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.

- **Walmore Road:** The three 30-inch RCP culverts at CAA-1 are in good condition; however, roadway overtopping under the 100-year storm event is expected. The drainage system downstream of CAA-1 on the west side of Walmore Road is undersized and is a restriction point. This downstream restriction significantly reduces available capacity of the 30-inch RCP culverts, which is affecting the ability to properly drain approximately 326 acres of upstream tributary land. Note that increasing the capacity of the downstream outfall may result in pushing the drainage issue onto the Airbase property. *Recommendation:* An additional assessment is recommended to further evaluate this area and identify corrective actions that may include a combination of upstream stormwater detention and/or replacement of the downstream outfall drainage system.

The following culverts were identified as in need of flushing and/or repair:

- The 36-inch CMP storm crossing at Walmore Road across from the Airbase was 90 percent plugged.
- The man-made ditch (tributary CAA-1) beginning at Walmore Road east needs to be cleaned and regraded. CAA-1 is located behind Inducon Park and is approximately 8,000 feet in total length. (CAA-1) diverts runoff from properties south of Lockport Road toward Cayuga Creek. The ditch changes direction in flow at a point approximately 4,000 linear feet east of Walmore Road, which drains westerly then southerly across Niagara Road ultimately discharging into Bergholz Creek.
- Proper maintenance and flow conveyance for CAA-1 is critical to protecting the residential neighborhoods along Niagara Road from flooding. This ditch also forms a boundary between the Cayuga Creek watershed and Bergholz Creek watershed. Alternatives to consider to improve reliability of the drainage system include:
  - Clean and regrade Tributary CAA-1 while extending the ditch to the east (as grade allows) to redirect surface water runoff away from the Bergholz Creek watershed.
  - Add regional stormwater storage pond(s) along the alignment to reduce downstream peak flows at Walmore Road and potentially reduce runoff volumes and peak flows realized at Bergholz Creek.
  - Improve outlet condition to maximize capacity of Tributary CAA-1 at Walmore Road.

4.1.2 Conclusions

The following summarizes the study conclusions for the assessment of Cayuga Creek:

- Replacing the culverts on Walmore Road and culverts crossing Cory Road (as noted above) will significantly improve conveyance capacities in the upper watershed and reduce potential localized flooding. Increasing these pipes will not result in an adverse downstream impact.
- Maintenance and improvements to the Cayuga Creek Tributary CAA-1 is critical to managing runoff and potentially reducing peak flows to Bergholz Creek. An additional study is recommended to determine the feasibility of extending the ditch system east.

4.2 Bergholz Creek

Bergholz Creek (BEA) and its two major tributaries (BEB and BEC), along with the four minor tributaries (BEA-1, BEA-2, BEA-3, BEA-4) were evaluated for points of restriction in conveyance, stream channel capacity and condition, culvert conditions, and opportunities to better manage flows while reducing risk of future flooding within the watershed.

Specific areas of concern involving Eagle Chase, Walck Drive/ Thornwoods Estates, which are located within the Bergholz Creek watershed, are discussed in Sections 4.7 and 4.8, respectively.

4.2.1 Findings

The storm modeling results generally show the greatest flow restriction at the upstream most bridges and culvert crossings. The assessment revealed that these restrictions provide protection of downstream areas by reducing peak flows and storing runoff in the upstream watershed areas. These flow restriction points will result in temporary shallow flooding of adjacent properties during the 10-, 25- and 100-year storm events, but will not adversely impact the existing structures.

Several culverts/bridges were identified as in need of repair/replacement. The following presents a summary of the culverts and associated condition by location:

- **Tributary BEA-1 at Walmore Road:** The existing 12-foot wide by 4-foot high box culvert is in poor condition, and debris, silt and vegetation needs to be removed immediately upstream and downstream of culvert. *Recommendation:* Replace with a 15-foot wide by 4-foot high bridge/box culvert.
- **Bergholz Creek at Hunt Street:** The existing 37-foot wide by 6-foot high bridge (County) foundation is in fair to poor condition. *Recommendation:* The approximate dimensions of a replacement structure are 45-foot wide by 7-foot high; however, an additional survey and hydraulic and analysis is required to select the final structure size and type. Alternatively, this structure could be removed with minimal impact to traffic patterns and residential property uses.

The following creek sections have been identified as having significant silt accumulation along with vegetative growth, and require maintenance:

- 5,500 linear feet of Tributary BEB from Nash Road to Ward Road; Note that the twin 36-inch CMP pipes located on the New York Power Authority (NYPA) easement north of Nash Road should be bypassed.
- Roadside ditch (500 feet) located along Lockport Road from roadway culvert crossing east to Eagle Chase outlet (30 inch).
- Existing drainage ditch (400 feet) located north of Thornwoods Drive and between Ward Road and Bergholz Creek (see Section 4.8 – Thornwoods Area).

Results from the storm model for Bergholz Creek (BEA) revealed a couple points of restriction and surcharging that potentially could result in overtopping the roadways. A summary of these structures, location and condition from downstream to upstream include:

- Cayuga Drive Extension: Three 80 inch CMP culverts (good condition)
- Walmore Road 42'W by 7'H bridge(County) (good condition)
- Rohr Street 42'W by 8'H bridge (County) (good condition)
- Luther Street 45'W by 6'H bridge (County) (good condition)
- Hunt Street 37'W by 6'H bridge (County) (**poor condition**)

Replacement of these five structures for the purpose of reducing flood elevations would impact approximately 6,000 linear feet of channel and approximately 75 parcels. Several stormwater modeling scenarios were run to determine the effects of a modified crossing (increasing roadway heights and culvert area) on surface water elevations. The results indicate that the Cayuga Drive Extension culverts and the Hunt Street structure have the greatest impact on water surface elevations. As calculated, the resulting decrease in flood water elevation is estimated at approximately 0.5 feet; however, the reported and observed conditions for this area did not match the model. Therefore, the conditions should continue to be monitored prior to replacement of either the culverts or the bridges.

