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Missoula Floods — Inundation Extent and Primary Flood Features in the Portland Metropolitan Area

2012

IMS-36
INTERPRETIVE MAP SERIES
Missoula Floods — Inundation Extent and Primary Flood Features in the Portland Metropolitan Area, Clark, Cowlitz, and Skamania Counties, Washington, and Clackamas, Columbia, Marion, Multnomah, Washington, and Yamhill Counties, Oregon

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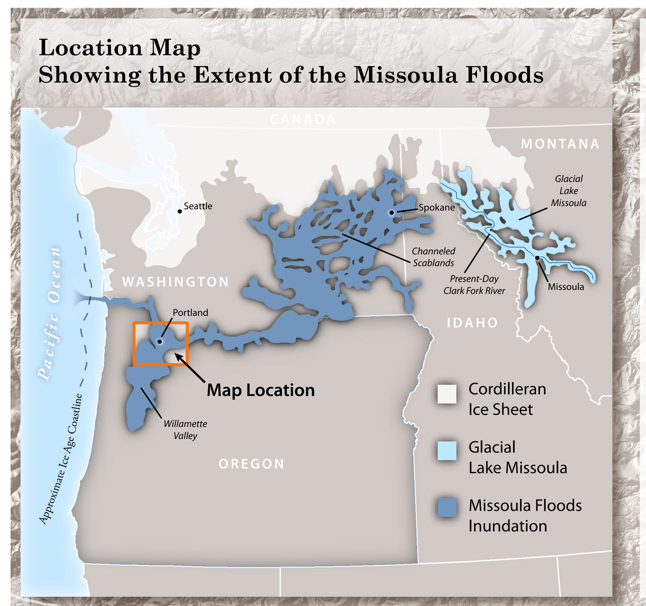
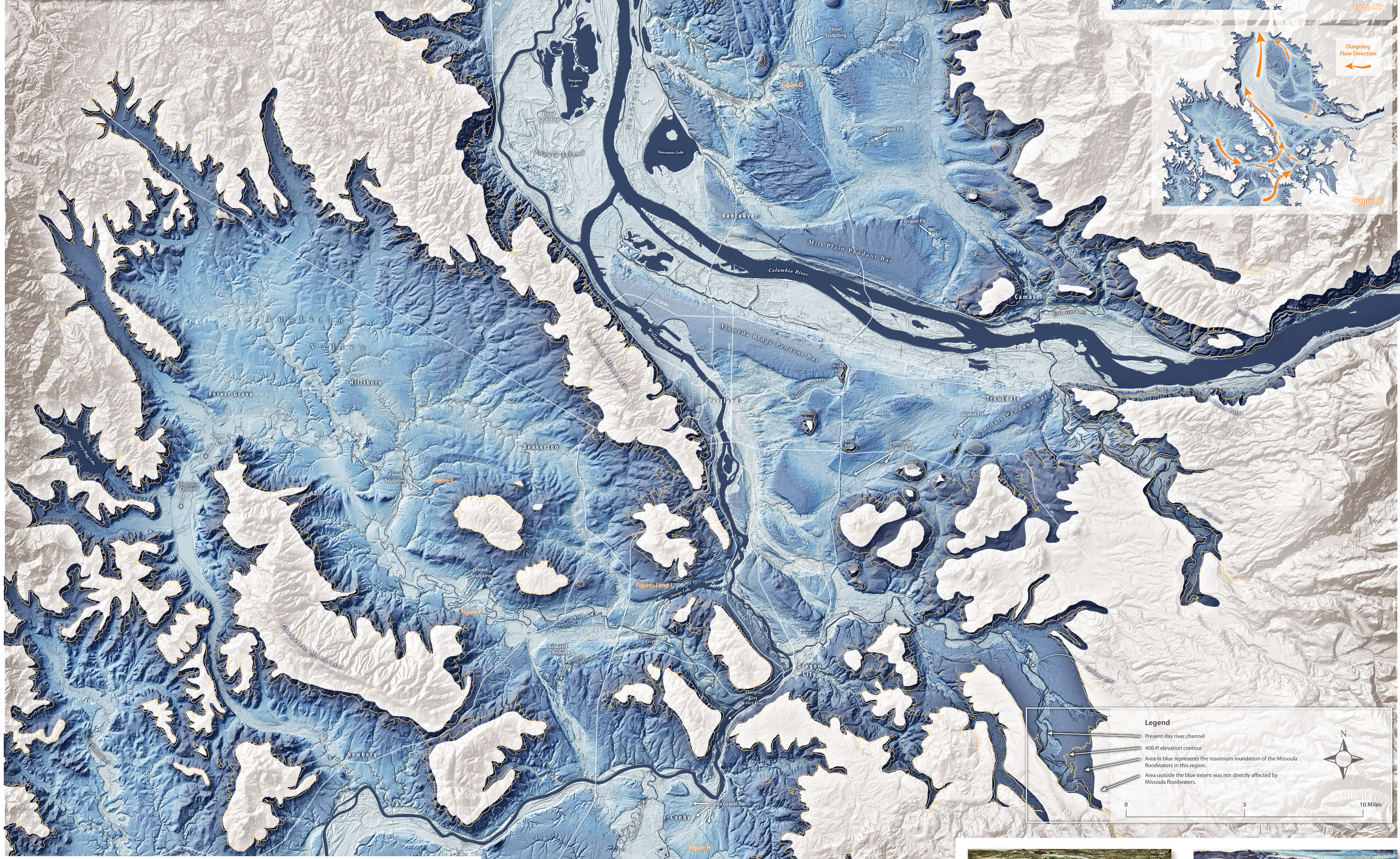
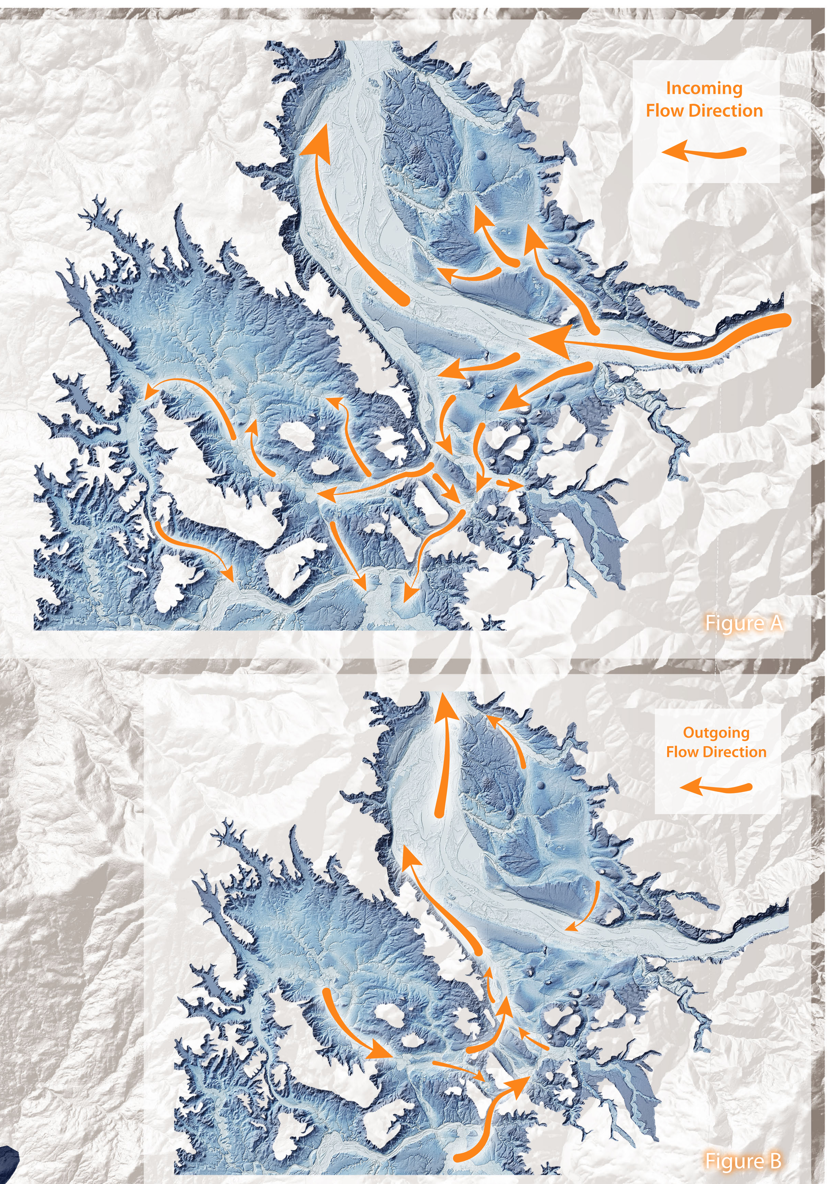
Location Map Showing the Extent of the Missoula Floods

