RHODE ISLAND DIVISION OF PLANNING

Legislative Task Force

Meeting #5

Tuesday, January 21, 2014
8:00 – 10:00 AM

Conference Room A, 2nd Floor
Department of Administration
One Capitol Hill, Providence, RI

Agenda

8:00 Welcome and Overview of Agenda – *Kevin Flynn, DOP*

8:05 Subject Topics and Technical Presentations:

1. Onsite Wastewater Treatment Systems (OWTS) and Groundwater Science:

- **a.** A snapshot of Water Resource Issues - Dr. Arthur Gold, Professor, Department of Natural Resources Science, URI
- **b.** OWTS 101 - George Loomis, Program Director, New England Onsite Wastewater Training Program, Cooperative Extension, URI
- c. Impacts & Nutrients in Buffer and Riparian Zones - Dr. Art Gold

2. Task Force Questions & Discussion of Presentations – *All - moderated by Kevin Flynn, DOP*

9:55 Next Steps – *Nancy Hess, DOP*

10:00 Adjourn

RI Legislative Task force: OWTS and Groundwater Science

Dr. Art Gold, Professor
University of Rhode Island

January 22, 2014

RHODE ISLAND DIVISION OF PLANNING

THE UNIVERSITY OF RHODE ISLAND
COLLEGE OF THE ENVIRONMENT AND LIFE SCIENCES

Onsite wastewater Pollutants:

- Pathogens
- Phosphorus
- Nitrogen

Pathogens in household wastewater

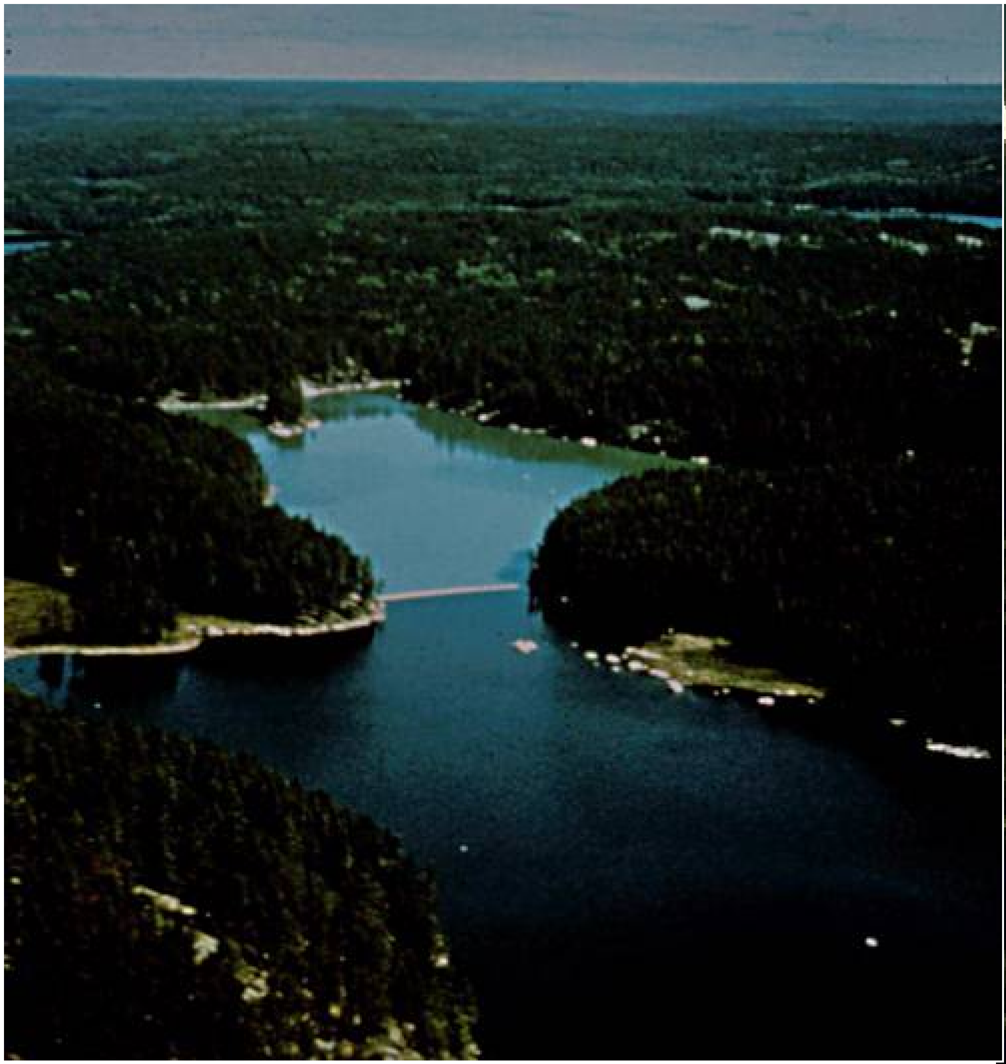
	Incidence (per 100.000) Typically	Excretion (per g wet weight) Typically	Duration (days) Typically
Bacteria			
Salmonella	500	$10^{6,0}$	37
EHEC	30	$10^{2,5}$	8
Viruses			
Rotavirus	1200	$10^{9,0}$	5
Hepatitis A	6	$10^{5,0}$	20
Parasites			
Giardia	1100	$10^{6,5}$	90
Cryptosporidium	200	$10^{7,5}$	7
Ascaris	20	$10^{4,0}$	245

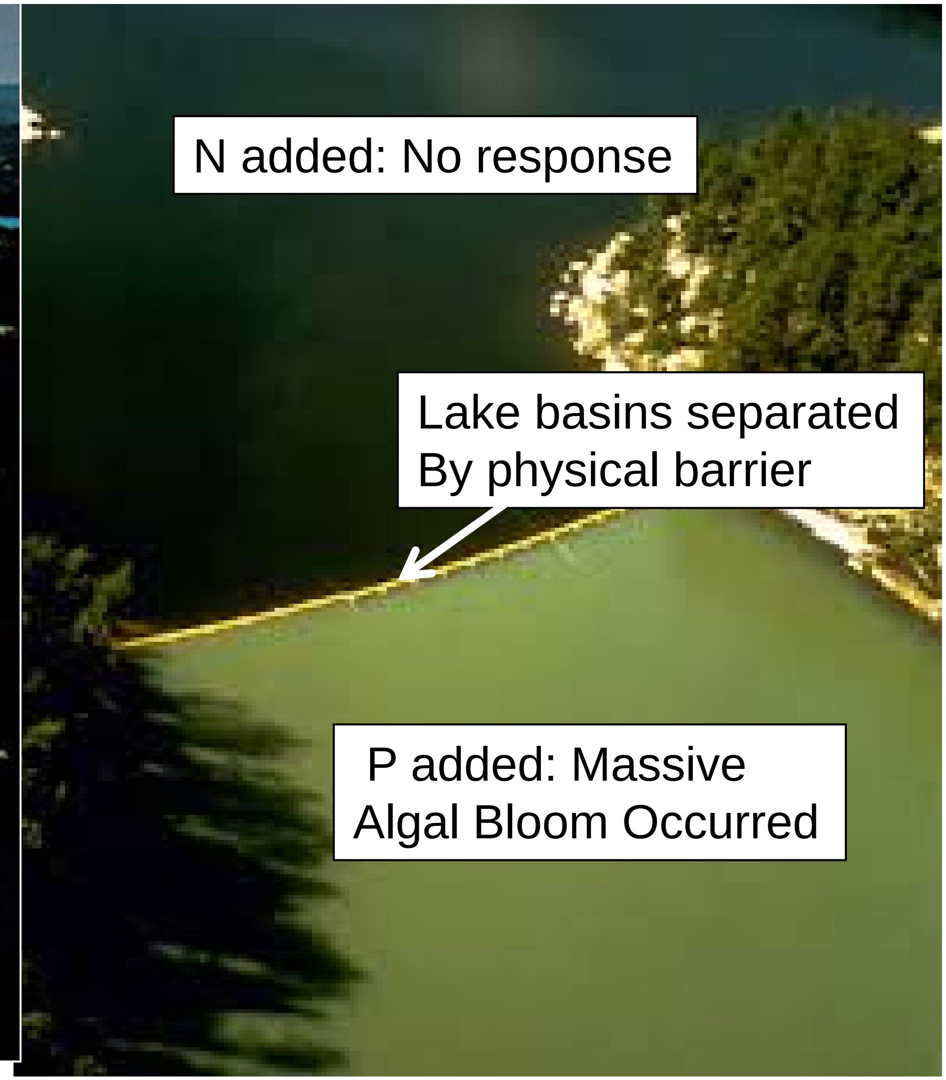
Table 4-3. Percent of Limited or Restricted Classified Shellfish Waters Affected by Types of Pollution (Leonard et al., 1991)

	Septic Systems	Urban Runoff	Ag. Runoff	POTWs	Boats	Industry
North Atlantic	26	23	3	67	17	7
Mid-Atlantic	11	58	12	57	31	20
South Atlantic	34	34	28	44	17	21
Gulf	48	35	8	27	14	14
Pacific	19	36	13	25	15	42
Nationwide	37	38	11	37	18	17

Phosphorus and lake quality

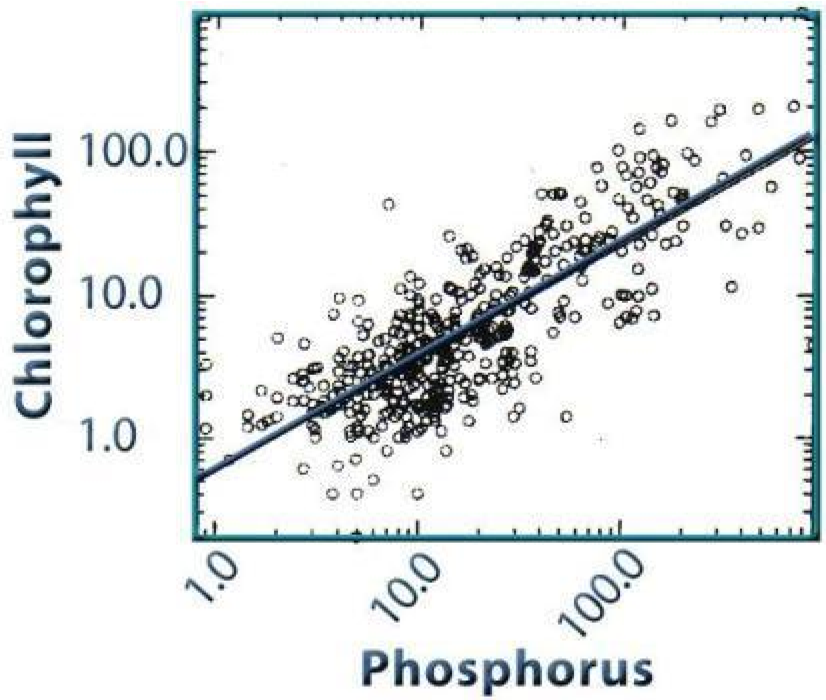
Famous Experiment: Canadian Lakes 227



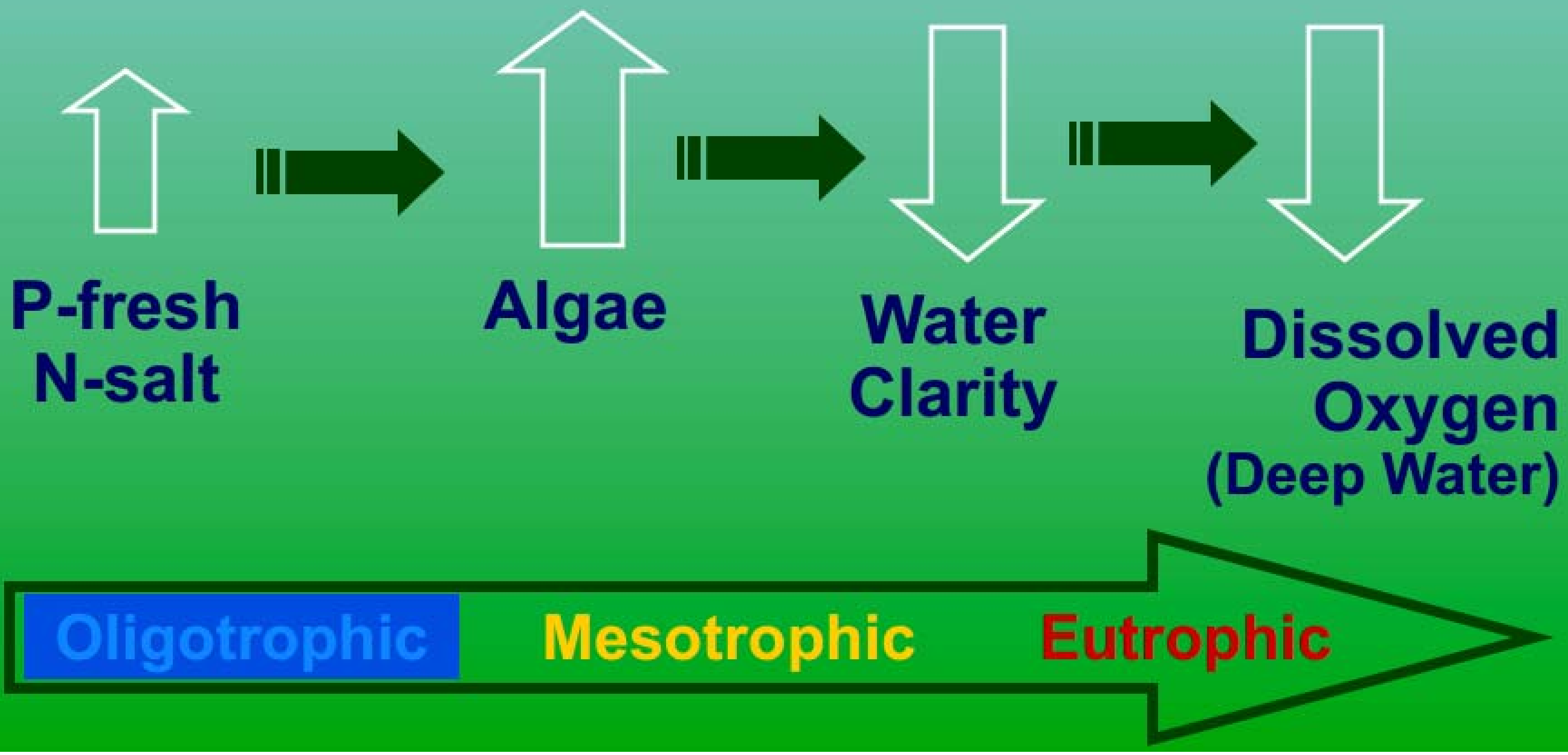


PHOSPHORUS/ CHLOROPHYLL RELATIONSHIPS

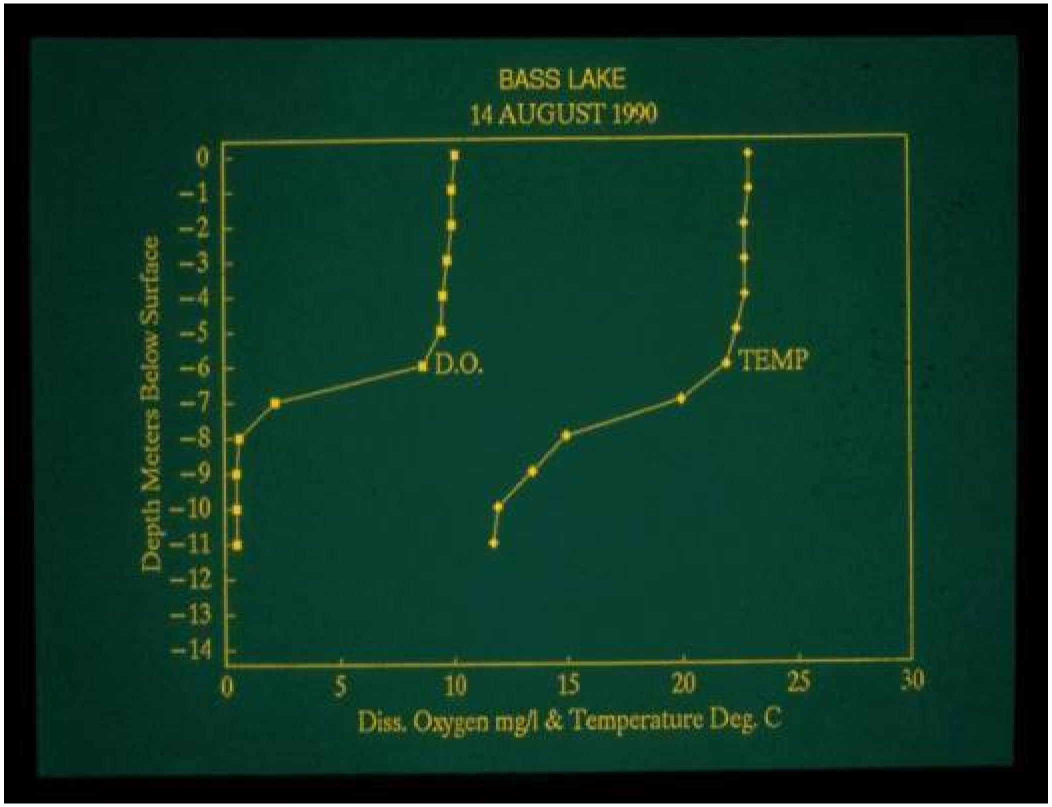
- Phosphorus causes algae growth
- Chlorophyll levels indicate algal biomass



