Regulating Septic Systems to Control Nitrate in the NGLA

July 28, 2028

GUAM ENVIRONMENTAL PROTECTION AGENCY
AHENSIAN PRUTEKSION LINA'LA GUAHAN

Sources & Health Impacts

Nitrate and Nitrite

- Breakdown product of human and animal wastes
- Good indicator of groundwater pollution
  - Remember: domestic sewage contains much more than just nitrate: PFAS, pharmaceuticals, cleaning products, fabric treatments, etc.
- Sources:
  - On-site sewage disposal
  - Farming (fertilizer use)
  - Animal wastes
  - Natural: mineral, nitrogen-fixing plants

Nitrate and Nitrite

- USEPA maximum contaminant levels:
  - 10 mg/L – Nitrate (as N)
  - 1 mg/L – Nitrite (as N)
  - 10 mg/L – Total Nitrate and Nitrite (as N)

- Health impacts:
  - Drinking water: methemoglobinemia ("blue baby syndrome")
  - Dietary (disputed): cancer, diabetes, adverse reproductive outcomes

- Numerous documented infant deaths in U.S. and world

Source: Fan, A. M., & Steinberg, V. E. (1996). Health implications of nitrate and nitrite in drinking water: An update on methemoglobinemia occurrence and reproductive and developmental toxicity. Regulatory Toxicology and Pharmacology, 23(1), 35–43. https://doi.org/10.1006/RTPH.1996.0006

TABLE 1
Incidences of Methemoglobinemia Reported Worldwide, 1941–1995

Subject/location	Cases reported, water concentration	References
1941–1949 Infants, Minnesota	114 cases of infant MetHgb, including 14 deaths (30-month period). All but 2 > 20 ppm nitrate–nitrogen	Rosenfield and Huston, 1950
1945–1970 Infants (worldwide)	2000 cases of infant MetHgb; fatality rate 8% Most cases > 4 × MCL; >80% unknown concn > 100 ppm nitrate; 3% from 14 countries < 40 ppm nitrate; 4.4% German cases < 50 ppm nitrate. Concentration not known in all cases.	Fan *et al.*, 1987, review of worldwide literature
1965 Infant, Colorado	1 infant: Municipal water, 13.3 ppm nitrate–nitrogen	Virgil *et al.*, 1965
1973 Infant, Texas	1 infant: Well water, 17.1 ppm nitrate–nitrogen	Jones *et al.*, 1973
1973 Infant, Oklahoma	1 infant: Well water, 24.4 ppm nitrate–nitrogen	Jones *et al.*, 1973
1972–1982 Infants, South Dakota	Survey of 353 physicians: 29 reported treating approximately 80 cases of MetHgb; 60 of these occurred more than 10 years earlier (1 case not infant)	Nelson *et al.*, 1984
1979 Infant, Petaluma, California,	Well water: Reported as high, but level not specified	DWR, 1982
1986 Infant, South Dakota	2 cases, 1 fatal, > 100 ppm nitrate–nitrogen	Johnson, 1988
1987 Infant, North Dakota	1 case, 50 ppm nitrate–nitrogen	
1991–1992 All ages (U.S.)	Reports from Am. Assoc. Poison Control Centers 1825 exposures to nitrate/nitrite, 542 <6 years old Environmental and other sources	*Am. J. Emerg. Med.* **10**, 452–505, 1992
1993 6-week-old girl Wisconsin	Formula mixed with 1 part water.	MMWR, 1993

A brief history of the Nitrate MCL

- 1945 – Comly concludes methemoglobinemia can occur in infants following ingestion of well water (in formula) high in nitrates
  - Recommended formula water "not more than 10 or possibly 20 ppm", based on zero cases in the record at 10 ppm or less
  - 2.3% of cases from water in range of 10 to 20 ppm
  - Most cases occurred at levels of 40 ppm or more
- Subsequent work explained why infants are susceptible – gastric acid levels are low enough to enable certain nitrite-producing bacteria to thrive.
- Bosch (1950): most affected wells less than 50 feet from barnyard, pig pen, privy, cesspool, or other animal or human waste contamination
- USPHS (Walton, 1951): most cases in private wells serving rural homes, but also some municipal wells

