US Army Corps of Engineers®
St. Paul District

Appendix I: Hydraulics

CAP Section 205 Flood Risk Management Study

Arcadia, WI

Feasibility Study Report with Integrated Environmental Assessment

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Contents

Hydraulics Appendix I

I.1 Project Overview

I.1.1 General Information

The City of Arcadia in Trempealeau County, Wisconsin, submitted a study request for the Corps to determine the feasibility of developing a flood risk management project to alleviate damages due to flooding (see Figure 1, Feasibility Report). Arcadia is located in the Trempealeau River Valley, with two tributary streams: Turton Creek on the northern part of the city, and Myers Valley Creek to the south. A considerable portion of Arcadia's urban development, including its entire downtown business district, is located within the 1% annual chance floodplain defined by FEMA (see Figure 2, Feasibility Report). Levees along the Trempealeau River and Turton Creek provide some level of protection, but rain and spring snow melt events overtop the existing system.

The city has experienced several large flood events, beginning as early as 1876. The entire Trempealeau River drainage basin lies within the driftless area of southwest Wisconsin, characterized by rugged ridges and rounded hills. Due to the steep slopes and relatively impervious soils in the watershed, floods in the basin typically have a short duration but rapid rise. The width of the river varies from roughly 120 feet in the lower limits to about 20 feet in the upper limits with fairly uniform normal flow channel depth of about 5 to 7 feet. At Arcadia, bankfull channel capacity is approximately 2,200 cfs. The duration of flows above flood stage at Arcadia generally varies between 2 and 4 days.

The most recent damaging flood in Arcadia occurred in July of 2017. In a 24-hour period, 5-7 inches of rain fell and much of the city was evacuated. Turton Creek overflowed and eroded Oak Street, cutting off the only access for some homeowners. The creek overtopped the levee and flowed into town. Hundreds of homes and several businesses were severely impacted (Reference 1).

Alternatives considered for this flood control project to reduce damages to property and economic losses include levees, floodwalls, and upstream storage. Other issues to be addressed in this study include the deficient interior water management system within the city of Arcadia which will need to be upgraded in conjunction with other primary measures.

I.1.2 Hydrology

The CAP Section 205 Feasibility Study, Trempealeau River and Tributaries at Arcadia, WI, Hydrology Study and Report (February 2019) included in Appendix N provides updated discharge frequency information for several stream sites near the city of Arcadia to aid in the development of the flood risk management project. The sites include three locations along the Trempealeau River, as well as Turton Creek and Myers Valley Creek at Arcadia. Existing hydrologic models from previous analyses were updated and used to develop an estimate of the 1% annual exceedance probability (AEP) event at Turton Creek.

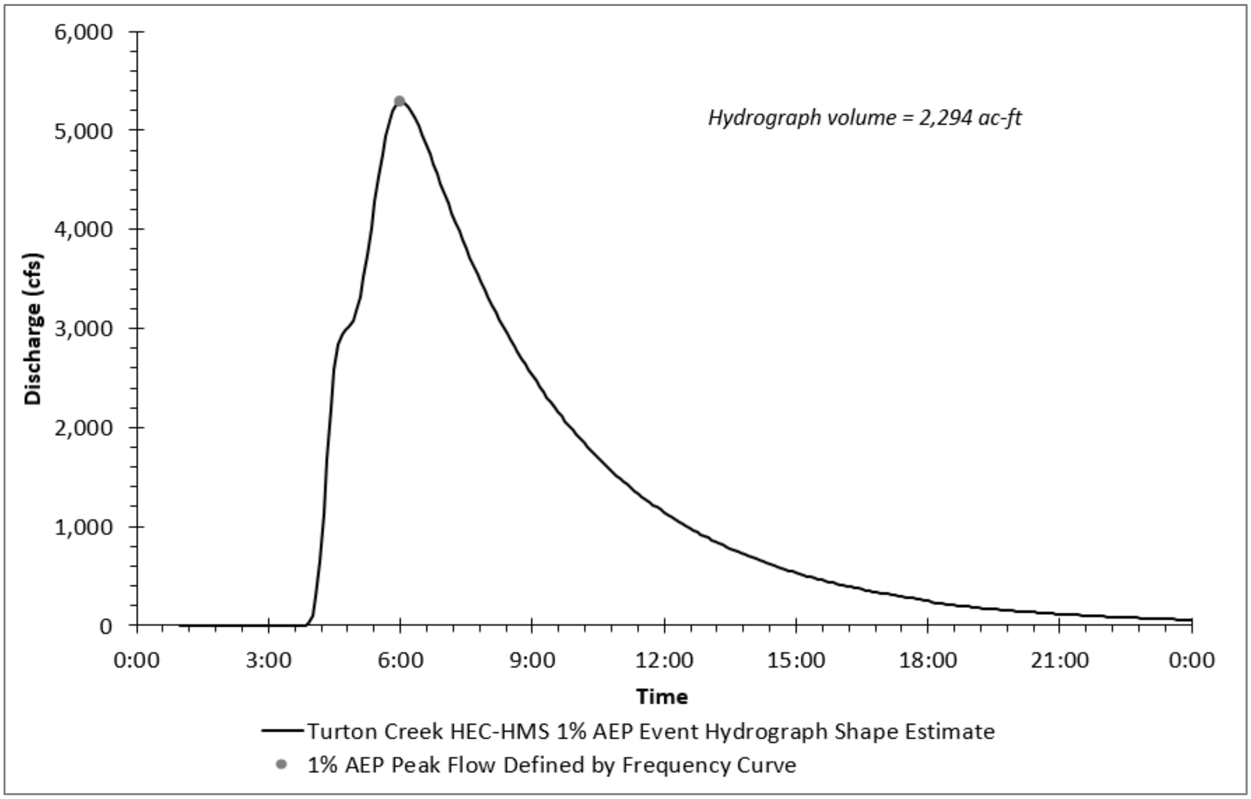


Figure I.1 Turton Creek 1% AEP Event Hydrograph Estimate (1% AEP storm, 6-hour duration) (Source: Appendix N)

I.2 Hydraulic Analysis

I.2.1 HEC-RAS Model

A geo-referenced hydraulic model of the Trempealeau River and Turton Creek was developed with HEC-RAS 5.0.3 (Reference 6) in the project vicinity. Discharges from the 0.2% to the 50% AEP were incorporated into two sets of unsteady flow data. One flow scenario included peak flow on the Trempealeau River with coincidental flows on Turton Creek (Trempealeau-Peak); the other included peak flow on Turton Creek with coincidental flow on the Trempealeau River (Turton-Peak). Results were compared from both scenarios and the maximum water surface was adopted for the final analysis. In general, the Trempealeau River water surface profiles controls for much of the project, with the exception of Turton Creek upstream of the railroad bridge through Oak Street. In order to reduce the number of plan files combining various flow events with the alternatives, all discharges were included in one flow file, stepping up each event every 24 hours of simulation time to generate a matrix of steady flow simulations as opposed to simulation of an event hydrograph. This window of time was sufficient to maximize each flow event and results for a particular event were extracted from the end of each respective window. Duration of the inundation was not a consideration.

Table I.2.1 Annual Peak Discharge Frequency Analysis for Trempealeau River

Exceedance Probability (%)	Peak Estimate (cfs)
0.2%	21,300
0.5%	17,900
1%	15,500
2%	13,200
5%	10,300
10%	8,300

Table I.2.2 Annual Peak Discharge Frequency Analysis for Turton Creek above Trempealeau River

Exceedance Probability (%)	Peak Estimate (cfs)
0.2%	7,100
0.5%	6,100
1%	5,300
2%	4,500
5%	3,400
10%	2,500

I.2.2 Geometry

The Trempealeau River and Turton Creek channels are modeled as one dimensional flow elements while the overbanks are modeled as two-dimensional flow areas. Previous studies of the Trempealeau River have not considered the two-dimensional nature of the flood flows. This study attempts to account for lateral gradient in flow rather than assuming the channel water surface elevation extends horizontally in the lateral direction from the stream until the water surface elevation intersects high ground. In the RAS model, the Trempealeau River extends from Highway 93 on the upstream end to approximately 6000 feet downstream of Ashley Furniture and the city of Arcadia, with one reach upstream of the Turton Creek junction and one downstream. The Turton Creek reach begins approximately 1500 feet upstream of Oak Street and ends at the junction with the Trempealeau River. Digital elevation models (DEM) for LiDAR from Trempealeau County (2014 flight, WiDNR, 5-meter cell size) and Buffalo County (2016 flight, WiDNR, 5-meter cell size) were used to generate the terrain. Floodplain areas were defined within the geometry as 2D flow areas with cell size from ranging from 100 to 200 feet (see Map I.1). Manning's "n" values were assigned from the 2011 National Land Cover Database (see Table I.2.3). Existing embankments were modeled as lateral structures which were delineated based on LiDAR along the banks of the Trempealeau River and Turton Creek. Data for the bridges at Oak Street, River Street, Main Street and the railroad bridge were derived from Wisconsin DOT or Trempealeau County drawings.

The geometry in the channel included cross-sections cut from the terrain. Channel "n" values were set at 0.038 for Turton Creek, and 0.032-0.034 on the Trempealeau River. Additional survey information was acquired on August 15, 2017. Eighteen cross-section were surveyed from top of levee or high bank on the left side of the channel to high bank on the right side of the channel. Culverts under the railroad on the Trempealeau River were surveyed and recorded upstream downstream invert elevation, size and type. All elevations in the model are in NAVD 1988. Locations of cross sections used in the hydraulic analysis are shown in Map I.2 for Turton Creek and Maps I.3 and I.4 for the Trempealeau River. Survey cross-sections are shown in Map I.5.

Table I.2.3 Land Cover Data

Land Cover ID	Land Cover Description	Manning's "n"
11	Open Water	0.025–0.03
21	Developed, Open Space	0.03–0.04
22	Developed, Low Intensity	0.04–0.06
23	Developed, Medium Intensity	0.04–0.07
24	Developed, High Intensity	0.06–0.07
31	Barren Land	0.025–0.035
41	Deciduous Forest	0.15–0.2
42	Evergreen Forest	0.14–0.18
43	Mixed Forest	0.18–0.2
52	Shrub/Scrub	0.09–0.11
71	Grassland/Herbaceous	0.06–0.08
81	Pasture/Hay	0.05–0.07
82	Cultivated Crops	0.045–0.065
90	Woody Wetlands	0.07–0.09
95	Emergent Herbaceous	0.06–0.08

I.2.3 Downstream Boundary Condition

A rating curve was estimated for the downstream boundary condition based on water surface elevations from the Trempealeau River Flood Insurance Study discharges. A vertical translation from USGS Gage 05379400 Trempealeau River at Arcadia, Wisconsin was compared to the rating curve. Minor adjustments were made to the rating curve when calibrating the model to reduce instability at the lower elevations and discharges.

I.2.4 Calibration

High water marks (HWM) surveyed shortly after the May 18, 2017 event were used to calibrate the model. USGS Gage 05379400 Trempealeau River at Arcadia, Wisconsin recorded a maximum flow of 8810 cfs. The surveyed high water mark on the Main Street bridge corresponding to this event was 728.46 and the calibrated water surface elevation (WSE) was 728.51. The Turton Creek discharge was estimated to be 600 cfs based on preliminary modeling. The Oak Street bridge HWM was at elevation 734.41. The modeled WSE at that location was 733.8, which was determined to be acceptable since the HWM was taken off the main channel and the energy elevation was a couple of tenths higher just upstream of the bridge. In addition, the HWM for that event at the Turton Creek railroad bridge was approximately at top of tie/base of rail elevation (HWM 731.32, WSE 731.50).

Another significant rain event occurred on July 20, 2017. Using the calibrated HEC-RAS model, the July event was estimated as a 1/200 annual chance exceedance event on Turton Creek with a corresponding discharge of 6,310 cfs. Additional survey date was acquired in August of 2017 on Turton Creek and the Trempealeau River to improve the cross section data and calibration. The peak discharge recorded by the Trempealeau River at Arcadia USGS gage (ID 05379400) was 9,260 cfs. High water marks from the event surveyed along Turton Creek included the damaged garage on Oak Street (HWM 739.87, WSE 739.58) and at the railroad bridge (HWM 732.83, WSE 733.04).

I.2.5 Myers Valley Creek

A steady flow HEC-RAS model for Myers Valley Creek was obtained from Davy Engineering (see Map I.6). It was developed for the Myers Valley Creek realignment constructed in 2016. In order to evaluate water surface profiles along the railroad track and up to the main pump station, the model was extended down to the railroad bridge and cross sections added from LiDAR. Details of the railroad bridge were added from surveys by Davy Engineering. The frequency analysis results in Appendix N were used to update the steady flow values in the model.

Table I.2.5.1 Annual Peak Discharge Frequency Analysis for Myers Valley Creek at Arcadia

Exceedance Probability (%)	Peak Estimate (cfs)
0.2%	2,910
0.5%	2,500
1%	2,180
2%	1,840
5%	1,390
10%	1,050

I.3 Alternatives

Alternatives for the flood control project that were evaluated from a hydraulic standpoint include structural measures such as levees or floodwalls, and upstream storage designed to control the flow of water from flood prone areas. A series of earthen levees or concrete floodwalls constructed along the Trempealeau River and Turton Creek would contain floodwaters. Detention basins or upstream storage would retain a volume of water upstream of Arcadia and be released after the flood event. See Attachment I-3 for a summary of HEC-RAS modeling alternatives analysis.

I.3.1 Initial Measure Screening

A levee and/or floodwall along the existing emergency levee system on the left bank of Turton Creek and the Trempealeau River was considered throughout the screening. Common to all alternatives is the interior flood control analysis, which assumes the main pump station at Ashley, along with the pump stations at Deer Park and Masseure Street will need to be modified to meet USACE standards. The alternatives outlined below were brought forward from inception of the project but eliminated after the initial analysis.

I.3.1.1 Oak Street

Several options were considered for Oak Street. To reroute Turton Creek to go around the house north of Oak Street, the road would have to be lowered north of the bridge to elevation 735 to provide a path for high flows. A road closure would need to be established in a timely manner to ensure public safety and prevent cars from crossing the road. A third option regarding Oak Street was discussed that would involve removing the Oak Street bridge, removing the north abutment and lowering the overbank area on the north side to elevation 731 to eliminate flow constriction. Two homes may have to be relocated and the sanitary sewer rerouted.

I.3.1.2 Storage

Two locations were considered for creating upstream storage: a gravel pit by the Trempealeau River and the Old Mill by Turton Creek. The gravel pit options had no effect on flood elevations because the site was higher ground than the river channel. Storage at the Mill site and other sites upstream on Turton Creek resulted in a 12-15% reduction in peak discharge for 1% annual chance exceedance event, but the benefit did not outweigh the potential costs of real estate, control structures or the environmental impacts.

