Floodplain visualization using lidar-derived relative elevation models

Daniel E Coe, Washington State Department of Natural Resources,
Division of Geology and Earth Resources
www.dnr.wa.gov/geology

Lidar-derived bare-earth digital elevation models (also known as digital terrain models) are useful to geoscientists because they provide a clear view of the Earth's surface—above-ground elements, such as vegetation and structures, have been removed. Digital elevation models (DEMs) are especially advantageous in areas where extreme vegetation makes performing geologic or geomorphic investigations difficult.

What is an REM?

In floodplains, DEMs can be converted to relative elevation models (REMs) to better visualize fluvial features that are difficult to discern using an aerial photo or standard DEM. REMs, also known as height above river (HAR) rasters, are produced by detrending the baseline elevation to follow the water surface of the stream. Figure 1 shows the difference between a standard DEM and a REM. In the DEM, the baseline elevation (0 feet) is at sea level and the downstream part of the river has a lower elevation than the upstream part. In the REM, the baseline elevation (0 feet) was detrended to follow the water surface of the river— elevations trend higher as one moves away from the river (showing the "relative" height above river).

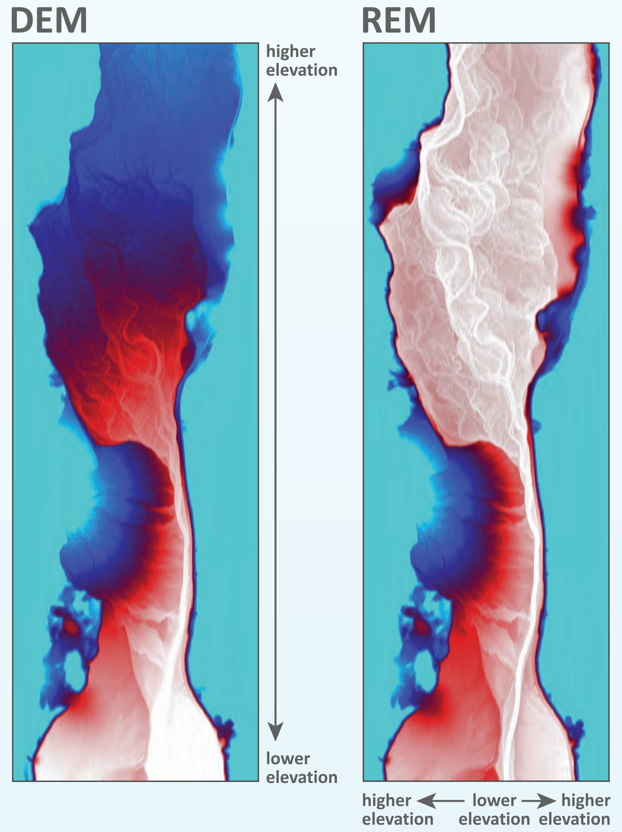

Figure 1. Comparison of a standard digital elevation model (DEM) and a relative elevation model (REM) of the Methow River, Washington. Both have an elevation color range of 100 vertical feet

As seen in Figure 3 at right, REMs are extremely useful in discerning where river channels have migrated in the past by vividly displaying fluvial features such as meander scars, terraces, and oxbow lakes. This type of information is very informative in channel migration and flood studies, as well as a host of other engineering and habitat assessments.

Figure 2 of the Chehalis River compares visualizing fluvial features using (A) aerial photography with a (B) REM in the same area. Subtle elevation changes in relation to the river surface enable the (C) delineation of fluvial features that would otherwise have been difficult to discern using photos or a DEM. Image D shows the same area with a monochromatic color scheme applied to the REM. The full map can be seen in Figure 5, upper right.

