

HAWTHORNE DRIVE COMPREHENSIVE STORMWATER MANAGEMENT STUDY



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EXECUTIVE SUMMARY

CEDARVILLE Engineering Group, LLC (CEDARVILLE) has performed a Comprehensive Stormwater Management Study (i.e. Study) for Hawthorne Drive within the Culbertson Run development in East Brandywine Township, Chester County, Pennsylvania. The Culbertson Run development has a history of complaints from residents regarding drainage and erosion concerns along Hawthorne Drive. At the request of the Township, CEDARVILLE conducted an assessment to identify the concerns and propose potential solutions.

The residential development was designed in the early 1970s as a community of single family homes, townhomes, and amenities. The Hawthorne Drive Right-of-Way (ROW) originally contained roadside swales to convey drainage (per the Utility Plan last revised June 14, 1976). Street trees that were planted within these swales and have become quite large and an important aesthetic feature within the development. The trees are impeding the functionality of the original drainage system in many locations by interrupting flow patterns and causing sediment deposition that has filled in the swale.

This Study provides four (4) Alternatives to effectively improve the existing stormwater management along Hawthorne Drive, developed based on the results of a resident survey, tree health assessment, existing conditions evaluation, and engineering analysis. Conceptual construction costs for each Alternative were also developed. Factors involved in determining the Alternatives included: impacts to private property, existing landscaping, street trees, potential utility line conflicts, and space restraints (i.e. limited to the existing Hawthorne Drive right-of-way).

The four (4) Alternatives for improving the stormwater management along Hawthorne Drive and associated construction costs are:

- Alternative #1- No-Build (Paving Only) (\$300,000)
- Alternative #2- Site-Specific Recommendations and Improvements (\$93,630 - \$178,450)
- Alternative #3- New Storm Sewer/Curb System (\$250,000 - \$501,000)
- Alternative #4- New Swale System (\$117,000 - \$234,000)

Alternative #1 addresses the existing pavement only, and does not provide any improvement to the existing stormwater management system. This alternative will be necessary when the road surface requires replacement.

Alternatives #2 through #4 will effectively improve the existing stormwater management along Hawthorne Drive. Considering construction costs only, Alternative #2 appears to be the most cost-effective option to manage stormwater while minimizing the impact to private property, existing landscaping, and healthy mature trees. The management strategies described in Alternative #2 include localized green infrastructure Best Management Practices (BMPs), and can either be pursued as stand-alone improvements or comprehensive solutions to the ongoing stormwater runoff concerns. The green infrastructure options in Alternative #2 provide an additional environmental benefit by reducing pollutant loading to Culbertson Run, but present long-term maintenance considerations.

Both Alternatives #3 and #4 would update the drainage system to current design standards including additional stormwater infrastructure such as curbing, inlets, piping, and swales. These Alternatives would adequately address stormwater concerns, but are more costly, require additional tree removal, and potentially require land acquisition for construction.

Each Alternative should be assessed for long-term maintenance considerations including personnel, frequency, and equipment needs. The financial impacts over time should be evaluated by Public Works personnel and crew prior to final determination of action.



1.0 INTRODUCTION

CEDARVILLE Engineering Group, LLC (CEDARVILLE) has performed a Comprehensive Stormwater Management Study (i.e. Study) for Hawthorne Drive within the Culbertson Run development in East Brandywine Township, Chester County, Pennsylvania.

The Culbertson Run development has a history of complaints from residents regarding drainage and erosion concerns along Hawthorne Drive. At the request of the Township, CEDARVILLE conducted a detailed assessment to identify the concerns, analyze their implications, and propose potential solutions.

1.1 BACKGROUND

The residential development was designed in the early 1970s as a community of single family homes, townhomes, and amenities. The Hawthorne Drive Right-of-Way (ROW) originally contained roadside swales to convey drainage (per the Utility Plan last revised June 14, 1976). Street trees that were planted within these swales and have become quite large and an important aesthetic feature within the development. The trees are impeding the functionality of the original drainage system in many locations by interrupting flow patterns and causing sediment deposition that has filled in the swale.

Assessment

In May 2015, CEDARVILLE conducted an assessment of the existing drainage system within the Hawthorne Drive ROW at the request of the Township in response to the drainage complaints by residents of Culbertson Run. During the course of this investigation, areas of localized accelerated erosion in the roadside swales were observed. Other areas of the roadside swales were blocked, or hydraulically disconnected, from the system due to the overgrown root system of the street trees.

Recommendations to the Township included the restoration of the original conveyance (swale) system which involved recreating the original geometric profile of the swale and the removal of street trees in many locations. These recommendations were met with strong opposition from residents of the development, as the street trees are a valued aspect of the community. The memo dated May 6, 2015 documenting this assessment is included in Appendix B.

Preliminary Evaluation and Alternatives Analysis

As a follow-up to the initial assessment, CEDARVILLE completed a preliminary evaluation of the existing drainage conditions and an alternatives analysis for Hawthorne Drive. Four (4) alternatives were presented to the Township in a letter, dated June 16, 2015, which was presented to the East Brandywine Township Board of Supervisors at the Board of Supervisors Meeting on June 17, 2015. This letter is included in Appendix B.

The following alternatives were offered:

- Alternative #1- No-Build (No Cost)
- Alternative #2- Re-establish Swale/Maintenance/Rain Garden Installation (Moderate Cost)
- Alternative #3- New Storm Sewer/Curb System (High Cost)
- Alternative #4- New Swale System (High Cost)



Due to the high cost associated with Alternatives #3 and #4 and the strong public response in favor of tree preservation, it was apparent that a more detailed holistic study of the neighborhood would be required to assess the feasibility of localized green infrastructure solutions while considering the preservation of street trees.

CEDARVILLE prepared a proposal for a Comprehensive Stormwater Management Study (i.e. Study) dated August 13, 2015 and was authorized to proceed by the East Brandywine Township Board at the public meeting on August 19, 2015.

1.2 LOCATION

The Culbertson Run development is located on the northeast side of U.S. Highway 322 (Horseshoe Pike) between Little Washington-Lyndell Road and Guthriesville Road. It is a private residential community whose common areas are owned and operated by Hedgerow Homeowners Association, Inc. (HOA).

Hawthorne Drive is a U-shaped Township-owned and maintained public road, accessed from Horseshoe Pike in two (2) locations. From Hawthorne Drive, there is access to a 185 homes from a number of privately owned and maintained cul-de-sacs: Hedgerow Drive, Hastings Court, Highland Court, Wyndham Court, Windemere Court, Brookfield Court, Lambeth Court, Chapel Court, Cambridge Court, Gloucester Court, Suffolk Court, Canterbury Court, Chatham Court, Somerset Court, and Essex Court.

Refer to the Location Maps in Appendix A for additional details.

2.0 SCOPE & METHODOLOGY

The goal of the Study is to provide the Township with additional information on the original alternatives including associated costs, to effectively improve the existing stormwater management along Hawthorne Drive, while minimizing impacts to private property, existing landscaping and healthy mature trees. To equitably assess potential management strategies, this Study is multi-faceted to identify comprehensive solutions to the ongoing stormwater runoff concerns considering environmental and socio-economic factors. Specifically, the goal is to further develop detailed options within Alternative #2 and provide conceptual design.

The following have been evaluated and fully analyzed as described below:

- Resident Survey
- Tree Health Assessment
- Existing Conditions Evaluation
- Engineering Analysis
- Stormwater Management Alternatives
- Cost Analysis of Localized Alternatives

3.0 RESIDENT SURVEY

CEDARVILLE created an online survey to gain an understanding of the perspective of the residents of Culbertson Run relating to stormwater runoff concerns, street tree removal, stream water quality, and



potential Township land acquisition for ROW expansion to construct additional stormwater Best Management Practices (BMPs).

CEDARVILLE posted the survey online through SurveyMonkey Inc. (www.surveymonkey.com). Residents were notified of the survey by the Hedgerow Homeowners Association (HOA) through the community Facebook page and newsletter. The survey was open from September 22, 2015 until January 31, 2016. Sixteen (16) responses were received during this time. Detailed results are included in Appendix C. Key highlights are presented below.

- 38 percent of respondents felt that their property has been negatively impacted by flooding from stormwater runoff.
- 43 percent of respondents felt that their property has been negatively impacted by erosion from stormwater runoff.
- 56 percent of respondents felt that the roads within Culbertson Run are adversely impacted by stormwater runoff.
- 61 percent of respondents indicated that the roadside swale often overflows during storm events.
- 31 percent of respondents felt that stormwater runoff is a “very serious” problem within the development; while 13 percent felt that it was “not at all” a problem.
- When asked about how the respondent would feel about selective street tree removal:
 - 38 percent of respondents were very against it.
 - 12 percent of respondents were moderately against it.
 - 0 percent of respondent were neutral.
 - 31 percent of respondents moderately supported it.
 - 19 percent of respondents fully supported it.

Overall, the majority of respondents recognized that the roads within the development are adversely impacted by stormwater runoff. The majority of respondents also felt that stormwater runoff is a serious problem within the development. The results of the survey indicate that residents believe there is a capacity and/or conveyance problem with the existing roadside swales.

Respondents were evenly split when considering selective street tree removal as a method to improve stormwater management.

4.0 TREE HEALTH ASSESSMENT

CEDARVILLE contracted Preservation Tree, LLC (Preservation) to conduct an assessment of the health all trees within and immediately adjacent to the Hawthorne Drive ROW. The purpose of the assessment was to identify trees in poor condition and prioritize stormwater improvements in these areas. Two (2) International Society of Arboriculture (ISA) certified arborists performed the assessment in October 2015. The trees were located with GPS and tagged utilizing the Open Tree Map system. The arborists identified the tree species, condition, diameter at breast height (dbh), and approximate height. Any structural, disease, insect, and soil /root crown issues were assessed. Recommendations for long-term maintenance of the trees were also provided.

The condition of each tree was classified as: Excellent, Very Good, Good, Fair, Poor, and Dead. These conditions are defined in Table 7.1 below. CEDARVILLE has incorporated the spatial data provided by Preservation Tree into a Tree Condition Map included in Appendix D.



Table 4.1 Tree Condition Definitions

Condition	Description
Excellent	Near perfect condition; this determination is generally used for trees with no defects and young trees that have been properly maintained.
Very Good	Very good condition with very minor defects that could be corrected by pruning. These trees generally “stand out” with respect to the aesthetic value they add to the Urban Forest.
Good	No major structural problems; no significant damage from diseases or pests; no significant mechanical damage; a full, balanced crown, and normal twig condition and vigor for its species.
Fair	May exhibit the following characteristics: minor structural problems and/or mechanical damage; significant damage from non-fatal or disfiguring diseases; minor crown imbalance or thin crown; minor structural imbalance; or stunted growth compared to adjacent trees.
Poor	May appear healthy, but have structural defects. Includes healthy trees that have unbalanced structures or have been topped. May also have severe mechanical damage, decay, severe crown dieback or poor vigor/failure to thrive.
Dead	In advanced states of decline are not included. Refers only to dead trees.

A total of 149 trees were inventoried. The majority of all trees were determined to be in “Good” (70%) and Fair (20%) condition; a small percentage of trees were determined to be in “Poor” condition (9%); and only 1% were determined to be in “Excellent” condition. No trees were identified as “Very Good” or “Dead”.

The dominant species present within the ROW was determined to be London planetree (*Platanus acerifolia*), which comprised 67% (101 trees) of the total number of trees surveyed. All of these trees were found to be in Good (93%) or Fair (7%) condition. The trees that were found to be in Fair condition were due to phototropic lean in heavily shaded areas, poor pruning, storm damage and/or mower damage. Some of the root plates were noted to have been comprised due to excessive storm flow. A breakdown of all tree species identified and their condition is provided in Table 7.2 below.

Table 4.2 Tree Species Observed within Hawthorne Drive ROW

TREE SPECIES		CONDITION (Number of Trees)						Total #
Common Name	Latin Name	Excellent	Very Good	Good	Fair	Poor	Dead	
Japanese maple	<i>Acer palmatum</i>	0	0	0	1	0	0	1
Red maple	<i>Acer rubrum</i>	0	0	1	3	2	0	6
Pignut hickory	<i>Carya glabra</i>	0	0	0	1	0	0	1
Shagbark hickory	<i>Carya ovata</i>	0	0	0	2	0	0	2
American beech	<i>Fagus grandifolia</i>	0	0	1	0	0	0	1
White ash	<i>Fraxinus americana</i>	0	0	0	2	1	0	3
Black walnut	<i>Juglans nigra</i>	0	0	0	1	0	0	1
Crabapple	<i>Malus tschonoskii</i>	0	0	0	0	1	0	1
Black tupelo	<i>Nyssa sylvatica</i>	0	0	1	0	0	0	1
Blue spruce	<i>Picea pungens</i>	0	0	1	2	1	0	4
Spruce	<i>Picea sp.</i>	0	0	0	1	0	0	1
Eastern white pine	<i>Pinus strobus</i>	1	0	6	1	0	0	8
Cherry	<i>Prunus sp.</i>	0	0	0	2	7	0	9
London planetree	<i>Platanus acerifolia</i>	0	0	94	7	0	0	101
Douglas fir	<i>Pseudotsuga menziesii</i>	0	0	0	1	0	0	1
White oak	<i>Quercus alba</i>	1	0	0	0	0	0	1
Eastern hemlock	<i>Tsuga canadensis</i>	0	0	0	6	1	0	7
TOTALS		2	0	104	30	13	0	149



For all trees classified as Fair or Poor, it is recommended that these trees undergo treatment, pruning, or preemptive removal.

The complete arborist report and supporting data from Preservation is included in Appendix E.

5.0 EXISTING CONDITIONS ON-SITE EVALUATION

Prior to recommending design alternatives for any structural or non-structural stormwater Best Management Practices for Hawthorne Drive, CEDARVILLE evaluated the existing condition of road drainage along Hawthorne Drive. This evaluation was performed to identify any deficiencies in the structural integrity of the roadside swale and stormwater management system (i.e. pipes and inlets).

This existing conditions evaluation included the field assessment of Hawthorne Drive by a CEDARVILLE Construction Inspector on October 12, 2015 and Design Engineer on January 10, 2016. During both inspections, areas were identified where the existing stormwater structures are not functioning as originally intended due to physical obstructions or constraints and where maintenance or repairs are necessary. The results are detailed below in Table 5.1. The inspection reports are included in Appendix F.

5.1 EXISTING STRUCTURES

The majority of the existing stormwater structures located within Hawthorne Drive ROW require some level of maintenance, mainly due to sediment and debris accumulation. Also, it is apparent that the stormwater is not being directed properly into the existing infrastructure, as the roadside swales are not functioning as intended.

The following table summarizes the observations of the existing stormwater structures within the Hawthorne Drive ROW:

Table 5.1 Stormwater Structures Inspection Results

Structure ID & Size	Location	Structure Conditions	Associated Photos in Appendix E	Corrective Actions reported by Field Inspection
INLET #1 (4'X4' Brick)	Between north entrance of Hawthorne Dr & Clubhouse Rd	Sediment/debris approx. 1' deep	Photo 2	Clean out sediment/debris from bottom of inlet box
INLET #2 (2.5'X4' Brick)	SW corner of Highland Ct	Sediment/debris approx. 1' deep	Photo 4	Clean out sediment/debris from bottom of inlet box
INLET #3 (4'X4' Brick)	NE corner of Wyndham Ct	Sediment/debris approx. 1' deep	Photo 5	Clean out sediment/debris from bottom of inlet box
Outfall from INLET #3 (12" CMP)	143 Brookfield Ct	Sediment/debris at the bottom of pipe	Photo 6	Add topsoil over the top of 12" CMP outlet for about 5 feet from end of pipe and minor grading
INLET #4 (2.5'X4' Brick)	SW corner of Windemere Ct	Sediment/debris approx. 1' deep	Photo 7	Clean out sediment/debris from bottom of inlet box
INLET #5 (2'X3' Brick)	NE corner of Brookfield Ct	Sediment/debris approx. 1' deep	Photo 8	Clean out sediment/debris from bottom of inlet box



Table 5.1 Stormwater Structures Inspection Results (continued)

Structure ID & Size	Location	Structure Conditions	Associated Photos in Appendix E	Corrective Actions reported by Field Inspection
INLET #6 (2'X4' Concrete)	NE corner of Lambeth Ct	Sediment/debris approx. 1' deep	Photo 9	Clean out sediment/debris from bottom of inlet box
INLET #7 (2'X4' Brick)	SE corner of 122 Lambeth Ct	Sediment/debris approx. 1' deep	Photo 10	Clean out sediment/debris from bottom of inlet box
INLET #8 (2'X4' Brick)	NE corner of 23 Windemere Ct	Sediment/debris approx. 1' deep	Photo 11	Clean out sediment/debris from bottom of inlet box
INLET #9 (2'X4' Concrete)	NW corner of Canterbury Ct	Sediment/debris approx. 1' deep	Photo 15	Clean out sediment/debris from bottom of inlet box
INLET #10 (2'X4' Concrete)	NW corner of Chatham Ct	Sediment/debris approx. 1' deep	Photo 16	Clean out sediment/debris from bottom of inlet box
HEADWALL #1 (Concrete)	Between north entrance of Hawthorne Dr & Clubhouse Rd	Satisfactory	Photo 1	None
ENDWALL #1 (Concrete)	Between north entrance of Hawthorne Dr & Clubhouse Rd	75% of 15" CMP is covered with sediment/debris	Photo 3	Clean out sediment/ debris from bottom of pipe and minor regrading
HEADWALL #2 (Concrete)	Between Cambridge Ct & Suffolk Ct	Satisfactory	Photo 12	None
CULVERT (42" CMP)	Between Canterbury Ct & Gloucester Ct	42" CMP bottom rusting/corroded, pipe has lost its structural integrity; chance of collapse	Photo 14	Replace entire length of 42" CMP
ENDWALL #2 (Concrete)	Between Canterbury Ct & Gloucester Ct	Sediment, debris & rocks at the end of 42" CMP, riprap apron full of sediment	Photo 13	Install new riprap & clean out the vicinity of Endwall #2

5.2 ROADSIDE SWALES

The existing drainage system along Hawthorne Drive was developed with stormwater controls that are not functioning effectively and are outdated compared to the standards of today. The primary stormwater control is roadside swales discharging to inlets. Roadside swales function solely as conveyance structures and provide little to no stormwater volume and velocity control. These roadside swales have subsequently filled in with sediment throughout the much of the Hawthorne Drive ROW. The street trees planted within the ROW inhibit the functionality of these swales as conveyances by blocking the flow path.



The reduction of capacity in the stormwater structures and conveyance swales result in flash flooding conditions during storm events, creating the potential for accelerated erosion within the ROW and adjoining properties. The field assessment of the drainage concerns within the Hawthorne Drive ROW revealed the following observations relating to the roadside swales:

- High runoff velocity occurring on steep slopes
- Lack of vegetation and poor swale stabilization
- Flow volume spilling out of the existing swale
- Obstructions within swale (vegetation, tree roots and trash/debris)
- Maintenance needed

Specific locations where accelerated erosion or washout areas were observed include:

- Washout areas along the east side of Hawthorne Drive approaching Hedgerow Court
- Accelerated erosion along the west side of Hawthorne Drive approaching Hastings Court
- Washout areas along the east side of Hawthorne Drive approaching Highland Court
- Accelerated erosion along the west side of Hawthorne Drive approaching Wyndham Court
- Accelerated erosion along the north side of Hawthorne Drive approaching Lambeth Court
- Washout area along the north side of Hawthorne Drive approaching Chapel Court
- Accelerated erosion along the west side of Hawthorne Drive approaching Headwall #2
- Washout area along the east side of Hawthorne Drive approaching Endwall # 2
- Washout area along the east side of Hawthorne Drive approaching Canterbury Court
- Washout area with debris along the east side of Hawthorne Drive approaching Chatham Court
- Accelerated erosion along the east side of Hawthorne Drive approaching Essex Court

These areas can be viewed in Photos 17 through 30 in Appendix G.

6.0 ENGINEERING ANALYSIS

The purpose of this engineering analysis is to evaluate existing drainage and flooding concerns within the Hawthorne Drive ROW (i.e. study area) and provide recommendations to East Brandywine Township for stormwater improvements. Specifically, the focus is to obtain information to develop small to medium-scale drainage solutions to reduce the frequency and duration of flooding.

6.1 TOPOGRAPHIC ANALYSIS & SURVEY

The topography within the study area ranges from 470 to 560 feet above mean sea elevation. Generally, the topography slopes to the northeast towards Culbertson Run from the highest point located north of Hawthorne Drive, just east of Horseshoe Pike. An unnamed tributary to Culbertson Run flows through the southcentral portion of the Culbertson Run Development in an east-northeasterly direction from Horseshoe Pike to Hawthorne Drive and continues offsite to the northeast.

Topography and detailed flow direction within the study area, on the Flow Direction Map are included in both Appendix H and on the Stormwater Concept Plan in Appendix N.

The entire project is located within the Culbertson Run watershed. The southeastern portion of the development drains to the northeast into the unnamed tributary to Culbertson Run. The rest of the development drains to the north into an existing stormwater management basin, discharging to an unnamed tributary to Culbertson Run. The Topographic Location Map is included in Appendix A.



Culbertson Run is designated as a High Quality-Trout Stocked Fishery (HQ-TSF) by Chapter 93 of the Pennsylvania Code. It has also been identified by the Pennsylvania Department of Environmental Protection (DEP) as not attaining its designated use or “impaired” due to siltation and habitat alterations.

A detailed survey of the Hawthorne Drive ROW was performed by Ash Associates, Inc. in October 2015, which is included on the Stormwater Concept Plan in Appendix N. Existing LIDAR 2-foot contour data was analyzed for all areas outside the ROW. LIDAR data was obtained from the PAMAP Program, PA Department of Conservation and Natural Resources, Bureau of Topographic and Geologic Survey (October 22, 2010). This information, along with observations made during the field assessments, were utilized to delineate drainage areas to Points of Interest (POI) in the Hydrologic Analysis described in Section 6.4 below.

6.2 LAND COVER

Land cover within each drainage area was assessed utilizing aerial basemap imagery in ArcMap 10.3 and impervious coverage GIS data from the Chester County Consortium provided by East Brandywine Township. The drainage areas are all composed of single family homes, townhomes, driveways, roads, other impervious coverage (sheds, walkways, patios, etc.), and maintained lawn.

For the purposes of the Hydrologic Analysis, any non-impervious coverage areas were assumed to be open space, good condition. The Drainage Area Map is included in Appendix I.

6.3 SOILS

The study area consists entirely of Urban Land-Glenelg complex, 0 to 8 percent slopes (UrmB) (USDA NRCS. SSURGO database, 2014). The UrmB soil map unit is comprised of approximately 65 percent Urban land, 30 percent Glenelg and similar soils, and five (5) percent minor components.

Urban land is pavement, buildings, and other land influenced by anthropogenic activities. The depth to a restrictive feature ranges from 10 to 99 inches to lithic bedrock. The available water storage in the soil is very low.

Glenelg soils formed from residuum weathered from mica schist. The soils are well drained, the depth to a restrictive feature is 60 to 120 inches to paralithic bedrock, and the depth to water table is greater than 80 inches. The available water storage in the soil is high.

Urban land does not have a Hydrologic Soil Group classification. Glenelg soils are classified as Hydrologic Soil Group B. Hydrologic Soil Group B is described by the NRCS as having a moderate infiltration rate when thoroughly wet, or a moderate rate of water transmission.

A detailed on-site soil investigation was not performed.

The soil map and all associated tables are included in Appendix J.

6.4 HYDROLOGIC ANALYSIS

To accurately consider the potential drainage improvements in Alternative # 2, CEDARVILLE performed hydrologic analyses to estimate runoff volume present in or conveyed by natural and engineered water systems such as channels and culverts.



Localized drainage issues and flooding are influenced by the hydrology and hydraulics of a drainage area. The hydrology of a drainage area is dependent on natural factors, such as topography, existing land use, impervious area, soil types, and rainfall. Hydraulic systems include stormwater conveyance structures (e.g., storm sewers, swales) that collect and transport stormwater runoff. Catch basins, stormwater inlets, swales, pipes, culverts, and other stormwater conveyance structures must be cleaned on a regular basis to maintain hydraulic function. Materials that can hinder hydraulic function include accumulated sediments, debris, vegetation, trash, and fallen tree limbs.

Methodology

A hydrologic analysis was performed for selected Points of Interest (POI) within the study area. The POIs were focused mainly at existing infrastructure (i.e. inlets). Drainage areas to each POI were delineated and impervious coverage quantified based on the information provided in Sections 6.2 and 6.3. Peak rate (runoff) was calculated utilizing the Rational Method. Hydraflow Hydrographs (Autodesk Inc.) were utilized to develop hydrographs for the 1, 2, 5, 10, 25, 50, and 100-year storm events for existing land use conditions.

The rainfall intensities for 24-hour storm events consistent with appropriate Times of Concentration (ToC) were obtained from the National Oceanic and Atmospheric Administration (NOAA) Atlas 14, Volume 2, Version 3 for the Culbertson Run watershed. ToC computations were calculated utilizing the NRCS TR-55 methodology. Runoff coefficients (C) for the existing conditions for use in the Rational Method were obtained from East Brandywine Township's Stormwater Management Ordinance. Design parameters (rainfall intensities, ToC, and runoff coefficients) can be found in Appendix K.

For the purposes of calculating the required surface runoff evaluations, thirteen (13) watershed design POIs have been established to correspond to strategic points of discharge from the study area with a total drainage area of 18.20 acres. A graphical breakdown of the above-referenced evaluation areas and the hydrologic report summarizing the results of the hydrologic analysis is included in Appendix K.

The hydraulics of existing storm sewer and inlets were investigated using Hydraflow Stormsewers by Autodesk Inc. for the 25-year storm event. The full-flow capacity of existing storm drain systems was computed using Manning's equation. Where pipe slopes were not known, slopes were assumed based on existing topography and knowledge of similar piped systems. Slopes were assumed to match road slopes and to have similar slopes to those systems for which survey data was available. The hydraulic report summarizing the results of the hydraulic modeling and analysis is included in Appendix K.

Results

The results of the hydrologic and hydraulic analysis were used to develop solutions for the recommendations in Alternative #2. The peak flow runoff and volume calculations conforms the field reconnaissance engineering judgements in the Existing Conditions On-Site Evaluation section above.

Based on the hydraulic analysis performed, the majority of existing storm drain systems (excluding 15-inch CMP from Inlet #10) has adequate capacity to convey the 25-year, 24-hour storm events. The existing 15-inch CMP from Inlet #10 is undersized for the 25-year event, resulting in a calculated inlet spread (i.e. width of water impacting road surface) of approximately thirty (30) feet encroaching the Hawthorne Drive roadway.

Table 6.1 presents the results of the hydrologic analysis for 25-year storm event and briefly describes these watersheds and associated design points.



Table 6.1 Existing Conditions Peak Flow

POI	Structure ID	Drainage Area (ac)	Runoff at POI (25 year)
POI-1	INLET#10	6.17	10.73 cfs
POI-2	INLET#9	3.11	5.21 cfs
POI-3	ENDWALL #2	1.08	4.33 cfs
POI-4	INLET#7	0.60	2.45 cfs
POI-5A	INLET#5	0.22	0.74 cfs
POI-5B	INLET#6	0.11	0.61 cfs
POI-6	INLET#3	0.93	4.45 cfs
POI-7	INLET#1	0.30	1.83 cfs
POI-8	ENDWALL #1	0.26	1.13 cfs
POI-9	INLET#2	0.20	0.72 cfs
POI-10	INLET#4	0.76	2.67 cfs
POI-11	INLET#8	3.58	7.57 cfs
POI-12	HEADWALL #2	0.88	4.89 cfs

The hydrologic and hydraulic modeling revealed high peak flow and large inlet spreads in the following areas that required major focus and are addressed in the following section (Section 7.0 Stormwater Management Alternatives):

- POI-1 (Inlet#10), between Essex Court and Chatham Court
- POI-2 (Inlet#9), between Chatham Court and Canterbury Court
- POI-6 (Inlet#3), between Hastings Court and Wyndham Court
- POI-10 (Inlet#4), between Highland Court and Windemere Court
- POI-11 (Inlet#8), between Windemere Court and Cambridge Court

7.0 STORMWATER MANAGEMENT ALTERNATIVES

The goal for this study is to identify, evaluate, and recommend potential solutions for drainage deficiencies in the Culbertson Run Development. The following alternatives are offered to restore the functionality of the original drainage system along Hawthorne Drive. Options for improving the drainage system are complex due to the restrictions in the existing width of the ROW, utility line conflicts, and the presence of street trees within the roadside swales.

A brief description and positive and negative impacts of each alternative is included below. Detailed options have been developed within Alternative #2 and are described thoroughly. Each proposed alternative was assessed considering the following:

- Construction easement requirements
- Maintenance considerations
- Utility conflicts
- Potential impact to trees
- Conceptual construction cost
- Effectiveness and ability of proposed solution to solve existing drainage concerns

The conceptual construction costs were developed based on engineering judgment and do not include design engineering and permitting. Typical unit costs are based on contractor estimates and/or unit price data for recent projects in Chester County, Pennsylvania.



These recommendations are for planning purposes and do not take into account all design limitations, including: cover requirements, structure placement, and detailed information regarding utility conflicts. If any of these alternatives are pursued, additional design will be required to determine pipe slopes, cover availability, and structure locations and elevations.

7.1 ALTERNATIVE #1- NO-BUILD

This alternative consists solely of re-paving Hawthorne Drive and not addressing the erosion concerns raised by residents. For planning purposes, the conceptual cost of paving has been estimated as \$100 per linear foot for a total of \$300,000.

Positives: No tree removal required.
Low cost.

Negatives: Does not address the ongoing drainage concerns of the residents.
Road deterioration caused by not unaddressed drainage concerns.
Allows for the potential of increased sediment load into Culbertson Run.

7.2 ALTERNATIVE #2- SITE SPECIFIC RECOMMENDATIONS AND IMPROVEMENTS

The focus of Alternative #2 was to develop the most appropriate and cost-effective small to medium scale drainage solutions to reduce the frequency and duration of flooding given current site conditions, while considering all site constraints. An estimated 30 to 40 trees in Good condition, 2 to 5 trees in Fair condition, and 4 trees in Poor condition would require removal under this alternative (a total of 36 to 49 trees). A detailed Summary Chart of Alternative #2 is presented in Appendix L.

This alternative involved identifying concerns at specific locations and then providing recommendations. These recommendations include: general maintenance, boulder and/or tree removal; and design improvement options such as re-establishing the existing roadside swale, or constructing linear infiltration trenches or bioswales within the ROW to address these issues. Design improvement options are based on best engineering judgment resulting from the field assessments and hydrologic analyses, directly correlating with the strategic POI.

The specific locations identified for modifications include the following structures: Inlets #1 through Inlet #10, Headwall #2, and Endwall #2. The recommendations and design improvements relate to the structure itself and areas owned by East Brandywine Township (i.e. Hawthorne Drive ROW) or the Culbertson Run HOA within the drainage area of each structure and are described in detail below. Options are included in the Alternative #2 Stormwater Concept Plan in Appendix N.

INLET #1

Inlet #1 is located between the north entrance of Hawthorne Drive and Hedgerow Court. Inlet #1 is a part of a headwall (Headwall #1) and endwall (Endwall #1) pipe system connected with a 15-inch CMP. Due to limited space and lower peak flow rates, specific improvements have not been generated.

Concerns

The roadside swale along both sides of Hawthorne Drive from the north entrance of Hastings Court to Hedgerow Court leading to Inlet #1 are poorly defined and contain trees acting as physical barriers. Indications of accelerated erosion are present.



From the northwest entrance of Hawthorne Drive to Hedgerow Court, the swale is poorly defined and there are boulders acting as physical barriers to stormwater flows within swale. There is a wood rail tie at the edge of Hedgerow Court, obstructing flows. In addition, there is significant sediment and debris accumulation in Inlet #1 and associated structures (15-inch BMP, Headwall #1, and Endwall #1).

Also, per the survey information, the 'invert out' elevation at Endwall #1 is higher than 'invert in' at Headwall #1, inhibiting proper drainage.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 800 feet of roadside swale along both sides of Hawthorne Drive from the north entrance of Hastings Court to the north entrance of Hawthorne Drive. In order to effectively re-establish the swale, the boulders, five (5) trees (Good condition) and wood rail tie should be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The 15-inch CMP from Inlet #1 to Endwall #1 should be replaced with 15-inch HDPE and the 'invert out' elevation lowered. The accumulated sediment and debris in Inlet #1, Headwall #1, and Endwall #1 should be removed. The swale at the outflow of Endwall #1 should be regraded and restabilized as required for proper drainage.

These recommendations would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing the conveyance capacity from localized runoff within the study area.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Potential utility conflicts.
Temporary construction easement may be required.

INLET #2

Inlet #2 is located at the southwest corner of Highland Court on Hawthorne Drive. No design improvement options were identified for this location due to limited space and lower peak flow rates.

Concerns

There is trash and debris blocking the inlet grate, and approximately one (1) foot of sediment accumulation in the inlet box, decreasing capacity,

Recommendations

It is recommended that the sediment, trash, and debris be removed from the inlet box and grate opening.

These recommendations would allow ponding water on Hawthorne Drive to properly drain.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: None.



INLET #3

Inlet #3 is located at northeast corner of Wyndham Court on Hawthorne Drive.

Concerns

The roadside swale along both sides of Hawthorne Drive from the north entrance of Hastings Court to Wyndham Court are poorly defined and contain trees acting as physical barriers to stormwater flow. Indications of accelerated erosion are present. Also, the hydrologic and hydraulic modeling revealed a high peak flow and large inlet spread in this location.

In addition, there is approximately one (1) foot of sediment and debris accumulation in the Inlet #3, as well as an accumulation of sediment/debris at the outfall of the 12-inch CMP (located at 143 Brookfield Court) where Inlet #3 discharges.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 220 feet of roadside swale along the western side of Hawthorne Drive from the north entrance of Hastings Court to Wyndham Court. In order to effectively re-establish the swale, ten (10) trees (Good condition) should be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The accumulated sediment and debris in the Inlet #3 box and at the 12-inch CMP outfall (located at 143 Brookfield Court) should be removed. Topsoil should be added with minor grading over the top of 12-inch CMP, as it has eroded. This area should be seeded and stabilized with erosion control blanket.

Design Improvement Options

Two (2) design improvement options were identified for this location and can be implemented in lieu of, or in addition to re-establishing the roadside swales: a linear 80' x 3' x 3' infiltration trench with new inlet box or a linear 80' x 2' x 3' bioswale with new inlet box within the Hawthorne Drive ROW. If either design improvement option were installed in lieu of re-establishing the roadside swale, only five (5) trees (Good condition) would require removal.

The proposed recommendations and design improvement options would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing both the conveyance capacity and storage from localized runoff within the within the study area.

- | | |
|-------------------|--|
| Positives: | Will adequately address the ongoing drainage concerns of the residents.
Improve stormwater quality within Culbertson Run watershed. |
| Negatives: | Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Potential utility conflicts.
Temporary construction easement may be required. |

INLET #4

Inlet #4 is located at southwest corner of Windemere Court on Hawthorne Drive.



Concerns

The roadside swale along the eastern side of Hawthorne Drive from Highland Court to Windemere Court are poorly defined and contain trees acting as physical barriers. Indications of accelerated erosion are present. Also, the hydrologic and hydraulic modeling revealed a high peak flow and large inlet spread in this location.

In addition, there is approximately one (1) foot of sediment and debris accumulation in the Inlet #4 box.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 240 linear feet of roadside swale along the eastern side of Hawthorne Drive from Highland Court to Windemere Court. In order to effectively re-establish the swale, one (1) tree (Fair condition) should be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The accumulated sediment and debris in the Inlet #4 box should be removed.

Design Improvement Options

Two (2) design improvement options were identified for this location and can be implemented in lieu of, or in addition to re-establishing the roadside swales: a linear 120' x 3' x 3' infiltration trench with new inlet box or a linear 120' x 2' x 3' bioswale with new inlet box within the Hawthorne Drive ROW.

The proposed recommendations and design improvement options combined would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing both the conveyance capacity and storage from localized runoff within the within the study area.

- Positives:** Will adequately address the ongoing drainage concerns of the residents.
Improve stormwater quality within Culbertson Run watershed.
- Negatives:** Tree removal may be required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Potential utility conflicts.
Temporary construction easement may be required.

INLET #5

Inlet #5 is located at the northeast corner of Brookfield Court on Hawthorne Drive. No design improvement options were identified for this location due to limited space and lower peak flow rates.

Concerns

There is trash and debris blocking the inlet grate, and approximately one (1) foot of sediment accumulation in the inlet box, decreasing capacity,

Recommendations

The sediment, trash, and debris in the inlet box and grate opening should be removed to allow ponding water on Hawthorne Drive to properly drain.

- Positives:** Will adequately address the ongoing drainage concerns of the residents.
- Negatives:** None.



INLET #6

Inlet #6 is located at the northeast corner of Lambeth Court on Hawthorne Drive.

Concerns

The roadside swale along the western side of Hawthorne Drive from Brookfield Court to Lambeth Court are poorly defined and contain trees acting as physical barriers. Indications of accelerated erosion are present.

In addition, there is approximately one (1) foot of sediment and debris accumulation in the Inlet #6 box.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 160 linear feet of roadside swale along the western side of Hawthorne Drive from Brookfield Court to Lambeth Court. In order to effectively re-establish the swale, five (5) trees (Good condition) should be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The accumulated sediment and debris in the Inlet #6 box and grate opening should be removed.

These recommendations would allow ponding water on Hawthorne Drive to drain.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.

INLET #7

Inlet #7 is located at the southeast corner of 122 Lambeth Court on Hawthorne Drive.

Concerns

There is approximately one (1) foot of sediment and debris accumulation in the Inlet #7 box. Also, runoff does not appear to be adequately directed into this inlet.

Recommendations

The accumulated sediment and debris in the Inlet #7 box and grate opening should be removed. Approximately 240 feet of rolled curb should be installed from Lambeth Court to Chapel Court to direct runoff into this inlet.

These recommendations would allow ponding water on Hawthorne Drive to drain and protect downslope properties (121 & 122 Lambeth Court) from flooding.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: None.

INLET #8

Inlet #8 is located at northeast corner of 23 Windemere Court on Hawthorne Drive.



Concerns

The roadside swale along the eastern side of Hawthorne Drive from Windemere Court to Cambridge Court is poorly defined and contains trees acting as physical barriers. Indications of accelerated erosion are present. Also, the hydrologic and hydraulic modeling revealed a high peak flow and large inlet spread in this location.

In addition, there is approximately one (1) foot of sediment and debris accumulation in the Inlet #8 box.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 360 feet of roadside swale along the eastern side of Hawthorne Drive from Windemere Court to Cambridge Court. In order to effectively re-establish the swale, five (5) trees (Good condition) should be removed, and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The accumulated sediment and debris in the Inlet #8 box should be removed.

Design Improvement Options

Two (2) design improvement options were identified for this location and can be implemented in lieu of, or in addition to re-establishing the roadside swales: a linear 360' x 3' x 3' infiltration trench with new inlet box or a linear 360' x 2' x 3' bioswale with new inlet box within the Hawthorne Drive ROW.

The proposed recommendations and design improvement options combined would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing both the conveyance capacity and storage from localized runoff within the within the study area.

- | | |
|-------------------|--|
| Positives: | Will adequately address the ongoing drainage concerns of the residents.
Improve stormwater quality within Culbertson Run watershed. |
| Negatives: | Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Potential utility conflicts.
Temporary construction easement may be required. |

INLET #9

Inlet #9 is located at northwest corner of Canterbury Court on Hawthorne Drive.

Concerns

The roadside swale along the eastern side of Hawthorne Drive from Canterbury Court to Chatham Court is poorly defined and contains trees acting as physical barriers. Indications of accelerated erosion are present. Also, the hydrologic and hydraulic modeling revealed a high peak flow and large inlet spread in this location.

In addition, there is approximately one (1) foot of sediment and debris accumulation in the Inlet #9 box.



Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 350 linear feet of roadside swale along the eastern side of Hawthorne Drive from Canterbury Court to Chatham Court. In order to effectively re-establish the swale, six (6) trees (5 Good/1 Fair condition) should be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The accumulated sediment and debris in the Inlet #9 box should be removed.

Design Improvement Options

Two (2) design improvement options were identified for this location and can be implemented in lieu of, or in addition to re-establishing the roadside swales: a linear 120' x 3' x 3' infiltration trench with new inlet box or a linear 120' x 2' x 3' bioswale with new inlet box within the Hawthorne Drive ROW. If either design improvement option were installed in lieu of re-establishing the roadside swale, only two (2) trees (good condition) would require removal.

The proposed recommendations and design improvement options combined would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing both the conveyance capacity and storage from localized runoff within the within the study area.

- Positives:** Will adequately address the ongoing drainage concerns of the residents.
Improve stormwater quality within Culbertson Run watershed.
- Negatives:** Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Potential utility conflicts.
Temporary construction easement may be required.

