November 10, 2015

Steven J. Tambini, Executive Director
Delaware River Basin Commission
25 State Policy Drive
West Trenton, NJ 08628-0360

Re: Public Comment: Pennsylvania Pipeline Project – Docket Number D-2015-018-1

The Delaware Riverkeeper and the Delaware Riverkeeper Network (collectively, DRN) hereby request the Delaware River Basin Commission (Commission), pursuant to its authority and obligations under Section 3.8 of the Delaware River Basin Compact (Compact), to reject the docket application as proposed for Sunoco Pipeline L.P.'s (Sunoco) Pennsylvania Pipeline Project (Project), or, in the alternative, set aside the docket for further review.

An Extension of the Public Review and Comment Period is Required: A Truncated Two-Month Review Period is Not Sufficient Time for Informed Decision-making

The public deserves and needs additional time to review the materials associated with this docket to craft and submit informed public comment to the DRBC.

For unknown reasons this application and docket seem to have been fast-tracked for review and approval. Upon information and belief, Sunoco pipeline submitted its application to the DRBC on September 2, 2015. The Notice of Application sent to the public announcing receipt of this application was sent on October 1, 2015. Within a week, on October 8, 2015, the Delaware Riverkeeper Network filed a request for all documents associated with this docket. October 26, 2015, the public was notified that a DRBC hearing would be held on November 10,

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2015, with the public comment period closing November 11, 2015 (as per the recently issued FAQ's for the new hearing process). On October 30, 2015 the Delaware Riverkeeper Network was given access to come in and review the docket files.

- When viewed in total, this timeline means the public had a mere **16 days** from the date of public notice of the hearing to the comment deadline on November 11 to secure the documents, review them, craft and submit comments.
- If the count begins on the date DRN had access to the supporting documents by virtue of our proactive efforts to review the file as soon as we learned of the application in the NAR, the time frame for review and comment is even shorter, spanning from October 30 (the day of our file review) to November 11, so a mere **12 days**.
- Even if we put in our file review request on October 1, which one would not think would be necessary given the application was only filed less than a month before, that would still have left a mere **19 days** for document review, assessment and comment.

In short, the public has had a woefully short period of time to secure access to all of the files associated with this docket, to review those documents, to secure necessary scientific/technical reviews, and to submit an informed comment to the DRBC. Additional time is necessary in order to ensure a fair and adequate opportunity for the public to comment.

The Draft Docket Significantly Undercounts Impacts to Wetlands

Sunoco has improperly undercounted wetlands impacts associated with the proposed Project. In the draft docket it is represented that only "0.18 acres of palustrine forested (PFO) wetlands" will be disturbed by the Project, and of that only "0.052 acres" will be permanently converted from "forested cover type to emergent wetland cover type." However, a review of the proposed location of the Project combined with the expected expansion of the right-of-way reveals that the calculation of expected impacts is grossly undercounted. Indeed, DRN estimates that a review of just two wetlands indicates that the amount of forested wetlands to be permanently converted by the Project is at least 652% more than what is stated in the docket.

Specifically, DRN staff examined two wetlands as a spot-check to determine the accuracy of the information provided in the proposed docket. DRN reviewed mapping images supplied by the National Wetlands Inventory and matched them with the locations of wetlands

C49[1] and B19[2] in Chester County. Even a cursory review of the mapping images demonstrates that there is significant wooded vegetation and forested cover type in these wetlands. Both of these wetlands are improperly classified as emergent cover type wetlands (PEM) in the supporting documentation for the proposed docket. The National Wetlands Inventory mapping images that show forested wetlands at wetlands C49 and B19 have also been field verified by DRN staff.[3] If the only two wetlands examined by DRN contained these significant flaws, it is likely that the rest of the wetlands impacts calculations are similarly off.

The best way to confirm wetlands impact calculations is field verification; but, this can also be accomplished – though to a lesser degree of accuracy – through an examination of Project construction alignment sheets. However, no such alignment sheets were included in the Project files, and or reviewed by the Commission. Furthermore, wetland delineation mapping supplements or images were similarly neither submitted nor reviewed by the Commission. Without these crucial images and supporting documents, the only evidence on the docket detailing the accuracy of Sunoco's wetlands impacts calculations are those provided here by the DRN as Exhibits A and B, which clearly show that Sunoco's impacts calculations are grossly understated.

As such, the record before the Commission dictates that the Commission cannot make an informed decision on whether to approve the docket absent further fact-finding. The Commission must require Sunoco to provide appropriate mapping supplements or the Commission should field verify each of the wetlands in the Project area. The docket as proposed should be rejected or set aside for further review until such time that Sunoco provides alignment sheets that allow for the accurate calculation wetlands impacts.

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[1] Exhibit A.
[2] Exhibit B.
[3] Exhibit C.

The Commission Failed to Identify that the Project Resulted in a Significant Disturbance of Groundcover Affecting Water Resources

In the DRBC's proposed docket, it states that the Project is subject to DRBC legal authority because of the fact that the "pipeline is designed to operate at pressures greater than 150 psi and crosses streams in the basin and crosses a recreation area listed in the Commission's Comprehensive Plan and therefore meets regulatory thresholds that subject the project to Commission review." Presumably, the Commission here is referencing its triggering mechanism for review pursuant to Article 3, Section 2.3.5.A(13) of the Commission's Rules of Practice and Procedure. Notably, the DRBC did not assert jurisdiction because the project involves a significant "disturbance of ground cover affecting water resources" (*see* RPP Article 3, Section 2.3.5.A(13)).

With respect to liquids pipeline projects, the RPP categorizes them as projects that presumptively do not have a substantial effect on the water resources of the Basin and that therefore do not automatically require Commission review unless certain triggers are met. One of these triggers is if such lines would involve significant disturbance of ground cover affecting water resources. (*see* RPP Article 3, Section 2.3.5.A(13)). For the reasons articulated below, the Project clearly results in a significant disturbance of ground cover affecting water resources.

Pipeline construction results in the loss of riparian vegetation as well as the clearing and maintaining of rights-of-way through forested lands; these significant disturbances of ground cover affect both surface and ground water resources within the meaning of RPP Article 3, Section 2.3.5.A(12). Indeed, the Project will result in 410 acres of land being impacted during construction activity. Accordingly, the Commission must take jurisdiction pursuant to its authority in Section 2.3.5A(13) for significant disturbance of ground cover affecting water resources for review under the Compact for consistency with the Comprehensive Plan.

The proposed Project will also have an adverse impact on numerous Exceptional Value ("EV") wetlands in Pennsylvania resulting from their permanent conversion from Palustrine Forested Wetlands and Scrub-Shrub Wetlands to Emergent Wetlands, thus resulting in a significant loss to the values and functionality of those EV wetlands. Exhibit D is an expert report prepared by consulting ecologists Schmid and Company, Inc.

Specifically, the reports detail the different functions and values of Palustrine Forested Wetlands, Scrub Shrub Wetlands, and Emergent (Herbaceous) Wetlands in Pennsylvania, and the way in which Forested Wetlands and Emergent Wetlands play significantly different roles with respect to the nine functions identified in the Pennsylvania Code. Therefore, to the extent that the Project results in permanent conversions of Forested Wetlands to Emergent Wetlands the functions that these wetlands fulfill are significantly altered. Additionally, the reports also demonstrates that the Pennsylvania Department of Environmental Protection's own technical guidance documents assign greater value to wetlands in and around forest cover as opposed to wetlands surrounded by herblands or ponds. Furthermore, the reports also describe the way in which a permanent conversion of Forested Wetlands to Emergent Wetlands degrades, diminishes, and or eliminates a number of different wetland functions recognized by the Pennsylvania Department of Environmental Protection.

Additionally, the reports also clearly articulates that even if some of the Forested Wetlands that are cleared are allowed to revert back to Forested Wetlands, the process takes decades to complete and oftentimes fails, and even if the regeneration is successful there is a high likelihood that the regenerated forest will lack the complexity and diversity of the existing Forested Wetland, and that during the time period in which regeneration is occurring the wetland's functions are dramatically impacted. A number of federal courts support this conclusion and have found that irreparable harm to the environment is measured in human time-scales, and the loss of mature forest habitat which, by definition, cannot grow back within a

person's lifetime, is adverse and irreparable. *See, e.g.*, *Conservation Cong. v. U.S. Forest Serv.*, 803 F. Supp. 2d 1126, 1132 (E.D. Cal. 2011) (cutting trees that will take decades or more to recover constitutes irreparable harm); *Envtl. Protection Info. Ctr. v. Blackwell*, 389 F. Supp. 2d 1174,1221 (N.D. Cal. 2004) (finding irreparable harm because "if the [tree cutting] were allowed to go forward, then old growth trees would be harvested and there would be no means to replace such trees in any meaningful fashion since it takes years for such trees to mature."); *Kettle Range Conservation Grp. v. U.S. Forest Serv.*, 148 F. Supp. 2d 1107, 1135 (E.D. Wash. 2001) ("implementation of the Project would result in irreparable harm – it would mean the permanent removal of thousands of trees . . ."). Together these reports specifically demonstrate the way in which the proposed Project will have a significant impact on ground cover affecting water resources.

Additionally, the Project must cross waterways both large and small. Many of the tributary crossings will involve in-stream excavation that causes sedimentation and other pollution inputs. No matter what pipeline construction method and stream crossing technique is used, there is vegetation loss associated with clearing stream banks. This reduction in foliage increases stream temperature and reduces its suitability for fish incubation, rearing, foraging and escape habitat. The loss of vegetation also makes the stream more susceptible to erosion events, as the natural barrier along the stream bank has been removed.

A report released by the U.S. Geological Survey, titled "Landscape Consequences of Natural Gas Extraction in Bradford and Washington Counties, Pennsylvania, 2004-2010" (Open-File Report 2012-1154), documents the significant impacts on forest cover resulting from the construction of unconventional fossil fuel extraction infrastructure, particularly pipelines.[4] Taking Bradford and Washington Counties as the basis for its study, this report documents the massive landscape changes that are reshaping forest and farm lands in Pennsylvania through the

[4] Available at http://pubs.usgs.gov/of/2012/1154/of2012-1154.pdf

construction of gas wells, impoundments, roads, and pipelines. The report documents the overall loss of forest habitat as well as the increase in forest fragmentation that shale gas and coalbed methane development has caused over a very short time period. In Bradford County, 0.12 percent of the county's forest was lost to gas development, contributing to a 0.32 loss of interior forest and a gain of 0.11 percent in edge forest. In Washington County, the USGS report documented a 0.42 percent forest loss, contributing to a 0.96 percent loss of interior forest and a gain of 0.38 percent in edge forest. USGS Report at 28-29.

According to the USGS data, pipeline construction and associated road construction had the greatest effect on the increase in forest fragmentation, patchiness, and forest edge. *Id.* Of particular concern, "[t]his type of extensive and long-term habitat conversion has a greater impact on natural ecosystems than activities such as logging or agriculture, given the great dissimilarity between gas-well pad infrastructure and adjacent natural areas and the low probability that the disturbed land will revert back to a natural state in the near future (high persistence)." *Id.* at 10.

Forests play an essential role in water purification.[5] The relationship between forest loss, degraded water quality, and increased runoff is well-established in the scientific literature, as the USGS Report recognizes. *Id.* at 8. The Commission is well aware of the links between forest cover and water quality, as summarized by Drs. Jackson and Sweeney in the expert report submitted on the Commission's behalf in the exploratory wells administrative hearing process.[6] The Jackson and Sweeney report shows that reductions in forest cover are directly correlated with negative changes in water chemistry, such as increased levels of nitrogen, phosphorus,

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[5] Robert A. Smail & David J. Lewis, Forest Service, U.S. Dep't of Agric., Forest Land Conversion, Ecosystem Services, and Economic Issues for Policy: A Review 12 (2009), available at http://www.fs.fed.us/openspace/fote/pnw-gtr797.pdf

[6] "Expert Report on the Relationship Between Land Use and Stream Condition (as Measured by Water Chemistry and Aquatic Macroinvertebrates) in the Delaware River Basin," November 2010, available at http://www.nj.gov/drbc/library/documents/Sweeney-Jackson.pdf

sodium, chlorides, and sulfates as well as reduced levels of macroinvertebrate diversity. Reducing forest cover decreases areas available for aquifer recharge, increases erosion, stormwater runoff, and flooding, and adversely affects aquatic habitats.[7] As detailed above, this Project will have substantial effects to the water resources of the Basin. These effects include impacts to surface water and ground water quality resulting from the direct effects of pipeline construction on both terrestrial and aquatic ecosystems as well as the longer-term effects of right-of-way maintenance. Among other impacts, this Project will likely cause direct pollution through sedimentation; exacerbate erosion; result in the removal of riparian vegetation and the loss of forest lands; contribute to forest fragmentation and degradation; and adversely affect wetlands and marshes.

The Commission Should Wait to Issue the Docket Until the Third Circuit Decides the *Delaware Riverkeeper Network v. Pennsylvania Department of Environmental Protection* Case

In May of 2015, the Delaware Riverkeeper Network initiated a lawsuit against the Pennsylvania Department of Environmental Protection alleging, among other things, that the Department violated Pennsylvania's water quality standards by approving a Clean Water Act Section 401 Water Quality Certification for Transcontinental Pipeline Company's Leidy Southeast Expansion Project. The issues were fully briefed and oral argument took place before the Third Circuit Court of Appeals on October 29, 2015. A decision from the Third Circuit is expected in February 2016. The same issues that are being considered by the Third Circuit with regard to wetland conversions are an issue for the proposed Project.

If the Commission grants the docket, and the Third Circuit later finds that the felling of trees in exceptional value wetlands violates Pennsylvania water quality standards, the Commission will be in the position not only of having to justify how it approved a project that

[7] State of N.J. Highlands Water Prot. and Planning Council, Ecosystem Management Technical Report 39
(2008).

expressly violates Pennsylvania's water quality standards, but will also have set bad precedent for future docket requests. Therefore, the Commission should wait until the Third Circuit rules in the *Delaware Riverkeeper Network* case before determining that the proposed Project does not conflict with the Comprehensive Plan.

The Failure to Ensure Healthy Native Buffer Protection Along Impacted Streams is a Serious Deficiency with Significant Adverse Impacts for Waterway Health

Of the 170 streams and/or floodways the two proposed pipelines will cross, 12 of the streams are designated as Exceptional Value, 40 of the streams are designated as High Quality-Trout Stocked Fishery, 12 of the streams are designated as Warm Water Fishery, 44 of the streams are designated as Cold Water Fishery, and 45 are designated as Trout Stocked Fishery. Healthy vegetated buffers are a key part of preserving and maintaining the kind of good water quality necessary to support these clean water designations. The removal of vegetation and subsequent revegetation with low growing grasses and plants will expose the waterways to degradation and pollution.

For each of the pipeline construction techniques proposed there is a resulting loss of vegetation and foliage associated with clearing the stream banks. Riparian vegetation is an important part of a healthy ecosystem that protects the land adjoining a waterway which in turn directly affects water quality, water quantity, and stream ecosystem health. The body of scientific research indicates that stream buffers, particularly those dominated by woody vegetation that are a minimum 100 feet wide, are instrumental in providing numerous ecological and socioeconomic benefits.[8]

Riparian corridors protect and restore the functionality and integrity of streams. A reduction in streamside health and mature streamside vegetation reduces stream shading, increases stream temperature and reduces its suitability for incubation, rearing, foraging and

[8] See e.g. Newbold et al. 1980, Welsch 1991, Sweeney 1992, Sweeney and Newbold 2014

escape habitat.[9] While horizontal directional drilling may move the construction footprint further away from the stream, it too results in vegetative losses and soil compaction that can have direct stream impacts.

