(24-hour) during which at least 2 inches of rain fell. Several of these more recent storm events have resulted in localized flooding in particular in and around existing residential subdivisions and residential neighborhoods. Given the significance of recently observed flooding and trends in the changing climatology, there is a clear need to develop mitigation strategies to protect existing structures from the risk of flooding during the larger precipitation events.

2.2 Supporting Documentation

The following summarizes the information, data, and documents collected and used for this study:

- Historical design plans, engineering reports, and subdivision drawings obtained from the Town's Building Department and Highway Department [i.e., Eagle Chase, Thornwood Estates, Parkside Estates, Willow Lake (Phase 3), The Briars, Country Meadows, Captains Way, Wheatfield Lakes, Summit Park Development and Lake Projects, and Southern Drainage]
- Topographical data**,** including GHD field topographic survey (2015), supplemented with 2008 LIDAR (Light Detection and Ranging) data (Niagara County)
- GIS public data [i.e., land use (NLCD), parcel boundary and ownership, roadways and streams, zoning, federal and New York State Department of Environmental Conservation (NYSDEC) wetlands, Federal Emergency Management Agency (FEMA) floodplain mapping, geological, Natural Resources Conservation Service (NRCS) soil types and soil classifications]
- 1988 Addendum to "Report on a Town Drainage Study (1961)"
- Hydraulic data and models from Flood Insurance Studies (FIS):
  - Cayuga Creek: (2008 updated flood model and FIS model)
  - Bergholz Creek (2008 updated flood model)
  - Bull Creek (2008 updated flood model)
  - Sawyer Creek West (2008 updated flood model)
  - Sawyer Creek East (2008 updated flood model)
- Drainage committee meeting minutes and reports to the committee (1980s to 1990s)
- New York Power Authority, "Upper Niagara River Tributary Backwater Study", dated August 2005

Results of the various field drainage inspections, topographic surveys and above-referenced documents are compiled and presented in Section 3, along with the field reconnaissance investigations, and summarized in Section 4**.**

3. Existing Conditions

Establishing existing drainage patterns, watershed boundaries and watershed characteristics are critical to the evaluation of alternatives and development of viable recommendations for drainage improvements and flood control measures. This study placed a strong emphasis on developing detailed mapping and estimating runoff flow rates for current conditions. The mapping presents the key drainage features, watershed characteristics, and drainage patterns for the Town.

This section presents the mapping developed for the existing conditions along with descriptions of each watershed area, a summary of the field investigation activities conducted, the watershed modeling effort, and a summary of the existing hydrologic and hydraulic conditions for the individual watershed areas.

3.1 Mapping of Existing Conditions

In general, the Town of Wheatfield has a natural gradient from north to south and is bisected by a series of natural watercourses and network of man-made ditches and culverts that convey surface runoff through the Town, and ultimately discharge to either the Niagara River or Tonawanda Creek.

The Town drains to seven major watershed areas consisting of Cayuga Creek, Bergholz Creek, Bull Creek, Sawyer Creek East and Sawyer Creek West, Black Creek, and Southern Drainage sub-catchment. Overall watershed boundaries that interface with the Town are presented in **Exhibit A - Town of Wheatfield Watershed Map**.

The following watershed features are depicted in **Exhibit A:**

- Watershed boundary delineations and associated area (acres)
- Identification of major streams watercourses
- General drainage patterns and contour elevations

Major watershed boundaries were delineated using a combination of USGS topographic mapping, aerial photography, LIDAR elevation data, field reconnaissance, and area inspections. The major watersheds were further divided into tributary sub-catchment areas primarily demarcated by roadway culvert crossings and topographic conditions, and are presented in **Exhibit B – Town of Wheatfield Watershed Master Map**.

Watershed information presented in **Exhibit B** is summarized below:

- Watershed and associated sub-catchment boundary delineations with designations
- Summary of watershed characteristics including acreage and runoff Curve Numbers (CN)
- Identification of town, county, and state roadway system
- Drainage flow patterns
- Identification of major and minor stream routes
- Identification of key culvert / storm roadway crossing
- Contour (1 foot) and spot elevations
- NYSDEC Wetland boundaries (as currently exist)
- Fish and Wildlife Service mapping of potential federal wetlands
- Lakes and other water features

In addition to the maps in Exhibits A and B, existing condition drawings for the known areas of concern are included in **Appendix A**, which were prepared to highlight individual areas with known drainage concerns.

