MAINE STORMWATER MANAGEMENT DESIGN MANUAL

Phosphorus Control Manual
Volume II

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MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
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Volume II - Phosphorus Control Manual

Chapter 1 Introduction

Phosphorus is a nutrient that controls the level of algae production in lakes. Algae are microscopic organisms that grow suspended in the open water of the lake or in concentrated clumps around the shallow margins of the lakeshore. The amount of algae in the lake water affects the clarity of the water, as well as the amount of well oxygenated, cold water available to cold water fish species (trout and salmon) in the summer months. Low phosphorus concentrations yield clear lakes with plenty of deep, well oxygenated cold water. High phosphorus concentrations yield cloudy lakes and oxygen may be severely depleted or eliminated from the deep, cold water in the summer months. Very high concentrations cause dense blooms of blue-green algae, which turns the water a murky green and accumulate as an odorous scum along the shoreline (for more information about lakes and phosphorus see Appendix A).

Excess Phosphorus Levels in a Lake Can Cause Dense Blooms of Blue-Green Algae which Cause:
- Murky green water
- Odors
- Depleted oxygen levels in the deep, cold water which can lead to fish kills

Phosphorus, a common nutrient typically associated with soil particles and organic matter, mostly reaches the lake in stormwater runoff from the lake's watershed, the land area draining to the lake. Since the portion of stormwater phosphorus that support algae growth tends to be associated with small, lightweight soil particles, it is easily carried by stormwater and can be delivered to the lake from anywhere in the watershed.

The amount of phosphorus reaching the lake depends on what the stormwater runs over on its way to the lake. For example, forested areas do not readily release phosphorus to stormwater due to duff and canopy coverage whereas developed areas, such as residential, commercial or industrial areas, contain high levels of phosphorus, which are readily released to stormwater runoff, yielding higher lake concentrations. Generally speaking, the more developed a lake's watershed is, the higher its phosphorus concentration will be (for more information about phosphorus sources and transport see Appendix A).

High phosphorus levels in lakes cause dense algae blooms, which can accumulate along the shoreline as shown above.

This volume addresses long-term phosphorus loadings to lakes by setting standards to limit phosphorus contributions from new developments, and outlines guidelines to meet these standards. It does not address the short term, often catastrophic, increase in stormwater phosphorus that can result from unmitigated soil erosion during the construction process (see Maine DEP Erosion and Sediment Control BMPs for information about addressing erosion from construction sites).

The standards in this volume focus on limiting, not preventing, phosphorus contributions from new developments to lakes and they are not likely to be applied to all new phosphorus sources in a lake's watershed. As such, the implementation of stormwater management alone may not be sufficient to prevent a noticeable decline in lake water quality. To effectively maintain lake water quality, the elimination of existing significant sources of phosphorus would be necessary.

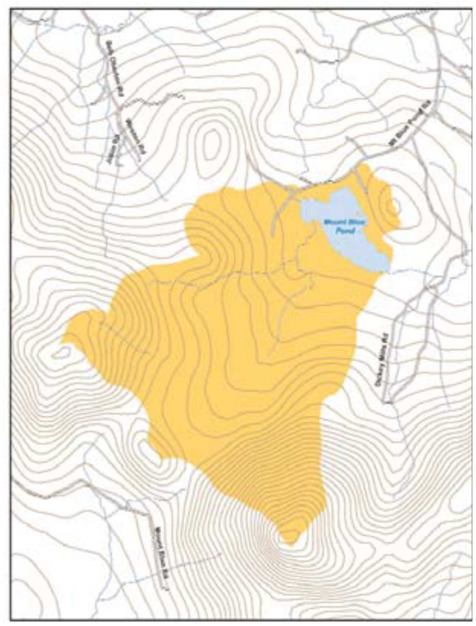
Chapter 2 of this volume presents the basic phosphorus standard for new development. Chapters 3 through 6 present a procedure for new developments to meet the standard that can be used by developers and reviewing agencies (i.e. planning board). The Appendices provide detailed supporting information.

Chapter 2 - The Watershed Phosphorus Budget

Lakes are individuals, each one differing from the others with varying size, shape and depth. Specific lake characteristics will affect the way a lake will respond to additions of phosphorus.

> Lakes can only accept so much phosphorus before a significant decline in water quality occurs.
> The Maine Department of Environmental Protection has developed phosphorus allocations for several Maine lakes to minimize phosphorus loadings and their impacts to lake water quality.

The watersheds draining to lakes also vary as they can be large or small relative to lake size and can contribute relatively large or small volumes of stormwater and groundwater to the lake. The watershed can be entirely upland or it may contain a number of upstream lakes and wetlands. It may contain steep slopes and hilly terrain, or be relatively flat. Soils may range from loose sands or gravels to tight clays or shallow tills. Watersheds can range from completely forested to highly agricultural or heavily developed, and may be located in areas ranging from little to rapid growth. These factors, along with the characteristics of the lake itself, determine the potential for increased phosphorus, and hence algae, in the lake over time. This chapter describes how to estimate the amount of additional stormwater phosphorus load to the lake, called phosphorus export that will be generated as a result of the project. It applies to commercial development projects and to subdivisions involving new road construction or expansion, or having more than five lots.



A lake's watershed boundary is dictated by local topography, generally following ridgelines or high points as shown by the shading above. Precipitation that falls within the watershed and is not 'evapo-transpired' reaches the lake as groundwater or stormwater runoff. The watershed and lake characteristics dictate the potential for increased phosphorus and algae in the lake over time.

2.1 - Watershed Per-Acre Phosphorus Allocation

The Department of Environmental Protection (DEP) has considered all of the factors described above in developing phosphorus budgets for the watershed of each lake. Each budget is based on how much additional phosphorus loading the lake could accept without risking a perceivable change in the lake's water quality. It then distributes this additional phosphorus load amongst anticipated new development sources in the lake's watershed on a per acre basis. The per acre phosphorus allocation (referred to as "P") defines how much phosphorus each acre of land in a lake's watershed is allowed to discharge in stormwater runoff when developed.

If a lake's watershed is located within more than one town, the value of P may vary slightly for each town, depending on its anticipated rate of growth. The process used to define watershed phosphorus budgets is presented in Appendix B.

For large subdivisions and commercial developments (Chapter 3), P defines the average amount by which a development may increase the annual stormwater phosphorus exported to the lake from each acre of the parcel being developed.

For small projects, such as single family residences and additions to existing development (Chapter 6), the budget simply defines the type and size of phosphorus runoff controls, such as wooded buffers, which should be applied. Phosphorus allocation values range from about 0.02 lb/acre/year for very sensitive lakes in high growth areas to 0.15 lb/acre/year for less sensitive lakes in very low growth areas.

P = Per Acre Phosphorus Allocation (lb/acre/year) = the watershed specific amount of stormwater phosphorus each acre of land within a parcel that is being developed is allowed to export annually. This is calculated by the DEP for selected Maine lakes as presented in Appendix C.

If a P for a lake/town combination is not listed or if you have information that suggests the P for a lake should be higher or lower than that presented in Appendix C, contact DEP's Division of Watershed Management.

2.2 - Project Phosphorus Budget (PPB)

A project's phosphorus budget (PPB) is the maximum amount of algal available phosphorus, which in a typical year, may be exported from the new development. Algal available phosphorus refers to that portion of phosphorus the stormwater runoff transports which can support algae growth in the lake. Typically about half of the total amount of phosphorus becomes available for algal growth.

PPB = Project's Phosphorus Budget = maximum amount of algal available phosphorus, which in a typical year, may be exported from the new development’s parcel.

To calculate the PPB, multiply the acreage of developable land in the project parcel by the per-acre phosphorus budget for the lake.

The developable land area includes all land within the parcel's boundaries except for NWI (National Wetlands Inventory) mapped wetlands over an acre in size and areas of sustained slope greater than 25% that are over one acre in size.

All areas need to be in acres to the second decimal place.

Use Worksheet 1 in Appendix D for calculating project phosphorus budgets.

Special Considerations: Alternative method for small commercial-type development located within designated growth areas. It can be difficult for densely developed projects on small parcels to meet their phosphorus budgets.

Because of the density of high phosphorus producing surfaces like parking lots and lawns, the stormwater draining these projects carries relatively large amounts of phosphorus. The small parcel size, however, means that the phosphorus budget for the parcel will also be small. As a result, highly intensive phosphorus control measures, which are often fairly costly, may be required for the project to meet its phosphorus budget.

In these cases it may cost less to develop outside the designated growth area where land is more readily available for larger parcel sizes (and hence larger project phosphorus budgets) and for less intensive, and less expensive, phosphorus control measures like natural wooded buffers. If a municipality is concerned that the phosphorus budget will counter local planning efforts by being a disincentive for locating development within designated growth areas, they may request that the department allow commercial developers within their designated growth areas to use an alternative means of defining the project phosphorus budget. This alternative is described in Appendix E.

Example 1: PPB Calculation for Subdivision Development

<u>Problem:</u> 'Homesweet Home Subdivision' is proposing a 12-lot subdivision on 40 acres. There are four acres of NWI wetlands and 1 acre of steep slopes. Calculate the PPB.

<u>Solution:</u> Use Worksheet 1 to calculate the PPB.

