Special Flood Hazard Evaluation

Gill Creek

City of Niagara Falls

Niagara County, New York

Prepared by the US Army Corps of Engineers

Buffalo District

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Introduction

Purpose of the Study

This Special Flood Hazard Evaluation (SFHE) documents the results of an investigation to determine the delineation of the boundaries of the base floodplain along Gill Creek within the city of Niagara Falls, Niagara County, New York. This study was conducted at the request of the city under Section 206 of the Flood Control Act, as amended. The Gill Creek study reach is from the corporate municipal boundary at Lockport Road to where it converges with the Niagara River.

Knowledge of the potential floods and flood hazards is important in land use planning. This report identifies the 1% and 0.2% annual chance exceedance (ACE) flood events for the reaches studied. The 1% and 0.2% annual chance exceedance events were formerly referred to as the 100-year and 500-year flood event.

Information developed for this study may be used by local officials to manage future floodplain development. While the report does not provide solutions to flood problems, it does provide a suitable basis for the adoption of land use controls to guide floodplain development, thereby preventing intensification of the flood losses. It will also aid in the development of other flood damage reduction techniques to modify flooding and reduce flood damages' which might be embodied in an overall Floodplain Management Services (FPMS) Program. Other studies, such as those of environmental nature and the current and future land use roles of the floodplain as part of its surroundings, would benefit from this information.

Coordination

The U.S. Army Corps of Engineers (USACE) Buffalo District office, the New York State Department of Environmental Conservation (NYSDEC) along with input from the Federal Emergency Management Agency (FEMA) Region 2, identified the community in the City of Niagara Falls located along Gill Creek in Niagara County would benefit from an updated SFHE. This portion of Gill Creek is entirely contained within the city of Niagara Falls. Past studies and the accuracy of the existing Flood Insurance Rate Maps (FIRMS) published by FEMA, were also discussed, and used as a reference for the update of this study.

Area Studied

Scope of the Study

This study covers the portion of Gill Creek within the City of Niagara Falls. The study incorporates new hydrologic and hydraulic analyses for Gill Creek. This area was surveyed by USACE in the spring of 2022 and data was supplemented with aerial photography and Light Detection and Ranging (LiDAR) mapping. Flood profiles and flooded area (inundation) maps were created and developed along Gill Creek and a comparison was made by the USACE to the existing flood maps of the area.

Community Description

The city of Niagara Falls is located in Niagara County along the Niagara River, approximately 13 miles north of the city of Buffalo. The city is bordered on the north by the towns of Niagara and Lewiston, on the east by the town of Wheatfield, and on the south and west by the Niagara River. The population of the city of Niagara Falls is 48,709 according to the 2020 census (U.S. Census Bureau, 2020). Gill Creek originates in the Town of Lewiston and flows in a southwestern direction through the City of Niagara Falls to its confluence with the Niagara River (USACE-LRB, 2002).

Niagara County is home to Niagara Falls, through which four of the Great Lakes drain. The Niagara River flows from Lake Erie to Lake Ontario and is separated into upper and lower sections at Niagara Falls. Large electrical power plants are fed by the Niagara River with intakes location just upstream of Niagara Falls on both the United States and Canadian sides. Niagara County has a temperate climate with warm summers and cold winters. The average daily high temperature is 57 degrees, and the average daily low temperature is 38 degrees. The average annual rainfall is approximately 36 inches, and the average annual snowfall is approximately 82 inches (FEMA, 2017).

According to the 2020 Census, the land area of the City of Niagara Falls the total land area in square miles is 14.09 (U.S. Census Bureau, 2020).

Table 1: Community in the Study Area

Community	Land Area (Sq. Mi.)	Population (2020 Census)
City of Niagara Falls	14.09	48,709

The City of Niagara Falls land use is a combination of predominantly urbanized, commercial and residential, and industrialized areas. There is some open space; however, the majority has been developed in some way. The upstream boundary in this study of Gill Creek starts in a rural area, just upstream of the corporate boundary at Lockport Road, then progresses through a wooded area of the Hyde Park golf course, continues under Porter Road into the southern portion of Hyde Park where Gill Creek is impounded as a narrow lake by a small dam near Pine Avenue. At Pine Avenue, Gill Creek exits the park and enters a more urbanized area of the city until it then flows through a section of industrialized land before entering the Niagara River. The portion of Gill Creek not included in this study extends upstream from the corporate boundary, between the City of Niagara Falls and the Town of Niagara, north through the Town of Niagara, enters the Town of Lewiston and extends east into the Tuscarora Indian Reservation.

Flood Protection Measures

There are no known existing flood control projects within the study area.

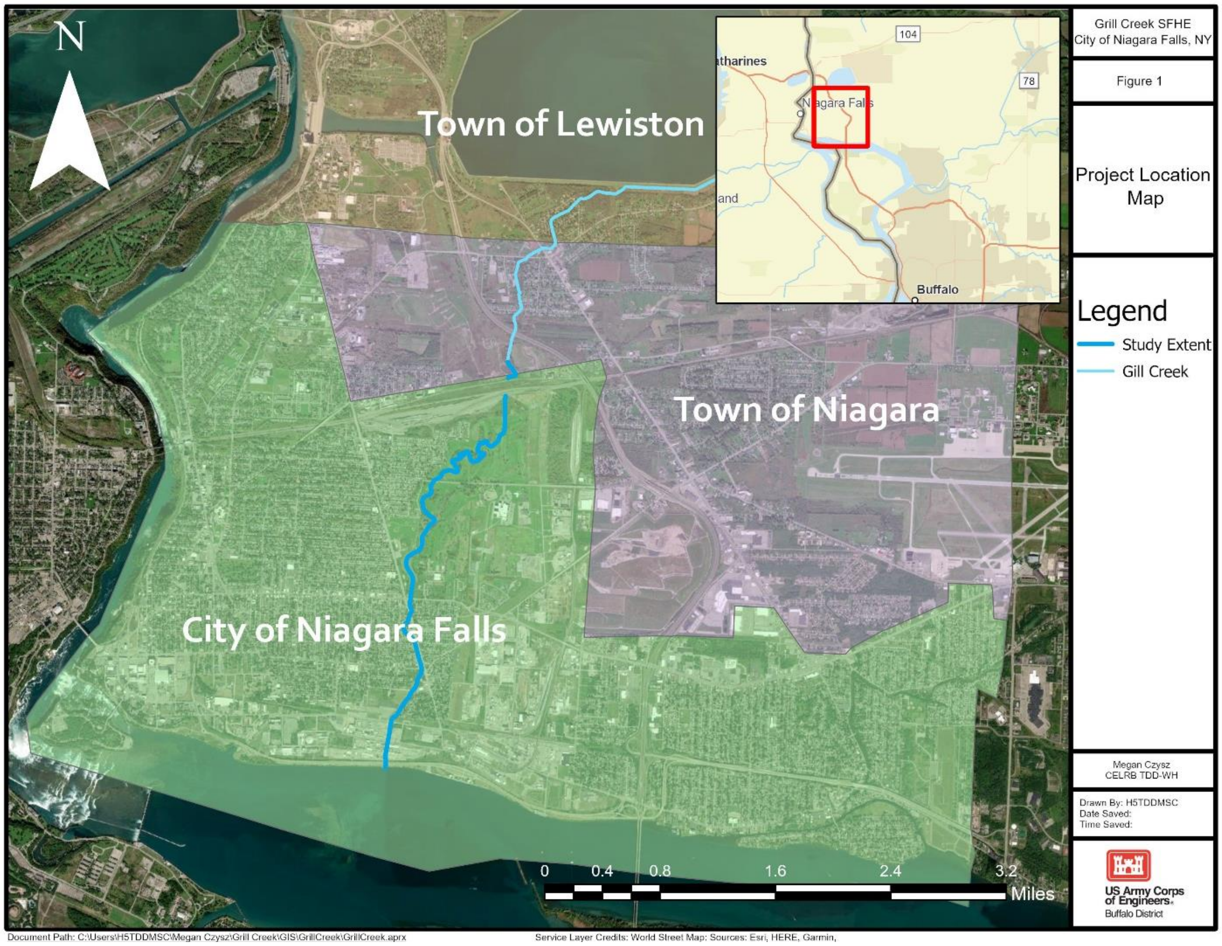

Figure 1: Project Location Map: Communities

Other Studies

The most recent effective Flood Insurance Study (FIS) for Niagara County, New York which included the City of Niagara Falls, was issued by the Federal Emergency Management Agency (FEMA) in November 2017 (FEMA, 2017). This was a revised version of an initial countywide FIS released in September 2010. The flows used for Gill Creek in the most recent FIS were from a Special Flood Hazard Evaluation Report of Gill Creek completed by the USACE Buffalo Distract in 2002 at the request of the city (USACE-LRB, 2002). This FIS was conducted to revise and update information on the existence and severity of flood hazards within the study area. This information is intended to be used to establish floodplain boundaries and assist the community in its efforts to promote floodplain management.

As specified in the Special Flood Hazard Evaluation Report for Gill Creek by the USACE Buffalo District (USACE, 2002), the study reach included Gill Creek from the Niagara River, upstream to the corporate boundary at Lockport Road. The study's scope of Gill Creek started slightly upstream of the corporate boundary upstream of Lockport Road, as the upstream limit, and continues downstream to the confluence with the Niagara River, as the downstream limit, and for a total length of 3.8 miles. As per USACE (2002), the hydrologic method used was USACE HEC HMS (USACE HEC-HMS, 1995) and the hydraulic method used was USACE HEC-RAS (USACE HEC-RAS, 1995).

The 2017 FIS (FEMA, 2017) described how flow frequencies were estimated for Gill Creek. Initially for Gill Creek, peak discharge-frequency relationships were determined using the Bureau of Public Roads (BPR) Circular No. 4 (U.S. Department of Commerce). The drainage area, length and slope of stream, and precipitation were used to develop the peak rates of runoff along the stream (FEMA, 2017). In 2002, USACE-LRB completed a Special Flood Hazard Evaluation for Gill Creek. The peak discharges were calculated using the COE HEC-HMS (USACE HEC-RAS, 1995) computer program. The SCS Dimensionless unit Hydrograph and Kinematic Wave methods were used to calculate the runoff and the Muskingum Cunge 8-point method was used for channel routing in most reaches. Additionally, Hyde Park Lake and the floodplain between Ferry Avenue and Buffalo Avenue were modeled as storage areas using the HMS reservoir and Modified Puls methods, respectively. Flows were calculated at the upstream corporate limits, the confluence of the eastern branch of Gill Creek, Hyde Park Dam, Ferry Avenue, and the confluence of Gill Creek with the Niagara River (Table 1) (USACE-LRB, 2002). The flows in the 2002 report are the same as what is reported in the most recent FIS.

The flood insurance rate maps from the 2017 FIS were developed by FEMA in accordance with their rules and standards. The flooded outlines shown on these maps reflect the condition of the existing channel at the time of the report completion.

Principal Flood Problems

In the City of Niagara Falls, low-lying areas are subject to flooding caused by overflow of Cayuga Creek, Bergholtz Creek and Gill Creek. Prolonged spring thaws and heavy summer rainfall create the most severe flooding conditions. Shallow flooding caused by ponding of runoff during heavy rains also occurs in several low-lying areas in the eastern portion of the city. In the past, flooding of Cayuga Island had been caused by the backwater effect created by ice jams in the Niagara River above the Falls, and long duration storms over Lake Erie (FEMA, 2017).

Although flooding may occur during any season, the principal flood problems have occurred during winter and spring months and are usually the result of spring rains and or snowmelt (USACE-LRB, 2002).

Flood Magnitudes and Frequencies

Special Flood Hazard Areas (SFHA's) are determined with reference to the 1% annual chance flood event, also known as the "100-year" flood. National standards for floodplain regulations are based on this event. The 1% annual chance event, also referred to as a base flood, is defined as the flood having a 1% probability of being equaled or exceeded in any given year. The risk of experiencing a flood of this magnitude increases with the length of time considered. While it represents the long-term average recurrence interval for a flood of this magnitude, such floods may be experienced in any given year. There is a greater than 50% probability that a 1% annual chance event will occur during a 70-year lifetime and there is a 26% (about a one in four) probability of experiencing such a flood event over a typical 30-year mortgage period. The 1% annual chance flood event is more properly termed the 1% chance exceedance flood or 1% flood, which represents its true probability of being equaled or exceeded in any year.

Hazards and Damages of Large Floods

The extent of damage caused by any flood depends on the topography of the flooded area, the depth and duration of flooding, the velocity of flows, the rate of rise in water surface elevation, and development of the floodplain. Each of these items must be taken into consideration because deep water flowing at a high velocity and carrying floating debris would create conditions hazardous to people and their vehicles as they attempt to cross the floodplain. For example, water three (3) or more feet deep, which flows at a velocity of three or more feet per second could easily sweep an adult off their feet and result in damage, injury or drowning. Rapidly rising and swift flowing floodwater may trap people in homes that might be destroyed during the flood or in vehicles that might be quickly submerged or swept away. Other examples include indirect hazards to people. Since water lines can be ruptured by debris accumulations and the hydraulic forces from floodwaters, there is a possibility of contaminated domestic water supplies. Damaged sanitary sewer lines and sewage treatment plants could result in the pollution of floodwaters and could create health hazards. Isolation of areas by floodwaters could create hazards in terms of medical, fire, or law enforcement emergencies.

Engineering Analysis

This report describes the assumptions and the methods used to complete the hydrologic and hydraulic analyses related to flood management for the Gill Creek watershed in Niagara County and for the delineation of the floodplain boundaries. This study estimates peak flood discharges and water stages for 0.2%, 1%, 2%, 4% and 10% chance exceedance floods (500, 100, 50, 25 and 10-year recurrence intervals, respectively) and the 1% plus. From these stages, the corresponding 1% annual chance event (100-year floodplain) and 0.2% (500-year floodplain) boundaries were identified for the city of Niagara Falls. Note that the extent of the watershed and Gill Creek extends further upstream, through the Town of Niagara , however only the section from the confluence with Niagara River to the corporate boundary of city of Niagara Falls was modeled.

Hydrologic Analysis

The Gill Creek watershed has a total area of 12.3 miles which drains through the towns of Lewiston, and Niagara, and the city of Niagara Falls then to the Niagara River. Flood Insurance Studies (FIS) at one time were completed at the municipal level and are now prepared on a county-wide basis. Accordingly, this analysis is the portions of Gill Creek affecting the City of Niagara Falls in Niagara County, New York, which is in USGS hydrologic unit 041201040605. The following state waterbody IDs contribute to the Gill Creek watershed in this study:

- NY0101-0002: Gill Creek and Tribs
- NY0101-0030: Hyde Park Lake

There are no stream gages on Gill Creek within the study area and no peak streamflow data exists. The 2017 FIS (FEMA, 2017) described how flow frequencies were estimated for Gill Creek. The flows in the 2002 report are the same as what is reported in the most recent FIS.

Due to the absence of stream gage data for Gill Creek, regression equations were used following the methods of first Lumia et al. (2006) and then Sauer, et al. (1983) to develop updated peak flow frequencies. The flows were calculated at the same locations as the previous Gill Creek hydrology analysis by USACE (2002), at the upstream corporate limits, the confluence of the eastern branch of Gill Creek, Hyde Park Dam, Ferry Avenue, and the confluence of Gill Creek with the Niagara River. Lumia et al. (2006) used peak-discharge-frequency data and basin characteristics from 388 streamflow-gaging stations in New York and adjacent states to develop multiple linear regression equations for flood discharges with recurrence intervals ranging from 1.25 to 500 years. A generalized least-squares (GLS) procedure was used to develop the regression equations. Separate sets of equations were developed for each of six hydrologic regions of New York. These equations can be used to give estimates for the magnitude and frequency of floods on rural, unregulated streams whose watershed was 15% or less urbanized (Lumia, et al. 2006). The Gill Creek watershed is more than 15% urbanized. The equations of Lumia et al. (2006) have been integrated into the USGS web-based tool StreamStats. Peak discharges for ungaged urban areas can be estimated through techniques of Sauer et al. (1983) and others (Lumia, et al., 2006). The Sauer, et al. (1983) regression equations adjust the equivalent rural discharge to an urban condition. The primary adjustment factor, or index of urbanization, is the basin development factor, a measure of the extent of development of the drainage system in the basin (Sauer et al., 1983). Sauer et al. (1983) developed three different sets of regression equations. For this study, the seven-parameter set with the lowest standard of error was used. Average standard errors of prediction range from about $\pm$ 38 percent for the 2-year flood to $\pm$49 for the 500-year flood.

The Lumia et al. (2006) regression equations (Table 2) utilize drainage area, slope ratio, defined as the ratio of main channel slope to basin slope, mean annual runoff, percentage of drainage area at or greater than 1200 ft above sea level, and basin storage, defined as the percentage of open water and wetlands. The USGS StreamStats online tool was used to calculate drainage area (which it does using digital elevation data) and slope of the Gill Creek watershed (USGS, 2016). StreamStats added portions of a reservoir that does not contribute to the watershed. GIS was used to correct the area of the watershed as well as to determine the correct percent of basin storage. StreamStats includes the capability to edit the delineated watershed. This did not affect calculation of longest path and its slope, so values for slope directly from StreamStats were used. To determine slope, StreamStats divides the change in elevation by length between points 10 and 85 percent of the distance along the longest flow path to the basin divide. It was confirmed that percentage open water and wetland estimates from an edited StreamStats watershed delineation matched that found by an ArcGIS analysis of NLCD 1992 land cover data. Land cover data from 1992 was used in accordance with the reasoning of Lumia et al. (2006). Parameter estimates used for Lumia et al. (2006) are shown in 3. Flow frequency results for Gill Creek based on Lumia et al. (2006) are presented in Table 4.

To account for urbanization, the Sauer et al. (1983) seven parameter regression equations (Table 5) were used. The seven parameters are the drainage area, the main channel slope, the basin storage, the basin development factor, the percent impervious area, rainfall intensity for the 2-hour, 2-year occurrence, and the peak discharge for an equivalent rural drainage basin which was calculated using the Lumia et al. (2006) regression equations. The basin development factor (BDF) was determined by dividing the watershed into three sections and assessing the degree to which channel improvements, storm sewers, impervious channel linings, and curb-and-gutter streets have been implemented in the watershed (as per Sauer et al. , 1983). The rainfall intensity was determined using the NOAA Atlas 14 Point Precipitation Frequency Estimates (NOAA 2017) for Niagara County. Parameter estimates used in updating the flow frequency estimates for urbanization (as per Sauer et al., 1983) are shown in Table 6.

Final urbanization-corrected flow frequency results for Gill Creek based on Lumia, et al. (2006) and Sauer et al. (1983) are presented in Table 7.

