LAFAYETTE
ENGINEERING COMPANY

Department of Civil and Environmental Engineering
Lafayette College
-
CE473 – Senior Capstone Design II
Spring 2015

POST-CONSTRUCTION STORMWATER MANAGEMENT REPORT

Due Date: May 5, 2015

From: **Emily Crossette, Luning Zhang**

Group: Environmental Group

Title: Post-Construction Stormwater Management Report

Executive Summary:

The purpose of this report was to determine necessary regulations regarding stormwater management at the development site. Additionally, this report contains designs of some stormwater Best Management Practices (BMPs) meeting regulatory requirements to control and manage runoff from the site post development. The proposed stormwater management includes:

1. Rain garden level spreaders at the Marquis Landing Site
2. Green roof on new construction of Intermodal Transportation Center
3. Rainwater cistern on existing structures at Spot Landing
4. Sumped Inlet for water quality management at the Spot Landing
5. Vegetated buffer zone along Bushkill Creek
6. Miscellaneous green spaces at Spot Landing for recreation

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1. Site Overview

The proposed development project is located on two Lafayette College-owned parcels in Easton, PA in Northampton County. The development project involves the installation of an inclined elevator and the erection of two buildings serving as the landing zones. Approximately 2,500 square feet of the development area is on existing paved areas. In addition to the buildings and elevator path, the proposed developments include rain gardens, an entry plaza, and improved pedestrian infrastructure. Runoff from the site enters the Bushkill Creek, Chapter 93 of Pennsylvania Code classifies by as High Quality, Cold Water Fishes and Migratory Fishes territory (HQ-CWF, MF). A map showing the classification of the Bushkill Creek is included in Appendix A.

Run-off volume and rate reduction will be accomplished by converting exiting developed area into rain gardens and by capturing rainwater from an existing roof for irrigation water. Proposed landing structures will support green roofs to both reduce peak discharge of rainwater and improve rainwater runoff quality.

1.1 Predevelopment Conditions

The majority of the development site is wooded area. Part of the sloping woodland includes a decommissioned pedestrian pathway. The top landing site is located on a partially wooded, landscaped grassy area. The landing area at the bottom of the inclined elevator (called the "Spot Landing" due to its proximity with the existing structure called "The Spot"), is a paved parking lot and roadway. Adjacent to the Spot is a partially vegetated ditch. This area will be covered with an elevated vegetated bridge/platform for pedestrian access to the Spot Landing site and Proposed Intermodal Welcome Center.

1.2 Topography

The predominant site topography includes a steep slope that separates the site from the Lafayette College campus. This poses interesting stormwater management challenges as water displaced by the elevator could channelize at relatively high velocities. The landing points are on fairly level ground. The USGS Topographical Quadrangle is included in Appendix B.

1.3 Soil

According to the USDA National Resources Conservation Service Web Soil Survey, included in Appendix C, the site contains the following soil types:

- RzF; Ryder-Rock outcrop complex, 25-50% slopes
- Ukb; Urban Land, occasionally flooded
- UoB; Urban Land-Dullield complex, 0-8% slopes

These areas were confirmed by the Easton Planning Commission Soil Map included in Appendix D.

2. Pre-Development Drainage Areas

The site contains two pre-development drainage areas (PrDDA) all located in Sub-Area 132 of the Bushkill Creek watershed, as shown in the Release Rate Map included as Appendix E. According to the Lehigh Valley Planning Commission, the sub-area is a "Conditional/Provisional No Detention Area" due to the proximity to the confluence with the Delaware River that provides adequate downstream capacity for increased peak flows.

The two PrDDA's are delineated in Appendix F and summarized below:

Drainage Area 1 (DA-1): This area (3.4 acres) in the north portion of the site that drains south to the Bushkill Creek. The area includes the gently sloping and terraced land that is predominantly mowed grass with some development. South of that area, the ground slopes an average of 70% and the predominant cover is woodland and rock outcroppings. The southernmost portion of Drainage Area 1 is paved, gently sloping developed land.

Drainage Area B (DA-2): This area (0.24 acres) includes the footprint of the Mohican Building south of Drainage Area A. This stormwater drains north into the Bushkill Creek.

3. Post-Development Stormwater Management

According to Section 106 of ACT 167, if the impervious area is less than 10,000 square feet, the proposed site will be exempted from the Drainage Plan preparation provisions of this ordinance. The total area of added impervious area is approximately 8,000 square feet comprised, at the top landing, of the Marquis Landing facility and additional pedestrian walkways, and at the base, the excavated land where the inclined elevator traverses Bushkill Drive. Since the added impervious area is less than 10,000 square feet, the project is exempt from such regulatory requirements. However, dedicated to sustainable infrastructure development, Lafayette Engineering Company will be taking measures to reduce stormwater runoff to protect the Bushkill Creek and demonstrate Lafayette's commitment to sustainability.

Post-Development, the two primary drainage areas remain. However, Drainage Area A is now subdivided into 5 sub-watersheds. The Post-Development Drainage Plan showing the delineated sub-watersheds is included in Appendix G. The Rational Method was used to determine calculations for sizing and runoff evaluations. Lehigh Valley Planning Commission protocol for Rational Method Calculations are included in Appendix H.

DA-1A: This area, comprised of 14,000 square feet of paved land at the southernmost portion of the site. This area is 95% impervious. The proposed design will reduce impervious cover by about 20 percent. This contribution will come from a vegetated roof on the proposed structure with an approximate footprint of 3,600 square feet. Additionally, rainwater from the roof of the existing Spot building will be harvested in a cistern for irrigation and additional non-potable water supply. The footprint of the Spot is about 2,700 square feet. The remaining impervious area including the parking lot will be fed to a sumped inlet that discharges into the Bushkill. This inlet will collect debris, some sediments, and grease and prevent such contaminants from entering the Bushkill during storm events, as illustrated in Figure 1. The calculations for the inlet sizing are included in Appendix I and the proposed storm sewer network and inlet designs are included in Appendix J.

DA-1B: This 2-acre (86,375 square foot) drainage area will also drain to the sumped inlet discussed above. The proposed inlet and pipe were sized according to the 10-year storm event as the site experiences flooding in the 25-yr and greater flooding events.

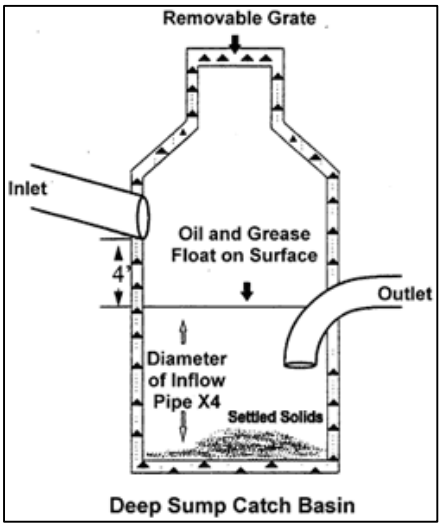

Figure 1: Sample Sump Design
Source: Sea Grant Northeast, Cornell Cooperative Extension

DA-1C: This drainage area, comprised of approximately 0.4 acres of land of predominately developed land is a tributary of DA-1B. The proposed Marquis Landing site cuts off this portion of the watershed from DA-1B. At the bottom of this site, a rain garden will serve as an enhanced infiltration area and a level-spreader to reduce channelization that could erode the hillslope. The level spreader sizing calculation is included in Appendix K.

