Holistic Watershed Management for Existing and Future Land Use Development Activities: Opportunities for Action for Local Decision Makers: PHASE 2 – FDC APPLICATION MODELING (FDC 2A PROJECT)

SUPPORT FOR SOUTHEAST NEW ENGLAND PROGRAM (SNEP) COMMUNICATIONS STRATEGY AND TECHNICAL ASSISTANCE

Task 4 Technical Memo on the Development of Future Land Cover Data for Taunton River Sub-Watershed Modeling and Hydrologic Response Unit Analyses

February 17, 2022

Prepared for:

U.S. EPA Region 1

Prepared by:

Paradigm Environmental

Great Lakes Environmental Center

Blanket Purchase Agreement: BPA-68HE0118A0001-0003
Requisition Number: PR-R1-20-00322
Order: 68HE0121F0001

Table of Contents

Figures

Tables

1. INTRODUCTION

This technical memo presents the data and methodology used to develop the Hydrological Response Units (HRUs) layer for 2060 projected new development conditions within the Taunton River watershed in support of Phase 2 of the EPA's flow duration curve (FDC) project. The future development land use and land cover data sets are reflective of projected watershed conditions in the year 2060 and are used to develop HRUs categories consistent with those used for the Opti-Tool in Phase 1. Two main outcomes of this task are the development of the HRUs layer for the projected 2060 future land use condition based on recent trends used in the New England Landscape Futures (NELF) dataset (Thompson et al., 2017) and comparing the estimates of unattenuated average annual runoff volume, groundwater (GW) recharge, evapotranspiration (ET), and nutrient (Total Nitrogen [TN] and Total Phosphorus [TP]) load export for both existing and future land use conditions. Three General Circulation Models (GCMs) are selected from Representative Concentration Pathway (RCP) 8.5 to represent the greatest increase in both precipitation and temperature, as well as the modeled ecodeficits and ecosurpluses for the Upper Hodges Brook watershed. The unattenuated and uncontrolled flow and pollutant loadings at the HRUs level are also compared for the projected future land use conditions using the projected meteorological data for the selected GCMs in the Taunton River watershed. The flow and loading analyses were performed for the municipal boundaries within the Taunton River watershed.

The following sections describe:

- A data review of the Geographic Information System (GIS) spatial layers for this analysis.
- A methodology for developing a future land use condition HRUs layer using the GIS layers described in the data review section. It includes the mapping rules for the conversion of coarse resolution (30-m) future land cover data to a fine resolution (1-m) land use and land cover data.
- An approach to select three GCMs based on the dry/wet/median conditions of precipitation, temperature, ecodeficit, and ecosurplus in the Taunton River watershed.
- A comparison between the baseline HRUs area distribution developed during Phase 1 of the FDC project and the projected HRUs area distribution at the municipality level within the Taunton River watershed. Also, an average annual runoff volume, GW recharge, ET, and nutrients (TN and TP) load were estimated for the 2016 baseline and 2060 projected land use conditions along with future climate conditions using three GCMs from RCP 8.5 projections. These comparisons show the percent increase in impervious cover (IC) and change in the hydrology and water quality due to the future development and future climate change conditions within each municipality in the Taunton River watershed.

2. GIS DATA REVIEW FOR TAUNTON RIVER WATERSHED

The Phase 2 methodology uses previously acquired data from MassGIS (Bureau of Geographic Information) during Phase 1, as well as new sources of future land use - land cover data from the NELF project. The subset of data used for Phase 2 is shown in Table 2-1.

Table 2-1. Landscape GIS data

Description	Dataset	Data Type	Period	Resolution	Source
Baseline Land Use-Land Cover	LULC_2016	polygon	2016	-	MassGIS
Future Land Cover	Recent_Trends_2010	raster	1990-2010	30m	NELF
	Recent_Trends_2060	raster	2010-2060	30m	NELF
Municipalities	Towns	polygon	2020	-	MassGIS
Buildings	Structures	polygon	2019	-	MassGIS

Description	Dataset	Data Type	Period	Resolution	Source
Baseline HRUs	Baseline_HRUs_2016	raster	2016	1m	FDC Phase 1

2.1. Baseline Land Use Land Cover Data

MassGIS 2016 land use – land cover layer contains a combination of land cover mapping from 2016 aerial imagery and land use derived from standardized assessor parcel information for Massachusetts. It contains both land use and land cover information as separate attributes and can be accessed independently or in a useful combination with one another. For example, it is possible to measure the portions of pervious and impervious surfaces for a commercial parcel. Figure 2-1 shows the land use – land cover map for the Taunton River watershed.

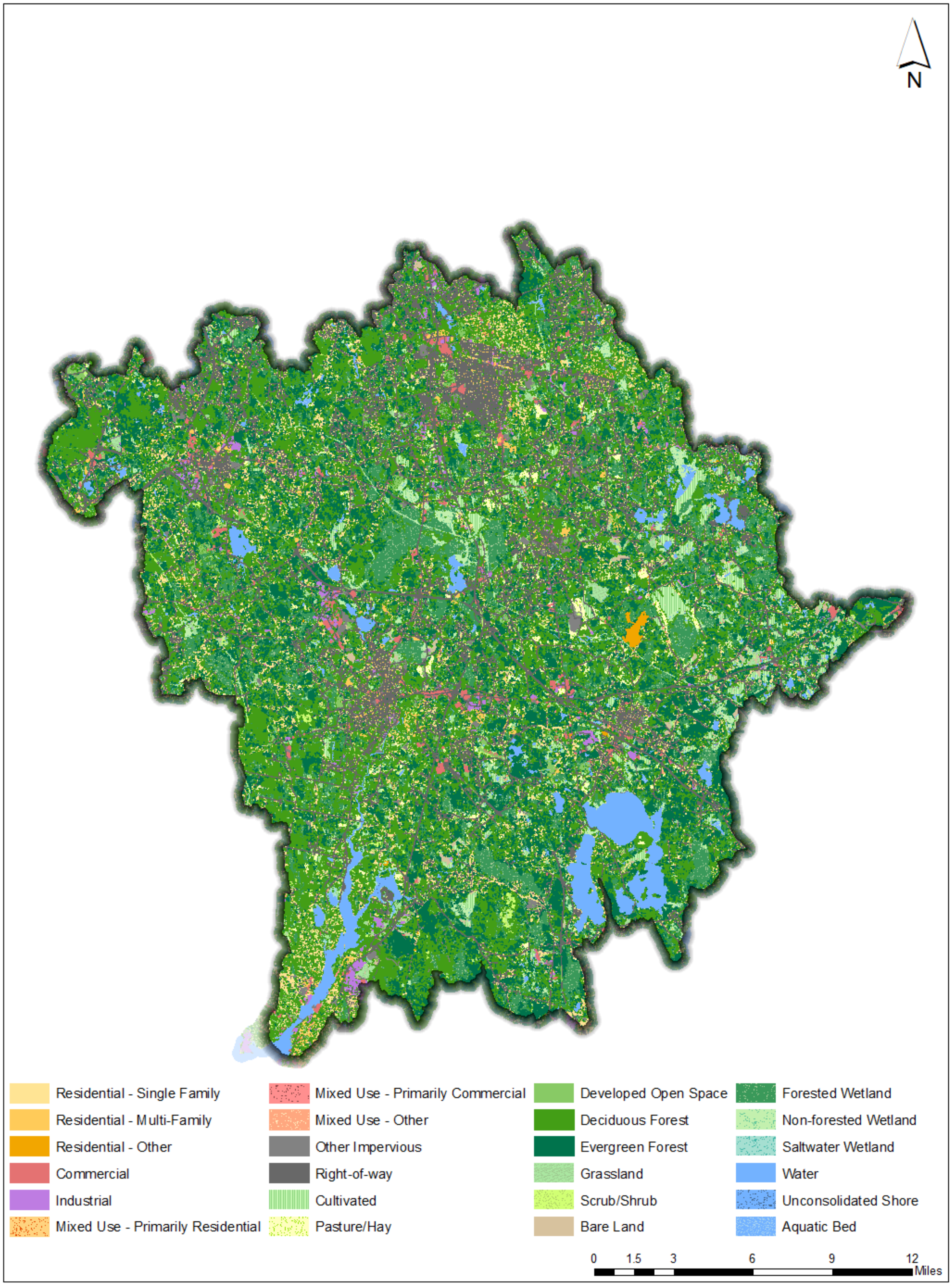

Figure 2-1. A map showing 2016 land use – land cover for the Taunton River watershed.

2.2. Future Land Cover Data

NELF is a multi-institutional project with the overarching goal of building and evaluating scenarios that show how land use choices could shape the landscape over the next 50 years. The NELF project envisions potential trends and impacts of landscape change in New England based on community collaboration and expert analysis (NELF, n.d.). Future land cover data representing historical and projected trends was acquired from the NELF project data repository (available on request at: https://databasin.org/groups/26ceb6c7ece64b0d9872e118bae80d41/). These datasets were created with a cellular land-cover change model using satellite imagery from 1990-2010 (Thompson et al., 2017). The historical data represents observed trends over 1990-2010; the statistical relationships of land cover change rate and spatial patterns were then linearly projected to the year 2060 as a baseline business-as-usual scenario (Figure 2-2). Major land cover changes over the 1990-2010 period include forest loss to low- and high-density development, as well as new land conservation (Thompson et al., 2017). Over 50 years between 2010 and 2060, the largest changes in land use across all of New England (not just the Taunton River watershed) were a 37% increase in developed area and a 123% increase in conserved area (Thompson et al., 2020). However, the conserved area is concentrated in core forest areas in northern New England (e.g., Maine and Vermont), while the more developed southern areas saw lower land conservation. At 30-m resolution, both of these datasets are consistent with the National Land Cover Databases (NLCD), however, they are limited to land cover projections of seven lumped categories and do not directly estimate the percent imperviousness within the land cover category. Both the Recent Trends 2010 and 2060 datasets, as well as other NELF future scenarios, can be explored on their web viewer.

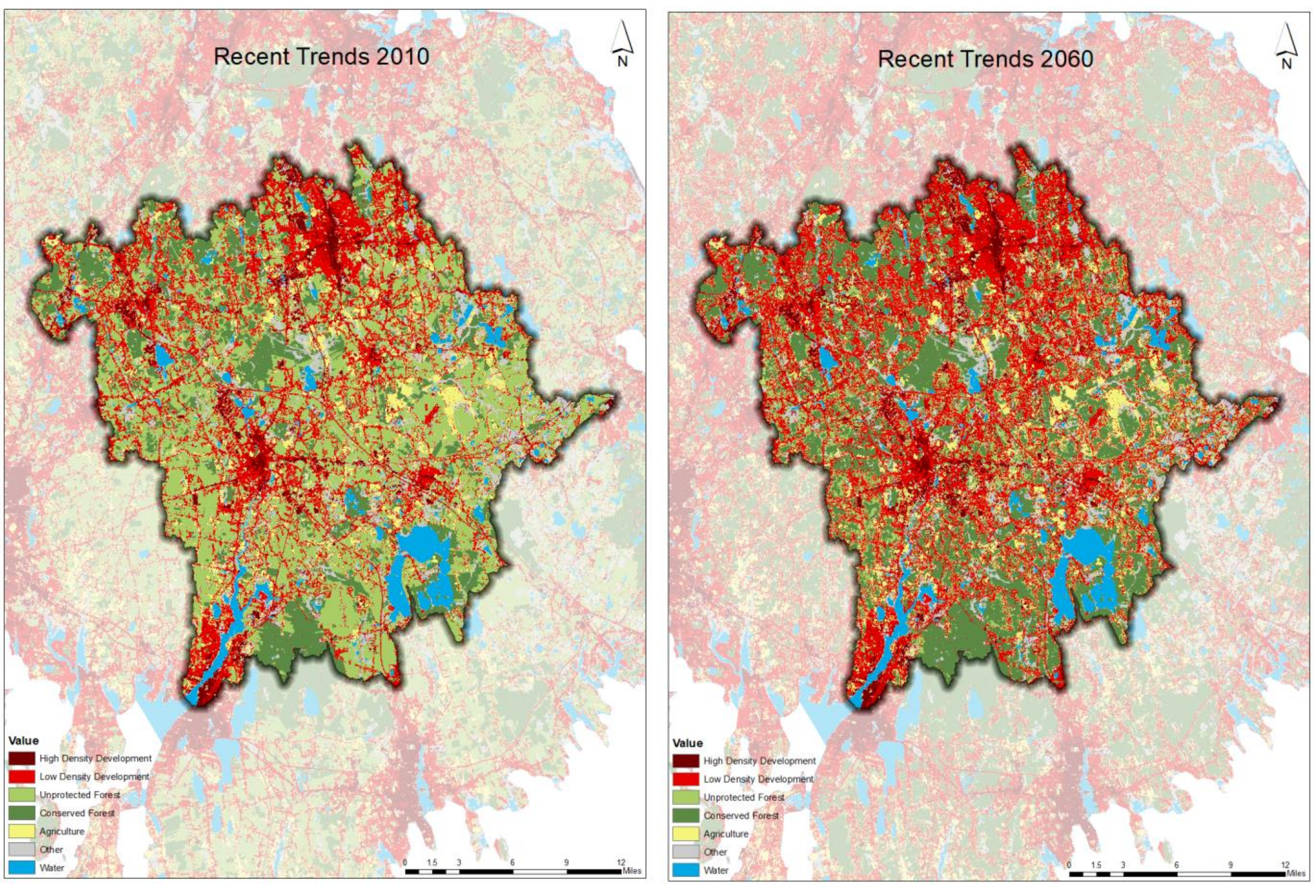

Figure 2-2. A historical land use trend for the year 2010 (left) and projected future land use trend for the year 2060 (right) for the Taunton River watershed.

2.3. Municipalities

MassGIS 2020 municipal boundaries were created by MassGIS by adjusting older USGS topo map town boundaries to connect the survey points of a community. In many areas, boundary creation was simply a matter of "connecting the dots" from one boundary point to the next. Where boundaries follow a stream/river or road right-of-way (ROW) the boundary was approximately delineated using the [2001 Aerial Imagery]() as a base. Figure 2-3 shows the municipal boundaries within the Taunton River watershed.

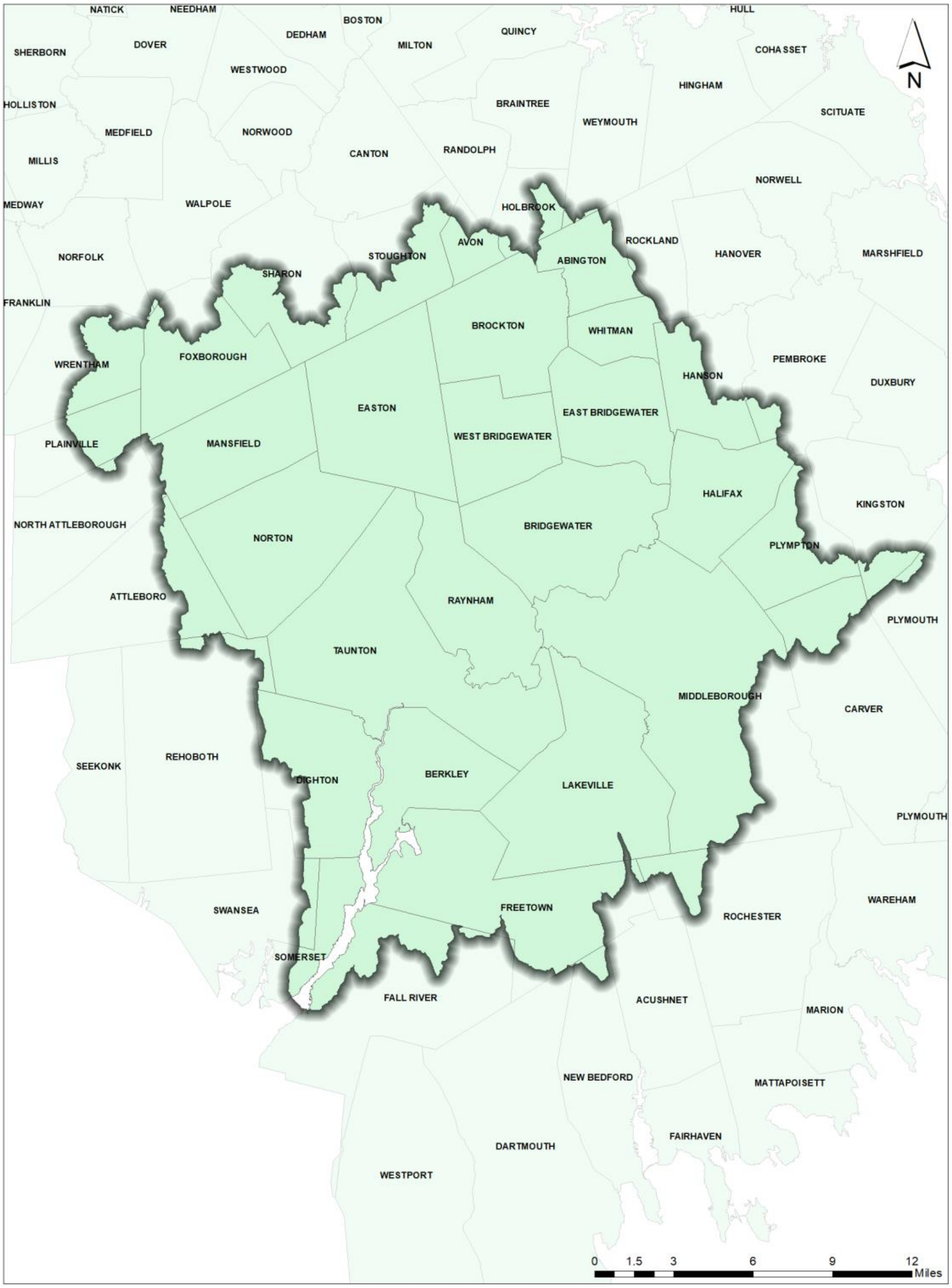

Figure 2-3. A map showing the municipal boundaries in the Taunton River watershed.

2.4. Buildings

MassGIS 2021 buildings dataset consists of 2-dimensional roof outlines ("roof-prints") for all buildings larger than 150 square feet for all of Massachusetts. In 2019, MassGIS refreshed the data to a baseline of 2016 and continues to update features using newer aerial imagery that allows MassGIS staff to remove, modify and add structures to keep up with more current ground conditions. In March 2021, the layer was updated with 2017 and 2018 structure review edits along with the first data edits compiled atop spring 2019 imagery. In July 2021, MassGIS completed the statewide update based on 2019 imagery. Figure 2-4 shows the building boundaries within the Taunton River watershed.