The effects of a clean channel bottom and embankments were assessed and the modeling results indicated a decrease in surface water elevation of approximately 0.5 feet. This decrease represents a decrease in water surface elevation for the areas that border Niagara Road. Maintaining this portion of the creek should be considered a high priority area.

During significant larger storm events or snowmelt, flows within Bergholz Creek (BEA) were determined to overtop the south embankment beginning at the bend point of the creek that turns westerly around Thornwoods Estates. These excess overbank flows cross into the adjoining watersheds of Sawyer Creek West (wetland area) and Sawyer Creek East (swale leading to Ward Road), and part of tributary SEB. Construction of a 500 to 1,000 linear foot 2-foot high berm could prevent crossover into the Sawyer Creek East tributary without adversely impacting flood water surface elevations along this section of Bergholz Creek. However, model results indicate that containing flood waters within the creek section adjacent to the Sawyer Creek West watershed would result in an increase in water surface elevations. Therefore, flood protection measures to include construction of stormwater flood basins, coupled with elevated earth embankments would be necessary to separate the interaction of the two watersheds. These improvements would control flows within the creek corridor while reducing flooding observed in the Sawyer Creek Watershed.

The Niagara County Highway Department of Public Works (NCHDPW) has advised that design for replacing the bridge structure that crosses Niagara Road (due to poor condition) is planned for 2017. The study analysis indicates the current structure has adequate capacity to handle the 100-year storm without overtopping the roadway. This structure is a critical crossing in which the creek slope decreases and flows are transitioning from high to low velocity; the Town should continue communications with the County in the selection of the replacement structure.

4.2.2 Conclusions

The following conclusions were made for Bergholz Creek based upon the study findings:

- A well-maintained and clean channel from the Cayuga Drive Extension upstream to Niagara Road is critical to maximize flow conveyance and reduce backwater effects and elevated surface water elevations for extended periods.
- The Cayuga Drive Extension culverts (Town) were identified as a potential candidate for replacement, while the Hunt Street Bridge (County) could be replaced or removed to improve flow conditions. The cost benefit for replacing the Cayuga Drive Extension culverts is low and likely not economically feasible, while replacing or removing the Hunt Street Bridge is a viable option. The Town should continue to monitor flood elevations at both locations during a storm and/or snowmelt event to further evaluate the situation.
- The construction of improvements along the Niagara Road corridor to keep flows within the primary stream corridor (floodway) will reduce drainage issues and potential flooding within the Sy Road residential area, as well as upstream properties of Lemke Drive. A subsequent study and evaluation is needed to determine the feasibility of incorporating flood protection measures (i.e., replacement of existing culverts, construction of earth berms, additional flood storage areas).

4.3 Bull Creek

Bull Creek (BUA), along with the major tributary (BUB) and associated minor tributaries were evaluated for points of restriction in conveyance, stream channel capacity and condition, culvert conditions, and opportunities to better manage flows while reducing risk of future flooding within the watershed. The assessment focused on stream sections and watershed areas within the Town.

The specific area of concern involving The Briars Subdivision (Timberlink Road), which drains into the BUB tributary, is discussed in Section 4.10.

4.3.1 Findings

The hydraulic model results for Bull Creek (BUA) reveal the creek crossing at Hill Road (47-foot wide by 7-foot high bridge) as a low point with the roadway being overtopped in excess of 1 foot under a scenario of saturated soils and storm events greater than the 10-year reoccurrence and/or a spring snowmelt. Based upon the topography of the surrounding area, raising the grade of Hill Road and replacing the bridge with a larger structure is not feasible. Therefore, maintenance of the existing stream corridor is critical to minimizing peak water surface elevations to the maximum extent practical.

The stream segments of Bull Creek within the Town of Wheatfield vary from poor condition at off-road locations to fair condition at roadway crossings. As observed, Bull Creek is generally free of major debris, sediment accumulation, and vegetation. The section of Bull Creek situated in Pendleton traversing along Townline Road is in poor condition. Based upon the model results, cleaning the main channel could reduce the water surface elevation by as much as 1 foot. However, backwater effects from Tonawanda Creek extend 1.5 miles upstream from the confluence of

Sawyer Creek East, reducing the effectiveness of cleaning and conveyance capacities while elevating surface waters.

The surface water elevations of Bull Creek (BUA) have a backwater effect on the main tributary BUB, which extends upstream from Loveland Road across Shawnee Road and behind the homes on Moyer Road. The areas that drain to BUB will pool for an extended period until flows recede in the main channel of Bull Creek.

The following culverts were identified for replacement (or adding an additional culvert) due to inadequate capacity resulting in excessive surcharging and upstream flooding, along with the risk of overtopping Lockport Road:

- **Tributary BUB at Lockport Road:** Add 2-foot high by 4-foot wide box culvert
- **Tributary BUB at Mapleton Road:** Add 2-foot high by 4-foot wide box culvert

The following creek section has been identified as having significant silt accumulation, along with vegetative growth and requires maintenance:

- **Tributary BUB:** Townline Road, 30-inch by 24-inch corrugated metal pipe arch (CMPA) is partially plugged at the outlet. *Recommendation:* Remove sediment and vegetation from existing ditch outlet at Townline Road downstream approximately 400 linear feet past the residential properties.

