SITE SELECTION FOR PHOSPHORUS REDUCTION

IMPLEMENTING BEST MANAGEMENT PRACTICES AT A SUB-WATERSHED SCALE IN THE MALDEN RIVER

Introduction

The goal of this project was to build on an analysis performed at a subwatershed scale in the Malden River for Water Resources Policy and Planning and Watershed Management graduate course at Tufts University. The GIS analysis aims to select sites for implementation of stormwater mitigation strategies to meet Water Quality Standards (WQS) that support swimming in the Malden River. Malden River is part of the larger Mystic River Watershed where phosphorus is a major source of pollutant and needs a Total Maximum Daily Load (TMDL) to meet WQS.1 According to the Mystic River Watershed Association (MyRWA), a primary contribution of phosphorus pollutants are algae blooms.² An algae called cyanobacteria can release toxic chemicals that can especially be harmful to humans and pets.3 Additionally, overgrowth of plants from excess phosphorus contributes to growth of invasive species that make it difficult for swimmers to navigate waters.4

- 1 "Phosphorous Pollution in the Mystic," Mystic River Watershed Association, accessed November 1, 2019, https://
- 4 "Phosphorous Pollution in the Mystic.

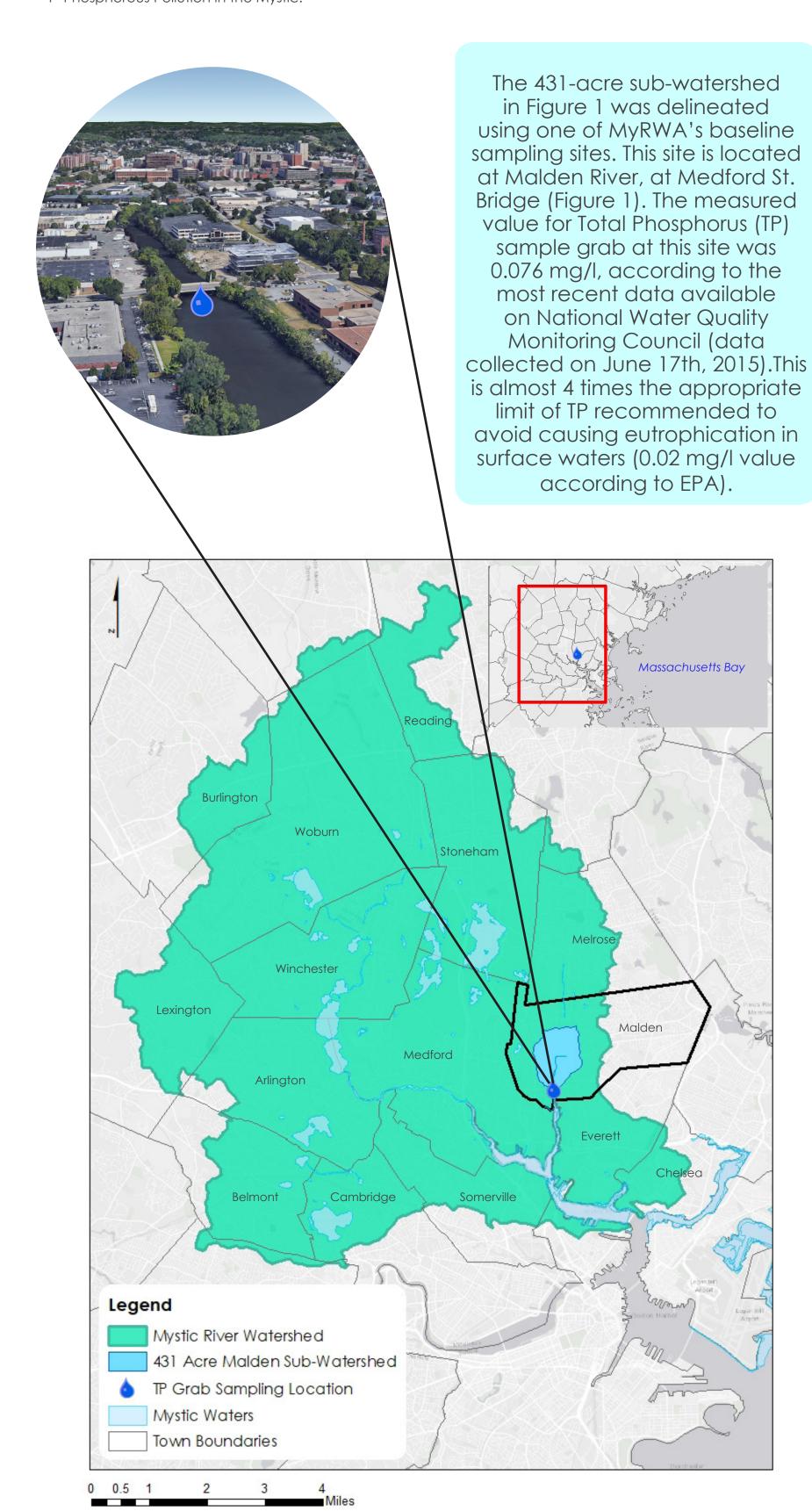


Figure 1: The Larger Mystic River Watershed 431-Acre Delineated Sub-Watershed in Malden

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Data & Methodology

Methodology included collecting source layers (land use cover, soil types, and slopes) and converting them to raster layers, reclassifying them using a range of values to create suitability layers (1 being high suitability and higher values being low suitability), and layering the suitability with weights of relative importance for optimal sites that could implement best management practices for phosphorus reduction in the delineated sub-watershed.

Land Use

Laria 03C				
Land Cover	Acres	Phosphorus Contribution Export Rates lbs/acre/year	Phosphorus Atmosphere Deposition lbs/acre/year	lbs/year
Commercial	85.96	0.81	0.04	73
Industrial	107.25	0.81	0.04	91
Urban Public/Institutional	38.94	0.54	0.04	23
High Density Residential	33.94	0.68	0.04	24
Multi-Family Residential	125.85	0.72	0.04	96
				Total: 307 lbs P/year 139.25 kg P/year

Table 1: Total Phosphorus contribution of top 5 land uses in the watershed, generated using export coefficients (average annual phosphorus loads associated with various land uses) from table 5-3 and source and concentration of nutrients from, table 2-1 (EPA TMDL Protocol for Nutrients).

The land use raster was reclassified with highest suitability value (1) given to impervious covers such as junkyards and transportation. Values 3-7 were assigned to land cover based on phosphorus contribution export rates and phosphorus atmospheric deposition noted in table 1.5 For example, industrial areas were assigned a value of 3, commercial assigned 4, multifamily residential assigned 5, and so on. The remaining land uses with least impervious cover such participation recreation and forested areas were assigned lowest suitability value (8-11). (Figure 3)

Map Unit Symbol	Map Unit Name	Rating	Acres in AOI	Percent of AOI
1	Water		2.6	0.6%
105E	Rock outcrop-Hollis complex, 3 to 35% slopes		2.6	0.6%
603	Urban land, wet substratum		290.3	67.3%
626B	Merrimac-Urban land complex, 0 to 8% slopes	A	37.0	8.6%
629C	Canton-Charlton-Urban land complex, 3 to 15% slopes	A	83.8	19.4%
631C	Charlton-Urban land- Hollis complex, 3 to 15% slopes, rocky	A	14.9	3.5%
Total Area of Interest			431.1	100%

Table 2: Hydrologic Soil Group, Summary by Map Unit, generated from USDA Web Soil Survey

Urban land, wet substratum is developed urban land such as buildings, industrial areas, pavement etc. that cover more than 75% of the land surface. Stormwater runoff allows pollutants from impervious and pervious surfaces such as dog waste, fertilizers, salt and de-icing materials, trash etc. to be carried into the Malden River.⁷

The soil survey was reclassified with highest suitability value (0) given to Urban land, wet substratum areas where there is large quantity of phosphorus⁸, value of 1 was given to 105E where there is moderate permeability. The remaining soil type with least impervious cover and were assigned lowest suitability value (2), where there is moderately rapid soil permeability. 9 10 (Figure 2)

Slope was derived using 1-foot elevation contours from National Oceanic Atmospheric Administration (NOAA). The elevation contours were converted to raster and surface analyst tool was used to derive slope. The slope was then reclassified with highest suitability value (1) given to steepest slopes (30-60%), as this is where there will be highest amount of runoff, value of 2 was given to 15-30% slopes, value of 3 was given to 10-15%, and so on with lowest suitability value (5) given to 0-5% slopes. (Figure 4)

Results & Conclusion

Green infrastructure or vegetation can be used to remediate, prevent or contain contaminants in soils, sediments, and groundwater.¹¹ Phosphorus is an inorganic material that can be picked up by wind (atmospheric deposition) or water (stormwater runoff). 12 The best method to remediate phosphorus in our sub-watershed is to capture and stabilize it on site before it reaches the Malden River. 13 This GIS analysis determined optimal sites appropriate for green infrastructure planning and low impact development for phosphorus reduction in the delineated sub-watershed using reclassify and weighted raster analysis. (Figure 6 and 7)

Since residential and urban areas are the sub-watershed's primary source of phosphorus, weighted criteria of 55% influence was assigned to land cover, 35% to soil covers since majority of the area was categorized as Urban land, wet substratum, and 10% to slopes since there weren't many steep areas in the delineated watershed. Optimal sites obtained through this analysis can implement phytotechnology to filter pollutants close to the source. Stormwater can be directed into a surface flow wetland along edges of the Malden River. A riparian buffer can be implemented along the Malden River to prevent pollution migration from adjacent land uses. 14 These strategies can work together as a system, stabilizing phosphorus where it can remain onsite in the soil instead of reaching the Malden River. (Figure

The analysis could use several other criteria to provide an opportunity enhance the weighted analysis. Analysis for optimal sites can include parcel use, population density, flow accumulation, and surface temperature in addition to criteria I have chosen for my analysis.

5 United States Environmental Protection Agency, "Protocol for Developing Nutrient TMDLs, First

Edition," accessed November 5, 2019, https://nepis.epa.gov/Exe/ZyNET.exe/20004PB2. TXT?ZyActionD=ZyDocument&Client=EPA&Index=1995+Thru+1999&Docs=&Query=&Time=&EndTime=&SearchMethod=1&TocRestrict=n&Toc=&TocEntry=&QField=&QFieldYe ar=&QFieldMonth=&QFieldDay=&IntQFieldOp=0&ExtQFieldOp=0&XmlQuery=&File=D%3A%5Czyfiles%5CIndex%20Data%5C95thru99%5CTxt%5C00000016%5C20004PB2. txt&User=ANONYMOUS&Password=anonymous&SortMethod=h%7C-&MaximumDocuments=1&FuzzyDegree=0&ImageQuality=r75g8/r75g8/x150y150g16/

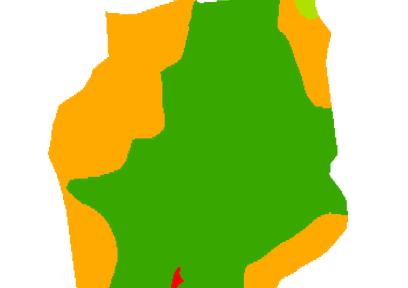
i425&Display=hpfr&DefSeekPage=x&SearchBack=ZyActionL&Back=ZyActionS&BackDesc=Results%20page&MaximumPages=1&ZyEntry=1&SeekPage=x&ZyPURL 6 "Soil Survey of Norfolk and Suffolk Counties, Massachusetts (Peragallo, 1989)," accessed November 7, 2019, http://nesoil.com/norfolk/Uw.htm.

7 "Pollution in the Mystic," Mystic River Watershed Association, accessed November 1, 2019, https://mysticriver.org/pollution.

8 "Uw-Urban Land, Wet Substratum, 0 to 3 Percent Slopes," accessed May 7, 2020, http://nesoil.com/norfolk/Uw.htm. 9 "CdC-Canton-Urban Land Complex, 3 to 15 Percent Slopes," accessed May 7, 2020, http://nesoil.com/norfolk/CdC.ht 10 "MnB-Merrimac-Urban Land Complex, 0 to 8 Percent Slopes," accessed May 7, 2020, http://nesoil.com/norfolk/MnB.htm.

11 Kate Kennen and Niall Kirkwood, Phyto: Prinicpals and Resources for Site Remediation and Landscape Design (Taylor & Francis Ltd, 2015). 12 Kennen and Kirkwood.

13 Kennen and Kirkwood. 14 Kennen and Kirkwood.



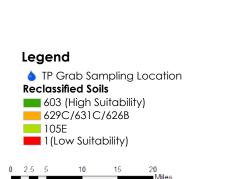


Figure 2: Soils Suitability

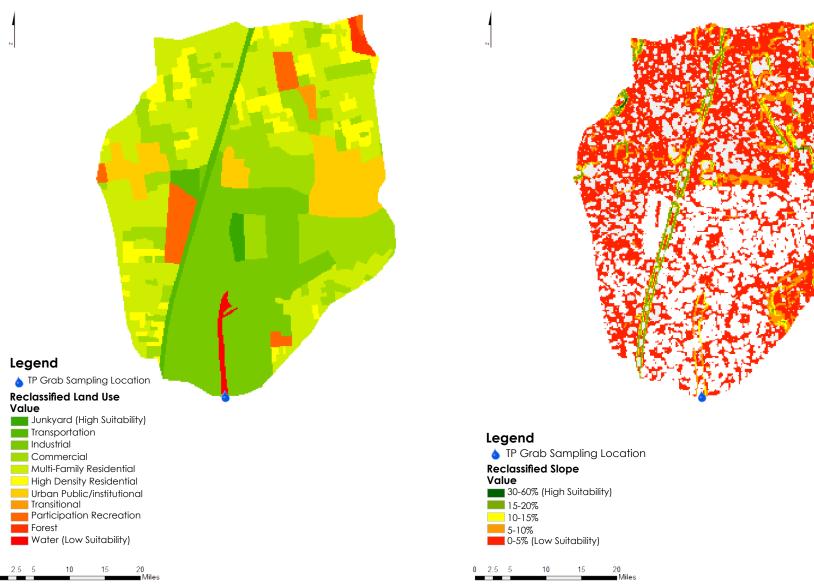


Figure 3: Land Use Suitability



Figure 4: Slope Suitability

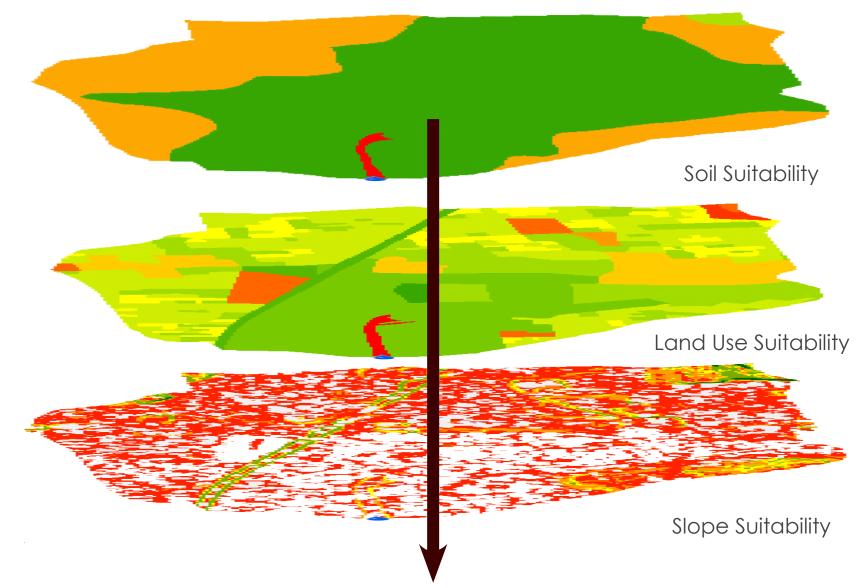


Figure 5: Weighted Overlay

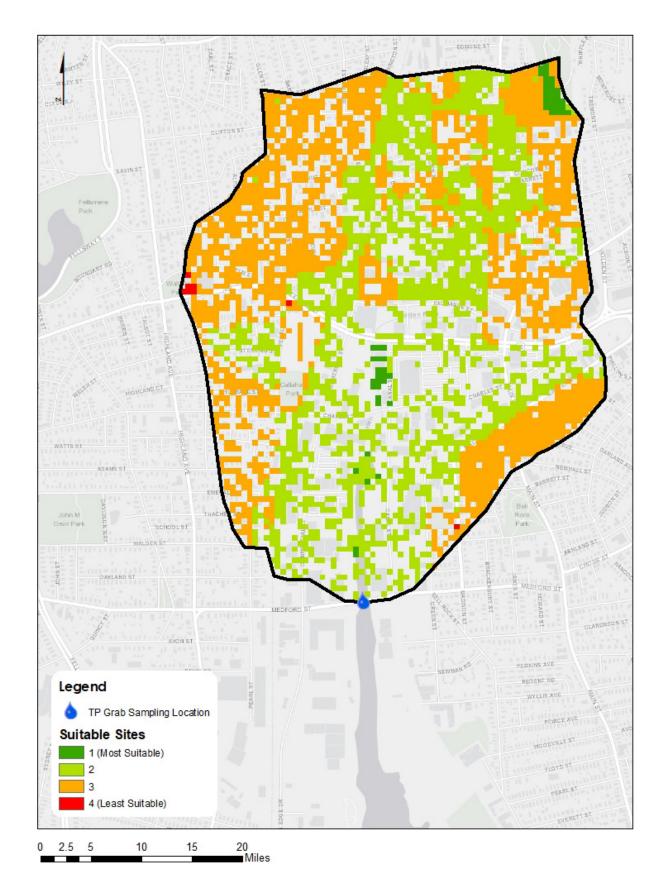


Figure 6: Suitable Sites



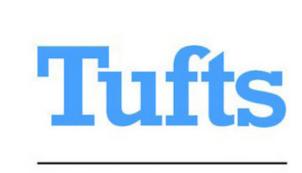
Figure 7: Optimal Sites

Data & Online Sources: MassGIS, Land Use (2005)

MassGIS, MassDEP, Watershed Delineations (2019) MassGIS, MassDEP, Water Quality Monitoring Stations (2019) MassGIS, MassDEP, Hydrography (2019) MassGIS, Community Boundaries (2014)

U.S Geological Survey (USGS), World Topographic Base Map (2020) United States Department of Agriculture (USDA), Hydrologic Soil Group (2019) National Oceanic and Atmospheric Administration (NOAA), LIDAR Elevation Contours (2013-2014) National Water Quality Monitoring Council, MyRWA Total Phosphorus Sample Grab (2015)

Coordinate System: StatePlane Massachusetts Mainland **Projection:** Lambert Conformal Conic



Urban and Environmental Policy and Planning