MASSACHUSETTS watershed·based plans

HEALTHY WATERSHED-BASED PLAN

Bartholomew's Cobble
Sheffield, MA

July 2020

Prepared By:

The Trustees of Reservations
Geosyntec Consultants, Inc.

Prepared For:

MassDEP
Commonwealth of Massachusetts
Department of Environmental Protection

This project has been financed with Federal Funds from the Environmental Protection Agency (EPA) to the Massachusetts Department of Environmental Protection (the Department) under an s. 319 competitive grant. The contents do not necessarily reflect the views and policies of EPA or of the Department, nor does the mention of trade names or commercial products constitute endorsement or recommendation for use.

Contents

Executive Summary

Introduction: The purpose of a Massachusetts Watershed-Based Plan (WBP) is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows the United States Environmental Protection Agency (USEPA) recommended format for "nine-element" watershed plans. This WBP was developed by Geosyntec Consultants (Geosyntec) under the direction of The Trustees of Reservations with funding, input, and collaboration from the Massachusetts Department of Environmental Protection (MassDEP).

Bartholomew's Cobble is a 329-acre designated National Natural Landmark by the United States Department of the Interior Natural Park Service due to its high biodiversity based on ancient limestone outcrops from hilltops down to the floodplain of the Housatonic River. This WBP specifically addresses the subwatersheds of the major gullies at Bartholomew's Cobble (approximately 114 acres).

Impairments and Pollution Sources: Bartholomew's Cobble is a healthy watershed and is not included on the 2016 Massachusetts Integrated List of Waters (MassDEP, 2016). However, Bartholomew's Cobble has suffered from severe hillside gully erosion (totaling approximately 7,400 linear feet) resulting in sedimentation into high quality wetland resources including floodplain forest and vernal pools. This relatively recent problem on a previously stable hillside was triggered by recent more frequent high-intensity rain events (most likely due to climate change) coupled with inadequate stormwater management along two roads (a steep private driveway and Weatogue Road identified in Figure C-1) in the watershed. Erosion and sedimentation have affected sensitive wetland habitats and state-listed rare species, both at the site where water cut through land, and where it deposited the resulting sediments.

Goals, Management Measures, and Funding: The water quality goal is to substantially reduce the extent of the gully erosion that has, in recent years, been exacerbated by change in storm frequency and intensity, and to restore valuable rare wetland species and wetland habitats, at Bartholomew's Cobble.

It is expected that this goal will be accomplished primarily through installation of best management practices (BMPs) to reduce erosion and sediment loading and through watershed education and outreach. Funding for management measures have been and will be obtained from a variety of sources including Section 319 Grant Funding, town capital funds, volunteer efforts, and other sources.

Public Education and Outreach: Outreach and education will build on recent efforts to educate the visitors of Bartholomew's Cobble; municipal officials; residents and local businesses; watershed organizations; and other user groups about erosion in natural areas under a changing climate, with the goal of ensuring continued improvement in wetland resource restoration and environmental stewardship. Recent efforts include, but are not limited to, BMP educational signage, public meetings, website postings, and presentations at conferences.

Implementation Schedule and Evaluation Criteria: Project activities will be implemented based on the information outlined in the following elements for inspection, implementation of structural BMPs, public education and outreach activities, and periodic updates to the WBP. It is expected that the inspection of recently implemented BMPs under the existing Operation and Maintenance Plan (Trustees, 2019) will enable direct evaluation of improvements over time. Other indirect evaluation metrics are also recommended, including the level of success of wetland resource restoration over time. The long-term goal of this WBP is to substantially

reduce the extent of the gully erosion and sedimentation issues at Bartholomew's Cobble by 2030. The WBP will be re-evaluated and adjusted, as needed, once every three years.

Introduction

What is a Watershed-Based Plan?

Purpose & Need

The purpose of a Massachusetts WBP is to organize information about Massachusetts' watersheds, and present it in a format that will enhance the development and implementation of projects that will restore water quality and beneficial uses in the Commonwealth. The Massachusetts WBP follows USEPA's recommended format for "nine-element" watershed plans, as described below.

All states are required to develop WBPs, but not all states have taken the same approach. Most states develop watershed-based plans only for selected watersheds. MassDEP's approach has been to develop a tool to support statewide development of WBPs, so **that good projects in all areas of the state may be eligible for federal watershed implementation grant funds** under Section 319 of the Clean Water Act.

USEPA guidelines promote the use of Section 319 funding for developing and implementing WBPs. WBPs are required for all projects implemented with Section 319 funds, and are recommended for all watershed projects, whether they are designed to protect unimpaired waters, restore impaired waters, or both.

Watershed-Based Plan Outline

This WBP for Bartholomew's Cobble includes nine elements (a through i) in accordance with USEPA Guidelines:

a) An **identification of the causes and sources** or groups of similar sources that will need to be controlled to achieve the load reductions estimated in this watershed-based plan (and to achieve any other watershed goals identified in the watershed-based plan), as discussed in item (b) immediately below.

b) An **estimate of the load reductions** expected for the management measures described under paragraph (c) below (recognizing the natural variability and the difficulty in precisely predicting the performance of management measures over time).

c) A **description of the nonpoint source (NPS) management measures** needed to achieve the load reductions estimated under paragraph (b) above (as well as to achieve other watershed goals identified in this watershed-based plan), and an identification (using a map or a description) of the critical areas in which those measures will be needed to implement this plan.

d) An **estimate of the amounts of technical and financial assistance needed**, associated costs, and/or the sources and authorities that will be relied upon, to implement this plan. As sources of funding, States should consider the use of their Section 319 programs, State Revolving Funds, United Stated Department of Agriculture (USDA) Environmental Quality Incentives Program and Conservation Reserve Program, and other relevant Federal, State, local and private funds that may be available to assist in implementing this plan.

e) An **information/education component** that will be used to enhance public understanding of the project and encourage their early and continued participation in selecting, designing, and implementing the NPS management measures that will be implemented.

f) A **schedule for implementing the NPS management measures** identified in this plan that is reasonably expeditious.

g) A description of **interim, measurable milestones** for determining whether NPS management measures or other control actions are being implemented.

h) A set of **criteria to determine if loading reductions are being achieved** over time and substantial progress is being made towards attaining water quality standards and, if not, the criteria for determining whether this watershed-based plan needs to be revised or, if a NPS Total Maximum Daily Load (TMDL) has been established, whether the TMDL needs to be revised.

i) A **monitoring component** to evaluate the effectiveness of the implementation efforts over time, measured against the criteria established under item (h) immediately above.

