# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = _____ acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | _____ | _____ |
| Parking lots | _____ | _____ |
| Driveways | _____ | _____ |
| Sidewalks/paths | _____ | _____ |
| Rooftops | _____ | _____ |
| Decks | _____ | _____ |
| Swimming pools/ponds | _____ | _____ |
| Other | _____ | _____ |
| Impervious Surface Area | _____ | _____ |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= (_____) / (_____)
= _____ %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= (_____) / (_____)
= _____ %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (_____)

= _____ lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (_____) = _____

$L_{pre}$ = (_____) (_____) (_____) (8.16)

= _____ lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Pre-development (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 (_____) = _____

$L_{post}$ = (_____) (_____) (_____) (8.16)

= _____ lbs/year of total phosphorus

Where:

$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{post}$ = Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= (_____) - (0.9) (_____)

= _____ lbs/year of total phosphorus

Where:

RR = Pollutant removal requirement (lbs/year)
$L_{post}$ = Average annual load of total phosphorus exported from the post-development site (lbs/year)
$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR |
|---|---|---|---|---|---|---|---|
| _____ | _____ | x | _____ | x | _____ | = | _____ lbs/year |
| _____ | _____ | x | _____ | x | _____ | = | _____ lbs/year |
| _____ | _____ | x | _____ | x | _____ | = | _____ lbs/year |
| _____ | _____ | x | _____ | x | _____ | = | _____ lbs/year |

Load Removed, LR (total) = _____ lbs/year

Pollutant Removal Requirement, RR (from Step 4) = _____ lbs/year

Where:

| | | |
|---|---|---|
| Load Removed, LR | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the site area within the critical area IDA served by the BMP (%) |
| RR | = | Pollutant removal requirement (lbs/year) |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☐ **Yes** ☐ **No**