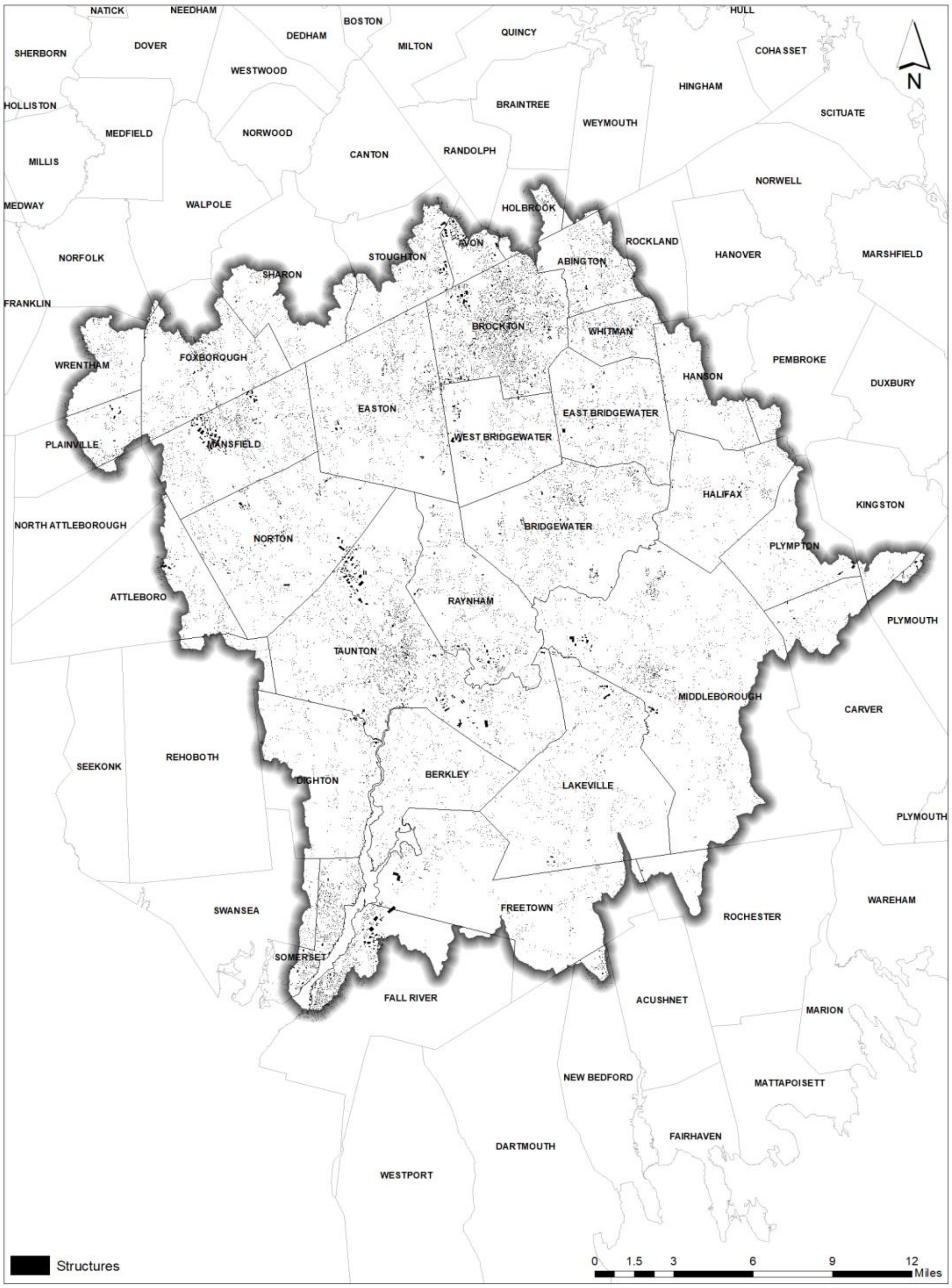

Figure 2-4. A map showing the building footprints in the Taunton River watershed.

2.5. Baseline HRUs Layer

Baseline HRUs layer representing the land use, land cover, soil, and slope characteristics in the Taunton River watershed was developed during Phase 1 of the FDC project. Each HRU represents areas of similar physical characteristics attributable to core processes identified through GIS overlays. The baseline HRUs layer for the Taunton River watershed combines spatial information into a single raster layer with 36 unique categories. The unit-area HRUs time series for the baseline conditions were developed using the most recent 20-year period of observed meteorological boundary conditions and calibrating the rainfall-runoff response on each HRU along with reach routing processes in the LSPC model under Phase 1 of the FDC project.

Figure 2-5 shows the spatial overlay process used to develop the baseline HRUs categories. During the HRUs development process, raw spatial data were reclassified into relevant categories. Table 2-2 shows the reclassification of Mass GIS 2016 land use and land cover data to derive the modeled land use categories in the Opti-Tool. Table 2-3 shows the reclassification of the Soil Survey Geographic (SSURGO) database and the State Soil Geographic (STATSGO2) database to derive the modeled Hydrologic Soil Group (HSG) categories in the Opti-Tool. Table 2-4 shows the reclassification of the percent slope attribute to derive the modeled slope categories in the Opti-Tool. Table 2-5 shows the final 36 HRUs categories developed for the Taunton River watershed. Figure 2-6 shows the spatial location of the baseline HRUs in the Taunton River watershed.

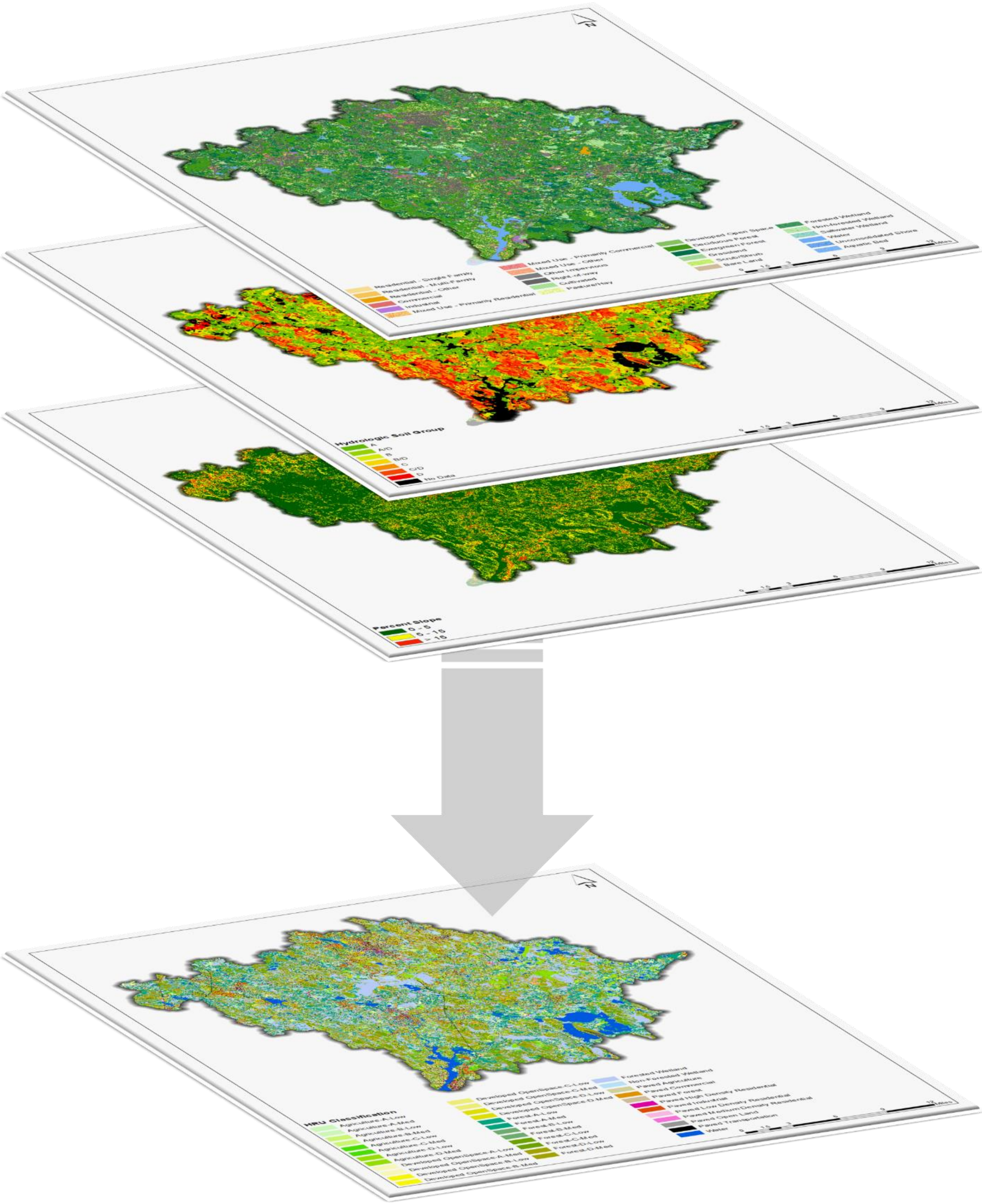

Figure 2-5. Baseline HRUs spatial overlay process (from top to bottom: land use – land cover, soil, and slope layers).

Table 2-2. Land use – land cover reclassification

Land Cover Code	Land Cover Description	Land Use Code	Land Use Description	Land Use Reclassification	Cover Type
2	Impervious	0	Unknown	Paved Open Land	Impervious
2	Impervious	2	Open land	Paved Open Land	Impervious
2	Impervious	3	Commercial	Paved Commercial	Impervious
2	Impervious	4	Industrial	Paved Industrial	Impervious
2	Impervious	6	Forest	Paved Forest	Impervious
2	Impervious	7	Agriculture	Paved Agriculture	Impervious
2	Impervious	8	Recreation	Paved Open Land	Impervious
2	Impervious	9	Tax exempt	Paved Open Land	Impervious
2	Impervious	10	Mixed use, primarily residential	Paved Medium Density Residential	Impervious
2	Impervious	11	Residential - single family	Paved Low Density Residential	Impervious
2	Impervious	12	Residential - multi-family	Paved High Density Residential	Impervious
2	Impervious	13	Residential - other	Paved Medium Density Residential	Impervious
2	Impervious	20	Mixed use, other	Paved Open Land	Impervious
2	Impervious	30	Mixed use, primarily commercial	Paved Commercial	Impervious
2	Impervious	55	Right-of-way	Paved Transportation	Impervious
2	Impervious	88	Water	Paved Open Land	Impervious
5	Developed Open Space	N/A	N/A	Developed Open Space	Pervious
6	Cultivated	N/A	N/A	Agriculture	Pervious
7	Pasture/Hay	N/A	N/A	Agriculture	Pervious
8	Grassland	N/A	N/A	Agriculture	Pervious
9	Deciduous Forest	N/A	N/A	Forest	Pervious
10	Evergreen Forest	N/A	N/A	Forest	Pervious
12	Scrub/Shrub	N/A	N/A	Agriculture	Pervious
13	Palustrine Forested Wetland	N/A	N/A	Forested Wetland	Pervious
14	Palustrine Scrub/Shrub Wetland	N/A	N/A	Non-Forested Wetland	Pervious
15	Palustrine Emergent Wetland	N/A	N/A	Non-Forested Wetland	Pervious
18	Estuarine Emergent Wetland	N/A	N/A	Water	Pervious
19	Unconsolidated Shore	N/A	N/A	Water	Pervious
20	Bare Land	N/A	N/A	Developed Open Space	Pervious
21	Water	N/A	N/A	Water	Pervious
22	Palustrine Aquatic Bed	N/A	N/A	Water	Pervious

Table 2-3. Soil – HSG reclassification

HSG - SSURGO	HSG - STATSGO2	HSG Reclassification	Justification
No Data	A	A	When no other information was available, the STATSGO2 data layer was used to fill the gaps.
No Data	B	B	
No Data	C	C	
No Data	D	D	-
A	N/A	A	
A/D	N/A	D	Dual HSGs were represented, and their undrained condition ('D') was selected as a conservative choice.
B	N/A	B	-
B/D	N/A	D	Dual HSGs were represented, and their undrained condition ('D') was selected as a conservative choice.
C	N/A	C	-
C/D	N/A	D	Dual HSGs were represented, and their undrained condition ('D') was selected as a conservative choice.
D	N/A	D	-

Table 2-4. Percent slope reclassification

Percent Slope	Slope Reclassification
<5%	Low
5% - 15%	Medium
>15%	High

Table 2-5. Summary of final HRU categories

HRU Code	HRU Description	Land Use	Soil	Slope	Land Cover
1000	Paved Forest	Paved Forest	N/A	N/A	Impervious
2000	Paved Agriculture	Paved Agriculture	N/A	N/A	Impervious
3000	Paved Commercial	Paved Commercial	N/A	N/A	Impervious
4000	Paved Industrial	Paved Industrial	N/A	N/A	Impervious
5000	Paved Low Density Residential	Paved Low Density Residential	N/A	N/A	Impervious
6000	Paved Medium Density Residential	Paved Medium Density Residential	N/A	N/A	Impervious
7000	Paved High Density Residential	Paved High Density Residential	N/A	N/A	Impervious
8000	Paved Transportation	Paved Transportation	N/A	N/A	Impervious
9000	Paved Open Land	Paved Open Land	N/A	N/A	Impervious
10110	Developed OpenSpace-A-Low	Developed OpenSpace	A	Low	Pervious
10120	Developed OpenSpace-A-Med	Developed OpenSpace	A	Med	Pervious
10210	Developed OpenSpace-B-Low	Developed OpenSpace	B	Low	Pervious
10220	Developed OpenSpace-B-Med	Developed OpenSpace	B	Med	Pervious
10310	Developed OpenSpace-C-Low	Developed OpenSpace	C	Low	Pervious
10320	Developed OpenSpace-C-Med	Developed OpenSpace	C	Med	Pervious
10410	Developed OpenSpace-D-Low	Developed OpenSpace	D	Low	Pervious
10420	Developed OpenSpace-D-Med	Developed OpenSpace	D	Med	Pervious

HRU Code	HRU Description	Land Use	Soil	Slope	Land Cover
11000	Forested Wetland	Forested Wetland	N/A	N/A	Pervious
12000	Non-Forested Wetland	Non-Forested Wetland	N/A	N/A	Pervious
13110	Forest-A-Low	Forest	A	Low	Pervious
13120	Forest-A-Med	Forest	A	Med	Pervious
13210	Forest-B-Low	Forest	B	Low	Pervious
13220	Forest-B-Med	Forest	B	Med	Pervious
13310	Forest-C-Low	Forest	C	Low	Pervious
13320	Forest-C-Med	Forest	C	Med	Pervious
13410	Forest-D-Low	Forest	D	Low	Pervious
13420	Forest-D-Med	Forest	D	Med	Pervious
14110	Agriculture-A-Low	Agriculture	A	Low	Pervious
14120	Agriculture-A-Med	Agriculture	A	Med	Pervious
14210	Agriculture-B-Low	Agriculture	B	Low	Pervious
14220	Agriculture-B-Med	Agriculture	B	Med	Pervious
14310	Agriculture-C-Low	Agriculture	C	Low	Pervious
14320	Agriculture-C-Med	Agriculture	C	Med	Pervious
14410	Agriculture-D-Low	Agriculture	D	Low	Pervious
14420	Agriculture-D-Med	Agriculture	D	Med	Pervious
15000	Water	Water	N/A	N/A	Pervious

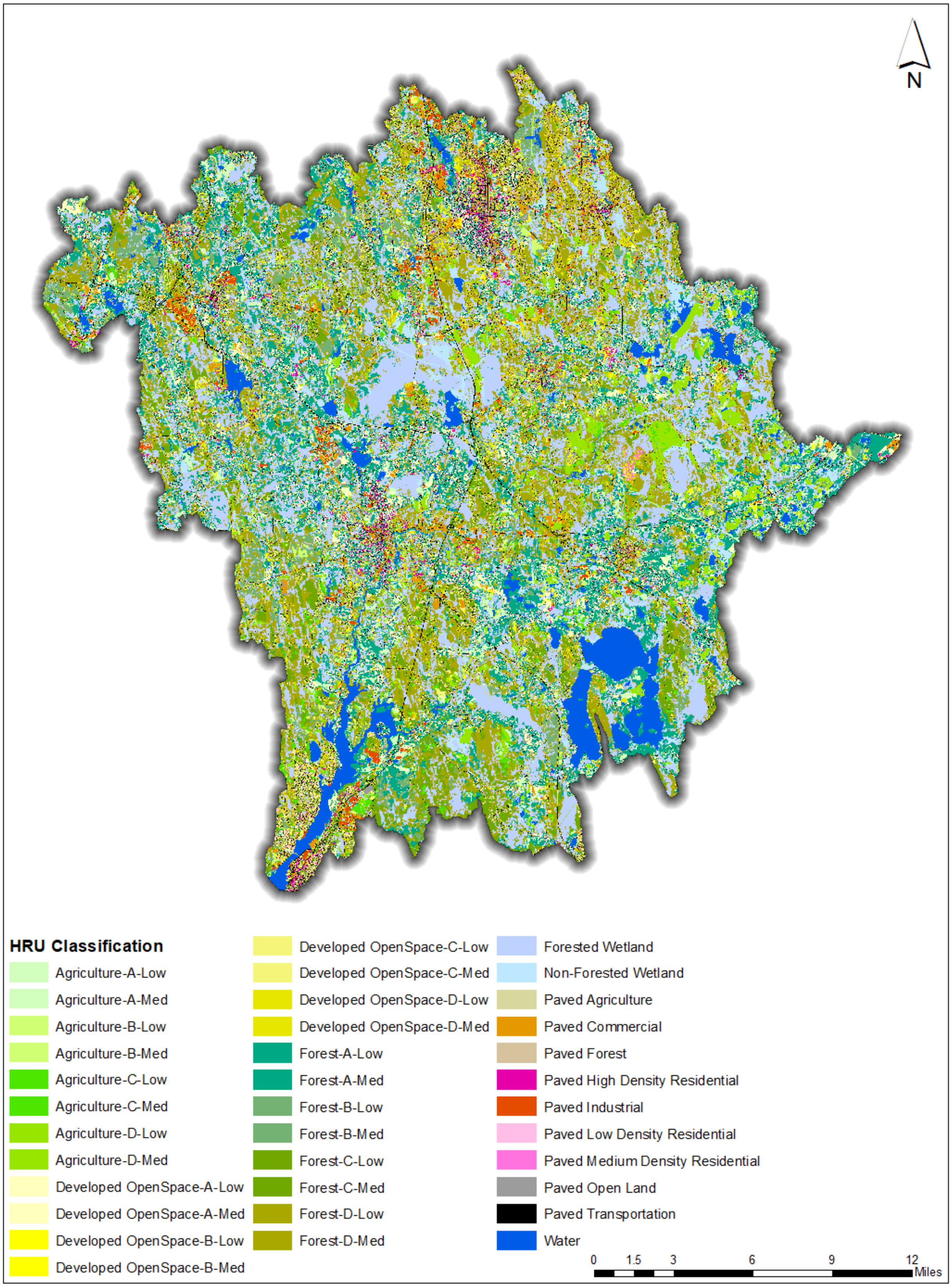

Figure 2-6. A map showing the 2016 baseline HRU raster layer for the Taunton River watershed.

