Londonderry Township

Dauphin County, Pennsylvania

Chesapeake Bay Pollutant Reduction Plan

Amendment 1

March 2022

HRG Project No. R001068.0436

HRG
Herbert, Rowland & Grubic, Inc.
Engineering & Related Services
AN EMPLOYEE-OWNED COMPANY

LONDONDERRY TOWNSHIP

DAUPHIN COUNTY, PENNSYLVANIA

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INTRODUCTION

Londonderry Township discharges stormwater to surface waters located within the Chesapeake Bay Watershed and is therefore regulated by PAG-13 General Permit, Appendix D (nutrients and sediment in stormwater discharges to waters in the Chesapeake Bay Watershed). The Township also has watershed impairments regulated by PAG-13 General Permit, Appendix E (nutrients and/or sediment in stormwater discharges to impaired waterways). This Chesapeake Bay Pollutant Reduction Plan (CBPRP) was developed in accordance with both PAG-13 requirements and documents how the Township intends to achieve the pollutant reduction requirements listed in the Pennsylvania Department of Environmental Protection (PADEP) Municipal MS4 Requirements Table[1].

This document was prepared following the guidance provided in the PADEP National Pollutant Discharge Elimination System (NPDES) Stormwater Discharges from Small Municipal Separate Storm Sewer Systems Pollutant Reduction Plan (PRP) Instructions[2] and serves as an addendum to the currently approved PRP.

General Information	
Permittee Name: Londonderry Township	**NPDES Permit No.:** PAG133547
Mailing Address: 783 S Geyers Church Road	**Effective Date:** 3/16/18
City, State Zip: Middletown, PA 17057	**Expiration Date:** 3/15/23
MS4 Contact Person: Monique Dykman	**Renewal Due Date:** 9/16/22
Title: Township MS4 Environmental Coordinator	**Municipality:** Londonderry Township
Phone: 717-944-1803	**County:** Dauphin
Email: mdykman@londonderrypa.org	**Consultant Name**: Herbert, Rowland & Grubic, Inc.
Co-Permittees (if applicable): N/A	**Consultant Contact:** Shawn E. Fabian, CPESC, CPSWQ 369 East Park Drive Harrisburg, PA 17109 (717) 564-1121 sfabian@hrg-inc.com

Londonderry Township is a small MS4 Community currently in its third permit term. The Township is approximately 15-percent developed and has 2,112.7 acres of Urbanized Area (UA) according to the United States Census Bureaus' 2010 census.

Londonderry Township is located in the Conewago Creek, Swatara Creek-Susquehanna River, and Laurel Run-Susquehanna River HUC-12 watersheds. The Conewago Creek and Swatara Creek-Susquehanna River watersheds have been classified as impaired by PADEP. The Pollutant Reduction Plan (PRP) requirements for these impaired watersheds are included within this CBPRP.

[1] PADEP, MS4 Requirements Table (Municipal) (rev. 5/9/2017)
[2] PADE PRP Instructions; Document #3800-PM-BCW0100k (rev. 3/2017)

SUMMARY OF PROPOSED AMENDMENTS

All proposed amendments are included in the following pages. They have been structured so that once approved, they can fully replace the equivalent section, figure, or table in the original PRP.

Section A: Public Participation
Amended to meet the requirements for public comment on the Amendment 1 portion of the Chesapeake Bay Pollutant Reduction Plan.

Section B: Map
No amendments proposed.

Section C: Pollutants of Concern
No amendments proposed.

Section D: Determine Existing Loading for Pollutants of Concern
No amendments proposed.

Section E: Select BMPs to Achieve the Minimum Required Reductions in Pollutant Loading
Amended to show the proposed BMPs updates.

Section F: Identify Funding Mechanisms
No amendments proposed.

Section G: Identify Responsible Parties for Operation and Maintenance (O&M) of BMPs
No amendments proposed.

Appendix A: Public Participation Documentation
Amended to display updated documentation of public participation for Amendment 1.

Appendix B: Mapping
No amendments proposed.

Appendix C: PADEP Municipal MS4 Requirements Table
No amendments proposed.

Appendix D: Existing Pollutant Load Reduction Calculations
No amendments proposed.

Appendix E: Proposed BMP Pollutant Load Reduction Calculations
Amended to show updated proposed BMP load reduction calculations.