I.3.1.3 Bridge and Railroad modification

Removing the River Street Bridge and raising the Main Street Bridge would reduce water surface profiles upstream of the bridges but would have no effect on water surface profiles downstream of the bridges. Raising the railroad bridge on Turton Creek did not have much effect on the water surface elevations, however, a raise would make the closure shallower and might alleviate some issues with clogging the bridge. The extent of the railroad raise to the north should be limited so as not to affect breakout flows from Turton Creek into the Trempealeau River. Increasing the Oak Street bridge opening by 50% lowers the upstream profile by 0.4 feet and could be combined with a levee or floodwall alternative, but did not have an effect on water surface profiles downstream of the bridge.

I.3.2 Refining Alternatives

The remaining alternatives were refined and evaluated further. A layout was developed for the left bank levee alternatives along Turton Creek and Trempealeau River which places the riverward toe of the levee at the floodway. The levee section has a riverward slope of 1 vertical on 3 horizontal, top width of 10 feet, landward slope of 1 vertical on 5 horizontal with a 15 foot clear zone at the toe of the levee for access and inspection. Several structures would need to be removed along Turton Creek and possibly some adjustments to buildings or roads by Ashley Furniture. A similar alignment was used for the floodwall alternative. Preliminary quantities and a parametric cost estimate were developed for both.

A hydraulic analysis compared structural alternatives for Reach 1 on Turton Creek. Option 1.1 included a new levee adjacent to Turton Creek with a road closure for the left bank of Turton Creek at Oak Street. Three additional alternatives include the left bank levee with additional features. Option 1.2 added a Texas crossing north of the creek on Oak Street ton convey flood flows and a small section of Turton Creek being rerouted to accommodate a larger levee footprint. The Oak Street Bridge would remain and a road closure would not be required. Several residential structures would be preserved, as well as the secondary access to the school. In Option 1.3, the Oak Street Bridge would be removed and an alternative access road would be constructed on the north side of the creek. The bank on the right side of the creek would be excavated to adjacent low ground to obtain additional flow capacity. Option 1.4 included rerouting Turton Creek in order to minimize impacts to residential structures on the left bank, removing the Oak Street Bridge and constructing an alternative access road on the north side of the creek.

Various alternatives were developed and compared in order to select the recommended plan. Features of the recommended plan are discussed in the main report; the individual reaches are discussed below.

I.4 Recommended Plan

The recommended is comprised of four reaches (see Figure 8, Feasibility Report). The line of protection begins at the Oak Street bridge on Turton Creek and generally follows the existing emergency levee alignment to the River Street and Main Street bridges on the Trempealeau River, continues to the Ashley Furniture campus and follows the west and south extents of Ashley property before tying in to high ground at County Road J.

I.4.1 Reach 1

Reach 1 begins at the Oak Street bridge and extends approximately 1250 feet downstream. The end of this reach was estimated based on the location where the 1% annual chance exceedance (ACE) controlled by Turton Creek transition to the Trempealeau River controlling the water surface profiles which coincides with HEC-RAS river section 3998.993. A Texas crossing will be constructed on the north side of the Oak Street bridge to reinforce the roadway during flood events and also help to convey flood flows. This increased capacity allows the Oak Street bridge to remain while eliminating the need for a road relocation. The emergency levee will be removed and a new levee constructed along the same alignment. To accommodate the new levee footprint, retain as many residences as possible, and keep the secondary access to the school, approximately 1080 feet of Turton Creek would be realigned starting immediately downstream of the Oak Street bridge. The new channel will be designed to replicate the existing channel shape, and attention will be given to maintaining the bank height and reconstructing natural levees in the floodplain to reduce any changes to the capacity and flow in the channel and floodplain. Riprap will be placed on the banks downstream of the Oak Street bridge where required by high velocities, at each transition between the existing and newly constructed channel, and also along the toe of the proposed levee.

I.4.2 Reach 2

Reach 2 starts at the end of Reach 1 and continues along Turton Creek to the confluence with the Trempealeau River, then along the Trempealeau River to the entrance of Ashley Furniture. The existing emergency levee along Turton Creek to the River Street bridge would be reconstructed. Approximately 600 feet of Turton Creek would be realigned to accommodate the new levee footprint. The new channel will be designed to replicate the existing channel top width, depth, slope and sinuosity. Natural levees in the floodplain would be reconstructed to minimize variations in the capacity and flow in the channel and floodplain. A floodwall will be constructed from River Street to Main Street, with closures at both bridges. The floodwall will continue along Ashley Way from the Main Street bridge to the entrance of Ashley Furniture.

I.4.3 Reach 3

Reach 3 is located entirely in the intermodal area of Ashley Furniture. The intermodal expansion will not be a levee embankment, but designed to function as engineered high ground. To ensure this reach provides the same level of flood risk management as the rest of the system and account for potential changes in hydrology or hydraulics, the minimum top elevation along the profile of the intermodal area should be 0.5 feet above the Wisconsin DNR standard of 1% ACE plus 3 feet of freeboard. On the south end of the intermodal area, the railroad tracks will need to be raised to require top of levee elevations.

I.4.4 Reach 4

Reach 4 completes the line of protection along Myers Valley Creek. It extends from the railroad tracks, through the main pump station, and then follows the existing lagoon embankment which will be excavated and rebuilt to design elevations and requirements. From the end of the lagoon it joins the alignment of the rerouted Myers Valley Creek, crosses through cattle pasture before tying into County Road J. Some areas of fill are necessary to meet the required top of levee and utility crossings will need to be addressed to comply with levee safety requirements. See Attachment I.2 for Reach 4 tieback alignment supporting information.

I.5 Water Surface Profiles

Water surface profiles were developed for the proposed levee from the calibrated HEC-RAS model for Turton Creek and the Trempealeau River using the discharge-frequency relationships in Appendix N. The water surface profiles were used in the economic analysis to develop the NED project plan. Table I.5 shows water surface elevations for Turton Creek and the Trempealeau River. A comprehensive table of results is included in Attachment I.3 for the entire HEC-RAS project.

Table I.5 Water Surface Profiles for NED Analysis

				Ex. Conditions	**With Project**
River Sta	Profile	Q Total	Min Ch El	W.S. Elev	W.S. Elev
19937.73	1/2	3700	721.18	728.27	728.27
19937.73	1/5	6200	721.18	729.65	729.65
19937.73	1/10	8100	721.18	730.47	730.47
19937.73	1/20	10000	721.18	731.29	731.29
19937.73	1/50	12800	721.18	732.31	732.31
19937.73	1/100	15000	721.18	732.91	732.99
19937.73	1/200	17400	721.18	733.34	733.63
19937.73	1/500	20700	721.18	733.82	734.30
18165.47	1/2	3700	719.69	727.03	727.03
18165.47	1/5	6200	719.69	728.32	728.32
18165.47	1/10	8100	719.69	729.15	729.15
18165.47	1/20	10000	719.69	730.01	730.01
18165.47	1/50	12800	719.69	731.19	731.19
18165.47	1/100	15000	719.69	731.78	731.88
18165.47	1/200	17400	719.69	732.14	732.49
18165.47	1/500	20700	719.69	732.51	733.15

Table I.5 (cont.) Water Surface Profiles for NED Analysis

				Ex. Conditions	**With Project**
River Sta	Profile	Q Total	Min Ch El	W.S. Elev	W.S. Elev
	(ACE)	(cfs)	(ft)	(ft)	(ft)
17645.07	1/2	3800	718.59	726.94	726.94
17645.07	1/5	6400	718.59	728.15	728.15
17645.07	1/10	8300	718.59	728.91	728.91
17645.07	1/20	10300	718.59	729.70	729.69
17645.07	1/50	13200	718.59	730.72	730.71
17645.07	1/100	15500	718.59	731.27	731.37
17645.07	1/200	17900	718.59	731.63	731.99
17645.07	1/500	21300	718.59	732.02	732.70
16804.04	1/2	3800	717.04	726.57	726.57
16804.04	1/5	6400	717.04	727.38	727.38
16804.04	1/10	8300	717.04	727.80	727.80
16804.04	1/20	10300	717.04	728.19	728.19
16804.04	1/50	13200	717.04	728.69	728.69
16804.04	1/100	15500	717.04	728.95	729.01
16804.04	1/200	17900	717.04	729.14	729.38
16804.04	1/500	21300	717.04	729.41	729.87
15496.06	1/2	3800	717.67	725.79	725.79
15496.06	1/5	6400	717.67	726.24	726.24
15496.06	1/10	8300	717.67	726.47	726.47
15496.06	1/20	10300	717.67	726.67	726.67
15496.06	1/50	13200	717.67	726.95	726.95
15496.06	1/100	15500	717.67	727.15	727.18
15496.06	1/200	17900	717.67	727.36	727.45
15496.06	1/500	21300	717.67	727.70	727.76
5345.724	1/2	710	727.33	733.96	733.96
5345.724	1/5	1700	727.33	735.60	735.60
5345.724	1/10	2500	727.33	737.12	737.18
5345.724	1/20	3400	727.33	737.93	737.96
5345.724	1/50	4500	727.33	738.44	738.50
5345.724	1/100	5300	727.33	738.81	738.95
5345.724	1/200	6100	727.33	739.34	739.52
5345.724	1/500	7100	727.33	739.90	740.00

I.6 Risk & Uncertainty Analysis

The HEC-FDA program was run for 8 index locations and corresponding reaches in Table I.6.1. The HEC-FDA reaches are included in the Figure I.6.1 and do not correspond to design reaches in the recommended plan. The index stations correspond with HEC-RAS cross sections. Based on the minimum required standard deviation of error in stage in EM 1110-2-1619, with the LiDAR data accurate enough to develop 2-foot contours and assuming fair Manning's n reliability, hydraulic uncertainty was set to 1 foot. The results of the analysis are summarized in Table I.6.2 and I.6.3.

Table I.6.1 Index Stations and Reaches for HEC-FDA

Reach	Stream_Name	Beginning_Station	Ending_Station	Index_Station
1	Trempealeau	150	15497	15496.06
2	Trempealeau	16176	17646	16804.04
3	Trempealeau	17927	18742	18165.47
4	Trempealeau	19361	30296	19937.73
5	Trempealeau	150	15497	15496.06
6	Trempealeau	16176	17646	17645.07
7	Trempealeau	18165	19938	18165.47
8	Turton Creek	196	6801	5345.724

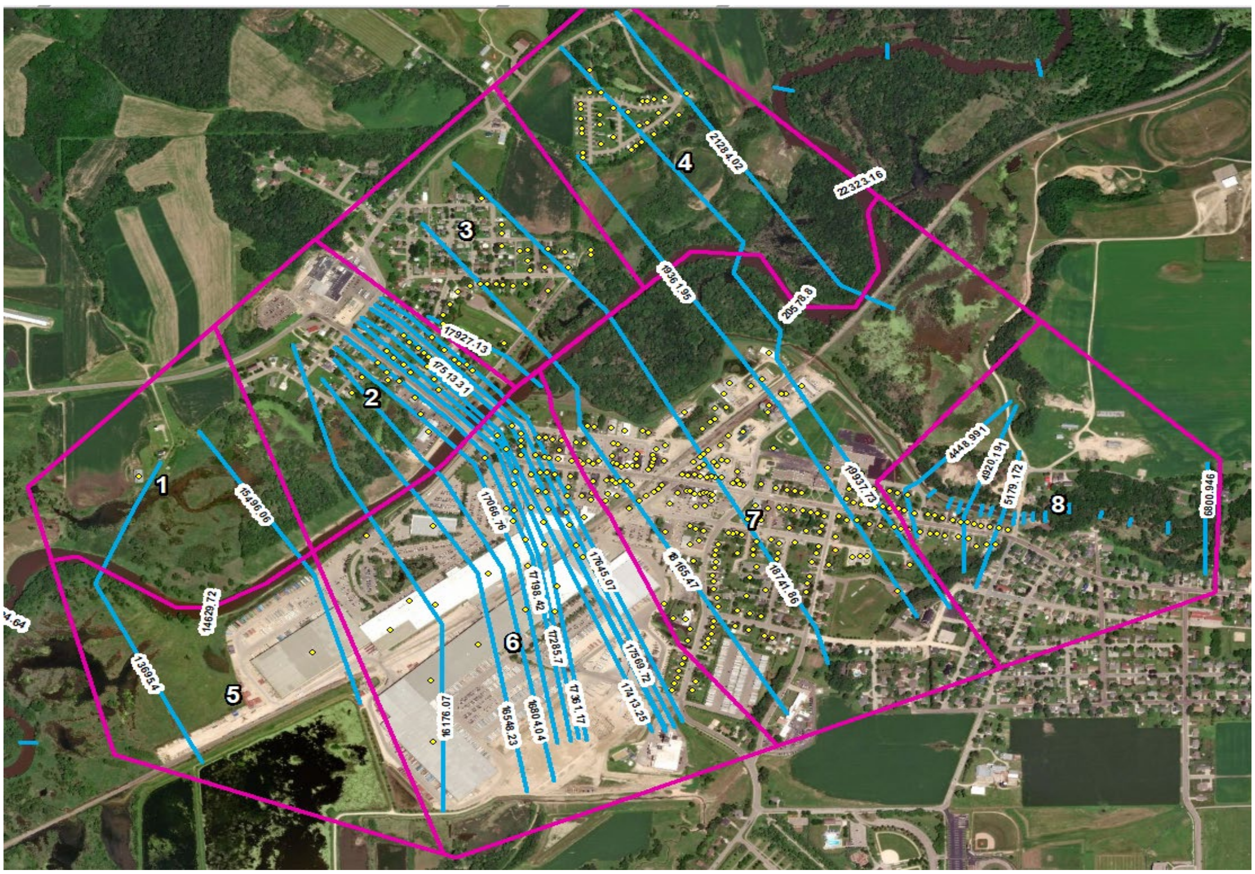


Figure I.6.1 HEC-FDA reaches

Table I.6.2 Target Stages for HEC-FDA

Study Area Reach	Target Stage	Target Stage Annual Exceedance Probability		Long-Term Risk (years)		
		Median	Expected	10	30	50
1	726.85	0.0264	0.1406	0.7802	0.9894	0.9995
2	728.44	0.0254	0.0833	0.5811	0.9265	0.9871
3	729.84	0.0488	0.0770	0.5514	0.9097	0.9818
4	731.41	0.0392	0.0619	0.4721	0.8529	0.9590
5	730.18	0.0001	0.0003	0.0029	0.0087	0.0145
6	734.87	0.0001	0.0002	0.0022	0.0067	0.0112
7	735.38	0.0001	0.0002	0.0021	0.0063	0.0105
8	742.45	0.0001	0.0002	0.0016	0.0048	0.0079

Table I.6.3 Conditional Non-Exceedance Probability for HEC-FDA

Study Area Reach	Target Stage	Conditional Non-Exceedance Probability by Events					
		0.10	0.04	0.02	0.01	0.004	0.002
1	726.85	0.6521	0.5449	0.4503	0.3536	0.2436	0.1935
2	728.44	0.7524	0.5803	0.4310	0.2887	0.1476	0.0892
3	729.84	0.7434	0.4148	0.2108	0.0855	0.0207	0.0055
4	731.41	0.8176	0.4881	0.2567	0.1106	0.0276	0.0092
5	730.18	0.9998	0.9996	0.9991	0.9978	0.9947	0.9923
6	734.87	1.0000	1.0000	1.0000	0.9995	0.9965	0.9930
7	735.38	1.0000	1.0000	1.0000	0.9997	0.9977	0.9955
8	742.45	1.0000	0.9998	0.9991	0.9980	0.9966	0.9956

I.7 Top of Levee Design

The top-of-levee profile provided was based on the 1% ACE water surface profile plus additional levee height necessary to provide a factor of safety and to meet design criteria. Per 44 CFR 65.10 and to meet FEMA requirements, a levee must generally have 3 feet of freeboard and provide a 90% assurance (non-exceedance probability) of containing the 1% event or a minimum of 2’ of freeboard and a 95% assurance of containing the 1% event. In addition, Wisconsin State statutes require a minimum 3’ of freeboard. Based on HEC-FDA analysis to evaluate assurance levels, a project with less than 3 feet minimum freeboard would likely meet criteria, but would not satisfy Wisconsin State statutes. The top-of-levee profile is more than 3’ above the water surface profile farther upstream to provide superiority. The “superiority” top of levee profile was developed by adding 0.5 foot of superiority at cross section 5272.433 on Turton Creek down to section 16804.04 on the Trempealeau River so the project would initially overtop at the downstream end, if overtopped. This downstream reach is preferred for overtopping due to its proximity to industrial areas as opposed to the vulnerable residences and businesses in the city that are affected when the upstream reach of the levee system overtops. The overtopping reach was established after performing hydraulic analysis for a range of levee heights and selecting the recommended plan. The overtopping reach design will provide protection above the 0.2% event and will be incorporated into the final levee profile design with consideration given to cost effectiveness of the overtopping resiliency measures. The overtopping length and depth will be determined to inform the type of resiliency measures that will be incorporated into the design.

