Ice Age Floods

Ice Age Floods National Geologic Trail
Montana / Idaho / Washington / Oregon

National Park Service
U.S. Department of the Interior

An erratic on Rattlesnake Mountain; Palouse Hills; Frenchman Coulee; Rhythmites at White Bluffs; West Bar Giant Current Ripples © BRUCE BJORNSTAD

Floods of Change

One of the greatest stories of ancient North America is written in the rocks and sediments of the Pacific Northwest. Massive floods swept across parts of Montana, Idaho, Washington, and Oregon, sculpting and changing the landscape, leaving clues for scientists and travelers to unravel. Explore the geologic evidence left behind as you travel the Ice Age Floods National Geologic Trail.

Around 18,000 years ago an advancing glacial lobe blocked the Clark Fork River in current-day northern Idaho. Behind this giant ice dam, water rose 2,000 feet (610 m) filling the valleys to the east, creating Glacial Lake Missoula. As the ice lobe retreated, pressure from the lake caused the ice dam to fail, releasing up to 600 cubic miles (~2,500 km³) of water, the volume of Lake Ontario and Lake Erie combined, in as little as two days. This wall of water, ice, and debris hundreds of feet tall raced westward over 16,000 square miles (41,440 km2) through present-day Montana, Idaho, Washington, and Oregon.

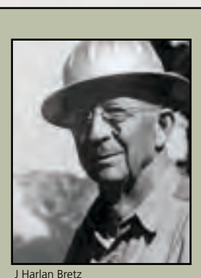
Over the course of the next 3,000 years, the glacial lobe continued the cycle of advancing, blocking the Clark Fork River, filling Glacial Lake Missoula, and then failing, releasing the water across the landscape. Over time, dozens of floods left a lasting change on the natural environment and human habitation in the region.

These glaciers and floods scoured all evidence of humans from this ancient landscape, leaving us with stories passed down by the American Indian tribes that have called this region home for the last 15,000 years. Their cultural and spiritual traditions are deeply tied to these lands, the powerful forces that created them, and that continue to shape their modern way of life.

Widespread reminders of the Ice Age Floods are scattered throughout the area. Drive the trail and make your own connections with gigantic basalt coulees and dry waterfalls, house-sized boulders moved by ice and water, ancient lake shores etched in hillsides, and huge ripple marks taller than your car.

Solving the Mystery

The story of the Ice Age Floods took nearly 50 years to piece together. During the 1920s–40s, geologists debated the origin of eastern Washington's Channeled Scabland where eroded volcanic basalt surrounds braided channels and coulees. Most geologists believed that the Channeled Scabland was made by slow erosion by glaciers and streams. Geologic evidence that didn't fit with this idea led geologist J Harlen Bretz to hypothesize that the Channeled Scabland was formed by a catastrophic flood. Initially ridiculed, Bretz's hypothesis was validated when new technologies like satellite photography provided supporting evidence. By the late 1970s it was universally accepted that the scoured landscape of the northwestern United States was the result of multiple Ice Age Floods.



J Harlan Bretz
© JULIAN GOLDSMITH

Joseph Pardee
USGS

J Harlen Bretz, 1882-1981
A high school teacher turned geology professor, J Harlen Bretz was fascinated with the glacial geology of the Puget Sound. He became an expert on the features of stream and glacial erosion and began field research in the Channeled Scabland of eastern Washington in 1922. Challenging common beliefs, Bretz believed that the Channeled Scabland was formed not by ordinary stream erosion but by a catastrophic flood. What eluded him, though, was the source of the floods.

Joseph Pardee, 1871-1960
Joseph Pardee, a geologist with the US Geological Survey, proposed a source for Bretz's catastrophic floods. As he studied the intermontane basins of Montana in 1910, he found high water marks near Missoula, Montana—evidence of a large glacial lake. Later, in the Camas Prairie of northwestern Montana, he discovered giant ripple marks of sediment made by powerful currents flowing over the bottom of ancient glacial Lake Missoula. Like Bretz, Pardee's discoveries played a key role in understanding the story of the Ice Age Floods. It was not until the late 1970's that geologists begain to generaly agree on the idea that multiple floods were a key part of this story.

The work of these and present-day scientists show us that the gradual processes shaping our Earth can be accentuated by sudden cataclysmic geologic events, and that such events are possible in our lifetimes!

