APPENDIX F

BMP COST CALCULATIONS
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This document describes the cost-effectiveness of urban and agricultural best management practices (BMPs) that reduce nutrients. Although the costs for Total Phosphorus (TP) removal appear high, they may be thought of as ancillary benefits of Total Nitrogen (TN) removal. In addition, they show the relative cost effectiveness of TP removal by each practice.

On-Site Wastewater Treatment and Disposal System (OWTDS) BMP Cost Calculations

I. Connecting OWTDS to Sewer Districts

According to DNREC's Financial Assistance Branch (personal communication, 2007), the average cost of constructing a sewer system is $8,500 per equivalent dwelling unit (EDU). In the future, this cost is expected to increase to $10,000/EDU. The debt service, or cost of financing these systems, at roughly an average 2% rate is currently $1,867/EDU and will be $2,194/EDU for future septic eliminations and sewer connections. Additionally, system owners must pay for the final septic system pump-out, crushing and filling the tank, and the connection costs associated with building the lateral line running from the building to the right of way. These three expenditures together run approximately $1,000/EDU. The costs can be summed and divided by the 20 year financing period to estimate an annual cost. Finally, operation and maintenance (O&M), including repair fees, of roughly $200 per EDU per year will also be added to these values (DNREC Financial Assistance Branch, personal communication, 2007) (Table 1).

Table 1. OWTDS Elimination Costs

Cost	**Past Conversions**	**Future Conversions**
Construction of sewer system	$8,500/EDU	$10,000/EDU
Debt service	$1,867/EDU	$2,194/EDU
Additional expenditures	$1,000/EDU	$1,000/EDU
Sub-total	$11,367/EDU	$13,194/EDU
Annual cost over 20 years	$568/EDU/yr	$660/EDU/yr
Annual O&M	$200/EDU/yr	$200/EDU/yr
Total	**$768/EDU/yr**	**$860/EDU/yr**

The cost per pound of total nitrogen (TN) or total phosphorus (TP) removed from receiving waters as a result of converting OWTDS to sewer can also be determined using the above values and nutrient reduction estimates. For the systems that have already been converted, these values are $80/lb TN and $938/lb TP, while in the future the cost will increase to $82/lb TN and $965/lb TP.

II. Holding Tank Inspection and Compliance Program

The cost of pumping-out a 2,800 gallon holding tank typically starts at $225 per system in Sussex County, and averages around $250 per system per pump-out (DNREC Small Systems Branch, personal communication, 2007). As a result of the holding tank inspection and compliance program, they have been shown to be pumped-out roughly 12 times a year. This information reveals that the owner of a single holding tank will spend $3,000 each year. In addition to this cost, there is an annual inspection fee of $60 per system (DNREC Small Systems Branch, personal communication, 2007), so that the total expenditure for holding tanks is **$3,060/system/year**. The cost per pound of removing TN is $94, while it is $250/lb TP removed from the ecosystem.

III. OWTDS Pump-outs

The cost of pumping-out OWTDS ranges from $185-200 per system, with an average cost of $193 per system (DNREC Small Systems Branch, personal communication, 2007). It is proposed that septic systems be pumped once every three years, which capitalizes this figure to $64/system/year. These proposed inspections will be performed by licensed inspectors at an estimated cost that ranges from $200 to $400 with an average cost of $300 at the time of pump-out (DNREC Small Systems Branch, personal communication, 2007). Thus, the inspection fee will only be incurred once every three years, so that annually it equates to $100. The total cost of the OWTDS inspection and compliance program will cost the system owner **$164/system/year**. Using the amount of TN and TP believed to be reduced from receiving waters as a result of bringing all systems in the watershed into compliance, it has been determined that this value equates to $96/lb TN and $241/lb TP.

IV. OWTDS Performance Standards

Licensed installers from Sussex County and members of DNREC's Small Systems Branch (personal communication, 2007) revealed that the installation of best available technologies (BATs) to existing small (<2,500 gallon per day (gpd)) OWTDSs for advanced nitrogen removal would cost between $3,500 and $6,000 per system. These technologies are believed to last for approximately 20 years and will be financed for the same amount of time. Using this time span and the average installation cost ($4,750), this figure capitalizes to $319/system/year. These technologies require a service contract by a certified service provider with an estimated annual cost that ranges from $150 to $300, with an average cost of $225/system/year. In addition, the systems will still require pump-outs, which costs $64/system/year (DNREC Small Systems Branch, personal communication, 2007), and they will need periodic mechanical parts repaired, estimated to cost $50/system/year and the electrical cost of running the systems is likely to also cost about $50/system/year (DNREC Financial Assistance Branch, personal communication, 2007). Taking all of this into account, the total cost of this strategy to the system owner will be **$708/system/year**. This equates to $113/lb TN reduced. The PCS regulations only require P reducing technologies in locations identified as having a high potential for phosphorus mobility and reductions per pound TP reduced have not been calculated.

