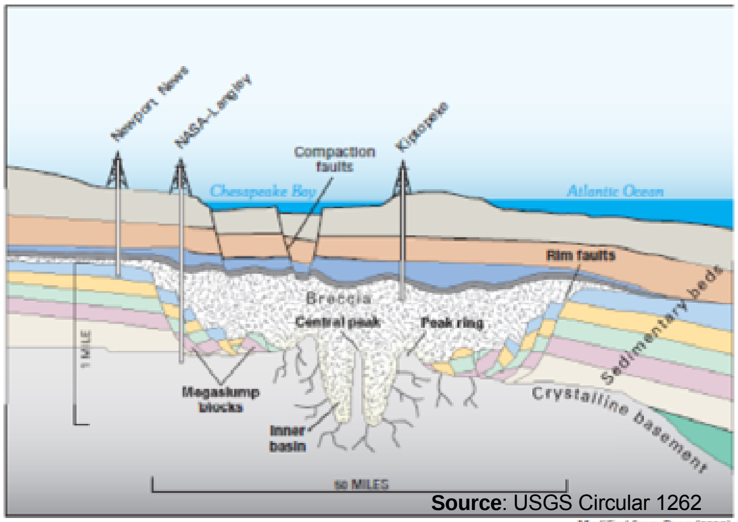


Source: USGS Circular 1262
Modified from Poag (2000)

Useful Definitions:

Precipitation: water falling from the sky in the form of rain, sleet, snow, and/or hail.

Recharge: the amount of precipitation that infiltrates to the water table aquifer.

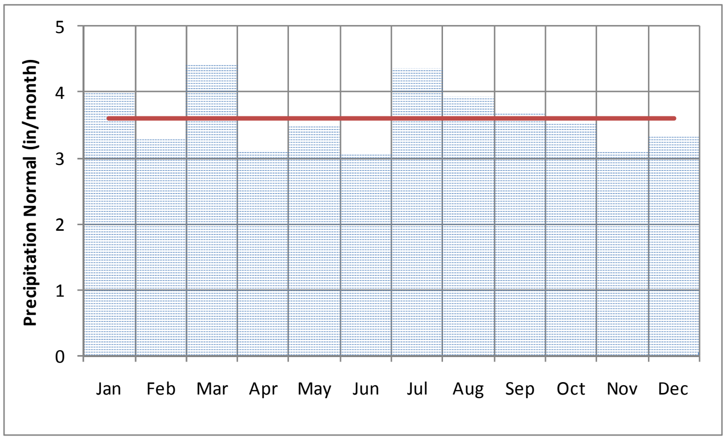
Discharge: the amount of water that flows from groundwater aquifers to surface water bodies, such as streams, rivers, ponds, lakes, bays, and oceans.

Evapotranspiration: the amount of water that evaporates directly from the land surface and shallow soils or indirectly through the leaves of plants.

2.2.2 Recharge

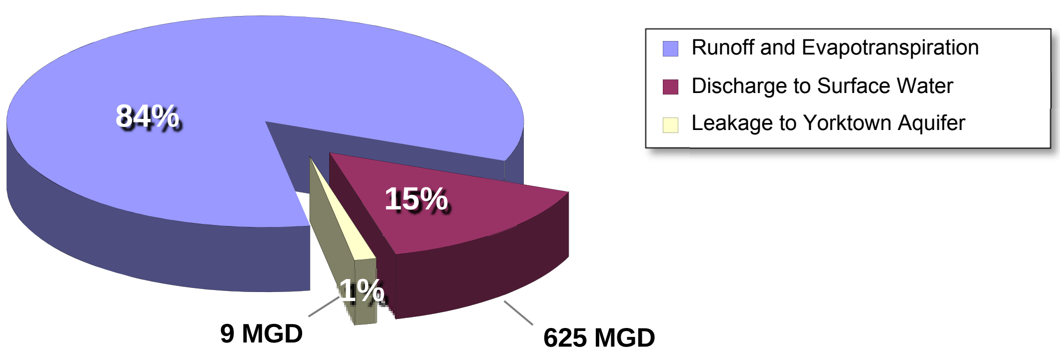
Fresh groundwater on the Eastern Shore of Virginia is replenished solely by precipitation that falls directly on the Shore. There is no fresh water contribution from the aquifers on the Mainland. Average annual precipitation on the Eastern Shore is approximately 44 inches. The precipitation normals vary seasonally between 3.0 and 4.5 inches; with the highest months being March and July and the lowest being June and November (**Figure 2.2-12**). While 44 inches of precipitation, on average falls on the Shore, the majority of the precipitation is lost to runoff and evapotranspiration, and only a small fraction reaches the Columbia aquifer (**Figure 2.2-13**). The portion of recharge reaching the Columbia aquifer remaining recharge water goes into storage (in the water table aquifer) or recharges the underlying confined aquifers.

