ASSESSMENT OF FLOODING ISSUES AND POSSIBLE MITIGATION STRATEGIES FOR THE CITY OF PLAINFIELD, IOWA

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Submitted to
The City of Plainfield

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OVERVIEW

Since the 1970s, Iowa has experienced increases in annual and seasonal precipitation totals, changes in the frequency of intense rain events and the seasonality of timing of precipitation (Takle, 2010). Based on historic events in 2008 and 2016, many residents of the City of Plainfield, Iowa, believe the community has experienced an increased frequency of flooding. The community's proximity to the Cedar River, increased frequency of heavy rainfall events, a high groundwater table, and drainage issues have likely aggravated flooding events. This report summarizes the investigation into the city's flooding issues and identifies potential flood mitigation alternatives. The community is particularly interested in reducing basement flooding in the West Street neighborhood and surface flooding as a result of runoff originating in nearby small upland agricultural catchments. Representatives from the City of Plainfield, Upper Cedar Watershed Management Improvement Authority (UCWMIA), Bremer County, Bremer County Emergency Management, Iowa Department of Transportation (Iowa DOT), Natural Resources Conservation Service (NRCS), Iowa Department of Natural Resources (Iowa DNR), Iowa Geological Survey (IGS), and the Iowa Flood Center contributed to these investigations and discussions.

A XPSWMM computer model was developed to simulate rainfall-runoff and storm water interaction with the terrain, culverts, ditches, and bridges. The model was used to simulate and quantitatively compare several flood mitigation alternatives. Many different flood mitigation scenarios were modeled to determine the greatest benefit to areas between US-218 and the west side of Plainfield. Based on the simulation results, some alternatives provided a slight improvement over other mitigation options, but would require the purchase of private property or flowage easements in order to be effective. The alternative determined to provide the most cost-effective hydraulic benefit to the area along the west side of Plainfield without the purchase of additional property or flowage easements is the East Ditch, in right-of-way (ROW), Extended alternative. The East Ditch, in ROW, Extended alternative would likely require relocation of a natural gas transmission pipeline, along with any other utilities within the ROW.

Based on these simulation results and partner input, several additional alternatives were identified to improve drainage conditions. The first set of recommended projects would improve surface drainage for the area south of Plainfield, near the Iowa DOT Wetland Mitigation Area and provide a more effective outlet for Plainfield's surface flood water. These recommended projects south of Plainfield alone would do little to reduce water depths between US-218 and the west side of Plainfield due to the presence of a control point or bottleneck likely resulting from an expansion of the Landus Coop in 2008. The second set of recommended projects would improve surface drainage for the area between US-218 and the west side of Plainfield, but surface flooding would still occur in low-lying areas. For example, simulated water depths for the 25-year rainfall event in the area between US-218 and the west side of Plainfield would be reduced from 1.7 feet to 1.0 feet. Any potential reductions in the frequency or severity of basement flooding are unknown. If the high groundwater table at this location is dominated by regional infiltration processes, terrain characteristics and influence of Cedar River water levels, these mitigation projects will likely have little to no effect on basement flooding.

1. INTRODUCTION

Since the 1970s, Iowa has experienced increases in annual and seasonal precipitation totals, changes in the frequency of intense rain events and the seasonality of timing of precipitation (Takle, 2010). Based on historic events in 2008 and 2016, many residents of the City of Plainfield, Iowa, believe the community has experienced an increased frequency of flooding. The community's proximity to the Cedar River, increased frequency of heavy rainfall events, a high groundwater table, and storm water drainage issues have likely aggravated flooding events. This report summarizes the investigation into the city's flooding issues and identifies potential flood mitigation alternatives. The community is particularly interested in reducing basement flooding and surface flooding as a result of runoff originating in nearby small upland agricultural catchments. Representatives from the City of Plainfield, Upper Cedar Watershed Management Improvement Authority (UCWMIA), Bremer County, Bremer County Emergency Management, Iowa Department of Transportation (Iowa DOT), Natural Resources Conservation Service (NRCS), Iowa Department of Natural Resources (Iowa DNR), Iowa Geological Survey (IGS), and the Iowa Flood Center contributed to these investigations and discussions.

2. STUDY AREA

The City of Plainfield, Iowa, population 436, is located in the northwest corner of Bremer County in Northeastern Iowa. The city footprint, shown in Figure 2.1, is adjacent to U.S. Highway 218, lying between small upland agricultural catchments to the west, and the Cedar River floodplain to the east. As a consequence, Plainfield is subjected to flash flooding originating in upland catchments, in addition to extended riverine flooding from the Cedar River. The US-218 bypass to the west of the community was completed in November 2002.

2.1 Topography

Plainfield is located on a relatively flat upland terrace near the Cedar River floodplain. The lowest lying areas of the terrace, shown in Figure 2.2, are located between US-218 and the Country View addition on the west side of Plainfield. Figure 2.2 depicts statewide LiDAR data collected sometime after 2008. The active Cedar River floodplain is located just to the east of Plainfield at an elevation approximately five feet lower than the upland terrace elevation.

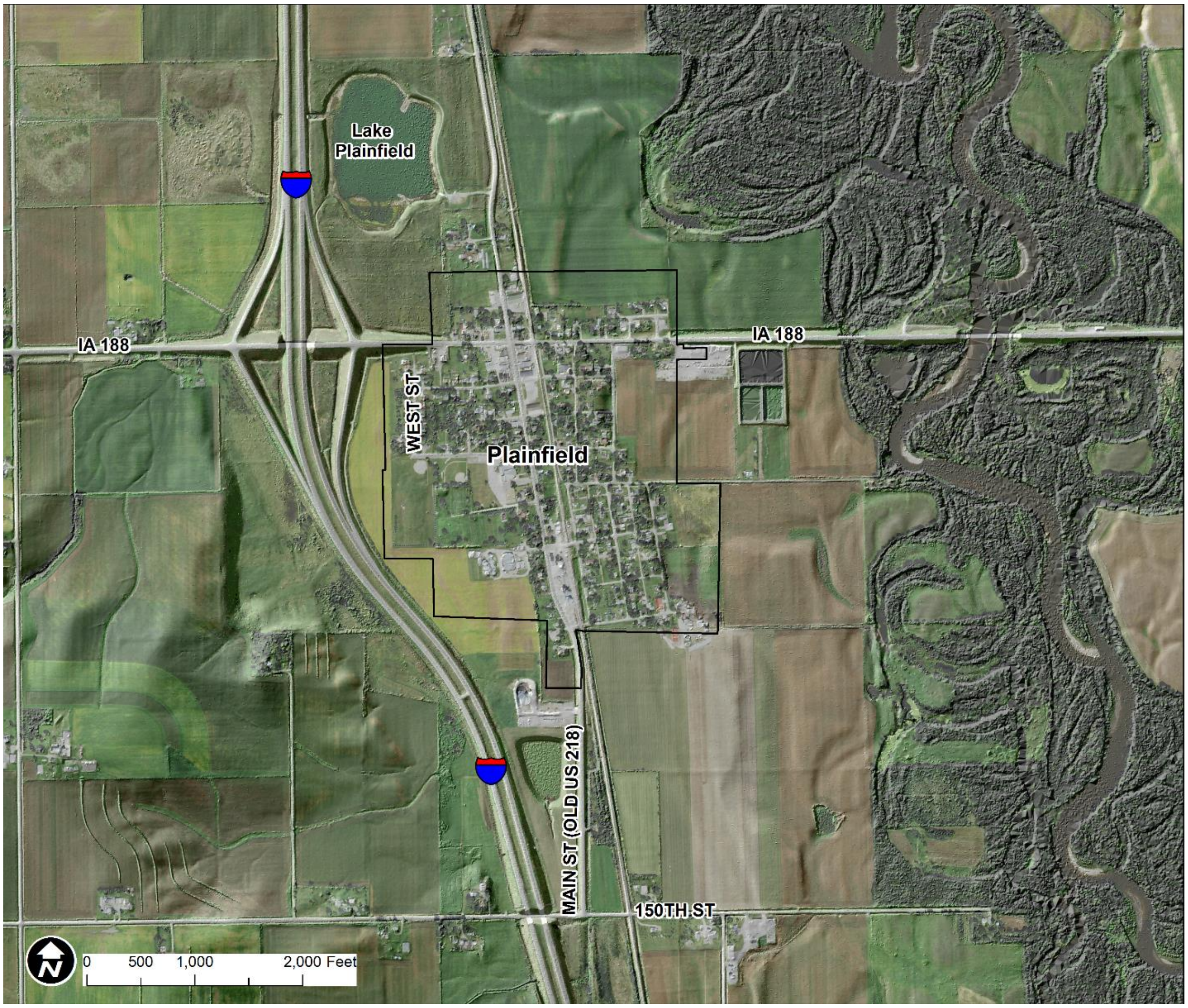

Figure 2.1. The City of Plainfield is situated near several small agricultural catchments and the Cedar River floodplain.

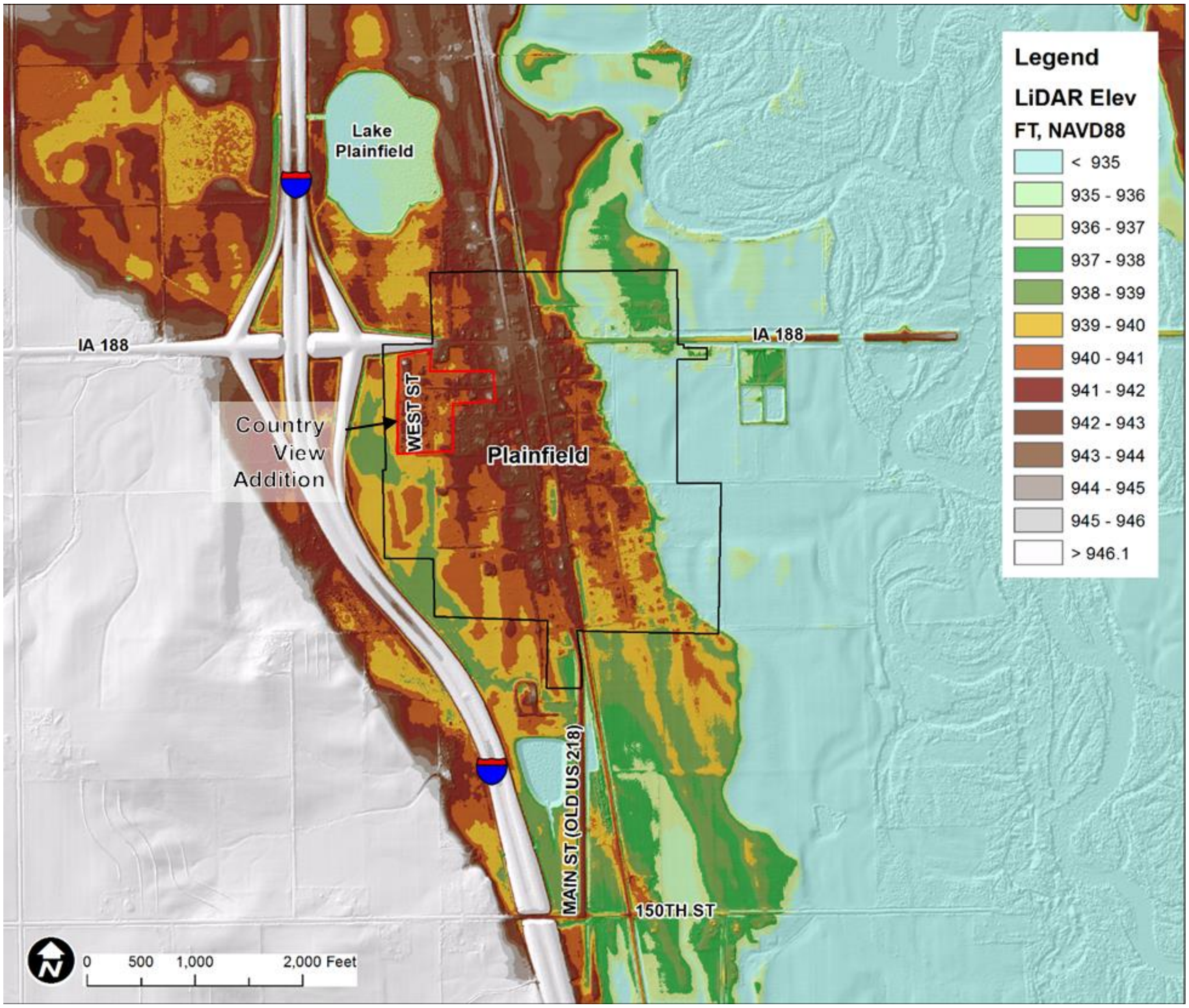

Figure 2.2. Base-earth LiDAR elevations (ft, NAVD88). Plainfield is located on a Cedar River floodplain terrace.

2.2 Land Use

The existing land use in Plainfield consists of low intensity residential development, with some impervious surface area due to roads, structures and parking lots, as depicted in high resolution land cover data provided by the Iowa DNR, shown in Figure 2.3. Much of the surrounding land use is agricultural, consisting of corn, soybeans and pasture.

2.3 Soil Characteristics

Plainfield is located on the Iowan Surface landform, which is characterized by long, gently rolling slopes, low relief and open views of the horizon. River valleys in this region were developed in glacial deposits of sand and gravel, creating deep aquifers (Prior, 1991). Drainage networks are well developed, but stream gradients are low with some areas of poor drainage. The glacial deposits are typically overlain with a thin layer of unconsolidated deposits, primarily lean clay (USACE, 1987). This overlying layer is typically impervious or semi-impervious, with low infiltration rates. This is also reflected in the USDA-NRCS's SSURGO data, shown in Figure 2.4, with the area characterized as being fine-loamy over a sandy or sandy skeletal layer.

In July 1985, the US Army Corps of Engineers (USACE) conducted sub-surface investigations as part of a proposed Section 205 Flood Control Project. Exploratory borings were drilled in the area to verify the subsurface characteristics. A thin layer of either a "dark brown silty sandy lean clay or a dark brown silty sand" was present in each of the ten exploratory borings (USACE, 1987). The thickness of the thin deposit ranged from 1 to 5 feet, with an average thickness of 3 feet. Underlying the thin layer were extensive deposits of sand and gravel.

The NRCS characterizes Hydrologic Soil Groups (HSGs) using the soil layer with the lowest saturated hydraulic conductivity within the profile. HSGs for the study area are shown in Figure 2.5. Corresponding soil characteristics for the HSGs are shown in Table 2.1. In general, groups A, B, C, and D have low, moderately low, moderately high, and high runoff potential, respectively. Much of the agricultural catchment areas contain several HSGs, with the lower lying waterway areas being type C/D, a dual hydrologic soil group, indicating a water table within 24 inches of the surface. Dual classifications describe the runoff potential for drained and undrained conditions. A narrow band of low-lying areas just west of US-218 are group B/D. These low-lying areas have historically experienced frequent flooding and issues resulting from a high water table. An adjacent area farther to the west are a mixture of groups A and B.

Table 2.1. NRCS Hydrologic Soil Group (HSGs) characteristics (NRCS, 2007) when a water impermeable layer exists at a depth between 20 and 40 inches

Soil property	Hydrologic soil group A	Hydrologic soil group B	Hydrologic soil group C	Hydrologic soil group D
Saturated hydraulic conductivity of the least transmissive layer	>40.0 µm/s (>5.67 in/h)	≤40.0 to >10.0 µm/s (≤5.67 to >1.42 in/h)	≤10.0 to >1.0 µm/s (≤1.42 to >0.14 in/h)	≤1.0 µm/s (≤0.14 in/h)
	and	and	and	and/or
Depth to water impermeable layer	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	50 to 100 cm [20 to 40 in]	<50 cm [<20 in]
	and	and	and	and/or
Depth to high water table	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	60 to 100 cm [24 to 40 in]	<60 cm [<24 in]

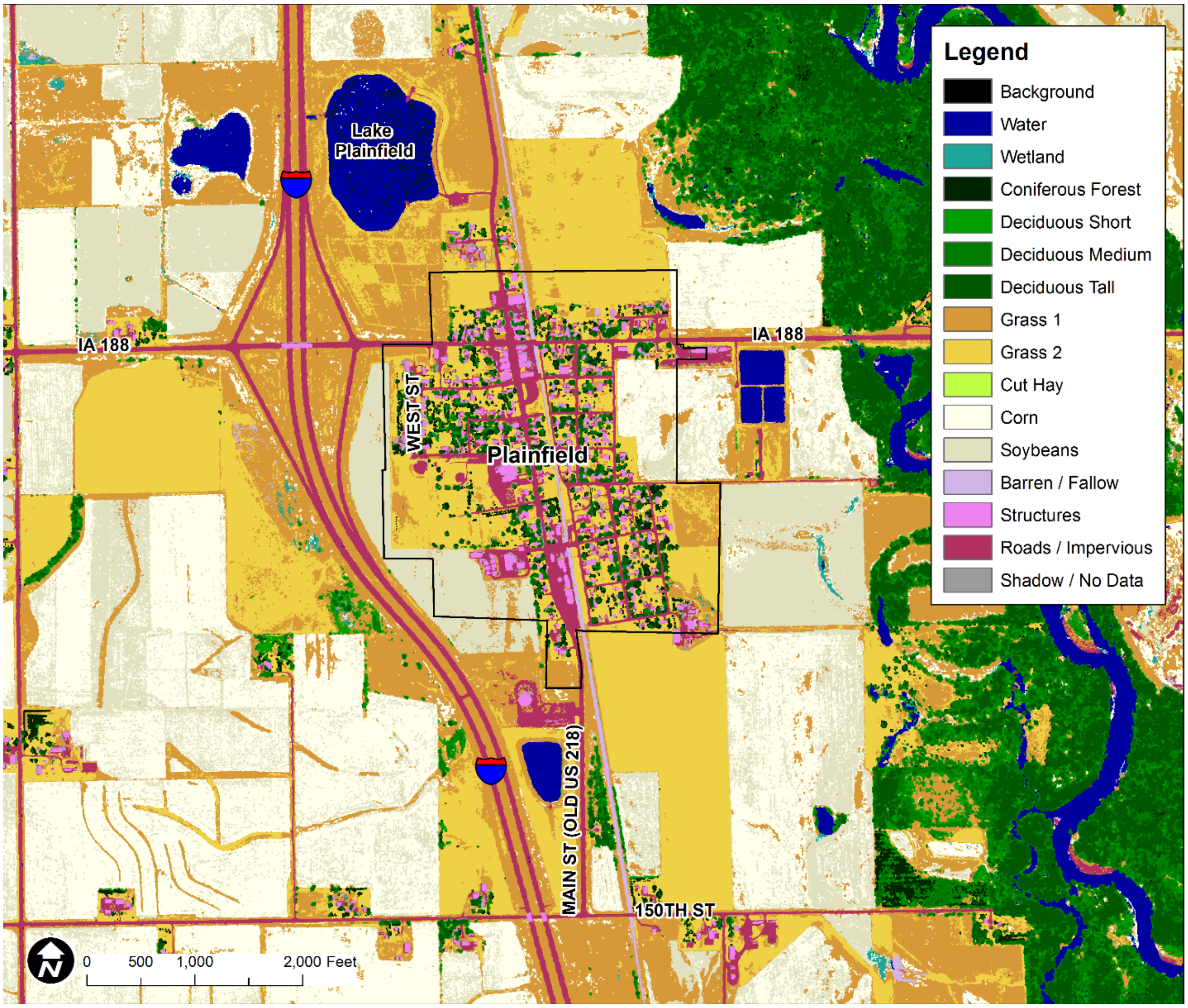

Figure 2.3. Land use in the study area based on High-Resolution Land Cover data provided by the Iowa DNR (2009).

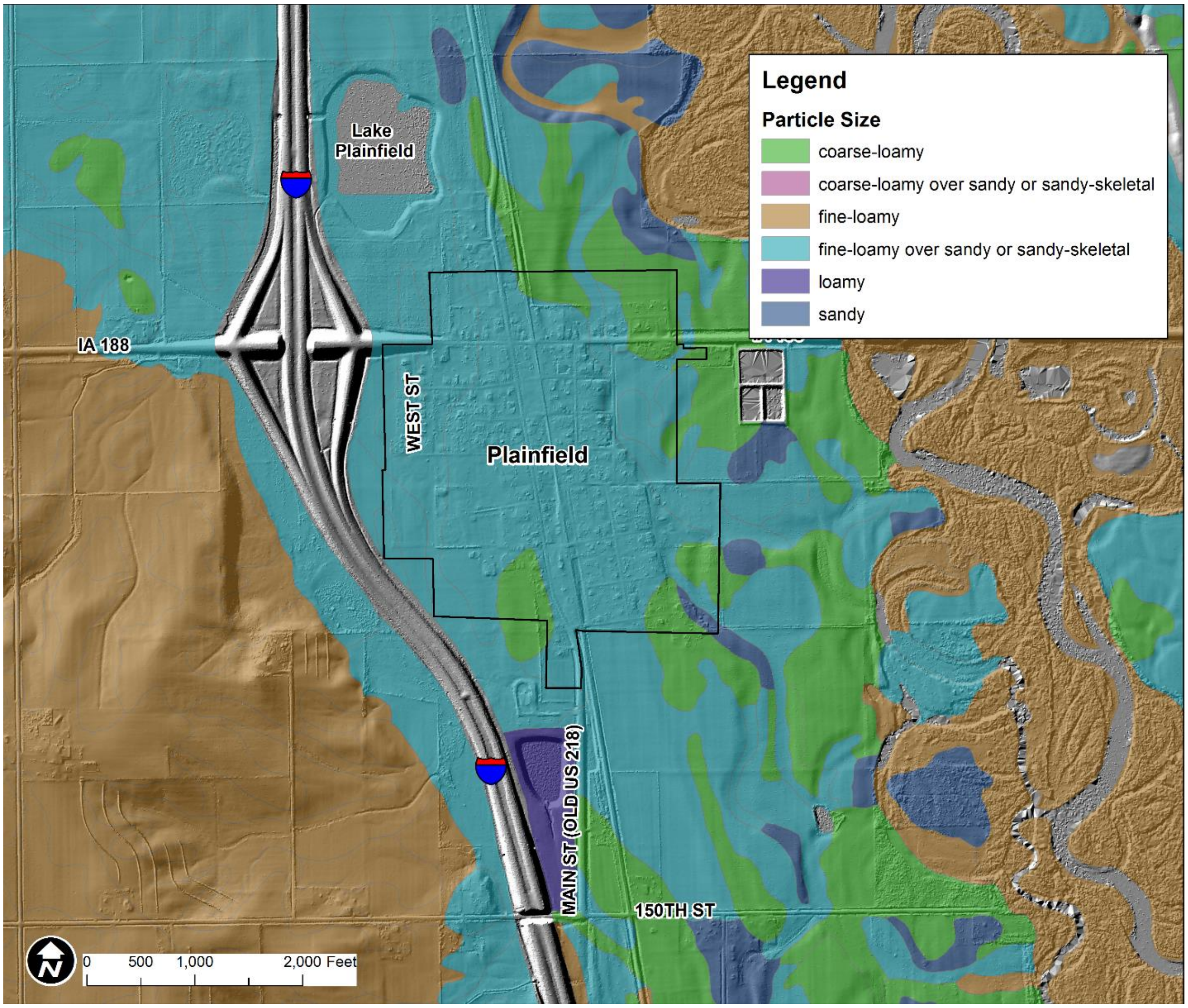

Figure 2.4. Soil particle size descriptions from USDA-NRCS SSURGO database. Much of the topsoil in Plainfield is characterized as fine-loamy soil over a sandy skeletal layer.

