Land Use Change and Sediment Transport in the Jordan River Watershed

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Hydrologic Data and Analysis

One of the overall objectives of the project is to understand the mechanisms for change in sediment flux in the Jordan River; both over the last 150 years and into the future. In order to address this question, we will implement the Integrated Landscape Hydrology Model (ILHM). This model allows us to quantify river discharge and sediment transport for different land use, climatic, and meteorological conditions. The first step in this process is to build and validate a groundwater model. In the past year we have constructed a groundwater model using the USGS package MODFLOW and we have measured flow characteristics in the watershed.

In three key stretches of the Jordan River and Deer Creek we have installed stream gages that measure the stage (water level) of the river at 15-minute time intervals (Figure 1). These instruments provide information in addition to the USGS gage at Webster Bridge. In order to interpret these stage data in terms of discharge, we have collected streamflow measurements during conditions of low and peak flow in the river. Discharge diagrams of the Jordan River and Deer Creek (Figure 2) illustrate the unique nature of the Jordan River. Peak flows, which develop during large rainfall events, show a quick return to baseflow following these events. In contrast Deer Creek peak flows are more dispersed, which is a result of the presence of wetlands and a lake in the Deer Creek watershed. Over the coming year we will collect more streamflow data to improve our stage-discharge relationships.

Cross sections through the Jordan River show an increase in depth and width for the upstream section of the river (Figure 3a); downstream of Webster Bridge the channel does not vary significantly in shape. Small changes in channel morphology over time indicate that (possibly seasonal) erosion of sediment does take place (Figure 3b).

Preliminary analysis of the MODFLOW model results show a good correlation between water levels observed in ground water wells and those simulated using the model. Over the coming year we will incorporate the MODFLOW model into ILHM. The use of NEXRAD precipitation data in ILHM and improved stage discharge relationships will improve the quality of stream flow predictions.

Analysis of Delta Area

Aerial photos dating back to 1950’s show the dynamic nature of the delta area. During periods with low levels of Lake Michigan and Lake Charlevoix, the sediments in the delta are subaerially exposed (as they are currently), with narrow channels dissecting the area. Conversely, during periods with high lake levels the delta area is entirely inundated. During the last 60 years, at least three transitions from inundated to subaerially exposed (and back) have occurred (Figure 4).

Several records suggest that prior to the dredging of Pine River in the late 1800’s the level of Lake Charlevoix was around 4 feet higher than Lake Michigan, which at that time had higher lake levels than today. The level of Lake Charlevoix is assumed to have been nearly constant before the dredging, which implies that the delta area was always below water level and that a paleodelta was located further upstream than anticipated. Further work, including detailed surveying, is needed to identify the address this point.

Initial characterization of the delta area using ground penetrating radar (GPR) presents different typical radar facies. Lake bottom sediments result in continuous horizontal reflections, while deposits associated with the Jordan River and delta deposition result in channel-like features and dipping reflections. The records show several channel features, some of which are located in places that match paleochannels that can be recognized in old aerial photographs (Figure 5). In several survey lines, in particular in the northern part of the delta, dipping reflections are seen. These reflections correspond to areas with sandy deposits and are underlain by clay- and organic-rich lake bottom deposits. Future work will include vibrocore drilling to obtain samples for age-dating the sand and organic material. A possible marine seismic survey will be undertaken to characterize the lake bottom material (which may include sandy delta deposits) in the south arm of Lake Charlevoix.

Key Findings and Future Work

The first phase of the project has resulted in several key findings. Our future research will build on these preliminary conclusions:

- The stream-gages installed in several stretches of the Jordan River show a unique hydrograph, which reflects the coarse-grained nature of the subsurface sediments and the fact that the area of the ground-watershed is much larger than the surface-watershed. Initial tests with our hydrologic model show that we can accurately simulate groundwater levels and stream flows.
- Aerial photography show that recent lake level variations have resulted in several rapid episodic changes in the morphology of the delta area. This suggests that most of what is now 'the delta' was inundated prior to the dredging of Pine River.
- Sandy sediment transported by the Jordan River has been deposited in the delta area. GPR and drilling records show that the area of deposition is limited to the northern part of the delta. The majority of the delta is lake bottom or swamp that has been exposed during the lake level drop in the late 1800's.

