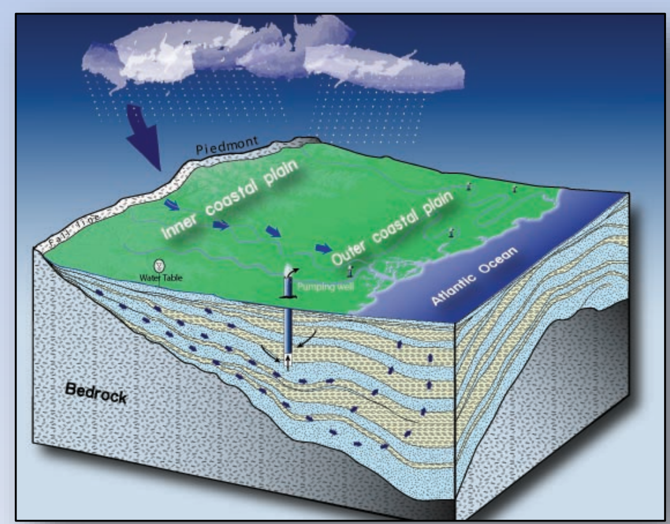
Connection between Surface Water and Groundwater

Bruce Campbell

US Geological Survey –

South Atlantic Water Science Center



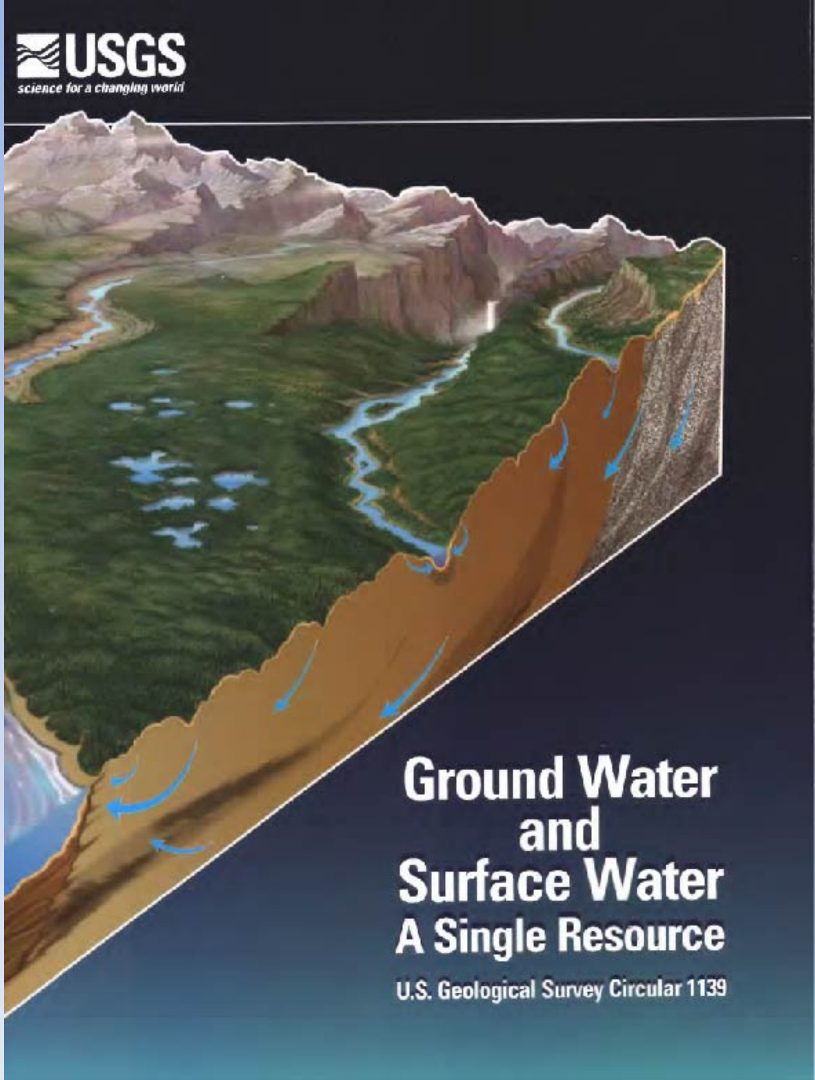
U.S. Department of the Interior
U.S. Geological Survey

Groundwater and Surface Water - A Single Resource

Winter, T.C., Harvey, J.W., Franke, O.L., and Alley, W.M., 1998, Ground water and surface water—A single resource: U.S. Geological Survey Circular 1139, 79 p.

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

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



science for a changing world

"Effective land and water management requires a clear understanding of the linkages between ground and surface water."