A brief history of the Nitrate MCL

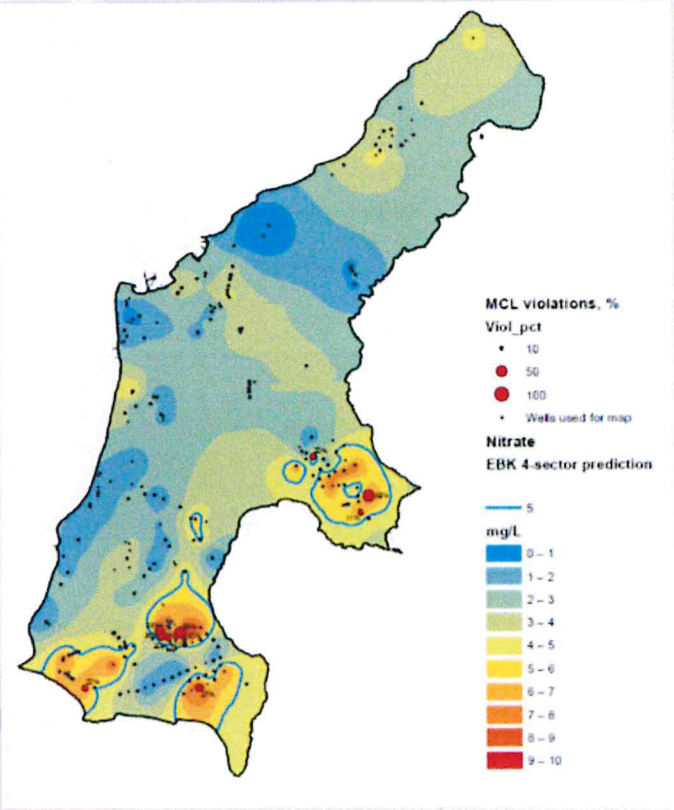
- 1962 – US Public Health Service establishes recommended limit of 10 mg/L nitrate nitrogen
- 1974 – EPA sets nitrate nitrogen MCL at 10 mg/L, nitrite nitrogen at 1 mg/L
- 1991 – EPA sets Total nitrate and nitrite (as N) MCL at 10 mg/L
  - theory: toxicity of both is additive
- Last two decades: EPA re-affirms nitrate and nitrite MCLs

Nitrate Levels in Guam & CNMI

Nitrate results - Saipan

Of 330 wells in database:

- 11 wells (3%) w/ MCL exceedences
  - worst well exceeded MCL on 56% of all samples
- 79 wells (32%) exceed the half-MCL
- Area exceeding half-MCL:
  - 4.47 square miles
  - 9.7% of Saipan's groundwater by surface area



Nitrate Results - Saipan

Comparison to other states:

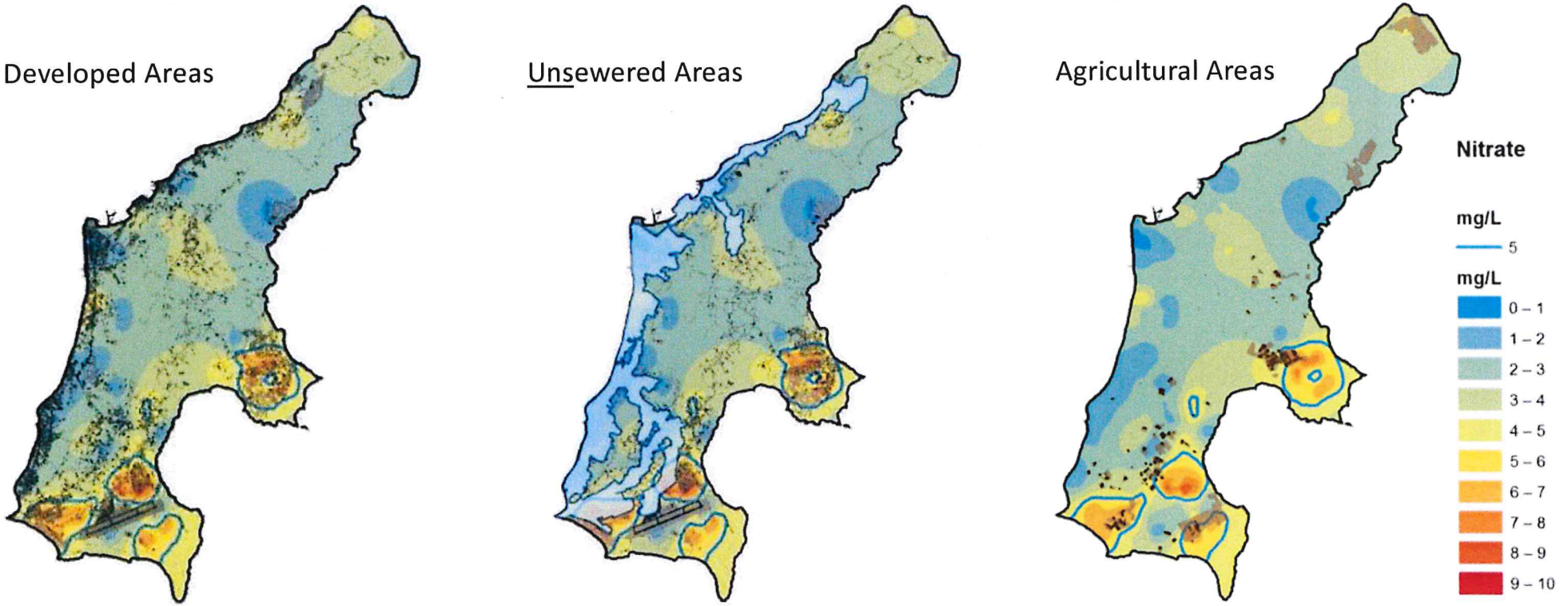
9th place

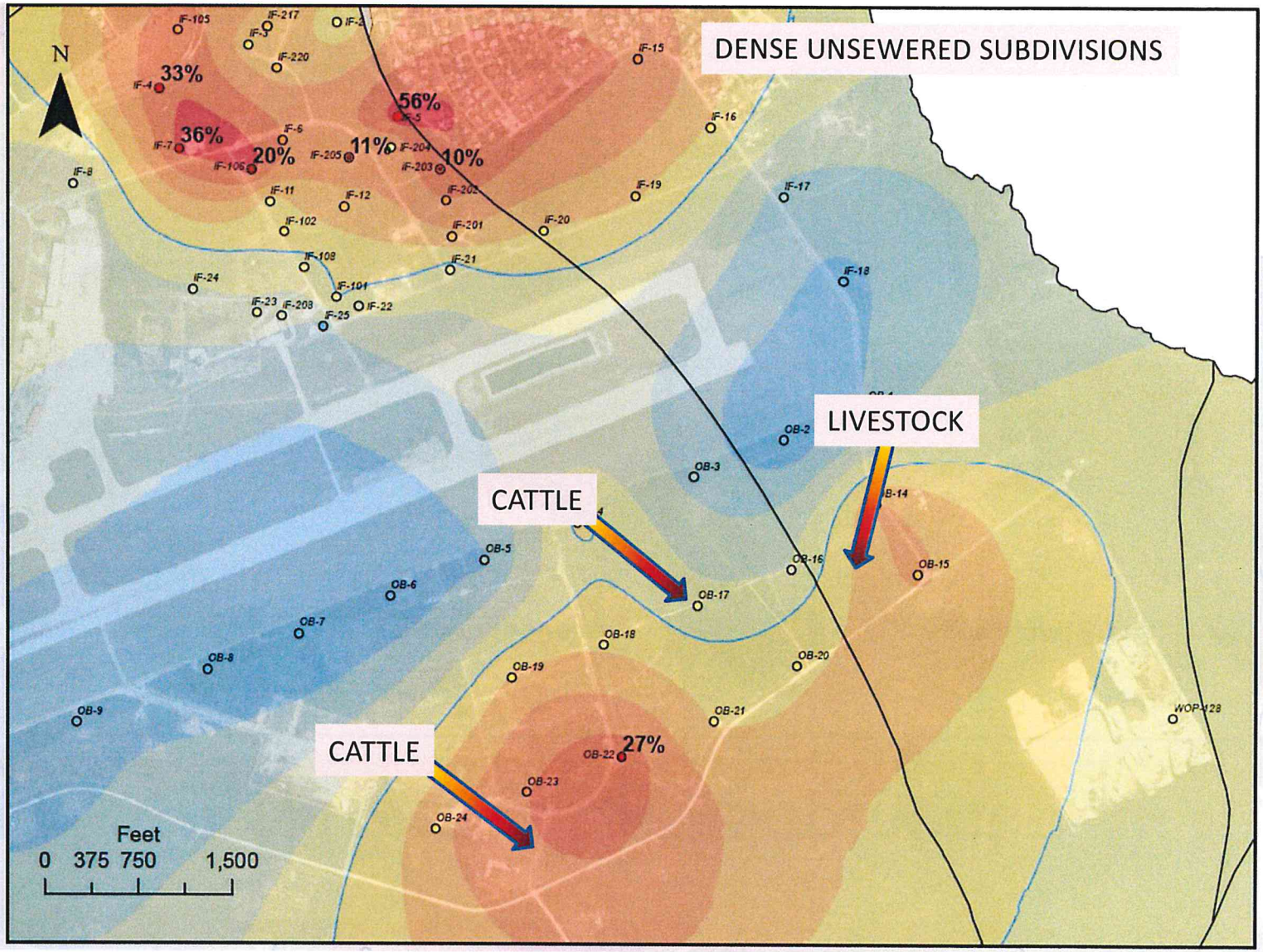
(if Saipan was the entire state)

(Based on EPA data: http://www2.epa.gov/nutrient-policy-data/estimated-nitrate-concentrations-groundwater-used-drinking)

State	Estimated % of state area with groundwater nitrate concentrations > 5 mg/L
Delaware	53%
Maryland	28%
Nebraska	17%
Rhode Island	16%
Louisiana	15%
Arizona	12%
Massachusetts	12%
California	10%
Saipan, CNMI	10%
Florida	9%
New Jersey	9%
North Carolina	9%
Kansas	8%
Washington	8%

