USGS
science for a changing world

Groundwater and Surface Water– A Single Resource in New England

John Mullaney

Hydrologist

U.S. Geological Survey,

New England Water Science Center

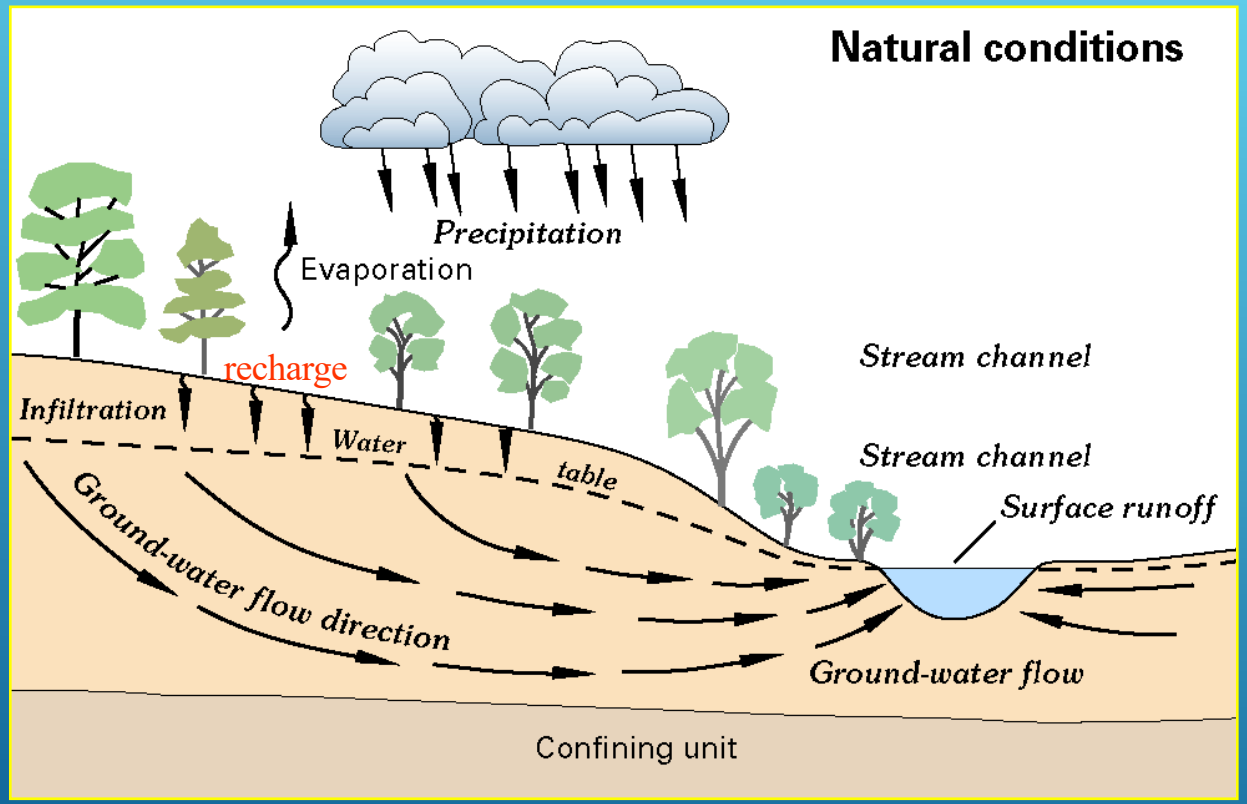
U.S. Department of the Interior
U.S. Geological Survey

Take Home Messages-Answer to Questions

- Why/How is that water flowing?
- How did that water get there, and
  - what pathway did the water follow?
- How does this system vary naturally?
- How do human activities affect this system?