INLET #10

Inlet #10 is located at northwest corner of Chatham Court on Hawthorne Drive.

Concerns

The roadside swale along the eastern side of Hawthorne Drive from Chatham Court to south entrance of Hawthorne Drive is poorly defined and contains trees acting as physical barriers. Indications of accelerated erosion are present. Also, the hydrologic and hydraulic modeling revealed a high peak flow and large inlet spread in this location.

In addition, there is approximately one (1) foot of sediment and debris accumulation in the Inlet #10 box.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 290 linear feet of roadside swale along the eastern side of Hawthorne Drive from Chatham Court to the south entrance of Hawthorne Drive and 110 linear feet along the western side of Hawthorne Drive from the south entrance of Hawthorne Drive. In order to effectively re-establish the swale, ten (10) trees (7 Good/3 Fair condition) should be removed and the swale regraded as necessary to establish conveyance. Four (4) Poor condition trees at the entrance of the community should also be removed. The swale should be seeded and stabilized with a medium grade erosion control blanket.



The accumulated sediment and debris in the Inlet #10 box should be removed.

Design Improvement Options

Two (2) design improvement options were identified for this location and can be implemented in lieu of, or in addition to re-establishing the roadside swales: a linear 180' x 3' x 3' infiltration trench with new inlet box or a linear 180' x 2' x 3' bioswale with new inlet box within the Hawthorne Drive ROW. If either design improvement option were installed in lieu of re-establishing the roadside swale, only seven (7) trees (good condition) would require removal.

Two (2) offsite improvement options were also identified. The first option includes the installation of new offsite inlets along Clearview Drive, just south of Horseshoe Pike, and directing this runoff to the existing basin northwest of Clearview Drive and southwest of Horseshoe Pike with a new HDPE pipe section and endwall. The second option includes the installation of new offsite inlets along Clearview Drive, just south of Horseshoe Pike, and directing this runoff into the existing PennDOT storm sewer system.

The proposed recommendations and design improvement options combined would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing both the conveyance capacity and storage from localized runoff within the within the study area.

- Positives:** Will adequately address the ongoing drainage concerns of the residents.
Improve stormwater quality within Culbertson Run watershed.
- Negatives:** Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Potential utility conflicts.
Temporary construction easement may be required.
PennDOT Construction permit required.
Potential coordination with additional private property owners (Clearview Drive)

HEADWALL #2

Headwall #2 is located on an HOA-owned property on the western side of Hawthorne Drive between Cambridge Court and Suffolk Court, and connects a deteriorating 42-inch CMP under Hawthorne Drive with Endwall #2. The 42-inch CMP receives drainage from outside of the study area and was not considered in the hydrologic and hydraulic modeling. Headwall #2 is in a satisfactory condition. .

Concerns

The roadside swale along the western side of Hawthorne Drive from Cambridge Court to Somerset Court is poorly defined and contain trees acting as physical barriers. Indications of accelerated erosion are present.

In addition, there is sediment and debris accumulation at Headwall #2.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 690 linear feet of roadside swale along the western side of Hawthorne Drive from Cambridge Court to Somerset Court. In order to effectively re-establish the swale, three (3) trees (Good condition) should



be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a minimum of North American Green (NAG) P300 erosion control blanket.

The accumulated sediment and debris at Headwall #2 should be removed.

These recommendations would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing the conveyance capacity within the within the study area.

- Positives:** Will adequately address the ongoing drainage concerns of the residents.
- Negatives:** Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Temporary construction easement may be required.

ENDWALL #2

Endwall #2 is located on a HOA-owned property on the eastern side of Hawthorne Drive between Gloucester Court and Canterbury Court and connects the deteriorating 42-inch CMP under Hawthorne Drive with Headwall #2.

Concerns

The roadside swale along eastern side of Hawthorne Drive between Gloucester Court and Canterbury Court is poorly defined and contain trees acting as physical barriers. Signs of accelerated erosion are present.

In addition, there is sediment and debris accumulation at the end of 42-inch CMP at Endwall #2 and in the riprap apron at Endwall #2. The bottom of the 42-inch CMP is rusted away and has lost its structural integrity. As a result, it may be subject to the threat of collapse.

Recommendations

The concerns identified above should be addressed through the re-establishment of approximately 310 linear feet of roadside swale along the eastern side of Hawthorne Drive between Gloucester Court and Canterbury Court. In order to effectively re-establish the swale, one (1) tree (Fair condition) should be removed and the swale regraded as necessary to establish conveyance. The swale should be seeded and stabilized with a medium grade erosion control blanket.

The accumulated sediment and debris at Endwall #2 should be removed. The entire length of the 42-inch CMP should be replaced with a 42-inch RCP. The rip-rap apron at Endwall #2 should also be replaced and the immediate surrounding area regraded and revegetated.

These recommendations would reduce the frequency and duration of water ponding on and adjacent to this section of Hawthorne Drive by increasing the conveyance capacity within the study area.

- Positives:** Will adequately address the ongoing drainage concerns of the residents.
- Negatives:** Tree removal required.
Re-establishing swales will likely impact the root systems of the healthy trees.
Grading may impact private property.
Temporary construction easement may be required.
Permitting required for CMP replacement.



7.2.1 ALTERNATIVE #2 COSTS

Alternative #2 conceptual construction cost estimates by linear foot are included in Table 7.1 below. Total construction cost estimates by proposed improvement are included in the Summary Chart in Appendix L. Maintenance items specified in the Recommendations sections above (sediment removal, etc.) were not considered. Construction costs with utility conflicts considered reflect a 25 to 100 percent cost increase, due to the uncertainty of the complexities of potential relocations.

Table 7.1 Alternative #2 Conceptual Construction Unit (per linear foot) Cost Estimates

Design Improvement Option	Conceptual Construction Cost (per LF)	Conceptual Construction Cost if Utility Conflicts (per LF)
Re-establish Swales	\$14.00	\$17.50 - \$28.00
Infiltration Trench	\$48.00	\$60.00 - \$96.00
Bioswale	\$40.00	\$50.00 - 80.00
New Inlet	\$5,000.00	\$5,000.00

Total costs as stand-alone improvements are presented below. Please note that these are options and can be implemented in conjunction with one another. A cost comparison is provided in the chart below.

Table 7.2 Alternative #2 Conceptual Construction Cost Comparison

Design Improvement Option	Total Conceptual Construction Cost	Total Conceptual Construction Cost if Utility Conflicts
Re-establish Swales	\$47,740	\$59,675 - 95,480
Infiltration Trenches (including new inlet)	\$66,280	\$82,850 - 132,560
Bioswales (including new inlet)	\$59,400	\$74,250 - 118,800
Replace 12" CMP at Inlet #1	\$8,340	N/A
Replace 42" CMP between Headwall #2 and Endwall #2	\$37,550	N/A

7.2.2 ALTERNATIVE #2 ENVIRONMENTAL BENEFITS

As mentioned in Section 6.1, the entire project is located within the Culbertson Run watershed. Culbertson Run is designated as a High Quality-Trout Stocked Fishery (HQ-TSF) by Chapter 93 of the Pennsylvania Code. It has also been identified by the Pennsylvania Department of Environmental Protection (DEP) as not attaining its designated use or "impaired" due to siltation and habitat alterations.

The Design Improvement Options described above (infiltration trenches and bioswales) provide a stormwater volume and velocity reduction function; and subsequently, also remove pollutants such as sediments and nutrients (phosphorous and nitrogen) through subsurface filtration.

It is anticipated that East Brandywine Township will be required to develop a Pollutant Reduction Plan (PRP) for sediment for Culbertson Run under the new 2018 National Pollution Discharge Elimination System (NPDES) Municipal Separate Storm Sewer (MS4) permit requirements. These improvements would reduce pollutant loading to Culbertson Run and could be incorporated into the Township PRP.



Preliminary pollutant load removal calculations revealed that this improvements would provide an estimated sediment reduction of 7.78 tons per year (or 42.66 lbs per day). Preliminary pollutant load removal calculations are provided in Appendix M, and are summarized in Table 7.3 below.

Table 7.3 Pollutant Load Removal Summary

ANNUAL POLLUTANT LOAD REMOVAL SUMMARY

BMP ID #	BMP Site Name	Drainage Area (Acres)	Sediment (tons)	Total Phosphorous (lbs)	Total Nitrogen (lbs)
Inlet #3	Infiltration Trench (3A) or Bioswale (3B)	0.9	0.40	2.47	1.13
Inlet #4	Infiltration Trench (4A) or Bioswale (4B)	0.8	0.39	2.14	0.90
Inlet #8	Infiltration Trench (8A) or Bioswale (8B)	3.6	1.87	9.91	4.21
Inlet #9	Infiltration Trench (9A) or Bioswale (9B)	3.1	1.69	8.95	3.67
Inlet #10	Infiltration Trench (10A) or Bioswale (10B)	6.2	3.43	17.89	7.34
TOTAL:			7.78	41.34	17.25

DAILY POLLUTANT LOAD REMOVAL SUMMARY

BMP ID #	BMP Site Name	Drainage Area (Acres)	Sediment (lbs)	Total Phosphorous (lbs)	Total Nitrogen (lbs)
Inlet #3	Infiltration Trench (3A) or Bioswale (3B)	0.9	2.18	0.007	0.003
Inlet #4	Infiltration Trench (4A) or Bioswale (4B)	0.8	2.16	0.006	0.002
Inlet #8	Infiltration Trench (8A) or Bioswale (8B)	3.6	10.24	0.027	0.012
Inlet #9	Infiltration Trench (9A) or Bioswale (9B)	3.1	9.28	0.025	0.010
Inlet #10	Infiltration Trench (10A) or Bioswale (10B)	6.2	18.79	0.049	0.020
TOTAL:			42.66	0.113	0.047

7.3 ALTERNATIVE #3- NEW STORM SEWER/CURB SYSTEM

This alternative involves reconstructing Hawthorne Drive with an underground storm sewer conveyance system designed to current standards and regulations. The proposed improvement under Alternative #3 would consist of the installation of approximately 6,000 linear feet of concrete curb, 6,000 linear feet of 15-inch (minimum) reinforced concrete pipe (RCP), and an estimated fifteen (15) Type C 2-foot x 4-foot inlet boxes.

The conceptual cost of construction is approximately \$83.50 per linear foot of roadway (\$250,500 total) without utility relocation consideration; and \$105.00 to \$167.00 per linear foot of roadway (\$315,000 to \$501,000) with utility relocation consideration. It is unknown how many trees would be impacted by this alternative, as the depth of the storm sewer may impact root systems, further damaging more trees.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: High cost.
 Construction of the system will likely impact the root systems of the trees, requiring removal.
 Grading may impact private property.
 Temporary construction easements may be required.
 Potential utility conflicts.



7.4 ALTERNATIVE #4- NEW SWALE SYSTEM

This alternative consists of constructing new roadside swales between the edge of road and the existing street trees located in the existing roadside swale. In order to provide the real estate needed to accommodate a swale in this location, the cartway width of Hawthorne Drive would be required to be reduced from existing thirty (30) feet to twenty (20) feet. Hawthorne Drive is categorized as a local street; 20 feet is the minimum width acceptable for this street type according to the East Brandywine Township Subdivision and Land Development Ordinance (SALDO) (§350-32).

However, there is still potential that the existing ROW would require expansion. This new swale system of approximate 5000 linear feet would be sized to convey the 25-year storm event. Because of slopes greater than two (2) percent along Hawthorne Drive, rock check dams would be required as part of the swale system to decrease storm flow energy and volume. The swales should be seeded and stabilized with a heavy grade erosion control blanket.

The conceptual cost of construction is approximately \$39.00 per linear foot of roadway (\$117,000 total) without utility relocation consideration or \$49.00 to \$78.00 per linear foot of roadway (\$146,250 to \$234,000) with utility relocation consideration. It is unknown how many trees would be impacted by this alternative, as the depth of the storm sewer may impact root systems, further damaging more trees.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: High cost.
Possibility of expansion of ROW/land acquisition.
Requires reduction of Hawthorne Drive cartway.
Construction of the system has the potential to impact the root systems of the trees, requiring removal.
Grading may impact private property.
Temporary construction easements may be required.
Potential utility conflicts.

8.0 RECOMMENDATIONS FOR HOMEOWNERS

Cumulative impacts to stormwater runoff resulting from additional impervious surfaces (i.e. additions, driveway expansions, pools, sheds, etc.) were not anticipated or considered during initial phases of subdivision design and likely contribute to the stormwater issues along Hawthorne Drive within the Culbertson Run development even during small rain events.

Recognizing that one (1) approach will not solve the flooding and stormwater quality challenges faced by the residents of Culbertson Run, CEDARVILLE suggests simple maintenance and residential stormwater management improvements that individual homeowners or homeowner associations can implement. These items can have significant community benefits, are low cost, and can be implemented immediately and concurrently with any improvements along Hawthorne Drive that may be planned by East Brandywine Township.

Maintenance

Homeowners can remove any sediment, trash, or debris accumulation from their property, so that it does not end up in the storm sewer system, and subsequently Culbertson Run. Also, homeowners



should remove structures or other objects, such as fences, etc. within the Hawthorne Drive ROW that inhibit the flow of water.

Reducing Impervious Coverage

The removal of any under-utilized impervious surfaces (i.e. excess parking, abandoned sheds, etc.) can have a positive overall cumulative impact, reducing peak flows and volume of stormwater runoff.

On-lot Improvements

On-lot improvements, such as disconnecting rooftop runoff to rain barrels or constructing rain gardens is recommended. Stormwater capture and reuse can also have a significant cumulative impact to reduction stormwater runoff volume and velocity. This reduction in volume will translate to overall peak rate reduction for the Hawthorne Drive study area.

9.0 FUTURE ACTIONS

CEDARVILLE has developed four (4) Alternatives and their associated costs for drainage and stormwater management improvements for the Hawthorne Drive Right-of-Way:

- Alternative #1- No-Build (Paving Only)
(\$300,000)
- Alternative #2- Site-Specific Recommendations and Improvements
(\$93,630 - \$178,450)
- Alternative #3- New Storm Sewer/Curb System
(\$250,000 - \$501,000)
- Alternative #4- New Swale System
(\$117,000 - \$234,000)

An effort was made to consider the needs of the community along with the environmental impacts in addressing these problems.

Alternative #1 addresses the existing pavement only, and does not provide any improvement to the existing stormwater management system. This alternative will be necessary when the road surface requires replacement.

Alternatives #2 through #4 will effectively improve the existing stormwater management along Hawthorne Drive. Considering construction costs only, Alternative #2 appears to be the most cost-effective option to manage stormwater while minimizing the impact to private property, existing landscaping, and healthy mature trees. The management strategies described in Alternative #2 include localized green infrastructure Best Management Practices (BMPs), and can either be pursued as stand-alone improvements or comprehensive solutions to the ongoing stormwater runoff concerns. The green infrastructure options in Alternative #2 provide an additional environmental benefit by reducing pollutant loading to Culbertson Run, but present long-term maintenance considerations.

Both Alternatives #3 and #4 would update the drainage system to current design standards including additional stormwater infrastructure such as curbing, inlets, piping, and swales. These Alternatives would adequately address stormwater concerns, but are more costly, require additional tree removal, and potentially require land acquisition for construction.



The construction costs for each Alternative do not include the cost of acquisition of additional property, temporary or permanent drainage easements, and grading and landscape improvements.

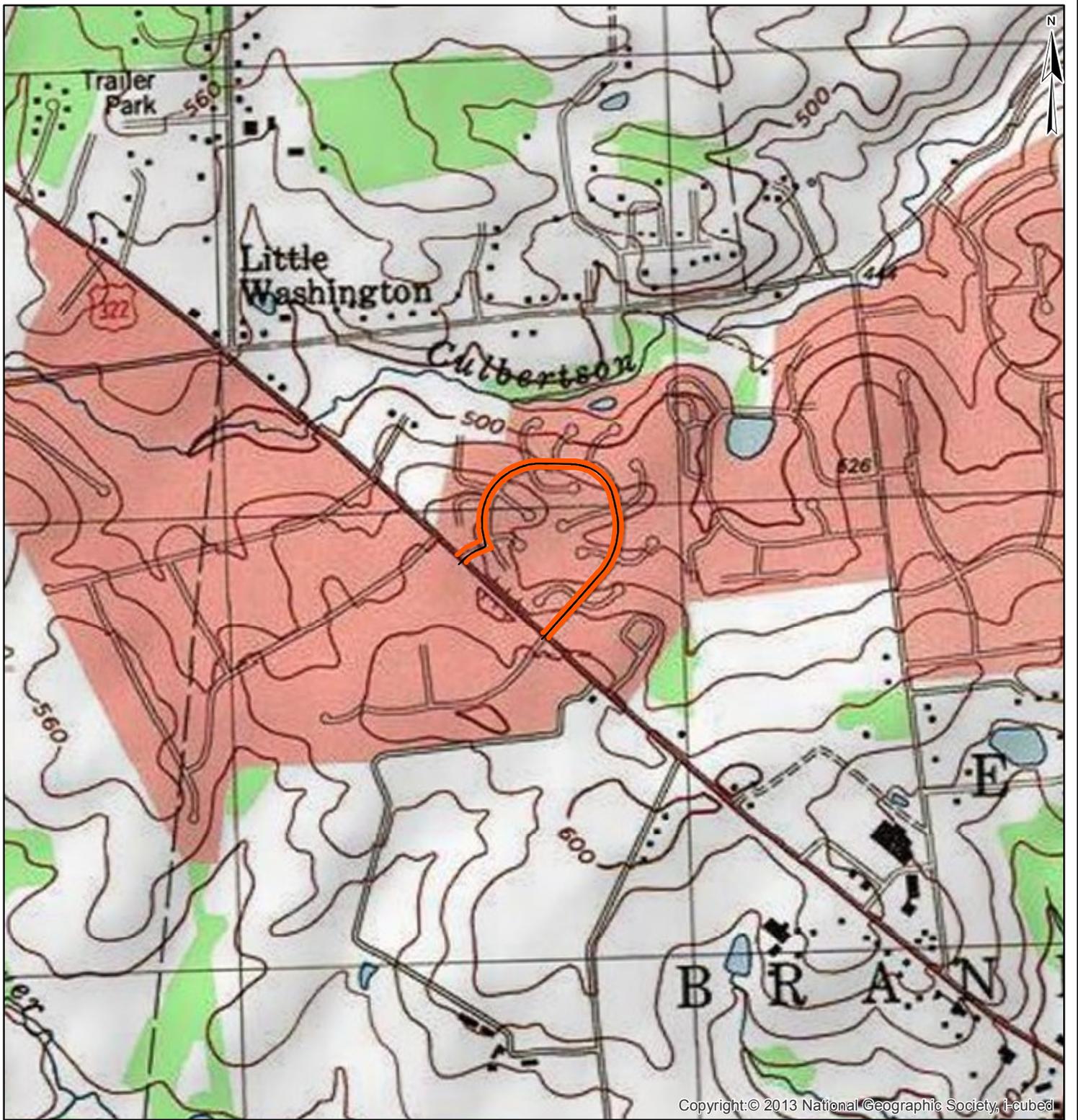
Each Alternative should also be assessed for long-term maintenance considerations including personnel, frequency, and equipment needs. The financial impacts over time should be evaluated by Public Works personnel and crew prior to final determination of action.





APPENDIX A

Location Maps



Copyright: © 2013 National Geographic Society, i-cubed



DRAWN BY: BH

LEGEND

— Hawthorne Drive Right-of-Way

**TOPOGRAPHIC LOCATION MAP
HAWTHORNE DRIVE
COMPREHENSIVE STORMWATER
MANAGEMENT STUDY
CULBERTSON RUN DEVELOPMENT
EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PA**

1 inch = 1,000 feet

CEG Proj #: EBT-15-066



02/08/2016



APPENDIX B

Background Documentation



May 6, 2015

Scott Piersol, Township Manager
East Brandywine Township
1214 Horseshoe Pike
Downingtown, PA 19335

RE: Culbertson Run Development (Hawthorne Drive)
Drainage Investigation
File No. EBT-15-066

Dear Mr. Piersol:

Per the request of the Township, CEDARVILLE Engineering Group, llc (CEDARVILLE) completed a field investigation of the Culbertson Run Development for current drainage conditions and recommendations. We understand the property owners have been experiencing erosion problems and drainage issues.

The site inspection was held on April 23, 2015 site visit with Matthew VanLew, Township Roadmaster of the Culbertson Run Development and myself in response to a drainage complaint filed by the property owners within the community. Prior to our investigation we reviewed the April 15, 2015 Memo from Matthew VanLew to the Board of Supervisors to gain an understanding of issues.

Based on our field investigation, without benefit of physical survey, we make the observations:

Site Evaluation/Analysis

- A. The road drainage was designed with roadside swales and various road crossings. The existing trees within the Township Right-of-Way have altered the drainage pattern by physically blocking the water path with the trunks and root structure.
- B. Boulders and other road physical site additions, such as a wood curb at the edge of Hedgerow Court have altered drainage patterns.
- C. The existing pipe crossing between Canterbury Court and Gloucester Court has significant sediment and appears to be structurally compromised (eroded CMP).

Recommendations

Based on our observations, we recommend the Township consider the following actions:

1. Hawthorne Drive from Chapel Court to Brookfield Court and Hawthorne Drive from Wyndham Court to Brookfield Court:
 - o Install a rolled curb on low side of road and direct drainage toward existing inlet.
2. Hawthorne Drive from Highland Court to Windmere Court:
 - o Remove existing trees within the ROW.
 - o Re-establish swales at road crossings.



3. Hawthorne Drive from Essex Court to Somerset Court
 - o Remove existing trees within the ROW.
 - o Re-establish swales at road crossings.
4. Hawthorne Drive from Highland Court to Hedgerow Drive (Clubhouse driveway)
 - o Remove trees on high side and re-establish swale to direct runoff to pipe (pipe needs to be cleaned out)
 - o Remove trees on low side, re-establish swale and provide rain gardens on private drives.
 - o Remove wood curb at intersection.
5. Remove all large rocks within the Township Right of Way and re-establish swale.
6. Hawthorne Drive from Canterbury Court to Gloucester Court
 - o Remove sediment build up.
 - o Rehabilitate CMP by replacing or slipping lining pipe.
7. Homeowners Association should have an engineering inspection of their stormwater management basin. The inspection should provide recommendations for maintenance plans and repairs of the basin.
8. Install Rain gardens at entrance off Horseshoe Pike to contain highway runoff. An additional rain garden may be appropriate on the HOA property at the entrance to Hedgerow Court.

Please do not to hesitate to contact me with any questions.

Best Regards,
CEDARVILLE Engineering Group, LLC

April M. Barkasi, P.E.
Principal Engineer

Hawthorne Drive Drainage Recommendations

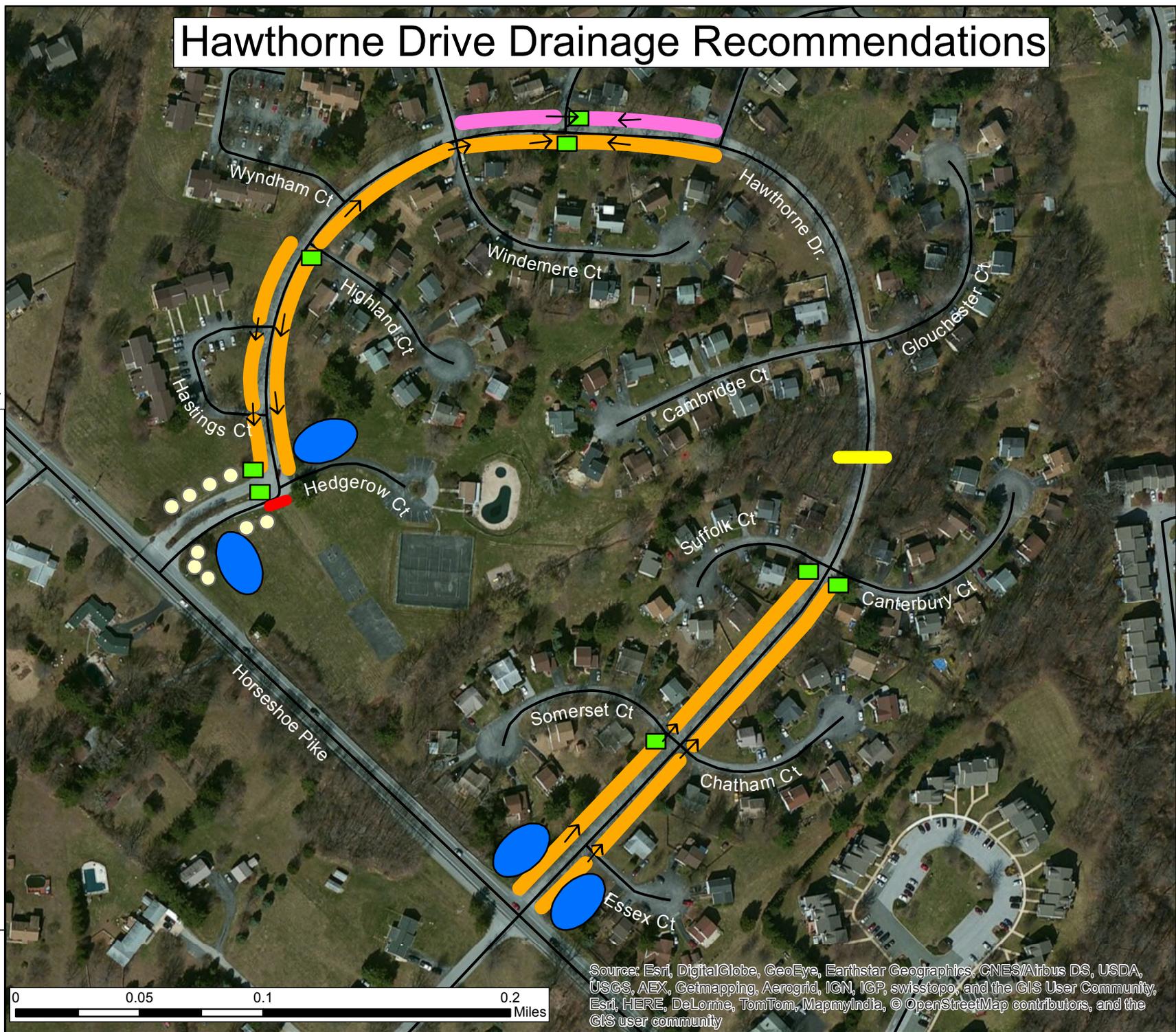


Notes:

- Pipe will be cleaned out and then the CMP will be rehabilitated.
- Trees will be removed and then the swale will be reestablished.
- Boulders will be removed and then the swale will be reestablished.
- Swale will be created to allow water to pass over street to inlet.

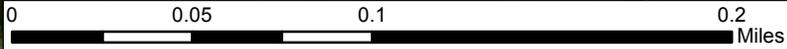
Legend

- Wood Curb
- Inlets
- Pipe
- Rain Garden
- Boulders
- Rolled Curb
- Trees
- Roads



CEDARVILLE
Engineering Group, LLC
 1033 S. Hanover Street, Suite 300
 North Coventry, PA 19465
 P: 610.705.4500 F: 610.705.4900
 www.cedarvilleeng.com

Note: Basemap is not to date



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community, Esri, HERE, DeLorme, TomTom, MapmyIndia, © OpenStreetMap contributors, and the GIS user community



June 16, 2015

Scott Piersol, Township Manager
East Brandywine Township
1214 Horseshoe Pike
Downingtown, PA 19335

RE: Culbertson Run Development (Hawthorne Drive)
Drainage Improvements Alternatives Analysis
File No. EBT-15-066

Dear Mr. Piersol:

Per the request of East Brandywine Township, CEDARVILLE Engineering Group, LLC (CEDARVILLE) presents the following analysis of alternatives for the restoration of the original drainage system in the Culbertson Run development along Hawthorne Drive. This letter is intended to supplement the informal recommendations provided in our letter dated May 6, 2015 of how to restore the functionality of the original drainage system of the development. The analysis includes a brief description and the positive and negative impacts of each alternative. Please note that each alternative is conceptual in nature as a detailed analysis including a land cover study has not been performed.

Background

The Culbertson Run development is located in the western portion of the Township, just north of Horseshoe Pike (US-322). Hawthorne Drive is the main thruway within the development from which both single family homes and townhouses are accessed. It is a horseshoe-shaped road that accesses Horseshoe Pike (S.R. 0322) in two locations. The Culbertson Run community was developed in the late 1970's. Hawthorne Drive is a 30-ft wide Road with a 50-ft Right-of-Way. All residences are serviced by both public water and sewer.

Natural Features

The topography ranges from 470 to 560 feet above mean sea elevation. Generally, the topography slopes downward to the North and to the East from the highest point located near Horseshoe Pike.

The property is located within the Culbertson Run watershed. A portion of the development drains to the east into an unnamed tributary to Culbertson Run. The remainder drains to the north into Culbertson Run. A small portion of Hawthorne Drive from Highland Court to Hedgerow Court drains to the south. Culbertson Run is designated as a High Quality-Trout Stocked Fishery (HQ-TSF) by Chapter 93 of the Pennsylvania Code. It has also been identified as an impaired water by the Department of Environmental Protection (DEP) with the causes being siltation and habitat alterations. Culbertson Run is located within the larger Christina Basin Watershed, which has a Total Maximum Daily Load (TMDL) requirement for the Township's Federal National Pollutant Discharge Elimination System (NPDES) Permit.



The swale within the Right-of-Way for Hawthorne Drive is lined with either American Sycamore (*Platanus occidentalis*) or London Plane (*Platanus x acerifolia*) trees on both sides of the road (the exact species has not been confirmed at this time). These trees vary in size from approximately 12 to 16 inches in diameter at breast height (dbh) and are recognized as a valued resource within the community.

Problem Description and Justification

It is our understanding that residents within the Culbertson Run development are concerned with drainage issues; primarily property erosion along Hawthorne Drive. The Hedgerow Homeowners Association (HOA) has filed a complaint with the Township expressing these concerns.

The erosion has been an ongoing documented problem challenging the proper maintenance of the Township-owned roads within this development. The roads within the Culbertson Run were scheduled to be repaired this year however, maintenance will be deferred due to the drainage concerns. As part of the maintenance of these roads, the Township would like to address and mitigate the drainage conditions to prevent future erosion.

In reviewing Pennsylvania Code as it applies to Second Class Townships, justification for improvement of drainage conditions for the roads in this development can be found in two sections:

Section 2320. Power to Open Drains and Ditches.-(a) The board of supervisors or its agents may enter any lands or enclosures and cut, open, maintain and repair drains or ditches through the property when necessary to carry the water from the roads.

Section 2325. Saving Trees and Shrubbery.-(a) The board of supervisors or its agents shall not remove any shrub or tree growing within the right-of-way of any township road or street except those shrubs and trees the board of supervisors finds to constitute a hazardous or dangerous condition to the use of the highway or those which impair the use or maintenance of the public road or street. No tree having a trunk diameter in excess of six inches shall be removed without notice of the proposed removal having first been given to the abutting property owner. The township supervisors shall determine by resolution the form of notice to property owners.

There are trees located where a swale within the Hawthorne Drive Right-of-Way is located. These trees are impeding the functionality of the existing drainage system as well as the maintenance of the Township-owned road.

Limitations

As previously stated, the Culbertson Run community was developed in the late 1970's and is nearly 40 years old. It is difficult to fully understand the engineering rationale behind the design of this development for several reasons:

- a) There are no land development plans at the Township for this development.
- b) Comprehensive Stormwater Management was not prioritized during that period of design.
- c) Stormwater management was not regulated by municipal ordinances or permits.
- d) The methodology used to quantify stormwater impacts were not standardized.
- e) Cumulative impacts to stormwater runoff resulting from additional impervious surfaces (i.e. additions, driveway expansions, pools, sheds, etc.) were not anticipated during initial phases of design.



The existing drainage system consisted of swales along the roads and six inlets. Because there are no records of the original stormwater drainage plan for this development, we can only assume that the swales were designed for conveyance and flood control, not quantity and quality cover as systems are designed today. CEDARVILLE was given strict direction for identifying ways in which to maximize the efficiency of these swales and inlets to convey stormwater, within the Townships controlled property being the existing Right-of-Way.

Observations

CEDARVILLE, accompanied by Matthew VanLew, Township Roadmaster, investigated the complaint on April 23, 2015 and made the following observations:

- The road drainage along Hawthorne Drive was designed with roadside swales and various road crossings. The existing trees within the Township Right-of-Way are located within the swales and have altered the drainage pattern. The trees physically block the flow path and have contributed to the accumulation of sediment within the swale over the years, preventing positive flow. The result is a non-functioning conveyance system which is causing local areas of accelerated erosion.
- Boulders and other road physical site additions, such as a wood curb at the edge of Hedgerow Court have altered drainage patterns along the Township Right-of-Way.
- The existing pipe crossing between Canterbury Court and Gloucester Court contains significant sediment accumulation and appears to be structurally compromised (eroded CMP).

Alternatives

The following alternatives are offered to restore the functionality of the original drainage system along Hawthorne Drive. Options for improving the drainage system are limited due to the restrictions in the existing width of the ROW. The analysis includes a brief description and the positive and negative impacts of each alternative.

Alternative #1- No-Build

This alternative consists solely of re-paving Hawthorne Drive and not addressing the erosion concerns raised by residents.

Positives: No tree removal required.
Low cost

Negatives: Does not address the ongoing drainage/erosion concerns of the residents
Allows for the potential of increased sediment load in Culbertson Run

Alternative #2- Re-establish Swale/Maintenance/Rain Garden Installation

This alternative involves re-establishing the existing roadside swale, performing specific maintenance on existing infrastructure, and constructing rain gardens at the entrances off Horseshoe Pike.

Specific details are as follows:

- Install a rolled curb on low side of road and direct drainage toward existing inlet from Brookfield Court to Chapel Court.*
- Remove existing trees within the ROW and re-establish swales at road crossings from Hedgerow Court to Chapel Court and Essex Court to Canterbury Court.
- Remove all large rocks within the ROW at northern entrance and re-establish swale.*



- Remove sediment accumulation in all existing stormwater conveyance structures.*
- Rehabilitate CMP between Gloucester Court and Canterbury Court by replacing or slipping lining pipe.*
- Engineering inspection of the HOA stormwater management basin to provide recommendations for maintenance plans and repairs of the basin.*

Positives: Will adequately address the ongoing drainage concerns of the residents.
Moderate cost. (\$1,000,000)

Negatives: Requires the removal of an estimated 100 trees.

Alternative #3- New Storm Sewer/Curb System

This alternative involves re-constructing Hawthorne Drive with an underground storm sewer conveyance system designed to current standards and regulations.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: High cost. (\$1,000,000)
Construction of the system will likely impact the root systems of the trees.
Grading may impact private property.

Alternative #4- New Swale System

This alternative consists of constructing a new roadside swale on the outside of the trees in the existing roadside swale. In order to provide the real estate needed to accommodate a swale in this location, the existing ROW would require expansion. The Township would have to petition to acquire additional land from the adjoining property owners.

Positives: Will adequately address the ongoing drainage concerns of the residents.

Negatives: High cost. (\$1,000,000)
Expansion of ROW/land acquisition necessary.
Construction of the system has the potential to impact the root systems of the trees.

Conclusions & Recommendations

The Culbertson Run development has a history of drainage and erosion complaints along Hawthorne Drive. Within the Right-of-Way where a drainage swale was originally constructed (approximately 40 years ago), large trees have become established and are now impeding the functionality of the original drainage system. CEDARVILLE was tasked with identifying alternatives to restore the functionality of these swales. Four (4) alternative options are presented to the Township based on the current drainage system for their review.

At a minimum, a detailed on-site evaluation should be conducted in order to identify localized areas for maintenance, removal of sediment accumulation, re-grading, and/or stabilization. A minimum number of trees will likely require removal as part of this routine maintenance to allow integral portions of the existing system to function (i.e. directing flow into existing inlets, etc.). This can be viewed as a short-term “band-aid” solution and will not address the overall functionality of the stormwater conveyance for the long-term.



Future Actions

We believe there may be a creative holistic solution to more fully address the stormwater conveyance issue along Hawthorne Drive on a holistic level. By targeting specific areas for stormwater improvements, the impacts to the existing trees may be able to be minimized. However, the most appropriate method of achieving this goal would be to conduct a Comprehensive Stormwater Management Study of the community. The study may include, but not be limited to, the following:

- Land Cover study for the continuing drainage areas which may be internal or external to the development, including impervious coverages of the existing properties.
- Topographic analysis which may require survey of the community to determine localized areas of concerns.
- Engineering analysis of the existing stormwater conveyance.
- Detailed on-site evaluation of existing environmental conditions (i.e. areas of erosion, structure conditions, etc.)
- Soil investigation to address the infiltration capacity and structural stability of the soils to aid in identifying optimal improvement options and BMPs.
- Assessment of the health of the existing roadside trees by a certified arborist to help concentrate improvement efforts in areas where the trees may be in a hazardous or dangerous condition.
- Survey of adjoining property owners to determine if land acquisition for the expansion of the ROW is an option.
- Detailed cost evaluation for consideration by the Township for assessment to the Homeowners Association is approved.

We understand the importance of the street trees for the aesthetic and environmental benefits of the community. Please provide direction to our office to permit the evaluation necessary for short term drainage improvements and a long term program of established drainage for the Culbertson Run community.

As always, it is our pleasure to work with the officials and residents of East Brandywine Township.

Best Regards,
CEDARVILLE Engineering Group, LLC



April M. Barkasi, P.E.
Principal Engineer



APPENDIX C

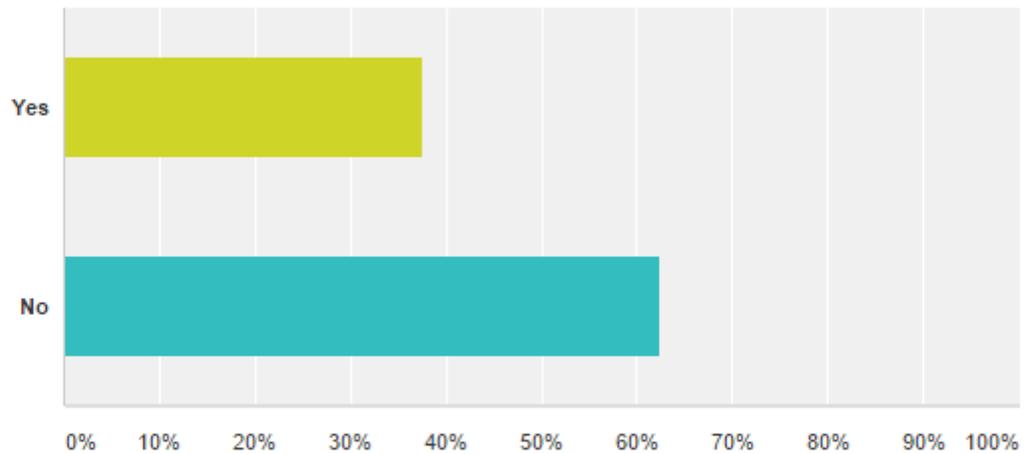
Resident Survey Results

HAWTHORNE DRIVE COMPREHENSIVE STORMWATER MANAGEMENT STUDY RESIDENT SURVEY RESULTS

QUESTION 1

Has your property been negatively impacted by flooding from stormwater runoff?

Answered: 16 Skipped: 0



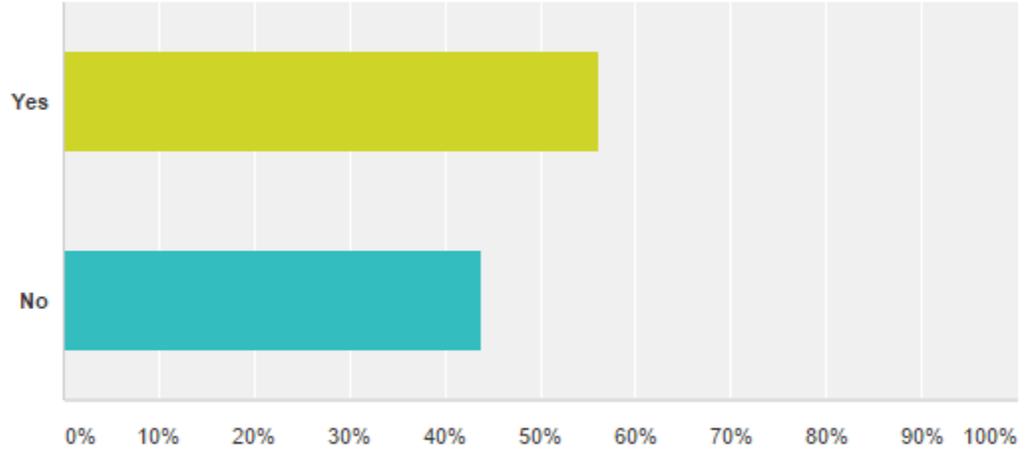
Answer Choices	Responses	
▼ Yes	37.50%	6
▼ No	62.50%	10
Total		16



QUESTION 2

Do you feel that the roads within Culbertson Run Development are adversely impacted by stormwater runoff?

