Appoquinimink Watershed Implementation Plan

Final Report
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Primary CWP staff involved in producing this report includes Ted Brown, Sally Hoyt, Anne Kitchell, Paul Sturm, and Tiffany Wright. Additional CWP staff included Viswa Apavou, Jessica Brooks, Neely Law, Stephanie Sprinkle, and Angie Temple.

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Executive Summary

The Appoquinimink River Watershed drains approximately 47 square miles of coastal plain farmland in southern New Castle County, as well as the urbanized areas of Middletown, historic Odessa, and Townsend before discharging into the Delaware Bay. More than half of the watershed is actively cultivated; these farmlands are rapidly converting into suburban residential uses. Most of the Appoquinimink was included in 1998 on the 303(d) impaired list for either dissolved oxygen or nutrients. Total Maximum Daily Loads (TMDLs) were approved in 1998 for the tidal portion and in 2003 for the entire watershed establishing a 60% nutrient reduction requirement.

The purpose of this report is to provide guidance on implementing specific recommendations of the 2003 Appoquinimink Pollution Control Strategy (APCS), which was crafted to help the community meet nutrient load reductions called for in the 1998 Appoquinimink River TMDL. The draft implementation plan presented here is intended to assist the Appoquinimink River Association (ARA) and the Delaware Department of Natural Resources and Environmental Control (DNREC) in moving forward with "on-the-ground" implementation of stormwater, stewardship, and land development recommendations of the APCS.

This report outlines a series of recommendations for watershed restoration and protection in the urban and urbanizing portions of the Appoquinimink, describes management strategies for each of the seven subwatersheds, and identifies priority projects for implementation. Most of these recommendations are geared towards the development, stewardship, and general elements of the APCS. Strategic agricultural and wastewater goals, while critical to overall watershed management, are not specifically addressed within this implementation plan. Planning level cost estimates are provided where feasible, and a preliminary schedule for implementation over a five-year horizon is outlined. This implementation plan is framed by elements of the APCS, and is based on findings from the 2004 *Appoquinimink Baseline Assessment Report* (CWP, 2004b) and on field observations reported in the *Appoquinimink Technical Memorandum* (CWP, 2004a).

The following is a list of 11 APCS goals targeted by implementation recommendations presented in this report:

1. Inform watershed residents of water quality problems and solutions.
2. Identify specific actions/projects for resident participation.
3. Establish a mechanism to measure progress in achieving water quality goals and public communication.
7. Coordinate efforts to preserve farmland in the Appoquinimink watershed.
9. Encourage local governments to enact codes and regulations that allow for and promote "conservation design" principles taking into account citizen input.
10. Enhance the community stormwater runoff education and maintenance program
11. Establish a process for implementation and monitoring plan for priority stormwater retrofits, and conduct a stormwater retrofit inventory for the watershed.
12. Adopt regulations restricting development in Water Resource Protection Areas at least as strict as those in the NCC Unified Development Code (UDC).

13. Set criteria and provide incentives for the use of alternative pervious materials.
14. Design and manage open space areas for water quality protection.
16. Establish guidelines that promote good lawn and yard stewardship.

Implementation recommendations to meet these goals are as follows:

1. **Build the capacity of watershed organization and coordinator** to implement recommendations, secure grant funding, and track progress on restoration commitments.
2. **Hire a part-time ESC and SWM inspector** or train the watershed coordinator (DNREC employee) to supplement existing practice inspection and enforcement program.
3. **Adopt local environmental protection ordinances** related to development requirements, riparian buffers, and forest conservation.
4. **Establish stormwater design criteria** for conveying stormwater from the practice to the stream (slope, level spreader, etc) in order to protect steep slopes from erosion. Engineers should also integrate channel protection, as well as water quality and/or recharge criteria into the design of new and retrofitted stormwater treatment practices.
5. **Adopt more stringent design standards for ESC practices** to reduce sediment loads to streams.
6. **Actively pursue and encourage land conservation**, particularly of remaining contiguous forests, recharge areas, as well as historic and agricultural areas.
7. **Develop an illicit discharge detection and elimination program** to quickly identify and prevent non-stormwater connections to the storm drain system.
8. **Develop an urban outreach and pollution prevention program** to minimize nonpoint source pollution in commercial and residential areas by generating watershed awareness and active stewardship primarily among businesses and residents in Middletown and surrounding area.
9. **Evaluate municipal programs and practices** such as the tax ditch network, street sweeping, catch basin cleaning, road repair, etc from a pollution prevention perspective.
10. **Implement priority stream restoration,** particularly stream repair projects, to prevent headcuts and significant stream bank erosion.
11. **Install priority stormwater retrofits** to provide water quality treatment of runoff from parking lots and other urban areas to help meet TMDL nutrient load requirements.
12. **Target priority residential neighborhoods and confirmed hotspots** for stewardship, pollution prevention, and enforcement activities.
13. **Implement monitoring and project tracking** to evaluate implementation success over time.
14. **Identify and secure long-term funding for watershed restoration**.

This plan presents opportunities for applying a variety of management practices within the urban or urbanizing portions of the Appoquinimink Watershed. These practices are geared towards protecting remaining resources from future impacts of development or restoring degraded resources in urban areas. Protection practices include land conservation and tools for minimizing impacts during the construction and post-construction development phases. Restoration practices include stormwater retrofits, stream corridor restoration, discharge prevention, pervious area restoration, pollution source control, and municipal practices and programs. Agricultural

BMPs are also important for overall nutrient load reduction in the watershed, but with the exception of buffer reforestation are considered outside the focus on urban management. Priority projects are identified within each subwatershed, and a watershed-wide ranking specifically of stormwater retrofits is also provided. Tables E-1- E-4 summarize high priority stormwater retrofits, stream corridor restorations, residential and hotspot source control, and discharge prevention and enforcement opportunities, respectively. Figure E-1 shows the locations of these projects, as well as the location of a priority upland reforestation project in Hangman's Run (PA-1).

Table E-1. High Priority Stormwater Retrofits

Project ID*	Jurisdiction**	Description
A1-1	NCC	Odessa Professional Park. Convert dry pond to wet pond. Potential DelDOT partnership
A1-2	DNREC/ DelDOT/ NCC	Public land adjacent to river in Odessa. Develop as recreation/education/historic area. Incorporate bioretention facility/rain garden (A and B)
DP-1	DelDOT	DelDOT Maintenance Yard. Retrofit existing stormwater pond to provide channel protection (A). Add water quality treatment downstream of salt barn (B). Link with stream repair, stream cleanup, and source control opportunities.
DP-8	M/DelDOT	Local park. Existing outfall has scour hole. Drainage area includes Broad Street. Incorporate plunge pool/energy dissipater, Shallow Marsh/Wet Pond w/ED. Link with stream repair (C); buffer plantings (currently mowed to edge).
DP-23	M	MOT Senior Center. Retrofit existing pond with standing water by creating micropool, adding wetland plantings-- 3.25 acres (A); Volunteer opportunity to create raingardens for parking and rooftop runoff (B).
DP-28	M	Old Acme. 100% impervious site with building and parking - to become new city hall; use biofiltration, tree plantings as part of redevelopment.
DV-2	M	Greenlawn. Existing SWM pond for residential and commercial; retrofit existing pond with new riser with channel protection (A); convert sediment basin to pond (B); add shallow wetland
DV-3	M	Villagebrook Entrance. Use grass swale to divert water to bioretention cell near existing sump inlet.
DV-4	M	Villagebrook Outfall. Some scour in stream downstream of outfall. Provide water quality treatment with peat filter and outfall stabilization.
DV-5	M	Middletown Square Shopping Center (Goodwill). Large commercial area, use dry swale in back to treat roof/road runoff (B); provide on-site treatment with bioretention between parking aisles (A).
DV-20	M	Middletown Town Hall. Demonstration site for rain barrels (front of building) and rain garden (back of parking lot)
NX-5	Appo School District	Townsend Elementary. Rooftop and parking lot drainage bioretention - educational opportunity (however portion of site may be outside of the watershed).

Notes: Some sites have multiple concepts (labeled as A, B, etc). These locations are identified on Figure E-1.)See Appendix A for a more detailed description of each retrofit concept.

* Where DV=Dove Nest; DR=Drawyer Creek; DP=Deep Creek; NX=Noxontown Pond; AP= Appoquinimink I and II; HM= Hangman's Run

** Where NCC=New Castle County; DNREC= DE Department of Natural Resources and Environmental Control; DelDOT=DE Department of Transportation; and M=Town of Middletown

Table E-2. High Priority Stream Restoration Projects*		
Project ID	**Jurisdiction**	**Description**
Stream Repair Projects		
DP- ER-2	DelDOT/NCC	DelDOT Maintenance Yard—below outfall is in excellent condition with exception of headcut at end of geotextile—drops 1.5-2 feet. Outfall stabilization and retrofit would address majority of the problem ~50 ft; Links with Link DP-1, TR1-2, and HS-1c.
DP-ER-1	M/NCC	Below Cricklewood— ~200ft reach severely eroded at outfall below residential development (OT-1). Channel actively eroding (>6 ft banks); heavy sediment deposition in the floodplain. Consider drop inlet and redirecting flow away from earthen wall, grade control, toe protection, and re-shaping streambanks (mature trees would likely be lost as a result);
DV-ER-4	M	Brickmill Rd. ` 100 ft eroded intermittent channel with 5-10ft eroding banks leaving ESC pond. Strong evidence of significant sediment transport. ESC Pond seems to be receiving considerable amounts of runoff from upstream commercial development. Consider upstream flow control, rock cross veins, toe protection. An alternate concept would be piped conveyance to floodplain or stream
DV-ER-5	M	Greenlawn. Majority of RCH-4 in excellent condition except area directly downstream of SWM pond. ~ 60 ft of eroded channel and sediment deposition from failed stormwater pond riser; Links with retrofit. Consider drop structure to level spreader
DR-ER-1	NCC	Near Chestnut Lane—outfall creating severe headcut through a approximately 40 ft of 6-8ft high ravine. Further retreat of headcut could undermine outfall. Consider stabilizing outfall and improve energy dissipation
DR-ER-2 & ER-3	NCC	RCH-9 Commodore Estates II. ~800-1000 ft of stream repair downstream to ensure a stable channel. Consider rock cross veins, bank reshaping, toe protection at ER-2 and cutoff sill and potential bank re-shaping at ER-3
NX-ER-1	T	RCH-11 is highly eroded. Large amount of sediment actively transported; totally covered in honeysuckle; significant headcut at base of railroad tracks difficult to measure; at least a 5.5 ft drop. High erosion severity; >500 ft (3-6 ft banks; both sides) Consider concrete sill to contain headcut – monitor to ensure effectiveness
Buffer Reforestation Projects		
DP-IB-1	M	RCH-20 Local Park. Stream channel through in park-like setting has poor buffer ~150ft. Linked with DP-8 retrofit.
DP-RCH-21	M	At retrofit DP-8, ~900 ft of stream need buffer plantings (currently mowed to edge) on both sides
DR-IB-1, 2, 3	NCC	RCH-5 Above Cedar Lane (south). Increase width of the existing stream buffer; ~2000ft
HM-RCH-9	NCC	Reach in poor condition; down cutting in channel; ~500 linear ft lack of buffer (mostly on right bank along farm field)
NX- RCH-3	NCC	Lawn mowed to edge of stream ~300 linear ft; loss of property due to bank erosion. Dog kennels adjacent to stream. Link with repair/maintenance of farm pond embankment.
NX-RCH-4/5 & RCH-6	T/NCC	Conditions poor due to lack of vegetation; reaches under Tax Ditch system; herbicide spraying; mowed to edge.. Homeowner education and work with conservation district to provide alternatives for spraying, etc. ~400 linear ft along RCH 4/5 and >1000 ft along RCH 6
Stream Cleanup Projects		
DP-TR1, 2	NCC	DelDOT Maintnenance Yard. Links with DP-1 retrofit; and HS-1 source control
NX-TR-2	NCC	Pump Station (RCH-13). County staff report repeated dumping of trash along road/creek. Block vehicle access with locked chain across entrance.

Notes:
Where DV=Dove Nest; DR=Drawyer Creek; DP=Deep Creek; NX=Noxontown Pond; AP= Appoquinimink I and II; HM= Hangman's Run; ER=Erosion Site; OT=Outfall; RCH=Reach
Where NCC=New Castle County; M=Town of Middletown; O=Odessa; T=Townsend; DelDOT=DE Department of Transportation
* Further investigation at these sites is required to get a better sense of overall project costs.

Table E-3. High Priority Pollution Source Control Projects

Project ID	Jurisdiction	Description	
Hotspots			
DP-HS-3	M	Happy Harry's; dumpster management	
DP-HS-6	DelDOT	DelDOT Maintenance Yard. PPP for vehicle maintenance, fueling, and washing; uncovered storage; pond maintenance. Links with retrofit and stream repair, and stream cleanup.	
DP-HS-9	M	Meineke. Outdoor storage, vehicle operations	
DP-HS-12	M	Middletown DPW Yard. Opportunities for pollution prevention practices such as truck washing station; proprietary products; rain barrels. Check drainage of washing station to make sure goes to underground practice rather than stormdrain. Potential retrofit for 3.19 acres (100% IC)	
DV-HS-1	M	Legends Golf Course. Uncovered storage and gas pump near clubhouse; links with outfall investigation	
DV-HS-3	M	Johnson's Control; links with outfall investigation.	
DV-HS-5	M	Middletown Square Shopping Center (Goodwill). Poor waste management for dumpsters and kitchen grease and application of pesticides or herbicides near field inlet. Site also retrofit candidate.	
DR-HS-2	NCC	Middletown Materials, LLC. Due to buffer impacts.	
NX-HS-3	T	Townsend Fire Dept. Dumpster mgmnt; vehicle operations; outdoor storage (could use a small berm, spill response plan)	
Residential*			
DP	M	Middletown Crossing (N2); Cricklewood (N5)	No residential neighborhoods in the watershed were considered high pollution risks, however priority areas were generally considered moderate sources of pollution with moderate to high opportunities for restoration. These priority neighborhoods were selected predominantly for lawn care and downspout disconnection opportunities, or because they are located upstream of priority stream corridor restoration or stormwater retrofits.
DV	M	The Legends Golf Course Community and Spring Mill (N2)	
DR	NCC	Commordore Estates II, andGrey Lag (N1); Chestnut Grove (N3); Commordore Estates (N2)	
NX	NCC	Minorca Place (N1)	
HM	NCC	Thomas Cove (N1); Cantewell Ridge (N2); Odessa Chase (N3); StoneField and Bishops Walk (N4)	

Notes: Project ID: DV=Dove Nest; DR=Drawyer Creek; DP=Deep Creek; NX=Noxontown Pond;; HM= Hangman's Run
Jurisdiction: NCC=New Castle County; M=Town of Middletown; O=Odessa; T=Townsend;
DelDOT=DE Department of Transportation

* Neighborhoods in the same subwatershed sharing an ID# were assessed as similar neighborhood types therefore do not have individual neighborhood IDs

Table E-4. High Priority Enforcement and Discharge Investigation

Project ID	Jurisdiction	Description
Illicit Discharge Investigation		
A1-OT-3	O	State Police Station in Odessa. Discharge prevention/ vehicle operations drain connection to stormwater network. Link with retrofit and source control.
DV-OT-6	M	Hayley Ct and Weston Drive. 54" outfall with possible paint thinner or oil based chemical discharge. Investigate homes and businesses in the drainage area including Johnson Controls to locate illicit connections.
DV-OT-8	M/NCC	Schagrin Gas Co., Southern States and Citgo gas station. Oil sheen at outfall pool
DV-OT-7	M	Legends Golf Course. Excessive algae covering rocks exiting outfall
NX-RCH-13	NCC	Pump station. RCH in excellent condition (section below Wiggins Mill Pond—saw Bass, used to be eagle's nest here (according to locals); beaver). Excessive algal mat at manhole. Suspected sewer overflows.
NX-OT-4	NCC	Minorca Place Outfall suspected illicit discharge from residential connection to stormdrain inlet. Link with outfall (OT-4) repair; potential retrofit, and residential rooftop disconnection practices; pool discharge education

Table E-4. High Priority Enforcement and Discharge Investigation		
Project ID	**Jurisdiction**	**Description**
ESC/SWM Inspection and Enforcement		
A1-RCH-2	M	Reach below development site and sediment pond experiencing significant sediment deposition. Stringent ESC enforcement needed
DV-ER-4	M/NCC	Brickmill Rd. erosion site; frequent inspection during phased construction process
DV-ER-5	M	Greenlawn-- failed stormwater pond riser
NX-SC-2	NCC	RCH-3. Maintenance at failing embankment below farm pond.
NX-OT-3	T	Near RCH4/5. Open riser structure looks like SWM pond rather than sediment basin. Giant flow paths cut through surface to get to pond. Some failure around oufall and slope failure observed. They have double silt fencing. Conveyance of stormwater down steep slope could create erosion problems
Notes: Where DV=Dove Nest; DR=Drawyer Creek; DP=Deep Creek; NX=Noxontown Pond; AP= Appoquinimink I and II; HM=Hangman's Run; ER=Erosion Site; OT=Outfall; RCH=Reach Where Jurisdiction: NCC=New Castle County; M=Town of Middletown; O=Odessa; T=Townsend;		

The 14 implementation recommendations should be loosely viewed as short-term, mid-term, and long-term implementation priorities, keeping in mind that many of the recommendations presented will be on-going. *Short-term* recommendations are initial actions to be carried out within the next year that set the framework for executing watershed recommendations (i.e. adoption of local ordinances, identification of land conservation priorities, discharge investigations, and education program planning). *Mid-term* recommendations involve continued programmatic and operational measures, distribution of educational materials, and construction of one or two large retrofit and/or stream restoration projects over the next two to four years. *Long-term* recommendations mark continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed implementation plan.

Table E-5 provides a draft budget and schedule for implementing the 14 watershed recommendations based on cost estimates provided in the previous section *(Please note that this table does not include land conservation costs or construction costs for of all priority stormwater retrofits).* Based on this budget, ARA should plan on a basic annual budget of approximately $50,000 (includes #1, 6, 8, 9, 12, 14, and portion of #7). Some of these costs may fall within the watershed coordinator's salary, others may be in addition to existing requirements of the position. On top of the basic program budget, ARA should set a fundraising goal of $70,000 for short-term implementation (includes #10 and 11).

A four-pronged approach to monitoring implementation activities in the Appoquinimink is recommended which includes: project monitoring, sentinel station monitoring, illicit discharge monitoring, and project tracking. Project monitoring should be geared towards quantitative measures of success for both structural and non-structural practices. Monitoring methods will depend upon the project, but can involve pre and post biological sampling and cross sections at stream repair projects, pre and post behavior surveys for educational activities, and simple accounting of the number of hotline calls or disconnections performed as part of a discharge prevention program. Continued monitoring at a few existing gauges/stations throughout the watershed is recommended for baseflow and stormflow sampling; additional stations for macroinvertebrate and habitat stations are recommended. ARA should take the lead on project tracking and annual reporting of implementation progress.

Table E-5. Implementation Costs and Schedule

Recommendation	APCS Goal	Responsible Parties	Planning Level Costs*		
			Short-term (year 1)	**Mid-term** (years 2-4)	**Long-term** (year 5+)*
1. Build capacity of watershed organization and coordinator	1,2,4,5	ARA	$15,000	$15,000 (@ $5,000/yr)	$5,000+
2. Hire part-time ESC/SWM inspector	4	NCC; M	$15,000	$45,000	$15,000+
3. Adopt local environmental protection ordinances†	10,13,14	M; T	$20,000-$60,000	--	--
4. Enhance stormwater criteria	10,13,14	M, NCC	$20,000	--	--
5. Adopt more stringent design standards for ESC practices	10	M, NCC	$20,000	--	--
6. Actively pursue land conservation	8	ARA; DDA; Land Trust	$5000 (identification)	Unknown	
7. Illicit discharge detection and elimination	11	ARA, M, NCC	$2400 (@ $400/site investigation) $1300 establish hotline	$4500 (@ $1500 annual hotline costs)	$1500+
8. Develop education program	1-3,10, 11	ARA	$15,000	$30,000 (@ $10,000/year)	$10,000+
9. Evaluate municipal programs/practices	--	NCCD; ARA; DelDOT; M	$15,000	--	--
10. Implement priority stream restoration	--	ARA; DNREC; NCC, M;	$10,000 (design of priority projects) $35,000 (repair DV-ER-4)	$260,000 (install DP-ER2/ -ER1;& DR-ER2/3) $6000 buffer (all projects)	$130,000 (install remaining)
11. Install priority stormwater retrofits	11,12	ARA; DNREC; NCC, M; DelDOT;	$25,000 (implement small demo project (DV-20 and DP-23 raingardens)	$25,000 (design & engineering) $475,000 (construct A1-2; DP-1; DP-8)	$820,000 (construct DV-2, DV-5)
12. Implement priority pollution prevention	1, 2, 11	ARA	Part of education program		
13. Monitoring and project tracking	3, 12, 23	DNREC; ARA; USGS	$6000 (10 bug stations @ $600/station) $500 (2 baseflow sites in high nuturient areas $20/sample/month) ††	$1200 (bugs year 2,4) $1500 (baseflow)	$6000+ (bugs) $500+ (baseflow)
14. Secure long-term funding	21	ARA; DNREC	Part of watershed group capacity funding		
Phase Totals			**$225,200**	**$873,200**	**$988,00**
Cumulative Total				**$1,098,400**	**$2,086,400**

* ARA=Appoquinimink River Association & watershed coordinator; DNREC=DE Dept of Natural Resources and Environmental Control; DelDOT= DE Dept of Transportation; DDA=DE Dept of Agriculture; NCC=New Castle County; M=Middletown; T=Townsend; USGS= US Geological Survey

** Light shading indicates ARA basic annual costs; darker shading indicates ARA lead in fundraising for short-term projects

† NCC and Odessa may also need to adopt/revise ordinances, however existing regulations for these jurisdictions were not evaluated as part of this work.

†† Baseflow monitoring costs are for analysis only. Note these costs do not include all recommended monitoring.

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Section 1.0 Introduction

The purpose of this report is to provide guidance on implementing specific elements of the 2003 Appoquinimink Pollution Control Strategy (APCS). The Appoquinimink Tributary Action Team and the Delaware Department of Natural Resources and Environmental Control (DNREC) crafted the APCS to help the community meet the 60% nutrient load reduction called for in the 1998 and 2003 Appoquinimink River Total Maximum Daily Loads (TMDLs). In addition to recommending agricultural practice implementation, the APCS highlighted the need to improve stormwater management in urbanized portions of the watershed through stormwater treatment practices, residential stewardship, stormwater education, and land development practices.

This report outlines a series of recommendations for watershed restoration and protection in the urban and urbanizing portions of the Appoquinimink, describes management strategies for each of the seven subwatersheds, and identifies priority projects for implementation. Planning level cost estimates are provided where feasible, and a preliminary schedule for implementation over a five-year horizon is outlined. Financial and technical partners for plan implementation are suggested for various recommendations and projects.

The implementation plan presented here is intended to assist the Appoquinimink Watershed Coordinator, Appoquinimink River Association (ARA), and DNREC in moving forward with "on-the-ground" implementation of stormwater, stewardship, and land development recommendations of the APCS.

1.1 Background

The Appoquinimink River Watershed drains approximately 47 square miles of coastal plain farmland in southern New Castle County, as well as the urbanized areas of Middletown, historic Odessa, and Townsend before discharging into the Delaware Bay (Figure 1). More than half of the watershed is actively cultivated; however, as development is directed into southern New Castle County, these farm lands are rapidly converting into suburban residential uses. Expansive tidal wetlands at the mouth of the Appoquinimink River are part of one of the largest undisturbed marsh systems in Delaware. These wetlands serve as important habitat for wildlife and waterfowl, spawning grounds for fish and other aquatic species, and passive recreation for local birdwatchers. Four large impoundments (Noxontown Pond, Shallcross Lake, Silver Lake, and Wiggins Mill Pond) separate the headwaters from the mainstem Appoquinimink River, and are defining features of three of the seven subwatersheds. The upland portion of the watershed is generally flat, but steep slopes can be found associated with stream valleys in the headwaters. Most of the Appoquinimink was included in 1998 on the 303(d) impaired list for either dissolved oxygen or nutrients. A Total Maximum Daily Load (TMDL) was recently approved for nutrients due to the impairment status, wastewater management needs, and available information on non-point source loadings.

In 2004, the Center for Watershed Protection (CWP) along with various local and state partners, conducted a stream corridor and upland areas assessment to identify potential opportunities for

stormwater retrofits, stream corridor restoration, and pollution source control practices in the watershed. More detail on assessment methods and findings can be found in the *Appoquinimink Technical Memorandum* (CWP, 2004a).

Concurrently, CWP began compiling existing information on land use characteristics; water quality, biological, and physical conditions that had been reported for the watershed. Sources of data included studies, reports, and GIS data from the Whole Basin Program, DNREC, Delaware Water Resources Agency, New Castle County, the University of Delaware, and others. A limited evaluation of existing environmental regulations for Middletown and New Castle County were evaluated (i.e. stormwater criteria, erosion and sediment control, buffer regulations, and development codes). A general summary of these data is provided in the *Appoquinimink Baseline Assessment Report* (CWP, 2004b). Notably absent from the *Baseline Assessment* is natural resources information (i.e. rare, threatened and endangered species, sensitive habitats, protected areas) from the Delaware Natural Heritage Program, as well as hydrologic and water quality analyses of the ponds and lakes in the watershed. Integration of this information will be important when revising and updating the watershed plan at a future time.

This report pulls information from both the *Technical Memorandum* and *Baseline Assessment* and references those documents for more detail.

1.2 Report Organization

Subsequent to this introductory section, the report is organized as follows:

Section 2 presents 23 watershed goals, which were taken from the APCS, and 14 implementation recommendations. The APCS goals were developed through the State's tributary action team process to meet 303(d) and TMDL requirements and incorporate issues important to local watershed stakeholders. A subset of these goals relating to urban development, stewardship, and monitoring were used as a framework for developing key implementation recommendations. The implementation recommendations are based on watershed impacts observed during field assessments, physical watershed characteristics, and a brief review of existing programs and municipal capacity.

Section 3 provides a brief description of the types of watershed protection and restoration practices recommended for the Appoquinimink. Protection practices include land conservation, better site design, erosion and sediment control, and stormwater management techniques. Restoration practice types include stormwater retrofits, stream corridor restoration, discharge prevention, pervious area restoration, pollution source control, and municipal practices and programs. More detail on stormwater retrofitting and concepts for priority projects can be found in **Appendix A**. More detail on stream corridor restoration, including costs and practice fact sheets can be found in **Appendix B**. Supplemental information on pollution source control practices for residential, municipal, and business stewardship programs can be found in **Appendix C**.

