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October 14, 2021 BY EMAIL

Newbury Conservation Commission
Newbury Municipal Offices
12 Kent Way, Suite 101
Byfield, MA 01922

Subject: Certified Vernal Pool Analysis at Proposed "Village at Cricket Lane" Newbury, MA

Dear Commission Members:

As I mentioned previously, I have been retained by direct abutters to the proposed Villages at Cricket Land project (the "Project") located at 55 Pearson Drive (the "Property") in Newbury to assess whether the Project complies with the MassDEP Wetland Protection Act (WPA) and more particularly, protects both the northerly Certified Vernal Pool ("CVP") and the westerly Potential Vernal Pool ("PVP").

My professional conclusion is that the Project, as submitted to the Conservation Commission (the "Commission"), fails to protect these jurisdictional areas under the WPA.

Note that all impacts I cite in this report to the CVP would also occur — and in fact be magnified — for the PVP. The watershed surrounding the PVP has far more proposed impervious area than that proposed within the CVP watershed. In addition, habitat around the PVP, if the Project were built according to the present design, would be almost 100% lost to buildings, roads, lawns and infrastructure.

Professional Background

As background, I am the Principal of Patrick C. Garner Co., Inc., an environmental consulting firm. I am a wetland scientist, professional land surveyor, certified soil evaluator and hydrologist with more than thirty years of experience in these fields.

I have performed hundreds of wetland studies and delineations. I frequently appear before Conservation Commissions in Massachusetts. I also regularly represent clients before the Massachusetts Department of Environmental Protection ("MassDEP") with respect to wetlands issues. I am a peer reviewer for numerous Conservation Commissions in Massachusetts. In that capacity, I frequently review medium and large scale proposals and advise Conservation Commissions about regulatory compliance. I was a member of the Harvard Conservation Commission from 1994 -1997.

Since 1993, I have taught numerous workshops and seminars for the Association of Massachusetts Wetland Scientists ("AMWS"). I have also been a frequent instructor for the Massachusetts Association of Conservation Commissions ("MACC"). I received the 2007 President's Award from AMWS for contributions to the field of wetland science. I was President of the Association of Massachusetts Wetland Scientists ("AMWS") from 1996 to 1998.

In addition, I was a Director of the MACC from 1997 to 2000 and again in 2008, and President between 2004-2006. I was elected MACC President a second time, serving between 2010-2012. I am an online continuing education instructor for professional education firms in the areas of wetland science, hydrology and land surveying.

I have been a member of five MassDEP Technical Advisory Committees, including the Intermittent/Perennial River Committee, the Mean Annual High Water/Bankfull Committee, the Ecological Restoration Committee, the Wetlands Advisory Subcommittee and the Stormwater Advisory Group. As a hydrologist, I have offered expert witness testimony in water-related cases in Massachusetts Superior Court on issues related to stormwater, rivers, vernal pools and groundwater. I have also testified as a wetlands and hydrology expert in MassDEP adjudicatory (OADR) appeals for over twenty years.

I have trained with the Natural Resources Conservation Service ("NRCS") in procedures to calculate storm runoff, including use of TR-20 (discussed in detail below), and have taken advanced courses from HydroCAD Software Solutions. I have advised MassDEP regarding use of extreme precipitation data and stormwater technology. I am a current peer reviewer for the federal Hydrometeological Design Studies Center (HDSC) regarding extreme precipitation.

For the last 20 years, I have certified Vernal Pools ("VPs") and I regularly monitor VPs on a monthly basis. That monitoring includes water quality testing for pH, dissolved oxygen, temperature, saline levels and turbidity. I monitor record fluctuations in water levels to track pool hydroperiods (i.e., the duration of flooding). In that capacity, I have analyzed the annual water budget of VPs for both private and public clients. Doing so entails determining and comparing existing and post-development conditions, and determining whether development may impact the function of a VP.

Review of the Proposed Project

I was asked to review the Notice of Intent ("NOI") for the Project by abutters to the Property. As part of my analysis, I submitted a Project review to the Commission dated June 6, 2021.

I also walked just outside the perimeter of Property on March 26, 2021, took photographs and made observations regarding protected wetland resource areas, topography, vegetative conditions and cover. I observed areas of Bordering Vegetated Wetlands ("BVW") in the rear of Lots 75 and 76, and a Potential Vernal Pool ("PVP") in the rear of Lot 79.