Table 2: Regional regression equation for rural, unregulated streams in New York Region 6 (from Lumia et al., 2006)

[A, drainage area, in mi^2; ST, basin storage, in percent; P, mean annual precipitation, in inches; LAG, basin lag factor; FOR, basin forested area, in percent; RUNF, mean annual runoff, in inches; MXSNO, seasonal maximum snow depth, 50th percentile, in inches; SR, slope ratio; SL, main channel slope, in ft/mi; EL12, percent of basin above 1,200 ft; Q, flow. subscript is recurrence interval; thus, Q_2 refers to discharge with 2-year recurrence interval]

Recurrence interval (years)		Full-regression equation *	Full equations		Drainage-area-only equations	
			Average SE (percent)	Equivalent years of record	Average SE (percent)	Equivalent years of record
Region 6						
$Q_{1.25}$	=	$4.50\,(A)^{0.811}\,(ST+0.5)^{-0.270}\,(RUNF)^{0.840}\,(EL12+1)^{0.066}\,(SR)^{0.168}$	34.7	2.3	48.2	1.2
$Q_{1.5}$	=	$6.36\,(A)^{0.809}\,(ST+0.5)^{-0.265}\,(RUNF)^{0.790}\,(EL12+1)^{0.079}\,(SR)^{0.190}$	33.3	2.0	48.5	1.0
Q_{2}	=	$8.98\,(A)^{0.807}\,(ST+0.5)^{-0.258}\,(RUNF)^{0.740}\,(EL12+1)^{0.093}\,(SR)^{0.209}$	32.3	1.9	49.1	0.9
Q_{5}	=	$17.1\,(A)^{0.807}\,(ST+0.5)^{-0.234}\,(RUNF)^{0.646}\,(EL12+1)^{0.120}\,(SR)^{0.248}$	32.2	2.4	51.0	1.0
Q_{10}	=	$23.4\,(A)^{0.810}\,(ST+0.5)^{-0.218}\,(RUNF)^{0.600}\,(EL12+1)^{0.133}\,(SR)^{0.268}$	32.9	3.1	52.5	1.3
Q_{25}	=	$32.1\,(A)^{0.815}\,(ST+0.5)^{-0.200}\,(RUNF)^{0.555}\,(EL12+1)^{0.148}\,(SR)^{0.290}$	34.4	3.9	54.4	1.7
Q_{50}	=	$39.0\,(A)^{0.819}\,(ST+0.5)^{-0.188}\,(RUNF)^{0.528}\,(EL12+1)^{0.157}\,(SR)^{0.305}$	35.8	4.5	56.0	2.0
Q_{100}	=	$46.0\,(A)^{0.823}\,(ST+0.5)^{-0.177}\,(RUNF)^{0.505}\,(EL12+1)^{0.166}\,(SR)^{0.318}$	37.2	4.9	57.6	2.2
Q_{200}	=	$53.2\,(A)^{0.828}\,(ST+0.5)^{-0.167}\,(RUNF)^{0.487}\,(EL12+1)^{0.173}\,(SR)^{0.330}$	39.0	5.2	59.3	2.5
Q_{500}	=	$62.7\,(A)^{0.834}\,(ST+0.5)^{-0.155}\,(RUNF)^{0.466}\,(EL12+1)^{0.183}\,(SR)^{0.345}$	41.4	5.5	61.7	2.7

Table 3: Gill Creek parameters used in rural regional regression equation (Lumia et al., 2006) frequency flow calculations

Location on Gill Creek	Drainage Area (Sq. Mi.)	Slope Ratio	% Basin Classified as Open Water/Wetlands	Mean Annual Runoff (in.)	% of Area with Elevation 1200 ft above Sea Level
City of Niagara Falls Corporate Boundary	5.17	.1	3.80	13.5	0
DS of East Gill	8.46	0.0627	2.38	13.5	0
DS Hyde Park	9.10	0.0599	2.43	13.5	0
At Ferry Avenue	9.19	0.059	2.41	13.5	0
Confluence with Niagara River	12.27	0.0575	1.64	13.6	0

Table 4**: Initial Rural Frequency flows for Gill Creek Sub-Basins using Lumia et al. (2006)**

Peak Discharge (cfs)										
	Drainage area (sq miles)		10% Annual Chance (cfs)		2% Annual Chance (cfs)		1% Annual Chance (cfs)		0.2% Annual Chance (cfs)	
Stream locations from upstream to downstream	Current Study	2002 Study	Current Study	2002 Study	Current Study	2002 Study	Current Study	2002 Study	Current Study	2002 Study
CNF Corporate Boundary	5.17	5.0	166	260	223	540	246	730	299	1250
DS of East Gill	8.45	8.3	238	450	312	880	341	1210	409	2100
DS Hyde Park Dam	9.10	9.3	248	480	325	960	355	1350	426	2330
DS of Ferry Avenue	9.19	10.5	250	530	327	1060	357	1530	428	2620
Confluence with Niagara River	12.26	12.1	329	620	429	1190	468	1490	559	2660

Table 5: Seven Parameter Regression Equations for Urban Watersheds (from Sauer et al. , 1983)

Recurrence Interval (yrs)	Equation	Constant	Exponents							Standard Error of Regression (%)
		X	a	b	c	d	e	f	g	
2	$UQ = XA^{a}SL^{b}(RI2+3)^{c}(ST+8)^{d}(13-BDF)^{e}IA^{f}RQ^{g}$	2.35	0.41	0.17	2.04	-0.65	-0.32	0.15	0.47	±38
5		2.70	0.35	0.16	1.86	-0.59	-0.31	0.11	0.54	±37
10		2.99	0.32	0.15	1.75	-0.57	-0.30	0.09	0.58	±38
25		2.78	0.31	0.15	1.76	-0.55	-0.29	0.07	0.60	±40
50		2.67	0.29	0.15	1.74	-0.53	-0.28	0.06	0.62	±42
100		2.50	0.29	0.15	1.76	-0.52	-0.28	0.06	0.63	±44
200		2.27	0.29	0.16	1.86	-0.54	-0.27	0.05	0.63	±49

A = basin size (area in square miles)
SL = Channel Slope (in feet per mile)
RI2 = Basin Rainfall (in inches for the 2-hour, 2-year occurrence)
ST = Basin Storage (in percentage)
BDF = Basin Development Factor, manmade changes to the drainage system (value 0 through 12)
IA = Impervious Area (in percentage)
RQ = Equivalent Rural Peak Discharge for the Recurrence Interval (in cubic ft per a second)

Table 6: Gill Creek Parameters Used in Regional Regression Equations

Location on Gill Creek	Drainage Area (Sq. Mi.)	Channel Slope, 10-85 Method	% Basin Classified as Open Water/ Wetlands	2-hr 2-yr Rainfall Intensity	% Impervious Area	Basin Development Factor	Equivalent Rural Peak Discharge (from Lumia et al., 2006)
City of Niagara Falls Corporate Boundary	5.17	0.1	3.51	1.18	3.60	3.51	Depends on Event
DS of East Gill	8.45	0.0627	2.26	1.18	12.18	2.26	Depends on Event
DS Hyde Park	9.10	0.0599	2.32	1.18	15.19	2.32	Depends on Event
At Ferry Avenue	9.19	0.059	2.86	1.18	15.77	2.86	Depends on Event
Confluence with Niagara River	12.26	0.0607	1.64	1.18	29.84	1.64	Depends on Event

Table 7: Urbanization Corrected Frequency Flows for Gill Creek Sub-Basins (as per Sauer et al. , 1983)

Peak Discharge (cfs)											
	Drainage area (sq miles)		10% Annual Chance (cfs)		2% Annual Chance (cfs)		1% Annual Chance (cfs)		0.2% Annual Chance (cfs)		1% Annual Chance Plus Error
Stream locations from upstream to downstream	Current Study	2002 Study	Current Study	2002 Study	Current Study	2002 Study	Current Study	2002 Study	Current Study	2002 Study	Current Study
CNF Corporate Boundary	5.17	5.0	209	260	288	540	319	730	372	1250	460
DS of East Gill	8.45	8.3	376	450	488	880	540	1210	616	2100	777
DS Hyde Park Dam	9.10	9.3	396	480	512	960	566	1350	644	2330	815
DS of Ferry Avenue	9.19	10.5	399	530	514	1060	568	1530	646	2620	818
Confluence with Niagara River	12.26	12.1	582	620	735	1190	813	1490	917	2660	1171

Hydraulic Analysis

The analysis of the hydraulic characteristics of flooding from Gill Creek in the city of Niagara Falls, Niagara County was completed to provide estimates for the elevations of floodwaters for the 10%, 2%, 1%, 0.2% and 1% plus annual chance exceedance floods (the [x] percent annual chance flood has a one in [100/x] chance of being exceeded in any given year). The hydraulic analysis completed in this study assumes that flow is unobstructed in the channel throughout the length of the study area and through all hydraulic structures modeled. The Hydrologic Engineer Center's River Analysis System, HEC-RAS version 6.2 (USACE 2022A), was used to calculate the steady-state water surface profiles.

The cross-section data used in the HEC-RAS model was obtained through a combination of LiDAR data and supplemented by a USACE Buffalo District field survey crew. The LiDAR was obtained from the USGS National Map (National Geospatial Program, 2022) and the LiDAR was collected in 2019 (Axis Geospatial LLC, 2019). The locations of all cross-sections are shown on the maps in Appendix B2 and profiles which are included in Appendix A. The cross sections were arranged following HEC-RAS rules for structures as well as referring to the previous FEMA FIS HEC-RAS model. Placement of the cross sections were not exact between this model and the previous model. The river stationing used in this report is based on the distance upstream from the confluence of Gill Creek with the Niagara River (in feet).

The vertical datum used for this project mapping was the North American Vertical Datum (NAVD) of 1988. Note that the hydraulic model's limit extends slightly upstream and downstream of the study area and reported results. The modeled section of Gill Creek spans from 2,750 ft above the corporate boundary of the city of Niagara Falls (upstream limit) to the confluence with Niagara River (downstream limit).

The stream channel and overbank Manning's "n" roughness coefficient values and the expansion and contraction coefficients used in the HEC-RAS model for the hydraulic analysis are presented in Table 6. These are based on suggested values, field observations, experience, engineering judgment, and the previously created HEC-RAS model.

Table 8: Manning's n and Expansion/Contraction Coefficients

Flooding Source	Channel	Overbank	Contraction	Expansion
Gill Creek	0.02-0.07	0.03 – 0.10	0.01	0.03
Structures	0.0275 – 0.04	0.06	0.03	0.05

Channel Manning's ns were determined using a table of Manning's n Values found in the HEC-RAS Hydraulic Reference Manual (USACE 2022C). Additionally, images of the channel were compared to images from "Roughness Characteristics of Natural Channels" (Barnes, 1967) and "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains" (Arcement and Schneider, 1989). Cowans method was also used as a check to verify that the assigned Manning's n values were reasonable. As Gill Creek does not have streamgage data, the Manning's n values cannot be calibrated and instead, following HEC-RAS guidance, "values of n computed for similar stream conditions of values obtained from experimental data should be used as guidelines in selecting n values" (USACE 2022B).

Additionally, images of the channel were compared to images from "Roughness Characteristics of Natural Channels" (Barnes, 1967) and "Guide for Selecting Manning's Roughness Coefficients for Natural Channels and Flood Plains" (Arcement and Schneider, 1989), as shown in Figures 2 through 10. As Gill Creek does not have streamgage data the Manning's n value cannot be calibrated and instead, following HEC-RAS guidance, "values of n computed for similar stream conditions of values obtained from experimental data should be used as guidelines in selecting n values" (USACE, 2022).

Figure 2: Photos from Upstream of Debris Dam

The section upstream of the debris dam exhibits medium vegetation and some minor bank irregularities resulting in a Manning's n of 0.04. This section most closely matches Tobesofkee Creek near Macon, Ga. (Barnes, 1967) which had an n value ranging from 0.039 to 0.043.

Figure 3: Corresponding Stream Section from Barnes (1967) Used to Estimate Manning's n for Reach Upstream of Debris Dam

A section almost immediately downstream was a lined concrete channel. An n value of 0.02 was assigned for this portion based on the table of Manning's n (USACE, 2022).

Figure 4: Concrete Channel Downstream of Debris Dam

Downstream of the concrete section the channel continued through forested wetlands, which has vegetation along the banks and some obstructions.

Figure 5: Forested Wetland Reach

The Manning's n assigned for this forested wetland portion of the creek was 0.070 based on the heavy vegetation and comparison to Pond Creek near Louisville, KY (Barnes, 1967) which had a Manning's n value 0f 0.070.

Figure 6: Corresponding Stream Section from Barnes (1967) Used in Estimating Manning's n for Forested Wetland Reach

Portions through the park/golf course had some sections with little vegetation and a Manning's n of 0.03 while others had medium vegetation resulting in a Manning's n of 0.04.

Figure 7: Typical Section of Gill Creek through Golf Course, Left Image has Low Vegetation and Right has Medium Vegetation.

Downstream of Hyde Park Dam most of the channel exhibits vegetation on the banks and have a corresponding Manning's n of 0.04 based on medium vegetation.

Figure 8: Typical Section of Gill Creek Downstream of Packard Rd (left) and Downstream of Buffalo Avenue (right) from Google Earth with Medium Vegetation

Further downstream of Buffalo Avenue, just upstream of the confluence with the Niagara River, the vegetation decreases however there is an increase of debris present resulting in an obstruction value that brings the Manning's n to 0.04.

Figure 9: Typical Section of Gill Creek Upstream of the Confluence with Niagara River

Floodplain Manning's n values were referenced from a couple different sources. For areas of the golf course or park that had low cut grass, the table in the HEC-RAS manual based on Chow (1959) was used to determine a Manning's n value of 0.03 (USACE, 2022). The overbanks in the forested wetlands region were determined based on the guide by Acrement and Schneider (1989). A value of 0.11 was selected based on comparing the conditions of Gill Creek to images and descriptions in the guide.

Figure 10: (Left) Image of Gill Creek and Surrounding Flood Plain within the Forested Wetland Area, (Right) Image from Acrement and Scheider (1989) with a Manning's n of 0.11

Manning's n for other sections of the floodplain were selected by referencing the table in the HEC-RAS user manual for NLCD (HEC-RAS, 2022).

NLCD Value	Manning's n	NLCD Class
21	0.03 - 0.05	Developed - Open Space
22	0.06 - 0.12	Developed - Low Intensity
23	0.08 - 0.16	Developed - Medium Intensity

Within the modeled area there are twenty-nine (29) bridges/culverts and three (3) hydraulic structures. The physical dimensions, configuration, and elevations of the bridges/culverts were obtained during a site survey conducted by the USACE Buffalo District. The three hydraulic structures are a debris dam, Hyde Park dam, and a low weir.

Flood profiles were generated showing the computed water surface elevations for the selected recurrence intervals using a steady flow analysis. The 1% and 0.2% floodplain boundaries were delineated using the flood elevations determined at each cross-section. Between cross-sections, the boundaries of the floodplain were interpolated in RAS Mapper using the LiDAR-based terrain. The floodway was developed by encroaching the floodplain to raise the water surface elevation by up to 1 foot.

A summary of the 1% water surface elevations and floodway elevations at selected cross-sections are shown in the floodway data tables for Gill Creek (Table 9). Flood water surface profile plots are shown in Appendix A. The extent of the estimated flooding is illustrated on maps included in Appendix B (Figures B1 thru B13). The hydraulic analyses for this study are based on unobstructed flow. The flood elevations shown on the profile are considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

Table 9: Gill Creek - Floodway Data Table

Flooding Source		Floodway			Base Flood Elevation Water Surface		
Cross-section	DISTANCE[1] (FT.)	WIDTH (FT)	SECTION AREA (SQ. FT.)	MEAN VELOCITY (FPS)	WITHOUT FLOODWAY (NAVD88[3])	WITH FLOODWAY (NAVD88[2])	DIFFERENCE (FT.)
Gill Creek, Niagara County, NY							
A	29	132	199	4.1	557.5	557.5	0.0
B	356	119	261	2.2	561.2	561.2	0.0
C	3289	52	272	2.1	567.0	567.0	0.0
D	3821	75	352	1.6	567.3	567.3	0.0
E	4608	52	209	2.7	567.9	567.9	0.0
F	5706	31	201	2.7	571.0	571.0	0.0
G	6071	45	299	1.8	571.2	571.2	0.0
H	6708	59	436	1.2	571.6	571.7	0.1
I	7932	398	3,821	0.1	575.7	575.7	0.0
J	8415	339	3,285	0.1	575.7	575.7	0.0
K	9724	253	2,238	0.1	575.7	575.7	0.0
L	11200	209	1,395	0.2	575.7	575.7	0.0
M	13070	99	348	0.9	576.0	576.1	0.1
N	13843	97	333	1.0	576.1	576.4	0.3
O	14438	77	248	1.1	576.3	576.7	0.4
P	16194	77	183	1.8	576.9	577.7	0.8
Q	16999	30	115	2.8	577.4	578.1	0.7
R	17598	33	97	3.3	578.0	578.4	0.4
S	18618	31	56	5.7	579.5	579.6	0.1
T	19566	38	89	3.6	581.4	581.4	0.0
U	19819	64	170	1.9	582.6	582.5	-0.1
1 - Distance upstream of Niagara River Confluence							
2 - North American Vertical Datum of 1988 (in ft.)							
Niagara County NY		Floodway Data					
		Flooding Source: Gill Creek					

Discrepancies in base flood elevations (i.e., water surface elevation for the 1% annual chance exceedance flood) between the hydraulic model from this study and the model from the previous 2002 study are significant; in some cases, the difference is over 3 ft (Table 10; Figure 11). The overall reason for discrepancies in the results is due to the significant differences in calculated peak flows. While there may be other contributing factors such as streambed profile, bridge geometries, topographic details, and channel/overbank Manning's ns it is hard to determine how significant these factors were.

The most obvious difference between models is the peak discharges. The 2002 calculated peak discharges are significantly higher than those calculated in this study. This is most likely due to a difference of approach. Table 11 shows a summary of the differences between the peak discharges. Due to the peak discharged being so significantly different it is hard to determine how much other factors may have impacted the results.

Beyond the peak discharge changes, some sections of the stream bed elevations are different from the previous flood profiles. Between cross sections A and B there is a steeper slope to the stream bed as well as cross section A having a lower invert elevation by about 2 feet. From just upstream of Hyde Park Dam to station 12000 the lake streambed is about 2.5.feet deeper and overall flatter. From cross section Q to U the streambed elevation in this study is generally 2 feet higher. This could also contribute to some of the differences seen, such as the larger BFE difference between cross sections A and B. The deeper streambed elevations in Hyde Park Lake may contribute to greater storage resulting in less flooding downstream.

Additionally, there are difference between the low and high chord of bridges modeled between this study and the previous study. However due to the lower water elevations resulting from the lower peak discharges the differences between the models due to the elevation differences are relatively low. Additionally, this study includes a new bridge immediately upstream of Robert Moses Parkway and eliminates a foot bridge that no longer exists between Walnut Avenue and Ferry Avenue. The table below, Table 12, summarizes the bridges where water reaches the low chords and compares the low chord and high chord elevations between this study and the 2002 Study for Gill Creek.

Table 10: Base Flood Elevations (BFE) Differences - Current Study vs. 2002 Study

CROSS-SECTION	DISTANCE[1] (FT.)	Current BFE (NAVD88[2])	2002 BFE (NAVD88[2])	DIFFERENCE (FT.)
A	29	557.5	561.2	-3.7
B	356	561.2	566.2	-5.0
C	3289	567.0	570.0	-3.0
D	3821	567.3	570.3	-3.0
E	4608	567.9	570.9	-3.0
F	5706	571.0	571.7	-0.7
G	6071	571.2	572.2	-1.0
H	6708	571.7	573.2	-1.5
I	7932	575.7	576.9	-1.2
J	8415	575.7	576.9	-1.2
K	9724	575.7	576.9	-1.2
L	11200	575.7	576.9	-1.2
M	13070	575.98	577.8	-1.82
N	13843	576.14	577.8	-1.66
O	14438	576.34	577.9	-1.56
P	16194	576.91	578.3	-1.39
Q	16999	577.41	578.8	-1.39
R	17598	577.95	579.1	-1.15
S	18618	579.07	583.9	-4.83
T	19566	581.38	584.8	-3.42
U	19819	582.60	585.0	-2.40
1 - Distance upstream of Niagara River Confluence				
2 - North American Vertical Datum of 1988				
3 - New cross-section				

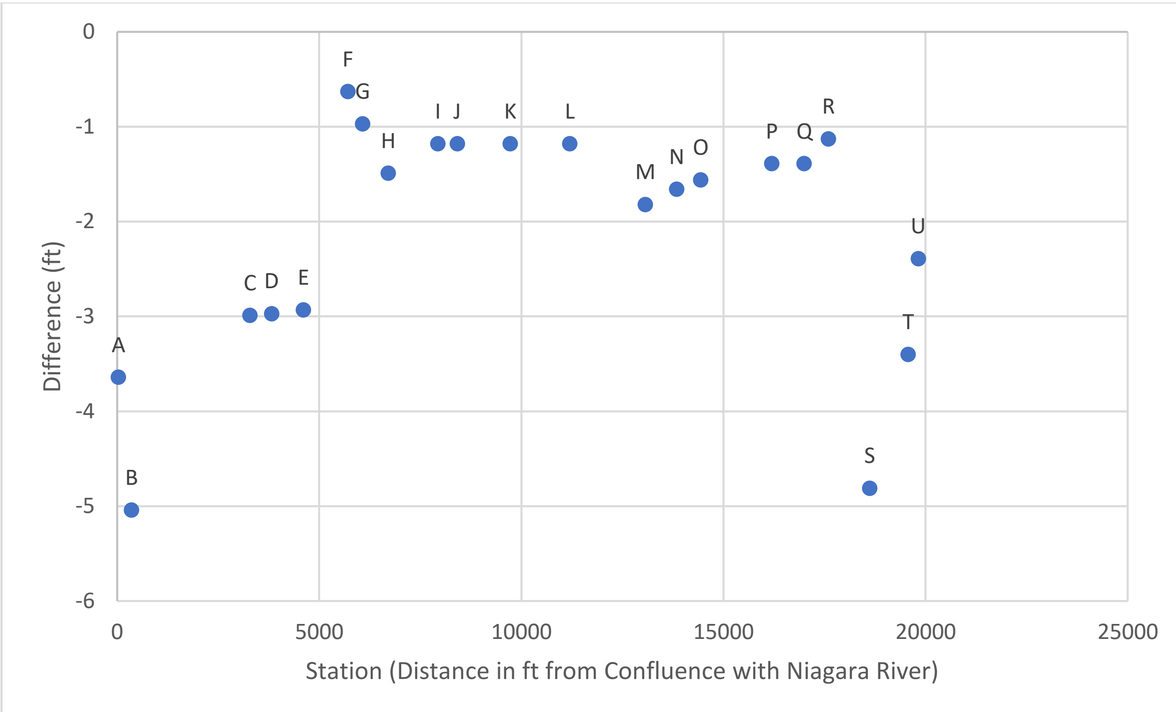

Figure 11: Difference in base flood elevation (BFE) between current study and 2002 study

Table 11: Summary of Percent Change Between 2002 Study and Current Study Peak Discharges

Percent Change of Peak Discharges				
% Change from 2002 Study to Current	**Storm Event Peak Discharge**			
	10-year	**50-year**	**100-year**	**500-year**
CNF Corporate Boundary	-19.7%	-46.7%	-56.3%	-70.3%
DS of East Gill	-16.5%	-44.5%	-55.4%	-70.7%
DS of Hyde Park	-17.4%	-46.7%	-58.1%	-72.4%
At Ferry Avenue	-24.7%	-51.5%	-62.9%	-75.4%
Confluence with Niagara River	-6.1%	-38.3%	-45.4%	-65.5%

Table 12: Differences in High Chord (HC) and Low Chord (LC) Elevations for Bridges where the Low Chord Intercepts Flow

Bridge	Distance[1] (ft)	Current		2002 Study		Difference	
		HC	LC	HC	LC	HC	LC
Railroad	938	568.4	564.8	568.1	565	-0.3	-0.2
Packard Road	3494.5	570.6	568.1	573.1	567	-2.5	1.1
Pipe Bridge	3636.5	570.1	566.7	570.5	567.6	-0.4	-0.9
Niagara Street	3963	570.5	567.1	574.1	567.6	-3.6	-0.5
Walnut Avenue (Culvert)	6218	574.8	569.8	574.0	570.9	0.8	1.1
Foot Bridge	11491.5	576.5	574.5	576.6	575.4	0.1	0.9
Foot Bridge	12226	577.0	576.0	577.3	576.1	0.3	0.1
1 - Distance upstream of Niagara River Confluence							

As seen in the table above, there are some discrepancies between the 2017 FIS and the current studies high and low chord for structures. The low chord was assessed as no structure was completely overtopped, even where high chord elevations decreased in elevation between the 2002 Study and the current study. The low chord for some bridges in this study were lower than the low chords in the 2002 Study. If a smaller portion of the bridge is in contact with the water, it causes a smaller backwater effect. Likewise, if a greater portion of the bridge deck is in contact with water, it causes a larger backwater effect. Packard Road was reconstructed in 2002 so it is probable that the high and low chords are based on the bridge prior to reconstruction (National Bridge Inventory Data). The other bridges in the table were not found in the National Bridge Inventory Data so it is unknown if they were reconstructed or not. I t is unclear why there are differences in elevations of the structures, but USACE feels most confident in the recent survey data from the USACE Buffalo District.