Section 4 is dedicated to management strategies for each of the subwatersheds. All candidate restoration opportunities identified by CWP (2004) are summarized and ranked as high, medium, or low subwatershed priorities. Project ranking is based on a combination of factors including feasibility, linkage with other projects, and cost. High priority projects are discussed further, referencing supplemental detail in the appropriate appendix. Detailed management maps depicting project locations, land use, riparian impacts, and other important features are provided in **Appendix D**.

Stormwater retrofits from each subwatershed were also ranked against each other on a watershed scale using a formal ranking matrix (Appendix A). This prioritization was not conducted for stream restoration, discharge prevention, or source control projects.

Section 5 provides planning level cost estimates and a schedule for implementing priority restoration projects and watershed recommendations over the next five years. Unit cost assumptions for the various restoration practices and cost estimates for priority projects are provided where feasible.

Section 6 outlines a basic monitoring and project tracking strategy to evaluate progress in plan implementation.

1.3 Caveats

It is important to keep in mind that this implementation plan is generally limited in scope to the development and stewardship elements of the APCS. More specifically, the recommendations and projects presented here apply to the urban and urbanizing portions of the watershed and do not include agricultural or wastewater related issues. Since the reduction of nutrient loading is a primary driver in watershed management activities in the Appoquinimink, and the majority of nutrient loading is reported to derive from agriculture, continued implementation of agricultural best management practices (e.g., animal waste control, conservation tillage, vegetative cover) identified by the Rural Clean Water Program is critical to overall water quality. Monitoring of the existing and future wastewater treatment plant and associated land application/spray irrigation is also important.

Preliminary implementation budgeting and scheduling are based on a set of planning level costs and capacity assumptions that may or may not accurately reflect local conditions. The watershed coordinator, ARA, and DNREC should refine this plan based on local resources and priorities.

In addition, a clearer understanding of the role of lakes and ponds (e.g.. are they sinks, or sources), as well as the location of natural resources (e.g., RTE species, sensitive habitats) will likely influence overall recommendations and watershed priorities.

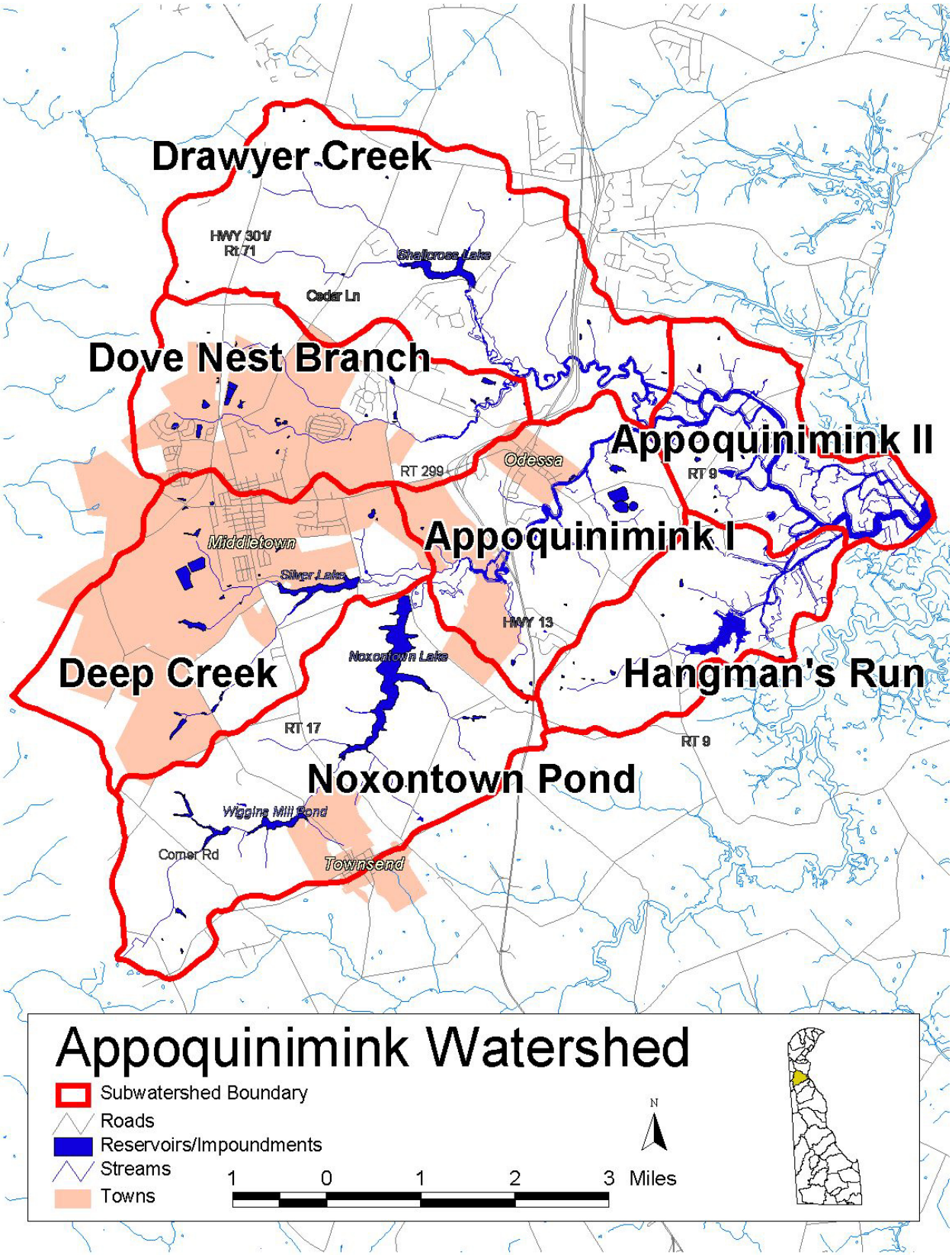

Figure 1. Location of Appoquinimink River Watershed

Section 2.0 Watershed Goals and Recommendations

Recommendations for managing the urban and urbanizing portions of the Appoquinimink watershed are guided by the overall goals set by the Appoquinimink Tributary Action Team to meet pollution reduction requirements of the TMDL and ultimately protect the larger resource, the Delaware Bay Estuary. This section presents the watershed goals established by stakeholders and implementation recommendations based on 2004 watershed assessments.

2.1 Appoquinimink Pollution Control Strategy Goals

In 1998, the U.S. EPA established TMDLs for the Appoquinimink River. To help meet these federal guidelines, DNREC has been working with a group of citizens, the Tributary Action Team (the Team), to craft pollution control strategies for the Appoquinimink River watershed. In 2003, DNREC published the Team's findings, which included 23 individual recommended goals for the Appoquinimink Pollution Control Strategy (APCS). APCS goals related to development, stormwater, stewardship and monitoring set the framework for this urban implementation plan. The following is a list of those recommendations as published by DNREC (2003); specific goals met by recommendations of this plan (see Section 2.2) are checked. Goals with a double checkmark have already been implemented.

<u>General</u>

1. Inform watershed residents to water quality problems and solutions. ✓
2. Identify specific actions/projects for resident participation.✓
3. Establish a mechanism to measure progress in achieving water quality goals and public communication.✓
4. Hire an Appoquinimink watershed coordinator to assist efforts in reducing nutrients using funds from various sources.✓✓
5. Form a citizen's organization for the benefit of the Appoquinimink watershed.✓✓

<u>Agriculture</u>

6. Develop BMP implementation goals for agriculture.
7. Encourage voluntary implementation of a Nutrient Management Plan prior to mandatory compliance. The State should continue to responsibly fund nutrient management planning and implementation.
8. Coordinate efforts to preserve farmland in the Appoquinimink watershed. These lands provide water quality and quantity benefits when farmed responsibly. ✓
9. Create a recognition program for farmers in the Appoquinimink watershed who do the most to protect water quality.

<u>Development</u>

10. Encourage local governments to enact codes and regulations that allow for and promote "conservation design" principles taking into account citizen input. Municipal codes should meet or exceed the watershed protective properties of New Castle County ordinances. In

addition, local governments should provide an on-going education and outreach program for communities to help maintain the elements of their community design. ✓

11. Enhance the community stormwater runoff education and maintenance program by targeting homeowner maintenance organizations (HMOs) and other groups maintaining, inspecting, or designing stormwater structures. ✓
12. Establish a process for implementation and monitoring plan for priority stormwater retrofits, and conduct a stormwater retrofit inventory for the watershed. ✓
13. Establish a watershed-wide limit for impervious cover with consideration for site-specific mitigation, and adopt regulations restricting development in Water Resource Protection Areas at least as strict as those in the NCC Unified Development Code (UDC). ✓
14. Set criteria and provide incentives for the use of alternative pervious materials. ✓

<u>Private Stewardship</u>

15. Design and manage open space areas for water quality protection. Reforestation, meadow development, wetlands construction, etc., should be encouraged through increased outreach efforts. The State, County and local governments should develop guidelines to maintain community open space. ✓
16. Encourage early implementation of the Nutrient Management Act for turf management over 10 acres. Programs such as the NRCS cost-share efforts and other incentive efforts should be better publicized to residents and maintenance corporations in order to support enhancement of the open spaces they manage.
17. Establish guidelines that promote good lawn and yard stewardship. Provide nutrient management training for retail fertilizer salesmen and landscaping companies. Revise the soil test result sheets that go to homeowners in order to make them more understandable by the public and better dissemination of soil test kits. All environmental information should be supplied periodically on the scrolling band under the picture on the Weather Channel. ✓

<u>Wastewater</u>

18. Initiate a septic system compliance program, which unifies both State permit requirements and UDC inspection provisions leading to the replacement and/or the repair of failing systems, and licensing of septic system inspectors.
19. The legislature should amend real estate law to require certification of septic system and the dissemination of educational materials on proper maintenance to homeowners at time of sale. Prohibit seepage pits, cesspools and permanent holding tanks within the watershed.
20. Consider replacing existing septic systems with central sewer.

<u>Other</u>

21. Create a watershed-wide stormwater utility to fund retrofits and infrastructure maintenance.

<u>Monitoring</u>

22. Monitor standard and alternative septic systems to determine whether alternative systems further reduce nutrient discharge. Large community systems are preferred to individual septic systems.
23. Re-establish a groundwater-monitoring program for southern New Castle County to ensure the quality of drinking and surface water. ✓

2.2 Implementation Recommendations

This section describes the 14 key recommendations, developed based on an overall watershed assessment, for meeting APCS goals. Most of these recommendations are geared towards the development, stewardship, and general elements of the APCS. Strategic agricultural and wastewater goals, while critical to overall watershed management, are not specifically addressed within this implementation plan.

Recommendations should be loosely viewed as short-term, mid-term, and long-term implementation priorities, keeping in mind that many of the recommendations presented will be on-going. *Short-term* recommendations are initial actions to be carried out within the next year that set the framework for executing watershed recommendations. Such actions include adoption of local ordinances, identification of land conservation priorities, discharge investigations, and education program planning. Construction of large retrofit practices and stream restoration projects is not included in this phase in order to accommodate required design, engineering, and permitting. *Mid-term* recommendations involve continued programmatic and operational measures, distribution of educational materials, and construction of one or two large retrofit and/or stream restoration projects over the next two to four years. Progress on land conservation and continued enforcement and inspection as the watershed develops should be made during this period, as well as project monitoring and tracking. *Long-term* recommendations mark continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed implementation plan.

A schedule presented in Section 5 shows how short, mid, and long-term implementation recommendations are distributed.

Implementation recommendations for the Appoquinimink are as follows:

1. **Build the capacity of watershed organization and coordinator** to implement recommendations, secure grant funding, and track progress on restoration commitments. As recommended in the APCS, DNREC has already hired a watershed coordinator and a watershed group is in the process of applying for non-profit status. The watershed coordinator should take the lead on implementation and should organize regular meetings of an informal watershed council that includes ARA leadership, local elected and administrative officials, engineering and planning staff, NCC Conservation District, St Andrews School, and other significant stakeholders.

2. **Hire a part-time ESC and SWM inspector** or train the watershed coordinator (DNREC employee) to supplement existing practice inspection and enforcement program. At a minimum, ARA members could be trained to serve as watchdogs. Consider approaching New Castle County and Middletown on hiring an inspector jointly, which may help alleviate some of their inspection burden and give the inspector enforcement authority. Given the rapid rate of development and observations from the field, special consideration should be

given in this watershed to maintaining a strong erosion and sediment control (ESC) inspection and enforcement program. CWP frequently observed impacts in the stream below outfalls likely caused by poor execution of ESC and stormwater practices. There is a significant amount of active construction, and this trend is only going to increase over the next decade, inspection of practices before, during, and after construction is crucial to protecting good quality channel conditions and preventing further degradation in impacted reaches.

3. **Adopt local environmental protection ordinances** related to development requirements, riparian buffers, and forest conservation. Municipal development codes should be reviewed and updated to encourage better site design for water quality and recharge protection, and agricultural preservation. Developments within New Castle County are subject to the County's Unified Development Code, however much of the new development in the watershed is within the jurisdictions of Middletown and Townsend. Reducing impervious cover, protecting forests and stream buffers, and effectively managing stormwater should be key site design considerations for new development. A review of Middletown's subdivision and development regulations found significant opportunities for improving the codes that guide environmentally sensitive site design. ARA should consider hosting a site planning roundtable which would allow stakeholders input in the process.

   Field crews noted buffer encroachment throughout the watershed, and observed excessive algae in many non-shaded streams and ponds. ARA should encourage greater protection and reforestation of stream and shoreline buffers either through the adoption of more stringent floodplain and buffer ordinances or through voluntary measures. Middletown currently does not have a riparian buffer ordinance. An effective stream buffer ordinance should include how the buffer should be delineated, a minimum width (generally not less than 100 feet), types of vegetation required, prohibited uses, maintenance requirements, and enforcement measures. It is recommended that the town, at a minimum, adopt New Castle County's buffer criteria. Voluntary landowner stewardship programs and incentives to enhance existing buffer areas are also important. ARA should work with landowners to pursue federal subsidies available for buffer protection in agricultural areas, and restoration grants for developed areas (see CREP program fact sheet in Appendix B). Additionally, more flexible site design standards can be used to protect valuable buffers in developing areas.

   Middletown and New Castle County should adopt strong tree conservation requirements, as well as reforestation (replanting) and/or afforestation (planting) criteria for new residential and commercial development to protect or restore forest canopy. Less than 9% of the watershed remains forested. Most forested areas are located along the stream valley, and very few large contiguous tracts of un-fragmented forest remain in the watershed. From a stormwater perspective, tree canopy coverage in urban settings helps intercept rainfall, promote infiltration, and regulate temperatures. Large mowed areas dedicated to open space within residential areas are prime locations for tree plantings, as are schools and other public lands. Street trees and parking lot landscaping should be incorporated into stormwater design.

Appendix E of the *Baseline Assessment Report* has copies of the Middletown code review and New Castle County's buffer ordinance.

4. **Establish stormwater design criteria** for conveying stormwater from the practice to the stream (slope, level spreader, etc) in order to protect steep slopes from erosion. Stream surveys show signs of impact in first order tributaries draining agricultural areas and below outfalls from both old and new development, particularly where drainage encounters steep slopes. Outfalls discharging concentrated flow onto steep slopes frequently were reported for infrastructure failure, headcuts, and downstream erosion. The state, NCC or Middletown should consider outfall protection criteria requiring discharge to be taken down to stream invert or floodplain elevation with target slopes ranging from 0-2%.

   Engineers should also integrate channel protection, as well as water quality and/or recharge criteria into the design of new and retrofitted stormwater treatment practices. Practice designs for the larger water quality facilities tend to incorporate recommended elements such as forebays, aquatic benches and wetland fringes; however, ponds are not necessarily being well designed for channel protection. Practices should be sized for channel protection as well as water quality and/or recharge in the non-tidal portions of the watershed. Currently, there are no criteria for channel protection; ponds are designed for only 2-yr peak discharge control. As the watershed develops, small storm events will likely result in increased stream bank erosion and channel scour. Channel protection is less important in the lower, tidal portion of the watershed when treated stormwater is discharged directly to tidal waters and not to ephemeral channels.

5. **Adopt more stringent design standards for ESC practices** to reduce sediment loads to streams. New Castle County and Middletown should consider requiring wrapped outlet pipes or risers, adequate storage volumes for a broader range of storms for sediment basins, super silt fences, etc. In addition, local regulators should take a look at the how construction phasing impacts stormwater practice efficiency—particularly the timing of sediment basin conversion to stormwater pond—and consider on-site practice applications to supplement the larger storage practices.

6. **Actively pursue and encourage land conservation**, particularly of remaining contiguous forests, recharge areas, as well as historic and agricultural areas. Over 30% of the watershed falls under a high recharge potential zone, and may be considered a Water Resource Protection Area (WRPA). Less than 9% of the watershed remains forested, dominated by oak, hickory, pine, and species common to southern floodplain and mixed forest assemblages. Most forested areas are located along the stream valley, and very few large contiguous tracts of un-fragmented forest remain in the watershed. Considering that less than 10% of the watershed is currently designated as protected open space (not including wetland, wellhead, and Water Resource Protection Area provisions), opportunities for protection and restoration of water resources still exist. ARA should work with the local land trust, Delaware Department of Agriculture, Natural Heritage Program, New Castle County, and large landowners to identify and prioritize sites for land acquisition or easements. If conservation is not a viable option, ARA should work with local plan reviewers to ensure better site design techniques are applied for new development in a manner that minimizes

impacts on sensitive areas. Consider working with the State to expand the Wildlife Management Areas at the mouth of the watershed.

7. **Develop an illicit discharge detection and elimination program** to quickly identify and prevent non-stormwater connections to the storm drain system. In both residential and commercial areas, CWP noted suspected illicit connections to the storm drain system. Due to New Castle County's status as a Phase I community under the NPDES system, detection and elimination of illicit discharges is a required program component. ARA should encourage local regulators to establish a hotline for reporting suspect discharges, and should follow-up with investigators to ensure appropriate enforcement measures are taken.

8. **Develop an urban outreach and pollution prevention program** to minimize nonpoint source pollution in commercial and residential areas by generating watershed awareness and active stewardship primarily among businesses and residents in Middletown and surrounding area. Field crews noted very little in the way of visible watershed awareness/education (signage, drain stenciling, etc). ARA has ample opportunity to improve local awareness and should consider coordinating with existing local education and outreach programs while developing a program that meets the specific needs of the Appoquinimink.

9. **Evaluate municipal programs and practices** such as the tax ditch network, street sweeping, catch basin cleaning, road repair, etc from a pollution prevention perspective. For example, chemical spraying of weed killer along stream buffers and directly in the stream channel was observed. Local residents report the free distribution of chemicals from the local conservation district for the purpose of "tax ditch" maintenance. This policy should be reviewed and maintenance recommendations revised based on water quality and stream buffer protection goals.

10. **Implement priority stream restoration** particularly stream repair projects to prevent headcuts and significant stream bank erosion. Buffer reforestation, invasive control, and stream cleanups are fairly simple projects that can be conducted by volunteers.

11. **Install priority stormwater retrofits** to provide water quality treatment of runoff from parking lots and other urban areas to help meet TMDL nutrient load requirements. In keeping with the 2003 Appoquinimink Pollution Control Strategy recommendations, over 50 retrofit opportunities were identified in the watershed (see *Technical Memo* and *Baseline Assessment*), and over 20 priority projects are described in Appendix A. ARA should work with Middletown, NCC, DelDOT, and DNREC to install at least three priority structural stormwater retrofits over the next few years. One or two small on-site retrofits should be constructed within the first year of plan implementation in the Town of Middletown using 2005 Delaware Estuary grant funding from National Fish and Wildlife Federation.

12. **Target priority residential neighborhoods and confirmed hotspots** for stewardship, pollution prevention, and enforcement activities. Most residential neighborhoods in the watershed are classified with a "moderate" pollution severity based on a combination of residential behaviors (i.e., excessive turf management, pet waste, downspout connection, etc). Of these, eight neighborhoods in particular were identified as having a high restoration

potential and should be targeted by ARA as watershed stewardship priorities. Based on a limited assessment of candidate commercial hotspots (e.g., shopping centers, municipal yards, and automotive stores), almost half were confirmed or potential polluters and should be stewardship or enforcement priorities. Link with stream corridor projects.

13. **Implement monitoring and project tracking** to evaluate implementation success over time. Enhance biological sampling and continue collected storm and baseflow samples at strategic sentinel stations across the watershed. Outfall monitoring at suspected illicit discharges should also be conducted. ARA should take the lead on establishing and maintaining a project tracking database. Restoration projects should include a plan for measuring success; this may involve in stream baseline and performance monitoring (e.g. pre-and post bug samples and cross sections) or simple accounting (# trees planted, # flyers distributed, # of homeowners contacted, etc). ARA should produce an annual report on implementation progress, measures of success, and monitoring results.

    DNREC is currently analyzing recent water quality data collected by USGS. This data should be used to calibrate the TMDL model. Given current estimates of agricultural nutrient contributions, the impact of watershed urbanization may be under estimated.

14. **Identify and secure long-term funding for watershed restoration**. By Year 3, ARA should identify watershed restoration partners and secure additional funding to support watershed coordinator and continued restoration and protection efforts in the watershed. Particularly, ARA should identify sources of funding to support a part-time inspector, installation of additional retrofits, continued outreach programming, track projects, and long-term practice maintenance.

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3.O Management Practices

This plan presents recommendations and projects for applying a variety of management practices within the urban or urbanizing portions of the Appoquinimink Watershed. These practices are geared towards protecting remaining resources from future impacts of development or restoring degraded resources in urban areas. Protection practices include land conservation and tools for minimizing impacts during the construction and post-construction development phases. Restoration practices include stormwater retrofits, stream corridor restoration, discharge prevention, pervious area restoration, pollution source control, and municipal practices and programs. Agricultural BMPs are also important for overall nutrient load reduction in the watershed, but with the exception of buffer reforestation are considered outside the focus on urban management.

Table 1 provides more information on specific components of these practices. Each practice is described in more detail below and referenced throughout the remainder of this report.

Table 1 . Urban Management Practices Recommended for the Appoquinimink

Type		Practices
Protection Practices		• Land conservation (acquisition and easements) • Riparian buffer protection (ordinance) • Better site design (afforestation, open space, ag preservation, recharge protection) • Erosion and sediment control • Stormwater management
Restoration Practices	Stormwater Retrofits*	• Storage (large, off-site ponds and wetland facilities) • On-site residential (rain gardens, rain barrels, etc) • On-site non-residential (bioretention, infiltration)
	Stream Corridor Restoration	• Simple stream repair (bank stabilization)** • Buffer reforestation (tree planting, invasive removal) • Stream cleanups and adoption**
	Discharge Prevention	• Discharge investigation and elimination • Community hotline • Education and employee training • Outfall monitoring
	Pervious Area Restoration	• Natural regeneration • Tree plantings
	Pollution Source Control***	• Residential pollution prevention • Hotspot source control
	Municipal Practices and Programs	• Street sweeping • Inspection and maintenance programs (ESC, SWM, catch basin cleanouts) • Spill prevention and response

* See Appendix A for more detail and guidance on each of these three different restoration practices
** See Appendix B for more detail on stream repair practices
*** See Appendix C for more detail on residential and hotspot source control practices

3.1 Watershed Protection Practices

Over 60% of the watershed is considered developable, and a relatively rapid conversion of farmland to medium or low density residential is expected. This shift in land use will likely result in significant hydrologic impacts to the stream corridor such as increased runoff volumes, peak discharge rates, and bankfull flows. A decrease in recharge volumes and subsequent baseflow conditions can also be expected as more impervious cover is added to the watershed. Therefore, land conservation and the application of protection tools such as riparian buffers, better site design, erosion and sediment control, and stormwater management should be implemented as soon as possible to reduce the impacts of new development. These tools should be strategically used to protect recharge areas; meet agricultural preservation goals; and protect riparian buffers, upland forests, and other sensitive habitats.

Land Conservation

Considering that less than 10% of the watershed is currently designated as protected open space (not including wetland, wellhead, and water resource protection area provisions) opportunities for additional open space protection still exist. Sensitive habitats, water resource protection areas (WRPA), agricultural preservation districts, and historic features should be considered conservation priorities. Tools for conservation include land acquisition, conservation easements, open space designation, and public and private stewardship options.

Acquisition is the most expensive of the tools to protect conservation areas and should be applied only when other conservation methods have been exhausted or when conservation areas coincide with other goals. Delaware instituted a Purchase of Development Rights program as part of the 1991 Delaware Agricultural Lands Preservation Act. Enrollment in this voluntary program is restricted to farmers with 200 contiguous acres of active farmland (called an agricultural preservation district) or smaller areas within 3 miles of an established district. Restrictions on development are applied in these districts for a period of 10 years in exchange for tax benefits, right-to-farm protection, and the opportunity to sell a permanent preservation easement to the state. Statewide, the program currently has 517 agricultural preservation districts totaling approximately 130,000 acres (DDA, 2004). Of these, almost 65,000 acres have been permanently protected. Program administrators report that participants willing to apply permanent protection are agreeing to sell easements at an average 51% below appraisal value (translates to an approximate average of $1,039 per acre). This bargain pricing makes easements a viable conservation option (DDA, 2004).

About 13% of the program's districts are within New Castle County (over 8,000 acres in the County have been permanently protected). Two districts fall within the Appoquinimink watershed (Deep Creek and Appoquinimink I); permanent protection status of these is unknown. ARA should consider encouraging more landowners to participate in the program, particularly those within WRPA districts or adjacent to wetlands or upland forests.

Less than 9% of the watershed remains forested, and this cover is generally associated with the stream corridor. Remaining upland forests are generally fragmented, which reduces the overall habitat quality and forest health. One remaining contiguous forest parcel was identified in the Drawyer Creek subwatershed—a priority for conservation. Expanding coverage of designated

open space areas such as the St. Augustine and the Appoquinimink Wildlife Management Areas, as well as the reforestation of associated open areas (see Section 4.5 Hangman's Run) is also important.

Forested Riparian Buffers

Riparian buffers are another element of comprehensive watershed protection strategy. While generally limited in their ability to remove pollutants in an urban setting (very helpful in an agricultural setting), a well-established and unbroken buffer network provides many benefits to overall watershed health. In addition to physically separating land disturbing activities from the stream system, forested buffers help maintain aquatic and terrestrial transition zone habitats, provide a wildlife corridor, protect sensitive wetland and floodplain areas, and provide shading to regulate water temperatures. Buffers can serve as a "stream right-of-way" allowing for lateral movement and help protect private property from flooding. A good buffer program generally meets the following criteria:

- Minimum width of 100 ft on each side of the stream, including the floodplain
- Three-zone buffer system with specific goals and restrictions for the outer, middle, and streamside zones
- A vegetative target based on pre-development plant community
- Clear and measurable criteria for delineation of buffer origin and boundaries
- Limited numbers and specific criteria for stream and buffer crossing
- Carefully prescribed use of buffer for stormwater treatment practices
- Highly visible buffer demarcation before, during, and after construction
- Commitment to buffer education, long-term management, and enforcement

New Castle County has a relatively strong buffer ordinance, but the Town of Middletown does not (Townsend and Odessa criteria are unknown). New Castle County's Unified Development Code defines riparian buffer areas (RBA) as:

- 100-ft on either side of perennial and intermittent streams, lakes, and tidal wetlands, as well as land adjacent to identifiable stream channels that drain areas > 10 acres.
- All of the floodplain, plus an additional 50 ft of adjacent land
- All of a non-tidal wetland greater than 20,000 square feet in area plus an additional 50 ft of adjacent land.
- Contiguous slopes in excess of 15% and erosion prone slopes draining towards a floodplain or watercourse upstream of an existing water supply intake.