The loss of vegetation also makes the stream more susceptible to erosion events, exacerbating the sedimentation impacts of construction. In crossings that result in open forest canopies, increases in channel width, reduced water depth, and reduced meanders have persisted in the years after using an open cut method of installation.[10] There is little if any discussion about the importance of restoring healthy streamside buffers of adequate width and vegetative cover in the draft docket. This is a significant short-coming of the DRBC's review.

The Floodplain Regulations Give DRBC Both the Opportunity and the Mandate to Reject this Project Given the Exceedingly Large Number of Stream Crossings and Floodplain Impacts it Requires

Section 6.3.4 of the DRBC Floodplain Regulations allow construction of pipelines in the floodplain if it is the subject of a special permit granted by the DRBC.

According to the DRBC Floodplain Regulations, a special permit "may" be granted in certain circumstances but there is by no means an expectation or presumption that special permits for pipelines will be granted. Given that the proposed Project will cross 65 streams, including their floodplains, and will also result in construction activities in the floodways of 36 additional streams, the quick determination that a special permit was appropriate with so little review is not appropriately supported and should be revisited with a greater level of scrutiny.

In order to secure a special permit DRBC's Rules of Practice and Procedure require that there is a "clear balance in favor of the public interest in terms of …" among other things:

- "The importance of the facility to the community."
- "The compatibility of the proposed use with existing development and development anticipated in the foreseeable future."

[9] CAPP (2005), *supra* note 16, at 1-4.
[10] Ibid 1.

- "The relationship of the proposed use to any applicable comprehensive plan or flood plain management program for the area."
- "The degree to which the proposed activity would alter natural water flow or water temperature."
- "The degree to which … endangered or rare species or animal or plants, high quality wildlife habitats, scarce vegetation types, and other irreplaceable land types would be degraded or destroyed."
- "The degree to which the natural, scenic and aesthetic values at the proposed activity site could be retained."

The criteria that allow for issuance of a special permit demonstrate that this permit should not be issued as part of the proposed docket.

The proposed Project will create more damage than benefit to the local communities. The Project is not needed by the community; in fact, the natural gas liquids it will carry are primarily targeted for export and not for use in our communities. Specifically ethane and propane are contracted to be shipped overseas via Norwegian and Austrian companies. As such, there is not a need for the project and certainly the Project is not "important" to the local community such that it outweighs the high level of damage and harm it will inflict.

The pipeline is not in keeping with existing or anticipated development in the Project area. In order to construct this pipeline Sunoco is using the power of eminent domain to gain access and use of numerous properties across the construction spread – this alone demonstrates an inconsistency with existing and expected development. Additionally, given the dangerous conditions due to incidents and accidents that the pipeline will expose the existing residential communities and families along its path, this pipeline is clearly not in keeping with existing development and community zoning expectations.

153 of the waterways to be crossed have some designation denoting high water quality and/or recreational value. That the pipeline will result in streambanks that are denied healthy forested buffers best for water quality and habitat protection, and that the buffer cuts with low growing vegetation will also adversely impact healthy habitats and aesthetics, also provides further evidence for denying the requested special permit.

In addition, in the time DRN had to review the Project files, it does not appear that there was consideration of local floodplain planning, protection, or regulations. Therefore, we question the consistency of the proposal with such local planning.

According to the DRBC Floodplain Regulations, special use permits "shall not" issue for projects that, among other things, "endanger human life", "have high flood damage potential" or degrade significantly runoff, erosion, sedimentation, the quality of surface water or the quality or quantity of ground water. The Mariner East pipeline is a significant danger to human life, and, as such, should not be the subject of a special permit.

Pipelines are a demonstrable source of human harm and property damage as a result accidents, ruptures, explosions, and blowouts. Between 1986 and 2012, "pipeline accidents have killed more than 500 people, injured over 4,000, and cost nearly seven billion dollars in property damages."[11] Looking at this 28 year period, on average pipelines killed or injured 173 people a year causing over $269 million a year (269,230,769) in property damage. In addition, the hazards of pipelines for human safety and property damage are increasing, and not decreasing. According to a report by the Pipeline Safety Trust, "the gas transmission lines installed in the 2010s had an annual average incident rate of 6.64 per 10,000 miles over the time frame considered, even exceeding that of the pre-1940s pipes. Those installed prior to 1940 or at unknown dates had an incident rate of 6.08 per 10,000 miles."[12]

Furthermore, pipelines are known to rupture as the result of scour from high flow and flood events, and when they rupture the impacts are severe. The proposed Project will cross 133 streams through either HDD or through open cut using the dry crossing method. This means that there will be 133 streams with a pipeline buried in their beds. Therefore, given the high flood

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[11] ProPublica, *Pipelines Explained: How Safe are America's 2.5 Million Miles of Pipelines?*
[12] https://www.snl.com/InteractiveX/Article.aspx?cdid=A-33791090-11060

damage potential that can result from rupture and given the high number of stream crossings in the basin, a special permit should not be issued by the Commission.

Because open trench pipeline installations may unnaturally alter both stream bank and streambed (i.e. channel) stability, there is an increased likelihood of scouring within backfilled pipeline trenches. This is because open trenches themselves, when backfilled, may not be compacted to stable pre-trench sediment permeability conditions. Flooding rivers can scour river bottoms and expose pipelines to powerful water currents and damaging debris. Additionally, unusually heavy rains including those associated with climate change, threaten to increase overall stream degradation and channel migration – thereby exposing shallowly buried pipelines.

Scour hole development proximal to pipelines is well-documented in both stream and seabed settings.[13] In 1993, the flooding Gila River in Arizona ruptured a 36-inch pipeline, sending natural-gas bubbling to the surface.[14] Several El Paso Natural Gas pipelines, which crossed the Gila River near Coolidge, Winkleman, and Kelvin were "scoured" and uncovered by the force of the water and failed.[15] Doeing et al. (1997)[16] further document six gas pipelines in the Gila River Basin that were either exposed on bridges or failed due to stream erosion stemming from January 1993 floods in Arizona. The failures were critical because these were major transmission lines that supplied natural gas to residential and industrial users in whole communities and groups of communities. Stream-based pipe *"(f)ailures were caused not only by vertical scour of the streambed but also by bank erosion, lateral channel migration, avulsions,*

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[13] Fogg, J. and Hadley, H., 2007, Hydraulic Considerations for Pipelines Crossing Stream Channels. Technical Note 423. BLM/ST/ST-07/007+2880. U.S. Department of the Interior, Bureau of Land Management, National Science and Technology Center, Denver, CO. 20 pp. http://www.blm.gov/nstc/library/techno2.htm.

[14] Randazzo, R., 2010, Arizona to assess gas- pipe safety after California blast. The Arizona Republic (9-20-10).

[15] Wikipedia. http://en.wikipedia.org/wiki/Coolidge_Dam

[16] Doeing, B.J., Williams, D.T. and Bradley, J.B., 1997, Gas Pipeline Erosion Failures: January 1993 Floods, Gila River Basin, Arizona. In Storm - Induced Geologic Hazards, Case Histories from the 1992 - 1993 Winter in Southern California and Arizona; Geological Society of America; Reviews in Engineering Geology, Volume XI (ed. Robert A. Larson).

bridge scour, and secondary flows outside the main channel. ... Several of the pipelines in the study failed as a result of a meander migration or avulsion of the stream into previously less active or nonexistent channels."[17] Based on field observations and hydraulic modeling for the 100-year design flood, researchers documented maximum vertical scour to 26.6 feet (8.1 meters) and lateral scour to 6,274 feet (2,050 meters) at some failed pipeline crossings.

An expert at HydroQuest has determined that, at a minimum, any pipeline installed using the open trench cut method needs to be installed at least 24 feet below the stream bed in order to prevent exposure from scour.[18] While bridge piers are more readily exposed to stream scouring than pipelines, it is telling that bridge failure analyses have determined that channel scour occurs to depths of up to three times that of maximum river floodwater depth (e.g., scour to 30 feet with a 10 foot floodwater depth).

A significant environmental risk associated with both wet and dry trench methods of gas pipeline crossings of rivers and streams is the potential of releasing hydrocarbons or other contaminants directly into surface water and fragile downstream ecosystems, including hydro-carbon laced liquids such as benzene that are part of the gas being delivered by the pipeline. Gas, as it is extracted from a well, may be mixed with hydraulic fracturing fluids. Hydrocarbon-laced condensate or natural gas liquids (NGLs) associated with natural gas (e.g., benzene) pose an environmental risk if pipe rupture occurs (e.g., to potential bog turtle habitat and travel corridors, fisheries, downstream drinking water supplies as well as underlying aquifers recharged by stream water). For example, a damaging flood event in Texas ruptured eight pipelines and spilled more than 35,000 barrels of oil and oil products into the San Jacinto River.[19] The Bureau of Land Management recognized and addressed this critical issue: *"In 2002, the U.S. Fish and Wildlife Service raised concerns about the potential for flash floods in ephemeral stream*

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[17] *Id*.
[18] Expert Report from HydroQuest.
[19] Billings Gazette, *supra note* 75.

channels to rupture natural-gas pipelines and carry toxic condensates to the Green River, which would have deleterious effects on numerous special-status fish species."[20]

Clean up associated with pipeline breaks can be extremely expensive. For example, ExxonMobile expects that cleanup costs associated with fouling an estimated 70 miles of shoreline of the Yellowstone River may cost about $135 million.[21] The Department of Environmental Quality in Montana is also concerned with the thousands of pipelines that cross small or intermittent streams. Federal officials investigating a July 2011 pipeline break that spilled 1,500 barrels of oil into a Montana river said that few companies take river erosion and other risks into account when evaluating pipeline safety.

The DRBC docket and special use permit does not adequately consider these important threats. Given the damage to stream banks, the frequent E&S failures during pipeline construction, the increased soil compaction that results during pipeline construction and exists beyond construction, and given that pipelines are known to redirect groundwater flows, the cumulative impacts of all of these harms coupled with the high number of stream crossings and floodplain development plans associated with it, a special use permit should not be issued by the Commission.

Conclusion

With the rapid expansion of the unconventional shale gas development industry, there has been a corresponding proliferation of transmission line construction and expansion projects that cross the Delaware River Basin. Whether considered individually or cumulatively, these pipeline projects demonstrably have had substantial effects and will continue to have substantial effects to the water resources of the Basin. The Commission must take a strong leadership position on

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[20] Fogg and Hadley, *supra note* 70.

[21] Billings Gazette. Feb. 8, 2012: http://billingsgazette.com/news/local/feds-few-pipeline-plans-account-for-river-risks/article_b2ecac80-d313-53c9-a914-906a97aedb9d.html?oCampaign=hottopics

natural gas pipeline construction to meet its obligations under the Compact and the Water Code to ensure all approved projects are consistent with the Comprehensive Plan. DRN respectfully requests the above referenced comments are considered and the draft docket is rejected by the Commission; or in the alternative, the draft docket is set aside for further review and consideration.

Thank you in advance for your cooperation with this request.

Sincerely,

/s/ Aaron Stemplewicz

Aaron J. Stemplewicz, Staff Attorney
Delaware Riverkeeper Network

Exhibit A

EXHIBIT A

WETLAND C49

Exhibit B

EXHIBIT B

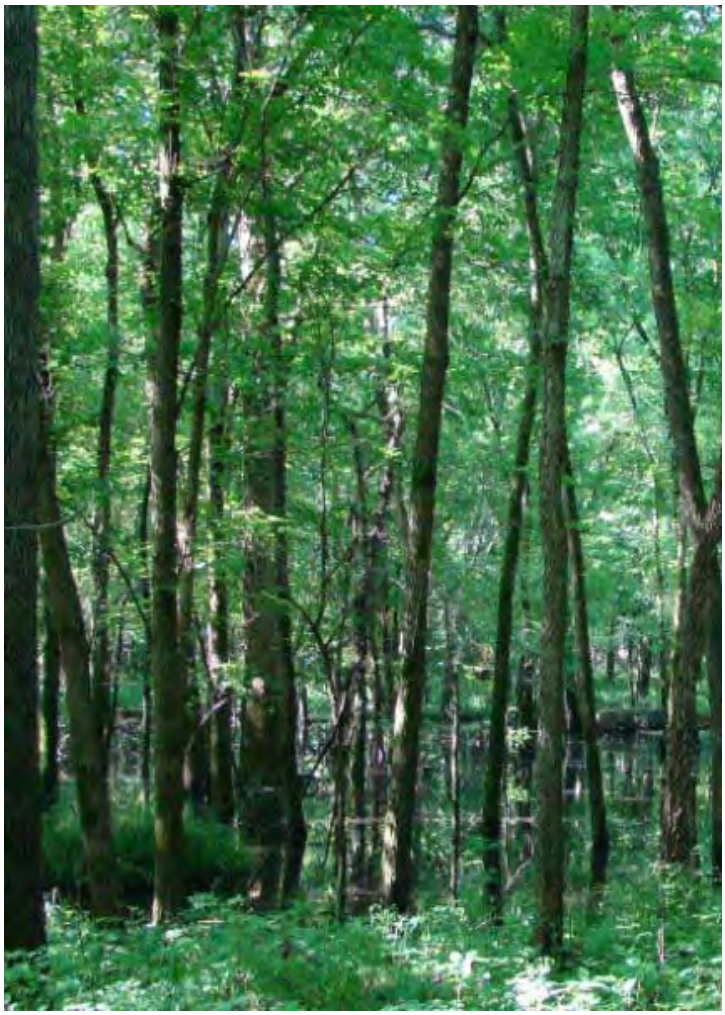
WETLAND B19

Exhibit C

Wetland C49

Wetland B19

Exhibit D



The Effects of Converting Forest or Scrub Wetlands

into Herbaceous Wetlands in Pennsylvania

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A Report to the Delaware Riverkeeper Network

2014

The Effects of Converting Forest or Scrub Wetlands into Herbaceous Wetlands in Pennsylvania

Prepared for: The Delaware Riverkeeper Network

Bristol, Pennsylvania

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Note: Appendix A is excerpted from Pennsylvania Department of Environmental Protection. 2010. Riparian Forest Buffer Guidance. Technical Guidance Document 394-5600-001. Harrisburg PA. 107 p.

The Effects of Converting Forest or Scrub Wetlands to Herbaceous Wetlands in Pennsylvania

Wetlands are tracts of land characterized by the recurrent and prolonged presence of surface water and/or near-surface groundwater. Their vegetation, wildlife, and soil properties are greatly influenced by wetness, that is, by their hydrology. Wetness has a profound effect on the biogeochemical reactions that occur in the top foot of wetland soil, allowing bacteria to render such soils anaerobic (oxygen-free) and thereby affecting the chemistry of the soil particles as observed in soil color and organic matter, determining the kinds of microorganisms present, selecting the kinds of rooted plants able to survive and compete, and in turn affecting the quality of habitat for animals including humans. Like streams, ponds, lakes, rivers, and oceans, wetlands today are deemed to be bodies of surface water, peculiar places transitional between (1) permanent open waters and (2) dry lands wet only during precipitation events. Some wetlands are associated with areas where surface waters and groundwater interconnect.

