APPENDIX M

Achieving Stormwater Pollution Control Strategy Reductions for Water Quality:

Stormwater

Background

Section 5 of the Regulations of the Pollution Control Strategy (PCS) for the Indian River, Indian River Bay, Rehoboth Bay and Little Assawoman Bay Watersheds, Delaware provides several options to control nutrient loadings in stormwater runoff from new development. These are generally divided into two categories: Performance-Based approaches and Standards-Based approaches. The Performance-Based approaches, as defined in Sections 5.3.3.1-5.3.3.3 of the PCS Regulation, require that the designer perform calculations to verify that the nutrient reduction goals for a given project have been satisfied. The first goal should always be to apply Green Technology BMPs in accordance with the Delaware Sediment & Stormwater Regulations. These BMPs are intended to recharge stormwater runoff and decrease pollutant loadings accordingly. A series of calculations based on the proposed BMP selection is then performed to determine whether the pollutant loadings have been reduced enough to meet target levels as defined in the PCS. The process also recognizes the concept of the “irreducible concentration.” That is, the current technology is only capable of reducing pollutant concentrations to a certain level. Once that level is reached, it is considered to have met the current Best Available Technology (BAT). If the irreducible concentration has not been met, the designer must employ a “treatment train” approach by adding BMPs in series and going through an iterative process to determine whether the required reductions have been met or the irreducible concentration has been reached. This iterative process continues up to a maximum of three (3) BMPs, which is also considered BAT for the purposes of this Regulation.

The Standards-Based approaches are contained in Sections 5.3.1 and 5.3.3.4 of the PCS Regulation. These approaches are based on preserving specific natural features of a site and preclude having to perform load reduction calculations to verify compliance.

Figure M.1 is a flow chart of the process described above. The rest of this Appendix contains an example problem which illustrates the computational process associated with the Performance-Based approach, as summarized in Figure M.2.

