



June 1, 2022

Stephen F. Norcini, P.E., Township Engineer  
Radnor Township  
301 Iven Avenue  
Wayne, PA 19087-5297

Dear Steve:

Subject: South Wayne Drainage Improvements Feasibility Study – Executive Summary

Carroll Engineering Corporation (CEC) has completed the above referenced study and issued a comprehensive report titled the “South Wayne Drainage Improvements Feasibility Study” which was completed in April 2022. The purpose of this study is multi-faceted with the following being the main goals of this Phase:

1. Identify each geometrically unique portion of the stream/culvert and catalog the following:
  - Stream/culvert bed slope
  - Bottom width and/or culvert dimensions
  - Side slopes
  - Channel depth
  - Composition of the stream bottom
  - Manning’s ‘n’ coefficient (relative roughness constant)
2. Identify the drainage area and flow rates for each design year storm for each geometrically unique portion of the stream/culvert.
3. Complete a Manning’s calculation to demonstrate the theoretical carrying capacity of each portion of the stream.
4. Identify which portions of the stream/culvert may be deficient based on the capacity calculations and provide approximate sizing required to convey the 100-yr storm.
5. Prepare a conceptual plan for storm sewer infrastructure along Midland Avenue and Saint David’s Road which shall connect to the main storm sewer culvert corridor.

*Today’s Commitment to Tomorrow’s Challenges*

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6. Prepare a conceptual plan for a potential storm sewer bypass beginning in the vicinity of the Pembroke Avenue between its intersections with Midland and Saint David's Road and running southeast to Encke Park.

Based on the results of this study, we note that Ithan Creek, which was historically a meandering stream with various intermittent ponds, has been severely encroached upon by residential development over the previous 150-years. This development has led to the addition of impervious surface, which has contributed to a significant increase in stormwater flow rates to the stream. Consequently, many stream cross-sections identified in the Feasibility Study are deficient in their ability to convey all design year storms.

We acknowledge that it is not feasible to return the stream to its former state, and that recognize that the Township has finite resources to complete capital improvements to improve these conditions. As such, we offer the following recommendations that provide the greatest improvement to the stream corridor compared to their cost and impacts on residents.

#### **SHORT TERM / LOW-COST IMPROVEMENTS:**

- **Sediment Removal Downstream of Pembroke Avenue Culvert**  
*\$40,000 - \$50,000*

There is sediment deposition in the stream which effectively reduces the overall carrying capacity of the upstream Pembroke Avenue closed conduit by approximately 1½ feet. As such, it is recommended that the sediment be removed along approximately 320 feet of the stream to allow the Pembroke Conduit to freely outfall and utilize its full carrying capacity.

- **Sediment Removal Downstream of Iven Avenue Culvert**  
*\$10,000 - \$15,000*

There is sediment deposition in the stream which effectively reduces the overall carrying capacity of the culvert under Iven Avenue by approximately 1 foot. As such, it is recommended that the sediment be removed along approximately 60 feet of the stream to allow the Iven Avenue culvert to freely outfall and utilize its full carrying capacity. This would be an advantageous time to also to remove any sediment in the adjacent corrugated metal pipe beneath the Township Building entrance drive.

- **Pedestrian Bridge Removal at Saint Katherine's**  
*\$15,000 - \$20,000*

A stone masonry pedestrian bridge is located on the eastern portion of the Saint Katherine of Siena School property. This decorative feature leads to a garden area near the intersection of Midland Avenue and South Aberdeen Avenue. This bridge serves as a significant “choke point” having a maximum flow capacity between the 5- and 10-yr storm and does not serve a particular function.

It is recommended that this feature be removed which would require an easement to be granted by Saint Katherines to facilitate the demolition work. Once the demolition is completed the channel would more closely resemble the upstream cross-section with the capacity to convey between a 50- and 100-year peak flow rate.

#### **INTERMEDIATE TERM IMPROVEMENTS:**

- **Replace the Stone Arch Culvert at Iven Avenue & Township Building Entrance Drive**  
*\$1.2 to 1.5 million (for both culverts)*

The theoretical capacity of the culverts at these locations are nearly equivalent to the 5-year peak flow rate and are considered vastly undersized based on the tributary flows. These culverts serve as a substantial “choke point” due to their low theoretical capacity and the hydraulic losses of stormwater entering a closed conduit from an open channel.