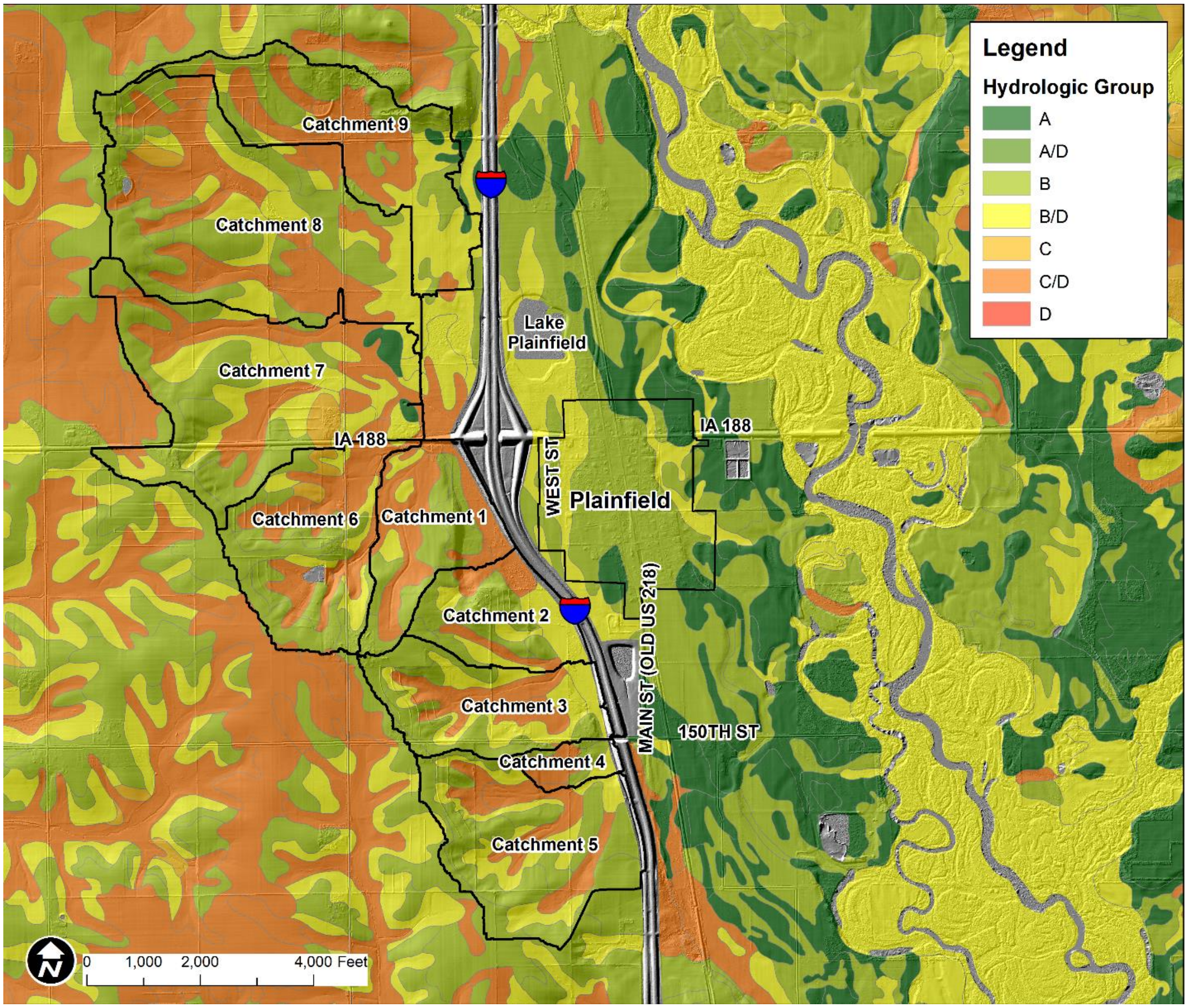

Figure 2.5. Hydrologic soil types based on the USDA/NRCS SSURGO dataset. Dual classifications (e.g., B/D) indicate a seasonal water table within 24 inches of the surface.

2.4 Hydrology

Upland agricultural catchments west of Plainfield, shown in Figure 2.6 and Figure 2.7, contribute runoff that leads to flooding of low-lying areas. These small agricultural catchments vary in drainage area of 25 to 388 acres, and total approximately 1730 acres.

Iowa DOT policy generally dictates that their constructed projects should not alter the existing general waterway flow path or outlet significant drainage areas into other waterways. After record flooding along the Cedar River in 2008 and a significant local rainfall event in 2016, the city of Plainfield expressed concern that drainage patterns had been adversely affected, resulting in an increased frequency of flooding near the west side of Plainfield, south of Highway 188. In 2010, the Iowa DOT completed a study that identified measures to restore the drainage patterns to pre-project conditions. Modifications to the inlet and outlet of Culvert #1 and nearby storm sewer systems were completed as a result of the study, improving the ability to contain the 50-percent-annual-chance (2-year) event within the City's storm sewer system.

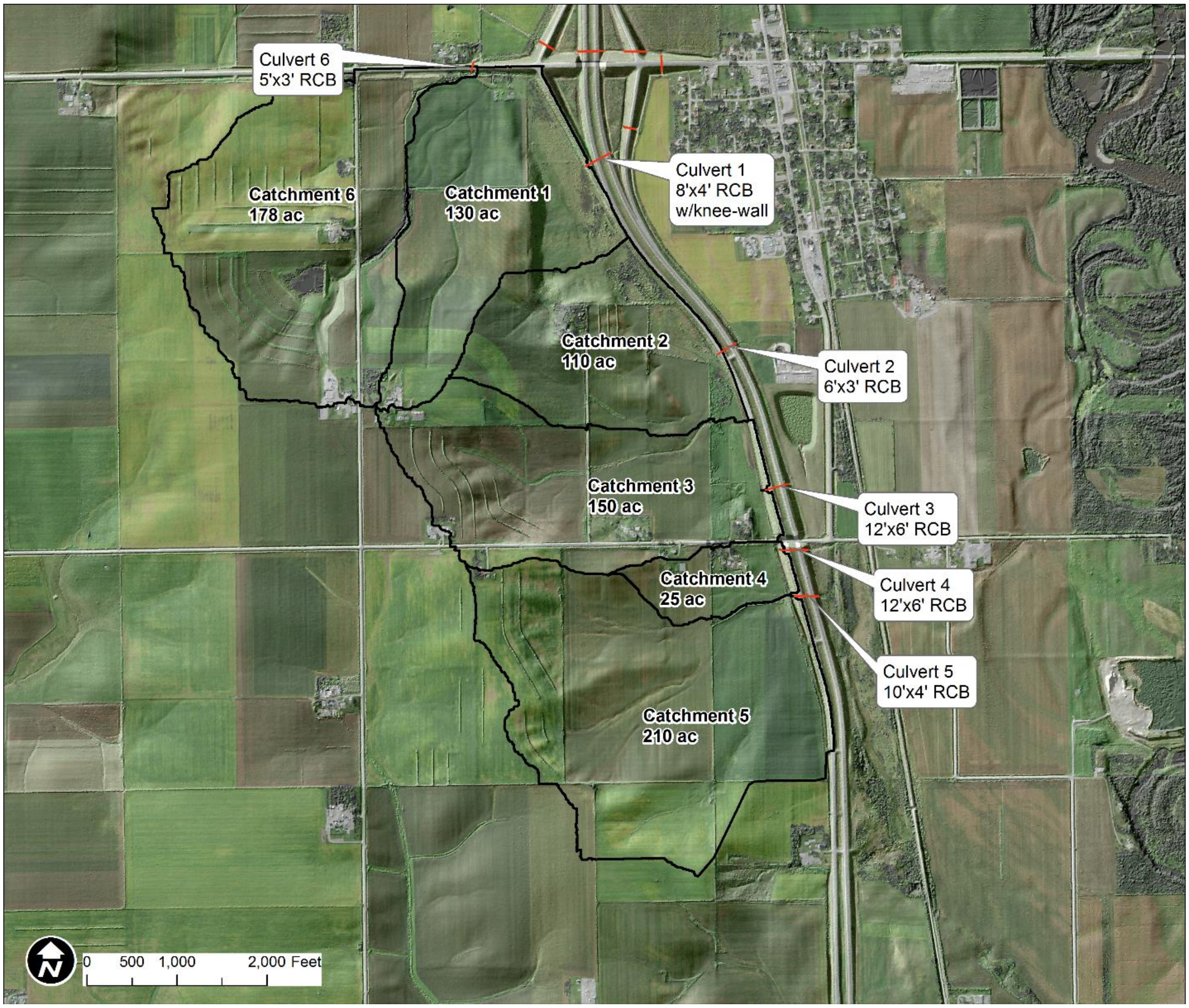

Figure 2.6. Catchments west of Plainfield.

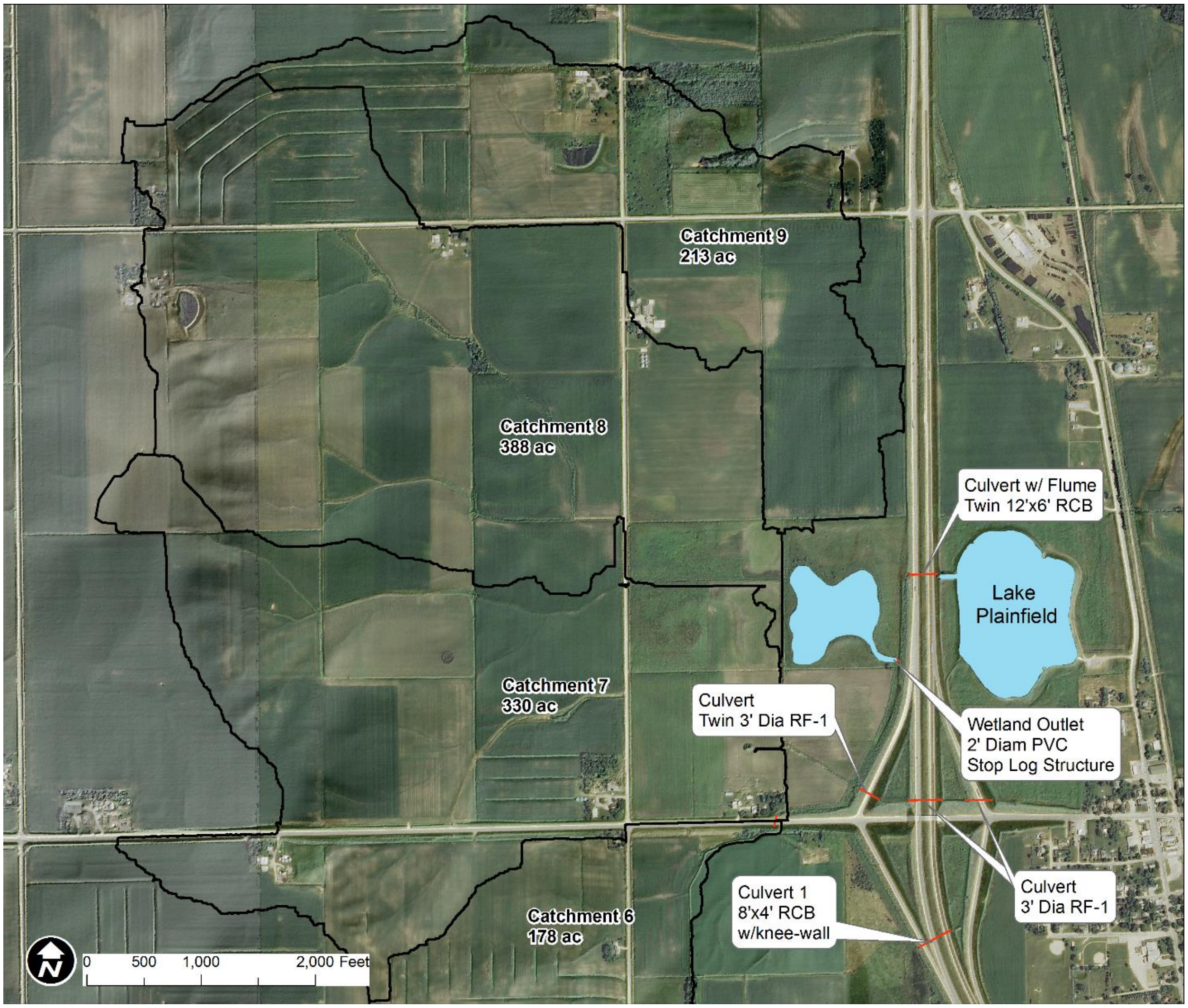

Figure 2.7. Catchments northwest of Plainfield.

As shown in Figure 2.6, catchment runoff conveyed under US-218 through culverts 1 through 5 proceeds in a southeasterly dominant overland flow path at high flow events. Smaller, more frequent, events result in runoff conveyed through culverts 1 through 5 that may flow in a northern direction, filling low lying areas, particularly those between US-218 and the west side of Plainfield, before beginning to flow southeast.

Catchments 6 through 9, shown in Figure 2.7, drain into an Iowa DOT wetland mitigation site, with an overflow draining into either Lake Plainfield or the northwest interchange quadrant through culvert structures. The primary outlet for Lake Plainfield is a 36-inch pipe, which conveys overflow through the city of Plainfield's storm sewer system, shown in Figure 2.8 before eventually being discharged to an open ditch that outlets to the Cedar River.

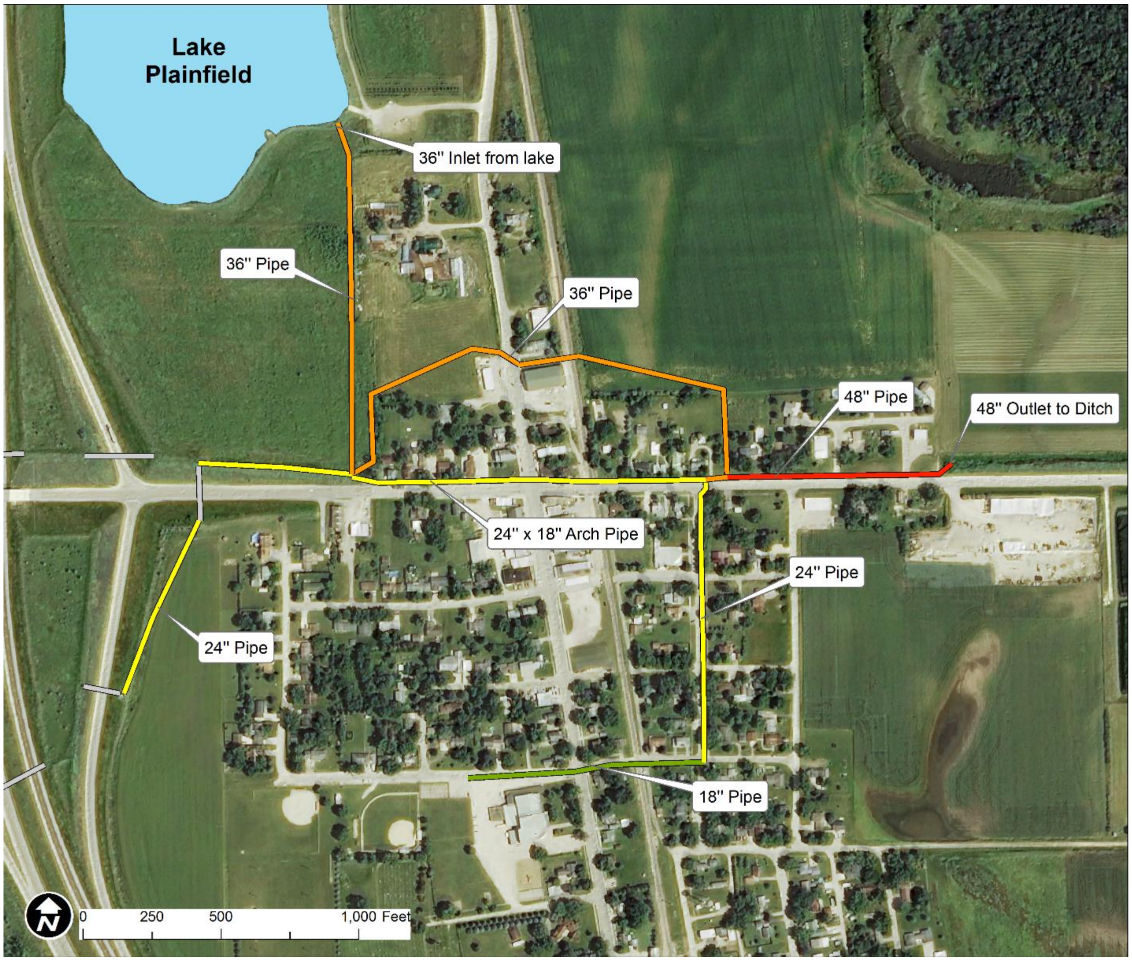

Figure 2.8. Storm sewer mains, colored by pipe size.

Surface water between US-218 and the west side of Plainfield can leave via two culvert locations along Main Street. The northernmost culvert under Main Street, shown in Figure 2.9, is located just east of the Landus Coop. The southernmost culvert under Main Street, shown in Figure 2.10, allows flow to enter two culverts under 150th Street. Once at the Iowa DOT Wetland Mitigation Area, flow must pond to a sufficient elevation to overcome natural ground within the wetland mitigation area. The construction of the wetland involved the lowering or matching of existing ground elevations which did not obstruct the natural flow of water. An abandoned entrance in the south ditch of 150th Street near the railroad likely obstructs low flow.

Figure 2.9. One of the outlets for runoff is a culvert under Main Street and two culverts under the railroad embankment. Photographs provided by Andy Luck.

Figure 2.10. The other outlet is through culverts near the intersection of Main and 150th Streets, prior to entering the Iowa DOT wetland Mitigation Area. Photographs provided by Andy Luck.

Smaller rainfall events can result in runoff traveling north from the wetland mitigation area through culverts under 150th St. This reverse flow was videotaped by City of Plainfield Maintenance Supervisor Andy Luck on February 26, 2018, following a snow melt event. A capture of the video with annotations is shown in Figure 2.11.

Once water ponds to a sufficient level near the intersection of Main and 150th streets, water will continue flowing through the wetland mitigation area, reaching a railroad trestle bridge located at the southeast corner of the wetland mitigation area, shown in Figure 2.12. It is possible that high ground on Canadian National Railway or the privately-owned property just to the east of the trestle bridge opening may be an impediment to flow. A defined outlet at this location would allow flood waters to continue flowing through the mitigation area.

Figure 2.11. Runoff flowing north from Iowa DOT Wetland Mitigation Area by traveling under 150th St. Video captured by Andy Luck following a snow melt.

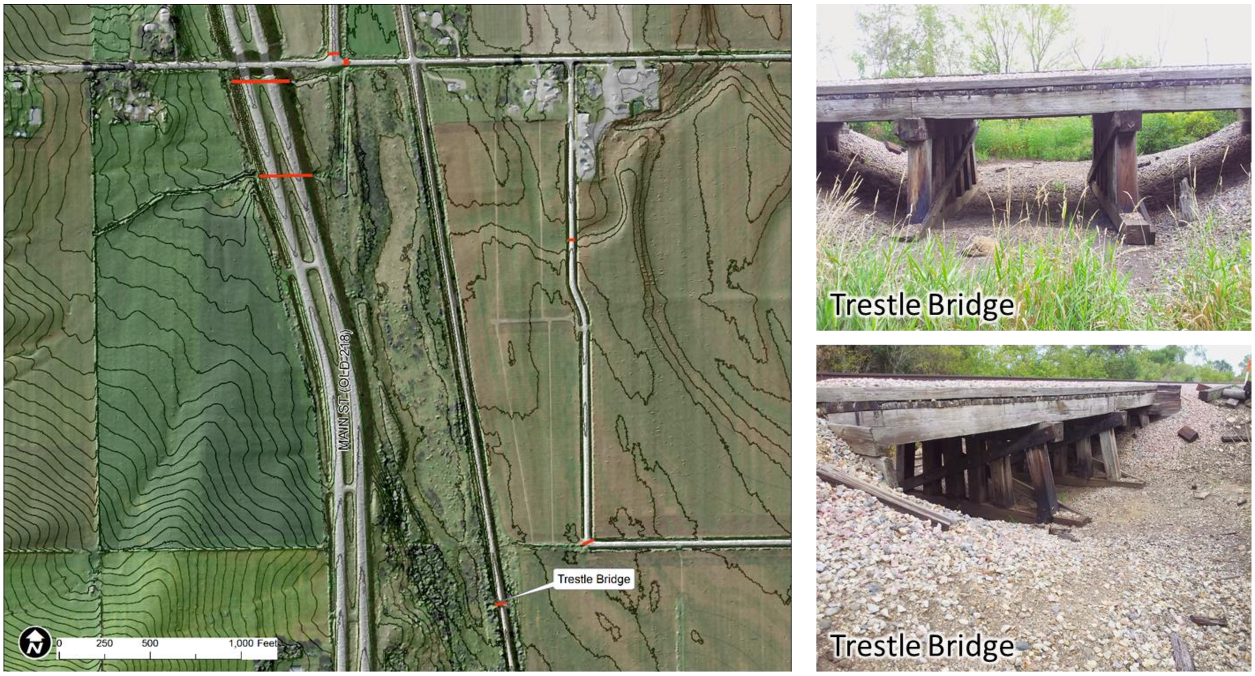

Figure 2.12. Location of the trestle bridge, the only outlet for the Iowa DOT Wetland Mitigation Area. Photographs provided by Andy Luck.

3. FLOOD OF 2016

3.1 Rainfall Events

A series of heavy rainfall events occurring from September 21 – 24, 2016, caused major flash flooding and overwhelmed the local drainage system. Estimated cumulative daily rainfall, shown in Figure 3.1, was provided by the National Center for Environmental Prediction (NCEP) (Lin, 2017). Portions of the study area received approximately 10 inches of rainfall in a 40 hour period, as shown in Figure 3.2. As successive rainfall events occurred, the event became increasingly more damaging and statistically uncommon. Figure 3.3 shows the first rainfall event totaled 2.9 inches over a 6 hour period, which corresponds to approximately the 2 – 5 year storm (National Weather Service, 2017). Over a 24 hour period, the rainfall totaled 6.3 inches, corresponding to the 25 – 50 year storm (National Weather Service, 2017). Over a 48 hour period, the rainfall totaled 9.2 inches, corresponding to approximately the 200 – 500 year storm (National Weather Service, 2017).

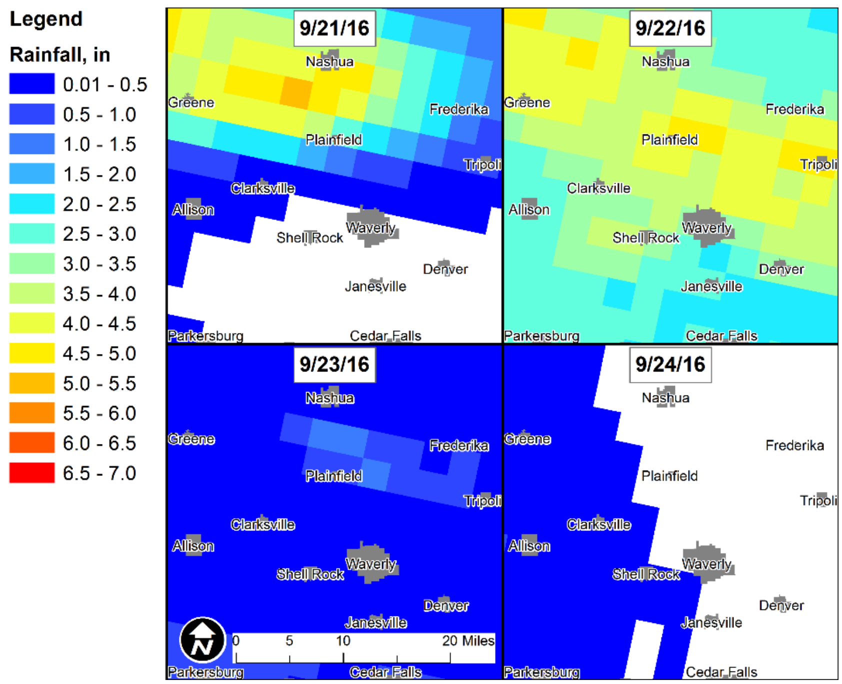

Figure 3.1. Estimated daily rainfall totals generated using Stage IV radar rainfall estimates. Stage IV radar rainfall is developed using multi-sensor corrections and quality control by the NWS River Forecast Centers.

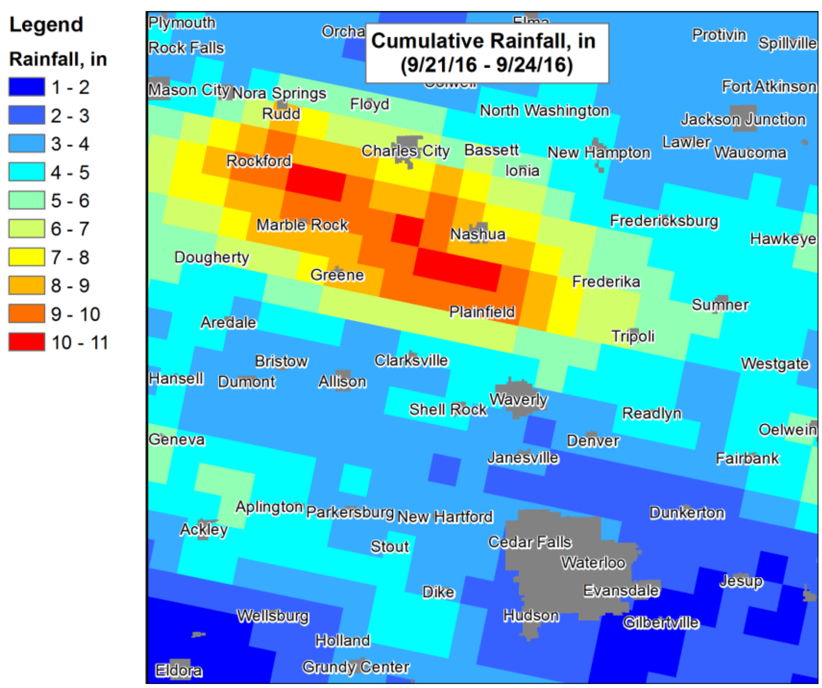

Figure 3.2. Estimated rainfall totals for September 21 - 24, 2016, generated from Stage IV radar rainfall estimates.