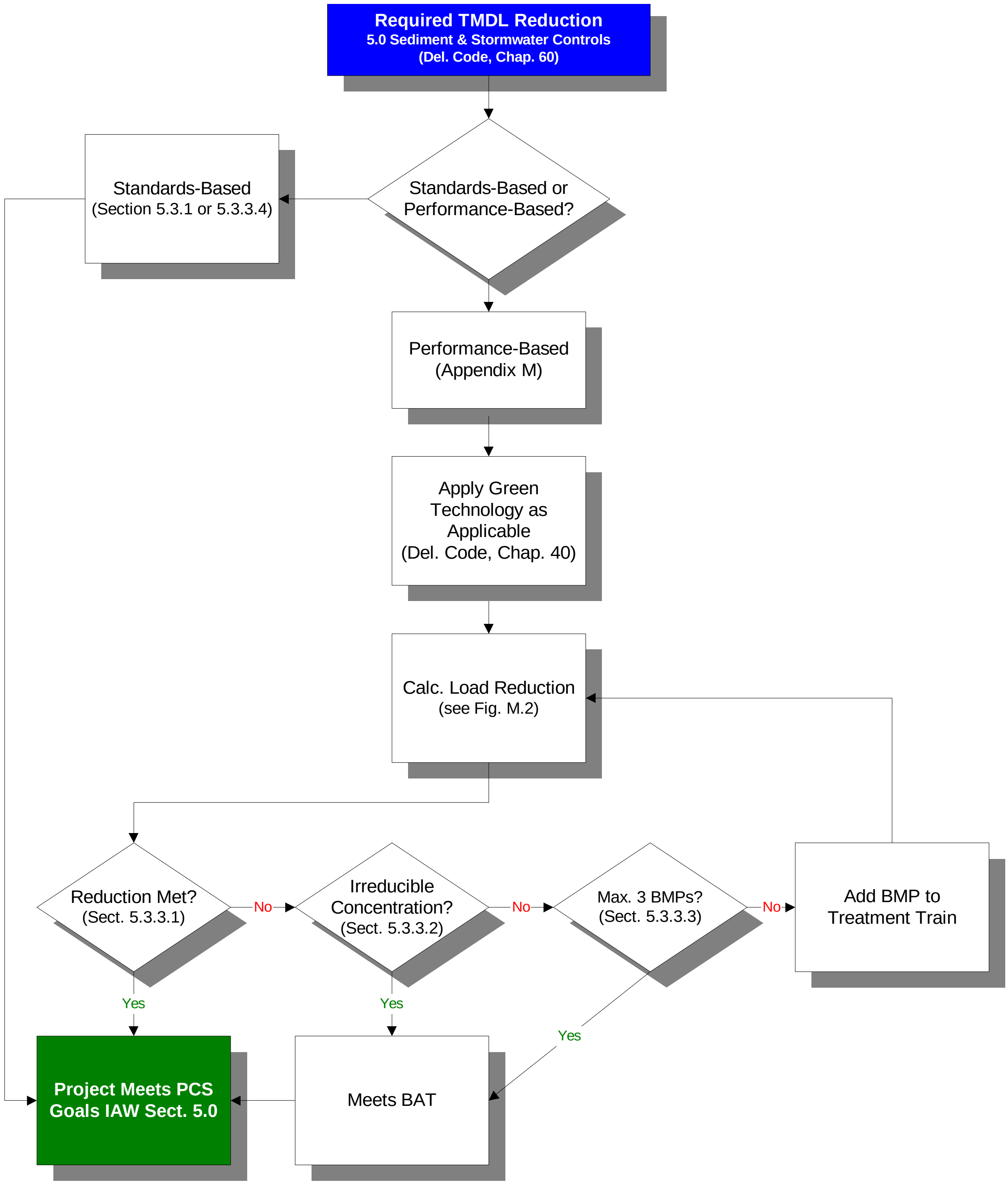


Fig. M.1 Flowchart of Pollution Control Strategy for Stormwater

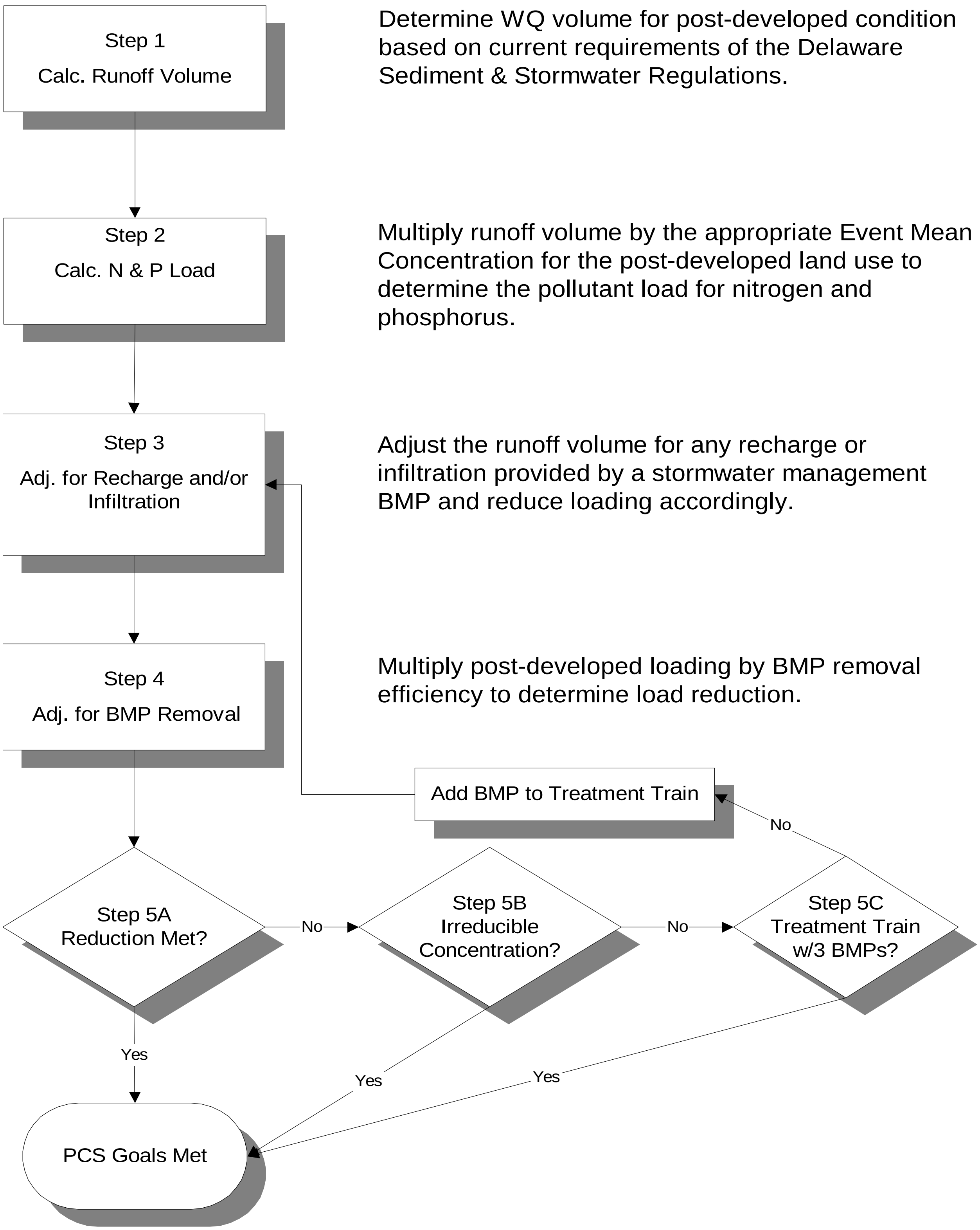


Fig. M.2 Flowchart of Computational Process to Determine Nutrient Reductions in accordance with the Pollution Control Strategy for Stormwater

Example Problem:

A developer has proposed to develop a small in-fill property into townhouse units. The site consists of soils mainly in hydrologic soil group (HSG) A. Since the site is located in the lower Inland Bays watershed, the stormwater management best management practices (BMPs) chosen will have to meet the nutrient reduction goals under the Total Maximum Daily Load (TMDL) Regulations for this water body. The Pollution Control Strategy (PCS) for stormwater from new development is outlined in the flowchart (see Fig. M.2). The following step-by-step example explains this procedure in more detail. The following data is provided:

Site area: 3.2 ac.

Composite Runoff Curve Number (RCN): 80

Water Quality (WQ) Storm Event: 2.0” NRCS 24-HR*

Event mean concentration for Nitrogen from New Development: 2.0 mg/l

Event mean concentration for Phosphorus from New Development: 0.26 mg/l

Required reduction for Nitrogen in Lower Inland Bays: 40%

Required reduction for Phosphorus in Lower Inland Bays: 40%

Irreducible concentration for Nitrogen: 1.2 mg/l

Irreducible concentration for Phosphorus: 0.11 mg/l

Select Green Technology BMPs have the following recharge capablities:

- Bioswales/Filter Strips: 10% reduction of WQ event runoff
- Bioretention w/underdrain: 25% reduction of WQ event runoff
- Bioretention w/infiltration: 90% reduction of WQ event runoff
- All other infiltration BMPs: 90% reduction of WQ event runoff

Efficiency reduction for BMPs in series: 50%

*NOTE: The calculations presented in this example are based on the WQ storm event as defined under the Delaware Sediment & Stormwater Regulations at the time of publication. It should be noted that these regulations were in the process of being revised. Proposed revisions could result in a modification to these calculations.