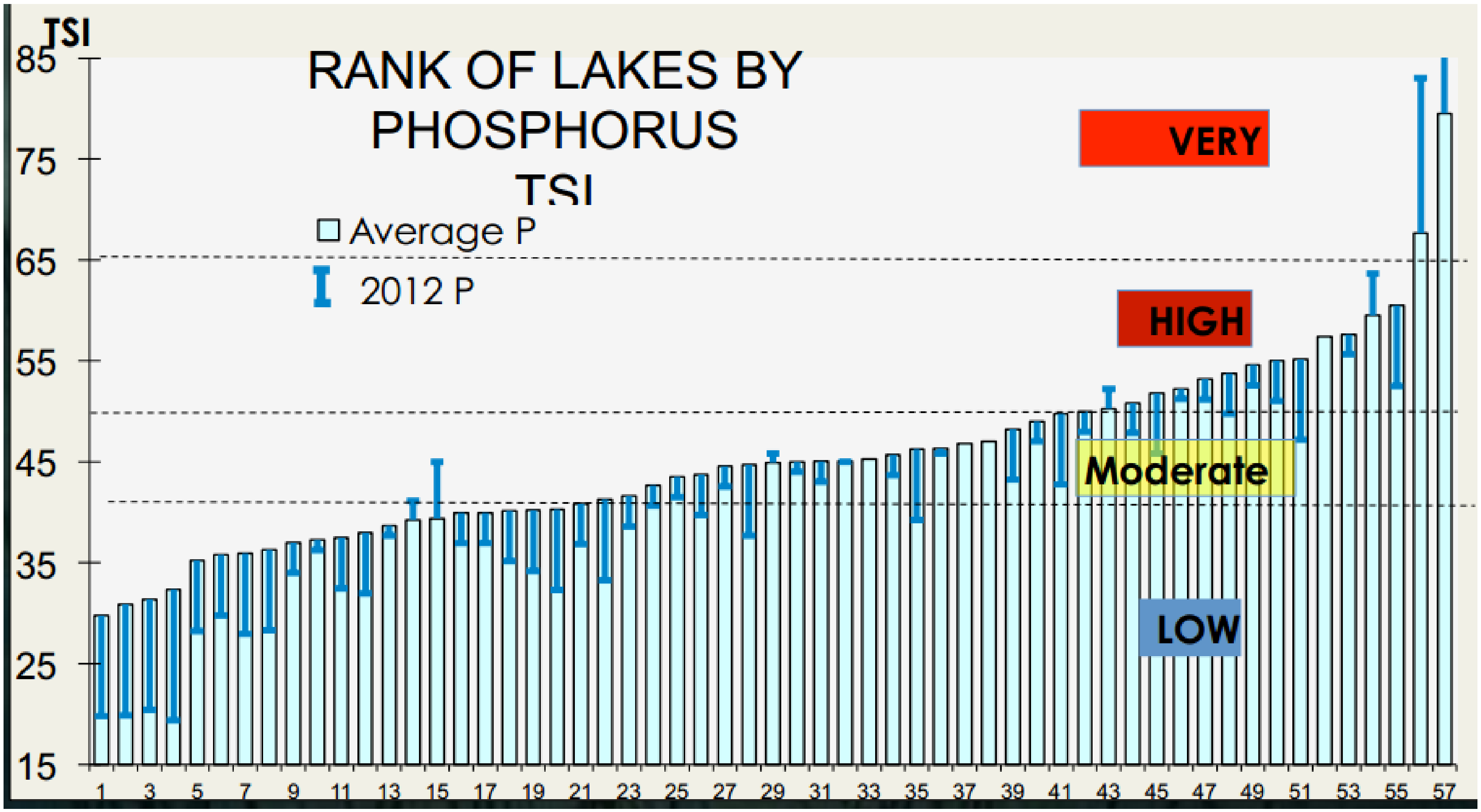
Nutrient Enrichment in Fresh Water = eutrophication



EUTROPHIC DEEP LAKE:
Oxygen depletion of bottom waters; fish habitat loss

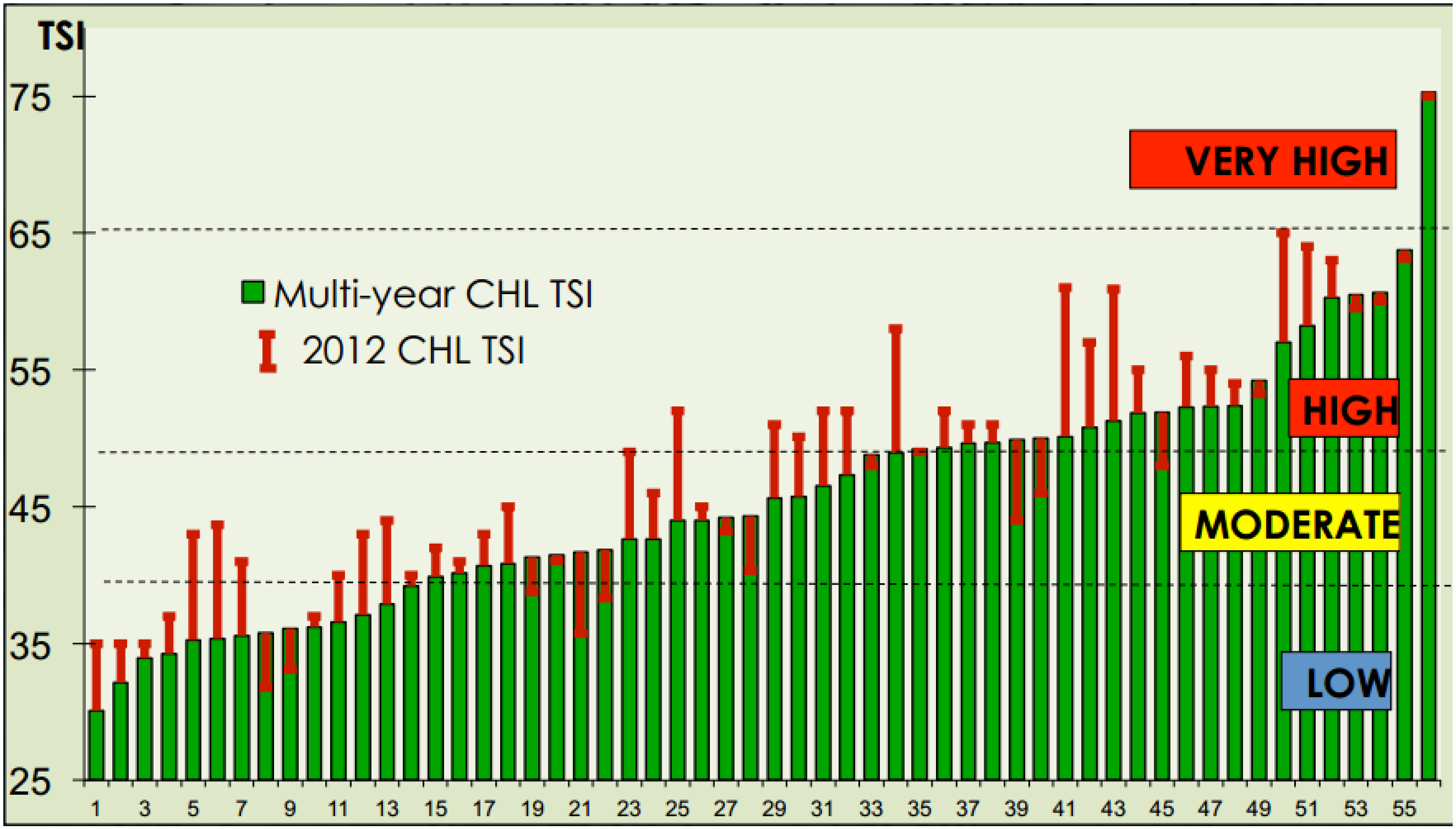


Water quality in Rhode Island's lakes and ponds show wide variation



Source: URI Watershed Watch

Lake algae levels, Rhode Island's lakes and ponds



Source: URI Watershed Watch

Phosphorus and Cyano-toxins

The Umpqua Post

October 9, 2013

Blue-green algae advisory for Tenmile Lakes.

“Oregon health officials say monitoring has confirmed the presence of cyanotoxin above guidelines”

“It’s been around since the dawn of time.”

“when it gets what it needs, which is nitrogen and phosphorus, it actually multiplies into what we call a bloom”

Cyanobacteria: Toxic(?) blue-green algae blooms in Rhode Island's lakes and ponds

Slack's Res, Smithfield
J. Sawyers, RI DEM

Melville Pond, Portsmouth
T. Gray

Cyanobacteria (blue-green algae) concerns

- Neurotoxins, liver toxins and skin toxins (based on type of blue-green algae)
- Human (swimming), pets and livestock risks
- Frequent documented incidents of dog deaths across country
- Exploring drinking water risks (suspected in mass gastro-enteritis epidemic in Brazil and liver disease in many locales)
  (Chorus and Bartram. 1999. WHO. ISBN 0-419-23930-8)

Why have blue-green algae emerged as a recent concern?

- Affordable testing for toxins and field detection
- World Health Organization concerns
- Increasing blooms due to phosphorus loading and summer weather

Blue-Green Algae Microcystin (toxin) Testing				
Laboratory	Phone	Drinking Water	Surface Water	Cost
Central Ontario Analytical Laboratory (COAL)	705 326 8285	✓	✓	$50/sample; requires 1 litre of water; sample only on Thursdays; results are known on Fri
City of Hamilton	905-546-2424	✓	✓	$495.91/sample
Near North Laboratories	(705) 497-0550	✓	✓	$120 + HST
Testmark Laboratories	(705) 693-1121	✓	✓	$180 + HST
York-Durham Regional Environmental Laboratory	(905) 686-0041	✓	✓	$74 algae only $150 toxins only $224 for both algae and toxins + HST
SGS Lakefield Research	(705) 652-2000		✓	$170 + HST

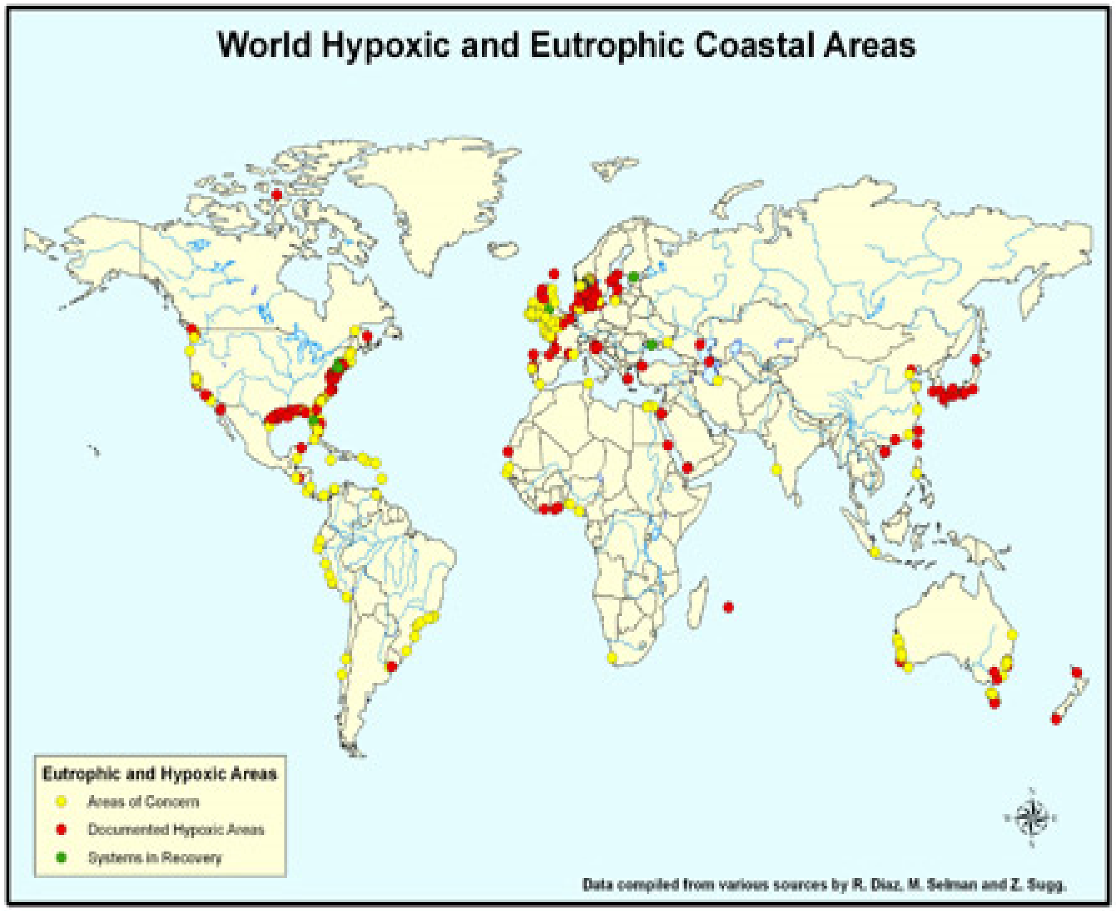
Algae torch: In-situ sensor for blue-green algae levels in seconds

Nitrogen and coastal waters:

Stimulates algal growth

Creates dead zones in bottom waters

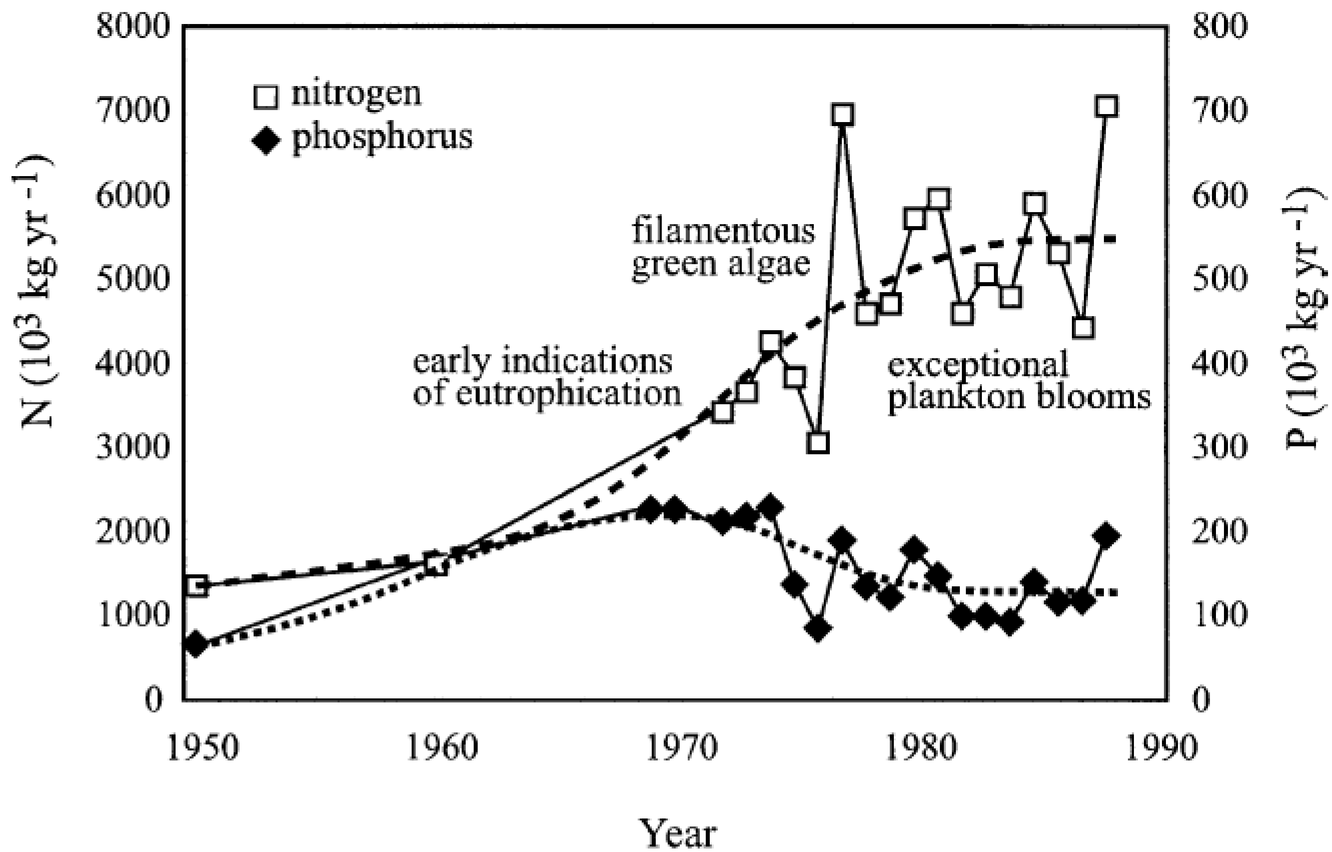
Alters habitats (e.g., degrades eelgrass beds)