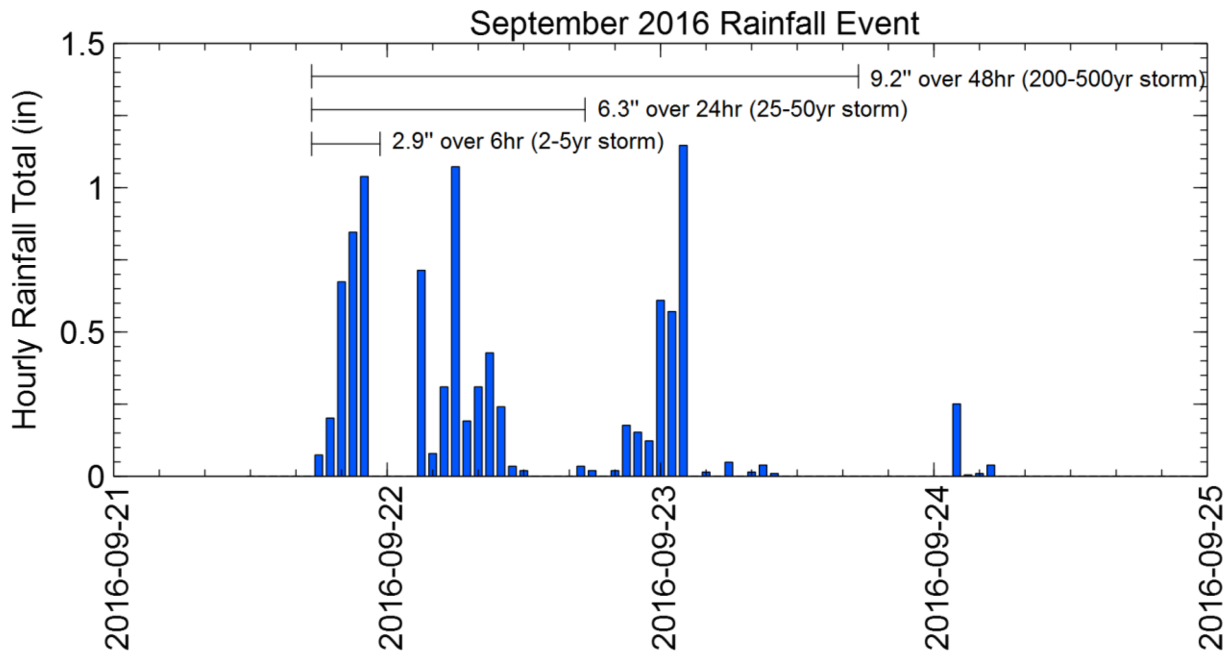

Figure 3.3. Hourly rainfall totals near Plainfield during the September 2016 Flood derived from Stage IV radar rainfall estimates. As successive rainfall events occurred, the event became increasingly more damaging and uncommon.

3.2 Flooding Extent

The series of rainfall events generated large quantities of runoff in the nearby agricultural catchments, and eventually caused severe flooding in Plainfield. Surface flooding was documented by Kip Ladage, Bremer County Emergency Management Coordinator, in several drone videos captured September 23rd and 24th, 2016. Runoff from catchments 6 – 9, west of US-218 and north of IA-188, flowed into Lake Plainfield, exhausted lake storage and overwhelmed the 36 inch storm sewer outlet. Surface water then flowed overland in a southerly direction, passing under IA-188 through a culvert and inundating several homes near West Street. In addition to surface flooding, many homes also incurred damages from ground water resulting in basement flooding. A view looking north towards Lake Plainfield during the 2016 event is shown in Figure 3.4.

Large quantities of runoff were generated in catchments 1 – 5 that eventually flowed under US-218 through several culverts, combining with Lake Plainfield overflow in the areas between US-218 and the west side of Plainfield, which can be seen in Figure 3.5. The main outlets for the flood water is traveling through Main St., 150th St. the railroad, and eventually, the Iowa DOT wetland mitigation area, shown in the bottom of Figure 3.6.

Figure 3.4. Drone footage captured at 5:00pm September 23, 2016 by Kip Ladage, Bremer County Emergency Management Coordinator. View is looking north towards Lake Plainfield.

Figure 3.5. Drone footage captured at 5:00pm September 23, 2016 by Kip Ladage, Bremer County Emergency Management Coordinator. View is looking south along the area between US-218 and the west side of Plainfield.

Figure 3.6. Drone footage captured at 5:00pm September 23, 2016 by Kip Ladage, Bremer County Emergency Management Coordinator. View is looking north near the intersection of Main and 150th streets, south of Plainfield.

4. HIGH GROUNDWATER TABLE

The high ground water table and subsequent basement water damages were occurring regularly prior to construction of the US-218 bypass in the early 2000s. In 1987, the USACE Rock Island District completed a draft report (USACE, 1987) investigating flooding affecting Plainfield under the authority of Section 205 of the 1948 Flood Control Act. The project was initiated following a meeting with former Plainfield Mayor Emmit Kiehm in 1983. At the time, several homes were sustaining almost annual basement water damages caused by the high groundwater table. Many of these homes were built in the 1970s as part of the County View Addition, along West Street. USACE determined the high ground water table was likely being maintained by the large areas of standing water just west and north of the community. USACE investigated the cost and effectiveness of several alternatives but concluded, "A new diversion channel would intercept the upstream drainage and divert it to the Cedar River, thus practically eliminating the flood problem and greatly reducing the groundwater problems in the Plainfield Community." However, the recommended construction projects presented in this report were not pursued.

Andy Luck, city maintenance supervisor, provided historical monthly measurements of the depth to the city well static water level from 2004 – 2017, shown in Figure 4.1. There is an apparent upward trend in the monthly water level measurements over the historical record. Peak water levels of at least 10 feet occurred in six of the 14 years of record. City Councilman David Lehman thought water levels of 10 feet and higher coincide with basement flooding at his residence on West Street (D. Lehman, personal communication, 2/28/2018). A well static water level of 10 feet would correspond to an elevation of approximately 931 ft, NAVD88 at the well location. Based on bare earth LiDAR, the basement floor elevation of many homes on West Street are likely located at approximately elevation 934 ft, NAVD88. Assuming the water table slopes upwards with the terrain, it is likely this could intersect basement floor elevations.

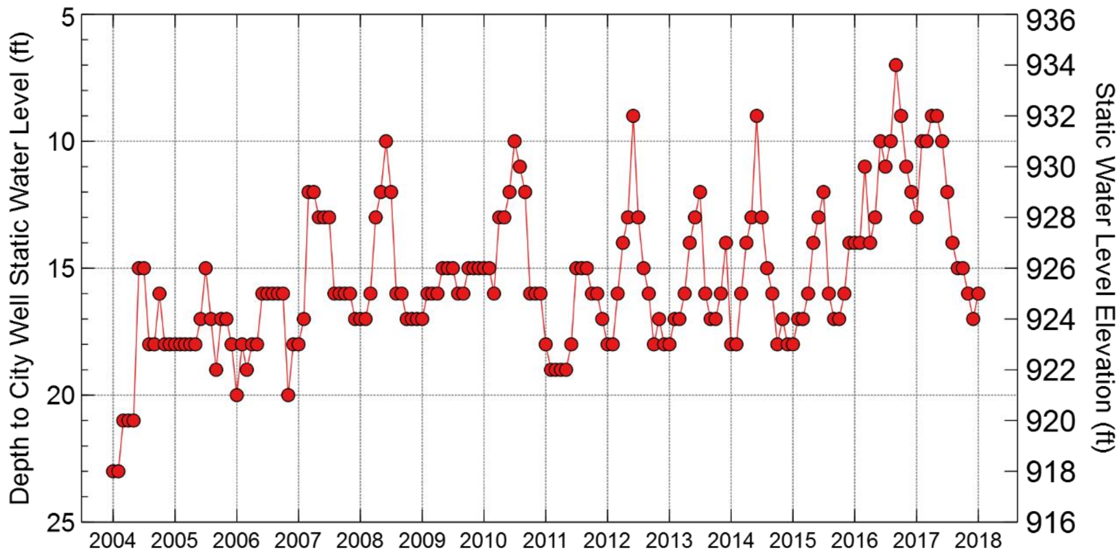

Figure 4.1. Historical monthly measurements of the depth to the city well static water level from 2004-2017. Water level elevations were estimated using the approximate LiDAR grade elevation at the well location.

Additional historical static water levels at the time and location of well drillings are available online in the Iowa Geological Survey's GeoSAM database (IGS, 2018). These measurements were also converted to an elevation using LiDAR data and plotted along an east-west cross-section through Plainfield, shown in Figure 4.2. A hypothetical normal water level profile was developed based on the city well historical measurements. Hypothetical low and high water level profiles were developed using the range of city well historical measurements. The hypothetical normal water level profile is typically around five feet below West Street basement floor elevations. Periodic high water levels would likely intersect the basement, causing flooding. This is consistent with City Councilman David Lehman's statements.

Development of the hypothetical water level profiles required several assumptions. In reality, water levels vary depending on location, presence of any underlying impervious soil layers, proximity to any ponded surface water, and many other factors. Given the presence of underlying impervious soil layers found in exploratory soil borings collected by USACE, and the conclusions of the 1987 Section 205 study, it is possible nearby standing water could be contributing to the high groundwater levels affecting the community.

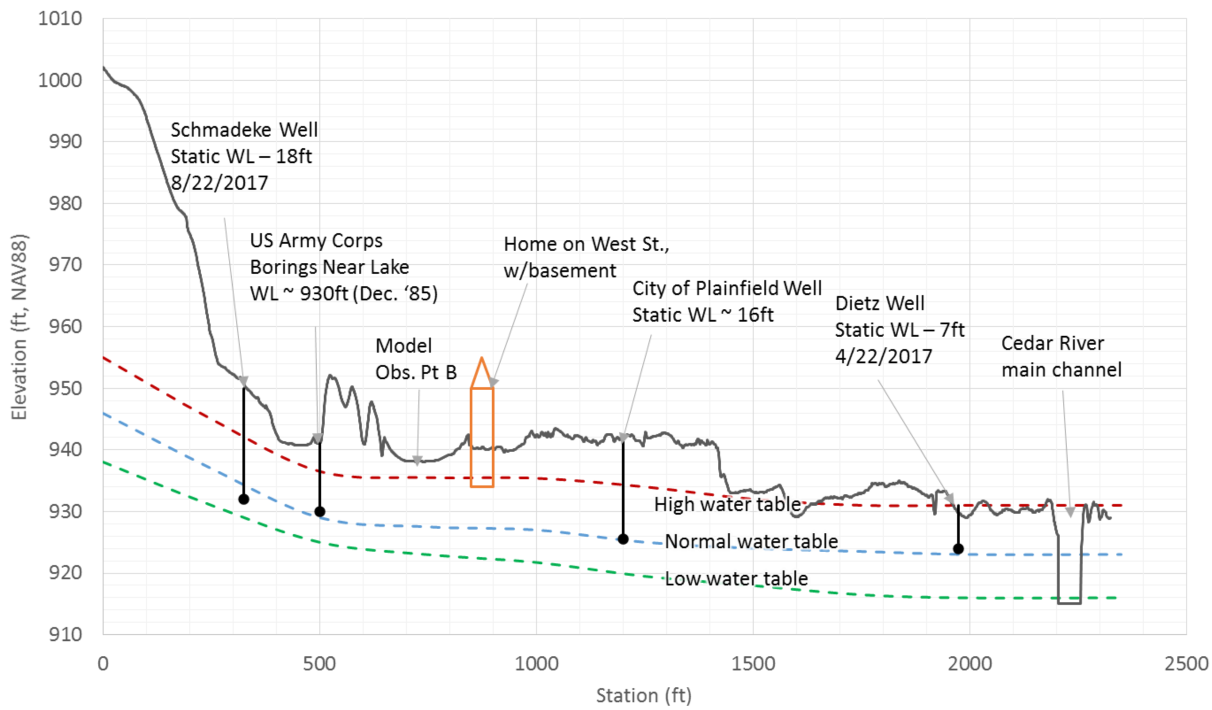

Figure 4.2. Plot of an east-west cross-section through Plainfield. Several historical measurements of depth to static water levels were plotted together with hypothetical high-, low, and normal water table profiles.

5. MODEL DEVELOPMENT

A computer model was developed to simulate the hydrologic and hydraulic processes occurring in the study area. The model was developed using XPSWMM, a fully dynamic hydrologic and hydraulic modeling software that combines one-dimensional (1D) elements with a two-dimensional (2D) overland hydraulic model (Innovyze, 2018). This model is capable of simulating rainfall-runoff and storm water flood flow as it travels through the study area and interacts with infrastructure including culverts, ditches, and bridges.

5.1 Hydrologic Modeling

Agricultural catchments west of US-218 were modeled using lumped parameter hydrologic models. The transformation of rainfall to a runoff hydrograph was modeled using the SCS Unit Hydrograph method. The time of concentration (TOC) for each catchment was calculated using NRCS's WinTR-55 software. TOCs ranged from 0.5 – 2 hours, which is expected due to the relatively short flow paths from the most distance location to the outlet of each catchment. The partitioning of rainfall into runoff and infiltration was accomplished using the SCS curve number (CN) method. Assuming average antecedent moisture conditions, CNs ranged from 76 – 81, indicating moderate runoff potential as a result of HSGs and agricultural land use.

Rainfall east of US-218 was modeled by applying rainfall volume directly onto the 2D hydraulic model grid of the terrain. Infiltration in this area was modeled using the Green-Ampt method. The underlying soil type was assumed to be sandy clay, with corresponding properties listed in Table 5.1.

Table 5.1. Infiltration method and soil properties used in the 2D hydraulic model.

Infiltration Method	Green-Ampt
General Soil Type	Sandy Clay
Average Capillary Suction	9.4 in
Porosity	0.321
Initial Moisture	0.16 (50% saturated)
Saturated Conductivity	0.05 in/hr

5.2 Hydraulic Modeling

Structures were modeled using 1D unsteady flow elements in XPSWMM. Structures modeled included culverts, storm sewers, and ditches. Culvert dimensions and invert elevations were provided by the Iowa DOT in the form of as-built plan sets and field measurements. Dimensions and photographs of county-owned culverts were provided by City of Plainfield Maintenance Supervisor Andy Luck. Storm sewer dimensions and invert elevations were provided in the form of as-built plan sets by the City of Plainfield. The resolution of the 2D hydraulic model was not sufficient to capture the geometry of some roadway ditches, therefore they were modeled using

1D elements with cross-sections extracted from bare-earth LiDAR elevation data provided by the Iowa DNR.

The 2D hydraulic model (XP2D) used to simulate overland flood flow had a resolution of 25 feet. The 2D model grid was also used on the west side of US-218 to account for storage and infiltration near the roadway embankment. Manning's n roughness values are shown in Figure 5.2.

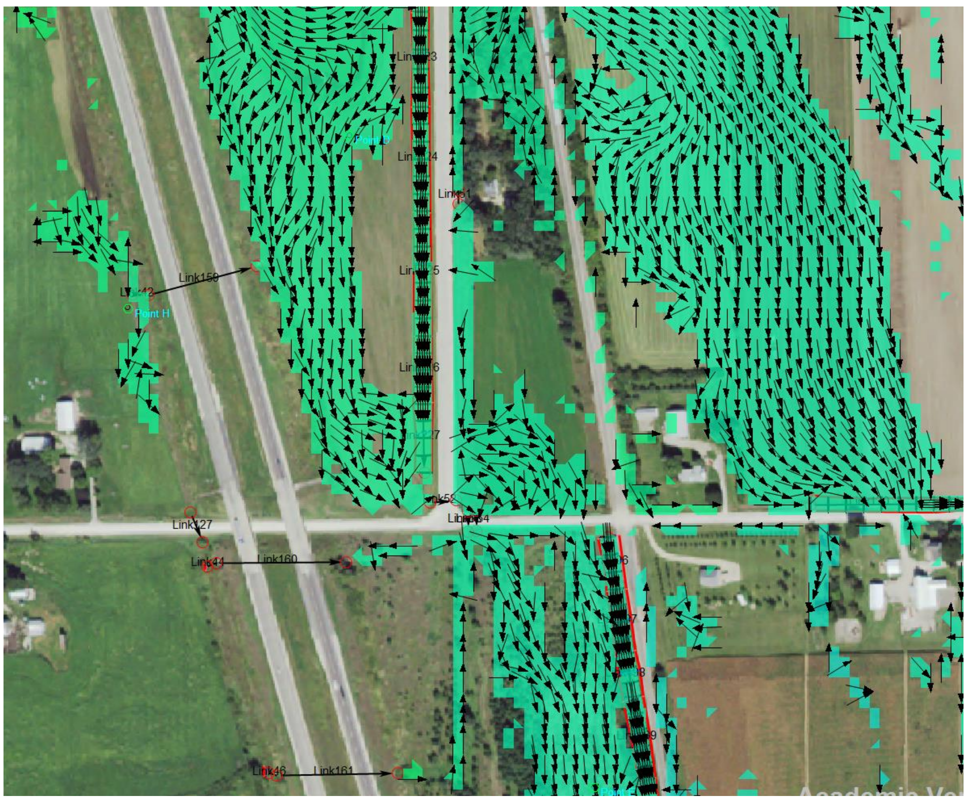

Figure 5.1. The XPSWMM model is capable of simulating rainfall-runoff, infiltration and flood through drainage system using a combination of 1D structure elements connected to a 2D grid of the terrain.

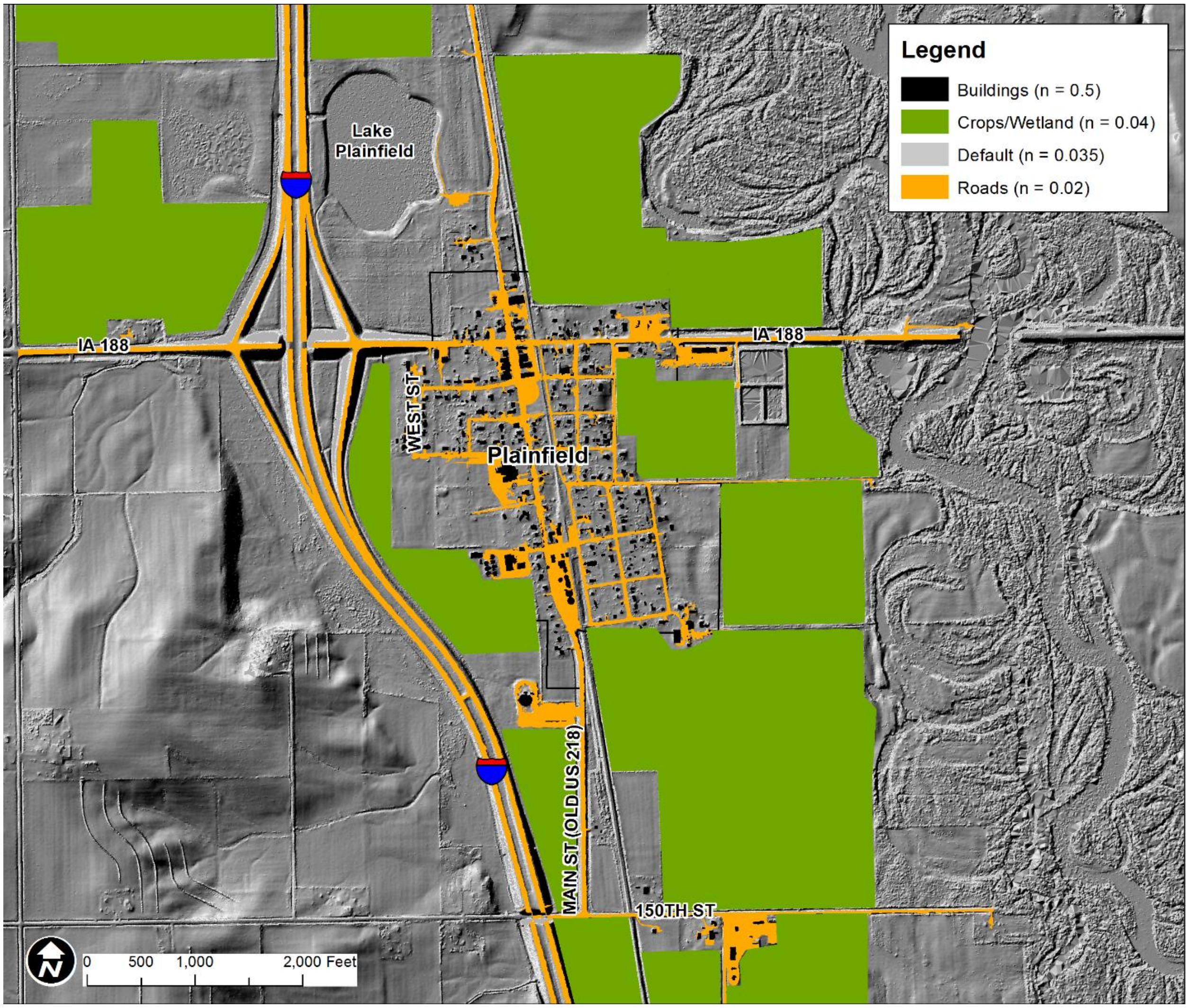

Figure 5.2. Manning's n roughness values for the 2D hydraulic model.

6. MODEL VALIDATION

The best available data for model validation are the Flood of September 2016 drone videos captured by Kip Ladage, Bremer County Emergency Management Coordinator. Qualitative comparisons of the simulated and observed flood extents were made from several viewpoints corresponding to the time of captured drone footage. An example comparison of the area between Plainfield and US-218 is shown in Figure 6.1. An example comparison of the area south of the Landus Coop and north of the Iowa DOT Wetland Mitigation Area is shown in Figure 6.2. The simulations appear to match the flooding extent in the drone videos closely.

Figure 6.1. Comparison of observed inundation during the September 2016 flood event (top) and XPSWMM simulated flood extent (bottom) displayed in Google Earth.

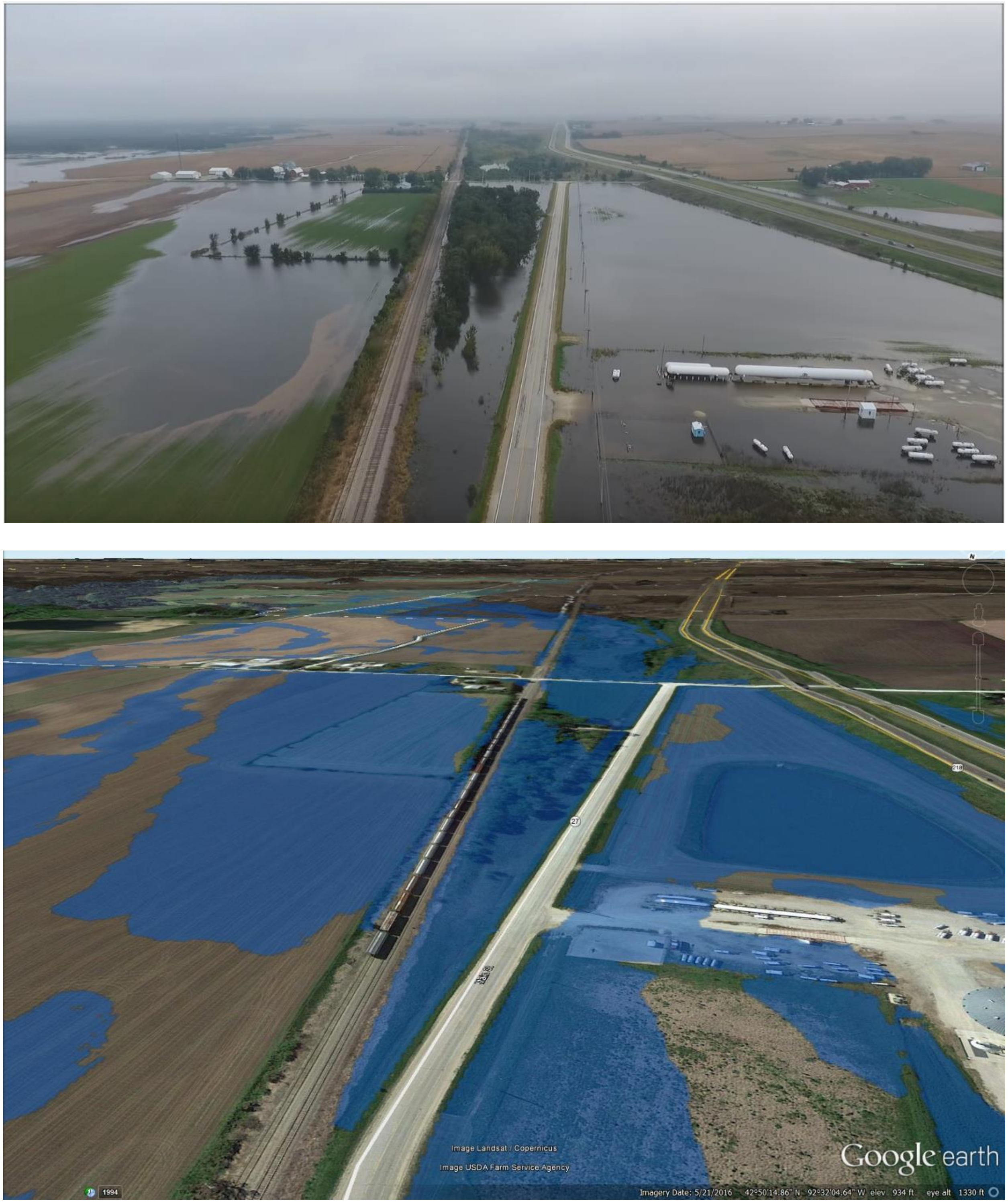

Figure 6.2. Comparison of observed inundation during the September 2016 flood event (top) and XPSWMM simulated flood extent (bottom) displayed in Google Earth.

7. MITIGATION SCENARIOS AND SIMULATION RESULTS

7.1 Mitigation Model Scenarios

The following subsections describe flood mitigation alternatives investigated with the final version of the model, created with XPSWMM software Version 2016.1.

Existing structure geometries were parameterized based on best available as-built plans, field measurements, and LiDAR data. This geometry was used as a baseline to quantify decreases in water surface elevations.