Step 1

Calc. Runoff Volume

Using Fig. M.3, determine the runoff volume from the contributing area for the water quality event based on the runoff curve number (RCN) for the developed condition.

Given:

Contributing area = 3.2 acres

RCN = 80

1.1 From Fig. M.3, runoff volume = 0.56 watershed inches

1.2 Calculate total runoff volume

3.2 ac x 0.56 in. = 1.792 ac-in

1.3 Convert runoff volume to liters

1.792 ac-in x 102790 l/ac-in = 184200 L

Runoff Curve Number (RCN)	*WQ Event Runoff* (in)
55	0.02
56	0.02
57	0.03
58	0.04
59	0.04
60	0.06
61	0.07
62	0.09
63	0.10
64	0.11
65	0.13
66	0.15
67	0.18
68	0.19
69	0.22
70	0.24
71	0.26
72	0.29
73	0.32
74	0.35
75	0.38
76	0.41
77	0.45
78	0.48
79	0.52
80	0.56
81	0.60
82	0.65
83	0.70
84	0.74
85	0.80
86	0.85
87	0.91
88	0.96
89	1.00
90	1.00
91	1.00
92	1.00
93	1.00
94	1.00
95	1.00
96	1.00
97	1.00
98	1.00

Fig. M.3 Table of Runoff Curve Numbers (RCN) and Regulatory Runoff Volume for the 2.0" NRCS 24-HR Storm Event

Step 2
Calc. N & P Load

Using the runoff volume determined in Step 1 and the event mean concentrations (EMC) for nitrogen (N) and phosphorus (P), calculate the nutrient load from the contributing area for the developed condition.

Given:

EMC-N = 2.0 mg/l

EMC-P = 0.26 mg/l

2.1.1 Nitrogen load:

N = 2.0 mg/l x 184200 L = 368400 mg

2.1.2 Convert N load to pounds:

N = 368400 mg x 2.205e-6 lbs/mg = 0.81 lbs

2.2.1 Phosphorus load:

P = 0.26 mg/l x 184200 L = 47892 mg

2.2.2 Convert P load to pounds:

P = 47892 mg x 2.205e-6 lbs/mg = 0.11 lbs

Step 3

Adj. for Recharge and/or Infiltration

Adjust the nitrogen and phosphorus load for any recharge and/or infiltration capability of the stormwater Best Management Practice (BMP) selected. Since the total storm runoff volume is reduced as a result of recharge/infiltration, the nutrient load is reduced by an equivalent amount. In this case, the developer has proposed to use a biofiltration swale as the initital stormwater BMP.

