

- Microbiological perspectives -
The impact of wastewater disposal systems on Florida's coastal waters



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Florida's Coastline

- 1,197 miles of coastline
- 663 miles of beach (~576 monitored via represented sites)
- Unique beach zones
 - East Coast = short steep-sloping coastal shelf and good water flow = good dilution potential. Abundant coastal development
 - Central and South West Coast = long shallow sloping shelf and moderate dilution potential. Abundant coastal development.
 - Big Bend = long very shallow sloping shelf and poor dilution potential. Abundant marsh w/limited but growing development
 - Western Panhandle = Long shallow shelf, enhanced flow relative to Big Bend, moderate dilution potential. Wooded and marsh bayou environments with moderate-growing coastal development
- Very porous subsurface (limestone) with enhanced groundwater transport rates due to tidal pumping

What can impact our water quality

- Chemical spills/seeps
- Harmful algae blooms
- Wastewater
 - Nearshore injection wells
 - Septic tanks
 - Stormwater runoff
 - Sewage treatment plant overflows and outfalls
 - Animal feces (animal to human transmission of pathogens....i.e. *Cryptosporidium parvum*)
 - Swimmers?

Coastal population and /sewage wastewater trivia

- 2006 Florida coastal county census = 13,786,323
- Average use of water per day = 78 gallons = ***1.1 billion gallons per day of sewage***
- 76 million tourists (2004) staying an average of 5 days = $78 \times 5 \times 38,000,000$ (with 50% going coastal)/365 = ***43 million gallons per day of tourism associated sewage***
- ***Total = 1,143 million gallons of sewage produced per day***

Disposal

- 1,769,182 septic tanks installed in coastal counties since 1970. If 40% converted to sewer = **206 million gallons per day via septic disposal**
- State wide 16 coastal counties dispose of **360 million gallons per day** of wastewater (sewage, industrial wastewater, stormwater) via **deep well injection**
- Three counties utilize **ocean outfalls** to dispose of **290 million gallons per day** of wastewater = ocean outfalls
- **Greater than 330 million per day** disposed of via wastewater treatment and **pumping to surface waters**

Wastewater Microbiology



KEEP OUT

1. 13 million fecal coliforms per gram of feces
2. 10 million enterococci per gram of feces
3. 1 trillion total bacteria per gram of feces (~400-500 species - ~30% mass of feces)
4. ~140 types of enteric viruses found in humans (~1 billion per gram) and 1-10% of the population is shedding them at any given time at 1 million to 1 billion per gram of feces (Hepatitis A viruses, Noroviruses, Poliovirus, Coxsackie viruses, Echoviruses, Astroviruses, Rotaviruses, etc.)
5. Enteric virus diseases - asymptomatic, gastroenteritis, cold and flu-like symptoms, myocarditis, paralysis, etc.

A microscopic view of various green bacteria, including rod-shaped and spherical forms, set against a dark brown background. The bacteria are brightly lit, showing their cellular structures and some flagella.

