Muddy, brown water funnels through two walls of rock at least a mile high. Floating in the middle of the river is what from some distance might appear to be a small dingy, bright yellow and packed with people. The boat in the river is, in fact, not a small dingy but a large 18-foot vessel. Its apparent minuteness is an optical illusion created by the sheer size of the river and the enormity of the rock walls extending ever upwards.

The people in the boat hang on for dear life as their boat is thrust upwards at an angle that seems impossible. The water in the river explodes around them. These people are experiencing a truly once-in-a-lifetime moment as they descend down some of the most infamous rapids in the U.S. – the rapids of the Colorado River through the Grand Canyon.

Rich Pauloo, a graduate student in the Hydrology Graduate Group at UC Davis and whitewater enthusiast, set this scene Wednesday, March 1, in his lecture to the Ecogeomorphology class.

More than simply a thrill for rafters, rapids provide aeration to rivers and habitat for species, Pauloo explained. Rapids are geomorphological features, or physical features on the Earth's surface. They form from the interaction of the rivers with the underlying geology of the river. Understanding how these rapids form is crucial to conservation of unique river habitat.

Rapids are the exciting part of the river, the segments between long flat stretches of river in which elevation drops rapidly, creating their iconic whitewater. As anybody who has ever been in one of the big inflatable boats cascading down a river knows, when the elevation plummets, the velocity and turbulence increase. Not only does this make the river exciting for rafters, but rapids are important to creating healthy river ecology.

Rapids allow for oxygenation of the river environment, keeping waters healthy and breathable for the fish and other animals that call the river home. Rapids are also a major tourist draw, and thus understanding how they form and function is crucial to protecting these vital habitats and exciting riverine features.

In most rivers, rapids form as river bedrock of different hardness erodes at different rates. Soft bedrock erodes more quickly than the hard bedrock, and so when the underlying geology transitions from hard to soft drops in elevation often form. However, not all rapids are created equal.

As Pauloo detailed, rapids in the Colorado River as it flows through the Grand Canyon are unique among rapids. Instead of forming simply from differences in the erodibility of river bedrock, "rapids in the Grand Canyon are formed by debris flow from side canyon tributaries," Pauloo said. The main tributaries dumping rapid-forming debris into the Grand Canyon are the Paria, the Kabab, and the Little Colorado River. Of these, the Little Colorado is most important.

According to Pauloo, "Side canyon tributaries that exhibit higher flow rates compared to the main Colorado river are responsible for mobilizing large debris flow into the main

channel." Because tributaries have narrower channels draining large areas of land, flows are fast and powerful. These intense flows pick up large rock debris and carry it onwards to the main channel of the Colorado.

Where does all of this debris come from? The debris that forms the infamous rapids of the Grand Canyon owes its origins to seismic activity in the region. When bedrock is split by a fault, new material is exposed to erosion by the river water. Rock is then carried downriver, and rapids ensue. As Pauloo explained, the debris deposits "constrict the channel and form rapids." Instead of a change in elevation driving the increase in velocity, it is the narrowing of the channel by the influx of debris.

Rapids are dynamic features, and as such, human activity on the Colorado River has had a big impact. The most obvious human impact on rapids of the Grand Canyon is the Glen Canyon Dam – a massive structure erected between 1956 and 1966 that blocks some of the water of the Colorado River from entering the Grand Canyon.

By reducing water flows into the Canyon, differences in elevation become more pronounced. Robert Dolan, a noted geomorphologist who studied the Grand Canyon extensively from the 1960s through the '80s, studied the impact of the Glen Canyon Dam. In Dolan's 1981 report on the Canyon, he expressed concern that the reduction in river flow caused by the dam would increase the gradient of the rapids to a point that the Canyon would become too dangerous to raft. Luckily, the river remains open for rafting.

Although Pauloo's primary area of research is groundwater management, his passion for whitewater rafting and scientific curiosity drove him to learn more about the rapids of the Grand Canyon. Pauloo explained his investigation of rapid formation saying, "Rapids are exciting, and just like anything in the physical world, they originate in some way. I was curious to understand how they came to be."