Discussion

The Soil Conservation Service (SCS) Curve numbers (CN) presented on the watershed map represents the weighted value for each sub-catchment area. The CN value is a parameter used to estimate the maximum possible retention of water in the soil. The lower the CN, the higher the infiltration and ability to retain water. The CN value depends upon soil type, land use, vegetative cover and moisture content prior to the storm event. GHD completed a GIS analysis to establish the weighted CN values (see **Appendix B** – Drainage Computations). Descriptions of the key parameters used in the CN value analysis are presented below.

Soils

Soils information plays an important role in establishing a CN value, as well as for storm design. The ability for water to flow through the soil has an important impact on how precipitation becomes runoff. NRCS originally developed a Hydrologic Soil Group (HSG) factor consisting of A, B, C, and D type soils. HSG is a group of soils having similar runoff potential under similar storm and cover conditions. Group A consists of sands and gravels with have high infiltration rates, while Group D typically are clays with low infiltration rates (high runoff potential). Groups B and C fall in between these two, with Group B. soils having a moderate infiltration rate when thoroughly wet and Group C soils having a slow infiltration rate when thoroughly wet.

HSGs have been updated county-by-county across the US over many years and now contain three dual Groups, A/D, B/D, and C/D. Certain wet soils are placed in Group D based solely on the presence of a water table within 24 inches of the surface, even though the ability to drain may be favorable. If these types of soils can be adequately drained, they are assigned to a dual hydrologic soil group. The first letter applies to the drained condition and the second to the undrained condition.

The majority of the soils within the Town consist of silty clay loams with a hydrologic soil group C/D and D. These soils make up 98 percent of the Town's soils and are considered poorly draining with a seasonal high swelling water table.

Land Use

A curve number table based upon land use and soil group was developed for the Town. For each catchment area in a watershed, a weighted CN value was estimated based on the NRCS CN values associated with each type of land use and hydrological soil group, and the number of acres of each land use/soil group in that particular catchment area. The NRCS CN values based on land cover/use for the various hydrologic soil groups that exist in the Town are presented in Table 1, while the acres associated with each of the Town’s land use classification by soil group are summarized in Table 2. Descriptions for the land use classifications in Tables 1 and 2 can be found at http://www.mrlc.gov/nlcd11_leg.php.

Table 1 NRCS Curve Numbers by Land Cover and Hydrologic Soil Group

Land Use Classification	Hydrologic Soil Group			
	B/D	C	C/D	D
Open Water	N/A	N/A	N/A	N/A
Developed, Open Space	74	74	76	79
Developed, Low Intensity	77	77	80	82
Developed, Medium Intensity	82	82	84	86
Developed, High Intensity	88	90	91	93
Barren Land (open space)	88	88	88	88
Deciduous Forest	73	73	76	79
Evergreen Forest	77	77	81	85
Mixed Forest	75	75	79	82
Shrub/Scrub	77	77	80	83
Grassland/Herbaceous	74	74	77	80
Pasture/Hay	71	71	74	78
Cultivated Crops	82	82	84	86
Woody Wetlands	82	82	84	86
Emergent Herbaceous Wetlands	77	77	80	83

NOTES:

1) Land Cover Classifications - National Land Cover Database 2011 (http://www.mrlc.gov/nlcd11_leg.php)
2) Curve Numbers - Stormwater Conveyance Modeling and Design, Haestad and Durrans, Table 5.5 to 5.7

Table 2 Wheatfield Land Use and Cover Summary

Land Use Classification	Hydrologic Soil Group / Area, acres			
	B/D	C/D	D	Total
Developed, Open Space	34	1,507	564	2,106
Developed, Low Intensity	19	1,561	489	2,069
Developed, Medium Intensity	12	640	192	845
Developed, High Intensity	0	310	65	375
Barren Land (open space)	1	41	16	58
Deciduous Forest	7	608	124	738
Mixed Forest	0	20	0	20
Shrub/Scrub	0	21	0	21
Grassland/Herbaceous	0	40	17	57
Pasture/Hay	39	5,130	922	6,091
Cultivated Crops	16	3,778	604	4,398
Woody Wetlands	93	1,545	621	2,258
Emergent Herbaceous Wetlands	20	225	106	351
Grand Total	**241**	**15,426**	**3,721**	**19,388**

A summary table of the weighted CN values for the specific catchment areas of each watershed is included on Exhibit B. The weighted CN values for the Town ranged from 72, representing areas of open pasture, to 86 for highly developed areas.

A description of the major watershed areas associated with the Town is described below.