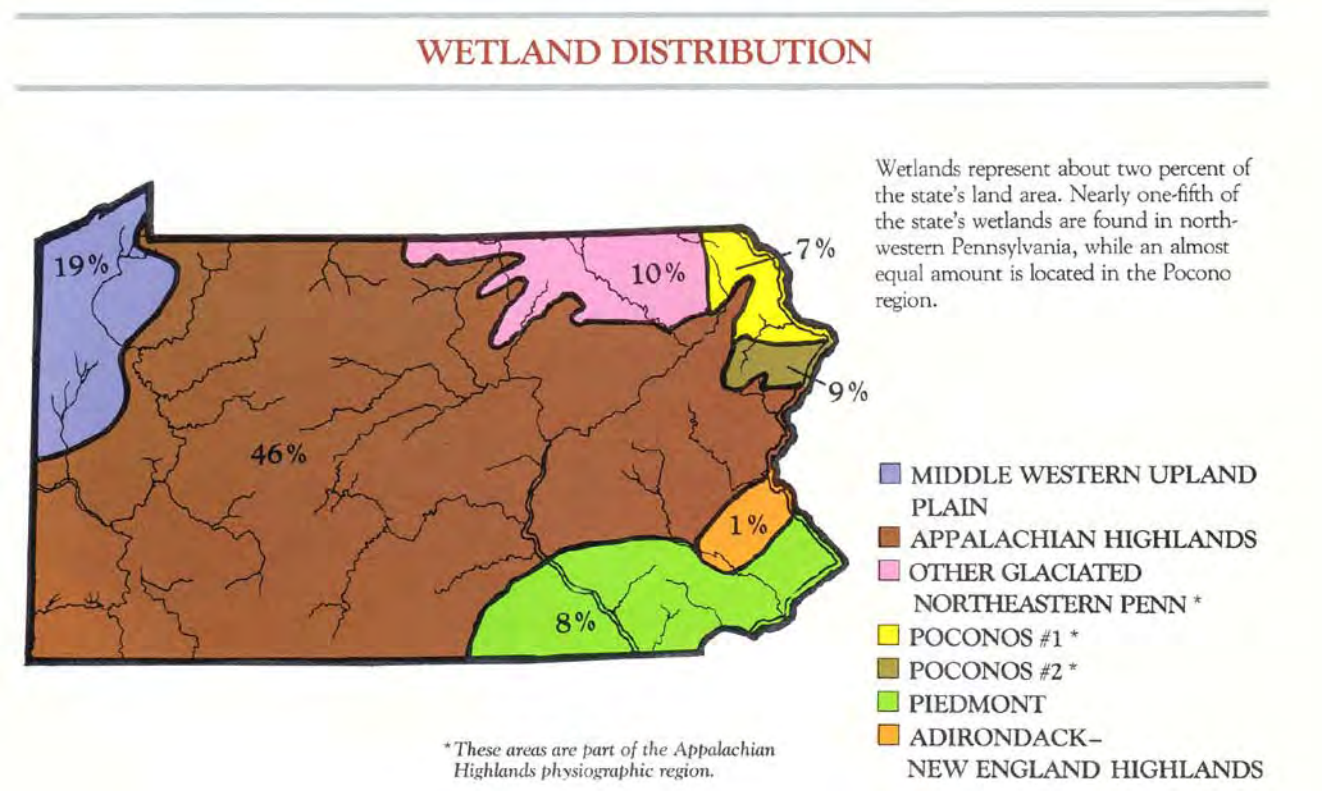
For many years wetlands were regarded as wastelands, and public policy encouraged their physical conversion to accommodate more highly valued land uses of many kinds (farms, cities, roads, residential and commercial development). In response, millions of acres of wetlands were destroyed across the United States, including more than half of Pennsylvania's wetlands (more than 600,000 acres). Not until the latter half of the twentieth century were the environmental and societal values of suddenly scarce wetlands broadly appreciated and subjected to legal protection against unnecessary alteration in the United States (Schmid 2000). Today most construction activities in wetlands are regulated by public agencies concerned with environmental protection. Regulators at the federal, State, and/or municipal level may be involved in permit review and approval. Most construction activities that would affect wetlands are unlawful, unless previously authorized by permit, but the applicable laws vary greatly from place to place in their scope and stringency.

Wetness (above-ground inundation or in-ground saturation within the uppermost foot of topsoil) for periods of two weeks or more, at least seasonally recurrent, is the primary characteristic that locally distinguishes individual wetlands from non-wetland areas that may display similar climate, exposure (aspect), slope, geology (rock type), soils, and biota (plants, animals, bacteria, fungi). The prolonged presence of surface water at relatively shallow depth (< 6 feet) and the presence of emergent vegetation distinguish wetlands from the deep, open waters of lakes and the flowing channels (some with submerged or floating plants) of streams---other bodies of surface water with which wetlands often are closely associated. Wetlands often occupy a landscape zone transitional between open waters and the seldom-wet uplands found at higher elevations. Along with groundwater, surface streams, rivers, lakes, ponds, and wetlands are regulated Waters of the Commonwealth of Pennsylvania. Many, but not all, of the wetlands and other

surface water bodies in Pennsylvania are also Waters of the United States (USEPA and USACE 2014).

In the large and diverse Commonwealth of Pennsylvania there are many kinds of wetlands. Pennsylvania wetlands in the aggregate occupy a small proportion of the land surface, and are most extensive in formerly glaciated areas such as the plateaus of the northeastern and northwestern counties, as shown below in a National Wetland Inventory drawing (from Tiner 1987). Individual wetlands can range in size from a few square feet to many acres. Wetlands today are recognized as contributing to water quality, wildlife habitat, endangered species protection, and the human landscape far out of proportion to their percentage share of the Pennsylvania land surface, and thus warrant stringent protection from human modifications to the extent practicable. These values increase as human population and population density increase. At the same time, the economic value of property where the destruction of wetlands has been authorized can greatly exceed the cash value of that property in its natural condition. Hence the extent to which public agencies can protect wetland resources often conflicts with the desire of private landowners to alter the property which they own.

Pennsylvania Wetlands Are Geographically Concentrated.



Agencies tasked with implementing the federal Clean Water Act (P.L. 92-500, 86 Stat. 816) and the Pennsylvania Dam Safety and Encroachments Act (32 P.S. 693) and Clean Streams Law (35 P.S. 691), long have defined wetlands as

> Areas that are inundated or saturated by surface water or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions, including swamps, marshes, bogs and similar areas (25 *Pa. Code* 105.1.)

Accurate wetland identification and delineation depend upon a careful analysis of plants, soils, and hydrology using the best available scientific guidance to apply the official definition in each real situation on the surface of the earth. In the central sections of most wetlands the general public can readily ascertain the distinctive conditions that characterize tree-filled swamps and herb-dominated marshes. Precisely locating the boundaries of a wetland, however, in gently sloping transitional areas where the requisite field indicators gradually drop out, typically requires specialized training in the visual appearance of vegetation, soils, and hydrology as they occur outdoors in all seasons, along with thorough knowledge of relevant agency rules for consistent decisionmaking. The details of scientific knowledge of wetland functions and regulatory adjustments in setting regulatory boundaries and analyzing impacts have changed over recent decades as our understanding of wetlands has increased.

To apply the regulatory definition of wetlands in the field, federal and Pennsylvania regulators (25 *Pa. Code* 105.451) employ the Army Corps of Engineers *Wetland Identification and Delineation Manual* (ERL 1987) in conjunction with its recent regional supplements (for example, USACE 2012) and other technical support documents (including Lichvar *et al*. 2014, Vasilas *et al*. 2010, USACE 2014). These official documents provide the guidance necessary for recognizing the current extent of regulated wetlands under various conditions of season, wetness, and human disturbance, using field indicators of vegetation, soil, and hydrology.

In Pennsylvania the Army Corps of Engineers provides, in response to landowner requests, formal written Jurisdictional Determinations (JDs) that confirm the accurately mapped extent of wetlands and bodies of surface water eligible for regulation at the federal, State, and municipal level on specific tracts of land. Absent the issuance of a valid JD, there is no way for a landowner or the public to ascertain accurately the limits of a regulated wetland. Topographic maps, National Wetland Inventory maps, floodplain maps, soil survey maps, and planning maps of many kinds can provide useful technical information, but do not identify in detail the limits of regulated wetlands (or streams) that need to be considered by the sponsors of construction projects. Consultants typically document sites on behalf of landowners and prepare paperwork for agency review. Careful documentation of wetlands whose proffered boundaries are superimposed onto a land ownership survey is required as part of a request for a

JD, and Corps staff typically inspect each property in the field prior to approving a JD. JDs remain valid for five years, in recognition of the fact that wetland boundaries can change over time as a result of natural changes as well as unregulated human activities nearby. Only the Natural Resources Conservation Service (NRCS), an arm of the US Department of Agriculture, issues permanent wetland identifications for purposes of eligibility for federal programs that support crop production. Such NRCS determinations apply only to farming, not to general construction activities.

Delineated wetlands are best avoided when new construction projects are proposed, and permit applicants are expected to minimize unavoidable impacts insofar as practicable. The JD forms the informational basis for permit calculations and for designing compensatory mitigation to offset agency-approved impacts to the extent practicable.

Recent experience confirms that applicant-proffered wetland boundaries continue to warrant detailed scrutiny by the Army Corps of Engineers and other regulators. In one 2010 mining application in Greene County, National Wetland Inventory maps disclosed 4 wetlands on a 642-acre site. The applicant's consultant submitted a proposed delineation to PADEP showing 10 wetlands. After field inspection by the Corps, the JD drawing of the same tract of land showed 27 wetlands (Schmid & Co., Inc. 2013). In Sullivan County a gas company consultant delineated streams and wetlands in a 50-foot wide right-of-way along some 4,000 feet of unpaved township road. After the adjoining landowners secured Corps JDs, the square footage of regulated streams and wetlands increased to 700% of that flagged for the gas company within the same 4-acre strip of land (Schmid & Co., Inc. 2011b). The Corps field representative commented that significant under-identification of wetlands had occurred at several recent gas well installations where he had been involved with enforcement actions. None of those permittees had secured a Corps JD, and PADEP as usual had approved their permits without questioning the accuracy of information in the applications. It is not possible to overemphasize the necessity for JD applications followed by field-checking by Corps staff of proffered delineations as critical to the identification of wetlands in Pennsylvania prior to permit approval. Unidentified wetlands are not protected at all.

Wetland Permits

Regulated activities in Pennsylvania wetlands and other bodies of water cannot legally be initiated prior to permit approval by the Department of Environmental Protection (PADEP), except for waivered activities (25 *Pa. Code* 105.12) and registered activities that conform to the requirements of pre-approved general permits (25 *Pa. Code* 105.441 *et seq*.). Above established minimum thresholds of impact, regulated activities in federally regulated wetlands and waters also require approval from the Army Corps of Engineers. Except for those areas and

activities excluded from regulation by waiver or authorized via general permits, wetland functions by regulation must be identified by an applicant when permit approval is sought for activities that will encroach upon wetlands and other bodies of water in Pennsylvania (25 *Pa. Code* 105.13). Permit applications for relatively small encroachments may be reviewed only by State agencies; larger or more damaging activities must be considered independently also by federal agencies. Few of the more than 2,500 Pennsylvania municipalities have adopted any ordinances protective of wetlands, but some have included wetlands as among resources to be reviewed at the local level, and their wetlands may be protected over and above what State and federal agencies require. Like PADEP, local agencies generally lack the staff resources to identify jurisdictional boundaries for wetlands.

After wetlands have been identified, permit applicants are expected to avoid impacts, and where unavoidable, to make every practicable effort to minimize impacts when planning their construction projects; PADEP is to review such efforts to avoid and minimize impacts [25 *Pa. Code* 105.14(b)(7)]. Where encroachments are proposed into wetlands, it is the responsibility of the permit applicant to identify onsite conditions in every affected wetland as a basis for ascertaining the probable alteration of functions when analyzing unavoidable adverse impacts and providing appropriate compensatory mitigation (25 *Pa. Code* 105.14, .15, and .18a). Impacts are to be analyzed in an Environmental Assessment (§105.15). The extent and nature of unavoidable impacts become the basis for developing the applicant's proposal for site restoration and compensatory mitigation. The quality of wetland assessment depends on the thoroughness and accuracy of underlying wetland inventory as well as the professional competence of the delineator and agency reviewer. Wetland functions form a principal aspect of the environmental assessment.

PADEP and district offices of the Army Corps of Engineers have adopted a joint permit application (Form 3150-PM-BWEW0036A, March 2013) and related forms that solicit the minimum information needed for agency decisionmaking regarding affected wetlands and other bodies of water on properties where construction is planned that may damage these resources. Public notice is required for individual joint permit applications, but not for waivered activities or for registrations of applicant intent to rely upon general permits. PADEP staffers are charged with reviewing each application to insure its completeness, its accuracy, and the applicant's proposed compliance with applicable regulations. Permit files, application data, and related correspondence are public records and can be examined by persons concerned about wetland protection through the procedures of Pennsylvania's Right to Know Law (Act 3 of 2008) and the federal Freedom of Information Act (5 USC 552 *et seq*.). Upon approval of a PADEP permit, the window for filing appeals to the Pennsylvania Environmental Hearing Board by any aggrieved party remains open for thirty days. Applicants are required to conform to the conditions and limitations set forth in general and individual permits. All recipients of individual permits by regulation are required

to file a statement of compliance with permit requirements within 30 days of work completion and to file final as-built plans within 90 days showing any changes from original plans and specifications (25 *Pa. Code* 105.107).

In Pennsylvania some wetlands are deemed more valuable than others. Exceptional Value wetlands deserve *specia*l protection. Such wetlands exhibit one or more of the following characteristics (25 *Pa. Code* 105.17):

1. Serve as habitat for fauna or flora listed as threatened or endangered under federal or Pennsylvania law.
2. Are hydrologically connected to or located within 0.5 mile of the above and maintain the habitat of the endangered species.
3. Are located in or along the floodplain of the reach of a wild trout stream or waters listed as having Exceptional Value and the floodplain of their tributary streams, or within the corridor of a federal or Pennsylvania designated Wild or Scenic River.
4. Are located along an existing public or private drinking water supply and maintain the quantity or quality of that surface water or groundwater supply.
5. Are located in State-designated natural or wild areas within State parks or forests, in federally designated Wilderness Areas or National Natural Landmarks.

Wetlands that qualify as having Exceptional Value are defined as surface waters of Exceptional Ecological Significance (25 *Pa. Code* 93.1), and thus (like Pennsylvania streams that have been designated or have attained Exceptional Value uses) are to be treated as Tier 3 Outstanding National Resource Waters in the language of the Clean Water Act of 1972 (as amended, 33 *USC* §1251 *et seq*.; *US Environmental Protection Agency Water Quality Handbook* - Chapter 4: Antidegradation [40 *CFR* 131.12]). These highest-quality resources are to be protected from degradation. Wetlands that do not exhibit any of the above-listed characteristics are deemed “Other” wetlands.