ARA should work with all jurisdictions in the watershed, especially Middletown, to either adopt the buffer ordinance in New Castle County's Unified Development Code (see *Baseline Report* for copy of this ordinance) or craft its own. A model buffer ordinance can be found at: http://www.stormwatercenter.net/Model%20Ordinances/Buffers.htm

Restoration of impacted riparian buffers is described in section 3.5.

Better Site Design (BSD)

The overwhelming majority of developable lands remaining in the watershed are zoned for residential development. The application of site design techniques to minimize the impact of this development on water resources is critical in a rapidly developing watershed. BSD (open space design, low impact development, cluster, traditional neighborhoods, etc) aims to reduce impervious cover, reduce stormwater generation, protect existing natural areas, and maintain a marketable product. Examples of BSD principles include reducing residential street widths and the number and area of cul-de-sacs; promoting alternative turnarounds, open section roads, and porous spillover parking areas; and integrating stormwater treatment into parking lot landscaping. Techniques to conserve natural areas include relaxing frontages and setback requirements to cluster homes on one portion of the site to conserve land on other portions of the site, limit clearing and grading, and reduce overall construction costs (CWP, 1998).

At a minimum, BSD should be used in recharge areas of the Appoquinimink and in development adjacent to riparian buffers and other conservation areas. BSD is particularly important in subwatersheds predicted to shift from "sensitive" to "impacted" conditions based on the impervious cover model. Table 2 summarizes the subwatersheds where BSD tools have the highest priority, based on current and projected future impervious cover.

Table 2. BSD strategies for Appoquinimink Subwatersheds

Subwatershed and (Current ICM category)	Remaining Developable Area and (Projected Future ICM category)	BSD Priority
Appoquinimink 1 (impacted)	25% (impacted/non-supporting)	Medium-Low
Appoquinimink 2 (sensitive)	8% (sensitive)	Low
Deep Creek (impacted)	38% (non-supporting)	Medium
Dove Nest (impacted)	33% (non-supporting)	Medium
Drawyer Creek (sensitive/impacted)	25% (impacted/non-supporting)	Medium-High
Hangman's Run (sensitive)	18% (impacted)	High
Noxontown Pond (sensitive)	38% (non-supporting)	High

A common barrier to on-the-ground application of BSD is a general lack of awareness of the environmental and economic benefits of BSD, feasibility within existing code requirements, and lack of a successful local model. We recommend the county provide information on the economic, social, and environmental benefits of BSD for planners, home builders, and developers. Middletown's development codes and ordinances were evaluated by CWP based on the principles of BSD. It was found that Middletown codes generally do not encourage, and in some cases actually prevent, the application of environmentally-sensitive development. Examples of recommended areas for improvement and a copy of the completed Codes and

Ordinance Worksheet can be found in the *Baseline Assessment Report* (Section 5.0 and Appendix E). ARA should advocate for revision of municipal development codes and the required application of BSD in vulnerable subwatersheds. Consider utilizing the Delaware Urban Runoff Management Model (DURMM) to measure the stormwater benefits associated with the application of BSD techniques. Jurisdictions within the Appoquinimink should institute incentives for BSD such as expedited review for projects utilizing better site design principles, or financial incentives such as stormwater credits, tax credits, or density bonuses. Planning staff should be recommending site design techniques during the plan review process. The Whitehall development in New Castle County can be used as an example of a local BSD community.

Erosion and Sediment Control (ESC)

One of the most destructive phases of the development cycle is the relatively short period where vegetation is cleared and the land graded for new construction. Potential impacts to receiving waters can be severe at this stage. A combination of clearing restrictions, erosion prevention and sediment controls, coupled with plan review and strict construction enforcement are needed to help mitigate these impacts. This is particularly true in the Appoquinimink watershed where impacts to the stream corridor were seen associated with current or recent construction activities.

The trigger point for applicability of the ESC regulations in the Appoquinimink is 5000 square feet of disturbance. A general permit is available for sites under ½ acre. Erosion and sediment control requirements include stabilization within 14 days, references to the extensive Delaware Erosion and Sediment Control Handbook, and site grading limited to 20 acres at a time.

More frequent inspection of ESC measures is needed in conjunction with stricter enforcement of the maintenance of these measures, particularly in phased and mixed use construction projects. Consider more stringent design standards for ESC practices (e.g. wrapped outlet pipe or riser; adequate storage volumes for smaller storms for sediment ponds; and super silt fences) in sensitive watersheds.

Stormwater Management

In addition to flood control, stormwater practices in the Appoquinimink should be designed to maintain groundwater recharge, reduce pollutant loads, and protect stream channels. Current stormwater requirements include both water quantity and quality controls. The quantity requirement in the Appoquinimink basin is the control of the post-development 2-year and 10-year storms to pre-development peak discharges. The current water quality regulations require treatment of the first 1” of runoff over 24 hours (e.g., wet ponds and stormwater wetlands). Practice designs for the larger water quality facilities in the watershed should incorporate recommended elements such as forebays, aquatic benches and wetland fringes; however, more consideration should be given to how the stormwater is conveyed from the practice to the stream (slope, level spreader, etc).

More information on stormwater controls can be found in Section 3.2 and Appendix A.

3.2 Stormwater Retrofits

In specific response to stormwater related recommendations of the APCS, stormwater retrofits were emphasized as part of this plan. Retrofitting is the art and science of identifying stormwater treatment opportunities in developed areas where stormwater control is currently absent or poorly provided. Retrofits can be broken down into three major categories: offsite storage, onsite nonresidential, and onsite residential. These include large ponds and wetlands, bioretention and infiltration practices, as well as backyard rain gardens and rain barrels. This restoration practice is best conducted at a watershed or subwatershed level, where on a cumulative basis, meaningful improvements can be made to conditions of receiving waters. Primary retrofit sites are often located upstream of impacted stream conditions, at failing or inadequate storm water facilities, on publicly owned land, and at uncontrolled hotspots. Application of practices in the different categories will vary according to the impervious cover and land use makeup of each subwatershed as well as the restoration goals being pursued

Over 44 sites were visited in the field by CWP (2004), and over 50 concepts were developed (see *Technical Memorandum* for preliminary concepts and Appendix D of *Baseline Assessment* for complete summary). Most of the retrofit opportunities were identified in Dove Nest Branch, Deep Creek, and Appoquinimink I subwatersheds. Potential concepts were ranked based on a suite of factors including cost, feasibility, ownership, and water quality benefits. Concepts for the top 20 retrofit projects were further developed. Appendix A offers a detailed discussion of these priority retrofits, the ranking process for identifying priority sites, and costs associated with the various types of retrofits.

Stormwater retrofits can be some of the most expensive urban restoration practices to implement due to the associated design, permitting, construction, and long-term maintenance costs. ARA will need to identify willing partners for technical and financial assistance in implementing many of the priority retrofits identified. Often times a small-scale, well-planned and visible "demonstration" retrofit is worth pursuing for the purpose of garnering support (e.g., financial and public approval) for future efforts that are more extensive.

3.3 Stream Corridor Restoration

Stream corridor restoration practices are used to enhance the appearance, stability, structure, and function of urban stream corridors. Primary practices for use in the Appoquinimink include stream repair, buffer reforestation, and trash cleanups. Efforts to enhance and restore stream corridors in agricultural areas should be continued as well.

Stream Repair

Stream repair practices recommended in the Appoquinimink are mainly for addressing existing headcuts below outfalls and preventing future streambank erosion from new development. In general, a combination of flow and grade control techniques to restore incised channels should result in an effective mitigation approach. Rock vortex weirs, cross veins, step pools, drop structures, and cutoff sills are applicable repair practices for these situations. CWP identified 14 locations in the watershed showing signs of nickpoint migration, channel incision, and severe

streambank erosion (Dove Nest ER-4 and Deep Creek RCH-2, for example). While conceptual designs were not developed for each of these sites, a preliminary determination of applicable practices is provided. Appendix B provides more detail on stream repair in the Appoquinimink, as well as fact sheets on the various repair practices recommended.

The practice of urban stream repair is relatively new; most of our experience has occurred in the last two decades. We have learned that controlling upstream hydrology is the only sustainable way to achieve actual stream restoration in urbanized systems, as opposed to simple repair efforts. If the upland sources of sediment and stormwater are not properly managed, stream repair practices have a high chance of failure. Therefore, stream repair combining upland stormwater retrofits and in-stream grade control strategies is the recommended approach in the Appoquinimink, and reflected in priority project descriptions.

ARA should coordinate with local engineers, consultants, or other experienced staff to conduct additional site investigations at these locations to develop complete concepts for stream repair projects.

Buffer Reforestation

Another aspect of stream corridor restoration is the enhancement or reforestation of impacted stream buffers. As discussed previously in section 3.1, the benefits of stream buffers are numerous and worth the restoration effort. A few reaches were identified in the watershed (see RCH-5 in Drawyers Creek), where efforts should be targeted, but no reforestation plans were developed. ARA will want to revisit these sites and consider site preparation techniques, planting approach, invasives management, and other factors in order to develop a complete project concept.

Since most reforestation projects will occur on private lands, watershed education on proper buffer management is important. ARA should target homeowners, lawn care companies, community management entities, and local agencies for education on the benefits of a buffer network and proper vegetative management of buffer areas on their property. Several neighborhoods exhibited evidence of homeowners dumping yard waste and other refuse in the buffer area. In some cases, these homeowners may not understand the benefits of buffers on the Appoquinimink streams. Buffer signage and outreach tools should be an important part of ARA's watershed education efforts.

Federal and state grant programs can provide partial funding for buffer reforestation in agricultural areas. ARA should pursue similar sources of funding for urban restoration activities to encourage voluntary participation by local residents and public land managers. The New Castle County Conservation District could be a potential partner.

Stream Clean Ups and Adoption

Stream cleanups are a simple practice to enhance the appearance of the stream corridor by removing unsightly trash, litter, and debris. The prevention of chronic dumping by preventing vehicular or easy public access to frequented dumping sites is also encouraged. Cleanups are

commonly conducted by volunteers and continue to be one of the most effective outlets for generating of community awareness involvement in watershed activities. In the Appoquinimink, many of the sites identified for stream cleanups appeared to be gully dumps in agricultural areas (Drawyer Creek TR1 and TR-2, Noxontown Pond TR-1), and may require heavy equipment for removal.

Stream adoption is another practice available to ARA to solicit community support. In this practice, a program is established where local stakeholders agree to "adopt" a stream reach and conduct trash cleanups, monitoring, or other stewardship measures over an extended time period. St. Andrews School, local boy scout troops, homeowners associations, or other civic groups may be interested in participating in this type of program. Appendix B contains more detail on both cleanup and adoption practices.

3.4 Discharge Prevention

Discharge prevention targets dry weather flows that contain significant pollutant loads. Examples include illicit discharges, sewage overflows, or industrial and transport spills. These dry weather discharges can be continuous, intermittent, or transitory, and depending on the volume and type, can cause extreme water quality problems in a stream. Sewage discharges can directly affect public health (bacteria), while other discharges can be toxic to aquatic life (e.g., oil, chlorine, pesticides, and trace metals). Discharge prevention focuses on four types of discharges that can occur in a subwatershed, as described in Table 3.

Table 3. Types of Discharges

Illicit Sewage Discharges	Sewage can get into urban streams when septic systems fail or sewer pipes are mistakenly or illegally connected to the storm drain pipe network. In other cases, "straight pipes" discharge sewage to the stream or ditch without treatment, or sewage from RVs or boats is illegally dumped into the storm drain network.
Commercial and Industrial Illicit Discharges	Some businesses mistakenly or illegally use the storm drain network to dispose of liquid wastes that can exert a severe water quality impact on streams. Examples include shop drains that are connected to the storm drain system; improper disposal of used oil, paints, and solvents; and disposal of untreated wash water or process water into the storm drain system.
Industrial and Transport Spills	Tanks rupture, pipelines break, accidents cause spills, and law-breaking individuals dump pollutants into the storm drain system. It is only a matter of time before these events occur in most urban subwatersheds, allowing potentially hazardous materials to move through the storm drain network and reach the stream.
Failing Sewage Lines	Sewer lines often follow the stream corridor, where they may leak, overflow or break, sending sewage directly to the stream. The frequency of failure depends on the age, condition and capacity of the existing sanitary sewer system.

CWP identified a handful of suspicious dry weather flows that warrant further investigation. Outfalls at the following locations had suspect flows or evidence of a toxic event that may have occurred: Minorca Place (NX-OT-3), the state police station in Odessa, the intersection of Hayley Court and Weston Drive (DV-OT-6), and near the intersection of North Broad St. and Rt. 301 (DV-OT-8). Investigation of chronic sewage overflows at the pump station on Wiggins Mill

Pond Road in Noxontown Pond should also be conducted. Based on the available data, it is difficult to determine the extent to which dry weather flows are contributing to the total nutrient load in the Appoquinimink watershed. It would appear based on the field work conducted during 2004 that dry weather flows are probably not a major source of pollutant load delivery, but are nevertheless present and should be addressed.

Several discharge prevention activities can be implemented throughout the watershed that are simple to do, can involve watershed volunteers, and can increase community awareness about the watershed issues. Examples of implementation projects include:

- Marking outfalls with unique identifications to facilitate locating reports of suspicious discharges
- Establishing a hotline to report suspicious discharges
- Conducting surveys about homeowner practices with respect to septic system maintenance, pool dewatering, and household hazardous waste disposal
- Creating fact sheets that can be distributed to homeowners and businesses or posted on a website

3.5 Pervious Area Restoration

Pervious areas and natural remnants present an opportunity for reforestation in the watershed. Priority sites should have little evidence of soil compaction, invasive plants, and trash/dumping, and be reforested with minimal site preparation. Parcels that meet these criteria are good candidates for more detailed investigations and landowner contact. Most pervious areas are municipally owned, but institutional landowners can also have extensive lawns and open space.

While not an assessment priority, CWP noted three areas in the watershed where active tree plantings and/or natural regeneration could be done: St. Andrew's School, Cedar Lane Elementary School, and an open space area in Hangman's Run (HR-PA-1). Each of these sites can be considered a potential or good candidate for regeneration or reforestation.

St. Andrew's has expressed an interest in being involved in the restoration of the Appoquinimink, and the campus has many sites that are potential candidates for reforestation, including buffer plantings around the lake. This will also serve as a great demonstration project, as more than 300 students and faculty live on campus and many, many more visit the campus each year. Access for tree plantings at St. Andrew's is generally not a problem, and most of the campus receives sunlight. Soil tests will be needed to determine if soil restoration is needed, and it will be necessary to determine if any utilities may constrain tree plantings around the campus.

Cedar Lane Elementary is another good demonstration site. The very large field behind the school is another ideal place to educate watershed residents, and it is an opportunity to involve school children in watershed restoration. Approximately 10 acres of open field is available with excellent access.

A large open space was identified in Hangman's Run, and it appears to have close proximity to the wildlife management area. This site is a prime candidate for reforestation, and is potentially a target to incorporate into the wildlife management area for further protection.

3.6 Pollution Prevention/Source Control Education

Residents and businesses engage in behaviors and activities that can negatively influence water quality, including over-fertilizing, using excessive amounts of pesticides, poor housekeeping practices, and dumping into storm drains. Alternatively, positive behaviors such as tree planting, disconnecting rooftops, and picking up pet waste can help improve water quality. Whether a pollution prevention program is designed to discourage negative behaviors or encourage positive ones, targeted education is needed to deliver a specific message that promotes behavior changes. ARA is in a position to be able to influence these changes using pollution prevention education and outreach to teach citizens how to properly care for the watershed.

Pollution source control happens on two fronts: residential and non-residential areas, or "hotspots," which are certain commercial, industrial, institutional, municipal, and transport-related operations in the watershed. These hotspots tend to produce higher concentrations of polluted stormwater runoff than other land uses and also have a higher risk for spills.

Residential Education
While most neighborhoods in the Appoquinimink were pretty similar, with respect to lawn maintenance and downspout disconnection, a few areas were called out for high input turf lawns and downspouts that are connected to the street and storm drain system. Throughout the watershed, 13 neighborhoods were found to have mostly medium to high input lawns, so the entire watershed is a target for better lawn care practices. Priority neighborhoods that should initially be targeted include Chestnut Grove (DR-N-3), Brick Mill Road Farms (DV-N-1), Greenlawn I (DV-N-4), and Longmeadow (DP-N-10), as they appeared to have the highest input lawns in the watershed.

Hotspot Education
The majority of the hotspots identified in the Appoquinimink had problems with outdoor storage of waste and materials. While most of the hotspot sites are in private ownership, some municipal sites were identified, as well. Every business generates waste and trash as part of its daily operations, most of which is temporarily stored at the site pending disposal. A common scenario in Appoquinimink was the way in which trash was stored and disposed of at the site in relation to the storm drain system. For some hotspot sites such as the Goodwill (DV-HS4) and the Townsend Fire Department (NX-HS3), simple practices such as better dumpster management can reduce pollutants. This can include simple things like making sure dumpster have lids and they remain closed, and maintaining it in good condition. Other sites, such as Happy Harry's (DP-HS-3) and the Townsend Fire Department (NX-HS-3) have their dumpsters located in a place where contaminated runoff is likely to enter the storm drain.

Appendix C provides more detail on the source control and education opportunities in the Appoquinimink, as well as supplemental guidance on priority practices for implementation.

3.7 Municipal Practices and Programs

Municipal programs and practices can directly support subwatershed restoration efforts. These programs range from more efficient trash/recycling pickup and street sweeping to construction inspection (especially erosion and sediment control enforcement) and educating municipal staff to be more aware of potential pollution sources. Septic inventories and maintenance tracking programs were not evaluated, however, they constitute an important municipal function.

Several observations regarding the current state of municipal practices in the watershed were made. Positive signs included evidence of stenciled storm drains (at Lowe's), frequent trash pickup and street sweeping, and wash stations for vehicles at municipal yards. The following observations denoted negative behaviors:

- Leaf and lawn clipping pickup service procedures that encourage residents to leave unbagged organic material on the street.
- Distribution of chemical spray by the Conservation District to homeowners for tax ditch "maintenance"
- Poor housekeeping at certain municipal facilities
- Poor erosion and sediment control inspection and enforcement at construction sites
- A potential illicit discharge at the state police station in Odessa
- Potential long-term sewer overflow at pump station on Wiggins Mill Rd.

Street Sweeping
Using street sweepers to remove debris, dirt and pollutants from the storm drain conveyance system is a very important activity, and is primarily undertaken by the municipality. Effective street sweeping usually involves using a vacuum assisted sweeper, and a schedule that coincides with things like trash pickup days or seasonal changes such as leaf litter in the fall and more frequent lawn care activities by residents in spring and summer.

Erosion and sediment control (ESC) inspection and enforcement
With the current rate of development in the Appoquinimink watershed, hiring an ESC inspector should be a very high priority. Most of the stream impacts found in the more developed subwatersheds can be attributed in part to the high sediment load being carried into streams from construction sites that are lacking proper controls. It may be possible to train the watershed coordinator to perform these duties.

Spill prevention and response
Spill prevention and response plans describe operational procedures to reduce spill risks and ensure that proper controls are in place when they do occur. Spill prevention plans standardize everyday procedures and rely heavily on employee training and education. The investment is a good one for most operations, since spill prevention plans reduce potential liability, fines and costs associated with spill cleanup.

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Section 4.0 Subwatershed Management Strategies

This section details management strategies and implementation priorities for each subwatershed. Restoration opportunities include stream restoration, stormwater retrofits, and pollution prevention measures. Priorities are based on existing stream condition, the potential to link various types of restoration activities, and the feasibility of implementation. A brief summary of existing stream corridor and upland conditions are presented here, but are described in more detail in the *Baseline Assessment* Report (CWP, 2004b). Subwatershed management maps are included, which show locations of restoration opportunities and priority projects. Estimated implementation costs for restoration projects can be found in Section 5 of this report.

The following subsections (subsections are based on subwatershed unit) are divided into five parts:

Overall Characterization—Summary of current and future land use characteristics, major water quality issues, and overall subwatershed management strategies. A map of the zoning classification of remaining developable parcels is provided. Refer to the *Baseline Assessment Report* for more information.

Existing Subwatershed Conditions—Highlights existing stream corridor and upland conditions detailed in *Baseline Assessment Report*.

Management Strategies—Discussion of recommended management approach and options. Refer to Section 3.0 for a description of what these practices entail, and refer to Appendix A, B, and C for more information on stormwater retrofits, stream repair, and source control, respectively.

Restoration Opportunities—Summary of individual restoration opportunities identified by CWP (2004) and a description of implementation priorities. Projects are ranked as high, medium, or low priorities based on stream conditions, ability to link with other projects, and overall feasibility (although it should be noted that actual implementation may not strictly adhere to this ranking). Appendix A provides more detail on priority stormwater retrofits.

Management Map—Subwatershed maps depicting implementation priorities and other restoration opportunities are located in Appendix D. The 2002 land use layer used on these maps is from New Castle County and may not accurately reflect current land use conditions. Stream conditions based on CWP (2004) assessment are also depicted. Subwatershed maps presented in the *Baseline Assessment* show aerial photos.

Table 4 summarizes the general characteristics and management recommendations for the six subwatershed management areas (note that Appo 1 and 2 have been combined).

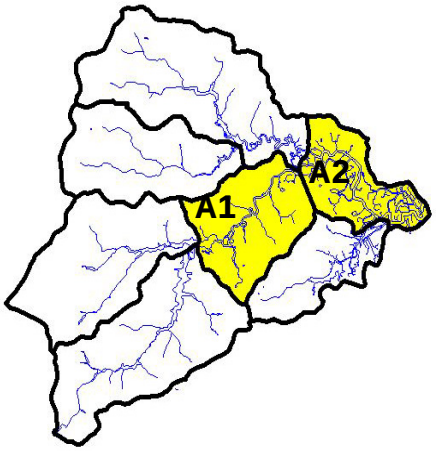
Table 4. Appoquinimink Subwatershed Characteristics

Subwatershed	General Characteristics	Primary Restoration Recommendations
Appoquinimink Mainstem	• Contains A1 and A2 (A1 more urban than A2) • Historic Odessa • Tidal mainstem; outstanding wetland complex • Water Farm I, and superfund site	• Protection of mainstem riparian corridor (land conservation; buffer regulations and voluntary enhancement) • Expansion of Wildlife Management Areas • Watershed education and awareness
Deep Creek	• Includes portions of Middletown and Silver Lake • Small nature park • Likely to shift from Impacted to Non-supporting under buildout	• Improved criteria for new development (i.e. afforestation, BSD, SWM, buffers) • Ag preservation and recharge protection • Stormwater retrofitting
Drawyer Creek	• Primarily agricultural and low density residential • Streams in relatively good physical condition • Some impacts from historical agriculture and erodible/impermeable soils • Drains to Shallcross Lake	• Minimize impacts from future development with BSD • Protect areas of high recharge potential • Perform one stream stabilization/ stormwater retrofit • Increase width of riparian buffer • Trash cleanups
Dove Nest	• Includes portions of Middletown • Rapidly developing watershed; expected to shift from Impacted to Non-supporting given buildout • Site specific erosion problems • Clear impacts from new development • Illicit discharge concerns	• Improved criteria and regulation on new development (i.e. afforestation, ESC, SWM, and buffers) • Investigate illicit discharges • Build stormwater retrofits and stream stabilization projects • Use of BSD with new development • Educate residents on proper lawn care and watershed awareness
Hangman's Run	• Tidal and freshwater wetlands • Completely within New Castle County • Expected to shift from Sensitive to Impacted given buildout conditions	• Improved criteria and regulation on new development (ie. afforestation, BSD, SWM, buffers) • ESC enforcement • Pervious area restoration (open space parcel) • Water quality sampling • Flooding investigations
Noxontown Pond	• Contains portions of Townsend; St. Andrews School • Noxontown & Wiggins Mill ponds • At buildout, expected to shift from Sensitive to Impacted	• Improved criteria for new development (ie. afforestation, BSD, SWM and buffers) • Protection of high recharge areas • Enforcement of ESC • Discharge prevention • Buffer protection/Tax Ditch restoration

Notes: BSD=Better Site Design; SWM=Stormwater Management; ESC=Erosion and Sediment Control

4.1 Appoquinimink Mainstem

Overall Characterization



Comprised of subwatersheds Appoquinimink I (A1) and Appoquinimink II (A2), the Appoquinimink Mainstem management area contains extensive freshwater and saline tidal wetlands, which are part of the largest tidal wetland complex in eastern Delaware. Most of historic Odessa and the eastern limits of Middletown, as well as the Augustine Wildlife Refuge, Middletown-Odessa-Townsend WWTP (Water Farm I), and a state superfund site (Healthways Truck Salvage) are located in this area. The entire length of the mainstem is included on the 303(d) impaired list; pollutant stressors reportedly include nutrients, DO, bacteria, PCBs, and dioxins.

Future development is likely to shift A1 from an impacted to non-supporting classification based on predicted increases in impervious cover under full buildout conditions; buildout in A2 will likely not result in a shift from the current sensitive classification (see Table 5). Remaining developable areas are zoned predominantly for low to medium density residential, and growth is targeted mainly for the upper portions of the mainstem (Figure 2).

The priority management recommendations for this area include protection of the mainstem corridor through buffer enhancement, land conservation (expansion of Augustine Wildlife Refuge), and open space design criteria for new development. In addition, opportunities for reconnecting watershed residents to the River such as restoration of public access points, establishment of canoe trails, sponsoring of fishing tournaments, or other activities should be pursued.