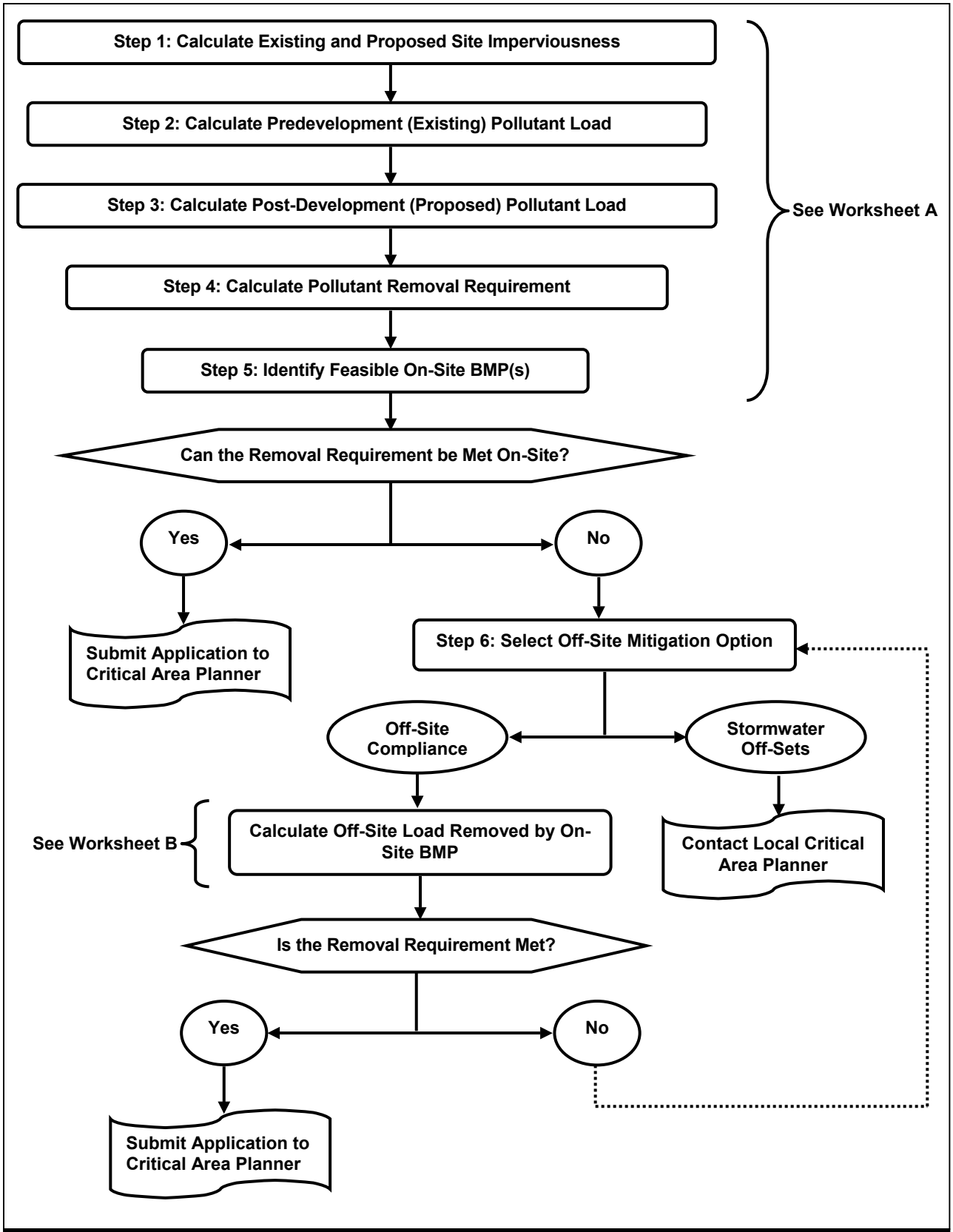



**Figure 4.1 Standard Application Process**

| Table 4.3 Relationship Between 10% Rule Compliance and the Maryland Stormwater Design Manual Stormwater Credits | |
|---|---|
| **MDE Manual Stormwater Credit** | **How the Credit is Incorporated into the 10% Calculations** |
| 1. Natural Area Conservation | • Application of this credit does not change the way calculations are done for the 10% Rule.<br>• Total site area, including the natural area conservation area, is used in the 10% Rule calculations.<br>• The natural area conserved is not impervious. |
| 2. Disconnection of Rooftop Runoff | • Application of this credit reduces the post-development site imperviousness used to calculate the average annual load of total phosphorus exported from the post-development site.<br>• The disconnected impervious surface area is deducted from total impervious surface area when calculating proposed imperviousness.<br>• See Worksheet A, Step 1. |
| 3. Disconnection of Non Rooftop Runoff | • If the runoff is directed to a grass channel, application of this credit reduces the post-development site imperviousness used to calculate the average annual load of total phosphorus exported from the post-development site.<br>• The disconnected impervious surface area is deducted from total impervious surface area when calculating proposed imperviousness.<br>• See Worksheet A, Step 1. |
| 4. Sheet Flow to Buffers | • Application of this credit does not change the way calculations are done for the 10% Rule.<br>• Total site area, including the 100-foot Critical Area Buffer area on the site, is used in 10% Rule calculations.<br>• Any impervious area draining to the 100-foot Critical Area Buffer is still considered impervious, and is included in impervious cover when calculating the post-development pollutant load. |
| 5. Grass Channel Use | • Application of this credit reduces the post-development site imperviousness used to calculate the average annual load of total phosphorus exported from the post-development site.<br>• The disconnected impervious surface area is deducted from total impervious surface area when calculating proposed imperviousness. |
| 6. Environmentally Sensitive Development | • If the Credit has been applied to a Single Lot Development, the application process outlined in Section 5, Residential Approach, must still be followed.<br>• If the Credit has been applied to a Multiple Lot Development, the 10% Rule calculations must still be completed and the 10% Rule worksheets must still be submitted. |

# Worksheet B: Standard Application Process

## Calculating Removal from Off-site Drainage Areas

**Step 1: Project Description**

**A. Calculate Percent Imperviousness**

1) Off-site Drainage Area to be Treated by On-site BMP, $A_{off\text{-}site}$ = _____ acres

2) Ultimate Off-site Drainage Area Imperviousness

(a) Ultimate Off-site Impervious Area (acres)

| | |
|---|---|
| Roads | _____ (acres) |
| Parking Lots | _____ (acres) |
| Driveways | _____ (acres) |
| Sidewalks/paths | _____ (acres) |
| Rooftops | _____ (acres) |
| Decks | _____ (acres) |
| Swimming pools/ponds | _____ (acres) |
| Other | _____ (acres) |

Total Off-site Impervious Area (sum of the above) = _____ (acres)

(b) Ultimate Off-site Imperviousness ($I_{off\text{-}site}$)

Off-site Imperviousness ($I_{off\text{-}site}$) = Total Off-site Impervious Area / $A_{off\text{-}site}$

= (Step 2a) / (Step 1)

= (_____) / (_____)

= _____ %

**B. Define Development Category of Off-site Drainage Area**

1) New Development: Ultimate imperviousness of off-site drainage area less than 15% I *(Go to Step 2A)*

2) Redevelopment: Ultimate imperviousness of off-site drainage area greater than or equal to 15% I *(Go to Step 2B)*

**Step 2: Calculate Post-Development Load for Off-site Drainage Area ($L_{off\text{-}site}$)**

**A. New Development**

$L_{off\text{-}site}$ = 0.5 ($A_{off\text{-}site}$)

= 0.5 (_____)

= _____ lbs/year of total phosphorus

Where:

$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)

$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)

**B. Redevelopment**

$L_{off\text{-}site}$ = ($R_v$) (C) ($A_{off\text{-}site}$) 8.16

$R_v$ = 0.05 + 0.009 ($I_{off\text{-}site}$)

= 0.05 + 0.009 (_____) = _____

$L_{off\text{-}site}$ = (_____) (_____) (_____) 8.16

= _____ lbs/year of total phosphorus

Where:

$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff

$I_{off\text{-}site}$ = Ultimate off-site imperviousness (i.e. I = 75 if site is 75% impervious)

C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l

$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)

8.16 = Includes regional constants and unit conversion factors

**Step 3: Calculate the Load Removed from Off-site Drainage Areas by On-site BMP**

Type of BMP: _____

Off-site Load Removed = ($BMP_{RE}$) ($L_{off\text{-}site}$)

= (_____) (_____)

= _____ lbs/year of total phosphorus

Where:
$BMP_{RE}$ = BMP removal efficiency for total phosphorus, see Table 4.8 (%)
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

**Step 4: Calculate the Total Load Removed by On-site and Off-site BMPs**

Total Load Removed = Load Removed On-site + Load Removed Off-site

= (Worksheet A, Step 5) + (Step 3)

= (_____) + (_____)