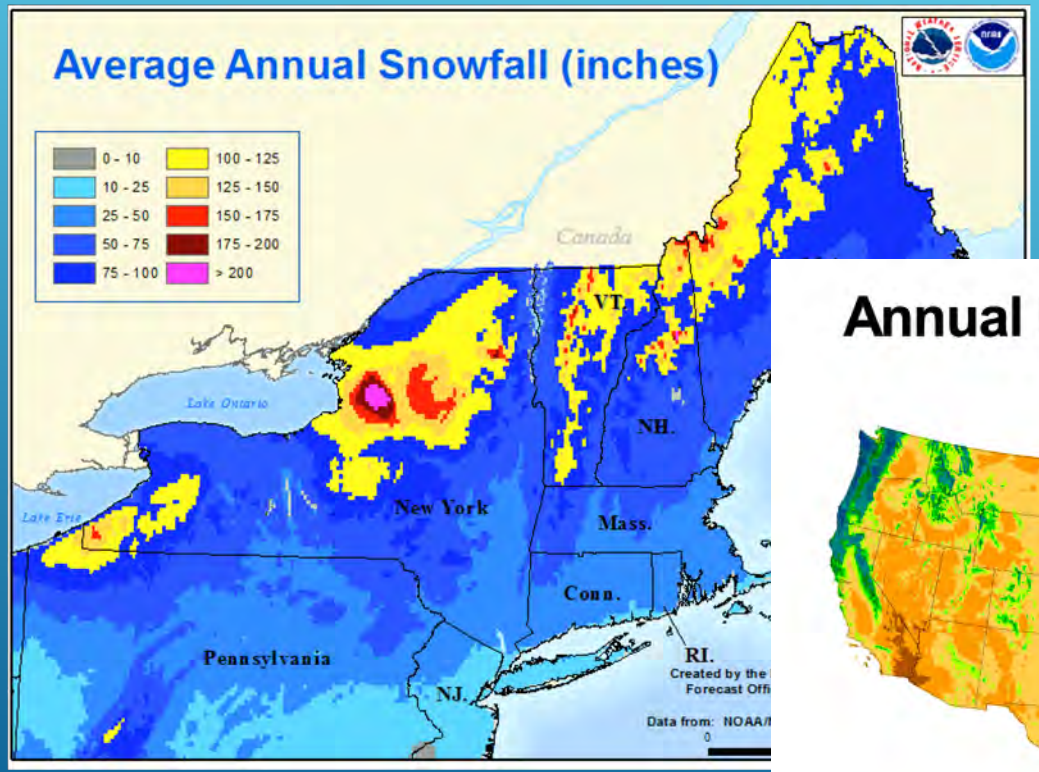
USGS

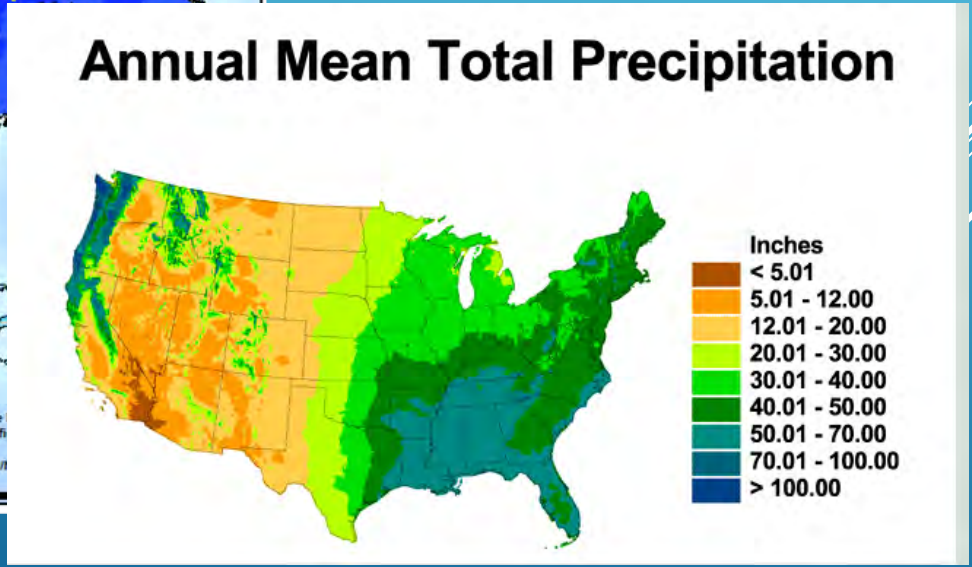
Why/How is that water flowing?



USGS

Precipitation





USGS

Runoff

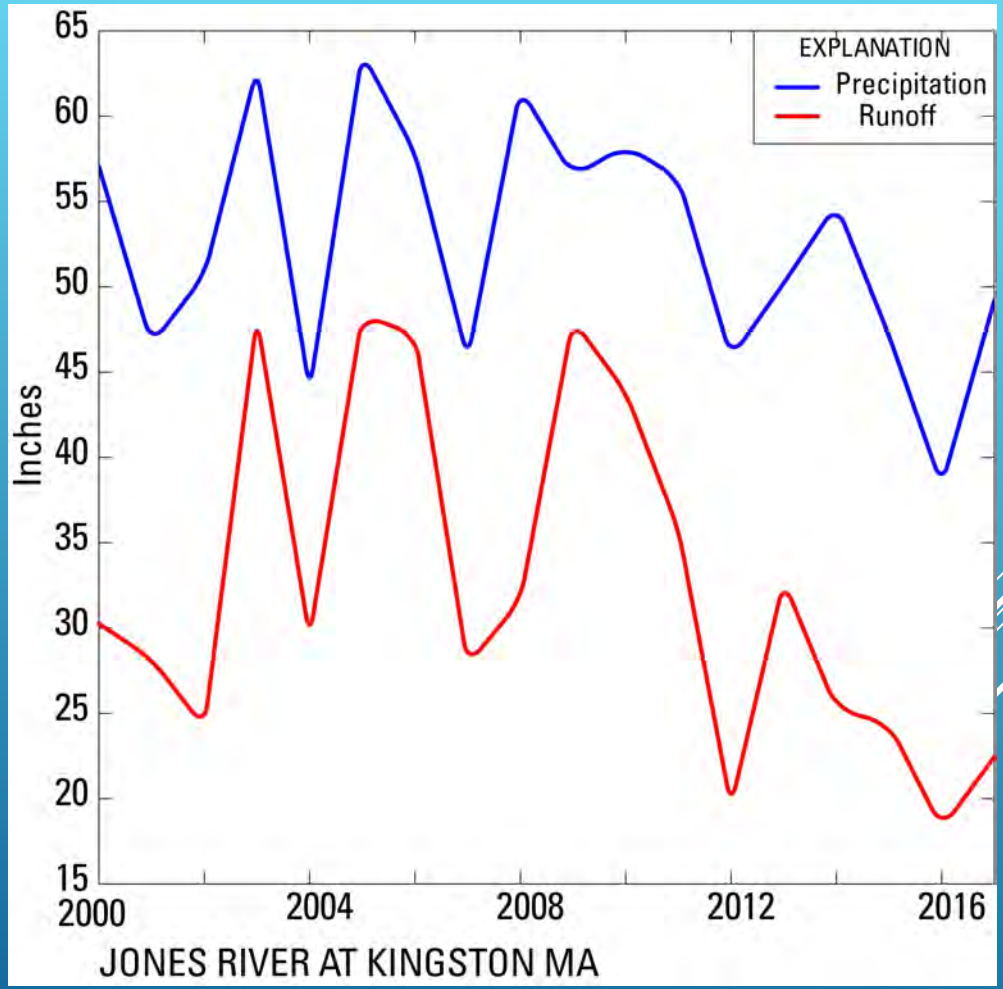
Photo by USGS, MA office

HERRING RIVER AT NORTH HARWICH, MA

The volume of water to pass the watershed outlet over a given time period, per unit area, includes groundwater and surface runoff

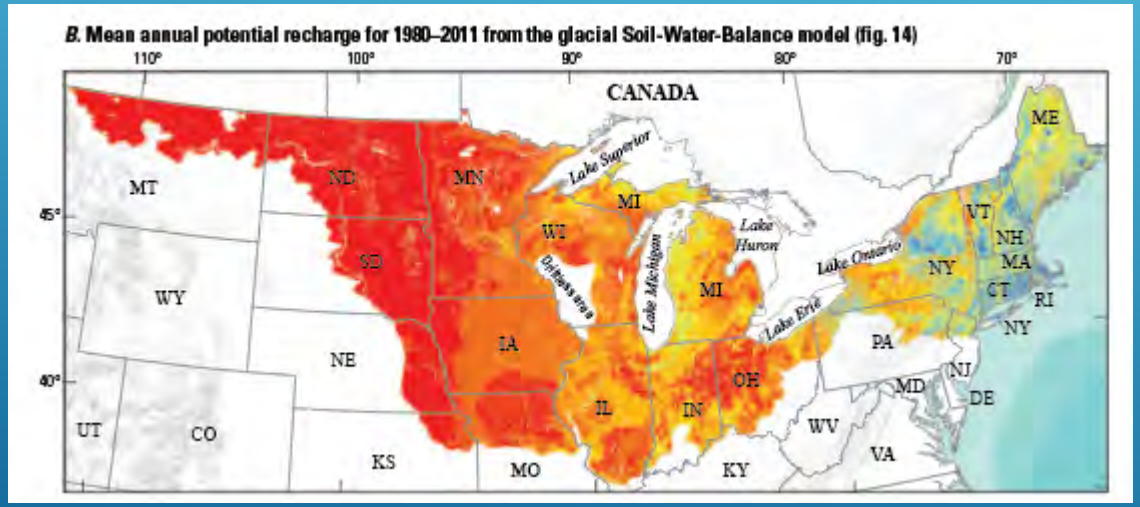
USGS

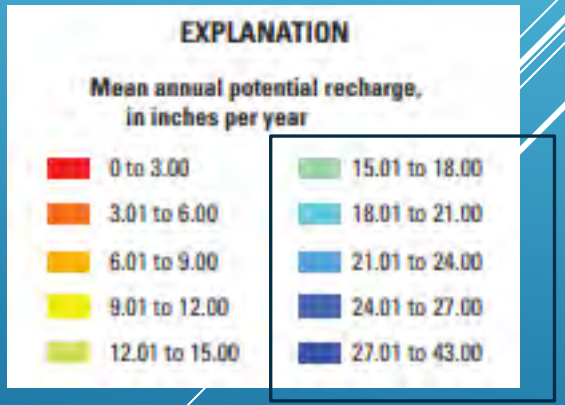
- The Difference Between Precipitation and Runoff
- In a natural system much of the long term average difference is due to ET; short term differences reflect changes in groundwater storage