It is recommended the Township replace both culverts in the future to increase their opening size to adequately pass the 100-year peak flow rate and reduce any flooding upstream due to this constriction. This would result in the culvert(s) being wider (approximately 14 feet) while maintaining its somewhat limited height at 4½ to 6 feet. These locations would be well suited for a CON/SPAN bridge or similar system.

- **Replace the Stone Arch Culvert at Meadowbrook Avenue**  
*\$500,000 to 600,000*

The theoretical capacity of the existing stone culvert is nearly equivalent to the 2-year peak flow rate and is considered vastly undersized based on the tributary flows. This culvert likely serves as a substantial “choke point” due to its low theoretical capacity and the hydraulic losses of stormwater entering a closed conduit from an open channel. Additionally, this culvert was determined to have a negative slope based on the topographic survey.

It is recommended the Township replace the culvert in the future largely due to its assumed advanced age as part of the Township's general infrastructure replacement programs. The opening of the bridge could be maximized at that time to adequately pass the 100-year peak flow rate and reduce any flooding upstream due to this constriction. This would result in the culvert being wider (approximately 23 to 24 feet) while maintaining its somewhat limited height at 4 feet. This location would be well suited for a CON/SPAN bridge or twin box culverts.

- **New Storm Sewer Along Saint David's Avenue (between S. Aberdeen and Pembroke Avenue)**  
*\$500,000 to \$600,000*

A high-level conceptual sketch of a new storm sewer is provided in the Feasibility Report (C-105) which proposes a series of stormwater inlets along Saint David's Road where there is presently little to no stormwater infrastructure. The alignment runs west to east with inlets spaced at approximately 100 feet on the north and south side of the roadway and ultimately discharges into the Pembroke conduit where a tie-in will be required. This stormwater system provides a means for conveying runoff to the receiving watercourse and will reduce flooding on Saint David's Avenue at all storm intervals (i.e., 2- through 100-year).

- **New Storm Sewer Along Midland Avenue (between S. Aberdeen and Pembroke Avenue)**  
*\$600,000 to \$700,000*

A high-level conceptual sketch of a new storm sewer is provided in the Feasibility Study (C-101 and C-102) which proposes a series of stormwater inlets on the north and south side of Midland Avenue where there is presently little to no stormwater infrastructure. This storm sewer system would ultimately discharge to the open channel portion of the Ithan Creek before it enters the Pembroke Avenue closed conduit. Inlets were spaced at approximately 100 feet. Two (2) existing city inlets and one (1) stormwater manhole are also proposed to be replaced at the intersection of Midland Avenue and Pembroke Avenue. This stormwater system provides a means for conveying runoff to the receiving watercourse and will reduce flooding along Midland Avenue at all storm intervals (i.e., 2- through 100-year).

- **New Storm Sewer Along Midland Avenue (between Louella and S. Aberdeen Avenue)**  
*\$1,250,000 to \$1,500,000*

A high-level conceptual sketch of a new storm sewer is provided in the Feasibility Report (C-103 and C-104) which proposes that the existing brick culvert along Midland Avenue be replaced with the largest elliptical concrete pipe available which is equivalent to an 84-inch diameter round pipe. This is likely the largest size pipe that can be accommodated in this area due to existing cover available and the adjacent existing utilities. This alternate proposes to modify the existing alignment to remove the portion located beneath the Saint Katherines of Sienna School and outfall to the existing open channel on the eastern portion of this parcel. This requires that the existing pedestrian bridge be removed, and the stream lowered by approximately 2½ feet. Inlets were spaced at approximately 100 feet on the north and south side of Midland Avenue with three

(3) existing city inlets being replaced. This work requires a permanent stormwater easement to be granted by Saint Katherines and would be a significant temporary interruption to the residents along this portion of Midland Avenue.

### **LONG TERM IMPROVEMENTS WITH SIGNIFICANT COST & COORDINATION:**

- **Replace Culvert Under Pembroke Avenue with larger Box Culvert**  
*\$2.5 to 2.75 million*

The theoretical capacity of this stone culvert is just above 5-year peak flow rate and likely serves as a substantial “choke point” for flow along the stream. It is recommended that this closed conduit be ultimately replaced with a larger concrete box culvert beneath Pembroke Avenue. Since the alignment of the stream runs along Pembroke Avenue, options for open channel flow are not feasible without the Township acquiring private property from the adjacent residents. The proposed box culvert would need to be approximately 15½ feet wide by 5½ feet in height to accommodate the 100-year peak flow rate. This project will likely need to be completed in phases with the first phase of the work focused on relocating miscellaneous utilities in the right-of-way to accommodate the eventual replacement.