3. DEVELOPMENT OF FUTURE HRU LAYER BASED ON PROJECTED LAND COVER DATA

To simulate future hydrological conditions within the Taunton River watershed, the NELF projected 2060 land cover datasets were analyzed and processed to update the 2016 baseline HRUs layer. The baseline HRUs were built with high-resolution (1-m) impervious cover data across the Taunton River watershed. However, the projected 2060 land cover data is at 30-m; this coarser-resolution also does not provide the percent imperviousness associated with the given land use classification, needed to develop HRUs. Additionally, the land use classification is much coarser and does not differentiate between commercial, industrial, residential, and open space but instead is lumped into just two developed categories: high-density and low-density development. The methodology to develop a 1-m resolution future HRU layer consistent with the baseline HRUs layer includes five main steps:

1. Compare the land cover change between the recent trends 2010 and 2060 NELF datasets and preserve the spatial footprints for the developed areas presented in the 2060 NELF dataset for developing the future HRUs layer for the Taunton River watershed.
2. Establish mapping rules between the major land use categories used in the Opti-Tool and the land use categories used in the NELF dataset. These rules define how to disaggregate the two developed land use (high-density and low-density) classifications from the NELF dataset into 7 major developed land use (commercial, industrial, high-density residential, medium-density residential, low-density residential, open land, and transportation) classifications for the Opti-Tool.
3. Estimate the percent imperviousness rules for the 7 major developed land use categories established in step 2 by using the MassGIS 2016 land use – land cover dataset for the Taunton River watershed. These rules are assumed to remain the same at different spatial extents. For example, the percent imperviousness for commercial land use remains the same for future development areas regardless of where they are located in the watershed. The projected future commercial areas in any municipal boundary will have the same percent imperviousness as it is overall in the Taunton River watershed based on the MassGIS 2016 land use - land cover dataset.
4. Estimate the area distribution rules between the 7 major developed land use categories (i.e., commercial, industrial, high-density residential, medium-density residential, low-density residential, open space, and transportation) by the municipality within the Taunton River watershed. Apply these rules to new development areas to break down the two developed NELF categories (high-density and low-density) into 7 developed Opti-Tool categories at the municipal level. These rules are derived at the municipality level and remain the same within the given municipal boundary but can vary from one municipality to another. It is assumed that area distribution between developed land use categories follows the same trend for the projected 2060 future land use – land cover classification.
5. Identify the undeveloped areas from the baseline HRUs layer that are subject to future development based on an overlay with the 2060 NELF dataset and apply the rules established in steps 3 and 4 at the municipality level. Apply the peppered raster method developed in Phase 1 of the FDC project to convert one-to-many HRUs categories using the probabilistic raster reclassification algorithm. For example, if there are 100 acres of forest category within a given municipality that is subject to high-density development, then those acres are split into paved commercial, paved industrial, paved high-density residential, paved transportation, and developed open space based on the established area distribution rules of those developed categories within the same municipal boundary. The underlying soil (i.e., HSG) and slope classifications remain the same as in the baseline HRUs layer.

The following sections provide more detail on the process of developing the future HRUs raster layer and summarize the change in the baseline HRUs due to the projected future development in the Taunton River watershed.

3.1. Land Cover Change Between 2010 and 2060 NELF Dataset

Within the Taunton River watershed, both low- and high-density development increased between the NELF 2010 and 2060 recent trend datasets (Table 3-1). This is generally due to the conversion of unprotected forest areas to developed areas. However, the recent trends underpinning the NELF datasets also indicate an increase in the conserved forest. The baseline HRUs developed under Phase 1 of the FDC project use higher resolution MassGIS 2016 land use – land cover data, so NELF 2060 projected future dataset was overlayed with the baseline HRUs layer to identify the areas subject to projected future development.

Table 3-1. NELF recent trend 2010 and 2060 land cover comparison

NELF Land Use Classification	Recent Trend 2010 (acre)	Recent Trend 2060 (acre)	Change (%)
Agriculture	23,735	24,568	4%
Conserved Forest	44,372	79,238	79%
High Density Development	14,889	20,906	40%
Low Density Development	79,795	112,477	41%
Other	32,758	32,758	0%
Unprotected Forest	129,871	55,474	-57%
Water	16,032	16,032	0%

3.2. Mapping Between Opti–Tool and NELF Land Use Classification

Table 3-2 shows a mapping table between NELF, Continuous Change Detection and Classification (CCDC), and National Land Cover Dataset (NLCD) datasets. These datasets were used in the NELF project and where CCDC data was not available, NLCD data was used to fill the gaps. The CCDC and NLCD maps were reclassified to a common legend consisting of High-Density Development, Low-Density Development, Forest, Agriculture, Water, and a composite "Other" class for developing the NELF datasets (Thompson et al., 2017). Based on the land use description shown in Table 3-2, new mapping rules were developed to disaggregate the NELF classification into the Opti-Tool land use classification as shown in Table 3-3. These mapping rules are assumed to remain the same across any municipal boundary within the Taunton River watershed.

Table 3-2. Reclassification Scheme for CCDC and NLCD Data for NELF Land Cover (Thompson et al., 2017)

NELF Classification	CCDC Class	CCDC Class Description	NLCD 2001/2011 Class	NLCD 2001/2011 Class Description
High Density Developed	Commercial/ Industrial	Area of urban development; impervious surface area target 80-100%	Developed High Intensity	Highly developed areas where people reside or work in high numbers. Examples include apartment complexes, rowhouses, and commercial /industrial. Impervious surfaces account for 80% to 100% of the total cover.

NELF Classification	CCDC Class	CCDC Class Description	NLCD 2001/2011 Class	NLCD 2001/2011 Class Description
	High Density Residential	Area of residential urban development with some vegetation; impervious surface area target 50-80%	Developed, Medium Intensity	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 50% to 79% of the total cover. These areas most commonly include single-family housing units.
Low Density Developed	Low Density Residential	Area of residential urban development with significant vegetation; impervious surface area target 0-50%	Developed, Low Intensity	Areas with a mixture of constructed materials and vegetation. Impervious surfaces account for 20% to 49% percent of total cover. These areas most commonly include single-family housing units.
			Developed, Open Space	Areas with a mixture of some constructed materials, but mostly vegetation in the form of lawn grasses. Impervious surfaces account for less than 20% of total cover. These areas most commonly include large-lot single-family housing units, parks, golf courses, and vegetation planted in developed settings for recreation, erosion control, or aesthetic purposes.
Agriculture	Agriculture	Non-woody cultivated plants; includes cereal and broadleaf crops	Pasture/Hay	Areas of grasses, legumes, or grass-legume mixtures planted for livestock grazing or the production of seed or hay crops, typically on a perennial cycle. Pasture/hay vegetation accounts for greater than 20% of total vegetation.
			Cultivated Crops	Areas used for the production of annual crops, such as corn, soybeans, vegetables, tobacco, and cotton, and also perennial woody crops such as orchards and vineyards. Crop vegetation accounts for greater than 20% of total vegetation. This class also includes all land being actively tilled.

NELF Classification	CCDC Class	CCDC Class Description	NLCD 2001/2011 Class	NLCD 2001/2011 Class Description
Forest	Mixed Forest	Forested land with at least 40% tree canopy cover comprising no more than 80% of either evergreen needle leaf or deciduous broadleaf cover	Mixed Forest	Areas dominated by trees are generally greater than 5 meters tall, and greater than 20% of total vegetation cover. Neither deciduous nor evergreen species are greater than 75% of total tree cover.
	Deciduous Broadleaf Forest	Forested land with at least 40% tree canopy cover comprising more than 80% deciduous broadleaf cover	Deciduous Forest	Areas dominated by trees are generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species shed foliage simultaneously in response to seasonal change.
	Evergreen Needleleaf Forest	Forested land with at least 40% tree canopy cover comprising more than 80% evergreen needle leaf cover	Evergreen Forest	Areas dominated by trees are generally greater than 5 meters tall, and greater than 20% of total vegetation cover. More than 75% of the tree species maintain their leaves all year. Canopy is never without green foliage.
	Woody Wetland	An additional class of wetland that tries to separate wetlands with considerable biomass from mainly herbaceous wetlands	Woody Wetlands	Areas where forest or shrubland vegetation accounts for greater than 20% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.
			Shrub/Scrub	Areas dominated by shrubs; less than 5 meters tall with shrub canopy typically greater than 20% of total vegetation. This class includes true shrubs, young trees in an early successional stage, or trees stunted from environmental conditions.
Other	Wetland	Vegetated land (woody and non-woody) with inundation from high water table; includes swamps, salt, and freshwater marshes and tidal rivers/mudflats	Emergent Herbaceous Wetlands	Areas where perennial herbaceous vegetation accounts for greater than 80% of vegetative cover and the soil or substrate is periodically saturated with or covered with water.

NELF Classification	CCDC Class	CCDC Class Description	NLCD 2001/2011 Class	NLCD 2001/2011 Class Description
	Herbaceous / Grassland	Non-woody naturally occurring or slightly managed plants; includes pastures	Barren Land (Rock/Sand/Clay)	Areas of bedrock, desert pavement, scarps, talus, slides, volcanic material, glacial debris, dunes, strip mines, gravel pits, and other accumulations of earthen material. Generally, vegetation accounts for less than 15% of total cover.
	Bare	Non-vegetated land comprised of above 60% rock, sand, or soil		
Water	Water	Lakes, ponds, rivers, and ocean	Open Water	Areas of open water, generally with less than 25% cover of vegetation or soil.

Table 3-3. Mapping table between NELF and Opti-Tool land use classification

NELF ID	NELF Land Use Classification	Opti-Tool Land Use Classification
1	High Density Development	Commercial
		Industrial
		High-Density Residential
		Transportation
2	Low Density Development	Low-Density Residential
		Medium-Density Residential
		Open Land
		Transportation
3	Unprotected Forest	Forest
4	Conserved Forest	
5	Agriculture	Agriculture
6	Other	Wetland
7	Water	Water

3.3. Percent Imperviousness for Developed Land Use Classification

Using the MassGIS 2016 land use – land cover dataset, the percent imperviousness was estimated for the 7 developed land use categories used in the Opti-Tool (Table 3-4). As well as the total percentage of IC, the percent of IC from buildings (i.e., roof-area) was calculated for each developed land use classification. These rules were developed at the Taunton River watershed scale and are assumed to hold at any spatial scale within the Taunton River watershed. For example, the projected future commercial land use in any municipality within the Taunton River watershed will have 67.4% paved areas and 23.8% of paved areas will be the building rooftops.

Table 3-4. Summary of percent imperviousness for developed land use classification

Developed Land Use Classification	Total Impervious Cover (%)	Buildings (% of Total IC)
Commercial	66.8%	23.8%
Industrial	75.3%	38.2%
High-Density Residential	51.4%	35.4%
Transportation	80.6%	0.0%
Low-Density Residential	31.5%	40.1%
Medium-Density Residential	43.0%	29.5%
Open Land	30.0%	19.9%

3.4. Developed Land Use Distribution by Municipality in Taunton River Watershed

For each municipality within the Taunton River watershed, the breakdown of developed land use area was calculated from the MassGIS 2016 land use – land cover data. This will allow conversion between the NELF and Opti-Tool classes (as shown in Table 3-3). Table 3-5 summarizes high-density developed areas into commercial, industrial, high-density residential, and transportation categories. Table 3-6 summarizes the breakdown of low-density developed areas into low-density residential, medium-density residential, open space, and transportation categories. These rules were developed at the municipality level that allows different development patterns across different municipalities based on the baseline development trends. It was assumed that the area distribution between the developed land use categories shown in Table 3-5 and Table 3-6 holds for the projected future development within the same municipal boundary.

Table 3-5. Summary of high-density development land use area distribution by municipality in the Taunton River watershed

Municipality		High-Density Development (MassGIS 2016)			
ID	Name	Commercial	Industrial	High Density Residential	Transportation
1	ABINGTON	40.5%	0.7%	34.4%	24.4%
16	ATTLEBORO	10.3%	43.8%	16.3%	29.6%
18	AVON	28.8%	38.0%	5.3%	27.9%
27	BERKLEY	31.6%	4.7%	27.7%	36.0%
42	BRIDGEWATER	22.9%	11.7%	40.7%	24.7%
44	BROCKTON	34.8%	8.9%	31.8%	24.5%
52	CARVER	43.2%	7.3%	6.0%	43.6%
72	DARTMOUTH	32.3%	16.2%	24.8%	26.7%
76	DIGHTON	35.8%	20.6%	16.1%	27.5%
83	EAST BRIDGEWATER	27.2%	19.3%	26.1%	27.4%
88	EASTON	32.4%	15.2%	26.8%	25.7%
95	FALL RIVER	16.3%	28.0%	30.2%	25.5%
99	FOXBOROUGH	39.4%	8.1%	20.1%	32.4%
102	FREETOWN	23.9%	38.0%	6.4%	31.6%
118	HALIFAX	34.7%	6.9%	35.0%	23.4%
123	HANSON	28.4%	24.7%	20.1%	26.8%

Municipality		High-Density Development (MassGIS 2016)			
ID	Name	Commercial	Industrial	High Density Residential	Transportation
133	HOLBROOK	36.2%	14.3%	18.7%	30.8%
145	KINGSTON	0.0%	0.0%	62.7%	37.3%
146	LAKEVILLE	37.0%	21.7%	15.7%	25.6%
167	MANSFIELD	25.1%	31.6%	15.2%	28.2%
182	MIDDLEBOROUGH	38.8%	10.3%	19.1%	31.9%
201	NEW BEDFORD	33.9%	0.0%	30.3%	35.8%
208	NORFOLK	32.3%	16.2%	24.8%	26.7%
211	NORTH ATTLEBOROUGH	64.9%	0.0%	0.0%	35.1%
218	NORTON	21.2%	19.9%	32.2%	26.7%
231	PEMBROKE	20.6%	9.6%	41.5%	28.3%
238	PLAINVILLE	46.0%	8.1%	20.9%	25.0%
239	PLYMOUTH	61.0%	0.0%	24.4%	14.6%
240	PLYMPTON	54.1%	9.9%	8.6%	27.3%
245	RAYNHAM	46.5%	9.5%	15.0%	28.9%
247	REHOBOTH	31.5%	0.0%	37.9%	30.5%
250	ROCHESTER	0.0%	0.0%	63.3%	36.7%
251	ROCKLAND	53.3%	0.0%	20.1%	26.6%
266	SHARON	47.4%	0.3%	10.3%	42.0%
273	SOMERSET	36.5%	12.8%	23.7%	27.0%
285	STOUGHTON	29.4%	34.4%	8.1%	28.1%
292	SWANSEA	9.4%	0.0%	61.2%	29.5%
293	TAUNTON	32.1%	12.0%	32.7%	23.3%
307	WALPOLE	32.3%	16.2%	24.8%	26.7%
322	WEST BRIDGEWATER	34.2%	26.6%	11.3%	27.8%
336	WEYMOUTH	0.1%	0.0%	65.9%	34.0%
338	WHITMAN	26.8%	12.5%	34.3%	26.3%
350	WRENTHAM	30.9%	5.6%	29.5%	34.0%

Table 3-6. Summary of low-density development land use area distribution by municipality in Taunton River watershed

Municipality		Low-Density Development (MassGIS 2016)			
ID	Name	Medium Density Residential	Low Density Residential	Open Land	Transportation
1	ABINGTON	0.6%	64.6%	20.4%	14.4%
16	ATTLEBORO	0.0%	72.9%	10.9%	16.1%
18	AVON	0.2%	57.9%	27.3%	14.6%
27	BERKLEY	5.7%	58.5%	12.9%	22.9%
42	BRIDGEWATER	1.3%	51.4%	32.8%	14.6%

Municipality		Low-Density Development (MassGIS 2016)			
ID	Name	Medium Density Residential	Low Density Residential	Open Land	Transportation
44	BROCKTON	0.6%	52.5%	32.8%	14.1%
52	CARVER	1.6%	59.2%	12.3%	26.8%
72	DARTMOUTH	2.1%	57.1%	24.9%	15.9%
76	DIGHTON	3.2%	53.5%	28.0%	15.3%
83	EAST BRIDGEWATER	1.8%	61.0%	21.5%	15.7%
88	EASTON	0.2%	58.4%	26.9%	14.6%
95	FALL RIVER	2.1%	41.6%	42.0%	14.3%
99	FOXBOROUGH	1.3%	54.8%	24.8%	19.1%
102	FREETOWN	6.2%	52.3%	24.1%	17.4%
118	HALIFAX	4.0%	66.3%	15.9%	13.8%
123	HANSON	1.9%	58.8%	24.3%	14.9%
133	HOLBROOK	1.2%	72.5%	8.4%	17.9%
145	KINGSTON	0.0%	31.0%	42.7%	26.3%
146	LAKEVILLE	0.7%	67.9%	17.3%	14.0%
167	MANSFIELD	0.5%	66.1%	17.9%	15.4%
182	MIDDLEBOROUGH	10.7%	50.6%	19.4%	19.3%
201	NEW BEDFORD	0.9%	62.4%	14.1%	22.7%
208	NORFOLK	0.0%	89.4%	0.2%	10.4%
211	NORTH ATTLEBOROUGH	0.0%	70.4%	9.3%	20.2%
218	NORTON	3.1%	59.0%	22.3%	15.6%
231	PEMBROKE	1.2%	69.3%	12.1%	17.4%
238	PLAINVILLE	0.1%	54.4%	31.4%	14.0%
239	PLYMOUTH	0.0%	81.3%	10.8%	7.9%
240	PLYMPTON	6.4%	62.3%	16.0%	15.4%
245	RAYNHAM	1.4%	56.9%	25.3%	16.4%
247	REHOBOTH	0.5%	73.5%	6.9%	19.2%
250	ROCHESTER	2.9%	52.1%	18.6%	26.4%
251	ROCKLAND	0.0%	84.0%	0.6%	15.4%
266	SHARON	0.0%	67.3%	6.6%	26.1%
273	SOMERSET	0.3%	68.2%	16.0%	15.5%
285	STOUGHTON	1.4%	66.8%	16.7%	15.1%
292	SWANSEA	0.3%	66.2%	13.8%	19.7%
293	TAUNTON	0.5%	52.9%	33.3%	13.3%
307	WALPOLE	0.0%	76.0%	0.1%	23.9%
322	WEST BRIDGEWATER	5.0%	50.2%	29.5%	15.3%
336	WEYMOUTH	0.0%	73.3%	2.7%	24.1%
338	WHITMAN	1.7%	60.6%	22.2%	15.5%
350	WRENTHAM	0.9%	43.0%	35.3%	20.9%

3.5. Future HRU Layer for Taunton River Watershed

Based on the relationships established between the MassGIS 2016 baseline and NELF future datasets, the future mapped HRU area distribution is estimated for each municipality based on the change from baseline undeveloped areas (e.g., agriculture and forest) to the developed areas in the projected NELF data. The spatial overlay process shown in Figure 3-1 illustrates how the relevant layers are aligned. Any areas that are undeveloped in the projected future NELF data layer maintain their baseline HRU values; areas that are undeveloped in the baseline but subject to development in the future layer are reclassified to the appropriate class from the baseline HRU layer. As an example, parcels of unprotected forest within a municipality boundary that are subject to projected future development are converted to developed parcels; the percentage distribution rules for the detailed developed land use categories (Table 3-5 and Table 3-6) and the corresponding imperviousness rules (Table 3-4) are used to predict the future HRUs. Table 3-7 summarizes the change in each HRU category between the baseline and future HRUs; Figure 3-2 shows the spatial distribution of future HRUs. Figure 3-3 shows the comparison between coarse resolution 2060 NELF classification and high resolution 2060 Future HRUs for the Upper Hodges Brook sub-watershed.

