NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION

SCIENCE ADVISORY BOARD

FINAL REPORT

VERNAL POOL: REVIEW OF MITIGATION APPROACHES

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VERNAL POOL: REVIEW OF MITIGATION APPROACHES REPORT

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A Report to the Science Advisory Board (SAB)
New Jersey Department of Environmental Protection

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EXECUTIVE SUMMARY

This report of the NJ Science Advisory Board Ecological Processes Standing Committee (EPSC) addresses charge questions focused on researching how the NJ Department of Environmental Protection might address impacts to vernal habitats (defined in state regulations at N.J.A.C. 7:7A-1.3) through effective mitigation. Vernal habitats are valuable to a variety of species of wildlife, particularly as breeding locations for amphibians such as frogs and salamanders in some cases have suffered population declines statewide and nationwide.

To address specific charge questions, the Committee performed a number of specific tasks:

- Reviewed existing federal and state regulations (from other states) to gather information on existing mitigation requirements required by other entities, and if possible, their success.

- Reviewed existing literature to provide examples on successful vernal habitat mitigation and evaluate how they might benefit specific species groups.

- Determined if existing regulatory approaches treat different types of vernal habitat based on their habitat, degree of permanence, etc.

- Evaluated monitoring requirements for vernal habitat mitigation projects, including appearance of disease or pathogens).

The Committee makes the following overall recommendations regarding restoration or creation of vernal habitats to mitigate for impacts:

- The preferred alternative to vernal pool mitigation is preservation. Where at all possible, functioning pools would be protected to the extent that both the pools themselves and sufficient upland area around them would be permanently preserved. Such an effort could be conducted regionally and perhaps focus on sites featuring high quality pools resulting in the long-term protection of fully functioning vernal pool communities. This would be more beneficial to New Jersey's vernal pool resources than trying to re-create pools on a site-by-site basis.

- Restoration is strongly preferable to the creation of vernal habitats, and the potential success rate of meeting mitigation goals is higher. Restoring vernal pool habitats allows for the ability to take advantage of a known hydrology. Creation of new vernal pool habitat starts from an ecological restoration point with too many unknowns.

- It is recommended that the NJDEP develop a consistent monitoring program for vernal pool mitigation/restoration projects with a concise set of performance criteria based on a full set of ecological parameters consistent with New Jersey wetlands. Performance criteria should consider local vernal pools unaffected by a proposed project as reference wetlands. Criteria should include not only measurement of vegetative parameters, but functional assessments and response from obligate wildlife species such as amphibians.

- While the EPSC did not find an example in the scientific literature where a vernal pool was created for the benefit of a single species (Charge Question #3), the EPSC does not recommend attempting to develop vernal pool habitat restoration or creation to benefit a single species. The EPSC found that it is challenging enough to restore or create a vernal pool to benefit several obligate species, it would be even harder to develop one to benefit one species. Particularly if the restoration or creation was part of a mitigation effort in which the NJDEP was requiring the applicant to meet certain success criteria to that species. This would be further confounded by the fact that there is so little know about the obligate species found in New Jersey and their exact habitat requirements and sensitivities.

- Restoration and/or creation of vernal habitats should incorporate strategy considerations outlined in Section 6, such as attempting to focus the restoration and/or creation on the various species found in the pools for which the mitigation is being conducted, as well as landscape level considerations including connectivity of restored or newly created vernal habitats.

1.0 INTRODUCTION

This report of the NJ Science Advisory Board Ecological Processes Standing Committee (EPSC) addresses charge questions focused on researching how the NJ Department of Environmental Protection might address impacts to vernal habitats (defined in state regulations at N.J.A.C. 7:7A-1.3) through effective mitigation. Vernal habitats are valuable to a variety of species of wildlife, particularly as breeding locations for amphibians such as frogs and salamanders which in some cases have suffered population declines statewide and nationwide. Vernal pools also support a variety of rare plant species regulated by the State of New Jersey. Additionally, vernal pools support many invertebrate species that are used as prey species by amphibians.

Vernal habitats are small, seasonal water bodies that pond water from the time of snowmelt into early to mid-summer (MNFI 2010). In the U.S., they are common throughout the glaciated Northcentral and Northeast Region, with most remaining pools being in forested settings. In New Jersey, they are found throughout the Coastal Plains physiographic province, especially in the Pinelands Management Area of South Jersey. Vernal habitats provide habitat for specific fauna, particularly amphibians and invertebrates that require the pools to complete their life cycles (Colburn 2004). Many of these species may be declining statewide and/or nationally. The vegetation present in and around these pools varies with hydrology; generally, the longer they are seasonally inundated the less they become vegetated later in the year.

In New Jersey, vernal habitats are specifically defined within the Freshwater Wetlands Protection Act (FWPA) rules at N.J.A.C. 7:7A-1.3.

"Vernal habitat" means a wetland as identified at N.J.A.C. 7:7A-3.1, or State open water, as defined above in this section that meets all the criteria at 1 through 4 below. Evidence of breeding by an obligate species under 2i below creates a rebuttable presumption that the criteria at 3 and 4 below are met:

> *1. Occurs in or contains a confined basin depression without a permanent flowing outlet;*
>
> *2. Features evidence of breeding by one or more species of fauna adapted to reproduce in ephemeral aquatic conditions, identified in N.J.A.C. 7:7A, Appendix 1, incorporated herein by reference. The following shall constitute evidence of breeding by such a species: i. One or more obligate species listed in Appendix 1, or evidence of such a species, is found in or immediately adjacent to the area of ponded water; or ii. Two or more facultative species listed in Appendix 1, or evidence of the presence of such a species, are found in or immediately adjacent to the area of ponded water;*
>
> *3. Maintains ponded water for at least two continuous months between March and September of a normal rainfall year; and*
>
> *4. Is free of reproducing fish populations throughout the year or dries up at some time during a normal rainfall year.*

It is noted that many regulatory agencies identify amphibian species found in vernal pools to be either "obligate" (dependent upon vernal pools for successful breeding) or "facultative" (animals that use vernal pools for resting or foraging, and may reproduce in vernal pools, but they use other habitats for reproduction as well) (Calhoun and Klemens 2002). Calhoun and Klemens (2002) go on to say that instead of obligate as a descriptor, the more correct designation should be indicator as several species commonly considered to be obligate species; wood frogs (*Lithobates sylvaticus*) and spotted salamanders (*Ambystoma maculatum*) for example, will breed in other types of wetlands, including roadside ditches. For purposes of convention, this document maintains the use of the term "obligate" but acknowledges that the term "indicator" may be more appropriate.

Vernal habitats, while themselves being defined in the regulations as either freshwater wetland or state open water, may be surrounded by wetland or non-wetland habitat. In New Jersey vernal habitats constitute small, ponded areas or pools that are often less than 0.25 acre in extent, and which may be smaller than 0.1 acre in extent in some cases.

Under FWPA regulations, impacting wetlands requires issuance of a general or individual permit. Requirements applicable to all general permits are described at N.J.A.C. 7:7A-5.7 and include a provision at N.J.A.C. 7:7A-5.7(b)15 that "*Activities authorized under a general permit-by-certification or general permit shall not take place in a vernal habitat, or in a transition area adjacent to a vernal habitat, with the exception of activities associated with general permits 1, 6, 6A, and 16, which shall be reviewed on a case-by-case basis in accordance with N.J.A.C. 7:7A-5.3(e).*"

Current mitigation requirements are presented at N.J.A.C. 7-7A-11, but these do not include specific mitigation requirements for vernal habitats. Under General Permits being used for projects, mitigation is required for impacting greater than 0.1 acre of wetlands or state open waters. Under Individual Permits, mitigation is required for all impacts to wetlands or state open waters.

Charge

The NJDEP has expressed an interest in finding out if there has been research on the need, ability, and success of mitigation for offsetting impacts to vernal habitat, specifically:

Question 1

Review of Vernal Pool Mitigation Requirements (What standards and/or ratios are typically utilized to assess whether vernal pond mitigation has been successful?)

a. Federal

b. State

Question 2

Examples of successful vernal pond mitigation. What were the general requirements and parameters (e.g., vegetation type, soils, area, other) for designing these mitigations?

Question 3

How do successful vernal pond mitigation strategies treat species? For example, are the approaches species-specific (e.g., tiger salamanders in CA) or broken down into categories (e.g., obligate and facultative)?

Question 4

Are there vernal pond 'banks' (like wetland banking) of credits utilized as a mitigation strategy? If known, what was the proximity of these banks to where the disturbance occurred?

Question 5

How does mitigation approach (regulatory buffers, timing restrictions, etc.) vary based on type of vernal pond (i.e., forest, open water, etc.)?

Question 6

How long following mitigation should vernal ponds be monitored and what variables of success are most important (i.e., hydroperiod, species diversity or population size, appearance of disease or pathogens)?

2.0 METHODOLOGY

To address the above specific charge questions, the Committee performed several tasks:

- Reviewed existing federal and state regulations (from other states) to gather information on existing mitigation requirements required by other entities, and if possible, their success.

- Reviewed existing literature to provide examples on successful vernal habitat mitigation and evaluate how they might benefit specific species groups.

- Determined if existing regulatory approaches treat different types of vernal habitat based on their habitat, degree of permanence, etc.

- Evaluated monitoring requirements for vernal habitat mitigation projects. Considered the appearance of disease or pathogens.

3.0 REGULATORY REVIEW

The following sections summarize Federal and State regulations in place to protect these natural resources.

3.1 Federal Wetland Regulations Pertinent to Vernal Pools

At the Federal level, some vernal pools can potentially receive protection under Section 404 of the Federal Clean Water Act, administered by the U.S. Army Corps of Engineers (USACE). The USACE cannot regulate "isolated wetlands" that lack a connection to a stream or waterway, and vernal habitats that meet that definition remain unprotected. However, the USACE has some flexibility if an indirect connection can be demonstrated. For example, a vernal pool may be considered connected to a waterway if it is connected to another wetland which drains into a stream, or if it is located in the floodplain of a stream, even if it does not usually have a direct surface connection to that stream.

As a type of wetland regulated pursuant to both Federal and State regulations (under certain circumstances), an intrusion or destruction of a vernal pool requires both a permit and associated mitigation as compensation for the injury or loss of the vernal pool. Compensatory mitigation involves actions taken to offset unavoidable adverse impacts to wetlands, streams and other aquatic resources authorized by Clean Water Act section 404 permits and other Department of the Army (DA) permits. As such, compensatory mitigation is a critical tool in helping the federal government to meet the longstanding national goal of ''no net loss'' of wetland acreage and function. For impacts authorized under section 404, compensatory mitigation is not considered until after all appropriate and practicable steps have been taken to first avoid and then minimize adverse impacts to the aquatic ecosystem pursuant to 40 CFR part 230 (i.e., the CWA Section 404(b)(1) Guidelines).

Compensatory mitigation can be carried out through four methods: the restoration of a previously existing wetland or other aquatic site, the enhancement of an existing aquatic site's functions, the establishment (i.e., creation) of a new aquatic site, or the preservation of an existing aquatic site. There are three mechanisms for providing compensatory mitigation: permittee-responsible compensatory mitigation, mitigation banks and in-lieu fee mitigation. Permittee-responsible mitigation is the most traditional form of compensation and continues to represent the majority of compensation acreage provided each year.

3.2 New Jersey Wetland Regulations Pertinent to Vernal Pools

New Jersey's freshwater wetlands program operates in place of the Federal 404 program throughout most of the State (although the U.S. EPA does have some oversight authority—N.J.A.C. 7:7A-19.5). The US Army Corps of Engineers (USACE) has retained responsibility for the Federal 404 program in interstate and navigable waters, including adjacent wetlands and areas under the jurisdiction of the New Jersey Sports and Exposition Authority (see http://www.state.nj.us/pinelands). Projects in these "non-delegable" waters require permits from both the USACE and the State.

