

Chapter 6: Economic Analysis

6.1 The Cost of Implementing the Christina Basin Pollution Control Strategy

The ultimate goal of this Christina Basin Pollution Control Strategy is to improve the water quality and meet the federal Clean Water Act (CWA) goals of fishable and swimmable in the Delaware portion of the Christina Basin. Currently the streams in the Delaware portion of the basin are potable and fishable, but they are not swimmable. Through the implementation of the 40 recommendations outlined in Chapter 4, the Christina Basin Tributary Action Team hopes to achieve both the fishable and swimmable criteria.

The reduction values set by the USEPA for the high flow TMDLs in the Delaware portion of the Christina Basin mandate significant reductions in the nitrogen, phosphorus, and bacteria loads in the Brandywine, Red Clay, and White Clay Creeks, and Christina River watersheds. This PCS recommends 40 specific methods that have the potential to reduce these loads. All of these recommendations are important tools to reduce the loads. In addition to the detailed information provided for each recommendation in Chapter 4 of this report, an additional cost analysis is an important component of the Christina Basin PCS. It is valuable to identify the costs associated with each recommendation because it helps prioritize which recommendations are the most and least expensive and which recommendations, or suite of recommendations, will achieve the highest reductions at the lowest cost. Cost shall not be the only tool to prioritize implementation, but it is one of the ways to identify which recommendations will be the most cost-effective tools to achieve the fishable and swimmable goals of the Clean Water Act. Additionally, estimating the costs and quantifying the benefits of the Christina Basin (discussed in Section 6.2), provides a starting point for further analysis on whether the benefits of the Delaware portion of the Christina Basin outweigh the costs of implementing the PCS to achieve the goals of the federal Clean Water Act.

There are significant costs associated with each one of the 40 recommendations set forth in the PCS. Tables 6.1–6.5 provide a summary of the cost estimates for each recommendation set forth. It is important to note the cost estimates provided in these Tables are approximations and will vary significantly depending on variables, including but not limited to: size of the site, chosen BMP on the site, characteristics of the site, characteristics of the BMP, types of nutrients and contaminants being treated on the site, concentration of nutrients and contaminants on the site, extent of contamination, and other miscellaneous costs associated with the implementation of a particular BMP. The costs presented in Tables 6.4–6.5 have been collected throughout the PCS development process from February 2006–September 2007 and are estimates based on existing literature research and communication with practitioners in Delaware. These cost estimates are provided as a general range for discussing the costs associated with implementing the Christina Basin PCS and may vary considerably upon implementation of the recommendation.

This cost analysis only considers costs to the state, county, and local governments and nonprofit organizations. The cost analysis provided for each recommendation does not reflect the costs for developers and homeowners to implement these recommendations. The costs for several recommendations in Tables 6.1–6.5 are estimated at \$20,000 per year. This estimate was determined through discussion with DNREC staff in the Division of Water Resources, Watershed Assessment Section. The cost per year for city or county staff to establish and

maintain a regulation is estimated at 25 percent of a full-time salaried staff or \$20,000 per year (Jones, 2007). According to our analysis, this estimate is the true cost for those recommendations that require only state or local regulations and city, county, or state staff time to establish and maintain the regulation. For those recommendations with the cost estimated of \$20,000, any additional costs associated with the recommendation beyond the scope of developing and maintaining a regulation are considered private costs to the business or homeowner and are not considered part of the cost estimate. The private costs associated with implementing the recommendation are considered the cost of doing business for the developer or homeowner.

Stormwater Costs

Table 6.1 outlines the costs associated with each stormwater recommendation. The total cost for implementing the nine stormwater recommendations is estimated at a range of \$10.8–\$12.1 million per year. In reviewing the stormwater recommendations it becomes obvious that the most costly recommendation is SW1 (require urban tree canopy). Assuming the highest end of the range of costs (or \$12.1 million per year), recommendation SW1 accounts for 81 percent of the total cost of implementing the entire suite of stormwater recommendations on an annual basis. The second most expensive stormwater recommendation is implementing SW8 (stormwater retrofits), which costs \$1.8 million at the high end of the range provided for the stormwater recommendations. Stormwater is a major source of nonpoint source pollution, specifically nitrogen, phosphorus, and bacteria loads to the streams. These stormwater recommendations cost estimates prove that implementing the Christina Basin PCS is costly but implementing the stormwater recommendations is critical to achieving the high flow TMDLs in the Delaware portion of the basin. To maximize the efforts in achieving the TMDLs at the lowest cost it is important to consider ways to decrease the annual cost of some of the more expensive recommendations, like SW1 and SW8, to ensure that important BMPs like these are implemented. For example reducing the cost of SW1, require urban tree canopy, can be accomplished by decreasing the number of trees planted, increasing the level of volunteer plantings, establishing a corporate donors program, and utilizing various methods. If the costs of these two most expensive BMPs are removed, the cost of implementing the remaining stormwater recommendations is relatively low at approximately \$0.5 million per year. This demonstrates that by identifying ways to reduce the cost of SW1 and SW8 the feasibility of implementing the stormwater recommendations of the Christina Basin PCS is largely increased. Considering the highly urbanized nature of the land use and the high population density in the Delaware portion of the Christina Basin, it is not surprising that the costs of the stormwater recommendations are so high. Once the costs for the stormwater recommendations are further refined, the costs may be significantly reduced and, meanwhile, this suite of recommendations has the potential to greatly improve the water quality in the most heavily populated and urbanized watershed in the state.

