Cocalico Creek Watershed CBPRP

Baseline Study and Implementation Strategies

Lancaster County, Pennsylvania

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Prepared for:

Cocalico Creek Watershed Association
P.O. Box 121
Reinholds, PA 17569

Prepared by:

Land Studies

315 North Street
Lititz, PA 17543
717-627-4440
www.landstudies.com

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1 Introduction

1.1 Purpose of the Baseline Chesapeake Bay Pollution Reduction Plan Evaluation

The purpose of this report is to establish reasonable baseline nutrient and sediment loading conditions within the Cocalico Creek watershed, as well as delineating loads from urbanized areas within the watershed. This information will be used to spearhead a cooperative effort of municipalities within the watershed to develop their individual Chesapeake Bay Pollution Reduction Plans (CBPRPs) which are required by their Municipal Separate Storm Sewer System (MS4) permits. MS4 permits are required for municipalities with "Urbanized Areas" as determined by the 2010 Census. The CBPRP must address nutrient and sediment loadings to streams from the regulated MS4 draining to the Chesapeake Bay.

A purpose of the CBPRP is for municipalities to explain and outline efforts to reduce Nitrogen, Phosphorus, and sediment loads delivered to waterways and ultimately the Chesapeake Bay through the implementation of Best Management Practices (BMPs). Although the permit requirements are for individual municipalities it is often practical to model an entire watershed and use the results as a tool to determine what kind and where BMPs can be implemented most cost effectively to improve water quality.

The specific objectives of this project are to:

- Quantify the baseline conditions relative to nutrient and sediment loading to the Chesapeake Bay in the Cocalico Creek watershed.
- Capture and input existing water quality and nutrient/sediment reduction BMPs to reflect more accurate conditions in the watershed.
- Outline the baseline data for municipal development of individual CBPRPs and provide a tool for planning and implementation
- Provide a template CBPRP for municipalities to develop final and individual approaches for nutrient and sediment reductions based on the watershed as a whole.

This project is a partnership between the Cocalico Creek Watershed Association (CCWA) and Lancaster County municipalities within the Cocalico Creek Watershed.

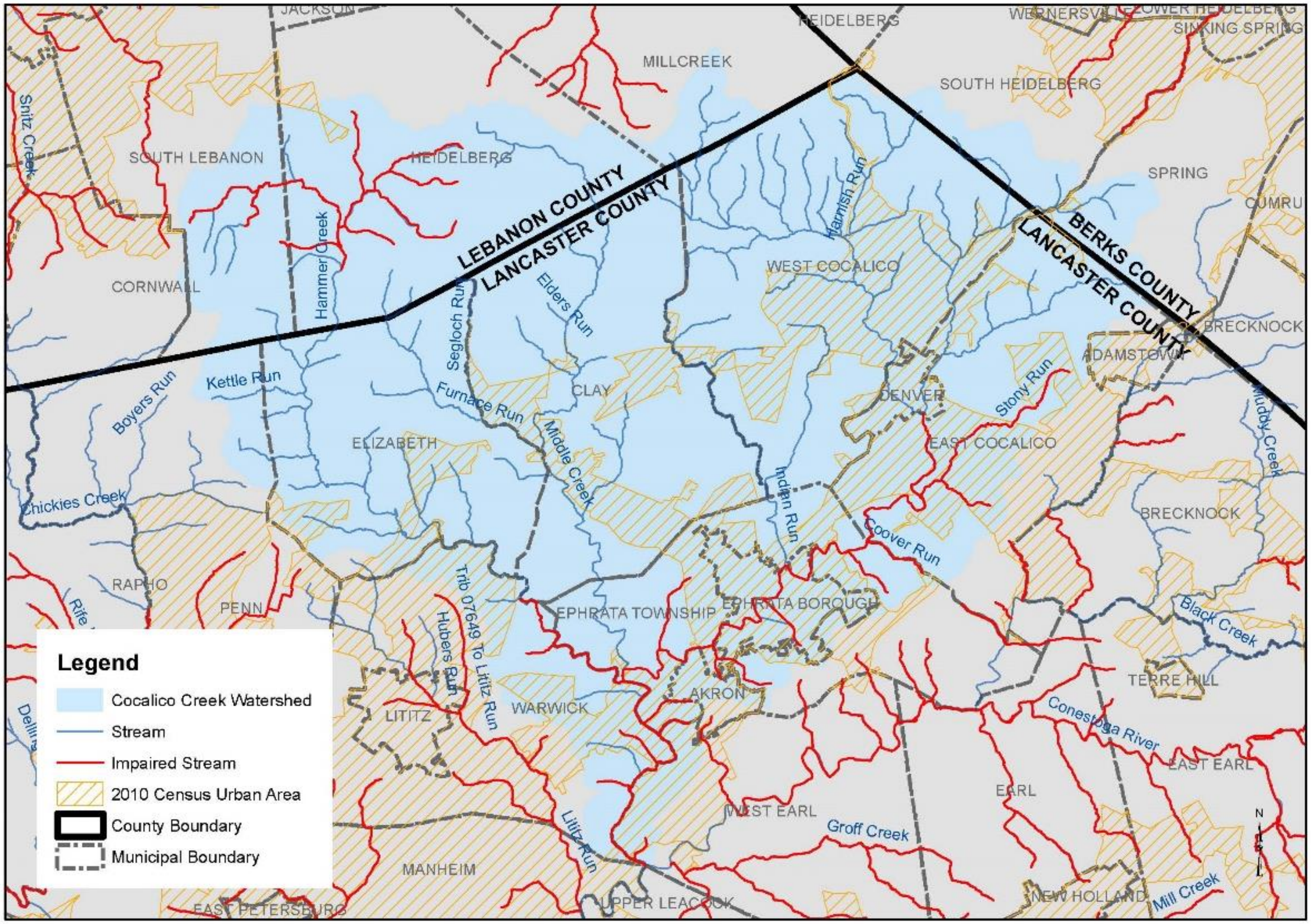

Figure 1. Cocalico Creek Watershed

1.2 Watershed Characteristics

The Cocalico Creek is located in Northern Lancaster County with a small portion extending in to Lebanon and Berks Counties. It is located within Hydrologic Unit Code (HUC) 02050306 and is a tributary of the Conestoga River. The watershed is 89,611 acres or 140 square miles. The majority of the watershed, 70,500 acres, is within Lancaster County. Primary tributaries to the Cocalico Creek include Hammer Creek, Middle Creek, Indian Run and the Little Cocalico Creek.

Watershed Impairments

Approximately 52.3 miles of stream within the Cocalico Creek Watershed are listed as impaired in the 2012 Pennsylvania Integrated Water Quality Assessment Report 303(d) list (see figure 1). Sources of impairments listed are primarily crop and grazing related agriculture resulting in nutrients and siltation. There are also small tributaries impaired by siltation and habitat alteration by urban runoff and storm sewers as well as nutrients from small residential runoff. A Total Maximum Daily Load (TMDL) has not been established. The target TMDL establishment date called out in the 303(d) list is 2015.

Land Use

The primary land uses within the watershed are agriculture and forest. Hay and row crops represent 43% of the watershed and forest cover is 39%. Baseline data was compiled using the 2005 PAMap Program Land Cover for Pennsylvania dataset, modified to fit the grid classification system for MapShed. Approximately 24,655 acres (~35%) of the land cover in Lancaster County portion of the watershed is located within the Urbanized Area per the 2010 census map. A GIS exercise to determine the land cover for each municipality was performed and the resulting data was provided to each municipality to confirm or edit based on first-hand knowledge. The results are provided in Table 1.

Table 1. Land Cover within the Cocalico Creek Watershed

Land Cover	Acreage
Hay	17,804
Row Crops	20,759
Forest	34,642
Disturbed	786
Water/Wetland	1,747
Turf/Golf	324
Low Density Residential (<30% impervious)	2,575
Medium Density Residential (30%-75%impervious	6,254
High Density Residential (>75% impervious)	52
Low Density Mixed Urban (<30% impervious)	54
Medium Density Mixed Urban (30%-75% impervious	1,416
High Density Mixed Urban (>75% impervious)	3,151

According to the Urban Area tool in MapShed, only 67% of the urban land use categories (residential and mixed use) fall within the Urbanized Area. In turn, the balance of "urban" land uses fall outside the Urbanized Area boundaries.

2 Watershed Approach to Addressing Nutrient & Sediment Loads

No prior pollutant load modeling has been performed in this watershed, and TMDLs for stream impairments have not been developed. Additionally, there are no quantified municipal nutrient and sediment reduction allocation requirements; however the Pennsylvania Chesapeake Bay Watershed Implementation Plan (WIP) has allocated planning targets for County reductions based on the Chesapeake Bay TMDL. Lancaster County assigned load reductions were further analyzed by Tetra Tech at the watershed level through an EPA and PADEP funded effort for the Lancaster County Clean Water Consortium (LCCWC). Further discussion of the efforts in relation to the Cocalico Creek watershed can be found in section 5.2.

The calculated nutrient and sediment loading rates for the watershed and the data generated by Tetra Tech for the watershed provide a cost-effective mechanism that can be used for planning purposes by the municipalities to develop appropriate load reductions in their CBPRPs. This watershed based approach will allow municipalities to work together to combine rather than duplicate BMP implementation efforts given the fact that an individual effort for nutrient and sediment reductions will benefit the watershed as a whole. Any improvement based on BMP implementation, whether in an urbanized area or not, will provide a nutrient and/or sediment reduction realized by the watershed. MS4 permits are required for municipalities with "Urbanized Areas" as determined by the 2010 Census. Urbanized areas in the Cocalico Creek watershed are shown on Figure 1. The only municipality without urbanized area in the watershed is Penn Township. The following 12 municipalities are located within the watershed in Lancaster County and provided data and feedback that was used to verify and customize the modeling data:

- Adamstown Borough
- Akron Borough
- Clay Township
- Denver Borough
- East Cocalico Township
- Elizabeth Township
- Ephrata Borough
- Ephrata Township
- Penn Township
- Warwick Township
- West Cocalico Township
- West Earl Township

2.1 MapShed Model Inputs

Sediment, Nitrogen and Phosphorus loading were modeled using MapShed. MapShed is a GIS-based watershed modeling tool which was developed by the Penn State Institute of Energy and the Environment (PSIEE). MapShed is a customized interface that is used to automatically create input data for the watershed model. In utilizing this interface, the user is prompted to identify required GIS files and to provide other "non-spatial" model information. This information is subsequently used to derive values for required model input parameters which are then written to the various input files needed for model execution. Also accessed through the interface is regional climate data stored in Excel-formatted files that are used to create the necessary "weather" data for a given watershed simulation. With MapShed, a user selects areas of interest, creates model input files, runs a simulation model, and views the output in a series of seamless steps. For more information regarding MapShed modeling procedures, refer to the MapShed Users Guide (Evans and Corradini, 2014), or the MapShed website (www.mapshed.psu.edu).

In addition to the input data gathered by MapShed from various GIS data layers, data can be modified or added manually to account for more accurate or current available data and assumptions. In order to improve the accuracy of the Cocalico Creek model run, a data survey was sent to each municipality in the watershed. Municipal representatives filled them out and returned them to LandStudies to process the data and customize the MapShed model.

Municipalities were provided with their land cover acreages within the watershed based on MapShed's land cover GIS layer. A few of the acreages were adjusted for various categories based on their first-hand knowledge of the area, however most remained unchanged.

Municipalities provided information regarding well groundwater withdrawals and Total Nitrogen (TN) content in the groundwater as well as waste water treatment plant average discharge and nutrient concentrations. A weighted average of the groundwater TN content and wastewater discharge nitrogen and phosphorus concentrations was entered in MapShed.

Municipalities provided varying degrees of stormwater BMP information. Available data was compiled and then numerous assumptions were made based on the available data to fill in the gaps. Known stormwater BMP volumes for a municipality were divided by the acreage of urban area to get a storage volume per acre which could then be applied to municipalities with unknown stormwater BMPs based on known urban land use acreages.

The number of septic systems was also customized based on municipal records as well as BMP implementation such as streambank stabilization and riparian buffers. The Chesapeake Bay Foundation provided a detailed estimate of the length of CREP buffers installed from their database. It was assumed that 50% of the CREP stream buffer length required fencing animals from the stream. In addition, adjustments were made to model assumptions affecting the nutrient and sediment loading from stream banks. The "percent bank fraction" was increased so nitrogen and phosphorus content from eroded bank sediments matched the values developed by Franklin and Marshall College (Walter et. al., 2007)).

Agricultural land use comprises the majority of the watershed. The Lancaster County Conservation District (LCCD) provided relative percentages of animal operations based on Agricultural Technician's firsthand knowledge of the watershed. Actual animal numbers were then derived by using the Lancaster County parcel layer to determine the number of animal operations in the watershed. In addition chicken and swine facilities were identified on aerial imagery to provide an approximation of animal numbers based on the number of houses visible on the aerial.

MapShed also allows the user to input detailed agricultural BMP implementation information including cover crop, conservation tillage, contour farming nutrient management, grazing land management, manure storage, barnyard runoff control and the use of phytase in feeds. Agricultural BMPs are implemented by many entities (the landowner, LCCD, the NRCS and private consultants); therefore, finding a complete record of BMPs implemented is not feasible at this time. Conservation plans are the property of the farmer, and any plans kept on file at government offices cannot be viewed without farmer permission. Due to the size of the watershed, LCCD and NRCS were unable to provide BMP implementation numbers so reasonable assumptions and estimates were made by LandStudies based on a basic understanding of BMP implementation in the county as a whole.

In addition to baseline data, BMP scenarios can be entered to evaluate how BMP implementation will affect loading rates. A series of data input screen shots used in the MapShed model is provided in Appendix A. Tables of the raw data input are included in Appendix B.

3 MapShed Modeling Results

3.1 Baseline Model Run

The baseline model run resulted in the loadings shown in Table 2. A screen shot of the modeling results that breaks down loading rates by land use is shown in Figure 2. This information can help to focus BMP implementation efforts.

The highest annual nutrient loading rates within the watershed are as follows:

- groundwater (stream baseflow) at 1,148,660 lbs N
- livestock at 639,368 lbs N and 168,895 lbs P,
- cropland at 91,074 lbs N and 14,814 lbs P,
- streambank erosion at 43,689 lbs N and 18,834 lbs P,
- septic systems at 19,390 lbs N; and
- pasture at 15,876 lbs N and 5755 lbs P

The highest annual sediment loading rates within the watershed are as follows:

- streambank erosion at 14,219 tons,
- cropland at 6,105 tons; and
- pasture at 1,444 tons.

Medium Density Residential land cover accounted for the highest Nitrogen, Phosphorus and sediment loadings (3,738.2 pounds, 402.7 pounds and 127,200 pounds respectively) in the urban land cover classifications. Agriculture (cropland, pasture, and livestock) represents 38 percent of the nitrogen loading, 88 percent of the phosphorus loading, and 9 percent of the sediment loading. Streambank erosion represents 2 percent of the nitrogen loading and 64 percent of the sediment loading. It should be noted, the greatest source of sediment loading in the watershed—including both urban and agricultural areas—is not directly associated with land use but with the erosion of streambanks. It should also be noted that stream baseflow accounts for over 58% of the total nitrogen load via groundwater discharge, which drives down the reported percentages of the total nitrogen load from other, more readily controlled sources.

Table 2. Baseline Nutrient and Sediment Loading Results

	Total Nitrogen lbs/yr	Total Phosphorous lbs/yr	Sediment tons/year
Entire Watershed	1,972,700.7	215,067.4	22,283.7
Loading per acre	22	2.4	0.25

The sediment tons/year values shown in Table 2 convert to 44,567,400 pounds/year for the entire watershed and to 500 pounds/acre per year.

