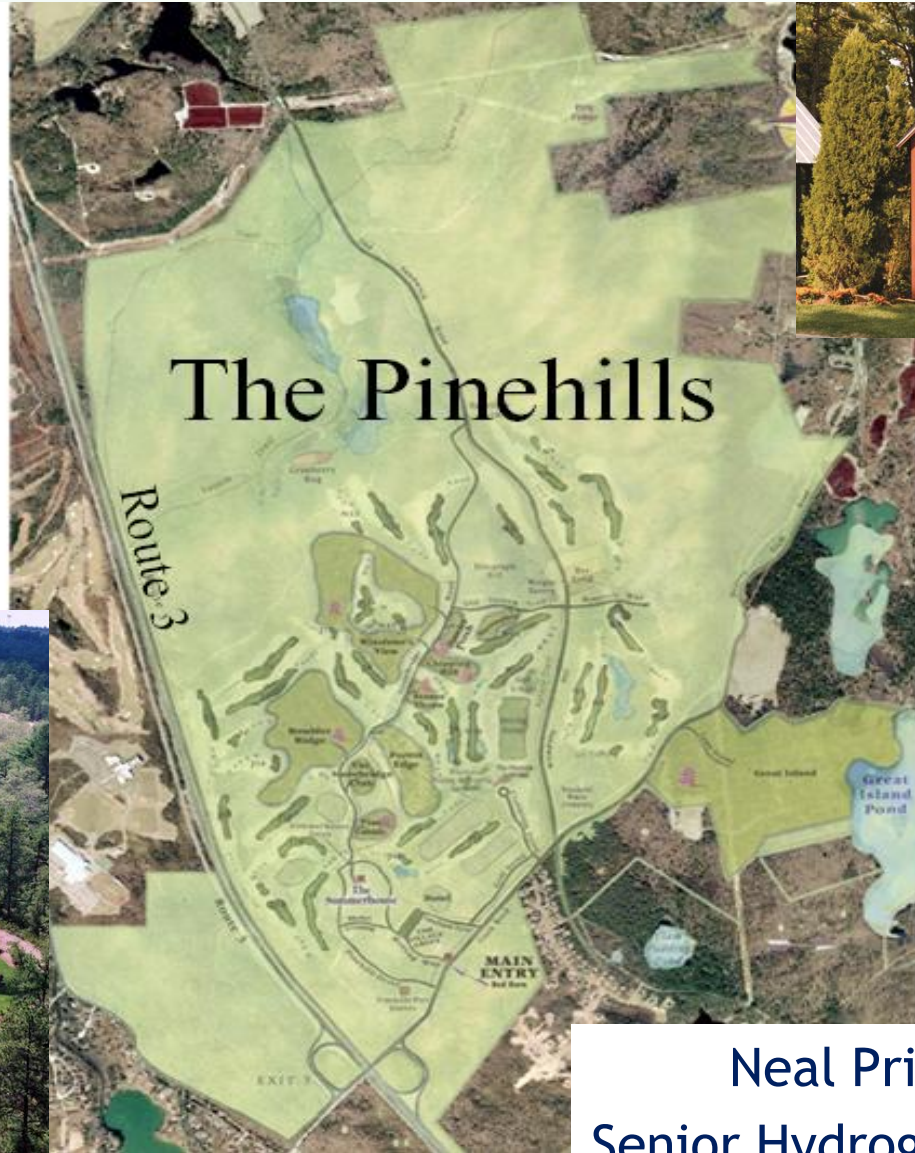


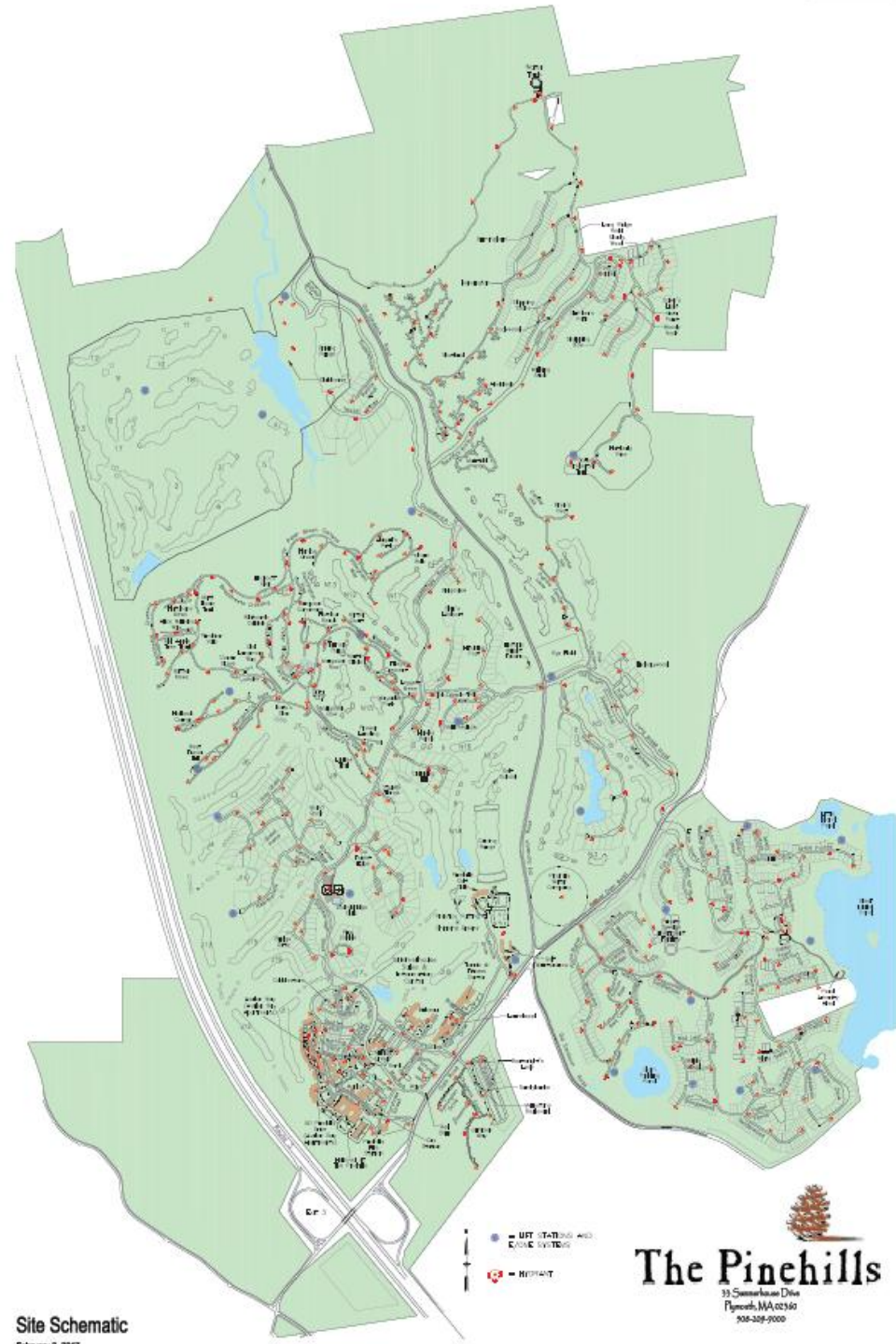
Integrated Water Management at The Pinehills Community - Plymouth, MA



Neal Price
Senior Hydrogeologist



- 3,052 homes on 3,050 acres
- 3 Golf courses
- 1.3M sf Commercial :
 - hotel/spa/resort
 - super market
 - village center
 - gas station
 - fire station
- 1.4 MGD water system
- 450K gpd WWTF



Pinehills Water Company - By the Numbers

- 167.9MG Permitted Annual Withdrawal (460,000 gpd average)
- 39 miles of water mains in 2 pressure zones
- 2 MG storage tank
- Treatment for pH only
- 2,161 connections (6,275 est. population)
- Regulated by MA DEP (310 CMR 22.00), WMA (310 CMR 36.00), & SWMI



Pinehills PSTF - By the Numbers

- 450,000 gpd PSTF
- SBR design
- TN average 5-6 mg/L
- 32 miles gravity sewer and forcemain
- 23 lift stations
- 2 Infiltration facilities



Pinehills Irrigation

- 4 WMA permits:
 - Drinking water and homeowner irrigation (167.9 MGY)
 - Common area irrigation (23 wells) (54 MGY)
 - Pinehills Golf (2 Courses) (4 wells) (81 MGY)
 - OS Golf Club (1 well) (23 MGY)
- Annual Reporting and Use restrictions under WMA and SWMI