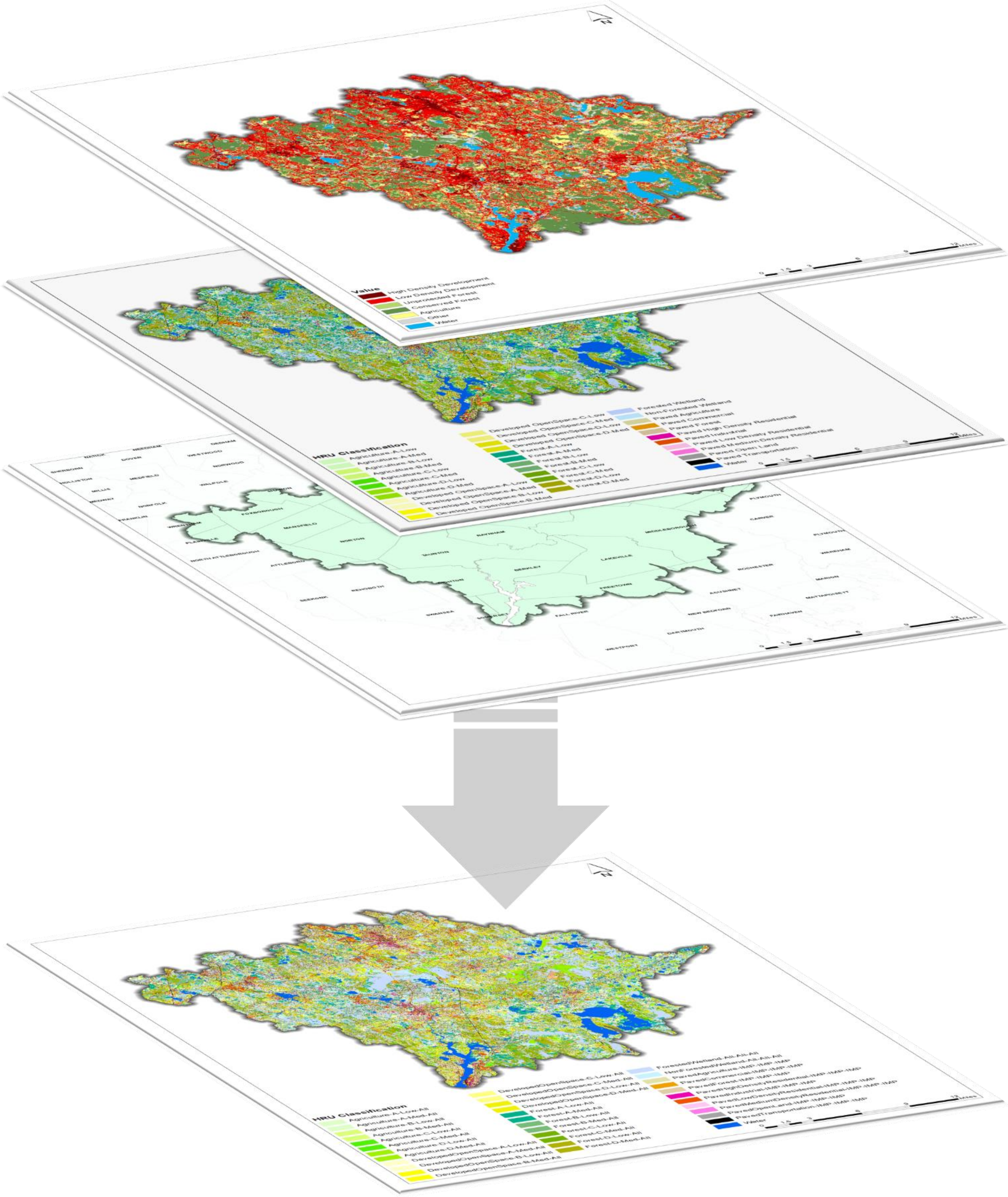

Figure 3-1. Mapped future HRU spatial overlay process (from top to bottom: NELF 2060 land cover, baseline HRUs, municipalities, and final future HRU layer).

Table 3-7. Comparison of HRU area distribution between the MassGIS 2016 baseline and NELF 2060 future conditions in Taunton River watershed

HRU Code	Land Use Classification	Land Cover	Soil	Slope	Baseline (acre)	Future (acre)	Change (%)
1,000	Paved Forest	Impervious	N/A	N/A	9	9	0.0%
2,000	Paved Agriculture	Impervious	N/A	N/A	128	158	23.0%
3,000	Paved Commercial	Impervious	N/A	N/A	4,858	6,873	41.5%
4,000	Paved Industrial	Impervious	N/A	N/A	2,745	3,892	41.8%
5,000	Paved Low Density Residential	Impervious	N/A	N/A	9,951	20,717	108.2%
6,000	Paved Medium Density Residential	Impervious	N/A	N/A	489	1,133	131.7%
7,000	Paved High Density Residential	Impervious	N/A	N/A	2,856	4,041	41.5%
8,000	Paved Transportation	Impervious	N/A	N/A	11,852	21,709	83.2%
9,000	Paved Open Land	Impervious	N/A	N/A	4,138	8,377	102.4%
10,110	Developed OpenSpace	Pervious	A	Low	13,210	18,203	37.8%
10,120	Developed OpenSpace	Pervious	A	Med	5,864	14,785	152.1%
10,210	Developed OpenSpace	Pervious	B	Low	3,621	5,792	59.9%
10,220	Developed OpenSpace	Pervious	B	Med	1,897	4,483	136.3%
10,310	Developed OpenSpace	Pervious	C	Low	4,326	7,243	67.4%
10,320	Developed OpenSpace	Pervious	C	Med	2,488	4,809	93.3%
10,410	Developed OpenSpace	Pervious	D	Low	7,944	17,328	118.1%
10,420	Developed OpenSpace	Pervious	D	Med	1,604	3,478	116.9%
11,000	Forested Wetland	Pervious	N/A	N/A	66,463	66,463	0.0%
12,000	Non-Forested Wetland	Pervious	N/A	N/A	9,734	9,734	0.0%
13,110	Forest	Pervious	A	Low	17,071	7,615	-55.4%
13,120	Forest	Pervious	A	Med	33,959	17,511	-48.4%
13,210	Forest	Pervious	B	Low	7,649	3,553	-53.6%
13,220	Forest	Pervious	B	Med	10,948	6,320	-42.3%
13,310	Forest	Pervious	C	Low	12,123	6,470	-46.6%
13,320	Forest	Pervious	C	Med	9,548	4,954	-48.1%
13,410	Forest	Pervious	D	Low	43,764	26,559	-39.3%
13,420	Forest	Pervious	D	Med	9,331	5,850	-37.3%
14,110	Agriculture	Pervious	A	Low	4,780	4,426	-7.4%
14,120	Agriculture	Pervious	A	Med	3,095	3,590	16.0%
14,210	Agriculture	Pervious	B	Low	1,204	1,187	-1.4%
14,220	Agriculture	Pervious	B	Med	1,106	1,090	-1.4%
14,310	Agriculture	Pervious	C	Low	1,925	1,966	2.1%
14,320	Agriculture	Pervious	C	Med	1,092	1,178	7.9%
14,410	Agriculture	Pervious	D	Low	10,907	11,157	2.3%
14,420	Agriculture	Pervious	D	Med	1,146	1,173	2.4%
15,000	Water	N/A	N/A	N/A	17,628	17,628	0.0%

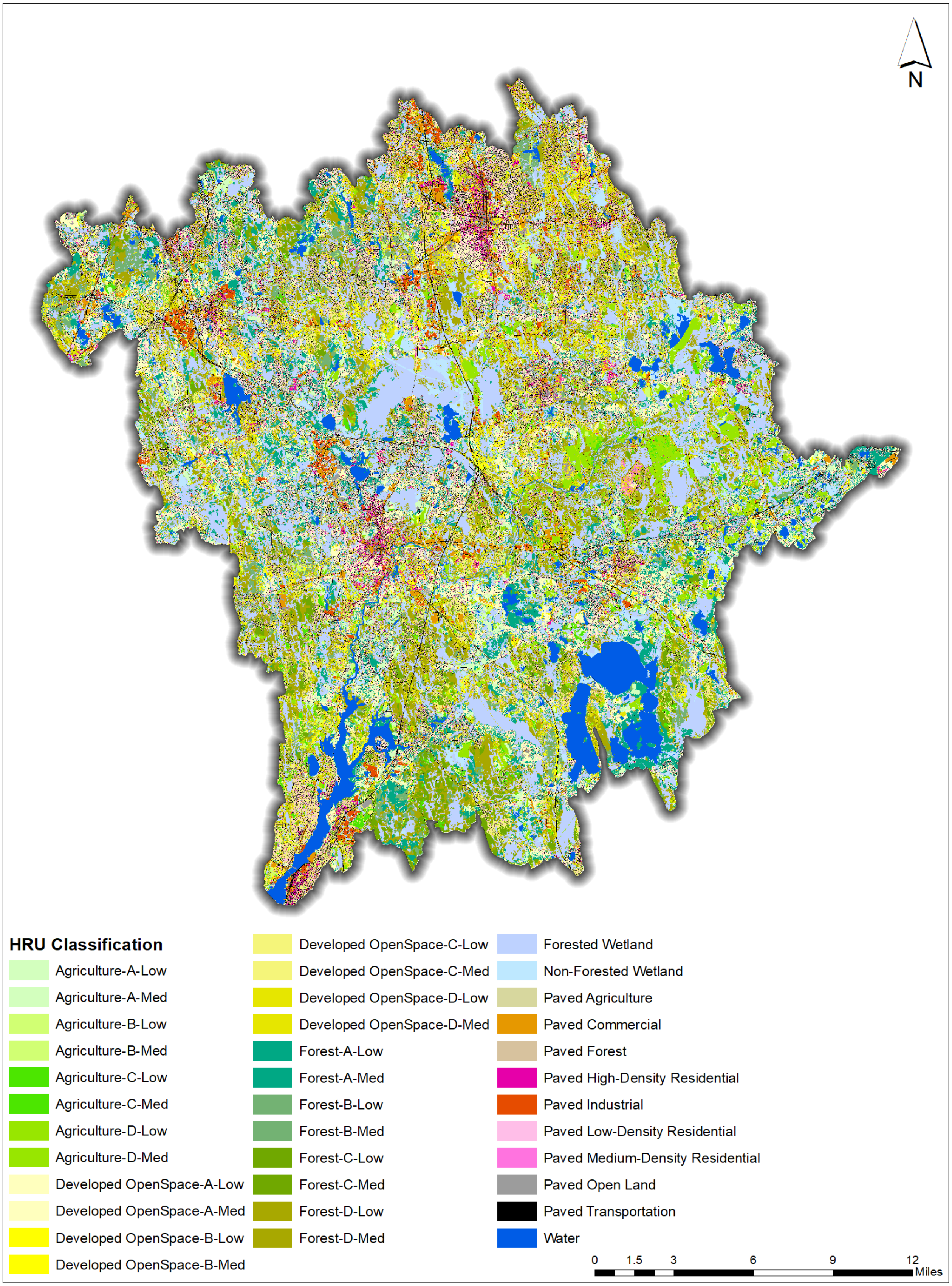

Figure 3-2. A map showing the 2060 future HRU raster layer for the Taunton River watershed.

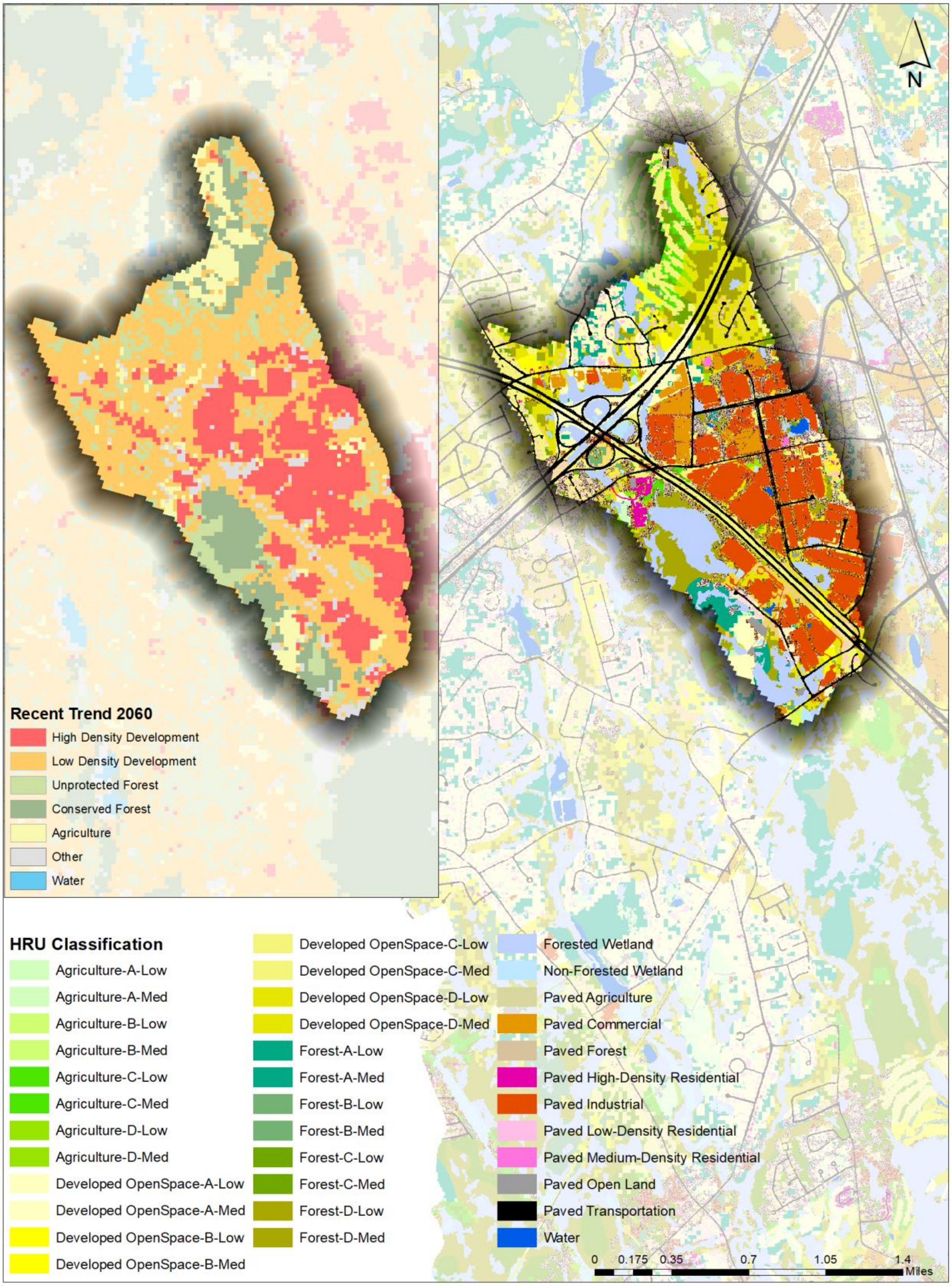

Figure 3-3. A map showing the comparison between the 30-m resolution 2060 future NELF layer (left) and 1-m resolution 2060 future HRU layer (right) for the Upper Hodges Brook sub-watershed.

4. SELECTION OF FUTURE CLIMATE CONDITIONS

To simulate future climate conditions, meteorological time series from three GCMs are selected from those used in FDC Phase 1 (Table 4-1) (Paradigm Environmental and Great Lakes Environmental Center, 2021). The GCMs for use in Phase 2 were selected to represent the greatest increase in both precipitation and temperature, as well as the modeled ecodeficits and ecosurpluses for the Upper Hodges Brook watershed from FDC Phase 1 (Figure 4-1 and Table 4-2). As shown in Table 4-1, these climate projections are from Representative Concentration Pathway (RCP) 8.5, which represents a scenario in which carbon emissions continue to climb at historical rates (in contrast, RCP 4.5 predicts a stabilization of carbon emissions by 2100). Using these models in conjunction with the projected future land cover conditions should provide "bookends" within which to evaluate innovative stormwater control measures and protective ordinances. The downscaled meteorological data for the selected GCMs will be used to drive the LSPC hydrology model in FDC Phase 2.

Table 4-1. FDC Phase 1 selected models from ensemble results for future climate projections (2079-2099)

RCP	Scenario [1]	Ecosuplus Model	Ecodeficit Model
RCP 4.5	Dry	hadgem2-cc-1	mpi-esm-mr-1
	Median	bcc-csm1-1-m-1	bcc-csm1-1-m-1
	Wet	bcc-csm1-1-1	miroc-esm-chem-1
RCP 8.5	Dry	inmcm4-1	miroc-esm-1
	Median	cesm1-cam5-1	cesm1-cam5-1
	Wet	cesm1-bgc-1	mri-cgcm3-1

1: Dry, Median, and Wet correspond to the 20th, 50th, and 80th percentile hydrological responses.
Models chosen for FDC Phase 2 are highlighted in yellow.