Figure 2. Baseline Model Run Total Loads by Land Use

GWLF Total Loads for file: CocalicoFinal9-30-14-0 **Period of analysis:** 21 years from 1978 to 1998

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	17804	2.8	26115.0	1444.1	8107.3	15875.8	2506.6	5755.3
Cropland	20759	4.9	265417.9	6105.0	40510.1	91073.6	1968.0	14814.3
Forest	34642	0.8	5806.6	323.6	1148.4	2886.2	56.8	783.5
Wetland	1747	4.2	74.5	4.1	299.6	321.8	14.8	24.1
Disturbed	786	8.8	624.0	34.8	30.0	216.8	14.1	92.2
Turfgrass	324	2.1	92.4	5.1	360.8	388.5	39.9	51.4
Open Land	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	27	7.4	515.9	28.7	8.2	162.6	0.4	65.0
LD Mixed	54	3.1	0.0	0.2	2.8	9.8	0.4	1.0
MD Mixed	1416	8.5	0.0	14.4	272.4	846.3	36.5	91.2
HD Mixed	3151	12.0	0.0	32.0	606.2	1883.1	81.2	202.8
LD Residential	2575	3.1	0.0	7.9	132.7	462.6	17.9	47.5
MD Residential	6254	5.2	0.0	63.6	1203.5	3738.2	161.2	402.7
HD Residential	52	7.2	0.0	0.5	10.0	31.0	1.3	3.4
Farm Animals						639368.4		168895.3
Tile Drainage				0.0		0.0		0.0
Stream Bank				14219.6		43691.2		18836.3
Groundwater					1148660.0	1148660.0	4654.2	4654.2
Point Sources					3694.0	3694.0	347.1	347.1
Septic Systems					19390.5	19390.5	0.0	0.0
Totals	89610.2	3.20	298646.1	22283.7	1224436.7	1972700.4	9900.4	215067.4

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3.2 BMP Model Run and Alternative BMP Reduction Calculations

BMPs were entered into the model to determine how the implementation of common BMPs such as floodplain restoration, stormwater basin retrofits, raingardens and riparian buffers will reduce nutrient and sediment loading. Alternative calculation methods recommended by the Chesapeake Bay Partnership Urban Stormwater Workgroup were also used to calculate nutrient reductions and were compared to the model results. Cost-effectiveness data generated by the LCCWC for the development of a county-wide Strategic Action Plan can also be used to estimate reductions. More information associated with the Strategic Action Plan (SAP) development can be found in Section 5.2.

Floodplain Restoration

Nutrient and sediment reductions resulting from the implementation of 1,000 feet of floodplain restoration was applied to the MapShed model. Load reduction calculations for the same amount of restoration was also calculated using a modified form of the methodology described in *Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects* (Schueler and Stack, 2013). A detailed description of this methodology and the modifications can be found in Appendix C. Delivery and reserve ratios were not included in the load reduction calculations. Estimated reduction values based on the LCCWC Strategic Action Plan (SAP) development are also included. A comparison of the results is provided in Table 3.

Table 3. Comparison of Calculated FPR Pollutant Loading Reductions

	Length (ft)	N Reduction (lbs/ yr)	P Reduction (lbs/ yr)	Sed. Reduction (T/yr)
Mapshed model	1000	835	206	24.5
Modified Expert Panel Methodology	1000	1784	160	150
SAP development data	1000	70	50	92.5

Stormwater Basin Retrofits

Load reductions from the implementation of one acre of Stormwater Basin Retrofits were modeled using MapShed as well as the methodology outlined in *The Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects* (Schueler and Lane, 2012). The SAP development data assumes 1 acre of basin treats 3 acres of impervious area. A comparison of the results is provided in Table 4.

Table 4. Comparison of Stormwater Basin Retrofit Pollutant Loading Reductions

BMP	Acres	N Removal (lb)	P Removal (lb)	Sediment Removal (T)
Mapshed Model	1	19.4	3.7	0.6
Expert Panel Methodology	1	147.30	9.31	3.9
SAP development data	1	9.96	0.92	0.5

Rain Gardens

Load reductions from the implementation of one acre of rain gardens were modeled using MapShed as well as the methodology outlined in *The Expert Panel to Define Removal Rates for Urban Stormwater Retrofit Projects* (Schueler and Lane, 2012). The SAP development data assumes 1 acre of rain garden treats 5 acres of runoff area (1 acre impervious and 4 acres pervious coverage). A comparison of the results is provided in Table 5.

Table 5. Comparison of Rain Garden Pollutant Loading Reductions

BMP	Acreage	N Removal (lb)	P Removal (lb)	Sediment Removal (T)
Mapshed Model	1	20.1	4.0	0.8
Expert Panel Methodology	1	103.11	5.59	2.4
SAP development data	1	19.0	2.57	0.6

Forested Riparian Buffer

Loading reductions from the application of 1 acre of 100-foot wide forested riparian buffer was calculated using Mapshed as well as alternative methods outlined by Chesapeake Bay Program (CBP) Best Management Practice Spreadsheet found on the DEP nutrient trading website. The CBP methodology assumes that 1 acre of 100-foot wide forested riparian buffer treats 5 acres of upland for nitrogen and 2 acres of upland for phosphorus and sediment. Credit is also given for the land use conversion of the 1 acre from pasture (used in this example) to forest.) The SAP data is also for implementation of a forested riparian buffer in degraded riparian pasture. A comparison of the results is provided in Table 6.

Table 6. Comparison of Forested Riparian Buffer Pollutant Loading Reductions

BMP	Acreage	N Removal (lb)	P Removal (lb)	Sediment Removal (T)
Mapshed Model	1	262.7	62.6	3.6
CBP Methodology	1	93	44	4.4
SAP development data	1	144.90	21.67	2.20

Comparison of Results

MapShed provides a good snapshot of conditions and corresponding pollutant loadings relative to a specific timeframe. It may also provide a reasonable estimate of the cumulative effect of watershed-wide BMP applications such as conservation plan implementation or the accumulation of a large number of stormwater BMPs. However, it is not designed to quantify load reductions on a site-specific scale, and as the results above demonstrate, it tends to underestimate, severely in some cases, the load reductions from individual BMPs. While MapShed is intended to model pollutant loading on a watershed scale, the various individual BMP load reduction methodologies are more appropriate for use in evaluating individual BMPs considered during conceptual and design implementation phases.

The SAP development data underestimates reductions as well. Similar to MapShed, the data was not intended to quantify load reductions on a site-specific scale. However, the intent of the SAP development data was to establish a relationship between implementation costs and types of BMPs. In turn, the SAP development data should only be used for establishing approximate implementation costs and initial planning reductions. More information is provided in Section 5 of this report.

3.3 Urbanized Area (UA) Loadings

MS4 Permits are the regulatory authorizations that allow municipalities to discharge to receiving waters from the MS4. The permits regulate areas defined as the Urbanized Area within a municipality and where an MS4 exists. In turn, municipalities are responsible for implementing BMPs to achieve nutrient and sediment reductions in the regulated area per MS4 Permit conditions. The MapShed Urban Area tool delineates nutrient and sediment loadings in the regulated Urbanized Area. Table 7 outlines loadings calculated by MapShed for the Urbanized Area for comparative purposes. UA (land use loading) references the list of all land use categories as outlined in Table 8. UA (other load contributors) is the collective values of other pollutant contribution factors calculated by MapShed; and includes livestock, streambanks, groundwater, non-MS4 point sources, and septic systems.

Table 7. Urbanized Area (UA) loadings in the Cocalico Creek Watershed

	Nitrogen (lb/yr)	Phosphorus (lb/yr)	Sediment (T/yr)
UA (land use loading)	30,738.8	5,529.9	1,905
UA (other load contributors)	514,600.1	57,235.7	7,238
Total	545,338.9	62,765.6	9,143

The "other load contributors" within the Urbanized Area provide the greatest loading values within the Urbanized Area boundaries, particularly streambanks (sediment), groundwater (nitrogen), and livestock (phosphorus). However, section 3a of Part C (Other Conditions) in the Authorization to Discharge section of the MS4 Permit indicates:

> *"Permittees with regulated small MS4s located in and discharging to receiving watersheds draining to the Chesapeake Bay shall....develop and submit to the Department for approval a Chesapeake Bay Pollutant Reduction Plan, including a schedule, to implement BMPs to reduce nitrogen, phosphorus, and sediment* ***associated with existing stormwater discharges into regulated small MS4s*** *discharging to receiving waters tributary to the Chesapeake Bay."*

Based on the above language, there is a plausible argument that only the UA (land use loading) sources and contributors that discharge to an MS4 are subject to the MS4 permit conditions. These loadings are shown in Table 8, below. However, an opportunity exists to address the primary nutrient and sediment load sources as identified by the results of the Cocalico Creek Watershed MapShed model. Additional considerations and discussion points are outlined in Sections 5 and 6 of this report.

The following represents notable considerations associated with the sources of pollutant loadings in the Cocalico Creek Watershed:

- 63.8% of the total annual sediment loading is contributed by streambank erosion

- 58.2% of the total annual nitrogen loading is contributed by groundwater
- 78.5% of the total annual phosphorus loading is contributed by livestock
- The Urbanized Area (land use loading) nutrient and sediment loadings, shown in Table 8, only account for approximately 25% of the total loadings across the pollutants of concern.

Table 8. Urbanized Area Loading by Land Use for Cocalico Creek Watershed Municipalities (Lancaster County Only)

		TOTAL LOAD		
UA Land Use	Acres in UA	Nitrogen (lb)	Phosphorus (lb)	Sediment (lb)
Hay/Pasture	4711	4192.8	1507.5	382.1
Cropland	4611	20242.3	3273.8	1356.1
Forest	4518	361.4	90.4	42.2
Wetland	178	32.0	1.8	0.4
Disturbed	465	130.2	55.8	20.6
Turfgrass	190	228.0	30.4	3.0
LD Mixed	17	3.1	0.3	0.1
MD Mixed	1041	624.6	62.5	10.6
HD Mixed	2272	1363.2	136.3	23.1
LD Residential	1005	180.9	20.1	3.1
MD Residential	5287	3172.2	317.2	53.7
HD Residential	54	32.4	3.2	0.6
Water	129	0.0	0.0	0.0
TOTAL	24498	30563.1	5499.4	1895.4

As shown in Table 8, the Urbanized Area includes agricultural land uses, and these areas provide relatively significant loadings. However, an assumption can be made that the MS4 system exists only in areas of urban/suburban land uses. The loadings identified in the urban/suburban land uses within the Urbanized Area are significantly less than other pollutant contributors identified. The primary pollutant loading sources (Nitrogen, Phosphorus, and sediment) in the Urbanized Area based on urban/suburban land uses was determined to be:

- Medium Density (MD) Residential
- High Density (HD) Mixed Use
- Medium Density (MD) Mixed Use

Appendix D provides a detailed summary of MapShed results showing the various sources of Urbanized Area loadings of individual municipalities. The values provided in the table do not equal the total value outlined within the body of this report. Only the municipalities that participated in the Cocalico Creek CBPRP Baseline are listed in the table in the appendix.

4 CBPRP

The PADEP issued Form 3800-FM-BPNPSM0493 in August 2013. The form is designed to assist municipal permittees with meeting the requirements for a TMDL Plan and/or CBPRP of an issued MS4 Permit. Section B of the form is dedicated to the CBPRP requirements, and is broken down into four (4) sections as follows:

1. Provide a narrative description of the drainage area of the MS4 within the Urban Area that discharges to the Chesapeake Bay Watershed. The description should discuss pervious and impervious cover.

2. Identify areas where municipal infrastructure upgrades are planned and include an evaluation of the suitability of green infrastructure, low impact development (LID) or Environmental Site Design (ESD) BMPs.

3. Optional – Provide estimates of the current loads (lbs/year) of Nitrogen (N), Phosphorus (P) and Sediment being discharged annually to receiving waters in the Chesapeake Bay Watershed. Explain how the estimates were made.

4. In the space provided, identify the control measures from Section II F of the NOI Instructions (3800-PM-BPNPSM0100c), or others, which will be implemented in the MS4 to reduce pollutant load to the Chesapeake Bay Watershed. Attach additional sheets if necessary. Identify a name or number for each BMP and indicate (1) the location(s) of the BMP (latitude/longitude, street name(s) or other locational information), (2) a timeline for implementation with interim milestones as appropriate, (3) how each BMP is expected to reduce N, P and/or Sediment in the receiving waters, (4) the rationale for selecting the BMP, and (5) a description of the planned inspection, operation and maintenance for the BMP. Optionally, for each BMP you may provide an estimate of the reduction (in lbs/year or %) of N, P and Sediment that are expected and how the estimate(s) were derived.

The Cocalico Creek CBPRP Baseline Project was designed to provide MS4 municipalities in the watershed with a tool to address the above requirements for their permitted areas in a cost-effective manner, while establishing a baseline of pollutant loadings by source. Appendix F contains a CBPRP template based on the descriptions below. LandStudies recommends the municipalities submit a copy of the Cocalico Creek Watershed CBPRP Baseline Report in its entirety with the initial Municipal CBPRP submission as well. The template was completed to demonstrate the use of information within the Baseline Report.

1. NARRATIVE DESCRIPTION: A general description has been generated describing the Cocalico Creek watershed as a whole; and more specifically the pervious and impervious areas of the watershed with a description of the overall Urbanized Area also delineated by individual municipalities. This description forms the framework for individual municipal CBPRP submissions. Additionally, the narrative describes the purpose of addressing pollutant reductions at a watershed level.

2. MUNICIPAL INFRASTRUCTURE UPGRADES: Information entered into this section is specific to individual municipalities. In turn, this section is not addressed by the CBPRP Baseline Project.

3. LOADING ESTIMATES: Despite the optional tag, this section is addressed at a watershed level in the project. While the decision to list estimated loadings by individual municipalities is reserved to those individuals, a description of the estimated loadings of the applicable pollutants across the watershed is described in this report. Per the requirement, the template includes a narrative description of how the estimated loadings were derived.

4. BMP IMPLEMENTATION: Information entered into this section is specific to individual municipalities. However, the baseline report provides supplemental information referenced for the CBPRP reporting submissions and will include 1) a narrative description of the CBPRP Baseline and the corresponding information associated with the project that allows the municipalities to describe "how each BMP is expected to reduce N,P and/or Sediment in the receiving waters" and "for each BMP…provide an estimate of the reduction of N, P and Sediment that are expected and how the estimate(s) were derived" based on the watershed. Additionally, a deliverable of the project is a cost data matrix generated from information provided by the Lancaster County Clean Water Consortium (LCCWC) through efforts of Tetra Tech to establish a county-wide Strategic Action Plan. The deliverable provides the municipalities a tool to estimate loading reductions and corresponding design/construction costs for certain BMPs for planning and reporting purposes.

LandStudies communicated with appropriate PADEP personnel regarding the applicability and approach developed for the Cocalico Creek Watershed municipalities. Based on discussions with the PADEP, primary considerations for municipalities include:

- Municipalities are not required to use PADEP Form 3800-FM-BPNPSM0493 (TMDL/CBPRP Template). Municipalities are only required to provide a submission that outlines the information included in the PADEP template.
- Municipalities are required to include information specific to their individual municipality (e.g. qualitative and quantitative description of the UA within the municipality).
- Municipalities need to ensure BMP implementation is appropriately outlined in the CBPRP.