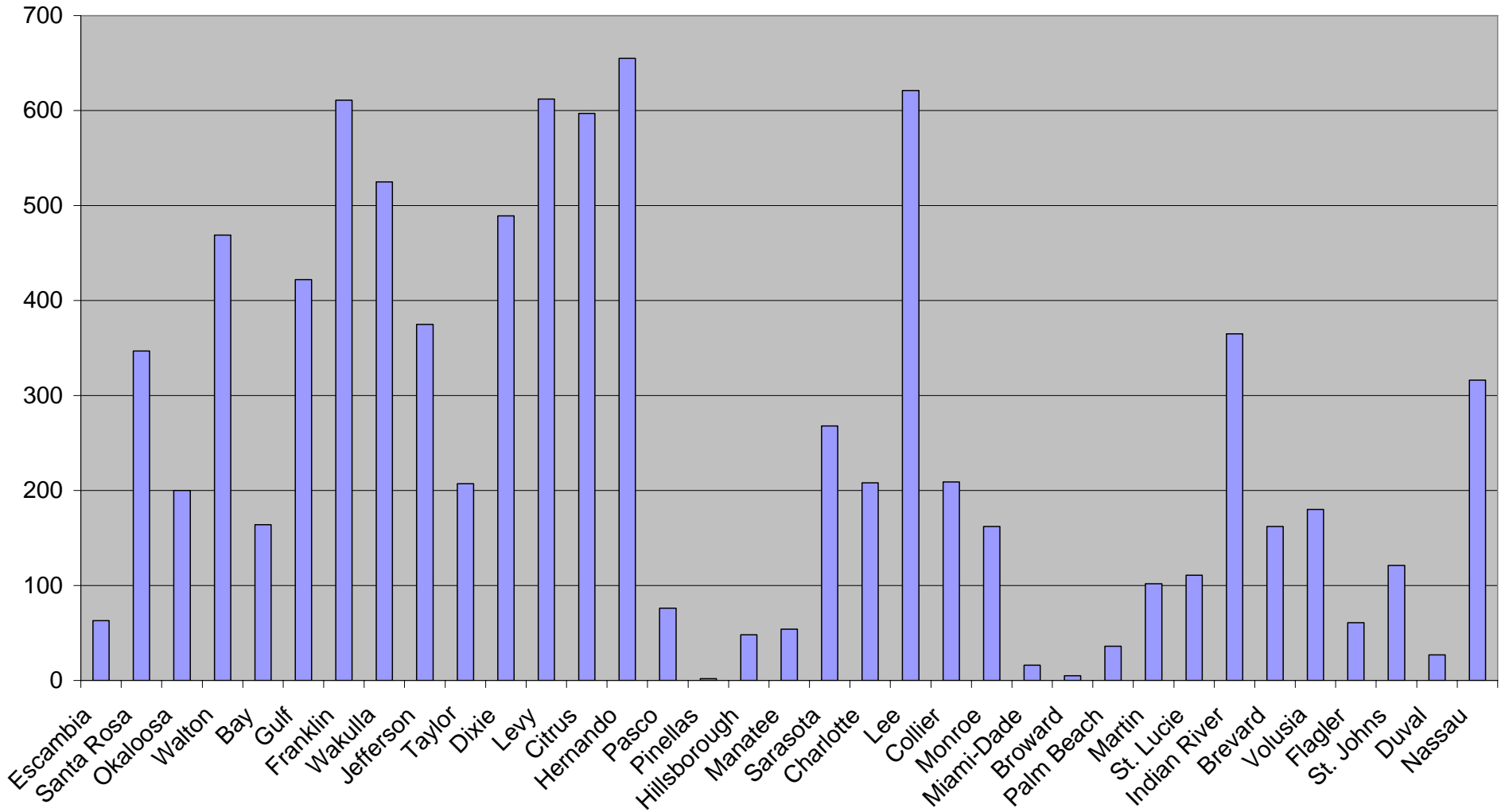
Wastewater Risks

- Health of marine organisms
 - Via nutrient loading and the introduction of pathogenic microorganisms
- Human health via recreational water use and consumption of contaminated organisms
 - The average swimmer inadvertently ingests ~ 100ml of water per recreational event.
 - Eye, ear, nose infections
 - Contaminated shellfish



**2006 - Florida Beaches exceeding standards > 25% of the time monitored
Out of 307 statewide beaches**

of septic tanks per 10,000



Most coastal pollution research = Central and South Florida
This example = viral source tracking in the Florida Keys