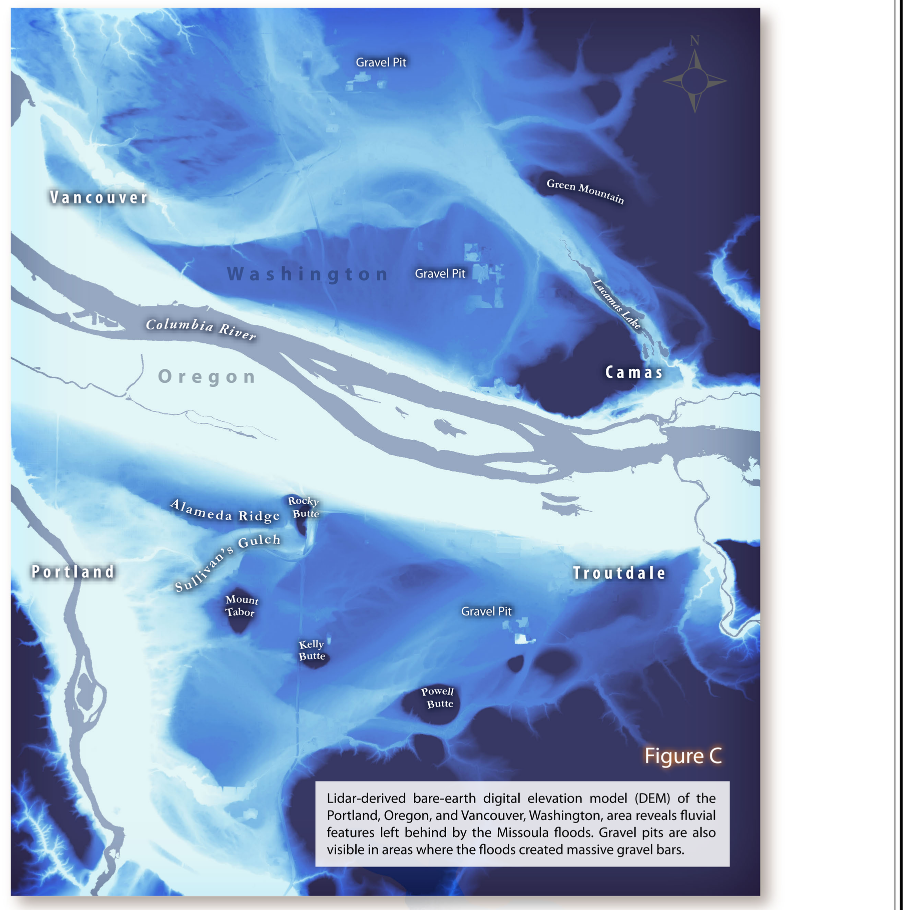


Glacial Lake Missoula and Ice Age Floods

In the early 20th century, geologist J Harlen Bretz suggested that the large-scale fluvial features he saw in the Pacific Northwest were caused by catastrophic flooding (Bretz, 1925). After decades of controversy, his theory was accepted, and other scientists began to study the floods and their effects. The currently established theory is that in the late Pleistocene (18,000 to 15,000 years ago), the massive Cordilleran ice sheet formed a dam along the northern Idaho-Montana border (see location map) and blocked the Clark Fork River, which drained western Montana. This dam resulted in the formation of Glacial Lake Missoula, which contained 530 cubic miles of water, roughly 120 times the volume of water in present-day Crater Lake (Allen and others, 2009). When Lake Missoula waters breached the ice dam, some of the largest floods known on earth discharged nearly 350 million cubic feet per second—over 1,000 times the average discharge of the current Columbia River (Allen and others, 2009). The dam-and-breach process was repeated at least 40 times over 3,000 years as the ice sheet advanced and retreated (Allen and others, 2009). With each breach, huge volumes of water raced across eastern Washington, eroding and depositing material and creating the channeled scablands noted by Bretz before converging into the Columbia River Gorge and scouring out the current shape of