Nitrate vs. Development



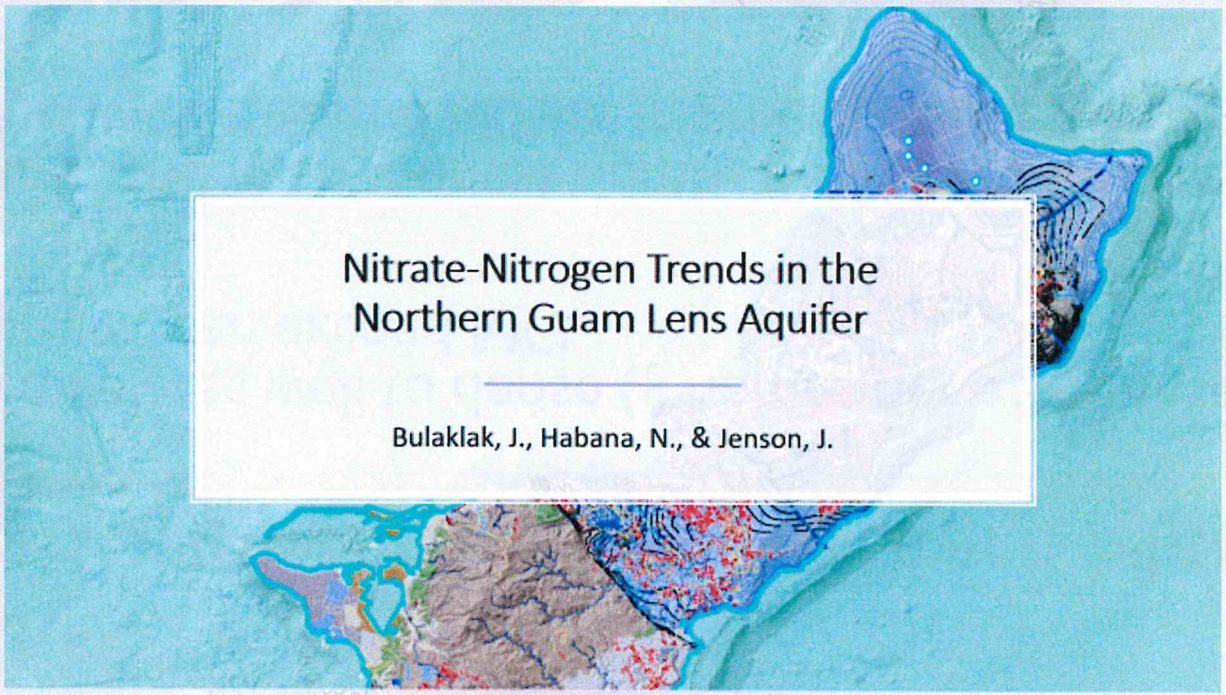

DENSE UNSEWERED SUBDIVISIONS
LIVESTOCK
CATTLE
CATTLE
N
33%
56%
36%
20%
11%
10%
27%
Feet
0 375 750 1,500

Observations from the Northern Marianas

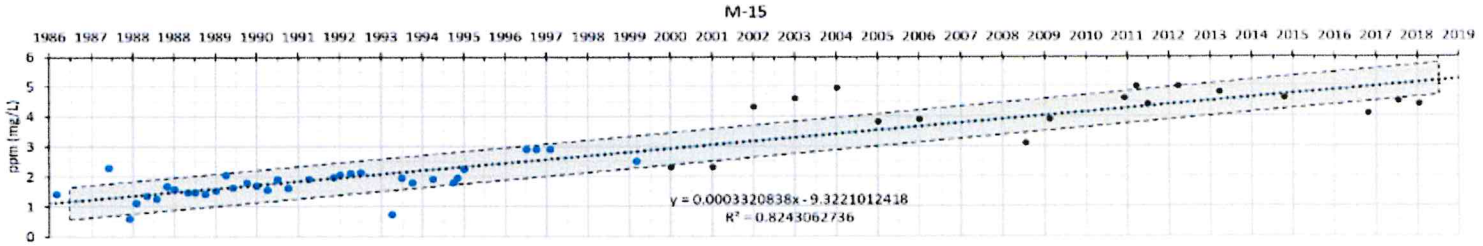
- Nitrate correlates well to dense (4 homes per acre) unsewered development, can exceed MCL
- Agriculture, and even modest numbers of livestock, seem to be associated with elevated nitrate in groundwater, even exceeding MCL
- Depth to groundwater might be a factor: Shallower groundwater (Tinian, ~100 ft) has higher concentrations vs. deeper (Rota, ~600 ft) with similar loadings