WORKSHEET 1 - PPB CALCULATIONS			
Project Name:	**Homesweet Home Subdivision**		
Standard Calculations			
Watershed per acre phosphorus allocation (Appendix C):	P	0.057	lbs/acre/year
Total acreage of development parcel	TA	40.00	acres
Existing impervious area (Pre 1980)	EIAB	0.00	acres
Existing impervious area (post 1980)	EIAA	0.00	acres
NWI wetland acreage:		4.00	acres
Steep slope acreage:	SA	1.00	acres
Project acreage:	A	35.00	acres
Project Phosphorus Budget:	PPB	1.995	lbs P/year

Based on these calculations, the PPB is 1.995 lbs P/year.

Project phosphorus budgets for large projects located within relatively small watersheds.
If a particularly large project is proposed in a relatively small watershed, there is a chance that the project's phosphorus budget may, by itself, use up most of, or even exceed, the watershed's total phosphorus budget, leaving little or no room for additional development within the watershed. In order to avoid this problem, an alternative method for calculating the project phosphorus budget for such projects is provided in Worksheet 1 under Small Watershed Adjustment. For each lake, DEP has identified the parcel size that would trigger use of this alternative method, called the small watershed threshold. If a project's parcel size exceeds the small watershed threshold (SWT) acreage given for each lake in the list of per acre phosphorus budgets in Appendix C, the PPB should be calculated using the Small Watershed Adjustment calculations in Worksheet 1.

Chapter 3 - Meeting the Project's Phosphorus Budget

To determine if a project meets or exceeds its PPB, the project's phosphorus export (PPE) needs to be estimated. This section outlines the procedure for estimating the pre-treatment PPE (Pre-PPE), that is, the phosphorus export from the project before passing through a stormwater management practice designed to remove phosphorus (i.e. buffers, wet ponds). Estimating post treatment phosphorus export will be discussed in the next section.

PPE = Project Phosphorus Export = amount of phosphorus that will reach the lake from a new development.

Pre-treatment PPE = Raw Phosphorus that the new development will create.

Post-treatment PPE = Phosphorus that will be discharged after treatment by all stormwater management treatment practices.

A site's phosphorus export must be calculated and compared to the Project Phosphorus Budget (PPB) to determine the extent of phosphorus reductions needed and the best method for achieving these reductions.

For all project development and subdivisions projects where the land use and impact has been determined and lot development will be restricted, the pre-treatment export is estimated by:

1. Dividing the project into various land use types (i.e. parking, roads, roofs, lawns by soil type),
2. Determining the area within each land use in acres and to the second decimal place,
3. Multiplying that area by the appropriate phosphorus export factor from Table 3.1 or Table 3.2 as is appropriate, and
4. Summing the resulting phosphorus exports to get the Pre-PPE.

Use the first four columns in Worksheet 2 in Appendix D to calculate the Pre-PPE.

The amount of phosphorus exported from a project site will depend on the land use and soil type, with greatest exports from impervious surfaces as the one shown here.

Table 3.1 gives pre-treatment phosphorus export for new commercial/industrial development and for roads in residential subdivision projects. Table 3.2 should be used for lots in residential subdivisions unless the dimensions and locations of buildings, driveways and lawns have been pre-determined, specifically restricted, and all construction and landscaping on the lot will be done by the developer, in which case the High Export Option from Table 3.1 may be used.

Table 3.2 gives pre-treatment phosphorus export for single family residential lots. In most cases, the specific area of the development on a lot (houses, garages, driveways, lawns) within the subdivision is usually not known. Table 3.2 must be used to determine the export from each lot unless the developer:

- Has pre-determined the area of each land use on each lot
- Will be constructing the buildings and driveways and landscaping the lots, and
- Will be restricting any further expansion of these land uses. A deed restriction will be required for each lot that incorporates an area restriction.

The Low Export Option factors may be selected for commercial/industrial development and roads if all of the following are incorporated in the project:

- A deed restriction prohibiting the use of fertilizers containing phosphorus except when establishing new turf or vegetation on bare soil will be established for all lots. It is recommended that the use of fertilizer containing phosphorus always be limited.
- All roads, driveways and parking areas are paved.
- All ditches and drainage ways are designed, constructed and maintained as stable vegetated swales in accordance with the specifications in Volume III, Chapter 9, or as riprapped swales where required by steep slopes. The algal available phosphorus export for ditches and swales is based on soil type and is the same as the export from a lawn.

If all of these elements are not clearly and permanently incorporated in the project design, use the High Export Option factors of Table 3.1.

Table 3.1

Algal Available Phosphorus Export (pre-treatment) for Commercial Development and Subdivisions

		Low Export Option	**High Export Option**
Land Use	Hydrologic Soil Group	P Fertilizers restricted, roads and drives paved and constructed with stable swales (lb/acre/yr)	No restrictions on fertilizer use, road surface or ditch design and construction (lb/acre/yr)
Landscaped Areas, Lawns & Ditches	A	0.1	0.2
	B	0.2	0.4
	C	0.3	0.6
	D	0.4	0.8
Roads/Driveways	N/A	1.25	1.75
Parking	N/A	1.25	1.25
Roofs/Other	N/A	0.5	0.5
Riprap/crushed rock	N/A	0.3	0.6

Table 3.2 Algal Available Phosphorus Export from Single Family Residential Lots (pre-treatment)				
Hydrologic Soil Group	**With Area Restrictions**		**Without Area Restrictions**	
	Cleared Area < 12,000 sq ft Driveway/Park < 1,750 sq ft (lb/lot/year)		No Restriction on cleared area or driveway/parking area (lb/lot/year)	
	w/ 75% drive/park area to buffer	w/o 75% drive/park area to buffer	w/ 75% drive/park area to buffer	w/o 75% drive/park area to buffer
A	0.09	0.14	0.12	0.18
B	0.12	0.17	0.17	0.24
C	0.15	0.20	0.22	0.29
D	1.08	0.23	0.27	0.34

Note: Driveways and parking are considered to be draining directly to a buffer if the flow path to the buffer is 50 feet or less and if the runoff reaches the buffer in well distributed overland flow.

Note: phosphorus export values in this table assume a driveway of 150 feet in length, or less. If driveways will likely exceed 150 feet, the excess driveway length should be considered a road and its export calculated using Worksheet 2 and Table 3.1.

Example 2: Pre-treatment PPE Calculation for Commercial Development

Problem: 'Good Intention Business Mall' is proposing a business mall on 6 acres. The development will consist of 3.5 acres of paved parking; a 0.5 acre paved access road, 1.5 acres of buildings and 0.5 acre of lawn. A deed restriction is proposed, prohibiting the use of fertilizers containing phosphorus. Soils on the site are classified as Hydrologic Soil Group C. Calculate the pre-treatment PPE for the proposed project.

Solution: Use Table 3.1 and Worksheet 2 to calculate the pre-treatment Algal Average Phosphorus Export.

Worksheet 2 Pre-PPE Calculations			
Project Name: Good Intention Business Mall		Development Type: Commercial	
Land Surface Type of Lot #(s) with description	**Acres or # of lots**	**Export Coefficient** from Table 3.1	**Pre-treatment Algal Av. P Export** (lbs P/year)
Parking (pavement)	3.50	1.25	4.375
Access Road (low export)	0.50	1.25	0.625
Buildings	1.50	0.50	0.750
Lawn	0.50	0.30	0.150
		Pre-PPE (lbs P/year)	5.900

Based on these calculations, the pre-treatment PPE is 5.9 lbs P/year.

Example 3: Pre-PPE Calculation for Subdivision Development

Problem: The 'Homesweet Home Subdivision' in Example 1 involves the development of 12 lots and 0.5 acres of road. Four lots will be constructed on HSG B soils with no restrictions on cleared area or driveway/ parking area. Eight of the lots will be constructed on HSG C soils and will have restrictions to minimize site clearing to <12,000 square feet each and to minimize driveway/parking areas to <1,750 square feet. Six of the restricted lots will not direct 75% of the driveway and parking area runoff to a buffer. Two of the restricted lots will direct the stormwater runoff from 75% or more of the driveways and parking areas to a buffer. Driveways from two of the lots will exceed 150 feet in length, with an anticipated 0.056 acres of driveway over the 150 length. The proposed road will be paved. Calculate the pre-treatment PPE for the proposed subdivision.

Solution: Use Tables 3.1 and 3.2 and Worksheet 2 to calculate the pre-treatment Algal Average Phosphorus Export.

Worksheet 2 Pre-PPE Calculations			
Project Name: Homesweet Home		Development Type: Residential	
Land Surface Type of Lot #(s) with description	**Acres or # of lots**	**Export Coefficient** from Table 3.1	**Pre-treatment Algal Av. P Export** (lbs P/year)
Lots 1-4 (HSG B) no restriction, w/o 75% to buffer	4	0.24	0.96
Lots 5-10 (HSG C) <12,000 sqft clearing, w/o 75% to buffer	6	0.20	1.2
Lots 11 & 12 (HSG C) <12,000 sqft clearing, w/ 75% to buffer	2	0.15	0.30
Lots 2 & 3 driveway access > 150 feet	0.056	1.25	0.07
Subdivision Road (low export)	0.50	1.25	0.625
		Pre-PPE (lbs P/year)	3.155

Since two of the driveways exceeded 150 feet in length, the excess driveway length was considered a road and its export calculated as such.

Based on these calculations, the Pre-treatment PPE is 3.155 lbs P/year.