the gorge. As the floods rushed out of the constricted Columbia River Gorge and entered the Portland Basin, the water gushing across the landscape created much of the large-scale geomorphology, or shape of the land surface, that exists today and can now be seen clearly on this map. Geomorphic features include huge primary channels that are in some places scoured down to bedrock, large sand and gravel bar deposits, and extensive fluvial sculpting throughout the basin (Allen and others, 2009; Allison, 1978; Minervini and others, 2003; Benito and O'Connor, 2003; Trimble, 1963). Using new technologies like light detection and ranging (lidar), from which high-resolution land surface imagery can be made, scientific investigation of these floods and their aftermath continues today.







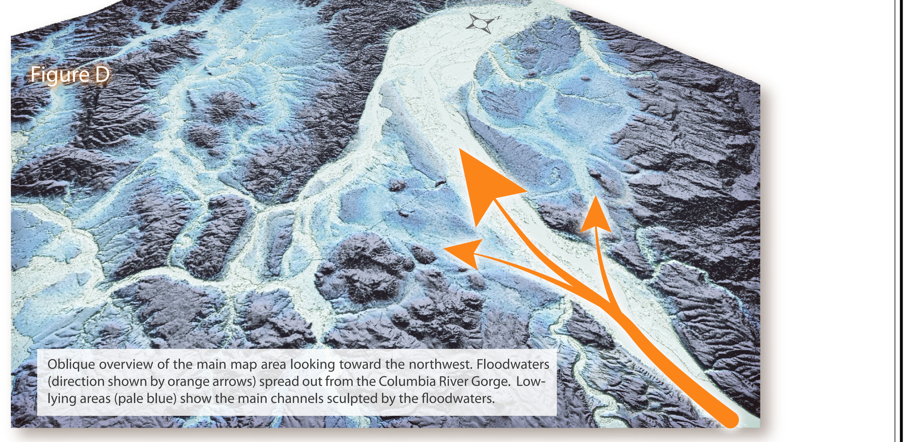
Lidar-derived bare-earth digital elevation model (DEM) of the Portland, Oregon, and Vancouver, Washington, area reveals fluvial features left behind by the Missoula floods. Gravel pits are also visible in areas where the floods created massive gravel bars.

Using Lidar to Identify Flood Features

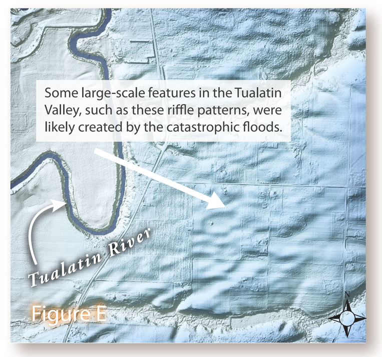
In 2007-2011, airborne light detection and ranging (lidar) data were collected throughout the Portland Basin. Lidar-derived imagery allows us to map the shape of the surface of the earth in resolution never before seen, especially in places that are densely vegetated, such as the Portland Basin.