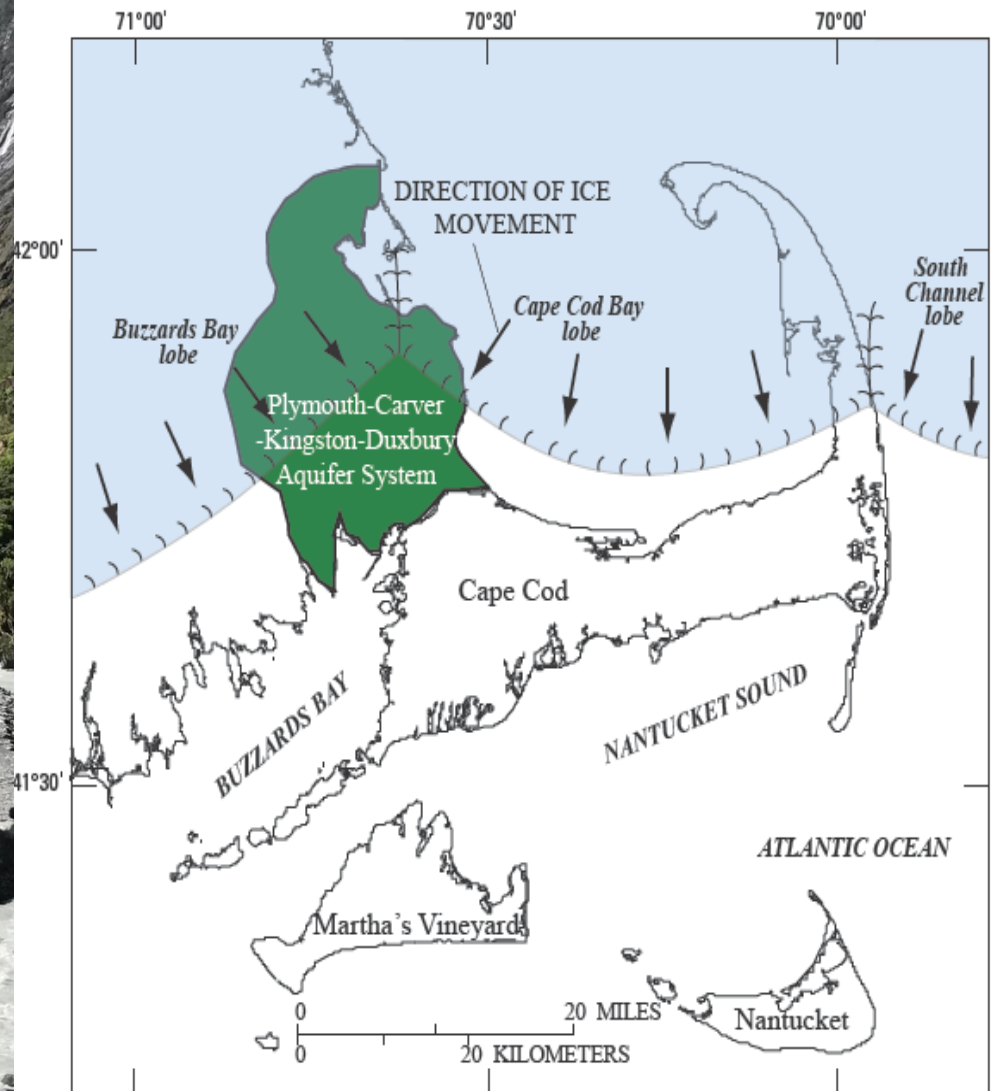


Plymouth-Carver Aquifer

- Second Largest in Massachusetts
- 200 Square Miles
- 500 Billion Gallons
- 400 Ponds
- 12 Rivers and Streams
- Cranberry Bogs
- Miles Standish State Forest at Peak of Mound (15,000 acres)

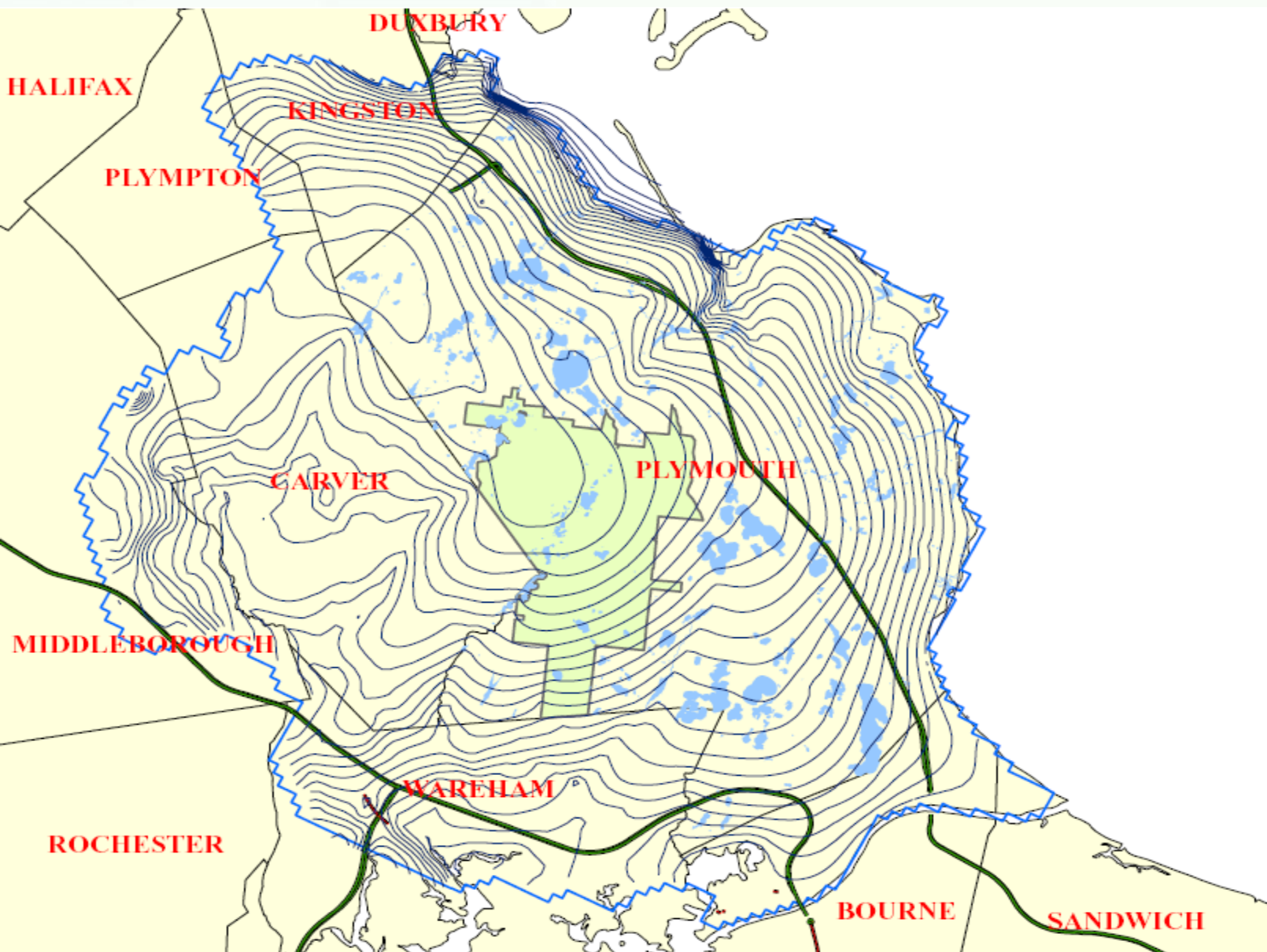


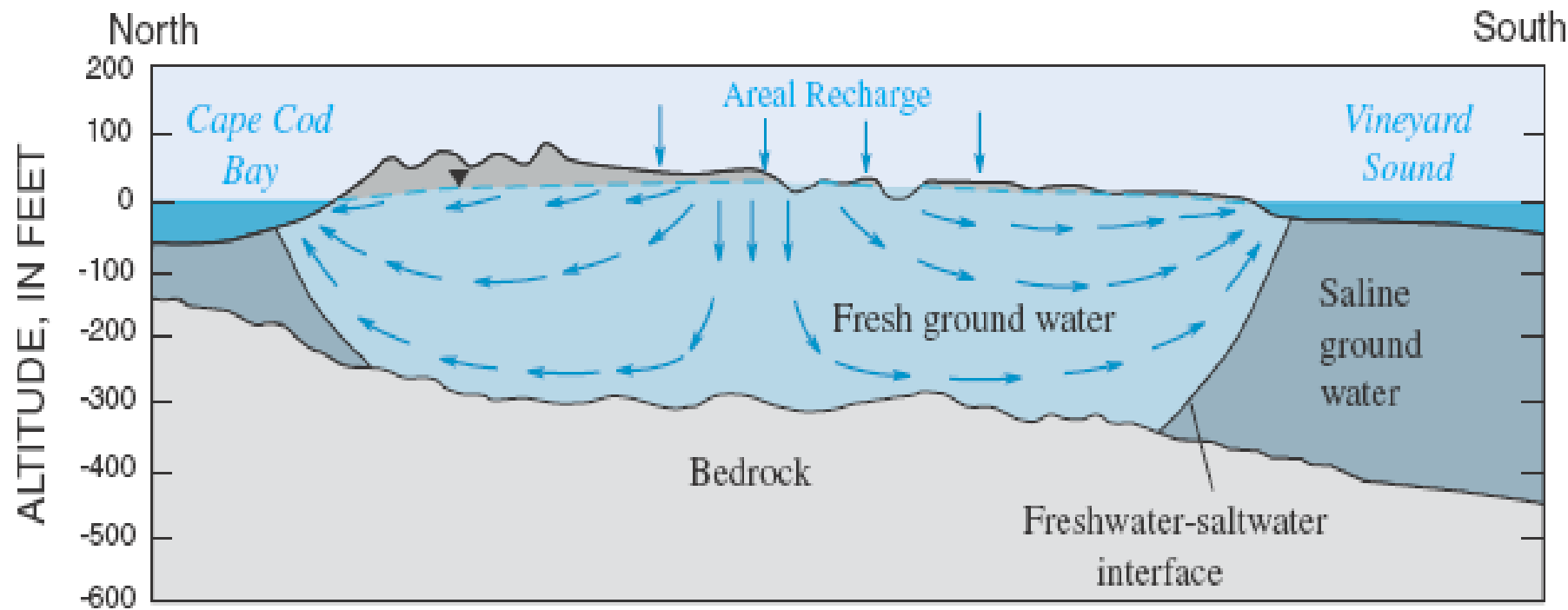
Glacial Geology



Base from U.S. Geological Survey and Massachusetts Geographic Information System data sources, Massachusetts State Plane Coordinate System, Mainland Zone