SECTION A: PUBLIC PARTICIPATION

A complete copy of this CBPRP addendum was made available for the public to review at the Londonderry Township municipal office from XXXXX XX, XXXX to XXXXX XX, XXXX. The availability of the document was publicized on the Township website for 30 days and published in *The Patriot News* on XXXXX XX, XXXX. The published public notice contained a brief description of the plan, the dates and locations at which the plan was available for review by the public, and the length of time provided for the receipt of comments. Copies of the public notice as posted on the Township website and published in *The Patriot News* are included in Appendix A.

Written comments were accepted for 30 days following the publication date of the public notice, *(Public comments addressed here).*

The information contained in this report was presented to the public during the regularly scheduled Londonderry Township Board of Supervisor's meeting held on XXXXX XX, XXXX. Comments and questions regarding the CBPRP addendum were received during the public presentation.

SECTION E: BMPS TO ACHIEVE THE REQUIRED POLLUTANT LOADING REDUCTIONS

E.1 Required Pollutant Reduction Calculation

No proposed changes for this section.

E.2 Proposed BMPs

The following section outlines the BMP implementation strategy developed to achieve the required pollutant load reduction goals stated in Section E.1. The proposed BMPs were determined through discussions with municipal staff, in-field site assessments, and public outreach meetings.

A summary of the type and scale of BMP projects included in the pollutant reduction strategy is listed in Table 7. The pollutant loading reductions for each proposed BMP were calculated in terms of pounds per year using PADEP's standard BMP Effectiveness Values[3] and Master Stream Restoration Crediting Guide[4]. Complete calculations for the anticipated pollutant load reductions for each BMPs listed below is provided in Appendix E.

Table 7: Londonderry Township Proposed BMP Summary

Proj Site	BMP ID	BMP Type	Planning Area	Length (ft)	Drainage Area (acres)	Load Reduction TSS (lbs/yr)
Former Davis Greenhouse	BMP-1	Bioswale A Restoration	CBPRP/ Conewago Creek	185	8.0	3,658
		Bioswale B Restoration		95	10.0	4,572
		Conewago Creek Stream Restoration (Including Brills Run)	CBPRP/ Conewago Creek	6,382	n/a	1,260,683
Township Fire Station	BMP-2	Detention Basin Retrofit	CBPRP/ Swatara Creek	100	2.5	1,157
Hills of Waterford	BMP-3	Detention Basin Retrofit	CBPRP/Swatara Creek	130	6.5	3,009
Total						**1,273,079**

E.3 BMP Project Descriptions

Londonderry Township has an active environmental department that works closely with the public works department, investigates and responds to citizen stormwater concerns, and conducts regular inspections of the Township MS4, existing BMPs, and streams. Therefore, it is anticipated that during the permit term, the MS4 Environmental Coordinator may discover other opportunities to implement BMPs elsewhere in the Township.

[3] PADEP Document 38-99-PM-BCW0100M, NPDES Stormwater Discharges from Small MS4s, BMP Effectiveness Values (5/2015)
[4] A Unified Guide for Crediting Stream and Floodplain Restoration Projects in the Chesapeake Bay Watershed (Wood, Schueler and Stack, 2021).

When this occurs, the potential projects will be evaluated in terms of cost, pollutant load reduction potential, and ease of implementation. If it is determined that a different BMP project will achieve the pollutant load reduction requirements outlined in Section E.1, in a more cost-effective manner or otherwise provide additional benefit to the Township, the Township may opt to replace the BMP projects listed below with the new project. If this occurs, site plans, design details, and pollutant load reduction calculations for each newly proposed project will be documented in the Annual Status Reports.

The following BMP strategy outlines the type and scale of BMPs that are required to meet the Township's pollutant load reduction goal. The proposed BMP projects described below are conceptual and have not been fully designed, with exception to the Former Davis Greenhouse Projects which have been fully designed at permitted. These projects are intended for planning purposes only. The proposed projects have been evaluated in terms of preliminary feasibility and estimated pollutant load reductions in order to meet the goals of this plan.

Former Davis Greenhouse Bioswale - This site is located in the southeastern portion of the Township between Hoffer Road and the Conewago Creek. In addition to bordering the Conewago Creek, this site also contains two small unnamed tributary streams which have been partially filled in. This project proposes to retrofit the former tributary streams into bioswales. The bioswales will utilize the existing natural drainage pathways at the site. From the site topography, it is estimated that the bioswale on the west side of the site (proposed Bioswale A) will receive drainage from approximately 8 acres and the bioswale on the east side of the site (proposed Bioswale B) will received drainage from approximately 10 acres.