DA-1D: Similar to DA-1C, this drainage area is a tributary of DA-1B but is cut off from the drainage area by the landing structure in the west. The runoff from this 0.2-acre area will also pass through a level-spreader, infiltration area to reduce flow and channelization.

DA-1E: This sub-area is unchanged by construction. This area was delineated separately from the DA-1B watershed because is not connected to the proposed storm sewer network and will instead drain through rain garden buffer zones to the Bushkill Creek.

DA-2: This site is also unchanged by construction. The rainwater from the roof of the Mohican will be captured with the rainwater from the Spot and applied to the green spaces as irrigation. The footprint of the Mohican is 10,372 square feet.

In addition to planning for the current development, the stormwater management plan included preparation for future development of the Marquis Landing Site. Two 8-inch pipes will be installed on the bridge that can be connected to a storm sewer system if additional development requires more runoff diversion capacity. The pipe sizing calculation is included in Appendix L. Runoff calculations assumed the Marquis Landing Watershed (DA-1C and DA-1D) would be 95% pervious to make a conservative calculation of development.

3.1 Runoff Volume and Rate Control Measures

Runoff volume and rate will be controlled by the proposed green roofs atop the spot landing facilities and the stormwater collection system. The proposed construction increases runoff volume and rate minimally (Table 1). Calculations of the pre- and post- construction runoff are included in Appendix M.

Table 1: Stormwater rate and peak flow pre- and post- development

	Pre-Development			Post Development		
Storm Return-Period	2	10	25	2	10	25
Tc (hr)	.121	.121	.121	.121	.121	.121
Runoff Rate (cfs)	4.89	6.84	8.46	5.32	7.44	9.14
Runoff volume (ft^3)	2129	2980	3684	2316	3243	3979

As mentioned previously, release rate volumes are not required in this area because the stream has sufficient downstream capacity. The other peak runoff control measures include the rainwater cisterns which depends on the size of the cisterns. Volume of stormwater that could be collected by cisterns (Table 2) were determined using the 24-hr rainfall depths for each respective storm interval defined by PennDOT Intensity - Duration - Frequency Field Manual ("PDT-IDF") (May 1986) and the area of the Spot and Mohican buildings. Cisterns can be installed underground or in the proposed Intermodal Welcome Center for educational purposes.

Table 2: Runoff Volumes generated by 1-yr, 2-yr and 5-yr storm events

	Square feet of Building	1-year volume	2-year volume	5-year volume	Units of Volume
Spot	2,697	539	674	809	Cubic feet
		4,035	5,043	6,052	gallons
Mohican	10,372	2,074	2,593	3,112	Cubic feet
		15,517	19,396	23,275	gallons

3.2 Water Quality Measures

Since the disturbed area is less than 10,000 square feet, water quality volume controls are not required. As per Chapter 93, Permits will be required to discharge the stormwater from the sumped inlet into the Bushkill Creek since it is a High Quality waterway and a Cold Water Fishes and Migratory Fishes territory.

Measures to improve runoff water quality include the sumped inlet, rain garden and green roof. Native planting will be used as a sustainable landscaping and for educational benefit and research opportunities.

4. Proposed Stormwater Collection and Conveyance Systems

The proposed collection system includes the sumped inlet and 15-in diameter pipe directing water to the Bushkill Creek. The Rational Method for small watersheds in conjunction with Manning's Equation was used to determine the sizing of pipes and the sump inlet mentioned in the description of the post-development stormwater management drainage areas.

5. Environmental Resources Site Design Assessment

Lafayette Engineering proposed best management practices even though regulations did not require such management methods due to the relatively low area of disturbance and increased impervious area. Such BMPs include the green roofs atop the new proposed intermodal transit center, green spaces around impervious area at the Spot Landing, rain garden level spreaders at the Marquis Landing Site, and the sumped inlet design to capture contaminants that would otherwise run off into the Bushkill Creek.

6. Resources

Jaber, F, Woodson, D, LaChance, C, York, C. Stormwater Management: Rain Gardens. 2012. Texas A&M AgriLife Extension.

"Field Manual of Pennsylvania Department of Transportation" STORM INTENSITY-DURATION-FREQUENCY CHARTS PDT-IDF" May 1986.

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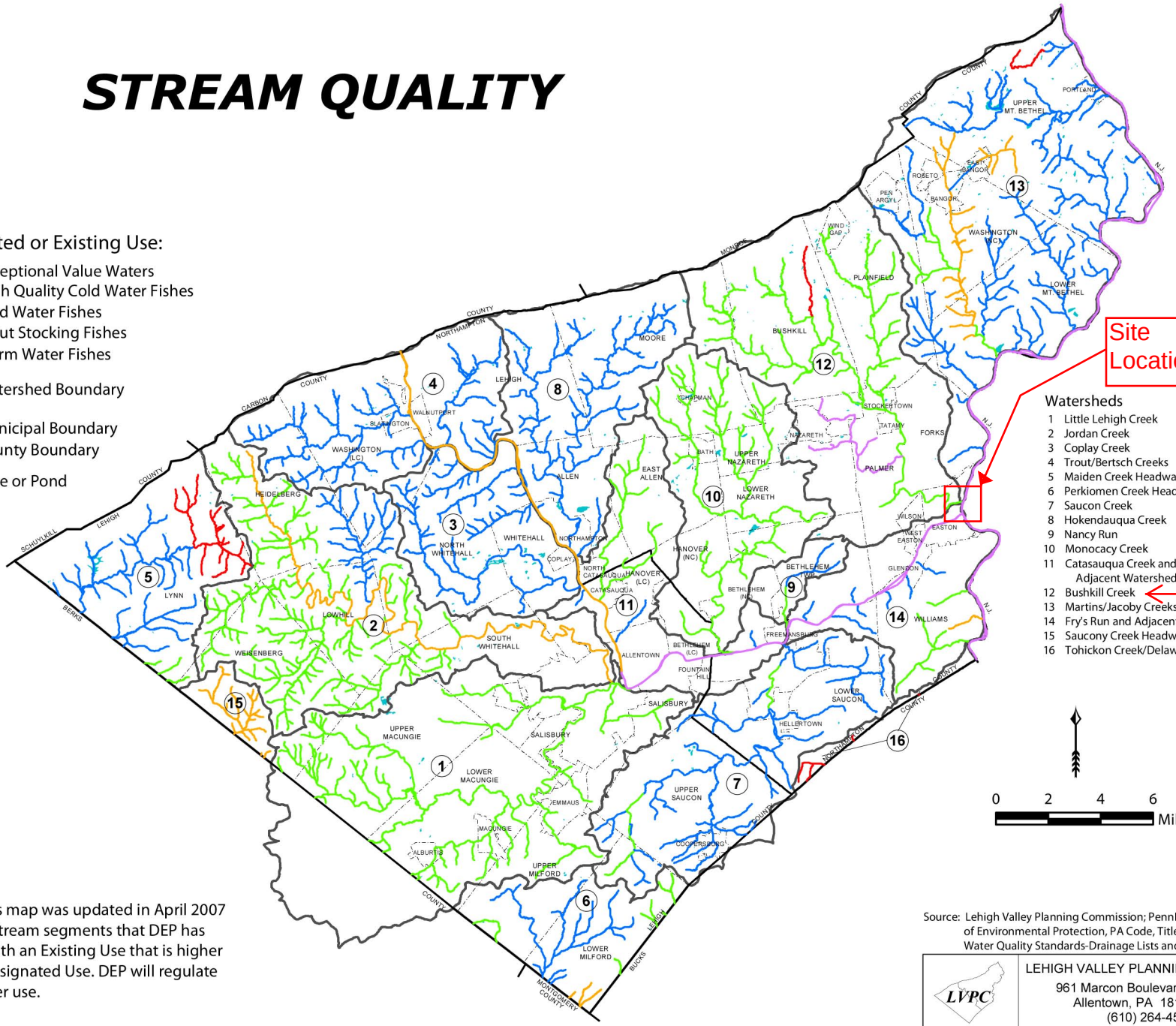
APPENDIX A