Permits for structures and activities in Exceptional Value wetlands are not to be approved unless PADEP finds that: the dam, water obstruction, or encroachment will not have an adverse impact on the wetland, as determined in accordance with §§ 105.14(b) and 105.15; the project is water dependent, requiring access to, proximity to, or siting within the wetland to fulfill its basic purpose; there is no practicable alternative that would not involve a wetland or that would have less adverse effect on the wetland and not have other significant adverse effects on the environment; the project will not cause or contribute to a violation of an applicable State water quality standard; the project will not cause or contribute to pollution of groundwater or surface water resources or diminution of resources sufficient to interfere with their uses; and the applicant replaces the affected wetland in accordance with criteria at § 105.20a [25 *Pa. Code* 105.18a(a)]. Yet Corps Jurisdictional Determinations are not required for Exceptional Value wetlands in Pennsylvania, so these wetlands are equally likely to be overlooked as those lacking exceptional value.

“Other” wetlands also are deemed “a valuable public natural resource” (25 *Pa. Code* 105.17) that is to be protected from significant impacts in similar fashion to

Exceptional Value wetlands. Permits are to be granted to dams, water obstructions, or encroachments affecting Other wetlands only when PADEP finds that: the project will not have a significant adverse impact considering the areal extent of the impacts, values, and functions of the wetlands, the uniqueness of the wetland functions and values in the area or region; comments from environmental agencies have been addressed; adverse impacts on the wetland are to be avoided or reduced to the maximum extent possible; there is no practicable non-wetland impacting alternative; the applicant has convincingly demonstrated that non water-dependent projects have no practicable alternative, overcoming the rebuttable presumption that such alternatives exist; the project will not cause or contribute to violation of an applicable State water quality standard; the project will not cause or contribute to pollution of groundwater or surface water resources or diminution of resources sufficient to interfere with their uses; the cumulative effect of this project and other projects will not result in a major impairment of the Commonwealth's wetland resources; and the applicant replaces the affected wetland in accordance with criteria at § 105.20a [25 *Pa. Code* 18a(b)]. On paper, Pennsylvania offers stringent protection to its wetlands.

Wetland Functions

Nine wetland functions are specifically identified in the definitions section of Pennsylvania's Dam Safety and Encroachments regulations (25 *Pa. Code* 25.1). By regulation, these functions are the minimum that require consideration as PADEP evaluates every encroachment permit affecting 1 acre or less of wetlands. Larger wetlands, as well as Exceptional Value wetlands smaller than 1 acre may require more complex assessment of additional functions and values in addition to these [25 *Pa. Code* 105.13(d)(3)]:

Wetland Functions Requiring Analysis in PADEP Permits

1. Serving natural biological functions, including food chain production; general habitat; and nesting, spawning, rearing and resting sites for aquatic or land species.
2. Providing areas for study of the environment or as sanctuaries or refuges.
3. Maintaining natural drainage characteristics, sedimentation patterns, salinity distribution, flushing characteristics, natural water filtration processes, current patterns or other environmental characteristics.
4. Shielding other areas from wave action, erosion, or storm damage.
5. Serving as a storage area for storm and flood waters.
6. Providing a groundwater discharge area that maintains minimum baseflows.
7. Serving as a prime natural recharge area where surface water and groundwater are directly interconnected.
8. Preventing pollution.
9. Providing recreation.

Different wetlands exhibit different combinations of functions. Some mutually exclusive functions (for example, groundwater recharge and groundwater

discharge) can alternate over time within a single wetland. The functions performed by a wetland may vary over seasons and from year to year. The functions that any given wetland is capable of performing result from both the internal characteristics of the wetland itself and the surrounding context in which that wetland exists, including its connection with other natural areas and with watercourses. Corridors for wildlife movement, for example, are important to allow populations of animals to move between areas of wetland habitat, and many streams function as wildlife corridors. Similarly, only a wetland located on the shore of an open water body can shield other areas from wave action. The success of a wetland in performing functions can be affected greatly by past or ongoing human activity. Most wetland functions are disrupted permanently or temporarily by construction activities that impinge upon the wetland vegetation, soils, or hydrology directly. Human activities that increase performance of one function can accompany decreasing performance of other functions by that wetland.

Wetland functions also can be affected by construction outside the wetland itself out to a distance of 1,500 feet or more (Houlahan *et al*. 2006). For example, wildlife that breed in wetlands, such as reptiles and amphibians including frogs and salamanders, normally range into the adjoining uplands for distances of many hundreds of feet in eastern North America during the course of an annual cycle. If the adjacent lands are deforested or paved, or the wetland isolated by an intervening road or fence, the wetland habitat can be rendered useless to such creatures. By way of further example, altering the light and wind by removing the surrounding forest can cause a major change in the plants and animals that can survive in a wetland. Surface disturbances outside a wetland also can have major impact on the hydrology of the wetland, profoundly altering its ecosystem by draining or flooding it.

There is no State-regulated wetland buffer in Pennsylvania, such as exists in New Jersey or New York. Those States have expressed concern for the variable boundaries of wetlands that result from differing weather conditions year to year. They wisely recognize that the associated transitional areas adjacent to wetlands comprise essential parts of the functioning ecosystem of each wetland. Hence they long have considered the preservation of ecosystems adjacent to a wetland to be an essential part of protecting that wetland's functions and values. The absence of regulated buffers around wetlands in Pennsylvania renders its wetlands at risk of unavoidable degradation, especially in areas of concentrated human populations. A few Pennsylvania municipalities have recognized or sought to remedy this environmental risk through local ordinances that provide for maintenance of some amount of undeveloped protective buffer outside the wetland. The functions of forested riparian buffers are reviewed in Appendix A.
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Wetland Classification

The functions and values of a wetland differ according to the placement of the wetland in the landscape and the manner in which it gains its wetness.

Functional analysis logically addresses different classes of wetlands differently when addressing their potential for damage or rehabilitation. Wetlands and shallow water bodies are usefully categorized at the most basic level by general hydrogeomorphic system. Across most of the Pennsylvania landscape, wetlands and small ponds are assigned to the Palustrine (P) system, which is distinguished from tidal estuarine and marine classes, lakes, and large rivers. Wetlands along the boundaries of water bodies are assigned to the Riverine (R) or Lacustrine (L) systems, although many floodplain wetlands are labeled as Palustrine. Marine (M) and Estuarine (E) classes are of limited extent in Pennsylvania.

The following table identifies the most recent hydrogeomorphic classifications under development by the PADEP (draft Technical Guidance Document 310-2137-002, 7 March 2014, p. 27). The classification is significant as it affects the functional analysis of all water bodies including wetlands.

Mid-Atlantic HGM Wetland Classification:

- Classes
  - Subclasses
    - Modifiers
- Marine
  - subtidal
  - intertidal
- Estuarine
  - subtidal
  - lunar intertidal
  - wind intertidal
  - impounded
- Riverine
  - lower perennial
  - floodplain complex
  - upper perennial
  - headwater complex
  - intermittent
    - beaver impounded
    - human impounded
- Lacustrine (fringe)
  - permanently flooded
  - semipermanently flooded
  - intermittently flooded
  - artificially flooded
- Palustrine
  - Flat
    - Flat mineral soil
    - Flat organic soil
  - Slope
    - Stratigraphic
    - Topographic
      - mineral soil
      - organic soil
  - Depression
    - perennial
    - seasonal
    - temporary
      - human impounded
      - human excavated
      - beaver impounded

PADEP goes on to offer additional detail on the principal kinds of wetlands in Pennsylvania classed by location associated with hydrology that require consideration during functional assessments. The modifiers give an idea of the variability of the basic types (draft Technical Guidance Document 310-2137-002, 7 March 2014, p. 24-25). Once these distinctions have been formally adopted by PADEP for consideration in each permit application, the precision and quality of data provided by applicants' consultants should improve, along with the quality of impact analysis.

Pennsylvania Hydrogeomorphic Wetland Classification Key.

1.	Wetland found along tidal fringe of a marine ecosystem (ocean, beach, rocky shore)	2
1.	Wetland not associated with marine ecosystem	3
2.	Continuously submerged littoral zone	**Marine subtidal** (MF1)
2.	Alternately flooded and exposed to air	**Marine intertidal** (MF2)
3.	Wetland associated with shallow estuarine ecosystem (Mixture of saline and freshwater)	4
3.	Wetland not associated with shallow estuarine ecosystem	7
4.	Wetland not impounded	5
4.	Wetland impounded	**Estuarine impounded** (EFh)
5.	Wetland continuously submerged	**Estuarine subtidal** (EF1)
5.	Wetland alternately flooded and exposed to air	6
6.	Wetland regularly or irregularly flooded by semidiurnal, storm, or spring tides	**Estuarine lunar intertidal** (EF2l)
6.	Wetland flooding induced by wind	**Estuarine wind intertidal** (EF2w)
7.	Wetland associated with freshwater stream or river	8
7.	Wetland not associated with freshwater stream or river	11
8.	Wetland associated with permanent flowing water from surface sources	9
8.	Wetland dominated by ground water or intermittent flows	10
9.	Wetland associated with low gradient tidal creek (see Estuarine types 3)	
9.	Wetland associated with low gradient and low velocities, within a well-developed floodplain (typically >3rd order)	**Riverine lower perennial** (R2)
9.	Wetland part of a mosaic dominated by floodplain features (former channels, depressions) that may include slope wetlands supported by ground water (see Slope 17)	**Riverine floodplain complex** (R2c)
9.	Wetland associated with high gradient and high velocities with relatively straight channel, with or without a floodplain (typically 1st - 3rd order)	**Riverine upper perennial** (R3)
10.	Wetland part of a mosaic of small streams, depressions, and slope wetlands generally supported by ground water	**Riverine headwater complex** (R3c)
10.	Wetland associated with intermittent hydroperiod	**Riverine intermittent** (R4)

Note:	For any riverine type that is impounded, distinguish between:	
	Wetland impounded by beaver activity	**Riverine...beaver impounded** (R...b)
	Wetland impounded by human activity	**Riverine...human impounded** (R...h)
11.	Wetland fringing on a lake or reservoir	**12**
11.	Wetland not fringing on lake or reservoir	**14**
12.	Wetland inundation controlled by relatively natural hydroperiod	**13**
13.	Wetland inundation is permanent with minor fluctuations (year round)	**Lacustrine permanently flooded** (LFH)
13.	Wetland inundation is semipermanent (growing season)	**Lacustrine semipermanently flooded** (LFF)
13.	Wetland inundation is intermittent (substrate exposed often)	**Lacustrine intermittently flooded** (LFJ)
12.	Wetland inundation controlled by dam releases	**Lacustrine artificially flooded** (LFK)
14.	Wetland water source dominated by precipitation and vertical fluctuations of the water table due to low topographic relief	**15**
14.	Wetland differs from above	**16**
15.	Wetland substrate is primarily of mineral origin	**Flat mineral soil** (FLn)
15.	Wetland substrate is primarily of organic origin	**Flat organic soil** (FLg)
16.	Wetland water source is primarily ground water and has unidirectional and horizontal flows	**17**
16.	Wetland forms a depression	**18**
17.	Water source for wetland derived from structural geologic discontinuities resulting in discharge of groundwater from distinct point(s) on slope	**Stratigraphic slope** (SLs)
17.	Water source for wetland accumulates at toe-of-slope before discharging	**Topographic slope** (SLt)
Note:	For any slope type, distinguish between: Wetland substrate is primarily of mineral origin	**...slope mineral soil** (SL...n)
	Wetland substrate is primarily of organic origin	**...slope organic soil** (SL...g)
18.	Wetland with frequent surface connections conveying channelized flow	**Depression perennial** (DFH)
18.	Wetland with infrequent surface water connections conveying channelized flow	**Depression seasonal** (DFC)
18.	Wetland with no surface outlet, often perched above water table	**Depression temporary** (DFA)
Note:	For any depression type that is impounded or excavated distinguish between:	
	Wetland is impounded by human activities	**Depression...human impounded** (DPh)
	Wetland is excavated by human activities	**Depression...human excavated** (DPx)
	Wetland is impounded by beaver activities	**Depression...beaver impounded** (DPb)

Another of the basic classifications of wetlands derived from their appearance and germane to assessing their functions is their vegetation type. The descriptive framework for vegetation structure was devised by the US Fish and Wildlife Service (Cowardin *et al*. 1979) and is used for small-scale mapping by the National Wetlands Inventory. Vegetation and hydrogeomorphic location are combined to identify the principal habitat types identified by PADEP in Pennsylvania (Draft Technical Guidance Document 310-2137-001, March 2014,

p. 7). Notably, PADEP to date has not identified any nontidal Riverine wetland habitat types:

Some Pennsylvania Wetland Habitat Types.

LAB	Lacustrine Aquatic Bed
LEM	Lacustrine Emergent
LFL	Lacustrine Flat
PAB	Palustrine Aquatic Bed
PEM	Palustrine Emergent
PFL	Palustrine Flat
PFO	Palustrine Forested
PSS	Palustrine Scrub/Shrub

Lacustrine Emergent Wetland and Lacustrine Aquatic Bed.

Palustrine wetlands are the most numerous and widespread kinds in Pennsylvania, accounting for 97% of the wetlands mapped in the Commonwealth by the National Wetland Inventory from high-elevation aerial photos taken during the late1970s and early 1980s (Tiner 1990). National Wetland Inventory mapping is a useful tool whose results are valuable for regional wildlife resource management, but it significantly omits many forested wetlands in Pennsylvania and is not a reliable guide to regulated wetland locations or boundaries.

Nevertheless, its incomplete and approximate data are readily available online and often are displayed on maps generated by geographical information systems. Hydric soil map units in county soil maps and wetland patterns on US Geological Survey topographic quadrangles also offer clues to wetland locations. But the actual extent of wetlands and streams can be determined only by field delineation of specific properties when construction activities are proposed.

The principal kinds of vegetation found in Palustrine wetlands are classed as forest (PFO), scrub (PSS), and herbland (PEM) based on visual observation and/or aerial photographs. Available statistics probably underestimate the proportion of forested wetlands in Pennsylvania, inasmuch as they are based on aerial photographs rather than field investigation and omit forested wetlands not distinguishable remotely. Palustrine flats (FL) devoid of vegetation are not common. The focus of vegetation classification is on the size and structure of the general mass of vegetation present in the landscape. An individual plant, depending on species, can pass through the structural stages of herb, shrub, and tree as it grows in wetlands or uplands. The US Fish and Wildlife Service has reported their estimate of cover types of National Wetland Inventory wetlands in Pennsylvania based on 1975-1985 aerial photographs (Tiner 1990):

Palustrine Forests.

Delhaas Woods, Bucks County. Photograph by Roger Earl Latham.

Columbus Bog, State Game Lands 197, Warren County. Photograph by Paul Wiegman.

Acres of National Wetland Inventory Wetlands in Pennsylvania, 1975-1985.