Table 6.1 Estimated Annual Costs of the Stormwater Recommendations

Recommendation	Basis	Unit Cost	Quantity	Total (per year)
SW1. Require urban tree canopy.	According to cost estimates provided by the Delaware Department of Agriculture Forest Service, Urban and Community Forestry Program.	\$50 per tree (assuming varied types of trees planted and maintenance costs not included)	197,000 trees/year	\$9,850,000
SW2. Design stormwater BMPs to reduce nutrients according to the TMDLs.	Estimated cost per year for DNREC staff to establish and maintain the regulation (costs of the BMPs are the cost of doing business).	\$20,000 (25% of a full-time position)	per year	\$20,000
SW3. Limit addition of new impervious cover to less than 20% of the watershed above public water supply intakes.	Estimated cost per year for city or county staff to establish and maintain the regulation (methods to reduce impervious cover are the cost of doing business).	\$20,000 (25% of a full-time position)	per year	\$20,000
SW4. Promote LID in new construction and redevelopment.	Estimated cost per year for City of County staff to establish and maintain the regulation (implementing LID is the cost of doing business).	\$20,000 (25% of a full-time position)	per year	\$20,000
SW5. Amend stormwater ordinances to create consistency throughout the watershed.	Based on cost estimates provided by the White Clay Creek Wild and Scenic Committee on an existing ordinance review project.	\$500 per township, borough or city	60 (townships, boroughs, cities)	\$30,000
SW6. Expand the role of RPTAC to create a Christina Basin group responsible for reviewing new development.	Based on cost figures associated with the RPTAC committee.	Staff time (chair, staff of NCC Dept. of LU) (approximately \$500.00 per day) meets 12 times per year = \$500.00 x 12 = \$6,000. All other committee members serve on a volunteer basis.	per year	\$6,000
SW7. Implement a stormwater utility.	Based on costs for establishing and implementing the City of Wilmington stormwater utility.	City of Wilmington = \$400,000, this cost estimate includes: technical work, establishing a defensible rate system, and public outreach.	per city/county to establish a stormwater utility	\$400,000
SW8. Identify areas where stormwater retrofits would effectively reduce sediment and nutrients.	Based on cost estimates provided by New Castle County Department of Special Services.	\$100,000 - \$365,000 per existing SWM facilities.	assume 5/year	\$500,000 - \$1,825,000
SW TOTAL			\$10,846,000-\$12,171,000	

Open Space Costs

Table 6.2 outlines the costs associated with each open space recommendation. The total cost for implementing the seven open space recommendations is estimated at approximately \$9.7 million per year. Many of the recommendations in the open space sector are relatively inexpensive due to the fact that they require analysis using existing data sources, development of plans, and the creation of and management of new ordinances that have the potential to further protect water quality. The most expensive recommendation in this suite of recommendations is recommendation OS6 (acquiring and conserving additional open space). The estimated cost of this recommendation is approximately \$8 million per year to acquire and conserve 100 acres per year of open space in the Delaware portion of the Christina Basin. It is important to note that land acquisition costs are highly variable based on location and other price factors. This recommendation (OS6) accounts for over 80 percent of the total annual estimated costs to implement the open space recommendations. This cost may be reduced significantly by decreasing the number of acres acquired, identifying land donors, and identifying other key tools used in land acquisition efforts. Although OS6 is a major portion of the total costs of these recommendations, it is an important tool that will provide natural filter systems throughout the watershed and it is a key tool in meeting the Clean Water Act goals of fishable and swimmable.