The 1% top of levee (project design with superiority) elevations are shown in Table I.7 and a profile plot shown in Figure I.7.

Table I.7 Top of levee elevations with superiority

Location	River Sta	1% W.S. Elev	TOL
D.S. of Oak St bridge	5179.172	737.0	740.5
	4756.956	734.2	737.7
	3998.993	733.3	736.8
	3078.974	732.7	736.2
	885.8156	732.3	735.8
U.S. of Main St bridge	17645.07	731.4	734.9
D.S. of Main St bridge	17198.42	729.6	733.1
	17066.76	729.7	733.2
	16804.04	729.0	732.5
Overtopping reach	16548.23	728.6	731.6
Overtopping reach	16176.07	728.1	731.1
Overtopping reach	15496.06	727.2	730.2

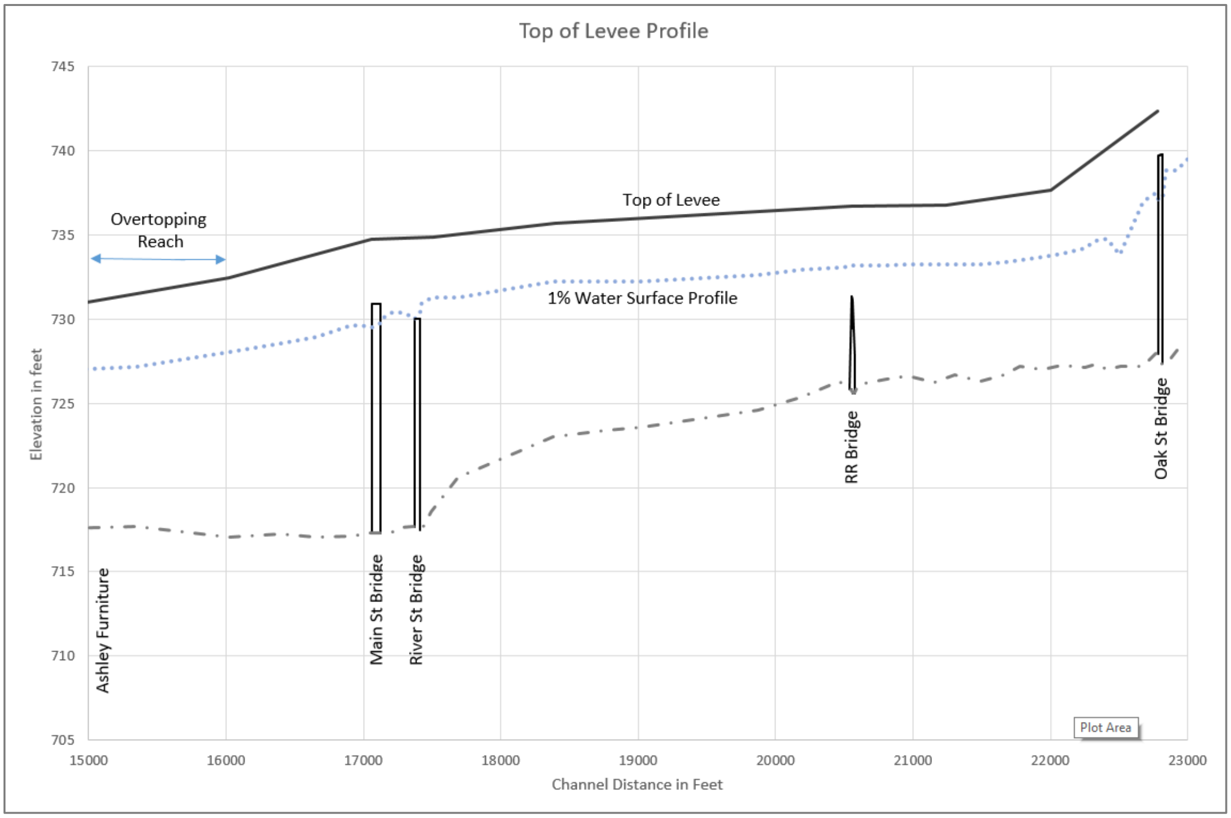


Figure I.7 Top of Levee Profile

I.8 Upstream and Downstream Impacts

The recommended plan has no impact on the 1% water surface profiles downstream of RAS section 8815.729. Due to the Texas Crossing in Reach 1 increasing the conveyance adjacent to the Oak Street bridge, 1% water surface profiles are lowered 0.5 feet approximately 1450 feet upstream of the bridge.

I.9 Riprap Design

Hydraulic modeling indicates the need for riprap armor in selected locations along the toe and bank of the riverward slope of the levee, and also high velocity and transition flow areas where Turton Creek will be realigned downstream of the Oak Street bridge. Riprap will be designed according to criteria outlined in EM 1110-2-1601, "Hydraulic Design of Flood Control Channels." This guidance is used to compute shear forces on riprap layer on the channel bottom and side slopes for the proposed design. Riprap size, weight gradation, vertical extent and layer thickness will need to be determined in the development of plans and specifications.

I.10 References

1. Arcadia flood event: http://www.weau.com/content/news/Arcadia-surveys-damage-after-flooding-impacts-parts-of-the-city-435713183.html.
2. Corps of Engineers, St. Paul District. "Trempealeau River and Tributaries at Arcadia, WI,

Hydrology Study and Report." 2019 (Appendix N).
3. United States Army Corps of Engineers. *Engineering Manual 1110-2-1619, Risk-based Analysis for Flood Damage Reduction Studies*, 1996.
4. United States Army Corps of Engineers. *Engineering Regulation 1110-2-1416, River Hydraulics*, October 1993.
5. United States Army Corps of Engineers. *Engineering Regulation 1105-2-1101, Risk Assessment for Flood Risk Management Studies*, 2017.
6. Hydrologic Engineering Centers River Analysis System (HEC-RAS), Version 5.0.6.
7. United States Army Corps of Engineers. *Engineering Manual 1110-2-1601, Hydraulic Design of Flood Control Channels*, 1991.

I.11 Attachments

Attachment I-1: Maps

I.1 HEC-RAS model 2-D flow areas

I.2 HEC-RAS model cross-sections for Turton Creek

I.3 HEC-RAS model cross-sections for the Trempealeau River

I.4 HEC-RAS model cross-sections for the Trempealeau River

I.5 2017 Survey cross-sections

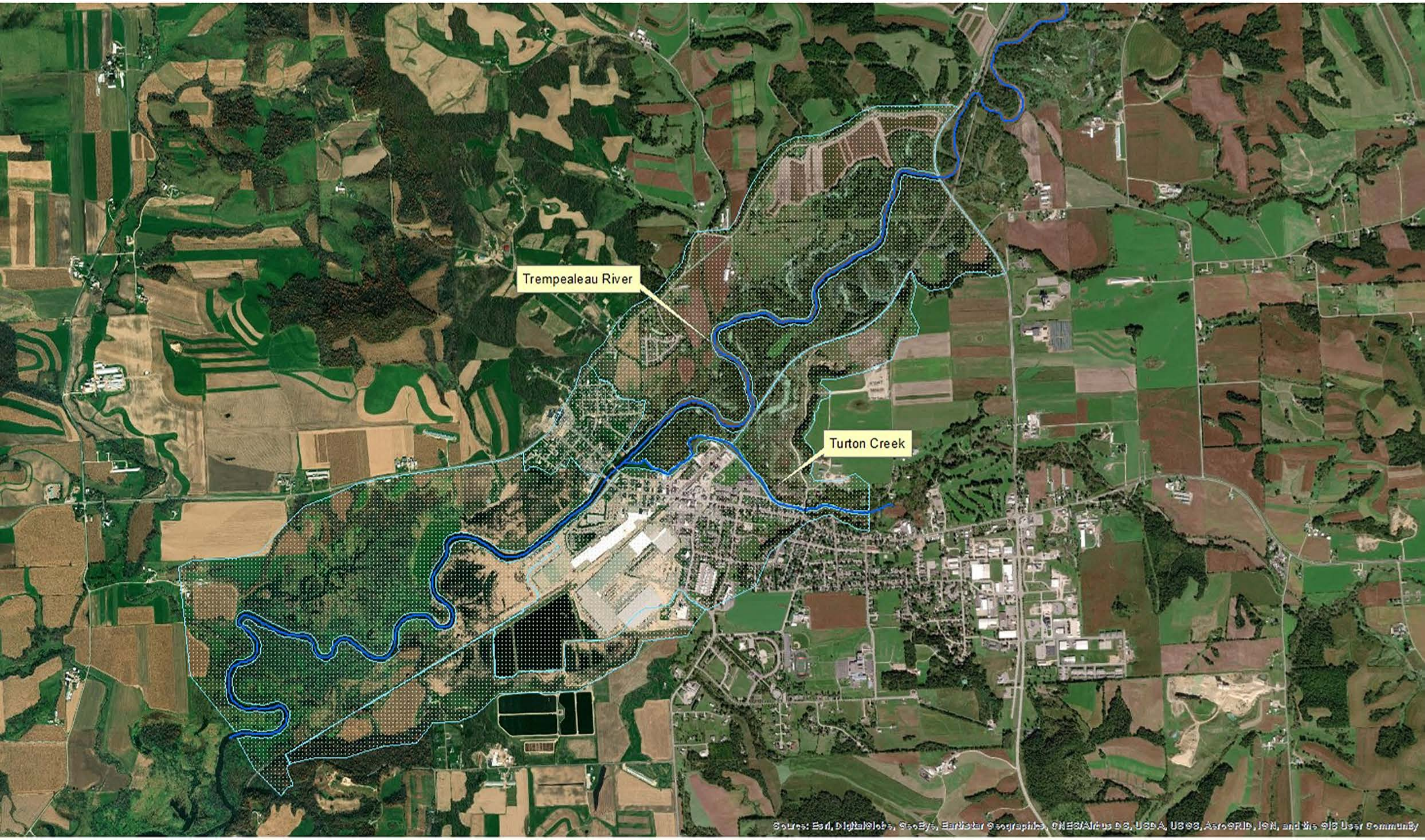
I.6 HEC-RAS model cross-sections for Myers Valley Creek

