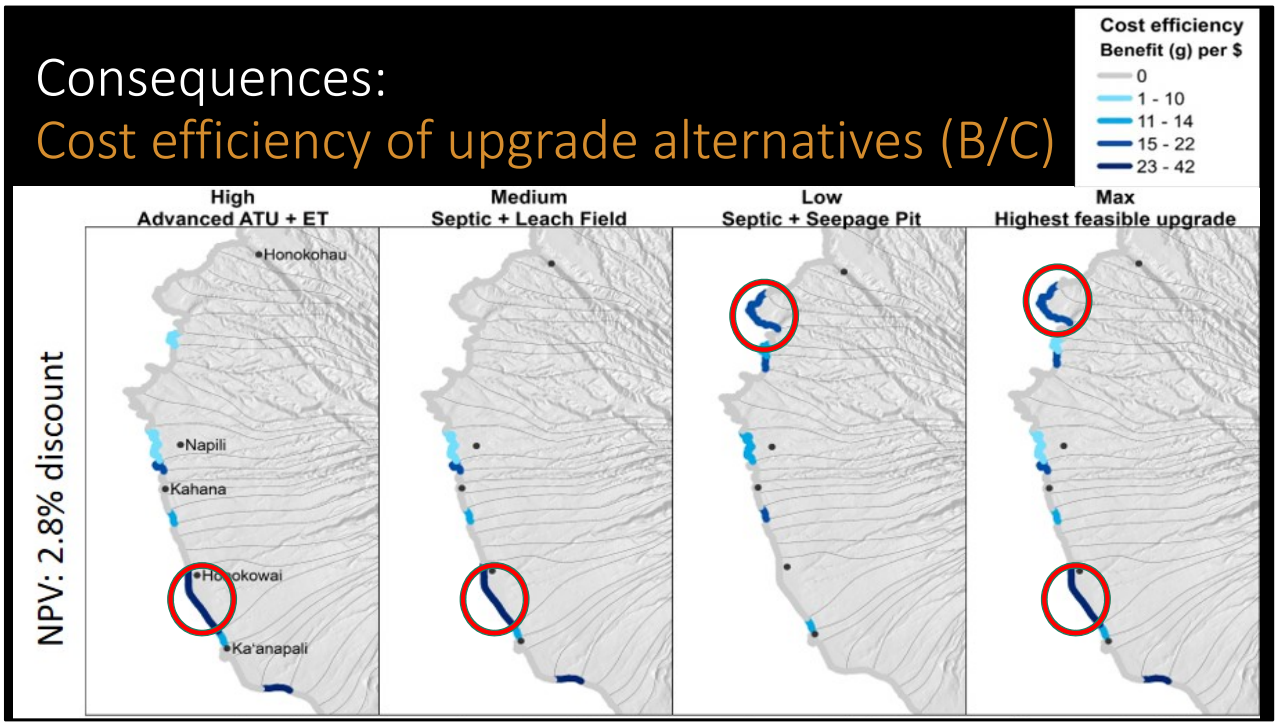
Consequences:
Nitrogen reduction of upgrade alternatives / Costs





REDUCTION

Consequences:
Cost efficiency of upgrade alternatives (B/C)



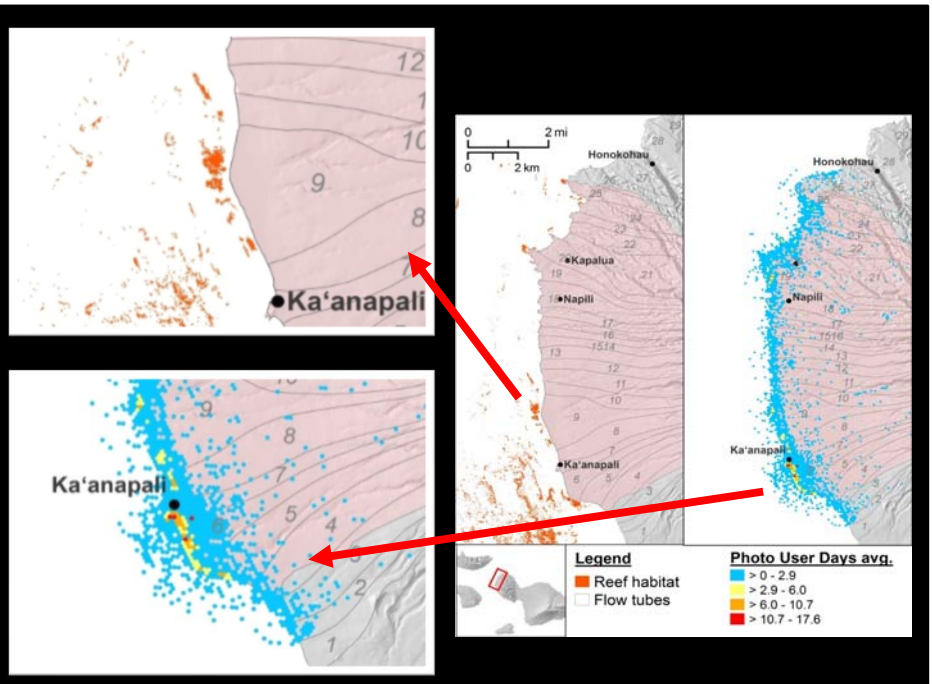
Trade-offs: Evaluation table

Blue = Good **Green = OK** **Yellow = Bad**

	QTY		NPV discount: 2.8%		NPV discount: 5%	
2007	484	DeltaN:				
2017	57	kg/30yrs	Cost	CE (B/C)	Cost	CE (B/C)
High	44	38,131	3,140,412	0.0121	2,763,992	0.0138
Med	40	29,223	2,259,720	0.0129	1,869,000	0.0156
Low	41	14,675	1,049,518	0.0140	988,141	0.0149
Max	49	40,493	3,268,402	0.0124	2,884,497	0.0140

Next step: Weighting

Proximity to reef and recreation sites weighted higher



Decide, Act & Monitor

Next project: Upcountry Maui (DOH)

Leverage our NREM student power!

- Undergraduate capstones
- Internships
- Graduate capstones
- Graduate theses

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Mahalo

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