Palustrine Wetlands	
Emergent	*52,338 a*
Deciduous Forested	*146,715 a*
Evergreen Forested	*31,204 a*
Deciduous Scrub-Shrub	*47,539 a*
Evergreen Scrub-Shrub	*1,849 a*
Mixed Deciduous Shrub-Emergent	*25,000 a*
Open Water	*61,841 a*
Other Mixed Types	*26,242 a*
Total Palustrine Wetlands	*392,728 a*
Lacustrine Wetlands	*8,521 a*
Riverine Wetlands	*2,675 a*
PENNSYLVANIA WETLANDS	***403,924 a***

Forest vegetation (FO) is dominated by trees at least 3 inches in minimum trunk diameter measured 4.5 feet above the ground and at least 20 feet tall. Shrubs and herbs can grow beneath the canopy trees, or the forest floor can be essentially bare. Scrub (SS) is dominated by shrubs with multiple stems less than 3 inches in diameter and rarely taller than 20 feet. Herbs can be abundant beneath the shrubs but trees are few; light tends to reach the land surface to a much greater degree than in forests. Herblands (EM) are generally devoid of woody plants but instead support various kinds of non-woody, herbaceous higher plants that emerge from the soil surface. Their plant cover can be sparse or dense. Tracts of land that qualify as forest, scrub, or herbland may intergrade and are mapped as mixed types (for example, FO/SS). The forest, scrub, and herbland categories each can be subdivided into numerous subtypes, depending on the purpose of such classification and appropriate level of detail. For example, Palustrine forest and scrub polygons on maps can be broadleaf deciduous (assigned the modifier “1” by the National Wetland Inventory, as in “PFO1”) or needleaf evergreen (“PFO4”); emergent herbs can be persistent year-round (“1” as in “PEM1”) or nonpersistent (“PEM2”), and any of these modifiers

can be further supplemented by codes for dominant plant genus or species or for other ecosystem attributes where more precise distinctions are needed.

In Pennsylvania Palustrine ecosystems, forested wetlands are more extensive than scrub and herbaceous wetlands. Natural plant succession generally trends toward forest conditions in eastern North America (Braun 1950, Küchler 1964), and thus herbaceous and scrub wetlands tend to reflect earlier stages of natural post-disturbance succession than forested wetlands. The first-approximation airphoto mapping of Pennsylvania wetlands by the US Fish and Wildlife Service reported deciduous forests making up 37% of Palustrine wetlands; evergreen forest, 8%; deciduous scrub, 12%; evergreen scrub, <0.1%; mixed deciduous scrub-herbland, 6%; herbland, 13%; open water (including farm ponds), 16%; and other mixed types, 7% based on 1975-1985 aerial photographs (Tiner 1990). Under natural conditions the forest community is disrupted occasionally by storms, fire, and beaver activity. Human activities today are a much more common source of forest removal. Not all herblands, however, are rapidly changing categories of plant succession on their way to becoming forests; some can persist naturally for long periods of time as viewed by humans. The plants found in particular wetland communities can range from diverse species to almost monotypic where invasives have become established.

State and federal agencies that keep records of wetlands and wetland modifications use these vegetation types for data collection and analysis. Each distinctive vegetation type also is associated with characteristic functions. Herbaceous wetland vegetation is capable of being reestablished relatively quickly following temporary disturbance, within only a few growing seasons, if soil and hydrologic conditions are favorable. Shrubs require additional years to reach full size, and forest trees require decades for canopy closure, even where soil disturbance has not been severe. Diverse populations of desirable native species can require long periods of time to become established in disturbed or newly created wetlands.

Functions of Pennsylvania Wetlands

This section discusses the functions listed above (as set forth in 25 *Pa. Code* 105.1) that are typically associated with Palustrine forested (PFO) wetlands and compares them with similar functions in scrub (PSS) and herbaceous (PEM) wetlands. These functions are subject to disruption by human activities as well as by catastrophic occurrences of weather (hurricanes, tornadoes), ice storms, landslides, floods, and fires. Reductions in some functions may accompany increases in others.

The PADEP list of nine wetland functions in Chapter 105 regulations is reasonably comprehensive and suited to project-scale analysis based on the specific acreage of wetlands affected by an individual permittee. Current regulations do not focus on quantitative annual productivity of timber or wildlife, removal of air pollutants, carbon sequestration, or less tangible functions such as

aesthetic or historic/cultural appreciation. Nor do they require measurement of the values of any identified functions to individuals or groups. They do not specify how to compare the relative values of different functions, how to index current, past, or future functions of specific wetlands to generally accepted "reference" natural wetlands, call attention to the context of land surrounding a wetland, address the scarcity of a vegetation type, or provide for actual consideration of cumulative wetland impacts beyond an individual permit. PADEP long has found it virtually impossible to consider cumulative impacts, even for a single large project, because of its longstanding willingness to consider permits for fragments of a project on a piecemeal basis independently. PADEP does not expect an applicant to address its entire single project in a joint permit submission, much less analyze its proposed impacts cumulatively with those of other permittees over large areas. PADEP also does not focus on the uniqueness or heritage value of specific wetlands (aside from their potential for classing a wetland as having Exceptional Value) or a wetland's actual replaceability or irreplaceability, should damage be authorized.

1. Natural Biological Functions and General Habitat

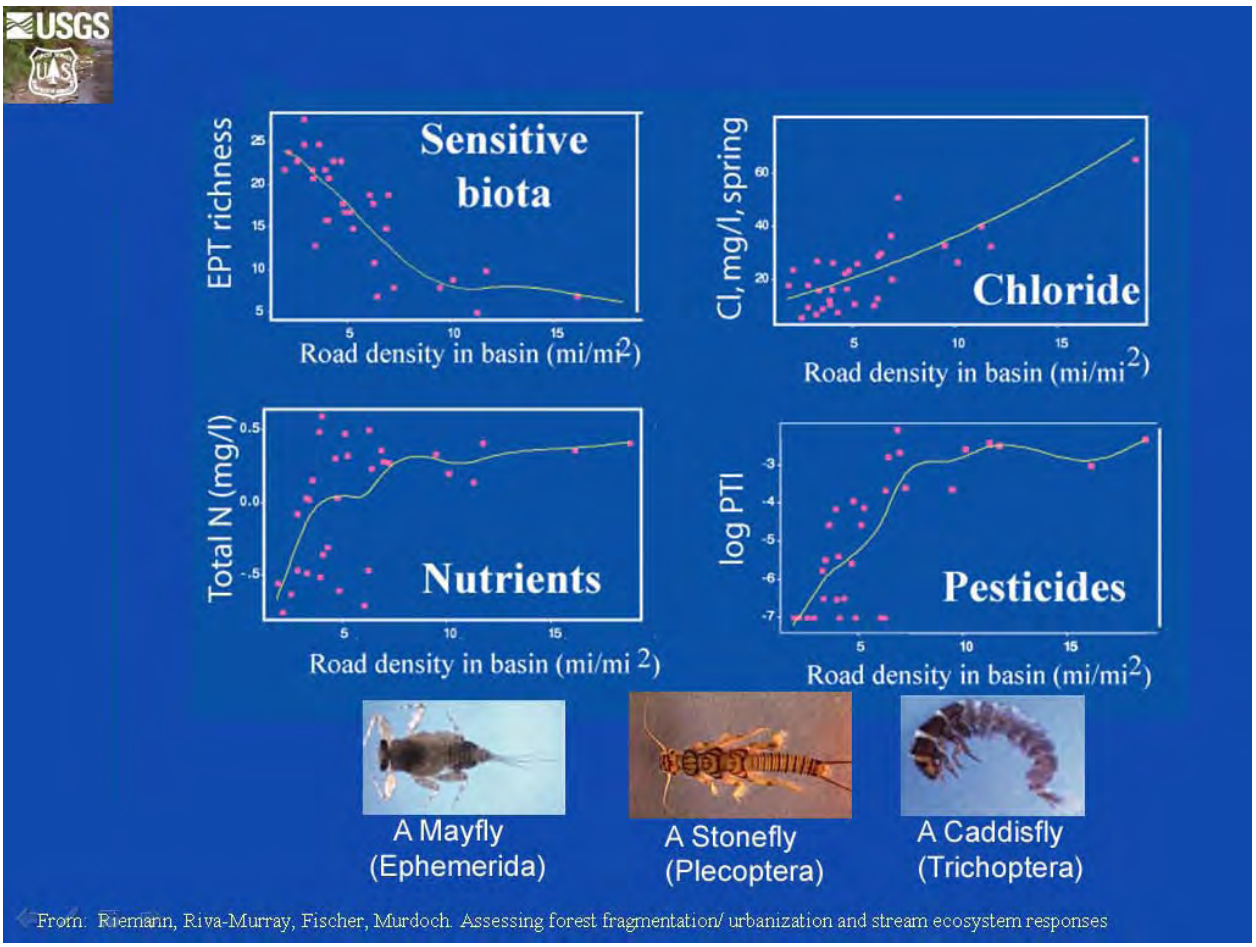
Natural biological functions of all wetlands include food chain production, general habitat, and resting-nesting-spawning-rearing sites for animals and fish. Many rare species of plants and animals are directly dependent on wetland habitats. Trees are the largest kinds of plants and have the greatest ability to modify the environmental effects of solar radiation, precipitation, temperature, humidity, and air quality as a result of their above-ground biomass. These natural, localized environmental modifications are of vital importance to the other plants and to the animals that live within and beneath forest cover. Tree leaves produce more tons of biomass per acre than shrubs for consumption by grazers and accumulate larger standing crops of organic material above ground. Tree trunks and limbs provide food for some animals and homes for many, with more complex structure than scrubs or herblands.

Pennsylvania forests consist of a wide variety of broadleaf deciduous trees, each species of which provides a somewhat different diet to the consumers that depend on it (Zimmerman *et al*. 2012; McShea & Healy 2002). Oaks, maples, ashes, elms, cherries, birches, and beech reflect the ancient geological history of Appalachia, and they returned to glaciated regions when the Pleistocene ice sheets melted. Pennsylvania forests also support many needleaf evergreen trees such as pines, hemlocks, and spruces. Very few stands of unharvested primeval forest remain in Pennsylvania; most of its forests have regrown following two or more episodes of intensive logging, burning, and other human disturbance during the past four centuries---episodes that have greatly affected the streams of the Commonwealth. Closed canopy forest consisting of mature trees requires about a century to recover to a recognizable mature forest structure after fire or clearcutting. About one third of Pennsylvania's forest stands are 80 years old or more; only 7%, 100 years old or more (McCaskill *et al*.

2013). Regenerated forest stands may or may not resemble their predecessors in their species composition when examined in detail, and the largest regrown individual trees are significantly smaller than historic records document as inherited by European colonists. Selective harvesting can remove key forest constituents, thereby reducing habitat value, and the forest canopy is further disrupted by logging roads, well pads, pipeline rights-of-way, borrow areas, and spills of fuel, brine, and other pollutants. Various kinds of shrubs and herbs grow only beneath a mature forest canopy. Wood ducks (*Aix sponsa*), a particularly handsome native species of waterfowl, require tree cavities for nesting as well as nearby water.

Trees growing in adjacent wetlands and streambanks are the major source of food for aquatic organisms in small, headwater streams. The intensity of ongoing human disturbance on the streams of forested areas can be estimated by the linear extent of roads per unit area. As summarized graphically by the United States Forest Service and US Geological Survey, human activity as approximated by road density has a dramatic effect on the quality of streams for sensitive aquatic insects that form the base of the aquatic food chain:

Road Density and Aquatic Parameters.



Both broadleaf and evergreen trees can dominate Pennsylvania wetlands, although broadleaf trees remain much more abundant (McCaskill *et al*. 2013). The value of forested wetlands to wildlife and to landowners is affected by the number of kinds of trees and other plants present (species diversity), their density and biomass (timber volume), the amount of dead timber standing and on the ground, the amount of grazing by domestic livestock and browsing by white-tailed deer, and the proportion of non-natives present. Diverse, high-quality vegetation is at greatest risk of human degradation and is the most difficult to restore (Olson and Doherty 2011). Wetland forests provide nesting, rearing, resting, and feeding sites for birds and mammals. One third of the bird species in the United States depend on wetlands (230 of 636; Welsch *et al*. 1995). Bears spend 60% of their time in forested wetlands during spring and summer (Newton 1988).

Unfragmented wetland forests are of great importance to many declining species of migratory songbirds. Wet forest floors are attractive wintering areas in which endangered bog turtles hibernate, and thick stands of evergreens shelter wintering deer and other animals. As already noted, the nutrients derived from tree leaves and twigs are vital to the macroinvertebrates and fish of Pennsylvania streams. Forest ecosystems are limited in their growth capability and affected in species composition by the availability of nutrients provided by the weathering of rock and transported in by air masses. The carbon from tree litter in turn can make up 99% of the total dissolved organic carbon at the base of the aquatic food web in forested streams (Stoler and Relyea 2011). Isolated vernal pools free of predatory fish are critically important to many uncommon reptiles and amphibians whose populations are dwindling. Discharges of stormwater, waste chemicals, and rubbish can degrade general habitat functions in forest and other wetlands.

Permanent forest disruption across Pennsylvania wetlands and uplands.

Scrub wetlands accumulate less standing biomass than mature forests. Hence any of the functions that derive from quantity of biomass are reduced in scrub as compared with forest wetlands, such as influence on microclimate, the amount of organic matter available for consumers of plant biomass, or the protection offered to soil from erosion. Some herbaceous wetlands can produce biomass in quantities rivaling forests above and below ground, but they lack the structural diversification of above-ground biomass of the woody wetlands. For animals adapted to herbaceous wetlands, such ecosystems provide important general habitat, nesting, resting, and rearing sites. The microtopography of hummocks provides habitat diversity critical to many species. Temporarily or permanently inundated herbaceous wetlands linked to streams and lakes have key importance as spawning and nursery grounds for fish, and inundated scrub wetlands are more common than inundated forests in Pennsylvania. The scrubs and sedge meadows with deep organic deposits associated with very wet herbaceous wetlands are prime spring and summer areas for various reptiles including the endangered bog turtle (*Glyptemys muehlenbergii*). Bog turtles prefer to overwinter in mats of tree roots where emerging groundwater warms near-surface temperatures. Herbaceous wetlands are of special importance to migrating waterfowl.

2. Environmental Study Areas and Refuges

Forested wetlands can serve as environmental study areas, particularly when located near schools, in public parks, and on other sites available to the public. Because natural plant succession in Pennsylvania normally trends toward forest vegetation, forests usually characterize refuges and sanctuaries relatively undisturbed by people, and forested wetlands typically provide high quality habitat to wildlife. The significance of forest cover to wetland wildlife increases as the size of wetlands decreases, particularly in landscapes with intensive human activity.

Scrub and herbaceous wetlands also can serve as study areas and biological refuges. They are less screened visually and aurally from adjacent human activities by their relatively lower quantities of biomass. They provide key habitat for wetland plants and animals that require open sun reaching the soil surface. Herbaceous wetlands are prime locations for birders.

3. Water Quality and Quantity Protection and Drainage Patterns

Forest wetland vegetation has maximal effect on processes affecting water movement and interaction with the land. By their mass, trees are able to slow the energy of falling raindrops and thereby limit soil erosion. Similarly, their mass and shade render the affected ground beneath the trees moister and cooler than nearby areas open to the sun. Decaying leaves provide a surface that readily accepts precipitation and allows it to infiltrate soil rather than quickly running off the surface.

The interflow through soils in turn contributes to natural extended flow of streams, minimizing both flooding and stream dryup. Nutrients can be bound up in tree trunks for centuries, and thereby kept out of waterways. The complex chemical reactions in wetland soils allow bacterial denitrification fostered by the carbon from leaves and vital to preventing excess nitrate-nitrogen from reaching streams. Wetland tree roots also can help anchor banks of streams against erosion. Forest loss to other land uses in Pennsylvania occurs at the rate of about 150 acres per day (McCaskill *et al*. 2013). Presumably most of these converted lands are not wetland forests, inasmuch as PADEP acknowledges the loss of less than 100 acres of all wetlands annually via individual permits, including forested wetlands.