7.1.1 Kneewalls

Kneewall weirs were considered at Iowa DOT culvert inlets located on the west side of US-218, as shown in Figure 7.1. Kneewalls have a relatively small opening to throttle low flows, and a knee-height weir to allow higher flows to over top.

7.1.2 East Ditch

The East Ditch was designed to contain runoff from the west side of US-218 resulting from the 100-year rainfall event, and conveyed along the east side of the embankment without overtopping. This configuration exceeds the current right-of-way width available. A plan view with ditch dimensions is shown in Figure 7.2, with a profile view shown in Figure 7.2A.

7.1.3 East Ditch with Kneewalls

This is a combination of the previous East Ditch and Kneewalls configurations.

7.1.4 Both Ditches

This incorporates the previous East Ditch configuration along with an additional ditch on the west side of US-218, called West Ditch. The West Ditch configuration is shown in plan view with dimensions in Figure 7.3, with a profile view shown Figure 7.3A.

7.1.5 Both Ditches with Kneewalls

This is a combination of the East Ditch, West Ditch, and Kneewalls configurations.

7.1.6 Ditch to Lake, Large Overflow

This configuration, shown in Figure 7.4, attempts to prevent overtopping of Lake Plainfield by providing an additional lake overflow structure on the northeast corner of the lake. A profile view of the additional overflow structure is shown in Figure 7.4A. In addition, a combination ditch/berm would be constructed from the culvert outlet box near the northbound exit ramp to the IA-188 culvert. The berm would continue north of IA-188 around the south side of Lake Plainfield.

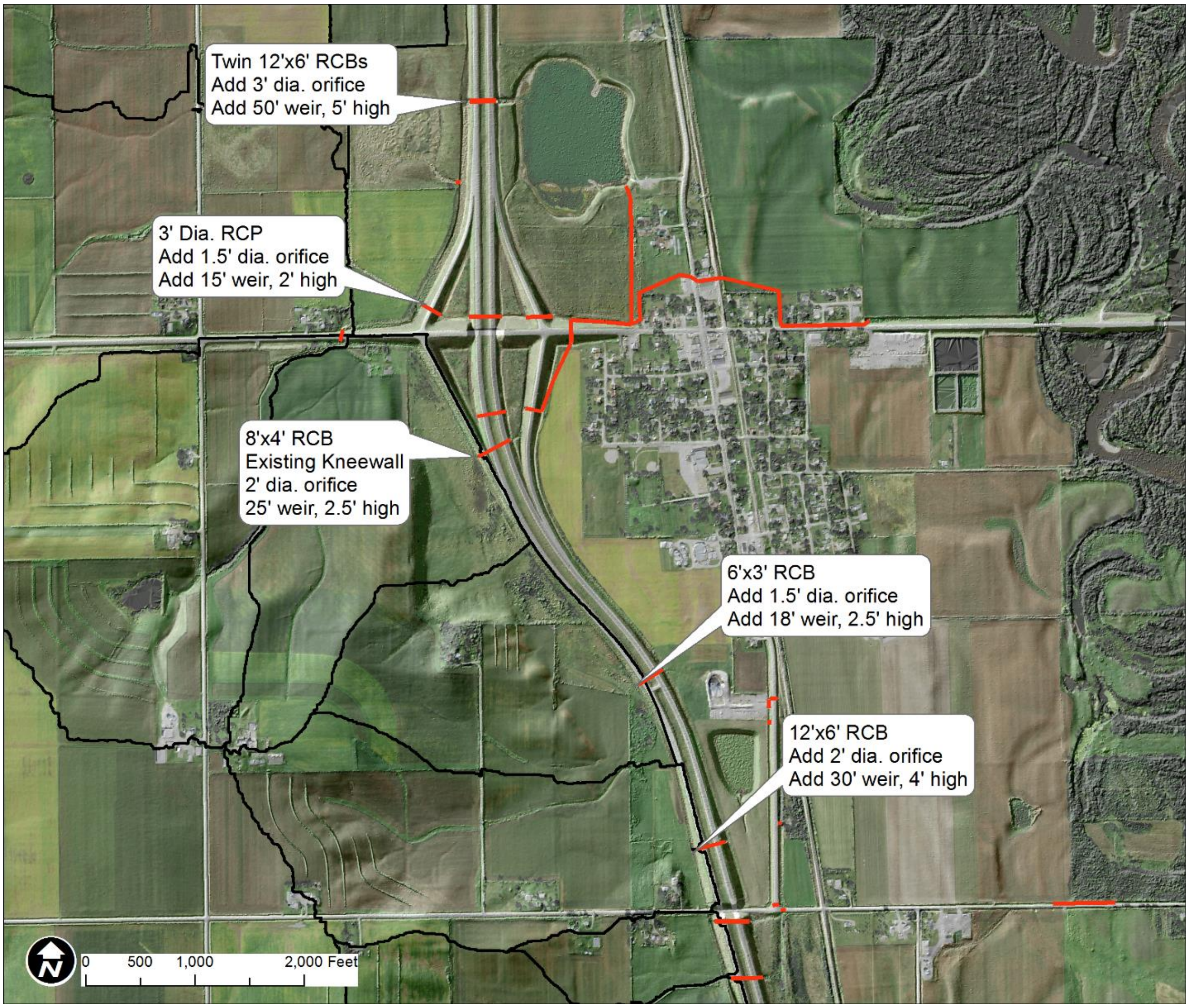

Figure 7.1. Potential kneewall weir locations at the inlets of Iowa DOT culverts. Kneewall weirs feature an orifice and knee-height weir to throttle low flows but allow high flows to overtop the weir.

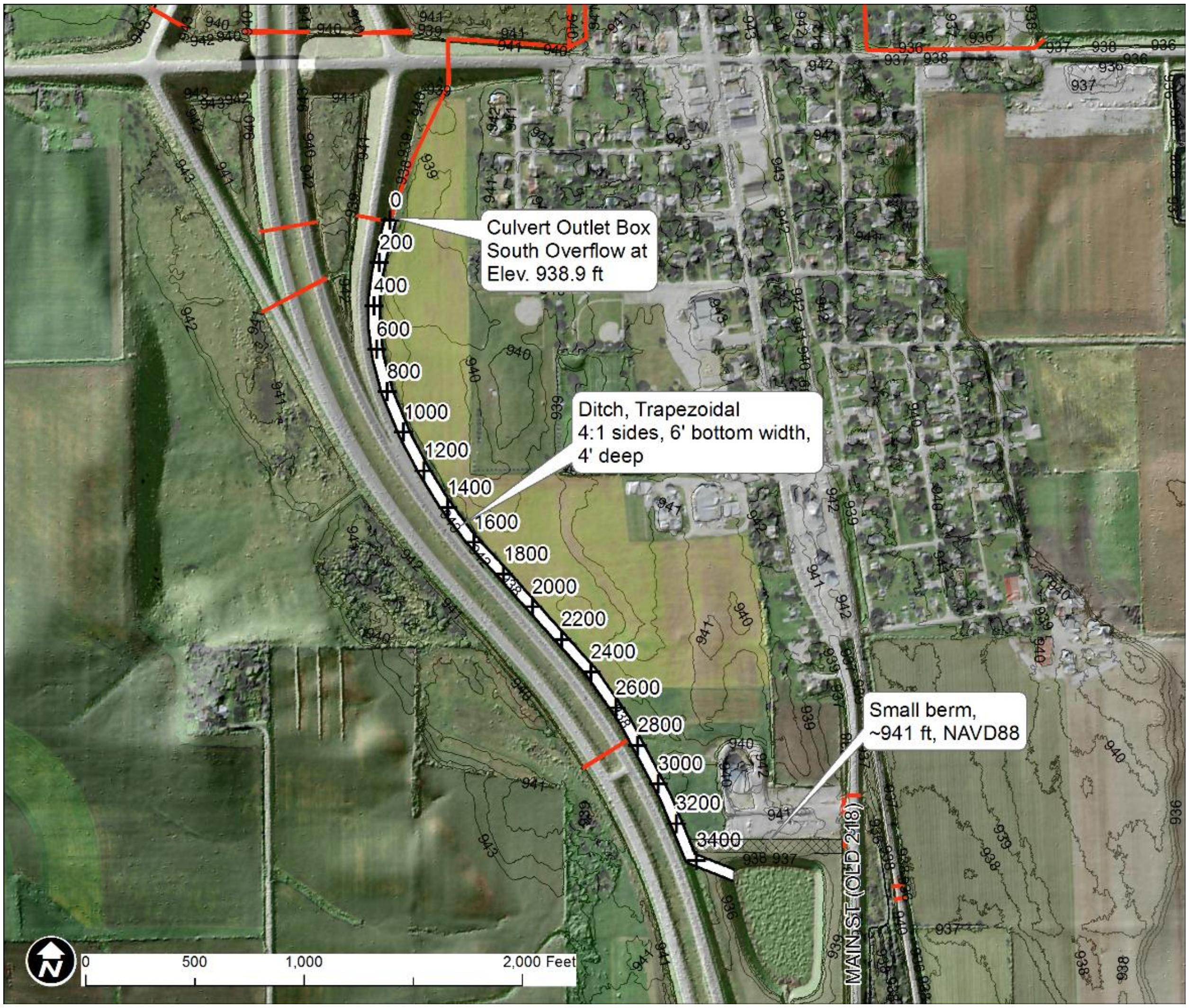

Figure 7.2. The initial East Ditch configuration.

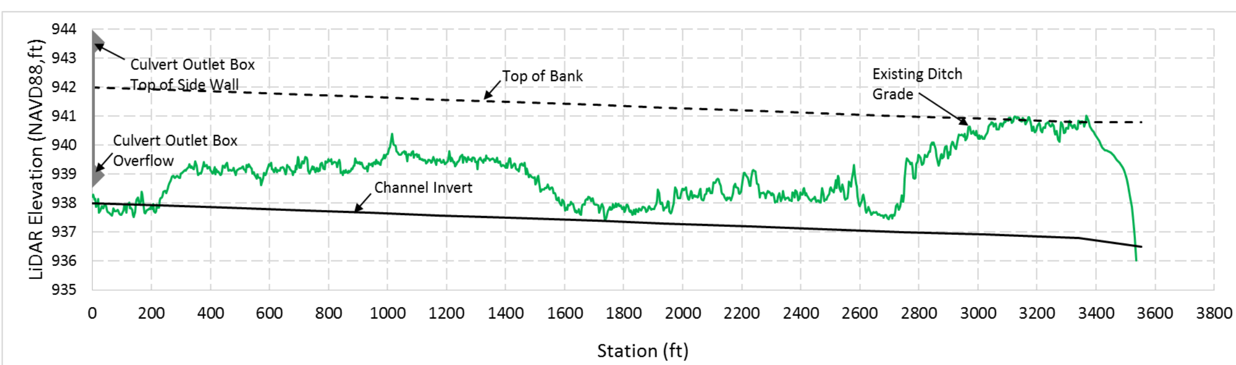

Figure 7.2A. Profile view of the initial East Ditch configuration.

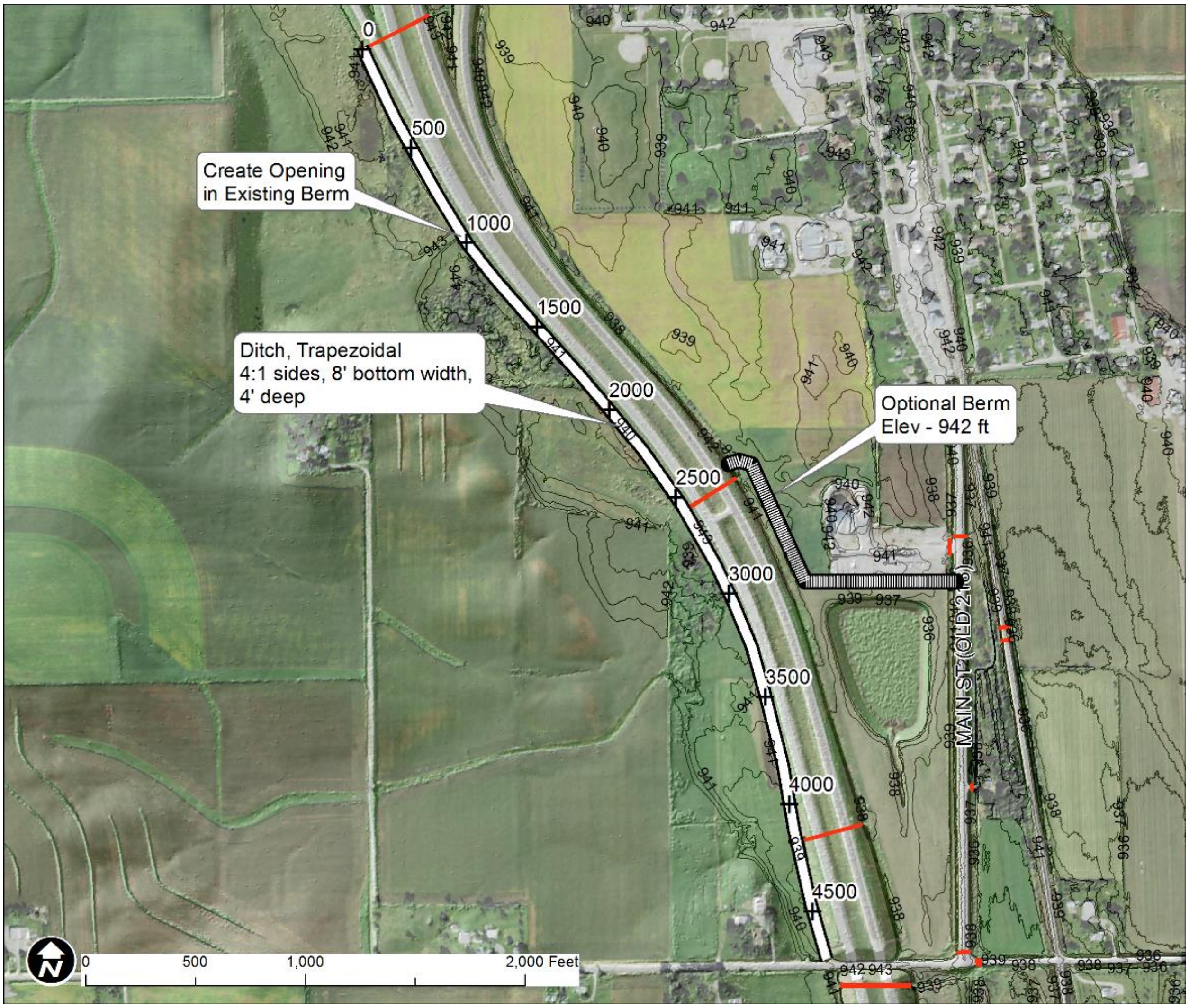

Figure 7.3. West Ditch configuration.

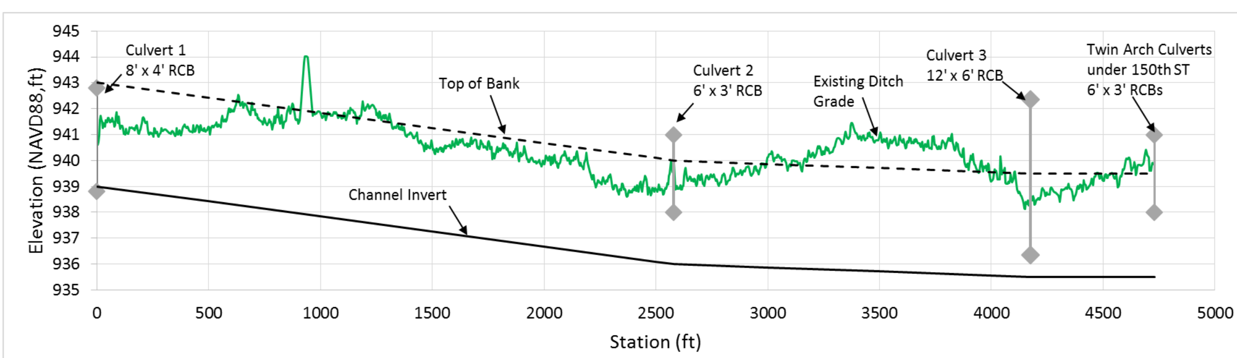

Figure 7.3 A. Profile view of the West Ditch configuration.

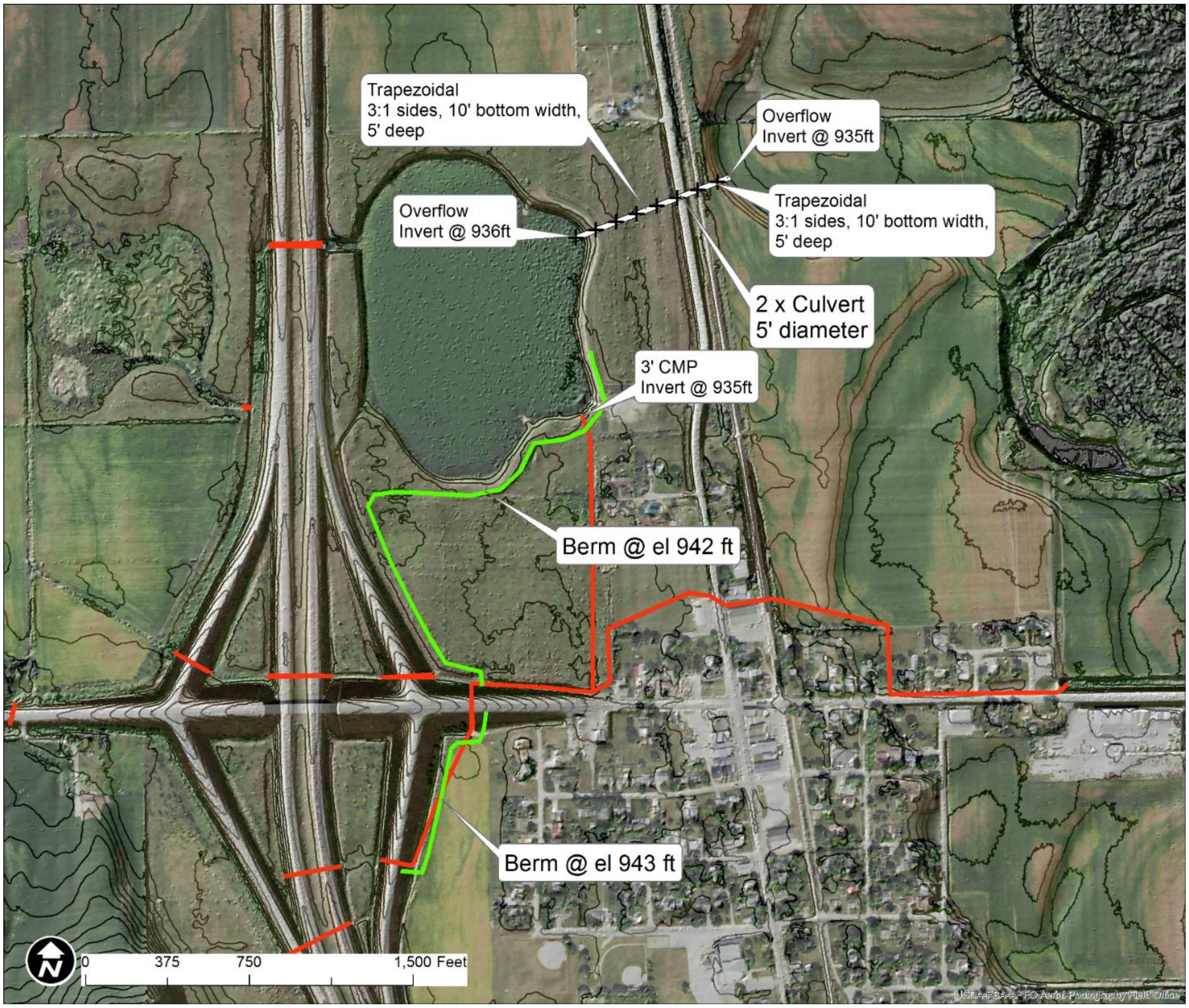

Figure 7.4. Ditch to Lake, additional large lake overflow structure.

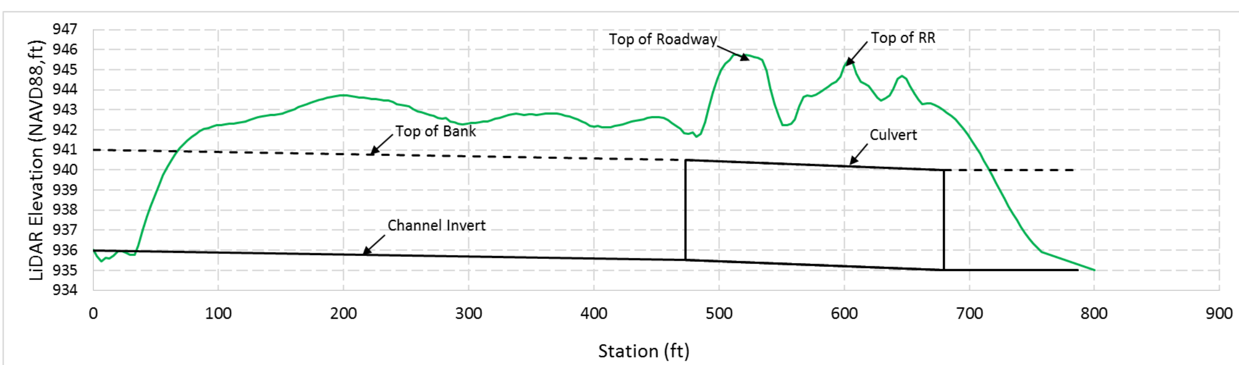

Figure 7.4A. Profile view of the additional Lake Plainfield overflow.

7.1.7 Berm around Lake, Large Overflow

This configuration, shown in Figure 7.5, also attempted to prevent overtopping of Lake Plainfield by providing an additional overflow structure and a berm around the south side of the lake.

7.1.8 Two Trestle Bridges, Ditch from Trestle

This configuration, shown in Figure 7.6, investigates the impact of removing any possible bottleneck created by the railroad trestle bridge, shown in Figure 2.12. The bridge opening area was doubled, and a ditch was constructed from the trestle bridge to the next downstream culvert. A profile view of the ditch is shown in Figure 7.6A.

7.1.9 Ditch from Culverts

This configuration, shown in Figure 7.7, includes a ditch from Culvert #2 to a Main Street culvert, and also a berm from the culvert outlet box around the south side of Lake Plainfield. The ditch's left top of bank is approximately equal to the existing grade, while the right top of bank is approximately 3 feet higher than the ditch invert, which can be seen in Figure 7.7A.

7.1.10 Removal of 150th Culverts

This configuration removes culverts, shown in Figure 2.10, that pass under 150th Street near its intersection with Main Street, just north of the Iowa DOT Wetland Mitigation Area.

7.1.11 Removal of the Landus Coop

This configuration investigates the impact of the berm surrounding the Landus Coop property. The facility's berm, which can be seen in Figure 7.8, is located in a low-lying area that would otherwise convey surface water to the south.

7.1.12 North/South Culvert Berms

This configuration, shown in Figure 7.9, includes a berm from the culvert outlet box around the south side of Lake Plainfield, and a berm from the outlet of Culvert # 2 along the south side of the Landus Coop parcel.

7.1.13 West Ditch, Plugged Culverts

This is the same as the West Ditch configuration, but with US-218 culverts plugged.

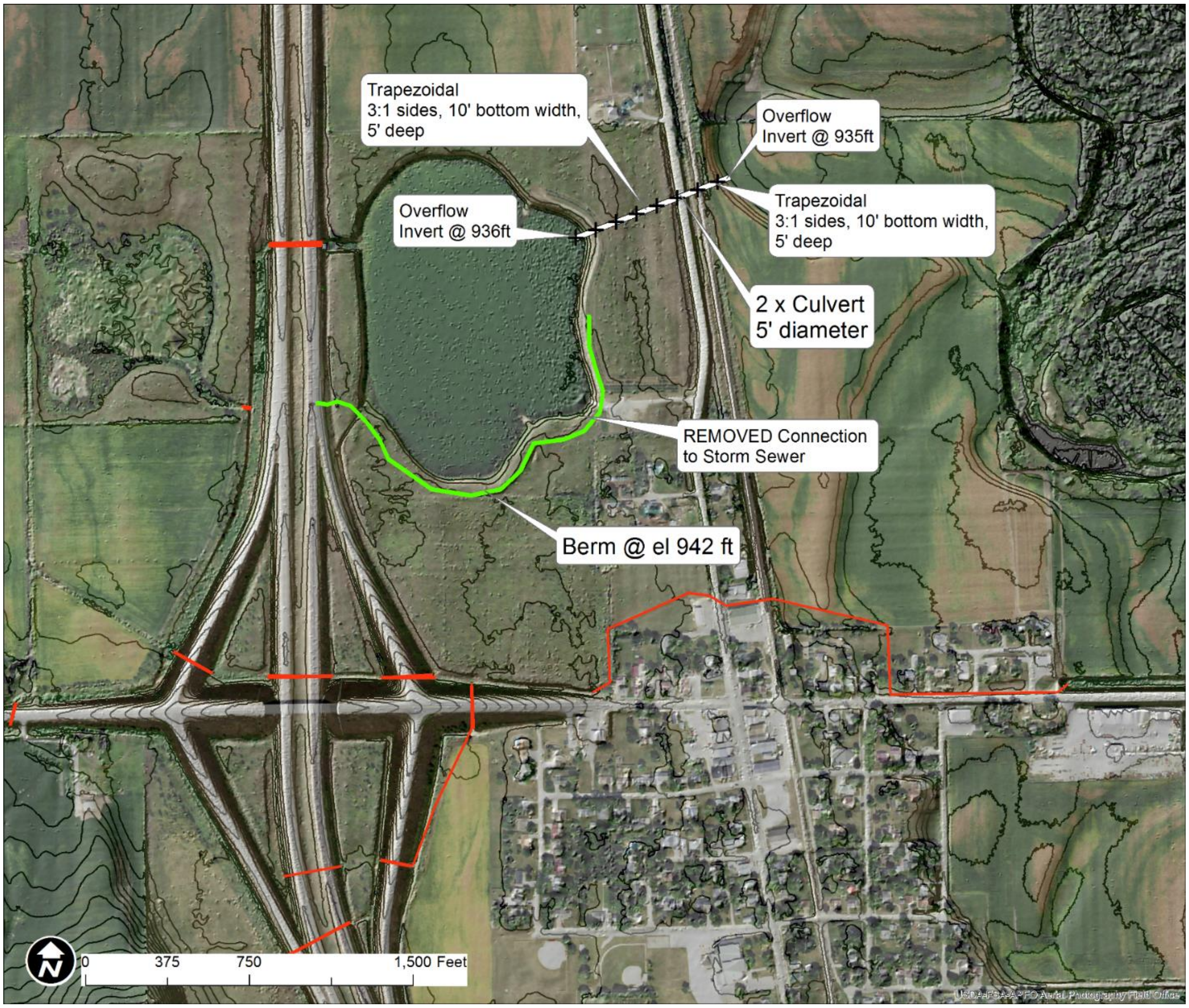

Figure 7.5. Berm around Lake, provide additional lake overflow, remove outlet to storm sewer.

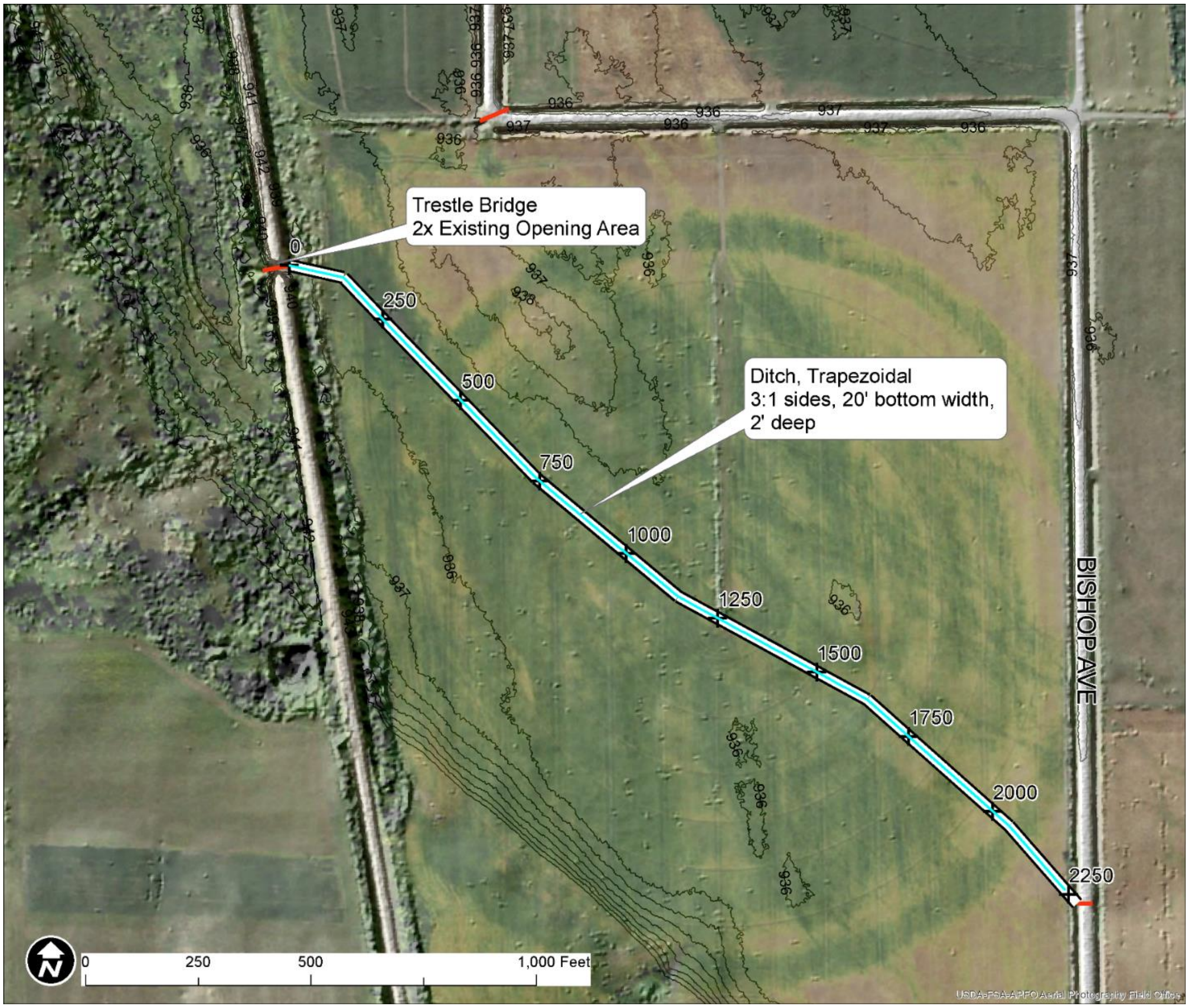

Figure 7.6. Ditch from Trestle Bridge. Bridge opening area doubled. Ditch from bridge to nearby culvert constructed.

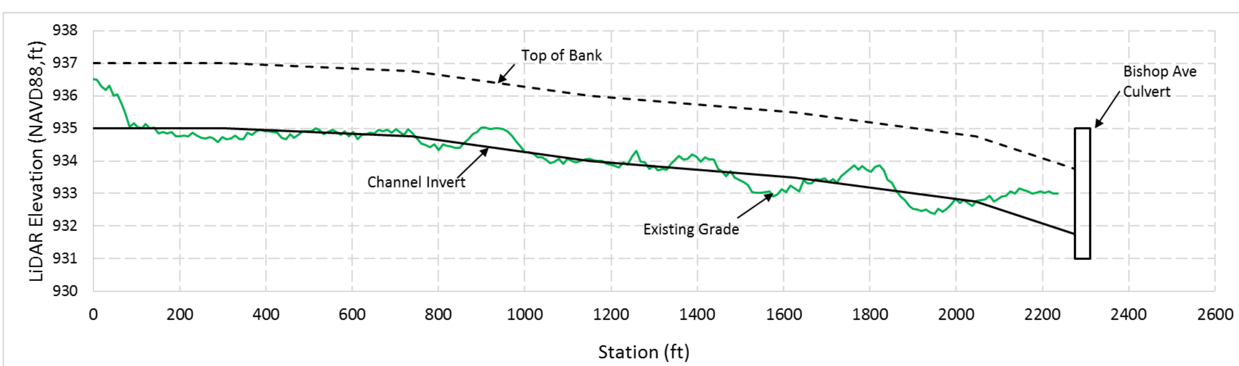

Figure 7.6A. Profile view of the ditch constructed from the bridge to the culvert.

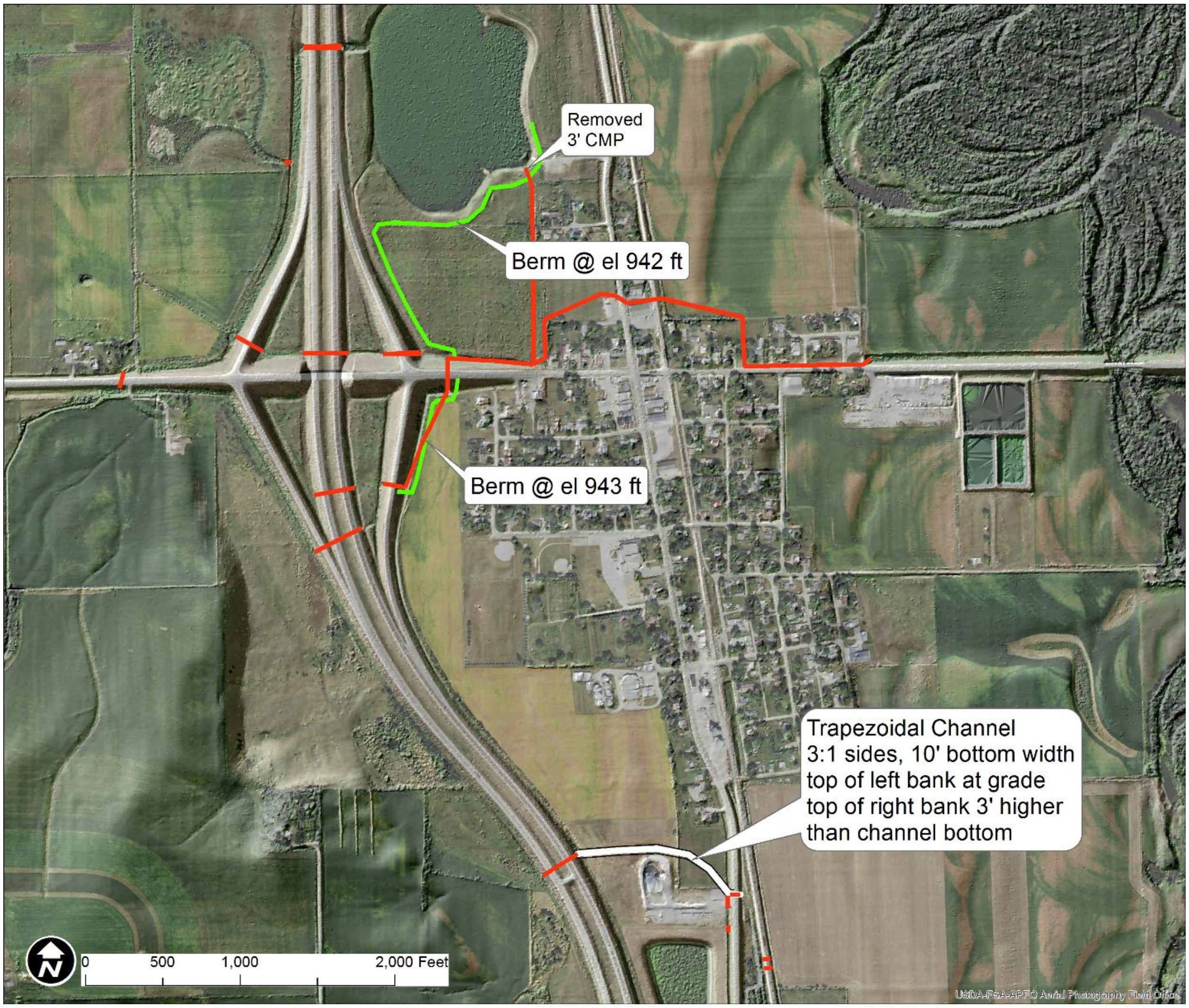

Figure 7.7. Ditch from culverts, a berm is also constructed from the culvert outlet box around the south side of Lake Plainfield.

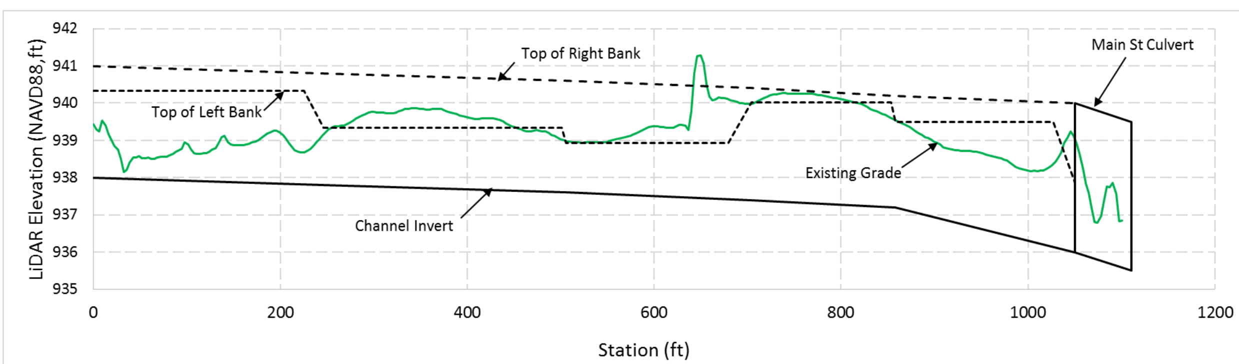

Figure 7.7A. Profile view of the ditch from Culvert #2 to a Main Street Culvert.

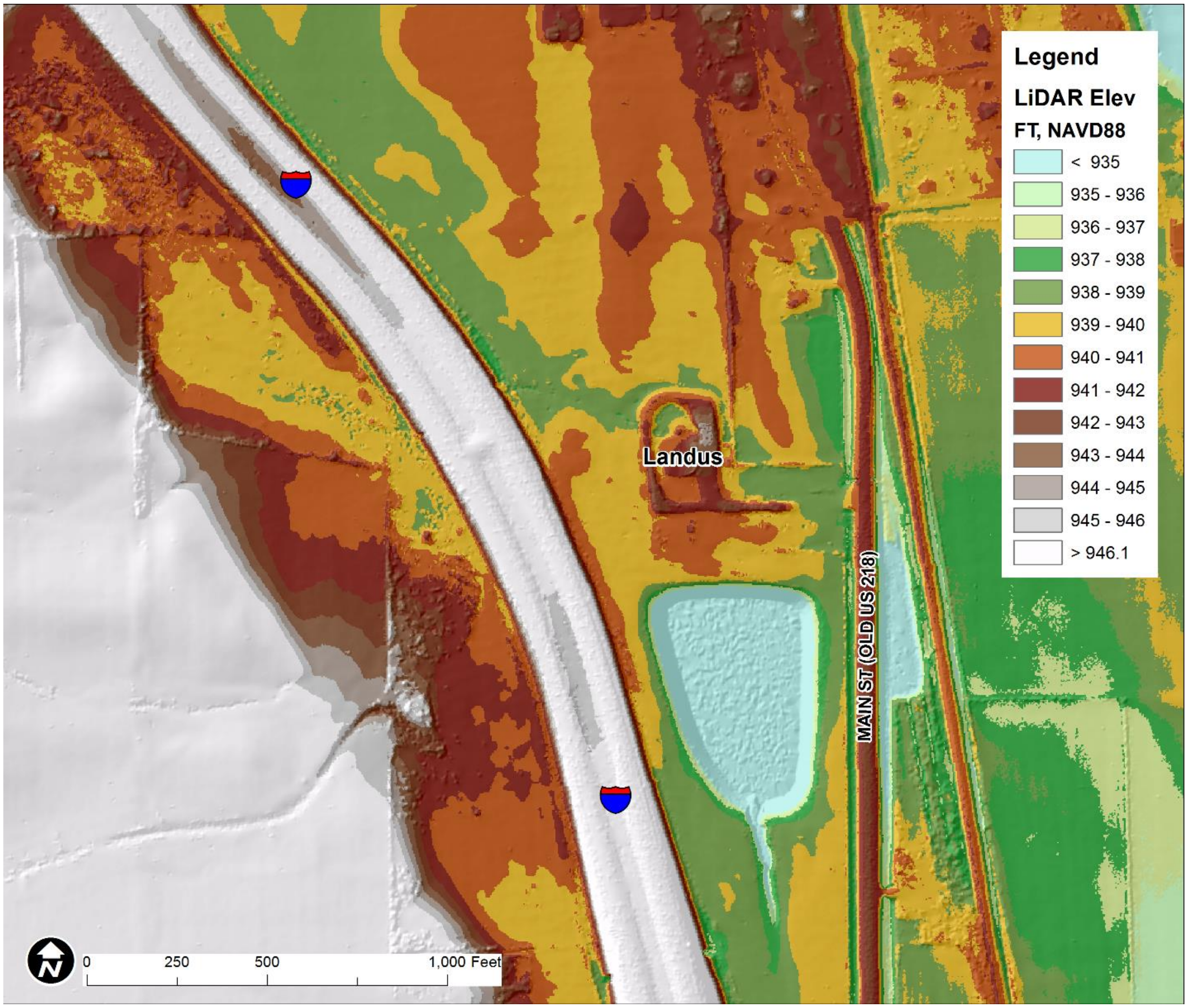

Figure 7.8. LiDAR elevations near the Landus Coop berm.

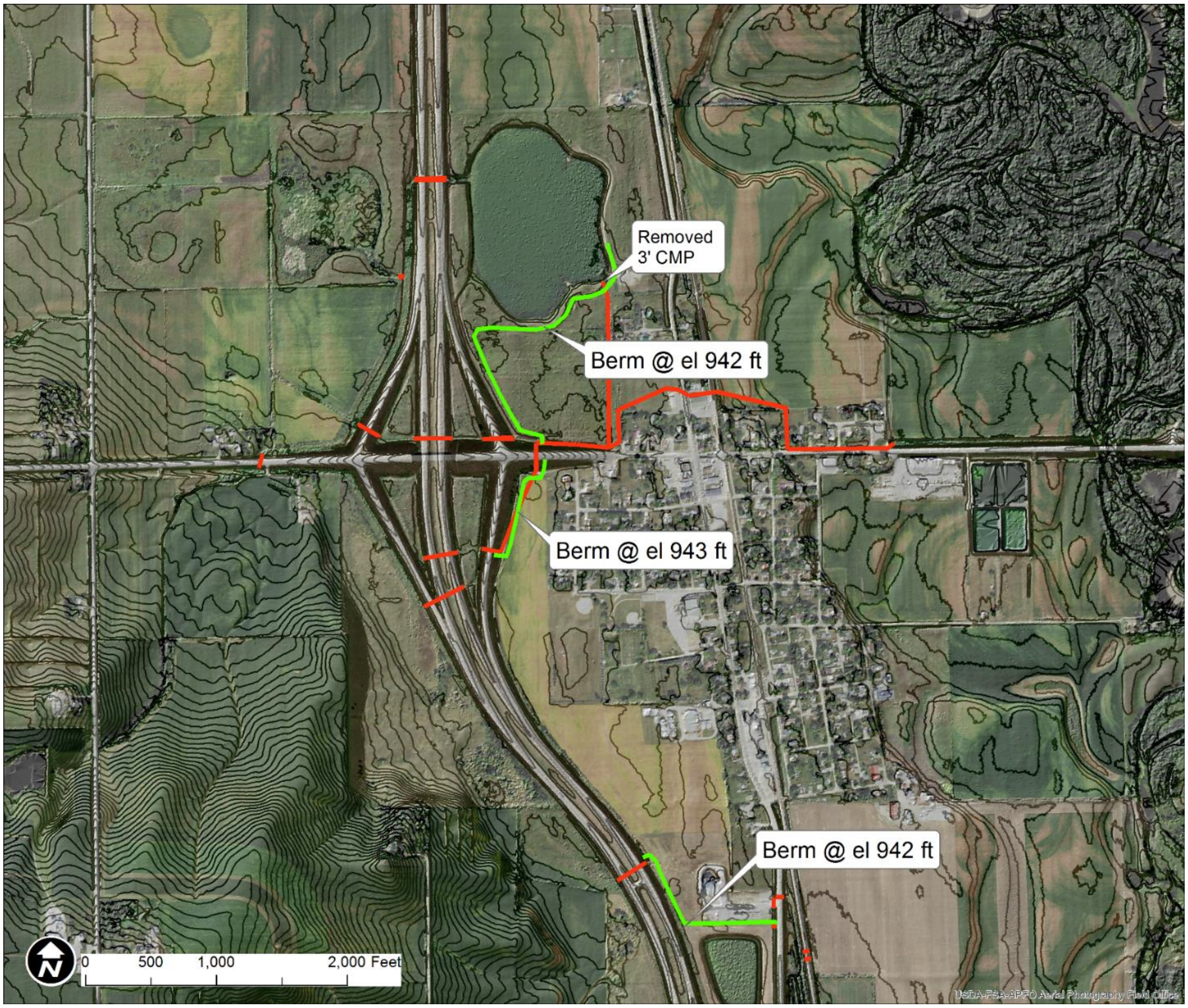

Figure 7.9. North/South Culvert Berms.

7.1.14 West Ditch, with Culverts

This is the same as the West Ditch configuration utilized in the Both Ditches configuration. Culverts are not plugged, and flow is allowed under US-218.

7.1.15 East Ditch, in ROW

This configuration, shown in Figure 7.10, is very similar to previous configuration, but was altered to fit within the Iowa DOT's right-of-way (ROW). The ditch depth, bottom width, and side slopes were reduced to minimize the footprint. A profile view of this configuration is shown in Figure 7.10A. Typical cross-sections for stations 600, 2075, and 3200 feet are shown in Figure 7.11, Figure 7.12, and Figure 7.13, respectively. The narrowest width between the Iowa DOT

ROW and the east toe of the US-218 embankment is approximately 25 feet, and occurs at approximately station 2700 feet in Figure 7.10. The designed ditch width at this location is approximately 24 feet. However, this configuration still enters private property at its downstream outlet into the south former borrow pit.

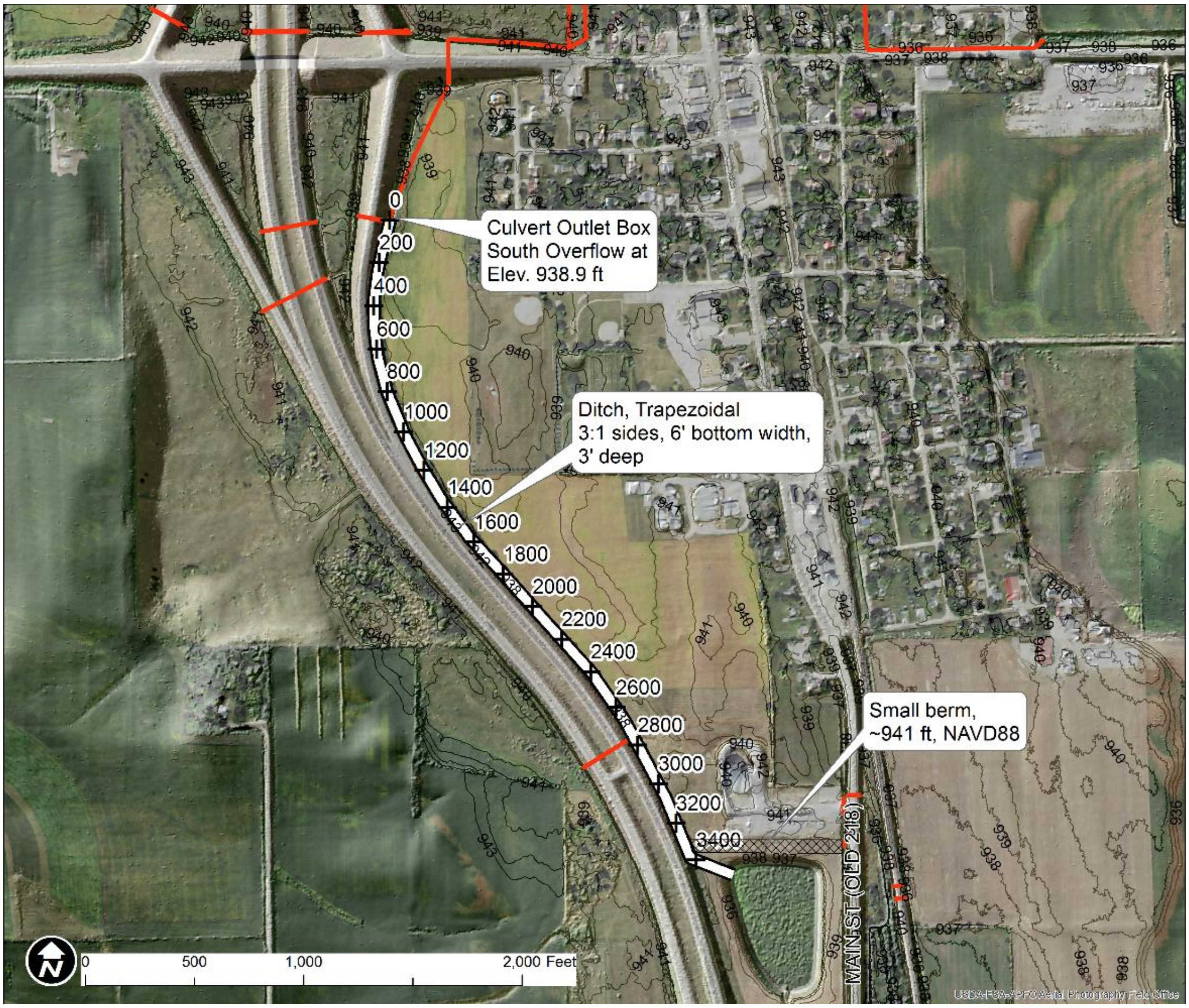

Figure 7.10. East Ditch, in ROW configuration. The ditch depth, bottom width, and side slope were altered to keep the project within the Iowa DOT right-of-way.

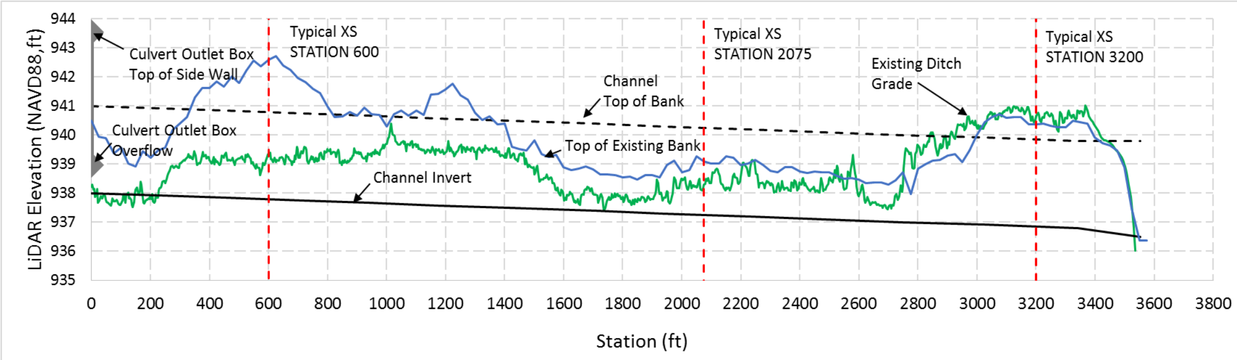

Figure 7.10A. Profile view of the East Ditch, in ROW configuration.

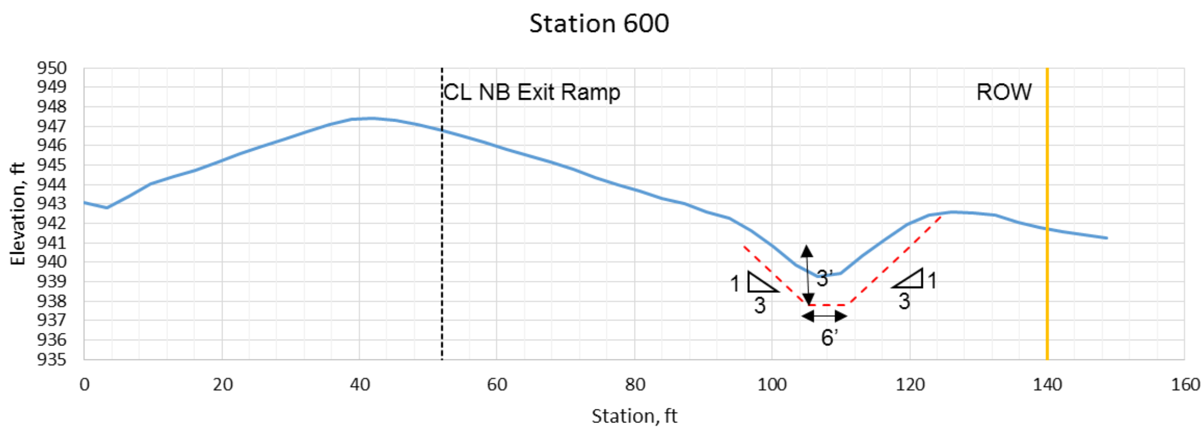

Figure 7.11. East Ditch, in ROW, typical cross-section at station 600 ft.

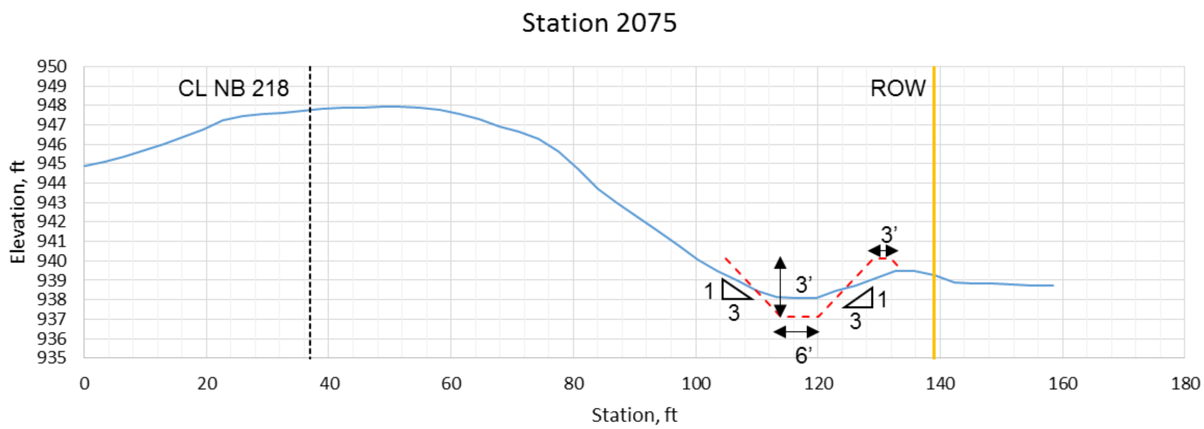

Figure 7.12. East Ditch, in ROW, typical cross-section at station 2075 ft.

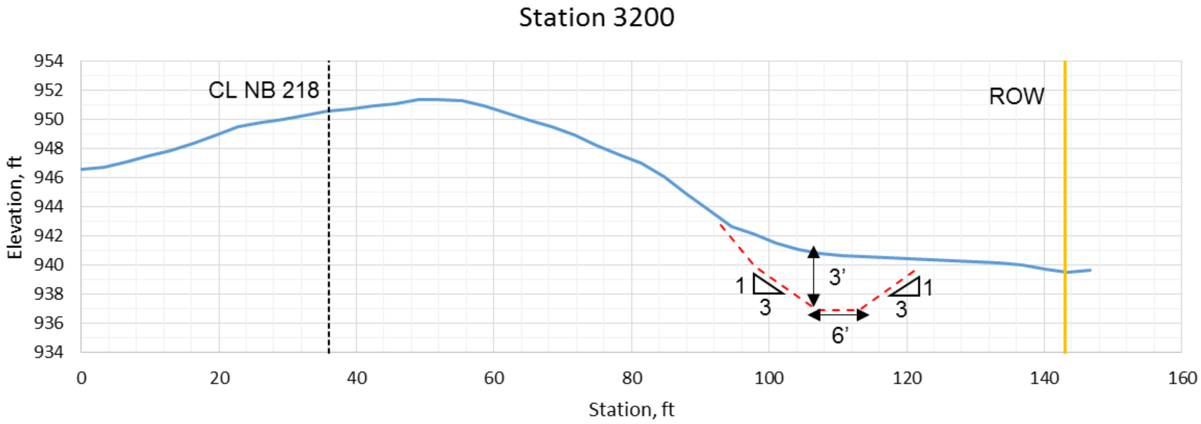

Figure 7.13. East Ditch, in ROW, typical cross-section at station 3200 ft.

7.1.16 East Ditch, in ROW, Extended

This configuration, shown in Figure 7.14, also utilizes reduces the footprint, but was also extended south, to the intersection of Main and 150th Streets. The purpose of this configuration is to avoid constructing the project on any privately-owned land. A profile view of this configuration is shown in Figure 7.14A.

7.1.17 West Ditch in ROW

This configuration, shown in Figure 7.15, is very similar to the previous West Ditch configuration but has been altered in an attempt to fit within the Iowa DOT's ROW. The ditch depth, bottom width, and side slopes were reduced to minimize the footprint. A profile view of this configuration is shown in Figure 7.15A. This configuration would also require the existing twin arch culverts passing under 150th Street be lowered to prevent ponding.

Despite efforts to minimize the footprint, the ditch still falls on private land outside of the ROW. The narrowest width between the Iowa DOT ROW and the west toe of the US-218 embankment is approximately 14 feet, and occurs at approximately station 2500 feet in Figure 7.15. The designed ditch width at this location is approximately 18 feet wide.

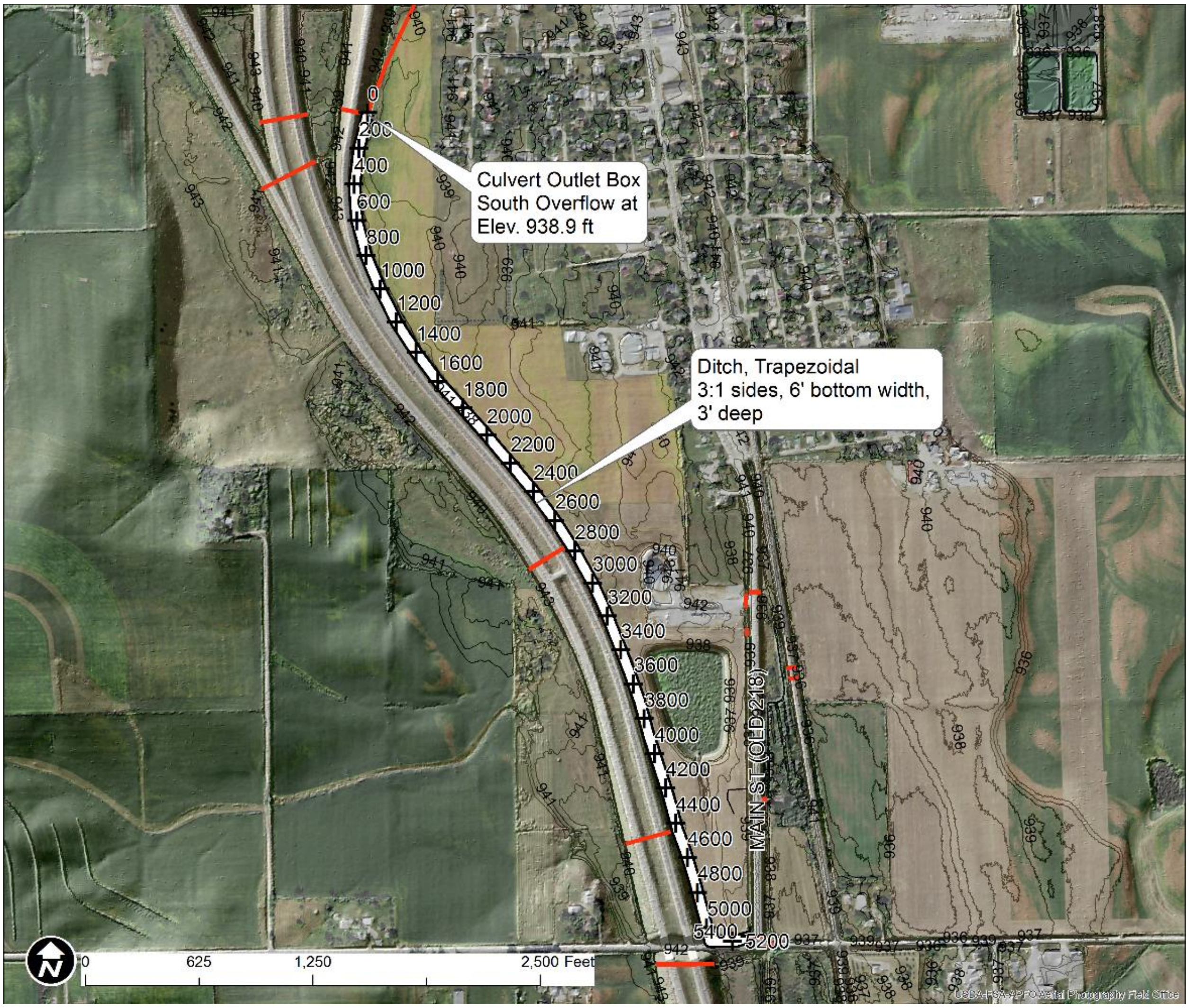

Figure 7.14. East Ditch, in ROW, Extended.

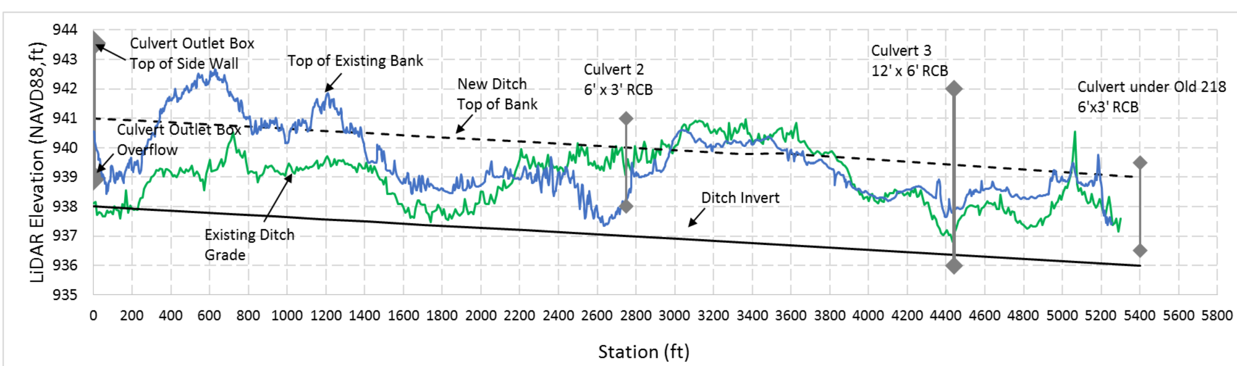

Figure 7.14A. Profile view of East Ditch, in ROW, Extended.

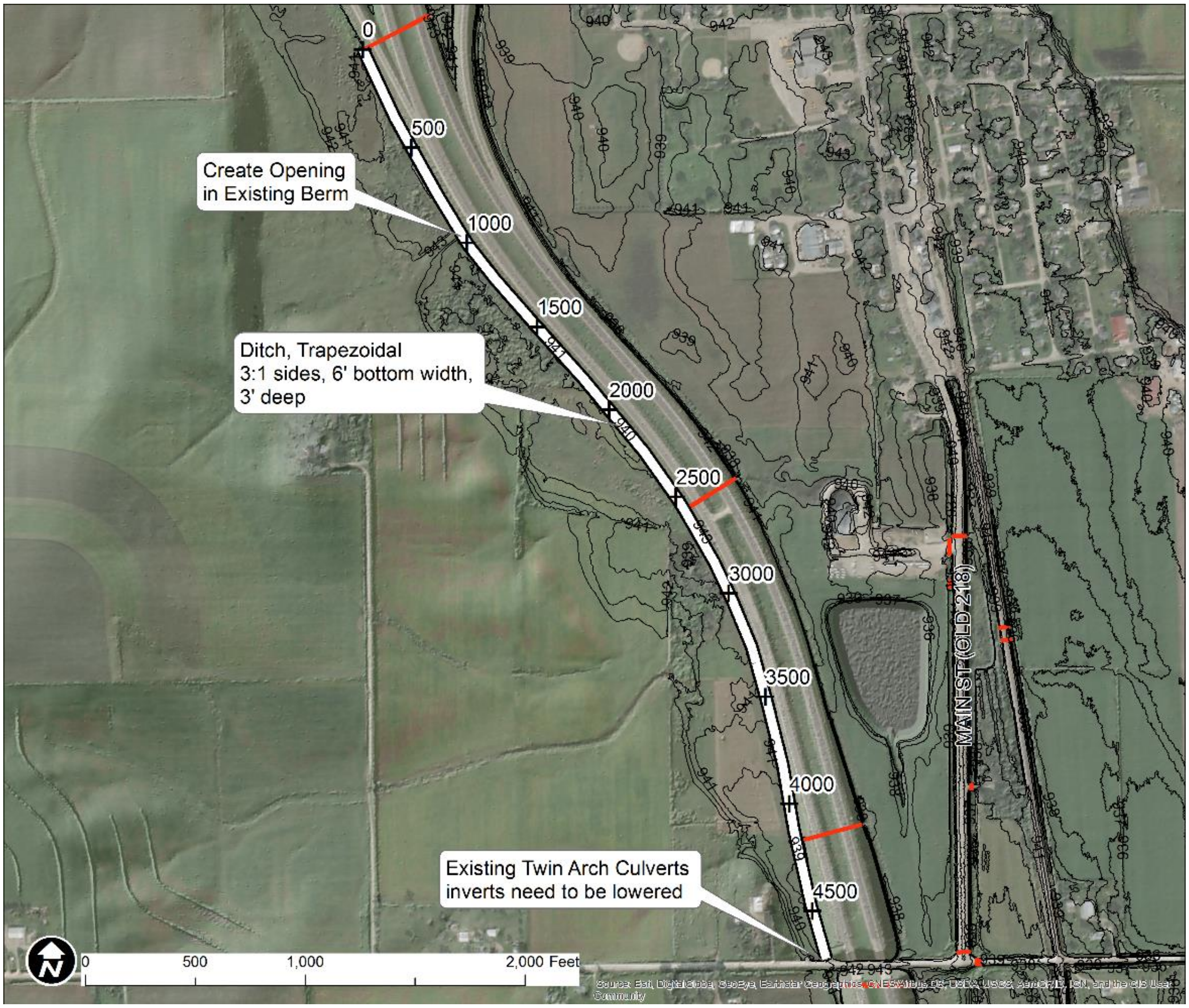

Figure 7.15. West Ditch, in ROW

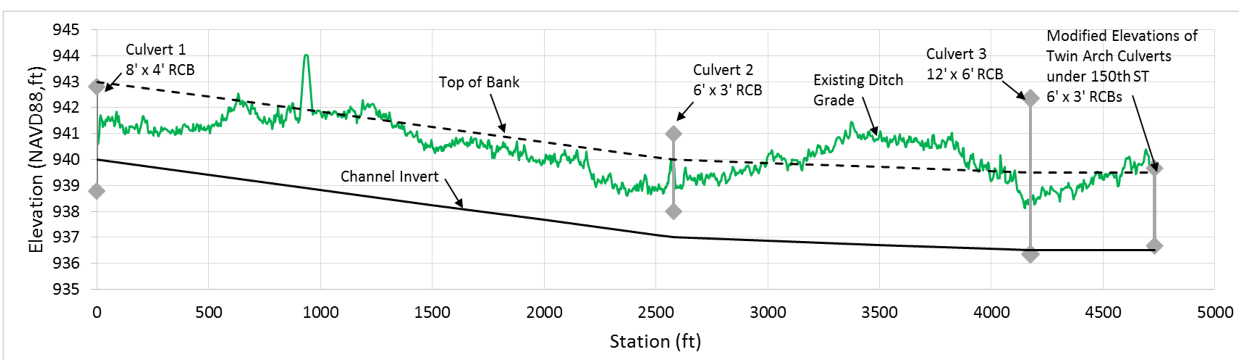

Figure 7.15A. Profile view of West Ditch, in ROW. The channel invert was raised in an effort to reduce the project footprint. The existing twin arch culverts that pass under 150th Street would need to be lowered to prevent ponding.

7.1.18 Remove Driveway in Mitigation Area

This configuration removes an abandoned driveway, shown in Figure 2.10, located in the northeast corner of the Iowa DOT Wetland Mitigation Area to promote drainage into the wetland. This simulation was only run for the 2-year rainfall event.

7.1.19 No Rain West of US-218

This configuration investigates the impact of completely containing runoff from the west side of US-218. This was accomplished by eliminating rainfall west side of US-218. This can be used as a baseline for evaluating the maximum benefit of any project intended to contain the west side runoff.

7.1.20 Pre-US-218 Bypass

This configuration attempts to evaluate the pre-US-218 Bypass condition, including the historic topography and culvert locations. A pre-US-218 terrain dataset was created using a high-resolution photogrammetry dataset provided by Iowa DOT. A side-by-side comparison of the pre- and post-US-218 Bypass terrain datasets are shown in Figure 7.16. The pre-US-218 Bypass terrain utilizes photogrammetry in the extent shown, and LiDAR data everywhere else. The post-US-218 Bypass terrain uses LiDAR data everywhere. The relative change between the pre- and post-US-218 Bypass terrain datasets is shown in Figure 7.17. Some areas may appear to have been altered, but could be attributed to differences in data collection methods and measurement accuracy for photogrammetry versus LiDAR. It is likely major alterations associated with the US-218 bypass were limited to Iowa DOT ROW, easements, wetland mitigation areas, and borrow pits. The pre-US-218 bypass scenario does not include the Landus Coop expansion in 2008. Other alterations may have been completed by other parties between data collection dates.

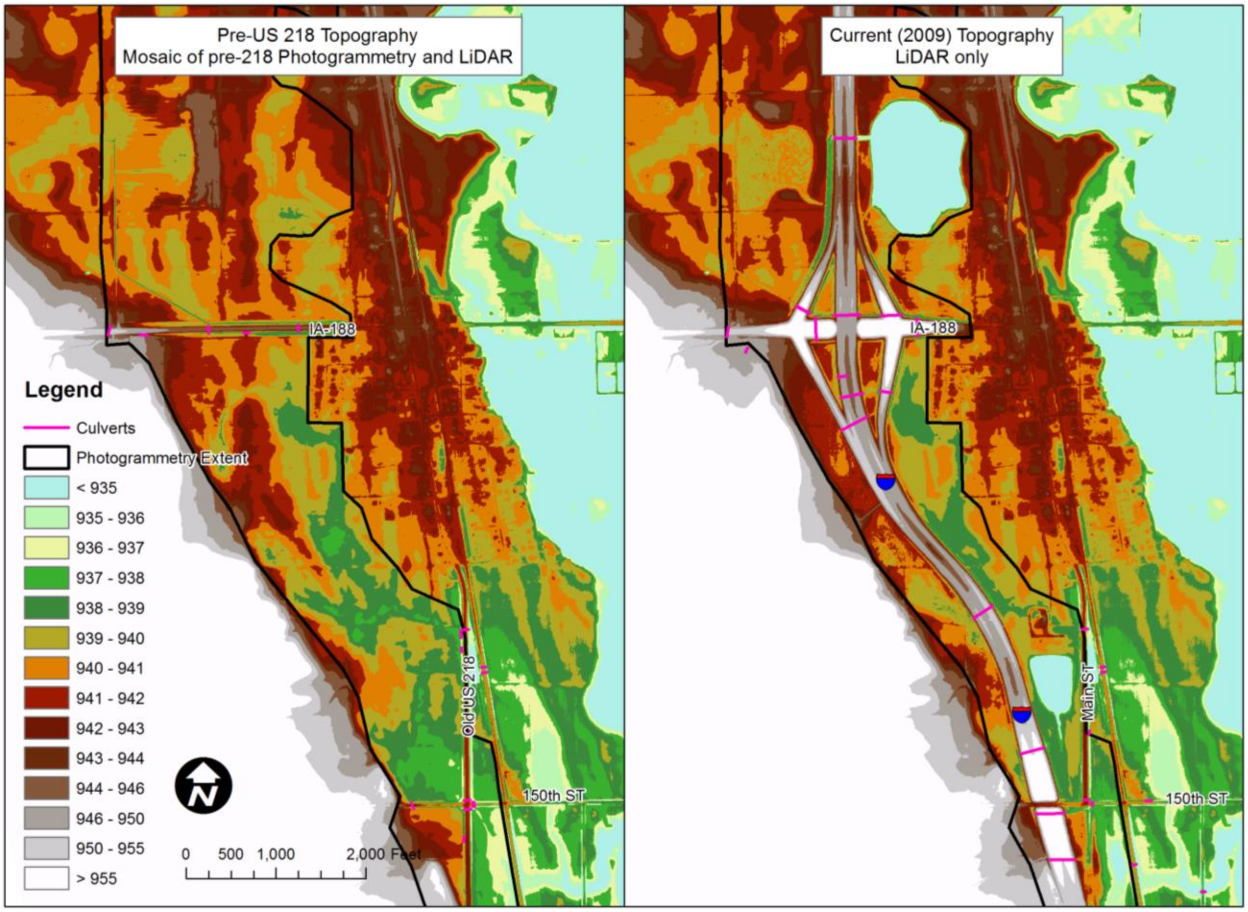

Figure 7.16. Side-by-side comparison of the terrain used for the pre- and post-US-218 Project. Photogrammetry collected pre-US-218 (left) was used within the pictured extent on the left, LiDAR was used for the post-US-218 terrain (right).

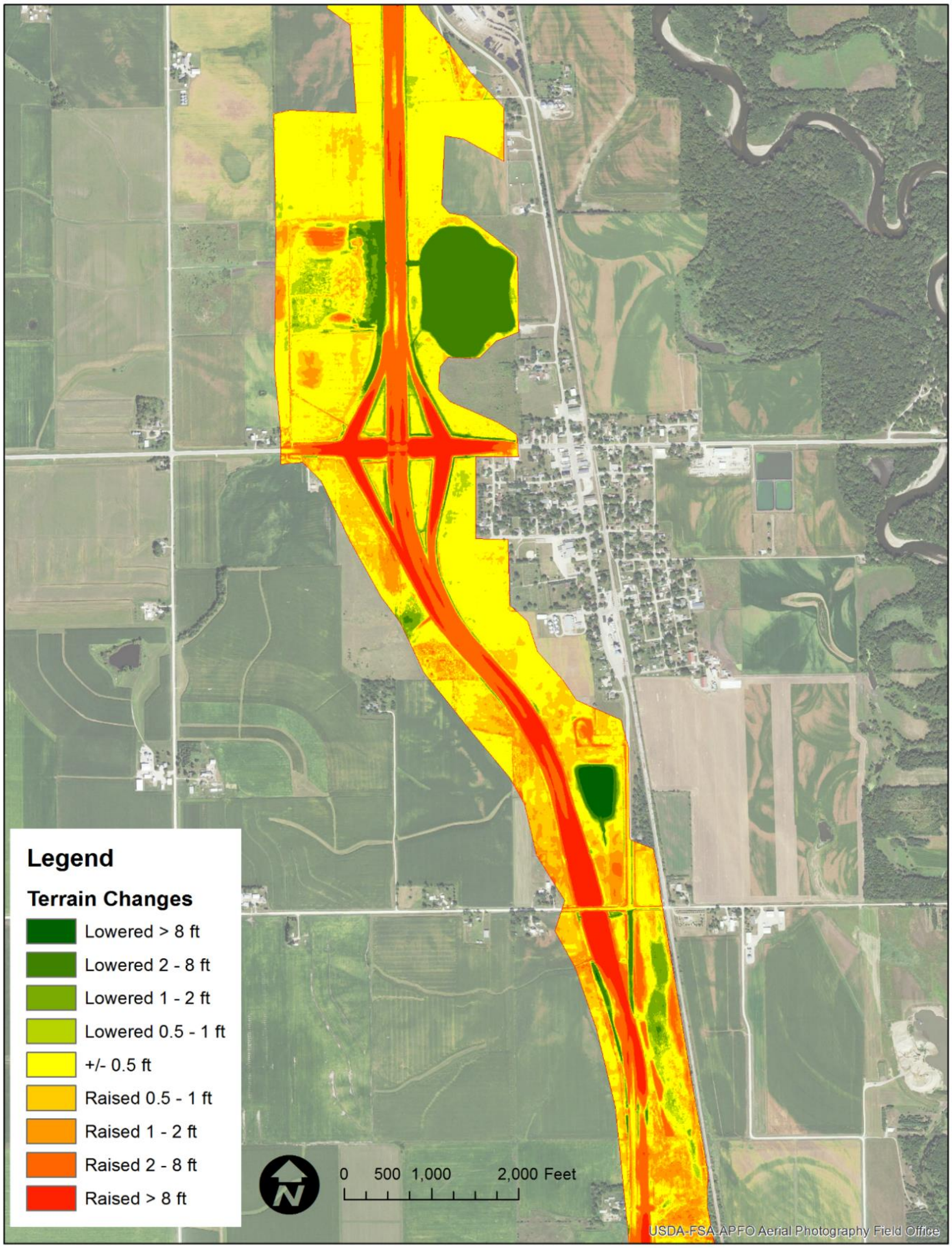

Figure 7.17. Differences between the pre- and post-US-218 project terrains. Some areas may appear to be changed, but may just be differences in the accuracy of data collection techniques.

7.2 Simulation Results

Simulations were completed using storm events with 2-, 5-, 10-, 25-, 50-, and 100-year NOAA Atlas 14 Point Precipitation Frequency Estimates for a 6-hour storm event. Rainfall totals corresponding to each 6-hour storm probability are shown in Table 7.2.1. Cumulative total rainfall occurring throughout the 6-hour storm for each return period is shown in Figure 7.18. Simulations were extended an additional 18 hours following the 6-hour storm to allow runoff to travel through the models.

Simulation results for the final set of models were compared using water surface elevations extracted at several observation points, shown in Figure 7.19. The difference in water surface elevations are summarized in tabular format with a color scale indicating the greatest reductions in depth as green and the greatest increases in depth as red. The references cases for "No Rain West of US-218" and "Pre-US-218 Bypass" are not included in the coloration. Simulation results for the 2-, 5-, 10-, 25-, 50-, and 100-year events are shown in Figure 7.20 through Figure 7.25. Using the East Ditch, in ROW, Extended configuration as an example, simulation of the 25-year event (Figure 7.23) indicates water depths at Points B and C would be decreased by 0.7 feet compared to the existing configuration. Comparing with the Existing water depths at the top of the table – water depth at Point B would be reduced from 1.7 feet to 1.0 feet, and water depth at Point C would be reduced from 2.2 feet to 1.5 feet with the East Ditch, in ROW, Extended (7.1.16) configuration in place.

Based on simulation results of these final mitigation projects, it appears the greatest improvements in water depth at Points A, B, and C occur with the "East Ditch" and "West Ditch" configurations. The "without rainfall east of US-218" simulations indicate the "East Ditch" and "West Ditch" configurations with an IA-188 culvert flap gate would completely contain and convey runoff occurring on the west side of US-218, decreasing the impacts at Points B and C.

Table 7.2.1. Rainfall totals used for each 6-hour storm event simulation. Rainfall totals were provided by NOAA Atlas 14 Point Precipitation Frequency Estimates.

Return Period (yr)	Annual Probability (%)	Precipitation Total (in) (6-hour storm)
2	50	2.44
5	20	3.12
10	10	3.72
25	4	4.61
50	2	5.34
100	1	6.11

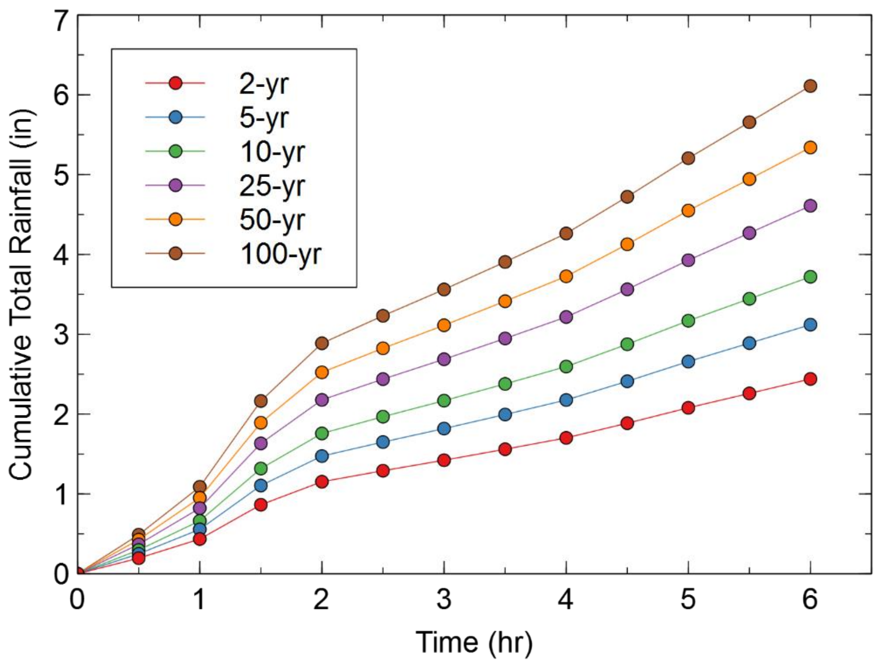

Figure 7.18. Total cumulative rainfall for each return period throughout each 6-hour storm event.

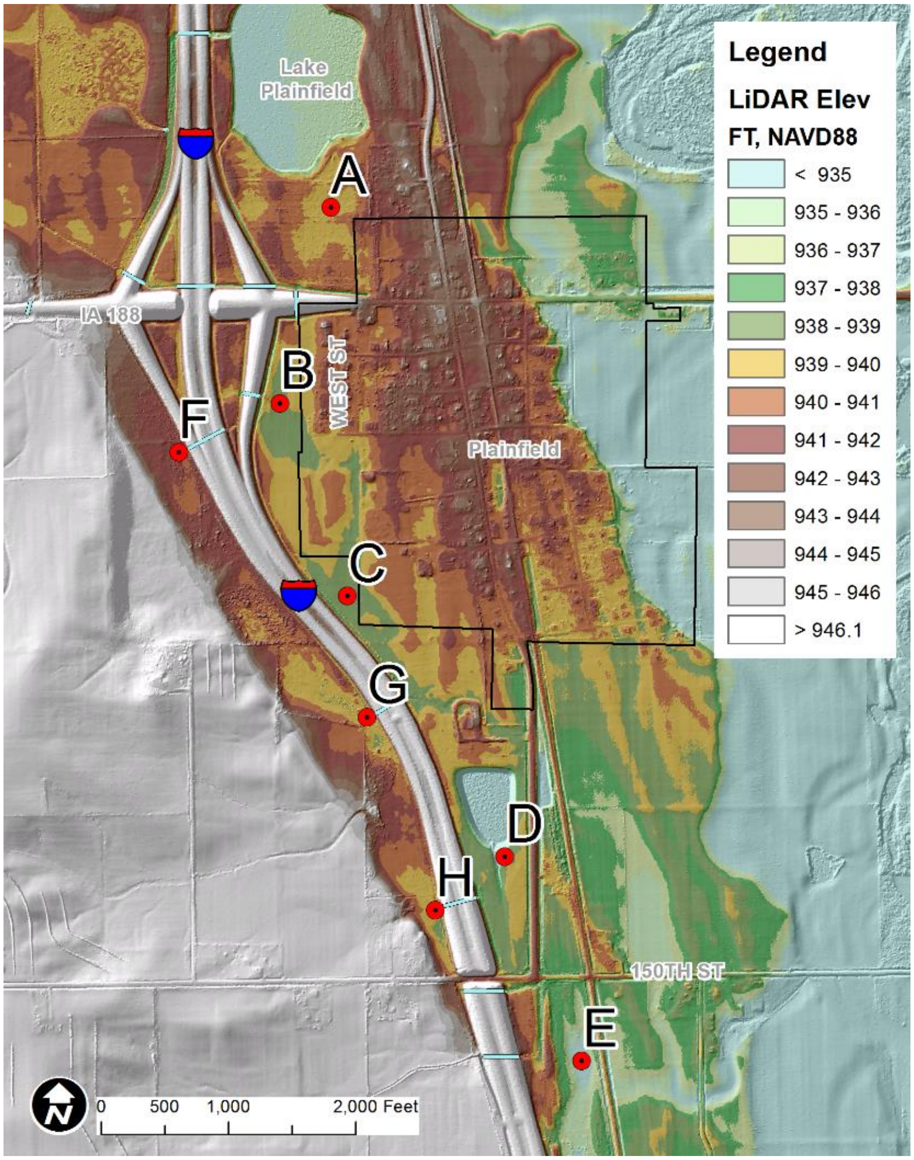

Figure 7.19. Observation points near Plainfield used to compare different model simulations. The impacts at points A, B, and C should be given more importance.

Scenario	Numbe	Lake	A	B	C	D	E	F	G	H
		Observation Point (2-yr depth, ft)								
Existing		0.4	0.5	0.5	1.4	0.0	2.1	1.2	0.9	0.1
Kneewalls	7.1.1	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.1	0.8
East Ditch	7.1.2	0.0	0.0	-0.2	-0.6	0.0	0.0	0.0	-0.9	0.0
East Ditch w/ Kneewalls	7.1.3	0.0	0.0	-0.2	-0.6	0.0	0.0	0.0	-0.2	0.8
Both Ditches	7.1.4	0.0	0.0	-0.2	-0.6	0.0	0.0	-0.3	-0.9	0.0
Both Ditches w/ Kneewalls	7.1.5	0.0	0.0	-0.2	-0.6	0.0	0.4	-0.3	-0.5	0.5
Ditch to Lake, Large Overflow	7.1.6	0.1	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Berm around Lake, Large Overflow	7.1.7	0.0	0.1	0.4	0.0	0.0	0.0	0.0	0.0	0.0
Two Trestle Bridges, Ditch from Trestle	7.1.8	0.0	0.0	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Ditch from Culverts	7.1.9	0.2	0.1	-0.2	-0.6	0.0	0.0	0.0	-0.8	0.0
Removal of 150th ST Culverts	7.1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Removal of Landus Coop	7.1.11	0.0	0.0	-0.2	-0.3	0.0	0.0	0.0	0.0	0.0
North/South Culvert Berms	7.1.12	0.2	0.1	-0.2	-0.2	0.0	0.0	0.0	0.2	0.0
West Ditch, Plugged Culverts	7.1.13	0.0	0.0	-0.2	-0.5	0.0	0.6	-0.3	-0.1	0.6
West Ditch, w/ Culverts	7.1.14	-0.3	0.0	-0.2	-0.5	0.0	-1.1	-1.3	-0.9	0.0
East Ditch keep in ROW	7.1.15	0.0	0.0	-0.2	-0.6	0.0	0.0	0.0	-0.9	0.0
East Ditch in ROW, extended	7.1.16	0.0	0.0	-0.2	-0.6	0.0	0.0	0.0	-0.9	0.0
West Ditch keep in ROW	7.1.17	0.0	0.0	-0.2	-0.5	0.0	0.0	-0.3	-0.9	0.0
Remove driveway in Mit Area	7.1.18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
No Rain West of 218	7.1.19	-0.3	0.0	-0.2	-0.5	0.0	-1.1	0.3	1.0	2.2
Pre-218 Bypass	7.1.20	4.8	0.0	0.3	-0.4	-0.1	0.5	-1.9	-1.4	-0.8

Change from Existing

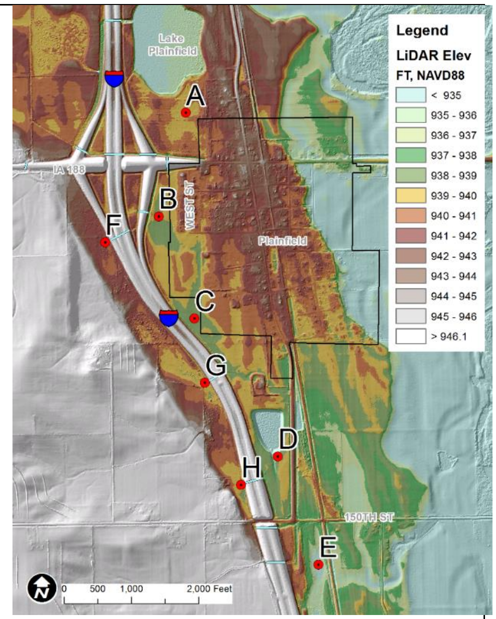

Figure 7.20. Differences in simulated water depths (left) from existing conditions at observation points (right) for the 2-year event.

Scenario		Lake	A	B	C	D	E	F	G	H
		Observation Point (5-yr depth, ft)								
Existing		1.2	0.7	1.2	1.7	0.0	2.7	1.8	1.0	0.1
Kneewalls	7.1.1	-0.1	0.0	-0.1	-0.1	0.0	0.1	0.0	0.3	1.2
East Ditch	7.1.2	0.0	0.0	-0.7	-0.6	0.0	0.0	0.0	-0.8	0.0
East Ditch w/ Kneewalls	7.1.3	-0.1	0.0	-0.7	-0.6	0.0	0.1	0.0	0.1	1.2
Both Ditches	7.1.4	0.0	0.0	-0.7	-0.6	0.0	0.0	-0.7	-1.0	0.1
Both Ditches w/ Kneewalls	7.1.5	-0.1	0.0	-0.7	-0.6	0.0	0.4	-0.7	0.0	0.9
Ditch to Lake, Large Overflow	7.1.6	0.4	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0
Berm around Lake, Large Overflow	7.1.7	0.0	0.1	0.1	0.1	0.0	0.0	0.0	0.0	0.0
Two Trestle Bridges, Ditch from Trestle	7.1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ditch from Culverts	7.1.9	0.5	0.1	-0.7	-0.7	0.0	0.0	0.0	-0.7	0.0
Removal of 150th ST Culverts	7.1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Removal of Landus Coop	7.1.11	0.0	0.0	-0.2	-0.3	0.0	0.0	0.0	0.0	0.0
North/South Culvert Berms	7.1.12	0.4	0.1	-0.3	-0.1	0.0	0.0	0.0	0.4	0.0
West Ditch, Plugged Culverts	7.1.13	0.0	0.0	-0.7	-0.6	0.0	0.5	-0.7	0.2	1.1
West Ditch, w/ Culverts	7.1.14	-1.0	0.0	-0.7	-0.6	0.0	-1.3	-1.8	-1.0	0.0
East Ditch keep in ROW	7.1.15	0.0	0.0	-0.7	-0.6	0.0	0.0	0.0	-0.8	0.0
East Ditch in ROW, extended	7.1.16	0.0	0.0	-0.7	-0.6	0.0	0.5	0.0	-0.7	0.0
West Ditch keep in ROW	7.1.17	0.0	0.0	-0.7	-0.6	0.0	0.0	-1.2	-0.1	0.3
No Rain West of 218	7.1.19	-1.0	0.0	-0.7	-0.6	0.0	-1.3	-0.7	1.5	2.4
Pre-218 Bypass	7.1.20	4.3	0.4	-0.2	-0.5	-0.1	0.2	-2.3	-1.4	-0.8

Change from Existing

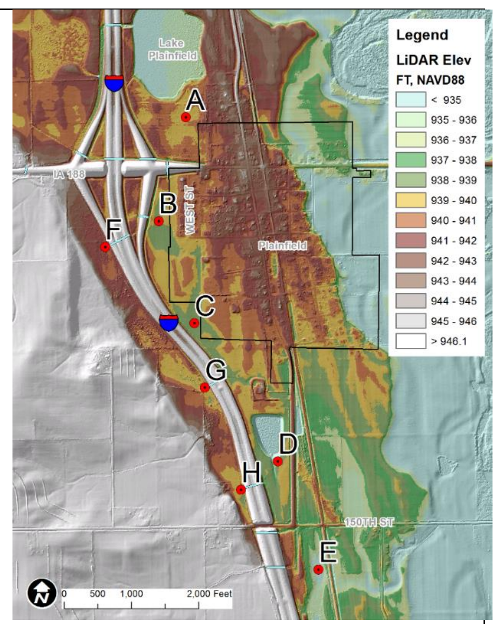

Figure 7.21. Differences in simulated water depths (left) from existing conditions at observation points (right) for the 5-year event.

		Observation Point (10-yr depth, ft)								
Scenario		Lake	A	B	C	D	E	F	G	H
Existing		2.2	0.9	1.4	1.9	0.0	3.0	2.1	1.2	0.1
Kneewalls	7.1.1	-0.4	0.0	-0.1	-0.1	0.0	0.1	0.0	0.5	1.3
East Ditch	7.1.2	0.0	0.0	-0.8	-0.6	0.0	0.0	0.0	-0.7	0.0
East Ditch w/ Kneewalls	7.1.3	-0.4	0.0	-0.7	-0.6	0.0	0.1	0.0	0.3	1.3
Both Ditches	7.1.4	0.0	0.0	-0.8	-0.6	0.3	0.1	-1.0	-1.1	0.4
Both Ditches w/ Kneewalls	7.1.5	-0.4	0.0	-0.8	-0.6	0.0	0.4	-1.0	0.3	1.2
Ditch to Lake, Large Overflow	7.1.6	0.2	0.0	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0
Berm around Lake, Large Overflow	7.1.7	-0.4	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0
Two Trestle Bridges, Ditch from Trestle	7.1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ditch from Culverts	7.1.9	0.8	0.0	-0.7	-0.7	0.0	0.0	0.0	-0.6	0.0
Removal of 150th ST Culverts	7.1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Removal of Landus Coop	7.1.11	0.0	0.0	-0.2	-0.4	0.0	0.0	0.0	0.0	0.0
North/South Culvert Berms	7.1.12	0.8	0.0	-0.3	-0.2	0.0	0.0	0.0	0.5	0.0
West Ditch, Plugged Culverts	7.1.13	0.0	0.0	-0.8	-0.6	0.0	0.5	-1.0	0.5	1.5
West Ditch, w/ Culverts	7.1.14	-1.9	0.0	-0.8	-0.6	0.0	-1.5	-2.2	-1.2	0.0
East Ditch keep in ROW	7.1.15	0.0	0.0	-0.8	-0.6	0.1	0.0	0.0	-0.6	0.0
East Ditch in ROW, extended	7.1.16	0.0	0.0	-0.8	-0.6	0.0	0.5	0.0	-0.4	0.3
West Ditch keep in ROW	7.1.17	0.0	0.0	-0.8	-0.6	0.0	0.0	-1.0	-0.1	0.4
No Rain West of 218	7.1.19	-1.9	0.0	-0.8	-0.6	0.0	-1.5	-1.0	1.9	3.3
Pre-218 Bypass	7.1.20	3.5	0.5	-0.2	-0.6	-0.1	0.1	-2.6	-1.3	-0.7

Change from Existing

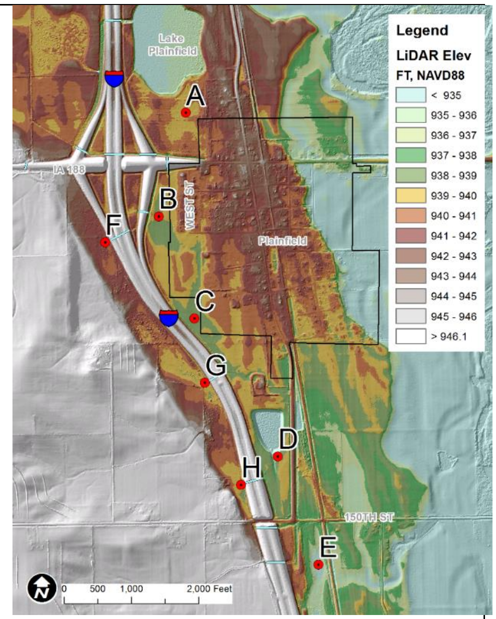

Figure 7.22. Differences in simulated water depths (left) from existing conditions at observation points (right) for the 10-year event.

		Observation Point (25-yr depth, ft)								
Scenario		Lake	A	B	C	D	E	F	G	H
Existing		3.7	1.0	1.7	2.2	0.0	3.3	2.5	1.4	0.1
Kneewalls	7.1.1	-0.5	0.0	-0.1	-0.1	0.0	0.2	0.0	0.5	1.4
East Ditch	7.1.2	-0.1	0.0	-0.8	-0.7	0.7	0.1	0.0	-0.5	0.0
East Ditch w/ Kneewalls	7.1.3	-0.6	0.0	-0.7	-0.7	0.4	0.2	0.0	0.4	1.4
Both Ditches	7.1.4	-0.2	0.0	-0.8	-0.7	0.8	0.3	-1.3	-0.5	0.6
Both Ditches w/ Kneewalls	7.1.5	-0.6	0.0	-0.8	-0.7	0.0	0.5	-1.3	0.4	1.6
Ditch to Lake, Large Overflow	7.1.6	-0.2	0.1	-0.3	-0.3	0.0	0.0	0.0	0.0	0.0
Berm around Lake, Large Overflow	7.1.7	-0.9	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Two Trestle Bridges, Ditch from Trestle	7.1.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Ditch from Culverts	7.1.9	1.5	0.1	-0.8	-0.8	0.0	0.0	0.0	-0.5	0.0
Removal of 150th ST Culverts	7.1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Removal of Landus Coop	7.1.11	-0.1	0.0	-0.3	-0.4	0.0	0.0	0.0	0.0	0.0
North/South Culvert Berms	7.1.12	1.5	0.1	-0.4	-0.4	0.0	0.0	0.0	0.5	0.0
West Ditch, Plugged Culverts	7.1.13	-0.1	0.0	-0.8	-0.7	0.0	0.6	-1.3	0.7	2.0
West Ditch, w/ Culverts	7.1.14	-0.1	0.0	-0.8	-0.7	0.5	0.2	-1.3	-0.2	0.8
East Ditch keep in ROW	7.1.15	-0.1	0.0	-0.7	-0.7	0.7	0.1	0.0	-0.4	0.0
East Ditch in ROW, extended	7.1.16	-0.1	0.0	-0.7	-0.7	0.0	0.4	0.0	-0.2	0.4
West Ditch keep in ROW	7.1.17	-0.1	0.0	-0.8	-0.7	0.5	0.2	-1.3	0.2	0.8
No Rain West of 218	7.1.19	-3.1	0.0	-0.8	-0.7	0.0	-1.5	-0.8	2.3	3.6
Pre-218 Bypass	7.1.20	2.4	0.8	-0.3	-0.6	0.3	0.1	-2.8	-1.2	-0.5

Change from Existing

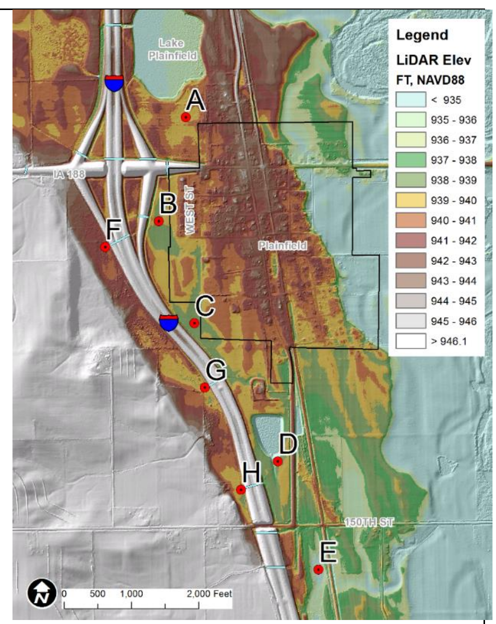

Figure 7.23. Differences in simulated water depths (left) from existing conditions at observation points (right) for the 25-year event.