Since the New Jersey freshwater wetlands program assumes the federal Clean Water Act § 404 permitting authority, the regulatory program is consistent with or more stringent than the § 404 permitting authority administered by the USACE. Regulated activities, however, include not only the deposition of dredged and fill material, but other activities such as ditching and cutting vegetation which adversely affect wetlands. N.J.A.C. 7:7A-2.1(a).

Freshwater wetlands in New Jersey are managed pursuant to the Freshwater Wetlands Protection Act (FWPA) (N.J.S.A. 13:9B-1 et seq.). Any person who proposes to engage in a regulated activity in a freshwater wetland must obtain an authorization from the New Jersey Department of Environmental Protection (DEP or Department) (as per N.J.A.C. 7:7A-2.1). The FWPA does allow for the intrusion into wetlands or their transition areas, provided those appropriate permits are obtained. The Act describes two types of permits, General and Individual, that may be applied for to allow various activities to occur in wetlands. The Wetland Rules implementing the Freshwater Wetlands Protection Act set forth the requirements for a permit application. They include a line delineation Letter of Intent (LOI) if it has been issued, and if not all, the information required for an application for a line delineation LOI or verification; the total amount of wetlands on the site before the activity and the amount that will remain; and a narrative that describes the basic project purpose and whether it is water dependent, which also includes an alternatives analysis.

In New Jersey, mitigation is required for all wetland impacts permitted under an Individual permit as well as for three general permits. When unavoidable disturbances to coastal and freshwater wetlands occur because of permitting, these losses are mitigated based upon ``equal ecological value.'' New Jersey generally requires a ratio of 2:1 for creation/restoration and at higher rates for enhancement and preservation of wetlands.

As at the Federal level, there are limitations under the FWPA in regulating impacts to vernal pools. Some general permits (e.g., GP 6) allow impacts up to 1 acre. Since many vernal pools in NJ are less than 0.25 acre, those habitats would remain potentially unprotected if a project used that permit to obtain regulatory approval to impact wetlands.

3.3 Wetland Regulations from Other States

The following summarize regulatory language that other states have pertaining directly or indirectly to vernal habitats:

Connecticut Vernal Pool Regulations

Regulatory Contact: Connecticut's municipal inland wetlands agencies regulate any activities that are likely to impact or affect vernal waterbodies.

Pursuant to the Connecticut Inland Wetlands and Watercourses Act the term 'watercourses' includes vernal or intermittent waterbodies. Therefore, under Connecticut law, vernal pools, which contain a specific ecology, are one type of vernal watercourse, and Connecticut's municipal inland wetlands agencies regulate any activities that are likely to impact or affect vernal waterbodies.

Regulation occurs at the municipal level via town Inland Wetlands Commissions. The Connecticut Department of Environmental Protection has model regulation and guidance documents which local townships should model their regulations after.

Maine Vernal Pool Regulations

Regulatory Contact: Department of Environmental Protection - Land & Water Bureau, Division of Land Resource Regulation. Vernal pools are regulated under the Natural Resources Protection Act (NRPA) program. There are 4 regional offices that have NRPA program staff. http://www.vernalpools.me/regulations

In organized towns, wetlands are regulated by the Maine Department of Environmental Protection through the Maine Natural Resources Protection Act (NRPA 44 1996). Vernal pools generally meet Federal and State wetland definitions and are subject to regulation. However, the degree of environmental review in Maine depends upon the size of the impact to the wetland. Impacts to wetlands that are less than 4,300 ft^2 (approximately 0.1 acres) require no reporting. Impacts between 4,300 ft^2 and 15,000 ft^2 (approximately 0.3 acres) require the lowest level of review, Tier 1, and have an expedited 30-day review process with no requirement of compensation for wetland loss. Tier II (impacts >15,000 ft^2 to 1 acre) and Tier III (impacts > 1 acre) require greater documentation and require input from professional delineators.

In unorganized towns and plantations, the Land Use Regulation Commission (LURC) regulates activities in wetlands. LURC's language on vernal pools is consistent with the statutory provisions in NRPA. However, LURC's regulatory authority over vernal pools is tied to the Maine Department of Inland Fisheries and Wildlife's (MDIFW) ability to define and identify vernal pools. In unorganized towns, MDIFW is relying on a voluntary, cooperative strategy for protecting vernal pools.

"Significant vernal pools" (SVPs) are listed as "Significant Wildlife Habitat" in Maine's 1995 revision of the NRPA. In September 2006, Maine passed legislation under NRPA to regulate Significant Vernal Pools as Significant Wildlife Habitat (SWH). Significant Wildlife Habitats host high concentrations of important wildlife populations and receive careful environmental review that may lead to restrictions on certain intensive land-use activities within and adjacent to the SWH, even if the adjacent land is not wetland. SWHs include seabird nesting islands, deer wintering areas, shorebird concentration areas, coastal and inland waterfowl and wading bird areas, and Significant Vernal Pools.

Massachusetts Vernal Pool Regulations

Regulatory Contact: In Massachusetts, both local Conservation Commissions and regional Department of Environmental Protection – Bureau of Water Resources, Wetlands Program staff review permit applications for work in or near wetlands.

The Massachusetts Wetlands Protection Act Regulations (310CMR 10.00, 1996) include measures for the regulation of vernal pool habitat, if it is located within another category of wetland regulated by the Act, and as long as it has been certified by the Massachusetts Division of Fisheries and Wildlife (MDFW) prior to the filing of a Notice of Intent by an applicant. A vernal pool must be certified and mapped by the Natural Heritage and Endangered Species Program (NHESP) prior to permitting of a wetland impact. Criteria are available through NHESP.

Official certification provides a vernal pool, and up to 100 feet beyond its boundary in some cases, certain protections under several state and federal laws.

Originally defined and protected under the Massachusetts Wetlands Protection Act regulations, Certified Vernal Pools now also receive protection under:

- Title 5 of the Massachusetts Environmental Code,
- Section 401 of the Federal Clean Water Act,
- the Massachusetts Surface Water Quality Standards which relate to Section 401, and
- the Massachusetts Forest Cutting Practices Act.

New Hampshire Vernal Pool Regulations

Regulatory Contact: Department of Environmental Services - Wetlands Bureau. There are 2 regional offices: Concord (603) 271-2147 and Portsmouth (603) 559-1500.

In New Hampshire, there is no minimum size limit to projects that require a wetland permit. Vernal pools are regulated in New Hampshire only if they are located within other regulated wetlands (Wetlands Board Code of Administrative Rules 1993); they have traditionally been assessed as low-value wetlands. New Hampshire Fish and Game (NHFG) developed a vernal pool identification manual (https://www.wildlife.state.nh.us/nongame/documents/vernal-pool-manual.pdf) to initiate local conservation efforts. Following documentation, the information is supposed to be forwarded to NHFG and the local conservation commission for informational purposes. However, there are no state or local regulations that give added protection to documented vernal pools.

New York Vernal Pool Regulations

Regulatory Contact: Department of Environmental Conservation - Division of Environmental Permits. Based in Albany 518-402-9167; however, there are regional contacts within the division.

Vernal pools are not specifically recognized and would only be subject to regulation under the following conditions (NYS DEC Article 24 Freshwater Wetlands law): 1. greater than 12.4 acres, 2. demonstrating unusual local importance for one or more of the specific benefits set forth in subdivision seven of section 24-0105, 3. contain a State-listed endangered or threatened species and have been added, through a public hearing process, to the official map of State-regulated wetlands, or 4. located within Adirondack park (minimum regulated size 1 acre).

Pennsylvania Vernal Pool Regulations

Regulatory Contact: Department of Environmental Protection – Bureau of Waterways Engineering and Wetlands. Based in Harrisburg 717-787-3411. However, there are 6 regional offices.

Vernal pools are protected in Pennsylvania under 25 Pennsylvania Code Chapter 105, Dam Safety and Waterway Management. Vernal pool habitats are not specifically identified in the code, but the Department of Environmental Protection (DEP) includes them in the "body of water" category as defined in Section 105.1 as 'a natural or artificial lake, pond, reservoir, swamp, marsh or wetland. Chapter 105 protects Pennsylvania's waters from encroachments including any structure or activity which changes the course, current, or cross section of a body of water. DEP has regulatory authority over the wetland itself but cannot enforce a protective upland buffer.

Additional protection for some seasonal pool species is provided under the Endangered Species section of the Pennsylvania Code (58 Pa. Code Chapter 75). Pennsylvania protects any of these [fish, amphibian, reptile, and invertebrate] species that are on the state's threatened or endangered species lists. Section 75.1 of the Pennsylvania Code states that ''The catching, taking, killing, possessing, importing to or exporting from this Commonwealth, selling, offering for sale or purchasing of any individual of these species, alive or dead, or any part thereof, without a special permit from the Executive Director is prohibited.- According to the Pennsylvania Code (Section 75), the eastern spadefoot toad (*Scaphiopus holbrookii*) and the blue-spotted salamander (*Ambystoma laterale*) are both state endangered amphibians that use seasonal pool habitats.

From a mitigation perspective, when wetlands are lost to filling or other alterations in Pennsylvania, state law requires that they are mitigated to ensure "no-net-loss" of wetland resources (see the Federal and State Regulations section for details). Wetland mitigation is a regulatory requirement to replace or enhance wetland areas destroyed or damaged during development activities.

When considering vernal pool creation as part of a wetland mitigation project, consider the following (adapted from Calhoun and deMaynadier [eds., 2008]):

1. If wetland loss mitigated by wetland creation is the only option for a site, consider adding a preservation or restoration component of existing vernal pools at another site for a stronger overall mitigation outcome.

2. Gather baseline data on pools before they are destroyed to know what has been lost and should be replaced.

3. Develop a list of desired plant and animal species for the created pool. Use baseline data from the pools that were lost, or, if mitigation is taking place off site, inventory natural

pools nearest where the pools will be created. These can be used as paired controls to evaluate the quality of constructed wetlands.

4. Extend the monitoring of created pools beyond the 3-5 year period typically required by regulatory agencies. Develop measures of success by which to evaluate the created wetland over a period of years. Identify what steps should be taken if the created pool does not meet the project goals and how any additional work will be funded.

5. Vernal pools created for mitigation should be managed as natural vernal pools with Best Management Practices.

Voluntary restoration of damaged or destroyed vernal pools or creation of new ones can yield benefits to the landowner and the surrounding community. In the right situations, restoring and creating new vernal pools can help turn the tide against the overwhelming loss of wetlands that has occurred over the past decades.

The decision to build or restore a wetland should only be made after consulting with someone who can provide an expert review of the property. Alteration of any existing wetland requires a permit from the PA Department of Environmental Protection. Great care must be taken not to alter natural healthy wetland habitats. Small quick-drying vernal pools and natural spring/seepage wetlands are unique habitats that are not necessarily in need of enlargement or deepening, even if they cannot support certain vernal pool species. Deepening a wetland may increase its water holding capacity to a point where species common in permanent ponds will be favored and vernal pool species will be discouraged.

Rhode Island Vernal Pool Regulations

Regulatory Contact: Department of Environmental Management – Office of Water Resources. Based in Providence (401) 222-3961

The Rhode Island Fresh Water Wetlands Act (RIFWWA) does not specifically regulate vernal pools but defines 'pond' as a place not less than one-quarter (1/4) of an acre in extent, natural or manmade, wholly, or partly within the state of Rhode Island, where open standing or slowly moving water shall be present for at least six (6) months a year.