Degraded eelgrass with epiphytes

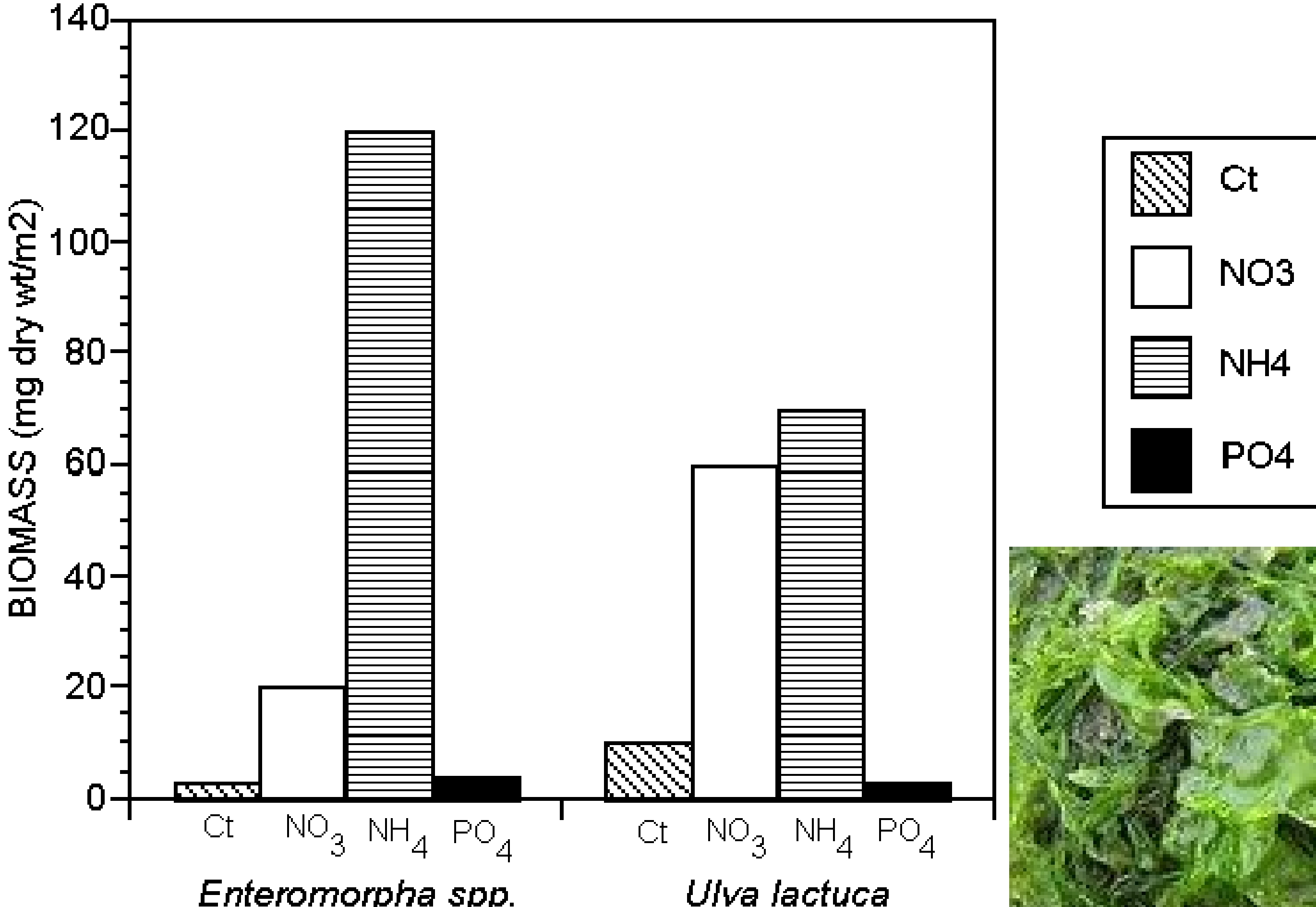
Fish Kill, Greenwich Bay, RI

Whole Ecosystem Scale Observations: Scandinavia: Eutrophication response to N inputs



Howarth RW et al. (2000) *Clean Coastal Waters: Understanding and Reducing the Effects of Nutrient Pollution*. National Academy Press, Washington, D.C.

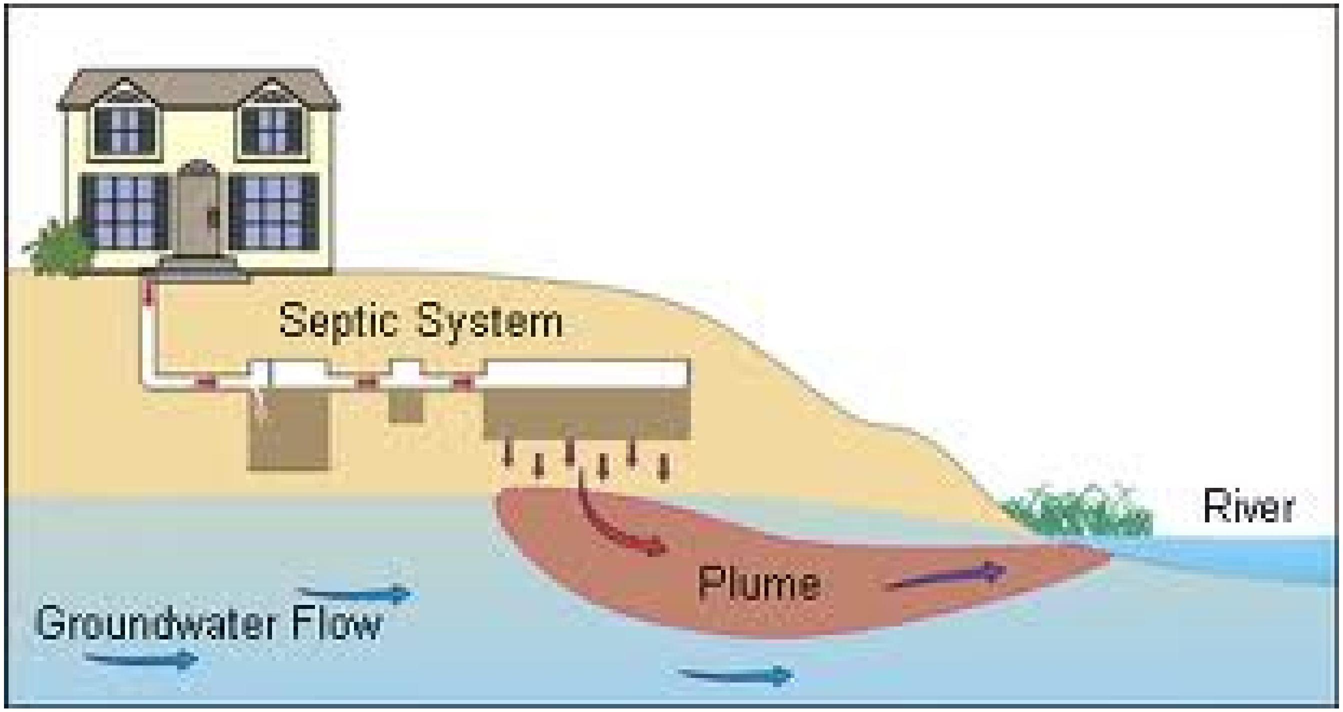
Figure 3-12. Response of green algae in Ninigret Pond to nutrient enrichment during the summer of 1980. Note the dramatic growth response to nitrogen additions compared to phosphorus. Data from Harlin and Thorne-Miller 1981.



George Loomis

Fate and treatment of OWTS Pollutants

Fate of OWTS contaminants in groundwater: Role of buffers



Dominant factors controlling removal of OWTS contaminants in groundwater?

Pathogens:

- Travel time in aerobic media
- (i.e. separation distance)

Phosphorus

- Loading rate
- Distance within mineral, aerobic
  media

Nitrogen

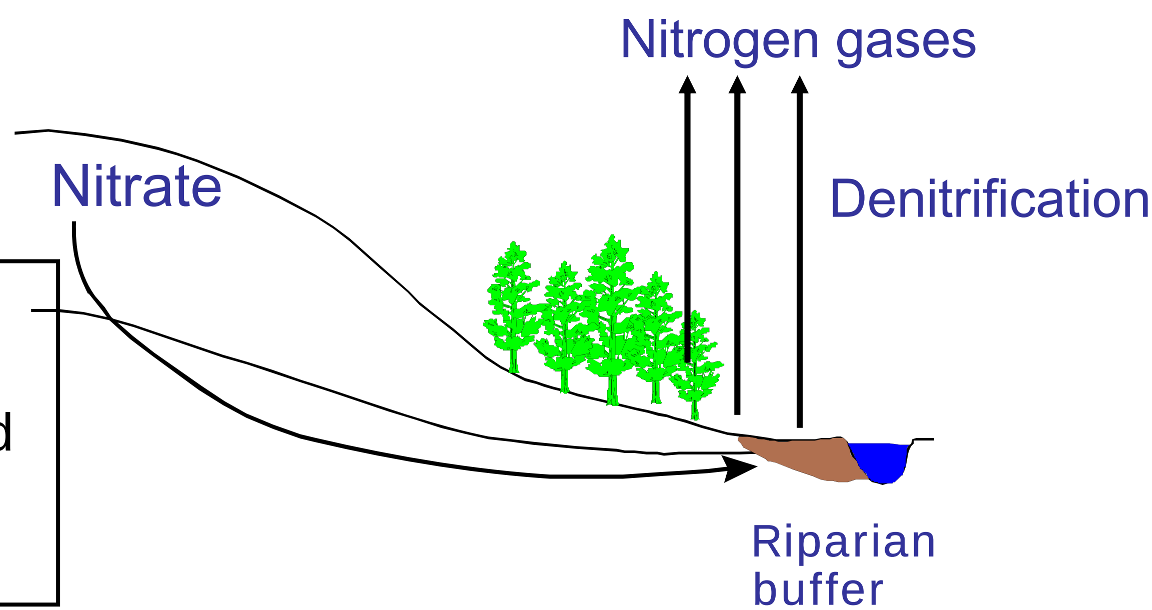
- Nitrate-N can travel long distances in mineral aquifers
  Can be removed in anaerobic, wetland soils

N removal in buffer zones is variable

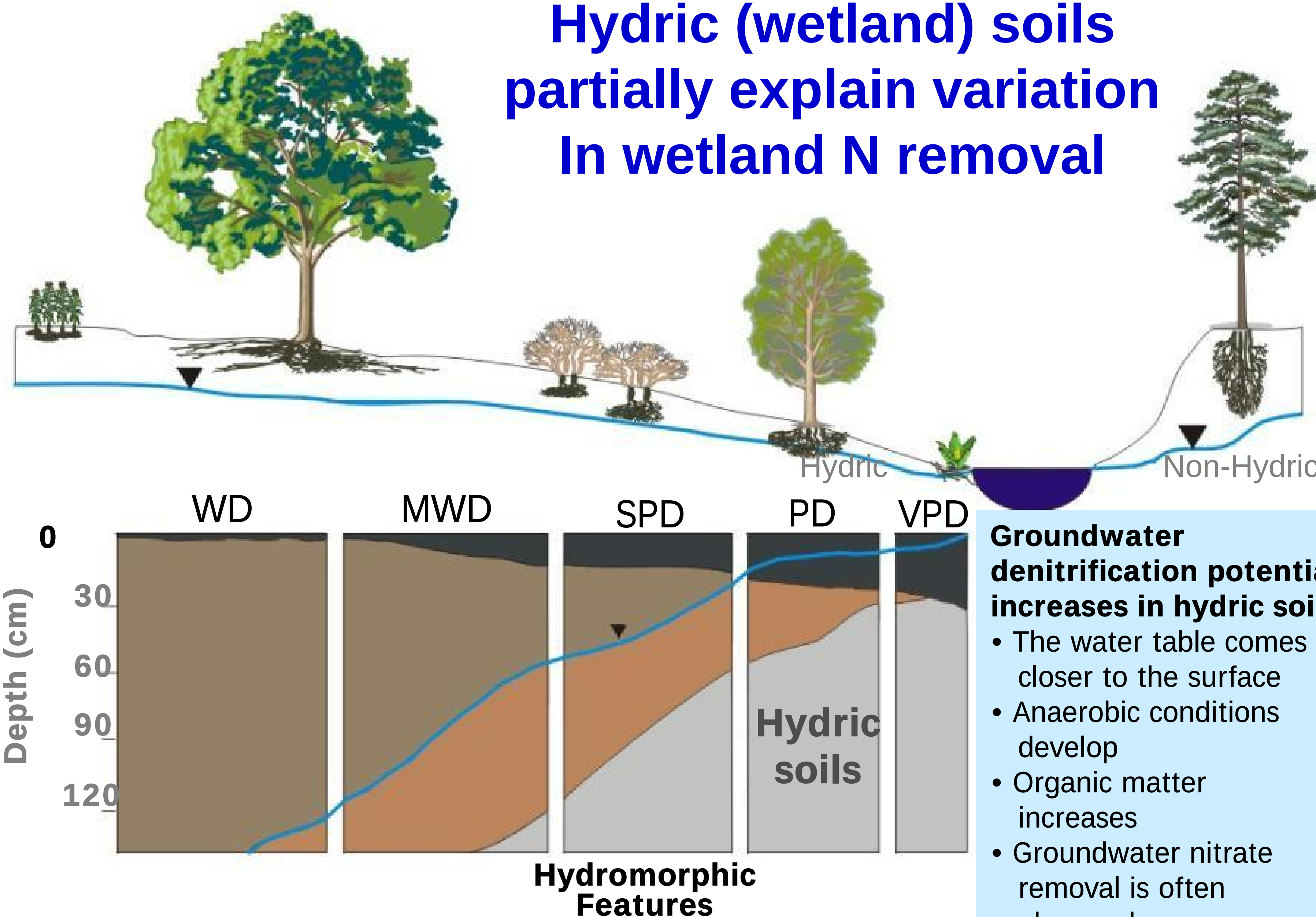
Uncertainties

- <u>Aquifer depth and flow paths</u>
- Depth of organic media
- Extensiveness of wetland buffer along shoreline

Ideal:
Shallow groundwater moves through vegetated anaerobic, organic soils (source: Louis Schipper)



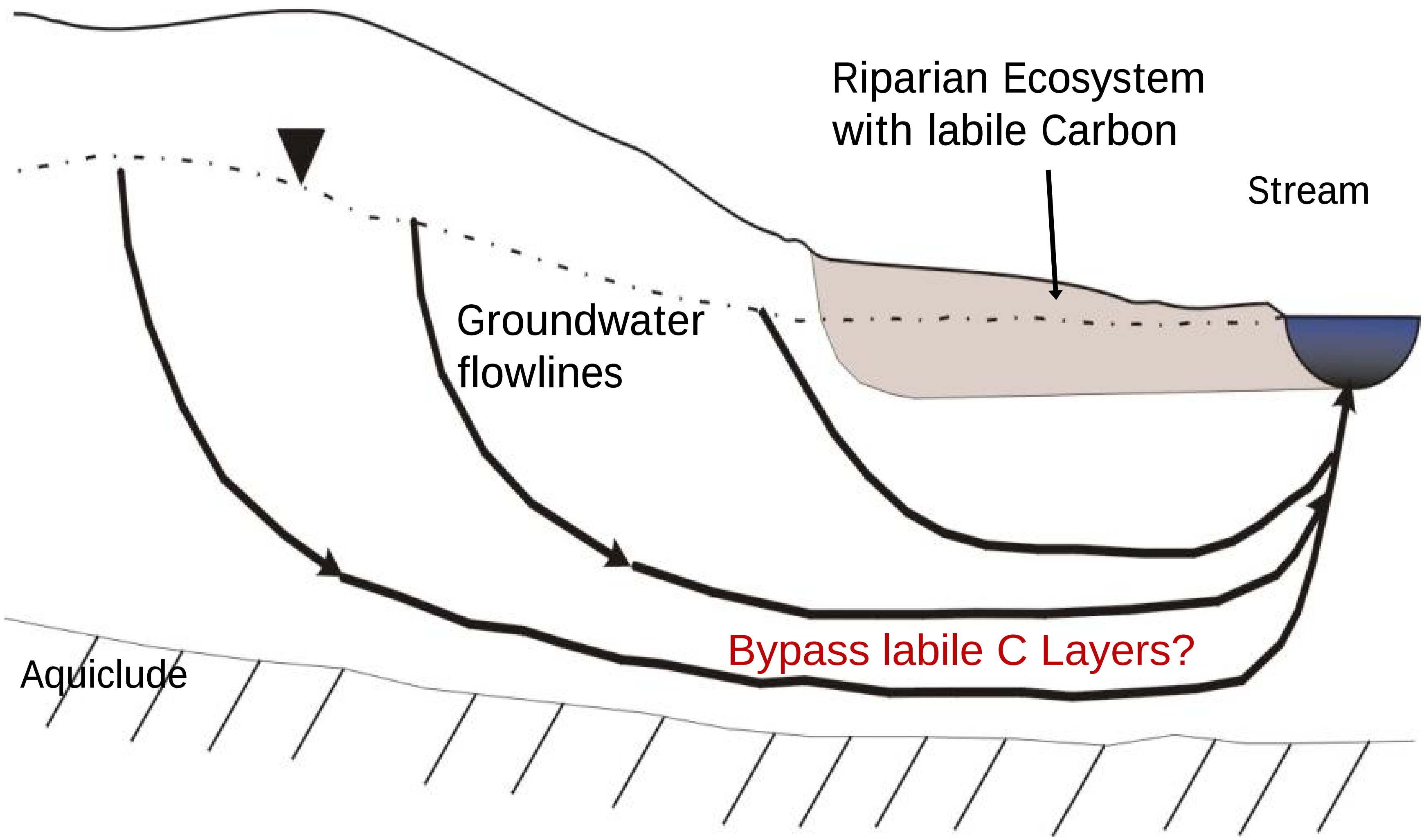
Hydric (wetland) soils partially explain variation In wetland N removal