Streamflow data may be provisional, and subject to revision
Precipitation data from: https://daymet.ornl.gov/

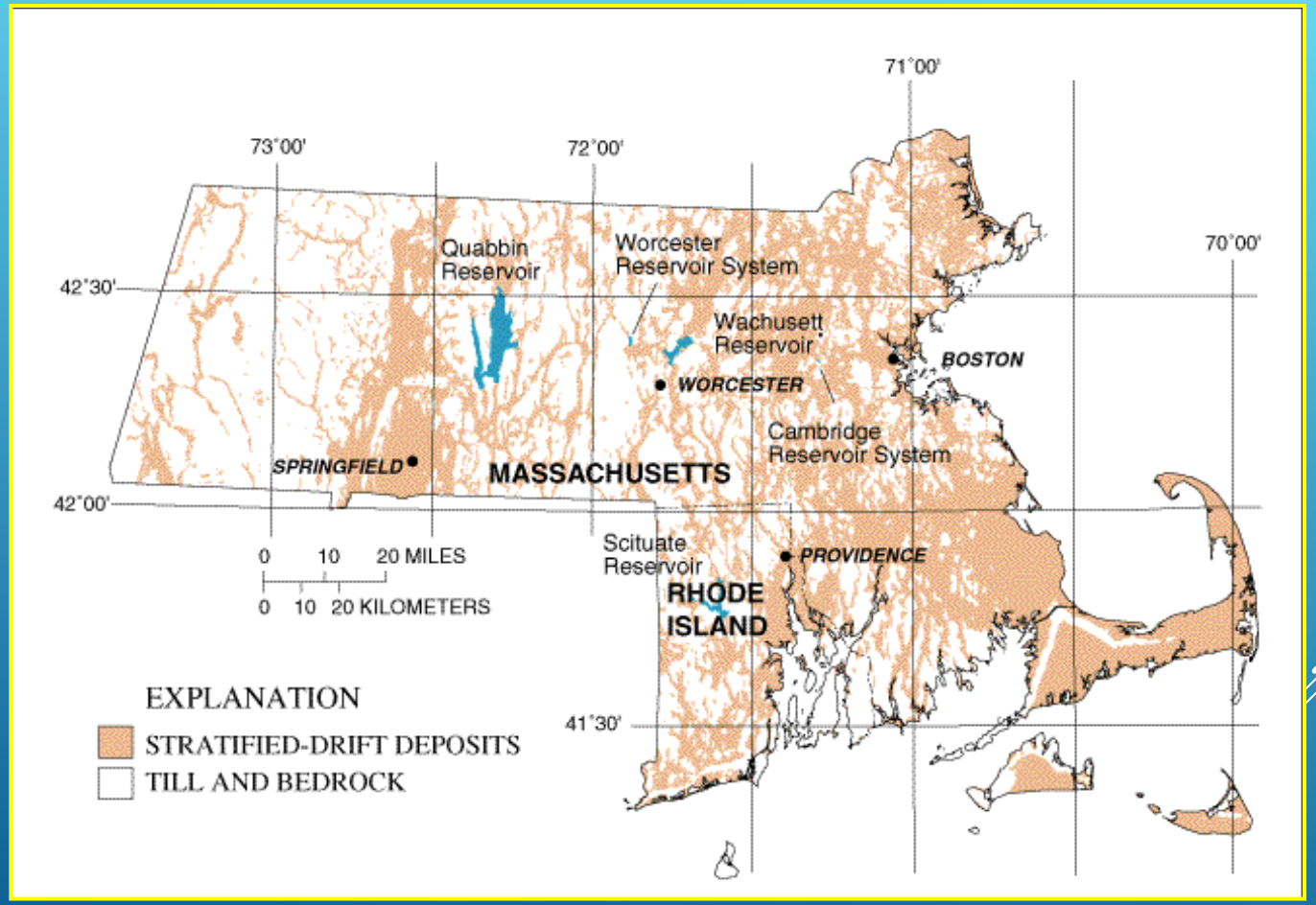
Effective Recharge - how much water reaches the water table





USGS

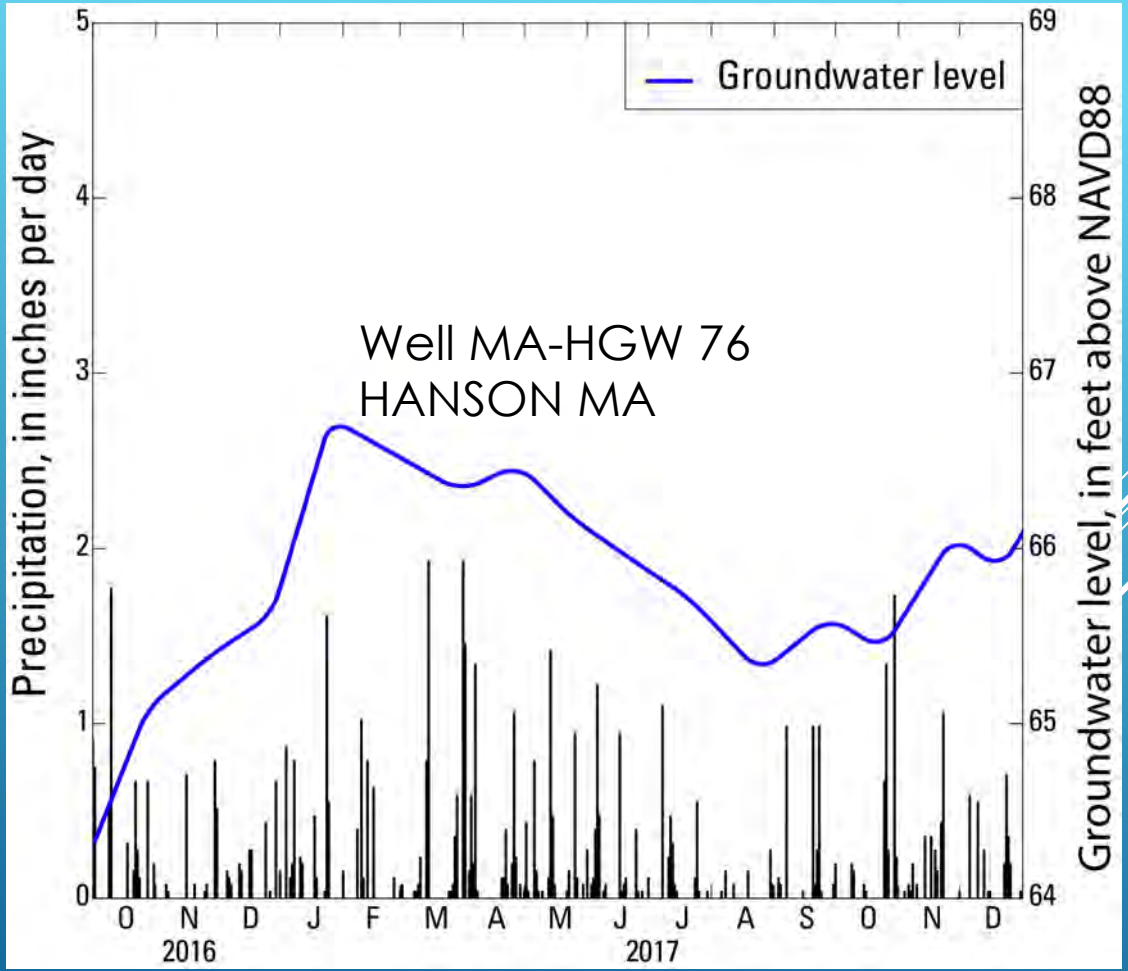
https://pubs.er.usgs.gov/publication/sir20185080


