# Flooding and Aggradation

## The Flood of 2006

Why was the flood of November 6 and 7, 2006 so much more damaging than any other event in more than 100 years of park history? Part of it, of course, was scale: the 17.9 inches of rain recorded at Paradise in 36 hours exceeded all previous records. Snow levels during the storm stayed above 10,000 feet elevation, so very little of the precipitation fell as snow. Some existing snow above 7,000 feet melted, adding to the runoff in the rivers. But Mount Rainier's glaciers also contributed, indirectly, to the severity of flooding in the park.

## Glaciers

Mount Rainier is encircled by 25 named glaciers with a combined surface area of more than 30 square miles, the largest glacial system on a single mountain in the United States outside of Alaska. The glaciers form as snow accumulates high on the mountain, where temperatures are too cold even in the summer for all of the snow to melt before winter sets in again. Over the years, the accumulated snow packs down under its own weight, becoming denser and denser, until it becomes ice.

In many places, the slopes of this great volcano are steep enough that these massive ice fields begin to flow downhill under the force of gravity. They slide across the ground at their base, tearing and grinding rocks out of the mountain as they move, and they twist and deform under their own weight. Avalanches and erosion deposit more rocks on the surface of the glacier, and eventually, the glacier becomes a thick, frozen mixture of ice and rock.
As the glacier flows down the mountainside at—well—a glacier's pace, about 7 inches per day on average, it eventually reaches an elevation where temperatures are warm enough for it to melt. At this point, the glacier becomes a river, and a source of drinking water, irrigation, and hydroelectric power for natural and human communities downstream. Meanwhile, snow continues to fall near the top of the mountain, replenishing the glacier. When the glacier melts, of course, all of the rock embedded in it melts out of the ice and into the riverbed. The river gradually tumbles the rock downstream, carrying it toward the ocean. The river is constantly rearranging the rock in its bed: piling it up here, washing it away there, then piling it up in a new location and changing course around it, always seeking the easiest path through the debris. This is why glacial riverbeds are wide and rocky, with the river itself braided into constantly-changing channels and sub-channels somewhere down the middle.

## Aggradation

Recent research at Mount Rainier National Park has measured the rate at which the park's glacial riverbeds fill with rock, a process called "aggradation." In most places, the rate is around 3 feet per decade (based on 1997-2010 data)—not much, until you multiply this number by the more than 120 years that people have maintained permanent residences in places like Longmire. In addition, local topography and variations among Mount Rainier's glaciers mean that in some places the rivers aggrade more quickly.

In a wilderness environment, none of this would matter much. As the riverbed aggrades, the river would simply choose another course, perhaps on the other side of the valley. Today, however, there are roads and campgrounds and buildings on the other side of the valley–structures which do not change in elevation, even as the riverbed rises. To protect the park's facilities, dikes and levees have been built over the years to keep the rivers in convenient channels. Over time, the levees have to be built higher and higher to keep them there. Today, locations throughout the park are in danger of being flooded by glacial rivers. Tahoma Creek, along the Westside Road, and the Carbon River have changed course aggressively over the years. The White River now runs 14 feet above adjacent Highway 410 for two miles. Parts of Longmire are 29 feet below the current elevation of the Nisqually River. The Nisqually River is now nearly level with the park road in several places, including, infamously, the former Sunshine Point Campground.

## Global Climate Change

The process of aggradation seems to be accelerating. One likely reason is that Mount Rainier's glaciers are melting faster than they are reforming—a symptom of the trend toward warmer temperatures locally over the past century. Glaciers like the Nisqually, which loomed over the park road less than a hundred years ago, have now melted almost out of sight around a bend in the canyon. As the glaciers melt, they release into the riverbed the huge volumes of rock formerly locked in the ice. Massive piles of rock called moraines, normally trapped between the glacier and the walls of the canyon, also begin to erode into the river. The volume of rock available for the rivers to carry increases; a major flood can cause several decades worth of normal aggradation to occur overnight. The riverbed where Tahoma Creek flows under the Nisqually Road rose more than four feet during the November 2006 flood, leaving the bottom of the road bridge just five feet above the river.

Many scientists believe that the melting of Mount Rainier's glaciers fits a pattern of melting glaciers and other weather phenomena worldwide—a pattern known as "global climate change." Most scientists now believe that pollutants released into the air by humans, especially carbon dioxide, have significantly contributed to climate change.

## Looking Ahead

Whatever the cause, the implications are clear: as Mount Rainier's rivers continue to aggrade, it will become harder and harder to keep them from flooding adjacent roads and facilities. The park will rely more and more on larger and stronger dikes, levees, engineered log jams, and other flood control structures to separate the rivers from the roads. In the long term, park managers will have to consider how much effort is warranted to protect vulnerable facilities. Some roads may be closed permanently, or only repaired well enough to be passable until the next flood. Some structures may be relocated to places less prone to flooding, or perhaps removed from the park entirely.

These management questions have become critical at places like the former Sunshine Point Campground, the Westside Road, and the Carbon River Road. Planning efforts will carefully consider the likelihood that these places will flood again, maybe in the near future. This may pose significant changes in how we access and develop certain areas of the park, and may require the repurposing of roads and other facilities into infrastructure more appropriate for the floodplains on which they're built. In the long term, park managers will have to find ways of living alongside the powerful forces of nature that continue to reshape this landscape.

Due to aggradation, Kautz Creek now flows off of its previous channel and into the surrounding forest.

Damage to the Emergency Operations Center and protective levee at Longmire during the 2006 flood.