Scrub and nonpersistent herbaceous wetlands stockpile less biomass on the land surface year-round than forested wetlands. They may offer less protection to the soil than forested wetlands, and their smaller roots may provide less resistance to physical erosion of streambanks.

Discharges of wastewater can contain pollutants at sufficient concentrations to overwhelm the ability of natural wetland systems to accommodate the pollutants, resulting in severe damage to the wetland ecosystems by manure, sewage, spilled brine, oil, and other chemicals. Rubbish also can degrade general habitat functions in forest and other wetlands.

4. Shoreline Protection and Stormwater Shielding

Aside from those on the banks of lakes and large rivers, forested wetlands in Pennsylvania generally have limited opportunity to shield other areas from wave and storm damage. Tree roots can stabilize streambanks large and small against stormwater erosion. To a lesser degree scrub wetlands can function similarly. Shrub willows often are planted to stabilize shorelines.

Some herbaceous wetlands occupy the shallow fringes of large water bodies, where they serve to reduce wave action and encourage sedimentation (thereby protecting water quality).

5. Flood Storage

Forested wetlands often serve as temporary storage areas for storm and flood waters. The economic value of such storage increases annually as flood damages rise in response to increased runoff from a growing human population, impervious surfaces from ever-expanding land development, and storm events of increasing severity driven by global warming in response to the burning of fossil fuels. Many forest ecosystems are adjusted to and dependent upon seasonal flooding, unlike most human structures that are easily damaged even by short-term inundation during flood peaks. Scrub and herbaceous wetlands, provided that they are suitably located, can function equally as well as forested wetlands for temporary

stormwater storage, although they may not shade the stored water so effectively and therefore not keep its temperature so low as a dense forest cover.

6. Groundwater Discharge

Spring seep areas are characteristic along the base of slopes in Pennsylvania forested wetlands. The forest shade keeps summer temperatures low as groundwater travels over the land surface toward headwater streams. Trout are a major feature of Pennsylvania streams and much sought-after by anglers. Many Pennsylvania streams have water near the limit of summer warmth that trout can tolerate. Forested wetlands along watercourses are essential to maintaining temperatures low enough for trout to survive and reproduce as global warming continues in response primarily to the burning of fossil fuels. Conversely, because of the warmth of groundwater, spring seeps may become snow-free earlier than dry uplands, and thereby attract feeding turkeys and other wildlife.

Shrub and herbaceous wetlands also can be associated with seeps flowing toward small streams. They are less able to keep surface water temperatures low than forests because of their lesser shade, but they may transpire fewer gallons of water during the course of a hot day. As mentioned previously, groundwater seeps closely associated with masses of tree roots are especially attractive areas for overwintering bog turtles.

Forested Wetland with Seeping Groundwater Discharge.

7. Groundwater Recharge

Countless local topographic depressions in forested wetlands store precipitation, slow its movement toward streams during periods of flood, and enable it to recharge local groundwater during wet seasons. Recharged groundwater, in turn, typically finds outlets to local streams. Recharge can be greater in scrub and herbaceous wetland depressions, because their plant cover transpires less water into the atmosphere than large trees.

8. Pollution Prevention and Sediment Control

Forested wetlands prevent pollution of water bodies by reducing the erosive force of rainstorms. Their trees break the fall of droplets hitting leaves and branches; they anchor the soil with roots and cover it with absorptive leaf litter; their roots bind streambank soils against erosion. Forested wetland soils enable sedimentation, denitrification, and other biogeochemical processing as surface waters pass through. Scrub and herbaceous wetlands can function comparably, but provide less physical protection against soil erosion by precipitation. Forested buffers surrounding wetlands can provide the most effective long-term protection of wetlands from sediment influx originating in disturbed lands.

9. Human Recreation

Wetland forests provide recreational opportunities for Pennsylvania citizens and visitors, calling forth significant contributions to the economy of the Commonwealth on a sustainable basis by those who use the outdoors. Great numbers of people find the seasonally changing display of blooms and colored leaves highly attractive and a sharp contrast to landscapes in urban centers. Recreational hunters seek the game animals---deer, bear, squirrels, waterfowl, and other game birds---that depend on wetland as well as upland forests. Anglers depend on riparian forests to keep the Pennsylvania streams cool enough and to supply food for salmonids. Forested wetlands are especially effective in providing humans with natural landscapes contrasting sharply with urban commercial and industrial environments.

Scrub and herbaceous wetlands also provide recreational opportunities for hiking and for game habitat. Herbaceous wetlands often attract spectacular flocks of migratory waterfowl.

Palustrine Deciduous Scrub Opening in Needleaf-Dominated Bog on Peat.

Rosencrans Bog Natural Area, Clinton County. Photograph by Staff of The Western Pennsylvania Conservancy.

Through its recent draft technical guidance documents PADEP appears to be seeking to expand from a strictly acreage-based evaluation of wetland impacts and working instead toward a weighting of functions, indexing to reference ecosystems, and consideration of conditions adjacent to the affected wetland. State methodology also is just beginning to consider cumulative effects on a watershed basis, which is essential for rationally offsetting the negative side effects (externalities) of construction in wetlands. The proposed technical guidance draws conceptually on federally sponsored work on wetland functions that has been underway for twenty years (Smith *et al*., 1995) as well as the more recent work by Robert Brooks and his coworkers at Riparia, the Cooperative Wetlands Research Center at Pennsylvania State University. PADEP's current list of functions is displayed below.

Table 2
Wetland Functions and Their Value

Functions Related to Hydrologic Processes	Benefits, Products, and Services Resulting from the Wetland Function
Short-Term Storage of Surface Water: the temporary storage of surface water for short periods.	Onsite: Replenish soil moisture, import/export materials, conduit for organisms. Offsite: Reduce downstream peak discharge and volume and help maintain and improve water quality.
Long-Term Storage of Surface Water: the temporary storage of surface water for long periods.	Onsite: Provide habitat and maintain physical and biogeochemical processes. Offsite: Reduce dissolved and particulate loading and help maintain and improve surface water quality.
Storage of Subsurface Water: the storage of subsurface water.	Onsite: Maintain biogeochemical processes. Offsite: Recharge surficial aquifers and maintain baseflow and seasonal flow in streams.
Moderation of Groundwater Flow or Discharge: the moderation of groundwater flow or groundwater discharge.	Onsite: Maintain habitat. Offsite: Maintain groundwater storage, baseflow, seasonal flows, and surface water temperatures.
Dissipation of Energy: the reduction of energy in moving water at the land/water interface.	Onsite: Contribute to nutrient capital of ecosystem Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality
Functions Related to Biogeochemical Processes	**Benefits, Products, and Services Resulting from the Wetland Function**
Cycling of Nutrients: the conversion of elements from one form to another through abiotic and biotic processes.	Onsite: Contributes to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Removal of Elements and Compounds: the removal of nutrients, contaminants, or other elements and compounds on a short-term or long-term basis through burial, incorporation into biomass, or biochemical reactions.	Onsite: Contributes to nutrients capital of ecosystem. Contaminants are removed, or rendered innocuous. Offsite: Reduced downstream loading helps to maintain or improve surface water quality.
Retention of Particulates: the retention of organic and inorganic particulates on a short-term or long-term basis through physical processes.	Onsite: Contributes to nutrient capital of ecosystem. Offsite: Reduced downstream particulate loading helps to maintain or improve surface water quality.
Export of Organic Carbon: the export of dissolved or particulate organic carbon.	Onsite: Enhances decomposition and mobilization of metals. Offsite: Supports aquatic food webs and downstream biogeochemical processes.
Functions Related to Habitat	**Benefits, Goods and Services Resulting from the Wetland Function**
Maintenance of Plant and Animal Communities: the maintenance of plant and animal community that is characteristic with respect to species composition, abundance, and age structure.	Onsite: Maintain habitat for plants and animals (e.g., endangered species and critical habitats), for rest and agriculture products, and aesthetic, recreational, and educational opportunities. Offsite: Maintain corridors between habitat islands and landscape/regional biodiversity.

Stressors

The functional values of wetlands can be reduced by many stressors, most of which are directly or indirectly the result of human activity and also are more intense and persistent than natural disruptive forces. The evolving PADEP list of stressors lists 37 kinds that are readily observable in the field, grouped into five categories (Draft Technical Guidance Document 310-2137-002, March 2014, p. 33). They prudently have left a blank for other, unlisted stressors in each of the five categories, for less commonly encountered conditions.

PADEP-listed Wetland Stressors.

Vegetation Alteration
Mowing
Moderate livestock grazing (within one year)
Crops (annual row crops, within one year)
Selective tree harvesting/cutting (>50% removal, within 5 years)
Right-of-way clearing (mechanical or chemical)
Clear cutting or Brush cutting (mechanized removal of shrubs and saplings)
Removal of woody debris
Aquatic weed control (mechanical or herbicide)
Excessive herbivory (deer, muskrat, nutria, carp, insects, etc.)
Plantation (conversion from typical natural tree species, including orchards)
Other:
Total Number:
Hydrologic Modification
Ditching, tile draining, or other dewatering methods
Dike/weir/dam
Filling/grading
Dredging/excavation
Stormwater inputs (culvert or similar concentrated urban runoff)
Microtopographic alterations (e.g., plowing, forestry bedding, skidder/ATV tracks)
Dead or dying trees (trunks still standing)
Thermal alteration (power plant or industrial discharges with evidence of high temperatures)
Stream alteration (channelization or incision)
Other:
Total Number:
Sedimentation
Sediment deposits/plumes
Eroding banks/slopes
Active construction (earth disturbance for development)
Active plowing (plowing for crop planting in past year)
Intensive livestock grazing (in one year, ground is >50% bare)
Active selective forestry harvesting (within one year)
Active forest harvesting (within two years, includes roads, borrow areas, pads, etc.)
Turbidity (moderate concentration of suspended solids in the water column, obvious sediment discharges)
Other:
Total Number:

Eutrophication
Direct discharges from agricultural feedlots, manure pits, etc.
Direct discharges from septic or sewage treatment plants, fish hatcheries, etc.
Heavy or moderately heavy formation of algal mats
Other:
Total Number:
Contaminant/Toxicity
Severe vegetation stress (source unknown or suspected)
Obvious spills, discharges, plumes, odors, etc.
Acidic drainages (mined sites, quarries, road cuts)
Point discharges from adjacent industrial facilities, landfills, railroad yards, or comparable sites
Chemical defoliation (majority of herbaceous and woody plants affected, within one year)
Fish or wildlife kills or obvious disease or abnormalities observed
Excessive garbage/dumping
Other:
Total Number:

The more numerous the stressors affecting a wetland, the lower its value. When rating the value of wetland conditions, the proposed PADEP scoring also assigns higher value to wetlands surrounded by forests than to those surrounded by scrub, and assigns higher value to those wetlands surrounded by scrub than to those surrounded by herblands or ponds. Managed wetland buffers are scored lower than wild, unmanaged buffers (Draft Technical Guidance Document 310-2137-002, March 2014, p. 33).

In 2006 PADEP sampled 204 wetlands and used their evolving protocols to rank the condition of those wetlands (PADEP 2014c). How representative the sampled wetlands might be of Pennsylvania wetlands as a whole was not stated, but the rankings from their protocol testing were reported as follows:

Condition Category	Number of Wetlands	Total Acreage	Percent of Resource
Highest	13	127.74	6.10%
High	59	556.19	26.70%
Medium	41	468.89	22.50%
Low	91	930.07	44.70%
Totals	**204**	**2082.88**	**100.00%**

Conversion of Woody Wetlands to Herbaceous Wetlands

Forest and scrub wetlands can be converted to herbaceous wetlands in various ways with effects more or less catastrophic, even if wetland conditions are not intentionally obliterated permanently to enable the construction of roads, buildings, or farm fields. Woody stems can be cut at the ground surface and merely the aboveground trees and shrubs removed, if the goal is to reduce disruption of the soil. More invasively, tree stumps and shrub roots can be grubbed. Biologically active soils can be removed entirely. Hydrology can be diverted or impounded. The amounts and kinds of functions lost and gained will be determined by what conditions previously existed in the wetland as well as the nature and extent of disturbance. If any one of the three major wetland characteristics (hydrophytic vegetation, hydric soils, or hydrology) is not or cannot be restored to natural conditions, then the conversion of wetland to non-wetland will be permanent. The conversion of forested wetlands to scrub or herbaceous wetlands is not readily reversible, inasmuch as forest regrowth at best requires many decades, and may be intentionally prevented by repeated cutting or by spraying herbicides.

When wetland vegetation is changed by people from forest or scrub to herbaceous, many of the wetland's functions can be altered. Detailed study is necessary in order to predict accurately the probable changes and compose plans for appropriate mitigation, because the affected functions will vary at each location supporting a natural wetland.

Where naturally variable wetland hydrology has been restored, some generalist wetland plants usually will follow quickly unless toxic substances also have been introduced, and hydric soils eventually will become recognizable after many years of weathering have elapsed. Pennsylvania wetlands evolved after the retreat of glacial ice, and their biota retains the ability to recover following natural disturbances that are less drastic than those of current technology. Unless artificial plantings are made to accelerate the establishment of desirable species, however, invasives that thrive in human-disturbed wetlands are likely to invade and crowd out preferred species of native plants. Construction activities usually provide ample opportunities for invasive plants and animals to arrive at construction sites. Various online sources provide links to information on invasive species, including those of the Governor's Invasive Species Council of Pennsylvania (www.invasivespeciescouncil.com), the Pennsylvania Department of Conservation and Natural Resources (www.dcnr.state.pa.us/conservationscience/), and the US Forest Service (www.fs.fed.us/invasivespecies).

If the objective is to restore pre-disturbance native wetland vegetation, then near-replacement of pre-disturbance hydrology and soils is most likely to yield the desired plant community. Such replacement only succeeds where careful investigation of plants, soils, and hydrology preceded the wetland disturbance, so that mitigation site modification effectively can mimic the structure of the lost

wetland. Light-tolerant herbaceous and scrub wetland plants can be restored more rapidly than forest vegetation, which takes many years for trees to reach mature size and natural diversity even where maximally successful. Protection of new plantings of native woody species from browsing deer and rabbits often is critical for the survival of the plants during the early years after wetland creation or restoration, and supplemental watering may be necessary during unusually dry years while root systems are being formed. Plantings of herbaceous wetlands can be devastated by migrating waterfowl. Moreover, the early-succession trees which will thrive in an open wetland only slowly are replaced by shade-tolerant species of late forest succession. Late-succession native herbs characteristic of mature Pennsylvania forested wetlands would not be expected to grow until the forest canopy has become reestablished and soil formation has proceeded to approximate natural conditions.

Compensatory mitigation in the form of replacement wetland creation or degraded wetland restoration is intended to result in functioning wetlands that do not require ongoing human intervention. Pennsylvania permit conditions long have required five years of monitoring for wetland restoration and creation projects along with written reports to PADEP, but post-construction monitoring has been sporadic at best and approved wetland restoration plans often have been unsuccessful in execution. Ponds are much easier and quicker to build than forested wetlands, but do not provide mitigation for various wetland functions. Similarly, basins engineered to detain stormwater flows from developed areas seldom result in high-value wetlands.