5 CBPRP Implementation Strategies

5.1 Pennsylvania Chesapeake Watershed Implementation Plan (WIP)

The Environmental Protection Agency (EPA) required each of the six Chesapeake Bay watershed states and the District of Columbia to develop Watershed Implementation Plans (WIPs), outlining the steps each state will take to improve the health of the Chesapeake Bay by 2025. The WIP emphasizes load reductions in three primary sectors; agriculture, urban/suburban, and wastewater. The plans need to quantitatively explain how the states will achieve reductions in nitrogen, phosphorus, and sediment pollutant loads. The required reduction levels for each of the states and the District of Columbia are set by the EPA, who uses the Chesapeake Bay Model to quantify the reduction loads needed to meet the desired Bay conditions. These pollution reduction targets are referred to as total maximum daily loads (TMDLs). The Chesapeake Bay TMDLs assign a quantitative allocation for the total amount of a given pollutant a state is allowed to have in its waters that leaves its borders. States are required to achieve 60% of their total pollution load reduction from the 2009 baseline by 2017, and 100% of their reductions by 2025.

The Phase II WIP specifically outlines the number and types of BMPs Pennsylvania will implement to achieve its 60% reduction goal by 2017. For the Phase II WIP, the PADEP divided the reductions into more manageable county planning targets; county planning targets were selected because the Chesapeake Bay Model is in part based on county level data. These targets are intended to inform local implementers (e.g. municipal elected officials and planning agency personnel, county conservation districts, watershed organizations and planning commissions) of the nutrient and sediment loads generated by their geographic areas and help them plan appropriate actions to reduce the target loads. According to the Phase I WIP executive summary, “Local implementation efforts should focus on compliance with existing rules and regulations, as well as seeking opportunities for additional management actions.” It is important to note that at this time the target reductions set forward in the Phase II WIP are not regulatory allocations at the county level. However, EPA has the authority to enforce “backstop measures” if the WIP does not have adequate assurances that the target reductions will be met. These backstop measures would primarily consist of more stringent NPDES standards for point source discharges, over which EPA has direct authority.

The county planning targets address only those loads that can be reduced by Best Management Practices (BMPs). This includes both regulatory and non-regulatory loads for agriculture, stormwater (urban/suburban) and forest. Wastewater treatment plant reductions are not addressed because they were previously addressed by the 2006 Chesapeake Bay Compliance Strategy. The Draft County Planning Targets are generated from EPA’s Chesapeake Bay Watershed Model input deck generated for the Phase II WIP, and may not reflect actual 2010 conditions or possible 2025 conditions. The targets are for planning purposes only, and do not become regulatory allocations at the county level. The Phase II WIP identifies Pollution Reduction Actions that represent one scenario from the Watershed Model that meets the planning targets (Table 9). There are other equally valid combinations of actions that could also meet the planning target.

Table 9. Draft Planning Targets for Lancaster County from the Phase II WIP

Nitrogen Planning Target	Pounds
2009 Progress Load	16,302,079
2010 Current Load	16,147,779
2017 Interim Planning Target – 60%*	12,906,938
2017 Nitrogen Reductions (2010 – 2017)	3,395,141
2025 Planning Target – 100%	10,643,511
2025 Total Nitrogen Reductions (2010 – 2025)	5,658,568

Phosphorus Planning Target	
2009 Progress Load	929,175
2010 Current Load	921,535
2017 Interim Planning Target – 60%*	776,151
2017 Phosphorous Reductions (2010 – 2017)	153,024
2025 Planning Target – 100%	674,136
2025 Total Phosphorous Reductions (2010 –2025)	255,040

Total Suspended Solids (TSS) Planning Target	
2009 Progress Load	486,627,741
2010 Current Load	454,182,682
2017 Interim Planning Target – 60%*	372,502,774
2017 TSS Reductions (2010 – 2017)	114,124,967
2025 Planning Target – 100%	296,419,462
2025 Total TSS Reductions (2010 – 2025)	190,208,279

NOTE: * 60% of reductions from the 2009 progress load.

An approximate set of reduction goals are further provided by three primary sectors: agricultural, forest, and urban. The draft planning targets provided by sector are provided only in a graph format in which the user must approximate values. The draft planning reduction targets for the Lancaster County urban sector are best described as follows:

Nitrogen
- 2010 loading: ~3.2 million pounds
- 2025 target loading: ~2.0 million pounds
- Total reduction: ~1.2 million pounds (~38%)

Phosphorus
- 2010 loading: ~115,000 pounds
- 2025 target loading: ~80,000 pounds
- Total reduction ~35,000 pounds (~30%)

TSS (Sediment)
- 2010 loading: ~55 million pounds
- 2025 target loading: ~35 million pounds
- Total reduction: ~20 million pounds (~36%)

For discussion purposes only, and following the estimated total reduction for sediment in the urban/suburban sector established in the draft planning targets for Lancaster County (~36%), a reduction of 6.51 million pounds of sediment would need to be achieved in the Urbanized Area of the Cocalico Creek watershed (land uses and contributors (e.g. streambank erosion)). It should be noted, this value is approximately twice the sediment loading estimated by MapShed for the Urbanized Area land use loadings.

5.2 Lancaster County Strategic Action Plan

The Lancaster County Clean Water Consortium (LCCWC) partnered with EPA and PADEP to develop a Strategic Action Plan. The overarching goal of LCCWC is to bring all parties impacted by the impending regulations to one table to design equitable policies and solutions. The Strategic Action Plan is intended to serve as a comprehensive approach to coordinate the many varied watershed planning efforts in Lancaster County, identify and fill existing gaps, and provide input as to how to implement the WIP Phase II. The Plan will benchmark the current watershed plans in place within the county, the BMPs they focus on, their nutrient reduction efficiencies, and an associated cost / benefit analysis. Overall, the goal is to provide a cost-effective road map for meeting the goals set out in the Phase II WIP, or showing how the goals in the Phase II WIP need to be re-structured to meet the required reductions in the most cost efficient manner. It is meant to be a proactive tool to address how reasonable nutrient and sediment reductions can be made within the County.

Tetra Tech served as the consultant for the first phase of development of the Strategic Action Plan. Tetra Tech performed a desktop analysis to quantitatively establish nutrient and sediment loadings across Lancaster County watersheds based on the Bay model. Tetra Tech collected this cost data along with associated design, permitting, construction, and maintenance phase costs of selected BMPs to establish a cost-effectiveness value with each BMP. This exercise was further delineated by watershed in Lancaster County including the Cocalico Creek Watershed. Scenarios involving BMP implementation (based on known information) were performed to establish a preliminary understanding of the costs associated with BMP implementation across all sectors necessary to meet draft planning targets described in Section 5.1.

Tetra Tech used the Chesapeake Assessment Scenario Tool (CAST) for modeling. The modeling conducted by Tetra Tech was comprehensive due to the fact a number of assumptions had to be implemented to allow the model to match assumptions of the Chesapeake Bay Model. The Strategic Action Plan development did not attempt to delineate by land use types or sectors for overall loading calculations. The primary purpose of the exercise was to establish a cost-effectiveness value of nutrient and sediment reduction BMPs.

The BMP Cost and Efficiency Table can be found in Appendix E. This matrix is a condensed version of the cost-effectiveness data tables provided by Tetra Tech to the LCCWC during

Strategic Action Plan development. The information is only applicable to the Cocalico Creek watershed. This table lists potential BMPs that municipalities could choose to implement as well as a wealth of related information including:

- the BMP's estimated nutrient and sediment reduction capabilities,
- cost of the BMP over its entire life cycle split into upfront cost and maintenance costs, and
- cost efficiency of the BMP in terms of dollars spend per pound of reduction.

It should be noted that the reduction and cost information values provided are for planning purposes only. Load reductions calculated by CAST are underestimated for individual BMPs, as noted in Section 3.2. Use of the data is further described in Section 5.3.

5.3 BMP Planning and Implementation

BMP Implementation will require a step-by-step development process that allows realization of the planned BMP to perform functionally as intended. The necessary steps are as follows:

1. Planning
2. Conceptual Design
3. Design & Permitting
4. Construction
5. Operations and Maintenance (O&M)

The data outlined in the BMP Cost and Efficiency Table found in Appendix E is intended to ease the planning process by providing municipalities readily-usable cost information associated with a set of BMPs. Using this data as a component of the planning process will allow municipalities to identify BMPs (and approximate quantities of the BMPs) for implementation based on individual monetary abilities.

The table included in Appendix D that summarizes BMP implementation data was developed based on the Tetra Tech efforts as part of the Lancaster County Strategic Action Plan. There are two approaches to using the data in this table. A municipality may have a set budget to spend on BMPs and can use the table to back into the amount and type of BMP implementation based on cost. The other option is to use the table to meet a certain load reduction target.

LandStudies recommends municipalities use the table to help derive the type and quantity of a BMP for implementation based on monetary abilities (set budget) for planning purposes. The following example demonstrates the use of the information and table, and corresponding reporting:

- ABC Township has allocated $325,000 for the up-front BMP implementation to meet the requirements of Section 4 (BMP IMPLEMENTATION) of the CBPRP of an issued MS4 Permit
- Based on the recommendations of the Cocalico Creek Watershed CBPRP Baseline Report, ABC Township desires to focus on BMPs associated with streambanks within the regulated area to allow the opportunity to address the largest sediment contributor more directly

- ABC Township calculates the costs (for planning purposes only) associated with the design and construction of a floodplain restoration using the BMP Cost and Efficiency Table
    - **Allocated monies divided by the up-front average unit cost equals the approximate quantity that may be implemented**
    - $325,000 / $609 = 533 feet of floodplain restoration
    - A potential location is identified to accommodate this type of BMP and length
- Additionally, and based on the Annual Reduction values provided in the matrix, ABC Township is able to calculate and report the following annual reductions in the CBPRP for planning purposes:
    - **Annual reduction (pounds) multiplied by the approximate quantity that may be implemented equals the approximate planning annual reduction**
    - Nitrogen: 0.07 pounds per foot annually x 533 feet = 37.3 pounds
    - Phosphorus: 0.05 pounds per foot annually x 533 feet = 26.7 pounds
    - Sediment: 185.07 pounds per foot annually x 533 feet = 98,642.3 pounds
- ABC Township reports that it plans to implement approximately 500 feet of floodplain restoration in its CBPRP.
    - The calculated planning reductions are provided along with a timeline of the BMP Implementation process (conceptual design development dates, approximate design phase timeline/dates, and approximate construction timeframe).
    - As the development process progresses, more accurate information will be developed relative to reductions. (e.g. a conceptual design for a floodplain restoration will consider more precise methodologies such as the modified Expert Panel methodology for nutrient and sediment reductions). Additionally, the conceptual design phase will consider site specific conditions that cannot be captured by all-encompassing planning data.
        - EXAMPLE: Based on the modified Expert Panel methodology described in Section 3.2 and corresponding calculated reductions for a floodplain restoration shown in Table 3, the conceptual and design process stages would reveal reductions as follows:
            - Nitrogen: 850-900 pounds
            - Phosphorus: 70-90 pounds
            - Sediment: 140,000-160,000 pounds
    - As the development process progresses, municipalities will provide CBPRP updates in the MS4 Permit Annual Report. It is appropriate to update timelines, calculated reductions, and similar in these submissions for proposed BMP implementation.

It should be noted that the BMP Cost and Efficiency Table information is only intended to be used for planning purposes only. However, the information provides a cost-effective mechanism for municipalities to plan and list BMPs for implementation in individual CBPRPs.

LandStudies recommends municipalities address multiple BMPs during the planning process prior to selection of BMPs. Costs and requirements for each BMP can vary significantly. Table 10 reveals estimated planning-level costs of BMPs listed in Section 3.2 with the corresponding information found in the BMP Costs and Efficiency Table.

Table 10. Comparison of Planning Phase Estimated BMP Implementation Costs

for BMPs listed in Section 3.2.

Floodplain Restoration – 1000 LF	$609,000
Basin Retrofit – 1 acre	$58,156
Rain Garden – 1 acre	$62,969
Riparian Buffer – 1 acre	$12,259

The floodplain restoration cost is significantly higher than the other listed BMPs. However, the BMP Cost and Efficiency Table establishes a cost-effectiveness of the listed BMPs. In turn, it is appropriate to evaluate the cost-effectiveness of the BMPs. The lower the cost-effectiveness value is in the table, the more effective the BMP. Table 11 outlines BMP implementation costs if the effectiveness is considered. Each BMP is constrained to reduce 100,000 pounds of sediment in the table, and the corresponding up-front costs are listed.

Table 11. Comparison of Planning Phase Estimated BMP Implementation Costs for BMPs listed in Section 3.2 (with sediment reduction value pre-determined)

	Sediment Reduction Goal (lb)	Annual Sediment Reduction by Unit	Amount of BMP	Up-Front Implementation Unit Cost	Planning Phase Implementation Cost
Floodplain Restoration	100,000	185.07 lbs/LF	540 LF	$609/LF	$328,860
Basin Retrofits	100,000	1105.71 lbs/acre	90.4 acres	$58,156/acre	$5.25 mil
Rain Gardens	100,000	1237.32 lbs/acre	80.8 acres	$62,969/acre	$5.09 mil
Riparian Buffers	100,000	289.16 lbs/acre	345.8 acres	$12,259/acre	$4.24 mil

The tables and examples provided in this section and report demonstrate three priority considerations for municipalities during the planning phases of CBPRP development:

1. BMP implementation locations should focus on primary pollutant contributors
2. Cost-effectiveness of BMPs should be considered in selection of appropriate BMPs to allow for "maximum" reduction
3. A reasonable monetary allocation should be identified to allow BMP implementation to occur to the Maximum Extent Practicable

6 Conclusion and Recommendations

This report provides detailed information that can be used to guide decision making within the watershed. It also demonstrates a variety of acceptable models and calculation methods that can be used to generate both loading rates and BMP reductions. This information will be valuable to determine cost effective ways to work towards meeting the pollutant load reductions in Pennsylvania's WIP while having a positive effect on local water quality.

MapShed was used to estimate the Nitrogen, Phosphorus, and sediment loadings across the Cocalico Creek watershed. Primary and individual pollutant contributors were determined to be:

- Nitrogen: groundwater (stream baseflow) at 1,148,660 pounds
  - 58.2% of the total loading
- Phosphorus: livestock at 168,895 pounds
  - 78.5% of the total loading
- Sediment: streambank erosion at 28.4 million pounds (14,219 tons)
  - 63.8% of the total loading

MapShed was able to delineate the Urbanized Area within the watershed. The primary pollutant loading sources in the Urbanized Area was determined to be:

- Nitrogen
  - Groundwater (stream baseflow)
  - Livestock
  - Streambank erosion
  - Cropland
- Phosphorus
  - Livestock
  - Streambank erosion
  - Cropland
  - Hay/Pasture
- Sediment
  - Streambank erosion
  - Cropland
  - Hay/Pasture
  - Medium Density Residential

MapShed output data includes pollutant loadings by land uses. The mapped Urbanized Area includes agricultural land uses, and these areas provide relatively significant sediment and nutrient loadings. However, an assumption can be made that the MS4 system exists only in areas of urban/suburban land uses. The loadings identified in the urban/suburban land uses within the Urbanized Area are significantly less than other pollutant contributors identified. The primary pollutant loading sources (Nitrogen, Phosphorus, and sediment) in the Urbanized Area based on urban/suburban land uses was determined to be:

- Medium Density (MD) Residential
- High Density (HD) Mixed Use
- Medium Density (MD) Mixed Use

A template was generated to assist municipalities with CBPRP development based on the information and tools provided in the Cocalico Creek CBPRP Baseline Report. The template outlines required information for submission based on the PADEP form. Final development will be the responsibility of individual municipalities. In turn, the following recommendations are provided for individual CBPRP development:

- Significant reductions could be achieved within the Urbanized Area boundaries with a focus directed towards streambank erosion and assisting the agricultural sector
    - Multi-municipal and coordinated efforts may provide the best opportunities to address streambank erosion and assisting the agricultural sector
- MD Residential, HD Mixed Use, and MD Mixed Use should be the "up-land" focus of land use BMP implementation efforts. However, loadings from these land uses are relatively minimal compared to the largest sources estimated by MapShed.
- The BMP Cost and Efficiency Table should be used to establish preliminary pollutant reduction values and assist with identifying monetary funding required for up-front implementation during the planning stage
    - More appropriate methodologies such as the modified Expert Panel methodology should be used during the conceptual design and design & permitting stages once site specific conditions are known.
    - Updated reductions calculated can be provided in Annual Report submissions
- BMP Implementation schedules should follow a planning-conceptual design-design & permitting-construction sequence of events
    - Operation & Maintenance (O&M) requirements and responsibilities should be addressed at each stage

7 References

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8 Certification

I, being a Registered Professional Engineer in Pennsylvania, do hereby certify to the best of my knowledge and belief, that this Baseline Study, intended to support the Chesapeake Bay Pollutant Reduction Plans for municipalities within the Cocalico Creek Watersheds, is based on the best information available and appropriate modeling techniques, to facilitate the planning of sediment and nutrient load reduction BMPs designed to achieve pollutant reductions consistent with the goals in the Chesapeake Bay Watershed Implementation Plan.