To ensure enhanced protection for vernal pools, the 1994 rules included a new wetland category, special aquatic site defined as a body of open standing water, either natural or manmade which does not meet the definition of 'pond' but which is capable of supporting and providing habitat for aquatic life forms as documented by:

a. presence of standing water during most years as documented on site or by aerial photographs; and

b. presence of habitat features necessary to support aquatic life forms of obligate wildlife species, or the presence, documented use, or evidence of aquatic life forms of obligate wildlife species (except biting flies).

There is no size minimum but, because most are smaller than 1/4 acre, they do not meet the definition of "pond"; therefore, there is no protection of the adjacent upland. The Rhode Island Department of Environmental Management (DEM) can regulate land use within 50 feet of the edge of ponds but not smaller water bodies. The applicant is expected to recognize special aquatic sites—based on the presence of aquatic life forms of obligate wetland species or their habitats—and to put them on plans for proposed development. DEM checks those sites, and other wetlands, in the field during the project review.

Vermont Vernal Pool Regulations

Regulatory Contact: Agency of Natural Resources – Department of Environmental Conservation, Watershed Management Division. Based in Montpelier 802-828-1115 – however, there are regional contacts within the division.

Vernal pools can be protected under Vermont's wetland rules only if they are part of a Class II wetland or better (i.e., show up on Vermont Significant Wetland Inventory maps derived from National Wetland Inventory maps). If a Class II wetland is protected under the wildlife habitat section or any other section, the maximum protection would be for the wetland and a 50-foot buffer. Class 1 wetlands can be protected with a 100-foot buffer, but there are few Class 1 wetlands at this time. Vernal pools are potentially protected under this rule only if they are within a mapped wetland or are contiguous to such a wetland. Again, only up to 50 feet of the adjacent land around such a pool could be protected for a Class II wetlands.

Vermont Wetland Rules (Water Resources Board 1990) do not specifically address vernal pools. Under the rules, Vermont evaluates wetlands based on 10 functions and values, wildlife habitat being one of those. The likely impact of a project on those functions is then assessed. If it is determined that a pool provides significant amphibian breeding habitat, this could trigger a larger buffer requirement or a potential denial of a project.

According to Rule 5.4 c (1), the following considerations are made in designating wetlands significant for wildlife:

a. The wetland provides habitat that supports the reproduction of uncommon Vermont amphibian species including Jefferson salamander, blue-spotted salamander, spotted salamander, and others found in Vermont of similar significance; and

b. The wetland supports or based on its habitat, is likely to support, breeding populations of any uncommon Vermont amphibian species including mountain dusky salamander, four-toed salamander, Fowler's toad, and others found in Vermont of similar significance.

4.0 VERNAL POOL MITIGATION

The following sections provide a summary of the technical basis for vernal pool mitigation.

4.1 General Wetland Mitigation Requirements

Both Section 404 of the Clean Water Act (federal) and the FWPA (New Jersey) emphasize avoiding impacts to wetlands and other water resources. This emphasis recognizes that despite progress over the last two decades there are still large gaps in the science of restoration ecology. The National Research Council (NRC) (NRC 2001) and others in the scientific community have stressed that, considering continued uncertainty associated with the successful replacement of many types of wetlands, the first step should always be to avoid impacting these important aquatic resources if possible. Except for a limited number of authors, the literature is consistent in stating that the destruction of vernal pools should be avoided, and if impact cannot be avoided, the vernal pool should be restored. Creation of a new vernal pool is to be used only as a final resort.

For unavoidable impacts, the Wetland Conservation Rule (USEPA and USACE 1998) incorporates key NRC recommendations associated with improving the planning, implementation and management of wetland replacement projects provided in the NRC's 2001 assessment of wetland replacement practices. Specifically, the rule:

- Emphasizes that the process of selecting a location for compensation sites should be driven by assessments of watershed needs and how specific wetland restoration and protection projects can best address those needs;
- Requires measurable and enforceable ecological performance standards for all types of compensation so that project success can be evaluated;
- Requires regular monitoring to document that compensation sites achieve ecological performance standards;
- Clearly specifies the components of a complete compensation plan based on the principles of aquatic ecosystem science; and
- Emphasizes the use of science-based assessment procedures to evaluate the extent of potential water resource impacts and the success of compensation measures.

While replacing a hectare of natural wetland with a hectare of created wetland may result in no net loss of wetland area, there is likely to be a net loss of ecological functioning (Hoeltje and Cole 2007; Dahl 2011; Moreno Mateos et al. 2012). Early reviews by Kusler and Kentula (1990) and Kentula et al. (1992) demonstrated that wetlands created for compensatory mitigation often failed to reliably replace natural wetland functions. A review of the literature (Calhoun et al. 2014) indicates that there is no wetland mitigation option more challenging than trying to replace ecological function than with vernal pools.

For vernal pools, active mitigation falls into two general categories: restoration and creation. Wetland restoration seeks to reestablish a wetland's physicochemical, hydrological, and ecological functions (NRC 2001), and presumably vernal pool creation also seeks to establish new pools with functions like those of natural pools. The FWPA defines restoration as the reestablishment of wetland and/or State open water characteristics and functions in an area that was once a wetlands and/or State open water but is no longer; or the reversal of a temporary disturbance and the reestablishment of the functions and values of the wetlands and/or State open water that was temporarily disturbed.

However, vernal pools are among the most difficult wetland ecosystems to create or restore primarily because of their hydrological properties: particularly, the seasonal water regime that is their defining feature. Furthermore, vernal pool creation or restoration must be coupled with adjacent high quality post breeding habitat for the biphasic amphibian species that depend on these pools for breeding but spend most of their lives in adjacent habitats (Lichko and Calhoun 2003; Semlitsch 2008; Simon et al. 2009).

Creation, on the other hand, is taking a non-wetland area and turning it into a wetland. The FWPA defines creation as the establishment of freshwater wetland or State open water characteristics and functions in uplands. Creation requires more information, particularly with respect to hydrology and soils. Vernal pool creation is essentially habitat conversion as it involves destroying one habitat to create another. The assumption would be that the upland area has less ecological value than it would if there was a vernal pool on site, but it just has less regulatory value. It could involve destruction of habitat for unregulated yet unassessed rare plant and animal species, not to mention alteration of broader soil microbial communities. Protection of existing vernal pools and their needed buffers presents a much better alternative to conversion of habitats where the true ecological value cannot be adequately determined.

The premise of protecting vernal habitats as opposed to restoring them as part of a mitigation effort was further defined by Yepsen et al. (2014). They compared plant community composition in 47 non-tidal wetlands under different management (natural, restored, and former wetlands that had been converted to cropland) in the Atlantic Coastal Plain. Plant communities in restored sites were more like natural sites based on the percentage of species that were native and hydrophytic, plant community evenness, and floristic quality. However, natural sites were forested, while restored and drained cropland sites were primarily herbaceous. Yepsen et al. (2014) findings demonstrate that restored wetlands in agricultural settings can develop diverse native wetland plant communities within a decade but they remain very different from natural wetlands, raising questions about restoration goals, ecosystem service tradeoffs, and our ability to restore wetlands to ecological conditions found in reference sites.

USACE (2016) notes that created vernal pools often fail to replicate vernal pool hydrology and may lure breeding amphibians away from more appropriate breeding sites and potentially serve as a population sink. Replacement of natural invertebrate communities is even more difficult. If loss is unavoidable, mitigation should focus on preservation of lands with existing natural vernal pool habitat (off-site or on-site), and restoration or rehabilitation of existing vernal pools and adjacent terrestrial habitat. In the USACE New England District vernal pool creation may be an acceptable form of mitigation for rare, case-specific situations, but any creation projects will require a detailed adaptive management and contingency plan. The USACE New England District also requires that all creation projects include the preservation of appropriate adjacent undeveloped terrestrial habitat.

A wetlands mitigation project will not be successful unless there is adequate planning, especially for vernal pools. For a wetlands mitigation project to be successful, the following project attributes must be at least be adequately defined:

- well-defined broad goals and refined objectives;
- measurable and specific success criteria incorporated into the project;
- functional value and biological integrity criteria used to evaluate the functional equivalency of the mitigated wetlands to the undisturbed, nonimpacted wetlands;
- long-term management plans incorporated with details of operations, responsibilities, and funding; and
- adequate monitoring established over a sufficient time frame (>5 years), with defined goals and established methods for evaluating the results.

The wetlands mitigation plan is the primary tool used in the successful completion of the mitigation action. For the wetlands project to be successful, the wetlands mitigation plan must be as complete and thorough as possible. As described in various documents, a wetlands mitigation plan should conceptually include the following:

- a statement of intent and goals,
- a description of the site to be restored/created before project,
- a description of the steps to be used in area preparation,
- the plant materials to be used,
- a detailed grading plan,
- a description of the soil to be used,
- a schedule/construction timetable,
- a maintenance plan,
- monitoring/assessment procedures, and

- performance guarantees.

4.2 Vernal Pool Mitigation Ratios

For wetlands, the objective is to provide, at a minimum, one-to-one functional replacement, i.e., no net loss of functions, with an adequate margin of safety to anticipated success. Focusing on the replacement of the functions provided by a wetland, rather than only calculation of acreage impacted or restored, will in most cases provide a more accurate and effective way to achieve the environmental performance objectives of the no net loss policy. Under most regulatory paradigms that involve a ratio of mitigated wetlands being restored or created in compensation of the loss of ecological function by the impacted wetlands, the most common ratio used is two acres of mitigated wetlands restored/created in ecological compensation for one acre of wetlands lost.

In some cases, replacing the functions provided by one wetland area can be achieved by another, smaller wetland; in other cases, a larger replacement wetland may be needed to replace the functions of the wetland impacted by development. Thus, for example, on an acreage basis, the ratio should be greater than one-to-one where the impacted functions are demonstrably high, and the replacement wetlands are of lower function. Conversely, the ratio may be less than one-to-one where the functions associated with the area being impacted are demonstrably low and the replacement wetlands are of higher function. As a result, a higher ratio of created wetlands should be considered as a means of compensating for the lost functions.

The amount of mitigation required for vernal pool impacts ranges significantly, at both the Federal and State level, from no mitigation required to multiple acres per acre of vernal pool impacted. Following is a synopsis of vernal pool mitigation ratios seen at both the Federal and State level:

Federal Level

- USACE New England District

  For direct impacts to the pool itself, the USACE New England District (NED) states that compensatory mitigation amounts should be based on the recommended multipliers for the wetland type (e.g., forested, scrub-shrub) impacted, which ranges from 2 – 3 acres of mitigated wetlands for every acre of vernal pool impacted. In addition, because of the uncertain success of vernal pool creation, preservation is preferred, even though it does not address "no net loss" of function or acreage. As such, in addition to the multiplier for wetland type, NED also asks for compensation for secondary impacts as determined on a case-by-case basis using the Vernal Pool Characterization Form (https://elr.info/sites/default/files/doj-consent-decrees/united_states_v._fkt_resort_mgmt._llc_p2.pdf).

- USACE South Pacific District

  The District has very specific guidelines on the creation of vernal pool habitat, but no specific ratios for vernal pool mitigation. In general, Federal and State regulatory agencies use mitigation ratios ranging from values of two acres of mitigation to one acre of impacts; to four acres of mitigation to one acre of impact, depending upon the type and location of the wetland (https://www.spd.usace.army.mil//Portals/13/docs/regulatory/publicnotices/DVPGL.pdf).

State Level

- Pennsylvania

In Pennsylvania, a DEP permit is needed to directly impact ANY wetland by fill or excavation, regardless of the size. Section 105.20a (Pennsylvania Code 25 Pa. Code § 105.20a) sets wetland replacement criteria for wetland losses. Mitigation (wetland replacement) is only required for alteration of wetlands over 0.05 acres in size. When a permit is granted for destruction of a wetland over 0.05 acres, it must be mitigated at a minimum 1:1 ratio. If a permit is granted for wetland losses after-the-fact a minimum 2:1 mitigation ratio is required.