Lehigh Valley Planning Commission
Stream Quality Map

STREAM QUALITY



*NOTE: This map was updated in April 2007 to include stream segments that DEP has classified with an Existing Use that is higher than the Designated Use. DEP will regulate to the higher use.

Source: Lehigh Valley Planning Commission; PennDOT, 1997; PA Dept. of Environmental Protection, PA Code, Title 25, Chapter 93, Water Quality Standards-Drainage Lists and Existing Use Lists

LEHIGH VALLEY PLANNING COMMISSION
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APPENDIX B

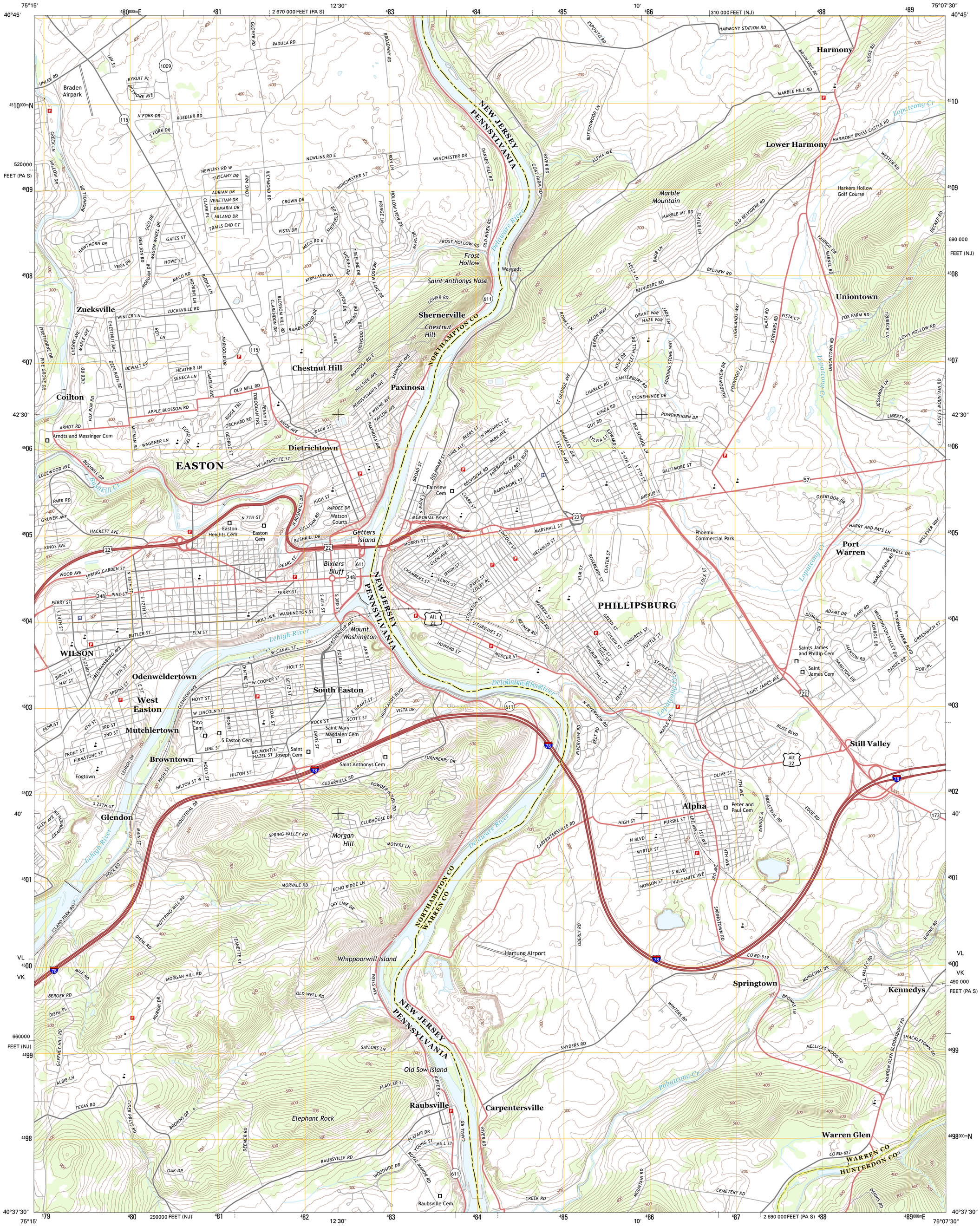
U.S.G.S Topographical Quadrangle

USGS science for a changing world

U.S. DEPARTMENT OF THE INTERIOR
U. S. GEOLOGICAL SURVEY

The National Map US Topo

EASTON QUADRANGLE
PENNSYLVANIA-NEW JERSEY
7.5-MINUTE SERIES



Produced by the United States Geological Survey
North American Datum of 1983 (NAD83)
World Geodetic System of 1984 (WGS84). Projection and 1 000-meter grid: Universal Transverse Mercator, Zone 18T
10 000-foot ticks: New Jersey Coordinate System of 1983, Pennsylvania Coordinate System of 1983 (south zone)

Imagery.....NAIP, July 2010
Roads.....©2006-2012 TomTom
Names.....GNIS, 2013
Hydrography.....National Hydrography Dataset, 2010
Contours.....National Elevation Dataset, 2011
Boundaries.....Census, IBWC, IBC, USGS, 1972 - 2012

MN 12° 24' 220 MILS GN 0° 7' 2 MILS
UTM GRID AND 2013 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET

U.S. National Grid
100,000-m Square ID: VL / VK
Grid Zone Designation: 18T

SCALE 1:24 000

1 0.5 0 KILOMETERS 1 2
1000 500 0 METERS 1000 2000
1 0.5 0 1
MILES
1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000
FEET

CONTOUR INTERVAL 20 FEET
NORTH AMERICAN VERTICAL DATUM OF 1988

This map was produced to conform with the National Geospatial Program US Topo Product Standard, 2011.
A metadata file associated with this product is draft version 0.6.11

PENNSYLVANIA
QUADRANGLE LOCATION

Wind Gap	Bangor	Belvidere
Nazareth	Easton	Bloomsbury
Hellertown	Riegelsville	Frenchtown

ADJOINING 7.5' QUADRANGLES

ROAD CLASSIFICATION
Expressway
Secondary Hwy
Ramp
Local Connector
Local Road
4WD
Interstate Route
US Route
State Route

EASTON, PA-NJ
2013

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APPENDIX C

NRCS Web Soil Survey

Map Scale: 1:703 if printed on A portrait (8.5" x 11") sheet.