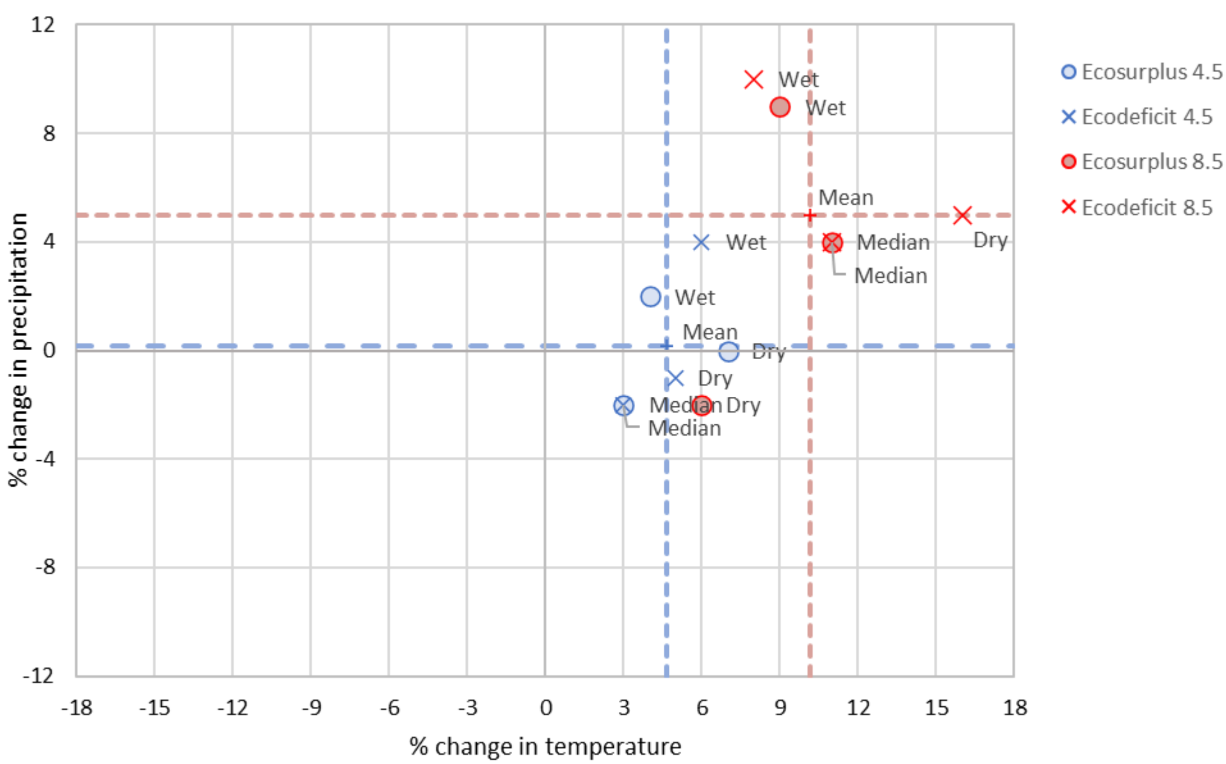

Figure 4-1. Percent change in annual average precipitation and temperature from baseline conditions for the FDC Phase 1 selected models presented in Table 4-1.

Table 4-2. Summary of ecosurpluses and ecodeficits (millions of gallons per year) within the Upper Hodges Brook watershed for RCP 4.5 and 8.5 scenarios

Scenario	Ecodeficit models					
	Ecodeficits			Ecosurplus		
	Dry	Median	Wet	Dry	Median	Wet
RCP 4.5	98.1	78.8	36.1	19.0	43.1	31.8
RCP 8.5	121.4	91.1	49.2	7.1	14.6	90.8
Scenario	Ecosurplus models					
	Ecodeficits			Ecosurplus		
	Dry	Median	Wet	Dry	Median	Wet
RCP 4.5	122.0	78.8	52.1	7.6	43.1	60.3
RCP 8.5	112.2	91.1	44.1	14.7	14.6	57.6

5. COMPARISON OF EXISTING AND FUTURE CONDITIONS IN TAUNTON RIVER WATERSHED

This section compares the results between the 2016 baseline, projected 2060 future land use – land cover conditions, and the three selected future climate scenarios. These comparisons include future estimates of IC (assuming conventional development patterns) and estimates of unattenuated average annual run-off volume, groundwater recharge, evapotranspiration, and nutrients (TN and TP) load export for both existing and future land cover and climate conditions for each municipality within the Taunton River watershed.

5.1. Impervious Cover by Municipality in the Taunton River Watershed

The change in impervious areas between the 2016 baseline and 2060 future conditions for 7 major land use categories, transportation (TRANS), commercial (COM), industrial (IND), high-density residential (HDR), medium-density residential (MDR), low-density residential (LDR), and open land (OPEN), are summarized by the municipality in Table 5-1. The change in IC reflects the increase in impervious cover due to the NELF 2060 projected future development in the Taunton River watershed. The impervious cover area for each municipality for the 2016 baseline and 2060 future conditions is given in the appendix (Table 6-1 and Table 6-2, respectively).

Table 5-1. Summary of increase in impervious cover by municipality in Taunton River watershed

Municipality		Increase in Impervious Cover (acre)						
ID	Name	TRANS	COM	IND	HDR	MDR	LDR	OPEN
1	ABINGTON	198.9	85.8	1.5	55.6	3.3	241.6	72.6
16	ATTLEBORO	125.4	4.1	19.4	4.9	0.0	197.9	28.3
18	AVON	95.4	29.9	44.3	4.2	0.4	94.3	42.4
27	BERKLEY	374.9	15.3	2.5	10.2	46.6	355.5	74.9
42	BRIDGEWATER	501.5	90.6	52.0	122.7	17.8	531.5	323.2
44	BROCKTON	506.2	218.2	63.0	152.4	6.8	470.6	280.0
52	CARVER	194.4	27.8	5.3	2.9	5.1	139.4	27.7
72	DARTMOUTH	0.2	0.0	0.0	0.0	0.0	0.3	0.1
76	DIGHTON	287.3	14.4	9.3	4.9	29.6	375.7	187.0

Municipality		Increase in Impervious Cover (acre)						
ID	Name	TRANS	COM	IND	HDR	MDR	LDR	OPEN
83	EAST BRIDGEWATER	409.4	81.9	65.3	60.1	19.0	472.3	158.6
88	EASTON	517.0	43.2	22.8	27.3	2.7	750.1	329.4
95	FALL RIVER	125.1	30.8	59.5	43.8	5.1	76.5	73.6
99	FOXBOROUGH	434.2	54.1	12.5	21.0	13.6	429.0	185.5
102	FREETOWN	438.9	30.8	55.1	6.3	72.8	461.1	202.1
118	HALIFAX	146.5	14.7	3.3	11.3	20.5	254.4	58.3
123	HANSON	130.9	11.2	11.0	6.1	7.8	182.8	72.1
133	HOLBROOK	60.8	26.2	11.6	10.3	1.2	54.4	6.0
145	KINGSTON	83.7	0.0	0.0	6.3	0.0	36.1	47.4
146	LAKEVILLE	386.6	36.8	24.2	12.0	9.1	676.5	164.6
167	MANSFIELD	466.5	125.5	177.2	57.9	4.9	501.0	129.5
182	MIDDLEBOROUGH	926.7	133.1	39.7	50.1	232.9	820.6	299.7
201	NEW BEDFORD	27.3	7.2	0.0	4.9	0.4	19.7	4.2
208	NORFOLK	0.9	0.3	0.2	0.2	0.0	2.0	0.0
211	NORTH ATTLEBOROUGH	6.3	0.7	0.0	0.0	0.0	8.0	1.0
218	NORTON	517.1	59.6	62.6	69.0	44.3	637.2	229.6
231	PEMBROKE	29.4	1.5	0.8	2.3	0.9	42.2	7.0
238	PLAINVILLE	116.0	72.9	14.4	25.2	0.3	104.6	57.6
239	PLYMOUTH	4.4	8.4	0.0	2.6	0.0	8.0	1.0
240	PLYMPTON	123.2	10.4	2.2	1.3	25.4	186.0	45.6
245	RAYNHAM	503.9	204.8	47.2	50.5	15.4	479.2	202.8
247	REHOBOTH	37.4	1.1	0.0	1.0	0.5	54.4	4.8
250	ROCHESTER	31.2	0.0	0.0	1.7	1.7	23.0	7.8
251	ROCKLAND	1.8	0.5	0.0	0.1	0.0	3.4	0.0
266	SHARON	259.0	7.4	0.0	1.2	0.0	254.1	23.8
273	SOMERSET	144.3	50.5	19.9	25.0	1.2	172.7	38.6
285	STOUGHTON	229.8	89.3	117.3	18.7	6.2	221.9	52.9
292	SWANSEA	49.9	0.3	0.0	1.5	0.4	64.3	12.8
293	TAUNTON	838.2	322.2	134.8	250.9	11.9	874.7	524.2
307	WALPOLE	2.7	0.6	0.3	0.3	0.0	2.6	0.0
322	WEST BRIDGEWATER	209.9	54.3	47.5	13.7	27.1	202.1	113.2
336	WEYMOUTH	3.1	0.0	0.0	1.4	0.0	2.3	0.1
338	WHITMAN	147.4	32.8	17.2	32.1	6.2	166.9	58.4
350	WRENTHAM	163.4	15.8	3.2	11.5	3.2	115.4	90.2
	Total	**9,857**	**2,015**	**1,147**	**1,186**	**644**	**10,766**	**4,239**

Land cover classes: TRANS – transportation, COM – commercial, IND – industrial, HDR – high-density residential, MDR – medium-density residential, LDR – low-density residential, OPEN – open land

5.2. Surface Runoff, Groundwater Recharge, Evapotranspiration, and Nutrient Loads in the Taunton River Watershed

Hydrology and water quality were calibrated for the modeled HRU categories during Phase 1 of the FDC project. The pollutant build-up and wash-off parameters from the Opti-Tool SWMM models were used as a starting point and were adjusted to calibrate the long-term annual average loading rates reported in the Opti-Tool. The model was simulated for 20 years (Oct 2000 – Sep 2020) and annual average loading rates from the model prediction were compared against the pollutant export rates for the similar HRU type in the Opti-Tool. Table 5-2 presents the summary of unit-area annual average runoff, groundwater recharge (GW), evapotranspiration (ET), and nutrients (TN and TP) loading rates by HRU from the calibrated watershed model in Phase 1 of the FDC project. Table 5-3 to Table 5-5 presents the same summaries for the Ecodeficit 8.5 Dry, Median, and Wet climate change scenarios (Oct 2079 – Sep 2099), respectively.

Table 5-2. Summary of unit-acre based annual average (Oct 2000 – Sep 2020) runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the modeled HRU types in the Wading River watershed (FDC Phase 1)

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
1000	Paved Forest	1.234	0.000	0.126	11.480	1.502
2000	Paved Agriculture	1.234	0.000	0.126	11.480	1.502
3000	Paved Commercial	1.234	0.000	0.126	15.240	1.794
4000	Paved Industrial	1.234	0.000	0.126	15.240	1.794
5000	Paved Low Density Residential	1.234	0.000	0.126	14.270	1.503
6000	Paved Medium Density Residential	1.234	0.000	0.126	14.270	1.970
7000	Paved High Density Residential	1.234	0.000	0.126	14.260	2.381
8000	Paved Transportation	1.234	0.000	0.126	10.260	1.532
9000	Paved Open Land	1.234	0.000	0.126	11.480	1.568
10110	Developed OpenSpace-A-Low	0.218	0.686	0.455	0.230	0.020
10120	Developed OpenSpace-A-Med	0.218	0.686	0.455	0.250	0.022
10210	Developed OpenSpace-B-Low	0.380	0.514	0.464	0.930	0.097
10220	Developed OpenSpace-B-Med	0.378	0.516	0.464	1.210	0.126
10310	Developed OpenSpace-C-Low	0.493	0.396	0.469	2.260	0.209
10320	Developed OpenSpace-C-Med	0.495	0.395	0.469	2.390	0.220
10410	Developed OpenSpace-D-Low	0.592	0.294	0.472	3.300	0.305
10420	Developed OpenSpace-D-Med	0.590	0.296	0.472	4.040	0.374
11000	Forested Wetland	0.331	0.159	0.876	0.520	0.109
12000	Non-Forested Wetland	0.333	0.160	0.874	0.520	0.109
13110	Forest-A-Low	0.077	0.614	0.673	0.120	0.023
13120	Forest-A-Med	0.077	0.614	0.673	0.120	0.025
13210	Forest-B-Low	0.170	0.513	0.681	0.520	0.102
13220	Forest-B-Med	0.170	0.514	0.681	0.550	0.109
13310	Forest-C-Low	0.259	0.421	0.684	1.100	0.204
13320	Forest-C-Med	0.258	0.422	0.684	1.170	0.217
13410	Forest-D-Low	0.453	0.223	0.689	1.780	0.360

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
13420	Forest-D-Med	0.451	0.224	0.689	1.840	0.373
14110	Agriculture-A-Low	0.125	0.661	0.577	0.510	0.088
14120	Agriculture-A-Med	0.124	0.661	0.577	0.540	0.093
14210	Agriculture-B-Low	0.244	0.529	0.589	2.320	0.409
14220	Agriculture-B-Med	0.244	0.530	0.589	2.490	0.439
14310	Agriculture-C-Low	0.346	0.422	0.595	5.040	0.773
14320	Agriculture-C-Med	0.345	0.423	0.595	5.410	0.829
14410	Agriculture-D-Low	0.437	0.326	0.599	8.020	1.366
14420	Agriculture-D-Med	0.436	0.328	0.599	8.490	1.447

Units: MG – million gallons, lb – pounds, ac – acre, yr – year

Table 5-3. Summary of unit-acre based annual average (Oct 2079 – Sep 2099) runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the modeled HRU types in the Wading River watershed (Ecodeficit 8.5 Dry)

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
1000	Paved Forest	1.245	0.000	0.120	10.806	1.425
2000	Paved Agriculture	1.245	0.000	0.120	10.806	1.425
3000	Paved Commercial	1.245	0.000	0.120	14.351	1.631
4000	Paved Industrial	1.245	0.000	0.120	14.351	1.631
5000	Paved Low Density Residential	1.245	0.000	0.120	13.430	1.366
6000	Paved Medium Density Residential	1.245	0.000	0.120	13.430	1.840
7000	Paved High Density Residential	1.245	0.000	0.120	13.424	2.175
8000	Paved Transportation	1.245	0.000	0.120	9.661	1.391
9000	Paved Open Land	1.245	0.000	0.120	10.806	1.425
10110	Developed OpenSpace-A-Low	0.175	0.656	0.519	0.237	0.021
10120	Developed OpenSpace-A-Med	0.175	0.664	0.518	0.259	0.023
10210	Developed OpenSpace-B-Low	0.308	0.509	0.531	0.896	0.094
10220	Developed OpenSpace-B-Med	0.305	0.504	0.531	1.126	0.118
10310	Developed OpenSpace-C-Low	0.404	0.398	0.539	1.968	0.182
10320	Developed OpenSpace-C-Med	0.405	0.399	0.538	2.071	0.191
10410	Developed OpenSpace-D-Low	0.495	0.303	0.544	2.827	0.261
10420	Developed OpenSpace-D-Med	0.491	0.303	0.544	3.422	0.316
11000	Forested Wetland	0.264	0.107	0.994	0.418	0.087
12000	Non-Forested Wetland	0.263	0.105	0.992	0.414	0.086
13110	Forest-A-Low	0.058	0.537	0.776	0.100	0.020
13120	Forest-A-Med	0.057	0.535	0.775	0.105	0.021
13210	Forest-B-Low	0.132	0.446	0.787	0.452	0.089
13220	Forest-B-Med	0.131	0.444	0.787	0.476	0.094
13310	Forest-C-Low	0.204	0.363	0.793	0.908	0.168

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
13320	Forest-C-Med	0.203	0.362	0.793	0.963	0.178
13410	Forest-D-Low	0.370	0.186	0.801	1.438	0.291
13420	Forest-D-Med	0.369	0.186	0.801	1.490	0.302
14110	Agriculture-A-Low	0.099	0.605	0.653	0.508	0.087
14120	Agriculture-A-Med	0.098	0.604	0.653	0.536	0.092
14210	Agriculture-B-Low	0.197	0.488	0.668	2.165	0.381
14220	Agriculture-B-Med	0.196	0.488	0.668	2.305	0.406
14310	Agriculture-C-Low	0.282	0.391	0.677	4.436	0.680
14320	Agriculture-C-Med	0.281	0.391	0.677	4.730	0.725
14410	Agriculture-D-Low	0.361	0.303	0.684	6.842	1.165
14420	Agriculture-D-Med	0.359	0.304	0.684	7.237	1.233

Units: MG – million gallons, lb – pounds, ac – acre, yr – year

Table 5-4. Summary of unit-acre based annual average (Oct 2079 – Sep 2099) runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the modeled HRU types in the Wading River watershed (Ecodeficit 8.5 Median)

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
1000	Paved Forest	1.251	0.000	0.126	11.147	1.477
2000	Paved Agriculture	1.251	0.000	0.126	11.147	1.477
3000	Paved Commercial	1.251	0.000	0.126	14.805	1.691
4000	Paved Industrial	1.251	0.000	0.126	14.805	1.691
5000	Paved Low Density Residential	1.251	0.000	0.126	13.854	1.416
6000	Paved Medium Density Residential	1.251	0.000	0.126	13.854	1.906
7000	Paved High Density Residential	1.251	0.000	0.126	13.848	2.254
8000	Paved Transportation	1.251	0.000	0.126	9.966	1.442
9000	Paved Open Land	1.251	0.000	0.126	11.147	1.477
10110	Developed OpenSpace-A-Low	0.185	0.674	0.498	0.209	0.019
10120	Developed OpenSpace-A-Med	0.185	0.682	0.498	0.232	0.021
10210	Developed OpenSpace-B-Low	0.327	0.520	0.508	0.901	0.094
10220	Developed OpenSpace-B-Med	0.323	0.516	0.508	1.144	0.120
10310	Developed OpenSpace-C-Low	0.428	0.405	0.515	1.999	0.184
10320	Developed OpenSpace-C-Med	0.429	0.406	0.515	2.108	0.194
10410	Developed OpenSpace-D-Low	0.522	0.307	0.519	2.893	0.267
10420	Developed OpenSpace-D-Med	0.518	0.308	0.519	3.525	0.326
11000	Forested Wetland	0.293	0.119	0.960	0.442	0.092
12000	Non-Forested Wetland	0.292	0.117	0.957	0.439	0.092
13110	Forest-A-Low	0.062	0.572	0.743	0.089	0.018
13120	Forest-A-Med	0.062	0.570	0.743	0.093	0.018
13210	Forest-B-Low	0.144	0.474	0.753	0.460	0.091

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
13220	Forest-B-Med	0.143	0.473	0.753	0.490	0.097
13310	Forest-C-Low	0.224	0.385	0.758	0.977	0.181
13320	Forest-C-Med	0.223	0.384	0.758	1.035	0.192
13410	Forest-D-Low	0.401	0.198	0.765	1.504	0.305
13420	Forest-D-Med	0.399	0.197	0.765	1.558	0.315
14110	Agriculture-A-Low	0.106	0.628	0.630	0.431	0.074
14120	Agriculture-A-Med	0.106	0.627	0.630	0.458	0.079
14210	Agriculture-B-Low	0.214	0.503	0.644	2.267	0.399
14220	Agriculture-B-Med	0.213	0.503	0.644	2.426	0.427
14310	Agriculture-C-Low	0.305	0.402	0.651	4.658	0.714
14320	Agriculture-C-Med	0.303	0.402	0.651	4.966	0.761
14410	Agriculture-D-Low	0.388	0.312	0.657	7.102	1.210
14420	Agriculture-D-Med	0.386	0.312	0.657	7.502	1.278

Units: MG – million gallons, lb – pounds, ac – acre, yr – year

Table 5-5. Summary of unit-acre based annual average (Oct 2079 – Sep 2099) runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the modeled HRU types in the Wading River watershed (Ecodeficit 8.5 Wet)

