11 Section 1: Physical Setting and Segmentation

11.1 Physical Setting

The Chesapeake Bay's 64,000-square-mile watershed includes parts of New York, Pennsylvania, West Virginia, Delaware, Maryland, Virginia, and the entire District of Columbia (Figure 11-2). Throughout the Chesapeake Bay watershed there are more than 100,000 streams and rivers that eventually flow into the Bay (USEPA 2003a). Runoff and groundwater from the watershed flow into an estuary with a surface area of 4,500 square miles, resulting in a land-to-water surface-area ratio of 14 to 1. That high ratio is a key factor in explaining the significant influence that the watershed has on Chesapeake Bay water quality. The nine major basins of the Chesapeake Bay watershed are the Susquehanna, Potomac, Patuxent, Rappahannock, York, and James rivers and the Maryland Western Shore, Maryland Eastern Shore, and the Virginia Eastern Shore.

Figure 11-1: States within the Chesapeake Bay watershed

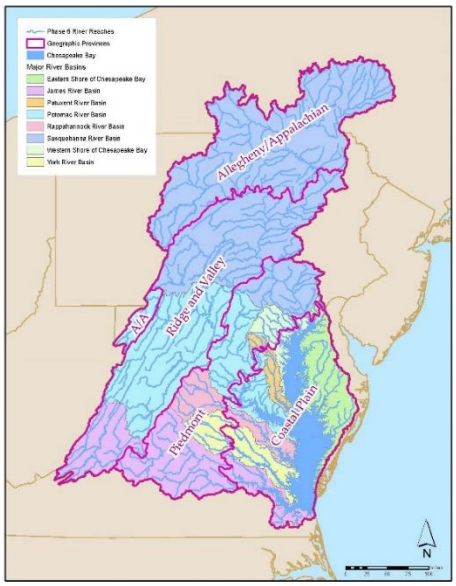

Figure 11-2: Geologic Provinces within the Chesapeake Bay Watershed

The Chesapeake Bay watershed is within the Appalachian, Ridge and Valley, Piedmont, and Atlantic Coastal Plain geologic provinces (Figure 11-1). The Atlantic Coastal Plain is a flat, lowland area with a maximum elevation of about 300 feet. The Coastal Plain extends from the edge of the continental shelf, east to a fall line that ranges from 15 to 90 miles west of the Chesapeake Bay. The fall line forms the boundary between the Piedmont Plateau and the Coastal Plain. Waterfalls and rapids clearly mark the line, which is marked by the Bay watershed cities of Baltimore, Washington, D.C., Fredericksburg, and Richmond. Those cities developed along the fall line taking advantage of both the potential water power generated by the falls and tidewater shipping. The confluence of geography and history placed the largest population centers in the watershed, including Baltimore, Washington, D.C., and Richmond, directly on the Chesapeake tidewater. The Eastern Shore of the Chesapeake Bay is entirely within the Coastal Plain.

The Piedmont Plateau extends from the fall line in the east to the Ridge and Valley province in the west. The Patuxent, Rappahannock, and York River basins span the Piedmont and Coastal Plain (Figure 11-1). The Susquehanna, Potomac, and James rivers span the Ridge and Valley region through a series of water gaps with some rivers, such as the Shenandoah, lying entirely within the Ridge and Valley province.

The Appalachian province covers the western and northern part of the watershed. Water from this province flows to the Chesapeake Bay through the upper reaches of the Susquehanna, Potomac, and James rivers. The Susquehanna is the largest river, followed by the Potomac and James rivers. The watershed land use is about two thirds wooded, one quarter agriculture, and about one tenth developed. According to the CBP population indicator 17.9 million people lived in the Chesapeake Bay watershed in 2014 and the population is estimated to increase to over 21 million by 2040. The major river basins of the Chesapeake Bay Watershed are shown in Figure 11-5.

11.2 Segmentation

The Phase 6 segmentation is similar to segmentation in the Phase 5 Watershed Model (USEPA 2010a-03). Key data inputs, such as crop types and associated nutrient application rates, are most readily calculated only at the county-level scale which do not generally follow watershed boundaries. To best represent the appropriate processes land and river simulations are performed on separate spatial delineations. A land segment is defined as an area in which all land in a given land use is simulated as being homogenous. That is, each land segment contains a single instance of each type of land use. A river segment is defined as the land draining to the river reach contained in the river segment. In areas of the coastal plain where there are no simulated river reaches, river segments are defined as the land draining directly to a Chesapeake Bay Water Quality Segment (Martucci et al. 2006).

