APPENDIX C

GUIDANCE CALCULATION PROCEDURE

INTRODUCTION

This procedure is designed to help applicants determine compliance with a locality's Chesapeake Bay Preservation Act program. This procedure does not supplant any information or requirement of other stormwater management programs, namely any local initiative adopted pursuant to either the Erosion and Sediment Control (ESC) Law [§ 10.1-560, et. seq.] or the Stormwater Management (SWM) Law [§ 10.1-603.1, et. seq.]. While all three programs are intended to protect water resources from further degradation, each requires separate engineering analysis. In general, these programs require calculations as follows:

- a CBPA program : stormwater quality
- a SWM program : stormwater quantity and quality
- an ESC program : two-year design storm runoff volumes and velocities

Many localities may combine all aspects into one, comprehensive program. This calculation procedure would then be just one aspect of that program and a development proposal's submittal.

STEP ONE: Determine if the site is in a Chesapeake Bay Preservation Area.

The Regulations[1] require localities to designate Chesapeake Bay Preservation Areas (CBPAs). Guidelines for local designation are contained in Chapters II and III of the *Local Assistance Manual* and Part III of the Regulations. CBPAs consist of two different classifications: Resource Protection Areas (RPAs) and Resource Management Areas (RMAs). The stormwater management criteria apply **equally** to both RPAs and RMAs.

While localities have flexibility to determine their own CBPAs, those areas will generally include the following land features:

In RPAs: tidal wetlands, nontidal wetlands contiguous to tidal wetlands, tidal shores, tributary streams, a buffer area (of not less than 100 feet), and other lands as designated by the locality;

In RMAs: floodplains, highly erodible soils, highly permeable soils, nontidal wetlands not in the RPA, and other land as designated by the locality.

(2) **If BMPs are structural, facilities must currently be in good working order, performing at the design levels of service.** The local authority may require a review of both the original structural design and maintenance plans to verify this provision. A new maintenance agreement **may** be required to ensure consistency with the locality's SWM requirements.

STEP THREE: **Determine the relative pre-development pollutant load of the Keystone Pollutant (L_{pre}).**

The Keystone Pollutant for Tidewater Virginia is total phosphorous. The selection of total phosphorous as the keystone pollutant is discussed in Attachment A. For the remainder of this procedure, "pollutant" or "pollutant loading(s)" will mean total phosphorous.

Following development or redevelopment, impervious cover is the key determinant in the levels of pollutant export. Up to 90 percent of the atmospheric pollutants deposited on impervious surfaces are delivered to receiving waters.[2] So, for **STEPS THREE** and **FOUR**, the site designer need only determine the amount of total area subject to these criteria and the proposed amount of impervious cover (or equivalent). Guidance on determining equivalents is given in Attachment B. Worksheets A and B will help with these next two steps.

The zoning classification or proposed density of a site will allow applicants to estimate impervious cover. Compliance and final engineering calculations, however, should be based on impervious cover shown on the final site plan. Even so, localities and applicants are encouraged to "err" conservatively, as properties tend to become more impervious with time, e.g. the expansion of a structure, paving a driveway, adding more parking spaces. A conservative estimate indicates more, rather than less, impervious cover. Localities may wish to set a minimum for particular land uses but require the determination of proposed impervious cover and **use the higher number**. Representative land use categories and associated pollutant exports are shown in Table 1.

FOR DEVELOPMENT:

Average Land Cover Conditions ($I_{watershed}$)

Just as a locality must designate CBPAs, a locality must also establish baseloads for watersheds within its jurisdiction. Once set, the baseload will not change unless technology provides a more precise answer. Watershed delineations serve as the baseline for a calculation procedure and do not constitute an additional regulatory step. The two options available to localities are:

With $I_{site(pre)}$, L_{pre} can be calculated using the Simple Method.

$$\boxed{L_{pre} = P \times P_j \times [0.05 + 0.009(I_{site(pre)})] \times C \times A \times 2.72 \ / \ 12}$$

where:

L_{pre} = relative pre-development total phosphorus load (in lbs)
P = average annual rainfall depth (in inches)
= 40 inches for Northern Virginia area
= 43 inches for Richmond Metropolitan area
= 45 inches for Hampton Roads area
P_j = unitless correction factor for storm with no runoff = 0.9
$I_{site(pre)}$ = equivalent pre-development impervious cover of the site (percent expressed in whole numbers)
C = flow-weighted mean pollutant concentration (in mg/l)
= 0.26 mg/l when $I_{site(pre)} < 20$
= 1.06 mg/l when $I_{site(pre)} \geq 20$
A = applicable area of site (in ac)

NOTE: 12 and 2.72 are conversion numbers

STEP FOUR: **Determine the relative post-development pollutant load (L_{post}).**

Just as with **STEP THREE**, the designer needs to know the post-development impervious cover (or equivalent). For both new development and redevelopment, post-development loadings are site-specific.

