MEMORANDUM

To: **File**

From: **US EPA R1 Stormwater Section**

RE: **PLERs for Charles RD Evaluation**

Date: **Draft - 2/22/2022**

EPA Region 1's evaluation of the RD petition has included a stormwater phosphorus loading analysis for all property parcels located within the Charles River watershed. This parcel loading analysis was accomplished by applying stormwater runoff phosphorus load export rates (PLERs) to land surface areas with differing land use and cover types such as commercial, industrial, high-density residential uses with impervious cover (IC) and pervious grassed and landscaped cover (i.e., developed land pervious). The PLERs provide estimates of the average annual phosphorus load export delivered by untreated stormwater runoff from areas with distinct cover and use types for the same climatic conditions as used in the development of the Charles River phosphorus TMDLs. Multiplying the area of interest by the distinct PLER provides an estimate of the average annual phosphorus loading rate. For example, one (1) acre of impervious cover in commercial use is estimated to deliver 1.78 lbs of phosphorus per year (e.g., 1.0 acre of commercial IC X 1/78 lbs/acre/yr = 1.78 lb/yr).

This document provides an overview of the derivation of the PLERs used in the Charles River RD analysis to assess absolute and relative contributions of phosphorus loading from properties with land area located within the Charles River watershed based on varying land cover characteristics such as IC area and land use. Table 1 provides the PLERs used in the Charles RD analysis. As indicated, distinct PLERs are provided for several land use categories and two cover types. Land use types are organized by names, (USEGENNAME in column 2) according to Mass GIS most recent classifications based on 2016 data. Each of the 14 Mass GIS land use categories have been assigned to one of six (6) PLER land use categories (column 3) for which there are average annual stormwater runoff PLERs. Lastly, distinct PLERs are provided for each land use category for both IC and developed land pervious area (columns 4 and 5). IC includes any surface that prevents or significantly impedes the infiltration of water into the underlying soil. This can include but is not limited to roads, driveways, parking areas and other areas created using non-porous material, buildings, rooftops, structures, artificial turf and compacted gravel or soil. Developed land pervious area include all managed pervious areas including lawns, gardens, and landscaped areas but excludes forested and naturally vegetated areas.

Table1: Charles River Watershed Residual Designation Phosphorus Loading Analysis - Average Annual Phosphorus Load Export Rates (PLERs) for Stormwater Runoff Source Areas in the Charles River Watershed.

Mass GIS 2016 Land Use Codes		Phosphorus Load Export Rate (PLER) Aggregate Land Use Category	PLER- Impervious Cover (lbs/acre/yr)	PLER-Developed Land Pervious Area (e.g., grassed & landscaped areas) (lbs/acre/yr)
USEGENCODE	USEGENNAME			
0	Unknown	Open	1.52	0.21
2	Open land	Open	1.52	0.21
3	Commercial	Commercial/Industrial	1.78	0.21
4	Industrial	Commercial/Industrial	1.78	0.21
6	Forest	Forest	1.52	Not Applicable
7	Agriculture	Agriculture	1.52	0.21
8	Recreation	Open	1.52	0.21
9	Tax exempt	Commercial/Industrial	1.78	0.21
10	Mixed use, primarily residential	Commercial/Industrial	1.78	0.21
11	Residential - single family	Medium Density Residential	1.96	0.21
12	Residential - multi-family	High Density Residential	2.32	0.21
13	Residential - other	Medium Density Residential	1.96	0.21
20	Mixed use, other	Commercial/Industrial	1.78	0.21
30	Mixed use, primarily commercial	Commercial/Industrial	1.78	0.21

The Mass GIS 2016 land use categories and cover types shown in Table 1 make up the entirety of the land area in the Charles River watershed that has been subject to stormwater phosphorus load reduction requirements as specified in the current MA MS4 permit. Also, these land area types are included in the WLAs and implementation plans of the established Lower (2007) and Upper (2011) Charles River Phosphorus TMDLs. Thus, EPA has focused the Charles RD phosphorus loading analysis on these land use and cover types to be consistent with both the basis of the MS4 permit requirements and the TMDL WLAs. The PLERs in Table 1 were derived as part of developing the phosphorus load reduction requirements included in the draft and final small MS4 permits for MA (2016). A complete description of the methodology used to estimate these PLERs is provided in the April 22, 2014, Memorandum - *Annual Average Phosphorus Load Export Rates (PLERs) for Use in Fulfilling Phosphorus Load Reduction Requirements in EPA Region 1 Stormwater Permits* ("2014 PLER Memo") provided in Attachment 1.

The aggregation of the 14 land use categories into 6 PLER land use categories shown in Table 1 was accomplished based on a review of land use activities and the results of a previous analyses of regionally representative stormwater quality data (discussed below). This aggregation process applied follows the same process conducted previously during the development of the most recent MA MS4 permit phosphorus reduction requirements and referenced in the 2014 PLER Memo.

