Neponset Watershed Stormwater BMP Prioritization Tool

BMP siting in small separate municipal sewer systems

Caitlin Spence, PhD, Metropolitan Area Planning Council

Overview

What the tool does

- Create a spatial dataset and attribute table of parcels in one or several municipalities, scored to reflect how promising each parcel is for stormwater BMP installation based on user-specified criteria
- Users can run the tool, then filter, sort, and map parcels to visit and investigate in-person.

Requirements

- ArcGIS for Desktop 10.6 or 10.7 (function not tested on other versions) basic license
- Spatial data publicly available from MAPC, MassGIS, and USDA
- Microsoft Excel 1997-2003

Caveats

- The tool combines spatial data products that reflect a range of spatial scales (e.g. minimum map unit). Attributes added to parcel geometry are subject to uncertainty.
- Nutrient load calculations are based on standard land use codes, a system that is generated for taxation and legal purposes rather than environmental management. While most parcels will be correctly classified, some parcels may be classified into stormwater-relevant land use categories based on their standard use code that do not reflect actual land use or land cover at the parcel.
- Nutrient load calculations are based on methods that are designed to estimate nutrient load at the watershed scale. When applied at the parcel level, there is substantial uncertainty in the nutrient load estimated through these methods.
- Priority scores should be used as an approximate screening method only. Attribute information in the parcel database should be confirmed by local experts and/or in-person visits to confirm accuracy before decisions are implemented based on the parcel database.

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Project Description

Many Massachusetts municipalities use small separate storm sewer systems as their main method of stormwater conveyance. While this method efficiently routes runoff into receiving water bodies, the nutrient load of water conveyed this way remains high from source to sink. The Clean Water Act (1972) set national standards for protecting the quality of U.S. Waters by regulating discharge into those waters. All municipalities that discharge stormwater into receiving waters must qualify for a stormwater discharge permit under the National Pollutant Discharge Elimination System (NPEDS) program to lawfully discharge stormwater. Because Small Municipal Separate Storm Sewer System (MS4) municipalities lack a centralized system to quantify discharged stormwater quality and volume, MS4 municipalities must meet alternative standards to qualify for a NPEDS permit. In Massachusetts, these standards include providing a plan for implementing Best Management Practices (BMPs) that "collectively control the discharge of pollutant(s) of concern)" into Impaired Waters (303(d) waters).

The Neponset River Watershed Association (NepRWA) and the Metropolitan Area Planning Council (MAPC) have established a set of online tools to assist MS4 municipalities in meeting Massachusetts MS4 permit requirements. Specifically, the tools and technical assistance resources assist municipalities with the following planning tasks:

(1) Delineate all area within the municipality that contributes stormwater runoff to storm sewer outfalls, as well as impaired waters.
(2) Prioritize storm sewer outfalls for field investigation. Field investigation would be conducted to detect illicit discharge, verify contributing catchment area, understand the storm sewer pipe network, and determine typical storm water quality.
(3) Prioritize areas within the municipality for field investigation to identify and characterize potential BMP retrofit sites.
(4) Create an online data entry form to assist municipal staff, volunteers, and/or external consultants create high quality datasets based on BMP field investigations.
(5) Develop an automatically generated "fact sheet" on each potential BMP site that has been studies through field investigation. The fact sheets will be compiled into a streamlined catalog to consult during planning.

NepRWA and MAPC have completed tasks one and two. This methodological document describes the data inventory and analysis that supports task three.

Study Area

MAPC analysts created the MAPC Stormwater Toolkit: BMP Prioritization Module to create a suite of online tools that Neponset River Watershed municipalities could use to support stormwater management planning. The resulting stormwater-themed parcel database contains parcels from the following municipalities, each of which overlaps the Neponset River Watershed:

- Boston
- Milton
- Randolph
- Dover
- Dedham
- Westwood
- Medfield
- Walpole
- Norwood
- Canton
- Foxborough

- Sharon
- Stoughton
- Quincy

Because the City of Boston is so large, we restricted the assessment of its parcel characteristics to parcels in the neighborhoods of Mattapan, Hyde Park, and Dorchester, which have the greatest degree of overlap with the Neponset River watershed.

In addition, MAPC is making the ArcGIS tools used to create the stormwater-themed parcel database publicly available so that any municipality in Massachusetts can create a local version of the parcel database that reflects locally specific management goals.

Data Requirements and Products

Products

This work produced several technical resources and online tools that assist Neponset watershed municipalities with MS4 permitting. The products are the following

- Spatial dataset of all parcels in the Neponset municipalities with attributes related to their suitability for stormwater management interventions.
- Custom, script-based ArcGIS desktop geoprocessing tools for creating the stormwater-themed parcel dataset from other publicly available datasets.
- Custom, script-based ArcGIS desktop geoprocessing tools for calculating BMP field visit priority scores based on user-specified criteria weights. The tool can be used to calculate priority scores either within either a single municipality or for the entire set of Neponset municipalities. Scores from the latter tool would be municipally specific.
- Four pre-calculated BMP field inspection priority scoring templates based on expert-informed criteria weights. The four priority scores reflect the criteria weights that indicate maximum suitability for BMP installations that reduce total phosphorus load, total nitrogen load, total suspended solids load, and promote groundwater recharge.

Software Requirements

The Neponset Stormwater Management Planning Suite was developed using ArcGIS 10.6.1 and 10.7.1. The Python Script tools require no special licenses or extensions beyond an ArcGIS 10.6.1 and onward basic license. The tools run on ArcGIS internal 32-bit Python 2.7.

Data and Ranking Criteria

The dataset creation tool adds a number of attributes to a spatial parcel dataset. The new attributes can be used by analysts and stormwater experts to rank parcels in terms of priority for field investigation and/or to filter out unsuitable parcels. The datasets used in the tool are outlined below in Table 1.

Criteria	Spatial Layers	Source(s)	Field Added	Access location
Documented parcel	MA Land Parcel Database	MassGIS, MAPC	All	https://datacommon.mapc.org/browser/datasets/360
Acres of Hydrologic Soil Group (HSG) A on parcel	Soils polygon (SSURGO), soils by slope	MassGIS/NRCS	hsgA_ac	https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils

Acres of Hydrologic Soil Group (HSG) B on parcel	Soils polygon (SSURGO), soils by slope	MassGIS/NRCS	hsgB_ac	https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils
Acres of Hydrologic Soil Group (HSG) C on parcel	Soils polygon (SSURGO), soils by slope	MassGIS/NRCS	hsgC_ac	https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils
Acres of Hydrologic Soil Group (HSG) CD on parcel	Soils polygon (SSURGO), soils by slope	MassGIS/NRCS	hsgCD_ac	https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils
Acres of Hydrologic Soil Group (HSG) D on parcel	Soils polygon (SSURGO), soils by slope	MassGIS/NRCS	hsgD_ac	https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils
Acres of Hydrologic Soil Group (HSG) UNC on parcel	Soils polygon (SSURGO), soils by slope	MassGIS/NRCS	hsgUNC_ac	https://docs.digital.mass.gov/dataset/massgis-data-nrcs-ssurgo-certified-soils
Land use suitability	MA Land Parcel Database	MassGIS, MAPC	luc_adj_1	Table provided
Activity Use Limitation Area on parcel	Activity Use Limitation Area	MassGIS, MassDEP	site_info	https://docs.digital.mass.gov/dataset/massgis-data-massdep-oil-andor-hazardous-material-sites-activity-and-use-limitations-aul
Parcel includes wetland	DEP Wetlands 2005 (Simple)	MassGIS, USGS, MassDEP	it_valdesc	https://docs.digital.mass.gov/dataset/massgis-data-massdep-wetlands-2005
Impervious cover area on parcel	MA Land Parcel Database	MassGIS, MAPC	imperv_pct	Attribute in MA Land Parcel Database.
Parcel has been previously evaluated for BMP installation	Database of locations previously investigated	NepRWA, Town Data	Date	Municipal/watershed association records
Fraction of parcel that overlaps a Zone 1 or Interim Wellhead Protection Area	Zone I Wellhead Protection layer	MassGIS, MassDEP	z1i_p	https://docs.digital.mass.gov/dataset/massgis-data-massdep-wellhead-protection-areas-

				zone-ii-zone-i-iwpa
Fraction of parcel that overlaps a Zone 2 Wellhead Protection Area	Zone II Wellhead Protection layer	MassGIS, MassDEP	zii_p	https://docs.digital.mass.gov/dataset/massgis-data-massdep-wellhead-protection-areas-zone-ii-zone-i-iwpa
Watershed	Major Basins	MassGIS, USGS	name	https://docs.digital.mass.gov/dataset/massgis-data-major-watersheds
Total Nitrogen loading	MA Land Parcel Database	MassGIS, MAPC, MassDEP, NepRWA	TN_lbacyr	Table provided
Total Phosphorus Loading	MA Land Parcel Database	MassGIS, MAPC, MassDEP, NepRWA, EPA, MEPA?	TP_lbacyr	Table provided
Total Suspended Solids loading	MA Land Parcel Database	MassGIS, MAPC, MassDEP, NepRWA	TSS_lbacyr	Table provided
Existing stormwater catch basin on parcel	Municipal records	Municipal records	Facility_I	Municipal records
Existing stormwater drain pipe on parcel	Municipal records	Municipal records	Feature_ID	Municipal records
Aquifer recharge potential	MAPC analysis (2014)	MAPC (K:\DataServices\Projects\Current_Projects\Environment\Neponset\Retrofit Task\Retrofit Documentation\Archive)	Ann_Rch_Depth	MAPC internal analysis
Municipally owned	--	Municipal records	'OWNER1'	Municipal records

Table 1: Data inventory and processing needs.