FOR NEW DEVELOPMENT

Again, the Simple Method is used.

$$\boxed{L_{post} = P \times P_j \times [0.05 + 0.009(I_{site(post)})] \times C \times A \times 2.72 \ / \ 12}$$

where:

L_{post} = relative post-development total phosphorus load (in lbs)
P = average annual rainfall depth (in inches)
= 40 inches for Northern Virginia area
= 43 inches for Richmond Metropolitan area
= 45 inches for Hampton Roads area
P_j = unitless correction factor for storms with no runoff = 0.9

FOR REDEVELOPMENT:

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

If the calculated number is less than or equal to zero, STOP. ***Note that in watersheds using the Tidewater weighted average, F_{VA} = 0.45 lbs/ac/yr, new single-family home parcels one acre or greater do not require BMPs.***

If no BMPS are required, the applicant need only submit documentation to support his or her findings. If such findings are found correct by local officials, the applicant has then satisfied the stormwater management criteria. The state Stormwater Management Law and the Erosion and Sediment Control Law also deal with other water resource related provisions, such as quantity-related requirements.

If removal efficiencies are required, continue on with **STEP SIX.**

STEP SIX: **Identify BMP options for the site.**

Best Management Practices (BMPs) can be used to remove pollutants. BMPs are not always structural. For instance, trash removal can drastically reduce the amount of solid wastes that reach our streams. However, for the purpose of this discussion BMPs will mean any structural or mechanical device capable of preventing or reducing the amount of pollution from nonpoint sources.

The use of certain BMPs may be limited on some sites by soils, topography, area and other physical characteristics. Most BMPs can only be applied under restricted site conditions. Improperly sited, a BMP cannot perform as designed and may become a chronic maintenance problem. A poorly maintained BMP may even contribute pollutants, e.g. an eroding pond embankment sends sediment into the receiving stream.

BMPs and their associated pollutant removal efficiencies are shown in Table 2. This list is by no means a complete listing of available BMPs, nor does appearance on this list indicate appropriateness for a given situation.

Endnotes

[1] Chesapeake Bay Local Assistance Board, Final Regulations: VR 173-02-01 ***Chesapeake Bay Preservation Area Designation and Management Regulations***. September 1989.

[2] Thomas R. Schueler, ***Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*** (Washington, D.C.: Metropolitan Washington Council of Government, Department of Environmental Programs, 1987), 1.4.

[3] Ibid, 1.9-1.13.

STRUCTURAL BMPs FOR CHESAPEAKE BAY PRESERVATION AREAS — TABLE 2

Acceptable BMP	Average Total P Removal Efficiency
A. Extended Detention	
(1) Design 2 (6-12):	20%
(2) Design 3 (24 hours):	30%
(3) Design 4 (shallow marsh):	50%
B. Wet Pond	
(1) Design 5 (0.5 in/imp.ac):	35%
(2) Design 6 (2.5 V_r):	40-45%
(3) Design 7 (4.0 V_r):	50%
C. Infiltration	
(1) Design 8 (0.5 in/imp. ac):	50%
(2) Design 9 (1.0 in/imp. ac):	65%
(3) Design 10 (2-year storm):	70%
D. Grassed Swale	
(1) Design 15 (check dams):	10-20%

These designs are taken from Metropolitan Washington Council of Governments, *Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMPs*, ,1987

Effeciency ratings are taken from John P. Hartigan, P.E., *Three Step Process for Evaluating Compliance with BMP Requirements for Chesapeake Bay Preservation Areas*, 1990

WORKSHEET A : NEW DEVELOPMENT *Option One: Locally Designated Watersheds*

5 **Calculate the pre-development load (L_{pre}).**

L_{pre} = $P \times P_j \times [0.05 + (0.009 \times I_{watershed})] \times C_{pre} \times A \times 2.72 / 12$