As one illustrative example of the conversion of woody wetlands to herbaceous cover, pipelines can be considered. The excavation of trenches for miles uphill, downhill, and across streams and wetlands is a catastrophic event followed by some measure of soil cover replacement on top of the pipes. But few pipeline operators

Pipeline construction through Pennsylvania wetlands. The corridor will be maintained free of woody vegetation after the pipe is buried.

Herbaceous Wetland 40 Years after Pipeline Installation.

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are prepared to allow reforestation to obscure right-of-way conditions. Thus pipelines are likely to involve vegetation stressors such as right-of-way clearing, clear-cutting of brush, and removal of woody debris both prior to and for the long term subsequent to pipeline installation. Mechanical clearing using equipment occurs, as does spraying with non-selective chemical herbicides to prevent the reestablishment of trees and shrubs so that rights-of-way can be quickly inspected on the ground and from the air.

In summary, the most probable, usually adverse effects of human conversion of forest or scrub to herbaceous wetlands on PADEP-listed wetland functions, the following would be expected and should be considered carefully:

1. **General Habitat and Natural Biological Functions**
   Aboveground biomass: decrease
   Forest interior habitat: loss
   Structural diversity: decrease within converted wetland
   Visual and aural screening from human activity: loss
   Local climate amelioration: decrease
   Evergreen winter cover for wildlife: loss
   Suitability for shade-loving species of plants: loss
   Production of mast (such as acorns) for wildlife: loss

Exposure to harsh wind, ice, sun: increase
Localized effects of global warming on biota: increase

2. **Study Areas and Refuges**
   Structural diversity of ecosystem: decrease within converted wetland
   Species diversity of plants and animals: decrease within converted wetland
   Visual and aural screening from human activity: loss
   Rare, ancient trees: loss

3. **Drainage Patterns, Water Quantity, and Water Quality**
   Streambank anchoring against erosion: decrease
   Soil stabilization: decrease
   Erosion and sedimentation: increase
   Nutrient storage in ecosystem: decrease
   Maintenance of cold water temperature for trout: decrease

4. **Storm Damage Shielding and Shoreline Protection**
   Streambank stabilization: decrease

5. **Flood Storage**
   Storage volume: no significant change

6. **Groundwater Discharge**
   Volume discharged: increase (reduced transpiration)

7. **Groundwater Recharge**
   Volume recharged: increase (if soil not disrupted)

8. **Pollution Prevention and Sediment Control**
   Erosion and sedimentation control: decrease

9. **Human Recreation**
   Landscape aesthetics: disruption
   Species composition, plants and animals: change
   Forest interior species: loss
   Maintenance of cold water temperature for trout: decrease
   View and hiking corridors: increase

How much functional loss will occur as a result of authorized conversion from forest or scrub to herbland at any wetland location will depend on the functions initially present in the forested wetland, the severity of the disruption to the elements of the environment such as its soil and surface elevation, the location of the converted area in the landscape, and its connection with other wetlands, especially along stream corridors. As some functions decrease, others may increase. Given the complexity of the natural world, under some sets of circumstances an anticipated negative change actually could prove beneficial.

The degree to which impacts are negative also depends on the context of reference: "edge" species such as whitetailed deer, for example, benefit from forest fragmentation. The functional loss of forested wetland is never quickly reversible, even if active maintenance were to stop, nor is it capable of offsite mitigation except, at best, after long time delays.

Not currently identified by PADEP in its list of functions, conversion of forest to herbaceous wetland also entails a reduction in the ability of the wetland to affect human climate and to reduce air pollution. Herbaceous wetlands cannot rival forests in providing shade and screening people from wind. Likewise, they cannot promote the deposition of airborne pollutant particles or take up as much gaseous pollution as wetland forest trees.

In principle, some of the functional losses of vegetation conversion eventually can be replaced by successful wetland mitigation onsite or offsite. But the actual substitution of lost functions by compensatory wetlands is not routine.

Wetland Compensatory Restoration and Creation

Because wetland damage and destruction routinely are authorized by permits, agencies by regulation are to require the restoration of temporary damage and the offsetting replacement of permanent loss of natural wetlands. A plan for the mitigation of unavoidable impacts by regulation is required as part of every individual joint permit application for wetland encroachments in Pennsylvania, other than "small" projects deemed by PADEP to have no significant impact on safety or protection of life, health, or the environment [25 *Pa. Code* 105.13(d)(1)(ix)]. Mitigation is defined (at 25 *Pa. Code* 105.1) as

> An action undertaken to accomplish one or more of the following:
>
> Avoid and minimize impacts by limiting the degree or magnitude of the action and its implementation.
>
> Rectify the impact by repairing, rehabilitating or restoring the impacted environment.
>
> Reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action.
>
> If the impact cannot be eliminated by [the foregoing measures], compensate for the impact by replacing the environment impacted by the project or by providing substitute resources or environments.

PADEP records fewer than 100 acres of wetlands authorized for damage annually under individual permits during recent years, along with about 40 miles of streams (PADEP 2014c). These wetland statistics do not include losses through construction authorized by general permits. The statistics also do not include enforcement against unauthorized encroachments into streams and wetlands. (These stream statistics omit altogether about half of the land area of

the Commonwealth that occupies small watersheds where stream, but not wetland, destruction is authorized automatically by waiver.)

Since the 1990s PADEP has sought 1:1 minimum replacement for wetland acreage and functions, with a preference for mitigation adjacent to the loss and on the same property. Mitigation has been designed on an acreage replacement basis, typically with no allowance for less than complete success or the time during which wetland functions are absent. Functional replacement itself has seldom if ever been mandated. For enforcement cases, PADEP policy long has sought to require 2:1 acreage mitigation (PADEP 1992, 1997a). PADEP's stated preference has been for onsite mitigation close to the allowed wetland destruction rather than for remote offsite mitigation. Such mitigation would be undertaken by the permittee, who seldom is expert in wetland mitigation.

Because less intervention is required, the restoration of wetlands previously converted to agricultural uses typically is easier and less uncertain than conversion of uplands to wetlands. Wetland hydrology, for example, sometimes can be restored simply by crushing the drainage tiles installed by farmers in order to dry fields sufficiently for commercial crops. To the extent hydrology is removed temporarily, but then restored, wetland vegetation and some semblance of a wetland ecosystem can be recovered onsite where care is taken to reconstruct natural conditions insofar as practicable. Habitat functions often can be attained more readily in rural mitigation areas than adjacent to urban development sites where the restored or created wetlands are isolated from other areas of comparable habitat. Areas amenable to wetland restoration, however, often are located offsite at considerable distance from impacted areas and affected watersheds. Wetlands in stream valleys and floodplains do not necessarily substitute functionally for wetlands along headwater streams.

Successful wetland creation from dry land, even more than restoration, depends on careful identification of water budgets pre-construction to guide attempted restoration. Abundant field experience has demonstrated that small inaccuracies in analyzing or reconstructing hydrology will result either in dry non-wetlands or in open water ponds rather than vegetated wetlands.

Hydrology normally is removed by blocking the movement of water into a wetland (1) by diking or channelizing and diverting its flow and/or (2) by expediting the removal of water from a wetland by drainage pipes or pumps. Restoration of hydrology may require detailed attention to creating almost flat slopes, and often requires design for seasonal variability in wetness. Most natural wetlands, unlike typical farm ponds and detention basins, have very gently sloping land surfaces rather than abrupt banks. Effective wetness of surface soils within a wetland can be reduced by removal of natural vegetation on and adjacent to the mitigation area, impeding the recovery of wild plants and affecting the survival of replacement plantings. Hydrology derived from channelized stormwater can be toxic to wetland plants, if the stormwater brings in road salts, oil, excessive

nutrients, and other pollutants. Trees typically are less tolerant of salinity change than herbaceous plants (Adamus & Brandt 1990). Where urban runoff is the source of wetland hydrology, functional mitigation may be difficult to achieve.

Timely restoration of near-surface hydric soils that have wetland characteristics depends on the successful removal and segregation of topsoil, and then its replacement above the subsoil. By keeping holding time for stockpiled topsoil to a minimum, some of the natural seed bank can be salvaged to aid in wetland revegetation. Where the structure of the soil layers has been drastically altered, years are required for horizontal layering to become restored by natural weathering. If wetland hydrology was caused by impermeable subsurface layers such as clay lenses, and those are disrupted by excavation, capturing sufficient hydrology for wetland restoration may be impossible. If surface soil density is compacted, additional years are required for natural porosity to return along with the ability for water to penetrate (Stoler and Relyea 2011). The placement of only a few inches of soil on wetland trees and shrubs, as well as herbs, can be fatal to the disturbed plants. Mulch and short-lived cover crops can help stabilize soils without offering severe competition to desirable native wetland plants. A natural balance of groundwater recharge and discharge in constructed or restored wetlands is not easily achieved.

Given these technical considerations and the historical fact that practical humans long focused on draining and converting rather than restoring wetlands and wetland functions, the actual mitigation of wetland impacts has proved generally unsuccessful in Pennsylvania for many decades (*see*, for example, McCoy 1987, 1992; Kline 1991) and has not improved recently (Campbell *et al*. 2002, Cole & Shaffer 2002, Gebo & Brooks 2012, Hoeltje & Cole 2007, Kislinger 2008, PADEP 2014c). Seldom has mitigation created the same kind of wetlands as those damaged. Most attempted mitigation that succeeded in creating wet areas resulted in open water ponds rather than forested or scrub wetlands (Cole and Shaffer 2002). Monitoring and reporting on mitigation success on paper is required of applicants, but often not performed. PADEP staff seldom monitor wetland mitigation sites or require remedial measures of permittees.

PADEP has found that the ability of permittee-constructed mitigation

> to address the needs of a watershed is limited at best. Applicants generally do not have adequate resources to identify watershed needs, plan for and identify high value project sites, and/or secure rights to and produce significant restoration activities. (PADEP 2014c)

69 Permit Wetland Mitigations Scored by PADEP Interns, 1992-1995

Size (acres)	Success	Failure	Not Rated	% Success
0-.10	5	3	1	62.5
.10-.25	8	6	1	57.1
.25-.50	9	7	0	56.3
.50-1.0	11	3	0	78.6
1.0->	13	2	0	86.7
Total	46	21	2	68.7

Most Pennsylvania wetland impacts authorized by individual permit, after avoidance and minimization have been addressed, affect small acreages. Thus PADEP has implemented an acreage-based fee-in-lieu program to enable most permittees affecting small (0.5 acre or less) areas of wetland to substitute a one-time cash payment instead of undertaking their own construction of mitigation wetlands (PADEP 1997b). The half-acre "allowance" for cash contributions was deemed sufficient to allow any landowner enough wetland impact to build a house. Fees were set by PADEP based on its expectation that willing landowners across the Commonwealth would allow conversion of uplands to wetlands or restoration of wetlands with higher quality through voluntary cooperation with PADEP and the National Fish and Wildlife Foundation. This program has greatly assisted permittees, but it has not demonstrably resulted in compensatory wetland mitigation similar in kind or location to wetlands destroyed.

Contributions to the Washington, D.C.-based National Fish and Wildlife Foundation's Pennsylvania Wetland Replacement Project ID 95-096 became routine across the Commonwealth beginning in the 1990s. According to its web page, as of May 2014 this Foundation had sponsored 486 environmental enhancement projects of various kinds in Pennsylvania. Locational and descriptive information for these projects are displayed on an interactive map. But no data apparently exist comparing wetland acreage or functions lost to mitigation accomplished under the Pennsylvania in-lieu-fee program or identifying the geographical proximity of wetland losses versus gains on a watershed basis. Only first-time readers of PADEP regulations might expect any applicant eligible to use the Fund even to consider undertaking onsite mitigation, which is always far more expensive than scheduled contributions to the State's

Fund. The in-lieu fees long have represented a major subsidy to permittees from Pennsylvania residents and their environment (Schmid 1996a, b). Pennsylvania mitigation fees have been the same for Exceptional Value as for Other wetlands, and the acreage-based fees have been presumed to compensate for any and all wetland functions associated with the wetlands lost.

Pennsylvania Wetland Mitigation Replacement Fees (1997-2013).

De minimis impact less than or equal to .05 acre	$ 0.00
Greater than .05 acre to .10 acre	$ 500.00
Greater than .10 acre to .20 acre	$ 1,000.00
Greater than .20 acre to .30 acre	$ 2,500.00
Greater than .30 acre to .40 acre	$ 5,000.00
Greater than .40 acre to .50 acre	$ 7,500.00

Contributions to the Fund relieve permittees of any followup responsibility for mitigation monitoring or success. Between 1997 and 2013 the buying power of cash contributions to the Fund dwindled by about 30% due to inflation, while the market costs of wetland creation can be $100,000 per acre in some locations, according to the Pennsylvania Department of Transportation. Costs are less where free land and prison labor can be obtained (FHWA 2011). Moreover, the success of the wetland mitigation work done under PADEP's Replacement Project apparently has been limited and certainly has been sparsely reported. Pennsylvania's in-lieu-fee program was deemed unacceptable for use to satisfy federal wetland mitigation requirements in 2008, and its "grandfathering" expired in 2013 (33 CFR 332.8). Hence the PADEP currently is seeking federal approval for a new in-lieu-fee program (PADEP 2014c).

The generally laudable goals of the new program include (1) high quality mitigation addressing wetland functions as well as acreage, (2) ecologically based mitigation site selection, (3) efficiencies of scale in constructing, monitoring, and administering a few large mitigation projects instead of many small ones, (4) streamlined federal and State permit approvals, and (5) more effective accounting and compliance reporting (PADEP 2014c). PADEP claims that it has the expertise and staff to run an in-lieu-fee program effectively. As has been repeatedly demonstrated by PADEP staff and by independent academics, mitigation to date by permittees affecting more than the half acre of wetlands to which Fund contributions are limited typically has been of poor quality in Pennsylvania and has failed altogether in replacing the functions of wetlands lost.

The new PADEP technical guidance potentially represents an opportunity to have those who hope to benefit from damaging wetlands more effectively internalize the negative externalities of their conduct, a goal consistent with both Pennsylvania and federal law. It is not self-evident that the functions of multiple small, scattered wetlands high in the landscape can be replaced effectively by

larger wetlands in floodplains, and PADEP may be asked to address this issue, as well as many other technical details, prior to gaining federal approval for its proposed in-lieu-fee program. Unquestionably, more information will need to be generated during preparation and review of each application to damage wetlands, if new PADEP technical guidance is adopted along the lines of its current draft. A significant outcome should be the more effective tailoring of compensatory mitigation to the amount and type of wetland impacts. The full costs of mitigation should include both the risk of mitigation failure and the temporal lag between impacts and restoration of functions---which, for forested wetlands can be immense.

Only if this opportunity is fully exploited will future mitigation begin to compensate for permitted impacts in Pennsylvania. The new guidance also can provide a corrective to the mitigation failures and lack of accountability long prevalent in Pennsylvania, while reducing the previous economic subsidies encouraging private destruction of wetland resources. The new information available also should allow better public understanding of the external costs of development and the benefits of successful mitigation, particularly if public access to permit records is made electronically available.