Table 5. Appoquinimink Mainstem Characteristics

Subwatershed		A1	A2
Drainage Area		3568 acres (5.6 sq. miles)	2588 acres (4.0 sq. miles)
Stream/Waterbody Miles		3.5 miles	7.2 miles
Land Use 2002	Current Impervious Cover	14% IMPACTED	3% SENSITIVE
	Agricultural	38%	31%
	Wetlands/Water	22%	64%
	Single Family Residential	18%	4%
	Forested	12%	1%
Designated Open Space		458 acres (13%)	431 acres (17%)
Developable Area		1858 acres (52%)	843 acres (33%)
Future Impervious Cover		25% IMPACTED/ NON-SUPPORTING	8% SENSITVE

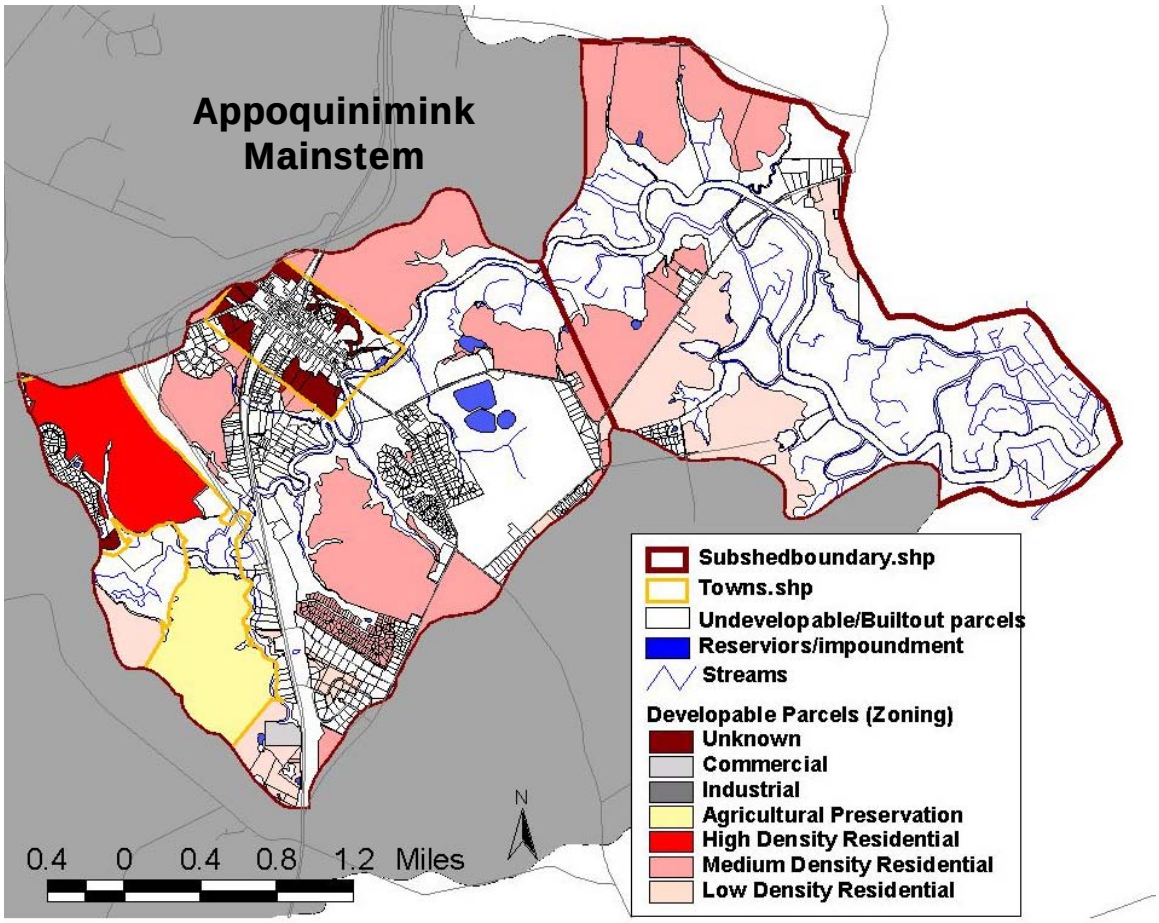


Figure 2. Zoning of Remaining Developable Parcels in the Appoquinimink Mainstem

Summary of Existing Subwatershed Conditions

The entire length of the mainstem is included on the 303(d) impaired list; pollutant stressors reportedly include nutrients, DO, bacteria, PCBs, and dioxins. Fish sampling sites rank highly in abundance. Less than 5% of the total waterways in this section were assessed by CWP (2004) due to extensive wetlands and tidal influence. Two first order tributaries below stormwater outfalls in A1 were surveyed and classified as poor (A1-2) and fair (A1-1) due to erosion. Two outfalls were subsequently recommended for retrofit (OT-5) and localized stream repair (OT-6). In Appoquinimink II, the outfall from an existing wetpond in Thomas Landing was identified as a retrofit potential (A2-1).

Two neighborhoods in A1 were assessed by CWP (2004), one in downtown residential Odessa, the other a small group of homes at the intersection of Old Corbitt Rd and Thomas Landing Road. Both classified as moderate pollution severity and low restoration potential. Longmeadow neighborhood (DP-N-10) is in both A1 and DP subwatersheds, and it was identified as a priority neighborhood. No neighborhoods in A2 were assessed by CWP (2004), though a portion of Thomas Cove Landing

(predominately in Hangman's Run) drains to the mainstem and is considered a high priority for turf conversion and downspout disconnection.

Eighteen potential contaminant sites, including a superfund site and the MOT WWTP, were identified by the state in the subwatershed. Two potential hotspot locations were also evaluated by CWP (2004), and no evidence was found to confirm hotspot status.

Management Recommendations

The priority management recommendations for this area include protection of the mainstem riparian corridor and enhancement of watershed awareness.

Corridor protection should be advanced through buffer enhancement and land conservation efforts such as the adoption of stringent buffer criteria for new development; establishment of a view corridor overlay district; or through voluntary buffer management and reforestation programs for existing developments. Incorporation of additional adjacent land into the Augustine Wildlife Refuge should also be investigated. New development in the area should utilize open space design techniques that shift infrastructure away from existing buffer areas.

These subwatersheds offer significant opportunities to reconnect watershed residents to the Appoquinimink River and raise watershed awareness. To such ends, the restoration of public access points, establishment of canoe trails, sponsoring of fishing tournaments, or other activities by the Appoquinimink Watershed Association should be pursued.

Additional management recommendations include enhanced inspection and enforcement of erosion and sediment control practices, discharge prevention, monitoring, and stormwater retrofitting. Sediment ponds, silt fencing, and other practices used at development sites to control erosion should be inspected frequently and design criteria enforced, particularly given that many of these areas drain directly to the mainstem. New Castle County and the Town of Middletown should conduct illicit discharge investigations at publicly owned facilities at a minimum. The ARA should ensure that proper water quality monitoring occurs for the tributaries draining Water Farm 1, where spray irrigation of treated sewage is conducted.

Restoration Opportunities

Table 6 summarizes restoration opportunities identified in A1 and A2 by CWP (2004). Priority projects are described in more detail below and in the appropriate appendix.

Of the eight potential projects identified in the Appoquinimink subwatershed management area, four were considered high priorities. Priority restoration projects were identified based on existing stream condition, the potential to link various types of restoration practices, and the feasibility of implementation.

See management map in Appendix D for project locations.

Table 6. Restoration Opportunities Identified in Appoquinimink Mainstem

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area/length**
High	A1-1	Odessa Professional Park	Stormwater Retrofit	Existing dry pond that captures office park and DE 13 drainage; convert to wet pond - address small erosion issues; DelDOT partnership	9.53 acres (>3 IC acres)
High	A1-2	Appoquinimink River at Odessa	Education; Stormwater Retrofit	State property adjacent to river is unused concrete slab. Develop as recreation/ education area. Incorporate bioretention.	0.5 acres (100% IC)
High	A1-RCH-2	--	Inspection and Enforcement	Reach below development site and sediment pond experiencing significant sediment deposition. Stringent ESC enforcement needed	--
High/ Medium	A1-3	State Police	Discharge prevention; Stormwater retrofit	Parking lot, buildings, garage, carwash (discharge); (A)- Infiltration basin to capture parking lot, (B)-raingardens to capture rooftop runoff	(A) 0.44 acre (B) 0.19 acre
Medium	A1-4	Odessa Fire Station	Stormwater Retrofit	Fire station and parking; outfall from DE-299 drainage behind parking lot A- raingarden/ bioretention for station; B- on-line shallow marsh to treat outfall; possible DelDot drainage	2.06 acres
Medium	OT-6	Longmeadow outfall	Stream repair; Stormwater retrofit	Stream Reach A1-1 rated "fair" with average 6"-1' banks; active headcut below outfall (OT-6) with 3 ft banks; 36 inch metal pipe; can see bank erosion downstream /sediment/algae. Rip rap in ok shape, but consider channel protection retrofit for existing pond.	50 ft (default estimate)
Low	OT-5	Longmeadow outfall	Stream repair	24 inch RCP. 3 ft headcut just below riprap. Flows discharge to flat area and appears to have formed a channel. This site was not visited during retrofit inventory	50 ft (default estimate)
Low	A2-1	Thomas Landing	Stormwater retrofit	Concept to provide ED/channel protection at existing wet pond. Not recommended for implementation because reach below outfall (OT-1) is in decent shape, rip rap intact and flow spreading well through flat, vegetated area.	Not estimated

* ID corresponds to location label on subwatershed management map (Appendix D)
** Where available, estimates provided for area treated for stormwater retrofits or linear stream length for stream restoration projects.

(A1-1) Odessa Professional Park

The Odessa Professional Park is located between north and south bound DE-13 south of Odessa and features an existing extended detention pond that captures over 9 acres of drainage (more than 3 acres of impervious cover). ARA should approach New Castle County and DelDOT regarding funding for a retrofit project to convert the existing facility (Figure 3) to a wetpond for water quality treatment, to capture runoff from DE-13, and to prevent erosion in roadside swales.

Figure 3. Existing stormwater pond at Odessa Professional Park

(A1-2) Appoquinimink River at Odessa

This half-acre paved parcel adjacent to the Appoquinimink River in Odessa is across from the boat ramp on Route 299 (Figure 4), which is currently the only public boat ramp to the Appoquinimink River. ARA should work with DNREC and the local historic society to redevelop this state-owned parcel of land as an attractive and educational recreation space. Consider posting informative signage describing the historic attributes of the site as well as features of the Appoquinimink watershed. Restoration options could include rain gardens, reforestation, bufferscapes, or other demonstration projects. This project would help meet PCS goals to educate watershed residents and implement stormwater retrofits and may meet community historic preservation goals.

Figure 4. State property adjacent to Appoquinimink River in Odessa

(Reach A1-2) Erosion and Sediment Control Enforcement

The need for ongoing enforcement of the erosion and sediment control regulations is evidenced by this site in the A1 subwatershed (Figure 5). Though the site has ESC controls installed, they have not been properly maintained. The downstream tributary (Reach A1-2) is covered with 2-3 feet of sediment and does not have a defined stream channel. As this site is developed and the pond is eventually converted to a stormwater facility, more stringent inspection and enforcement should be implemented.

Figure 5. Sediment Pond and Downstream Sediment Deposition at Reach A1-2

(A1-3) Discharge Investigation

Figure 6 shows an illicit discharge to the storm drain system witnessed by CWP at state police headquarters in Odessa. The car washing bay appears at this site to be connected to the storm drain rather than to the sanitary system. Simple diversion of this runoff to a landscape feature as part of a larger retrofit project would be appropriate.

Figure 6. Suds discharging to the storm drain at the State Police station in Odessa

4.2 Deep Creek (DP)

Overall Characterization
Deep Creek is mostly within the jurisdiction of Middletown and is bisected by Route 71. Features within this subwatershed include Silver Lake, Industrial Drive, Lowes shopping plaza, and a small Nature Park. Recently, a new wastewater treatment plant was built in this subwatershed. Most of the stream reaches in Deep Creek are included on the 303(d) impaired list for DO, bacteria, nutrients, and biology. Silver Lake is listed for bacteria, nutrients, PCB, dioxin, dieldrin, and DDT.

Future development is likely to shift DP from an impacted to non-supporting classification based on predicted increases in impervious cover under full buildout conditions (Table 7). Remaining developable areas are zoned predominantly for high and low density residential as existing agricultural land is converted (Figure 7). Only one parcel is zoned for Agricultural Preservation.

The priority management recommendations for this area include land conservation, particularly for agricultural preservation and recharge protection purposes, as well as subwatershed restoration activities such as stormwater retrofitting, stream stabilization, and commercial and residential pollution prevention.

Table 7. Deep Creek Subwatershed Characteristics

Drainage Area		5104 acres (8.0 sq. miles)
Stream/Waterbody Miles		2.9 miles
Land Use 2002	Impervious Cover	16% IMPACTED
	Agricultural	62%
	Wetlands/Water	5%
	Single Family Residential	12%
	Other Urban	8%
	Forested	5%
Designated Open Space		181 acres (3.5%)
Developable Area		3337 acres (65%)
Future Impervious Cover		38% NON-SUPPORTING

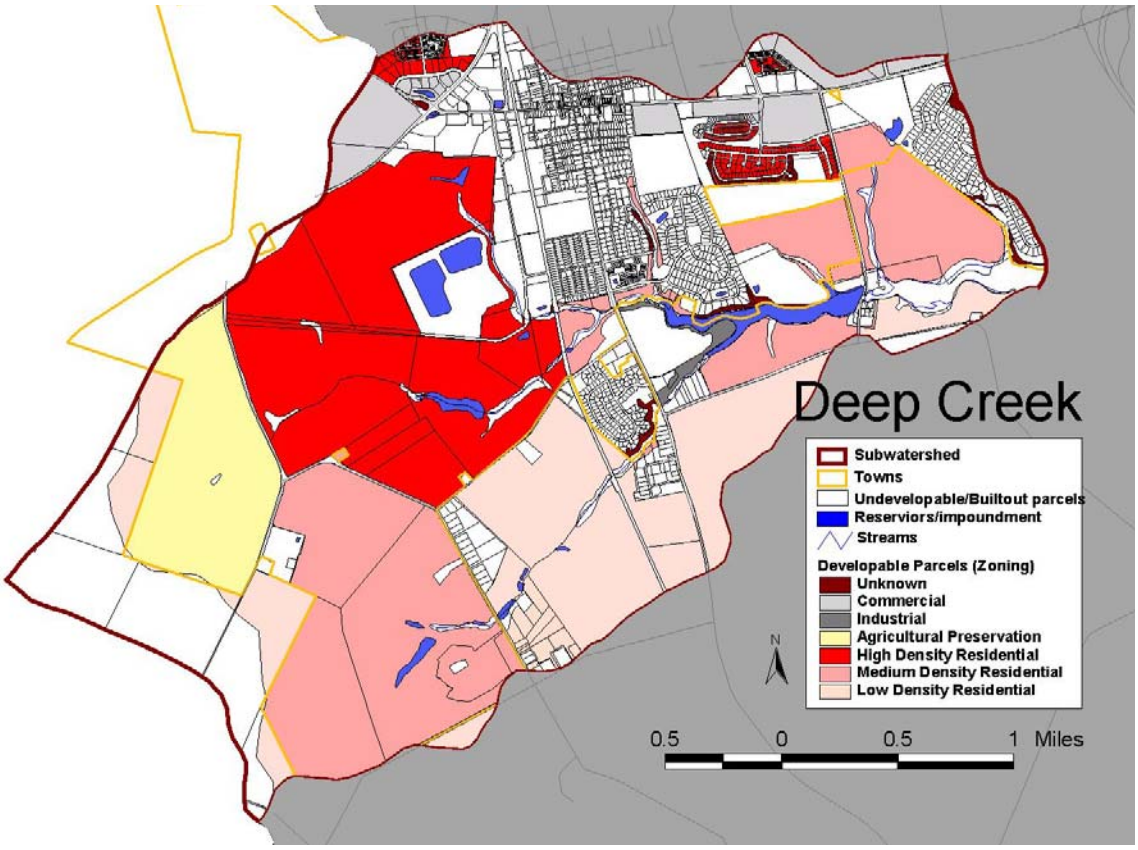


Figure 7. Zoning of Remaining Developable Parcels in Deep Creek

Existing Subwatershed Conditions

Almost the entire length of the stream, including Silver Lake, is on the 303(d) impaired list. Pollutant stressors include nutrients, dissolved oxygen, bacteria, PCBs, dioxin, dieldrin, DDT, and biology. Just under six miles of stream are considered biologically impaired (USEPA, 2003). Almost 90% of the stream corridor was surveyed by CWP (2004), and the majority of reaches were classified as good or excellent, with the exception of three impacted reaches draining Cricklewood (DP-N-5) and Sharondale (DP-N-6) neighborhoods. Six outfalls were identified for follow-up action. Two sites were identified for stream bank stabilization, three for trash cleanups/dumping prevention, and four stream crossings for retrofitting or repair. Buffer reforestation was recommended at five locations.

Eleven neighborhoods were assessed by CWP (2004); eight were classified as having moderate pollution severity. Of those, Middletown Crossing and Cricklewood were identified as having a high restoration potential, which may make them subwatershed and watershed stewardship priorities. Thirty-nine potential contaminant sites were identified in the subwatershed by the state. Of twelve potential stormwater hotspots evaluated by CWP (2004), Meineke and the Middletown DPW yard were confirmed pollution generators.

Management Recommendations

The priority management recommendations for this area include land conservation and restoration practice implementation.

Land conservation should be advanced through use of open space design techniques that serve to protect valuable recharge areas and preserve aspects of the agricultural character of the area as development occurs. Some communities have adopted open space requirements designed to retain large tracts of useable agricultural fields.

This subwatershed also offers significant opportunities for restoration of existing conditions. Open space design and afforestation requirements can be used to enhance existing riparian buffers as agricultural lands convert to residential developments. Significant opportunities for stormwater retrofits and pollution prevention also exist in Deep Creek. The DelDOT maintenance facility in particular, is an opportunity for ARA to partner with the state agency on implementing stormwater retrofits and "good housekeeping" that can have positive implications state-wide. The relocation of Town Hall to the old ACME site offers a chance for ARA to actively encourage the incorporation of bioretention, green roof, porous pavement, or other on-site practices during the site design phase of redevelopment. Overall observations of non-residential areas in this subwatershed include the need for better dumpster management and secondary outdoor storage.

Additional management recommendations include enhanced inspection and enforcement of erosion and sediment control practices, discharge prevention, monitoring, and stormwater retrofitting. Sediment ponds, silt fencing, and other practices used at development sites to control erosion should be inspected frequently and design criteria enforced, particularly given that many of these areas drain directly to the mainstem. The ARA should ensure that proper water quality monitoring occurs for the tributaries draining the new wastewater treatment facility.

There are a few areas in the watershed (RCH-14 and RCH-3) where heavy all-terrain vehicle (ATV) use is apparent. Impacts from stream crossings and buffer encroachment related to ATV use should be minimized.

Restoration Opportunities

Table 8 summarizes restoration opportunities identified by CWP (2004). Priority projects are described in more detail below and in the appropriate appendix.

In addition to priority residential and hotspot pollution prevention and source control opportunities, twenty-eight potential projects were identified in the Deep Creek subwatershed. Of these projects, nine are considered high priorities based on existing stream condition, the potential to link various types of restoration practices, and the feasibility of implementation. See management map in Appendix D for project locations.
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Table 8. Restoration Opportunities Identified in Deep Creek

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area/length**
High	RCH-0	DelDOT Maintenance Yard (HS-6)	Stormwater Retrofit (DP-1)	Retrofit existing stormwater pond to provide channel protection. Add water quality treatment downstream of salt barn.	>15 acres total (>4 IC acres)
			Local stream repair (ER-2)	RCH-0 below outfall is in excellent condition with exception of headcut at end of geotextile—drops 1.5-2 feet. Outfall stabilization and retrofit would address majority of the problem– improve energy dissipation headcut (see Appendix B).	<50 ft
			Stream Cleanup (TR-1 & 2)	(TR-1) Historic dumping of residential type trash mostly metal and glass, about 4-5 truck loads below outfall. Volunteers could do this with trash bags. (TR-2) Commerical type dumping of tires and glass. Right bank. Will require heavy equipment.	--
High	RCH-20	Local Park	Buffer Reforestation (IB-1)	Stream channel through in park-like setting has poor buffer.	150ft x 25 ft x 2
			Stormwater Retrofit (DP-8A)	Existing outfall has scour hole. Drainage area includes Broad Street. Use stream channel stabilization; buffer plantings (currently mowed to edge); Plunge Pool/Energy Dissipator, Shallow Marsh/Wet Pond w/ED	57.47 drainage acres
High	DP-23	MOT Senior Center	Stormwater Retrofit	Retrofit existing pond with standing water by creating micropool, adding wetland plantings	3.25 acres (1.34 IC acres)
				Volunteer opportunity to create raingardens for parking and rooftop runoff.	0.46 acres (100% IC)
High	DP-28	Old Acme	Stormwater Retrofit	100% impervious site with building and parking - to become new city hall; use biofiltration, tree planting	1.65 acres (100% IC)
High	DP-20	Middletown DPW Yard (HS-12)	Pollution prevention	Opportunities for pollution prevention practices such as truck washing station; proprietary products; rain barrels. Check drainage of washing station to make sure goes to underground practice.	3.19 acres (100% IC)
Low			Stormwater Retrofit		
High	RCH-2	Cricklewood	Stream Repair (ER-1)	This reach is severely eroded at outfall below residential development (OT-1). Channel actively eroding (>6 ft banks); heavy sediment deposition in the floodplain. Consider drop inlet and redirecting flow away from earthen wall, grade control, toe protection, and re-shaping streambanks (mature trees would likely be lost as a result)	200 linear ft
Medium			Stormwater Retrofit (DP-27)	Existing SWM with significant erosion downstream; excavate forebays at outfalls, remove accumulated sediment.	21.41 acres
Medium-High	RCH-24	Lakeside Dr. /Route 71	Stormwater Retrofit (DP-2)	Flow from DE-71 uncontrolled. Erosion at outfall (OT-3). Retrofit existing wet pond/wetland that provides treatment for town homes to ensure channel protection or provide bioretention in R/W.	10 acres total (0.5 IC acres with no WQ treatment)
			Maintenance; stream repair (OT-3)	30 inch diameter needing regular maintenance and exhibiting downstream bank erosion. Some stormwater being controlled, but not majority draining town homes. Headcut occurring; topsoil removed and roots starting to appear. Geotextile exposed, beginning to undermine at scour hole.	
Low			Maintenance (OT-2)	12 inch clay pipe. May not be in use, 2 sections of pipe unconnected, consider further investigation	--
Low			Maintenance (SC-3)	RT 71 at Middletown Nature Center. Erosion occurring under concrete channels at bridge.	--

Table 8. Restoration Opportunities Identified in Deep Creek

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area/length**
Medium	DP-12	Goodyear	Stormwater Retrofit	Existing dry pond w/cmp riser; add water quality treatment with bioretention	1.1 acres (100% IC)
Medium	DP-13	Rinker	Stormwater Retrofit	Pond behind pipe manufacturer's yard; add improved forebay to remove sediment	?
Medium	DP-15	Verizon	Stormwater Retrofit	Existing dry pond treats parking lot for fleet vehicles. Use filtration practice to add water quality.	0.66 acres (>0.5 IC acres)
Medium	DP-26	Ashley Plaza	Stormwater retrofit	Parking & roof drains from shopping center to fairly new infiltration basin along DE-299 Retrofit eyesore with shallow wetland or biofiltration.	2.62 acres (100% IC)
Medium	RCH-21	--	Buffer reforestation	Reach in poor condition; additional buffer needed along some residential areas.	~200 ft
			Local stream repair (OT-1)	OT-1 needs stabilization. Seeing bank erosion especially btwn 2 SMHs. maybe put in culvert to slow erosion? Scour hole 10x15 ft. no downstream channel protection. Outfall ~ 3 ft above stream invert.	<50ft
			Discharge prevention (UT-1)	Protect exposed pipe	--
Low	DP-25	Railroad and Main	Stormwater Retrofit	Flooding occurs at small rain events. As no storm drain network is present, shallow gutters carry flow from 1/4 mi of Main St (DE-299). Create storm drain system and tie into one of many ponds west of tracks	--
Low	DP-17	Armory	Stormwater Retrofit	Site has mowed grass, gravel parking lot - limited impervious; direct downspouts to raingarden.	--
Low	RCH-6	--	Repair/ remove fish blockage (SC-4)	Reach is in good condition with farm road crossings. 4.5 ft barrel diameter culvert. 20 ft in length; not flow aligned at downstream end. Partial blockage from woody debris with sediment and rocks. There is a 4-6 inch water drop.	--
Low		--	Buffer reforestation (IB-3)	Lack of vegetation around private ponds. Mostly turf/lawn mowed to edge. No shading provided to ponds/algal mats present. Room for 25 ft buffer around perimeter of ponds. Its on private land so will involve homeowner participation.	~300 ft
Low	RCH-12	RV Storage	Maintenance (OT-5)	Check out outlet structure as it needs to be cleaned/ dead vegetation clogging outlet. Located at RV storage park next to LOWES.	--
Low	RCH-1		Buffer reforestation (IB-1)	Sporadic sections along residential area where mowing close to stream on the Left bank. 25-50 feet in width available for restoration. Total of 50-75 yards in length. Some invasive present	~200 ft
Low	RCH-15		Cleanup	Amazing amount of trash. Check history on this and look for local landfill; or use of trash for pond embankment. Illegal dump of auto, appliances; shingles; etc. no nearby dumpster, would require heavy equipment; more than 10 truck loads	--

* ID corresponds to location label on subwatershed management map in Appendix D
** Where available, estimates provided for area treated for stormwater retrofits or linear stream length for stream restoration projects

In addition to these specific retrofit, discharge prevention, and stream restoration projects, neighborhood and hotspot inventories identified priority areas for targeting education and pollution source control. For a listing of all neighborhood and hotspot assessments, please refer to the *Baseline Assessment* (CWP, 2004).

Highest priority is given to neighborhoods considered to have a high or moderate pollution severity and a high restoration potential. Secondary targets are those areas with a moderate restoration potential. Turf conversion, lawn care, and downspout disconnection programs should be targeted to Middletown Crossing (N-2) and Cricklewood (N-5). Secondary priorities include Hamstead Courts (N-1) , Longmeadow (N-10) and Middletown Crossing Townhomes (N-3).

Highest priority pollution prevention efforts at hotspot locations are given to municipal facilities and observed (confirmed) or potential hotspots, particularly at municipal or state owned facilities. The Meineke (HS-9) and the Middletown DPW yard (HS-12) are the primary targets for outdoor storage upgrades, and vehicle washing practices, respectively. Happy Harry's (HS-3) should be targeted for dumpster management, and the DelDOT Middletown yard (HS-6; see below) is also a priority for retrofitting.

<u>(DP-1; HS-6) DelDOT Maintenance Yard</u>

The Middletown DelDOT (Figure 8) yard was found to be a potential hotspot (HS-6) and a good opportunity for a stormwater retrofit. A primary recommendation for this site is to review its pollution prevention plan as vehicle maintenance, fueling, and washing appeared to be conducted outside on an asphalt parking lot. Uncovered storage areas and poorly-controlled fill-dirt extraction areas were also observed. While this site does have an existing wet pond, maintenance on it appears lacking.

The stream reach (RCH-0) draining from this site was in good condition with the exception of a headcut (ER-2) below the yard's stormwater outfall (OT-1) and some historic trash dumping (TR-1 and TR-2). Structural recommendations for the DelDOT yard include retrofit (DP-1) of the existing pond to provide channel protection; covering the salt truck loading area; providing water quality treatment for the runoff from the salt barn area; stabilizing eroding channel. Also, the existing pollution prevention plan for the facility should be reviewed. This retrofit provides a good opportunity to work with DelDOT on a high priority project.