71°00'
73°00'
72°00'
70°00'
42°30'
42°00'
41°30'
Quabbin Reservoir
Worcester Reservoir System
Wachusett Reservoir
BOSTON
WORCESTER
Cambridge Reservoir System
SPRINGFIELD
MASSACHUSETTS
Scituate Reservoir
PROVIDENCE
RHODE ISLAND
0 10 20 MILES
0 10 20 KILOMETERS
EXPLANATION
STRATIFIED-DRIFT DEPOSITS
TILL AND BEDROCK

USGS

Glacial Stratified Deposits (Coarse Sand and Gravel)
Have the Largest Recharge Rates

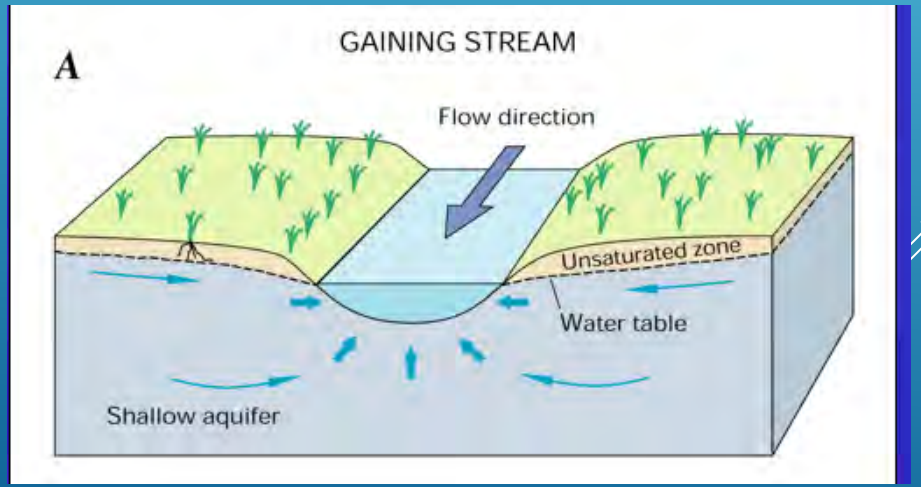
- Groundwater Recharge
- Occurs mainly in the non-growing season, due to evapotranspiration during the growing season



Groundwater-level data may be provisional, and subject to revision
Precipitation data from: https://daymet.ornl.gov/

The Groundwater Component of Streamflow

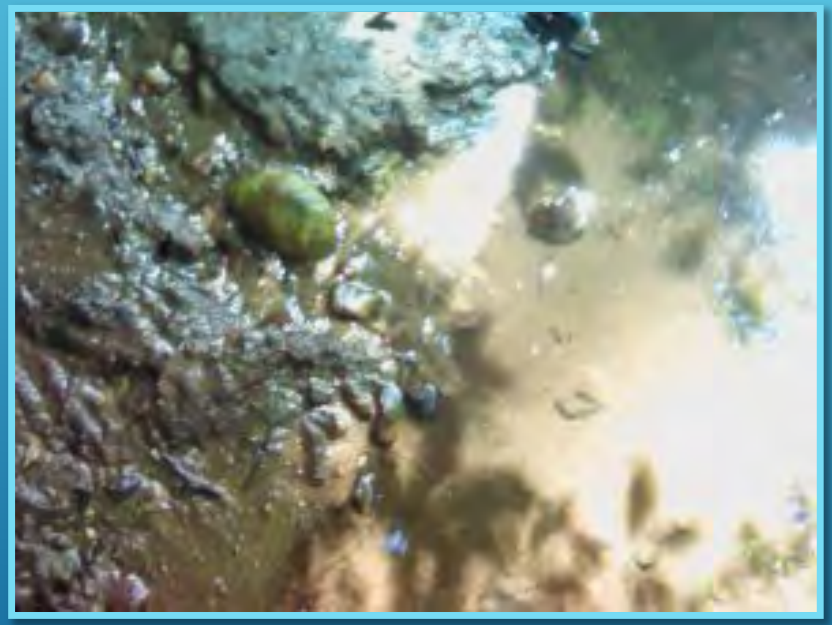
- The reason streams are flowing when there has not been any precipitation
  - Almost all streams in New England are gaining streams