Guam

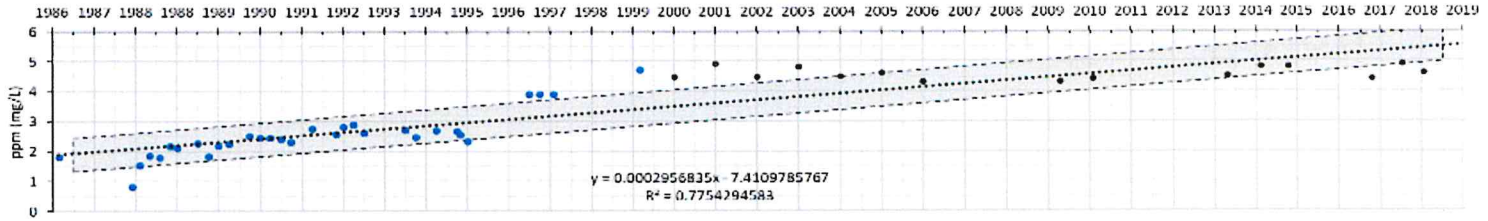
- Research still underway by University of Guam, Water and Environment Research Institute (UOG-WERI):



increasing over entire period
68 wells (47%)

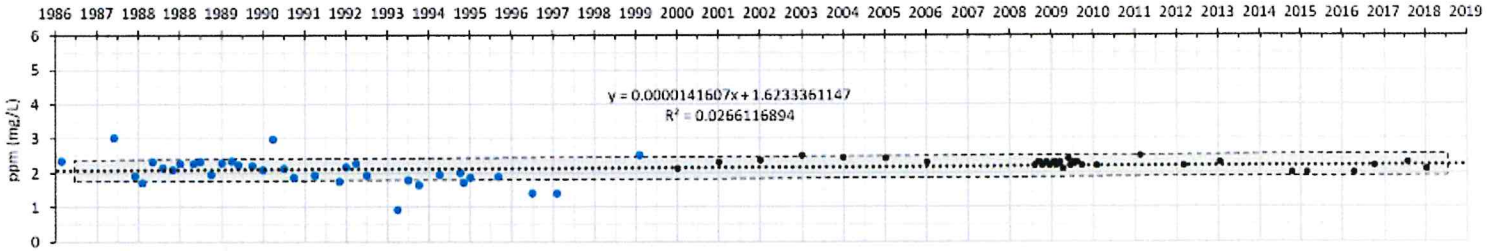


increasing then flattens
16 wells (11%)

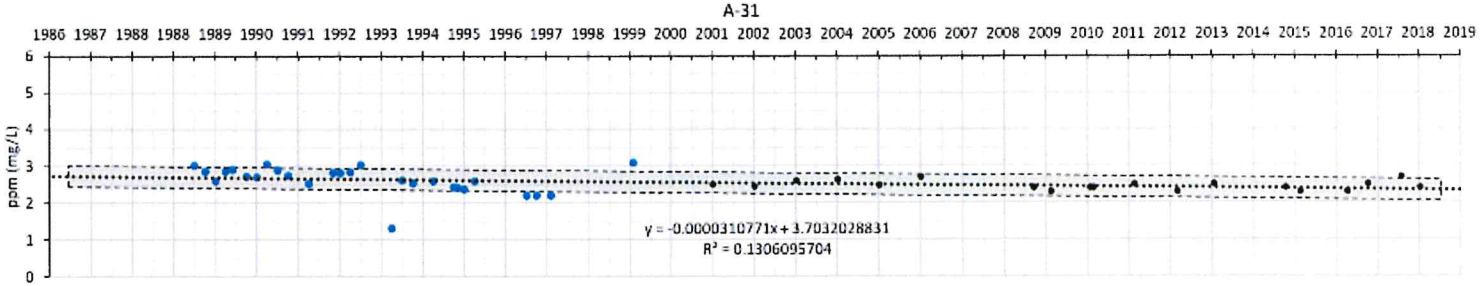


84 wells (58%)

stable
55 wells (38%)



decreasing
7 wells (5%)



Guam Results & Concerns

- Nitrate is increasing in majority of wells (58%)
- Unsewered development is steadily increasing in Northern Guam
- Saipan shows what could happen to groundwater if no action is taken

Nitrate Control on Guam

Policy: in theory and in practice

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1982 Northern Guam Lens Study

- John Mink's landmark report
  - Nitrate is the primary concern for the regulation of on-site wastewater disposal systems
  - Little to no removal of nitrate can be expected from systems installed in Guam's limestone

  - Mink's 1982 computed maximum septic system density: **1 home per 3 acres**
    - Simple, mass balance calculation:
      9400 people
      60 gallons per day wastewater per capita
      54 mg/L nitrate-nitrogen in wastewater
      35 inches per year rainfall recharge rate

1982 Northern Guam Lens Study

- Mink's 1982 revised density calculation: **1 home per 1 acre**

  ASSUMPTIONS:

  - Two-thirds of GPZ will remain undeveloped:

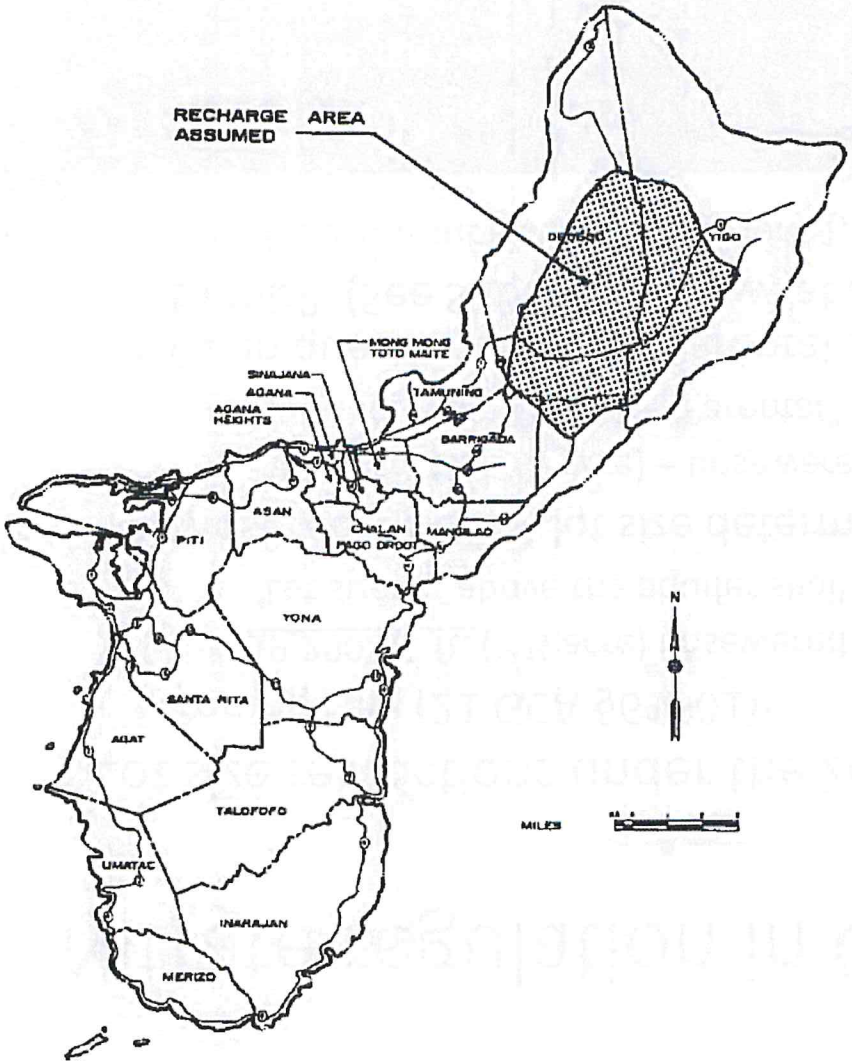
    3 acre min. lot becomes 1 acre

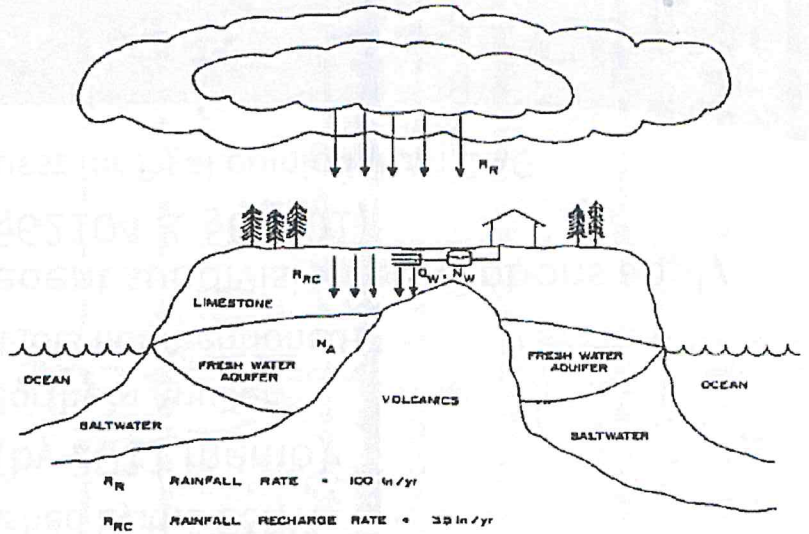
    (same number of septic systems, spread over a smaller area)
  - Background nitrate ("natural"): 1.5 mg/L
  - GOAL: Maximum allowable nitrate contamination: 4.0 mg/L (less than half MCL)
  - Nitrate monitoring to inform revisions to minimum lot size, over time (GEPA monitoring program)

1982 Northern Guam Lens Study

- Mink's 1982 calculated livestock limitations:
  - 4,500 sq. ft. per pig
  - 300 sq. ft. per chicken
  - Strong controls (collection & proper treatment of wastes) highly recommended

- Mink's 1982 fertilizer recommendations:
  - 15 pounds N/acre-year is okay: adds about 0.24 mg/L to aquifer nitrate





R_R RAINFALL RATE = 100 in/yr

R_{RC} RAINFALL RECHARGE RATE = 35 in/yr

Q_W WASTEWATER FLOW = 80 gpcd

N_W NO_3 - N CONCENTRATION IN WASTEWATER = 54 mg/l NO_3 - N

N_A NO_3 - N CONCENTRATION IN AQUIFER ATTRIBUTED TO ON - SITE WASTEWATER SYSTEMS

A RECHARGE AREA = 25 sq. mi.