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
1000	Paved Forest	1.336	0.000	0.119	11.761	1.551
2000	Paved Agriculture	1.336	0.000	0.119	11.761	1.551
3000	Paved Commercial	1.336	0.000	0.119	15.623	1.777
4000	Paved Industrial	1.336	0.000	0.119	15.623	1.777
5000	Paved Low Density Residential	1.336	0.000	0.119	14.617	1.488
6000	Paved Medium Density Residential	1.336	0.000	0.119	14.617	2.056
7000	Paved High Density Residential	1.336	0.000	0.119	14.614	2.377
8000	Paved Transportation	1.336	0.000	0.119	10.517	1.514
9000	Paved Open Land	1.336	0.000	0.119	11.761	1.551
10110	Developed OpenSpace-A-Low	0.206	0.742	0.489	0.205	0.018
10120	Developed OpenSpace-A-Med	0.206	0.750	0.489	0.230	0.021
10210	Developed OpenSpace-B-Low	0.364	0.573	0.498	0.863	0.090
10220	Developed OpenSpace-B-Med	0.361	0.568	0.498	1.102	0.115
10310	Developed OpenSpace-C-Low	0.479	0.445	0.504	2.000	0.185
10320	Developed OpenSpace-C-Med	0.480	0.446	0.504	2.120	0.196
10410	Developed OpenSpace-D-Low	0.584	0.337	0.507	3.152	0.291
10420	Developed OpenSpace-D-Med	0.580	0.339	0.507	3.903	0.361
11000	Forested Wetland	0.368	0.147	0.939	0.575	0.120
12000	Non-Forested Wetland	0.367	0.146	0.936	0.573	0.119
13110	Forest-A-Low	0.079	0.640	0.740	0.092	0.018

HRU	HRU Category	Runoff (MG/ac/yr)	GW (MG/ac/yr)	ET (MG/ac/yr)	TN (lb/ac/yr)	TP (lb/ac/yr)
13120	Forest-A-Med	0.079	0.638	0.740	0.097	0.019
13210	Forest-B-Low	0.177	0.531	0.747	0.463	0.092
13220	Forest-B-Med	0.176	0.529	0.747	0.493	0.098
13310	Forest-C-Low	0.271	0.428	0.751	1.031	0.191
13320	Forest-C-Med	0.270	0.427	0.751	1.101	0.204
13410	Forest-D-Low	0.478	0.216	0.755	1.788	0.362
13420	Forest-D-Med	0.476	0.215	0.755	1.859	0.376
14110	Agriculture-A-Low	0.126	0.699	0.618	0.426	0.073
14120	Agriculture-A-Med	0.126	0.698	0.618	0.453	0.078
14210	Agriculture-B-Low	0.250	0.561	0.630	2.231	0.393
14220	Agriculture-B-Med	0.249	0.561	0.630	2.387	0.420
14310	Agriculture-C-Low	0.356	0.447	0.636	4.805	0.737
14320	Agriculture-C-Med	0.355	0.447	0.636	5.161	0.791
14410	Agriculture-D-Low	0.452	0.344	0.641	7.890	1.344
14420	Agriculture-D-Med	0.450	0.344	0.641	8.395	1.430

Units: MG – million gallons, lb – pounds, ac – acre, yr – year

The unit-acre unattenuated values were applied to the baseline and future development HRUs areas to estimate the net change in hydrology and water quality for the Taunton River watershed. As expected, with the same historic climate data and increased IC from the 2060 land use, runoff and pollutant loads increased, while groundwater recharge and evapotranspiration decreased (Figure 5-1, blue). The selected future climate scenarios had increased precipitation and temperature compared to the baseline. Of the future scenarios, the 2060 land use Ecodeficit 8.5 Dry combination had the smallest change in the runoff, TN, and TP compared to the 2016 baseline with historic climate, but the greatest decrease in groundwater recharge (Figure 5-1, orange). While the Ecodeficit 8.5 Dry scenario has a 5% increase in annual average precipitation, it also has a 16% increase in annual average temperature (Figure 4-1). The increase in temperature increased ET by 18MG/yr compared to the 2016 baseline with historic climate and drove the reduced runoff and groundwater recharge, and subsequently the lower changes in TN and TP. At the other extreme, the Ecodeficit 8.5 Wet scenario had the greatest changes in runoff, groundwater recharge, and TN (Figure 5-1, red). The 8% increase in temperature for this scenario did lead to a lower reduction in ET compared to the 2060 land use-historic climate scenario, however, the 10% increase in precipitation still drove the increases in the other parameters. Results for the Ecodeficit 8.5 Median climate scenario fell between the Wet and Dry extremes with a consistent pattern across all of the parameters (Figure 5-1, green).

The trends seen at the Taunton River watershed scale are also reflected at the municipality level (annual average runoff and loadings and the change between baseline and future conditions by the municipality are shown in the appendix (Table 6-3 through Table 6-11). As an example (Table 6-8), IC in the Taunton Municipality increased by nearly 3,000 acres. This led to an increase in runoff of nearly 3,600 million gallons/year and an additional 38,000 pounds and 4,500 pounds of TN and TP per year on average for the 2060 land use-historic climate scenario. Correspondingly, groundwater recharge and evapotranspiration decreased by 1,300 and 2,300 million gallons/year.

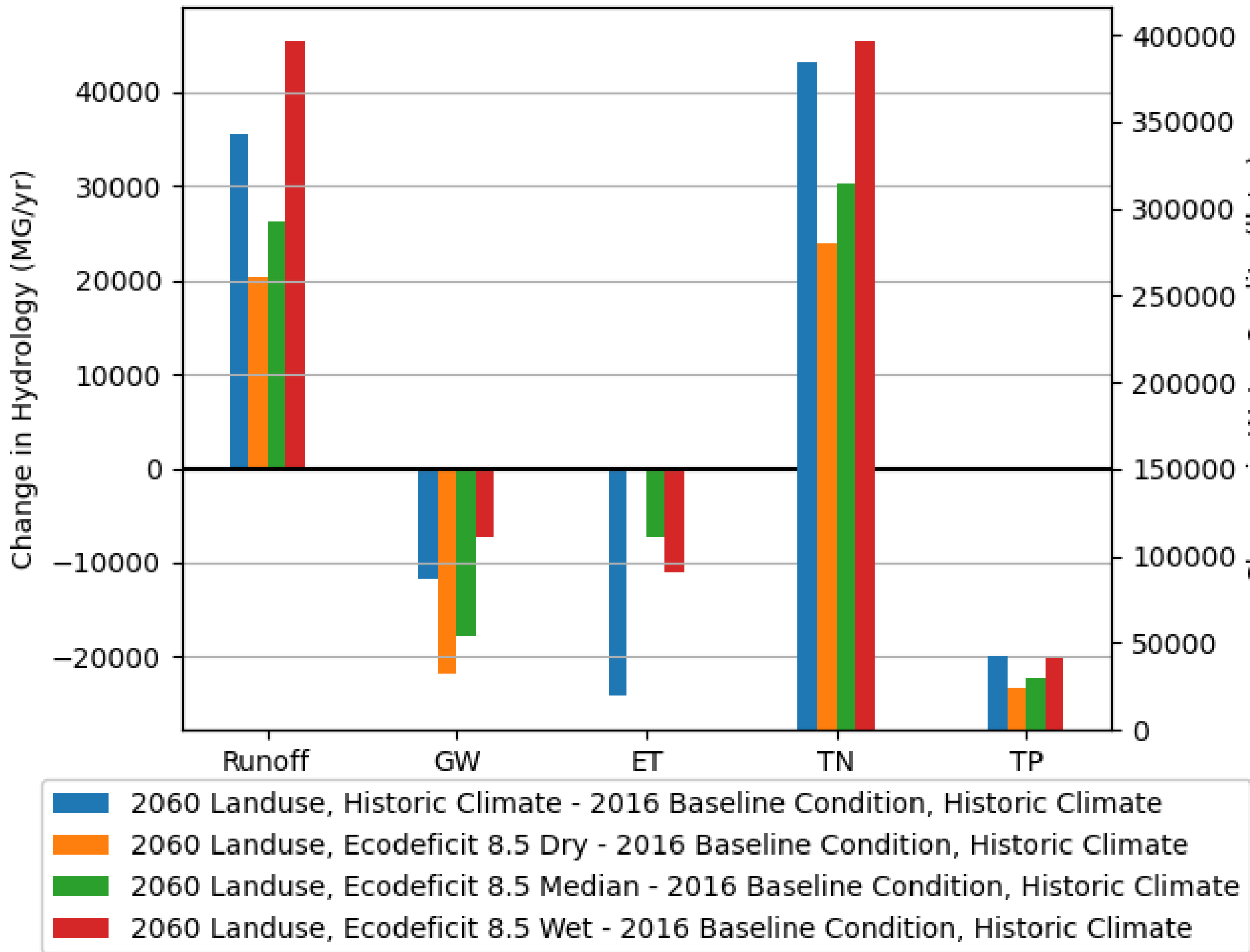

Figure 5-1. Comparison of changes in hydrology (runoff, groundwater recharge GW, and evapotranspiration ET) and water quality parameters (total nitrogen TN and total phosphorous TP) between the baseline and future land use/climate conditions across the entire Taunton River watershed.

5.3. Summary

Through the methodology detailed in this technical memo, a new HRUs layer was created that represents potential future development conditions in the Taunton River watershed. This new configuration of HRUs reflects increased development due to the conversion of unprotected forest areas into land uses with greater impervious cover (Table 5-6). The loss of vegetative cover (forests) shifts the water balance towards higher runoff. As impervious surfaces increase, baseflows may fall due to more water being conveyed immediately to receiving waters with fewer opportunities for infiltration and evapotranspiration. When the future distribution of HRUs is applied to the unattenuated modeling results from FDC Phase 1 (e.g., using historic climate data), net increases in runoff (35,674 million gallons/year) and nutrient loadings (383,765 lbs and 42,545 lbs of TN and TP per year on average) are observed across the entire Taunton River watershed while groundwater recharge and evapotranspiration decreased by 11,734 and 24,240 million gallons per year, respectively (Table 5-7). Simulating future climate conditions increases the variability of these results, with differences between the scenarios being driven by the amount of increase in precipitation and temperature compared to the historic climate data.

A standard water tower can hold 1 million gallons of water and a typical large dump truck can carry about 28,000 pounds. Using the 2060 land use and historic climate results as an example, these numbers can be visualized as 11.7 thousand water towers of groundwater recharge as the annual loss, 13.7 large dump trucks of TN and 1.5 large dump trucks of TP as the average annual increase in nutrients load in the entire Taunton River watershed.

The outputs of this technical memo are the building blocks to model future land use scenarios and optimize innovative stormwater control measures and protective ordinances that will be established in collaboration with local stakeholders and practitioners.

Table 5-6. Summary of change in major land use area distribution between 2016 baseline and 2060 future conditions in Taunton River watershed

Major Land Use Classification	Land Cover	2016 Baseline (acre)	2060 Future (acre)	Change (%)
Paved Forest	Impervious	9	9	0%
Paved Agriculture	Impervious	128	158	23%
Paved Commercial	Impervious	4,858	6,873	41%
Paved Industrial	Impervious	2,745	3,892	42%
Paved Low Density Residential	Impervious	9,951	20,717	108%
Paved Medium Density Residential	Impervious	489	1,133	132%
Paved High Density Residential	Impervious	2,856	4,041	42%
Paved Transportation	Impervious	11,852	21,709	83%
Paved Open Land	Impervious	4,138	8,377	102%
Developed OpenSpace	Pervious	40,955	76,120	86%
Forested Wetland	Pervious	66,463	66,463	0%
Non-Forested Wetland	Pervious	9,734	9,734	0%
Forest	Pervious	144,393	78,832	-45%
Agriculture	Pervious	25,255	25,768	2%

Table 5-7. Summary of changes between baseline land use and historic climate model results and the future land use and climate scenarios for annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load by major land use in Taunton River watershed

Major Land Use Classification	Runoff (MG/yr)				GW Recharge (MG/yr)				ET (MG/yr)				TN (lb/yr)				TP (lb/yr)			
	2060 FLULC	Ecodef. 8.5 Dry	Ecodef. 8.5 Med.	Ecodef. 8.5 Wet	2060 FLULC	Ecodef. 8.5 Dry	Ecodef. 8.5 Med.	Ecodef. 8.5 Wet	2060 FLULC	Ecodef. 8.5 Dry	Ecodef. 8.5 Med.	Ecodef. 8.5 Wet	2060 FLULC	Ecodef. 8.5 Dry	Ecodef. 8.5 Med.	Ecodef. 8.5 Wet	2060 FLULC	Ecodef. 8.5 Dry	Ecodef. 8.5 Med.	Ecodef. 8.5 Wet
Paved Forest	0	0	0	1	0	0	0	0	0	0	0	0	0	-6	-3	3	0	-1	0	0
Paved Agriculture	36	38	39	53	0	0	0	0	4	3	4	3	339	233	287	384	44	32	40	52
Paved Commercial	2,486	2,559	2,601	3,185	0	0	0	0	254	212	256	202	30,707	24,599	27,714	33,340	3,615	2,494	2,905	3,495
Paved Industrial	1,416	1,457	1,480	1,811	0	0	0	0	145	121	146	115	17,484	14,025	15,789	18,975	2,058	1,424	1,656	1,990
Paved Low Density Residential	13,285	13,503	13,630	15,390	0	0	0	0	1,357	1,230	1,364	1,201	153,634	136,222	145,011	160,824	16,182	13,352	14,390	15,878
Paved Medium Density Residential	795	807	814	910	0	0	0	0	81	74	82	73	9,192	8,239	8,720	9,585	1,269	1,122	1,196	1,367
Paved High Density Residential	1,463	1,505	1,530	1,874	0	0	0	0	149	125	151	119	16,905	13,528	15,241	18,335	2,823	1,992	2,311	2,807
Paved Transportation	12,164	12,392	12,525	14,369	0	0	0	0	1,242	1,110	1,250	1,079	101,133	88,134	94,758	106,720	15,101	12,042	13,152	14,720
Paved Open Land	5,231	5,319	5,370	6,080	0	0	0	0	534	483	537	471	48,661	43,020	45,875	51,011	6,646	5,447	5,884	6,506
Developed OpenSpace	14,083	8,832	10,186	13,169	17,380	16,647	17,524	21,417	16,308	21,417	19,698	18,925	59,202	44,899	45,999	51,368	5,516	4,203	4,309	4,801
Forested Wetland	0	-4,420	-2,529	2,444	0	-3,463	-2,631	-767	0	7,816	5,554	4,199	0	-6,797	-5,163	3,631	0	-1,459	-1,118	715
Non-Forested Wetland	0	-683	-403	330	0	-540	-418	-141	0	1,145	810	602	0	-1,027	-785	511	0	-220	-170	100
Forest	-15,491	-19,672	-18,225	-14,457	-29,320	-33,833	-32,054	-28,694	-44,636	-36,120	-38,835	-39,411	-56,406	-70,920	-68,137	-58,062	-11,193	-14,100	-13,549	-11,522
Agriculture	174	-1,287	-785	416	220	-707	-355	891	304	2,402	1,738	1,374	2,916	-14,091	-10,533	-301	485	-2,386	-1,791	-58
TOTAL	**35,642**	**20,349**	**26,233**	**45,576**	**-11,720**	**-21,895**	**-17,933**	**-7,295**	**-24,259**	**18**	**-7,245**	**-11,046**	**383,765**	**280,057**	**314,774**	**396,321**	**42,545**	**23,943**	**29,216**	**40,850**

Units: MG – million gallons, lb – pounds, yr – year

6. APPENDIX

6.1. Impervious Cover by Municipality within the Taunton River Watershed

Table 6-1. Summary of 2016 baseline impervious cover by the municipality in the Taunton River watershed

Municipality		2016 Baseline Impervious Cover (acre)						
ID	Name	TRANS	COM	IND	HDR	MDR	LDR	OPEN
1	ABINGTON	277.6	153.7	2.8	99.7	4.0	294.1	88.4
16	ATTLEBORO	117.0	10.8	51.4	13.0	0.0	142.2	20.3
18	AVON	185.1	109.2	161.8	15.4	0.4	90.8	40.9
27	BERKLEY	259.5	22.0	3.6	14.7	30.3	230.6	48.6
42	BRIDGEWATER	594.6	144.3	82.8	195.4	18.8	564.3	343.1
44	BROCKTON	1,427.7	788.8	227.9	550.9	16.1	1,113.1	662.4
52	CARVER	145.8	47.8	9.1	5.0	2.8	76.3	15.1
72	DARTMOUTH	0.0	0.0	0.0	0.0	0.0	0.0	0.0
76	DIGHTON	227.0	77.7	50.1	26.6	16.8	213.2	106.2
83	EAST BRIDGEWATER	360.2	89.8	71.6	65.8	15.4	382.8	128.6
88	EASTON	564.4	179.6	94.6	113.6	2.2	620.8	272.6
95	FALL RIVER	350.8	120.0	231.9	170.6	9.6	142.3	137.0
99	FOXBOROUGH	512.8	220.8	51.1	85.7	10.6	333.1	144.1
102	FREETOWN	399.8	98.6	176.2	20.2	45.5	287.9	126.2
118	HALIFAX	186.2	72.1	16.1	55.5	19.5	241.9	55.5
123	HANSON	142.1	38.1	37.2	20.6	6.6	153.1	60.3
133	HOLBROOK	46.6	13.5	6.0	5.3	1.2	52.4	5.8
145	KINGSTON	41.3	0.0	0.0	0.2	0.0	19.1	25.1
146	LAKEVILLE	369.8	126.6	83.3	41.2	6.7	502.8	122.3
167	MANSFIELD	643.4	256.3	362.0	118.2	4.9	502.6	129.9
182	MIDDLEBOROUGH	830.7	287.4	85.6	108.1	160.3	565.0	206.3
201	NEW BEDFORD	44.4	7.7	0.0	5.3	0.7	37.4	8.0
208	NORFOLK	0.5	0.0	0.0	0.0	0.0	1.6	0.0
211	NORTH ATTLEBOROUGH	3.4	0.2	0.0	0.0	0.0	4.5	0.6
218	NORTON	471.6	133.2	140.0	154.4	28.1	404.0	145.6
231	PEMBROKE	34.3	2.7	1.4	4.2	1.0	46.7	7.8
238	PLAINVILLE	141.3	139.7	27.6	48.4	0.2	76.7	42.2
239	PLYMOUTH	18.1	59.4	0.0	18.2	0.0	4.5	0.6
240	PLYMPTON	100.8	65.8	13.6	8.0	13.3	97.1	23.8
245	RAYNHAM	534.9	355.5	81.9	87.6	11.8	368.5	156.0
247	REHOBOTH	23.1	3.7	0.0	3.4	0.3	28.3	2.5
250	ROCHESTER	27.2	0.0	0.0	2.6	1.4	19.3	6.6
251	ROCKLAND	3.4	3.6	0.0	1.0	0.0	2.7	0.0