Wetlands under 0.05 acres in size are considered 'deminimus' (for scale, a square with 47 feet per side is ~0.05 acres). Permittees are not required to mitigate the loss of these very small wetlands which include many vernal pools. But their acreage is added to the total acreage of wetlands lost. Pennsylvania has a 'net wetland gain' policy and has programs to create new wetlands to offset all lost acreage.

The DEP also implemented the Pennsylvania Wetland Replacement Project (PWRP) to address issues specific to small wetlands. Wetlands under 0.50 acres are eligible to participate in this project. Mitigation can be in the form of physical wetland replacement, or a monetary contribution to the PWRP fund.

- Maryland

In Maryland, the standard replacement ratios are 2:1 for forested and scrub/shrub wetlands and 1:1 for emergent wetlands, with higher ratios for impacts to Wetlands of Special State Concern and other sensitive resources (e.g., vernal pools) (MDE 2014).

5.0 MEASURES OF VERNAL POND MITIGATION SUCCESS

In reviewing literature on vernal pool restoration and construction, it was determined that there was not a deep body of information related to the completion and success of vernal pool mitigation projects. Additionally, the identified literature was not always consistent in their conclusions. Biebighauser (2011) writes that vernal pool creation is a straight-forward process, while Calhoun et al. (2014) takes exception to Biebighauser's work and describes vernal pool creation as exceptionally challenging with limited examples of success. The NRC (2001) lists vernal pools as a type of wetland that is difficult to restore or create.

Lichko and Calhoun (2003) reviewed vernal pool mitigation projects in New England that were required by federal regulatory action. There were 15 vernal pool creation projects (36 pools total) between 1991 and 2000 that were identified by federal agencies. These included seven projects in Maine, three in New Hampshire, three in Connecticut, one in Massachusetts, and one in Vermont. The goal of the assessment was to determine if the compensatory mitigation of created vernal pools in New England replaced key vernal pool functions that were lost from permitted development projects. This was done by reviewing project goals and documentation, including mitigation plans, pool design criteria, monitoring protocol and performance standards. The results indicate that creation attempts often fail to replicate lost pool functions.

Many of the projects failed to meet the goal of replacing lost vernal pool functions primarily due to poor planning. This lack of planning was evidenced by the lack of detailed mitigation plans. Many projects also lacked a clear set of criteria for measuring success.

Most of the early studies of vernal pool mitigation come from the Great Central Valley in central and southern California. There are limited studies that have been conducted in the eastern and northeastern part of the country.

5.1 Reports on Vernal Pool Mitigation Success

Generally, the peer-reviewed scientific literature related to vernal pool creation suggests that successful vernal pool creation is challenging. DeWeese (1996) reports that the U.S. Fish & Wildlife Service evaluated 1,543 vernal pools constructed between 1988 and 1994 in central California. The regimes were adequately assessing the target physical and biological properties of constructed vernal pools. Hydrology standards were met by 96% of the pools and 69% met vegetation standards. However, DeWeese also notes that in most instances, ecological function was not equivalent in comparison to background locations.

Leidy and White (1996) reported that vernal pool mitigation was controversial. They noted that this controversy was largely the result of: 1) the low success rate of mitigation projects (Zedler, 1991; Race and Fonseca, 1996); 2) an inability to scientifically document the existing functions of vernal pools, which in turn limits our ability to determine whether various mitigation measures result in improved wetland functions and fully offset impacts (NRC, 1992; Race and Fonseca, 1996); and 3) the lack of regulatory mechanisms to effectively monitor the success of mitigation projects. Leidy and White (1996) also noted that vernal pool creation continues to be the most controversial form of mitigation because of the high rate of failure and general disagreement among regulators, consultants, permit applicants, and academics over whether reconstruction of vernal pools, where they never historically existed, is technically feasible. Schlatter et al. (2016) reports that a review of wetland construction projects in California found that constructed vernal pools received the lowest ratings for replacing lost habitat values. Calhoun et al. (2014) suggest that vernal pool construction projects should be used as a "last resort" only when attempts at protection have been exhausted.

Korfel et al. (2009) notes that the most challenging issue in vernal pool restoration and creation is adequately mimicking proper hydrology to serve as suitable habitat for wetland biota. Hydrology is the driving component in structuring vernal pool community composition and specialist breeding success (Semlitsch et al. 1996; Snodgrass et al. 2000; Babbitt & Baber 2003; Mitsch & Gosselink 2007). Korfel et al. (2009) compared the hydrology, physiochemistry, and amphibian biomass between a complex of created vernal pools and a complex of natural vernal pools in 2007 in central Ohio, United States. Eleven years after construction, the created vernal pools did not mimic natural pools in surface inundation and groundwater–surface water exchange, dissolved oxygen, and water temperature. Korfel et al. (2009) reported that hydrologic connectivity of surface water and groundwater differed between the natural and the created pool complexes. Surface inundation duration for created pools exceeded that of natural pools, although spring water depths were similar.

5.2 Parameters for Designing Vernal Pool Mitigation Projects

Calhoun et. al. (2014) reviewed the scientific literature on wetland mitigation projects conducted in the northeastern United States. They argued that successful pool creation is demonstrated by reproduction and metamorphosis by key indicator species such as wood frogs and Ambystomatid salamanders for the long-term. They found the usual 5-year monitoring period too short as created pools may be colonized by dispersing individuals from other breeding pools, or, in the case of onsite mitigation, by returning members of the original pool-breeding population, but their presence is not indicative of successful breeding (Vasconcelos and Calhoun 2006). A minimum of 5 years is needed to incorporate demographic and environmental variability such as the interaction between climate (temperature and precipitation variability) and hydroperiod. For example, it may take more than 5 years for green frog (*Lithobates clamitans*) or bullfrogs (*L. catesbeianus*), voracious predators of wood frog and salamander egg masses and larvae, to establish in semi-permanent or permanent pools at densities that generate a detrimental effect on the classic pool breeders using those same pools (Vasconcelos and Calhoun 2004; Denton and Richter 2013).

The following section reviews key factors stated by Calhoun et al. (2014) that they reported to affect pool success from the perspective of key pool-breeding amphibians.

5.2.1 Hydrology

Wetland hydroperiod, defined as the length of time when standing water is present, is a key factor that directly shapes the community composition and reproductive success of pond-breeding amphibians (Brunnell and Ciraolo, 2010). The timing and duration of wetland flooding must coincide with amphibian-breeding biology for successful oviposition, hatching, larval development, and metamorphosis to occur (Paton and Crouch 2002). Periodic drying excludes resident populations of predatory fish, reduces the diversity and abundance of invertebrate predators, and limits competition and depredation from other amphibian species, thus enhancing vernal pool specialist survival (Drayer 2012; Denton and Richter 2013; Julian et al. 2013). Additionally, amphibian diseases may be more likely to persist in permanent wetlands than in those that dry (Gray et al. 2009; Richter et al. 2013a). For these reasons, hydroperiod (i.e., the timing and duration of inundation), is particularly critical to vernal pool ecosystem functions (Zedler 2000); even variations in vernal pool filling and drying on the order of 2 to 3 weeks can alter pool-breeding amphibian community composition and the success of any given species (Paton and Crouch 2002; Babbitt et al. 2003; Baldwin et al. 2006a; Good 2006; Seigel et al. 2006; Timm et al. 2007). For example, wood frog and spotted salamanders deposit eggs early in the spring, but wood frog embryos and larvae develop more rapidly than spotted salamanders, necessitating a substantially longer hydroperiod to support successful reproduction for spotted salamanders. In contrast, marbled salamanders (*Ambystoma opacum*) deposit eggs in dry basins in autumn. Eggs hatch after vernal pools recharge, and overwintered larvae metamorphose on a schedule like wood frogs.

Longer hydroperiods, particularly semi-permanent to permanent, may mean increased numbers of amphibian species and invertebrates that prey upon and target vernal-pool breeders. Notably, green frog and bullfrog larvae, which take 2 to 3 years to develop, and eastern newt (*Notophthalmus viridescens*) adults are efficient predators of wood frog and ambystomatid egg masses and larvae and may be abundant in created semi-permanent to permanent ponds (Kross 2014). These species are also potential reservoirs of disease, such as *Batrachochytrium dendrobatidis* (amphibian chytrid fungus) and *Ranavirus* (Daszak et al. 2004; Gahl et al. 2012). Failure of created pools to support viable populations of specialized pool breeders is often directly attributable to improper hydrological regime (Porej et al. 2004; Vasconcelos and Calhoun 2006; Gamble and Mitsch 2009; Drayer 2012; Denton and Richter 2013; Kross 2014).

5.2.2 Hydrogeomorphic Setting

Wetland restoration helps to support the regulation of hydrologic flows and natural hazards (e.g., flooding). According to the Mid-Atlantic Regional Wetland Assessment (USDA, 2015) restored wetlands exhibit surface water flows intermediate to natural wetlands and prior converted croplands. Wetland area was found to be significantly correlated with the periodicity of surface water flows. Even when depressional wetlands are not directly connected to streams via surface water flow, their size and arrangement has been found to be critical for supporting flow in adjacent streams (McLaughlin et al. 2014).

Vernal pools may develop in a variety of hydrogeomorphic settings including riparian areas, surface water depressions (often in the upper reaches of a watershed), and as groundwater depressions in low-lying areas. Each of these settings is characterized by different hydroperiods (ranging from ephemeral to semi-permanent vernal pools) and major water inputs (e.g., precipitation, groundwater inflow, subsurface flow, and runoff) that may influence water temperature, pool substrate, and water chemistry (Whigham and Jordan 2003; Sacerdote and King 2009; Gebo and Brooks 2012). For example, pools that receive inputs from groundwater as well as from surface runoff tend to have mucky soils and water chemistry that is less variable than pools supported primarily by surface water. Water chemistry and temperature will affect rates of embryo and larval development in pools (Newman 1998; Karraker et al. 2008; Battaglin et al. 2009). Local populations of amphibians may be particularly adapted to these subtle differences in pool setting (Rice and Emery 2003; Brady 2012).

However, no published information was found on how to create pools in these different landscape settings to ensure replication of the abiotic environment.

5.2.3 Slope

Most natural vernal pools have shallow littoral zones available with gradual slopes to the center, which has been linked to greater species richness compared to constructed wetlands (Porej and Hetherington 2005; Drayer 2012). In the ridgetop wetland ecosystem of Kentucky, Drayer (2012) found natural wetlands to have significantly lower slope (measured as depth at 1 m from shore; mean±1 SE=9.1±0.8 cm) than constructed wetlands (15.4±1.6 cm). Created pools that do not mimic the slope of natural pools may be less suitable for amphibian recruitment (Porej and Hetherington 2005; Croshaw and Scott 2006). Steep, abrupt slopes may cause access problems for salamanders and may limit the growth of vegetation (Simon et al. 2009; Shulse et al. 2012) or the rate of melting ice cover in northern climates. Additionally, shallow areas can be important for predator avoidance (Porej and Hetherington 2005), thermoregulation of amphibians for growth (Wellborn et al. 1996) and to decrease the occurrence of diseases (Raffel et al. 2010). Marbled salamanders are particularly sensitive to changes in pool slope because their selection of nesting sites depends on the interplay of pool bathymetry and water levels determined by winter and fall rains (Croshaw and Scott 2006).