N

Meters: 0 10 20 40 60

Feet: 0 30 60 120 180

Map projection: Web Mercator Corner coordinates: WGS84 Edge tics: UTM Zone 18N WGS84

MAP LEGEND

Area of Interest (AOI)
- Area of Interest (AOI)

Soils
- Soil Map Unit Polygons
- Soil Map Unit Lines
- Soil Map Unit Points

Special Point Features
- Blowout
- Borrow Pit
- Clay Spot
- Closed Depression
- Gravel Pit
- Gravelly Spot
- Landfill
- Lava Flow
- Marsh or swamp
- Mine or Quarry
- Miscellaneous Water
- Perennial Water
- Rock Outcrop
- Saline Spot
- Sandy Spot
- Severely Eroded Spot
- Sinkhole
- Slide or Slip
- Sodic Spot
- Spoil Area
- Stony Spot
- Very Stony Spot
- Wet Spot
- Other
- Special Line Features

Water Features
- Streams and Canals

Transportation
- Rails
- Interstate Highways
- US Routes
- Major Roads
- Local Roads

Background
- Aerial Photography

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:12,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL: http://websoilsurvey.nrcs.usda.gov
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: Northampton County, Pennsylvania
Survey Area Data: Version 5, Sep 22, 2014

Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 20, 2011—May 10, 2011

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Northampton County, Pennsylvania (PA095)			
Map Unit Symbol	**Map Unit Name**	**Acres in AOI**	**Percent of AOI**
RzF	Ryder-Rock outcrop complex, 25 to 75 percent slopes	0.3	35.1%
Ukb	Urban land, occasionally flooded	0.4	48.2%
UoB	Urban land-Duffield complex, 0 to 8 percent slopes	0.1	16.8%
Totals for Area of Interest		**0.8**	**100.0%**

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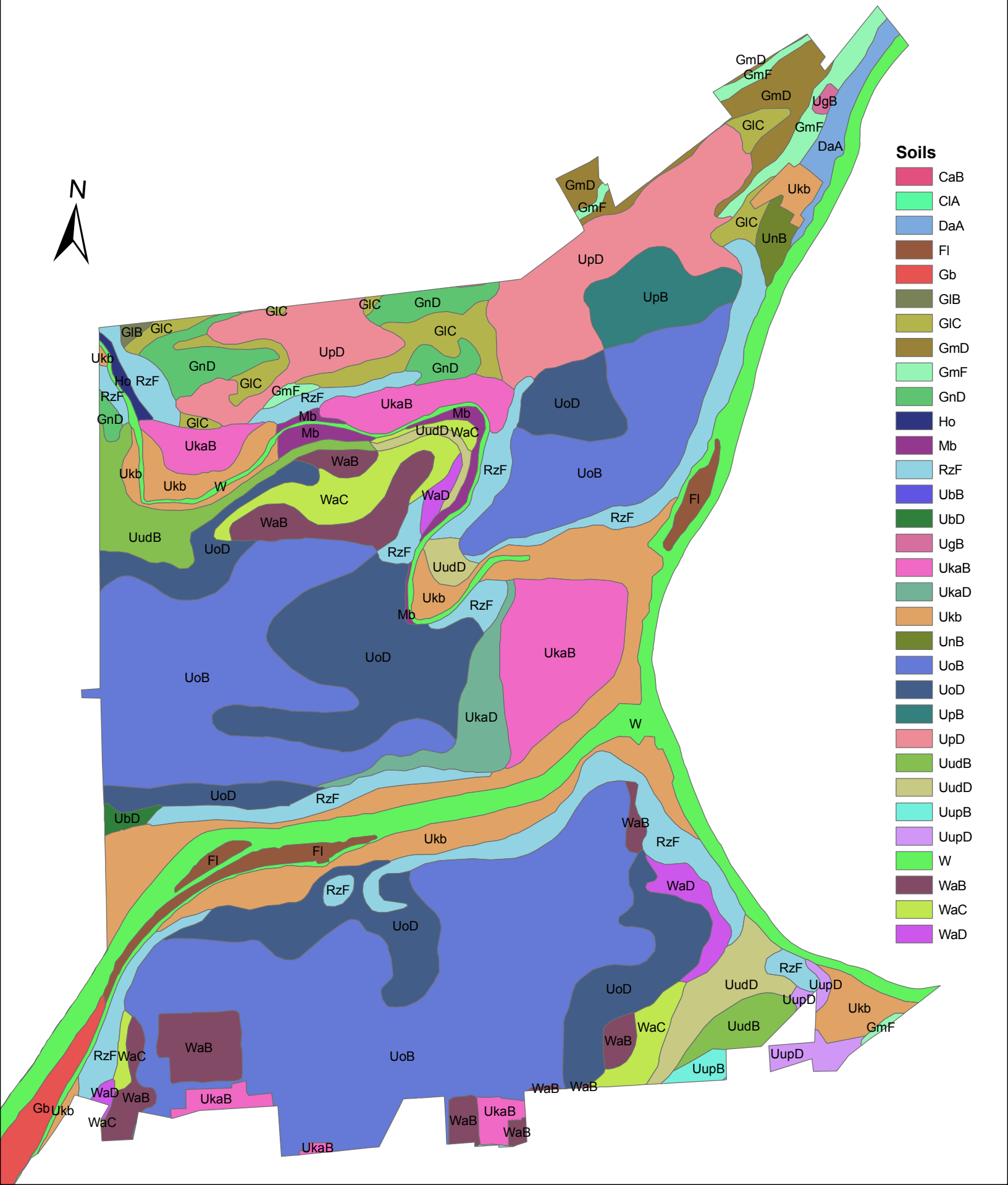
APPENDIX D