The existing channels will be retrofitted into bioswales through the addition of amended soil media (compost/soil mix) to facilitate infiltration and then lined with an assortment of native plantings to assist in the filtration of pollutants. The bioswales will be designed to infiltrate the anticipated runoff volume from the 2-year storm. As the majority of annual precipitation comes from frequent, small rain events, the bioswales are anticipated to provide significant water quality improvement by infiltrating and filtering nearly all of this runoff. During heavier storm events that exceed the bioswale's infiltration capacity, the bioswales improve water quality by infiltrating the "first flush" of storm water runoff. The first flush is the initial surface runoff of a rainstorm which generally has a higher concentration of pollutants when compared to runoff from the remainder of the storm. After the initial runoff is trapped by the bioswale for infiltration, the bioswale plantings will provide some filtration for any additional runoff conveyed by the bioswale to the Conewago Creek rather than infiltrated.

Former Davis Greenhouse/Conewago Creek Stream Restoration – This project proposes stream and floodplain restoration along 4,960-LF of the Conewago Creek and 1,422-LF of the tributary Brills Run. The restoration originates immediately downstream of the Hertzler Rd bridge on Brills Run, and approximately 3,500-LF downstream of the Mill Rd bridge on the mainstem. The restoration continues through the Brills Run-Conewago Creek confluence and downstream through an existing farm bridge to its terminus approximately 750-LF upstream of the PA-230 bridge.

The purpose of this project is to restore Conewago Creek, Brills Run, the associated floodplain, and existing wetland system as close as possible to historical pre-settlement conditions by removing legacy sediment from the floodplain. The stream restoration will include both structural repairs (as needed), in-stream calming measures (rock vanes, wing deflectors, etc.) to decrease water velocity and direct stream flow away from eroding streambanks. The structures will be constructed of natural materials such as rock, root wads, and logs. If needed, additional plantings will be added to areas in which the existing riparian buffer is in poor condition. Buffer rehabilitation will include the removal and replacement of dead and diseased vegetation, as well as the addition of new plantings to provide further streambank stabilization. The exact number and locations for structural and in-stream structures, and riparian planting areas will be determined during engineering design of the project. The Township anticipates partnering with neighboring municipalities and private property owners to complete this project.

Basin Retrofits – Two existing detention basins in the Swatara Creek PRP Planning Area are proposed for basin retrofits, the Londonderry Township Fire Station basin, and the Hills of Waterford residential community basin. As currently constructed, these detention basins receive, temporarily hold, and discharges stormwater at a controlled rate. While this can provide rate and volume control, the basins offer only a limited water quality benefit. The only water quality benefit is realized through minimal infiltration. This project proposes to retrofit the existing basins with bioretention features to transform the basins from a simple catch, store, and release ponds into a BMPs which will provide infiltration and improved sediment and nutrient removal capabilities. These benefits are achieved by extending the storage time by modifying the structure, improving soil conditions to allow for greater infiltration rates, and naturalizing the basins with native and/or wetland plant species.

The extent and nature of the retrofits will rely on the results of future engineering investigations, however for modeling purposes, the load reduction attributed to the basin retrofits were calculated by applying the standard bioretention removal efficiency to only the portion of the stormwater runoff not currently being treated by the basins. Therefore the pollutant load reduction attributed to a basin retrofit is slightly lower than the pollutant load reduction of a similarly-sized new bioretention basin.

Table 8: BMP Implementation Schedule

Proj Site	BMP ID	BMP Type	Permitting & Engineering Design (Permit Year)	Construction/Reporting (Permit Year)
Former Davis Greenhouse	BMP-1	Bioswale A Restoration	1-3	4/5
		Bioswale B Restoration		
		Conewago Creek Stream Restoration (Including Brills Run)		
Township Fire Station	BMP-2	Detention Basin Retrofit	TBD	TBD
Hills of Waterford	BMP-3	Detention Basin Retrofit	TBD	TBD

E.4 BMP Project Location Evaluation

No proposed changes for this section.

APPENDIX A

Public Participation Documentation

Notice of Public Participation & Public Meeting Notice Published on Township Website
(https://www.londonderrypa.org/announcements.php)

Photo of post on website to be added

Notice of Public Participation & Public Meeting Notice from Patriot News (XXXXX XX, XXXX)

Photo of Patriot News Reciept and Notice to be added

Replace page with public meeting agenda

Replace page with public meeting minutes

Public Comments Received & Record of Consideration

Public comments to be addressed here when received.