Several of the datasets (municipally owned parcels, locations of past BMP suitability field evaluations, existing stormwater infrastructure) are not publicly available and, if available, are most likely records maintained by municipal government. For compatibility with the tool, we recommend the analyst add a field to each dataset identical to the text in the "Field Added" column of Table 1. We recommend the value in the added field be meaningful to the municipal stormwater management system. For example, the feature class of municipally owned parcels must have a field named "OWNER1" and the analyst might fill out this field with a description of the exact owner or use of each municipally owned parcel.

The analyst creating the stormwater-themed database for their municipality or a group of municipalities should store copies of the above datasets clipped or selected to only the spatial extent of interest in one file geodatabase. In addition, the analyst should add to the file geodatabase a feature class of municipal boundaries covering only the municipalities of interest. We recommend that the extent of the municipal

boundaries feature class match the extent of each layer in Table 1 exactly. The feature class of municipal boundaries must include a field containing the proper-case name of each municipality.

Load Calculation Methods

Total Nitrogen and Total Suspended Solids Estimated Loading

Total nitrogen Loading resulting from the parcel is estimated using the Unit Limited Area method from Table 3-12 of the Massachusetts Stormwater Handbook, which provides estimates of total phosphorus (TP) load, total nitrogen (TN) load, and total suspended solids (TSS) load from a list of land use type in terms of the pounds of each nutrient expected to run off from one acre of land of the corresponding land use type in one year.

NepRWA staff experts created a logical mapping between the several hundred standard land use codes native to the Massachusetts Land Parcel Database and the generalized land use categories of the Unit Area Loading method. Each parcel was assigned a total nitrogen load and a total suspended solids load based on its standard land use code.

Total Phosphorus Estimated Loading

The Massachusetts MS4 general permit provides instructions for calculating estimated phosphorus load based on land use, land cover (pervious/impervious surface), and soil type. The instructions are provided in Appendix F: "Requirements for Discharges to Impaired Waters with an Approved TMDL", Attachment 1: "Method to Calculate Baseline Watershed Phosphorus Load for Lake and Pond Phosphorus TMDLs (Applicable to part II of Appendix F Only) And Method to Calculate Increases in Phosphorus Load due to Development." We adopt this method to estimate total phosphorus load at each parcel.

The parcel database contains four attributes that are combined with the table to estimate total nitrogen loading: Parcel area (A), parcel impervious area (A_i), parcel pervious area (A_p), and parcel hydrologic soil group classification (HSG). HSG classification is not part of the MA land parcel database standard attributes, and is added to the parcel attributes during the stormwater-themed database creation. Table 1-2 of the MA MS4 General Permit Appendix F, Attachment 1 provides phosphorus loading constants for combinations of land use type, pervious vs. impervious land cover, and hydrologic soil group classification for pervious land cover at each land use type.

The total phosphorus loading (P_{parcel}) for each parcel is calculated as an area-weighted sum of the total phosphorus loading figures of the parcel's primary land use category *k* and soil classification *j* ($P_{pervious,k,j}$) within Table 1-2 and the total phosphorus loading figure of "Directly connected impervious" land use type in Table 1-2, $P_{impervious,k}$.

$$P_{parcel} = \frac{A_p}{A} P_{pervious,k,j} + \frac{A_p}{A} P_{impervious,k}$$

Priority Calculation Methods

Say a parcel has *n* attributes a_i with i between 1 and n, that are relevant to the priority that parcel should receive for field investigation. The values of each attribute a may take any form, including categorical, bounded continuous, positive only, or unbounded continuous.

Attribute values a are translated into pre-summed scores s_{a_i} using m discrete user-provided category designations $c_{k,i}$ or thresholds $t_{k,i}$ for quantitative attributes. The number of categorical designations may vary for each attribute, but must not exceed nine separate designations. Users also provide corresponding category scores $v_k^{a_i}$ with k between 1 and m as follows:

$$s_{a_i} = \begin{Bmatrix} v_1^{a_i}, & a_i < t_1^{a_i} \\ & \vdots \\ v_k^{a_i}, & t_{k-1}^{a_i} < a_i \leq t_k^{a_i} \\ & \vdots \\ v_m^{a_i}, & a_i > t_m^{a_i} \end{Bmatrix}$$

For categorical variables, the translation of attribute values into scores takes place as follows:

$$s_{a_i} = \begin{Bmatrix} v_1^{a_i}, & a_i \in t_1^{a_i} \\ & \vdots \\ v_k^{a_i}, & a_i \in t_k^{a_i} \\ & \vdots \\ v_m^{a_i}, & a_i \in t_m^{a_i} \end{Bmatrix}$$

To avoid redundance between attribute weights and attribute's sub-category weights, the sub-category weights, v, must take on values between 0 and 1.

A simplified example of the user entry table is shown below:

Attribute name	Attribute overall weight	Number of designations	Threshold or category 1	…	Threshold or category m	Category weight 1	…	Category weight m
a_1	w_{a_1}	m_{a_1}	$t_1^{a_1}$	…	$t_m^{a_1}$	$v_1^{a_1}$	…	$v_m^{a_1}$
⋮	⋮	⋮	⋮	⋱	⋮	⋮	⋱	⋮
a_n	w_{a_n}	m_{a_n}	$t_1^{a_n}$	…	$t_m^{a_n}$	$v_1^{a_n}$	…	$v_m^{a_n}$

The prioritization score of each parcel, p, is then the weighted sum of attribute scores s_{a_i} associated with parcel. The weight of each attribute, w_{a_i}, is provided by users. Scores attributed to parcels based on the acreage of each hydrologic soil group type on the parcel are pre-filtered by eliminating all but the highest soil type score before summing the individual criteria scores as shown below. The multiple soil criteria are therefore reduced to a single soil criterion which contributes to the parcel's overall priority score to avoid redundant contributions of multiple soil types as could occur on large parcels.

$$p = \sum_{i=1}^{n} w_{a_i} s_{a_i}$$

Parcel scores, based on user-designated value utilities and attribute weights, are used to rank parcels for field investigation priority.

Using the BMP Suitability Toolbox

The BMP Suitability toolbox manages two main tasks: Assembling the parcel database (stormwater edition) and calculating parcel suitability for stormwater best management practice retrofits based on information in the parcel database and user-provided preferences.

1. Set up the BMP Prioritization toolbox
   The BMP Prioritization toolbox is a custom toolbox. You will receive the python scripts on which the toolbox is based. Save the scripts (.py) files in an appropriate folder. The following sections describe how to set up the ArcToolbox.

   Because the Python script files are not packaged inside the .tbx file, the user needs to set the data source of each .tbx tool to the appropriate script in the same way an ArcMap user would connect a layer in the ArcMap Table of Contents to the appropriate shapefile, raster, or feature class.

   Within the BMP suitability toolbox are give tools. These are listed below matched with the appropriate script name.
   a. Load Calculator → load_calc.py
   b. Nutrient Percentiles By Municipality → nutrient_muni_percentile.py
   c. Parcel Combine → parcel_combine.py
   d. Parcel Prioritization Tool → prioritization.py
   e. Combine multiple priority scores into one table → parcel_priorityscore.py

   The following sections describe how to set up each Python Script tool within the Suitability toolbox.

Tool Setup Instructions

Parcel Combine

This tool joins external data layers to an existing parcel database shapefile based on location. Only attributes of interest are preserved in the resulting feature class. No change in values or spatial analysis is performed beyond determining which values of other point and polygon features in external data sources should be associated with each parcel.

To set up the Parcel Combine tool, right-click on the toolbox name ("BMP_suitability.tbx") and select "Add" → "Script" from the menu that appears. In the pop-up window that appears, type "ParcelCombine" in the "Name" box and "Parcel Combine" in the "Label" box. Click "Next" at the bottom of the window.

In the "Script File" box, navigate to the location where the "parcel_combine.py" script is saved. Click on it, then click "Open." Click "Next" at the bottom of the window.

The next pane allows the user to configure the inputs and input data types to the tool. Set up the "Display Name" and "Data Type" columns as follows:

Display Name	**Data Type**
Workspace	Workspace

Parcels with Nutrient Percentiles	Feature Class
Municipal Boundaries	Feature Class
Major Basins	Feature Class
Activity Use Limitation Sites	Feature Class
Soil type	Feature Class
Wetlands	Feature Class
Zone 1 Wellhead Protection Areas	Feature Class
Zone 2 Wellhead Protection Areas	Feature Class
Estimated Annual Recharge Depth	Feature Class
Municipally Owned Parcels	Feature Class
Stormwater Catch Basins	Feature Class
Stormwater Drain Pipe	Feature Class
Past BMP Inspections	Feature Class

Below the "Display Name/Data Type" table is another table labeled "Parameter Properties." The default properties are sufficient for other script tools. However, this tool uses several optional input datasets that are not publicly available and rely on municipal records.