P RURAL POPULATION ABOVE RECHARGE AREA THAT USE ON - SITE WASTEWATER DISPOSAL SYSTEMS = 9,400 PEOPLE

$$N_A = \frac{N_W \, Q_W \, P}{Q_W P + R_{RC} \, A}$$

$$= 0.72 \text{ mg/l } NO_3\text{-N}$$

NOTE: ASSUMES ALL OF THE NITROGEN IN THE WASTEWATER INFILTRATES INTO THE GROUNDWATER

FIGURE 4-1

NITRATE CONCENTRATION CONTRIBUTION OF ON-SITE SYSTEMS INTO NORTHERN LENS

Nitrate regulation in Guam

- Lot size restrictions under the Zoning Law (21 GCA Ch. 61):
  - Zoning Law (21 GCA §61501):
    - 19,200 sq. ft. (~ ½ acre) unsewered "on top of Northern Aquifer"
    - "Lot sizes … above the aquifer shall be established by the GEPA"
  - Most recent GEPA lot size determination (by 2011 memo):
    - 19,200 sq. ft. (~ ½ acre) – unsewered, "over Northern Aquifer"
    - 9,600 sq. ft. (~ ¼ acre) – "Parental" (Decedent lots not mentioned)
  - Open question: how do Parental and Decedent subdivision exemptions apply to this? (See Subdivision Law at 21 GCA §62104 & §62501)
    - This is the subject of GEPA's April 1, 2019 request for legal opinion from OAG

Nitrate regulation in Guam

- Guam Water Quality Standards (22 GAR §5101(c)(1)(B)):

  "high density residential development, more than one (1) dwelling per one-half (1/2) acre, should not occur without adequate public sewer service"

- The basis for the one-half acre density requirement in the Zoning Law and Water Quality Standards – as opposed to Mink's 1- or 3-acre recommendation – is not known to current agency staff.

Summary of the current regulatory controversy:

- Zoning Law and GEPA rules are clear on one-half acre being the minimum unsewered lot size within the NGLA (GPZ)
- 2011 GEPA lot size memorandum: a memo can't override regulation (Water Quality Standards)
- 2011 GEPA memo mentions only "Parental" lots as exception to one-half acre rule – not "Decedent" lots
- Subdivision Law seemingly contradicts Zoning Law – but unclear and the subject of GEPA's request for Legal Opinion (open since 2019)
- GEPA is concerned with rising nitrate levels, increasing pressure to develop more unsewered areas, & use of Parental and Decedent rules to evade regulation.

FY 2022 to-date Parental Subdivision Septic System Statistics (Oct. 1 through June 27)