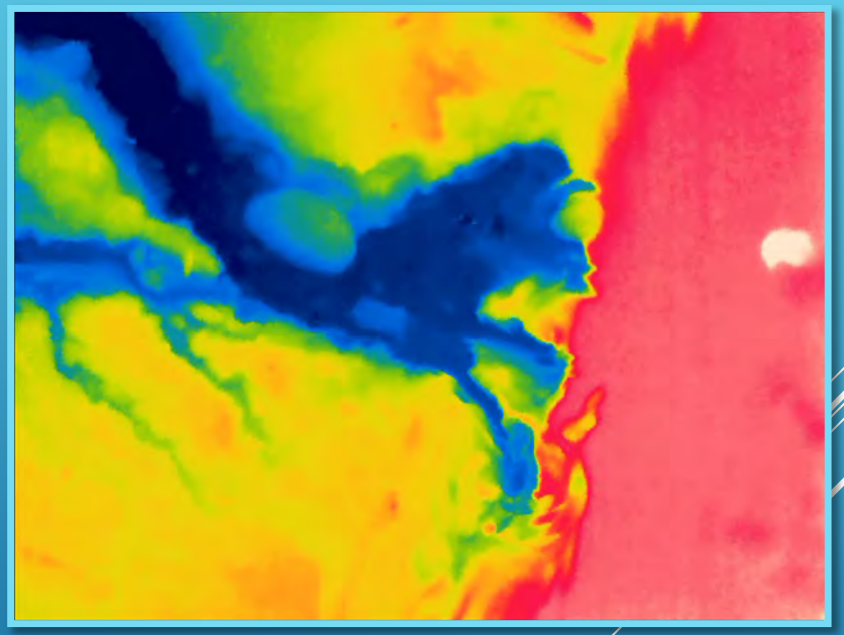


https://pubs.usgs.gov/circ/1998/1139/report.pdf

USGS

The Groundwater Component of Streamflow





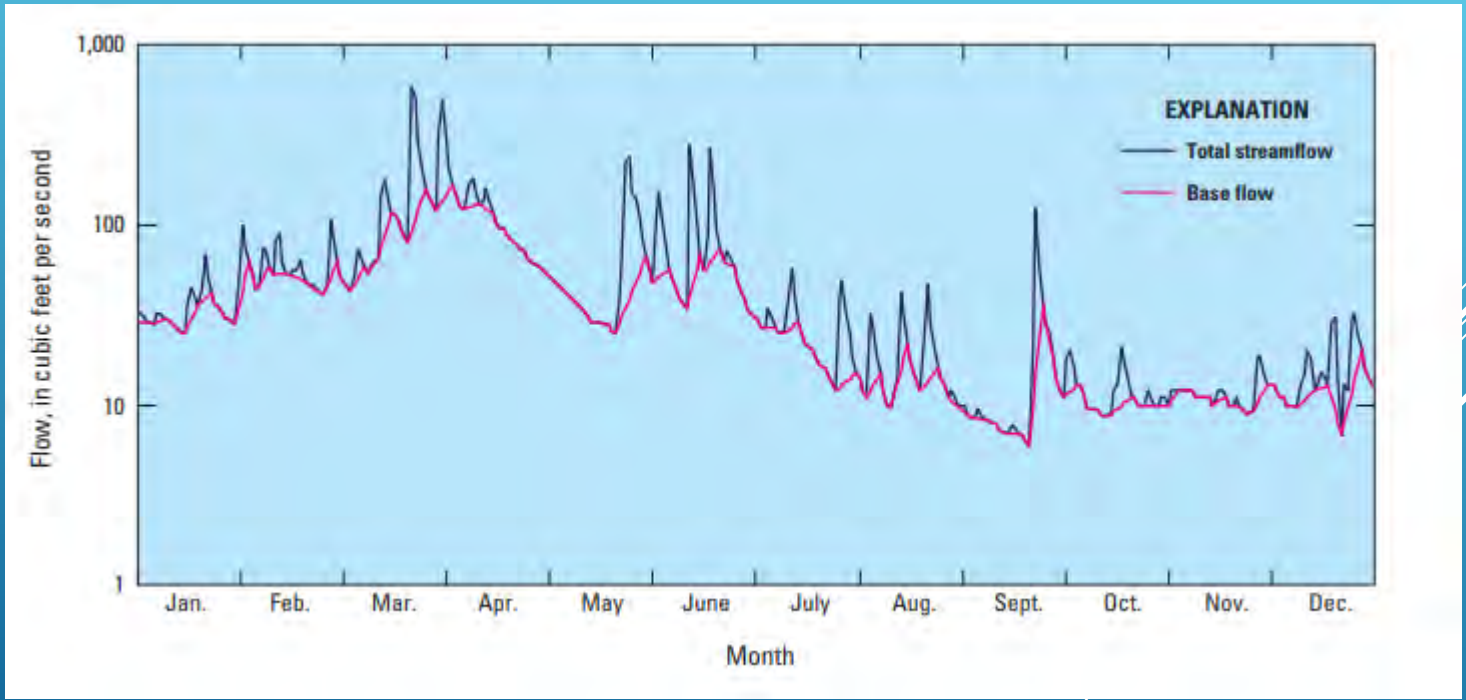
Images from infrared camera
c/o Janet Barclay USGS

USGS

Baseflow- the groundwater component of streamflow

Hunt River near E. Greenwich, RI

Can range from about 35 – 95 percent of streamflow in New England

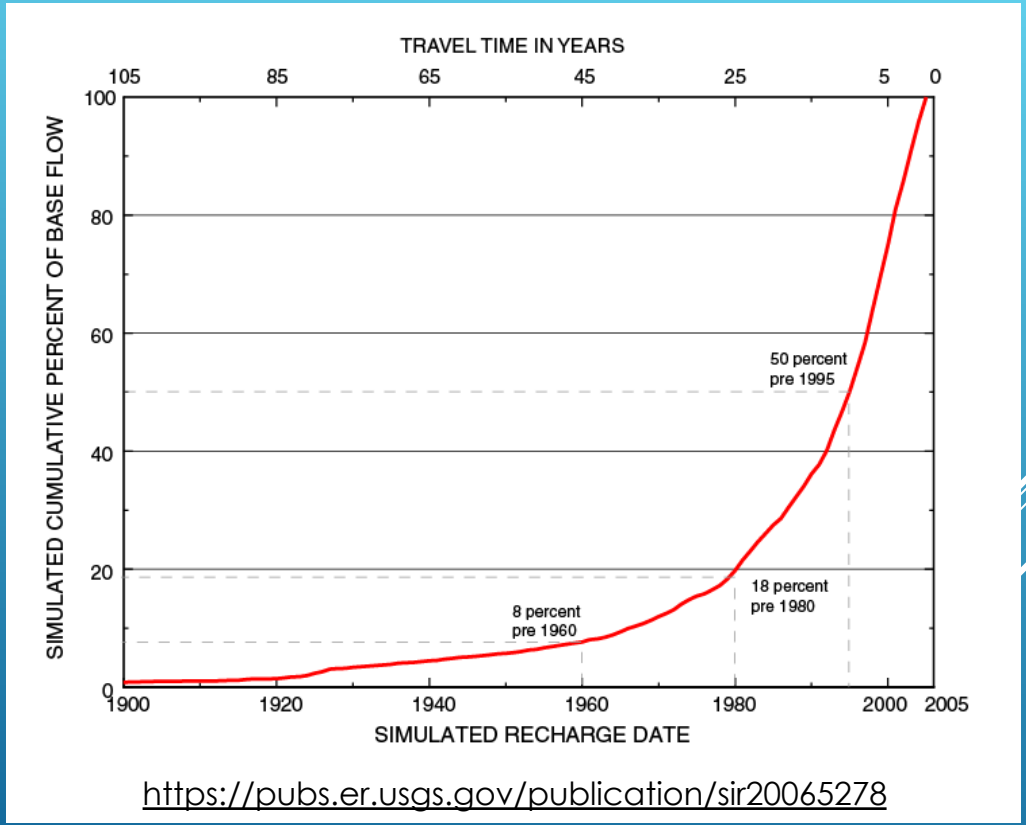


USGS

Image from https://pubs.usgs.gov/circ/1376/pdf/circ1376_barlow_report_508.pdf

Simulated Recharge Age of Discharge

Implications for water quality related to the time lag for groundwater discharge from different parts of the watershed