As the user enters the "Municipally Owned Parcels", "Past BMP Inspections", "Estimated Annual Recharge Depth", "Stormwater Catch Basins", and "Stormwater Drain Pipe" parameters, they should navigate to the "Parameter Properties" box below and set the Property Type value to "Optional."

When the table is set up as shown above, click "Finish" at the bottom of the window, which will vanish. A script tool labeled "Parcel Combine" will appear under "BMP_suitability.tbx." The tool is now ready to use.

Load Calculator

The load calculator tool calculates an estimate of total nitrogen, total phosphorus, and total suspended solid runoff from each parcel in (1) pounds per year from the parcel and (2) pounds per acre-year from the parcel based on the assessor's standard use code. MAPC and NepRWA compiled a table of standard use codes translated into MA Stormwater Handbook Table 3-12 and Massachusetts EPA Table 1.1 of land use categories, impervious area, and associated nutrient loads. The NepRWA added an additional category of "Low Priority Loading", assigned to vacant, open area, and water land use types, with an estimated load of zero.

To set up the Load Calculator tool, right-click on the toolbox name ("BMP_suitability.tbx") and select "Add" → "Script" from the menu that appears. In the pop-up window that appears, type "LoadCalculator" in the "Name" box and "Load Calculator" in the "Label" box. Click "Next" at the bottom of the window.

In the "Script File" box, navigate to the location where the "load_calculator.py" script is saved. Click on it, then click "Open." Click "Next" at the bottom of the window.

The next pane allows the user to configure the inputs and input data types to the tool. Set up the "Display Name" and "Data Type" columns as follows:

Display Name	Data Type
Workspace	Workspace
Parcels	Feature Class
Load Map Table	Table View
Land Use Load Table	Table View
Phosphorus Land Use Lookup Table	Table View
Table 1.2	Table View
Municipal Boundaries	Feature Class

When the table is set up as shown above, click "Finish" at the bottom of the window, which will vanish. A scrip tool labeled "Load Calculator" will appear under "BMP_suitability.tbx." The tool is now ready to use.

Nutrient Load Percentile by Municipality

The Nutrient Load Percentile by Municipality tool calculates the percentile within each municipality of the total nitrogen, total phosphorus, and total suspended solid runoff load from each parcel pounds per acre-year.

To set up the Nutrient Percentiles by Municipality tool, right-click on the toolbox name ("BMP_suitability.tbx") and select "Add" → "Script" from the menu that appears. In the pop-up window that appears, type "NutrientMuniPercentiles" in the "Name" box and "Nutrient Percentiles by Municipality" in the "Label" box. Click "Next" at the bottom of the window.

In the "Script File" box, navigate to the location where the "nutrient_muni_percentiles.py" script is saved. Click on it, then click "Open." Click "Next" at the bottom of the window.

The next pane allows the user to configure the inputs and input data types to the tool. Set up the "Display Name" and "Data Type" columns as follows:

Display Name	Data Type
Workspace	Workspace
Parcels with Nutrient Loads	Feature Class
Municipal Boundaries	Feature Class

When the table is set up as shown above, click "Finish" at the bottom of the window, which will vanish. A scrip tool labeled "Nutrient Percentiles by Municipality" will appear under "BMP_suitability.tbx." The tool is now ready to use.

Prioritization

The "Prioritization" tool calculates priority scores for each parcel based on parcel attributes and user-specified preferences.

To set up the prioritization tool, right-click on the toolbox name ("BMP_suitability.tbx") and select "Add" → "Script" from the menu that appears. In the pop-up window that appears, type "ParcelPrioritization" in the "Name" box and "Parcel Prioritization" in the "Label" box. Click "Next" at the bottom of the window.

In the "Script File" box, navigate to the location where the "prioritization.py" script is saved. Click on it, then click "Open." Click "Next" at the bottom of the window.

The next pane allows the user to configure the inputs and input data types to the tool. Set up the "Display Name" and "Data Type" columns as follows:

Display Name	**Data Type**
Workspace	Workspace
Parcel database	Feature Class
Prioritization table	File
Theme	String

When the table is set up as shown above, click "Finish" at the bottom of the window, which will vanish. A script tool labeled "Parcel Prioritization" will appear under "BMP_suitability.tbx." The tool is now ready to use.

Parcel Priority Combine

If the analyst wishes to calculate only one prioritization weighting scheme, they may not need to set up or use the Parcel Priority Combine tool. The Parcel Priority Combine tool adds one or more tables generated by the Parcel Prioritization tool to the parcel feature class generated by the Nutrient Load Percentiles by municipality tool with a neatly organized attribute table.

To set up the Parcel Priority Combine tool, right-click on the toolbox name ("BMP_suitability.tbx") and select "Add" → "Script" from the menu that appears. In the pop-up window that appears, type "ParcelPriorityScore" in the "Name" box and "Parcel Priority Combine" in the "Label" box. Click "Next" at the bottom of the window.

In the "Script File" box, navigate to the location where the "parcel_prioritycombine.py" script is saved. Click on it, then click "Open." Click "Next" at the bottom of the window.

The next pane allows the user to configure the inputs and input data types to the tool. Set up the "Display Name" and "Data Type" columns as follows:

Display Name	**Data Type**

Workspace	Workspace
Parcel database	Feature Class
Municipal Boundaries	Feature Class
Score 1	Table
Score 2	Table
Score 3	Table
Score 4	Table

As the analyst enters scores 2, 3, and 4 into the tool parameters, they should use the "Parameter Properties" box below to set Score 2, Score 3, and Score 4 to "Optional" parameters.

When the table is set up as shown above, click "Finish" at the bottom of the window, which will vanish. A script tool labeled "Parcel Priority Score" will appear under "BMP_suitability.tbx." The tool is now ready to use.

Running the BMP Suitability Tools

Three tools within the BMP Suitability toolbox assist users with creating a streamlined database that contains the necessary information to analyze parcel retrofit suitability. These are the "Load Calculator", "Nutrient Percentiles by Municipality", and "Parcel Combine" tools. These tools require a base parcel geography that covers the entire extent of the intended parcel database. The base parcel geography must come from or include some of the fields included in the Massachusetts Land Parcel Database, which is a standardized shapefile of Level 3 parcel data spanning all of Massachusetts.

Data Preparation

Prior to running either tool, assemble all spatial data required to run the tools in a file geodatabase. We recommend the following process:

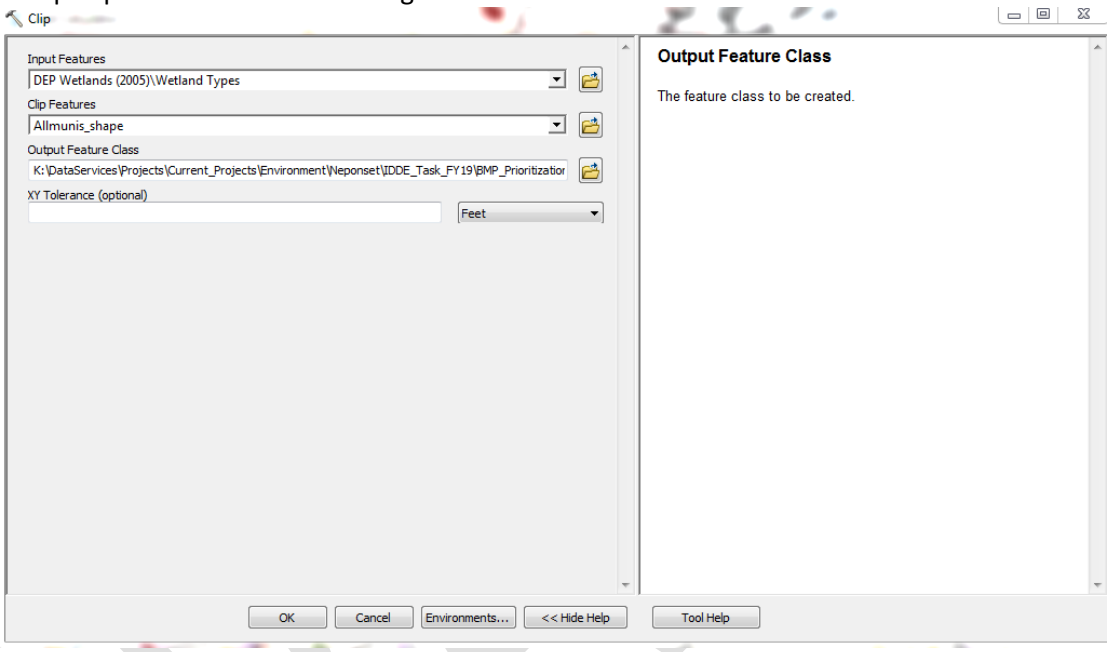
a. Create a feature class that contains a single polygon outlining the desired extent of the resulting stormwater-themed parcel database. To create the Neponset Parcel Database: Stormwater Edition, MAPC analysts used "Select by Attribute" on a polygon shapefile of all municipalities in Massachusetts to select all municipalities within a list of municipalities that overlap with the Neponset River Watershed. The list of municipalities was provided by the Neponset River Watershed Association (NepRWA).

```
town IN ('DEDHAM', 'SHARON', 'STOUGHTON', 'NORWOOD', 'WESTWOOD', 'MEDFIELD', 'WALPOLE', 'FOXBOROUGH', 'CANTON', 'RANDOLPH', 'MILTON', 'QUINCY', 'BOSTON', 'DORCHESTER')
```