As part of my investigation, I reviewed MassGIS data layers, including aerial photography. I also reviewed USGS mapping, USDA soils data, and wetland resource data layers for the Property. I confirmed through MassGIS data that a CVP lies on the northern property line; CVPs are classified as Outstanding Resource Waters ("ORW"). I also confirmed that pursuant to 314 CMR 4.06(2), the CVP is designated as a Class B ORW.

I have reviewed the engineering plans, drainage calculations, and supporting documents submitted with the NOI, including the 40B Comprehensive Permit plan dated August 17, 2020, revised January 28, 2021, prepared by Ranger Engineering Group ("Ranger"), which was re-issued to the Conservation Commission on March 8, 2021.

Project Impacts on Vernal Pool Water Budget, Water Quality and Wildlife Habitat

My professional opinion is that the proposed Project will cause adverse impacts to protected Resource Areas, including the CVP. I have quantified these impacts by:

- calculating water budgets for the northerly CVP;
- analyzing water quality impacts from the proposed Project;
- analyzing the adequacy of the proposed Buffer Zone between the development and the Resource Areas;
- analyzing the impact of the proposed slopes that lie in proximity to the Resource Areas;
- and analyzing impacts to Wildlife Habitat associated with the CVP.

Each component plays a key role in maintaining the integrity and function of a viable VP, as explained below.

<u>1. Vernal Pool Water Budget Impacts</u>
In my June 6, 2021 review to the Conservation Commission regarding the Applicant's NOI, I stated that the Applicant's designer should provide a water budget analysis for the CVP. I noted that, at a minimum, a water budget analysis for the CVP was necessary to ensure that the Project did not impact this protected resource.

To my knowledge, the Applicant's designer has not provided the Commission with that analysis, nor explained the omission. Consequently, I have performed the water budget analysis and reviewed habitat impacts.

My CVP annual water budget analysis includes the following data:

- pre- and post-development velocity changes;
- pre- and post-development watershed areas;
- pre- and post-development change in impervious area;
- and pre- and post-development volume changes.

These factors are, in my professional opinion, required to determine whether impacts to the CVP are likely.

I have also reviewed potential water quality changes, that is, whether the Project may alter stormwater chemistry in a manner that could affect the biological balance of the CVP after development.

To calculate potential CVP water budget changes, I first determined the *pre-development* project-related watershed area for the CVP, which is 1.76 acres. I then determined the watershed area for the CVP after (or post) development. The post-development watershed area — 1.04 acres — *decreased* by 40%, which itself is a significant alteration.

Other components of my analysis included determining the hydrologic soil group (HSG) of the natural soils, slope, time of concentration (Tc) and the curve number of the soil (Cn) (a measure of imperviousness). I used federal Soil Conservation Service (now NRCS) methodology and data for that purpose.

After developing base data for the CVP watershed, I ran calculations in HydroCAD,[1] which is a commercial iteration of the SCS Technical Release-55 (June 1986 — note that TR-55 and 20 were developed specifically to calculate runoff and discharges in small watersheds). HydroCAD is accepted for this purpose by MassDEP and is the most widely used program in New England (and in much of the United States) to calculate runoff data.