Groundwater denitrification potential increases in hydric soils

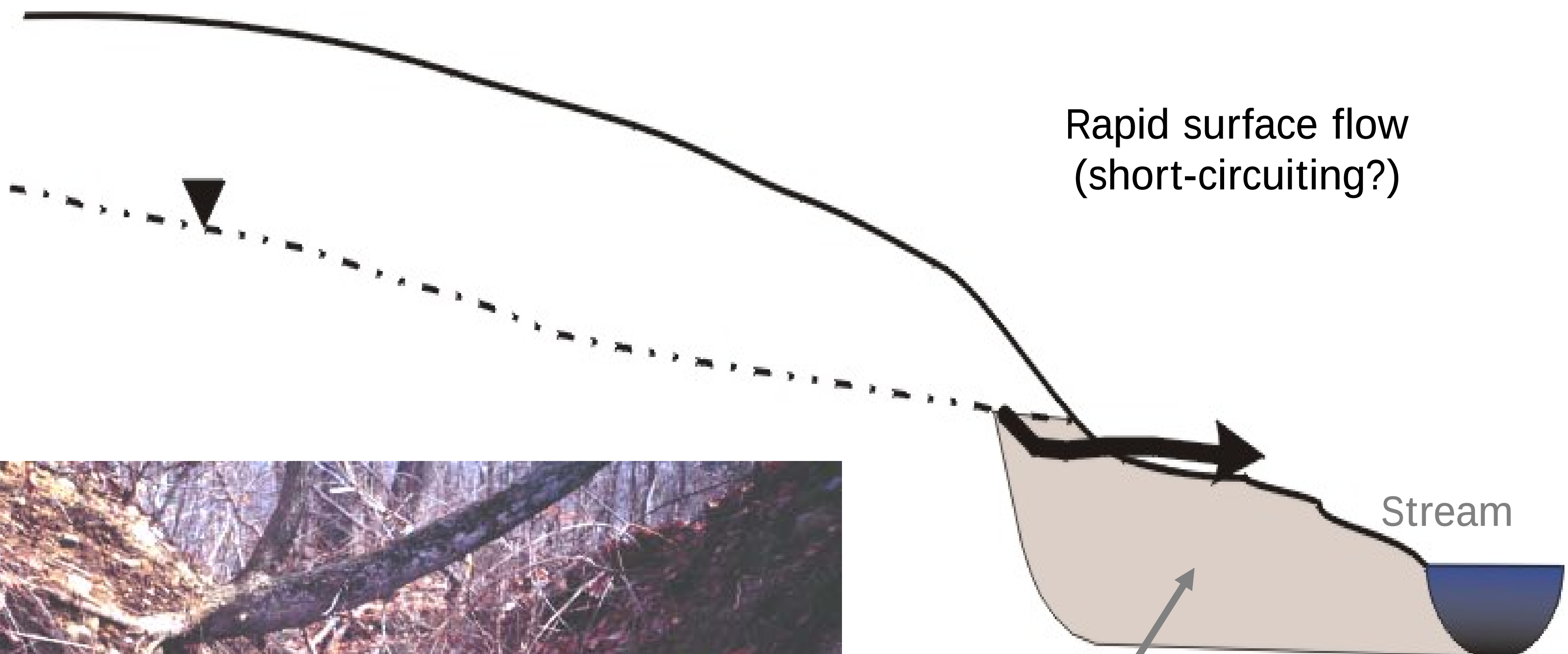
- The water table comes closer to the surface
- Anaerobic conditions develop
- Organic matter increases
- Groundwater nitrate removal is often observed

In deep aquifers nitrate-enriched groundwater may bypass organically enriched media



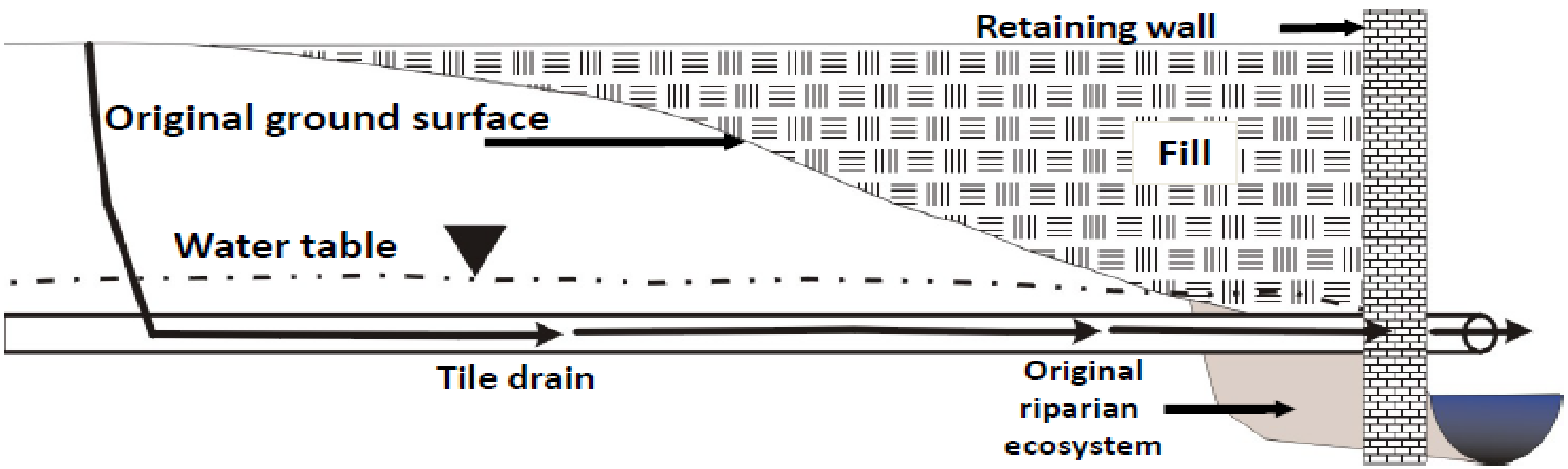
Groundwater Seeps

- Seeps found at 29/34 **hydric** till sites during field reconnaissance
- Expect reduced groundwater N removal potential in till



Rosenblatt et al., 2001; JEQ

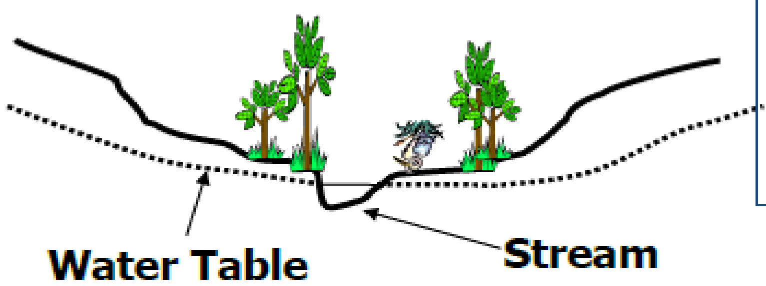
Altered Hydrology:
Riparian Buffer Zones will NOT remove N with artificial drainage



- Groundwater bypasses under riparian ecosystem
- Trees or grass buffers will not lower N loading from fields.

Gold et al., 2001

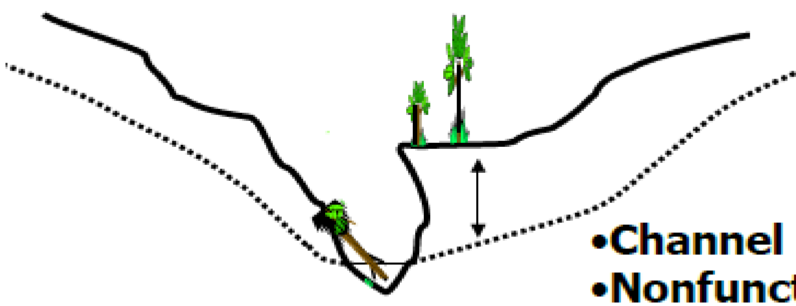
I. Natural Channel



Urbanization:
- **Lower Riparian Water Tables**
- **Disconnects flow paths from riparian ecosystem**

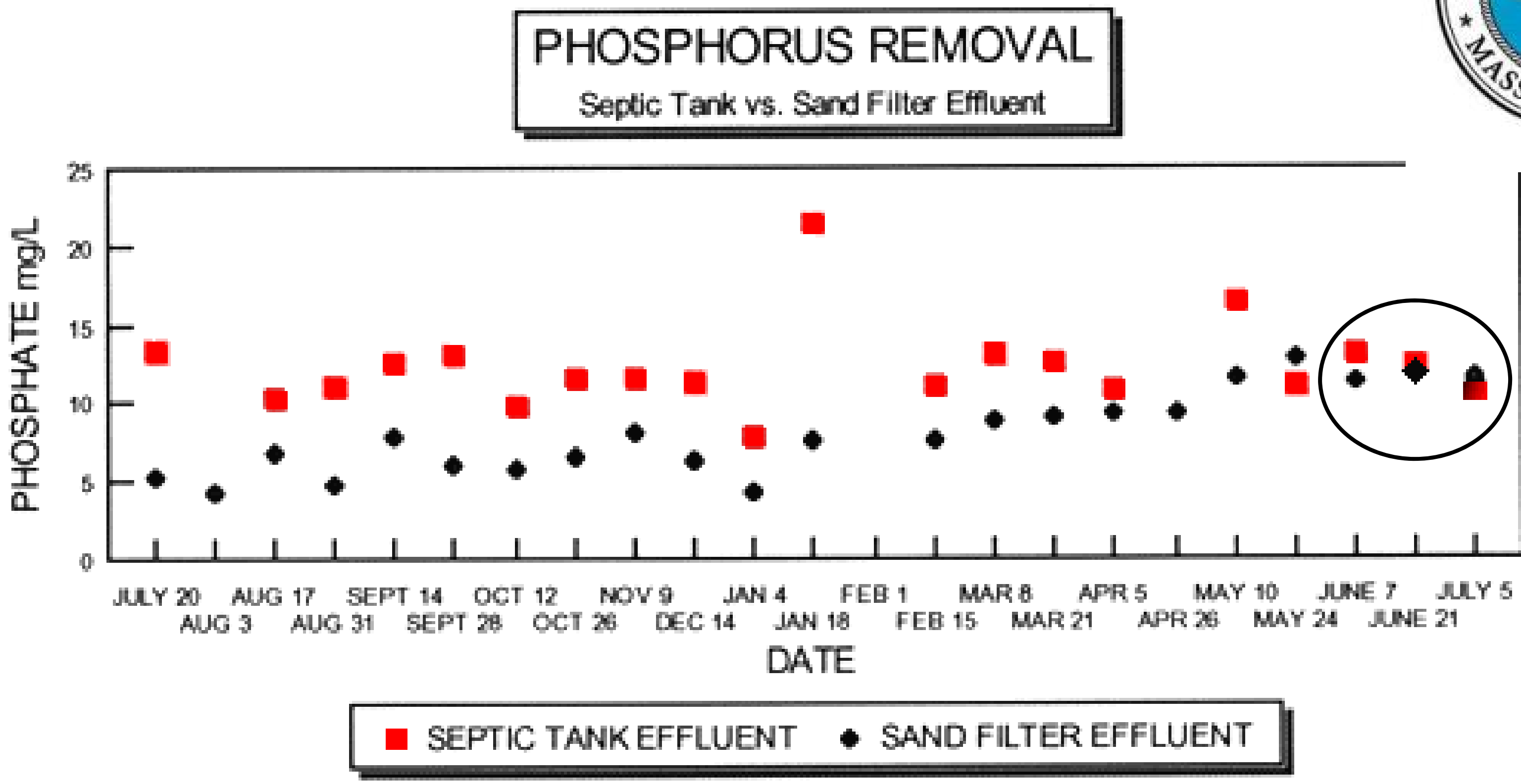
Groffman et al, 2004

II. Channel with Incision Due to Increased Runoff



- **Channel Erosion**
- **Nonfunctional Floodplain**
- **Dry Riparian Soils**

P removal in Onsite Wastewater Treatment Systems: Limited removal with time (saturation occurs)

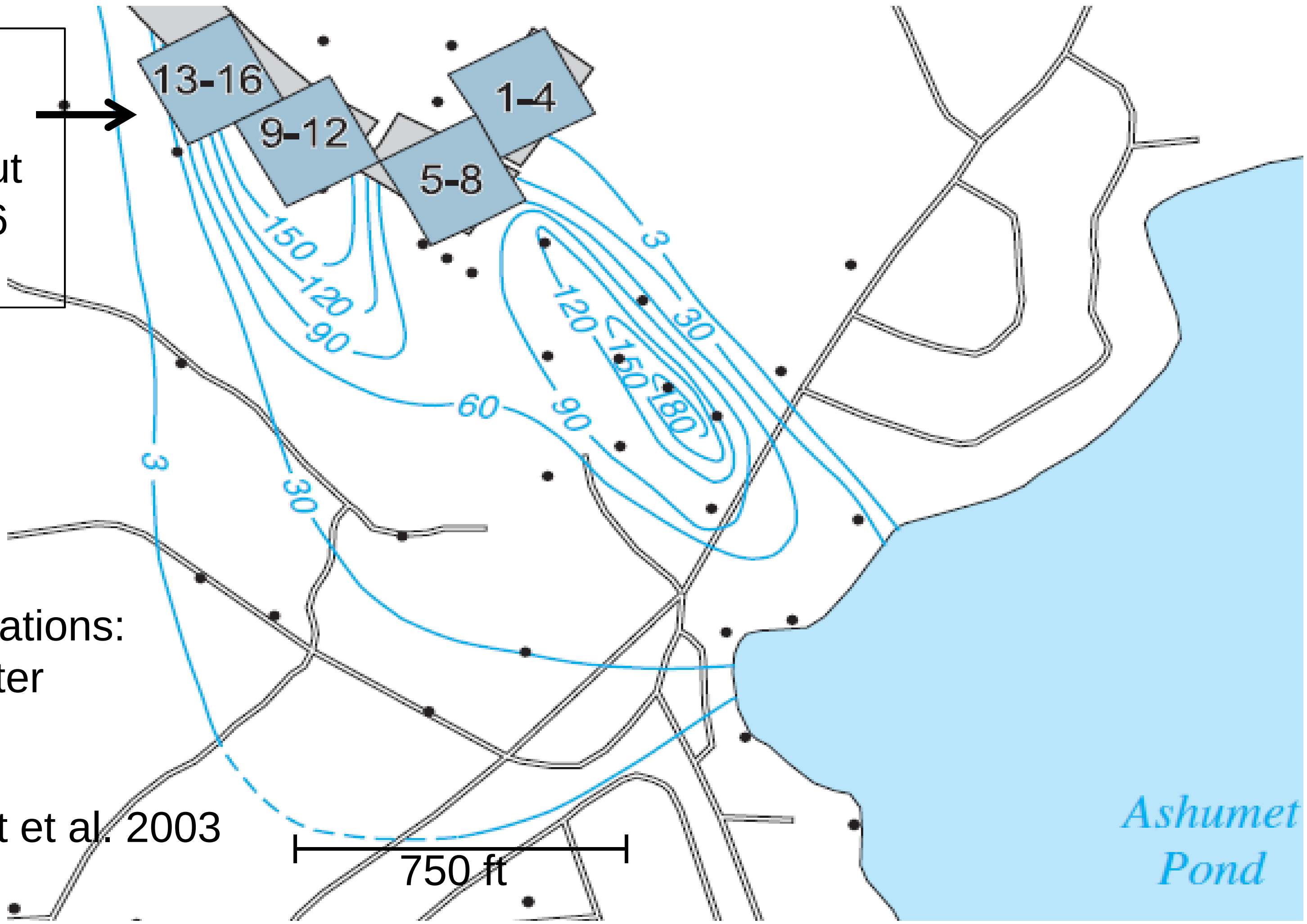


< 10% removal of P after 1 year of operation

Groundwater P concentrations: 60 years of subsurface wastewater disposal: Cape Cod

Phosphorus Doesn't Migrate in Ground Water? Better Think Again!