Professional Engineer Name: Benjamin J. Ehrhart

Signature:______________________________

Date:__________________________________

License No: PE062219

License Expiration Date: September 30, 2015

Company: LandStudies, Inc.

Telephone: 717-627-4440

Engineer's Seal

Appendix A:
MapShed Model Inputs and Results

Baseline Model Run Inputs

Urban Land	Area (ha)	%Imp	CNI	CNP
LD Mixed	22	0.15	92	74
MD Mixed	573	0.52	98	79
HD Mixed	1275	0.87	98	79
LD Residential	1042	0.15	92	74
MD Residential	2531	0.52	92	74
HD Residential	21	0.87	92	74

Rural Land	Area (ha)	CN	K	LS	C	P
Hay/Pasture	7205	75	0.295	2.203	0.03	0.45
Cropland	8401	82	0.304	1.331	0.42	0.45
Forest	14019	60	0.292	3.815	0.002	0.45
Wetland	707	80	0.294	0.867	0.01	0.1
Disturbed	318	89	0.3	1.979	0.08	0.1
Turf/Golf	131	71	0.313	0.909	0.03	0.2
Open Land	8	0	0.0	0.0	0.0	0.0
Bare Rock	0	0	0.0	0.0	0.0	0.0
Sandy Areas	0	0	0.0	0.0	0.0	0.0
Unpaved Road	11	87	0.295	0.481	0.8	1.0

Month	Ket	Adjust %ET	Day Hours	Grow Seas	Eros Coef	Stream Extract	Ground Extract
Jan	0.62	1.0	9.4	0	0.12	0.0	0.0
Feb	0.67	1.0	10.4	0	0.12	0.0	0.0
Mar	0.7	1.0	11.8	0	0.3	0.0	0.0
Apr	0.87	1.0	13.2	1	0.3	0.0	0.0
May	0.97	1.0	14.3	1	0.3	0.0	0.0
Jun	1.02	1.0	14.9	1	0.3	0.0	0.0
Jul	1.06	1.0	14.6	1	0.3	0.0	0.0
Aug	1.07	1.0	13.6	1	0.3	0.0	0.0
Sep	1.09	1.0	12.2	1	0.3	0.0	0.0
Oct	1.09	1.0	10.8	1	0.12	0.0	0.0
Nov	0.95	1.0	9.7	0	0.12	0.0	0.0
Dec	0.86	1.0	9.1	0	0.12	0.0	0.0

Sediment A Factor	1.0216E-03
Sed A Adjustment	1.0
Avail Water Cap (cm)	17.42
Sed Delivery Ratio	0.078

Values 0 - 1

GW Recess Coeff	0.1
GW Seepage Coeff	0.0
% Tile Drained (Ag)	0.0

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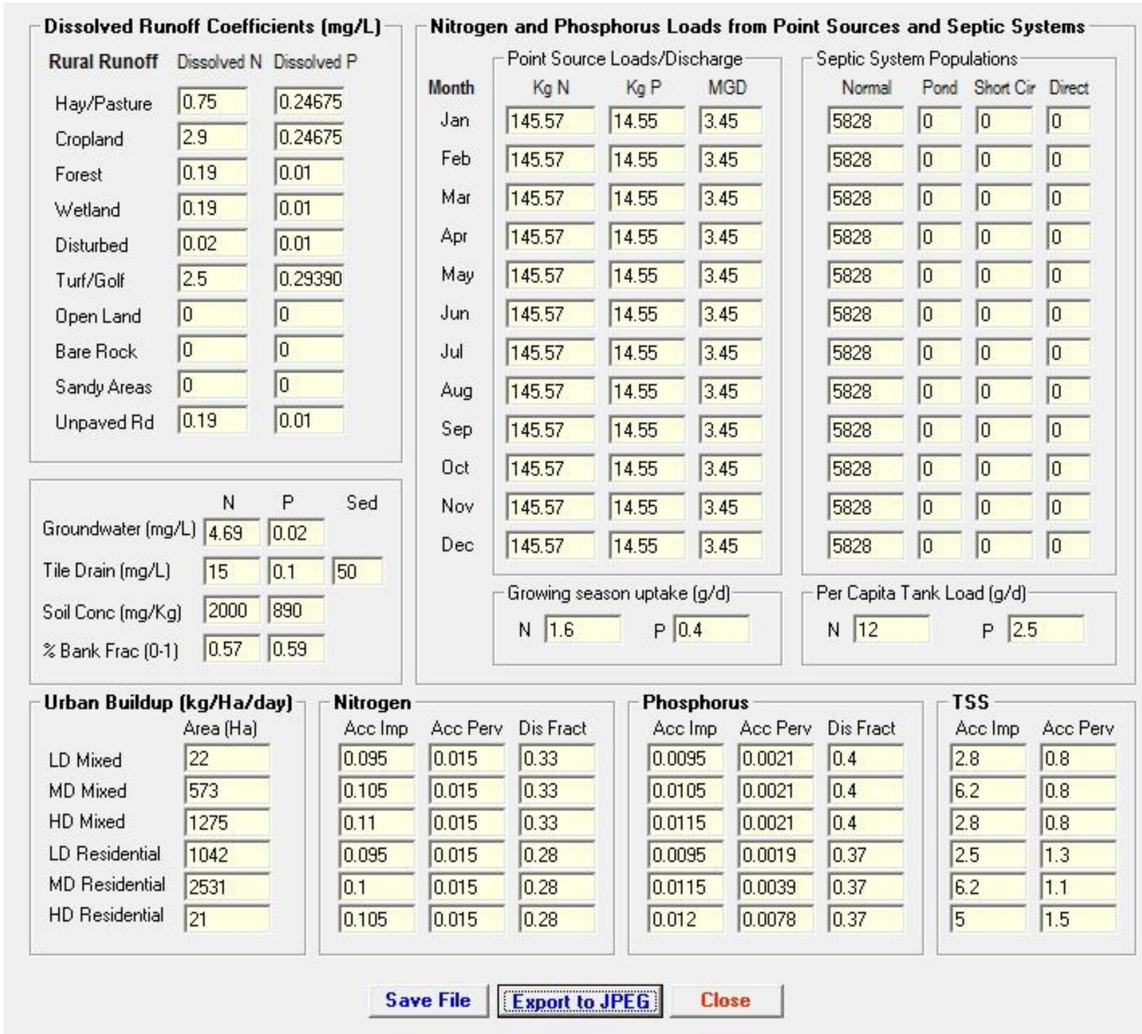
Baseline Model Run Inputs



Dissolved Runoff Coefficients (mg/L)

Rural Runoff	Dissolved N	Dissolved P
Hay/Pasture	0.75	0.24675
Cropland	2.9	0.24675
Forest	0.19	0.01
Wetland	0.19	0.01
Disturbed	0.02	0.01
Turf/Golf	2.5	0.29390
Open Land	0	0
Bare Rock	0	0
Sandy Areas	0	0
Unpaved Rd	0.19	0.01

	N	P	Sed
Groundwater (mg/L)	4.69	0.02	
Tile Drain (mg/L)	15	0.1	50
Soil Conc (mg/Kg)	2000	890	
% Bank Frac (0-1)	0.57	0.59	

Nitrogen and Phosphorus Loads from Point Sources and Septic Systems

Month	Point Source Loads/Discharge: Kg N	Kg P	MGD	Septic System Populations: Normal	Pond	Short Cir	Direct
Jan	145.57	14.55	3.45	5828	0	0	0
Feb	145.57	14.55	3.45	5828	0	0	0
Mar	145.57	14.55	3.45	5828	0	0	0
Apr	145.57	14.55	3.45	5828	0	0	0
May	145.57	14.55	3.45	5828	0	0	0
Jun	145.57	14.55	3.45	5828	0	0	0
Jul	145.57	14.55	3.45	5828	0	0	0
Aug	145.57	14.55	3.45	5828	0	0	0
Sep	145.57	14.55	3.45	5828	0	0	0
Oct	145.57	14.55	3.45	5828	0	0	0
Nov	145.57	14.55	3.45	5828	0	0	0
Dec	145.57	14.55	3.45	5828	0	0	0

Growing season uptake (g/d): N 1.6, P 0.4

Per Capita Tank Load (g/d): N 12, P 2.5

Urban Buildup (kg/Ha/day)	Area (Ha)	Nitrogen: Acc Imp	Acc Perv	Dis Fract	Phosphorus: Acc Imp	Acc Perv	Dis Fract	TSS: Acc Imp	Acc Perv
LD Mixed	22	0.095	0.015	0.33	0.0095	0.0021	0.4	2.8	0.8
MD Mixed	573	0.105	0.015	0.33	0.0105	0.0021	0.4	6.2	0.8
HD Mixed	1275	0.11	0.015	0.33	0.0115	0.0021	0.4	2.8	0.8
LD Residential	1042	0.095	0.015	0.28	0.0095	0.0019	0.37	2.5	1.3
MD Residential	2531	0.1	0.015	0.28	0.0115	0.0039	0.37	6.2	1.1
HD Residential	21	0.105	0.015	0.28	0.012	0.0078	0.37	5	1.5

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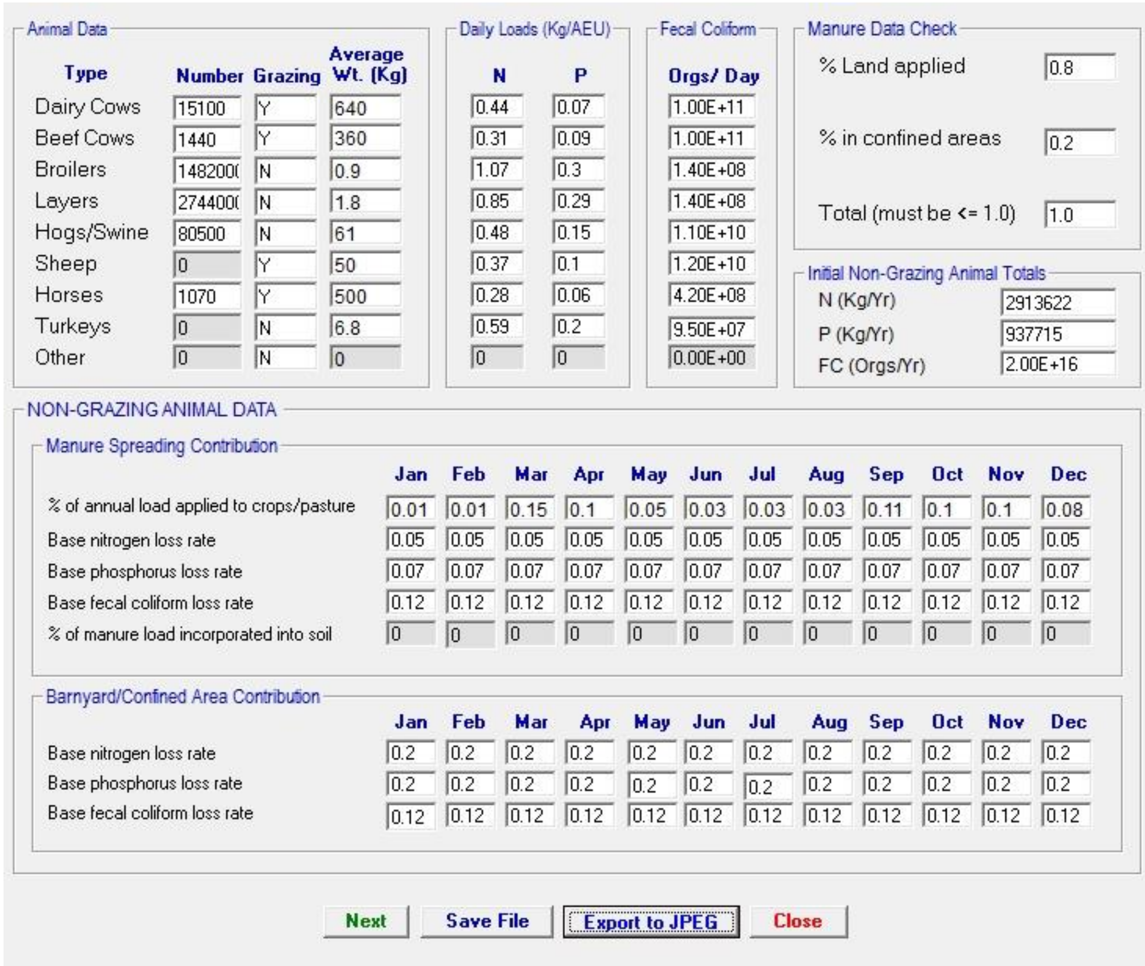
Baseline Model Run Inputs



Animal Data / Daily Loads (Kg/AEU) / Fecal Coliform

Type	Number	Grazing	Average Wt. (Kg)	N	P	Orgs/ Day
Dairy Cows	15100	Y	640	0.44	0.07	1.00E+11
Beef Cows	1440	Y	360	0.31	0.09	1.00E+11
Broilers	148200(	N	0.9	1.07	0.3	1.40E+08
Layers	274400(	N	1.8	0.85	0.29	1.40E+08
Hogs/Swine	80500	N	61	0.48	0.15	1.10E+10
Sheep	0	Y	50	0.37	0.1	1.20E+10
Horses	1070	Y	500	0.28	0.06	4.20E+08
Turkeys	0	N	6.8	0.59	0.2	9.50E+07
Other	0	N	0	0	0	0.00E+00

Manure Data Check

% Land applied	0.8
% in confined areas	0.2
Total (must be <= 1.0)	1.0

Initial Non-Grazing Animal Totals

N (Kg/Yr)	2913622
P (Kg/Yr)	937715
FC (Orgs/Yr)	2.00E+16

NON-GRAZING ANIMAL DATA

Manure Spreading Contribution

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
% of annual load applied to crops/pasture	0.01	0.01	0.15	0.1	0.05	0.03	0.03	0.03	0.11	0.1	0.1	0.08
Base nitrogen loss rate	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Base phosphorus loss rate	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12
% of manure load incorporated into soil	0	0	0	0	0	0	0	0	0	0	0	0

Barnyard/Confined Area Contribution

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Base nitrogen loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base phosphorus loss rate	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Base fecal coliform loss rate	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12	0.12