3.1 - Redevelopment or Expansion of Existing Uses

Phosphorus export need not be estimated for any land uses that were in existence prior to 1997 (prior to 1980 for projects that require a Site Location of Development Act (SLODA) Permit from the DEP). For any proposed project that will be built within a parcel having existing development (built before 1997 or 1980 for SLODA projects) that will be enlarged, upgraded or expanded, the phosphorus export should only be estimated for the net increase. This would apply to the redevelopment or expansion of any existing buildings, parking, roads and lawns. Any existing development or land disturbance that was created after 1997 (1980 for SLODA Projects) must be included as a new phosphorus export. This includes logging roads, new access roads, and all other projects created from an undisturbed condition that did not require a phosphorus design and permit at the time of construction.

For example, if a proposed subdivision is served by an existing 2000 foot gravel road, which was built before 1997, and will be upgraded and expanded from a width of 14 feet to a width, with shoulders, of 24 feet, the phosphorus export should only be estimated for the net increase in road area, or 10 feet x 2000 feet = 20,000 square feet.

3.2 - Reduction of Phosphorus Export

Most projects will generate more phosphorus than the project's phosphorus budget (PPB) will allow. In order to meet the budget, the excess phosphorus export must be reduced. Comparison of the pre-treatment PPE with the PPB will determine how much export will need to be reduced. This section describes options for reducing phosphorus export and how to estimate phosphorus export after treatment. There are two basic options for reducing long term phosphorus export.

Option 1. Redesign to Reduce Phosphorus Export: The first option is to redesign the project so that initial phosphorus export is minimized. This can be accomplished by:

- Limiting the size or intensity of the project (i.e. reducing the number of lots, the length of roads, the size of a parking area),
- Locating the developed portion of the project on the best soils and shallowest slopes, and
- Incorporating such measures as clearing restrictions and limitations on the use of phosphorus fertilizers.

These reductions in phosphorus export will be reflected in the calculation of pre-treatment PPE described in the previous section.

Option 2. Implement Best Management Practices (BMPs): The second option for reducing a project's stormwater phosphorus export is to incorporate stormwater best management practices (BMPs) to remove phosphorus from the stormwater before it leaves the site. Some examples of BMPs are vegetated buffer areas, wet ponds, soil filters and infiltration beds. Volume III presents detailed design standards for a number of commonly used BMPs.

All BMPs are not created equal. Some BMPs do a better job of removing phosphorus from stormwater than others. Also, within a given type of BMP, differing designs or locations may result in different levels of effectiveness is removing phosphorus. For example, a broad, wooded buffer on permeable soils with a shallow slope will retain much more phosphorus than a narrow, field buffer on tight soils and steeper slopes. For stormwater treatment ponds, such as wetponds, the size of the pond relative to its contributing watershed, its depth, and its shape determine its effectiveness.

In this Volume, a BMP's effectiveness in treating stormwater runoff is described in terms of a "treatment factor". The Treatment Factor (TF) indicates the fraction of stormwater phosphorus that will pass through the BMP and not be retained. For example, if a wooded buffer was projected to retain 60% and discharges 40% of the inflow phosphorus, it would have a treatment factor of 0.4 and a removal efficiency of 0.6. A simple way of estimating treatment factors for a variety of BMPs based on an adjustment of the standard sizing specifications for BMPs described in Volume III of this manual is presented in Chapter 4 of this volume.

When planning the project, the project designer should look for opportunities to locate the most effective BMPs (those with the highest removal efficiency) to collect runoff from the portions of the project which produce the most phosphorus export (i.e. roads, parking areas, driveways, house lots). If the project site is large enough, the preferred BMP is a natural wooded buffer area located immediately downhill of the stormwater source area. Buffers are preferred because they are natural and they require little, if any, maintenance (just don't cut the trees or disturb the ground cover). The critical element in siting buffers is to insure that the stormwater runoff enters the buffer in overland, non-channelized flow that will not concentrate into a channelized flow within the buffer. By comparison, other BMPs require site specific design and careful construction as well as regular inspection and maintenance.

RE = Removal efficiency = The fraction of stormwater phosphorus that will be removed by the BMP. The higher the removal efficiency, the more effective it will be at retaining phosphorus from reaching the resource.

TF= Treatment factor = (1.0 - RE) = The fraction of the stormwater phosphorus that will pass through a BMP and not be retained. The lower the treatment factor, the more effective the BMP.

When phosphorus from a project draining to a BMP is multiplied by that BMP's Treatment factor (1.0 - RE), the resulting product is the amount of phosphorus that, after treatment, will still be exported to the lake.

3.3 - Estimating Project Phosphorus Export after Treatment (Post-PPE)

In order to determine if the BMPs incorporated into the project are adequate to meet the PPB (Project Phosphorus Budget), the pre-treatment PPE must be revised to reflect the treatment capabilities of those BMPs. This is accomplished by multiplying the phosphorus export from each source area (i.e. a parking lot, a house lot, a segment of road) by the treatment factor (1.0 - RE) of the BMP to which it drains. See Section 4.1 BMP Rules of Thumb, if the individual source areas (or subcatchments) drain cumulatively to more than one BMP. The export values for all source areas, both treated and untreated, are then added together to get the total phosphorus export for the project using Worksheet 2.

For large projects or projects where the natural topography divides the site drainage into a number of sub-drainage areas, this process may not be as straight forward. For instance, often the entire length of a road will not drain to the same BMP. The local topography will result in one segment of road being treated by one BMP, other segments by other BMPs, and still other segments receiving no treatment at all. In the case of a crowned road, the uphill side of the road might drain to a road ditch that flows to a wet pond, while sheet runoff from the downhill side of the road may drain to a wooded buffer, which for part of the road length is 75 feet wide, meadow and on shallow slopes and for the remaining length is only 50 feet wide, wooded on steep slopes. Since all three BMPs, the wetpond and the two buffers, have different treatment factors, it is necessary to break the road surface area into three discreet subcatchments based on the BMP(s) to which each road segment drains to calculate treated phosphorus export from the road. This is true not only for roads but for all other types of development as well.

Summarize the project's phosphorus export and treatment as follows:

1. Show, on a topographic site plan, all the BMPs that will be incorporated into the project.
2. Delineate all subcatchments for which each BMP is providing treatment.
3. Identify all portions of the developed area (i.e. buildings, road segments, parking, lawns, house lots) which are being treated by a given BMP or combination of BMPs on Worksheet 2.
4. List on the worksheet each subcatchment and export area with the pre-treatment phosphorus export factor from Table 3.1 or Table 3.2 and the treatment factor(s) for the BMP(s) to which the area drains. If the runoff from a subcatchment receives no treatment, enter 1.0 in the treatment factor column.
5. BMP treatment factors and removal efficiencies can be calculated from Chapter 4 of this volume and Volume III. Enter these values on the worksheet.
6. Multiply each export area with its export factor and treatment factor to obtain the post-treatment phosphorus export value. For areas receiving no treatment, use a treatment factor of 1.0.
7. See "Section 4.1. BMP Rules of Thumb", if the source area drains to more than one BMP.
8. Sum the export from all treated and untreated areas to obtain the total post- treatment phosphorus export (Post-PPE) from the project.

3.4 - Evaluating Project Overall Phosphorus Export

For an acceptable site development, the Post- PPE needs to be smaller than the PPB for the parcel. The calculations can be summarized in Worksheet 4. If the resulting project phosphorus export (Post-PPE) is less than or equal to the project phosphorus budget (PPB) from Worksheet 1 than the project meets its budget. If not, further reductions in stormwater phosphorus are required. Credits for mitigation of existing sources may be another option for reducing the net project phosphorus export (Post-PPE) or paying a compensation fee may be an option (See Chapter 5, Credits for Mitigation and Compensation Fee for guidance).

Using Worksheet 4, summarize the Net Project Phosphorus Export as follows:

1. Bring in the Project Phosphorus Budget (PPB) from Worksheet 1
2. Bring in any Mitigation Credits from Worksheet 3
3. Bring in the total Pre-Treatment Phosphorus Export (Pre-PPE) as calculated on Worksheet 2
4. Bring in the total Post-Treatment Phosphorus Export (Post-PPE) as calculated on Worksheet 2
5. If the Post PPE is less than or equal to the site's PPB, the project meets its phosphorus budget.
6. If the Post-PPE is larger than the site's PPB but the Post-PPE is less than or equal to 0.4 times the Pre-PPE, then paying a compensation fee may be an option in certain lake watersheds. That list is available in Appendix F.
7. If the Post-PPE is larger than the site's PPB and the Post-PPE is more than 0.4 times the Pre-PPE, then more phosphorus treatment needs to be provided or less development must occur.

Example 4: Post-PPE Calculation for Subdivision Development

Problem: The 'Homesweet Home Subdivision' project described in Example 1 and 3 is proposing to treat a portion of the stormwater runoff from the subdivision through the use of buffers. Lots 1-4 will not receive any treatment. Lots 5 through 12, the excess driveway lengths from Lots 2 and 3, and the access road is super-elevated and will be directed to a downgradient buffer sized in accordance with Chapter 5 of Volume III of this manual. Calculate the post-treatment PPE for the proposed subdivision.

Solution: The pre-treatment PPE was calculated in Example 3. A forested buffer treating stormwater runoff that meets the standard sizing as provided in Chapter 5 of Volume III will achieve a Removal Efficiency of 0.6. Thus, the corresponding Treatment Factor is 0.4, which should be entered into Worksheet 2 as shown below. Note that 1.0 has been entered into the treatment factor column for lots 1 through 4 for which no BMPS are providing stormwater treatment.