The magnitude of the erosive changes wrought by these glacial streams is nothing short of amazing. —J Harlen Bretz, 1923

Lasting Impressions

As the Ice Age Floods swept across the landscape from present-day Montana to the Pacific Ocean, they eroded massive amounts of rock and debris from the land and deposited them farther down the flood route. Along the National Geologic Trail, deeply eroded coulees, scoured water gaps, remnant waterfalls, and basalt cliffs lead to gravel bars, giant ripple marks, and large boulders. These clues from the past guide your passage through geologic time and space.

Of the thousands of large flood features that decorate the landscape of the Northwest US, thirteen are featured here to help explain the story. Find them on the map side of this brochure marked by numbered callouts.

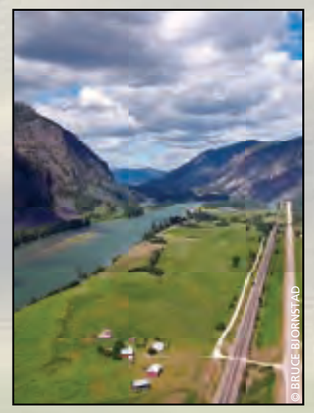
1. Lake Missoula Strandlines
Imagine you are standing on the edge of glacial Lake Missoula 15,000 years ago. You can hear lapping waves cutting benches known as "strandlines" into the shoreline. Today, you can see these huge strandlines on hills surrounding Missoula, Montana, marking changes in lake level over time. On Mount Sentinel, marked with an "M", and Mount Jumbo, marked with an "L", the strandlines are seen as horizontal lines in the vegetation or highlighted by snow in the winter. Public hiking trails switchback through the strandlines on Mount Sentinel and Mount Jumbo.

© BRUCE BJORNSTAD

2. Camas Prairie Ripples
Water alters everything it touches. Floodwaters deposited giant gravel bars in the Camas Prairie Basin of present-day western Montana. Similar in shape to small ripple marks on a sandy beach, these gravel bars are up to 30 feet (9m) tall. Formed by deep, raging floodwaters as the lake drained, they remind us of the sheer power of the Ice Age Floods. Observe the Camas Prairie Ripples by driving Montana Highway 382 north over Markle Pass.

© DAVE BENNET

3. Eddy Narrows
West of the Camas Prairie Ripples is a flume-shaped section of canyon called the Eddy Narrows. Draining glacial Lake Missoula waters dischared at a rate of 15 million cubic meters per second, scouring the valley walls down to bare bedrock up to 1,000 feet (305 m) above the valley floor. On Montana Highway 200, between mileposts 59 and 60, stop at the KooKooSint Bighorn Sheep Viewing Interpretive Site to see these vertical canyon walls.



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4. Glacial Dam at Green Monarch Ridge
As the Purcell Trench ice lobe of the Cordilleran Ice Sheet advanced south from Canada, it was stopped by the Green Monarch Ridge, building an ice dam 4,000 feet (1219 m) tall and nearly 40 miles (64 km) wide that blocked the Clark Fork river, thus filling glacial Lake Missoula. View the Green Monarch Ridge and the Purcell Trench from a large pullout on Idaho State Route 200, about one mile (1.6 km) west of Hope, Idaho and 15 miles (24 km) east of Sandpoint, Idaho.

© BRUCE BJORNSTAD

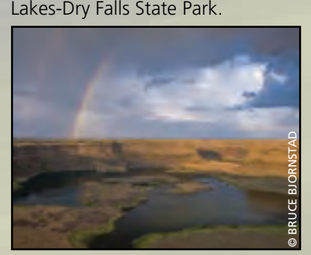
5. Missoula Floods Outburst Plain
When the ice dam holding back glacial Lake Missoula burst, water was not the only thing to rocket through the breach. Ice, boulders, and other debris were deposited in the Rathdrum Prairie by escaping floodwaters. Explore this and other flood remnants like debris-damned lakes, giant ice-rafted boulders and erratics, and huge gravel bars at Farragut State Park on the southern tip of Lake Pend Oreille, Idaho.

