Groundwater on Fire Island and its relation to human and environmental needs

The Health & Science of our Bays: A Fire Island Perspective
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In cooperation with National Park Service
Problem

- About 2.2 million people visit Fire Island each year. The arrival of summer residents and vacationers increases the population 50-fold.
- Wastewater from most septic systems discharges directly into the shallow (water-table) aquifer. The associated nutrients, pathogens, and organic compounds can eventually seep into back-barrier estuaries and threaten their ecological health.
- Elevated concentrations of nutrients in groundwater that discharges to surface waters can lead to increased production of phytoplankton and macroalgae; these, in turn, can cause oxygen depletion, declines in estuarine fish and shellfish communities, and loss of submerged seagrass habitat.
Fire Island study area
Land use

Four local study areas
- Kismet
- Robbins Rest
- Watch Hill
- National Wilderness
Land use

Percent of total area

A Fire Island land use—Percent of total area
- Residential: 12.5%
- Other: 3.4%
- Vacant: 3.1%
- Recreation and open space: 81%

B Fire Island residential density—Dwellings per acre and percent of total area
- Low ≤ 1: 0.2%
- Medium 2–4: 3.8%
- High ≥ 5: 8.5%
Shallow aquifer system

Diagram showing the geographical layout of the aquifer system, including the Atlantic Ocean, Fire Island, Great South Bay, and Long Island. Notable features include:
- Unconfined aquifer containing fresh groundwater (Upper glacial aquifer)
- Zone of transition between fresh groundwater and salty groundwater (brackish water)
- Seaward extension of unconfined aquifer containing salty groundwater
- Confining unit (Gardiners Clay)
- Confining unit (Monmouth greensand)
- Underlying confined aquifer (Magethy aquifer) containing fresh groundwater

The water table is shown as a purple dashed line, and recharge areas are indicated by arrows. The diagram also highlights the freshwater lens and brackish water layers.
Fire Island study area

- Modeled recharge areas (numbered in white) to marine surface waters under 2005 mean annual conditions
- Results show that most freshwater from the shallow aquifer system discharges toward the back-barrier estuaries (recharge areas in blue)
Fire Island study area

Total nitrogen (TN) load in groundwater discharge

- (A) distribution by percent and kilograms per year (kg/yr) to back bays and the ocean
- (B) sources of TN load to back bays by percent of contributing land-use area

![Distribution and amount of annual total nitrogen load from Fire Island](image)

![Sources of total nitrogen load to back bays by land use on Fire Island](image)
Nitrogen loading rates by watershed

Rate of annual discharge of nitrogen from shallow groundwater to marine surface waters

- Fire Island
- South Shore Estuary Reserve (SSER)
- North Shore of Long Island
What are CECs?
“umbrella term”

- Pharmaceuticals
- 1,4-dioxane
- PAHs
- Fragrances
- Detergents
- Algal toxins
- Microplastics
- Hormones
- PFAS
- Phytoestrogens
- Illicit drugs
- Fire retardants
- Pathogens
- Pesticides

1. Not currently regulated
2. Incomplete knowledge of fate or effects
CECs in Groundwater at Fire Island

- Monitoring since 2011
- Dense residential, mixed use setting
- Seasonal changes in population
- Unsewered

Shallow groundwater, along with contaminants, ultimately discharges to the Great South Bay.

2015-18 study: assess (seasonal) variation in concentrations and types of pharmaceuticals in the shallow groundwater of Fire Island.
Fire Island Data 2015-2017

Pharmaceuticals detected at every location sampled

Number & concentration of pharmaceuticals varies between each sampling event

Consistent detection and maximum total concentrations >100 ng/L
Fire Island Data

33 different pharmaceuticals were detected in Fire Island groundwater

- Antidepressants
- Antihistamines
- Antivirals
- Heart medications/beta-blocker
- Antacid/anti-diabetic
- Pain medications
- Antifungals
- Topical anesthetic
- Anti-anxiety
- Muscle relaxants
- Anticoagulant (blood thinner)

...plus many others
SLR Effects on Groundwater Dependent Ecosystems

Current Conditions

Future Conditions
For more information

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