Figure 8. DelDOT (DP-HS-6) fill dirt removal area (left) and existing stormwater facility (right).

<u>(RCH-2) Stream Stabilization Below Cricklewood Outfall</u>

This short first order tributary to Deep Creek is in poor condition with evidence of extensive sediment deposition throughout the floodplain and lower portions of the reach and severe areas of active bank erosion (6 foot banks in some locations) and (Figures 9 and 10, respectively). Much of this damage was likely done during the construction phase of development, however the channel is still actively adjusting. After investigation of upstream stormwater practice, it seems that the restoration option here is to stabilize the headcut and safely convey stormwater discharges from the outfall to the stream (Figure 11). NCC should inspect the stormwater facility during and after a rain event to make sure it is functioning properly.

Figure 9. Extensive sediment deposition in floodplain

Figure 10. Evidence of significant channel erosion (widening and downcutting) as result of headcut to Cricklewood outfall.

Figure 11. Outfall to stream from dry pond at Cricklewood neighborhood.

<u>RCH-20 Broad Street Drainage/Middletown Tributary</u>

Four outfalls at the intersection of Park Street and Cox Street in the Town of Middletown (Figure 12) constitute the drainage for 57.5 acres of residential and commercial land, including the runoff from DE-71 (Broad Street). This project should be pursued with DelDOT, as it combines stormwater retrofit and stream restoration: a stormwater treatment practice on the vacant lots across Cox Street (DP-8), a replanted buffer (IB-1), and stream repair/culvert replacement (SC-1).

Figure 12. Outfall draining to Reach DP-20 and un-buffered stream corridor.

<u>(DP-23) MOT Senior Center Retrofit</u>

The MOT Senior Center parking lot presents an opportunity for volunteer-created rain gardens (Figure 13). Additionally, the existing dry pond should be retrofitted to include a micropool, defined low flow channels, and wetland plantings. Rain gardens in the parking lot and at building downspouts.

Figure 13. MOT Senior Center parking lot, a proposed rain garden site.

HS-12 Middletown DPW Yard Source Control

Pending further drainage investigation, this site may drop off the priority list for implementation of source control practices. CWP observed many good housekeeping practices at this site, including covered storage and secondary containment, however it is unclear if the vehicle washing area drains to a treatment practice. In addition, this is an excellent opportunity to demonstrate downspout disconnection efforts, such as the installation of rainbarrels (Figure 14). Fueling for Department vehicles is done off-site.

Figure 14. Opportunity for rain barrel demonstration (left) and drain at washing station (right)

(N-5 and N-2) Residential Pollution Prevention

Priority neighborhood targets in Deep Creek include Middletown Crossing (DP-N-2) and Cricklewood (DP-N-5). Each of these neighborhoods showed a moderate pollution potential and high restoration potential. Cricklewood affords an opportunity to link restoration projects with homeowner pollution prevention and on-site retrofitting (rooftop disconnection). Potential pollution sources identified in these neighborhoods were high input turf lawn, which may contribute nutrients and pesticides to Deep Creek, and downspouts that were draining onto impervious areas and into the road. Homeowner education regarding nonpoint source pollution is a priority here, as well as throughout the entire Appoquinimink watershed, and rain gardens and rain barrels may be appropriate practices for many of these houses.

(HS-3 and HS- 9) Commercial Hotspot Pollution Prevention

Meineke (HS-9), was a confirmed hotspot as gas and oil were stored without secondary containment on concrete and asphalt areas, and evidence of leakage was found (Figure 15). ARA should conduct dumpster and outdoor storage education with this business to educate them on how to properly store hazardous wastes such as gas and oil. Happy Harry's (HS-3) is another example of poor dumpster management in commercial areas. Figure 16 shows how Happy Harry's rusting dumpster is oriented in close proximity to the storm drain. Dumpster education is important here, but the solution could be as simple as the owner moving the dumpster up onto the grassy area, which would probably best be accomplished by installing a gravel trench on the grass under the dumpster.

Figure 15. Poor outdoor storage and waste management found at the Meineke location on Main Street in Middletown (site DP-HS-9).

Figure 16. Rusting dumpster located on top of the storm drain inlet at Happy Harry's on Main Street in Middletown (HS-3).

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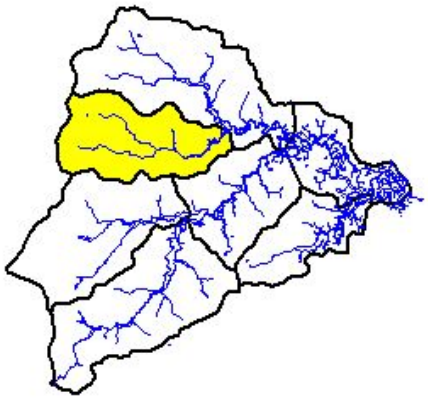
4.3 Dove Nest (DV)



Overall Characterization
Most of the subwatershed is within the jurisdiction of Middletown and is rapidly developing from agricultural fields to shopping centers and medium to high density residential. Older communities such as Village Brook are being targeted by DNREC for stormwater and stream restoration activities. With the exception of the Appoquinimink mainstem, this is the only subwatershed without a large lake or pond on the main tributary. Currently, DV is not included on the 303(d) impaired list.

Future development is likely to shift DV from the impacted to the non-supporting category based on future impervious cover (Table 9). New development is zoned for medium to high density residential. Judging by the number of signs for new subdivisions, a lot of development is expected in the near future (Figure 17). As a result many of our recommendations are focused on minimizing the impact of future development on the watershed and minimizing the impacts of existing development. Recommendations for this subwatershed include improving regulations and development standards to minimize the impact of new development, addressing suspected illicit discharges, improving watershed education of residents, and performing stream stabilization and stormwater retrofits in priority locations.

Table 9. Dove Nest Branch Subwatershed Characteristics

Drainage Area		4124 acres (6.4 sq. miles)
Stream/Waterbody Miles		2.39 miles
Land Use 2002	Impervious Cover	19% IMPACTED
	Agricultural	37%
	Wetlands/Water	8%
	Single Family Residential	25%
	Other Urban	14%
	Forested	7%
Designated Open Space		559 acres (14%)
WRPA		2477 acres (60%)
Developable Area		1969 acres (48%)
Future Impervious Cover		33% NON-SUPPORTING

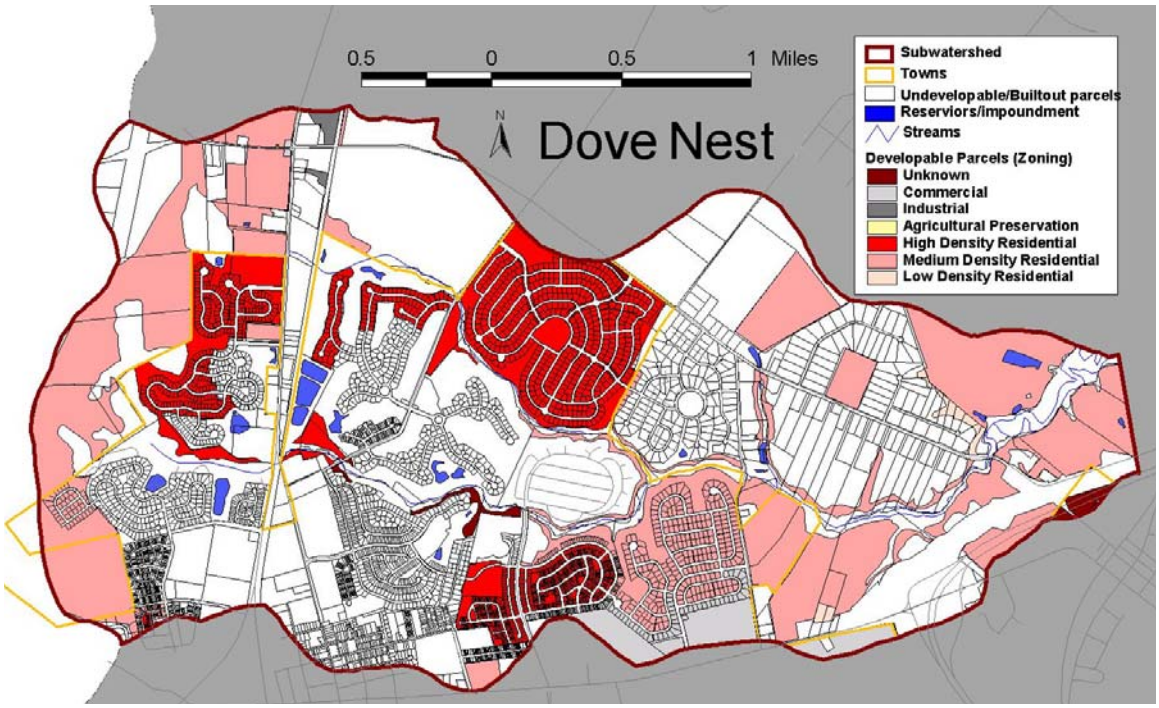


Figure 17. Zoning of Remaining Developable Parcels in Dove Nest Branch.

Existing Subwatershed Conditions

This subwatershed contains a low gradient stream system characterized by adjacent streamside wetlands and an occasional beaver dam. Rapid development is occurring in the relatively flat uplands. The topography exhibits increased relief between the uplands and the stream system as one progresses downstream. The flat uplands transition to ravines then to a low gradient, wetland dominated stream system with a broad floodplain. Impacts from urbanization in this type of stream system are less obvious than in a higher gradient system. Almost 85% of the stream corridors walked by CWP (2004) were considered excellent. Impacts were primarily seen in the intermittent channels where stormwater is discharged down ravine slopes resulting in headcutting and significant erosion. Evidence of floodplain scour and more frequent floodplain and wetland inundation were seen as well, which will likely increase with additional new development. Not surprisingly, aquatic insect communities were classified as non-supporting (DNREC 2003), and physical habitat at this station was classified as partially supporting. DNREC also walked the headwater sections of Dove Nest Branch in 2001.

Fifteen neighborhoods were assessed by CWP (2004) in this subwatershed, and all classified as moderate pollution severity. Two areas, Legends golf course community and Springmill were considered to have a high restoration potential and should be targeted for residential stewardship. Village Brook was considered a low restoration potential from the perspective of source control because very few pollution sources were identified, and the neighborhood is predominantly open section. Four priority hotspot areas were identified in Dove Nest Branch.

Management Recommendations

The priority management strategies for Dove Nest Branch include illicit discharge investigation, stormwater retrofits and stream restoration, as well as more general recommendations for improved design criteria, enforcement, watershed education and the use of better site design in new development.

Priority restoration projects in Dove Nest Branch include retrofits of untreated existing development and existing stormwater practices, and stream restoration projects primarily associated with outfalls with considerable stream channel erosion. A relatively common occurrence was erosion below outfalls where stormwater was conveyed to the top of a slope and then allowed to pass down the slope without adequate conveyance. Significant opportunities also exist in this subwatershed to treat existing unmanaged development in a portion of Middletown. All stream repair/restoration opportunities identified in this subwatershed were associated with stormwater conveyance in intermittent channels down or adjacent to ravine slopes.

Illicit discharge investigation is another priority due to the number of suspect outfalls including a potentially toxic discharge observed during the stream survey. These types of illicit discharges are illegal and have the potential to severely affect water quality and stream biota. Illicit discharge investigation is recommended in order to map the stormwater infrastructure draining to individual outfalls and perform tests to determine the businesses or homes that may have illicit connections. Guidance for illicit discharge detection can be found in Brown et al. (2004). Of six outfalls evaluated in this subwatershed, three were identified for follow-up discharge investigations.

One of the most important recommendations is to minimize the long-term additional impacts to the subwatershed by improving the design criteria and enforcement for erosion and sediment control, stream buffers and stormwater management. Other components of minimizing the long-term impacts include homeowner education and the use of better site design to minimize stormwater runoff and impacts on the natural resources in DV. Homeowner education on low impact lawn care is critical in this subwatershed due to a high percentage of high input lawns/turf, which tends to have higher nitrogen and phosphorus loads associated with it. As this subwatershed is developed, turf is expected to become the dominant land cover, so it is critical for residents to be aware of their potential impact on the Appoquinimink and the Delaware Bay Estuary. Business pollution prevention and source control is the other aspect of an education program for DV and should focus on contained outdoor storage, illicit connection identification, stormwater retrofits and overall pollution prevention.

Restoration Opportunities

Table 10 summarizes 25 candidate restoration projects identified in DV. High priority projects are described below in more detail. High priority retrofits are also described in Appendix A. See management map in Appendix D for project locations.

Table 10. Restoration Opportunities Identified in Dove Nest Branch

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area or length**
High	OT-6 HS-3	Hayley Ct and Weston Drive	Illicit discharge investigation	54 inch outfall with a toxic event occurring possible paint thinner or oil based chemical. Investigate homes and businesses in the drainage catchment including Johnson Controls to locate illicit connections.	--
High	OT-8	Schagrin Gas Co., Southern States and Citgo gas station (HS-2)	Illicit discharge Investigation	Oil sheen associated with outfall pool	--
Low	DV-1		Stormwater retrofit	Convert existing drainage ditch in front of Southern States to wet swale. Capture runoff from Schagrin buildings and parking in bioretention in front.	0.63 acres (100% IC)
High	OT-7	Legends Golf Course (HS-1)	Illicit discharge investigation	Excessive algae covering rocks exiting outfall	--
High	DV-2	Greenlawn Pond	Stormwater retrofit	Existing SWM pond for residential and commercial; retrofit existing pond with new riser with channel protection; convert sediment basin to pond; add shallow wetland.	230 acres
	RCH-4		Stream restoration (ER-5)	Majority of reach in excellent condition except in area directly downstream of SWM pond. Eroded channel and sediment deposition from failed stormwater pond riser	60ft
High	DV-3	Villagebrook Entrance	Stormwater retrofit	Use grass swale to divert water to bioretention cell near existing sump inlet.	10.8 acres (4.32 IC acres)
High	DV-4	Villagebrook Outfall	Stormwater retrofit	Some scour in stream downstream of outfall. Provide water quality treatement with peat filter and outfall stabilization.	13.49 acres (5.44 IC acres)
High	ER-4	Brickmill Rd.	Stream Restoration	Erosion of intermittent channel with 5-10ft eroding banks leaving ESC pond. Strong evidence of significant sediment transport. ESC Pond seems to be receiving considerable amounts of runoff from upstream commercial development.	100ft
High	DV-5	Middletown Square Shopping Cntr (Goodwill) (HS-5)	Stormwater retrofit	Large commercial area, Use dry swale in back to treat roof/road runoff; provide on-site treatment with bioretention between parking aisles.	9.24 acres (8.62 IC acres)
High	DV-20	Middletown Town Hall	Stormwater retrofit	Demonstration site for rain barrels (front of building) and rain garden (back of parking lot). Located on subwatershed boundary.	0.49 acres (0.43 IC acres)
Medium-High	DV-14	Middletown Plaza	Stormwater Retrofit	Existing dry pond receives sheet flow from parking lot and building; increase size of parking lot islands, more trees, retrofit existing pond to add forebays, berm (see Appendix A)	5.2 acres (100% IC)
Medium-High	DV-18	Middletown Trace Apartments	Stormwater Retrofit	Drains to center grassy area; residents of rental townhomes report nuisance flooding; install biofiltration with underdrain and overflow inlets. (see Appendix A)	1.19 acres (>0.5 IC acres)
Medium-High	DV-19	St. Joseph's Church	Stormwater Retrofit	Church on a large lot, mostly turf covered. Existing detention cells as SWM. reforestation; convert SWM to bioretention for quality. On boundary of DV and DP. (see Appendix A)	10.4acres (~ 3.5 IC acres)

Table 10. Restoration Opportunities Identified in Dove Nest Branch

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area or length**
Medium-High	ER-6	West Reybold	Stream Restoration	Outfall creating a headcut and undermining existing concrete associated with an outfall	40ft
Medium	DV-22	Greenlawn Roundabout	Stormwater retrofit	At large intersection of Greenlawn, Reden, and Javier convert to roundabout with landscaped island. Make island a bioretention cell and capture flows.	0.63acres (100% IC)
Medium	DV-7	Park and Ride	Stormwater retrofit	Convert dry pond to wet pond or biofiltration. Additional tree planting. Work with DelDOT.	--
Medium	DV-13	NAPA/Quaker City	Stormwater Retrofit	A) Use biofiltration behind NAPA retail for drainage to existing trench drain.	0.32 acres (0.19 IC acres
				B) Rain garden in grass area in front of Quaker City for rooftop runoff.	0.24 acres (100% IC)
				C) In location of trench drains behind loading docks, install underground sand filter.	2.99 acres (2.69 IC acres)
				D) Along north side of warehouse, use dry swale for roof drains	0.68 acres (100% IC)
Low	DV-10	Middletown Diner Plaza	Stormwater retrofit	Treat parking lot and Rt 301 drainage; use shallow marsh, bioretention; divert flows to new subdivision pond.	1.5 acres (100% IC)
Low	DV-15	County Police	Stormwater retrofit	Parking lot and roof runoff flow into storm drain system; divert to sheet flow to biofiltration; add landscape island; tree planting.	0.85 acres (100% IC)
Low	DV-16	Greenlawn Apartments	Stormwater retrofit	Treat the parking lot by using removing above ground planters and installing biofiltration cells.	1.71acres (100% IC)
Low	DV-21	Family Dollar	Stormwater retrofit	Runoff sheet flows off of parking lot and roof to road gutters; Add biofiltration and/or porous pavement	0.86 acres (100% IC)

* ID corresponds to location label on subwatershed management map
** Where available, estimates provided for area treated for stormwater retrofits or linear stream length for stream restoration projects

Based on the upland assessment several confirmed or potential hotspots and residential priorities were identified in Dove Nest. The primary outreach need in this subwatershed is geared towards businesses with poor outdoor storage practices and potential illicit connections. The highest priority hotspots based on the upland assessment in Dove Nest are the Middletown Square shopping center (HS-5) followed by Johnson Controls (HS-3) and the Legends golf course site (HS-1A). HS-5 exhibited poor waste management for dumpsters and for kitchen grease, as well as landscape practices. Uncovered storage and vehicle fueling practices were identified at HS-1. Shagrin Gas and Citgo Gas (HS-2) were low priorities, but potential for improved vehicle storage and outdoor fueling exists. The Legends and Springmill neighborhoods (both grouped as N-2) were considered primary targets for lawn care education. Refer to the *Baseline Assessment* for a listing of all neighborhood and hotspot opportunities.

In addition to priority residential and hotspot pollution prevention opportunities, 25 potential projects were identified. Of these projects, twelve are considered high priorities based on existing stream condition, the potential to link projects, and feasibility.

(OT-6) Suspected Toxic Discharge

OT-6 is another site where an illicit discharge had occurred at a 54-inch outfall located between Hayley Court and Weston Drive. When CWP staff and a DNREC biologist visited the site, some form of toxic event was occurring in the pool below the outfall. There were dead insects in a white viscous liquid, possibly paint or paint thinner, that formed a film with thick oily globs of the unknown substance (Figure 18). The outfall pool, which likely would have been inhabited by amphibians and possibly small fish, appeared to be lifeless. The recommendation is to initiate monitoring and utilize neighbors to assist in keeping an eye out for suspicious conditions. Mapping the drainage pipe network to the outfall is also critical to determine where the discharge may be originating – perhaps even initiating dye testing of businesses to determine possible sources of illicit discharges in the catchment. This is the highest priority illicit discharge found in this subwatershed due to the presence of toxicity in the pool.

Figure 18. Illicit discharge and dead insects in OT-6 outfall pool

(OT-8) Illicit Discharge Investigation

OT-8 is a site with potential illicit discharges located along North Broad Street near the intersection with Rt. 301 (Figure 19). Potential illicit discharges could be occurring based on the presence of oil sheens in the pool below the outfall. Commercial land uses in the drainage to the outfall includes: Schagrin gas, Southern States, a Citgo gas station, and a portion of Johnson Controls. The drainage to this outfall should be investigated further as it falls in the upper portion of the watershed and any impairment here may affect downstream waters.

Figure 19. OT-8 outfall

<u>(OT-7, HS-1, and N-2) Legends Golf Course</u>

OT- 7 is a site that drains a portion of the Legends golf course including the maintenance facility along Cedar Lane. Algae covered the bottom of the stream in the vicinity of the outfall, though it was dying back and a green tinge to the water was observed (Figure 20). The combination of the algae and it rapidly dying back may suggest a potential for high levels of nutrients and the potential use of herbicides or pesticides. It is recommended that grab sample monitoring for nitrogen, phosphorus and possibly pesticides and herbicides is initiated. The Legends golf course complex (HS-1) specifically the clubhouse, maintenance facility and surrounding greens are considered potential hotspots due to presence of oil/gas without secondary containment at the clubhouse area, and probability of high fertilization and chemical application.

Figure 20. OT-7 outfall with decaying algae on stream bottom

The residential neighborhood (N-2) associated with the Legends golf course is a priority area for targeting residential education. Springmill neighborhood is also a priority in this subwatershed (grouped as N-2). Each of these neighborhoods demonstrated that turf management is an important homeowner education/outreach need. Well-manicured lawns were abundant, suggesting use of fertilizers and/or pesticides. Lawn watering resulting in "non-target irrigation," which is when sprinklers or hoses watering lawns are not properly positioned and result in runoff into the streets and storm drains. This runoff may contain toxic chemicals and excessive nutrients (Figure 21). Outreach in these neighborhoods should include turf management education, which may include recommending rain gardens to reduce watering needs and polluted runoff.

Figure 21. Well-manicured, high input lawns (left) often result in runoff of excess fertilizers and pesticides, especially when non-target irrigation occurs.

<u>(ER-4) Brickmill Rd. Erosion Site</u>

ER4 This site is located downstream of a recently developed commercial area and a housing development still under construction (approximately 1/3 to 1/2 finished) on the west side of Brickmill Road and the intersection of Middletown Odessa Rd. A large volume of sediment is leaving the site mostly due to the outlet of stormwater onto a steep slope down an unstable channel (Figure 22). The ravine that has formed down the steep slopes has 6-10ft, highly unstable streambanks. Water that overflows the sediment pond, receiving runoff from a new large commercial area and housing development under construction, is directed toward an 8-10ft high eroding bank. Due to the lack of elevation between the pond surface and the conveyance down the slope there does not appear to be adequate storage to prevent stormwater discharge during even frequent storms. Our assumption is that the ESC pond was designed to handle sediment and volume only during construction and not post construction. We suspect the structure is undersized now that the commercial area has been completed, and the pond has not been converted to a stormwater practice due to the ongoing construction in the housing development.


Figure 22. (Left) Location where the small drainage channel outlets to the stream; note: several feet of sediment aggradation to the right and center of the picture. (Right) Water is conveyed into a steep highly eroding slope with no toe protection.

<u>(ER-5 and DV-2) Greenlawn</u>

ER-5 Greenlawn complex is a site where a stormwater pond riser has failed causing extensive sediment transport and erosion downstream. The pond is located to the east of Brady Circle and together with an older dry pond treats neighboring residential and commercial areas. There is ample space for stormwater retrofits, which could be combined with improvements to community open space. Channel protection and/ or outfall stabilization should be utilized to minimize future erosion (Figure 23).

Figure 23. Failing pond outlet (ER-5) near Brady Circle

The 230-acre Greenlawn subdivision and associated multi-family housing and commercial development drain to the stormwater pond shown in Figure 24. As this development was the last to be approved under old stormwater regulations, this facility does not provide significant water quality benefits. The old sediment basin(s) should be converted to shallow marsh wetlands, and the pond riser should be replaced with a concrete riser that is designed with water quality and channel protection control (DV-2).

Figure 24. Existing Greenlawn pond and open area (DV-2)

<u>(ER-6) West Reybold Dr. Outfall</u>

ER-6 is an eroding outfall near West Reybold Drive where the headwall has fallen away from the pipe – the eroding area only lasts a short distance (less than 30ft; Figure 25). The area is in need of repair though the limited extent of impact makes this project not as high of a priority compared to other eroding areas in this subwatershed.

Figure 25. Erosion and failed conveyance from stormwater from adjacent neighborhood

<u>(DV-3 and DV-4) Villagebrook</u>

DNREC has obtained funding for water quality retrofits in the Villagebrook mobile home community. At the entrance to the community is a highly visible location for a proposed bioretention cell (DV-3). Flow can be diverted to grass swales from upstream inlets. The existing inlet shown in Figure 26 can be used to connect the overflow and underdrain of the proposed bioretention to the existing outfall.

Figure 26. Inlet at Villagebrook entrance, a proposed bioretention site (DV-3)

At an outfall location currently under retrofit design by DNREC, flow from the outfall currently traverses a grassy area before crossing a slope into a small wetland complex (Figure 27). The retrofit concept (DV-4) here is to convert the grassy area into a peat filter, and incorporate a level spreader and rock step pools into the design to convey discharges safely across slopes.

Figure 27. Outfall in Villagebrook (DV-4)

<u>(DV-5 and HS-5) Middletown Square Shopping Center</u>
This shopping center, currently anchored by Goodwill, drains to the Greenlawn pond described as retrofit DV-2 (Figure 28). However, water quality benefits can be provided in this parking lot through the use of linear bioretention between parking aisles. Trees used in the bioretention could provide canopy cover for the parking lot.

Figure 28. Middletown Square Shopping Center (DV-5)

The Middletown Square shopping center (HS-5) was a confirmed hotspot for two reasons: poor waste management/outdoor storage and poor landscaping practices. Dumpsters along the back of the shopping center were frequently found in poor condition (rusting bottoms), located near storm drain inlets and showed visible signs of continual leaks from a used cooking oil storage vat (Figure 29). Secondary containment and waste management education are two primary needs at this hotspot. Poor landscaping practices were found at the site, as well. Behind the shopping center, a storm drain located in a grassy area was a matter of feet away from a sign indicating that "noxious chemicals" are used to treat plants in the area (Figure 30).

Figure 29. Poor waste management was evident at the Middletown Square shopping center, including this oil storage container with obvious and continual leaks.

Figure 30. This storm drain, located behind the Middletown Square shopping center, should be a priority to prevent "noxious chemicals" from entering it.

(HS-3) Johnson Controls

This site is located above an outfall where a toxic event had occurred (OT-6) (though it is unknown whether they could be the source of the contamination as many other homes and businesses drain to this point). An additional outfall, OT-8, where a petroleum smell and oil sheen was found in the outfall pool, also drains a portion of these sites as well as a Citgo gas station. Johnson Controls has been cited by DNREC and U.S. EPA for various environmental violations in the past, but since the assessment team was asked to leave the Johnson Control site just after beginning the assessment, pollution prevention and source controls recommendations cannot be made. But with the evidence at the outfalls that drains these sites, an illicit discharge investigation should be conducted.

(DV-20) Middletown Town Hall

While not a high priority based on volume treated, rainbarrels and raingardens at the town hall make great demonstration projects. Opportunities for rainbarrels were identified at downspouts located on the front corners of the building and a grassy area in the rear was identified for capturing parking lot runoff—though it currently just drains to the grassy area (Figure 31). The Appoquinimink Watershed Association (ARA) should work with Town Hall to install some of these practices at the existing building. In

addition, ARA should actively encourage the local government to incorporate these types of practices into designs for the new town hall building, which is will be located at the old Acme grocery store downtown (figure 32).