Figure 2.2-12: Precipitation Normals for the Eastern Shore of Virginia



Source: NOAA, 2002[3].

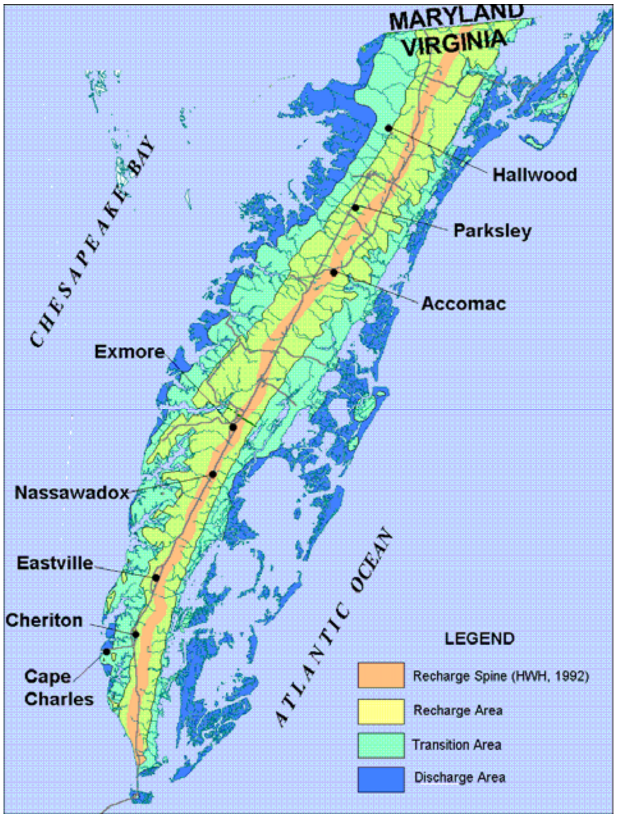
Figure 2.2-13: Recharge Rates on the Eastern Shore



There have been a number of groundwater recharge values previously estimated for the Eastern Shore. Holme[4] conducted a detailed two year study of ground water recharge from monthly ground water budgets in the Beaverdam Creek basin in Maryland, near the border with Accomack. From his work a recharge value of 12 in/yr was determined, after subtracting ground water loss through evapotranspiration. The 12 in/yr estimate includes recharge which is later lost through discharge to surface waters. Harsh and Laczniak conducted a study of the regional aquifer system of the Northern Atlantic coastal Plain[5]. In this study, they estimated that ground water recharge to the water table aquifer is approximately 15 inches/year. A digital-flow-model study in the Coastal Plain of central and southern Delaware[6] used 14 inches/year as an estimate of ground water recharge for the area and other studies on the Eastern Shore have estimated that recharge to the unconfined aquifer ranges between 8.5 and 15 in/yr[2] and 12 and 26 in/yr[7]. The most recent estimate was developed by the USGS as part of the Eastern Shore Model[10] and is currently the best estimate for recharge on the Shore. The current estimates of recharge are presented on Figure 2.2-13, with 6.6 in/yr recharging the Columbia aquifer.