The 2002 Study had Manning's n ranging from 0.02 – 0.04 for the channel and 0.05-0.06 for the overbanks. USACE had access to the previous studies HEC-RAS model, provided by FEMA. The overall channel had similar Manning's n values. The only area of significant difference was the upstream portion that passed through a forested wetland area. The overbank values did differ in some sections, including the forested wetland and golf course area, however as the floodplain width is significantly smaller in this study, the impact of the different overbank Manning's n could not be assessed. The contraction and expansion coefficients were the same between the two studies.

Beyond the factors discussed above, differences between models can be attributed to higher resolution elevation mapping (i.e., LiDAR), new and improved modeling software, and more recent surveys with additional cross-sections. This effort was completed using state-of-the-art hydraulic modeling techniques and in accordance with USACE Great Lakes and Ohio River Division's best practices. While some of the differences in base flood elevations are significant (over 3.0 ft), all available information was utilized to assess the discrepancy. Moreover, USACE is confident that these results constitute the best flood hazard information available for this section of Gill Creek.

Engineering Summary

Hydrologic and hydraulic analyses were completed on the Gill Creek watershed in the city of Niagara Falls, Niagara County, New York to estimate various flood stages and to delineate the 1%, 0.2%, and floodway boundaries. The information used in the analyses were gathered from site visits, a field survey, and various published data sources. The analyses were completed using engineering tools, such as StreamStats and HEC-RAS version 6.2 (USACE 2022A). The geometric model for the HEC-RAS program was developed using survey field data obtained by the USACE and LiDAR. Roughness coefficients were estimated using several approaches (Chow, 1959; Barnes, 1967; Arcement and Schneider, 1989; Brunner, 2016a).

The project was undertaken to develop a hydraulic model of the area and to redefine the 1%, 0.2%, and floodway boundaries. It was necessary to undertake this update due to any physical changes that may have occurred over time in the city of Niagara Falls such as residential and commercial development and/or reconstructed bridge structures, as well updated hydrologic analysis techniques and more detailed topographic data (LiDAR).

Unified Floodplain Management

Historically, the alleviation of flood damage has been accomplished almost exclusively by the construction of protective works such as reservoirs, channel improvements, floodwalls, and levees. However, despite funding that has been spent to construct well-designed and efficient flood risk management projects, annual flood damages continue to increase because the number of people and structures occupying lands subject to flooding is increasing faster than protective works can be provided.

Recognition of this trend has forced a re-assessment of the flood risk management concept and has resulted in the broadened concept of unified floodplain management programs. Legislative and administrative policies frequently cite two approaches: structural and non-structural measures for adjusting to the flood hazard. In this context, “structural” is usually intended to mean adjustments that modify the behavior of floodwaters using constructing measures such as dams, channel work and the construction of levees and floodwalls. “Nonstructural” is usually intended to include all other adjustments in the way society acts when occupying or modifying a floodplain. Nonstructural measures include stronger regulations, flood proofing measures such as elevation or the acquisition and demolition of structures, and flood insurance. Both structural and nonstructural tools are used for achieving desired future floodplain conditions. There are three basic strategies which may be applied individually or in combination:

(1) Modifying the susceptibility to flood damage and disruption,

(2) Modifying the floods themselves, and

(3) Modifying (reducing) the adverse impacts of floods on the individual and the community

Modify Susceptibility to Flood Damage and Disruption

The strategy to modify susceptibility to flood damage and disruption consists of actions to avoid dangerous, economically undesirable, or unwise use of the floodplain. Responsibility for implementing such actions rests largely with the non-Federal sector and primarily at the local government level. These actions include restriction in the mode and time of occupancy, in the ways and means of access: in the pattern, density, and elevation of structures and in the character of their materials (structural strength, absorptivity, solubility and corrodibility) in the shape and type of building and in their contents and in the appurtenant facilities and the landscaping of the grounds. The strategy may also necessitate changes in the interdependencies between floodplains and surrounding areas not subject to flooding, especially interdependencies regarding utilities and commerce. Implementing mechanisms for these actions include land use regulations, development and redevelopment policies, flood proofing, disaster preparedness and response plans, and flood forecasting and warning systems. Different tools may be more suitable for developed or underdeveloped floodplains or for urban or rural areas. The information contained in this report will be useful for the preparation of floodplain regulations.

Floodplain Regulations

Floodplain regulations apply to the full range of ordinances and other measures/means designed to control land use and construction within flood prone areas. The term encompasses comprehensive land use plans, zoning ordinances, subdivision regulations, building and housing codes, encroachment line issues/statutes, open area regulations, and other similar methods of management which affect the use and development of flood prone areas.

Floodplain land use management does not prohibit use of flood prone areas, to the contrary, floodplain land use management seek the best use of floodplain lands. The flooded area maps and the water surface profile plates contained in this report can be used to guide development in the floodplain. The elevations shown on the profile should be used to determine flood heights since they are more accurate than the flooded area maps. It is also recommended that development in areas susceptible to frequent flooding adhere to the principles expressed in Executive Order 11988 – Floodplain Management, whose objective is to "...avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains…wherever there is a practicable alternative." Accordingly, development in areas susceptible to frequent flooding should consist of construction that has low damage thresholds such as parking areas, parks, and golf courses. High value construction such as buildings should be fully located outside the floodplain possible. In instances where no practicable alternative exists, the land should be elevated to minimize structural damages. If it is not feasible to elevate the land or structure in these areas, means of flood proofing the structure should be given careful consideration.

Developmental Zones

A floodplain consists of two zones. The first zone is designated as a "floodway: of that cross-sectional area required for carrying or discharging the anticipated flood waters with a maximum 1-foot increase in flood level." Velocities are the greatest and most damaging in the floodway. Regulations essentially maintain the flow conveying carrying capability of the floodway to minimize inundation of additional adjacent areas.

The second zone of the floodplain is termed the floodway fringe or restrictive zone, in which inundation might occur but where depths and velocities are generally low. Although not recommended if practicable alternatives exist, such areas can be developed provided structures are placed high enough or “flood- proofed” to be reasonably free from flood damage from the 1% flood. Typical relationships between the floodway and floodway fringe are shown in **Error! Reference source not found.**.

The floodway developed for this study was computed for Gill Creek based on equal conveyance reduction from each side of the floodplain. Floodway widths were computed at each cross-section. Between cross-sections, the floodway boundary was interpolated. The results of the floodway computations have been tabulated for selected cross-sections and are shown in **Error! Reference source n ot found.**.

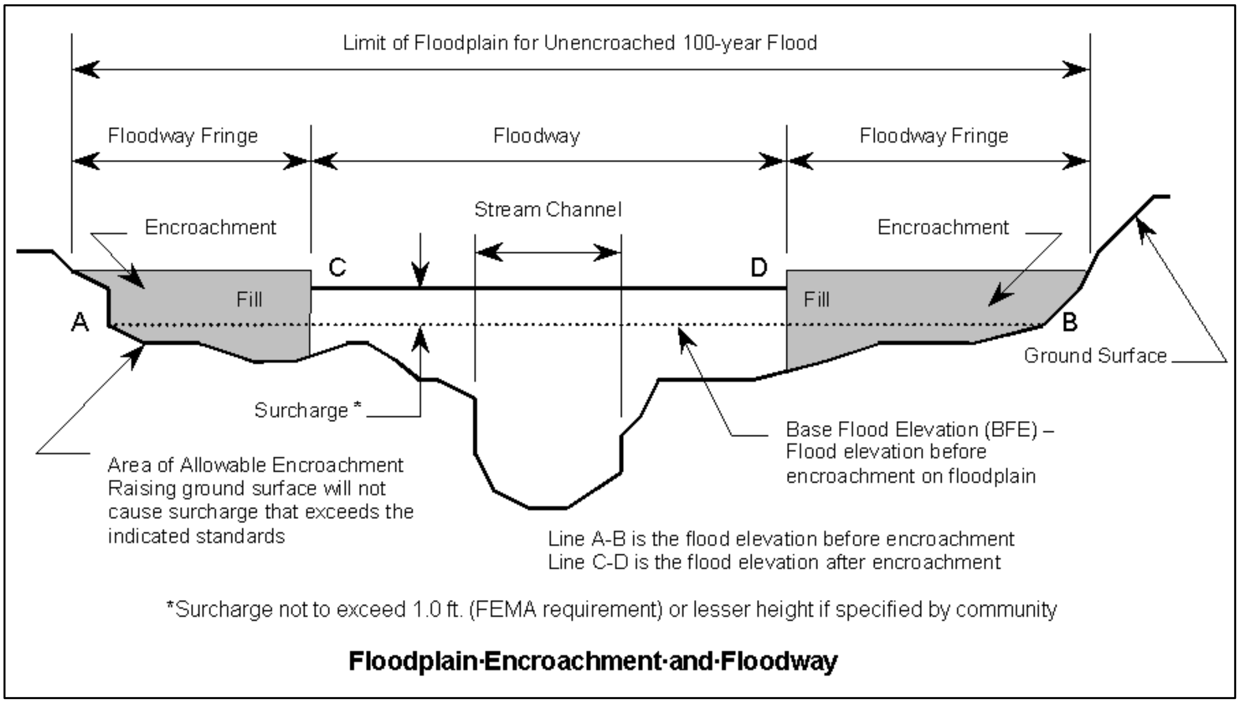

Figure 12: Floodway Schematic (100-year = 1%) (Source: MoDOT, 2014)

Formulation of Floodplain Regulations

Formulation of floodplain regulations in a simplified sense involves selecting the type and degree of control to be exercised for each specific floodplain. In principle, the form of the regulations is not as important as a maintained adequacy of control. The degree of control normally varies with the flood hazard as measured by depth of inundation, velocity of flow, frequency of flooding, and the need for available land. Considerable planning and research are required for the proper formulation of floodplain regulations. Formulation of flood plain regulations may require a lengthy period during which development is likely to occur. In such cases, temporary regulations should be adopted and amended later as necessitated.

Modify Flooding

The traditional strategy of modifying floods through the construction of dams, dikes, levees and floodwalls, channel alternation, high flow diversions, spillways, and land treatment measures has repeatedly demonstrated its effectiveness in protecting property and saving lives, and it will continue to be a strategy of floodplain management. However, future reliance solely upon a flood modification strategy is neither possible nor desirable. Although the large capital investment required by flood modifying tools has been preceded largely by the Federal government, sufficient funds from Federal sources have not been and are not likely to be available to meet all situations for which flood modifying measures would be both effective and economically feasible. Another consideration is that the cost of maintaining and operating flood control structures falls upon local governments.

Flood modifications acting alone leave a residual flood loss potential and can encourage an unwarranted sense of security leading to inappropriate use of lands in the areas that are directly protected or in adjacent areas. For this reason, measures to modify possible floods should usually be accompanied by measures to modify the susceptibility to flood damage, particularly by land use regulations.

Modify the Impact of Flooding on Individuals and the Community

A third strategy for mitigating flood losses consists of action designed to assist individuals and communities in their preparatory, survival and recovery response to floods. Tools include information dissemination and education, arrangements for spreading the cost of the loss over time, purposeful transfer of some of the individual's loss to the community by reducing taxes in flood prone areas, and the purchase of federally subsidized flood insurance. The distinction between a reasonable and unreasonable transfer of costs from the individual to the community can also be regulated and is a key to effective floodplain management.

Conclusion

This report presents local floodplain information for Gill Creek in the city of Niagara Falls, Niagara County, New York and presents the results of the study completed. It was determined that the 1% annual chance exceedance (i.e., 100-year) water surface elevations are considerably different from the previous 2002 study at certain cross-sections. The source of these discrepancies can mainly be contributed to the different peak discharges. They are also due in part to bridge geometry, higher resolution elevation mapping (i.e., LiDAR), updated surveys, Manning's n values, and new and improved modeling software. While the differences in water surface elevation from the previous study are significant, USACE is confident that these results constitute the best flood hazard information available for this section of Gill Creek. Additionally, given the significant changes in the floodplain extent and BFEs in this study compared to the current FIS, USACE recommends the City of Niagara Falls submit a letter of map revision (LOMR) request to FEMA to revise the FIS and FIRM.

The extent of the estimated flooding is illustrated on separate site maps completed by USACE for this specific study. These maps are included in Appendix B as "Figure B1 thru B13". The USACE, Buffalo District, uses methods for developing interpretation in the application of the data contained in this report, particularly as to its use in developing effective floodplain regulations.

Glossary

BACKWATER EFFECT	The resulting rise in water surface in a given stream due to a downstream obstruction or high stages in an intersecting stream.
BASE FLOOD	A flood which has an average return interval on the order of once in 100 years, although the flood may occur in any year. It is based on statistical analysis of stream flow records available for the watershed and analysis of rainfall and runoff characteristics in the general region of the watershed. It is commonly referred to as the “100-year flood”, now referred to as the 1% ACE.
DISCHARGE	The quantity of flow in a stream at any given time, usually measured in cubic feet per second (cfs).
FLOOD	An overflow of lands not normally covered by water. Floods have two essential characteristics: the inundation of land is temporary, and the lands are adjacent to and inundated by overflow from a river, stream, ocean, lake, or other body of standing water. Normally a “flood” is considered as any temporary rise in streamflow or stage, but not the ponding of surface water, that results in significant adverse effects in the vicinity. Adverse effects may include damages from overflow of land areas, temporary backwater effects in sewers and local drainage channels, creation of unsanitary conditions or other unfavorable situations by deposition of materials in stream channels during flood recessions and rise of groundwater coincident with increased streamflow.
FLOOD CREST	The maximum stage or elevation reached by floodwaters at a given location.
FLOOD FREQUENCY	A statistical expression of the percent chance of exceeding a discharge of a given magnitude in any given year. For example, a 100-year flood has a magnitude expected to be exceeded on the average of once every hundred years. Such a flood has a 1% chance of being exceeded in any given year. Often used interchangeably with RECURRENCE INTERVAL.
FLOODPLAIN	The areas adjoining a river, stream, watercourse, ocean, lake, or other body of standing water that have been or may be covered by floodwater.
FLOOD PROFILE	A graph showing the relationship of water surface elevation to location; the latter generally expressed as distance upstream from a known point along the approximate centerline of a stream of water that flows in an open channel. It is generally drawn to show surface elevation for the rest of a specific flood but may be prepared for conditions at a given time or stage.
FLOOD STAGE	The stage or elevation at which overflow of the natural banks of a stream or body of water begins in the reach or area in which the elevation is measured.

FLOODWAY	The channel of a watercourse and those portions of the adjoining floodplain required to provide for the passage of the selected flood (normally the 100-year flood) with an insignificant increase in the flood levels above that of natural conditions. As used in the National Flood Insurance Program, floodways must be large enough to pass the 100-year flood without causing an increased in elevation of more than a specified amount.
RECURRENCE INTERVAL	A statistical expression of the average time between floods exceeding a given magnitude (see FLOOD FEQUENCY).
SUB-BASIN	A sub-basin is a structural geologic feature where a basin forms within a larger basin.
WATERSHED	An area or ridge of land that separates waters flowing to different rivers, basins, or seas.

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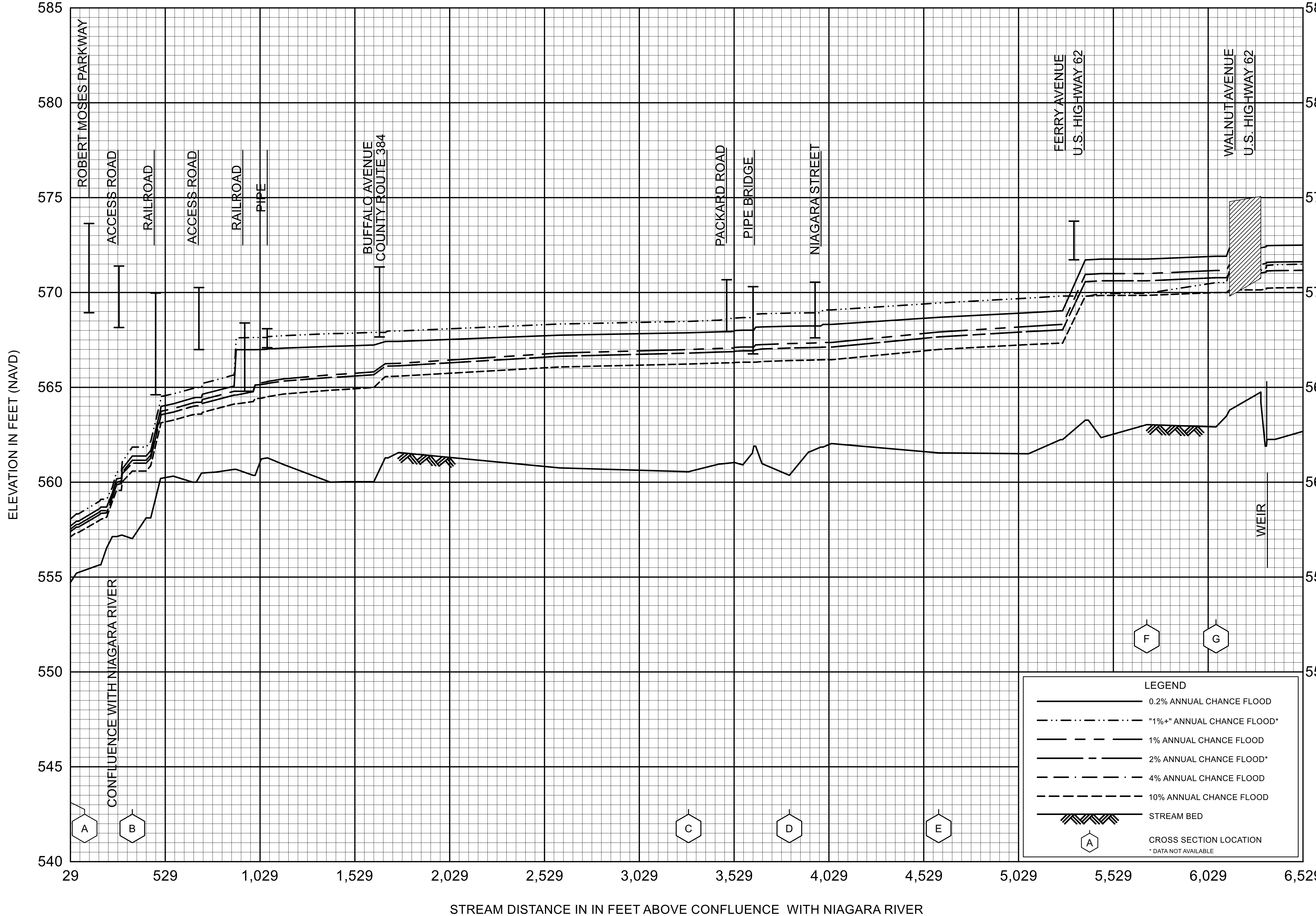