Answered: 16 Skipped: 0



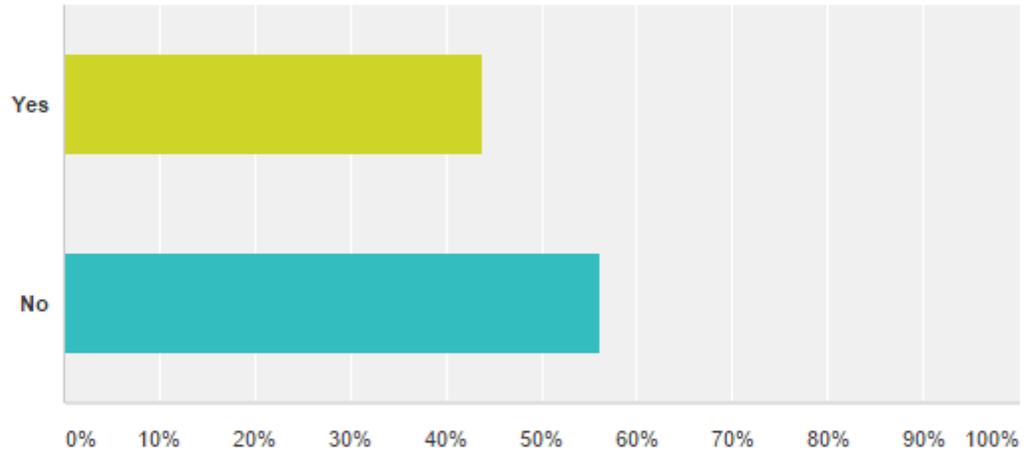
Answer Choices	Responses
Yes	56.25% 9
No	43.75% 7
Total	16



QUESTION 3

Has your property been negatively impacted by erosion from stormwater runoff?

Answered: 16 Skipped: 0



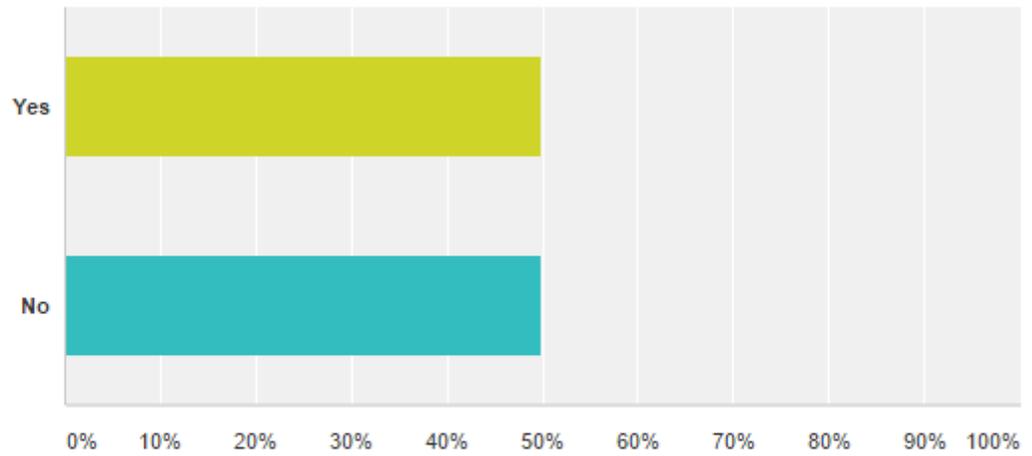
Answer Choices	Responses
Yes	43.75% 7
No	56.25% 9
Total	16



QUESTION 4

Are you concerned about water quality in East Brandywine streams?

Answered: 14 Skipped: 2



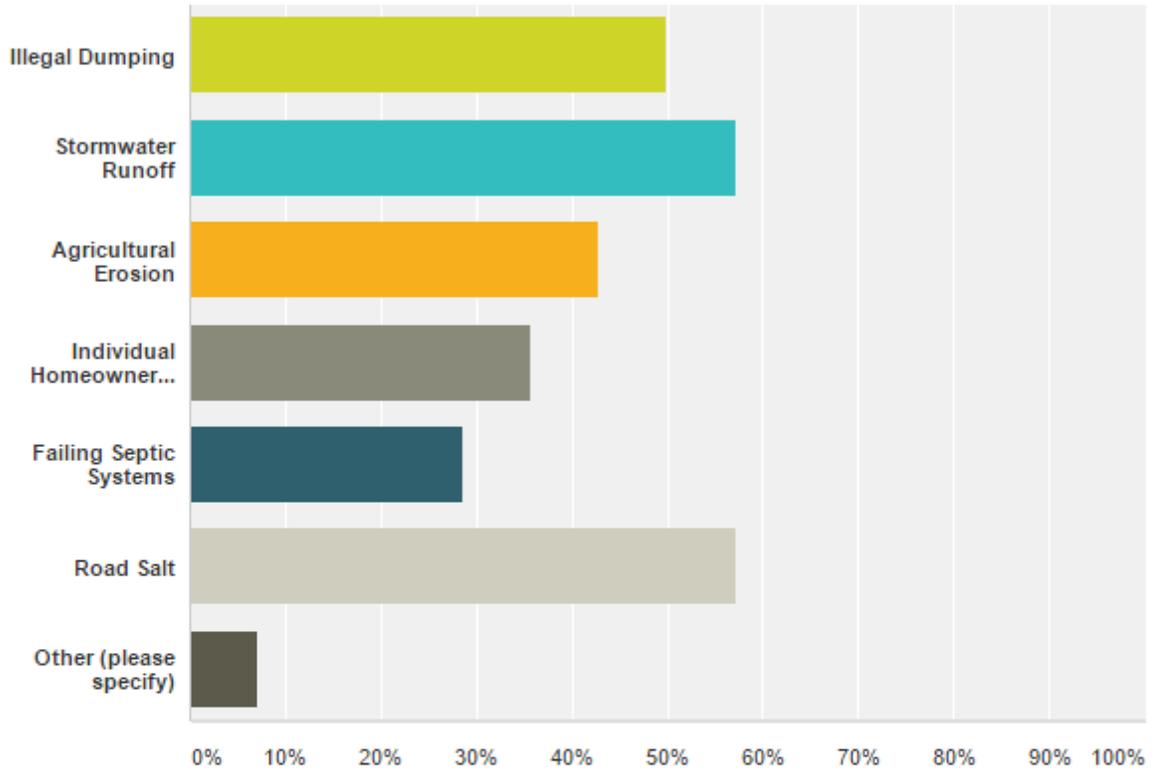
Answer Choices	Responses
Yes	50.00% 7
No	50.00% 7
Total	14



QUESTION 5

What do you think are the greatest sources of pollution to East Brandywine streams?
Select all that apply.

Answered: 14 Skipped: 2



Answer Choices	Responses
Illegal Dumping	50.00% 7
Stormwater Runoff	57.14% 8
Agricultural Erosion	42.86% 6
Individual Homeowner Actions	35.71% 5
Failing Septic Systems	28.57% 4
Road Salt	57.14% 8
Other (see below) Responses	7.14% 1
Total Respondents: 14	



QUESTION 5 (CONTINUED)

Other Reponses:

Lack of drains in high volume watershed areas

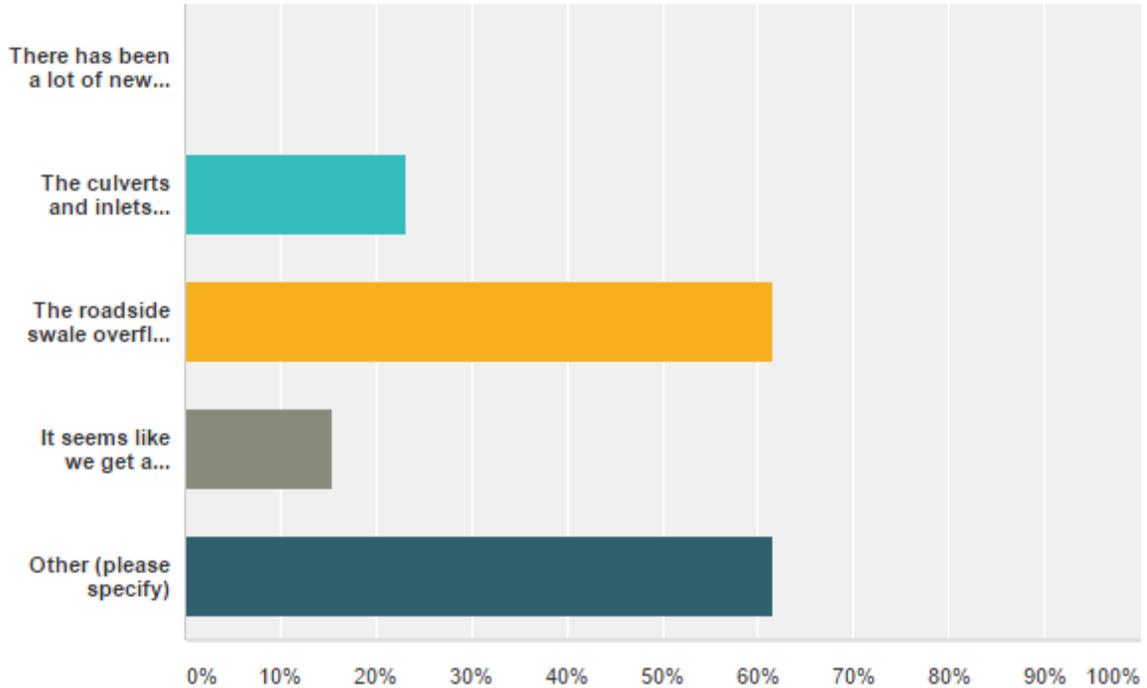
10/12/2015 12:40 PM



QUESTION 6

What are your observations during storm events in Culbertson Run Development? Select all that apply.

Answered: 13 Skipped: 3



Answer Choices	Responses
There has been a lot of new impervious coverage added in the neighborhood, producing more runoff.	0.00% 0
The culverts and inlets overflow often during storm events.	23.08% 3
The roadside swale overflows often during storm events.	61.54% 8
It seems like we get a 100-year storm every year!	15.38% 2
Other (see below) Responses	61.54% 8
Total Respondents: 13	



QUESTION 6 (CONTINUED)

Other Responses:

It's quite simple, after verizon & comcast dug their new lines along hawthorne didn't do the proper burial, IE;stone and aggrate to help the situation, which has added to the void of the edge of hawthorne. I have personally added over 8 tons of top soil, as well as grass, water etc.to make this not wash away 2 edges of my property Funny how PECO, came to fix my corner sinking box, yet took quite a few calls to get that fixed., and I did the rest. There is a very lack of comminciation of safety for our public/piivate utilites with part of this drainage issue.

10/12/2015 12:40 PM

During storm events many yards have standing mini ponds of water from excessive runoff combined with improper grading

10/11/2015 9:45 PM

I don't know

10/7/2015 9:37 PM

water pools in various sections on my property

10/7/2015 8:47 PM

The valley-like water collection basin in the common area behind our house is almost always damp and is a breeding ground for bugs. Even during dry spells, this area is often wet enough to feel the moisture in bare feet (at best), and spongy with pooly liquid water plainly visible (at worse).

10/7/2015 1:36 PM

Stormwater is directed away from the roadway and onto private property.

10/7/2015 10:14 AM

I don't have a problem so I really can't answer.

10/7/2015 10:12 AM

Water not making it to the Storm drains

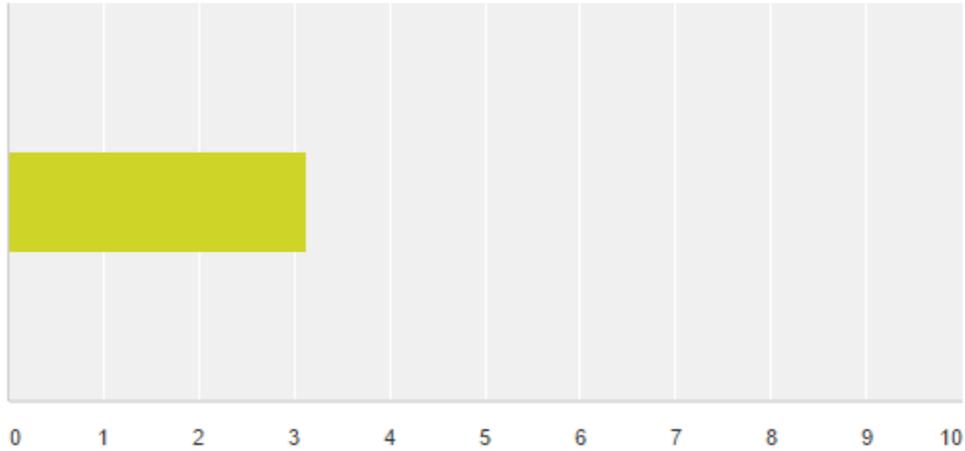
9/25/2015 7:00 AM



QUESTION 7

What is your level of concern about water quality in Culbertson Run (stream)?

Answered: 16 Skipped: 0



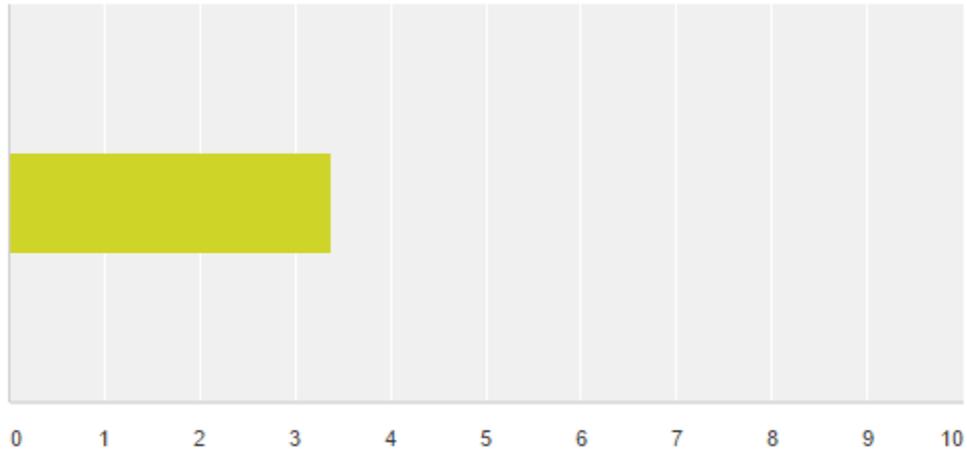
Not At All	Somewhat	N/A	Moderately Concerned	Very Concerned	Total	Weighted Average
18.75% 3	18.75% 3	6.25% 1	43.75% 7	12.50% 2	16	3.13



QUESTION 8

How serious of a problem is stormwater runoff in the Culbertson Run Development?

Answered: 16 Skipped: 0



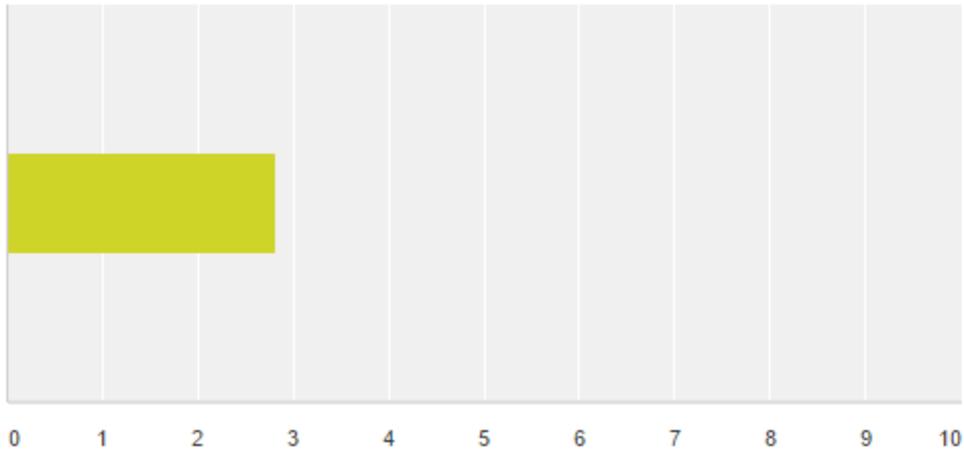
Not At All	Somewhat	N/A	Moderately Serious	Very Serious	Total	Weighted Average
12.50% 2	25.00% 4	6.25% 1	25.00% 4	31.25% 5	16	3.38



QUESTION 9

There currently are large trees located within the stormwater management swale. In some instances the trees are hindering stormwater flow, causing flooding and producing erosion. How would you feel about selective tree removal in areas where stormwater flows are being obstructed?

Answered: 16 Skipped: 0



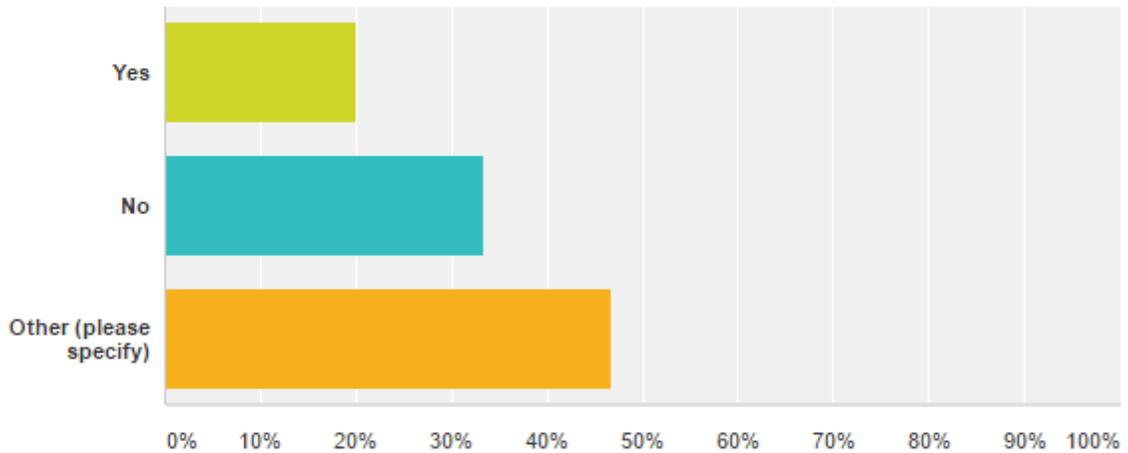
Very Against ▾	Moderately Against ▾	Not For or Against ▾	Moderately Support ▾	Fully Support ▾	Total ▾	Weighted Average ▾
37.50% 6	12.50% 2	0.00% 0	31.25% 5	18.75% 3	16	2.81



QUESTION 10

Currently the Township is restricted to making all stormwater improvements within the Right-of-Way along Hawthorne Drive. Would you be willing to enter a portion of your property into an easement agreement with the Township for construction of stormwater Best Management Practices (BMPs)?

Answered: 15 Skipped: 1



Answer Choices	Responses
Yes	20.00% 3
No	33.33% 5
Other (see below)	46.67% 7
Total	15



QUESTION 10 (CONTINUED)

Other Responses:

We have lived here since 2001, and have not seen any new delvp. of properties that would cause these issues. The problem is with the contractors/ past and present. I have placed under ground small drain pipes to direct the water run off towards where it is supposed to go. The EB twp is looking for an excuse to cut down,, Trees. If this contractor, as well as advisor to such, has no experinecce of drainage issues. All these issues could be handled within a couple of days, not tens of thousands of dollars. Trees actually roots, hold the ground together espc old growth. For upper culb. run would take a contractor less than a week to minorly remove some of the top soil, Prob @ 100 tons of #3 stone, @ 60 tons #2, all compacted correctly, and graded just slightly with another 100 tons of fill, top soil, being the last. Erosion hay, seeding. Do you understand the math on that? 22 tons of stone @ 250\$ each, clean fill usually free, maybe hauling charge, cheap. Top soil and grass replacement the most expensive, for just hay fabric and seeding, best bid wins. I have already Offered my services, besides a back hoe, to do the final grading with the skid loader I own just for a 800\$ dues payment.

10/12/2015 12:40 PM

I would need more information to respond

10/11/2015 9:45 PM

I would have to have more information in order to make this decision.

10/9/2015 10:43 AM

I would want to see the this agreement before I can answer

10/8/2015 11:38 AM

If it would help the community, we would be willing to entertain such an agreement.

10/7/2015 1:36 PM

Yes, as long as it was reasonable and did not impact current property conditions (ie fences, sheds, etc.)

10/7/2015 10:14 AM

My Property is not in the right of way

9/25/2015 7:00 AM



QUESTION 11

Do you have any additional comments on how to best manage stormwater and erosion in the Culbertson Run Development?

9 Responses

The trees are not hindering water flow and removal would increase the problem. Create a diversion into the storm drains with perhaps a curb.

1/24/2016 11:44 PM

PennDOT should relocate the storm drain on Horseshoe Pike so less water runs down Hawthorne at the eastern entrance.

10/19/2015 6:21 AM

Proper evaluation of the problem, or issue. Second the worst hit are "down hill from 322" I would have no problem with putting a drain in front of my house, yet as explained earlier, writ of way has already been compromised. Final would take some very minor paving, and or edge adjustments would be it. D.M Schulze, 105 glouchester ct.

10/12/2015 12:40 PM

Please figure out a way to save our trees.

10/9/2015 10:43 AM

Not at this time

10/8/2015 11:38 AM

We don't see any problems. Please leave the trees alone. Utilize the engineers within the development who care about our development to make critical decisions when it comes to taking down trees. Township personnel and contractors shouldn't be the ones making the decisions.

10/7/2015 8:13 PM

It seems to me that removing trees, which drink up water, is counter-intuitive. Additionally, I feel the trees add aesthetic beauty to our development and I'd hate to see them removed.

10/7/2015 1:36 PM

While there will be no "perfect" solution, one that ensures water stays largely to the sides of the roadway until it can be directed to a drain inlet would be ideal. While I am no engineer, I am sure there is a way this could be obtained without a negative impact to the visual appeal of the neighborhood (ie massive tree removal). Certain areas may need less attention than others, but those where erosion issues exist cannot afford to be ignored.

10/7/2015 10:14 AM

no...but I live in the townhomes and my trees have become a hazard. They need trimming or might even need to come down before damage is done to my house or neighbor's cars.

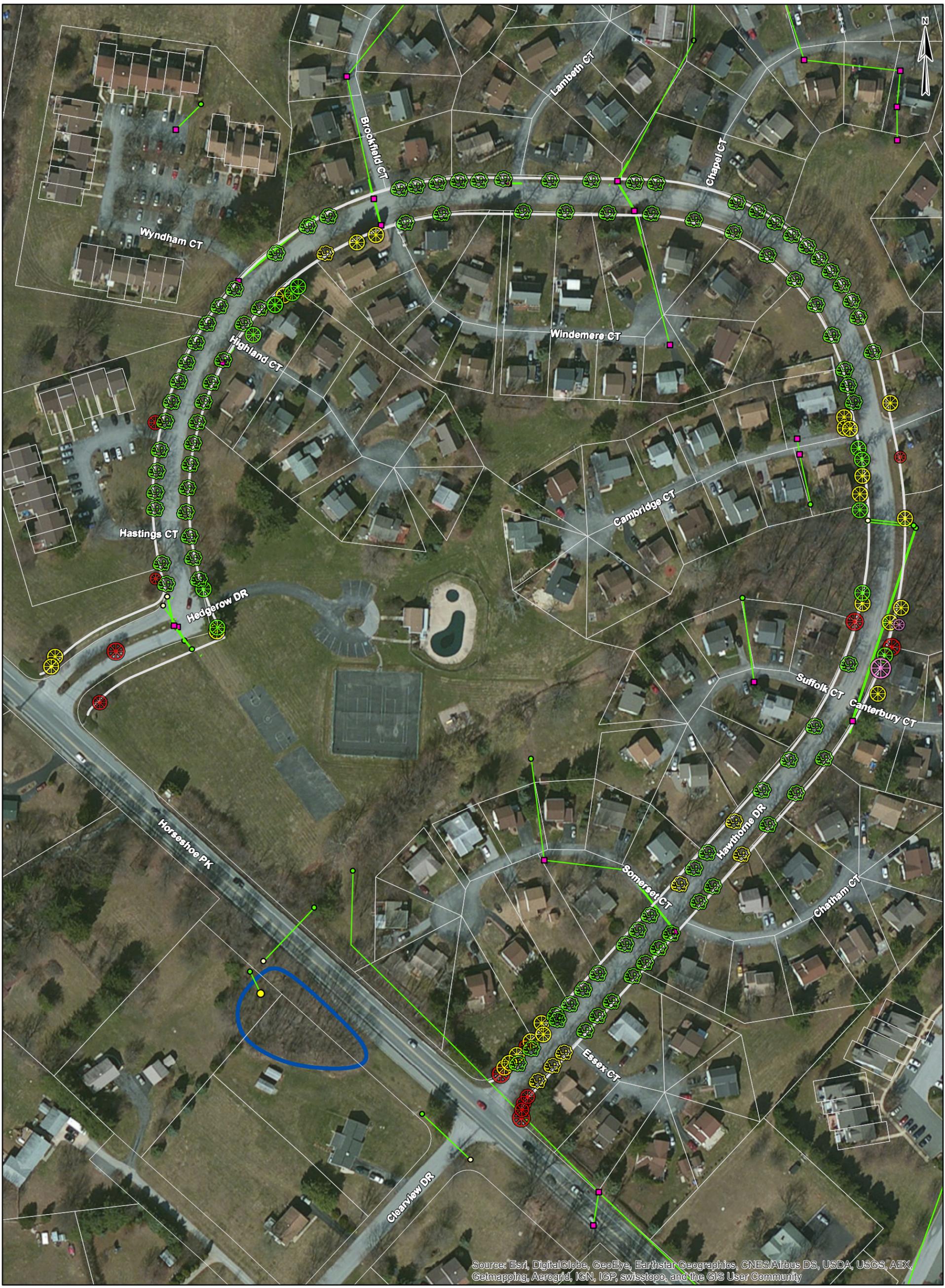
10/7/2015 10:12 AM





APPENDIX D

Tree Condition Map



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

CEDARVILLE
Engineering Group, LLC

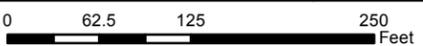
DRAWN BY: BH

**TREE CONDITION MAP
HAWTHORNE DRIVE
COMPREHENSIVE STORMWATER
MANAGEMENT STUDY**

CULBERTSON RUN DEVELOPMENT
EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PA

1 inch = 125 feet

CEG Proj #: EBT-15-066



02/04/2016

NOTES:
1. Tree data was acquired from health assessment conducted by Preservation Tree, LLC in October 2015.
2. Storm structures outside Hawthorne Drive ROW from Township MS4 GIS data,
3. Storm structures within Hawthorne Drive from Ash Associates, Inc. survey dated 10/5/15.

LEGEND

Trees

- Excellent Condition
- Good Condition
- Fair Condition
- Poor Condition
- London Planetree
- Parcels
- Hawthorne Drive ROW

- Storm Pipe
- Inlets
- Headwalls
- Endwalls
- Stormwater Basins



APPENDIX E

*Tree Health Assessment Report and Data
from Preservation Tree, LLC*



917 Old Fernhill Rd
Suite 500
West Chester PA 19380

November 4, 2015

Report provided for Cedarville Engineering Group, LLC

1033 Hanover Street
Pottstown PA 19465

Location: Culbertson Run Development

500 Hawethorne Drive
Downingtown PA 19335

Summary:

Preservation Tree was contracted to do a tree health assessment of the street trees along Hawthorne Drive in the Culbertson Run Development by Cedarville Engineering in the Fall of 2015. Two ISA certified arborists conducted the survey and inventoried a total of 149 trees. The trees were digitally tagged using the Open Tree Map system and a cloud based interactive map is available for the client's reference. The survey included taking diameter at breast height, measuring approximate height, noting various insect, disease and structural issues as well as the ISA health assessment. Recommendations have been made for long term maintenance. Environmental benefits have been calculated and include averages for storm water filtration, energy conservation, air quality, carbon dioxide removed and stored. All assessments were visual and wood density testing, tomography, and sonar devices were not used to assess internal structure or root systems.

The overall landscape is dominated by London Plane. London Planes are a great tree for the urban and suburban environment as they tolerate high rates of stress from pollution and human encroachment. They are an accidental hybrid of American Sycamore and Oriental Plane that happened in the 18th century. They have low incidences of disease and have very good structural integrity. The majority of these trees were listed from fair to good condition. The only issues they displayed were a phototropic tilt in heavily shaded areas. This is really only a concern for long term maintenance and a lean of less than forty five degrees is not a hazard. Also some of the root plates have been compromised from excessive storm flow. This can remove the appropriate soil levels around critical roots and make them subject to mower damage.

Other trees on site were ornamental Cherries, Ash and Eastern Hemlock. Most of the Cherry trees at both entrances have shown signs of Bacterial Canker. Unfortunately there is no cure for Bacterial Canker in the Prunus genus and preemptive removal and replacement would be a wise choice. The Eastern Hemlock are riddled with Woolly Adelgid and Elongated Hemlock Scale. Treatment for this has a fairly high success rate and a cost benefit analysis should be considered for long term care of these trees. The White Ash appear healthy but should either be preemptively removed or treated for Emerald Ash Borer. Emerald Ash Borer will be a considerable issue in the years to come. Although it has not yet been discovered in Chester County preemptive treatment is critical to keep preservation a viable option. The insect attacks the same vector that the treatment is applied to. Should a tree be compromised the success rate of treatment is extremely diminished. Treatment for EAB is an expensive endeavor and many communities with low value Ash trees are electing to preemptively remove them as they become extremely hazardous when they decline.

Tree Condition Defined: *please see attached spreadsheet for tree by tree breakdown*

Excellent – The tree is near perfect condition, this determination is generally used for trees with no defects and young trees that have been properly maintained.

Very Good – The tree is in very good condition with very minor defects that could be corrected by pruning. These trees generally “stand out” with respect to the aesthetic value they add to the Urban Forest.

Good – The tree has no major structural problems; no significant damage from diseases or pests; no significant mechanical damage; a full, balanced crown, and normal twig condition and vigor for its species.

Fair – The tree may exhibit the following characteristics: minor structural problems and/or mechanical damage; significant damage from non-fatal or disfiguring diseases; minor crown imbalance or thin crown; minor structural imbalance; or stunted growth compared to adjacent trees.

Poor – The tree may appear healthy, but may have structural defects. This classification also includes healthy trees that have unbalanced structures or have been topped. Trees in this category may also have severe mechanical damage, decay, severe crown dieback or poor vigor/failure to thrive.

Dead – Trees in advanced states of decline are not included. This category refers only to dead trees

Recommended Maintenance Explanations:

Structure Prune: Structure pruning is how to train young and middle aged trees for proper branch architecture. Rubbing, crossing and interfering materials are removed to promote healthy growth patterns

Crown Cleaning: Crown cleaning is the removal of dead, dying and diseased materials. This serves to improve the plants aesthetics as well as prevent overhead hazards. Crown cleaning is also seen as a means of keeping insects and disease at bay. A well maintained tree is able to compartmentalize wound tissue much faster and use its energy in upward and root growth.

Removal: Tree removal has been recommended for trees that are hazardous, are conflicting with structures and other trees or have poor specimen quality. Some recommendations are recommended based on potential disease pressure.

Cabling: Cabling is recommended for trees with co-dominant stems and included bark. Trees of this nature are highly prone for catastrophic failure. Proper cabling using ANSI A300 standards and the Best Management Practices(BMPs) provided by the International Society of Arboriculture are risk management techniques that reduce the likelihood of such events occurring. Two types of cables are prescribed, extra high strength(EHS) steel and dynamic. EHS cables are installed using through bolts and are suggested for very large co-dominant stems. These are permanent fixtures and need to be inspected and updated periodically. Dynamic cables are good for small to medium trees. These cables are high strength hollow braid ropes that are spliced around branch unions. This allows them to be adjusted

through time and be very minimally impactful on the cambium tissue. However like the EHS cables periodic inspections are a must.

Restoration: Restoration pruning is recommended for trees that have been improperly pruned, topped or storm damaged. This practice entails selectively removing materials at the inappropriate cut areas and selecting new leads for apical dominance. Restoring a tree that has been topped can take several pruning cycles and is not an option recommended for every tree. This can also mean making penetration cuts to promote interior light for shrub material that has been over sheared.

End Weight Reduction: End-weight reduction pruning is the practice of selectively removing branch material from the outer periphery of the canopy. In lieu of removing entire leads this allows the wind and snow loading to be effectively reduced while making a very minimally impactful wound. Clearance pruning can be achieved in sync with end-weight reduction if done properly.

Clearance: Clearance pruning is recommended for trees in contact with structures and over walks and drives. Allowing a ten to fifteen foot bubble of clearance around a structure is ideal. This allows the tree to move in wind events and not hit the house. It will also reduce snow load bending the limbs to the house. Ground to sky clearance is not a healthy or effective means of creating more light to the structure or reducing tree refuse from hitting the roof. Excessively pruned trees will respond by sprouting water sprouts and negate any net gain. If the tree is seen as this much of a nuisance the removal option might be the best way to deal with the situation. Eight to ten feet of clearance is usually ideal for trees over walk ways while 12-15' of clearance should accommodate most vehicular traffic over road systems.

TREE HEALTH ASSESSMENT DATA
 Conducted by Preservation Tree, LLC, October 2015

ID	Tree Species (Common Name)	Species (Genus)	Species (species)	dbh	Risk Rating	Structural Issues	Disease Issues	Insect Issues	Soil/Root Crown Issues	Recommendations	Longitude	Latitude
857608	Cherry	Prunus		16	(2)Poor	Utility	Bact canker	Borers	Root crown	Remove	-75.77697	40.042
857609	Cherry	Prunus		14	(2)Poor	Utility	Bact canker		Root crown	Prune	-75.777	40.04205
857610	Cherry	Prunus		14	(2)Poor	Poor planting/utility	Bact canker		Root crown	Remove	-75.77699	40.0421
857611	Cherry	Prunus		13		Poor planting	Bacterial canker		Bad graft	Remove	-75.77694	40.04216
857612	Cherry	Prunus		17	(2)Poor	Poor planting	Bacterial canker	Borers	Root crown	Remove	-75.77711	40.04222
857613	Eastern hemlock	Tsuga	canadensis	8	(3)Fair			Wooly adelgid/scale		Treat for Insect/Disease	-75.7771	40.04225
857614	Eastern hemlock	Tsuga	canadensis	8	(3)Fair	Storm damage		Wooly adelgid/scale		Treat for Insect/Disease	-75.77706	40.04227
857615	London planetree	Platanus	acerifolia	26	(4)Good	Road encroachment				Prune	-75.77705	40.04224
857616	Eastern hemlock	Tsuga	canadensis	8	(3)Fair			Wooly adelgid/scale		Treat for Insect/Disease	-75.77703	40.04229
857617	Eastern hemlock	Tsuga	canadensis	8	(3)Fair			Wooly adelgid/scale		Treat for Insect/Disease	-75.77701	40.0423
857618	Eastern hemlock	Tsuga	canadensis	5	(2)Poor	Top dieback		Wooly adelgid/scale		Remove	-75.77701	40.04232
857619	Eastern hemlock	Tsuga	canadensis	4	(3)Fair	Poor specimen		Wooly adelgid/scale		Remove	-75.77699	40.04232
857620	London planetree	Platanus	acerifolia	26	(4)Good	Road clearance				Prune	-75.77698	40.04229
857621	Eastern hemlock	Tsuga	canadensis	9	(3)Fair	Clearance		Wooly adelgid/scale		Treat for Insect/Disease	-75.77697	40.04235
857622	London planetree	Platanus	acerifolia	25	(4)Good	Road clearance				Prune	-75.77694	40.04235
857623	London planetree	Platanus	acerifolia	24	(3)Fair	Phototropic lean/ clearance				Prune	-75.77692	40.04218
857624	London planetree	Platanus	acerifolia	19	(3)Fair	Phototropic lean/clearance /poor pruning			Runoff/exposed roots	Prune	-75.77689	40.04222
857625	London planetree	Platanus	acerifolia	15	(3)Fair	Phototropic lean			Runoff	Prune	-75.77686	40.04225
857626	London planetree	Platanus	acerifolia	20	(4)Good	Clearance				Prune	-75.77676	40.0423
857627	London planetree	Platanus	acerifolia	20	(4)Good	Clearance				Prune	-75.77679	40.04238
857628	London planetree	Platanus	acerifolia	23	(4)Good	Clearance/poor pruning			Run off/exposed roots	Prune	-75.77673	40.04236
857629	London planetree	Platanus	acerifolia	17	(4)Good	Clearance				Prune	-75.77685	40.04243
857630	London planetree	Platanus	acerifolia	23	(4)Good	Clearance			Run off	Prune	-75.77666	40.04242
857631	London planetree	Platanus	acerifolia	14	(4)Good	Clearance/over pruned				Prune	-75.77679	40.04248
857632	London planetree	Platanus	acerifolia	23	(4)Good	Clearance			Plate bulge	Prune	-75.77671	40.04253
857633	London planetree	Platanus	acerifolia	23	(4)Good	Clearance/poor pruning			Runoff	Prune	-75.77652	40.04251
857634	London planetree	Platanus	acerifolia	24	(4)Good	Clearance				Prune	-75.77655	40.04266
857635	London planetree	Platanus	acerifolia	25	(4)Good	Clearance			Runoff/mower damage	Prune	-75.77642	40.04258
857636	London planetree	Platanus	acerifolia	22	(4)Good	Clearance/poor pruning			Run off	Prune	-75.77636	40.04264
857637	London planetree	Platanus	acerifolia	24	(4)Good	Clearance				Prune	-75.77648	40.04272
857638	London planetree	Platanus	acerifolia	20	(4)Good	Clearance/poor pruning				Prune	-75.77643	40.04278
857639	London planetree	Platanus	acerifolia	26	(4)Good	Clearance			Run off, drain	Prune	-75.77631	40.04269
857640	London planetree	Platanus	acerifolia	24	(4)Good	Mower damage/clearance				Prune	-75.77619	40.04279
857641	London planetree	Platanus	acerifolia	22	(3)Fair	Storm damage/clearance				Prune	-75.7763	40.04287
857642	London planetree	Platanus	acerifolia	24	(4)Good	Clearance				Prune	-75.77614	40.04285
857643	London planetree	Platanus	acerifolia	23	(4)Good	Clearance				Prune	-75.77622	40.04294
857644	London planetree	Platanus	acerifolia	28	(4)Good	Clearance				Cable/Brace	-75.77615	40.043
857645	London planetree	Platanus	acerifolia	18	(3)Fair	Mower damage/phottropic lean			Sucker growth	Prune	-75.77596	40.04299
857646	London planetree	Platanus	acerifolia	26	(3)Fair	Phototropic lean/clearance				Prune	-75.77602	40.0431
857647	London planetree	Platanus	acerifolia	24	(4)Good	Clearance				Prune	-75.77583	40.04309
857648	London planetree	Platanus	acerifolia	24	(4)Good	Clearance				Prune	-75.77586	40.04324
857649	London planetree	Platanus	acerifolia	29	(4)Good	Clearance			Runoff	Prune	-75.7757	40.04321
857650	London planetree	Platanus	acerifolia	20	(4)Good	Clearance/mower damage			Exposed roots	Prune	-75.7757	40.04337
857651	London planetree	Platanus	acerifolia	30	(4)Good	Clearance			Runoff	Prune	-75.77551	40.04338
857652	London planetree	Platanus	acerifolia	24	(4)Good	Clearance				Prune	-75.7756	40.04348
857682	White ash	Fraxinus	americana	26	(3)Fair	Conflicting with oak		Eab probability		Treat for Insect/Disease	-75.77528	40.04361
857683	London planetree	Platanus	acerifolia	20	(4)Good	Drainage				Prune	-75.77544	40.0437
857684	White oak	Quercus	alba	46	(5)Excellent	Included bark				Cable/Brace	-75.77525	40.04369
857685	Blue spruce	Picea	pungens	6	(4)Good		Needlecast			Treat for Insect/Disease	-75.77525	40.04373
857686	Shagbark hickory	Carya	ovata	22	(3)Fair	Photorropic lean				Prune	-75.77522	40.04381
857687	Eastern white pine	Pinus	strobus	5	(5)Excellent					Prune	-75.77519	40.0438
857688	Red maple	Acer	rubrum	16	(2)Poor	Storm damage				Prune	-75.7752	40.04375
857689	Red maple	Acer	rubrum	17	(2)Poor	Storm damage				Remove	-75.77538	40.04385
857690	Shagbark hickory	Carya	ovata	18	(3)Fair					Prune	-75.77534	40.04392
857691	American beech	Fagus	grandifolia	14	(4)Good	Storm damage				Prune	-75.77534	40.04396
857692	White ash	Fraxinus	americana	15	(3)Fair			Eab prob		Treat for Insect/Disease	-75.77515	40.0439
857693	Black walnut	Juglans	nigra	15	(3)Fair					Prune	-75.77512	40.04424
857694	Black tupelo	Nyssa	sylvatica	17	(4)Good						-75.77532	40.04428
857695	Japanese maple	Acer	palmatum	8	(3)Fair					Prune	-75.77532	40.04435
857696	Blue spruce	Picea	pungens	9	(3)Fair		Needlecast			Treat for Insect/Disease	-75.77532	40.04442
857697	Red maple	Acer	rubrum	26	(4)Good	Storm damage				Prune	-75.77534	40.04447
857698	Eastern white pine	Pinus	strobus	10	(4)Good					Prune	-75.77538	40.04451
857699	Blue spruce	Picea	pungens	8	(2)Poor		Needlecast		Root plate failure	Remove	-75.77515	40.04449
857700	Red maple	Acer	rubrum	13	(3)Fair	Included bark				Prune	-75.77539	40.04462