Winter and others, 1998

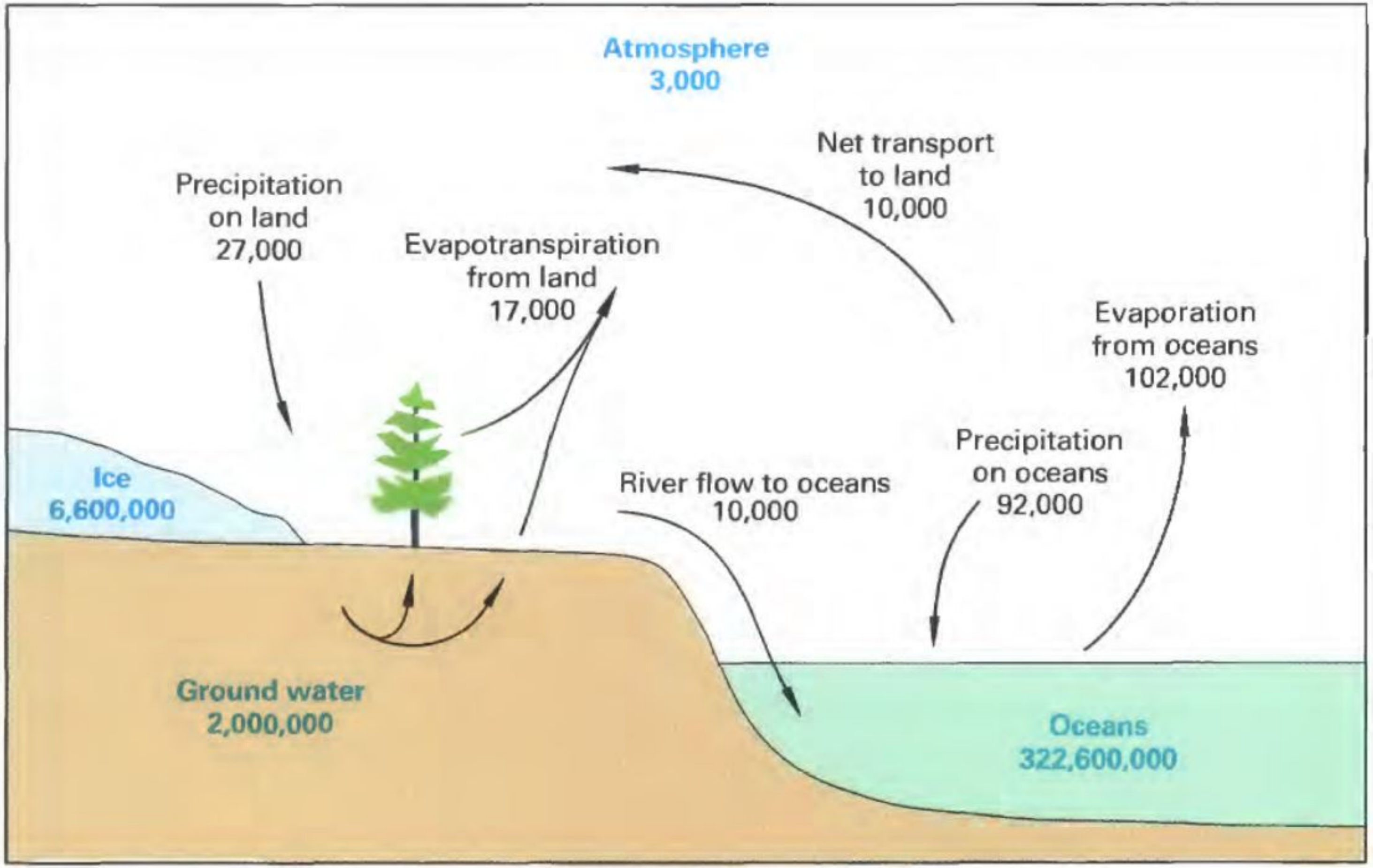
USGS
science for a changing world

Groundwater and Surface Water

- Traditionally viewed as separate resources
- Nearly all surface-water features interact with groundwater
- Water can move from GW to SW or from SW to GW
- Withdrawals from SW can deplete GW
- Withdrawals from GW can deplete SW

“Movement of water in the atmosphere and on the land surface is relatively easy to visualize, but the movement of groundwater is not.”