Observation Point (50-yr depth, ft) — Change from Existing

Scenario		Lake	A	B	C	D	E	F	G	H
Existing		5.0	1.0	1.9	2.4	0.1	3.4	2.8	1.6	0.1
Kneewalls	7.1.1	-1.0	0.0	-0.1	-0.1	-0.1	0.2	0.0	0.4	1.4
East Ditch	7.1.2	-0.2	0.0	-0.7	-0.7	1.0	0.2	0.0	-0.3	0.3
East Ditch w/ Kneewalls	7.1.3	-1.2	0.0	-0.7	-0.7	0.6	0.2	0.0	0.4	1.4
Both Ditches	7.1.4	-0.2	0.0	-0.8	-0.7	1.1	0.5	-1.5	-0.3	0.9
Both Ditches w/ Kneewalls	7.1.5	-1.2	0.0	-0.8	-0.8	-0.1	0.6	-1.5	0.5	1.8
Ditch to Lake, Large Overflow	7.1.6	-0.8	0.1	-0.3	-0.3	-0.1	0.0	0.0	0.0	0.0
Berm around Lake, Large Overflow	7.1.7	-1.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Two Trestle Bridges, Ditch from Trestle	7.1.8	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
Ditch from Culverts	7.1.9	1.0	0.1	-0.8	-0.8	-0.1	0.0	0.0	-0.4	0.0
Removal of 150th ST Culverts	7.1.10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Removal of Landus Coop	7.1.11	-0.1	0.0	-0.3	-0.4	-0.1	0.0	0.0	0.0	0.0
North/South Culvert Berms	7.1.12	1.0	0.1	-0.6	-0.6	-0.1	0.0	0.0	0.4	0.0
West Ditch, Plugged Culverts	7.1.13	-0.2	0.0	-0.7	-0.7	-0.1	0.6	-1.5	0.9	2.3
West Ditch, w/ Culverts	7.1.14	-0.2	0.0	-0.8	-0.8	0.6	0.4	-1.5	-0.1	1.0
East Ditch keep in ROW	7.1.15	-0.2	0.0	-0.5	-0.5	0.9	0.2	0.0	-0.3	0.3
East Ditch in ROW, extended	7.1.16	-0.2	0.0	-0.5	-0.5	-0.1	0.4	0.0	-0.1	0.5
West Ditch keep in ROW	7.1.17	-0.2	0.0	-0.7	-0.7	0.6	0.3	-1.5	0.2	0.9
No Rain West of 218	7.1.19	-4.2	0.0	-0.8	-0.8	-0.1	-1.4	-0.6	2.5	3.9
Pre-218 Bypass	7.1.20	1.4	1.1	-0.3	-0.6	0.7	0.0	-3.0	-1.1	-0.1

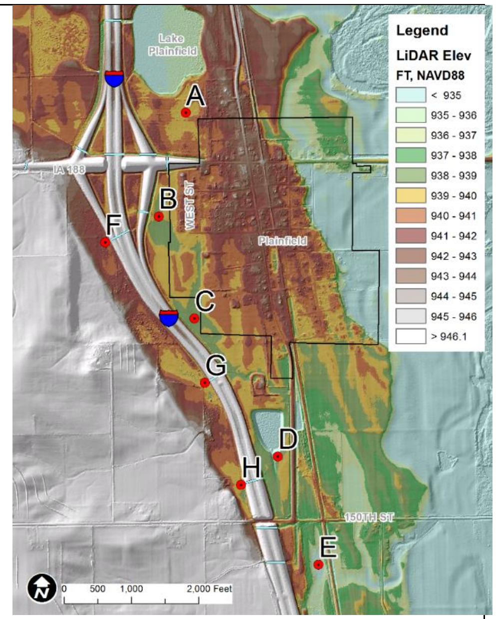

Figure 7.24. Differences in simulated water depths (left) from existing conditions at observation points (right) for the 50-year event.

Observation Point (100-yr depth, ft) — Change from Existing

Scenario		Lake	A	B	C	D	E	F	G	H
Existing		5.7	1.3	2.0	2.5	0.5	3.6	2.9	2.0	0.5
Kneewalls	7.1.1	-0.8	-0.4	0.0	0.0	-0.5	0.3	0.0	0.3	1.3
East Ditch	7.1.2	-0.1	-0.1	-0.6	-0.6	1.0	0.3	0.0	-0.1	0.4
East Ditch w/ Kneewalls	7.1.3	-1.0	-0.4	-0.7	-0.7	0.5	0.3	0.0	0.3	1.3
Both Ditches	7.1.4	-0.1	-0.1	-0.7	-0.7	0.9	0.6	-1.6	-0.3	0.9
Both Ditches w/ Kneewalls	7.1.5	-1.0	-0.4	-0.7	-0.7	-0.1	0.6	-1.6	0.4	1.8
Ditch to Lake, Large Overflow	7.1.6	-0.9	-0.1	-0.4	-0.3	-0.5	0.0	0.0	0.0	0.0
Berm around Lake, Large Overflow	7.1.7	-1.7	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Two Trestle Bridges, Ditch from Trestle	7.1.8	0.0	0.0	0.0	0.0	0.0	-0.1	0.0	0.0	0.0
Ditch from Culverts	7.1.9	0.8	-0.1	-0.8	-0.7	-0.5	0.0	0.0	-0.3	0.0
Removal of 150th ST Culverts	7.1.10	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Removal of Landus Coop	7.1.11	-0.1	-0.1	-0.3	-0.4	0.0	0.0	0.0	0.0	0.0
North/South Culvert Berms	7.1.12	0.8	-0.1	-0.6	-0.6	0.1	0.0	0.0	0.3	0.0
West Ditch, Plugged Culverts	7.1.13	-0.1	-0.1	-0.7	-0.7	-0.5	0.7	-1.6	1.0	2.4
West Ditch, w/ Culverts	7.1.14	-0.1	-0.1	-0.7	-0.7	0.4	0.5	-1.6	-0.2	1.0
East Ditch keep in ROW	7.1.15	-0.1	-0.1	-0.4	-0.4	0.7	0.3	0.0	-0.2	0.3
East Ditch in ROW, extended	7.1.16	-0.1	-0.1	-0.4	-0.3	-0.5	0.4	0.0	-0.1	0.3
West Ditch keep in ROW	7.1.17	-0.1	-0.1	-0.6	-0.6	0.3	0.5	-1.6	0.1	0.9
No Rain West of 218	7.1.19	-4.5	-0.4	-0.7	-0.7	-0.5	-0.2	0.2	3.0	4.4
Pre-218 Bypass	7.1.20	1.0	1.0	-0.2	-0.5	0.8	0.0	-3.0	-1.2	0.1

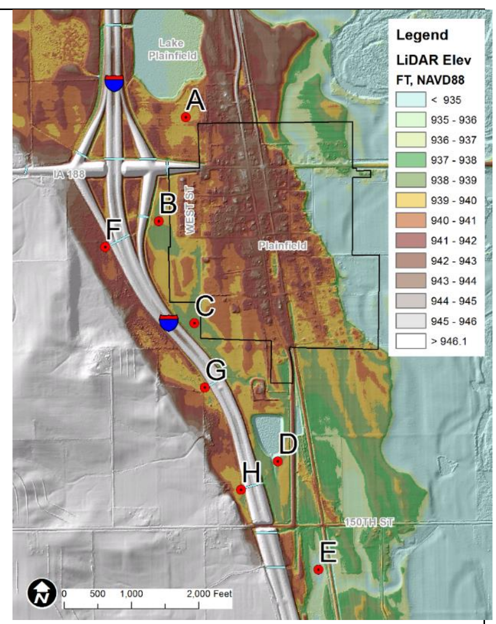

Figure 7.25. Differences in simulated water depths (left) from existing conditions at observation points (right) for the 100-year event.

8. DISCUSSION

The largest reductions in water depth at Points A, B, and C for any storm event and mitigation project are less than one foot. The "No Rain West of 218" simulations emulate total containment of runoff generated west of US-218, and are the best case for reductions in water depths. It is an unrealistic event, but serves as an estimate of the largest expected water depth reductions of any mitigation alternative. It is worth noting that localized runoff occurring east of US-218 still results in water depths approximately one foot and greater at Points A, B, and C for the 25-year storm and larger events.

Kneewalls were not effective at reducing water depths at Points A, B, and C. However, they were effective at reducing the peak discharge through each Iowa DOT culvert. For example, the existing kneewall structure installed on the inlet of Culvert #1 was designed to reduce the peak discharge for the 2-year event such that the nearby storm sewer infrastructure can handle it effectively. Additional kneewalls would also reduce the peak discharge at other Iowa DOT culverts and detain runoff, but the water surface elevations and depths at Points A, B, and C are only slightly decreased. Example simulation results at Culvert #2 with and without all additional kneewalls are shown in Figure 8.1. The discharge through Culvert # 2 is decreased significantly, by 24 cfs, but only a slight decrease in the water surface elevation, 0.1 feet, at the culvert outlet. The model does simulate additional soil infiltration occurring west of US-218 with additional kneewall structures.

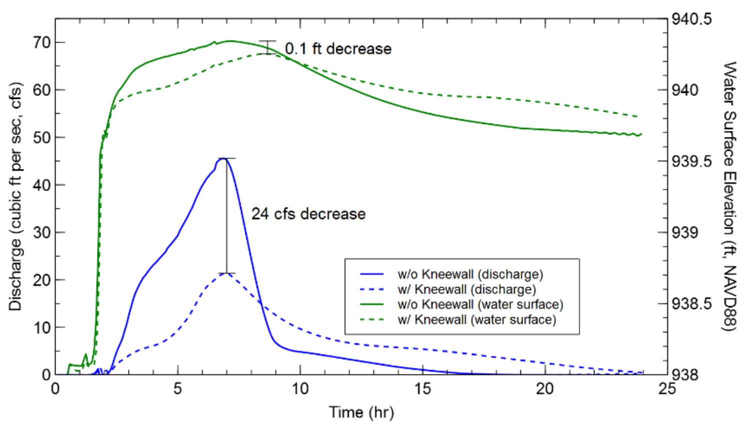

Figure 8.1. Simulation results at Culvert #2 with and without all additional kneewalls structures for the 25-year event. There is a significant decrease in discharge (blue, left axis), but only a slight decrease in water surface elevation (green, right axis).

The largest expected reductions in water depths at Points A, B, and C are achieved when all runoff generated west of US-218 is contained by ditching or berm configurations and routed to Lake Plainfield or the Iowa DOT Wetland Mitigation Area. The configuration that contains all runoff west of US-218, and would require the shortest segments of ditching or berms is the "Ditch from Culverts" option. However, as can be inferred from Figure 7.7, this would require an easement on the Landus Coop parcel and another nearby privately-owned property. Additionally, a natural gas pipeline owned by MidAmerican Energy Company (MEC), shown in Figure 8.2, is located nearby that would likely need to be relocated or altered. The transmission line alignments were estimated using the National Pipeline Mapping System (NPMS). This alternative (7.1.9) is also not viable because additional drainage area is being routed to Lake Plainfield, which already has an under-sized outlet connected to the city's storm sewer system.

The configuration with the largest reductions in water depths at Points A, B, and C that is also located within the ROW is the "East Ditch, in ROW, Extended" option. The configuration was capable of containing the 25-year event, and continues to provide some benefit for the 50- and 100-year events according to simulation results. This scenario would essentially mitigate any impacts the US-218 bypass may have had on flood elevations at Points B and C up to the 100-year flood event. This option would also likely require relocation of the MEC pipeline, in addition to any other utilities located within the Iowa DOT ROW.

Simulation results of the 2-year event indicate the presence of at least two control points, or bottlenecks, within the area south of Plainfield. A control point likely exists just north of the Landus Coop berm, as demonstrated in Figure 8.3 by the grouping of water surface contour lines with a 0.5 feet interval. The water surface drops approximately 1.5 feet downstream of this control point. The control point at this location affects small and large rainfall events.

A control point for smaller events is likely located at the abandoned entrance at the south ditch of 150th St. and the north end of the Iowa DOT Wetland Mitigation Area, shown in Figure 8.4. This control point is likely created by high ground in the wetland area that causes water to flow north, as observed in Figure 2.11. Once water ponds to an elevation greater than 937 feet, sufficient to overcome existing ground, it will begin flowing into the mitigation area. At larger events, a control appears to form northwest of the intersection of Main and 150th Streets, likely due to the culvert passing under Main Street reaching capacity. An additional control point forms at the downstream trestle bridge at larger events.

Simulation results using the "Pre-US-218 Bypass" configuration show increased water depths at Lake Plainfield and Point A. The increased water depth at Lake Plainfield is a result of the borrow pit being removed from the terrain, consistent with the pre-US-218 Bypass condition. The increased water depth at Point A is likely a result of runoff collecting on the north side of the former IA-188 roadway embankment. Decreases in water depths at points B and C range from 0.2 – 0.6 feet. These decreases could result from removal of the bypass, but are more likely a result of the removal of the Landus Coop facility. Comparing the "Pre-US-218 Bypass" and "Removal of Landus Coop" simulation results at Points B and C, it appears the absence of the Landus Coop could account for the majority of these decreases.

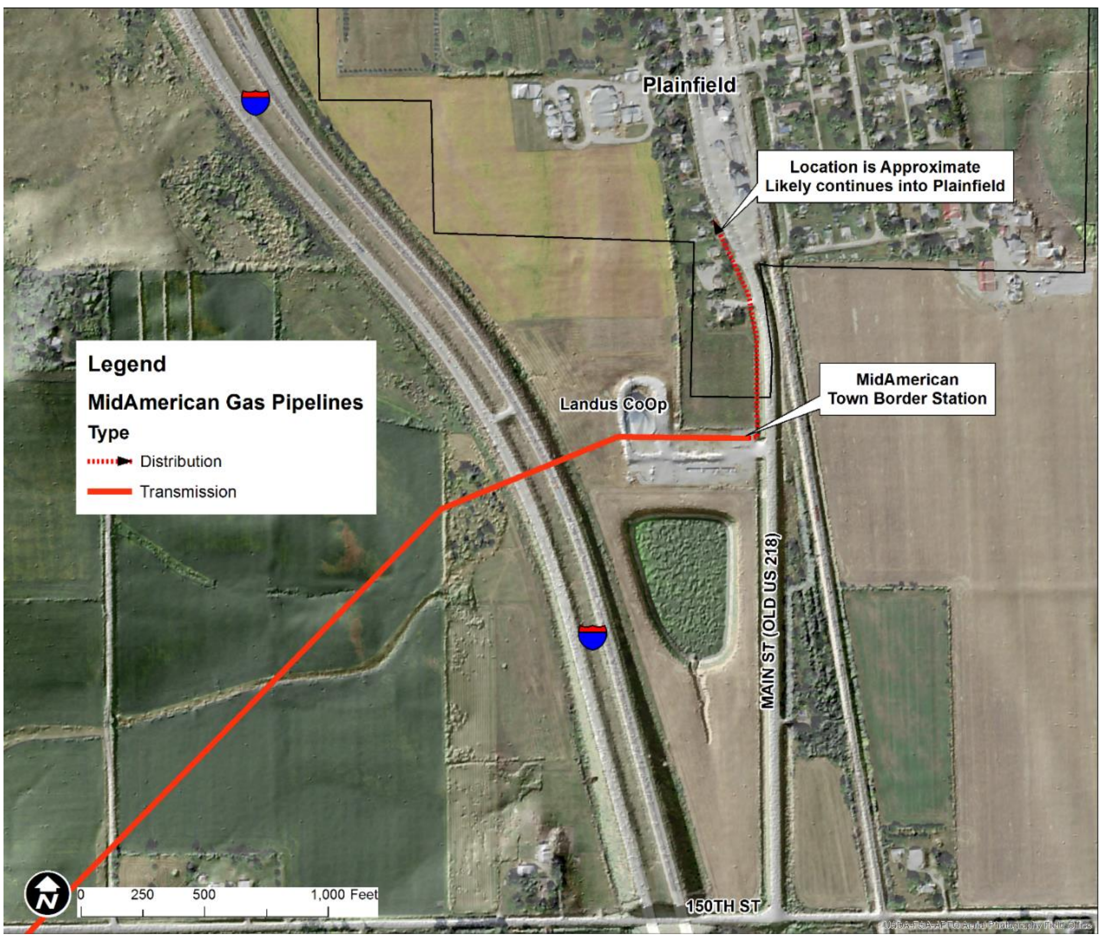

Figure 8.2. Location of MidAmerican Energy Company's natural gas transmission pipeline.

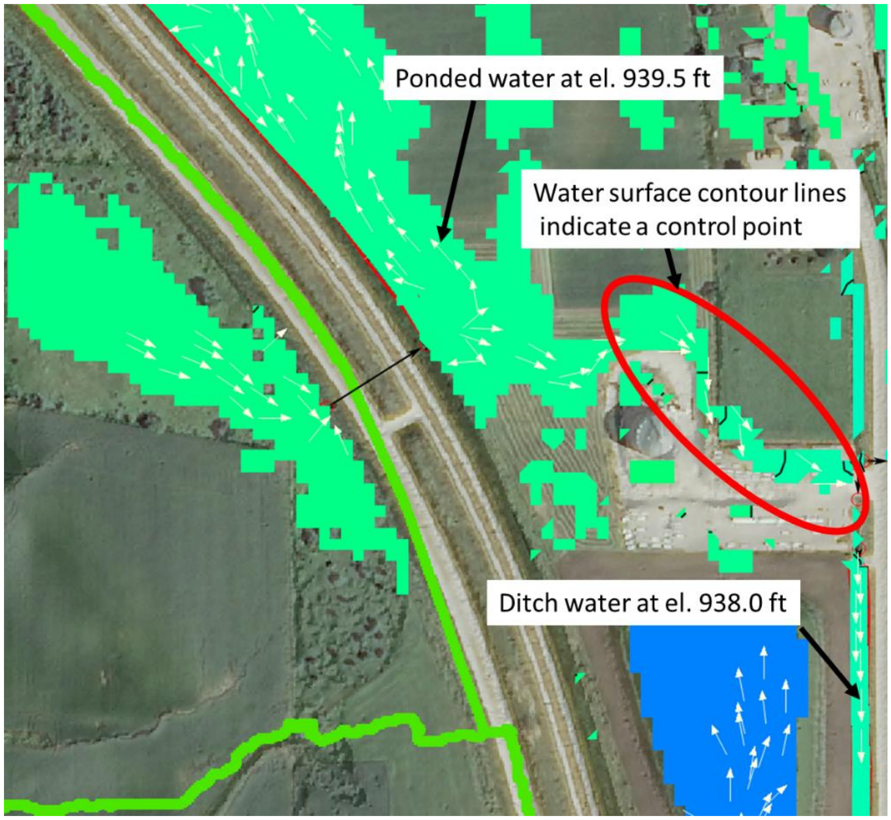

Figure 8.3. Simulation results for the 2-year event indicate a control point for the low-lying area northwest of the Landus Coop. The circled group of water surface contour lines indicate the water surface drops downstream of the control point.

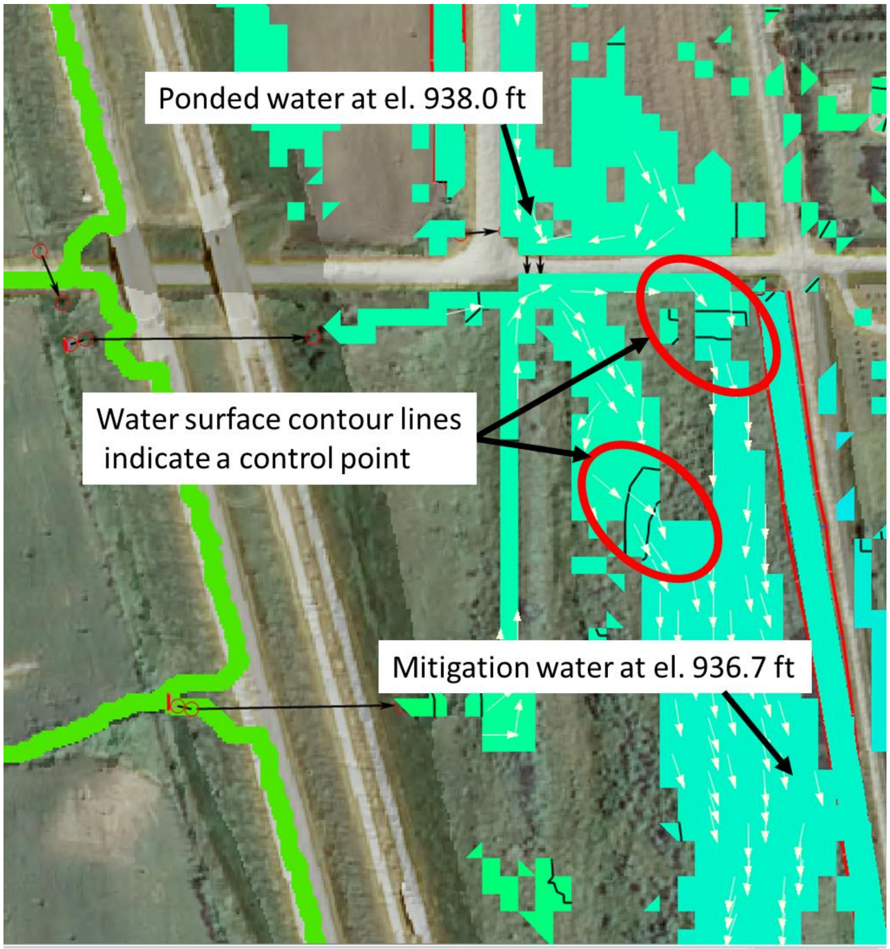

Figure 8.4. Simulation results for the 2-year event indicate a control point along the north end of the Iowa DOT Wetland Mitigation Area. The circled groups of water surface contour lines indicate the water surface drops downstream of abandoned entrance and natural ground elevations.

9. RECOMMENDATIONS

City representatives have shared concerns regarding several drainage issues at various locations. Based on these conversations, basement and surface flooding occurring between US-218 and the west side of Plainfield are their priority. The following recommendations would improve drainage conditions south of the City of Plainfield and provide a more effective outlet for Plainfield's surface flood water. Implementation of these projects alone would not significantly reduce surface flooding between US-218 and the west side of Plainfield.

- Coordinate with Bremer County to facilitate removal of overgrown vegetation in ditches and sediment from existing culverts near the intersection of Main and 150th Streets. (high priority)
- Coordinate with Iowa DOT, Bremer County, and Canadian National Railways to facilitate removal of the driveway located in the northeast corner of the Iowa DOT Wetland Mitigation Area to promote drainage into the wetland area. (high priority)
- Modification to the former US-218 road embankment within the Iowa DOT Wetland Mitigation Area to prevent flow from being directed north, towards the intersection of Main and 150th Streets. (medium priority)
- Coordinate with Canadian National Railways, and Bass Family Farms, LLC to facilitate modification of the high ground just east of the Trestle Bridge to promote flow out of the Iowa DOT Wetland Mitigation Area. (low priority)

The following recommendations could potentially reduce surface flooding between US-218 and the west side of Plainfield. Implementation of projects south of Plainfield would provide a more effective outlet for many of the following recommendations. Based on simulation results, reductions in surface water depths will likely be less than one foot.

- Based on the recommendation of representatives from the City of Plainfield, Bremer County and other agencies, the East Ditch, in ROW, Extended Alternative (7.1.16) was recommended for mitigating flood elevations west of Plainfield. Gas pipelines owned by MidAmerican Energy Company would likely be impacted, and require relocation. The depth of cover on the west, median, and east sides of US-218 are 45.5 inches, 9 feet, and 50.5 inches, respectively. (high priority).

Note: The largest simulated reductions in water depths between US-218 and the west side of Plainfield are achieved with construction of a ditch on either the east or west side of the US-218 embankment. However, additional ROW would be need to be acquired to accommodate the project footprint of East or West Ditch configurations. The East Ditch, in ROW, Extended configuration would provide similar benefit up to the 25-year rainfall event, but would not be as effective as the East or West Ditch options at larger rainfall events. However, this alternative will also mitigate any impacts the US-218 bypass may have had on flood elevations at Points B and C up to the 100-year event.

- Construction of a swale or installation of additional tiling and surface intakes to drain low-lying areas between US-218 and the west side of Plainfield. Much of this property has been entered into the Iowa DNR's Conservation Reserve Program (CRP). Any modification of these parcels would require coordination with Iowa DNR. This recommendation was not modeled, but would theoretically reduce the time required for this area to flow into a nearby ditch or standing water to infiltration. It would not completely prevent ponding. The swale or tile would need sufficient slope to convey flow. A tile would likely need an outlet below natural grade, in a pond or ditch. Discharging the tile into the former borrow pit south of the Landus Coop would be a viable outlet. (medium priority)
- Continue to collaborate with NRCS and other partners (Nature Conservancy, SWCD, Pheasants Forever, Trees Forever, Upper Cedar Watershed Management Improvement Authority (UCWMIA), etc.) in identifying any conservation programs or funding for construction of any additional wetlands or detention ponds on land west of US-218. Additional runoff storage would likely provide some degree of flood attenuation, in addition to potential environmental and ecological benefits. (medium priority)
- Provide an additional outlet to the east for Lake Plainfield (see USACE Section 205 Study), designed to prevent any overtopping and the need for connection to the city's storm sewer system. This will likely require coordination with Canadian National Railways. (low priority)

Mitigation projects that reduce surface flooding between US-218 and the west side of Plainfield have the potential to reduce the severity of basement flooding. However, these measures will provide little benefit if the groundwater table at this location is dominated by regional infiltration processes, terrain characteristics and influence of Cedar River water levels.

The recommended mitigation projects are not likely to adversely affect any properties within Plainfield city limits. Simulation results of the East Ditch, within ROW, Extended configuration (7.1.16) indicate slight increases in water surface elevations of less than 0.5 feet within the Iowa DOT Mitigation Area (Point E) and the inlet of Culvert #3 (Point H) during large storm events. Any increase in water surface elevations at these locations would not impact any buildings.

10. REFERENCES

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