11.2.1 Land Segments

Phase 6 land segments are primarily counties, but some counties were subdivided in allow for significant differences in rainfall. The Phase 5.3 Watershed Model used in the 2010 TMDL had a similar approach. The Phase 5.3.2 Watershed Model used in the Phase II WIPs had land segmentation split between federal and non-federal areas as well.

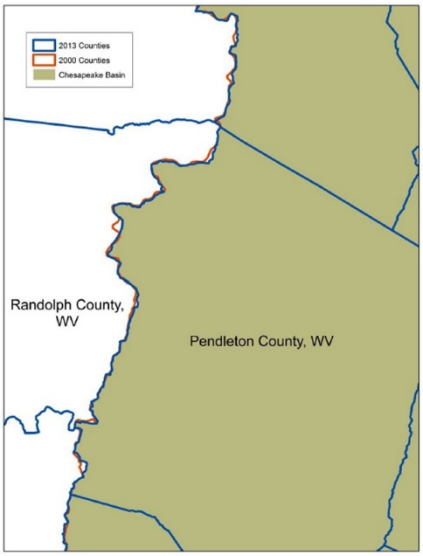

Figure 11-3: improved county boundaries

The following changes were made for Phase 6.

1. Federally-owned land segment divides were removed
2. County boundaries were updated with newer data
3. Divisions for rainfall were updated using PRISM data (Daly et al. 2008).

County boundaries for Phase 6 use the 2013 TIGER file available from Census Bureau available at https://www.census.gov/geo/maps-data/data/tiger-line.html. There are numerous changes from the Census 2000 data used in Phase 5, with most of those changes being minor. The county boundaries (Figure 11-3 blue line) now correctly match the western Chesapeake basin boundary between VA and WV and within WV where they are coincident (Figure 11-3).

Counties were further subdivided by rainfall under certain circumstances. The 30-year long term normal data from the PRISM Climate Group (Daly et al. 2008) were used at a resolution of 30 seconds, which is about 800 meters. A mean precipitation was calculated for each county and then the deviation from that county mean was calculated for each individual 30 second pixel. Pixels with rainfall 100 mm or more below the county mean were designated as low. Pixels with rainfall 100mm or more above the county mean were designated as high. High and low pixels were aggregated into contiguous areas designated as high and low patches. A minimum patch of 72 square km size was enforced to remove patches that were too small to be adequately represented by the NLDAS-2 rainfall data set.

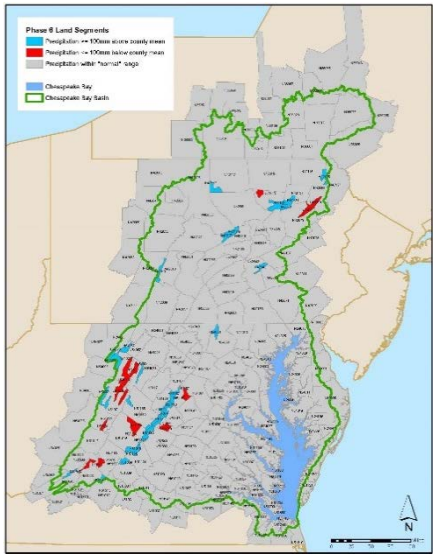

Figure 11-4: Finer segmentation of counties for rainfall differences

Figure 11-4 shows the final Phase 6 land segments with areas of high rainfall in blue and areas of low rainfall in red. Land segment names are formed by combining each county's 5-digit FIPS code with a prefixed 'N' for normal rainfall, 'L' for low rainfall, or 'H' for high rainfall. The list of land segments is available in Appendix 1.A.

11.2.2 River Segments

A river reach is section of a river or reservoir that is simulated as a single unit. A river segment is the land draining directly to each river reach. Each river with at least 100 cubic feet per second average flow is a separate reach and river segment. The confluence of two or more such rivers creates a new reach and river segment. Further divisions are made in the coastal plain such that each river segment drains to exactly one CBP Water Quality segment in the estuary. It is a requirement of the TMDL that the drainage to each designated use be well-defined. The Phase 6 river segments and major watersheds are shown in Figure 11-5.