Water Cycle

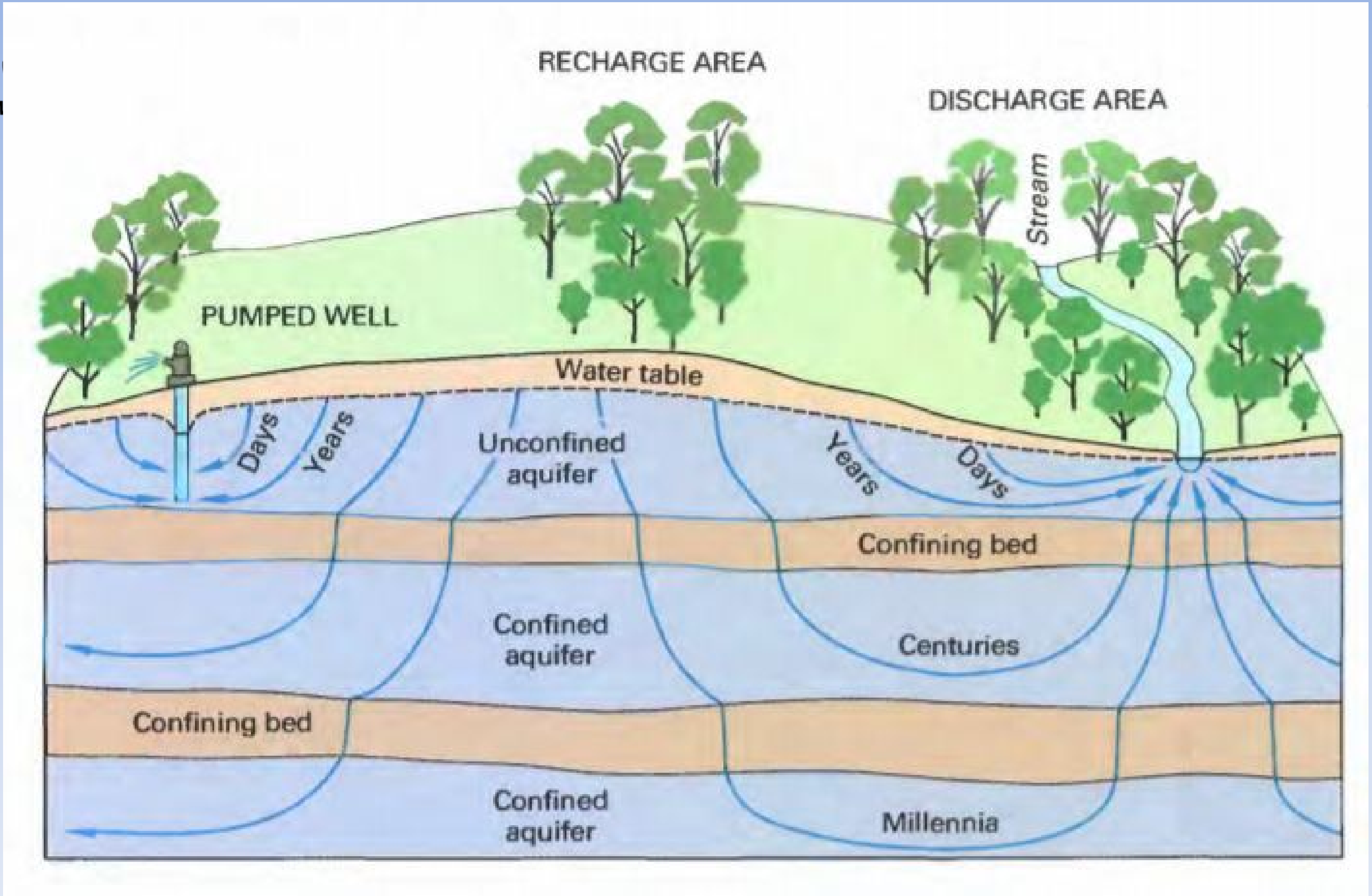


Pools are in cubic miles
Fluxes are in cubic miles per year

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

science for a changing w

GW Flow Paths



Water Table

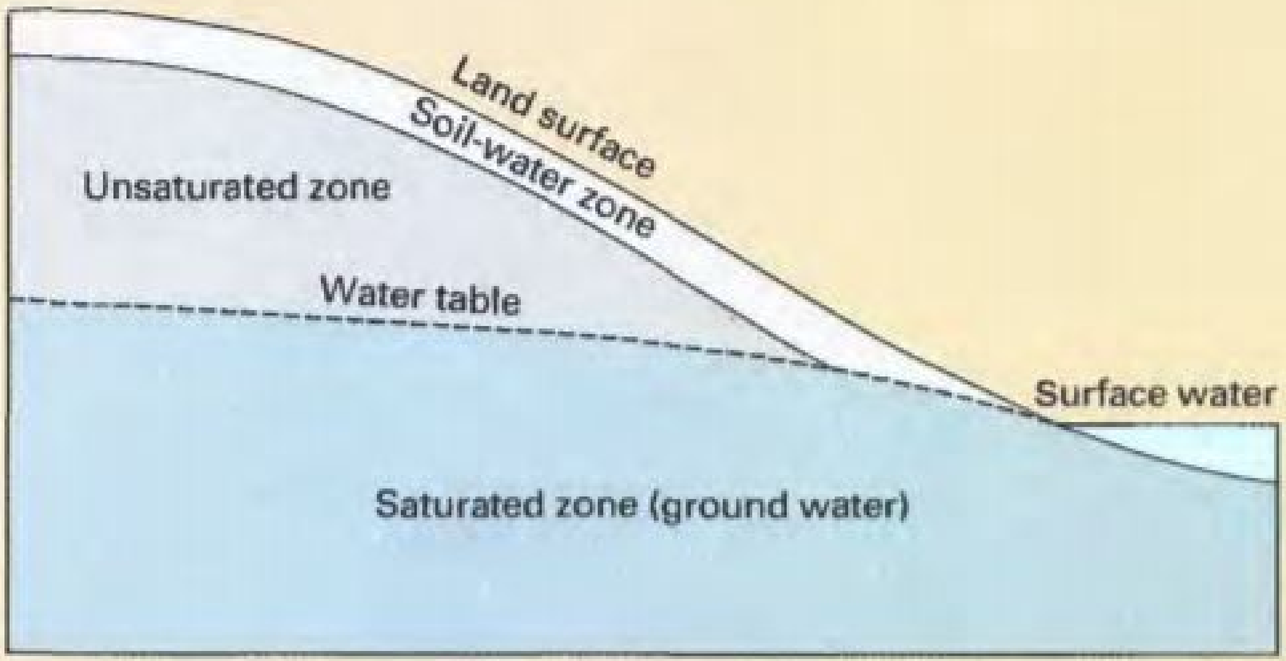
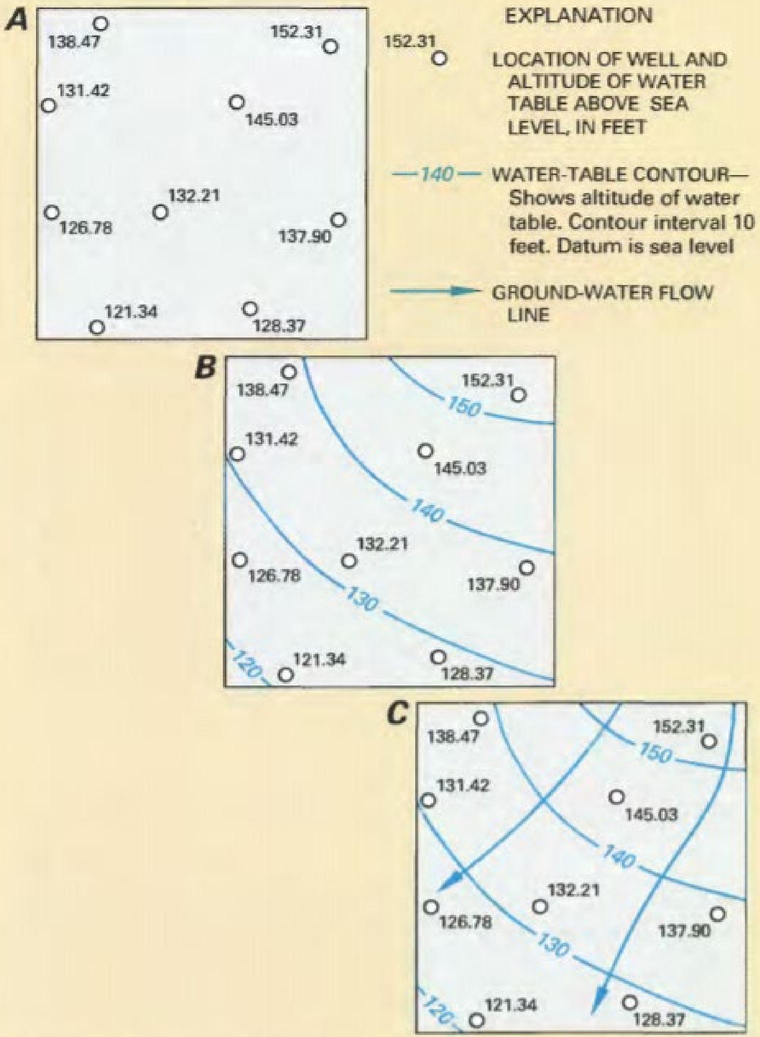