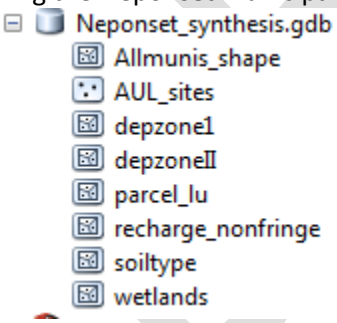
MAPC analysts then exported the selected municipal polygons to a new shapefile containing only those polygons. MAPC analysts then used the "Dissolve" geoprocessing tool to combine the separate municipal polygons into a single polygon covering the entire desired extent of the resulting database. Depending on the goals of the analysis, it would also be possible to simply use a polygon covering a relevant watershed's extent or a single municipal outline. Store the "outline" feature class in a dedicated file geodatabase that will be used as a workspace environment for the

database creation process. If the desired extent covers multiple municipalities, import the shapefile of the relevant municipalities into the file geodatabase as a feature class.

b. Clip (or restrict by selecting) spatial layers relevant to parcel stormwater retrofit suitability to the parcel database outline created in step 1a. This minimizes processing time later in the process. For example, use the geoprocessing "clip" tool to clip a statewide wetlands layer to the desired extent of the parcel database using the statewide wetlands layer as the input. Store the results of each "clip" operation in the same file geodatabase that contains the database outline.



MAPC analysts used the Massachusetts Land Parcel Database to create the base geography covering the Neponset municipalities.

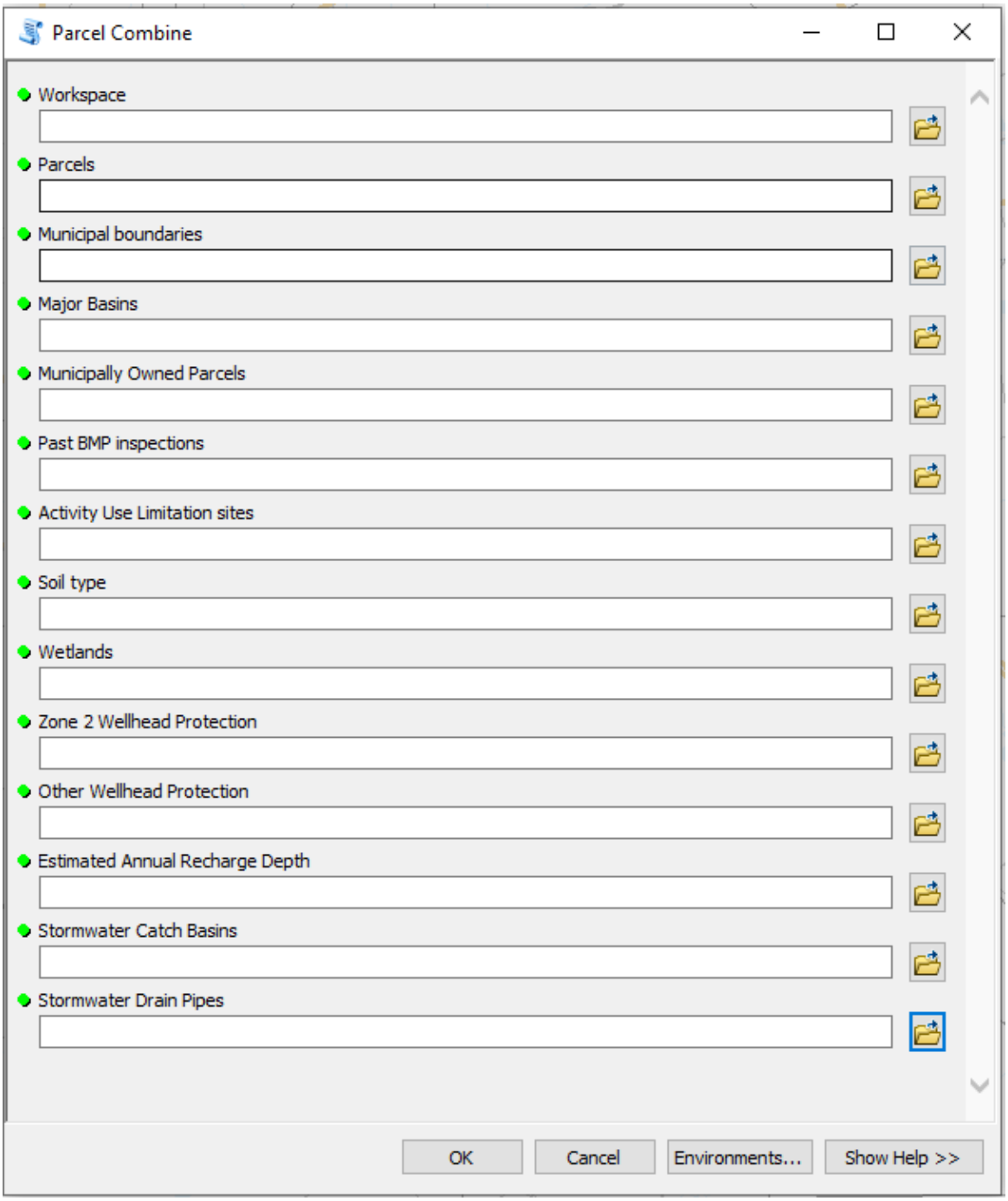


Tabular data are also needed to complete the parcel prioritization analysis. These include two classes of tables: Tables that include the information needed to translate land use classes and impervious surface percentage into estimated nutrient load and tables used to score the parcels based on user-specified preferences. These tables are available for download from MAPC's github page. The tables used by the Load Calculator tool should be imported to the working file geodatabase

Running the Tools

Parcel Combine

Run the "Parcel Combine" tool first- the "Load Calculator" tool depends on several attributes that will be added to the parcel feature class now.



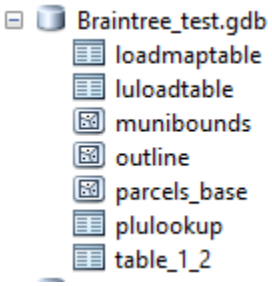
In the "Workspace" space, add the file geodatabase that stores the parcel feature class, municipal boundaries feature class, and other relevant spatial datasets.

The remaining inputs should already have been added to the workspace file geodatabase while preparing the data to run the tool. Add each appropriate feature class file path in the appropriate space in the Parcel Combine window. The latter five inputs are optional and will be added to the parcel base geometry if the analyst enters appropriately formatted data in any of the optional parameter windows.