APPENDIX E

Proposed BMP Pollutant Load Reduction Calculations

Appendix E – Table 1: Proposed BMPs

BMP ID	BMP Type	Planning Area	Lat	Long	Size (acre) / length (ft)	Drainage Area (acres)	Urbanized Area				Loading Rate TSS (lb/ac/yr)		Loading TSS (lb/yr)	BMP Efficiency***	Load Reduction TSS (lb/yr)
							% Imperv.	% Pervious	Imperv. (acres)	Pervious (acres)	Imperv.	Pervious			
BMP-1	Bioswale A Restoration	CBPRP/ Conewago Creek PRP	40.16754	-76.638351	185	8.42	11%	89%	0.92	7.50	1,999.14	299.62	4,091.8	80%	3,273
	Bioswale B Restoration				95	10.86	11%	89%	1.16	9.71	1,999.14	299.62	5,221.9	80%	4,178
	Conewago Creek Stream Restoration (Including Brills Run)				6,382	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	See attached calculations	1,260,683
BMP-2	Fire Station Basin Retrofit	CBPRP/ Swatara Creek	40.190520	-76.690816	0.05	2.46	13%	87%	0.32	2.14	1,999.14	299.62	1,280.7	78%	899
BMP-3	Hills of Waterford Basin Retrofit	CBPRP/ Swatara Creek	40.225107	-76.657813	0.04	7.98	5%	95%	0.41	7.57	1,999.14	299.62	3,088.5	79%	2,196
Total															**1,273,079**

*PADEP - Statewide MS4 Land Cover Estimates

**PADEP PRP Instructions - Attachment B, Developed Land Loading Rates for PA Counties

***PADEP - BMP Effectiveness Value

Conewago Creek Floodplain Restoration

Load Reduction Summary

LSI Project No. D-131.14-18

October 28, 2021 – REV 1

Introduction

Londonderry Township's Conewago Creek Floodplain Restoration Project proposes floodplain restoration along 4,960-LF of the Conewago Creek (TSF/MF) and 1,422-LF of the tributary Brills Run. The restoration originates immediately downstream of the Hertzler Rd bridge on Brills Run, and approximately 3,500-LF downstream of the Mill Rd bridge on the mainstem. The restoration continues through the Brills Run-Conewago Creek confluence and downstream through an existing farm bridge to its terminus approximately 750-LF upstream of the PA-230 bridge.

The purpose of this project is to restore Conewago Creek, Brills Run, the associated floodplain and existing wetland system as close as possible to historical pre-settlement conditions by removing legacy sediment from the floodplain. The effort will provide significant sediment and nutrient load reductions within the watershed. Both Londonderry and Mt. Joy Township intend to use the resulting load reductions to contribute toward obligations of their respective Pollutant Reduction Plans. This summary documents the assessment, monitoring & calculations used to predict the sediment load reduction provided by the restoration.

Site Assessment and Monitoring

As part of the geomorphic site assessment completed prior to the floodplain restoration, bank erosion rates were estimated using the Bank Assessment for Non-point source Consequences of Sediment (BANCS) method, which utilizes a Bank Erodibility Hazard Index (BEHI) and Near Bank Stress (NBS) evaluation to approximate annual bank erosion based on regional curves developed from empirical data (Rosgen, 2009). Six sets of bank pins were installed throughout the reach at locations that were chosen to represent a composite of the ranges found in the restoration area. Four sets of bank pins are present on the mainstem of Conewago Creek, and two sets of bank pins are on the Brills Run tributary. Initial BANCS assessments and estimates were conducted in July 2018 at the time of bank pin installation. The bank pins were measured again in November 2019 to determine actual rates of erosion and this data was used to calibrate the remainder of the reach to get a more accurate estimate for erosion within the project reach.

Load Reduction Calculations

Load reduction calculations for the Conewago Creek floodplain restoration project were developed using the procedures established in A Unified Guide for Crediting Stream and Floodplain Restoration Projects in the Chesapeake Bay Watershed (Wood, Schueler and Stack, 2021). The floodplain restoration design at Conewago Creek (similar to numerous other floodplain restoration projects) has two factors that will lead to an extremely high efficiency with regard to sediment load reductions:

- The shallow channel and well-connected floodplain effectively eliminate the potential for sedimentation present in the existing erosive condition.
- The restoration allows increased flows to escape the channel, dissipating otherwise erosive energy across the expansive floodplain.

Protocol 1

The Expert Panel's Protocol 1 specifies using the BANCS method to estimate bank erosion rates. The bank pin monitoring data was then used to calibrate the BANCS to reduce potential variability and provide a more robust erosion rate estimate. Based on past coordination with PA DEP and precedent set on previous floodplain restorations where pollutant loading was calculated for PRP reductions (Brubaker Run Floodplain Restoration at Lime Spring Square), the calculations utilize 75% efficiency value for the bank erosion reduction component of the load reduction calculations.