Plymouth-Carver Aquifer

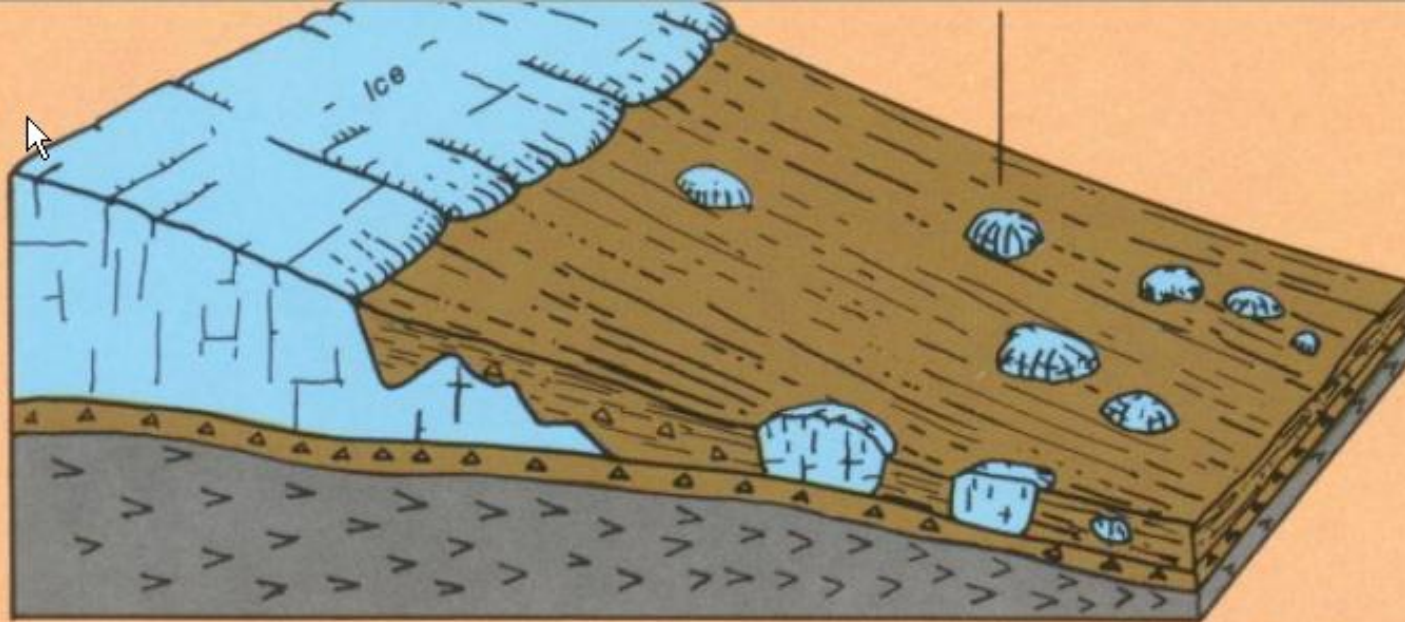




Schematic diagram; horizontal not to scale. Altitude, in feet relative to NGVD29

Modified from Masterson, 2000

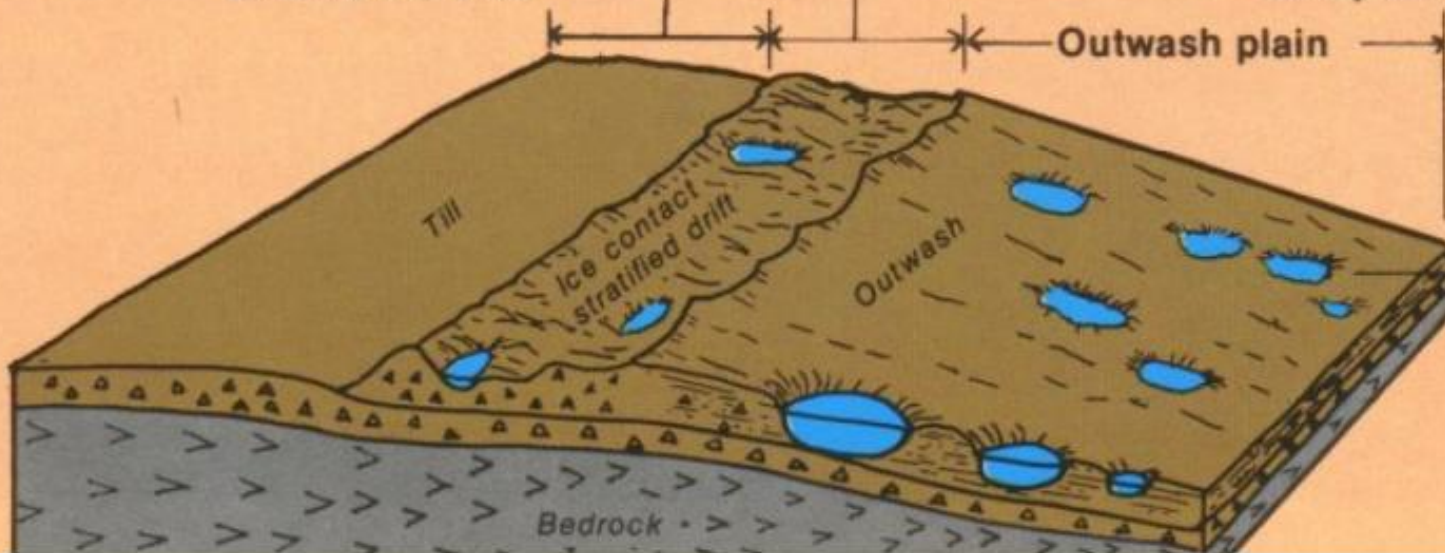




Ground moraine

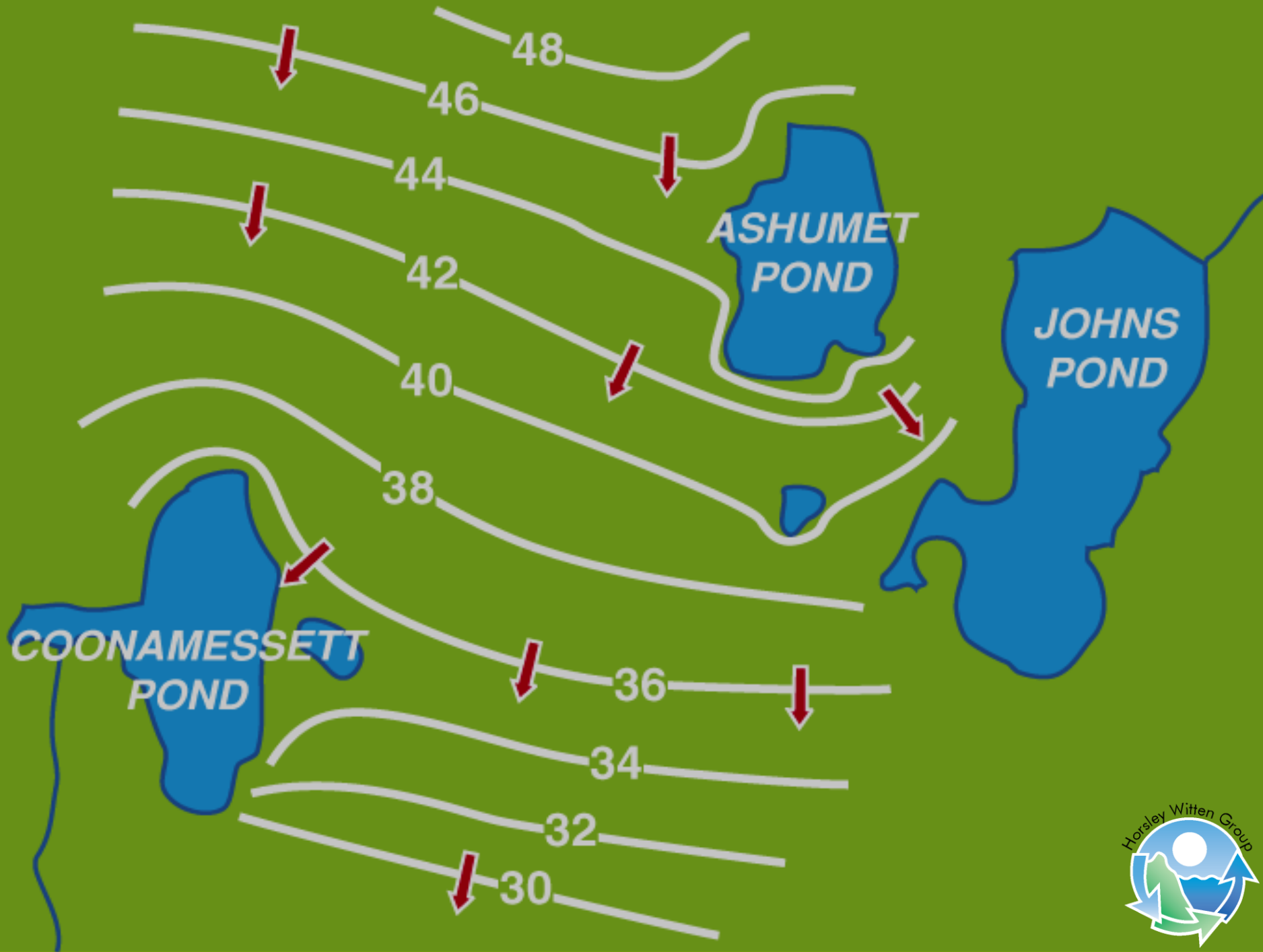
Collapsed zone of outwash

Outwash plain



Kettle

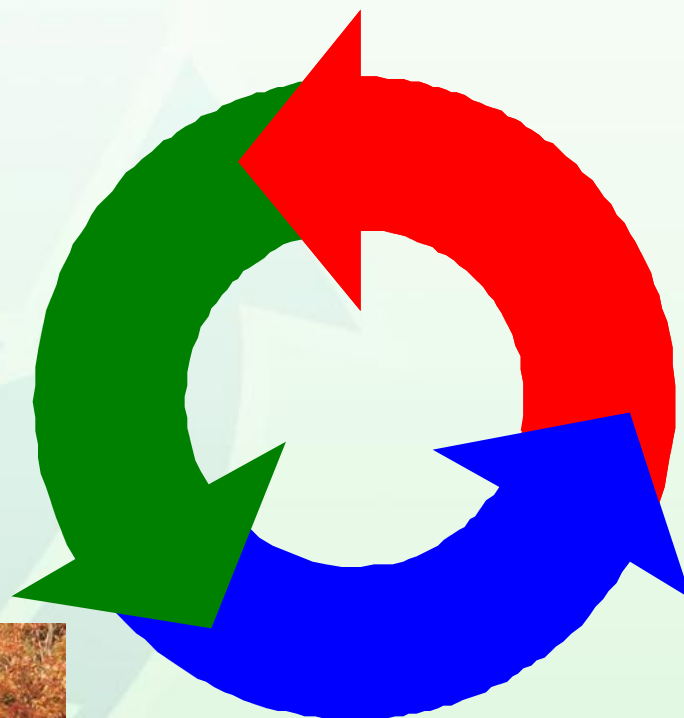




INTEGRATED WATER MANAGEMENT

Wastewater Treatment
and Recharge

Stormwater Treatment
and Recharge



Water Supply
Withdrawals



Horsley Witten Group, Inc.



Begin with Better Site Design

- Design for water resources management from the beginning
- Then select LID BMP's to mitigate impacts

Goal TO REDUCE IMPACTS ON WATER RESOURCES:

- **Water Quantity**
- **Water Quality**



Traditional Design Practices Do NOT tend to Minimize the Footprint or Impact of Development