- Future work with respect to the characterization of the Jordan River discharge will include coupling of the MODFLOW model with ILHM and development of a sediment transport module for the Jordan River.
- Future work in the delta area will include age-dating the deposits in the delta, characterizing the South Arm of Lake Charlevoix, and further analysis of the effects of lake level variation.

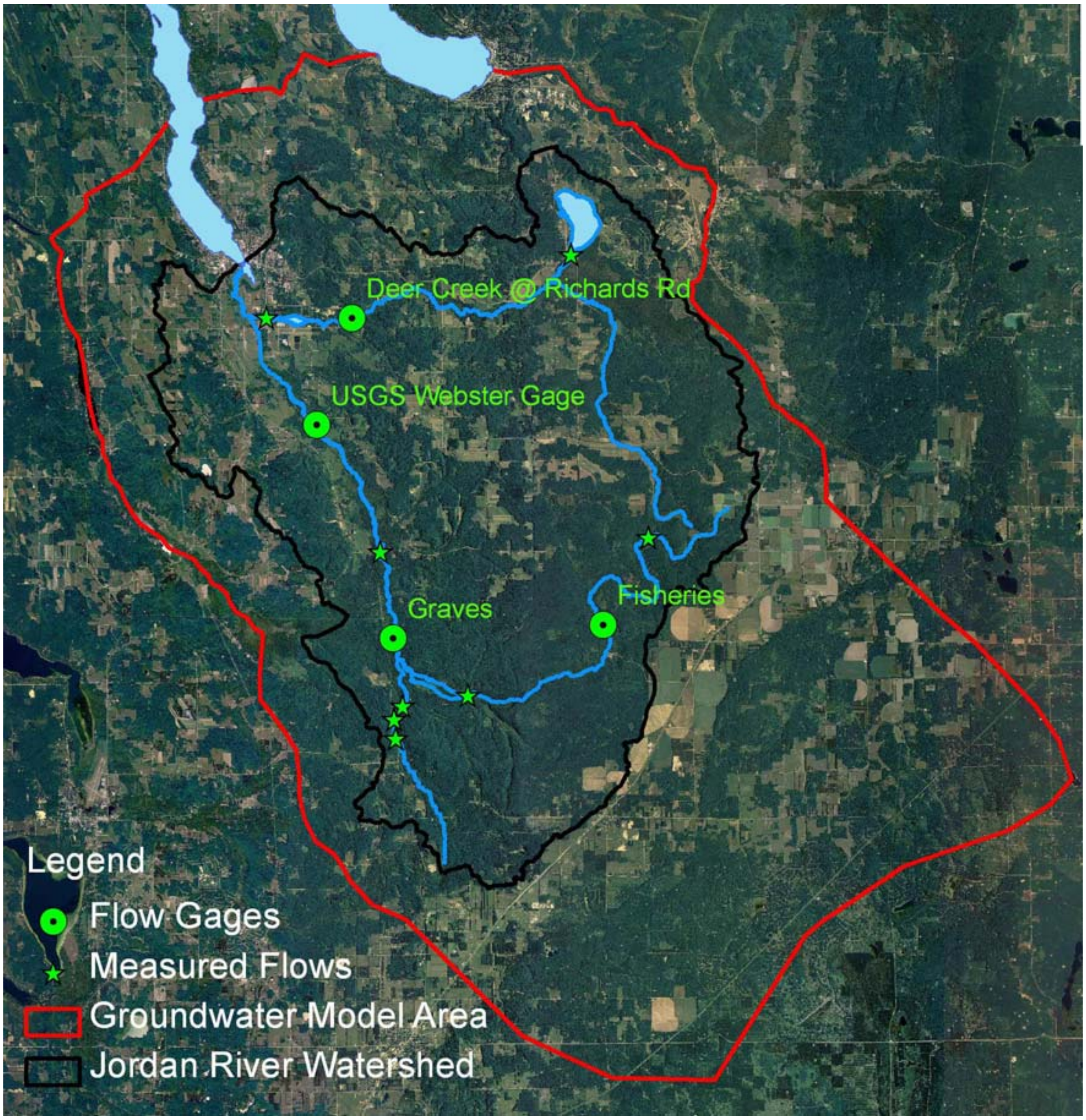

Figure 1. Overview of Jordan River watershed with locations of installed flow gages and seepage runs; at all these locations cross sectional geometry and discharge has been measured.

