AGENDA
EAST GOSHEN TOWNSHIP
CONSERVANCY BOARD MEETING
March 14, 2018
7:00 PM

1. CALL TO ORDER / PLEDGE OF ALLEGIANCE / MOMENT OF SILENCE

2. APPROVAL OF MINUTES

   February 14, 2018

3. NEW BUSINESS

   a. Representatives from Natural Lands & Toth Brothers will be in attendance to discuss pond dredging and answer questions regarding the township ponds.

4. OLD BUSINESS

   a. Continue discussing plans for "Keep East Goshen Beautiful" Day

   b. Spring Planting - Confirm site visit on March 17th.

5. CHAIRMAN'S REPORT

   a. Announce that John Scheidt has resigned from the Conservancy Board due to health reasons.

   b. Announce that the BOS will be reviewing recommendations on the pond study at their March 20th meeting. If approved, we should have what is expected of us at our April meeting.

6. VARIANCES

7. BOARD MEMBER CONCERNS

8. LIAISON REPORTS

9. CORRESPONDENCE

10. DATES OF IMPORTANCE

March 15, 2018	Historical Commission	07:00 pm
March 19, 2018	Zoning Hearing Board	07:00 pm
March 20, 2018	Board of Supervisors	07:00 pm
March 21, 2018	Planning Commission	07:00 pm
March 26, 2018	Futurist Committee	07:00 pm
March 30, 2018	Office Closed	----------

April 03, 2018	Board of Supervisors	07:00 pm
April 04, 2018	Planning Commission	07:00 pm
April 05, 2018	Park and Rec Commission	07:00 pm
April 09, 2018	Municipal Authority	07:00 pm
April 10, 2018	Board of Supervisors	07:00 pm

11. PUBLIC COMMENT

12. ADJOURNMENT

Draft

EAST GOSHEN TOWNSHIP
CONSERVANCY BOARD MEETING
FEBRUARY 14, 2018

The East Goshen Township Conservancy Board held a regularly scheduled meeting on Wednesday, February 14, 2018 at 7:00 p.m. at the Township Building. In attendance were: Chairman Erich Meyer, Sandy Snyder, and Scott Sanders. Others in attendance: Mike Lynch, Township Supervisor.

Call to Order

Erich called the meeting to order at 7:00 p.m.

Pledge of Allegiance & Moment of Silence

Erich led those present in the Pledge of Allegiance and then asked for a moment of silence to remember those who serve in our military and our first responders.

Minutes

The minutes of the January 10, 2018 meeting were approved.

New Business

1. 2018 Goals – Erich reported that the Board of Supervisors assigned goals similar to the Conservancy Board's annual presentation in January.
2. PECO Green Grants – There was discussion about these grants and making application for one. Scott suggested planting trees around one of the ponds based on the pond study. Applications can be submitted by March 31 and again in September.

Old Business

1. Keep East Goshen Beautiful –This event on Saturday, April 21, 2018 is the 33rd year. Sandy will send out emails to the groups. Erich designed a flyer which he gave to Jason and put some in the lobby. He will also contact Brian to put it on the electronic signs. Mike suggested putting a flyer in the kiosks in the park and Historic Goshenville. He went to the Reservoir dam area and picked up several bags of litter. Scott suggested putting recycling cans next to all of the trash cans.
2. Spring Planting – On Saturday March 17, 2018 the Board members will walk the area along E. Boot Road to check the trees and see what needs to be done.
3. Serpentine Rock – Mark Miller will do a burn in the Spring. This may be a scout project.

Liaison Reports

Board of Supervisors – Mike mentioned that Community Day will be held on Saturday, June 30, 2018. The BOS is in negotiations with the WEGO police.

Adjournment

There being no further business, Scott moved to adjourn the meeting. Sandy seconded the motion. The meeting was adjourned at 8:00 p.m. The next meeting will be March 14, 2018 at 7:00 pm.

Respectfully submitted,

Ruth Kiefer
Recording Secretary

Study of Ponds

East Goshen Township
Chester County, PA

FEBRUARY 2018

Natural Lands

Study of Ponds

East Goshen Township
Chester County, PA

FEBRUARY 2018

Natural Lands

Hildacy Preserve
1031 Palmers Mill Road
Media, PA 19063
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natlands.org

with contributions from

Toth Brothers Clearing and Dredging
Aquascapes Unlimited, Inc.
Brandywine Science Center, Inc.
Pennoni

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provided in digital format

background

The East Branch Chester Creek and the Ridley Creek played a significant role in East Goshen's agricultural past. These major streams and their many tributaries which stretch across the township provided water for the farms which once dominated the landscape. Farmers often dammed a tributary, or diverted water from them, to create a pond, easily collect water or feed their animals. Now, most of the farms are gone, but some of the ponds remain. They now provide the residents with aesthetic beauty and some recreational use. Some ponds have been created to manage stormwater, while others have been retro fit by developers, as residential developments have replaced the farms.

No longer serving a utilitarian role, and surrounded by homes, the beauty and overall health of the ponds has been called into question. Many of them are filled with sediment, overrun by geese, and covered with algae for long periods of time, particularly in the summer. Fish kills have also been reported over the past few summers. Recent tests show that by some measures, the ponds do not meet standards for water quality for their current uses. Natural Lands has examined these issues, worked with the Township and partners, and has prepared this report on the causes of these problems and potential solutions.

approach

Natural Lands owns and operates 43 nature preserves, many of which are former farms. Some of these properties include ponds. In most cases, we have converted the ponds into wetlands, a more natural state. Ponds do not occur naturally in Pennsylvania, making their maintenance an ongoing battle against nature.

Natural Lands' ponds are different than those found throughout East Goshen. The six ponds included in this study are large and manage stormwater. They also serve the residents as they provide aesthetic beauty and recreational opportunities. **Therefore, we do not recommend converting any of the ponds included in this study, to wetlands, as it would upset the neighbors and require extensive redesign.**

Pond ecology and management are complicated, especially when stormwater management is involved. Where ponds have become filled with sediment and water quality is degraded, its important to take a holistic view of the factors affecting the ponds. Scientists are needed to test water samples to determine the levels of chemicals and sediment in the water. The test results provide clues

Natural Lands draws on our experience managing 43 nature preserves, including the Willisbrook Preserve, nearby in Willistown Township.

to what is causing the problems. A landscape architect or engineer then determines the causes. A construction company with experience in ponds and basins advises on the pond structures. An aquatic plant and pond management professional provides insights on the pond itself. Finally, the landscape architect or engineer provides recommendations for how to change the surroundings and the ponds themselves, to address the causes of the problems, rather than simply treating the symptoms.

In order to provide a holistic approach, a diverse team of professionals is required to examine the water, plants and other natural and manmade features which affect the ponds. Natural Lands subcontracted with **Toth Brothers, Clearing and Dredging, Inc.**, to assess the levels of sedimentation, the functionality of the existing structures and provide recommendations regarding dredging and construction. Natural Lands also consulted with **Aquascapes Unlimited**, on plantings and aeration. East Goshen Township hired the **Brandywine Science Center** to perform laboratory tests to determine the quality of the water, including percentages of chemicals, in each pond. **Pennoni**, the Township Engineer, also provided insights in an advisory role. Information provided by each consultant has been used to conduct a comprehensive study of the six ponds and basins, focused on reducing algae and sediment and improving water quality.

additional challenges

The ponds can be improved from their current state. The amount of algae can be reduced. The number of fish kills can be reduced, if not eliminated. The ponds can be dredged of the excess sediment which fills them now. But it is likely that the ponds will never be perfect. They will never be completely algae free. They will never be in a perfect natural balance. They will never be maintenance free when it comes to sediment. Three important truths will challenge work around these ponds forever:

1. Ponds do not occur naturally in southeastern Pennsylvania;
2. These are not just ponds, they are stormwater management areas;
3. Some algae is natural and normal.

In Pennsylvania, the combination of hydrology, soils and geology and topography, does not support the existence of ponds. We often see wetlands, springs and vernal pools, but not large ponds, like the ones examined in this study. Wetlands typically exist in floodplains, or in low lying areas near streams. They are shallow, with a fluctuating depth, and sometimes flowing water. Springs are fairly common, and often exist in groups, close together. Springs more typically act as headwaters, with their flows combining to form streams. Vernal pools could be described in laymen's terms as large, seasonal puddles. They are extremely

Dredging may be necessary at some of the ponds, as they have filled with sediment. CREDIT: Toth Brothers Clearing and Dredging

Berms, dams or other types of impoundments maintain water levels, as ponds do not occur naturally in southeastern Pennsylvania.

important for wildlife, especially amphibians such as frogs and salamanders, but they are much smaller in size and disappear in the dry months.

Where ponds do exist in our area, they are man-made. They all have a water source, such as a pipe carrying stormwater, or an existing stream. Sometimes a spring feeds a pond too. They also all have either a dam on one end, or raised berms completely surrounding the water, holding it in place. They also all have a place where water can flow out if the pond overflows. The outfall is usually in the form of a spillway, where water simply flows over an edge, or a piped structure, which acts as a drain, diverting water through a dam or side, towards a nearby stream.

Ponds like these are in a constant battle against nature and time. The concrete pipe structures degrade over time. Trees can take root and tear them apart. The berms, typically made of clay, can also subside or fall apart over the course of many years. Over time, the man made features which hold the water in place, simply fall apart without ongoing monitoring, maintenance and repairs. Additionally, the forces of nature work against ponds, trying to return them to a natural condition. Where water flows in, it brings sediment to fill the depression. Where water flows out, it can erode the areas around the structures or tear at the berms themselves, again, with the ability to undermine the berms which hold the water. Without ongoing intervention, over the course of time, nature would fill the ponds with sediment, tear apart the impoundments and restore the areas to stream channels and wetlands.

The ponds examined in this study are primarily stormwater management areas. In addition to the natural forces at play, man-made forces also affect the ponds. Stormwater inlets in the neighborhoods surrounding the ponds bring even more water into the ponds. The forces of erosion and sedimentation which are naturally present in stream systems are exacerbated with the addition of stormwater, making it even more difficult to keep the ponds in balance. Stormwater also brings other issues, as the water typically carries pollutants, such as motor oil and gasoline, fertilizers, soaps and other substances which end up in the pond water. These substances can affect the water chemistry in ways which encourage algae growth.

Inlets feed stormwater, and sediment and pollutants, from the streets into the ponds.

The presence of some algae is natural and normal. This study was commissioned in part because some of the ponds were completely covered in algae in the warmer months. The residents consider this an eyesore. More importantly, a pond completely covered in algae is not a healthy pond. The recommendations included in this study seek to reduce the amount of algae in the ponds, but not to completely eliminate it. Algae are plants which occur naturally in water bodies, so some should be expected. But just like in a forest, its not healthy for one plant species to dominate the ecosystem. We seek to reduce the amount of algae, and bring it back into balance within a healthier pond ecosystem. The community will need to accept some algae in the ponds.

goals of this study

Each pond and basin in the study is different, but they all serve the same basic functions- to manage stormwater, look attractive and serve the residents of the community. Some of the ponds and basins were designed as stormwater management measures, collecting piped water through inlets and pipes, while others collect sheet flow from their surroundings. They are all in plain view of residents, some providing the view from the front window, while others provide scenic beauty to backyards. The ponds could also serve as recreational areas, for fishing, or as a setting for walking paths. With these ideas in mind, the study set out to achieve the following goals:

1. **Assess the overall functionality of the ponds** – Toth Bros, with Natural Lands, inspected the ponds,

measured them for depth and depth of sediment, and visually assessed structures such as inlets, outflows and emergency spillways, to ensure that they were safe and functional.

2. **Assess overall health of the ponds** – In accordance with the existing and potential uses for the ponds, Natural Lands has reviewed the laboratory tests performed by Brandywine Science Center, highlighted deficiencies at each pond and prepared recommendations for improvement.
3. **Provide recommendations to reduce the amount of seasonal algae growth, improve aesthetic beauty and provide recreational opportunities** – The ponds, with some improvement, can become centers for passive recreation within each neighborhood, providing people with a place to walk, watch birds and animals, fish or simply enjoy the scenery.

context

Detailed descriptions and recommendations related to each individual pond are found later in this report. However, a number of findings and existing conditions relate to most or all of the ponds in the study. Some are results of similar land management approaches at each of the ponds, while others, such as the state of the watershed throughout southeastern Pennsylvania, are outside of the control of the Township. The following section provides a description of the state of the ponds, the effects of their surroundings and an overview of some of the common issues.

As stormwater management measures, the ponds feature outfall structures, which allow water to escape when the ponds fill too high.

disconnection from the people

When we visited the ponds, we saw little evidence to suggest that the nearby residents visit or use the ponds on a regular basis. There were no social trails or tracks, no garbage and few other signs of use. We did see some evidence of fishing, with some line stuck in branches over the ponds, but even that was minimal. Comments at the public meetings seemed to confirm that the residents rarely visit the ponds, mostly due to the presence of geese and their waste. There are also few amenities to draw people to the sites.

The closest residents enjoy the views of the ponds, but even they rarely visit the water's edge. They don't have a connection to the water, or to the birds, amphibians and fish that depend on it. They view the ponds from afar and have little reason to think about the processes, natural and man-made, which affect the ponds, their water quality and the animals that depend on it.

The ponds get covered with algae in the summer, and sometimes fish die, but the causes aren't obvious. Only when people visit the ponds and begin to care about them, will they ask questions like: Where is this water coming from? Is it clean? Is it good for the fish? Is it causing algae? Is there some way I can help? The neighborhoods surrounding the ponds can play a vital role in improving the ponds' health, but first they need a reason to care. Through a holistic approach to improving the ponds health, places can be made which benefit the ponds, the wildlife that depends on them and the people who surround them.

state of the watersheds

East Goshen Township is divided between the East Branch Chester Creek and Ridley Creek watersheds. Each creek has watershed wide issues which sometimes manifest themselves at East Goshen's pond sites. Every pond in the study is connected to a creek, whether as a headwater pond from which a tributary flows, or as a collection point

along the stream. This means that the state of the ponds and the state of the creeks will forever affect one another.

The Pennsylvania Department of Environmental Protection (DEP) has classified all streams in East Goshen as impaired, due to **siltation**, **water flow variability** or unknown reasons. All tributaries of the East Branch Chester Creek are additionally impaired due to **other habitat alterations**. The Chester County Water Resource Authority (CCWRA) has produced a series of maps available on their website, depicting these classifications. *(See Appendix 2 for relevant maps.)* DEP defines these impairments as follows:

- ***Siltation*** – Aggradations of "clean" sediments or soils in excess of what the stream channel can transport. Results in smothering of habitat for macro invertebrates and fishes.
- ***Water/Flow Variability*** – Changes in hydrologic regime caused by water releases, increased surface runoff from impervious surfaces during storm events, scouring and drought results in unstable environment for macro invertebrates and fishes. Habitat alterations include stream widening, substrate paving, shallower pools,etc .
- ***Other Habitat Alterations*** – Habitat changes due to severe bank erosion, removal or lack of riparian vegetation, and concrete channels and streambeds.

These three impairments demonstrate that the connected streams face some of the same issues as the ponds, namely siltation and a high degree of sediment. Additionally, the fact that the streams are not listed as impaired due to any nutrient or chemical load, shows that any nutrient or chemical issues in the ponds are localized, and not the result of flowing in from the surrounding streams.

surrounding development, erosion, and sedimentation

Streams throughout the state have been overwhelmed with stormwater, leading to degradation, erosion, siltation and water flow variability. The ponds in this study are being similarly affected. Five of the ponds are fed by inlets and pipes, which convey stormwater directly from the Township streets into the ponds. The Hershey's Mill Pond is the only one which does not have a direct input from an inlet. However, the stream which feeds the pond does accept stormwater through a number of inlets on Tanglewood and Millstream Drives. With the stormwater comes sediment and chemicals, washed off the streets and neighboring residential properties.

The amount of impervious surfaces including roofs, driveways, sidewalks and streets, appears typical of most suburban communities, but generates more stormwater runoff than the streams and ponds can handle. The hydrologic cycle has been thrown out of balance. In a heavy storm, large amounts of water flow powerfully through the pipes and inlets. When they reach the streams and ponds, the force of the water erodes the banks and channel. The eroded material, sediment, drops out of the water and settles when the water slows down as it reaches the ponds. Over time, enough sediment fills the ponds to reduce their

Area streams are typically eroded, due to high stormwater volumes, which carry sediment into the ponds.

Wide streets, rooftops, driveways and other impervious surfaces create runoff, which increases flow into the stormwater system.

holding capacities, thereby making them shallower and affecting the pond ecology.

chemical testing results

Brandywine Science Center tested the water from each of the six ponds for each of the following:

- Dissolved Oxygen
- Nitrogen – in the form of Nitrate, Nitrite and Ammonia
- pH
- Phosphorous
- Fecal Coliform

The results were then compared to the standards set forth by Penn State Extension, in their web publication titled, "Water Quality Concerns for Ponds" *(see Appendix 1 for details)*. The standards are established differently for each potential use of a pond. For the purpose of this study, the standards set forth for ponds being used for "Beauty" and "Fishing" were utilized. The ponds support populations of bass, sunfish, catfish and carp.

The chemical test results showed that every pond failed to meet acceptable standards for at least one category. Every pond showed higher than preferred phosphorous levels for pond beauty. Bow Tree Pond 1 had less dissolved oxygen than acceptable for pond beauty. A number of ponds showed too much nitrogen, in various forms, for fishing. The full chemical test results produced by Brandywine Science Center are included as an appendix to this report. Additional details are included in the pond profiles included later in this report.

Penn State Extension recommends testing pond water at least on an annual basis. Where bacteria levels are found to be high, the Township may wish to test more frequently, to confirm initial results, measure the effectiveness of improvement strategies, and to identify seasonal fluctuations.

Geese frequent lawn areas surrounding the ponds, leaving their waste, which contributes nutrients into the ponds and makes the surroundings unpleasant.

meaning of the results

In some cases, the results of chemical testing show us the presence or amount of a certain chemical or bacteria, which is unhealthy, and may require some action to eliminate it. But in other cases, the results of the chemical tests provide clues as to why certain things are happening in the ponds. For instance, the presence of phosphorous or nitrogen in the water is not in itself a problem. Phosphorous and nitrogen are in fertilizers we use to grow food and in soap which we put on our bodies. But high quantities of these chemicals can start chain reactions which result in many of the problems we see in the ponds.

phosphorous, nitrogen and algae

"A shallow, nutrient rich pond, exposed to sunlight with little water flowing through it will be teeming with algae and aquatic plants," according to "Pond Ecology," an article posted online by the Penn State Extension. Every pond tested showed high levels of phosphorous, a nutrient known to encourage algae growth. Additionally, four ponds showed Nitrogen levels, in various forms, which could be detrimental to fish or pond aesthetics. Phosphorous and nitrogen can travel on soil particles in sediment. They also come from animal waste and decomposing plant material. Many fertilizers used in commercial and residential settings also contain phosphorous and nitrogen and can wash into the neighboring ponds and streams with stormwater.

The ponds in East Goshen are largely surrounded by grass lawns, which are preferred by Canada geese. The combination of goose waste and grass clippings adjacent to the ponds is likely contributing to the phosphorous levels in the water. Additionally, sediment washing into the ponds may also carry phosphorous. These factors are all likely contributing heavily to the algae growth in the ponds.

warm water and dissolved oxygen

Dissolved oxygen is an important component of water quality. Fish need dissolved oxygen to breathe and aerobic bacteria, which play a crucial role in breaking down waste materials, also depend on it. Ponds with consistently moving water tend to have higher levels of dissolved oxygen. Dissolved oxygen is also incorporated into ponds through photosynthesis conducted by aquatic plants. Cooler water also tends to hold more dissolved oxygen than warmer water.

The Marydell and Bow Tree 1 ponds each had low levels of dissolved oxygen. At Bow Tree 1, oxygen levels were low enough to affect the aesthetics at the pond, as well as fish communities. At Marydell, dissolved oxygen levels were high enough to support good aesthetics, but not high enough to adequately support trout and bass communities. These ponds do not feature aerators. Hershey's Mill also does not feature an aerator, but had adequate dissolved oxygen levels, likely due to the running water which flows continuously in and out of the pond through the connected stream.

When ponds have low levels of dissolved oxygen, fish can't breathe and die.

general recommendations

The results of the chemical tests combined with the results of Toth Bros. field analysis, reveals three important steps to improve the health and beauty of the ponds:

- Reduce Phosphorous and Nitrogen Levels
- Increase Dissolved Oxygen Levels
- Reduce Sediment Levels

A number of measures can be implemented to take these steps. Some are as simple as planting trees and changing mowing schedules, while others, such as installing forebays, will require additional engineering and further study. Friends groups or similar community organizations could be created to assist the Township in implementing these recommendations.

reduce phosphorous and nitrogen

There are three main approaches which can be taken to reduce the amount of phosphorous and nitrogen entering the ponds. All are relatively simple and straightforward. These include the installation of vegetated buffers, reduction in use of fertilizers and other chemicals and reduction of the goose population.

implement vegetated buffers

Most of the ponds are bordered on at least one side by areas of mown grass, with little tree, shrub or herbaceous plant material nearby. Mowed grass provides a relatively unimpeded course for stormwater to flow into a pond, wetland or stream. This stormwater, flowing quickly over turfgrass, carries with it sediment, grass clippings, animal waste and any chemicals, such as fertilizers, which may have been applied in the area. All of these bring phosphorous and nitrogen into the waterway.

Vegetated buffers made up of trees, shrubs and more hardy herbaceous materials would help to filter nutrients out before reaching the ponds. *(See Appendix 2 for planting list.)* When water flows over turf grass, it is able to flow quickly. The short and narrow grass blades do little to slow

the water. Additionally, soil under turf grass is typically very compacted, as turf has shallow roots which do not keep the soil loose and aerated. Therefore, the water is able to flow quickly through the turfgrass over the hard soil. This fast moving water is able to carry sediment and flow into the ponds.

The addition of vegetated buffers would go a long way towards protecting the ponds. Trees, shrubs and herbaceous materials such as meadow grasses and perennials keep the soil healthier and act as physical barriers. When water, carrying the nutrients towards the ponds, encounters a vegetated buffer, it is slowed down. As the water slows down, it is forced to drop its sediment and nutrient load before reaching the pond. Additionally, as the water slows down, it has a better chance to infiltrate directly into the soil, before ever reaching the pond. Infiltrating more stormwater into the ground helps protect not only the ponds, but also the streams they are connected to, by reducing the amount of stormwater that enters them. Too much stormwater is causing the watershed wide degradation of streams, leading to sedimentation and siltation. Additionally, measures which encourage infiltration may help East Goshen Township meet state mandated MS4 requirements.

The Township could establish buffers by seeding the turfgrass areas with meadow seed mixes and planting additional trees and shrubs. Alternatively, but less effectively, the Township could simply reduce the mowing frequency of the turfgrass, allowing it to grow taller and thicker. Mowing could be done just once or twice a year, to eliminate woody plants, vines and other invasive plant species. When the grass is mowed, the clippings should be collected, so as not to be allowed to wash into the ponds. Most current buffer ordinances require vegetated buffers on areas within 100–150 feet of the banks of ponds, streams or wetlands. A similar width would be appropriate for East Goshen's ponds.

Buffer plantings at the edges of the ponds would help to stabilize the banks, shade the water and filter and absorb stormwater flowing into the ponds.

limit the introduction of soaps, fertilizer and other chemicals

Fertilizers and other products, including soap, can contain phosphorous and nitrogen as main ingredients. While fertilizers help lawns and landscape plants grow, they are detrimental to pond health. Where stormwater flows over lawns and landscaped areas, it can pick up fertilizers, and other chemicals, and carry them into the ponds. While it does not appear that the Township uses fertilizers in close vicinity to the ponds, neighboring residents may. The Township should further inform nearby residents as to the damage that fertilizers can do, as they can encourage the growth of algae by adding nutrients to the water.

Many car washing soaps also contain phosphates. So when a resident washes their car in their driveway, or on the street, these soap phosphates drain to an inlet and eventually reach a stream or pond. The phosphates then promote the growth of algae. Residents should be encouraged to use biodegradable, phosphate free soaps, wash their cars on pervious surfaces such as grass or visit a commercial car wash, which are regulated and required to drain the used water to a water treatment plant, rather than into our streams.

Swimming pool water can also contain phosphates. It is illegal in Pennsylvania to drain a pool to a storm sewer system. Residents should be reminded to always drain their pools in accordance with local and state regulations.

reduce the goose populations

Waste from geese and other animals can contribute to the nutrient loads in the ponds. Aside from that, their waste can make an open space unenjoyable for residents who don't want to walk through it. Additionally, the geese themselves can be unfriendly and discourage people from using the open space. Goose management is an issue municipalities throughout the area are dealing with. Measures to control populations include addling eggs, dispatching dogs and placing silhouettes or other decoys of predators.

These measures may work to some degree. However, in Natural Lands' experience, we find the best way to discourage geese is to remove their habitat. Geese like open, mowed grass areas, as they easily detect predators. At our preserves, we strive to eliminate grass areas, for many reasons. We have largely eliminated geese from our preserves simply by eliminating their habitats. Meadows and other vegetation, as described above, provide the dual benefit of filtering water and eliminating goose habitat. Eliminating grass areas will reduce the goose populations, leading to less waste in the ponds and in the surrounding neighborhoods. *(See "From Mowing to Meadows" in Appendix 2.)*

Two of the ponds tested, Hersheys Mill and Marydell, also showed higher concentrations of fecal coliform. This could be due to large amounts of goose waste, or other animal waste, finding its way into the water system. The Township may wish to monitor this result through ongoing testing. Should the goose population be reduced, but the fecal coliform measurements remain high, it could be an indication of a sewage leak in close proximity to the stormwater system or the ponds.

increase dissolved oxygen

Dissolved oxygen is an important component of the overall health of the ponds. The testing performed by Brandywine Science Center revealed that Bow Tree Pond 1 has insufficient dissolved oxygen for beauty and for fishing. Marydell Pond has insufficient levels of dissolved oxygen for fishing. Dissolved oxygen is not a problem in most of the ponds, as aerators or stream flow keep the water moving, which dissolves more oxygen into it. Below, the report describes relatively simple ways to increase dissolved oxygen.

Over the past few decades, its been determined that conventional basins are ineffective in managing stormwater, leading to degradation of area streams.

provide shade over the water

Previous sections of this report described the filtering and infiltration benefits of vegetated buffers. By planting trees as part of these buffers, close to the pond edges, they can also potentially increase the amount of dissolved oxygen that the water can hold. Cooler water can hold more dissolved oxygen than warmer water. Planting large tree species, such as oaks and maples near the shorelines will provide shade to cool the water.

decrease plant and animal waste

Plant and animal waste can increase nutrient levels in ponds, as already described in this report, but it can also cause the elimination of dissolved oxygen. Aerobic bacteria act in the process of breaking down and decomposing plant and animal waste. An abundance of this waste can lead to an abundance of the bacteria, which will exhaust the supply of oxygen. Low levels of dissolved oxygen can lead to fish kills and algae growth. Recommendations for reducing the goose populations and the amount of plant waste through changes in mowing regimes and plant types have been described previously in this report. The same recommendations can help increase dissolved oxygen.

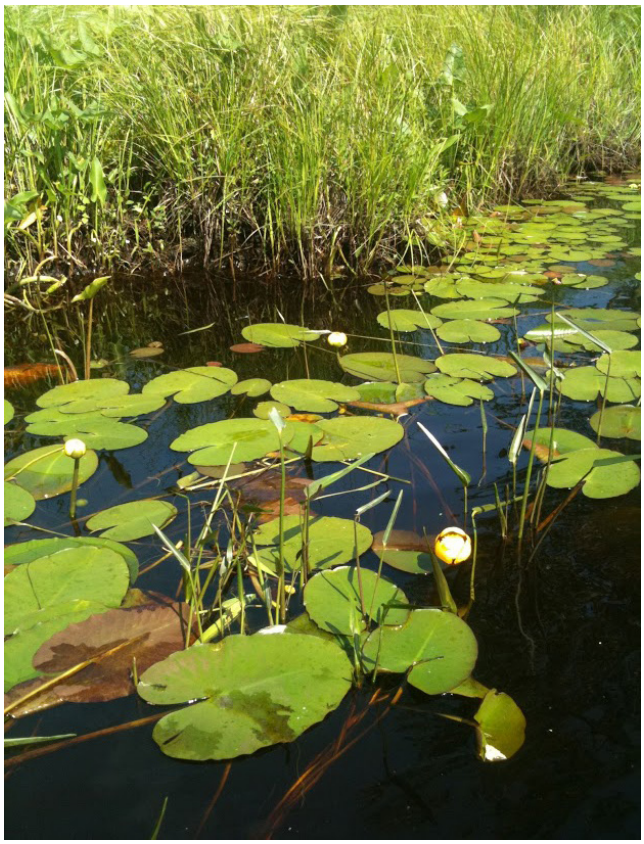
install aquatic plants

As aquatic plants "breathe", they process carbon dioxide and produce oxygen. This oxygen is released into the water. The ponds currently have very few aquatic plants. More aquatic plants of diverse, native species, could be introduced to the ponds at their edges, through bench plantings. *(See Appendix 2 for planting list.)* Sediment from within the ponds could be regraded to create a shallow "bench," a gradually sloped ramp down into the pond. Aquatic plants could be planted on the bench. The plants would help to clean and filter the pond water, while providing habitat and food sources for other aquatic species, while, most importantly, providing more dissolved oxygen. Additionally, benches could make the ponds safer, as they would eliminate any steep drop-offs from the pond banks into the water.

Coverage of approximately 40–60% of the pond surface with aquatic plants would be ideal for shading the water and introducing additional dissolved oxygen. This ratio of aquatic plants would lead to a balanced population of algae, rather than complete algae coverage as happens now. Additionally, aquatic plants at this ratio would help reduce phosphates, likely to 0% during the growing season, as they would utilize and process the nutrients.

install aeration systems

The Pin Oaks Pond and Bow Tree 2 & 3 Pond each feature aeration systems, which contribute to the health and beauty of the ponds. The aerators keep water in motion, which makes it harder for algae to get established. More importantly, they incorporate more dissolved oxygen into the water, which helps keep healthy levels of bacteria which break down nutrients and waste. Fish rely on dissolved oxygen to breath, and they die off when not enough dissolved oxygen is present. After dredging, to a minimum depth of four feet, aerators should be considered for installation at Bow Tree 1 Pond, the Bow Tree 2 & 3 Basin and Marydell Pond.



Aquatic plants can provide habitat and shade, compete with algae, and increase levels of dissolved oxygen.

Further study and consultation with a pond maintenance professional will be required to install an aeration system, but some labor can be carried out by the Township staff. A system of aerators would consist of grids of pipe which rest on the bottom of the ponds, fed with air through hoses from a compressor in a cabinet on land. Electricity would also need to be extended to the cabinet. The compressor sends air to the grids, which then allows the air to bubble out, creating a column of oxygen, which mixes with the water and helps keep the water circulating horizontally and vertically.

Aeration systems can be installed when the ponds are full, using boats and cables, or they can be coordinated with dredging, and installed more easily when the ponds are dry. Township staff can likely install one aeration system with assistance from a consultant, and then install additional systems on their own. The Pentair Aquatics 4GL54-230 system would be appropriate for the ponds. The system is designed to serve ponds with a surface up to ¾ of an acre, but multiple systems can be installed to handle larger ponds *(see Appendix 2)*.

reduce sediment levels

Sediment is entering the ponds in two ways—through direct sheet flow into the ponds off of the surrounding land, and through stormwater flowing through pipes into the ponds. There is already too much sediment in four of the ponds, while the other two will need to be addressed in the near future. Therefore, the methods for reducing sediment address elimination of the sediment already in the ponds, and reducing the amount of sediment which enters in the future.

dredge the ponds as necessary

Toth Brothers Clearing and Dredging, Inc. "floated" each of the ponds. Using a small boat, Mike Toth entered each pond, and using a variety of instruments, measured the pond depths and depth of sediment. Additionally, he inspected the associated structures and visually assessed other attributes of each pond. Considering the existing conditions of stormwater management throughout the

watersheds, it appears that dredging will remain part of ongoing maintenance well into the future. Maintaining a proper pond depth is an important factor of pond health. Most of the ponds are filling with sediment, which can add nutrients and contribute to warming of the water, which encourages growth of algae. Dredging is an important aspect of pond maintenance now, but we believe that recommendations in this plan can lessen the frequency or amount of necessary dredging in the future.

Toth Brothers found that four of the ponds are in need of dredging in the very near future. These are Hershey's Mill, Marydell, Bow Tree Farm Pond 1 and Bow Tree 2 & 3 Pond. The remaining two ponds, Bow Tree 2 & 3 Basin and the Pin Oak Pond, can wait to be dredged and/or reassessed in five years. In addition to dredging, Toth Bros also found a number of structural issues which should be addressed. These issues are described further in the pond profiles later in the report. Additionally, Toth Bros. full reports are included in the appendix to this document.

install forebays

Forebays are smaller ponds or catchment areas which filter sediment out of water as it enters a larger body. Forebays are typically planted with wet tolerant or aquatic plant species and constructed from rock or earth. As water flows out of a pipe, into a pond or basin, it first flows into the forebay. The water hits the rocks and plants, slows down and drops the sediment there, before entering the pond. Installation of forebays would reduce the amount of sediment which reaches the ponds. As nitrogen and phosphorous can cling to sediment, they too would be reduced. *(See Appendix 2 for details.)*

Not all of the ponds and basins would be suitable to be retrofit with a forebay. It appears that forebays may be appropriate for use at Marydell, Pin Oak and Bow Tree 1, as these ponds all take on a great deal of sediment and receive heavy storm water flows. Bow Tree 2 & 3 Pond and Basin are in good shape and are functioning well without forebays. Hershey's Mill Pond is fed by a stream which flows through the pond and out over the dam. This stream should not be modified with a forebay, as it is in generally good shape.

Forebay design would require additional study and engineered design. Forebays would not eliminate sediment from the system, but would capture it and keep in one section of the existing pond. This would make it easier to remove the sediment as it builds up. Sediment could then be removed more often, but from a smaller area of the ponds. This could mean that the sediment could be removed more cheaply, with simpler equipment such as a vacuum truck, rather than entering the pond with heavy equipment.

implement vegetated buffers

Vegetated buffers were previously described at length in the section regarding reduction of phosphorous and nitrogen. While buffers help to eliminate nutrients, they

Where stormwater flows uncontrolled over mowed lawn, it creates channels, erodes the soil, and carries sediment downstream, into ponds and basins.

Vacuum trucks can be used to clean out ponds where sediment is more localized in forebays. This can be a less costly option than dredging.

are also effective at filtering out sediment and stabilizing shorelines and streambanks. Buffers should be installed along pond banks where they can intercept sheet flow. Trees and shrubs should also be planted where channelized water flows through the landscape and into the ponds. In these situations, the roots of the trees and shrubs will help stabilize the channels and hold the soil in place, rather than allowing it to be carried into the ponds. *(See Appendix 2 for planting list.)*

inlet filter bags

Much of the sediment entering the ponds comes directly from water piped through inlets along the Township streets. Therefore, protecting the inlets and keeping sediment from ever getting into the stormwater system would benefit the ponds. The PA DEP Erosion and Sediment Pollution Control Program Manual lists inlet filter bags as an effective sediment barrier. However, they should only be used where an inlet has a ¼-acre maximum drainage area. They also need to be inspected on a weekly basis and after each runoff event and need to be cleaned out when they are half full. Inlet filter bags require more annual care, but may reduce the frequency and cost of dredging. *(See Appendix 2 for details.)*

Due to the quantity of inlets feeding the ponds, inlet filter bags should be used strategically. The township could install them at the inlets feeding Pin Oak, Hershey's Mill, or both, as there are only 13 inlets between them. This small number of filter bags could likely be managed by Township staff, who could also track their time spent maintaining them. The Township could then determine whether to expand use of inlet filter bags by measuring the amounts of silt captured in the bags and continuing to test the pond water quality.

rain gardens and rain barrels

Sediments and chemicals are carried to the ponds with stormwater. By capturing stormwater and infiltrating it in place or collecting it for reuse, homeowners can do their part to keep the ponds healthy. Residential properties are the primary producers of stormwater, as roofs, driveways and turf grass all generate runoff during storms. This is the water which eventually carries sediment, chemicals and nutrients to the ponds. Rain gardens on private properties can help to capture water and infiltrate it into the ground, rather than allowing it to drain to pipes. *(See Appendix 2 for details.)* Rain gardens can also benefit native pollinators, birds and small mammals, by providing food sources and habitat. Rain barrels can also help protect ponds. By draining roof drains into barrels, the water can be collected for garden use before it reaches the inlets. When this collected water is used in the garden in smaller quantities at a time, it can infiltrate into the ground, watering plants and recharging ground water supplies.

Rain gardens provide habitat and food for native birds, mammals, bees and butterflies, and capture stormwater and infiltrate it into the ground.

Rain barrels capture stormwater running off of roofs, keeping it out of the stormwater system. This water can be used to water gardens.

friends groups and community organizations

The citizens of East Goshen have demonstrated that they care about the future of the ponds, by attending the series of public meetings as part of the planning process. They stood up and spoke of how much they enjoy having the ponds. Many of them also expressed an interest in helping the situation however they can, whether through planting rain gardens on their properties, or by volunteering. An opportunity exists to rally the residents together to take action to improve the ponds.

It is important to connect the residents to the ponds, for them to see the effects of the surroundings on the water quality. Friends groups dedicated to each pond, or organized by community would help to keep the neighbors connected. More importantly, they could empower the citizens to make positive change at the ponds, by working alongside with the Township, as partners. Friends groups could take some of the workload off the Township and the Conservancy Board, and could also strengthen the communities, by bringing neighbors together and by giving them ownership of their community spaces.

The Conservancy Board could work with the Township staff, including the Parks and Recreation Director, to create friends groups for each pond or community. They may wish to refer to the Philadelphia Park Friends Group Toolkit, a 48-page guide to establishing friends groups, available on the Philadelphia Parks and Recreation website (**www.phila.gov/ParksandRecreation/getinvolved**).

pond profiles

The six ponds face many of the same issues. All of them tested high for phosphorous. All of them are receiving too much sediment and need to be dredged immediately or likely within the next 5 to 10 years. Many of them have low levels of dissolved oxygen, making it difficult to support fish communities and contributing to algae problems. However, each pond sits within its own landscape and is affected differently by its surroundings. Therefore, each pond requires a different approach to improvement. Strategies for improving each pond are outlined below in the individual pond profiles.

The ponds in East Goshen provide beauty and recreational opportunities to the surrounding neighborhoods.

Hershey's Mill Estates

Uses: Beauty

Approximate Surface Area: 0.30 acres

Parcel Size: 1.22 acres

Inlets: 2 – Tanglewood Drive
2 – Millstream Drive
1 – Bell Flower Lane

Outlets: One stream flow over regulated dam

Watershed: Ridley Creek

Headwater Location: King Road, West of Frazier Road, East Whiteland Township

Drainage Area: 243 acres

Depth of Water: 6 inches

Aerators: None

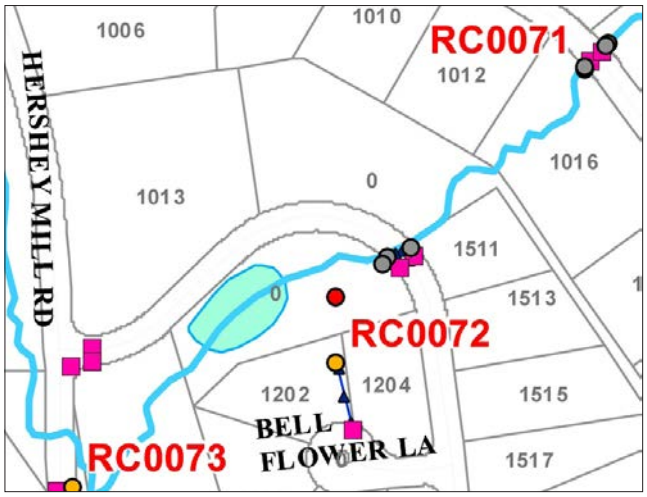
Notable Chemical Testing Results: High Phosphorous and Nitrogen (Ammonia-N and Nitrate-N)

Hershey's Mill Pond Watershed

general description

The Hershey's Mill Pond is located on Tanglewood Drive, near the intersection with Hershey Mill Road, on a 1.22-acre parcel. The pond is fed by an Unnamed Tributary to the Ridley Creek, which flows directly through the pond. No inlets feed the pond. However, a number of inlets feed the stream upstream of the pond. The stream also flows though the Lockwood homeowners association open space, where it may be connected the pond/basin there. It is unclear, but an upstream farm and apartment complex could also be contributing stormwater to the creek.

Where the stream enters the pond, it flows through healthy woodland, which is providing buffering, cooling the streamwater and stabilizing the streambanks. Approximately ¾ of the pond's banks are surrounded by forest. The remaining bank features some mature trees and mowed grass. This bank separates the pond from Tanglewood Drive.



Hershey's Mill Pond stormwater management system consists of five inlets (pink squares) which convey stormwater to the pond. CREDIT: East Goshen Township

The Hershey's Mill pond is quite full of sediment, with an average depth of water of only 6 inches. As the pond sits on a small parcel, with little mowed grass around it and is relatively well buffered, it appears likely that most of the pond's issues are being caused by upstream conditions.

strategies for improvement

dredging

The pond is full of sediment and has a very shallow depth of water. It is unclear whether the pond can accommodate adequate stormwater in a major storm event. It is likely that the upstream forest is acting as a floodplain for the stream in these situations and absorbing some stormwater. **Per Toth Bros. findings and recommendations, this pond should be dredged in the very near future.**

The stream feeding the Hershey's Mill Pond is well shaded and appears relatively healthy.

inlet filter bags

As it appears that most of the sediment entering the pond is coming from offsite, it is imperative to capture this sediment before it enters the stormwater system. Inlet filter bags should be considered for use in the five inlets in Tanglewood and Millstream Drives and Bell Flower Lane, which feed the stream. These could be installed as a pilot project, to determine whether the bags provide enough impact in light of the time required to maintain them.

stream buffer plantings with partners

Where the stream flows through land owned by East Goshen Township, it is well buffered. However, upstream of the pond, the stream flows through private residential properties, and land owned by the Lockwood Community Association and the Convent of the Servants of the Immaculate Heart of Mary. Aerial photography of these properties shows gaps in forest cover along the stream here. It may be that the stream is eroding the banks in these areas and carrying the sediment downstream to the pond. There could also be sheet flow off neighboring properties carrying sediment and nutrients downstream into the pond. **East Goshen Township should work with these neighbors to educate them about the effects of stormwater on the streams and ponds, and work with them to plant trees and install other better management practices on their own properties.**

The grass area near the pond attracts geese and could be planted with trees and shrubs.

rain gardens and rain barrels

The residents upstream could do their part by reducing the amount of water entering the stormwater system by installing rain gardens and rain barrels. Lower volumes of water entering the stream would also reduce the amount of sediment and nutrients entering the pond.

pond edge tree and shrub plantings

The pond is well buffered on three sides by forest. A few large trees exist along Tanglewood Drive. However, there are gaps where additional trees and shrubs could be planted to provide shade and cover for fish and help keep the water cool. Shrub plantings would also reduce the area to be mowed, thereby reducing the chance for grass clippings to enter the pond and increase nutrient levels.

conclusion

Upstream conditions appear to be the major cause of the issues in this pond. The pond should be dredged to return it to its designed/intended condition. Then upstream mitigation measures, including buffer plantings, inlet filter bags, rain gardens, rain barrels and other BMPs, should be implemented to reduce sediment loads. Finally, additional vegetation should be planted around the pond edges to beautify, provide fish habitat and reduce nutrient levels.

The Hershey's Mill Pond adds beauty to the neighborhood entrance road.


Hershey's Mill Pond
TANGLEWOOD DRIVE
BELL FLOWER LN
HERSHEY MILL ROAD
dredge
tree and shrub plantings on bank
Unnamed Tributary to Ridley Creek
Contours (2ft interval)
Waterways
Municipal Boundaries
Parcel boundaries
Natural Lands
1031 Palmers Mill Road, Media, PA 19063
610-353-5587 | natlands.org
N
Feet
0
40
80

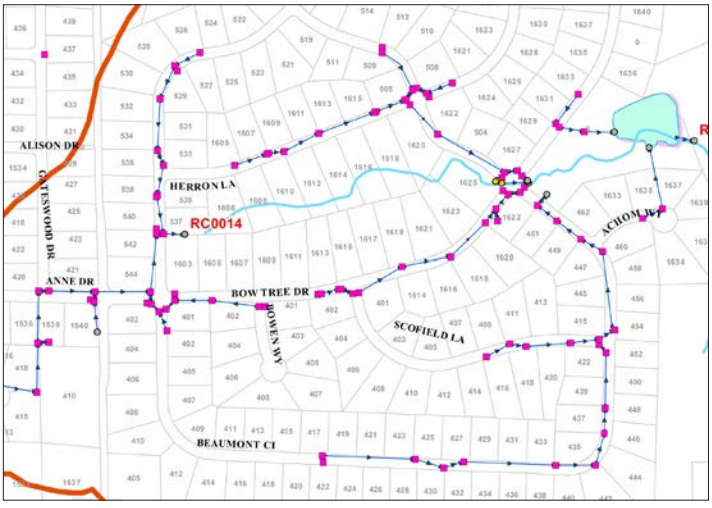
Bow Tree 1 Pond

Uses:	Beauty and Potentially Fishing/Habitat
Approximate Surface Area:	1.37 acres
Parcel Size:	6 acres (connected downstream to 42-acre open space)
Inlets:	96 (±)
Outlets:	Two 5-foot diameter concrete structures
Watershed:	Ridley Creek
Headwater Location:	537 Beaumont Circle
Drainage Area:	Less than 10 acres
Depth of Water:	Varies 4 inches to 2 feet
Aerators:	None
Notable Chemical Testing Results:	Phosphorous, Nitrogen (Ammonia-N) and Low Dissolved Oxygen

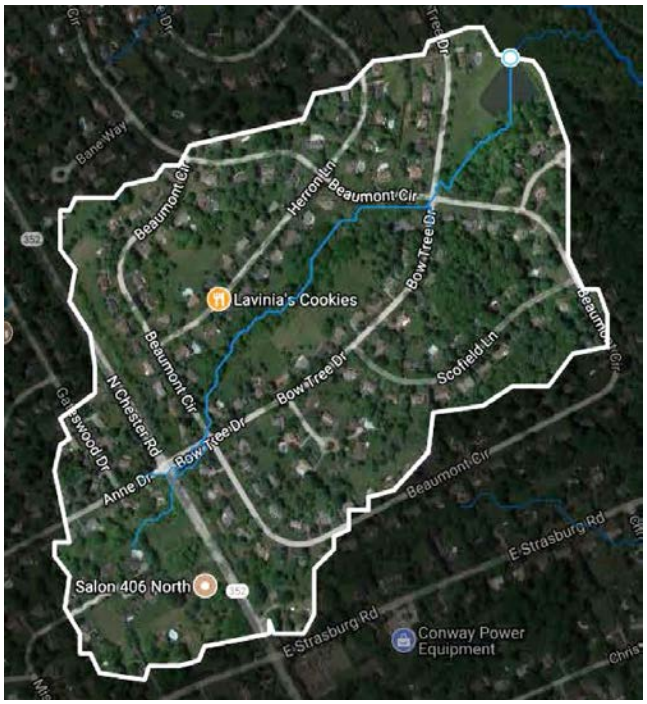
general description

The Bow Tree 1 Pond is the primary stormwater management area for the Bow Tree 1 development. It is fed by an unnamed tributary to the Ridley Creek, with its headwaters within the development, at 537 Beaumont Circle and 1606 Herron Lane. The pond and tributary collect stormwater through no fewer than 96 inlets spread throughout the development.

The pond sits mostly within a 6-acre open space parcel which fronts on Bow Tree Drive. It is surrounded by private lots on two sides and connects to a larger open space parcel which contains the tributary as it flows out of the pond. Much of the south side of the pond is buffers by woodlands. The remaining three sides are surrounded by large swaths of mown lawn on steep slopes, sloping down to the pond.



The Bow Tree 1 Pond is fed by 96 inlets (pink squares).
CREDIT: East Goshen Township



Bow Tree 1 Pond Watershed

strategies for improvement

dredging

With a variable depth between 4 inches and 2 feet, the pond has accumulated a great deal of sediment. The sediment has likely come from the steep slopes of mown grass surrounding the pond as well as with water conveyed through the stormwater system. **Per Toth Bros. recommendations, this pond should be dredged in the near future.** The dredged spoils can be spread on the surrounding hillside. However, without additional plantings, the spoils could ultimately be washed back into the pond over time.

aerator system

Installation of an aeration system would help to increase dissolved oxygen levels. The pond surface is currently approximately 1.37 acres. At this size, two aeration systems would be necessary. Should the Township also install a forebay, it may be possible to reduce the pond surface area in need of aeration, as forebays do not need to be aerated. **Aeration would only be recommended if the pond is first dredged to a minimum depth of 4 feet.**

forebay

Ninety-six inlets feed the two pipes and one tributary which lead into the pond. These three stormwater sources all enter the pond on the south bank. A large forebay could potentially be constructed which would capture water flowing in from all three sources. A forebay could collect sediment in a portion of the pond, rather than allowing it to spread across the entire pond. Ongoing sediment removal, through dredging or vacuuming could then be focused on a smaller area.

upstream BMPs and education

With over 300 units contributing to the stormwater system in Bow Tree 1, education of the residents could make a difference in protecting the pond's health. Every resident who installs a rain barrel or rain garden can help to decrease the amount of sediment, water volume and nutrients which make their way into the pond. Every resident who chooses to take their car to a commercial car wash helps to keep phosphorous and other pollutants out of the ecosystem.

Sediment entering the pond through the stormwater system has collected and formed an island, complete with vegetation.

vegetated buffers

At the pond site, a shift in land management and the implementation of vegetated buffers would benefit the pond. The hillsides of mown grass are contributing sediment and nutrients to the ponds. There is very little shade over the water. The turf grass areas could be converted to meadows, which would require less frequent mowing and would keep grass clippings from washing into the pond. Additionally, deep rooted meadow plants will help stabilize the soil, reduce erosion and decrease the amount of sediment washing directly into the pond.

Additional trees would also help buffer the pond and stabilize the soil. Trees could also shade the water, cooling it down, which would help to increase the dissolved oxygen level. More trees could also make the open space a more appealing place to visit.

vegetated infiltration swale

A linear rain garden called a vegetated infiltration swale could also be implemented parallel to the edge of the pond. This swale would be designed to catch any stormwater which escapes the meadow uphill, before it reaches the basin. It would be planted with meadow grasses and flowering perennials. The water, captured in the swale, would keep nutrients, sediment and grass clippings from ever reaching the basin. It would also encourage the water to infiltrate directly into the ground, rather than entering the basin and the stream system. Soil and infiltration tests, and potentially an engineering study would be necessary to determine whether a vegetated infiltration swale would function here.

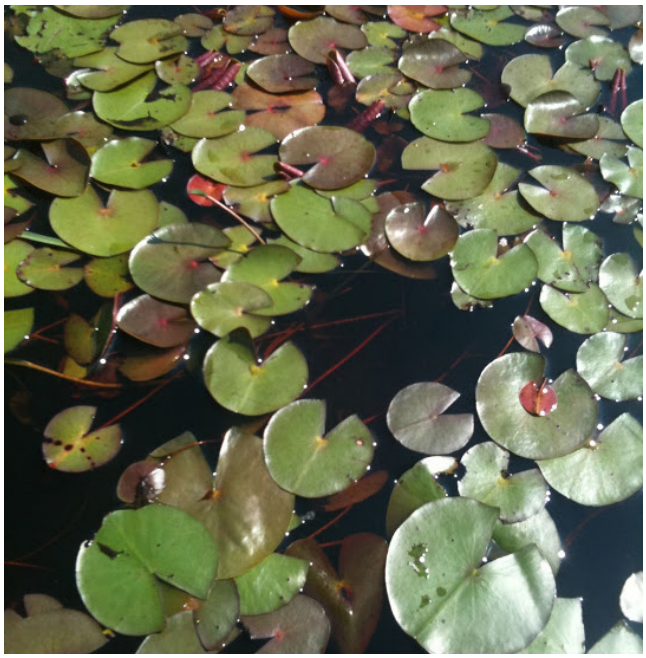
aquatic plants

Installation of aquatic plants would also benefit the pond by increasing the dissolved oxygen levels, shading the water and providing habitat for fish. Aquatic plants, covering approximately 40–60% of the water surface would also further beautify the pond and contribute to the aesthetic value of the open space.

conclusion

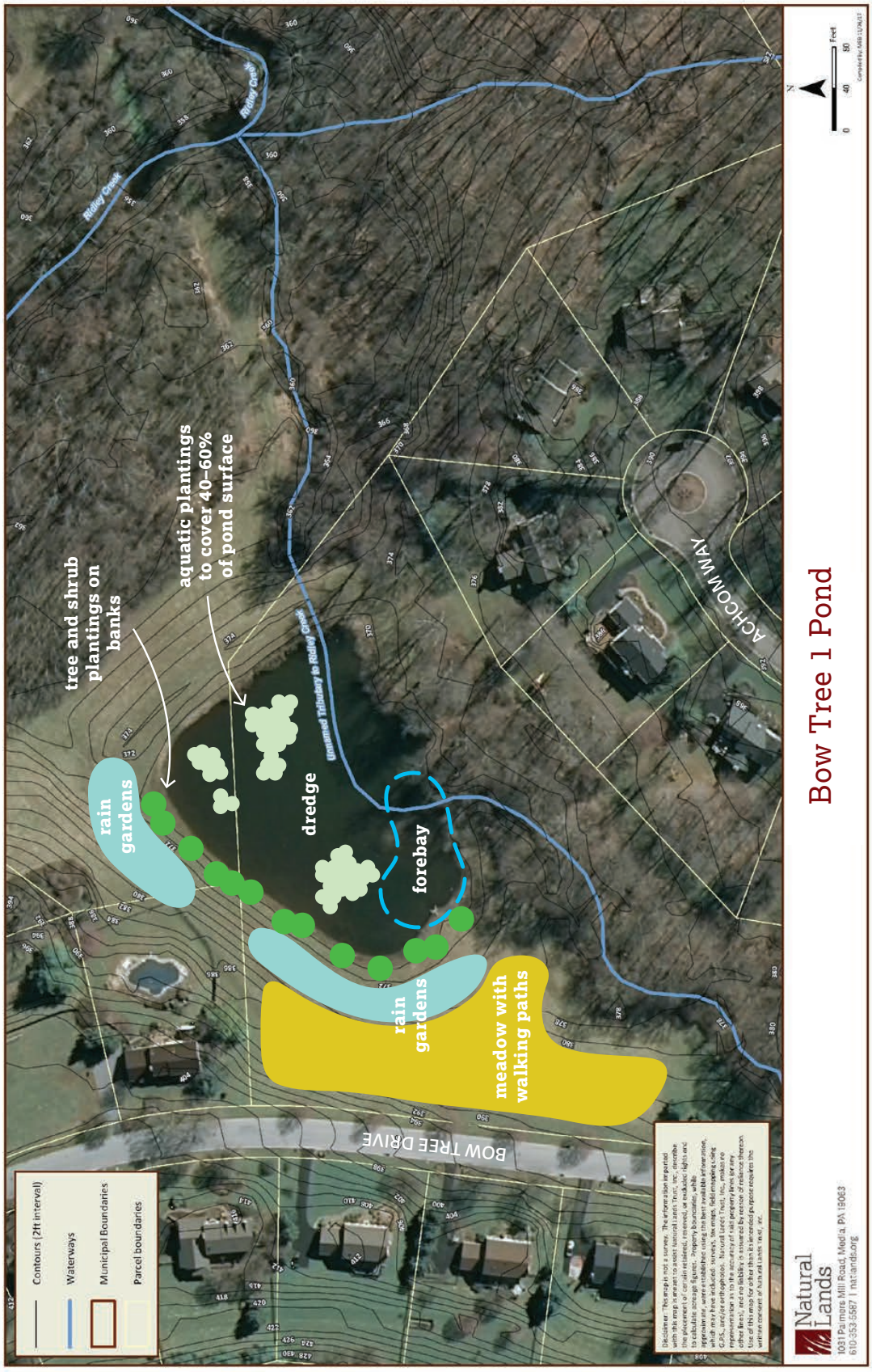
The future health of the Bow Tree 1 Pond is in the hands of the residents who surround it. The stormwater which leaves their streets and properties provides the water for the pond, but also the nutrients and sediments which are causing its problems. It is necessary to dredge the pond soon, and this pond will continue to require dredging into the future unless significant changes are made to the stormwater management upstream and immediately surrounding the pond.