- **Replace Culvert Under Rear yards along Midland and Saint David’s with open channel**  
*\$1 to \$1.25 million*

The theoretical capacity of this stone culvert falls below the 5-year peak flow rate and likely serves as a substantial “choke point” for flow along the stream. It is recommended that this closed conduit be ultimately replaced with an open channel having a bottom width of approximately 10½ feet, with 1:1 side slopes, and an approximate top width of 21½ feet. Typically, new channels would be designed to have 3:1 side slopes or less to minimize any bank erosion and allow for ease of maintenance. However, there are number of existing features which are in close proximity to the stream which preclude the channel from having more gradual side slopes. These areas are discussed in detail in the Feasibility Study with the major impacts listed below:

- **Garage at 313 Saint David’s Road (Parcel ID 36030190800)**

The existing garage in the rear yard of this parcel is located within 10.3 feet of the existing closed conduit. The proposed open channel option would effectively move the edge of the stream 7.5 feet closer to this garage leaving approximately 3 feet of separation between the top of bank and northern side of the garage.

- **Garage / SWM Facility at 321 Saint David's Road (Parcel ID 36030190600)**

The existing garage in the rear yard of this parcel is located within 12 feet of the existing closed conduit. The proposed open channel option would effectively move the edge of the stream 7.5 feet closer to this garage leaving approximately 4½ feet of separation between the top of bank and northern side of the garage. Additionally, the private stormwater facility on this parcel would need to be modified to move the berm to the south by approximately 6 feet.

- **Fencing at 301 Saint David's Road (Parcel ID 36030191000), 305 Saint David's Road (Parcel ID 36030190900), and 319 Saint David's Road (Parcel ID 36030190700)**

The existing fence lines at these parcels would need to be relocated.

- **Shed & Fence at 318 Midland Avenue (Parcel ID 36030179600)**

An existing fence line at the rear of this parcel would need to be moved to the north approximately 6 feet. Additionally, an existing shed at the southwestern corner of the parcel would need to be moved north by approximately 6 feet.

- **Large Trees and Landscaped Areas**

Several large diameter trees and various landscaped areas along this culvert would need to be removed to accommodate the open channel. This would significantly change the visual character of this area.

The option to replace the closed conduit with open channel would require that each homeowner along Midland Avenue and Saint David's Avenue (between South Aberdeen and Pembroke Avenue) grant a permanent drainage easement to facilitate the work and allow the Township to maintain this reach of the stream in perpetuity. The acquisition of these easements will pose as a significant challenge to the Township.

There are various other stream improvements discussed in greater detail in the Feasibility Study but have not been listed here since they represent more modest improvements when compared to cost and coordination required for implementation.

### **Storm Sewer Bypass**

Lastly, the stormwater bypass concept as presented by various members of the community was examined to determine if this represents a viable option to convey excess runoff downstream where property damage may be minimized. We examined several locations for the placement of a potential storm sewer bypass beginning in the vicinity of the Pembroke Avenue between its intersections with Midland and Saint David's Road and west of South Aberdeen Avenue at the Saint Katherine Sienna School property. From these locations the bypass would run east toward Encke Park. Three (3) routes were considered and have been depicted on the "Storm Sewer Bypass Conceptual Plan" in the Feasibility Report which

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represent the most viable routes for such a bypass. These include following Saint David's Court, Orchard Way to Meadowbrook Circle, and an option to parallel Ithan Creek. A topographic survey of these areas was completed to determine if adequate slope exists to facilitate this bypass, and storm water profiles were developed for each route which are also included in the Feasibility Study.

After careful consideration of the existing topography, the storm water bypass has been determined to not be feasible for a variety of reasons which are discussed in detail in the Feasibility Study. The major hinderances include issues with constructability, insufficient hydraulic grade, and permitting limitations. As such, this office would not recommend the Township commit further funding to the exploration of this alternative and instead focus efforts on making incremental improvements to the existing stream corridor.

Thank you for the opportunity to present this study. Should you have any questions or require additional information, please feel free to contact this office.

Very truly yours,

CARROLL ENGINEERING CORPORATION

*Christopher Peterson*

Christopher A. Peterson, P.E.

CAP:cam

cc: Dennis Capella, Project Manager, Radnor Township  
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