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September 10, 2018

MEMORANDUM

TO: Chad Bird, City of Decorah

FROM: Larry Weber and Dan Gilles, Iowa Flood Center, IIHR – Hydroscience & Engineering

COPY TO: Dana Werner, St. Paul District Corps of Engineers, Tyler Edwards, Menards, Inc., Nathan Young (IFC, IIHR)

SUBJECT: Hydraulic Modeling of Proposed Menards Site

I. Introduction

The Iowa Flood Center (IFC) received a request for technical assistance from the City of Decorah regarding proposed development within their floodplain. Members of the Cities of Decorah and Freeport, Iowa, are concerned development and construction of a Menards store would adversely affect water surface elevations upstream and downstream of the proposed site. The IFC investigated the impacts of the proposed project on water surface profiles upstream and downstream of the property during high flow events.

II. Recent Flooding Events

Communities in the Upper Iowa River Watershed continue to experience historic flooding, most recently in 2008 and 2016. While considerable damage was sustained during each of these events, unique rainfall patterns preceding these events produced different types of flooding. The 2008 event experienced at Decorah and Freeport was largely riverine flooding, setting the record for river stage and flow at the Upper Iowa River at Decorah USGS gaging station. While significant riverine flooding also occurred during the 2016 Flood, stage and flow observed at the Decorah gaging station were the fourth highest on record, as shown in Table 1. The severity of the 2016 event experienced at Decorah and Freeport was likely dominated by flash flooding, originating from small, local tributaries like Trout Run Creek Watershed and a small tributary southeast of Freeport. Stage and flow records were set at the Dorchester USGS gaging station as this runoff volume traveled downstream. Cumulative rainfall totals for each event are shown in Figure 1.

III. Estimation of Flood Frequency Flows

Several recent studies have concluded Iowa has experienced increased frequency of flooding and heavy rainfall events in recent decades. As a consequence, the magnitude of the “100-Year Flood”, or the flood with a 1-percent chance of occurring in any given year, is also increasing. Annual peak flows recorded at the Decorah USGS gaging station are plotted with a running estimate of the 100-year flow event in Figure 2. As more annual peak observations are added to the record, the estimated 100-year flow changes. Large flow events in recent decades have increased the 100-year flow estimate. A similar figure with estimates of the 500-year flow event is shown in Figure 3. Estimates of the 100- and 500-year flows using the entire period of record are 26,350 and 35,800 cfs, respectively.

Table 1. Historic stage and flow observations at Upper Iowa River USGS gaging stations.

Historic Crests At Decorah, IA	Historic Crests at Dorchester, IA
(1) 17.90 ft, 34100 cfs, on 06/09/2008	(1) 24.30 ft, 38000 cfs, on 08/25/2016
(2) 15.20 ft, 25640 cfs, on 05/29/1941	(2) 22.46 ft, 31200 cfs, on 06/09/2008
(3) 14.35 ft, 20500 cfs, on 08/17/1993	(3) 22.20 ft, on 02/28/1948 (ice)
(4) 13.68 ft, 19800 cfs, on 08/24/2016	(4) 21.80 ft, 30400 cfs, on 05/30/1941
(5) 13.08 ft, 20200 cfs, on 03/27/1961	(5) 20.89 ft, on 03/05/1937 (ice)
(6) 12.31 ft, 15300 cfs, on 06/01/2000	(6) 20.02 ft, 25500 cfs, on 06/23/2013
(7) 12.20 ft, 14754 cfs, on 03/17/1945	(7) 20.00 ft, 22000 cfs, on 08/17/1993

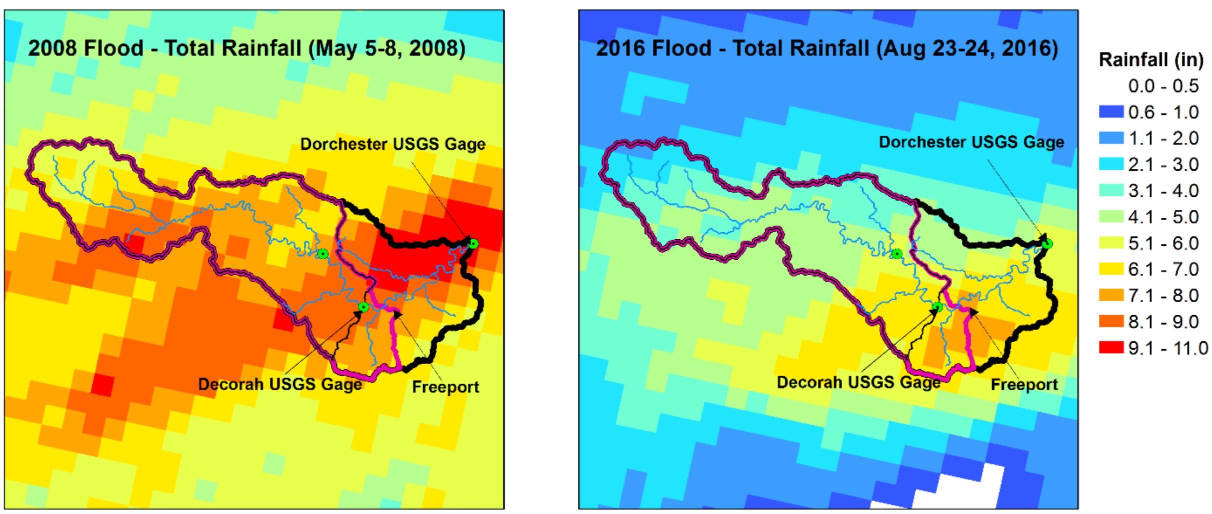

Figure 1. Cumulative rainfall totals preceding historic flooding events in 2008 and 2016, created using maps of daily rainfall totals.

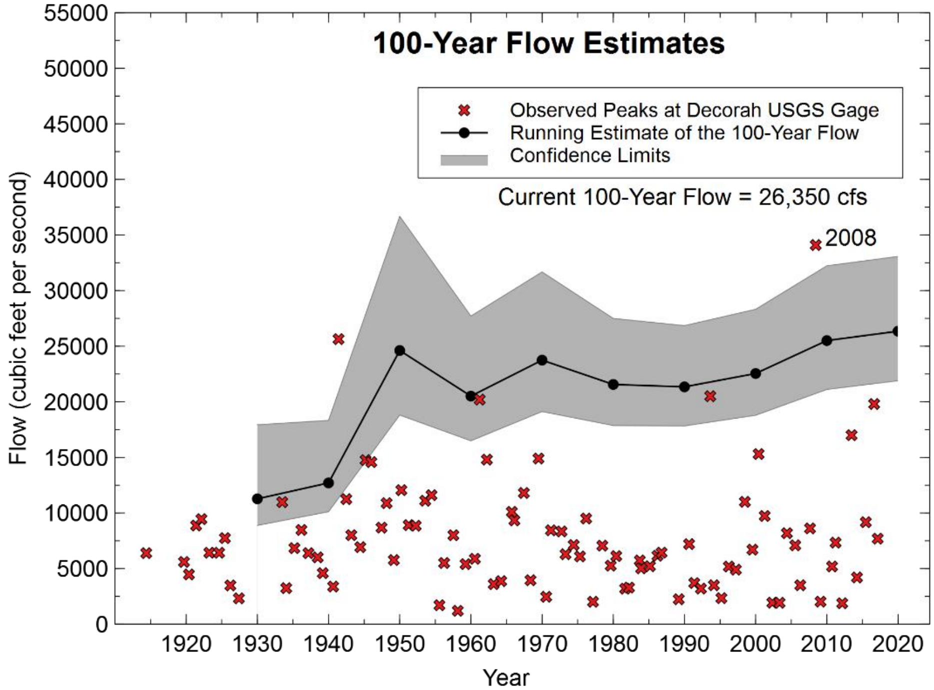

Figure 2. Historic annual peak flow observations at the Decorah USGS gaging station, with running estimate of the 100-year flow.

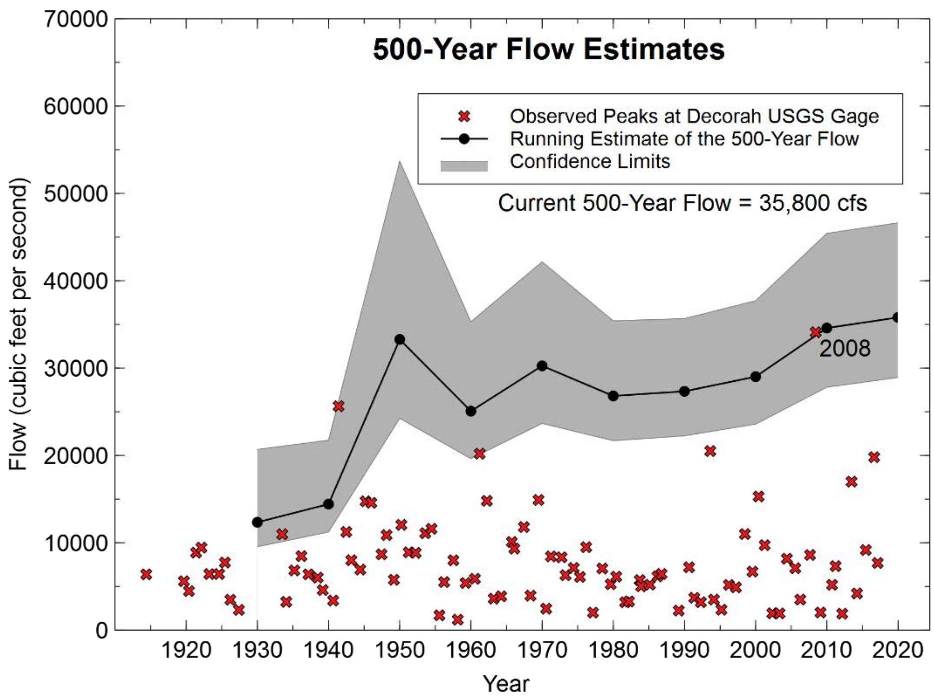

Figure 3. Historic annual peak flow observations at the Decorah USGS gaging station, with running estimate of the 500-year flow.