Fortunately, the Bow Tree 1 Pond holds much greater potential than it currently utilizes. A rehabilitated pond could become the centerpiece of a reinvigorated passive open space park. Grass trails could be cut into a newly planted meadow, where birds nest and butterflies hunt for nectar. Trees could provide shade over benches and the pond could be the place to admire ducks, catch tadpoles or chase dragonflies. As the pond site connects to an additional 150 acres of township owned open space, it could become a hub or entrance to a larger trail system. Transforming the pond area into a cherished open space, which contributes to the lives of the residents, will help to make them care more about how their actions affect the pond and the creatures which live in it.



LEFT: Aquatic plants, such as lillies, can provide habitat, shade, and dissolved oxygen.

BELOW: Buffer plantings have grown around some edges of the pond, but more plantings would improve the pond's health.


Bow Tree 1 Pond
tree and shrub plantings on banks
aquatic plantings to cover 40–60% of pond surface
rain gardens
dredge
forebay
rain gardens
meadow with walking paths
BOW TREE DRIVE
ACHCOM WAY
Ridley Creek
Unnamed Tributary to Ridley Creek
Contours (2ft interval)
Waterways
Municipal Boundaries
Parcel boundaries
Natural Lands
1031 Palmers Mill Road, Media, PA 19063
610-353-5587 | natlands.org
Feet
0
40
80

Bow Tree 2 & 3 Pond

Uses: Beauty and Fish Habitat

Approximate Surface Area: 0.95 acres

Parcel Size: 47.4 acres (8 acres focus)

Inlets: 21

Outlets: 1 concrete channel emptying into Bow Tree 2 & 3 Basins

Watershed: Ridley Creek

Headwater Location: Inlets on Bow Tree Drive and Beaumont Circle

Drainage Area: 30 acres

Depth of Water: Average depth of 4 feet

Aerators: 5

Notable Chemical Testing Results: Phosphorous and Nitrogen (Ammonia-N)

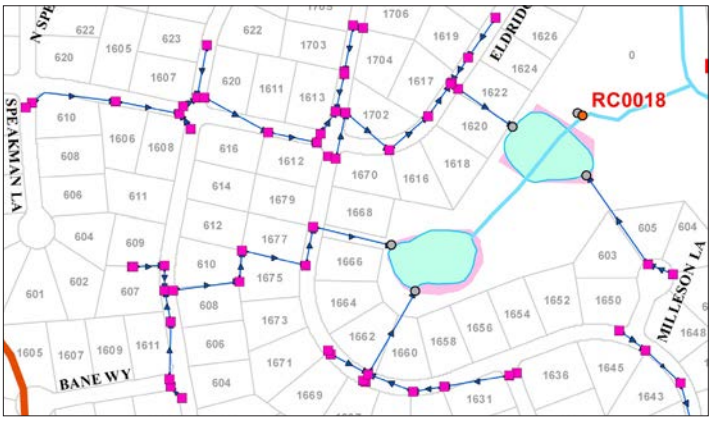
general description

The Bow Tree 2 & 3 Pond is in relatively good condition. It is fed by 21 inlets spread throughout the Bow Tree development, as well as sheet flow from surrounding residential properties and a steeply sloped hillside above. Water flows out of the pond into a concrete channel, which then feeds into the Bow Tree 2 & 3 Basin, and ultimately into the Ridley Creek. The pond is surrounded by backyards and has one access between homes on Bow Tree Drive.

The pond holds five aerators which keep the water moving and keep the dissolved oxygen at adequate levels. Nutrients, phosphorous and nitrogen (Ammonia-N) are high. This pond is also collecting sediment, but does not require immediate dredging.

The pond is surrounded mostly by mowed grass, but some edge vegetation and mature tree stands exist as well. The pond is at a low point in comparison to the surrounding homes' backyards. Stormwater is flowing from the backyards, over the mown areas and into the pond, likely

Bow Tree 2 & 3 Pond and Basin Watershed



Twenty-one inlets (pink squares) feed the Bow Tree 2 & 3 Pond, which then feeds the Basin. CREDIT: East Goshen Township

The five aerators at the Bow Tree 1 & 2 pond keep the water well oxygenated.

carrying grass clippings and nutrients with it. The property lines are in close proximity to the pond edges, as close as a few feet in some areas, making major site improvements on the Township owned land difficult.

strategies for improvement

dredging

Toth Bros. report states that they would not recommend dredging at this point and that they see this pond to be in good shape for the next five years. The pond is receiving sediment with the most impact likely coming from the inlets which feed it. The pond should be reassessed for dredging in 2022, at which point a more comprehensive effort could also be implemented around multiple improvement strategies.

mark property boundaries

When private spaces border public spaces, it is typical for residents to encroach on publicly owned property. This sometimes takes the form of placing buildings over property lines, but more often it is more subtle, like dumping grass clippings on Township property, or mowing beyond property lines. Should the Township wish to engage in any altered management of the land surrounding the pond and basin at Bow Tree 2 & 3, the property lines should be delineated with permanent markers and the Township should reach out the residents to explain why.

mowing to meadows

Most of the area surrounding the pond is too narrow for the installation of a meadow, which would help to slow down stormwater on its way to the ponds. However, the Township could simply mow the area less frequently, allowing the grass to grow taller and thicker. This would allow the grass to help slow and filter stormwater and also discourage geese. Mowing the area only once or twice a year would keep woody species, trees and shrubs, from establishing. *(See Appendix 2 for "From Mowing to Meadows.")*

rain gardens and rain barrels

The residents upstream could help in reducing the amount of water entering the stormwater system by installing rain gardens and rain barrels. Lower volumes of water entering the stream would also reduce the amount of sediment and nutrients entering the pond. The residents whose backyards surround the Bow Tree 2 & 3 Pond and Basin could install rain gardens along their rear property lines to catch the water flowing off of their properties and into the ponds. Rain gardens and rain barrels do require some maintenance. These measures are completely voluntary.

vegetated buffers

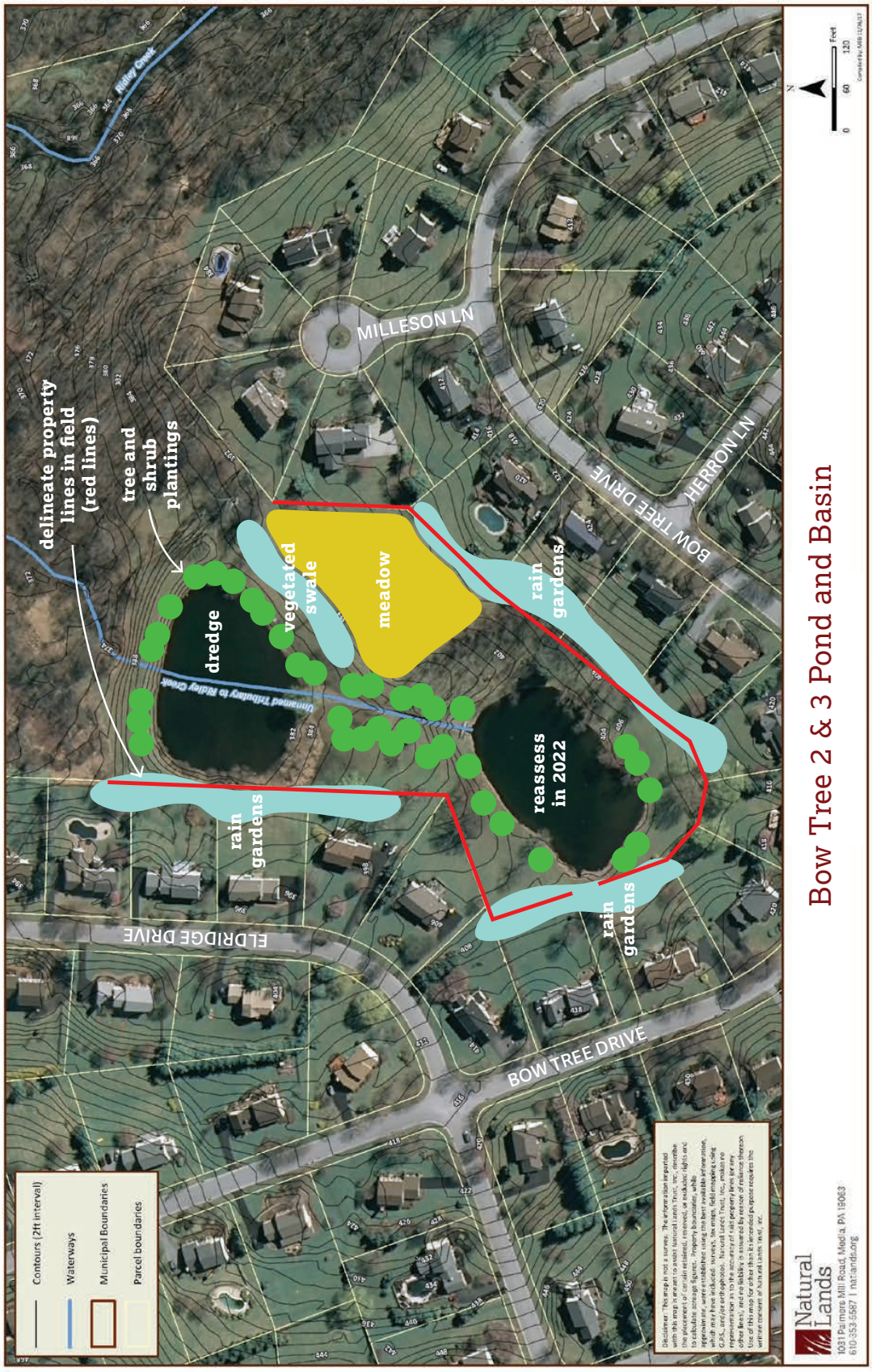
Additional trees would help buffer the pond and stabilize the soil. Trees could also shade the water, cooling it down, which would help to increase the dissolved oxygen level and make the water more suitable for some fish species. More trees could also make the open space a more appealing place to visit for the surrounding residents.

The grass areas around the pond attract geese, which leave their waste and add nutrients to the pond.

The concrete channel which connects the pond to the basin could benefit from tree and shrub plantings which would help to shade the water and keep it cool.

conclusion

The aerators in the Bow Tree 2 & 3 Pond are doing the majority of the work in keeping the pond from being covered over by algae. The pond is in relatively good condition and sediment levels are acceptable but should be reassessed in 2022. At that point, the Township should consider undertaking a more comprehensive approach to land management, education and stormwater infiltration as a means to improving the ongoing health of the pond.


Bow Tree 2 & 3 Pond and Basin
delineate property lines in field (red lines)
tree and shrub plantings
dredge
vegetated swale
meadow
rain gardens
reassess in 2022
rain gardens
rain gardens
MILLESON LN
BOW TREE DRIVE
HERRON LN
ELDRIDGE DRIVE
BOW TREE DRIVE
Unnamed Tributary to Ridley Creek
Ridley Creek
Contours (2ft interval)
Waterways
Municipal Boundaries
Parcel boundaries
Natural Lands
1031 Palmers Mill Road, Media, PA 19063
610-353-5587 | natlands.org
Feet
0
60
120

Bow Tree 2 & 3 Basin

Uses: Beauty and Potentially Fishing/Habitat

Approximate Surface Area: 1.17 acres

Parcel Size: 47.4 acres (8 acres focus)

Inlets: 28

Outlets: 1 to Ridley Creek

Watershed: Ridley Creek

Headwater Location: Bow Tree 2 & 3 Pond and Inlets throughout Bow Tree

Drainage Area: 30 acres

Depth of Water: Average 1.5 feet

Aerators: None

Notable Chemical Testing Results: Phosphorous

general description

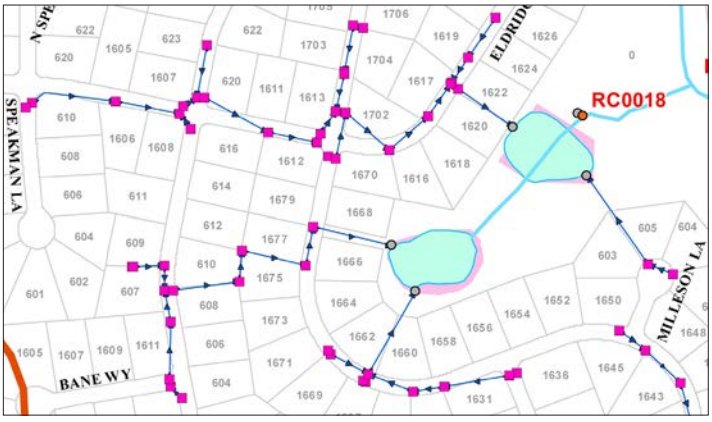
Like the Bow Tree 1 & 2 Pond, the basin is also largely surrounded by residential backyards. It is also surrounded by some steeply sloped, mown lawns on three sides which are contributing sheet flow to the basin. The fourth side opens up to a large swath of wooded Township open space. The banks of the basin are relatively steep and feature little edge vegetation. The outflow from the pond travels through a concrete channel into the basin. An additional 28 inlets in Bow Tree 1 & 2 also feed the basin.

The Bow Tree 2 & 3 Basin is not in as good a condition as its neighbor, the pond. It tested high for phosphorous and needs dredging and structural repair of the channel. Scrub vegetation has also grown into the channel, impeding the water flow.

Bow Tree 2 & 3 Pond and Basin Watershed

strategies for improvement

Toth Bros. recommends dredging of the basin as the average depth is 1.5 feet. Additionally, the concrete channel should be repaired and brush should be removed where it is impeding the flow of the water.



Twenty-eight inlets (pink squares) convey stormwater into the Basin. CREDIT: East Goshen Township

The Bow Tree 2 & 3 Basin is covered in algae in the summer months.

aerator system

Installation of an aeration system would help to increase dissolved oxygen levels. The pond surface is currently approximately 1.17 acres. At this size, two aeration systems would be necessary. Should the Township also install a forebay, it may be possible to reduce the pond surface area in need of aeration, as forebays do not need to be aerated. **Aeration would only be recommended if the pond is first dredged to a minimum depth of 4 feet.**

vegetate steep banks

The basin is surrounded by steep banks on the north east end. All of the pond edges should be planted with trees and shrubs to shade the water and provide fish and animal habitat. Additional vegetation could also help stabilize the steeper slopes and make them safer if people walk along the top of the berm. More vegetation would also make the basin less appealing to geese.

trees over channel

The channel which leads from the pond to the basin conveys water at a shallow depth, typically less than one inch, and in full sun. Warm water contributes to lowered levels of dissolved oxygen and reduced suitability for fish habitat. Trees should be planted along the length of the channel to help shade the water flowing through it. Additionally, trees and shrubs would help to camouflage the channel, making the site more aesthetically pleasing.

Some edge vegetation helps to filter stormwater and also provides a barrier for people who may walk on the berm.

rain gardens and rain barrels

The residents upstream could do their part by reducing the amount of water entering the stormwater system by installing rain gardens and rain barrels. Lower volumes of water entering the stream would also reduce the amount of sediment and nutrients entering the pond. The residents whose backyards surround the Bow Tree 2 & 3 Pond and Basin could install rain gardens along their rear property lines to catch the water flowing off of their properties and into the ponds.

infiltration swale and meadow plantings

The hill to the southeast of the basin stretches approximately 240 feet from the edge of the pond to the neighboring resident's backyard. The average slope of the

The channel which connects the pond and basin has been damged by overgrown vegetation, which causes water to stop, stagnate and grow algae.

hillside is approximately 10%. The hillside is mowed on a regular basis to keep the turfgrass short. Its likely that large volumes of stormwater flow down this hillside, carrying nutrients, sediment and grass clippings with it. The hillside could be converted to a meadow, which would discourage geese from gathering there as well as slowing, filtering and infiltrating the stormwater.

A vegetated infiltration swale could also be implemented parallel to the edge of the basin. This swale would essentially act as a linear rain garden, to catch any stormwater which escapes the meadow, before it reaches the basin. It would be planted with meadow grasses and flowering perennials. The water, captured in the swale, would keep nutrients, sediment and grass clippings from ever reaching the basin. It would also encourage the water to infiltrate directly into the ground, rather than entering the basin and the stream system. Soil and infiltration tests, and potentially an engineering study would be necessary to determine whether a vegetated infiltration swale would function here.

conclusion

When this basin is dredged, it would be a good time to implement the additional strategies to ensure the long term health of the basin. When residents see the cost, difficulty and scale of dredging, it may be the right time to begin educating them on the actions they can take to help improve the health of the basin. Once the basin is dredged back to its ideal condition, it would be logical to implement the other physical changes, such as tree planting, and meadow and rain garden installation, to help it stay in the best condition possible, for as long as possible.

See previous section for plan.

Marydell Pond

Uses: Beauty and Potentially Fishing/Habitat

Approximate Surface Area: 1.98 acres

Parcel Size: 16.6 acres

Inlets: 19

Outlets: 1 – Flows to smaller ponds, then East Branch Chester Creek

Watershed: East Branch Chester Creek

Headwater Location: Subdivision inlets and spring

Drainage Area: <24 acres

Depth of Water: 1.5 to 5 feet

Aerators: None

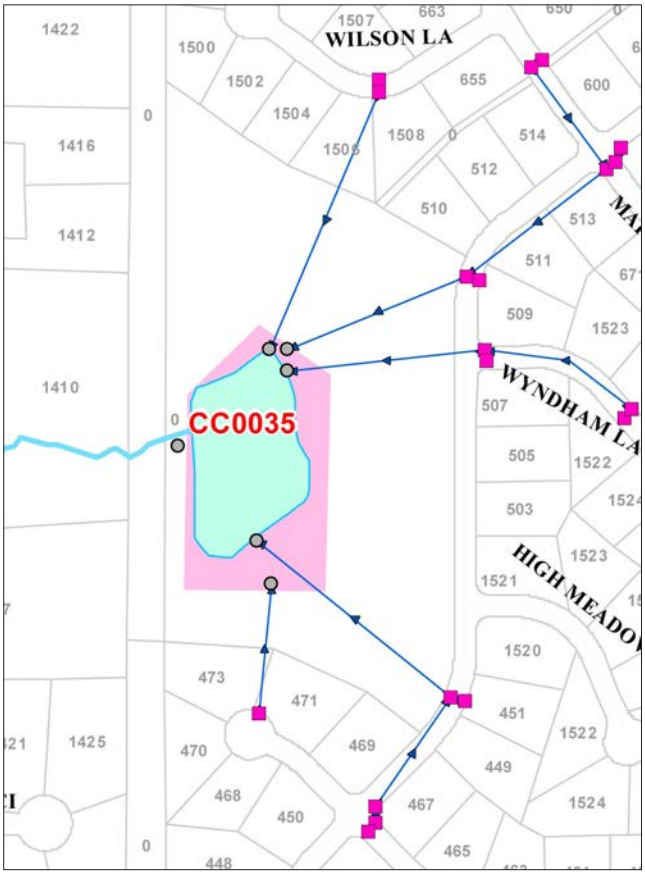
Notable Chemical Testing Results: Phosphorous, Nitrogen (Ammonia-N), and Low Dissolved Oxygen

general description

The Marydell Pond sits within a 16-acre open space parcel surrounded by the Marydell subdivision. The space is mostly mowed lawn, with a forested area to the northwest. Barker Drive runs along the eastern edge of the property, approximately 30 feet in elevation above the surface of the pond. The horizontal distance from the road to the pond is approximately 330 feet. It appears that the space is relatively unused, aside from some fishing, as evidenced by some stray fishing line. Kids sled there in the winter as well. A hockey goal in the pond suggests that residents use the pond for skating and ice hockey in the winter as well. The neighbors used to hold civic events in the lawn area, but don't any longer as the goose population and goose waste has made the space unpleasant to use.

The Conservancy Board recently planted a dozen trees along the northeastern edge of the pond. They are in rough, double rows, ranging in distance from the shoreline from approximately 10–40 feet. The trees are a mix of oaks, birches and redbuds. These three native species will

Marydell Pond Watershed



Nineteen inlets (pink squares) feed the Marydell Pond stormwater management system. CREDIT: East Goshen Township

provide food and habitat to a variety of mammals, birds and insects. They are also all tolerant of wet soils and are appropriate for a pond side planting. The mix of species will grow to three different heights, providing an understory and canopy layer. The redbuds will likely grow to approximately 30 feet in height, the birches to 50–70 feet in height, with the oaks most likely topping out around 80 feet in height. At maturity, the birches and oaks should provide some shade to the pond.

In addition to shade, the trees will also provide some stormwater management. They are planted at the bottom of a slope, near the pond edge. As they grow and establish their root systems, they will help to stabilize the soil, slow flowing water and reduce erosion. They are the first step in establishing a vegetated buffer, recommended at all the ponds. In the future, the Conservancy Board could supplement these trees with more trees, further uphill to widen the buffer. Additionally, shrubs could be added beneath the trees once the canopies begin to connect.

The pond is fed by 19 inlets throughout the subdivisions, sheet flow across the vast hillside, a spring and a few channelized, intermittent waterways across the lawn area. The eastern pond edges lack significant vegetation for the most part, save for the newly planted trees and a few other more mature shade trees. The western edge is bordered by forest. The large lawn area is often occupied by geese, as evidenced by their abundant waste. One outlet drains pond water to an unnamed tributary of the East Branch Chester Creek.

The Marydell Pond seems to be affected by every negative impact possible. Geese occupy the site and leave an abundance of waste. The pond water is exposed to full sun, with little shade. There is little edge vegetation for fish habitat and no significant vegetated buffers on three sides, allowing stormwater to sheet flow into the pond. Finally, 28 inlets drain stormwater from the neighboring yards and streets directly into the pond, bringing sediment, nutrients and chemicals into the water. These factors have led to the pond being low in dissolved oxygen, high in phosphorous and nitrogen and in need of dredging and physical repair.

strategies for improvement

dredging and repairs

Toth Bros. recommends dredging this pond and spreading the sediment on the hillside above. Additionally, the outflow structure should be repaired simultaneously.

two forebays

Only 19 inlets feed the four pipes and one swale which lead into the pond. Three pipes feed the pond at its north end, while one pipe and the swale feed the pond at its south end. Two forebays, one north and one south, would be necessary to capture sediment as it exits the pipes and swale. The foorebays would collect sediment in smaller areas of the pond, rather than allowing it to spread across the entire pond. Ongoing sediment removal, through dredging or vacuuming could then be focused on two smaller areas.

The trees planted at Marydell include oaks, birches and redbuds, native species which will shade the pond, filter stormwater and provide habitat for native birds, insects and mammals.

A sycamore tree is growing out of the outlow structure at Marydell and should be removed.

aerator system

Installation of an aeration system would help to increase dissolved oxygen levels. The pond surface is currently approximately 1.98 acres. At this size, two aeration systems would be necessary. Should the Township also install two forebays, it may be possible to reduce the pond surface area in need of aeration, as forebays do not need to be aerated. **Aeration would only be recommended if the pond is first dredged to a minimum depth of 4 feet.**

meadow plantings and vegetated swale

The vast mowed hillsides surrounding the pond on three sides allow stormwater to sheet flow directly into the pond. As the water flows through the grass, it carries clippings, sediment and nutrients into the pond. The large grass hillsides between the pond and the road could be converted to meadow plantings, which would help to slow, filter and infiltrate the water before it reaches the pond. Beyond the initial costs of installation, meadow maintenance would likely be less costly than the typical lawn maintenance, as meadows need to be mowed only a few times per year.

A vegetated infiltration swale could also be implemented parallel to the edge of the basin. This swale would essentially act as a linear rain garden, to catch any stormwater which escapes the meadow, before it reaches the basin. It would be planted with meadow grasses and flowering perennials. The water, captured in the swale, would keep nutrients, sediment and grass clippings from ever reaching the basin. It would also encourage the water to infiltrate directly into the ground, rather than entering the basin and the stream system. Soil and infiltration tests, and potentially an engineering study would be necessary to determine whether a vegetated infiltration swale would function here.

The Marydell pond features some edge plantings, but more plantings would provide more shade and better filter stormwater.

vegetated buffers

The Marydell Pond site lacks vegetation, aside from the wooded areas along the western edge. The pond would benefit from additional plantings which could help to filter runoff, stabilize the soil and shade the water. More trees would also make the site more aesthetically pleasing and comfortable during the hotter seasons. Buffer plantings should be planted along the pond banks and where stormwater runoff is channelizing and forming intermittent streams down the hillside.

aquatic plants

The Marydell Pond tested low for dissolved oxygen. Fish need dissolved oxygen to breathe and aerobic bacteria, which break down decaying matter in the water, are also dependent on dissolved oxygen. The introduction of native aquatic plants would be an effective method for increasing dissolved oxygen levels. Should this pond be dredged, some of the spoils could be graded into the banks to create a shallow bench underwater, on which to plant the aquatic plant species.

inlet filter bags

This plan recommends a pilot program for the use of inlet filter bags at inlets feeding the Pin Oak and Hershey's Mill Ponds. These two ponds are fed by a total of 13 inlets between them. The Marydell Pond is fed by 19 inlets, which is the third fewest of the six ponds. Inlet filter bags should be considered for use at Marydell based upon review of the results of the pilot program at Pin Oak and Hershey's Mill. Should inlet filter bags be found to be effective there, the Township could incrementally increase their use. Marydell would be the next logical step, based on the relatively low number of inlets.

upstream BMPs and education

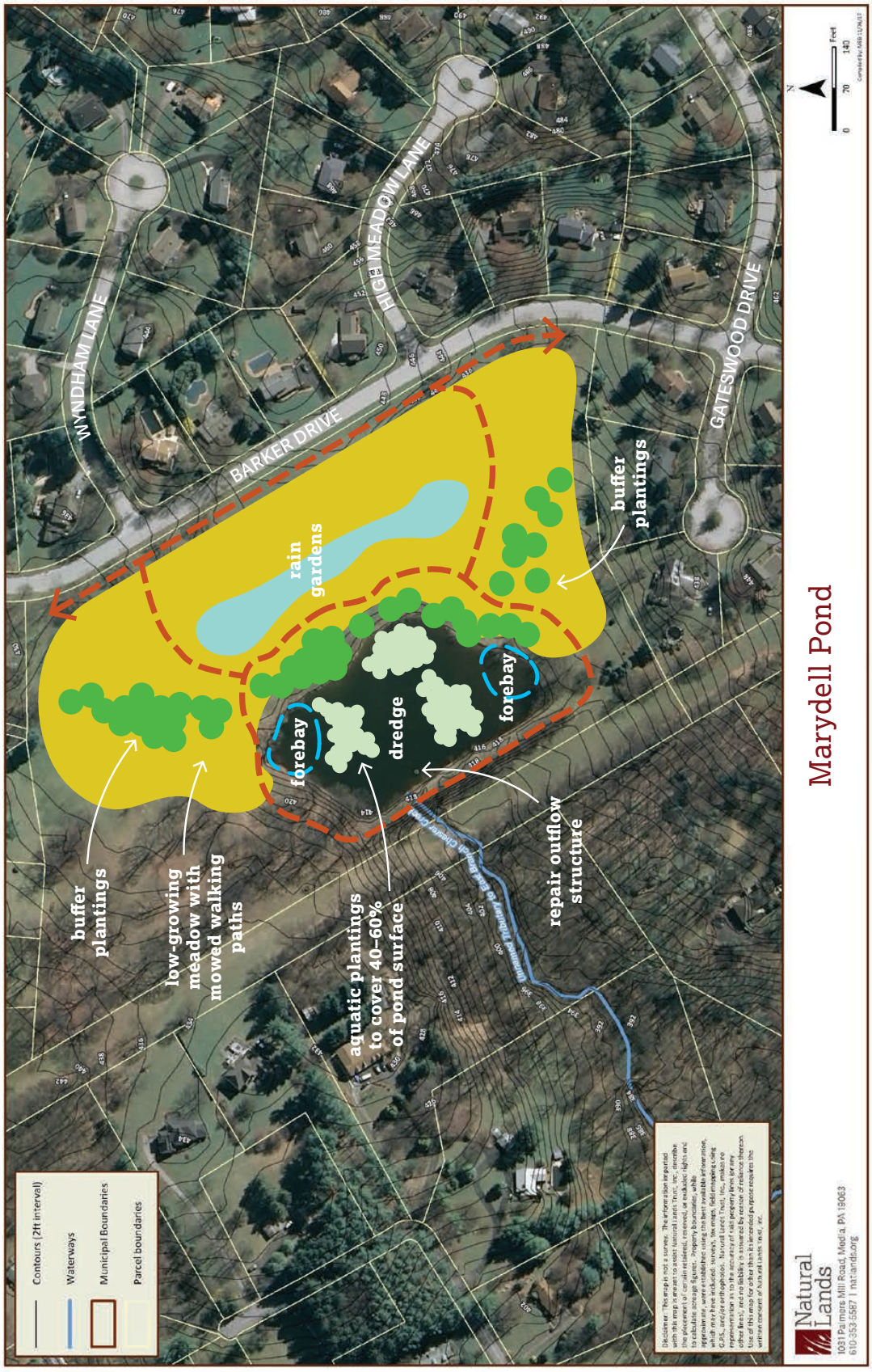
With the surrounding neighborhood contributing to the stormwater system in Marydell, education of the residents could make a difference in protecting the pond's health.

Every resident who installs a rain barrel or rain garden can help to decrease the amount of sediment, water volume and nutrients which make their way into the pond. Every resident who chooses to take their car to a commercial car wash helps to keep phosphorous and other pollutants out of the ecosystem.

conclusion

The Marydell Pond open space has the potential to be transformed into a passive park which could become a new centerpiece of the neighborhood. The strategies for improvement would be designed in a manner to improve the ponds health as well as encourage use by the residents. Grass walking paths could bring residents comfortably to the pond. Meadow plantings would discourage geese from inhabiting the site. More trees would provide summer shade and habitat for birds. The pond and the 16 acres surrounding it could be transformed into a natural area with gathering space for neighborhood events, educational programs and recreational events.

Some aquatic plants, like duckweed, are growing naturally in the pond.


Marydell Pond
WYNDHAM LANE
BARKER DRIVE
HIGH MEADOW LANE
GATESWOOD DRIVE
buffer plantings
low-growing meadow with mowed walking paths
aquatic plantings to cover 40–60% of pond surface
dredge
forebay
forebay
rain gardens
buffer plantings
repair outflow structure
Contours (2ft interval)
Waterways
Municipal Boundaries
Parcel boundaries
Natural Lands
1031 Palmers Mill Road, Media, PA 19063
610-353-5587 | natlands.org

Pin Oak Pond

Uses: Beauty and Potentially Fishing/Habitat

Approximate Surface Area: 0.46 acres

Parcel Size: 4.6 acres

Inlets: 8

Outlets: 1

Watershed: East Branch Chester Creek

Headwater Location: Inlets on Brian and Richard Drives

Drainage Area: 42.4 acres

Depth of Water: 2 to 6 feet

Aerators: 1

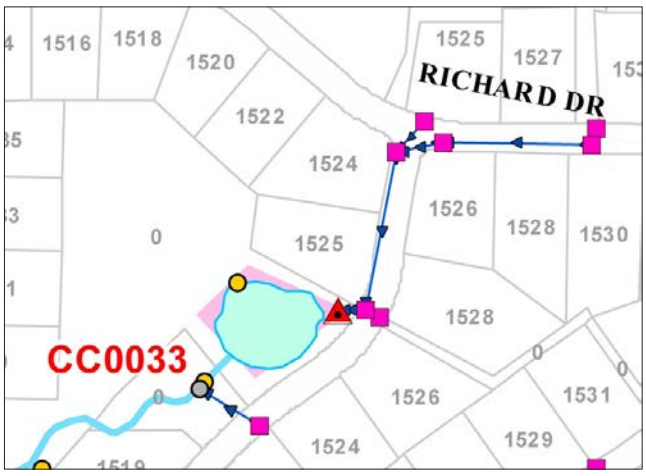
Notable Chemical Testing Results: Phosphorous

Pin Oak Pond Watershed

general description

The Pin Oak Pond rests in a more intimate setting than the others. It sits along a quiet street, on a smaller parcel, adjacent only to a few homes. It's a small pond at just under a half acre. It is clearly well loved by the neighborhood, as residents asked what we were doing at every site visit.

The pond is just a few feet from Brian Drive to the east and a private residence to the north. The majority of the 4.6-acre parcel on which it resides, lies to the west and south of the pond. Most of the area to the west is mowed grass, stretching from the banks of the pond to the residents'



Only eight inlets (pink squares) feed the Pin Oak Pond, making it suitable for an inlet filter bag pilot program
CREDIT: East Goshen Township

Some edges of the pond are well vegetated, but more plantings would help to stabilize the banks.

rear yards, just about 250 feet away. Due to the slopes, it appears that most of the sheet flow from the grass area is missing the pond, but likely flowing directly into the unnamed tributary of the East Branch Chester Creek, to which the pond drains as well.

The pond is fed by a series of eight inlets on Brian and Richard Drives. The inlets channel water into a single pipe which feeds the pond. The pond banks near the pipe have scoured, creating a "neck" from the pipe to the pond. It appears that water likely rushes out of the pipe at high velocities, carrying sediment and scouring the pond banks before slowing down in the body of the pond and dropping its sediment there. In addition to sedimentation, the pond also has a few structural issues. The emergency spillway has failed and a 60-foot stretch of shoreline is being undercut. Water drains from the pond through an outlet structure, but is also leaking through the spillway and making a new channel towards the creek.

The water tested high for phosphorous. Unlike many of the other ponds, it does not appear that sheet flow off the adjacent lawn is a major culprit. It is more likely that the phosphorous is being carried in with sediment, or washing in from the inlets in the form of fertilizers or other chemicals.

strategies for improvement

dredging and forebay

Toth Bros. recommends dredging this pond in approximately 2022. Between now and then, the Township could prepare the pond for a major makeover. In addition to fixing the spillway, this pond could be fitted with a forebay. A forebay is a smaller ponding area, designed to slow water's velocity, so that it drops sediment there, rather than in the open water of the pond. The "neck" referred to earlier could potentially be fashioned into a spillway. If the sediment were concentrated here, future removal of sediment could be achieved with lighter equipment, such as vacuum trucks, at a lesser cost. It is also possible that the water rushing in through the neck is causing the undercutting of the opposite bank. Installation of a forebay, designed to slow the water on entry, could also reduce future undercutting and could allow the bank to be stabilized through tree plantings.

tree plantings

Much of the land surrounding the pond is unstable, due to the forces of the pond water. Additional trees planted around the pond would help to hold the soil and stabilize the land, keeping more sediment from entering the stream.

The existing channel entering the pond could potentially be converted into a forebay, to capture sediment in a smaller area before it enters the pond.

The existing spillway is unstable, and should be reconstructed. Additionaly plantings could also help to stabilize the banks.

inlet filter bags

As only eight inlets feed the pipes which lead to the pond, inlet filter bags could greatly reduce the amount of sediment entering the stormwater system off of the residential properties and streets.

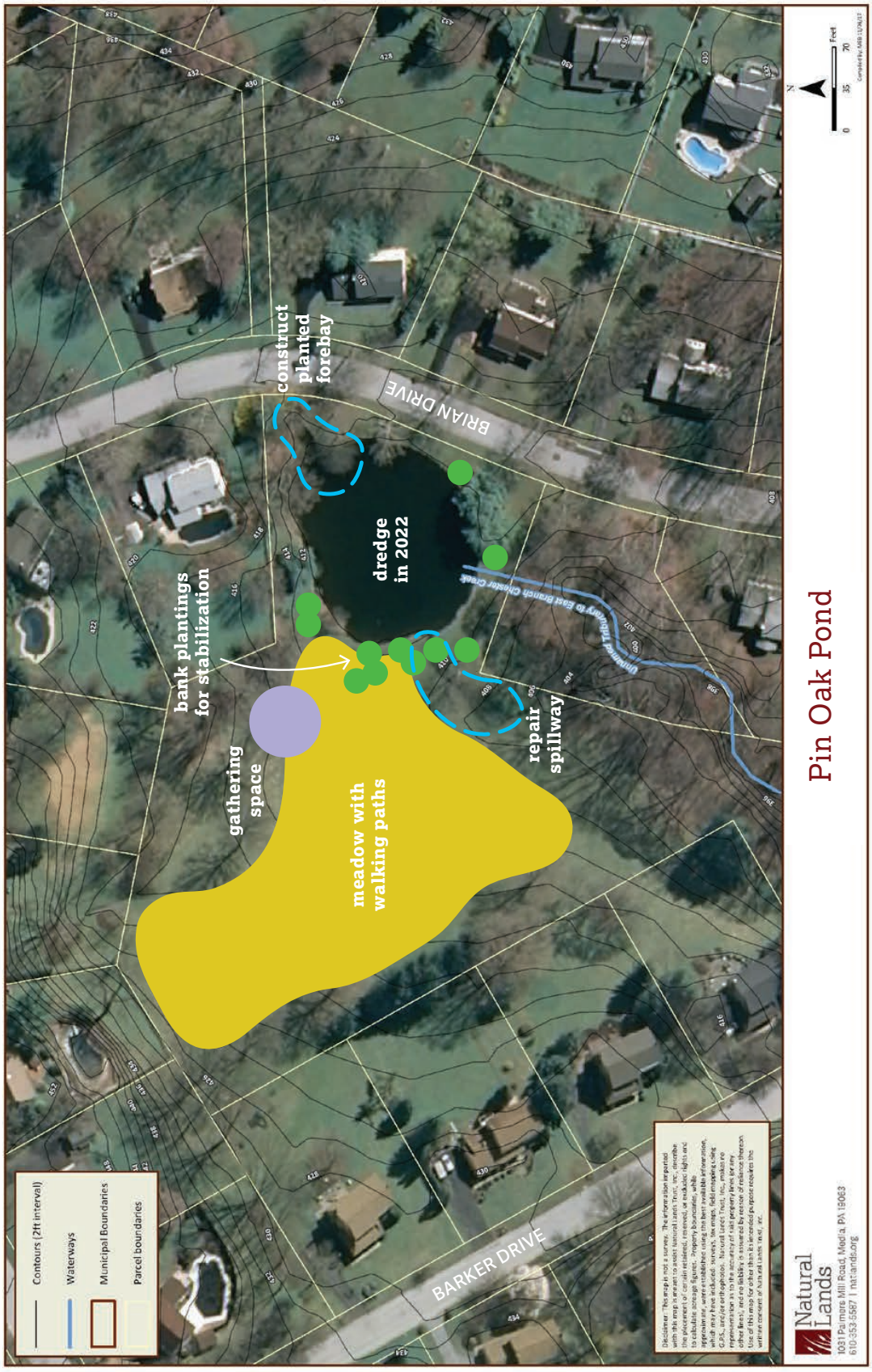
upstream BMPs and education

With the surrounding neighborhood contributing to the effects on the Pin Oak Pond, education of the residents could make a difference in protecting the pond's health. Every resident who installs a rain barrel or rain garden can help to decrease the amount of sediment, water volume and nutrients which make their way into the pond. Every resident who chooses to take their car to a commercial car wash helps to keep phosphorous and other pollutants out of the ecosystem.

conclusion

The Pin Oak Pond site is well loved by the neighboring residents, but could serve them better. The site connects to another 75 acres of adjacent open space. The recommendations for improving the pond's health could be implemented in a way to transform the site into a neighborhood passive park and trailhead. Trees intended to stabilize the pond banks would also shade visitors. Meadows intended to infiltrate ground water would also provide habitat for birds and interest for walkers. Beautifying the site, upgrading it to better serve the neighbors and strengthening their connections to it are the best ways to get them to care about the health of the pond and make positive changes to improve it.

The aerator in the Pin Oak pond helps keep the water moving and well oxygenated, which benefits water quality and the fish that live in the pond.


Pin Oak Pond
construct planted forebay
dredge in 2022
bank plantings for stabilization
gathering space
meadow with walking paths
repair spillway
BRIAN DRIVE
BARKER DRIVE
Unnamed Tributary to East Branch Chester Creek
Contours (2ft interval)
Waterways
Municipal Boundaries
Parcel boundaries
Natural Lands
1031 Palmers Mill Road, Media, PA 19063
610-353-5587 | natlands.org
Feet
0
35
70

conclusion

East Goshen's ponds are each unique, slightly different from each other, but face the same issues as most ponds and basins within southeastern Pennsylvania. They are already full of sediment, deposited over decades. They aren't well planted and aren't supported by a robust ecosystem. They continue to accept stormwater carrying sediment and pollutants. Every pond has slightly different needs for improvement, but the same general recommendations are relevant to each of East Goshen's Ponds.

All of the ponds need to be dredged, now or in the future. All of the ponds need more plantings. All of the ponds need better filtration of the stormwater which enters them. And in addition to these physical changes, there needs to be social change as well. As long as the people who live around the ponds don't care about them, it will be very difficult for anyone to keep them in good health.

The ponds are all in need of some improvement, but East Goshen has the right people in leadership and the community, to make sure that the ponds are well cared for in the future. The residents are interested and see an opportunity to transform the ponds into important centerpieces for their communities. They see that these can be beautiful places to gather, to watch birds, to fish, to follow butterflies and frogs and to simply enjoy the outdoors. Through the recommendations in this report, the community can make this a reality.

The ponds in East Goshen hold great potential as small neighborhood parks, where people can hold events, enjoy the wcenery of simply go for a walk in nature.

appendix 1

subconsultant reports & cost estimates

1A: Water Quality Laboratory Tests

1B: Site Inspection Report Outlines

1C: Cost Estimates

LAB #
714897

BRANDYWINE SCIENCE CENTER INC.
204 LINE ROAD
KENNETT SQUARE, PA 19348
DEP# 15-301
(610) 444-9850

LABORATORY REPORT
FOR

ORIGIN	NAME	Hershey Mill Estates		**Client:**	East
OF	ADDRESS				Goshen
SAMPLE	CITY/STATE				Township
	TOWNSHIP			COUNTY	
SOURCE	POND	x	**MANNER**	INSIDE TAP	
OF	SPRING		**OF**	OUTSIDE TAP	
SUPPLY	TREATED		**COLLECTION**	HOLDING TANK	
SAMPLE	LAB STAFF			SAMPLE DATE	10/13/2017
COLLECTED	WELL DRILLER		**SAMPLE**	SAMPLE TIME	9:00
BY	OTHER	East Goshen	**INFORMATION**	DATE RECEIVED	10/13/2017
TRANSPORT	ICE /REFRIG	x		TIME RECEIVED	10:30
INFORMATION				DATE OF REPORT	10/27/2017

SAMPLE ID:

ANALYSIS	RESULT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
AMMONIA-N	0.21	mg/L	SM 5210 D	10/13/17 18:30	HC
DISSOLVED OXYGEN	9.0	mg/L	SM 4500 OG	10/13/17 10:35	HC
NITRATE-N	16.4	mg/L	SM 4500-NO3- D	10/14/17 14:30	HC
NITRITE-N	<0.01	mg/L	SM 4500-NO2- B	10/14/17 12:30	HC
pH	7.22	SU	SM 4500-H+ B	10/13/17 17:32	HC
T-PHOSPHORUS (P)	0.09	mg/L	SM 4500-P E	10/16/17 17:05	HC
FECAL COLIFORM	48	mg/L	SM 9222 D	10/13/17 12:00	MJ

Henry D. Clemens III

Henry D. Clemens III
Laboratory Director

< Less Than
SM refers to Standard Methods for the Examination of Wastewater
and Water, 18th Edition, APHA-AWWA-WPCF.
Chemical Analyses performed in accordance with " STANDARD METHODS FOR THE EXAMINATION
OF WATER AND WASTEWATER, 18th EDITION APHA-AWWA-WPCF.

LAB #
714902

BRANDYWINE SCIENCE CENTER INC.
204 LINE ROAD
KENNETT SQUARE, PA 19348
DEP# 15-301
(610) 444-9850

LABORATORY REPORT
FOR

ORIGIN	NAME	Bow Tree I		**Client:**	East
OF	ADDRESS	Retention Pond			Goshen
SAMPLE	CITY/STATE				Township
	TOWNSHIP			COUNTY	
SOURCE	POND	x	**MANNER**	INSIDE TAP	
OF	SPRING		**OF**	OUTSIDE TAP	
SUPPLY	TREATED		**COLLECTION**	HOLDING TANK	
SAMPLE	LAB STAFF			SAMPLE DATE	10/13/2017
COLLECTED	WELL DRILLER		**SAMPLE**	SAMPLE TIME	8:45
BY	OTHER	East Goshen	**INFORMATION**	DATE RECEIVED	10/13/2017
TRANSPORT	ICE /REFRIG	x		TIME RECEIVED	10:30
INFORMATION				DATE OF REPORT	10/27/2017

SAMPLE ID:

ANALYSIS	RESULT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
AMMONIA-N	1.33	mg/L	SM 5210 D	10/13/17 18:30	HC
DISSOLVED OXYGEN	4.9	mg/L	SM 4500 OG	10/13/17 10:35	HC
NITRATE-N	2.4	mg/L	SM 4500-NO3- D	10/14/17 14:30	HC
NITRITE-N	0.272	mg/L	SM 4500-NO2- B	10/14/17 12:30	HC
pH	7.08	SU	SM 4500-H+ B	10/13/17 17:37	HC
T-PHOSPHORUS (P)	0.13	mg/L	SM 4500-P E	10/16/17 17:05	HC
FECAL COLIFORM	240	mg/L	SM 9222 D	10/13/17 12:00	MJ

Henry D. Clemens III

Henry D. Clemens III
Laboratory Director

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LAB #
714900

BRANDYWINE SCIENCE CENTER INC.
204 LINE ROAD
KENNETT SQUARE, PA 19348
DEP# 15-301
(610) 444-9850

LABORATORY REPORT
FOR

ORIGIN	NAME	Bow Tree II & III		**Client:**	East
OF	ADDRESS	Farm Pond			Goshen
SAMPLE	CITY/STATE				Township
	TOWNSHIP			COUNTY	
SOURCE	POND	x	**MANNER**	INSIDE TAP	
OF	SPRING		**OF**	OUTSIDE TAP	
SUPPLY	TREATED		**COLLECTION**	HOLDING TANK	
SAMPLE	LAB STAFF			SAMPLE DATE	10/13/2017
COLLECTED	WELL DRILLER		**SAMPLE**	SAMPLE TIME	8:30
BY	OTHER	East Goshen	**INFORMATION**	DATE RECEIVED	10/13/2017
TRANSPORT	ICE /REFRIG	x		TIME RECEIVED	10:30
INFORMATION				DATE OF REPORT	10/27/2017

SAMPLE ID:

ANALYSIS	RESULT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
AMMONIA-N	<0.10	mg/L	SM 5210 D	10/13/17 18:30	HC
DISSOLVED OXYGEN	7.2	mg/L	SM 4500 OG	10/13/17 10:35	HC
NITRATE-N	2.47	mg/L	SM 4500-NO3- D	10/14/17 14:30	HC
NITRITE-N	0.282	mg/L	SM 4500-NO2- B	10/14/17 12:30	HC
pH	7.38	SU	SM 4500-H+ B	10/13/17 17:36	HC
T-PHOSPHORUS (P)	0.17	mg/L	SM 4500-P E	10/16/17 17:05	HC
FECAL COLIFORM	29	mg/L	SM 9222 D	10/13/17 12:00	MJ

Henry D. Clemens III

Henry D. Clemens III
Laboratory Director

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LAB #
714901

BRANDYWINE SCIENCE CENTER INC.
204 LINE ROAD
KENNETT SQUARE, PA 19348
DEP# 15-301
(610) 444-9850

LABORATORY REPORT
FOR

ORIGIN	NAME	Bow Tree II & III		**Client:**	East
OF	ADDRESS	Retention Pond			Goshen
SAMPLE	CITY/STATE				Township
	TOWNSHIP			COUNTY	
SOURCE	POND	x	**MANNER**	INSIDE TAP	
OF	SPRING		**OF**	OUTSIDE TAP	
SUPPLY	TREATED		**COLLECTION**	HOLDING TANK	
SAMPLE	LAB STAFF			SAMPLE DATE	10/13/2017
COLLECTED	WELL DRILLER		**SAMPLE**	SAMPLE TIME	8:45
BY	OTHER	East Goshen	**INFORMATION**	DATE RECEIVED	10/13/2017
TRANSPORT	ICE /REFRIG	x		TIME RECEIVED	10:30
INFORMATION				DATE OF REPORT	10/27/2017

SAMPLE ID:

ANALYSIS	RESULT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
AMMONIA-N	<0.10	mg/L	SM 5210 D	10/13/17 18:30	HC
DISSOLVED OXYGEN	7.8	mg/L	SM 4500 OG	10/13/17 10:35	HC
NITRATE-N	2.51	mg/L	SM 4500-NO3- D	10/14/17 14:30	HC
NITRITE-N	0.115	mg/L	SM 4500-NO2- B	10/14/17 12:30	HC
pH	7.18	SU	SM 4500-H+ B	10/13/17 17:37	HC
T-PHOSPHORUS (P)	0.09	mg/L	SM 4500-P E	10/16/17 17:05	HC
FECAL COLIFORM	35	mg/L	SM 9222 D	10/13/17 12:00	MJ

Henry D. Clemens III

Henry D. Clemens III
Laboratory Director

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Chemical Analyses performed in accordance with " STANDARD METHODS FOR THE EXAMINATION
OF WATER AND WASTEWATER, 18th EDITION APHA-AWWA-WPCF.

LAB #
714898

BRANDYWINE SCIENCE CENTER INC.
204 LINE ROAD
KENNETT SQUARE, PA 19348
DEP# 15-301
(610) 444-9850

LABORATORY REPORT
FOR

ORIGIN	NAME	Mary Dell		**Client:**	East
OF	ADDRESS				Goshen
SAMPLE	CITY/STATE				Township
	TOWNSHIP			COUNTY	
SOURCE	POND	x	**MANNER**	INSIDE TAP	
OF	SPRING		**OF**	OUTSIDE TAP	
SUPPLY	TREATED		**COLLECTION**	HOLDING TANK	
SAMPLE	LAB STAFF			SAMPLE DATE	10/13/2017
COLLECTED	WELL DRILLER		**SAMPLE**	SAMPLE TIME	9:15
BY	OTHER	East Goshen	**INFORMATION**	DATE RECEIVED	10/13/2017
TRANSPORT	ICE /REFRIG	x		TIME RECEIVED	10:30
INFORMATION				DATE OF REPORT	10/27/2017

SAMPLE ID:

ANALYSIS	RESULT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
AMMONIA-N	0.20	mg/L	SM 5210 D	10/13/17 18:30	HC
DISSOLVED OXYGEN	5.2	mg/L	SM 4500 OG	10/13/17 10:35	HC
NITRATE-N	2.28	mg/L	SM 4500-NO3- D	10/14/17 14:30	HC
NITRITE-N	<0.01	mg/L	SM 4500-NO2- B	10/14/17 12:30	HC
pH	7.02	SU	SM 4500-H+ B	10/13/17 17:34	HC
T-PHOSPHORUS (P)	<0.06	mg/L	SM 4500-P E	10/16/17 17:05	HC
FECAL COLIFORM	570	mg/L	SM 9222 D	10/13/17 12:00	MJ

Henry D. Clemens III

Henry D. Clemens III
Laboratory Director

< Less Than
SM refers to Standard Methods for the Examination of Wastewater
and Water, 18th Edition, APHA-AWWA-WPCF.
Chemical Analyses performed in accordance with " STANDARD METHODS FOR THE EXAMINATION
OF WATER AND WASTEWATER, 18th EDITION APHA-AWWA-WPCF.

LAB #
714899

BRANDYWINE SCIENCE CENTER INC.
204 LINE ROAD
KENNETT SQUARE, PA 19348
DEP# 15-301
(610) 444-9850

LABORATORY REPORT
FOR

ORIGIN	NAME	Pin Oaks		**Client:**	East
OF	ADDRESS				Goshen
SAMPLE	CITY/STATE				Township
	TOWNSHIP			COUNTY	
SOURCE	POND	x	**MANNER**	INSIDE TAP	
OF	SPRING		**OF**	OUTSIDE TAP	
SUPPLY	TREATED		**COLLECTION**	HOLDING TANK	
SAMPLE	LAB STAFF			SAMPLE DATE	10/13/2017
COLLECTED	WELL DRILLER		**SAMPLE**	SAMPLE TIME	9:00
BY	OTHER	East Goshen	**INFORMATION**	DATE RECEIVED	10/13/2017
TRANSPORT	ICE /REFRIG	x		TIME RECEIVED	10:30
INFORMATION				DATE OF REPORT	10/27/2017

SAMPLE ID:

ANALYSIS	RESULT	UNITS	METHOD	DATE/TIME ANALYZED	ANALYST
AMMONIA-N	<0.10	mg/L	SM 5210 D	10/13/17 18:30	HC
DISSOLVED OXYGEN	8.2	mg/L	SM 4500 OG	10/13/17 10:35	HC
NITRATE-N	2.77	mg/L	SM 4500-NO3- D	10/14/17 14:30	HC
NITRITE-N	0.112	mg/L	SM 4500-NO2- B	10/14/17 12:30	HC
pH	7.40	SU	SM 4500-H+ B	10/13/17 17:35	HC
T-PHOSPHORUS (P)	0.07	mg/L	SM 4500-P E	10/16/17 17:05	HC
FECAL COLIFORM	22	mg/L	SM 9222 D	10/13/17 12:00	MJ

Henry D. Clemens III

Henry D. Clemens III
Laboratory Director

< Less Than
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TOTH BROS.
CLEARING & DREDGING, INC.

JOSEPH TOTH • MICHAEL TOTH
P.O. Box 426 Sellersville, PA 18960
p: 215-368-7178 f: 215-257-3665
e: tothbros7178@comcast.net
www.tothbrothers.com

WET EXCAVATION • LAND CLEARING • DEMOLITION

November 3, 2017

SITE INSPECTION REPORT OUTLINE

PROJECT NAME: Hersheys Mill pond

Location- Vicinity 1511 Tanglewood Drive

Date of Inspection- 11/1/17

Water Quality East Branch Chester Creek; TSF / MF

PNDI Status: - No permit required

Watershed Area: 243 acres

Coordinates- 40 01.033 / 75 33.648

DREDGING INFORMATION:

Pond has a maximum water depth this date of 6 inches overall. It seriously needs dredging. Sediment load is 6 feet or 4442 cubic yards. This dredge material must be hauled off-site at a cost of $132,000.

SUGGEST:

This should be considered a "Regulated" dam due to the drainage area/watershed & dam height.

This is a very sensitive dredging project, as the private pond just Below has been an issue for more than 20 years and is in serious need of dredging. We do not want to give the owner any reason to consider the Township's work part of his concern.