Keys Canal Study

Standard Microbial indicators = good water quality

Pathogenic human viruses = 95% of sites positive

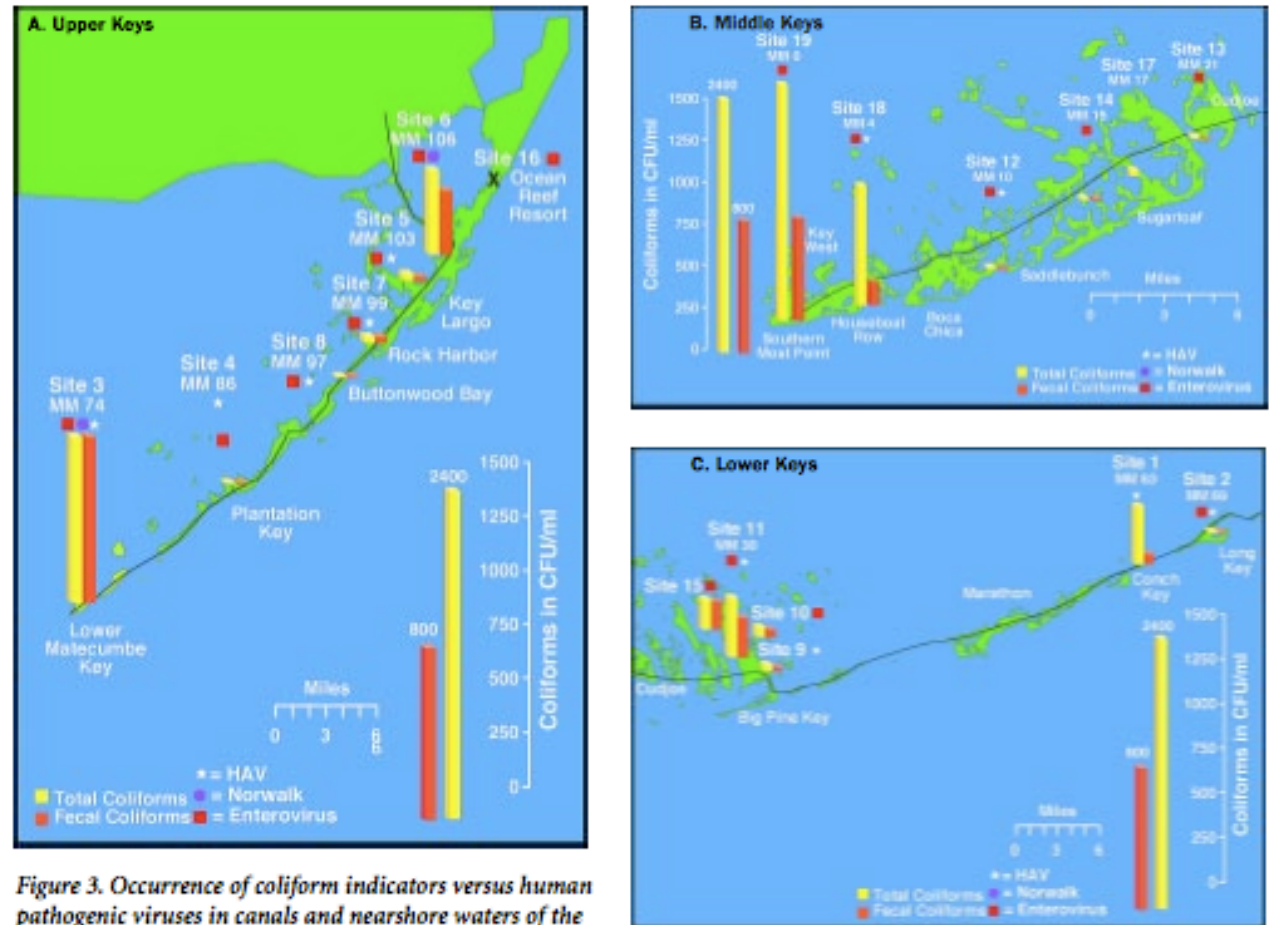


Figure 3. Occurrence of coliform indicators versus human pathogenic viruses in canals and nearshore waters of the Florida Keys. The total coliform and fecal coliform columns next to the reference concentration bar in each panel indicate the maximum single-sample limits for the respective coliform group. No coliforms were isolated at the X at site 16.

Both molecular and conventional methods were used to study the microbiological risk to swimmers at wastewater-impacted beaches in Hawaii (Colwell et al. 1996). It was found that 13%, 20%, and 30% of the samples from three different

Florida Coastal Septic Tank Trivia

- Let be conservative (*really conservative as 50% of the US population reside in coastal communities*) - If 1% of the coastal counties septic tanks are coastal in nature = 137,863 septic tanks
- 2.5 people per household shedding 100g feces each.
- 1 trillion bacteria per gram
- $137863 \times 2.5 \times 100g \times 10^{12} = 34.46$ Quintillion bacteria
 - **34,465,800,000,000,000,000**
- And don't forget the viruses ~34.46 quadrillion
- *Everyday*

Port Largo Canal Plum
Study – End of incoming
tide, 4/28/04, 1630hrs
Blue dots are sample sites
Yellow = < 5 CFU/100ml



Image © 2006 The Florida Department of Environmental Protection

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**Port Largo Canal Plum
Study – End of outgoing
tide, 4/28/04, 10:25hrs**

Blue dots are sample sites

Yellow = < 5 CFU/100ml

Orange = > 5 CFU/100ml

Red = ≥ 10 CFU/100ml

Brown = ≥ 20 CFU/100ml

Black = ≥ 50 CFU/100ml



Image © 2006 The Florida Department of Environmental Protection

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Port Everglades - surface water, outgoing tide, 7/31/07, ~11am. Enterococci colony forming units (CFU).