Protocol 2

Protocol 2 addresses Nitrogen load reduction credit for nutrient processing during baseflow. This project qualifies for Protocol 2 as the expansive floodplain design serves to encourage hyporheic exchange and promote denitrification. The protocol provides an estimated hyporheic exchange rate used in conjunction with dimensions of a "hyporheic box" provided by average floodplain area and an assumed hyporheic depth based on site data.

Protocol 3

This protocol accounts for annual pollutant loading entering the site and are treated within the floodplain footprint through floodplain deposition, plant uptake, and denitrification. This is maximized by creating a floodplain system that receives flow in a significant range of flow events.

Summary

Based on the discussion provided above, and the attached Sediment Load Reduction Calculations, the net sediment load reduction to be realized by the Conewago Creek Floodplain Restoration is presented in the following table:

Conewago Creek Floodplain Restoration - Load Reduction Summary			
	Total Nitrogen (lbs/yr)	Total Phosphorus (lbs/yr)	Total Suspended Sediment (lbs/yr)
Conewago Creek	8,102	2,533	903,264
Brills Run	2,522	1,034	357,419
Overall Project	**10,624**	**3,567**	**1,260,683**

Attachments *–Conewago Creek FPR Mainstem & Brills Run Load Reduction Calculations*

Conewago Creek FPR - Brills Run

Load Reduction Summary **10/28/2021**

Load Reduction Method	Nitrogen (lb/yr)	Phosphorus (lb/yr)	Sediment (lb/yr)
Protocol 1	2,231	1,027	1,956,601
Protocol 2	265	N/A	N/A
Protocol 3	26	7	18,087
Total	**2,522**	**1,034**	**1,974,688**

Adjusted Sediment Load Reduction Based on SDR = **357,419** lb/ yr

Sediment Deivery Ratio 0.181

10/28/2021

Protocol 1
Nutrient and Sediment Load Reductions from Prevented Bank Erosion

Existing Channel Length	1422	lf
BANCS Estimated Erosion Rate	0.9173	T/ft/yr
Field Measured Bulk Density	96.0	lb/ cf
Adjusted Erosion Rate	0.9173	T/ft/yr
Adjusted Erosion Rate	1,834.60	lb/ft/yr
Annual Sediment Load	2,608,801	lbs/ yr
Existing Soil Nitrogen Concentration	2.28	lbTN/ T Sed
Annual Nitrogen Load	2974.0	lbs/ yr
Existing Soil Phosphorus Concentration	1.05	lbTP/ T Sed
Annual Nitrogen Load	1369.6	lbs/ yr
Efficiency Factor	75%	

Credited Load Reductions

Sediment	**1,956,601**	**lb/yr**
Total Nitrogen	**2230.5**	**lb/yr**
Total Phosphorus	**1027.2**	**lb/yr**

10/28/2021

Protocol 2
Nitrogen Reduction in the Hyporheic Zone

Length of Proposed Stream Channel	1,422	ft
Average Proposed Channel Width	12	ft
Proposed Channel Area	17,064	sf
Total Restoration Area	98,670	sf
Net Floodplain Area	81,606	sf
Denitrification Rate	2.69E-03	lb NO3/sf/yr
Prelim. Channel Denitrification	45.90	lb NO3/ yr
Prelim Floodplain Denitrification	219.52	lb NO3/ yr
Baseflow Reduction Criteria	Perennial Base Flow	
Baseflow Reduction Factor (Bf)	1.00	
Floodplain Height Criteria	0 ft-0.75 ft	
Floodplain Height Factor (Sf)	1.00	
Channel Aquifer Conductivity Criteria	Gravel, Sandy Gravel, Sand, or Peat	
Channel Aquifer Conductivity Factor (Afc)	1.00	
Floodplain Aquifer Conductivity Criteria	Gravel, Sandy Gravel, Sand, or Peat	
Floodplain Aquifer Conductivity Factor (Aff)	1.00	
Final Channel Denitrification =	45.90	lb NO3/ yr
Final Floodplain Denitrification =	219.52	lb NO3/ yr
Total Denitrification =	**265.42**	**lb NO3/ yr**

10/28/2021

Protocol 3
Floodplain Sediment and Nutrient Removal

Drainage Area =	3.61	SM	**Karst %=**	0	%	**Urban %=** 4 %

Proposed Conditions

Benchmark Discharge Values

Qbase=	0.704	cfs	
Qtob=	5	cfs	
Q1ft=	17.76	cfs	
Q2fps=	46	cfs	
	1471		46.01
Use 1ft or 2 fps	2 fps velocity		