IV. Proposed Menards Project

A proposal to develop a portion of the Upper Iowa River floodplain for a Menards home improvement center has concerned some citizens of Decorah and Freeport. Some of their concerns include: increased runoff and decreased floodplain storage, adversely impacting the Decorah Wastewater Treatment Plant and increasing flooding upstream and downstream of the proposed site. The approximate location of the proposed Menards is shown in Figure 4. Fill needed to elevate the building structure is planned to be excavated on site, creating a large stormwater detention pond. This pond would be used to store runoff from the new building and parking lot. A portion of the development would be within the regulatory floodway area.

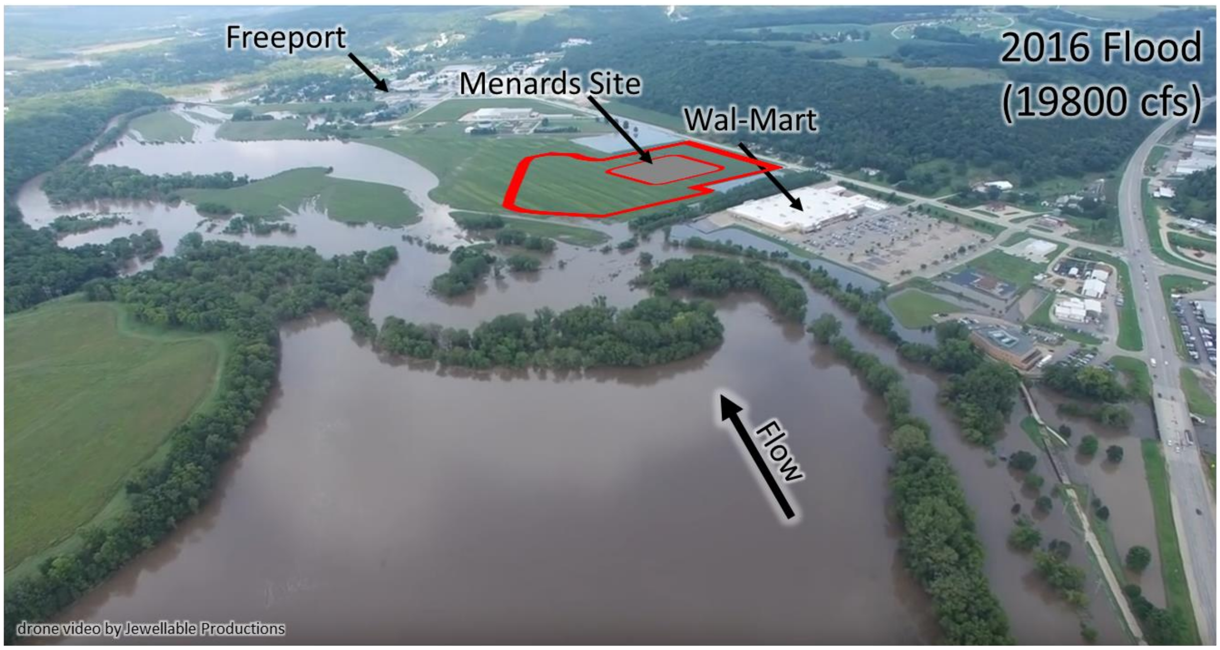

Figure 4. Proposed location of the Menards site overlain on an aerial photo taken during the 2016 flood.

For a community to participate in the National Flood Insurance Program (NFIP), it must adopt and enforce floodplain management regulations that meet or exceed the minimum NFIP standards and requirements. These standards are intended to prevent damage and economical and social hardships resulting from flooding. One specific rule is that development must not increase the flood hazard on other properties. This rule is enforced through the use of the regulatory floodway area, which identifies the channel or watercourse and adjacent floodplain that must be reserved in order to discharge base flood flows without cumulatively increasing water surface elevations more than a designated height. This is detailed in 44 CFR 60.3. A conceptual schematic of the floodway is shown in Figure 5. A portion of the Draft Flood Hazard Maps for Winneshiek County showing the extent of the 100-year floodplain (Zone AE), along with the spatial extent of the floodway is shown in Figure 6.

The proposed stormwater storage pond for the Menards site is denoted by the "Cut" area in Figure 6, which falls within the floodway area. A portion of the development that would include elevating the existing grade is within the floodway fringe. Theoretically, if modifications to the floodway corridor area do not include raising existing elevations or additional fill, the development will not significantly increase water surface elevations during the 100-year flow event.

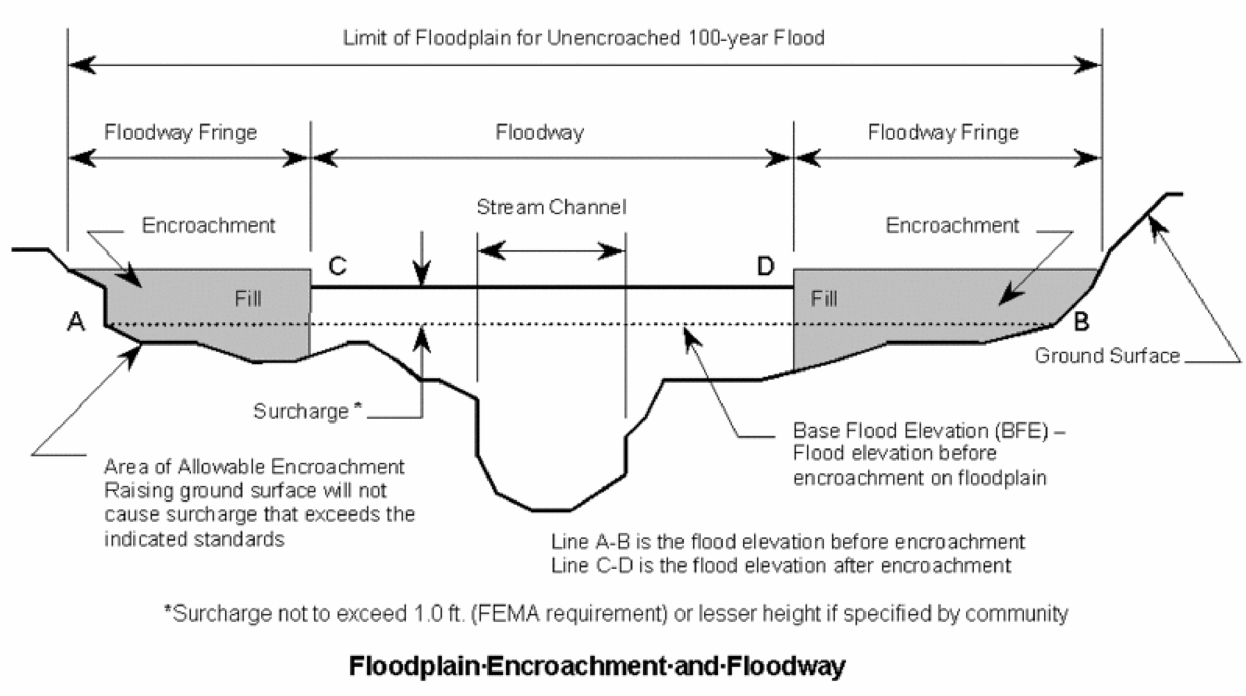

Figure 5. Schematic of the floodway and floodway fringe concept.