Worksheet 2 Pre-PPE and Post-PPE Calculations						
Project Name: Homesweet Home Subdivision			Development Type: Residential			Sheet #
Land Surface Type of Lot #(s) with description	**Acres or # of lots**	**Export Coefficient from Table 3.1 Table 3.2**	**Pre-treatment Algal Av. P Export (lbs P/year)**	**Treatment Factor for BMP(s) from Chapter 6**	**Post-treatment Algal Av. P Export (lbs P/year)**	**Description of BMPs**
Lots 1-4 (HSG B) no restriction, w/o 75% to buffer	4.00	0.24	0.96	1.0	0.96	No treatment provided
Lots 5-10 (HSG C) <12,000 sqft clearing, w/o 75% to buffer	6.00	0.20	1,2	0.4	0.48	75 ft forest buffer
Lots 11 & 12 (HSG C) <12,000 sqft clearing, w/ 75% to buffer	2.00	0.15	0.30	0.4	0.012	75 ft forest buffer
Lots 2 & 3 driveway access > 150 feet	0.056	1.25	0.07	0.4	0.028	55 ft roadside forest buffer
Access Road (low export)	0.50	1.25	0.625	0.4	0.25	
		Pre-PPE (lbs P/year)	3.155	Post-PPE (lbs P/year)	1.838	

Based on these calculations, the Post-treatment PPE is 1.838 lbs P/year.

Example 5: Project Phosphorus Export Summary for Subdivision Development

Problem: Summarize the Project Phosphorus Export for the 'Homesweet Home Subdivision' project described in Example 1, 3 and 4. Determine whether the project as proposed meets its phosphorus budget.

Solution: Use Worksheet 4 to summarize the Project Phosphorus Export as shown below.

Worksheet 4 Project Phosphorus Export Summary			
Summarizing the project’s algal available phosphorus export (PPE)			
Project name: Homesweet Home Subdivision			
Project Phosphorus Budget	PPB	1.995	lbs P/year
Mitigation Credit - Source Elimination Credit	SEC	0.00	lbs P/year
Source Treatment Credit	STC	0.00	lbs P/year
Total Phosphorus Mitigation Credit (SWC+STC)	TMC	0.00	lbs P/year
Total Pre-treatment Phosphorus Export Worksheet 2	Pre-PPE	3.155	lbs P/year
Total Post-treatment Phosphorus Export Worksheet 2	Post-PPE	1.838	lbs P/year
Project Phosphorus Export (Post-PPE - TMC)	PPE	1.838	lbs P/year

Since the calculated PPE of 1.838 lbs P/year is less than the PPB of 1.995 lbs P/year, the project meets its phosphorus budget and no further treatment or reduction actions are necessary.

Chapter 4 - Treatment Factors for Phosphorus BMPs

This chapter presents the treatment factors that the Department recommends using for the design of a variety of phosphorus control BMPs.

IMPORTANT:
Best Management Practices (BMPs) must be designed to meet the required phosphorus reductions based on the Project Phosphorus Budget (PPB). The lowest maintenance BMP that meets the PPB should be selected.

4.1 - Rules of Thumb for BMP Selection

Consider these rules before selecting a BMP:

1. **Given a choice, select the lowest maintenance BMP that will provide the required phosphorus removal.** For example, natural wooded buffers require much less long term inspection and maintenance than most other BMPs, so, if space and topography allow, buffers are the preferred BMP.
2. **The buffer and source area (lawn, parking lot, etc.) should be laid out for runoff to pass in non-channelized sheet flow from the source area and be evenly distributed across the face of the buffer.** If this design is not possible, runoff may first be concentrated and then redistributed into the buffer using a level spreader or ditch turnout, but care must be taken not to hydrologically overload the buffer and to maintain the level spreader (see design standards for level lip spreaders in Volume III, Chapter 9).

Natural wooded buffers are preferred over other BMPs due to their low maintenance.

4.2 - Common BMPs and their Standard Sizing

Volume III of this manual, BMP Technical Design Manual, presents the standard designs for the most commonly used BMPs. These standard BMP designs are sized to provide retention of approximately 60% of the annual stormwater phosphorus export, and thus would have a treatment factor of 0.40. The standard sizing of these BMPs is as follows:

- ***Wetponds*:** Standard sizing for wet ponds requires a storage volume below the permanent pool elevation of at least 2.0 inch of runoff times the subcatchment's impervious area plus 0.8 inch of runoff times the subcatchment's non-impervious developed area. The pond must have a mean depth of at least three feet, and a length to width ratio of 2:1 or greater. See Chapter 4 of Volume III.
- ***Underdrained vegetated soil filter or other approved filter:*** Standard sizing for filters requires storage of a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's non-impervious developed area. Filter examples are underdrained vegetated soil filters having a single outlet with a diameter no greater than eight inches, or proprietary filter systems approved by the department. See Chapter 7 of Volume III.
- ***Infiltration Systems:*** Standard sizing for infiltration systems requires storage of a runoff volume equal to 1.0 inch times the subcatchment's impervious area plus 0.4 inch times the subcatchment's non-impervious developed area. Pre-treatment of stormwater must occur prior to discharge to the infiltration area. See Chapter 6 of Volume III.
- ***Vegetated Buffers***: Standard sizing of flow path lengths for buffers depends on the type of buffer, the soil type and slope of the buffer, and the nature and extent of land use in the contributing watershed for phosphorus export reduction. Standard sizing for a given buffer type in a given landscape and development setting can be determined using the tables found in Chapter 5, of Volume III.

4.3 - Determining BMP Phosphorus Treatment Factors

In designing the stormwater management system, the treatment factor of the selected BMPs for the project can be adjusted based on their sizing. A BMP's treatment factor may be reduced or enhanced by modifying either the volume of stormwater runoff it will store and treat or the length of flow path through a buffer. The two formulas presented below provide a way of (1) adjusting the standard sizing of BMPs described in Volume III and in Section 4.2 of this volume to provide a desired treatment factor, or (2) determining the treatment factor of a given size BMP.

Wetponds, underdrained soil filters, infiltration systems may be sized to provide various degrees of treatment by adjusting the storage and treatment volume. In the case of buffers, the flow path length may be adjusted (Volume III, Chapter 5). There is, however, a point at which further increase in sizing of a BMP is not likely to significantly improve the BMP's ability to retain phosphorus. This limit is expressed as a minimum treatment factor for each type of BMP. Treatment factors may not be adjusted below this minimum. Minimum treatment factors are discussed later in this chapter and are presented in Table 4.1.

(1) If you know the treatment factor that is needed and can adjust your BMP design to meet it, use the following equation to determine either the volume of runoff that must be stored and treated or the necessary buffer flow path length to provide a required treatment factor:

$$BMP_{TF} = 0.4*(BMP_{ST} / TF)$$

Where:

TF = Desired treatment factor (1-Removal Efficiency of the BMP)
BMP_{ST} = Standard sizing for the BMP, as described in Section 4.2
BMP_{TF} = Required sizing to achieve the desired treatment factor

BMP sizing is based on either volume of runoff stored and treated or buffer flow path length.

Example 6: Alternative BMP Sizing

Problem: 5.0 pounds per year of phosphorus is created from the runoff of a four acre parking lot. The owner wishes to design a wetpond to achieve a desired maximum phosphorus export from the parking lot of 1.8 pounds/year to meet the project's phosphorus budget for that area. What size pond will be needed to achieve this export?

Solution: The desired treatment factor is calculated as:

TF = Desired Export/Existing Export = 1.8/5.0 = 0.36 or

Using the Volume III sizing criteria, 60% removal efficiency can be achieved with a wetpond, or a 0.4 TF. This requires a minimum permanent pool volume of 2.0 inches times the impervious area (parking lot). Since this project requires a 36% TF (64% removal efficiency), the permanent pool volume must be larger by an equally proportional amount. Thus, the wetpond can be sized as follows:

$$BMP_{TF} = 0.4*(BMP_{ST}/TF)$$
$$= 0.4*(2.0/0.36)$$
$$= 2.22 \text{ inch of runoff for the impervious area}$$

The permanent pool of the pond must be sized for 2.22 inches of runoff over the impervious area. If the pond is discharging to a stream before reaching the lake, then the channel protection volume needs to be provided per Volume III.

(2) If, on the other hand, you know the size of a given BMP, and need to determine its treatment factor, use the following formula:

$$TF = 0.4\ BMP_{ST} / BMP_{TF}$$

Where:
TF = Treatment Factor (1-Removal Efficiency of the BMP) of the BMP
BMP_{ST} = Standard sizing for the BMP as described in Section 4.2
BMP_{TF} = Actual sizing of the given BMP

BMP sizing is based on either volume of runoff stored and treated or buffer flow path length.

Example 7: Alternative Treatment Factor and Minimum Treatment Factor

Problem: The available downgradient meadow buffer for a one acre parking lot has 150 feet of sheet flow on a 6% slope and on HSG C soil (sandy loam). What would be the allowable treatment factor for this buffer?

Solution: According to the buffer table, "Buffer Flow Path Length Downgradient of Residential, Largely Pervious or Small Impervious Areas" (Chapter 5 in Volume III, the required forested buffer length on sandy loam C soils to adequately treat stormwater runoff is 100 feet. Thus, the treatment factor for the available buffer on this project is:

$$TF = 0.4\ BMP_{ST}/BMP_{TF}$$
$$= 0.4\ (100/150)$$
$$= 0.27$$

However, according to Table 4.1, the minimum treatment factor that may be used for a forested buffer on C sandy loam soil is 0.3. Therefore, the treatment factor is limited to 0.3.