Table 6.2 Estimated Annual Costs of the Open Space Recommendations

Recommendation	Basis	Unit Cost	Quantity	Total (per year)
OS1. Map, inventory, and prioritize existing wooded open space areas.	Based on cost estimates for an IPA-WRA graduate student full-time.	\$14,000	per year	\$14,000
OS2. Protect existing wooded/vegetated open space areas.	There is no cost associated with this recommendation.	\$0	per year	\$0
OS3. Require management plans for community and HOA open space areas.	Estimated cost per year for city or county staff to establish and maintain the regulation (maintenance costs are the responsibility of the HOA).	\$20,000 (25% of a full-time position)	per year	\$20,000
OS4. Require riparian forest buffers of adequate and proper widths sufficient to reduce or eliminate nonpoint source pollution for all new development abutting all waters of the state—including private/state/county land. Encourage establishing and restoring riparian forested buffers on existing development.	Estimated cost per year for DNREC staff to establish and maintain the regulation (tree, installation, and management costs for new development are the cost of doing business).	\$20,000 (25% of a full-time position)	per year	\$20,000
	Based on current cost estimates for establishing riparian forest buffers on existing development in the Christina Basin.	\$2,500/acre for 300 sheltered trees, \$4,860/acre for 400 sheltered trees, \$14-\$15 per tree for labor costs (Existing Development)	\$4,860 per acre and 5 acres/year	\$24,300
OS5. Implement stream restoration projects.	Based on cost estimates for the Pike Creek stream restoration project.	\$1 million per 1 mile	1 mile/year	\$1,000,000
OS6. Acquire/conserve additional open space and retain conservation easements.	Using maximum cost of open space acquisition in New Castle County, this estimate is based on the purchase price for the following properties in the Delaware portion of the Christina Basin: City of Newark Reservoir, Thompson Station Reservoir in White Clay Creek Preserve, and Glasgow Regional Park.	\$45,000 - \$80,000 per acre (Open Space Acquisition)	100 acres/year	\$8,000,000
	Estimated cost per year for nonprofit organizations to work with property owners and manage conservation easements.	\$20,000 (25% of a full-time position) (Conservation Easements)	per year	\$20,000
OS7. Reforest watersheds and headwaters.	400 trees per acre x \$14 per tree for installation = \$5,600 per acre for tree costs and installation (costs for land acquisition and invasive species management are not included) x 100 acres = \$560,000.	\$5,600 per acre	100 acres/year	\$560,000
OS Total				\$9,658,300

Wastewater Costs

Table 6.3 outlines the costs associated with each wastewater recommendation. The total cost for implementing the seven wastewater recommendations is estimated at approximately \$9.3 million per year. Table 6.3 includes CSO elimination cost estimates, but the total cost estimated for the wastewater recommendations that are discussed in this chapter does not include the costs associated with eliminating the CSOs in the City of Wilmington because this recommendation is not under the purview of the Christina Basin PCS. The combined sewer system is regulated according to the federal CSO policy, and controls associated with this program are not within the realm of the Christina Basin PCS. Since Chapter 4 of this document discusses the importance of eliminating the CSOs and notes their significant role in reducing the pollutant loads to the waters of the Christina Basin, it is included in the cost comparison provided in Table 6.3 but shall not be considered in the final cost analysis for implementing the Christina Basin PCS. The CSO recommendation (WW5), which carries an estimated cost of \$26.9 million dollars to eliminate the entire system, is the most expensive wastewater recommendation, and the second most expensive wastewater recommendation is WW6 (continue sewer repair projects and conduct regular inspections) with an estimated cost of \$8.19 million per year. The estimated cost for this recommendation is expensive due to the high costs associated with aging infrastructure improvements and repair. This recommendation accounts for approximately 89 percent of the annual total cost of implementing the wastewater recommendations in the Delaware portion of the Christina Basin. The cost of WW6 may appear high, but it is important to consider that the majority of the Delaware portion of the Christina Basin is served by a centralized sewer and much of this infrastructure is aged and entails costly repairs. Committing to repairing the infrastructure, however, has the potential to greatly improve the water quality.

Table 6.3 Estimated Annual Costs of the Wastewater Recommendations

Recommendation	Basis	Unit Cost	Quantity	Total (per year)
WW1. Performance standards, inspections, and pump-outs of OWTS.	Estimated cost per year for DNREC staff to establish and maintain the performance standard regulation (remaining costs are the cost to the homeowner: \$5,000–\$7,000/system; annual maintenance fee: \$300–\$500/system).	\$20,000 (25% of a full-time position)	Per year	\$20,000
	Estimated cost per year for DNREC staff to establish and maintain the inspection and pump-out regulation (remaining costs are the costs to the homeowner \$100–\$230/system/year).	\$20,000 (25% of a full-time position)	Per year	\$20,000
WW2. Systematically eliminate cesspools and seepage pits.	Based on cost estimates from New Castle County Department of Special Services. Cost range is \$30,000–\$35,000/household to connect to sewer. If the removal is part of the county’s cost-share program the county covers 30%, and the homeowner covers 70%, therefore \$9,000–\$10,500 is the cost to the County.	Cost-share program	7 systems/year (part of NCC cost-share program)	\$63,000–\$73,500
WW3. Remove OWTS through connection to centralized WWTP.		Individual to Sewer	25 systems/year (cost to homeowner)	\$0