Sewage disposal beds: Input P = 190 (6 mg/l)

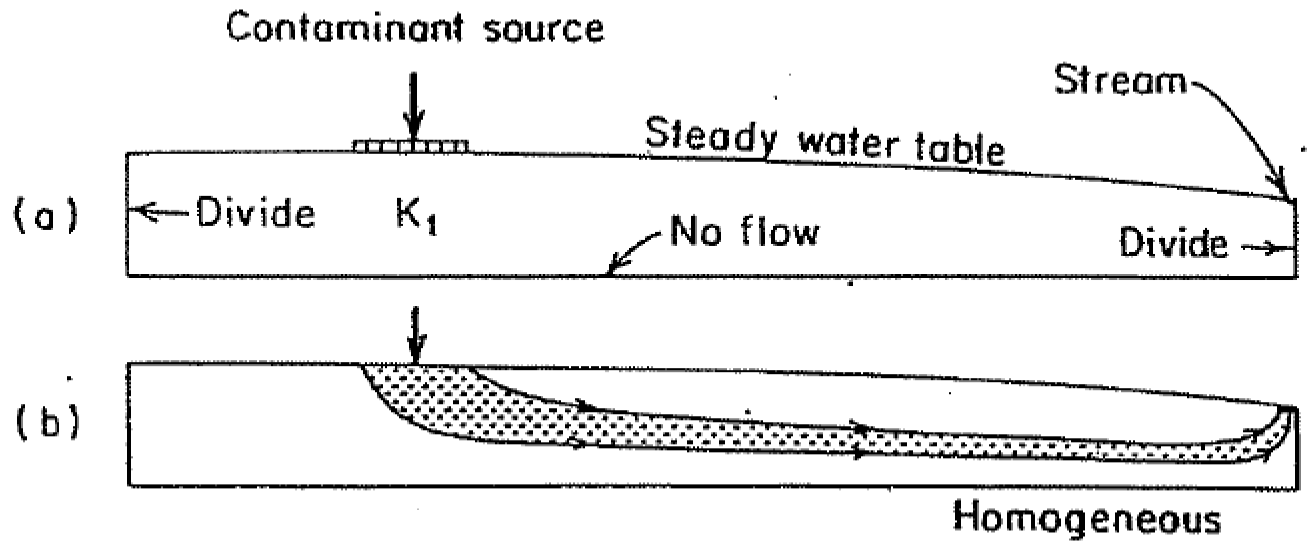


Concentrations: umoles/liter

Parkhurst et al. 2003

Reducing risks: Buffer distance vs. hydrologic investigations

The pattern of aquifer deposits controls the pathway, retention times and possible fate of OWTS contaminants (cross-sectional view)



Uniform deposits can yield extended travel times and result in high removal of many contaminants

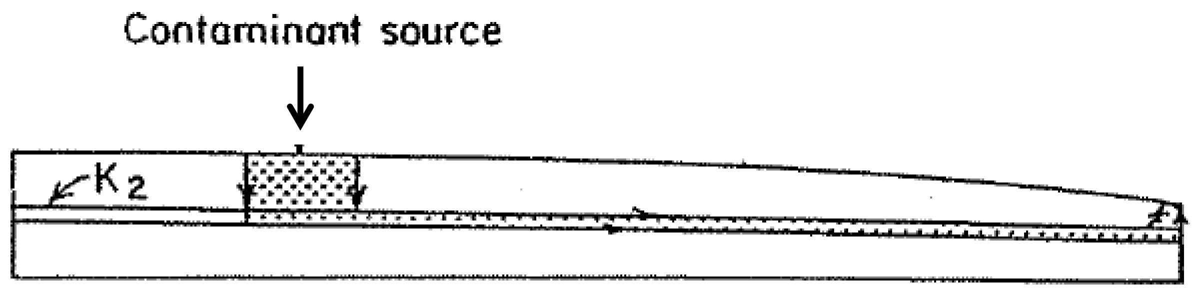
Coastal wetland aquifers: Complex stratigraphy. Alternating sand and organic deposits

Sandy
Storm Overwash

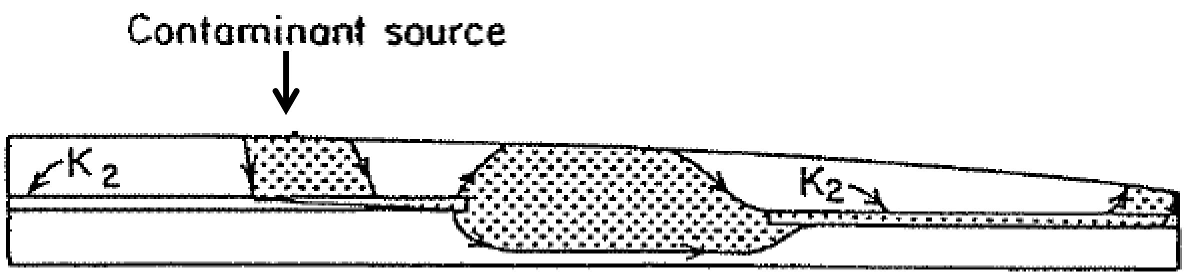
Sandy deposits over salt marsh soils

Photos: Don & Nate Bousquet

Where wetlands have layers of sand – most of the flow will move rapidly through the sand: Potential short-circuit of removal processes



More extended buffers permit more opportunities for interaction with the buffer media



Characterizing subsurface flow requires extensive (and expensive) field work -- buffers

Parting Thoughts

- **There is no “magic” distance**

- **Aquifer characteristics are highly uncertain and have strong influence on contamination reaching receiving waters**

- **Characterizing subsurface flow requires extensive (and expensive) field work – hydrologists are not cheap.**

- **Buffer length reduces contamination risks**

References:

http://www.barnstablecountyhealth.org/ia-systems/information-center/compendium-of-information-on-alternative-onsite-septic-system-technology/recirculating-sand-filters-rsf

Parkhurst et al. 2003. Water Resources Investigations Report 03-4017

Gold, A. J. and J.T. Sims. 2000. Risk Based Decision Making for On-site Wastewater Treatment. U.S.EPA/EPRI. pp. 114-146

Gold et al., 2001. Journal of American Water Resources Association. 37:1457-1464

Groffman, P.M., K. Butterbach-Bahl, R. W. Fulweiler, A. J. Gold, E.K. Stander, C. Tague, C.Tonitto, P. Vidon. 2009. Challenges to incorporating spatially and temporally explicit phenomena (hotspots and hot moments) in denitrification models. Biogeochemistry. 93:49-77.

Leonard et al. 1991. The 1990 National Shellfish Register. NOAA.

Rosenblatt, A.E., A.J. Gold, M.H. Stolt, P.M. Groffman and D.Q. Kellogg. 2001J. Environ. Quality. 30:1596-1604.

Onsite Wastewater Treatment Systems

Legislative Task Force on Setbacks and Buffers

January 21, 2014

George Loomis

New England Onsite Wastewater Training Program @ URI

NEOWTC @ URI

- We are a USDA, state and training class fee funded program
- Coverage area: Regions 1&2 – New England, NY, NJ, PR & USVI
- Provide third party, non-biased technical assistance
- Clientele includes federal and state regulatory agencies, communities, NGOs, wastewater professionals, homeowners
- Conduct approx. 50 classes a year reaching over 1,800 wastewater practitioners and decision makers
- We perform onsite wastewater research
- Work closely with state regulatory programs

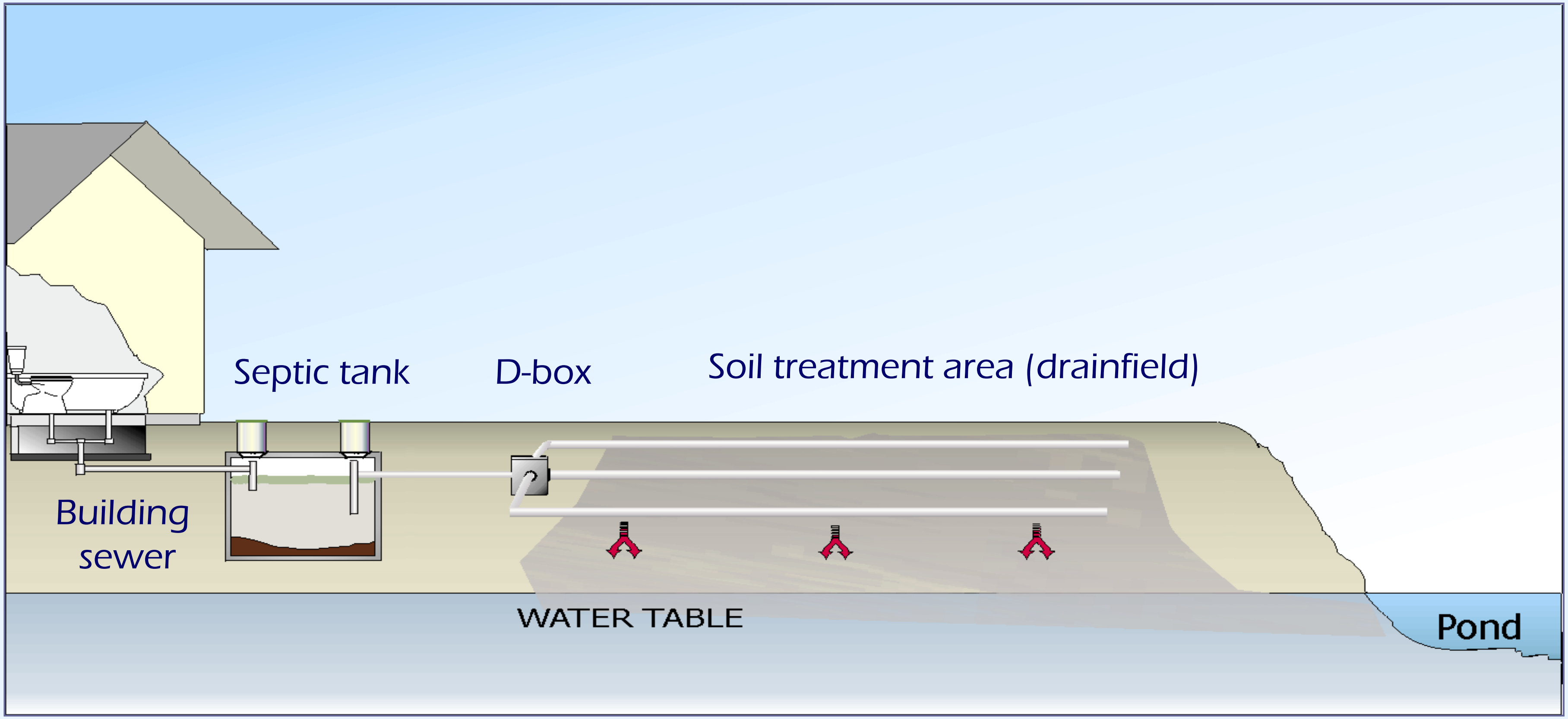
THE UNIVERSITY OF RHODE ISLAND

USDA NIFA United States Department of Agriculture National Institute of Food and Agriculture

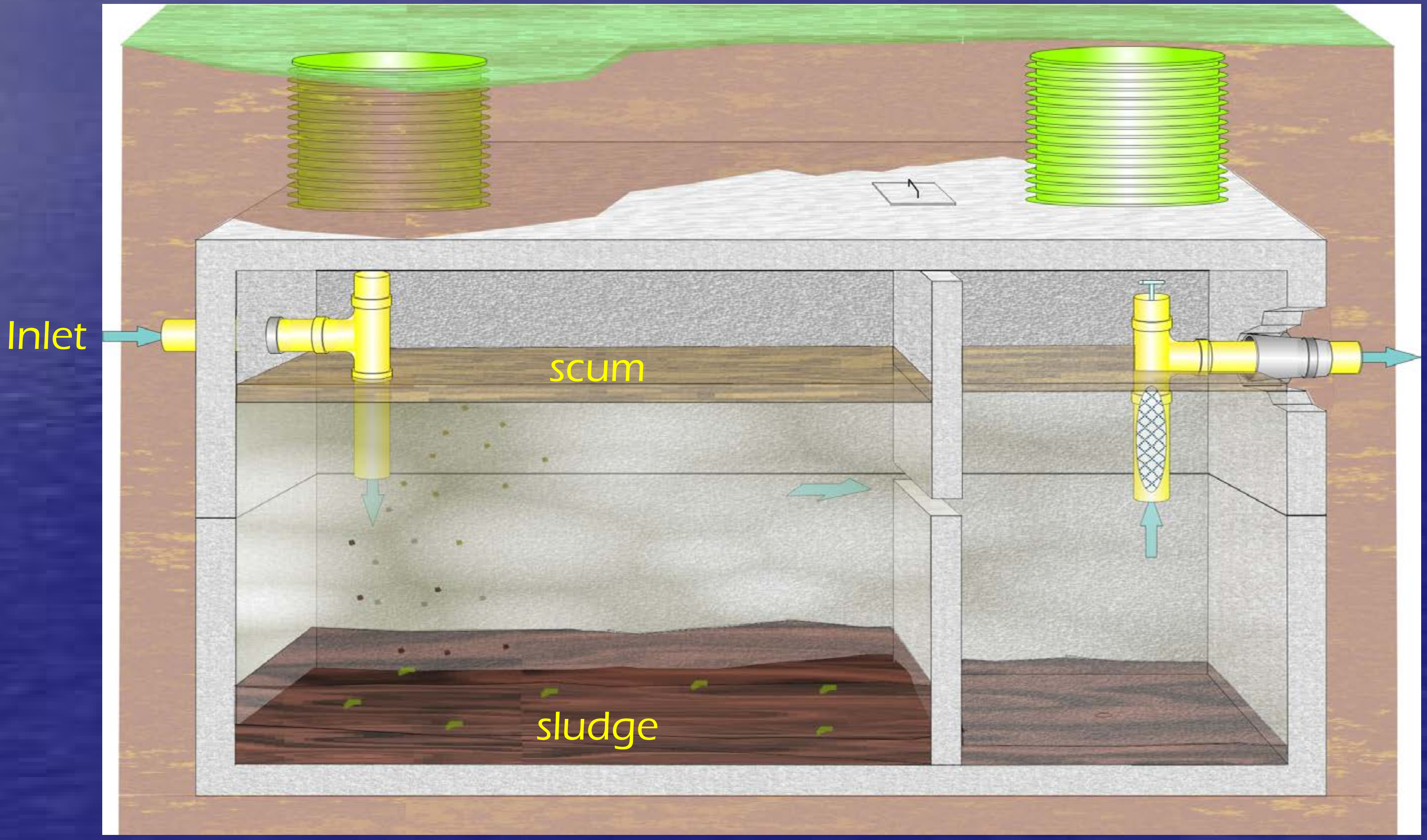
What we will cover –

1) Conventional OWTS basics
2) Cesspools
3) Contaminant treatment potential
4) Advanced treatment technologies
5) System management - O&M, inspection and pumping
6) Future challenges

1) Conventional septic system

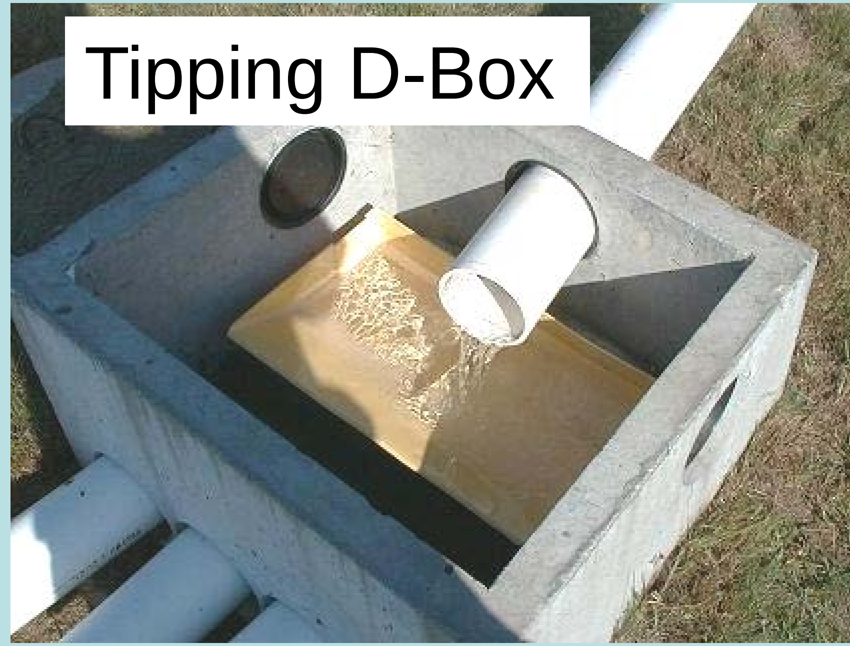


Conventional Septic Tank



Conventional D-Box

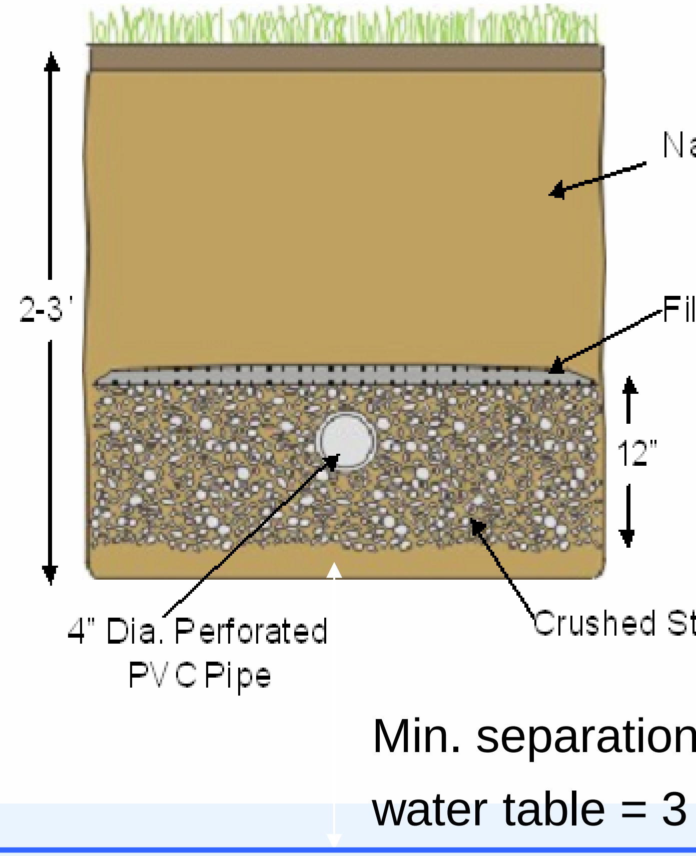
Operates on trickle flow to the lowest pipe invert