TREE HEALTH ASSESSMENT DATA
 Conducted by Preservation Tree, LLC, October 2015

857701	Red maple	Acer	rubrum	20 (3)Fair	Included bark		Prune	-75.7754	40.04462
857702	Red maple	Acer	rubrum	23 (3)Fair	Lean		Prune	-75.77541	40.04463
857703	Pignut hickory	Carya	glabra	21 (3)Fair		Tree in well, root flare covered	Soil Remediation	-75.77518	40.04468
857704	London planetree	Platanus	acerifolia	18 (4)Good			Prune	-75.77539	40.0447
857705	London planetree	Platanus	acerifolia	15 (4)Good	Clearance		Prune	-75.77539	40.04477
857706	London planetree	Platanus	acerifolia	19 (4)Good	Clr		Prune	-75.77541	40.04482
857707	London planetree	Platanus	acerifolia	22 (4)Good	Clr	Root crown buried	Prune	-75.77526	40.0449
857708	London planetree	Platanus	acerifolia	19 (4)Good	Poor pruning		Prune	-75.77547	40.04496
857709	London planetree	Platanus	acerifolia	21 (4)Good	Poor pruning		Prune	-75.77532	40.04503
857710	London planetree	Platanus	acerifolia	20 (4)Good	Poor pruning		Prune	-75.77538	40.04509
857711	London planetree	Platanus	acerifolia	22 (4)Good	Storm damage		Prune	-75.77541	40.04515
857712	London planetree	Platanus	acerifolia	24 (4)Good		Runoff	Prune	-75.77555	40.04507
857713	London planetree	Platanus	acerifolia	20 (4)Good	Hangers		Prune	-75.77546	40.0452
857714	London planetree	Platanus	acerifolia	22 (4)Good	Clr		Prune	-75.77551	40.04525
857715	London planetree	Platanus	acerifolia	21 (4)Good	Clr		Prune	-75.77565	40.04517
857716	London planetree	Platanus	acerifolia	17 (4)Good	Clr		Prune	-75.77557	40.04531
857717	London planetree	Platanus	acerifolia	23 (4)Good	Clr		Prune	-75.77565	40.04535
857718	London planetree	Platanus	acerifolia	19 (4)Good	Clr		Prune	-75.77578	40.04526
857719	London planetree	Platanus	acerifolia	21 (4)Good	Clr		Prune	-75.77573	40.04539
857720	London planetree	Platanus	acerifolia	21 (4)Good	Clr		Prune	-75.77582	40.04543
857721	London planetree	Platanus	acerifolia	22 (4)Good	Clr		Prune	-75.77595	40.04535
857722	London planetree	Platanus	acerifolia	20 (4)Good	Clr		Prune	-75.77599	40.0455
857723	London planetree	Platanus	acerifolia	26 (4)Good	Clr		Prune	-75.77613	40.04539
857724	London planetree	Platanus	acerifolia	22 (4)Good	Poor pruning, clr		Prune	-75.77631	40.04556
857725	London planetree	Platanus	acerifolia	25 (4)Good	Clr		Prune	-75.77633	40.04543
857726	London planetree	Platanus	acerifolia	22 (4)Good	Clr, poor pruning		Prune	-75.77641	40.04556
857727	London planetree	Platanus	acerifolia	23 (4)Good	Clr		Prune	-75.77654	40.04543
857728	London planetree	Platanus	acerifolia	22 (4)Good	Clr, poor pruning cuts		Prune	-75.77663	40.04557
857729	London planetree	Platanus	acerifolia	21 (4)Good	Poor pruning, clr		Prune	-75.77677	40.04545
857730	London planetree	Platanus	acerifolia	23 (4)Good	Poor pruning, clr		Prune	-75.77684	40.04557
857731	London planetree	Platanus	acerifolia	24 (4)Good	Poor pruning, clr		Prune	-75.77698	40.04545
857732	London planetree	Platanus	acerifolia	25 (4)Good	Poor pruning, clr		Prune	-75.77705	40.04559
857733	London planetree	Platanus	acerifolia	22 (4)Good	Clr		Prune	-75.77718	40.04558
857734	London planetree	Platanus	acerifolia	23 (4)Good	Clr		Prune	-75.77729	40.04558
857735	London planetree	Platanus	acerifolia	25 (4)Good	Cle		Prune	-75.7774	40.04557
857736	London planetree	Platanus	acerifolia	26 (4)Good	Clr	Girdled	Prune	-75.77737	40.04545
857737	London planetree	Platanus	acerifolia	24 (4)Good	Poor pruning, cle		Prune	-75.77749	40.04556
857738	London planetree	Platanus	acerifolia	21 (4)Good	Clr		Prune	-75.77759	40.04554
857739	London planetree	Platanus	acerifolia	26 (4)Good	Poor pruning, clr		Prune	-75.77753	40.04543
857740	Spruce	Picea		19 (3)Fair		Needlecast	Treat for Insect/Disease	-75.77772	40.04537
857741	Blue spruce	Picea	pungens	22 (3)Fair		Needlecast	Treat for Insect/Disease	-75.77778	40.04534
857742	London planetree	Platanus	acerifolia	25 (4)Good	Clr, poor pruning		Prune	-75.77797	40.04544
857743	London planetree	Platanus	acerifolia	22 (4)Good	Clr		Prune	-75.77811	40.04537
857744	London planetree	Platanus	acerifolia	24 (3)Fair	Poor pruning, decay spots		Prune	-75.77794	40.0453
857745	London planetree	Platanus	acerifolia	19 (4)Good	Storm damage		Prune	-75.77824	40.04531
857746	Eastern white pine	Pinus	strobus	20 (4)Good	Storm damage		Prune	-75.77805	40.04523
857747	Douglas fir	Pseudotsuga	menziesii	17 (3)Fair		Needlecast	Treat for Insect/Disease	-75.77809	40.04521
857748	Eastern white pine	Pinus	strobus	17 (4)Good	Deadwood		Prune	-75.77813	40.04519
857749	Eastern white pine	Pinus	strobus	22 (4)Good			Prune	-75.77818	40.04515
857750	London planetree	Platanus	acerifolia	21 (4)Good	Clr, storm damage		Prune	-75.77827	40.0451
857751	London planetree	Platanus	acerifolia	18 (4)Good	Clr,		Prune	-75.77842	40.04519
857752	London planetree	Platanus	acerifolia	19 (4)Good	Poor pruning, clr		Prune	-75.77847	40.04512
857753	London planetree	Platanus	acerifolia	21 (4)Good	Clr, poor pruning		Prune	-75.77835	40.04504
857754	London planetree	Platanus	acerifolia	18 (4)Good	Clr, poor pruning		Prune	-75.77857	40.04505
857755	London planetree	Platanus	acerifolia	20 (4)Good	Poor pruning, clr		Prune	-75.77863	40.04496
857756	London planetree	Platanus	acerifolia	20 (4)Good	Clr,		Prune	-75.77847	40.04493
857757	London planetree	Platanus	acerifolia	22 (4)Good	Clr, poor pruning		Prune	-75.77868	40.04489
857758	London planetree	Platanus	acerifolia	21 (4)Good	Clr		Prune	-75.77852	40.04485
857759	London planetree	Platanus	acerifolia	21 (4)Good	Clr, storm damage		Prune	-75.7787	40.04482
857760	London planetree	Platanus	acerifolia	21 (4)Good	Clr		Prune	-75.77856	40.04477
857761	London planetree	Platanus	acerifolia	15 (4)Good	Clr		Prune	-75.77875	40.04477
857762	London planetree	Platanus	acerifolia	17 (4)Good	Clr, poor pruning		Prune	-75.77859	40.0447
857763	London planetree	Platanus	acerifolia	18 (4)Good	Clr		Prune	-75.77876	40.04469
857764	White ash	Fraxinus	americana	12 (2)Poor		Eab probability	Remove	-75.77881	40.04469
857765	London planetree	Platanus	acerifolia	18 (4)Good	Clr		Prune	-75.77863	40.04464
857766	London planetree	Platanus	acerifolia	15 (4)Good	Poor pruning		Prune	-75.77882	40.04457

TREE HEALTH ASSESSMENT DATA
 Conducted by Preservation Tree, LLC, October 2015

857767	London planetree	Platanus	acerifolia	18 (4)Good	Clr, poor pruning			Prune	-75.77864	40.04453
857768	London planetree	Platanus	acerifolia	15 (4)Good	Clr, poor pruning			Prune	-75.77882	40.04449
857769	London planetree	Platanus	acerifolia	20 (4)Good	Storm damage, poor pruning			Prune	-75.77865	40.04446
857770	London planetree	Platanus	acerifolia	19 (4)Good	Clr, poor pruning			Prune	-75.77881	40.04442
857771	London planetree	Platanus	acerifolia	22 (4)Good	Storm damage		Standing water	Prune	-75.77866	40.04436
857772	London planetree	Platanus	acerifolia	17 (4)Good	Clr			Prune	-75.77882	40.04434
857773	London planetree	Platanus	acerifolia	21 (4)Good	Storm damage			Prune	-75.77866	40.04425
857774	London planetree	Platanus	acerifolia	18 (4)Good	Clr			Prune	-75.77881	40.04416
857775	London planetree	Platanus	acerifolia	19 (4)Good	Clr			Prune	-75.77864	40.04418
857776	London planetree	Platanus	acerifolia	19 (4)Good	Clr			Prune	-75.77878	40.04407
857777	London planetree	Platanus	acerifolia	20 (4)Good	Clr			Prune	-75.77861	40.04409
857778	Eastern white pine	Pinus	strobus	19 (4)Good	Clr			Prune	-75.77859	40.04403
857779	Crabapple	Malus	tschonoskii	6 (2)Poor				Remove	-75.77883	40.04409
857780	Eastern white pine	Pinus	strobus	21 (4)Good	Clr			Prune	-75.77853	40.04391
857781	Eastern white pine	Pinus	strobus	19 (3)Fair	Heavy lean, cavity, storm damage			Remove	-75.7785	40.04387
857782	Cherry	Prunus		18 (2)Poor		Bacterial canker		Remove	-75.77902	40.04381
857783	Cherry	Prunus		14 (2)Poor	High amount of dead wood,	Bacterial canker,		Remove	-75.77912	40.04362
857784	Cherry	Prunus		14 (3)Fair	Storm damage, poor pruning, deadwood		Buried root flare	Prune	-75.77934	40.04376
857785	Cherry	Prunus		17 (3)Fair	Deadwood, tearout	Bact canker		Prune	-75.77934	40.04379



APPENDIX F

Existing Structure Inspection Reports



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	HW # 1
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	Anthony LaBella

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet
 Basin
 Outfall
 Other Headwall

Township Owned and Operated Facility?

- Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards: <p align="center">N/A</p>	
Recommended maintenance & any immediate corrective actions taken: <p align="center">N/A</p>	
Inspector signature:	Date:
	10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	EW #1
TIME:	10:00 AM	Facility Address:	Culbertson Run Development
WEATHER:	Clear	INSPECTOR:	Anthony Lauletta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?

- Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input type="checkbox"/> Satisfactory <input checked="" type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
3/4 of 15" CMP is covered	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Remove sediment from pipe outfall	
Inspector signature:	Date:
	10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

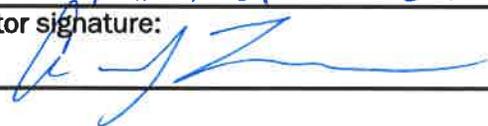
DATE:	10/12/15	Facility Number:	Inlet #1
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	Anthony Laurietta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

Inlet 4x4 Brick Basin Outfall Other _____

Township Owned and Operated Facility? Yes No

OBSERVATIONS:	
Stormwater facility conditions: <input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory	
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth) <p style="text-align: center;">+ - 1'</p>	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards: <p style="text-align: center;">NA</p>	
Recommended maintenance & any immediate corrective actions taken: <p>Clean out bottom of Inlet.</p>	
Inspector signature: 	Date: 10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	Inlet # 2
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	Anthony Lauletta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet 2.5x4 Brick
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility? Yes No

OBSERVATIONS:	
Stormwater facility conditions: <input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory	
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
N/A	
Sediment accumulation: (area, depth)	
Bottom of Inlet +/- 1'	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clean out leaves and minimal debris in the inlet.	
Inspector signature: 	Date: 10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	Inlet # 3
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	Anthony Lauletta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet 4x4 Brick
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?
 Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
Bottom of inlet +/- 1'	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clean out of leaves and debris.	
Inspector signature:	Date:
	10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	Outflow from Inlet #3
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	AK

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?

- Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
Small amount of sediment at the bottom of the pipe.	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clear sediment from the bottom of pipe and add some topsoil over the top of CMP for about 5' from end of pipe.	
Inspector signature:	Date:
	10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	Inlet #4
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	Anthony L. ...

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet 2.5x4 brick
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility? Yes No

OBSERVATIONS:	
Stormwater facility conditions: <input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory	
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth) Bottom of inlet + - 1' leaves & debris	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards: N/A	
Recommended maintenance & any immediate corrective actions taken: Clear Sediment and leaves from inlet.	
Inspector signature:	Date: 10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	Inlet # 5
TIME:	10:00 AM	Facility Address:	Culbertson Run
WEATHER:	Clear	INSPECTOR:	Anthony Lambetta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet *2x3 Brick*

 Basin

 Outfall

 Other _____

Township Owned and Operated Facility? Yes No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
<i>+ - 1'</i>	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
Recommended maintenance & any immediate corrective actions taken:	
<i>Clear debris and leaves from bottom,</i>	
Inspector signature: <i>Anthony Lambetta</i>	Date: <i>10/12/15</i>



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/12/15	Facility Number:	Inlet #6
TIME:	10:00AM	Facility Address:	Outletson Run
WEATHER:	Clear	INSPECTOR:	A. Longfellow

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet ^{2x4} Concrete
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?
 Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
+- 1'	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clean debris and leaves from bottom of Inlet	
Inspector signature:	Date:
A. Longfellow	10/12/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/13/15	Facility Number:	Inlet # 7
TIME:	9:00 AM	Facility Address:	Culbertson Run
WEATHER:	Overcast	INSPECTOR:	Audrey Lambert

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet *2x4 Brick*

 Basin

 Outfall

 Other _____

Township Owned and Operated Facility? Yes No

OBSERVATIONS:	
Stormwater facility conditions: <input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory	
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
<i>+ - 1'</i>	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
<i>N/A</i>	
Recommended maintenance & any immediate corrective actions taken:	
<i>Clean debris? leaves from bottom.</i>	
Inspector signature: <i>Audrey Lambert</i>	Date: 10/13/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

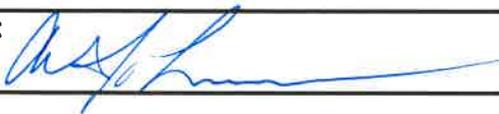
DATE:	10/13/15	Facility Number:	Inlet # 8
TIME:	9:00 AM	Facility Address:	Culbertson Run
WEATHER:	Overcast	INSPECTOR:	Anthony Lauletta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet 2x4 Brick
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?
 Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
+ - 1' at bottom of Inlet	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clean out debris and leaves.	
Inspector signature:	Date:
	10/13/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/13/15	Facility Number:	Headwell # 2
TIME:	9:00 AM	Facility Address:	Culbertson Run
WEATHER:	Overcast	INSPECTOR:	Anthony Lauletta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet
 Basin
 Outfall
 Other Headwell

Township Owned and Operated Facility? Yes No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards: <p align="center" style="font-size: 2em; color: blue;">N/A</p>	
Recommended maintenance & any immediate corrective actions taken: <p style="color: blue;">Headwell is in good shape. 42" cul is deteriorating.</p>	
Inspector signature: <p align="center" style="font-size: 1.5em; color: blue;">Anthony Lauletta</p>	Date: <p align="center" style="font-size: 1.5em; color: blue;">10/13/15</p>



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/13/15	Facility Number:	Endwell # 2
TIME:	9:00 AM	Facility Address:	Culbertson Run
WEATHER:	Overcast	INSPECTOR:	Anthony Lambetta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?

- Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth) <i>Small amount of sediment and rocks at the end of the pipe</i>	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.) <i>Riprap is full of sediment. Will need to be replaced</i>	
Identify any safety hazards: <i>N/A</i>	
Recommended maintenance & any immediate corrective actions taken: <i>Clean end of pipe and install new riprap.</i>	
Inspector signature: <i>[Signature]</i>	Date: <i>10/13/15</i>



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/13/15	Facility Number:	42" CMP under Hawthorne Dr.
TIME:	9:00 AM	Facility Address:	Culbertson Run
WEATHER:	Overcast	INSPECTOR:	Anthony Lauletta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet
 Basin
 Outfall
 Other 42" CMP

Township Owned and Operated Facility?
 Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input type="checkbox"/> Satisfactory <input checked="" type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.) <i>The 42" CMP is rusted away on most of the bottom.</i>	
Identify any safety hazards: <i>Pipe has lost its structural integrity and is a chance of collapse.</i>	
Recommended maintenance & any immediate corrective actions taken: <i>Replace entire length of 42" CMP under Hawthorne Dr.</i>	
Inspector signature: <i>Anthony Lauletta</i>	Date: 10/13/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/13/15	Facility Number:	Inlet #9
TIME:	9:00 AM	Facility Address:	Culberson Run
WEATHER:	Overcast	INSPECTOR:	Anthony Lantier

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet ^{2x4} Concrete
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?
 Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
+- 1'	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clean out leaves and debris	
Inspector signature:	Date:
	10/13/15



EAST BRANDYWINE
Township

STORMWATER FACILITY INSPECTION REPORT

Inspection #:

DATE:	10/13/15	Facility Number:	Inlet #10
TIME:	9:00 AM	Facility Address:	Culbertson Run
WEATHER:	Overcast	INSPECTOR:	Ashley Lambetta

TIME SINCE LAST RAINFALL: _____

Stormwater Facility Type:

- Inlet ^{2x4} _{concrete}
 Basin
 Outfall
 Other _____

Township Owned and Operated Facility?
 Yes
 No

OBSERVATIONS:	
Stormwater facility conditions:	<input checked="" type="checkbox"/> Satisfactory <input type="checkbox"/> Unsatisfactory
Water levels and observations: (discoloration, oily sheen, odor, turbidity, etc.)	
Sediment accumulation: (area, depth)	
+ - 1' debris & leaves	
Condition of vegetation: (health, height, presence of invasive species)	
Vegetation management type: (mowing frequency, natural state, etc.)	
Condition of structural facility components: (inlets, outlets, pipes, fences, berms, spillway, rip-rap, etc.)	
Identify any safety hazards:	
N/A	
Recommended maintenance & any immediate corrective actions taken:	
Clean out any leaves & debris.	
Inspector signature:	Date:
Ashley Lambetta	10/13/15



APPENDIX G

Site Photographs



Photograph 1: Headwall #1



Photograph 2: Inlet #1



Photograph 3: Endwall #1



Photograph 4: Inlet #2



Photograph 5: Inlet #3



Photograph 6: Inlet #3 Outfall



Photograph 7: Inlet #4



Photograph 8: Inlet #5



Photograph 9: Inlet #6



Photograph 10: Inlet #7



Photograph 11: Inlet #8



Photograph 12: Headwall #2



Photograph 13: Endwall #2



Photograph 14: 42" CMP between Headwall #2 and Endwall #2



Photograph 15: Inlet #9



Photograph 16: Inlet #10



Photograph 17: Physical barrier of boulders within swale along eastern side of Hawthorne Drive from north entrance of Hawthorne Drive to Hedgerow Court



Photograph 18: Poorly defined swale along western side of Hawthorne Drive from north entrance of Hawthorne Drive to Hedgerow Court



Photograph 19: Washout areas along the east side of Hawthorne Drive approaching Hedgerow Court.



Photograph 20: Accelerated erosion along the west side of Hawthorne Drive approaching Hastings Court.



Photograph 21: Washout areas along the east side of Hawthorne Drive approaching Highland Court.



Photograph 22: Accelerated erosion along the west side of Hawthorne Drive approaching Wyndham Court.



Photograph 23: Accelerated erosion along the north side of Hawthorne Drive approaching Lambeth Court.



Photograph 24: Washout area along the north side of Hawthorne Drive approaching Chapel Court.



Photograph 25: Accelerated erosion along the west side of Hawthorne Drive approaching Headwall #2.



Photograph 26: Washout area along the east side of Hawthorne Drive approaching Endwall #2.



Photograph 27: Surface tree roots blocking existing swale along the west side of Hawthorne Drive approaching Somerset Court



Photograph 28: Washout area along the east side of Hawthorne Drive approaching Canterbury Court



Photograph 29: Debris/trash blocking existing swale along the west side of Hawthorne Drive approaching Somerset Court



Photograph 30: Washout area with debris along the east side of Hawthorne Drive approaching Chatham Court



Photograph 31: Accelerated erosion along the east side of Hawthorne Drive approaching Essex Court

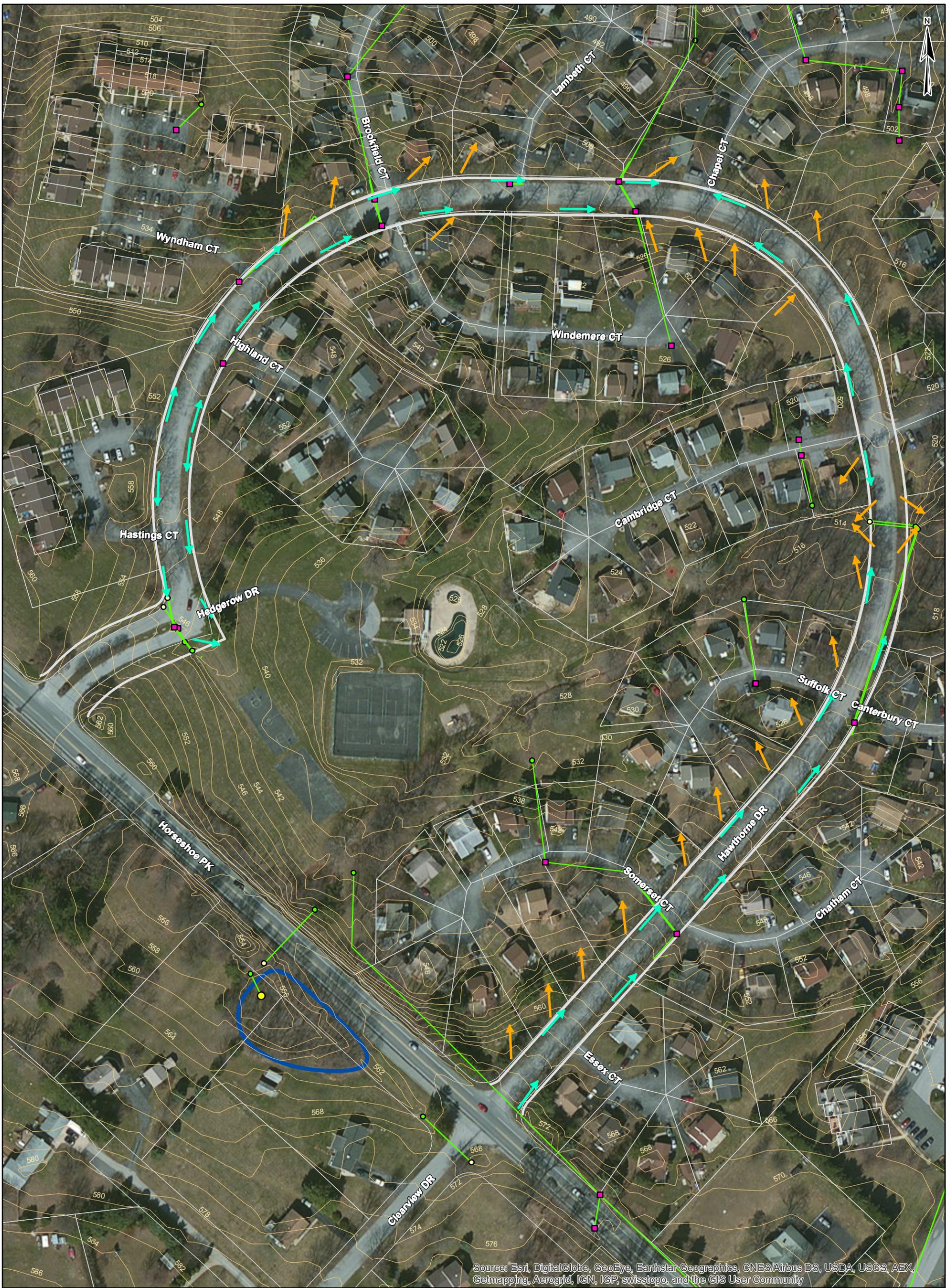


Photograph 32: Poor condition trees along the west side of Hawthorne Drive approaching south entrance of Hawthorne Drive



APPENDIX H

Flow Direction Map



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



DRAWN BY: BU

**FLOW DIRECTION MAP
HAWTHORNE DRIVE
COMPREHENSIVE STORMWATER
MANAGEMENT STUDY**

**CULBERTSON RUN DEVELOPMENT
EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PA**

1 inch = 125 feet

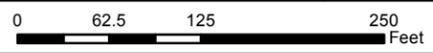
CEG Proj #: EBT-15-066

NOTES:

1. Contours are 2-ft intervals. (PAMAP Program LIDAR 2010).
2. Storm structures outside Hawthorne Drive ROW from Township MS4 GIS data,
3. Storm structures within Hawthorne Drive from Ash Associates, Inc. survey dated 10/5/15.

LEGEND

- Flow Direction (Inside ROW)
- Flow Direction (Outside ROW)
- Storm Pipe
- Inlets
- Headwalls
- Endwalls
- Contours
- Stormwater Basins
- Parcels
- Hawthorne Drive ROW

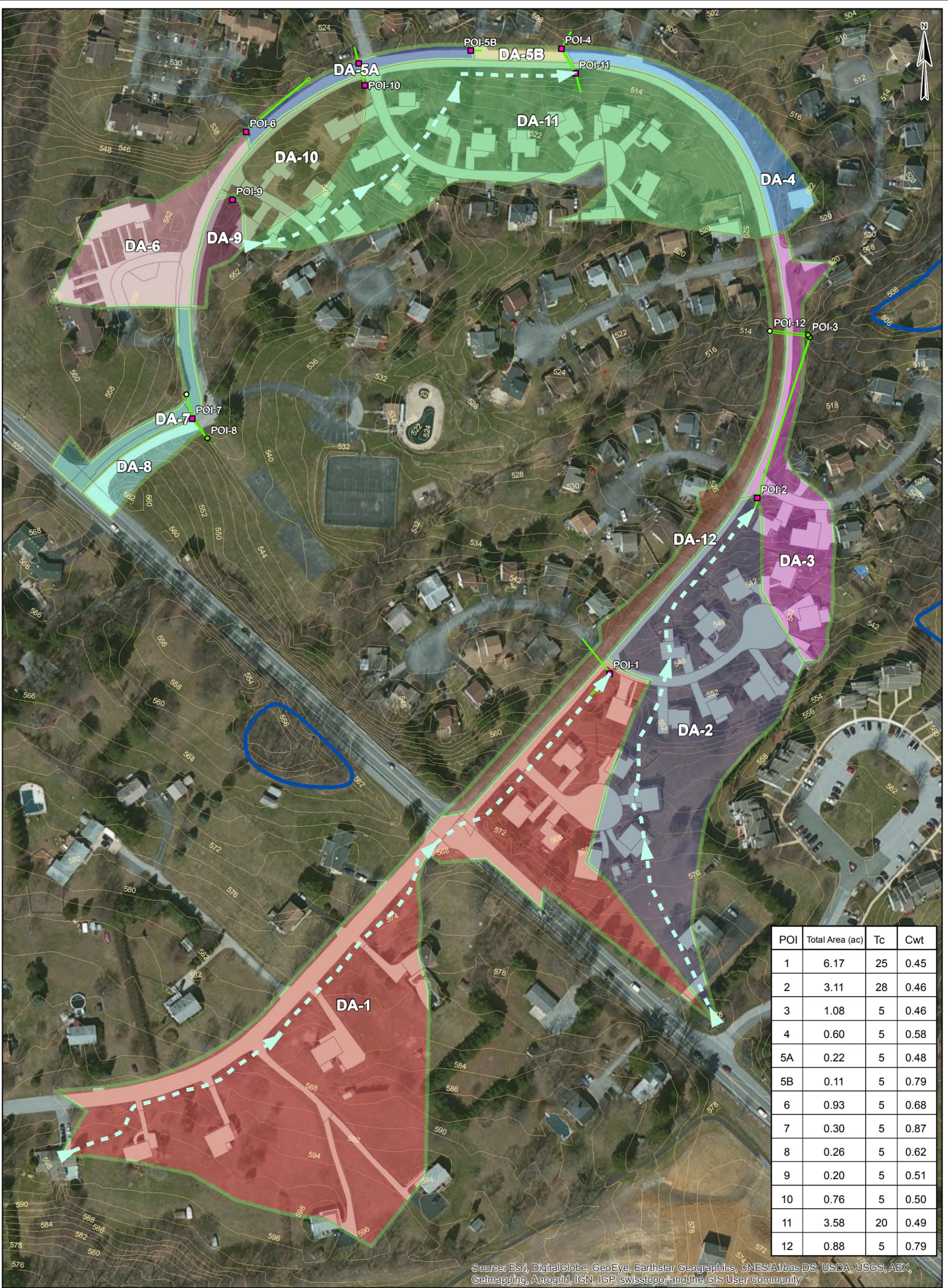


02/04/2016



APPENDIX I

Drainage Area Map



POI	Total Area (ac)	Tc	Cwt
1	6.17	25	0.45
2	3.11	28	0.46
3	1.08	5	0.46
4	0.60	5	0.58
5A	0.22	5	0.48
5B	0.11	5	0.79
6	0.93	5	0.68
7	0.30	5	0.87
8	0.26	5	0.62
9	0.20	5	0.51
10	0.76	5	0.50
11	3.58	20	0.49
12	0.88	5	0.79

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



DRAWN BY: BU

**DRAINAGE AREA MAP
HAWTHORNE DRIVE
COMPREHENSIVE STORMWATER
MANAGEMENT STUDY**

**CULBERTSON RUN DEVELOPMENT
EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PA**

1 inch = 150 feet

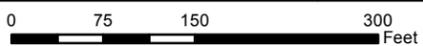
CEG Proj #: EBT-15-066

NOTES:

1. Total Area is in Acres (ac).
2. Tc (min.).
3. Cwt = Total (Area x C) / Total (Area).
4. Contours are 2-ft intervals. (PAMAP Program LIDAR 2010).
5. Storm structures within Hawthorne Drive from Ash Associates, Inc. survey dated 10/5/15.

LEGEND

- Drainage Areas
- Impervious Coverage
- Storm Pipe
- Inlets
- Headwalls
- Endwalls
- Contours
- Time of Concentration
- Stormwater Basins

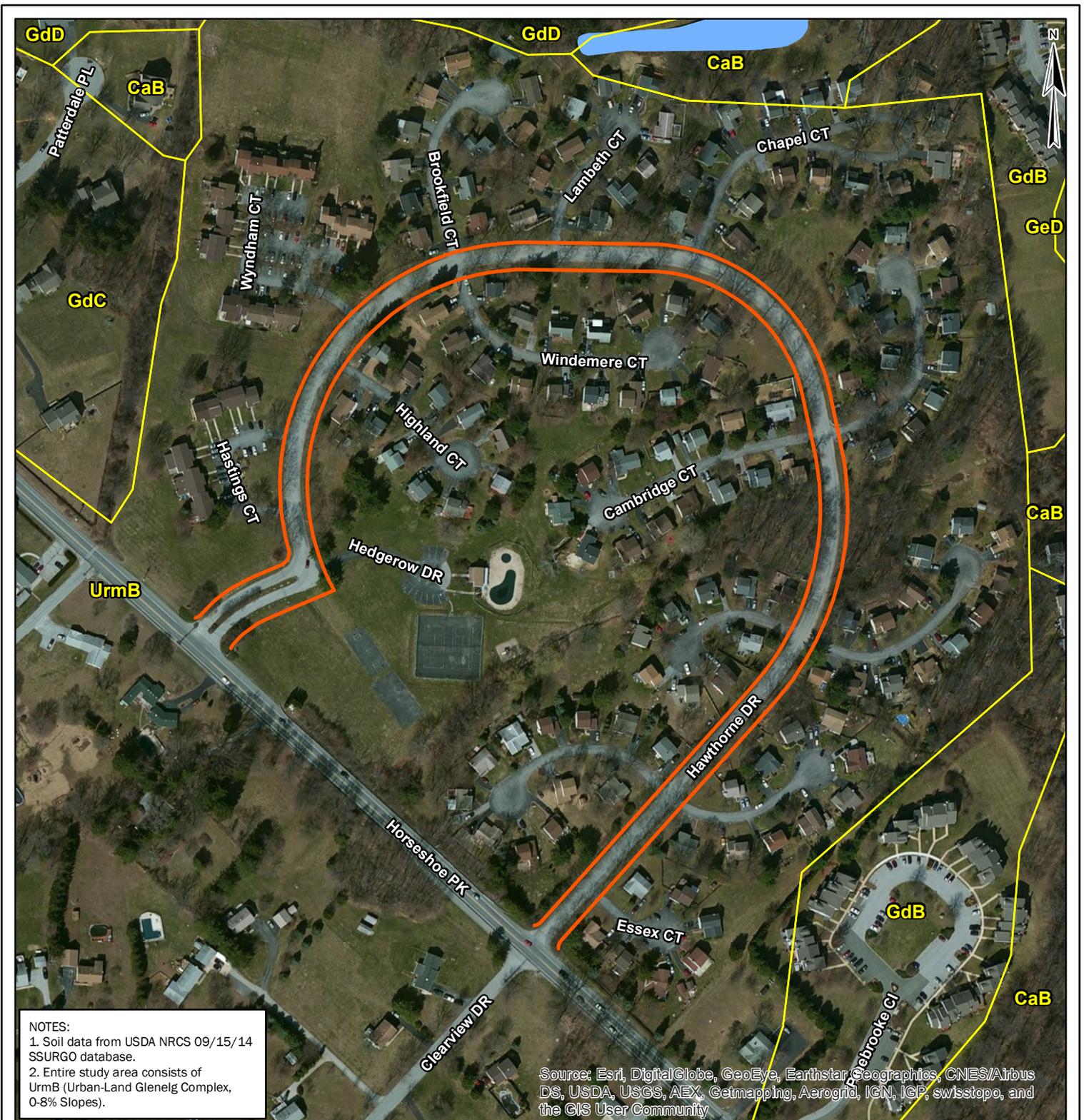


02/04/2016



APPENDIX J

Soil Data and Map



NOTES:
 1. Soil data from USDA NRCS 09/15/14 SSURGO database.
 2. Entire study area consists of UrmB (Urban-Land Glenelg Complex, 0-8% Slopes).

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

 CEDARVILLE Engineering Group, LLC	DRAWN BY: BU	LEGEND  Hawthorne Drive Right-of-Way  Soils  Streams  Waterbodies
SOIL MAP HAWTHORNE DRIVE COMPREHENSIVE STORMWATER MANAGEMENT STUDY CULBERTSON RUN DEVELOPMENT EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PA		
1 inch = 250 feet	CEG Proj #: EBT-15-066	
	02/08/2016	

Chester County, Pennsylvania

UrmB—Urban land-Glenelg complex, 0 to 8 percent slopes

Map Unit Setting

National map unit symbol: pjnd
Elevation: 200 to 2,000 feet
Mean annual precipitation: 40 to 55 inches
Mean annual air temperature: 45 to 61 degrees F
Frost-free period: 110 to 235 days
Farmland classification: Not prime farmland

Map Unit Composition

Urban land: 65 percent
Glenelg and similar soils: 30 percent
Minor components: 5 percent
Estimates are based on observations, descriptions, and transects of the mapunit.