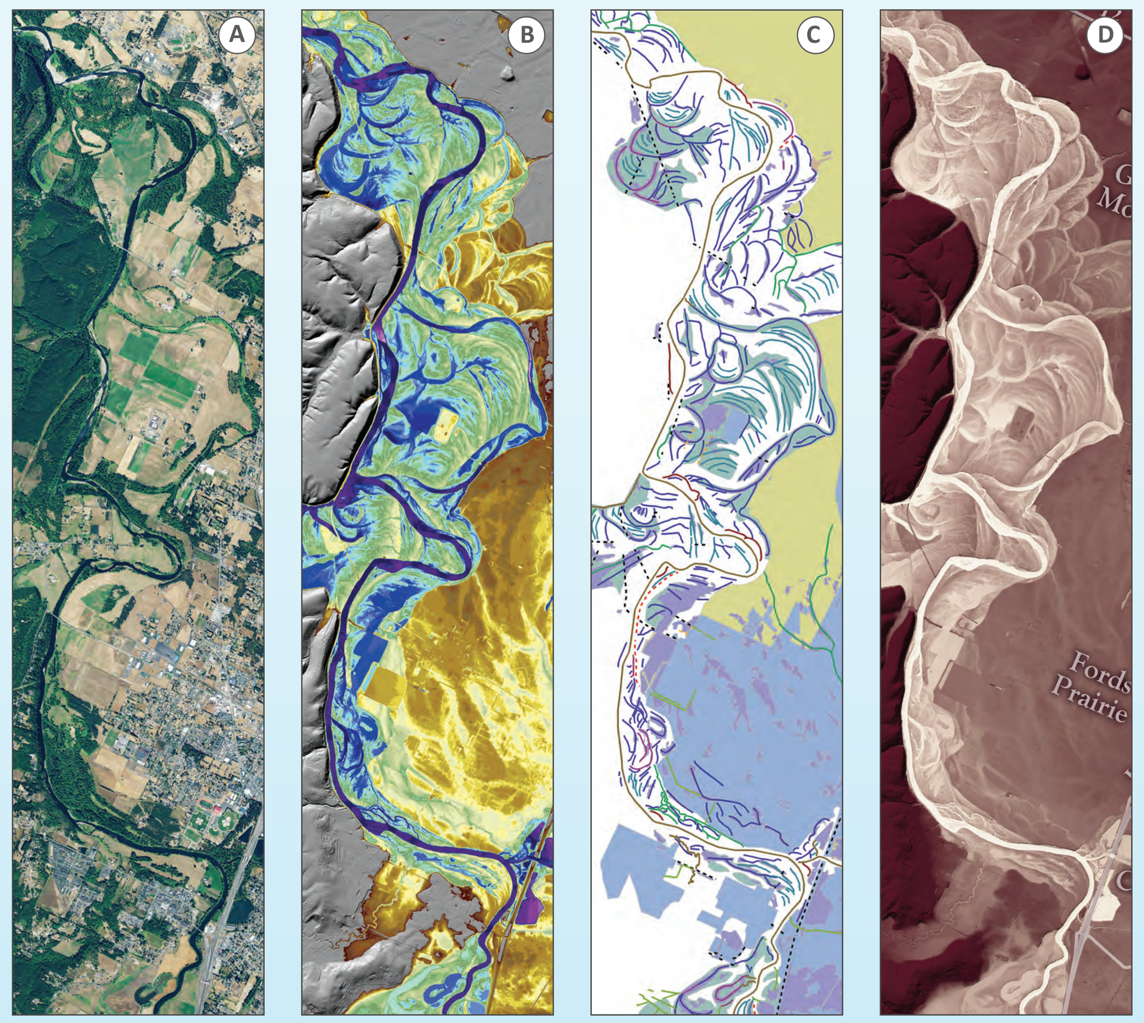

Figure 2. Comparison of aerial photo (**A**), multi-color REM view (**B**), REM-derived fluvial features (**C**), and monochromatic REM image (**D**) of the Chehalis River, Washington. Images **B** and **C** from Slaughter and Hubert (2014)