Table 2 provides the PLERs derived for the MA MS4 permit with a brief description of the basis of the individual values. As, indicated all IC PLERs provided in Table 1 for use in the RD loading analysis are taken directly from the values derived for the MA MS4 permit (see Attachment 1 and Table 3-1 in Attachment 3 to Appendix F to the MS4 permit: https://www3.epa.gov/region1/npdes/stormwater/ma/2016fpd/appendix-f-attach-3-2016-ma-sms4-gp-mod.pdf). Regarding the developed land pervious area, EPA is applying a more streamlined approach for estimating the stormwater runoff phosphorus load export from developed land pervious areas for the RD loading analysis than the approach used in the MS4 permit analysis. As indicated in Table 1, a single PLER value of 0.21 lbs/acre/year (Table 1) was derived for calculating phosphorus load for the developed land pervious area of property parcels rather than the more detailed approach used for MS4 permit development in which several PLERs were applied based on hydrologic soil group (HSG) of the developed land pervious area (Table 2 and Attachment 1- 2014 Methodology). However, the PLER value of 0.21 lbs/acre/year is based on the more detailed PLER information presented in the 2014 methodology and represents an approximation of typical phosphorus load export from such areas when evaluated on a larger watershed-scale basis. This value was derived by calculating the weighted average of distinct developed land pervious area PLERs that account for combinations of land use area (e.g., commercial) and hydrologic soil group (HSG) (i.e., HSG A, B, C and D) in the Charles River watershed.

Table 2: Average Annual Phosphorus Load Export Rates (PLERs) derived for the 2016 MA MS4 Permit*

Phosphorus Source Category by Land Use	Land Surface Cover	Phosphorus Load Export Rate, lb/acre/yr	Notes
Commercial (Com) and Industrial (Ind)	Directly connected impervious	1.78	Derived using a combination of the Lower Charles USGS Loads study and NSWQ dataset. This PLER is approximately 75% of the HDR PLER and reflects the difference in the distributions of SW TP EMCs between Commercial/Industrial and Residential.
	Pervious	See* DevPERV	
Multi-Family (MFR) and High-Density Residential (HDR)	Directly connected impervious	2.32	Largely based on loading information from Charles USGS loads, SWMM HRU modeling, and NSWQ data set
	Pervious	See* DevPERV	
Medium -Density Residential (MDR)	Directly connected impervious	1.96	Largely based on loading information from Charles USGS loads, SWMM HRU modeling, and NSWQ data set
	Pervious	See* DevPERV	
Low Density Residential (LDR) - "Rural"	Directly connected impervious	1.52	Derived in part from Mattson & Isaac (1999), HRU modeling, lawn runoff TP quality information from Chesapeake Bay and subsequent modeling to estimate PLER for DCIA (Table 14) to approximate literature reported composite rate 0.3 kg/ha/yr.
	Pervious	See* DevPERV	
Highway (HWY)	Directly connected impervious	1.34	Largely based on USGS highway runoff data, HRU modeling, information from Shaver et al and subsequent modeling to estimate PLER for DCIA for literature reported composite rate 0.9 kg/ha/yr.
	Pervious	See* DevPERV	
Forest (For)	Directly connected impervious	1.52	Derived from Mattson & Isaac (1999) and subsequent modeling to estimate PLER for DCIA that corresponds with the literature reported composite rate of 0.13 kg/ha/yr (Table 14)
	Pervious	0.13	
Open Land (Open)	Directly connected impervious	1.52	Derived in part from Mattson & Isaac (1999), HRU modeling, lawn runoff TP quality information from Chesapeake Bay and subsequent modeling to estimate PLER for DCIA (Table 14) to approximate literature reported composite rate 0.3 kg/ha/yr.
	Pervious	See* DevPERV	
Agriculture (Ag)	Directly connected impervious	1.52	Derived from Budd, L.F. and D.W. Meals and subsequent modeling to estimate PLER for DCIA to approximate reported composite PLER of 0.5 kg/ha/yr.
	Pervious	0.45	
*Developed Land Pervious (DevPERV)- Hydrologic Soil Group A	Pervious	0.04	Derived from continuous simulation HRU modeling SWMM and P8 (Curve Number with assumed TP concentration of 0.3 mg/L for pervious runoff from developed lands. TP of 0.3 mg/L is

*Developed Land Pervious (DevPERV)- Hydrologic Soil Group B	Pervious	0.17	based on TB-9 (CSN, 2011), and other PLER literature and assumes 50% fertilized conditions*
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group C	Pervious	0.36	
*Developed Land Pervious (DevPERV) - Hydrologic Soil Group D	Pervious	0.55	
Footnote: *The PLERs for developed land pervious areas represent overall loading that includes partial use of phosphorus containing fertilizers at a rate of 50%. These values differ from those in the MS4 permit which assumed complete implementation of the MA phosphorus-free fertilizer legislation adopted in 2015.			

Overview of the Derivation of PLERs for the MA MS4 Permit:

Following is a summary of the approach used to develop the PLERs presented in Table 2 and described in detail in the 2014 PLER Memo. The export rates presented in Table 2 have been developed based on detailed analyses of the following types of information using a weight of evidence approach.