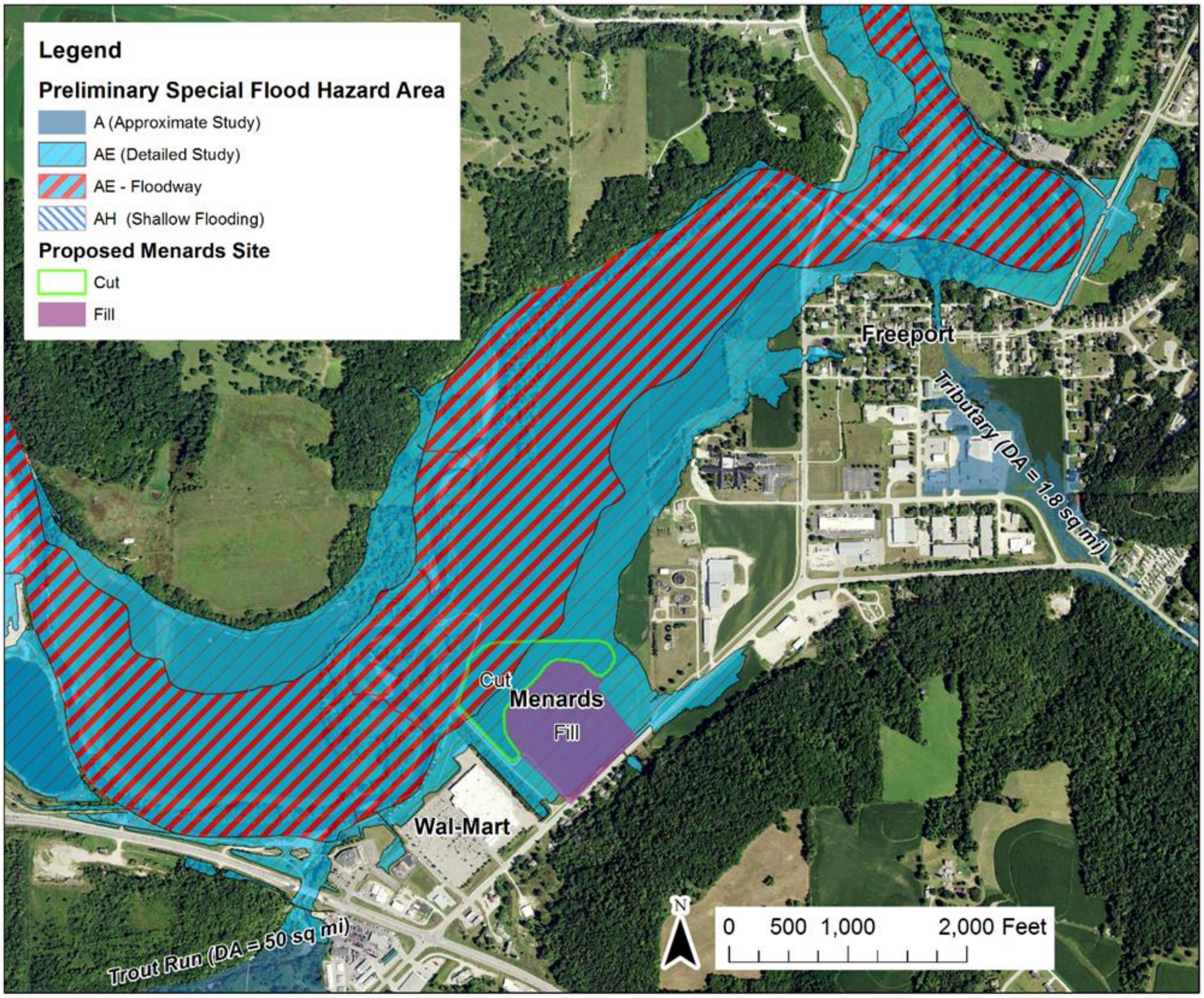

Figure 6. Preliminary FEMA map showing the extent of the 100-Year floodplain (Zone AE) and the floodway.

V. Existing USGS Hydraulic Model

The Draft Flood Hazard Map, shown in Figure 6, was developed by the Iowa DNR using a one-dimensional (1D) hydraulic model developed by Dan Christiansen of the United States Geological Survey (USGS) in 2010 using the U.S. Army Corps of Engineers Hydrologic Engineering Center's River Analysis System (HEC-RAS). The Draft Flood Hazard Maps for Winneshiek County are currently under FEMA review. Decorah is currently using the preliminary map as the best available data to regulate their floodway. The HEC-RAS model developed by Dan Christiansen was transmitted to IFC in late 2014.

a. Improvements to the USGS Existing Conditions Model

The original USGS model geometry did not reduce conveyance on the right overbank just downstream of the Walmart development. Therefore, additional ineffective flow areas were inserted at cross-sections just downstream of the Walmart development in an effort to more conservatively model the loss of conveyance and flow expansion on the right overbank for existing conditions. This model geometry is named "Existing_1D" in the HEC-RAS model accompanying this memo. Locations of model cross-sections are shown overlain on LiDAR terrain data in Figure 7.

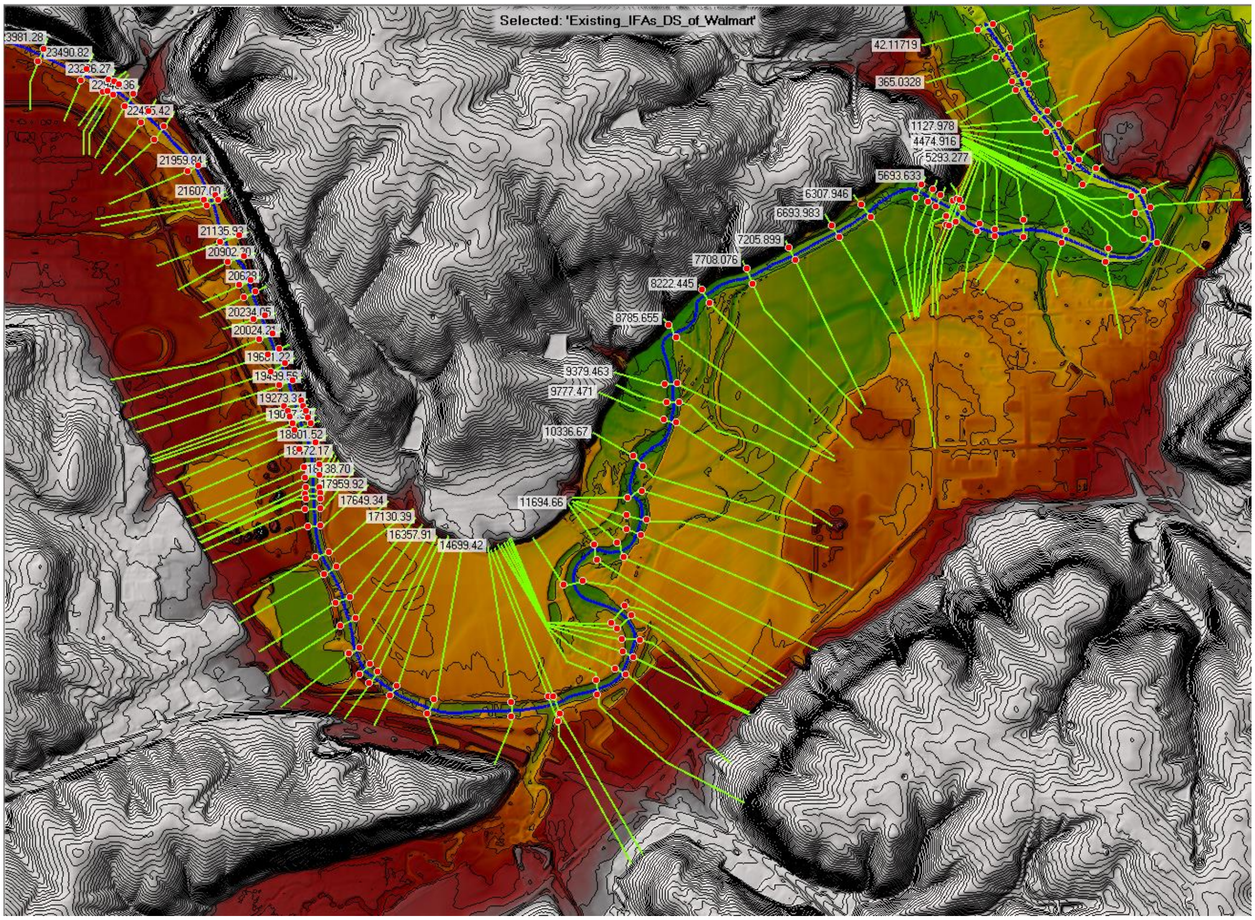

Figure 7. HEC-RAS model cross-section locations, overlain on LiDAR Terrain.

b. Incorporation of Menards Development

The "Existing_1D" model geometry was modified to conservatively incorporate impacts of the proposed Menards development. The proposed contour lines describing the site elevations were digitized from plans provided by the City of Decorah. A triangular irregular network (TIN) was created from the contour lines and converted to a high-resolution (1-meter) raster surface. This surface was imported into HEC-RAS RASMapper to update relevant elevation data, and is shown in Figure 8. Station-elevation data points associated with cross-sections overlapping the proposed Menards development on the right overbank were replaced using the raster surface elevation values.

In an effort to be conservative, the excavated stormwater storage pond was filled to the overflow elevation, blocked obstructions were used to reduce the flood plain conveyance and storage within the pond. Permanent ineffective flow areas were inserted above the blocked obstructions within the pond to prevent active flow below the approximate grade elevation surrounding the development.

Manning's roughness values were left unchanged in the proposed Menards development footprint.

This model geometry is named "Proposed_Menards_site" in the HEC-RAS model accompanying this memo.

