Understanding the Geologic Background for the September, 2008 Flooding Event that Led to the Temporary Closure of IU Northwest

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Figure 1. Flooding of the main parking lot on the north side of campus. (Photo by E.P. Argyilan)

The campus of Indiana University Northwest (IUN) in Gary, Indiana was closed for two weeks (September 15-28, 2008) due to extreme flooding. Flood waters submerged the IUN parking lot spreading over the campus, causing minor water damage to several of the other buildings and ultimately forcing the closure of Tamarack Hall.

Flooding in northwest Indiana led to extensive damage and evacuations in the towns of Gary, Munster, and Hammond as well as other areas of northwest Indiana. In the end the Federal Emergency Management Authority (FEMA) approved Lake, Porter, and LaPorte counties for financial assistance.

But why was the flooding so severe at IUN and northwest Indiana and why did it take so long for the waters to recede?

Ultimately this "natural" disaster was caused by a combination of extreme weather, the location of these areas within the floodplain of the Little Calumet River, and human modifications to the hydrology of the Little Calumet River and its floodplain.

Northwest Indiana experienced an *extreme* rain event.

The rainfall that affected northwest Indiana from September 12-15 is considered part of a historical rainfall event, according to data from the National Weather Service (NWS) and the Midwest Regional Climate Center (MRCC), divisions of the National Oceanic and Atmospheric Administration (NOAA). Two important weather conditions combined to create this extreme rainfall event. First, a nearly stationary cold front positioned in northern Illinois on Friday and Saturday produced considerable rainfall amounts on already saturated soils. Second, additional rainfall on Sunday occurred as the remnants of Hurricane Ike penetrated the Midwest region.

When studying an individual rain event two things are important (1) *how much* rain fell (rainfall amount) and (2) *how fast* did the rain fall (rainfall intensity). The September 12-15 rainfall can be considered extreme in terms of both the amount and intensity of the total precipitation that occurred.

According to the Indiana State Climate Office the average total rainfall for the month of September is 3.12 inches. Three-day total rainfall amounts in northwest Indiana for September 12-15 were between 8-13 inches with a maximum a reported rainfall of 13.06 inches in LaPorte. The high amount of rain combined with the rainfall intensity caused flooded roads, raised the waters of the Little Calumet River above flood stage, and overwhelmed municipal sewer system. Simply stated, the amount of rainfall and the intensity with which it fell overwhelmed both the municipal sewer system and the natural drainage processes of the Little Calumet River.

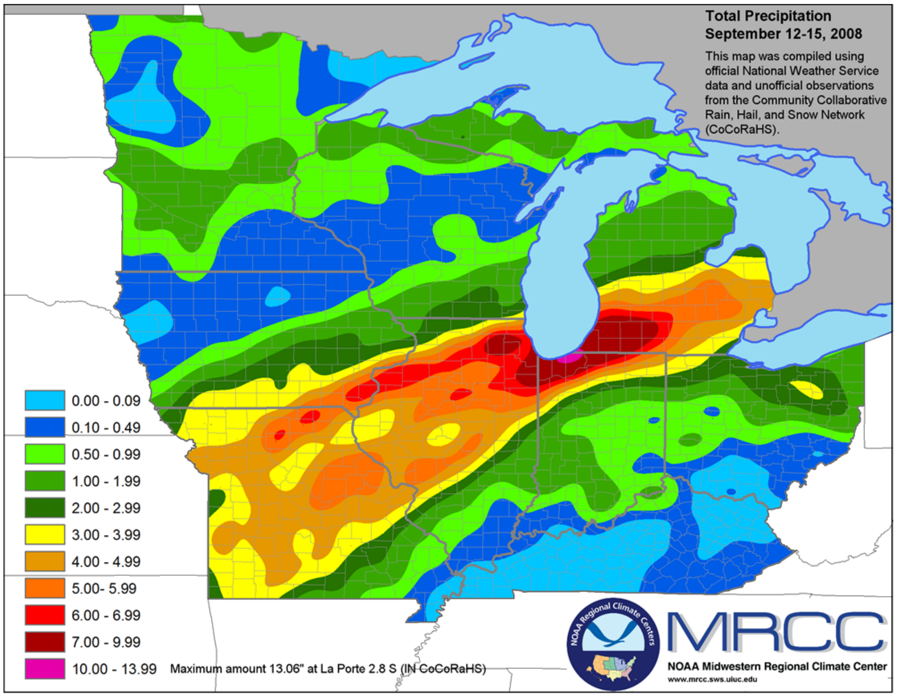

Figure 2. Map of 3-day total precipitation affecting the upper Midwest on September 12-15, 2008. Source: The Midwestern Regional Climate Center (www.sws.uiuc.edu/atmos/statecli/Events/September2008/ike-mrcc-big.png)

IUN is built within the natural floodplain of the Little Calumet River.