Attachment I-2: Reach 4 Design Memorandum for Record

Attachment I-3: HEC-RAS Alternatives Analysis

Attachment I-1

Maps

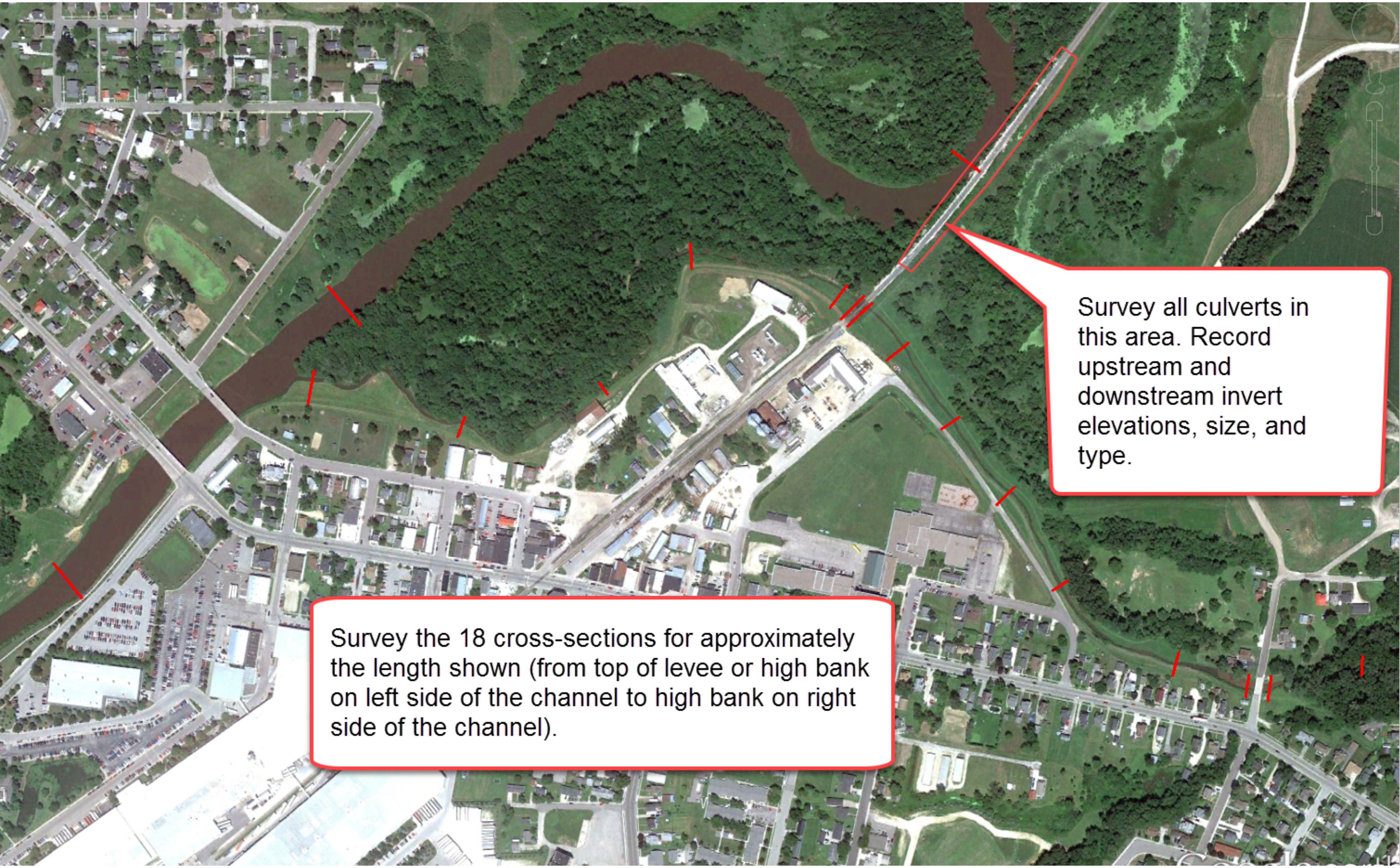


Map I.1 HEC-RAS Model 2-D Flow Areas

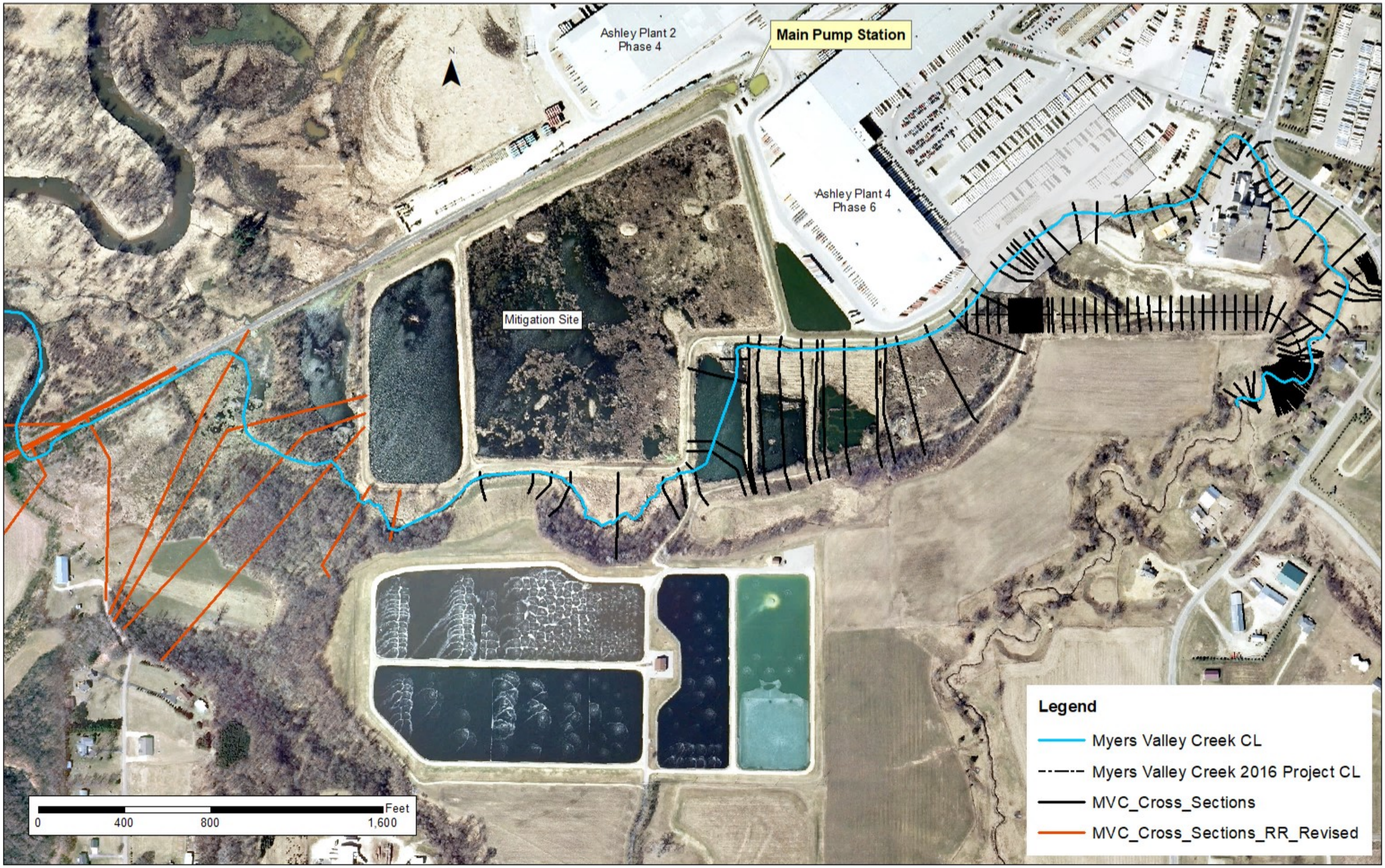
Map I.2: HEC-RAS cross sections along Turton Creek

Map I.3: HEC-RAS cross sections along Trempealeau River

Map I.4: HEC-RAS cross sections along Trempealeau River



Map I.5 2017 Survey Cross-sections



Map I.6 HEC-RAS model cross-sections for Myers Valley Creek

Attachment I-2
Reach 4
Design Memorandum for Record

CEMVP-ECH 25 April 2018

MEMORANDUM FOR: Michael Bart, P.E., Chief, Engineering and Construction Division, St. Paul District

SUBJECT: Arcadia, WI, CAP 205 Flood Risk Management Project, Myers Valley Creek

1. This memo includes information for potential tieback alignments for Myers Valley Creek as part of the Arcadia CAP 205 project and also presents information for a Myers Valley Creek channel relocation project completed by the City in 2016. The intent of the alternative tieback alignments is to incorporate an existing pump station into the CAP 205 project for Arcadia. The City of Arcadia and Ashley Furniture feel the existing pump station is adequate both in capacity and performance and can be incorporated into the CAP project to save project costs. The pump station does not meet USACE criteria and will have to be modified to incorporate it into the project. The creek channel was relocated to eliminate a sharp bend and a very restrictive bridge on the creek that overtopped during a September 2010 rainfall event and flooded the city. The relocated creek project completes the line of protection and will likely have to be incorporated into the project.

2. Following is some background information for the creek including the drainage area and 1% event discharges. The 1% event discharges include the USACE CAP 205 project discharge and discharges developed by the City's A/E for the creek relocation project. **Figure 1** and **Figure 2** show the pre-project and relocated creek alignments. These figures also show the Trempealeau River regulatory floodplain and floodway. Myers Valley Creek was not included in the effective flood insurance study. **Figure 1** shows the creek alignments and HEC-RAS model cross sections. The City A/E's HEC-RAS model did not extend far enough downstream to evaluate the potential tieback alignments so it was extended downstream to the RR tracks. **Figure 2** shows the pre-project creek alignment and an aerial view of the relocated creek channel. **Figure 3** is a Myers Valley Creek profile showing the channel thalweg, 1% event profiles based on the City A/E's discharges and right bank elevations.

Myers Valley Creek Drainage area – 6.38 square miles
Myers Valley Creek 1% Discharge – 1,020 cfs (USACE CAP 205)
Myers Valley Creek 1% Discharges for City Diversion Channel Project
- D/S End – 1,240 cfs
- Ponds to Diversion/Pre-Project Channel – 1,130cfs
- Diversion/Pre-Project Channel – 1,050 cfs

Myers Valley Creek 1% Event Backwater Elevation – 724.1 (based on City Diversion Project discharges)
Required Elevation with 3' of freeboard – 727.1

3. The proposed CAP project has been divided into reaches as shown on **Figure 4**. Reach 1 is along Turton Creek, Reaches 2 and 3 are along the Trempealeau River and Reach 4 is along Myers Valley Creek. In addition, the City's creek channel relocation project would likely be considered Reach 5 if it is incorporated into the project.

4. The three alternatives considered for Reach 4 are shown in **Figure 5**. Note that the Reach 4 alternatives assume the Reach 3 alternative to raise the Ashley intermodal and truck parking area is acceptable. **Figure 6** shows ground profiles along the three alignments along with the backwater elevation of 724.1 and the three feet of freeboard elevation of 727.1. A minimum three feet of freeboard is being used in lieu of reasonable assurance from a risk-based analysis because Wisconsin statue generally requires this. There are exceptions in the statute regarding if the 0.2% event and/or the SPF is confined riverward of the levee; however, the DNR would not grant an exception for the Wisconsin River at Portage, WI project. As shown in the **Figure 6** profiles, the first 900 feet are up to 0.7 feet lower than the with 3' of freeboard elevation of 727.1. This should be remedied if Ashley Furniture raises their intermodal area and siding railroad track to provide Trempealeau River protection for Reach 3. **Figure 7** shows utilities in the Reach 4 area that are based on an AutoCAD drawing supplied by the City's A/E. Note that the utility locations are not georeferenced and the locations are approximate. All utility/feature locations are off by 50 to 70 feet. This map is included to show general utility complications with the Reach 4 alternative alignments. The storm sewers are shown in pink, the sanitary sewers are shown in light green and water mains are shown in blue.

5. A short description of each alternative along with advantages/disadvantages is shown in the table on the following page. Based on this information, Alternative 2 is the preferred alignment as it is relatively short and has the least complications with the existing utilities except for the sanitary force main that is within the mitigation site embankment. **Figure 8** is a cross section cut from the LiDAR DEM at the location of Section A-A shown in **Figure 5**. Based on this it is likely that the sanitary sewer is not within what would be considered the levee prism which supports the selection of Alternative 2. Alternative 1 was not selected because it would require gates on the existing storm sewers which may cause issues with the interior flood control system. Alterative 3 was not selected because of the much longer length.

Reach 4 Alternatives	
Alternative 1 Along RR tracks by Ashley Plant 4, Phase 4 Building across Pump Station to high ground by Ashley Furniture Plant 4, Phase 6 Building.	
Advantages	Disadvantages
Shortest, most direct alignment to high ground	2-42" RCP culverts, 12" PVC storm sewer, sanitary force main and water main cross alignment.
Alternative 2 Along RR tracks by Ashley Plant 4, Phase 4 Building across Pump Station and along mitigation site berm just west of Ashley Plant 4, Phase 6 Building.	
Advantages	Disadvantages
Less issues with existing utilities except for sanitary force main	Sanitary force main is in mitigation site embankment portion of alignment (general location within embankment shown in Section A-A in **Figure 5**).
Alternative 3 Alignment between Ashley Building and RR tracks across Pump Station and around mitigation site.	
Advantages	Disadvantages
Less issues with existing utilities except for sanitary force main	Longest Alignment
	Sanitary force main is in mitigation site embankment portion of alignment (general location within embankment shown in Section A-A in **Figure 5**).

6. Another issue with all of the Reach 4 alternatives is the existing City pump station. As stated previously, the City of Arcadia and Ashley Furniture feel the existing pump station is adequate both in capacity and performance and can be incorporated into the CAP project to save project costs. An interior flood control analysis is currently underway; however, it appears the pump station has adequate capacity based on the capacity of the storm sewers entering the pond at the station entrance. However, the pump station does not meet USACE criteria and significant modifications will be necessary to incorporate the station into the project. **Figure 9** shows the general layout of the station and **Figure 10** shows pictures of it. Information was requested from the City and their A/E regarding the station. Most of that information has been received except for information about the pump sump dimensions and whether the sumps were based on Hydraulic Institute Standards, etc.

7. A meeting was held on 17 April 2018 to discuss Reaches 3 and 4. The significant concerns with Reach 4 are the existing pump station and the sanitary force main within a

portion of the existing embankment. After considerable discussion, it was decided that Alternative 2 was acceptable with the following conditions.

a. It must be determined that the existing City pump station can be incorporated into the project.
b. Additional information must be obtained regarding the existing sanitary force main. This will include a more exact location, depth, construction materials and condition. Condition information should include whether a camera inspection has been performed or whether it has been pressure tested.
c. For the reach where the sanitary force main is within the existing embankment, the embankment will have to be widened to ensure there is full levee section. The top elevation of the widening will be based on the required levee elevation which is lower than the existing embankment top elevation. The extent of the widening will be determined once a more exact location and depth of the sanitary force main is determined.

8. The City's Myers Valley Creek channel relocation project was also discussed at the 17 April 2018 meeting. The right bank of this project completes the leveed area by tying into high ground at the upstream end. The discussion at the meeting was whether the right bank should be considered high ground or a levee reach. As shown in the **Figure 3** profiles, the minimum amount of freeboard is more than 3 feet, so it should be acceptable from that standpoint. The right bank elevations along the relocated channel in the profiles are based on the construction drawings and point survey elevations provided in an Ashley Furniture CAD drawing. The general consensus at the meeting was that it could be considered high ground because the slope away from the right bank was relatively mild at 5% or less. More information was obtained after the meeting including discussions with the local sponsor and their A/E. Both said there is a small levee that is two to three high along the top of the right bank. This is supported by a cross section at station 78+50 from the construction plans that is shown in **Figure 11**. In addition, the reach just downstream of the relocated channel has a levee along it as shown in the three **Figure 11** cross sections at station 71+50, 74+00 and 75+50. As also shown in **Figure 11**, there is a short levee upstream of the relocated channel that ties into high ground. This information was discussed with levee safety program personnel and the opinion now is that this should be considered a project levee reach. This reach could be incorporated into the project as Reach 5 or could be an extension of Reach 4. There is a storm sewer into the channel with the only means of closure being an inline Red Valve Checkmate Valve. A secondary means of closure will have to be added to that storm sewer.

9. This memorandum is intended to obtain concurrence that Alternative 2 is acceptable and is the recommended Reach 4 alignment and that the relocated Myers Valley channel reach should be a project levee reach (Reach 4 extension or Reach 5). This memorandum has been reviewed by Kari Hauck, P.E., Chief, Hydraulics Section.