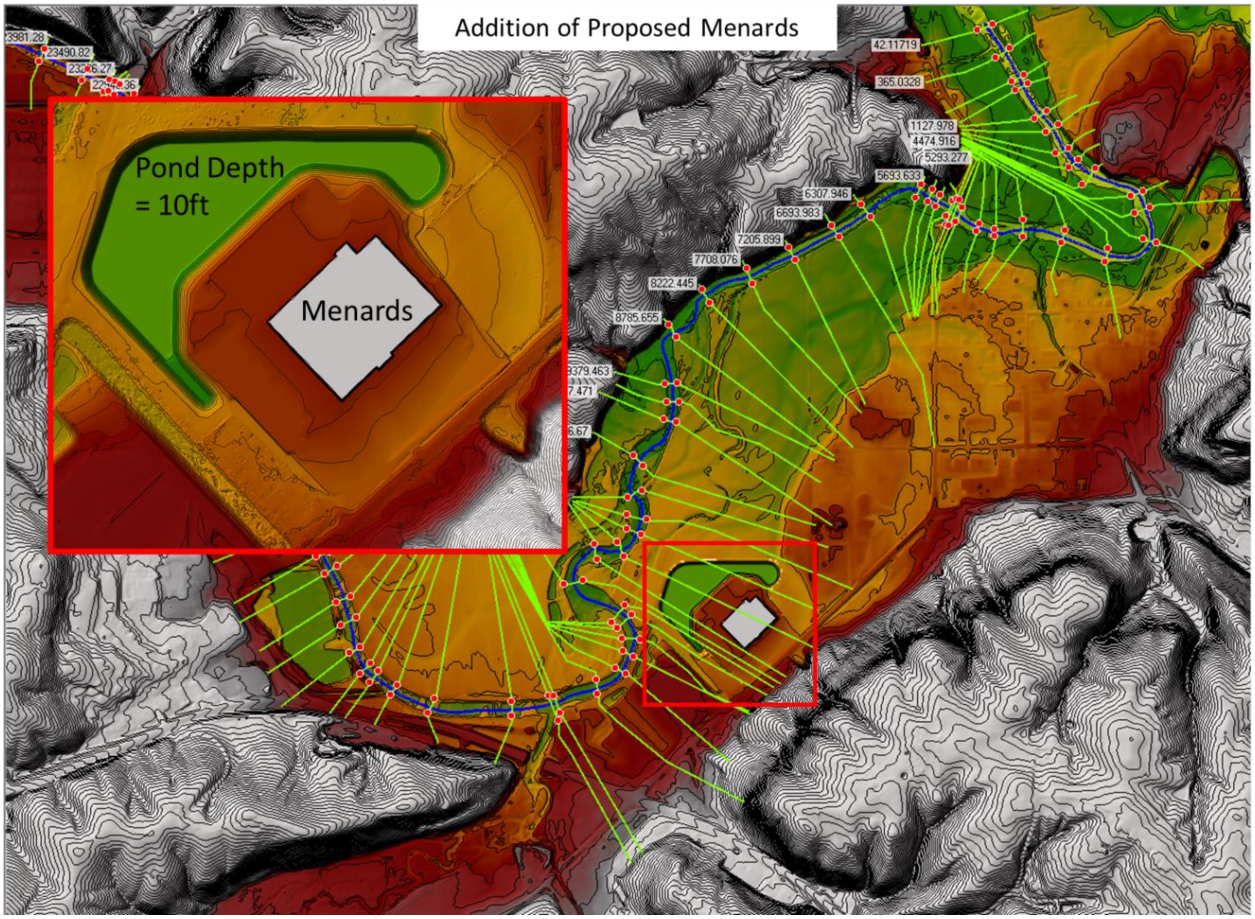

Figure 8. Incorporation of the proposed Menards development into the model terrain. Corresponding cross-sections were updated with the proposed changes to the overbank elevations. In an effort to be conservative, the excavated pond planned for stormwater storage was assumed to be filled with water.

c. Removal of the Walmart Development

The footprint of the existing Walmart Super Center, an area which has been built-up to an approximate elevation of 855 feet, was removed and lowered to an elevation of 845 feet. The blocked obstructions and ineffective flow areas capturing loss of conveyance around the Walmart development were also removed. Manning's roughness values were left unchanged from the existing conditions model (Existing_1D). This model geometry is named "Remove_Walmart" in the HEC-RAS model accompanying this memo.

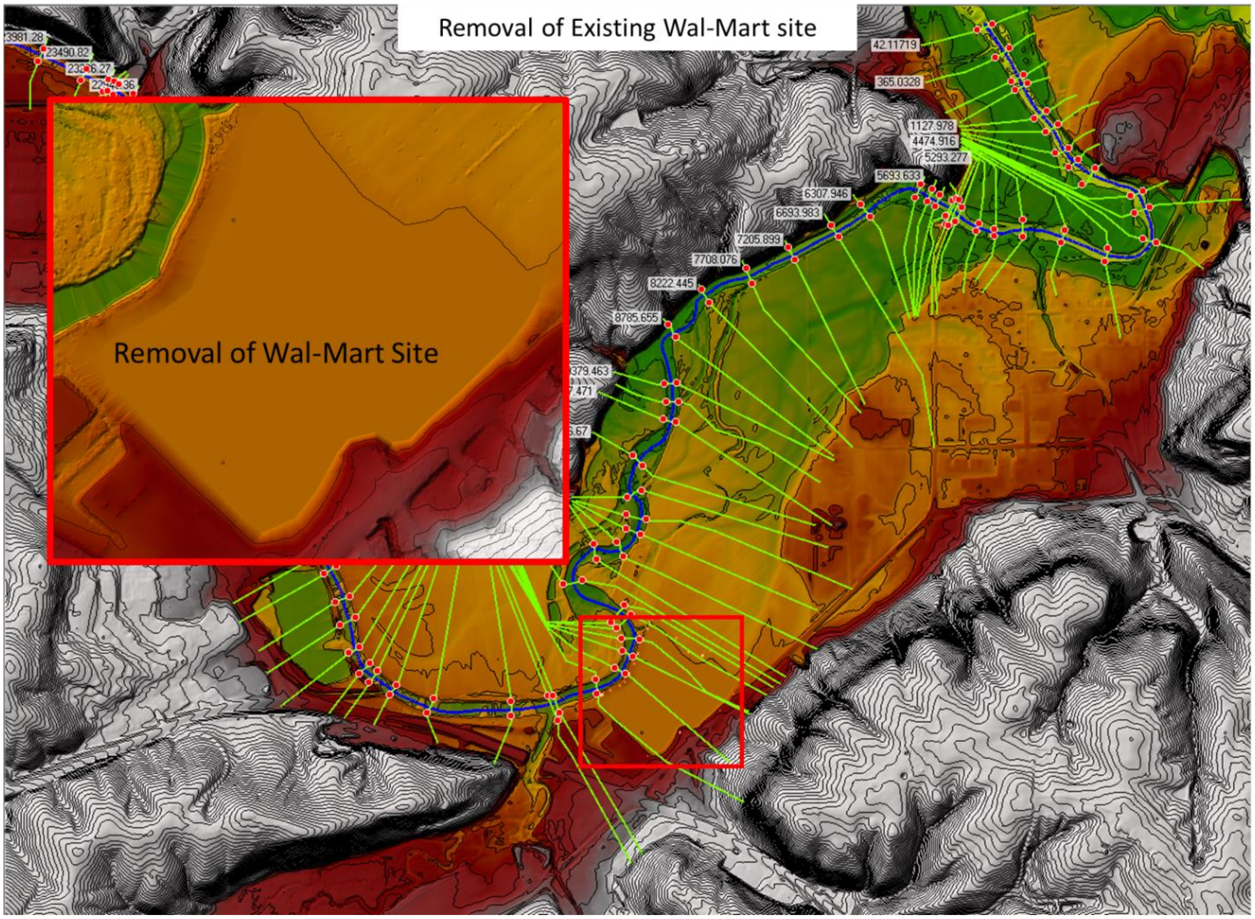

Figure 9. Terrain scenario showing removal of the current Walmart development.

VI. Comparison of Simulated to Observed 2008 Flood High Water Marks

Using the "Existing_1D" geometry, the 2008 flood was simulated using the inflow hydrograph, shown in Figure 10, observed at the Upper Iowa River USGS gaging station at Decorah. The simulated water surface elevations had close agreement to the surveyed 2008 Flood high water marks shown in Figure 11. Based on this agreement, the existing conditions model was used to develop the alternative geometry scenarios.

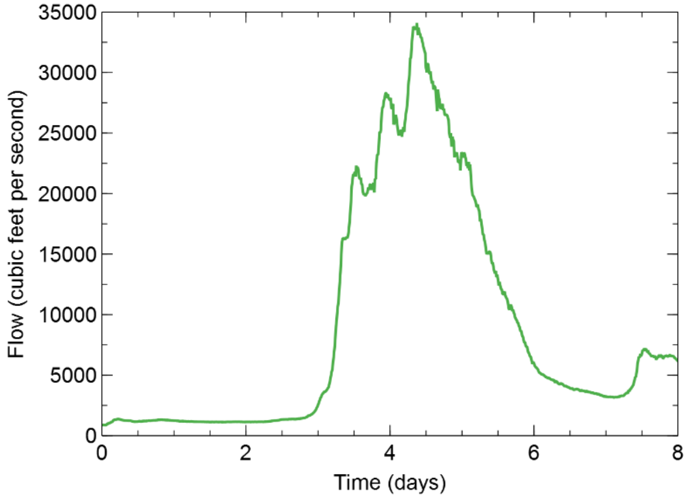

Figure 10. The 2008 Flood hydrograph observed at the Upper Iowa River USGS gaging station at Decorah.

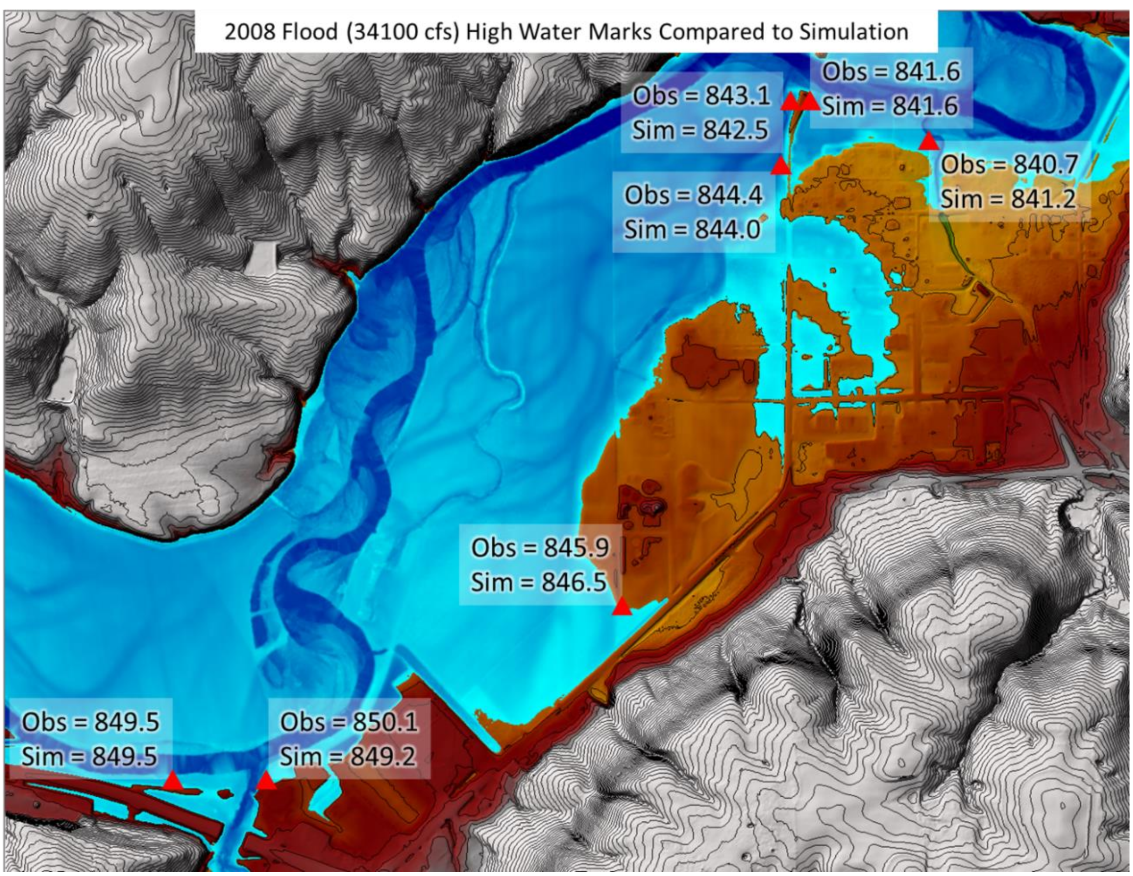

Figure 11. Comparison of simulated water surface elevations to observed 2008 Flood high water mark elevations.