Select Gage Station: Conewago

Streamstats mean annual flow
Hydraflow Model
HEC-RAS Model 1ft in Floodplain
HEC-RAS Model 2ft in Floodplain

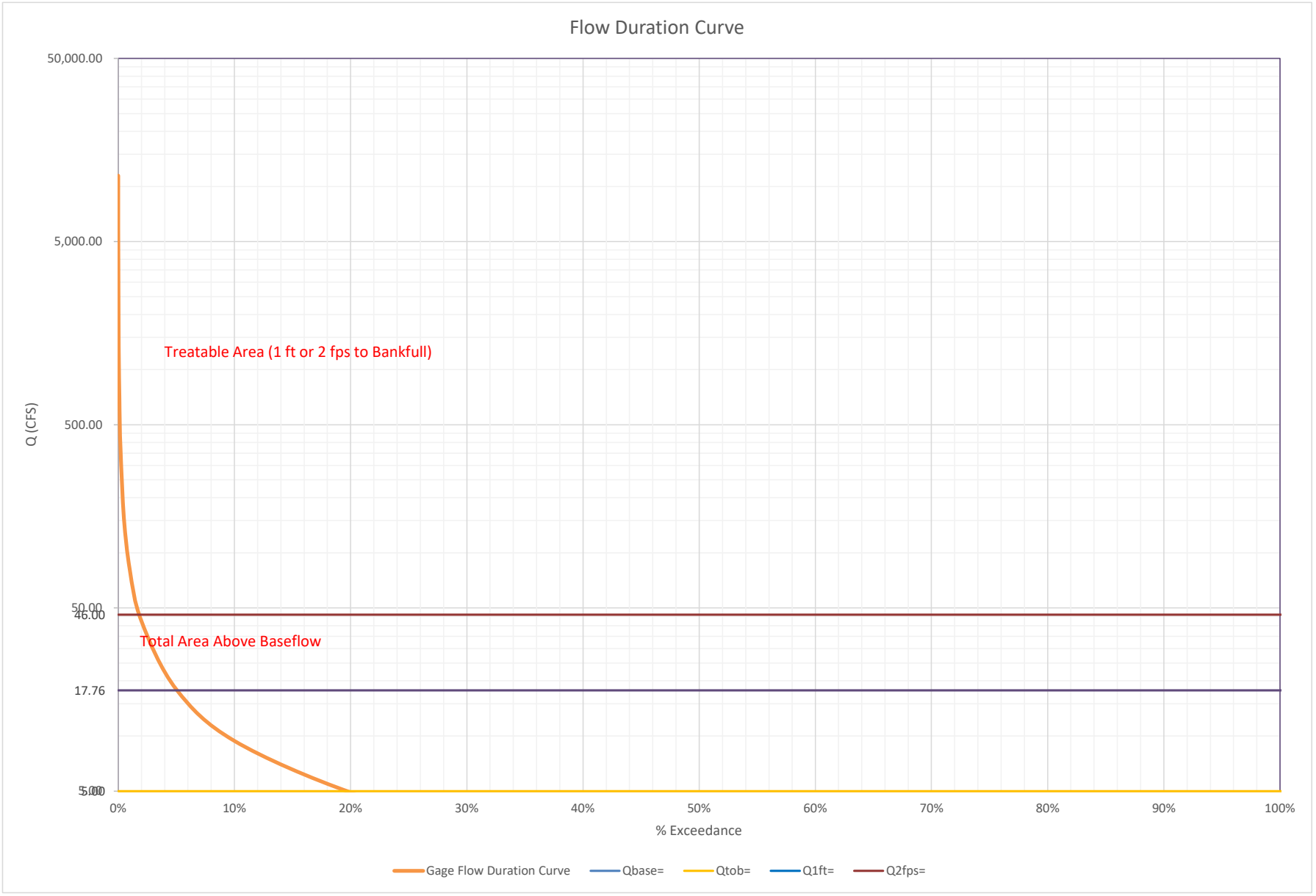
760

Proposed % Runoff Treated=		**12.6%**
Existing % Runoff Treated=		10.0%
Net% Runoff Treated=		**2.6%**

Annual Sediment Load=	2,274,164	lb. Sediment
Treatable Sed. Load =	58,346	lb. Sediment
Sediment Efficiency=	31%	
Total Load Reduction	**18,087**	**lb. Sediment**
	9	**T. Sediment**