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Mike Knoff, P.E.
Chief Hydraulics and Hydrology Branch

☒ Concur ☐ Non-Concur

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Michael Bart, P.E.
Chief, Engineering and Construction
Engineering and Construction Division

☑ Concur ☐ Non-Concur

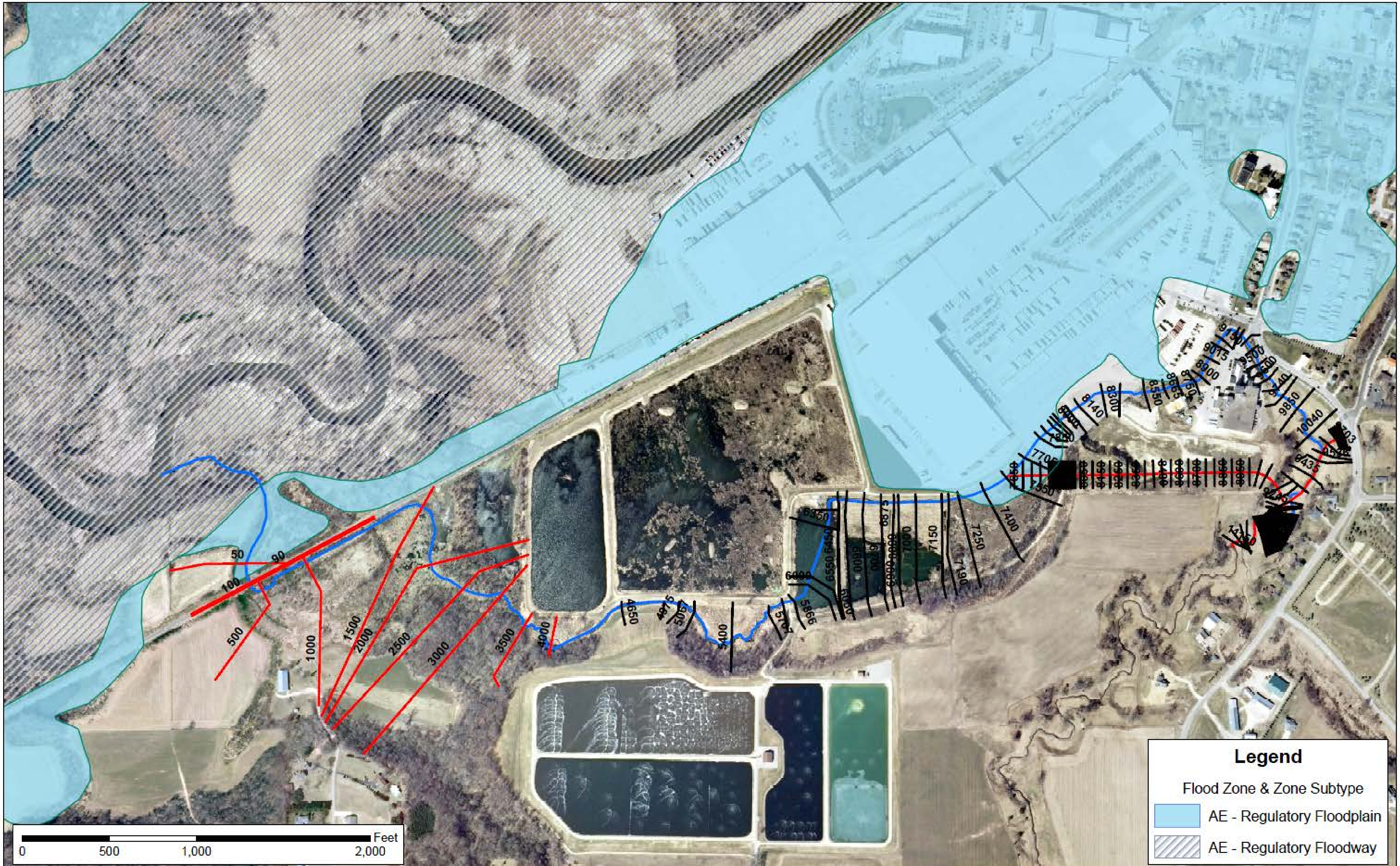


Figure 1 – Myers Valley Creek, HEC-RAS Model Cross Section Locations & Trempealeau River Floodplain & Floodway

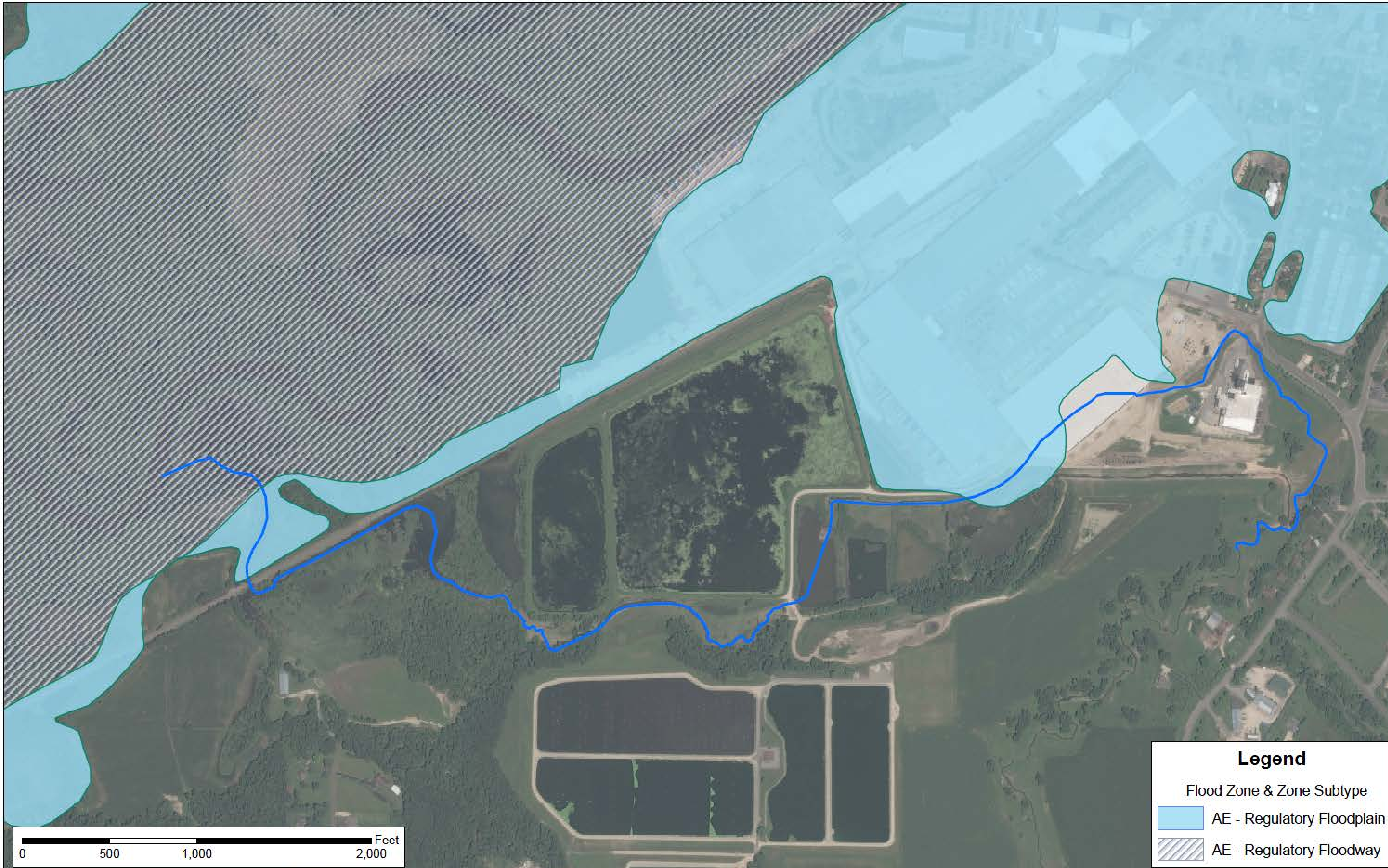


Figure 2 – Aerial Image showing Myers Valley Creek Diversion

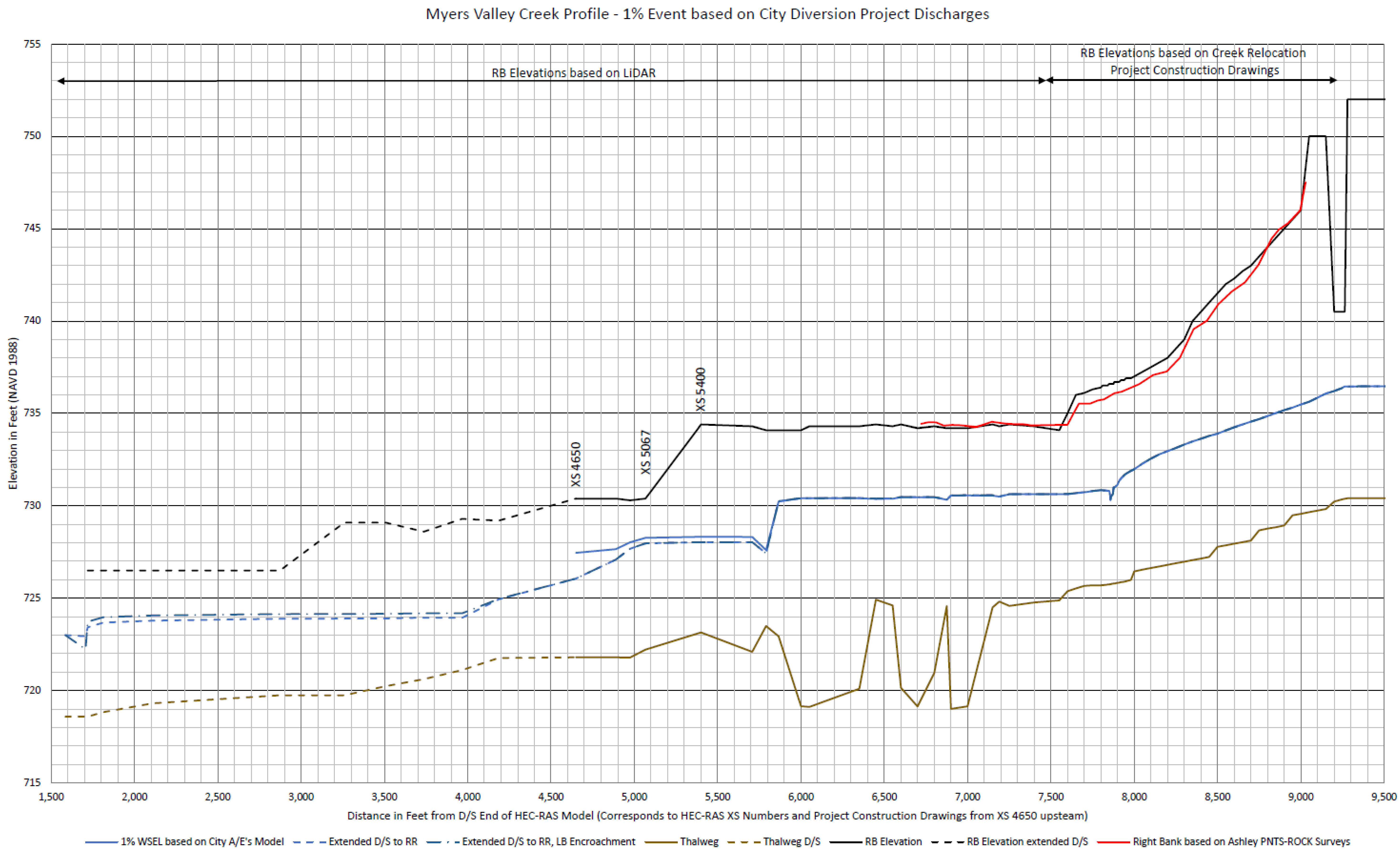


Figure 3 – Myers Valley Creek, 1% Event Water Surface Profiles and Right Bank Profiles

