235 Promenade Street, Suite 310
Providence, RI 02908
401-633-0550
info@nbep.org
www.nbep.org

State of Narragansett Bay and Its Watershed
Technical Report
Errata

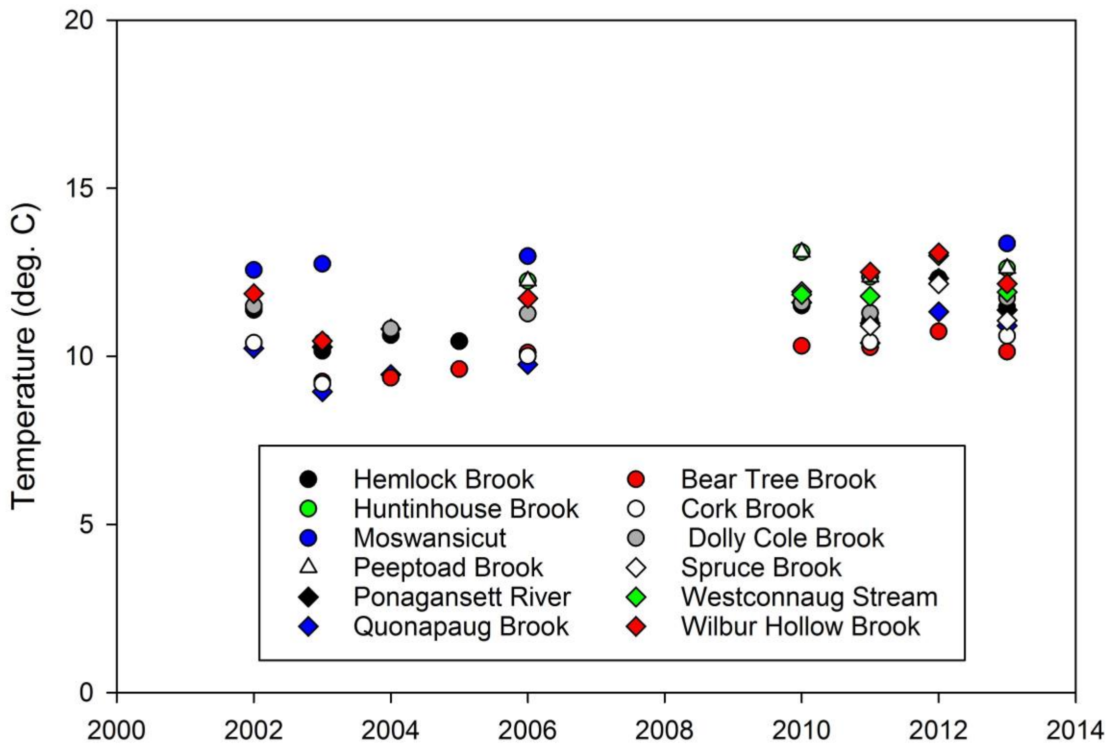
After the publication of the *State of the Bay and Its Watershed*, errors were noted in some chapters. The errors are organized by chapter below.

The errors (in bold red text) are detailed in order of appearance in the chapter. All tables and graphs in this errata are corrected. They will not be in bold red text.

Chapter 1: Temperature
Revised 18 January 2018

Page 55:

Figure 5. The sample site name "Willow Hollow Brook" should read "Wilbur Hollow Brook". The amended figure is below.



Chapter 9: Legacy Contaminants
Revised 18 January 2018

Page 200:

Figure 5 is correct, however the caption contains one error. Figure 5 caption should read:
Figure 5. (A) Total surface sediment mercury (Hg) concentrations in parts per million (ppm) dry weight. Note that the ERM = 0.71 ppm and the ERL = 0.15 ppm, so most of the Bay was highly to moderately contaminated with mercury. (b) The surface sediment concentration of methylmercury **(MeHg) in parts per billion (ppb)** dry weight. (C) The percent of total mercury that was methylmercury. Areas with the dark shades (high percent) were areas of particular concern. Source: Taylor et al. 2012.

Chapter 8: Nutrient Loading
Revised 18 January 2018

There were some arithmetic errors that led to required changes to the nitrogen and phosphorus budgets. While the errors do change specific loading values and relative percentages, the general trends reported in the document remain the same.