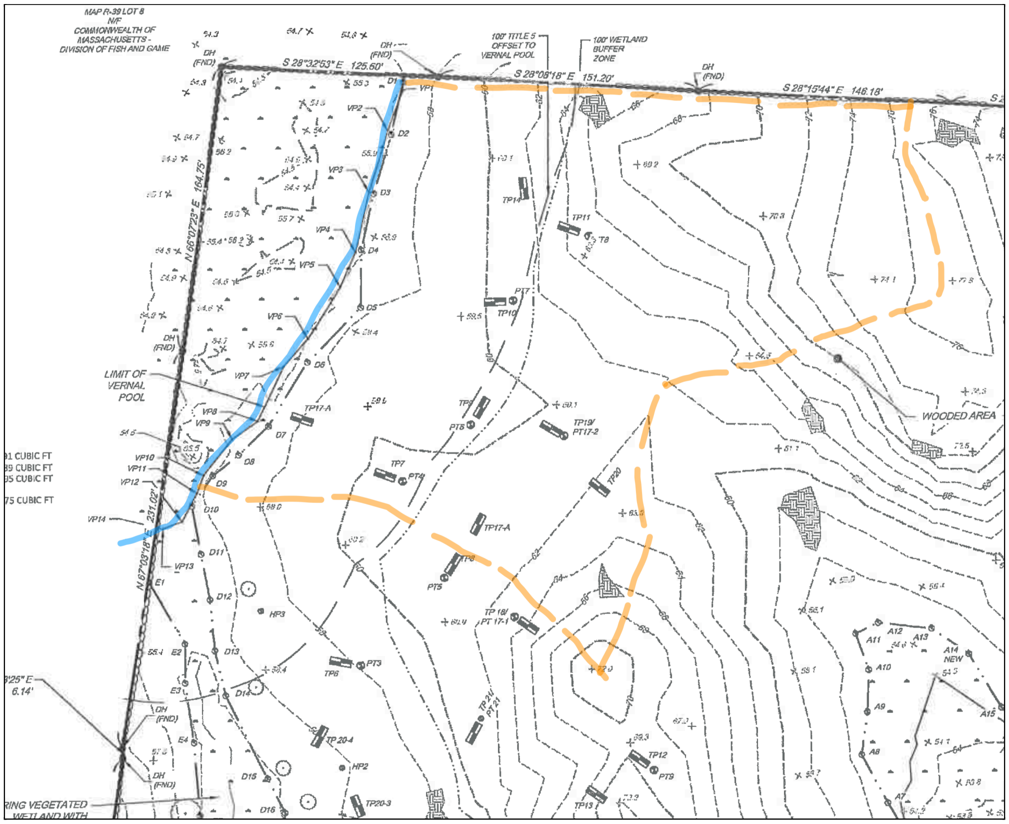


Figure 1. Pre-development CVP watershed.

HydroCAD calculates peak rate of discharge, hydrographs, stormwater volume and other data. The use of the TR-55 method is recommended in the MassDEP publication, *Hydrology Handbook for Conservation Commissions* (March 2002), pages 4-5 and 4-6.[2]

Precipitation for an annual water budget is based on a 24-hour, 1-year storm event. My source for that data is the Extreme Precipitation Tables, Northeast Regional Climate Center (NRCS, version 1.12, 2021). For Byfield, the 24-hour 1-year storm event is 2.69-inches.

<u>2. Vernal Pool Water Source Impacts</u>

VP water budgets are derived from two sources: groundwater and surface water flow. To quote from the *Field Guide to the Animals of Vernal Pools*,[3] VPs “are ephemeral wetlands which fill annually from *precipitation*, *runoff* and rising *groundwater*.” Groundwater within a VP fluctuates daily, weekly and seasonally. As the *Field Guide* notes, VPs lose or gain water through changes in groundwater, evaporation and transpiration.

[1] See attachment: HydroCAD Water Budget analysis.

[2] TR-55 is also referenced in the Wetlands Protection regulations, and in the Department’s *Stormwater Management Policy Handbook* (1997).

[3] Kenney & Burne, 2001.

In addition to rising and falling vertically, groundwater moves horizontally. Directional flow can be determined by using specialized monitoring wells (often referred to as piezometers). Many wetland experts will set a small network of these wells in the vicinity of VPs to determine directional movement. *To my knowledge, this analysis was not done by Ranger, and consequently, information about the direction of groundwater flow is missing from the project data.*