- Larger lot development;
- Clearing and grading of significant site area;
- Wider streets and larger cul-de-sacs;
- Enclosed drainage systems for stormwater.

Better Site Design Planning Process:

1. Avoid the Impacts

Preserve Natural Features and use Conservation Design Techniques

2. Reduce the Impacts

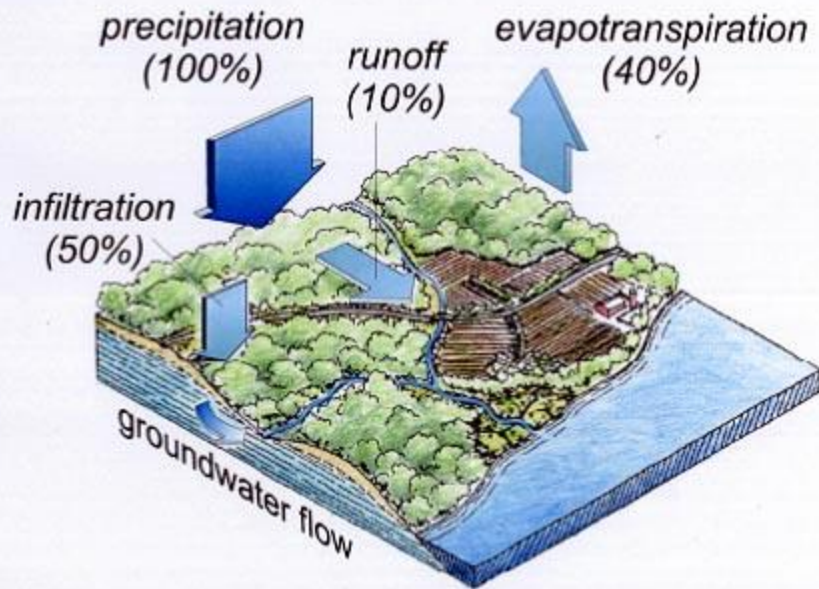
Reduce Impervious Cover

3. Manage the Impacts

Utilize Natural Features and Natural Low-Impact techniques to manage stormwater



Natural Conditions

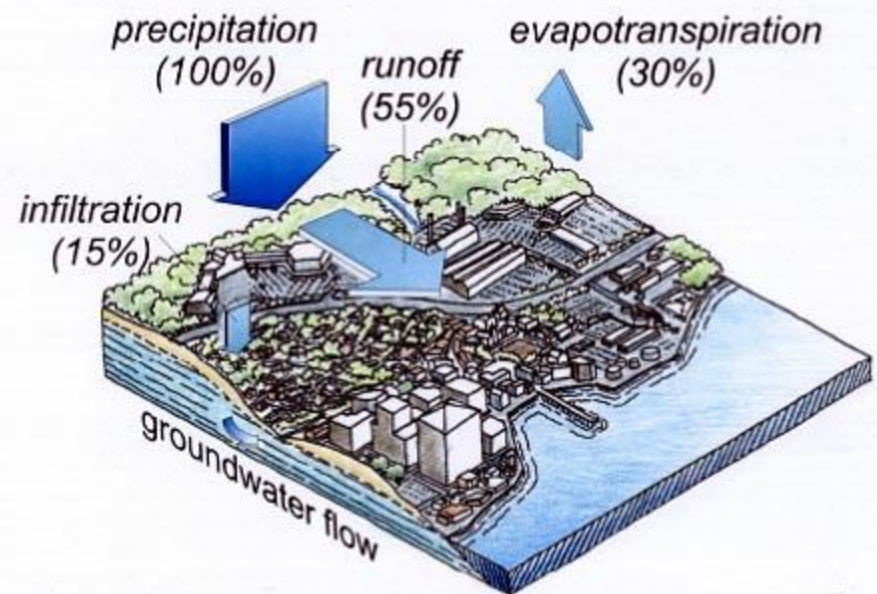


Infiltration/recharge to groundwater supplies

Natural filtration of pollutants by vegetation

Minimal runoff

Conventional Development



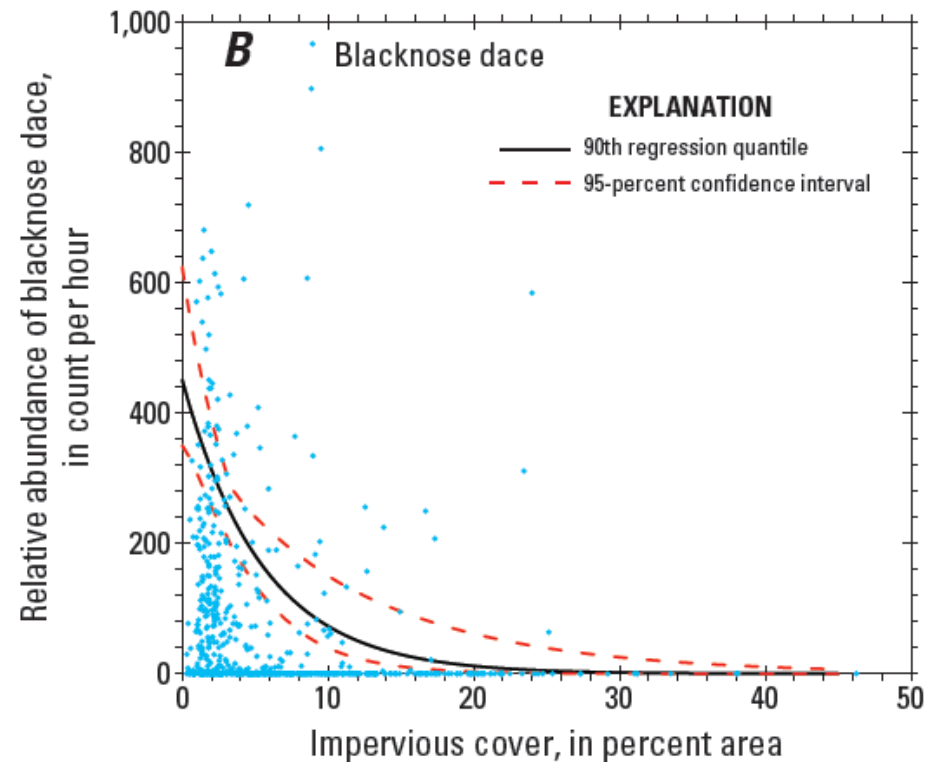
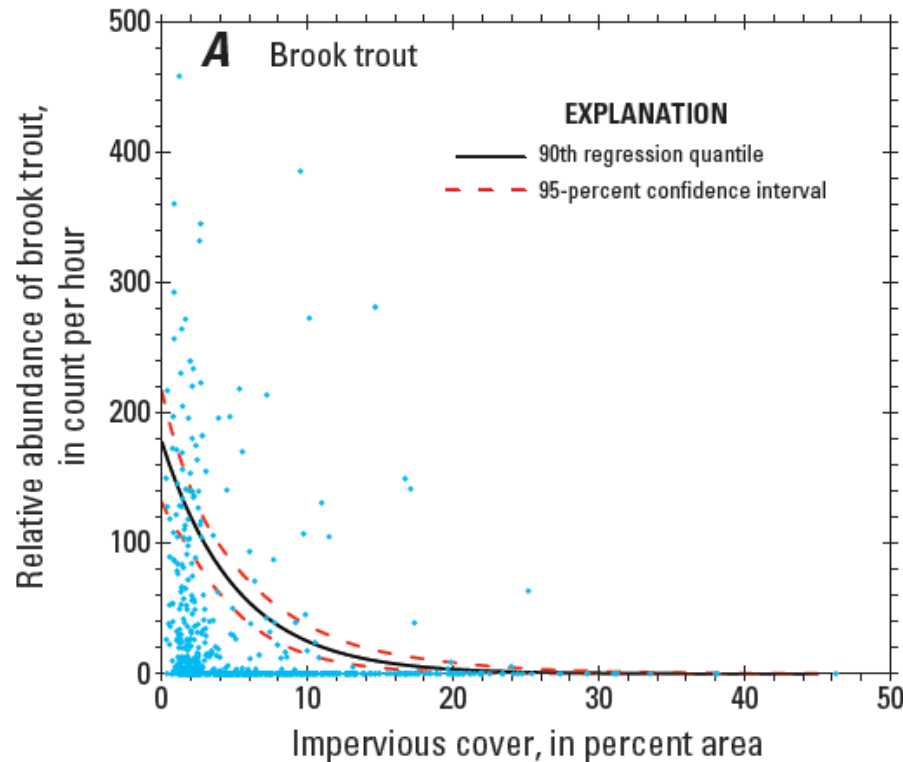
Loss of natural land or open space