White dots = non-detect sample point

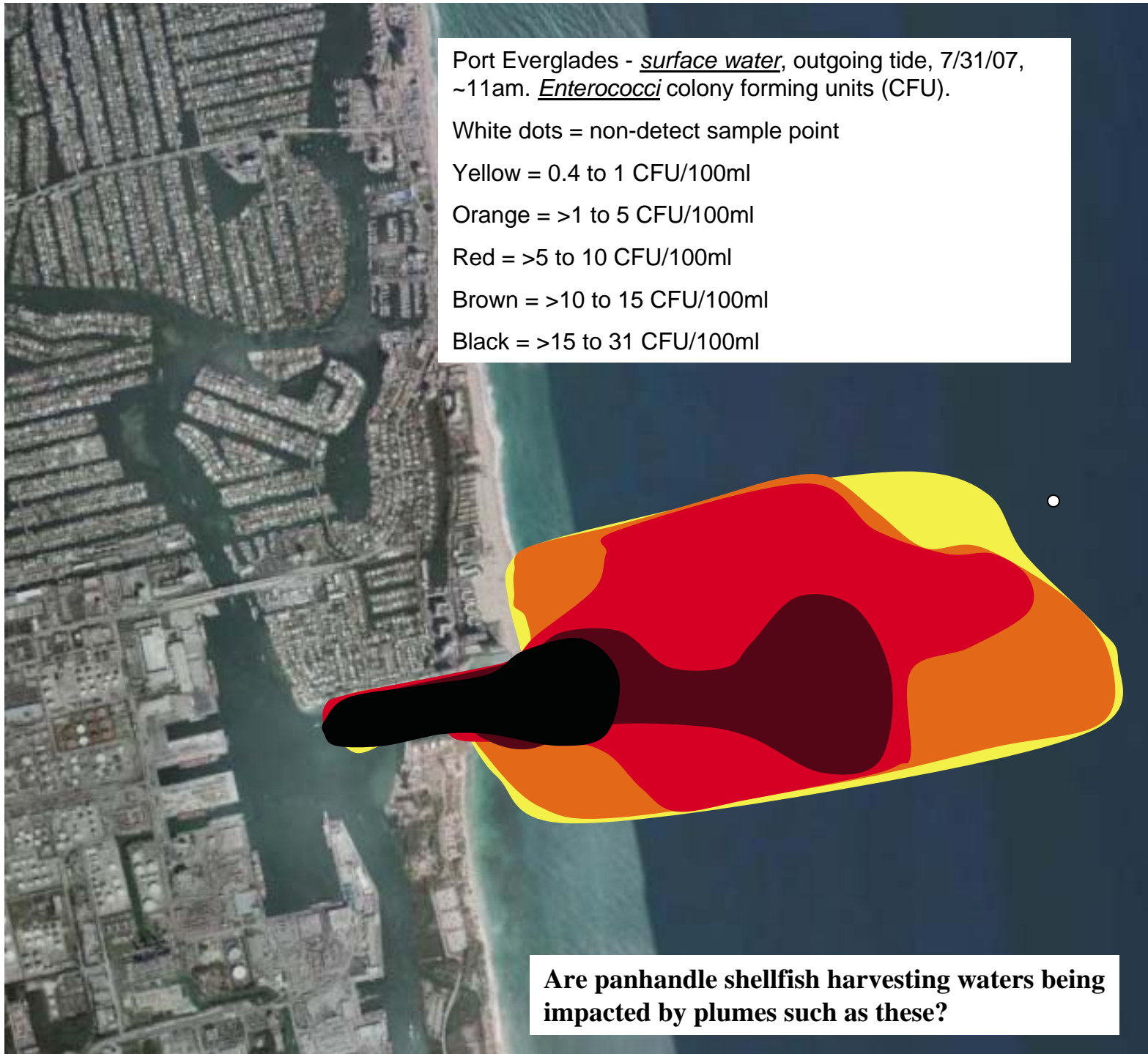
Yellow = 0.4 to 1 CFU/100ml

Orange = >1 to 5 CFU/100ml

Red = >5 to 10 CFU/100ml

Brown = >10 to 15 CFU/100ml

Black = >15 to 31 CFU/100ml



Are panhandle shellfish harvesting waters being impacted by plumes such as these?

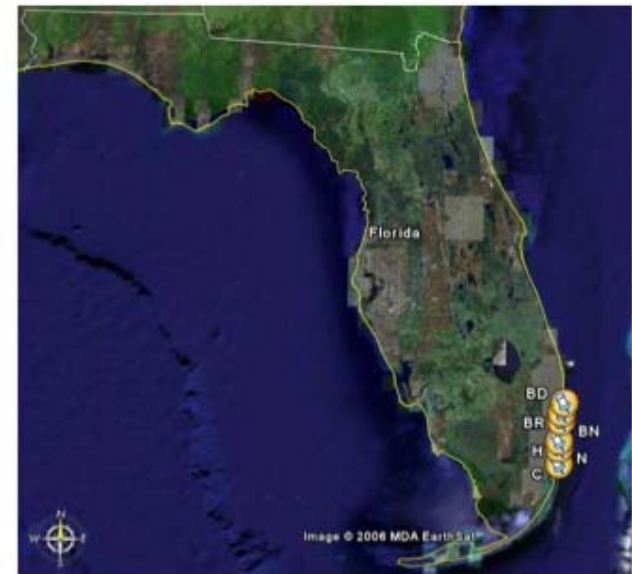