© BRUCE BJORNSTAD

6. Bowl and Pitcher
As floodwaters flowed west, they scoured and displaced an enormous amount of soil and material. Sand from the bed of Lake Pend Oreille once filled the Spokane River drainage. Visit the Bowl, a circular depression in the Spokane River likely caused by a kolk vortex similar to an underwater tornado, and Pitcher, a detached block of basalt, at Riverside State Park just outside of Spokane, Washington. From here floods waters rushed out across Washington State creating the Channeled Scabland.

NPS JUSTIN RADFORD

7. Dry Falls at Grand Coulee (NNL)
In eastern Washington, The Okanogan lobe of the Cordilleran ice sheet diverted the Columbia River south along the path of the Grand Coulee. During the floods, water hundreds of feet deep erroded the canyon upstream forming a huge waterfall. The recession of the waterfall's lip during each flood event carved a canyon 18 miles (29 km) upstream from the fall's original location at Soap Lake. A huge "dry waterfall" remains as an unmistakable clue of the floods' power. Four times larger than Niagara Falls, the Great Cataract Group around Dry Falls was 3.5 miles (5.6 km) wide and 400 feet (122 m) tall. Imagine the roar of the ancient falls from the Dry Falls Visitor Center viewpoint off Washington State Route 17 between Coulee City and Sun Lakes-Dry Falls State Park.



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8. Drumheller Channels (NNL)
As floodwaters from Grand Coulee emerged from Quincy Basin, they left behind "butte-and-basin scabland"—a landscape marked by hundreds of buttes surrounded by a network of braided channels. Known as the Drumheller Channels, they were the largest outlet of floodwaters from the Quincy Basin. Water, ice and debris eroded the topsoil and underlying basalt to create the channels, basins, potholes, and buttes. View this prime example of Ice Age Floods erosion at the Drumheller Channels National Natural Landmark (NNL) viewpoint 9.1 miles (14.6 km) northwest of Othello, Washington along McManamon Road.

© BRUCE BJORNSTAD

9. Palouse Falls
To the east of Drumheller Channels, another flood path showcases an active waterfall. Palouse Falls was created when floodwaters rerouted the ancestral Palouse River from flowing into the Columbia River and into its current course towards the Snake River. The Palouse River drops 200 feet (61 m) over a sheer cliff into a roiling bowl, then zigzags six miles (9.7 km) through the 300-foot (91 m) coulee cliffs of the Palouse River Canyon before flowing into the Snake River. View Palouse Falls from viewpoints at Palouse Falls State Park, 2.3 miles (3.7 km) east of Washington State Route 261.

NPS KATHERINE PERSON

10. Wallula Gap (NNL)
All floodwaters crossing the Channeled Scabland funneled through a narrow two-mile-wide (3.2 km) gap in the Horse Heaven Hills called Wallula Gap. Like the neck of an hourglass, Wallula Gap restricted the flow of floodwaters along the Columbia River. As water, ice, and debris hit this constriction floodwaters backed up creating an enormous temporary hydraulic pond 900 feet (274 m) deep temporarily flooding Pasco Basin and its tributaries. See Wallula Gap by driving south on eastbound US 12 from Pasco, Washington. After crossing the Snake River, look for the gap across the Horse Heaven Hills to the south.

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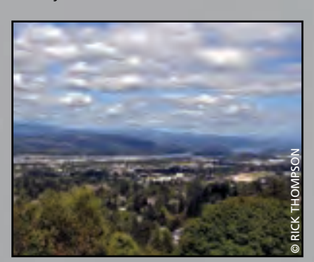
11. Columbia River Gorge - National Secnic Area
Past Wallula Gap, the Ice Age Floods overwhelmed the Columbia Gorge for 200 miles (322 km), creating alien-looking hoodoos and scablands, massive landslides, and giant gravel bars. As the churning, muddy waters rampaged, they stripped the river valley of rock and debris, dug pits, and tore massive basalt columns from the bedrock. A drive along Oregon's Interstate 84 between Wallula Gap and Crown Point Natural Natural Landmark:—or a more leisurely drive along Washington State Route 14 that parallels I-84 between Plymouth and Vancouver—highlights the aftermath of these cataclysmic floodwaters. Along I-84, the Vista House atop Crown Point provides a stunning panorama.