Page 168:

Overview
Trends: Over the last fifteen years, management policies and significant investments in wastewater facilities have reduced the amount of nitrogen and phosphorus loadings to the Watershed. A comparison of nutrient budgets from 2000–2004 and 2013–2015 revealed a 55 percent decrease in wastewater treatment facility loadings throughout the Watershed in total nitrogen and a **42** percent decrease in total phosphorus. This same comparison showed a 62 percent decline in total nitrogen and a 78 percent decline in total phosphorus loadings from the rivers. Over the last 30 years, since 1982–1983, total nitrogen and phosphorus loadings to the Watershed have decreased **46** percent and 57 percent, respectively.

Page 172:

Status and Trends
Wastewater Treatment Facility Loading
Status and Trends of Nitrogen Loading
The current status of nitrogen loading was calculated for 37 wastewater treatment facilities (WWTFs) in the Narragansett Bay Watershed that discharged **5,569** thousand pounds per year based upon the 2013 to 2015 nutrient budget. The fifteen WWTFs discharging in the Coastal Narragansett Bay Basin accounted for 58 percent of the total nitrogen loading in the Watershed (Table 3; Figure 1). Of these fifteen facilities, twelve discharge directly to Narragansett Bay, which includes the Providence and Seekonk Rivers along with Mount Hope Bay and Greenwich Bay (53 percent of total loadings), and the remaining discharge to the Ten Mile and Woonasquatucket Rivers. The nine facilities discharging in the Taunton River Basin have the second largest nitrogen loading with nineteen percent of the total loading. The Blackstone River Basin has the third largest nitrogen loading with ten facilities contributing fourteen percent. The Pawtuxet River Basin only has three WWTFs and has eleven percent of the total loading.

Page 177:

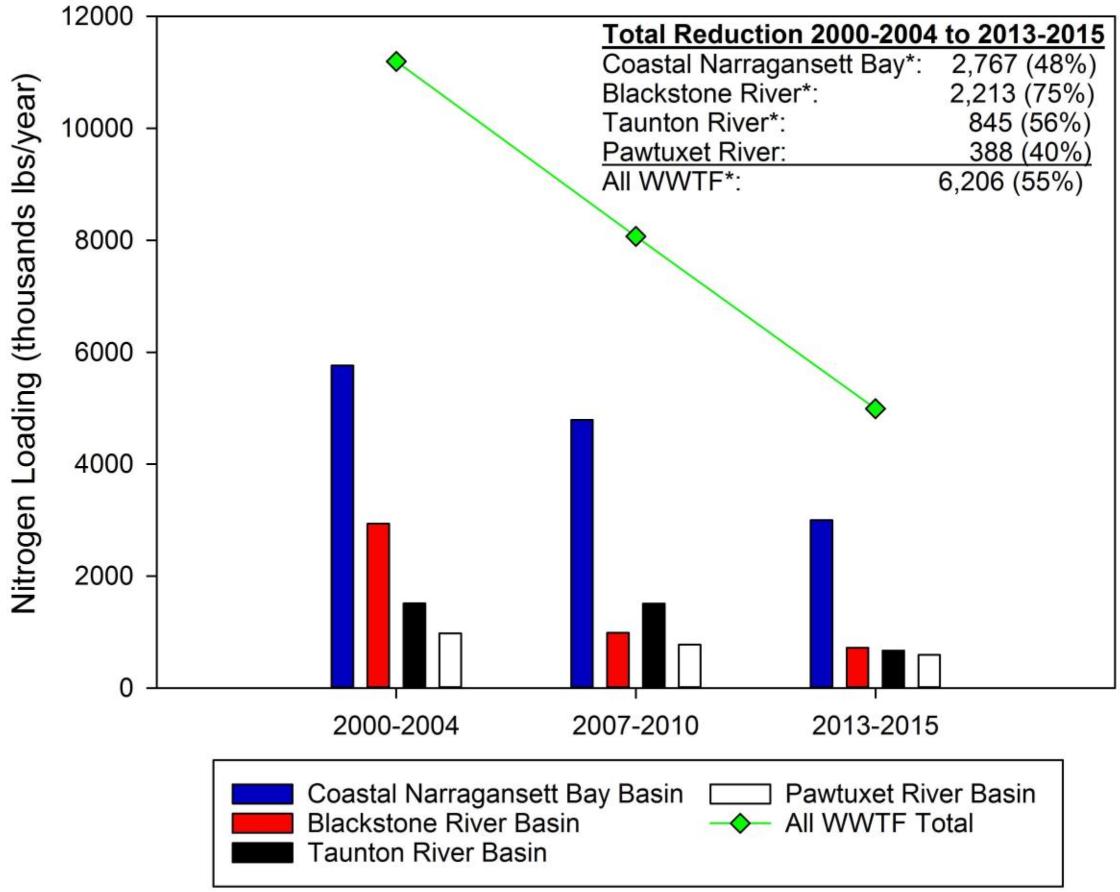


Figure 2. Comparison of WWTF nitrogen loading budgets, including only those WWTFs assessed by Nixon and colleagues (2008) and Krumholz (2012) (Table 4). "All WWTF Total" is the total of all WWTF loadings discharged to the Watershed. Asterisks (*) indicate Basins for which loadings were calculated using population estimation. Monitoring and estimation data were combined to create Watershed-wide loadings. Reduction units are in thousands ($x10^3$) of pounds per year.

Page 178:

Table 5. WWTFs with more than 50 percent reduction in nitrogen loading from the 2000–2004 budget (Nixon et al. 2008) to the 2013–2015 budget. Facilities for which Nixon and colleagues (2008) used population estimates and the Estuary Program used Discharge Monitoring Report data were not included. Sorted from largest to smallest decrease in pounds per year.

WWTF	**Change in Nitrogen Loading (1,000 lbs/year) 2000–2004 to 2013–2015**	**Percent Reduction 2000–2004 to 2013–2015**
Upper Blackstone (Worcester)	*-1,659*	*80%*
Field's Point	-1,266	64%
Bucklin Point	-810	70%
Woonsocket	-447	78%
Cranston	-341	59%
East Providence	-178	59%

Attleboro	*-157*	*60%*
Smithfield	-82	61%

Page 180:

Table 7. WWTF phosphorus loading from 2000–2004, 2007–2010, and 2013–2015. Dashes (-) indicate data not available or not reported. Italics indicate WWTFs located in Massachusetts. River Basin names are shaded. Loadings with an asterisk (*) were calculated using population estimates.

	WWTF Total Phosphorus Loading (x10^3 lbs/year)		
Discharge Basin	**Nixon et al. (2008)(3)**	**Krumholz (2012)(3)**	**This Study**
Receiving Waters			
Name of WWTF	**2000–2004**	**2007–2010**	**2013–2015**
Coastal Narragansett Bay Basin(1)	**598**	**622**	**530**
Narragansett Bay	**551**	**618**	**526**
Field's Point	160	211	171
Bucklin Point	148	207	137
Fall River	*79**	*76**	*96**
Newport	32*	39*	45*
East Providence	51	34	26
Bristol	12	12	22*
Quonset Point	5*	7	11*
Warren	7	3	9*
East Greenwich	38	28	7*
Jamestown	19*	1	2*
Ten Mile River	**26**	**3**	**3**
North Attleborough	*15*	*2*	*2*
Attleboro	*11*	*1*	*1*
Woonasquatucket River	**21**	**1**	**1**
Smithfield	21	1	1
Taunton River Basin	**85**	**85**	**77**
Taunton River			
Taunton	*19**	*19**	*57*
Somerset	*11**	*11**	*14**
Brockton	*55**	*55**	*6*
Blackstone River Basin	**328**	**147**	**57**
Blackstone River			
Woonsocket	143	37	25
Upper Blackstone (Worcester)	*149*	*71*	*19*

Hopedale	*1**	*1**	*6**
Grafton	*8**	*9**	*4*
Northbridge	*9**	*11**	*1*
Burrillville	2	1	1
Douglas	*1**	*1**	*0.5*
Millbury[(2)]	*15**	*16**	-
Upton	*0**	*0**	*0.1*
Pawtuxet River Basin	**212**	**72**	**41**
Pawtuxet River			
Cranston	86	28	23
West Warwick	90	30	11
Warwick	36	14	7
Total (28 WWTFs)	**1,223**	**926**	**705**

[(1)] The Coastal Narragansett Bay Basin includes both the Bay and some tributary rivers. The WWTFs that discharge directly to the Bay are listed under the heading "Narragansett Bay" as the receiving waters.
[(2)] This facility was decommissioned in 2005 and connected to Worcester's Upper Blackstone facility.
[(3)] For some of the population estimates from these authors, actual data may exist. However, the Estuary Program chose to report the authors' data as they published them.