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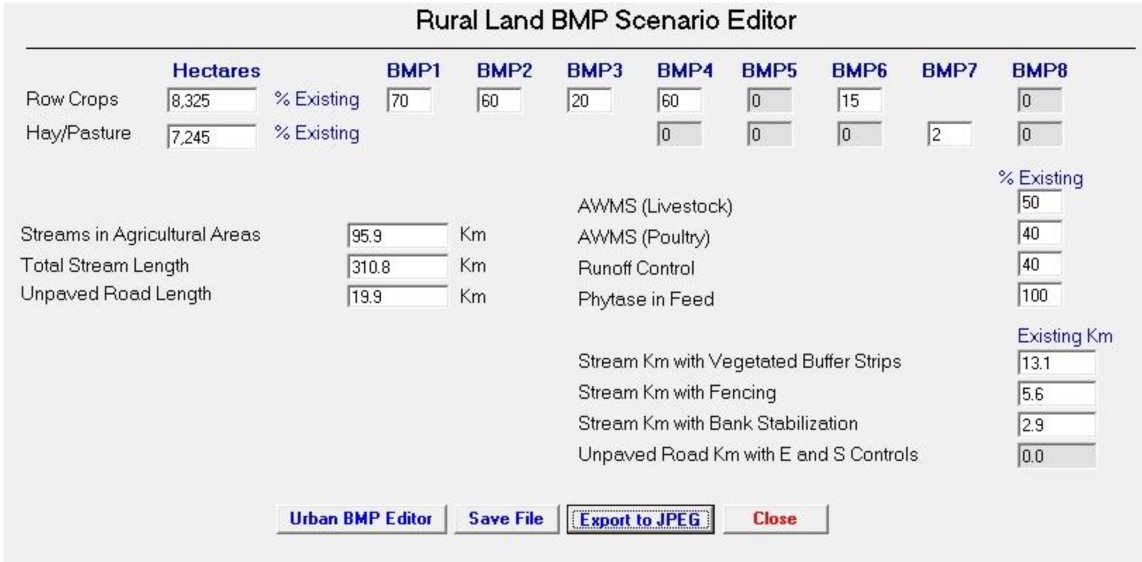
Baseline Model Run Inputs


Rural Land BMP Scenario Editor

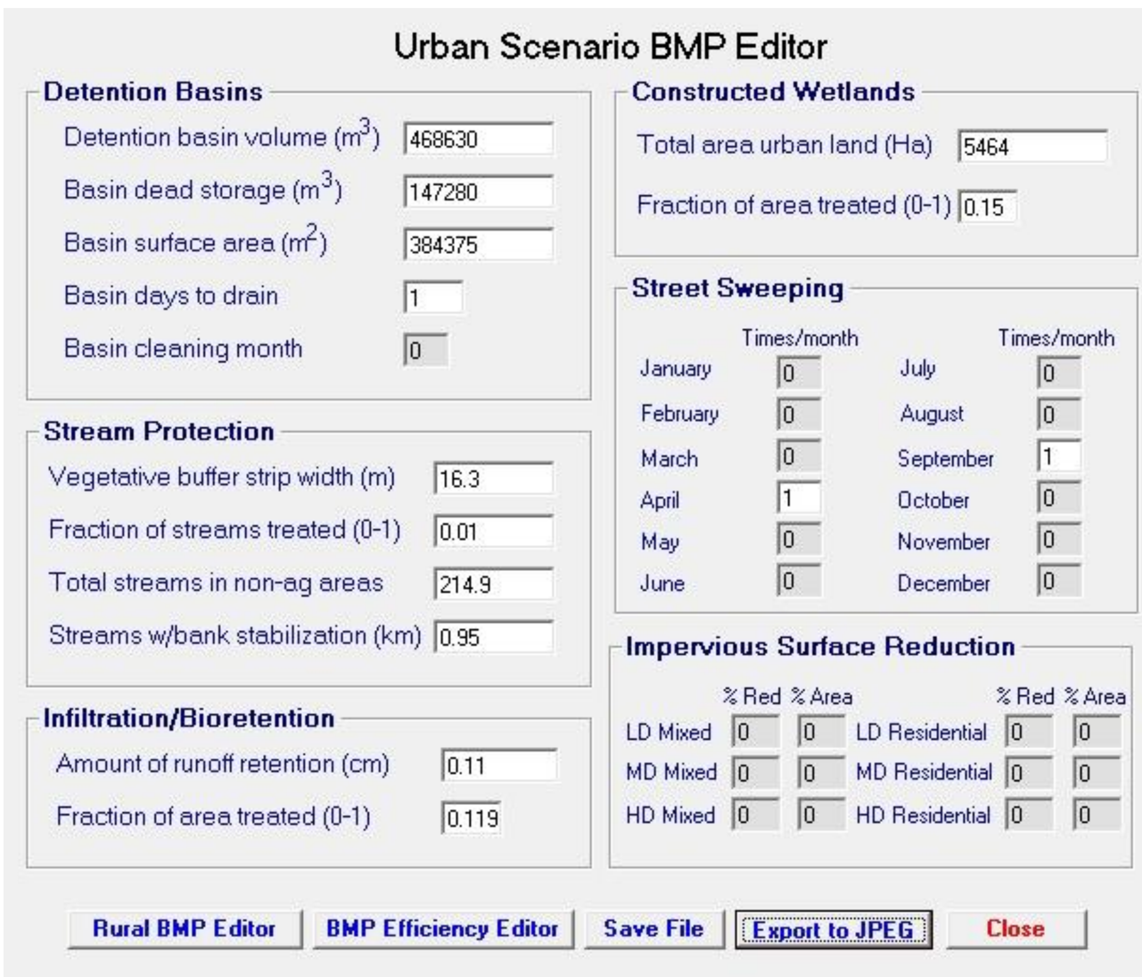
	Hectares		BMP1	BMP2	BMP3	BMP4	BMP5	BMP6	BMP7	BMP8
Row Crops	8,325	% Existing	70	60	20	60	0	15		0
Hay/Pasture	7,245	% Existing				0	0	0	2	0

Streams in Agricultural Areas	95.9	Km
Total Stream Length	310.8	Km
Unpaved Road Length	19.9	Km

	% Existing
AWMS (Livestock)	50
AWMS (Poultry)	40
Runoff Control	40
Phytase in Feed	100

	Existing Km
Stream Km with Vegetated Buffer Strips	13.1
Stream Km with Fencing	5.6
Stream Km with Bank Stabilization	2.9
Unpaved Road Km with E and S Controls	0.0

Urban BMP Editor | Save File | Export to JPEG | Close


Urban Scenario BMP Editor

Detention Basins

Detention basin volume (m^3)	468630
Basin dead storage (m^3)	147280
Basin surface area (m^2)	384375
Basin days to drain	1
Basin cleaning month	0

Constructed Wetlands

Total area urban land (Ha)	5464
Fraction of area treated (0-1)	0.15

Stream Protection

Vegetative buffer strip width (m)	16.3
Fraction of streams treated (0-1)	0.01
Total streams in non-ag areas	214.9
Streams w/bank stabilization (km)	0.95

Street Sweeping

	Times/month		Times/month
January	0	July	0
February	0	August	0
March	0	September	1
April	1	October	0
May	0	November	0
June	0	December	0

Infiltration/Bioretention

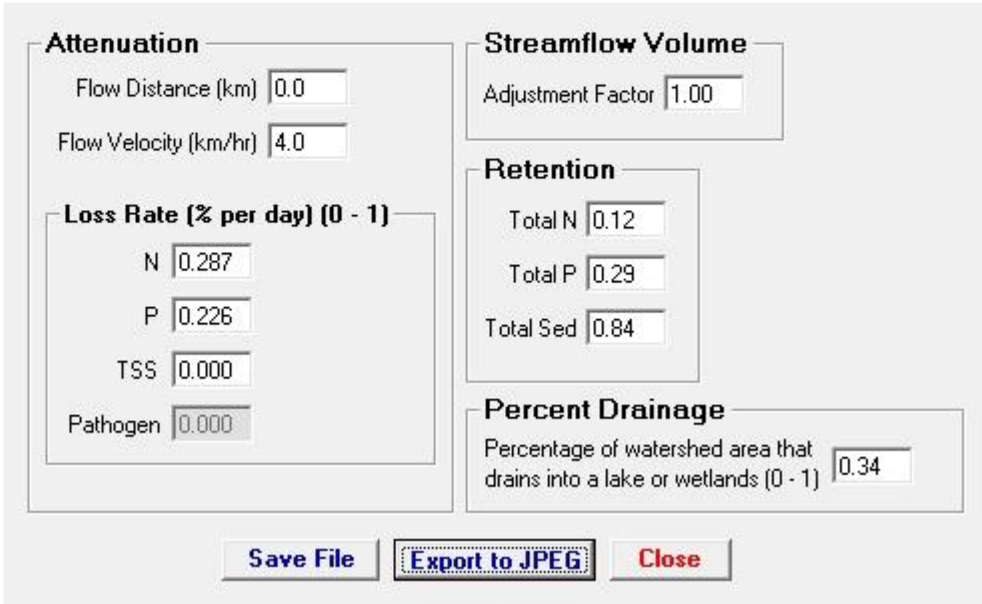
Amount of runoff retention (cm)	0.11
Fraction of area treated (0-1)	0.119

Impervious Surface Reduction

	% Red	% Area		% Red	% Area
LD Mixed	0	0	LD Residential	0	0
MD Mixed	0	0	MD Residential	0	0
HD Mixed	0	0	HD Residential	0	0

Rural BMP Editor | BMP Efficiency Editor | Save File | Export to JPEG | Close

Baseline Model Run Inputs



Baseline Model Run Results

GWLF Total Loads for file: CocalicoFinal9-30-14-0 **Period of analysis:** 21 years from 1978 to 1998

			Tons		Total Loads (Pounds)			
Source	**Area (Acres)**	**Runoff (in)**	**Erosion**	**Sediment**	**Dissolved N**	**Total N**	**Dissolved P**	**Total P**
Hay/Pasture	17804	2.8	26115.0	1444.1	8107.3	15875.8	2506.6	5755.3
Cropland	20759	4.9	265417.9	6105.0	40510.1	91073.6	1968.0	14814.3
Forest	34642	0.8	5806.6	323.6	1148.4	2886.2	56.8	783.5
Wetland	1747	4.2	74.5	4.1	299.6	321.8	14.8	24.1
Disturbed	786	8.8	624.0	34.8	30.0	216.8	14.1	92.2
Turfgrass	324	2.1	92.4	5.1	360.8	388.5	39.9	51.4
Open Land	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	27	7.4	515.9	28.7	8.2	162.6	0.4	65.0
LD Mixed	54	3.1	0.0	0.2	2.8	9.8	0.4	1.0
MD Mixed	1416	8.5	0.0	14.4	272.4	846.3	36.5	91.2
HD Mixed	3151	12.0	0.0	32.0	606.2	1883.1	81.2	202.8
LD Residential	2575	3.1	0.0	7.9	132.7	462.6	17.9	47.5
MD Residential	6254	5.2	0.0	63.6	1203.5	3738.2	161.2	402.7
HD Residential	52	7.2	0.0	0.5	10.0	31.0	1.3	3.4
Farm Animals						639368.4		168895.3
Tile Drainage				0.0		0.0		0.0
Stream Bank				14219.6		43691.2		18836.3
Groundwater					1148660.0	1148660.0	4654.2	4654.2
Point Sources					3694.0	3694.0	347.1	347.1
Septic Systems					19390.5	19390.5	0.0	0.0
Totals	89610.2	3.20	298646.1	22283.7	1224436.7	1972700.4	9900.4	215067.4

Go Back | Pathogen Loads | Export to JPEG | Print | Close

BMP Model Run Results – 1000 Feet Floodplain Restoration

GWLF Total Loads for file: CocalicoFPR-0 **Period of analysis:** 21 years from 1978 to 1998

Source	Area (Acres)	Runoff (in)	Tons: Erosion	Tons: Sediment	Total Loads (Pounds): Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	17801	2.8	26111.4	1443.9	8106.2	15873.6	2506.3	5754.5
Cropland	20759	4.9	265417.9	6094.1	40455.1	90949.9	1965.4	14794.7
Forest	34642	0.8	5806.6	323.6	1148.4	2886.2	56.8	783.5
Wetland	1750	4.2	74.6	4.2	300.0	322.3	14.8	24.2
Disturbed	786	8.8	624.0	34.8	30.0	216.8	14.1	92.2
Turfgrass	324	2.1	92.4	5.1	360.8	388.5	39.9	51.4
Open Land	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	27	7.4	515.9	28.7	8.2	162.6	0.4	65.0
LD Mixed	54	3.1	0.0	0.2	2.8	9.8	0.4	1.0
MD Mixed	1416	8.5	0.0	14.4	272.4	846.3	36.5	91.2
HD Mixed	3151	12.0	0.0	32.0	606.2	1883.1	81.2	202.8
LD Residential	2575	3.1	0.0	7.9	132.7	462.6	17.9	47.5
MD Residential	6254	5.2	0.0	63.6	1203.5	3738.2	161.2	402.7
HD Residential	52	7.2	0.0	0.5	10.0	31.0	1.3	3.4
Farm Animals						638900.8		168727.4
Tile Drainage				0.0		0.0		0.0
Stream Bank				14206.2		43649.3		18818.6
Groundwater					1148459.7	1148459.7	4654.2	4654.2
Point Sources					3694.0	3694.0	347.1	347.1
Septic Systems					19390.5	19390.5	0.0	0.0
Totals	89610.2	3.20	298642.6	22259.2	1224180.6	1971865.1	9897.4	214861.4

Go Back | Pathogen Loads | Export to JPEG | Print | Close

BMP Model Run Results – 1 Acre Stormwater Basin Retrofit

GWLF Total Loads for file: CocalicoBasin1-0   Period of analysis: 21 years from 1978 to 1998

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	17804	2.8	26115.0	1444.1	8107.3	15875.8	2506.6	5755.3
Cropland	20759	4.9	265417.9	6105.0	40510.1	91073.6	1968.0	14814.3
Forest	34642	0.8	5806.6	323.6	1148.4	2886.2	56.8	783.5
Wetland	1747	4.2	74.5	4.1	299.6	321.8	14.8	24.1
Disturbed	786	8.8	624.0	34.8	30.0	216.8	14.1	92.2
Turfgrass	324	2.1	92.4	5.1	360.8	388.5	39.9	51.4
Open Land	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	27	7.4	515.9	28.7	8.2	162.6	0.4	65.0
LD Mixed	54	3.1	0.0	0.2	2.8	9.7	0.4	1.0
MD Mixed	1416	8.5	0.0	14.4	271.9	844.2	36.4	91.0
HD Mixed	3151	12.0	0.0	32.0	605.1	1878.4	81.1	202.5
LD Residential	2575	3.1	0.0	7.9	132.6	461.9	17.9	47.4
MD Residential	6254	5.2	0.0	63.4	1201.1	3728.7	160.9	401.9
HD Residential	52	7.2	0.0	0.5	10.0	30.9	1.3	3.3
Farm Animals						639368.4		168895.3
Tile Drainage				0.0		0.0		0.0
Stream Bank				14219.2		43689.0		18834.1
Groundwater					1148660.0	1148660.0	4654.2	4654.2
Point Sources					3694.0	3694.0	347.1	347.1
Septic Systems					19390.5	19390.5	0.0	0.0
Totals	89610.2	3.20	298646.1	22283.1	1224432.5	1972681.0	9899.9	215063.7

Go Back | Pathogen Loads | Export to JPEG | Print | Close

BMP Model Run Results – 1 Acre Raingarden Implementation

GWLF Total Loads for file: CocalicoRainGardens1-0 **Period of analysis:** 21 years from 1978 to 1998