3.1.1 Cayuga Creek Watershed

In general, the Cayuga Creek watershed and tributaries drain approximately 9.638 acres (15 sq-miles) to the Niagara River and extends north through the City of Niagara Falls, Town of Niagara, into the Town of Wheatfield at Walmore Road, and continues north into the Town of Lewiston. The Cayuga Creek watershed extends as far north as Lower Mountain Road and east to Townline Road. Cayuga Creek (CAA) is the confluence point of Bergholz Creek (BEA) (downstream within the City of Niagara Falls). Sawyer Creek West (SWA) is also tributary to Cayuga Creek.

Approximately 3,468 acres (35 percent) of the total watershed area and 2.25 miles of creek bed are located within the Town. Cayuga Creek is well defined as it traverses southerly crossing Walmore Road, then Lockport Road and Walmore Road into the Niagara Falls Airbase (Airbase) property. The stream bed is well defined with average slopes of 0.45 percent as the creek meanders under Walmore Road and into the Airbase property. There are a total of seven structures that cross the main channel of Cayuga Creek between Walmore Road and the northern corporate limits. Within the watershed, there is one minor stream tributary (CAB) to Cayuga Creek, and one minor ditch system (CAA-1) located along the southern boundary of the Cayuga Creek watershed.

The floodplain generally follows the alignment of the creek with an approximate width of 300 feet until near the municipal border of the Town of Lewiston where the floodplain expands into adjacent lands. The Airbase collection and conveyance system controls the upstream drainage and flood impacts.

3.1.2 Bergholz Creek Watershed

The Bergholz Creek watershed and tributaries drain approximately 8,155 acres or 12.7 square miles from the headwaters in the Town of Cambria to the western Town corporate limits at Williams Road. Upstream contribution from the Town of Cambria accounts for approximately 3,500 acres or 44 percent of the total watershed area. The main creek channel is approximately 11.7 miles long, of which approximately 5.7 miles lie within the Town of Wheatfield. Bergholz Creek's main channel (BEA) generally flows from the headwaters in Cambria southerly across Raymond Road, Lockport Road, Ward Road, Niagara Road, and Thornwoods Drive, then westerly parallel with Niagara Road crossing Niagara Falls Boulevard, Walmore Road, Plaza Drive, and Williams Road. The average slope of the creek is approximately 1.25 percent from Raymond Road to Thornwoods Drive, then 0.6 percent downstream to Williams Road. There are a total of 25 culvert/structures that cross Bergholz Creek within the Town of Wheatfield.

Bergholz Creek also includes two significant stream tributaries. These streams have been identified for the purposes of this study as BEB and BEC. BEB extends from the confluence of Bergholz Creek northeasterly across Ward Road, Nash Road, Lockport Road (downstream of Eagle Chase Subdivision), then upstream across Baer Road and northerly into the Town of Cambria. BEC is a smaller tributary stream that begins in the Town of Cambria and drains south discharging into Bergholz Creek north of Lockport Road.

3.1.3 Bull Creek Watershed

Bull Creek (BUA) primarily drains the northwest section of the Town of Pendleton and portions of the Towns of Wheatfield and Cambria. The course of Bull Creek flows sinuously from its headwater in the Town of Cambria, south to the Town of Pendleton, then crosses Townline Road back and forth between the Towns of Wheatfield and Pendleton before turning south and discharging into Tonawanda Creek in the City of North Tonawanda. The total estimated Town drainage area contributing to Bull Creek is approximately 4,500 acres which constitutes approximately 30 percent of the overall Bull Creek watershed.

There is a major tributary (BUB) located within the Town of Wheatfield that discharges into Bull Creek (BUA) at Loveland Road. This tributary drains approximately 3,400 acres and extends from the headwaters in the Town of Cambria traversing Townline and Mapleton Roads south, then east crossing Shawnee at Moyer Road then draining along Loveland Road and ultimately discharging to Bull Creek near Townline Road. The main channel of Bull Creek is approximately 10 miles long, of which only 1,600 feet is located within the Town of Wheatfield corporate limits. The average channel slope of the creek in the Town reach is approximately 0.4 percent. There are also a total of 10 culverts/structures located along the Town of Wheatfield stream reach. Sawyer Creek East (SEA) also discharges into Bull Creek (BUA) at a point south of Shawnee Road and Niagara Falls Boulevard (see Section 3.1.5).

3.1.4 Sawyer Creek West Watershed

Sawyer Creek West (SWA) drains approximately 786 acres beginning at a point near Ward Road flowing westerly, and ultimately discharging to Bergholz Creek at Plaza Drive. This channel reach is approximately 1,300 feet long, with an average bottom slope less than 0.1 percent. There are approximately 28 structures located along this short stretch of stream. Sawyer Creek also contains a small tributary stream (SWA-1) with a watershed area of approximately 259 acres. This tributary discharges into Sawyer Creek West at the railroad crossing south of Niagara Falls Boulevard.