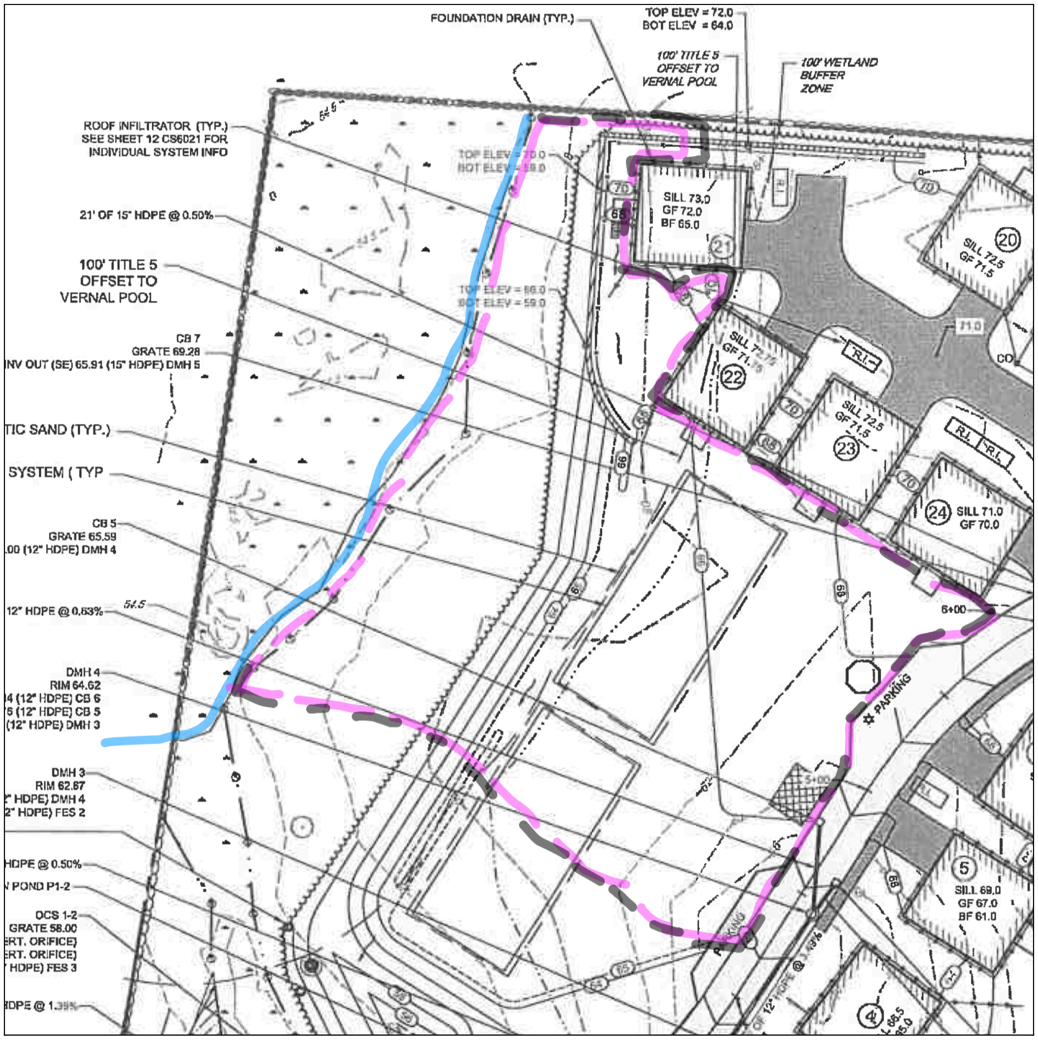


Figure 2. Post-development CVP watershed.

Regardless, groundwater movement is typically disrupted or redirected by site “improvements” such as roads, drainage infrastructure, subsurface infiltration, retaining walls and foundations. All of these disruptions would occur on the Project site. More than 50% of the Project CVP watershed is substantially altered after development, and more than 90% of the PVP watershed.

Therefore, my professional opinion is that the natural groundwater flows into the CVP are likely to be altered by the Project. Because project data provided by the Applicant’s designer is insufficient — that is, information regarding directional groundwater flow is missing — specific analysis of this component is not possible. Consequently, the focus of my analysis has been on the components I can reliably quantify, which are the changes to surface runoff described in this report.

3. Vernal Pool Water Budget Findings

My calculations indicate that the CVP would be adversely impacted by the Project. CVP impacts are found in all measurable parameters, such as watershed area, impervious area, runoff velocity (measured in cu. ft/sec, or cfs), and volume, which are illustrated in Tables 1 and 2 below.

Table 1. Comparison of Changes to CVP Water Budget, Pre- and Post-Development

	Area (ac)	Cn	Velocity (cfs)	Volume (af)	Depth (in)	Tc
PRE-DEV	1.76	59	0.14	0.030	0.2	12.2
POST-DEV	1.04	68	0.30	0.035	0.4	8.9

Viewed as percentages of change, the differences are apparent.

Table 2. Percentages of Change, Pre- and Post-Development

	Area (ac)	Cn	Velocity (cfs)	Volume (af)	Depth (in)	Tc
PRE-DEV						
POST-DEV	-41%	+13%	+53%	+14%	+50%	+23%

All of these watershed changes are significant. Post-development alterations include,

- the volume of stormwater entering the CVP increases by 14%;
- the timing of volume entering the pool by increases by 23%;
- the amount of impervious area in the CVP watershed increases by 13%;
- the depth of stormwater entering the pool increases by 50%; and
- the velocity of stormwater entering the CVP watershed increases by 53%.