4.3.2 Conclusions

The following summarizes the conclusions based upon the study findings for Bull Creek:

- A well-maintained and clean channel for Bull Creek is beneficial in order to reduce the effects of flow stacking and move as much flow through the Town before the backwater effects of Tonawanda Creek take control. Coordination with the Town of Pendleton to keep a continuously maintained channel from Townline Road to Niagara Falls Boulevard is required. Permitting from the ACOE and NYSDEC will be required for work within Bull Creek.
- Surcharging experienced in Bull Creek significantly reduces the ability of tributary BUB to drain, which impacts residents along Loveland Road, and the rear yards of Timberlink Road and Moyer Road. The resulting effects are standing water in the rear yards for extended periods of time.
- Replacement of the 24-inch culverts (or adding a second culvert) that cross Lockport and Mapleton Roads will improve upstream ponding in the upland area and not adversely affect downstream drainage. These culverts are in good condition and replacement is not a high priority. Both roads are County maintained roads and will require a permit.

4.4 Sawyer Creek West

Sawyer Creek West (SWA) and associated tributary (SWA-1) were assessed for points of restriction in conveyance, hydrologic and hydraulic conditions, opportunities for reducing localized flooding and water surface elevations, identification of channel reaches in need of cleaning, and culverts/drainage systems that needed to be flushed or repaired.

4.4.1 Findings

4.4.1.1 Sawyer Creek West (SWA) – Ward Road to Niagara Falls Boulevard

Extended periods of standing water are expected within Sawyer Creek West (SWA) due to channel slope (0.004 percent). The flow regime for Sawyer Creek West (SWA) is further complicated with flow direction changes occurring in response to water surface elevations associated with Sawyer Creek East and potential overflows from Bergholz Creek. The influences of these neighboring creeks add to the poorly drained condition associated with SWA.

The assessment revealed that extensive cleaning of Sawyer Creek West (SWA) (cleaning bottom, removing debris and vegetation along embankments) would not result in an appreciable decrease in surface water elevations. Calculations show a decrease in surface water elevations between 0.12 feet to 0.27 feet for the 10-year and 100-year storm, respectively.

Spot cleaning at culvert locations to remove sediment accumulation and vegetation is suggested to maintain pipe capacities. Areas noted for cleaning include spot locations between Errick Road and Ward Road. Additional spot inspections are required to identify culvert locations in need of cleaning.

Several driveway/roadway creek crossings along the north side of Niagara Falls Boulevard will likely be overtopped during a significant storm or snowmelt event due in part to the channel slope and flow contribution from Sawyer Creek East and potentially Bergholz Creek. Overtopping is primarily a result of backwater effects. Restriction in conveyance was also determined to occur at the higher frequency storm events of 10 years and greater due to undersized culverts.

Listing the culverts from downstream to upstream include:

- **Sawyer Creek (SWA) at Niagara Falls Boulevard:** The 8-foot wide by 5-foot high box culvert is a New York State Department of Transportation (NYSDOT) Structure is a restriction point resulting in upstream surcharging during storm events of 10 years and greater.
- **Sawyer Creek (SWA) at Sy Road:** The recommendation is to replace the existing 6-foot wide by 3-foot high box culvert with a 10-foot wide by 5-foot high box culvert/bridge (NOTE: This is a low priority project since replacement of the Niagara Falls Boulevard structure by the NYSDOT is required before the Sy Road structure is replaced).

4.4.1.2 Sawyer Creek (SWA) Niagara Falls Boulevard to Bergholz Creek

Flow from Sawyer Creek West (SWA) splits downstream of the railroad crossing and is directed to either Tributary BEA-1 or along the southern boundary of the Cayuga Drive Extension. A 60/40 split (60 percent toward BEA-1) is suggested based upon the downstream conditions and available

existing capacities. The following improvements and additional investigations are suggested along the Sawyer Creek (SWA) corridor downstream of the railroad bridge crossing:

- **Tributary BEA-1:** Spot check channel and remove sediment and trees, as required, to improve stream capacity and flow. Based upon a review of the aerials, there appears to be a piped crossing on private property that may be restricting flow.
- **Sawyer Creek (SWA):** Remove sediment and vegetation as needed to allow for even distribution of flow to be directed north toward the Cayuga Drive Extension.
- **Sawyer Creek (SWA) at Walmore Road:** The culvert crossing is 50 percent blocked. Removal of sediment buildup upstream and downstream is needed.
- **Sawyer Creek (SWA) downstream of Walmore Road:** A section of the creek appears to be piped with twin 42-inch RCP culverts (on private property). These pipes are likely a point of restriction resulting in pooling on adjacent properties. Additional investigation is required to confirm crossing information and creek condition.

4.4.1.3 Tributary SWA-1 (Niagara Falls Boulevard to Rose Court)

The twin 24-inch culverts that cross under Niagara Falls Boulevard have adequate capacity to carry the 25-year storm event, while the 100-year storm will result in surcharge conditions, but flows are not anticipated to overtop the roadway. The NYSDOT has identified this culvert for replacement. The selection of replacement and schedule remain to be determined. See **Drawing CI-04** (Appendix A) for the layout of existing conditions.

The Town recently constructed a man-made ditch behind Rose Court properties, south toward Niagara Falls Boulevard (Sawyer Creek West) that cuts off approximately 80 percent of the upland area flows. The existing downstream drainage system has limited capacity and, therefore, the maintenance of this ditch system is critical to protect the neighborhood.

As flows are directed downstream, Tributary SWA-1 has piped crossings decreasing from 36-inch under Sy Road to a 30-inch under Old Falls Boulevard, then three 18-inch pipes on private property, then routed across private property via a 24-inch pipe to the twin 24-inch pipes crossing Niagara Falls Boulevard. This system has limited capacity with minimal opportunity for improvement. Future investigations should be conducted and improvements could include constructing a piped or open channel system that diverts flow prior to Sawyer Creek before the 24-inch single pipe.

4.4.2 Conclusions

Replacement of the culverts at Niagara Falls Boulevard and Sy Road will reduce surcharging and upstream water surface elevations during the larger storm events; however, replacing these culverts is not feasible. Keeping the culverts and bridge crossings clear of debris will help maintain surface water elevations and reduce the risk of flooding.