Ward Road is also the approximate tipping point to Sawyer Creek East, which flows easterly toward Bull Creek and ultimately discharging into Tonawanda Creek. Flows in Sawyer Creek East and West are greatly influenced by the water surface elevations of Sawyer Creek and backwater effects of Bull Creek and Tonawanda Creek. Flow direction depends upon a variety of factors including ice jamming, wind direction, and flood stage of the downstream creeks.

3.1.5 Sawyer Creek East Watershed

Sawyer Creek East (SEA) has a contributing watershed area of approximately 2,925 acres and flows along Niagara Falls Boulevard from approximately Ward Road to the confluence of Bull Creek at Shawnee Road. This channel reach is approximately 1,800 feet with an average channel slope of less than 0.3 percent. The watershed is generally bounded by Niagara Falls Boulevard to the south, and extends as far north as 1,200 feet at Nash Road.

Sawyer Creek East has one significant tributary stream (SEB). The SEB tributary maintains a watershed of approximately 1,415 acres and drains from Pearce Road south across Lemke Drive, then Errick Road, and ultimately discharging to Sawyer Creek West at a point east of Errick Road. The remaining watershed area of 1,510 acres either drains north directly to Sawyer Creek East or is collected in man-made and roadside ditches and conveyed to Sawyer Creek East.

Drainage along this stream corridor has historically been a problem, with localized flooding occurring on an annual basis. In 2015, the Town completed a project to restore the hydraulic capacity of the drainage channel by removing debris and sediment buildup, and reshaping the tributary from downstream of Errick Road to upstream of Lemke Drive. The ditches and swales leading to the Lemke Drive crossing have also been cleaned, resulting in a stream corridor that is in good condition, with the exception of the two culvert crossings at Lemke Drive and Errick Road.

3.1.6 Southern Drainage

The Southern Drainage watershed can generally be described as the area south of Niagara Falls Boulevard and north of the City of North Tonawanda, and abuts the Black Creek Watershed to the west. The Southern Drainage watershed is located entirely within the Town corporate limits. The Southern Drainage watershed was once part of the Black Creek watershed. The construction of two large lakes as part of the Summit Park Lakes Project severed the ditching system to the west and were either redirected into the lakes or routed to the south toward the Niagara River. Discharge of the Southern Drainage occurs at two separate outlets that cross under River Road. In general, the Southern Drainage watershed consists of a network of natural and man-made drainage ditches, stormwater management lakes, and storm sewers to convey flows to the Niagara River. The total contributing watershed area is estimated at 1,844 acres.

This watershed area can be further divided into a north and south drainage system. The north drainage system directs runoff under Nash Road westerly under Ward and Witmer Roads, then into the Summit Park Lakes. Flows from the lakes are then routed south, via a concrete outlet structure, ultimately discharging into the Niagara River outlets. The overall average channel slope from Nash Road to the Niagara River is less than 0.1 percent.

The southern portion of this watershed is directed into the Summit Park Lakes via a combination of drainage ditches and storm sewers, which outlets westerly into a ditching network crossing under Ward and Witmer Roads, then turning south toward the Niagara River outlets. The northern and southern watershed areas combine at the Wheatfield Lakes outlet structure.

3.1.7 Black Creek Watershed

Black Creek (BLA) has a contributing watershed area of approximately 1,707 acres, and with the exception of an 85-acre wetland area located west of Williams Road, the watershed is located within the Town corporate limits. The course of Black Creek has a flow direction from its headwaters west under Ward Road, Witmer Road, Sy Road, and the railroad, then south under Liberty Drive and River Road, ultimately discharging into the Niagara River. The main channel flows behind the homes along David Drive, then into the Wheatfield Lakes Subdivision where flows are conveyed via the storm sewer system into a series of two stormwater detention ponds for the subdivision.

Downstream of the pond outlets, the stream bed and banks are not well defined with a general flow path that meanders westerly through large open undeveloped wetland areas toward a collector channel that crosses under Liberty Drive and River Road to the Niagara River. The channel slope varies from 0.3 percent at the headwaters to less than 0.1 percent in areas in the undeveloped open areas.

3.1.8 Storm Culvert Mapping

The existing storm drainage system in the Town is comprised of natural streams/major creeks, minor creeks consisting of small channels and man-made drainage ditches, roadside ditches, and an assortment of storm culverts varying in size, shape and material of construction. The mapping of key culverts/structures, along with minor and major stream alignments is presented in **Exhibit C – Culvert Map**. The culvert mapping was developed based upon information and data collected from field inspections, existing construction drawings, and field topographic surveys completed by GHD.