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WET EXCAVATION • LAND CLEARING • DEMOLITION

November 3, 2017

SITE INSPECTION REPORT OUTLINE

PROJECT NAME: Bow Tree 1 Pond

Location- 1631 Bow Tree Drive

Date of Inspection- 11/1/17

Water Quality Ridley Creek; TSF/MF

PNDI Status: N/A No Permit Required

Watershed Area: <10 acres

Coordinates- 39 59.036 / 75 31.951

DREDGING INFORMATION:

Pond has a maximum depth of 2 feet surrounding (2) 5 foot diameter concrete outflow structures including steel trash racks, all in good repair. The pond has a minimum depth of 4 inches, thus it is in need of dredging with an average sediment load of 7,647 cubic yards. This dredged material could be blended with existing contours at a cost of $ 130,000

SUGGESTION:

All components appear to be working fine at this farm pond

Outlet Struc. Bow Tree #1 / Good Shape

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WET EXCAVATION • LAND CLEARING • DEMOLITION

November 3, 2017

SITE INSPECTION REPORT OUTLINE

PROJECT NAME: Bow Tree 2 & 3 Pond

Location- Vicinity 1679 Bow Tree Drive

Date of Inspection- 11/1/17

Water Quality- Ridley Creek; TSF/MF

PNDI Status: N/A No Permit Required

Watershed Area: 30 acres

Coordinates- 39 59.137/ 75 32.27

SILT LEVELS:

Pond has a maximum depth now of 5.5 feet at outlet and a minimum depth of 1.5 feet at inlet; average sediment load of 5,733 cubic yards. This old farm pond was dug at 11 feet at the outlet; this is the reason for the large amounts of sediment. However, the water depth is still favorable for a healthy pond. At this point we would not recommend dredging as on average there is 4 feet of water.

SUGGESTION:
We see this pond to be in good shape for the next 5 years. The aeration system is working great at the Bow tree Farm Pond.

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WET EXCAVATION • LAND CLEARING • DEMOLITION

November 3, 2017

SITE INSPECTION REPORT OUTLINE

PROJECT NAME: Bow Tree 2 & 3 Basin

Location- Vicinity 1679 Bow Tree Drive

Date of Inspection- 11/1/17

Water Quality- Ridley Creek; TSF/MF

PNDI Status: N/A No Permit Required

Watershed Area: 30 acres

Coordinates- 39 59.137/ 75 32.27

SILT LEVELS:

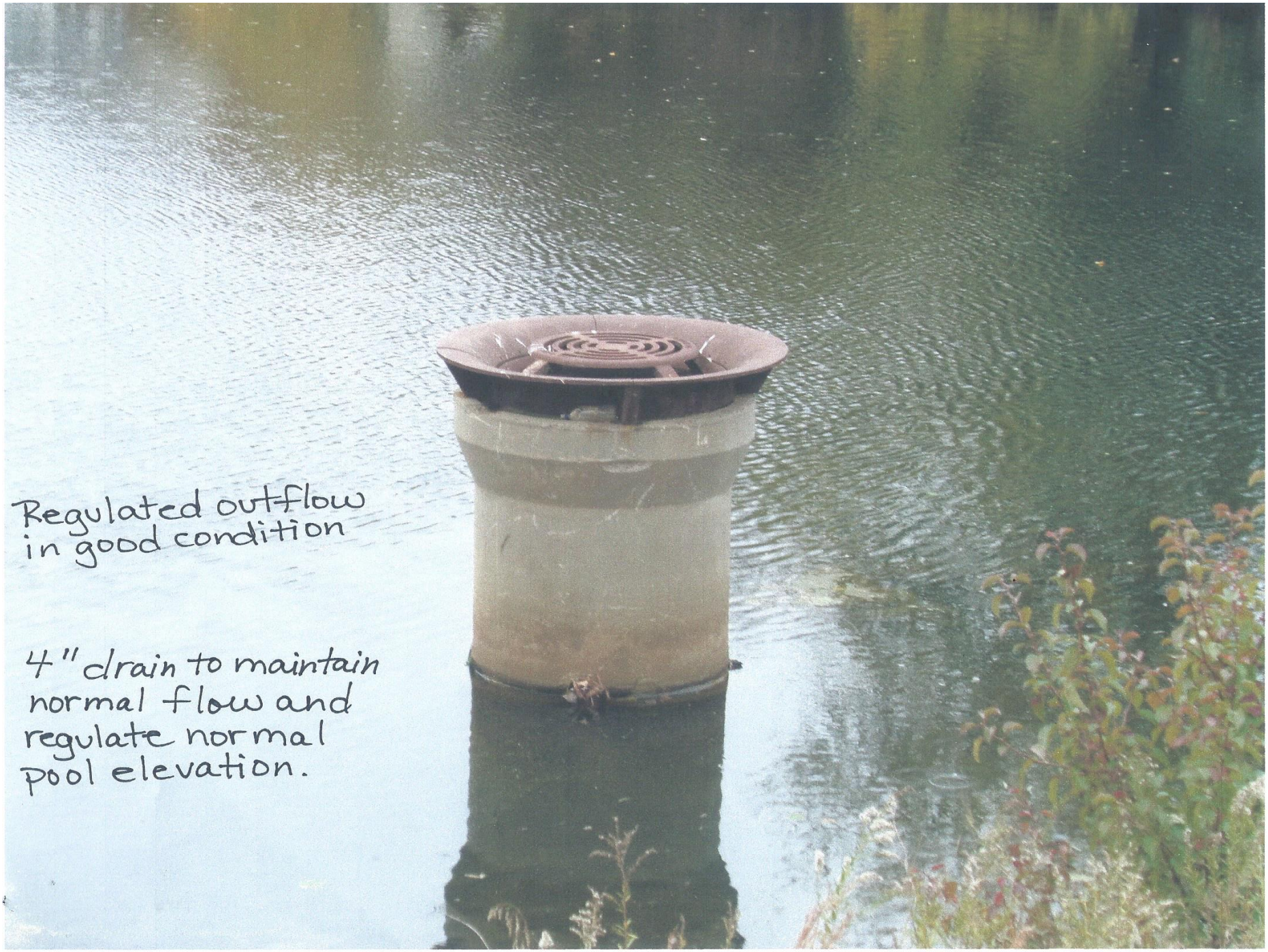
Pond has a maximum depth of 2.5 surrounding concrete outflow structure and a minimum depth of 1 foot surrounding the inlet, with an average sediment load of 1060 cubic yards. Average water depth is 1.5 feet overall. Pond needs dredging.
Estimated cost $20,000

SUGGESTION:

Minor brush clearing should be done at pond inlet; concrete retaining walls have failed in 2 sections; however it is stable with root growth.
Estimated Clearing cost… $1,500

Channel 2 to 3

Bow Tree Inlet No 3


Regulated outflow
in good condition
4" drain to maintain
normal flow and
regulate normal
pool elevation.

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WET EXCAVATION • LAND CLEARING • DEMOLITION

November 3, 2017

SITE INSPECTION REPORT OUTLINE

PROJECT NAME: Marydell Pond

Location- Vicinity 509 Baker Drive

Date of Inspection- 11/1/17

Water Quality East Branch Chester Creek

PNDI Status: N/A No Permit Required

Watershed Area: <24 acres

Coordinates- 39.98333 / 75.54861

DREDGING INFORMATION:

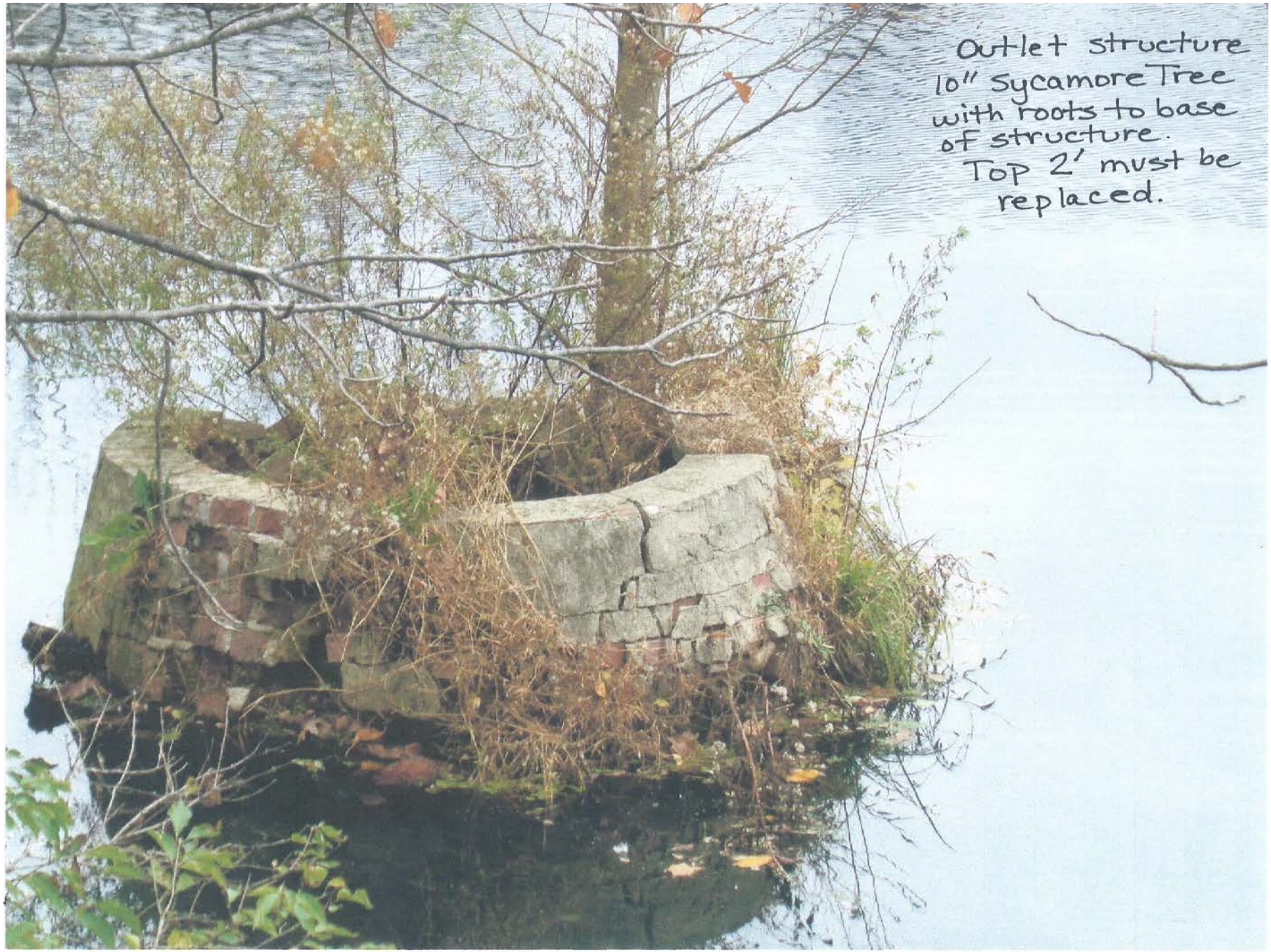
Currently, pond has a maximum depth of 5 feet at the dilapidated top section brick outflow structure and a minimum depth of 1.5 feet. This pond is in need of dredging; current silt average is 3.5 feet overall totaling 5,690 cubic yards.

ESTIMATED COSTS:

Dredge material could be blended in with existing contours at a cost of $100,000.

Suggestion #1- Repair brick outflow structure- Cost if done simultaneously with dredging would be $3,000. Should Township request this repair with pond full; estimated cost would be $5,000.

Note; Emergency spillway is in good condition; mowed lawn.



Failing Outflow Structure at Mayfield Pond 10" Sycamore Roots 8' long to floor

Base in good shape 2' Top Sec falling apart

Tree Roots to Floor

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WET EXCAVATION • LAND CLEARING • DEMOLITION

November 3, 2017

SITE INSPECTION REPORT OUTLINE

PROJECT NAME: Pin Oak Pond

Location- Vicinity 1524 Brian Drive

Date of Inspection- 11/1/17

Water Quality- East Branch Chester Creek; TSF/MF

PNDI Status: N/A No Permit Required

Watershed Area: 42.4 acres

Coordinates- 3958.746 / 75 32.569

DREDGING INFORMATION:

Pond has a maximum depth of 6.5 feet at aerator, approximately 2 feet at the inlet & an average sediment load of 3.5 feet; total sediment 860 cubic yards. It has been 20 years & the Township could wait another 5 years of so to dredge this pond.

Suggestion #1: The emergency spillway introduces water to the lawn area, this site should be abandoned and replaced with a mild geo-web/grass swale overtop existing outflow pipe-
Estimated cost - $5,000.00

Suggestion #2- Sixty feet of shoreline at the 30" white pines is under cutting; this could be easily corrected with stone rip-rap approximately 15 ton & fabric- Estimated cost $3,500.00

ESTIMATED COSTS:

Estimated Costs; Suggestions #1 & #2- $8,500.00

Emerg Spillway on Pin Oak Pond

Pin Oak Emg Spillway to Abandon

Rough Cost Estimates

The following rough cost estimates have been compiled through the use of cost estimating software, opinions of other experts and past experience. These estimates are intended to provide the Township with a rough estimate of costs for improvements to each pond. It should be noted that additional study or more detailed landscape or engineering design may be necessary in order to prepare detailed, construction cost estimates. Also, permit applications and associated fees or costs have not been included.

The following notes apply to the estimates as footnoted throughout the spreadsheets.

(1) Trees may be available at subsidized costs through grant programs including TreeVitalize Watersheds and the Arbor Day Foundation.

(2) Labor costs may be reduced through the use of volunteers.

(3) Labor costs may be reduced through the use of Township staff.

(4) Consulting costs for aeration system installation may only be necessary for the first installation. Township staff may be able to handle installation without a consultant on subsequent installations. Therefore, this fee should only be accounted for once.

(5) Estimates for meadows include typical per acre costs for herbicide treatments, purchase of seed and spreading of seeds. However, these costs can be eliminated if the Township chooses to simply reduce the frequency of mowing in order to establish a tall grass meadow.

(6) These costs may be reduced if the item is implemented in concert with dredging, while the pond is empty.

Hershey's Mill Estate - Rough Cost Estimate

A. Pond Upgrades	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Dredging	LS	NA	1	$ 132,000.00	$ 132,000.00	$ -	$ -	$ 132,000.00
Forebay Construction	EA	NA	0	$ -	$ -	$ -	$ -	$ -
Structural Repairs	LS	NA	0	$ -	$ -	$ -	$ -	$ -
SUBTOTAL					**$ 132,000.00**		**$ -**	**$ 132,000.00**

B. Aeration	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
PentAir System	EA	NA	0	$ 3,071.00	$ -	$ -	$ -	$ -
Consulting	Day	NA	0	$ 1,000.00	$ -	$ -	$ -	$ -
Electricity Source	LS	NA	0	$ 10,000.00	$ -	$ -	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

C. Plantings	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Trees (1)(2)	EA	1" cal	35	$ 70.00	$ 2,450.00	$ 140.00	$ 4,900.00	$ 7,350.00
Tree Tubes (2)	EA	60" ht	35	$ 2.50	$ 87.50	$ 5.00	$ 175.00	$ 262.50
Shrubs (2)	EA	24-36" ht	35	$ 36.00	$ 1,260.00	$ 70.00	$ 2,450.00	$ 3,710.00
Deer Mesh Fence (shrubs) (2)	LF	7' ht x 100LF	1	$ 125.00	$ 125.00	$ 200.00	$ 200.00	$ 325.00
Perennials	EA	SP2	0	$ 6.00	$ -	$ 2.00	$ -	$ -
Meadow	AC	NA	0	$ 2,000.00	$ -	$ -	$ -	$ -
Aquatic Plants	EA	2" Plug	0	$ 1.00	$ -	$ 2.00	$ -	$ -
Plug Planting Fence	LF	NA	0	$ 1.50	$ -	$ 3.50	$ -	$ -
SUBTOTAL					**$ 3,922.50**		**$ 7,725.00**	**$ 11,647.50**

D. BMPs	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Rain Garden/Swale Bed Prep	CY		0	$ 13.00		$ -	$ -	$ -
Inlet Filter Bags	EA	Varies	5	$ 100.00	$ 500.00	$ -	$ -	$ 500.00
Install by Twp	hour	NA	10	$ 40.00	$ 400.00	$ -	$ -	$ 400.00
SUBTOTAL					**$ 900.00**		**$ -**	**$ 900.00**

E. Other Features	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Benches	EA	4'	0	$ 500.00	$ -	$ 1,000.00	$ -	$ -
Gazebo	EA	8'x 10'	0	$ 4,000.00	$ -	$ 8,000.00	$ -	$ -
Split Rail Fence	LF	4' height	0	$6	$ -	$ 12.00	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

TOTAL: **$ 144,547.50**

Bow Tree 1 Pond - Rough Cost Estimate

A. Pond Upgrades	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Dredging	LS	NA	1	$ 130,000.00	$ 130,000.00	$ -	$ -	$ 130,000.00
Forebay Design	EA	NA	1	$ 5,000.00	$ 5,000.00	$ -	$ -	$ 5,000.00
Forebay Construction	LS	NA	1	$ 15,000.00	$ 15,000.00	$ -	$ -	$ 15,000.00
Structural Repairs	LS	NA	0	$ -	$ -	$ -	$ -	$ -
SUBTOTAL					**$ 150,000.00**		**$ -**	**$ 150,000.00**

B. Aeration	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
PentAir System	EA	NA	2	$ 3,071.00	$ 6,142.00	$ -	$ -	$ 6,142.00
Consulting (4)	Day	NA	2	$ 1,000.00	$ 2,000.00	$ -	$ -	$ 2,000.00
Install by Twp	hour	NA	16	$ 40.00	$ 640.00	$ -	$ -	$ 640.00
Trenching (3)	B.C.Y.	NA	11	$ -	$ -	$ 6.00	$ 66.00	$ 66.00
Mobilization Backhoe	LS	NA	1	$ 1,000.00	$ 1,000.00	$ -	$ -	$ 1,000.00
Wire (Electricity)	LF	UF-B	200	$ 0.40	$ 80.00	$ -	$ -	$ 80.00
Conduit (Electricity)	LF	3/4" D	200	$ 0.30	$ 60.00	$ -	$ -	$ 60.00
SUBTOTAL					**$ 9,922.00**		**$ 66.00**	**$ 9,988.00**

C. Plantings	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Trees (1)(2)	EA	1" cal	150	$ 70.00	$ 10,500.00	$ 140.00	$ 21,000.00	$ 31,500.00
Tree Tubes (2)	EA	60" ht	150	$ 2.50	$ 375.00	$ 5.00	$ 750.00	$ 1,125.00
Shrubs (2)	EA	24-36" ht	150	$ 36.00	$ 5,400.00	$ 70.00	$ 10,500.00	$ 15,900.00
Deer Mesh Fence (shrubs) (2)	EA	7' ht x 100LF	5	$ 125.00	$ 625.00	$ 200.00	$ 1,000.00	$ 1,625.00
Perennials (2)	EA	SP2	2000	$ 6.00	$ 12,000.00	$ 2.00	$ 4,000.00	$ 16,000.00
Meadow (5)	AC	NA	1	$ 2,000.00	$ 2,000.00	$ -	$ -	$ 2,000.00
Aquatic Plants	EA	2" Plug	1000	$ 1.00	$ 1,000.00	$ 2.00	$ 2,000.00	$ 3,000.00
Plug Planting Fence	LF	NA	500	$ 1.50	$ 750.00	$ 3.50	$ 1,750.00	$ 2,500.00
SUBTOTAL					**$ 32,650.00**		**$ 41,000.00**	**$ 73,650.00**

D. BMPs	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Rain Garden/Swale Bed Prep	CY	Avg .75' depth x 3'W	41	$ 13.00		$ -	$ 533.00	$ 533.00
Inlet Filter Bags	EA	Varies	0	$ 100.00	$ -	$ 200.00	$ -	$ -
SUBTOTAL					**$ -**		**$ 533.00**	**$ 533.00**

E. Other Features	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Benches (3)	EA	4'	5	$ 500.00	$ 2,500.00	$ 1,000.00	$ 5,000.00	$ 7,500.00
Gazebo	EA	8'x 10'	0	$ 4,000.00	$ -	$ 8,000.00	$ -	$ -
Split Rail Fence	LF	4' height	0	$ 6.00	$ -	$ 12.00	$ -	$ -
SUBTOTAL					**$ 2,500.00**		**$ 5,000.00**	**$ 7,500.00**

TOTAL: **$ 241,671.00**

Bow Tree 2 & 3 Pond - Rough Cost Estimate

A. Pond Upgrades	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Dredging	LS	NA	0	$ -	$ -	$ -	$ -	$ -
Forebay Construction	EA	NA	0	$ -	$ -	$ -	$ -	$ -
Structural Repairs	LS	NA	0	$ -	$ -	$ -	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

B. Aeration	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
PentAir System	EA	NA	0	$ 3,071.00	$ -	$ -	$ -	$ -
Consulting (4)	Day	NA	0	$ 1,000.00	$ -	$ -	$ -	$ -
Trenching (Electricity)	B.C.Y.	NA	0	$ -	$ -	$ 6.00	$ -	$ -
Mobilization Backhoe	LS	NA	0	$ 1,000.00	$ -	$ -	$ -	$ -
Wire (Electricity)	LF	UF-B	0	$ 0.40	$ -	$ -	$ -	$ -
Conduit (Electricity)	LF	3/4" D	0	$ 0.30	$ -	$ -	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

C. Plantings	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Trees (1)(2)	EA	1" cal	15	$ 70.00	$ 1,050.00	$ 140.00	$ 2,100.00	$ 3,150.00
Tree Tubes (2)	EA	60" ht	15	$ 2.50	$ 37.50	$ 5.00	$ 75.00	$ 112.50
Shrubs (2)	EA	24-36" ht	15	$ 36.00	$ 540.00	$ 70.00	$ 1,050.00	$ 1,590.00
Deer Mesh Fence (shrubs)(2)	EA	7' ht x 100LF	1	$ 125.00	$ 125.00	$ 200.00	$ 200.00	$ 325.00
Perennials	EA	SP2	0	$ 6.00	$ -	$ 2.00	$ -	$ -
Meadow	AC	NA	0	$ 2,000.00	$ -	$ -	$ -	$ -
Aquatic Plants	EA	2" Plug	0	$ 1.00	$ -	$ 2.00	$ -	$ -
Plug Planting Fence	LF	NA	0	$ 1.50	$ -	$ 3.50	$ -	$ -
SUBTOTAL					**$ 1,752.50**		**$ 3,425.00**	**$ 5,177.50**

D. BMPs	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Rain Garden/Swale Bed Prep	CY	Avg .75' depth x 3'W	0	$ 13.00		$ -	$ -	$ -
Inlet Filter Bags	EA	Varies	0	$ 100.00	$ -	$ 200.00	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

E. Other Features	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Benches (3)	EA	4'	2	$ 500.00	$ 1,000.00	$ 1,000.00	$ 2,000.00	$ 3,000.00
Gazebo	EA	8'x 10'	0	$ 4,000.00	$ -	$ 8,000.00	$ -	$ -
Split Rail Fence (3)	LF	4' height	216	$ 6.00	$ 1,296.00	$ 12.00	$ 2,592.00	$ 3,888.00
SUBTOTAL					**$ 2,296.00**		**$ 4,592.00**	**$ 6,888.00**

TOTAL: $ 12,065.50

Bow Tree 2 & 3 Basin - Rough Cost Estimate

A. Pond Upgrades	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Dredging	LS	NA	1	$ 20,000.00	$ 20,000.00	$ -	$ -	$ 20,000.00
Forebay Construction	EA	NA	0	$ -	$ -	$ -	$ -	$ -
Brush Clearing (3)	LS	NA	1	$ 1,500.00	$ 1,500.00	$ -	$ -	$ 1,500.00
SUBTOTAL					**$ 21,500.00**		**$ -**	**$ 21,500.00**

B. Aeration	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
PentAir System	EA	NA	1.56	$ 3,071.00	$ 4,790.76	$ -	$ -	$ 4,790.76
Consulting (4)	Day	NA	2	$ 1,000.00	$ 2,000.00	$ -	$ -	$ 2,000.00
Install by Twp	hour	NA	16	$ 40.00	$ 640.00	$ -	$ -	$ 640.00
Trenching (3)	B.C.Y.	NA	40	$ -	$ -	$ 6.00	$ 240.00	$ 240.00
Mobilization Backhoe	LS	NA	1	$ 1,000.00	$ 1,000.00	$ -	$ -	$ 1,000.00
Wire (Electricity)	LF	UF-B	480	$ 0.40	$ 192.00	$ -	$ -	$ 192.00
Conduit (Electricity)	LF	3/4" D	480	$ 0.30	$ 144.00	$ -	$ -	$ 144.00
SUBTOTAL					**$ 8,766.76**		**$ 240.00**	**$ 9,006.76**

C. Plantings	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Trees (1)(2)	EA	1" cal	50	$ 70.00	$ 3,500.00	$ 140.00	$ 7,000.00	$ 10,500.00
Tree Tubes (2)	EA	60" ht	50	$ 2.50	$ 125.00	$ 5.00	$ 250.00	$ 375.00
Shrubs (2)	EA	24-36" ht	50	$ 36.00	$ 1,800.00	$ 70.00	$ 3,500.00	$ 5,300.00
Deer Mesh Fence (shrubs)(2)	EA	7' ht x 100LF	2	$ 125.00	$ 250.00	$ 200.00	$ 400.00	$ 650.00
Perennials (2)	EA	SP2	1000	$ 6.00	$ 6,000.00	$ 2.00	$ 2,000.00	$ 8,000.00
Meadow (5)	AC	NA	1	$ 2,000.00	$ 2,000.00	$ -	$ -	$ 2,000.00
Aquatic Plants	EA	2" Plug	0	$ 1.00	$ -	$ 2.00	$ -	$ -
Plug Planting Fence	LF	NA	0	$ 1.50	$ -	$ 3.50	$ -	$ -
SUBTOTAL					**$ 13,675.00**		**$ 13,150.00**	**$ 26,825.00**

D. BMPs	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Rain Garden/Swale Bed Prep (6)	CY	Avg .75' depth, 3'W	28	$ 13.00		$ -	$ 364.00	$ 364.00
Inlet Filter Bags	EA	Varies	0	$ 100.00	$ -	$ 200.00	$ -	$ -
SUBTOTAL					**$ -**		**$ 364.00**	**$ 364.00**

E. Other Features	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Benches (3)	EA	4'	2	$ 500.00	$ 1,000.00	$ 1,000.00	$ 2,000.00	$ 3,000.00
Gazebo	EA	8'x 10'	0	$ 4,000.00	$ -	$ 8,000.00	$ -	$ -
Split Rail Fence (3)	LF	4' height	72	$ 6.00	$ 432.00	$ 12.00	$ 864.00	$ 1,296.00
SUBTOTAL					**$ 1,432.00**		**$ 2,864.00**	**$ 4,296.00**

TOTAL: **$ 61,991.76**

Marydell Pond - Rough Cost Estimate

A. Pond Upgrades	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Dredging	LS	NA	1	$ 100,000.00	$ 100,000.00	$ -	$ -	$ 100,000.00
Forebay Design	EA	NA	2	$ 5,000.00	$ 10,000.00	$ -	$ -	$ 10,000.00
Forebay Construction	LS	NA	1	$ 20,000.00	$ 20,000.00	$ -	$ -	$ 20,000.00
Structural Repairs (6)	LS	NA	1	$ 5,000.00	$ 5,000.00	$ -	$ -	$ 5,000.00
SUBTOTAL					**$ 135,000.00**		**$ -**	**$ 135,000.00**

B. Aeration	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
PentAir System	EA	NA	2.66	$ 3,071.00	$ 8,168.86	$ -	$ -	$ 8,168.86
Consulting (4)	Day	NA	2	$ 1,000.00	$ 2,000.00	$ -	$ -	$ 2,000.00
Install by Twp	hour	NA	16	$ 40.00	$ 640.00	$ -	$ -	$ 640.00
Trenching (3)	B.C.Y.	NA	55	$ -	$ -	$ 6.00	$ 330.00	$ 330.00
Mobilization Backhoe	LS	NA	1	$ 1,000.00	$ 1,000.00	$ -	$ -	$ 1,000.00
Wire (Electricity)	LF	UF-B	660	$ 0.40	$ 264.00	$ -	$ -	$ 264.00
Conduit (Electricity)	LF	3/4" D	660	$ 0.30	$ 198.00	$ -	$ -	$ 198.00
SUBTOTAL					**$ 12,270.86**		**$ 330.00**	**$ 12,600.86**

C. Plantings	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Trees (1)(2)	EA	1" cal	150	$ 70.00	$ 10,500.00	$ 140.00	$ 21,000.00	$ 31,500.00
Tree Tubes (2)	EA	60" ht	150	$ 2.50	$ 375.00	$ 5.00	$ 750.00	$ 1,125.00
Shrubs (2)	EA	24-36" ht	110	$ 36.00	$ 3,960.00	$ 70.00	$ 7,700.00	$ 11,660.00
Deer Mesh Fence (shrubs) (2)	EA	7' ht x 100LF	4	$ 125.00	$ 500.00	$ 200.00	$ 800.00	$ 1,300.00
Perennials	EA	SP2	0	$ 6.00	$ -	$ 2.00	$ -	$ -
Meadow	AC	NA	0	$ 2,000.00	$ -	$ -	$ -	$ -
Aquatic Plants	EA	2" Plug	1100	$ 1.00	$ 1,100.00	$ 2.00	$ 2,200.00	$ 3,300.00
Plug Planting Fence	LF	NA	550	$ 1.50	$ 825.00	$ 3.50	$ 1,925.00	$ 2,750.00
SUBTOTAL					**$ 17,260.00**		**$ 34,375.00**	**$ 51,635.00**

D. BMPs	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Rain Garden/Swale Bed Prep	CY	Avg .75' depth, 3'W	0	$ 13.00		$ -	$ -	$ -
Inlet Filter Bags	EA	Varies	0	$ 100.00	$ -	$ 200.00	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

E. Other Features	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Benches (3)	EA	4'	5	$ 500.00	$ 2,500.00	$ 1,000.00	$ 5,000.00	$ 7,500.00
Gazebo	EA	8'x 10'	0	$ 4,000.00	$ -	$ 8,000.00	$ -	$ -
Split Rail Fence	LF	4' height	0	$ 6.00	$ -	$ 12.00	$ -	$ -
SUBTOTAL					**$ 2,500.00**		**$ 5,000.00**	**$ 7,500.00**

TOTAL: **$ 206,735.86**

Pin Oak Pond - Rough Cost Estimate

A. Pond Upgrades	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Dredging	LS	NA	0	$ -	$ -	$ -	$ -	$ -
Forebay Design	EA	NA	1	$ 5,000.00	$ 5,000.00	$ -	$ -	$ 5,000.00
Forebay Construction	EA	NA	1	$ 5,000.00	$ 5,000.00	$ -	$ -	$ 5,000.00
Structural Repairs	LS	NA	1	$ 8,500.00	$ 8,500.00	$ -	$ -	$ 8,500.00
SUBTOTAL					**$ 18,500.00**		**$ -**	**$ 18,500.00**

B. Aeration	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
PentAir System	EA	NA	0	$ 3,071.00	$ -	$ -	$ -	$ -
Consulting	Day	NA	0	$ 1,000.00	$ -	$ -	$ -	$ -
Installation	hour	NA	0	$ 40.00	$ -	$ -	$ -	$ -
Trenching (Electricity)	B.C.Y.	NA	0	$ -	$ -	$ 6.00	$ -	$ -
Mobilization Backhoe	LS	NA	0	$ 1,000.00	$ -	$ -	$ -	$ -
Wire (Electricity)	LF	UF-B	0	$ 0.40	$ -	$ -	$ -	$ -
Conduit (Electricity)	LF	3/4" D	0	$ 0.30	$ -	$ -	$ -	$ -
SUBTOTAL					**$ -**		**$ -**	**$ -**

C. Plantings	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Trees (1)(2)	EA	1" cal	15	$ 70.00	$ 1,050.00	$ 140.00	$ 2,100.00	$ 3,150.00
Tree Tubes (2)	EA	60" ht	15	$ 2.50	$ 37.50	$ 5.00	$ 75.00	$ 112.50
Shrubs (2)	EA	24-36" ht	15	$ 36.00	$ 540.00	$ 70.00	$ 1,050.00	$ 1,590.00
Deer Mesh Fence (shrubs)	EA	7' ht x 100LF	1	$ 125.00	$ 125.00	$ 200.00	$ 200.00	$ 325.00
Perennials	EA	SP2	0	$ 6.00	$ -	$ 2.00	$ -	$ -
Meadow (5)	AC	NA	1.5	$ 2,000.00	$ 3,000.00	$ -	$ -	$ 3,000.00
Aquatic Plants	EA	2" Plug	0	$ 1.00	$ -	$ 2.00	$ -	$ -
Plug Planting Fence	LF	NA	0	$ 1.50	$ -	$ 3.50	$ -	$ -
SUBTOTAL					**$ 4,752.50**		**$ 3,425.00**	**$ 8,177.50**

D. BMPs	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Rain Garden/Swale Bed Prep	CY	Avg .75' depth, 3'W	0	$ 13.00		$ -	$ -	$ -
Inlet Filter Bags	EA	Varies	8	$ 100.00	$ 800.00	$ -	$ -	$ 800.00
Install by Twp	hour	NA	16	$ 40.00	$ 640.00	$ -	$ -	$ 640.00
SUBTOTAL					**$ 1,440.00**		**$ -**	**$ 1,440.00**

E. Other Features	UNIT	SIZE	QTY.	UNIT PRICE	MAT'L COST	LABOR	LABOR COST	TOTAL
Benches	EA	4'	3	$ 500.00	$ 1,500.00	$ 1,000.00	$ 3,000.00	$ 4,500.00
Gazebo	EA	8'x 10'	1	$ 4,000.00	$ 4,000.00	$ 8,000.00	$ 8,000.00	$ 12,000.00
Split Rail Fence	LF	4' height	0	$ 6.00	$ -	$ 12.00	$ -	$ -
SUBTOTAL					**$ 5,500.00**		**$ 11,000.00**	**$ 16,500.00**

TOTAL: $ 44,617.50

appendix 2

supporting documents – *provided in digital format*

2A: PSU Materials – Water Quality

2B: Chester County Water Resource Authority maps

2C: East Goshen Township Stormwater Management Quad Maps

2D: DEP – Stormwater Inlet Bag Detail

2E: TreeVitalize Watershed Grant Information

2F: Forebay Detail

2G: Philadelphia Water Department Residential Rain Garden Information

2H: Rain Barrel Assembly Instructions

2I: Downspout Planter Details

2J: Wetland Planting Guide

2K: Pentair Aeration Products

2L: Meadows in Southeastern Pennsylvania

2M: From Mowing to Meadows article in County Lines Magazine

2N: Aquatic Plant List

2O: Buffer Plant List

Natural Lands' Hildacy Preserve
Media, PA
55 acres

Natural Lands

Hildacy Preserve
1031 Palmers Mill Road
Media, PA 19063
610-353-5587
natlands.org

PennState Extension

Pond Ecology

A brief overview of the natural processes of an earthen pond and how to maintain a healthy pond.

ARTICLES | **UPDATED: AUGUST 14, 2017**

Introduction

Pond ecology is best described as the interaction of the life in your pond with the environment that exists there. A shallow, nutrient rich pond, exposed to sunlight with little water flowing through it will be teeming with algae and aquatic plants. It may have very little animal life present because of low oxygen levels. In contrast a newly created, deep, spring fed pond may have little life of any kind in it because of low temperatures and lack of food supply.

All ponds age. A pond begins with mostly water, few nutrients, and little aquatic life. Over time the pond accumulates nutrients. This enrichment process is called eutrophication. The addition of nutrients stimulates the growth of aquatic life. These organisms live and grow and die. Their remains decay in the pond and the nutrients it took to grow them are released back into the water of the pond to keep the cycle going. Eventually, though, there will be an accumulation of material that resists decay and the pond will fill up. It will become a bog and someday will resemble dry land. The process of return to dry land can happen in a decade or may take

centuries. As a pond owner your job is to slow the process down as much as possible. Some of the principles you can employ are described below.

Exclude Nutrients

Four basic elements are required to make aquatic organisms. They are carbon, oxygen, nitrogen, phosphorous. Of course it takes more than these to make even the simplest organism, but these are the materials required in abundance. To prevent the rapid aging of a pond (eutrophication) aim to exclude the rapid introduction of these, especially nitrogen and phosphorus. There are three practices that are particularly helpful in slowing the aging process.

Animal access to ponds or streams that feed ponds should be restricted to limit inputs of nitrogen and phosphorus from their wastes.

Buffers

Maintaining vegetation in all areas through which water must flow to reach the pond is very beneficial to the pond. Such buffers both slow water down and filter it. Slow moving water allows sediment to drop out of the water. Much phosphorus is attached to soil particles so that sedimentation is effective in keeping phosphorus out of the pond. Keeping sediment out of the pond also prevents the pond from being made shallow by filling it with sediment. This contributes directly to our primary objective keeping the pond from returning to dry land. A deeper pond, will also be a cooler pond. A general principle of biology is that lower temperatures slow the growth of organisms. So again the buffer area contributes to conditions that help slow the aging process for the pond.

Sedimentation

Another method of keeping sediment out of ponds is to provide a shallow pool at the inlet of the pond. Water passing through this pool on its way to the pond will have an opportunity to drop its sediment load in the pool. This pool should be of such dimensions that it can be easily cleaned with a backhoe from the shore of the pool. A sedimentation pool helps the pond in the same way that sediment removal by buffer strips does.

Limit Fertilization

When it is possible to decrease the use of fertilizer on turf or crops grown in the watershed area of the pond, the pond will receive a benefit. One of the reasons for this is that plants are never 100 percent efficient in their use of fertilizer elements. So even applying fertilizers at appropriate rates results in some elements, particularly nitrogen, being not used and moving off site. Reductions in fertilizer rates will decrease the amounts getting off site.

Maintain Ecological Balance

Ponds are most satisfactory when there is a complete and balanced food web in place. Starting at the top this means that planktonic algae are present in sufficient quantity to feed some zooplankton. The zooplankton in turn provides food for the smallest fish and aquatic insects. These in turn become prey for larger fish which finally may be taken by raccoons, bears, or fishermen.

Another part of ecological balance involves the higher plant community. Too many plants are discouraging to the pond owner and are also detrimental to the food side of the ecology just described. From the pond owners point of view, a pond full of vegetation presents a poor appearance, interferes with fishing, swimming, and boating. From the view point of aquatic life there are problems too. Some aquatic plants are valuable in providing shade, hiding places for small fish, habitat for some aquatic insects and animals, as well as being a food source for some fish and animals. When the vegetation becomes excessive not only does the angler's hook get entangled, the bait is hidden from that trophy bass. The vegetation that hides the bait also hides his prey making the hunt unsuccessful. Such a pond decreases its capacity to produce fish.

Two other examples of excessive vegetation will serve to illustrate undesirable consequences than can occur. A pond completely covered with water lilies or lotus will so shade the pond that no other vegetation will grow under the water. Neither will their be light enough to grow planktonic algae. This will be a very unproductive pond for anything besides lilies. The other example is excessive growth of duck weed or Watermeal. When the whole pond surface is covered with these plants, again the light is shut off and the pond will contain little life beneath the surface. These plants also virtually eliminate oxygenation of the water by maintaining a

pond becomes oxygen deficient to such an extent that any fish present are killed from lack of oxygen.

A seldom discussed problem in the management of aquatic vegetation is the potential to eliminate too much vegetation or to eliminate beneficial plants along with the targeted weeds. This is something to remember when considering weed control in ponds. Some helps are to treat the pond in parts over time, to use mechanical methods, or perhaps to use an appropriate number of grass carp to keep things "pruned up" instead of wiped out.

Maintain Water Flow

A discussion that occurs when a new pond is planned concerns the water supply for the pond. A pond with a continuous supply of water is almost always going to be a more satisfactory pond than one with an intermittent water supply. Ponds lose significant water by evaporation during the summer. Ponds with sufficient inflow stay full while the water level in others declines exposing an unattractive muddy beach around the perimeter of the pond. The nutrient conditions in a pond with a continuous overflow are likely to be better, because excess nutrients will leave with the overflow water. In contrast the pond having intermittent flows only has a chance to purge excess nutrients during storm events. Such ponds are prone to accumulate nutrients much more rapidly than their overflowing cousins. The accumulation of nutrients leads to excessive vegetative growth of all kinds as was noted above.

Encourage Aeration

Oxygen in pond water is very beneficial to the overall health of the pond. The value to fish is obvious. Less obvious, but of great importance, is the ability of the pond to get rid of waste. The waste that occurs in the pond includes "deposits" from its animal life - fish and geese, waste material that enter with storm water runoff, as well as plant and animals that die in the pond. Aerobic bacteria work about 20 times faster than anaerobic bacteria in breaking this waste down and putting it into solution. Once in solution it can be flushed out or is available to grow new life.

Oxygenation of pond is quite interesting. It happens in two major ways. Plants and algae do photosynthesis during the day and wind adds oxygen at night. The oxygen plants produce is released into the pond water and maintains high levels of oxygen in the pond. That's why conditions that prevent light from entering the pond have to

be monitored or disaster can occur such as the complete cover by Watermeal mentioned earlier. All the oxygen manufactured by the Watermeal is released to the atmosphere rather than into the pond water. Any part of the pond that is too dark for photosynthesis to occur is also likely to be oxygen deficient unless the pond is being mixed from top to bottom. A Secchi disk can be lowered into the water to check for visibility. The depth of disappearance is noted. The surface water above this disappearance depth will be oxygenated by photosynthesis while water below that depth must be mixed to receive oxygen.

The other method of getting oxygen into pond water occurs by oxygen exchange with the atmosphere at the surface of the pond. The rougher the surface the more rapid the exchange. Also the more deficient the oxygen content of the water the faster the exchange occurs. This process is important at night and is critical for the pond with a heavy load of plants and animals. At night the plants do respiration instead of photosynthesis the same as the animals. By dawn the pond may be oxygen deficient if atmospheric aeration is impeded by lack of wind or especially by a covered surface.

Winter Pond Ecology

In the winter water gets much colder and ice may cover the top of the pond for an extended period of time. How do these factors affect the animals living in the pond?

Fish, frogs, and turtles are amphibians with adaptive features to accommodate this less friendly environment. Their body temperature falls with the water temperature decreasing their respiration rate and energy needs. Frogs and turtles burrow into the mud at the bottom of the pond and hibernate there. They are able to do this by breathing through their skin.

Since ice cuts off the entry of oxygen into the pond water through the surface you may wonder how even the low level of oxygen needed is supplied during this time. Enough light gets through the ice to cause some photosynthesis among aquatic plants. A completely snow covered pond can cause "winter kill," the death of fish, frogs, and turtles. However, hand plowing lanes across a pond to clear the snow from about half the ice prevents that from happening.

A winter management consideration is to keep about 30% of the ice free of extended snow cover. Be sure that the ice is safe for the method of snow removal

proposed. An alternative is to use a diffuser type aerator to add oxygen and keep a small area free of ice.

Summary

Ponds have a life cycle. A long life is best achieved by limiting the inputs of nutrients to the pond. Capture sediment before it enters the pond, limit the use of fertilizers within the pond's watershed to the extent possible, limit animal access when possible, and prevent the addition of organic matter. Flushing of nutrients from the pond is encouraged by a clean, year round water supply. Mechanical removal of plant vegetation is also a method of removing significant nutrients from a pond. Finally the values of aeration in both supporting aquatic life and promoting the decay of waste material were noted. Keeping the surface clear of plant cover and open to wind action are aids to better aeration.

More Information

More detailed information on all aspects of pond management can be found at your local county extension office or on the Penn State Extension website.

Prepared by Thomas McCarty, extension educator in Cumberland County.

PENNSTATE

College of Agricultural Sciences • Cooperative Extension

School of Forest Resources

Pond Facts #5

Water Quality Concerns for Ponds

A 1998 survey of 557 pond owners in Pennsylvania found that about 10 percent had experienced water quality problems in their ponds, ranging from muddy water to fish kills. Unfortunately, most pond owners have never tested their ponds, and water quality problems are usually only detected after they cause a problem. This fact sheet discusses some common water quality parameters that may cause problems in ponds and how to detect and treat them.

Water quality conditions in a pond are controlled by both natural processes and human influences. Natural factors such as the source of the pond water and the types of rock and soil in the pond watershed will influence some water quality characteristics. These factors are difficult to control but usually cause few problems. Instead, most serious water quality problems originate from land uses or other activities near or in the pond. The effects of these activities can often be minimized through proper management and early detection of problems through testing.

Pond Uses and Water Quality Concerns

Concerns about pond water quality are directly related to the use(s) of the pond. As with all pond management decisions, consider the primary uses of your pond to determine which water quality parameters are of greatest concern. For example, a pond used to supply drinking water for animals should be tested for different parameters than a pond used exclusively for fishing. Table 1 summarizes the important water quality parameters and pond uses that are described in this fact sheet.

Common Water Quality Parameters

Temperature

Temperature is most important for fish and other aquatic life in the pond. Ponds that are generously fed from underground springs will have colder water that can support cold-water fish such as trout. Temperature can vary greatly throughout the pond, with surface water affected more by air temperature than deeper water. Thus, the top of the pond will be slightly warmer in the summer and colder in the winter than deeper portions of the pond.

Little can be done to alter the temperature of pond water. Groundwater may be pumped into the pond to create cold-water ponds during the summer. In most cases, however, it is best to match the types of fish stocked in a pond with the existing temperature regime. Cold-water fish prefer maximum water temperatures below 70°F, while warm-water fish like bass and bluegill prefer summer temperatures in the 80s. Water temperature is also important when using aquatic herbicides to treat plant or algae growth. Aquatic herbicides are most effective when water temperatures are between 60 and 75°F. Consult the herbicide label for details.

Dissolved Oxygen

The amount of oxygen that is dissolved in the water is critical for fish and other pond life. The maximum amount of oxygen that can be dissolved is controlled by the water temperature. Warmer water can hold less dissolved oxygen than colder water. In general, most pond water can hold about 10 to 12 mg/L of oxygen. Dissolved oxygen is reduced by the biological decay of organic material such as decaying plants and animals or animal and human wastes. Dissolved oxygen levels below about 6 mg/L can

Table 1. Important water quality parameters and criteria for common pond uses in Pennsylvania. Missing values represent parameters that are not important for that use.

Parameter	Primary Pond Use				
	Animal Drinking	**Swimming**	**Fishing**	**Irrigation**	**Beauty**
Fecal coliform bacteria	Less than 10 colonies per 100 mL	Less than 200 colonies per 100 mL			
E. coli bacteria	0 colonies per 100 mL	Less than 150 colonies per 100 mL			
pH	5.5 to 8.5		6.0 to 9.0	6.5 to 8.4	
Copper	< 1 mg/L		< 1 mg/L		
Iron	< 0.3 mg/L			< 0.3 mg/L	
Manganese	< 0.05 mg/L			< 0.05 mg/L	
Nitrate-Nitrogen	< 23 mg/L				< 3 mg/L
Phosphorous					< 0.01 mg/L
Ammonia-Nitrogen			< 0.1 mg/L		
Blue-green algae	None				None
Pesticides	See pesticide label for information on harmful effects in water.				
Turbidity		Secchi disk > 3’	Secchi disk > 1’		Secchi disk > 5’
Parasites	None	None			None
Summer Maximum Water Temperature			Less than <70° F for trout and smallmouth bass		
Dissolved oxygen			Trout > 6 mg/L Bass > 5 mg/L		> 5 mg/L
Aquatic herbicides	See herbicide label for water use restrictions and concentrations for different pond uses.				

begin to have detrimental effects on pond life.

A lack of dissolved oxygen is the most common cause of fish kills in ponds. This occurs frequently when aquatic plants and algae die in the summer or when they are treated with aquatic herbicides. Fish kills due to low oxygen are most common during hot, dry spells when algae grow and then die quickly. The organisms that decompose the dead algae may use so much oxygen that what remains is insufficient for fish. In very deep ponds, the deepest portions of the pond may have very low dissolved oxygen concentrations due to poor aeration.

Problems with dissolved oxygen can usually be controlled by carefully using aquatic herbicides to prevent excessive plant and algae growth in the pond. Ponds that frequently have reduced dissolved oxygen concentrations could benefit

Figure 1. Low dissolved oxygen is the most common cause of fish kills in ponds.

from commercially available continuous aeration devices.

Muddy Water (Turbidity)

Muddy or turbid pond water is usually only an aesthetic problem. It is frequently caused by runoff from disturbed areas around the pond or from bottom-dwelling fish and muskrats. Muddy water is best solved by eliminating the source of the problem. This might include planting grass or other vegetation on exposed areas, putting a layer of rocks over exposed banks, or removing muskrats or bottom-dwelling fish. Persistent muddy water problems can be treated with additions of ground limestone, hydrated lime, gypsum, or alum. Ponds that are only turbid or colored during the summer are probably experiencing zooplankton blooms. Zooplankton are small animals that serve as a food source for fish and other aquatic life. Zooplankton can be distinguished from sediment in water by holding a clear glass of pond water up to a bright light. If most of the particles in the water move erratically, the pond is experiencing a zooplankton bloom. If the particles do not move, sediment is the cause of the water discoloration. Zooplankton blooms can be eliminated with copper sulfate, but in most cases the health of the pond is best served if they are left untreated.

Muddy water is very common in new ponds and usually disappears as vegetation grows around the pond. In established ponds, muddy water can almost always be traced to a preventable source.

Sediment or turbidity in pond water can be measured using a simple device called a Secchi disk. This black and white weight is lowered into the water until it is barely visible and the depth of water is recorded. Recommended Secchi disk values for various pond uses are given in Table 1 with larger values representing clearer water.

Coliform Bacteria

Coliform bacteria are a large group of many different bacteria, some of which can cause waterborne illnesses. Some coliform bacteria will occur in all ponds, but dangerously high levels may occur in ponds that receive animal wastes from barnyards or wildlife or human wastes from septic systems. Large numbers of waterfowl will increase bacterial contamination in small ponds. Coliform bacteria from human or animal wastes can be identified through separate water tests for fecal coliform bacteria or *E. coli* bacteria. A certified water-testing laboratory should do this test. These bacteria are generally only a concern if the water will be used for animal drinking water or for swimming. It is recommended that ponds used for swimming contain less than 200 fecal coliform bacteria per 100 mL of water and less than 150 *E. coli* bacteria per 100 mL of water. Pond waters used for livestock watering should contain less than 10 fecal coliform bacteria per 100 mL and no *E. coli* bacteria, especially for calves and other young livestock.

Nutrients

Many ponds suffer from excessive amounts of nitrogen and phosphorous from barnyards, crop fields, septic systems, lawns, golf courses, and waterfowl. Nitrogen is usually present in ponds as ammonia or nitrate, while phosphorous occurs as phosphate. Ammonia usually originates from animal or human wastes directly entering the pond. It is extremely toxic to fish and other aquatic life and any measurable amount of ammonia-nitrogen above 0.1 mg/L can be detrimental to the pond's health. Both nitrogen and phosphorous can be readily

used by aquatic plants and algae, which may lead to excessive growth. Long-term control of overabundant plants is best accomplished by reducing or redirecting nutrient sources to the pond. This may be done by reducing fertilizer use near the pond, maintaining, improving or relocating septic systems, directing nutrient-laden runoff away from the pond, or maintaining buffer strips around the pond. If you fail to address the underlying cause of plant growth, you must rely on continuous control of the plants using mechanical, biological, or chemical techniques. The death of large amounts of aquatic plants or algae, whether naturally or as a result of herbicide use, will consume dissolved oxygen from the water and may lead to fish kills.

Nitrate-nitrogen concentrations above 3 mg/L are indicative of pollution. Phosphate concentrations as low as 0.01 mg/L may be sufficient to increase plant and algae growth. Excessive amounts of nitrate can also be dangerous for drinking water. Dairy cows should not drink water with nitrate concentrations in excess of about 23 mg/L measured as nitrate-nitrogen.

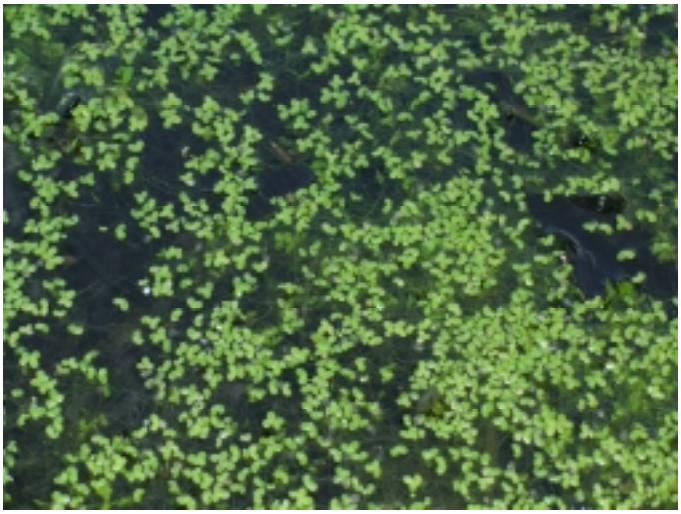

Figure 2. Excessive nutrients cause abundant plant growth (like duckweed in this picture) than can result in reduced dissolved oxygen in the pond.

Nitrate and phosphate can both be measured with simple water test kits or through certified commercial water testing laboratories.

Pesticides

Pesticides in ponds may result from their use on nearby land areas or from aquatic herbicides used to reduce plant and algae growth. When using aquatic herbicides, make sure you obtain the required state permit, and read and follow the herbicide label instructions carefully. In some cases, the pond water should not be used for swimming, irrigation, livestock watering, or fish consumption for a specified period of time. Many aquatic herbicides are also toxic to fish and should be used carefully in ponds with fish.

Pesticides applied to the land surrounding a pond may occasionally reach the pond, especially on windy days or when heavy rain occurs shortly after application. Excessive concentrations are usually short lived, but they may result in fish kills, waterfowl death, animal sickness, and plant injury if the pond water is used for irrigation. Insecticides are especially problematic and have occasionally caused fish kills in ponds. These problems are rare and short-lived but underscore the importance of careful use of pesticides in and around ponds.

pH

The pH of a pond is a measure of the acidity of the water. Farm ponds in valleys underlain by limestone will usually have a pH of 7.0 to 8.5. Higher elevation ponds or those located in the Poconos or northern Pennsylvania tend to have a lower pH, often less then 7.0. The pH of pond water is important for a number of pond uses. Different types of fish tolerate different pH levels but, in general, most fish will do better in ponds with a pH near 7.0. Ponds with a pH less than 6.0 may result in stunted or reduced fish populations. Ponds with a pH less than 5.5 or above 8.5 should not be used for dairy cows. Very low pH may be found in ponds in mining areas that are affected by acid mine drainage. In this case, the pH may be too low to support fish life, and the water also may be unusable for livestock watering. Low-pH ponds are often treated by applying limestone. This is most easily done by broadcasting one to two tons of pulverized limestone over the pond ice during

the winter. Repeated applications are often necessary to maintain a high pH in acidic ponds.

Hardness

Hardness is a measure of calcium and magnesium concentration in water and is controlled by the source of the pond water. Ponds in limestone areas will generally have harder water than those in areas underlain by sandstone or shale. The hardness of pond water is usually unimportant except when using some aquatic herbicides. Hardness concentrations above 50 mg/L can reduce the effectiveness of some copper-based herbicides. Consult the label of aquatic herbicides to see if water hardness needs to be considered.

Algae

Some types of blue-green algae are a water quality concern in ponds used for livestock watering. Although they are very rare in Pennsylvania, some of these algae can produce toxins that may sicken or quickly kill animals that drink the water. These toxins are produced during or following excessive growth or "blooms," which usually occur after extended periods of hot weather. Testing for toxic blue-green algae is difficult and not commonly available. Thus, farmers using a pond for livestock watering should prevent excessive algae growth or limit animal access to these ponds during and immediately after algae blooms. The common types of filamentous algae that produce long strands or mats are not harmful to animals.