Description of Urban Land

Setting

Landform: Hills
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluvial, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Pavement, buildings and other artificially covered areas

Typical profile

C - 0 to 6 inches: variable

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 10 to 99 inches to lithic bedrock
Available water storage in profile: Very low (about 0.0 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 8s

Description of Glenelg

Setting

Landform: Hillslopes
Landform position (two-dimensional): Summit, shoulder, backslope
Landform position (three-dimensional): Interfluvial, side slope, nose slope
Down-slope shape: Linear, convex
Across-slope shape: Convex, linear
Parent material: Residuum weathered from mica schist

Typical profile

A - 0 to 8 inches: channery silt loam
Bt - 8 to 26 inches: channery silt loam
C - 26 to 60 inches: channery loam

Properties and qualities

Slope: 0 to 8 percent
Depth to restrictive feature: 60 to 120 inches to paralithic bedrock
Natural drainage class: Well drained
Runoff class: Low
Capacity of the most limiting layer to transmit water (Ksat):
Moderately high to high (0.60 to 2.00 in/hr)
Depth to water table: More than 80 inches
Frequency of flooding: None
Frequency of ponding: None
Available water storage in profile: High (about 9.4 inches)

Interpretive groups

Land capability classification (irrigated): None specified
Land capability classification (nonirrigated): 2e
Hydrologic Soil Group: B

Minor Components

Glenville

Percent of map unit: 5 percent
Landform: Hillslopes
Landform position (two-dimensional): Footslope, backslope
Landform position (three-dimensional): Side slope, head slope
Down-slope shape: Linear, concave
Across-slope shape: Concave, linear

Data Source Information

Soil Survey Area: Chester County, Pennsylvania
Survey Area Data: Version 7, Nov 16, 2015



APPENDIX K

Hydrologic and Hydraulic Calculations and Data

RATIONAL METHOD
HYDROLOGIC DATA FOR WATERSHED
RUNOFF COMPUTATIONS

PROJECT: EBT-15-066 Hawthorne Drive
Township: East Brandywine
Description: Culbertson Run Development

DATE: 12/1/2015
REV:
BY: AP

POI - 1

Total Area = **6.17** acres
Tc = **25** min
Cwt = **0.45**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	1.63	1.61
Open Space-Good	B	0.25	4.54	1.14
				0.00
				0.00
				0.00
TOTAL			6.17	2.75

POI - 2

Total Area = **3.11** acres
Tc = **28** min
Cwt = **0.46**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.87	0.86
Open Space-Good	B	0.25	2.24	0.56
				0.00
				0.00
				0.00
TOTAL			3.11	1.42

POI - 3

Total Area = **1.08** acres
Tc = **5** min
Cwt = **0.57**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.46	0.46
Open Space-Good	B	0.25	0.62	0.16
				0.00
				0.00
				0.00
TOTAL			1.08	0.61



POI - 4

Total Area = 0.60 acres

Tc = 5 min

Cwt = 0.58

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.27	0.27
Open Space-Good	B	0.25	0.33	0.08
				0.00
				0.00
				0.00
TOTAL			0.60	0.35

POI - 5A

Total Area = 0.22 acres

Tc = 5 min

Cwt = 0.48

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.10	0.10
Open Space-Good	B	0.25	0.03	0.01
			0.09	0.00
				0.00
				0.00
TOTAL			0.22	0.10

POI - 5B

Total Area = 0.11 acres

Tc = 5 min

Cwt = 0.79

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.08	0.08
Open Space-Good	B	0.25	0.03	0.01
				0.00
				0.00
				0.00
TOTAL			0.11	0.09

POI - 6

Total Area = 0.93 acres

Tc = 5 min

Cwt = 0.68

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.54	0.53
Open Space-Good	B	0.25	0.39	0.10
				0.00
				0.00
				0.00
TOTAL			0.93	0.63



POI - 7

Total Area = **0.30** acres
 Tc = **5** min
 Cwt = **0.87**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.25	0.25
Open Space-Good	B	0.25	0.05	0.01
				0.00
				0.00
				0.00
TOTAL			0.30	0.26

POI - 8

Total Area = **0.26** acres
 Tc = **5** min
 Cwt = **0.62**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.13	0.13
Open Space-Good	B	0.25	0.13	0.03
				0.00
				0.00
				0.00
TOTAL			0.26	0.16

POI - 9

Total Area = **0.20** acres
 Tc = **5** min
 Cwt = **0.51**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.07	0.07
Open Space-Good	B	0.25	0.13	0.03
				0.00
				0.00
				0.00
TOTAL			0.20	0.10

POI - 10

Total Area = **0.76** acres
 Tc = **5** min
 Cwt = **0.50**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.26	0.26
Open Space-Good	B	0.25	0.50	0.13
				0.00
				0.00
				0.00
TOTAL			0.76	0.38



POI - 11

Total Area = **3.58** acres

Tc = **20** min

Cwt = **0.49**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	1.18	1.17
Open Space-Good	B	0.25	2.40	0.60
				0.00
				0.00
				0.00
TOTAL			3.58	1.77

POI - 12

Total Area = **0.88** acres

Tc = **5** min

Cwt = **0.79**

$$Cwt = \frac{\text{Total (Area x C)}}{\text{Total (Area)}}$$

Cover Type	Hydrological Soil Group	C	Area acres	Area x C acres
Paved & Roof	B	0.99	0.64	0.63
Open Space-Good	B	0.25	0.24	0.06
				0.00
				0.00
				0.00
TOTAL			0.88	0.69



TIME OF CONCENTRATION (TR-55)

Worksheet 3: Time of Concentration (Tc) or Travel Time (Tt)

PROJECT: EBT-15-066 **DATE:** 12/1/2015
Township: East Brandywine **BY:** AP
Drainage Area: POI - 1 **Checked BY:** _____

- Pre-Development Post-Development
 Tc Tt

Notes: Space for as many as three segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments

Sheet Flow (Applicable to Tc only)

- 1 Surface Description (table 3-1)
- 2 Manning's roughness coefficient, n (table 3-1)
- 3 Flow Length, L (total L ≤ 300 ft)
- 4 Two-year 24-hour rainfall, P₂
- 5 Land slope, s

6
$$T_c = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Segment ID	1			
	Grass	Dense		
	0.24			
ft	150			
in	3.24			
ft/ft	0.0260			
Compute T_t	hr	0.29		= 0.29

Shallow Concentrated Flow

- 7 Surface description (paved or unpaved)
- 8 Flow length, L
- 9 Watercourse slope, s
- 10 Average velocity, V (figure 3-1)

11
$$T_c = \frac{L}{(3600V)}$$

Segment ID	2	3		
	Unpaved	Paved		
ft	605	170		
ft/ft	0.0363	0.0029		
ft/s	3.1	1.1		
Compute T_t	hr	0.05	0.04	= 0.10

Channel Flow

- 12 Cross sectional flow area, a
- 13 Wetted perimeter, P_w
- 14 Hydraulic radius, r = a/P_w
- 15 Channel slope, s
- 16 Manning's roughness coefficient, n
- 17 V = (1.49r^{2/3}s^{1/2})/n
- 18 Flow length, L

19
$$T_t = \frac{L}{(3600V)}$$

Segment ID	4			
ft ²	1.08			
ft	3.81			
ft	0.28			
ft/ft	0.0592			
ft/s	3.13			
ft	338			
Compute T_t	hr	0.03		= 0.03
				hr 0.42

20 Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19)

Minutes 25

Notes:



TIME OF CONCENTRATION (TR-55)

Worksheet 3: Time of Concentration (Tc) or Travel Time (Tt)

PROJECT: EBT-15-066 **DATE:** 12/1/2015
Township: East Brandywine **BY:** AP
Drainage Area: POI - 2 **Checked BY:** _____

- Pre-Development Post-Development
 Tc Tt

Notes: Space for as many as three segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments

Sheet Flow (Applicable to Tc only)

- 1 Surface Description (table 3-1)
- 2 Manning's roughness coefficient, n (table 3-1)
- 3 Flow Length, L (total L ≤ 300 ft)
- 4 Two-year 24-hour rainfall, P₂
- 5 Land slope, s

6
$$T_c = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Segment ID	1				
	Grass	Dense			
	0.24				
	ft	250			
	in	3.24			
	ft/ft	0.0320			
Compute T_t	hr	0.41			= 0.41

Shallow Concentrated Flow

- 7 Surface description (paved or unpaved)
- 8 Flow length, L
- 9 Watercourse slope, s
- 10 Average velocity, V (figure 3-1)

11
$$T_c = \frac{L}{(3600V)}$$

Segment ID	2				
	Unpaved				
	ft	460			
	ft/ft	0.0608			
	ft/s	4.0			
Compute T_t	hr	0.03			= 0.03

Channel Flow

- 12 Cross sectional flow area, a
- 13 Wetted perimeter, P_w
- 14 Hydraulic radius, r = a/P_w
- 15 Channel slope, s
- 16 Manning's roughness coefficient, n
- 17 V = (1.49r^{2/3}s^{1/2})/n
- 18 Flow length, L

19
$$T_t = \frac{L}{(3600V)}$$

Segment ID	3				
	ft ²	1.08			
	ft	3.81			
	ft	0.28			
	ft/ft	0.0573			
	ft/s	3.08			
	ft	244			
Compute T_t	hr	0.02			= 0.02
	hr				= 0.46

20 Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19)

Minutes 28

Notes:



TIME OF CONCENTRATION (TR-55)

Worksheet 3: Time of Concentration (Tc) or Travel Time (Tt)

PROJECT: EBT-15-066 DATE: 12/1/2015
 Township: East Brandywine BY: AP
 Drainage Area: POI - 11 Checked BY: _____

- Pre-Development Post-Development
 Tc Tt

*Notes: Space for as many as three segments per flow type can be used for each worksheet.
 Include a map, schematic, or description of flow segments*

Sheet Flow (Applicable to Tc only)

- 1 Surface Description (table 3-1)
- 2 Manning's roughness coefficient, n (table 3-1)
- 3 Flow Length, L (total L ≤ 300 ft)
- 4 Two-year 24-hour rainfall, P₂
- 5 Land slope, s

6
$$T_c = \frac{0.007 (nL)^{0.8}}{P_2^{0.5} s^{0.4}}$$

Segment ID	1			
	Grass	Dense		
	0.24			
	ft	150		
	in	3.24		
	ft/ft	0.0280		
Compute T _t	hr	0.29		= 0.29

Shallow Concentrated Flow

- 7 Surface description (paved or unpaved)
- 8 Flow length, L
- 9 Watercourse slope, s
- 10 Average velocity, V (figure 3-1)

11
$$T_c = \frac{L}{(3600V)}$$

Segment ID	2			
	Unpaved			
	ft	321		
	ft/ft	0.0996		
	ft/s	5.1		
Compute T _t	hr	0.02		= 0.02

Channel Flow

- 12 Cross sectional flow area, a
- 13 Wetted perimeter, P_w
- 14 Hydraulic radius, r = a/P_w
- 15 Channel slope, s
- 16 Manning's roughness coefficient, n
- 17 $V = (1.49r^{2/3}s^{1/2})/n$
- 18 Flow length, L

19
$$T_t = \frac{L}{(3600V)}$$

Segment ID	4			
	ft ²	1.08		
	ft	3.81		
	ft	0.28		
	ft/ft	0.0245		
	ft/s	2.01		
	ft	204		
Compute T _t	hr	0.03		= 0.03
	hr			0.33

20 Watershed or subarea Tc or Tt (add Tt in steps 6, 11, and 19)

Minutes 20

Notes:



Sheet flow

Sheet flow is flow over plane surfaces. It usually occurs in the headwater of streams. With sheet flow, the friction value (Manning's n) is an effective roughness coefficient that includes the effect of raindrop impact; drag over the plane surface; obstacles such as litter, crop ridges, and rocks; and erosion and transportation of sediment. These n values are for very shallow flow depths of about 0.1 foot or so. Table 3-1 gives Manning's n values for sheet flow for various surface conditions.

For sheet flow of less than 300 feet, use Manning's kinematic solution (Overton and Meadows 1976) to compute T_t :

$$T_t = \frac{0.007 (nL)^{0.8}}{(P_2)^{0.5} s^{0.4}} \quad [\text{Eq. 3-3}]$$

Table 3-1.—Roughness coefficients (Manning's n) for sheet flow

Surface description	n ¹
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover ≤ 20%	0.06
Residue cover > 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses ²	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods: ³	
Light underbrush	0.40
Dense underbrush	0.80

¹The n values are a composite of information compiled by Engman (1986).

²Includes species such as weeping lovegrass, bluegrass, buffalo grass, blue grama grass, and native grass mixtures.

³When selecting n, consider cover to a height of about 0.1 ft. This is the only part of the plant cover that will obstruct sheet flow.

where

- T_t = travel time (hr),
- n = Manning's roughness coefficient (table 3-1),
- L = flow length (ft),
- P_2 = 2-year, 24-hour rainfall (in), and
- s = slope of hydraulic grade line (land slope, ft/ft).

This simplified form of the Manning's kinematic solution is based on the following: (1) shallow steady uniform flow, (2) constant intensity of rainfall excess (that part of a rain available for runoff), (3) rainfall duration of 24 hours, and (4) minor effect of infiltration on travel time. Rainfall depth can be obtained from appendix B.

Shallow concentrated flow

After a maximum of 300 feet, sheet flow usually becomes shallow concentrated flow. The average velocity for this flow can be determined from figure 3-1, in which average velocity is a function of watercourse slope and type of channel. For slopes less than 0.005 ft/ft, use equations given in appendix F for figure 3-1. Tillage can affect the direction of shallow concentrated flow. Flow may not always be directly down the watershed slope if tillage runs across the slope.

After determining average velocity in figure 3-1, use equation 3-1 to estimate travel time for the shallow concentrated flow segment.

Open channels

Open channels are assumed to begin where surveyed cross section information has been obtained, where channels are visible on aerial photographs, or where blue lines (indicating streams) appear on United States Geological Survey (USGS) quadrangle sheets. Manning's equation or water surface profile information can be used to estimate average flow velocity. Average flow velocity is usually determined for bank-full elevation.

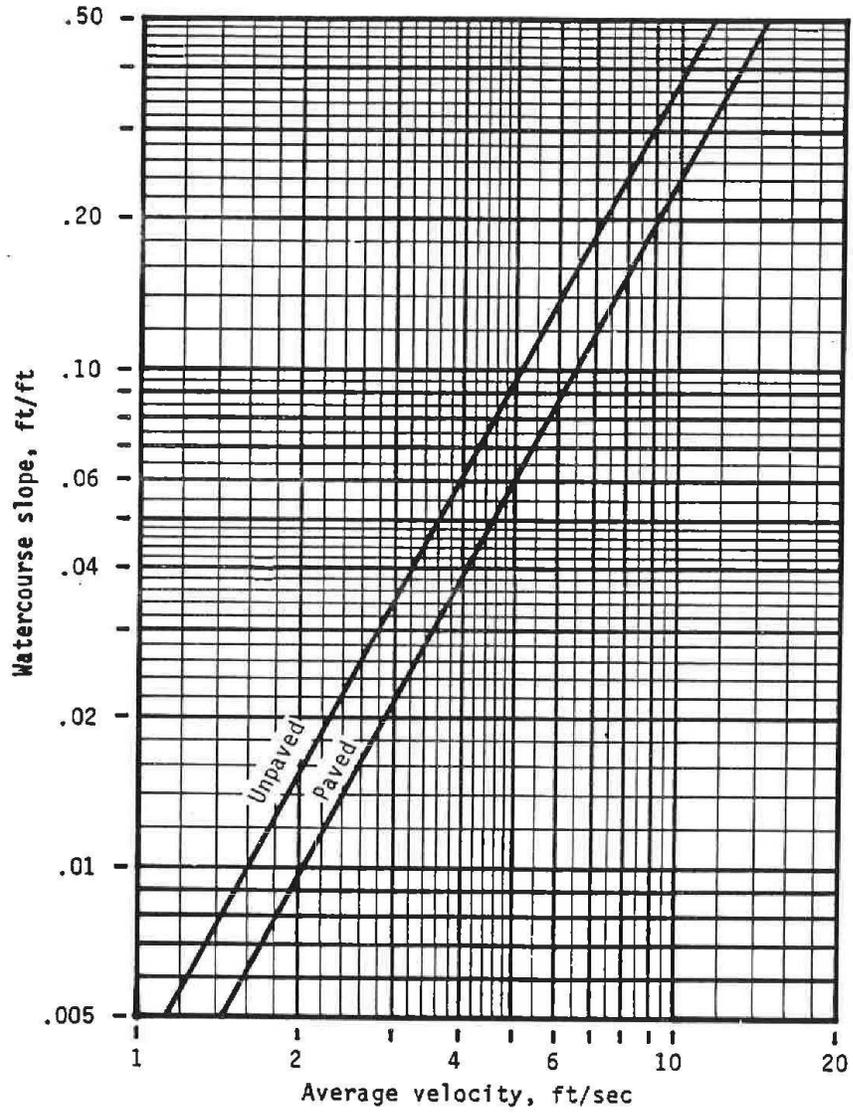


Figure 3-1.—Average velocities for estimating travel time for shallow concentrated flow.

Hydrograph Return Period Recap

Hydroflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Inflow Hyd(s)	Peak Outflow (cfs)								Hydrograph description
			1-Yr	2-Yr	3-Yr	5-Yr	10-Yr	25-Yr	50-Yr	100-Yr	
1	Rational	-----	5.888	7.089	-----	8.566	9.580	10.73	11.58	12.36	POI-1
2	Rational	-----	2.836	3.416	-----	4.140	4.640	5.210	5.634	6.027	POI-2
3	Rational	-----	2.561	3.052	-----	3.569	3.917	4.329	4.614	4.880	POI-3
4	Rational	-----	1.448	1.725	-----	2.018	2.214	2.447	2.608	2.759	POI-4
5	Rational	-----	0.439	0.523	-----	0.612	0.672	0.743	0.791	0.837	POI-5A
6	Rational	-----	0.361	0.431	-----	0.504	0.553	0.611	0.651	0.689	POI-5B
7	Rational	-----	2.631	3.135	-----	3.666	4.024	4.447	4.740	5.013	POI-6
8	Rational	-----	1.086	1.294	-----	1.513	1.661	1.835	1.956	2.069	POI-7
9	Rational	-----	0.671	0.799	-----	0.935	1.026	1.134	1.208	1.278	POI-8
10	Rational	-----	0.424	0.506	-----	0.591	0.649	0.717	0.764	0.809	POI-9
11	Rational	-----	1.581	1.884	-----	2.203	2.418	2.672	2.848	3.012	POI-10
12	Rational	-----	4.220	5.072	-----	6.096	6.791	7.569	8.144	8.665	POI-11
13	Rational	-----	2.892	3.446	-----	4.030	4.423	4.889	5.210	5.511	POI-12

Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	5.888	1	25	8,833	-----	-----	-----	POI-1
2	Rational	2.836	1	28	4,764	-----	-----	-----	POI-2
3	Rational	2.561	1	5	768	-----	-----	-----	POI-3
4	Rational	1.448	1	5	434	-----	-----	-----	POI-4
5	Rational	0.439	1	5	132	-----	-----	-----	POI-5A
6	Rational	0.361	1	5	108	-----	-----	-----	POI-5B
7	Rational	2.631	1	5	789	-----	-----	-----	POI-6
8	Rational	1.086	1	5	326	-----	-----	-----	POI-7
9	Rational	0.671	1	5	201	-----	-----	-----	POI-8
10	Rational	0.424	1	5	127	-----	-----	-----	POI-9
11	Rational	1.581	1	5	474	-----	-----	-----	POI-10
12	Rational	4.220	1	20	5,063	-----	-----	-----	POI-11
13	Rational	2.892	1	5	868	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 1 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Thursday, Jan 21, 2016

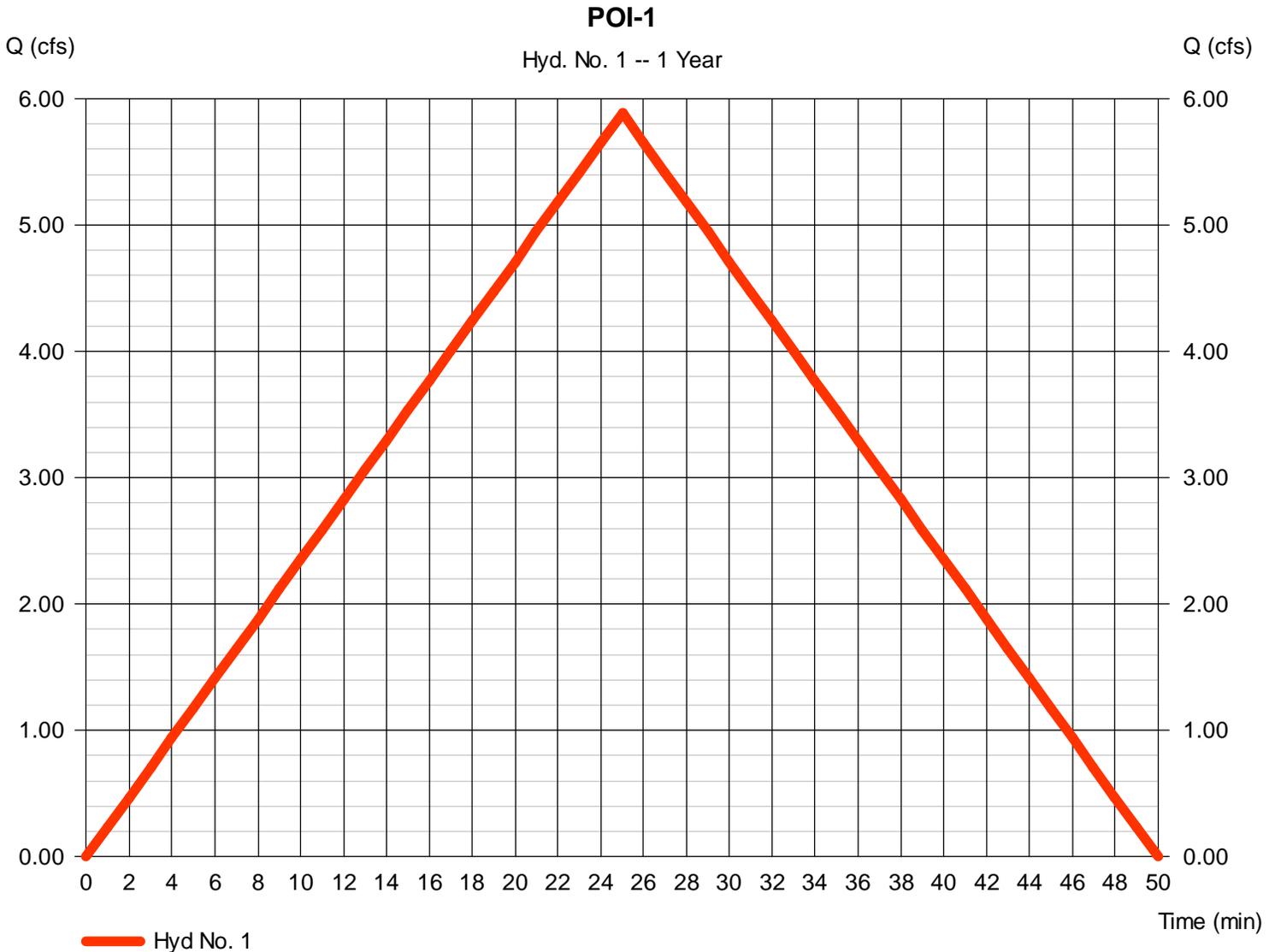
Hyd. No. 1

POI-1

Hydrograph type = Rational
 Storm frequency = 1 yrs
 Time interval = 1 min
 Drainage area = 6.170 ac
 Intensity = 2.121 in/hr
 IDF Curve = East Brandywine.IDF

Peak discharge = 5.888 cfs
 Time to peak = 25 min
 Hyd. volume = 8,833 cuft
 Runoff coeff. = 0.45*
 Tc by User = 25.00 min
 Asc/Rec limb fact = 1/1

* Composite (Area/C) = [(1.630 x 0.99) + (4.540 x 0.25)] / 6.170



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	7.089	1	25	10,633	-----	-----	-----	POI-1
2	Rational	3.416	1	28	5,739	-----	-----	-----	POI-2
3	Rational	3.052	1	5	915	-----	-----	-----	POI-3
4	Rational	1.725	1	5	518	-----	-----	-----	POI-4
5	Rational	0.523	1	5	157	-----	-----	-----	POI-5A
6	Rational	0.431	1	5	129	-----	-----	-----	POI-5B
7	Rational	3.135	1	5	940	-----	-----	-----	POI-6
8	Rational	1.294	1	5	388	-----	-----	-----	POI-7
9	Rational	0.799	1	5	240	-----	-----	-----	POI-8
10	Rational	0.506	1	5	152	-----	-----	-----	POI-9
11	Rational	1.884	1	5	565	-----	-----	-----	POI-10
12	Rational	5.072	1	20	6,087	-----	-----	-----	POI-11
13	Rational	3.446	1	5	1,034	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 2 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

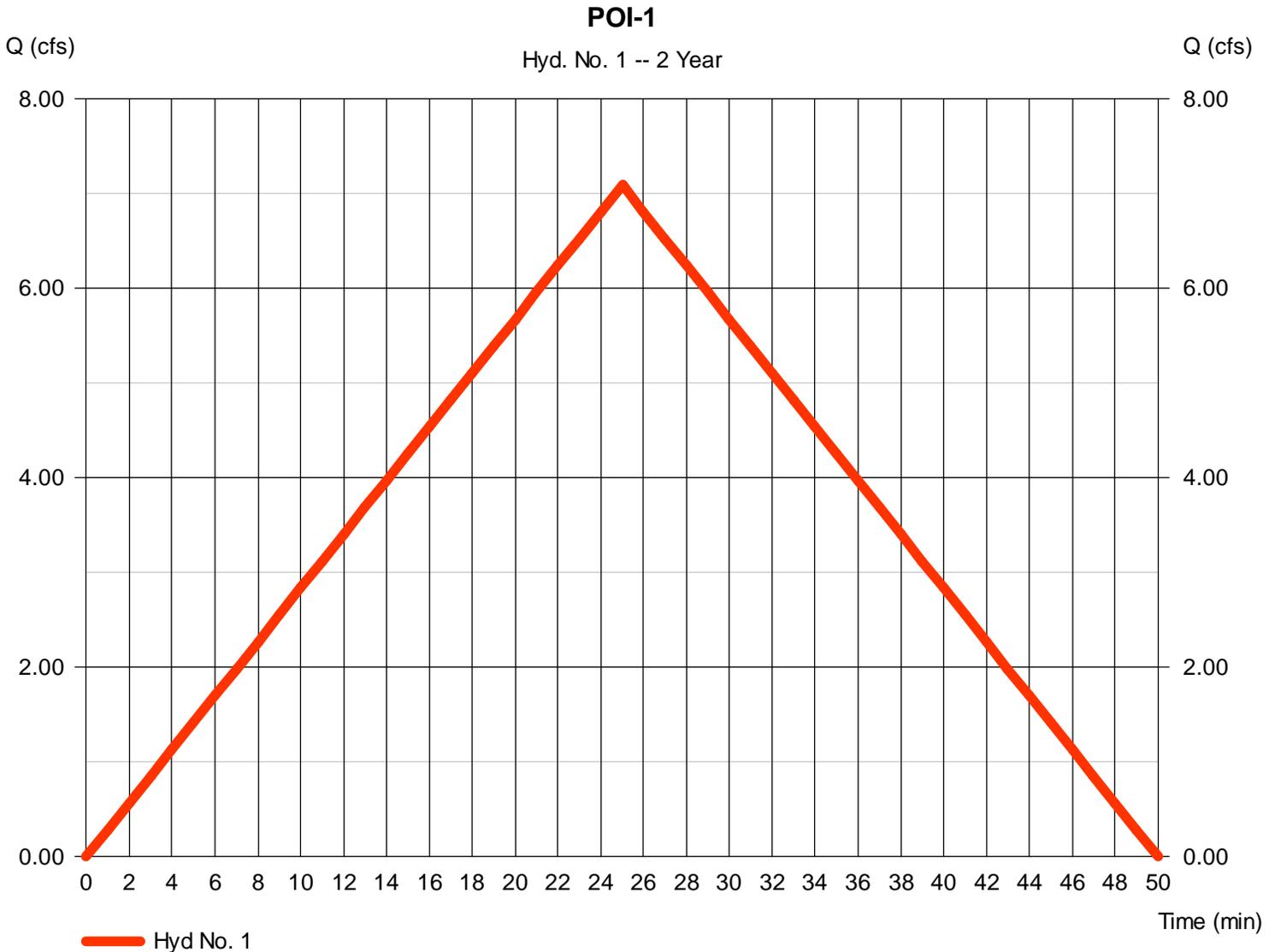
Thursday, Jan 21, 2016

Hyd. No. 1

POI-1

Hydrograph type	= Rational	Peak discharge	= 7.089 cfs
Storm frequency	= 2 yrs	Time to peak	= 25 min
Time interval	= 1 min	Hyd. volume	= 10,633 cuft
Drainage area	= 6.170 ac	Runoff coeff.	= 0.45*
Intensity	= 2.553 in/hr	Tc by User	= 25.00 min
IDF Curve	= East Brandywine.IDF	Asc/Rec limb fact	= 1/1

* Composite (Area/C) = [(1.630 x 0.99) + (4.540 x 0.25)] / 6.170



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	8.566	1	25	12,850	-----	-----	-----	POI-1
2	Rational	4.140	1	28	6,955	-----	-----	-----	POI-2
3	Rational	3.569	1	5	1,071	-----	-----	-----	POI-3
4	Rational	2.018	1	5	605	-----	-----	-----	POI-4
5	Rational	0.612	1	5	184	-----	-----	-----	POI-5A
6	Rational	0.504	1	5	151	-----	-----	-----	POI-5B
7	Rational	3.666	1	5	1,100	-----	-----	-----	POI-6
8	Rational	1.513	1	5	454	-----	-----	-----	POI-7
9	Rational	0.935	1	5	280	-----	-----	-----	POI-8
10	Rational	0.591	1	5	177	-----	-----	-----	POI-9
11	Rational	2.203	1	5	661	-----	-----	-----	POI-10
12	Rational	6.096	1	20	7,315	-----	-----	-----	POI-11
13	Rational	4.030	1	5	1,209	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 5 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Thursday, Jan 21, 2016

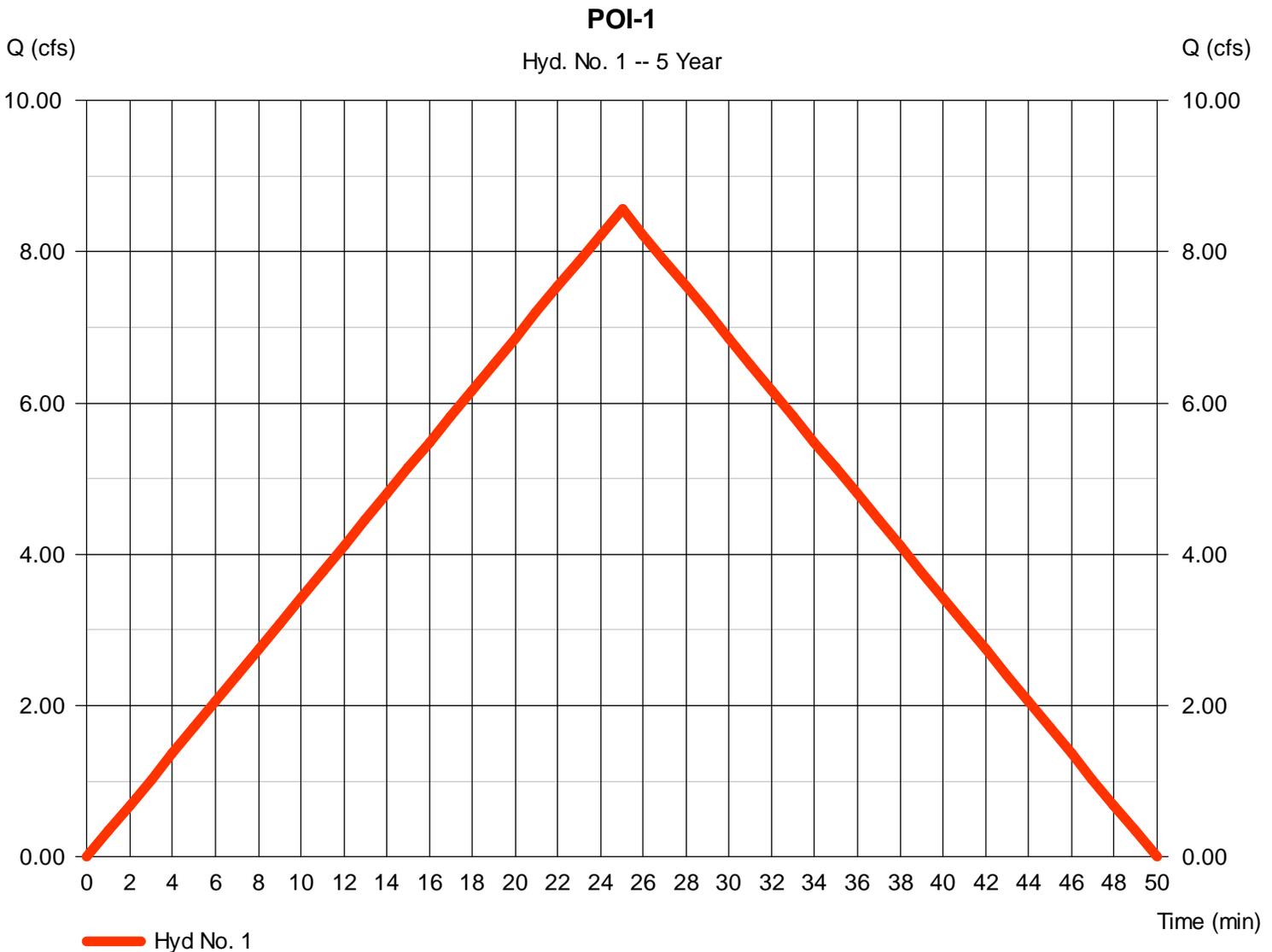
Hyd. No. 1

POI-1

Hydrograph type = Rational
 Storm frequency = 5 yrs
 Time interval = 1 min
 Drainage area = 6.170 ac
 Intensity = 3.085 in/hr
 IDF Curve = East Brandywine.IDF

Peak discharge = 8.566 cfs
 Time to peak = 25 min
 Hyd. volume = 12,850 cuft
 Runoff coeff. = 0.45*
 Tc by User = 25.00 min
 Asc/Rec limb fact = 1/1

* Composite (Area/C) = $[(1.630 \times 0.99) + (4.540 \times 0.25)] / 6.170$



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	9.580	1	25	14,370	-----	-----	-----	POI-1
2	Rational	4.640	1	28	7,795	-----	-----	-----	POI-2
3	Rational	3.917	1	5	1,175	-----	-----	-----	POI-3
4	Rational	2.214	1	5	664	-----	-----	-----	POI-4
5	Rational	0.672	1	5	202	-----	-----	-----	POI-5A
6	Rational	0.553	1	5	166	-----	-----	-----	POI-5B
7	Rational	4.024	1	5	1,207	-----	-----	-----	POI-6
8	Rational	1.661	1	5	498	-----	-----	-----	POI-7
9	Rational	1.026	1	5	308	-----	-----	-----	POI-8
10	Rational	0.649	1	5	195	-----	-----	-----	POI-9
11	Rational	2.418	1	5	725	-----	-----	-----	POI-10
12	Rational	6.791	1	20	8,149	-----	-----	-----	POI-11
13	Rational	4.423	1	5	1,327	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 10 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Thursday, Jan 21, 2016

Hyd. No. 1

POI-1

Hydrograph type = Rational
 Storm frequency = 10 yrs
 Time interval = 1 min
 Drainage area = 6.170 ac
 Intensity = 3.450 in/hr
 IDF Curve = East Brandywine.IDF

Peak discharge = 9.580 cfs
 Time to peak = 25 min
 Hyd. volume = 14,370 cuft
 Runoff coeff. = 0.45*
 Tc by User = 25.00 min
 Asc/Rec limb fact = 1/1

* Composite (Area/C) = [(1.630 x 0.99) + (4.540 x 0.25)] / 6.170



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	10.73	1	25	16,092	-----	-----	-----	POI-1
2	Rational	5.210	1	28	8,753	-----	-----	-----	POI-2
3	Rational	4.329	1	5	1,299	-----	-----	-----	POI-3
4	Rational	2.447	1	5	734	-----	-----	-----	POI-4
5	Rational	0.743	1	5	223	-----	-----	-----	POI-5A
6	Rational	0.611	1	5	183	-----	-----	-----	POI-5B
7	Rational	4.447	1	5	1,334	-----	-----	-----	POI-6
8	Rational	1.835	1	5	551	-----	-----	-----	POI-7
9	Rational	1.134	1	5	340	-----	-----	-----	POI-8
10	Rational	0.717	1	5	215	-----	-----	-----	POI-9
11	Rational	2.672	1	5	802	-----	-----	-----	POI-10
12	Rational	7.569	1	20	9,083	-----	-----	-----	POI-11
13	Rational	4.889	1	5	1,467	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 25 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Thursday, Jan 21, 2016

Hyd. No. 1

POI-1

Hydrograph type = Rational
 Storm frequency = 25 yrs
 Time interval = 1 min
 Drainage area = 6.170 ac
 Intensity = 3.864 in/hr
 IDF Curve = East Brandywine.IDF

Peak discharge = 10.73 cfs
 Time to peak = 25 min
 Hyd. volume = 16,092 cuft
 Runoff coeff. = 0.45*
 Tc by User = 25.00 min
 Asc/Rec limb fact = 1/1

* Composite (Area/C) = [(1.630 x 0.99) + (4.540 x 0.25)] / 6.170



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	11.58	1	25	17,369	-----	-----	-----	POI-1
2	Rational	5.634	1	28	9,465	-----	-----	-----	POI-2
3	Rational	4.614	1	5	1,384	-----	-----	-----	POI-3
4	Rational	2.608	1	5	782	-----	-----	-----	POI-4
5	Rational	0.791	1	5	237	-----	-----	-----	POI-5A
6	Rational	0.651	1	5	195	-----	-----	-----	POI-5B
7	Rational	4.740	1	5	1,422	-----	-----	-----	POI-6
8	Rational	1.956	1	5	587	-----	-----	-----	POI-7
9	Rational	1.208	1	5	362	-----	-----	-----	POI-8
10	Rational	0.764	1	5	229	-----	-----	-----	POI-9
11	Rational	2.848	1	5	854	-----	-----	-----	POI-10
12	Rational	8.144	1	20	9,773	-----	-----	-----	POI-11
13	Rational	5.210	1	5	1,563	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 50 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Thursday, Jan 21, 2016

Hyd. No. 1

POI-1

Hydrograph type = Rational
Storm frequency = 50 yrs
Time interval = 1 min
Drainage area = 6.170 ac
Intensity = 4.171 in/hr
IDF Curve = East Brandywine.IDF

Peak discharge = 11.58 cfs
Time to peak = 25 min
Hyd. volume = 17,369 cuft
Runoff coeff. = 0.45*
Tc by User = 25.00 min
Asc/Rec limb fact = 1/1

* Composite (Area/C) = [(1.630 x 0.99) + (4.540 x 0.25)] / 6.170



Hydrograph Summary Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Hyd. No.	Hydrograph type (origin)	Peak flow (cfs)	Time interval (min)	Time to peak (min)	Hyd. volume (cuft)	Inflow hyd(s)	Maximum elevation (ft)	Total strge used (cuft)	Hydrograph description
1	Rational	12.36	1	25	18,542	-----	-----	-----	POI-1
2	Rational	6.027	1	28	10,125	-----	-----	-----	POI-2
3	Rational	4.880	1	5	1,464	-----	-----	-----	POI-3
4	Rational	2.759	1	5	828	-----	-----	-----	POI-4
5	Rational	0.837	1	5	251	-----	-----	-----	POI-5A
6	Rational	0.689	1	5	207	-----	-----	-----	POI-5B
7	Rational	5.013	1	5	1,504	-----	-----	-----	POI-6
8	Rational	2.069	1	5	621	-----	-----	-----	POI-7
9	Rational	1.278	1	5	383	-----	-----	-----	POI-8
10	Rational	0.809	1	5	243	-----	-----	-----	POI-9
11	Rational	3.012	1	5	904	-----	-----	-----	POI-10
12	Rational	8.665	1	20	10,398	-----	-----	-----	POI-11
13	Rational	5.511	1	5	1,653	-----	-----	-----	POI-12
151201 EBT Hawthorne.gpw					Return Period: 100 Year			Thursday, Jan 21, 2016	

Hydrograph Report

Hydraflow Hydrographs Extension for AutoCAD® Civil 3D® 2009 by Autodesk, Inc. v6.066

Thursday, Jan 21, 2016

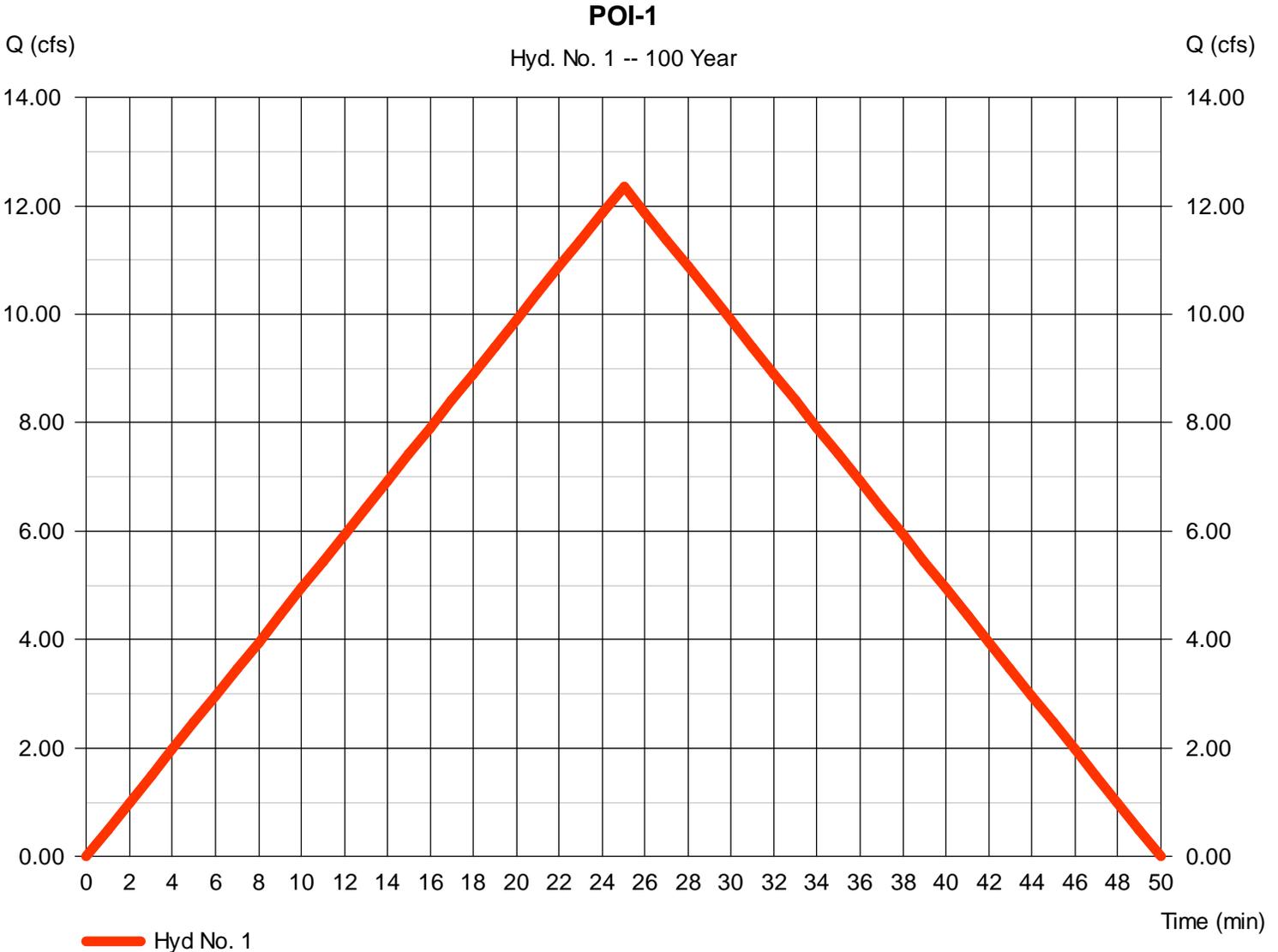
Hyd. No. 1

POI-1

Hydrograph type = Rational
Storm frequency = 100 yrs
Time interval = 1 min
Drainage area = 6.170 ac
Intensity = 4.452 in/hr
IDF Curve = East Brandywine.IDF

Peak discharge = 12.36 cfs
Time to peak = 25 min
Hyd. volume = 18,542 cuft
Runoff coeff. = 0.45*
Tc by User = 25.00 min
Asc/Rec limb fact = 1/1