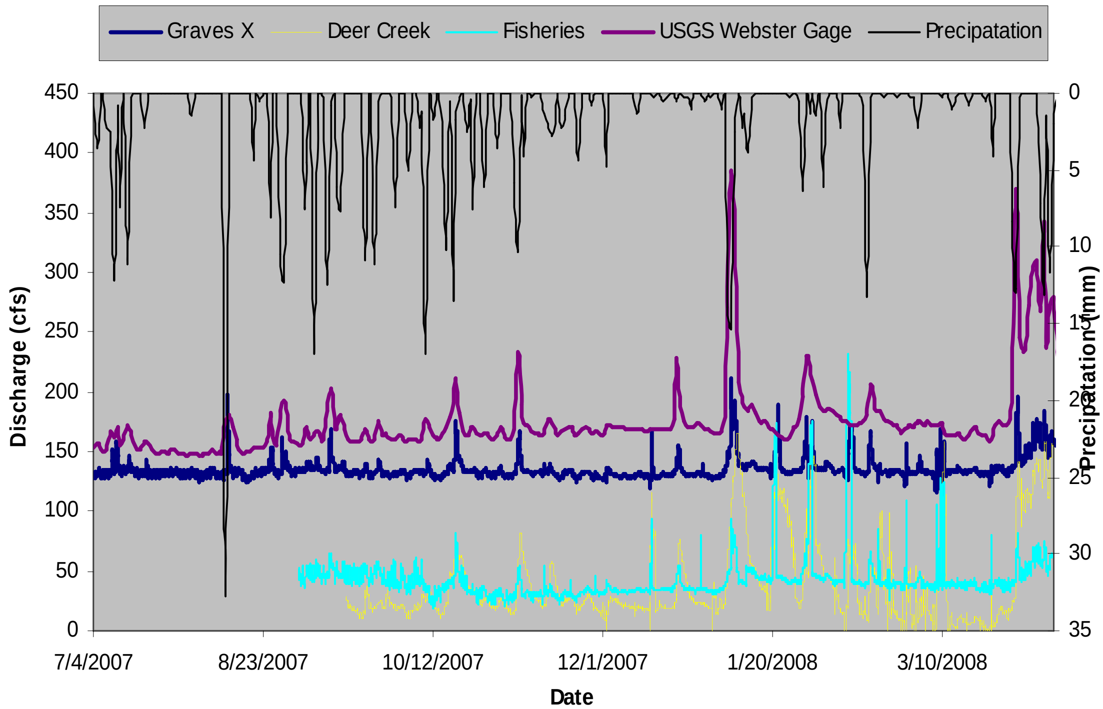

Figure 2. Discharge for 3 locations in the Jordan River and one in Deer Creek. Precipitation data was obtained from MAWN rain gage at Torch Lake.

a) b)

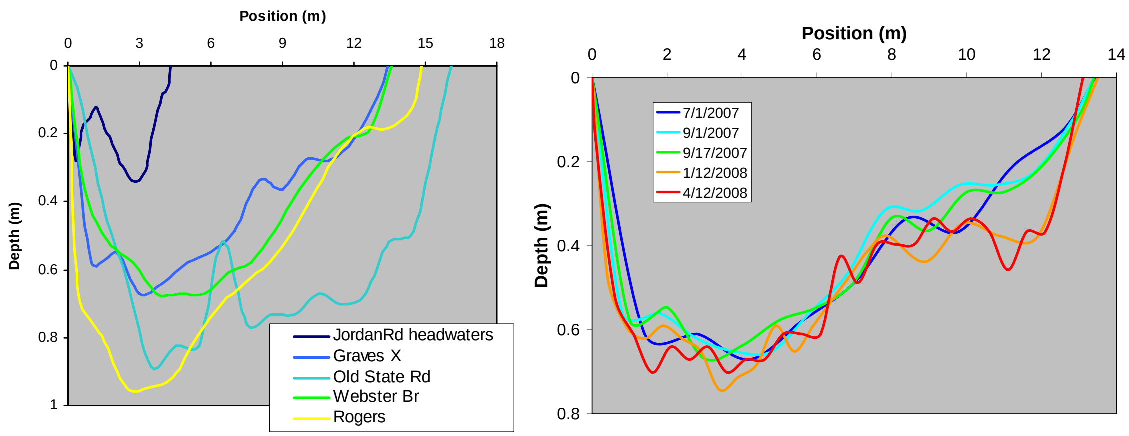

Figure 3. a) Jordan River channel cross sections at five different locations. b) Temporal changes in the channel morphology at Graves Crossing.