Metals

Metals such as iron, manganese, and copper in ponds can produce offensive tastes that may affect animal intake. Iron and manganese are most common in ponds in coal mining areas in western Pennsylvania. While these metals are not harmful, they may cause offensive tastes that will cause animals to limit or refuse intake of the water. High iron concentrations may also adversely affect pond aesthetics by precipitating as an orange coating on the pond bottom, docks, and vegetation. Iron concentrations above 0.3 mg/L and manganese concentrations above 0.05 mg/L will impart a metallic taste to water and may cause problems with irrigation injury to plants. Similarly, copper concentrations above 1.0 mg/L can cause an offensive metallic taste. High copper concentrations may result from repeated use of copper-based algaecides in a pond.

Protozoan Parasites

Various protozoa or parasites can occasionally affect ponds. *Giardia* and *Cryptosporidium* are protozoa that can occur in any surface water and may cause severe gastrointestinal problems if ingested. Even if they are present, they are unlikely to cause a problem for animal consumption or for humans swimming in the water. Another rare parasite in ponds may cause "swimmer's itch." This parasite burrows into the skin of swimmers where it dies, causing an itchy feeling after leaving the water. While rare, this problem can occur occasionally in ponds especially those with low fish populations. The parasite requires snails in the pond to complete its life cycle. It can be controlled by reducing the snail population by treating the water with copper sulfate. Snail populations may also be reduced by stocking red-ear sunfish in the pond; however, they may compete with other fish in the pond.

Water Testing Options

Testing your pond's water quality is relatively simple and inexpensive. Identify the uses of your pond, then test the water for the parameters that are important for that use. Inexpensive water testing kits are available at many pet stores and also online. Two large manufacturers of water testing kits are:

LaMotte Company: http://www.lamotte.com/
Hach Company: http://www.hach.com/

Water testing can also be accomplished by dozens of certified commercial water testing laboratories in Pennsylvania. A list of these laboratories is available at your local Penn State Cooperative Extension Office or online at http://www.dep.state.pa.us/labs/.

Figure 3. Simple water test kits, available from many pet stores or online retailers, are adequate for most water quality pa-

Preventing Water Quality Problems

Water quality problems in ponds can usually be prevented with some proper management techniques. Here are some tips:

- Test the pond water periodically to determine bacteria levels and to monitor the presence of any other nonvisible problems.
- Match fish to the natural temperature regime of the pond.
- Prevent overabundant growth of aquatic plants and algae.
- Never treat more than half of the pond with aquatic herbicides.
- Carefully read and follow label directions when using aquatic herbicides.
- Strictly limit polluting activities near the pond or in areas that drain into the pond.
- Maintain a vegetated buffer strip around the pond. For gentle slopes around a pond, a buffer four to ten feet wide of unmowed grass will suffice. A wider buffer would be needed if the land slopes more steeply around the pond.
- Use ditches and grading to divert polluted surface water away from the pond.

More Information

More detailed information on pond water quality and other aspects of pond management can be found in *Management of Fish Ponds in Pennsylvania* available from your county Penn State Cooperative Extension office or online at: http://pubs.cas.psu.edu/FreePubs/uh137.html

For further information and publications on pond management visit our Web page at: http://www.sfr.cas.psu.edu/water/ or contact your local cooperative extension office.

Prepared by Bryan R. Swistock, extension associate; William E. Sharpe, professor of forest hydrology; and Tom McCarty, extension educator in Cumberland County.

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This publication is available in alternative media on request.

CODE XH0009

PennState Extension

Interpreting Water Tests for Ponds and Lakes

This document describes parameters included in the Penn State pond/lake water test kit to help pond owners detect common water quality problems.

ARTICLES | UPDATED: AUGUST 8, 2017

The recommendations below assume that the pond or lake is used for recreational purposes. If your pond is used as a source of drinking water for livestock, consult Interpreting Drinking Water Results for Dairy Cows.

E. coli Bacteria

These bacteria originate from the wastes of animals or humans. Thus, high numbers of *E. coli* in a pond could come from septic systems, runoff from barnyards, or from wildlife (especially large numbers of waterfowl). Ponds and lakes used for swimming and other recreation should have less than 126 colonies of *E. coli* bacteria per 100 mL of water. High levels of *E. coli* bacteria can be reduced by limiting animal access to the pond, maintaining nearby septic systems, and redirecting runoff from barnyards and other areas where animal wastes accumulate.

Nitrate-Nitrogen and Total Phosphorus

Nitrogen and phosphorus are nutrients that may cause increased growth of aquatic plants and algae. Nitrate-nitrogen concentrations above 3 mg/L and any detectable

amounts of total phosphorus (above 0.025 mg/L for our laboratory) may be indicative of pollution from fertilizers, manures or other nutrient-rich wastes.

Reducing nutrient levels is critical to control nuisance growth of aquatic plants and algae. This can be accomplished by reducing the use of fertilizers near the water, keeping geese and domestic animals away from the pond, redirecting runoff from barnyards and fertilized areas, maintaining a 30-foot or wider buffer strip of higher grass around the perimeter of the pond and maintaining or relocating nearby septic systems.

Total Dissolved Solids (TDS)

The sum of all the chemical ions dissolved in the water is called total dissolved solids or TDS. TDS is controlled by the natural source of pond water and by nearby land use activities. Some ponds will have naturally high TDS levels while others will be naturally low. Therefore, it is important to monitor TDS in ponds and watch for significant increases over time that might indicate pollution. Single measurements of TDS above 1,000 mg/L could be indicative of a pond that has an existing water quality problem.

pH

The pH of a pond or lake should generally fall between 6.0 and 9.0. Different types of fish tolerate different pH levels but, in general, most fish will do better in ponds with a pH near 7.0. Ponds with a pH less than 6.0 may result in stunted, reduced or even absent fish populations. Low-pH ponds are often treated by applying limestone. This is most easily done by broadcasting pulverized limestone over the pond surface. Application rates of one to two tons of limestone per surface acre of pond are common but will vary depending on the pond pH and the rate of water moving through the pond.

Alkalinity

Measurable alkalinity in a pond provides a buffer that maintains the pH of the pond or lake. The pH of ponds with low or zero alkalinity may easily change resulting in damage to aquatic life. A healthy pond should have some measurable alkalinity. Ponds with less than 20 mg/L of alkalinity are more prone to stunted or absent fish

populations. These ponds may benefit from liming to increase the pH and alkalinity as described above.

Hardness

Hardness is a measure of calcium and magnesium concentration in water and is controlled by the source of the pond water. Ponds in limestone areas will generally have harder water than those in areas underlain by sandstone or shale. The hardness of pond water is usually unimportant except when using some aquatic herbicides. Hardness concentrations above 50 mg/L can reduce the effectiveness of some copper-based herbicides. Consult the label of aquatic herbicides to see if water hardness needs to be considered. Very high levels of hardness, above 150 mg/L, may also cause clogging problems with drip irrigation equipment.

Iron and Manganese

Iron and manganese are most common in ponds in coal mining areas in western Pennsylvania. While these metals are not directly harmful, they may adversely affect pond aesthetics by precipitating as an orange-brown coating on the pond bottom, docks, and vegetation. These precipitates may also smother aquatic life and they may cause injury to plants that are irrigated with water from the pond. Iron concentrations above 0.3 mg/L and manganese concentrations above 0.05 mg/L are problematic.

Aluminum

Aluminum is extremely toxic to aquatic life. Concentrations above 0.1 mg/L have been shown to be toxic to the most sensitive species such as trout and various minnows. High aluminum levels usually result from nearby coal mining or from the release of aluminum from soils near the pond due to acid rain.

Sulfate

High sulfate levels, above 250 mg/L, are indicative of a pond that is impacted by acid mine drainage or acid rain. These ponds usually have a low pH and high levels of metals (iron, manganese or aluminum). High sulfate levels alone are only problematic if the pond water is used for irrigation purposes.

Other Important Pond and Lake Tests

There are other important measures of pond and lake water quality that are not included in the Penn State water test kit because they must be tested directly at the pond or lake.

Water Temperature

A simple thermometer can be used to test pond water temperature. Maximum summer water temperatures are critical for fish and other aquatic life in the pond. Coldwater species like trout must have summer water temperatures below 72°F while warm water fish like bass prefer summer water temperatures above 80°F. Temperature will vary throughout the pond, with surface water affected more by air temperature than deeper water. Little can be done to alter the temperature of pond water

Dissolved Oxygen

Dissolved oxygen must be measured quickly at the pond or lake using either expensive meters or less expensive (but less accurate) kits. The amount of oxygen that is dissolved in the water is critical for fish and other pond life. The maximum amount of oxygen that can be dissolved is controlled by the water temperature. Warmer water can hold less dissolved oxygen than colder water. Thus, like water temperature, dissolved oxygen also varies considerably with water depth. Dissolved oxygen is reduced by the biological decay of organic material such as decaying plants and animals or animal and human wastes. Dissolved oxygen levels below about 6 mg/L can begin to have detrimental effects on pond life. A lack of dissolved oxygen is the most common cause of fish kills in ponds. Problems can often be controlled by controlling aquatic plant and algae growth. Aeration devices can be use to increase dissolved oxygen in ponds that experience frequent problems.

Secchi Depth

A Secchi disk is a black and white oval that is lowered into the water until it cannot be seen from the water surface. The depth where it is no longer visible is known as the Secchi depth. This measures the cloudiness of the water due to plankton growth or suspended sediment in the water. Ponds with less than one foot of Secchi depth

are candidates for lethally low levels of dissolved oxygen levels A Secchi depth of less then three feet suggests a need to reduce nutrient levels in the pond water.

More Information

Consult the Penn State Extension website or by contacting your local county Extension office.

Water Tests:

What Do the Numbers Mean?

PENNSTATE
1855
College of Agricultural Sciences
Agricultural Research and Cooperative Extension

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About This Publication

Congratulations! If you are interested in this publication, you must have had your water tested. That's a big step toward ensuring that your water supply is safe to drink. But are you able to understand and interpret what your water test report really means? Water test reports sometimes seem as though they are written in another language. That's where this publication fits in—it will help you translate your water test report into more understandable terms.

If water tests are completely new to you, you might want to read the first few pages, which give a description of a sample water test report and provide specific explanations of drinking water standards and measurement units. If you're more experienced with water tests, you might want to go straight to the detailed discussions of 40 common water quality problems in Pennsylvania or consult the quick reference guide that summarizes these 40 contaminants in one table. References to more detailed written and Web-based publications can be found in many of the topics and near the end of the publication. You can even get some tips on what to do if your water test report indicates a water quality problem. In the Appendices, you'll find a detailed listing of up-to-date drinking water standards and a glossary that defines some of those confusing water quality terms. Finally, you can use the last two pages to compile a record of information essential to the operation of your water supply. The pocket provided inside the back cover is a handy place to store water test reports and other important information (well logs, treatment equipment manuals, etc.).

That water test report may look confusing, but with a little help you can make sense out of it in no time! If you're ready, let's start learning about your report and what it tells you about the safety of your drinking water.

Why Test Your Water?

If you've had your water tested, you probably did so to find out if it is safe to use as a drinking water supply. Even if your water tastes, smells, and looks fine, water testing is necessary because many contaminants have no obvious odors or tastes. In other cases, where a water quality problem is obvious, testing can determine the exact concentration of the pollutant to assist in determining the best solution to the problem.

Water testing is especially necessary if your house is served by a private water system, because many of these systems have water quality problems. Private water systems include drilled wells, dug wells, springs, or cisterns that serve an individual home. There are no regulations or laws that require water testing, system maintenance, or water treatment on these water supplies. Rather, owners must voluntarily arrange for water testing and must voluntarily correct any problems to provide safe drinking water. Regardless of whether your water supply is private or public, the information in this publication will help you interpret water test results.

If you live in a community that is served by a public water supply (i.e., one source of water for multiple customers), then the water company already does water testing for you. Public water suppliers are required by law to routinely test their water and treat it to meet water quality standards. They are also required to issue water test reports to their customers on a regular basis. This publication may be helpful in interpreting these reports also.

Although drinking water standards are applicable to all types of water supplies, they are not legally binding for private water supplies. It is recommended, however, that private water supply owners maintain their water quality to the same standards required by law for public water supplies.

Use a Certified Laboratory

Always have your water tested by a certified water testing laboratory. The Pennsylvania Department of Environmental Protection (DEP) certifies water testing laboratories in Pennsylvania to ensure they are using analytical procedures designed to give accurate test results. Be sure to ask if the lab is certified every time you have your water tested. Laboratories are re-evaluated periodically, and their certification status may change. You can obtain a list of certified labs from your local Penn State Cooperative Extension Office or from your local DEP office. Also, your local DEP office can arrange for bacteria testing through their state laboratory.

Be cautious of water test results from uncertified labs. In addition, be cautious of water test results from salespeople and others who say they have their own laboratories or who try to test water at your residence. Always have these tests confirmed by a certified laboratory and, if possible, interpreted by a knowledgeable and neutral third party before taking corrective action.

Once you have received your water test report from the laboratory, you're ready to interpret exactly what it means. The example water test report on the next page will get you started by familiarizing you with the information presented in the report.

For More Information on Having Your Water Tested

Testing your water is like a trip to the doctor. If you have no idea what is wrong, the doctor will have to run every known test to pin down the problem, and the cost could be enormous. Fact sheet #F-104, *Water Testing*, is available from your local extension office to help you determine which water tests are most appropriate for your water supply.

Water Analysis Report

1

Client: John Doe

12 University Street

Anytown, PA 10000

Sample Number:	1000034
Sample Description:	Well water at kitchen tap
Sampled By:	Client
Date/Time Sampled:	3/22/00 10:00 AM
Date/Time Sample Received:	3/22/00 1:00 PM

2 3 4 5

Analysis	Result	Unit	Standard
Total Coliform Bacteria	20	per 100 ml	0 per 100 ml
Fecal Coliform Bacteria	ND	per 100 ml	0 per 100 ml
pH	7.2	pH units	6.5 to 8.5
Hardness	7.3	gpg	no standard
Total Dissolved Solids	260	mg/L	< 500 mg/L
Iron	0.4	mg/L	< 0.3 mg/L
Nitrate	4.23	mg/L	< 45 mg/L
Lead	11	µg/L	< 15 µg/L

6

Comments:

Sample does not meet safe drinking water standards. Total coliform bacteria are present. Iron concentration is above recommended level. Water should be disinfected to remove bacteria. Treatment of iron may be necessary if staining or taste are objectionable.

Submitted by:

Laboratory Director

ANYLAB LABORATORIES INC.

The Components of a Typical Water Test Report

Pennsylvania has dozens of water testing laboratories, each with its own way of presenting results. Your water test may not look exactly like the one shown here, but it probably contains the same basic components. Read about each water test component below and try to find it on your own water test report.

Remember that these are only the most common components of a typical water test report. Some laboratories will include additional information such as the method used for each test (usually an EPA number), the initials of the person that completed each test, and the date each test was completed. This information is generally unimportant to the client.

1. Client and Sample Information

Basic information at the top of most water test reports identifies the person who submitted the water sample, where the sample came from, who received it at the laboratory, etc. This is called the chain-of-custody information and could be very important if the results were to be used in any type of legal action.

2. Analysis

All water test reports will list the water quality parameters that were tested. The list will include only those that you asked the laboratory to analyze or those that the lab recommended for your water sample. The number of parameters can vary from just a few to dozens of tests. Consult other sections of this publication for a description of each of these tests.

3. Results

The most important information on your water test report are the actual results that the laboratory found for your water sample. The numbers indicate the concentration of each water quality parameter in your water sample. In some cases, the unit of measure for each test will be shown next to the result. In others, the units will be shown in a separate column (as in the example test report). The result for each test should be compared to the drinking water standard for that parameter. Sometimes, a water test result will be reported as “ND” (Not Detected), which means that the lab was unable to detect any of that pollutant with its equipment. Similarly, some results may have a less-than sign (<) in front of a number. This result means the sample contained less than the detection level for that test. Detection levels are often set at the permissible drinking water concentration for a particular pollutant. If the less-than symbol (<) appears before a number and the number is equal to the drinking water standard, the water is likely safe to drink for that particular contaminant.

4. Units

Concentrations of pollutants are usually measured in water by a unit of weight such as milligrams per liter (mg/L), or by number such as number of bacteria per 100 milliliters of water (#/100 ml). You might see several different measurement units on your water test report. Refer to the section “Understanding Units” on page 6 to learn more about these.

5. Standards

Many laboratories include the specific drinking water standards on the report next to each test result. This allows for an easy comparison of your result with the safe or recommended level for each test parameter. A complete list of up-to-date drinking water standards can be found in Appendix I in this publication.

6. Comments

Some water testing laboratories will include a brief explanation of your water test results. Specifically, they often will list those pollutants that did not meet the drinking water standard. Occasionally, these comments will also describe the potential harmful effects of pollutants that exceeded the standard and how these pollutants may be removed from the water.

What Are Drinking Water Standards?

Drinking water standards give the level of a pollutant that is acceptable in water. These standards are set by the U.S. Environmental Protection Agency (EPA) using available research data. The EPA sets standards for contaminants that are known to occur in water, are detectable in water, and cause a health or aesthetic problem in water. EPA sets these standards, but it is up to the Pennsylvania Department of Environmental Protection to enforce the standards when and where they apply.

Two types of drinking water standards are used: primary and secondary. Primary standards are set for contaminants that cause some health effect such as illness, disease, cancer, or another health problem. Adherence to these standards is mandatory for public water systems, but on private water systems these standards are voluntary. Primary standards are also known as Maximum Contaminant Levels or MCLs.

Secondary standards are created for water contaminants that cause aesthetic problems such as bad taste, discoloration, or odor. In the past, these standards were always voluntary and were used mainly as guides. Recently, however, some community water systems have been required to meet some of these secondary standards. Secondary standards are also known as Secondary Maximum Contaminant Levels (SMCLs) or Recommended Maximum Contaminant Levels (RMCLs).

Understanding Units

All drinking water test results and standards have a unit associated with them. These units give the amount of the pollutant per unit of water. The most common unit is the milligram per liter (mg/L), which expresses the milligrams of a pollutant in every liter of water. Some laboratories prefer to use parts per million (ppm), which is identical to milligrams per liter. Some contaminants that can be measured in very small quantities are reported in micrograms per liter (µg/L), which is identical to a part per billion (ppb). Keep in mind that concentrations expressed in mg/L (or ppm) can be converted to µg/L (or ppb) by multiplying by 1,000, and that µg/L (or ppb) can be converted to mg/L (or ppm) by dividing by 1,000.

The Most Common Water Test Units

milligrams per liter (mg/L) = parts per million (ppm)

micrograms per liter (µg/L) = parts per billion

Most pollutants occur in water in very small concentrations. The units shown above are designed to express these small concentrations. The following examples illustrate just how small these units really are.

- One milligram per liter (mg/L) or part per million (ppm) corresponds to one minute in two years or a single penny in $10,000.
- One microgram per liter (µg/L) or part per billion (ppb) corresponds to one minute in 2,000 years or a single penny in $10,000,000.

Although most water quality measurements are expressed in these units, some tests such as bacteria, corrosivity, turbidity, and radon use different units. To learn more about these other units, refer to the discussions on individual parameters in the following section.

Descriptions of Common Pollutants (by category)

Hundreds of pollutants can occur in drinking water in Pennsylvania. They can be grouped into four basic categories: microbial, inorganic, organic, and radiological. Although over 100 pollutants have drinking water standards (see Appendix I for a complete list), many of these pollutants are very rare in Pennsylvania. The following sections briefly discuss 40 of the most common pollutants in Pennsylvania drinking water. These pollutants are listed alphabetically within the four categories.

Microbial Pollutants

Microbial pollutants include bacteria, viruses, and protozoans. These are living organisms that are visible in water only with the help of a high-powered microscope. Many different kinds of bacteria, some disease-causing but many not, may be present in a water supply. The tests discussed below are specific bacteria tests that are used to determine whether disease-causing bacteria may be present in the water. Protozoans are less common in water than bacteria, but a few can be problems. Viruses will not be discussed because they rarely occur in Pennsylvania drinking water; however, viruses such as hepatitis are carried by water and can cause serious illness.

Coliform Bacteria

Coliform bacteria are a large group of bacteria that occur throughout the environment. They are used as an indicator organism to indicate the potential for disease-causing bacteria to be present in water. In other words, if coliform bacteria are present, it is presumed that a contamination pathway exists between the bacteria source and the water supply and that disease-causing bacteria may use this pathway to enter the water supply. Coliform bacteria occur frequently in private water systems, usually from contamination by surface runoff or from human or animal wastes.

Most coliform bacteria do not cause disease, but the greater their number the greater the likelihood that disease-causing bacteria may be present. Since coliforms persist in water longer than most disease-causing organisms, the absence of coliform bacteria leads to the assumption that the water supply is microbiologically safe to drink. Consuming water with coliform bacteria present may cause gastrointestinal illnesses, fever, and other flu-like symptoms. Therefore, the drinking water standard requires that no coliform bacteria be present in public drinking water supplies.

Results from coliform bacteria tests are normally expressed as the number of bacteria colonies present per 100 milliliters (ml) of water. Some laboratories may simply express coliform bacteria results as “Present” (P), or “Absent” (A). In this case, “Present” indicates only that at least one bacterium was present in each 100 ml of water. Occasionally, bacteria results will be expressed as “MPN,” which stands for Most Probable Number. This simply means that a statistical relationship was used to estimate the number of bacteria in your sample. Finally, bacteria results also may be reported as “TNTC,” or “Too Numerous To Count,” meaning the bacteria concentration was too high to quantify.

Fecal Coliform Bacteria

Fecal coliform bacteria are a smaller group of bacteria within the coliform bacteria group. Water may be tested for fecal coliform bacteria if the total coliform test is positive. Fecal coliform bacteria are specific to the intestinal tracts of warm-blooded animals and are thus a more specific test for sewage or animal waste contamination. The ratio of fecal coliform bacteria to fecal streptococcus bacteria is often used to estimate the source of bacterial contamination (see discussion below). Fecal coliform bacteria levels are expressed as the number of colonies per 100 ml of water. No fecal coliform bacteria are permitted in public drinking water supplies.

Fecal Streptococcus Bacteria

Fecal streptococcus bacteria are another smaller group of bacteria within the coliform bacteria group that are especially numerous in animal waste (as opposed to human waste). The ratio of fecal coliform to fecal streptococcus bacteria is usually much higher in humans than it is in animals. As a rule of thumb, a fecal coliform to fecal streptococcus ratio greater than 4.0 is indicative of a human source of bacteria such as a septic system. A ratio less than 1.0 is indicative of an animal source of bacteria such as runoff from a feedlot. Ratios between 1.0 and 4.0 are inconclusive about the source of the bacteria. Fecal streptococcus bacteria are expressed as the number of colonies per 100 ml of water. No fecal streptococcus bacteria are permitted in drinking water.

E. Coli

An even more specific bacteria test is the test for *E. coli* (short for *Escherichia coli).* This is a type of fecal coliform bacteria commonly found in the intestines of animals and humans. A positive *E. coli* result is a strong indication that human sewage or animal waste has contaminated the water.

Hundreds of strains of *E. coli* exist. Although most are harmless and live in the intestines of healthy humans and animals, a few can produce a powerful toxin that causes severe illness and even death. Infection often causes severe bloody diarrhea and abdominal cramps; sometimes the infection causes non-bloody diarrhea. Frequently, no fever is present. It should be noted that these symptoms are common to a variety of diseases and may be caused by sources other than contaminated drinking water.

E. coli tests are reported as the number of bacteria per 100 ml of water. The presence of any *E. coli* in a water sample is unacceptable; thus, the primary drinking water standard for *E. coli* is 0 per 100 ml of water.

Standard Plate Count (Heterotrophic Plate Count)

The Standard Plate Count (SPC) or Heterotrophic Plate Count (HPC) is a more general indicator of bacterial contamination. On some test reports, this also may be referred to as the "Total Bacteria Count." It measures all of the bacteria, including coliform and many other groups, in a water sample. The SPC is usually reported as the number of bacteria per milliliter of sample. There are no drinking water standards for SPC, but if more than 500 bacteria are counted in one milliliter of sample, further testing for total coliform or fecal coliform bacteria is suggested.

Iron Bacteria

Iron bacteria are a type of bacteria that feed on small amounts of iron in water. Iron bacteria do not constitute a health threat, but they are a nuisance in private water systems because they form gelatinous strands, masses, or thin films that plug pipes, toilets, and plumbing fixtures and reduce flow from wells. Their appearance can vary from orange or brown to clear. Iron bacteria can colonize an entire water system from the well itself through the plumbing, or they may be present only in parts of the plumbing system.

There are no drinking water standards for iron bacteria. Rather, their presence is normally aesthetically degrading enough to require treatment. Water testing is rarely available to determine if iron bacteria are present. Confirmation is usually based upon the visual symptoms in the water.

For More Information on Bacteria in Water

Contact your local Penn State Cooperative Extension office and ask for Extension Circular #345, *Safeguarding Wells and Springs from Bacterial Contamination.*

Giardia and *Cryptosporidium*

Giardia lamblia and *Cryptosporidium parvum* are small microscopic animals known as protozoa. They both can live in the intestinal tract of mammals, including humans. While there, they multiply by producing oocysts. Infected animals and humans can excrete the oocysts, which can then contaminate water sources. Once ingested, the organism emerges from the protective oocyst and infects the lining of the intestine. Both giardiasis and cryptosporidiosis cause severe diarrhea, nausea, fever, headache, vomiting, and loss of appetite. Both illnesses can be life-threatening to people with depressed immune systems.

Many private water system owners are familiar with *Giardia* and *Cryptosporidium* as a result of publicity following outbreaks of illnesses in public water supplies. Most of these outbreaks have occurred in communities that use surface water supplies (streams, rivers, lakes) where the oocysts can commonly be found. *Giardia* and *Cryptosporidium* are rarely a concern for private water systems using deeper groundwater sources, because the oocysts are efficiently filtered as water passes through soil and rock. Shallow springs or poorly constructed wells that become contaminated with surface water would be most likely to contain *Giardia* and *Cryptosporidium* oocysts. This is one reason that roadside springs are not a good alternative source of drinking water.

Both *Giardia* and *Cryptosporidium* are measured in water by filtering large volumes of the water through a small filter and examining the filter under a microscope for oocysts. Oocysts should be totally absent from water for it to be safe to drink.

For more information on *Giardia* and *Cryptosporidium*:

Contact your local extension office and ask for Penn State Agricultural and Biological Engineering Fact Sheet F-134, *Removing Giardia Cysts from Drinking Water.*

Consult the following Pennsylvania Department of Environmental Protection fact sheet: http://www.dep.state.pa.us/dep/deputate/watermgt/wsm/wsm_dwm/complian/cryto-giardia.htm

Inorganic Chemicals (IOCs)

The second category of water pollutants includes inorganic chemicals. These are usually substances of mineral origin. Salt, metals, and minerals are examples of inorganic chemicals. The chemicals discussed alphabetically below are the most common inorganic pollutants in Pennsylvania water supplies, or they are of the greatest health concern. Unless otherwise stated, these inorganic chemicals are usually reported in mg/L or ppm units.

Alkalinity

Alkalinity is a commonly measured water characteristic that has little meaning or importance to the typical homeowner. It is a measure of the ability of water to neutralize acids. Calcium is a major component of alkalinity, as it is with hardness. Thus, if your water has a high alkalinity, it is probably hard also. There is no drinking water standard for alkalinity.

Arsenic (As)

Arsenic occurs in groundwater from both natural sources and human activities. In drinking water, it is odorless and tasteless. It is relatively rare in Pennsylvania water supplies, compared to those of the western United States.

In Pennsylvania, arsenic can originate natually from certain types of rock, or it may be traced to deep-water brines produced from gas and oil well drilling or from industrial activity. Arsenic has a primary drinking water standard because it can cause skin lesions, circulatory problems, and nervous system disorders. Prolonged exposure also can cause various forms of cancer. The present arsenic drinking water standard (0.05 mg/L) is being studied and will likely be lowered to 0.005 mg/L (5 µg/L) in the near future. A recent survey by the U.S. Geological Survey (USGS) found that arsenic exceeded 5 µg/L in 5% of wells in Pennsylvania.

Barium (Ba)

Like arsenic, barium occurs naturally in small concentrations in many groundwater supplies. Barium contamination is not common in private water systems in Pennsylvania, but it may occur sporadically in western and northern Pennsylvania near active and abandoned gas and oil wells.

Barium has a primary drinking water standard of 2.0 mg/L because it causes nervous and circulatory system problems, especially high blood pressure. Standard water softeners are effective in removing barium.

Chloride (Cl)

Chloride is common in Pennsylvania water supplies, but it rarely reaches levels of concern. It occurs naturally in most groundwater but may become elevated due to leaching from salt storage areas around highways or from brines produced during gas well drilling. Other possible sources of chloride are sewage effluent, animal manure, and industrial waste.

Chloride has a secondary drinking water standard of 250 mg/L because it may cause a salty taste in the water. Groundwater in Pennsylvania usually contains less than 25 mg/L of chloride.

Copper (Cu)

Copper usually originates from corrosion of copper plumbing in the home (see “Corrosivity,” below). Copper has a secondary drinking water standard of 1.0 mg/L because it causes a bitter, metallic taste in water and a blue-green stain in sinks and bathtubs. Copper levels above 1.3 mg/L are a health concern because they may cause severe stomach cramps and intestinal illnesses. Copper can be reduced in water using the corrosion control strategies outlined below.

Corrosivity

Corrosive water is a term used to describe aggressive water that can dissolve materials with which it comes in contact. It is a problem because many homes have copper or galvanized pipes, lead solder joints, and brass plumbing fixtures. Thus, corrosive water may cause increases in copper and lead concentrations in drinking water. In rare cases, corrosive water may dissolve even PVC plastic plumbing, causing vinyl chloride contamination of the water. This generally occurs only when inferior plastic pipe that was not approved for drinking water systems has been used. Approved plastic pipe is directly stamped with "NSF" (National Sanitation Foundation) and "Drinking Water" on the side.

Symptoms of corrosive water problems include metallic taste, bluish-green stains in sinks and bathtubs, and, in severe cases, small leaks in the plumbing system. Because corrosive water is not a health concern by itself, there is only a secondary or recommended standard that water be noncorrosive.

Water that is soft and acidic (pH < 7.0) tends to be more corrosive, but the only true measure of water corrosivity is a stability or saturation index. These indices use chemical characteristics of the water such as hardness and pH to estimate its corrosiveness. A stability index greater than about 6.5 indicates water that is probably corrosive, with higher values being increasingly corrosive. A negative saturation index value likewise indicates a corrosive water supply. The most common saturation index in use is the Langelier Saturation Index (LSI).

Past surveys of private water supplies in Pennsylvania have indicated that corrosive water is a common water quality problem, present in over 60% of the groundwater wells and springs tested. It tends to be most common in northern and western Pennsylvania where more acidic groundwater is prevalent, although areas underlain by Triassic shales in southeastern Pennsylvania also produce corrosive water. It is least common in the agricultural valleys underlain by limestone where groundwater typically has a higher pH and hardness. Cistern water can be quite corrosive.

If your water test indicates that your water is corrosive, you should test your water for copper and lead. Corrosive water problems can be corrected using an acid neutralizing filter or by replacing metal plumbing with NSF-approved plastic components.

Hardness

Hardness is a general term used to refer to the $CaCO_3$ (calcium carbonate) content of water. Hardness does not pose a health threat, but it does cause aesthetic problems. It can ruin hot water heater elements, reduce soap lathering, and make laundry difficult to clean. Moderate levels of hardness are beneficial because they inhibit plumbing system corrosion. Removal of hardness using a water softener is necessary only if the water is causing aesthetic problems. Use of water softeners may result in undesirable levels of sodium in drinking water and may increase plumbing system corrosion.

Hardness may be reported in milligrams per liter (mg/L) or in a special unit called grains per gallon (gpg). One grain per gallon is equal to about 17 mg/L or parts per million (ppm). Since the level of hardness or calcium carbonate means little to consumers, a chart of water hardness classifications has been developed and appears on the next page. A water hardness of about 90 to 100 mg/L provides excellent corrosion control and is usually acceptable aesthetically, but there are no drinking water standards for hardness.

For More Information on Water Softening

Contact your local Penn State Cooperative Extension office and ask for Agricultural and Biological Engineering Fact Sheet F-141, *Water Softening.*

Classification	Hardness (mg/L or ppm)	Hardness (gpg)
Soft	Less than 17	Less than 1.0
Slightly hard	17 to 60	1.0 to 3.5
Moderately hard	60 to 120	3.5 to 7.0
Hard	120 to 180	7.0 to 10.5
Very hard	More than 180	More than 10.5

Hydrogen Sulfide (H_2S)

Hydrogen sulfide (H_2S) is a noxious gas that imparts a disagreeable rotten egg odor when dissolved in water. It is a naturally occurring gas that is common in groundwater in parts of Pennsylvania. Very small concentrations of hydrogen sulfide in water are offensive to most individuals. Although hydrogen sulfide is a highly toxic gas, only under the most unusual conditions would it reach levels toxic to humans as a result of its occurrence in drinking water. More often, it is simply an aesthetic odor problem that can be removed using several treatment processes.

Iron (Fe)

Iron is a common natural problem in groundwater in Pennsylvania that may be worsened by mining activities. It occurs throughout Pennsylvania but is most problematic in the western region of the state. Iron does not occur in drinking water in concentrations of health concern to humans. The secondary drinking water standard for iron is 0.3 mg/L because it causes a metallic taste and orange-brown stains that make water unsuitable for drinking and clothes washing.

Lead (Pb)

If lead is detected in your drinking water, it probably originated from corrosion of your plumbing system. Lead was a common component of solders used in plumbing systems until it was banned in 1991. In homes built in the early 1900s, lead pipe also may be present. Thus, if your home was built before 1991 and has a metal plumbing system, it is likely that some lead is present. If your water supply is corrosive (see discussion above), then any lead present in the plumbing system may be dissolved into your drinking water. Lead concentrations are usually highest in the first water out of the tap (known as "first-draw" water), since this water has been in contact with the plumbing for a longer time. Lead concentrations typically decrease as water is flushed through the plumbing system.

A survey in 1989 found that about 20% of the private water supplies in Pennsylvania contained lead concentrations above the MCL of 0.015 mg/L (15 µg/L). Lead poses a serious health threat to the safety of drinking water. It is colorless, odorless, and tasteless. Long-term exposure to lead concentrations in excess of the drinking water standard has been linked to many health effects in adults including cancer, stroke, and high blood pressure. At even greater risk are the fetus and infants up to four years of age, whose rapidly growing bodies absorb lead more quickly and efficiently. Lead can cause premature birth, reduced birth weight, seizures, behavioral disorders, brain damage, and lowered IQ in children. The U.S. Environmental Protection Agency considers lead to be the most serious environmental health hazard for children in the United States.

It should be noted that in rare cases, the source of lead in drinking water might be from groundwater pollution rather than corrosion of the plumbing system. Such pollution may be the result of industrial or landfill contamination of an aquifer. The source of the lead usually can be determined by comparing water test results from a first-draw sample versus a sample collected after the water runs for several minutes. If the lead concentration is high in both samples, then the source of the lead is likely from groundwater contamination.

For More Information on Lead

Contact your local Extension office and ask for Extension Circular #416, *Lead in Drinking Water*.

This publication is also available online at http://pubs.cas.psu.edu/FreePubs/ec416.html

Manganese (Mn)

Like iron, manganese is a naturally occurring metal that can be worsened by mining activities. Manganese at concentrations normally found in drinking water does not constitute a health hazard; however, even small amounts of manganese may impart objectionable tastes or blackish stains to water. For this reason, manganese has a recommended drinking water standard of 0.05 mg/L.

Nitrate (NO_3) or Nitrate Nitrogen (NO_3-N)

Nitrate in drinking water usually originates from fertilizers or from animal or human wastes. Nitrate concentrations in water tend to be highest in areas of intensive agriculture or where there is a high density of septic systems. In Pennsylvania, nitrate concentrations tend to be highest in the southeastern and southcentral counties where agriculture is most prevalent.

Nitrate has a primary drinking water standard that was established to protect the most sensitive individuals in the population (infants under 6 months of age and a small component of the adult population with abnormal stomach enzymes). These segments of the population are prone to methemoglobinemia (blue baby disease) when consuming water with high nitrates. The need for a nitrate MCL has been questioned lately because blue-baby disease occurs very rarely in the United States.

Nitrate may be reported on your water test report as either nitrate (NO_3) or nitrate-nitrogen (NO_3-N). Look carefully at your report to determine which form of nitrate is being reported. The primary drinking water standard or MCL is 10 mg/L as nitrate-nitrogen (NO_3-N), but it is 45 mg/L as nitrate (NO_3).

For More Information on Nitrates

Contact your local Penn State Cooperative Extension office and ask for Agricultural and Biological Engineering Fact Sheet F-136, *Nitrates in Drinking Water.*

pH

The pH of water is a measure of how acidic or basic the water is. It is measured on the pH scale (from 0 to 14) in pH units. If the pH of water is less than 7.0, it is acidic, and if it is greater than 7.0, it is basic. Water with a pH of exactly 7.0 is considered neutral. If pH values deviate very far from neutral, other water quality problems may be indicated. These would include the presence of toxic metals such as lead (at low pH) and high salt contents (at high pH).

It is recommended that the pH of your water be between 6.5 and 8.5 to minimize other potential water quality problems. Acidic water with a pH less than 6.5 is much more common in Pennsylvania than high-pH water, especially in the northern and western regions of the state. In general, pH is an indicator of other potential water quality problems and is very rarely a problem by itself.

Sulfate (SO_4)

Sulfates normally are present at some level in all private water systems. Sulfates occur naturally as a result of leaching from sulfur deposits in the earth. Private water systems with excessive sulfate in Pennsylvania are generally confined to the western portion of the state or other coal mining regions. Even in these areas, surveys indicate less than 10% of the water supplies have excessive sulfate. Other less common sources are industrial waste and sewage effluent.

Sulfate has a secondary drinking water standard of 250 mg/L because it may impart a bitter taste to the water at this level. A proposal also exists to make sulfate a primary contaminant with an MCL of 500 mg/L, because it may have a laxative effect and cause other gastrointestinal upset above this concentration.

Total Dissolved Solids (TDS)

The total amount of substances dissolved in water is referred to as the total dissolved solids (TDS) content of water. Waters high in TDS often contain objectionable levels of dissolved salts such as sodium chloride. Thus, high TDS may indicate the presence of other water quality problems. The recommended drinking water standard of 500 mg/L for TDS exists because high-quality waters generally have lower TDS levels.

Turbidity

Drinking water should be sparkling clear for health and aesthetic reasons. Turbidity refers to fine particles of clay, silt, sand, organic matter, or other material that might reduce the clarity of water. Turbidity makes water unappealing to drink because of its muddy appearance. Particles also might act to shield disease-causing bacteria from chlorine or ultraviolet light treatment and provide nutrients for bacteria and viruses to flourish.

Turbidity usually indicates direct pollution from surface runoff often during or shortly after heavy rainfall. Turbidity might increase in wells because of borehole cave-ins; it also might increase when water levels in the well are low such as during a drought, because the submersible pump may disturb sediments near the bottom of the well.

Turbidity is usually measured in a special unit known as an NTU or Nephelometric Turbidity Unit. Drinking water should not exceed 1 NTU, for both health and aesthetic reasons. Water with less than 1 NTU of turbidity is essentially clear to the naked eye. Water with more than 1 NTU of turbidity makes disinfection to kill bacteria difficult and is the primary reason for the 1 NTU standard.

Organic Chemicals

Organic chemicals are a large group of over 100 mostly man-made chemicals. They can occur in drinking water sources from industrial activity, landfills, gas stations, pesticide use, or air deposition. Organic chemicals vary in their ability to pollute groundwater and their toxicity. Many organic chemicals are carcinogenic (cancer causing), so they often have very low drinking water standards, usually measured in µg/L. Remember that µg/L are the same as ppb (parts per billion).

Generally speaking, organic chemicals can be grouped into two major categories: volatile organic chemicals (VOCs) and nonvolatile or synthetic organic chemicals (SOCs). The discussion below introduces these general groups of organic chemicals and describes in detail the most common examples in each group. Specific drinking water standards for all organic chemicals are given in Appendix I in the back of this publication. More detailed information on organic pollutants can be found at the following locations.

For More Information on Organic Chemicals

Agency for Toxic Substances and Disease Registry (ATSDR)
1-888-422-8737 (toll free)
or online at http://www.atsdr.cdc.gov/toxfaq.html

U.S. Environmental Protection Agency Fact Sheets on Common Organic Pollutants
http://www.epa.gov/safewater/hfacts.html

Volatile Organic Chemicals (VOCs)

VOCs are man-made compounds that volatilize from water into air. They present a health risk not only from drinking contaminated water, but also from inhaling VOCs that escape from the water as it is used during showering or other home uses. VOCs also are absorbed directly through the skin during bathing and showering. They are commonly used as solvents, fuels, paints, or degreasers. Virtually all VOCs produce an odor in water, although it may not be obvious before the drinking water standard is exceeded. Nearly all VOCs have primary drinking water standards, because they are carcinogenic (cancer-causing) or cause damage to the liver, kidneys, nervous system, or circulatory system.

VOCs are not common in private water systems in Pennsylvania, but they are becoming a more important concern as industrial activities, landfills, gas stations, and other sources of these pollutants encroach on rural areas. The U.S. Geological Survey conducted a recent survey of 118 wells in southern and eastern Pennsylvania. The survey analyzed well water for 60 different VOCs and detected at least one VOC in 27% of the samples. (Although the VOCs were commonly detected, none of the samples exceeded drinking water standards.) VOC contamination of wells was much more common in urban areas than agricultural areas.

Dozens of VOCs are regulated in public water supplies, but the most common are described below. Consult Appendix I for a complete list of drinking water standards for all regulated VOCs.

Benzene

Benzene is a clear, colorless liquid that is used primarily as an industrial solvent and chemical intermediate. It is lighter than water, migrates easily in groundwater, and is slow to decay. It is also present as a gasoline additive. Because it is a known human carcinogen, benzene has a primary drinking water standard of 0.005 mg/L (5 µg/L).

Carbon Tetrachloride

Carbon tetrachloride is a colorless liquid that is heavier than water but migrates easily in groundwater. It has been used mostly for the production of chlorofluorocarbons and in the dry-cleaning industry. Carbon tetrachloride has a primary drinking water standard of 0.005 mg/L (5 µg/L) because it is a probable human carcinogen with other acute effects on the gastrointestinal and nervous systems.

Chloroform

Chloroform is a colorless liquid that is used primarily to make other chemicals. It also can be found in small amounts when chlorine is added to water. Chloroform travels easily in groundwater and does not easily degrade. Chloroform is believed to be a carcinogen. It has been one of the most commonly reported organic chemicals in Pennsylvania groundwater.

Chloroform is one of a group of organics known as trihalomethanes or THMs. No specific drinking water standard exists for chloroform, but the primary standard for THMs is 0.08 mg/L (80 µg/L).

MTBE (Methyl Tert-Butyl Ether)

MTBE is the most common organic chemical found in Pennsylvania groundwater. It has been used extensively as a gasoline additive in some parts of the United States to reduce air pollution emissions from automobiles. It smells like turpentine and can often be detected in water at low concentrations. Most MTBE originates from gasoline spills or leaking underground storage tanks. It is more water-soluble than other components of gasoline, so it contaminates groundwater more easily. Once in groundwater, MTBE is slow to decay. MTBE is a possible human carcinogen, but little information is available on other health effects. Pennsylvania presently has no drinking water standard, but numerous other states have set standards in the 0.02 to 0.2 mg/L range (20 to 200 µg/L). More information on MTBE is available online at the U.S. Environmental Protection Agency and U.S. Geological Survey Web sites listed at the end of this publication.

Tetrachloroethylene (PCE) and Trichloroethylene (TCE)

Tetrachloroethylene (commonly known as PCE) and Trichloroethylene (commonly known as TCE) are similar chemicals that have been found in Pennsylvania around industrial sites and landfills. Most of the groundwater contamination from these chemicals has occurred due to improper disposal of industrial wastes. Both chemicals are used as industrial solvents for metal degreasing, but PCE is used primarily in the dry-cleaning industry. Both are heavier than water and move freely through soil and groundwater, but TCE is much more water-soluble than PCE. PCE is a possible carcinogen that causes liver, kidney, and nervous system damage. TCE is a probable carcinogen that also causes acute effects to the liver, kidneys, and central nervous system. Both PCE and TCE have primary drinking water standards of 0.005 mg/L (5 µg/L).

Xylenes

Xylenes are a component of gasoline. They also are used in the manufacturing of some chemicals, and therefore appear commonly in industrial wastes. Xylenes cause liver, kidney, and nervous system damage. Xylenes biodegrade and move slowly in groundwater. Xylene has been reported in much higher concentrations than most other VOCs in Pennsylvania, but the drinking water standard for xylenes is also much higher (10 mg/L or 10,000 µg/L).

For More Information on Volatile Organic Chemicals (VOCs)

U.S. Geological Survey, Water Resources Investigations Report 96-4141
Occurrence and Concentrations of Volatile Organic Compounds in Shallow Ground Water in the Lower Susquehanna River Basin, Pennsylvania and Maryland
http://pa.water.usgs.gov/reports/wrir_96-4141/report.html

Pennsylvania Department of Environmental Protection
Citizen's Guide to Volatile Synthetic Organic Chemicals in Drinking Water
http://www.dep.state.pa.us/dep/deputate/watermgt/WSM/Facts/BK0208_TOC.htm (Also available from your local DEP office.)

Nonvolatile or Synthetic Organic Chemicals (SOCs)

Nonvolatile organic chemicals are also known as Synthetic Organic Chemicals or SOCs. Nearly all SOCs are pesticides, with a few notable exceptions (PCBs and dioxin). They differ from VOCs because they do not escape readily into the air from water.

Dozens of pesticides, including herbicides, insecticides, and fungicides, are used throughout Pennsylvania on crops, golf courses, and lawns. The risk to private water supplies from pesticide applications depends on many factors including the amount, mobility, and toxicity of the pesticide, the proximity of the application to the water supply, and the depth and construction of the water source.

Pesticides are not common in private water supplies, but they are often detected in agricultural areas of the state. A 1993 study by Penn State scientists found detectable residues of at least one pesticide in 27% of the rural wells surveyed in corn-producing regions of Pennsylvania. (Although the pesticides were commonly detected, none of these wells contained a concentration above the drinking water standard.) Pesticide concentrations are generally higher in wells located in limestone, which includes most of the prime agricultural regions of Pennsylvania.

Detailed descriptions are given below for some of the pesticides most often found in Pennsylvania groundwater. For more information on these and other less common pesticides, consult the following:

For More Information on Pesticides

U.S. Environmental Protection Agency
http://www.epa.gov/pesticides/

Penn State Pesticide Education Program
http://www.cas.psu.edu/docs/casdept/pested/index.html

Publication NRAES-34, *Pesticides and Groundwater*, can be ordered for $5.00 from your local extension office.

Atrazine

Atrazine is the most commonly used herbicide in Pennsylvania. It is applied to nearly 90% of the corn crop in the state. It is water-soluble, moves easily into groundwater and surface water after application, and is by far the most common pesticide reported in private water supplies in Pennsylvania. In a 1993 study, Atrazine was detected in 22% of private water supplies in corn-producing regions of Pennsylvania. Because it is classified as a possible human carcinogen that also damages the liver, kidney, and heart, Atrazine has a primary drinking water standard of 0.003 mg/L (3 µg/L).

2,4-Dichlorophenoxyacetic Acid (2,4-D)

2,4-D is widely used to kill broadleaf weeds in farm fields and pastures and on lawns and golf courses. It also is used to kill algae and aquatic plants in ponds and lakes. 2,4-D damages the liver, circulatory, and nervous systems. Like atrazine, it is one of the most commonly used pesticides in Pennsylvania and also one of the most commonly found in groundwater in agricultural areas of the state. 2,4-D has a primary drinking water standard of 0.07 mg/L (70 µg/L).

Chlorpyrifos

Chlorpyrifos, also known as Dursban, is one of the most commonly used insecticides on corn crops in Pennsylvania. It is also used to control pests on cattle, and it is widely used around the home for control of cockroaches, fleas, and termites. Chlorpyrifos does not mix well with water and sticks tightly to soil particles. It was detected in trace amounts in a small percentage of private water systems in a 1993 study. Chlorpyrifos is presently considered a possible human carcinogen. No drinking water standard exists for chlorpyrifos, but the U.S. Environmental Protection Agency recommends that children not drink water containing levels greater than 0.03 mg/L. The U.S. EPA recently announced a ban on the production of chlorpyrifos, starting in June 2000.

Glyphosate

Glyphosate is one of the most widely used pesticides in the United States. It is a herbicide used mostly for control of broadleaf weeds and grasses in pastures, corn, soybeans, and lawns. It is a component of the often-used herbicide Roundup. Glyphosate has a primary drinking water standard of 0.7 mg/L (700 µg/L) because it causes kidney damage and reproductive effects after long-term exposure. Glyphosate is strongly adsorbed to soil and does not readily move to or in groundwater.

Metolachlor

Metolachlor is the second most commonly used herbicide on corn in Pennsylvania. It is slightly less mobile than atrazine but still moves easily through soil to groundwater. A 1993 survey of private water systems in Pennsylvania found metolachlor to be the third most commonly detected pesticide in the state.

There are no reported short-term effects from exposure to metolachlor in water, but it is listed as a possible carcinogen with prolonged exposure. No drinking water standard exists, but further testing is being done by the U.S. Environmental Protection Agency. In the interim, the EPA has issued a health advisory for metolachlor of 0.07 mg/L (70 µg/L).

Simazine

Simazine is commonly used for control of broad-leaved and grassy weeds on crops, orchards, and Christmas tree farms. It is also used to control plants and algae in ponds and lakes. Simazine has a primary drinking water standard of 0.004 mg/L (4 µg/L) because it is a probable carcinogen that also can cause damage to the testes, kidneys, liver, and thyroid after long exposure. Simazine travels easily through soils to groundwater and persists in groundwater for long periods of time.

Other Synthetic Organic Chemicals

Dioxin (2,3,7,8-TCDD)

Dioxin (also known as 2,3,7,8-Tetrachlorodibenzo-1,4-dioxin or 2,3,7,8-TCDD) is a contaminant formed in the production of some chlorinated organic compounds, including a few herbicides. It may also be formed when some chlorinated organic chemicals are burned. Dioxin has been linked to a variety of health effects including liver damage, reproductive effects, birth defects, and cancer. Most dioxin in water comes from improper disposal of industrial wastes. It is not very water-soluble, and most dioxin is found adhering to sediment or organic particles. It does not move easily into groundwater because it is usually trapped in soil. It has the lowest drinking water standard of any regulated substance (0.00000005 mg/L or 0.00005 µg/L).

Polychlorinated Biphenyls (PCBs)

PCBs are a group of manufactured organic chemicals that are odorless and tasteless in water. They have been used widely as insulating materials, coolants, and lubricants in electrical equipment. The manufacture of PCBs stopped in the United States in 1977 because of health effects, but products containing PCBs are still prevalent. Most PCBs in groundwater originate from improper waste disposal. In water, a small amount of PCBs may remain dissolved, but a larger amount sticks to organic particles and sediments. PCBs have been shown to cause numerous health effects including liver, kidney, and nervous system damage. They are also considered probable carcinogens. As a result, a primary drinking water standard of 0.0005 mg/L (0.5 µg/L) exists for PCBs.

Radiological Pollutants

Radioactivity usually occurs in water from radium, uranium, or radon. These materials emit radioactivity as alpha, beta, or gamma radiation. Each form of radiation affects the human body differently, yet all can lead to cancer. Radioactivity in water is normally measured in picocuries per liter (pCi/L). Although several drinking water standards exist for radioactivity (see Appendix I), radon is likely to be the most common problem in Pennsylvania.

Radon

Radon is a naturally occurring radioactive gas formed underground by the decay of uranium or radium deposits. Radon can enter groundwater as it escapes from surrounding rocks. The gas is then released during household uses of the water such as showering, dishwashing, or laundering. Radon has been shown to cause lung cancer upon inhalation, but ingestion of radon in water is not thought to be a major health concern. Thus, the most serious threat from radon in water is the inhalation of escaping gas during showering or bathing. For this reason, the U.S. Environmental Protection Agency has proposed a primary drinking water standard for radon in water of 300 pCi/L.

Recent surveys by the Pennsylvania Department of Environmental Protection and the U.S. Geological Survey indicate that over 60% of the private water supplies in Pennsylvania contain more than 300 pCi/L of radon. The problem is most severe in southeastern counties, but it is present throughout the state.

For More Information on Radon in Water

Pennsylvania Department of Environmental Protection
Radon Hotline: 1-800-237-2366

Penn State College of Agricultural and Biological Engineering Fact Sheet F-135, *Reducing Radon in Drinking Water*, is available from your local extension office.

U.S. EPA Fact Sheet
http://www.epa.gov/safewater/radon/qa1.html

Need More Information?

Do you still have questions? There are numerous sources of both written and online information related to drinking water and interpreting water test results. In addition to the specific references listed throughout this circular, the following general locations may be helpful for finding more information on interpreting water test information.

Your Local Penn State Cooperative Extension Office

Penn State Cooperative Extension has many agents and university specialists trained in water resources who can help solve your water supply problems. Numerous publications also are available on many water issues.

Water publications online
http://pubs.cas.psu.edu/Water.html
http://wqext.psu.edu

U.S. Environmental Protection Agency

Safe Drinking Water Hotline
1-800-426-4791

Office of Groundwater and Drinking Water
http://www.epa.gov/ogwdw/

U.S. EPA Drinking Water and Health
http://www.epa.gov/safewater/dwhealth.html

U.S. Department of Agriculture—National Extension Water Quality Database

http://www.waterdatabase.org/

Pennsylvania Department of Environmental Protection

Bureau of Water Supply Management
http://www.dep.state.pa.us/dep/deputate/watermgt/WSM/WSM.HTM

U.S. Geological Survey

http://www.usgs.gov/
http://water.usgs.gov/pandp.html

What's Your Next Step?

If your water test has indicated a problem with your water, you're probably wondering what you should do about it. You have a number of options.

More Water Testing?

In some cases, further water testing may be a good idea. If your first water test was not done by a certified laboratory, then you should arrange to have your water retested by a certified lab to confirm the results. Even if a certified lab was used for the first test, you may want to have them retest for parameters that were shown to be a problem, before you invest in water supply improvements.

Maintenance

Some simple maintenance on your water supply may take care of some problems. For example, making sure that the ground slopes away from your well and that it has a good sanitary seal may help prevent surface water contamination of your well and thereby reduce coliform bacteria contamination.

Pollution Prevention

If the source of your water quality problem is obvious, you may be able to take some action to reduce or remove the source. For example, if your water contains excessive amounts of copper and/or lead, you can probably eliminate this problem by removing your metal plumbing and replacing it with approved PVC plastic pipes.

New Source

In some cases, it may be easier and less expensive to develop a new source of water. This might include drilling a new well at a different location away from a source of pollution, developing a more shallow or deeper well or spring to avoid contaminated groundwater, or building a rainwater cistern to avoid contaminated groundwater altogether.

Water Treatment

Water treatment processes are available that remove many contaminants from water to make it drinkable. The other options listed above should be considered and compared to the cost of treatment equipment and maintenance.

Specific publications on treatment and removal of some pollutants have been referenced throughout this circular. In addition, you might want to consult the following publications before purchasing water treatment equipment.

For More Information on Water Treatment

Contact your local Penn State Cooperative Extension office and ask for publication NRAES-48, *Home Water Treatment* (available for $15.00), or Agricultural and Biological Engineering Fact Sheet F-131, *Home Water Treatment in Perspective*.

NSF—National Sanitation Foundation
http://www.nsf.org
An independent organization that tests and certifies water treatment equipment.