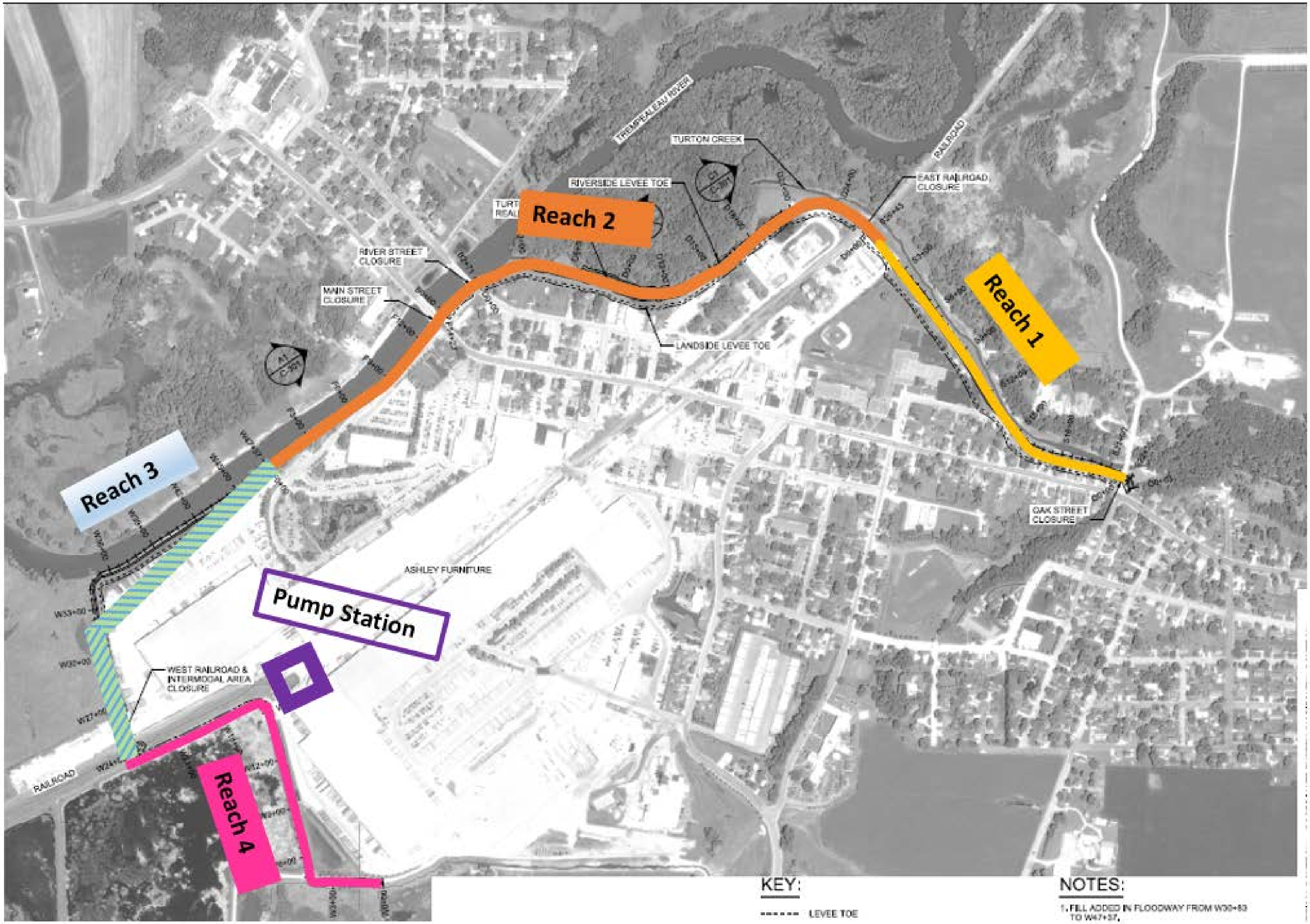


Figure 4 – Project Reaches

Figure 5 – Myers Valley Creek, Reach 4, Alternative Alignment

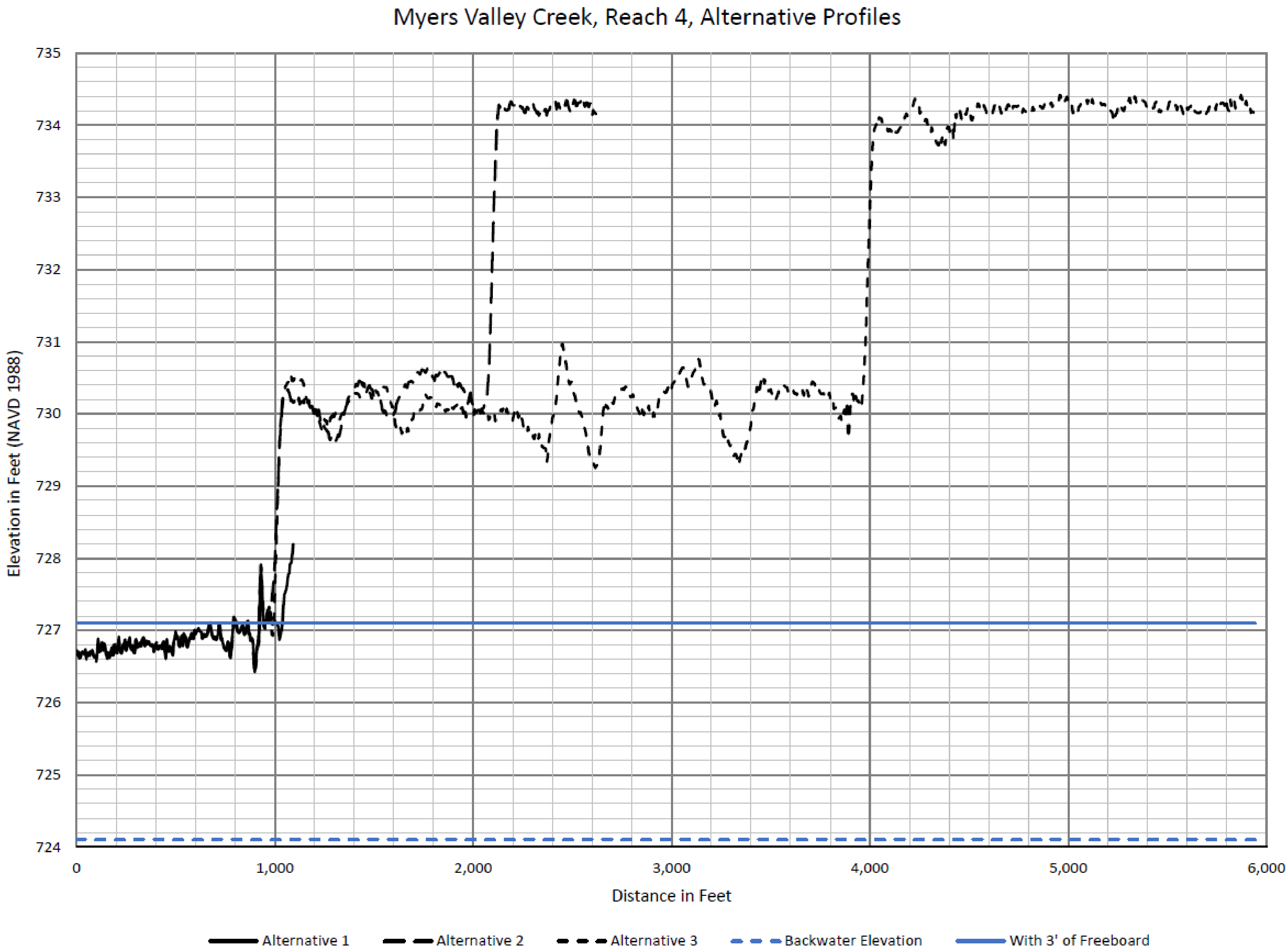


Figure 6 – Myers Valley Creek, Reach 4, Alternative Profiles

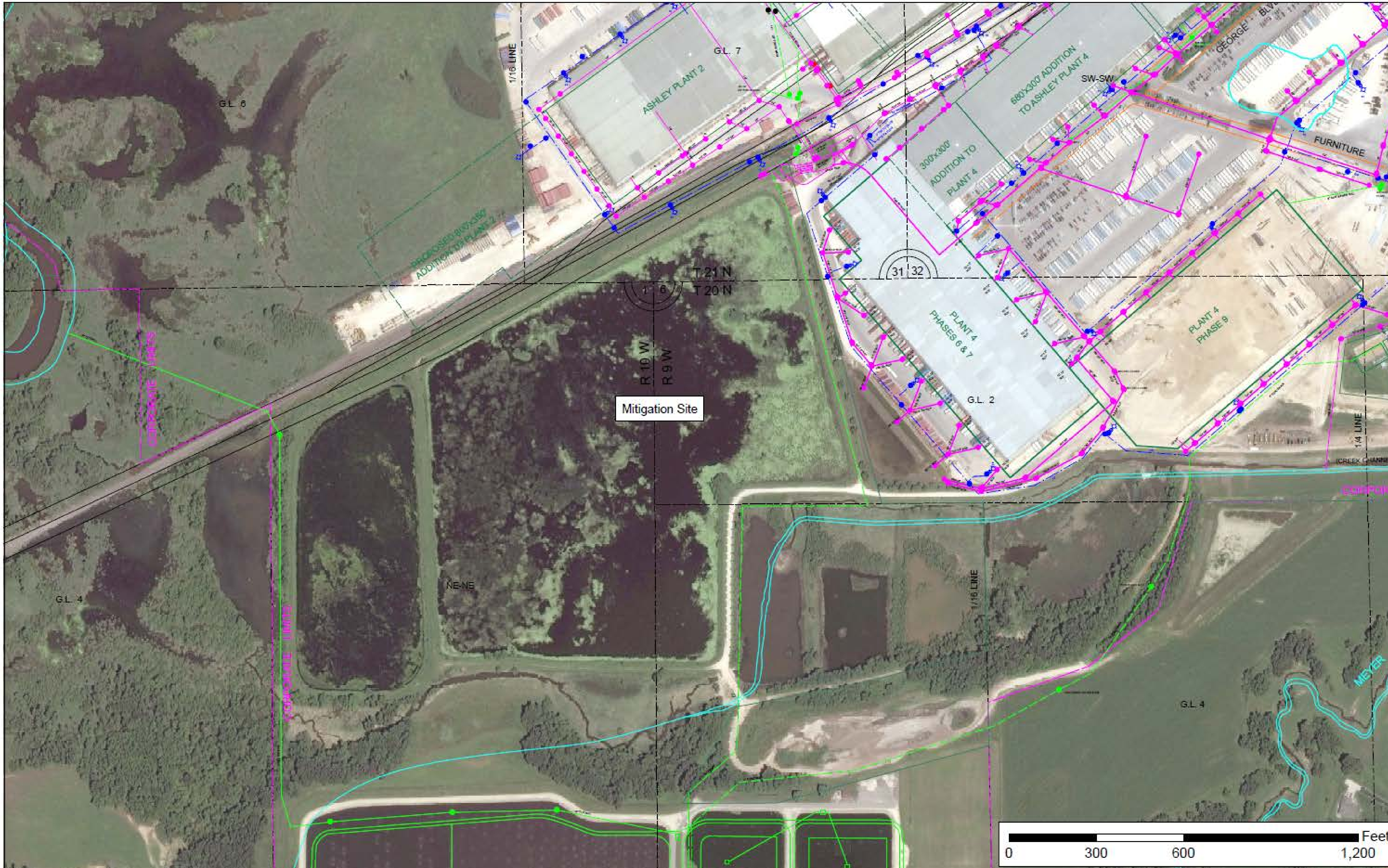


Figure 7 – Utility Map (based on AutoCAD drawing supplied by City's A/E)

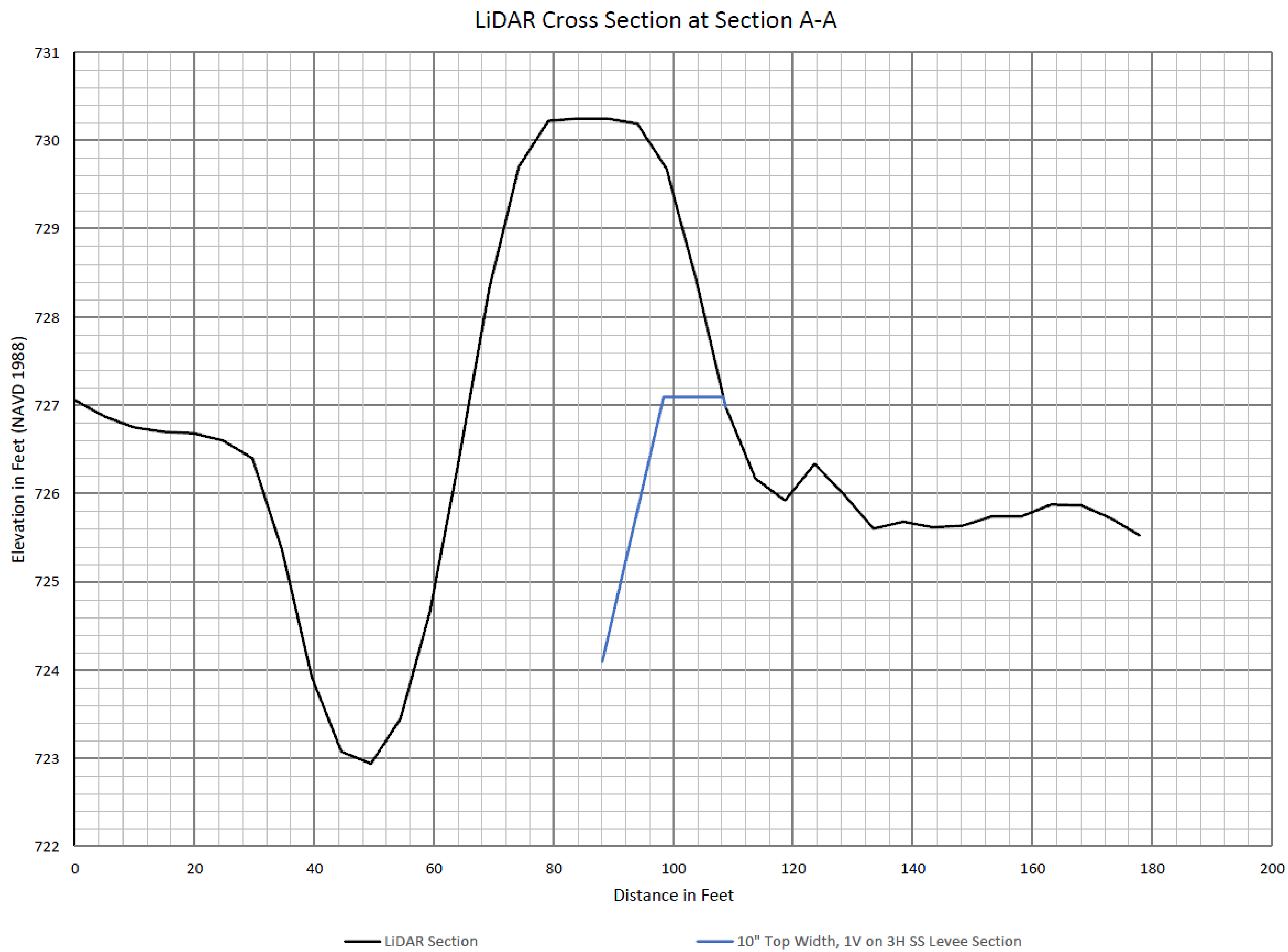


Figure 8 – LiDAR Cross Section at Section A-A

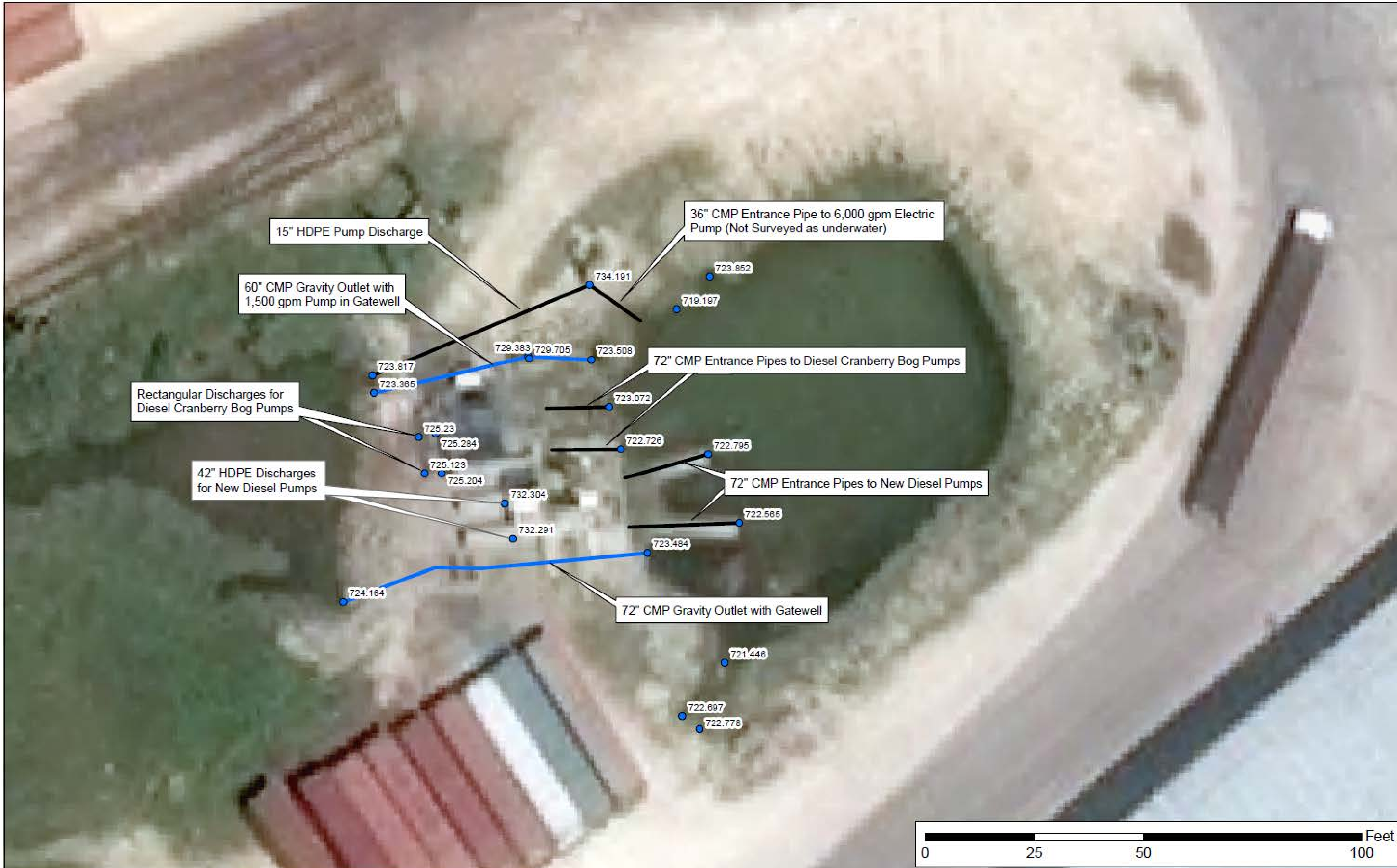


Figure 9 – City Pump Station Layout

2 – 50,000 gpm Diesel Driven
2 - 25,000 gpm Diesel Driven
1 – 6,000 gpm Electric
1 – 1,500 gpm Electric
Total – 157,500 gpm