= _____ $\times 0.9 \times [0.05 + (0.009 \times$ _____ $)] \times$ _____ $\times$ _____ $\times 2.72 / 12$

= __________ pounds per year

6 **Calculate the post-development load (L_{post}).**

L_{post} = $P \times P_j \times [0.05 + (0.009 \times I_{site})] \times C_{post} \times A \times 2.72 / 12$

= _____ $\times 0.9 \times [0.05 + (0.009 \times$ _____ $)] \times$ _____ $\times$ _____ $\times 2.72 / 12$

= __________ pounds per year

7 **Calculate the pollutant removal requirement (RR).**

RR = $L_{post} - L_{pre}$

= __________ - __________

= __________ pounds per year

To determine the overall BMP efficiency required (%RR) when selecting BMP options:

%RR = $RR / L_{post} \times 100$

= (_____ / _____) $\times$ 100

= __________ %

WORKSHEET A : NEW DEVELOPMENT

OPTION TWO: VA. CHESAPEAKE BAY DEFAULT

5 **Calculate the pre-development load (L_{pre}).**

L_{pre} $= P \times P_j \times [0.05 + (0.009 \times I_{watershed})] \times C_{pre} \times A \times 2.72 / 12$

$=$ _____ $\times 0.9 \times [0.05 + (0.009 \times$ _____ $)] \times 0.26 \times$ _____ $\times 2.72 / 12$

$=$ _________ pounds per year

6 **Calculate the post-development load (L_{post}).**

L_{post} $= P \times P_j \times [0.05 + (0.009 \times I_{site})] \times C \times A \times 2.72 / 12$

$=$ _____ $\times 0.9 \times [0.05 + (0.009 \times$ _____ $)] \times 0.26 \times$ _____ $\times 2.72 / 12$

$=$ _________ pounds per year

7 **Calculate the pollutant removal requirement (RR).**

RR $= L_{post} - L_{pre}$

$=$ _________ - _________

$=$ _________ pounds per year

To determine the overall BMP efficiency required (%RR) when selecting BMP options:

%RR $= RR / L_{post} \times 100$

$=$ (_____ / _____) $\times 100$

$=$ _________ %

WORKSHEET C: COMPLIANCE

Select BMP options using screening tools and list them below. Then calculate the load removed for each option. DO NOT LIST BMPs IN SERIES HERE.

1

Selected Option	Removal Efficiency (%/100)	×	Fraction of CBPA Drainage Area Served (expressed in decimal form)	×	L_{post} (lbs/yr)	=	Load Removed (lbs/yr)
________	________		________		________		________
________	________		________		________		________
________	________		________		________		________

2a **Estimate parameters for non-CBPA drainage areas on the project site (if the locality does not require complete compliance for the whole site). If the locality requires compliance for the whole site, omit this step.**

A (on site, non-CBPA) = ________ acres

I_a: structures = ________ acres

parking lot = ________ acres

roadway = ________ acres

other = ________ acres

= ________ acres

= ________ acres

total I_a = ________ acres

$I = (\text{total } I_a / A) \times 100$ = ________ %

$R_v = 0.05 + (0.009 \times I)$ = ________

C: $I \geq 20 = 1.08$ mg/l = ________ mg/l

$I < 20 = 0.26$ mg/l

When using Virginia Chesapeake Bay Default (F_{V_a} = 0.45 lbs/ac/yr), C=0.26 mg/l for all I_{site}.

2b **Calculate post-development load for on-site non-CBPAs.**

$L_{post(outside)} = P \times P_j \times R_v \times C \times A \times 2.72 / 12$

$= \_\_\_\_ \times 0.9 \times \_\_\_\_ \times \_\_\_\_ \times \_\_\_\_ \times 2.72 / 12$

= ________ pounds per year

ATTACHMENT A

Many different pollutants can be identified in our streams and water bodies. The Regulations merely require the control of "nonpoint source (nps) pollution." The Model Ordinance defines NPS as pollution consisting of constituents such as sediment, nutrients, and organic and toxic substances from diffuse sources. Trying to deal with all the possible pollutants would make any calculation procedure complicated and expensive. To simplify the calculations needed, a "keystone" pollutant can be selected. A keystone pollutant shares the general characteristics of most other pollutants. By removing the keystone pollutant, other important pollutants will be simultaneously removed. Chapter 2 of *A Framework for Evaluating Compliance with the 10% Rule*[1] reviews each of the major pollutants found in urban runoff for their suitability as the keystone pollutant, based on the following three criteria:

1. The pollutant must have a well-defined adverse impact on the Chesapeake Bay.

2. The pollutant should exist in a "composite" form, i.e. in a roughly equal split between particulate and soluble phases.