Source	Area (Acres)	Runoff (in)	Tons		Total Loads (Pounds)			
			Erosion	Sediment	Dissolved N	Total N	Dissolved P	Total P
Hay/Pasture	17804	2.8	26115.0	1444.1	8107.3	15875.8	2506.6	5755.3
Cropland	20759	4.9	265417.9	6105.0	40510.1	91073.6	1968.0	14814.3
Forest	34642	0.8	5806.6	323.6	1148.4	2886.2	56.8	783.5
Wetland	1747	4.2	74.5	4.1	299.6	321.8	14.8	24.1
Disturbed	786	8.8	624.0	34.8	30.0	216.8	14.1	92.2
Turfgrass	324	2.1	92.4	5.1	360.8	388.5	39.9	51.4
Open Land	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	27	7.4	515.9	28.7	8.2	162.6	0.4	65.0
LD Mixed	54	3.1	0.0	0.2	2.8	9.7	0.4	1.0
MD Mixed	1416	8.5	0.0	14.4	271.9	844.1	36.4	90.9
HD Mixed	3151	12.0	0.0	31.9	605.1	1878.2	81.0	202.4
LD Residential	2575	3.1	0.0	7.9	132.6	461.8	17.9	47.4
MD Residential	6254	5.2	0.0	63.4	1201.1	3728.4	160.8	401.7
HD Residential	52	7.2	0.0	0.5	10.0	30.9	1.3	3.3
Farm Animals						639368.4		168895.3
Tile Drainage				0.0		0.0		0.0
Stream Bank				14219.1		43689.0		18834.1
Groundwater					1148660.0	1148660.0	4654.2	4654.2
Point Sources					3694.0	3694.0	347.1	347.1
Septic Systems					19390.5	19390.5	0.0	0.0
Totals	89610.2	3.20	298646.1	22282.9	1224432.4	1972680.3	9899.8	215063.4

Go Back | Pathogen Loads | Export to JPEG | Print | Close

BMP Model Run Results – 1 Acre Forested Riparian Buffer

GWLF Total Loads for file: CocalicoBuffer1-0 **Period of analysis:** 21 years from 1978 to 1998

			Tons		Total Loads (Pounds)			
Source	**Area (Acres)**	**Runoff (in)**	**Erosion**	**Sediment**	**Dissolved N**	**Total N**	**Dissolved P**	**Total P**
Hay/Pasture	17804	2.8	26115.0	1444.1	8107.3	15875.8	2506.6	5755.3
Cropland	20759	4.9	265417.9	6101.4	40491.8	91032.4	1967.1	14807.8
Forest	34642	0.8	5806.6	323.6	1148.4	2886.2	56.8	783.5
Wetland	1747	4.2	74.5	4.1	299.6	321.8	14.8	24.1
Disturbed	786	8.8	624.0	34.8	30.0	216.8	14.1	92.2
Turfgrass	324	2.1	92.4	5.1	360.8	388.5	39.9	51.4
Open Land	20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bare Rock	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sandy Areas	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Unpaved Roads	27	7.4	515.9	28.7	8.2	162.6	0.4	65.0
LD Mixed	54	3.1	0.0	0.2	2.8	9.8	0.4	1.0
MD Mixed	1416	8.5	0.0	14.4	272.4	846.3	36.5	91.2
HD Mixed	3151	12.0	0.0	32.0	606.2	1883.1	81.2	202.8
LD Residential	2575	3.1	0.0	7.9	132.7	462.6	17.9	47.5
MD Residential	6254	5.2	0.0	63.6	1203.5	3738.2	161.2	402.7
HD Residential	52	7.2	0.0	0.5	10.0	31.0	1.3	3.4
Farm Animals						639212.5		168839.3
Tile Drainage				0.0		0.0		0.0
Stream Bank				14219.6		43691.2		18836.3
Groundwater					1148594.4	1148594.4	4654.2	4654.2
Point Sources					3694.0	3694.0	347.1	347.1
Septic Systems					19390.5	19390.5	0.0	0.0
Totals	89610.2	3.20	298646.1	22280.1	1224352.8	1972437.7	9899.5	215004.8

Go Back Pathogen Loads Export to JPEG Print Close

Appendix B
Raw Data

Land Cover

Land Cover	Hectares
Hay	7205
Row Crops	8401
Forest	14019
Disturbed	329
Wetland	707
Open Space	8
Turf/Golf	131
Low Intensity Residential (<30% Impervious)	1042
Med. Intesity Residential (30%-75% Impervious)	2531
High Intensity Residential (>75% Impervious)	21
Low Intensity Mixed Urban (<30% Impervious)	22
Med. Intesity Mixed (30%-75% Impervious)	573
High Intensity Mixed (>75% Impervious)	1275

Septic Systems

On-Lot Septic Systems	**5828**

Agricultural BMPs

BMP	Units	Amount Implemented
Cover Crop	% Acres Treated	70%
Conservation Tillage	% Acres Treated	60%
Strip Cropping/ Contour Farming	% Acres Treated	20%
Conservation Plan	% Acres Treated	60%
Nutrient Management	% Acres Treated	15%
Grazing Land Management	% Acres Treated	2%
Manure Storage (Livestock)	% Animals	50%
Manure Storage (Poultry)	% Animals	40%
Barnyard Runoff Control	% Animals	40%
Phytase	% Animals	100%

Riparian BMP Implementation

Riparian BMP Project	Urban or Rural	Buffer Length (ft)	Buffer width (ft)	Buffer Total Area (ac)	Bank Stabilization Length (ft)	Wetland Created (ac)	Fencing/ Livestock Exclusion Length	Floodplain Restoration (Ac.)
Merv Miller Builders	Urban	686	35	0.55				
Snavely Mill	Rural	3200	120	8.82	3200	2		2
Good Farm	Rural	0	0	0.00	3200			
Fox Zimmerman	Rural	3150	35	2.53	3150	2.7		2.7
Grater Park	Urban	2500	35	2.01	1200	0.6		
Church Road	Urban	1900	84.83	3.70	1900	3.7		3.7
Moyer CREP	Urban			0.00		0.9		
CREP	Rural	36473	104	88.4			18236.5	
Bon View Linear Park - Monroe Street	Urban	3000	70	5				
Urban Total		**5086**	**54**	**6.26**	**3100**	**5.2**		**3.7**
Rural Total		**42823**	**101**	**99.75**	**9550**	**4.7**	**18236.5**	**4.7**

Stormwater Management BMPs

Detention Basins

Total Volume	468,629.56	m3
Dead Storage	147,279.93	m3
Surface Area	384,374.64	m2

Infiltration/ Bioretention

Runoff Retention	0.11	cm
Fraction of Area Treated	11.97%	%

Constructed wetlands

Total Area of Urban Land	5464	Ha
Fraction of Area Treated	0.15%	%

% of Watershed Draining to Lakes Ponds and Wetlands

Speedwell DA	24.76	sm
Middle Creek DA	7.76	sm
Blue Lake	14.4	sm
Total	46.92	sm
Total	30028.8	ac
% of watershed	**34%**	

Appendix C
Summary of Floodplain Restoration Nutrient and Sediment Calculation Methodology

Modified load reduction calculation protocols using Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects (Schueler and Stack, 2014)

The protocols presented in these recommendations provide methods for quantifying direct bank erosion and the resulting sediment and nutrient load reductions realized from restoring the floodplain and eliminating the sediment source (Protocol 1), quantifying the nitrogen removal associated with biological activity in the restored hyporheic zone (Protocol 2), and the filtration of flood flows through a re-connected floodplain (Protocol 3). The protocols were followed, as presented to develop initial load reduction estimates. However, based on LSI's experience with floodplain restoration projects, the protocols as presented likely underestimate the actual load reduction that can be realized through this BMP. Therefore two modifications were made to these protocols to better represent the anticipated load reductions for FPR, as described below.

Protocol 1 recommends applying a 50% safety factor to the calculated bank erosion load to account for some project failure. LSI experience with floodplain restoration projects indicates that bank erosion rates for this type of restoration are in fact very near zero. Preliminary data from the Big Spring Run project in Lancaster County indicates that these restoration sites become sediment sinks, removing significant amounts of sediment mobilized from eroding banks upstream. Therefore, the safety factor was not applied to this calculation.

Protocol 2 was used as an estimate for the floodplain reconnection component of the calculations for FPR. The Expert Panel Report does not recommend that Protocol 2 is used for FPR project, but we feel strongly that the nitrogen cycling in the hyporheic zone of riparian wetlands created by FPR projects is significant and should not be discounted. Protocol 2 assumes that the hyporheic zone extends only five feet beyond the top of bank, but to a depth of five feet. Floodplain restoration projects lower the floodplain elevation and create riparian wetlands that connect the active floodplain to groundwater for the extent of the restoration area. Therefore, the full width of the restored floodplain was considered, but at a more realistic depth of two feet.

Appendix D
Urbanized Area Loadings By Municipality

URBANIZED AREA NITROGEN LOAD BY MUNICIPALITY

		Adamstown Boro.		Akron Boro.		Clay Twp.		Denver Boro.		East Cocalico Twp.		Elizabeth Twp.		Ephrata Boro.		Ephrata Twp.		Warwick Twp.		West Cocalico Twp.		West Earl Twp.	
	Land Use Loading Rate (lb/ac)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)
Hay/Pasture	0.89	15	13.4	54	48.1	689	613.2	151	134.4	1102	980.8	37	32.9	0	0.0	437	388.9	551	490.4	1465	1303.9	210	186.9
Cropland	4.39	2	8.8	17	74.6	1016	4460.2	40	175.6	759	3332.0	531	2331.1	30	131.7	652	2862.3	558	2449.6	717	3147.6	289	1268.7
Forest	0.08	82	6.6	64	5.1	477	38.2	47	3.8	682	54.6	141	11.3	151	12.1	306	24.5	534	42.7	1972	157.8	62	5.0
Wetland	0.18	0	0.0	0	0.0	2	0.4	17	3.1	30	5.4	2	0.4	7	1.3	2	0.4	2	0.4	116	20.9	0	0.0
Disturbed	0.28	0	0.0	2	0.6	27	7.6	12	3.4	166	46.5	7	2.0	0	0.0	27	7.6	17	4.8	185	51.8	22	6.2
Turfgrass	1.2	0	0.0	15	18.0	0	0.0	0	0.0	126	151.2	0	0.0	49	58.8	0	0.0	0	0.0	0	0.0	0	0.0
Open Land		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	0.0	0	0.0	0	0.0	0	0.0
Bare Rock		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Sandy Areas		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Unpaved Roads		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LD Mixed	0.18	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	1.8	0	0.0	7	1.3	0	0.0
MD Mixed	0.6	7	4.2	2	1.2	69	41.4	49	29.4	316	189.6	77	46.2	188	112.8	128	76.8	54	32.4	62	37.2	89	53.4
HD Mixed	0.6	0	0.0	67	40.2	136	81.6	188	112.8	292	175.2	395	237.0	423	253.8	321	192.6	72	43.2	220	132.0	158	94.8
LD Residentail	0.18	0	0.0	7	1.3	143	25.7	25	4.5	203	36.5	0	0.0	12	2.2	89	16.0	89	16.0	437	78.7	0	0.0
MD Residential	0.6	7	4.2	329	197.4	420	252.0	301	180.6	741	444.6	101	60.6	1342	805.2	880	528.0	625	375.0	393	235.8	148	88.8
HD Residential	0.6	0	0.0	0	0.0	0	0.0	0	0.0	10	6.0	0	0.0	0	0.0	2	1.2	20	12.0	12	7.2	10	6.0
Water		0		5		5		2		22		2		12		27		10		27		17	
Subtotal		**113**	**37.1**	**562**	**386.4**	**2984**	**5520.3**	**832**	**647.5**	**4449**	**5422.4**	**1293**	**2721.4**	**2214**	**1377.8**	**2901**	**4100.0**	**2532**	**3466.5**	**5613**	**5174.0**	**1005**	**1709.7**
Farm Animals			639.4		3836.2		21099.2		5754.3		31968.5		8951.2		15984.2		20459.8		17902.3		40280.3		7033.1
Streambank			43.7		1004.9		1878.7		1354.4		3801.1		1092.3		4238.0		2708.9		2097.2		2752.5		1004.9
Groundwater			1148.7		6892.0		37905.8		10338.0		57433.1		16081.3		28716.5		36757.2		32162.5		72365.7		12635.3
Point Sources			3.7		22.2		121.9		33.2		184.7		51.7		92.4		118.2		103.4		232.7		40.6
Septic System			19.4		116.3		639.9		174.5		969.5		271.5		484.8		620.5		542.9		1221.6		213.3
Total			**1892.0**		**12258.0**		**67165.8**		**18301.9**		**99779.3**		**29169.4**		**50893.7**		**64764.6**		**56274.8**		**122026.8**		**22636.9**
Percent of Total Load*			**0.3%**		**2.2%**		**12.2%**		**3.3%**		**18.2%**		**5.3%**		**9.3%**		**11.8%**		**10.2%**		**22.2%**		**4.1%**

*percent does not total 100 due to additional loading from Lebanon County

URBANIZED AREA PHOSPHORUS LOAD BY MUNICIPALITY

		Adamstown Boro.		Akron Boro.		Clay Twp.		Denver Boro.		East Cocalico Twp.		Elizabeth Twp.		Ephrata Boro.		Ephrata Twp.		Warwick Twp.		West Cocalico Twp.		West Earl Twp.	
	Land Use Loading Rate (lb/ac)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)
Hay/Pasture	0.32	15	4.8	54	17.3	689	220.5	151	48.3	1102	352.6	37	11.8	0	0.0	437	139.8	551	176.3	1465	468.8	210	67.2
Cropland	0.71	2	1.4	17	12.1	1016	721.4	40	28.4	759	538.9	531	377.0	30	21.3	652	462.9	558	396.2	717	509.1	289	205.2
Forest	0.02	82	1.6	64	1.3	477	9.5	47	0.9	682	13.6	141	2.8	151	3.0	306	6.1	534	10.7	1972	39.4	62	1.2
Wetland	0.01	0	0.0	0	0.0	2	0.0	17	0.2	30	0.3	2	0.0	7	0.1	2	0.0	2	0.0	116	1.2	0	0.0
Disturbed	0.12	0	0.0	2	0.2	27	3.2	12	1.4	166	19.9	7	0.8	0	0.0	27	3.2	17	2.0	185	22.2	22	2.6
Turfgrass	0.16	0	0.0	15	2.4	0	0.0	0	0.0	126	20.2	0	0.0	49	7.8	0	0.0	0	0.0	0	0.0	0	0.0
Open Land		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	20	0.0	0	0.0	0	0.0	0	0.0
Bare Rock		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Sandy Areas		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
Unpaved Roads		0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0
LD Mixed	0.02	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	10	0.2	0	0.0	7	0.1	0	0.0
MD Mixed	0.06	7	0.4	2	0.1	69	4.1	49	2.9	316	19.0	77	4.6	188	11.3	128	7.7	54	3.2	62	3.7	89	5.3
HD Mixed	0.06	0	0.0	67	4.0	136	8.2	188	11.3	292	17.5	395	23.7	423	25.4	321	19.3	72	4.3	220	13.2	158	9.5
LD Residentail	0.02	0	0.0	7	0.1	143	2.9	25	0.5	203	4.1	0	0.0	12	0.2	89	1.8	89	1.8	437	8.7	0	0.0
MD Residential	0.06	7	0.4	329	19.7	420	25.2	301	18.1	741	44.5	101	6.1	1342	80.5	880	52.8	625	37.5	393	23.6	148	8.9
HD Residential	0.06	0	0.0	0	0.0	0	0.0	0	0.0	10	0.6	0	0.0	0	0.0	2	0.1	20	1.2	12	0.7	10	0.6
Water		0		5		5		2		22		2		12		27		10		27		17	
Subtotal		**113**	**8.7**	**562**	**57.3**	**2984**	**995.0**	**832**	**112.1**	**4449**	**1031.2**	**1293**	**426.9**	**2214**	**149.7**	**2901**	**694.0**	**2532**	**633.3**	**5613**	**1090.8**	**1005**	**300.6**
Farm Animals			168.9		1013.4		5573.6		1520.1		8444.8		2364.5		4222.4		5404.7		4729.1		10640.4		1857.9
Streambank			18.8		433.2		810.0		583.9		1638.8		470.9		1827.1		1167.9		904.1		1186.7		433.2
Groundwater			4.7		27.9		153.6		41.9		232.7		65.2		116.4		148.9		130.3		293.2		51.2
Point Sources			0.3		2.1		11.5		3.1		17.4		4.9		8.7		11.1		9.7		21.9		3.8
Septic System			0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0		0.0
Total			**201.4**		**1533.9**		**7543.7**		**2261.1**		**11364.9**		**3332.4**		**6324.3**		**7426.6**		**6406.5**		**13233.0**		**2646.7**
Percent of Total Load*			**0.3%**		**2.4%**		**12.0%**		**3.6%**		**18.1%**		**5.3%**		**10.1%**		**11.8%**		**10.2%**		**21.1%**		**4.2%**