* Composite (Area/C) = [(1.630 x 0.99) + (4.540 x 0.25)] / 6.170



Hydrograph Return Period Recap	1
1 - Year	
Summary Report	2
Hydrograph Reports	3
Hydrograph No. 1, Rational, POI-1	3
2 - Year	
Summary Report	4
Hydrograph Reports	5
Hydrograph No. 1, Rational, POI-1	5
5 - Year	
Summary Report	6
Hydrograph Reports	7
Hydrograph No. 1, Rational, POI-1	7
10 - Year	
Summary Report	8
Hydrograph Reports	9
Hydrograph No. 1, Rational, POI-1	9
25 - Year	
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Hydrograph Reports	11
Hydrograph No. 1, Rational, POI-1	11
50 - Year	
Summary Report	12
Hydrograph Reports	13
Hydrograph No. 1, Rational, POI-1	13
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Summary Report	14
Hydrograph Reports	15
Hydrograph No. 1, Rational, POI-1	15
IDF Report	16

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr line No.	Line length (ft)	Defl angle (deg)	Junc type	Known Q (cfs)	Drng area (ac)	Runoff coeff (C)	Inlet time (min)	Invert El Dn (ft)	Line slope (%)	Invert El Up (ft)	Line size (in)	Line shape	N value (n)	J-loss coeff (K)	Inlet/ Rim El (ft)	
12	11	40.000	30.000	Hdwl	0.00	1.17	0.41	5.0	542.19	6.35	544.73	15	Cir	0.024	1.00	546.54	HW1-1
11	End	40.000	25.806	DrGrt	0.00	0.30	0.87	5.0	541.90	0.45	542.08	15	Cir	0.024	0.83	545.80	1-EW1
10	End	160.000	16.206	DrGrt	0.00	0.20	0.51	5.0	535.00	6.46	545.33	15	Cir	0.024	1.00	547.08	2-UNK
9	End	130.000	12.365	DrGrt	0.00	0.93	0.68	5.0	529.69	5.79	537.22	12	Cir	0.024	1.00	539.65	3-UNK
8	7	37.000	12.651	DrGrt	0.00	0.76	0.50	5.0	517.53	8.41	520.64	15	Cir	0.024	1.00	523.68	4-5
7	End	210.000	33.394	DrGrt	0.00	0.22	0.48	5.0	505.00	5.92	517.43	15	Cir	0.024	0.50	523.64	5-UNK
6	End	100.000	15.180	DrGrt	0.00	0.11	0.79	5.0	506.50	4.02	510.52	15	Cir	0.024	1.00	513.63	6-UNK
5	4	190.000	-14.000	DrGrt	0.00	0.72	0.53	5.0	505.74	7.51	520.00	18	Cir	0.013	1.00	525.00	UNK-8
4	3	47.000	30.000	DrGrt	0.00	3.58	0.49	20.0	503.07	5.55	505.68	18	Cir	0.013	0.50	509.04	8-7
3	End	230.000	110.000	DrGrt	0.00	0.60	0.58	5.0	490.00	5.69	503.08	18	Cir	0.013	0.83	509.04	7-UNK
2	End	275.000	51.660	DrGrt	0.00	3.11	0.46	28.0	509.80	3.54	519.53	18	Cir	0.013	1.00	523.16	9-EW2
1	End	115.000	46.610	DrGrt	0.00	6.17	0.45	25.0	541.50	3.32	545.32	15	Cir	0.024	1.00	546.12	10-UNK

Project File: 120415 Hawthorne.stm

Number of lines: 12

Date: 02-05-2016

Structure Report

Struct No.	Structure ID	Junction Type	Rim Elev. (ft)	Structure			Line Out			Line In		
				Shape	Length (ft)	Width (ft)	Size (in)	Shape	Invert (ft)	Size (in)	Shape	Invert (ft)
12	HEADWALL-1	OpenHeadwall	546.54	n/a	n/a	n/a	15	Cir	544.73			
11	INLET-1	DropGrate	545.80	Rect	4.00	4.00	15	Cir	542.08	15	Cir	542.19
10	INLET-2	DropGrate	547.08	Rect	2.50	2.50	15	Cir	545.33			
9	INLET-3	DropGrate	539.65	Rect	4.00	4.00	12	Cir	537.22			
8	INLET-4	DropGrate	523.68	Rect	2.50	4.00	15	Cir	520.64			
7	INLET-5	DropGrate	523.64	Rect	2.00	3.00	15	Cir	517.43	15	Cir	517.53
6	INLET-6	DropGrate	513.63	Rect	2.00	4.00	15	Cir	510.52			
5	OFFSITE	DropGrate	525.00	Rect	2.00	4.00	18	Cir	520.00			
4	INLET-8	DropGrate	509.04	Rect	2.00	4.00	18	Cir	505.68	18	Cir	505.74
3	INLET-7	DropGrate	509.04	Rect	2.00	4.00	18	Cir	503.08	18	Cir	503.07
2	INLET-9	DropGrate	523.16	Rect	2.00	4.00	18	Cir	519.53			
1	INLET-10	DropGrate	546.12	Rect	2.00	4.00	15	Cir	545.32			

Project File: 120415 Hawthorne.stm	Number of Structures: 12	Run Date: 02-05-2016
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Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line slope (%)	HGL down (ft)	HGL up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns line No.	Junction Type
12	HW1-1	3.37	15	Cir	40.000	542.19	544.73	6.350	544.22	545.47	n/a	545.47 j	11	OpenHeadwall
11	1-EW1	5.16	15	Cir	40.000	541.90	542.08	0.450	542.81*	543.99*	0.23	544.22	End	DropGrate
10	2-UNK	0.72	15	Cir	160.000	535.00	545.33	6.456	535.34	545.67	n/a	545.67	End	DropGrate
9	3-UNK	4.45	12	Cir	130.000	529.69	537.22	5.792	530.59	538.11	n/a	538.11 j	End	DropGrate
8	4-5	2.67	15	Cir	37.000	517.53	520.64	8.405	518.17	521.29	0.26	521.29	7	DropGrate
7	5-UNK	3.39	15	Cir	210.000	505.00	517.43	5.919	506.14	518.17	n/a	518.17 j	End	DropGrate
6	6-UNK	0.61	15	Cir	100.000	506.50	510.52	4.020	507.56	510.83	n/a	510.83 j	End	DropGrate
5	UNK-8	2.68	18	Cir	190.000	505.74	520.00	7.505	506.84	520.63	n/a	520.63 j	4	DropGrate
4	8-7	9.22	18	Cir	47.000	503.07	505.68	5.553	504.33	506.84	n/a	506.84 j	3	DropGrate
3	7-UNK	10.68	18	Cir	230.000	490.00	503.08	5.687	491.49	504.33	n/a	504.33 j	End	DropGrate
2	9-EW2	5.21	18	Cir	275.000	509.80	519.53	3.538	511.28	520.40	n/a	520.40 j	End	DropGrate
1	10-UNK	10.73	15	Cir	115.000	541.50	545.32	3.322	545.76*	556.58*	1.19	557.77	End	DropGrate

Project File: 120415 Hawthorne.stm

Number of lines: 12

Run Date: 02-05-2016

NOTES: Return period = 25 Yrs. ; *Surcharged (HGL above crown). ; j - Line contains hyd. jump.

Hydraulic Grade Line Computations

Line	Size (in)	Q (cfs)	Downstream								Len (ft)	Upstream								Check		JL coeff (K)	Minor loss (ft)
			Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)		Invert elev (ft)	HGL elev (ft)	Depth (ft)	Area (sqft)	Vel (ft/s)	Vel head (ft)	EGL elev (ft)	Sf (%)	Ave Sf (%)	Enrgy loss (ft)		
12	15	3.37	542.19	544.22	1.25	1.23	2.75	0.12	544.33	0.930	40.000	544.73	545.47 j	0.74**	0.75	4.49	0.31	545.78	2.192	1.561	n/a	1.00	0.31
11	15	5.16	541.90	542.81	0.91*	0.96	5.40	0.45	543.26	2.819	40.000	542.08	543.99	1.25	1.23	4.21	0.28	544.26	2.180	2.500	1.000	0.83	0.23
10	15	0.72	535.00	535.34	0.34*	0.27	2.67	0.11	535.45	1.627	160.000	545.33	545.67	0.34**	0.27	2.67	0.11	545.78	1.627	1.627	n/a	1.00	n/a
9	12	4.45	529.69	530.59	0.90	0.74	5.97	0.55	531.14	4.678	130.000	537.22	538.11 j	0.89**	0.74	6.05	0.57	538.67	4.752	4.715	n/a	1.00	0.57
8	15	2.67	517.53	518.17	0.64	0.63	4.25	0.28	518.45	2.189	37.000	520.64	521.29	0.65**	0.65	4.11	0.26	521.56	2.002	2.096	n/a	1.00	0.26
7	15	3.39	505.00	506.14	1.14	1.17	2.89	0.13	506.27	0.820	210.000	517.43	518.17 j	0.74**	0.75	4.50	0.32	518.48	2.198	1.509	n/a	0.50	0.16
6	15	0.61	506.50	507.56	1.06	1.11	0.55	0.00	507.56	0.029	100.000	510.52	510.83 j	0.31**	0.24	2.54	0.10	510.93	1.620	0.824	n/a	1.00	0.10
5	18	2.68	505.74	506.84	1.10	1.39	1.93	0.06	506.90	0.083	190.000	520.00	520.63 j	0.63**	0.70	3.85	0.23	520.86	0.495	0.289	n/a	1.00	0.23
4	18	9.22	503.07	504.33	1.26	1.58	5.83	0.53	504.86	0.741	47.000	505.68	506.84 j	1.16**	1.46	6.29	0.62	507.45	0.867	0.804	n/a	0.50	n/a
3	18	10.68	490.00	491.49	1.49	1.77	6.05	0.57	492.06	0.967	230.000	503.08	504.33 j	1.25**	1.57	6.80	0.72	505.05	1.009	0.988	n/a	0.83	n/a
2	18	5.21	509.80	511.28	1.48	1.76	2.96	0.14	511.42	0.224	275.000	519.53	520.40 j	0.87**	1.06	4.89	0.37	520.77	0.603	0.414	n/a	1.00	n/a
1	15	10.73	541.50	545.76	1.25	1.23	8.74	1.19	546.95	9.411	115.000	545.32	556.58	1.25	1.23	8.74	1.19	557.77	9.407	9.409	10.82	1.00	1.19

Project File: 120415 Hawthorne.stm

Number of lines: 12

Run Date: 02-05-2016

Notes: * Normal depth assumed.; ** Critical depth.; j-Line contains hyd. jump. ; c = cir e = ellip b = box

Structure Report

Struct No.	Structure ID	Junction Type	Rim Elev. (ft)	Structure			Line Out			Line In		
				Shape	Length (ft)	Width (ft)	Size (in)	Shape	Invert (ft)	Size (in)	Shape	Invert (ft)
12	HEADWALL-1	OpenHeadwall	546.54	n/a	n/a	n/a	15	Cir	544.73			
11	INLET-1	DropGrate	545.80	Rect	4.00	4.00	15	Cir	542.08	15	Cir	542.19
10	INLET-2	DropGrate	547.08	Rect	2.50	2.50	15	Cir	545.33			
9	INLET-3	DropGrate	539.65	Rect	4.00	4.00	12	Cir	537.22			
8	INLET-4	DropGrate	523.68	Rect	2.50	4.00	15	Cir	520.64			
7	INLET-5	DropGrate	523.64	Rect	2.00	3.00	15	Cir	517.43	15	Cir	517.53
6	INLET-6	DropGrate	513.63	Rect	2.00	4.00	15	Cir	510.52			
5	OFFSITE	DropGrate	525.00	Rect	2.00	4.00	18	Cir	520.00			
4	INLET-8	DropGrate	509.04	Rect	2.00	4.00	18	Cir	505.68	18	Cir	505.74
3	INLET-7	DropGrate	509.04	Rect	2.00	4.00	18	Cir	503.08	18	Cir	503.07
2	INLET-9	DropGrate	523.16	Rect	2.00	4.00	18	Cir	519.53			
1	INLET-10	DropGrate	546.12	Rect	2.00	4.00	18	Cir	545.32			

Project File: 120415 Hawthorne.stm

Number of Structures: 12

Run Date: 01-21-2016

Inlet Report

Line No	Inlet ID	Q = CIA (cfs)	Q carry (cfs)	Q capt (cfs)	Q byp (cfs)	Junc type	Curb Inlet		Grate Inlet			Gutter						Inlet			Byp line No	
							Ht (in)	L (ft)	area (sqft)	L (ft)	W (ft)	So (ft/ft)	W (ft)	Sw (ft/ft)	Sx (ft/ft)	n	Depth (ft)	Spread (ft)	Depth (ft)	Spread (ft)		Depr (in)
12	HEADWALL-1	3.37	0.00	3.37	0.00	Hdwl	0.0	0.00	0.00	0.00	0.00	Sag	0.00	0.000	0.000	0.013	0.00	0.00	0.00	0.00	0.0	Off
11	INLET-1	1.84	0.00	1.84	0.00	DrGr	0.0	0.00	6.60	4.00	4.00	Sag	2.00	0.033	0.033	0.013	0.11	10.87	0.11	10.87	0.0	Off
10	INLET-2	0.72	0.00	0.72	0.00	DrGr	0.0	0.00	3.30	4.00	2.50	Sag	2.00	0.033	0.033	0.000	0.07	6.72	0.07	6.72	0.0	Off
9	INLET-3	4.45	0.00	4.45	0.00	DrGr	0.0	0.00	6.66	4.00	4.00	Sag	2.00	0.033	0.033	0.000	0.20	16.40	0.20	16.40	0.0	Off
8	INLET-4	2.67	0.00	2.67	0.00	DrGr	0.0	0.00	3.30	4.00	2.50	Sag	2.00	0.033	0.033	0.000	0.17	12.64	0.17	12.64	0.0	Off
7	INLET-5	0.74	0.00	0.74	0.00	DrGr	0.0	0.00	2.50	3.00	2.00	Sag	2.00	0.033	0.033	0.000	0.08	7.14	0.08	7.14	0.0	Off
6	INLET-6	0.61	0.00	0.61	0.00	DrGr	0.0	0.00	3.30	4.00	2.00	Sag	2.00	0.033	0.033	0.000	0.07	6.00	0.07	6.00	0.0	Off
5	OFFSITE	2.68	0.00	2.68	0.00	DrGr	0.0	0.00	3.30	4.00	2.00	Sag	2.00	0.033	0.033	0.000	0.18	12.72	0.18	12.72	0.0	Off
4	INLET-8	7.57	0.00	7.57	0.00	DrGr	0.0	0.00	3.30	4.00	2.00	Sag	2.00	0.033	0.033	0.000	0.35	23.42	0.35	23.42	0.0	Off
3	INLET-7	2.45	0.00	2.45	0.00	DrGr	0.0	0.00	3.30	4.00	2.00	Sag	2.00	0.033	0.033	0.000	0.17	12.09	0.17	12.09	0.0	Off
2	INLET-9	5.21	0.00	5.21	0.00	DrGr	0.0	0.00	3.30	4.00	2.00	Sag	2.00	0.033	0.033	0.000	0.28	18.70	0.28	18.70	0.0	Off
1	INLET-10	10.73	0.00	10.73	0.00	DrGr	0.0	0.00	3.30	4.00	2.00	Sag	2.00	0.033	0.033	0.000	0.45	29.03	0.45	29.03	0.0	Off

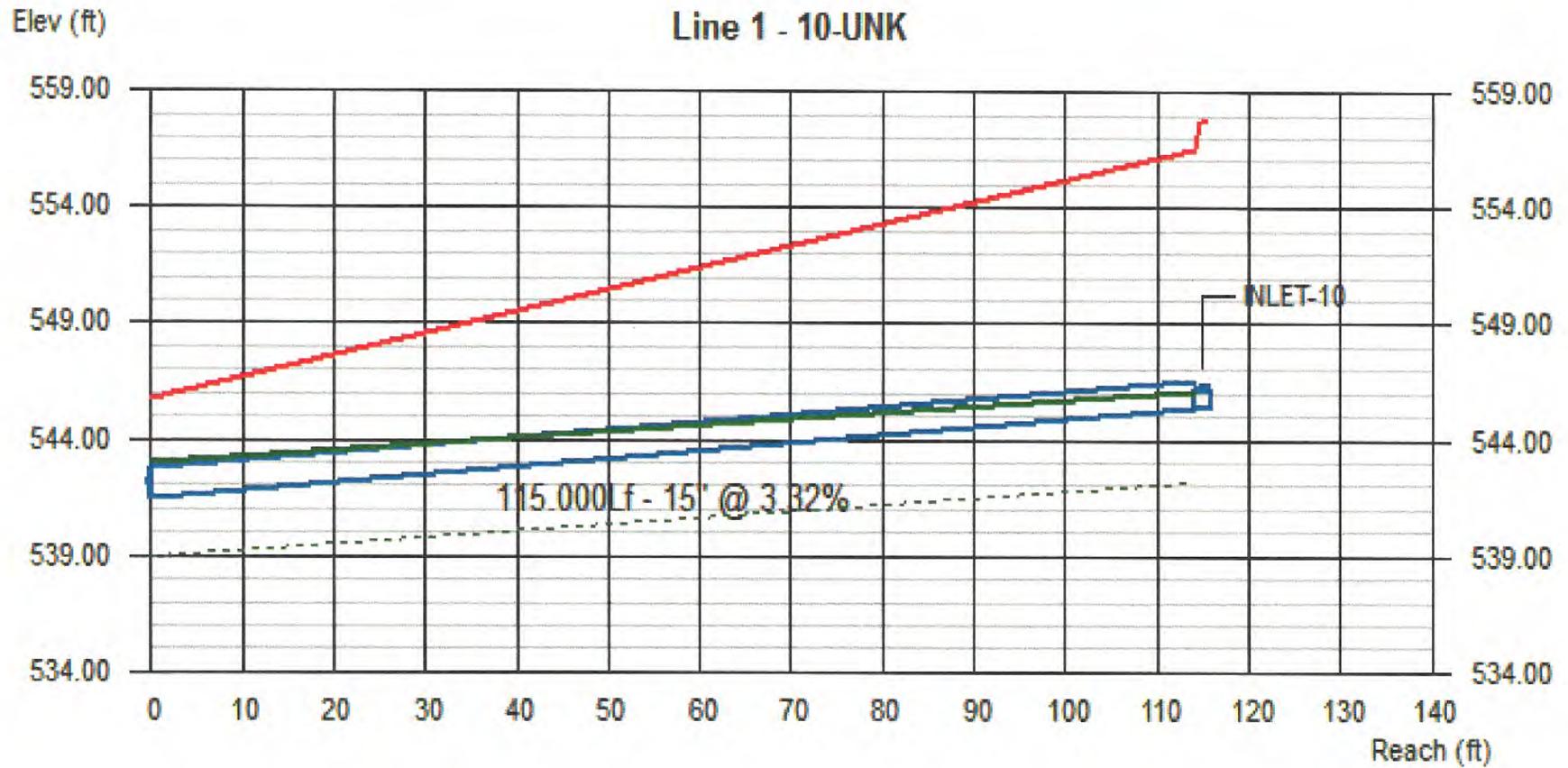
Project File: 120415 Hawthorne.stm

Number of lines: 12

Run Date: 01-21-2016

NOTES: Inlet N-Values = 0.016 ; Intensity = 54.48 / (Inlet time + 11.00) ^ 0.74; Return period = 25 Yrs. ; * Indicates Known Q added. All curb inlets are Horiz throat.

Line Profile (Line 1) - 10-UNK



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	10.73	541.50	545.32	1.25	1.25	12.45	545.76	556.58	557.77	8.74	8.74	0.25	-0.45

Project File:

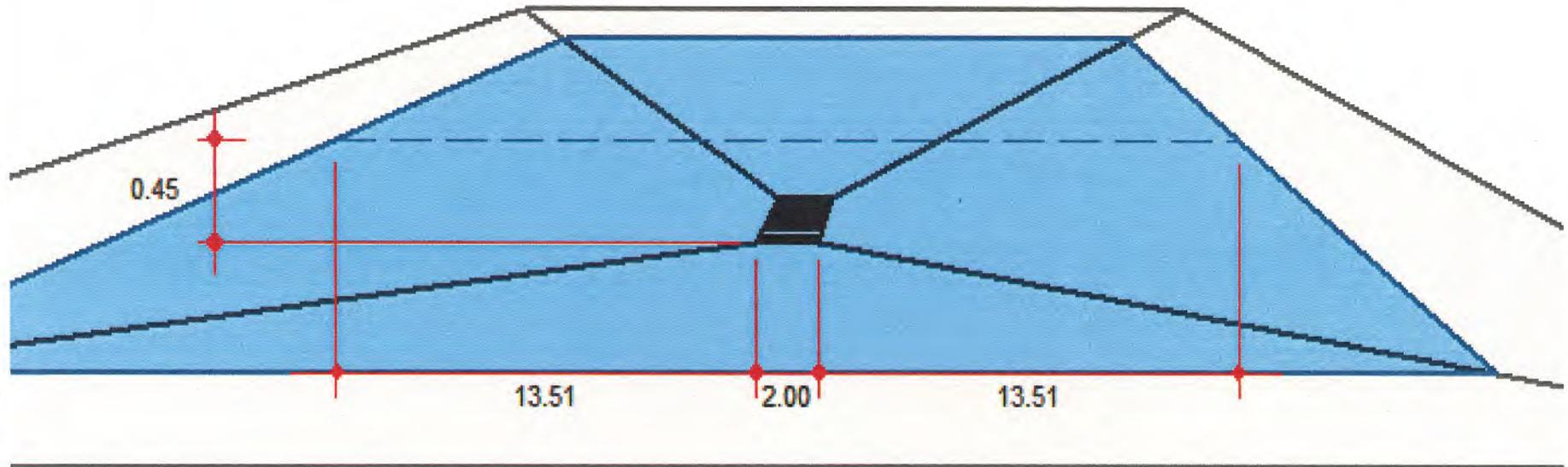
No. Lines: 12

Run Date: 02-05-2016

Inlet Section (Line 1 - Drop Grate Inlet) - INLET-10

All dimensions in feet

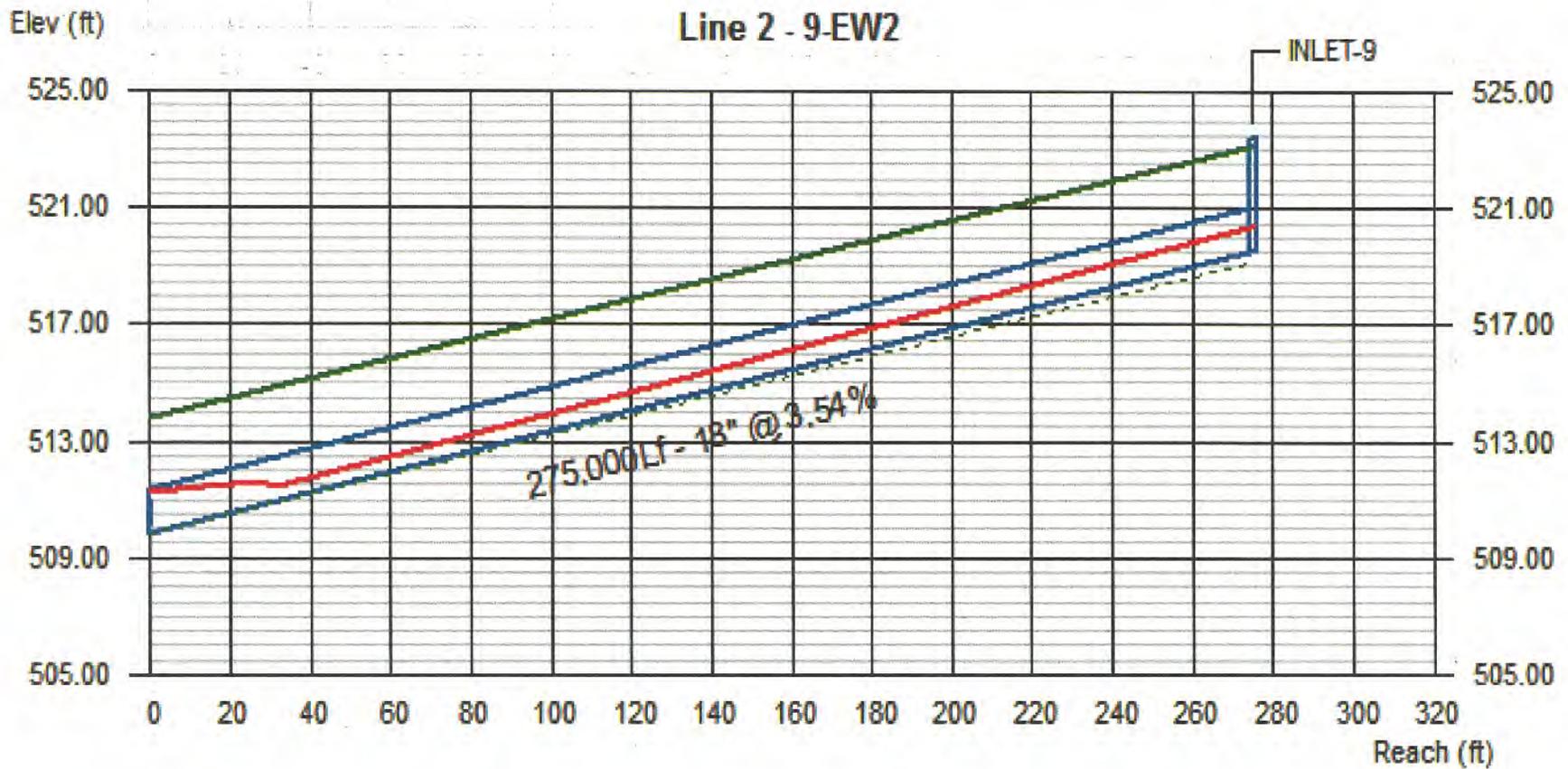
Line 1 - Drop Grate Inlet in Sag - INLET-10



Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
1	10.73	0.00	10.73	0.00	4.00	3.30	2.00	Sag	0.033	0.033	0.45	0.45	29.03	29.03	Sag

Project File:	No. Lines: 12	Run Date: 01-21-2016
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Line Profile (Line 2) - 9-EW2



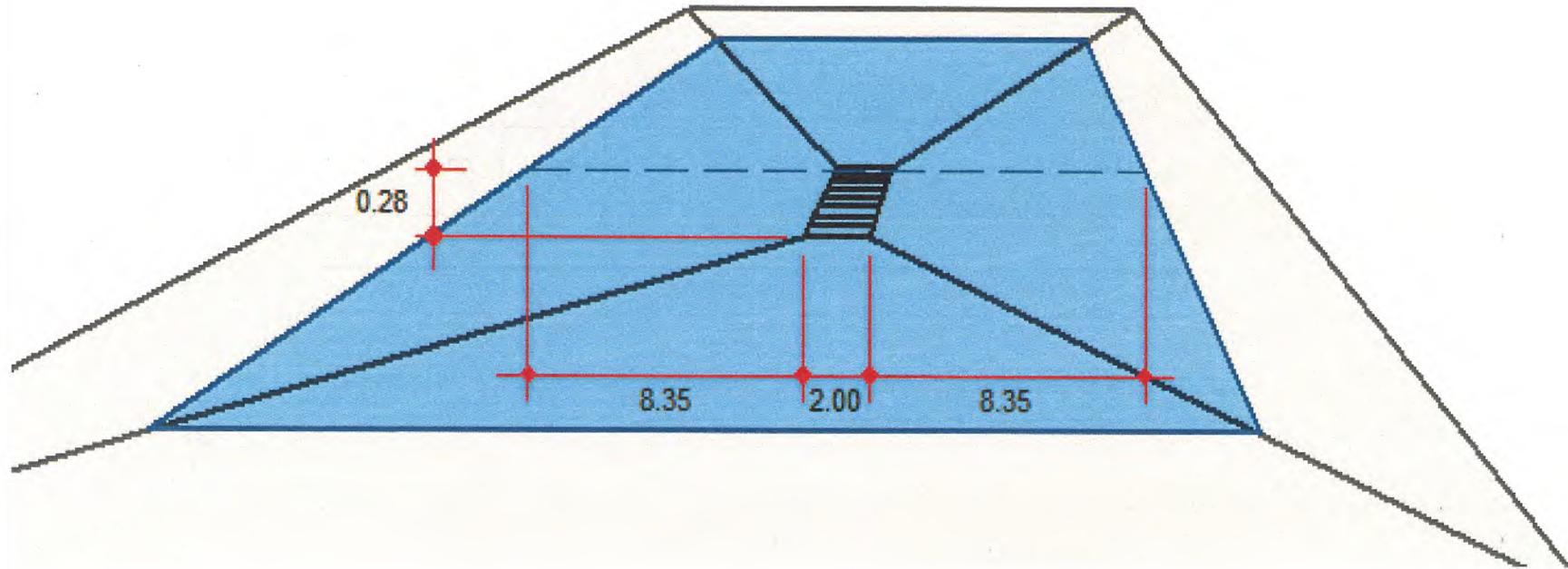
Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
2	5.21	509.80	519.53	1.48	0.87	0.87	511.28	520.40 j	520.40	2.96	4.89	2.53	2.13

Project File:	No. Lines: 12	Run Date: 01-21-2016
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Inlet Section (Line 2 - Drop Grate Inlet) - INLET-9

All dimensions in feet

Line 2 - Drop Grate Inlet in Sag - INLET-9



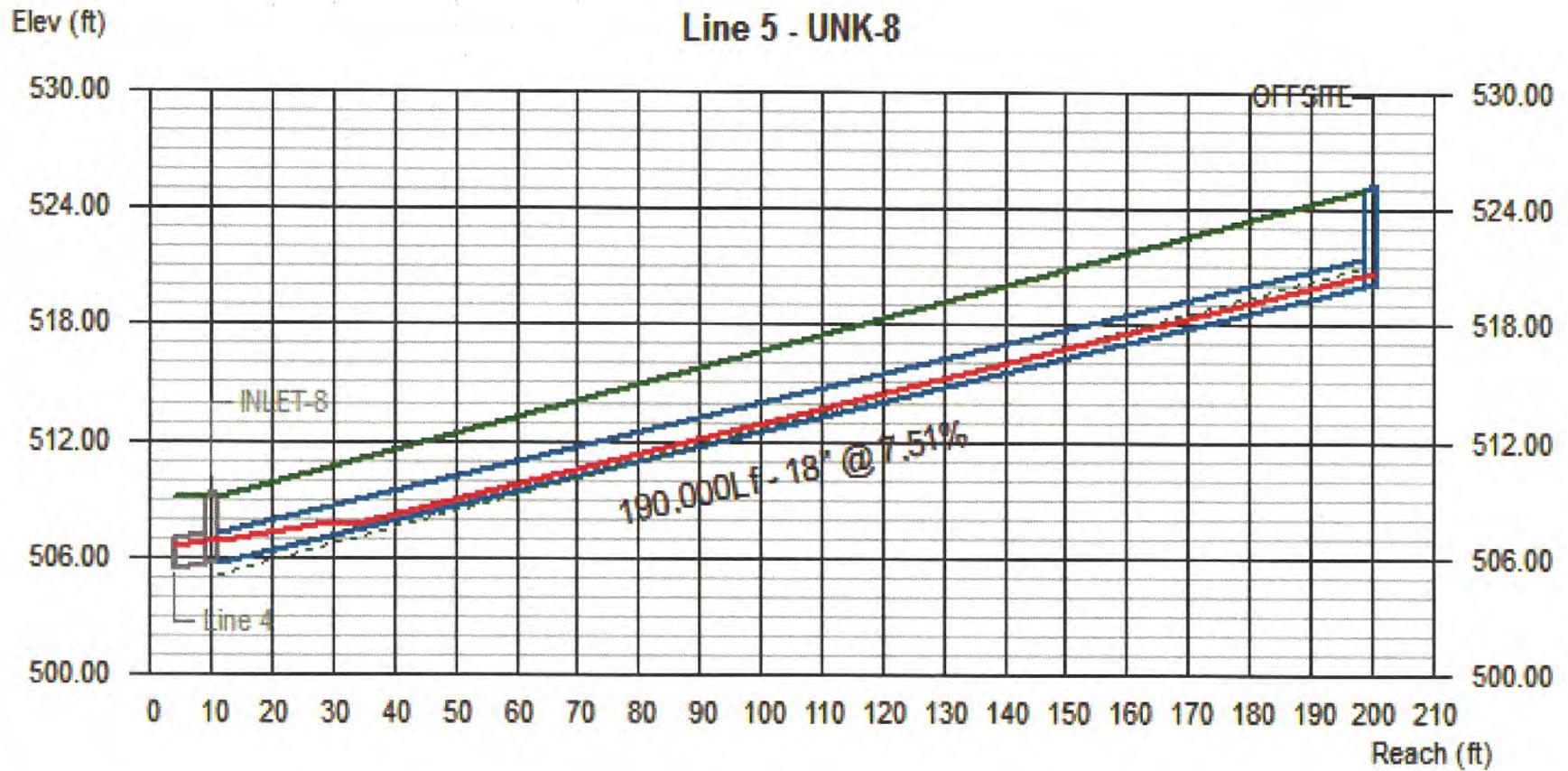
Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
2	5.21	0.00	5.21	0.00	4.00	....	3.30	2.00	Sag	0.033	0.033	0.28	0.28	18.70	18.70	Sag

Project File:

No. Lines: 12

Run Date: 01-21-2016

Line Profile (Line 5) - UNK-8



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
5	2.68	505.74	520.00	1.10	0.63	0.63	506.84	520.63 j	520.63	1.93	3.85	1.80	3.50

Project File:

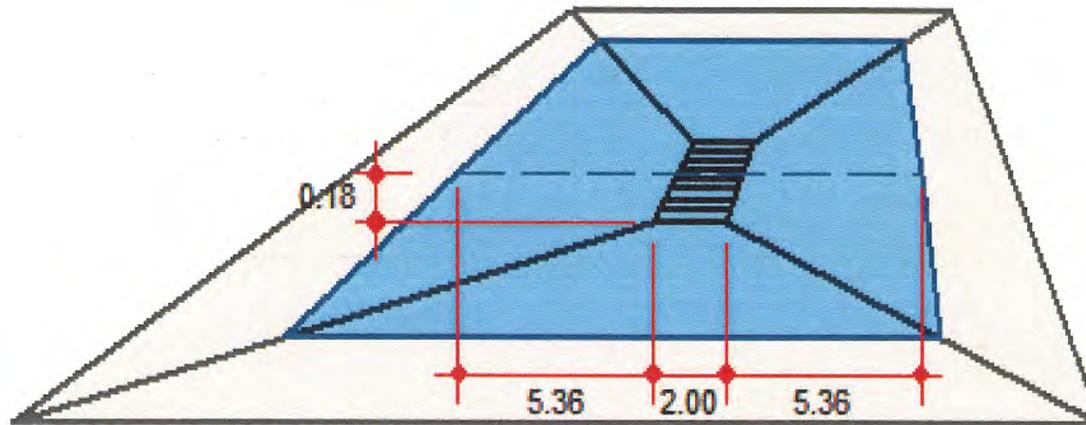
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 5 - Drop Grate Inlet) - OFFSITE

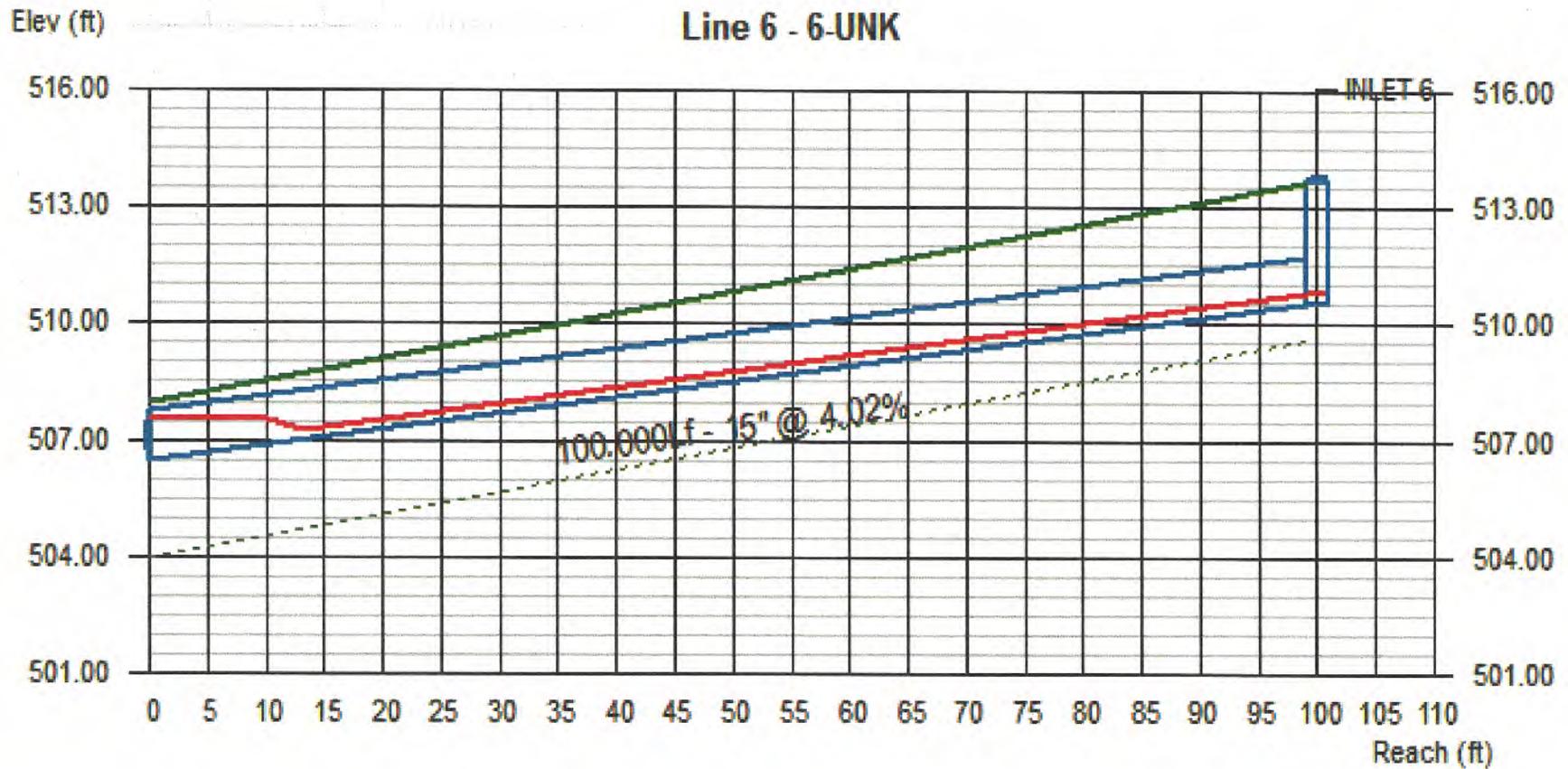
All dimensions in feet

Line 5 - Drop Grate Inlet in Sag - OFFSITE



Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
5	2.68	0.00	2.68	0.00	4.00	....	3.30	2.00	Sag	0.033	0.033	0.18	0.18	12.72	12.72	Sag
Project File:										No. Lines: 12			Run Date: 01-21-2016			

Line Profile (Line 6) - 6-UNK



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
6	0.61	506.50	510.52	1.06	0.31	0.31	507.56	510.83 j	510.83	0.55	2.54	0.25	1.86

Project File:

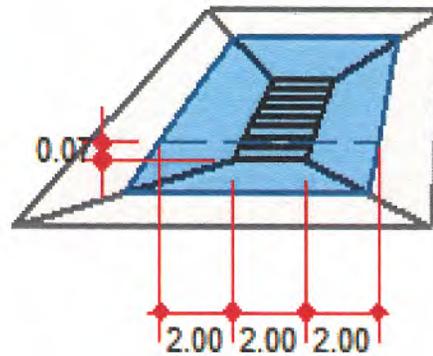
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 6 - Drop Grate Inlet) - INLET-6