According to DNREC's Groundwater Discharges Section (personal communication, 2007) cost estimates for large systems between 2,500 and 20,000 gpd and greater are not currently available. There is a large variability in size, treatment requirements, and disposal methods (rapid infiltration basin versus drip irrigation, for example) for these larger types of systems, making estimates of costs difficult at this time.

Stormwater BMP Cost Calculations

I. Wet and Dry Ponds

Typical costs for retention basins were retrieved from Chapter 6.0, “Costs and Benefits of Storm Water BMPs,” of an EPA on-line document (EPA, 1999). In this document, it states that a retention basin treating a 50-acre residential site in 1999 costs about $100,000, such that the cost per unit area was $2,000/acre. All values reported in the document need to be divided by an adjustment factor to account for regional differences. Delaware falls in Region 2, which has a 0.90 adjustment factor (EPA, 1999). Thus, retention basins in Delaware in 1999 cost approximately $2,222.22/acre. Using the average annual federal inflation rate (3%), the capital cost of Delaware retention basins in 2005 is $2,622.22/acre. Capitalized at a 3% interest rate over a 25 year finance period, this value becomes $150.59/acre/year. It should be noted though that stormwater ponds can be expected to function for up to 50 years. To this value, the annual operation and maintenance costs must be added. Operation and maintenance costs for retention basins can range from 3-6% of the construction costs (EPA, 1999). We have used an average value of 4.5% and applied this to the regionally adjusted construction cost, to get $118.00/acre/year O&M cost. Thus, the final cost of wet and dry ponds is **$268.59/acre/year** (Table 3). Wet and dry ponds have different nutrient reduction efficiencies. Using nutrient reduction estimates, the prior value equates to $112/lb TN reduced and $698/lb TP reduced for wet ponds, while for dry ponds the cost per pound nutrient reductions are $90/lb TN and $1,535/lb TP.

II. Infiltration Structures

The 1999 construction costs of infiltration trenches and infiltration basins treating 5-acre commercial sites were averaged to represent the range of infiltration structures utilized as stormwater BMPs throughout Delaware. These costs were $45,000 for trenches and $15,000 for basins (EPA, 1999), which equates to $9,000/acre and $3,000/acre, respectively, and averages $6,000/acre. Once adjusted for the regional variability in cost (0.90 factor), and inflated to 2005, this value becomes $7,866.67/acre treated by infiltration structures. Infiltration structures are believed to have a 25 year life expectancy, thus the capitalized construction cost at a 3% rate is $451.77/acre/yr. Annual O&M costs for infiltration structures range anywhere from 1-20% of the construction cost (EPA, 1999), and average 10.5%. This produces an annual O&M cost of $826.00/acre/yr. The total cost of infiltration structures annually is **$1,277.77/acre/yr** (Table 3). This corresponds to $100/lb TN reduced and $2,643/lb TP reduced.

III. Sandfilters

Cost data for sandfilters was obtained from a publication of the Environmental and Water Resources Institute of the American Society of Civil Engineers (ASCE, 2001). This guide reports costs of sandfilters installed in Delaware in the early 1990s. Since sandfilters treat runoff from pavement and impervious areas, the construction cost was reported as $10,117.36 per impervious acre. The 2005 cost can be estimated using the average federal inflation rate and the early 1990s values to be $14,670.17/acre. Capitalized over 25 years at a 3% interest rate, this becomes $842.48/acre/yr. The O&M costs typically range from 11-13% of the construction costs (EPA, 1999), which on average, is $1,760.42/acre/year. Taking the two values together yields a total cost of **$2,602.90/acre/year** (Table 3). The cost per pound nutrient reduction is thus, $277/lb TN and $9,067/lb TP.

IV. Biofilters

The EPA on-line document reported that the construction costs for biofiltration devices in 1999 were $60,000 for a 5-acre commercial site (EPA, 1999), which equates to $12,000/acre. This value must also be divided by the 0.90 adjustment factor to account for regional cost differences, which yields $13,333.33/acre, and then adjusted to the 2005 value, $15,733.33/acre. This value becomes $903.53/acre/year when capitalized over the 25 year expected lifetime of the structure at a 3% interest rate. The annual O&M costs range from 5-7% of the construction cost (EPA, 1999). When using 6% as the average, annual O&M costs $944/acre/year. Thus, total costs for biofilters are **$1,847.53/acre/year** Table 2). The price per pound nutrient reduction has not been determined since a recent inventory of stormwater BMPs in the watershed did not reveal any biofilters present.