Appendix I—Drinking Water Standards as of April 2000

Parameter	Standard	Unit	Page Number
Microbial (all are primary standards)			
Total Coliform Bacteria	0	bacteria per 100 ml	7
Fecal Coliform Bacteria	0	bacteria per 100 ml	7
E. Coli	0	bacteria per 100 ml	8
Giardia Lamblia	0	oocysts	8
Cryptosporidium Parvum	0	oocysts	8
Inorganic Chemicals with Primary Standards			
Antimony (Sb)	0.006	mg/L	
Arsenic (As) (proposed)	0.005	mg/L	9
Asbestos	7 million	fibers/L	
Barium (Ba)	2	mg/L	9
Beryllium (Be)	0.004	mg/L	
Bromate	0.01	mg/L	
Cadmium (Cd)	0.005	mg/L	
Chlorite	1.0	mg/L	
Chromium (Cr)	0.1	mg/L	
Copper (Cu)	1.3	mg/L	9
Cyanide	0.2	mg/L	
Fluoride (Fl)	4	mg/L	
Lead (Pb)	0.015	mg/L	11
Mercury (Hg)	0.002	mg/L	
Nickel (Ni)	0.1	mg/L	
Nitrate (as Nitrogen) (NO_3-N)	10	mg/L	12
Nitrite (as Nitrogen) (NO_2-N)	1	mg/L	
Nitrate + Nitrite (as Nitrogen)	10	mg/L	
Selenium (Se)	0.05	mg/L	
Sulfate (SO_4) (proposed)	500	mg/L	12
Thallium (Tl)	0.002	mg/L	
Volatile Organic Chemicals (all are primary standards)			
Benzene	0.005	mg/L	14
Carbon Tetrachloride	0.005	mg/L	14
o-Dichlorobenzene	0.6	mg/L	
p-Dichlorobenzene	0.075	mg/L	
1,2-Dichloroethane	0.005	mg/L	
1,1-Dichloroethylene	0.007	mg/L	
cis-1,2-Dichloroethylene	0.07	mg/L	
trans-1,2-Dichloroethylene	0.1	mg/L	
Dichloromethane	0.005	mg/L	
1,2-Dichloropropane	0.005	mg/L	
Ethylbenzene	0.7	mg/L	
Monochlorobenzene	0.1	mg/L	
Styrene	0.1	mg/L	
Tetrachloroethylene (PCE)	0.005	mg/L	14
Toluene	1	mg/L	
1,2,4-Trichlorobenzene	0.07	mg/L	
1,1,1-Trichloroethane	0.2	mg/L	
1,1,2-Trichloroethane	0.005	mg/L	
Trichloroethylene (TCE)	0.005	mg/L	14
Total Trihalomethanes	0.08	mg/L	
Vinyl Chloride	0.002	mg/L	
Xylenes (Total)	10	mg/L	14

Note: Standards in mg/L can be converted to µg/L units by multiplying by 1,000.

Parameter	Standard	Unit	Page Number
Synthetic Organic Chemicals (all are primary standards)			
Alachlor	0.002	mg/L	
Atrazine	0.003	mg/L	15
Benzo(a)pyrene	0.0002	mg/L	
Carbofuran	0.04	mg/L	
Chlordane	0.002	mg/L	
2,4-D	0.07	mg/L	15
Dalapon	0.2	mg/L	
Dibromochloropropane (DBCP)	0.0002	mg/L	
Di(2-Ethylhexyl) Adipate	0.4	mg/L	
Di(2-Ethylhexyl) Phthalate	0.006	mg/L	
Dinoseb	0.007	mg/L	
Diquat	0.02	mg/L	
Endothall	0.1	mg/L	
Endrin	0.002	mg/L	
Ethylene Dibromide (EDB)	0.00005	mg/L	
Glyphosate	0.7	mg/L	15
Heptachlor	0.0004	mg/L	
Heptachlor Epoxide	0.0002	mg/L	
Hexachlorobenzene	0.001	mg/L	
Hexachlorocyclopentadiene	0.05	mg/L	
Lindane	0.0002	mg/L	
Methoxychlor	0.04	mg/L	
Oxamyl (Vydate)	0.2	mg/L	
PCBs	0.0005	mg/L	16
Pentachlorophenol	0.001	mg/L	
Picloram	0.5	mg/L	
Simazine	0.004	mg/L	16
2,3,7,8-TCDD (Dioxin)	0.00005	µg/L	16
Toxaphene	0.005	mg/L	
2,4,5-TP (Silvex)	0.05	mg/L	

Parameter	Standard	Unit	Page Number
Radionuclides (all are primary standards)			
Alpha emitters	15	pCi/L	
Radium 226 + 228	5	pCi/L	
Radium 226	20	pCi/L	
Radium 228	20	pCi/L	
Beta-particle & photon emitters	4	mrem	
Radon (proposed)	300	pCi/L	16
Uranium	20	µg/L	
Inorganic Chemicals with Secondary Drinking Water Standards			
Aluminum (Al)	0.05-0.2	mg/L	
Chloride (Cl)	250	mg/L	9
Color	15	color units	
Copper (Cu)	1.0	mg/L	9
Corrosivity	Noncorrosive		10
Fluoride	2	mg/L	
Foaming Agents	0.5	mg/L	
Iron (Fe)	0.3	mg/L	11
Manganese (Mn)	0.05	mg/L	12
Odor	3	T.O.N.	
pH	6.5-8.5	pH units	12
Silver (Ag)	0.1	mg/L	
Sulfate (SO_4)	250	mg/L	12
Total Dissolved Solids (TDS)	500	mg/L	12
Zinc (Zn)	5	mg/L	

Appendix II—Glossary of Common Terms and Abbreviations

Acid Mine Drainage
Drainage of water from areas that have been mined for coal or other mineral ores; the water has low pH, sometimes less than 2.0 because of its contact with sulfur-bearing minerals, and often contains metals in concentrations toxic to aquatic life.

Acidic
The condition of water or soil containing a sufficient amount of acid substances to lower the pH below 7.0.

Action Level
The level of lead or copper which, if exceeded, triggers treatment or other requirements that a public water system must follow.

Acute Health Effect
An immediate effect that may result from exposure to certain drinking water contaminants.

Alkaline
The condition of water or soil containing a sufficient amount of alkali substances to raise the pH above 7.0.

Background Level
The average presence of a substance in the environment or occurring naturally.

Bacteria
Microscopic living organisms usually consisting of a single cell. Some bacteria in soil, water, or air may cause human, animal, and plant health problems.

Calcium Carbonate ($CaCO_3$) Equivalent
An expression of the concentration of specified constituents in water, in terms of their equivalent value to calcium carbonate. For example, the hardness in water caused by calcium, magnesium, and other ions is usually described as calcium carbonate equivalent.

Carcinogen
Any substance that produces cancer in an organism.

Central Nervous System (CNS)
Portion of the nervous system consisting of the brain and spinal cord.

Chronic Health Effect
The possible result of exposure over many years to a drinking water contaminant at levels above its MCL.

Cistern
A storage facility used to store water for a home or farm. Often used to store rain water.

Coliform
A group of bacteria found in the intestines of warm-blooded animals (including humans) and in plants, soil, air, and water. Fecal coliforms are a specific class of bacteria that inhabit only the intestines of warm-blooded animals. The presence of coliform is an indication that the water is polluted and may contain disease-causing organisms.

Conductivity
A measure of the ability of water to carry an electric current. Related to the total dissolved solids (TDS) in the water.

Contaminant
Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on air, water, or soil.

Corrosivity
An indication of the corrosiveness of a water sample, as described by the water pH, alkalinity, hardness, temperature, total dissolved solids, and dissolved oxygen concentration. The Langelier Index combines several of these features and is the commonly accepted measure of corrosivity.

Cryptosporidium Parvum
Flagellate protozoan that is shed during its oocyst stage with the feces of man and animals. When water containing these oocysts is ingested, the protozoan causes a severe gastrointestinal disease.

Exposure
Contact with a chemical or physical agent.

Fecal Coliform Bacteria
Bacteria found in the intestinal tracts of animals. Their presence in water is an indicator of pollution and possible contamination by pathogens.

Filtration
A process for removing particulate matter from water by passage through porous media.

First Draw
The water that immediately comes out when a faucet is first opened. This water is likely to have the highest levels of lead and copper contamination from plumbing materials.

Gallons Per Minute (gpm)
A common unit used to express the flow of water over time.

Gastroenteritis
An inflammation of the stomach and intestine resulting in diarrhea, with vomiting and cramps when irritation is excessive. When caused by an infectious agent, it is often associated with fever.

Giardia Lamblia
Flagellate protozoan that is shed during its oocyst stage with the feces of man and animals. When water containing these oocysts is ingested, the protozoan causes a severe gastrointestinal disease called giardiasis.

Grain Per Gallon (gpg)
A unit of measure for hardness, equal to 17.1 mg/L.

Gram (g)
A unit of mass (weight) equivalent to one milliliter of water at 4 degrees Celsius. 1/454 of a pound.

Granular Activated Carbon (GAC)
Material used in water treatment devices to remove organic chemicals, radon, and other pollutants.

Gross Alpha Particle Activity
The total radioactivity due to alpha particle emission, as inferred from measurements on a dry sample. Alpha particles do not penetrate solid materials.

Gross Beta Particle Activity
The total radioactivity due to beta particle emission, as inferred from measurements on a dry sample. Beta particles penetrate solid materials and are more hazardous.

Groundwater
The supply of fresh water found beneath the Earth's surface. Usually in aquifers, which are often used for supplying wells and springs. Because groundwater is a major source of drinking water, there is growing concern over areas where leaching agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating groundwater.

Hard Water
Alkaline water containing dissolved salts that interfere with some industrial processes and prevent soap from lathering. Some textbooks define hard water as water with a hardness of more than 100 mg/L (as calcium carbonate).

Hardness
A characteristic of water caused mainly by the salts of calcium and magnesium such as bicarbonate, calcium sulfate, chloride, and nitrate. Excessive hardness in water is undesirable because it causes the formation of soap curds, increased use of soap, deposition of scale in boilers, damage in some industrial processes, and sometimes objectionable tastes in drinking water.

Heavy Metals
Metallic elements with high atomic weights; e.g., mercury, chromium, cadmium, arsenic, and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Heterotrophic Plate Count (HPC)
A measure of the total number of bacteria in a sample. Also known as the Standard Plate Count (SPC).

Inorganic Chemicals (IOCs)
Chemicals of mineral origin.

Maximum Contaminant Level (MCL)
The maximum level of a health-related contaminant permitted in a public water system. Also known as a primary drinking water standard.

Maximum Contaminant Level Goal (MCLG)
The maximum level of a contaminant in drinking water at which no known or anticipated adverse effect on the health of persons would occur, and which allows an adequate margin of safety. Maximum contaminant level goals are nonenforceable health goals.

Microgram (μg)
One-millionth of a gram.

Micrograms Per Liter (μg/L)
One microgram of a substance dissolved in each liter of water. This unit is equal to parts per billion (ppb).

Microorganisms
Living organisms that can be seen individually only with the aid of a microscope.

Milligram (mg)
One-thousandth of a gram.

Milligrams Per Liter (mg/L)
A measure of concentration of a dissolved substance. A concentration of one mg/L means that one milligram of a substance is dissolved in each liter of water. For practical purposes, this unit is equal to parts per million (ppm).

Most Probable Number (MPN)
MPN is the Most Probable Number of coliform group organisms per unit volume of sample water as determined by a statistical relationship. Expressed as the number of organisms per 100 ml of sample water.

ND
Abbreviation for "Not Detected." Laboratory expression for a concentration of a substance in water too small to be detected by the instrumentation used.

Nonpotable
Water that may contain objectionable pollution, contamination, minerals, or infective agents and is considered unsafe and/or unpalatable for drinking.

National Sanitation Foundation (NSF)
Independent testing organization for water treatment equipment.

Nephelometric Turbidity Unit (NTU)
Unit of measure for turbidity in water.

Nonvolatile Organic Chemicals
Organic chemicals that do not escape readily into air from water. Also known as Synthetic Organic Chemicals (SOCs).

Organics
A term used to refer to chemical compounds made from carbon molecules.

Parts Per Million (ppm)
Parts per million parts, a measurement of concentration on a weight or volume basis. This term is equivalent to milligrams per liter (mg/L).

Parts Per Billion (ppb)
Parts per billion parts, a measurement of concentration on a weight or volume basis. This term is equivalent to micrograms per liter (µg/L).

Pathogens
Microorganisms that can cause disease in other organisms or in humans, animals, and plants. They may be bacteria, viruses, or parasites, and are found in sewage in runoff from animal farms or rural areas populated with domestic and/or wild animals, and in water used for swimming.

Pesticide
Any substance or chemical designed or formulated to kill or control weeds or animal pests.

pH
An expression of the intensity of the basic or acid condition of a liquid. Mathematically related to the hydrogen ion concentration, the pH may range from 0 to 14, where 0 is most acid, 14 most basic, and 7 neutral. Natural waters usually have a pH between 6.5 and 8.5.

Picocurie per liter (pCi/L)
A measure of radioactivity in water, commonly used for radon. One picocurie of radioactivity is equivalent to 0.037 nuclear disintegrations per second as measured by a Geiger counter.

Potable Water
Water that is safe and satisfactory for drinking and cooking.

Primary Drinking Water Standard
See Maximum Contaminant Level (MCL).

Public Water System
A system for providing piped water for human consumption to the public, having at least 15 service connections or regularly providing water at least 60 days out of the year to 25 or more people per day. A public water system is either a "community water system" (town) or a "noncommunity water system" (gas station, camp, etc).

Recommended Maximum Contaminant Level (RMCL)
See "Secondary Maximum Contaminant Level," below.

Septic System
An onsite system designed to treat and dispose of domestic sewage.

Secondary Maximum Contaminant Level (SMCL)
Limits or standards given to pollutants that have only aesthetic effects in water. Also called Recommended Maximum Contaminant Levels or RMCLs.

Secondary Drinking Water Standard
See Secondary Maximum Contaminant Level (SMCL).

Soft Water
Water having a low concentration of calcium and magnesium ions. According to U.S. Geological Survey guidelines, soft water is water having a hardness of 60 milligrams per liter or less.

Standard Plate Count (SPC)
See Heterotrophic Plate Count (HPC) above.

Surface Water
All water naturally open to the atmosphere, and all springs, wells, or other collectors that are directly influenced by surface water.

Synthetic Organic Chemicals (SOC)
Term used to describe nonvolatile organic chemicals such as most pesticides.

Total Dissolved Solids (TDS)
A measure of all of the dissolved ions in water.

TNTC
Abbreviation for "Too Numerous to Count." A measure of bacteria concentration.

Turbidity
The cloudy appearance of water caused by the presence of suspended and colloidal matter. Used to indicate the clarity of water.

Virus
The smallest form of microorganism capable of causing disease.

Volatile Organic Chemicals (VOCs)
Organic chemicals that escape readily into the air from water.

Quick Reference Table to Common Pollutants in Pennsylvania

Contaminant	Source	Standard	Effects
Microbial			
Coliform Bacteria	Surface water, human and animal waste	0 per 100 ml	Gastrointestinal problems, waterborne diseases
Fecal Coliform Bacteria	Human and animal waste	0 per 100 ml	Gastrointestinal problems, waterborne diseases
Fecal Streptococcus Bacteria	Human and animal waste	0 per 100 ml	Gastrointestinal problems, waterborne diseases
E. Coli	Human and animal waste	0 per 100 ml	Gastrointestinal problems, waterborne diseases
Standard Plate Count or Heterotrophic Plate Count	Common bacteria including coliform and other groups	No standard	> 500 per milliliter may indicate coliform bacteria contamination (see above)
Iron Bacteria	Naturally occurring	No standard	Unsightly growth, clogged pipes, reduced well yield
Giardia	Human and animal waste, surface water	0 cysts	Giardiasis (nausea, fever, diarrhea, etc.)
Cryptosporidium	Human and animal waste, surface water	0 cysts	Cryptosporidiosis (nausea, fever, etc.)
Inorganic Chemicals			
Arsenic	Natural deposits, gas well brines	0.005 mg/L (proposed)	Skin lesions, nervous system disorders, cancer
Alkalinity	Natural sources	No standard	Influences hardness
Barium	Natural deposits, gas well brines	2.0 mg/L	High blood pressure, nervous system damage
Chloride	Natural sources, road salt, sewage	250 mg/L (recommended)	Salty taste, corrosion of metal
Copper	Corrosion of plumbing	1.3 mg/L 1.0 mg/L (recommended)	Gastrointestinal illness Metallic taste, bluish stains
Corrosivity	Natural sources	Noncorrosive (recommended)	Dissolves plumbing components
Hardness	Natural sources	No standard	Scaly deposits, decreased soap cleansing
Hydrogen Sulfide	Naturally occurring	No standard	Rotten egg odor
Iron	Coal mining or natural sources	0.30 mg/L (recommended)	Metallic taste, stains
Lead	Plumbing corrosion, industrial wastes, gas well brines	0.015 mg/L	Numerous health effects, especially in children
Manganese	Coal mining or natural sources	0.05 mg/L (recommended)	Blackish stains, metallic taste
Nitrate (as Nitrogen)	Animal and human wastes, fertilizers	10 mg/L	Blue-baby disease in infants

Quick Reference Table to Common Pollutants in Pennsylvania

Contaminant	Source	Standard	Effects
pH	Natural sources, mining, acid rain	6.5 to 8.5 (recommended)	Corrosion (low pH), taste (high pH)
Sulfate	Coal mining or natural sources	500 mg/L (proposed MCL) 250 mg/L (recommended)	Laxative effects Bitter taste
Total Dissolved Solids	Sum of all dissolved ions in water	500 mg/L (recommended)	Objectionable taste, odor, color
Turbidity	Surface water, runoff	1.0 NTU	Objectionable appearance, promotes bacteria
Volatile Organic Chemicals (VOCs)			
Benzene	Industrial solvent, gasoline additive	0.005 mg/L	Carcinogen
Carbon Tetrachloride	Production of chlorofluorocarbons	0.005 mg/L	Gastrointestinal and nervous system effects
Chloroform	Industrial processes	No standard	Possible carcinogen, part of trihalomethanes (THMs), which have a MCL of 0.08 mg/L
Methyl Tert-Butyl Ether (MTBE)	Gasoline additive	No standard	Possible carcinogen
Tetrachloroethylene (PCE)	Dry-cleaning industry, industrial solvent	0.005 mg/L	Possible carcinogen; liver, kidney, nerve damage
Trichloroethylene (TCE)	Industrial solvent, metal degreaser	0.005 mg/L	Probable carcinogen; liver, kidney, nerve damage
Xylenes	Gasoline, industrial processes	10 mg/L	Liver, kidney, nervous system damage
Nonvolatile (Synthetic) Organic Chemicals (SOCs)			
Atrazine	Common herbicide	0.003 mg/L	Possible carcinogen; liver, kidney, heart damage
2,4-D	Common herbicide on farms and lawns	0.07 mg/L	Liver, circulatory and nervous system damage
Chlorpyrifos (Dursban)	Common insecticide	No standard	Possible carcinogen
Dioxin	Production of chlorinated chemicals	0.00000005 mg/L	Carcinogen, birth defects, liver and reproductive effects
Glyphosate	Common herbicide	0.7 mg/L	Kidney and reproductive damage
Metolachlor	Common herbicide	No standard	Possible carcinogen
Polychlorinated Biphenyls (PCBs)	Insulating material, coolant, lubricant	0.0005 mg/L	Probable carcinogens; liver, kidney, nervous system damage
Simazine	Common herbicide	0.004 mg/L	Carcinogen; damage to testes, kidneys, liver, and thyroid
Radiological			
Radon	Naturally occurring gas	300 pCi/L (proposed)	Carcinogen if inhaled, possible carcinogen if ingested

Important Information About Your Water Source

Provide as much of the following information as possible about your water supply. This information will be useful should you need help solving a future water problem.

Type of Water Supply (circle one): Drilled Well Dug Well Spring Cistern Public Water Other

How deep is your well? feet

When was it drilled or dug?

What was the approximate flow or yield from the well? gallons per minute

Do you have a copy of your completed well log? If yes, you may want to place it in the pocket inside the back cover of this publication.

If you have a spring, when was it developed or redeveloped?

What is the approximate flow or yield from the spring? gallons per minute

If you have public water, what is the name of your water supplier?

How far is your water supply from the nearest septic system?

How close are other contaminant sources (mines, gas stations, industries, farm fields etc.)?

Contaminant Source Distance from My Water Supply

1.

2.

3.

Name and address of the person who installed or developed your well, spring, or cistern:

Name

Address

City State Zip

Phone Fax E-Mail

What water treatment devices do you have on your water supply?

Name and address of the person or company who installed your water treatment equipment:

Name

Address

City State Zip

Phone E-Mail

Additional comments:

Record any water testing information from your water supply on the next page.

Water Test Results

Date Sampled	Water Source	Water Test Results	Comments
Example: August 15, 2001	Spring Feeding the House	OK ☐ Not OK ☑	Iron level high
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	
		OK ☐ Not OK ☐	

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Chester County
2016 Impaired Waters Map Series

Map IW-1-2016

Impairments as of 2016 PADEP
Integrated Water Quality Report

All Causes of Impairment

Of the 2,348 miles of streams in Chester County, Pennsylvania Department of Environmental Protection (PADEP) routinely assesses 1,394 stream miles using an assessment methodology approved by the U.S. Environmental Protection Agency to determine if a stream is meeting water quality standards. In the 2016 report, PADEP listed 957 miles of streams in Chester County as impaired, which means they do not meet water quality standards.

The list of impaired streams, as well as the list of streams assessed that met the water quality standards, are found in the "2016 Pennsylvania Integrated Water Quality Monitoring and Assessment Report" on the PADEP web site.

- Waters listed as impaired for at least one impairment in the 2016 PADEP Integrated Water Quality Report
- Waters assessed for at least one parameter and with no listed impairments in the 2016 PADEP Integrated Water Quality Report
- Municipal Boundaries
- County Boundary
- Watersheds
- Delaware River Basin
- Chesapeake Bay Basin
- Pickering Creek Reservoir - Not Assessed as of 2016 Report

DATA SOURCES:
2016 Non-Attaining Streams; 2016 Attaining Streams; 2016 Non-Attaining Lakes; 2016 Attaining Lakes - Pennsylvania Department of Environmental Protection. Data downloaded from Pennsylvania Spatial Data Access (PASDA) web site in August 2017.
Administrative Boundaries and Watersheds - Chester County, 2017.

Chester County Water Resources Authority
www.chesco.org/water
October 17, 2017

Chester County Water Resources Authority
CHESTER COUNTY ~ PENNSYLVANIA

Chester County
2016 Impaired Waters Map Series

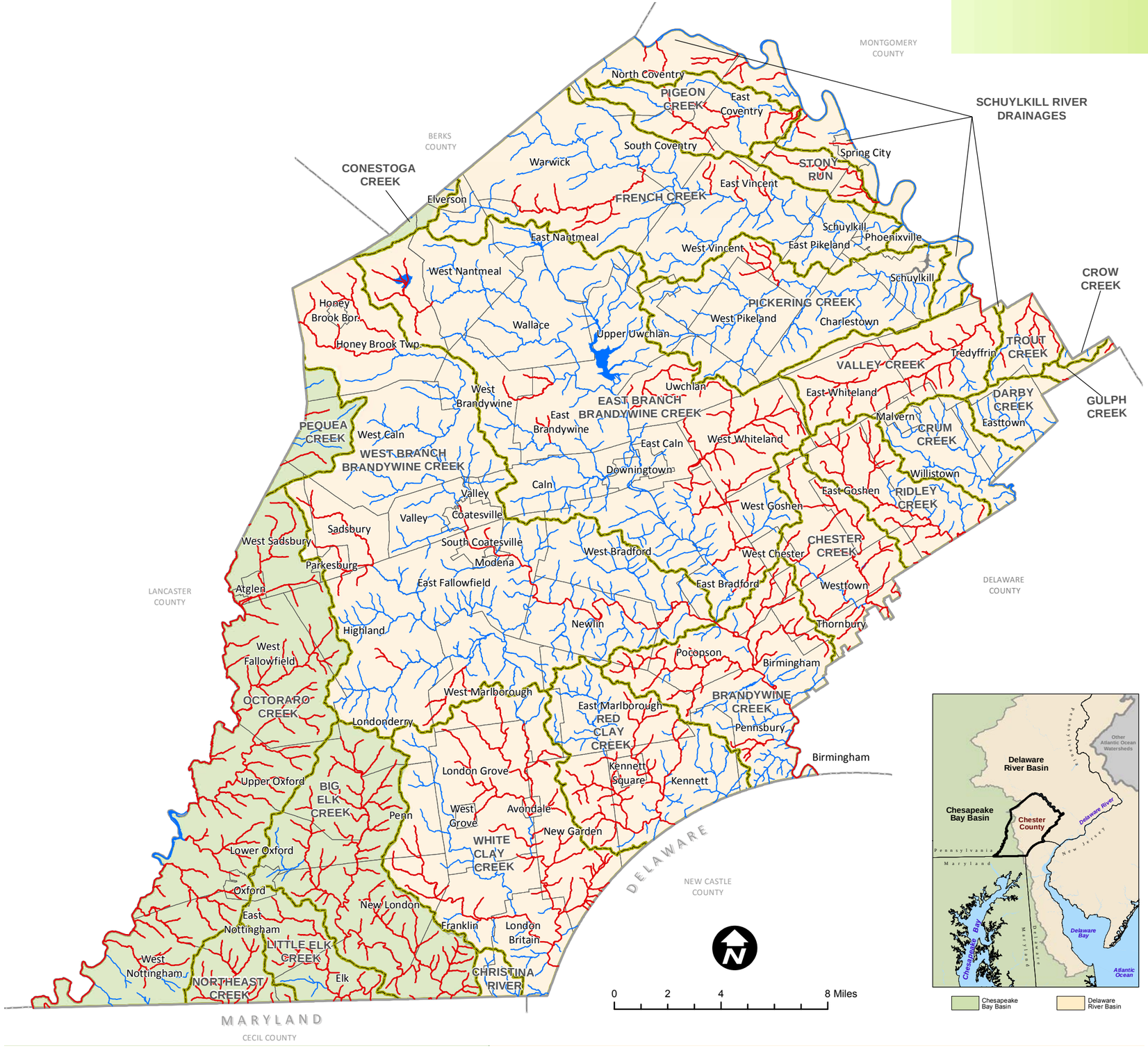
Map IW-14-2016

Impairments as of 2016 PADEP
Integrated Water Quality Report

Siltation

Siltation – Aggradation of “clean” sediments or soils in excess of what the stream channel can transport. Results in smothering of habitat for macroinvertebrates and fishes.

- Waters listed as impaired for "Siltation" in the 2016 PADEP Integrated Water Quality Report
- Waters assessed for at least one parameter and not listed as impaired for "Siltation" in the 2016 PADEP Integrated Water Quality Report
- Municipal Boundaries
- County Boundary
- Watersheds
- Delaware River Basin
- Chesapeake Bay Basin
- Pickering Creek Reservoir - Not Assessed as of 2016 Report



DATA SOURCES:
2016 Non-Attaining Streams; 2016 Attaining Streams; 2016 Non-Attaining Lakes; 2016 Attaining Lakes - Pennsylvania Department of Environmental Protection. Data downloaded from Pennsylvania Spatial Data Access (PASDA) web site in August 2017.
Administrative Boundaries and Watersheds - Chester County, 2017.

DISCLAIMER:
This map was generated using the best information available at the time of publication. This map should not be relied upon as the sole basis of determination of regulatory requirements or responsibilities. The relevant PADEP reports and other documents should be consulted for official designations and associated regulatory information. Should any conflicts exist between this map and the PADEP reports and regulations, the latter supersede this map.

This map was digitally compiled for internal maintenance and developmental use by the County of Chester, Pennsylvania to provide an index to parcels and for other reference purposes. Parcel lines do not represent actual field surveys of premises. County of Chester, Pennsylvania makes no claims as to the completeness, accuracy or content of any data contained hereon, and makes no representation of any kind, including, but not limited to, the warranties of merchantability or fitness for a particular use, nor are any such warranties to be implied or inferred, with respect to the information or data furnished herein.

Chester County Water Resources Authority
www.chesco.org/water
October 17, 2017

Chester County Water Resources Authority
CHESTER COUNTY ~ PENNSYLVANIA

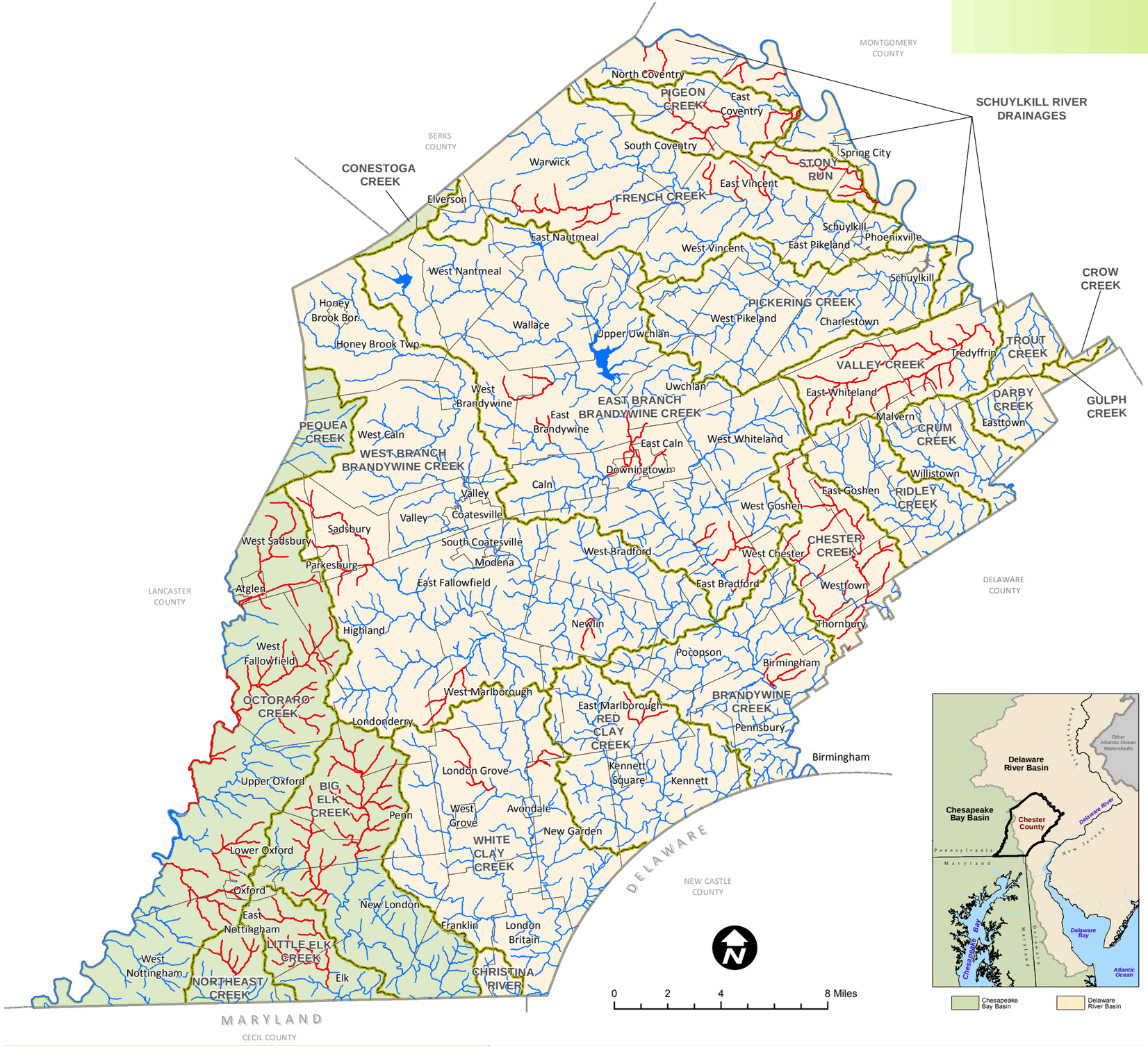
Chester County
2016 Impaired Waters Map Series

Map IW-10-2016

Impairments as of 2016 PADEP
Integrated Water Quality Report

Other Habitat Alterations

Other Habitat Alterations – Habitat changes due to severe bank erosion, removal or lack of riparian vegetation, and concrete channels and streambeds.



Waters listed as impaired for "Other Habitat Alterations" in the 2016 PADEP Integrated Water Quality Report

Waters assessed for at least one parameter and not listed as impaired for "Other Habitat Alterations" in the 2016 PADEP Integrated Water Quality Report

Municipal Boundaries

County Boundary

Watersheds

Delaware River Basin

Chesapeake Bay Basin

Pickering Creek Reservoir - Not Assessed as of 2016 Report

DATA SOURCES:
2016 Non-Attaining Streams; 2016 Attaining Streams; 2016 Non-Attaining Lakes; 2016 Attaining Lakes - Pennsylvania Department of Environmental Protection. Data downloaded from Pennsylvania Spatial Data Access (PASDA) web site in August 2017.
Administrative Boundaries and Watersheds - Chester County, 2017.

Chester County Water Resources Authority
www.chesco.org/water
October 17, 2017

Chester County Water Resources Authority
CHESTER COUNTY ~ PENNSYLVANIA

Chester County
2016 Impaired Waters Map Series

Map IW-17-2016

Impairments as of 2016 PADEP
Integrated Water Quality Report

Water/Flow Variability

Water/Flow Variability – Changes in hydrologic regime caused by water releases, increased surface runoff from impervious surfaces during storm events, scouring and drought. Results in unstable environment for macroinvertebrates and fishes. Habitat alterations include stream widening, substrate paving, shallower pools, etc.

Waters listed as impaired for "Water/Flow Variability " in the 2016 PADEP Integrated Water Quality Report

Waters assessed for at least one parameter and not listed as impaired for "Water/Flow Variability " in the 2016 PADEP Integrated Water Quality Report

Municipal Boundaries

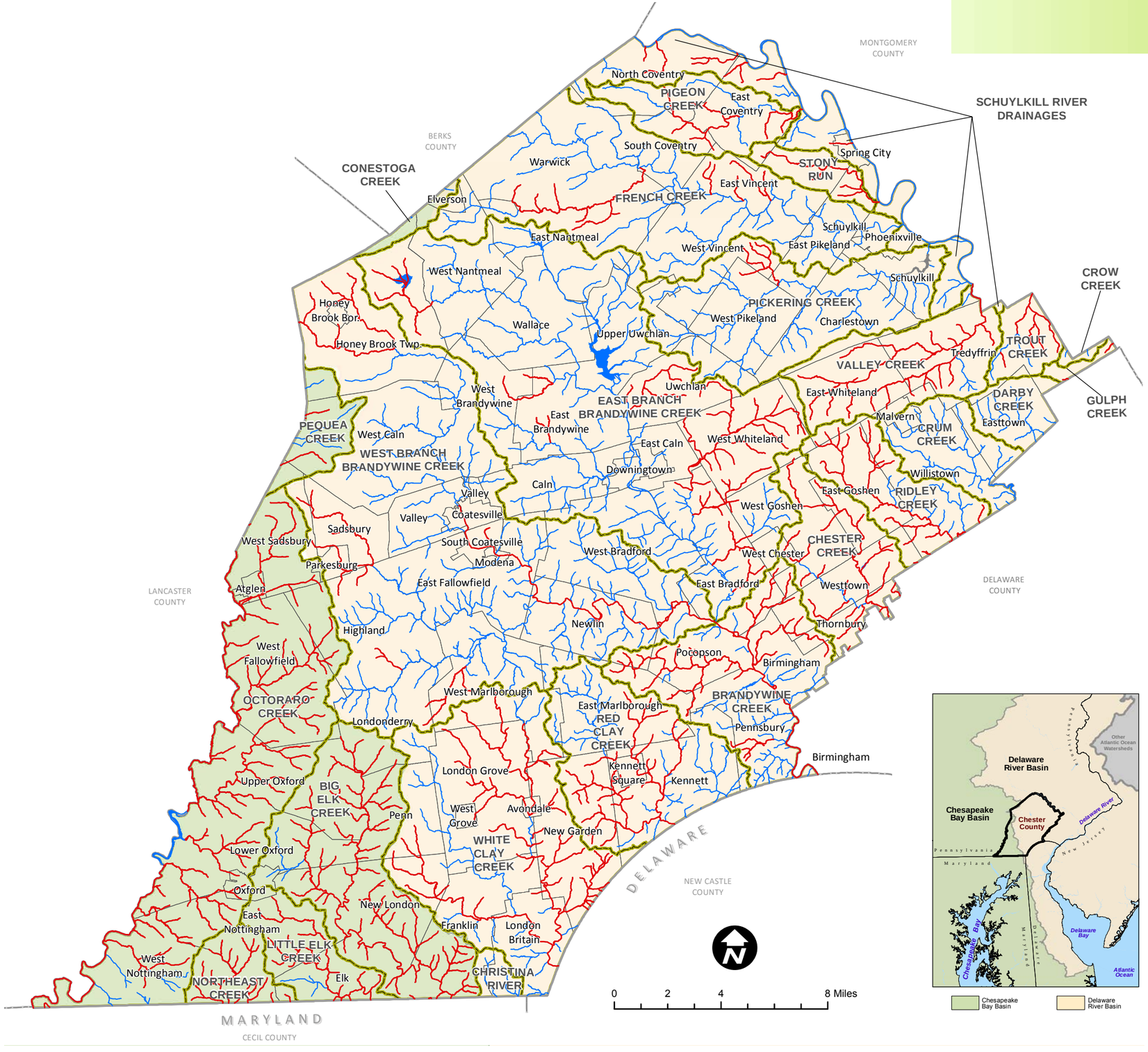
County Boundary

Watersheds

Delaware River Basin

Chesapeake Bay Basin

Pickering Creek Reservoir - Not Assessed as of 2016 Report



DATA SOURCES:
2016 Non-Attaining Streams; 2016 Attaining Streams; 2016 Non-Attaining Lakes; 2016 Attaining Lakes - Pennsylvania Department of Environmental Protection. Data downloaded from Pennsylvania Spatial Data Access (PASDA) web site in August 2017.
Administrative Boundaries and Watersheds - Chester County, 2017.

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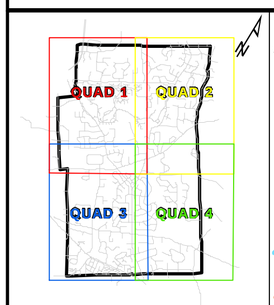
Chester County Water Resources Authority
www.chesco.org/water
October 17, 2017

Chester County Water Resources Authority
CHESTER COUNTY ~ PENNSYLVANIA

EAST GOSHEN TOWNSHIP

QUAD MAP 1
STORMWATER INFRASTRUCTURE



Storm Structures
- Outfall
- Misc
- Junction Box
- Pipe Inlet/Outlet
- Swale
- Headwall/Endwall
- Storm Drain Inlet
- Ponds
- Streams
- Storm Basins
- Watersheds

0 200 400 800 Feet
1 inch = 400 feet

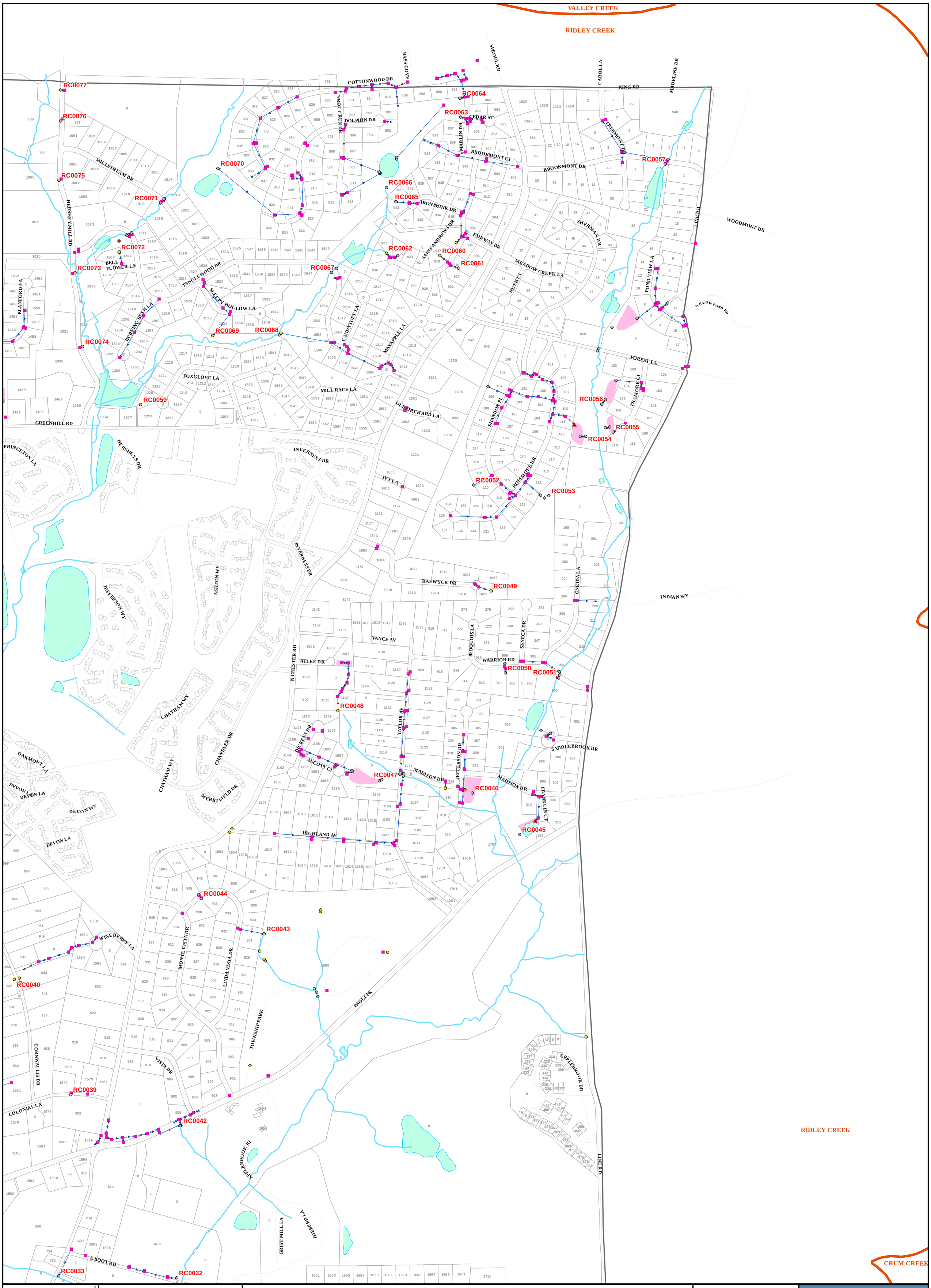
DATE :	11/16/2016
SCALE:	1 inch = 400 feet
FILE:	StormwaterQuad1.mxd

NOTES:
Parcel and Road data provided by Chester County GIS. Storm Structures located by East Goshen Public Works. All data Projected in:

NAD_1983_StatePlane Pennsylvania_South_FIPS_3702_Feet

CREATED BY: Matthew Convery
Convery64@gmail.com 484-252-9500

East Goshen Township
Incorporated 1817
Chester County, Pennsylvania



EAST GOSHEN TOWNSHIP

QUAD MAP 2
STORM WATER INFRASTRUCTURE

DATE : 11/16/2015

SCALE: 1 inch = 400 feet

FILE: StormwaterQuad2.mxd

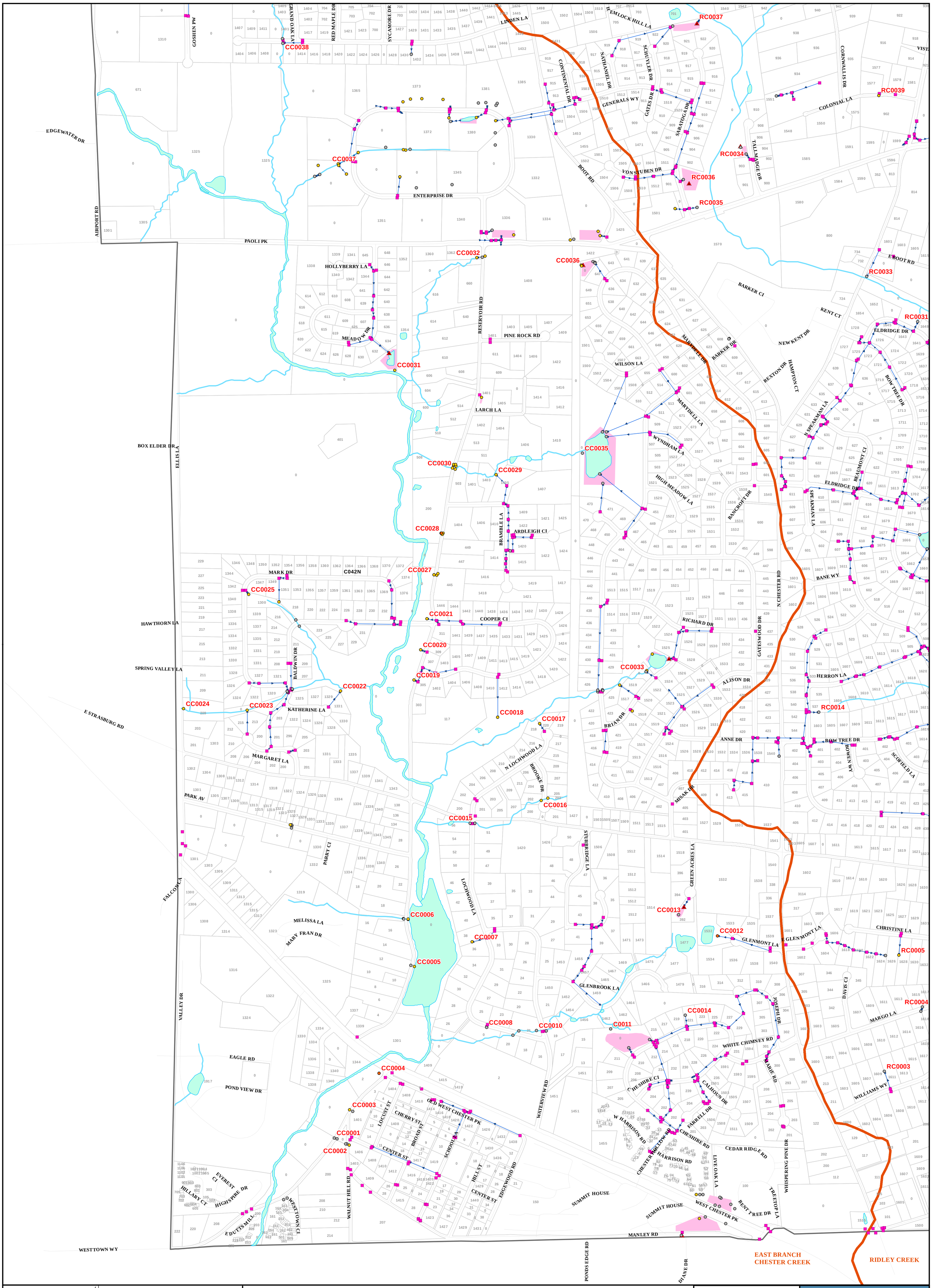
NOTES:
Parcel and Road data provided by Chester County GIS. Storm Structures GPS located by East Goshen Public Works. All data Projected in:

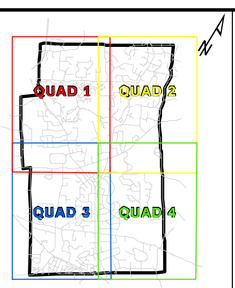
NAD_1983_StatePlane Pennsylvania_South_FIPS_3702_Feet

CREATED BY: Matthew Convery

Convery64@gmail.com 484-252-9500

East Goshen Township
Incorporated 1817
Chester County, Pennsylvania





Storm Structures

- Outfall
- Misc
- Junction Box
- Pipe Inlet/Outlet
- Swale
- Headwall/Endwall
- Storm Drain Inlet
- Storm Pipe
- Watersheds
- Ponds
- Streams
- Storm Basins

0 200 400 800 Feet

1 inch = 400 feet

EAST GOSHEN TOWNSHIP

QUAD MAP 3
STORM WATER INFRASTRUCTURE

DATE : 11/16/2016

SCALE: 1 inch = 400 feet

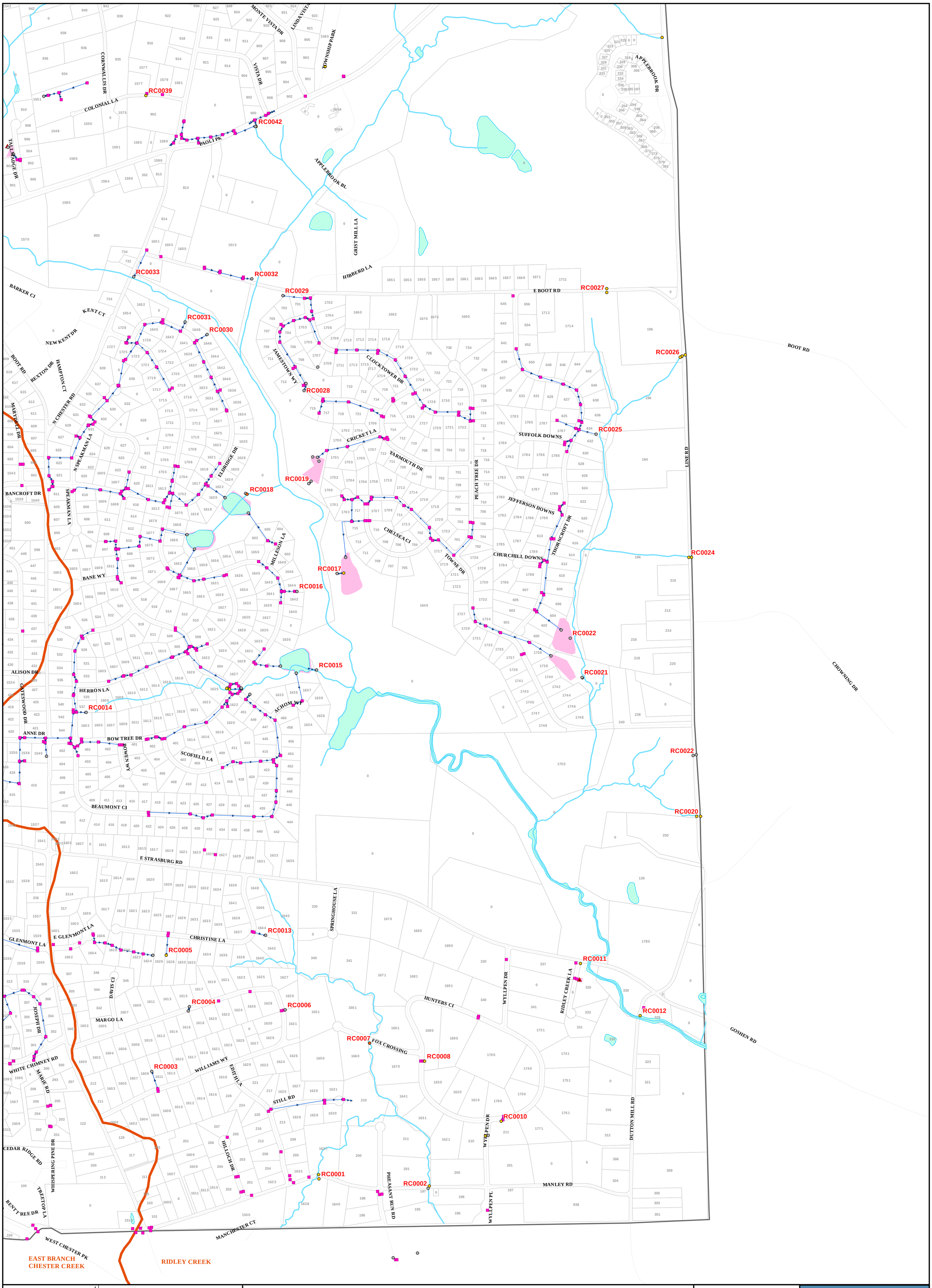
FILE: StormwaterQuad3.mxd

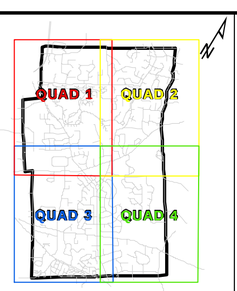
NOTES:
Parcel and Road data provided by Chester County GIS. Storm Structures GPS located by East Goshen Public Works. All data Projected in:

NAD_1983_StatePlane Pennsylvania_South_FIPS_3702_Feet

CREATED BY: Matthew Convery
Convery64@gmail.com 484-252-9500

East Goshen Township
Incorporated 1817
Chester County, Pennsylvania





Storm Structures

- Outfall
- Misc
- Junction Box
- Pipe Inlet/Outlet
- Swale
- Headwall/Endwall
- Storm Drain Inlet
- Storm Pipe
- Streams
- Watersheds
- Ponds
- Storm Basins

0 200 400 800 Feet

1 inch = 400 feet

EAST GOSHEN TOWNSHIP

QUAD MAP 4
STORM WATER INFRASTRUCTURE

DATE : 11/16/2016

SCALE: 1 inch = 400 feet

FILE: Quad1SewerBasemap.mxd

NOTES:
Parcel and Road data provided by Chester County GIS. Storm Structures GPS located by East Goshen Public Works. All data Projected in:

NAD_1983_StatePlane Pennsylvania_South_FIPS_3702_Feet

CREATED BY: Matthew Convery
Convery64@gmail.com 484-252-9500

East Goshen Township
Incorporated 1817
Chester County, Pennsylvania

INLET FILTER BAG - **Sediment Removal Efficiency: MODERATE. This device is an ABACT for HQ but not EV watersheds.** Filter bags should be capable of trapping all particles not passing a No.40 Sieve.