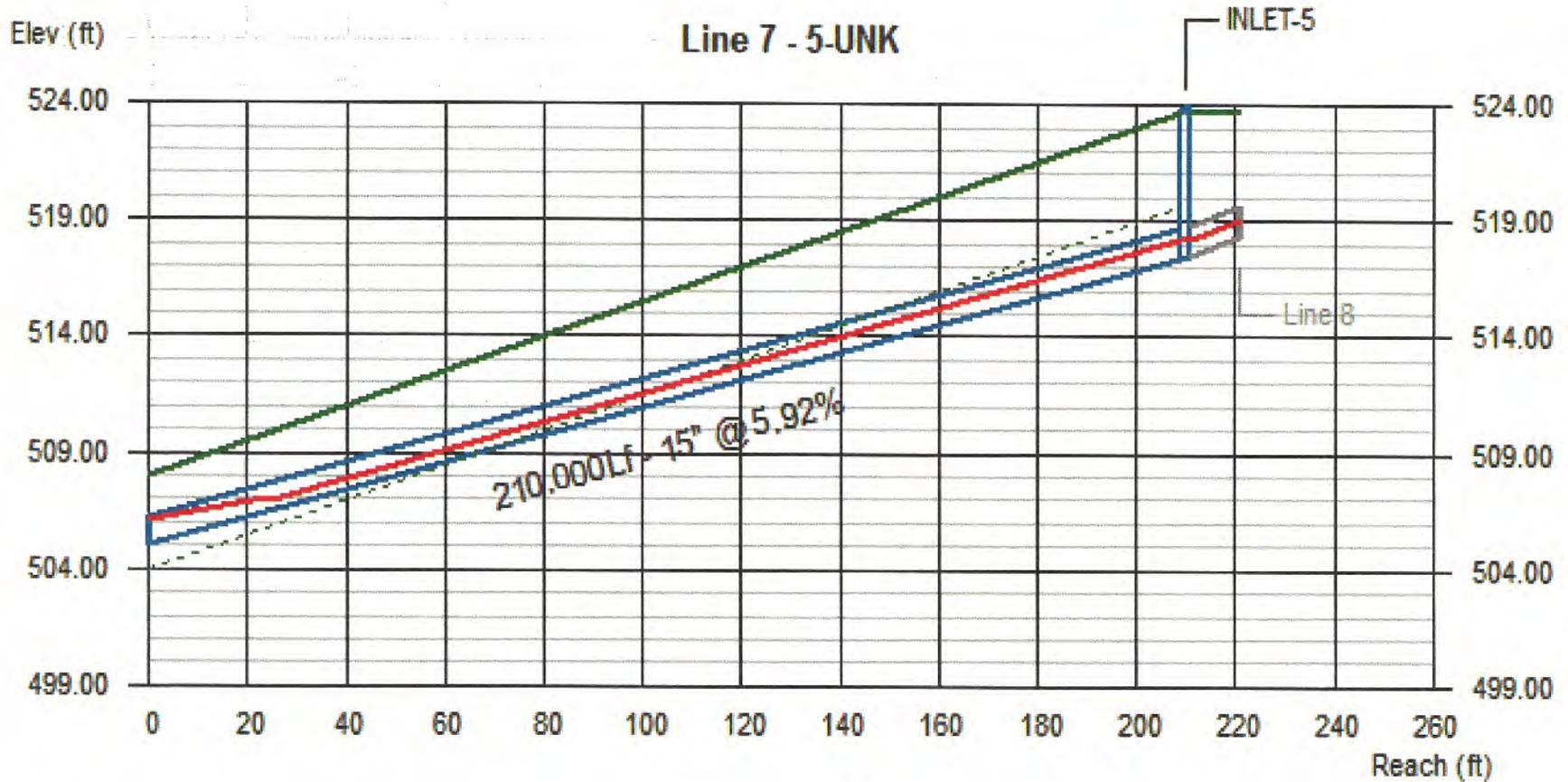
All dimensions in feet

Line 6 - Drop Grate Inlet in Sag - INLET-6



Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
6	0.61	0.00	0.61	0.00	4.00	....	3.30	2.00	Sag	0.033	0.033	0.07	0.07	6.00	6.00	Sag
Project File:										No. Lines: 12				Run Date: 01-21-2016		

Line Profile (Line 7) - 5-UNK



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
7	3.39	505.00	517.43	1.14	0.74	0.74	506.14	518.17 j	518.17	2.89	4.50	1.75	4.96

Project File:

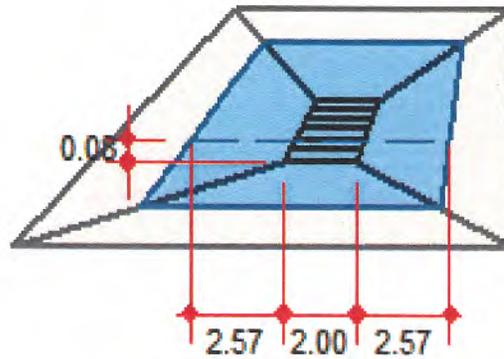
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 7 - Drop Grate Inlet) - INLET-5

All dimensions in feet

Line 7 - Drop Grate Inlet in Sag - INLET-5



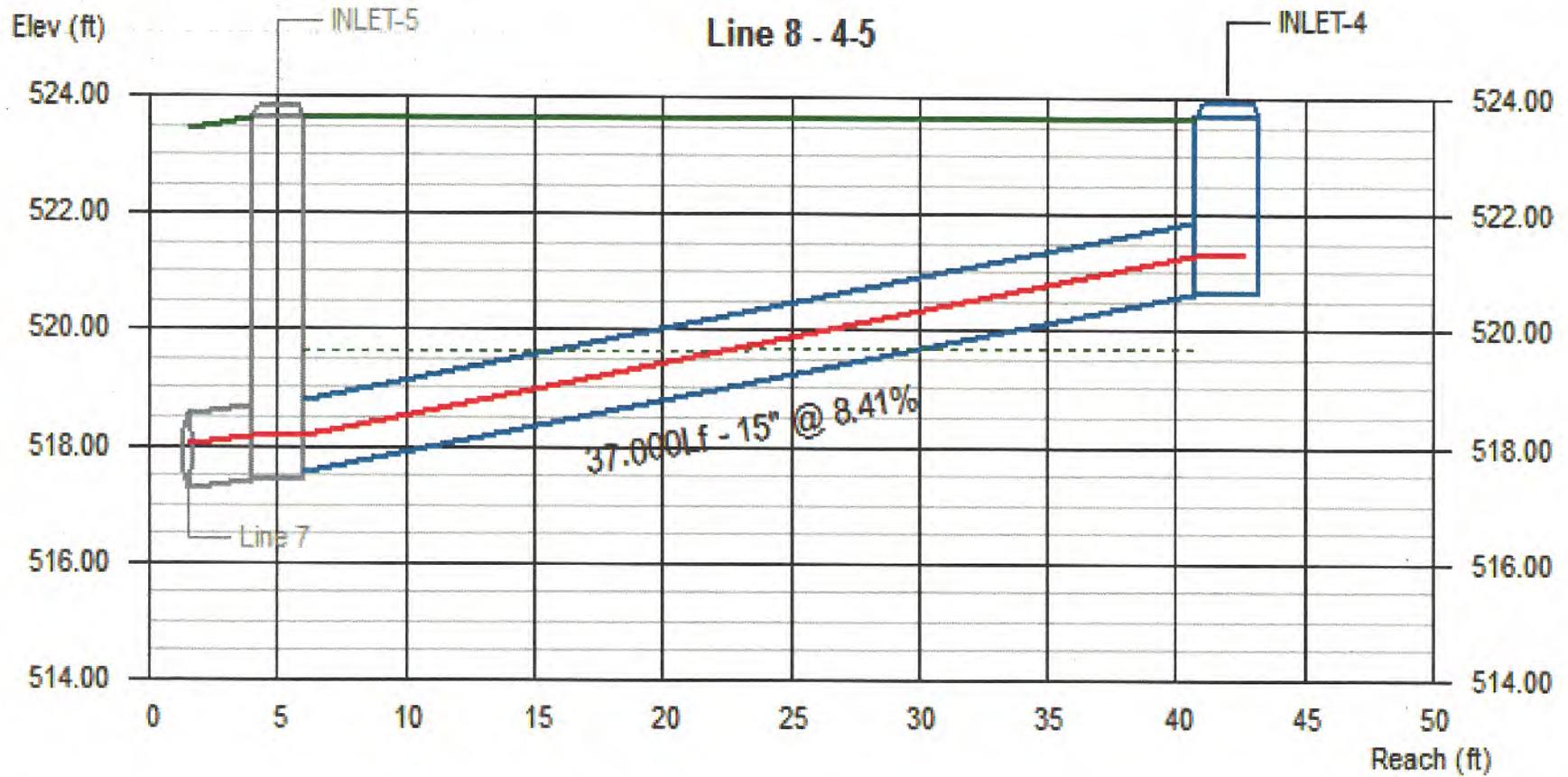
Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
7	0.74	0.00	0.74	0.00	3.00	....	2.50	2.00	Sag	0.033	0.033	0.08	0.08	7.14	7.14	Sag

Project File:

No. Lines: 12

Run Date: 01-21-2016

Line Profile (Line 8) - 4-5



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
8	2.67	517.53	520.64	0.64	0.65	0.65	518.17	521.29	521.29	4.25	4.11	4.86	1.79

Project File:

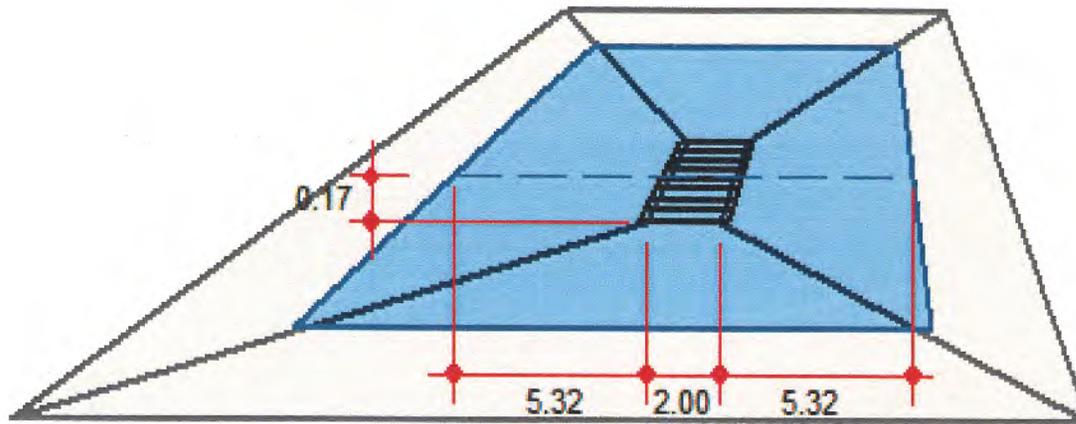
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 8 - Drop Grate Inlet) - INLET-4

All dimensions in feet

Line 8 - Drop Grate Inlet in Sag - INLET-4



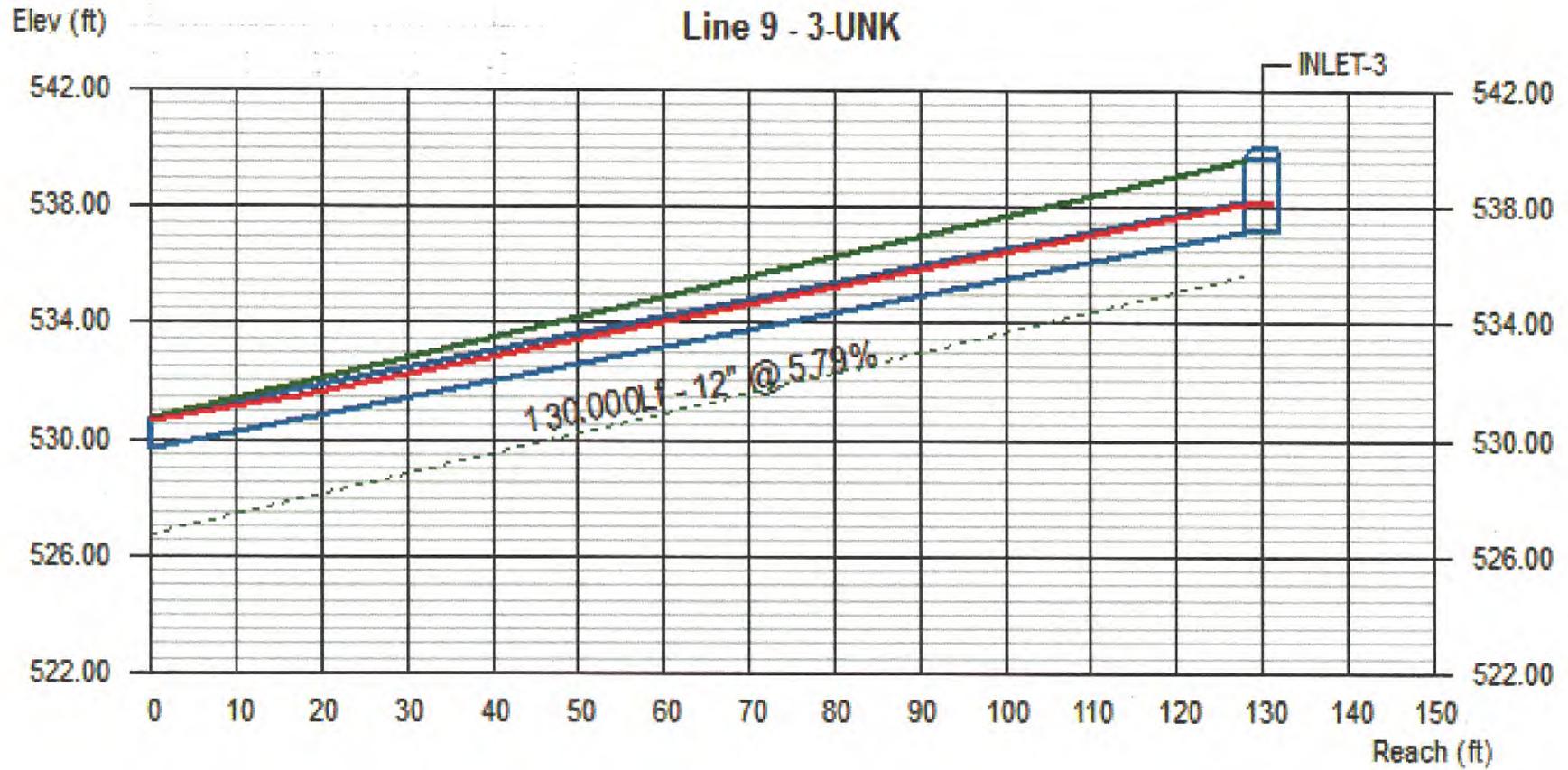
Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
8	2.67	0.00	2.67	0.00	4.00	....	3.30	2.00	Sag	0.033	0.033	0.17	0.17	12.64	12.64	Sag

Project File:

No. Lines: 12

Run Date: 01-21-2016

Line Profile (Line 9) - 3-UNK



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
9	4.45	529.69	537.22	0.90	0.89	0.89	530.59	538.11 j	538.11	5.97	6.05	0.01	1.43

Project File:

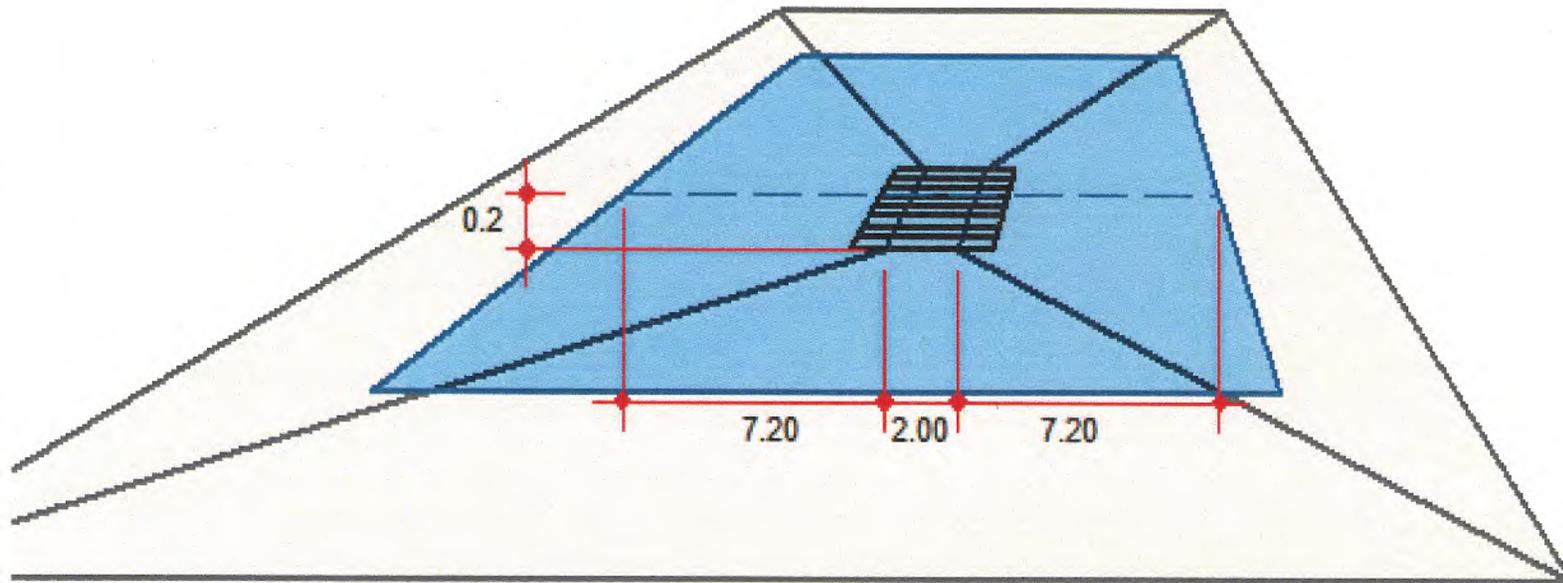
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 9 - Drop Grate Inlet) - INLET-3

All dimensions in feet

Line 9 - Drop Grate Inlet in Sag - INLET-3



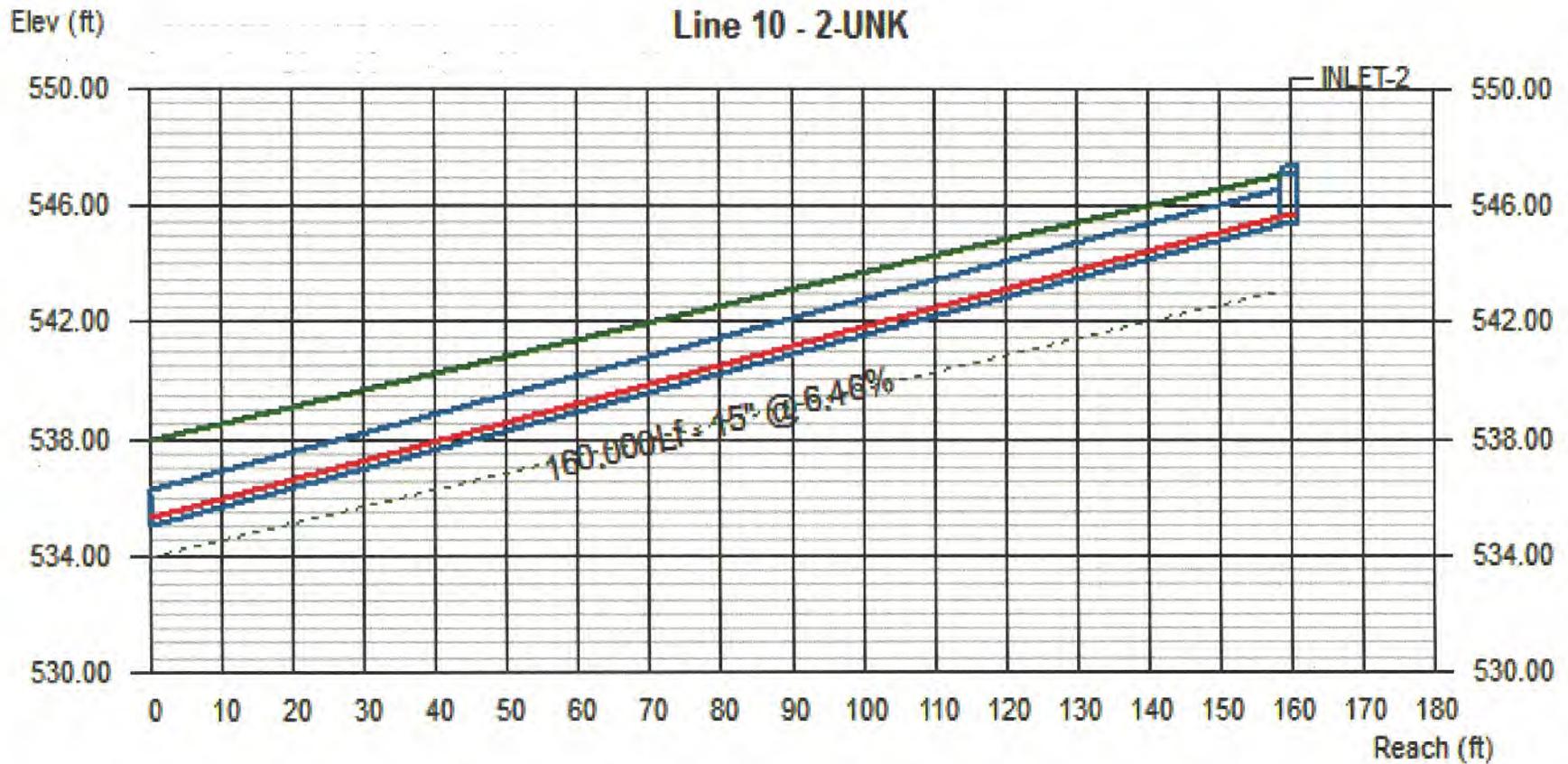
Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
9	4.45	0.00	4.45	0.00	4.00	....	6.66	2.00	Sag	0.033	0.033	0.20	0.20	16.40	16.40	Sag

Project File:

No. Lines: 12

Run Date: 01-21-2016

Line Profile (Line 10) - 2-UNK



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
10	0.72	535.00	545.33	0.34	0.34	0.34	535.34	545.67	545.67	2.67	2.67	1.75	0.50

Project File:

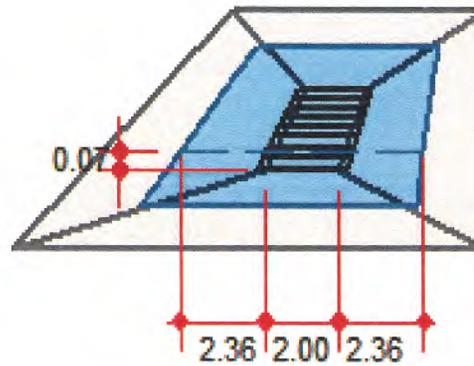
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 10 - Drop Grate Inlet) - INLET-2

All dimensions in feet

Line 10 - Drop Grate Inlet in Sag - INLET-2



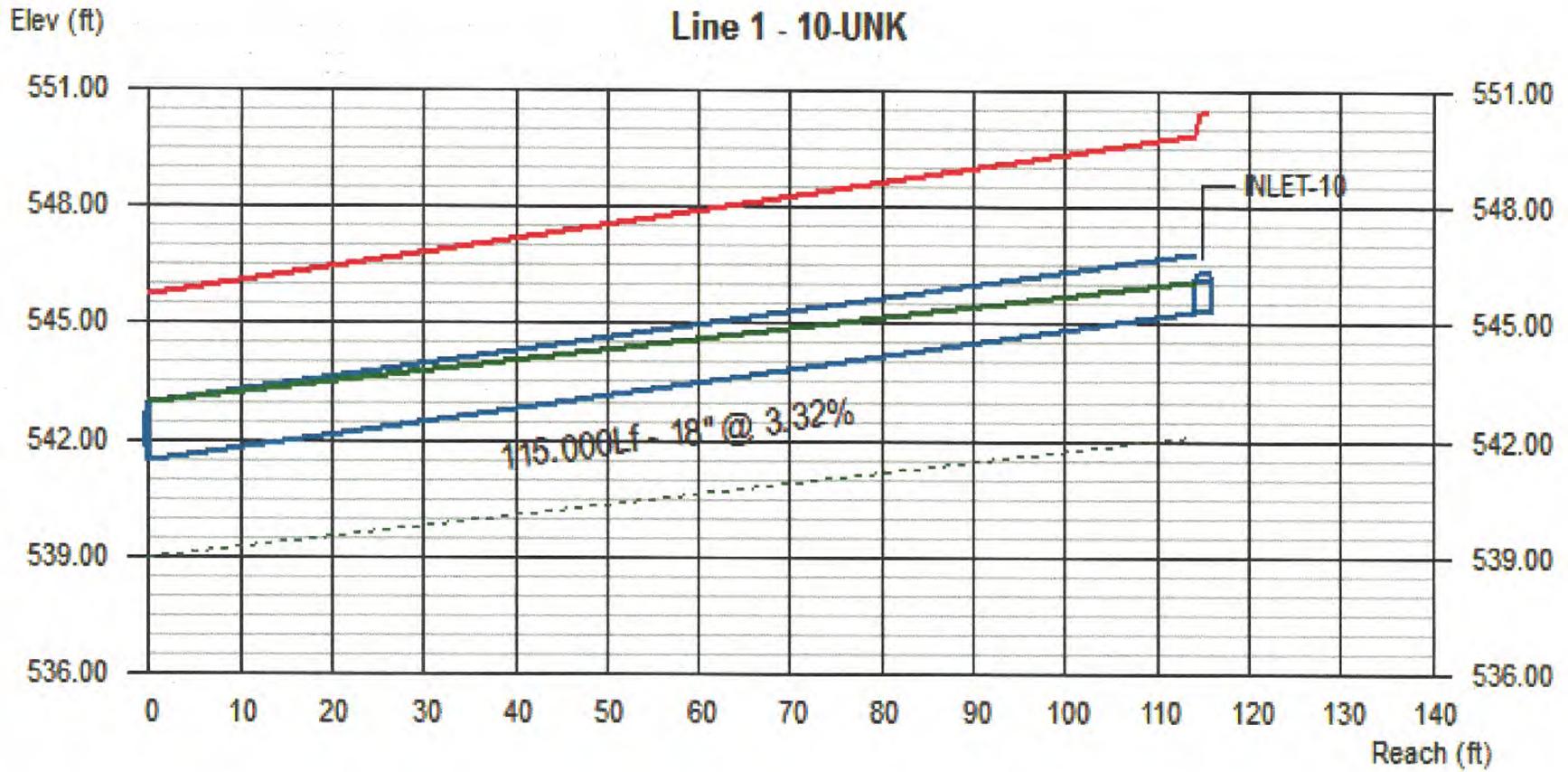
Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
10	0.72	0.00	0.72	0.00	4.00	....	3.30	2.00	Sag	0.033	0.033	0.07	0.07	6.72	6.72	Sag

Project File:

No. Lines: 12

Run Date: 01-21-2016

Line Profile (Line 1) - 10-UNK



Line #	Q (cfs)	Invert Elevation		Depth of Flow			Hydraulic Grade Line			Velocity		Cover	
		Dn (ft)	Up (ft)	Dn (ft)	Up (ft)	Hw (ft)	Dn (ft)	Up (ft)	Jnct (ft)	Dn (ft/s)	Up (ft/s)	Dn (ft)	Up (ft)
1	10.73	541.50	545.32	1.50	1.50	5.10	545.76	549.85	550.42	6.07	6.07	0.00	-0.70

Project File:

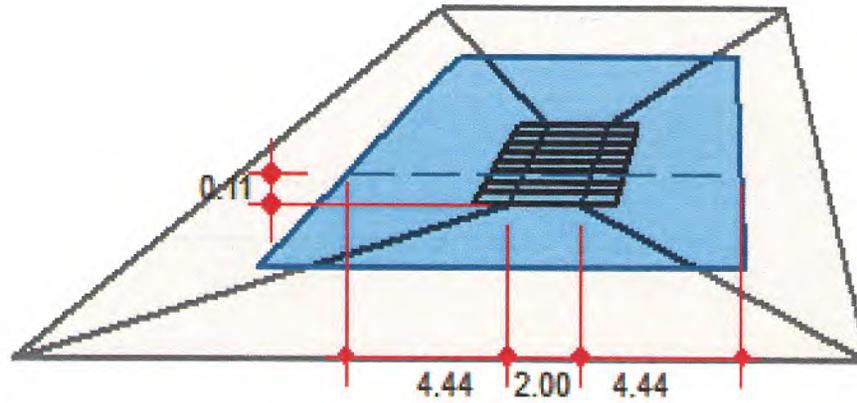
No. Lines: 12

Run Date: 01-21-2016

Inlet Section (Line 11 - Drop Grate Inlet) - INLET-1

All dimensions in feet

Line 11 - Drop Grate Inlet in Sag - INLET-1



Line #	Q				Inlet			Gutter				Depth		Spread		Byp Line (ft)
	Catch (cfs)	Carry (cfs)	Capt (cfs)	Byp (cfs)	Length (ft)	Depr (in)	Area (sqft)	Width (ft)	Slope (ft/ft)	Sw (ft/ft)	Sx (ft/ft)	Gutter (ft)	Inlet (ft)	Gutter (ft)	Inlet (ft)	
11	1.84	0.00	1.84	0.00	4.00	6.60	2.00	Sag	0.033	0.033	0.11	0.11	10.87	10.87	Sag

Project File:	No. Lines: 12	Run Date: 01-21-2016
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APPENDIX L

Stormwater Management Alternative #2 Summary Chart

STORMWATER MANAGEMENT ALTERNATIVE #2 SUMMARY CHART

Structure ID	Location	Minimum Recommendations	Design Improvement Options	Tree Removal Required	Temporary Construction Easement Needed	Utility Conflicts	Effectiveness	Construction Cost ¹	Construction Cost (with utility conflicts considered) ¹²
INLET #1	Between north entrance of Hawthorne Dr and Clubhouse Rd	Reestablish approx. 800' of swale on both sides of road, removing boulders, wood curb; replace pipe from Inlet#1 to EW#1 and lower invert out; remove sediment/debris from Inlet#1, HW#1, EW#1.	N/A	5 GOOD	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$19,540 (with culvert rep.)	\$22,340 - 30,740
INLET #2	SW corner of Highland Ct	Remove sediment/debris from Inlet#2.	N/A	No	No	No	This solution would allow ponding water to drain.	N/A	N/A
INLET #3	NE corner of Wyndham Ct	Reestablish approx. 220' of swale along western side of road; remove sediment at 12" CMP outfall located on 143 Brookfield Ct and add topsoil, minor grading over the top of CMP; remove sediment/debris from Inlet #3.	(3A) Infiltration trench (80 LF) with inlet, perforated pipe, minor grading	5 GOOD	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$8,840	\$11,050 - 17,680
			(3B) Bioswale (80 LF) with inlet, perforated pipe, minor regrading	5 GOOD	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$8,200	\$10,250 - 16,400
			Minimum Recommendations Only	10 GOOD	Potential	Yes	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$3,080	\$3,850 - 6,160
INLET #4	SW corner of Windemere Ct	Reestablish approx. 120' of swale from Highland Ct to Windemere Ct, removing boulders, as necessary.	(4A) Infiltration trench (120 LF) with inlet, perforated pipe, minor grading and tree removal	1 FAIR	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$10,760	\$13,450 - 21,520
			(4B) Bioswale (120 LF) with inlet, perforated pipe, minor regrading and tree removal	1 FAIR	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$9,800	\$12,250 - 19,600
			Minimum Recommendations Only	1 FAIR	Yes	Yes	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$1,680	\$2,180 - 3,360
INLET#5	NE corner of Brookfield Ct	Remove sediment/debris from Inlet #5.	N/A	No	No	No	This solution would allow ponding water to drain.	N/A	N/A
INLET #6	NE corner of Lambeth Ct	Reestablish approx. 160' of swale along western side of Hawthorne Dr from Brookfield Ct to Lambeth Ct; remove sediment/debris from Inlet #6.	N/A	5 GOOD	Potential	No	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$2,240	\$2,800 - 4,480
INLET #7	SE corner of 122 Lambeth Ct	Remove sediment/debris from Inlet #7, install approx. 240' rolled curb to direct runoff into Inlet #7.	N/A	No	No	No	This solution would allow ponding water to drain.	\$5,200	N/A
INLET #8	NE corner of 23 Windemere Ct	Reestablish approx. 360' of swale from Cambridge Ct to Windemere Ct; remove sediment/debris from Inlet #8.	(8A) Infiltration trench (360 LF) with inlet, perforated pipe, minor grading and tree removal	5 GOOD	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$22,280	\$27,850 - 44,560
			(8B) Bioswale (360 LF) with inlet, perforated pipe, minor regrading and tree removal	5 GOOD	Yes	Yes	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$19,400	\$24,250 - 38,800
			Minimum Recommendations Only	5 GOOD	Potential	Yes	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$5,040	\$6,300 - 10,080
INLET #9	NW corner of Canterbury Ct	Reestablish approx. 350' of swale from Chatham Ct to Canterbury Ct, remove sediment/debris from Inlet #9.	(9A) Infiltration trench (120 LF) with inlet, perforated pipe, minor grading and tree removal	Yes	Yes	Potential	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$10,760	\$13,450 - 21,520
			(9B) Bioswale (120 LF) with inlet, perforated pipe, minor regrading and tree removal	Yes	Yes	Potential	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$9,800	\$12,250 - 17,600
			Minimum Recommendations Only	5 GOOD / 1 FAIR	Potential	Potential	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$4,900	\$6,125 - 9,800
INLET #10	NW corner of Chatham Ct	Reestablish approx. 290' of swale along the eastern side of Hawthorne Dr from Chatham Ct to the south entrance of Hawthorne Dr and 110' along the western side of Hawthorne Dr from the south entrance of Hawthorne Dr; remove sediment/debris from Inlet #10.	(10A) Infiltration trench (180 LF) with inlet, perforated pipe, minor grading and tree removal	7 GOOD / 4 POOR	Yes	Potential	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$13,640	\$17,050 - 27,280
			(10B) Bioswale (180 LF) with inlet, perforated pipe, minor regrading and tree removal	7 GOOD / 4 POOR	Yes	Potential	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	\$12,200	\$15,250 - 24,400
			Minimum Recommendations Only	7 GOOD / 3 FAIR / 4 POOR	Potential	Potential	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$5,600	\$7,000 - 11,200
			Offsite inlet on Clearview Dr connecting to existing basin on the south side of Horseshoe Pike, off of Clearview Dr	Unknown	Yes	Potential	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	*No estimate provided at this time	*No estimate provided at this time
			Offsite inlet on Clearview Dr connecting to PennDOT system on Horseshoe Pike	Unknown	Yes	Potential	This solution has the potential to decrease the frequency and duration of flooding from localized runoff.	*No estimate provided at this time	*No estimate provided at this time
HEADWALL #2	HOA property on western side of Hawthorne Dr between Cambridge Ct and Suffolk Ct	Reestablish approx. 690' of swale along western side of Hawthorne Dr from Cambridge Ct to Somerset Ct; remove sediment/debris from Endwall #2.	N/A	3 GOOD	Potential	Potential	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$9,660	\$12,075 - 19,320
ENDWALL #2	HOA property on eastern side of Hawthorne Dr between Cambridge Ct and Suffolk Ct	Reestablish approx. 310' of swale along eastern side of Hawthorne Dr from Gloucester Ct to Canterbury Ct; remove sediment/debris from Headwall #2; replace 42" CMP with 42" RCP.	N/A	1 FAIR	Potential	Yes	This solution allows for more rapid drainage of flood water and ponding due to localized runoff may decrease.	\$41,890 (with culvert rep.)	\$42,975 - 46,230

¹Maintenance items specified in the Minimum Recommendations (sediment removal, etc.) were not considered in Construction Cost Estimates.

²Construction Cost Estimate with Utility Relocation Considered is an increase of approximately 25-100% of Construction Cost.

*Construction costs for Design Improvement Options are stand alone.



APPENDIX M

Pollutant Load Removal Calculations

WATER QUALITY ANALYSIS
POLLUTANT LOADING AND REDUCTION PER BMP

PROJECT: Hawthorne Drive Comprehensive Stormwater Management Study
SITE NAME: Inlet #3
PROPOSED BMP: Infiltration Trench (3A) or Bioswale (3B)
BMP 6.4.4 Infiltration Trench/BMP 6.4.5 Rain Garden Bioretention

BMP ID #: Inlet #3
DATE: 2/9/16
BY: BU

Drainage Area: 0.93 ac Annual Rainfall (P): 45.4 in

LAND COVER CLASSIFICATION	POLLUTANT			COVER (Acres)	CN*	RUNOFF VOLUME				POLLUTANT LOAD				
	TSS EMC (mg/l)	TP EMC (mg/l)	Nitrate-Nitrite EMC (mg/l as N)			S	Ia (0.2*S)	Q Runoff (in)	RUNOFF VOLUME (AF)	TSS (lbs)	TP (lbs)	TN (lbs)		
PERVIOUS SURFACES	Forest	39	0.15	0.17		55	8.18	1.64	36.87	0.00	0.00	0.00	0.00	
	Meadow	47	0.19	0.30		58	7.24	1.45	37.73	0.00	0.00	0.00	0.00	
	Fertilized Planting Area	55	1.34	0.73		70	4.29	0.86	40.63	0.00	0.00	0.00	0.00	
	Native Planting Area	55	0.40	0.33		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
	Lawn, Low-Input	180	0.40	0.44	0.39	61	6.39	1.28	38.54	1.25	608.69	1.35	1.49	
	Lawn, High-Input	180	2.22	1.46		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
	Golf Course Fairway/Green	305	1.07	1.84		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
	Grassed Athletic Field	200	1.07	1.01		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
IMPERVIOUS SURFACES	Rooftop	21	0.13	0.32	0.20	98	0.20	0.04	45.16	0.75	42.67	0.26	0.65	
	High Traffic Street/Highway	261	0.4	0.83		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
	Medium Traffic Street	113	0.33	0.58		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
	Low Traffic/Residential Street	86	0.36	0.47	0.30	98	0.20	0.04	45.16	1.13	262.13	1.10	1.43	
	Res. Driveway, Play Courts, etc.	60	0.46	0.47	0.04	98	0.20	0.04	45.16	0.15	24.38	0.19	0.19	
	High Traffic Parking Lot	120	0.39	0.6		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
	Low Traffic Parking Lot	58	0.15	0.39		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
DRAINAGE AREA				0.93	TOTAL ANNUAL POLLUTANT LOAD						937.88	2.90	3.76	
						TOTAL DAILY POLLUTANT LOAD						2.570	0.008	0.010
						BMP POLLUTANT REMOVAL EFFICIENCY (%)						85	85	30
						TOTAL ANNUAL POLLUTANT REMOVAL						797.20	2.47	1.13
						TOTAL DAILY POLLUTANT REMOVAL						2.184	0.007	0.003

Runoff (in) = Q = (P-0.2S)² / (P+0.8S) where:

P = Annual Rainfall (in)

S = (1000/CN)-10

Runoff Volume (AF) = Q x Area x 1/12

Q = Runoff (in)

Area = Land Cover (ac)

Pollutant Load = [EMC, mg/l] x [Volume, AF] x [2.7, Unit Conversion]

Notes:

1) Worksheet developed from Worksheets 4, 12 & 13 of PADEP Stormwater BMP Manual.

2) *CN assumes Type B Soil, Good Condition

3) Land cover acreage derived from Bing Maps GIS aerial coverage (2014).



WATER QUALITY ANALYSIS
POLLUTANT LOADING AND REDUCTION PER BMP

PROJECT: Hawthorne Drive Comprehensive Stormwater Management Study
SITE NAME: Inlet #4
PROPOSED BMP: Infiltration Trench (4A) or Bioswale (4B)
BMP 6.4.4 Infiltration Trench/BMP 6.4.5 Rain Garden Bioretention

BMP ID #: Inlet #4
DATE: 2/9/16
BY: BU

Drainage Area: 0.76 ac Annual Rainfall (P): 45.4 in

	LAND COVER CLASSIFICATION	POLLUTANT			RUNOFF VOLUME					POLLUTANT LOAD					
		TSS EMC (mg/l)	TP EMC (mg/l)	Nitrate- Nitrite EMC (mg/l as N)	COVER (Acres)	CN*	S	Ia (0.2*S)	Q Runoff (in)	RUNOFF VOLUME (AF)	TSS (lbs)	TP (lbs)	TN (lbs)		
PERVIOUS SURFACES	Forest	39	0.15	0.17		55	8.18	1.64	36.87	0.00	0.00	0.00	0.00		
	Meadow	47	0.19	0.30		58	7.24	1.45	37.73	0.00	0.00	0.00	0.00		
	Fertilized Planting Area	55	1.34	0.73		70	4.29	0.86	40.63	0.00	0.00	0.00	0.00		
	Native Planting Area	55	0.40	0.33		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
	Lawn, Low-Input	180	0.40	0.44	0.50	61	6.39	1.28	38.54	1.61	780.38	1.73	1.91		
	Lawn, High-Input	180	2.22	1.46		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
	Golf Course Fairway/Green	305	1.07	1.84		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
	Grassed Athletic Field	200	1.07	1.01		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
IMPERVIOUS SURFACES	Rooftop	21	0.13	0.32	0.10	98	0.20	0.04	45.16	0.38	21.34	0.13	0.33		
	High Traffic Street/Highway	261	0.4	0.83		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
	Medium Traffic Street	113	0.33	0.58		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
	Low Traffic/Residential Street	86	0.36	0.47	0.10	98	0.20	0.04	45.16	0.38	87.38	0.37	0.48		
	Res. Driveway, Play Courts, etc.	60	0.46	0.47	0.06	98	0.20	0.04	45.16	0.23	36.58	0.28	0.29		
	High Traffic Parking Lot	120	0.39	0.6		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
	Low Traffic Parking Lot	58	0.15	0.39		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
	DRAINAGE AREA				0.76	TOTAL ANNUAL POLLUTANT LOAD					925.66	2.51	3.00		
										TOTAL DAILY POLLUTANT LOAD			2.536	0.007	0.008
										BMP POLLUTANT REMOVAL EFFICIENCY (%)			85	85	30
										TOTAL ANNUAL POLLUTANT REMOVAL			786.82	2.14	0.90
										TOTAL DAILY POLLUTANT REMOVAL			2.156	0.006	0.002

Runoff (in) = Q = (P-0.2S)² / (P+0.8S) where:

P = Annual Rainfall (in)

S = (1000/CN)-10

Runoff Volume (AF) = Q x Area x 1/12

Q = Runoff (in)

Area = Land Cover (ac)

Pollutant Load = [EMC, mg/l] x [Volume, AF] x [2.7, Unit Conversion]

Notes:

1) Worksheet developed from Worksheets 4, 12 & 13 of PADEP Stormwater BMP Manual.