Easton Soils Survey Map

Soils in the City of Easton



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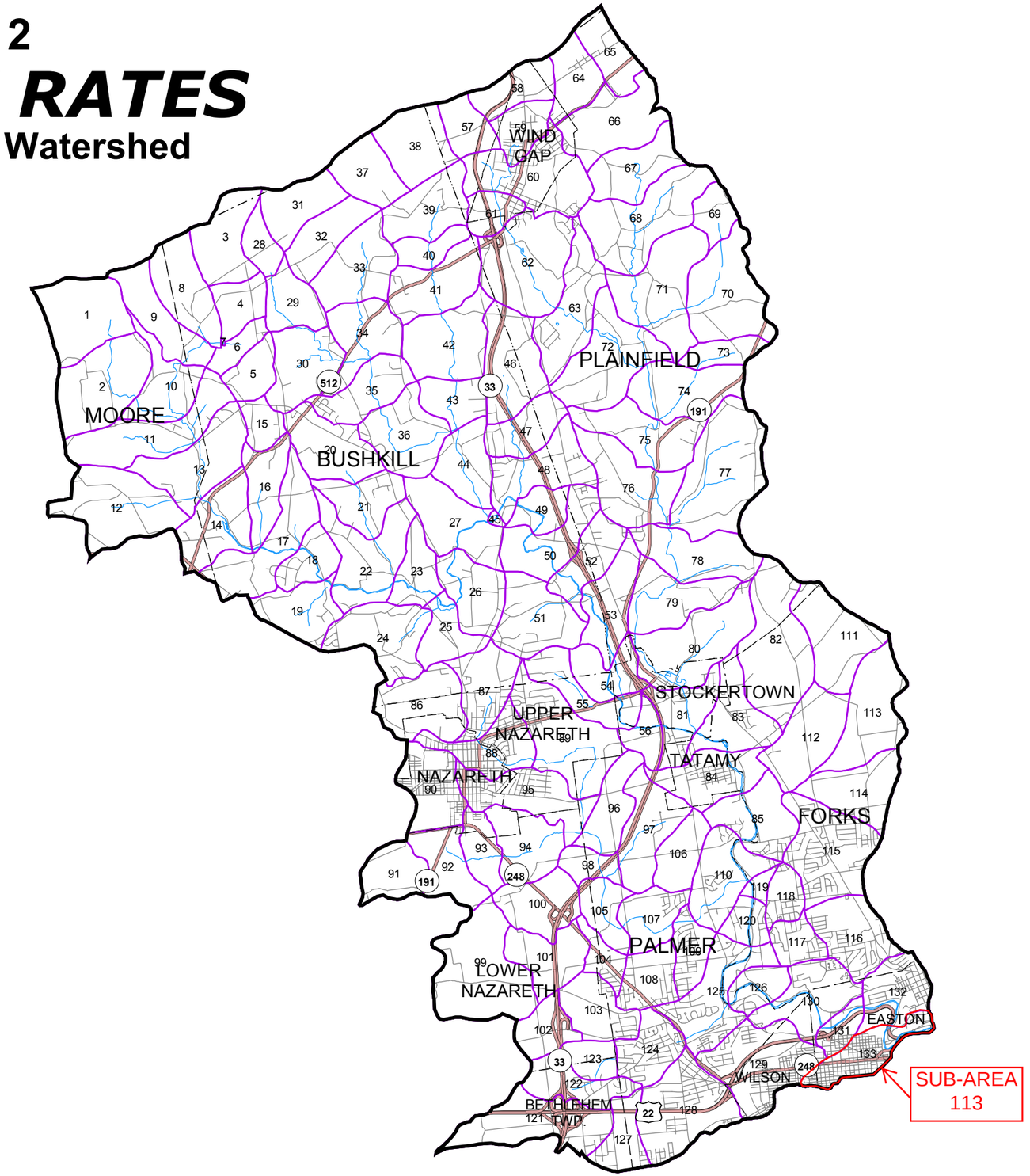
APPENDIX E

Release Rate Map of Bushkill Creek Watershed

MAP 2

RELEASE RATES

Bushkill Creek Watershed



23 Subarea Boundaries

Watershed Boundary

Municipal Boundaries

Streams

Major Roads

Minor/Other Roads

RELEASE RATE SUMMARY TABLE

Dual Release Rate Categories (30/--) define a 30% Release Rate for the 2-Year storm and the indicated Release Rate for the 10-, 25- and 100-Year storms.

BUSHKILL CREEK			
Subarea	Release Rate (%)	Subarea	Release Rate (%)
1 - 38	30/100	86 - 93	30/100
39 - 42	30/60	94 - 96	30/PND*
43 - 48	30/100	97	30/100
49 - 50	30/PND*	98	30/PND*
51	30/100	99 - 103	30/100
52 - 56	30/PND*	104 - 105	30/PND*
57 - 58	30/100	106	30/100
59 - 63	30/90	107	30/PND*
64 - 67	30/100	108	30/100
68	30/90	109 - 110	30/PND*
69 - 70	30/100	111 - 116	30/100
71	30/90	117 - 120	30/PND*
72 - 73	30/100	121 - 124	30/100
74 - 81	30/PND*	125 - 126	30/PND*
82	30/100	127 - 128	30/100
83 - 85	30/PND*	129 - 133	30/PND*

*Conditional/Provisional No Detention Areas do not need detention controls for the 10-, 25-, or 100-year storms provided that adequate downstream capacity can be shown for increased peak flows. (See Plan Update for additional data.)

N

0 7,500 15,000 Feet

1" = 7,500'

Source: Lehigh Valley Planning Commission

LEHIGH VALLEY PLANNING COMMISSION
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Allentown, PA 18109-9368
(610) 264-4544

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APPENDIX F

Pre-Development Drainage Area Plan

LEGEND

- EX. CONTOUR LINE
- EX. EDGE OF PAVE
- PROP. EDGE OF PAVE
- EX. ROADWAY CENERLINE
- EX. BUILDING
- PROP. BUILDING
- EX. SIDEWALK

N

0 100 200
50 150

SCALE: 1"=20'

NOTES

REV:	DESCRIPTION:	BY:	DATE:

STATUS:

LAFAYETTE ENGINEERING COMPANY

POST-CONSTRUCTION STORMWATER MANAGEMENT

SHEET TITLE:

PRE-DEVELOPMENT DRAINAGE AREA PLAN

PROJECT/OWNER/LOCATION:

ELEVATING EASTON
Pedestrian & Bicyle Transportation Improvement Project
Lafayette College
City of Easton, Northampton County, Pennsylvania

SCALE:	DRAWN BY:	CHECKED BY:	DRAWING NO.:
1:100	LZ	EC	SW 301
PROJECT NO:	DATE:	REVISION:	
LC-Co2015	5/5/2015	0	

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APPENDIX G

Post-Development Drainage Area Plan

LEGEND

- EX. CONTOUR LINE
- EX. EDGE OF PAVE
- PROP. EDGE OF PAVE
- EX. ROADWAY CENERLINE
- EX. BUILDING
- PROP. BUILDING
- EX. SIDEWALK

N

0 100 200
50 150

SCALE: 1"=20'

NOTES

REV:	DESCRIPTION:	BY:	DATE:

STATUS:

LAFAYETTE ENGINEERING COMPANY

POST-CONSTRUCTION STORMWATER MANAGEMENT

SHEET TITLE:

POST-DEVELOPMENT DRAINAGE AREA PLAN

PROJECT/OWNER/LOCATION:

ELEVATING EASTON
Pedestrian & Bicyle Transportation Improvement Project
Lafayette College
City of Easton, Northampton County, Pennsylvania