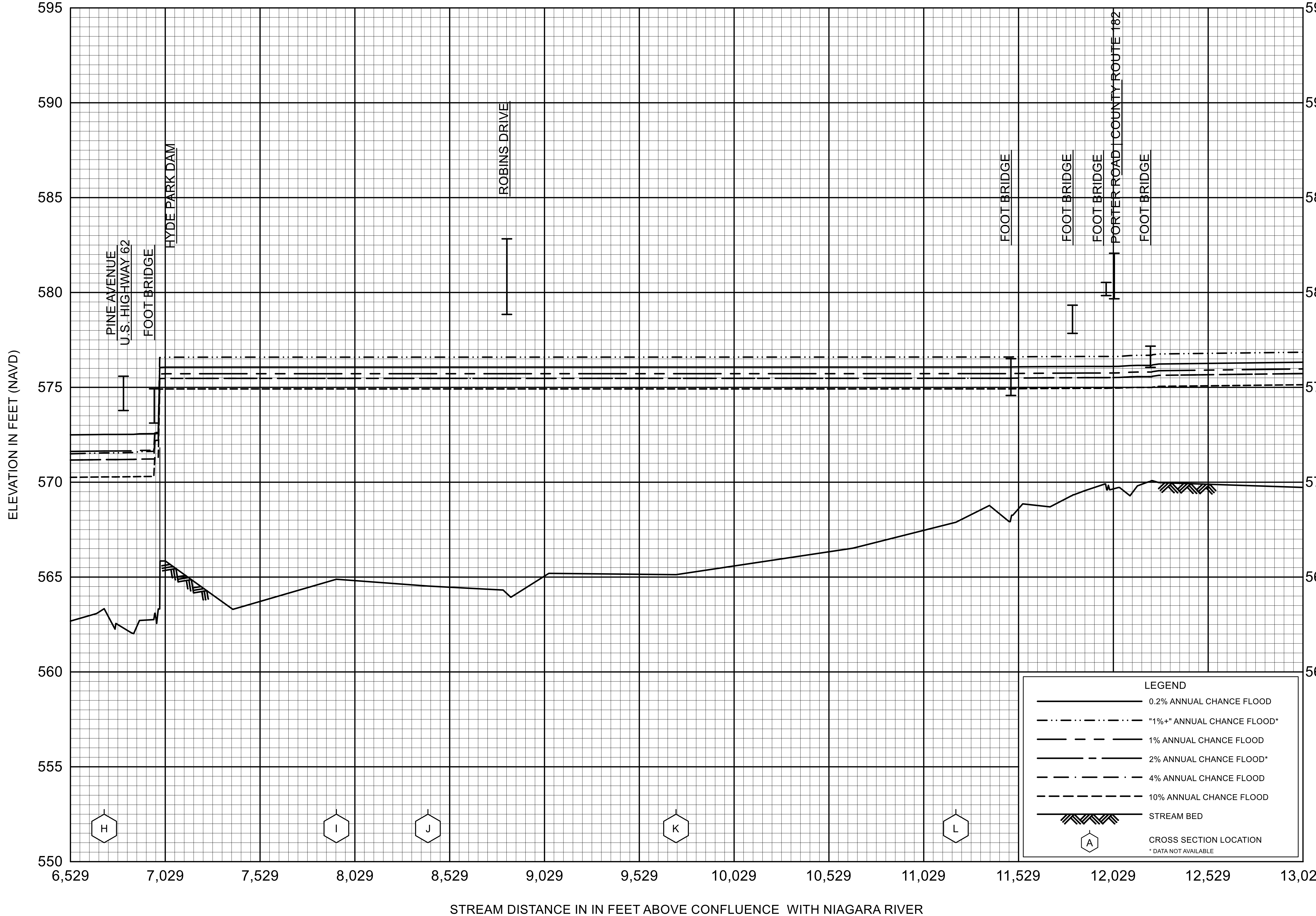
FLOOD PROFILES

GILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NIAGARA COUNTY, NY

CITY OF NIAGARA FALLS



FLOOD PROFILES

GILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NIAGARA COUNTY, NY

CITY OF NIAGARA FALLS

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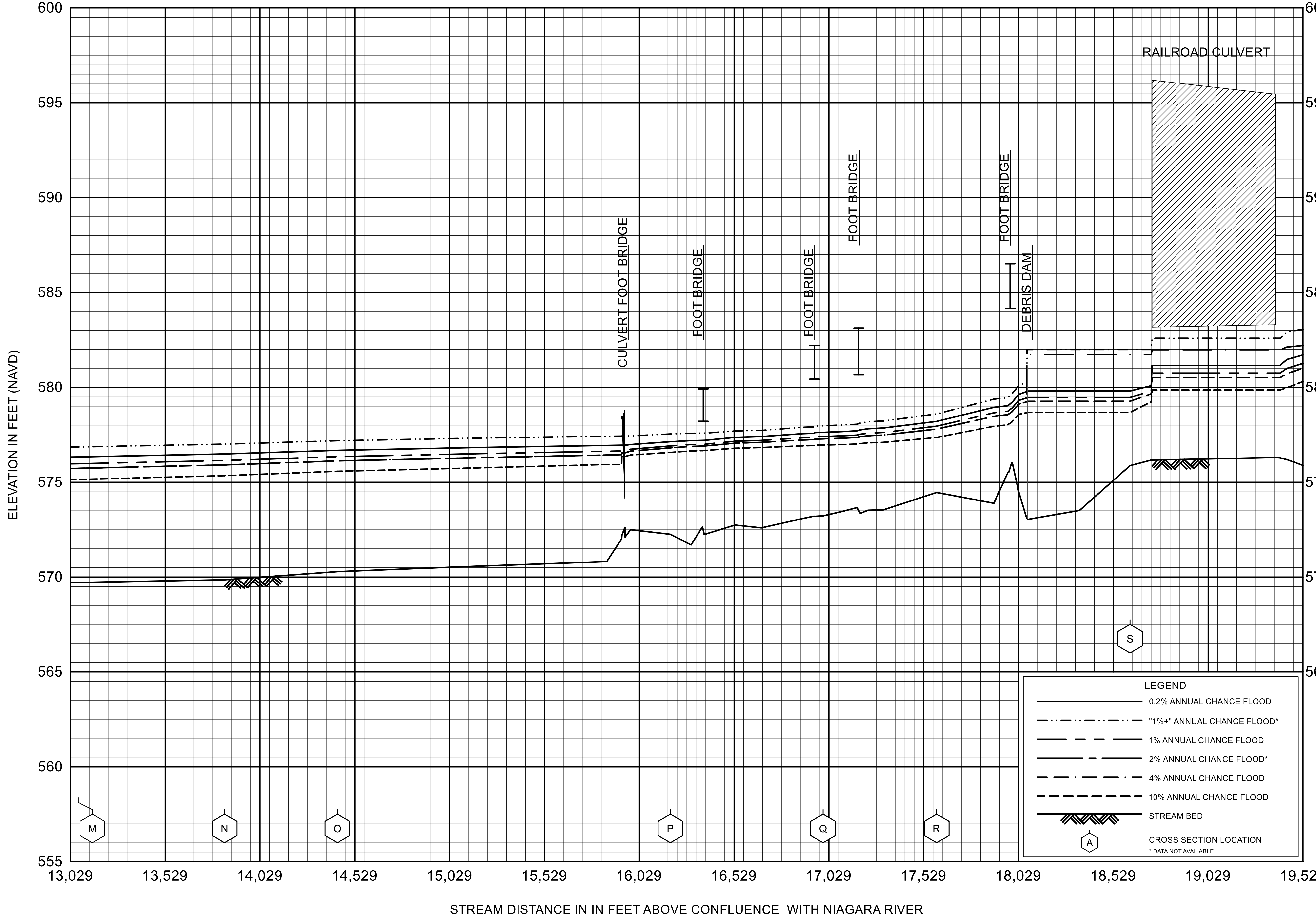


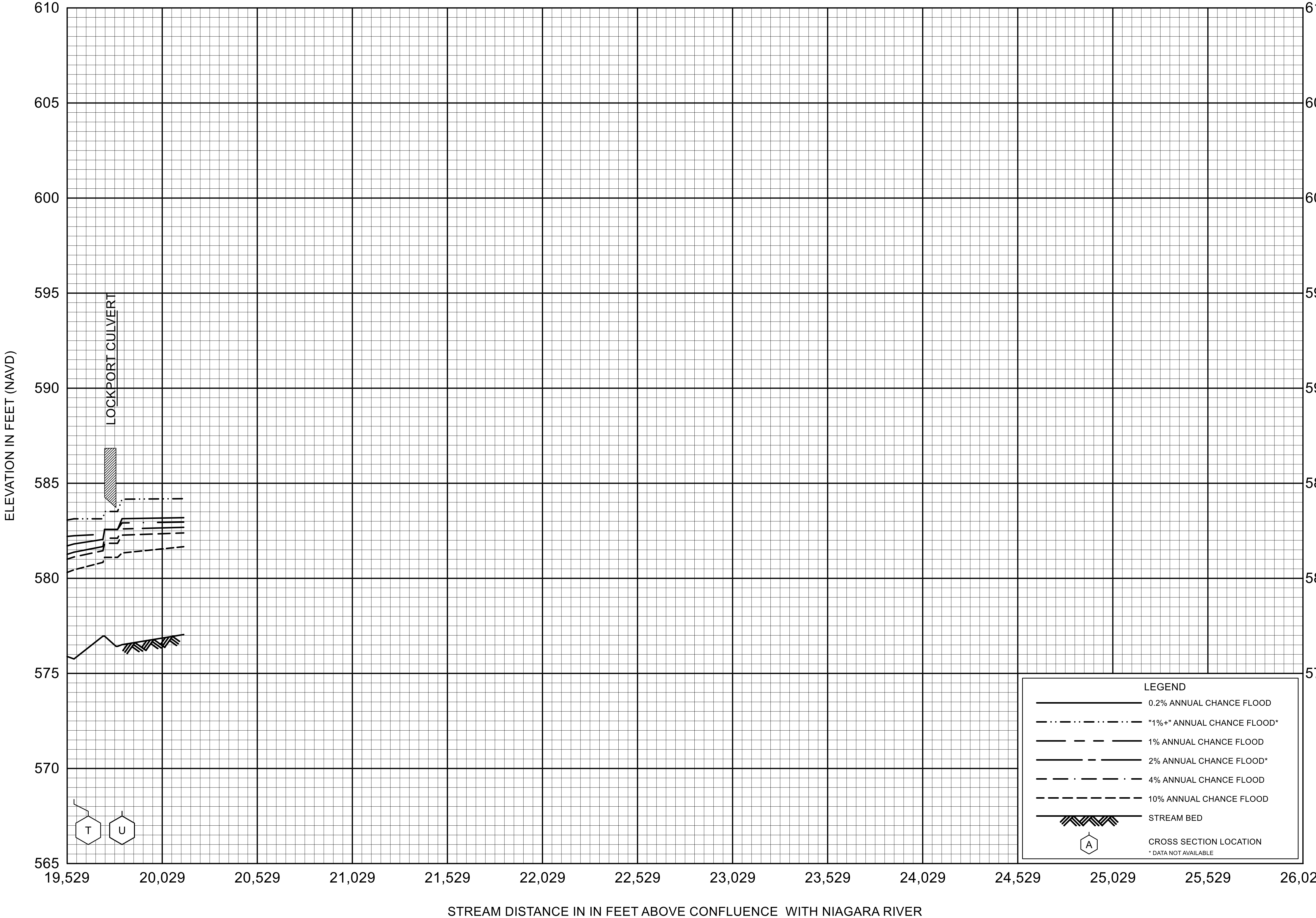
FLOOD PROFILES

GILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NIAGARA COUNTY, NY

CITY OF NIAGARA FALLS



FLOOD PROFILES

GILL CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

NIAGARA COUNTY, NY

CITY OF NIAGARA FALLS

LOCATION		FLOODWAY			1% ANNUAL CHANCE FLOOD WATER SURFACE ELEVATION (FEET NAVD88)			
CROSS SECTION	DISTANCE	WIDTH (FEET)	SECTION AREA (SQ. FEET)	MEAN VELOCITY (FEET/SEC)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
A	29	132	199	4.1	557.5	557.5	557.5	0.0
B	356	119	261	2.2	561.2	561.2	561.2	0.0
C	3,289	52	272	2.1	567.0	567.0	567.0	0.0
D	3,821	75	352	1.6	567.3	567.3	567.3	0.0
E	4,608	52	209	2.7	567.9	567.9	567.9	0.0
F	5,705	31	201	2.7	571.0	571.0	571.0	0.0
G	6,070	45	299	1.8	571.2	571.2	571.2	0.0
H	6,707	59	436	1.2	571.6	571.6	571.7	0.1
I	7,932	398	3,821	0.1	575.7	575.7	575.7	0.0
J	8,414	339	3,285	0.1	575.7	575.7	575.7	0.0
K	9,723	253	2,238	0.1	575.7	575.7	575.7	0.0
L	11,199	209	1,395	0.2	575.7	575.7	575.7	0.0
M	13,070	99	348	0.9	576.0	576.0	576.1	0.1
N	13,842	97	334	1.0	576.1	576.1	576.4	0.3
O	14,437	77	285	1.1	576.3	576.3	576.7	0.4
P	16,193	77	179	1.8	576.9	576.9	577.7	0.8
Q	16,998	30	114	2.8	577.4	577.4	578.1	0.7
R	17,597	33	96	3.3	578.0	578.0	578.4	0.4
S	18,617	31	56	5.7	579.5	579.5	579.6	0.1
T	19,565	38	89	3.6	581.4	581.4	581.4	0.0
U	19,818	64	170	1.9	582.6	582.6	582.5	-0.1

[1] Feet above confluence with Niagara River

FLOODWAY DATA

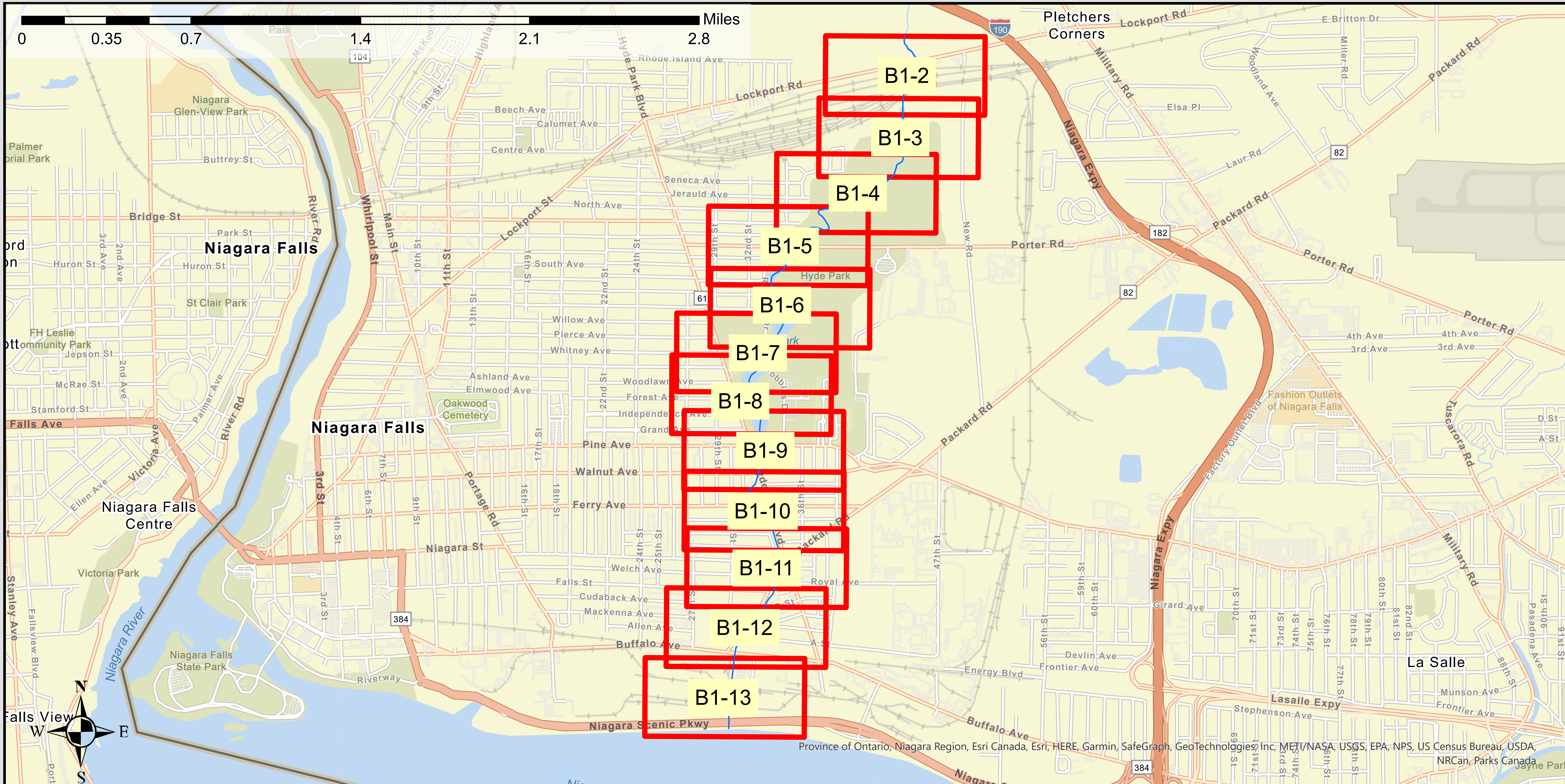
FEDERAL EMERGENCY MANAGEMENT AGENCY

NIAGARA COUNTY, NEW YORK

CITY OF NIAGARA

FLOODWAY DATA

FLOODING SOURCE: GILL CREEK



Legend
Gill Creek
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SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

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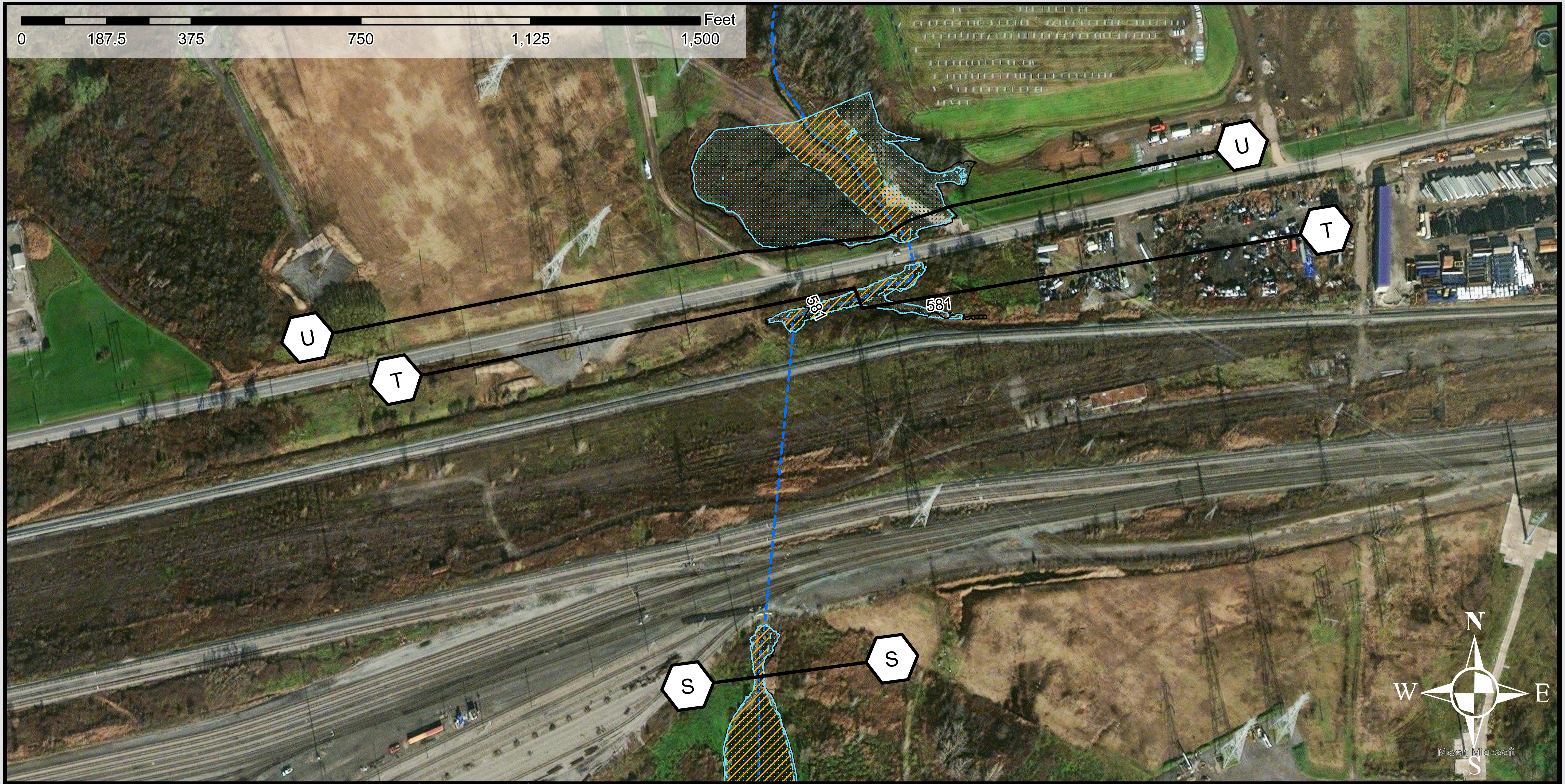
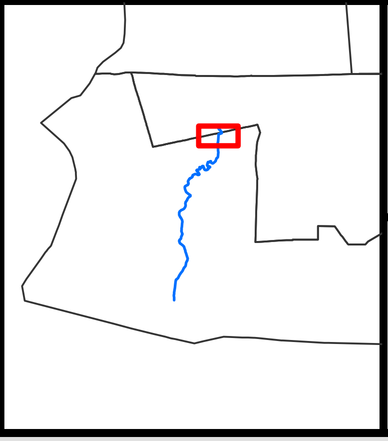
GILL CREEK: STUDY AREA

FIGURE B1-1



Legend

- Gill Creek
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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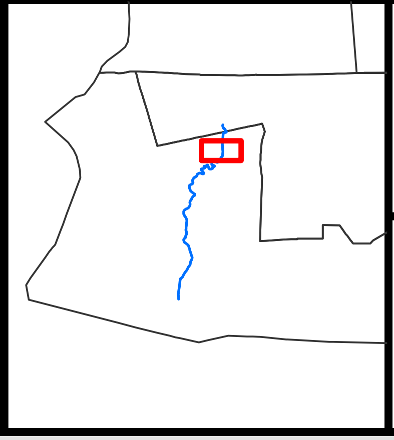
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA FALLS, NEW YORK

GILL CREEK

FIGURE B1-2

Legend

- Gill Creek
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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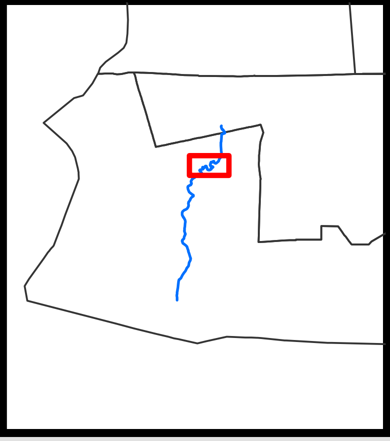
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA FALLS, NEW YORK