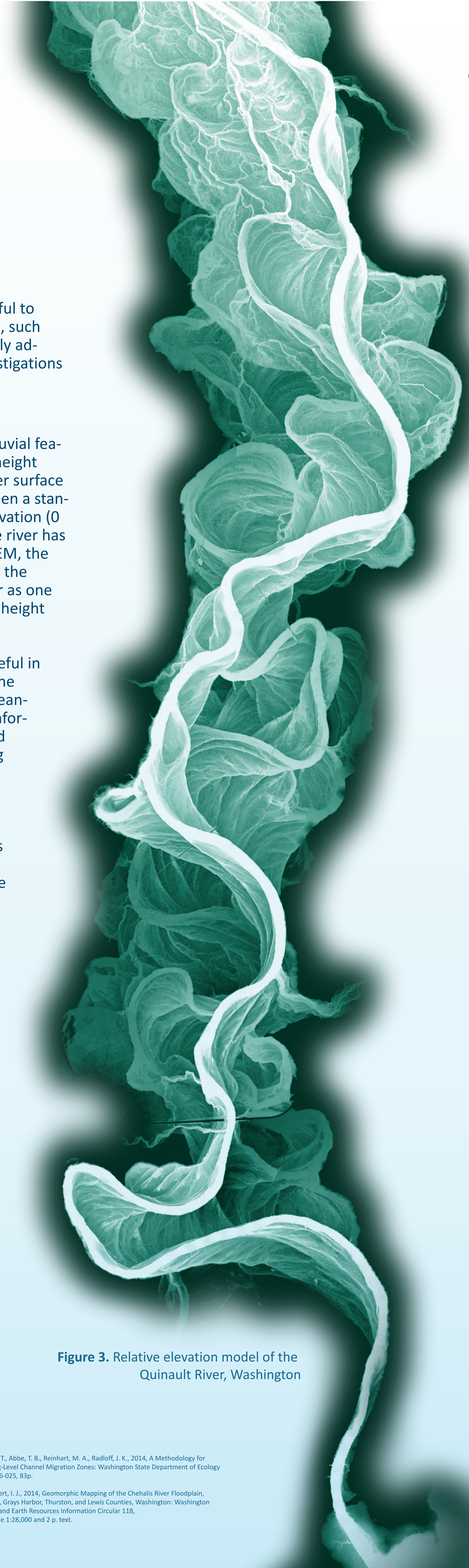

Figure 3. Relative elevation model of the Quinault River, Washington

References:
Olson, P. L., Legg, N. T., Abbe, T. B., Reinhart, M. A., Radloff, J. K., 2014, A Methodology for Delineating Planning-Level Channel Migration Zones: Washington State Department of Ecology Publication no. 14-06-025, 83p.

Slaughter, S. L.; Hubert, I. J., 2014, Geomorphic Mapping of the Chehalis River Floodplain, Cosmopolis to Pe Ell, Grays Harbor, Thurston, and Lewis Counties, Washington: Washington Division of Geology and Earth Resources Information Circular 118, 59 p. map book, scale 1:28,000 and 2 p. text.