The Little Calumet and Grand Calumet River systems are low gradient, meandering river systems that formed during the past approximately 4000 years during the evolution of the southern Lake Michigan shoreline. In a natural system, these types of rivers typically overflow the banks of the channel and flood the surrounding, low-lying areas in response to high rainfall or snowmelt. The low-lying areas that border the rivers are called floodplains and are actually created by the movement of the channel through time and by flooding events. While floodplains are created by flooding, they also function as natural flood control, allowing water to spread out laterally when there is too much water for the river channel to hold.

The landscape of northwest Indiana that includes the towns of Gary and Munster are built on beach sand that was deposited as the shoreline built or prograded northward during the past approximately 4000 years. In the Lake Michigan basin, sand is generated from erosion of beaches and bluffs along the shores of Michigan and Wisconsin. Longshore drift transports sediment from the north to the southern portion of Lake Michigan where it is deposited as beach ridges and dunes. This coastal process of sediment erosion-transport-and deposition created the majestic dunes and environment of the National Lakeshore and Indiana Dunes State Park.

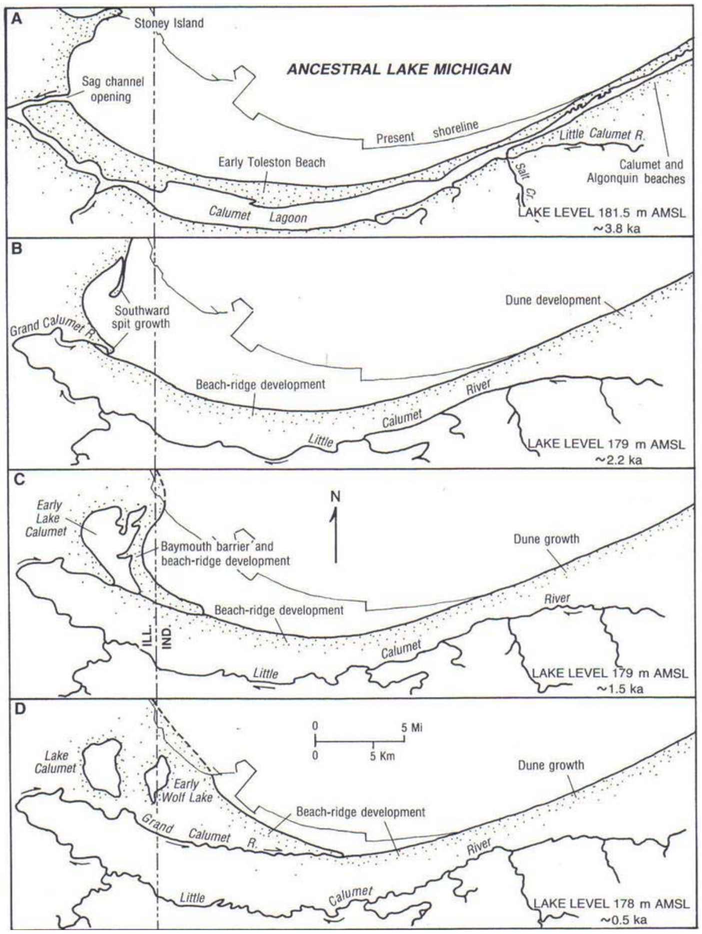

Figure 3. Paleogeographic reconstruction of the shoreline progradation of the Toleston Beach since about 3,800 years ago and the corresponding changes in drainage patterns along the Little and Grand Calumet Rivers.
(From Chrzastowski and Thompson, 1992)

The Little Calumet River formed in what was formerly a low-lying area occupied by the Calumet Lagoon. A topographic map shows that there is less than 10 feet of elevation change between the Little Calumet and the campus of IUN. The channel of the Little Calumet River, as we know it today, formed as sand and mud infilled the Calumet Lagoon. Hence, the ground directly under IUN is composed primarily of unconsolidated sand. Sand is highly permeable allowing water to move through it easily both *laterally* and *vertically*.