Figure A–1. *The water table is the upper surface of the saturated zone. The water table meets surface-water bodies at or near the shoreline of surface water if the surface-water body is connected to the ground-water system.*

Water Table Contours



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

USGS
science for a changing world

Gaining and Losing Streams

- Streams interact with ground water in all types of landscapes
- Streams gain water from inflow of ground water through the streambed
- Streams lose water to ground water by outflow through the streambed
- Do both, gaining in some reaches and losing in other reaches

Gaining and Losing Streams

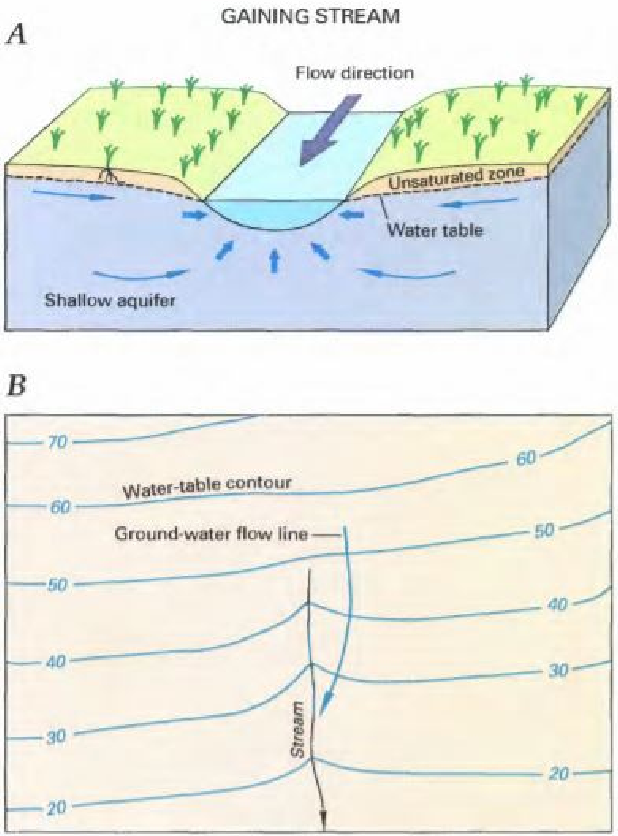


Figure 8. *Gaining streams receive water from the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the upstream direction where they cross the stream (B).*

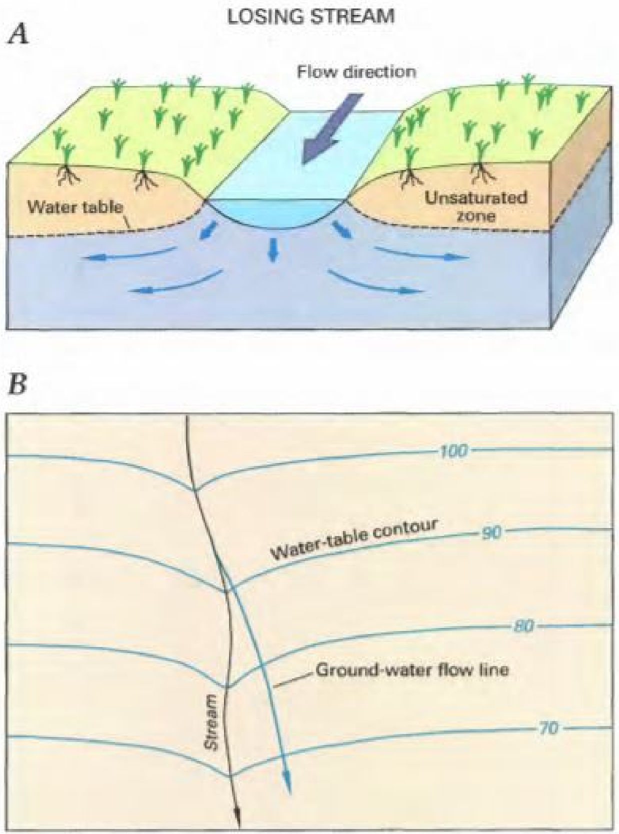


Figure 9. *Losing streams lose water to the ground-water system (A). This can be determined from water-table contour maps because the contour lines point in the downstream direction where they cross the stream (B).*

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

The Ground-Water Component of Streamflow

- The proportion of stream water that is derived from ground-water inflow varies across physiographic and climatic settings
- Analyze streamflow hydrographs to determine the ground-water component
- Determine the base-flow component of streamflow
- In a national study, ground-water contributions ranged from 14 percent to 90 percent, and the median was 55 percent.