Recommendation	Basis	Unit Cost	Quantity	Total (per year)
WW4. No new OWTS drainfields placed within 100-feet of wetlands, tidal waters, perennial streams, perennial ditches, and ponds in-line with perennial watercourses.	Estimated cost per year for DNREC staff to establish and maintain the regulation (remaining costs are the cost of doing business).	\$20,000 (25% of a full-time position)	Per year	\$20,000
WW5. Abate combined sewer overflows.	\$30 million already spent, \$26,900,000 + \$30,000,000 = \$57,000,000 for entire system to meet Enhanced Long Term Control Plan goals.	\$26,900,000	Entire system	\$26,900,000
WW6. Continue sewer repair projects and conduct regular inspections.	The New Castle County cost information is from the Fiscal Year 2007 Comprehensive Annual Budget Summary, New Castle County Delaware. The New Castle County report notes that the ongoing rehabilitation of existing sewer lines continues to involve both large and small projects.	Average cost of NCC sewer projects slated for FY07 budget = \$8,190,000	Per year	\$8,190,000
WW7. Remediate contaminated sites	According to DNREC Site Investigation and Restoration Branch, this cost estimate provides a range for costs associated with the remediation of a Brownfield site. These costs are approximated and the presented values are not absolute. Costs per site can vary due to various factors including, but not limited to, size of the site, chosen remedy of the site, types of contaminants on the site, concentration of contaminants on the site, extent of contamination, type of site, end use of the site, length of monitoring after the remediation required, and other miscellaneous costs associated with the identification, investigation, remediation, and oversight.	Remediation of an average Hazardous Substance site is \$100,000 to \$3,000,000. A few sites cost in the range of \$20 million.	It is difficult to estimate the number of sites per year, so assume \$1,000,000 per year dedicated to site remediation.	\$1,000,000
Wastewater Total (including CSOs)				\$36,213,000-36,223,500
Wastewater Total (excluding CSOs)				\$9,313,000-9,323,500

Agriculture Costs

Table 6.4 outlines the costs associated with a select group of agriculture recommendations listed in the Christina Basin PCS. The total cost for implementing the seven agriculture recommendations is estimated at approximately \$21,620 per year. In this cost analysis the cost

estimates are used by the USDA's NRCS and NCCD pending the program funding source. The cost share list is updated each year, and these costs are the 2007 unit cost estimates. These unit costs reflect only the capital costs of implementing agriculture BMPs. In addition, there are only a select number of BMPs listed, yet there are numerous agriculture BMPs that can be implemented. In comparison to the costs outlined for the recommendations in the stormwater, open space, and wastewater sectors, the agriculture costs are relatively inexpensive. The lower costs are due to the cost-share programs, the limited agriculture areas available for agriculture BMP implementation in the Delaware portion of the basin, and the lower costs associated with these types of BMPs.

Table 6.4 Estimated Annual Costs of the Agriculture Recommendations

Recommendation	Basis	Unit Cost	Quantity	Total (per year)
<i>Select BMPs from Ag Recommendations</i>				
AG1. Nutrient Management Plans	These cost estimate lists are used by the NRCS and NCCD pending the program funding source. The cost share list is updated each year. These are 2007 unit cost estimates. These unit costs reflect only the capital costs of implementing agriculture BMPs.	\$3/acre (100% cost share)	750 acres/year	\$ 2,250
AG2. Cover Crops		\$35.00/acre (100% cost share)	125 acres/year	\$4,375
AG3. Pasture Stream Fencing		\$1.50/foot (50% cost share)	700 feet/year	\$525
AG4. Grassed Filter Strips		\$160/acre (75% cost share)	6 acres/year	\$720
AG5. Grassed Waterways		\$3,000/acre (75% cost share)	1 acre/year	\$2,250
AG6. Riparian Forested Buffers		\$5/large seedling (75% cost share)	5 acres/year and 400 trees/acre	\$7,500
AG7. Pasture and Hay Planting		\$200/acre (50% cost share)	40 acres/year	\$4,000
Agriculture Total				\$21,620

Education Costs

Based on estimates provided by the group and representatives of nonprofit organizations that have worked on projects such as this in the basin, the total annual cost estimated for implementing a portion of the education recommendations each year is \$114,000 per year. The education recommendations are the least costly of the five groups of recommendations. Although the education recommendations are the least expensive, they are one of the most important sets of recommendations due to the significant impact that behavior change and social awareness can have on reducing the impact of individuals' daily activities on the waters that make up the Christina Basin. Research has shown that behavior changes and the goals and programs outlined in the education set of recommendations are very difficult to achieve and require a very focused and concerted effort, but, if successful, result in beneficial behavior changes and positive impacts on water quality. Table 6.5 outlines each recommendation and the associated cost estimate per year to implement the education recommendations.