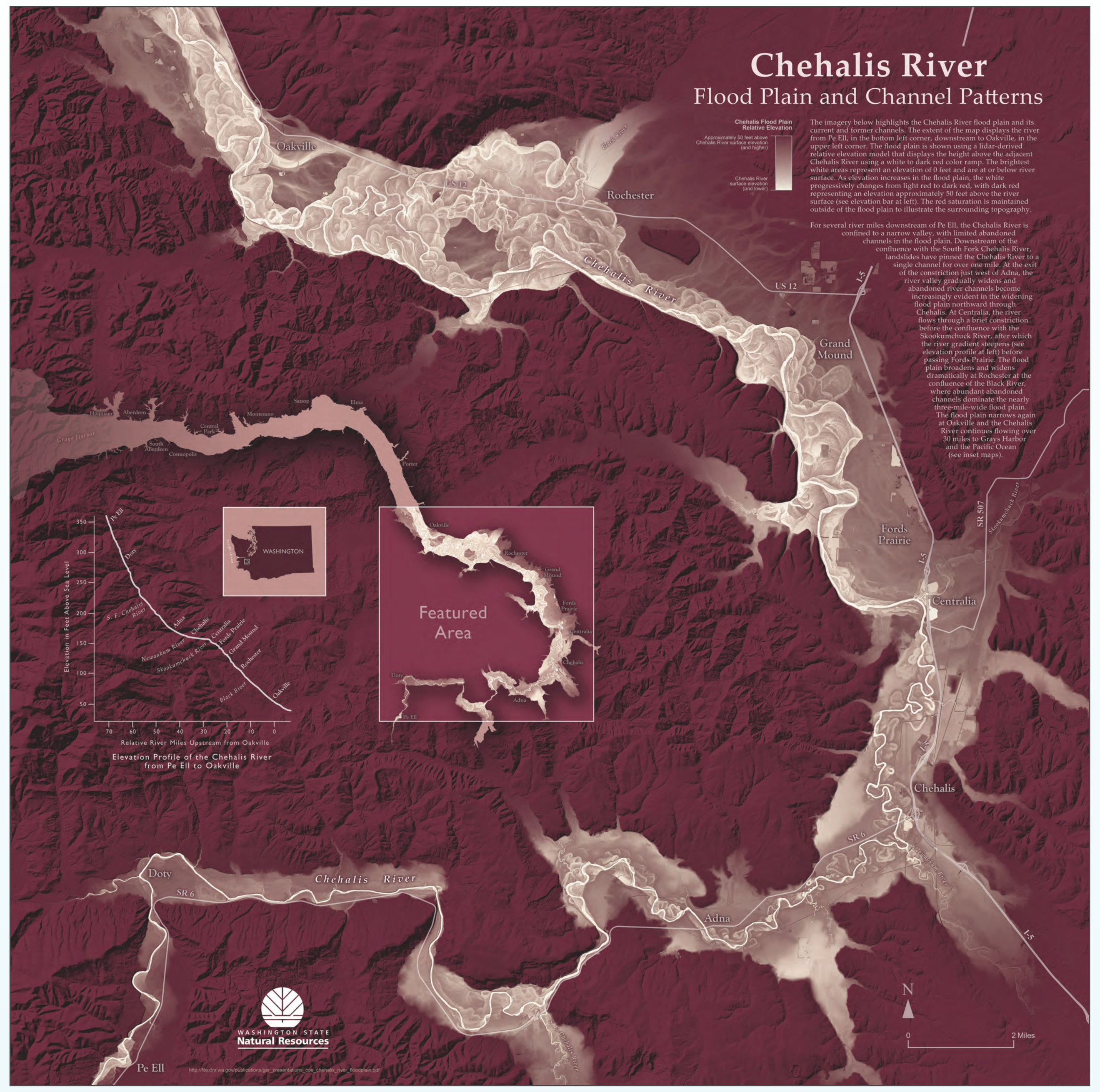

Figure 5. Poster of the Chehalis River Floodplain with a lidar-derived relative elevation model

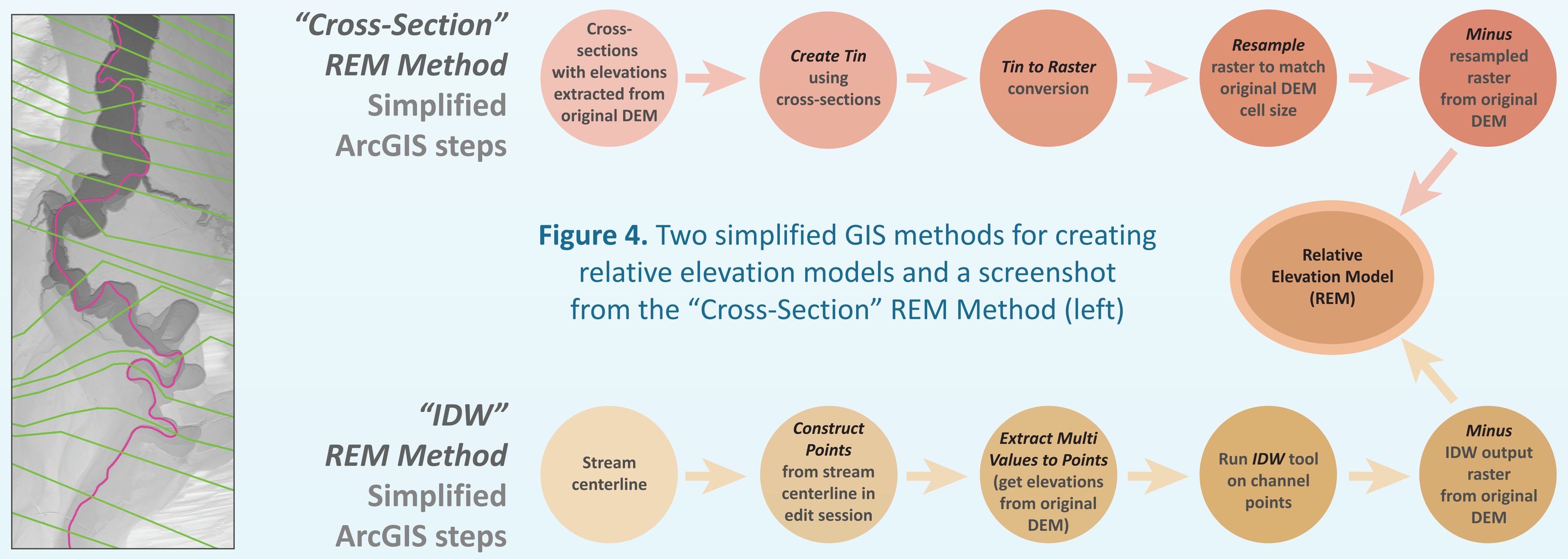

Figure 4. Two simplified GIS methods for creating relative elevation models and a screenshot from the "Cross-Section" REM Method (left)