Figure 10 – City Pump Station Pictures

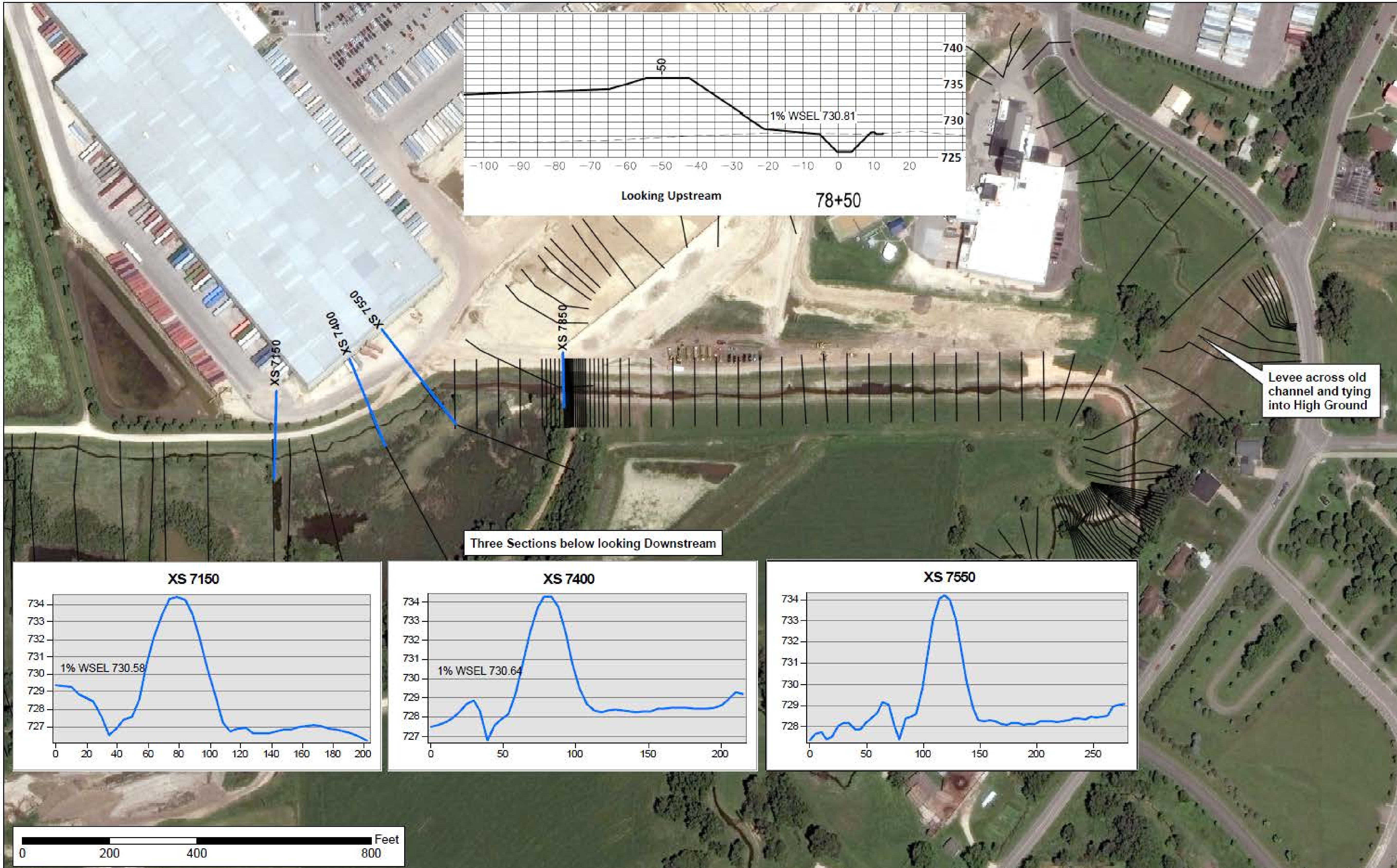
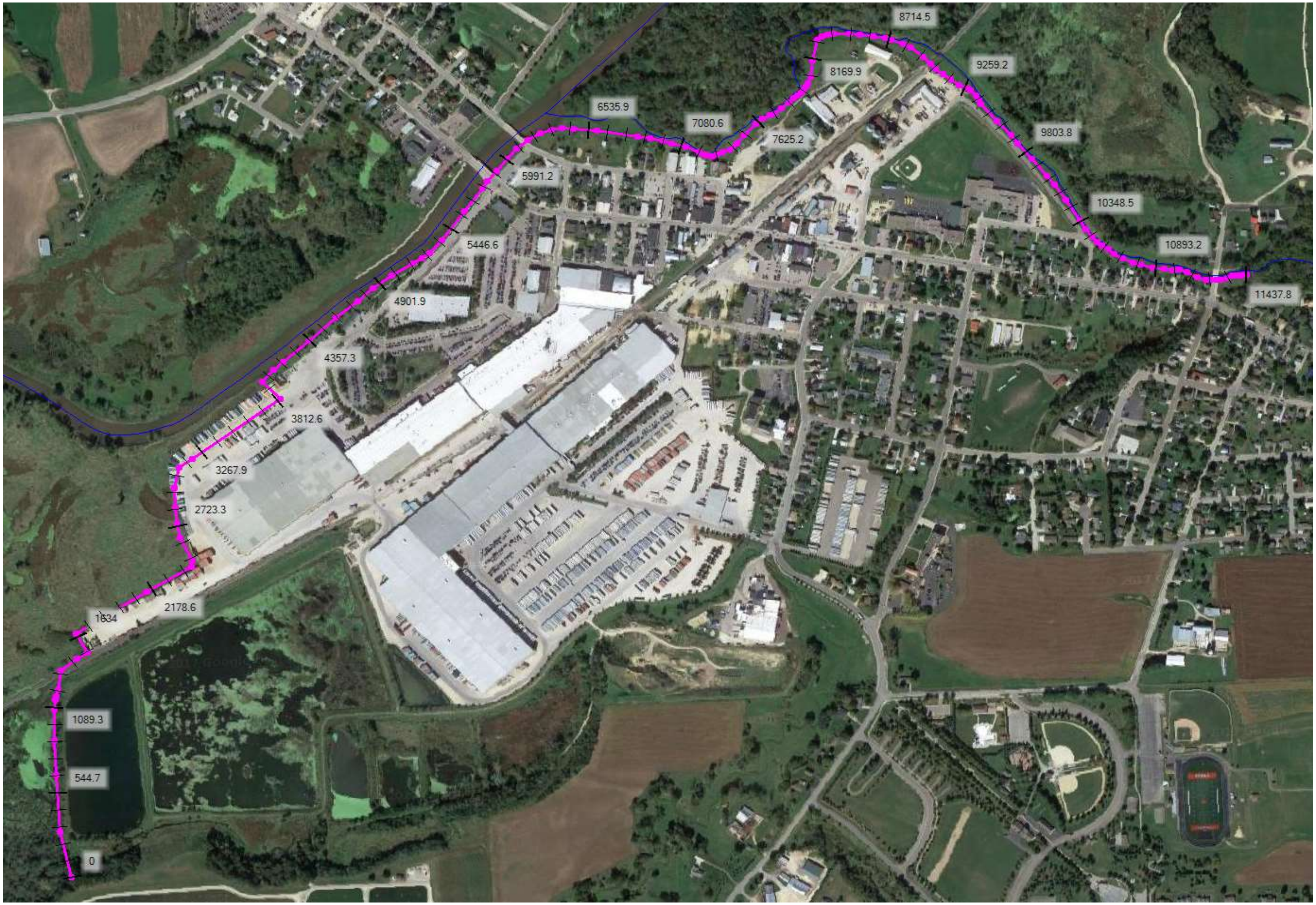


Figure 11 – Myers Valley Creek Relocated Channel

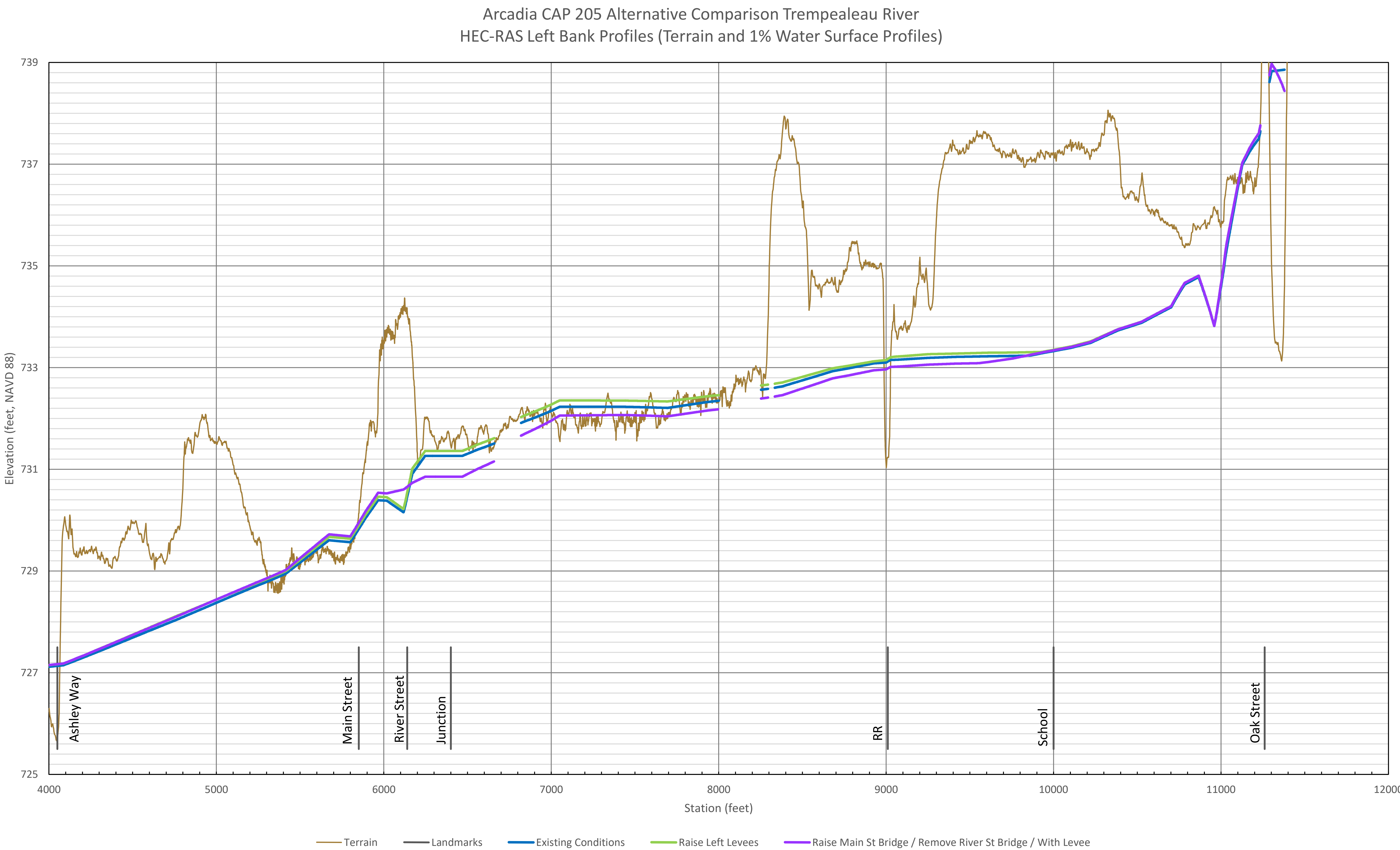
Attachment I-3

HEC-RAS

Alternatives Analysis

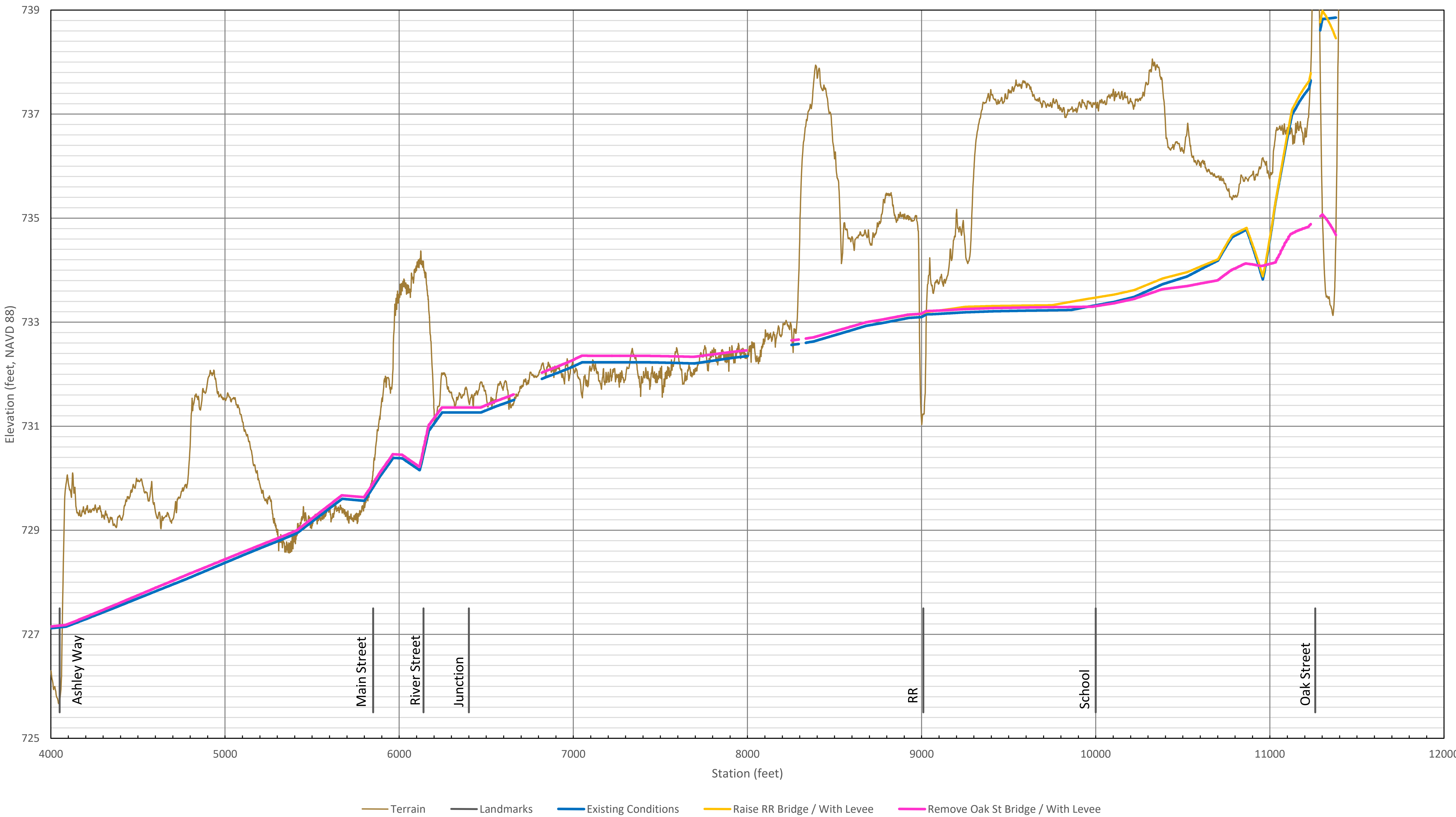


HEC-RAS Stationing on Left Bank
Arcadia Alternative Comparison



Arcadia CAP 205 Alternative Comparison Trempealeau River
HEC-RAS Left Bank Profiles (Terrain and 1% Water Surface Profiles)
Elevation (feet, NAVD 88)
739
737
735
733
731
729
727
725
Station (feet)
4000
5000
6000
7000
8000
9000
10000
11000
12000
Ashley Way
Main Street
River Street
Junction
RR
School
Oak Street
Terrain
Landmarks
Existing Conditions
Raise Left Levees
Raise Main St Bridge / Remove River St Bridge / With Levee