Table 6.5 Estimated Annual Costs of the Education Recommendations

Recommendation	Basis	Unit Cost	Quantity	Total (per year)
ED1. Educate Christina Basin stakeholders on nonpoint source pollution and their role in reducing it, specifically targeting behavior change.	This estimate is based on a rough calculation of the following: \$35,000 for DNREC part-time staff person for research, \$4,000 stipend for task force coordination, \$75,000 for regrant project implementation, totaling \$114,000 per year.	\$114,000	Per year	\$114,000
ED2. Encourage nutrient management plans for turf fields at education facilities.				
ED3. Encourage golf course managers to decrease nutrient application, stormwater runoff, and erosion.				
ED4. Educate pet owners on cleaning up pet waste.				
ED5. Educate homeowners on residential stormwater BMPs and BMP maintenance.				
ED6. Integrate education into state and local permitting processes.				
ED7. Encourage corporate environmental stewardship programs.				
ED8. Coordinate nonprofit organizations throughout the basin.				
ED9. Support and encourage water conservation and water quality measures to reduce nutrients leaving a site.				
ED10. Work with organizations to provide education programs on lawn and garden BMPs.				
ED11. Advise DNREC to research nutrient reductions related to bacteria counts and BMPs.				
Education Total				\$114,000

Total Costs of the PCS Recommendations for the Delaware Portion of the Christina Basin

Overall, the total cost of implementing the recommendations set forth in Christina Basin PCS is estimated at \$31.28 million per year. The basis for the \$31.28 cost estimate is literature research, communication with practitioners, and peer review. These costs are a reflection of 39 of the 40 recommendations that the Christina Basin Tributary Action Team formulated for the stormwater, open space, wastewater, agriculture, and education categories. The CSO elimination recommendation (WW7) is not included in this final cost estimate. As discussed previously, CSO elimination is not part of the charge of this group and is handled separately through the national CSO Policy. Therefore the cost is not included in the final estimated annual cost in Table 6.6. Table 6.6 summarizes the costs for each category discussed in the sections above. In Tables 6.1 and 6.3 a range of costs is estimated for the stormwater and wastewater categories but for the purposes of these tables the highest end of the range of the cost estimate is used to estimate the total annual costs to implement the Christina Basin PCS.

Table 6.6 shows that the suite of stormwater recommendations is the most expensive set of recommendations with a total estimated cost of \$12.17 million per year. This is not surprising due to the fact that the Christina Basin is a highly urbanized watershed with over half of the state’s population contained in it. Overall, the stormwater, open space, and wastewater recommendations are relatively close in cost and make up 99 percent of the costs for implementing the Christina Basin PCS.

While the cost of implementing the Christina Basin PCS is significant at \$31.28 million per year, there are three recommendations that make up over 80 percent of the total annual cost totaling approximately \$26 million per year. These BMPs include SW1 (requiring urban tree canopy), OS6 (acquiring open space), and WW6 (repairing and inspecting the centralized sewer). Although these three recommendations are costly, it does not mean that they should not be implemented. There are ways that the costs associated with these recommendations can be reduced, for example reducing the number of urban trees planted, making efforts to get trees and planting labor donated, acquiring fewer than 100 acres of open space per year, finding ways for landowners to donate tracks of open space, and utilizing multiple other options that can serve as alternatives. All of the recommendations outlined in this document—no matter what the cost—have the potential to significantly reduce the nitrogen, phosphorus, and bacteria loads and all are important to consider for implementation.

It is important to note that although there are several recommendations contained in each of the five categories that are costly, there are numerous recommendations that can be considered low cost options. Specifically, the agriculture and education categories are the least costly recommendations contained in the Christina Basin PCS. The education recommendations may be the most difficult to implement and achieve success, but, if the programs are successful, the potential to have a significant impact on pollution reduction is high and it is at a minimal cost. The agriculture recommendations are relatively inexpensive as well for a variety of reasons. These reasons are that a lot of agriculture BMPs have already been implemented in the Delaware portion of the Christina Basin, the agriculture land in the Delaware portion of the Christina Basin in which implementation is feasible is limited, and the cost-share programs significantly reduce the costs associated with implementing the agriculture BMPs. Although the education and agriculture recommendations have a relatively low cost, the land use in the Delaware portion of the Christina Basin is largely urbanized and the pollutant loads that are coming from the urban and suburban areas are significant and essential to address. The stormwater, open space, and wastewater recommendations are intended to address these areas and, therefore, although they are costly, these recommendations are extremely significant in achieving the fishable and swimmable goals of the Clean Water Act for the waters of the Christina Basin. There are several recommendations within these three categories that are as low as \$20,000 or less per year and require minimal expense. These include the following recommendations:

- SW2. Design stormwater BMPs that reduce nutrients according to the TMDLs.
- SW3. Limit addition of new impervious cover to less than 20 percent of the watershed above public drinking water supply intakes.
- SW4. Promote LID in new construction and redevelopment.
- SW6. Expand the role of RPTAC to create a Christina Basin group responsible for reviewing new development.
- OS1. Map, inventory, and prioritize existing wooded open space areas.
- OS2. Protect existing wooded/vegetated open space areas.
- OS3. Require management plans for community and HOA open space areas.
- OS4. Require vegetated buffers of adequate and proper widths sufficient to reduce or eliminate nonpoint source pollution for all new development abutting all waters of the state—including private, state, and county land.
- OS6. Acquire/conservate additional open space and retain conservation easements (applies only to the conservation easements portion of the recommendation).
- WW1. Install performance standards and conduct inspections and pump-outs of OWTS.