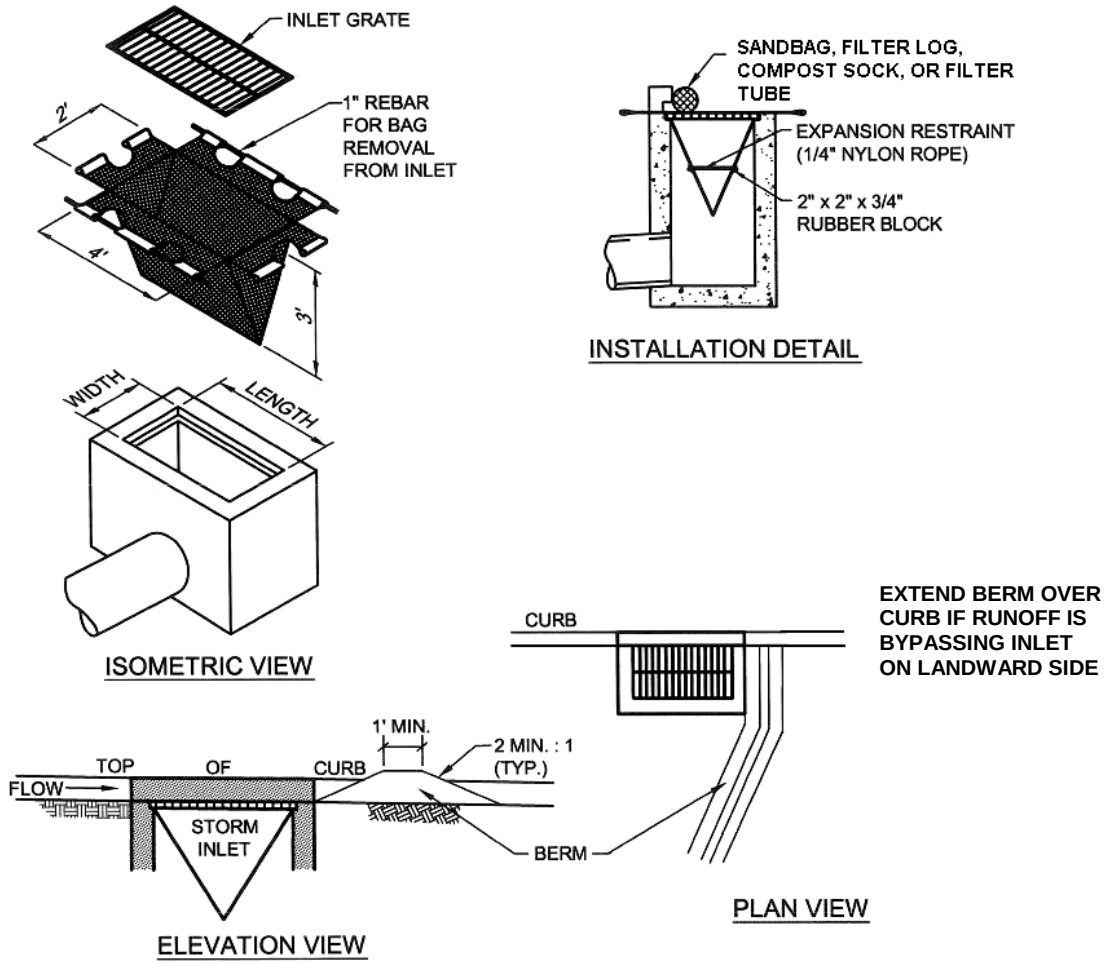
Northampton Conservation District

Wherever filter bags are used they should be installed according to the manufacturer's specifications. Typical installation details should be provided on the drawings. Standard Construction Details # 4-15 and # 4-16 are recommended. NOTE: Filter bags designed to fit over the inlet grate are not recommended for most storm sewer inlets. Use of such filter bags could result in a severe reduction of the inlet capacity resulting in flooding or runoff bypassing the inlet. Wherever such bags are used, they should be located at topographic low points and limited to ¼ acre maximum drainage areas. Inlet filter bags are not acceptable as the primary BMP to remove sediment from site runoff water.

Inlet filter bags should be inspected on a weekly basis and after each runoff event. Filter bags should be cleaned and/or replaced when the bag is half full or when flow capacity has been reduced so as to cause flooding or bypassing of the inlet. Accumulated sediment should be disposed in the approved manner. Bags that will be reused should be rinsed at a location where the rinse water will enter a sediment trap or sediment basin. Damaged filter bags should be replaced.

Needed repairs should be initiated immediately after the inspection.

STANDARD CONSTRUCTION DETAIL # 4-15
Filter Bag Inlet Protection - Type C Inlet



Adapted from PennDOT RC-70, 2008 Edition

Maximum drainage area = ½ acre.

Inlet protection shall not be required for inlet tributary to sediment basin or trap. Berms shall be required for all installations.

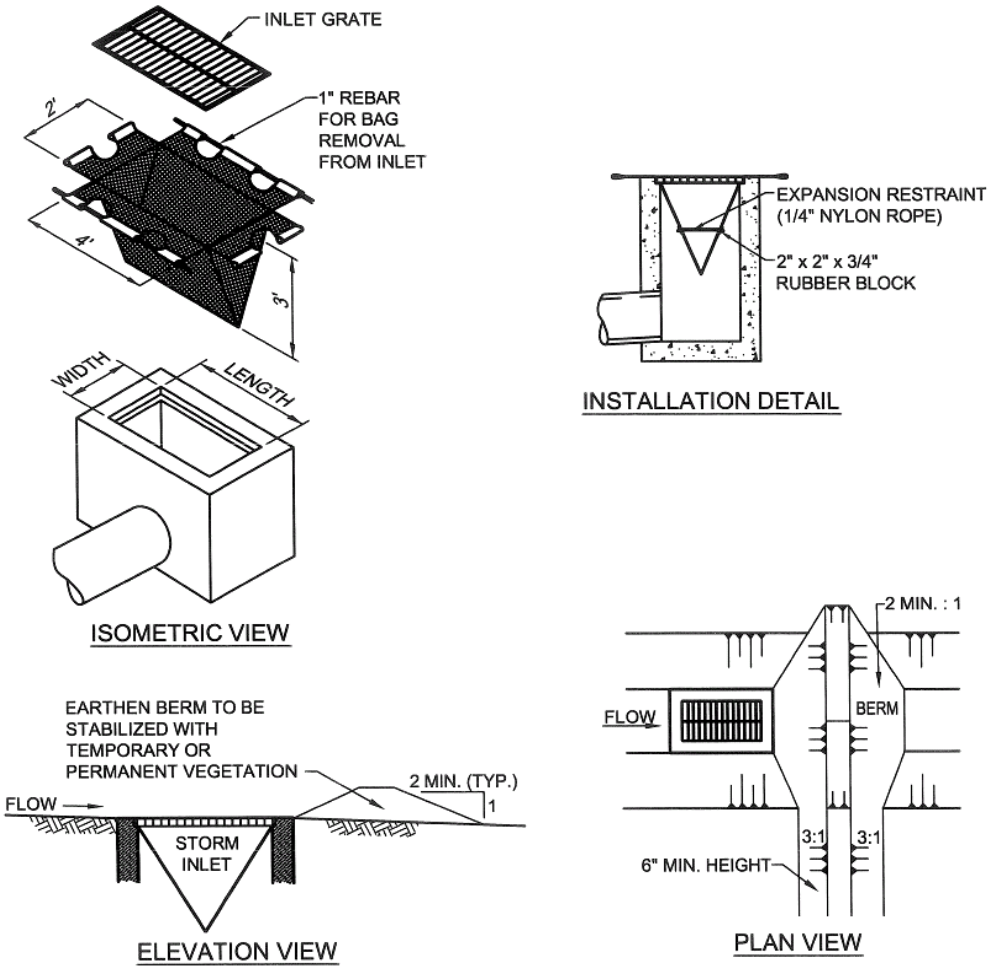
Rolled earthen berm shall be maintained until roadway is stoned. Road subbase berm shall be maintained until roadway is paved. Six inch minimum height asphalt berm shall be maintained until roadway surface receives final coat.

At a minimum, the fabric shall have a minimum grab tensile strength of 120 lbs, a minimum burst strength of 200 psi, and a minimum trapezoidal tear strength of 50 lbs. Filter bags shall be capable of trapping all particles not passing a No. 40 Sieve.

Inlet filter bags shall be inspected on a weekly basis and after each runoff event. Bags shall be emptied and rinsed or replaced when half full or when flow capacity has been reduced so as to cause flooding or bypassing of the inlet. Damaged or clogged bags shall be replaced. A supply shall be maintained on site for replacement of bags. All needed repairs shall be initiated immediately after the inspection. Dispose of accumulated sediment as well as all used bags according to the plan notes.

DO NOT USE ON MAJOR PAVED ROADWAYS WHERE PONDING MAY CAUSE TRAFFIC HAZARDS.

STANDARD CONSTRUCTION DETAIL # 4-16
Filter Bag Inlet Protection - Type M Inlet



Adapted from PennDOT RC-70, 2008 Edition

Maximum drainage area =½ acre.

Inlet protection shall not be required for inlet tributary to sediment basin or trap. Berms shall be required for all installations.

Rolled earthen berm in roadway shall be maintained until roadway is stoned. Road subbase berm on roadway shall be maintained until roadway is paved. Earthen berm in channel shall be maintained until permanent stabilization is completed or remain permanently.

At a minimum, the fabric shall have a minimum grab tensile strength of 120 lbs., a minimum burst strength of 200 psi, and a minimum trapezoidal tear strength of 50 lbs. Filter bags shall be capable of trapping all particles not passing a No. 40 sieve.

Inlet filter bags shall be inspected on a weekly basis and after each runoff event. Bags shall be emptied and rinsed or replaced when half full or when flow capacity has been reduced so as to cause flooding or bypassing of the inlet. Damaged or clogged bags shall be replaced. A supply shall be maintained on site for replacement of bags. All needed repairs shall be initiated immediately after the inspection. Dispose accumulated sediment as well as all used bags according to the plan notes.

DO NOT USE ON MAJOR PAVED ROADWAYS WHERE PONDING MAY CAUSE TRAFFIC HAZARDS.

TreeVitalize Watersheds Grant Program 2018

Since 2005, **TreeVitalize Watersheds,** led by the Pennsylvania Horticultural Society (PHS) in the five-county southeastern PA (SE PA) region, has focused on tree planting along stream corridors, wetlands, adjacent upland areas, headwaters, and "naturalized" stormwater basins. Through this program, dozens of such watershed restoration projects are conducted throughout the region every year, resulting in well over one hundred thousand trees planted in those sensitive water protection zones. The program receives funding from the Pennsylvania Department of Environmental Protection (DEP) and corporate sponsor Aqua PA, as well as substantial in-kind contributions from various partners.

TreeVitalize Watersheds depends on collaboration with six organizations that funnel, guide, and help implement watershed restoration projects in their service areas: Philadelphia Parks & Recreation, the Conservation District offices in each of the four surrounding SE PA counties, and the Stroud Water Research Center in Chester County. These organizations will provide technical assistance to you as you develop your project and write your application. Look for contact information on last page.

Who can apply:
Anyone with a good project on permanently protected land can apply, such as non-profit organizations, municipalities, schools, scouting groups and community organizations. If your organization is not for profit but not registered as a non-profit, you can partner with a non-profit or your local government to apply. New applicants must complete Tree Tender training to be eligible (see below for details). Private landowners can apply through a non-profit if they are willing to sign a 20-year agreement promising to leave the plantings undisturbed and allow maintenance of the plantings

Grant applications should only be submitted for projects that are "shovel ready" *(meaning that with sufficient funding, plantings can be completed and billed prior to the reimbursement request deadline, as all associated permits and/or authorizations have already been secured, where necessary).*

How to apply: Contact your County Conservation District Watershed Specialist or, within Philadelphia, PHS (contact information included on page 3.) Your grant advisor will guide you through the steps involved in planning a stream bank restoration or related project, including plant material selection, site preparation, landowner agreements, matching funds, and the required grant application documents (see below under "Grant Application Submittal Deadline")

Grant Application Package: A complete grant application package must be submitted (for "initial" review) to the local Conservation District, or within Philadelphia, to the Parks & Recreation Department. The grant application package **includes 1) an Application Completion Checklist, with all required items checked; 2) a Project Bid Sheet; 3) a brief Project Narrative; 4) a Site Location map (in color); 5) a signed Operation, Maintenance and Repair Plan; and 6) a Landowner Agreement form.** All forms listed are available from the Treevitalize Watersheds page of the PHS Plant One Million website: http://phsonline.org/programs/plant-one-million/treevitalize-watersheds-grant-program/

Grant Package Submittal Deadline for TreeVitalize 2018 Projects: November 10, 2017

New this year! Apply online, including mapping and form uploads, using the Urban Forest Cloud web tool: https://pg-cloud.com/phs/ . Once there, you can click on "Help and Tutorials" for more assistance. NOTE: You will need to register an account first. You will also be able to submit your Request for Reimbursement there.

Important! *If you start your application on the Urban Forest cloud site, you cannot save your application. In other words, if you exit your application or click on the "back" arrow, everything you have entered so far will be lost. So, have all the necessary documents (project narrative, etc.) finished, saved to your computer and ready for upload before you start. Once you have successfully submitted your application, a copy will be saved for you.*

If you are computer-averse, you can continue to use the paper application documents. Please send the documents in the order that they are listed on the Grant Application Completion Checklist, starting with the Checklist. Send your Application materials to your

County Conservation District Watershed Specialist (your grant advisor); those addresses are listed on pages 3 and 4. **Only complete grant application packets will be considered for funding.**

Deadlines: Submission of your complete grant application is due to the above entities by **November 10, 2017.** Once initial reviews have been completed, the Conservation Districts, Philadelphia Parks and Recreation and Stroud will forward all complete grant application packages to PHS for final review.

Target areas and project types: Streamside and sourcewater protection areas, on public lands or private permanently protected lands. Projects may include stream buffers, wetlands, plantings on adjacent uplands (where stormwater "sheet flow" across the land would drain directly into the stream below) and naturalization of stormwater basins. Landowners must be willing to sign the DEP Landowner Agreement, which requires all plantings to be undisturbed for a period of **20 years**. Either the Landowner, Applicant or both must sign the Operations and Maintenance Agreement.

Tree stock: All projects must use native Pennsylvania species. Trees are typically acquired as container stock, though bare root and ball-and-burlap trees (B&B should be limited and cost less than $100 each) are also acceptable. The size of the tree stock can vary widely, depending on the site, planting method, and other considerations; but an average cost of $25 per tree or less is preferred. Note: The natural plant community (**http://www.naturalheritage.state.pa.us/communities.aspx)** present in the project site area should be taken in consideration when selecting the planting material for the project.

Other plants: Trees alone are rarely enough for an ecological restoration project. Shrubs and herbaceous plants may be needed as well. TreeVitalize Watersheds funding can be used to cover the cost of some complementary plant material, provided it is also native to Pennsylvania. However, trees must account for at least 80% of the overall cost of plant materials.

Eligible and ineligible expenses: In addition to covering plant costs (including transport), the TreeVitalize grant may be applied toward site preparation and supplies such as mulch, watering bags and tree shelters. Non-profit staff project management time is allowed as an expense but it must be justified and no more than $1,000. Ineligible expenses include shirts, hats, and food for volunteers, although such expenses can generally be counted as in-kind or cash "match" (below). Other expenses may not be covered by TreeVitalize without express permission of the PHS grants manager. PHS TreeVitalize Watersheds Regional Manager Bob Adams may be reached at 215-988-8795. More detail on allowable project expenses can be found in the Treevitalize Eligible Expenses document included with this announcement. **New this year- watering bags are an eligible expense, limit 30 bags per year.**

Required match: TreeVitalize will cover up to 75% of the total project costs. The remainder must be covered by other sources as part of the required minimum 25% match. In-kind contributions, such as volunteer and staff time for planting, site preparation, and maintenance are applicable towards those match requirements. For volunteer effort match, sign-in sheets are required and must be submitted to document the number of volunteers and the hours those volunteers participated. Staff time must be documented with timesheets. **New this year- monitoring and maintenance of previous TreeVitalize Watersheds projects may be counted as match.**

Consultant costs: The use of consultants is discouraged for most TreeVitalize Watersheds projects, but may be necessary in some cases. The maximum allowed amount in such cases is $1,000 toward consultants' fees. Additional fees may be counted as match.

Conservation District fee: The County Conservation District Office may add a $200 fee for each project to help offset the staff time spent by the Watershed Specialist. Please keep in mind that this $200 will not be available for project expenses.

Overall approval considerations: In order to fund as many projects as possible with limited and increasingly competitive funding, project approval will take into account various factors, including the level of partner match, the price of plant material used, and consultant costs, if any. Individual site and project considerations will also be taken into account.

Completion and reimbursement: The grant is on a 100% reimbursement basis after project completion. Your County Conservation District, Stroud Water Research Center, or PHS (in Philadelphia) will provide reimbursement to grantees for completed projects upon submission of: **1) completed Request for Reimbursement Checklist; 2) completed Project Expense Reimbursement form; 3) Cover letter from applicant organization; 4) Invoices and copies of receipts detailing all project related costs, including staff time and volunteer hours; 5) copy of completed PA Stream Releaf form, submitted online at http://www.ahs.dep.pa.gov/streamreleaf/newapplication.aspx; 6) a signed updated Operation, Maintenance and Repair Plan if**

project has changed; 7) before and after photos of the site; and 8) updated Site Location Map in color.

Reimbursement requests for spring projects must be submitted to your grant advisor by May 31, 2018. The final deadline for submission is **November 19, 2018.** Earlier submission is encouraged, especially for spring planting projects. Incomplete or late (fall) submissions may result in a lower ranking on future projects.

Project changes: Sometimes a project must be cancelled or modified. If this occurs, please contact your County Conservation District Watershed Specialist or PHS (in Philadelphia only) to discuss any changes. PHS must issue final approval. Any cancellations should be reported as soon as possible, so that those funds might be used elsewhere. Failure to discuss changes with your Watershed Specialist may result in ineligibility for reimbursement.

Funding credit: In all communications, the following statement must be used to attribute credit to each funder: "**This restoration project was made possible by the TreeVitalize Watersheds Grant program, and the Plant One Million campaign, managed by the Pennsylvania Horticultural Society, with funding from the Pennsylvania Department of Environmental Protection's Growing Greener program, as well as Aqua PA for projects located within its source water protection zones**."

Signage: Each restoration site must display the TreeVitalize Watershed informational signage (provided by PHS, available from your grant advisor) with proper credit for the partnering organizations, including PHS, Plant One Million, TreeVitalize, DEP Growing Greener, Aqua PA, and any other funders. These signs should be displayed a week prior and a week after the planting, and should be returned to your grant advisor. Permanent signs must give credit to the above funders and display their logos. Signage is eligible for reimbursement up to a $1000 limit. You may erect a more expensive sign if you are able to afford the extra amount, which you can count as match. Logos are available from Bob Adams at PHS (215-988-8795).

PA One Call Notification: In certain cases, underground utilities (including but not limited to electric, gas and sanitary sewer) and their associated "rights-of-way" exist within areas where riparian buffer restoration and/or enhancement activities are being planned and implemented. For public safety and other reasons, the Commonwealth of Pennsylvania's Underground Utility Line Protection Law PA Act 287 of 1974 (as amended by Act 121 of 2008) *requires you to inform the utilities of any type of work involving the movement of earth with powered equipment*. Know what's below. Call 1-800-242-1776 before you dig. For additional information, please visit PA One Call System, Inc. at http://www.pa1call.org

Training Requirements: New applicants need to complete a **PHS Tree Tenders ®** training or equivalent education on proper tree selection, planting and establishment prior to completing their TreeVitalize Watersheds project.

PHS Tree Tenders ® In support of TreeVitalize and in partnership with Penn State Cooperative Extension, the Pennsylvania Horticultural Society offers comprehensive hands-on tree care training for residents of the five-county Philadelphia region. For more information, contact Barley Van Clief, Regional Tree Tenders Program Manager, at 215-988-8793 or bvanclief@pennhort.org. Information about Tree Tenders training opportunities can be found at http://phsonline.org/programs/tree-tenders

To apply for a TreeVitalize Watersheds grant, contact the appropriate point of contact below for your area:

Bucks County Conservation District
Meghan Rogalus
215-345-7577 x 107
meghanrogalus@bucksccd.org

Chester County Conservation District
Zack Stepan
610-925-4920 x 103
zstepan@chesco.org

Delaware County Conservation District
Brian Vadino
610-892-9484
vadinob@co.delaware.pa.us

Montgomery County Conservation District
Jessica Moldovsky
610 489 4506
jmoldovsky@montgomeryconservation.org

Philadelphia
Bob Adams, PHS
215-988-8795
badams@pennhort.org

For more information about the TreeVitalize Watersheds program, contact Bob Adams, PHS Plant One Million Trees Regional Manager, at 215-988-8795 or badams@pennhort.org.

Plant One Million Trees is a regional partnership led by the Pennsylvania Horticultural Society (PHS) to plant one million trees throughout 13 counties in southeastern Pennsylvania, New Jersey, and Delaware. The initiative will educate and mobilize volunteers throughout the region to "plant, count and tend" trees. For more information, go to http://www.plantonemillion.org/.
*Plant One Million is supported in part by Pennsylvania's **TreeVitalize** program, a public-private partnership launched by the Department of Conservation and Natural Resources and the Pennsylvania Horticultural Society in 2004 to reverse the loss of tree cover in southeast PA. It is now a statewide effort to restore tree cover managed by the Pennsylvania Department of Conservation and Natural Resources (DCNR). For more information, go to www.treevitalize.net.*

pennsylvania

DEPARTMENT OF ENVIRONMENTAL PROTECTION

EROSION AND SEDIMENT POLLUTION CONTROL PROGRAM MANUAL

FINAL

Technical Guidance Number
363-2134-008

March 2012

BUREAU OF WATERWAYS ENGINEERING AND WETLANDS
DIVISION OF WETLANDS, ENCROACHMENT AND TRAINING

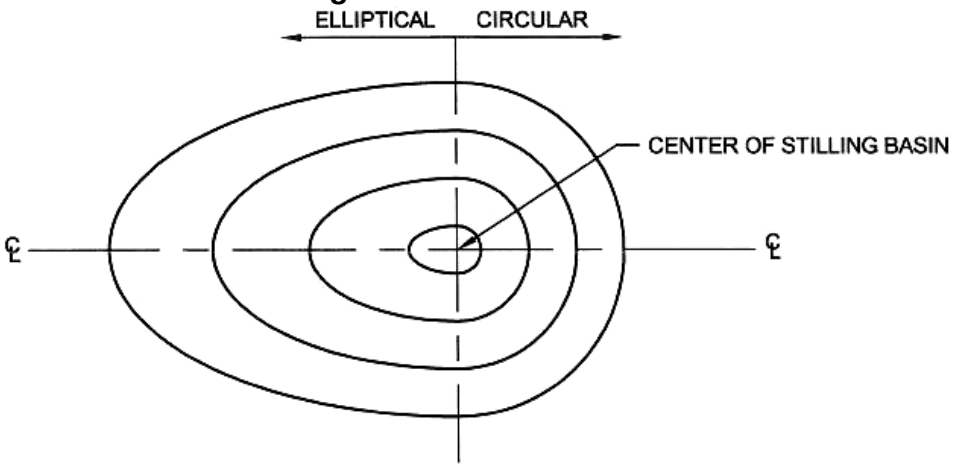
STILLING BASIN (Plunge Pool) - Stilling basins may be used at pipe outfalls where the discharge is at or near horizontal, and sufficient room exists to construct the basin between the pipe and the receiving watercourse. The size and shape of stilling basins is based upon the anticipated scour hole below a pipe outfall due to a design discharge. Experience has shown that the size and amount of the riprap required for a stilling basin are often less than would be required for a riprap apron.

Vernon County Land and Water Conservation

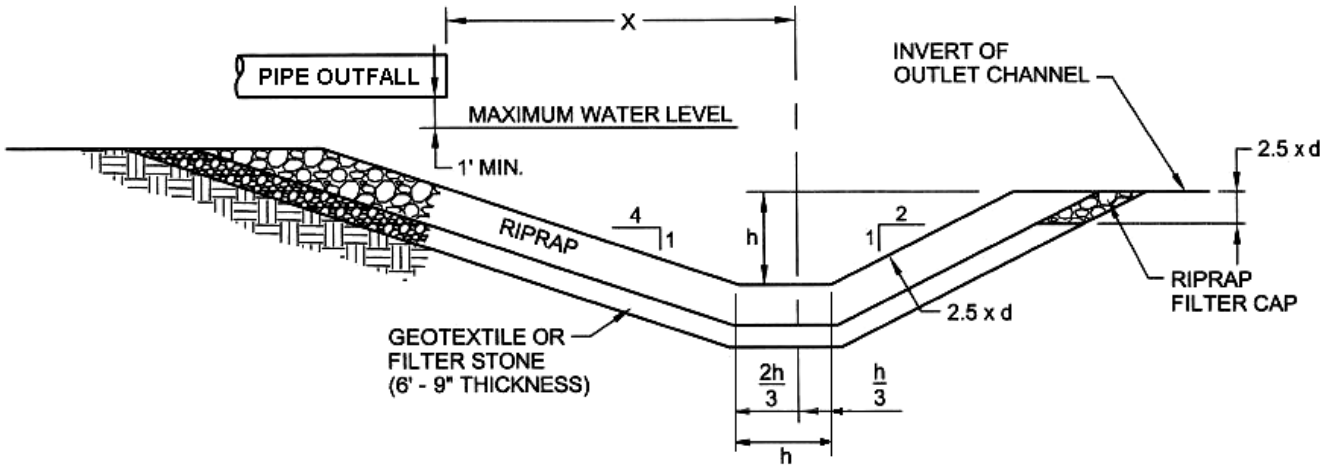
Stilling basins should be designed and constructed according to the details shown in Standard Construction Detail # 9-4. Geotextile may be substituted for the filter stone underlayment.

The minimum vertical distance from the bottom of the pipe to the maximum water surface elevation is 12 inches.

STANDARD CONSTRUCTION DETAIL # 9-4
Stilling Basin



PLAN VIEW



SECTION ALONG CENTERLINE

Adapted from USDOT, FHWA HEC 14

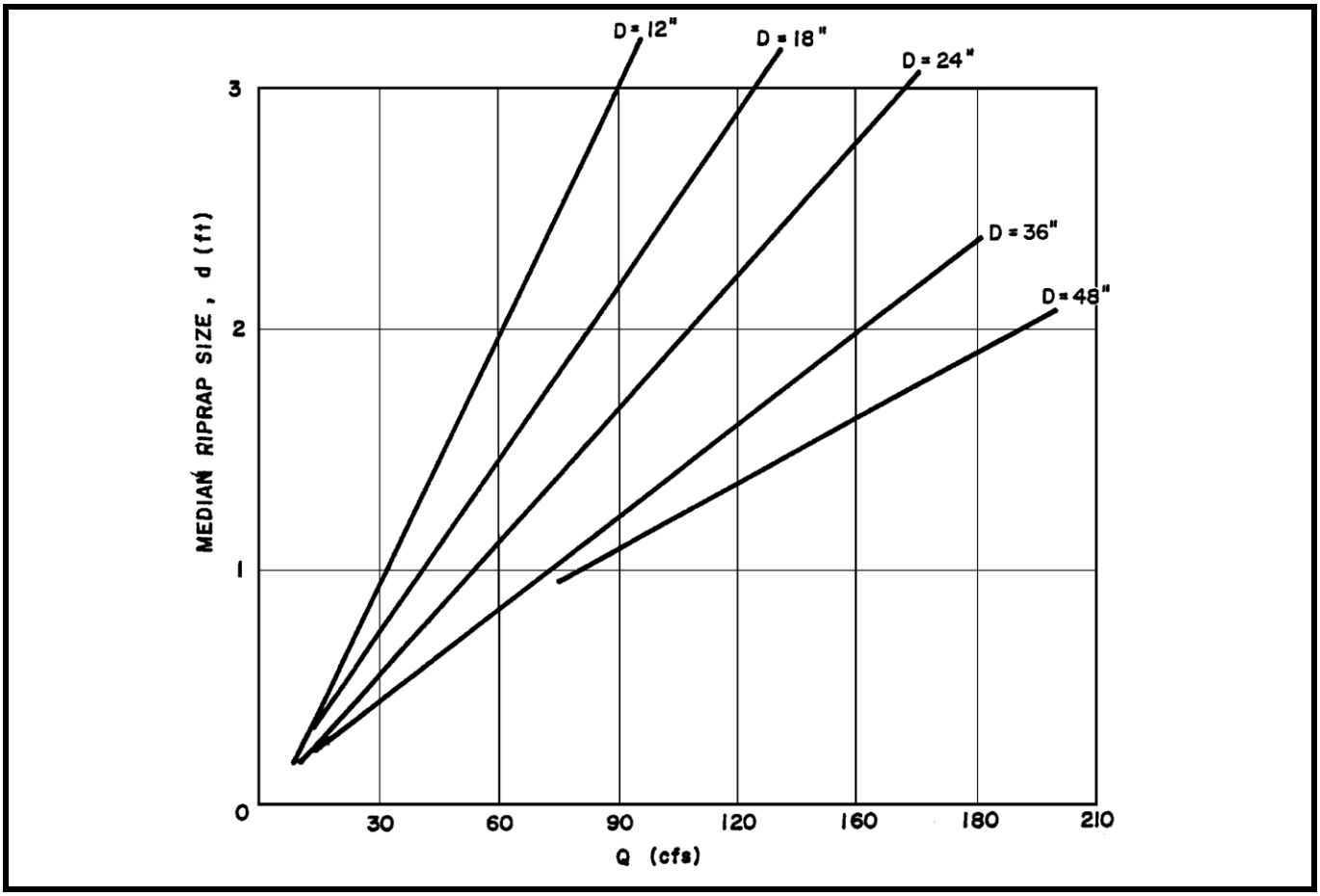
NOTE: This table is intentionally blank and should be filled in by the plan preparer.

OUTLET NO.	X (ft)	h (ft)	Riprap Size (R_)	d_{50} Stone Size d (in)

Riprap thickness shall be 1.5 times the maximum stone size.

Determine the d_{50} stone size (d) for the stilling basin from Figure 9.7 using the design discharge and the pipe diameter.

FIGURE 9.7
d_{50} Stone Size for Stilling Basins



Adapted from USDOT, FHWA HEC 14

Calculate the required basin depth (h) by the formula:

$$h = D^{1/3}\left[0.148\ \frac{Q}{Dd^{1/2}} - 1.82\ (d)\right]^{2/3}$$

where: h = Basin depth (ft)
D = Inside diameter of the pipe (ft)
d = d_{50} stone size of the riprap (ft)
Q = Design discharge (cfs)

Calculate the distance (X) in feet from the end of the discharge pipe to the "center" of the basin by using the following formula: $X = (V^2/2g)^{0.5}\left[(1+m/p)^{0.5} + 1 + m/2p\right]p^{0.5}$

where: v = Discharge velocity (fps)
g = Acceleration due to gravity (32.2 ft/sec^2)
m = Depth of water (ft) in the basin during maximum pipe discharge (i.e. h + channel flow depth)
p = Vertical distance (ft) from inside crown of the pipe to the maximum water surface

PENNSYLVANIA

Stormwater BMP Manual

December 30, 2006

BMP 6.6.2: Wet Pond/Retention Basin

Wet Ponds/Retention Basins are stormwater basins that include a substantial permanent pool for water quality treatment and additional capacity above the permanent pool for temporary runoff storage.

Key Design Elements

- Adequate drainage area (usually 5 to 10 acres minimum) or proof of sustained baseflow
- Natural high groundwater table
- Maintenance of permanent water surface
- Should have at least 2 to 1 length to width ratio
- Robust and diverse vegetation surrounding wet pond
- Relatively impermeable soils
- Forebay for sediment collection and removal
- Dewatering mechanism

Potential Applications

Residential: Yes
Commercial: Yes
Ultra Urban: Yes
Industrial: Yes
Retrofit: Yes
Highway/Road: Yes

Stormwater Functions

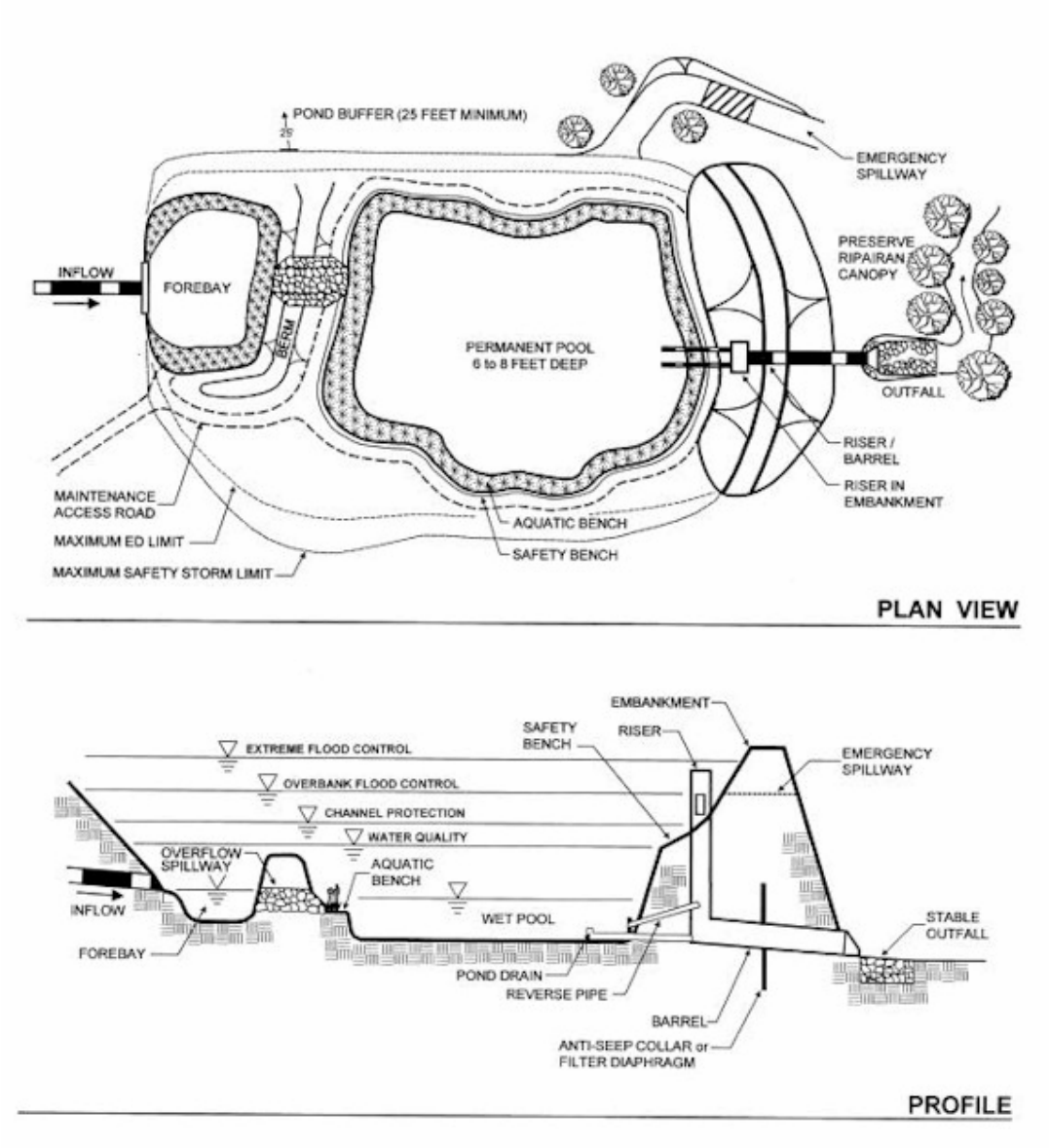
Volume Reduction: Low
Recharge: Low
Peak Rate Control: High
Water Quality: Medium

Water Quality Functions

TSS: 70%
TP: 60%
NO3: 30%

Description

Wet Detention Ponds are stormwater basins that include a permanent pool for water quality treatment and additional capacity above the permanent pool for temporary storage. Wet Ponds should include one or more forebays that trap course sediment, prevent short-circuiting, and facilitate maintenance. The pond perimeter should generally be covered by a dense stand of emergent wetland vegetation. While they do not achieve significant groundwater recharge or volume reduction, they can be effective for pollutant removal and peak rate mitigation. Wet Ponds (WPs) can also provide aesthetic and wildlife benefits. WPs require an adequate source of inflow to maintain the permanent water surface. Due to the potential to discharge warm water, wet ponds should be used with caution near temperature sensitive waterbodies. Properly designed and maintained WPs generally do not support significant mosquito populations (O'Meara).

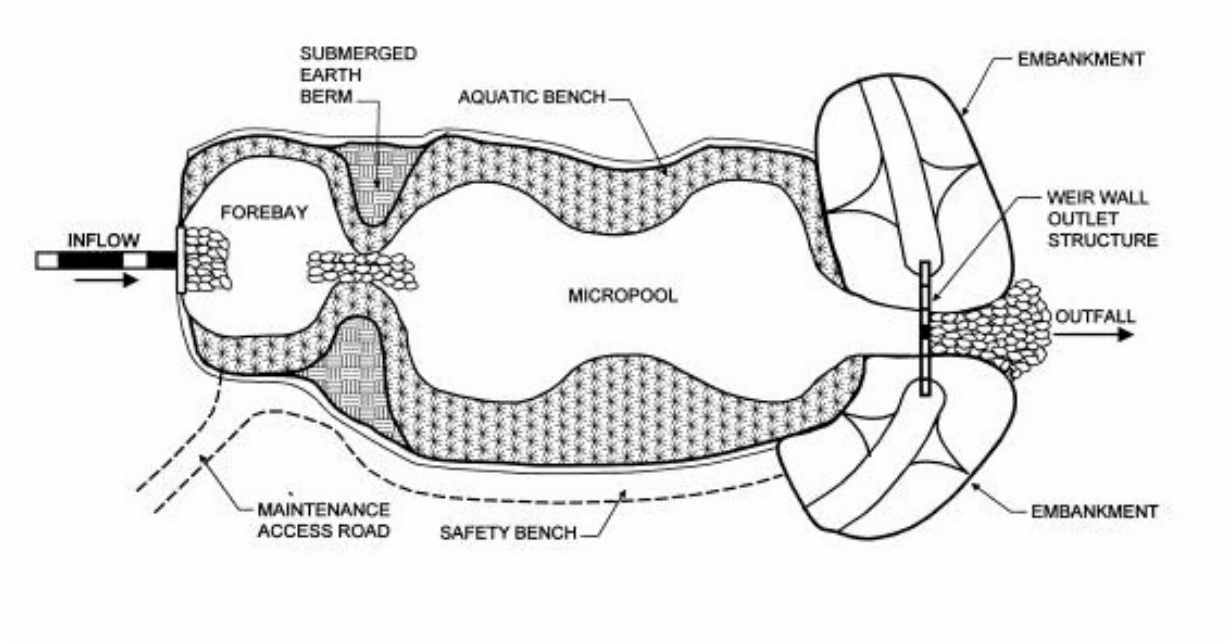


Variations

Wet Ponds can be designed as either an online or offline facilities. They can also be used effectively in series with other sediment reducing BMPs that reduce the sediment load such as vegetated filter strips, swales, and filters. Wet Ponds may be a good option for retrofitting existing dry detention basins. WPs are often organized into three groups:

- Wet Ponds primarily accomplish water quality improvement through displacement of the permanent pool and are generally only effective for small inflow volumes (often they are placed offline to regulate inflow).
- Wet Detention Ponds are similar to Wet Ponds but use extended detention as another mechanism for water quality and peak rate control.
- Pocket Wet Ponds are smaller WPs that serve drainage areas between approximately 5 and 10 acres and are constructed near the water table to help maintain the permanent pool. They often include extended detention as well.

This BMP focuses on Wet Detention Ponds as described above because this tends to be the most common and effective type of Wet Pond. For more information on other types of wet ponds, please consult the "References and Additional Resources" list.



Applications

- **Wet Ponds**
- **Wet Detention Ponds**
- **Pocket Wet Pond**
- **Offline Wet Pond**
- **Retrofit for existing detention basins**

Design Considerations

1. HYDROLOGY. Wet Ponds should be able to receive and retain enough flow from rain, runoff, and groundwater to ensure long-term viability. A permanent water surface in the deeper areas of the WP should be maintained during all but the driest periods. A relatively stable permanent water surface elevation will reduce the stress on vegetation in and adjacent to the pond. A WP should have a drainage area of at least 10 acres (5 acres for Pocket Wet Ponds) or some means of sustaining constant inflow. Even with a large drainage area, a constant source of inflow can improve the biological health and effectiveness of a Wet Pond while discouraging mosquito growth. Pennsylvania's precipitation is generally well distributed throughout the year and is therefore suited for WPs.
2. UNDERLYING SOILS. Underlying soils must be identified and tested. Generally hydrologic soil groups "C" and "D" are suitable without modification, "A" and "B" soils may require modification to reduce permeability. Soil permeability must be tested in the proposed Wet Pond location to ensure that excessive infiltration will not cause the WP to dry out.
3. PLANTING SOIL. Organic soils should be used for shallow areas within Wet Ponds. Organic soils can serve as a sink for pollutants and generally have high water holding capacities. They will also facilitate plant growth and propagation and may hinder invasion of undesirable species.
4. SIZE AND VOLUME. The area required for a WP is generally 1 to 3 percent of its drainage area. WPs should be sized to treat the water quality volume and, if necessary, to mitigate the peak rates for larger events.
5. VEGETATION. Vegetation is an integral part of a Wet Pond system. Vegetation in and adjacent to a pond may enhance pollutant removal, reduce algal growth, limit erosion, improve aesthetics, create habitat, and reduce water warming (Mallin et al., 2002; NJ DEP, 2004; University of Wisconsin, 2000). Wet Ponds should have varying depths to encourage vegetation in shallow areas. The emergent vegetation zone (areas not more than 18" deep) generally supports the majority of aquatic vegetation and should include the pond perimeter. Robust, non-invasive, perennial plants that establish quickly are ideal for WPs. The designer should select species that are tolerant of a range of depths, inundation periods, etc. Monoculture planting should be avoided due to the risk from pests and disease. See local sources for recommended plant lists or Appendix B.

6. CONFIGURATION.
    a. General. Wet Ponds should be designed with a length to width ratio of at least 2:1 wherever possible. If the length to width ratio is lower, the flow pathway through the WP should be maximized. A wedge-shaped pond with the major inflows on the narrow end can prevent short-circuiting and stagnation. WPs should not be constructed within 10 feet of the property line or within 50 feet of a private well or septic system. Slopes in and around Wet Ponds should be 4:1 to 5:1 (horizontal:vertical) or flatter wherever possible (10:1 max. for safety/aquatic benches, see 6.d. below). Wet Ponds should have an average depth of 3 to 6 feet and a maximum depth of 8 feet. This should be shallow enough to minimize thermal stratification and short-circuiting and deep enough to prevent sediment resuspension, reduce algal blooms, and maintain aerobic conditions. Wet ponds should not be constructed within a natural watercourse.
    b. Forebay/Inflows. Wet Ponds should have a forebay at all major inflow points to capture coarse sediment, prevent excessive sediment accumulation in the remainder of the WP, and minimize erosion by inflow. The forebays should contain 10 to 15 percent of the total permanent pool volume and should be 4 to 6 feet deep. They should be physically separated from the rest of the pond by a berm, gabion wall, etc. Flows exiting the forebay should be non-erosive to the newly constructed WP. Vegetation within forebays can increase sedimentation and reduce resuspension/erosion. The forebay bottom can be constructed of hardened materials to facilitate sediment removal. Forebays should be installed with permanent vertical markers that indicate sediment depth. Inflow channels should be fully stabilized. Inflow pipes can discharge to the surface or be partially submerged. Forebays should be offline (out of the path of higher flows) to prevent resuspension of previously collected sediment during large storms.
    c. Outlet. Outlet control devices should draw from open water areas 5 to 7 feet deep to prevent clogging and allow the WP to be drained for maintenance and to provide for additional temperature benefits. Outlet devices are generally multistage structures with pipes, orifices, or weirs for flow control. A reverse slope pipe terminating 2 to 3 feet below the normal water surface, minimizes the discharge of warm surface water and is less susceptible to clogging by floating debris. Orifices, if used, should be at least 2.5 inches in diameter and should be protected from clogging. Outlet devices should be installed in the embankment for accessibility. If possible, outlet devices should enable the normal water surface to be varied. This allows the water level to be adjusted (if necessary) seasonally, as the WP accumulates sediment over time, if desired grades are not achieved, or for mosquito control. A pond drain should also be included which allows the permanent pool to be completely drained for maintenance within 24 hours. The outlet pipe should generally be fitted with an anti-seep collar through the embankment. Online facilities should have an emergency spillway that can safely pass the 100-year storm with 1 foot of freeboard. All outflows should be conveyed downstream in a safe and stable manner.
    d. Safety/Aquatic Benches. All areas that are deeper than 4 feet should have two safety benches, totaling 15 feet in width. One should start at the normal water surface and extend up to the pond side slopes at a maximum slope of 10 percent. The other should extend from the water surface into the pond to a maximum depth of 18 inches, also at slopes no greater than 10 percent.
7. WET POND BUFFER. To enhance habitat value, visual aesthetics, water temperature, and pond health, a 25-foot buffer should be added from the maximum water surface elevation. The buffer should be planted with trees, shrubs, and native ground covers. Except in maintenance access areas, turf grass should not be used. Existing trees within the buffer should be preserved. If soils in the buffer will become compacted during construction, soil restoration should take place to aid buffer vegetation.

8. MAINTENANCE ACCESS. Permanent access must be provided to the forebay, outlet, and embankment areas. It should be at least 9 feet wide, have a maximum slope of 15%, and be stabilized for vehicles.
9. PLAN ELEMENTS. The plans detailing the Wet Ponds should clearly show the WP configuration, inlets and outlets, elevations and grades, safety/aquatic benches, and the location, quantity, and propagation methods of pond/buffer vegetation. Plans should also include site preparation techniques, construction sequence, as well as maintenance schedules and requirements.
10. REGULATION. Wet Ponds that have drainage areas over 100 acres, embankments greater than 15 feet high, or a capacity greater than 50 acre-feet may be regulated as a dam by PADEP (see Title 25, Chapter 105 of the Pennsylvania Code).

Detailed Stormwater Functions

Volume Reduction Calculations

Although not typically considered a volume-reducing BMP, Wet Ponds can achieve some volume reduction through infiltration and evapotranspiration, especially during small storms. According to the International Stormwater BMP Database, wet ponds have an average annual volume reduction of 7 percent (Strecker et al., 2004). Hydrologic calculations that should be performed to verify that the WP will have a viable amount of inflow can also predict the water surface elevation under varying conditions. The volume stored between the predicted water level and the lowest outlet elevation will be removed from the that design storm.

Peak Rate Mitigation Calculations

Peak rate is primarily controlled in Wet Ponds through the transient storage above the normal water surface. See Section 8 for Peak Rate Mitigation methodology.

Water Quality Improvement

Wet Ponds improve runoff quality through settling, filtration, uptake, chemical and biological decomposition, volatilization, and adsorption. WPs are relatively effective at removing many common stormwater pollutants including suspended solids, heavy metals, total phosphorus, total nitrogen, and pathogens. The pollutant removal effectiveness varies by season and may be affected by the age of the WP. It has been suggested that this type of BMP does not provide significant nutrient removal in the long term unless vegetation is harvested because captured nutrients are released back into the water by decaying plant material. Even if this is true, nutrients are usually released gradually and during the non-growing season when downstream susceptibility is generally low (Hammer, 1990). See Section 8 for Water Quality Improvement methodology, which addresses pollutant removal effectiveness of this BMP.

Construction Sequence

1. Separate wet pond area from contributing drainage area:
    a. All channels/pipes conveying flows to the WP should be routed away from the WP area until it is completed and stabilized.
    b. The area immediately adjacent to the WP should be stabilized in accordance with the PADEP's *Erosion and Sediment Pollution Control Program Manual* (2000 or latest edition) prior to construction of the WP.

2. Clearing and Grubbing:
    a. Clear the area to be excavated of all vegetation.
    b. Remove all tree roots, rocks, and boulders.
    c. Fill all stump holes, crevices and similar areas with impermeable materials.

3. Excavate bottom of WP to desired elevation (Rough Grading).

4. Install surrounding embankments and inlet and outlet control structures.

5. Grade and prepare subsoil.

6. Apply and grade planting soil.
    a. Matching design grades is crucial because aquatic plants can be very sensitive to depth.

7. Apply erosion-control measures.

8. Seed, plant and mulch according to Planting Plan

9. Install any anti-grazing measures, if necessary.

10. Follow required maintenance and monitoring guidelines.

Maintenance Issues

Wet Ponds should have a maintenance plan and privately owned facilities should have an easement, deed restriction, or other legal measure to prevent neglect or removal. During the first growing season or until established, vegetation should be inspected every 2 to 3 weeks. WPs should be inspected at least 4 times per year and after major storms (greater than 2 inches in 24 hours) or rapid ice breakup. Inspections should access the vegetation, erosion, flow channelization, bank stability, inlet/outlet conditions, embankment, and sediment/debris accumulation. The pond drain should also be inspected and tested 4 times per year. Problems should be corrected as soon as possible. Wet Pond and buffer vegetation may need support (watering, weeding, mulching, replanting, etc.) during the first 3 years. Undesirable species should be carefully removed and desirable replacements planted if necessary.

Once established, properly designed and installed Wet Ponds should require little maintenance. Vegetation should maintain at least an 85 percent cover of the emergent vegetation zone and buffer area. Annual harvesting of vegetation may increase the nutrient removal of WPs; if performed it should generally be done in the summer so that there is adequate regrowth before winter. Care should be taken to minimize disturbance, especially of bottom sediments, during harvesting. The potential disturbance from harvesting may outweigh its benefits unless the WP receives a particularly high nutrient load or discharges to a nutrient sensitive waterbody. Sediment should be removed from the forebay before it occupies 50 percent of the forebay, typically every 5 to 10 years.

Cost Issues

The construction cost of Wet Ponds can vary greatly depending on the configuration, location, site-specific conditions, etc. Typical construction costs in 2004 dollars range from approximately $25,000 to $50,000 per acre-foot of storage (based on USEPA, 1999). Costs are generally most dependent on the amount of earthwork and the planting. Annual maintenance costs have been reported to be approximately 3 to 5 percent of the capital costs although there is little data available to support this.In addition to the construction and maintenance costs, there is the cost or loss of value for the property involved.

Specifications:

The following specifications are provided for information purposes only. These specifications include information on acceptable materials for typical applications, but are by no means exclusive or limiting. The designer is responsible for developing detailed specifications for individual design projects in accordance with the project conditions.

1. **Excavation**
    a. The area to be used for the WP should be excavated to the required depth below the desired bottom elevation to accommodate any required impermeable liner, organic matter, and/or planting soil.
    b. The compaction of the subgrade and/or the installation of any impermeable liners will follow immediately.
2. **Subsoil Preparation**
    a. Subsoil shall be free from hard clods, stiff clay, hardpan, ashes, slag, construction debris, petroleum hydrocarbons, or other undesirable material. Subsoil must not be delivered in a frozen or muddy state.
    b. Scarify the subsoil to a depth of 8 to 10 inches with a disk, rototiller, or similar equipment.
    c. Roll the subsoil under optimum moisture conditions to a dense layer with four to six passes of a sheepsfoot roller or equivalent. The compacted layer shall be at least 8 inches thick.
3. **Planting Soil (Topsoil)**
    a. Use a minimum of 12 inches of topsoil in the emergent vegetation zone (less than 18" deep) of the pond. If natural topsoil from the site is to be used it must have at least 8 percent organic carbon content (by weight) in the A-horizon for sandy soils and 12% for other soil types.
    b. If planting soil is being imported it should be made up of equivalent proportions of organic and mineral materials.
    c. Lime should not be added to planting soil unless absolutely necessary as it may encourage the propagation of invasive species.
    d. The final elevations and hydrology of the vegetative zones should be evaluated prior to planting to determine if grading or planting changes are required.
4. **Vegetation**
    a. Plant Lists for WPs can be found locally. No substitutions of specified plants will be accepted without prior approval of the designer. Planting locations shall be based on the Planting Plan and directed in the field by a qualified wetland ecologist.
    b. All Wet Pond plant stock shall exhibit live buds or shoots. All plant stock shall be turgid, firm, and resilient. Internodes of rhizomes may be flexible and not necessarily rigid. Soft or mushy stock shall be rejected. The stock shall be free of deleterious insect infestation, disease and defects such as knots, sun-scald, injuries, abrasions, or disfigurement that could adversely affect the survival or performance of the plants.
    c. All stock shall be free from invasive or nuisance plants or seeds.
    d. During all phases of the work, including transport and onsite handling, the plant materials shall be carefully handled and packed to prevent injuries and desiccation. During transit and onsite handling, the plant material shall be kept from freezing and shall be kept covered, moist, cool, out of the weather, and out of the wind and sun. Plants shall be watered to maintain moist soil and/or plant conditions until accepted.
    e. Plants not meeting these specifications or damaged during handling, loading, and unloading will be rejected.
    f. Detailed planting specifications can be found locally, and in Appendix B.
5. **Outlet Control Structure**
    a. Outlet control structures shall be constructed of non-corrodible material.
    b. Outlets shall be resistant to clogging by debris, sediment, floatables, plant material, or ice.
    c. Materials shall comply with applicable specifications (PennDOT or AASHTO, latest edition)

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Getting the most bang for your buck:

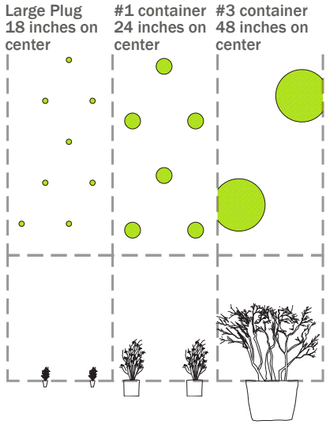
Fast Growing & Wide Spreading Plants

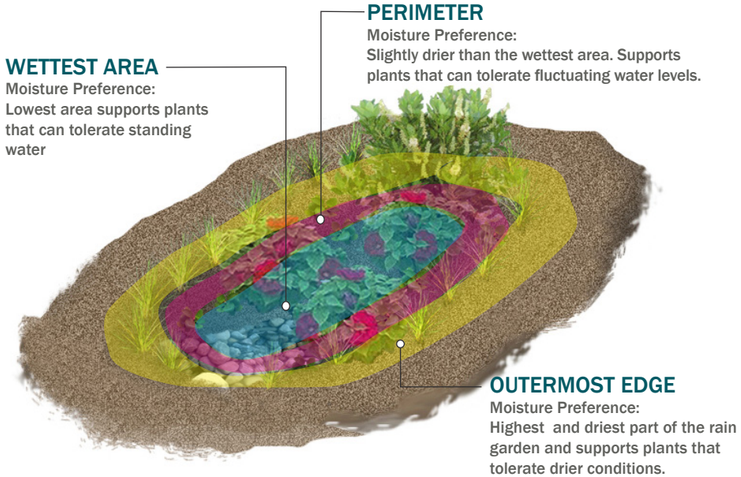
There are many plants that make for successful rain gardens. The plants listed below have been selected because they can be planted at lower densities and grow quickly, resulting in a rain garden that is lush and full while using fewer plants.