It is high time that human behaviors with harmful side effects in Pennsylvania be mitigated more effectively to enable continued prosperity for its residents and the planet's survival, as well as compliance with Article 1, Section 27, of the Pennsylvania Constitution:

> The people have a right to clean air, pure water, and to the preservation of the natural, scenic, historic and esthetic values of the environment. Pennsylvania's public natural resources are the common property of all the people, including generations yet to come. As trustee of these resources, the Commonwealth shall conserve and maintain them for the benefit of all the people.

When completed, the new PADEP technical guidance may make possible the actual functional mitigation for conversion of forest and scrub wetlands to herbaceous wetlands. If effective, it also should help reduce so-called "natural" hazards from waters---hazards which are in fact failures of human design, construction, planning, and community development in areas subject to natural processes of stormwater movement. If the opportunity is missed, the alternative includes increased environmental plundering of remaining wetland resources, high costs for disaster survivors, especially the most vulnerable, as well as harm to communities and ever growing costs to taxpayers.

Completion of public review, PADEP revision, and implementation of the new technical guidance for wetland assessment and mitigation may take considerable time. Pennsylvania wetlands only slowly have begun to receive some attention from regulators in the context of damage by longwall (that is, high-extraction underground) bituminous coal mining, which was first allowed by Act 54 of 1994. PADEP long refused to recognize even the possibility of damage to wetlands from

longwall mining, but gradually has been implementing more thorough data collection for mine applications (Schmid & Co., Inc. 2000, 2010a, 2011a, 2012, 2013).

The minimal current PADEP information and review requirements for oil and gas permits provide virtually no assurance that wetlands will be identified and protected from this extractive industry, which currently is experiencing a boom across much of the Commonwealth. Similarly, PADEP has failed to protect too many streams, particularly those streams of highest ecological value (Van Rossum *et al*. 2011; Kunz 2011; Schmid & Co., Inc. 2010b). Oil and gas permit applications generate far less environmental information than coal mining applications. Proposed regulations governing surface oil and gas activities currently are under review (25 *Pa. Code* 78, Subchapter C). PADEP and the Environmental Quality Board are preparing responses to the 24,000 comments received on their proposed oil and gas regulations. New Chapter 78 regulations could specify protection for streams and wetlands far more effectively than the regulations they are replacing.

Whether the proposed wetland analysis and mitigation technical guidance will receive similar public attention remains to be seen. Its comment period is still open and likely to be extended.

Authorship

This report was prepared by James A. Schmid, a biogeographer and plant ecologist. Dr. Schmid received his BA from Columbia College and his MA and PhD from the University of Chicago. After serving as Instructor and Assistant Professor in the Department of Biological Sciences at Columbia University and Barnard College, he joined the environmental consulting firm of Jack McCormick & Associates of Devon, Pennsylvania. Since 1980 he has headed Schmid & Company of Media, Pennsylvania.

Dr. Schmid has analyzed and secured permits for some of the largest wetland mitigation projects in the mid Atlantic States, as well as a myriad of smaller projects. He is certified as a Senior Ecologist by the Ecological Society of America, as a Professional Wetland Scientist by the Society of Wetland Scientists, and as a Wetland Delineator by the Baltimore District, Army Corps of Engineers. He has served on the professional certification committees of the Ecological Society and the Society of Wetland Scientists.

When the US Fish & Wildlife Service Pleasantville Office evaluated actual compliance with approval conditions requiring mitigation by about 100 of the Clean Water Act Section 404 fill permits issued by the Corps of Engineers in the State of New Jersey during the period 1985-1992, every Schmid & Company mitigation project was judged in the field to exhibit full compliance with all permit requirements and mitigation goals. Schmid & Company mitigation projects

represented 21% of all the mitigation projects judged fully successful in New Jersey by USFWS in its written report to USEPA. Dr. Schmid analyzed and secured Wetland Mitigation Council approval for the first major freshwater mitigation bank in New Jersey on behalf of DuPont. That bank was donated to The Nature Conservancy.

Dr. Schmid has often analyzed environmental regulatory programs and commented on proposed regulations. His clients continue to include the construction industry, conservation groups, and government agencies, including the Pennsylvania Department of Environmental Protection.

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APPENDIX A
Functions and Benefits of Riparian Forest Buffers

Riparian forest buffers serve many functions and provide many benefits including:

1. Protection and Enhancement of Water Quality

a. **Filtration of pollutants in runoff:** Mature riparian forest buffers can slow overland runoff from any source by increasing the water's contact time with the spongy forest floor. Runoff containing pollutants such as sediments, nutrients, pathogens, and toxics from rooftops, streets, lawns, farm fields, and parking lots can flow into a riparian forest buffer from the area up grade and be considerably cleaner when it enters the perennial or intermittent stream, lake, pond, or reservoir. The forest floor of the riparian forest buffer soaks up the water and makes pollutants contained in it available for processing into less harmful forms. The tree roots can also remove pollutants from shallow groundwater flowing beneath the forest floor to the waterbody.

b. **Light control and water temperature moderation:** A mature riparian forest buffer that is at least 100 feet in width lowers light levels in the streambank or shoreline area of a waterbody that inhibits the growth and production of harmful algae and helps maximize stream width by shading out grasses. The shading that a riparian forest buffer provides helps to lower water temperatures in summer and moderates harsh winter temperatures by trapping back-radiation (Beschta et al., *Stream*). Both light control and water temperature moderation maximize dissolved oxygen content in lake and stream waters and increase the amount of instream pollutant processing.

c. **Pollutant processing:** Trees in a mature riparian forest buffer, their fallen leaves and the plants and animals that live on, in, and under the trees form an ecosystem that is capable of processing pollutants such as sediments, nutrients, and toxics in the water that passes through the riparian forest buffer as sheet flow. The leaves of native trees in the riparian forest buffer that wash into the stream serve as a rich food source for benthic macroinvertebrates which are capable of instream pollutant processing.

d. **Infiltration and maintenance of streamflow**: Riparian forest buffers slow overland runoff allowing for infiltration of surface water that helps to maintain base flow in streams and rivers.

e. **Channel and shoreline stability/decrease in erosion:** The canopy of a mature riparian forest buffer collects water and protects the ground below in storm events. The rain water also tracks along the trunk of the large trees before reaching the ground. The root network of the riparian forest buffer is tightly intertwined and holds soil particles together keeping them securely in place against the forces of both direct precipitation and stormwater runoff from areas surrounding the riparian forest buffer. This reduces the force of the water as it reaches the waterbody. In this way, riparian forest buffers minimize shoreline and streambank erosion, instream scour, and sedimentation associated with channel instability.

2. **Protection and Enhancement of Aquatic Habitat**

a. **Water quality:** The water quality functions described in Section 1 of this appendix are crucial to the protection of aquatic habitat. Moderating water temperatures and light levels in both summer and winter and maintaining sufficient dissolved oxygen levels and stream width are essential to a healthy ecosystem. Removing pollutants from runoff helps to ensure clean water and oxygen for aquatic organisms. Maintaining stream volume ensures flowing water even during the driest months to provide habitat for aquatic biota. Reducing the amount of sediment entering a perennial or intermittent stream, river, or lake protects the eggs and young fish, amphibians, and benthic macroinvertebrates from suffocation. This also helps increase the epifaunal substrate and cover, which provide important habitat for benthic macroinvertebrates and other aquatic organisms.

b. **Shoreline and streambank stability:** Tree roots in the mature riparian forest buffer stabilize shorelines and streambanks. They also allow for undercut banks that provide cover and cool water refuge for fish, reptiles, and amphibians.

c. **Stream width:** The shading associated with mature riparian forest buffers along the banks of rivers and streams prevents channel narrowing due to riparian grasses.

d. **Food supply:** Organic detritus (leaves, twigs, and other materials) derived from riparian forest buffers is a critical source of the energy for supporting aquatic food chains in most aquatic ecosystems.

e. **Woody debris:** Large woody debris (LWD) from the riparian forest buffer enters the aquatic ecosystem as trees fall into the perennial or intermittent stream, river, lake, pond, or reservoir or are delivered to the waterbody through floodwaters. LWD provides: refuge from high flows for aquatic biota; overhead cover for fish; substrate and food for benthic macroinvertebrates; and substrate for plants. LWD influences the formation of pools, backwaters, and shallow slack water, increasing the complexity of aquatic habitat and influencing the storage and transport of aquatic food sources. During high flows, LWD traps sediments and retards scouring of the channel bed and banks. This reduces the affects of wave action on lake shorelines, maintaining habitat for aquatic biota.

f. **Lakeshore, channel, and floodplain stability:** Attenuating floodwater is as important for aquatic biota as it is for the channel or lake shoreline itself. Floodwaters that are not allowed to dissipate horizontally over a floodplain build up energy within the channel, often causing excessive scour of the channel bed that can cause fish kills and amphibian mortality due to mobilization of large substrates in the channel bed. The mature trees of the riparian forest buffer stabilize both streambanks and lake shorelines preventing the collapse of undercut banks that provide cover and cool water refuge for fish, reptiles, and amphibians.

3. **Moderation of the Effects of Climate Change**

a. **Aquatic ecosystem adaptation:** Riparian forest buffers maintain or enhance instream ecological health. Keeping the aquatic system as healthy as possible will help to keep the ecosystem stable and better able to adapt to a changing climate. Mature riparian forest

buffers contribute significantly to the energy source for the ecosystem and provide habitat and ecological niches leading to a diverse and stable aquatic community (Seavy, N.E. et al., *Why)*.

b. **Temperature moderation:** Mature riparian forest buffers, properly sized, provide a significant temperature moderating effect, keeping water and riparian temperatures cooler and diurnal temperature fluctuations less extreme (Jones et al, *Quantifying*).

c. **Reduction in suspended sediment:** Riparian forest buffers stabilize streambanks leading to less suspended sediment entering the water column. Suspended sediment will lead to increased stream temperatures and a depressed aquatic community.

d. **Reduction of carbon source (footprint):** Riparian forest buffers reduce the carbon source of the ecosystem due to their fallow nature. Also carbon sequestration values could be attributed to the mature trees within a riparian forest buffer.

4. **Protection and Enhancement of Terrestrial Habitat**

a. **Habitat for wildlife and vegetation:** The vertical and horizontal dimensions of riparian forest buffers provide multiple habitat benefits. The trees provide cavities for birds and small mammals to rest, nest, and breed. The native trees and shrubs of the riparian forest buffer also provide fruits, nuts, and seed for a diverse population of native wildlife. A large part of the life cycles of amphibians and reptiles occur in mature riparian forest buffers. The same is true for many aquatic insects, which use riparian vegetation as reproductive swarming sites, nymph emergence sites, and food. In addition, many species of native forbs can survive only in areas near water.

b. **Support of aquatic food chains and webs as they relate to terrestrial food webs:** The vertical and horizontal dimensions of riparian forest buffers provide multiple habitat benefits. Vegetation, such as fallen leaves and branches, are important in providing food and cover for benthic macroinvertebrates and fish. These macroinvertebrates and small fish, in turn, provide food for many larger fish, reptiles, amphibians, mammals, and birds.

c. **Habitat for rare, threatened, and endangered species:** Many of Pennsylvania's rare species of plants and animals are dependent on riparian forest buffers for at least a part of their life cycle.

d. **Preventing the spread of exotic or invasive species:** Nonnative invasive or exotic species and noxious weeds can easily establish in disturbed areas that were historically riparian forest buffers. These plants can significantly disrupt natural communities. Maintaining and restoring riparian forest buffers that are composed of predominantly native species is a key component in controlling the spread of these species.

e. **Travel corridors for migration and dispersal:** Many wildlife species in Pennsylvania are dependent on riparian forest buffers that act as corridors for safe travel for a wide array of wildlife. They also provide for wildlife passage through otherwise uninhabitable regions during periods of food shortage, for seasonal or diurnal movements within home ranges, and dispersal routes for juveniles of many species.

f. **Breeding habitat:** Many wildlife species, especially waterfowl, shore birds, many songbirds, and most amphibians and reptiles require the habitat provided by mature riparian forest buffers as conditions for breeding and for raising their young. Vernal pools found in many riparian forest buffers in Pennsylvania are critical habitat for breeding reptiles and amphibians.

g. **Genetic interchange:** Riparian forest buffers around Pennsylvania's streams, rivers, lakes, ponds, and reservoirs provide important dispersal routes for juveniles and breeding adults of some wildlife species. In this way the riparian forest buffers assist in genetic interchange with other local populations.

5. **Protection of Channel and Lake Shoreline Stability**

a. **Flood attenuation:** Riparian forest buffers that are a minimum of 100 feet wide provide space for channel meanders, stream movement, and floodwaters to spread out horizontally. This dissipates stream energy and protects channel stability and shoreline integrity in receiving waterbodies. The spongy floor of a riparian forest buffer along a pond, lake, or reservoir slows the affect of direct precipitation and runoff from areas adjacent to the riparian forest buffers and protects shorelines during floods.

b. **Reduced effects of storm events:** Mature riparian forest buffers that are sufficiently wide can slow the speed and reduce the volume of surface runoff from upland areas. The spongy floor of a riparian forest buffer along a pond, lake, or reservoir slows the affect of direct precipitation and runoff from areas adjacent to the riparian forest buffers. This protects stream channel beds and banks from powerful flash flooding that can scour and erode the channel. It also protects lake shorelines from erosive forces during large storms events and flooding.

c. **Streambank and shoreline stabilization:** The trees and shrubs in riparian forest buffers bind soil and increase the strength of the soil matrix. This enhances streambank and lake shoreline stability, which are important for reducing soil and property loss from the bank or shore, reducing sediment input to the waterbody, and maintaining overall channel stability. Mature trees also protect lakeshores from wave action.

d. **Ice damage control:** Riparian forest buffers along streams and rivers trap ice slabs during spring breakup, reducing the potential of jamming at downstream constrictions. Jamming can result in backwater and flooding upstream, which can lead to channel instability. Mature riparian forest lakeshore buffer zones are able to absorb the pressures of mid-winter ice push, protecting upland development from ice damage (Northwest Regional Planning Commission, *The Shoreline*).

6. **Social and Economic Benefits**

a. **Flood control:** Riparian forest buffers moderate floodwaters and protect human land use and investments from hazards associated with stream dynamics and shore erosion.

b. **Ice damage control:** The trees in Zone 1 of a mature riparian forest buffer insulate and warm the waters on the near shoreline/streambank area. This protects human land use

and investments from ice damage on the near shoreline/streambank and from affects of ice jamming and subsequent upstream flooding.

c. **Maintenance of optimal water quality for drinking water and recreation:** This would include protection of water quality for activities such as boating, swimming, fishing, and wildlife viewing.

d. **Maintenance of wastewater assimilation capacity of streams for reducing wastewater treatment costs:** Mature riparian forest buffers that are properly sized lower water temperature thereby increasing dissolved oxygen. This increases the waterbody's capacity to assimilate organic wastes, such as from wastewater treatment plants, and can greatly lower the cost of wastewater treatment (Ernst, *Protecting*).

e. **Passive recreational activities:** Riparian forest buffers provide natural surroundings for relaxation, observation of wildlife, photography, hunting, fishing, and other activities important to the people of Pennsylvania. Frequently pervious paths are cut through riparian areas and are used for hiking, bicycling, jogging, bird watching, and leisurely walks.

f. **Intrinsic values:** Mature riparian forest buffers composed of predominantly native vegetation enhances the preservation of natural functioning ecosystems and biological diversity.