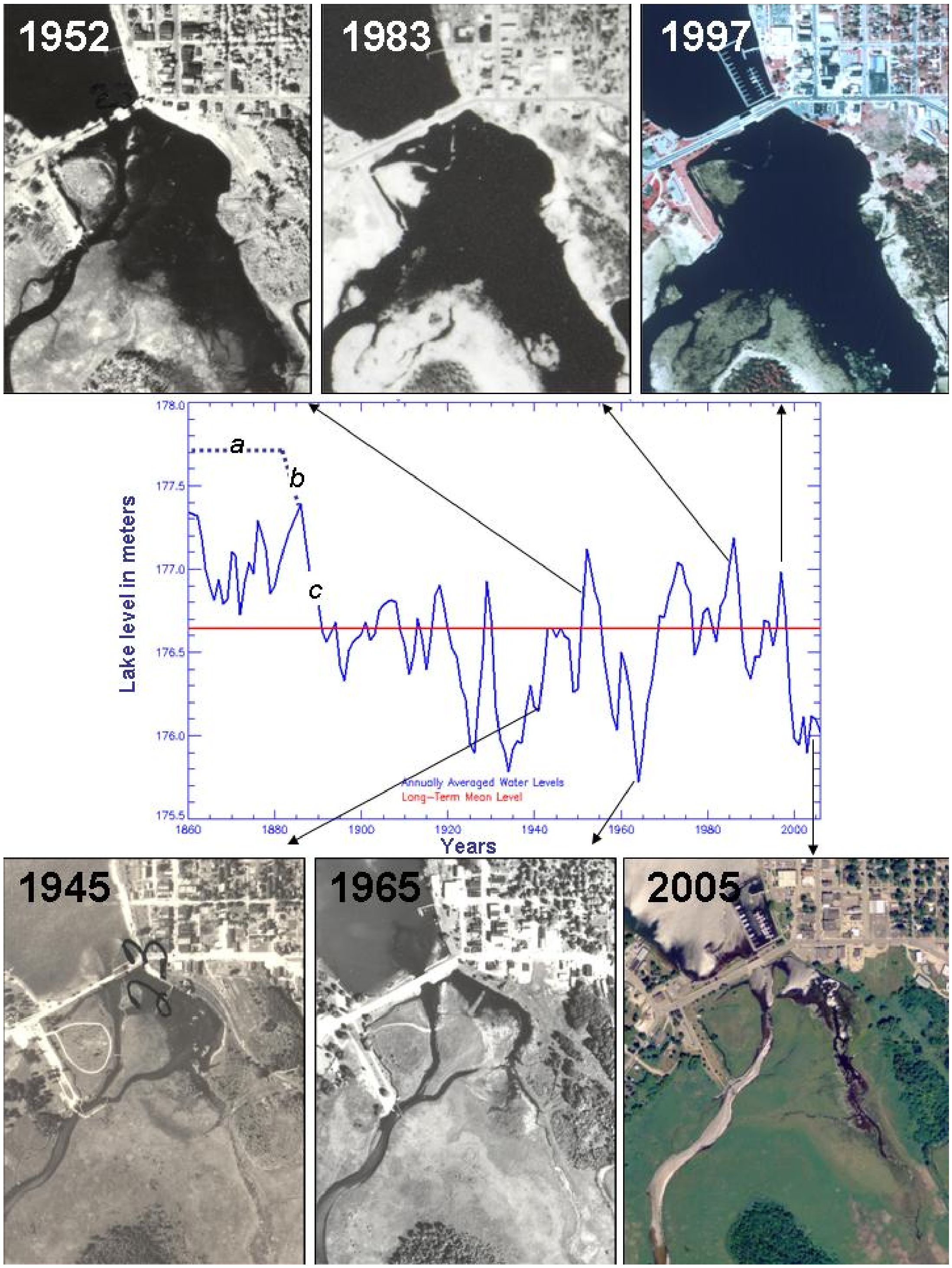

Figure 4. Aerial photographs of the Jordan River delta (top and bottom) and lake level variations (center). The lake level data were obtained from the NOAA Lake Michigan-Huron gage; the red line is the long-term average lake level. The lettered symbols in the center diagram refer to: *a*. Lake Charlevoix level before dredging was relatively stable *b*. Dredging of the Pine River lowered the level of Lake Charlevoix. *c*. After dredging of the Pine River the water levels of Lake Charlevoix followed the fluctuations in Lake Michigan.