3. Enough research data must be available to provide a reasonable basis for estimating how keystone pollutant loads change in response to development and to current stormwater control measures.

The only urban pollutants that appear to meet all three criteria for suitability as a keystone pollutant are: total phosphorus, total nitrogen and zinc (Table 3). Of these three, total phosphorus exists in the most equivalent proportions of soluble and particulate forms (40/60). Total nitrogen and zinc are less proportionate, at 20/80 and 25/75, respectively.

TABLE 3

Pollutant	Well-Defined Impacts on the Bay?	Composite Form?	Adequate Data?
Sediment	yes	no	no
Total Phosphorous	yes	yes	yes
Total Nitrogen	yes	yes	yes
Coliform Bacteria	yes	no	no
BOD/COD	yes	yes	no
Oil/Grease	yes	no	no
Zinc	yes	yes	yes
Lead	yes	no	yes
Toxics	no	no	no

ATTACHMENT B

The Regulations require new development stormwater management criteria be based on "average land cover conditions." Watershed designations serve as the baseline for a calculation procedure and do not constitute an additional regulatory step. Localities will have two options:

1. A locality will designate watersheds within its jurisdiction and calculate the average phosphorus loading and impervious cover for each individual watershed, or

2. A locality will declare its entire watershed as part of Virginia's Chesapeake Bay watershed with an average phosphorus loading of 0.45 pounds/acre/year and impervious cover of 16 percent.

A locality may begin with Option Two while they gather the necessary data for Option One. Figure 1 shows how Fairfax County could break up its watersheds. This discussion revolves around Option One. Option Two is discussed in Attachment C.

To determine average land cover conditions within a watershed, the locality must follow a three-step procedure:

1. **Evaluate individual watersheds.** We recommend a minimum watershed area of 100 acres. Localities may wish however, to use watershed delineations used for other aspects of its work, e.g. a sanitary sewer master plan.

2. **Know existing land use data.** The Regulations are based on present land uses, not proposed land uses. A comprehensive plan is more future oriented than a zoning map. Still, a zoning map does not always indicate present use. A locality may also be able to use current aerial photographs. Data may be cross-referenced with Commissioner of Revenue information.

3. **Compute a weighted average of impervious cover (or its equivalent).** The Simple Method (and the nonpoint source pollution load) is highly dependent on the percent of impervious cover. Some land uses contribute nonpoint source pollution but do not have "impervious covers," e.g. forest and agriculture lands. Therefore, conversions, or equivalents, must be determined. Use Table 1 to find equivalent loading/impervious factors for non-urban uses. Localities may use other documented loading factors, especially if found to be more appropriate to that locality, as long as the factors are used consistently.

   Weighted averages are frequently computed for quantity related analyses and this process is identical. Figure 2 shows how average land cover conditions might be calculated for a 100-acre watershed.