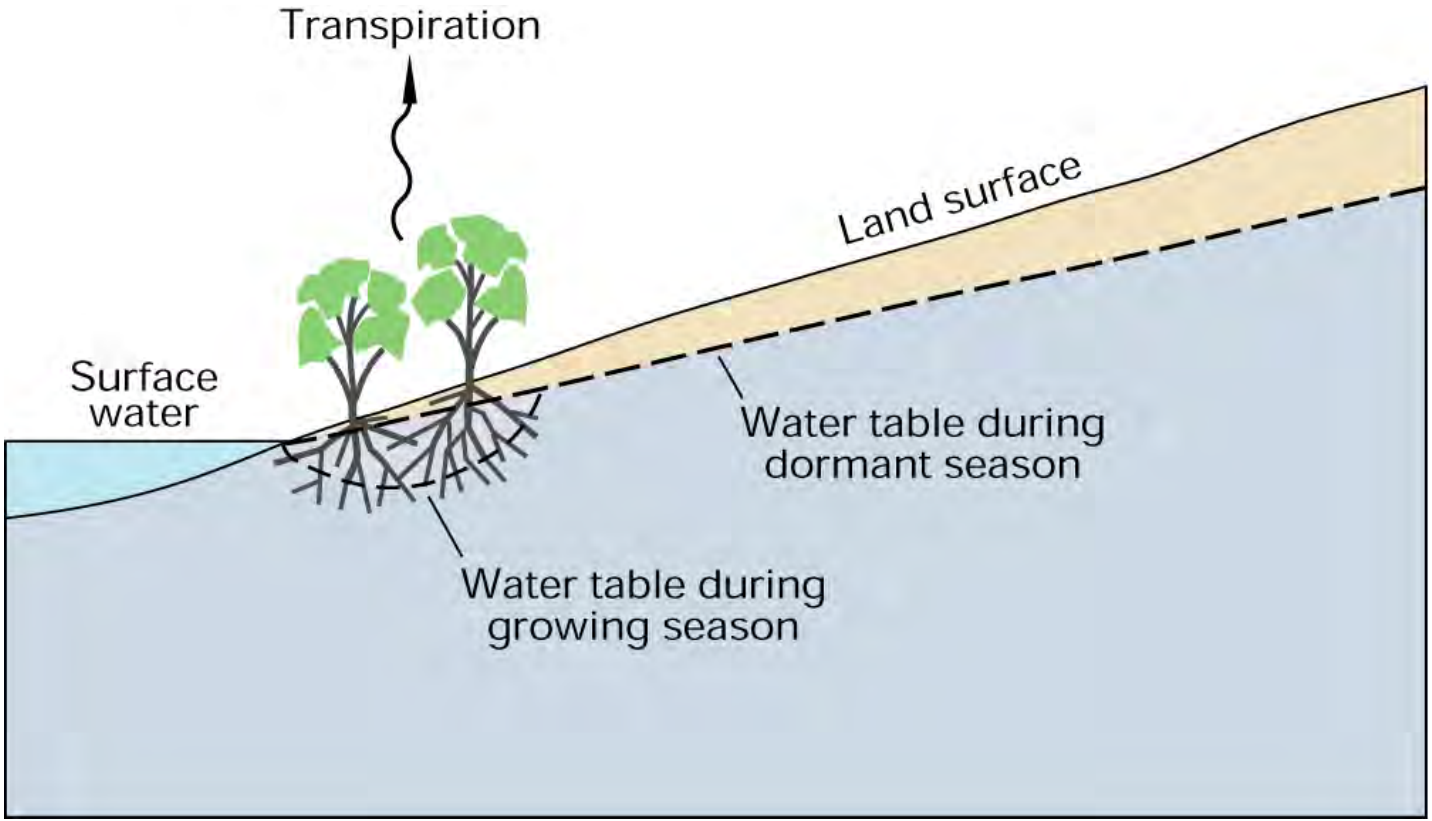


https://pubs.er.usgs.gov/publication/sir20065278

USGS

Example from Broad Brook, Connecticut

Groundwater Evapotranspiration



https://pubs.usgs.gov/circ/1998/1139/report.pdf

USGS

Recharge, and the question of using recharge volume to size groundwater supply development

Long-Term Groundwater Availability=

- (Average annual precipitation) -
- (the amount of overland runoff) -
- (the amount of evapotranspiration) -
- (current or projected consumptive use) -
- (the amount required in streams for habitat sustainability, fire protection, effluent dilution, public-water supply etc.)

USGS

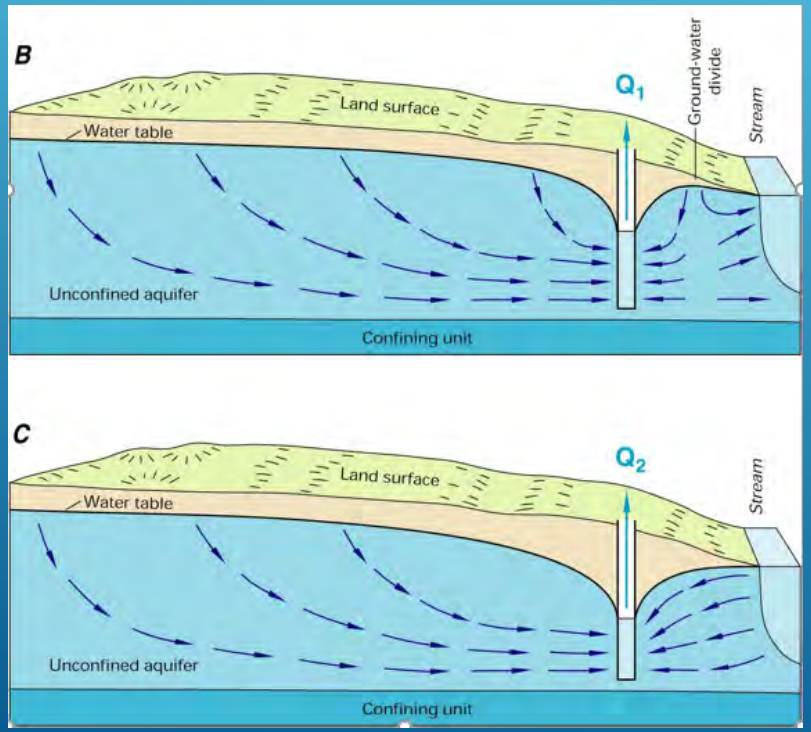
Changes to the Groundwater/Surface Water System due to Human Activities

- Urbanization
  - Surface water impoundments, withdrawals, and diversions
  - Large groundwater withdrawals
  - Private well use and return flow
  - Impervious surfaces
  - Changes to land cover
  - Return flows- wastewater facilities