VII. Simulation Results (2008 Flood, 100- and 500-Year Discharges)

Inflow hydrographs for the estimated 100- and 500-year peak flows were created by scaling the 2008 Flood hydrograph, shown in Figure 12. Simulated maximum water surface elevation profiles of the 2008 Flood event using the Existing, with Proposed Menards, and with Removal of Walmart scenarios are shown in Figure 13. The approximate extent of the Menards and Walmart sites along the main channel are also shown. Differences in the simulated maximum water surface elevation profiles for the 2008 Flood event compared to the Existing conditions scenario are shown in Figure 14. The maximum increase in water surface elevation for the with Proposed Menards scenario was 0.13 feet. This increase dissipates to 0.01 feet approximately 5,100 feet upstream of the Menards site, just downstream of the fairgrounds.

Simulated maximum water surface elevation profiles for the 100-year flow event using the Existing, with Proposed Menards, and with Removal of Walmart are shown in Figure 15. Differences in the simulated maximum water surface elevation profiles for the 100-year flow event compared to the Existing conditions scenario are shown in Figure 16. The maximum increase in water surface elevation for the with Proposed Menards scenario was 0.10 feet. This increase dissipates to 0.01 feet approximately 2,700 feet upstream of the Menards site.

Simulated maximum water surface elevation profiles for the 500-year flow event using the Existing, with Proposed Menards, and with Removal of Walmart are shown in Figure 17. Differences in the simulated maximum water surface elevation profiles for the 100-year flow event compared to the Existing conditions scenario are shown in Figure 18. The maximum increase in water surface elevation for the with Proposed Menards scenario was 0.13 feet. This increase dissipates to 0.01 feet approximately 5,300 feet upstream of the Menards site.

A table summarizing the main channel distances from the Menards site that the water surface impact dissipates to 0.01 feet is shown in Table 2. The upstream and downstream locations where impacts dissipate to 0.01 feet is shown in Figure 19.

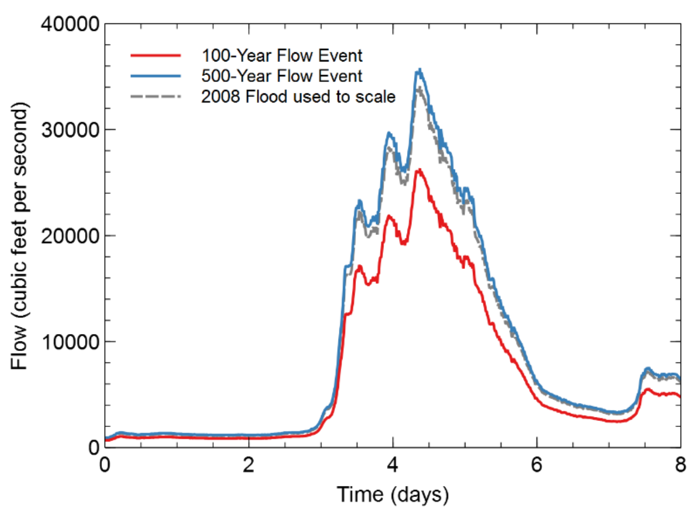

Figure 12. Inflow hydrographs for the 100- and 500-year flow events created by scaling the observed 2008 Flood event.

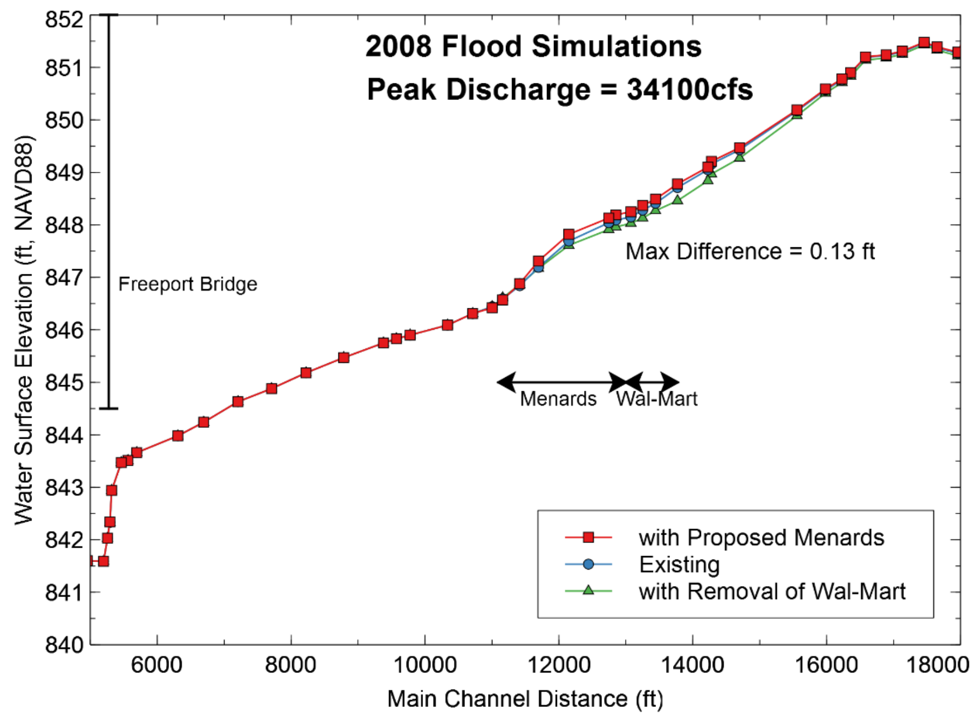

Figure 13. Simulated maximum water surface elevation profiles for the 2008 Flood event using the Existing, with Proposed Menards, and Removal of Walmart geometry scenarios. The maximum difference between Existing and with Proposed Menards was 0.13 feet.

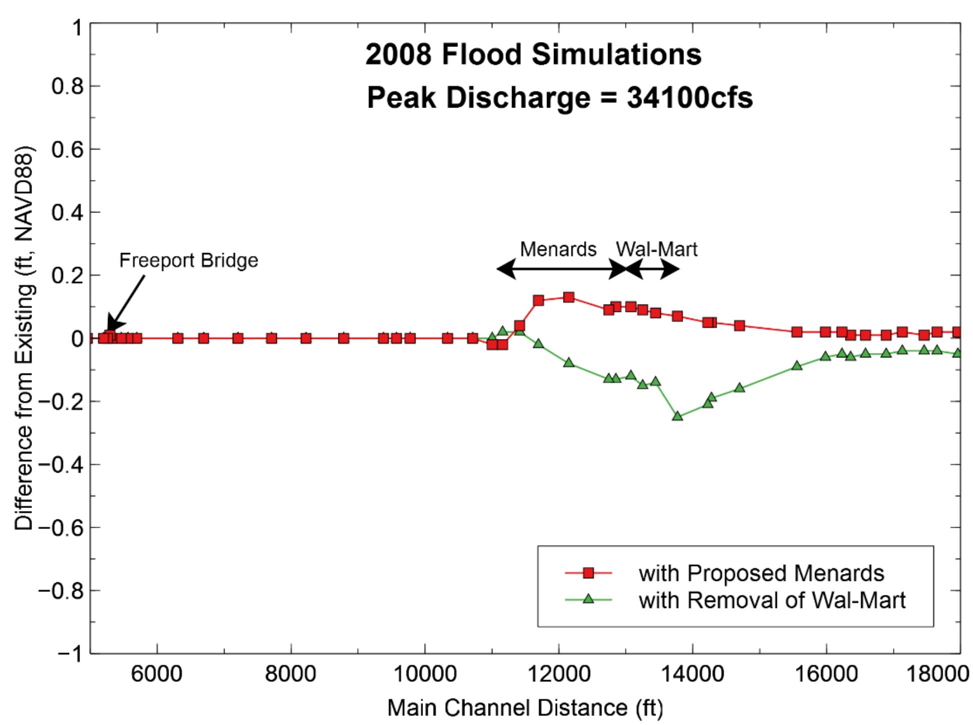

Figure 14. Differences (ft) in the simulated maximum water surface elevation profiles for the 2008 Flood event compared to the Existing conditions scenario.