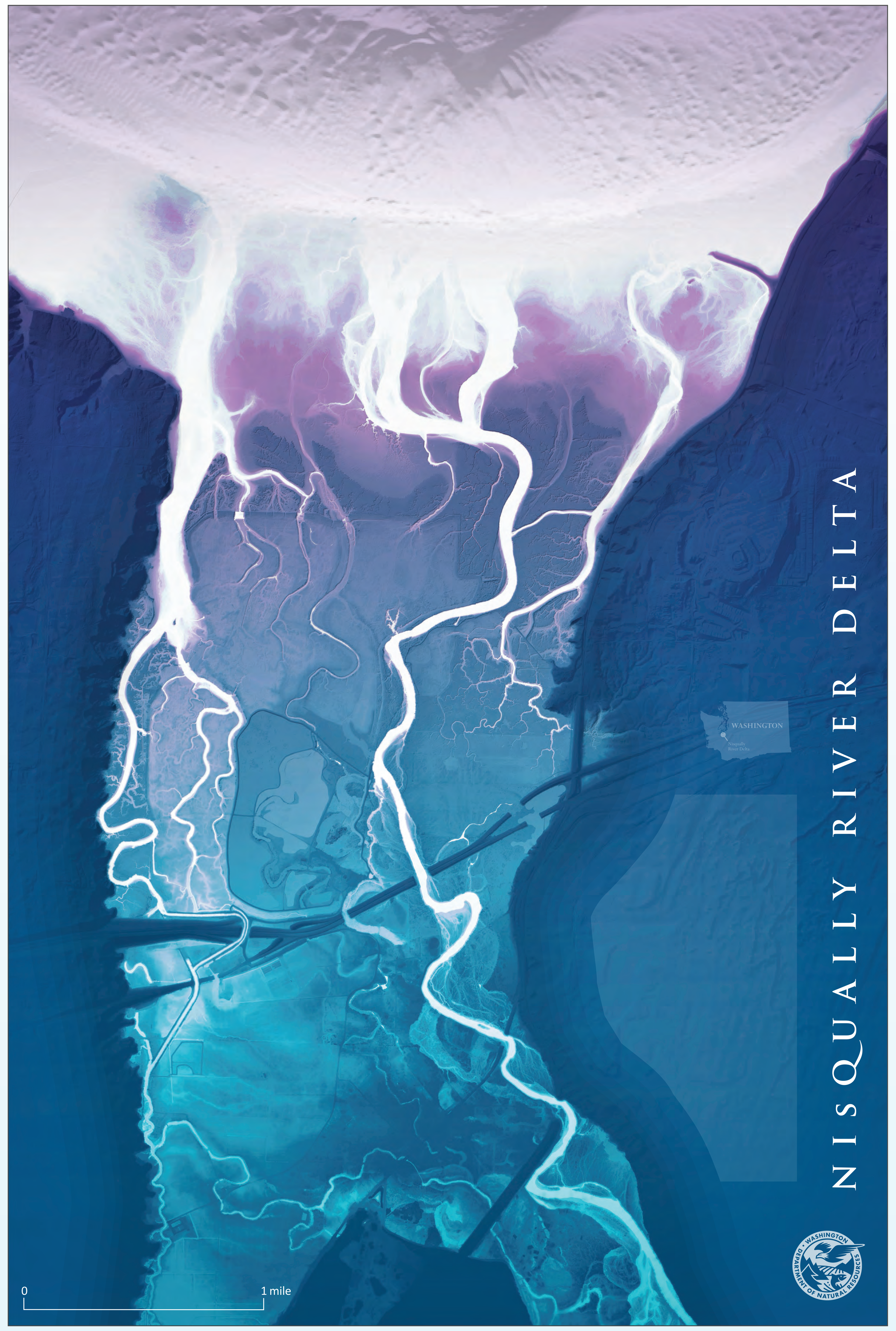

Figure 6. Preliminary lidar REM image of the Nisqually River Delta and estuary, Washington

Creating an REM

REMs can be created using a number of different methods. Two of these techniques, the Cross -Section and IDW methods, are described briefly in the above simplified model diagram. These two methods along with the Kernel Density method (not shown) are described in detail by Olson and others (2014). All three methods use point or line GIS data that possess elevations corresponding to the river's surface. The data are then interpolated to create a new raster surface and then subtracted from the original DEM raster to create the REM.