The volumetric change would alter the CVP water elevation, and consequently, Wildlife Habitat conditions for the CVP. In addition, the volumetric alteration will appreciably change the hydroperiod (the rate and timing of water flows into vernal pools from storms) of the pool. This change threatens the species identified in the CVP on this site.

Of particular note, times of concentration (Tc — the time it takes water to travel from the highest point in a watershed to the lowest) of stormwater flow will be markedly decreased, with frequent, low-intensity storm events far more likely to flow into the CVP than under existing conditions.

Compounding the impacts, the flow length (that is, the total distance stormwater flows from one end to another through a watershed) is reduced after development. The existing flow length for the CVP is 320 feet; under proposed conditions that length is decreased by 80 feet. This 25% decrease in length is a significant change that would, when combined with a shortened Tc, increase the impact of frequent, low-intensity storm events.

Therefore, stormwater entering the pool would become “flashier,” with flows and fluctuations becoming more abrupt. More volatile storm flows are known to negatively impact fauna life cycles. In *Vernal Pools,*[4] Elizabeth A. Colburn notes that such changes result in "shifts in predator-prey dynamics and community composition.” Further, “changes in the hydroperiod alter the fauna of vernal pools and affect the ability of amphibians and other species to reproduce successfully in the pools.”

[4] See, *Vernal Pools,* Colburn (2008) p. 245.

To maintain the fragile habitat characteristic of a vernal pool, a site designer normally strives to ensure that the annual water budget post-development, including runoff characteristics, is in balance with pre-development conditions. In the case of this Project, there appears to be no attempt to mimic pre-development hydrologic characteristics for the CVP.

In sum, my water budget analysis indicates that the CVP's hydroperiod would be altered by the Project, and that pre- and post-development conditions are not balanced for the CVP, as is required.

4. Water Quality Impacts

I also analyzed changes in water quality that would occur from a project of this intensity. My multi-year monitoring of vernal pools, which now cumulatively includes hundreds of monthly water quality measurements, indicates that post-development changes — unless carefully designed — typically affect water quality, which in turn affect breeding potential. Typical changes that occur when new high intensity development is located next to VPs include higher saline measurements, lower Biological Oxygen Demand (BOD) and higher pH values, which are all detrimental to the fauna of vernal pools.

Corroborating my observations, Colburn states,[5] "Water quality also changes with development ... Significantly disturbed watersheds have a higher pH, more mineral substrate, and more algae, on average, than do pools whose watersheds are not developed. The fauna of pools may change dramatically in response to development…." She notes, as I consistently observe during my own monitoring of VPs across Massachusetts, that development leads to an increase in "turbidity, nutrient levels and dissolved contaminants."

In addition, changes to stormwater temperature also affect pool fauna. Short-circuited flows off lawns and unshaded areas are hotter than stormwater from wooded areas. Colburn states, "… the amount of oxygen that can be dissolved in water decreases with increasing temperature. Some marine invertebrates can maintain a constant metabolic rate over the range of temperatures typical of their habitat, but this has not been demonstrated for invertebrates that are found in vernal pools…." Therefore, decreasing stormwater travel time, as well as changing the vegetative conditions from undisturbed woods to lawns will inevitably create warmer stormwater discharges into the CVP on the Property.

I also reviewed whether the proposed Project complied with the MassDEP recommendation to "Design the development using environmentally sensitive site design and low impact development techniques to preserve natural vegetation, minimize impervious surfaces, slow down times of concentration, and reduce runoff."[6] My conclusion is that the Project design is not "environmentally sensitive," as it does not "preserve natural vegetation," and does not "minimize impervious surfaces."

Post-development lawn runoff from the Project may include fertilizers and herbicides. The biological integrity of the pool would be impacted by these changes. Habitat would be affected

[5] Ibid, p. 249

[6] MassDEP Stormwater Handbook, Volume 2, Chapter 1

by the multiple hydrologic changes to the CVP, as described above.[7] Potential impacts from herbicides, fertilizers and road runoff into the CVP should be evaluated. To my knowledge, Ranger has not conducted such an evaluation.

Therefore, it is my professional opinion that the numerous alterations proposed in the vicinity of the CVP would impair the functions of the pool, negatively impact the ORW and wildlife habitat, and would introduce pollution in violation of 310 CMR 10.01(2). In addition, the Project would significantly alter the hydrology of the CVP and impact the habitat of this Resource.