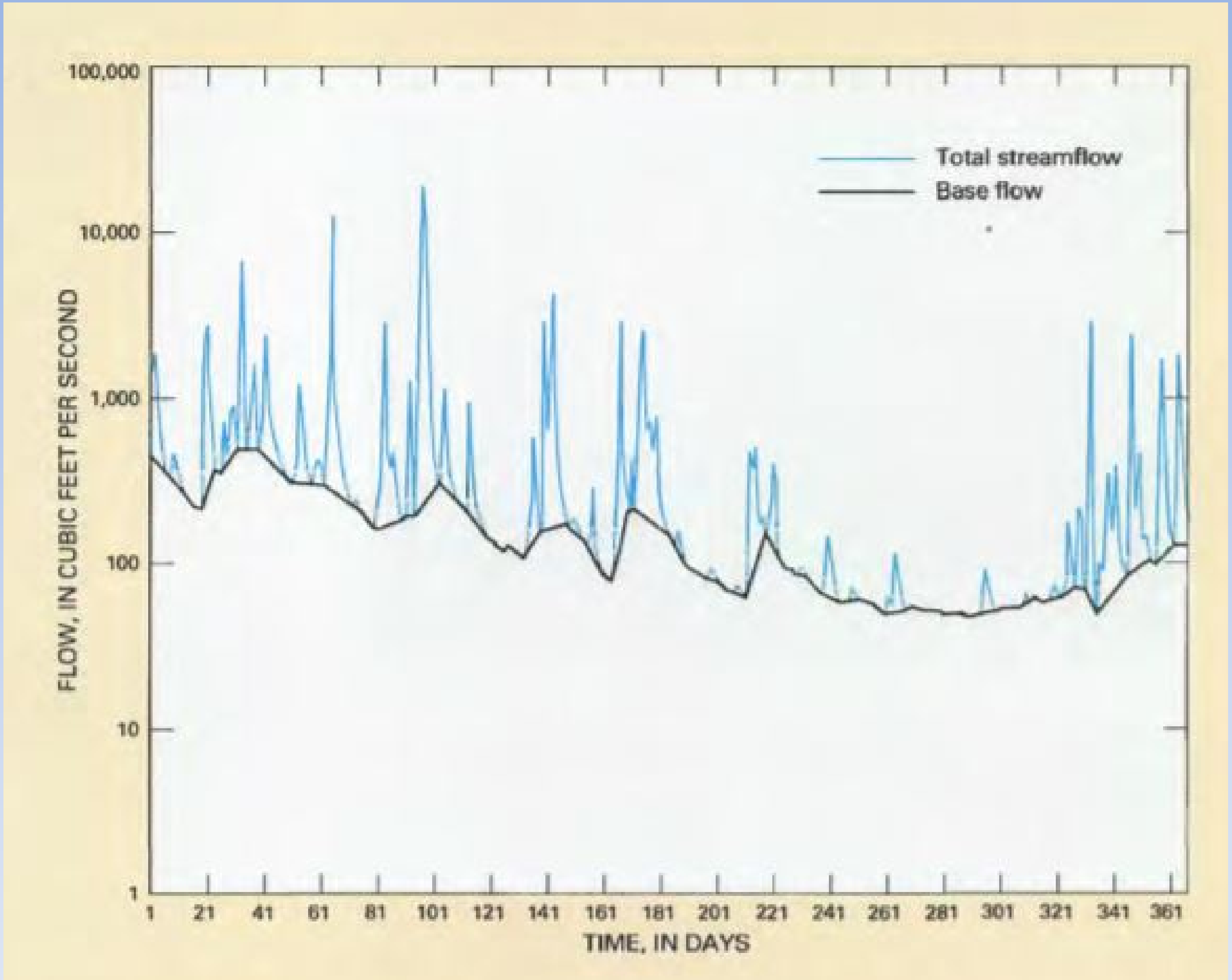
USGS

What is Hydrograph or Baseflow Separation?

Baseflow separation is used to determine what portion of a streamflow hydrograph occurs from **baseflow**, and what portion occurs from overland flow.

USGS

The ground-water component of streamflow was estimated from a streamflow hydrograph for the Homochitto River in Mississippi



USGS

Edisto River Stream Gage – Calculated GW Baseflows

Station name	Drainage Area	Period of Record	Streamflow CFS	Baseflow CFS	Precent Baseflow
NORTH FORK EDISTO RIVER AT ORANGEBURG, SC	683.0	1939–1987	785	684	**87**
NORTH FORK EDISTO RIVER AT ORANGEBURG, SC	683.0	1989–2015	616	535	**87**
DEAN SWAMP CREEK NEAR SALLEY, SC	31.2	1989–1999	25	24	**93**
MCTIER CREEK (RD 209) NEAR MONETTA, SC	15.6	2002–2015	14	11	**75**
SOUTH FORK EDISTO RIVER NEAR MONTMORENCI, SC	198.0	1941–1965	244	196	**80**
SOUTH FORK EDISTO RIVER NEAR DENMARK, SC	720.0	1932–1970	793	686	**87**
SOUTH FORK EDISTO RIVER NEAR DENMARK, SC	720.0	1981–2015	623	544	**87**
EDISTO RIVER NEAR BRANCHVILLE, SC	1,720.0	1946–1995	1,994	1,761	**88**
EDISTO RIVER NEAR GIVHANS, SC	2,720.0	1939–2015	2,432	2,056	**85**

