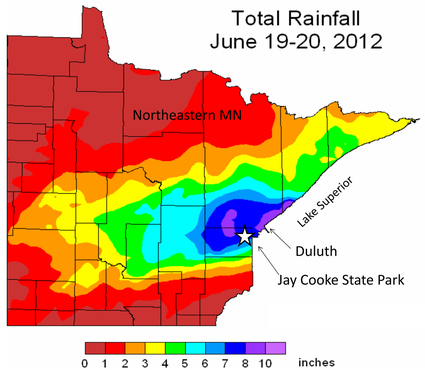
# Seize the day: What to do when a 500-year flood strikes in your backyard

**Karen Gran[1], Kristin Riker-Coleman[2], Kristine Hiller[3]**
[1]Department of Geological Sciences, University of Minnesota Duluth, E-mail: kgran@d.umn.edu
[2]Department of Science, University of Wisconsin-Superior
[3]Minnesota Department of Natural Resources, Jay Cooke State Park

## Abstract

The Duluth, MN, area experienced massive flash flooding following 8-10 inches of rain in 24 hours in June 2012, causing extensive damage at Jay Cooke State Park. One affected site involved a levee breach on Forbay Lake, releasing a flood wave downslope, carving a deep valley and destroying part of Highway 210. Although devastating for the park, the event provided opportunities for student research and outreach. Students from two classes at the University of Minnesota Duluth (UMD) conducted research in October 2012 to reconstruct magnitude and timing of the flood wave, impoundment behind the road, breaching of the road, and subsequent incision. Students from a mid-level geomorphology course first visited the site during a 4-hour lab to qualitatively reconstruct major events. Over the next week, small groups developed research questions and wrote proposals focused on mapping and quantitative analyses at the site. They had one additional lab to collect field data and a third lab dedicated to data analysis. Student projects focused on delineating the flood wave's lateral extent; determining peak shear stress and its effect on sediment mobility; estimating volumes of material eroded from the levee and deposited in the temporary impoundment; and tracking knickpoint propagation. Graduate students in a fluvial geomorphology course also developed independent research projects. These were completed outside normal lab time and were able to address more complex issues including paleoflood discharge, levee geotechnical stability, and detailed long profile development. In both cases, students spent significant time outside of class working on projects, but collectively, they were able to extensively document what happened during the flood event at this site. Research projects were written up in scientific paper format and presented to an audience including staff from Jay Cooke State Park and students from the University of Wisconsin Superior (UWS). To explain this dramatic event to park visitors, science education students from UWS are taking data collected by UMD students and developing education materials. This collaboration between UMD, UWS, and the Minnesota Department of Natural Resources has provided research and public outreach opportunities for students that will eventually help educate the general public.

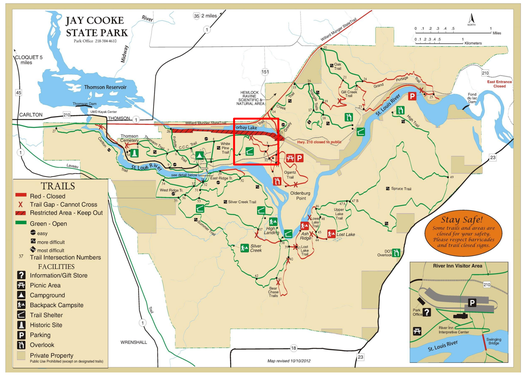
## The June 2012 Flood





*Following the flood, Lake Superior turned red with clay, remaining off-color until it over-turned in early August.*

*Duluth harbor – red with clay from flood. (It's usually blue!)*




*Jay Cooke State Park suffered greatly in the flood and was closed the rest of the summer. This map was created in Fall 2012, when portions of the park reopened to visitors. Our site is shown in the red box.*

## Student Workflow

1. One field lab (2-3 hours of field time) to determine chronology of what happened here.
2. Research proposal due one week later to address some aspect of the event (organized collectively to be non-overlapping)
3. One field lab as a class collecting data in independent groups
4. Several weeks of independent work, followed by half of a lab period in the computer lab to assist with data analysis (esp. GIS)

## Synthesis and Presentation

5. Group research presentations (12-15 minutes) were given to class, UWS students, and Park naturalists
6. Each group wrote a research paper in scientific paper format
7. All materials were given to UWS students and Jay Cooke State Park naturalists
8. Key results have been shared with park visitors
9. UWS student is now preparing outreach materials
10. UMD student is now synthesizing and extending research

## What happened?

**(A)** On June 20, 2012, a levee breached on Forbay Lake, during a 500-year flood event. Forbay Lake is a diversion canal used by Minnesota Power to send water to a hydropower plant to the east.



*Levee breach as viewed from above (top) and from the ground (left). The failure occurred rapidly, sending a wave of water and sediment downslope.*

**(B)** The levee breach caused widespread scour, scarring on trees, and deposition of levee material across a wide area.