GILL CREEK

FIGURE B1-3

Legend

- Gill Creek
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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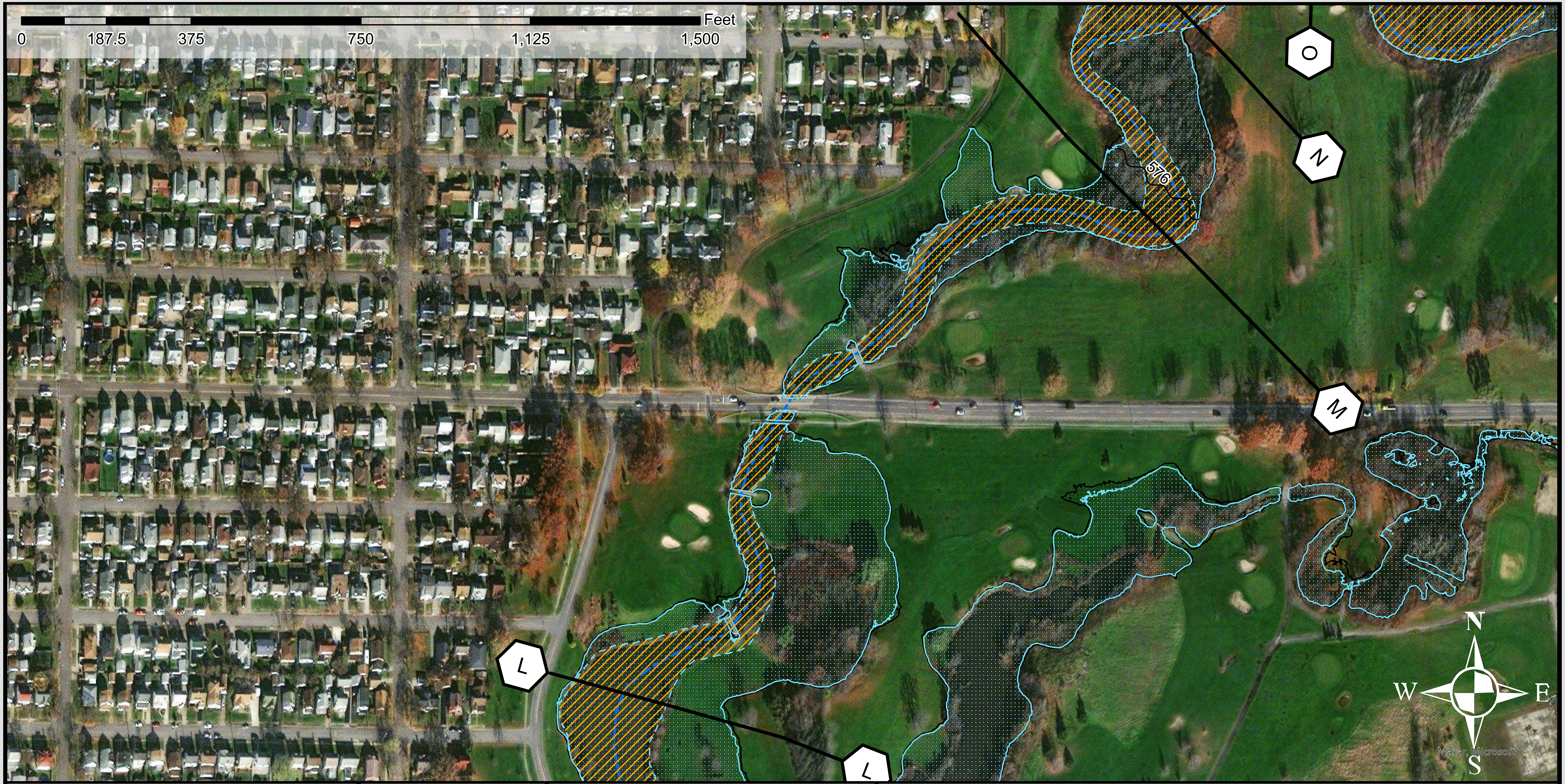
GILL CREEK

FIGURE B1-4



Legend
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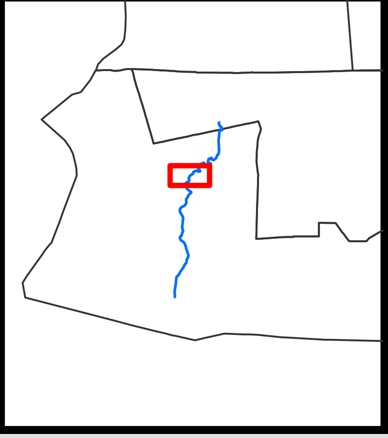
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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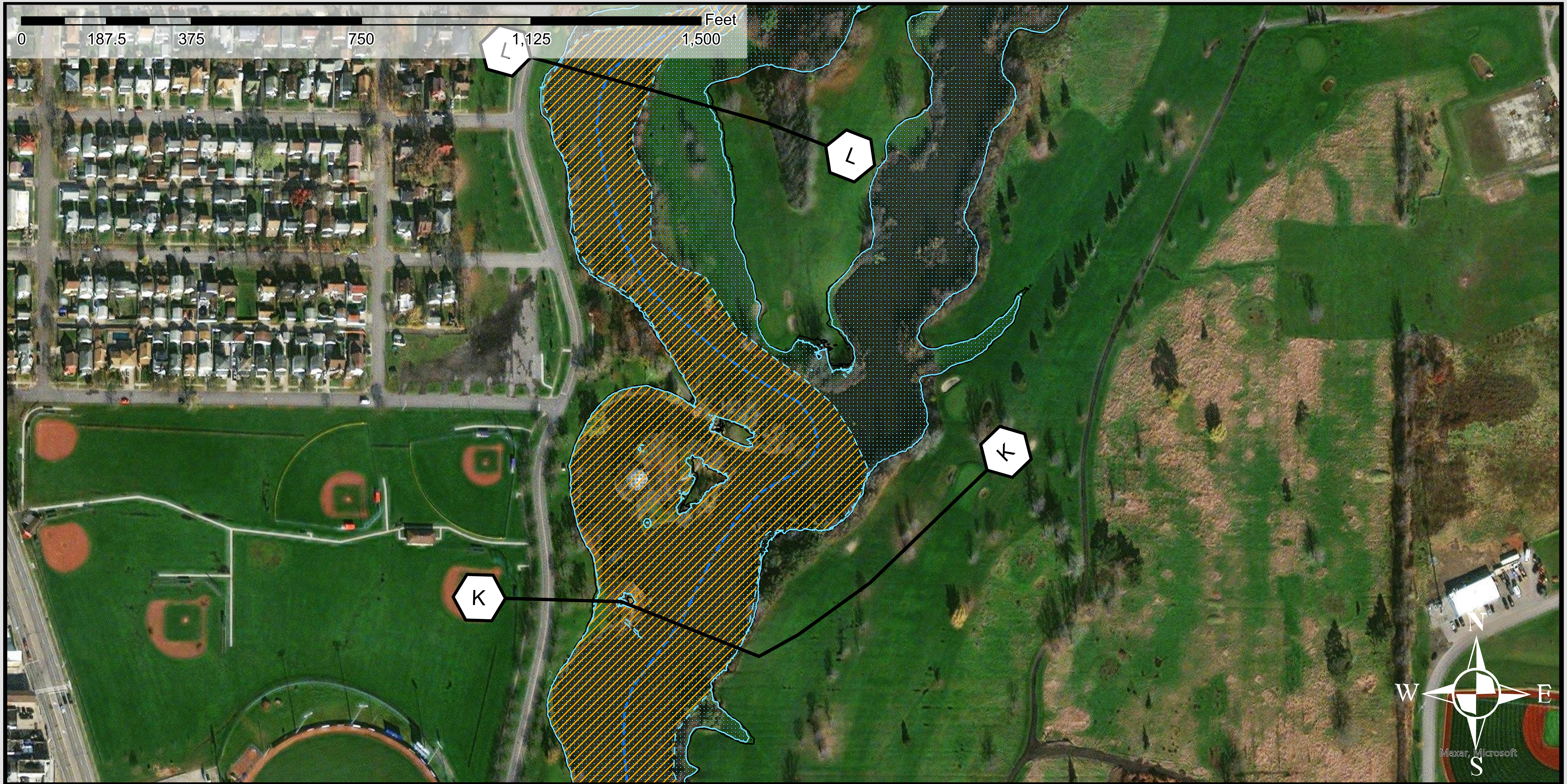
GILL CREEK

FIGURE B1-5



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- Cross Sections
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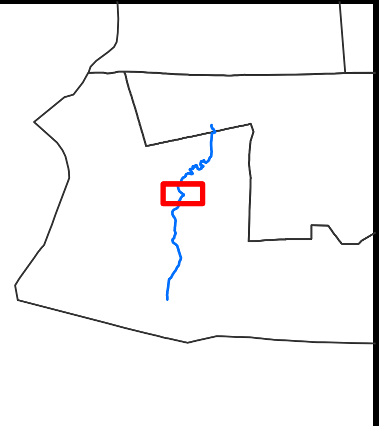
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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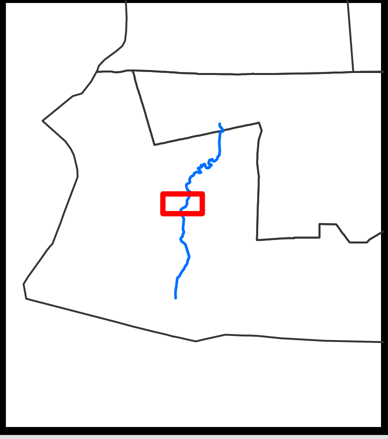
GILL CREEK

FIGURE B1-6

Legend

- Gill Creek
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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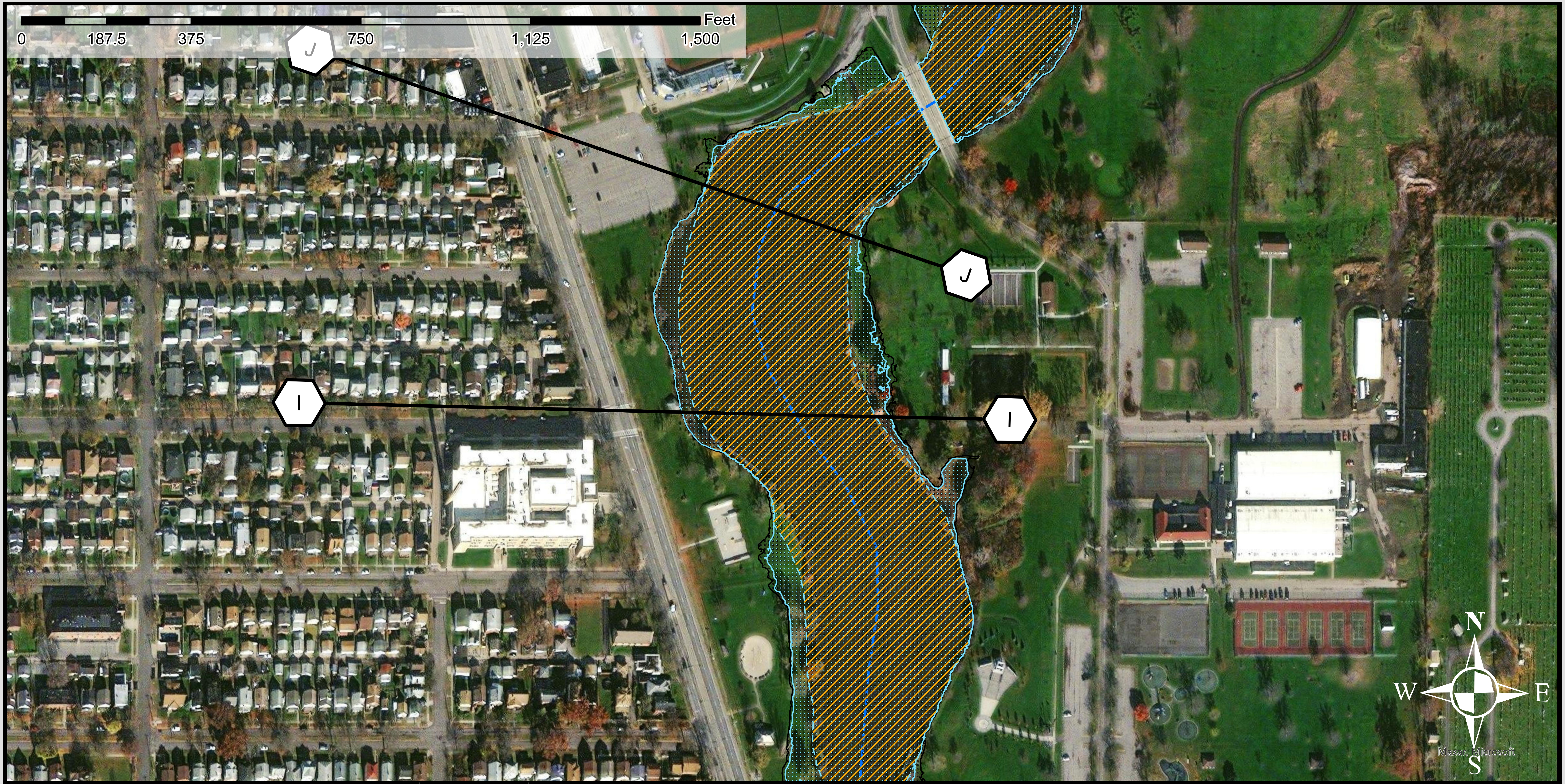
GILL CREEK
NIAGARA FALLS, NEW YORK

GILL CREEK

FIGURE B1-7



Legend

- Gill Creek
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE

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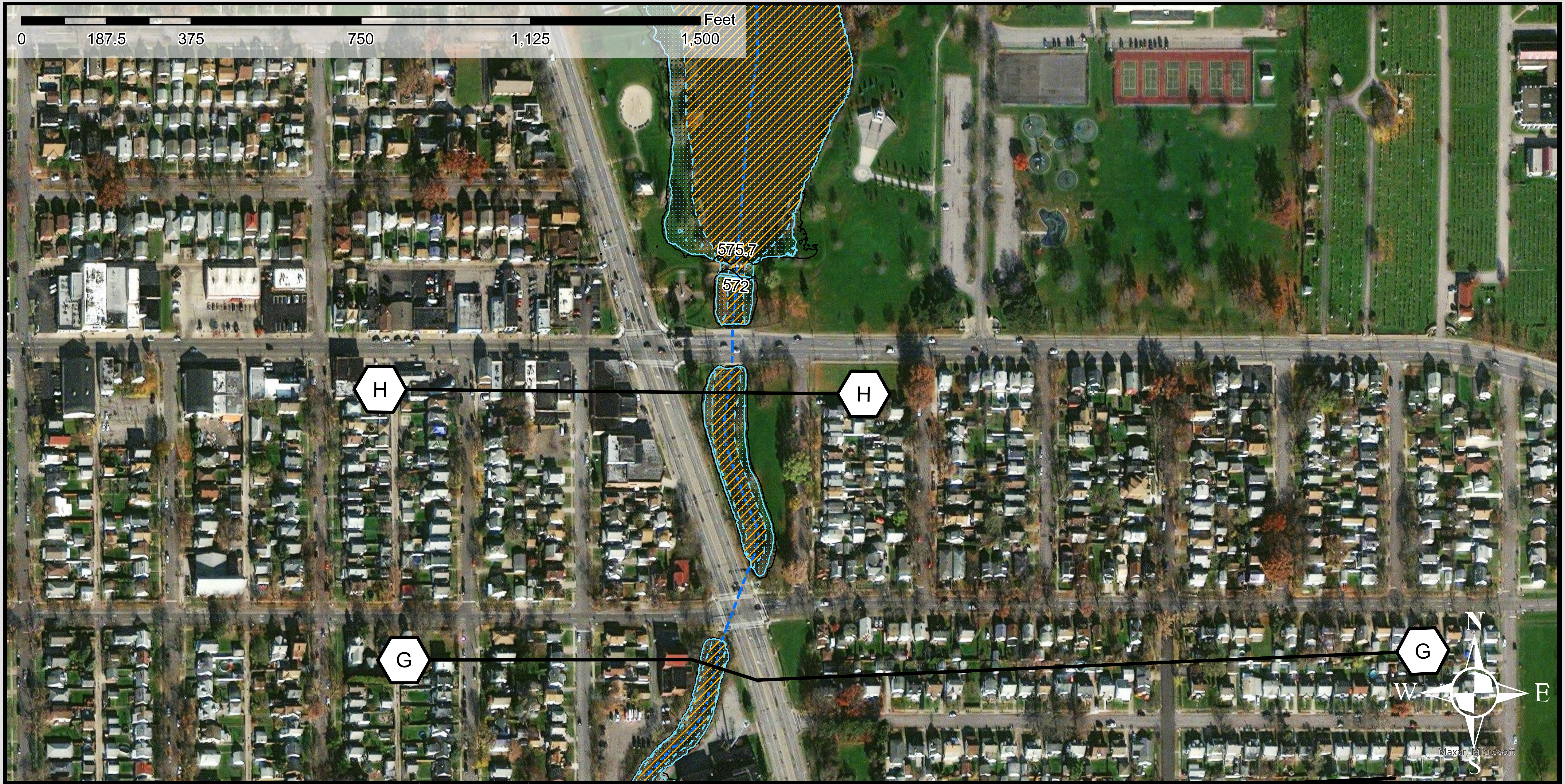
GILL CREEK

FIGURE B1-8



Legend
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- Cross Sections
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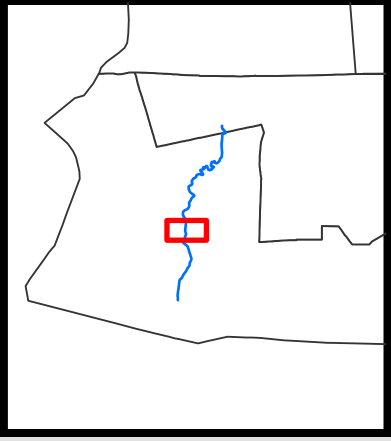
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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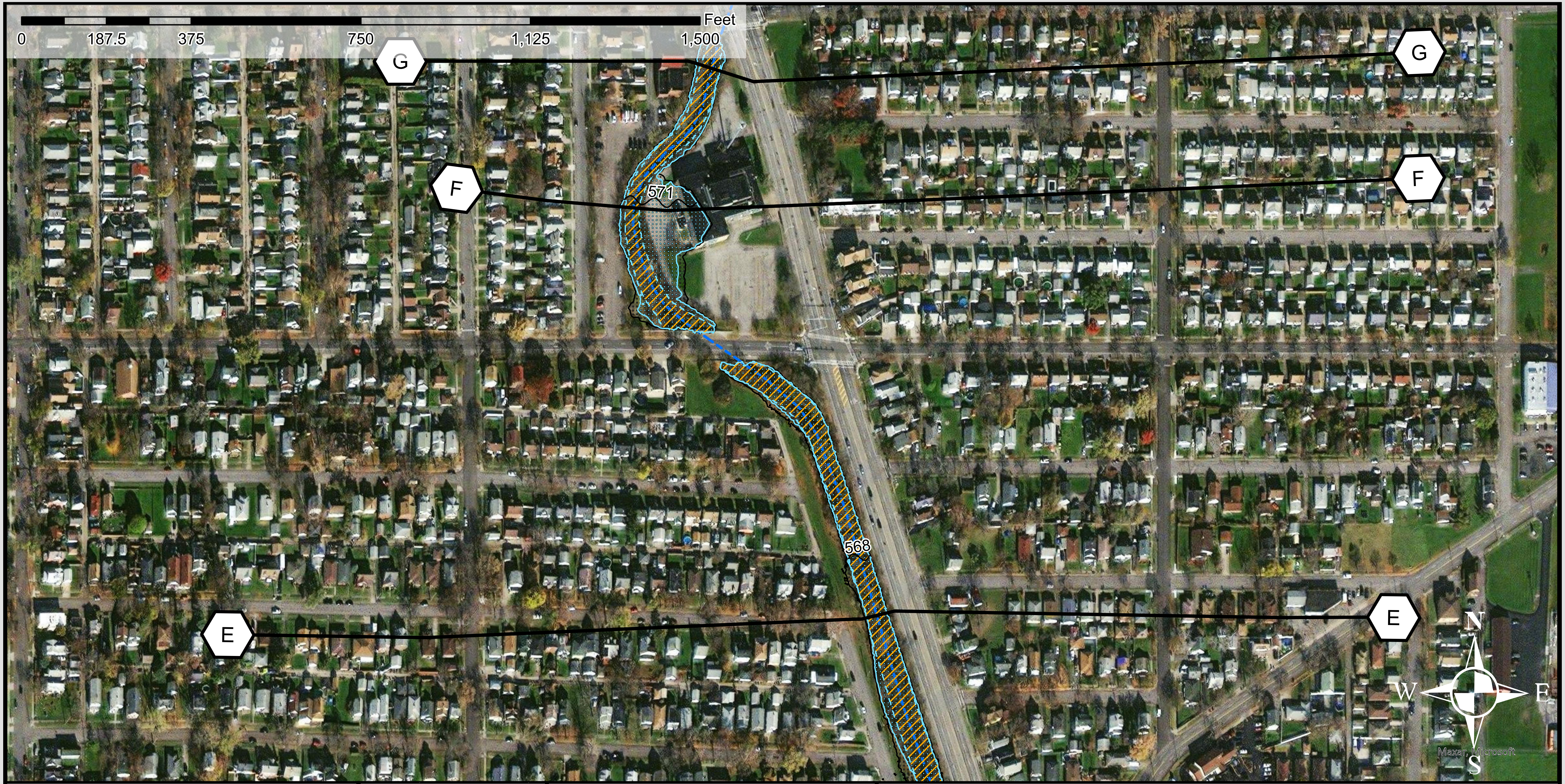
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA FALLS, NEW YORK