Lidar data in this map have been colored and shaded to reveal relative and absolute changes in elevation within the area inundated by the Missoula floods. This was done to assist in identification of geomorphic features produced by the floods. Figure A in the upper right of the main map displays likely flow directions out of the Columbia River Gorge into the Portland Basin, where the waters spread into and filled the broad, flat Willamette Valley. Once the incoming surge stopped, the water poured out of the Willamette Valley, back into the Portland Basin, and toward the Pacific Ocean (Figure B). Figure C (above) also shows likely major flow paths. As the water repeatedly entered the basin, it shaped the land, leaving 1) primary flood channels (Map C, Figure D); 2) bedrock scour areas, especially at constriction locations such as Lacamas Lake, Oswego Lake, Oregon City, and the northern end of the basin along the current Columbia River channel (main map, Map A, Figures I and J); and 3) primary deposition areas such as the Alameda Ridge, Mill Plain, and Troutdale pendant bars (main map, Map A) and the gravel bar/delta near Canby (Figure H). Many primary channels and bedrock scour areas are occupied by modern lakes and rivers, although the scale of these current features is much smaller than the Missoula flood features. Several gravel pits in the area, clearly visible on the map, are mined for material deposited by the floods.

Other interesting artifacts from the floods are ice-rafted glacial "erratic" boulders (Map B). Floodwaters rushing out of Glacial Lake Missoula carried large pieces of glacial ice that had plucked up and ground up rock as the glacier scraped along. The ice and the rock came to rest at locations throughout the Portland Basin. When the ice melted, the rock material, including huge boulders, was dropped onto the land (Allison, 1935).

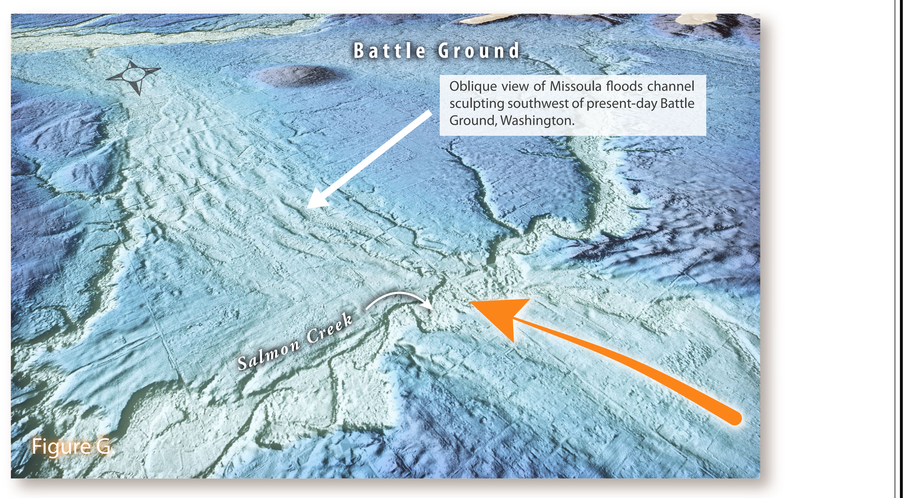


Oblique overview of the main map area looking toward the northwest. Floodwaters (direction shown by orange arrows) spread out from the Columbia River Gorge. Low-lying areas (pale blue) show the main channels sculpted by the floodwaters.

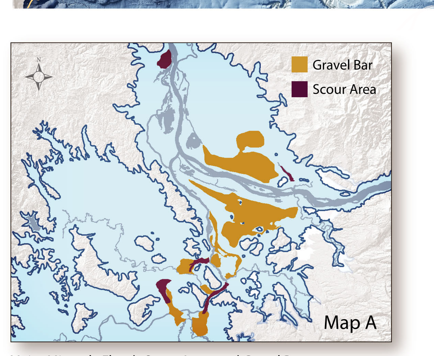


Some large-scale features in the Tualatin Valley, such as these riffle patterns, were likely created by the catastrophic floods.