Increased runoff/flooding

Reduced infiltration/recharge to groundwater

Increased infrastructure costs & maintenance

Relative Abundance of Indicator Fish Species Metrics in Relation to Impervious Cover

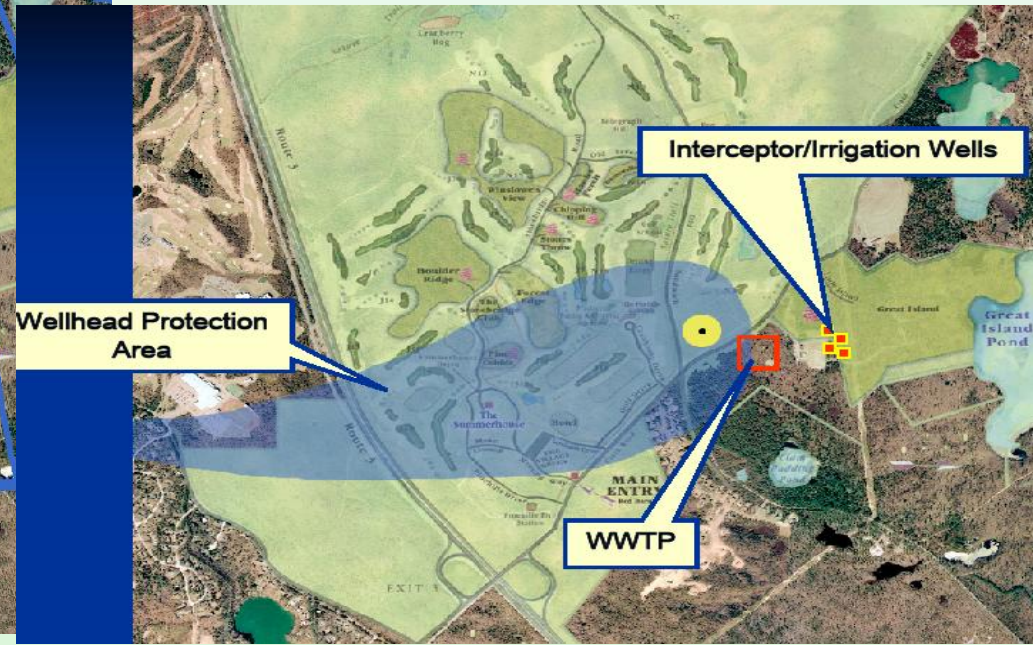


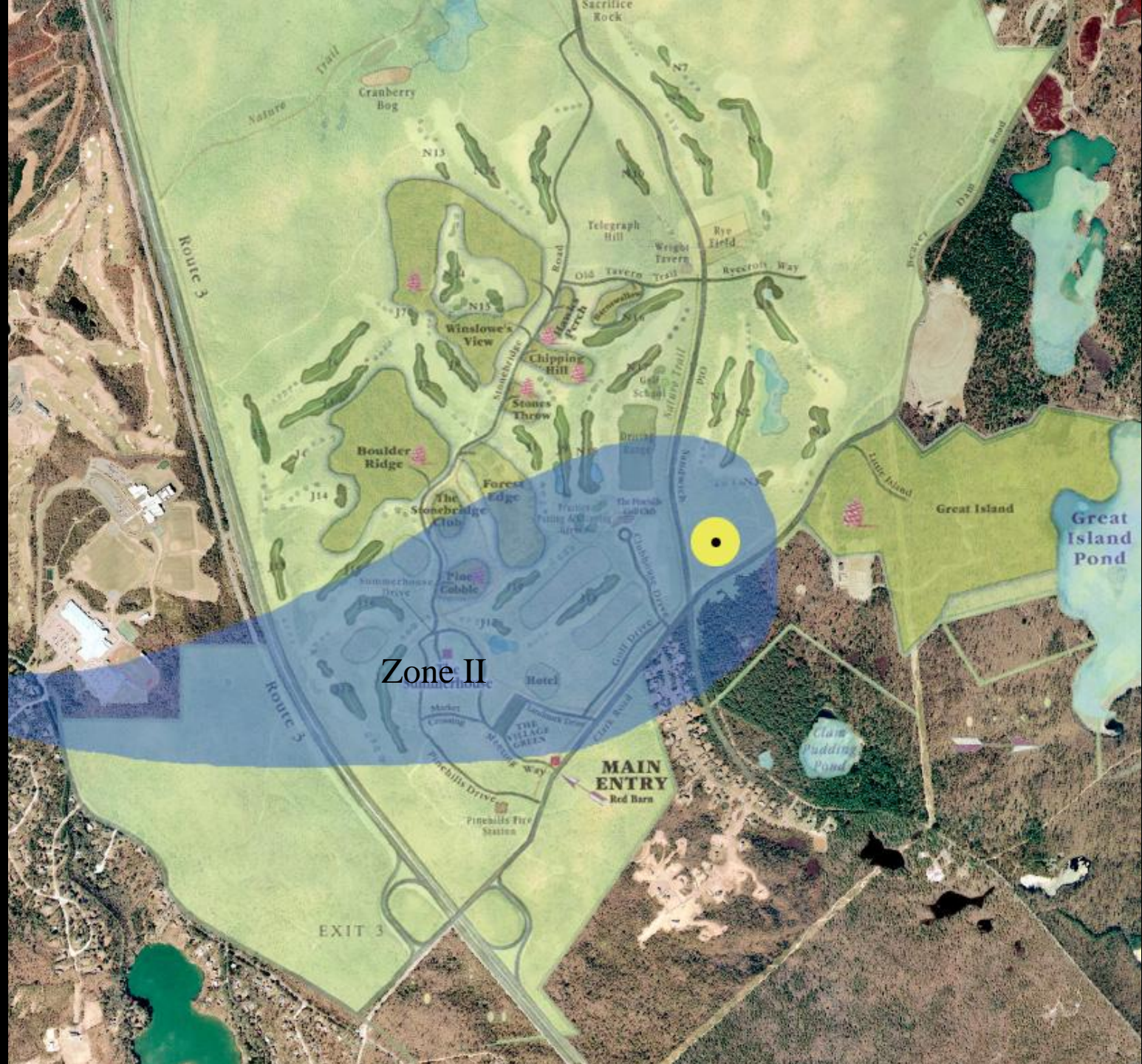
Source: Armstrong et al., Preliminary Assessment of Factors Influencing Riverine Fish Communities in Massachusetts, USGS 2010