Figure 31. Downspouts direct untreated rooftop runoff through the parking lot and into storm drains. This turf area can be used to treat parking lot runoff.

Figure 32. Old Acme, location of new Town Hall (DP-28)

4.4 Drawyer Creek (DR)

Overall Characterization

Drawyer Creek lies at the northern portion of watershed, and is almost exclusively within the jurisdiction of New Castle County. Boyds Corner road roughly follows the northern boundary of the watershed, and Summit Bridge Rd. (DE 71/US-301), Cedar Lane, and US-13 are crossroads. Almost half of this subwatershed is considered prime developable area, and approximately 900 acres are slated for the watershed's second wastewater spray irrigation facility (Water Farm II). The majority of streams (tidal and non-tidal) as well as Shallcross Lake are on the 303(d) impaired list, though streams appeared to be in relatively good condition. There are a few existing impacts from agriculture, erodible/impermeable soils, and pockets of relatively low-density residential development.

Currently classified as borderline SENSITIVE, this subwatershed could possibly shift to NON-SUPPORTING if the remaining 66% of developable area in the watershed is built out (predominately as medium density residential). Table 11 summarizes existing land use information and Figure 33 shows the zoning categories of remaining developable parcels. Future development remains the greatest concern in this watershed. Strong development regulations and the use of better site design are important components of a future management strategy for DR, particularly to protect high recharge areas (almost half of subwatershed falls under WRPA). Isolated restoration opportunities identified in DR include several locations for expansion of stream buffers, locations for trash cleanups and two erosion sites created by unmanaged stormwater. One of the erosion sites is considered high priority for rehabilitation and stormwater retrofitting because it affects a significant length of stream.

Table 11. Drawyer Creek Subwatershed Characteristics

Drainage Area		6311 acres (9.9 sq. miles)
Stream/Waterbody Miles		4.9 miles
Land Use 2002	Impervious Cover	10% SENSITIVE/IMPACTED
	Agricultural	62%
	Wetlands/Water	13%
	Single Family Residential	14%
	Other Urban	0%
	Forested	10%
Designated Open Space		624 acres (9.9%)
WRPA		2812 acres (46%)
Developable Area		4175 acres (66%)
Future Impervious Cover		25% IMPACTED/NON-SUPPORTING

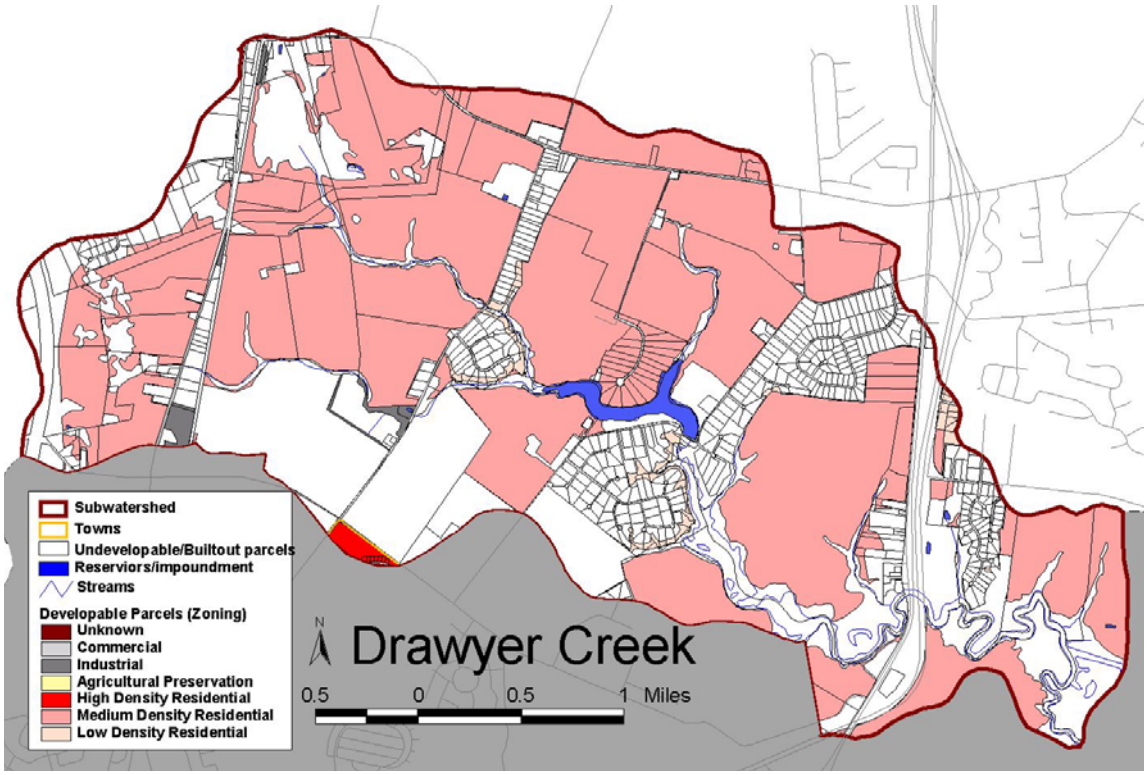


Figure 33. Zoning of Remaining Developable Parcels in Drawyer Creek

Existing Subwatershed Conditions

Biological and habitat impairment are cited for extensive 303(d) listed sections of Drawyer Creek, though most of the streams walked by CWP appeared to be in relatively good condition. Impacted reaches were observed near a large excavation site with no erosion and sediment control, as well as adjacent to residential areas. Impacts were generally buffer related; however, three stream cleanup locations were identified, three eroded areas for stream restoration, one outfall retrofit, and one stream crossing repair site were identified. No confirmed hotspots were identified by CWP crews, although DNREC has identified sixteen potential contaminant sites. Refer to the *Baseline Report* for more detail on existing conditions.

Management Recommendations

A number of important management recommendations can be made for Drawyer Creek. First it is important to recognize that much of this subwatershed is slated for medium density development in the future and has been identified as a growth area for the county. If and when future development does occur, efforts to ensure the use of better site design (to limit impervious cover, protect recharge areas, and reduce stormwater runoff), and to protect and improve existing resources including stream buffers and forestland. Almost half of the subwatershed falls under the WRPA and is considered to have a high recharge potential.

One of the largest forested/wetland sites (~500 acres) in the watershed is situated at the headwaters of the northernmost tributary. If possible, this tract should be considered for conservation easement or land acquisition due to the limited amount of forestland left in the watershed. Efforts should also be made to replant trees at Cedar Lane Elementary.

Specific restoration projects that should be pursued in the watershed include the stabilization of a chronically eroding reach (RCH-9) that ideally would co-occur with a stormwater retrofitting effort. Trash dump sites within the watershed should be cleaned up, and stream buffer reforestation efforts should be focused along RCH-5, particularly at Middletown Materials, LLC. Earthwork occurring adjacent to the stream should avoid impacting a designated stream buffer zone and place silt fence to avoid future impacts.

Restoration Opportunities
Table 12 summarizes six restoration candidates in Drawyer Creek. High priority projects are described in more detail below. Retrofit priorities can also be found in Appendix A.

Table 12. Restoration Opportunities Identified in Drawyer Creek

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area or length**
High	RCH-5 (IB-1-3)	Above Cedar Lane South	Buffer reforestation	Increase the width of the existing stream buffer	~2000ft
High	ER-1	Chestnut Lane	Stream repair	Outfall is creating a severe headcut through a steep ravine. The length of the ravine is approximately 40 feet and the banks are 6-8ft high. Further retreat of the head cut could undermine the outfall.	<50 ft
High	RCH-9	Commodore Estates II	Stream restoration (ER-2, ER-3)	Stream repair downstream to ensure a stable channel in the reach also to include a small feeder channel. Consider rock cross veins, bank reshaping, toe protection at ER-2 and cutoff sill and potential bank re-shaping at ER-3	800-1000 linear ft
Medium			Pervious area restoration (PA-2)	Potential reforestation upstream in well house field.	--
Medium			Stormwater retrofit (DR-1)	New development upstream of severely eroded outfall. Open section- no obvious SWM. Possible that D/S culvert is undersized for new development. Possible modification of existing Old Stagecoach Rd culverts to provide detention. Yard and streetscape raingardens in the neighborhood associated with Virginia Dr. to reduce flow on eroded outfall.	>200 acres (>30 IC acres)
Medium	DR-2	Chestnut Way	Stormwater retrofit	To address eroded outfall between 2 houses, use wet swale at yard inlets and plunge pool/energy dissipater at outlet.	12 acres (1.5 IC acres
Medium	PA-1	Cedar Lane Elementary	Pervious area restoration	Tree planting at the Cedar Lane Elementary	--
Low	RCH-6 (TR-2)	Above Cedar Lane South	Trash cleanup	Two agricultural dumps with some mixed residential items	2 locations
Low	RCH-1 (TR-1)	Above Cedar Lane North	Trash cleanup	Agricultural dump with mixed residential items	1 location

* ID corresponds to location label on subwatershed management map
** Where available, estimates provided for area treated for stormwater retrofits or linear stream length for stream restoration projects

In addition to the projects listed above, three neighborhoods in Drawyer Creek were classified as having moderate pollution severity: Grey Lag Rd (N-2), Chestnut Grove (N-3); and Cedar Lane (N-4); however both N-4 and N-3 were considered to have a low restoration potential. Neighborhoods adjacent to stream restoration or stormwater should be priorities to target for education (Commodore Estates II, Chestnut Grove, and Grey Lag).

While hotspot status was unconfirmed, buffer and ESC impacts to the stream flowing through Middletown Materials (HS-2) make this commercial site a priority as well.

In addition to priority residential opportunities, eight potential projects were identified in Drawyer Creek. Of these projects, four are considered high priorities based on existing stream condition, the potential to link various types of restoration practices, and the feasibility of implementation. The priority projects identified in the upper portion of Drawyer Creek were consistent with what would be expected in a largely agricultural watershed with small areas of low-density residential development: impacted buffers; erosion associated with unmanaged stormwater in low-density subdivisions; and trash dumping. Descriptions of the priority restoration projects are provided below.

<u>(ER-2, ER-3; DR-1A/B) Commodore Estates II</u>
RCH-9 is a reach of stream in the eastern portion of the watershed experiencing severe erosion (Figure 34). Stormwater from a relatively large drainage area is conveyed to a natural channel which is severely eroding for approximately 800-1000ft. Overall, the stream banks are 2-5ft high and were often raw from frequent scouring. Considerable erosion has occurred at the outfall and has now been fixed, although clearly the source of the problem, runoff from the adjacent subdivisions, has not been addressed. Other restoration opportunities are available at this site including a modification of the existing culverts under Old Stagecoach Rd road to provide disperse the flow over a longer duration, reforestation near the neighborhood well head off of Old Stagecoach Rd., and adding rain gardens to the yards and streetscape on Virginia Dr.

Figure 34. (Left) View of the outfall erosion; note: water is likely running off from adjacent street and contributing to the problem. (Right) Stream bank erosion.

(RCH-5) Buffer Reforestation

The tributary upstream of Cedar Lane contained several large stretches of stream that could benefit from an increase in riparian buffer width (IB-3 is approximately 2000 ft; IB-1 approx 50 ft; IB-2 approximately 400 ft) and possibly wetland creation along the stream corridor. IB-2 is a perennial stream draining the Middletown Materials LLC; check NPDES status because they should be a regulated industry (Figure 35). IB-3 is adjacent to a large agricultural parcel where funding is generally available for riparian reforestation. After development these locations are likely to become more difficult to reforest due to the increase in the number of property owners. Refer to subwatershed map for visual.

Figure 35. Middletown Materials Recycling Center

(ER-1) Chestnut Lane Stream Stabilization

Site ER-1 is located in a low-density residential neighborhood off of Chestnut Lane near Cedar Lane where a small outfall is creating a severe headcut through a steep ravine. The length of the ravine is approximately 40 feet and the banks are 6-8ft high. Further retreat of the head cut could undermine the outfall.

(TR-1 and TR-2) Upstream of Cedar Lane Road

While considered a low priority, trash cleanups make great opportunities for getting volunteers involved in watershed restoration. These locations contain several to dozens of empty pesticide/herbicide containers, household waste, and appliances or old agricultural equipment (Figure 36). Some caution should be exercised when removing the materials due to the presence of spent pesticide cans and other potentially contaminated items. TR-2 (two sites in close proximity) in the southern portion of the watershed may require equipment or a strong workforce to help remove some the larger items.

Figure 36. Typical trash dumping site in a ravine in Drawyer Creek

4.5 Hangman's Run (HR)

Subwatershed Characterization

Hangman's Run is the only subwatershed completely within the jurisdiction of New Castle County. Route 9 (Taylor's Bridge Road) bisects this subwatershed at the uppermost end of a large wetland complex/impoundment. The subwatershed contains extensive wetlands and forested stream buffers, and provides connectivity between the Wildlife Management Areas and Blackbird watershed to the south, making it an ideal subwatershed for land conservation and other protection measures. This subwatershed is not currently included on the 303(d) list.

Predominantly agricultural, this subwatershed is currently classified as SENSITIVE, based on the impervious cover model (impacts from historic and active farming not withstanding). This subwatershed could possibly shift to IMPACTED if the remaining 65% of developable area in the watershed is built out in medium to low density residential. Table 13 summarizes land use features of HM, and Figure 37 shows New Castle County's proposed zoning.

Table 13. Hangman's Run Subwatershed Characteristics

Drainage Area		2611 acres (4.1 sq. miles)
Stream/Waterbody Miles		3.12 miles
Land Use 2002	Impervious Cover	7% SENSITIVE
	Agricultural	55%
	Wetlands/Water	23%
	Single Family Residential	11%
	Other Urban	0%
	Forested	4%
Designated Open Space		433 acres (17%)
Developable Area		1701 acres (65%)
Future Impervious Cover		18% IMPACTED

Existing Subwatershed Conditions

Very little information has been compiled in this subwatershed. No USGS surface water monitoring stations are located on the mainstem of Hangman's Run (station 109181 located in headwaters of a downstream tributary). No groundwater monitoring wells were identified, nor biological or stream habitat data collected by DNREC. RTE species or sensitive habitats reports were not available from the Delaware Natural Heritage Program. Only 9% of the stream length was walked in this subwatershed by CWP (2004)

due to extensive wetlands and tidal influence. Impacted reaches were observed below stormwater outfalls and crossings in Bishops Walk neighborhood (HM-N-4). Four neighborhoods were assessed by CWP (2004), and all classified as moderate pollution severity with a high restoration potential making these neighborhoods specific stewardship priorities. No potential hotspot locations were evaluated by CWP (2004). No potential contaminant sites were identified by the state.

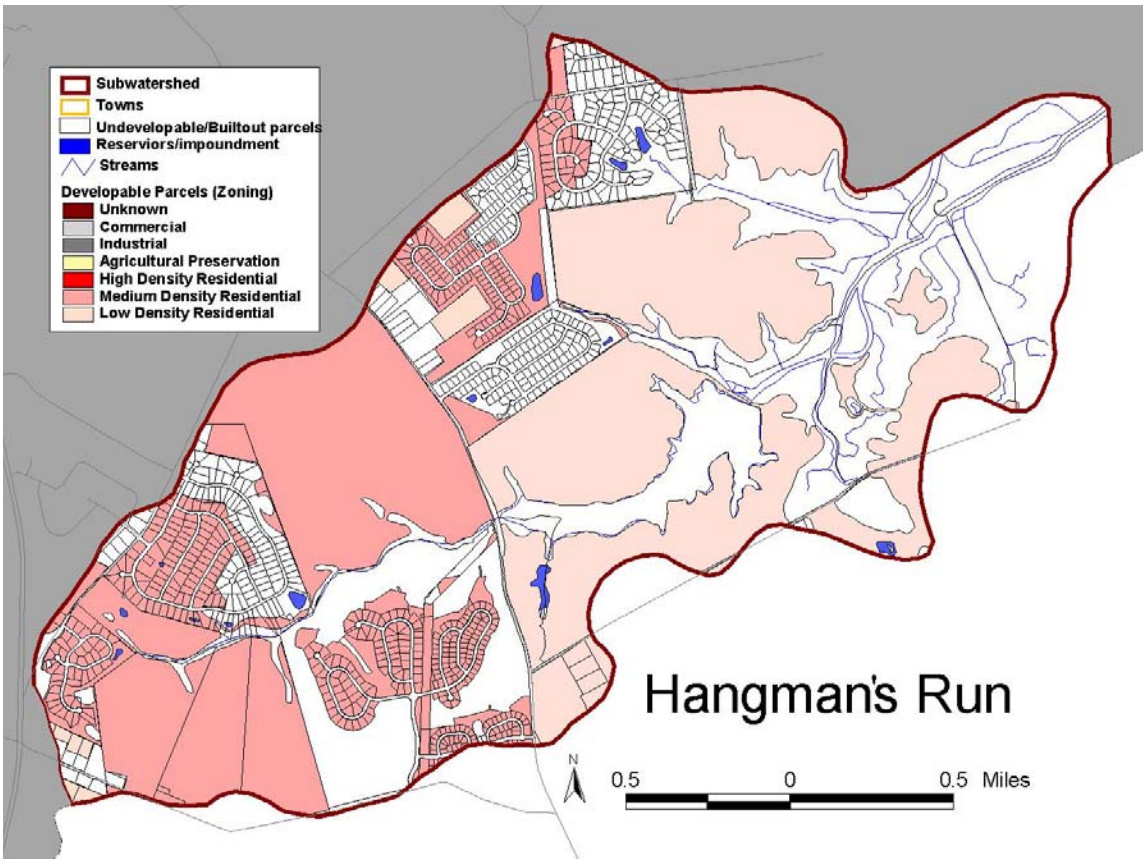


Figure 37. Zoning of Remaining Developable Parcels in Hangman's Run

Management Recommendations

The priority management recommendations for this area include protection efforts such as land conservation, better site design, and stringent ESC enforcement, as well as residential pollution prevention.

Watershed protection should be advanced through use of open space design techniques for new development that serve to enhance aquatic and wetland buffers, and protect or extend existing open space areas. Proper enforcement of erosion and sediment control requirements for new subdivisions, and better conveyance practices for treated stormwater discharges to the stream will help prevent sediment deposition and stream

erosion. In addition to ongoing efforts to apply agricultural best management practices, educating residents on pollution prevention practices is the primary restoration activity recommended for the subwatershed given its low level of development.

Currently, there is an open parcel of unforested land designated as open space at the mouth of Hangman's Run that serves to connect marshland areas of the Blackbird and of the mainstem Appoquinimink. This wildlife corridor is potentially a prime location for reforestation and habitat rehabilitation.

While there appears to be at least one water quality sampling station located in the headwaters of a tributary close to the mouth of Hangman's Run, this station only records data from a small portion of the watershed. Consider establishing a stream gauge in the mainstem of Hangman's Run and begin collecting biological data.

Restoration Opportunities

Table 14 summarizes restoration opportunities identified by CWP (2004). Priority projects are described in more detail below and in the appropriate appendix. See Appendix D for management map.

Table 14. Restoration Opportunities Identified in Hangman's Run

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area/length**
High	PA-1		Pervious Area Restoration	Restore habitat and reforest existing upland parcel of designated open space	20 acres
High	RCH-9	--	Buffer Restoration	Reach in poor condition; down cutting in channel; lack of buffer (mostly on right bank along farm field)	~ 500 ft
Medium	RCH-7	OT-4	--	Reach in excellent condition except for sediment from adjacent construction site. Maintenance at (OT-4) needs more rip rap	--
Medium	RCH-6	--	Stream restoration	Reach in poor condition due to significant stream erosion. Investigat e further for potential restoration near community park.	~ 300 ft
Low	RCH-2	OT-2	--	Maintenance on flap gate for 30" CMP	--
		SC-1	Maintenance	May cause flooding	--
Low	RCH-5	SC-5	Culvert replacement	Reach in fair condition. Retrofit of possible fish barrier	--

* ID corresponds to location label on subwatershed management map
** Where available, estimates provided for area treated for stormwater retrofits or linear stream length for stream restoration projects

Four neighborhoods were identified for residential pollution prevention activities. These neighborhoods include Thomas Cove (N-1); Cantwell Ridge (N-2); Odessa Chase (N-3), and Bishops Walk (N-4). General restoration options include turf conversion and downspout disconnection.

In addition to priority residential and hotspot pollution prevention opportunities, eight potential projects were identified in Hangman's Run. Of these projects, three are considered high priorities based on existing stream condition, the potential to link various types of restoration practices, and the feasibility of implementation.

PA-1 Reforestation of Open Space

Situated between the Appoquinimink Wildlife Management Area and the Blackbird, this parcel is a critical link in an extensive wildlife corridor stretching northward along the Augustine WMA (Figure 38). Field crews did not visit this site, and no natural resource information was available in time for this report. Based on aerial photos, it appears that this area is currently managed as open field. Approximately 20 acres falls within Hangman's Run, however this effort should not be limited to watershed boundaries.

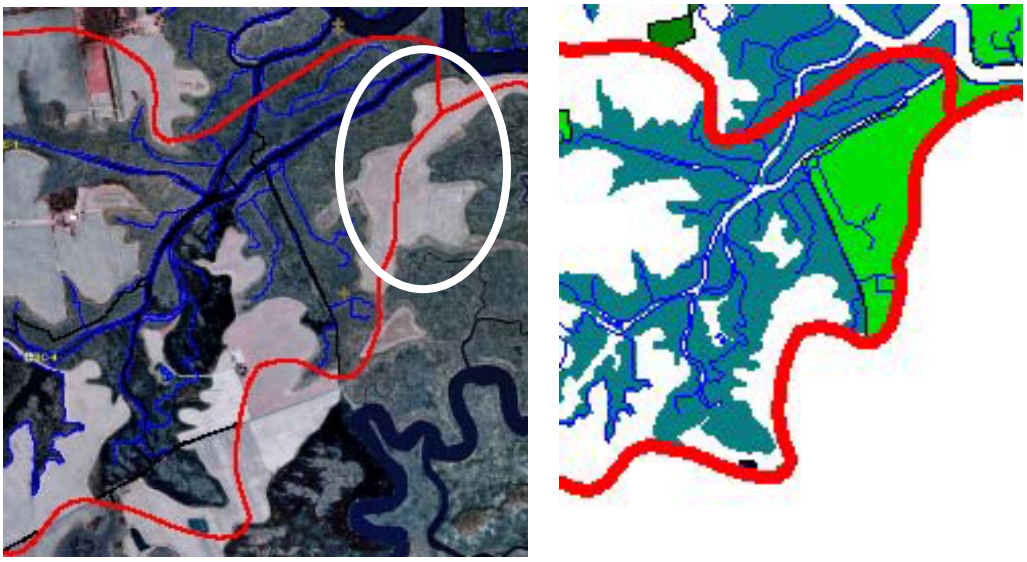


Figure 38. Upland open space area (area circled on left is in light green on right)

N-4 and N-1 Neighborhood disconnection and raingardens

Four neighborhoods in Hangman's Run were assessed, and two of these showed signs of high turf management including the use of fertilizers and pesticides (Figure 39). Primary education objectives for this subwatershed include turf management and promoting the use of rain gardens and rain barrels. Priority neighborhoods to target are Cantwell Ridge and Bishops Walk due to channel erosion and associated impacts downstream of these neighborhoods.

Figure 39. Neighborhoods in Hangman's Run featured high or medium input lawns.

RCH-9 Buffer Reforestation

This reach is adjacent to the Bishops Walk residential area, where roads are in poor condition, the channel is downcutting and buffer is lacking on the right bank along the farm field. A local homeowner complained of frequent flooding at this location, which is likely due to timing of phased construction. Further investigation at this site should occur. No retrofit concept was developed for this site. Active cornfields are also adjacent to the stream and there are areas where buffer reforestation should be pursued.

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4.6 Noxontown Pond (NX)

Overall Characterization
The subwatershed is named for the 160 acre Noxontown Pond located at the downstream end of the drainage area (Noxontown Rd.). Upstream is Wiggins Mill Pond, the second largest impoundment in the subwatershed. Most of the watershed is under the jurisdiction of New Castle County and Townsend. Live freshwater mussels (*Elliptio complanata*) were found below Rt 71, which crosses the subwatershed. The majority of this subwatershed is 303(d) impaired for nutrients, dissolved oxygen and bacteria. Management priorities for NX include protection measures applied during development, as well as restoration practices such as discharge prevention and buffer restoration. St. Andrews School is one of the larger landowners and given their association with the pond, could easily become champions of subwatershed management.

Currently classified as SENSITIVE, this mostly agricultural subwatershed could possibly shift to IMPACTED if the remaining 79% of developable area in the watershed is built out into low density residential. Table 15 summarizes current land use conditions and Figure 40 shows potential buildout conditions based on recent New Castle County zoning. Only a small portion of the subwatershed is designated as open space; however almost a quarter of the area was identified as a water recharge protection area (see *Baseline Report* for location of WRPA areas).