Table 2. Stormwater BMP Costs

Cost	Wet and Dry Ponds	Infiltration Structures	Sandfilters	Biofilters
Construction (per ac)	$2,622.22	$7,866.67	$14,670.17	$15,733.33
Finance period (years)	25	25	25	25
Sub-total capitalized over lifespan (per ac/yr)	$150.59	$451.77	$842.48	$903.53
O&M (% of Construction)	4.5%	10.5%	12%	6%
Annual O&M (per ac/yr)	$118.00	$826.00	$1,760.42	$944.00
Total (per ac/yr)	**$268.59**	**$1,277.77**	**$2,602.90**	**$1,847.53**

Agriculture BMP Cost Calculations

The costs of the following agricultural BMPs have been estimated using data gathered by the United States Department of Agriculture (USDA) Natural Resources & Conservation Service (NRCS) staff at the county and state level. These are estimates, as costs for specific projects may vary.

I. Cover Crops

NRCS staff report that the Sussex Conservation District incentive payment for cover crops ranges between $30 and $40/acre and averages **$35/acre** (personal communication, 2006). Several years ago, the Wye Research Center estimated that it cost $27/acre to seed and plant cover crops each year, however, this value has likely increased in recent years due to inflation and rising fuel costs. The current incentive payment likely covers the cost of implementing this BMP. Additionally, farmers are allowed to harvest the cover crop for on farm use, so that there is **no cost to the farmer**. This practice costs $2.81/lb TN reduction and $890/lb TP reduction.

II. Ponds (CRP)

Currently, not enough data is available on the installation costs of Conservation Reserve Program (CRP) ponds. Some information suggests that shallow ponds cost approximately $2,500-$3,000 per acre. Ancillary cost data does exist, however. Land assigned to CRP is rented from the farmer for $65/acre/year and is maintained at a rate of $5/acre/year, which is paid by the program to the farmer.

In 2003, cost sharing levels of capital costs were 50% from the Farm Service Agency (FSA) and 37.5% from the State. Thus, any costs to the farmer for constructing the pond would only be 12.5% of the, as yet, undetermined construction costs, less rental and maintenance reimbursements.

III. Grassed Waterways (CRP)

Grassed waterways constructed for the CRP program cost approximately $2,500/acre or $293.08/acre/year when capitalized over 10 years, which is the length of a CRP contract at a 3% interest rate. To this expense, annual land rental ($65/acre/year) and annual maintenance ($5/acre/year) fees must be added. This brings the total cost to **$363.08/acre/year**.

Capital costs are shared at 87.5% (50% FSA, 37.5% State), which indicates that the farmer must pay $36.63/acre/year for BMP installation. Once reimbursed for land rental and maintenance, there is **no cost** to the farmer for taking the cropland out of production for use as a grassed waterway.

IV. **<u>Grass Filter Strips/Wildlife Habitat (CRP)</u>**
These CRP practices are estimated to cost $300/acre for installation. The cost can be capitalized over the 10 year contract at a 3% interest rate to yield a cost of $35.17/acre/year. Land is rented for $65/acre/year and maintained at $5/acre such that the total expenses equal **$105.17/acre/year**. This equates to $12/lb TN and $524/lb TP reduced for both best management practices.

The installation of these BMPs are cost shared at a total rate of 87.5%, such that the farmer must pay $4.40/acre/year of the capital costs. Reimbursement for land rental and maintenance provides for virtually **zero cost** to the farmer.

V. **<u>Grass Buffers/Grass Filter Strips (CREP)</u>**

Conservation Reserve Enhancement Program (CREP) grass buffer practices are estimated to cost $300/acre. Capitalized over the 15 year CREP contract period at the 3% interest rate, the installation cost becomes $25.13/acre/year. The average rental of lands put into CREP programs is $138/acre/year and the maintenance fee is also $5/acre/year. Thus, the total cost for these practices is **$168.13/acre/year**. The cost per pound reduction is $6.05/lb TN and $157/lb TP.

If you assume that 87.5% of capital costs are shared, the farmer would only be responsible for paying $3.14/acre/year for installing the grass BMPs. Since the CREP program provides an annual maintenance and rental payment to the farmer as well as incentives for participating in the program, there is **no cost** to the farmer.