Tipping D-Box

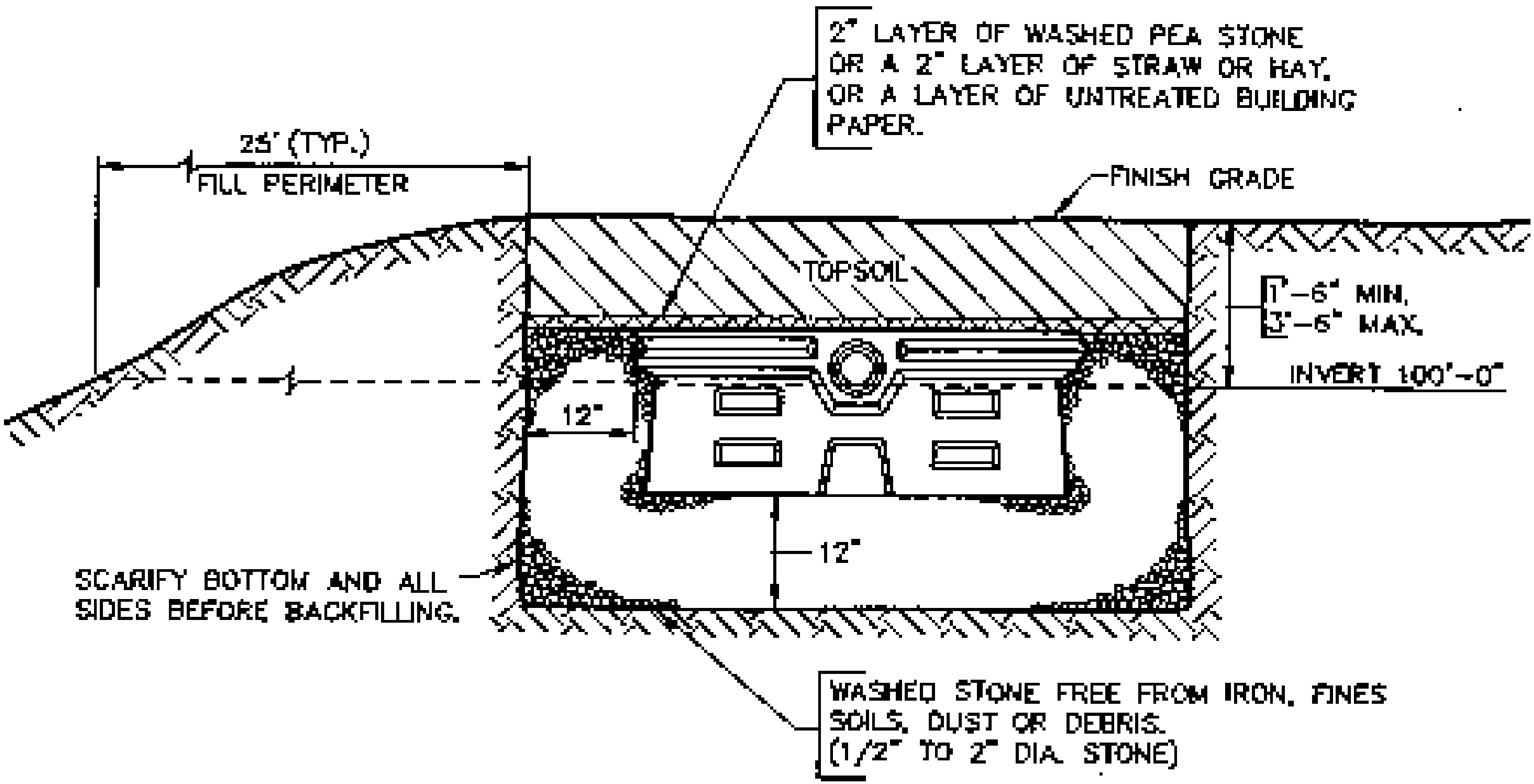
Even surge flow of effluent

Conventional Septic System Drainfield Trench



1989 to present

Min. separation distance to water table = 3 or 4 feet

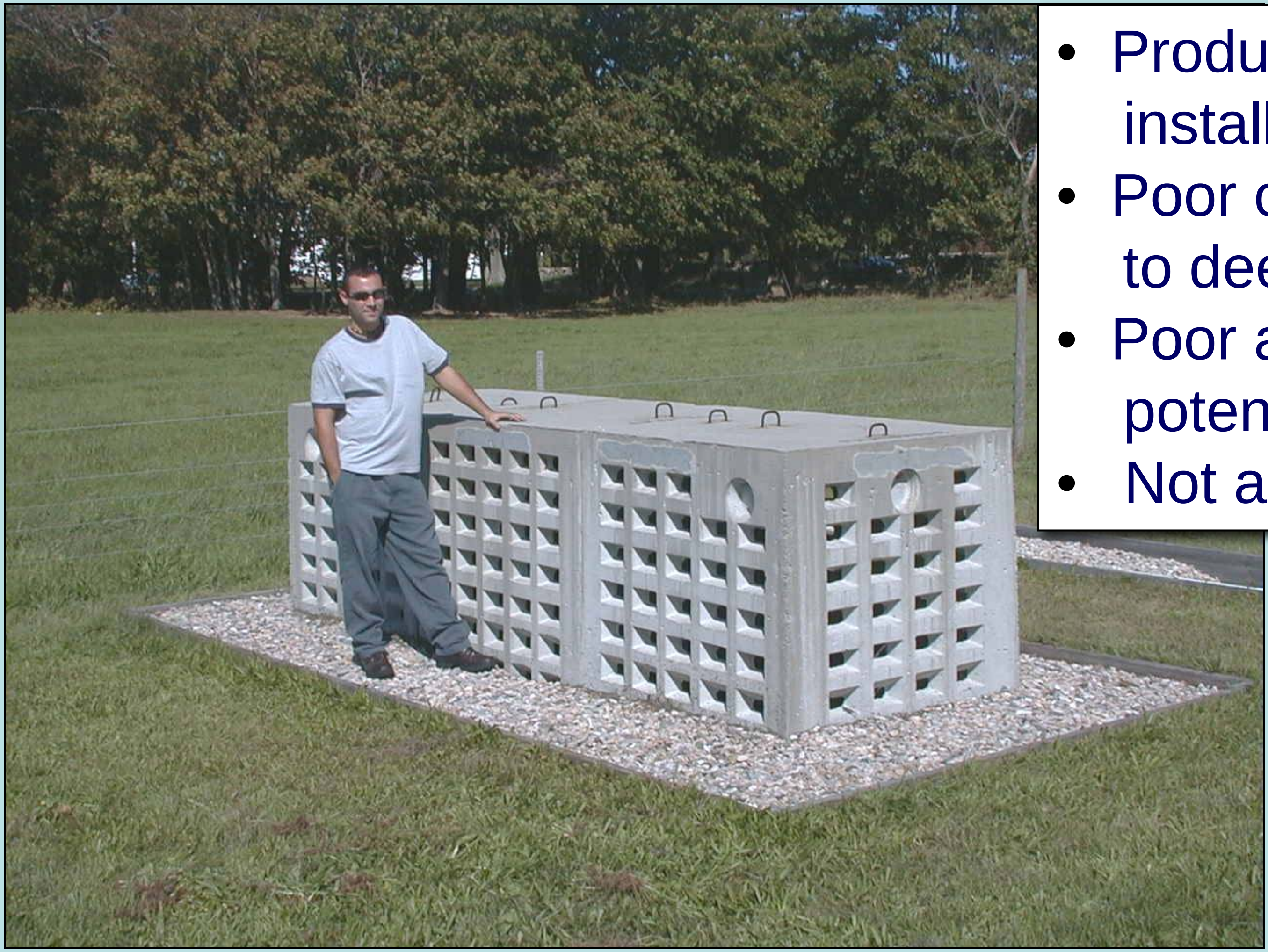


TYPICAL FLOWDIFFUSOR CROSS-SECTION

NO SCALE

SEE MAIN PLAN FOR LOCATION AND
NUMBER OF FLOWDIFFUSORS AND TRENCH LINES.

Typical concrete galley configuration



- Produces a deep installation base
- Poor oxygen diffusion to deep soil layers
- Poor aerobic treatment potential
- Not allowed

2) Cesspools

- Substandard system
- Antiquated and inadequate
- Often violates vertical separation distance regulation
- In coastal areas - may be tidally connected
- Prioritize replacement with approved system
- Cesspool phase out act 2007

3) Pollutants common in septic tank effluent

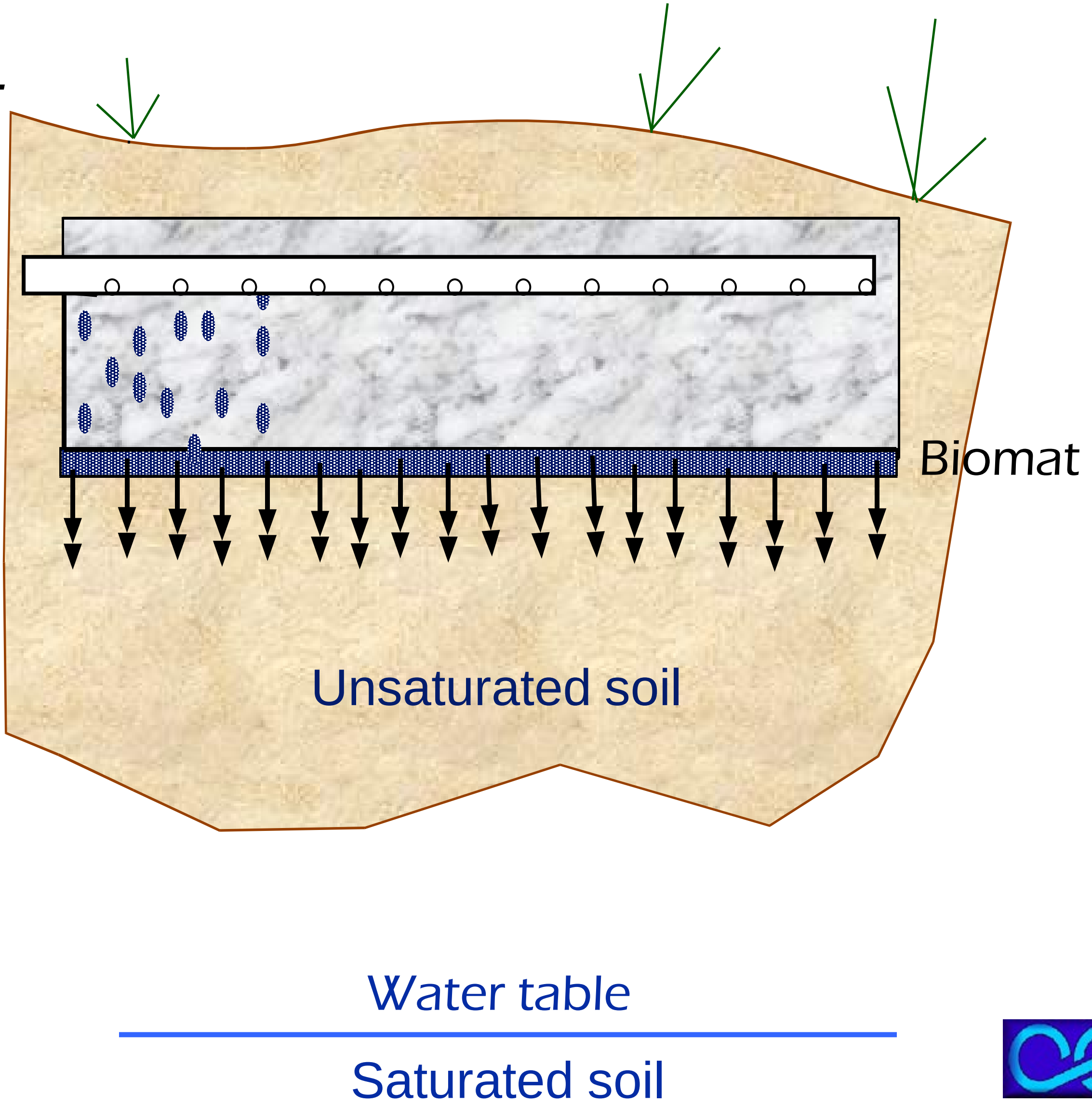
- TSS, BOD - 5
- Nutrients - nitrogen, phosphorus
- Organic chemicals
- Pathogenic organisms

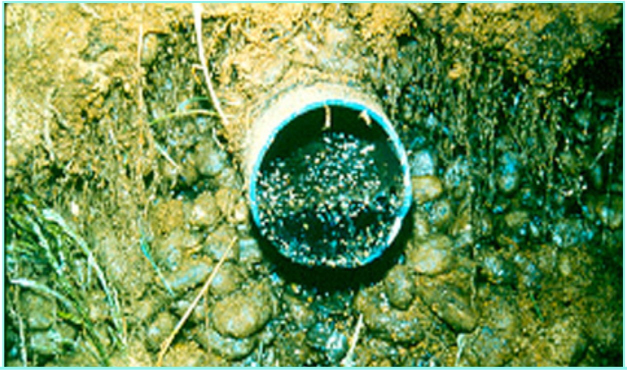
  - Helminths (septic worms)
  - Protozoa
  - Bacteria
  - Viruses

Vadose zone wastewater treatment

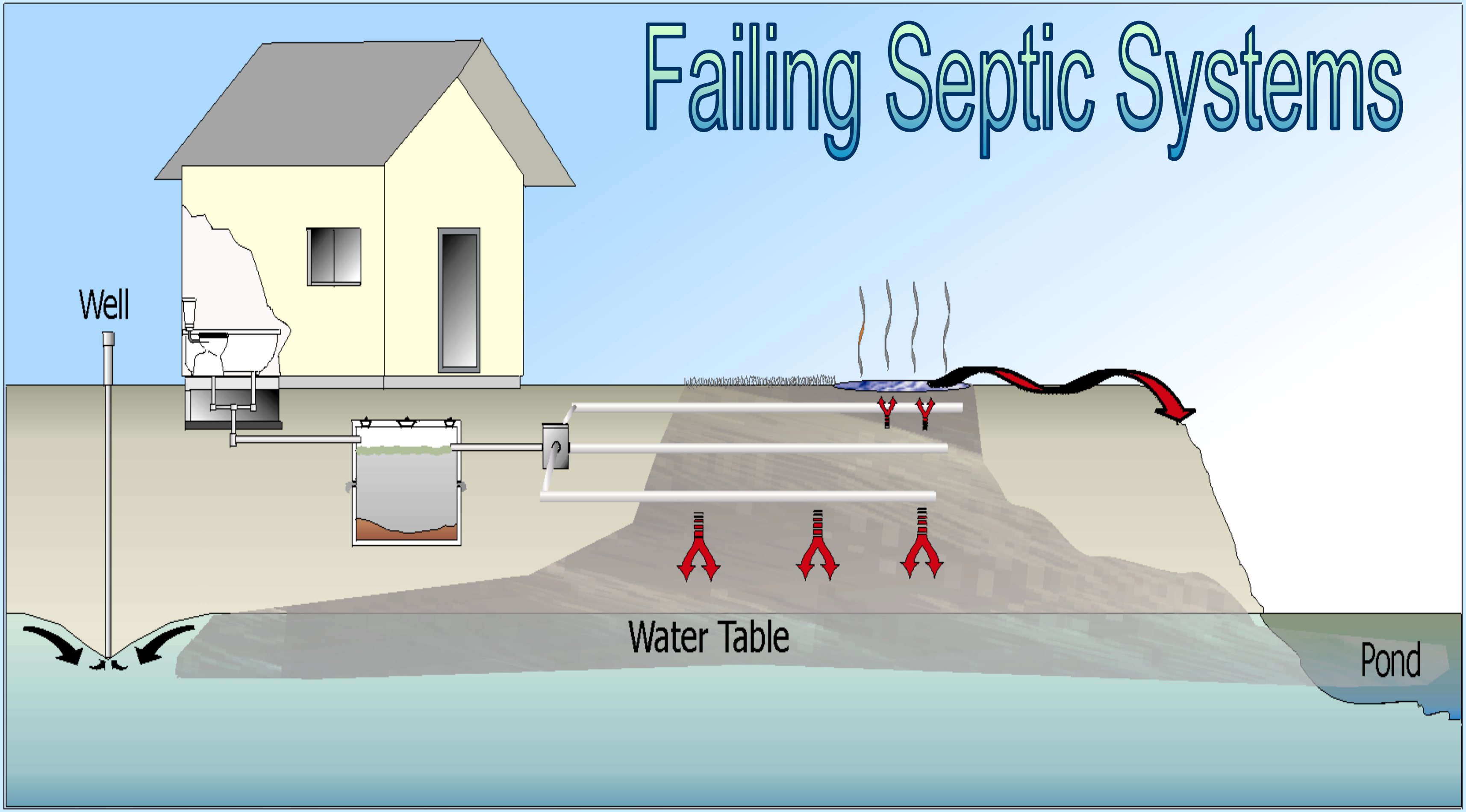
Controlling factors –

- Environmental
  - Temp., moisture, oxygen levels
- Wastewater char.
  - Loading rates, strength, types of pollutants
- Soil properties
  - Physical, chemical, biological
- Retention time



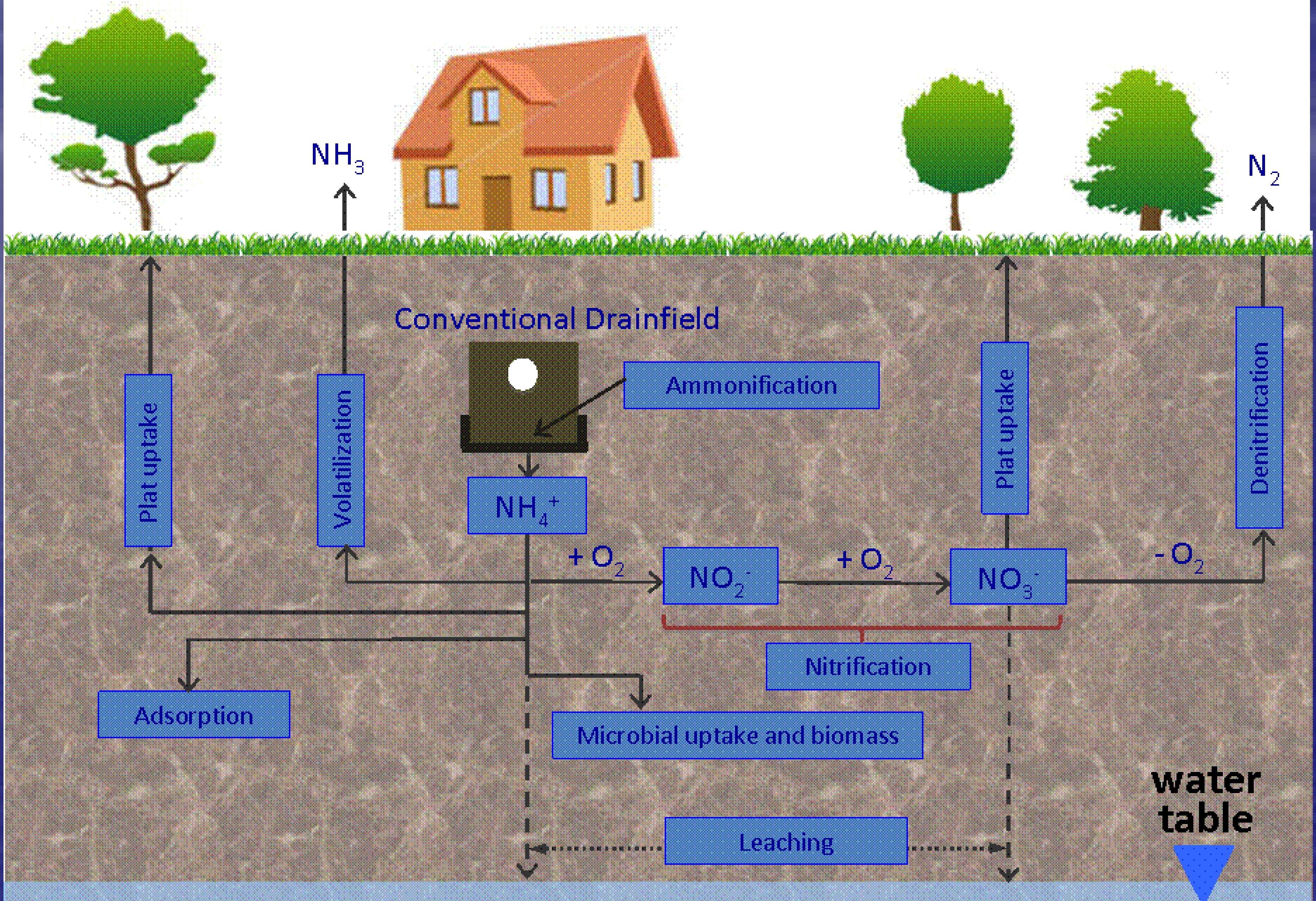


When organic inputs exceed removals and all soil pore spaces are clogged, then hydraulic failure occurs.