Given:

Bioswales have the ability to recharge 10% of the water quality storm volume.

3.1.1 Calculate Nitrogen load reduction due to recharge/infiltration:

N reduction = 0.81 lbs x 0.10 = 0.08 lbs

3.1.2 Adjust the Nitrogen load:

Adjusted N = 0.81 lbs - 0.08 lbs = 0.73 lbs

3.2.1 Calculate Phosphorus load reduction due to recharge/infiltration:

P reduction = 0.11 lbs x 0.10 = 0.01 lbs

3.2.2 Adjust the Phosphorus load:

Adjusted P = 0.11 lbs - 0.01 lbs = 0.10 lbs

Step 4

Adj. for BMP Removal

Using the appropriate BMP removal efficiency from Fig. M.4, calculate the load reduction for nitrogen and phosphorus.

Given:

Bioswale is a an open channel practice specifically designed for water quality.

4.1.1 Calculate BMP removal of Nitrogen:

From Fig. M.4, N removal efficiency = 25%

N reduction = 0.73 lbs x 0.25 = 0.18 lbs

4.1.2 Adjust the Nitrogen load:

Adjusted N = 0.73 lbs - 0.18 lbs = 0.55 lbs

4.2.2 Calculate BMP removal of Phosphorus:

From Fig. M.4, P removal efficiency = 34%

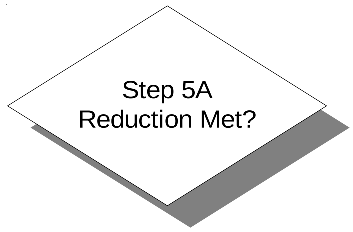
P reduction = 0.10 lbs x 0.34 = 0.03 lbs

4.2.2 Adjust the Phosphorus load:

Adjusted P = 0.10 lbs - 0.03 lbs = 0.07 lbs

Stormwater BMP Category	***Example BMPs in Category***	***Removal Efficency (%)***	
		Total N	***Total P***
Dry Detention Ponds	NOTE: Quantity Control Only	negligible	negligible
Dry Extended Detention (ED) Ponds	NOTE: Requires wet forebay and micro-pool for WQ	15	25
Wet Ponds	Wet ED Ponds Multiple Pond Systems Wet Ponds	33	51
Stormwater Wetlands (NOTE: Some limitations apply due to mosquito issues.)	Shallow Marsh ED Wetland Pond/Wetland Systems	30	49
Filtering Practices	Organic Filter Surface Sand Filter StormFilter Bioretention/Rain Garden Filter Strips Riparian Buffers	38	59
Infiltration Practices	Infiltration Trench Infiltration Basin Porous Pavers	NOTE: Removal efficiency = load reduction	NOTE: Removal efficiency = load reduction
Open Channel Practices (NOTE: Does not include channels designed only for conveyance)	Bioswales Terraces	25	34
Hydro-Dynamic Devices	NOTE: Contact DNREC Sediment & Stormwater Program for Approved Products	10	10

Fig. M.4 Stormwater BMP Categories and Removal Efficiencies



Once the nutrient loads for the developed condition have been adjusted for recharge/infiltration and/or BMP removal efficiency, they are compared to the required reductions under the TMDL to determine if the Pollution Control Strategy goals have been met. In this case, the proposed project is located in the lower Inland Bays watershed.

Given:

TMDL-N = 40% reduction

TMDL-P = 40% reduction

5A.1 Calculate Nitrogen reduction:

N reduction = (0.81 lbs - 0.55 lbs) / 0.81 lbs = 0.32

32% < 40%, therefore the required reduction has not been met for N.

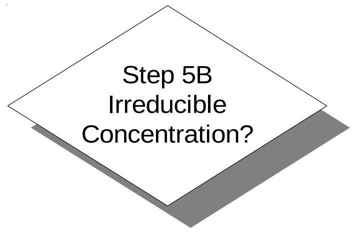
Go to Step 5B

5A.2 Calculate Phosphorus reduction:

P reduction = (0.11 lbs - 0.07 lbs) / 0.11 lbs = 0.36

36% < 40%, therefore the required reduction has not been met for P.