Municipality		2016 Baseline Impervious Cover (acre)						
ID	Name	TRANS	COM	IND	HDR	MDR	LDR	OPEN
266	SHARON	193.9	14.4	0.1	2.4	0.0	180.7	16.9
273	SOMERSET	314.1	88.6	34.9	43.9	2.8	408.8	91.5
285	STOUGHTON	240.8	95.4	125.3	20.0	6.4	228.9	54.5
292	SWANSEA	36.8	0.6	0.0	2.9	0.3	45.6	9.1
293	TAUNTON	1,215.3	729.9	305.4	568.3	12.3	910.5	545.6
307	WALPOLE	1.8	0.0	0.0	0.0	0.0	2.3	0.0
322	WEST BRIDGEWATER	326.5	176.0	153.9	44.5	26.8	199.5	111.7
336	WEYMOUTH	3.6	0.0	0.0	0.4	0.0	3.9	0.1
338	WHITMAN	278.7	93.5	49.2	91.5	9.6	258.6	90.4
350	WRENTHAM	154.9	31.1	6.3	22.7	2.5	92.1	72.0
	Total	**11,852**	**4,858**	**2,745**	**2,856**	**489**	**9,951**	**4,124**

Land cover classes: TRANS – transportation, COM – commercial, IND – industrial, HDR – high-density residential, MDR – medium-density residential, LDR – low-density residential, OPEN – open land

Table 6-2. Summary of 2060 future impervious cover by municipality in Taunton River watershed

Municipality		2060 Future Impervious Cover (acre)						
ID	Name	TRANS	COM	IND	HDR	MDR	LDR	OPEN
1	ABINGTON	476.4	239.4	4.3	155.3	7.2	535.7	160.9
16	ATTLEBORO	242.4	14.8	70.8	18.0	0.0	340.1	48.7
18	AVON	280.4	139.1	206.1	19.6	0.8	185.0	83.3
27	BERKLEY	634.4	37.2	6.2	24.9	76.9	586.1	123.4
42	BRIDGEWATER	1,096.1	234.9	134.8	318.1	36.6	1,095.8	666.3
44	BROCKTON	1,933.9	1,007.0	290.9	703.3	23.0	1,583.7	942.4
52	CARVER	340.2	75.7	14.4	8.0	7.9	215.8	42.8
72	DARTMOUTH	0.2	0.0	0.0	0.0	0.0	0.3	0.2
76	DIGHTON	514.3	92.1	59.3	31.6	46.4	588.9	293.2
83	EAST BRIDGEWATER	769.6	171.6	136.9	125.9	34.4	855.1	287.1
88	EASTON	1,081.4	222.8	117.4	140.9	4.9	1,371.0	602.0
95	FALL RIVER	475.9	150.8	291.4	214.4	14.7	218.8	210.5
99	FOXBOROUGH	947.0	275.0	63.7	106.7	24.2	762.2	329.6
102	FREETOWN	838.7	129.4	231.3	26.5	118.2	749.0	328.3
118	HALIFAX	332.7	86.7	19.4	66.8	40.0	496.2	113.8
123	HANSON	272.9	49.3	48.2	26.7	14.4	335.9	132.4
133	HOLBROOK	107.4	39.6	17.6	15.6	2.4	106.8	11.8
145	KINGSTON	125.0	0.0	0.0	6.5	0.0	55.3	72.5
146	LAKEVILLE	756.4	163.3	107.5	53.2	15.8	1,179.3	287.0
167	MANSFIELD	1,109.9	381.8	539.2	176.0	9.9	1,003.6	259.4
182	MIDDLEBOROUGH	1,757.4	420.5	125.3	158.2	393.2	1,385.6	506.0
201	NEW BEDFORD	71.7	14.9	0.0	10.2	1.1	57.1	12.3

Municipality		2060 Future Impervious Cover (acre)						
ID	Name	TRANS	COM	IND	HDR	MDR	LDR	OPEN
208	NORFOLK	1.3	0.3	0.2	0.2	0.0	3.5	0.0
211	NORTH ATTLEBOROUGH	9.7	0.8	0.0	0.0	0.0	12.5	1.6
218	NORTON	988.8	192.8	202.5	223.5	72.3	1,041.2	375.2
231	PEMBROKE	63.7	4.2	2.2	6.4	2.0	88.9	14.8
238	PLAINVILLE	257.4	212.6	42.0	73.6	0.4	181.3	99.8
239	PLYMOUTH	22.5	67.8	0.0	20.7	0.0	12.5	1.6
240	PLYMPTON	224.0	76.3	15.7	9.3	38.6	283.1	69.4
245	RAYNHAM	1,038.7	560.2	129.1	138.1	27.2	847.7	358.7
247	REHOBOTH	60.5	4.8	0.0	4.4	0.7	82.7	7.4
250	ROCHESTER	58.4	0.0	0.0	4.3	3.1	42.3	14.4
251	ROCKLAND	5.3	4.1	0.0	1.2	0.0	6.0	0.0
266	SHARON	452.9	21.8	0.1	3.6	0.0	434.8	40.7
273	SOMERSET	458.4	139.2	54.9	68.9	4.0	581.5	130.1
285	STOUGHTON	470.6	184.7	242.5	38.7	12.6	450.8	107.4
292	SWANSEA	86.7	0.9	0.0	4.4	0.6	109.8	21.9
293	TAUNTON	2,053.5	1,052.2	440.3	819.1	24.2	1,785.2	1,069.9
307	WALPOLE	4.5	0.6	0.3	0.3	0.0	4.9	0.0
322	WEST BRIDGEWATER	536.4	230.3	201.5	58.2	53.9	401.5	225.0
336	WEYMOUTH	6.6	0.0	0.0	1.8	0.0	6.2	0.2
338	WHITMAN	426.1	126.2	66.4	123.6	15.7	425.5	148.8
350	WRENTHAM	318.3	47.0	9.6	34.3	5.7	207.5	162.2
	Total	**21,709**	**6,873**	**3,892**	**4,041**	**1,133**	**20,717**	**8,363**

Land cover classes: TRANS – transportation, COM – commercial, IND – industrial, HDR – high-density residential, MDR – medium-density residential, LDR – low-density residential, OPEN – open land

6.2. Surface Runoff, Groundwater Recharge, Evapotranspiration, and Nutrient Loads by Municipality within the Taunton River Watershed

Table 6-3. Summary of annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for 2016 baseline condition by the municipality in Taunton River watershed

Municipality		2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	920	2,726	1,546	3,243	18,195	2,542
16	ATTLEBORO	355	1,631	1,417	2,995	8,482	1,268
18	AVON	603	1,158	626	1,071	9,495	1,240
27	BERKLEY	609	3,799	3,587	6,791	20,446	3,218
42	BRIDGEWATER	1,943	7,372	5,522	11,025	48,960	7,333
44	BROCKTON	4,787	8,591	3,752	6,125	71,987	9,585
52	CARVER	302	1,238	1,623	2,446	9,849	1,522
72	DARTMOUTH	0	1	2	3	6	1
76	DIGHTON	718	4,455	3,470	7,474	25,278	3,991
83	EAST BRIDGEWATER	1,114	4,800	3,249	6,955	30,073	4,486
88	EASTON	1,848	7,227	5,891	12,015	40,785	6,031
95	FALL RIVER	1,162	2,714	1,545	2,867	21,233	3,006
99	FOXBOROUGH	1,358	3,934	3,894	6,261	24,670	3,537
102	FREETOWN	1,154	6,474	6,652	12,528	34,845	5,446
118	HALIFAX	647	3,730	3,130	6,700	26,500	4,183
123	HANSON	458	2,300	1,595	3,804	13,406	2,056
133	HOLBROOK	131	495	291	660	2,997	434
145	KINGSTON	86	284	654	811	1,499	223
146	LAKEVILLE	1,253	6,440	6,762	12,240	37,043	5,645
167	MANSFIELD	2,017	5,311	4,296	7,401	35,360	4,883
182	MIDDLEBOROUGH	2,244	12,026	11,076	22,048	72,474	11,413
201	NEW BEDFORD	104	237	142	259	1,667	222
208	NORFOLK	2	6	6	9	41	5
211	NORTH ATTLEBOROUGH	9	47	55	93	278	42
218	NORTON	1,477	6,269	6,376	11,759	33,113	4,972
231	PEMBROKE	98	261	324	435	2,296	334
238	PLAINVILLE	476	1,233	1,091	1,726	8,820	1,245
239	PLYMOUTH	101	154	126	123	1,464	191
240	PLYMPTON	322	2,513	2,155	4,778	15,786	2,570
245	RAYNHAM	1,596	5,287	4,360	8,256	32,710	4,717
247	REHOBOTH	61	412	379	779	2,257	363
250	ROCHESTER	57	402	639	1,071	1,701	279

Municipality		2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
251	ROCKLAND	11	26	15	30	188	25
266	SHARON	408	1,658	2,194	3,511	8,621	1,291
273	SOMERSET	985	2,163	993	1,676	17,565	2,259
285	STOUGHTON	771	2,345	1,744	3,205	15,386	2,142
292	SWANSEA	95	504	288	677	3,316	491
293	TAUNTON	4,287	12,032	10,605	18,125	78,324	11,208
307	WALPOLE	4	14	8	16	93	13
322	WEST BRIDGEWATER	1,039	4,491	2,484	6,522	29,716	4,499
336	WEYMOUTH	8	50	33	106	183	29
338	WHITMAN	871	2,523	875	2,524	17,449	2,439
350	WRENTHAM	382	1,416	1,571	2,504	7,869	1,201
	Total	**36,874**	**130,750**	**107,047**	**203,647**	**832,428**	**122,579**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-4. Summary of annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for 2060 future condition by municipality in Taunton River watershed

Municipality		2060 Future Condition, Historic Climate					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	1,579	3,454	1,342	2,712	26,709	3,439
16	ATTLEBORO	735	2,100	1,264	2,674	13,348	1,775
18	AVON	914	1,524	496	832	13,451	1,677
27	BERKLEY	1,489	4,842	3,258	6,067	31,592	4,426
42	BRIDGEWATER	3,582	9,316	4,911	9,672	69,842	9,654
44	BROCKTON	6,484	10,559	3,056	4,836	93,426	12,065
52	CARVER	705	1,742	1,418	2,144	14,407	2,060
72	DARTMOUTH	1	2	1	3	15	2
76	DIGHTON	1,626	5,539	3,174	6,674	37,246	5,196
83	EAST BRIDGEWATER	2,381	6,204	2,858	5,927	45,588	6,047
88	EASTON	3,540	9,344	5,227	10,539	62,633	8,340
95	FALL RIVER	1,577	3,174	1,372	2,577	26,310	3,604
99	FOXBOROUGH	2,508	5,364	3,400	5,313	39,155	5,173
102	FREETOWN	2,421	8,037	6,107	11,495	50,541	7,171
118	HALIFAX	1,156	4,368	2,929	6,256	32,996	4,874
123	HANSON	880	2,800	1,459	3,435	19,116	2,649
133	HOLBROOK	301	674	238	533	5,138	660
145	KINGSTON	259	511	563	673	3,501	484
146	LAKEVILLE	2,562	8,098	6,242	11,084	54,582	7,511

Municipality		2060 Future Condition, Historic Climate					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
167	MANSFIELD	3,480	7,051	3,657	6,286	54,354	7,066
182	MIDDLEBOROUGH	4,746	15,034	10,146	19,941	107,423	15,483
201	NEW BEDFORD	167	312	114	212	2,460	316
208	NORFOLK	5	10	5	6	89	10
211	NORTH ATTLEBOROUGH	25	67	48	81	463	60
218	NORTON	3,096	8,265	5,705	10,415	53,583	7,265
231	PEMBROKE	182	371	284	364	3,314	450
238	PLAINVILLE	867	1,691	916	1,439	13,670	1,797
239	PLYMOUTH	125	184	112	107	1,798	232
240	PLYMPTON	716	2,991	2,027	4,422	21,571	3,201
245	RAYNHAM	3,100	7,068	3,746	7,073	51,933	6,881
247	REHOBOTH	161	531	341	697	3,401	473
250	ROCHESTER	123	484	611	1,017	2,555	383
251	ROCKLAND	17	33	13	25	263	33
266	SHARON	954	2,353	1,935	3,069	15,329	2,061
273	SOMERSET	1,437	2,683	815	1,330	23,430	2,885
285	STOUGHTON	1,507	3,175	1,458	2,655	24,833	3,177
292	SWANSEA	224	648	252	567	4,924	640
293	TAUNTON	7,244	15,600	9,323	15,809	116,482	15,689
307	WALPOLE	11	21	6	11	178	21
322	WEST BRIDGEWATER	1,707	5,219	2,283	5,987	38,203	5,383
336	WEYMOUTH	15	58	30	101	268	40
338	WHITMAN	1,332	2,981	785	2,150	23,301	3,004
350	WRENTHAM	784	1,911	1,398	2,178	12,774	1,770
	Total	**66,727**	**166,393**	**95,326**	**179,388**	**1,216,193**	**165,124**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-5. Summary of annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the 2060 future condition and the Ecodeficit 8.5 Dry climate scenario by municipality in Taunton River watershed

Municipality		2060 Future Condition, Ecodeficit 8.5 Dry					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	1,579	3,193	1,221	3,068	24,600	3,076
16	ATTLEBORO	735	1,877	1,106	3,040	12,184	1,567
18	AVON	914	1,459	458	930	12,560	1,515
27	BERKLEY	1,489	4,289	2,908	6,920	28,520	3,885
42	BRIDGEWATER	3,582	8,432	4,419	10,970	63,586	8,544

Municipality		2060 Future Condition, Ecodeficit 8.5 Dry					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
44	BROCKTON	6,484	10,156	2,883	5,376	87,262	10,922
52	CARVER	705	1,582	1,282	2,429	13,104	1,822
72	DARTMOUTH	1	2	1	3	13	2
76	DIGHTON	1,626	4,892	2,815	7,618	33,500	4,548
83	EAST BRIDGEWATER	2,381	5,626	2,583	6,725	41,552	5,357
88	EASTON	3,540	8,431	4,640	11,971	57,398	7,404
95	FALL RIVER	1,577	2,954	1,228	2,922	24,233	3,220
99	FOXBOROUGH	2,508	4,950	3,065	6,031	36,197	4,629
102	FREETOWN	2,421	7,081	5,366	13,127	45,640	6,282
118	HALIFAX	1,156	3,823	2,573	7,113	29,431	4,245
123	HANSON	880	2,487	1,276	3,904	17,251	2,322
133	HOLBROOK	301	621	214	604	4,714	587
145	KINGSTON	259	474	508	765	3,274	437
146	LAKEVILLE	2,562	7,177	5,554	12,625	49,453	6,602
167	MANSFIELD	3,480	6,557	3,299	7,106	50,446	6,342
182	MIDDLEBOROUGH	4,746	13,335	8,958	22,696	96,812	13,594
201	NEW BEDFORD	167	294	104	238	2,284	284
208	NORFOLK	5	10	4	7	83	9
211	NORTH ATTLEBOROUGH	25	60	43	92	424	54
218	NORTON	3,096	7,438	5,060	11,837	49,139	6,450
231	PEMBROKE	182	345	261	412	3,039	400
238	PLAINVILLE	867	1,580	831	1,628	12,688	1,615
239	PLYMOUTH	125	179	105	119	1,695	211
240	PLYMPTON	716	2,601	1,773	5,034	19,171	2,779
245	RAYNHAM	3,100	6,481	3,357	8,008	47,793	6,133
247	REHOBOTH	161	469	301	794	3,075	415
250	ROCHESTER	123	418	531	1,161	2,301	334
251	ROCKLAND	17	31	12	28	244	29
266	SHARON	954	2,130	1,722	3,493	14,112	1,832
273	SOMERSET	1,437	2,533	786	1,489	21,682	2,597
285	STOUGHTON	1,507	2,942	1,318	3,008	22,918	2,838
292	SWANSEA	224	583	232	644	4,448	564
293	TAUNTON	7,244	14,388	8,373	17,894	107,753	14,051
307	WALPOLE	11	20	6	12	163	19
322	WEST BRIDGEWATER	1,707	4,656	1,985	6,798	34,421	4,719
336	WEYMOUTH	15	51	24	114	243	34
338	WHITMAN	1,332	2,755	711	2,427	21,354	2,677

Municipality		2060 Future Condition, Ecodeficit 8.5 Dry					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
350	WRENTHAM	784	1,736	1,256	2,481	11,729	1,572
	Total	**66,727**	**151,099**	**85,151**	**203,665**	**1,112,485**	**146,521**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-6. Summary of annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the 2060 future condition and the Ecodeficit 8.5 Median climate scenario by municipality in Taunton River watershed

Municipality		2060 Future Condition, Ecodeficit 8.5 Median					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	1,579	3,293	1,272	2,962	25,361	3,186
16	ATTLEBORO	735	1,964	1,162	2,931	12,567	1,624
18	AVON	914	1,487	476	903	12,942	1,569
27	BERKLEY	1,489	4,494	3,043	6,659	29,410	4,024
42	BRIDGEWATER	3,582	8,770	4,610	10,582	65,605	8,855
44	BROCKTON	6,484	10,336	2,977	5,231	89,915	11,310
52	CARVER	705	1,642	1,338	2,344	13,494	1,884
72	DARTMOUTH	1	2	1	3	14	2
76	DIGHTON	1,626	5,133	2,949	7,329	34,626	4,722
83	EAST BRIDGEWATER	2,381	5,845	2,692	6,486	42,861	5,551
88	EASTON	3,540	8,782	4,863	11,543	59,181	7,671
95	FALL RIVER	1,577	3,043	1,286	2,820	25,028	3,342
99	FOXBOROUGH	2,508	5,107	3,207	5,816	37,288	4,792
102	FREETOWN	2,421	7,440	5,646	12,629	47,145	6,520
118	HALIFAX	1,156	4,032	2,698	6,855	30,413	4,402
123	HANSON	880	2,608	1,340	3,763	17,811	2,409
133	HOLBROOK	301	642	224	583	4,863	609
145	KINGSTON	259	487	533	738	3,362	451
146	LAKEVILLE	2,562	7,519	5,821	12,157	50,984	6,836
167	MANSFIELD	3,480	6,756	3,445	6,866	51,968	6,566
182	MIDDLEBOROUGH	4,746	13,980	9,399	21,863	99,943	14,090
201	NEW BEDFORD	167	301	108	230	2,353	294
208	NORFOLK	5	10	5	7	85	10
211	NORTH ATTLEBOROUGH	25	62	45	88	438	56
218	NORTON	3,096	7,754	5,309	11,412	50,603	6,675
231	PEMBROKE	182	355	271	398	3,130	414
238	PLAINVILLE	867	1,624	868	1,572	13,072	1,672
239	PLYMOUTH	125	182	109	116	1,743	218