SCALE:	DRAWN BY:	CHECKED BY:	DRAWING NO.:
1:100	LZ	EC	SW 302
PROJECT NO:	DATE:	REVISION:	
LC-Co2015	5/5/2015	0	

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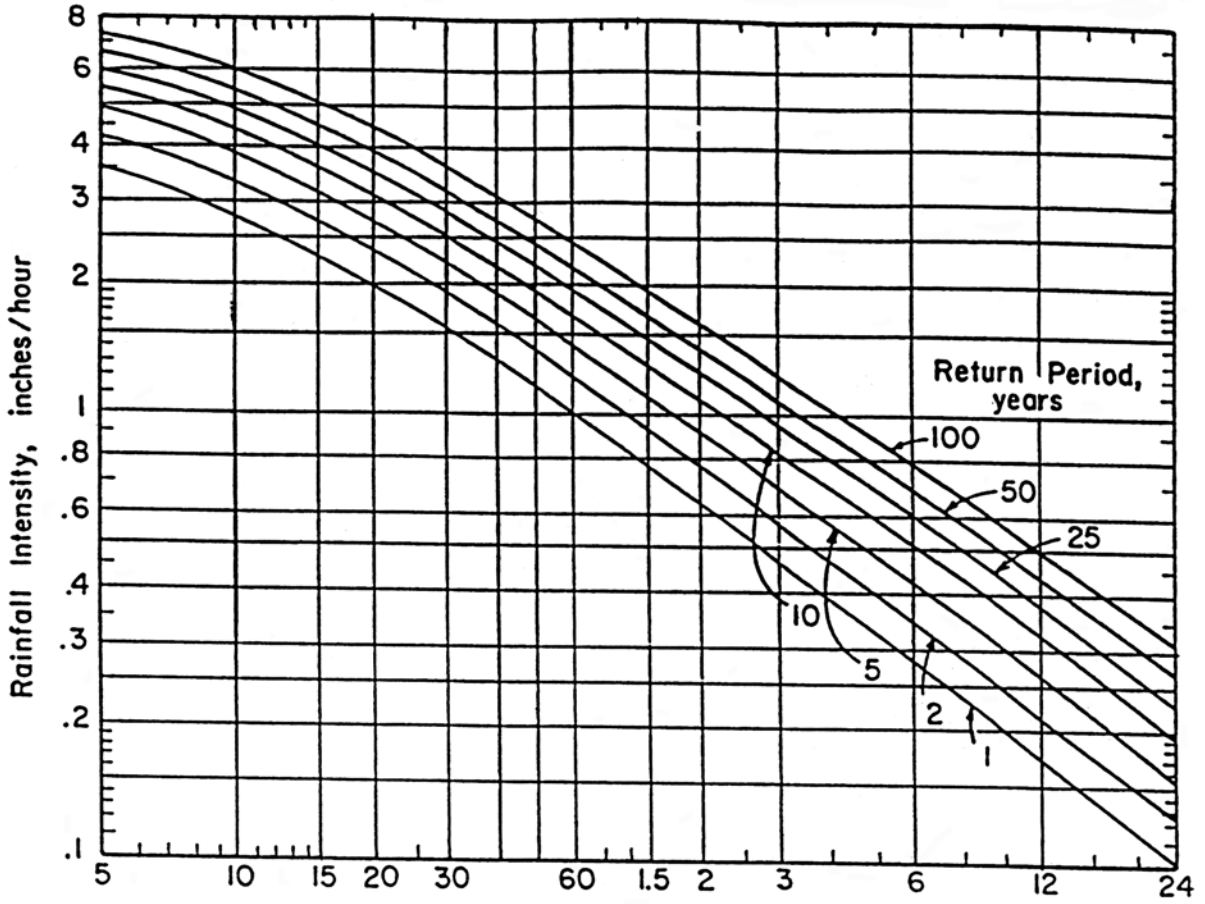
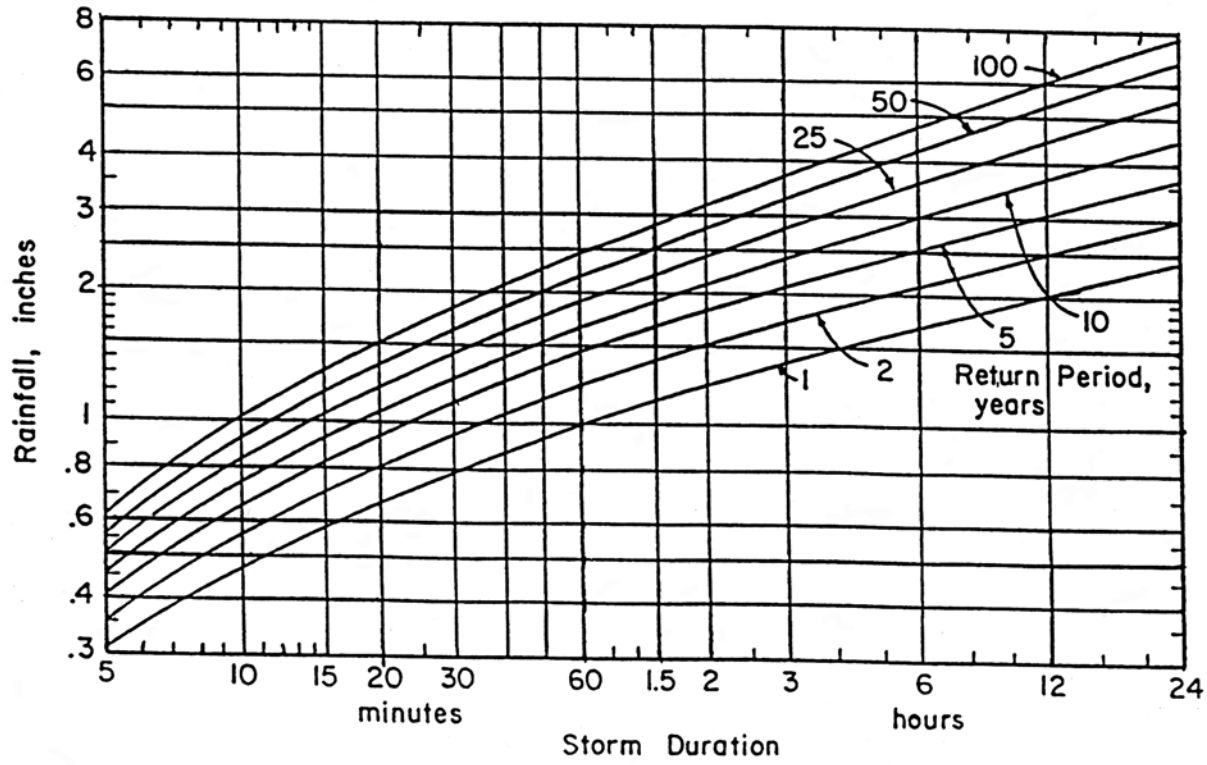
APPENDIX H

Lehigh Valley Planning Commission
Rational Method Protocol

INTENSITY–DURATION–FREQUENCY CURVES*





*Source:Pennsylvania Dept. of Transp. Design Rainfall Curves (1986).