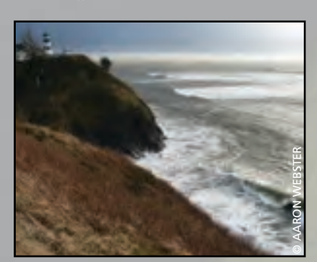
© KATHERINE PERSON

12. Lower Columbia
Each time Ice Age Floods surged beyond the confines of the Columbia Gorge, they covered the lowlands of current-day Portland, Oregon and Vancouver, Washington, as well as Oregon's Willamette and surrounding valleys, with flood waters up to 400 feet (122 m) deep. These temporary hydraulic ponds formed behind Kalama Gap, a constriction of the Columbia River where it flows through the Coast Range. Over 200 feet (61 m) of sediment were deposited and now underlie the fertile valley floor all along the flood paths from Portland to Eugene. Find panoramic views of the lower Columbia River—and nearby former volcanoes that would have been islands during the Ice Age Floods—from James Woodhill Park atop Portland's Rocky Butte.



© RICK THOMPSON

13. Astoria Fan
Glacial floodwaters continued along the path of the Columbia River eventually reaching the Pacific Ocean. However, when the Ice Age Floods reached the mouth of the Columbia River, sea level was about 300 feet (91 m) lower than it is today. The dense, sediment-laden floodwaters created powerful currents that cut deeper into the Astoria Submarine Canyon across the continental shelf. These currents deposited massive amounts of sediment hundreds of miles offshore across the Astoria Deep Sea Fan and as far south as the Cape Mendocino, California some 400 miles (644 km) away. Overlook the confluence of the Columbia River and the Pacific Ocean from Lewis and Clark Interpretive Center in Cape Disappointment State Park, Washington.



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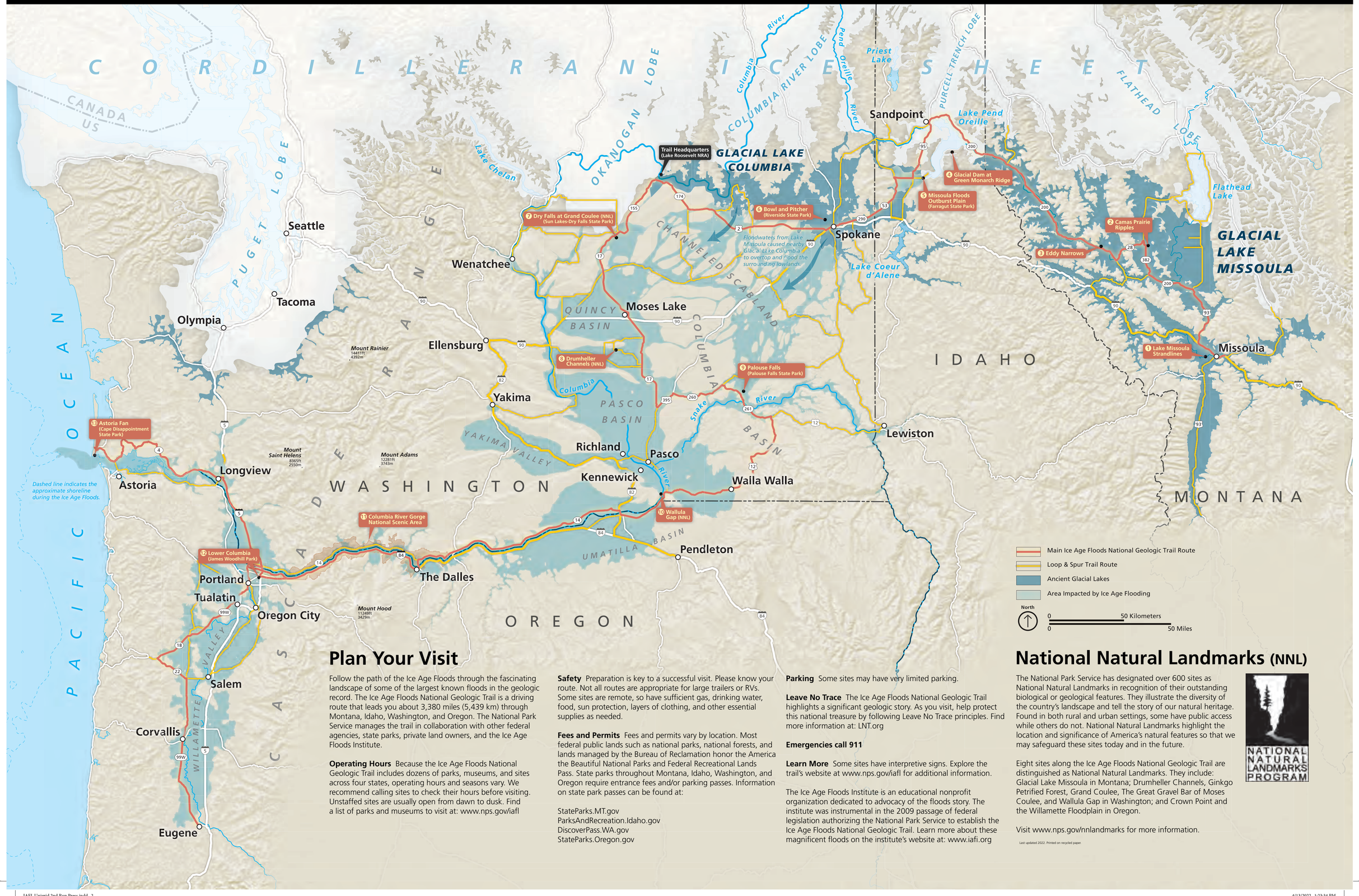
Exploring the Ice Age Floods