Fresh groundwater recharge to the underlying confined Yorktown-Eastover aquifer is generally greatest near the central "spine recharge" area of the peninsula, where the difference in water level between the Columbia aquifer and Yorktown-Eastover aquifer is greatest (**Figure 2.2-14**). Some of the water that recharges near the center of the peninsula flows vertically through the water table aquifer and underlying confining units to recharge the confined aquifers. This downward flow component decreases with distance from the central recharge area. The Yorktown-Eastover aquifers are recharged at a much lower rate than the Columbia aquifer. Current estimates for recharge rate to the Upper Yorktown-Eastover aquifer is ½ in/yr (less than 1% of the precipitation falling on the Shore. Recharge to the Middle and Lower Yorktown-Eastover aquifers are progressively lower with depth. Age measured from groundwater samples collected from the Columbia and Yorktown-Eastover aquifers[10] illustrates these low recharge rates with average ages as follows:

Figure 2.2-14: Recharge Areas of the Eatern Shore



- Columbia aquifer ≈ 50 years
- Upper Yorktown-Eastover ≈ 4,500 years
- Middle Yorktown-Eastover aquifer ≈ 9,700 years
- Lower Yorktown-Eastover aquifer ≈ 13,900 years

Ground water flow in the confined aquifers is also primarily horizontal, with some downward flow in the central peninsula and upward flow in coastal discharge areas (**Figure 2.2-2**).

Recharge to the Yorktown-Eastover aquifer along the recharge spine is not uniform across the Shore, and can vary significantly depending on:

- Local thickness and composition (amount of silt and clay) of the confining unit,
- Presence of Paleochannels, and
- Local Yorktown-Eastover groundwater use that lowers the water level in the confined aquifer creating a higher downward hydraulic gradient (higher downward flow rate).

The degree the above factors influence recharge to the Yorktown-Eastover aquifer is poorly understood.

Useful Definitions:

Hydraulic conductivity: a property indicating the ability of water to flow through a standard volume of aquifer due to differences in pressure across the aquifer.

Transmissivity: the hydraulic conductivity measured across the water-bearing thickness of an aquifer. It is a common metric indicative of the amount of water that can be withdrawn from an aquifer. An aquifer with a high transmissivity is likely to produce more water than an aquifer with a low transmissivity.

2.2.3 Hydraulic Characteristics

2.2.3.1 Columbia Aquifer

Groundwater levels in the Columbia aquifer are generally subparallel to the land surface of the Eastern Shore, with depths to water ranging from 20 ft along the recharge spine to intersecting the land surface at streams, rivers, ponds, the Bay and the Atlantic.

The hydraulic conductivity of the Columbia aquifer ranges from approximately 10 to 200 ft/day and generally increases northward. Transmissivities reported for the Columbia aquifer range from 100 to 50,000 ft^2/day. On the Eastern Shore of Virginia, transmissivities are somewhat lower, typically ranging between 1,000 and 4,000 ft^2/day. The general increase in transmissivity to the north appears to be a function of both increasing thickness and increasing hydraulic conductivity.

2.2.3.2 Upper Yorktown Aquifer

Groundwater levels on the Eastern Shore follows the same general pattern as the overlying Columbia aquifer, since recharge to this aquifer is from the Columbia. Because the confining unit separating the two aquifers is consistently present over most of the area, there is significant pressure loss between the two aquifers. A maximum groundwater level of +25 ft msl occurs in south central Accomack County, decreasing radially from this point. In Northampton County, the groundwater level is between +5 and +10 ft , and in central Accomack County, groundwater level is +15 to +20 feet MSL, decreasing to +8 to +12 ft msl near the state boundary with Maryland. At the eastern and western coastline, groundwater level decreases to approximately +5 ft msl. A short distance offshore, vertical groundwater flow direction is expected to reverse, with fresh groundwater flow from the upper Yorktown aquifer into the overlying Columbia aquifer.