CALCULATING AVERAGE LAND COVER CONDITIONS

FIGURE 2

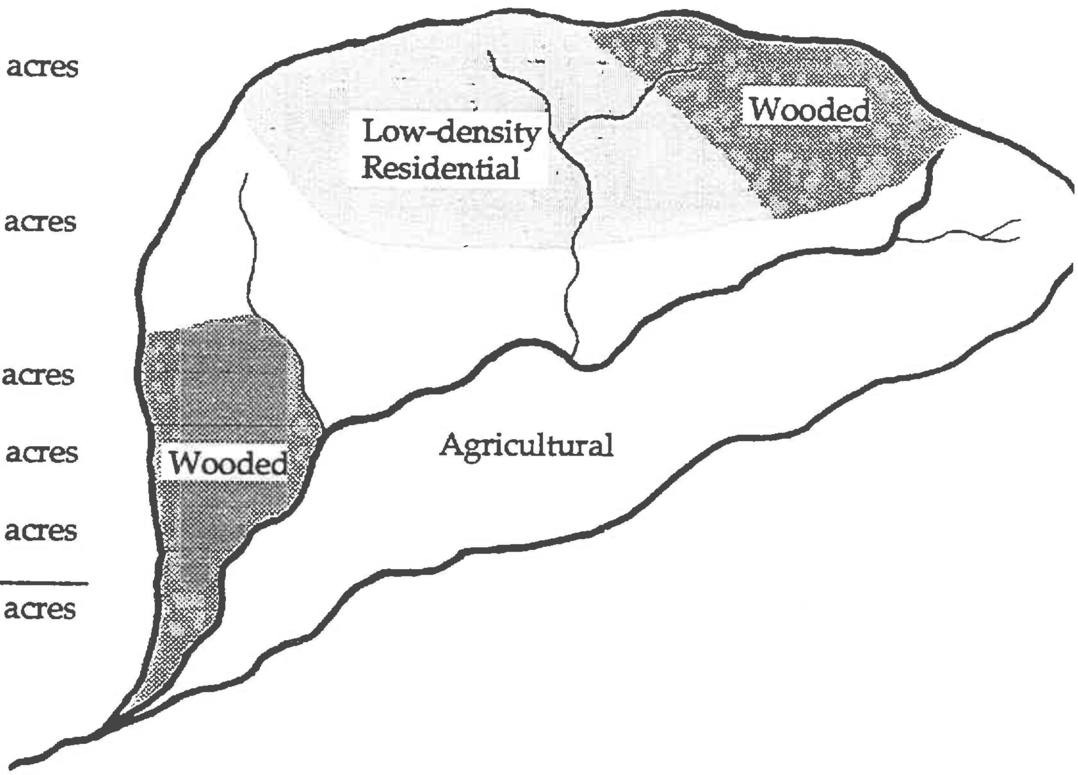
100 acre Watershed

Wooded = 20 acres

Low-density Residential = 20 acres
(1-acre lots)

Agriculture
Pasture = 30 acres
Conservation tillage = 15 acres
Conventional tillage = 15 acres

Total acreage 100 acres



Land Use	Loading: * lbs/acre/year	# of Acres	Weighted Load: lbs/year
Wooded	0.12	20	2.4
1-acre lots	0.42	20	8.4
Pasture	0.59	30	17.7
Conventional	2.42	15	36.3
Conservation	1.52	15	22.8
		100	87.6

* Phosphorous; based on rainfall of P=43 inches/year and loam soils.

$$\Sigma = \frac{\text{Sum of weighted loadings}}{\text{total acreage}}$$

$$= \frac{0.12(20) + 0.42(20) + 0.59(30) + 2.42(15) + 1.52(15)}{20 + 20 + 30 + 15 + 15} = \frac{\text{88 lbs per year}}{\text{100 acres}} = \text{0.88 lbs per acre per year}$$

Equivalent Impervious Cover = $I_{watershed}$ = 19

Therefore, the default load for Virginia's Chesapeake Bay watershed is 0.45 lb/ac/yr with an equivalent impervious cover of 16 percent. Localities are encouraged, but not required, to customize this aspect of the procedure, even if computing individual watersheds is not feasible. The Town of Herndon might use $I_{VA} = 18$, Caroline County might use $I_{VA} = 17$ and Isle of Wight County would retain $I_{VA} = 16$.

Virginia Land Use Data

Figure 3

River Basin	total area (sq.mi.)	% URB	URB area (sq.mi.)	% FOR	FOR area (sq.mi.)	% PAST	PAST area (sq.mi.)	% CST	CST area (sq.mi.)	% CVT	CVT area (sq.mi.)
Potomac	14670	7	1027	56	8215	26	3814	7	1027	4	587
Rappahannock	2630	1	26	64	1684	20	526	8	210	7	184
York	2980	0.2	6	70	2090	13	388	10.1	302	6.7	200
James	10495	3	315	73	7661	14	1469	6	630	4	420
Eastern Shore	1000	1.5	15	50	500	805	85	9	90	31	310
Total (w/urban)	31781	5	1389	63	20150	20	6286	7	2259	5	1701
Total (w/o urban)	30398	n/a	n/a	66	20150	21	6286	7	2259	6	1701

URB = urban land uses
FOR = forest cover
PAST = pasture land
CST = conservation till acreage
CVT = conventional till acreage

Source: Commonwealth of Virginia, Council on the Environment, ***Virginia's Chesapeake Bay Initiatives: First Annual Report*** (Richmond, Va.: Council on the Environment, 1985).