Annual TN Load=	2,407	lb. TN
Treatable TN Load =	62	lb. TN
TN Efficiency=	42%	
Total Load Reduction	**26**	**lb. TN**

Annual TP Load=	634	lb. TP
Treatable TP Load =	16	lb. TP
TP Efficiency=	40%	
Total Load Reduction	**7**	**lb. TP**


Flow Duration Curve
50,000.00
5,000.00
500.00
50.00
46.00
17.76
5.00
Q (CFS)
Treatable Area (1 ft or 2 fps to Bankfull)
Total Area Above Baseflow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Exceedance
Gage Flow Duration Curve
Qbase=
Qtob=
Q1ft=
Q2fps=

Conewago Mainstem

Load Reduction Summary **10/28/2021**

Load Reduction Method	Nitrogen (lb/yr)	Phosphorus (lb/yr)	Sediment (lb/yr)
Protocol 1	4,187	1,928	3,673,128
Protocol 2	1,815	N/A	N/A
Protocol 3	2,100	605	1,317,282
Total	**8,102**	**2,533**	**4,990,410**

Adjusted Sediment Load Reduction Based on SDR = **903,264** lb/ yr

Sediment Deivery Ratio 0.181

10/28/2021

Protocol 1 10/28/2021

Nutrient and Sediment Load Reductions from Prevented Bank Erosion

Existing Channel Length	4960	lf
BANCS Estimated Erosion Rate	0.4937	T/ft/yr
Field Measured Bulk Density	96.0	lb/ cf
Adjusted Erosion Rate	0.4937	T/ft/yr
Adjusted Erosion Rate	987.40	lb/ft/yr
	18.10%	
Annual Sediment Load	4,897,504	lbs/ yr
Existing Soil Nitrogen Concentration	2.28	lbTN/ T Sed
Annual Nitrogen Load	5583.2	lbs/ yr
Existing Soil Phosphorus Concentration	1.05	lbTP/ T Sed
Annual Nitrogen Load	2571.2	lbs/ yr
Efficiency Factor	75%	

Credited Load Reductions

Sediment	**3,673,128**	**lb/yr**
Total Nitrogen	**4187.4**	**lb/yr**
Total Phosphorus	**1928.4**	**lb/yr**

10/28/2021

Protocol 2
Nitrogen Reduction in the Hyporheic Zone

Length of Proposed Stream Channel	4,960	ft
Average Proposed Channel Width	38	ft
Proposed Channel Area	188,480	sf
Total Restoration Area	674,641	sf
Net Floodplain Area	486,161	sf
Denitrification Rate	2.69E-03	lb NO3/sf/yr
Prelim. Channel Denitrification	507.01	lb NO3/ yr
Prelim Floodplain Denitrification	1307.77	lb NO3/ yr
Baseflow Reduction Criteria	Perennial Base Flow	
Baseflow Reduction Factor (Bf)	1.00	
Floodplain Height Criteria	0 ft-0.75 ft	
Floodplain Height Factor (Sf)	1.00	
Channel Aquifer Conductivity Criteria	Gravel, Sandy Gravel, Sand, or Peat	
Channel Aquifer Conductivity Factor (Afc)	1.00	
Floodplain Aquifer Conductivity Criteria	Gravel, Sandy Gravel, Sand, or Peat	
Floodplain Aquifer Conductivity Factor (Aff)	1.00	

Final Channel Denitrification =	507.01	lb NO3/ yr
Final Floodplain Denitrification =	1,307.77	lb NO3/ yr
Total Denitrification =	**1,814.78**	**lb NO3/ yr**

10/28/2021

Protocol 3 10/28/2021
Floodplain Sediment and Nutrient Removal

Drainage Area = 33.4 SM **Karst %=** 0 % **Urban %=** 3 %

Proposed Conditions

Benchmark Discharge Values **Select Gage Station:** Conewago

Qbase=	0.181	cfs	Streamstats mean annual flow
Qtob=	13	cfs	Hydraflow XS
Q1ft=	186	cfs	HEC-RAS Model 1ft in Floodplain
Q2fps=	856	cfs	HEC-RAS Model 2fps in Floodplain