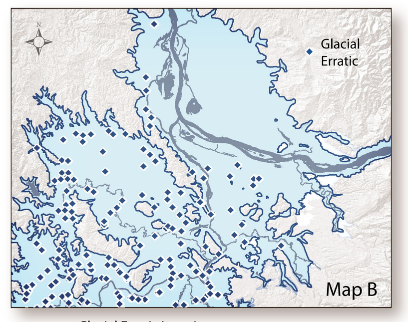
Present-day Tualatin River cuts across Missoula floods sculpted channels.



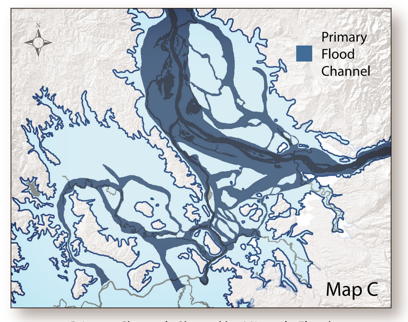
Oblique view of Missoula floods channel sculpting southwest of present-day Battle Ground, Washington.



Major Missoula Floods Scour Areas and Gravel Bars



Glacial Erratic Locations



Primary Channels Shaped by Missoula Floods

Water Inundation Area

The line defining the area inundated by water from the Missoula floods in the Portland Basin was interpreted using datasets in a Geographic Information System (GIS). The datasets included 1) two elevation contour lines derived from the lidar DEM: one at 850-ft elevation throughout the Columbia River Gorge (O'Connor and Burns, 2009), and one at 400-ft elevation throughout most of the Portland Basin; the 400-ft elevation is suggested as the maximum flood height for most of the Willamette Valley from deposits, glacial erratics, and modeling (Minervini and others, 2003); 2) locations of glacial erratics (Minervini and others, 2003); 3) mapped locations of deposits from the Missoula floods (Ma and others, in press); and 4) lidar-DEM-derived images used to identify large-scale fluvial geomorphic features.

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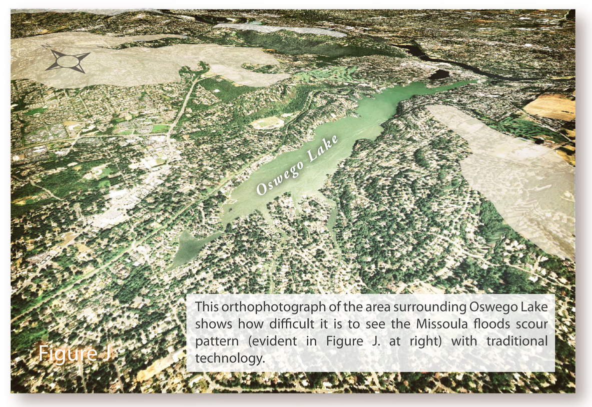
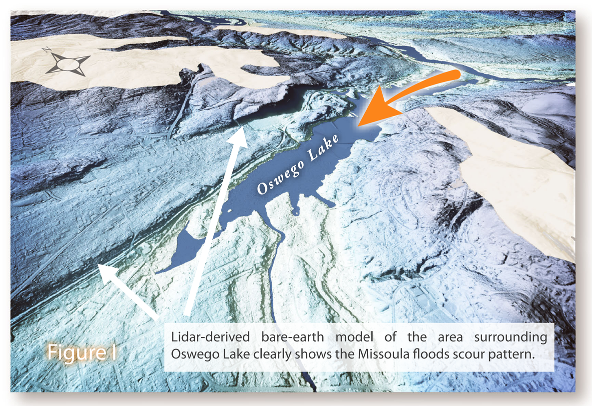


This orthophotograph of the area surrounding Oswego Lake shows how difficult it is to see the Missoula floods scour pattern (evident in Figure J. at right) with traditional technology.



Lidar-derived bare-earth model of the area surrounding Oswego Lake clearly shows the Missoula floods scour pattern.

Oblique view of Missoula floods outflow features at present-day Canby, Oregon. The incoming floods burst though the Oregon City Water Gap and spilled out across the northern Willamette Valley.