GILL CREEK

FIGURE B1-9



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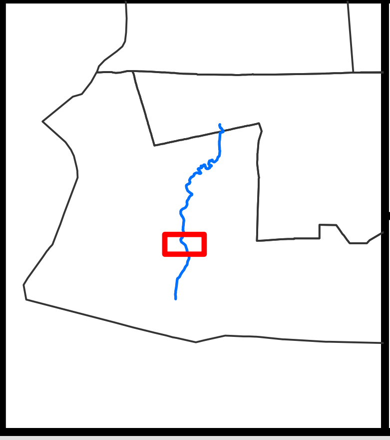
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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GILL CREEK
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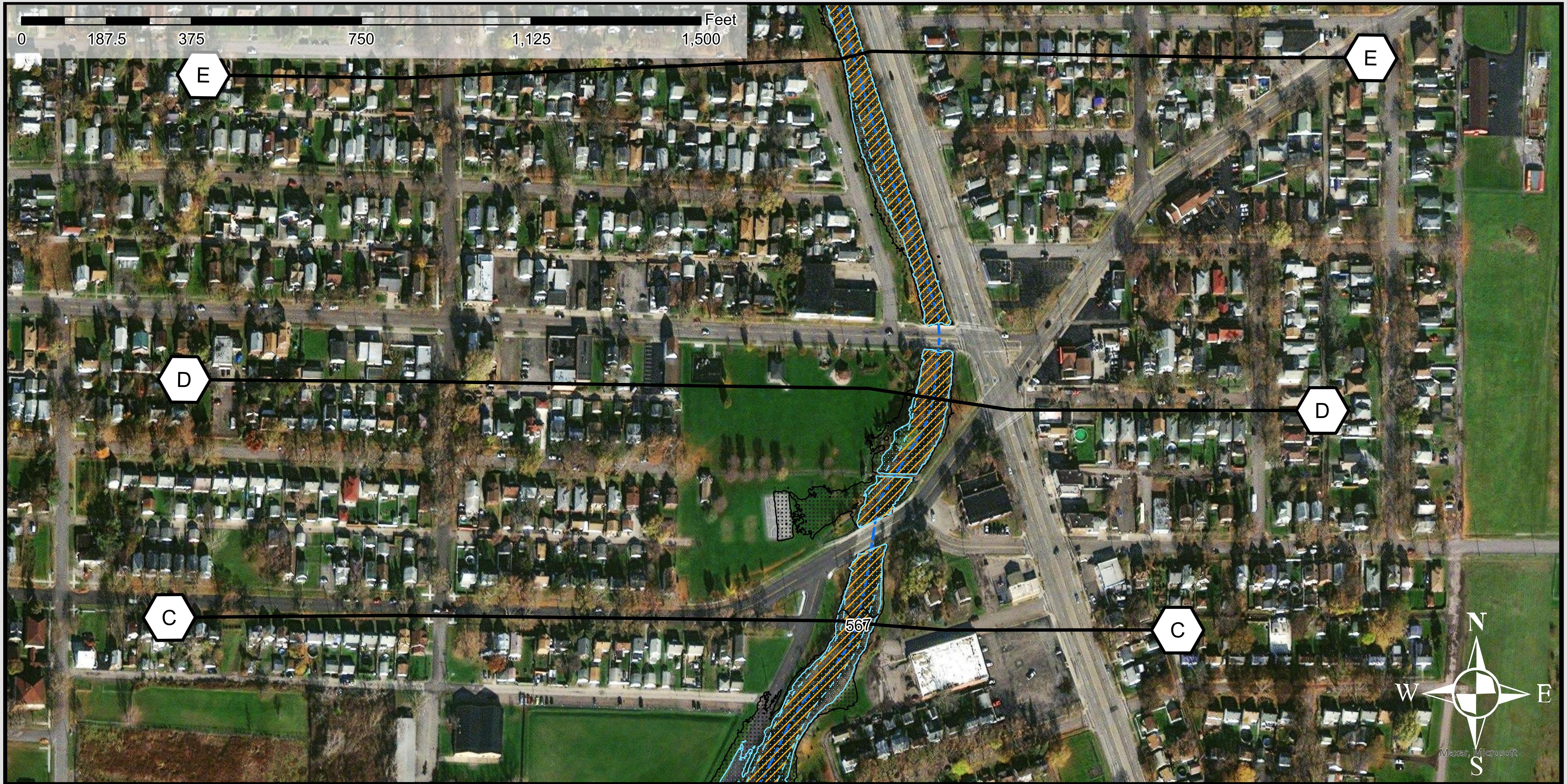
GILL CREEK

FIGURE B1-10



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- 100-Year Flood Boundary
- Floodway Boundary
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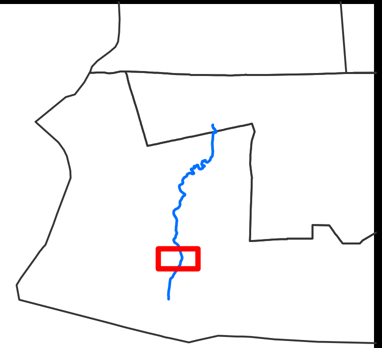

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GILL CREEK
NIAGARA FALLS, NEW YORK

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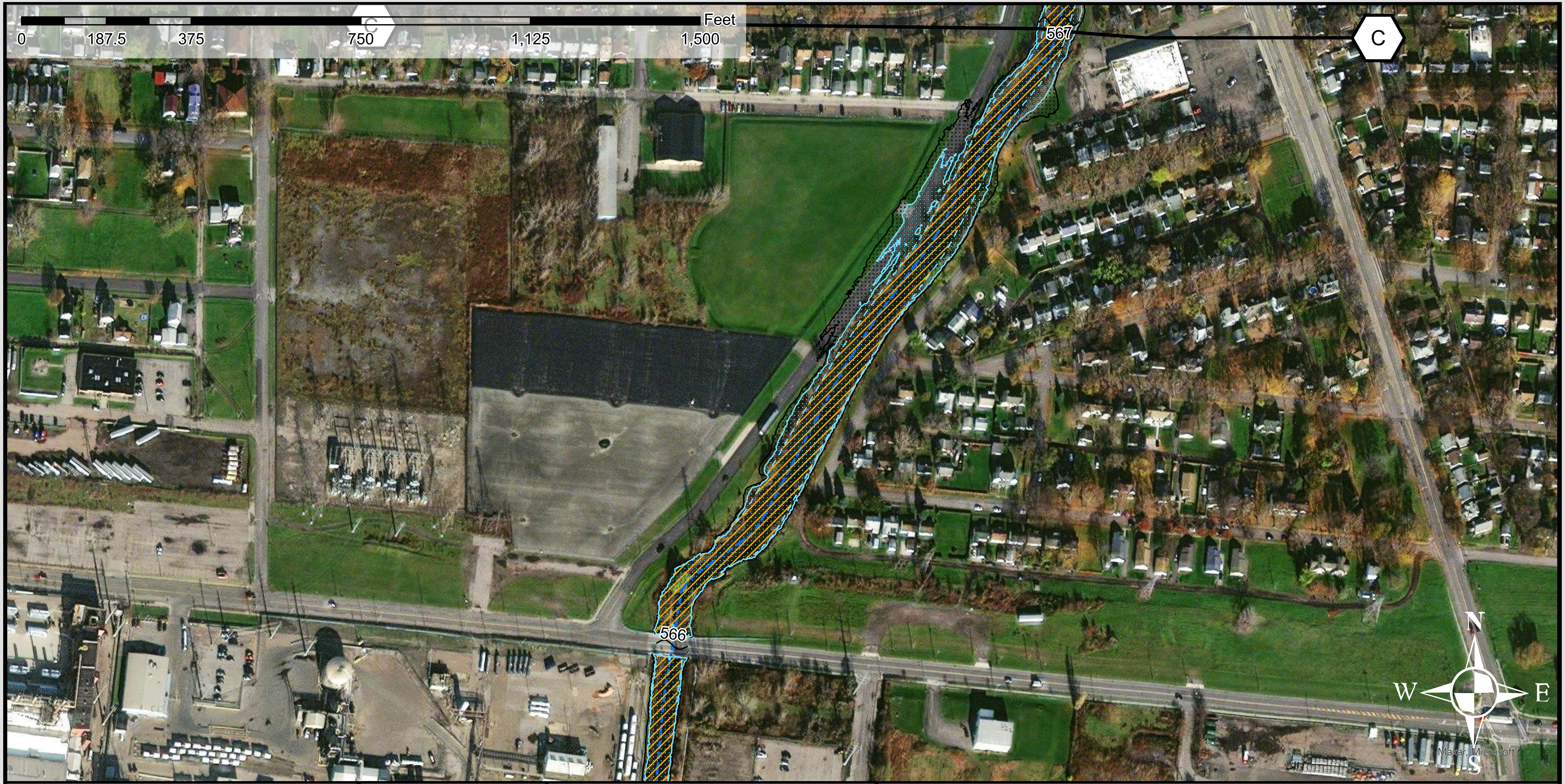
FIGURE B1-11



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- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE

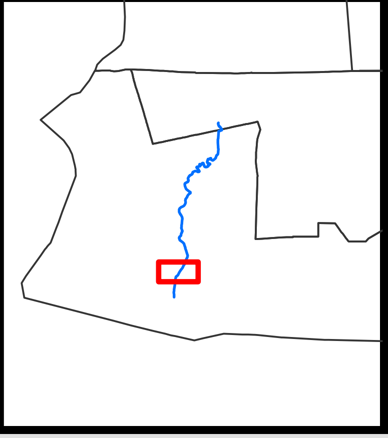

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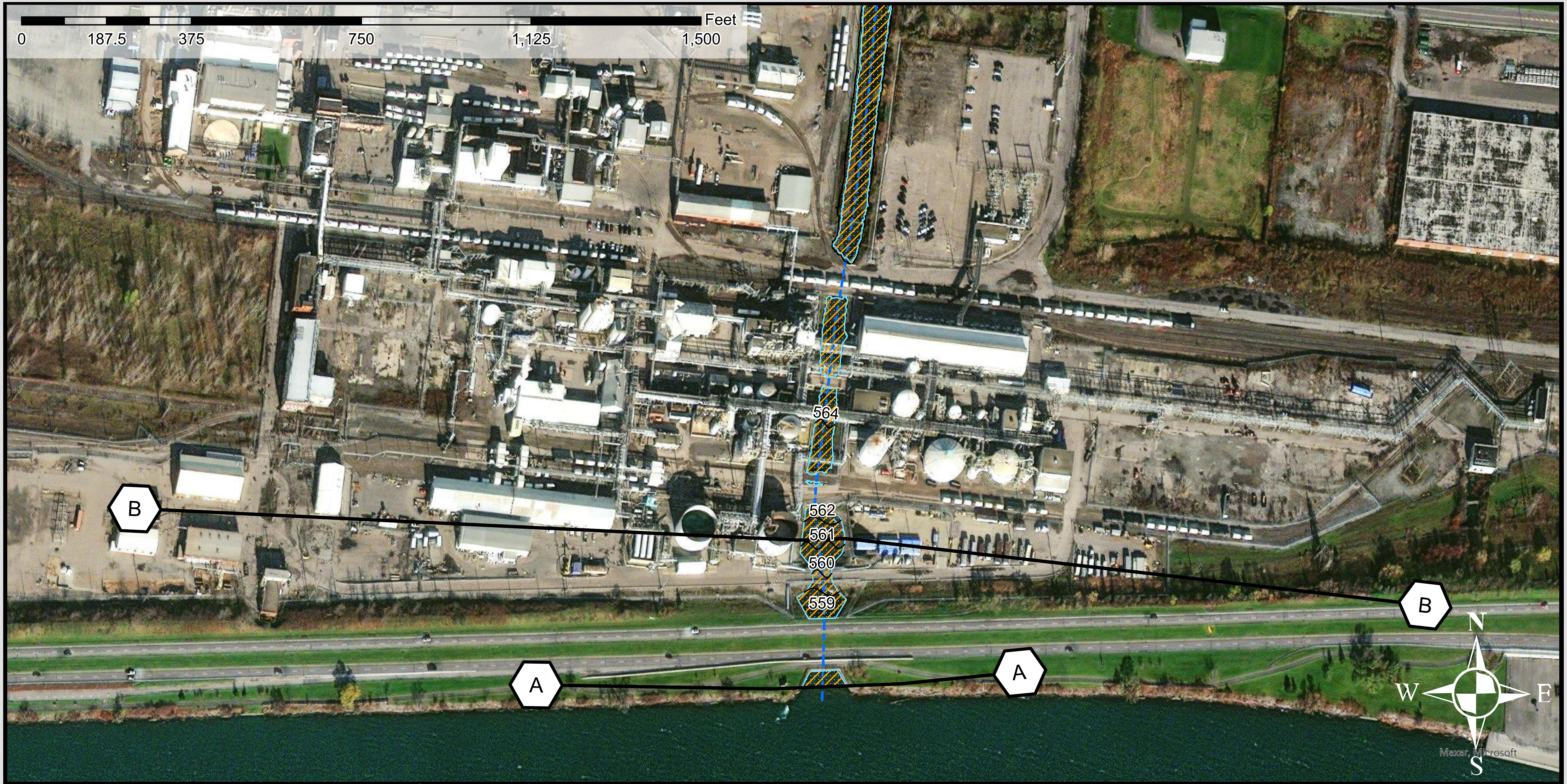
FIGURE B1-12



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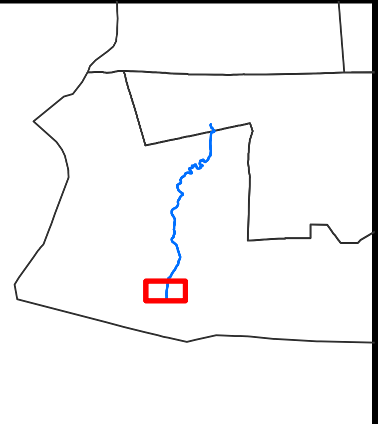
- Cross Sections
- 500-Year Boundary
- 100-Year Flood Boundary
- Floodway Boundary
- BFE



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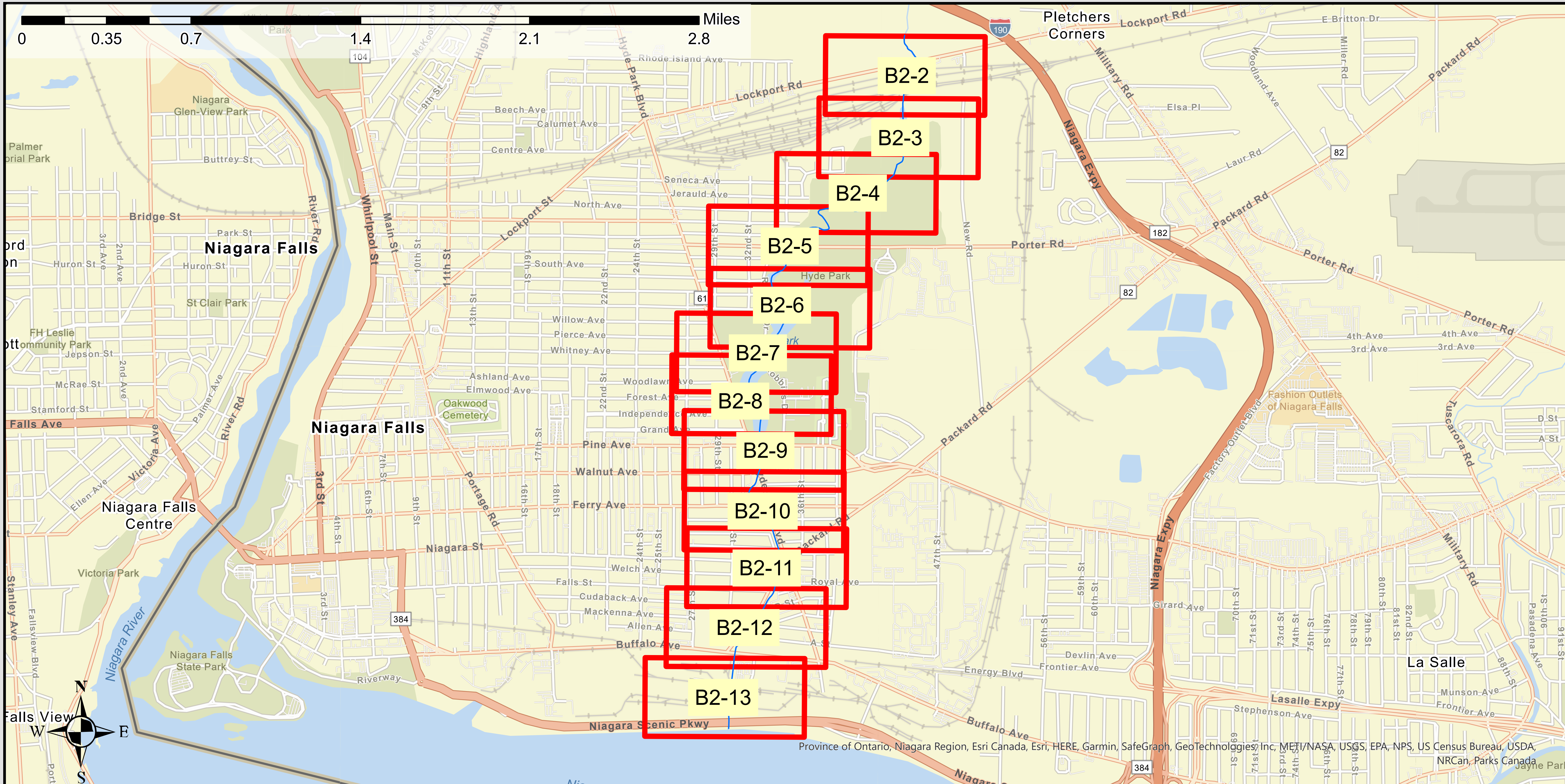
GILL CREEK

FIGURE B1-13



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GILL CREEK
NIAGARA COUNTY, NEW YORK

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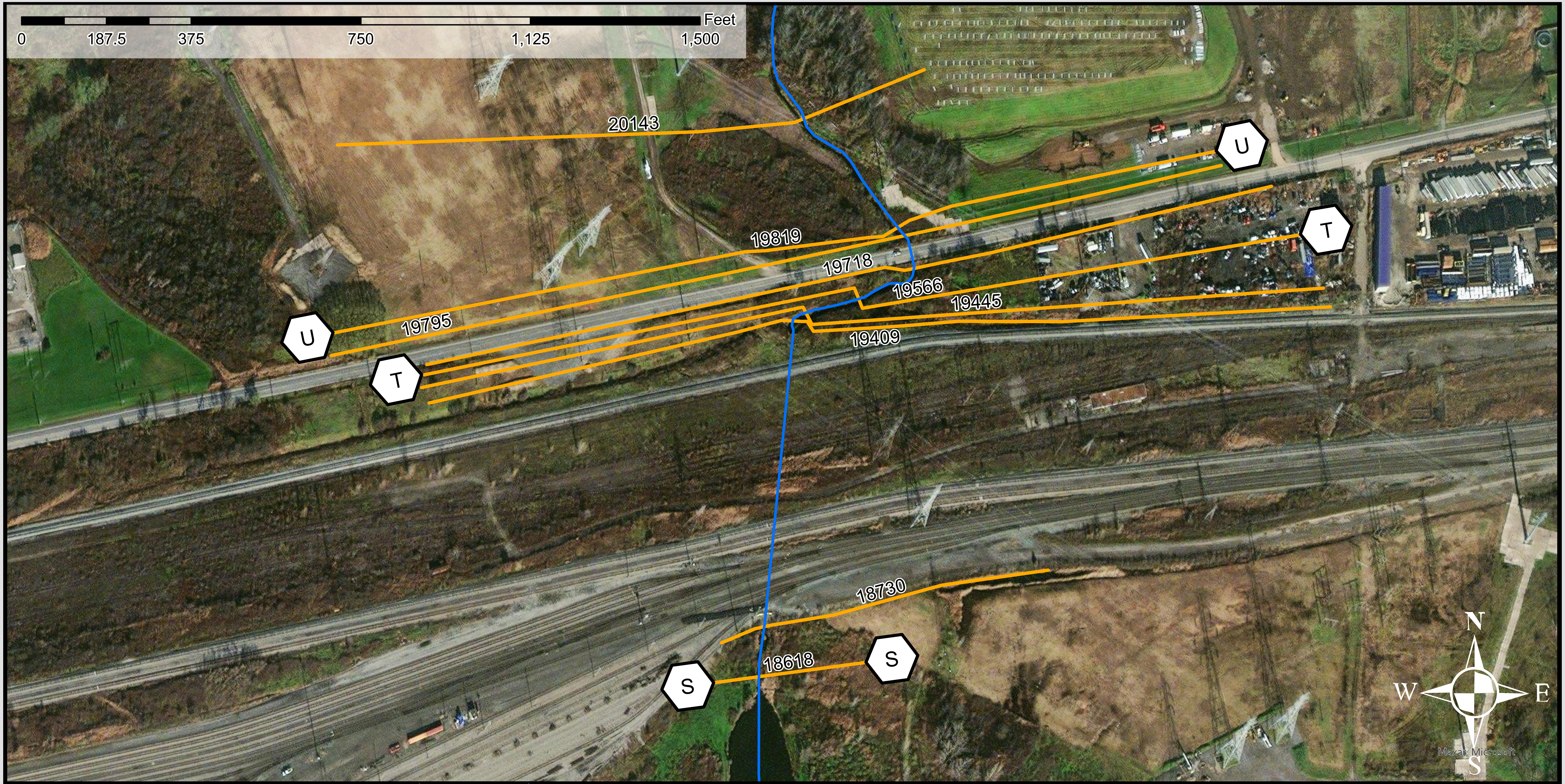
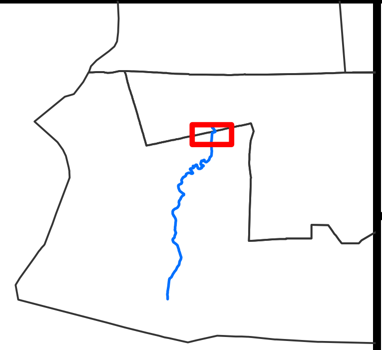
GILL CREEK: STUDY AREA