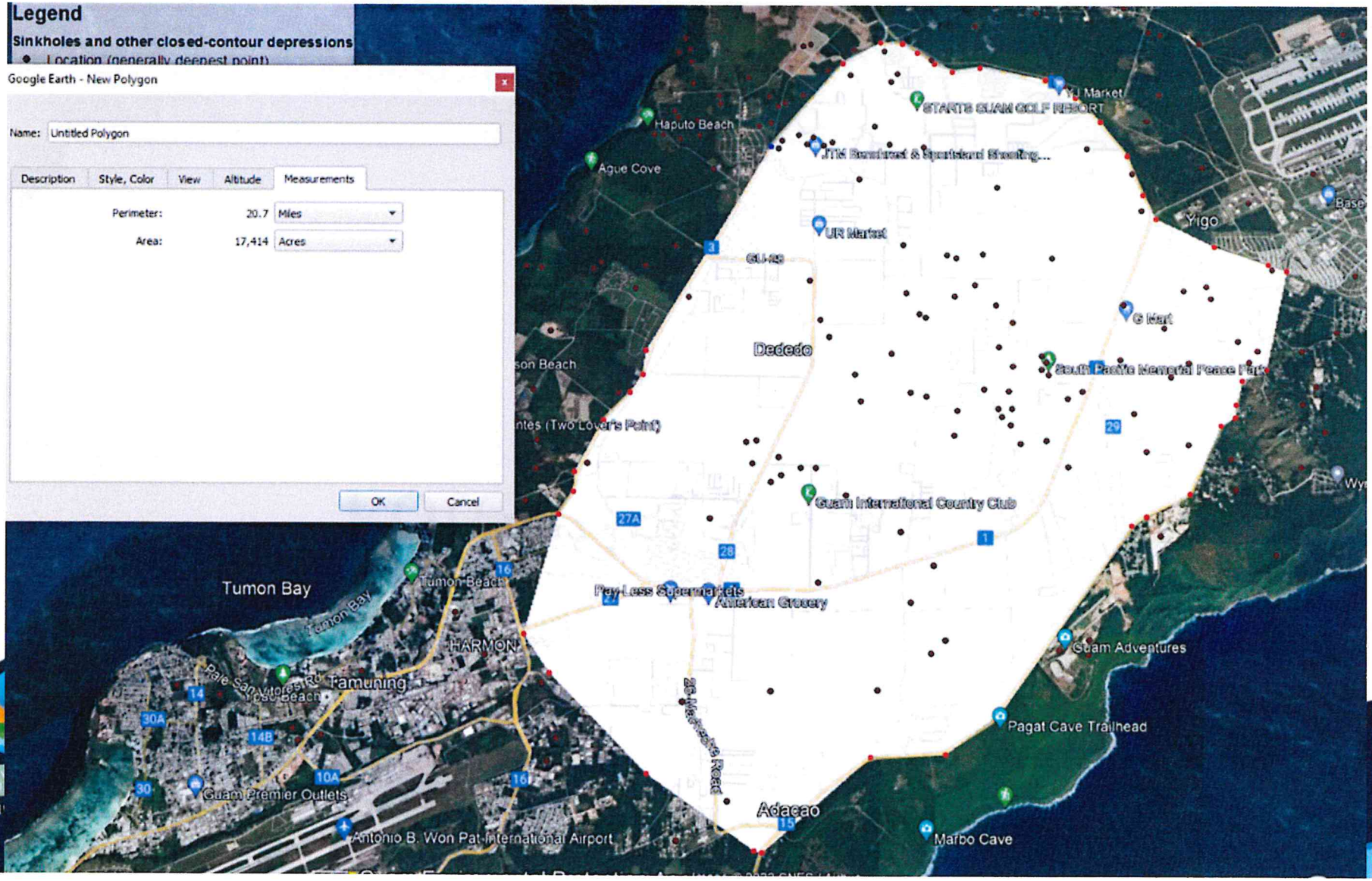
- 79% of new homes built on Guam are on septic systems (145 of 183)
- 52% of new septic systems are located over NGLA (76 of 145)
- 53% of NGLA septic systems are ¼ acre Parental lots (40 of 76)
- 80% of NGLA Parental Lot septic systems are not the original owner (32 of 40)

Current conditions vs. 1982 recommendations:

- Total septic systems allowable within recharge area, per Mink's 1 home per 3 acre calculation to stay within 4 mg/L:

$$\frac{\text{17,400 acres}}{\text{3 acres per septic systems}} = \text{5,800 septic systems}$$

- Actual 2022 count? Records not kept at GEPA
  - 20 years ago: 15,500 septic systems in recharge area (McDonald, 2002)
  - Increasing at around 100 per year, recently
  - Many parts of NGLA are already at 4 mg/L or greater


Legend
Sinkholes and other closed-contour depressions
Location (generally deepest point)
Google Earth - New Polygon
Name: Untitled Polygon
Description
Style, Color
View
Altitude
Measurements
Perimeter: 20.7 Miles
Area: 17,414 Acres
OK
Cancel
Haputo Beach
Ague Cove
YJ Market
UR Market
G Mart
Dededo
Guam International Country Club
Pay Less Supermarkets
American Grocery
Guam Adventures
Pagat Cave Trailhead
Marbo Cave
Adacao
Yigo
Tumon Bay
Tumon Beach
HARMON
Famuning
Guam Premier Outlets
Antonio B. Won Pat International Airport

Potential Solutions

Potential Solutions

- Extend sewer service & connect existing homes
  - The best solution, but costly
  - Who pays? Much of current development is by investors – but skirting the subdivision rules through the Parental and Decedent exceptions
- Density restrictions or moratorium based on nitrate levels
  - Not likely to be supported by developers & land owners
- Technology: nitrogen-reducing onsite treatment systems
  - Costly & require oversight, maintenance. Still adds to the problem.
  - 4 advanced systems equals 2 "old" systems; but still adds 4 homes worth of sewage to NGLA

Current activities

- GEPA working to adopt International Private Sewage Disposal Code
  - 2009 Code adopted as part of 2010 Building Code law – never implemented
  - Numerous conflicts with existing GEPA septic system rules
  - MANY differences – will require transition period (2 years?) and extensive industry training
  - Need to adopt latest edition (2021) to qualify for FEMA training funds
  - DOES NOT address density, or nitrate control

Current activities

- GEPA considering rules to require nitrogen-reducing systems for Parental (& Decedent?) Lots
  - NSF-245 Standard: tested & certified to reduce nitrogen by 50% or more
  - Complicated systems that require O&M oversight
  - Annual operating permit? Third-party maintenance contracts? Already unpopular with the realtors
- GEPA working with legislature to clarify lot size/density issue
  - This is a policy issue and best resolved through policy/law

Questions?

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