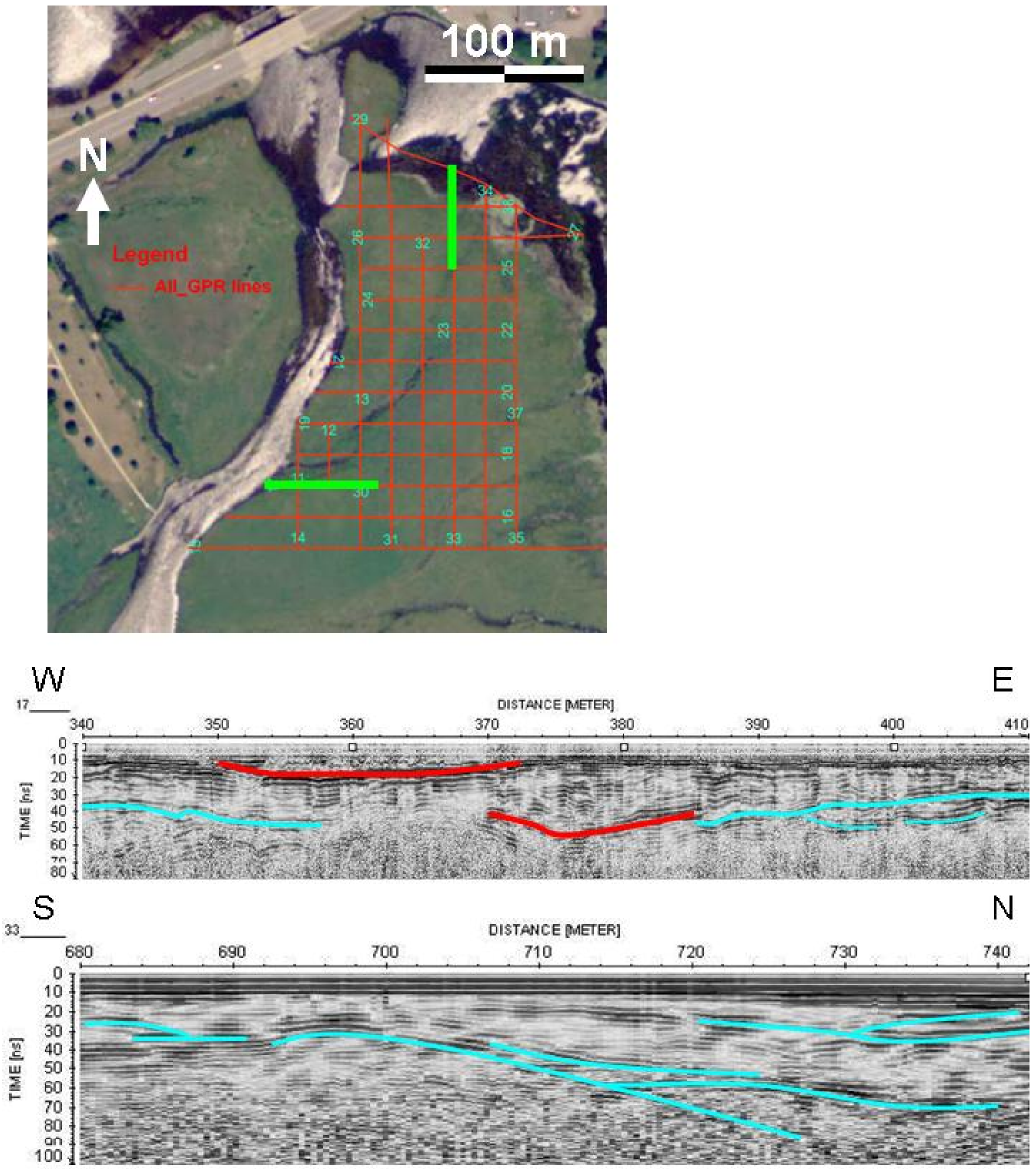

Figure 5. Ground penetrating radar lines collected in the delta area. Augering has confirmed that dipping events (highlighted in blue) correspond to sandy deposits overlying clay-rich lake bottom deposits. The red lines highlight concave features.