Table 15. Noxontown Subwatershed Characteristics

Drainage Area		5912 acres (9.2 sq. miles)
Stream/Waterbody Miles		4.12 miles
Land Use 2002	Impervious Cover	8% SENSITIVE
	Agricultural	65%
	Wetlands/Water	9%
	Single Family Residential	9%
	Other Urban	0%
	Forested	14%
Designated Open Space		206 acres (3.5%)
WRPA		1,443 acres (24%)
Developable Area		4691 acres (79%)
Future Impervious Cover		20% IMPACTED

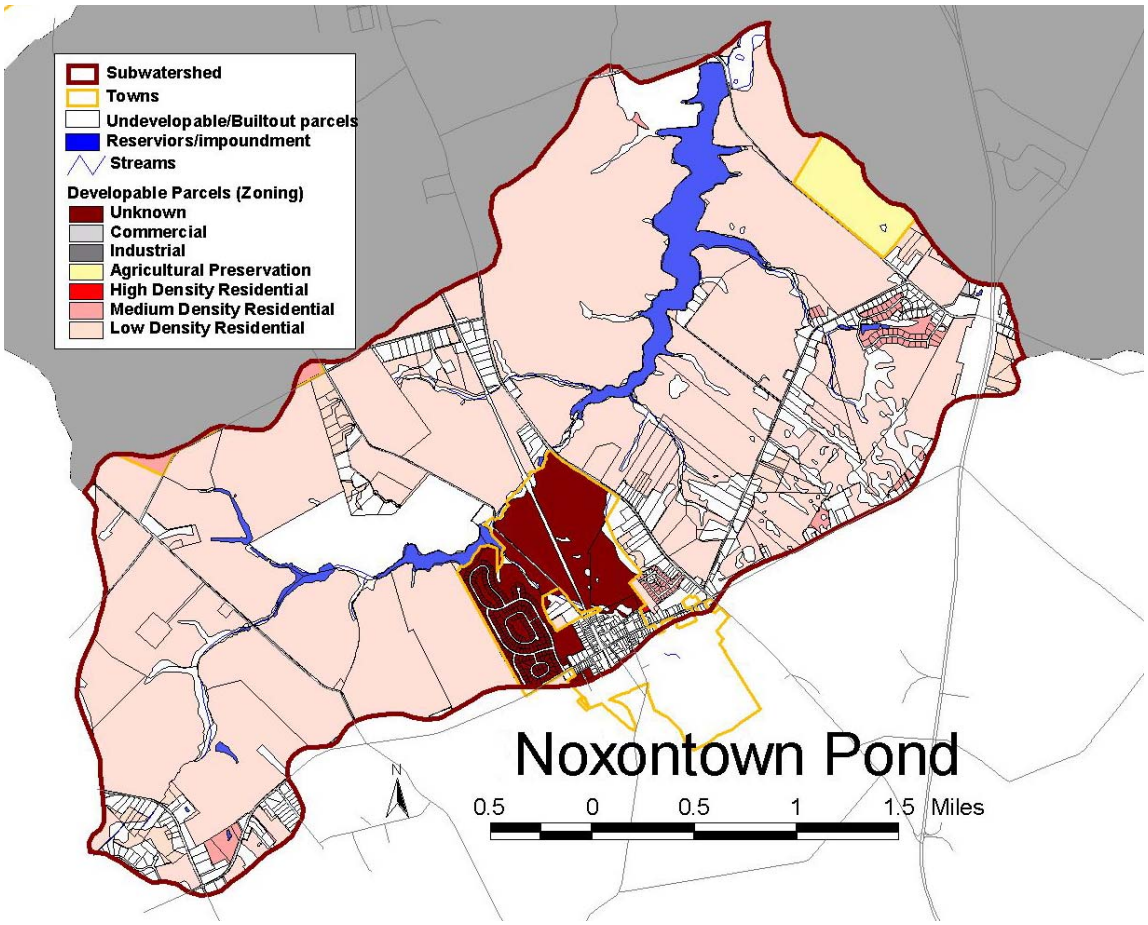

Figure 40. Zoning of Remaining Developable Parcels in Noxontown Pond

Existing Subwatershed Conditions

Three USGS surface water monitoring stations and four groundwater monitoring wells are located in this subwatershed. Over 3.4 miles of stream in addition to Noxontown Pond are on the 303(d) impaired list (USEPA, 2003). Pollutant stressors include nutrients, dissolved oxygen, and bacteria. Macroinvertebrate communities sampled also indicated enriched nutrient conditions and high sediment loads. Physical conditions of most of the streams walked by CWP (2004) were considered "fair".

Two neighborhoods were assessed by CWP (2004), both classified as moderate pollution severity. Minorca Place, where a potential illicit discharge was observed, was considered to have a moderate restoration potential. Twelve potential contaminant sites were identified by the state in the subwatershed. Three potential hotspot locations were also evaluated by CWP (2004). No evidence was found to confirm hotspot status at St. Andrews or the Mini-storage; however, the Townsend Fire Department was a confirmed hotspot.

Management Recommendations

The primary management recommendations for this subwatershed involve the application of protection practices such as better site design, ESC enforcement, and stormwater management during the development process. As agricultural lands are converted into low-density residential areas, the opportunity to conserve recharge areas within the WPRA and enhance riparian buffers should be taken. Restoration practices such as discharge investigation, buffer reforestation, and stream restoration are the primary recommendations. Inspection and maintenance of existing outfalls and embankments, as well as trash cleanup and dumping prevention opportunities were also commonly identified.

While not a priority, St. Andrews school is a critical stakeholder in this subwatershed. The school was undergoing significant construction during the field assessment period; therefore little was identified in the way of restoration activities. School grounds should be investigated further for upland reforestation and downspout disconnection opportunities. In addition, the school is a great resource for generating volunteers for monitoring, restoration and stormwater education activities. School science clubs may want to consider participating in the Breeding Bird Survey (whose route cuts through the subwatershed). ARA should take a look at the stormwater plans for the school to identify opportunities for additional treatment.

Restoration Opportunities

Table 16 summarizes restoration opportunities identified by CWP (2004). Priority projects are described in more detail below and in the appropriate appendix.

Table 16. Restoration Opportunities Identified in Noxontown Pond

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area or length**
High	NX-5	Townsend Elementary	Stormwater Retrofit	Rooftop and parking lot drainage bioretention - educational opportunity.; sits on watershed boundary.	2.99 acres
High	RCH-14; N-1	Minorca Place Outfall (OT-4)	Discharge investigation; outfall repair; homeowner ed	Reach in fairly good condition; except for outfall needing repair (propped up by bricks); suspected illicit discharge. Rooftop disconnection for residents.	--
Low			Stormwater Retrofit (NX-3)	Flow splitter to bioretention; lose some trees in the process	2.53 acres (~1 IC acre)
High	RCH-3	SC-2	Maintenance	Reach in poor condition due to bank erosion and buffer encroachment. Failing embankment, triple barrel below farm pond. 24-28 inch diameters.	--
		--	Buffer reforestation; Education	Lawn mowed to edge of stream; loss of property due to bank erosion. Dog kennels adjacent to stream.	~300 linear ft

Table 16. Restoration Opportunities Identified in Noxontown Pond

Priority	Project ID*	Site Name	Practice Type	Description	Treated Area or length**
High	RCH-4/5; RCH-6	--	Education; Buffer reforestation	Conditions poor due to lack of vegetation; reaches under Tax Ditch system; herbicide spraying; mowed to edge. RCH-4 is spring fed. Homeowner education and work with conservation district to provide alternatives for spraying, etc.	~400 linear ft (RCH 4/5) >1000 ft (RCH 6)
		OT-3	Inspection/ maintenance	Near RCH4/5. Open riser structure looks like SWM pond rather than sediment basin. Giant flow paths cut through surface to get to pond. Some failure around oufall and slope failure observed. They have double silt fencing.	--
High	RCH-13	Pump station	Discharge Investigation	RCH in excellent condition (section below Wiggins Mill Pond—saw Bass, used to be eagle's nest here (according to locals); beaver). Excessive algal mat on manhole cover at pump station. Suspected sewer overflows.	--
			Dumping prevention (TR-2)	County staff report repeated dumping of trash along road/creek. Block vehicle access with locked chain across entrance.	--
High	RCH-11	ER-1	Stream restoration	Whole reach is highly eroded. Amazing amount of sediment being actively transported; totally covered in honeysuckle; significant headcut at base of railroad tracks difficult to measure; at least a 5.5 ft drop. Consider concrete sill to contain headcut – monitor to ensure effectiveness	>500 ft (3-6 ft banks; both sides)
Medium		TR-1	Cleanup/ prevention of dumping	Extensive dumping of railroad ties, tractor tires, appliances; would take heavy equipment to remove; confined to base of railroad	--
Low	NX-2	Townsend Fire Dept (HS-3)	Stormwater Retrofit	Runoff from the large parking lot; install Delaware sand filters in back; use porous pavement, planters, cistern; source control	1.97 acres (~100% IC)
Low	RCH-10	OT-1	Maintenance/ inspection	Reach in good condition. No problems really, found freshwater mussels. Check farm pond embankment	--
Low	RCH-1	TR-1	Cleanup/ prevention	Reach in fair condition; braided, dry channels. Heavily impacted floodplain, lots of sediment transport; slope erosion; forest floor has no understory or forbes. Rubble filling bank; concrete, appliances on the left bank over 30 pickup truck loads. Will take heavy equipment (contractor or local government) …if its even worth it. This area is near new home under construction with buffer encroachment	--
Low		ER-1	Bank stabilization	Stream erosion at areas of steep slopes of meander bends. This occurs in multiple locations. Soil is spongy; easily crumbles. At this particular location, it was about 75 ft of 6.5 ft left bank.	<100 linear ft
Low	NX-4	Attic Mini-Storage	Stormwater Retrofit	Shallow excavated linear rain garden	1.91 acres
Low	--	Wiggins Mill Pond Hobby Farm	Buffer reforestation	Replant vegetated buffer along creek draining pond; encourage use of alternative water supplies (i.e., ag BMPs)	~200 feet

* ID corresponds to location label on subwatershed management map Appendix D
** Where available, estimates provided for area treated for stormwater retrofits or linear stream length for stream restoration

Of the two neighborhoods assessed by CWP (2004), Minorca Place (N-1), is considered a higher priority due to a suspected illicit discharge. Sunnyside Lane and Brook Bramble Lane (N-2) were also evaluated, but should be considered lower priorities. Few hotspots were identified in this subwatershed. The Townsend Fire Department (HS-3) is the priority hotspot for follow-up education and retrofitting. Refer to the baseline report for more detail.

In addition to priority residential and hotspot pollution prevention opportunities, sixteen potential projects were identified in Noxontown. Of these projects, nine are considered high priorities based on existing stream condition, the potential to link various types of restoration practices, and the feasibility of implementation.

<u>(RCH 4/5 and RCH 6) Tax Ditch.</u>
Private residence at confluence of two small tributaries off of Wiggins Mill Rd has over 300 linear feet of impacted buffer (RCH 4/5). Stream in rear of house (RCH-4) is fed by a spring. RCH 6, which is off of Dogtown Rd. in the uppermost headwaters of the subwatershed, has over 1000 ft of impacted buffer (mainly one side of stream). In both cases, homeowners have mowed to the edge of streams and applied herbicides, which were provided by the county, along the banks to reduce vegetation (Figure 41). These drainages are part of the County's Tax Ditch network. Funds from this network could be used to help restore buffer conditions and educate homeowners. At a minimum, ARA should work with the Conservation District to minimize the impact of chemical usage in these areas.

Figure 41. Evidence of spraying and mowing along "tax ditch" at RCH4/5 (left) and RCH-6 (right)

<u>(N-1, OT-1) Minorca place outfall repair and discharge investigation</u>
During two separate visits, field crews noted sudsy, dry weather discharge from OT-1 at the end of the large cul-de-sac in Minorca. Based on an observed hose from a residence across the street directed into the stormdrain, this discharge is likely connected to a washing machine. These types of connections should be removed from the stormdrain system as part of a watershed-wide illicit discharge elimination and homeowner

education program. In addition, the outfall at this location is in need of repair as the end of the pipe has been undermined, is disconnected, and causing bank erosion. A retrofit concept for the area was developed (NX-3), involving the creation of a bioretention facility. This is a lower priority than discharge investigation and education. Further downstream, multiple 6-inch black corrugated plastic pipes are discharging directly into the stream. These appear to be downspout connections or potentially swimming pool drains.

Education focus in this neighborhood should be on proper discharge of wastewater and pool water, and downspout disconnection/rain gardens. Figure 42a shows the hose inserted into the stormdrain. It was not possible to determine where the hose originated, as it was buried under the lawn. Downspouts on the right side of the house were draining directly onto the street through pipes placed down both sides of the driveway (Figure 42b). Another recommendation in this neighborhood is to offer incentives to owners to disconnect their downspouts. Rain barrels and rain gardens are two possible alternatives in this neighborhood, as there is the potential for adequate space to plant a rain garden or landscaping areas on which water collected in a rain barrel could be applied.

Finally, organic matter was found dumped in the buffer area near the outfall. Buffer education is needed, and signs that prohibit dumping should be posted. ARA could possibly work with homeowners and the local jurisdiction to collect leaves and lawn clippings, if needed.

Figure 43: (a) Hose leading directly into storm drain with unknown source; (b) downspouts directly connected to street; (c) outfall end section supported by bricks with dry weather flow; (d) suds from dry weather flow.

NX-5 Townsend Elementary Retrofit

This site appears to straddle the watershed boundary, however it is an excellent opportunity for a demonstoration project and education. An existing storm drain outfall, conveying rooftop and parking lot runoff, discharges to in the back play area of the school (Figure 43). This is a small site that provides a good opportunity to create a rain garden, which could enhance infiltration and evapotranspiration of runoff. Further, such a practice can provide excellent educational opportunities with the introduction of native plants and interpretive signage that describes the importance of and benefits from reducing nutrients to the Appoquinimink. Maintenance of existing drains and rooftop disconnection would help alleviate some of the evident flooding problems.

Figure 43. Clogged drain and evidence of flooding issues at loading area for Townsend Elementary (on left). Twin 6" outfalls in back of school in retrofit area (on right).

(OT-3 near RCH 4/5) Sediment Pond Inspection

The new residential construction site off Main Street in Townsend provides a good example of why ESC inspection and enforcement is critical in the Appoquinimink (Figure 44). It appears that a majority of the runoff at the site flows across the surface to the large sediment basin at the back of the development. Large gullies have formed where flow is concentrated and plastic reinforcement matting has been applied unsuccessfully to reduce erosion. An existing pipe inlet is visible at the basin, however it is starting to be eroded out. The sediment basin outlet structure has an open trash rack on top, which is not designed to filter out sediment. In addition, there is no baffle system to help encourage sedimentation in the pond. The outfall structure is designed to help dissipate velocity and spread flow out. A double silt fence has been constructed at the downstream end to filter remaining sediment out of runoff. Discharges then drain freely across a steep slope directly to Noxontown Pond. Rock pad at construction entrance should be maintained.

This site should be monitored constantly during the construction process. When the facility is converted to a stormwater pond, proper design considerations for conveying water across the steep slopes should be made.

Figure 44. (A) Rock pad at entrance to construction site; (B) gully formed from surface runoff to sediment pond (see reinforcement matting in forground); (C) view of large sediment basin; (D) outfall structure (see downstream silt fencing).

<u>(RCH-3) Pond Embankment Repair and Buffer Reforestation</u>

Erosion behind outfall/embankment structure from farm pond is beginning to threaten infrastructure (Figure 45). Downstream, this reach show signs of bank erosion and buffer encroachment, particularly on the right bank (facing downstream; Figure 46). The embankment should be inspected and homeowners educated on the benefits of riparian buffers. If a maintenance project is to occur here, perhaps linking it with buffer reforestation could persuade homeowners to participate.

Figure 45. (Left) RCH-3 looking upstream towards farm pond. Note lack of buffer, sediment bars, and stream bank erosion. (Right) Shows outfall from farm pond with eroded embankment in the background.

Figure 46. Buffer continues to be impacted futher downstream along RCH-3

<u>(HS-3) Townsend Fire Station</u>

Townsend fire department was found to be a confirmed hotspot. A retrofit concept was developed, although due to cost, size, and safety considerations, it did not rank as a high priority. This suggests an even higher priority for pollution prevention. Evidence of poor outdoor storage and dumpster management were found, including staining from the dumpster to the storm drain indicating continual leaks (Figure 47). A fueling area is located across the parking lot from the storm drain, and it does not have any secondary containment in the event of a spill. The Fire Department should develop a spill prevention and response plan. The parking lot at this fire department is quite large, suggesting that public events may take place here. If so, this would also be a good education site to get the pollution prevention message to the public.

Figure 47. An outdoor fueling area (left) and dumpsters (right) are located too close to the storm drain without runoff diversion methods. A bermed facility around both of these storage areas may prevent polluted water from entering the storm drain.

<u>(RCH-13) Wiggins Mill Pump Station</u>
This pump station has two potential projects. The first involves further investigation of the potential sewer overflow at this location. Thick algal mats around a manhole cover, draining across the parking lot towards the stream is a likely indicator of excess nutrients over a long period of time. County staff at the site reported continuous flow of spring water from a small pipe show in Figure 48b, which should also be investigated. County staff also report continuous trash dumping along roadway and creek. Preventing vehicular access by installing a locked chain and or gate across entrance would help limit public access.

Figure 48. (A) Pump station and algal mat across parking lot. (B) Close up of algal mat and manhole cover. (C) Trash dumping.

<u>(RCH-11) Headcut at ER-1</u>

This small tributary drains farmland and starts at the base of the railroad track, both uses have impacted the stream. There is a 5.5 to 6 foot headcut near the base of the railroad tracks at the top of this reach (Figure 49). Over 500 ft of severe streambank erosion was observed and significant sediment loads are being transported throughout the reach. Heavy dumping of trash and debris was observed at the base of the railroad tracks (including tires, farming equipment, railroad ties, etc). We recommend further investigation of the causes of erosion at this site, as well as an evaluation of restoration feasibility. This site provides an example of how much sediment bank erosion along steep slopes can produce.

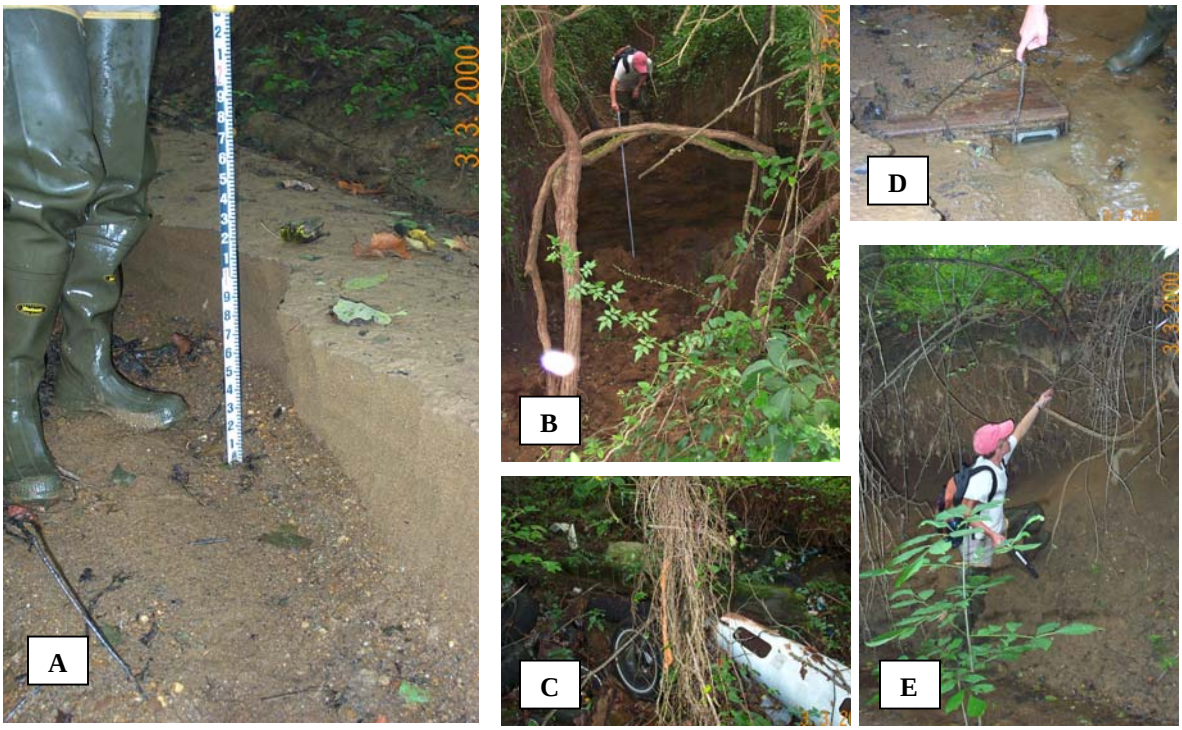

Figure 49. (A) shows almost a foot of sediment rapidly transported through channel; (B) 5-6 ft head cut; (C) trash and debris along stream bank; (D) standard television buried in middle of stream channel; (E) actively eroding (widening) stream channel

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Section 5.0 Implementation Costs and Schedules

Implementation is by far the longest and most expensive step in the watershed protection and restoration process. In fact, restoration and protection costs for a single urban subwatershed can range from half a million to two million dollars depending on the extent of restoration activities, number of jurisdictions involved, land costs, and other factors. Salaries, land conservation, and construction of restoration projects often account for a majority of these costs. A minimum of five years is usually needed to design and construct all the necessary restoration projects, which are normally handled in several annual "batches." Sustaining progress over time and adapting the plan as more experience is gained are vital aspects of implementation.

This section presents planning level costs and phasing for implementing watershed recommendations, and attempts to estimate general costs for the construction of priority stream restoration projects and stormwater retrofits. Overall costs presented here are planning level estimates only and should be used to guide ARA and partners in estimating annual operational and implementation budgets for the Appoquinimink. Estimates should be adapted to include more appropriate local costs where available.

It is not intended that ARA be responsible for generating the full range of estimated funding required; costs should be distributed across implementation partners, existing programs, and responsible property owners (i.e, DelDOT, NCC, DNREC; DDA; businesses and landowners).

5.1 Estimating Costs

Watershed protection and restoration is not cheap. This section presents cost assumptions used to estimate construction and installation costs of high priority restoration projects and recommended protection practices. The cumulative estimate for implementing the 14 recommendations presented in Section 2.2 over next five years exceeds two millions dollars (Table 19). This estimate does not include land conservation or construction of all priority stormwater retrofits. Also excluded are costs associated with continued implementation of agricultural BMPs and wastewater efforts necessary to meet TMDL criteria.

High Priority Restoration Projects
Tables 17 and 18 present planning level cost estimates for the twelve high priority stormwater retrofits and twelve stream restoration projects described throughout Section 4.0. Cost assumptions for illicit discharge investigations, pervious area restoration, and pollution prevention are also discussed. Note that project estimates should be used for planning level efforts and that cost estimates should be refined as actual concepts designs are pursued, particularly for stream repair and retrofit projects. It should also be noted that priority project costs may not include the necessary design, permitting, and maintenance costs ultimately associated with project construction.

Retrofit construction costs are primarily based on a cost per impervious acre treated basis. Typical construction costs for onsite retrofits (bioretention, filters, etc) and larger storage retrofits applied here are presented in Appendix A, specifically Tables A-7 and A-8. As a general rule of thumb, engineering and design costs for retrofits are 15-25%of construction costs, and annual maintenance is approximately 5% of the construction cost.

Table 17. High Priority Stormwater Retrofits

Project ID*	Description	Planning Level Cost**
A1-1	Odessa Professional Park. Convert dry pond to wet pond. DelDOT partnership	$100-125K
A1-2	Public land adjacent to river in Odessa. Develop as recreation/ education area. Incorporate bioretention/rain garden.	$10K-$25K
DP-1	DelDOT Maintenance Yard. Retrofit existing stormwater pond to provide channel protection. Add water quality treatment downstream of salt barn. Link with ER-1, TR1-2, and HS-1	$50K
DP-8	Local park. Existing outfall has scour hole. Drainage area includes Broad Street. Plunge Pool/Energy Dissipater, Shallow Marsh/Wet Pond w/ED. Link with stream repair; buffer plantings (currently mowed to edge);	$400K
DP-23	MOT Senior Center. Retrofit existing pond with standing water by creating micropool, adding wetland plantings-- 3.25 acres (1.34 IC acres); Volunteer opportunity to create raingardens for parking and rooftop runoff	$35K-$60K
DP-28	Old Acme. 100% impervious site with building and parking - to become new city hall; use biofiltration, tree planting	$40K-$70K
DV-2	Greenlawn. Existing SWM pond for residential and commercial; retrofit existing pond with new riser with channel protection; convert sediment basin to pond; add shallow wetland	$650K
DV-3	Villagebrook Entrance. Use grass swale to divert water to bioretention cell near existing sump inlet.	$100-$200K
DV-4	Villagebrook Outfall. Some scour in stream downstream of outfall. Provide water quality treatement with peat filter and outfall stabilization.	$130K-$240K
DV-5	Middletown Square Shopping Center (Goodwill). Large commercial area, Use dry swale in back to treat roof/road runoff; provide on-site treatment with bioretention between parking aisles.	$120K-$220K
DV-20	Middletown Town Hall. Demonstration site for rain barrels (front of building) and rain garden (back of parking lot)	$5-$10K
NX-5	Townsend Elementary. Rooftop and parking lot drainage bioretention - educational opportunity	$24K-$44K

* Where DV=Dove Nest; DR=Drawyer Creek; DP=Deep Creek; NX=Noxontown Pond; AP= Appoquinimink I and II; HM= Hangman's Run; ER=Erosion Site; OT=Outfall; RCH=Reach

** Costs are general planning level costs for practice based on general rules of thumb detailed in Tables A-7 and A-8 in Appendix A. These costs do not include buffer planting, stream repair, or other practices applied at the site.

Planning level estimates for stream repair projects are based on a general rule of thumb of $100-200/linear stream foot, plus installation of practices such as cutoff sills and drop structures. These costs do not include design and permitting costs. Average repair practice costs are provided in Appendix B (Table B-1 and associated fact sheets). Riparian buffer reforestation costs are based on a $500 per acre average (tree planting costs range $225-$1200/acre depending on labor, species, protection measures, maintenance, etc). Unless otherwise noted, area determinations were made by multiplying linear stream feet by a width of 25 ft for each stream bank. Refer to

Appendix B fact sheets for supplemental cost information for various planting methods and materials. Further investigation at stream repair and buffer reforestation sites will be required to get a better sense of overall project costs

Table 18. High Priority Stream Repair and Buffer Reforestation Projects

Project ID*	Description	Planning Level Cost
Stream Repair Projects†		
DP-ER-2	DelDOT Maintenance Yard (RCH-0)—headcut below outfall at end of geotextile—drops 1.5-2 feet. Outfall stabilization and retrofit would address majority of the problem; <50 ft steep gully – improve energy dissipation; Links with retrofit DP-1, TR1-2, and HS-1c. (50ft x2=100 ft)	$10K
DP-ER-1	Below Cricklewood— reach severely eroded at outfall (OT-1). ~ 200 linear ft of channel actively eroding (>6 ft banks); heavy sediment deposition in the floodplain. Consider drop inlet and redirecting flow away from earthen wall, grade control, toe protection, and re-shaping streambanks --mature trees would likely be lost as a result. (200 ft x2 = 400ft)	$60K (includes $20K for drop inlet structure)
DV-ER-4	Brickmill Rd. ~100 ft of eroded intermittent channel with 5-10ft banks leaving ESC pond. Strong evidence of significant sediment transport. ESC pond receiving considerable amounts of runoff from upstream commercial development. Consider upstream flow control, rock cross veins, toe protection. Alternate concept would be to pipe conveyance to floodplain/stream. (100 ft x 2=200 ft; high range of $200/linear ft)	$25K-$50K (includes $3K for two RCV; does not include upstream retrofit)
DV-ER-5	Greenlawn. Majority of RCH-4 in excellent condition except in area directly downstream of SWM pond. ~60 ft of eroded channel and sediment deposition from failed stormwater pond riser; links with retrofit. Consider drop structure to level spreader (60 ft x2=120 ft)	$30K (includes $20K for drop inlet structure)
DR-ER-1	Near Chestnut Lane—outfall creating severe headcut through approximately 40 ft of 6-8ft high ravine. Further retreat of headcut could undermine outfall. Consider stabilizing outfall and improve energy dissipation	$8K- $12K
DR-ER-2 /ER-3	RCH-9 Commodore Estates II. ~800-1000 ft stream repair downstream to ensure a stable channel in the reach also to include a small feeder channel. Consider rock cross veins, bank reshaping, toe protection at ER-2 and cutoff sill and potential bank re-shaping at ER-3	$180K-$220K (includes 20K for specified practices)
NX-ER-1	RCH-11 is highly eroded. Large amount of sediment being actively transported; totally covered in honeysuckle; significant headcut at base of railroad tracks difficult to measure; at least a 5.5 ft drop. High erosion severity; access along RR; >500 ft (3-6 ft banks; both sides) Consider concrete sill to contain headcut – monitor to ensure effectiveness (500 x2=1000 ft)	$100K+
Buffer Reforestation Projects††		
DP-IB-1	RCH-20 Local Park. 150 ft of stream channel in park-like setting has poor buffer. Linked with DP-8 retrofit. (50 ft x 300ft=15,000 ft^2 or 0.34 acres)	$200
DP-RCH-21	At retrofit DP-8 ~900 ft of stream need buffer plantings (currently mowed to edge) on both sides (50 ft x 1800ft=90,000 ft^2 or 2.1 acres)	$1050
DR-IB-1, 2,3	RCH-5 Above Cedar Lane (south). ~2000ft of impacted buffer. Increase width of the existing stream buffer; (50 ft x 4000ft=200,000 ft^2 or 4.6 acres)	$1050
HM-RCH-9	Reach in poor condition; down cutting in channel; ~500 linear ft lacking buffer (mostly on right bank along farm field); (25 ft x 500 ft=12,500 ft^2 or 3.0 acres)	$1500
NX-RCH-3	~300 linear ft of lawn mowed to edge of stream; loss of property due to bank erosion. Dog kennels adjacent to stream (25 ft x 300 ft=7500 ft^2 or 0.2 acres)	$100
NX-RCH-4/5, 6	Conditions poor due to lack of vegetation; reaches under Tax Ditch system; herbicide spraying; mowed to edge. Homeowner education and work with conservation district to provide alternatives for spraying, etc. ~400 linear ft along RCH 4/5 (50 ft x 800ft=40,000 ft^2) and >1000 ft along RCH 6 (25 ft x 1000ft=25,000 ft^2) ; Total 1.5 acres	$750

* Where DV=Dove Nest; DR=Drawyer Creek; DP=Deep Creek; NX=Noxontown Pond; AP= Appoquinimink I and II; HM= Hangman's Run; ER=Erosion Site; OT=Outfall; RCH=Reach

† Costs are general planning level costs for practice based on general rules of thumb of $100-200/linear foot, plus installation of practices such as cutoff sills and drop structures estimated in Appendix B (Table. B-1 and associated fact sheets). These costs do not always include design and permitting costs. Project estimates assume $100 per linear foot x 2 (to accommodate both sides of the stream)

†† Based on riparian tree planting costs of $225-$1200/acre depending on labor, species, protection measures ,etc (Appendix B).. Project estimates use an average $500/acre and assume both sides of stream at 25 ft width on each, unless otherwise stated.