USGS

Groundwater Model Derived Water Budgets for the Edisto Basin

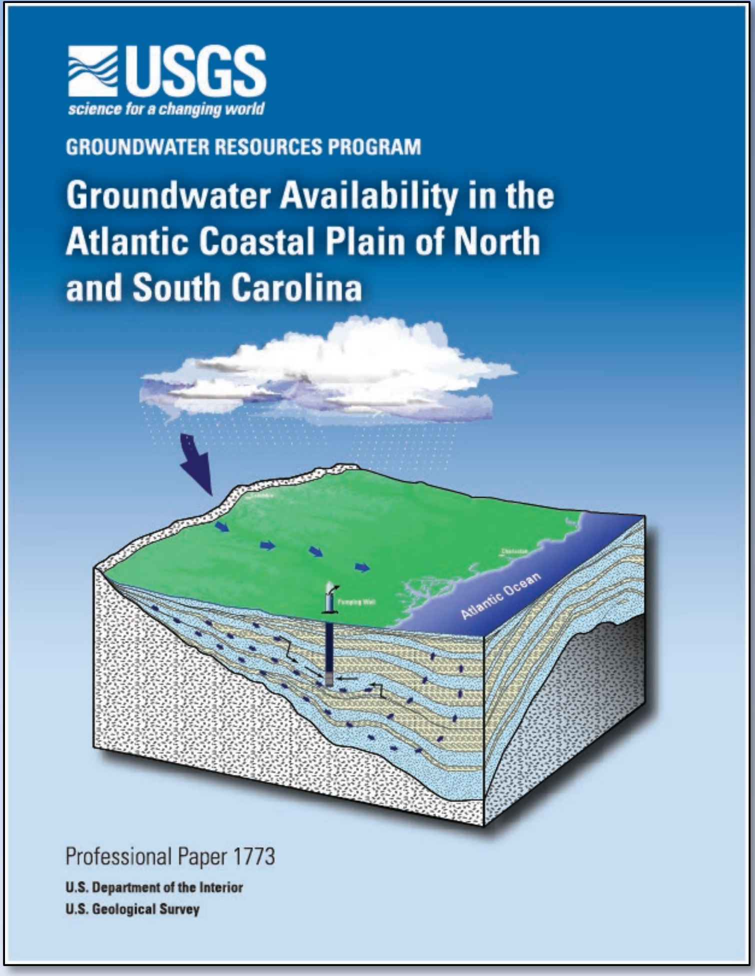
Simulated Water Budgets

USGS

USGS Groundwater Resources Program

Groundwater Flow Model of the Atlantic Coastal Plain of NC, SC, eastern GA, southern VA

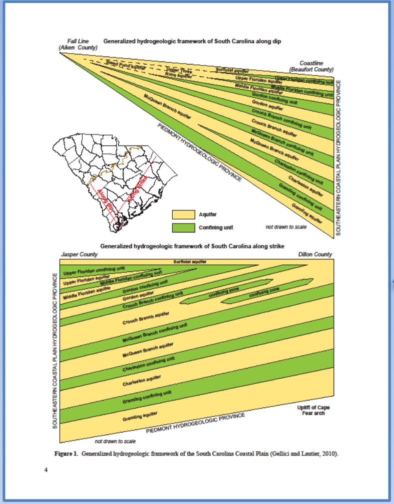
- Calibrated to 2004 conditions
- Revised hydrogeologic framework
- Analysis of GW monitoring networks
- Climate change predictions



GW Model Updates

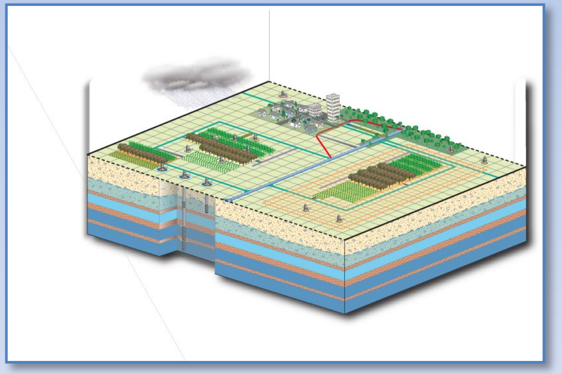
- Overall update the 2010 groundwater flow model
- Activating the entire surficial aquifer model layer
- Recharge from SWB Model
- Adding recent groundwater-related data (2005-2015)
- Refine the model grid from 2 x 2 miles to 2,000 x 2,000 ft
- Incorporate a more detailed representation of the Fall Line area
- Incorporate new MODFLOW packages – Newton Formulation, Multi-Node Well Package, etc
- Re-calibration, and apply the model to a series of scenarios