Go to Step 5B



Studies have shown that stormwater BMPs have practical limits to their removal capabilities. This so-called “irreducible concentration” represents the Best Available Technology (BAT) for these practices. If the effluent concentration after treatment is at or below the irreducible concentration for that constituent, then the goals of the Pollution Control Strategy are considered to have been met.

Given:

N irreducible = 1.2 mg/l

P irreducible = 0.11 mg/l

Adjusted runoff volume due to recharge/infiltration:

Adj. R.O. = 184200 L x (1 - 0.10) = 165780 L

5B.1.1 Convert BMP adjusted N load to milligrams:

Adj. N = 0.55 lbs x 453600 mg/lb = 249480 mg

5B.1.2 Calculate effluent N concentration:

N effluent = 249480 mg / 165780 L = 1.5 mg/l

1.5 mg/l > 1.2 mg/l, therefore BAT for N has not been met.

Go to Step 5C.

5B2.1 Convert BMP adjusted P load to milligrams:

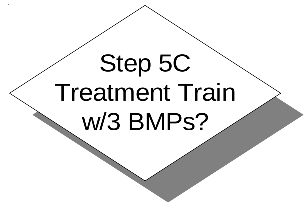
Adj. P = 0.07 lbs x 453600 mg/lb = 31752 mg

5B2.2 Calculate effluent P concentration:

P effluent = 31752 mg / 165780 L = 0.19 mg/l

0.19 mg/l > 0.11 mg/l, therefore BAT for P has not been met.

Go to Step 5C



If the required nutrient reductions have not been met and the effluent concentration is not at the irreducible concentration, it will be necessary to add another BMP in series to achieve additional reductions. This “treatment train” approach, however, also has practical limits as the removal efficiency decreases for each subsequent practice. For the purposes of meeting TMDL requirements, this limit has been established as a maximum of three (3) BMPs in series.

Given:

Number of BMPs in treatment train = 1.

1 < 3, therefore add another BMP and repeat steps 3 through 5.

Step 3, 2nd Round

Adjust for Recharge and/or Infiltration

The developer has proposed to have the effleunt from the bioswale discharge into a wet pond.

Wet ponds do not have the ability to recharge, therefore proceed to Step 4, 2nd Round.

Step 4, 2nd Round

Adjust for BMP Removal

Using the appropriate BMP removal efficiency from Fig. M.4, calculate the load reduction for nitrogen and phosphorus. Since this analysis is for a downstream BMP, the adjusted load computed in Step 4, 1st round is used. In addition, a BMP downstream in the treatment train is less efficient. Therefore, the BMP removal efficiency must be adjusted accordingly.

Given:

Removal efficiency for BMP2 and BMP3 in series is reduced by 50%.

4.1.1 Calculate BMP removal of Nitrogen:

From Fig. M.4, N removal efficiency = 33%

Removal efficiency for BMP in series = (0.33)(0.50) = 17%

N reduction = 0.55 lbs x 0.17 = 0.09 lbs

4.1.2 Adjust the Nitrogen load:

Adjusted N = 0.55 lbs - 0.09 lbs = 0.46 lbs

4.2.2 Calculate BMP removal of Phosphorus:

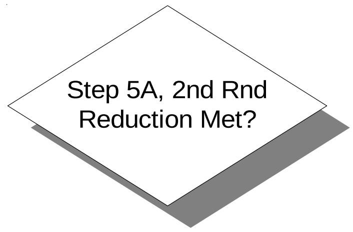
From Fig. M.4, P removal efficiency = 51%

Removal efficiency for BMP in series = (0.51)(0.50) = 25%

P reduction = 0.07 lbs x 0.25 = 0.02 lbs

4.2.2 Adjust the Phosphorus load:

Adjusted P = 0.07 lbs - 0.02 lbs = 0.05 lbs



Once the nutrient load reductions for the additional BMPs in series have been accounted for, they are again compared to the required reductions under the TMDL to determine if the Pollution Control Strategy goals have been met. As before, the proposed project is located in the lower Inland Bays watershed.

Given:

TMDL-N = 40% reduction

TMDL-P = 40% reduction

5A.1 Calculate total Nitrogen reduction for the treatment train:

N reduction = (0.81 lbs - 0.46 lbs) / 0.81 lbs = 0.43

43% > 40%, therefore the required reduction has been met for N.

Project meets the goals of the PCS.

5A.2 Calculate total Phosphorus reduction for the treatment train:

P reduction = (0.11 lbs - 0.05 lbs) / 0.11 lbs = 0.55

55% > 40%, therefore the required reduction has been met for P.

Project meets the goals of the PCS.