Illicit discharge investigation costs assume $400 per incident investigated. Average cost to fix the problem is approximately $2500 per incident based on Phase I community surveys (Brown et al., 2004). Most costs to fix will be born by the responsible party. In Appoquinimink, two of the six suspected discharges appear to be relatively simple to isolate and fix (disconnecting wash water drain hose from residential home at Minorca Pl., and disconnecting vehicle washing pad drain at police station in Odessa). Isolating discharges at Hayley Court/Weston Drive (OT-6) and below Schagrin Gas Co. (OT-8) will be more complex and potentially more expensive to correct. Low-end costs for establishing a hotline are approximately $1300 startup costs and $1500 annual operation (Brown et al., 2004). This assumes that a public works emergency hotline already exists. Costs may be three to four times higher in absence of such a hotline.

Reforestation costs for the 20-acre open space parcel in Hangman's Run can be based on an upland reforestation estimate of $400/acre by the US Fish and Wildlife Service Partners Program (see fact sheet in Appendix B). Species planted, planting technique, and use of tree shelters or other types of protection measure to enhance survival rates will affect these estimates.

Local pollution prevention education programs surveyed by Swann (1999) reportedly had miniscule annual budgets ranging from $2,000 to $25,000. ARA should anticipate a $15,000 start up cost and a minimum $10,000 annual budget for an education program. Appendix C provides supplemental information on costs associated with various parameters of an education program for residential and hotspot areas. Targeting the effort to specific neighborhoods, hotspots, and pollution generating behaviors (lawn care, downspout disconnections, stormdrain stenciling, dumpster management, etc) will help streamline program costs.

Protection Practices

Land acquisition and the purchase of conservation easements can be the highest costing items in a watershed protection plan. Only one area was specifically identified for land conservation by CWP in the Appoquinimink, 500 acres in the northwestern portion of Drawyer Creek. Based on estimates from the Delaware Department of Agriculture (DDA) Agricultural Preservation Program, average cost of permanent protection (easement) occur at a modest cost of $1,039 per acre. This may or may not be applicable to the 500 acre site identified earlier; however there are several conservation opportunities in agricultural parcels that are within WRPA coverage and adjacent to existing preservation districts.

Internal costs for adopting new buffer, development codes, and tree protection ordinances for Middletown are estimated at $20,000 per ordinance. This cost was also used for enhancing stormwater criteria and adopting more stringent ESC standards. This estimate is based on CWP (1998) corrected for inflation, and it assumes legal fees, public meetings, hearings, and no legal challenges.

Costs for hiring a part-time (0.2-0.5 FTE) erosion and sediment control and stormwater inspector dedicated to the Appoquinimink is approximately $15,000 per year. This cost could be reduced if the position falls within a larger municipal program.

5.2 Implementation Schedule

The costs described in the previous section should be applied across the implementation horizon based on recommendation priorities. Recommendations should be loosely viewed as short-term, mid-term, and long-term implementation priorities, keeping in mind that many of the recommendations presented will be on-going.

Short-term recommendations are initial actions to be carried out within the next year that set the framework for executing remaining watershed recommendations. In general, time-sensitive activities to protect the watershed from future degradation are considered highest priorities for implementation. Such actions include adoption of local ordinances and the identification of parcels for land conservation. Discharge investigations at suspect outfalls, and the development of a comprehensive watershed education program to target stewardship priorities and pollution source control projects should begin during this stage. Small, inexpensive demonstration projects (i.e. rain gardens, trash cleanup, tree planting) can be done to generate support for continued action. Construction of large retrofit practices and stream restoration projects is not included in this phase in order to accommodate required design, engineering, and permitting.

Mid-term recommendations involve continued programmatic and operational measures, distribution of educational materials, and construction of one or two large retrofit and/or stream restoration projects over the next two to four years. Securing funding for stormwater and stream restoration projects during this phase is crucial. Progress on land conservation, continued enforcement and inspection, and establishment of a monitoring and tracking plan should occur during this period.

Long-term recommendations mark continued implementation of any additional projects necessary to meet watershed objectives, as well as an evaluation of progress, accounting of successes and lessons learned, and an update of the watershed plan.

Table 19 provides a draft budget and schedule for implementing the 14 watershed recommendations from Section 2.2 based on cost estimates provided in the previous section *(Please note that this table does not include land conservation costs or construction costs for of all priority stormwater retrofits).*

Based on this budget, ARA should plan on a basic annual budget of approximately $50,000 (includes #1, 6, 8, 9, 12, 14, and portion of #7). Some of these costs may fall within the watershed coordinator's salary, others may be in addition to existing requirements of the position. On top of the basic program budget, ARA should set a fundraising goal of $70,000 for short-term implementation (includes #10 and 11).

Table 19. Costs and Schedule for Recommendation and Priority Project Implementation

Recommendation	Responsible Parties	Planning Level Costs*		
		Short-term (year 1)	**Mid-term** (years 2-4)	**Long-term** (year 5+)*
1. Build capacity of watershed organization and coordinator	ARA	$15,000	$15,000 (@ $5,000/yr)	$5,000+
2. Hire a part-time ESC/SWM inspector	NCC; M	$15,000	$45,000	$15,000+
3. Adopt local environmental protection ordinances†	M; T	$20,000-$60,000	--	--
4. Enhance stormwater design criteria	M, NCC	$20,000	--	--
5. Adopt more stringent design standards for ESC practices	M, NCC	$20,000	--	--
6. Actively pursue land conservation	ARA; DDA; Land Trust	$5000 (identification)	Unknown	
7. Illicit discharge detection and elimination	ARA, M, NCC	$2400 (investigate 6 discharges @ $400/site); cost to fix born by owner @$2500/each $1300 establish hotline	$4500 (@ $1500 annual hotline costs)	$1500+
8. Develop education and outreach program	ARA	$15,000	$30,000 (@ $10,000/year)	$10,000+
9. Evaluate municipal programs/practices	NCCD; ARA; DelDOT; M	$15,000	--	--
10. Implement priority stream restoration	ARA; DNREC; NCC, M;	$10,000 (design of priority projects) $35,000 (repair DV-ER4)	$260,000 (install DP-RCH-0-ER1, DP-RCH2-ER1;and DR-ER2/3) $6000 buffer reforest (all projects)	$130,000 (install remaining)
11. Install priority stormwater retrofits	ARA; DNREC; NCC, M; DelDOT;	$25,000 (implement small demo project (DV-20 and DP-23 raingardens)	$25,000 (design and engineering) $475,000 (construct A1-2; DP-1; DP-8)	$820,000 (construct DV-2, DV-5)
12. Implement priority residential and hotspot pollution prevention	ARA	Part of education program		
13. Monitoring and project tracking	DNREC; ARA; USGS	$6000 (10 bug stations @ $600/station) $500 (2 baseflow sites at $20/sample/month) ††	$1200 (bugs year 2,4) $1500 (baseflow)	$6000+ (bugs) $500+ (baseflow)
14. Identify & secure funding for watershed restoration	ARA; DNREC	Part of watershed group capacity funding		
Phase Totals		**$225,200**	**$873,200**	**$988,00**
Cumulative Total			**$1,098,400**	**$2,086,400**

* ARA=Appoquinimink River Association & watershed coordinator; DNREC=DE Dept of Natural Resources and Environmental Control; M=Middletown; DelDOT = DE Dept of Transportation; DDA=DE Dept of Agriculture; NCC=New Castle County; USGS=US Geological Survey

** Light shading indicates ARA basic annual costs; darker shading indicates ARA lead in fundraising for short-term projects

† NCC and Odessa may also need to adopt/revise ordinances, however existing regulations for these jurisdictions were not evaluated as part of this work.

†† Baseflow monitoring costs are for analysis only. Note these costs do not include all recommended monitoring (see Section 6.0)..

Section 6.0 Appoquinimink Monitoring Plan

Watershed restoration (particularly the urban component) is such a new field that each restoration plan is basically its own experiment. As a result, it is important to institute tracking and monitoring systems to measure improvements in subwatershed indicators over time. These systems include the internal tracking of the delivery of restoration projects in a subwatershed, as well as monitoring of stream indicators at sentinel monitoring stations. Performance monitoring of individual restoration projects can be tracked to improve the design of future restoration practices. Information gathered from a tracking system is then used to revise or improve the restoration plan over a five- to seven-year cycle.

The difficulty in monitoring success in the Appoquinimink is further compounded by the fact that considerable development is expected in the future based on existing zoning and the on-going development observed during the field assessment. Therefore, the prospect of trying to measure improvements on a subwatershed scale while additional impacts from land use change are occurring is tenuous at best. As a result, we are recommending a four-pronged approach to monitoring in the Appoquinimink which includes:

- *Project monitoring* at a small scale (reach or smaller) to illustrate benefits of individual restoration efforts. Communities may want to invest in both in-stream and non-stream monitoring of individual restoration projects to assist in measuring project success. Such monitoring can be relatively simple (observing the success of a reforestation project or measuring public awareness through surveys) or extremely complex and expensive (measuring the pollutant reduction of a storm water retrofit or the biological response to a comprehensive stream restoration project). Restoration practices are often experimental or implemented as demonstration projects, which sometimes makes it difficult to show improvement in overall water quality or watershed indicators.

- *Sentinel station monitoring* to track long-term health and water quality trends. Sentinel monitoring stations are fixed, long-term monitoring stations which are established to measure trends in key indicators over many years (USGS gauging stations are good examples of these). Sentinel monitoring is perhaps the best way to determine if conditions are changing in a subwatershed or watershed. Few communities have the resources to continuously maintain a long-term monitoring program, but the existence of sentinel stations ensures that the right indicators are measured at the same places when money is available for monitoring.

- *Illicit discharge monitoring* to facilitate identifying and tracking down inappropriate discharges. Illicit discharge detection and investigation are critical elements of watershed restoration and planning especially when there are obvious indicators of illicit discharges as in the Appoquinimink. Illicit discharges are often a significant source of pollution in a watershed that occur repeatedly in association with specific polluting behaviors. Monitoring and keeping watch on individual outfalls and

heading up the pipe to determine possible entry points for illicit discharge connections are critical to removing them.

- *Project Tracking and Plan Implementation.* Few people fully comprehend the complexity of delivering a large group of restoration projects within a small subwatershed. It is a good idea to use a spreadsheet or GIS system to track project implementation data over time, such as project location, inspection, maintenance and performance. Project tracking data chronicles progress made in subwatershed implementation, and can isolate management problems to improve the delivery of future restoration projects.

The proposed monitoring approach for the Appoquinimink is summarized in Table 20. Figure 50 shows the locations of proposed and existing monitoring stations.

Table 20. Components of a Monitoring Plan for Appoquinimink

Component	Monitoring Activity and Locations	Protocols/ Parameters	Rationale
Project Monitoring (representative)	Monitor macroinvertebrates/ habitat and stream channel cross sections for Reach DR-9 both pre and post construction of retrofits and stream restoration	EPA Rapid Bioassessment Protocol for Habitat and Macroinvertebrates (or existing DNREC protocol); Harrelson et al. (1994) for cross sections	Example for assessing the effectiveness of restoration measures at improving the biological community and stream stability
	General accounting of on-the-ground progress	Number of trees planted, rainbarrels installed, fliers distributed, etc	Measure of success
	Before/after residential behavior surveys	None specifically identified	Measure influence of homeowner education;
	Development codes review	Codes and Ordinance Worksheet	Higher scores indicate more environmentally sensitive regulations
Sentinel stations	Yearly macroinvertebrate/ habitat monitoring at nine stations (see map for proposed stations)	EPA Rapid Bioassessment Protocol for habitat and macroinvertebrates (or existing DNREC protocol)	Tracking long-term health and habitat in the watershed
	Stream gaging & monitoring for baseflow & stormflow WQ at existing Cedar Lane (1483165) and Brickmill Rd. (1483170) sites to track existing nutrient & sediment loading over time	Continue existing methods being used at the sites to monitor for TN, nitrate, TP and suspended sediment	Evaluate status of TMDL progress and assumptions resulting from land use conversion
	Monthly baseflow monitoring at two existing sites with elevated nutrient concentrations (109241 and 109251)	TN, nitrate, TP using existing DNREC methods	Continue to track elevated levels while working to identify the source of the elevated nitrogen levels
Illicit Discharge Monitoring/ Detection	Immediate monitoring and illicit discharge pipe investigation of high priority sites (DV-OT6, OT7, OT8 and pump station at NX-RCH-13).	Outfall Reconnaissance Inventory (ORI), chemical and pipe investigations from Brown *et al.*,2004)	Determine sources of illicit discharges and correct the problems
Tracking & Plan Implementation	An accounting spreadsheet of restoration efforts in the watershed; annual report	Excel or similar spreadsheet and perhaps GIS system; DNREC's Delaware Environmental Navigator (DEN)	Track implementation efforts on a watershed and subwatershed basis

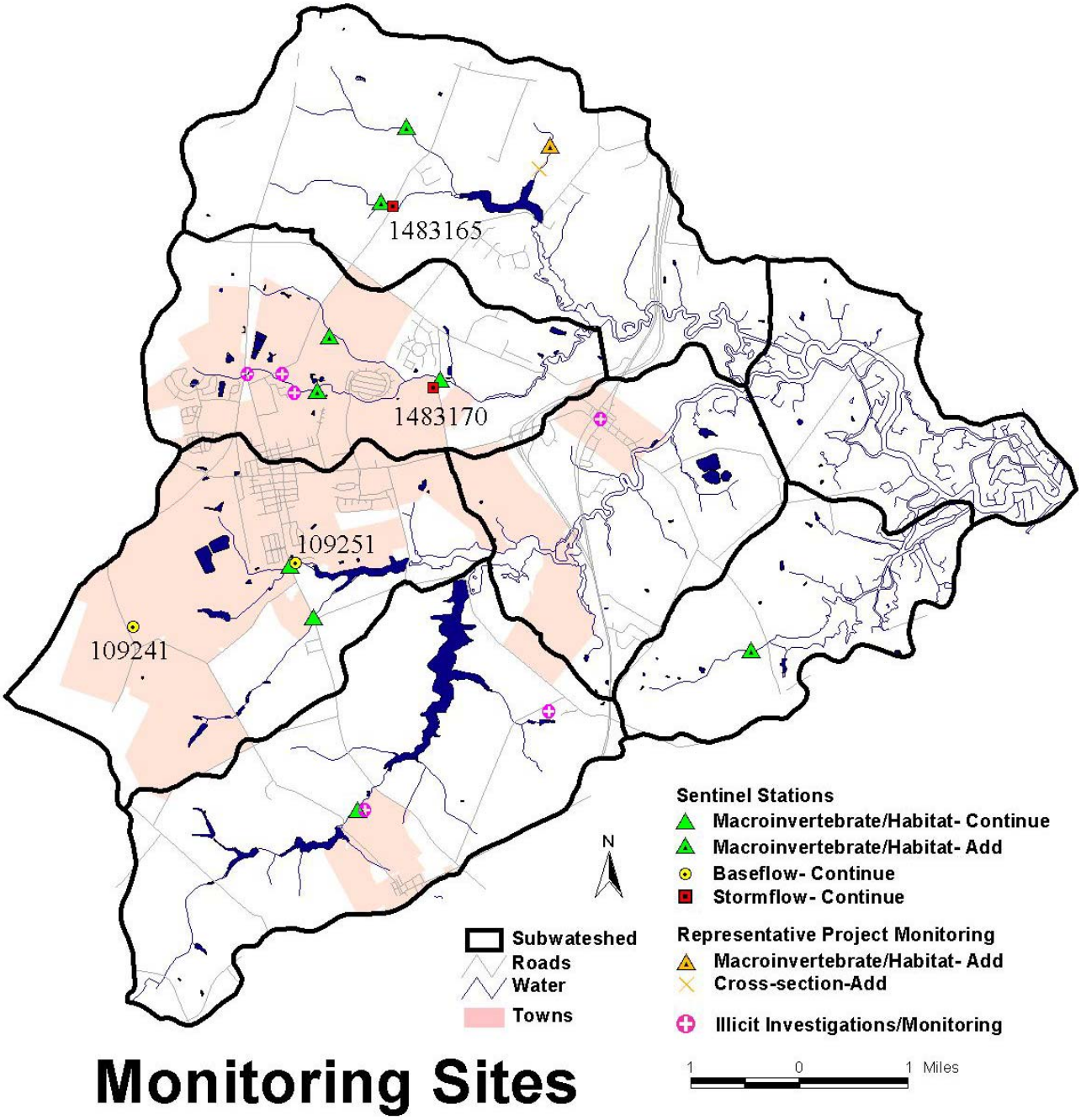

Figure 50. Proposed Monitoring Locations

6.1 Project Monitoring (Performance Monitoring)

ARA, DNREC, funders, and other restoration partners will have a keen interest in measuring whether the restoration projects they implement are successful. Success can be measured in a number of ways including direct improvements in watershed indicators (e.g. reduced pollutant loading or improved aquatic insect communities) or indirectly (e.g. number of rain gardens installed, number of volunteers, acres conserved). Communities may want to invest in performance monitoring of individual restoration projects in order to improve future designs. Performance monitoring is generally applied to larger restoration projects such as stream repairs, riparian reforestation and stormwater retrofits. Such monitoring can be relatively simple (visually assessing the structural or vegetative integrity of a restoration practice) or extremely complex and expensive (measuring the pollution removal performance associated with a storm water retrofit or other restoration practice). Not all projects are structural; however, and methods for measuring their success (before and after behavior surveys, program or regulatory evaluations) are just as critical as traditional in-stream monitoring.

Some kind of physical inspection should be performed at every individual restoration project to assess its function over time, with the specific measures of success depending on the type of restoration practice. For example, if stream restoration at DR-RCH-9 is going to occur, we recommend monitoring macroinvertebrates/ habitat and stream channel cross sections at the site before and after construction over a period of time in order to evaluate project success at stabilizing banks and restoring habitat. A reforestation project might be inspected to determine tree survival or the effects of invasive species, whereas a storage retrofit might be inspected to determine if is functioning properly or needs maintenance (e.g., clogged pipes, sediment deposition, etc.). Municipal programs should be evaluated every few years to measure changes resulting from pollution prevention education, and homeowners should be surveyed on their lawn care practices before and after education programs have been targeted to their neighborhood.

Project inspection should be required as part of the construction contract and/or maintenance agreement, and should include performance measures such as vegetative stabilization, landscaping care and replacement, erosion control, slope stability and initial adjustment.

6.2 Sentinel Stations

Sentinel stations are fixed, long-term stations that measure long-term trends in selected aquatic indicators over many years that are directly related to watershed goals. They are often located at historic monitoring stations. Appoquinimink has over 30 monitoring sites, including four USGS stormflow gauges, and more than 20 baseflow stations. Five historic macroinvertebrate sampling stations were also identified in the watershed. In

some cases, it makes sense to continue long-term sampling at some of these sites because of the existing data record.

Priority baseflow stations 109241 and 10925 for example, are called out for continued monthly monitoring due to elevated nitrogen levels. Stormflow stations 143165 and 1483170 are also recommended for continued quarterly monitoring to evaluate status of TMDL progress and assumptions resulting from land use conversion. However, for implementation purposes, none of the existing stations below lakes and ponds are recommended as sentinel locations due to complex internal lake processes. Currently, macroinvertebrate sampling is limited to a single station in Dove Nest Branch, two in Deep Creek, and two historic sites in Noxontown Pond. The addition of two sites in Drawyer Creek upstream of Cedar Lane, two sites in Doves Nest, and one in Hangman's Run are recommended for annual sampling. Continuance of sampling at the two stations in Deep Creek and at the downstream station in Noxontown Pond is recommended.

The selection of which biological, physical, habitat and water quality indicator to sample is extremely important. The indicator needs to be directly linked to watershed goals, repeatable *(*with a consistent sampling method that produces comparable results over many years), and relatively inexpensive, in order to limit the annual cost so that communities will be able to sustain monitoring over the long-term. Consider collecting macroinvertebrates and habitat data, TN, nitrate, TP and suspended sediment at given stations as these parameters relate to the Appoquinimink TMDL.

Sentinel stations should be routinely monitored before, during and after subwatershed implementation over several years (5 to 10 years minimum) as trend monitoring is the best way to determine if stream conditions are improving and watershed goals are being met.

The precise sampling schedule at each sentinel station will vary depending on the specific indicator(s) selected. In each case, however, sampling should be scheduled to occur within a common window each year at the sentinel station – the same time of day during the same season and under the same flow conditions. In general, biological, habitat and stream geometry indicators are less influenced by year-to-year variation and may be skipped in some years if budgets are limited. Dry weather water quality, on the other hand, tends to be much more variable, which may require more samples each year, or strict sampling protocols to collect samples during the same season and flow conditions. Sentinel station monitoring results should be compiled and reported annually.

6.3 Illicit Discharge Monitoring

Illicit discharges are defined as "discharges that are not composed entirely of stormwater." Many forms of illicit discharges can be toxic including laundry wastewater, sanitary wastewater, car washing effluent and illegally discharged industrial/ commercial effluent. These discharges are often episodic and result in periodic assaults on the

biological community and water quality in the streams. Removing existing illicit discharges should be a high priority of a watershed plan.

Six locations for further IDDE investigation were identified by CWP. These should be investigated and monitored to determine sources of the discharge and fix the problem, particularly at DV-OT6, OT7, OT8 and near pump station at NX-RCH-13. ARA should consider working with local governments to establish a hotline for reporting suspected discharges at these and other locations. Brown et al (2004) provides more detail on illicit discharge detection and elimination procedures.

6.4 Project Tracking

Managing the delivery of a large group of restoration projects within a subwatershed can be a complex enterprise. Therefore, it is a good idea to create a master project spreadsheet linked to a GIS system that tracks the status of individual projects through final design, permitting, construction, inspection, maintenance and any performance monitoring. For non-structural efforts, tracking systems should include measures such as number of outfalls inventoried, number of discharges removed, number of hotline calls, or number of dedicated volunteers. By tracking the delivery of restoration projects, ARA can assess implementation progress over time, which in turn, helps explain future changes in stream quality. Project tracking can also improve the delivery of future projects, and creates reports that can document implementation progress for key funders and stakeholders.

Ideally, the watershed coordinator should manage implementation tracking. This person will need to determine what information to track, update project information in spreadsheet/GIS format, and periodically report on the status of implementation. The tracking system should account for all restoration practices undertaken in the subwatershed plan regardless of their type or size. The tracking system for structural projects, for example, should contain enough information so that watershed managers can quickly:

- Determine actual project costs
- Track individual project implementation status from design through construction
- Access design and permit information when needed
- Schedule construction and maintenance inspections
- Report on overall progress in subwatershed implementation

Table 21 indicates some of the specific project management information to include in a tracking spreadsheet database that can be directly linked to a GIS. This table is primarily geared towards structural projects such as stormwater retrofits or stream corridor restoration practices.

Table 21: Common Project Management Information to Include in Tracking Database	
• Project Identification No. • Project Type • Description • GIS Coordinates • Cost Share • Total Design Cost • Total Construction Cost • Sponsoring Agency • Subwatershed • Property or Land Owner • Property Owner Phone # • Property Owner Address • Location on Property • Date Installed	• Final Design • Permit file • As-Built Drawings • Installer/Contractor name • Installer/Contractor phone # • Inspection Schedule • Initial Inspection Date • Initial Inspection Comments • Follow-up Inspection • Follow-up Inspection Comments • Next Inspection Date • Maintenance Performed • Digital Photographs • Project Archive File No.

The tracking database should be updated frequently (several times per year) to include new project information. If budget resources allow, a short report should be prepared that summarizes the overall status of subwatershed implementation, with an emphasis on project successes and failures. This will allow for adjustments in program implementation and incremental assessments of program effectiveness.

6.5 Data Reporting

On an annual basis, ARA should compile the information derived from the baseline, tracking and project monitoring. The annual report should summarize current biological and physical conditions in the watershed; the number, type, and extent of projects taken; and the success to date of the plan in improving watershed conditions. Reporting on an annual basis will allow for mid-course corrections and adjustments to be made based on the monitoring data.

Consider integrating this effort with DNREC's Delaware Environmental Navigator **(DEN)** system which allows users to explore the many types of information collected by DNREC such as permitted facilities, enforcement actions and environmental monitoring. It can be found at **http://www.dnrec.state.de.us/DNRECeis/.**

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