4.4 - Minimum Treatment Factors

There is a limit to the amount of phosphorus removal a BMP can accomplish, no matter how large one makes it. The physical, chemical, and biological processes that a BMP relies on to remove pollutants have limitations and making a BMP larger generally does not change the limits on the effectiveness of these processes. It only means that the BMP will treat a larger fraction of the runoff generated by infrequent storms. Hence, upper limits have been placed for BMP sizing. Table 4.1 presents the minimum treatment factors that are allowed for selected BMPs. BMPs may be enlarged from their standard sizing criteria as outlined in Volume III to reduce their treatment factors to a point, but treatment factors may not be reduced below the minimums in Table 4.1.

4.5 - Multiple BMPs Placed in Series

If multiple BMPs are being used in series, make sure that the last BMP in the series has the ability to remove the types of pollutants which are likely to reach it. For example, treatment credit should not be taken for a filter located downstream of an efficient forested buffer. The filter will not add significant additional treatment because the buffer will most likely have already removed all the fractions of stormwater phosphorus that the filter could.

If multiple BMPs are being used appropriately in series, the net treatment factor for the series of BMPs is the product of the lowest (most efficient) treatment factor of the individual BMPs in the series and the square root of the treatment factor(s) of the less effective BMP(s). For example, if a small wetpond with a treatment factor of 0.6 drained to an engineered infiltration area with a treatment factor of 0.4, the net treatment factor for the two BMPs would be $0.4 \times (0.6)^{1/2} = 0.31$.

Table 4.1 Minimum Treatment Factors for Selected BMPs		
BMPs	**Treatment Factor (1-RE)**	
Wetponds		
Single Pond	**0.3**	
Two ponds in series (per Volume III, Chapter 4)	**0.25**	
Three ponds in series (per Volume III, Chapter 4)	**0.2**	
Underdrained Soil Filters and Other Approved Filters		
On sand, loamy sand or sandy loam	**0.15**	
All other filters (including filters with an impermeable liner)	**0.25**	
Infiltration		
All infiltration BMPs	**0.1**	
Vegetated Buffers *		
Hydrologic Soil Group (and Texture)	**Forest**	**Meadow**
A or B	**0.15**	**0.2**
C (sandy loam or loamy sand)	**0.2**	**0.3**
C (silt loam, clay loam or silty clay loam)	**0.3**	**0.4**
D (non-wetland)	**0.4**	**N/A**
The maximum allowed flow path length in a buffer is 150 feet unless the runoff is redistributed by a midcourse stone bermed level lip spreader. RE= Removal Efficiency N/A = not applicable		

Example 8: Maximum Treatment

Problem: Using the minimum treatment factors in Table 4.1, calculate the maximum amount of runoff that can be treated using an underdrained filter that has less than 2 feet of separation between the bottom of the system and the restrictive layer and that is treating runoff from an impervious area.

Solution: For this situation, the minimum treatment factor from Table 4.1 is 0.25. Standard BMP sizing calls for treatment of 1.0 inch of runoff over the impervious surface. The maximum runoff that can be treated in such a filter is calculated as follows:

BMPTF = 0.4*(BMPST/TF)
= 0.4*(1.0/0.25)
= 1.6 inch of runoff

The filter bed can only be expanded by area and not depth.

Chapter 5 - Credits for Mitigation and Compensation Fees

The objective of this project planning process is to limit increases in phosphorus loading to the lake resulting from development. The methods discussed thus far have focused on limiting the scope of the development or reducing its phosphorus export by incorporating BMPs. Phosphorus load to the lake can also be limited by reducing export from long standing, existing sources of phosphorus, a trade off usually referred to as mitigation.

> Phosphorus reduction can also be achieved through mitigation measures that focus on eliminating or reducing phosphorus loads from existing sources.

5.1 - Types of Mitigation

Mitigation can take a number of forms. It can involve the elimination of an historical source or a reduction of the source, usually by treatment with BMPs.

> Phosphorus loads can also be limited by reducing export from existing sources of phosphorus on a site, a trade-off usually referred to as mitigation. Mitigation credits can be achieved through two means:
>
> - *Elimination of existing phosphorus sources* (e.g., elimination of an old gravel road so it can revert back to a forested condition); or
> - *Reduction of existing phosphorus sources through treatment* (e.g., diverting stormwater flows from an existing road to a treatment device for phosphorus removal).
>
> However, the following must also be true:
>
> - To be considered an existing source, it must be in existence prior to 1980.

Elimination: A wood lot being developed as a subdivision can provide a good example of elimination. An old, gravel road passes through the wood lot. It will not, however, be used by the developer, who plans to eliminate the old road and construct a new road in a different location to access the new house lots. The old road has been exporting phosphorus to the lake for the last 50 years.

Elimination of the road and return to a forested condition will result in a reduction of phosphorus loading to the lake. This reduction in historical phosphorus export can be used to balance, or mitigate, some of the project's new phosphorus export. In this chapter we will discuss various ways of mitigating new phosphorus export by reducing or eliminating historical phosphorus sources, and how credit for this mitigation can be applied to a project's phosphorus budget.

Reduction by Treatment: Suppose the developer actually wants to use the old road in his subdivision scheme. In order to reduce phosphorus export from other parts of his development he is constructing a wet pond BMP down gradient of the development. The old road, which formerly drained directly to the lake, now drains first to the wet pond, which has a treatment factor of 0.40. This means that only 40% of the old road's phosphorus export is now reaching the lake, with the remainder retained in the wet pond. Phosphorus export from the road has now been reduced by 60%. This reduction in phosphorus, called a credit, can now be subtracted from the phosphorus export associated with newly developed portions of the project.

Another variation on this example illustrates an even more common situation. Suppose the old gravel road is not wide enough to meet current town standards for subdivision roads and it must be widened from 12 feet to 24 feet. This expansion of road width means that half of the 24 foot road must be considered new in terms of phosphorus export. Its export, as modified by the wet pond's treatment factor, would be included in the list of phosphorus exports in Worksheet 2. Stormwater from the half of the road which can be considered old, however, is now being treated and the resulting reduction in phosphorus export is a credit that can be subtracted from the project's total phosphorus export.

Problems with Estimating Credit for Mitigation: But how does one estimate the amount of phosphorus export that is being reduced or eliminated? Phosphorus export from old, preexisting sources can be estimated in the same way as new sources, using the export factors in Table 3.1. However, in doing so two important issues must be considered.

- **Comparability of existing and proposed phosphorus export sources:** Let us return to the road example. Suppose the old gravel road has seen only very light use as a woods road over the last 50 years. It has started to revert with vegetation encroaching on the sides and in the middle between the tire tracks. It is unlikely that it currently exports nearly as much phosphorus per square foot as will the new subdivision road, which will receive comparably heavy use. So treatment or elimination of this export will not provide equivalent mitigation for the new road which replaces it. To avoid this problem, this evaluation process automatically cuts the estimated phosphorus export from preexisting sources in half unless it is clearly demonstrated that the old source is equivalent in both structure and use to the new sources being mitigated. A multiplier of 0.5 is included in Worksheet 3 for this purpose.

- **Historic drainage patterns of the phosphorus export:** If the runoff from the historic road immediately drained into a road ditch and continued, untreated, to the lake there is no problem with taking credit for elimination or treatment of the old road. But often the runoff from old roads sheets into the woods or fields adjacent to the road where much of its phosphorus export is retained in a natural buffer, and never reaches the lake. In this case credit should not be taken for treatment of the road's stormwater runoff because it was already receiving treatment, unless the new BMP has a much better treatment factor than the historic BMP. In that case, credit may be taken for treatment, but only for the difference between the old and new phosphorus export. If the road is being eliminated, credit should only be taken for an amount of export which has been reduced by the treatment factor of the historic buffer.

<table>
<tr><th colspan="2">Mitigation Dos and Don’ts</th></tr>
<tr><td>Don't take credit for mitigation of relatively recent phosphorus sources. Credit should not be allowed on sources, which were not in existence prior to 1980.</td><td>Do halve the phosphorus export from mitigation sources unless it is clearly demonstrated that the old source is equivalent in both structure and use to the new sources being mitigated.</td></tr>
<tr><td rowspan="2">Don't take mitigation credit for the treatment of sources which have been historically treated by adjacent buffers or treatment ponds.</td><td>Do adjust the credit for any source elimination to reflect historical treatment by buffers or ponds.</td></tr>
<tr><td>Do insure - through property owner agreements, deed covenants and restrictions, conservation easements, endowments and/or long term agreements with maintenance contractors - that eliminated sources will be allowed to revert and remain in a forested condition and that BMPs will be properly maintained.</td></tr>
</table>

5.2 Estimating Credits for Mitigation

Worksheet 3 may be used to calculate mitigation credits. The upper portion of the worksheet is used to calculate credit when a pre-existing source is being eliminated. The lower portion is used when a pre-existing, historically untreated source is being treated by new BMPs. Credits are determined as follows:

1. List the size of the source area (in acres and to the second decimal place) and phosphorus export coefficient from Table 3.1 for each pre-existing mitigation source in the appropriate spaces.
2. If the source is being eliminated, enter the estimated treatment factor for historical BMPs that provided treatment of the source or enter 1.0 if the source drains directly to the lake.
3. If the source is being treated, enter the treatment factor for the new BMP which will be treating each mitigation source in the worksheet. Also enter the estimated treatment factor for any natural buffers or other BMPs that historically provided treatment of the source or enter 1.0 if the source drained directly to the lake.
4. For source elimination and treatment multiply the source area with the phosphorus export factor and by the modifier 0.5 (unless it has been clearly demonstrated that the old source is equivalent in both structure and use to the new sources being mitigated) to calculate the creditable pre-treatment historical phosphorus export from each source area. The modifier can be selected as 1.0 only if it is clearly demonstrated that the old source is equivalent in both structure and use to the new source being mitigated. Then the pre-treatment historical phosphorus export is multiplied with any treatment factors for historical BMPs to obtain the historical phosphorus export.
5. For each source that is being eliminated, the mitigation credit value is equivalent to the historical phosphorus export value (from Step 3). For sources being treated by new BMP(s), subtract the treatment factor for the new BMP from 1.0 and multiply this times the source's historical phosphorus export (from Step 3) to get the mitigation credit value for each source.
6. Sum the phosphorus export credit values for all mitigation sources to obtain the total credit value in Worksheet 3.