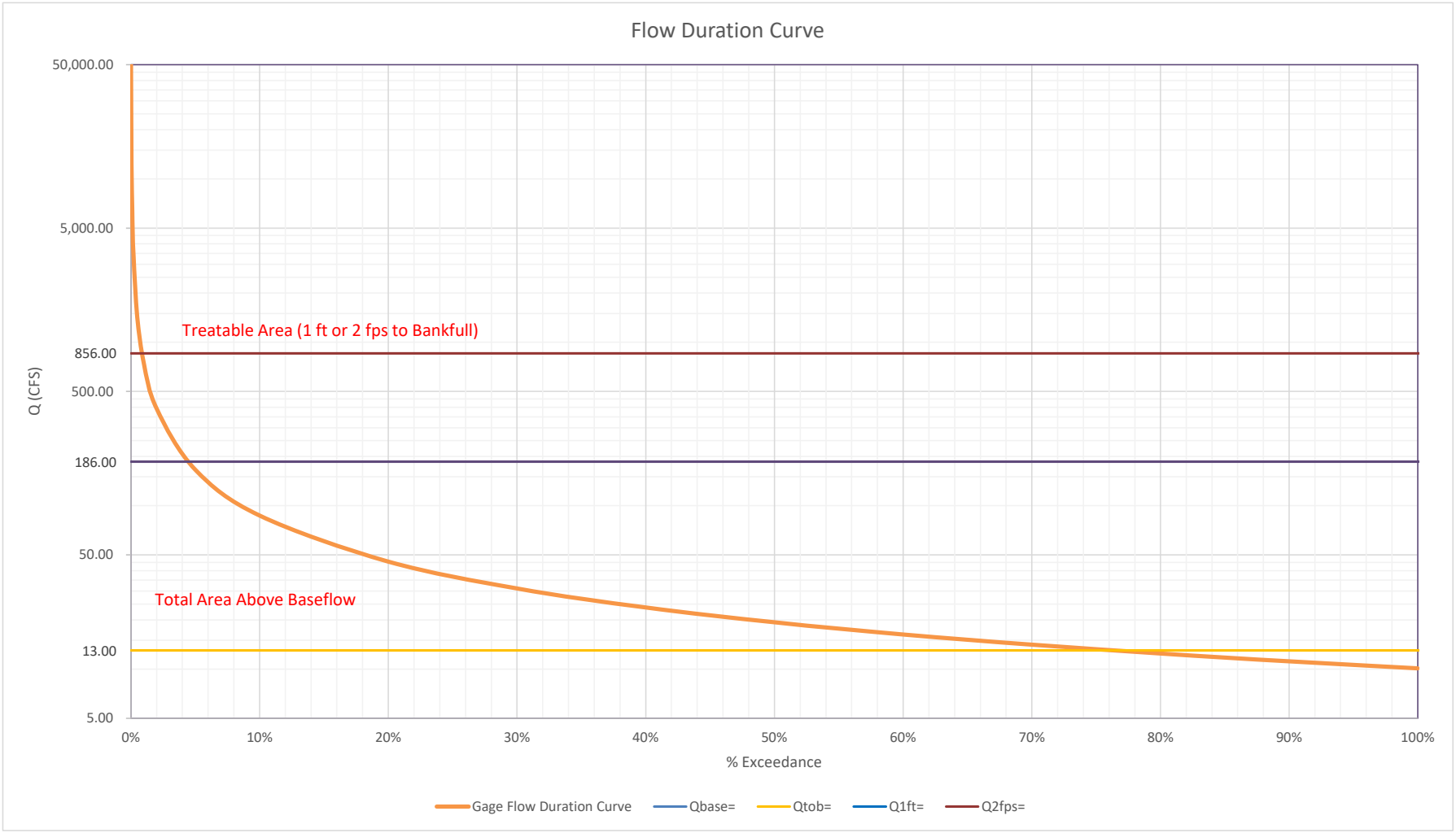
5283 856 4110

Use 1ft or 2 fps 2 fps velocity

Proposed %	Runoff Treated=	**23.2%**
Existing %	Runoff Treated=	0.7%
Net%	Runoff Treated=	**22.5%**

Annual Sediment Load=	18,883,000	lb. Sediment
Treatable Sed. Load =	4,249,296	lb. Sediment
Sediment Efficiency=	31%	
Total Load Reduction	**1,317,282**	**lb. Sediment**
	659	**T. Sediment**

Annual TN Load=	22,223	lb. TN
Treatable TN Load =	5,001	lb. TN
TN Efficiency=	42%	


Flow Duration Curve
50,000.00
5,000.00
856.00
500.00
186.00
50.00
13.00
5.00
Q (CFS)
Treatable Area (1 ft or 2 fps to Bankfull)
Total Area Above Baseflow
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
% Exceedance
Gage Flow Duration Curve
Qbase=
Qtob=
Q1ft=
Q2fps=