The structures identified on the mapping represent key points of potential restriction and locations in which surface runoff can be regulated. Associated with the culvert map are a series of separate existing condition drawings (included in Appendix A) that were prepared to highlight individual areas with known drainage concerns. These existing site condition drawings include:

- CI-01 Walck Drive / Thornwood Estates – Existing Conditions
- CI-02 Sawyer Creek East Tributary – Existing Conditions
- CI-03 Southern Drainage – Existing Conditions
- CI-04 Sawyer Creek West Tributary – Existing Conditions
- CI-05 Eagle Chase Drive – Existing Conditions
- CI-06 Timberlink Road – Existing Conditions

3.1.9 Floodplain Mapping

In 2008, FEMA completed a Countywide Flood Insurance Study (FIS) to update the floodplain boundaries using LIDAR and surveyed data, as well as detailed hydraulic modeling. The FIS and associated Flood Insurance Rate Maps (FIRMs) were adopted in 2010. The most recent FEMA mapped 100-year floodplain boundaries and flood models were obtained and incorporated into the development of this study. An overall flood map showing the FEMA 100-year floodplain boundaries is included as **Exhibit D.** Detailed mapping of FEMA regulated floodplains is available on the Town's GIS website. Hydraulic models that were used for this study are described in greater detail in Section 3.3.

3.2 Field Investigations and General Observations

Field reconnaissance investigations during wet weather conditions were completed during the period between April 2015 and October 2015 to assess existing drainage patterns and hydrologic characteristics, and conveyance conditions. Observations made during these storm events were used to adjust input variables in the development of the hydrologic models and to validate modeled results. The data and observations made were then used as a means to observe runoff relationships and drainage patterns, and assess conditions at areas historically prone to flooding.

In general, 2015 was a particularly dry year with a total rainfall of 25 inches, which is 9 inches less than the average rainfall of 34 inches. Precipitation data from the Niagara Falls Airport, as reported by the National Weather Service (a component of the National Oceanic and Atmospheric Administration, or NOAA), was used to benchmark storm events. There were four local personal weather stations that were used to obtain precipitation data (via Weather Underground) to verify that rainfall was evenly distributed across the watersheds that impact the Town. These individual weather stations were located at Bear Ridge Road, Mapleton Road, Shawnee Road, and Lancelot Drive.

For the field reconnaissance, precipitation events with a total rainfall of at least 1.0 inch for durations between 12 and 24 hours that were evenly distributed over the entire watershed areas were targeted. In 2015, there were four rainfall events that distributed 1.0 inch or greater over a 24-hour period. These storms had similar characteristics in being equally distributed across the Town, with similar intensity and duration.

A summary of the rain events, as reported at the Niagara Falls Airport, were as follows:

May 31, 2015 (Sunday)	1.38 inches (24 hours)
June 27 to 28, 2015	2.0 inches (12 hours)
September 12, 2015 (Saturday)	2.20 inches (24 hours)
October 28, 2015 (Wednesday)	1.96 inches (12 hours)

GHD also completed a series of field investigations during the period of snowmelt from March to April 2015.

Over the course of the project, there was an isolated thunderstorm or micro cell with precipitation that fell in excess of 5.0 inches of rain over a small area isolated to the southeastern portion of the Town in the early morning of August 15, 2015. As a result of the storm, the Town received a few drainage complaints, mostly within the Spice Creek Subdivision, that primarily involved sump pump failures. No other drainage problems were reported or observed during this event.

3.2.1 General Drainage Patterns Observed

The following list summarizes the general drainage pattern observations made during the field investigations:

For description purposes, the Town can be divided into three areas consisting of the upper drainage areas (north of Niagara Road), central area (between Niagara Falls Boulevard and Niagara Road), and southern area (south of Niagara Falls Boulevard to the Niagara River).

Beginning in the upper area of the watersheds, the drainage channels and stormwater collection system are well defined with positive slope to convey storm runoff. Flows were observed to stay within roadside ditches and stream embankments. Culvert crossings acted as control structures with the immediate area upstream providing impoundment flood storage (within the farm field areas). Minor flooding was observed in these areas, and was generally gone within 24 hours of an event. Although there are poor soil conditions, these upper watershed areas were generally observed to drain well as flows traverse toward the central portion of the Town.