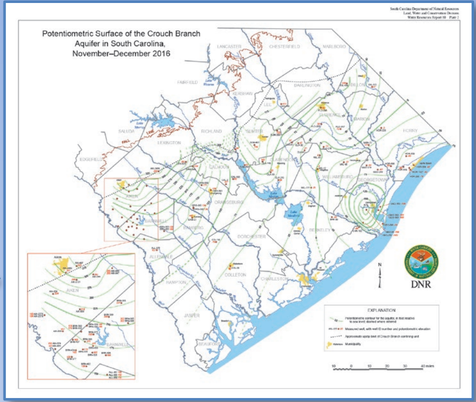
USGS



Framework

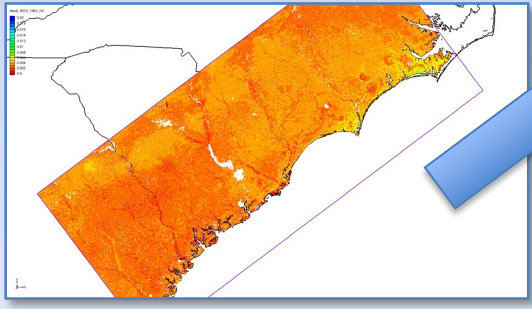
Groundwater Model



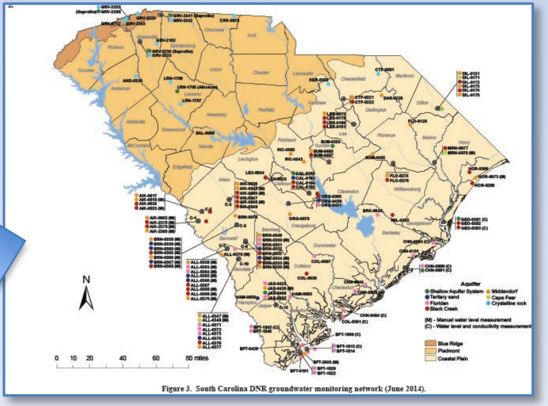


Potentiometric Maps

Recharge Model



Groundwater Levels



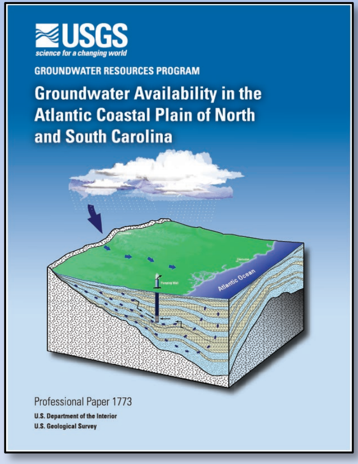
USGS Soil Water Balance Model

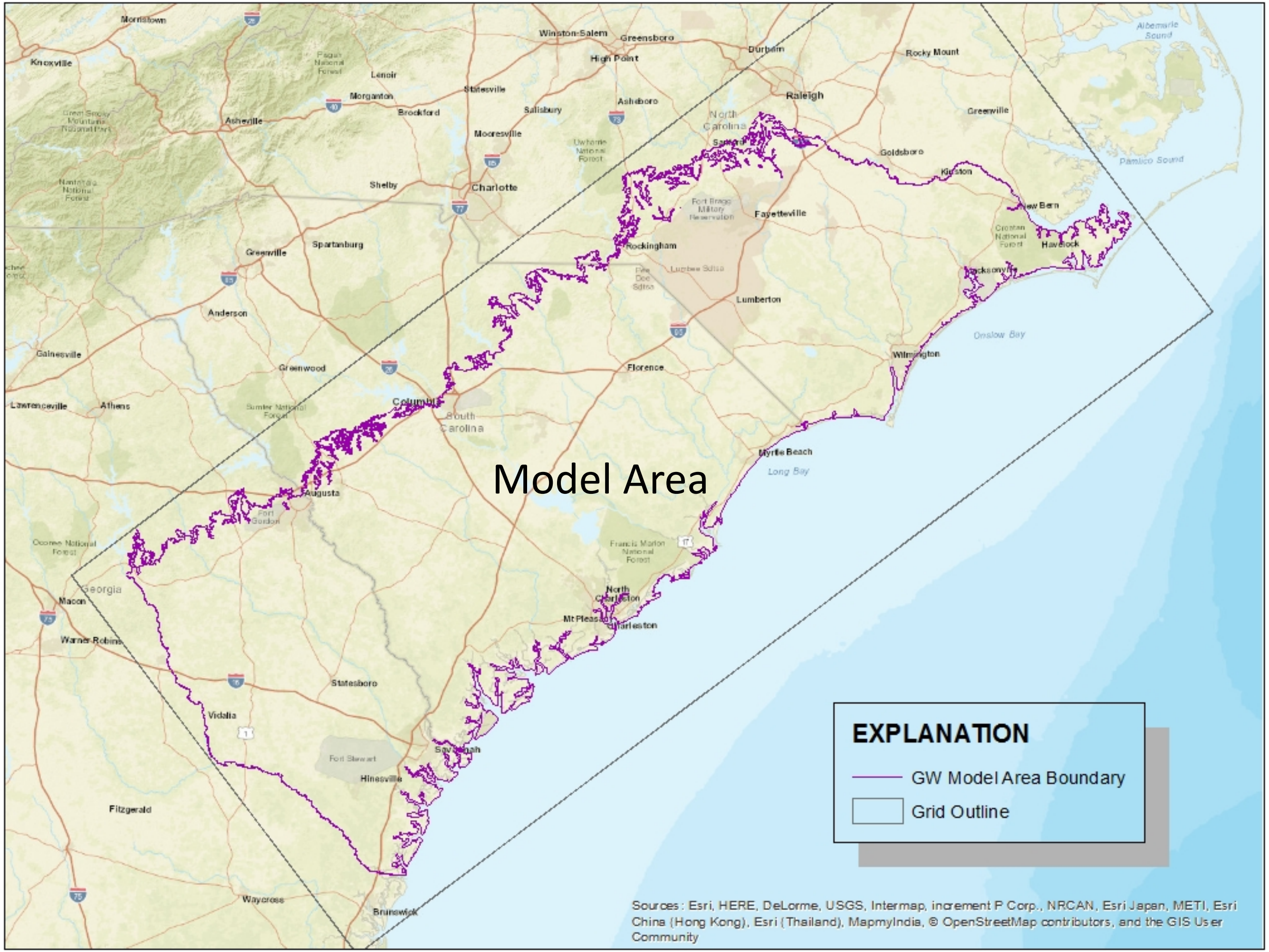
Separate Model from Groundwater Flow Model
Used to Simulate Historical and Possible Future Recharge Rates
Incorporates:

- Precipitation and Temperature
- Soil Characteristics
- Slopes
- Land Use/Land Cover
- Uses same grid as GW Model

USGS

Groundwater Model Area





USGS

SC River Basins

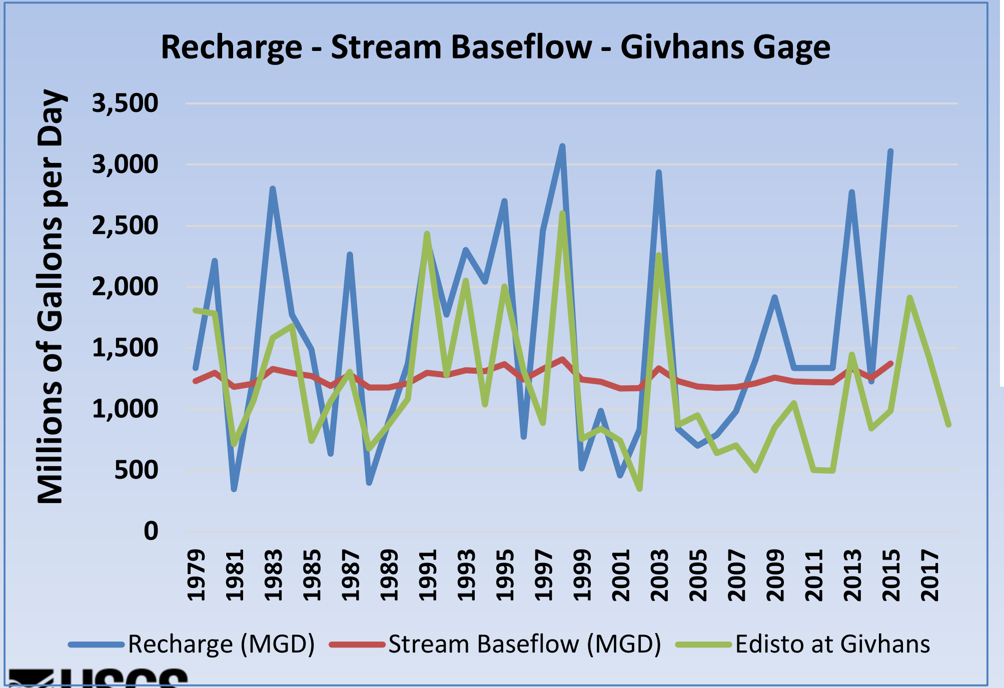
USGS

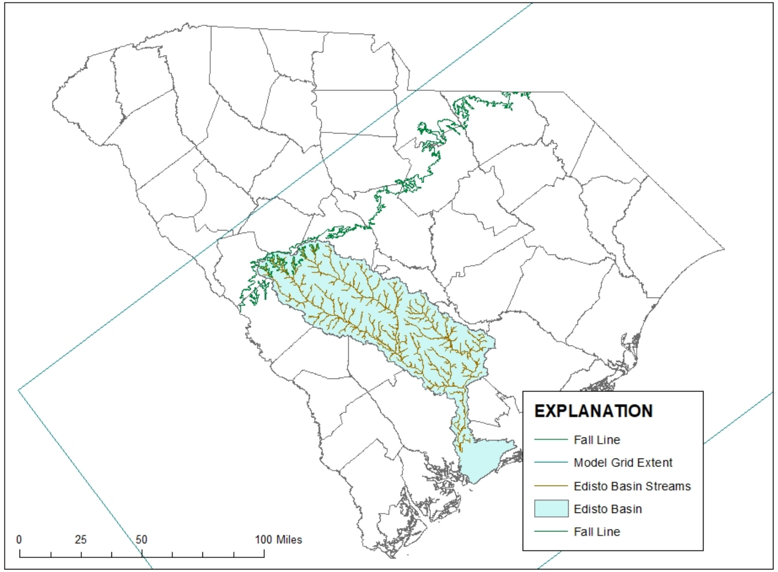
Groundwater Budget Components

- Inputs
  - Recharge
  - Storage Changes
  - Flow from Boundaries
- Outputs
  - Stream Baseflow
  - Storage Changes
  - Wells
  - Flow to Boundaries

Edisto Basin

All Simulated
3,143 Square miles
2,011,352 Acres





Recharge (MGD)
Mean – 1,221
Max – 3,151 (1998)
Min – 344 (1981)

Stream Baseflow (MGD)
Mean – 1,254
Max – 1,407 (1998)
Min – 1,169 (2001)

USGS

Qualifications

- <u>NOT</u> a surface-water model
- Only calculating groundwater baseflows in a very simple manner

USGS

Summary

- Significate GW – SW interaction in the Edisto Basin
- Groundwater is the primary source of water for the Edisto Basin
- Baseflow budgets have been simulated by the GW model
- Historic GW recharge estimates at a 2,000 x 2,000 ft scale are simulated

USGS

Questions?

bcampbel@usgs.gov
803-750-6161

USGS