Project Partners and Stakeholder Input

This WBP was developed by Geosyntec under the direction of the Trustees of Reservations with funding, input, and collaboration from the MassDEP. This WBP was developed using funds from the Section 319 program to assist grantees in developing technically robust WBPs using MassDEP's Watershed-Based Planning Tool (WBP Tool). The Trustees of Reservations was a recipient of Section 319 funding in Fiscal Year 2017 to implement BMPs at Bartholomew's Cobble through the project entitled "*Mitigation of Erosion Impacts at Bartholomew's Cobble and Naumkeag"* (Section 319 project number: 17-08 319).

Core project stakeholders included:

- Julie Richburg – The Trustees of Reservations
- Matthew Reardon – MassDEP

This WBP was developed as part of an iterative process. The Geosyntec project team collected and reviewed existing data from The Trustees of Reservations. This information was then used to develop a preliminary WBP for review by core project stakeholders. A stakeholder conference call was then held to solicit input and gain consensus on elements included in the plan (e.g., water quality goals, public outreach activities, etc.). The WBP was finalized once stakeholder consensus was obtained for all elements.

Data Sources

This WBP was developed using the framework and data sources provided by MassDEP's WBP Tool and supplemented by information provided in the Section 319 Nonpoint Source Pollution Grant Program application and final report for "Mitigation of Erosion Impacts at Bartholomew's Cobble and Naumkeag" (Trustees, 2016 and 2019).

Element A: Identify Causes of Impairment & Pollution Sources

Element A: Identify the causes and sources or groups of similar sources that need to be controlled to achieve the necessary pollutant load reductions estimated in the watershed based plan (WBP).

General Watershed Information/Pollution Sources

Bartholomew's Cobble is a 329-acre designated National Natural Landmark by the United States Department of the Interior Natural Park Service due to its high biodiversity based on ancient limestone outcrops from its hilltops down to the floodplain of the Housatonic River. Bartholomew's Cobble is a healthy watershed and is not included on the 2016 Massachusetts Integrated List of Waters (MassDEP, 2016). However, Bartholomew's Cobble has suffered from severe hillside gully erosion (totaling approximately 7,400 linear feet) resulting in sedimentation into high quality wetland resources including floodplain forest and vernal pools. Undermined trees have fallen over resulting in canopy gaps where invasive species have established in some areas. This relatively recent problem on a previously stable hillside was triggered by recent more frequent high-intensity rain events (most likely due to climate change) coupled with inadequate stormwater management along two roads (a steep private driveway and Weatogue Road) in the watershed. Increased storm intensity and frequency exceeded the capacity of existing swales and pipes used to collect and convey stormwater runoff, resulting in stormwater flowing in concentrated flow paths across the fragile soils on steep slopes. The erosion from gullies upstream of Weatogue Road has also caused at least one catch basin along the road to fill with sediment. Erosion and sedimentation affected sensitive wetland habitats and state-listed rare species, both at the site where stormwater eroded through land, and where it deposited the resulting sediments. **Figure A-1** identifies the location of Bartholomew's Cobble within the Housatonic River watershed. This WBP specifically addresses the subwatersheds of the major gullies at Bartholomew's Cobble. **Figure A-2** identifies these subwatersheds and **Table A-1** presents the areas of the subwatersheds. The total subwatershed area of the gullies (areas labeled A—G) is approximately 114 acres.

Water Quality Goal

The water quality goal is to substantially reduce the extent of the gully erosion that has, in recent years, been exacerbated by change in storm frequency and intensity, and to restore valuable rare wetland species and wetland habitats, at Bartholomew's Cobble.

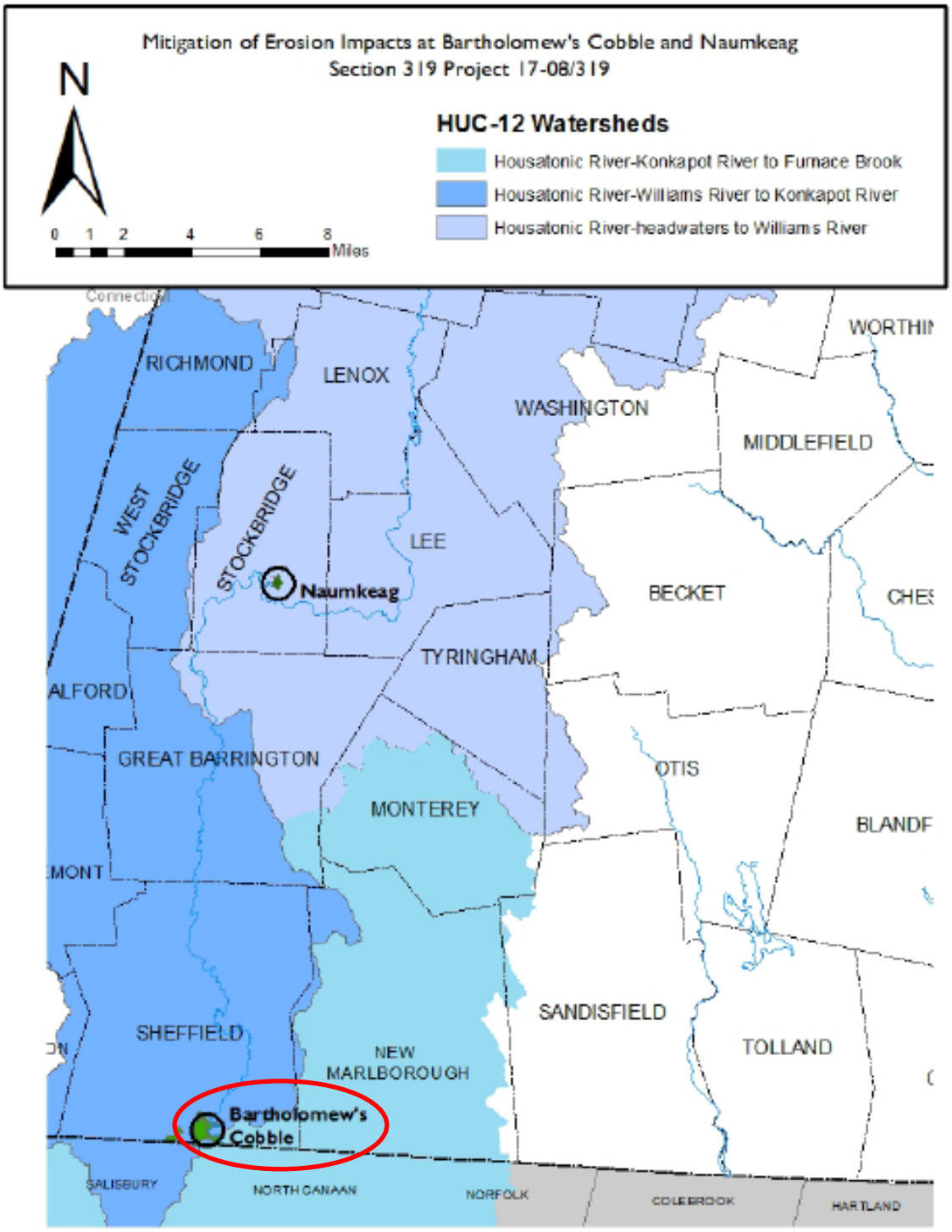


Figure A-1: Location of Bartholomew's Cobble in the Housatonic River Watershed
(Trustees, 2019)

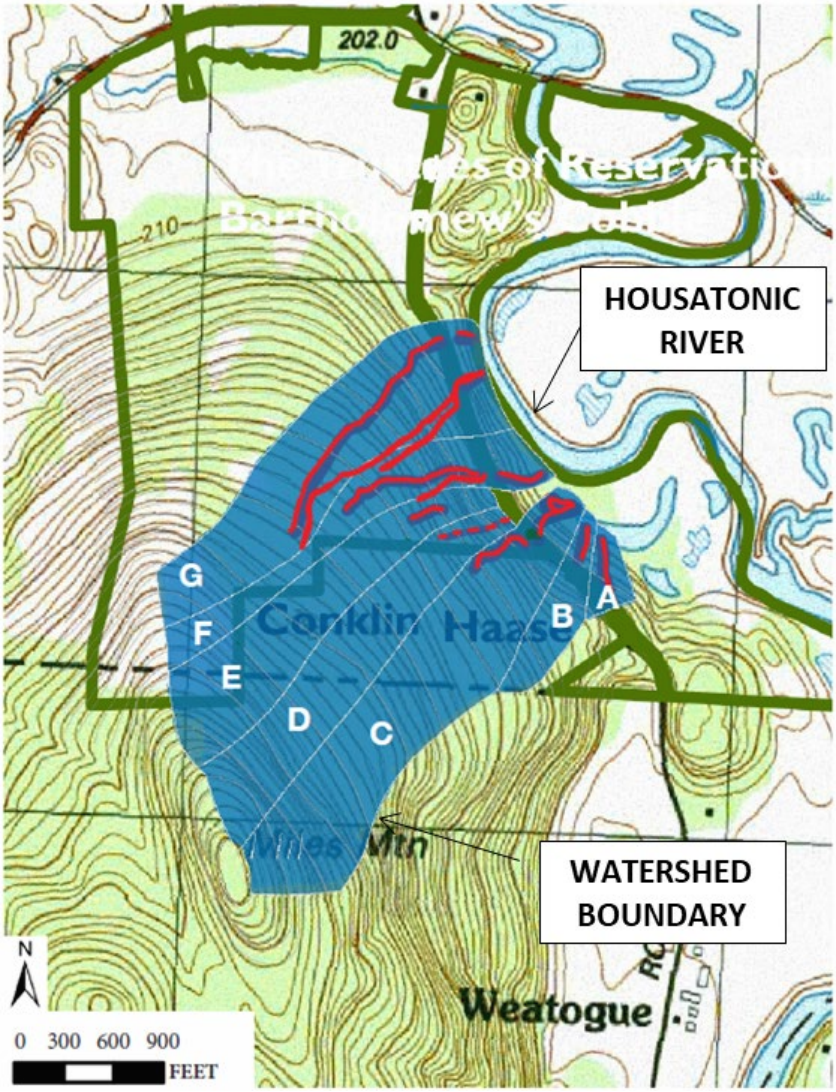


Figure A-2: Watershed Area (blue) of Bartholomew's Cobble Gullies (red lines) *(Trustees, 2019)*

Table A-1: Subwatershed areas (identified in Figure A-2) at Bartholomew's Cobble *(Trustees, 2019)*

Subwatershed (From Figure A-2)	Area (square feet)
A	90,500
B	225,200
C	1,370,000
D	786,500
E	784,900
F	555,200
G	1,177,100

Land Use Information

The watershed of the gullies is primarily undeveloped and forested and mostly within the Trustees-owned 329-acre reservation. There is one privately-owned property within the watershed; the "Conklin property" identified in **Figure A-3** has one home with a gravel access drive that traverses, at points, the adjacent "Haase Property". The Haase Property is forested and undeveloped and was privately-owned but was recently acquired by the Trustees in May of 2020. The area in the watershed upland of the Conklin and Haase properties (within the State of Connecticut) is forested and undeveloped. Weatogue Road is the only road within the watershed. Aside from the gravel access drive mentioned above and Weatogue Road, there is no additional impervious area within the watershed.

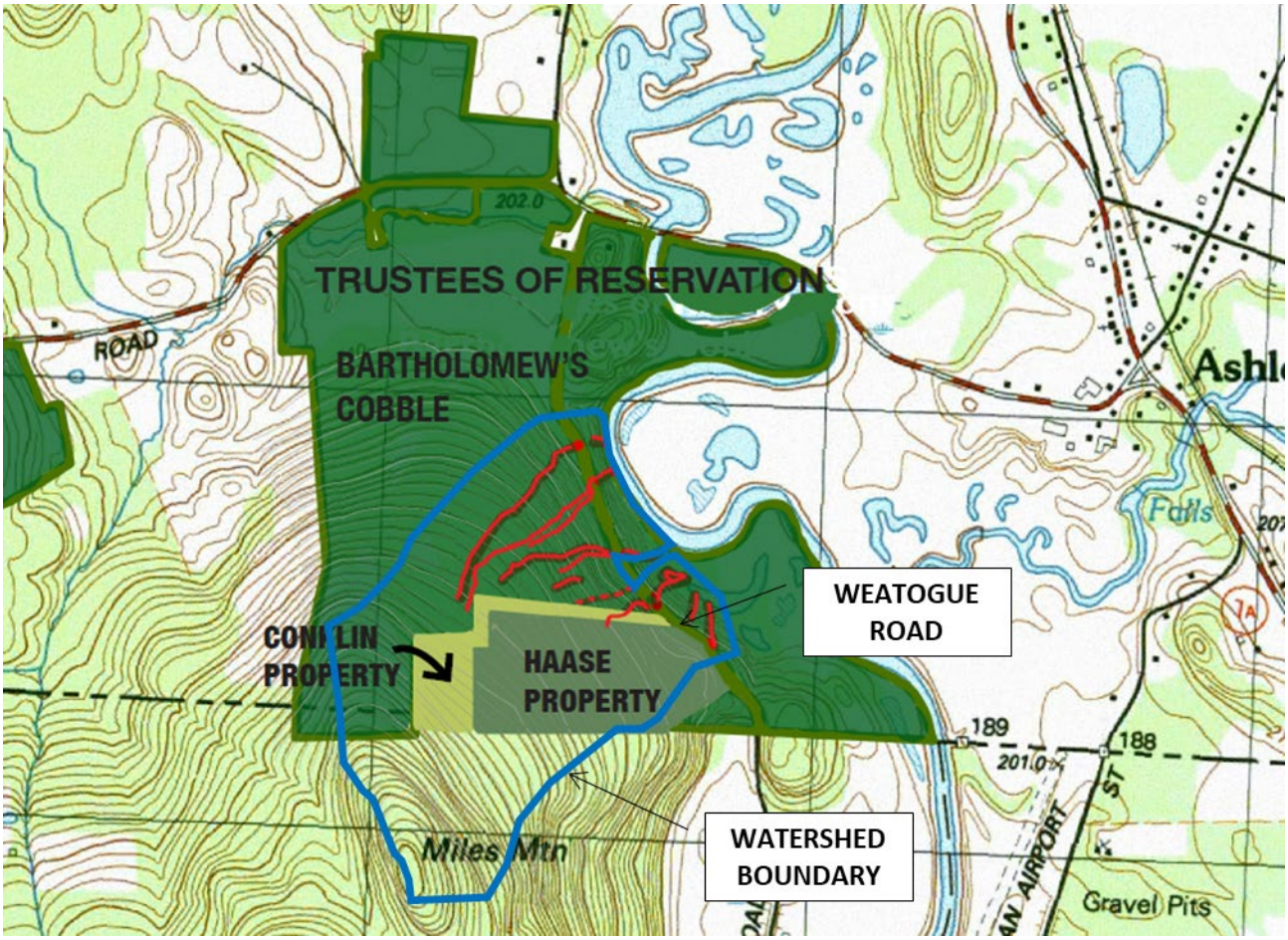


Figure A-3: Properties in the Bartholomew's Cobble Gully watershed
(Trustees, 2019)

Pollutant Loading

This WBP is covered under MassDEP's 319 Programmatic Quality Assurance Project Plan (QAPP), FFY 2015-2020, approved by USEPA on September 8, 2015. The Simple Method (Schueler, 1987) is a model intended for use in assessment and design analysis for stormwater management practices in urban areas, as such, it would not typically be used for the mainly forested watershed at Bartholomew's Cobble. It is also not structured to evaluate sediment load reductions due to gully management when eroded gully materials are themselves the dominant source of sediment loading. However, the Simple Method is a useful tool for establishing baseline functions, as

well as being a standard requirement of the QAPP, and was used to facilitate evaluation and help quantify management measure success (see also Element B and C). Recognizing the emerging nature of this type of locally scaled climate projection application, and allowing for a range of inherent uncertainty, published annual rainfall data were modified upwards by 20% (following professional judgement incorporating the factors noted above) while the fraction of annual rainfall events that produce runoff (Pj) was reduced from a standard assumption of 0.9 to 0.8. Hence, to be conservative, inputs to the Simple Method model applied at Bartholomew's Cobble started with published climate data from the National Oceanic and Atmospheric Administration (NOAA) for Great Barrington of 48.6 inches of annual rainfall; this amount was adjusted upwards by 20% to obtain an input P value of 58.4 inches. The table included in Appendix A presents the Simple Method calculation for the gullies at Bartholomew's Cobble. The estimated existing total suspended solid (TSS) load, calculated with the Simple Method, is 165 lbs TSS/yr (Trustees, 2019). It should be noted that while Bartholomew's Cobble has hilly terrain that is expected to generate moderate sediment yields, the dense forest cover reduces sediment transport. The main source of sediment is from the gully erosion, which has been observed to generate an estimated average sediment volume of over 0.5 cubic yards (roughly 1,000 lbs) of soil per linear foot of gully in single extreme rainstorms (Trustees, 2019). Future iterations of this WBP may consider using a more appropriate model, such as the USDA Revised Universal Soil Loss Equation (RUSLE), for calculating the soil loss from the gully erosion[1].

[1] More information on USDA's RUSLE can be found here: https://www.ars.usda.gov/midwest-area/west-lafayette-in/national-soil-erosion-research/docs/rusle/

Element B: Determine Pollutant Load Reductions Needed to Achieve Water Quality Goals

Element B of your WBP should:

Determine the pollutant load reductions needed to achieve the water quality goals established in Element A. The water quality goals should incorporate Total Maximum Daily Load (TMDL) goals, when applicable. For impaired water bodies, a TMDL establishes pollutant loading limits as needed to attain water quality standards.

Estimated Pollutant Loads

Estimated pollutant loads for TSS (165 lbs/yr) were previously presented in Element A of this WBP. As stated in Element A, future iterations of this WBP may consider re-evaluating this estimate using a different model such as RUSLE.

Recommended Load Reduction

The goal of this WBP is to design and implement a set of preventive and restorative measures, which will reduce the ongoing gully erosion and stormwater runoff problems that have been caused by poor stormwater management along access roads and exacerbated by the change in storm frequency and intensity most likely due to climate change.

Management measures will primarily focus on reducing erosion and sedimentation thereby reducing TSS loading to the environmentally sensitive floodplain. The following adaptive sequence is proposed to establish and track quantitative load reduction goals:

1. Evaluate success of recently implemented management measures (described in more detail under Element C of this WBP) in reducing gully erosion and TSS loading to the floodplain at Bartholomew's Cobble. The recently implemented management measures were estimated to reduce the existing TSS loading at Bartholomew's Cobble by 85 percent (i.e., 140 lbs/yr)
2. Identify remaining problem areas (if any) (by 2022)
3. If erosion problem areas remain, estimate rate of soil erosion caused by rainfall and associated overland flow using the RUSLE (by 2022)
4. Based on results of the RUSLE, establish a long-term numeric load reduction goal to substantially reduce the extent of the gully erosion at Bartholomew's Cobble

Element C: Describe management measures that will be implemented to achieve water quality goals

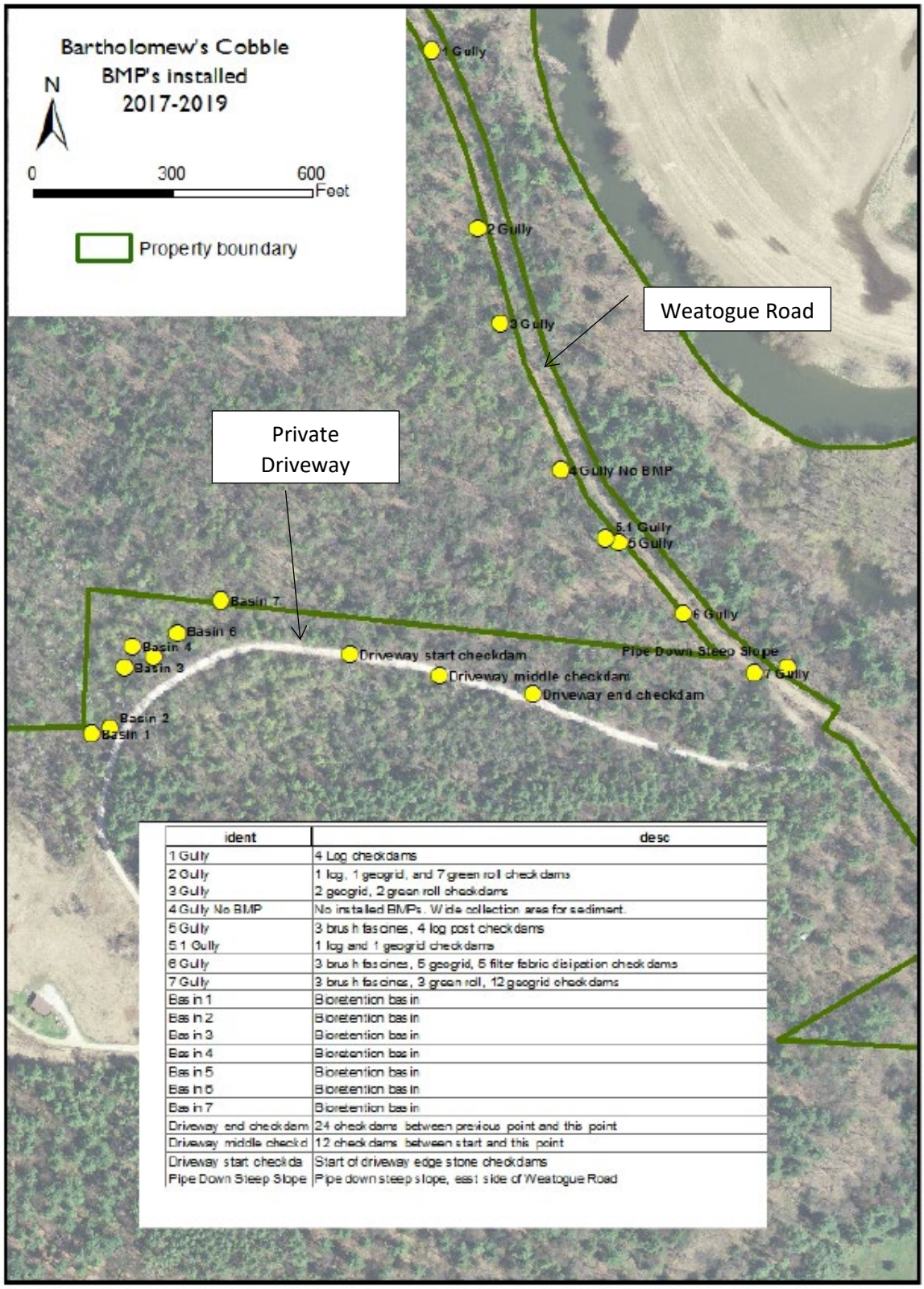
Existing Management Measures

As part of a Fiscal Year 2017 Section 319 Grant, The Trustees have implemented a set of BMPs at Bartholomew's Cobble to address the gully erosion and sedimentation problems. The Trustees and its partners designed and installed BMPs above and below Weatogue Road. Much of the work depended upon cut and fill activities to excavate shallow areas suitable for impounding stormwater, while salvaging and preserving topsoil for use in finish grading. Sediment deposited below gullies was excavated where feasible and replaced into the gullies where it originated (a preferential treatment to avoid the introduction of invasive plant species that likely arrive with offsite fill). Sediments were then stabilized by environmentally sensitive measures largely dependent upon bioengineering practices supplemented with synthetic and durable construction materials (Trustees, 2019). A detailed list of the BMPs installed at Bartholomew's Cobble between 2017—2019 is included in **Table C-1** and **Figure C-1** identifies the locations of the implemented BMPs.

Table C-1: BMPs implemented at Bartholomew's Cobble, 2017—2019 *(Trustees, 2019)*

BMP type and numbers	Waypoint label	Latitude	Longitude	Date of Completed Installation	Targeted Pollutants (see note for annual removal estimates)*	Size of targeted treatment area (sq ft)
4 Log checkdams	1 Gully	42.054316	-73.350849	August 2019	Sediment	1,177,090
1 log, 1 geogrid, and 7 green roll checkdams	2 Gully	42.053275	-73.350453	August 2019	Sediment	1,177,090
2 geogrid, 2 green roll checkdams	3 Gully	42.052721	-73.350258	August 2019	Sediment	555,175
No installed BMPs. Wide collection area for sediment.	4 Gully No BMP	42.051863	-73.349762	August 2019	Sediment	784,865
3 brush fascines, 4 log post checkdams	5 Gully	42.051446	-73.349286	August 2019	Sediment	786,502
1 log and 1 geogrid checkdams	5.1 Gully	42.051469	-73.349393	August 2019	Sediment	786,502
3 brush fascines, 5 geogrid, 5 filter fabric disipation checkdams	6 Gully	42.051037	-73.348763	August 2019	Sediment	1,370,018
3 brush fascines, 3 green roll, 12 geogrid checkdams	7 Gully	42.050695	-73.348200	August 2019	Sediment	225,191
Pipe down steep slope, east side of Weatogue Road	Pipe Down Steep Slope	42.050735	-73.347949	March 2018	Sediment	225,191
Bioretention basin	Basin 7	42.051056	-73.352419	March 2018	Sediment	784,865
Bioretention basin	Basin 6	42.050857	-73.352754	March 2018	Sediment	784,865
Bioretention basin	Basin 5	42.050715	-73.352937	December 2017	Sediment	784,865
Bioretention basin	Basin 4	42.050773	-73.353109	December 2017	Sediment	784,865
Bioretention basin	Basin 3	42.050650	-73.353171	December 2017	Sediment	784,865
Bioretention basin	Basin 2	42.050291	-73.353266	December 2017	Sediment	784,865
Start of driveway edge stone checkdams	Driveway start checkdam	42.050752	-73.351387	March 2018	Sediment	784,865
12 checkdams between start and this point	Driveway middle checkdam	42.050642	-73.350676	March 2018	Sediment	784,865
24 checkdams between previous point and this point	Driveway end checkdam	42.050545	-73.349942	March 2018	Sediment	784,865
Bioretention basin	Basin 1	42.050259	-73.353411	December 2017	Sediment	784,865

*Note: Approximately 140.62 lbs of sediment will be removed from the site through the implemented BMPs. Calculations using the Simple Method.



ident	desc
1 Gully	4 Log checkdams
2 Gully	1 log, 1 geogrid, and 7 green roll checkdams
3 Gully	2 geogrid, 2 green roll checkdams
4 Gully No BMP	No installed BMPs. Wide collection area for sediment.
5 Gully	3 brush fascines, 4 log post checkdams
5.1 Gully	1 log and 1 geogrid checkdams
6 Gully	3 brush fascines, 5 geogrid, 5 filter fabric dissipation checkdams
7 Gully	3 brush fascines, 3 green roll, 12 geogrid checkdams
Basin 1	Bioretention basin
Basin 2	Bioretention basin
Basin 3	Bioretention basin
Basin 4	Bioretention basin
Basin 5	Bioretention basin
Basin 6	Bioretention basin
Basin 7	Bioretention basin
Driveway end checkdam	24 checkdams between previous point and this point
Driveway middle checkd	12 checkdams between start and this point
Driveway start checkda	Start of driveway edge stone checkdams
Pipe Down Steep Slope	Pipe down steep slope, east side of Weatogue Road

Figure C-1: BMPs implemented at Bartholomew's Cobble, 2017—2019 *(Trustees, 2019)*

Future Management Measures

The Town of Sheffield has received a Municipal Vulnerability Preparedness (MVP) Action Grant (2020—2021)[2] to:

- conduct a field assessment of rural dirt roads within the Massachusetts communities of Sheffield, New Marlborough, and Sandisfield (planned for September 2020);
- develop an assessment and recommendations report that may be applied within other communities in the region (planned for February 2021);
- engage and inform the public about climate projections and impacts as well as tools and techniques such as nature-based solutions that improve infrastructural, environmental and societal resiliency (planned for April 2021); and
- improve roadway sustainability via a pilot project that will apply nature-based solutions to Weatogue Road in the Bartholomew's Cobble watershed. The Weatogue Road Pilot Study is planned to occur in June 2021.

It is also recommended that the recently implemented management measures identified in Table C-1 be inspected and maintained according to the Operation and Maintenance Plan included in the Project Final Report (Trustees, 2019). It is also suggested that the *Massachusetts Unpaved Roads BMP Manual: A Guidebook on How to Improve Water Quality While Addressing Common Problems* (Berkshire Regional Planning Commission,2001) (98-06/319) is consulted as part of MVP efforts.

The Trustees may also consider additional investigation with the following recommended general sequence to identify and implement future structural BMPs within the Bartholomew's Cobble watershed if needed in the future:

1. **Identify Potential Implementation Locations:** Maintain and evaluate the performance of the recently implemented BMPs. Identify areas that are still experiencing erosion. Additional analysis can also be performed to fine-tune locations to maximize sediment removals such as performing RUSLE calculations on specifically delineated subareas draining to single gullies and selecting those areas with the highest soil loss per acre.
2. **Visit Potential Implementation Locations:** Perform field reconnaissance, preferably during a period of active runoff-producing rainfall, to evaluate potential implementation locations, gauge feasibility, and identify potential future BMPs. During field reconnaissance, assess identified locations for space constraints, potential accessibility issues, site-specific drainage patterns, and other factors that may cause issues during design, construction, or long-term maintenance.
3. **Develop BMP Concepts:** Once potential BMP locations are conceptualized, use the BMP-selector tool of the WBP Tool to help develop concepts. Concepts can vary widely. One method is to develop 1-page fact sheets for each concept that includes a site description, including definition of the problem, a description of the proposed BMPs, annotated site photographs with conceptual BMP design details, and a discussion of potential conflicts such as property ownership, O&M requirements, and permitting constraints. The fact sheet can also include information obtained from the BMP-selector tool including cost estimates, load reduction estimates, and sizing information (i.e., BMP footprint, drainage area, etc.).
4. **Rank BMP Concepts:** Once BMP concepts are developed, perform a priority ranking based on site-specific factors to identify the implementation order. Ranking can include many factors including cost, expected pollutant load reductions, implementation complexity, potential outreach opportunities and visibility to

[2] More information on the MVP Grant can be found here: https://mvpresilientdirtroadsproject.wordpress.com/

public, accessibility, expected operation and maintenance effort, and others. Prioritized BMP concepts should focus on reducing erosion and soil loss, as summarized in **Element B**.

Element D: Identify Technical and Financial Assistance Needed to Implement Plan

Element D: Estimate of the amounts of technical and financial assistance needed, associated costs, and/or the sources and authorities that will be relied upon to implement this plan.

Current and Ongoing Management Measures

Table D-1 presents the funding that was needed to implement the Section 319 grant funded management measures presented in this WBP. The table includes costs for BMP design, construction, operation and maintenance plan, and materials and supplies (Trustees, 2019). Additionally, annual operation and maintenance costs were estimated to be approximately $3,750 annually (Trustees, 2019).

Table D-1: Completed Project Budget for Bartholomew's Cobble BMPs (Trustees, 2019)

Expense Item	s.319 Amount	Non-Federal Match and Source	Total Amount
Salary and Wages	$800	$10,100	$10,900
Sub contractual Services (included construction, final conservation plan, operation and maintenance plan, and performance and outreach program)	$71,400	$70,900	$142,300
Materials and Supplies	$9,200	$5,500	$14,700
Travel (for auto mileage)	$0	$1,200	$1,200
Totals	$81,400	$87,700	$169,100
	48%	**52%**	**100%**

Future Management Measures

Funding for future BMP installations to further reduce erosion and soil loss within Bartholomew's Cobble may be provided by a variety of sources, such as the Section 319 Nonpoint Source Pollution Grant Program, Town of Sheffield capital funds, or other grant programs such as hazard mitigation funding. The Trustees has previously been successful with and will continue to pursue securing grant funding through various sources. Guidance is available to provide additional information on potential funding sources for nonpoint source pollution reduction efforts[3].

[3] Guidance on funding sources to address nonpoint source pollution: http://prj.geosyntec.com/prjMADEPWBP_Files/Guide/Element%20D%20-%20Funds%20and%20Resources%20Guide.pdf

Element E: Public Information and Education

Element E: Information and Education (I/E) component of the watershed plan used to:

1. Enhance public understanding of the project; and
2. Encourage early and continued public participation in selecting, designing, and implementing the NPS management measures that will be implemented.

Step 1: Goals and Objectives

The goals and objectives for the watershed information and education program.

1. Increase public awareness of erosion in natural areas under a changing climate.
2. Provide information about stormwater improvements and their anticipated water quality benefits.
3. Provide information to promote watershed stewardship.

Step 2: Target Audience

Target audiences that need to be reached to meet the goals and objectives identified above.

1. Visitors of Bartholomew's Cobble.
2. Town of Sheffield Municipal officials.
3. Residents and businesses within the Town of Sheffield, MA and Caanan, CT.
4. Watershed organizations and other user groups.

Step 3: Outreach Products and Distribution

The outreach product(s) and distribution form(s) that will be used for each.

1. Implement MassDEP-approved signage visible from commonly used roads and/or trails as well as incorporation of information into public programming (see **Figure E-1** for example).
2. Ongoing dialogue with Town of Sheffield municipal officials through meetings
3. Demonstration video summarizing the context, goals, and methods of the project at Bartholomew's Cobble
4. Posted description of the project and the demonstration video to the Trustees website.
5. Posters and presentations at conferences and meetings, such as the Massachusetts Land Trust Conference (March 2017 and 2020), the Massachusetts Ecosystem Climate Adaptation Network – Mass ECAN Conference (October 2019), the Berkshire County Highway Superintendents Association meeting, the Northeast Climate Science Center's Regional Science meeting, and the Society of Ecological Restoration (New England Chapter) conference.

Figure E-1: Signage at Bartholomew's Cobble

Step 4: Evaluate Information/Education Program

Information and education efforts and how they will be evaluated.
The Outreach Products conducted by the Trustees can be evaluated by:

1. Tracking the number of visitors to Bartholomew's Cobble.
2. Tracking the number of views of the demonstration video.
3. Tracking the number of webpage visits.
4. Tracking attendance at presentations and posters.

Additional outreach products may be determined when future management measures and activities are planned for implementation at Bartholomew's Cobble. This section of the WBP will be updated when the plan is re-evaluated in 2023 in accordance with Element F&G.

Elements F & G: Implementation Schedule and Measurable Milestones

Element F: Schedule for implementing the nonpoint source management measures identified in this plan that is reasonably expeditious.

Element G: A description of interim measurable milestones for determining whether nonpoint source management measures or other control actions are being implemented.

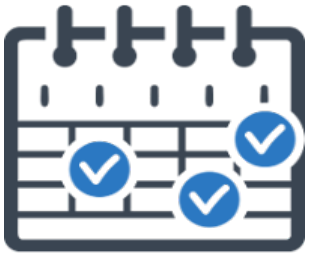


Table FG-1 provides a preliminary schedule for implementation of recommendations provided by this WBP. It is expected that the WBP will be re-evaluated and updated in 2023, or as needed, based on ongoing inspection and other ongoing efforts. New projects will be identified through future analysis and stakeholder engagement and will be included in updates to the implementation schedule.

Table FG-1: Implementation Schedule and Interim Measurable Milestones

Category	Action	Estimated Cost	Year(s)
Inspection/Operation and Maintenance (from Operations and Maintenance Plan (Trustees, 2019))	Late fall inspection (after leaves drop and before snow) to verify catch basins, culverts and channels are free of branches and litter prone to clogging; as needed, remove potential debris jam materials	$3,750 annually	Annual by season
	Spring inspection (after snow melt) to verify that check dam structures have not been compromised by branches, or erosion at bank edges, or other substantive changes; as needed perform repairs to restore prior functional conditions		
	Road maintenance activities from routine plowing to re-crowning/grading warrant keeping an eye on roadside or downslope effects due to inadvertent watershed modifications; as needed coordinate with Town or obtain consultation		
	After every intense storm (estimated at greater than 2 inches over 12 hours) inspect gully areas easily visible from Weatogue Road and Conklin driveway to identify spot erosion on banks or channel bed and/or concentrated flow entering channel by pipe or overland flow; as needed, take corrective action or obtain consultation		As needed (storm-driven or construction related)
	After every intense storm (estimated at greater than 2 inches over 12 hours) inspect bioretention areas to identify spots where erosion or settlement may have caused flow patterns to "short circuit" the ponded cells; as needed, apply "filter fabric soil burritos" covered with a 6" layer of soil, then seeded with forest restoration mix or winter rye to reinforce and stabilize ground		
	Additional attention will be required whenever nearby construction activities pose new inputs that may affect the installed BMPs		
	After every severe storm (estimated at greater than 4 inches over 24 hours) inspect the entire length of all gullies; as needed, take GPS points, photos, and written notes for areas requiring (or approaching) necessary intervention to adjust or repair BMP features (note, this O&M task is only estimated to occur on average once in three years, and the exact rainfall amount isn't key—it's just a number corresponding to a large storm capable of generating short cloudbursts causing high periods of erosive runoff which could further erode gullies. Trustees staff are typically very tuned into when the problematic storms happen)		
	Identify remaining problem areas (if any). If erosion problem areas remain, estimate rate of soil erosion caused by rainfall and associated overland flow using the RUSLE. Based on results of the RUSLE, establish a long-term numeric load reduction goal to substantially reduce the extent of the gully erosion at Bartholomew's Cobble	TBD	2022
Structural BMPs	Weatogue Road		
	Identify priority locations for BMP implementation (if any)	TBD	2023
	Obtain funding and implement additional BMPs	TBD	2023
Public Education and Outreach *(See Element E)*	Periodically post project updates to websites, social media, and blog profiles	TBD	Annual
	Maintain and update informational signs at BMP locations	TBD	Annual
	Present the project at conferences and meetings	TBD	Once every 3 years
Adaptive Management and Plan Updates	Establish working group comprised of stakeholders and other interested parties to implement recommendations and track progress. Meet at least twice per year.	TBD	2021
	Re-evaluate Watershed Based Plan at least once every three (3) years and adjust, as needed, based on ongoing efforts (e.g., based on inspection results, 319 funding, etc.). – Next update, June 2023	TBD	2023
	Reach long-term goal to substantially reduce the extent of the gully erosion and sedimentation issues at Bartholomew's Cobble	**NA**	**2030**

Elements H & I: Progress Evaluation Criteria and Monitoring

Element H: A set of criteria used to determine (1) if loading reductions are being achieved over time and (2) if progress is being made toward attaining water quality goals. Element H asks "**how will you know if you are making progress towards water quality goals?**" The criteria established to track progress can be direct measurements (e.g., E. coli bacteria concentrations) or indirect indicators of load reduction (e.g., number of beach closings related to bacteria).

Element I: A monitoring component to evaluate the effectiveness of implementation efforts over time, as measured against the Element H criteria. Element I asks "**how, when, and where will you conduct monitoring?**"

Indirect Indicators of Load Reduction

Inspection and Operation and Maintenance of Recently Implemented BMPs

Inspection will be conducted according to the Operation and Maintenance Plan included in the Trustees (2019) report. Inspections should also evaluate success in natural restoration of environmentally sensitive wetland resources and habitat over time. Results from the inspection activities can be used as a metric for understanding erosion trends (i.e., linear feet of gully erosion) in response to implementation of the management measures (described in Element C) that have been implemented. It is recommended that annual assessments are provided for the BMPs at Bartholomew's Cobble, which include recommendations as feasible for future BMP improvements.

Project-Specific Indicators

Number of BMPs Installed and Pollutant Reduction Estimates:

Anticipated pollutant load reductions from existing, ongoing (i.e., under construction), and future BMPs will be tracked as BMPs are installed. It is recommended that the RUSLE model be used for estimates of TSS load reductions resulting from gully erosion management measures.

Adaptive Management

The recently installed BMPs at Bartholomew's Cobble will be periodically inspected according to the schedule set forth in the Operation and Maintenance Plan (Trustees, 2019) and in Element F&G of this WBP. If additional problem areas are identified, the rate of soil erosion should be estimated using the RUSLE. Based on results of the RUSLE, a long-term numeric load reduction goal to substantially reduce the extent of the erosion at Bartholomew's Cobble should be estimated. Future management measures will be identified and prioritized according to the sequence in Element C. If inspection results and indirect indicators (e.g., restoration of wetland resources) do not show improvement, the management measures and loading reduction analysis (Elements A through D) will be revisited and modified accordingly. Long-term goals will be re-evaluated at least **once every three years** and adaptively adjusted based on additional inspection results and other indirect indicators.

References

Berkshire Regional Planning Commission (2001). "*Massachusetts Unpaved Roads BMP Manual: A Guidebook on How to Improve Water Quality While Addressing Common Problems".* Pittsfield, MA. 319 Nonpoint Source Pollution Grant Program, Project 98-06/319. Available online at: https://www.mass.gov/doc/unpaved-roads-bmp-manual/download

MassDEP (2016). "*Massachusetts Year 2016 Integrated List of Waters Final Listing of the Condition of Massachusetts' Waters Pursuant to Sections 305(b), 314 and 303(d) of the Clean Water Act*"

Schueler, T. (1987). "Contro*lling urban runoff: a practical manual for planning and designing urban BMPs".* Metropolitan Washington Council of Governments. Washington, DC. https://www.mwcog.org/documents/1987/07/01/controlling-urban-runoff-bmp-stormwater/

Trustees of Reservations (Trustees) (2016). "*Mitigation of Erosion Impacts at Bartholomew's Cobble and Naumkeag*". 319 Nonpoint Source Pollution Grant Program, 4/01/16, BRP-RFR-2016-08-319.

Trustees of Reservations (Trustees) (2019). "*Final Project Report, Mitigation of Erosion Impacts at Bartholomew's Cobble and Naumkeag, Section 319 Project 17-08/319, March 2, 2017—September 30, 2019*".

Appendices

Appendix A – Simple Method Calculation for Total Suspended Solids (TSS) at Bartholomew's Cobble Gullies

Simple Method Pollutant Loading Calculation Worksheet- Sediment

The Simple Method estimates pollutant loading of stormwater runoff for urban and developed areas. This worksheet includes the data and calculations to be used for computation of existing and post-development loads. Fill in the shaded fields bas ed on the project site attributes.

$L = 0.226 * P * P_j * R_v * A * C$

Where:

L = Annual load (lbs)

P = Yearly rainfall depth (in)

P_j = Fraction of rainfall events producing runoff (use 0.9)

A = Site area (acres)

C = Average annual pollutant concentration (mg/l)

0.226 = Unit conversion factor

And:

$Rv = 0.05 + 0.009 * I_a$

Where:

R_v = Runoff Coefficient

I_a = Whole number percent impervious

Offset Calculations		
Project Name:	Bartholomew's Cobble	
C-Values* from:	Table 1, Integrated in Model	
P_j	0.8	Modified for future climate assumptions
Project P*	58.35	Modified for future climate assumptions

*http://www.ncdc.noaa.gov/cdo-web/datatools/normals

Pre-Development	Land Cover type	Site Area (ac)	Imp. Area (ac)	I_a (%)	R_v	C (mg/L)*	Load (lbs)
Existing Conditions	Agriculture/Forest	98	1	1	0.059183673	0.17	10.40
	Open Urban Land	16	4	25	0.275	3.34	155.04
				0	0.05		0.00
				0	0.05		0.00
	Pre-Dev. Total						**165.44**

Post-Development	Land Cover	Site Area (ac)	Imp. Area (ac)	I_a (%)	R_v	C (mg/L)	Load (lbs)
	Agriculture/Forest	98	1	1	0.059183673	0.17	10.40
	Open Urban Land	16	4	25	0.275	3.34	155.04
				0	0.05		0.00
				0	0.05		0.00
	Post-Dev. Total						**165.44**
						Load reduction from treatment (%)	85
						Post-dev. load after treatment is provided	**24.82**

Load Difference	**Lbs to be offset**	None

* C-values for sediment obtained from Table 1 integrated with Simple Model

If the final load says "none", no further action is needed. If the number is positive, an offset is required. There are several different options for satisfying offset requirements including the use of additional on-site treatment, the purchase of an existing offset (if available), or the development of an offsite offset project within the same impaired watershed.