The split in Sawyer Creek downstream of the railroad represents a critical flow control point and can be used to manage flows traversing toward Bergholz Creek. Additional field investigation is required to further develop alternatives.

Maintenance of the downstream creek and Tributary BEA-1 will help reduce standing water upstream of Niagara Falls Boulevard. Additional investigation into the condition of Tributary BEA-1 is required to further develop alternatives.

The 24-inch drainage pipe located at the outlet of Tributary SWA-1 currently results in upstream surcharging and a potential risk for significant flooding. Additional investigation and survey is required to further develop alternatives.

4.5 Sawyer Creek East

Sawyer Creek East (SEA) along with the major Tributary SEB, and minor tributaries (SEB-1 and SEB-2) were assessed for points of restriction in conveyance, creek hydrologic and hydraulic conditions, opportunities for reducing localized flooding and water surface elevations, and culverts/drainage systems that needed to be replaced, flushed and/or repaired.

Assessment of the Walck Drive and Thornwoods area, which is located within the Sawyer Creek watershed area and associated with Tributary SEB, is discussed in Section 4.8.

4.5.1 Findings

4.5.1.1 Sawyer Creek East (SEA)

Extended periods of standing water are expected within Sawyer Creek East (SEA) due to the marginal channel slope of less than 0.06 percent. The flow regime for Sawyer Creek West (SEA) is further complicated with a potential for change in flow direction near Ward Road (Sawyer Creek West), backwater effects from Tonawanda Creek and Bull Creek, and potential overflows from Bergholz Creek into Tributary SEB. The downstream channel conditions have the greatest influence on the ability of Sawyer Creek East (SEA) to drain with backwater effects extending upstream approximately 1.5 miles.

Major roadway culvert crossings are in good condition, have adequate hydraulic capacity, and the main channel can be described as in fair condition and generally free of blockages.

Private properties with shallow overland flooding are primarily experienced in the upper watershed areas between Nash and Ward Roads. Maintaining culvert openings free of debris, sediment accumulation should be considered as a best management practice for SEA.

The assessment revealed that extensive cleaning of Sawyer Creek West (SEA) (cleaning bottom, removing debris and vegetation along embankments) would not result in an appreciable decrease in flood water elevations. Calculations show a decrease in surface water elevations between 0.10 feet to 0.30 feet for the 10-year and 100-year storm, respectively.

Additionally, a broken 18-inch flap gate was observed on the end of a pipe at Niagara Falls Boulevard near the Mavis Drive intersection (**see Exhibit C**).

4.5.1.2 Tributary SEB (Niagara Falls Boulevard north to Ward Road)

Tributary SEB to Sawyer Creek East (SEA) was analyzed for existing conditions and potential structure replacements at Errick Road and Lemke Drive (see existing conditions **Drawing CI-02,**

Appendix A). A hydraulic analysis was performed using the ACOE Hydrologic Engineering Center, River Analysis System (HEC-RAS) Software (version 4.1.0). The hydraulic water surface profile from Sawyer Creek East to Lemke Drive is presented on Figure 3. Under the existing conditions, the hydraulic model indicated that the 100-year storm (343 cfs) would overtop Marc Drive, as well as Errick Road and Lemke Drive (247 cfs), while the 10-year event remained below the crest of these roads. For the 100-year storm event, the downstream boundary condition was set to 577.6, which is the regulatory base flood elevation (BFE) for Sawyer Creek East. Flow rates for the stormwater model were presented in Table 6 (Section 3.4.4).

The box culvert for Marc Drive was installed in recent years, is in good condition, and based on the assessment conducted provides reasonable protection of neighboring properties from flood damage. The culvert structures crossing under both Errick Road and Lemke Drive are in poor condition, are undersized, and should be considered for replacement.

Major road culvert crossings identified for replacement are as follows:

- Errick Road Existing 14-foot wide by 7-foot high CMP Arch
- Lemke Drive Existing Twin 4-foot diameter CMP

A preliminary analysis was completed to size replacement culverts for Errick Road and Lemke Drive with the objective of reducing water surface elevations so as not to have flows overtop the road crossings. The analysis resulted in the preliminary selection of a 95-inch wide by 67-inch CMPA pipe at Lemke Drive and a 117-inch by 79-inch CMPA pipe at Errick Road. The crossings would also include additional 36-inch pipes set above the normal flow elevation to handle the larger storm events (100 year). The above options, as well as other potential replacement alternatives, such as pipe lining, box culvert or bridge configuration, should be considered during a subsequent study phase. Proposed cross sections at Lemke Drive and Errick Road are presented on Figures 6 and 7, respectively.

There is a minor drainage ditch located behind the residential properties along Ward Road that will likely collect and discharge potential overflows from Bergholz Creek into Tributary SEB at Ward Road (see **Drawing CI-08**, Appendix A). Potential options to minimize impact to Tributary SEB include:

- Construct a berm at the collection point
- Construct a restriction plate across the top of the Ward Road box culvert. This structure has excess capacity; however, surcharging and temporary upstream flooding could occur as a result of the reduced flow area. Additional assessment is required prior to implementation of corrective actions.

4.5.1.3 Tributary SEB-1 (Errick Road/Stieg Road to Nash Road)

Tributary SEB-1 conveys flows from farmland upland of Nash Road to a culvert crossing under Stieg Road, then into a drainage collection system that is routed along the boundary of Errick Road Elementary School and under Errick Road, ultimately discharging into Tributary SEB north of Lemke Drive (see Drawing CI-09, Appendix A). Based on review of historical aerials, it appears that

Tributary SEB-1 previously conveyed flows south and at some point was redirected to cross Errick Road. The crossing at Stieg Road and associated downstream drainage system is a major restriction point with limited capacity and can only handle peak flows no greater than 70 cfs without overtopping the roadway at Stieg Road. The drainage area of 458 acres to Stieg Road results in an estimated peak flow of 81 cfs and 133 cfs under the 25-year and 100-year events, respectively (see Table 6). As observed and modeled, the Stieg Road drainage system causes significant upstream flooding.