Page 181:

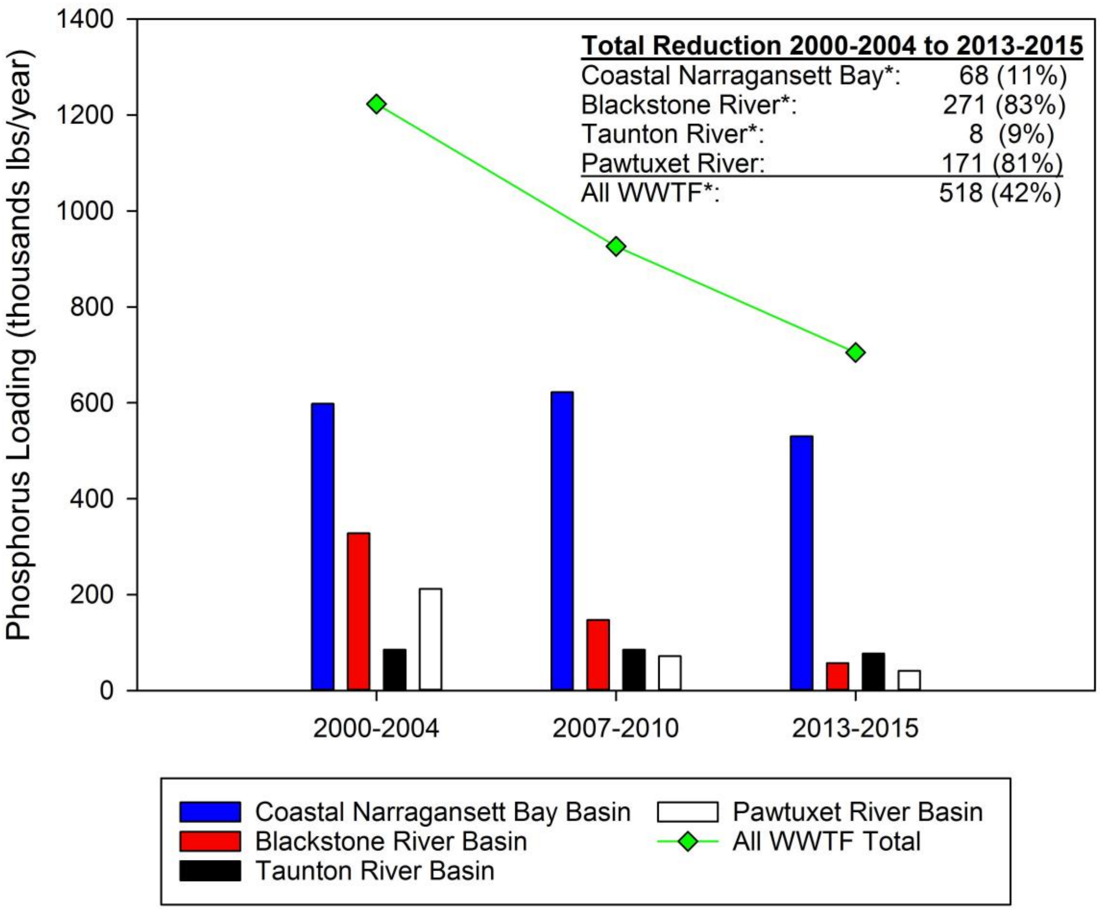


Figure 3. Comparison of WWTF phosphorus loading budgets, including only those WWTFs assessed by Nixon and colleagues (2008) and Krumholz (2012) (Table 7). "All WWTF Total" is the total of all WWTF loadings discharged to the Watershed. Asterisks (*) indicate Basins for which loadings were calculated using population estimation. Monitoring and estimation data were combined to create Watershed-wide loading. Reduction units are in thousands ($x10^3$) of pounds per year.

Page 182:

Discussion

Wastewater Treatment Facility Loading

Since 2000–2004, wastewater treatment facility loading has decreased 55 percent in nitrogen and **42** percent in phosphorus across the Watershed (Tables 4 and 7; Figures 2 and 3). The majority of the decrease in nitrogen loading was due to compliance with the goal of reducing loading from eleven Rhode Island WWTFs by 50 percent of 1995/1996 loading levels (RIDEM 2005). Six of those WWTFs are listed in Table 5 as having greater than 50 percent reductions in the last fifteen years. Additionally, Massachusetts has made similar reductions at WWTFs along the Blackstone and Ten Mile Rivers, and since 2000 those WWTFs have also contributed to the large decline in nitrogen loading (Table 5). Phosphorus has a significant impact on freshwater ecosystems, and the majority of load reductions have been focused in facilities discharging to freshwater. The majority of phosphorus declines were realized on the Blackstone (83 percent) and Pawtuxet Rivers (81 percent) (Table 7; Figure 3).

Table 8. River nitrogen budget comparison. Dashes (-) indicate data not available or not reported.

Discharge Basin Rivers	**Total Nitrogen (x10^3 lbs/year)** **Nixon et al. (1995) 1982–1983**	**Nixon et al. (2008) 2000–2004**	**Krumholz (2012) 2007–2010**	**Estuary Program 2013–2015**
Coastal Narragansett Bay Basin	**2,680**	**1,308**	**2,775**	**876**
Ten Mile River	-	434	443	313
Woonasquatucket River	308	265	176	110
Moshassuck River	154	147	83	50
Unmeasured Rivers[(1)]	2,218	462	2,073	403
Blackstone River Basin	**4,035**	**3,038**	**2,610**	**1,536**
Blackstone River	4,035	3,038	2,610	1,536
Taunton River Basin	**3,604**	**4,220**	**1,161**	**1,925**
Taunton River[(2)]	3,604[(3)]	4,220[(3)]	1,161[(4)]	1,925
Pawtuxet River Basin	**1,971**	**1,826**	**1,133**	**756**
Pawtuxet River	1,971	1,826	1,133	756
Total River Nitrogen Loading	**12,290**	**10,392**	**7,679**	**5,093**

[(1)] The Unmeasured Rivers loading value for 2013–2015 was calculated following the method of Nixon et al. 2008. Krumholz (2012) followed the method of Nixon et al. (1995), which used larger nitrogen yields (for full discussion, see Nixon et al. 2008). See text.
[(2)] The Taunton River loading value for 2013–2015 was calculated following the method of Nixon et al. (2008). Krumholz (2012) reduced the drainage area of the Taunton River based on the locations of the USGS Taunton River gage at Bridgewater and the location of the NBC nutrient monitoring station (see Table 1), reducing the overall loading. He added the ungaged drainage area into the "unmeasured rivers" element of the budget (Krumholz 2012).
[(3)] The increase between 1982–1983 and 2000–2004 is based solely on a land-use model, and it is believed that actual loadings from the Taunton River decreased during this time, based on the 20 to 25 percent decreases observed in the other rivers (Nixon et al. 2008).
[(4)] Krumholz (2012) did not calculate his Taunton River loading in the same manner as previous or the current budgets. The Estuary Program estimated the Taunton River loading from Krumholz (2012) as if he had used the same method as the previous budgets, which would be 2,508x10^3 pounds per year. See text.

Page 183:

Discussion
Wastewater Treatment Facility Loading **(continued; last paragraph on page)**
The wastewater treatment facility loadings were calculated two ways throughout the years: by population estimation and by monitoring data. Loadings that were calculated by population estimates were noted in the tables (3, 4, 6, and 7) and removed from the analysis presented in Table 5. However, those data were not removed from the trends analysis presented above or from the Watershed-wide total nutrient budget. Removing those facilities from the Watershed-wide trends analysis showed a 45 percent decrease in nitrogen loading and a **49** percent decrease in phosphorus loading. These loading reductions are still quite significant over the last fifteen years.

Page 184:

Table 10. Nitrogen budget comparison with previous budgets. Components with an asterisk (*) were carried over to the 2013–2015 budget from the 2007–2010 budget. Dashes (-) indicate data not available or not reported.

Source	Annual Total Nitrogen Loading ($x10^3$ lbs/year)			
	Nixon et al. 1995 1982–1983[1]	**Nixon et al. 2008 2000–2004[2]**	**Krumholz 2012 2007–2010[3]**	**Estuary Program 2013–2015[4]**
	Direct Discharge to the Bay			
Atmospheric Deposition*	924	924	924	924
WWTF Discharge[5]	5,636	5,253	4,420	2,777
Urban Run-Off *	1,140	1,140	1,910	1,910
Groundwater Discharge*	-	-	123	123
Rivers[5]	12,290	10,390	7,679	5,093
Total	**19,990**	**17,707**	**15,056**	**10,827**

[1] 1982–1983 budget numbers from Tables 16 and 19 in Nixon et al. (1995).
[2] 2000–2004 budget numbers from Table 5.15 in Nixon et al. (2008).
[3] 2007–2010 budget numbers from Table 3-1 in Krumholz (2012).
[4] 2013–2015 budget numbers from Tables 4, 7, 8, and 9.
[5] The term "WWTF Discharge" only includes WWTFs that discharge directly to the Bay. WWTFs discharging to rivers are included in the Rivers term along with other sources to rivers (run-off, groundwater, atmospheric deposition).

Page 185:

Discussion

Riverine Loading

(first paragraph)

River loading for both nitrogen and phosphorus declined across the Watershed. For nitrogen, loadings declined **56** percent since 1982–1983, and for phosphorus, loadings declined 85 percent since 1982–1983. These large declines may be due to a combination of factors: (1) changes in how the unmeasured rivers and Taunton River elements were calculated, (2) reductions in base flow at the USGS river gages, and/or (3) load reductions from the WWTFs that discharge to the rivers.

(sixth paragraph)

From 2000–2004 to 2013–2015, total nitrogen river loading decreased by **51** percent and total phosphorus decreased by 78 percent. Wastewater treatment facility load reductions should account for the majority of the observed decreases. On a Watershed-wide scale, loading from WWTFs discharging to rivers decreased by **63** percent for nitrogen and **73** percent for phosphorus since 2000–2004 (Tables 4 and 7). With the loadings from population estimates removed, nitrogen decreased by **50** percent and phosphorus by **71** percent, which more than accounts for the reductions noted in the river loadings.

(seventh paragraph)

The Estuary Program's analysis provided an interesting insight into variations in loadings from nonpoint sources. Loading from the Moshassuck River declined **66** percent in nitrogen and approximately **89** percent in phosphorus since 2000–2004. No treatment facilities discharge to the Moshassuck River, so those point-source load reductions were not a factor in the load declines observed for this river. In addition, the average river flow at the USGS gage was similar for 2000–2004 and 2013–2015: 23.2 MGD and 21.1 MGD, respectively, for a difference of nine percent. Therefore, some other factors were influencing nutrient loading reductions in the Moshassuck River. These factors could include best management practices (BMPs) designed to decrease nutrient loading to the rivers, or a reduction of loading from sources discharging to the river. More research is needed to understand this phenomenon, although it is difficult to quantify these nonpoint source loadings. However, it is important to recognize that for rivers with WWTFs, in addition to improvements to the facilities, other factors are also contributing to the estimated temporal trend of declining nutrient loadings.

Page 186:

Discussion
Nutrient Budgets
(first paragraph)

Analysis of nutrient budgets for the Narragansett Bay Watershed spanning from 1982–1983 to 2013–2015 revealed a general trend of declining nutrient loading—**46** percent for total nitrogen and 57 percent for total phosphorus (Tables 10 and 11). As mentioned previously, the atmospheric deposition, urban runoff, and groundwater components only apply to deposition directly on Narragansett Bay, including the Providence and Seekonk River as well as Greenwich Bay and Mount Hope Bay. Atmospheric deposition has been held steady throughout all budgets due to a lack of new data. Given changes in air pollution standards, it is expected that atmospheric deposition of NO_x has decreased, but without updated data, the term was not changed in these studies. Also, although urban runoff was recalculated after the two budgets by Nixon and colleagues (1995, 2008), it was held steady to the Krumholz budget in the most recent calculations. This assumption therefore does not reflect changes in urban runoff due to changing precipitation patterns, recent land use change, and stormwater infrastructure improvements (see "Precipitation" and "Land Use" chapters).

Table 12. Wastewater discharge directly to the Bay with population-estimated data removed. All units are thousand pounds per year.

	Nixon et al. 1995 1982–1983[1]	**Nixon et al. 2008 2000–2004**	**Krumholz 2012 2007–2010**	**Estuary Program 2013–2015**
		Nitrogen		
WWTF Discharge	5,636	4,853	3,074	2,777
		Phosphorus		
WWTF Discharge	924	416	506	334

[1] The 1982–1983 budget cannot be altered because Nixon and colleagues (1995) did not indicate if they used population estimates for any data.

Chapter 21: Open Space
Revised 30 August 2019

There were twelve numeric errors in Table 6, reporting incorrect acres and percent of unprotected and protected ecologically significant lands in the Assonet River, Annaquatucket River, and Jamestown WPAs. These are updated in bold red text in the table below. The ratios associated with those three WPAs were correct, thus the results reported in the chapter remain unchanged.

Page 406:

Table 6.

River Basin(2)	WPA(2)(3)	Ratio Unprotected to Protected	Unprotected		Protected	
			Acres	Percent	Acres	Percent
	Ratio greater than 5:1					
Taunton River	Mount Hope Bay	20.8	1,958	15.3	94	0.7
Taunton River	Segreganset River	18.1	5,745	61.1	318	3.4
Coastal Narragansett Bay	Barrington - Palmer - Warren Rivers	9.1	14,471	33.4	1,597	3.7
Coastal Narragansett Bay	Bristol - Kickemuit River	8.7	4,869	19.4	560	2.2
Taunton River	Winnetuxet River-Taunton River	6.9	9,925	31.4	1,428	4.5
Coastal Narragansett Bay	Woonasquatucket River	6.6	3,112	9.5	474	1.4
Taunton River	Taunton River	6.3	839	9.9	133	1.6
	Ratio greater than 2:1					
Blackstone River	Quinsigamond River	4.8	550	2.3	115	0.5
Blackstone River	Lower Blackstone River	4.2	9,531	14.2	2,281	3.4
Coastal Narragansett Bay	Hunt River	3.7	2,062	13.2	557	3.6
Blackstone River	Kettle Brook	3.1	2,487	11.9	809	3.9
Taunton River	Nemasket River	3.0	3,271	24.4	1,075	8.0
Blackstone River	Branch River	2.9	20,236	33.9	6,866	11.5
Blackstone River	Mill River - Blackstone River	2.7	4,007	18.4	1,508	6.9
Pawtuxet River	Scituate Reservoir-Pawtuxet	2.6	19,795	33.0	7,605	12.7

River Basin[2]	WPA[2][3]	Ratio Unprotected to Protected	Unprotected		Protected	
			Acres	Percent	Acres	Percent
Blackstone River	Mumford River	2.6	10,363	28.8	3,992	11.1
Taunton River	Cotley River-Taunton River	2.6	4,017	10.4	1,571	4.1
Blackstone River	West River	2.5	8,564	36.1	3,418	14.4
Taunton River	Threemile River	2.5	3,864	14.5	1,565	5.9
Blackstone River	Singletary Brook-Blackstone River	2.4	1,793	7.0	744	2.9
Coastal Narragansett Bay	Ten Mile River	2.2	1,755	4.9	781	2.2
Taunton River	Assawompsett Pond	2.1	9,933	31.6	4,660	14.8
Taunton River	Matfield River	2.1	976	3.6	472	1.8
	Ratio less than 2:1					
Pawtuxet River	Pawtuxet River	1.6	13,212	15.0	8,209	9.3
Taunton River	Wading River	1.5	4,295	15.4	2,783	10.0
Coastal Narragansett Bay	Sakonnet - East	1.4	2,494	14.1	1,838	10.4
Coastal Narragansett Bay	Narrow River	1.2	1,103	12.9	890	10.4
Taunton River	Satucket River	1.2	1,833	8.2	1,521	6.8
	Ratio 1:1					
Taunton River	Assonet River	1.0	**6426**	**29.5**	**6562**	**30.1**
Coastal Narragansett Bay	Annaquatucket River	1.0	**131**	**2.8**	**131**	**2.8**
Coastal Narragansett Bay	Jamestown	1.0	**882**	**14.6**	**856**	**14.2**

Chapter 4: Population
Revised 26 September 2019

There was one numeric error in Table 9, reporting incorrect developed acres per 100 people in the Woonasquatucket River-Moshassuck River HUC10. This is updated in bold red text in the table below.

Page 101:

Table 9. Developed land per capita in 1990, 2000, and 2010 in the HUC10 watersheds of the Narragansett Bay Watershed. Sorted from highest to lowest values of developed land per capita in 2010.

Watershed (HUC10) Name[1]	**Developed Acres per 100 people**		
	1990	**2000**	**2010**
Middle Taunton River	34	38	39
Palmer River	31	35	38
Threemile River	30	32	33
Lower Blackstone River	21	24	26
Lower Taunton River-Frontal Mount Hope Bay	17	19	21
Pawtuxet River	18	19	21
Narragansett Bay	18	19	20
Upper Taunton River	17	19	19
Upper Blackstone River	16	18	19
Ten Mile River	17	18	18
Woonasquatucket River-Moshassuck River	**12**	11	12
Total Narragansett Bay Watershed	**18**	**20**	**21**

(1) See Appendix A for HUC10 code numbers and map.