Municipality		2060 Future Condition, Ecodeficit 8.5 Median					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
240	PLYMPTON	716	2,750	1,862	4,849	19,805	2,881
245	RAYNHAM	3,100	6,713	3,508	7,732	49,250	6,351
247	REHOBOTH	161	493	315	765	3,172	430
250	ROCHESTER	123	442	562	1,117	2,366	345
251	ROCKLAND	17	32	13	27	251	30
266	SHARON	954	2,215	1,807	3,365	14,532	1,896
273	SOMERSET	1,437	2,590	807	1,443	22,346	2,689
285	STOUGHTON	1,507	3,033	1,377	2,904	23,628	2,941
292	SWANSEA	224	607	240	621	4,593	585
293	TAUNTON	7,244	14,866	8,754	17,280	110,968	14,541
307	WALPOLE	11	20	6	12	168	20
322	WEST BRIDGEWATER	1,707	4,877	2,084	6,556	35,559	4,896
336	WEYMOUTH	15	54	25	110	251	36
338	WHITMAN	1,332	2,844	740	2,346	22,025	2,774
350	WRENTHAM	784	1,801	1,315	2,389	12,084	1,628
	Total	**66,727**	**156,984**	**89,113**	**196,401**	**1,147,202**	**151,795**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-7. Summary of annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load for the 2060 future condition and the Ecodeficit 8.5 Wet climate scenario by municipality in Taunton River watershed

Municipality		2060 Future Condition, Ecodeficit 8.5 Wet					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	1,579	3,649	1,422	2,900	27,024	3,400
16	ATTLEBORO	735	2,234	1,308	2,874	13,509	1,761
18	AVON	914	1,620	531	883	13,680	1,655
27	BERKLEY	1,489	5,105	3,398	6,538	31,701	4,374
42	BRIDGEWATER	3,582	9,855	5,160	10,363	70,447	9,557
44	BROCKTON	6,484	11,217	3,302	5,098	95,009	11,925
52	CARVER	705	1,845	1,495	2,298	14,529	2,036
72	DARTMOUTH	1	2	1	3	15	2
76	DIGHTON	1,626	5,840	3,297	7,193	37,291	5,127
83	EAST BRIDGEWATER	2,381	6,551	3,010	6,351	46,003	5,988
88	EASTON	3,540	9,903	5,458	11,319	63,306	8,256
95	FALL RIVER	1,577	3,369	1,434	2,767	26,530	3,548
99	FOXBOROUGH	2,508	5,675	3,576	5,713	39,641	5,106
102	FREETOWN	2,421	8,511	6,322	12,416	50,774	7,085
118	HALIFAX	1,156	4,639	3,036	6,718	33,163	4,841

Municipality		2060 Future Condition, Ecodeficit 8.5 Wet					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
123	HANSON	880	2,972	1,510	3,688	19,292	2,632
133	HOLBROOK	301	713	250	571	5,203	654
145	KINGSTON	259	540	594	727	3,549	476
146	LAKEVILLE	2,562	8,559	6,515	11,938	54,965	7,428
167	MANSFIELD	3,480	7,491	3,849	6,729	55,230	6,993
182	MIDDLEBOROUGH	4,746	15,936	10,544	21,452	108,057	15,358
201	NEW BEDFORD	167	331	121	225	2,490	311
208	NORFOLK	5	11	5	7	90	10
211	NORTH ATTLEBOROUGH	25	70	50	87	462	59
218	NORTON	3,096	8,770	5,953	11,202	54,310	7,216
231	PEMBROKE	182	392	302	390	3,351	444
238	PLAINVILLE	867	1,793	968	1,542	13,858	1,773
239	PLYMOUTH	125	196	121	113	1,838	229
240	PLYMPTON	716	3,175	2,095	4,754	21,656	3,180
245	RAYNHAM	3,100	7,506	3,930	7,576	52,619	6,815
247	REHOBOTH	161	563	354	751	3,434	470
250	ROCHESTER	123	515	632	1,100	2,577	379
251	ROCKLAND	17	35	14	27	267	32
266	SHARON	954	2,495	2,021	3,309	15,508	2,033
273	SOMERSET	1,437	2,822	893	1,407	23,542	2,829
285	STOUGHTON	1,507	3,362	1,535	2,847	25,145	3,138
292	SWANSEA	224	679	268	608	4,912	629
293	TAUNTON	7,244	16,572	9,793	16,943	118,229	15,538
307	WALPOLE	11	22	7	12	179	21
322	WEST BRIDGEWATER	1,707	5,550	2,353	6,417	38,585	5,355
336	WEYMOUTH	15	63	30	108	276	40
338	WHITMAN	1,332	3,156	831	2,291	23,575	2,976
350	WRENTHAM	784	2,018	1,465	2,348	12,931	1,749
	Total	**66,727**	**176,326**	**99,752**	**192,601**	**1,228,749**	**163,429**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-8. Summary of net increase between the 2060 Future Condition and 2016 Baseline Condition in annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load by municipality in Taunton River watershed

Municipality		2060 Future Condition - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	659	728	-205	-531	8,514	897

Municipality		2060 Future Condition - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
16	ATTLEBORO	380	469	-153	-321	4,866	507
18	AVON	311	365	-130	-238	3,956	436
27	BERKLEY	880	1,043	-329	-724	11,146	1,208
42	BRIDGEWATER	1,639	1,944	-611	-1,352	20,881	2,321
44	BROCKTON	1,697	1,968	-696	-1,289	21,439	2,480
52	CARVER	403	504	-205	-303	4,558	538
72	DARTMOUTH	1	1	0	-1	9	1
76	DIGHTON	908	1,083	-296	-800	11,968	1,205
83	EAST BRIDGEWATER	1,267	1,404	-391	-1,028	15,515	1,561
88	EASTON	1,693	2,118	-664	-1,476	21,848	2,309
95	FALL RIVER	414	460	-173	-290	5,077	598
99	FOXBOROUGH	1,150	1,429	-494	-948	14,485	1,637
102	FREETOWN	1,267	1,563	-544	-1,033	15,696	1,725
118	HALIFAX	509	639	-201	-444	6,496	691
123	HANSON	422	499	-136	-369	5,709	593
133	HOLBROOK	171	179	-54	-127	2,141	227
145	KINGSTON	174	227	-91	-138	2,002	261
146	LAKEVILLE	1,310	1,658	-520	-1,156	17,539	1,866
167	MANSFIELD	1,462	1,740	-639	-1,115	18,995	2,183
182	MIDDLEBOROUGH	2,503	3,007	-930	-2,107	34,949	4,070
201	NEW BEDFORD	64	75	-29	-47	793	94
208	NORFOLK	3	4	-1	-3	48	5
211	NORTH ATTLEBOROUGH	16	20	-7	-13	185	18
218	NORTON	1,619	1,996	-671	-1,344	20,470	2,293
231	PEMBROKE	84	110	-41	-71	1,018	115
238	PLAINVILLE	391	458	-175	-287	4,851	552
239	PLYMOUTH	24	30	-14	-16	334	41
240	PLYMPTON	394	478	-128	-356	5,785	631
245	RAYNHAM	1,504	1,781	-614	-1,183	19,223	2,164
247	REHOBOTH	99	119	-38	-82	1,145	111
250	ROCHESTER	65	81	-28	-54	854	104
251	ROCKLAND	6	7	-2	-5	75	8
266	SHARON	546	696	-259	-442	6,709	769
273	SOMERSET	452	520	-178	-346	5,865	626
285	STOUGHTON	736	829	-286	-550	9,446	1,034
292	SWANSEA	129	144	-36	-110	1,608	149
293	TAUNTON	2,957	3,568	-1,282	-2,316	38,158	4,481

Municipality		2060 Future Condition - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
307	WALPOLE	6	7	-2	-5	84	9
322	WEST BRIDGEWATER	668	728	-200	-535	8,487	884
336	WEYMOUTH	7	8	-3	-5	85	11
338	WHITMAN	461	458	-90	-374	5,852	565
350	WRENTHAM	403	495	-173	-326	4,905	569
	Total	**29,854**	**35,642**	**-11,720**	**-24,259**	**383,765**	**42,545**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-9. Summary of net increase between the 2060 Future Condition, Ecodeficit 8.5 Dry and 2016 Baseline Condition in annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load by the municipality in Taunton River watershed

Municipality		2060 Future Condition, Ecodeficit 8.5 Dry - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	659	467	-326	-175	6,404	534
16	ATTLEBORO	380	246	-311	45	3,702	298
18	AVON	311	300	-168	-140	3,065	275
27	BERKLEY	880	490	-679	129	8,075	667
42	BRIDGEWATER	1,639	1,060	-1,103	-54	14,626	1,211
44	BROCKTON	1,697	1,564	-869	-749	15,274	1,337
52	CARVER	403	345	-342	-17	3,255	300
72	DARTMOUTH	1	1	0	0	7	1
76	DIGHTON	908	437	-656	144	8,222	557
83	EAST BRIDGEWATER	1,267	826	-666	-230	11,479	871
88	EASTON	1,693	1,204	-1,251	-43	16,613	1,373
95	FALL RIVER	414	240	-317	56	3,000	214
99	FOXBOROUGH	1,150	1,016	-828	-229	11,527	1,092
102	FREETOWN	1,267	606	-1,285	599	10,795	836
118	HALIFAX	509	93	-557	414	2,931	62
123	HANSON	422	187	-318	101	3,844	267
133	HOLBROOK	171	127	-77	-56	1,717	154
145	KINGSTON	174	190	-146	-46	1,775	215
146	LAKEVILLE	1,310	737	-1,208	385	12,410	957
167	MANSFIELD	1,462	1,246	-997	-295	15,086	1,459
182	MIDDLEBOROUGH	2,503	1,308	-2,118	648	24,338	2,182
201	NEW BEDFORD	64	57	-38	-21	617	62
208	NORFOLK	3	4	-2	-2	42	4
211	NORTH ATTLEBOROUGH	16	13	-12	-1	146	12
218	NORTON	1,619	1,169	-1,316	78	16,026	1,478

Municipality		2060 Future Condition, Ecodeficit 8.5 Dry - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
231	PEMBROKE	84	84	-63	-23	743	66
238	PLAINVILLE	391	347	-260	-99	3,869	371
239	PLYMOUTH	24	25	-21	-4	231	20
240	PLYMPTON	394	89	-382	257	3,384	209
245	RAYNHAM	1,504	1,194	-1,003	-248	15,083	1,416
247	REHOBOTH	99	58	-79	15	818	52
250	ROCHESTER	65	15	-108	90	601	55
251	ROCKLAND	6	5	-3	-2	56	4
266	SHARON	546	473	-472	-18	5,491	541
273	SOMERSET	452	370	-207	-187	4,117	337
285	STOUGHTON	736	597	-426	-197	7,531	696
292	SWANSEA	129	80	-56	-33	1,132	73
293	TAUNTON	2,957	2,357	-2,231	-231	29,429	2,843
307	WALPOLE	6	6	-2	-4	70	6
322	WEST BRIDGEWATER	668	165	-498	276	4,705	220
336	WEYMOUTH	7	1	-9	8	60	6
338	WHITMAN	461	232	-164	-97	3,905	238
350	WRENTHAM	403	320	-315	-23	3,859	371
	Total	**29,854**	**20,349**	**-21,895**	**18**	**280,057**	**23,943**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-10. Summary of net increase between the 2060 Future Condition, Ecodeficit 8.5 Median and 2016 Baseline Condition in annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load by the municipality in Taunton River watershed

Municipality		2060 Future Condition, Ecodeficit 8.5 Median - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	659	567	-274	-281	7,165	644
16	ATTLEBORO	380	333	-255	-64	4,085	356
18	AVON	311	329	-150	-167	3,448	329
27	BERKLEY	880	694	-544	-132	8,964	806
42	BRIDGEWATER	1,639	1,397	-912	-443	16,645	1,522
44	BROCKTON	1,697	1,744	-776	-893	17,928	1,725
52	CARVER	403	405	-286	-103	3,645	361
72	DARTMOUTH	1	1	0	0	8	1
76	DIGHTON	908	677	-521	-145	9,348	732
83	EAST BRIDGEWATER	1,267	1,045	-557	-469	12,788	1,065
88	EASTON	1,693	1,555	-1,028	-472	18,396	1,640
95	FALL RIVER	414	329	-259	-47	3,795	336

Municipality		2060 Future Condition, Ecodeficit 8.5 Median - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
99	FOXBOROUGH	1,150	1,173	-687	-445	12,618	1,255
102	FREETOWN	1,267	965	-1,005	101	12,299	1,074
118	HALIFAX	509	302	-432	155	3,913	220
123	HANSON	422	307	-254	-40	4,405	353
133	HOLBROOK	171	147	-68	-77	1,866	175
145	KINGSTON	174	203	-121	-74	1,863	228
146	LAKEVILLE	1,310	1,079	-941	-83	13,941	1,191
167	MANSFIELD	1,462	1,445	-851	-535	16,608	1,682
182	MIDDLEBOROUGH	2,503	1,954	-1,678	-184	27,469	2,677
201	NEW BEDFORD	64	65	-34	-29	687	72
208	NORFOLK	3	4	-2	-2	44	4
211	NORTH ATTLEBOROUGH	16	15	-10	-5	159	14
218	NORTON	1,619	1,485	-1,067	-348	17,489	1,703
231	PEMBROKE	84	94	-53	-37	834	79
238	PLAINVILLE	391	391	-223	-154	4,253	427
239	PLYMOUTH	24	27	-17	-7	279	27
240	PLYMPTON	394	237	-293	71	4,018	311
245	RAYNHAM	1,504	1,426	-851	-524	16,541	1,634
247	REHOBOTH	99	81	-64	-14	915	67
250	ROCHESTER	65	40	-78	46	665	66
251	ROCKLAND	6	6	-3	-3	63	5
266	SHARON	546	557	-387	-146	5,911	604
273	SOMERSET	452	427	-186	-233	4,781	430
285	STOUGHTON	736	687	-368	-302	8,242	798
292	SWANSEA	129	103	-48	-56	1,277	94
293	TAUNTON	2,957	2,835	-1,851	-845	32,644	3,333
307	WALPOLE	6	6	-2	-4	75	7
322	WEST BRIDGEWATER	668	386	-400	34	5,843	397
336	WEYMOUTH	7	4	-8	5	68	7
338	WHITMAN	461	321	-135	-178	4,577	336
350	WRENTHAM	403	385	-256	-115	4,214	427
	Total	**29,854**	**26,233**	**-17,933**	**-7,245**	**314,774**	**29,216**

Units: MG – million gallons, lb – pounds, yr – year

Table 6-11.Summary of net increase between the 2060 Future Condition, Ecodeficit 8.5 Wet and 2016 Baseline Condition in annual average runoff volume, groundwater (GW) recharge, evapotranspiration (ET), total nitrogen (TN) load, and total phosphorus (TP) load by the municipality in Taunton River watershed

Municipality		2060 Future Condition, Ecodeficit 8.5 Wet - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
1	ABINGTON	659	923	-125	-343	8,829	858
16	ATTLEBORO	380	603	-109	-120	5,027	493
18	AVON	311	462	-96	-188	4,185	415
27	BERKLEY	880	1,306	-189	-253	11,255	1,156
42	BRIDGEWATER	1,639	2,483	-362	-661	21,487	2,225
44	BROCKTON	1,697	2,626	-451	-1,027	23,022	2,340
52	CARVER	403	607	-129	-148	4,680	514
72	DARTMOUTH	1	1	0	0	9	1
76	DIGHTON	908	1,384	-173	-281	12,013	1,136
83	EAST BRIDGEWATER	1,267	1,751	-239	-605	15,930	1,502
88	EASTON	1,693	2,676	-433	-696	22,521	2,225
95	FALL RIVER	414	655	-111	-100	5,297	542
99	FOXBOROUGH	1,150	1,740	-318	-548	14,971	1,569
102	FREETOWN	1,267	2,037	-330	-112	15,928	1,639
118	HALIFAX	509	910	-94	18	6,663	658
123	HANSON	422	671	-84	-116	5,886	576
133	HOLBROOK	171	219	-42	-89	2,206	220
145	KINGSTON	174	255	-60	-84	2,050	253
146	LAKEVILLE	1,310	2,120	-247	-302	17,921	1,784
167	MANSFIELD	1,462	2,180	-446	-672	19,870	2,110
182	MIDDLEBOROUGH	2,503	3,910	-533	-595	35,583	3,945
201	NEW BEDFORD	64	95	-21	-34	824	89
208	NORFOLK	3	5	-1	-3	49	5
211	NORTH ATTLEBOROUGH	16	23	-5	-6	184	17
218	NORTON	1,619	2,501	-423	-557	21,197	2,244
231	PEMBROKE	84	131	-23	-45	1,054	110
238	PLAINVILLE	391	560	-123	-184	5,038	528
239	PLYMOUTH	24	41	-5	-9	373	38
240	PLYMPTON	394	662	-60	-23	5,869	610
245	RAYNHAM	1,504	2,219	-430	-680	19,909	2,098
247	REHOBOTH	99	151	-26	-29	1,177	107
250	ROCHESTER	65	113	-7	29	876	101
251	ROCKLAND	6	9	-1	-3	79	7
266	SHARON	546	838	-174	-202	6,887	741

Municipality		2060 Future Condition, Ecodeficit 8.5 Wet - 2016 Baseline Condition					
ID	Name	IC (acre)	Runoff (MG/yr)	GW (MG/yr)	ET (MG/yr)	TN (lb/yr)	TP (lb/yr)
273	SOMERSET	452	659	-101	-270	5,977	570
285	STOUGHTON	736	1,016	-209	-359	9,759	996
292	SWANSEA	129	176	-20	-69	1,596	138
293	TAUNTON	2,957	4,541	-811	-1,182	39,905	4,330
307	WALPOLE	6	8	-1	-4	86	8
322	WEST BRIDGEWATER	668	1,059	-130	-105	8,868	856
336	WEYMOUTH	7	13	-4	2	92	11
338	WHITMAN	461	634	-44	-232	6,126	537
350	WRENTHAM	403	602	-107	-156	5,061	549
	Total	**29,854**	**45,576**	**-7,295**	**-11,046**	**396,321**	**40,850**

Units: MG – million gallons, lb – pounds, yr – year

7. REFERENCES

NELF, n.d. New England Landscape Futures Project [WWW Document]. URL https://newenglandlandscapes.org/story/ (accessed 12.31.21).

Paradigm Environmental and Great Lakes Environmental Center, 2021. Holistic Watershed Management For Existing And Future Land Use Development Activities: Opportunities For Action For Local Decision Makers: Phase 1 – Modeling And Development Of Flow Duration Curves (FDC 1 Project).

Thompson, J.R., Plisinski, J.S., Lambert, K.F., Duveneck, M.J., Morreale, L., McBride, M., MacLean, M.G., Weiss, M., Lee, L., 2020. Spatial Simulation of Codesigned Land Cover Change Scenarios in New England: Alternative Futures and Their Consequences for Conservation Priorities. Earth's Futur. 8, 23. https://doi.org/10.1029/2019EF001348

Thompson, J.R., Plisinski, J.S., Olofsson, P., Holden, C.E., Duveneck, M.J., 2017. Forest loss in New England: A projection of recent trends. PLoS One 12. https://doi.org/10.1371/journal.pone.0189636