- WW3. Remove OWTS through connection to centralized WWTP (applies only to the cases where the homeowners and developers do not use the county cost-share program).
- WW4. Prohibit new OWTS drainfields placed within 100 feet of wetlands, tidal waters, perennial streams, perennial ditches, and ponds in-line with perennial watercourses.

Although the total annual cost estimates for implementing the Christina Basin PCS is in the millions of dollars, the waters of the Christina Basin in Delaware, Maryland, and Pennsylvania provide numerous benefits to the region. The waters provide water supply, ecological, and recreational benefits, and these benefits provide substantial economic value to society. The estimated economic value of these benefits provided by the waters of the Christina Basin can be quantified and will be discussed in detail in the following section.

Table 6.6 Estimated Annual Cost

Recommendations	Total Costs (\$M/per year)
Stormwater	12.17
Open Space	9.66
Wastewater	9.32
Agriculture	0.02
Education	0.11
Total	\$31.28

6.2 The Benefits of the Christina Basin and Meeting the TMDLs

In September 2006, the USEPA issued a high flow TMDL that recommends load reductions of at least 60 percent for bacteria, 20–80 percent for nitrogen, and 50–90 percent for phosphorus to meet Delaware stream water quality standards. This Christina Basin Pollution Control Strategy, prepared by DNREC, the University of Delaware’s IPA-WRA, and the Christina Basin Tributary Action Team, recommends multimillion dollar costs to implement solutions to meet the TMDLs as required by the federal Clean Water Act.

The waters of the Christina Basin in Delaware provide substantial water supply, ecological, and recreational benefits to society. The University of Delaware’s IPA-WRA conducted an analysis of the economic benefits of the waters of the Delaware portion of the Christina Basin and, based on this analysis, the benefits amount to approximately \$51.4 million per year. The total benefits are divided among the three areas and further divided within these categories. For example, the drinking water supply is worth at least \$25.9 million annually. Using plug-in values, the warm water fishery is estimated to be worth \$4.4 million per year. Additionally, primary recreation (boatable water quality) in the Delaware portion of the Christina Basin is estimated to be worth \$4.7 million annually. The canoe and kayak ecotourism businesses are estimated to earn approximately \$0.8 million annually. The trout fishing industry is worth approximately \$1.2 million per year. Motor boating in the tidal waters of the Christina Basin is worth approximately \$7.2 million annually. Further economic analysis estimates the present value of wetland habitat using the mid-range plug-in value is equal to \$7.2 million per year. Overall, the net present value of these water-related benefits in the basin over a 30-year period, assuming a 3 percent annual discount rate, is over \$1 billion. The lofty economic value of the Delaware portion of the

Christina Basin indicates it is worth substantial public and private investments to improve the quality of its waters. Detailed information on the calculations for the economic benefits of the drinking water supply, warm water fishery, primary recreation, ecotourism, trout fishing, motor boating, and wetlands are provided below.

Drinking Water Supply

Public water purveyors in the Delaware portion of the Christina Basin deliver 71 million gallons per day (mgd) of drinking water (peak) to residential, industrial, commercial, and institutional customers. Table 6.7 provides information obtained from the four water purveyors that supply drinking water to residents and industry in the Delaware portion of the Christina Basin, the sources of the drinking water supply, and the peak withdrawal amount obtained from the associated water source.

Table 6.7 Public Drinking Water Supply in the Delaware Portion of the Christina Basin

<i>Purveyor</i>	<i>Source</i>	<i>Peak Withdrawal (mgd)</i>
City of Wilmington	Brandywine Creek	35
City of Newark	White Clay Creek	3
United Water Delaware	White Clay/Red Clay Creeks	30
Artesian Water Company	Cockeysville Formation/Mill Creek	3
Total		71

Northern Delaware water purveyors estimate that the approximate cost to withdraw and pump the water from the streams, or the value of the raw water supply, is \$1.00 per 1,000 gallons or \$1,000 per one million gallons. A recent analysis of the value of the raw water supply in New Jersey, conducted by the Department of Environmental Protection, places the in situ market value of untreated water supply at \$0.394 per 1,000 gallons (Mates, 2007). For the purposes of this analysis, the economic benefit of the raw water in the Christina Basin will be estimated using the value of the raw water supply at \$1,000 per one million gallons as provided by the northern Delaware water purveyors. Therefore, assuming a peak withdrawal value of 71 million gallons per day, the present value of the raw water supply in the Delaware portion of the Christina Basin is estimated at \$25.9 million per year and is calculated using the following equation:

$$\begin{aligned}
 PV_{ws} &= 71 \text{ mgd } (\$1,000 / \text{mg}) (365 \text{ days/yr}) \\
 &= \$25,915,000/\text{yr} \\
 &= \$25.9 \text{ M/yr}
 \end{aligned}$$