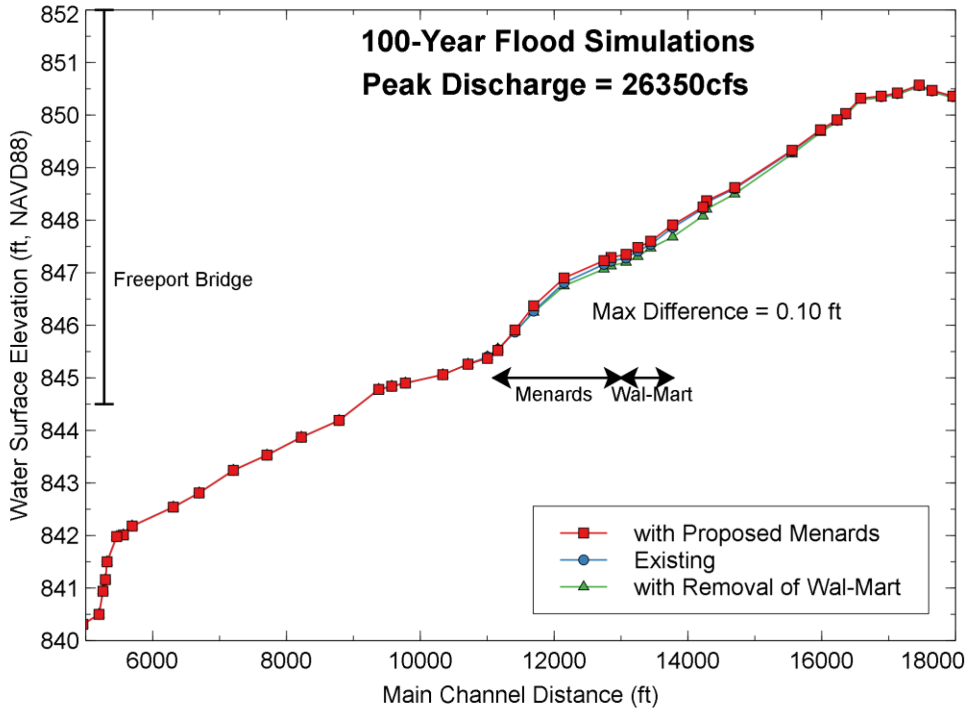

Figure 15. Simulated maximum water surface elevation profiles for the 100-year flow event using the Existing, with Proposed Menards, and Removal of Walmart geometry scenarios. The maximum difference between Existing and with Proposed Menards was 0.10 feet.

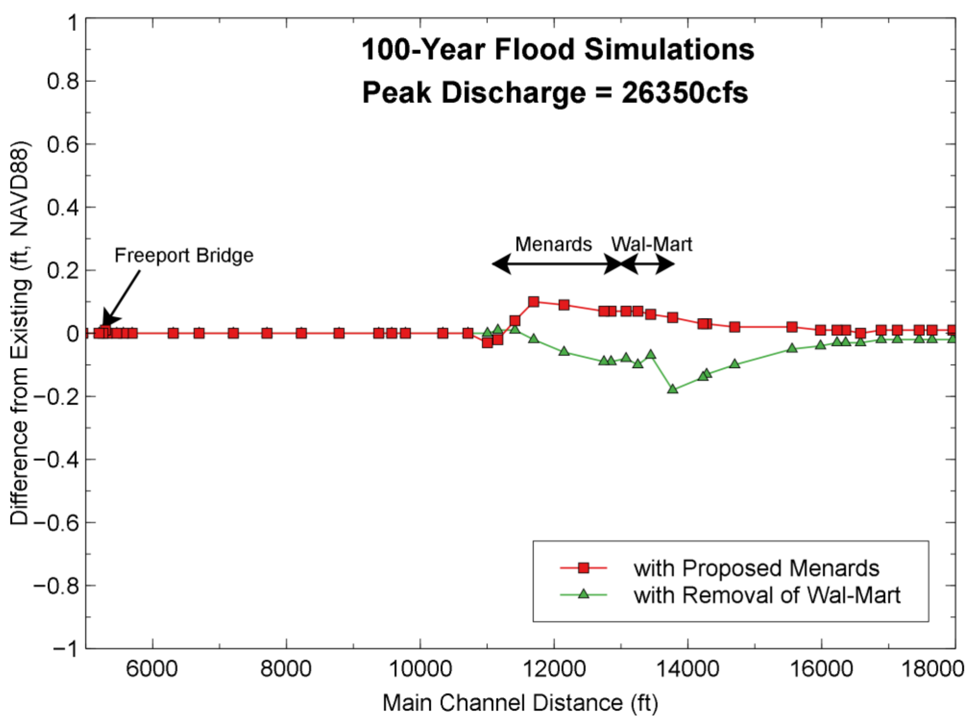

Figure 16. Differences (ft) in the simulated maximum water surface elevation profiles for the 100-year flow event compared to the Existing conditions scenario.

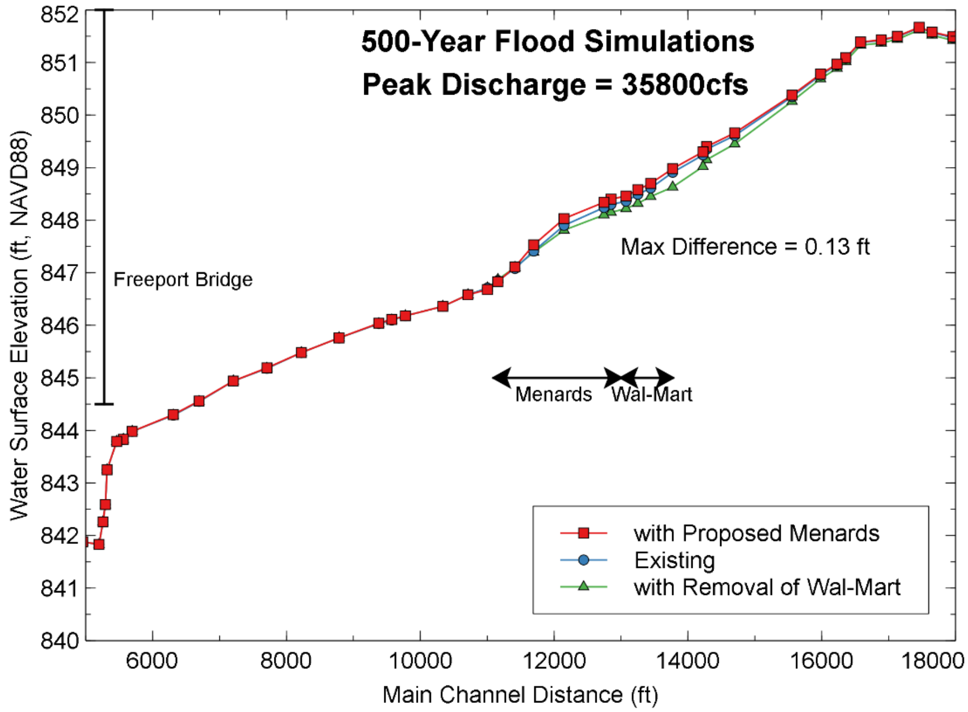

Figure 17. Simulated maximum water surface elevation profiles for the 500-year flow event using the Existing, with Proposed Menards, and Removal of Walmart geometry scenarios. The maximum difference between Existing and with Proposed Menards was 0.13 feet.

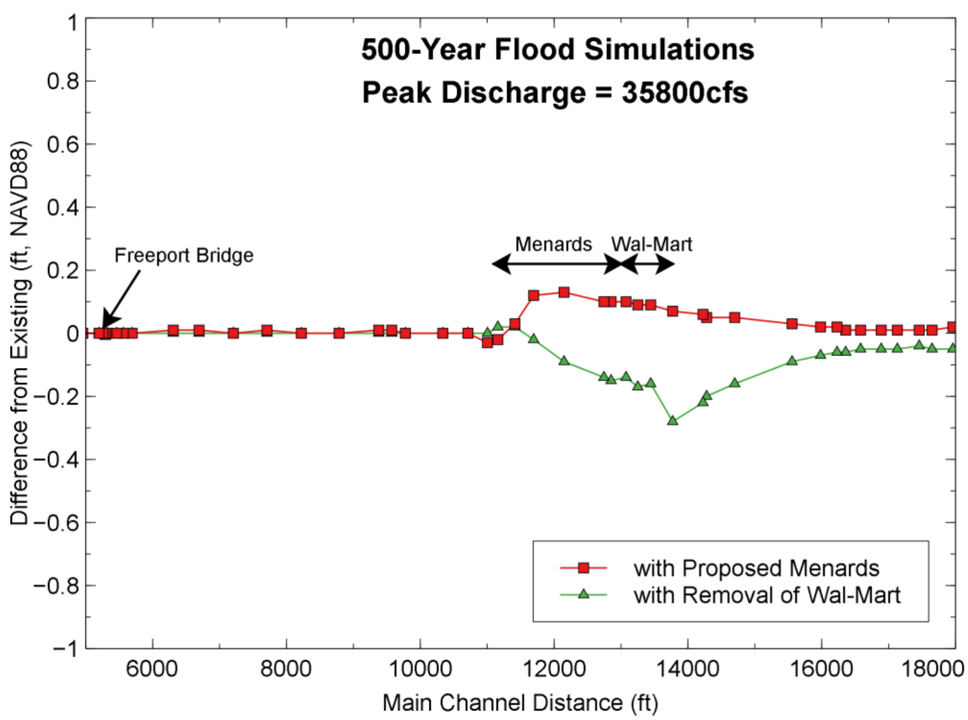

Figure 18. Differences (ft) in the simulated maximum water surface elevation profiles for the 500-year flow event compared to the Existing conditions scenario.

Table 2. Locations where the water surface impact due to the Menards development dissipates to 0.01 feet.