5.2.4 Substrate

Soil development is highly dependent upon hydroperiod (i.e., longer hydroperiods result in saturated conditions that can create mucky, organic surface layers) and parent materials (e.g., highly permeable sandy outwash materials versus compact, restrictive tills; Tiner and Veneman 1989). If creation efforts properly mimic the necessary hydrology and pools are placed in appropriate hydrogeomorphic settings, soil development in created sites should be like that of natural pools (see Biebighauser 2003). If soils from the original wetland are excavated and used in the created wetland, this should enhance the likelihood of colonization by native species (i.e., by plant seeds and resting stages of invertebrates or dormant cysts or eggs; Stauffer and Brooks 1997; Colburn et al. 2008). Soil compaction in created pools may influence hydroperiod (Whittecar and Daniels 1999; Gamble and Mitsch 2009). For example, in Kentucky, constructed wetlands with the same hydrogeomorphic parameters as natural wetlands and maximum depths less than 30 cm were permanently inundated, presumably because of soil compaction (Drayer 2012; Denton and Richter 2013). Ducey et al. (2015) studied restored wetlands on relatively flat landscape with the groundwater close to the surface, where the restoration involved blocking ditches and shallow water areas for wildlife were excavated. The study found that the restored pools built up organic material quickly while the water table remained shallow. These pools also exhibited high total carbon values and a carbon/nitrogen (C/N) ratio close to natural wetlands.

5.2.5 Vegetation

According to the Mid-Atlantic Regional (MIAR) Wetland Assessment (USDA, 2015) restored wetlands are hotspots of plant biodiversity, surpassing the diversity of natural wetlands. However restored wetlands are early successional ecosystems dominated by native herbaceous vegetation, whereas natural wetlands are dominated by native woody plants. The report predicts that restored wetlands will develop similarly to natural sites if succession can progress for decades. Natural and restored wetlands support a similar number of amphibian species, while prior converted croplands harbored significantly fewer species. Restored and natural wetlands have approximately equal proportions of amphibian habitat generalists and specialists, but community similarity is usually low. These findings imply that overall landscape scale biodiversity is enhanced through the presence of a combination of natural and restored ecosystems.

In northern New Jersey, vernal pools found in hardwood forests are classified under the NatureServe ecological classification system as CEGL006453 – Eastern Woodland Vernal Pool. Species composition is variable among sites, variable annually, and variable seasonally. Species documented within this type of vernal pool include *Dulichium arundinaceum, Glyceria sp., Leersia oryzoides, Scirpus cyperinus, Lycopus uniflorus, Polygonum spp., Thelypteris palustris, Carex gynandra, Carex crinita, Carex leptonervia, Carex stipata, Carex canescens, Carex versicaria, Juncus effusus, Bidens spp., Hypericum mutilum, Hypericum canadense, Osmunda cinnamomea, Osmunda regalis, Agrostis scabra, Utricularia geminiscapa, Triadenum virginicum, Sagittaria sp.,* and *Eleocharis spp*. Due to the extreme variability of these pools, only a few of the aforementioned species are likely to be found on any one site. Additionally, although these pools are pre-dominantly herbaceous, shrubs and small trees may be present. Typical woody species include *Vaccinium corymbosum, Lyonia ligustrina, Quercus palustris, Nyssa sylvatica, Acer rubrum, Salix spp., Cephalanthus occidentalis,* and *Ilex verticillata.* Additional information can be found at the following link:

https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.791626/Eastern_Woodland_Vernal_Pool

Northern New Jersey also has an ecological community referred to as a "Calcareous Sinkhole Pond", which occurs in karst topography over limestone or dolomite bedrock. These ponds are seasonally flooded and are known to harbor Jefferson salamanders (*Ambystoma jeffersonianum*), an obligate vernal pool species. This ecological community is *Chara sp. / Potamogeton spp., classified as Nonvascular Aquatic Vegetation*, classified under the NatureServe Ecological Classification System as CEGL00*Chara*; although, during the later parts of the growing season or in drought year, the community is comprised of *Chara sp. / Boltonia montana, Cyperus strigosus, Panicum capillare, Potamogeton amphibium,* and *Mentha arvensis*. *spp. Nonvascular Aquatic Vegetation*. The dominant species is the green algae in the genus *Chara*. Associated herbaceous species in semi-permanently flooded ponds that dry out during the later parts of the growing season or in drought years include *Boltonia montana, Cyperus strigosus, Panicum capillare, Polygonum amphibium,* and *Mentha arvensis*. Additional information can be found at the following link:

https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.950094/Chara_sp_-_Potamogeton_spp_Nonvascular_Aquatic_Vegetation

In southern New Jersey, mostly in the Pine Barrens region, one can find Coastal Plain Intermittent Ponds, classified under the NatureServe Ecological Classification System as CEGL006762 – *Cladium mariscoides – Juncus canadensis* Marsh. These systems are dominated by *Cladium mariscoides* and *Juncus canadensis*, but also include *Coreopsis rosea, Dichanthelium dichotomum, Dichanthelium spretum, Drosera intermedia, Euthamia graminifolia, Lachnanthes caroliana, Rhexia aristosa, Vaccinium macrocarpon, Viola lanceolata, Xyris smalliana, Sphagnum spp.*, and occasionally *Saccharum giganteum*. Additional information can be found at the following link:

https://explorer.natureserve.org/Taxon/ELEMENT_GLOBAL.2.902951/Cladium_mariscoides_-_Juncus_canadensis_Marsh

Both Calcareous Sinkhole Ponds and Coastal Plain intermittent ponds are open, depressional wetlands that are seasonally flooded, and both contain rare and State Endangered plant species. Any restoration, enhancement, creation, or mitigation efforts should avoid planting or seeding of rare or endangered plant species and should include botanical surveys prior to work being conducted to ensure work does not negatively impact state-listed plant species.

Other types of vernal pools are likely present in New Jersey. Further data collection is required to adequately classify their ecological composition, including abandoned gravel pits in Cape May county, canopied depressions in Pitch Pine Lowlands, and seasonally flooded portions of river floodplains.

Vegetation composition and structure within a vernal pool varies greatly, and only a few plant species are true vernal pool obligates (e.g., *Scirpus ancistrochaetus* [northeastern bulrush] and *Hottonia inflata* [featherfoil]; Cutko and Rawinski 2008; Drayer 2012; Denton and Richter 2013; Pennsylvania Natural Heritage Program 2013). On the other hand, if the vegetation structure is complex, some ambystomatid species may be able to breed successfully for a while, but evidence suggests that wood frogs will not persist (Vasconcelos and Calhoun 2006; Denton and Richter 2013; Julian et al. 2013; Kross 2014).

Although vegetation in pools may be important for providing shade, refuge, and potential egg attachment sites (Porej and Hetherington 2005; Vasconcelos and Calhoun 2006; Skidds et al. 2007; King 2012), many pools may be largely devoid of vascular plants. In these cases, fine and coarse woody material deposited in pools from adjacent trees and shrubs may serve as egg attachment sites and refugia from predation.

Potential for weedy species: The potential for colonization by weedy plants in created pools is high, and pools can become dominated by monocultures of cattail (*Typha spp.*), duckweed (*Lemna spp.*), the invasive common reed (*Phragmites spp.*), purple loosestrife (*Lythrum salicaria*), reed canarygrass (*Phalaris arundinacea)*, Japanese stiltgrass (*Microstegium vimineum*), and moneywort (*Lysimachia nummularia*) in disturbed sites, especially in pools located in more open settings. These plants can eventually fill or dry out a vernal pool, dramatically changing the hydroperiod and altering pool chemistry and temperature (Vasconcelos and Calhoun 2004; Cutko and Rawinski 2008).

Pool canopy cover: The MIAR CEAP-Wetland (USDA, 2015) referrers to woody wetlands as the preferred final successional stage for restored ephemeral wetlands. Therefore, this report suggests that the practice of mowing should undergo benefit analysis, since it prevents the establishment of woody species, which are more characteristic of natural wetlands in the MIAR. It notes however, that increased forest canopy cover has been found to reduce the abundance and diversity of amphibian larvae or may impact suitability for migratory bird habitat. It is also noted that in some instances, herbaceous vegetation or only partial woody coverage may be the natural cover for a particular vernal pool. It is for that reason that a benefits analyses is suggested to evaluate the anticipated effects from mowing.

Canopy cover adjacent to pools affects pool temperature and supporting detrital food webs through inputs of leaf litter, which impacts developmental rates and species interactions (reviewed in deMaynadier and Hunter 1995; Schiesari 2006; deMaynadier and Houlahan 2008). Canopy removal directly over and around vernal pools may alter amphibian community composition as increased light, temperature, and primary productivity may attract a broader array of amphibian and invertebrate species that either compete or prey on pool-breeding specialists (Brooks et al. 1998; Calhoun and deMaynadier 2002; Skelly et al. 2002; Denton and Richter 2013). Thus, reduction in canopy cover may preferentially support species typically found in open canopy wetlands to the detriment of vernal pool specialists. For example, Schiesari (2006) found that northern leopard frogs (*Lithobates pipiens*) outperformed wood frogs in open canopy, but not closed canopy conditions. Additionally, pools may become dominated by algae and duckweed (*Lemna minor*), ultimately reducing oxygen levels (e.g., by limiting light infiltration and reducing algal photosynthesis) and limiting their suitability for target pool breeders (Vasconcelos, unpublished data).

5.2.6 Landscape and population scale

Because of the complex life histories of pool-breeding specialists, conservation efforts must support critical population dynamics including migration from winter hibernacula to breeding pools, migration from breeding pools to summer habitat, migration from summer refugia to hibernacula, and juvenile dispersal (leaving the natal pool to breed in new pools). For example, wood frogs in the northeastern U.S. often require three distinct habitat elements including the breeding pool, summer refugia of forested wetlands or hillside seeps, and well-drained upland forests for hibernation (Baldwin et al. 2006b). In contrast, salamanders may require fewer habitat elements, but may be more sensitive to habitat disturbance closer to the pool and to disruption of migration routes (McDonough-Haughley and Paton 2007).

Abundant coarse woody material and leaf litter on the forest floor and at least 50% canopy cover have been suggested as key components of suitable forest habitat (Gibbs 1998; Patrick et al. 2006; deMaynadier and Houlahan 2008).

In addition to affecting upland habitat quality for amphibians, upland vegetation characteristics may influence pool characteristics at large spatial scales. It is generally accepted that the area within 300 m of a breeding pool is core foraging and migration habitat for most adult pool-breeding species (Rittenhouse and Semlitsch 2007; Harper et al. 2008), but this area can exceed 1,000 m (e.g., Humphries and Sisson 2012). Genetically significant linkages among pools typically occur in neighborhoods of pool-based populations within 10 km of one another (see Smith and Green 2005; Gibbs and Reed 2008). Dispersing juveniles may travel more than 1 km from natal pools (Patrick et al. 2006; Gamble et al. 2007), if not significantly farther (Smith and Green 2005). Frogs typically travel farther than salamanders, and females generally travel farther than males (Regosin et al. 2003; Rittenhouse and Semlitsch 2007).

Many researchers have documented that amphibians are particularly sensitive to vernal pool structure, as well as the quality of the surrounding habitat (Kolozsvary and Swihart 1999; Lehtinen et al. 1999; Guerry and Hunter 2002; Babbitt et al. 2009; Simon et al. 2009). Petranka and Holbrook (2006) urged restoration ecologists who are designing creation or restoration projects to consider whether natural pools are patchy (clustered, allowing free flow from pool to pool within a single amphibian population) or distant (suggesting a metapopulation structure with limited interaction among pools). If pools are patchy, they suggest that creation should provide clusters of pools with varying hydroperiods to support local anti-predator responses (i.e., allowing amphibians to switch to pools with less predation pressure, which can fluctuate annually).