RUNOFF COEFFICIENTS FOR THE RATIONAL METHOD* HYDROLOGIC SOIL GROUP AND SLOPE RANGE**												
	A			*B*			C			D		
LAND USE	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Cultivated[A]	[a]0.18 [b]0.23	0.23 0.29	0.28 0.34	0.24 0.30	0.29 0.36	0.33 0.40	0.30 0.36	0.34 0.41	0.38 0.45	0.33 0.39	0.37 0.44	0.41 0.48
Pasture[B]	0.09 0.12	0.13 0.17	0.17 0.23	0.19 0.24	0.24 0.30	0.29 0.36	0.27 0.33	0.31 0.38	0.36 0.43	0.31 0.37	0.35 0.42	0.39 0.46
Meadow, Lawn[C]	0.05 0.07	0.08 0.12	0.12 0.17	0.15 0.19	0.20 0.25	0.24 0.30	0.23 0.28	0.28 0.34	0.32 0.39	0.28 0.33	0.32 0.39	0.36 0.43
Forest, Woods	0.03 0.04	0.05 0.08	0.08 0.12	0.11 0.15	0.16 0.21	0.20 0.26	0.20 0.25	0.25 0.31	0.29 0.36	0.25 0.31	0.30 0.37	0.34 0.41
Gravel	0.24 0.30	0.29 0.36	0.33 0.40	0.32 0.38	0.36 0.43	0.40 0.47	0.35 0.42	0.39 0.46	0.43 0.50	0.37 0.44	0.41 0.48	0.44 0.51
Parking, Other Impervious	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97
Residential, Commercial, Industrial and Other "Developed"	Runoff coefficients should be calculated based upon weighted average of impervious area coefficients and pervious area coefficients from above based upon soil type, slope and the particular development proposal.											

***Coefficients for all land uses except parking and other impervious cover are based on the Rossmiller Equation for translating NRCS curve numbers into Rational Method 'c' values. The source for the parking and other impervious cover coefficients is RAWLS, W.J., S.L. WONG and R.H. McCUEN, 1981. Comparison of urban flood frequency procedures. Preliminary draft report prepared for the Soil Conservation Service, Beltsville, MD.**

**Hydrologic Soil Group based on the county soil survey latest edition.

a – Runoff coefficients for storm recurrence intervals less than 25 years.
b – Runoff coefficients for storm recurrence intervals of 25 years or more.

[A]Represents average of cultivated land with and without conservation treatment from TR-55, January 1975. These values are consistent with several categories of cultivated lands from TR-55, June 1986.
[B]Represents grasslands in fair condition with 50% to 75% grass cover.
[C]Represents grasslands in good condition with greater than 75% grass cover.

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APPENDIX I

Sump Inlet Sizing Calculation

Post-Development Runoff Calculation for Sumped Inlet Sizing

Section	Area (sq ft)	cover	Sub Area (sq ft)	Soil Type	slope	C (2, 10 yrs)
DA-1A	135355	impervious	55607	B	>6%	0.87
		meadow	46486	B		0.24
		woods	33262	B		0.2
Total	**3.107 acres**					**0.447777**

Time of Concentration				
Flow Type	**Length (ft)**	**Slope (ft/ft)**	**Surface**	**Time (hr)**
Sheet	100	0.092	Cultivated>20% residue (0.17)	0.101
Shallow Concentrated	290	0.093	paved	0.013
	300	0.48	unpaved	0.007
Total	**580**			**0.121**

Calculating flow	Section	i(inch/hour)	C	A (acre)	Q (cfs)
2-yr	DA-1A	3.5	0.448	3.107	4.034602
10-yr	DA-1A	4.9	0.448	3.107	5.28672

Assuming 10-yr Rainfall:

Using D=(nQ/0.464S^1/2)^3/8		n	S (assume to be 0.4)	D (ft)	D (in)
Option 1	Steel (lockbar and welded)	0.012	0.01	1.23	14.8
Option 2	Concrete (culvert with bends, connections and soe debis)	0.013	0.01	1.27	15.3

Choose 15” Diameter Corrugated Steel Pipe

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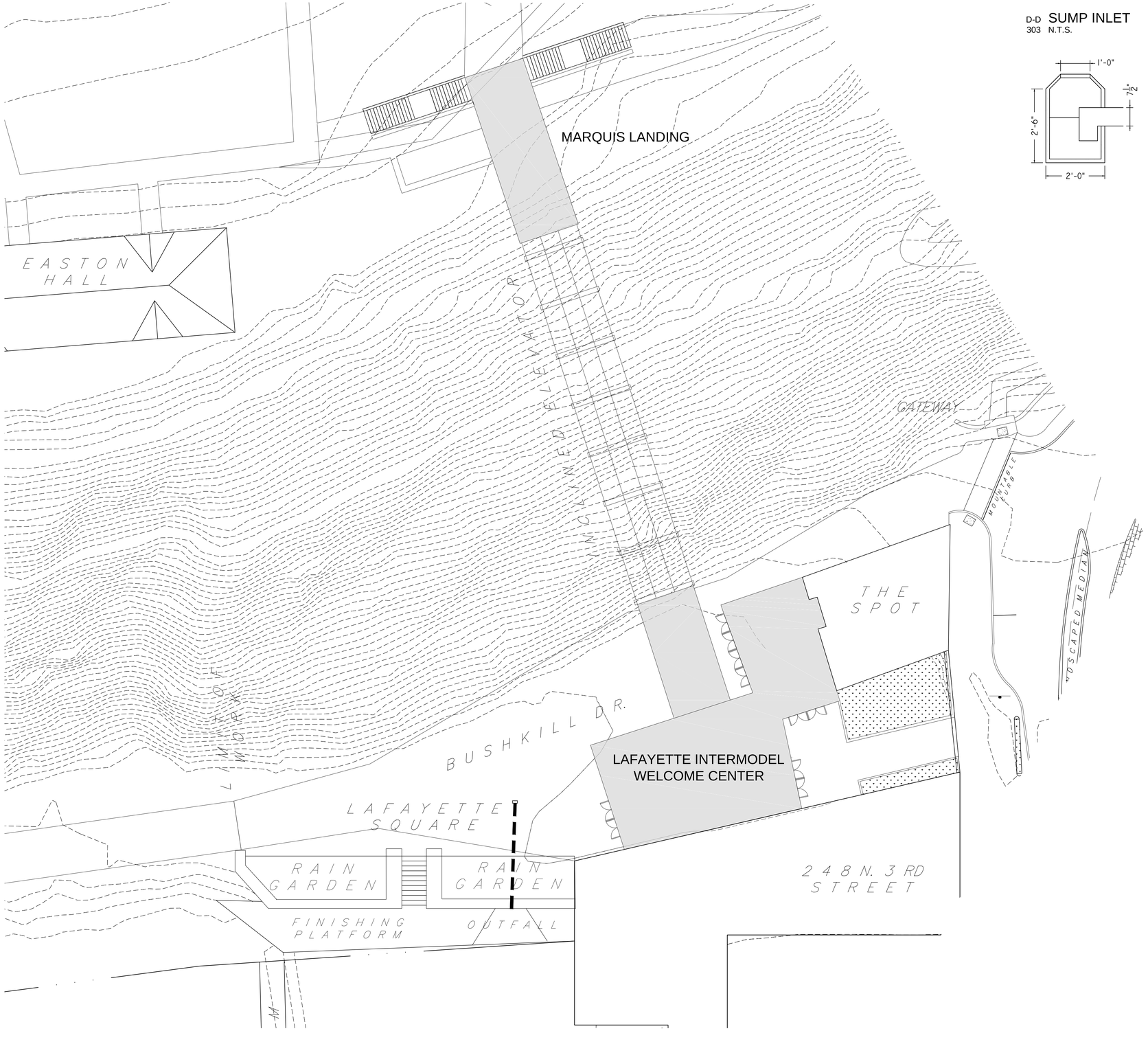
APPENDIX J

Stormwater Management Plan



D-D SUMP INLET
303 N.T.S.