5. Impact to the CVP from Other Work in the Buffer Zone

If constructed, the Project will create an abrupt edge that immediately shifts from woods to lawn. This modification will inevitably create warmer stormwater runoff, shading changes to the BVW, and alterations to the CVP/ORW. These changes would therefore impair the functions of the CVP, and would negatively impact public water supply in violation of 310 CMR 10.01(2) by adding pollutants to surface and groundwater flows.

6. Impact to the CVP from Project Slopes and Retaining Wall

Natural slopes beside the CVP and BVW are relatively flat. Under existing conditions, grades run between 1% and 3%. However, proposed final grades behind the buildings (specifically Units 21 and 22) are unusually steep. A retaining wall is proposed within 40 feet of the CVP. In addition, proposed slopes within 60 feet of the CVP increase to more than 30% (3:1), 10 times greater than existing grades.

Any construction errors resulting in destabilization of unvegetated slopes could result in fill entering the adjoining CVP. Further, the proposed retaining wall (125 feet long) will eliminate wildlife passage between the CVP and its critical uplands.

7. Impacts to CVP Wildlife Habitat from Project

Evidence of human disturbance within the proposed Project area is currently minimal; the site is almost entirely wooded. A large percentage of the woods appear to have been unlogged for decades. This condition is ideal habitat for the fauna identified as breeding in the CVP on this site. Species identified include salamanders and wood frogs.

As Kenney and Burne note in *Field Guide*, salamanders “live underground in the forest up to one-half mile [more than 2,500 feet] from their breeding pool.” Similarly, wood frogs are found “in moist woodlands.” Both species are highly dependent on contiguous undisturbed woods.

In *Habitat Values of New England Wetlands*,[8] the authors state, “salamanders of the genus *Ambystoma* (spotted, blue-spotted, Jeffersons), as well as the wood frog, breed exclusively in vernal pools. These salamanders travel in mass migrations along traditional routes to return to the pools where they were born to breed.” The key phrase in this quote is that the “salamanders

[7] In a 1998 California study that recommended methods to preserve VPs, “Management Considerations for Small Vernal Pool Preserves,“ (Clark, Roscoe, van Ess & Wyler), the authors note under a section entitled, *Changes in Hydrology*, “Summer water runoff is a substantial problem facing vernal pool preserves adjacent to developed or irrigated lands… Runoff from residential lawns and playing fields may also contain significant amounts of fertilizer. Since the quality and quantity of water received could substantially influence the flora and fauna of the pool (Holland and Jain, 1973; Ferren and Gervitz, 1990), it is important to consider potential impacts to vernal pools from modifications to their watershed (Stromberg and Hecht, 1991).”

[8] US Army Corps of Engineers (1995).

travel in mass migrations along traditional routes to return to the pools….” Loss of these routes disrupts “traditional” travel ways to the pools.

DeGraaf and Rudis[9] note that habitat includes “undisturbed damp, shady deciduous or mixed woods, bottomlands, swamps, ravines, moist pastures and lake shores.” The Project site mirrors that description and can be accurately described as being composed of “undisturbed damp, shady deciduous or mixed woods, bottomlands, [and] swamps.”

The same authors, describing wood frog habitat, state that their habitat is “often far from water during summer months as woodland ponds dry up” and that they prefer “wooded areas with small ponds for breeding.” The authors further note that, in various studies, home range movement was found to be as little as 200 feet away, and as far as 1,320 feet.

310 CMR 10.04 states:

> Vernal pool habitat means confined basin depressions which, at least in most years, hold water for a minimum of two continuous months during the spring and/or summer, and which are free of adult fish populations, as well as the area within 100 feet of the mean annual boundaries of such depressions, to the extent that such habitat is within an Area Subject to Protection Under M.G.L. c. 131, § 40 as specified in 310 CMR 10.02(1). These areas are essential breeding habitat, and provide other extremely important wildlife habitat functions during non-breeding season as well, for a variety of amphibian species such as wood frog (*Rana sylvatica*) and the spotted salamander (*Ambystoma macultum*), and are important habitat for other wildlife species.

This same section of the WPA (10.04) specifically notes that an area up to 100-feet outside of the “mean annual boundaries” of VPs is essential breeding habitat for many species, including the Wood frog. Yet as noted directly above, academic studies indicate that 100-feet is inadequate to protect habitat for either salamanders (commonly ranging up a one-half mile from breeding pools) or the Wood frog (ranging between 200 and 1,320 feet).