	Channel Distance of Menards Impacts (feet)		
	100-Year	2008 Flood	500-Year
Upstream from Menards	2700	5100	5300
Downstream from Menards	<300	<300	<300

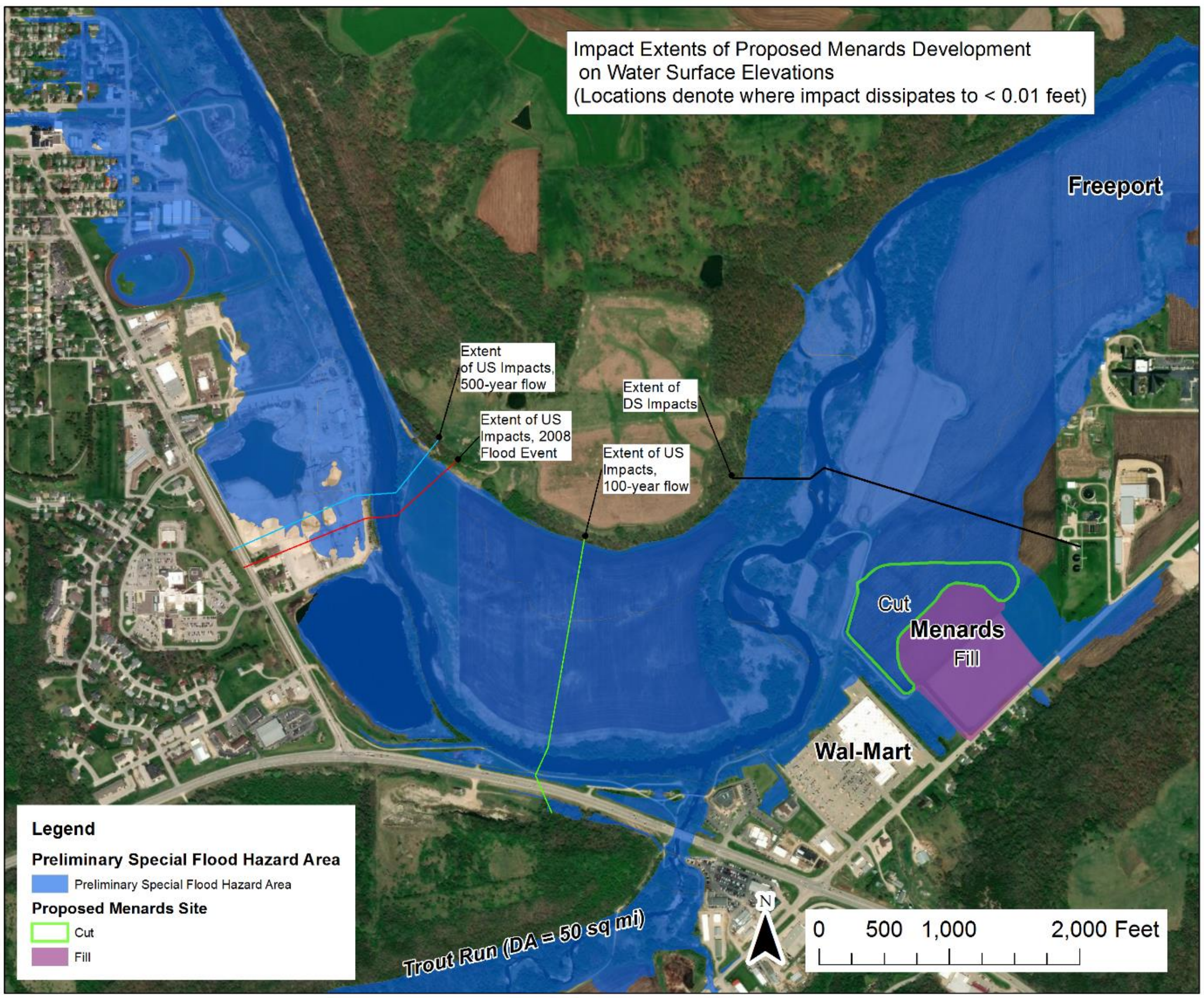

Figure 19. Extent of upstream and downstream water surface elevation impacts with Menards development.

VIII. Simulation Results (2008 Flood +2%, +5%, +10%, +25%) with Proposed Menards

A range of hypothetical percent increases in the 2008 Flood peak flow were created for +2%, +5%, +10%, and +25% scenarios to consider events more severe than the record 2008 Flood event. Inflow hydrographs were developed for these events, shown in Figure 20, by scaling the 2008 Flood hydrograph. Simulated maximum water surface elevation profiles for these flow scenarios, all with the proposed Menards in place are shown in Figure 21. Differences in water surface elevations along the reach using the 2008 Flood event with Menards in place are shown in Figure 22. As the peak 2008 Flood flow increases, the water surface elevations also increase. The largest increase of 1.4 feet occurs with the +25% scenario near the Freeport bridge. This increase is the result of the increase in flow, rather than the effect of the Menards development. Upstream of the Menards location, the difference in water surface elevations for the +25% scenario are near 1.0 feet. The magnitude of this water surface elevation increase is also likely due to the flow increase rather than effect of the Menards development.

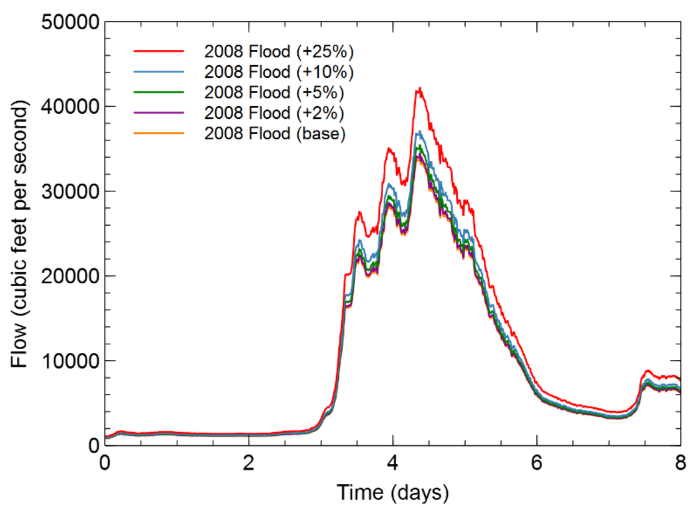

Figure 20. Inflow hydrographs for the 2008 Flood (base), +2%, +5%, +10%, and +25% peak flow events created by scaling the observed 2008 Flood event.

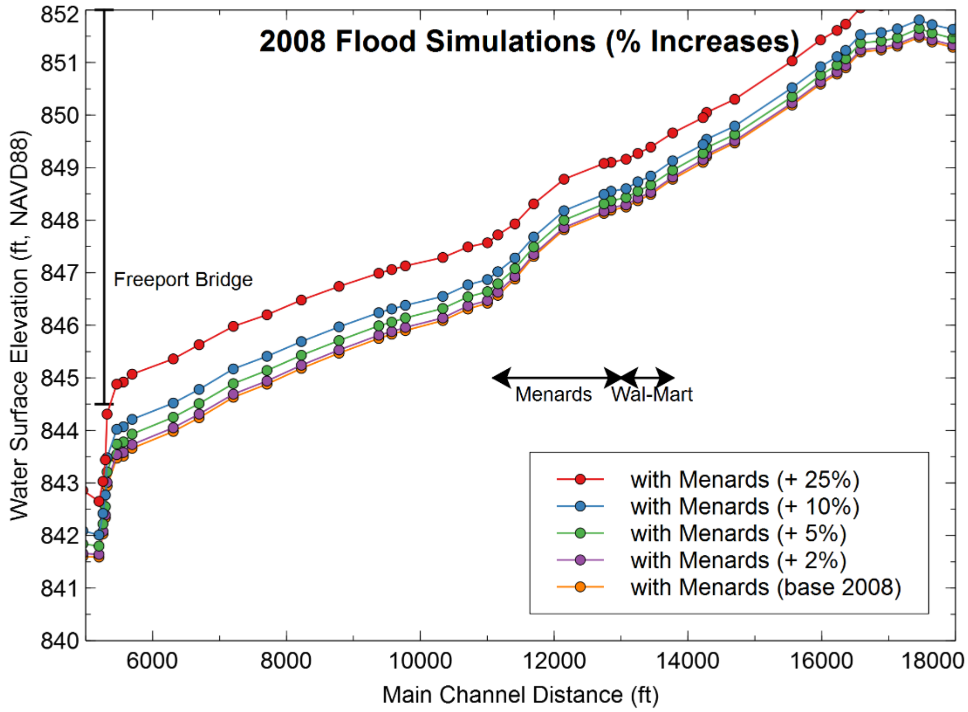

Figure 21. Simulated maximum water surface elevation profiles for the 2008 Flood (base), +2%, +5%, +10%, and +25% flow events with Proposed Menards scenario.

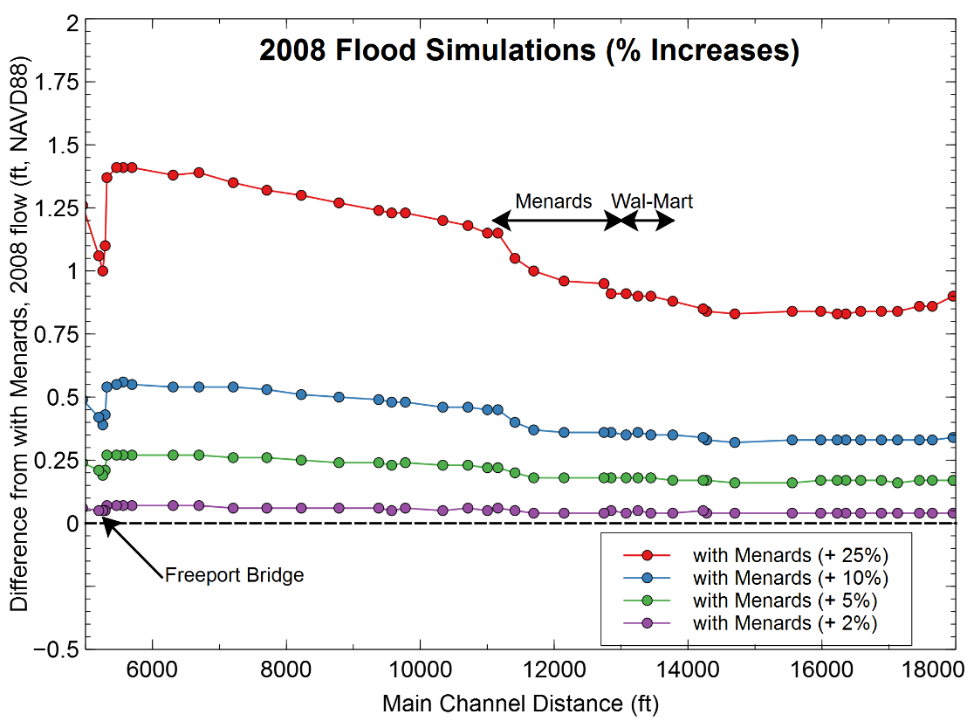

Figure 22. Differences (ft) in the simulated maximum water surface elevation profiles for 2008 Flood +2%, +5%, +10%, and +25% flow events compared to the 2008 Flood event with Proposed Menards scenario.