Scientific Name	Common Name	Moisture Preference	Sun/Shade Preference	Height	Width	Recommended Plug Plant Spacing	Planting Area in Rain Garden
Herbaceous Perennials:							
Acorus americanus	Sweetflag	Moist to Wet	Sun	2-3'	12”	12”	Wettest Area
Hibiscus moscheutos	Swamp Mallow	Moist to Wet	Sun	3-6'	24”	24”	Wettest Area
Iris versicolor	Blue Flag Iris	Moist to Wet	Sun to Partial Shade	2-3'	36”	12”	Wettest Area
Lobelia cardinalis	Cardinal Flower	Moist to Wet	Sun to Partial Shade	2-4'	24”	12”	Wettest Area
Mimulus ringens	Monkey Flower	Moist to Wet	Sun to Partial Shade	1-3'	18”	12”	Wettest Area
Vernonia noveboracensis	New York Ironweed	Moist to Wet	Sun	4-6'	36”	18”	Wettest Area
Eupatorium dubium ‘Little Joe’	Dwarf Joe Pye Weed	Moist to Wet	Sun	3-4'	24”	24”	Wettest Area
Helenium sp.	Sneezeweed	Moist to Wet	Sun	18-40"	18”	18”	Perimeter
Aster novae-angliae	New England Aster	Moist to Dry	Sun	1-2'	30”	12”	Perimeter
Helianthus sp.	Sunflower	Average to Dry	Sun	4-6'	30”	24”	Outermost Edge
Vernonia glauca	Upland Ironweed	Average to Dry	Sun	3-5'	36”	12”	Outermost Edge
Amsonia hubrichtii	Thread-leaf Blue Star	Average to Dry	Sun to Partial Shade	2-3'	30”	18”	Outermost Edge
Eragrostis spectabilis	Purple Love Grass	Average to Dry	Sun	24”	30”	12”	Outermost Edge
Echinacea purpurea	Purple Coneflower	Average to Dry	Sun to Partial Shade	2-3'	18”-24”	12”	Outermost Edge
Shrubs:							
Aronia melanocarpa	Black Chokeberry	Moist to Wet	Sun to Partial Shade	4’-10’	3’-6’		Wettest Area
Viburnum dentatum	Arrowwood Virburnum	Moist to Wet	Sun to Shade	5’-10’	5’-10’		Wettest Area
Rhododendron viscosum	Swamp Azalea	Moist to Wet	Sun to Partial Shade	4’-8’	4’-8’		Wettest Area
Ilex verticillata ‘Red Sprite’	Dwarf Winterberry Holly	Moist to Wet	Sun to Partial Shade	2’-3’	2’		Wettest Area
Ilex glabra	Inkberry Holly	Average	Sun to Shade	5’-8’	5’-8’		Perimeter
Cornus sericea	Redosier Dogwood	Average	Sun	4’-8’	4’-8’		Perimeter
Clethra alnifolia	Summersweet Pepperbush	Average	Sun to Shade	4’-6’	5’-8’		Perimeter
Itea virginica	Virginia Sweetspire	Average	Sun to Shade	4’-8’	4’-8’		Perimeter
Viburnum trilobum	American Cranberry	Average to Dry	Partial Shade to Shade	4’-8’	4’-8’		Outermost Edge
Ceanothus americanus	New Jersey Tea	Average to Dry	Sun to Partial Shade	3’	3’-5’		Outermost Edge
Rhus aromatica ‘Gro Low’	Dwarf Aromatic Sumac	Average to Dry	Sun	2’-4’	3’-8’		Outermost Edge
Trees:							
Betula nigra	River Birch	Moist to Wet		30’-60’	15’-40’		Wettest Area
Quercus bicolor	Swamp Oak	Moist to Wet		40’-80’	30’-60’		Wettest Area
Platanus occidentalis	Sycamore	Moist to Wet		40’-80’	30’-80’		Wettest Area
Taxodium distichum	Bald Cypress	Moist to Wet		40’-80’	20’-30’		Wettest Area
Acer rubrum	Red Maple	Average		30’-60’	30’-60’		Perimeter
Amelanchier sp.	Serviceberry	Average		15’-25’	20’-30’		Perimeter
Chionanthus virginicus	Fringtree	Average		15-30’	15-30’		Perimeter
Halesia carolina	Carolina Silverbell	Average to Dry		15-25’	15-25’		Outermost Edge
Rhus typhina	Staghorn Sumac	Average to Dry		15’-30’	15’-30’		Outermost Edge

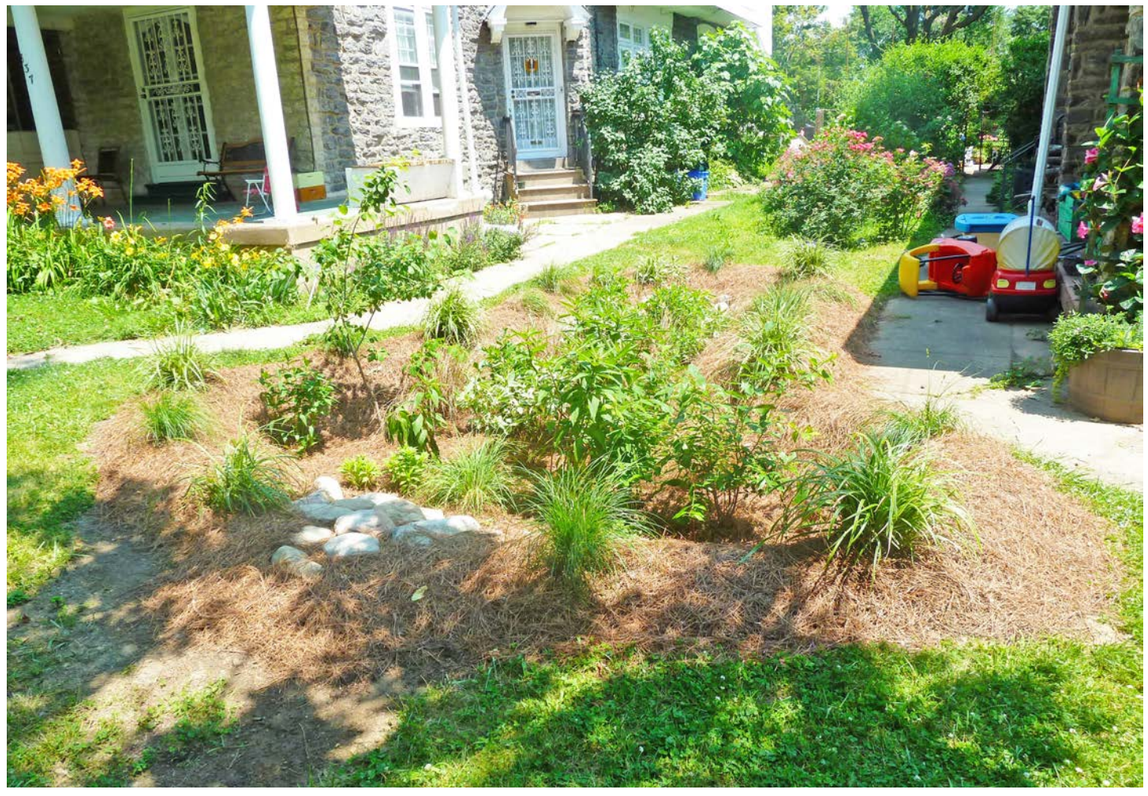
PLANT SPACING LAYOUT

Spacing for fast growing & wide spreading plants





Residential
Rain Garden
Design Guidelines



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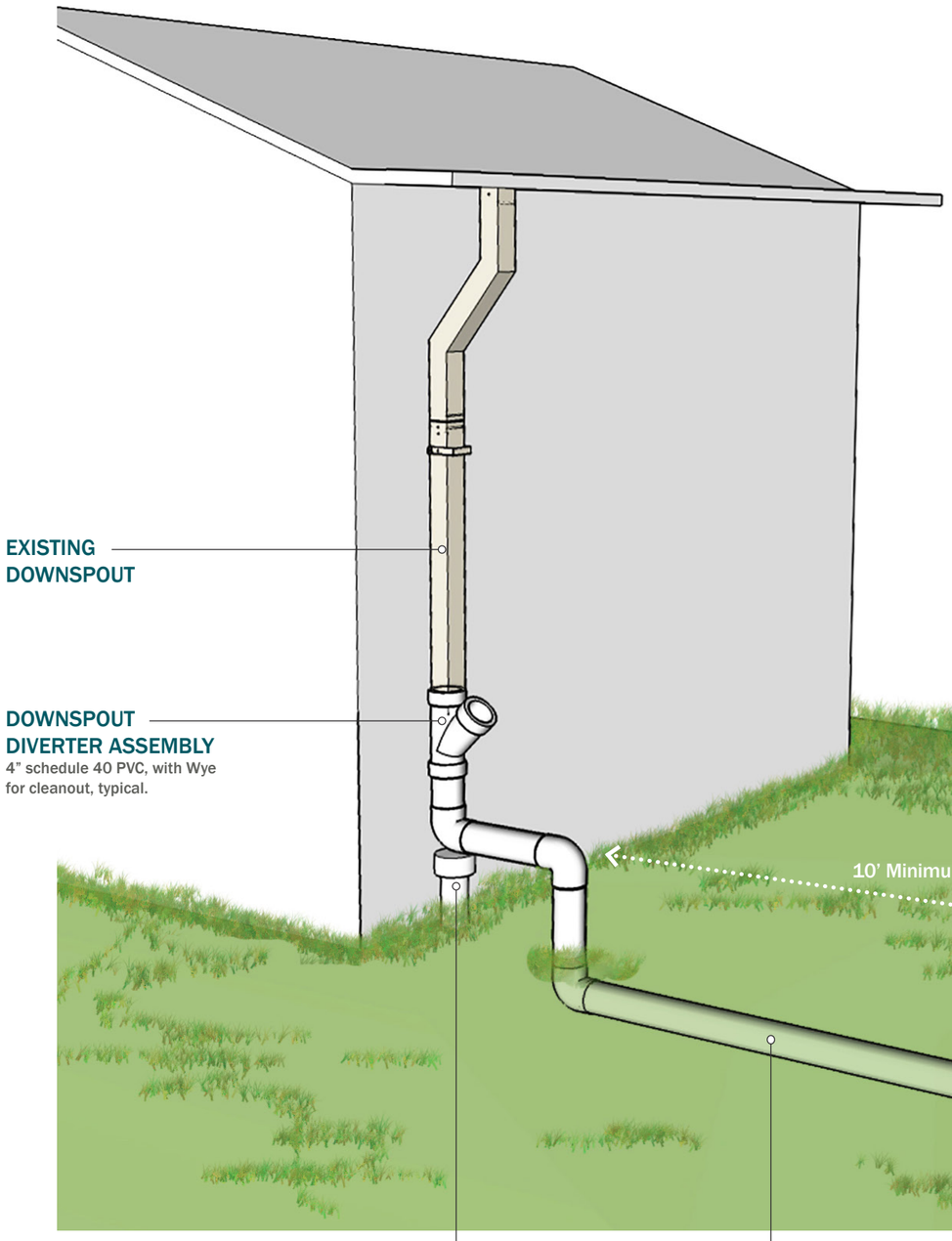
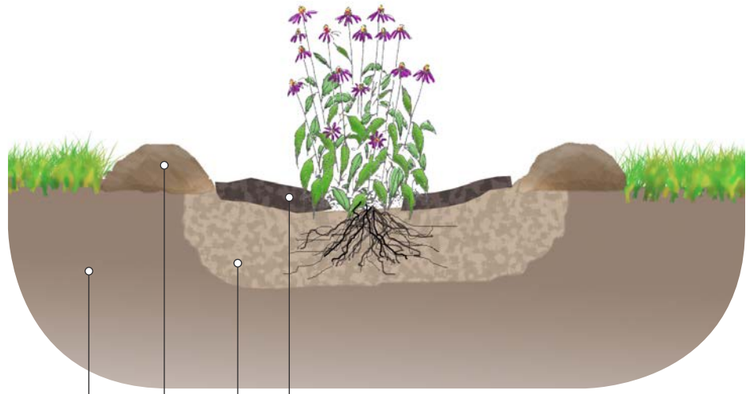
Typical Residential Rain Garden





Siting Requirements

- ☐ 1. The rain garden should be 10 feet from all basements or sub-surface structures.
- ☐ 2. The rain garden should not be near a septic field.
- ☐ 3. There should be a suitable spot for overflow from the rain garden that will not impact any nearby structures or properties (e.g. downslope pervious surface, area drain).
- ☐ 4. The infiltration rate should be adequate to safely infiltrate runoff (typically between 0.5 in/hr and 6 in/hr).
- ☐ 5. The rain garden cannot be within a drip line of a tree.
- ☐ 6. Rain garden must manage stormwater from existing downspout that would otherwise run into sewer.

Installation Requirements

- ☐ 1. Garden meets sizing requirements as specified in design.
  The rain garden must be between 20% and 30% the size of the total roof area draining to garden and 6-12 inches deep.
- ☐ 2. Water conveyance to rain garden cannot create trip or ice hazard.
- ☐ 3. Plants meet coverage requirements specified in the Plant Spacing Diagram.
- ☐ 4. Splash rock greater than 4 inches in diameter must be installed in the rain garden at the downspout discharge to dissipate flow and avoid erosion. Splash rock must be placed so as to slow the flow of water conveyed to the rain garden while not impeding it.
- ☐ 5. Berms should be created on the perimeter of the rain garden at 1.5:1 horizontal to vertical. Berms may be constructed of soils removed from the rain garden excavation.

For additional guidance please refer to
Philadelphia Water Department's
Rain Check Website
http://www.phillywatersheds.org/whats_in_it_for_you/residents/how-build-rain-garden

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Rain Barrel

ASSEMBLY & INSTALLATION GUIDE

PHILADELPHIA WATER

phillywatersheds.org/raincheck

1. Confirm location of installation with participant.
2. Take “Before” photo of the location.
3. Place concrete blocks at ground level at the installation location. Level using shims if necessary.
4. Using a 1-1/4” hole saw, drill two holes in barrel for the spigots. One should be at the bottom of the barrel (for complete drainage); the other should be at ~1/3 of the height of the barrel (for filling up a bucket or watering can).

5. Place the planter onto the base, with the spigots facing an area that is accessible for the participant.
6. Using a 2” hole saw, drill a hole into the downspout slightly above the top rim of the rain barrel.
7. Using a 1-1/2” hole saw, drill a hole into the side of the rain barrel, near the top.
8. Insert collection end of flexi-spout into downspout, fasten using stainless steel screws. Insert the other end into the hole on the rain barrel (as shown below).




9. Double check to make sure all connections are secure.
10. Take “After” photo.

Note: To view an instructional video, visit https://www.youtube.com/watch?v=eFM-J5OGR7c or search for “DIY Rain Barrel Kit” by aquabarrel on YouTube.

Downspout Planter
FABRICATION GUIDE

PHILADELPHIA WATER

phillywatersheds.org/raincheck

The following summary is provided to detail the fabrication of a 2 foot x 4 foot planter box constructed primarily of ¾ inch x 6 inch lumber (¾ x 6) to be used as the body of a downspout planter box for use in residential stormwater management. A list of tools required for construction, summary of materials needed, and the steps to build the planter box are provided below.

Tool List

- Electric drill/driver with Phillips head drill bit
- Table saw or circular saw
- Chop saw (miter saw)
- Tape measure
- Square
- Clamps
- Marker and pencil

Material List

Note: When using pressure treated lumber, it is recommended that the lumber be allowed to dry before fabrication to prevent shrinking and swelling of the lumber in a completed downspout planter.

Material	Quantity	Final cut sizes
¾" exterior grade plywood	(1) sheet	(1) 24" x 48" - planter base
¾" x6" pressure treated lumber	(8) 8' boards or (4) 16' boards	(4) 22" (4) 24" (4) 46" (4) 48" — planter body (2) 50 ¼" (with 45° angled edges) - skirt (2) 26 ¼" (with 45° angled edges) - skirt
¾" x6" pressure treated lumber (ripped to 4 ¼" wide)	(2) 8' boards or (1) 16' board	(2) 51" (with 45° angled edges) - trim (2) 27"(with 45° angled edges) - trim
2"x2" pressure treated lumber	(3) 8' boards	(4) 22" - interior bracing (2) 20 ½" - interior bracing for 4' planters (2) 42 ½" - horizontal cleat (2) 18 ½" - horizontal cleat (4) 3" pieces - skirt bracing
Deck (galvanized) screws	(100+) 2" and 3"	NA

The Rain Check Program is funded by Philadelphia Water and managed by the Pennsylvania Horticultural Society in partnership with the Sustainable Business Network.

Fabrication Instructions

1. Take two 46" ¾" x 6"s and two 24" ¾" x 6"s and stand them on edge. Place the short and long pieces at right angles (perpendicular) to form a rectangular frame with the 46" lengths abutted inside the 24" lengths. Attach clamps to hold the pieces together on edge. The frame should measure 24"x48".

2. Lay the 24"x48" plywood piece on top of the frame. This will be the bottom of the box. Make sure the edges are all flush.

3. Starting in a corner, drill a pilot hole through the plywood into the frame.

4. Drive a deck screw into the pilot hole so the head of the screw is flush with the surface of the plywood. Continue this around the perimeter of the bottom. There should be four screws in each long side and three screws in each short side for a total of fourteen screws.

5. Create three additional rectangular frames from the remaining ¾ x 6s. There will be no plywood component to these three frames. One of these additional frames will be constructed from two (46") ¾" x 6"s and two (24") ¾" x 6"s (as in Step 1), and the other two frames will be constructed from two (48") ¾ x 6s and two (22") ¾ x 6s. Drill pilot holes into each corner and secure with two 3" deck screws. Make sure each frame measures 24" by 48". This step requires (24) 3" deck screws.

6. Once the frames are stacked and flush, the corners of the planter box must be reinforced with the 22" 2x2s. One 2x2 should be attached to each corner of the box; 8 screws should be used to drill each 2x2 to the ¾ x 6 frames of the box as shown in the photo. Be sure to pre-drill each hole as in the steps above. This step requires (32) 3"

deck screws. (An angled cut at the top edge of the 2x2 supports is shown). For the 2'x4' and 1.5 'x.4' boxes, insert a 20 ½" brace in the middle of each of the 4' sides.

7. The cleats should be drilled into the top interior of the planter using 2" screws and pilot holes.

PHILADELPHIA WATER

Downspout Planter
FABRICATION GUIDE

Trim Fabrication

1. The trim will be constructed using the ¾" x 6" boards that were ripped to 4¼" and cut to form (2) 51" and (2) 27" with 45° angled edges.

2. Lay the (2) 51" and (2) 27" pre-cut boards so they abut one another at right angles (perpendicular) to form a rectangular frame for the trim. Confirm that the boards line up properly.

3. Trim assembly will be attached to the planter during the liner and plumbing installation (see the Downspout Liner and Plumbing Guide) .

4. To reinforce strength of miter joints on trim assembly and to reduce risk of joints separating, joints should be secured using wood glue and either dowels, keys, biscuits, or splines. Sand joints as necessary to ensure smooth finish on the top side of the trim assembly.

Skirt Fabrication

1. The ¾" x 6" boards that were cut to (2) 50 ¼" and (2) 26 ¼" with 45° angled edges will be used for the skirt.

2. Stand the two 51" boards and the two 27" boards on edge. Place them at right angles (perpendicular) to one another to form a rectangular frame.

3. Place a 3" 2x2 in each inside corner of the rectangular frame so it is flush with both boards and the base of the frame. There will be a gap between the top of the 2x2 and the top of the frame.

4. Starting in one corner, drill at least two pilot holes in both directions of the inner faces of the 2x2s (towards the long and short ends of the rectangular frame). This requires a total of four pilot holes per corner; two along each inner face. Evenly space the pilot holes along the length of the 2x2s to avoid interference during deck screw installations.

5. Drive deck screws into the pilot holes until the head of the screw is flush with the surface of the 2x2s. Continue this step for all pilot holes. There should be four total screws installed per corner (2 on each side). This requires a total of sixteen screws.

6. After skirt fabrication, follow the Downspout Planter Installation Guide for installation of the skirt.

Planter Box Skirt Trim

Downspout Planter
INSTALLATION GUIDE

phillywatersheds.org/raincheck

Tool List

- Power drill
- Measuring tape
- Digital camera
- Reciprocating saw ("Sawzall") and metal cutting blades
- Power grinder with metal cutting blade
- Level
- Masonry drill bit (if drilling into block or brick)
- Gardening hand tools
- Ladder
- Safety glasses
- Dust mask
- Work gloves

Material List

Provided by PHS

- Pre-fabricated downspout planter and skirt
- Rain Check signage
- 6' garden hose
- Concrete Masonry Units (CMUs) or cinderblocks (for base)
- Drainage stone (pea gravel)
- WeedBlock landscape fabric
- Pre-mixed soil medium
- Plants
- Splash rock (mean 2" diameter)

Provided by Contractor

- Exterior grade (composite) shims or other leveling material
- $1\frac{5}{8}$" galvanized or stainless steel fasteners (decking screws)
- ½" or $\frac{5}{8}$" stainless steel screws (white top gutter screws)
- Masonry screws and/or anchors
- ¾" metal cutting drill bit (for hose)
- Assorted 3" and 4" plumbing pieces (straight, 45° elbow, 90° elbow, coupler, "Wye", cleanout cap, rubber boot, rubber cap, etc.)
- Assorted downspout pieces (3" or 4", round and rectangular, elbows, straights, diverters, braces, fasteners)

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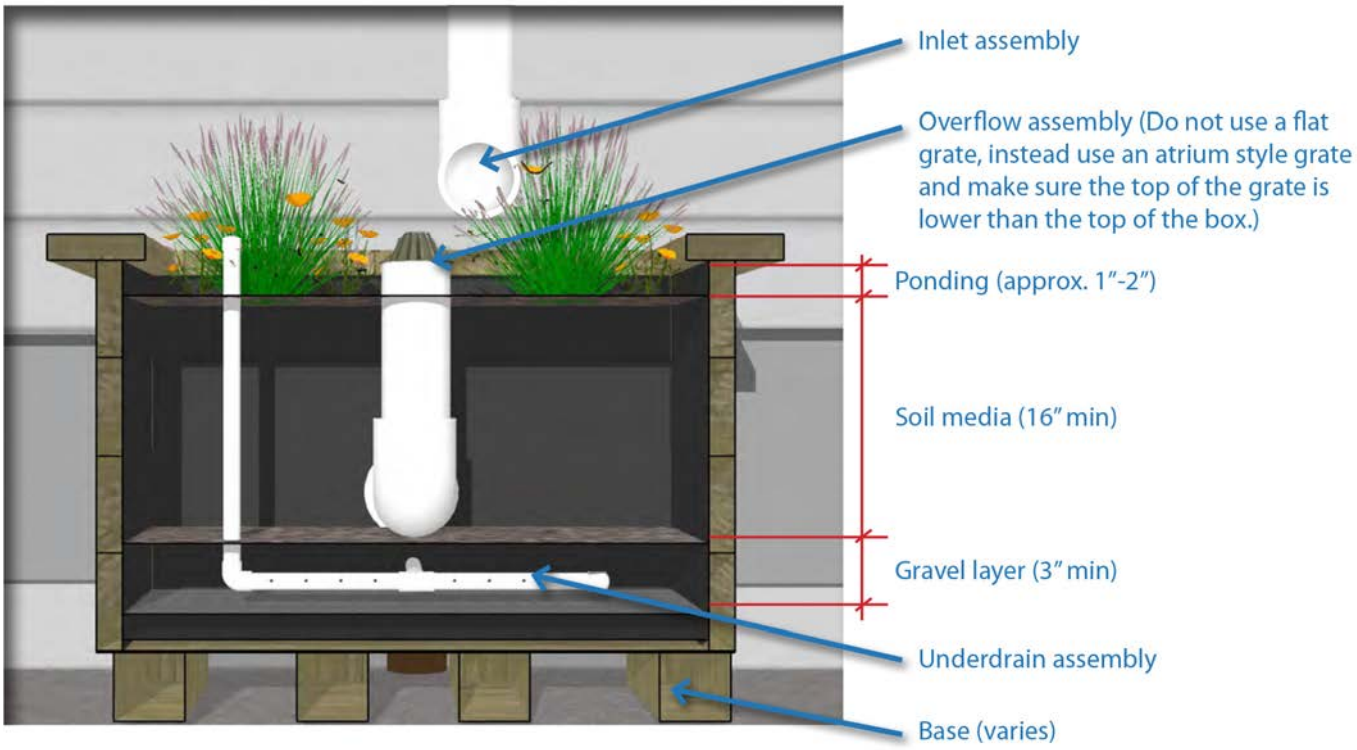
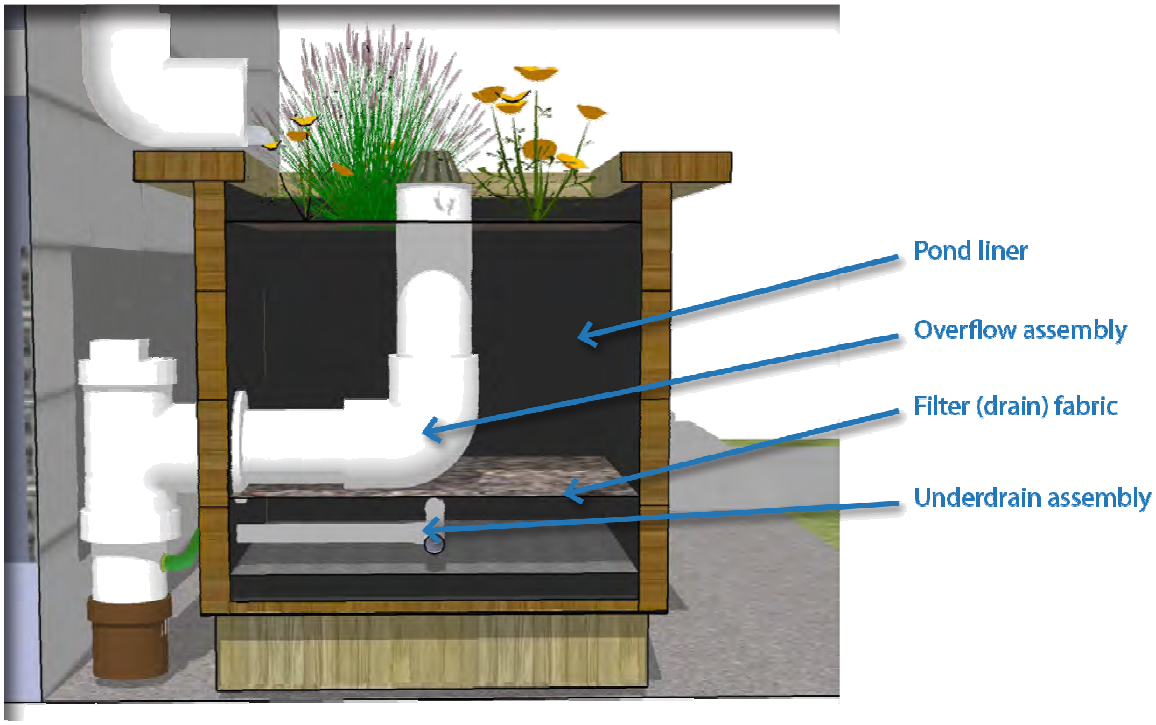
Anatomy of a Downspout Planter Box





rain check

Initial Assessment

1. Consult assessment report and confer with participant to confirm location of installation.
2. Take a "Before" photo that includes the downspout.

Placement

1. Using the nominal measurements of the planter, place CMUs or cinderblocks at ground level to create the base.

2. Use exterior grade composite shims (or other moisture-proof leveling material) to level the base. Shims should be placed to promote a fairly even distribution of weight. The base should be level in all directions.
3. Place the skirt on the ground, surrounding the base. The 2x2 braces in each corner of the skirt should be situated so that the gap is facing upwards.
4. Place the planter onto the base. Double check that the base is level – this will be the last chance to ensure level. Make sure the skirt will fit around bottom of planter by lifting it straight up. Adjust as necessary.
5. Lift the skirt so that the gap above the 2x2 braces are flush with the base of the planter and secure with $1^{5}/_{8}$" decking screws. The skirt will be elevated above the ground.

rain check

Plumbing

1. Cut the downspout at the appropriate height (there must be a slight downward slope from downspout to diverter outlet – at least ¼" per 4 linear feet). Add additional bracing to downspout, if necessary.

2. Using grinder and/or reciprocating saw, cut sewer riser to appropriate height, if necessary. From planter, all piping should maintain at least ¼" per every 4 feet of downward pitch for proper drainage. Exact height of riser cut will vary.

3. Connect garden hose to underdrain and connect to appropriate drainage location.

4. Connect overflow to appropriate drainage location using plumbing components. If tying drainage back into riser, install a removable cleanout cap (PVC "Wye" with cap). If riser pipe is being abandoned, install a rubber cap over opening of pipe. Exterior plumbing components should not be glued.

rain check

Plumbing (Continued)

5. Configure downspout to enter planter. Planters located directly underneath or adjacent to downspout may use flexible "accordion-style" diverters as long as the planter is supporting the diverter. Any run of pipe that is not directly supported by the planter must use rigid downspout material. Ensure piping has a slight downward slope (at least ¼" per 4 linear feet) and is secure at both the downspout and at the outlet (fasten to trim assembly using downspout strapping, if necessary). Downspout should drain to area with splash rock and should not be directed to overflow drain.

Filling & Planting

1. Make sure the horizontal portion of the underdrain is correctly sloped (towards drainage outlet). Fill the bottom of the planter with a minimum of 3" of clean washed drainage stone (pea gravel) to create a base drainage layer. Use just enough gravel to completely cover the horizontal portion of the underdrain.

2. Place WeedBlock filter fabric over base drainage layer. Tuck ends of fabric between gravel and the planter box liner to secure it.

3. Place soil medium into planter to a height 1-2" below overflow drain inlet (atrium grate).

rain check

Filling & Planting (Continued)

4. Plant vegetation according to planting instructions provided with the plants. Taller species should be planted in the rear with shorter species in front. Grasses may be isolated. Be sure to water plants after planting is completed.

5. Place splash rock underneath the downspout diverter outlet to a depth of approximately 1" and covering around 1/3 of the soil. This will allow stormwater to disperse throughout the planter.

Completion

1. Attach skirt to planter using 1-5/8" screws. Attach screws from the side (not the front) when possible.

2. Affix Rain Check signage to planter using ½" or 5/8" stainless steel fasteners (white top gutter screws preferred). Signage should be facing street or passersby.

3. Take "After" photos.

rain check

Downspout Planter
PLANTING GUIDE

PHILADELPHIA WATER

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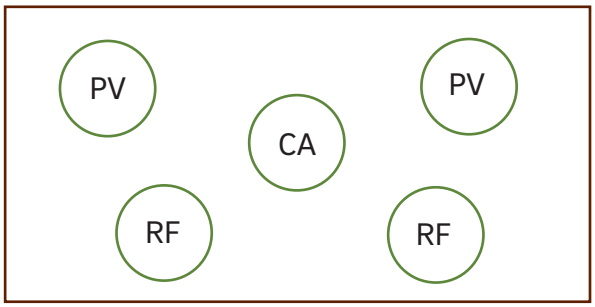
This section provides a series of examples, along with planting guides, of existing downspout planters. After installation of plants, install a 1-2 inch layer of shredded hardwood mulch or stone mulch (e.g., river pebbles) as a top dressing to cover this soil media. This will deter weeds from growing in the downspout planter and will also serve as an energy dissipater for incoming water.

Sun - Partial Shade



Plant Recommendations for Sun to Partial Shade			
Symbol	Scientific Name	Common Name	Plant Form
CA	*Calamagrostis x acutiflora* 'Karl Foerster'	Feather Reed Grass	Grass
PV	*Panicum virgatum* 'Shenandoah'	Red Switch Grass	Grass
RF	*Rudbeckia fulgida* 'Goldstrum'	Black-eyed Susan	Perennial wildflower

PHS sbn

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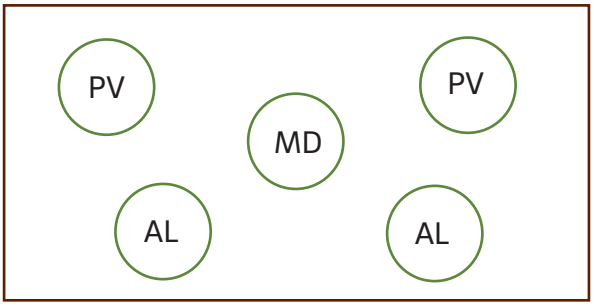
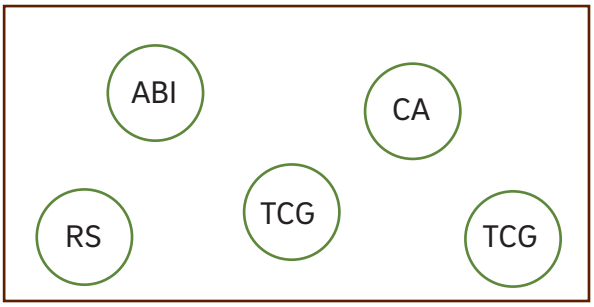
Downspout Planter
PLANTING GUIDE

Full Sun



Plant Recommendations for Full Sun			
Symbol	Scientific Name	Common Name	Plant Form
AL	*Aster laevis*	Smooth Aster	Perennial wildflower
MD	*Monarda didyma*	Bee Balm	Perennial wildflower
PV	*Panicum virgatum* 'Shenandoah'	Red Switch Grass	Grass

Shade



Plant Recommendations for Shade			
Symbol	Scientific Name	Common Name	Plant Form
ABI	*Amsonia 'Blue Ice'*	Blue Star	Perennial wildflower
CA	*Calamagrostis x acutiflora* 'Karl Foerster'	Feather Reed Grass	Grass
RS	Rudbeckia fulgide var. speciosa	Black-eyed Susan	Perennial wildflower
TCG	*Tradescantia 'Concord Grape'*	Spiderwort	Perennial wildflower

Additional Plant Options

Full Sun to Partial Sun Perennials

- *Aster 'Raydon's Favorite'
- Aster 'Bluebird'
- *Agastache foeniculum
- Calamintha 'White Cloud'
- Chelone lyonii 'Hot Lips'
- *Panicum 'Shenandoah'-'Ruby Ri
- Pycnanthemum muticum
- Eupatorium 'Little Joe'
- Filipendula rubra
- Helenium cv.
- Hibiscus 'Fantasia'-'Kopper King'-'Robert Fleming'-'Plum Crazy'
- Iris ensata, Iris versicolor, Iris sibirica.
- *Liatris spicata 'Kobold'
- *Lobelia cardinalis
- *Lobelia siphilitica
- Salvia nemerosa cv.
- Sedum 'Autumn Fire'
- *Salidago 'Little Lemon'-'Golden Fleece'-'Firework's
- *Vernonia lettermannii 'Iron Butterflies'

Full Sun to Partial Sun Grass Species

- Bouteloua gracilis 'Blond Ambition'
- Carex 'Prairie Fire'
- Chasmanthium latifolium
- *Juncus effusus
- *Schizachyrium cv.
- *Panicum (short variey like 'Shenandoah' or 'Ruby Ribbons')

*indicates particularly hardy species

Partial Shade to Full Shade Perennials

- Aruncus aethusifolia
- *Aster divaricatus 'Eastern Star'
- Chelone glabra
- Euphorbia amygdaloides var. robbiae
- *Pycnanthemum muticum
- Hemerocallis cv.
- Heuchera 'Autumn Bride'
- *Lobelia cardinalis
- *Lobelia siphilitica
- Tricyrtis 'Sinonome'
- *Veroniscastrum virginica

Partial Shade to Full Shade Grass Species

- Carex flacca 'Blue Zinger'
- Carex appalachica
- Carex 'Bunny Blue'
- Carex 'Oehme'
- *Chasmanthium latifolium
- Sesleria autumnalis

Native Wetland Planting Guide

Native Wetland & Aquatic Plants for:

- Restoration
- Storm Water Management
- Erosion Control
- Rain Gardens
- Ponds/Lakes/Streams
- Basins / Swales
- Bio-remediation

Simple Plug Spacing Chart – On Center				
Total sq. ft. of bed	12”	18”	24”	36”
50	50	22	13	6
100	100	44	25	11
250	250	110	63	28
500	500	220	125	55
1,000	1,000	440	250	110
5,000	5,000	2,200	1,250	550
10,000	10,000	4,400	2,500	1,100
Multiplier	(1)	(.44)	(.25)	(.11)

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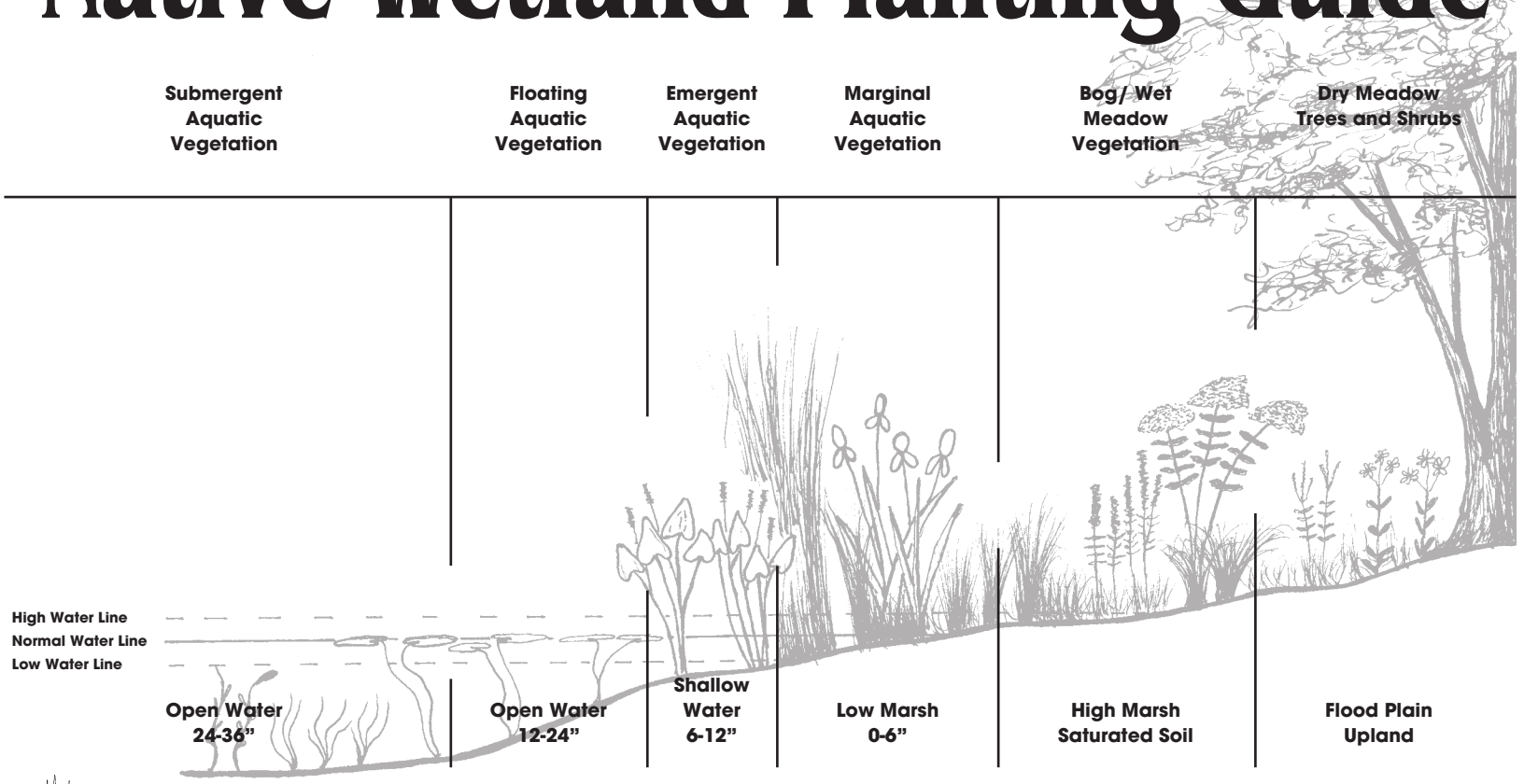
Native Wetland Planting Guide



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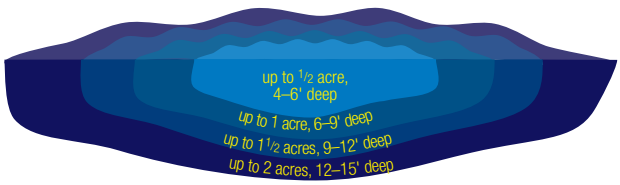
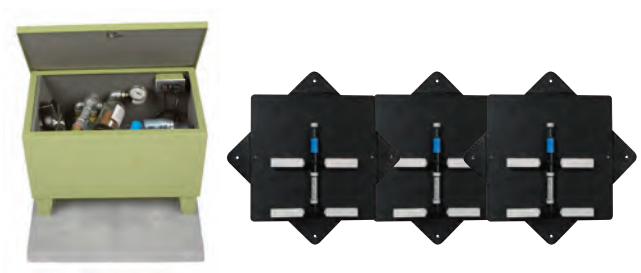
FOR SHALLOW LAKES:

Systems come factory wired for either 115V or 230V single-phase (add "**-230**" after part number for 230V). Three-phase models, not wired, are also available. Great Lakes® systems feature Sweetwater® oilless rotary vane compressors that include a muffler, inlet check valve, control valves, 0–30 psi liquid-filled pressure gauge and pressure relief valve. Our shallow lake systems, which use the **ALA4GLB** diffuser manifold(s), are recommended when the majority of the lake is 4–15 feet deep. Tubing is not included; we recommend **P200S** polyethylene tubing on the land and **WD1** weighted tubing underwater. Maintenance kits include four sacrificial carbon vanes, gasket and two inlet filter elements.

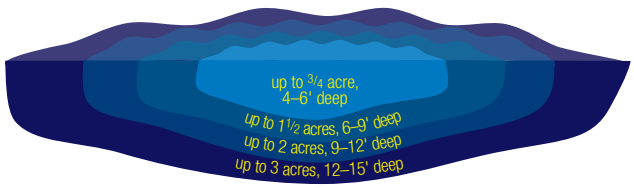
FOR SHALLOW LAKES



MODEL		SHIP WT (LBS)	EACH
4GL32	¼-HP AERATION SYSTEM + 2 DIFFUSERS W/CABINET	127	**$2,520.00**
SL3MK	MAINTENANCE KIT FOR ¼-HP SYSTEM	2	**109.69**

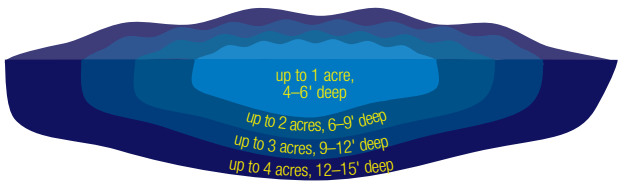


4GL53



MODEL		SHIP WT (LBS)	EACH
4GL53	¾-HP AERATION SYSTEM + 3 DIFFUSERS W/CABINET	147	**$2,614.00**
SL5MK	MAINTENANCE KIT FOR ¾-HP SYSTEM	2	**128.79**

4GL54



MODEL		SHIP WT (LBS)	EACH
4GL54	¾-HP AERATION SYSTEM + 4 DIFFUSERS W/CABINET	150	**$3,071.00**
SL5MK	MAINTENANCE KIT FOR ¾-HP SYSTEM	2	**128.79**

Note: Maintenance kits include four sacrificial carbon vanes, gasket and two inlet filter elements.

Natural Lands Trust

Meadows

in Southeastern Pennsylvania

Bill Moses

Most grasslands and meadows in eastern North America are short-lived ecosystems. Without repeated disturbance, woody cover (trees and shrubs) quickly returns. It is now believed that agriculture and burning by Native Americans, coupled with the more recent agriculture of European settlers, maintained extensive herbaceous openings in this region for thousands of years, and that feeding, wallowing, and trampling by now-extinct "megaherbivores"—mammoths, mastodons, giant ground sloths, horses, tapirs, peccaries, and others—created and maintained a patchwork of meadows and grasslands for millions of years before that, until their demise upon arrival of humans to our region about 13,000 years ago. As a result, numerous native plant and animal species, particularly birds and butterflies, are completely dependent upon these habitats and are now threatened as they decline.

Most meadows in southeastern Pennsylvania have an agricultural past—old hayfields or pasture—and are dominated by non-native cool-season grasses planted for centuries as fodder, such as tall fescue, perennial ryegrass, Kentucky bluegrass, orchard grass, and timothy. Cool-season grasses are so named because they grow best during spring and fall. Warm-season grasses grow mainly in the heat of the summer.

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Although native meadows are attractive throughout the year, summer and early fall is the period when meadows exhibit their full glory. Between early July and late October, the warm-season species will dominate, creating lush foliage of varying shades of blue and green punctuated by wildflowers in a meadow tapestry. Common meadow wildflowers at this time include black-eyed Susan, sunflower, aster, and goldenrod. As winter sets in from November to March, the warm season grasses, which remain upright, will provide a spectacle of color, often described as "wine-red, ash grey, steel blue, gold russet, ochre, copper and amethyst."

Two misconceptions are widespread: one is that most cool-season grasses are non-native, and the other, that most native grasses are warm-season. Considering the state's flora as a whole, the facts are somewhat the opposite. Of the 173 grasses (165 species, plus varieties and subspecies) native to Pennsylvania, 105 are cool-season grasses and 68 are warm-season grasses. The higher diversity of cool-season grasses also holds

Darin Groff

Unlike the shallow roots of turf grasses, the deep roots of native warm-season grasses like big bluestem *(above)* **help them tolerate marginal soils and, in turn, protect these soils from water and wind erosion.**

when considering species only native to the Piedmont and Coastal Plain areas of southeastern Pennsylvania. There are a total of 149 grasses considered to be native to this region with 83 cool-season and 66 warm-season representatives.

The cool-season grasses' new leaves emerge in late winter or early spring and they generally flower and set fruit in spring or early summer. In warm-season grasses emergence is usually delayed until late spring or early summer and they generally flower and set fruit in late summer or fall. Native cool-season and warm-season grasses can perform well together in mixture because competition between grasses of the two types is reduced, due to differences in rooting depth (cool-season species tend to have shallower roots than warm-season species) and the separation of peak growth and photosynthesis to different parts of the growing season. Native warm-season grasses thrive on marginal soils and survive periods of low rainfall due to their deep, fibrous root systems, which can penetrate the soil to a depth of 5–10 feet. In native meadow plantings, a reasonable goal is to achieve 50–75% cover of warm-season grasses (e.g., little bluestem, big bluestem, Indian-grass, broomsedge, switchgrass), with the remainder in native cool-season grass and forb cover.

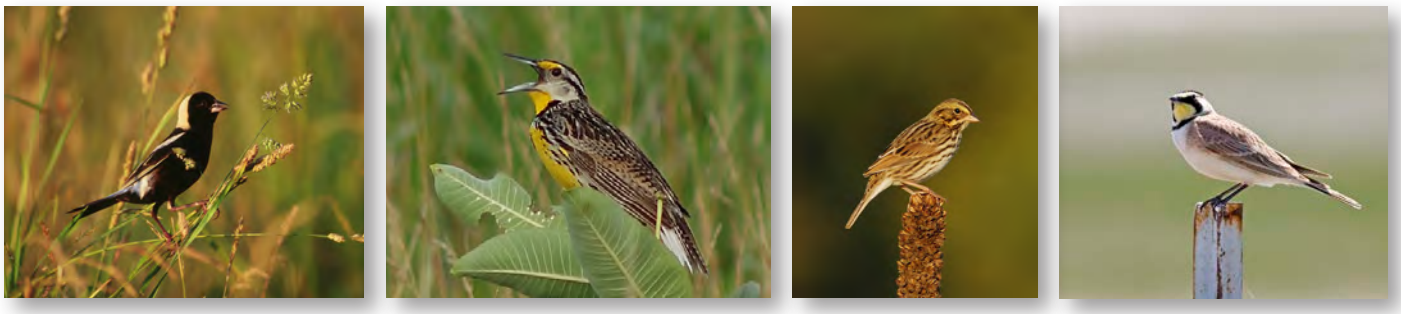
WILDLIFE BENEFITS

The beauty of native grasses and wildflowers is complimented by the wildlife attracted to them for food and shelter. Native grasslands and meadows are prime habitat for several threatened bird species because this habitat has steadily declined in size and species diversity since European settlement.

Declines are especially devastating of *interior* grassland and meadow species, that is, those that need blocks of contiguous habitat, usually greater than 50 acres, where there are large areas at least 100 meters (about 300 feet) from any forest edge or other non-meadow land cover. Populations of birds such as bobolink, eastern meadowlark, grasshopper sparrow, savannah sparrow, vesper sparrow, upland sandpiper, and northern bobwhite have fallen off drastically in recent years due to the loss of habitat and the fragmentation of remaining habitat into pieces that are too small to meet their needs.

There is an ongoing effort by scientists and resource managers to better understand what makes ideal habitat for grassland and meadow birds. Over the past decade, there has been wide promotion of native warm-season grasses as the ideal habitat. Warm-season grasses are a key part of prime habitat for grassland birds because they are bunch grasses, in contrast to the sod-forming growth habit of the common non-native cool-season grasses, such as those planted for hay, pasture, or turf. This means that they grow upright with bare ground between clumps. This characteristic provides high-quality nesting sites and materials and allows grassland birds to move more easily and better protected from avian predators in their search for food. The open space between clumps also provides space for wildflowers to become established.

In spring, ground-nesting birds utilize the cover afforded by the grasses and wildflowers to brood and rear their young. Flowers attract insects, which



Bill Moses (3), © iStockphoto.com/ Frank Leung (far right)

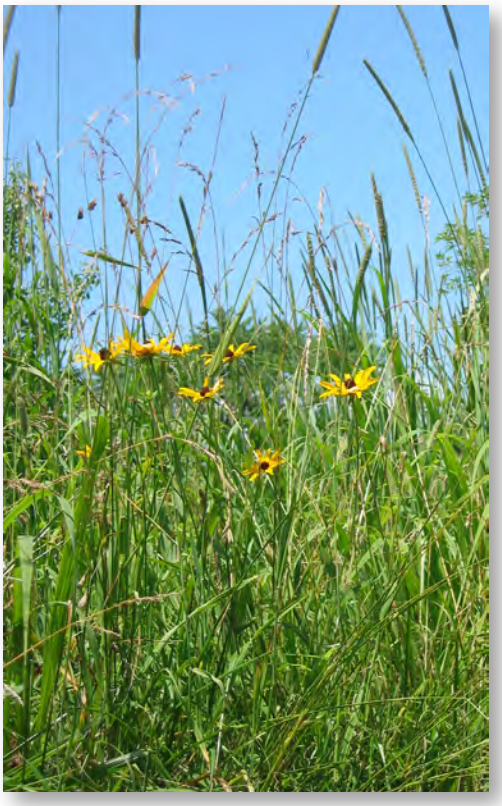
Birds of large open landscapes: bobolink *(far left)* **and eastern meadowlark** *(middle left)* **are two birds that prefer cool-season grasslands; savanna sparrows** *(middle right)* **prefer warm-season grasslands; and horned larks** *(far right)* **are "dirt birds," using bare soil in cultivated fields.**

constitute the most important element in the diet of young birds. During the autumn months, native wildflowers and grasses produce highly nutritious seeds. These are relished by a variety of songbirds and will attract many migrants that stop over on their long journey south. Throughout the winter, the upright grasses provide food and cover for the resident birds to help them survive the winter months.

Despite the great benefits of native warm-season grasses, research is showing that they do not fit the needs of all grassland birds. While savannah and grasshopper sparrows prefer warm-season grasses, bobolink and meadowlark do best in cool-season grasslands. And some birds, e.g., horned larks, are full- or part-time "dirt" birds, using the bare soil created by traditional cultivation (moldboard plowing) and heavy grazing, which mimics the trampling, wallowing, and grazing by megaherbivores that occurred during most of the evolutionary history of native grassland and meadow plant and animal species. There is a growing consensus that a large open landscape (hundreds of acres) with diverse cover types in patches of various sizes, including warm- and cool-season grasslands and forb-dominated meadows, is best. Agriculture (row crops, pasture, hay fields) without hedgerows can be a compatible economic land use within a mosaic of native grasslands and meadows intended to provide habitat for grassland-interior birds. Structural diversity—created by planting a patchwork of meadow types, each with a mix of species—produces preferred cover for the greatest variety of grassland and meadow wildlife species.

Little is known about the effects of declining native grassland habitat to other kinds of wildlife in Pennsylvania, including small mammals, snakes, lizards, turtles, insects and other arthropods, and various animals that live in the soil. But we can get some idea of the probable magnitude of the problem from surveys of one of the few groups that has been studied—moths—in the native grasslands of the State Line Serpentine Barrens along the southern borders of Chester and Lancaster Counties. These ancient grassland remnants harbor, according to discoveries so far, at least three dozen moth species listed as endangered, threatened, or rare in Pennsylvania.

Many butterfly species have also developed close relationships with native meadow wildflowers, which they use for the nectar (adults) and the leaves and stems (larvae). As our few remaining undisturbed habitats continue to be lost to suburban development, many native plants are becoming increasingly rare. The implications for butterflies are dire; with the loss of their host plants, some butterfly species are inching closer toward extinction. Unless native wildflowers and butterfly habitats are restored, we can expect to see further declines in overall butterfly populations and continued losses of rare and endangered species.



Gary Gimbert

ESTABLISHMENT

Conversion to native grasses and forbs is best achieved by eliminating existing vegetation that can aggressively compete for nutrients and water, particularly turf grass species, trees, shrubs, and invasive vines. Trees and shrubs can also obstruct mowing and other future maintenance activities. If rapid conversion to native grasses is not an option for lack of funding or equipment, the landowner can

encourage a gradual change from exotic to native grass dominance through the timing of management. Certain bird species, particularly bobolinks and meadowlarks, can thrive in large open areas dominated by exotic turf grasses created simply by reducing the mowing frequency of turf, pasture, or hay field to once per year.

One of the challenges of meadow establishment and management is a tendency for the planted native grass species to become over-dominant. This is particularly true of the warm-season "tallgrasses," notably big bluestem, Indian-grass, and switchgrass. It is best to mass forb plantings and separate them spatially from the tallgrass plantings. This type of patchiness is common in nature and should be imitated to the extent possible in new meadow establishment. Grasses should be planted in rates not exceeding 1–2 pounds per acre in order to achieve high species diversity.

Initial failure of meadow and grassland plantings, especially of warm-season grasses, is not uncommon. Weather and other factors are beyond the control of even an experienced practitioner. Such setbacks are temporary and should not be a cause to give up on efforts to establish native meadow vegetation. Often, where initial plantings do not produce the desired result, a follow-up attempt a year later is successful.

Paul Claypoole (both)

Meadow establishment through spraying *(top)* **and then planting with a no-till drill** *(bottom)***.**

MANAGEMENT

Because a meadow is typically a short-lived successional stage, it must be periodically disturbed to prevent woody vegetation from becoming established. This can be accomplished either by mowing annually or prescribed burning every few years.

The frequency and timing of mowing has a dramatic affect on the composition of a meadow and its wildlife residents. When and how often to mow will depend upon your conservation priority and the environmental conditions of the grassland or meadow. In general it is best to mow when wildlife is

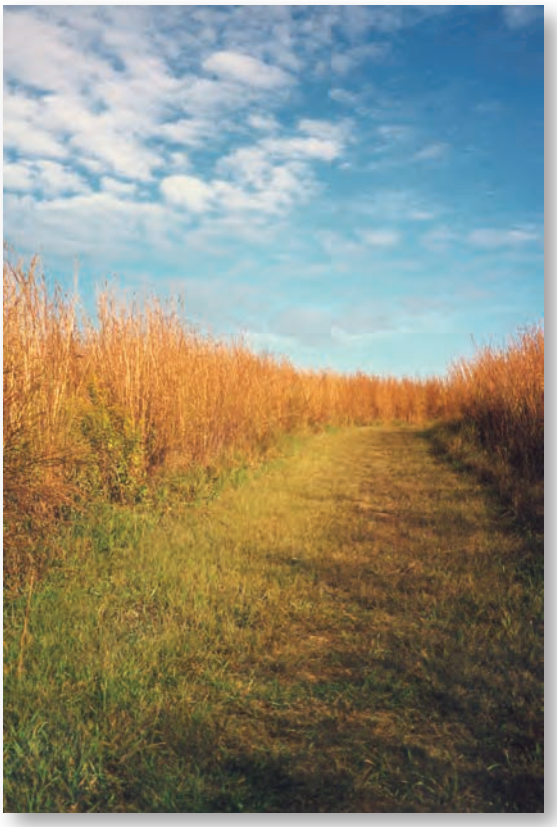
Jim Thompson

Generally, an annual mowing is all that is needed to maintain a meadow, but sometimes a second mowing is needed during the growing season to control undesirable plants.

Recommended Mowing Regimen

ENVIRONMENTAL CONDITIONS	CONSERVATION PRIORITY	
	Most Meadow Wildlife (<50 acres of total habitat)*	*Grassland/Meadow-Interior Birds (>50 acres total contiguous habitat*)*
Dry or frozen in late winter/early spring	Mow in March	
Wet in late winter/ early spring	Mow after first hard frost (mid-November)	
Heavy invasives	Mow entire area in March; mow one-third to one-half the area in mid-**July**, alternating in subsequent years	Mow entire area in March; mow one-third to one-half the area in mid-**August**, alternating in subsequent years

*** To determine the extent of meadow habitat, individual meadows must be connected on at least one side and can have no more than a few sparse trees (no shrubs or vines under the trees) in order to be connected enough to function as a single meadow.**



Mark Eberle

Mowed edges and trails give meadows the appearance that they are intentional and managed, as well as encourage people to discover their beauty up close.

less vulnerable to disturbance, that is, during the non-growing season (roughly mid-November to mid-March in southeastern Pennsylvania). A late winter or early spring mowing (prior to April 1st) is best. Mowing at this time conserves winter cover for wildlife and avoids disturbing nesting and feeding wildlife (birds, small mammals, butterflies) in spring and summer. If wet soil conditions prohibit mowing in late winter/early spring a fall mowing (after the first hard frost) when these areas are dry or a winter mowing when the ground is frozen are other preferred options. Sometimes a second mowing is needed to control undesirable plants during the growing season; a mid-July to early August mowing will help control woody and invasive plants, encourage warm-season grasses, and provide sufficient time to establish winter cover. The only case where this would not be appropriate is in larger (>50 acres) grasslands and meadows (or smaller meadows in a larger open landscape), which can support threatened interior grassland and meadow birds. These birds can nest into mid-August. In this situation it is best to mow only one-third to one-half of the grassland or meadow each year to minimize disturbance of ground-nesting birds.