Where:

- PV_{ws} = present value of the raw water supply
- mgd = million gallons per day
- mg = million gallons
- yr = year
- M = million dollars

Warm Water Fishery

The streams in the Christina Basin support a warm water fishery. The economic benefit of the fishery can be estimated using plug-in environmental shadow price values (Boardman, Greenberg, Vining, Weimer, 2006). The plug-in value of rough fishing (warm water fishery) ranges from \$12.70–\$51.00 per year per household with a mid-range value of \$32.00 per year per household. It is estimated that approximately 400,000 people live in the Delaware portion of the Christina Basin. Using this population estimate and the U. S. Census’s estimate that there are approximately 2.9 people per household, the present value of the warm water fishery using the mid-range plug-in value can be estimated at \$4.4 million per year using the following equation:

$$\begin{aligned} PV_{fh} &= \$32/\text{yr}/\text{household} (400,000 \text{ p}) / (2.9 \text{ p}/\text{household}) \\ &= \$4,414,000/\text{yr} \\ &= \$4.4 \text{ M}/\text{yr} \end{aligned}$$

Where:

$$\begin{aligned} PV_{fh} &= \text{present value of the warm water fishery} \\ p &= \text{people} \\ p/\text{household} &= \text{people per household} \end{aligned}$$

Primary Recreation (Boating)

The streams in the Christina Basin have sufficient water quality to support primary recreation such as boating and canoeing. Currently, the water quality is not sufficient to support secondary recreation such as swimming due to high bacteria levels. The plug-in value used in this analysis to determine the economic value of boatable water quality ranges from \$8.50–\$59.00 per year per household with a mid-range value of \$34.00 per year per household (Boardman et al., 2006). The present value of boatable water quality in the Christina Basin using the mid-range plug-in value is \$4.7 million per year using the following equation:

$$\begin{aligned} PV_{bt} &= \$34/\text{yr}/\text{household} (400,000 \text{ p}) / (2.9 \text{ p}/\text{household}) \\ &= \$4,700,000 / \text{yr} \\ &= \$4.7 \text{ M}/\text{yr} \end{aligned}$$

Where:

$$PV_{bt} = \text{present value of primary recreation}$$

Ecotourism

The Brandywine Creek in the Christina Basin supports a sizable ecotourism business through canoe and kayak liveries. Two outfitters—Wilderness Canoe Travels and Northbrook Canoe—provide services to approximately 20,000 customers per summer. The average cost of a canoe or kayak trip is \$40 per person. Therefore, using the estimate of 20,000 customers per year at a fee of \$40 per person, the present value of the ecotourism business can be estimated at \$0.8 million per year using the following equation:

$$\begin{aligned}
PV_{et} &= \$40(20,000 \text{ p/yr}) \\
&= \$800,000/\text{yr} \\
&= \$ 0.8 \text{ M/yr}
\end{aligned}$$

Where:
 PV_{et} = present value of ecotourism

Trout Fishing

The Christina Basin in Delaware has sufficient watershed health to support six put and take trout streams that are cold enough to support a stocked cold water fishery during the winter, spring, and fall seasons of the year. Presently, the streams are too warm during the summer to support a reproducing wild trout fishery. Over 2,700 Delaware trout stamps are sold to licensed anglers, and 30,000 trout are stocked annually to fish in the following trout streams:

- White Clay Creek above Newark
- Beaver Run
- Wilson Run
- Mill Creek
- Upper Christina River above Newark
- Pike Creek

According to Boardman et al., the value of recreational fishing is estimated at \$43.63 per activity day (Boardman et al., 2006). If each licensed trout fisherman wets a line ten days per year, the present value of trout fishing can be estimated at \$1.2 million per year using the following equation:

$$\begin{aligned}
PV_{tf} &= \$43.63 \text{ per day (2,700 fishermen) (10 days/yr)} \\
&= \$1,178,000/\text{yr} \\
&= \$1.2 \text{ M/yr}
\end{aligned}$$

Where:
 PV_{tf} = present value of the warm water fishery

Motor Boating

Delaware recreational mariners own 8,400 registered boats that ply the tidal waters of the Christina River and Brandywine Creek. According to Boardman et al., the value of recreational motor boating is estimated at \$42.80 per activity day (Boardman et al., 2006). If a registered boater cruises the waters for an average of 20 days per year, the present value of motor boating is estimated at \$7.2 million per year using the following equation:

$$\begin{aligned}
PV_{mb} &= \$42.80 \text{ per day (8,400 boaters) (20 days/yr)} \\
&= \$7,190,000/\text{yr} \\
&= \$7.2 \text{ M/yr}
\end{aligned}$$