As flows were conveyed into the central portion of the Town, drainage channels were wide and shallow with minimal slope, and meandered within the contours of the surrounding topography. Flows conveyed from the upper watershed areas to the central area were observed to overtop embankments, primarily in farm field and wetland areas, and surcharging was observed at roadway storm crossings; however, overtopping of roadways was not observed (with the exception of the intersection of Ward and Pearce Roads). Channel slopes and runoff velocities were minimal, resulting in elevated surcharged conditions as flows migrate to Sawyer Creek (East and West). The smaller tributaries and yard swales were swollen, but drained as conditions allowed. In general, the Town-owned roadside ditches were of sufficient capacity to adequately convey flows downstream.

Drainage associated with the southern portion of the Town is extremely poor. As stormwater runoff is collected and directed downstream, channel slopes are flat and flows move slowly as they drain through the various subdivisions. Residential detention pond elevations had extended periods of high water elevation as flows were backed up in the main channels. As observed, high water conditions dominated this area and would take several days to drain before returning to normal pre-storm conditions. Roadside ditches held water for extended periods as well.

There are two primary outlets for the southern area (Black Creek outlet at River Road and Southern Drainage at River Road). Both outlets were observed to be flowing well with no obstructions at the outlet; however, the areas immediately upstream were poorly drained.

3.3 Watershed Modeling

Watershed modeling was completed to further define and establish peak discharge-frequency relationships for the creeks and streams that influence Town drainage. These flow relationships were also used to assess culvert capacities, evaluate alternatives, and provide recommended culvert replacements and other stream improvements.

3.3.1 Engineering Methods

Information and data used in support of the evaluation included wet and dry weather area reconnaissance, mapping of watershed characteristics, the Erie and Niagara Counties Regional Planning Board Design Manual, hydraulic modeling data from the FEMA FIS, and the Hydraflow AutoCAD 2012 Program.

For the flooding sources and drainage areas studied, a combination of FEMA model data and stormwater hydrologic and hydraulic modeling was used to establish surface water runoff conditions for critical Town drainage systems.

Storm events of a magnitude that are expected to be equal to or exceed once on the average during any 10-, 25-, and 100-year period (recurrence interval) are typically selected as having special significance for stormwater management planning and evaluation of existing and future projects. The 10-year and 25-year storm events were selected for capacity analysis of the roadway storm collection and culvert crossings. Culverts associated with minor streams and tributaries with the capacity to handle the 10-year storm without overtopping the roadway were generally considered to be acceptable, while major streams were assessed under the 25-year storm period.

Flood modeling data (elevation-frequency relationships and associated peak flow rates) for the major streams that interface with the Town were obtained from FEMA. Available FEMA flood models included: Cayuga Creek, Bergholz Creek, Bull Creek, and Sawyer Creek West and East (**See Appendix C)**. The data from these models were also used for evaluation of "what if" scenarios presented in Section 4.

With the FEMA modeled data available, watershed modeling was developed for establishing peak flows for select creek reaches and tributaries within the Town limits. The SCS method was employed for developing runoff hydrographs and peak flows for watershed sub-catchment areas. The hydrographs were then combined and routed downstream to establish peak flows for the 10-, 25-, and 100-year storm events. Culvert crossings were modeled as outlets to channels or detention basin areas. The models were reviewed and calibrated with FEMA data, and water surface and flow characteristics observed in the field. Individual watershed model summaries are included in **Appendix B**.

Watersheds and sub-catchment areas included with the SCS hydrologic evaluation method included:

- Black Creek
- Southern Drainage
- Cayuga Creek
- Bergholz Creek Tributary (BEB)
- Bull Creek Tributary (BUB)

The creek [Sawyer Creek tributary (SEB)] that crosses Lemke Drive and Errick Road was identified as an area for siting of a proposed residential development (Cobblestone) and is an area of concern for this study. Therefore, tributary SEB was also selected to complete a detailed hydrologic and hydraulic analysis. The model was developed to evaluate stream corridor impacts and establish elevation–storm frequency relationships (10-, 25-, 100-year storm events).

Sawyer Creek East Tributary (SEB) - A stormwater model using the United States Army Corps of Engineers (ACOE) Hydrologic Engineering Center, River Analysis System (HEC-RAS) Software (version 4.1.0) was developed for the stream segment that is tributary to Sawyer Creek East in the vicinity of Errick Road. The extents of the modeled section are Lemke Drive at the upstream end and the confluence with Sawyer Creek East at the downstream end. Five existing crossings were identified and included in the model. These include road bridges for Lemke Drive, Errick Road, and Marc Drive. The model also includes two private culvert crossing locations. Cross sections directly near the bridge crossings were manually entered into HEC-RAS using recently collected survey data. Cross sections for all other areas were generated by uploading LIDAR data through HEC GEO's ArcView interface.