The existing drainage system located along 6769 Errick Road conveys flows from a swale that potentially collects excess runoff and overflows from Tributary SEB-1. This drainage system is considered a control point and could provide potential relief for the Stieg Road area residents. Improvements to the swale and drainage system on Errick Road would be required.

Opportunities to improve the drainage conditions and flooding for impacted residents along Stieg and Errick Roads were completed. A summary of alternative solutions is presented on **Drawing CI-09** (Appendix A) and summarized below:

- Clean and re-establish drainage patterns to the ditch system for Tributary SEB-1
- Stieg Road: Construct a stormwater management system behind the residential properties along Stieg Road and utilize the natural topography (woodland marsh area) to store excess runoff.
- An alternate solution to the above Stieg Road option would be to construct a separate drainage system to redirect excess flows (via a second outlet to the drainage system at the Errick Road Elementary School) , south into an existing drainage ditch downstream that conveys flows directly to Tributary SEB near the confluence of Tributary SEB-2. This alternative would require access easements from private properties to construct.
- Errick Road: Clean the swale and construct a secondary pipe across Errick Road or replace the existing 24-inch RCP drainage system.

4.5.2 Conclusions

Replacement of the culverts at Errick Road and Lemke Drive will reduce surcharging and water surface elevations upstream of Errick Road. Keeping the culverts and bridge crossings clear of debris will help maintain surface water elevations and reduce the risk of flooding as well.

The drainage system under Stieg Road is a control point resulting in backwater surcharging and localized flooding. Reducing peak flows before reaching Stieg Road will minimize impacts to residents. Construction of a secondary drainage system to bypass a portion of flows at Stieg Road would also reduce the risk of flooding and downstream impacts at Lemke Drive.

Potential overflows from Bergholz Creek into the headwaters of Tributary SEB may be mitigated with a combination of berms and construction of a flow control structure at Ward Road.

4.6 Black Creek and Southern Drainage

The watersheds associated with Black Creek and Southern Drainage were evaluated and analyzed for points of restriction in conveyance, hydrologic and hydraulic conditions, opportunities to improve flow conveyance efficiently, and the capacity to the Niagara River with the objective of reducing the risk of flooding damage and water surface elevations within the existing developments.

The boundary between these watersheds was difficult to define due to the flat terrain and lack of defined elevation differential between Black Creek and Southern Drainage watersheds. Black Creek watershed drains approximately 1,700 acres, while Southern Drainage drains approximately 1,844 acres. Both drain to the Niagara River and the topography in these watersheds is very flat with minimal relief for drainage. The areas also contain large plots of wetland areas.

One of the specific areas of concern, Wilrose Court, is located within the Southern Drainage area watershed and discussed in Section 4.9.

Based upon survey data and field investigations, the assessment included an evaluation of combining these watersheds as further described below.

4.6.1 Findings

4.6.1.1 Black Creek

Black Creek watershed (BLA) appears to have been at some time, prior to area development, directly tributary to Cayuga Creek, discharging downstream of the confluence point of Bergholz Creek. The drainage pattern and flow path for Black Creek has been altered over a period of time with the development of the Summit Park Mall, residential and commercial development, and construction of the Summit Park Lakes, such that surface water runoff pools within the large wetland/low areas before being collected upstream of Liberty Drive and discharging to the Niagara River.

Observations and general opportunities for improving flow conditions and minimizing the risk of flooding are presented below:

- The upper watershed area of Black Creek (BLA) is defined by a shallow ditch that traverses through Country Meadows Subdivision (David Homes), then through the Wheatfield Lakes and pond system, discharging westerly into wetland areas. The outlet is submerged all year and does not allow upstream areas to properly drain.
- Located behind Deborah Lane properties are two 24-inch RCPs (under the railroad) that are 80 percent blocked. These culverts allow property and swales on the east side of the railroad to drain.
- The Liberty Drive culvert crossing, a 43-inch by 27-inch CMPA, has crushed end sections and is 80 percent plugged; drainage of upland areas is restricted with a potential for roadway flooding.
- The Colvin Blvd. culvert crossing west of Williams Road is a 30-inch CMP crossing and is 80 percent plugged; the drainage system is tied to a wetland area that does not drain. No major impacts are associated with the blockage.

- The creek from downstream of Liberty Drive is typically 50 percent full of water regardless of the seasonal conditions. After a typical rain event, the creek water surface elevations surcharge and remain high for extended periods of time, while downstream at River Road the creek has drained. There are spot locations of debris blockages along the creek, indicating blockages within the channel reach between Liberty Drive and River Road; further field investigation is required to define the extent of impact.

The following presents a summary of the hydrologic and hydraulic modeling findings:

- The River Road box culvert crossing is a critical flow control point for Black Creek (BLA) and provides some downstream flood protection by reducing the peak flow. The calculated peak flow for the 100-year storm event was 223 cfs with a water surface elevation within approximately 1 foot of overtopping the roadway. Discharge downstream of River Road will overtop the existing culverts that outlet to the Niagara River. The overflows will likely result in erosion and scouring, but damage to surrounding structures is not anticipated.
- Wheatfield Lakes Subdivision: Due to the outlet condition (submerged), the effectiveness of the interconnected detention ponds is reduced and upstream flows are stacked. The subdivision has an emergency overflow structure that directs flow westerly toward the railroad tracks and the twin 24-inch culverts that are referenced above as 80 percent plugged. The existing ditch from the overflow structure needs to be cleaned and regraded westerly.

4.6.1.2 Southern Drainage

Southern Drainage was likely once part of Black Creek, but was separated or cutoff with the construction of the man-made lakes and associated man-made ditch and single outfall under River Road via a 30-inch steel pipe to the Niagara River. The Town has completed improvements that included regrading and construction of a second outfall to the Niagara River via a twin 36-inch HDPE pipe (located downstream within the City of North Tonawanda limits).