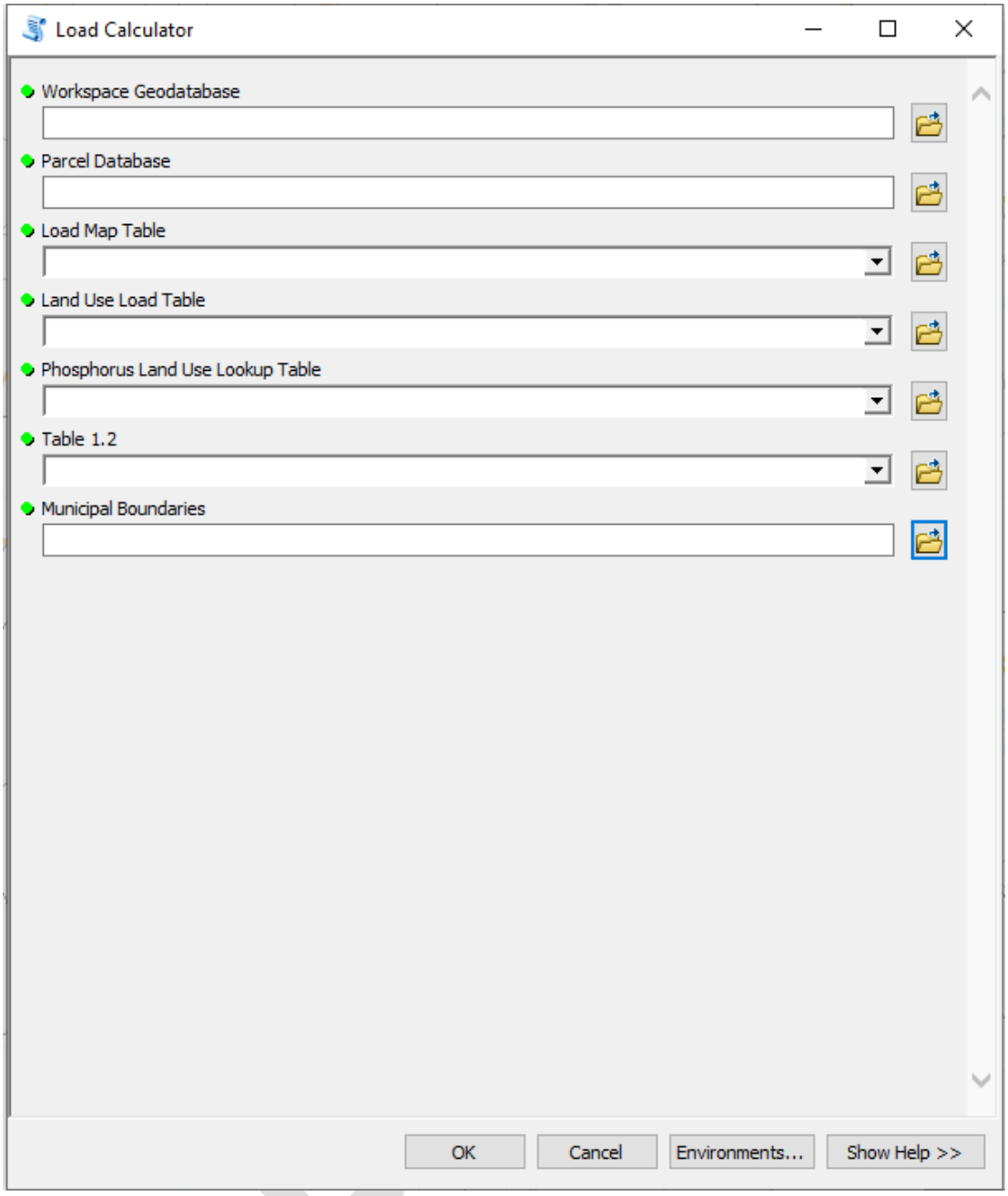
The Parcel Combine tool will create a new parcel feature class called “Parcels_Reunited.”

Load Calculator

Set up the file geodatabase with parcels, municipal boundaries, and the nutrient load calculation tables. The nutrient load tables “loadmaptable”, “luloadtable”, “plulookup”, and “table_1_2” are available as excel file downloads from the MAPC Stormwater Toolbox github page (<link>). The analyst must use the conversion tools to import the excel files as tables in to the working file geodatabase.



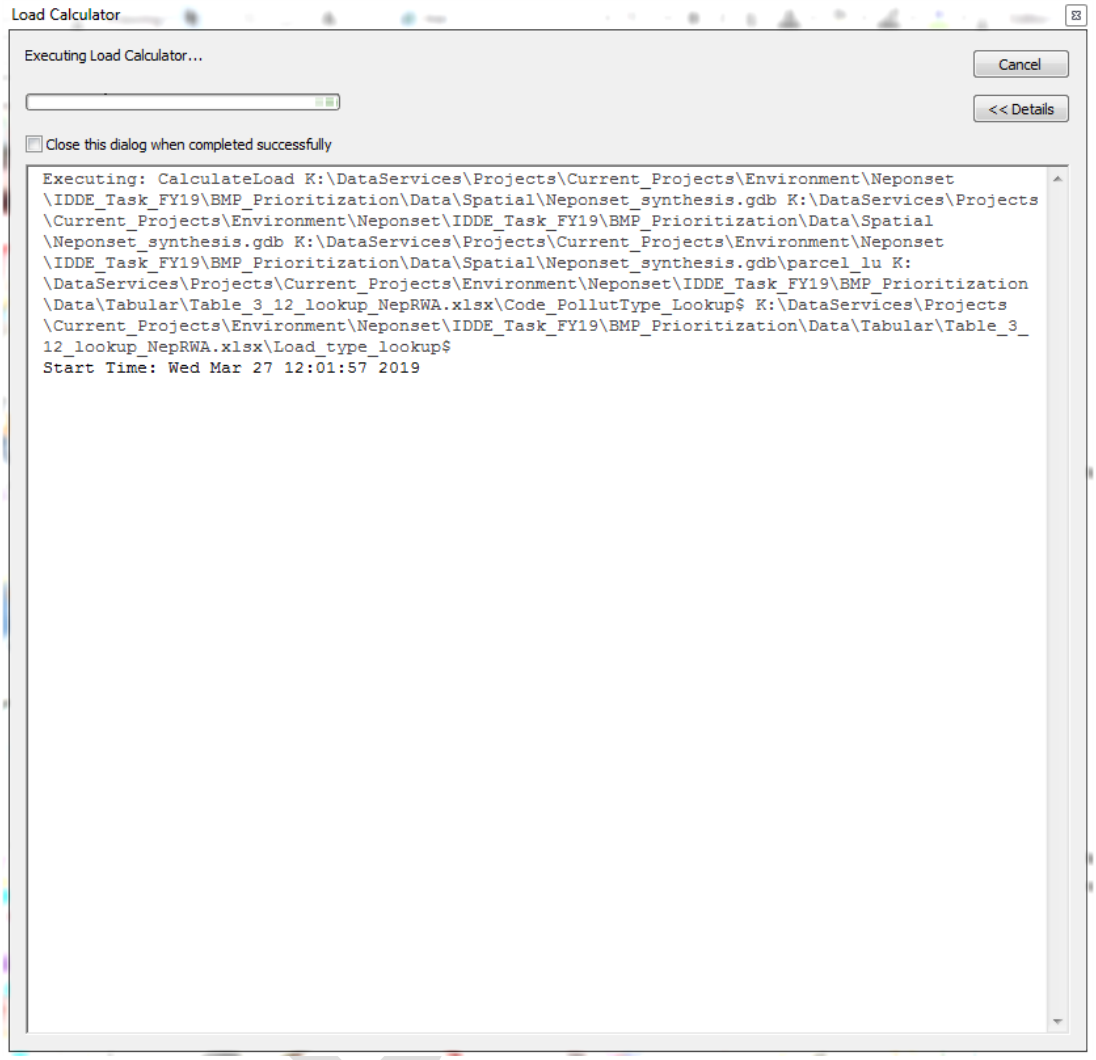
Add estimated parcel nutrient loads to the “Parcels_Reunited” database using the “Load Calculator” tool.



In the “Workspace Geodatabase” space and the “Output Folder” space, add the file geodatabase used to store the parcel base geography, parcel database extent outline, and clipped retrofit suitability attribute layers. In the “Parcel Database” space, add the feature class in the file geodatabase that represents the base parcel geography and land use characteristics. In the “Land Use Category Lookup Table”, add the excel sheet that stores each standard land use code matched to stormwater nutrient load-relevant land use categories.

In the “Land Use Nutrient Table” space, add the table matching each stormwater nutrient load-relevant land use category to loading parameters.

When all data inputs have been added to the tool window, click "OK." The window's appearance will change to show updates as the tool runs, estimating the annual total nitrogen, total phosphorus, and total suspended solids (TSS) load generated per acre on each parcel based on its land use classification. This is likely to take a few minutes for an individual municipality, and as long as an afternoon for a larger database extent such as the Neponset River watershed. A message will appear in the window notifying you when the script is completed.