In a river like the Little Calumet, even after a heavy rainfall the additional water is not simply carried off downstream. Instead under heavy rainfall or snowmelt conditions the waters of the Little Calumet will rise and overflow the channel, flowing laterally over the flat-lying areas or the floodplain that surrounds it. Basically, IUN is built on land that Mother Nature intended for flood control.

Water levels in the Little Calumet River set a historical high.

During the rain event of September 12-15, 2008 the Little Calumet set a record high water level. The USGS maintains stream-gauges that report real-time hydrologic data (www.usgs.water.gov). The height of the water level within the channel is reported in units of feet. The USGS stream gauge on the Little Calumet located in Munster, Indiana designates flood categories as follows:

Major flood stage	**– 17.0 ft**
Moderate flood stage	**– 14.0 ft**
Flood stage	**– 12.0 ft**
Action stage	**– 11.5 ft**

Minor overbank flooding immediately adjacent to the river begins at 12.0 feet. Flooding begins to affect some residences near the river at 15.0 feet. On September 14, 2008 the stream gage on the Little Calumet River at Munster recorded a historical high water level of 17.31 feet!

Top 10 Historical Crests

(1) 17.31 ft on 09/14/2008
(2) 17.03 ft on 11/28/1990
(3) 16.40 ft on 06/14/1981
(4) 16.20 ft on 07/19/1996
(5) 16.03 ft on 12/04/1982
(6) 15.68 ft on 02/22/1997
(7) 15.66 ft on 06/02/1989
(8) 15.35 ft on 05/13/2002
(9) 14.88 ft on 08/25/2007
(10) 14.43 ft on 12/25/1965

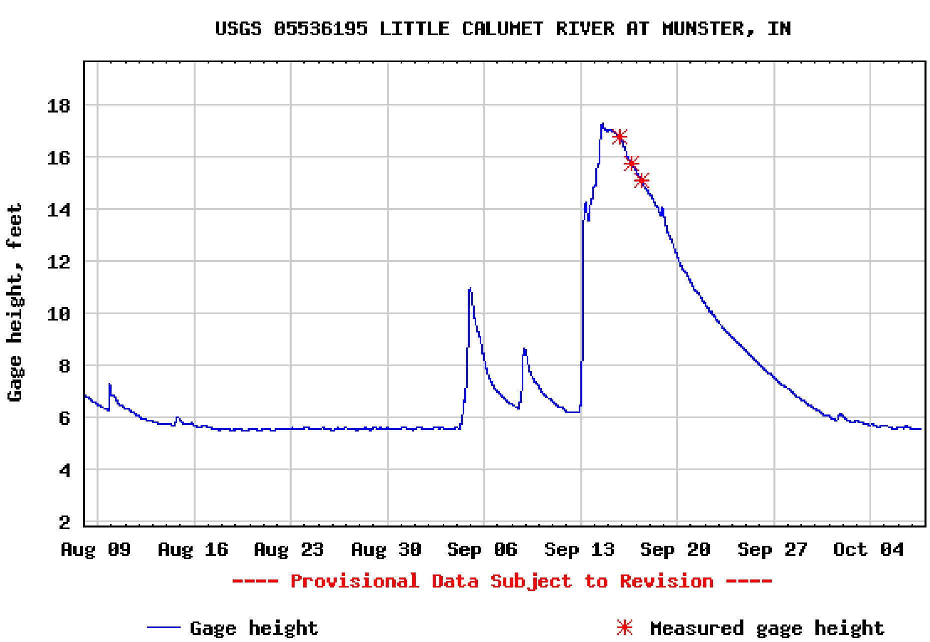

Figure 4. Hydrograph for the Little Calumet River at Munster, Indiana for August 30 to September 29, 2008. Source. http://water.usgs.gov

The levees are designed to control the flooding of areas around the Little Calumet River.

It may seem strange that towns and cities are built within floodplains. Levees are built along river channels to help control flooding in response to increased water supply that can occur due to rainfall or seasonal snowmelt. Humans have designed levees to help keep water *within* the river's channel and out of the floodplain. Levees are vertical structures, like walls, that function to allow the water in a river to rise higher within the channel rather than spilling laterally and flooding the nearby low-lying areas. The channel of the Little Calumet River has been modified by constructing levees along one or both its banks. In response to the extreme rainfall, the water in the Little Calumet filled the channel and rose to the level of Broadway. Without the levees water from the Little Calumet would have caused even greater flooding of the IUN campus.