5.3 On-site vs. Off-site Mitigation

Another important mitigation consideration is whether the mitigation source and, in the case of treatment, the BMP, are located on the parcel (on-site) or elsewhere in the lake's watershed (off-site). If the treatment source and the treatment BMP are located ”on-site”, the developer can insure - through property owner agreements, deed covenants and restrictions, conservation easements, endowments and/or long term agreements with maintenance contractors - that eliminated sources will be allowed to revert and remain in a forested condition and that BMPs will be properly maintained. Essentially these mitigation measures are treated no differently than the buffers and other BMPs incorporated in the project to address new sources of phosphorus export.

If the mitigation measures are being implemented elsewhere in the watershed, it is a much greater challenge, for both the developer and any regulating body which is requiring the mitigation, to insure that the measures are maintained over the long term. In the case of elimination or reduction of off-site mitigation sources by change of land use (i.e. conversion of road to forest), these areas can be reasonably protected by deed restrictions and conservation easements. However, insuring long term maintenance of offsite BMPs is much more problematic. Because of these difficulties, it is recommended that treatment of on-site mitigation sources with “off-site” BMPs be allowed only if the property on which the off-site mitigation is taking place and the project parcel are in common ownership, and that owner is a permanent entity, such as a town or a school district, that is not likely to transfer ownership of either parcel. Treatment of off-site mitigation sources is only allowed as described in section 3.C.2 of the Chapter 501 Stormwater Management Compensation Fees and Mitigation Credit Rules.

5.4 Compensation Fees

The Maine Stormwater Management Law (38 MRSA § 420-D) and its accompanying regulations (DEP Chapter 500 and 501) address some of the problems associated with off-site mitigation discussed above by allowing an alternative known as the Compensation Fee Program. The law recognizes the difficulties a state agency would have in tracking and insuring the maintenance of off-site BMPs used for mitigation on a project. The regulations therefore allow mitigation credit only for the elimination or reduction (by land use change) of off-site sources of phosphorus (Chapter 501, Section 3.C.1) and the limited off-site treatment options described in Chapter 501, Section C.3.2.As an alternative to project based off-site treatment mitigation, the Compensation Fee Program allows the department to let the developer offset a portion of the phosphorus reduction required for the project to meet its phosphorus budget by paying a compensation fee to an approved regional organization that performs watershed management activities. The authorized local entity accumulates compensation fee funds in accounts for each individual lake watershed, and uses these funds to provide long term solutions to priority chronic phosphorus sources within the watershed.

The Compensation Fee option is only available on some lakes. Lakes for which the option is not available include many small, relatively undeveloped lake watersheds that happen to be in a region of high growth. In these cases there are few if any opportunities to address existing problems in the watershed. It may also include watersheds where a large amount of restoration work has already been performed and any problems remaining to be addressed are more expensive than what the compensation rate can cover. Lastly, it includes areas where there are no local watershed management agencies (i.e. soil and water conservation districts, watershed districts, etc.) interested in developing and implementing mitigation projects. The regional organizations which the Department has approved for management of compensation funds and implementation of compensation projects have each developed a list of lakes for which they will accept compensation fees. Developers should not assume that the compensation fee is an option until they have checked with the Department to be sure it is available in the lake watershed in which the proposed development is located.

The Compensation Fee option is only available if the project incorporates onsite treatment and mitigation measures that reduce the pre-treatment phosphorus export by at least 60%. To express this in terms of the worksheets used to calculate project phosphorus export, the sum of post-treatment export expressed on Worksheet 2 must be less than or equal to 0.4 times the sum of pre-treatment export expressed on Worksheet 2 in order for a project to offset any additional phosphorus reductions through payment of a compensation fee.

In addition to the above limitations, the Compensation Fee option is not available for residential subdivision projects unless the wooded or meadow buffers are the only BMPs used to provide the reduction in pre-treatment phosphorus export.

Compensation Fee Calculations: Projects in lake watersheds regulated by the state under the Stormwater Management Law may have the opportunity to use compensation fees to help meet their project's phosphorus budget as required by that law. These projects may, however, also come under local regulation, which may or may not recognize compensation fee payment as an alternative to on-site reduction of phosphorus export. If it is available for the lake in question, the Compensation Fee option allows the developer to off-set the difference between the projects phosphorus export and the project's phosphorus budget by paying a compensation fee based on the amount, in pounds of phosphorus, of that difference.

The current compensation rate (August 2015) is $25,000 per pound for a project that provides on-site reduction of pre-treatment phosphorus export by 60%. The fee becomes progressively less as on-site reduction of pre-treatment export is reduced, as shown in Table 5.1 below. This means that if a project's phosphorus budget was 0.6 lb P/yr and, after application of reasonable BMPs, the project export could only be reduced 60% to 1.0 lb P/yr, the remaining 0.4 lb reduction required to meet the project's budget could be offset by a compensation fee payment of $10,000 (0.4 lb x $25,000 /lb). Exemptions to the compensation fee application are stated in Chapter 501(3)(C)(3).

Table 5.1 **Compensation Fee per Pound of Phosphorus Export**	
Percentage Of Project Phosphorus Export	**Additional Phosphorus Compensation Fee** ***($/pound)- fees are prorated***
60%	$25,000
75%	$12,500
100%	$0

Note:

a. 25,000 per pound fee is reduced by $500 per percentage point of project's phosphorus export between 60 and 75%.

b. $12,500 per pound fee is reduced by $834 per percentage point of project's phosphorus export over 75%.

Example 9: Project Phosphorus Export Summary for Subdivision Development

Problem: The Project Phosphorus Export for a subdivision project called 'Sunnydays' is similar to the 'Homesweet Home Subdivision', but it can only meet its post-treatment phosphorus export for some of the lots. Determine whether the project as proposed meets its phosphorus budget and what will the compensation fee be.

Solution: Use Worksheet 4 to summarize the Project Phosphorus Export as shown below.

Worksheet 4 **Project Phosphorus Export Summary**			
Summarizing the project's algal available phosphorus export (PPE)			
Project name: Sunnydays Subdivision			
Project Phosphorus Budget – Worksheet 1	PPB	0.995	lbs P/year
Total Pre-treatment Phosphorus Export Worksheet 2	Pre-PPE	3.155	lbs P/year
Total Post-treatment Phosphorus Export – Worksheet 2	Post-PPE	1.213	lbs P/year
Total Phosphorus Mitigation Credit - Worksheet 3	TMC	0.0	lbs P/year
Project Phosphorus Export (Post-PPE - TMC)	PPE	1.213	lbs P/year

The calculated PPE of 2.213 lbs P/year is more than the PPB of 0.995 lbs P/year by 1.218lbP/year; and the project does not meet its phosphorus budget.

A compensation fee is available to off-set the 1.218 lb P/year difference because treatment is buffer only, and the treatment level is more than 60% (Post-PPE/Pre-PPE).

The PPE has been reduced by 61.55% (1 - (1.213/3.155)). The fee is prorated at 1.55% less than the fee for 60% or $25000 – 1.55($12,500/15) or $23,708 per pound.

The compensation fee for Sunnydays Home Project is $5,168 ($23,708x0.218).

Chapter 6 - Performance Standards for Smaller Projects

Alternative performance standards may be used for certain smaller, residential projects. These generally include specific development restrictions and the use of Low Impact Development (LID) practices.

Smaller residential development projects can use alternative performance standards to meet their phosphorus control obligations. These generally involve restrictions on disturbance, buffers and impervious area or the incorporation of Low Impact Development (LID) techniques.

6.1 - Single Family Residences and Small Subdivisions with No New Road

There are some kinds of relatively low impact, residential development where the level of analysis applied in the previous sections may be inappropriate or unreasonable. This section prescribes comparatively simple, alternative performance standards which may be applied to: (1) new single family residences or duplexes on existing lots which are not part of a subdivision that has already incorporated appropriate phosphorus controls; and (2) subdivisions of five or fewer lots that do not involve the construction of a new road or expansion of an existing road. New residential developments which fall into either of these categories may meet their phosphorus control obligations by incorporating the phosphorus control measures listed either under Basic Single Family Residential Lot Standards or Alternative Single Family Residential Lot Standards below; and by maintaining these measures over the long term.

Basic Single Family Residential (SFR) Lot Standards. The following basic Single Family Residence Lot Standard is the preferred way of addressing new development of individual residential lots or small residential subdivisions that do not include a new road. A project must meet all provisions of the standard. The standards for appropriate buffer design and maintenance are presented below.