Figure 2-1. Ocean Outfalls in Florida. BD–Boynton-Delray, BR–Boca Raton, BN–Broward/North, H–Hollywood, N–Miami-Dade/North, C–Miami-Dade/Central. Photo from Google Earth (2005).

2005 = 290 million gallons per day



Injection Wells

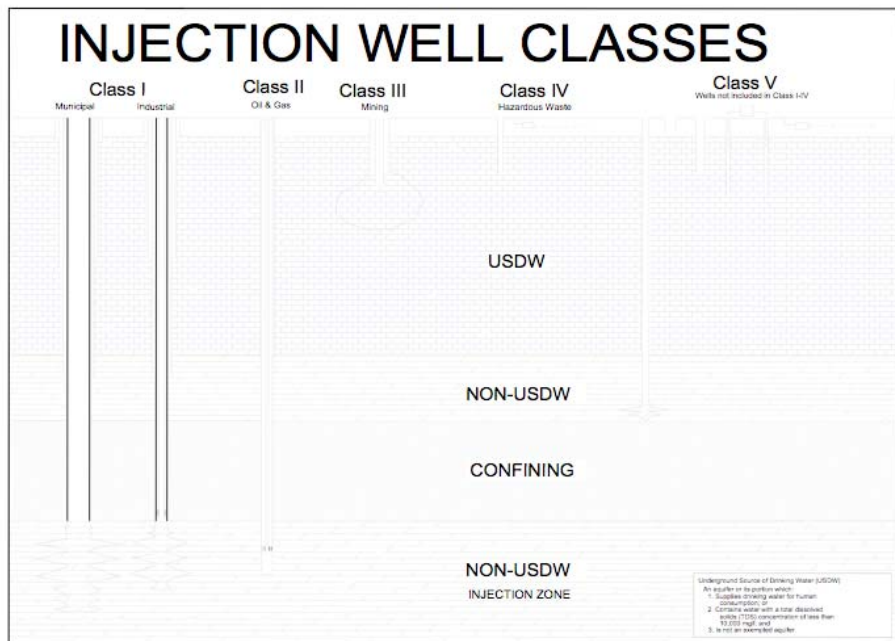
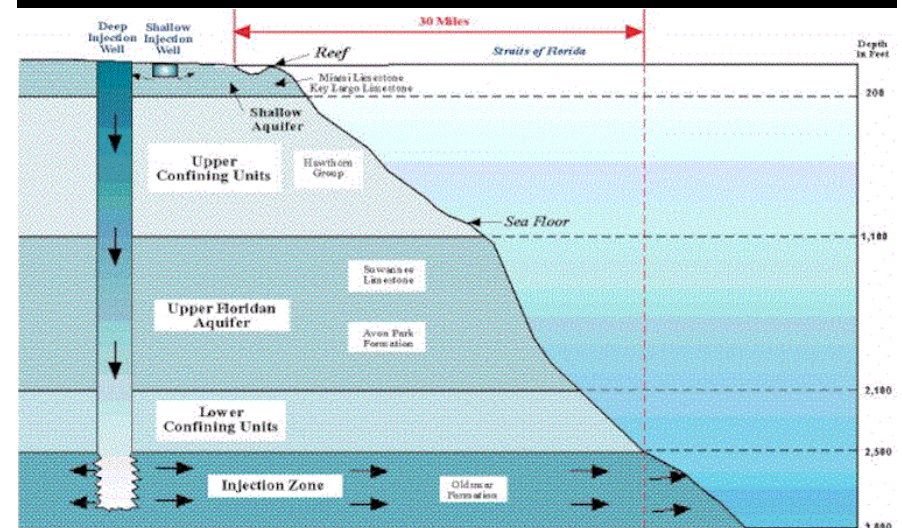