Flow rates for the 10-, 25-, and 100-year storm events were generated from the delineated catchment areas and developed SCS hydrographs for the SEB Tributary. The Hydraflow Hydrographs extension for Civil 3D was also used to develop the runoff hydrographs. The existing conditions model for SEB is included in **Appendix C.**

3.4 Existing Hydrologic and Hydraulic Conditions

The following sections summarize the existing hydrologic and hydraulic conditions by watershed area.

3.4.1 Cayuga Creek (CAA)

Several hydrologic and hydraulic models of the Cayuga Creek Corridor have been completed over the years. For the 2008 FEMA Countywide FIS, the hydraulic model for Cayuga Creek was revised downstream from a point beginning at Walmore Road at the Airbase property. The previous flood model extended into the Town of Lewiston and was completed by the United States ACOE in the early 1990s. In 2012, the Niagara Frontier Transportation Authority (NFTA) completed a runway improvement project that included stormwater management upgrades near the Walmore Road creek crossing. Detailed calculations and modeling was completed as part of the runway project to ensure that storm surface water elevations at Walmore Road were not adversely impacted or altered. A copy of both Cayuga Creek models is included in **Appendix C**.

Peak runoff rates for the 10-, 25- and 100-year storm events were generated for Cayuga Creek from delineated catchment areas from the northern boundary of the Town to the Airbase property at Walmore Road. The calculated 10-, 25- and 100-year flow rates at Walmore and peak flow rates at culvert roadway crossings were calculated at 455 cfs, 667 cfs, and 1137 cfs, respectively. Discharge rates at the various roadway crossings are presented in Table 3.

Table 3 Cayuga Creek Flow Summary

Tributary	Roadway Crossing	Flow (CFS) 10 Year	Flow (CFS) 25 Year	Flow (CFS) 100 Year
CAA	Walmore Road	89	130	221
CAA	Lockport Road	443	650	1,111
CAA	Walmore Road	455	667	1,137

3.4.2 Bergholz Creek (BEA)

The hydraulic model for the entire reach of Bergholz Creek from the confluence of Cayuga Creek to the headwaters in the Town of Cambria was updated as part of the FEMA 2008 Countywide FIS. The data from the study were reviewed and updated to reflect existing conditions. A copy of the model is included in **Appendix C**. A flood profile was developed from the model and is presented on **Figure 1 - Bergholz Creek Hydraulic Profile**.

Peak discharge rates for the 10-, 25- and 100-year storm events for the main channel of Bergholz Creek were obtained from the FEMA model, while discharge rates for the Bergholz Creek tributary (BEB) were calculated as part of this study. The peak 100-year discharge flow of 1,210 cfs was calculated at Plaza Drive. A summary of peak discharges at select roadway crossings for both Bergholz Creek and associated tributary BEB are presented in Table 4.

Table 4 Bergholz Creek Flow Summary

Tributary	Roadway Crossing	Flow (CFS) 10 Year	Flow (CFS) 25 Year	Flow (CFS) 100 Year
BEA*	Raymond Road	279	394	444
BEA*	Lockport Road	528	743	837
BEA*	Niagara Road	620	867	975
BEA*	Plaza Drive	779	1,080	1,210
BEB	Baer Road	38	58	102
BEB	Lockport Road	63	95	172
BEB	Ward Road	188	283	520
* FEMA Hydrologic Model Data				

3.4.3 Bull Creek (BUA)

The hydraulic model for the entire reach of Bull Creek from the confluence at Tonawanda Creek to the headwaters in the Town of Cambria was updated as part of the FEMA 2008 Countywide FIS. The data from the study accurately reflects existing conditions. A copy of the model is included in **Appendix C**. A flood profile was developed from the model and is presented on **Figure 2 – Bull Creek Hydraulic Profile**.

A summary of peak discharges at select roadway crossings for both Bull Creek and associated tributary BUB are presented in Table 5. Note that peak discharge rates for the main channel of Bull Creek were obtained from the FEMA flood model, while flow rates for tributary (BUB) were calculated as part of this study. The peak 100-year discharge flow of 1,960 cfs is estimated at Niagara Falls Boulevard.