Failure defined (RIDEM regs):

- Surfacing wastewater
- Improper treatment of wastewater



The Nitrogen Cycle in the Conventional Drainfield

Summary - Nitrogen removal in conventional septic systems

- Less than 15 percent removal in septic tank
- Septic tank effluent composed of organic-N and ammonium-N
- Conversion to nitrate-N in soil below drainfield
- Nitrate-N very mobile and conservative
- 10 ppm EPA nitrate-N drinking water standard

Summary - Phosphorus (P) removal in conventional septic systems

- Phosphorus adsorbed to iron, aluminum, manganese, calcium, and magnesium in soils
- P removal depends on soil surface area
- Sands have far less surface area than finer soil particles
- P saturation can and does occur
- Wet soils conditions result in iron removal, so less P removal potential

Summary - Wastewater microorganism movement

Organism	Approx. Size	Mobility Potential
Helminths	sand	low
Protozoa	c. silt	↓
Bacteria	f. silt - c. clay	↓
Viruses	v.f. clay	high

Enhanced removals with aerobic soils and long retention times

Summary – Emerging contaminants of concern

- *Pharmaceuticals*
- *Antimicrobials*
- *Endocrine disrupters*
- *Personal care products (PCPs)*

- ➢ Removals based upon complex biochemistry - are compound and site specific
- ➢ Aerobic soil conditions and long retention times are key treatment factors

Biochemical reactivity in soils

- 99% of soil bioreactivity is within 10 – 20 inches of soil surface

Sources:

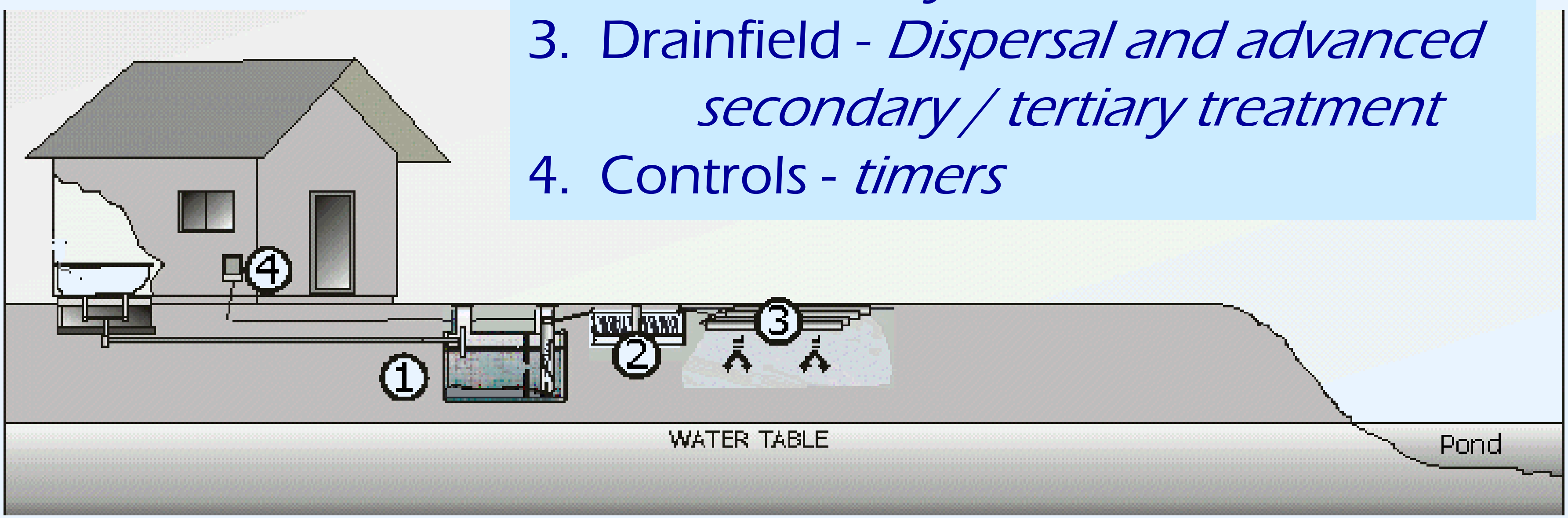
“Introduction to Soil Microbiology”, Second Edition – Martin Alexander - John Wiley & Sons,1977.

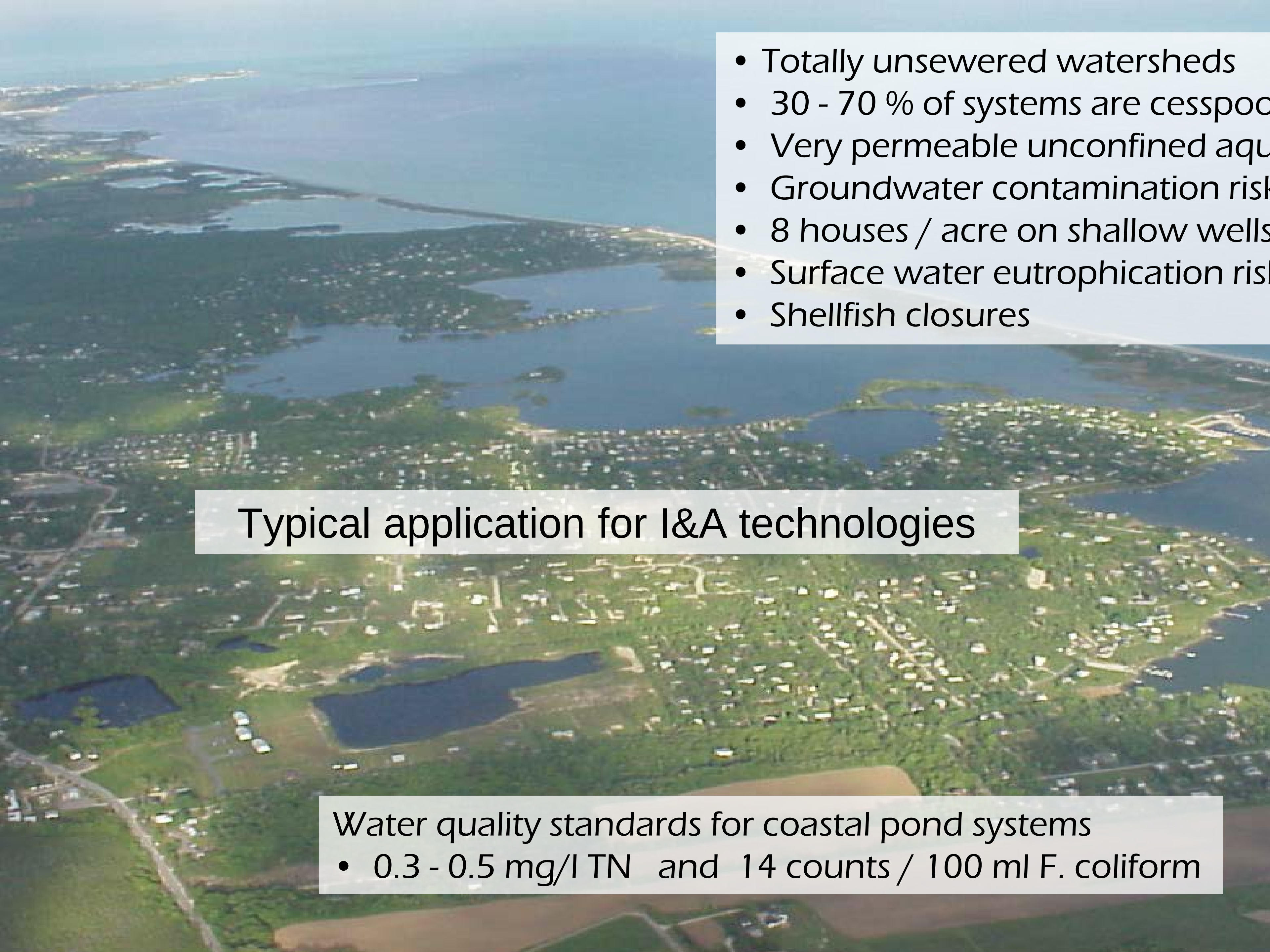
"Soil Microbiology" Selman Waksman - John Wiley & Sons, 1952.

RIDEM OWTS regs promote shallow drainfield placement

4) Alternative technology treatment train

1. *Primary treatment zone*
2. Alternative technology
   Secondary treatment
3. Drainfield - *Dispersal and advanced secondary / tertiary treatment*
4. Controls - *timers*





- Totally unsewered watersheds
- 30 - 70 % of systems are cesspoo
- Very permeable unconfined aqu
- Groundwater contamination risk
- 8 houses / acre on shallow wells
- Surface water eutrophication risk
- Shellfish closures

Typical application for I&A technologies

Water quality standards for coastal pond systems

- 0.3 - 0.5 mg/l TN   and 14 counts / 100 ml F. coliform

Summary of nitrogen reducing treatment technologies in Rhode Island

- Began in early 1980s
- Requires Rhode Island Technical Review Committee (TRC) approval
- Over 4,700 system applications approved
- O&M contract needed
- Entered into land evidence record
- Training required OWT 105 – Innovative and Alternative Technologies

Advanced treatment technologies approved in RI

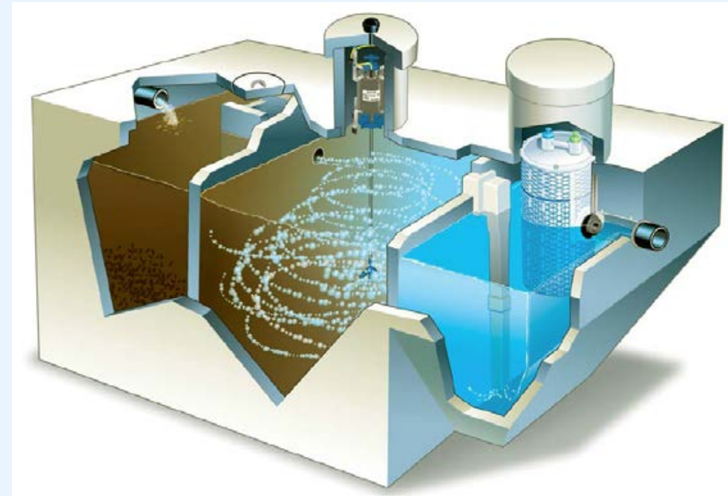
ca.1983

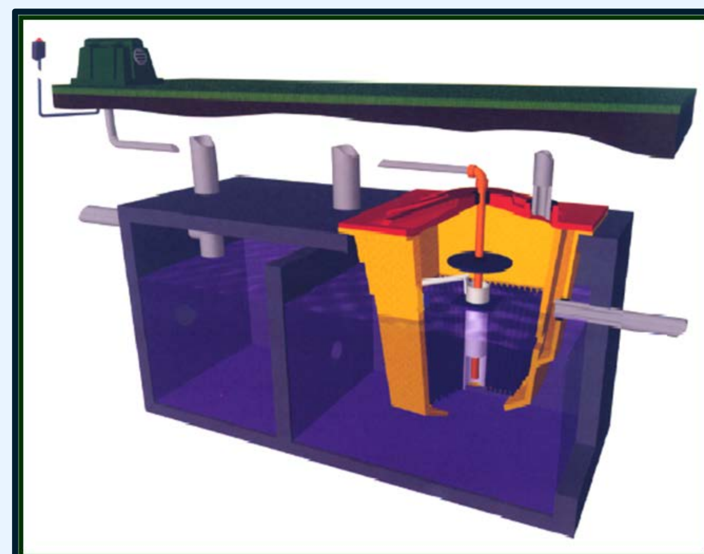
ca.1996

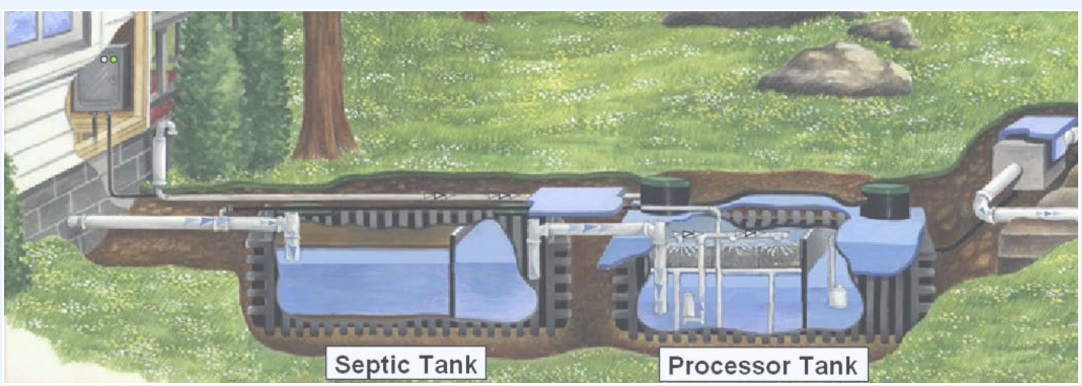
ca.2014

- RUCK
- ATUs
- Single pass sand filters
- Recirc. sand filters
- Early textile filters
- Foam biofilters
- Shallow narrow pres. drainfields
- Bottomless sand filters - early
- Modular peat filters
- Textile filters
- Fixed activated sludge systems
- Bottomless sand filters – current
- Denite upflow filters
- Trickling filters
- UV disinfection
- Soil treatment area renovation technologies