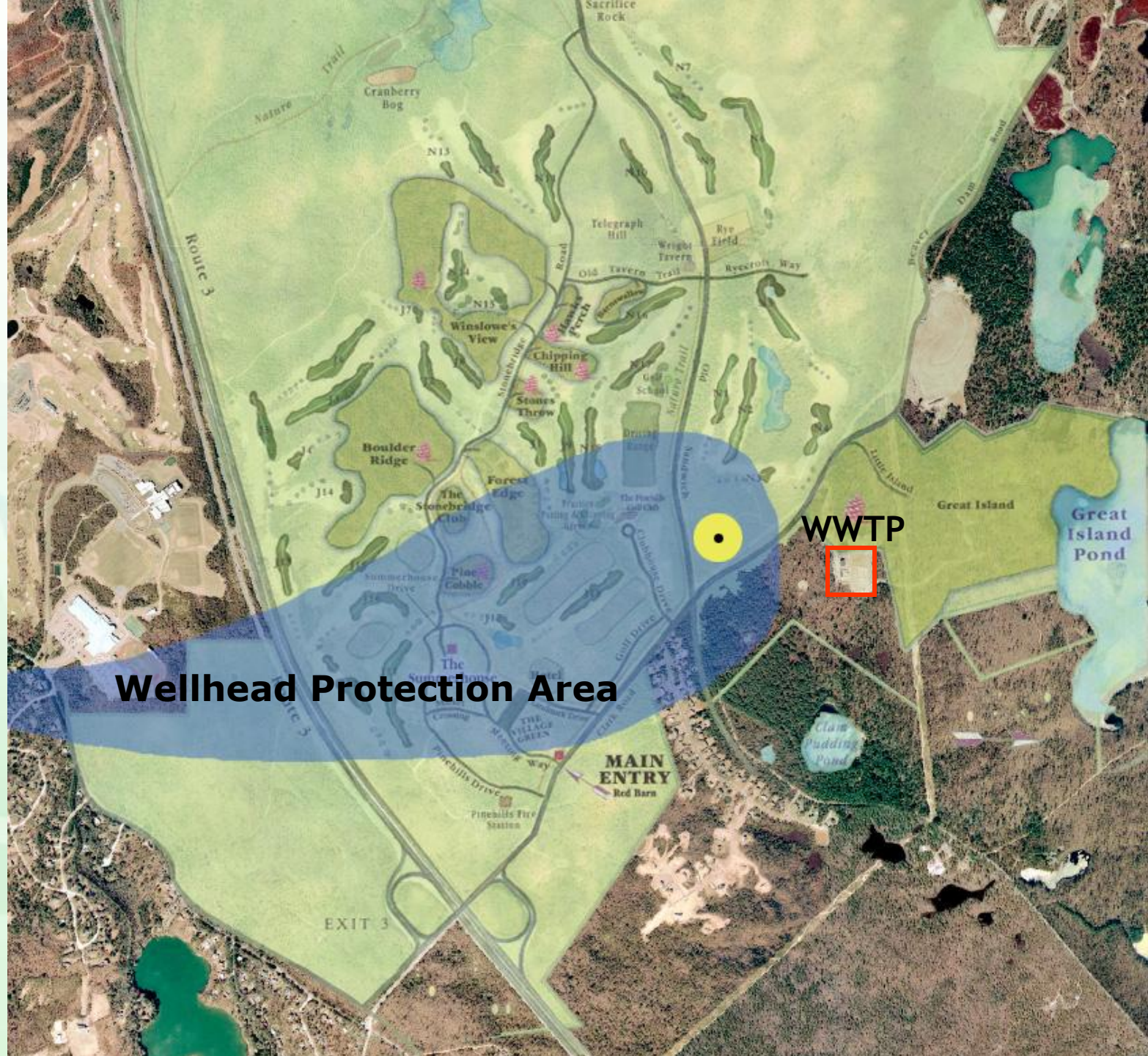




- Designed with LID and Integrated Water concepts from its beginning in 1998:
 - Layout designed around existing features
 - Begin with water supply and wastewater
 - Minimize env. impacts
- 70% open space
- 20% CR