Alternative Single Family Residential Lot Standards. A property owner or developer may choose not to meet the Basic Single Family Residential Lot Standard due to site constraints or design preference. In situations where the Basic Standard is not met on a project, the project must meet the following Alternative Single Family Residential Lot Standards.

Meeting this standard may require the use of more than one LID practice on the site, due to existing site topography and the layout of the property. For example, half of the roof may drain to the front of a building while the other half drains to the back of the building, and the lawn and driveway/parking area drain off to one side of the property. Drainage in each of these directions must be captured and treated using an LID practice. The selection, size, and location of the LID practices used on a given site will depend on the size of the area draining to each practice and the impervious area versus lawn area. While this may not always be feasible, applicants are encouraged to maintain natural buffers to the extent possible as a primary LID technique, which can then be augmented by other practices on the site. Guidance on how to size each LID practice is found in section 6.2 below.

Requirements for New Single Family Lot Development	
Basic SFR Lot Standard	**Alternative SFR Lot Standards**
Disturbance on an individual lot must be less than 15,000 square feet (including building, driveway, walkways, lawn area, construction access, grading). And, no more than 7,500 square feet of impervious cover is located on the property.	Low Impact Development (LID) practices are used and sized to treat 0.5 inches of runoff from all impervious surfaces on the site, and 0.2 inches o runoff from all disturbed pervious areas of the site (lawn).*
A minimum natural vegetated buffer must be maintained downgradient of all developed area on the lot. This buffer shall be 35 feet deep if naturally forested or 50 feet deep if maintained as a natural meadow.*	The LID practices installed on the site are maintained in perpetuity. If necessary, LID practices may be replaced with new LID practices as long as the overall site treatment standard above is met.
A minimum of 25 percent of the lot area must be maintained as undisturbed natural area.*	
** If the lot or a portion of the lot is located within a watershed of a Lake Most at Risk from New Development, an Urban Impaired Stream, or other impaired or sensitive waterbodies as designated by the municipality for the purposes of this standard, a minimum of:* • *50 feet if naturally forested buffer, or 75 feet if maintained as meadow must be maintained downgradient of all developed area on the lot,* • *A minimum of 40% of the lot area must be maintained as undisturbed natural area.* *If the existing land has been disturbed by prior activities, a natural vegetated buffer and/or undisturbed natural area may be proposed through restoration and revegetation.*	** If the lot or a portion of the lot is located within watersheds of Lakes Most at Risk from New Development or other impaired or sensitive waterbodies as designated by the municipality for the purposes of this standard, the project must treat one inch of runoff from impervious surfaces and 0.4 inch from disturbed pervious surfaces.*

6.2 – Low Impact Development Practices

Low Impact Development (LID) practices can be used to capture and treat runoff from residential rooftops, non-rooftop impervious areas such as paved driveways, patios and walkways, and maintained lawn areas. While there are a number of practices considered to be LID practices, a lengthy discussion of these is not practicable for this volume but can be found in Volume III of this manual. The most popular LID practices are the following:

- Buffers,
- Underdrain soil filters (rain gardens and swales),
- Infiltration practices (dry wells and infiltration trench),
- Pervious pavements.

The design and maintenance standard for Buffer are presented below, and should be applied to projects meeting the Basic SFR Lot Standard. Design and maintenance standards for other LID practices (i.e. underdrain soil filters, dry wells and infiltration trenches, pervious pavements, rain barrels and cisterns, green roofs, stormwater planters, micro bio-inlets) are described in detail in the Maine LID Guidance Manual (September 2007), http://www.maine.gov/dep/land/watershed/materials/lid-guidance-manual.pdf, and these should be applied to projects meeting the Alternative SFR Lot Standards.

Vegetative Buffers

Vegetative buffers are areas of dense forest or meadow vegetation located adjacent and downgradient of developed areas that provide storage and treatment for stormwater that enters them in diffuse overland flow. They should be designed, implemented and maintained in accordance with the following:

- *Discharge of stormwater to the buffer:* It is essential that the stormwater entering the buffer not be channelized prior to discharge into the buffer. Grading of developed areas upgradient of the buffer must be done in a way that maintains diffuse overland flow and avoids concentration of the runoff.

- *Topography:* The topography of a buffer area must maintain well-distributed stormwater runoff and cannot allow stormwater runoff to concentrate as it flows across the buffer. Flow paths of runoff through a buffer must not converge, but must be essentially parallel or diverging.
- *Vegetative cover:* The vegetative cover of a buffer must be either forest or meadow. In most instances the sizing of a buffer varies depending on vegetative cover type.
- *Forest buffer:* A forest buffer must have a well distributed stand of trees with essentially complete canopy cover, and must be maintained as such. A forested buffer must also have an undisturbed layer of duff covering the mineral soil. Activities that may result in disturbance of the duff layer are prohibited in a buffer
- *Meadow buffer*: A meadow buffer must have a dense cover of grasses, or a combination of grasses and shrubs or trees. A buffer must be maintained as a meadow with a generally tall stand of grass, not as a lawn. It must not be mown more than twice per calendar year. If a buffer is not located on natural soils, but is constructed on fill or reshaped slopes, a buffer surface must either be isolated from stormwater discharge until a dense sod is established, or must be protected by a three inch layer of erosion control mix or other wood waste material approved by the department before stormwater is directed to it, with vegetation established using an appropriate seed mix.
- *Mixed meadow and forest buffer:* If a buffer is part meadow and part forest, the required sizing of the buffer must be determined as a weighted average, based on the percent of the buffer in meadow and the percent in forest.
- *Deed restrictions and covenants*: Areas designated as vegetated buffers must be clearly identified on site plans and protected from disturbance by deed restrictions and covenants.

Appendix A - Phosphorus and Lake Water Quality

The Relationship between Phosphorus and Lake Water Quality: Lakes are biological systems that are clearly affected by changes in water quality. They are most noticeably affected by an increase in nutrients, particularly phosphorus. Increases in phosphorus usually result in more noticeable changes to water quality than increases in other nutrients. Algae, which are microscopic organisms common in lakes, need phosphorus in order to grow. Consequently, when phosphorus is abundant in lake water, algal populations soar in number, causing a decline in water transparency. In some cases, algal blooms may occur causing the growth of billions of algae to color the lake water green and release strong odors as they decay.

Beyond the aesthetic impacts, algal blooms have serious impacts on a lake's biological community. Through a complex chain of events, algal blooms lead to depletion of the lake water's oxygen supply, usually resulting in the eventual loss of trout and salmon (cold water) fisheries. In addition, large algal populations cause odor, taste, and treatment problems in lakes used for public water supplies.

The biological term for the process described above is eutrophication, which can manifest itself over time as a gradual increase in the lake nutrient concentrations under natural conditions. Lake eutrophication can be dramatically accelerated by human activities, causing the noticeable changes described above in a relatively short period of time. Many lakes in Maine have already experienced dramatic declines in water quality as a result of human disturbances.

How Phosphorus Gets into Lakes: Understanding how phosphorus gets into lake water requires an understanding of where lake water comes from. Precipitation and stormwater runoff are significant sources of water in rivers and lakes. Rain and melting snow flow downhill over the land surface into streams and lakes or seep into the ground becoming groundwater, which also ultimately discharges to streams and lakes.

The land area that contributes water to a particular lake is known as its watershed. Watershed boundaries can be identified by connecting points of highest elevation around a lake and its tributaries. All rain and snow falling within this area eventually flow by gravity in surface runoff, streams, and groundwater to the lake, which is the lowest point in the watershed.

The quality of water in a lake depends on the condition of the land in its watershed. Phosphorus is abundant in the environment, but in an undisturbed environment it is tightly bound up by soil and organic matter for eventual use by plants. Natural systems conserve and recycle nutrients, water, and other materials needed to sustain plant growth. Water is stored in depressions on the uneven forest floor and seeps into the ground to become groundwater, thereby preventing it from running over the land surface and exporting valuable nutrients from the system.

Land development changes the natural landscape in ways that alter the normally tight cycling of phosphorus. The removal of vegetation, smoothing of the land surface, compaction of soils, and creation of impervious surface combine to reduce the amount of precipitation stored and retained onsite, dramatically increasing the amount of water running off the land as surface runoff.

These changes to the land surface and the associated increase in surface runoff dramatically increase phosphorus export. Land disturbance upsets the environment's ability to retain phosphorus. Stormwater flowing over the land surface picks up phosphorus and transports it in soluble form or attached to eroded soil particles. The phosphorus in stormwater comes from natural and human sources, including eroded soil, road dust, plants, lawn fertilizer, and detergents. The smooth surfaces, closely cropped lawns, and compacted soils common in developed areas do not retain phosphorus, and only speed its export by generating surface runoff. The end result is more phosphorus is stormwater, and thus more phosphorus in lakes.

A study in Maine has documented the elevated levels of phosphorus exported from developed land (Dennis, 1985). In adjacent watersheds, one developed and one undisturbed, phosphorus export from the developed watershed was up to 10 times greater than the export from the forested watershed. Because the built watershed was developed years ago, these figures represent the permanent increase in phosphorus export caused by alteration of the landscape. This permanent increase in the phosphorus supply of the lake creates an equally permanent and irreversible decline in water quality.