A portion of the drainage area tributary to Southern Drainage is collected in a network of drainage ditches and culverts that convey flow under Nash Road westerly into Willow Lake, which then discharge west via a controlled outlet under Ward Road, Witmer Road, and then southerly via the man-made ditch system to the outfall structures at River Road (see **Drawing CI-03**, Appendix A).

The remaining drainage areas are tributary to the Summit Park Lakes. These lakes are interconnected and have an outfall located at the southeast corner of the south lake. An overflow structure consisting of rip rap is located at the northwest corner of the north pond and is connected to the Black Creek watershed. The primary outlet structure discharges into the man-made ditch that traverses south to the River Road outlet structures. The water surface elevation of the Summit Park lakes vary seasonally (0.5 feet) and are approximately 1.5 feet above the surrounding storm drainage and ditch network.

A summary of the observations and general opportunities for improving flow conditions is presented below:

- Nash Road: The pipe outlet of the 24-inch CMP is partially collapsed and plugged.
- Nash Road: The pipe outlet of the 44-inch by 22-inch CMPA at the south boundary with North Tonawanda is partially collapsed and plugged; the downstream ditch to Graydon Drive has silt accumulation and vegetative growth that needs to be cleaned.
- Witmer Road at Stenzel Avenue: The 18-inch pipe crossing is partially plugged.
- The ditch at the outlet for Willow Lake is filled with standing water, with minimal changes in elevation based on the season. Survey data indicate an elevation drop of 3 feet over 2.25 miles (Willow Lake outlet to the 30-inch outlet) for an overall slope of 0.025 percent. As flows continue to the second outlet, the grade greatly improves to 0.30 percent. The analysis indicates that the outlet structures have the capacity to handle peak flows; however, the capacity is underutilized as water remains stagnant upstream.

The following summarizes the hydrologic and hydraulic modeling findings:

- There are two primary control structures that affect the drainage of the Southern Drainage system: 1) Willow Lake outlet structure, and 2) the River Road outlets. The 25-year storm event peak flow conveyed to the River Road outlet was calculated at 77 cfs, while the available combined full flow capacity is approximately 154 cfs.

4.6.1.3 Combined Watershed Areas

An analysis was completed to determine the impacts on both watershed areas under a scenario of reconfiguring the secondary spillway, and lowering the Summit Park Lakes primary outlet elevation from 570.7 to 569.0. Additionally, the existing man-made ditch from the River Road outlet to the Summit Park Lakes could be regraded to allow the upstream areas to drain more efficiently. The assessment revealed the following about this scenario:

- Black Creek Outlet – peak flows would be reduced by 30 percent.
- Black Creek Outlet – the free board at River Road would be increased and would reduce the risk of downstream flooding.
- A greater portion of the available capacity within the existing lake system would be utilized.
- Flow rates to the River Road outlets would be increased to maximize available capacity.
- The risk of flooding in the Wheatfield Lakes Subdivision and other upstream residential areas would be reduced.

4.6.2 Conclusions

Both the Black Creek and Southern Drainage watersheds are poorly drained, with limited opportunities to improve flow patterns and redirect runoff to the Niagara River. Keeping culverts clear of debris and sediment accumulation will help keep surface water elevations from being further elevated.

The greatest opportunity for improving drainage is to regrade the man-made ditch from River Road north to the ponds and reconfigure the outlet control structures to open up additional storage volume for the Black Creek watershed.

4.7 Eagle Chase Subdivision

The existing conditions for the Eagle Chase Subdivision (Lockport Road) were evaluated for the purpose of developing alternative solutions that will help reduce the risk of flood damage within Phase 1 and Phase 2 and impacts to the future buildout of the subdivision. Significant flooding and drainage problems within the project area of Eagle Chase have been reported on an annual basis since construction (with the exception of 2015). Of note, the Town Highway Department cleaned and regraded a section of Tributary BEB from the outlet structure at Lockport Road (near Eagle Chase) downstream to Nash Road. Ditch cleaning activities for the next section of the ditch downstream toward Ward Road are planned for 2016.

4.7.1 Findings

Existing conditions are presented on **Drawing CI-05** (Appendix A). In general, there are 17 homes constructed within the subdivision with an additional six residential homes that abut the subdivision and are directly impacted by the subdivision drainage. The subdivision was constructed directly over Tributary BUB with a drainage design that passed off-site runoff through the subdivision downstream to Lockport Road. Drainage within the subdivision was designed to handle runoff separately via the collection storm system and detention.

The following items summarize the assessment of existing conditions and study findings:

- The upstream watershed area of 198 acres drains under Baer Road via a storm collection system consisting of 18-inch and 24-inch pipes, which combine to a 36-inch pipe outlet. This drainage system will surcharge, resulting in temporary flooding of the upstream area under the 25-year storm event, with the 100-year event overtopping Baer Road. The existing conditions protect downstream areas from additional flooding. No further improvements were considered.
- Off-site drainage from a combined upstream tributary area of 325 acres is collected at the east boundary of Eagle Chase via a 30-inch pipe and conveyed to the drainage system located on Lockport Road. The drainage system along Lockport Road collects runoff from an additional 44 acres, which is then combined with the off-site area discharge, then routed downstream to a 10-foot wide by 3.5-foot high box culvert crossing at Lockport Road. The 30-inch storm sewer system is a point of flow restriction and surcharging and flooding of upstream areas is anticipated. In review, storm events greater than the 25-year reoccurrence will overtop the existing embankment at the inlet to the existing 30-inch drainage system and flow overland across existing residential properties toward Lockport Road (as shallow flooding).
- Recommended short-term measures to minimize future flooding conditions include:
- Maintain the inlet to the 30-inch culvert clear of debris, ice and sediment accumulation.
- Keep the Lockport Road drainage ditch and driveway culvert crossings clear of debris, ice buildup, and sediment buildup.