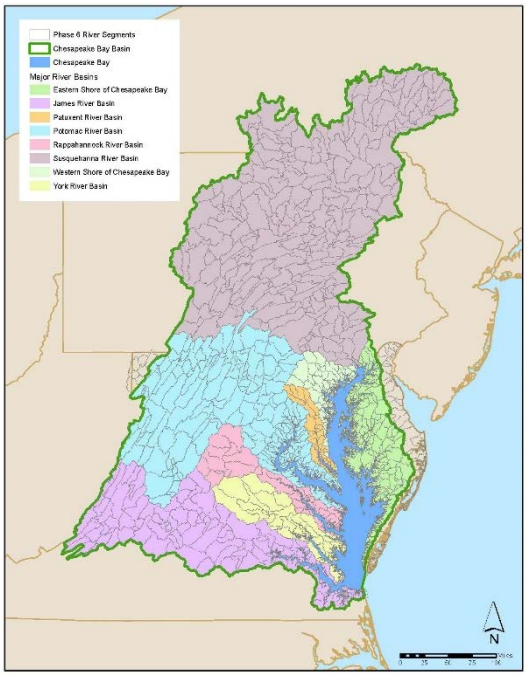

Figure 11-5: River segments and Major Watersheds

Phase 5.3.2 river segments were carried forward with a few major exceptions. It was decided by the Modeling Work Group that the Phase 6 river segments would incorporate a boundary of the Chesapeake Bay Basin derived from the USGS Watershed Boundary Dataset (WBD) Hydrologic Units (USDA-NRCS et al. 2015). The new basin boundary was overlaid on the Phase 5.3.2 river segments. Areas outside of the new basin boundary were deleted and areas within the new boundary that were previously outside the basin were incorporated into the nearest existing river segment.

The areal extent of the Phase 6 river-segment data layer is smaller than that of the Phase 5.3.2 river segments. Only river segments that are within the Chesapeake Bay Basin as well as the Virginia portion

of the Delmarva Peninsula draining to the Atlantic, the rest of Delaware, and river segments that are at least partly within western Maryland are included in Phase 6.

While most changes between Phase 5.3.2 and Phase 6 were minor, there were a few areas that had noticeable changes, particularly in southeastern VA. The two biggest changes in land area were the addition approximately 31 square miles of the Great Dismal Swamp and the removal of approximately 22 square miles of Virginia Beach, Virginia that drain to the Atlantic Ocean were removed from the model domain. The list of river segments is available in Appendix 1.A.

11.2.3 Land-River Segments

The intersection of land and river segments are known as land-river segments. They are the lowest geographic unit of output for the Phase 6 Watershed Model. The list of land-river segments is available in Appendix 11A. An interactive map of segments, land use, and other spatial data is available on the CAST page or directly through this URL: https://gis.chesapeakebay.net/mpa/scenarioviewer/

11.2.4 Shoreline Length

Shoreline length is needed as a domain for BMPs which alter the shoreline erosion. Land-river segments were first converted polygon to polylines and then to lines. The tidal Bay was defined as the inverse of the land-river segments. Lines that intersect with the Bay are considered shoreline as in Figure 11-6. Shoreline length by land-river segment was then calculated.

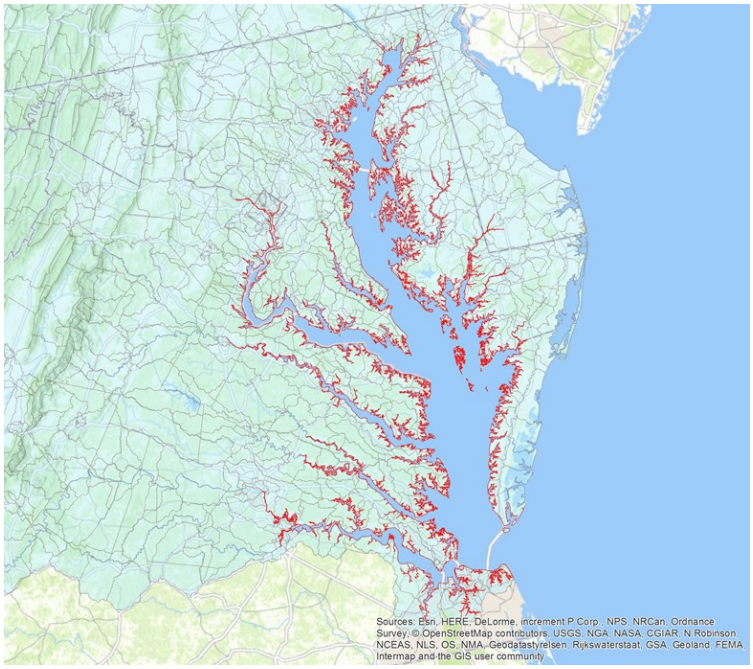

Figure 11-6: Calculation of Shoreline Length