Emulating natural patterns of pool distribution and post breeding habitat may be difficult depending on the extent and spatial pattern of the disturbance that initiated the mitigation effort, availability of suitable terrestrial habitat and suitable pool sites, and access to information on historical patterns of pools or other wetlands. For example, Denton and Richter (2013) and Drayer (2012) compared created and natural wetlands on ridgetops in Kentucky's Daniel Boone National Forest and found that the creation of permanent pools over the last 20 years has likely provided avenues of dispersal and migration for green frogs, bullfrogs, and eastern newts, thereby potentially exposing naturally occurring ridge-top amphibian species to direct predation and to diseases such as *Batrachochytrium dendrobatidis* (amphibian chytrid fungus) and *Ranavirus* (Daszak et al. 2004; Gahl et al. 2009; Greenspan et al. 2012; Richter et al. 2013a). In that landscape, permanent created pools did not support wood frogs and marbled salamanders; those species remained restricted to natural, ephemeral pools.

6.0 RELATIONSHIP OF VERNAL POND MITIGATION STRATEGIES TO SPECIES

In New Jersey, vernal pools provide habitat to many species of amphibians, insects, reptiles, plants, and other wildlife. The absence of fish is the essence of these ecosystems. Fish are highly predatory on amphibian eggs and larvae. Over the course of evolution, several species of salamanders and frogs exploited these fish-less water bodies. Today, these species exhibit "hardwired" instincts and behaviors that are geared exclusively towards fish-free aquatic habitats.

Species that are dependent upon vernal pools are known as "obligate vernal pool breeders." In New Jersey there are seven species - two frogs and five salamanders - that fit this category. Another 14 of New Jersey's amphibians also use vernal pools for breeding, but unlike the 'obligate' species, these species can successfully reproduce in habitats that contain fish. These species are known as "facultative vernal pool breeders." Following is a list of the relevant species identified by the NJDEP as either obligate or facultative (https://www.state.nj.us/dep/fgw/ensp/vernalpool.htm):

Obligate Vernal Pool Breeding Amphibians

Eastern tiger salamander	*Ambystoma t. tigrinum*	Endangered
Marbled salamander	*A. opacum*	Special Concern
Spotted salamander	*A. maculatum*	
Jefferson salamander	*A. jeffersonianum*	Special Concern
Blue-spotted salamander	*A. laterale*	Endangered
Wood frog	*Rana sylvatica*	
Eastern spadefoot toad	*Scaphiopus holbrookii*	

Facultative Vernal Pool Breeding Amphibians

Green frog	*Lithobates clamitans melanota*	
Bullfrog	L. *catesbeianus*	
Pickerel frog	*L. palustris*	
Southern leopard frog	*L. utricularia*	
Carpenter frog	*L. virgatipes*	Special Concern
Northern cricket frog	*Acris crepitans*	
Northern spring peeper	*Pseudacris crucifer*	
New Jersey chorus frog	*P. triseriata kalmii*	
Upland chorus frog	*P. triseriata ferarium*	
Northern gray treefrog	*Dryophytes versicolor*	
Southern gray treefrog	*D. chrysocelis*	Endangered
Pine Barrens treefrog	*D. andersonii*	Threatened
Four-toed salamander	*Hemidactylium scutatum*	
Long-tailed salamander	*Eurycea l. longicauda*	Threatened
American toad	*Bufo americanus*	
Fowler's Toad	*B. fowlerii*	Special Concern

As Calhoun and Klemens (2002) noted:

"The average distance that a spotted salamander moves from a pool into the surrounding forest is 386 feet; Jefferson salamanders may travel 477 feet (see Figure 4; Windmiller 1996; Semlitsch 1998; Faccio, in prep.) with as much as half the population, in some instances, travelling even greater distances. Wood frog juveniles, on average, disperse approximately 1,550 feet from a breeding pool (Berven and Grudzien 1990). Therefore, long-term persistence of vernal pool amphibian populations depends on the availability of habitat that connects local populations and enables dispersal among them (Semlitsch and Bodie 1998).

Other animals (including reptiles, birds, and small mammals) also depend on these small wetlands. Beetles and water bugs, for example, that overwinter in permanent water migrate to vernal pools to breed and feed during the spring and summer. Medium- to large-sized mammals, including raccoon, skunk, fox, deer, moose, and bear, visit pools to feed on amphibian eggs and fresh green shoots emerging in spring or, later in the season, on amphibians and insects. Therefore, the loss of individual vernal pools may weaken the health of entire wildlife communities."

As a result, in addition to consideration of issues such as mitigation ratios, and the design considerations discussed in Section 5 above, the mitigation strategy for loss of vernal habitat should consider the following:

1. Existing habitat being impacted (what species are most likely affected?)

   The extent, location and type of habitat being created or restored should reflect the specific species impacts the mitigation project is attempting to offset. Baseline sampling or monitoring may be required over months to understand what species are using the vernal habitat.

2. Spatial juxtaposition of the created or restored habitat relative to other undeveloped areas, including wetlands and vernal habitats.

   The success of the restoration or creation project may well reflect not just the design considerations of the habitat itself (see case study in Section 7.1 below) but also the relationship of the vernal habitat to surrounding habitats. Re-establishing vernal habitats in areas surrounded by inhospitable habitat, such as development, contaminated surface runoff from agricultural activity, residential or commercial land use, is less likely to be successful than if other vernal habitats and wetlands are adjacent or nearby.

3. Regional management objectives, including connectivity.

   The Connecting Habitats Across New Jersey (CHANJ) initiative implemented by the NJDEP Endangered and Nongame Species Program should be used to help identify and refine mitigation objectives. The location and juxtaposition of created vernal habitats could be used to help connect areas of favorable habitat beyond the site in question.

4. Wildlife and natural lands management objectives, including presence of endangered of threatened species.

   The specific vernal pools to be created or restored could benefit populations of threatened species such as Pine Barrens tree frog, if present within the vicinity, even if the current site does not provide habitat.

Table 5-1 and Table 5-2 provide information on select amphibians dependent on vernal pools relative to specific parameters within the vernal pool. The list includes species identified both as obligates and as facultative vernal pool breeders. An evaluation of the available scientific literature provides little research on amphibian species living in vernal pools. The species selected for consideration in this tables simply represents those species for which information could be found.

Table 6-1. Summary of Amphibian Vernal Pool Preference – First Set of Elements

Species	*Obligate or Facultative Species*	*pH*	*Hydroperiod*	*Pool Size*	*Pool Depth*	*In Pool Vegetation Structure*
Spotted salamander ***(Ambystoma maculatus)***	**Obligate**	**Optimal: 7-9** Pough and Wilson (1977) **suboptimal: 5-6** Pough and Wilson (1977), Gosner and Black (1957) and Brodman (1993) **lethal <4.5** Pough and Wilson (1977), Gosner and Black (1957) and Brodman (1993)	**Temporary hydroperiod preferred over permanent** Vasconcelos and Calhoun (2006); Denton and Richter (2013)	**0.03-0.1 Ha** Millikin et. al. (2019), Petranka et al. (2003a), Egan and Paton (2004), Groff et al. (2017)	**Shallower is preferred for oviposition – depth up to 0.5 m** Egan and Paton (2004) and Rothenberger, et al. (2019)	**More complex vegetation structure, higher larvae survivor rate** Egan and Paton (2004)
Jefferson salamander ***(Ambystoma jeffersonianum)***	**Obligate**	**Optimal: pH 5-6** Pough and Wilson (1977); Chambers et al. (2013)	**Temporary hydroperiod preferred over permanent** Vasconcelos and Calhoun (2006); Denton and Richter (2013)			
Blue-spotted salamander (Ambystoma maculatum)	**Obligate**	In general pH below 6.0-6.3 limits anural sperm mobility (Mitchel, 2016)	**Intermediate hydroperiod preferred over permanent** Semlitsch et al. (1996), Babbitt et al. (2003)		Up to 1.5m depth with gentle slope (Mitchel, 2016)	From natural, usually circular, wetlands with partial canopies to shallow forested wetlands with full canopies primarily consisting of red maple and sweetgum (Mitchel, 2016)

Species	***Obligate or Facultative Species***	***pH***	***Hydroperiod***	***Pool Size***	***Pool Depth***	***In Pool Vegetation Structure***
Marble salamander ***(Ambystoma opacum)***	**Obligate**	In general pH below 6.0-6.3 limits anural sperm mobility (Mitchel, 2016)	**Intermediate hydroperiod preferred over permanent** Semlitsch et al. (1996), Babbitt et al. (2003)		Up to 1.5m depth with gentle slope (Mitchel, 2016)	From natural, usually circular wetlands with partial canopies to shallow forested wetlands with full canopies primarily consisting of red maple and sweetgum (Mitchel, 2016)
Wood frog (Rana sylvatica)	**Obligate**	**Optimal 7-9** McPherson, et. al. (2020)	**Intermediate hydroperiod preferred over permanent** Semlitsch et al. (1996), Babbitt et al. (2003)			
Spring peeper *(Pseudacris crucifer)*	**Facultative**	**Optimal 7-9** McPherson, et. al. (2020) In NJ Pinelands found at ~4.5 (Brunnell and Ciraolo, 2009)	**Intermediate hydroperiod preferred over permanent** Semlitsch et al. (1996), Babbitt et al. (2003), both Intermediate and permanent are preferred according to Brunnell and Ciraolo, 2009	0.04-0,22 Ha (Brunnell and Ciraolo, 2009)	Preferred depth up to 65cm (Brunnell and Ciraolo, 2009)	In pools often embedded in a forested matrix, typically support open water with herbaceous and shrub communities (Brunnell and Ciraolo, 2009)
Leopard frog (*Lithobates sphenocephalus*)	**Facultative?**	In NJ Pinelands found at ~4.5 (Brunnell and Ciraolo, 2009)	**Both intermediate hydroperiod and are permanent preferred** (Brunnell and Ciraolo, 2009)	0.04-0,22 Ha (Brunnell and Ciraolo, 2009)	Preferred depth up to 65cm (Brunnell and Ciraolo, 2009)	In pools often embedded in a forested matrix, typically support open water with herbaceous and shrub communities (Brunnell and Ciraolo, 2009)

Species	***Obligate or Facultative Species***	***pH***	***Hydroperiod***	***Pool Size***	***Pool Depth***	***In Pool Vegetation Structure***
Pine Barrens treefrog (*Hyla andersonii*)	**Facultative?**	In NJ Pinelands found at ~4.5 (Brunnell and Ciraolo, 2009)	**Both intermediate hydroperiod and are permanent preferred** (Brunnell and Ciraolo, 2009)	0.04-0,22 Ha (Brunnell and Ciraolo, 2009)	Preferred depth up to 65cm (Brunnell and Ciraolo, 2009)	In pools often embedded in a forested matrix, typically support open water with herbaceous and shrub communities (Brunnell and Ciraolo, 2009)

Table 6-2. Summary of Amphibian Vernal Pool Preference – Second Set of Elements

Species	*Obligate or Facultative Species*	*Vegetation Cover Surrounding the Pool*	*Vegetation Closure Above the Pool*	*Distance to Anthropogenic Disturbances*	*Created Vs Natural Habitats*	*Migration Distance from Pool – Protective Zone*
Spotted salamander (Ambystoma maculatus)	**Obligate**	**Prefers forest cover over clear cut area within 300-1000m of pool perimeter** Skidds et al. (2007); Felix et al. (2010); Scheffers et al. (2013), Windmiller, 1996	**Higher species richness at low closure compared to full canopy cover** Brune and Griffin (2005)	**Not affected** Brune and Griffin (2005)	**Not affected** Calhoun et. al. (2014), Rothenberge, et.al. (2019)	**Maximum 800 ft** Semlitsch et al. (1996), Windmiller, (1996), Faccio, (2003), Calhoun et. al. (2004)
Jefferson salamander (Ambystoma jeffersonianum)	**Obligate**		**Higher species richness at low closure compared to full canopy cover** Brune and Griffin (2005)			**Maximum 2000 ft** Semlitsch et al. (1996), Windmiller, (1996), Faccio, (2003), Calhoun et. al. (2004)
Blue-spotted salamander (Ambystoma maculatum)	**Obligate**		**Higher species richness at low closure compared to full canopy cover** Brune and Griffin (2003)			**Maximum 500 ft** Semlitsch et al. (1996), Windmiller, (1996), Faccio, (2003), Calhoun et. al. (2004)