= _____ lbs/year of total phosphorus

Pollutant Removal Requirement (Worksheet A, Step 4) = _____ lbs/year

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the Pollutant Removal Requirement been met?** ☐ **Yes** ☐ **No**

| Table 4.9 Examples of Acceptable Stormwater Offset Projects |
| --- |
| Having shown that on-site compliance is not feasible, the applicant may choose from the following offset options (see Section 6, Offset Program for more details):<br>• Construct a new BMP<br>• Convert an existing BMP to achieve higher pollutant removal<br>• Modify the existing conveyance network to enhance pollutant removal<br>• Reduce the imperviousness of an existing property<br>• Restore a degraded tidal or non-tidal wetland<br>• Restore a channelized stream<br>• Daylight a stream<br>• Implement a riparian reforestation project<br>• Install trash interceptors on existing stormwater inlets<br>• Improve existing stormwater ponds by planting forested buffer areas around the facility<br>• Develop and implement a public education program about stormwater management in conjunction with local government<br>• Over-design another pending project |

**Case Study #1**

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = 3.36 acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | 2.37 | 2.16 |
| Parking lots | 0.08 | 0.08 |
| Driveways | | |
| Sidewalks/paths | | 0.05 |
| Rooftops | | |
| Decks | | |
| Swimming pools/ponds | | |
| Other | | |
| Impervious Surface Area | 2.45 | 2.29 |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( 2.45 ) / ( 3.36 )
= 72.9 %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= ( 2.29 ) / ( 3.36 )
= 68.2 %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

## Case Study #1

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (_____)

= _____ lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 ( 72.9 ) = 0.706

$L_{pre}$ = ( 0.706 ) ( 0.30 ) ( 3.36 ) (8.16)

= 5.81 lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Pre-development (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

## Case Study #1

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 ( 68.2 ) = 0.6064

$L_{post}$ = ( 0.6064 ) ( 0.30 ) ( 3.36 ) (8.16)

= 5.46 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| $I_{post}$ | = | Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= ( 5.46 ) - (0.9) ( 5.81 )

= 0.23 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| RR | = | Pollutant removal requirement (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |

## Case Study #1

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| Per. Sand Filter | 5.46 | x | 50% | x | 10% | = | 0.30 | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = 0.30 lbs/year

Pollutant Removal Requirement, RR (from Step 4) = 0.23 lbs/year

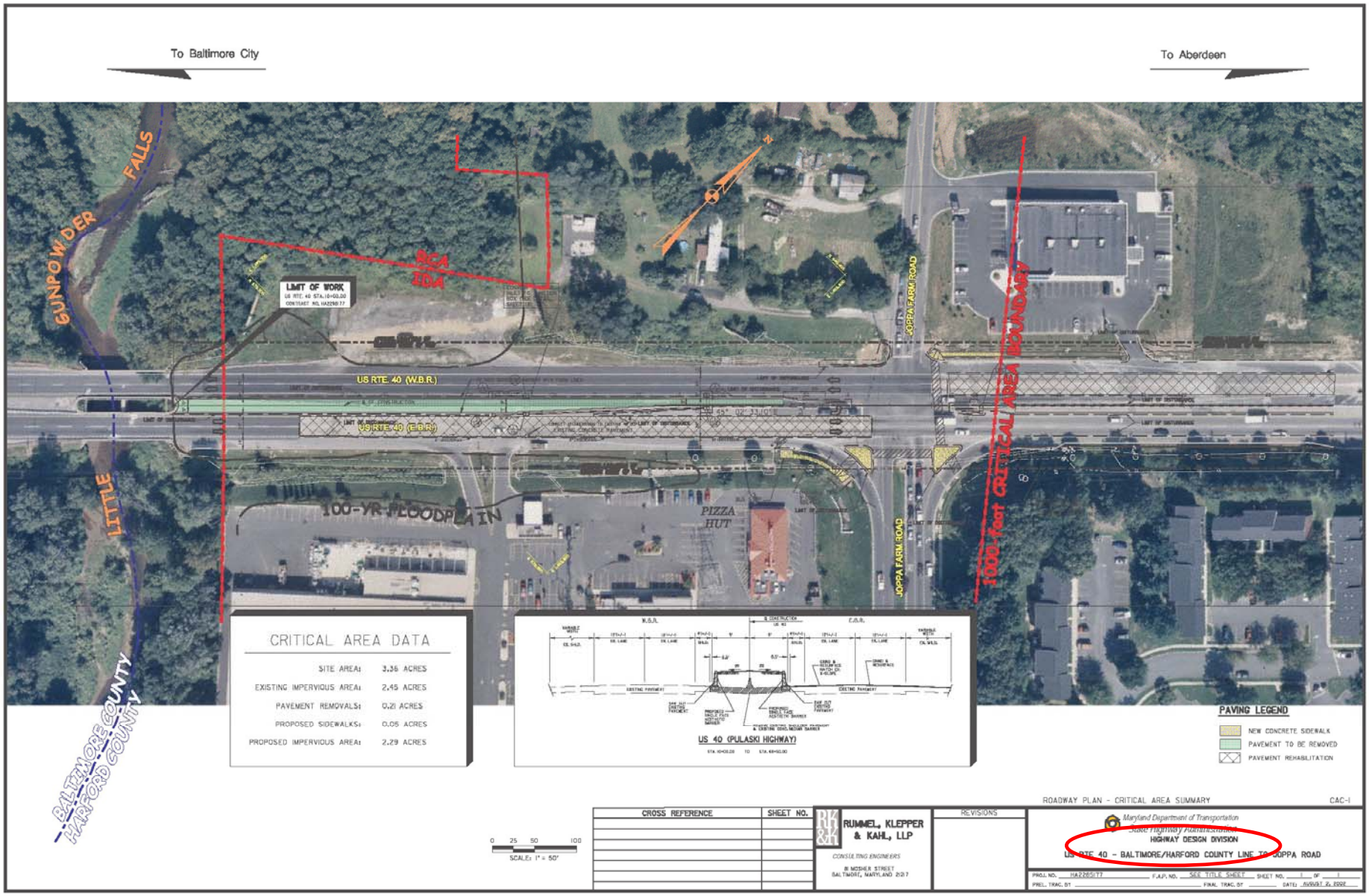
Where:

| | | |
|---|---|---|
| Load Removed, LR | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the site area within the critical area IDA served by the BMP (%) |
| RR | = | Pollutant removal requirement (lbs/year) |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☑ Yes ☐ No

# Case Study #1, Session 7



# Case Study #1, Session 7

## Worksheet A: Standard Application Process

### Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = 3.36 acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | 2.37 | 2.16 |
| Parking lots | 0.08 | 0.08 |
| Driveways | | |
| Sidewalks/paths | | 0.05 |
| Rooftops | | |
| Decks | | |
| Swimming pools/ponds | | |
| Other | | |
| Impervious Surface Area | 2.45 | 2.29 |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Sit
= (Step 2a) / (Step 1)
= (_____) / (_____
= _____ %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Sit
= (Step 2b) / (Step 1)
= (_____) / (_____)
= _____ %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

**Because SHA and the Commission have an executed MOU-General Approval Agreement, which includes Landscaping Projects as a part of a beautification project,**

**No 10% Computations Required**

**Case Study #2**

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = 9.30 acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | 0.05 | 0.80 |
| Parking lots | | 1.05 |
| Driveways | | |
| Sidewalks/paths | | 0.03 |
| Rooftops | | |
| Decks | | |
| Swimming pools/ponds | | |
| Other | 0.57 | |
| Impervious Surface Area | 0.62 | 2.80 |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( 0.62 ) / ( 9.30 )
= 6.7 %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= ( 2.80 ) / ( 9.30 )
= 30.1 %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) ~~Redevelopment~~: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

## Case Study #2

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) ( 9.30 )

= 4.65 lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (_____) = _____

$L_{pre}$ = (_____) (_____) (_____) (8.16)

= _____ lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Pre-development (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

## Case Study #2

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{post}$)

= 0.05 + 0.009 ( 30.1 ) = 0.321

$L_{post}$ = ( 0.321 ) ( 0.30 ) ( 9.30 ) (8.16)

= 7.31 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| $I_{post}$ | = | Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= ( 7.31 ) - (0.9) ( 4.65 )

= 3.13 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| RR | = | Pollutant removal requirement (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |

## Case Study #2

| Step 5: | Identify Feasible BMP(s) |
|---|---|

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| **Pocket Pond** | 7.31 | x | 50% | x | **32.6%** | = | 1.19 | lbs/year |
| **Con. Wetland** | 7.31 | x | 40% | x | **14.2%** | = | 0.42 | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = 1.61 lbs/year

Pollutant Removal Requirement, RR (from Step 4) = 3.13 lbs/year

Where:

| | | |
|---|---|---|
| Load Removed, LR | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the site area within the critical area IDA served by the BMP (%) |
| RR | = | Pollutant removal requirement (lbs/year) |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☐ **Yes** ☑ **No**

Must complete Worksheet B

**Case Study #2**

# Worksheet B: Standard Application Process

## Calculating Removal from Off-site Drainage Areas

**Step 1: Project Description**

**A. Calculate Percent Imperviousness**

1) Off-site Drainage Area to be Treated by On-site BMP, $A_{off\text{-}site}$ = 4.60 acres

2) Ultimate Off-site Drainage Area Imperviousness

(a) Ultimate Off-site Impervious Area (acres)

| | | |
|---|---|---|
| Roads | 1.38 | (acres) |
| Parking Lots | | (acres) |
| Driveways | | (acres) |
| Sidewalks/paths | | (acres) |
| Rooftops | | (acres) |
| Decks | | (acres) |
| Swimming pools/ponds | | (acres) |
| Other | | (acres) |

Total Off-site Impervious Area (sum of the above) = 1.38 (acres)

(b) Ultimate Off-site Imperviousness ($I_{off\text{-}site}$)

Off-site Imperviousness ($I_{off\text{-}site}$) = Total Off-site Impervious Area / $A_{off\text{-}site}$

= (Step 2a) / (Step 1)

= ( 1.38 ) / ( 4.60 )

= 30 %

**B. Define Development Category of Off-site Drainage Area**

1) New Development: Ultimate imperviousness of off-site drainage area less than 15% I *(Go to Step 2A)*

2) Redevelopment: Ultimate imperviousness of off-site drainage area greater than or equal to 15% I *(Go to Step 2B)*

## Case Study #2

**Step 2: Calculate Post-Development Load for Off-site Drainage Area ($L_{off\text{-}site}$)**

**A. New Development**

$L_{off\text{-}site}$ = 0.5 ($A_{off\text{-}site}$)

= 0.5 (_____)

= _____ lbs/year of total phosphorus

Where:

$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)

$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)

**B. Redevelopment**

$L_{off\text{-}site}$ = ($R_v$) (C) ($A_{off\text{-}site}$) 8.16

$R_v$ = 0.05 + 0.009 ($I_{off\text{-}site}$)