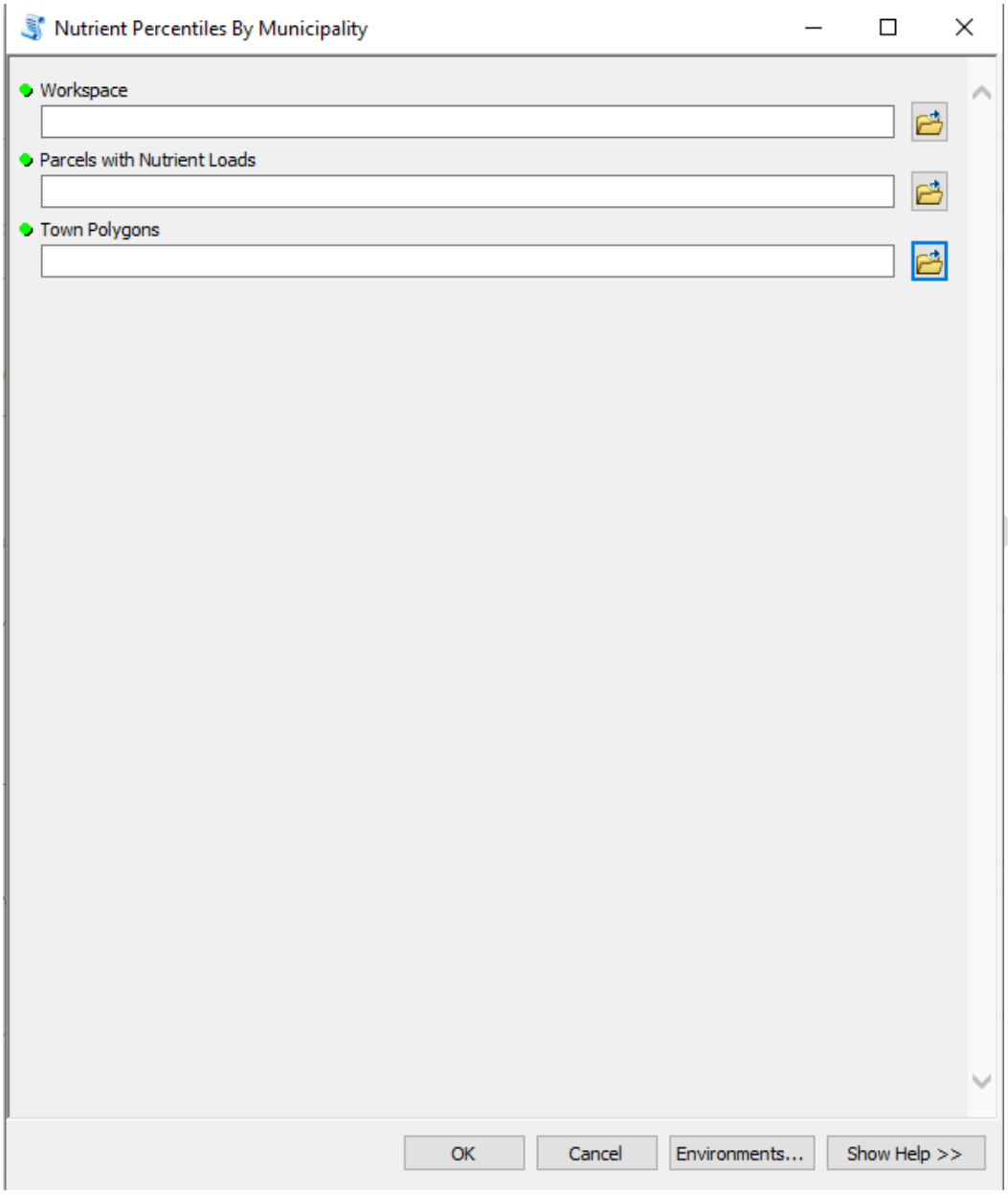


When the tool has finished running, a new feature class called "parcels_withnutrientload" will be stored in the file geodatabase. This feature class will contain all relevant attributes from the original parcel base geography feature class with additional attributes reflecting the parcel's estimated nutrient load on a per-parcel and per-acre basis.

Nutrient Percentiles by Municipality

Calculate nutrient load percentiles by municipality: This tool calculates the estimated phosphorus load per acre percentile, nitrogen load per acre percentile, and total suspended solids load per acre percentile of each parcel within a municipality.

The tool has three inputs: A “Workspace” (ideally the same file geodatabase in which the analyst ran the Load Calculator tool), the “Parcels with Nutrient Loads” feature class (the output of the Load Calculator tool), and the “Town Polygons” feature class, which was also an input to the Load Calculator tool.

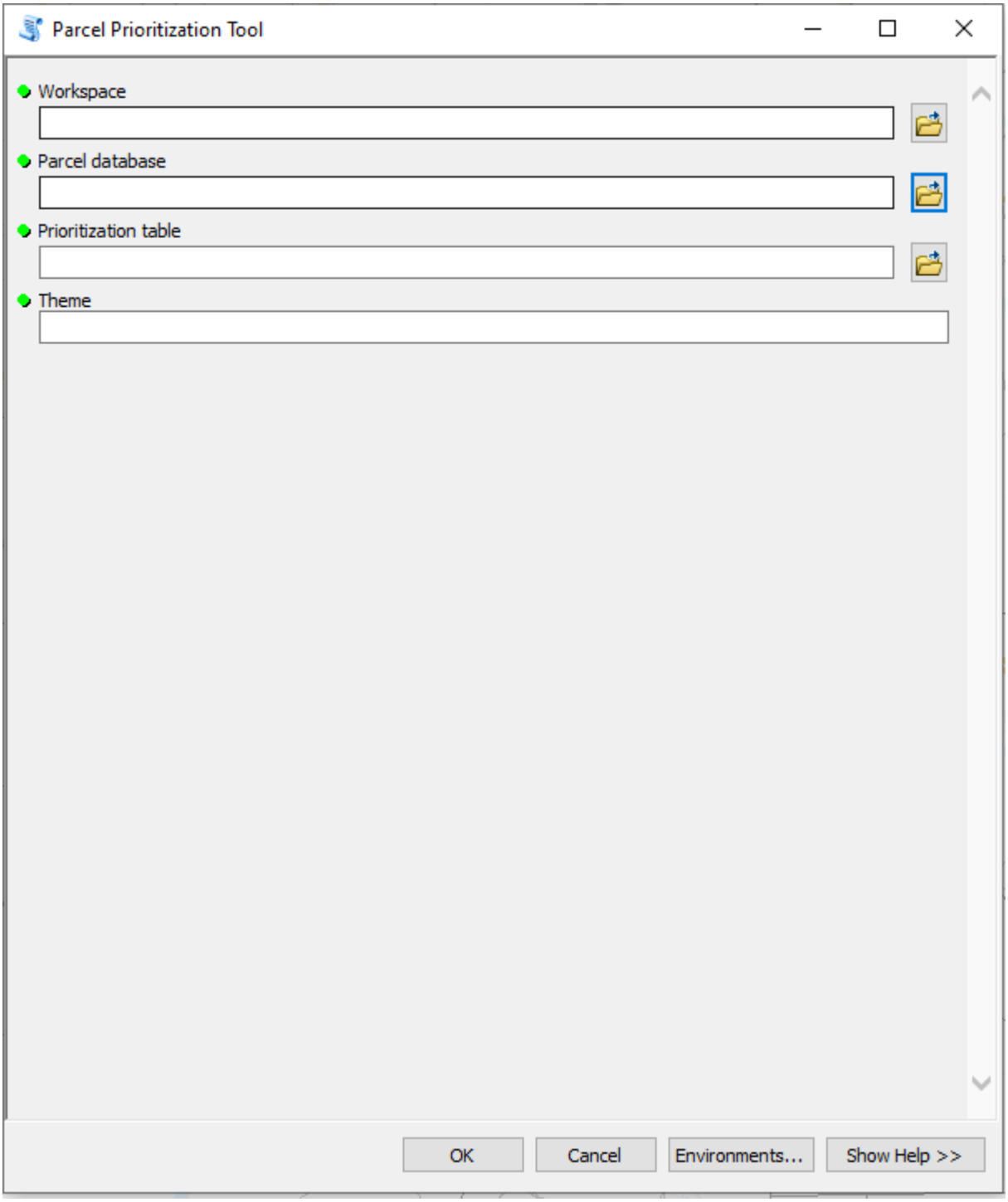


Click “OK.” A window will open showing the progress of the tool as it runs. When the run is complete, the moving green bars across the top of the window will still and a message will appear in the window stating “Completed script prioritization …” and list the time of completion below. The tool will create a new feature class in the working file geodatabase called “Parcels_withnutrientpctiles.”

Calculating Priority Scores

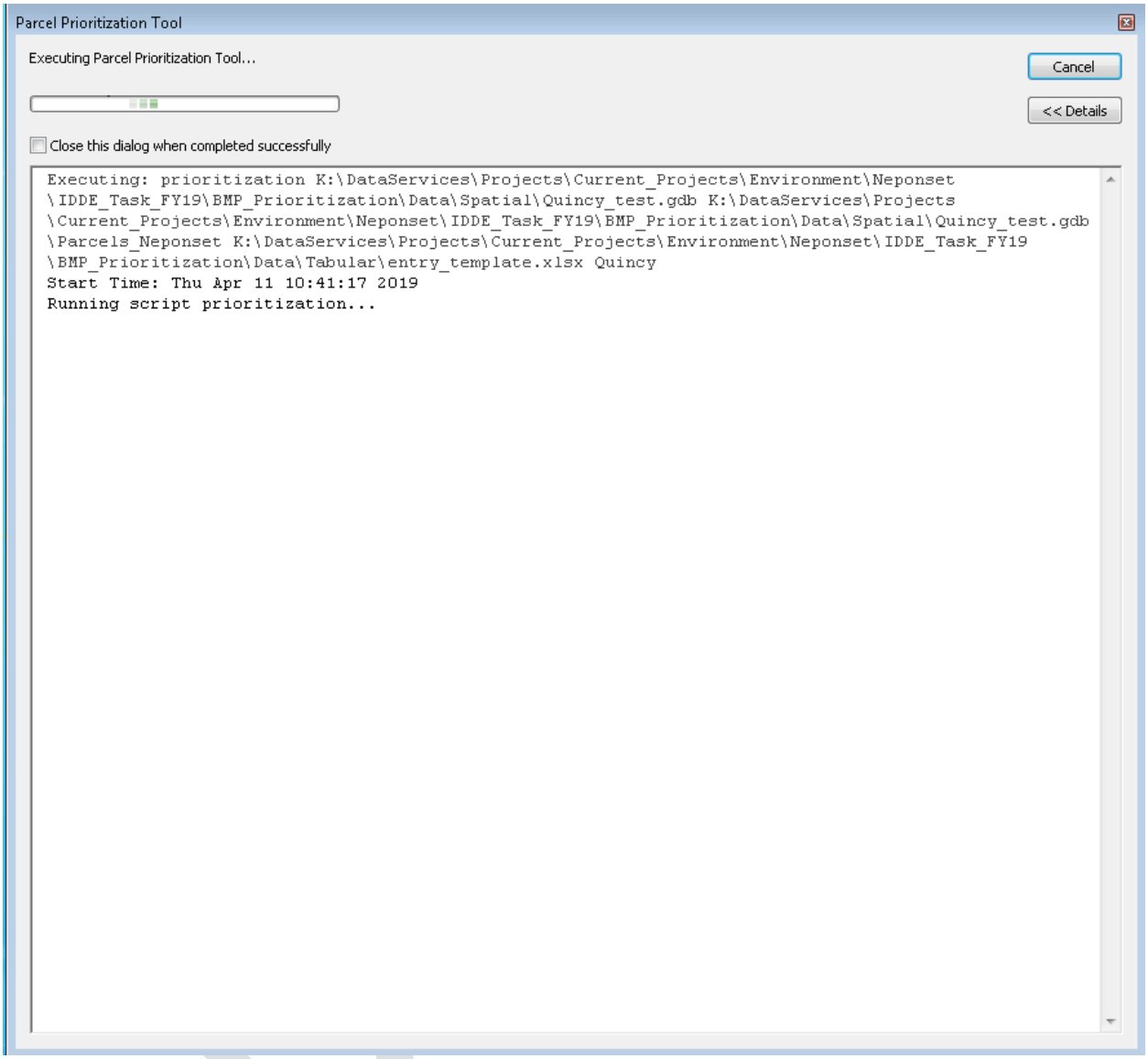
If considering only one weighting scheme, the “Parcel Prioritization” tool will be the last step. The tool takes four inputs: The file geodatabase workspace, the parcel feature class with all attributes necessary to