- Maintain the outlet and downstream ditch at Lockport Road free of vegetation and sediment accumulation.

Alternative solutions to further reduce and minimize the risk of flooding damage and protect residential structures within the neighborhood include (See **Drawing CI-07**, Appendix A):

- **Alternative A**: Alternative A consists of a combination of upland storage and downstream protection. The upland storage involves the construction of a detention basin located upstream and off-site. Runoff from the Baer Road ditch would be directed into the detention basin prior to discharge into the 30-inch piped system through Eagle Chase. Detention would be created by constructing an embankment out of excavated earth material. Embankment storage would be required to avoid rock excavation, which will likely be encountered within 3 feet below grade. The challenges with this alternative include impacts to potential wetlands, and acquisition of property in order to implement this alternative. The probable cost to construct the off-site detention basin is estimated at $70,000, exclusive of land acquisition costs.

  The downstream protection portion of the alternative consists of constructing an earthen berm (1 to 2 feet high) and swale along the eastern property line of 3380 Lockport Road to direct excess flows around the eastern-most residential property to Lockport Road. In addition to the berm and swale listed above, an additional flood protection measure includes the installation of a second pipe crossing at Lockport Road. The new crossing would require the ditch downstream on the south side of Lockport Road to be cleaned. The proposed improvements will require construction on private property and a bore across Lockport Road. The probable cost to construct these improvements is estimated at $90,000.

- **Alternative B**: This alternative involves the construction of a drainage system (pipes and open channel) that intercepts the flows upstream of the existing 30-inch storm collection system, and reroute flows around the existing residents downstream to the Lockport Road. These improvements could potentially impact the design of future phases of the subdivision, which will require significant rock excavation and drainage easements on private property. The probable cost to construct this alternative is estimated at $525,000, exclusive of land acquisition costs.

Additional observations that require maintenance include the following:

- Clean and regrade the Lockport ditch from the outlet at Eagle Chase to the box culvert crossing Lockport Road (300 linear feet).
- Lockport Road drainage system (15-inch) – Remove sediment accumulation, debris and vegetation at driveway culvert crossings.
- Clean and regrade the ditch from Eagle Chase pond outlet to Lockport Road.

4.7.2 Conclusions

The existing drainage system that handles the off-site runoff has the capacity to handle high frequency annual storm events (10-year reoccurrence). In order to minimize the risk of flooding, the existing drainage system must be maintained to maximize available capacity.

Construction of subsequent phases should not be approved without subsequent investigation and design of improvements that provide additional flood protection measures.

4.8 Thornwoods and Walck Drive Area

The existing drainage conditions associated with the Thornwoods Drive entrance and the Walck Drive residential area were evaluated for the purpose of developing alternative solutions to help reduce flooding and seasonal drainage issues.

Drainage issues associated with this area include:

- Extended periods of standing water in front and rear yards of the neighborhood between Pearce Road and Walck Drive.
- Annual flooding of the Walck Drive roadway (typically during spring or winter thaws).
- Extended periods of standing water in the open field behind the residential properties of Walck Drive.
- Significant pooling of water has also been reported at the storm sewer catch basins located at the low point on the Thornwoods Drive entrance.
- Frequent flooding of the intersection of Ward and Pearce Roads.

4.8.1 Findings

Existing conditions and conceptual drainage improvements are presented on **Drawing CI-08** (Appendix A).

The following presents a general summary of the findings for this area:

- The swale located along the abutting field of Walck Drive delineates the boundary between the watershed of Bergholz Creek and Sawyer Creek Tributary SEB. This swale has significant silt accumulation and does not drain properly. Runoff from 140 acres is conveyed to a 15-inch culvert, which crosses under Ward Road via a 36-inch pipe. The 15-inch culvert is undersized.
- The piped drainage system at the intersection of Ward and Pearce Roads is undersized and is partially collapsed.
- Conceptual drainage improvements as shown on **Drawing CI-08** (Appendix A) include:
- Replace 15-inch culvert with 30-inch culvert
- Clean/regrade ditch along rear lots of Walck Drive
- Construct a berm along the rear lots of Walck Drive
- Replace 15-inch storm system on Ward Road with an 18-inch
- Replace 18-inch on Pearce Road with 24-inch
- Replace 12-inch Pearce Road crossing with 24-inch
- Clean existing ditch to Bergholz Creek from 30-inch pipe on Ward Road
- Remove 10-inch riser in Thornwoods catch basin
- Thornwoods Drive pond – increase berm east top of bank approximately 18 inches to elevation 581

- Remove sediment accumulated upstream and downstream of the Thornwoods Drive entrance culvert

4.8.2 Conclusions

There are two main items identified for corrective action for the Thornwoods and Walck Drive area: 1) Improvements to the existing drainage swale and storm system behind Walck Drive will reduce the risk of flooding significantly, and 2) The storm sewer on Ward Road is in poor condition and needs to be replaced to restore capacity and reduce the risk of flooding the intersection.

4.9 Willow Lake Outfall Assessment

Willow Lake is located within the Southern Drainage watershed. The outlet to Willow Lake and associated downstream drainage system is depicted on **Drawing CI-03** (Appendix A). In general, the outlet consists of twin 15-inch pipes that combine at Wilrose Court into a single 24-inch pipe that discharges to the Southern Drainage main channel. The outlet pipe has a flap gate that was installed to eliminate flows from the ditch reversing direction and flowing into Willow Lake.

Prior to the installation of the flap gate, it had been reported that surcharging in Willow Lake surcharged the catch basins on Wilrose Court and pooled in the street rights-of-way at two locations (catch basins at the bend on Wilrose Court and along the alignment of the outfall). Street flooding was reported to typically occur during a winter thaw coupled by spring rain, resulting in a dangerous driving condition.