1. Stormwater quality data from the National Stormwater Quality Database (NSQD, 2008) for rainfall Regions 1 and 2.
2. Various stormwater quality datasets collected in New England (many sources).
3. Hydrologic Response Unit (HRU) Modeling: Results of long-term (5 year) continuous hydrologic model simulations using the Stormwater Management Model (SWMM) and P8 Model (Curve Number Method) that are representative of the same local climatic conditions (hourly precipitation and daily temperature) used in developing the Charles River Phosphorus TMDL analyses. These models were applied to watershed areas with homogeneous land characteristics relating to surface type (impervious or pervious), hydrologic soil condition (e.g., hydrological soil groups A, B, C and D) and vegetative cover (e.g., grass or forested).
4. Various stormwater/watershed modeling efforts including the following pollutant loading analyses:
    a. *Streamflow, Water Quality, and Contaminant Loads in the Lower Charles River Watershed, Massachusetts, 1999-2000*, Breault, et al., 2002.
    b. *Measured and Simulated Runoff to the Lower Charles River, Massachusetts, October 1999–September 2000,* Zariello and Barlow, 2002.
    c. *Calibration of Phosphorus Export Coefficients for Total Maximum Daily Loads of Massachusetts Lakes*, Mattson and Isaac, 1999.
    d. *Optimal Stormwater Management Plan Alternatives: A Demonstration Project in Three Upper Charles River Communities, Tetra Tech, Inc., December 2009.*
    e. *Updating the Lake Champlain Basin Land Use Data to Improve Prediction of Phosphorus Loading,* Troy, et al., 2007.
    f. *Literature Review of Phosphorus Export Rates and Best Management Practices, LaPlatte River Watershed Project*, Artuso, et. al., 1996.
    g. *Lake Champlain Nonpoint Source Pollution Assessment,* Budd and Meals, 1994.
5. Literature values from various sources including the *Fundamentals of Urban Runoff Management*, (Shaver, et al., 2007); *Review of Published Export Coefficient and Event Mean Concentration Data* (Lin, 1994); and the *Draft Chesapeake Stormwater Network (CSN) Technical*

Bulletin No. 9, Nutrient Accounting Methods to Document Local Stormwater Load Reductions in the Chesapeake Bay Watershed, Version 1.0, (Schueler, 2011).

6. Data collected by the USGS in the study of *Potential Reductions of Phosphorus in Urban Watershed using a High-Efficiency Street-Cleaning Program, Cambridge, Massachusetts*, Sorenson, 2011.

EPA conducted a weight of evidence approach to derive the PLERs that included the following elements.

- Compile and evaluate representative stormwater quality event mean concentration (EMC) data to determine phosphorus characteristics and relative differences among land use source types. This process was used to aid identification of appropriate groupings of land use categories for characterizing phosphorus loadings, to determine the relative strength of phosphorus loading among the various land use groups and to determine the typical magnitude of phosphorus concentrations in stormwater runoff from developed lands.
- Conduct continuous simulation Hydrologic Response Unit (HRU) modeling to estimate average annual runoff yields from impervious cover and pervious cover types and corresponding average annual PLERs for a varying stormwater phosphorus quality based on land surface type, hydrologic soil condition, vegetative-cover and regional climatic conditions. The HRU modeling results was used to develop the linkage between stormwater monitoring results for many individual events that measured EMCs (mg/L) and average annual PLERs (lb/acre/year).
- Conduct review of published papers and reports related to SW quality and watershed assessments. For certain categories such as forested, agricultural sources and rural/open space type sources, estimates of PLERs are based both directly and indirectly on reported values from published papers and reports. For example, the PLERs for low density residential, highway and forested are based in part on reported "composite" PLERs values (i.e., represent combined influence of areas with both impervious and pervious surfaces) and subsequent HRU modeling to estimate the individual PLERs for IC and pervious surface within that source category. For example, the composite PLER for forested (For) of 0.13 kg/ha/yr (Mattson and Isaac, 1999) was used as a starting point and then refined further into distinct PLERs for DCIA and PA by using continuous simulation hydrologic modeling with regional climatic data, estimated % DCIA, average % impervious associated with forested, and a typical pervious runoff total phosphorus (TP) concentration (0.1 mg/L) to estimate PLERs of 1.7 kg/ha/yr for impervious surfaces and 0.13 kg/ha/yr for pervious areas.
- Review SW pollutant loading studies in combination with the HRU modeling results to assist in developing the relationship between source category phosphorus EMC data and annual loading rates. The USGS pollutant load study for the Lower Charles River, MA (Breault, et. al, 2002) provides relevant information in that it included extensive flow and quality monitoring data for each of three land use categories, medium density residential, multi-family residential and commercial. Additionally, the USGS developed and calibrated hydrologic (SWMM) models of these drainages and estimated annual phosphorus loads for the year-long flow-gauging and monitoring period (water year 2000). EPA used HRU modeling results in combination with the USGS data and the robust NSQD dataset to estimate impervious and pervious PLERs for these land use groupings.
- Finally, EPA cross-checked various sources of information to ensure that the derived PLERs are in reasonable agreement with other reported information related to phosphorus loading.
- EPA further evaluated the PLERs in light of expanded HRU modelling and the updated NSQD 2015 to confirm that PLERs appear reasonable.