FIGURE B2-1



Legend
- Cross Sections
- Gill Creek



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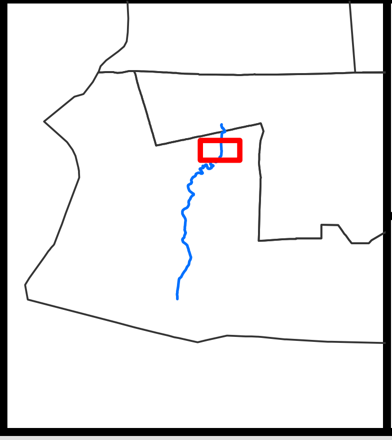
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

GILL CREEK: CROSS SECTIONS

FIGURE B2-2

Legend
Cross Sections
Gill Creek



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SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

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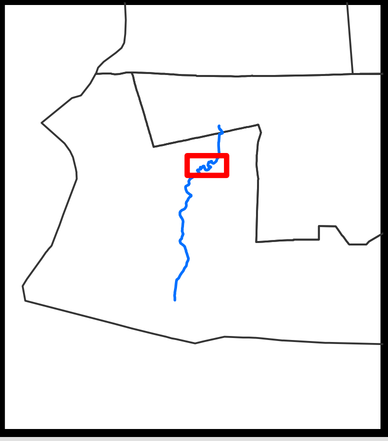
GILL CREEK: CROSS SECTIONS

FIGURE B2-3

Legend

- Cross Sections
- Gill Creek



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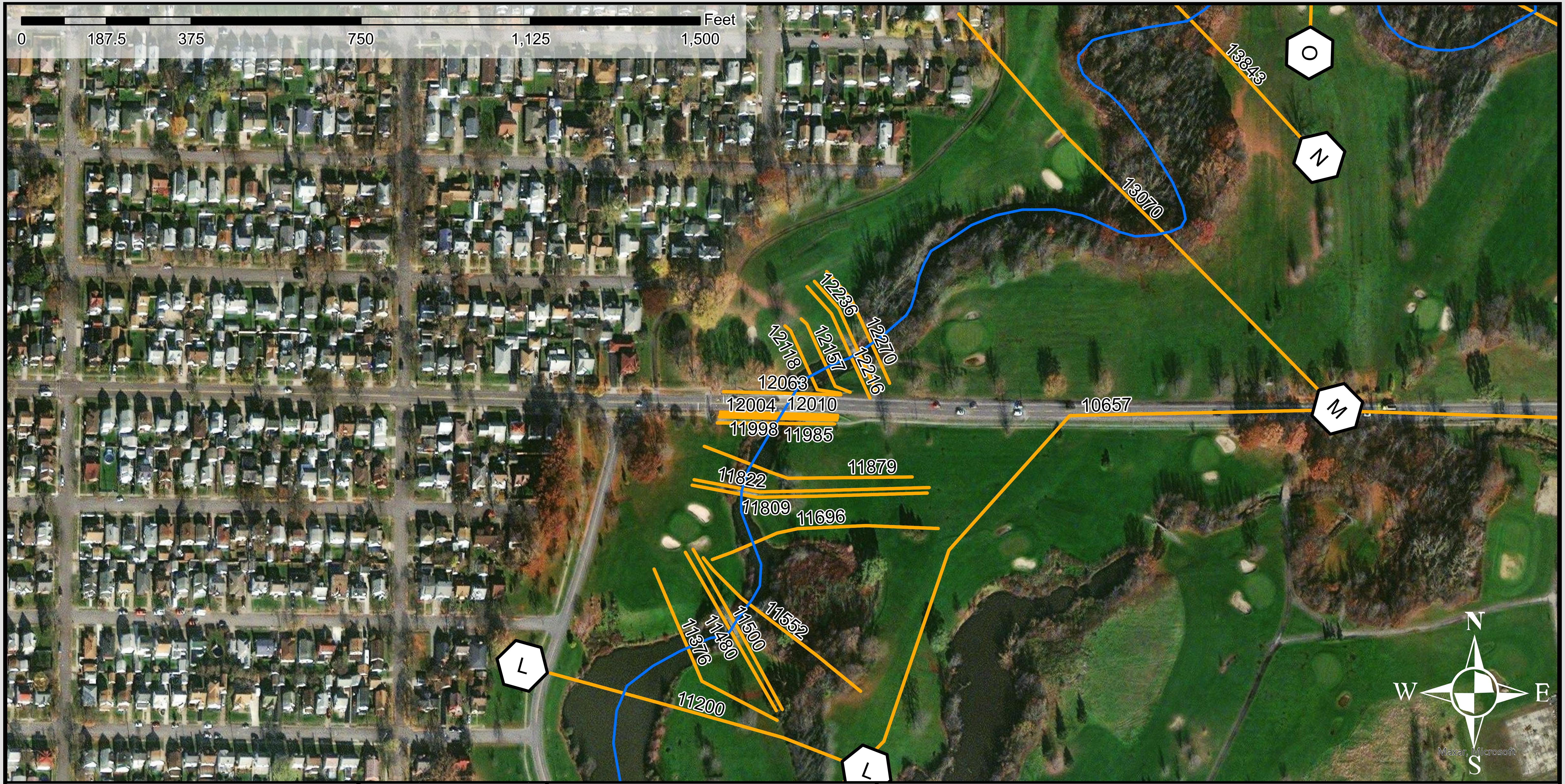
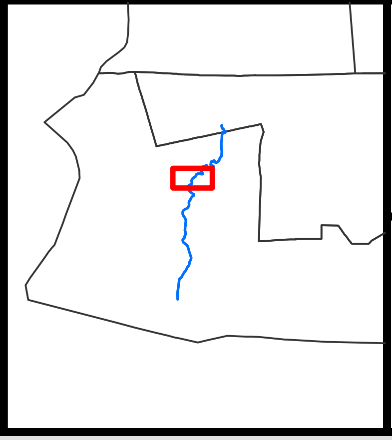
GILL CREEK: CROSS SECTIONS

FIGURE B2-4



Legend
- Cross Sections
- Gill Creek



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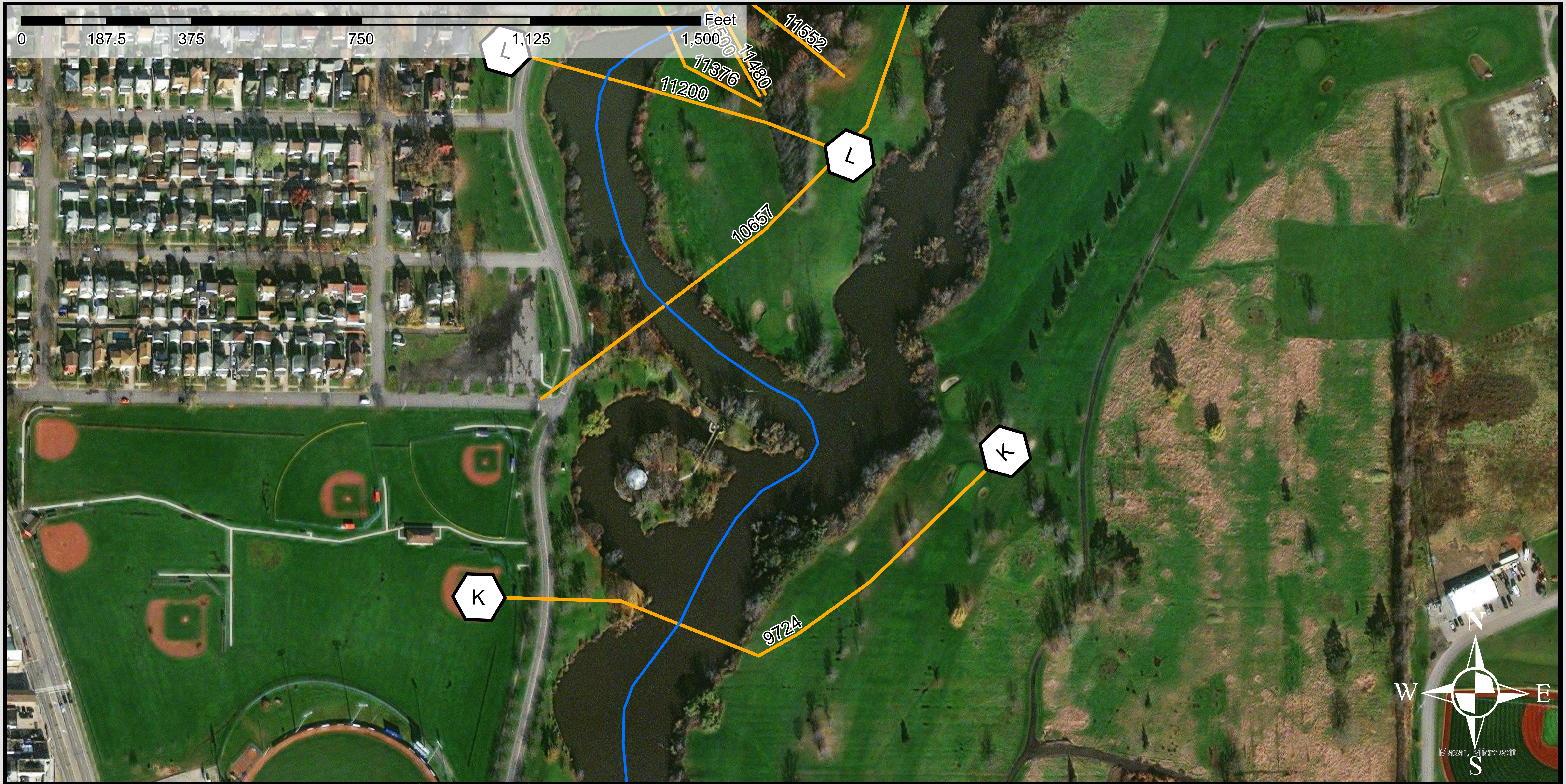
GILL CREEK: CROSS SECTIONS

FIGURE B2-5



Legend
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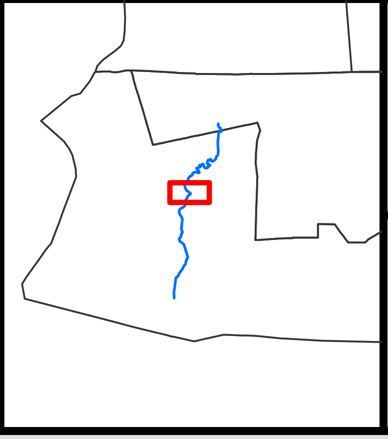
- Gill Creek



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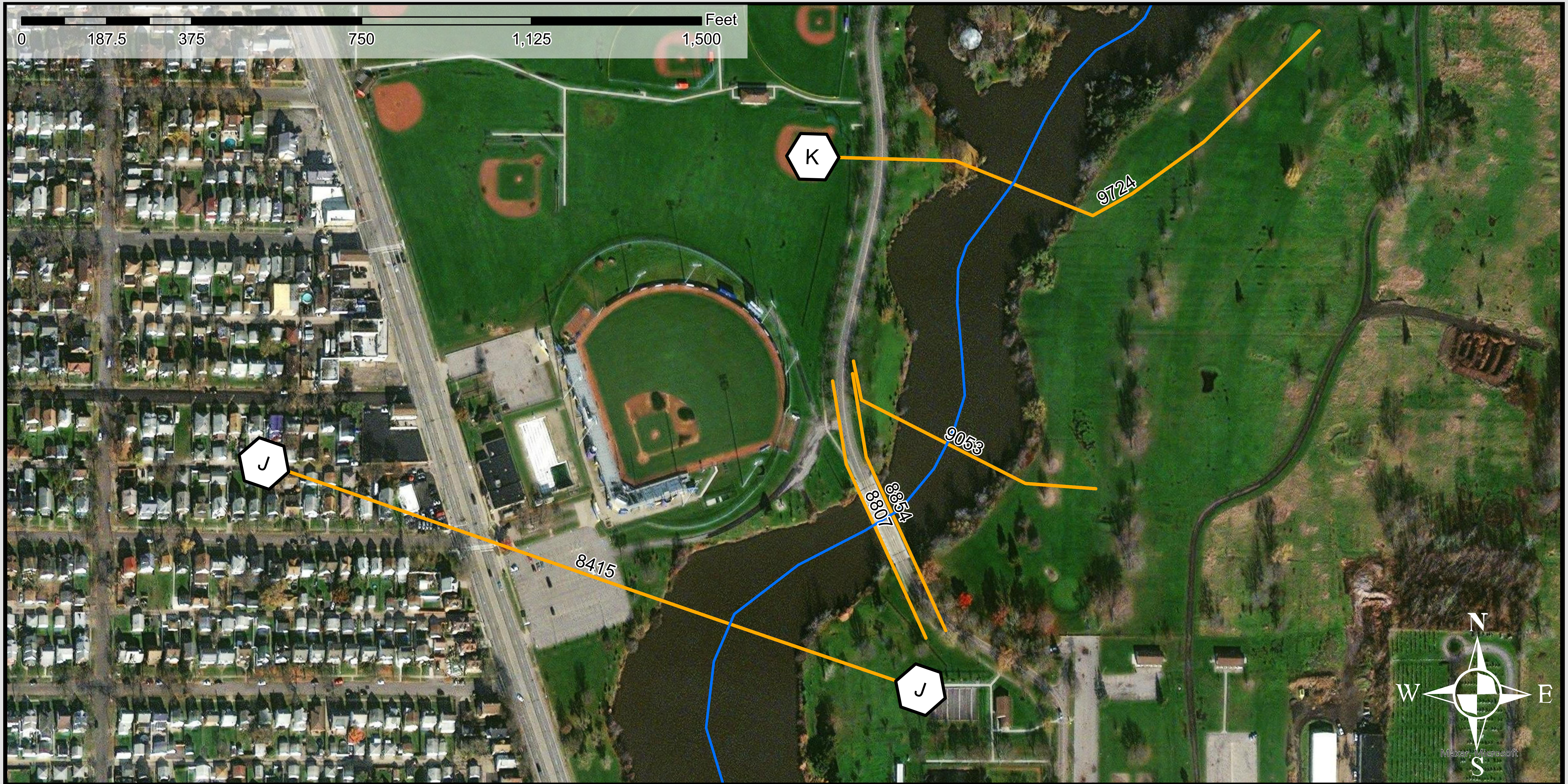
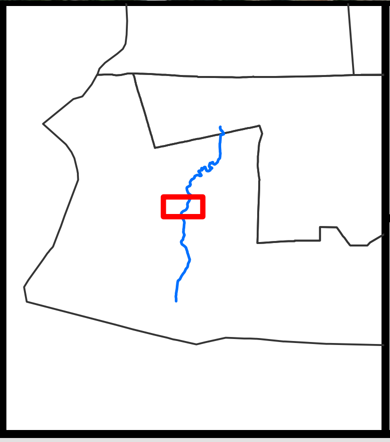
GILL CREEK: CROSS SECTIONS

FIGURE B2-6



Legend
Cross Sections
Gill Creek



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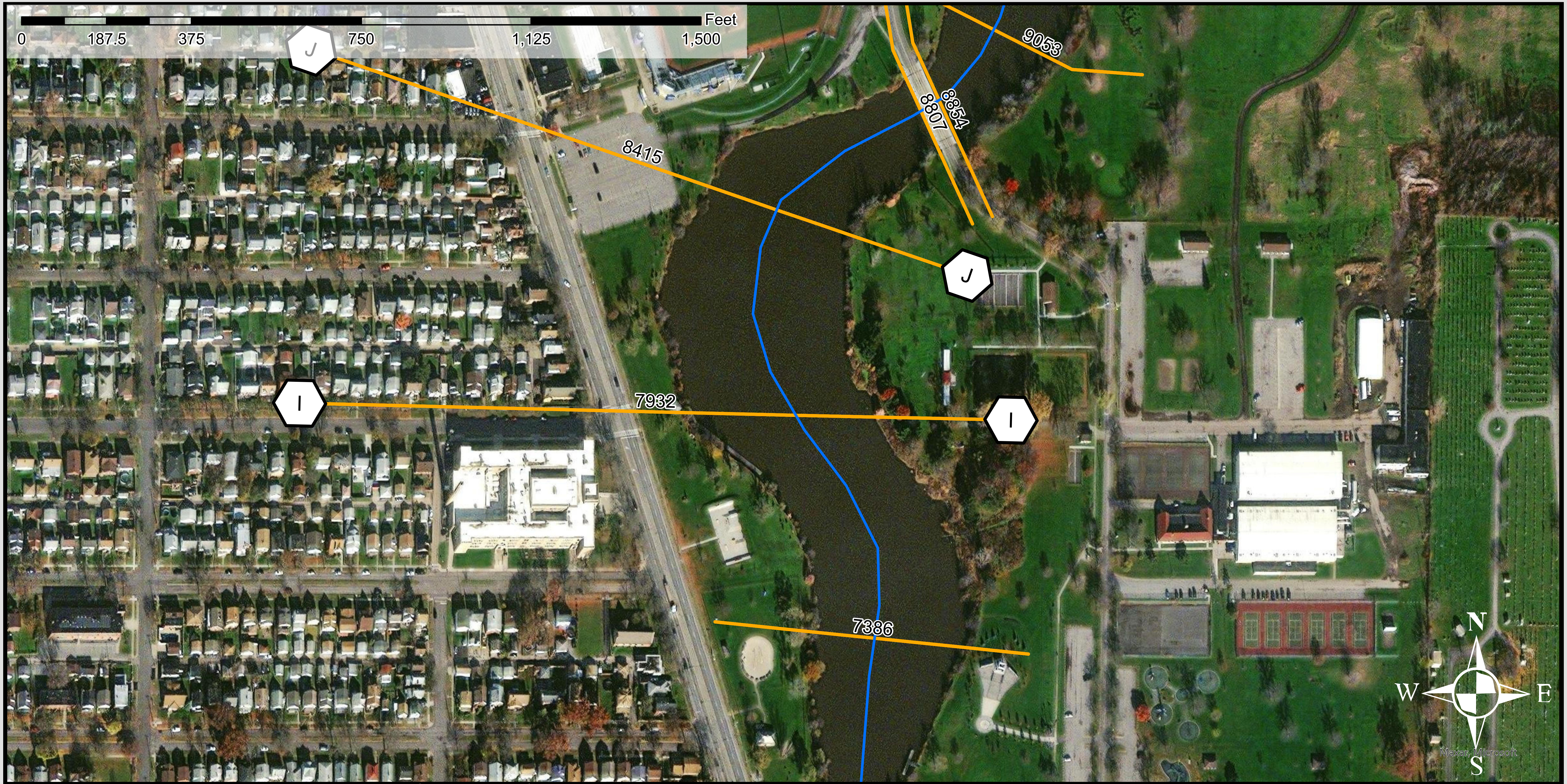
GILL CREEK: CROSS SECTIONS