Selected approved N reducing technologies

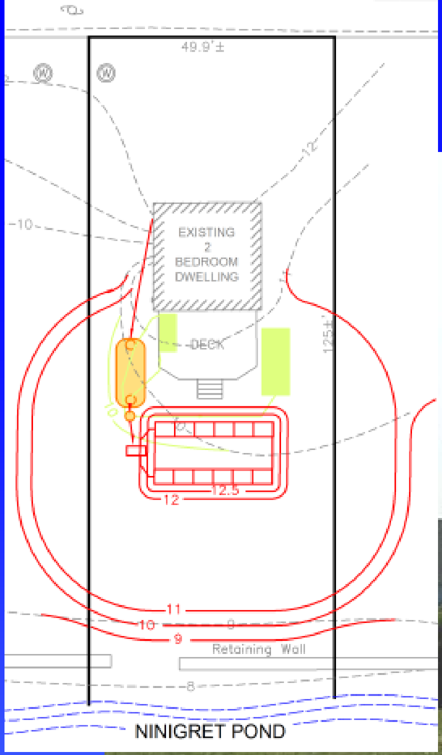




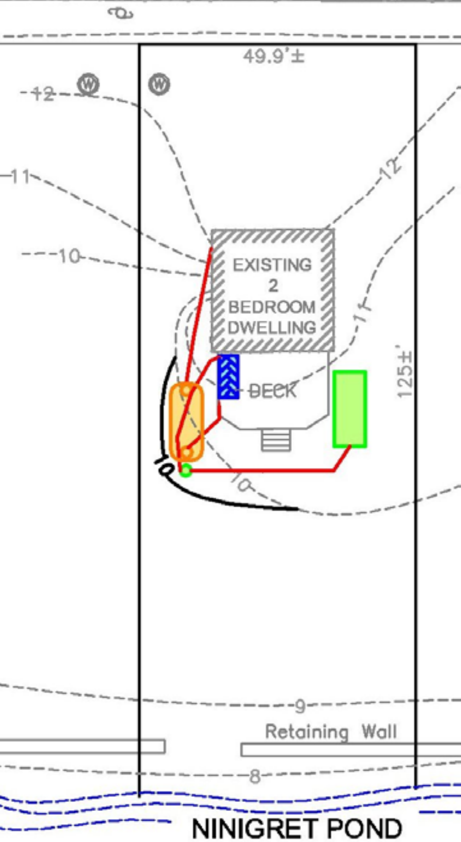


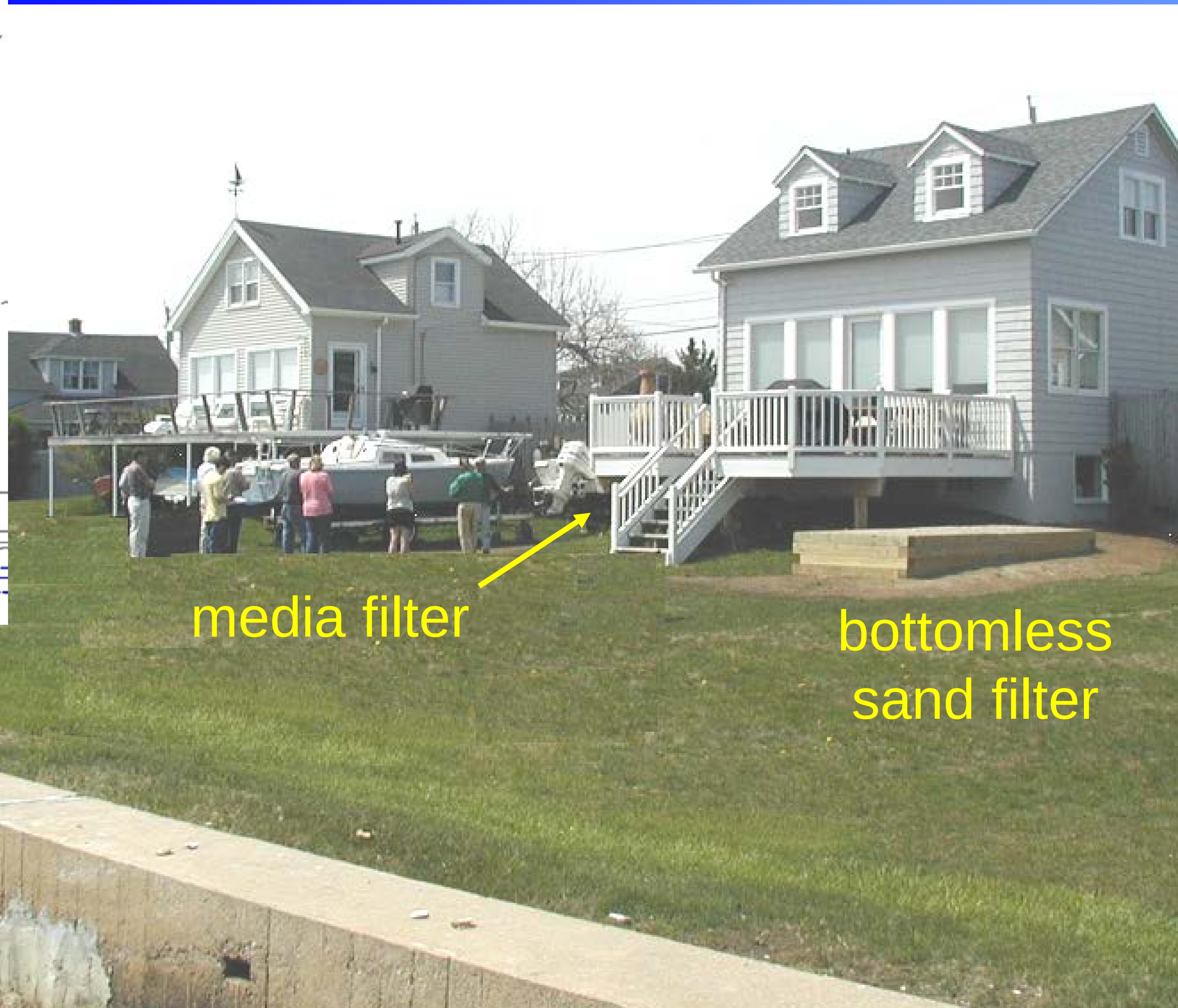
Typical use for I&A technologies

The conventional system “fix”



Advanced technology solution





Pressurized shallow narrow drainfield

Bottomless sand filter

Relative installation costs

System type	Ideal sites	Difficult sites
Conventional	$10 – 15K	$20 – 40K
Advanced	$16 – 25K	$25 – 35K

Based on a repair system for a 3 bedroom home in 2013 economy
Conventional system includes design fee
Advanced technologies design fee not included in above ($1.5 to 5K)

5) System management, operation and maintenance (O&M)

- Is *not* difficult
- Is *not* expensive
- But, *IS ESSENTIAL*

Conventional system *inspections* and tank *pumping*

Identifies problems

Protects –

- Owner investment
- Public health
- Water quality
- Resources
- Property values

Costs - $250 (pumping) and $50 to150 (inspection)
Frequency – every 3 to 5 years

Managed systems last longer than neglected ones

Alternative technology operation and maintenance

- More system complexity
- Greater treatment capability
- Requires more oversight than conventional system
- Treatment levels directly related to O&M

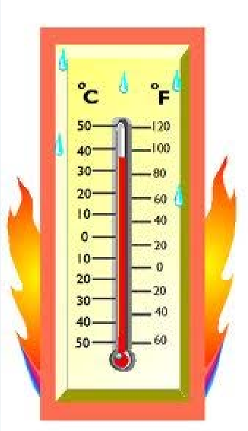
Frequency – 1 to 2 visits per year

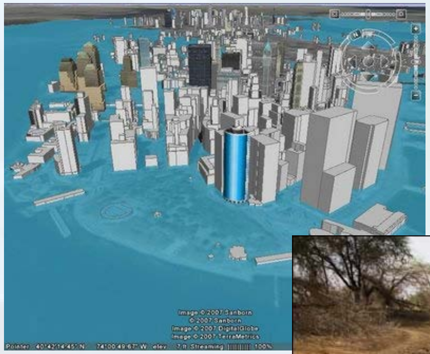
Annual cost – $250 to $400

Plus $250 pump out every 3 to 6 years

6) **Future challenges**
Climate change overview

- IPCC: It's here. To stay.
- Temp: Up 2.5 – 10^{o}F next 100 yrs
  - More frequent, longer heat waves
  - Fewer days with frost
- Sea level: up 3' next 100 yrs
- In NE U.S.: SL 4' by 2100
- Precip: Changes in spatial & temporal patterns
  - Droughts
  - Floods





Wickford Village Spring Tides

Photos: Melissa Devine

Wickford Bridge
Number 10

North Kingstown, RI

Low tide Oct. 27, 2011

Extreme tidal stage 5.1 feet
Normal tidal stage 3.6 feet
Difference = 1.5 feet

High tide Oct. 28, 2011

Photos: Melissa Devine

Storm event impacts

- Sea level rise and more coastal erosion
- Loss of structures and OWTS
- Flooding from storm surge extending further inland

Greenhill (post Hur. Sandy)

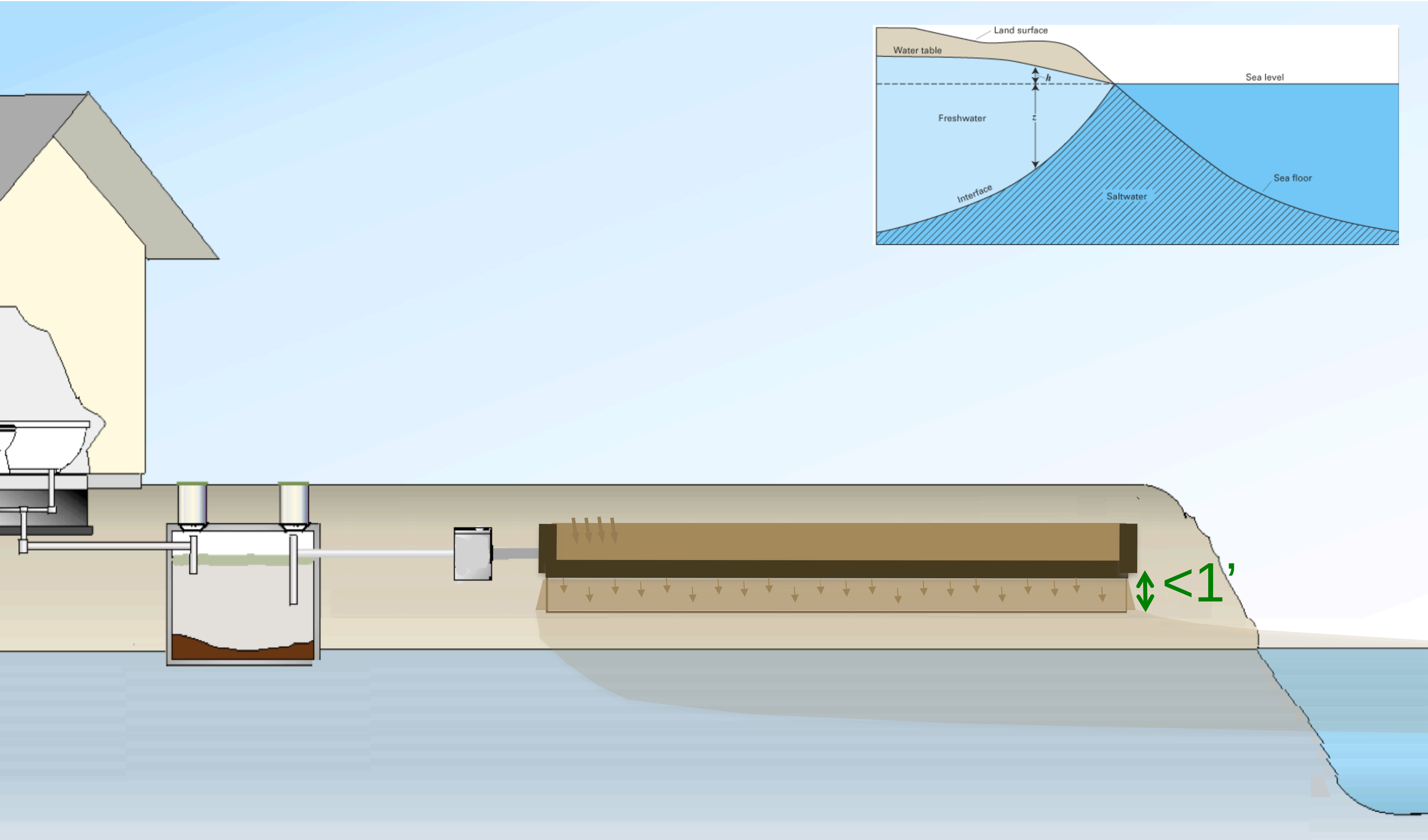
Matunuck, RI

Hurricane Sandy Damage - Atlantic Ave., Misquamicut, RI

December 2012 Storm Event
Dune face on Atlantic Ave., Misquamicut, RI

Photo: Brian Moore, RIDEM

Long-term sea level rise also raises groundwater table levels



Reduced OWTS function under elevated sea level / groundwater conditions

To further complicate things……

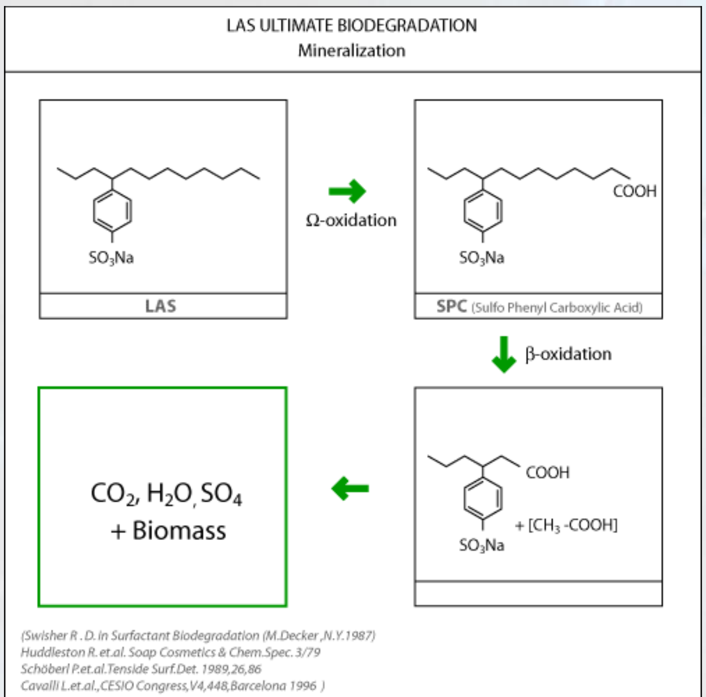
Warmer soil temperatures –

- Lower O_2 solubility
- Raise soil microbial activity
- Results in more O_2 consumption near soil surface
- Less O_2 available to diffuse
- Further reducing O_2 available for wastewater treatment

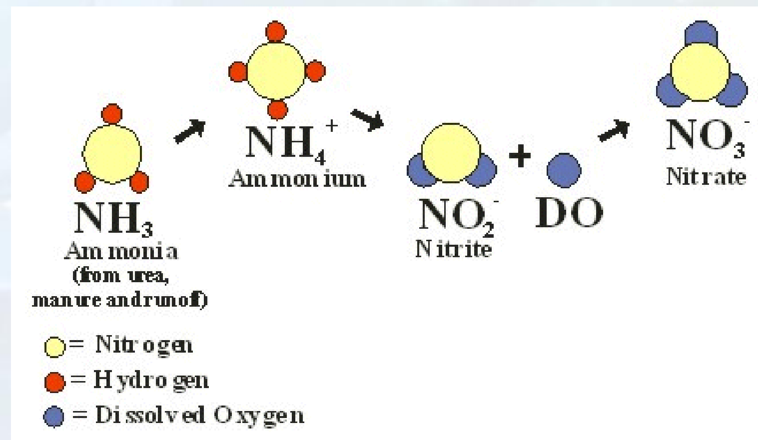
Aerobic processes affected

- Less O_2 in a smaller unsaturated zone → Slower rates of aerobic microbial processes

Biodegradation



Nitrification



Phosphorus

Wet soils → Iron reduction → Release of bound Phosphate

More, happier pathogens

- Wet and saturated conditions favor viral and bacterial pathogen **survival and transport**
- Increased surface and groundwater contamination
- Higher public and environmental health risks

Mitigation and adaptation

- Increase separation and setback distances
- Account for projected sea and groundwater level rise in future designs
- Improve component-based treatment efficiency
- Develop new technologies
- Utilize shallow soil dispersal of wastewater
- Proactive management of soil moisture
- Amend soil with silver nanoparticles to enhance pathogen removal – Very promising but research is needed

Climate change OWTS research at URI

- 9 intact soil mesocosms
- 3 treatments, 3 reps
  - Conventional stone trench with STE
  - PSND with ATE
  - Ultra shallow PD with ATE
- All wastewater from same source
- Funded by RI AES, Sea Grant, USDA-NIFA

Climate change OWTS research at URI

- Evaluate response of existing OWTS technologies to climate change
  - Nutrients
  - Pathogens
  - Organic contaminants
- Jose Amador and Jennifer Cooper, Laboratory for Soil Ecology and Microbiology
- Modeling Component
  Thomas Boving and Ivan Morales – Geosciences Department

Can alter – wastewater application rate, temp., water table level

Collect and analyze – soil gas, soil pore water, temp., soil moisture, redox potential

Thanks for your attention!

George Loomis
GLoomis@uri.edu
401. 874. 4558

http://www.uri.edu/ce/Cwq/OWT/index.htm

Arthur J. Gold

Professor, Department of Natural Resources Science
110 Coastal Institute in Kingston, One Greenhouse Road
University of Rhode Island, Kingston, RI 02881.
Phone: 401-874-2903; Fax: 401-874-4561; email: agold@uri.edu

Art's primary research focus concerns the sources and sinks of nitrogen in coastal watersheds. He conducts studies on nitrate dynamics and uses GIS techniques to scale up from the site level to the watershed scale. Other areas of research are research on environmental flows. He teaches undergraduate and graduate courses in watershed hydrology at URI. Since 1998 he has served as the Natural Resources Program Leader, the State Extension Water Quality Coordinator, and most recently the Associate Director for the URI Coastal Institute. He has the following degrees:

- Ph.D., 1983, Department of Agricultural Engineering, Michigan State Univ.
- M.S., 1978, Water Resource Management, University of Michigan.
- B.S., 1973, School of Natural Resources, University of Michigan.

A detailed cv for Art can be can be found at: http://www.uri.edu/cels/nrs/whl/People/art.html

George Loomis

Program Director
001C Coastal Institute
Kingston, RI 02881
Ph: (401) 874-4558
Fax: (401) 874-4561
gloomis@uri.edu

George is a Research and Extension Soil Scientist and the Director of the URI Onsite Wastewater Training Center. He has nineteen years experience in siting, design, operation and maintenance, and research in conventional and alternative septic systems. George served on the several committees involved with developing the Rhode Island Septic System Check Up, and is a member of the Rhode Island DEM Technical Review Committee and Septic System Task Force. George co-developed the Rhode Island sand filter guide and bottomless sand filter guide for RIDEM. More information on the New England Onsite Wastewater Training Program can be can be found here:

http://www.uri.edu/ce/wq/OWT/Staff/index.htm