Often, more than one iteration of the model is needed to accurately represent the water surface at 0 elevation. Some common factors that reduce model accuracy are (1) rivers with a steep elevation gradient and (or) high sinuosity and (2) models that incorporate more than one stream.

REM Cartography

When used for analysis, multi-color gradients can be applied to the REM to show the subtle elevation changes necessary for scientific interpretation. When used for cartographic purposes, however, a monochromatic gradient produces a more aesthetically pleasing effect. Using graphics software such as Adobe Illustrator or Photoshop, the REM can be enhanced and combined with other raster or vector data to produce maps and imagery such as in Figures 5 and 6 above. The REM can also be visualized in perspective view (Figure 7) using GIS applications such as ArcGlobe or Global Mapper.

REMs are also useful in visualizing other kinds of geomorphic features. REMs were used to create enhanced views of ice-age glacial outwash plains in Figure 8A below, and of Mount St. Helens' lava flows in Figure 8B.

Figure 7. 3D-perspective view of a REM of the Deschutes River, Oregon

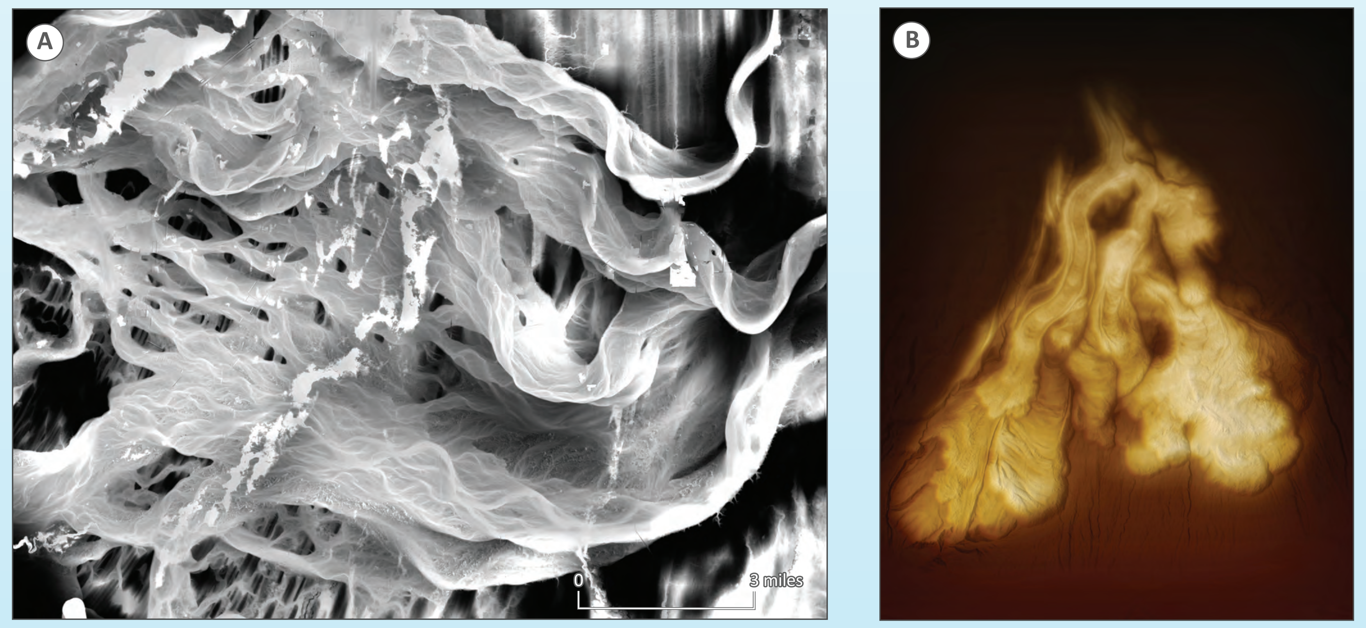

Figure 8. REMs can also be used to visualize glacial and volcanic features

A. Recessional outwash plain in Pierce County, Washington. Almost all of these channels are inactive

B. Andesite flows off the southeast flank of Mount St. Helens, Washington