calculate weights (this should be the “Parcels_withnutrientpctiles” feature class generated by the previous step), the prioritization table as an excel sheet, and a brief “Theme” string that will be appended to the output file name to indicate which weighting scheme was used.



The parcel prioritization tool creates two new items in the working file geodatabase: The “entryform”, a table containing the weighting information from the excel entry template, and another table labeled

"Parcels_[]" where the latter part of the table name is the string entered by the user under the "Theme" input parameter.



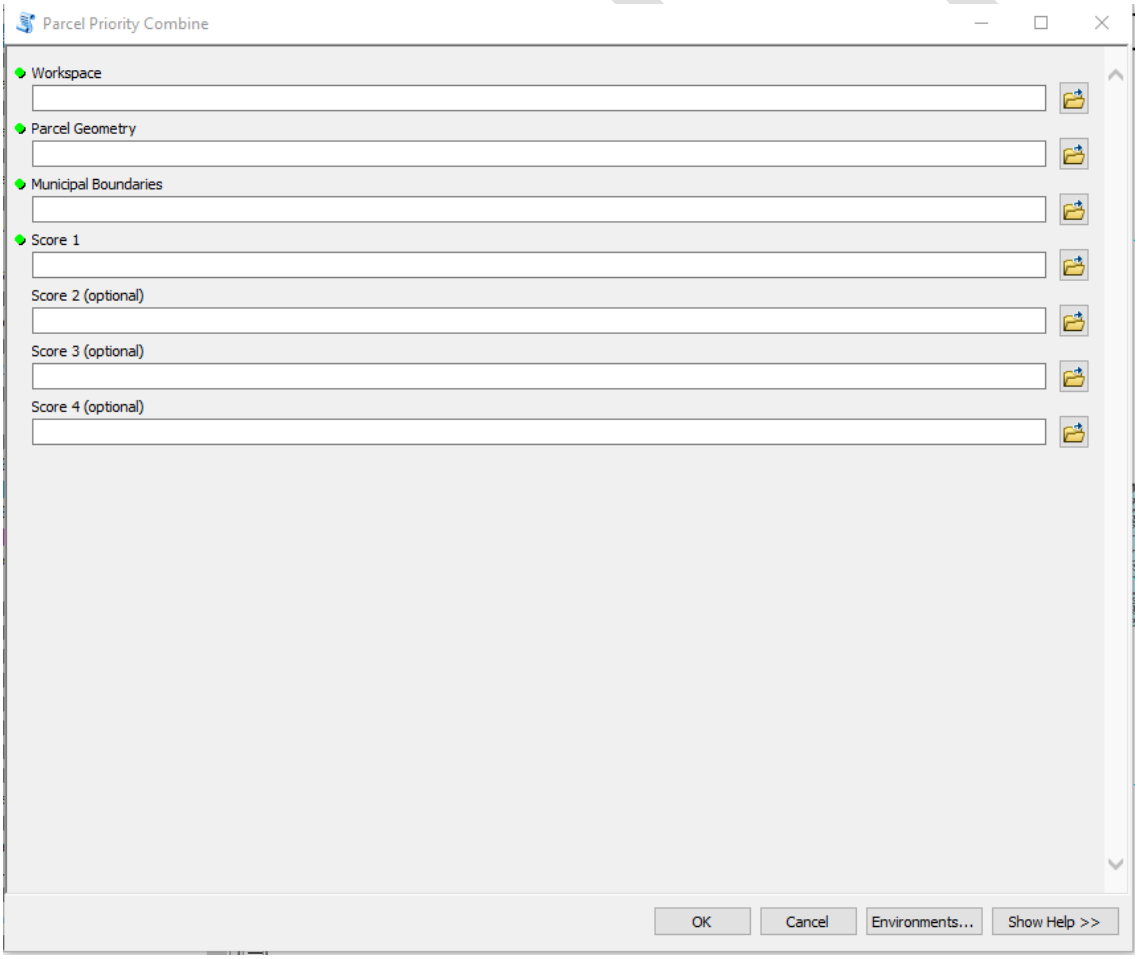
The Parcels_[Theme] table can be joined to parcel geometry by a unique identifier such as mapc_id, which developed by MAPC to assign each parcel in Massachusetts a unique ID. The analyst may then wish to filter the parcels based on attributes relevant to municipal stormwater management (for example, whether the parcel is municipally owned and/or the amount of non-impervious area available on the parcel) and sort the remaining parcels based on the priority score, which has the field name "pri_scr." The priority score percentile within each municipality may also be useful. This is labeled "pri_pct" and higher values indicate greater potential for BMP stormwater retrofits based on the spatial data and user-specified weighting scheme.

If the analyst wishes to run multiple priority weighting schemes, they may run the "Parcel Prioritization" tool several times, each time using a different criteria weighting template file to score the parcels. When all scoring runs are complete, the working file geodatabase will contain multiple tables labeled

"Parcels_[Theme]", for which the "Theme" text reflects the basis for the weighting scheme used to generate the priority scores in that table. On the MAPC Stormwater Toolbox github page, pre-filled scoring templates are provided to reflect four different representative stormwater management prioritization schemes: parcel suitability for installing stormwater BMPs that reduce total nitrogen runoff, total phosphorus runoff, total Suspended Solids runoff, and that promote groundwater recharge. Users may download these templates and either use them as is to run the parcel prioritization tool in their region of interest or alter the criteria, thresholds, and weights to better reflect their region's preferences, constraints, and stormwater management goals.

Parcel Priority Combine

If the analyst has chosen to calculate multiple priority scores, the "Parcel Priority Combine" tool will combine between one and four resulting tables into a single feature class with a neatly organized attribute table. Even if only one priority score is calculated, the Parcel Priority Combine tool will join the resulting table to parcel geometry and create a neatly-groomed attribute table. The priority percentile will be retained from each priority theme rather than the raw priority score for better intercomparison of parcel priority rank under each theme.



The Parcel Priority Combine tool will create a feature class labeled "Parcels_complete." This feature class will include all attributes of Parcels_withnutrientpctiles" as well as the priority percentile score field from each weighting theme, labeled "pri_pct_[theme]." Higher values are superior.

Troubleshooting Run Problems in the BMP Suitability Toolbox

This section of the documentation lists common problems that may arise when running tools in the BMP Suitability Toolbox, setup errors that may cause each problem, and how to fix the problem.

Prioritization Errors

Tool fails to run

If the prioritization tool fails to run, check that the input datasets are on the correct path.

Check also that the field names in the entry template spreadsheet match the exact field names in the base parcel database. When viewing field names in the parcel database attribute table, ensure you are viewing the actual field names using the drop-down menu at the top left of the attribute table and un-checking "Show field aliases." Alternately, view field names in the data properties "Fields" tab.

Check each field categories and the number of categorical groups in the entry template. If the "num_groups" field does not match the number of categories given in the threshold section and weight section of the template, the tool will encounter run errors. For categorical "cat_type" fields, ensure all possible values of the categorical field are represented on the data entry table.