= 0.05 + 0.009 ( 30.0 ) = 0.32

$L_{off\text{-}site}$ = ( 0.32 ) ( 0.30 ) ( 4.60 ) 8.16

= 3.60 lbs/year of total phosphorus

Where:

$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff

$I_{off\text{-}site}$ = Ultimate off-site imperviousness (i.e. I = 75 if site is 75% impervious)

C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l

$A_{off\text{-}site}$ = Off-site drainage area to be treated by on-site BMP (acres)

8.16 = Includes regional constants and unit conversion factors

## Case Study #2

**Step 3: Calculate the Load Removed from Off-site Drainage Areas by On-site BMP**

Type of BMP: _____

Off-site Load Removed = ($BMP_{RE}$) ($L_{off\text{-}site}$)

= ( 65% ) ( 3.60 )

= 2.34 lbs/year of total phosphorus

Where:
$BMP_{RE}$ = BMP removal efficiency for total phosphorus, see Table 4.8 (%)
$L_{off\text{-}site}$ = Average annual load of total phosphorus exported from the off-site drainage area (lbs/year)

**Step 4: Calculate the Total Load Removed by On-site and Off-site BMPs**

Total Load Removed = Load Removed On-site + Load Removed Off-site

= (Worksheet A, Step 5) + (Step 3)

= ( 1.61 ) + ( 2.34 )

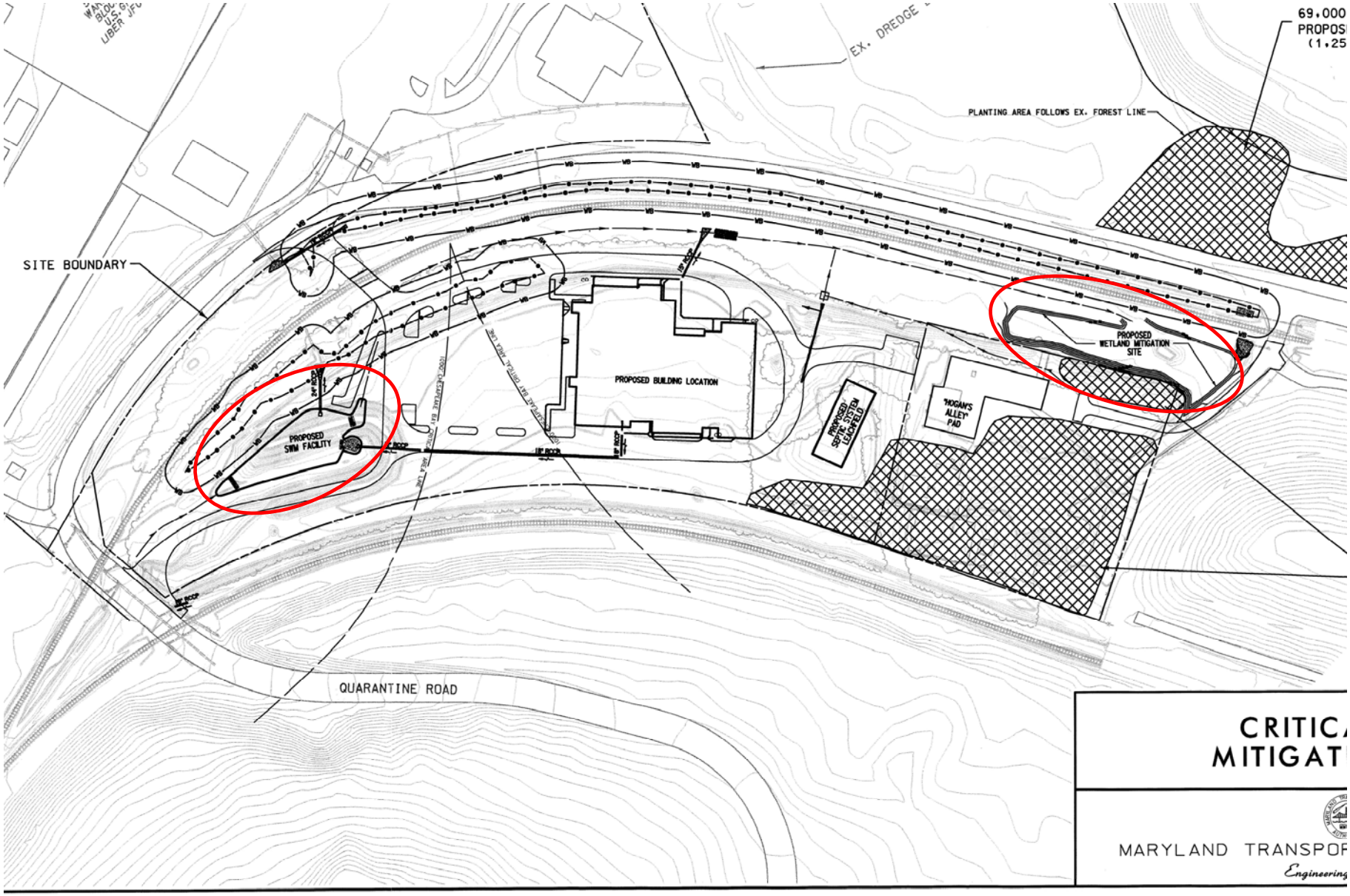
= 3.95 lbs/year of total phosphorus

Pollutant Removal Requirement (Worksheet A, Step 4) = 3.13 lbs/year

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the Pollutant Removal Requirement been met?** ☑ Yes ☐ No