Arcadia CAP 205 Alternative Comparison Turton Creek
HEC-RAS Left Bank Profiles (Terrain and 1% Water Surface Profiles)



Arcadia CAP 205

Water Surface Elevations for Alternatives

11/14/2017

1% ACE Water Surface Profiles						
Station	Location	Existing Conditions	Raise Left Levee	Raise Main St Bridge Remove River St Bridge With Levee	Raise RR Bridge With Levee	Remove Oak St Bridge With Levee
4050	Ashley Way	727.13	727.17	727.17	727.17	727.17
5850	Main St	729.82	729.89	729.95	729.89	729.89
6140	River St	730.48	730.56	730.66	730.56	730.56
6400	U.S. of Junction	731.26	731.36	730.85	731.36	731.36
9010	RR	733.12	733.17	732.98	733.17	733.16
10000	School	733.32	733.35	733.34	733.47	733.31
11260	Oak St	738.08	738.2	738.2	738.2	734.97

CAP 205 Arcadia - Turton Creek at Oak Street Alternatives

1% ACE Water Surface Elevations

Geometry	Terrain	WSE *	Notes
TrTurGeomCalib	Terrain	738.0	Calibrated base geometry with no alternative
OakStBr	Terrain	738.0	Open Oak Street bridge 50%
OakStEx	OakStEx	735.1	Oak Street bridge in place, north overbank excavated to elev. 731. Two houses removed
OakStWeir	OakStWeir	737.7	Oak Street bridge in place, north overbank excavated to elev. 735. Weir added along Oak Street at elev. 736.
OakSt735	OakStWeir	737.7	Oak Street bridge in place, north overbank excavated to elev. 735.
OakStBrX	OakStBrX	734.9	Oak Street bridge removed, north abutment and overbank excavated to elev. 731
OakStBrX_TurRe	TurtonRerouteOakSt_Terrain	735.4	Turton Creek and levee realignment

* Water surface elevations in Turton Creek channel at Oak Street bridge. Required top of levee approximately 3 feet higher

Arcadia CAP 205 -- Reach 1 Option comparison for Top of Levee (TOL)

RAS Station	RAS Plan	Alternative	WSE	TOL
5345.724 Just upstream of Oak St. bridge	LeveeL	Option 1.1	739.0	742.5
	OakStBrX	Option 1.3	735.1	738.6
	OakStBrXTurRe	Option 1.4	735.5	739.0
	OakStExRdTuRe	Option 1.2	736.0	739.5
4756.956 Approx. 550 ft downstream of Oak St. bridge	LeveeL	Option 1.1	734.2	737.7
	OakStBrX	Option 1.3	733.8	737.3
	OakStBrXTurRe	Option 1.4	733.7	737.2
	OakStExRdTuRe	Option 1.2	733.7	737.2

HEC-RAS results for Trempealeau Peak 1% event With Project

HEC-RAS Plan: TrTurGeomCalib_LeveeL_Tremp-Peak Profile: 07APR3000 1200

River	Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Crit W.S.	E.G. Elev	E.G. Slope	Vel Chnl	Flow Area	Top Width	Froude # Chl
				(cfs)	(ft)	(ft)	(ft)	(ft)	(ft/ft)	(ft/s)	(sq ft)	(ft)	
Turton Creek	Main	6800.946	07APR3000 1200	500.00	730.81	735.57		735.63	0.000652	2.18	356.16	190.86	0.21
Turton Creek	Main	6750		Lat Struct									
Turton Creek	Main	6740		Lat Struct									
Turton Creek	Main	6511.143	07APR3000 1200	499.99	730.44	735.14		735.29	0.001792	3.15	158.79	58.64	0.34
Turton Creek	Main	6213.517	07APR3000 1200	500.00	729.72	734.74		734.87	0.001065	2.92	173.98	56.34	0.27
Turton Creek	Main	5975.467	07APR3000 1200	493.42	729.72	734.36		734.56	0.001604	3.59	139.60	43.09	0.33
Turton Creek	Main	5728.459	07APR3000 1200	485.34	729.25	734.18		734.27	0.000756	2.47	198.49	70.04	0.23
Turton Creek	Main	5520.033	07APR3000 1200	483.52	728.21	733.92		734.08	0.001124	3.26	157.28	58.68	0.28
Turton Creek	Main	5426.25	07APR3000 1200	493.29	728.17	733.66		733.93	0.002092	4.21	126.44	60.34	0.38
Turton Creek	Main	5345.724	07APR3000 1200	499.89	727.33	733.69	730.33	733.80	0.000833	2.64	190.00	56.23	0.24
Turton Creek	Main	5303.045		Bridge									
Turton Creek	Main	5272.433	07APR3000 1200	499.89	727.93	733.69		733.77	0.000513	2.18	229.21	56.92	0.19
Turton Creek	Main	5250		Lat Struct									
Turton Creek	Main	5200		Lat Struct									
Turton Creek	Main	5179.172	07APR3000 1200	499.89	727.20	733.62		733.71	0.000685	2.43	205.45	52.96	0.22
Turton Creek	Main	5086.413	07APR3000 1200	495.39	727.20	733.44		733.63	0.001375	3.47	148.54	57.32	0.30
Turton Creek	Main	5011.788	07APR3000 1200	486.50	727.20	733.41		733.54	0.000950	2.95	179.36	73.61	0.26
Turton Creek	Main	4920.191	07APR3000 1200	405.89	727.04	733.44		733.50	0.000468	2.09	208.36	69.06	0.18
Turton Creek	Main	4834.891	07APR3000 1200	337.25	727.33	733.41		733.48	0.000634	2.23	171.71	76.18	0.21
Turton Creek	Main	4756.956	07APR3000 1200	296.49	727.12	733.38		733.45	0.000589	2.16	158.52	73.65	0.20
Turton Creek	Main	4588.114	07APR3000 1200	211.54	727.29	733.36		733.40	0.000341	1.56	143.84	54.79	0.15
Turton Creek	Main	4448.991	07APR3000 1200	167.31	726.99	733.35		733.38	0.000213	1.37	143.51	58.35	0.12
Turton Creek	Main	4286.367	07APR3000 1200	139.00	727.18	733.34		733.35	0.000133	1.10	155.20	61.67	0.10
Turton Creek	Main	4168.408	07APR3000 1200	126.10	726.72	733.33		733.34	0.000059	0.76	214.15	79.73	0.07
Turton Creek	Main	3998.993	07APR3000 1200	116.61	726.33	733.33		733.33	0.000045	0.67	234.97	79.27	0.06
Turton Creek	Main	3810.835	07APR3000 1200	119.94	726.70	733.32		733.32	0.000054	0.81	201.38	61.72	0.06
Turton Creek	Main	3661.631	07APR3000 1200	123.03	726.27	733.31		733.32	0.000041	0.71	214.62	58.81	0.05
Turton Creek	Main	3463.801	07APR3000 1200	149.02	726.63	733.29		733.30	0.000063	0.87	245.42	75.90	0.07
Turton Creek	Main	3307.879	07APR3000 1200	192.74	726.45	733.28		733.29	0.000080	0.96	295.02	88.89	0.08
Turton Creek	Main	3108.483	07APR3000 1200	377.29	726.15	733.24		733.26	0.000139	1.33	470.59	132.53	0.10
Turton Creek	Main	3078.974	07APR3000 1200	428.53	725.60	733.23	729.03	733.25	0.000113	1.34	589.83	144.87	0.10
Turton Creek	Main	3062.854		Bridge									
Turton Creek	Main	3039.632	07APR3000 1200	428.53	725.82	733.17		733.19	0.000110	1.32	538.22	132.85	0.09
Turton Creek	Main	3000		Lat Struct									
Turton Creek	Main	2990		Lat Struct									
Turton Creek	Main	2966.953	07APR3000 1200	393.06	726.32	733.15		733.18	0.000163	1.56	411.60	99.32	0.11
Turton Creek	Main	2690.243	07APR3000 1200	523.49	725.35	733.01		733.10	0.000449	2.42	254.32	58.52	0.19
Turton Creek	Main	2378.1	07APR3000 1200	948.72	724.60	732.72		732.84	0.000605	3.04	424.12	97.21	0.22
Turton Creek	Main	1528.619	07APR3000 1200	626.05	723.59	732.35		732.48	0.000456	3.00	256.69	51.37	0.19
Turton Creek	Main	1264.947	07APR3000 1200	483.95	723.41	732.37		732.39	0.000087	1.33	614.09	112.21	0.09
Turton Creek	Main	885.8156	07APR3000 1200	-369.35	723.03	732.37		732.39	0.000063	-1.19	506.15	97.24	0.07
Turton Creek	Main	196.464	07APR3000 1200	2440.34	720.58	731.37		731.69	0.001495	5.52	727.35	125.26	0.35
Trempealeau	DS Turton	17645.07	07APR3000 1200	14693.51	718.59	731.37		731.90	0.000852	5.80	2555.45	303.73	0.34
Trempealeau	DS Turton	17644		Lat Struct									
Trempealeau	DS Turton	17640		Lat Struct									
Trempealeau	DS Turton	17569.72	07APR3000 1200	14446.21	717.47	731.03	726.13	731.85	0.001218	7.31	2061.31	270.41	0.41
Trempealeau	DS Turton	17539.2		Bridge									
Trempealeau	DS Turton	17513.31	07APR3000 1200	14446.21	717.69	730.23		731.30	0.001846	8.33	1754.51	233.75	0.50
Trempealeau	DS Turton	17413.25	07APR3000 1200	14416.97	717.62	730.46		731.15	0.001216	6.64	2172.62	261.30	0.40
Trempealeau	DS Turton	17361.17	07APR3000 1200	14386.33	717.39	730.47		731.09	0.001092	6.30	2284.24	275.94	0.38
Trempealeau	DS Turton	17285.7	07APR3000 1200	14323.51	717.28	730.11	724.71	731.01	0.001266	7.60	1883.53	184.27	0.42
Trempealeau	DS Turton	17243.55		Bridge									
Trempealeau	DS Turton	17198.42	07APR3000 1200	14323.51	717.34	729.64		730.66	0.001507	8.10	1768.61	180.67	0.46
Trempealeau	DS Turton	17190		Lat Struct									
Trempealeau	DS Turton	17066.76	07APR3000 1200	14323.22	717.14	729.68		730.47	0.001340	7.15	2005.45	232.20	0.42
Trempealeau	DS Turton	16804.04	07APR3000 1200	14047.11	717.04	729.01		730.14	0.001591	8.56	1690.06	188.94	0.47
Trempealeau	DS Turton	16548.23	07APR3000 1200	12193.32	717.23	728.64		730.01	0.002147	9.39	1328.41	154.60	0.54
Trempealeau	DS Turton	16176.07	07APR3000 1200	10867.40	717.04	728.14		729.50	0.002231	9.36	1173.81	134.26	0.54
Trempealeau	DS Turton	15496.06	07APR3000 1200	9308.52	717.67	727.18		728.29	0.002419	8.44	1105.81	156.21	0.55
Trempealeau	DS Turton	15491		Lat Struct									
Trempealeau	DS Turton	15490		Lat Struct									
Trempealeau	DS Turton	14629.72	07APR3000 1200	6394.03	717.48	726.89		727.35	0.000936	5.50	1267.59	218.60	0.35
Trempealeau	DS Turton	13695.4	07APR3000 1200	6275.30	717.48	725.53		726.17	0.001623	6.46	978.60	159.29	0.45
Trempealeau	DS Turton	12624.64	07APR3000 1200	3737.57	715.40	725.24		725.45	0.000462	3.67	1033.97	155.66	0.24
Trempealeau	DS Turton	11240.32	07APR3000 1200	4138.59	714.58	723.85		724.29	0.001132	5.36	782.75	129.01	0.37
Trempealeau	DS Turton	10074.68	07APR3000 1200	3530.62	713.92	723.15		723.39	0.000584	4.01	901.54	151.68	0.27
Trempealeau	DS Turton	8815.729	07APR3000 1200	2975.23	714.44	722.16		722.47	0.001030	4.48	682.15	148.76	0.34
Trempealeau	DS Turton	8811		Lat Struct									
Trempealeau	DS Turton	8810		Lat Struct									
Trempealeau	DS Turton	7931.877	07APR3000 1200	2888.30	712.35	721.59		721.79	0.000550	3.55	829.42	157.04	0.26
Trempealeau	DS Turton	7287.389	07APR3000 1200	2426.44	712.35	721.42		721.54	0.000379	2.85	862.99	159.07	0.21
Trempealeau	DS Turton	6173.862	07APR3000 1200	2249.67	711.94	721.18		721.25	0.000164	2.10	1091.14	175.44	0.14
Trempealeau	DS Turton	4774.167	07APR3000 1200	2680.77	711.06	720.83		720.95	0.000227	2.81	983.76	131.76	0.17
Trempealeau	DS Turton	3812.735	07APR3000 1200	4486.35	709.95	719.76		720.17	0.000929	5.17	908.99	139.76	0.34
Trempealeau	DS Turton	2427.643	07APR3000 1200	-847.70	710.49	719.80		719.81	0.000020	-0.79	1173.55	191.00	0.05
Trempealeau	DS Turton	1321.488	07APR3000 1200	3503.06	710.45	718.89		719.22	0.000798	4.67	820.57	147.23	0.32
Trempealeau	DS Turton	150.8649	07APR3000 1200	15486.50	707.70	717.16	716.19	717.44	0.001600	6.44	6288.04	2658.65	0.44