Stormwater-Themed Parcel Database Data Dictionary

The parcel database is based on the Massachusetts Land Parcel Database geometry and attributes. At the time the Neponset Stormwater Parcel Database was created, the MA Land Parcel Database had last been updated in

Field Name	Data type	Long-form definition	Units	Origin	Filtering App?
TSS_lbacyr	Double	Estimated load of Total Suspended Solids (TSS) running off of each acre of the parcel each year	Pounds of suspended solids per acre-year	MAPC calculation	No
TP_lbacyr	Double	Estimated load of total phosphorus compounds running off of each acre of the parcel each year	Pounds of phosphorus-containing compounds per acre-year	MAPC calculation	No
TN_lbacyr	Double	Estimated load of total nitrogen compounds running off of each acre of the parcel each year	Pounds of nitrogen-containing compounds per acre-year	MAPC calculation	No
Desc_full	Text	Extended description of land use on the parcel based on assessor's standard use code.	N/A	Assessor's records	No
mapc_id	String	Standardized identifier for parcels in	N/A	MAPC data management	No

		Massachusetts. Each parcel in Massachusetts has a unique MAPC ID.			
muni_id	integer	Integer identifier for each of the 351 municipalities in Massachusetts/	N/A	Massachusetts	No
muni	String	Proper-case municipality name.	N/A	Massachusetts	Yes
parloc_id	String	Parcel location identifier	N/A	MA Land Parcel Database	No
poly_type	String	Type of parcel: TAX, right-of-way (ROW), private right-of way (PRIV-ROW), rail right-of-way (RAIL-ROW), FEE, or WATER	N/A	MA Land Parcel Database	No
map_num	Integer	Assessor's map number of map showing parcel.	Map	MA Land Parcel Database	No
mappar_id	String	Standardized combination of map, block, and lot number of parcel in assessor's records.	Map	MA Land Parcel Database	No
loc_id_cnt	Integer			MA Land Parcel Database	No
land_value	Double	Value of parcel land	U.S. Dollars	MA Land Parcel Database	No
bldg._value	Double	Value of building(s) on parcel	U.S. Dollars	MA Land Parcel Database	No
othr_value	Double	Value of parcel attributes other than land or buildings	U.S. Dollars	MA Land Parcel Database	No
total_valu	Double	Total value of parcel	U.S. Dollars	MA Land Parcel Database	No
ls_price	Double	Last sale price	U.S. Dollars	MA Land Parcel Database	No
ls_date	String	Date of last sale	YYYYMMDD	MA Land Parcel Database	No
bldg_area	Double	Building area	Square feet	MA Land Parcel Database	No

res_area	Double	Residence area	Square feet	MA Land Parcel Database	No
luc_1	String	Land use code 1	N/A	MA Land Parcel Database	No
luc_2	String	Land use code 2	N/A	MA Land Parcel Database	No
luc_adj_1	String		N/A	MA Land Parcel Database	No
luc_adj_2	String		N/A	MA Land Parcel Database	No
num_units	Double	Number of housing units on parcel reported by owner	Units	MA Land Parcel Database	No
units_est	Double	Estimated number of housing units on parcel based on land use code	Units	MA Land Parcel Database	No
units_src	String	Source of the "number of units" estimate: report or land use code	N/A	MA Land Parcel Database	No
num_rooms	Double	Number of rooms on the parcel	Rooms	MA Land Parcel Database	No
yr_built	Long integer	Year primary building on the parcel was first constructed	Year (Common Era)	MA Land Parcel Database	No
site_addr	String	Parcel street address (number and street name)	N/A	MA Land Parcel Database	No
addr_str	String	Parcel address street name	N/A	MA Land Parcel Database	No
addr_num	String	Parcel address street number	N/A	MA Land Parcel Database	No
addr_zip	String	Parcel address zip code	N/A	MA Land Parcel Database	No
owner_name	String	Name of parcel owner	N/A	MA Land Parcel Database	No
owner_addr	String	Address of parcel owner (street number and street name)	N/A	MA Land Parcel Database	No

owner_city	String	City of parcel owner address	N/A	MA Land Parcel Database	No
owner_stat	String	Two-digit state abbreviation of parcel owner address state	N/A	MA Land Parcel Database	No
owner_zip	String	Zip code of parcel owner address	N/A	MA Land Parcel Database	No
fy	Long Integer	Fiscal Year???	Year (Common Era)	MA Land Parcel Database	No
lot_areaft	Double	Parcel lot area	Square feet	MA Land Parcel Database	No
far	Double	Floor area ratio	Dimensionless	MA Land Parcel Database	No
pct_imperv	Double	Percent of lot area that is impervious	Percentage points	MA Land Parcel Database	No
pct_bldg	Double	Percent of lot that is covered by building	Percentage points	MA Land Parcel Database	No
pct_pave	Double	Percent of lot that is paved	Percentage pints	MA Land Parcel Database	No
landv_pac	Double	Land value per acre	U.S. Dollars per acre	MA Land Parcel Database	No
bldgv_pasf	Double	Building value per square foot	U.S. Dollars per square foot	MA Land Parcel Database	No
totv_pac	Double	Total value per acre	U.S. Dollars per acre	MA Land Parcel Database	No
bldlnd_rat	Double	Building value to Land value ratio	Dimensionless	MA Land Parcel Database	No
sqm_imperv	Double	Square meters of impervious surface on parcel	Square meters	MA Land Parcel Database	No
sqm_bldg	Double	Square meters of building area on parcel	Square meters	MA Land Parcel Database	No
realesttyp			N/A	MA Land Parcel Database	No
wetland_ty	String	Description of wetland type overlapping with parcel, if any	N/A	MassDEP & MassGIS	Yes

hsgtype	String	Letter classification of main hydrologic soil group at parcel	N/A	USGS SSURGO Soil Survey	Yes
aulsite	String	Web address to information on activity use limitation site on parcel, if any	N/A	MassDEP & MassGIS	Yes
visityear	Long integer	Year before 2019 that parcel was last visited for field investigation of BMP potential, if any	N/A	NepRWA database (2019)	Yes
rech_depth (Optional)	Double	Estimated recharge depth based on local characteristics	N/A	MAPC Analysis (2014)	No
zii_pwsid	String	Identification number of public water supply whose zone 2 wellhead protection area overlaps parcel, if any	N/A	MassDEP & MassGIS	Yes
z1i_pwsid	String	Identification number of public water supply whose zone 1 wellhead protection area overlaps parcel, if any	N/A	MassDEP & MassGIS	Yes
watershed	String	Capitalized name of watershed parcel's center resides in	N/A	MassGIS & USGS	Yes
Owner (Optional)	String	Name of municipal owner of parcel, if any	N/A	NepRWA database of municipally-owned parcels	Yes
cbid (Optional	String	Municipal identifier for stormwater catch basin on parcel, if any	N/A	NepRWA database (2019)	Yes
dpid (Optional)	String	Municipal identifier for stormwater drain pipe running through parcel, if any	N/A	NepRWA database (2019)	Yes
TN_lbyr	Double	Total pounds of nitrogen compounds estimated to run off	Pounds per year	MAPC & NepRWA analysis	No

		of parcel in one year.			
TP_lbyr	Double	Total pounds of phosphorus compounds estimated to run off of parcel in one year.	Pounds per year	MAPC & NepRWA analysis	No
TSS_lbyr	Double	Total pounds of suspended solids estimated to run off of parcel in one year.	Pounds per year	MAPC & NepRWA analysis	No
TN_pctile	Double	Total nitrogen load percentile within all parcels in municipality (load calculated in pounds/acre/year).	Percentile	MAPC & NepRWA analysis	Yes
TP_pctile	Double	Total phosphorus load percentile within all parcels in municipality (load calculated in pounds/acre/year).	Percentile	MAPC & NepRWA analysis	Yes
TSS_pctile	Double	Total suspended solids load percentile within all parcels in municipality (load calculated in pounds/acre/year).	Percentile	MAPC & NepRWA analysis	Yes
pri_pct_TN	Double	Total nitrogen remediation priority score percentile, i.e. percentage of parcels in municipality that are lower-priority for field investigations intended to gather information about which sites are best for installing stormwater retrofits that reduce nitrogen runoff.	Percentile	MAPC & NepRWA analysis	No
pri_pct_TP	Double	Total phosphorus remediation priority score percentile, i.e. percentage of parcels in	Percentile	MAPC & NepRWA analysis	No

		municipality that are lower-priority for field investigations intended to gather information about which sites are best for installing stormwater retrofits that reduce phosphorus runoff.			
pri_pct_TS	Double	TSS remediation priority score percentile, i.e. percentage of parcels in municipality that are lower-priority for field investigations intended to gather information about which sites are best for installing stormwater retrofits that reduce TSS runoff.	Percentile	MAPC & NepRWA analysis	No
pri_pct_GW	Double	Groundwater Recharge priority score percentile, i.e. percentage of parcels in municipality that are lower-priority for field investigations intended to gather information about which sites are best for installing stormwater retrofits that increase groundwater recharge.	Percentile	MAPC & NepRWA analysis	No

References

Metropolitan Area Planning Council (MAPC) (2015). "Massachusetts Land Parcel Database: Dataset description and field list." *MAPC DataCommon Datasets*. < https://mapc-org.sharefile.com/share/view/s8eb6a592d18450f9> Accessed October 30, 2019.