Species	***Obligate or Facultative Species***	***Vegetation Cover Surrounding the Pool***	***Vegetation Closure Above the Pool***	***Distance to Anthropogenic Disturbances***	***Created Vs Natural Habitats***	***Migration Distance from Pool – Protective Zone***
Marble salamander ***(Ambystoma opacum)***	**Obligate**		**Higher species richness at low closure compared to full canopy cover** Brune and Griffin (2003)			
Wood frog (Rana sylvatica)	**Obligate**	**Forest surrounding the breeding pool at least in a 150m radius** Brune and Griffin (2005)	**Higher species richness at low closure compared to full canopy cover** Brune and Griffin (2005)	**Not affected** Brune and Griffin (2005)	**Prefers natural wetlands over created wetlands** Rothenberge, et.al. (2019), McPherson, et.al. (2020)	**Maximum 1500 ft** Semlitsch et al. (1996), Windmiller, (1996), Faccio, (2003), Calhoun et. al. (2004)
Spring peeper ***(Pseudacris crucifer)***	**Facultative**		**Higher species richness at low closure compared to full canopy cover** Brune and Griffin (2005)		**Larval development is not affected by wetland type** Rothenberge, et.al. 2019, McPherson, et.al. 2020	

7.0 VERNAL POOL MITIGATION BANKS

A wetland mitigation bank is a wetland area that has been restored and protected to provide compensation for impacts to wetlands. A mitigation bank may be created when a government agency, corporation, nonprofit organization, or other potential bank sponsor undertakes wetland restoration and protection activities under a formal agreement with the USACE, with representation on the Interagency Review Team (IRT) with the state representative, NMFS, USFWS, and USEPA. This formal agreement, called a Mitigation Banking Instrument (MBI) describes the wetland area's restoration plan and establishes the number of environmental credits the restoration work can potentially generate.

In the western USA, a multitude of mitigation banks have been established to protect large, intact expanse of vernal pools. They offer mitigation credits for permitted impacts to vernal pools and vernal pool species. Some such banks are Rogue Valley Mitigation/Conservation Bank in Oregon, https://www.wildlandsinc.com/banks/rogue-valley-mitigationconservation-bank-vpp/, and Locust Road Mitigation Bank, Barry Jones Wetland Mitigation Bank, https://mccollum.com/mitigation/index.html#Mitigation, and Toad Hill Ranch Mitigation Bank, https://www.wildlandsinc.com/banks/toad-hill-ranch-mitigation-bank-wetl/ in California. All are large mitigation banks (30-50) that have been approved through agreements with the U.S. Fish and Wildlife Service and U.S. Army Corps of Engineers and offer mitigation credits for permitted impacts to vernal pools, wetlands, and the vernal pool fairy shrimp.

It is interesting to note that California, in addition to wetland mitigation banking, has a process in place for conservation banking. Conservation banks are set up to protect specific threatened and endangered species and habitat; credits are established for the sensitive species that occur on these sites. Thus, small, fragmented sensitive species compensation projects are consolidated into large contiguous preserves which have much higher wildlife habitat values. Agencies that typically participate in the regulation and approval of conservation banks are the U.S. Fish and Wildlife Service and National Oceanic and Atmospheric Administration-National Marine Fisheries Service.

In New Jersey, 24 wetland mitigation banks have certified by the State of New Jersey. Basic information on the banks, including the type of credits offered, location, and Water Management of HUC zone served can be found through the New Jersey Office of Policy can be found at https://www.state.nj.us/dep/opi/mitigation-banks.html.

A review of the NJDEP website and the available literature suggests that no mitigation banks have been created specifically for vernal pool mitigation. Vernal pools have been included in some mitigation banks, but not as the only wetland type, and there are no specific vernal habitat credits. Noting the return on the investment of a mitigation bank, it is expected that banks would be developed with a general eye towards freshwater or tidal wetlands mitigation and would only add vernal pools if the habitat circumstances of the mitigation bank site are appropriate.

A review of the New Jersey wetland mitigation bank information suggests that there are at least three banks that include vernal pools, the Cranbury Mitigation Bank in Cranbury Township, Middlesex County, NJ (https://www.greenvestus.com/projects/cranberry-mitigation-bank/), the Rancocas Mitigation Bank Eastampton Township, Burlington County, NJ (https://www.greenvestus.com/projects/rancocas-mitigation-bank/), and the Oradell Reservation Bank, in the Boroughs of Closter and Haworth, Bergen County, NJ, https://www.greenvestus.com/projects/oradell-reservoir-mitigation-bank/. It is noted that the EPSC was only able to find information on these sites, though we are aware that there are other banks, though none have vernal pool credits.

The Cranbury Mitigation Bank (mitigation bank for Watershed Management Areas (WMA) 8, 9, and 10) has restored the project site by converting 80 acres of active agricultural fields back to its roots as a forested headwater wetlands/uplands complex; restoring hydrology to 37 acres of ditched, drained and impaired headwater forested wetlands; restoring 1,500 linear feet of historic headwater stream and enhancing 37 acres of zero and first order stream habitat; restoring and enhancing over 65 acres of riparian wetlands and uplands, enhanced and created 13 vernal pools (five currently certified by NJDEP), and enhanced/restored/created habitat for vernal species, wood turtle, barred owl & other interior dwelling species. The Rancocas Bank (WMA 20) encompasses approximately 400 acres of forested wetlands, forested uplands, and former agricultural lands and represents one of the largest contiguous forested areas in northwestern Burlington County. Interventions included restoration, enhancement and preservation of floodplain forest, vernal habitat, early successional forest, and scrub-shrub/emergent marsh. The project site contains confirmed habitat for the state threated wood turtle and federally endangered bog turtle occur along the riparian zone of Barks Brook. The Oradell Reservation Bank will restore, create and enhance vernal, stream and threatened and endangered species habitat. The bank provides credits to satisfy State/Federal freshwater wetland mitigation requirements, as well as enforcement related impacts within the Hackensack-Hudson-Pascack Watershed (WMA 5)

Similarly, the Oradell Reservation Bank, in the Boroughs of Closter and Haworth, Bergen County, NJ, https://www.greenvestus.com/projects/oradell-reservoir-mitigation-bank/ was constructed to restore, create, and enhance vernal, stream and threatened and endangered species habitat. The bank has been approved the New Jersey Department of Environmental Protection and once credits are released, they can be used to satisfy State/Federal freshwater wetland mitigation requirements, as well as enforcement related impacts within the Hackensack-Hudson-Pascack Watershed (WMA 5).

8.0 VERNAL POOL MITIGATION MONITORING

As stated by USACE-New England Division (NED) (2016) a Mitigation Monitoring Plan is part of an adaptive management program that provides an early indication of potential problems and possible corrective actions and is used to determine if the project is meeting its performance standards. Monitoring of aquatic resource structure, processes, and function from the onset of restoration, creation, or rehabilitation can indicate potential problems. Process monitoring (e.g., water-level fluctuations, sediment accretion and erosion, plant flowering, and bird nesting) is particularly important because it may identify the source of a problem and remedial measures, as well as identifying functional development. Monitoring and control of invasive species must be a part of any effective adaptive management program. Assessment of aquatic resource performance must be integrated with adaptive management. Both require understanding the processes that drive the structure and characteristics of developing the desired aquatic resource. Simply documenting the structure (i.e., vegetation, sediments, fauna, and nutrients) will not provide the knowledge and guidance required to make adaptive “corrections” when adverse conditions are discovered. Although the full maturation of a compensatory aquatic resource may take many years or even decades, process-based monitoring facilitates adaptive management to ensure that the mitigation site is developing along an appropriate trajectory.

8.1 U.S. Army Corps of Engineers – New England District Performance Standards

An important component of the Mitigation Monitoring Plan are the performance standards by which the vernal pool mitigation should be measured. USEPA-NED (2016) reports that performance standards and monitoring requirements are developed with the permit applicant on a site-by-site basis. Performance standards may be based on variables or measures of functional capacity; measurements of hydrology, vegetative diversity, or physical characteristics (e.g., height, aerial cover, stem counts per specified area); or other aquatic resource characteristics. Another option is to provide comparisons to reference aquatic resources of similar type and landscape position. When practicable, the performance standards should consider the expected stages of aquatic resource development.

USACE-NED lists the following elements as potential performance standards to be considered as part of a monitoring plan:

- The site has the necessary depth of hydrology, as demonstrated with well data collected at least weekly from March through June or other substantial evidence, to support the designed wetland type as compared to the reference wetland. Minimum of 90% of the site must meet desired hydrology levels. Areas that are too wet or too dry (i.e., seasonal high-water tables are more than 3” above or below target levels) should be identified along with suggested corrective measures.

- Target hydroperiod must be met, within two weeks at beginning and end of proposed wet season (if minimum hydrology technical standard is met).

- The proposed vegetation diversity and/or density goals for woody plants from the plan are met. Unless otherwise specified in the mitigation plans, this should be at least 500 trees and shrubs per acre, of which at least 350 per acre are trees for proposed forested cover types, that are healthy and vigorous and are at least 18" tall in 75% of each planned woody zone and at least the following number of non-invasive species including planted and volunteer species. Volunteer species should support functions consistent with the design goals. To count a species, it should be well represented on the site (e.g., at least 50 individuals of that species per acre).

- Each mitigation site shall have at least a) 95% areal cover, excluding planned open water areas or planned bare soil areas (such as for turtle nesting), by native species; b) Planned emergent areas on each mitigation site shall have at least 80% cover by non-invasive hydrophytes; and c) Planned scrub-shrub and forested cover types shall have at least 60% cover by non-invasive hydrophytes, including at least 15% cover by woody species.

- Until canopy coverage exceeds 30%, the average height of all woody stems of tree species including volunteers in each site, must increase by not less than an average of 10% per year by the fifth (Year 5 following construction) and tenth (Year 10 following construction) monitoring years.

- The fifth year (Year 5) and tenth year (Year 10) monitoring reports shall contain documentation that all vegetation within the buffer areas is healthy and thriving and the average tree height of all established and surviving trees is at least 5 feet in height.

- There is evidence of expected natural colonization as documented by the presence of at least 100 volunteer native trees and/or shrubs at least 3 feet in height per acre.

- Site will have documented use by breeding populations of target amphibian species.

- Site will have documented use by target wildlife species.

- Site will have documented use by target macroinvertebrate species.

- Soil pH will be within target range of 6.2 – 6.8 for the site.

- Soil has documented evidence of redoximorphic features developing by the third year (Year 3) after construction.

- All slopes, soils, substrates, and constructed features within and adjacent to the mitigation site(s) are stable.

- No nylon netting or non-biodegradable netting may be used in the mitigation area.

- Replace culvert which severs aquatic connectivity with one complying with the Stream Crossing Standards. New culvert complies with all applicable Stream Crossing Standards and maintains compliance through the monitoring period.

- 25 foot wide riparian zones should be maintained on both sides of any abutting stream/river linear feet; zones will have >60% aerial coverage by native species by the end of the first growing season, >85% by the end of the second growing season, and >95% by the end of the monitoring period.

8.2 Calhoun et al. (2014) Monitoring Recommendations

Calhoun et al. (2014) writes that although an amphibian species may be present at the site of interest, it is a poor indicator of population health; individuals may be transient animals that are no longer able to breed successfully in the pool. Trends in abundance of target species over at least 5 years post creation is a better measure of population robustness, although even abundance may not reflect breeding success in the pool. Ideally, the best measure of success is evidence of breeding and metamorphosis by intended species over five or more years.