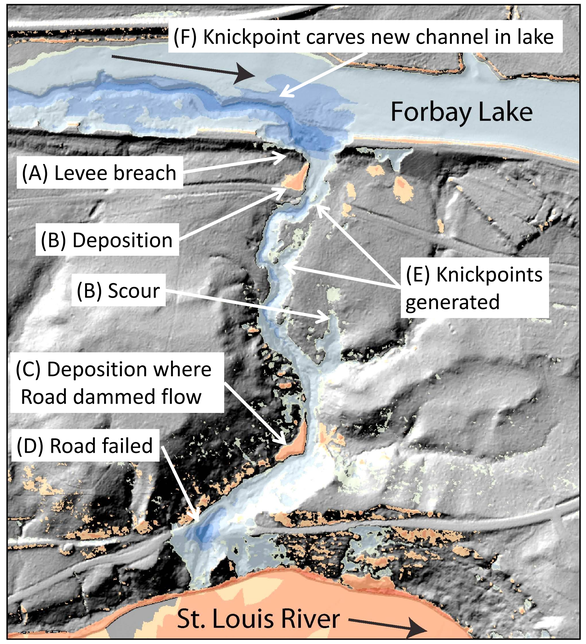


**(C)** Downstream, water backed up behind a road, leading to deposition of sediment.

**(D)** Eventually, the road failed, and the river scoured down through the deposits and into underlying glacial tills.

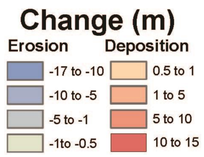

**(E)** Knickpoints initiated in the flood moved upstream, excavating a deep, narrow valley.

**(F)** Meanwhile, a knickpoint generated at the levee breach site itself moved upstream over 500 m, carving a new channel up to 5.5 m deep.



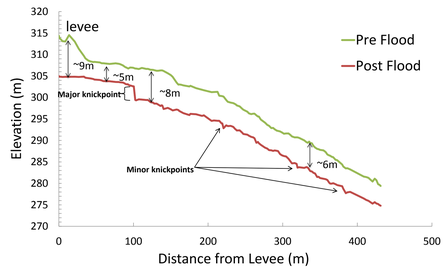

*Hillshade of Forbay Lake breach at Jay Cooke State Park, MN. Overlain on the hillshade are data from repeat aerial lidar showing the difference pre- and post-flood. Lidar data were flown in spring 2011 and November 2012.*

*Multiple knickpoints migrated rapidly upstream, incising through glacial tills.*




## Examples of student research projects

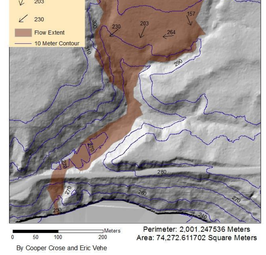
(1) Students surveyed the long profile of the channel downstream from the levee breach with a total station and compared the long profile to a pre-flood profile using lidar data from Spring 2011.




*Long profile of incised channel downstream of the levee, compared with pre-flood lidar elevation data, by Grant Neitzel.*

(2) Students used a GPS to mark the edges of the lake impounded behind the road, and estimated the volume of water held there temporarily. An extension of this was to determine potential discharge rates when the road failed.

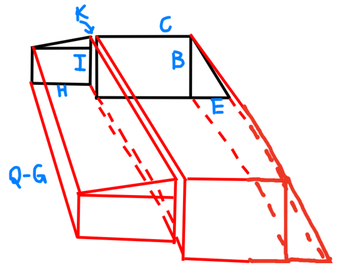
*Map of impoundment created behind road, by Michael Harris.*




(3) Students mapped the extent of the flood wave with a handheld GPS. They used debris caught in trees as flow directional markers to capture the dynamics of the flow.

(4) Students used a laser rangefinder to map out the size of the missing levee material and compared that to the volume of material trapped in downstream deposits.

*Photo of Derek Rode, using laser rangefinder.*




*Schematic of levee geometry, used to calculate volume eroded, by Derek Rode, Kaitlin Johnson, and Jacob Kolke.*

## Challenges & Lessons learned

1. This was a great way to both document a large flood event and get students involved in research at the level of an undergraduate course.
2. Students got a range of experiences: crafting a research question, collecting field data, analyzing data, often plotting them up in GIS, and presenting the findings orally and in writing.
3. Many students shared datasets, allowing them to go more in-depth on their own topic. This synergy was valuable.
4. Topics needed to be distributed across the class to both ensure that we covered the event properly and everyone had an appropriately-sized project. We also had to ensure that everyone had access to the equipment they needed, with limited quantities of the "nicer" field equipment.
5. Logistics (and weather!) can be challenging. After our first visit, students had just one week to form groups, pick a topic, write a proposal, AND get feedback from the instructor. (Meanwhile, the instructor had to pull this together at the last minute, dropping several other labs in favor of more time for this project.)
6. It was worth it!

## Many thanks...

to Jay Cooke State Park, for allowing us access to the site many times, to the students in UMD's Geology 3210 and Geology 5260 who did an amazing job collecting, analyzing, and presenting their data, and to independent research students (Jacob Kolke, Emily Scheller) who are currently carrying this project forward.