*Phosphorus loading from Lebanon County is negligible

URBANIZED AREA SEDIMENT LOAD BY MUNICIPALITY

		Adamstown Boro.		Akron Boro.		Clay Twp.		Denver Boro.		East Cocalico Twp.		Elizabeth Twp.		Ephrata Boro.		Ephrata Twp.		Warwick Twp.		West Cocalico Twp.		West Earl Twp.	
	Land Use Loading Rate (lb/ac)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)	Acres	Total Load (lb)
Hay/Pasture	162.2	15	2433	54	8758.8	689	111755.8	151	24492.2	1102	178744.4	37	6001.4	0	0	437	70881.4	551	89372.2	1465	237623	210	34062
Cropland	588.2	2	1176.4	17	9999.4	1016	597611.2	40	23528	759	446443.8	531	312334.2	30	17646	652	383506.4	558	328215.6	717	421739.4	289	169989.8
Forest	18.7	82	1533.4	64	1196.8	477	8919.9	47	878.9	682	12753.4	141	2636.7	151	2823.7	306	5722.2	534	9985.8	1972	36876.4	62	1159.4
Wetland	4.7	0	0	0	0	2	9.4	17	79.9	30	141	2	9.4	7	32.9	2	9.4	2	9.4	116	545.2	0	0
Disturbed	88.5	0	0	2	177	27	2389.5	12	1062	166	14691	7	619.5	0	0	27	2389.5	17	1504.5	185	16372.5	22	1947
Turfgrass	31.8	0	0	15	477	0	0	0	0	126	4006.8	0	0	49	1558.2	0	0	0	0	0	0	0	0
Open Land		0	0	0	0	0	0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0
Bare Rock		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sandy Areas		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Unpaved Roads		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
LD Mixed	6.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	61	0	0	7	42.7	0	0
MD Mixed	20.3	7	142.1	2	40.6	69	1400.7	49	994.7	316	6414.8	77	1563.1	188	3816.4	128	2598.4	54	1096.2	62	1258.6	89	1806.7
HD Mixed	20.3	0	0	67	1360.1	136	2760.8	188	3816.4	292	5927.6	395	8018.5	423	8586.9	321	6516.3	72	1461.6	220	4466	158	3207.4
LD Residentail	6.1	0	0	7	42.7	143	872.3	25	152.5	203	1238.3	0	0	12	73.2	89	542.9	89	542.9	437	2665.7	0	0
MD Residential	20.3	7	142.1	329	6678.7	420	8526	301	6110.3	741	15042.3	101	2050.3	1342	27242.6	880	17864	625	12687.5	393	7977.9	148	3004.4
HD Residential	20.4	0	0	0	0	0	0	0	0	10	204	0	0	0	0	2	40.8	20	408	12	244.8	10	204
Water		0		5		5		2		22		2		12		27		10		27		17	
Subtotal		**113**	**5427**	**562**	**28731.1**	**2984**	**734245.6**	**832**	**61114.9**	**4449**	**685607.4**	**1293**	**333233.1**	**2214**	**61779.9**	**2901**	**490132.3**	**2532**	**445283.7**	**5613**	**729812.2**	**1005**	**215380.7**
Streambank			28439.17		654100.98		1222884.45		881614.37		2474208.07		710979.33		2758599.8		1763228.74		1365080.31		1791667.91		654100.98
Total			**33866.17**		**682832.08**		**1957130.05**		**942729.27**		**3159815.47**		**1044212.43**		**2820379.7**		**2253361.04**		**1810364.01**		**2521480.11**		**869481.68**
Percent of Total Load*			**0.2%**		**3.7%**		**10.7%**		**5.2%**		**17.3%**		**5.7%**		**15.4%**		**12.3%**		**9.9%**		**13.8%**		**4.8%**

*percent does not total 100 due to additional loading from Lebanon County

Appendix E

BMP and Cost Efficiency Data Table

BMP	Unit	Annual Reduction (lbs)			20 Year Reduction (lbs)			Life Cycle Cost ($) (20 yr cycle)			Up Front costs ($)			Maintenance		Cost-Effectiveness ($/lb redcued)			Notes/Source of cost data development	
		TN	TP	TSS	TN	TP	TSS	Low	High	Avg	Low	High	Avg	Value*	UFC/LCC Factor	TN Median	TP Median	TSS Median		
Detension Basin	impervious acre treated	2.49	0.46	184.29	49.78	9.21	3685.75	$89,352	$166,990	$128,171	$63,890	$132,541	$98,216	$29,956	23.37%	$2,575	$13,916	$34.80	King and Hagan (2011)	Typical pond treating 3 impervious acres; new costs mulitplied by 2.3 and 1.5 to convert to retrofit
Hydrodymanic structures	impervious acre treated	2.49	0.46	184.29	49.78	9.21	3685.75	$126,177	$210,163	$168,170	$68,805	$132,541	$100,673	$67,497	40.14%	$3,378	$18,258	$45.60	King and Hagan (2011)	New costs mulitplied by 2.3 and 1.5 to convert to retrofit
Dry Extended Detention Ponds	impervious acre treated	9.96	0.92	1105.71	199.11	18.42	22114.24	$68,056	$99,182	$83,619	$42,593	$73,719	$58,156	$25,463	30.45%	$420	$4,540	$3.80	King and Hagan (2011)	Typical pond treating 3 impervious acres; Retrofit/New
Bioretention/raingardens - no underdrain	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	19.01	2.57	1237.32	380.21	51.49	24746.38	$53,749	$128,493	$91,121	$25,597	$100,340	$62,969	$28,153	30.90%	$240	$1,770	$3.70	King and Hagan (2011)	Retrofit, Highly Urban/ New Suburban, adjusted for lack of underdrain
Bioretention/raingardens - underdrain (A/B soils) (includes bioswale)	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	16.63	1.08	607.95	332.68	21.54	12159.08	$79,346	$228,833	$154,090	$51,194	$200,680	$125,937	$28,153	18.27%	$463	$7,153	$12.70	King and Hagan (2011)	Retrofit, Highly Urban/ New Suburban
Bioretention/raingardens - underdrain (C/D soils)	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	5.94	1.36	756.14	118.82	27.26	15122.78	$79,346	$228,833	$154,090						$1,297	$5,652	$10.20	King and Hagan (2011)	Retrofit, Highly Urban/ New Suburban
Permeable Pavement w/ Sand, Veg. - no underdrain	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	12.06	2.00	1035.74	241.22	40.05	20714.81	$340,774	$461,047	$400,911	$340,674	$460,912	$400,793	$118	0.03%	$1,662	$10,010	$19.40	King and Hagan (2011)	Cost for permeable pavers in addition to asphalt or concrete, adjusted for lack of underdrain
Permeable Pavement w/ Sand, Veg. - underdrain (A/B soils)	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	7.54	1.25	852.96	150.76	25.03	17059.23	$416,036	$562,872	$489,454	$366,316	$495,604	$430,960	$58,494	11.95%	$3,247	$19,555	$28.70	King and Hagan (2011)	Cost for permeable pavers in addition to asphalt or concrete, adjusted for lack of underdrain
Permeable Pavement w/ Sand, Veg. - underdrain (C/D soils)	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	3.02	0.50	670.18	60.30	10.01	13403.66	$416,036	$562,872	$489,454						$8,116	$48,890	$36.50	King and Hagan (2011)	Cost for permeable pavers in addition to asphalt or concrete
Permeable Pavement w/o Sand, Veg. - no underdrain	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	11.31	2.00	1035.74	226.14	40.05	20714.81	$278,890	$377,321	$328,106	$243,339	$329,223	$286,281	$41,825	12.75%	$1,451	$8,193	$15.80	King and Hagan (2011)	Cost for permeable pavers in addition to asphalt or concrete, adjusted for lack of underdrain
Permeable Pavement w/o Sand, Veg. - underdrain (A/B soils)	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	6.78	1.25	852.96	135.68	25.03	17059.23	$297,206	$5,620,673	$2,958,940	$261,654	$354,003	$307,829	$2,651,111	89.60%	$21,808	$118,219	$173.50	King and Hagan (2011)	Cost for permeable pavers in addition to asphalt or concrete
Permeable Pavement w/o Sand, Veg. - underdrain (C/D soils)	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	1.51	0.50	670.18	30.15	10.01	13403.66	$297,206	$5,620,673	$2,958,940						$98,134	$295,559	$220.80	King and Hagan (2011)	Cost for permeable pavers in addition to asphalt or concrete
Sand filter	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	9.51	1.82	1099.84	190.10	36.35	21996.88	$69,934	$94,617	$82,276	$45,488	$61,542	$53,515	$28,761	34.96%	$433	$2,263	$3.70	King and Hagan (2011)	Typical cost of either new or retrofit
Forest Buffers - Urban (Riparian Buffers)	acres in buffer	8.50	0.88	289.16	169.94	17.60	5783.12	$20,379	$27,571	$23,975	$10,420	$14,097	$12,259	$11,717	48.87%	$141	$1,362	$4.10	King and Hagan (2011)	Assumed that 3 acres of buffer treats 1 acre of impervious surface; buffer assumed not developable - no land costs
Disconnection of rooftop runoff and rain barrels	impervious acre treated	6.39	1.98	1062.28	127.79	39.54	21245.56	$147,989	$200,221	$174,105	$89,351	$120,886	$105,119	$68,987	39.62%	$1,362	$4,403	$8.20	King and Hagan (2011)	Includes concrete/asphalt removal and site restoration; land costs reflect one acre purchased per one impervious acre treated.
Infiltration Basin w/ Sand, Veg	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	42.31	3.91	1750.71	846.25	78.27	35014.15	$120,522	$159,679	$140,101	$100,340	$135,754	$118,047	$22,054	15.74%	$166	$1,790	$4.00	King and Hagan (2011)	New costs mulitplied by 1.5 to convert to retrofit
Infiltration Basin w/o Sand, Veg	impervious acre treated+ ~4x acres of pervious (based on ratio of impervious/pervious in LR Segment)	39.82	3.91	1750.71	796.47	78.27	35014.15	$115,285	$155,974	$135,630	$95,753	$129,548	$112,651	$22,979	16.94%	$170	$1,733	$3.90	King and Hagan (2011)	New costs mulitplied by 1.5 to convert to retrofit
Septic System Hook-ups	system	2.98	0.00	0.00	59.67	0.00	0.00	$115,285	$155,974	$135,630	$2,060	$10,300	$6,180	$129,450	95.44%	$2,273			Nephin (2012); Tassone (2011)	Conversion from septic system to sewer system hookup
Tree Planting - Urban	acre	6.00	0.42	102.95	120.00	8.32	2059.09	$219,522	$297,000	$258,261	$36,041	$48,761	$42,401	$215,860	83.58%	$2,152	$31,045	$125.40	King and Hagan (2011)	Assumes that 3 acres of tree planting treats 1 acre of impervious surface
Urban Nutrient Management	acre	1.48	0.12	0.00	29.54	2.31	0.00	$67,124	$90,815	$78,970	$66,620	$90,133	$78,377	$593	0.75%	$2,674	$34,118		King and Hagan (2011)	Includes direct mailings to medium density households (5,941 square feet of turf and 2,406 sf of impervious cover); 2 percent participation
Urban Stream Restoration	foot	0.07	0.05	185.07	1.32	0.95	3701.41	$849	$1,149	$999	$704	$953	$829	$171	17.07%	$757	$1,056	$0.27	King and Hagan (2011)	Typical project size of 300 linear feet; 100 linear feet of stream restoration assumed to treat one impervious acre
Wet Ponds & Wetlands	acre treated	9.96	2.07	1105.71	199.11	41.44	22114.24	$40,919	$84,476	$62,698	$26,337	$69,895	$48,116	$14,582	23.26%	$315	$1,513	$2.80	King and Hagan (2011)	Retrofit/New; typical pond treats 3 impervious acres
Flood Plain Restoration (FPR)	foot	0.07	0.05	185.07	1.32	0.95	3701.41	$355	$1,204	$780	$210	$1,008	$609	$171	21.87%	$591	$824	$0.21	King and Hagan (2011); M. LaSala, LandStudies, Inc., comm. to H. Fisher, February 2013	Upfront cost based on Lancaster County restoration projects; annual costs based on urban stream restoration annual costs

BMP	Unit	Annual Reduction (lbs)			20 Year Reduction (lbs)			Life Cycle Cost ($) (20 yr cycle)			Up Front costs ($)			Maintenance		Cost-Effectiveness ($/lb redcued)			Notes/Source of cost data development	
		TN	TP	TSS	TN	TP	TSS	Low	High	Avg	Low	High	Avg	Value*	UFC/LCC Factor	TN Median	TP Median	TSS Median		
Septic system denitrification	system	1.49	0.00	0.00	29.83	0.00	0.00	$10,625	$14,375	$12,500	$10,625	$14,375	$12,500	$0	0.00%	$419			Tt project experience	Cost of nitrogen removal system to achieve modeled load reduction (50% reduction in total nitrogen)
Septic pumping	system	0.15	0.00	0.00	2.98	0.00	0.00	$3,161	$4,277	$3,719	$3,161	$4,277	$3,719	$0	0.00%	$1,247			Tt project experience	Frequency assumed annual
Green Roof	impervious acres treated	6.39	1.98	1062.28	127.79	39.54	21245.56	$435,600	$1,132,560	$784,080	$435,600	$1,132,560	$784,080	$0	0.00%	$6,136	$19,828	$36.90	M. Gattis, Lancaster Count Planning Commission, personal communication to H. Fisher, February 2012	PA DEP Energy Harvest Grant funded Lancaster County Roof Greening Project; upfront cost includes 2 years of maintenance

Appendix F

CBPRP Template

Chesapeake Bay Pollutant Reduction Plan

Cocalico Creek Watershed

Municipality Name, Lancaster County, PA

MS4 Permit # XXXXXXXXXX

DATE

TEMPLATE

Prepared by:

Consultant/Engineer Name

Address

Address

Prepared for:

Municipal Name

Address

Address

Table of Contents

Table of Appendices

1 Introduction

1.1 Purpose

This Chesapeake Bay Pollutant Reduction Plan (CBPRP) was developed to outline and administer the requirements set forth in the Municipal Separate Storm Sewer System (MS4) Permit No. ##### (National Pollutant Discharge Elimination System (NPDES) Stormwater Discharges From Small Municipal Separate Storm Sewer Systems (MS4s) General Permit (PAG-13)) for NAME OF MUNICIPALITY—specifically Section 3 of Part C (Other Conditions) in the Authorization to Discharge. Additionally, this CBPRP addresses Section B sub- sections 1-4 as outlined on Pennsylvania Department of Environmental Protection (PADEP) Form 3800-FM-BPNPSM0493 for CBPRPs.