Calhoun et al. (2014) recommends a minimum of five years of post-creation/restoration monitoring of reproductive effort for the target species (number of egg masses laid) and recruitment (number of animals successfully metamorphosing and returning to breed). Seemingly, functional pools may be ecological traps where individuals breed though larvae are not able to mature and leave the pool; thus, recruitment is a superior metric to egg mass counts. Survivorship to metamorphosis is a better predictor of population health than the presence or abundance of eggs or larvae (Richter et al. 2003; Cushman 2006; Rittenhouse and Semlitsch 2007; Harper et al. 2008).

In considering the vegetative element, Calhoun et al. (2014) recommends monitoring pool vegetation for at least five years after creation. They do not recommend using species richness as an indicator of pool success (or the contribution of that pool to regional biodiversity). In fact, Calhoun et al. (2014) report that vegetative richness can be similar between constructed and natural pools across the same landscape, while community composition is different (Drayer 2012; Denton and Richter 2013). Wood frogs and most of the region’s ambystomatid salamanders are forest pool specialists, in part because shaded pools are less likely to harbor competitors and predators including green frogs, bullfrogs, northern leopard frogs, pickerel frogs (*Lithobates palustris*), and eastern newts (Korfel et al. 2009).

Calhoun et al. (2014) strongly discourages using occupation by widespread, generalist species such as green frogs and their tadpoles as a criterion for success as such species do not adequately replace pool functions or contribute to landscape scale biodiversity. In contrast, these species are an indicator of failure to replace pool functions, especially for wood frogs.

Calhoun et al. (2014) also recommends monitoring from a long-term perspective because natural vernal pools tend towards extreme variability, from pool to pool and even within the same pool from year to year. Just as a natural vernal pool may not be productive or "successful" each year, a similar allowance should be considered in evaluating created pools. Factors such as weather, ecological context, and the developmental and demographic needs of target species can inform locally appropriate success criteria. Indeed, they hypothesize that having occasional years where pool hydroperiod is very short may facilitate amphibian reproductive success over the long run by both limiting disease and reducing populations of predatory invertebrates.

9.0 CONCLUSIONS AND RECOMMENDATIONS

The EPSC has reviewed the available research that has been published regarding vernal pool creation and mitigation. In general, the peer reviewed literature indicates that the creation of vernal pools is very challenging and should only be attempted by either avoiding the pools or restoring pools that may be impacted. As opposed to other forms of wetlands mitigation which can be measured by more straight forward standards as hydrophytic vegetative cover, and the presence of wetland soil and hydrology parameters, the success of vernal pool creation should be measured based on ecological function and the ability of the pool to support species typically found in vernal pools in the northeastern United States.

9.1 New Jersey Case Study Lessons Learned

Beginning in 2013, the Committee Chair for the EPSC was retained as the onsite representative overseeing a wetlands mitigation project that included the creation of 24 vernal pools, ranging in size from 0.02 acres to almost 1.5 acres. Due to confidentiality requirements, neither the location or project name, nor the applicant or the parties involved with the preparation of the mitigation plans will be identified. It is recognized that this is one project and is not meant to represent any judgement of the project but is simply a presentation of observations based on information developed for this paper. It is also noted that the wetlands mitigation and vernal pool creation was part of an approved Individual Wetlands Permit issued by the NJDEP pursuant to the Freshwater Wetlands Protection Act and both regulators and consultants had input into how the vernal pool creation was conducted.

The project was observed over a period of more than two years, from project initiation and completion to monitoring of project status for two years. The pools were constructed in areas covered by deciduous woods which were cleared to allow for the construction of the pools. Pools were designed based on hydrologic assessment. Prior to final grading, the pools were underlain with clay that was compacted to ensure that the pools would retain water. After the observation of the monitoring for the first two years (the project had a five-year monitoring period) the following observations were made:

- The performance standards issued by the NJDEP in the Individual Permit were standard wetland performance standards based on aerial cover and survivorship of wetlands vegetation, as well as hydrology and soil conditions. There were no permit conditions that required an examination of targeted amphibian species and invertebrates typical of vernal pools. So ecological function of the pools was not considered in terms of trying to measure success.

- As a result of the compacted clay liner under the pools, when the pools filled with water after the first rainfall after completion of construction, the pools never dried up. The liner was too tight (it was completed to construction specifications) and so the ponds remained permanently inundated. As has been discussed at length in this paper, the life cycle of the vernal pool and its inhabitants are based on periodic drying and wetting.

- As was discussed in Section 5.2.5, canopy cover is an important element of native vernal pools. For the created vernal pools in question, the majority had limited or no cover. The impact from the increased exposure of the water to the sun was evident by the thick layer of algae and duckweed, which would impact habitat suitability for vernal pool specific species.

While the ponds may eventually develop wetland characteristics and be considered successful from the permit standpoint, from an ecological perspective, it is hard seeing the created pools developing the characteristic of a true vernal pool.

This case study illustrates the complexities of attempting creation of vernal pool habitats. In contrast, restoration of vernal pool habitats may be easier by characterizing baseline conditions and then attempting to replicate those as closely as practicable.

9.2 Recommendations

The EPSC provides the following recommendations relative to vernal pool mitigation.

9.2.1 Vernal Habitat Creation

The EPSC proposes the following recommendations for NJDEP consideration, many of which follow those provided by Calhoun et al. (2014) relative to mitigation plans and proposals for vernal pool creation:

- If pool hydroperiod is successfully recreated, generally appropriate species should follow if source populations exist within viable colonization distances. However, hydroperiod is perhaps the most difficult parameter to reproduce. Therefore, we caution practitioners to carefully consider the effects of substrate composition, compaction, maintenance of canopy, and construction on pool fauna when building vernal pools. If pool hydrology is permanent or even semi-permanent with connections to other waters, fish and amphibian species typically restricted to permanent wetlands may colonize the pool and decimate vernal pool-breeding amphibians by depredating both egg masses and larvae.

- Calhoun et al. (2014) recommends the creation of pools that support appropriate, natural vegetation (Pearl et al. 2005), hydro-geomorphic setting, and soil type and compaction as much as possible. Limiting removal of adjacent trees and root damage during construction will preserve canopy cover and reducing soil compaction will facilitate colonization by herbaceous plants and trees, and connection with groundwater.

- Because littoral zones with a gradual slope are important for life history requirements of some species (e.g., marbled salamanders) and provide more opportunity for establishment of vegetation, thermoregulation of larvae, and refuge from predation, Calhoun et al. (2014) recommends using that approach in developing vernal pools.

- Calhoun et al. (2014) advises against creating permanent pools. Addition of created pools with permanent hydroperiods, especially at unnaturally high densities, may subsidize local populations of bullfrogs, green frogs, and eastern newts. This can negatively affect nearby pool-breeding specialists by increasing predation pressure on eggs and larvae and by increasing the likelihood of disease introductions (Gahl et al. 2009; Brown et al. 2012; Greenspan et al. 2012; Denton and Richter 2013).

- Calhoun et al. (2014) recommends ample post-breeding habitat and pool connections be maintained for long-term amphibian population persistence. The 30 m buffer surrounding pools often serves as critical habitat for newly emerged amphibians and should provide ample canopy cover, leaf litter, and coarse woody material for cover and foraging (Regosin et al. 2003; deMaynadier and Houlahan 2008). However, persistence of populations is favored by at least 300 m of forested habitat and connections that allow movements among pools and pool clusters.

- Presence of an amphibian species is a poor indicator of population health; individuals may be transient animals that are no longer able to breed successfully in the pool. Trends in abundance of target species over at least 5 years post-creation is a better measure of population robustness, although even abundance may not reflect breeding success in the pool. Ideally, the best measure of success is evidence of breeding and metamorphosis by intended species over five or more years.

- Calhoun et al. (2014) recommends a minimum of five years of post-creation/restoration monitoring reproductive effort of target species (number of egg masses laid) and recruitment (number of animals successfully metamorphosing and returning to breed).

- Calhoun et al. (2014) do not recommend using species richness as an indicator of pool success (or the contribution of that pool to regional biodiversity). In fact, richness can be similar between constructed and natural pools across the same landscape, while community composition is different, driven by the presence of species not historically breeding in the ecosystem (Drayer 2012; Denton and Richter 2013).

- Calhoun et al. (2014) also recommends monitoring from a long-term perspective because natural vernal pools tend towards extreme variability, from pool to pool and even within the same pool from year to year.

9.2.2 Restoration of Vernal Pool Habitat

Vernal habitat creation procedures should mirror those for wetland restoration by first having a solid understanding of baseline vegetation, soils, and hydrology conditions prior to a permitted disturbance. In addition, overlain onto that are the following considerations specific to vernal habitat restoration:

- Understanding of the extent of the hydroperiod. This may require pre-disturbance monitoring to understand the length of time during the year that the area is inundated as well as the water depth. This in turn should be related to precipitation data over several years so the present conditions are understood (e.g., are we in a drier year than typical?).

- Topography and depth of the depression. This can easily be measured from site topographic maps (using 1-foot contours) as well as field measurements of the maximum and average water depth during spring conditions.

- Characterization of the substrate below the habitat. This should include characterization of soil texture and organic content, which may be done qualitatively in the field or employing laboratory analysis of samples taken.

- Understanding of existing water quality conditions during spring months as well as the remainder of the year. This should include dissolved oxygen levels, total dissolved solids and/or turbidity, salinity (amphibians are generally not salt tolerant) and temperature.

- Understanding baseline species use of the vernal habitat, answering questions such as what amphibian species are using it, what are their predators, whether state-listed species may use it, and what is the distance of the vernal habitat to other vernal habitats nearby.

- Characterization of the existing habitat of the area surrounding the pool, for example, whether it is a red maple swamp, a floodplain dominated by pin oak, or a shallow pool surrounding by emergent wetland vegetation in an open area.

9.2.3 Overall EPSC Recommendations

Finally, the Committee makes the following overall recommendations regarding restoration or creation of vernal habitats to mitigate for impacts:

- The preferred alternative to vernal pool mitigation is preservation. Where at all possible, functioning pools would be protected to the extent that both the pools themselves and sufficient upland area around them would be permanently preserved. Such an effort could be up regionally and perhaps focus on sites featuring high quality pools resulting in the long-term protection of fully functioning vernal pool communities. This would be more beneficial to the New Jersey's vernal pool resources than trying to re-create pools on a site-by-site basis.

- Restoration is strongly preferable to creation of vernal habitats and the potential success rate of meeting mitigation goals is higher. Restoring vernal pool habitats allows for the ability to take advantage of a known hydrology. Creation of new vernal pool habitat starts from an ecological restoration point with too many unknowns.

- It is recommended that the NJDEP develop a consistent monitoring program for vernal pool mitigation/restoration projects with a concise set of performance criteria based on a full set of ecological parameters consistent with New Jersey wetlands. Performance criteria should consider local vernal pools unaffected by a proposed project as reference wetlands. Criteria should include not only measurement of vegetative parameters, but functional assessments and response from obligate wildlife species such as amphibians.

- While the EPSC did not find an example in the scientific literature where a vernal pool was created for the benefit of a single species (Charge Question #3), the EPSC does not recommend attempting to develop vernal pool habitat restoration or creation to benefit a single species. The EPSC found that it is challenging enough to restore or create a vernal pool to benefit several obligate species, it would be even harder to develop one to benefit one species. Particularly if the restoration or creation was part of a mitigation effort in which the NJDEP was requiring the applicant to meet certain success criteria for that species. This would be further confounded by the fact that there is so little known about the obligate species found in New Jersey and their exact habitat requirements and sensitivities.

- Restoration and/or creation of vernal habitats should incorporate strategy considerations outlined in Section 6, such as attempting to focus the restoration and/or creation on the various species found in the pools for which the mitigation is being conducted, as well as landscape level considerations including connectivity of restored or newly created vernal habitats.

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