Plan Your Visit

Follow the path of the Ice Age Floods through the fascinating landscape of some of the largest known floods in the geologic record. The Ice Age Floods National Geologic Trail is a driving route that leads you about 3,380 miles (5,439 km) through Montana, Idaho, Washington, and Oregon. The National Park Service manages the trail in collaboration with other federal agencies, state parks, private land owners, and the Ice Age Floods Institute.

Operating Hours Because the Ice Age Floods National Geologic Trail includes dozens of parks, museums, and sites across four states, operating hours and seasons vary. We recommend calling sites to check their hours before visiting. Unstaffed sites are usually open from dawn to dusk. Find a list of parks and museums to visit at: www.nps.gov/iafl

Safety Preparation is key to a successful visit. Please know your route. Not all routes are appropriate for large trailers or RVs. Some sites are remote, so have sufficient gas, drinking water, food, sun protection, layers of clothing, and other essential supplies as needed.

Fees and Permits Fees and permits vary by location. Most federal public lands such as national parks, national forests, and lands managed by the Bureau of Reclamation honor the America the Beautiful National Parks and Federal Recreational Lands Pass. State parks throughout Montana, Idaho, Washington, and Oregon require entrance fees and/or parking passes. Information on state park passes can be found at:

StateParks.MT.gov
ParksAndRecreation.Idaho.gov
DiscoverPass.WA.gov
StateParks.Oregon.gov

Parking Some sites may have very limited parking.

Leave No Trace The Ice Age Floods National Geologic Trail highlights a significant geologic story. As you visit, help protect this national treasure by following Leave No Trace principles. Find more information at: LNT.org

Emergencies call 911

Learn More Some sites have interpretive signs. Explore the trail's website at www.nps.gov/iafl for additional information.

The Ice Age Floods Institute is an educational nonprofit organization dedicated to advocacy of the floods story. The institute was instrumental in the 2009 passage of federal legislation authorizing the National Park Service to establish the Ice Age Floods National Geologic Trail. Learn more about these magnificent floods on the institute's website at: www.iafi.org

National Natural Landmarks (NNL)

The National Park Service has designated over 600 sites as National Natural Landmarks in recognition of their outstanding biological or geological features. They illustrate the diversity of the country's landscape and tell the story of our natural heritage. Found in both rural and urban settings, some have public access while others do not. National Natural Landmarks highlight the location and significance of America's natural features so that we may safeguard these sites today and in the future.

Eight sites along the Ice Age Floods National Geologic Trail are distinguished as National Natural Landmarks. They include: Glacial Lake Missoula in Montana; Drumheller Channels, Ginkgo Petrified Forest, Grand Coulee, The Great Gravel Bar of Moses Coulee, and Wallula Gap in Washington; and Crown Point and the Willamette Floodplain in Oregon.

Visit www.nps.gov/nnlandmarks for more information.

NATIONAL NATURAL LANDMARKS PROGRAM

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