Though in most lakes the majority of phosphorus comes from the watershed, there is another source of phosphorus that can be very significant in some lakes. Over the centuries phosphorus rich organic sediments have accumulated on the bottom of our lakes. In most cases, the phosphorus in these sediments is trapped there by a blanket of iron hydroxide and or aluminum hydroxide, which makes the sediments a sink for, rather than a source of, phosphorus. However, in lakes with sufficient algal production to cause a severe loss of oxygen concentrations above the sediments, the iron hydroxide blanket dissolves and large amounts of phosphorus may be recycled into the lake water. The "surges" of phosphorus feed algal growth which further depletes dissolved oxygen, thus creating a vicious cycle of very rapid, internally driven eutrophication. This process, which can be initially triggered by relatively small increases in phosphorus input from the watershed, may drive a lake from apparently good, clear water quality to having intense algal blooms in a matter of years. It is particularly important to limit any increases in phosphorus input from the watershed to lakes with a high potential for sediment phosphorus recycling.

How Stormwater Phosphorus can be controlled: All land disturbance and development in a lake's watershed increases phosphorus export to a lake. Although some increase must be accepted as the inevitable and unavoidable effect of development, a variety of measures can substantially reduce phosphorus export to lakes and help to preserve good water quality.

The simplest way to reduce phosphorus export is to limit clearing of vegetation and minimize the area developed, especially road length. Beyond this, a variety of control measures are available. They generally focus on detaining and storing stormwater where it can be treated and released or infiltrated into the soil.

Buffer areas are naturally vegetated areas preserved downslope of developed areas. These buffers intercept and store surface runoff, allowing it to infiltrate rather than flow off-site as surface flow.

Infiltration systems are more sophisticated. Runoff is collected from rooftops, driveways and/or impervious parts of a lot and then directed to surface or underground storage, similar to a subsurface disposal area, from which wastewater infiltrates into the soil. Soils must be fairly deep, coarse, and permeable for infiltration systems to work.

Underdrained soil filters are similar to infiltration systems in that runoff is collected and directed to a storage depression, but the depression is vegetated with flood and drought tolerant species and is lined with a specific soil filter media which is underlain with a pipe system to discharge the filtered runoff.

Wet ponds are generally used to treat runoff from a large area. They receive and retain stormwater from large drainage areas, allowing sediment to settle out and dissolve phosphorus to be removed by biological activity.

Development can proceed in lake watersheds without generating more phosphorus than the lake can tolerate by limiting the extent of development and incorporating one or more of these phosphorus controls. Once a lake has accepted more phosphorus than it can tolerate, there will be a noticeable decline in water quality.

Appendix B - DEP’s Method for Defining Watershed per Acre Phosphorus Allocations

The Department defines per acre phosphorus allocations (P) for lake watersheds and these are presented in Appendix C. The list in Appendix C is not complete, so if a per acre allocation for a town's portion of a lake watershed is needed and it is not listed in Appendix C, request the Division of Watershed Management to provide a per acre allocation for the desired watershed. The Department will continually update Appendix C, both by adding new lakes to the list and by revising allocations for lakes already on the list as new information becomes available. This Appendix describes the process the Department uses to define watershed per acre phosphorus allocations.

Step 1. Defining the Acceptable Increase in Lake Phosphorus Concentration (C)

The first step is to determine how much the lake's phosphorus concentration could be increased without risking a perceivable increase in its algal production or a decline in its healthy, natural fish community. This value, the acceptable increase in lake phosphorus concentration (C), is a function of two variables: Water Quality Category of the lake and the Level of Protection appropriate for the lake. The Department has assigned Water Quality Categories to each lake for which sufficient water quality data is available based on the information in the following table. If insufficient data is available, the lake is assigned a default water quality category of Moderate Sensitive.

Lake Water Quality Categories	
Category	**Conditions**
Outstanding	Exceptional clarity; very low phosphorus and chlorophyll concentrations; low risk of internal recycling from sediments
Good	Average to better than average clarity, phosphorus and chlorophyll; low risk of internal recycling from bottom sediments
Moderate Sensitive	Average clarity, phosphorus and chlorophyll; high potential for internal recycling from the bottom sediments
Poor (Restorable)	Poor clarity; high phosphorus and chlorophyll concentrations; supports blue green algal blooms; good prospects for restoration
Poor (Natural)	Poor clarity; high phosphorus and chlorophyll concentrations; supports blue green algal blooms; poor prospects for restoration because lake is naturally very productive

Step 2. Determine the Allowable Increase in Annual Phosphorus Load

The next step is to determine how much the annual phosphorus load to the lake could be increased without risking an increase in lake phosphorus concentration greater than the acceptable increase (C) defined in Step 1.

> This is accomplished by multiplying "C" by a lake specific coefficient (F) that estimates the amount of increase in annual phosphorus load to the lake that will result in a 1.0 ppb lake phosphorus concentration. Where a lake has upstream lakes draining to it, "F" represents the direct watershed's (that portion of the total watershed that does not first pass through an upstream lake) share of this load. Where a lake's direct watershed is located in more than one town, "F" reflects the given town's portion of the load. "F" is derived using a steady state solution of Vollenweider's 1976 phosphorus loading model and is expressed in lbs/ppb/year.
>
> **Allowable increase in annual phosphorus load = F x C or FC**

Step 3. Determine the Per Acres Phosphorus Budget (P)

The next and final step is to determine the per acre phosphorus budget (P, in lbsP/acre/year) by allocating the allowable increase in annual phosphorus load (FC) over the portion of the direct watershed

> This is accomplished by projecting how much of the direct watershed area is likely to be developed (D, in acres) and dividing FC by this acreage.
>
> **P = FC / D**
>
> "D" is estimated by:
>
> - Determining the area available for development within the town's share of the direct watershed by subtracting undevelopable acreage (i.e. wetlands, steep slopes, state parks) and already developed land from direct watersheds area.
> - Projecting how much of the area available for development will be developed over time based on:
>   - The general growth rate in the town or region
>   - The quality, density and distribution of the road network within the town's share of the direct watershed
>   - Other lake specific, locally identified information

Appendix C - Per Acre Phosphorus Allocations for Selected Maine Lakes

The attached spreadsheet presents per acre phosphorus allocations (P) for all the lake/town combinations that have been calculated to this point. This Appendix will be modified on a regular basis as additional lake/town combinations are added and allocations are amended as new information becomes available. If you do not find the lake watershed/town combination you are looking for in the appendix, contact Jeff Dennis at the DEP Division of Environmental Assessment (207-287-7847 or jeff.dennis@maine.gov) to request an allocation.

Appendix D - Worksheets

The Excel spreadsheet provides four worksheets to assist in the calculations required to determine:

- **Worksheet 1, Project Phosphorus Budget (PPB)**
- **Worksheet 2, Pre-treatment and Post-treatment Phosphorus Export Calculations**
- **Worksheet 3, Mitigation Credits**
- **Worksheet 4, Project Phosphorus Export Summary**

The spreadsheets have the calculations built into them and can be used either as active excel spreadsheets or may be printed out as worksheets for use by hand.

Appendix E - Alternative Method for Small Commercial-type Developments Located within Designated Growth Areas

It can be difficult for densely developed projects on small parcels to meet their phosphorus budgets. Because of the density of high phosphorus producing surfaces like parking lots and lawns, the stormwater draining these projects carries relatively large amounts of phosphorus. The small parcel size, however, means that the phosphorus budget for the parcel will also be small. As a result, highly intensive phosphorus control measures, which are often fairly costly, may be required for the project to meet its phosphorus budget.

In these cases it may cost less to develop outside the designated growth area where land is more readily available for larger parcel sizes (and hence larger project phosphorus budgets) and for less intensive, and less expensive, phosphorus control measures like natural wooded buffers. If a municipality is concerned that the phosphorus budget will counter local planning efforts by being a disincentive for locating development within designated growth areas, they may request that the department allow commercial developers within their designated growth areas to use an alternative means of defining the project phosphorus budget. This alternative is described below.

To prevent sprawl and encourage building within designated growth areas, a municipality may request that projects with no more than 1.0 acre of impervious surfaces (building, parking, driveways, both paved and gravel) located on a small parcel with less than 5 acres within an area specifically designated for commercial growth in the municipality's DEP approved comprehensive plan be allowed to calculate the site's PPB as follows:

Alternative PPB Calculation for a Small Commercial-type Development (as defined by having less than 1 acre of impervious area and on a parcel that is less than 5 acres and located within a designated growth area)

The alternative PPB shall be the lesser of the following:

- *Option A = PPB = PPB as calculated (using Worksheet 1) multiplied by 5, or*
- *Option B = PPB = Project's proposed impervious area multiplied by 0.5 lb per acre*

Example: PPB for Small Commercial Development

Problem: 'Parking for Rent' is proposing a one acre impervious parking lot on a 1.5 acre lot within the identified growth zone of a watershed with a phosphorus allocation of 0.03 lb/acre/year. The proposed treatment is through a buffer. Calculate the Project Phosphorus Budget.

Solution: The standard PPB would be 1.5 acre X 0.03 lb/acre/year = 0.045 lb P /year. However, since the project is a small commercial-type development with no more than 1 acre of impervious area and on a parcel that is less than 5 acres and is located in a municipality's designated growth area, the alternative method for calculating the PPB may be used upon request by the municipality. The alternative PPB calculation is the lesser of:

- *Option A.* Standard PPB (as calculated on Worksheet 1) X 5 = 0.045 lb P /year X 5 = 0.225 lb P /year
- *Option B.* Project's Proposed Impervious Area X 0.5 lb P /acre / year = 1 acre X 0.5 = 0.5 lb P /year

Thus, the PPB is 0.225 lb P /year as in Option A.