Where:
 PV_{mb} = present value of motor boating

Wetlands

According to 2002 land use data, there were three square miles (1,920 acres) of wetlands in the Delaware portion of the Christina Basin. According to Boardman et al., the existence value of wetland habitat ranges from \$8–\$97 per household per year with a mid-range value of \$52 per household per year (Boardman et al., 2006). About 400,000 people live in the Delaware portion of the Christina Basin, and there are approximately 2.9 people per household. Therefore, the present value of the wetland habitat using the mid-range plug-in value is estimated at \$7.2 million per year using the following equation:

$$\begin{aligned} PV_{we} &= \$52/\text{yr}/\text{household} (400,000 \text{ p}) / (2.9 \text{ p}/\text{household}) \\ &= \$7,172,000/\text{yr} \\ &= \$7.2 \text{ M}/\text{yr} \end{aligned}$$

Where:

$$PV_{we} = \text{present value of the wetlands}$$

Total Present Value

Based on the values calculated above, it can be estimated that the total present value of the Delaware portion of the Christina Basin, including the economic benefits of the water supply, warm water fishery, primary recreation, ecotourism, trout fishing, and wetlands in the Delaware portion of the Christina Basin, is estimated at a value of \$51.4 million per year. Table 6.8 below sums all of these benefits and provides a total estimate of the present value of the benefits provided by the Delaware portion of the Christina Basin in million dollars per year.

Table 6.8 Present Value of the Benefits Provided by the Delaware Portion of the Christina Basin

Benefit	Present Value (\$M/yr)
Drinking Water Supply	25.9
Warm Water Fishery	4.4
Recreation (Boating)	4.7
Ecotourism (Kayaking)	0.8
Trout Fishing	1.2
Motor Boating	7.2
Wetlands	7.2
Total	\$51.4 M/yr

6.3 Discussion of the Costs and Benefits of the Christina Basin

Meeting the Delaware stream water quality standards is a necessary improvement for the rivers and streams that make up the Delaware portion of the Christina Basin. Not only does it benefit the water supply, recreation, and habitat uses in the basin, but it also makes good economic sense. According to the cost and benefit analysis conducted for the Delaware portion of the Christina Basin, achieving the fishable and swimmable criteria has significant economic value to

the citizens, businesses, and community in the Christina Basin region. At this time, the streams in the Delaware portion of the Christina Basin do not meet the water quality criteria, and reductions must be made in the nitrogen, phosphorus, and bacteria loads. The reductions that must be made range anywhere from 20–90 percent and the highest overall reductions are necessary for the bacteria loads reaching the rivers and streams. Making the reductions mandated by the high flow TMDL will return the waters of the Christina Basin to fishable and swimmable status. If the water quality criteria are met, the streams will not only serve their current benefit of providing water supply, habitat, boating, and fishing value, but the waters will be accessible for swimming and will offer an even greater economic value to the residents of the state and the basin.

As reflected in the cost analysis in Section 6.1, implementing the Christina Basin PCS is a costly endeavor at an estimated \$31.28 million per year. The PCS outlines 40 recommendations in the stormwater, open space, wastewater, agriculture, and education categories that, if implemented, have the potential to return the streams and tributaries in the Delaware portion of the Christina Basin to fishable and swimmable status. It is difficult to precisely determine the costs of implementing the recommendations outlined in the Christina Basin PCS, yet it is critical to the implementation of these recommendations that an analysis and calculation of the major costs are performed. The costs outlined in this report are highly variable and are likely to change, but they serve as a useful tool in estimating the cost of achieving the Christina Basin high-flow TMDL. This analysis is a way to begin prioritizing the recommended pollution reduction activities, determining the best approach, and identifying where further research is needed to begin the implementation phase of the Christina Basin Pollution Control Strategy. New sources of money are not being requested, but existing sources of funding shall be prioritized to focus on the most cost-effective recommendations and ways to achieve the goals of the federal Clean Water Act goals set for the Delaware portion of the Christina Basin. These recommendations are costly but if the costs are viewed in light of the benefits gained from the resources in the Christina Basin, the benefits far exceed the costs to implement the PCS.

The benefit analysis estimates that if the waters of the Delaware portion of the Christina Basin meet the Delaware water quality criteria, the estimated annual benefit is approximately \$51.4 million per year. Clearly this analysis demonstrates that the Christina Basin is worth restoring, and it is economically beneficial to begin implementing the Christina Basin recommendations and working toward achieving the fishable and swimmable status. Freshwater is a necessity, and it is becoming increasingly scarce. It is difficult to estimate the economic value of the benefits of a freshwater system like water supply, recreation, and habitat, but, based on existing studies, the benefits calculated for the Delaware portion of the Christina Basin reflect a highly valuable resource that is worth restoration, preservation, and investment.