Image courtesy FLDEP



Primary concerns - vertical movement and contamination of drinking water sources and nearshore marine waters = via submarine groundwater discharge and transport from impacted inland waterways



The Swimmer

- Average swimmer/bather sheds 0.14grams of feces per bathing event.
 - Average of 1.8 million fecal coliforms/gram = 252,000 fecal coliforms shed per person
 - Average of 1 million enteroviruses shed per gram = 140,000 shed per person (~10% of the population shedding at any given time)
- Average person ingests ~ 100ml of water per bathing event

An underwater photograph of a coral reef. The scene is dimly lit, showing various types of coral and marine life. A semi-transparent grey text box is overlaid on the upper portion of the image, containing the title and a list of bullet points. The background shows a diverse ecosystem with different coral species, some appearing healthy and others possibly affected by disease or nutrient loading.

Wastewater Threats to Marine Organisms

- Corals - White pox - first identified in the Florida Keys and the pathogen is *Serratia marcescens*, an organisms which can be cultured from human feces.
- Coral reefs - nutrient loading of the water column (nitrogen, phosphorus) - corals have evolved to thrive in nutrient limited waters - algae does well in nutrient laden waters i.e., like in your aquarium.
- Protozoa's such as *Giardia* sp. and *Cryptosporidium* sp. which are shed in human feces can infect marine mammals (identified in seals, dolphins, and manatees).

Human Health Events

- Contaminated shellfish consumption
 - Hepatitis A outbreak in 1988 - 61 cases - oysters harvested from Bay County waters.
 - Norwalk/Norwalk-like viruses - Panhandle oysters 1993 - 7 outbreaks, 1995 1 outbreak, etc.
 - *Moral of the story - don't eat Florida sushi.*
- Swimming
 - 23rd Annual Swim Around Key West, 12 June 1999 with 300 participants (Noble et al. 2000, FJPH).
 - June 8th fecal coliforms 2000cfu/100ml
 - June 10th fecal coliforms 1980cfu/100ml
 - June 12th fecal coliforms 3600cfu/100ml
 - June 13th fecal coliforms 20,000cfu/100ml
 - (single sample limit for ambient water is 800cfu/100ml)
 - Case group 164 respondents with 50 reporting at least one of 16 listed illnesses (30.3%)
 - Control group 27 respondents with no reported illnesses
- Brevitoxins?



Conclusion

• Human waste is impacting nearshore marine waters throughout the State of Florida

- Septic tanks**
 - Ocean outfalls**
 - Injection wells via submarine groundwater discharge**
 - Wastewater discharged to inland surface waters**
- Septic systems in close proximity to inland rivers and along coastal waters are a significant source of nutrients and microorganisms (no disinfection).**
- Utilization of these types of all of these waste disposal systems in Florida poses a risk to both human and marine ecosystem health.**
- A solution - reuse and spray-fields**