Table 5 Bull Creek Flow Summary

Tributary	Roadway Crossing	Flow (CFS) 10 Year	Flow (CFS) 25 Year	Flow (CFS) 100 Year
BUB-1	Lockport Road	63	92	155
BUB	Shawnee	136	200	340
BUB	Mapleton/Shawnee	168	252	440
BUB	Shawnee/Loveland	274	394	663
BUA*	Loveland	815	1,110	1,240
BUA*	Niagara Falls Blvd	1,050	1,430	1,960
* FEMA Hydrologic Model Data				

3.4.4 Sawyer Creek East (SEA) and West (SWA)

Sawyer Creek flows both east and west with the tipping point near the intersection of Ward Road. Hydraulic flood models for both streams were developed as part of the 2008 FEMA FIS updates. Data associated with these models were reviewed and determined to accurately reflect current conditions.

A hydraulic flood model was also developed for the Sawyer Creek tributary SEB (stream associated with Errick Road and Lemke Drive crossing). A copy of the flood models for Sawyer Creek and the tributary is included in **Appendix C**.

The following flood profiles were developed for Sawyer Creek:

- Figure 3 Sawyer Creek Tributary (SEB) Hydraulic Profile
- Figure 4 Sawyer Creek East Hydraulic Profile (SEA)
- Figure 5 Sawyer Creek West Hydraulic Profile (SWA)

A summary of peak discharges at select roadway crossings for both Sawyer Creek and associated tributaries are presented in Table 6. Note that peak discharge rates for the main channel of Sawyer Creek were obtained from the FEMA flood model, while flow rates for the creek tributaries were established as part of this study.

Table 6 Sawyer Creek (East & West) Flow Summary

Tributary	Roadway Crossing	Flow (CFS) 10 Year	Flow (CFS) 25 Year	Flow (CFS) 100 Year
SWA-1	Rose Court (west)	3	4	6
SWA-1	Rose Court (south)	9	14	25
SWA-1	Niagara Falls Blvd.	18	25	42
SWA	Walmore Road	52	76	130
SEB-1	Nash Road	28	42	74
SEB-1	Stieg Road	54	81	133
SEB	Errick Road	100	153	261
SEB/SEB-2	Marc Drive	136	204	343
SEA	Ward	136	183	204
SEA	Niagara Falls Blvd	279	375	417

3.4.5 Black Creek (BLA) and Southern Drainage (SD)

Black Creek and Southern Drainage were evaluated as one watershed model to allow for an analysis of impacts associated with re-routing flows from Black Creek into the Southern Drainage system. A copy of the output is included in **Appendix B**. Peak discharge rates for Black Creek and the Southern Drainage system at key stream crossings and outlets are illustrated in Table 7.

Table 7 Southern Drainage and Black Creek Flow Summary

Tributary	Roadway Crossing	Flow (CFS) 10 Year	Flow (CFS) 25 Year	Flow (CFS) 100 Year
SD	Nash/Evergreen Drive	17	25	41
SD	Nash/Town Boundary	12	18	31
SD	Witmer	44	63	104
SD	Summit Park Lakes Outlet	11 / 23*	17 / 35*	30 / 64*
SD	Outlet to Niagara River	54 / 61*	77 / 90*	128 / 153*
BL	Ward Road	17	25	43
BL	Witmer Road	24	35	59
BL	Sy Road	61	89	150
BL	Liberty Drive	158	250	484
BL	River Road (upstream)	194	308	545
BL	River Road (downstream)	156 / 108*	181 / 144*	223 / 182*
* Peak flow under a scenario of combining Black Creek watershed and Southern Drainage at Summit Park Lakes				

4. Study Findings and Conclusions

The findings and conclusions of the assessment for each watershed area and each specific area of concern are presented in this section.

4.1 Cayuga Creek

Cayuga Creek was assessed for points of restriction in conveyance, hydrologic and hydraulic condition of the creek and associated tributary channels, opportunities for reduced localized flooding and water surface elevations, culverts with inadequate capacity and drainage systems, and culverts that needed to be cleaned.

4.1.1 Findings

Several culverts were identified as critical stormwater control points in the Cayuga Creek watershed. The following summarizes the culverts that need to be replaced due to either the condition or to improve capacity and reduce area flooding:

- **Walmore Road:** The existing two 48-inch reinforced concrete pipes (RCP) and one 48-inch corrugated metal pipe (CMP) are in poor condition and have significant restrictions with upstream flooding under the 25-year storm event and roadway overtopping under the 100-year storm event. *Recommendation:* Replace crossing with a 15-foot wide by 5-foot high box culvert.
- **Cory Road:** The existing three 40-inch RCP culverts are in fair condition, and have significant restrictions with upstream flooding under the 25-year storm event and roadway overtopping under the 100-year storm event). *Recommendation:* Replace with 15-foot wide by 5-foot high box culvert.