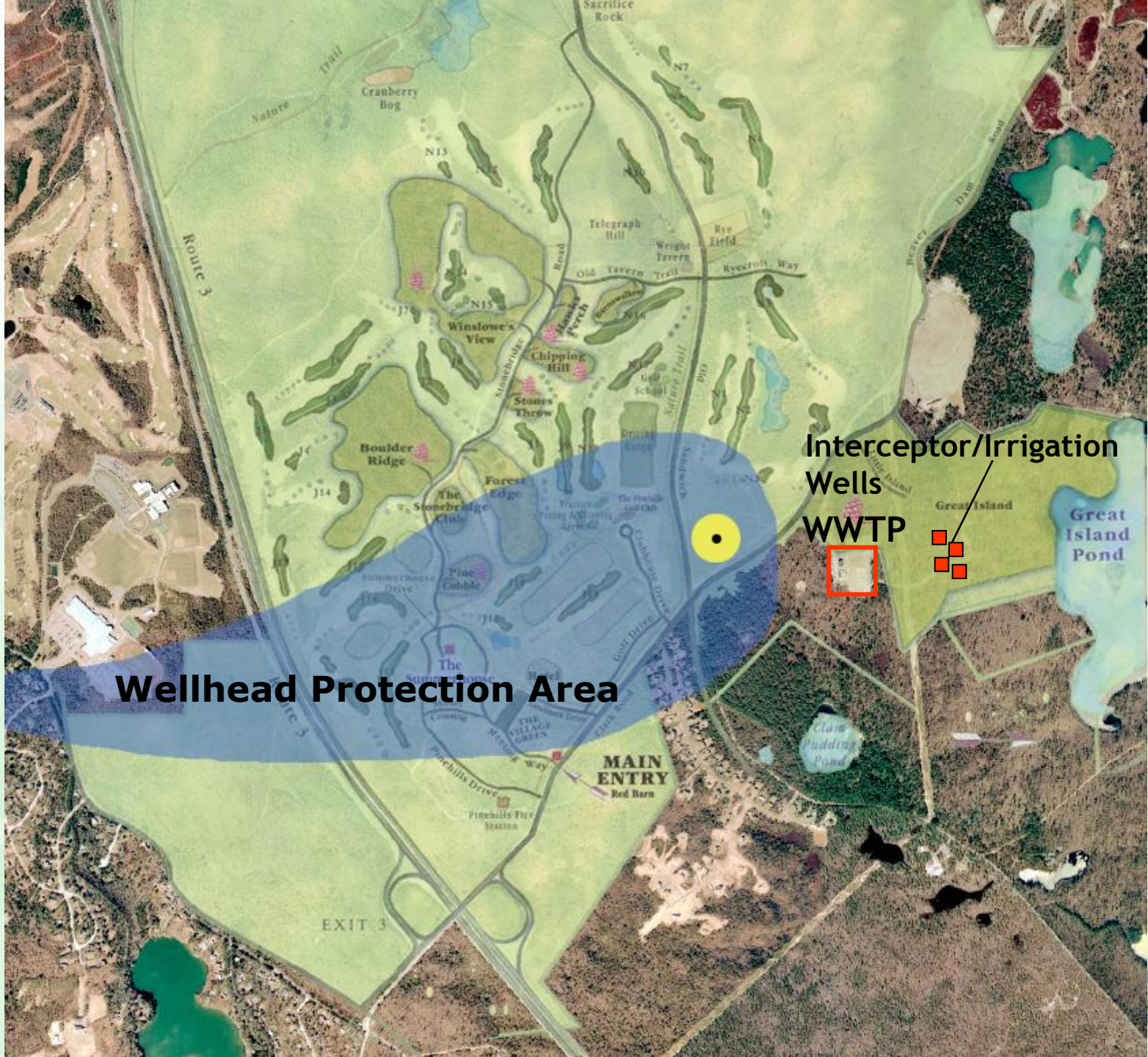




Wellhead Protection Area

WWTP





Wellhead Protection Area

Interceptor/Irrigation Wells
WWTP





Site Design Minimizes Impervious Surfaces

Designing with the Landscape



Treated Wastewater Recharge

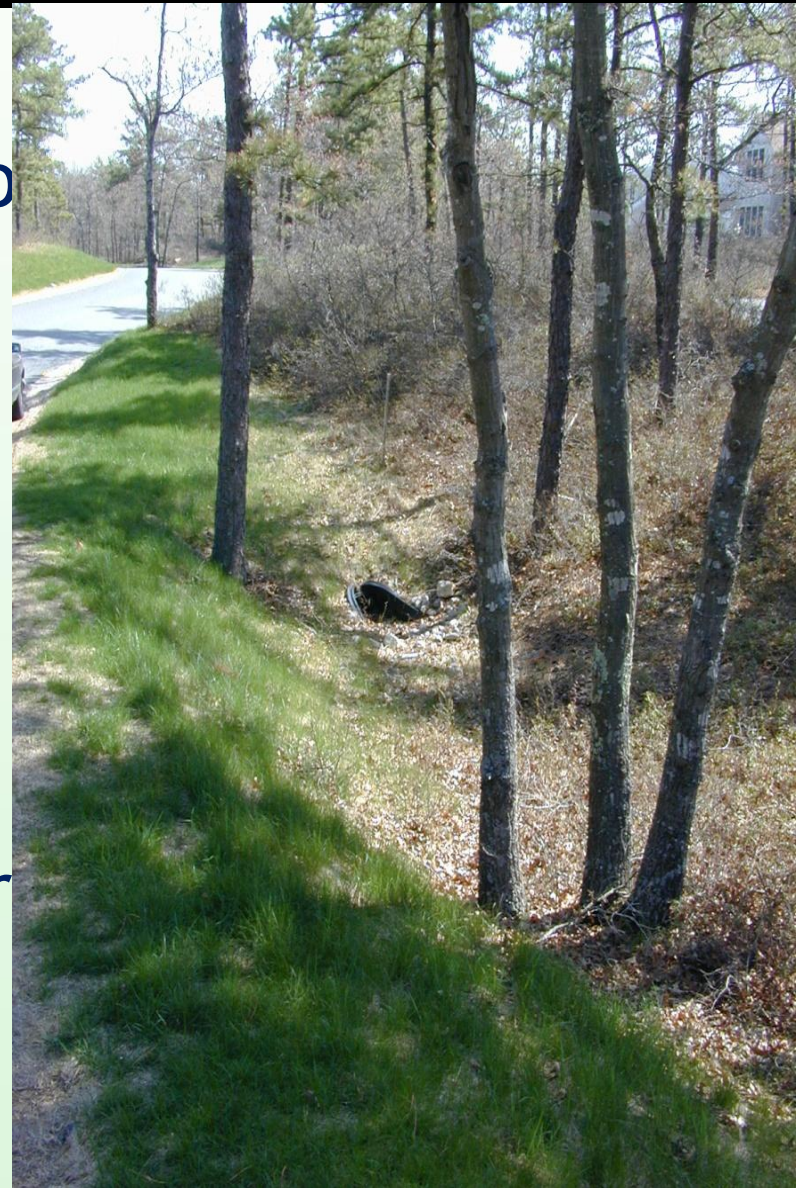
- Rye Field

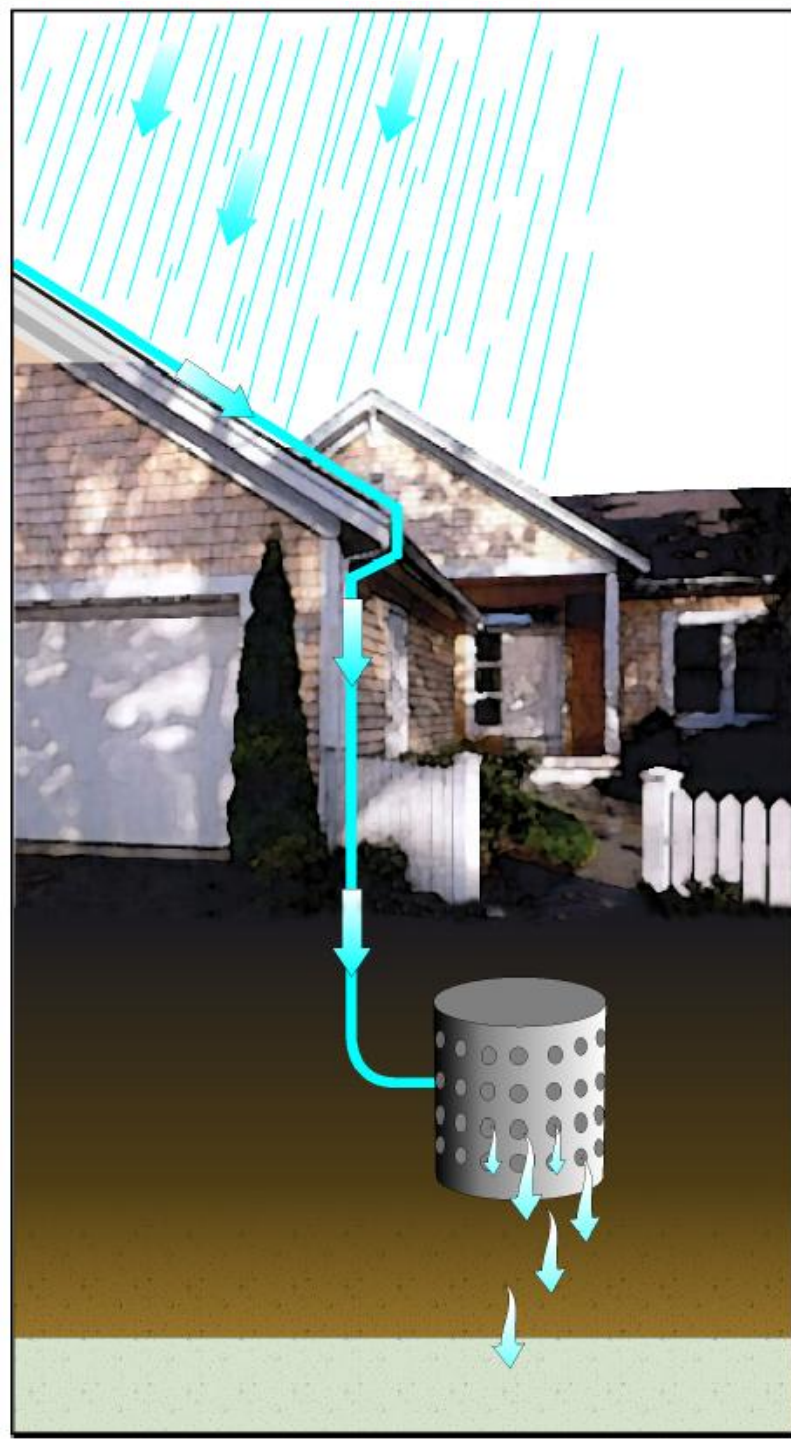
PSTF



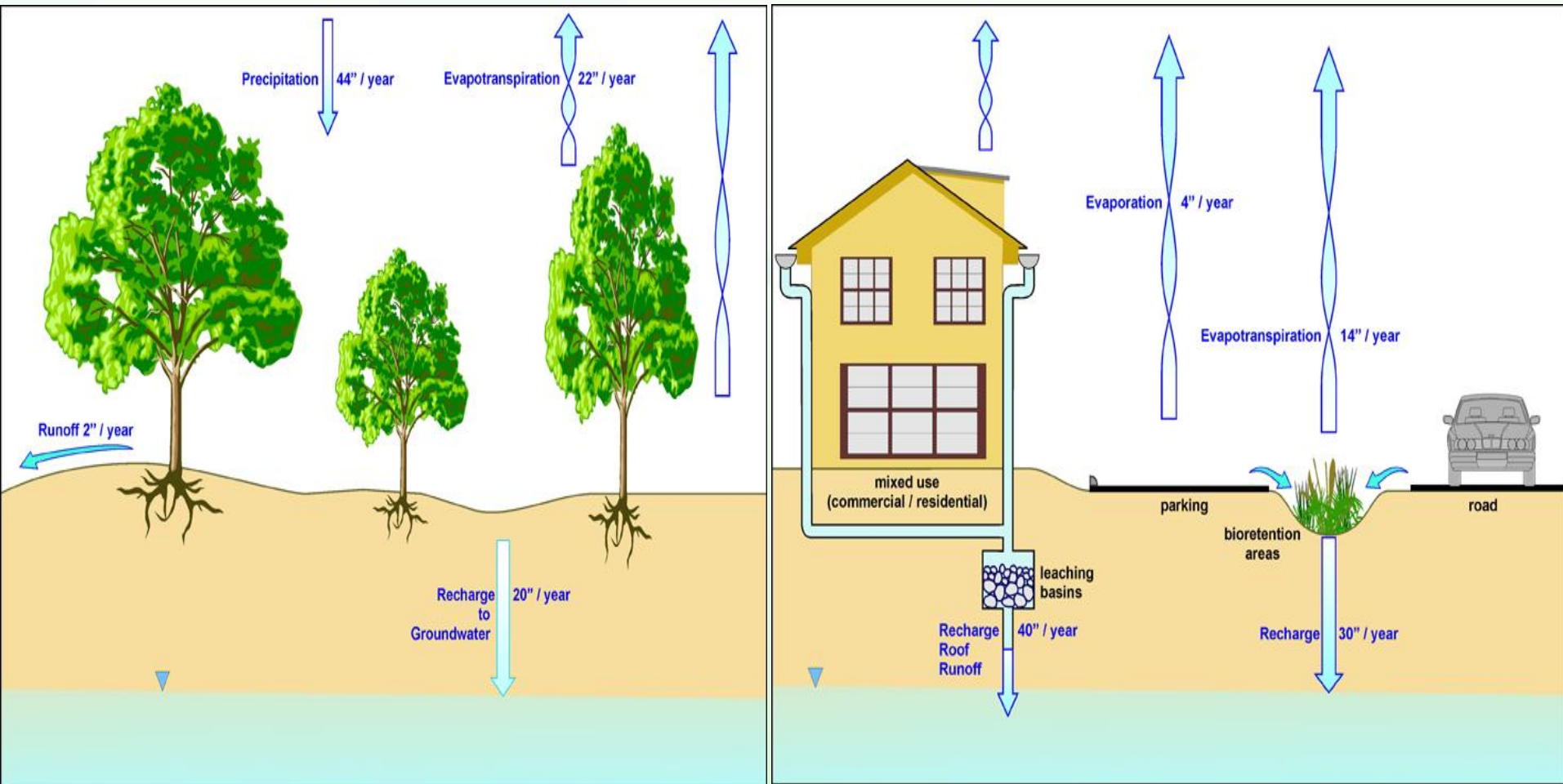
Pinehills Stormwater Management

- All roof drainage to drywells
- Road and parking drainage to vegetated swales, natural vegetated depressions, or infiltrating catch basins
- 100% Infiltration except immediate proximity to Eel River
- 200 ft setback from Eel River for phosphorus management





Natural vs. LID Water Balance



Eel River Watershed

OS Golf Irrigation Well



en Group, Inc.