1.2 CBPRP Development

NAME OF MUNICIPALITY cooperated with other municipalities with regulated MS4s in the Cocalico Creek watershed in Lancaster County, PA for the development of a baseline study and template addressing requirements for a CBPRP. Section 2 outlines the baseline results of the cooperative approach. Section 3 outlines specific information for NAME OF MUNICIPALITY, and as required by PADEP for the CBPRP.

2 Cocalico Creek CBPRP Baseline

2.1 Purpose of Watershed Approach

The purpose of a watershed-based approach for CBPRP development is to establish reasonable baseline nutrient and sediment loading conditions within the Cocalico Creek watershed, as well as delineating loads from urbanized areas within the watershed. MapShed was used to quantify loadings. This information will be used to spearhead a cooperative effort of municipalities within the watershed, and to develop their individual Chesapeake Bay Pollution Reduction Plans (CBPRPs) which are required by their Municipal Separate Storm Sewer System (MS4) permits. MS4 permits are required for municipalities with “Urbanized Areas” as determined by the 2010 Census. The CBPRP must address nutrient and sediment loadings to streams from the regulated MS4 draining to the Chesapeake Bay.

A purpose of the CBPRP is for municipalities to explain and outline efforts to reduce Nitrogen, Phosphorus, and sediment loads delivered to waterways and ultimately the Chesapeake Bay through the implementation of Best Management Practices (BMPs). Although the permit requirements are for individual municipalities it is often practical to model an entire watershed and use the results as a tool to determine what kind and where BMPs can be implemented most cost effectively to improve overall water quality in the watershed.

2.2 Cocalico Creek Watershed Characteristics

The Cocalico Creek is located in Northern Lancaster County with a small portion extending in to Lebanon and Berks Counties. It is located within Hydrologic Unit Code (HUC) 02050306 and is a tributary of the Conestoga River. The watershed is 89,611 acres or 140 square miles. The majority of the watershed, 70,500 acres, is within Lancaster County. Primary tributaries to the Cocalico Creek include Hammer Creek, Middle Creek, Indian Run and the Little Cocalico Creek.

Watershed Impairments

Approximately 52.3 miles of stream within the Cocalico Creek Watershed are listed as impaired in the 2012 Pennsylvania Integrated Water Quality Assessment Report 303(d) list. Sources of impairments listed are primarily crop and grazing related agriculture resulting in nutrients and siltation. There are also small tributaries impaired by siltation and habitat alteration by urban runoff and storm sewers as well as nutrients from small residential runoff. A Total Maximum Daily Load (TMDL) has not been established. The target TMDL establishment date called out in the 303(d) list is 2015.

Land Use

The primary land uses within the watershed are agriculture and forest. Hay and row crops represent 43% of the watershed and forest cover is 39%. Baseline data was compiled using the 2005 PAMap Program Land Cover for Pennsylvania dataset, modified to fit the grid classification system for MapShed. Approximately 24,655 acres (~35%) of the land cover in Lancaster County portion of the watershed is located within the Urbanized Area per the 2010 census map. A GIS exercise to determine the land cover for each municipality was performed and the resulting data was provided to municipalities to confirm or edit based on first-hand knowledge. The results are provided in Table 1.

Table 1. Land Cover within the Cocalico Creek Watershed

Land Cover	Acreage
Hay	17,804
Row Crops	20,759
Forest	34,642
Disturbed	786
Water/Wetland	1,747
Turf/Golf	324
Low Density Residential (<30% impervious)	2,575
Medium Density Residential (30%-75%impervious	6,254
High Density Residential (>75% impervious)	52
Low Density Mixed Urban (<30% impervious)	54
Medium Density Mixed Urban (30%-75% impervious	1,416
High Density Mixed Urban (>75% impervious)	3,151

Additional details associated with the Cocalico Creek Watershed can be found in Appendix A (Cocalico Creek CBPRP Baseline Report).

2.3 Watershed Baseline

Sediment, Nitrogen and Phosphorus loading were modeled using MapShed. MapShed is a GIS-based watershed modeling tool which was developed by the Penn State Institute of Energy and the Environment (PSIEE). MapShed is a customized interface that is used to automatically create input data for the watershed model. In utilizing this interface, the user is prompted to identify required GIS files and to provide other "non-spatial" model information. This information is subsequently used to derive values for required model input parameters which are then written to the various input files needed for model execution. Also accessed through the interface is regional climate data stored in Excel-formatted files that are used to create the necessary "weather" data for a given watershed simulation. With MapShed, a user selects areas of interest, creates model input files, runs a simulation model, and views the output in a series of seamless steps. For more information regarding MapShed modeling procedures, refer to the MapShed Users Guide (Evans and Corradini, 2014), or the MapShed website (www.mapshed.psu.edu).

Information and details associated with the baseline model can be found in Appendix A. This information can help to focus BMP implementation efforts.

The highest annual nutrient loading rates within the watershed are as follows:

- groundwater (stream baseflow) at 1,148,660 lbs N
- livestock at 639,368 lbs N and 168,895 lbs P,
- cropland at 91,074 lbs N and 14,814 lbs P,
- streambank erosion at 43,689 lbs N and 18,834 lbs P,
- septic systems at 19,390 lbs N; and
- pasture at 15,876 lbs N and 5755 lbs P

The highest annual sediment loading rates within the watershed are as follows:

- streambank erosion at 14,219 tons,
- cropland at 6,105 tons; and
- pasture at 1,444 tons.

Medium Density Residential land cover accounted for the highest Nitrogen, Phosphorus and sediment loadings (3,738.2 pounds, 402.7 pounds and 127,200 pounds respectively) in the urban land use classifications. Agriculture (cropland, pasture, and livestock) represents 38 percent of the nitrogen loading, 88 percent of the phosphorus loading and 9 percent of the sediment loading. Streambank erosion represents 2 percent of the nitrogen loading and 64 percent of the sediment loading. It should be noted, the greatest source of sediment loading in the watershed—including both urban and agricultural areas—is not directly associated with land use but with the erosion of streambanks. It should also be noted that stream baseflow accounts for over 58% of the total nitrogen load via groundwater discharge, which drives down the reported percentages of the total nitrogen load from other, more readily controlled sources.

2.4 Urbanized Area Baseline (watershed-based)

The MapShed Urban Area tool provides an ability to delineate nutrient and sediment loadings in the regulated Urbanized Area based on land uses. Table 2 outlines loadings calculated by MapShed for the Urbanized Area in the watershed.

Table 2. Urbanized Area (UA) loadings in the Cocalico Creek Watershed

	Nitrogen (lb/yr)	Phosphorus (lb/yr)	Sediment (lb/yr)
UA (land uses)	29,960.1	5532.8	1,900
UA (other load contributors)	514,600.1	56,774.9	7,152
Total	544,560.2	62,307.7	9,040

Table 2 further provides a delineation of calculated loadings from “other load contributors” (sources other than land use classifications). UA (other load contributors) is the collective values of additional pollutant contribution factors calculated by MapShed; and include livestock, streambanks, groundwater, non-MS4 point sources, and septic systems (see The Cocalico Creek Baseline Study in the appendix for more information). Streambank erosion contributes the greatest sediment loading value across the watershed by a significant margin, including within the Urbanized Area boundaries. These values along with the other output data reveal the following considerations:

- 63.8% of the total annual sediment loading is contributed by streambank erosion
- 58.2% of the total annual nitrogen loading is contributed by groundwater
- 78.5% of the total annual phosphorus loading is contributed by livestock
- The Urbanized Area (land use loading) nutrient and sediment loadings only account for approximately 25% of the total loadings across the pollutants of concern.

2.5 Watershed Approach

Establishment of a baseline provides the municipalities of the Cocalico Creek Watershed an ability to coordinate more effectively the implementation of Best Management Practices (BMPs) to focus and address appropriate pollutant loadings for individual CBPRPs. Efforts may be coordinated with the Cocalico Creek Watershed Alliance. This will, in turn, promote the goals and objectives of Minimum Control Measure #2 (Public Involvement and Participation) of the Stormwater Management Program (SWMP) in the issued MS4 Permit as well. A cooperative approach with focus on the largest pollutant contributors would result in significant reductions in lieu of applying limited resources to sources of pollutants providing very minimal loadings. For example, watershed-wide focus on the improvement of streambank erosion will provide the greatest reductions in the overall health of the watershed. The final recommendations of the Cocalico Creek CBPRP Baseline Report included:

- Significant reductions could be achieved within the Urbanized Area boundaries with a focus directed towards streambank erosion and assisting the agricultural sector
    - Multi-municipal and coordinated efforts may provide the best opportunities to address streambank erosion and assisting the agricultural sector
- MD Residential, HD Mixed Use, and MD Mixed Use should be the “up-land” focus of land use BMP implementation efforts. However, loadings from these land uses are relatively minimal compared to the largest sources estimated by MapShed. BMPs could be implemented in conjunction with planned public works projects.
- The BMP Cost and Efficiency Table should be used to establish preliminary pollutant reduction values and assist with identifying monetary funding required for up-front implementation during the planning stage
    - More appropriate methodologies such as the modified Expert Panel methodology should be used during the conceptual design and design & permitting stages once site specific conditions are known.
    - Updated reductions calculated can be provided in Annual Report submissions
- BMP Implementation schedules should follow a planning-conceptual design-design & permitting-construction sequence of events
    - Operation & Maintenance (O&M) requirements and responsibilities should be addressed at each stage

The baseline report provides further information of modeling results associated with land uses and contributors to pollutant loadings.

3 NAME OF MUNICIPALITY CBPRP

3.1 Narrative Description

NAME OF MUNICIPALITY is located in northern Lancaster County, PA within the Cocalico Creek Watershed. NAME OF MUNICIPALITY is comprised of XXXXX acres; and includes—but is not limited to—residential, commercial, institutional, open space, and agricultural land uses. XX% (or XXXX acres) is located within the regulated Urbanized Area of the municipality. XX% of the Urbanized Area includes components of the MS4 (e.g. piping, outfalls, etc.). The regulated MS4 discharges to the following waterways:

- List waterways

MapShed was used to derive and organize the nutrient and sediment loadings in the Urbanized Area across the Cocalico Creek watershed and by individual municipality. Table 3 provides the delineation of pollutant loadings and land use contributions for NAME OF MUNICIPALITY in the Urbanized Area.

Table 3. UA Baseline Summary for NAME OF MUNICIPALITY

INSERT INDIVIDUAL MUNICIPAL LOADING TABLE

	Acres	Percent Impervious Model Assumption	Nitrogen Total Load (lb)	Phosphorus Total Load (lb)	Sediment Total Load (Tons)
Hay/Pasture	XXX		XXX	XXX	XXX
Cropland	XXX		XXX	XXX	XXX
Forest	XXX		XXX	XXX	XXX
Wetland	XXX		XXX	XXX	XXX
Disturbed	XXX		XXX	XXX	XXX
Turfgrass	XXX		XXX	XXX	XXX
Open Land	XXX		XXX	XXX	XXX
Bare Rock	XXX		XXX	XXX	XXX
Sandy Areas	XXX		XXX	XXX	XXX
Unpaved Roads	XXX		XXX	XXX	XXX
LD Mixed	XXX	15%	XXX	XXX	XXX
MD Mixed	XXX	52%	XXX	XXX	XXX
HD Mixed	XXX	87%	XXX	XXX	XXX
LD Residential	XXX	15%	XXX	XXX	XXX
MD Residential	XXX	52%	XXX	XXX	XXX
HD Residential	XXX	87%	XXX	XXX	XXX
Water	XXX	0	XXX	XXX	XXX
Subtotal	**XXX**		**XXX**	**XXX**	**XXX**
Farm Animals			XXX	XXX	
Streambank			XXX	XXX	XXX
Groundwater			XXX	XXX	
Point Sources			XXX	XXX	
Septic System			XXX	XXX	
Total			**XXX**	**XXX**	**XXX**

Table 3 provides a qualitative and quantitative description of the land uses within the Urbanized Area. The residential and mixed use land use categories encompass a variety of zoning classifications including commercial, institutional, and so on. MapShed categorizes the land use distribution based on impervious coverage as follows:

- Light Density Residential/Mixed Use: <30% impervious coverage
- Medium Density Residential/Mixed Use: 30%-75% impervious coverage
- High Density Residential/Mixed Use: >75% impervious coverage

Impervious coverage is considered "minimal" for other categories (e.g. hay/pasture, open space, turf/golf, etc.). Based on the above categorization and information outlined in Table 3, impervious coverage was calculated to be XX% of the Urbanized Area. See derived calculations in Appendix B. The balance of coverage is considered pervious.

3.2 Municipal Infrastructure Upgrades

Insert narrative regarding where municipal infrastructure upgrades are planned and outline an evaluation of the suitability of GI, LID or ESD BMPs

3.3 Loading Estimates

Despite the optional tag for this component, NAME OF MUNICIPALITY has elected to address pollutant loadings in a more effective manner as a part of a coordinated multi-municipal effort. Table 2 outlines the estimated loadings within the Urbanized Area of the watershed. Table 3 provides estimated loadings by categorized land uses and other contributors in the municipality. Appendix A contains the complete Cocalico Creek Baseline Study and CBPRP Implementation Strategies that summarizes the methodology and processes associated with establishing estimated Nitrogen, Phosphorus, and sediment loadings.

The largest sources of Nitrogen, Phosphorus, and sediment loadings within the Urbanized Areas of the watershed and within the municipality itself were determined to be:

- Nitrogen: groundwater (stream baseflow)
- Phosphorus: livestock (Medium Density Residential was determined to be the largest contributor by urban land use categorization (see Table 3))
- Sediment: streambank erosion

3.4 BMP Implementation

NAME OF MUNICIPALITY plans to implement appropriate BMPs to the Maximum Extent Practicable with a focus on the sectors and primary pollutant contributors in the Urbanized Area for reductions as outlined in the Cocalico Creek Baseline Study and CBPRP Implementation Strategies.

The following BMP(s) will be implemented to satisfy the requirements of the issued MS4 Permit and achieve reductions in nutrients and sediment loadings delivered to the Chesapeake Bay:

BMP: Name of BMP (and approximate quantity)
BMP Identification: Name, number, or other
Location of BMP: general description and long/lat info
Status of BMP Implementation: Planning, Conceptual, Design, Other stage
Milestones for BMP Implementation
- Planning: DATE
- Conceptual Design: DATE(s)
- Design & Permitting: DATE(s)
- Construction: DATE(s)

Estimated Reductions
- Nitrogen: AMOUNT
- Phosphorus: AMOUNT
- Sediment: AMOUNT

Rationale for BMP Selection: The BMP selected provides the best ability for Name of Municipality to achieve significant nitrogen and sediment reductions to the Maximum Extent Practicable. Additionally, this BMP focuses on a significant contributor as identified in the Cocalico Creek Baseline Study and Implementation Strategy Report. Insert additional narrative as applicable

BMP Operation & Maintenance (O&M): Insert description

Additional BMP Information: Insert as applicable

4 Certifications

4.1 Engineer Certification

I, being a Registered Professional Engineer in Pennsylvania, do hereby certify to the best of my knowledge and belief, that the Chesapeake Bay Pollutant Reduction Plan is designed to achieve pollutant reductions consistent with the goals in the Chesapeake Bay Watershed Implementation Plan.

Professional Engineer Name: Insert

Signature: ______________________________

Engineer's Seal

Date: Insert
License No: Insert
License Expiration Date: Insert
Company: Insert
Telephone: Insert

4.2 Responsible Official Certification

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system or those persons directly responsible for gathering information, the information is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowledge of violations. See 18 Pa. C.S. § 4904 (relating to unsworn falsification).

______________________________	______________________________
Name of Responsible Official	Signature
______________________________	______________________________
Telephone No.	Date

Appendix A
Cocalico Creek Watershed
Baseline Study and Implementation Strategies Report

Appendix B
CBPRP Calculation Sheets