VI. **<u>Forested Buffers/Riparian Buffers (CREP)</u>**

The cost of installing a CREP forested buffer is estimated to range between $125-$725/acre, and averages about $425/acre. If you capitalize that figure over 15 years at 3%, the annual cost is $35.60/acre. Land rental ($138/acre/year) and maintenance ($5/acre/year) fees bring the total cost to **$178.60/acre/year**. Total cost per pound of nutrient reduction is $4.25/lb TN and $128/lb TP reduced.

Construction costs are cost shared at a rate of 87.5%, so that the cost to the farmers for BMP installation is $4.45/acre/year. Once the farmer is compensated for taking the land out of production, reimbursed for maintenance and given incentives, the farmer bears **no costs**.

VII. **<u>Wetland Restoration (CREP)</u>**

The cost of restoring farmed wetlands is high if extensive earth movement is required. Costs may range from $1,500/acre to $3,000/acre. The average costs of actual restoration projects in the Inland Bays watershed have been $1,702/acre. Capitalized over 15 years, representing a single CREP contract period, the actual cost per acre becomes $142.57. Annual rental ($138/acre/year) and maintenance ($5/acre/year) fees bring the total cost of wetland restoration to **$285.57/acre/year**. For nutrient reduction calculations, this BMP is treated as a land use change from agriculture to wetlands and each wetland acre is additionally assumed to treat 2 upland acres of cropland. Using reduction estimates, the above figure equates to $6.80/lb TN reduced and $204/lb TP.

Assuming that established cost share levels for capital costs from FSA (50%) and the State (37.5%) remain the same as they were in 2003, the farmer will only be responsible for $17.82/acre/year. After receiving the land rental and maintenance fees and incentives, the farmer **pays nothing.**

VIII. **Water Control Structures (WCS)**

Water control structure installation costs range from $5,000-$8,000 and typically drain between 30 and 100 acres of cropland. Thus, on average, WCS cost $6,500 and drain 65 acres so that the cost per unit land area is considered to be $100/acre. Since these structures have a lifetime of roughly 10 years, the capitalized cost at a 3% interest rate is **$11.72/acre/year**. The annual operation and maintenance costs associated with this practice are negligible. Currently, nutrient reductions from WCS are only calculated for nitrogen and the above cost equates to $1.69/lb TN reduced.

The Sussex Conservation District has a cost share rate of 75% for WCS, with a cap of $5,000. This reveals that the cost to farmers is **$2.93/acre/year**, which can also be expressed as $0.42/lb TN reduced.

IX. **Poultry Compost Sheds**

These structures cost roughly $10,000 each and have a lifespan of 15 years. Capitalized at 3%, this BMP costs **$837.63/structure/year**. Annual operation and maintenance costs are negligible. The cost sharing level for this BMP is 75%, so that the cost to the farmer is **$166.67/structure/year**. If funded through the State Revolving Fund, finance periods of 10 years will be used instead of 15 years, causing the annual cost to increase slightly.

X. **Poultry Manure Storage Sheds**

On average, these structures cost $23,000 and have a 15 year lifespan as well. Thus, the annual cost using a 3% interest rate becomes **$1,926.63/structure/year**. Annual operation and maintenance costs are negligible. The cost to the farmer once 75% of the construction costs are shared is **$383.33/structure/year**. If funded through the State Revolving Fund, finance periods of 10 years will be used instead of 15 years, causing the annual cost to increase slightly.

XI. **Manure Relocation**

The cost per ton of manure relocated is roughly **$13.00/ton**. The cost per pound of removing total nitrogen and total phosphorus was thus, $2.32/lb and $22/lb, respectively.

The Delaware Nutrient Management Commission designs their relocation cost-share program to fully subsidize the cost of the manure transfer, including the clean out so that the farmer bears **no cost**.

XII. Nutrient Management Plans (NMPs)

The cost to develop a nutrient management plan decreases as the acreage in the plan increases. A three year plan for an operation with less than 500 acres costs $5.70, with 501-1,000 acres cost $4.50, with 1,001-2,000 acres cost $3.90, and with more than 2,000 acres cost $3.30 (DNMC, 2004). The average of these values is $4.35/acre every three years, which when annualized is $1.45/acre/year. Farmers can be reimbursed the entire cost for developing a nutrient management plan from the Delaware Nutrient Management Commission. The cost can also be expressed as $0.34/lb TN reduction. At this time, phosphorus reductions are not being calculated for NMPs.

References

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SCD, 2003. *FY 2004 Sussex Conservation District Cover Crop Program Fact Sheet*. Sussex Conservation District, Georgetown, Delaware.