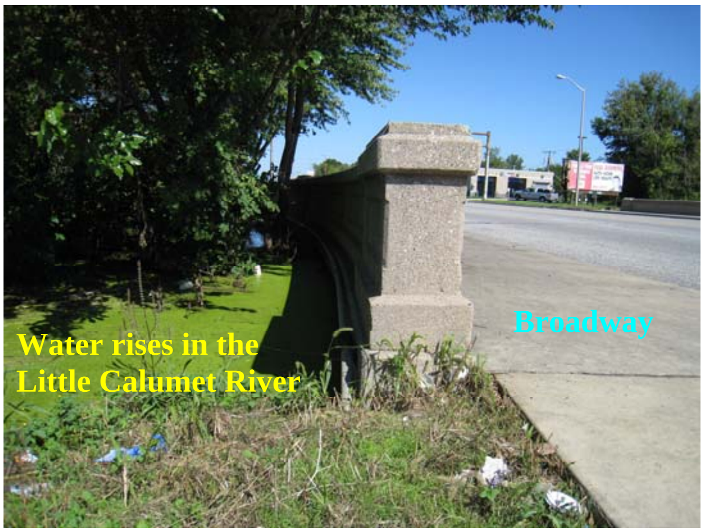

Figure 5. Water level in the Little Calumet River rose to the level of Broadway. Photo by E.P.Argyilan

But just as waters rose in the Little Calumet River, water also rose up in to the parking lot. A look in the USGS monitoring well adjacent to the parking lot will show that throughout the year the water table remains within inches of the level of the parking lot. With a rain event, infiltrating water causes the water table in the ground to rise causing flooding of the parking lot. During the September event, the excess water could not infiltrate the already saturated soils. At the same time, with water levels so high in the Little Calumet River, the storm and sanitary water system could not drain the water but actually backed up through the manholes.

Figure 6. As water level rose within the levees of the Little Calumet River the water table also rose and caused ponding south of the levee system Broadway. Photo by E.P.Argyilan

How do human modifications affect the natural hydrology of the Little Calumet River and its floodplain?

The natural system of the Little Calumet River was heavily modified by the construction of the levee system by the U.S. Army Corp of Engineers. But human activities like building roads, structures, and even parking lots also change the way that water naturally infiltrates in to the ground during a rainfall event and how it recedes after flooding has occurred. Urbanization of the landscape typically decreases the infiltration capacity of the ground and precipitation rushes more quickly over the landscape as runoff, overwhelming roads and sewers, further increasing the severity of a flooding event. During the September event, the parking lot of IUN flooded with approximately a foot of water! In this case the flooding occurred primarily as a result of the fact that the parking lot is built on land that is only a few inches above the natural water table. Once flooding occurs, the impermeability of the pavement prevents the infiltration of standing water in to the soil and drainage through the already overwhelmed sewer systems can be slow. Ultimately the campus was forced to wait until the water level went down in the Little Calumet and water could be mechanically pumped from the IUN campus, back in to the channel of the river.

Summary

This paper was designed to explain the geologic and climatic factors that contributed to the flooding of IUN. The IUN parking lot is especially prone to frequent flooding because it is positioned near the level of the water table. The primary reason for the widespread flooding of the IUN campus is its location in a low-lying portion of the floodplain and a historical rainfall event. Other factors such as sewer and stormwater discharges from surrounding municipalities, the blockage of culverts by debris, and old sewer and stormwater systems also contributed to flooding in parts of northwest Indiana and infrastructure improvements must be considered. IUN survived a historical climatic event. But beware; climate change predictions forecast an increase in the occurrence of extreme rainfall events in the future.

Primary References:

Illinois State Climatologist Office: http://www.sws.uiuc.edu/atmos/statecli/index.htm

Midwest Regional Climate Center (MRCC). http://mcc.sws.uiuc.edu/

National Weather Service. http://www.nws.noaa.gov

U.S. Geological Survey (USGS): http://water.usgs.gov/in/nwis/rt. USGS stream gage 05536195 – Little Calumet River at Munster.