2) *CN assumes Type B Soil, Good Condition

3) Land cover acreage derived from Bing Maps GIS aerial coverage (2014).



WATER QUALITY ANALYSIS

POLLUTANT LOADING AND REDUCTION PER BMP

PROJECT: Hawthorne Drive Comprehensive Stormwater Management Study
SITE NAME: Inlet #8
PROPOSED BMP: Infiltration Trench (8A) or Bioswale (8B)
BMP 6.4.4 Infiltration Trench/BMP 6.4.5 Rain Garden Bioretention

BMP ID #: Inlet #8
DATE: 2/9/16
BY: BU

Drainage Area: 3.58 ac Annual Rainfall (P): 45.4 in

	LAND COVER CLASSIFICATION	POLLUTANT			RUNOFF VOLUME					POLLUTANT LOAD			
		TSS EMC (mg/l)	TP EMC (mg/l)	Nitrate- Nitrite EMC (mg/l as N)	COVER (Acres)	CN*	S	Ia (0.2*S)	Q Runoff (in)	RUNOFF VOLUME (AF)	TSS (lbs)	TP (lbs)	TN (lbs)
PERVIOUS SURFACES	Forest	39	0.15	0.17		55	8.18	1.64	36.87	0.00	0.00	0.00	0.00
	Meadow	47	0.19	0.30		58	7.24	1.45	37.73	0.00	0.00	0.00	0.00
	Fertilized Planting Area	55	1.34	0.73		70	4.29	0.86	40.63	0.00	0.00	0.00	0.00
	Native Planting Area	55	0.40	0.33		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00
	Lawn, Low-Input	180	0.40	0.44	2.40	61	6.39	1.28	38.54	7.71	3745.80	8.32	9.16
	Lawn, High-Input	180	2.22	1.46		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00
	Golf Course Fairway/Green	305	1.07	1.84		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00
	Grassed Athletic Field	200	1.07	1.01		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00
IMPERVIOUS SURFACES	Rooftop	21	0.13	0.32	0.50	98	0.20	0.04	45.16	1.88	106.68	0.66	1.63
	High Traffic Street/Highway	261	0.4	0.83		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00
	Medium Traffic Street	113	0.33	0.58		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00
	Low Traffic/Residential Street	86	0.36	0.47	0.50	98	0.20	0.04	45.16	1.88	436.88	1.83	2.39
	Res. Driveway, Play Courts, etc.	60	0.46	0.47	0.18	98	0.20	0.04	45.16	0.68	109.73	0.84	0.86
	High Traffic Parking Lot	120	0.39	0.6		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00
	Low Traffic Parking Lot	58	0.15	0.39		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00
	DRAINAGE AREA				3.58	TOTAL ANNUAL POLLUTANT LOAD					4399.10	11.65	14.03
					TOTAL DAILY POLLUTANT LOAD					12.052	0.032	0.038	
					BMP POLLUTANT REMOVAL EFFICIENCY (%)					85	85	30	
					TOTAL ANNUAL POLLUTANT REMOVAL					3739.23	9.91	4.21	
					TOTAL DAILY POLLUTANT REMOVAL					10.244	0.027	0.012	

Runoff (in) = $Q = (P-0.2S)^2 / (P+0.8S)$ where:

P = Annual Rainfall (in)

S = $(1000/CN)-10$

Runoff Volume (AF) = $Q \times \text{Area} \times 1/12$

Q = Runoff (in)

Area = Land Cover (ac)

Pollutant Load = $[\text{EMC, mg/l}] \times [\text{Volume, AF}] \times [2.7, \text{Unit Conversion}]$

Notes:

1) Worksheet developed from Worksheets 4, 12 & 13 of PADEP Stormwater BMP Manual.

2) *CN assumes Type B Soil, Good Condition

3) Land cover acreage derived from Bing Maps GIS aerial coverage (2014).



WATER QUALITY ANALYSIS
POLLUTANT LOADING AND REDUCTION PER BMP

PROJECT: Hawthorne Drive Comprehensive Stormwater Management Study
SITE NAME: Inlet #9
PROPOSED BMP: Infiltration Trench (9A) or Bioswale (9B)
BMP 6.4.4 Infiltration Trench/BMP 6.4.5 Rain Garden Bioretention

BMP ID #: Inlet #9
DATE: 2/9/16
BY: BU

Drainage Area: 3.11 ac Annual Rainfall (P): 45.4 in

LAND COVER CLASSIFICATION	POLLUTANT			COVER (Acres)	CN*	RUNOFF VOLUME				POLLUTANT LOAD				
	TSS EMC (mg/l)	TP EMC (mg/l)	Nitrate-Nitrite EMC (mg/l as N)			S	Ia (0.2*S)	Q Runoff (in)	RUNOFF VOLUME (AF)	TSS (lbs)	TP (lbs)	TN (lbs)		
PERVIOUS SURFACES	Forest	39	0.15	0.17		55	8.18	1.64	36.87	0.00	0.00	0.00	0.00	
	Meadow	47	0.19	0.30		58	7.24	1.45	37.73	0.00	0.00	0.00	0.00	
	Fertilized Planting Area	55	1.34	0.73		70	4.29	0.86	40.63	0.00	0.00	0.00	0.00	
	Native Planting Area	55	0.40	0.33		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
	Lawn, Low-Input	180	0.40	0.44	2.24	61	6.39	1.28	38.54	7.19	3496.08	7.77	8.55	
	Lawn, High-Input	180	2.22	1.46		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
	Golf Course Fairway/Green	305	1.07	1.84		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
	Grassed Athletic Field	200	1.07	1.01		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00	
IMPERVIOUS SURFACES	Rooftop	21	0.13	0.32	0.30	98	0.20	0.04	45.16	1.13	64.01	0.40	0.98	
	High Traffic Street/Highway	261	0.4	0.83		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
	Medium Traffic Street	113	0.33	0.58		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
	Low Traffic/Residential Street	86	0.36	0.47	0.30	98	0.20	0.04	45.16	1.13	262.13	1.10	1.43	
	Res. Driveway, Play Courts, etc.	60	0.46	0.47	0.27	98	0.20	0.04	45.16	1.02	164.59	1.26	1.29	
	High Traffic Parking Lot	120	0.39	0.6		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
	Low Traffic Parking Lot	58	0.15	0.39		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00	
DRAINAGE AREA				3.11	TOTAL ANNUAL POLLUTANT LOAD						3986.82	10.52	12.24	
						TOTAL DAILY POLLUTANT LOAD						10.923	0.029	0.034
						BMP POLLUTANT REMOVAL EFFICIENCY (%)						85	85	30
						TOTAL ANNUAL POLLUTANT REMOVAL						3388.79	8.95	3.67
						TOTAL DAILY POLLUTANT REMOVAL						9.284	0.025	0.010

Runoff (in) = Q = (P-0.2S)² / (P+0.8S) where:

P = Annual Rainfall (in)

S = (1000/CN)-10

Runoff Volume (AF) = Q x Area x 1/12

Q = Runoff (in)

Area = Land Cover (ac)

Pollutant Load = [EMC, mg/l] x [Volume, AF] x [2.7, Unit Conversion]

Notes:

1) Worksheet developed from Worksheets 4, 12 & 13 of PADEP Stormwater BMP Manual.

2) *CN assumes Type B Soil, Good Condition

3) Land cover acreage derived from Bing Maps GIS aerial coverage (2014).



WATER QUALITY ANALYSIS
POLLUTANT LOADING AND REDUCTION PER BMP

PROJECT: Hawthorne Drive Comprehensive Stormwater Management Study
SITE NAME: Inlet #10
PROPOSED BMP: Infiltration Trench (10A) or Bioswale (10B)
BMP 6.4.4 Infiltration Trench/BMP 6.4.5 Rain Garden Bioretention

BMP ID #: Inlet #10
DATE: 2/9/16
BY: BU

Drainage Area: 6.17 ac Annual Rainfall (P): 45.4 in

	LAND COVER CLASSIFICATION	POLLUTANT			RUNOFF VOLUME					POLLUTANT LOAD					
		TSS EMC (mg/l)	TP EMC (mg/l)	Nitrate- Nitrite EMC (mg/l as N)	COVER (Acres)	CN*	S	Ia (0.2*S)	Q Runoff (in)	RUNOFF VOLUME (AF)	TSS (lbs)	TP (lbs)	TN (lbs)		
PERVIOUS SURFACES	Forest	39	0.15	0.17		55	8.18	1.64	36.87	0.00	0.00	0.00	0.00		
	Meadow	47	0.19	0.30		58	7.24	1.45	37.73	0.00	0.00	0.00	0.00		
	Fertilized Planting Area	55	1.34	0.73		70	4.29	0.86	40.63	0.00	0.00	0.00	0.00		
	Native Planting Area	55	0.40	0.33		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
	Lawn, Low-Input	180	0.40	0.44	4.54	61	6.39	1.28	38.54	14.58	7085.81	15.75	17.32		
	Lawn, High-Input	180	2.22	1.46		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
	Golf Course Fairway/Green	305	1.07	1.84		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
	Grassed Athletic Field	200	1.07	1.01		61	6.39	1.28	38.54	0.00	0.00	0.00	0.00		
IMPERVIOUS SURFACES	Rooftop	21	0.13	0.32	0.50	98	0.20	0.04	45.16	1.88	106.68	0.66	1.63		
	High Traffic Street/Highway	261	0.4	0.83		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
	Medium Traffic Street	113	0.33	0.58	0.10	98	0.20	0.04	45.16	0.38	114.81	0.34	0.59		
	Low Traffic/Residential Street	86	0.36	0.47	0.50	98	0.20	0.04	45.16	1.88	436.88	1.83	2.39		
	Res. Driveway, Play Courts, etc.	60	0.46	0.47	0.53	98	0.20	0.04	45.16	1.99	323.09	2.48	2.53		
	High Traffic Parking Lot	120	0.39	0.6		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
	Low Traffic Parking Lot	58	0.15	0.39		98	0.20	0.04	45.16	0.00	0.00	0.00	0.00		
DRAINAGE AREA				6.17	TOTAL ANNUAL POLLUTANT LOAD					8067.28	21.05	24.45			
										TOTAL DAILY POLLUTANT LOAD			22.102	0.058	0.067
										BMP POLLUTANT REMOVAL EFFICIENCY (%)			85	85	30
										TOTAL ANNUAL POLLUTANT REMOVAL			6857.18	17.89	7.34
										TOTAL DAILY POLLUTANT REMOVAL			18.787	0.049	0.020

Runoff (in) = Q = (P-0.2S)² / (P+0.8S) where:

P = Annual Rainfall (in)

S = (1000/CN)-10

Runoff Volume (AF) = Q x Area x 1/12

Q = Runoff (in)

Area = Land Cover (ac)

Pollutant Load = [EMC, mg/l] x [Volume, AF] x [2.7, Unit Conversion]

Notes:

1) Worksheet developed from Worksheets 4, 12 & 13 of PADEP Stormwater BMP Manual.

2) *CN assumes Type B Soil, Good Condition

3) Land cover acreage derived from Bing Maps GIS aerial coverage (2014).



WATER QUALITY ANALYSIS

TOTAL POLLUTANT LOADING AND REDUCTION THROUGH BMP APPLICATION

PROJECT: Hawthorne Drive Comprehensive Stormwater Management Study
DATE: 2/9/2016
BY: BU

ANNUAL POLLUTANT LOAD REMOVAL SUMMARY		ANNUAL POLLUTANT LOAD				REMOVAL		
BMP ID #	BMP Site Name	Drainage Area (Acres)	TSS (lbs)	TP (lbs)	TN (lbs)	TSS (tons)	TP (lbs)	TN (lbs)
Inlet #3	Infiltration Trench (3A) or Bioswale (3B)	0.9	937.88	2.90	3.76	0.40	2.47	1.13
Inlet #4	Infiltration Trench (4A) or Bioswale (4B)	0.8	925.66	2.51	3.00	0.39	2.14	0.90
Inlet #8	Infiltration Trench (8A) or Bioswale (8B)	3.6	4399.10	11.65	14.03	1.87	9.91	4.21
Inlet #9	Infiltration Trench (9A) or Bioswale (9B)	3.1	3986.82	10.52	12.24	1.69	8.95	3.67
Inlet #10	Infiltration Trench (10A) or Bioswale (10B)	6.2	8067.28	21.05	24.45	3.43	17.89	7.34
TOTAL ANNUAL POLLUTANT REMOVAL						7.78	41.34	17.25

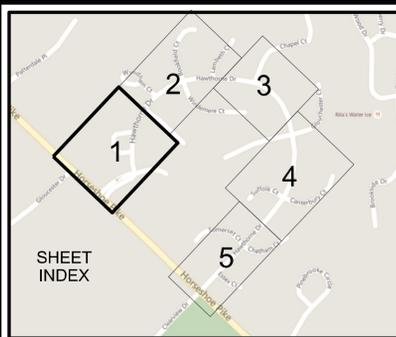
DAILY POLLUTANT LOAD REMOVAL SUMMARY		DAILY POLLUTANT LOAD				REMOVAL		
BMP ID #	BMP Site Name	Drainage Area (Acres)	TSS (lbs)	TP (lbs)	TN (lbs)	TSS (lbs)	TP (lbs)	TN (lbs)
Inlet #3	Infiltration Trench (3A) or Bioswale (3B)	0.9	2.57	0.008	0.010	2.18	0.007	0.003
Inlet #4	Infiltration Trench (4A) or Bioswale (4B)	0.8	2.54	0.007	0.008	2.16	0.006	0.002
Inlet #8	Infiltration Trench (8A) or Bioswale (8B)	3.6	12.05	0.032	0.038	10.24	0.027	0.012
Inlet #9	Infiltration Trench (9A) or Bioswale (9B)	3.1	10.92	0.029	0.034	9.28	0.025	0.010
Inlet #10	Infiltration Trench (10A) or Bioswale (10B)	6.2	22.10	0.058	0.067	18.79	0.049	0.020
TOTAL DAILY POLLUTANT REMOVAL						42.66	0.113	0.047





APPENDIX N

Stormwater Concept Plan

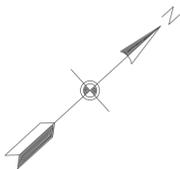


SITE LOCATION MAP
SCALE: 1" = 250'



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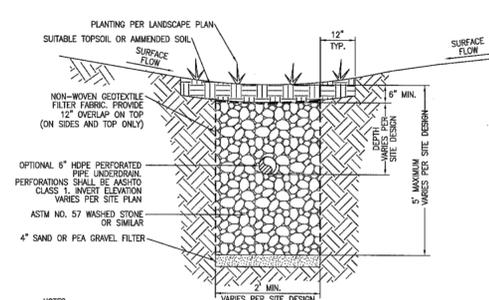
GENERAL NOTES:

- TOPOGRAPHIC FEATURES SHOWN FROM ACTUAL FIELD SURVEY BY ASH ASSOCIATES SEPTEMBER, 2015 AND LIMITED TO SHOWING FEATURES OF INTEREST ONLY.
- VERTICAL DATUM IS NAVD 1988 AND ESTABLISHED BY GPS OBSERVATIONS REFERENCED TO THE NGS CORS NETWORK. SITE BENCHMARKS ARE METAL SPIKES SET AS SHOWN. SITE BM A ELEVATION=537.81'. SITE BM B ELEVATION=522.45'.
- HORIZONTAL DATUM IS NAD 83, STATE PLANE COORDINATES OF PENNSYLVANIA AND ESTABLISHED GPS OBSERVATIONS REFERENCED TO THE NGS CORS NETWORK.
- THIS IS NOT A BOUNDARY SURVEY. A COMPLETE BOUNDARY SURVEY WOULD BE REQUIRED TO SHOW ADDITIONAL DETAILS.
- RIGHT-OF-WAY WIDTHS SHOWN PER DEEDS OF RECORD AND REFERENCE PLANS LISTED BELOW.
- THIS PLAN WAS MADE AS PER INSTRUCTIONS OF APPLICANT AND WITHOUT THE BENEFIT OF A TITLE REPORT. OTHER RIGHTS TO PROPERTY MAY EXIST.
- THIS PLAN DOES NOT SHOW ENVIRONMENTAL HAZARDS, OR ARCHEOLOGICAL SITES.
- ENTIRE SITE IS LOCATED IN FLOOD ZONE "X" AREAS DETERMINED TO BE OUTSIDE THE 0.2% ANNUAL CHANCE FLOODPLAIN. PER FEMA FLOOD INSURANCE RATE MAP (FIRM) OF CHESTER COUNTY, PANEL 140 OF 380, MAP # 42029C0140F, REVISED SEPTEMBER 29, 2006.
- REFERENCE PLANS:
 - "HEDGEROW, FINAL SITE & ROAD PLAN, SINGLE FAMILY DEVELOPMENT", PREPARED BY ROBERT F. HARSCH & ASSOCIATES, INC., DATED JANUARY 19, 1976 AND ISSUED MARCH 12, 1976, RECORDED IN THE CHESTER COUNTY RECORDER OF DEEDS OFFICE IN PLAN BOOK 360, PAGE 1 ON APRIL 23, 1976.
 - "FINAL, CULBERTSON FARMS", PREPARED BY BERGER & HAYS, INC., DATED FEBRUARY 27, 1978, LAST REVISED JULY 10, 1978, AND RECORDED IN THE CHESTER COUNTY RECORDER OF DEEDS OFFICE AS PLAN 2046, ON DECEMBER 8, 1978.
- THIS IS AN ABOVE-GROUND SURVEY. LOCATIONS OF EXISTING UTILITIES SHOWN HEREON HAVE BEEN DEVELOPED FROM ABOVEGROUND INSPECTION OF THE SITE. UTILITY COMPANY RECORDS AND/OR PLANS BY OTHERS, COMPLETENESS OR ACCURACY OF THE TYPE, SIZE, DEPTH OR HORIZONTAL LOCATION OF UNDERGROUND FACILITIES OR STRUCTURES CANNOT BE GUARANTEED BY ASH ASSOCIATES, INC. PURSUANT TO REQUIREMENTS OF THE PENNSYLVANIA LEGISLATIVE ACT NUMBER 287 OF 1974 AS AMENDED BY ACT 121 OF 2008, CONTRACTORS MUST VERIFY LOCATION AND DEPTH OF ALL UNDERGROUND UTILITIES AND FACILITIES PRIOR TO START OF WORK. PA1CALL SERIAL NUMBER 20152432863 WAS PLACED FOR DESIGN PURPOSES ONLY.

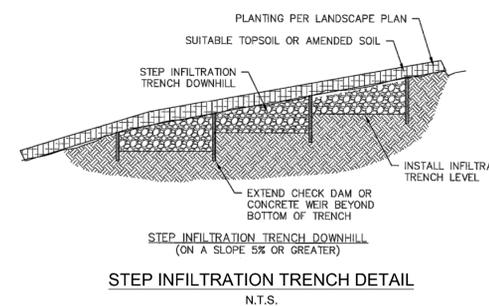
RESPONSE

UTILITY	CONFLICT, LINES NEARBY, - PLANS RECEIVED AND PLOTTED
AQUA PA BRANDYWINE TWP	CONFLICT, LINES NEARBY, - NO PLANS RECEIVED
BUCKEYE	CLEAR - NO FACILITIES.
COMCAST	DID NOT RESPOND.
PECO ENERGY	CONFLICT, LINES NEARBY, - PLANS RECEIVED AND PLOTTED
VERIZON	CONFLICT, LINES NEARBY, - PLANS RECEIVED AND PLOTTED

- AN EXISTING CONDITIONS EVALUATION WAS CONDUCTED AND INCLUDED THE FIELD ASSESSMENT OF HAWTHORNE DRIVE BY A CONSTRUCTION INSPECTOR ON OCTOBER 12, 2015 AND A DESIGN ENGINEER ON JANUARY 10, 2016.
- CERTIFIED ARBORISTS FROM PRESERVATION TREE, LLC CONDUCTED AN ASSESSMENT OF THE HEALTH OF ALL TREES WITHIN AND IMMEDIATELY ADJACENT TO THE HAWTHORNE DRIVE RIGHT-OF-WAY IN OCTOBER 2015.
- THE ORIGINAL SURVEY BASE PLAN WAS MODIFIED PER INFORMATION COLLECTED DURING THE EXISTING CONDITIONS EVALUATION AND TREE HEALTH ASSESSMENT.
- THE RE-ESTABLISHMENT OF SWALES SHOULD INCLUDE MINIMAL GRADING WITHIN THE HAWTHORNE DRIVE RIGHT-OF-WAY TO ESTABLISH POSITIVE DRAINAGE AND RUNOFF CONVEYANCE. SWALES SHOULD BE RE-ESTABLISHED WITH AS MINIMAL TREE REMOVAL AS NECESSARY. THE TREES LABELED "TBR" MAY NOT NEED TO BE REMOVED IN SOME CASES, AS LONG AS POSITIVE DRAINAGE CAN BE ESTABLISHED.
- THE DESIGN IMPROVEMENT OPTIONS CAN BE IMPLEMENTED IN LIEU OF OR IN ADDITION TO REESTABLISHING THE ROADSIDE SWALES.
- REESTABLISHING ROADSIDES, INFILTRATION TRENCHES, AND/OR BIOSWALES WILL NEED TO BE STABILIZED WITH SEED AND A MINIMUM OF NAG P300.



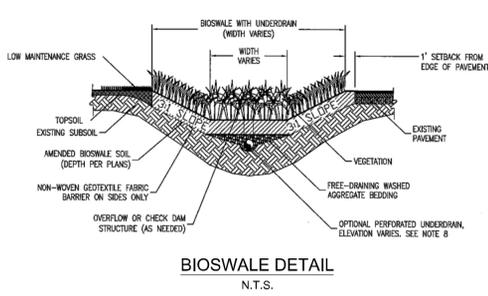
- NOTES:
- PROVIDE 4" TO 6" DIAMETER PVC OBSERVATION WELL TO BOTTOM OF TRENCH.
 - DURING EXCAVATION, HEAVY MACHINERY SHOULD NOT DRIVE OVER EXPOSED UNDERLYING SOILS.
 - EXCAVATE IN DRY CONDITIONS AS OFTEN AS PRACTICABLE.
 - USE TRACKED VEHICLES.
 - EXCAVATE FINAL 9"-12" WITH TEETH OF BUCKET (DO NOT SMEAR).
 - SUBSOILS SHALL BE SCARIFIED (NOT COMPACTED) PRIOR TO PLACEMENT OF CLEAN-WASHED AGGREGATE SUBBASE.



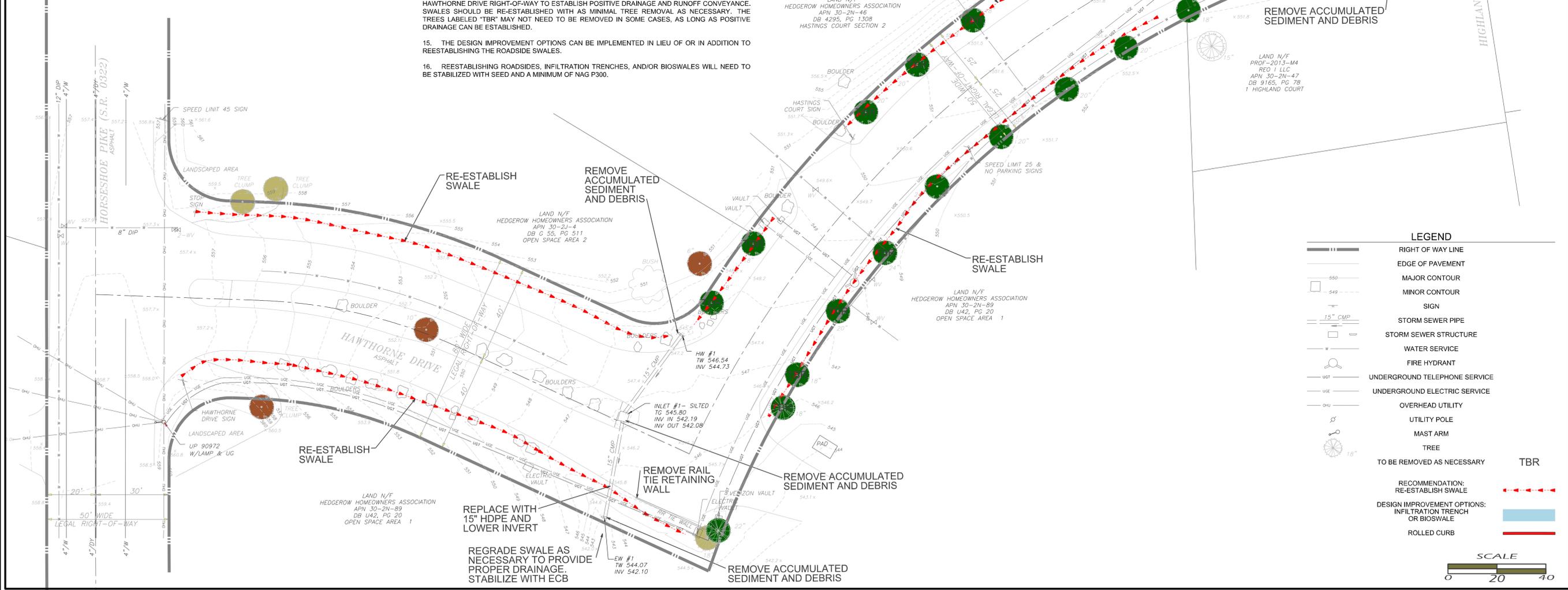
STEP INFILTRATION TRENCH DETAIL
N.T.S.

TREE CONDITION LEGEND

SYM	TREE CONDITION
	POOR
	FAIR
	GOOD
	EXCELLENT



BIOSWALE DETAIL
N.T.S.



LEGEND

	RIGHT OF WAY LINE
	EDGE OF PAVEMENT
	MAJOR CONTOUR
	MINOR CONTOUR
	SIGN
	15" CMP
	STORM SEWER PIPE
	STORM SEWER STRUCTURE
	WATER SERVICE
	FIRE HYDRANT
	UNDERGROUND TELEPHONE SERVICE
	UNDERGROUND ELECTRIC SERVICE
	OVERHEAD UTILITY
	UTILITY POLE
	MAST ARM
	TREE
	TO BE REMOVED AS NECESSARY
	TBR
	RECOMMENDATION: RE-ESTABLISH SWALE
	DESIGN IMPROVEMENT OPTIONS: INFILTRATION TRENCH OR BIOSWALE
	ROLLED CURB

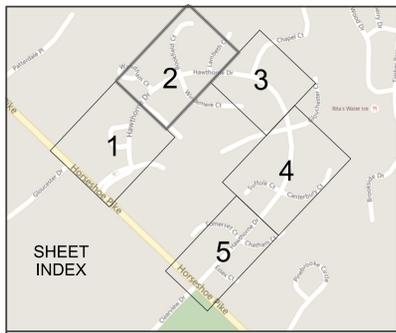


NOT FOR CONSTRUCTION

CEDARVILLE Engineering Group LLC
SUSTAINING COMMUNITIES BY DESIGN
1033 S. Harrower Street, Suite 300, N. Coventry, PA 19465
P: 610-255-4500 (office) 610-255-4900 (fax)

ALTERNATIVE #2
STORMWATER CONCEPT PLAN
EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PENNSYLVANIA
HAWTHORNE DRIVE COMPREHENSIVE
STORMWATER MANAGEMENT STUDY

DESIGNED BY: **BEU/ANP**
DRAWN BY: **TMF**
CHECKED BY: **AMB**
PROJECT NO.: **EBT-15-066**
DATE: **01/22/2016**
SCALE: **1" = 20'**
SHEET **1** OF **5**
C-1

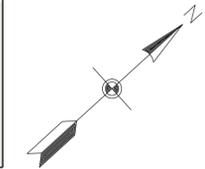


SITE LOCATION MAP
SCALE: 1" = 250'



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Underground Service Alert
Call: TOLL FREE
1-800-242-1776

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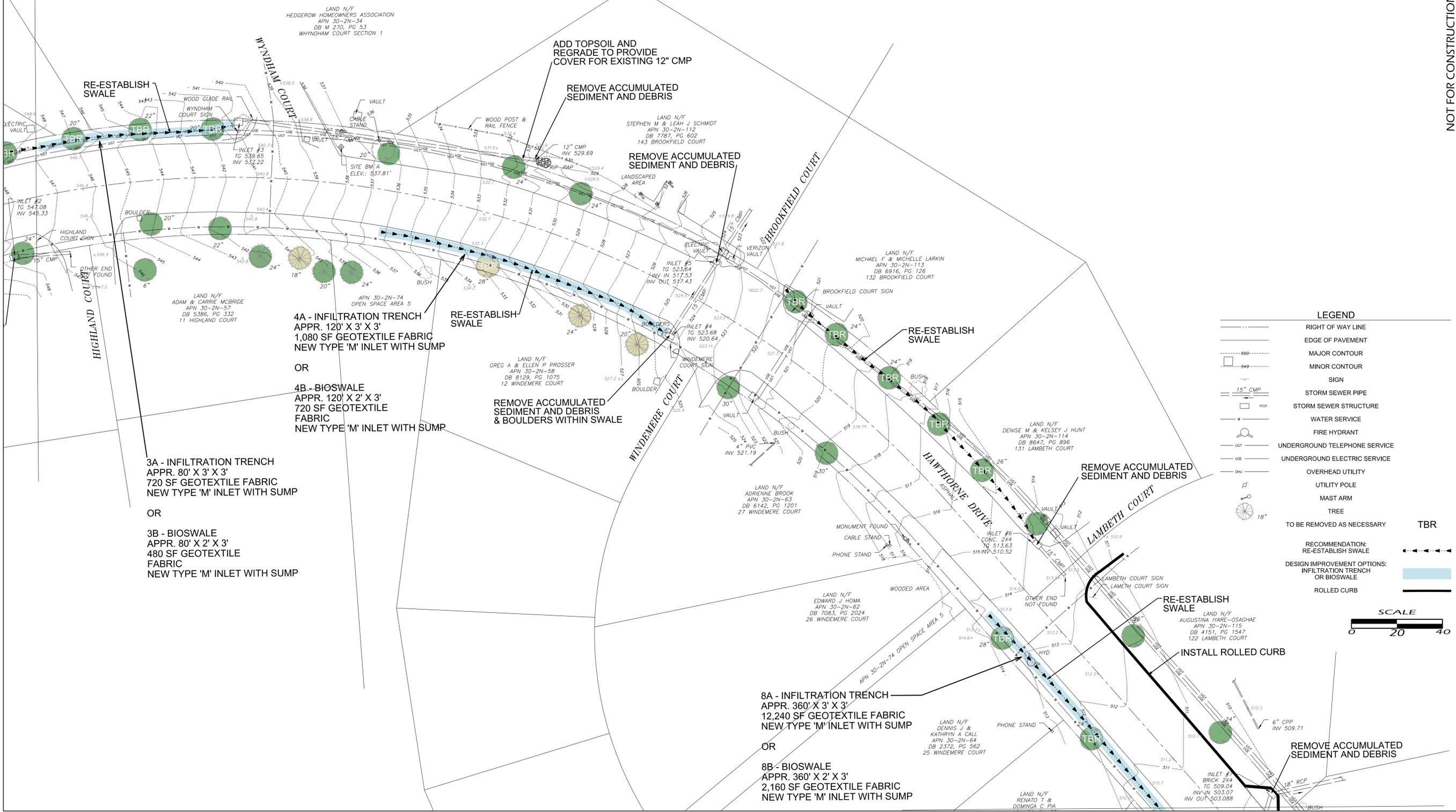


SYM	TREE CONDITION
	POOR
	FAIR
	GOOD
	EXCELLENT

DATE	REVISIONS
XX/XX/XX	1
XX/XX/XX	2
XX/XX/XX	3
XX/XX/XX	4
XX/XX/XX	5

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SUSTAINING COMMUNITIES BY DESIGN
1033 S. Harbore Street, Suite 300, N. Coventry, PA 19465
610.705.4500 (Office) 610.705.4900 (Fax)



3A - INFILTRATION TRENCH
APPR. 80' X 3' X 3'
720 SF GEOTEXTILE FABRIC
NEW TYPE 'M' INLET WITH SUMP

OR

3B - BIOSWALE
APPR. 80' X 2' X 3'
480 SF GEOTEXTILE
FABRIC
NEW TYPE 'M' INLET WITH SUMP

4A - INFILTRATION TRENCH
APPR. 120' X 3' X 3'
1,080 SF GEOTEXTILE FABRIC
NEW TYPE 'M' INLET WITH SUMP

OR

4B - BIOSWALE
APPR. 120' X 2' X 3'
720 SF GEOTEXTILE
FABRIC
NEW TYPE 'M' INLET WITH SUMP

8A - INFILTRATION TRENCH
APPR. 360' X 3' X 3'
12,240 SF GEOTEXTILE FABRIC
NEW TYPE 'M' INLET WITH SUMP

OR

8B - BIOSWALE
APPR. 360' X 2' X 3'
2,160 SF GEOTEXTILE FABRIC
NEW TYPE 'M' INLET WITH SUMP

LEGEND	
	RIGHT OF WAY LINE
	EDGE OF PAVEMENT
	MAJOR CONTOUR
	MINOR CONTOUR
	SIGN
	STORM SEWER PIPE
	STORM SEWER STRUCTURE
	WATER SERVICE
	FIRE HYDRANT
	UNDERGROUND TELEPHONE SERVICE
	UNDERGROUND ELECTRIC SERVICE
	OVERHEAD UTILITY
	UTILITY POLE
	MAST ARM
	TREE
	TO BE REMOVED AS NECESSARY
	RECOMMENDATION: RE-ESTABLISH SWALE
	DESIGN IMPROVEMENT OPTIONS: INFILTRATION TRENCH OR BIOSWALE
	ROLLED CURB



ALTERNATIVE #2

STORMWATER CONCEPT PLAN

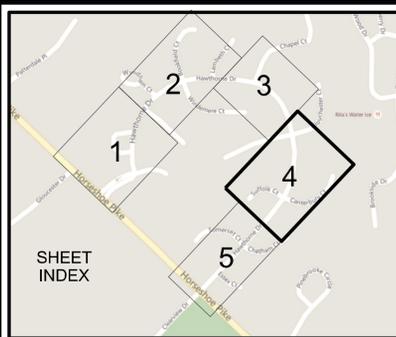
EAST BRANDYWINE TOWNSHIP, CHESTER COUNTY, PENNSYLVANIA

**HAWTHORNE DRIVE COMPREHENSIVE
STORMWATER MANAGEMENT STUDY**

DESIGNED BY: BEU/ANP
DRAWN BY: TMF
CHECKED BY: AMB
PROJECT NO.: EBT-15-066
DATE: 01/22/2016
SCALE: 1" = 20'

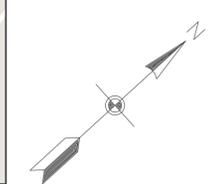
SHEET 2 OF 5

C-2



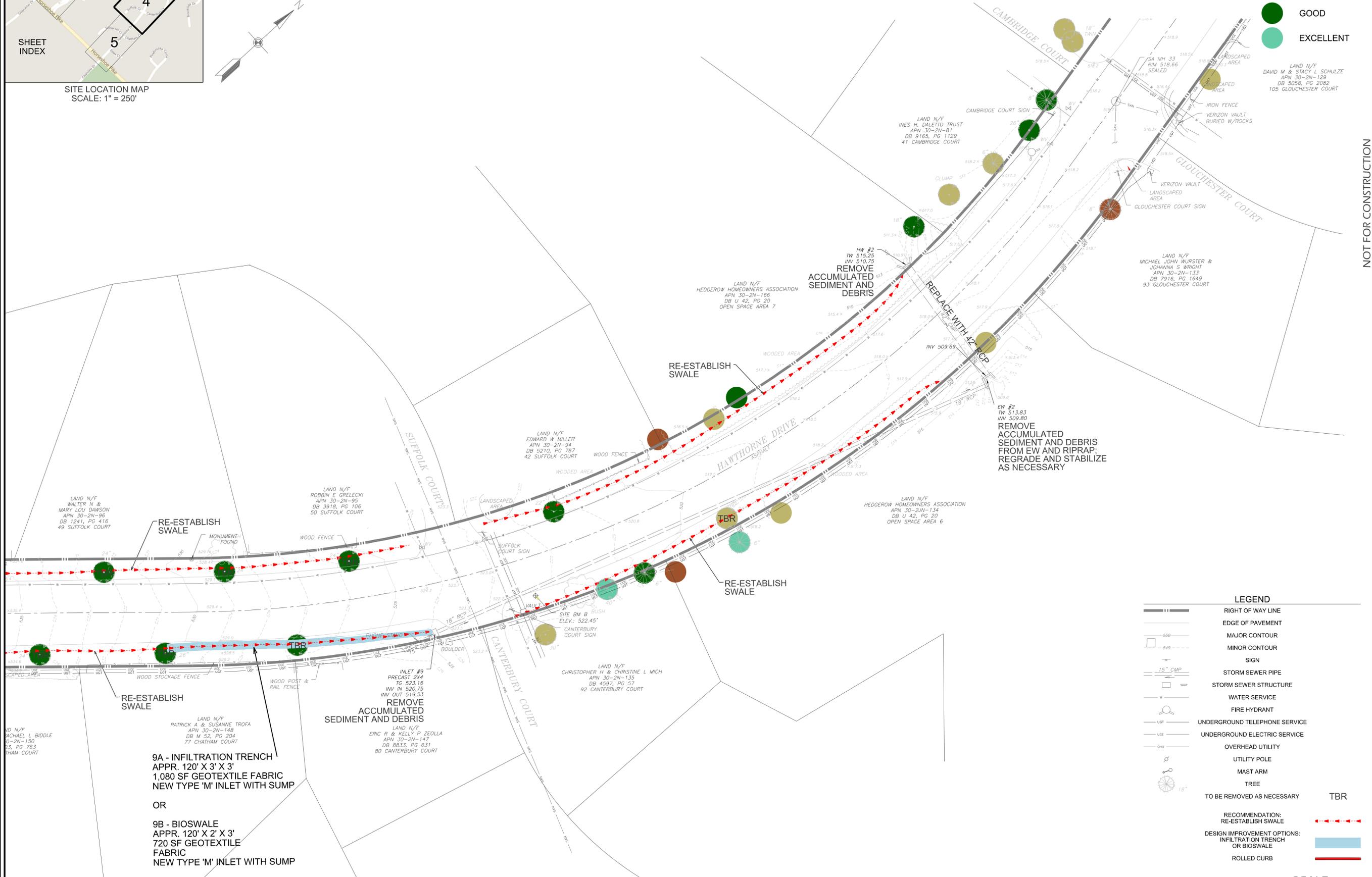
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SYM	TREE CONDITION
	POOR
	FAIR
	GOOD
	EXCELLENT

LAND N/F
DAVID M & STACY L SCHULZE
APN 30-2N-129
DB 5058, PG 2082
105 GLOUCESTER COURT



9A - INFILTRATION TRENCH
APPR. 120' X 3' X 3'
1,080 SF GEOTEXTILE FABRIC
NEW TYPE 'M' INLET WITH SUMP

OR

9B - BIOSWALE
APPR. 120' X 2' X 3'
720 SF GEOTEXTILE FABRIC
NEW TYPE 'M' INLET WITH SUMP

LEGEND	
	RIGHT OF WAY LINE
	EDGE OF PAVEMENT
	MAJOR CONTOUR
	MINOR CONTOUR
	SIGN
	15" CMP
	STORM SEWER PIPE
	STORM SEWER STRUCTURE
	WATER SERVICE
	FIRE HYDRANT
	UNDERGROUND TELEPHONE SERVICE
	UNDERGROUND ELECTRIC SERVICE
	OVERHEAD UTILITY
	UTILITY POLE
	MAST ARM
	TREE
	TO BE REMOVED AS NECESSARY
	TBR
	RECOMMENDATION: RE-ESTABLISH SWALE
	DESIGN IMPROVEMENT OPTIONS: INFILTRATION TRENCH OR BIOSWALE
	ROLLED CURB



REVISIONS	DATE

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HAWTHORNE DRIVE COMPREHENSIVE
STORMWATER MANAGEMENT STUDY

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CHECKED BY: **AMB**
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DATE: **01/22/2016**
SCALE: **1" = 20'**

SHEET **4** OF **5**
C-4