LEGEND

- EX. CONTOUR LINE
- EX. EDGE OF PAVE
- PROP. EDGE OF PAVE
- EX. ROADWAY CENERLINE
- EX. BUILDING
- PROP. BUILDING
- EX. SIDEWALK

N

0 100 200
50 150

SCALE: 1"=20'

NOTES

REV.	DESCRIPTION:	BY:	DATE:

STATUS:

LAFAYETTE ENGINEERING COMPANY

POST-CONSTRUCTION STORMWATER MANAGEMENT

SHEET TITLE:

STORMWATER MANAGEMENT PLAN

PROJECT/OWNER/LOCATION:

ELEVATING EASTON
Pedestrian & Bicyle Transportation Improvement Project
Lafayette College
City of Easton, Northampton County, Pennsylvania

SCALE:	DRAWN BY:	CHECKED BY:	DRAWING NO.:
1:100	EC	LZ	SW 303
PROJECT NO:	DATE:	REVISION:	
LC-Co2015	5/5/2015	0	

LAFAYETTE
ENGINEERING COMPANY

APPENDIX K

Level Spreader Area Calculation

Rain Garden Level-Spreader Area Calcualtion

Drainage Area Flow Calculaions

Section	Area (sq ft)	cover	Area (sq ft)	Slope	Soil Type	C (2, 10 yrs)	C
DA-1C	17614	impervious	7844	>6%	B	0.87	0.454
		meadow	9770		B	0.12	
DA-1D	7061	impervious	2983		B	0.87	0.437
		meadow	4078		B	0.12	

Time of Concentration	DA-1C			
Flow Type	Length (ft)	Slope (ft/ft)	Surface	Time (hr)
Sheet	100	0.092857	Cultivated>20% residue (0.17)	0.101
Shallow Concentrated	180	0.092857	paved	0.008
Total	280			0.109

Time of Concentration	DA-1D			
Flow Type	Length (ft)	Slope (ft/ft)	Surface	Time (hr)
Sheet	100	0.135714	Cultivated>20% residue (0.17)	0.087
Shallow Concentrated	180	0.135714	paved	0.007
Total	280			0.094

	Section	i(inch/hour)	C	A (acre)	Q (cfs)
2-yr	DA-1C	2.9	0.454	0.404	0.531901
2-yr	DA-1D	2.9	0.437	0.162	0.20523

Sizing Calculation

$$\boldsymbol{Surface\ Area\ of\ raing\ Garden\ (ft^2) = \frac{Volume\ of\ Runoff\ (ft^3)}{Volume\ per\ square\ foot\ (ft)}}$$

	DA-1C	DA-1D
Water Depth	1	1
Volume Square Foot (ft3)	1	1
Surface Area of Rain Garden ft2	45,956	17,732

*AssuminG A 24-hr 2-year storm event and a water depth of 1ft

Source: Stormwater Management: Rain Gardens, Texas A&M ArgirLife Extension

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APPENDIX L

Pipe Sizing Calculations for Future Development of Marquis Landing Site

Sizing of Pipe for Elevator to Prepare for Future Development

Proposed Sub-drain	Assumed 1.5% slope					
Subarea	Area (sq ft)	Cover	Slope	Soil Type	C (1, 2, 10 year)	C (25, 100 yr)
Grey	32196	Impervious	1.50%	B	0.85	0.95
Purple	3876	Impervious	>6%	B	0.87	0.97
	1824	meadow	>6%	B	0.12	0.17
Total	37896	0.86 acres			**0.81691**	**0.914503**

Time of Concentration Determination				
Flow Type	Length (ft)	Slope (ft/ft)	Surface	Time (hr)
Sheet	93	0.015	Cultivated>20% residue (0.17)	0.197
Shallow Concentrated	200	0.015	paved	0.022
Total				**0.219**

	i(inch/hour)	C	A (acre)	Q (cfs)
1-yr	2.4	0.817	0.86	**1.69**
2-yr	2.9	0.817	0.86	**2.04**
10-yr	3.8	0.817	0.86	**2.67**
25-yr	4.3	0.915	0.86	**3.38**
100-yr	5.5	0.915	0.86	**4.33**

Assume full flow for pipes for 100-yr rainfall

Using D=(nQ/0.464S^1/2)^3/8		n	S (assume 0.4)	D (ft)	D (in)
Option 1	Steel (lockbar and welded)	0.012	0.4	0.522	6.27
Option 2	Concrete (culvert with bends, connections and soe debis)	0.013	0.4	0.538	6.46

Choose 8” Pipe. Material at Discretion of Structures Team

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APPENDIX M

Pre- and Post- Stormwater Runoff and Volume Calculations

Pre-Development Runoff Calculation

Area (sq ft)	cover	Sub Area (sq ft)	Soil Type	slope	C (2, 10 yrs)	C (25 yrs)
135355	impervious	47,599	B		0.87	0.97
	meadow	46,487	B	>6%	0.24	0.3
	woods	41,270	B		0.2	0.26
3.107 acres		135,356			0.449	0.523

Flow Type	Length (ft)	Slope (ft/ft)	Surface	Time (hr)
Sheet	100	0.093	Cultivated>20% residue (0.17)	0.101
Shallow Concentrated	290	0.093	paved	0.013
	300	0.48	unpaved	0.007
Total	580			0.121

Calculating flow	i(inch/hour)	C	A (acre)	Q (cfs)	Volume (ft^3)
2-yr	3.5	0.449	3.107	4.89	1933
10-yr	4.9	0.449	3.107	6.84	2707
25-yr	5.2	0.523	3.107	8.46	3684

Post-Development Drainage Calculation

Area (sq ft)	cover	Sub Area (sq ft)	Soil Type	slope	C (2, 10 yrs)	C (25 yrs)
135355	impervious	47,599	B		0.87	0.97
	meadow	46,487	B	>6%	0.24	0.3
	woods	41,270	B		0.2	0.26
3.107 acres		135,356			0.489	0.565

Flow Type	Length (ft)	Slope (ft/ft)	Surface	Time (hr)
Sheet	100	0.093	Cultivated>20% residue (0.17)	0.101
Shallow Concentrated	290	0.093	paved	0.013
	300	0.48	unpaved	0.007
Total	580			0.121

Calculating flow	i(inch/hour)	C	A (acre)	Q (cfs)	Volume (ft^3)
2-yr	3.5	0.489	3.107	5.32	2316
10-yr	4.9	0.489	3.107	7.44	3243
25-yr	5.2	0.556	3.107	9.14	3979