Eel River Irrigation Water Balance

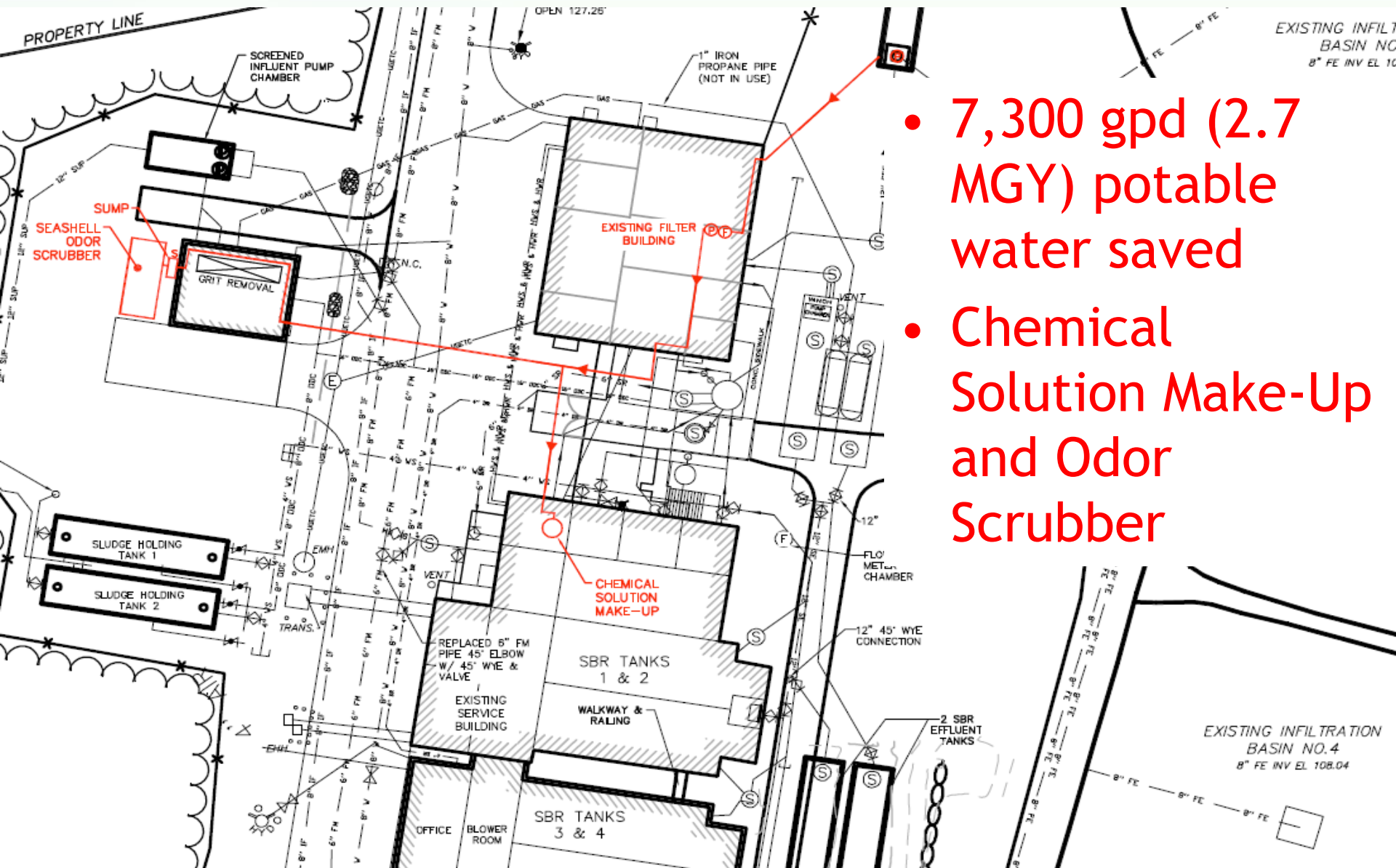
	Amount
Long-term irrigation demand for proposed golf course:	47.00

Offsets:

- 1. 16% return of irrigation water from existing golf courses 2.54**
 - 2. 16% return of irrigation water from proposed golf course: 7.52**
 - 3. Wastewater return via septic for 35 homes: 1.34**
 - 4. Stormwater recharge from impervious surfaces related to approved/proposed homes (approximately 700 homes): 17.91**
 - 5. Stormwater recharge from new golf course parking lot: 0.29**
 - 6. Stormwater recharge from road area: 16.01**
-

Total Offset:	47.41
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Water Re-Use at PSTF



- 7,300 gpd (2.7 MGY) potable water saved
- Chemical Solution Make-Up and Odor Scrubber

Pinehills Integrated Water Summary

- Community designed to minimize impervious surfaces & maximize groundwater recharge of stormwater
- Drinking water and wastewater facilities located prior to defining rest of community



Pinehills Integrated Water Summary

- Irrigation to 2 golf courses supplied by 4 Interceptor Wells located to capture nutrient-rich groundwater down-gradient of PSTF
- Irrigation supplies spread out over community to minimize localized impacts and preserve potable water



Pinehills Integrated Water Summary

- Stormwater and wastewater recharge offsets much of the irrigation and drinking water withdrawals community-wide
- Complete offset for OS Golf in sensitive Eel River watershed
- 2.7 MGY potable water saved through re-use at PSTF for process water



Questions?



Neal Price
Senior Hydrogeologist
Horsley Witten Group
nprice@horsleywitten.com




70°47'30"

70°37'30"

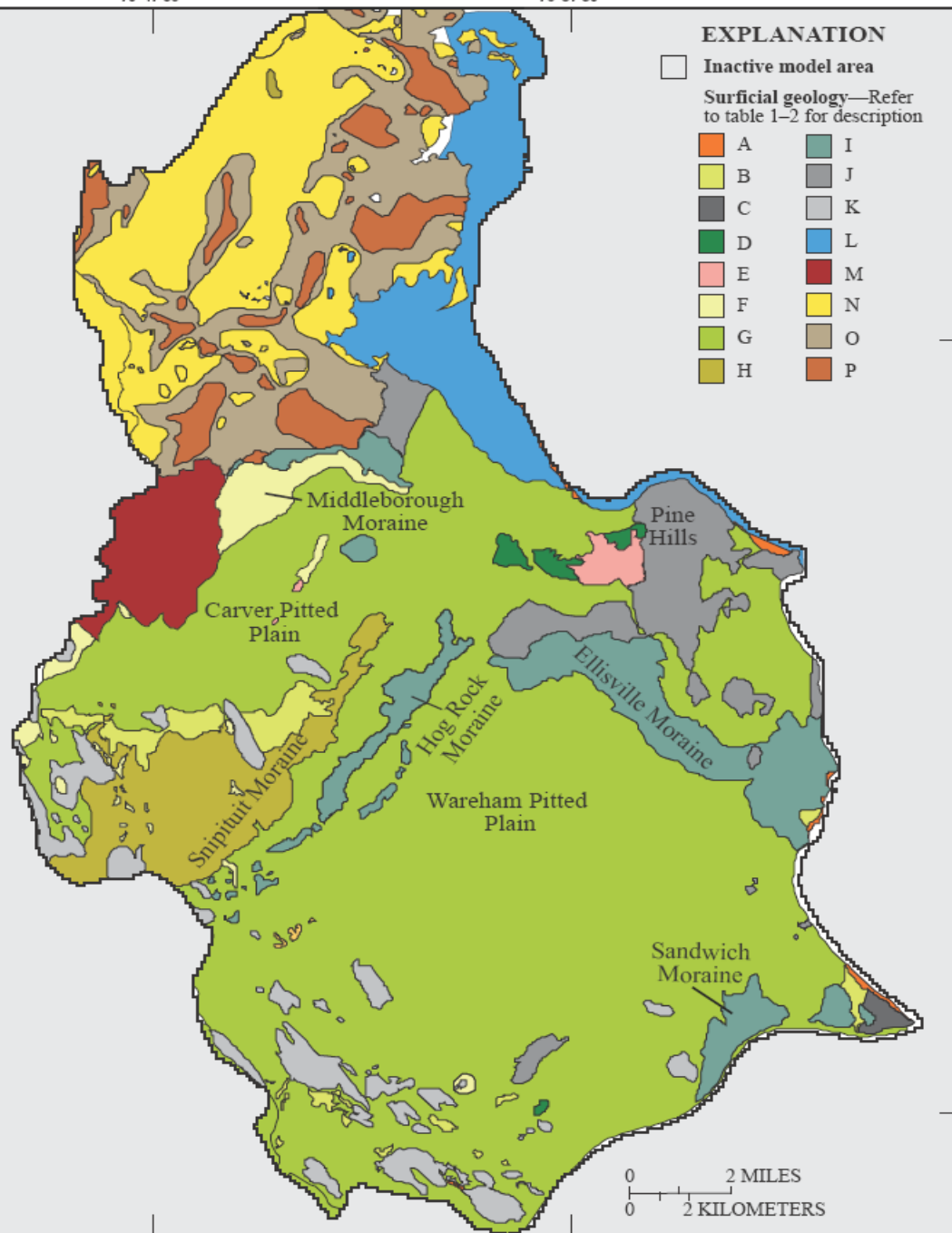
EXPLANATION
 Inactive model area

Surficial geology—Refer to table 1–2 for description

 A	 I
 B	 J
 C	 K
 D	 L
 E	 M
 F	 N
 G	 O
 H	 P

42°00'

41°45'



Base from U.S. Geological Survey and Massachusetts Geographic Information System data sources, Massachusetts State Plane Coordinate

Surficial geology modified from Williams and Tasker, 1974; and from Persky, 1993

orsley Witten Group, Inc.



Vegetated Filter Strips



Open Vegetated Channels