USGS

Changes to the Groundwater/Surface Water System due to Human Activities

- Groundwater withdrawals



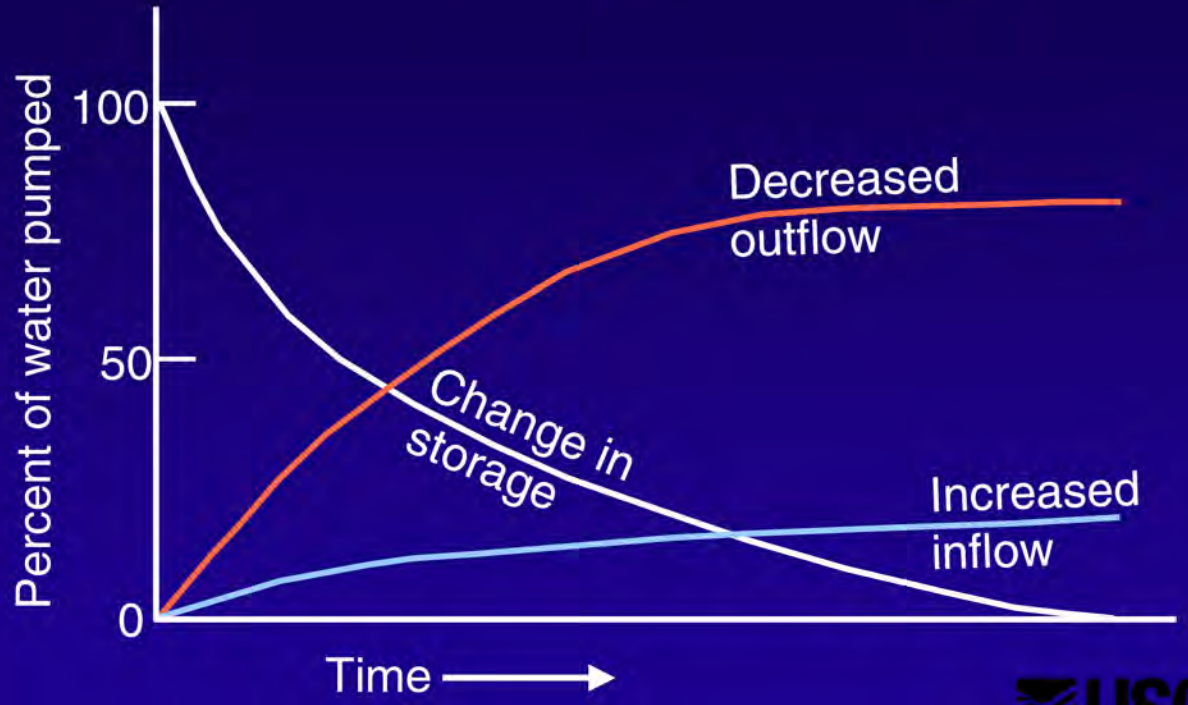
Interception of groundwater in the flowpath to a stream

Induced infiltration of water from a stream

https://pubs.usgs.gov/circ/1376/pdf/circ1376_barlow_report_508.pdf

USGS

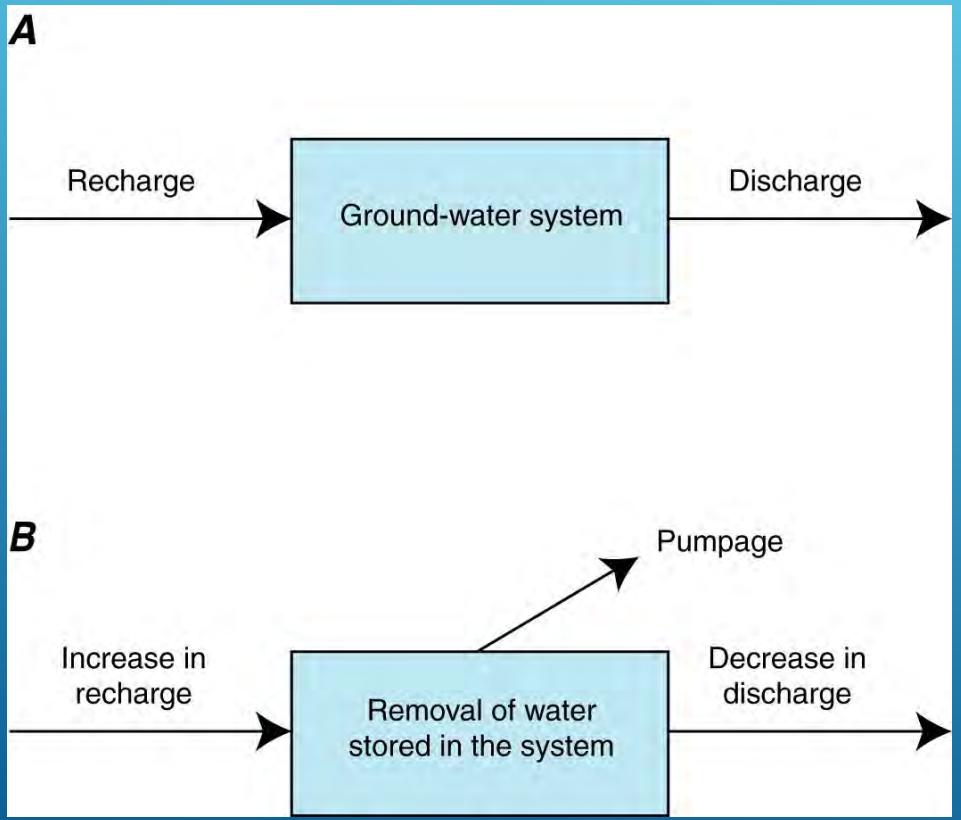
Effects of pumping on inflow, outflow, and change in storage



USGS

USGS

Changes to the Groundwater/Surface Water System due to Human Activities



Increase in recharge could be from induced infiltration or from pulling water from over the groundwater divide

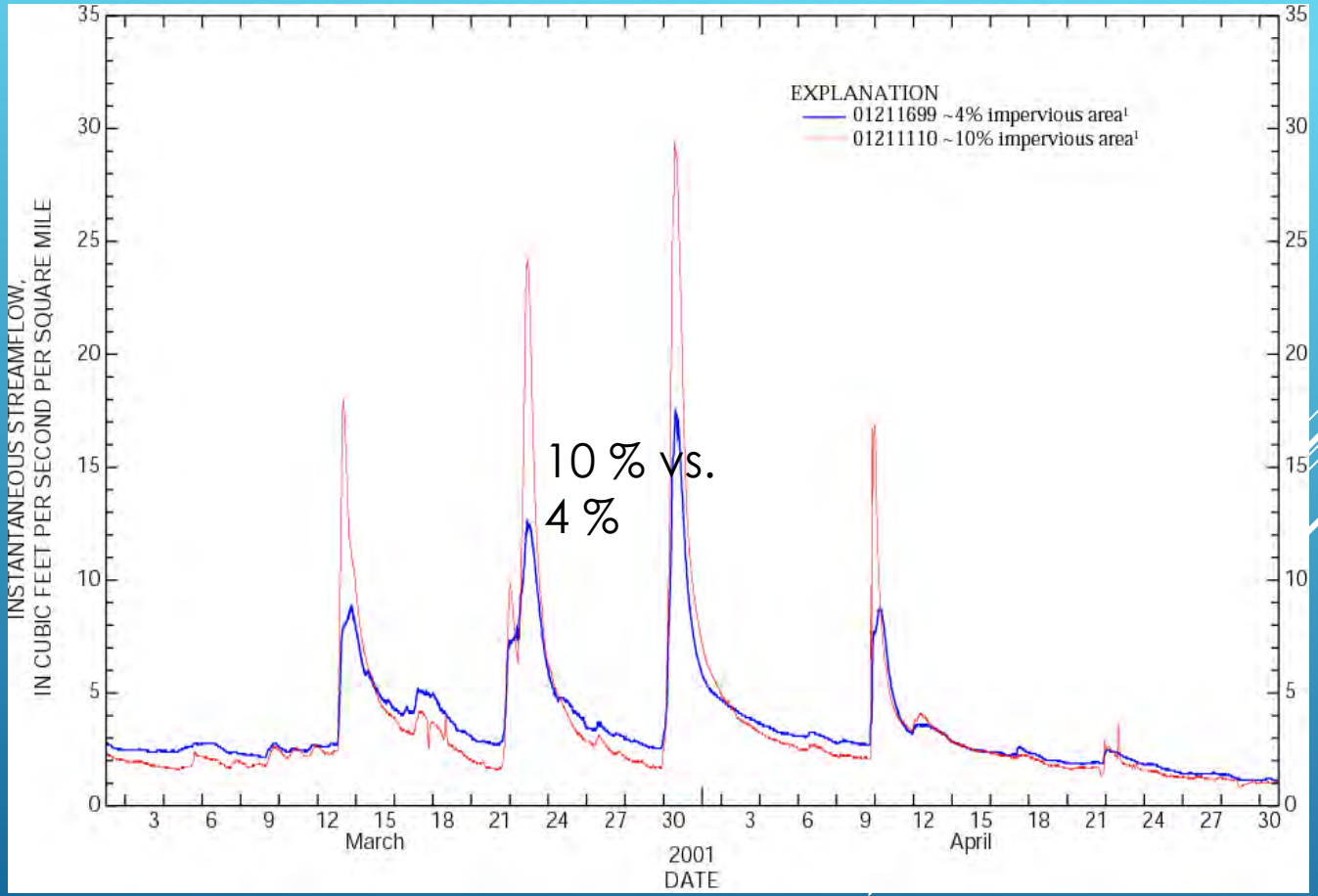
USGS

Please note: Septic systems vary. Diagram is not to scale.

https://www.epa.gov/septic/types-septic-systems

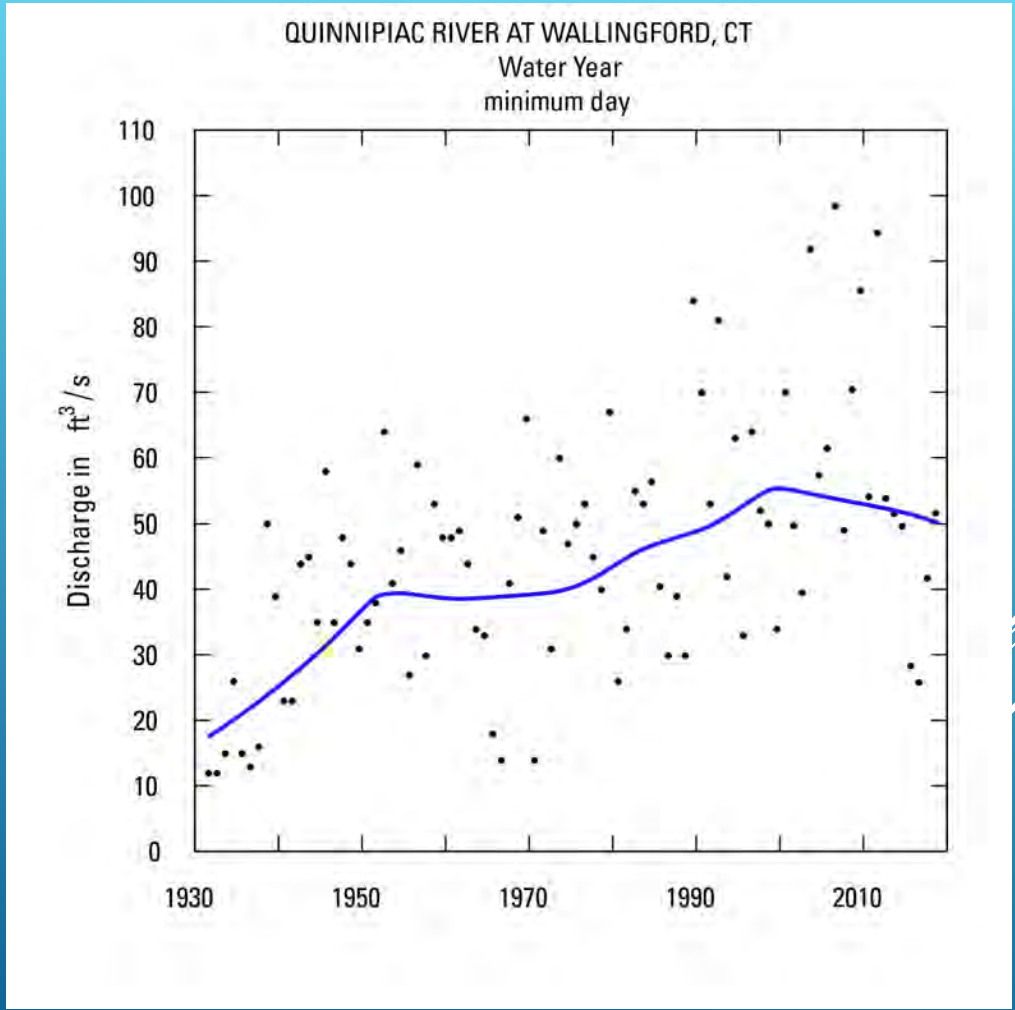
USGS

Urbanization increases overland runoff, bypassing the groundwater system



https://pubs.usgs.gov/wri/wri034300/

Changes to minimum flows over time due to augmentation of streamflow from wastewater discharge, and possibly changes in regulation



USGS

Possible Changes to the Groundwater/Surface water System Under Changing Climate

- Greater precipitation, more variable
  - Extreme events (wet, dry)?
- Smaller proportion as snow
  - Changes in volume and timing of recharge and runoff
- Warmer temperatures/longer growing season
  - Greater evapotranspiration?
  - Greater water demand?
- Sea level rise
  - High groundwater levels in coastal areas, rising salinity, inundation of water supplies during storm surge

USGS