We can further investigate the impact of hypothetical percent increases in the 2008 Flood peak flow by comparing simulation results from the Existing and the proposed Menards conditions using the same flow increments. Comparing the simulation results in this way isolates the change between models as geometry differences, rather than differences in flow and geometry. Figure.23 shows simulated maximum water surface elevation profiles for flow increments with Existing and the proposed Menards in place. Profiles for each flow increment are similar. Differences between the Existing and the proposed Menards water surface elevation profiles for each flow increment are shown in Figure 24. The maximum differences between scenarios across all flow increments are similar, between 0.10 and 0.15 feet. The differences dissipate approximately one mile upstream of the Menards site.

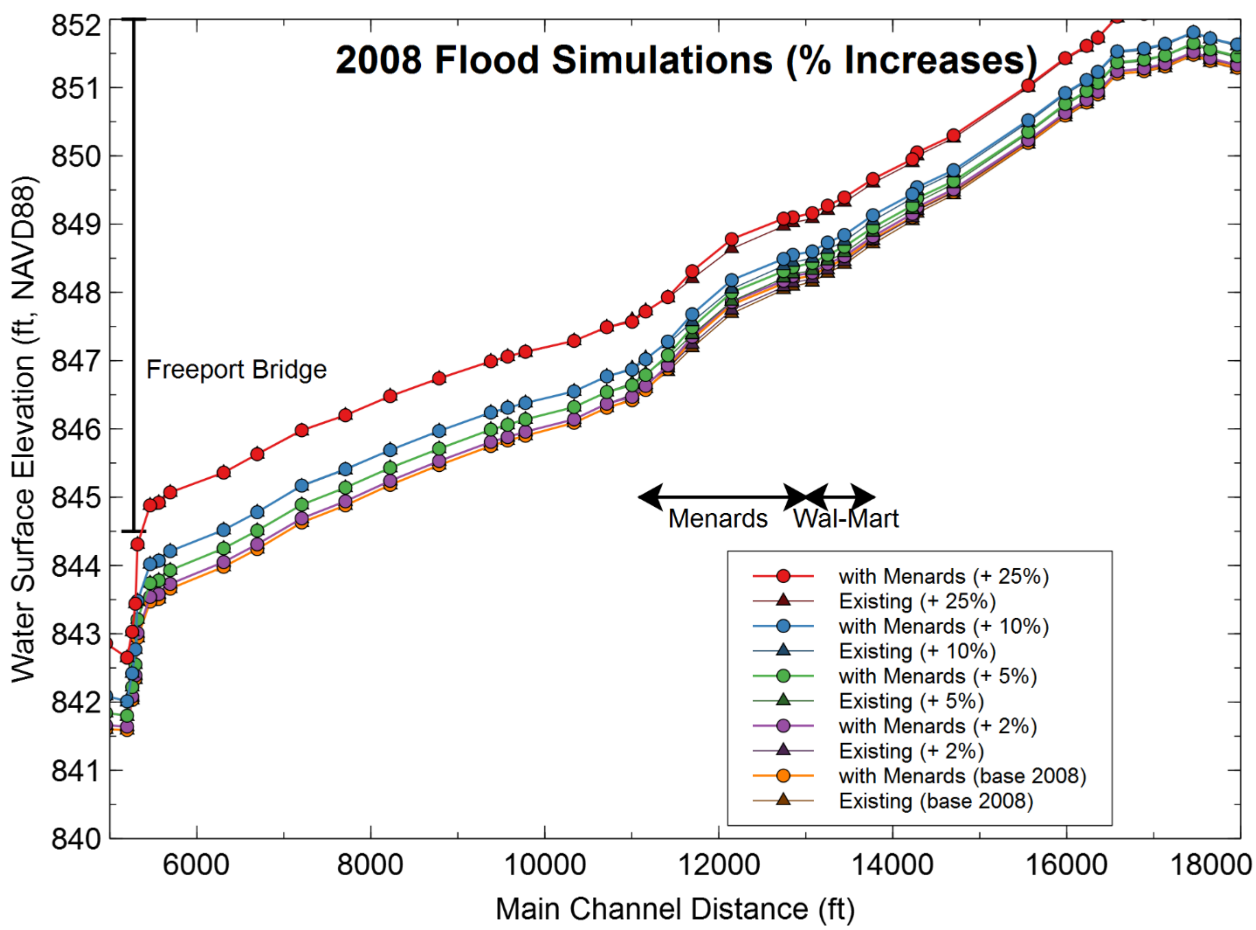

Figure.23. Simulated maximum water surface elevation profiles for the 2008 Flood (base), +2%, +5%, +10%, and +25% flow events for Existing and with Proposed Menards geometry scenarios.

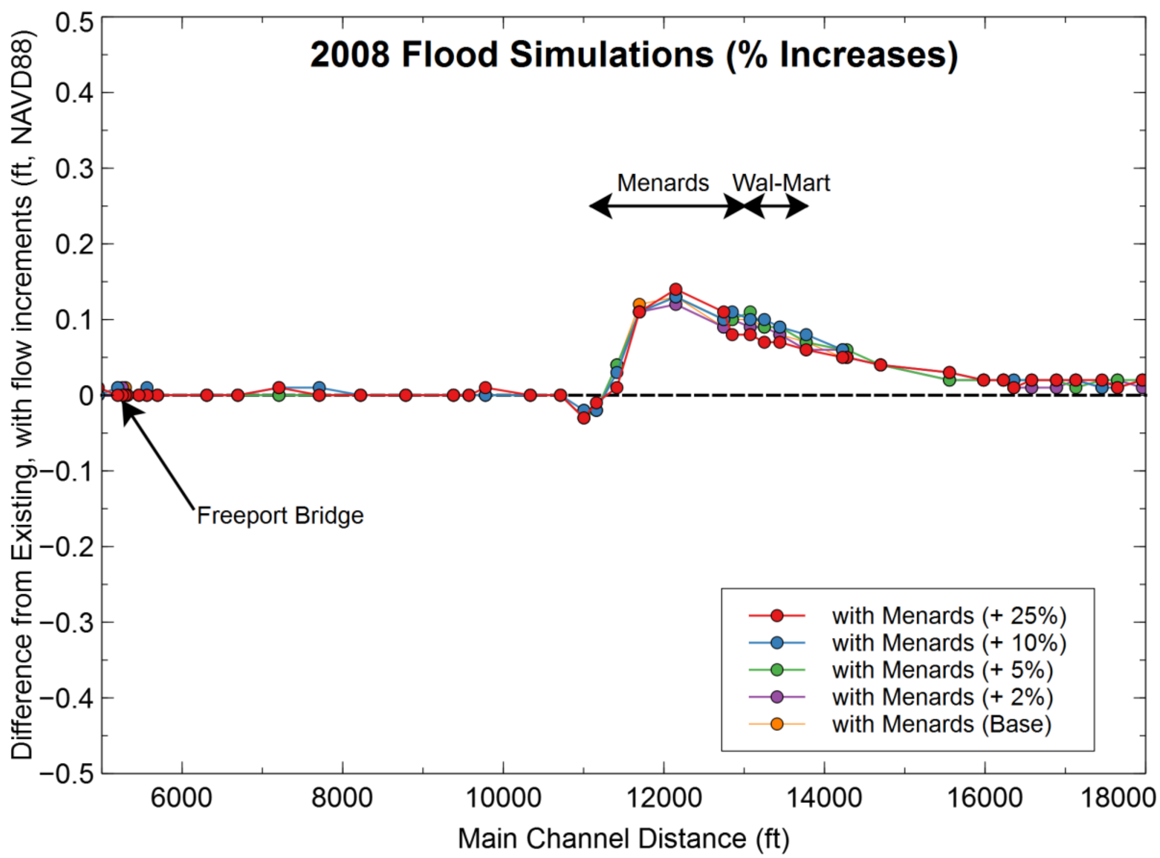

Figure 24. Differences (ft) in the simulated maximum water surface elevation profiles for 2008 Flood +2%, +5%, +10%, and +25% flow events for Existing and with Proposed Menards geometry scenarios.

IX. Concluding Remarks

The simulation results indicate the proposed Menards development scenario will have a small effect on water surface elevations upstream and downstream of the Menards site under current flow conditions. Changes in the current flow conditions (e.g., 2008 Flood +2%, +5%, +10%, +25%, and 500-year flow) can significantly increase water surface elevations. However, much of the increase in water surface elevations can be attributed to flow increases and corresponding head loss increases at the Freeport Bridge, rather than the impact of the Menards site. This was further investigated by comparing Existing and with Menards scenarios using the same flow increments. Maximum differences in water surface elevation profiles across the range of hypothetical flow increases using the Existing and proposed Menards scenarios were between 0.10 and 0.15 feet. These impacts dissipated approximately one mile upstream of the Menards site. It is important to note – proposed changes to the right overbank attributed to the Menards development were incorporated into the hydraulic model in a conservative manner. Any actual impacts due to the Menards development during high flow events are likely smaller than those presented in this report.

Typically, any single proposed development project within the floodplain or floodway will not adversely affect water surface profiles or increase severity of flooding such that it will be rejected on those criteria alone. Concerns about continued floodplain development and their cumulative impacts might be addressed more efficiently by updating long term planning and zoning policies, rather than case-by-case analysis.