# Case Study #2, Session 7



## Case Study #3 – 1.27 Acre Grass Channel Credit

# Worksheet A: Standard Application Process

### Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = 9.30 acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | 0.05 | 0.80 |
| Parking lots | | 1.05 |
| Driveways | | |
| Sidewalks/paths | | 0.03 |
| Rooftops | | 0.73 |
| Decks | | |
| Swimming pools/ponds | | |
| Other | 0.57 | 0.19 |
| Impervious Surface Area | 0.62 | ~~2.80~~ |

2.80 − 1.27 = 1.53

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( 0.62 ) / ( 9.30 )
= 6.7 %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= ( 1.53 ) / ( 9.30 )
= 16.5 %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

## Case Study #3

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) ( 9.30 )

= 4.65 lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 (_____) = _____

$L_{pre}$ = (_____) (_____) (_____) (8.16)

= _____ lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Pre-development (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

## Case Study #3

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = $0.05 + 0.009\ (I_{post})$

= $0.05 + 0.009$ ( 16.5 ) = 0.199

$L_{post}$ = ( 0.199 ) ( 0.30 ) ( 9.30 ) (8.16)

= 4.53 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| $I_{post}$ | = | Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= ( 4.53 ) - (0.9) ( 4.65 )

= 0.35 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| RR | = | Pollutant removal requirement (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |

## Case Study #3

**Step 5: Identify Feasible BMP(s)**

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| **Pocket Pond** | 4.53 | x | 50% | x | **32.6%** | = | 0.73 | lbs/year |
| **Con. Wetland** | 4.53 | x | 40% | x | **14.2%** | = | 0.26 | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = 0.99 lbs/year

Pollutant Removal Requirement, RR (from Step 4) = 0.35 lbs/year

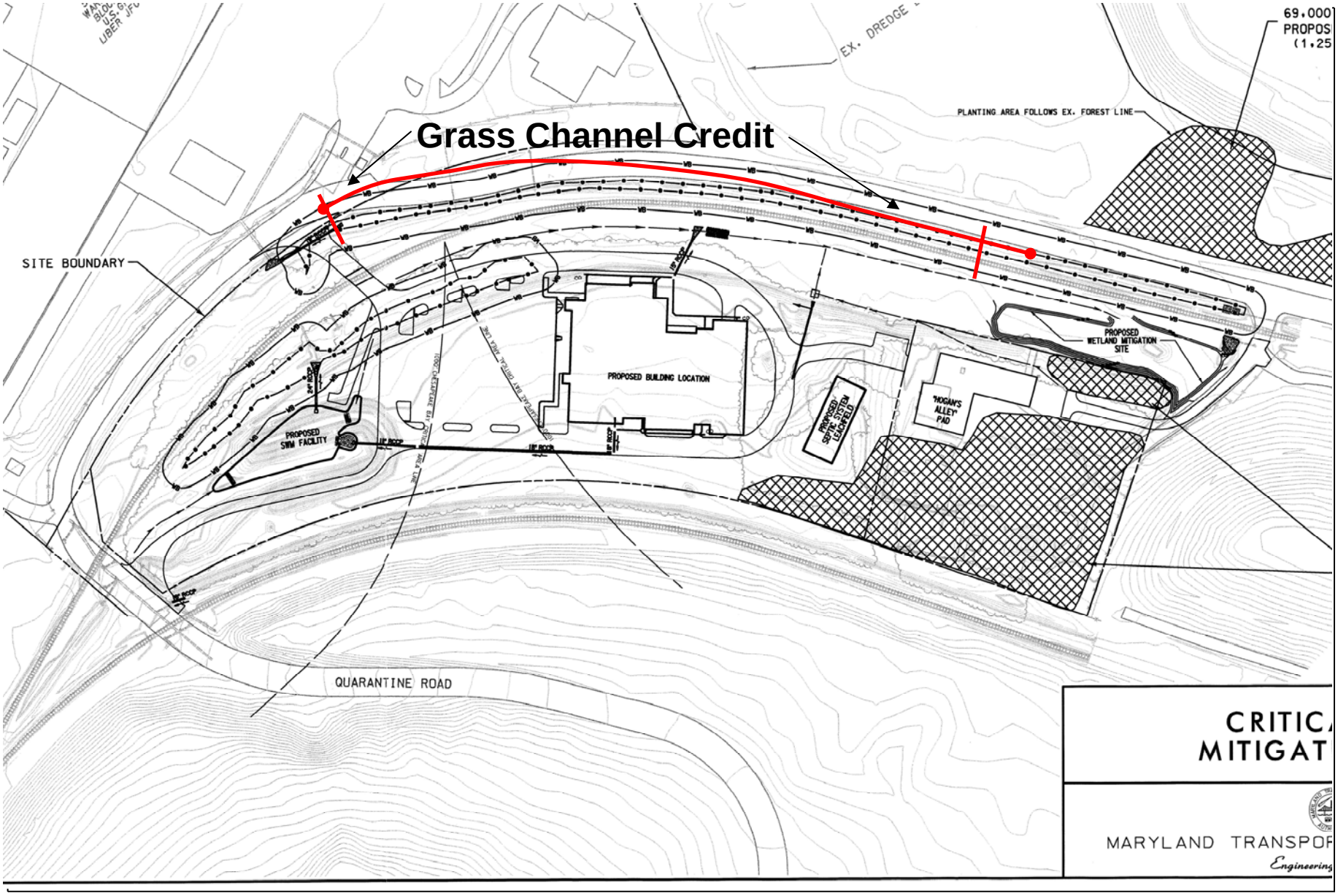
Where:

| | | |
|---|---|---|
| Load Removed, LR | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the site area within the critical area IDA served by the BMP (%) |
| RR | = | Pollutant removal requirement (lbs/year) |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☑ Yes ☐ No

# Case Study #3, Session 7



**Case Study #4**

# Worksheet A: Standard Application Process

## Calculating Pollutant Removal Requirements[1]

**Step 1: Calculate Existing and Proposed Site Imperviousness**

**A. Calculate Percent Imperviousness**

1) Site Area within the Critical Area IDA, A = **11.26** acres

2) Site Impervious Surface Area, Existing and Proposed, (See Table 4.1 for details)

| | (a) Existing (acres) | (b) Proposed (acres) |
|---|---|---|
| Roads | | **3.86** |
| Parking lots | | |
| Driveways | | |
| Sidewalks/paths | | |
| Rooftops | **11.26** | **7.40** |
| Decks | | |
| Swimming pools/ponds | | |
| Other | | |
| Impervious Surface Area | **11.26** | **11.26** |

3) Imperviousness (I)

Existing Imperviousness, $I_{pre}$ = Impervious Surface Area / Site Area
= (Step 2a) / (Step 1)
= ( 11.26 ) / ( 11.26 )
= 100 %

Proposed Imperviousness, $I_{post}$ = Impervious Surface Area / Site Area
= (Step 2b) / (Step 1)
= ( 11.26 ) / ( 11.26 )
= 100 %

**B. Define Development Category (circle)**

1) New Development: Existing imperviousness less than 15% I *(Go to Step 2A)*

2) Redevelopment: Existing imperviousness of 15% I or more *(Go to Step 2B)*

3) Single Lot Residential Development: Single lot being developed or improved; single family residential development; and more than 250 square feet of impervious area and associated disturbance (Go to Section 5, Residential Approach, for detailed criteria and requirements).

[1] NOTE: All acreage used in this worksheet refers to areas within the IDA of the Critical Area only.

## Case Study #4

**Step 2: Calculate the Predevelopment Load ($L_{pre}$)**

**A. New Development**

$L_{pre}$ = (0.5) (A)

= (0.5) (_____)

= _____ lbs /year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
0.5 = Annual total phosphorus load from undeveloped lands (lbs/acre/year)
A = Area of the site within the Critical Area IDA (acres)

**B. Redevelopment**

$L_{pre}$ = ($R_v$) (C) (A) (8.16)

$R_v$ = 0.05 + 0.009 ($I_{pre}$)

= 0.05 + 0.009 ( 100 ) = 0.95

$L_{pre}$ = ( 0.95 ) ( 0.30 ) ( 11.26 ) (8.16)

= 26.19 lbs/year of total phosphorus

Where:

$L_{pre}$ = Average annual load of total phosphorus exported from the site prior to development (lbs/year)
$R_v$ = Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff
$I_{pre}$ = Pre-development (existing) site imperviousness (i.e., I = 75 if site is 75% impervious)
C = Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l
A = Area of the site within the Critical Area IDA (acres)
8.16 = Includes regional constants and unit conversion factors

## Case Study #4

**Step 3: Calculate the Post-Development Load ($L_{post}$)**

**A. New Development and Redevelopment:**

$L_{post}$ = $(R_v)$ (C) (A) (8.16)

$R_v$ = $0.05 + 0.009\ (I_{post})$

= $0.05 + 0.009$ ( 100 ) = 0.95

$L_{post}$ = ( 0.95 ) ( 0.30 ) ( 11.26 ) (8.16)

= 26.19 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $R_v$ | = | Runoff coefficient, which expresses the fraction of rainfall which is converted into runoff |
| $I_{post}$ | = | Post-development (proposed) site imperviousness (i.e., I = 75 if site is 75% impervious) |
| C | = | Flow-weighted mean concentration of the pollutant (total phosphorus) in urban runoff (mg/l) = 0.30 mg/l |
| A | = | Area of the site within the Critical Area IDA (acres) |
| 8.16 | = | Includes regional constants and unit conversion factors |

**Step 4: Calculate the Pollutant Removal Requirement (RR)**

RR = $L_{post}$ - (0.9) ($L_{pre}$)

= ( 26.19 ) - (0.9) ( 26.19 )

= 2.62 lbs/year of total phosphorus

Where:

| | | |
|---|---|---|
| RR | = | Pollutant removal requirement (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $L_{pre}$ | = | Average annual load of total phosphorus exported from the site prior to development (lbs/year) |

## Case Study #4

| Step 5: | Identify Feasible BMP(s) |
|---|---|

Select BMP Options using the screening matrices provided in the Chapter 4 of the 2000 Maryland Stormwater Design Manual. Calculate the load removed for each option.

| BMP Type | ($L_{post}$) | x | ($BMP_{RE}$) | x | (% DA Served) | = | LR | |
|---|---|---|---|---|---|---|---|---|
| Perim. Sand Filter | 26.19 | x | 50% | x | 20.0% | = | 2.62 | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |
| | | x | | x | | = | | lbs/year |

Load Removed, LR (total) = 2.62 lbs/year

Pollutant Removal Requirement, RR (from Step 4) = 2.62 lbs/year

Where:

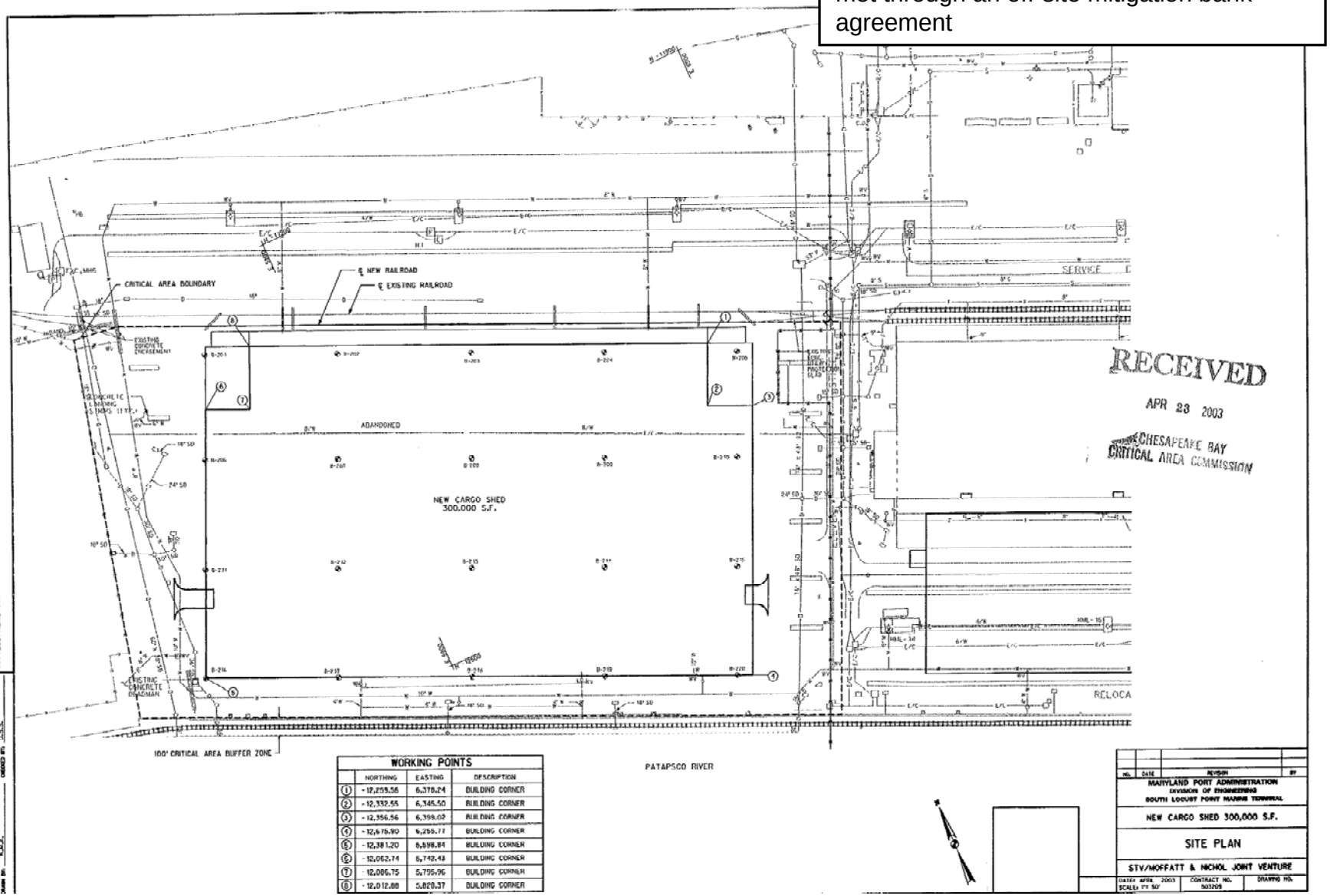
| | | |
|---|---|---|
| Load Removed, LR | = | Annual total phosphorus load removed by the proposed BMP (lbs/year) |
| $L_{post}$ | = | Average annual load of total phosphorus exported from the post-development site (lbs/year) |
| $BMP_{RE}$ | = | BMP removal efficiency for total phosphorus, Table 4.8 (%) |
| % DA Served | = | Fraction of the site area within the critical area IDA served by the BMP (%) |
| RR | = | Pollutant removal requirement (lbs/year) |

If the Load Removed is equal to or greater than the Pollutant Removal Requirement computed in Step 4, then the on-site BMP complies with the 10% Rule.

**Has the RR (pollutant removal requirement) been met?** ☑ Yes ☐ No

# Case Study #4, Session 7

In this actual project, the 10% Rule was met through an off-site mitigation bank agreement




| WORKING POINTS | | | |
|---|---|---|---|
| | NORTHING | EASTING | DESCRIPTION |
| 1 | -12,259.56 | 6,378.24 | BUILDING CORNER |
| 2 | -12,332.55 | 6,345.50 | BUILDING CORNER |
| 3 | -12,356.56 | 6,399.02 | BUILDING CORNER |
| 4 | -12,675.90 | 6,259.77 | BUILDING CORNER |
| 5 | -12,381.20 | 6,598.84 | BUILDING CORNER |
| 6 | -12,062.74 | 6,742.43 | BUILDING CORNER |
| 7 | -12,086.75 | 5,795.96 | BUILDING CORNER |
| 8 | -12,012.88 | 5,828.37 | BUILDING CORNER |