Dan Barringer

Prescribed fire is an effective meadow management tool for discouraging invasion by woody plants and killing or setting back non-native and/or invasive species such as thistle, multiflora rose, oriental bittersweet, and Japanese honeysuckle.

It is best to mow meadows when the ground is dry or frozen. They should be cut at a height of 8–12 inches. Meadows must also be monitored for intrusion by invasive plants. Invasives in meadows can be eliminated by spot mowing, spot-spraying or wick application of an appropriate herbicide, or manual or mechanical pulling.

To emphasize that a meadow is intentional and managed, it is often beneficial to maintain a mowed turf swath around the public edges and consider incorporating a trail network. Well-maintained trails encourage people to get into the meadow and discover its beauty up close. However, care should be taken to minimize the extent of trails to prevent undue disturbance of wildlife. This is especially true in meadows that support grassland-interior birds where trails can fragment the habitat and provide easy access for predators.

Another tool for managing meadows is prescribed fire. Native Americans used fire to manage the landscape for thousand of years, which selected fire-adapted species to dominate native grasslands and meadows. Periodic spring fires (with at least 3–5 years between burns in a given area), rotating among sections of the meadow landscape to maintain a refugium from which insects can re-colonize the treated area (for meadows less than 50 acres only 10–20% should be burned in any year; for larger meadows one-third to one-half can be treated), will effectively discourage invasion by woody plants. Prescribed burning should be done only by well-trained personnel and in accordance with federal, state, and local laws.

Excerpted from Natural Lands Trust's *Stewardship Handbook for Natural Areas in Southeastern Pennsylvania* (2008). For a more detailed discussion of meadows and information on stewardship of natural areas in general, please consult the *Stewardship Handbook*, available for free download or purchase at www.natlands.org/handbook.

For more information about meadow installation and management, contact Gary Gimbert at 215-699-1578.

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From Mowing to Meadows… *Developing a Wilder Aesthetic*

Kirsten L. Werner, Natural Lands Trust

Converting part of your yard to meadow can save you time and money — think about less frequent mowing. And meadows help filter our groundwater, control flooding, add visual appeal and provide critical habitat for songbirds and pollinators. So sit back and watch the grass grow!

Grass is Far from "Green"

Americans spend about $30 billion every year to maintain more than 32 million acres of lawn—that's about the size of Pennsylvania. We pour 270 billion gallons of water per week on our lawns and apply 10 times more fertilizer, herbicides and pesticides than farmers do to their crops.

A typical 3.5-horsepower gas lawn mower emits about the same amount of volatile organic compounds in an hour as a car driven 340 miles. On top of that, the EPA estimates that we spill 17 million gallons of fuel each year filling our mowers—more than the Exxon Valdez oil spill!

Making Meadows

The easiest way to convert a portion of lawn to meadow is simply to mow only once or twice a year. Often the best areas to convert are those that are difficult to mow, such as wet or steep areas. Other ideal locations include transition areas between turf and woodlands, stream corridors and areas that aren't often used by your family.

At first, your new meadow will be a new home to the species that originally made up the lawn: usually non-native, cool-season grass species such as Kentucky bluegrass, fescues and ryes. With time, the vegetation diversifies. Native warm-season grasses—little and big bluestem and purpletop—will begin to appear.

Wildflowers will follow, depending on what species are seeded by local plants and by seeds in wildlife droppings. Species such as goldenrod, asters, black-eyed Susan, daisy, yarrow, Queen Anne's lace and purple coneflower are common in meadows.

Better Habitat for Wildlife

Over the last century, changes in agricultural technology and loss of land to development have caused a decline in the quantity and quality of grasslands habitats for wildlife. In particular, these changes have threatened the survival of birds—such as Eastern Meadowlark, Bobolink, Grasshopper Sparrow—that depend on large meadows (25+ acres).

While small meadows won't provide breeding habitat for these threatened species, they do provide important resting and feeding areas along migratory pathways. And you'll get to enjoy the sight of avian species such as Red-wing Blackbird, American Goldfinch, and various swallows and sparrows that are far less likely to frequent your manicured lawn.

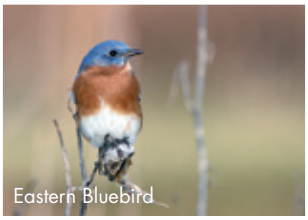
Beneficial Pollinators

Another benefit of allowing turf to evolve to meadow is the increased presence of pollinators. Many beneficial pollinators—bees, beetles, butterflies—are currently at risk from loss of habitat and pesticide use. This is especially troubling because pollinators are essential to the production of 75 percent of the staple crops that feed humans and for 90 percent of all flowering plants in the world.

Beneficial pollinators have very basic habitat requirements: flowers to forage, host plants for egg laying, and an environment free of pesticides. Grasslands and wildflower meadows offer these essentials in spades.

Visual Appeal

Meadows offer a sensory experience every season of the year. A meadow of tall, waving grass is a beautiful sight on a breezy



June day. In mid-summer, it's literally abuzz with activity. There's much to observe: a bird looking for a meal, bees flying from flower to flower, the iridescence of a butterfly, or the steady chatter of crickets. Many meadow wildflowers persist into fall and attract songbirds that feast on seed heads. Even in winter, the dried stalks of meadow grasses and flowers are striking.

To make clear that a meadow is intentional and managed, and not a landscaping oversight, maintain a mowed turf swath as a sharp edge around the borders. If your meadow is large enough, consider incorporating a trail network so you (and your senses) can get closer to the action!

Meadow Maintenance

Mow your meadow at least once a year to keep it from reverting to a forest. But remember: timing is everything. Mowing between April 1 and early July is detrimental to wildlife because it removes nesting cover, destroys nests and eggs, and kills young birds and animals. Similarly, mowing between mid-July and late-October doesn't allow vegetation enough time to renew itself before winter, so it won't offer food and cover for wildlife until the following spring.

Mowing between March 1 and April 1 is ideal. Set your mower deck to a height of six to eight inches and mow away!

Keep an eye out for invasive plants that can quickly take over your new meadow. Eliminate invasives by spot mowing, selective spraying with an herbicide, or manual or mechanical pulling. Use only aquatic approved herbicides within 50 feet of streams.

Given the myriad of benefits of replacing turf with meadow, it's certainly worth considering. You can start small, but beware … making meadows can be addictive! After a few seasons of observing the flourishing grasses and wildflowers, you'll never look at turf the same again. ♦

Natural Lands Trust is dedicated to protecting forests, fields, streams and wetlands essential to the sustainability of life in eastern PA and southern NJ. Since 1953, it has preserved more than 100,000 acres, including 42 nature preserves. Millions of residents enjoy the healthy habitats, clean air and water, recreational opportunities, and scenic beauty provided by these preserved land. Visit NatLands.org.

Aquatic Plant List

Shoreline Zone (Occasionally Inundated)

Bayonet rush *(Juncus bigel)*
Rush family *(Juncus sp.)*
Spike-rush *(Eleocharis R. Br.)*
Northeastern bulrush *(Scirpus ancistrochaetus)*
Three-way sedge *(Dulichium arundinaceum)*
Great bulrush *(Schoenoplectus tabernaemontani)*

Elevation Zero Zone (Always Inundated, water's edge)

Bayonet rush *(Juncus bigel)*
Rush family *(Juncus sp.)*
Spike-rush *(Eleocharis R. Br.)*
Northern blue flag *(Iris versicolor)*
Southern blue flag *(Iris virginica)*

Obligate Zone (6-12" Depth)

Water star-grass *(Heteranthera dubia)*
Mud plantain *(Heteranthera multiflora)*
Mud plantain *(Heteranthera reniformis)*
Pickerel-weed *(Pontederia cordata)*
Arrow arum *(Peltandra virginica)*
Spatterdock *(Nuphar advena)*
Bur-reed *(Sparganium americanum)*
American lotus *(Nelumbo lutea)*

Native Plant Materials

Nearly 1,600 vascular plant species are known to be native to the greater southeastern Pennsylvania region (the roughly 15 counties that lie south and east of Blue Mountain or Kittatinny Ridge). They include almost 1,350 herbaceous species (wildflowers, grasses, sedges, rushes, ferns), 133 shrubs, 102 trees, and 19 woody vines. Here we suggest a relatively small fraction of those species for use in natural land restoration and landscaping. For natural land restoration we highlight 134 wildflowers; 48 grasses, sedges, and rushes; 19 ferns; 68 shrubs; 62 trees; and 2 woody vines in tables on pages 173–190. A shorter list of plants that provide wildlife benefits and horticultural values can be found on pages 191–198. All species were selected for their ability to thrive under a range of environmental conditions and for their commercial availability (see sources of native plants on page 198), mainly from nurseries and seed suppliers who specialize in plants that are native to southeastern Pennsylvania and immediately adjacent areas of Pennsylvania, New Jersey, Delaware, and Maryland. Don't be discouraged if the availability of some of these plants is limited. Your interest will encourage nurseries to increase their supply.

The plants we recommend for restoration projects are sorted into three major habitat categories: ***forest***, ***shrubland***, and ***meadow***. Within each major category are separate lists of trees, shrubs, and herbaceous species, and each of those groups is further broken down into height classes, based on the maximum height that each species could attain under ideal growing conditions. Maximum height is particularly important in meadow plantings. Most native meadow species have low tolerance of shade and require full sun for at least a part of every day to survive. If species of markedly different heights are planted together, the shorter species are likely to fail due to shade suppression. In any given patch of meadow, the mix of species planted from seeds or plugs should range across no more than two consecutive size categories (the overall planting can be a mosaic of patches of different heights).

All of the shrub and herbaceous species listed under "Native Forest Plants" have intermediate to high tolerance of shade. The list of upper canopy trees includes a mixture of species with low, intermediate, and high shade tolerance, but all native upper canopy tree species—including those that are highly shade tolerant—should be planted where they will get at least some full sun every day. (Subcanopy trees species generally are more tolerant of shading, but will also benefit from some direct sun exposure while they become established; a few have low shade tolerance and thrive best in savannas or open woodlands, including pitch pine, Virginia pine, black jack oak, post oak, sassafras, and black willow.) Seedlings and saplings of even

the most shade tolerant tree species tend to grow extremely slowly or not at all in deep shade. Shade tolerance does not allow young trees of upper canopy species to grow to full size in the shade; it merely enables them to survive many years in a suppressed state until adult trees in the canopy above them die. The natural course of forest canopy renewal takes place when old trees fall or die, opening up a canopy gap that admits enough sunshine to fuel a growth spurt of the advance regeneration (established seedlings and saplings), which soon fill the gap. If the gap is large enough to provide sufficient sunlight, it often becomes a race to fill the gap between shade tolerant tree species, which are already established and have a head start but have slower maximum growth rates, and shade intolerant tree species, which must start from seed but generally grow much more rapidly. Owners or managers of natural lands can choose the winners in this race by judicious weeding and by planting tree seedlings or saplings of upper canopy species far enough apart that none will shade or otherwise interfere with each other's growth.

FOREST TREES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
*maximum height: 70–140 feet or more (**upper canopy**)*		
Acer rubrum	red maple	dry to wet
Acer saccharinum	silver maple	moist to wet
Acer saccharum	sugar maple	dry to moist
Betula lenta	sweet birch, black birch	dry to moist
Betula nigra	river birch	moist
Carya cordiformis	bitternut hickory	moist
Carya laciniosa	shellbark hickory	moist to wet
Carya ovata	shagbark hickory	dry to moist
Carya tomentosa	mockernut hickory	dry to moist
Celtis occidentalis	common hackberry	dry to moist
Fagus grandifolia	American beech	moist
Fraxinus americana	white ash	moist
Fraxinus pennsylvanica	red ash, green ash	moist to wet
Gleditsia triacanthos	honeylocust	moist
Juglans nigra	walnut	moist
Liquidambar styraciflua	sweetgum	moist to wet
Liriodendron tulipifera	tuliptree	moist
Nyssa sylvatica	blackgum, sourgum, tupelo	dry to wet
Pinus echinata	shortleaf pine	dry

FOREST TREES, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
*maximum height: 70–140 feet or more (**upper canopy**)*		
Pinus strobus	white pine	dry to wet
Platanus occidentalis	American sycamore	moist to wet
Prunus serotina	black cherry	moist
Quercus alba	white oak	dry to moist
Quercus bicolor	swamp white oak	moist to wet
Quercus coccinea	scarlet oak	dry to moist
Quercus falcata	southern red oak	dry to moist
Quercus montana [=*Quercus prinus*]	chestnut oak	dry
Quercus palustris	pin oak	moist to wet
Quercus phellos	willow oak	moist to wet
Quercus rubra	northern red oak	dry to moist
Quercus velutina	black oak	dry to moist
Tilia americana	basswood	moist
Tsuga canadensis	eastern hemlock	moist
Ulmus americana	American elm	moist to wet
Ulmus rubra	slippery elm	moist to wet
*maximum height: 30–65 feet (**subcanopy**)*		
Amelanchier arborea	shadbush, serviceberry, juneberry	dry to moist
Amelanchier laevis	shadbush, serviceberry, juneberry	dry to moist
Aralia spinosa	devil's walking-stick, Hercules'-club	moist
Asimina triloba	pawpaw	moist
Carpinus caroliniana	American hornbeam, musclewood	moist
Cercis canadensis	redbud	rich
Cornus florida	flowering dogwood	moist
Diospyros virginiana	persimmon	dry to moist
Ilex opaca	American holly	moist
Juglans cinerea	butternut	moist
Magnolia virginiana	sweetbay magnolia	moist to wet
Malus coronaria	sweet crabapple	dry to moist
Morus rubra	red mulberry	moist

FOREST TREES, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
*maximum height: 30–65 feet (**subcanopy**)*		
Ostrya virginiana	hop-hornbeam	dry to moist
Pinus rigida	pitch pine	dry
Pinus virginiana	Virginia pine	dry
Quercus marilandica	blackjack oak	dry
Quercus stellata	post oak	dry
Salix nigra	black willow	wet
Sassafras albidum	sassafras	dry to moist
Viburnum lentago	nannyberry	moist

FOREST SHRUBS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 20–25 feet		
Alnus serrulata	smooth alder	wet
Amelanchier canadensis	shadbush, juneberry, serviceberry	moist
Cornus alternifolia	alternate-leaved dogwood	moist
Euonymus atropurpureus	wahoo	moist to wet
Prunus americana	wild plum	moist
Prunus virginiana	choke cherry	dry to moist
Viburnum prunifolium	black-haw	wet
maximum height: 10–15 feet		
Cephalanthus occidentalis	buttonbush	wet
Clethra alnifolia	sweet pepperbush	wet
Cornus amomum	silky dogwood	wet
Cornus racemosa	gray dogwood	wet
Cornus rugosa	round-leaved dogwood	dry
Corylus americana	American filbert	dry to moist
Corylus cornuta	beaked hazelnut	dry to moist
Hamamelis virginiana	witch-hazel	dry to moist
Ilex verticillata	winterberry, black-alder	wet

FOREST SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 10–15 feet		
Kalmia latifolia	mountain-laurel	dry to moist
Lindera benzoin	spicebush	moist
Photinia melanocarpa [=*Aronia melanocarpa*]	black chokeberry	dry to wet
Photinia pyrifolia [=*Aronia pyrifolia*]	red chokeberry	moist to wet
Physocarpus opulifolius	ninebark	moist to wet
Rhododendron arborescens	smooth azalea	moist
Rhododendron maximum	rosebay rhododendron	moist to wet
Rhododendron periclymenoides	pinxter-flower	dry to moist
Rhododendron viscosum	swamp azalea	wet
Salix discolor	pussy willow	moist to wet
Sambucus canadensis	American elder	moist to wet
Sambucus racemosa	red-berried elder	moist
Staphylea trifolia	bladdernut	dry to moist
Vaccinium corymbosum	highbush blueberry	dry to wet
Viburnum cassinoides	witherod	moist to wet
Viburnum dentatum	southern arrow-wood	wet
Viburnum recognitum	northern arrow-wood	wet
Viburnum trilobum	highbush-cranberry	wet
maximum height: 5–7 feet		
Amelanchier stolonifera	low juneberry, low shadbush	dry to moist
Dirca palustris	leatherwood	dry to moist
Euonymus americanus	hearts-a-bursting	moist
Gaylussacia frondosa	dangleberry	dry to wet
Hydrangea arborescens	sevenbark, wild hydrangea	dry to moist
Ribes americanum	wild black currant	moist to wet
Rosa palustris	swamp rose	wet
Rubus idaeus	red raspberry	dry to moist
Rubus occidentalis	black-cap, black raspberry	dry to moist
Spiraea alba	meadow-sweet	moist to wet

FOREST SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 5–7 feet		
Spiraea latifolia	meadow-sweet	moist to wet
Taxus canadensis	American yew	moist
Vaccinium stamineum	deerberry	dry
Viburnum acerifolium	maple-leaved viburnum	moist
maximum height: 2–4 feet		
Diervilla lonicera	bush-honeysuckle	dry
Gaylussacia baccata	black huckleberry	dry to wet
Spiraea tomentosa	hardback, steeple-bush	moist to wet
Vaccinium angustifolium	low sweet blueberry	dry to moist
Vaccinium pallidum	lowbush blueberry	dry to moist

FOREST VINES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
Lonicera sempervirens	trumpet honeysuckle	moist
Parthenocissus quinquefolia	Virginia-creeper	moist

FOREST PERENNIAL WILDFLOWERS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet)*		
Actaea racemosa [=*Cimicifuga racemosa*]	black cohosh	dry to moist
Aralia racemosa	spikenard	moist
Polygonatum biflorum	Solomon's-seal	dry to moist
maximum height: ***intermediate*** *(3½–5 feet)*		
Arisaema triphyllum	jack-in-the-pulpit	moist
Eurybia divaricata [=*Aster divaricatus*]	white wood aster	dry to moist

FOREST PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Eurybia macrophylla [=*Aster macrophyllus*]	bigleaf aster	dry to moist
Eurybia schreberi [=*Aster schreberi*]	Schreber's aster	dry to moist
Maianthemum racemosum [=*Smilacina racemosa*]	false Solomon's-seal, Solomon's plume	dry to moist
Medeola virginiana	Indian cucumber-root	moist
Polygonatum pubescens	Solomon's-seal	dry to moist
Sanicula odorata	yellow-flowered sanicle, fragrant snakeroot	moist
Solidago caesia	bluestem goldenrod	dry to moist
Solidago flexicaulis	zigzag goldenrod	moist
Symphyotrichum cordifolium [=*Aster cordifolius*]	blue wood aster	dry to moist
Triosteum aurantiacum	wild-coffee	moist
maximum height: ***short*** *(1½–3 feet)*		
Actaea pachypoda	doll's-eyes	dry to moist
Allium tricoccum	ramps, wild leek	dry to moist
Aquilegia canadensis	wild columbine	dry to moist
Aralia nudicaulis	wild sarsaparilla	dry to moist
Aristolochia serpentaria	Virginia snakeroot	dry to moist
Caulophyllum thalictroides	blue cohosh	dry to moist
Dicentra eximia	wild bleeding-heart	dry to moist
Geranium maculatum	wild geranium	dry to moist
Hybanthus concolor	green-violet	moist
Hydrophyllum canadense	Canadian waterleaf	moist
Hydrophyllum virginianum	Virginia waterleaf	moist
Lysimachia quadrifolia	whorled loosestrife	dry
Mertensia virginica	Virginia bluebells	moist
Oclemena acuminata	wood aster	moist
Osmorhiza claytonii	sweet-cicely	moist
Osmorhiza longistylis	anise-root	moist

FOREST PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***short*** *(1½–3 feet)*		
Phlox divaricata ssp. *divaricata*	eastern wild blue phlox	dry to moist
Podophyllum peltatum	mayapple	moist
Polemonium reptans	spreading Jacob's-ladder	moist
Scutellaria serrata	showy skullcap	moist
Thalictrum dioicum	early meadow-rue	moist
Trillium cernuum	nodding trillium	moist
Trillium erectum	purple trillium, wakerobin	moist
Trillium flexipes	declined trillium	moist to wet
Trillium grandiflorum	large-flowered trillium	moist
Uvularia perfoliata	bellwort	moist
Uvularia sessilifolia	bellwort	moist
Zizia aptera	golden-alexander	moist
Zizia aurea	golden-alexander	moist
maximum height: ***very short*** *(up to 1 foot)*		
Asarum canadense	wild ginger	moist
Hydrastis canadensis	goldenseal	moist
Iris cristata	dwarf crested iris	dry to moist
Jeffersonia diphylla	twinleaf	dry to moist
Maianthemum canadense	Canada mayflower	moist
Mitchella repens	partridge-berry	moist
Sanguinaria canadensis	bloodroot	dry to moist
Thalictrum thalictroides	rue anemone	dry to moist
Tiarella cordifolia	foamflower	moist

FOREST GRASSES, SEDGES, AND RUSHES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet)*		
Scirpus cyperinus	wool-grass	wet
maximum height: ***intermediate*** *(3½–5 feet)*		
Carex crinita	fringed sedge, short-hair sedge	wet
Carex folliculata	northern long sedge	wet
Carex gynandra	nodding sedge	wet
Carex lurida	lurid sedge, shallow sedge	wet
Carex scoparia	broom sedge	moist to wet
Carex stipata	stalk-grain sedge, owlfruit sedge	wet
Carex tribuloides	blunt broom sedge, bristlebract sedge	wet
Chasmanthium latifolium	Indian wood-oats	moist
Elymus hystrix	bottlebrush-grass	moist
Glyceria canadensis	rattlesnake mannagrass	wet
Glyceria melicaria	slender mannagrass	wet
Glyceria striata	fowl mannagrass	wet
Leersia virginica	whitegrass	moist to wet
maximum height: ***short*** *(1½–3 feet)*		
Carex intumescens	greater bladder sedge	wet
Carex pensylvanica	Pennsylvania sedge	dry to moist
Carex plantaginea	plaintain sedge	dry to moist
Carex platyphylla	broad-leaf sedge	dry to moist
Carex vulpinoidea	fox sedge, brown fox sedge	wet
Cyperus esculentus	yellow nutsedge	moist to wet
Juncus tenuis	path rush	dry to moist

FOREST FERNS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Athyrium filix-femina	lady fern	moist
Dennstaedtia punctilobula	hay-scented fern	moist
Deparia acrostichoides	silvery glade fern	moist
Diplazium pycnocarpon	narrow-leaved glade fern	moist
Dryopteris goldiana	Goldie's wood fern	moist
Dryopteris marginalis	marginal wood fern	moist
Matteuccia struthiopteris	ostrich fern	moist to wet
Onoclea sensibilis	sensitive fern	wet
Osmunda cinnamomea	cinnamon fern	wet
Osmunda claytoniana	interrupted fern	moist to wet
Osmunda regalis	royal fern	wet
maximum height: ***short*** *(1½–3 feet)*		
Adiantum pedatum	northern maidenhair fern	dry to moist
Asplenium platyneuron	ebony spleenwort	dry to moist
Dryopteris carthusiana	spinulose wood fern	moist to wet
Dryopteris intermedia	evergreen wood fern	moist
Polystichum acrostichoides	Christmas fern	dry to moist
Thelypteris noveboracensis	New York fern	moist to wet
Woodwardia areolata	netted chain fern	moist to wet

SHRUBLAND TREES AND SHRUBS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 30–40 feet		
Aralia spinosa	devil's walking-stick, Hercules'-club	moist
Asimina triloba	pawpaw	moist
Betula populifolia	gray birch	dry
Cercis canadensis	redbud	dry to moist
Chionanthus virginicus	fringetree	moist
Cornus florida	flowering dogwood	moist
Juniperus virginiana	eastern red-cedar	dry to moist
Malus coronaria	sweet crabapple	dry to moist
Pinus pungens	Table Mountain pine	dry
Quercus marilandica	blackjack oak	dry
Rhus typhina	staghorn sumac	dry
Salix bebbiana	long-beaked willow, gray willow	dry to moist
Viburnum lentago	nannyberry	moist
maximum height: 20–25 feet		
Alnus serrulata	smooth alder	wet
Amelanchier canadensis	shadbush, juneberry	moist
Cornus alternifolia	alternate-leaved dogwood	moist
Euonymus atropurpureus	wahoo	moist to wet
Prunus americana	wild plum	moist
Prunus virgininana	choke cherry	dry to moist
Rhus copallina	winged sumac, shining sumac	dry
Salix eriocephala	heart-leaf willow	moist to wet
Salix exigua	sandbar willow	wet
Salix lucida	shining willow	wet
Viburnum prunifolium	black-haw	wet
maximum height: 10–15 feet		
Celtis tenuifolia	*dwarf hackberry, Georgia hackberry*	*dry*
Cephalanthus occidentalis	*buttonbush*	*wet*
Clethra alnifolia	*sweet pepperbush*	*wet*
Cornus amomum	*silky dogwood*	*wet*

SHRUBLAND TREES AND SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 10–15 feet		
Cornus racemosa	gray dogwood	moist to wet
Cornus rugosa	round-leaved dogwood	dry
Corylus americana	American filbert	moist
Corylus cornuta	beaked hazelnut	dry
Hamamelis virginiana	witch-hazel	moist
Ilex verticillata	winterberry, black-alder	wet
Kalmia latifolia	mountain-laurel	dry to moist
Lindera benzoin	spicebush	moist
Photinia melanocarpa [=*Aronia melanocarpa*]	black chokeberry	dry to wet
Photinia pyrifolia [=*Aronia pyrifolia*]	red chokeberry	moist to wet
Physocarpus opulifolius	ninebark	moist to wet
Quercus ilicifolia	scrub oak, bear oak	dry
Quercus prinoides	dwarf chestnut oak, dwarf chinkapin oak	dry
Rhododendron maximum	rosebay rhododendron	moist to wet
Rhododendron viscosum	swamp azalea	wet
Rhus glabra	smooth sumac	dry
Salix discolor	pussy willow	moist to wet
Salix humilis	upland willow, sage willow	dry to moist
Salix sericea	silky willow	wet
Sambucus canadensis	American elder	moist to wet
Sambucus racemosa	red-berried elder	moist
Staphylea trifolia	bladdernut	dry to moist
Vaccinium corymbosum	highbush blueberry	dry to wet
Viburnum cassinoides	witherod	moist to wet
Viburnum dentatum	southern arrow-wood	wet
Viburnum recognitum	northern arrow-wood	wet
Viburnum trilobum	highbush-cranberry	wet

SHRUBLAND TREES AND SHRUBS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: 5–7 feet		
Amelanchier stolonifera	low juneberry, low shadbush	dry to moist
Comptonia peregrina	sweet-fern	dry
Dirca palustris	leatherwood	dry to moist
Euonymus americanus	hearts-a-bursting	moist
Gaylussacia frondosa	dangleberry	dry to wet
Hydrangea arborescens	sevenbark, wild hydrangea	dry to moist
Myrica pensylvanica	bayberry	dry to moist
Ribes americanum	wild black currant	moist to wet
Rosa palustris	swamp rose	wet
Rosa virginiana	wild rose, pasture rose	moist
Rubus idaeus	red raspberry	dry to moist
Rubus occidentalis	black-cap, black raspberry	dry to moist
Spiraea alba	meadow-sweet	moist to wet
Spiraea latifolia	meadow-sweet	moist to wet
Taxus canadensis	American yew	moist
Vaccinium stamineum	deerberry	dry
Viburnum acerifolium	maple-leaved viburnum	dry to moist
maximum height: 2–4 feet		
Diervilla lonicera	bush-honeysuckle	dry
Gaylussacia baccata	black huckleberry	dry to wet
Rosa carolina	pasture rose	dry
Spiraea tomentosa	hardback, steeple-bush	moist to wet
Vaccinium angustifolium	low sweet blueberry	dry
Vaccinium pallidum	lowbush blueberry	dry

MEADOW PERENNIAL WILDFLOWERS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***very tall*** *(9–10 or more feet)*		
Coreopsis tripteris	tall tickseed	moist to wet
Eutrochium fistulosum [=*Eupatorium fistulosum*]	hollow-stemmed joe-pye-weed, trumpetweed	moist to wet
Helianthus giganteus	swamp sunflower	wet
Rudbeckia laciniata	cutleaf coneflower	wet
maximum height: ***tall*** *(6–8 feet)*		
Angelica atropurpurea	purple-stemmed angelica	moist to wet
Apocynum cannabinum	Indian-hemp	moist to wet
Asclepias incarnata	swamp milkweed	wet
Asclepias syriaca	common milkweed	moist to wet
Baptisia australis	blue false-indigo	moist to wet
Boltonia asteroides	aster-like boltonia	moist to wet
Eupatorium perfoliatum	common boneset	wet
Eutrochium purpureum [=*Eupatorium purpureum*]	joe-pye-weed, sweet-scented joe-pye-weed	dry to wet
Filipendula rubra	queen-of-the-prairie	moist
Helenium autumnale	common sneezeweed	moist to wet
Helianthus divaricatus	rough sunflower, woodland sunflower	dry
Heliopsis helianthoides	ox-eye	dry to wet
Hypericum pyramidatum [=*H. ascyron*]	great St. John's-wort	moist to wet
Lespedeza capitata	round-headed lespedeza	dry
Liatris spicata	dense blazing-star	moist
Lilium canadense	Canada lily	moist to wet
Lilium superbum	Turk's-cap lily	moist to wet
Lobelia cardinalis	cardinal-flower	wet
Lobelia siphilitica	great blue lobelia	moist to wet
Mimulus ringens	Allegheny monkey-flower	wet
Oenothera biennis	common evening-primrose	dry to moist
Penstemon digitalis	tall white beard-tongue	dry to moist
Polygonatum biflorum	smooth Solomon's-seal	dry to moist

MEADOW PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet)*		
Rudbeckia triloba	three-lobed coneflower	dry to moist
Senna hebecarpa	northern wild senna	dry to moist
Senna marilandica	southern wild senna	dry
Solidago canadensis	Canada goldenrod	dry to moist
Solidago gigantea	smooth goldenrod	moist to wet
Solidago rigida [=*Oligoneuron rigidum*]	stiff goldenrod	moist
Solidago rugosa	wrinkle-leaf goldenrod	dry to wet
Solidago speciosa	showy goldenrod	dry to moist
Symphyotrichum lanceolatum [=*Aster lanceolatus, A. paniculatus, A. simplex*]	panicled aster	dry to wet
Symphyotrichum novae-angliae [=*Aster novae-angliae*]	New England aster	dry to moist
Symphyotrichum novi-belgii [=*Aster longifolius*]	New York aster	moist to wet
Symphyotrichum pilosum [=*Aster ericoides var. pilosus, A. pilosus*]	heath aster	dry to moist
Verbena hastata	blue vervain, simpler's-joy	moist to wet
Verbesina alternifolia	wingstem	moist
Vernonia glauca	Appalachian ironweed, tawny ironweed	dry
Vernonia noveboracensis	New York ironweed	moist to wet
Veronicastrum virginicum	Culver's-root	moist
maximum height: ***intermediate*** *(3½–5 feet)*		
Asclepias purpurascens	purple milkweed	dry to moist
Eupatorium hyssopifolium	hyssop-leaved thoroughwort	dry
Gentiana andrewsii	bottle gentian, prairie closed gentian	moist to wet
Gentiana clausa	meadow closed gentian, bottle gentian	moist
Geum laciniatum	herb-bennet, rough avens	wet
Hypericum punctatum [=*H. maculatum*]	spotted St. John's-wort	moist

MEADOW PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Ludwigia alternifolia	seedbox, false loosestrife	wet
Monarda fistulosa	horsemint, wild bergamot	dry to moist
Monarda punctata	spotted bee-balm	dry
Physostegia virginiana	false dragonhead	moist
Pycnanthemum virginianum	Virginia mountain-mint	moist to wet
Rudbeckia fulgida	eastern coneflower	moist
Rudbeckia hirta	black-eyed-susan	dry to moist
Scutellaria incana	downy skullcap	dry to moist
Solidago bicolor	silver-rod, white goldenrod	dry
Solidago juncea	early goldenrod	dry to moist
Solidago nemoralis	gray goldenrod	dry
Symphyotrichum laeve [=*Aster laevis var. laevis*]	smooth blue aster	dry
Vicia americana	purple vetch	moist
maximum height: ***short*** *(1½–3 feet)*		
Allium cernuum	nodding onion	dry
Asclepias tuberosa	butterfly-weed	dry
Asclepias verticillata	whorled milkweed	dry
Chrysopsis mariana	golden aster	dry
Conoclinium coelestinum [=*Eupatorium coelestinum*]	mistflower, wild ageratum	dry to moist
Dodecatheon meadia	shooting-star, pride-of-Ohio	dry to moist
Geranium maculatum	wood geranium	moist
Iris prismatica	slender blue flag	moist
Juncus tenuis	path rush	dry to moist
Lupinus perennis	blue lupine	dry to moist
Oenothera fruticosa	sundrops, narrow-leaved evening-primrose	dry to moist
Packera aurea [=*Senecio aureus*]	golden ragwort	moist
Penstemon hirsutus	northeastern beard-tongue	dry
Phlox maculata	wild sweet-william	moist to wet

MEADOW PERENNIAL WILDFLOWERS, *continued*

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***short*** *(1½–3 feet)*		
Phlox pilosa	downy phlox, prairie phlox	moist to wet
Pycnanthemum tenuifolium	narrow-leaved mountain-mint	moist
Sisyrinchium angustifolium	narrow-leaved blue-eyed-grass	moist to wet
Tradescantia ohiensis	Ohio spiderwort, blue-jacket	moist
Tradescantia virginiana	spiderwort, widow's-tears, Virginia spiderwort	dry to moist
Zizia aptera	golden-alexander	moist
Zizia aurea	golden-alexander, golden zizia	moist to wet

MEADOW PERENNIAL COOL-SEASON GRASSES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Calamagrostis canadensis	Canada bluejoint	wet
Deschampsia cespitosa	tufted hairgrass	moist to wet
Deschampsia flexuosa	wavy hairgrass, common hairgrass	dry
Dichanthelium clandestinum [=*Panicum clandestinum*]	deer-tongue, deer-tongue grass	moist
Elymus canadensis	Canada wild-rye	moist
Elymus riparius	riverbank wild-rye	moist to wet
Elymus virginicus	Virginia wild-rye	moist to wet
Leersia oryzoides	rice cutgrass	wet
Poa palustris	fowl bluegrass	wet
maximum height: ***short*** *(1½–3 feet)*		
Danthonia compressa	northern oatgrass	dry
Danthonia spicata	poverty grass, poverty oatgrass	dry
Hordeum jubatum [=*Critesion jubatum*]	foxtail-barley	dry

MEADOW PERENNIAL WARM-SEASON GRASSES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***very tall*** *(9–10 feet or more)*		
Andropogon gerardii	big bluestem, turkeyfoot	dry to moist
Tripsacum dactyloides	gammagrass	wet
maximum height: ***tall*** *(6–8 feet or more)*		
Andropogon glomeratus	bushy bluestem, bushy broomsedge	moist to wet
Andropogon virginicus	broomsedge, Virginia broomsedge	dry
Panicum virgatum	switchgrass	dry to moist
Sorghastrum nutans	Indian-grass	dry to moist
Spartina pectinata	prairie cordgrass, freshwater cordgrass	moist to wet
Tridens flavus	purpletop	dry to moist
maximum height: ***intermediate*** *(3½–5 feet)*		
Bouteloua curtipendula	side-oats grama, tall grama	dry
Muhlenbergia capillaris	hairgrass, short muhly	dry
Schizachyrium scoparium	little bluestem	dry to moist
Sporobolus cryptandrus	sand dropseed	dry
Sporobolus heterolepis	prairie dropseed	dry
maximum height: ***short*** *(1½–3 feet)*		
Andropogon gyrans	Elliott's beardgrass	dry to moist
Eragrostis spectabilis	purple lovegrass, tumblegrass	dry

MEADOW SEDGES AND RUSHES

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***tall*** *(6–8 feet or more)*		
Scirpus cyperinus	wool-grass	wet
maximum height: ***intermediate*** *(3½–5 feet)*		
Carex lurida	lurid sedge, shallow sedge	wet
Carex scoparia	broom sedge	moist to wet
Carex stipata	stalk-grain sedge, owlfruit sedge	wet
Carex tribuloides	blunt broom sedge, bristlebract sedge	wet
maximum height: ***short*** *(1½–3 feet)*		
Carex intumescens	greater bladder sedge	wet
Carex vulpinoidea	fox sedge, brown fox sedge	wet
Cyperus esculentus	yellow nutsedge	moist to wet
Juncus tenuis	path rush	dry to moist

MEADOW FERNS

SCIENTIFIC NAME	COMMON NAME(S)	SOIL MOISTURE PREFERENCE
maximum height: ***intermediate*** *(3½–5 feet)*		
Dennstaedtia punctilobula	hay-scented fern	dry to wet
Onoclea sensibilis	sensitive fern	wet
Pteridium aquilinum	northern bracken fern	dry

NATIVE TREES AND SHRUBS FOR LANDSCAPING AND WILDLIFE

Large Trees

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Acer rubrum	red maple	Piedmont Coastal Plain	Height: 40'–60', Spread: same Habit is pyramidal in youth and rounded with age. Tolerant of most soils, but prefers slightly acid, moist conditions. Naturally occurs in wet area. Excellent fall color.	Buds, flowers, and leaves provide food for many birds and mammals. Chipmunks and squirrels eat seeds and some songbirds use twigs for nest building.
Acer saccharinum	silver maple	Piedmont Coastal Plain	Height: 50'–70', Spread: 40'–50' Has strong spreading branches which form a rounded crown. Tolerant of many soil types. One of the best trees for poor soils and wet conditions (often found on floodplains). Use of this tree should be limited to areas free of buildings and heavy human use as it is prone to internal decay and subsequent loss of branches. Provides fast shade.	See red maple.
Acer saccharum	sugar maple	Piedmont Coastal Plain	Height: 60'–70', Spread: 40'–50' Upright oval to rounded habit. Prefers moist, well drained soils. Tolerates some shade.	See red maple.
Betula nigra	river birch	Piedmont Coastal Plain	Height: 40'–70', Spread: 40'–60' Pyramidal in youth and rounded with age. Often grown multistemmed. Best adapted to moist soils (often found on floodplains). Used in areas that are alternately wet and dry.	Catkins are used by redpolls and pine siskins. Foliage is used by browsers.
Betula lenta	sweet birch	Piedmont Coastal Plain	Height: 40'–55'+, Spread: 35'–45' Pyramidal in youth, forming an irregular, rounded, sometimes wide-spreading crown at maturity. Best in deep, rich, moist, slightly acid soils, however, often found on rocky, drier sites. Flowers are catkins, 2"–3" long. Yellow leaves in fall are best among birches.	See river birch.

Large Trees, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Carya ovata	shagbark hickory	Piedmont Coastal Plain	Height: 60'–80', Spread: 40'–60' Straight trunk with an oblong crown. Bark breaks up in thin plates. Difficult to transplant, start as seedling. Good for woodland border.	Leaves are used by browsers. Nuts are also consumed by deer, turkey, foxes, wood ducks, and squirrels.
Celtis occidentalis	common hackberry	Piedmont Coastal Plain	Height: 40'–60', Spread: same In youth weakly pyramidal; in old age the crown is a broad top of ascending-arching branches. Medium to fast growth. Prefers rich, moist soils, but grows in dry, heavy, or sandy, rocky soils; withstands acid or alkaline conditions; moderately wet or very dry areas; tolerates wind; full sun. Fruit is fleshy, orange to dark purple, ripening in September to October. Leaves are yellow to yellow-green in fall. Useful tree for adverse growing conditions.	Fruit is popular with winter birds, especially cedar waxwing, mockingbird, and robin.
Fagus grandifolia	American beech	Piedmont Coastal Plain	Height: 50'–70'+, Spread: same Often has short trunk with wide-spreading crown. Likes moist, well drained soils. Can grow well in full sun or shade.	Beechnuts are eaten by birds and mammals and are important food for chipmunks and squirrels.
Fraxinus americana	white ash	Piedmont Coastal Plain	Height: 50'–80', Spread: same Pyramidal in youth and later developing an open rounded crown. Grows best on deep, well drained soils and full sun.	Moderate importance to wildlife. Seeds eaten by wood ducks, finches, and cardinals.
Fraxinus pennsylvanica	red ash	Piedmont Coastal Plain	Height: 50'–60'+, Spread: 25'–30' Pyramidal in youth, developing upright, spreading habit at maturity. Grows quickly in full sun and in a wide range of soil conditions. Naturally found on moist bottomlands	See white ash.
Gleditsia triacanthos	common honeylocust	Piedmont Coastal Plain	Height: 30'–70', Spread: same Usually has short trunk with open, oval crown. Fast grower. Withstands a wide range of conditions but prefers rich, moist bottomlands (often found on floodplains).	Limited wildlife value.

Large Trees, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Juglans nigra	black walnut	Piedmont Coastal Plain	Height: 50'–75', Spread; same Well-formed trunk with an oval crown. Prefers rich, moist soils. Often found on bottomlands. Difficult to transplant; should be started as seedling. Produces toxins which are poisonous to many plants giving it an advantage in open field situations but creating problems for gardeners.	Nuts are eaten by woodpeckers, foxes, and squirrels.
Juniperus virginiana	eastern redcedar	Piedmont Coastal Plain	Height: 40'–50', Spread: 8'–20' Densely pyramidal when young and slightly pendulous in old age. Medium rate of growth. Tolerant of adverse conditions. Prefers deep, moist soils. Will tolerate shade only in youth. Handsome reddish brown bark. Produces small fleshy blue cones. Useful for windbreaks, shelter belts, hedges.	Twigs and foliage eaten by browsers. Seeds are eaten most extensively by cedar waxwings. Evergreen foliage provides nesting and roosting cover for sparrows, robins, mockingbirds, juncos, and warblers.
Liquidambar styraciflua	American sweetgum	Coastal Plain	Height: 60'–75'+, Spread: 40'–50' Pyramidal in youth, rounded crown at maturity. Likes deep, moist, acid soils. Occurs naturally on bottomlands.	Goldfinches and purple finches eat winged seeds.
Liriodendron tulipifera	tuliptree	Piedmont Coastal Plain	Height: 70'–90', Spread: 30'–50' Long, straight trunk with a narrow canopy. Fast grower. Plant in full sun and a well drained loam. Wood somewhat weak.	Moderate wildlife importance. The purple finch and cardinal are principal users.
Nyssa sylvatica	black gum	Piedmont Coastal Plain	Height: 30'–50', Spread: 20'–30' Pyramidal in youth and irregularly crowned at maturity. Prefers moist, well drained, acid soils. Full sun or semi-shade. Deep taproot.	Fruit is relished by many songbirds. Users include wood ducks, robins, woodpeckers, thrashers, flickers, and mockingbirds.

Large Trees, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Pinus strobus	eastern white pine	Piedmont Coastal Plain	Height: 50'–80'+, Spread: 20'–40'+ Pyramidal in youth, crown at maturity has several horizontal and ascending branches. Fast grower. Grows best on fertile, well drained soils but is very adaptable.	Provides valuable cover and nesting sites for songbirds and mammals. Needles are used as nesting material. Seeds are eaten by quail, chickadees, grosbeaks, nuthatches, and woodpeckers.
Quercus alba	white oak	Piedmont Coastal Plain	Height: 100', Spread: 50'–80' Pyramidal in youth, becoming broad and rounded with wide spreading branches. Transplant as small tree. Prefers moist, well drained soils. Difficult to obtain from nurseries. Sometimes available as seedling.	Oaks, in general, are of major importance to wildlife. Acorns are at the top of the food preference list for wood ducks, pheasants, grackles, jays, nuthatches, thrushes, woodpeckers, rabbits, foxes, squirrels, and deer.
Quercus palustris	pin oak	Piedmont Coastal Plain	Height: 60'–70', Spread: 25'–40' Strongly pyramidal with ascending branches. One of the faster growing oaks. Full sun. Found naturally in wet soils but is adaptable to many soil types.	See white oak.
Quercus rubra	red oak	Piedmont Coastal Plain	Height: 60'–75'+, Spread: 40'–50' Habit is round-topped and symmetrical. Full sun. Prefers loamy, well drained soils. Fast growing.	See white oak.
Tilia americana	American linden	Piedmont Coastal Plain	Height: 60'–80', Spread: 35'–50' Pyramidal in youth, assuming a rounded shape with age. Full sun or part shade. Prefers deep, moist soils, but is tolerant of heavier soils.	Limited wildlife value.
Tsuga canadensis	eastern hemlock	Piedmont Coastal Plain	Height: 40'–70', Spread: 25'–35' Pyramidal in youth becoming more pendulous with age. Likes moist, well drained soils. Plant in sheltered area. Tolerates shade. Relatively fast growing. Excellent for screens, hedges.	Provides excellent cover for deer and songbirds. Nesting site for several warblers. Seeds are eaten by juncos, chickadees, and siskins.

Small Trees/Large Shrubs

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Amelanchier arborea/laevis	shadbush or shadblow serviceberry	Piedmont Coastal Plain	Height: 6'–20', Spread: 10' Erect stems, often clumped. Blends well on the forest edge.	Important berry producer during the early summer months. Fruit eaten by crows, bluebirds, cardinals, and tanagers. Foliage used by browsers.
Cercis canadensis	eastern redbud	Piedmont	Height: 20'–30', Spread: 25'–35' Small tree with rounded crown. Likes moist, well drained soils. Found naturally only on limestone or diabase soils in Pennsylvania. Full sun to light shade.	Limited wildlife value.
Chionanthus virginicus	white fringetree	Coastal Plain	Height: 12'–20', Spread: same Open habit, often wider than high. Prefers moist, fertile soils and full sun.	Limited wildlife value.
Cornus florida	flowering dogwood	Piedmont Coastal Plain	Height: 20', Spread: 15'–20' Small tree with flat-topped crown. Place in well drained soil. Full sun to partial shade. Has character in all four seasons.	Fruit is an important source for songbirds including evening grosbeak, cardinals, robins and cedar waxwings.
Hamamelis virginiana	common witchhazel	Piedmont Coastal Plain	Height: 20'–30', Spread: 20'–25' Small tree or multi-stemmed shrub. Prefers moist soils in full sun or partial shade.	Limited wildlife value.
Ilex opaca	American holly	Coastal Plain	Height: 15'–30', Spread: 18'–25' Dense, pyramidal in youth, opening up with age. Plant in moist, well drained soil. Full sun or partial shade. Use one male for every three females.	Used extensively by many songbirds including thrushes, mockingbirds, catbirds, bluebirds, and thrashers. Foliage provides cover for songbirds and mammals.
Magnolia virginiana	sweetbay magnolia	Coastal Plain	Height: 10'–20', Spread: same Multi-stemmed, open shrub. Likes wet, acid soils. Tolerates shade.	Wildlife value is low. Seeds are eaten by some mammals and birds. Foliage is used by several birds for nest building.

Small Trees/Large Shrubs, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Viburnum lentago	nannyberry	Piedmont Coastal Plain	Height: 15'–18', Spread: 6'–10' Shrub or small tree with open habit. Adapts to a wide range of soil conditions. Sun or partial shade.	Used by grouse, brown thrasher, cedar waxwing, squirrels, and deer.
Viburnum prunifolium	blackhaw virburnum	Piedmont Coastal Plain	Height: 12'–15', Spread: 8'–12' Round-headed tree or multi-stemmed shrub. Adaptable to many soil types. Sun or shade.	See nannyberry.

Shrubs

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Aronia arbutifolia	red chokeberry	Piedmont Coastal Plain	Height: 6'–10', Spread: 3'–5' Upright multi-stemmed shrub, somewhat open and rounded. Adaptable to many soil types. Full sun to half shade.	Fruit eaten by grouse, chickadees, and other songbirds.
Aronia melanocarpa	black chokeberry	Piedmont Coastal Plain	See red chokeberry.	See red chokeberry.
Clethra alnifolia	summersweet clethra	Coastal Plain	Height: 3'–8', Spread: 4'–6' Oval, round-topped, erect, dense, leafy shrub. Transplant into moist organic soils. Full sun or shade. Good plant for wet areas and heavy shade.	Limited wildlife value.
Cornus racemosa	silky dogwood	Piedmont Coastal Plain	Height: 10'–15', Spread: 10'–15' Erect, multi-stemmed shrub with short spreading branches. Suckers profusely and forms large colonies. Very adaptable, withstanding wet or dry soils, but prefers moist, well drained conditions. Full sun or shade.	High wildlife value for fruit and browse. Used by a wide variety of mammals and songbirds, including cardinals, evening grosbeaks, robins, thrush, vireos, and cedar waxwings.
Ilex glabra	inkberry	Coastal Plain	Height: 6'–8', Spread 8'–10' Upright, multi-branched, rounded shrub. Prefers moist, acid soils.	Berries used by a wide variety of wildlife.

Shrubs, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Ilex verticillata	winterberry	Piedmont Coastal Plain	Height: 6'–10', Spread: same Oval, rounded, deciduous shrub holly. Tends to form multi-stemmed clumps. Does well in light and heavy soils. Prefers moist, organic soils. Red fruit is beautiful in winter. A male plant is necessary for fertilization.	Used extensively by many songbirds, particularly thrushes, mockingbirds, robins, bluebirds, and thrashers.
Itea virginica	Virginia sweetspire	Coastal Plain	Height: 3'–5', Spread: 6'–8' Erect shrub with clustered branches. Prefers moist, fertile soils. Full sun or shade. Suited for wet areas. Excellent fall color.	Fruit capsules are used by some songbirds.
Kalmia latifolia	mountain laurel	Piedmont Coastal Plain	Height: 7'–15', Spread: same Large, robust shrub, becomes open with age. Requires moist, well drained soils in full sun or shade.	Mammals eat foliage and twigs. Utilized extensively by mammals and birds for winter shelter.
Myrica pensylvanica	northern bayberry	Coastal Plain	Height: 5'–12', Spread: same Tends to sucker to form large colonies. Deciduous to semi-evergreen. Upright, rounded, dense shrub. Adaptable to many soil conditions, including poor soils. Full sun to partial shade.	Fruit is eaten by a variety of birds in small quantities including tree swallows and myrtle warblers.
Rhododendron maximum	rosebay rhododendron	Piedmont Coastal Plain	Height: 4'–10', Spread: same Rounded, evergreen shrub. Plant in moist, well drained soil. Prefers partial shade.	Limited wildlife value except as browse for deer and winter cover for songbirds.
Rhododendron periclymenoides	pinxter-flower	Piedmont Coastal Plain	Height: 4'–6', Spread: 6'–8' Multi-stemmed, stoloniferous shrub. Adapted to dry, sandy, rocky soils. Useful for naturalizing.	Limited wildlife value except as browse for deer and grouse

Shrubs, *continued*

SCIENTIFIC NAME	COMMON NAME	PHYSIOGRAPHIC REGION	DESCRIPTION	WILDLIFE USERS
Vaccinium corymbosum	highbush blueberry	Piedmont Coastal Plain	Height: 6'–12', Spread: 8'–12' Upright, multi-stemmed shrub with spreading branches. Requires moist, well drained soils. Full sun or light shade.	Used heavily by grouse, scarlet tanager, bluebirds, thrushes, and other songbirds.
Viburnum acerifolium	maple-leaved viburnum	Piedmont Coastal Plain	Height: 4'–6', Spread: 3'–4' Low, sparsely branched shrub. Adaptable to dry soils. Extremely shade tolerant.	Twigs are eaten by deer and rabbits. Fruit is used by grouse.
Viburnum dentatum	southern arrow-wood	Piedmont Coastal Plain	Height: 6'–8', Spread: 6'–15' Multi-stemmed, dense, rounded shrub. Adaptable to most soil conditions, but prefers well drained. Suckers freely.	Used by grouse, brown thrasher, cedar waxwing, squirrels, and deer.

SOURCES

Nurseries Specializing in Native Plants

David Brothers Bean Road Nursery
P.O. Box 123
Whitehall and Bean Roads
Worcester, PA 19490
610-584-1550

Edge of the Woods Native Plant Nursery
2415 Route 100
Orefield, PA 18069
610-395-2570
www.edgeofthewoodsnursery.com

Natural Landscapes
354 North Jennersville Road
West Grove, PA 19380
610-869-3788

North Creek Nurseries, Inc.
388 North Creek Road
Landenberg, PA 19350
877-ECO-PLUG
www.northcreeknurseries.com

Octoraro Farm and Gardens
698 Lees Bridge Road
Nottingham, PA 19362
610-932-0225
www.octorarofarm.com

Octoraro Native Plant Nursery
6126 Street Road
Kirkwood, PA 17536
717-529-3160
www.octoraro.com

Pinelands Nursery
323 Island Road
Columbus, NJ 08022
609-291-9486
www.pinelandsnursery.com

Redbud Native Plant Nursery
1214 N. Middletown Road
Glen Mills, PA 19342
610-358-4300
www.redbudnativeplantnursery.com

Sylva Native Nursery and Seed Company
3815 Roser Road
Glen Rock, PA 17327
717-227-0486
www.sylvanative.com

Temple University/Ambler Nursery
580 Meetinghouse Road
Ambler, PA 19002-3994
215-283-1330
(Wholesale only)

Yellow Springs Farm
1165 Yellow Springs Road
Chester Springs, PA 19425
610-827-2014
www.yellowspringsfarm.com

Other Nurseries That Carry Native Plants

Buddies Nursery
P.O. Box 14
Birdsboro, PA 19508
610-582-2410

Moon Nurseries
P.O. Box 672
145 Moon Road
Chesapeake City, MD 21915
800-803-TREE
www.moonnurseries.com

Musser Forests
1880 Route 119 North
Indiana, PA 15701
800-643-8319
www.musserforests.com
(Seedlings only)

New Moon Nursery
13 Ways Lane
Kennett Square, PA 19348
888-998-1951
www.newmoonnursery.com

Princeton Nurseries
P.O. Box 185
Allentown, NJ 08501
800-916-1776
www.princetonnurseries.com

Shemin Nurseries
P.O. Box 649
100 Green Tree Road
Oaks, PA 19456
610-666-0595
www.sheminnurseries.com
(Wholesale only)

Wildflower Sources

Brandywine Conservancy
Box 141
Chadds Ford, PA 19317
610-388-2700

Ernst Conservation Seeds
9006 Mercer Pike
Meadville, PA 16335
800-873-3321
www.ernstseed.com

Prairie Nursery
P.O. Box 306
Westfield, WI 53964
800-476-9453
www.prairienursery.com

Sandy Wilson
Native Plants and Aquatic Nursery
834 Church Road
Harleysville, PA 19438
610-584-6302

Additional Sources for General Lists

Guide to Pennsylvania Nursery Stock
Pennsylvania Nurserymen's Association, Inc.
1924 North Second Street
Harrisburg, PA 17102

New England Wild Flower Society, Inc.
Garden in the Woods
180 Hemenway Road
Framingham, MA 01701
508-877-7630

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Michael Dirr
Stipes Publishing Company, 1990

American Wildlife and Plants: A Guide to Wildlife Food Habits
Alexander C. Martin, et. al.
Dover Publications, 1951

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Ann F. Rhoads and Timothy A. Block
University of Pennsylvania Press, 2007