An assessment of the Willow Lake drainage system and associated tributary areas was completed to define existing conditions under various storm events, and to develop alternative solutions for reducing the risk of future flooding and improve the reliability of the stormwater drainage system.

4.9.1 Findings

Based upon a review of available construction drawings, survey data collected, and field reconnaissance activities, the identified catch basin locations are the two lowest points within the Willow Lake storm system in which flooding will first occur (the catch basins at the bend point in the road being first). This flooding would also occur prior to overtopping the embankment of the lake. Flood damage to area homes is not anticipated as the grade around the homes is substantially higher than the storm sewer rims in the roadway.

As observed from April through end of October 2015, the downstream channel was filled with water and the Willow Lake inlet and outlet were partially submerged (50 percent or greater). Willow Lake will only drain if the water surface elevation within the lake is greater than the downstream ditch elevation. Given the poor downstream drainage and submerged condition, runoff from the lake will be stored for an extended period of time and drain slowly as conditions allow.

Based upon this assessment, Willow Lake has the capacity to handle flows for typical annual storms, while temporary pooling in the roadway will occur under storm events greater than 25-year occurrences.

Various alternative solutions developed to reduce and potentially eliminate roadway flooding include:

- Construct new separate storm sewers for the two piped systems that cause the roadway flooding surcharge. This alternative would require construction of a new storm sewer and ditch from the bend in the road west and then south along the rear properties and connecting into the Southern Drainage ditch downstream of the outlet. The Willow Lake outlet would also need to be separated from the roadway storm system. This alternative would reduce, but not eliminate the overall duration of temporary flooding based upon the water surface elevations downstream. This alternative was not considered to be a viable option due to constructability issues, land access and requirements for drainage easements.
- Expand the lake capacity by constructing an overflow flood storage area to the south of Willow Lake. Conceptual drainage improvements associated with this alternative are shown on **Drawing CI-10** (Appendix A). In general, flows from the east would be redirected to a stormwater management area (Town-owned property) prior to discharging into Willow Lake. The increase in capacity would eliminate roadway flooding. The challenges with this alternative include construction that is located within a wooded wetland area.

4.9.2 Conclusions

Keeping the existing outfall to Willow Lake free of debris and maintenance of the flap gate is critical to managing flows. The focus should be on improving the downstream drainage conditions to reduce both the water surface elevations and surcharging duration at the outlet of the lake.

Based upon the assessment of existing conditions and alternatives available, the expanded stormwater storage should be considered if the frequency of roadway flooding increases.

4.10 Moyer Road and Briars Development Assessment

This assessment was focused on the adjoining rear yard drainage between Moyer Road and Timberlink Road, located west of Shawnee Road. The assessment was completed to define existing conditions under various storm and seasonal conditions, and to develop alternative solutions to help improve drainage conditions.

In general, the rear yard drainage system consists of a storm collection system (on the Timberlink residential properties) along with an open drainage swale/ditch that drains 2,800 feet east to Shawnee Road. The last phase of the subdivision has a rear yard drainage system that conveys surface water runoff to the Briars detention pond. The open ditch section of the drainage system impacts 19 Moyer Road residential properties, with an additional seven properties that drain toward an ACOE jurisdictional wetland area, and three Moyer Road properties that drain to the separate Timberlink Road rear yard drainage system.

4.10.1 Findings

With respect to the abutting rear yard drainage ditch, the piped drainage system constructed for the subdivision is collecting runoff as designed. Furthermore, the piped system with the turned down tees at the property lines helps collect water that would otherwise pool in the ditch. The rear yard

open drainage ditch system is in fair condition with the exception of a few locations where piles of leaves and grass clippings have been placed. This ditch has minimal slope and was observed to have standing water for extended periods of time during periods of a rain event (see Existing Conditions **Drawing CI-06**, Appendix A).

Flows from the rear yard ditch are directed to Shawnee Road (west ditch) and are collected in a roadside piped storm drainage system that crosses under Moyer Road with an outlet to Tributary SEB. The ability of Tributary SEB to drain is directly related to the water surface elevations of Bull Creek. Water filled 50 percent of the ditch capacity for the majority of the year.

Corrective Measures identified to help improve the drainage conditions are as follows:

- The storm pipe crossing Moyer and Shawnee Roads is reverse pitched and holding flows back from a portion of the rear yard ditch system. The recommended corrective measure is to install a new 12-inch pipe adjacent to the existing pipe at proper grade, or re-align the 24-inch pipe crossing Shawnee Road.
- Construct a French drain system under the center of the open ditch as a means to store sitting water below grade. This alternative would consist of installing a 4-inch perforated pipe bedded with 1-inch clean stone.
- With respect to the residents that abut the open buffer to the wetland area, the recommended course of action would be to construct two shallow swales (approximately 75 feet in total length) from the upland buffer area to the ACOE wetland area.

4.10.2 Conclusions

Topography is flat with minimal opportunity to relieve surface water runoff quickly from the Moyer Road and neighboring area. Extended periods of standing water within this area are to be expected in response to the downstream conditions of Loveland Road and Bull Creek.

Opportunities for improving the drainage system include a combination of adjusting the storm sewer along Shawnee Road, constructing a French drain and constructing swales to the ACOE wetland.

5. Recommendations

Recommendations have been separated into non-structural, maintenance, and capital improvement type projects. The non-structural recommendations include updates to the Town code and policies for future planning purposes. The maintenance type improvements are for inclusion in annual budgets, while the capital improvements are mainly one-time projects to correct or alleviate flooding problems. This section also includes recommendations for additional confirmatory investigations and future studies to further evaluate select alternatives and conceptual improvements.

5.1 Non-Structural Recommendations

During the course of this study, GHD identified potential updates to the Town Code and stormwater management policies to assist in managing potential drainage impacts of future planning and development. These suggested modifications include: