Benthic TMDL Development for the James River Tributaries Watersheds

Third Technical Advisory Committee Meeting

May 9, 2022

1. Summary of Prior Work

In order to identify the most probable stressors in the James River tributaries watersheds (Bailey Creek, Nuttree Branch, Oldtown Creek, Proctors Creek, Rohoic Creek, and Swift Creek), DEQ used a formal causal analysis approach developed by EPA, known as CADDIS (Causal Analysis Diagnosis Decision Information System). CADDIS results indicate that sediment is the most probable stressor in all watersheds, and Phosphorus is a probable stressor in Oldtown Creek, Rohoic Creek, and Swift Creek. As such, sediment and phosphorus (where applicable) will be a target of the TMDL for each impaired segment.

The computer model selected to develop sediment and phosphorus TMDLs in the James River Tributaries watersheds is the Generalized Watershed Loading Functions (GWLF) model. GWLF is widely used throughout Virginia in developing sediment TMDLs. It is a continuous simulation model operating on a daily timestep for water balance calculations to generate monthly sediment yields for the watershed. The model allows for multiple land cover categories to be incorporated, but spatially it is lumped, meaning that it does not account for the spatial distribution of sources and has no method of spatially routing sources within the watershed. The TMDL study area was divided up into subwatersheds to obtain a more granular assessment of the pollutant loads throughout the watershed. Locations of monitoring stations, junctions of streams, subwatershed size, and broad differences in land cover all guided subwatershed divisions.

2. TMDL Load Inputs

Permitted Sources

There are a variety of permitted sources in the study watersheds, including: VPDES individual permits, VPDES industrial stormwater permits, VPDES concrete permits, domestic sewer permits, MS4 permits, construction general permits, and a vehicle wash permit. **Table 1** through **Table 7** summarizes the different permit types and their allocated loads when applicable.

Table 1. Summary of VPDES Individual Permits in the study area.

Permit No	Receiving Stream	Permitted Discharge (MGD)	Permitted Load (lb/yr TSS)	Permitted Load (lb/yr TP)
VA0006254	Swift Creek	0.5	91,382	10
VA0023426	Swift Creek	0.065	8,910	46

Table 2. Summary of VPDES Industrial Stormwater Permits in study area.

Permit No	Receiving Stream	Allocated Load (lb/yr TSS)	Allocated Load (lb/yr TP)
VAR050594	Bailey Creek	41,743	124.4
VAR050614	Bailey Creek	1,320	4.5
VAR050619	Rohoic Creek	105,160	358.5
VAR051218	Rohoic Creek	3,409	11.6
VAR052059	Rohoic Creek	1,980	6.8
VAR050672	Rohoic Creek	515	1.8
VAR051893	Rohoic Creek	4,532	15.5
VAR050549	Proctors Creek	9,636	32.9
VAR050625	Proctors Creek	8,800	30.0
VAR051023	Proctors Creek	31,108	106.1
VAR051168	Proctors Creek	6,459	22.0
VAR052263	Proctors Creek	1,012	3.5
VAR052314	Proctors Creek	1,320	4.5
VAR050583	Nuttree Branch	6,600	22.5
VAR050666	Nuttree Branch	2,288	7.8
VAR051683	Swift Creek	1,320	4.5
VAR051684	Swift Creek	99,440	339.0
VAR052351	Swift Creek	968	3.3
VAR052185	Proctors Creek	6,424	21.9

Table 3. Summary of VPDES Concrete Permits in study area.

Permit No	Receiving Stream	Load Type	Allocated Load (lb/yr TSS)	Allocated Load (lb/yr TP)
VAG110231	Bailey Creek	Stormwater	1944.8	6.6
VAG110158	Rohoic Creek	Stormwater	1166.0	4.0
VAG110171	Rohoic Creek	Stormwater	1592.8	5.4
		Process Water	5482.9	64.9
VAG110159	Nuttree Branch	Stormwater	325.6	1.1
VAG110157	Proctors Creek	Stormwater	1188.0	4.1

Table 4. Summary of Domestic Sewer Permits in study area.

Permit No	Receiving Stream	Allocated Load (lb/yr TSS)	Allocated Load (lb/yr P)
VAG404286	Swift Creek	91.44	4.30
VAG404275	Swift Creek	91.44	4.30
VAG404357	Swift Creek	91.44	4.30

Table 5. Summary of MS4 Permits in study area.

Permit No	Permitted Entity
VAR040013	City of Petersburg
VAR040009	City of Colonial Heights
VAR040015	City of Hopewell
VA0088609	Chesterfield County
VAR040006	Central State Hospital
VAR040007	Fort Lee
VA0092975	VDOT
VAR040110	John Tyler Community College

While a permitted entity, MS4's are considered a nonpoint source. To assign a load to each MS4, the permit's area and underlying land cover is extracted and the modelled pollutant annual loading rates for each land cover type are used to assign an overall annual loading rate for the MS4's permitted area within each watershed. The MS4 area within each watershed is then removed from general nonpoint source loading calculations to avoid double counting. MS4 loading is detailed for each watershed in **Section 5.**

Table 6. Summary of disturbed area in each watershed from Construction General Permits.

Receiving Stream	Estimated Potential Disturbed Area (ac)
Bailey Creek	16.7
Nuttree Branch	64.4
Oldtown Creek	40.2
Proctors Creek	297.8
Rohoic Creek	64.9
Swift Creek	652.9

All active CGP's within the study watersheds were assessed, and the associated annual disturbed area was calculated. This active annual disturbance is assumed to be representative of typical construction related disturbance on a yearly basis and was used to assign an annual load for all CGP's in each watershed. Additionally, the calculation assumed that erosion and sediment control measures were able to capture 85% of all sediment (and associated phosphorous) leaving the site.

Table 7. Summary of Vehicle Wash Permit in study area.

Permit No	Permitted Discharge (MGD)	Permitted Load (lb/ yr TSS)	Permitted Load (lb/ yr TP)
VAG750205	0.0003	54.8	0.7

Questions:
Do any TAC members have additional input on permitted sources we may have missed?

Does the amount of disturbed area from CGP's seem reasonable, does an 85% removal efficiency seem accurate?

Existing BMPs

To ensure credit is given for prior work completed in the watershed, data on BMPs within the watershed tracked by the Department of Conservation and Recreation has been compiled (**Table 8**) and associated reductions to sediment loading will be subtracted from the existing loads prior to allocation scenario development. BMP reductions were based on Chesapeake Bay TMDL Model guidance documents and appropriate changes in land cover within the model.

Table 8. DCR BMP data within the James River Tributaries watersheds.

Practice Code	Practice	Watershed	Reduction (lb/yr TSS)	Reduction (lb/yr TP)
SL-6	Stream Exclusion With Grazing Land Management	Swift	5,966	26.9
SL-9	Grazing Land Management	Swift	3,757	23.2
FR-1	Afforestation of Crop, Hay and Pasture Land	Swift	716	3.4

Questions:
Do any TAC members know of BMP's we don't have listed?

3. Margin of Safety and Future Growth

To account for uncertainties inherent in model outputs, a margin of safety (MOS) is incorporated into the TMDL development process. The MOS can be implicit, explicit, or a combination of the two. An implicit MOS involves incorporating conservative assumptions into the modeling process to ensure that the final TMDL is protective of water quality in light of the unavoidable uncertainty in the modeling process. A MOS can also be incorporated explicitly into the TMDL development by setting aside a portion of the TMDL.

This TMDL includes both implicit and explicit MOSs. An example of implicit MOS assumptions incorporated into this TMDL are the inclusion of permitted loads at their maximum permitted rates, even when data shows that they are consistently discharging well below that threshold. An explicit MOS of 10% is also included in the TMDLs.

An allocation of 2% of the total load is specifically set aside for future growth within the watersheds. This leaves flexibility in the plan for future permitted loads to be added within the watersheds, as the development of a TMDL looks at a snapshot in time of a dynamic system within the watershed and is not meant to prevent future economic growth.

Questions:
Do the margin of safety and future growth allocations seem appropriate for this watershed?

4. TMDL Pollutant Reduction Targets

TMDL development requires an endpoint or water quality goal to target for the impaired watershed(s). Many pollutants have numeric water quality criteria set in regulatory documentation, and it is assumed that compliance with these numeric criteria will lead the waterbody to achieve support of all designated uses. However, sediment does not have numeric criteria established, as the acceptable levels of sediment is expected to vary from stream to stream based on a range of contributing factors. Therefore, an alternative method must be used to determine the water quality target for sediment TMDLs.

The method proposed to set TMDL endpoint loads for the James River tributaries watersheds is called the "all-forest load multiplier" (AllForX) approach, which has been used in developing many sediment TMDLs in Virginia since 2014. AllForX is the ratio of the simulated pollutant load under existing conditions to the pollutant load from an all-forest simulated condition for the same watershed. In other words, AllForX is an indication of how much higher current sediment loads are above an undeveloped condition. These multipliers were calculated for a total of 15 watersheds of similar size and within the same ecoregion as the TMDL watersheds. These watersheds included both unimpaired and impaired streams to represent a wide distribution of current conditions. Watersheds used in developing the VSCI and AllForX regression should be similar in size and

located near the study watershed to minimize differences in flow regime, soils, and other physiographic properties. Additionally, there must be adequate and recent VSCI data for a watershed to be a useful data point.

A regression was then developed between the Virginia Stream Condition Index (VSCI) scores at monitoring stations and the corresponding AllForX ratio calculated for each station. **Figure 1** and **Figure 2** show the regression developed for James River tributaries watersheds. Based on the regression, a VSCI score of 60 corresponded to a target AllForX ratio of 5.86 for TSS and 3.37 for phosphorus. This means that the TMDL streams are expected to achieve consistently healthy benthic conditions if sediment and phosphorus loads are less than 5.86 and 3.37 times the simulated load of an all-forested watershed, respectively. The AllForX targets were then used to determine the allowable pollutant TMDL loads in the study watersheds (**Table 9** and **Table 10**).

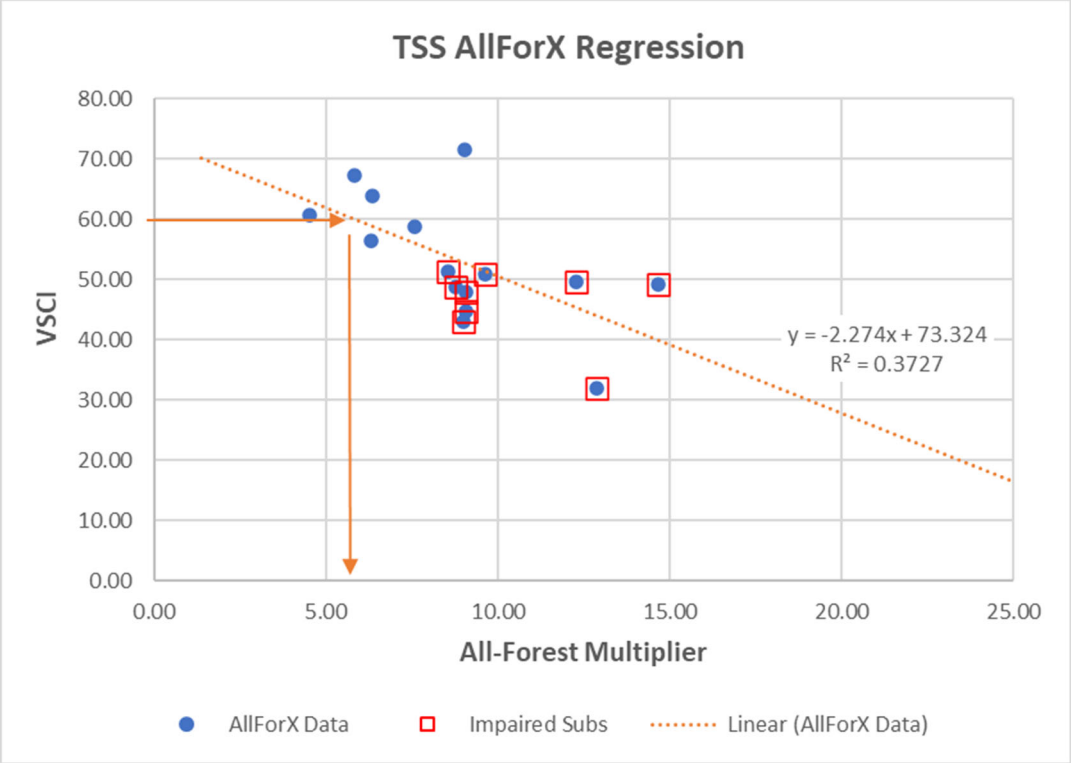

Figure 1. AllforX TSS regression developed for the James River tributaries TMDL.

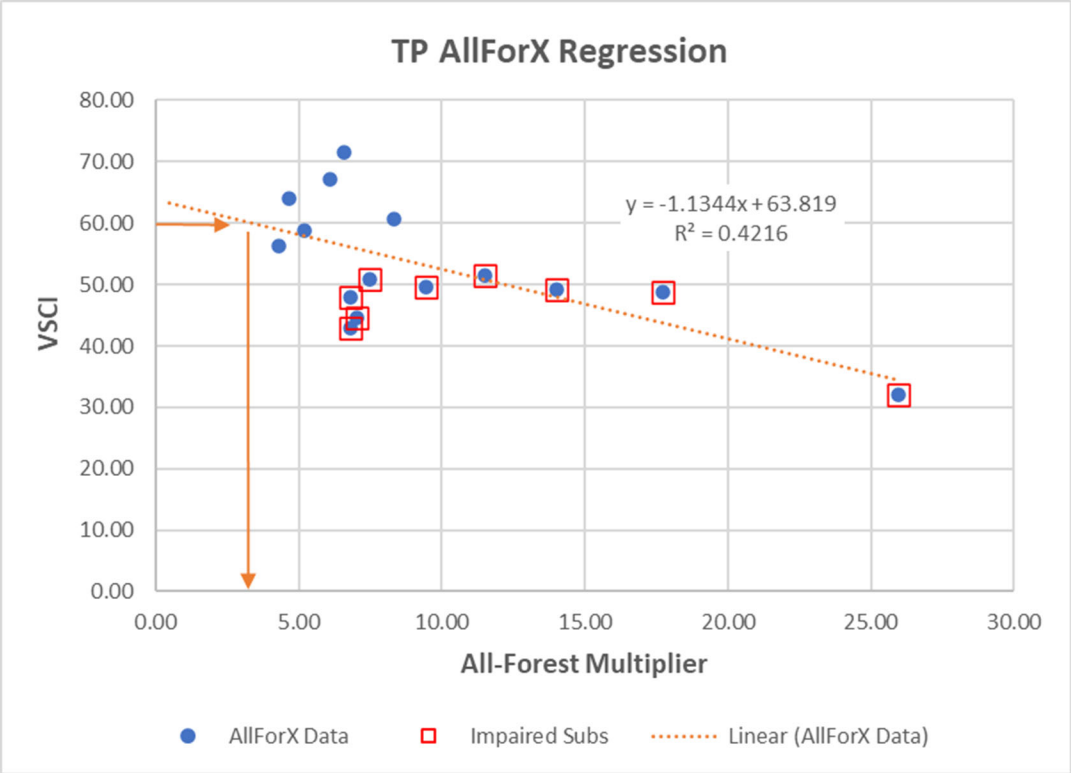

Figure 2. AllforX TP regression developed for the James River tributaries TMDL.

Table 9. Target Sediment loading rates and reductions as determined by AllForX regression for the James River tributaries TMDL. Existing loads incorporate allowable Sediment loads from permits and any BMP's present in the watershed. *Swift creek existing sediment load doesn't include Nuttree Branch.

Impaired Stream	**TSS Existing** (lb/yr)	**TSS AllForest** (lb/yr)	**TSS Target** (lb/yr)	**Estimated % Reduction**
Bailey Creek	2109998	204174	1196315	43.3
Nuttree Branch	642279	90928	532771	17.0
Oldtown Creek	1435574	106696	625162	56.5
Proctors Creek	2871021	174248	1020966	64.4
Rohoic Creek	1150002	110709	648674	43.6
Swift Creek	16898614	1875265	10987699	35.0

Table 10. Target Phosphorus loading rates and reductions as determined by AllForX regression for the James River tributaries TMDL. Existing loads incorporate allowable TP loads from permits and any BMP's present in the watershed.

Impaired Stream	TP Existing (lb/yr)	TP AllForest (lb/yr)	TP Target (lb/yr)	Estimated % Reduction
Oldtown Creek	2,607	269	904	65.3
Rohoic Creek	2,146	194	654	69.5
Swift Creek	18,930	2,594	8,730	53.9

Questions:
Is the general concept applied in developing the AllForX regression and target loads understandable?

Is the range of required reductions reasonable?

5. TMDL Allocation Scenarios

Preliminary sediment allocation scenarios are presented for the impaired streams in **Table 11** through **Table 16** (TSS) and **Table 17** through **Table 19** (TP). Each table presents a range of scenarios, common ones include:

- Even reductions across sources
- Higher reductions on agricultural loads
- Higher reductions on urban loads
- Higher or lower intensity of stream restoration (streambank erosion)

The allocation scenario reductions are higher overall than the predicted reductions from **Table 9** and **Table 10**, which is due to the inclusion of explicit MOS and Future Growth loads.

Questions:

Are there any questions on the reasoning behind the allocation scenarios?

Which allocation scenarios do you prefer? Is a reasonable option presented for each watershed? Are there other scenarios that would be useful to see?

Table 11. Preliminary allocation scenarios for Bailey Creek sediment load.

Bailey Creek Sediment (2-BLY005.73)		**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	26,619	54.2	12,191	39.7	16,051	77.1	6,096	50.0	13,309
Hay	6,796	54.2	3,113	39.7	4,098	77.1	1,556	50.0	3,398
Pasture	6,592	54.2	3,019	39.7	3,975	77.1	1,510	50.0	3,296
Forest	52,787	-	52,787	-	52,787	-	52,787	-	52,787
Trees	65,786	-	65,786	-	65,786	-	65,786	-	65,786
Shrub	15,245	-	15,245	-	15,245	-	15,245	-	15,245
Harvested	38,881	54.2	17,807	39.7	23,445	77.1	8,904	50.0	19,440
Wetland	56,735	-	56,735	-	56,735	-	56,735	-	56,735
Baren	216,716	54.2	99,256	60.0	86,686	45.0	119,194	50.0	108,358
Turfgrass	78,632	54.2	36,014	60.0	31,453	45.0	43,248	50.0	39,316
Developed Pervious	10,935	54.2	5,008	60.0	4,374	45.0	6,014	50.0	5,468
Developed Impervious	219,160	54.2	100,375	60.0	87,664	45.0	120,538	50.0	109,580
Streambank Erosion	410,560	54.2	188,037	39.7	247,568	77.1	94,018	67.5	133,432
Const. Permits	33,496	-	33,496	-	33,496	-	33,496	-	33,496
ISW Permit	43,063	-	43,063	-	43,063	-	43,063	-	43,063
Other Permits	1,945	-	1,945	-	1,945	-	1,945	-	1,945
MS4	695,653	54.2	318,609	60.0	278,261	45.0	382,609	50.0	347,826
MOS (10%)	62,516	-	119,631	-	119,631	-	119,631	-	119,631
Future Growth (2%)	12,503	-	23,926	-	23,926	-	23,926	-	23,926
TOTAL	**2,054,620**		**1,196,043**		**1,196,190**		**1,196,301**		**1,196,038**
	0% red.		**41.8%**		**41.8%**		**41.8%**		**41.8%**

Table 12. Preliminary allocation scenarios for Nuttree Branch sediment load.

Nuttree Branch Sediment (2-NUT000.62)		**Scenario 1**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	0	-	0	-	0	-	0
Hay	0	-	0	-	0	-	0
Pasture	0	-	0	-	0	-	0
Forest	16,414	-	16,414	-	16,414	-	16,414
Trees	32,267	-	32,267	-	32,267	-	32,267
Shrub	10,827	-	10,827	-	10,827	-	10,827
Harvested	0	-	0	-	0	-	0
Wetland	4,520	-	4,520	-	4,520	-	4,520
Barren	0	-	0	-	0	-	0
Turfgrass	44,645	51.6	21,608	58.9	18,349	0.0	44,645
Developed Pervious	3,547	51.6	1,717	58.9	1,458	64.9	1,245
Developed Impervious	164,682	51.6	79,706	58.9	67,684	64.9	57,803
Streambank Erosion	68,125	51.6	32,973	0.0	68,125	0.0	68,125
Const. Permits	129,593	-	129,593	-	129,593	-	129,593
ISW Permits	8,888	-	8,888	-	8,888	-	8,888
Other Permits	326	-	326	-	326	-	326
MS4	267,548	51.6	129,493	58.9	109,962	64.9	93,909
MOS (10%)	53,277	-	53,277	-	53,277	-	53,277
Future Growth (2%)	10,655	-	10,655	-	10,655	-	10,655
TOTAL	**815,314**		**532,264**		**532,346**		**532,495**
	0% red.		**34.7%**		**34.7%**		**34.7%**

Table 13. Preliminary allocation scenarios for Oldtown Creek sediment load.

Oldtown Creek Sediment (2-OTC001.54)		**Scenario 1**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	159,181	72.3	44,093	40.0	95,509	81.5	29,448
Hay	6,105	72.3	1,691	40.0	3,663	81.5	1,129
Pasture	1,690	72.3	468	40.0	1,014	81.5	313
Forest	37,252	-	37,252	-	37,252	-	37,252
Trees	19,723	-	19,723	-	19,723	-	19,723
Shrub	5,024	-	5,024	-	5,024	-	5,024
Harvested	24,671	72.3	6,834	40.0	14,802	81.5	4,564
Wetland	37,547	-	37,547	-	37,547	-	37,547
Barren	11,287	72.3	3,127	77.7	2,517	81.5	2,088
Turfgrass	31,175	72.3	8,635	77.7	6,952	81.5	5,767
Developed Pervious	3,218	72.3	891	77.7	718	81.5	595
Developed Impervious	179,117	72.3	49,615	77.7	39,943	81.5	33,137
Streambank Erosion	337,834	72.3	93,580	77.7	75,337	45.0	185,809
Const. Permits	80,810	-	80,810	-	80,810	-	80,810
MS4	576,586	72.3	159,714	77.7	128,579	81.5	106,668
MOS (10%)	62,516	-	62,516	-	62,516	-	62,516
Future Growth (2%)	12,503	-	12,503	-	12,503	-	12,503
TOTAL	**1,586,239**		**624,024**		**624,408**		**624,894**
	0% red.		**60.7%**		**60.6%**		**60.6%**

Table 14. Preliminary allocation scenarios for Proctors Creek sediment load.

Proctors Creek Sediment (2-PCT002.46)		**Scenario 1**		**Scenario 2**	
Source	Existing	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	8,824	88.4	1,024	0.0	8,824
Hay	2,111	88.4	245	0.0	2,111
Pasture	3,043	88.4	353	0.0	3,043
Forest	36,463	-	36,463	-	36,463
Trees	45,160	-	45,160	-	45,160
Shrub	8,735	-	8,735	-	8,735
Harvested	0	-	0	-	0
Wetland	68,883	-	68,883	-	68,883
Barren	199,632	88.4	23,157	88.9	22,159
Turfgrass	58,684	88.4	6,807	88.9	6,514
Developed Pervious	4,151	88.4	482	88.9	461
Developed Impervious	361,063	88.4	41,883	88.9	40,078
Streambank Erosion	955,902	88.4	110,885	88.9	106,105
Const. Permits	373,567	-	373,567	-	373,567
ISW Permits	64,759	-	64,759	-	64,759
Other Permits	1,243	-	1,243	-	1,243
MS4	973,087	88.4	112,878	88.9	108,013
MOS (10%)	102,097	-	102,097	-	102,097
Future Growth (2%)	20,419	-	20,419	-	20,419
TOTAL	**3,287,822**		**1,019,039**		**1,018,633**
	0% red.		**69.0%**		**69.0%**

Table 15. Preliminary allocation scenarios for Rohoic Creek sediment load.

Rohoic Creek Sediment (2-RHC000.58)		**Scenario 1**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	52,142	71.0	15,121	32.5	35,196	80.0	10,428
Hay	16,407	71.0	4,758	32.5	11,075	80.0	3,281
Pasture	4,153	71.0	1,204	32.5	2,803	80.0	831
Forest	22,268	-	22,268	-	22,268	-	22,268
Trees	31,909	-	31,909	-	31,909	-	31,909
Shrub	9,145	-	9,145	-	9,145	-	9,145
Harvested	4,129	71.0	1,197	32.5	2,787	80.0	826
Wetland	21,337	-	21,337	-	21,337	-	21,337
Barren	0	-	0	-	0	-	0
Turfgrass	68,255	71.0	19,794	75.0	17,064	80.0	13,651
Developed Pervious	9,356	71.0	2,713	75.0	2,339	80.0	1,871
Developed Impervious	198,801	71.0	57,652	75.0	49,700	80.0	39,760
Streambank Erosion	247,174	71.0	71,681	75.0	61,794	50.3	122,846
Const. Permits	130,544	-	130,544	-	130,544	-	130,544
ISW Permit	115,596	-	115,596	-	115,596	-	115,596
Other Permits	3,371	-	3,371	-	3,371	-	3,371
MS4	215,417	71.0	62,471	75.0	53,854	80.0	43,083
MOS (10%)	64,867	-	64,867	-	64,867	-	64,867
Future Growth (2%)	12,973	-	12,973	-	12,973	-	12,973
TOTAL	**1,227,843**		**648,601**		**648,621**		**648,587**
	0% red.		**47.2%**		**47.2%**		**47.2%**

Table 16. Preliminary allocation scenarios for Swift Creek sediment load.

Swift Creek Sediment (2-SFT012.84)		**Scenario 1**		**Scenario 2**		**Scenario 3**		**Scenario 4**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TSS (lb/yr)	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*	*%*	*TSS (lb/yr)*
Cropland	119,508	56.2	52,345	36.9	75,410	80.5	23,304	0.0	119,508
Hay	26,214	56.2	11,482	36.9	16,541	80.5	5,112	0.0	26,214
Pasture	144,675	56.2	63,368	36.9	91,290	80.5	28,212	0.0	144,675
Forest	305,707	-	305,707	-	305,707	-	305,707	-	305,707
Trees	142,330	-	142,330	-	142,330	-	142,330	-	142,330
Shrub	19,858	-	19,858	-	19,858	-	19,858	-	19,858
Harvested	70,205	56.2	30,750	36.9	44,299	80.5	13,690	0.0	70,205
Wetland	134,260	-	134,260	-	134,260	-	134,260	-	134,260
Barren	668,007	56.2	292,587	36.9	421,513	80.5	130,261	57.5	283,903
Turfgrass	155,485	56.2	68,102	36.9	98,111	80.5	30,320	57.5	66,081
Developed Pervious	20,965	56.2	9,183	36.9	13,229	80.5	4,088	57.5	8,910
Developed Impervious	1,516,621	56.2	664,280	36.9	956,988	80.5	295,741	57.5	644,564
Streambank Erosion	10,969,179	56.2	4,804,500	65.0	3,839,213	45.0	6,033,049	57.5	4,661,901
Const. Permits	1,314,329	-	1,314,329	-	1,314,329	-	1,314,329	-	1,314,329
ISW Permits	101,728	-	101,728	-	101,728	-	101,728	-	101,728
Other Permits	100,566	-	100,566	-	100,566	-	100,566	-	100,566
MS4	2,309,800	56.2	1,011,692	36.9	1,457,484	80.5	450,411	57.5	981,665
Nuttree Branch TMDL Target	532,771	-	532,771	-	532,771	-	532,771	-	532,771
MOS (10%)	1,098,770	-	1,098,770	-	1,098,770	-	1,098,770	-	1,098,770
Future Growth (2%)	219,754	-	219,754	-	219,754	-	219,754	-	219,754
TOTAL	**19,970,732 0.0%**		**10,978,362 45.0%**		**10,984,150 45.0%**		**10,984,260 45.0%**		**10,977,699 45.0%**

Table 17. Preliminary allocation scenarios for Oldtown Creek Phosphorus load.

Oldtown Creek Phosphorous (2-OTC001.54)		**Scenario 1**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TP (lb/yr)	*%*	*TP (lb/yr)*	*%*	*TP (lb/yr)*	*%*	*TP (lb/yr)*
Cropland	102.4	76.8	23.8	50.0	51.2	78.7	21.8
Hay	84.8	76.8	19.7	50.0	42.4	78.7	18.1
Pasture	3.1	76.8	0.7	50.0	1.5	78.7	0.6
Forest	18.0	-	18.0	-	18.0	-	18.0
Trees	13.4	-	13.4	-	13.4	-	13.4
Shrub	0.9	-	0.9	-	0.9	-	0.9
Harvested	7.1	76.8	1.7	50.0	3.6	78.7	1.5
Wetland	4.1	-	4.1	-	4.1	-	4.1
Barren	1.3	76.8	0.3	79.2	0.3	78.7	0.3
Turfgrass	238.6	76.8	55.3	79.2	49.6	78.7	50.8
Developed Pervious	4.7	76.8	1.1	79.2	1.0	78.7	1.0
Developed Impervious	394.1	76.8	91.4	79.2	82.0	78.7	83.9
Streambank Erosion	118.2	76.8	27.4	79.2	24.6	40.0	70.9
Septic	0.9	0.0	0.9	0.0	0.9	0.0	0.9
Groundwater	150.9	-	150.9	-	150.9	-	150.9
Construction Permits	58.2	-	58.2	-	58.2	-	58.2
MS4	1,406.5	76.8	326.3	79.2	292.5	78.7	299.6
MOS (10%)	90.4		90.4		90.4		90.4
Future Growth (2%)	18.1		18.1		18.1		18.1
TOTAL	**2,716**		**903**		**904**		**904**
	0% red.		**66.8%**		**66.7%**		**66.7%**

Table 18. Preliminary allocation scenarios for Swift Creek Phosphorus load.

Swift Creek Sediment (2-SFT012.84)		**Scenario 1**		**Scenario 2**		**Scenario 3**	
Source	Existing	Red.	Allocation	Red.	Allocation	Red.	Allocation
	TP (lb/yr)	*%*	*TP (lb/yr)*	*%*	*TP (lb/yr)*	*%*	*TP (lb/yr)*
Cropland	70.9	71.8	20.0	0.0	70.9	80.2	14.0
Hay	362.6	71.8	102.3	0.0	362.6	80.2	71.8
Pasture	190.9	71.8	53.8	0.0	190.9	80.2	37.8
Forest	143.3	-	143.3	-	143.3	-	143.3
Trees	115.1	-	115.1	-	115.1	-	115.1
Shrub	2.5	-	2.5	-	2.5	-	2.5
Harvested	22.6	71.8	6.4	0.0	22.6	80.2	4.5
Wetland	7.9	-	7.9	-	7.9	-	7.9
Barren	43.7	71.8	12.3	74.9	11.0	80.2	8.6
Turfgrass	1,266.9	71.8	357.3	74.9	318.0	80.2	250.8
Developed Pervious	35.3	71.8	10.0	74.9	8.9	80.2	7.0
Developed Impervious	4,236.7	71.8	1,194.8	74.9	1,063.4	80.2	838.9
Streambank Erosion	4,382.9	71.8	1,236.0	74.9	1,100.1	50.0	2,191.4
Septic	17.4	0.0	17.4	0.0	17.4	0.0	17.4
Groundwater	1,587.9	-	1,587.9	-	1,587.9	-	1,587.9
Construction Permits	946.8	-	946.8	-	946.8	-	946.8
ISW Permits	346.8	-	346.8	-	346.8	-	346.8
Other Permits	78.5	-	78.5	-	78.5	-	78.5
MS4	5,071.3	71.8	1,430.1	74.9	1,272.9	80.2	1,004.1
MOS (10%)	873.0		873.0		873.0		873.0
Future Growth (2%)	174.6		174.6		174.6		174.6
TOTAL	**19,978**		**8,717**		**8,715**		**8,723**
	0% red.		**56.4%**		**56.4%**		**56.3%**

Table 19. Target phosphorus load in Rohoic Creek was unable to be achieved due to existing permitted point-source loading.

Rohoic Creek Sediment (2-RHC000.58)		**Scenario 1**		**Scenario 2**	
Source	Existing	Red.	Allocation	Red.	Allocation
	TP (lb/yr)	*%*	*TP (lb/yr)*	*%*	*TP (lb/yr)*
Cropland	31.3	100	0.0	91.8	2.6
Hay	113.1	100	0.0	91.8	9.3
Pasture	4.1	100	0.0	91.8	0.3
Forest	9.7	-	9.7	-	9.7
Trees	14.3	-	14.3	-	14.3
Shrub	1.5	-	1.5	-	1.5
Harvested	1.2	100	0.0	91.8	0.1
Wetland	2.6	-	2.6	-	2.6
Barren	0.0	100	0.0	91.8	0.0
Turfgrass	290.9	100	0.0	91.8	23.9
Developed Pervious	9.7	100	0.0	91.8	0.8
Developed Impervious	437.4	100	0.0	91.8	35.9
Streambank Erosion	86.5	100	0.0	91.8	7.1
Septic	0.9	0	0.9	0.0	0.9
Groundwater	122.3	-	122.3	-	122.3
Construction Permits	94.0	-	94.0	-	94.0
ISW Permits	394.1	-	394.1	50.0	197.0
Other Permits	9.4	-	9.4	-	9.4
MS4	523.4	100	0.0	91.8	17.9
MOS (10%)	65.4		65.4		65.4
Future Growth (2%)	13.1		13.1		13.1
TOTAL	**2,225**		**727**		**653**
	0% red.		**67.3%**		**70.6%**