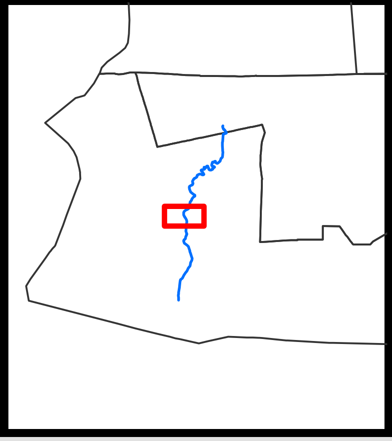
FIGURE B2-7



Legend

Cross Sections

Gill Creek



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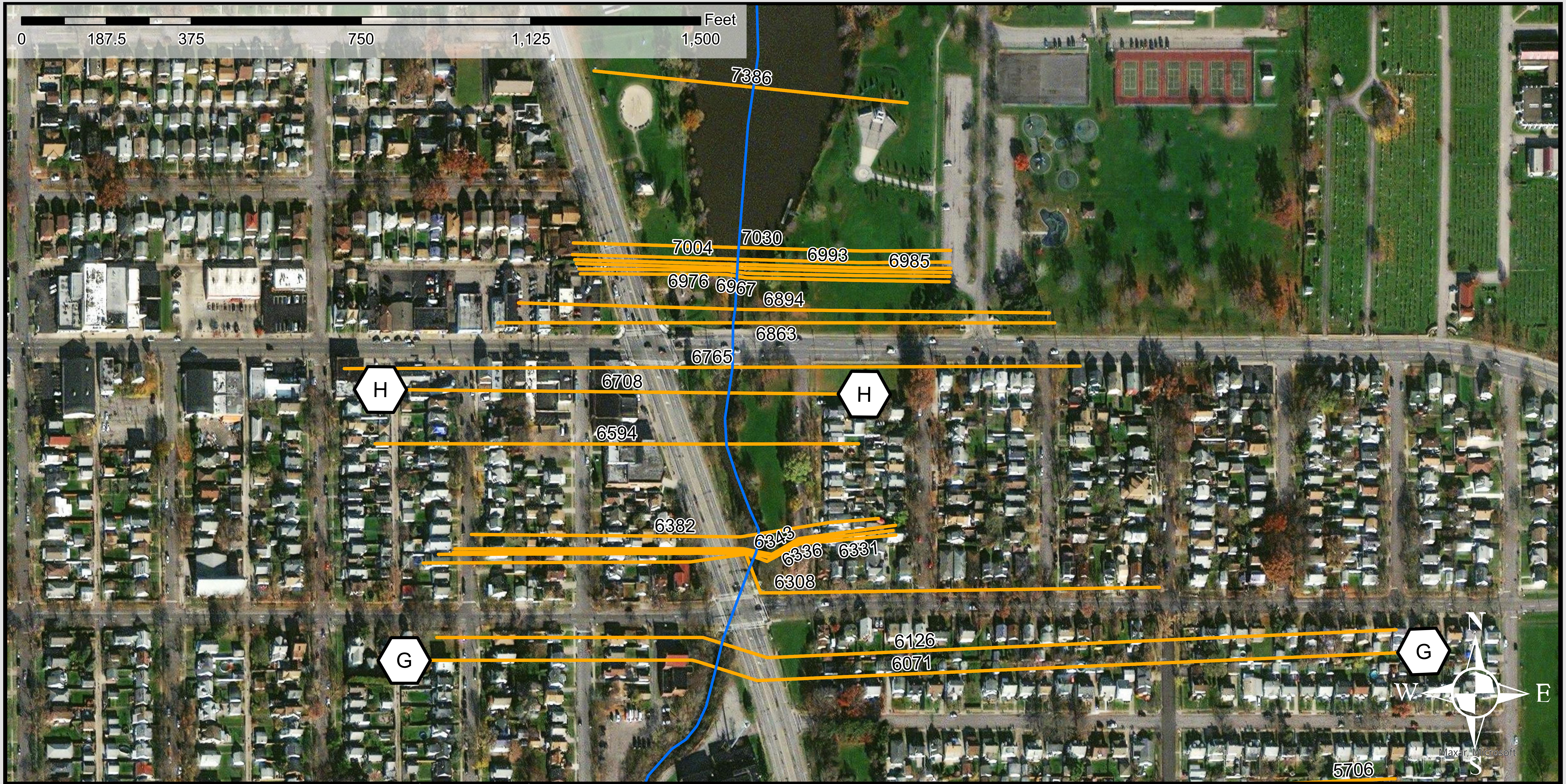
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

GILL CREEK: CROSS SECTIONS

FIGURE B2-8



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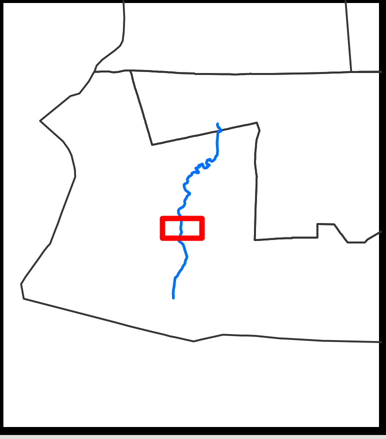
Cross Sections

Gill Creek



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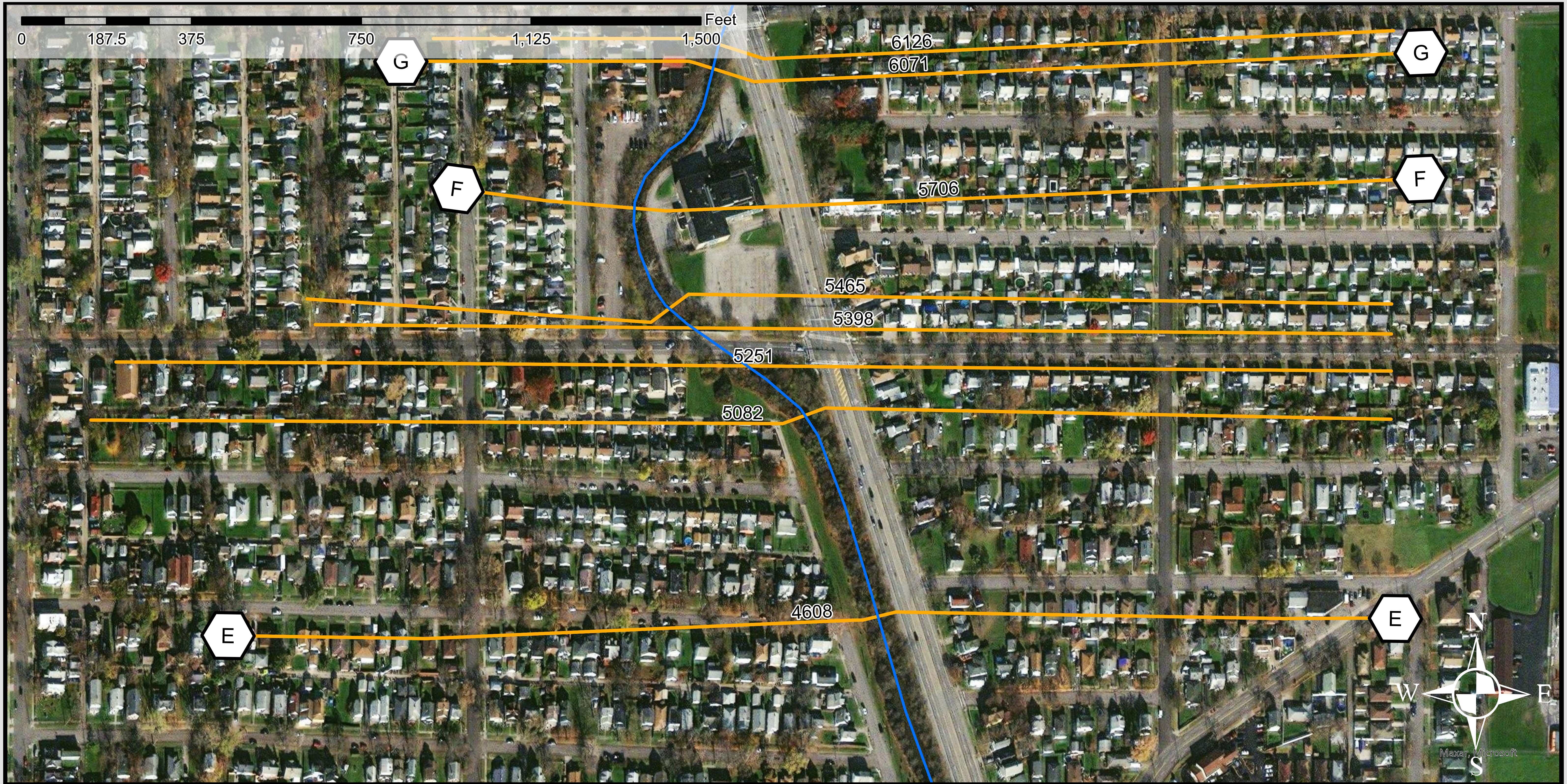
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

GILL CREEK: CROSS SECTIONS

FIGURE B2-9



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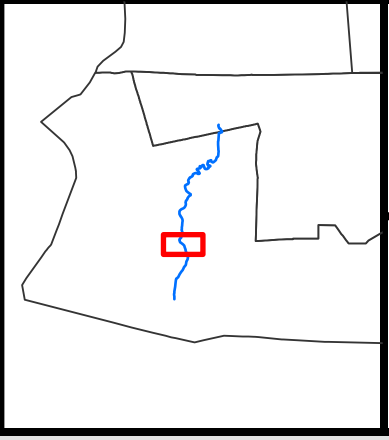
Cross Sections

Gill Creek



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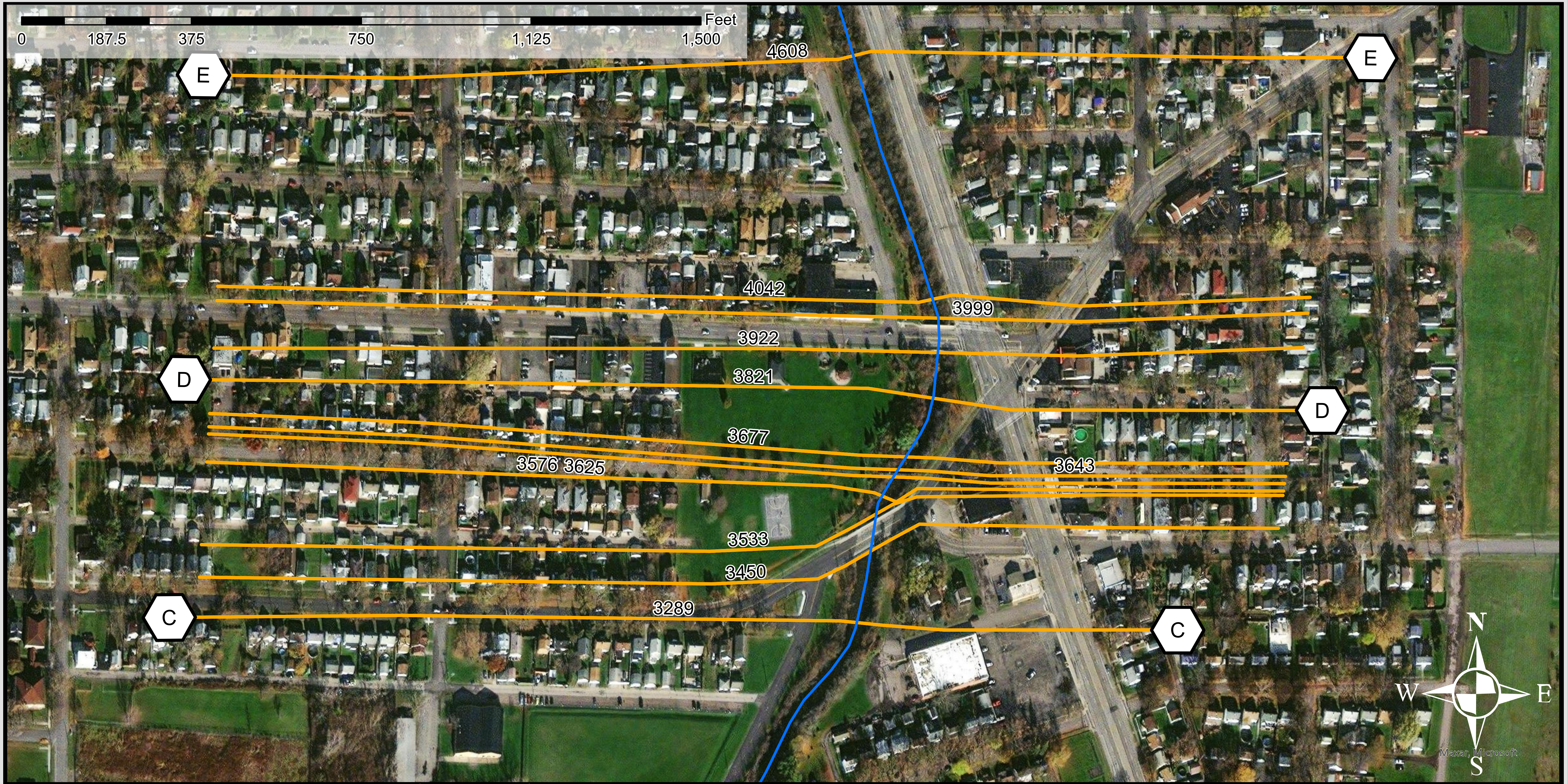
GILL CREEK: CROSS SECTIONS

FIGURE B2-10



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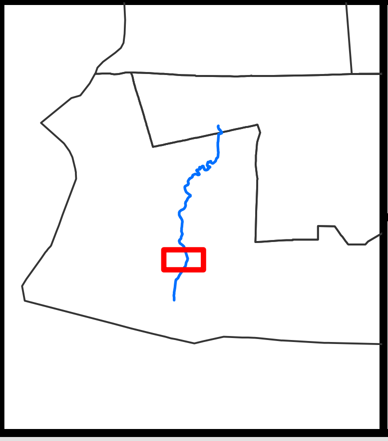
Cross Sections

Gill Creek



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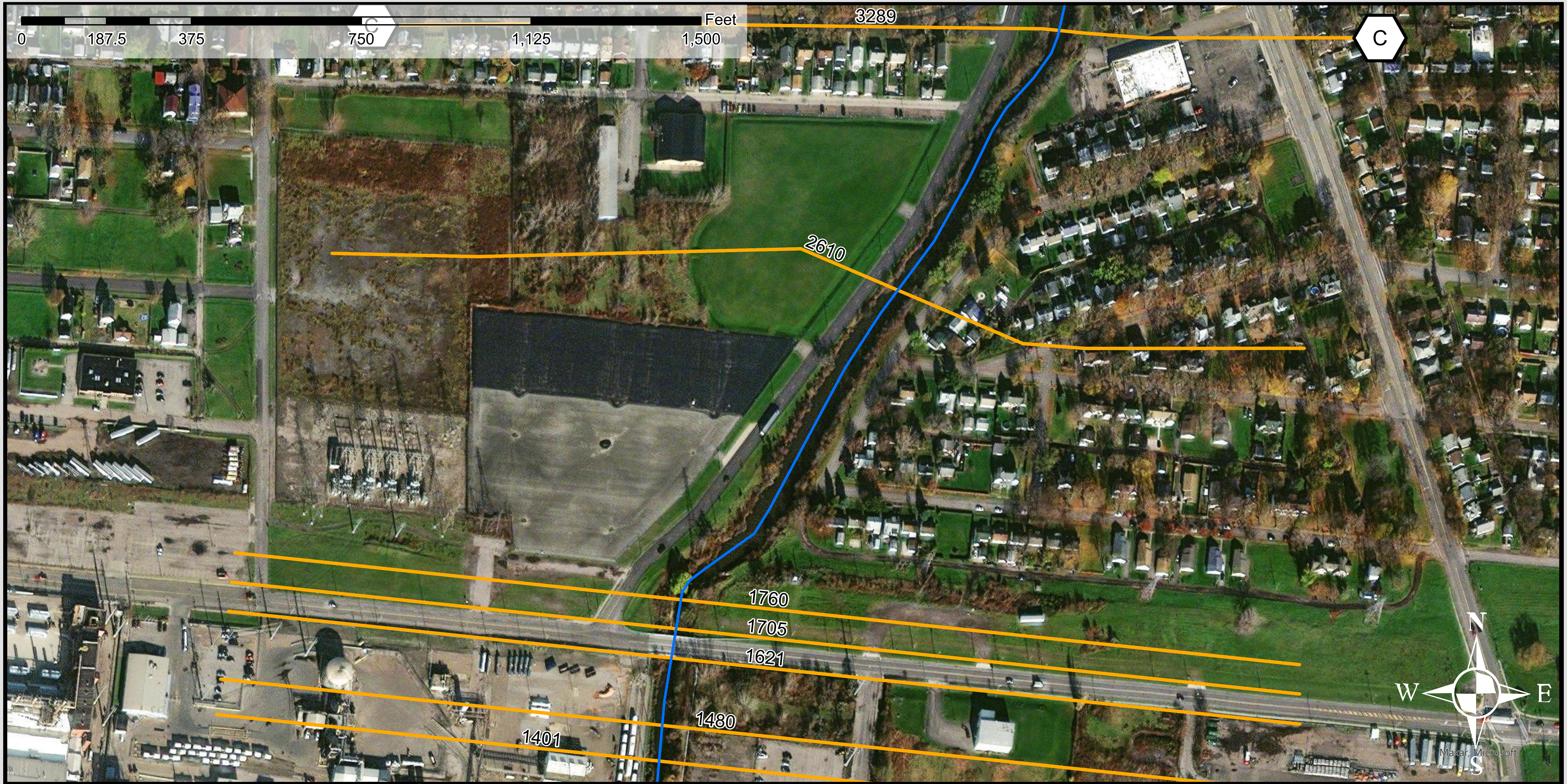
GILL CREEK: CROSS SECTIONS

FIGURE B2-11



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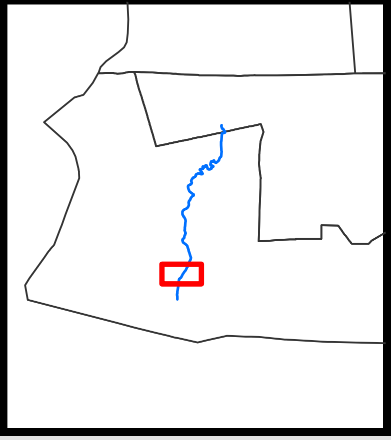
Cross Sections

Gill Creek



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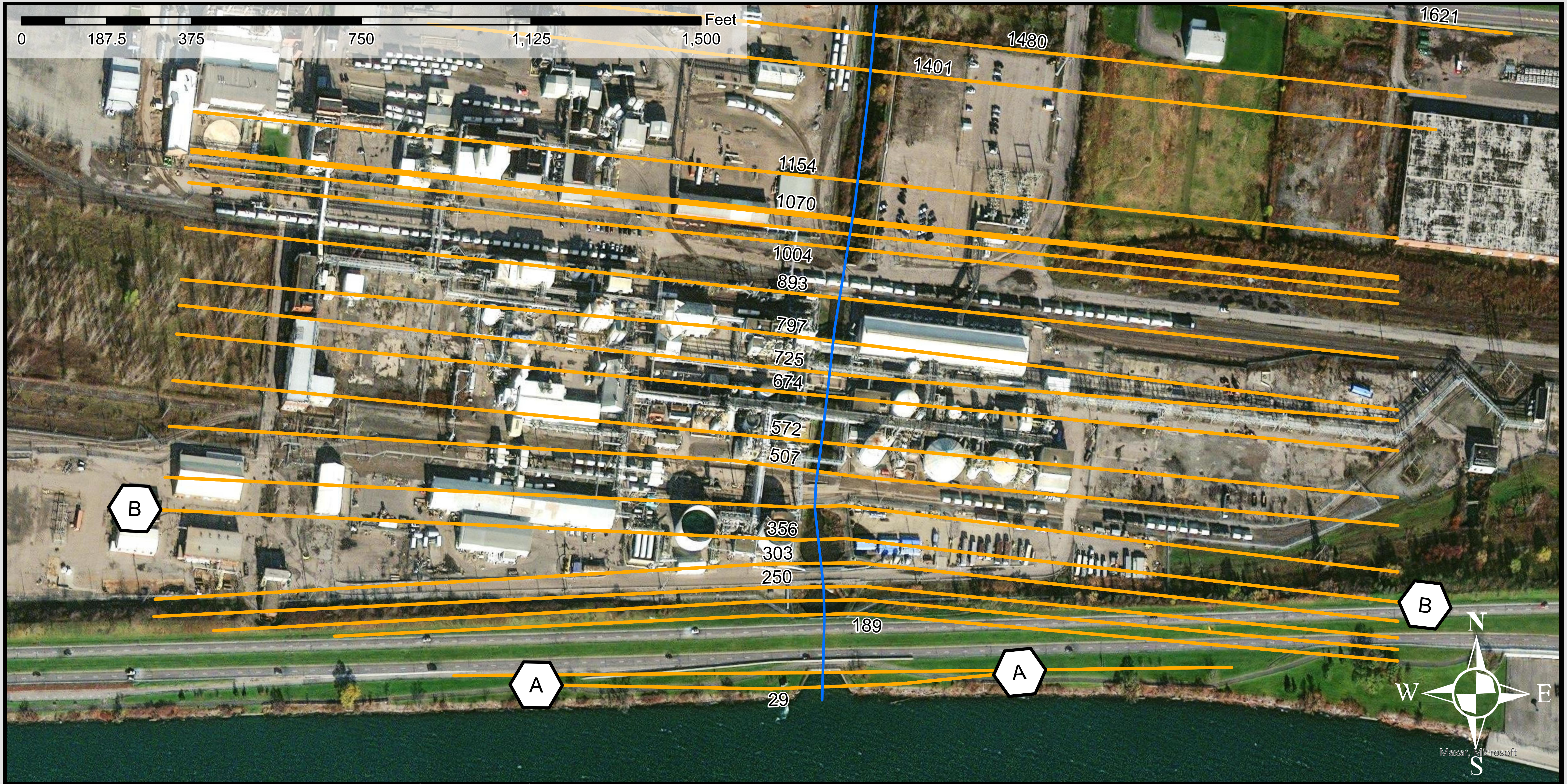
SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

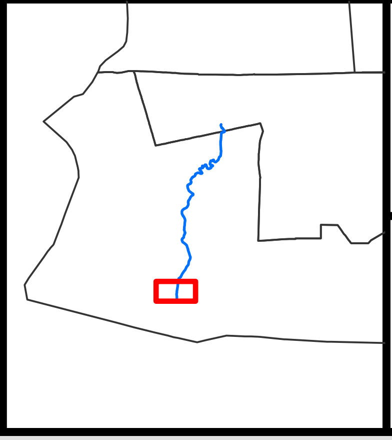
GILL CREEK: CROSS SECTIONS

FIGURE B2-12



Legend

- Cross Sections
- Gill Creek



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SPECIAL FLOOD HAZARD EVALUATION
GILL CREEK
NIAGARA COUNTY, NEW YORK

GILL CREEK: CROSS SECTIONS

FIGURE B2-13