As discussed above, the Project proposes to only protect a 30- to 40-foot area around BVW and the CVP. Through its road system, drainage and buildings, the Project disregards and uniformly severs the interconnections of a significant percentage of the southerly CVP habitat.

In March 2006, MassDEP issued a definitive manual entitled, *Massachusetts Wildlife Habitat Protection Guidance*. In section F (page 7), the guidance states:

> IMPACTS TO CERTIFIED OR DOCUMENTED VERNAL POOL HABITAT IN ALL RESOURCE AREAS
> In all resource areas, any direct alteration associated with certified or documented vernal pool habitat requires a detailed wildlife habitat evaluation (Appendix B). A finding that impacts to vernal pool habitat will not result in an adverse effect will only occur under rare and unusual circumstances. A finding of no adverse effect must include consideration of the restoration and/or replication proposed after two growing seasons. However, replication and restoration of vernal pool habitat is difficult to successfully accomplish. Therefore, avoidance of impacts to vernal pool habitat is almost always necessary to meet performance standards.

Although — as my calculations clearly indicate —the CVP water budget would be impacted, no Appendix B has been filed for this Project. Further, no “replication and restoration of vernal pool habitat” is proposed for the Project. As I have detailed elsewhere in this report, significant

[9] *Amphibians and Reptiles of New England* (1983).

alteration of the hydrology for the CVP constitutes, in my professional opinion, a direct alteration of the resource.

Section C.3 of the same guidance goes on to state,

> Vernal Pool Habitat: Mitigation for direct alterations to vernal pool habitat in resource areas may involve restoration or replication of that habitat. Careful design of restored or replicated vernal pool habitat must closely replicate the hydrology of the existing condition, and must be in close proximity to the existing vernal pool. The substrate of the pool (i.e. dead leaves, organic or mineral soil) and the vegetation in and around the pool must also mimic existing conditions. However, there are other indirect and potentially important alterations that must be identified and mitigated if they cannot be avoided. Projects altering resource areas can inadvertently disrupt existing migration routes between vernal pool systems, or between vernal pool habitat and other wetlands or upland nesting areas. In some cases, effective mitigation can involve a field survey to identify the migration patterns of obligate and facultative species and design features that maintain connections between vernal pool/wetland/upland habitats used. Some strategies may include wildlife tunnels, oversized stream culverts or arch culverts combined with fencing to direct wildlife movement to crossing structures. In addition, design features may include restrictions on construction during breeding, egg-laying or dispersal periods for the identified species, creation of nesting areas and monitoring and adjustment of erosion controls as necessary to prevent obstruction of animal movement. Some vernal pool hydrology depends on overland surface water drainage that should not be diverted....

The Project as currently designed would "disrupt existing migration routes between vernal pool systems" and "between vernal pool habitat." To my knowledge, no field survey has been conducted to "identify the migration patterns of obligate and facultative species. No "design features that maintain connections between vernal pool/wetland/upland habitats" have been proposed. This MassDEP guidance applies to instances of "direct alterations" within resource areas, which I conclude will occur to the CVP if the Project is permitted as designed.

Indeed, from my own years of monitoring vernal pools, I have documented pools wherein all identified vernal pool species became extirpated within a single breeding season, even when undisturbed buffer zones were greater than 50-feet.

The *MACC Environmental Handbook*[10] emphasizes that proposed activities should "not impair wildlife habitat functions (feeding, breeding, nesting, over-wintering and migration)." As I have emphasized, the proposed Project does not adequately protect the interest of wildlife habitat on the Property. Further, the proposed Project would impair the wildlife habitat functions of the CVP in violation of 310 CMR 10.01(2) by destroying travel ways, as well as essential breeding and overwintering habitat.

In conclusion, the changes brought about by the Project will alter the CVP and adversely impact the Wildlife Habitat function of the BVW associated with the CVP. As such, the Project fails to adequately protect Wildlife Habitat and Vernal Pool Habitat under the WPA.

Summary

The Project as submitted to the Commission will alter the CVP and the PVP. Those alterations will include direct and quantifiable impacts to the CVP and the PVP water budgets, alter hydroperiods and create the loss of species habitat.

[10] Page 292 (9th ed.)

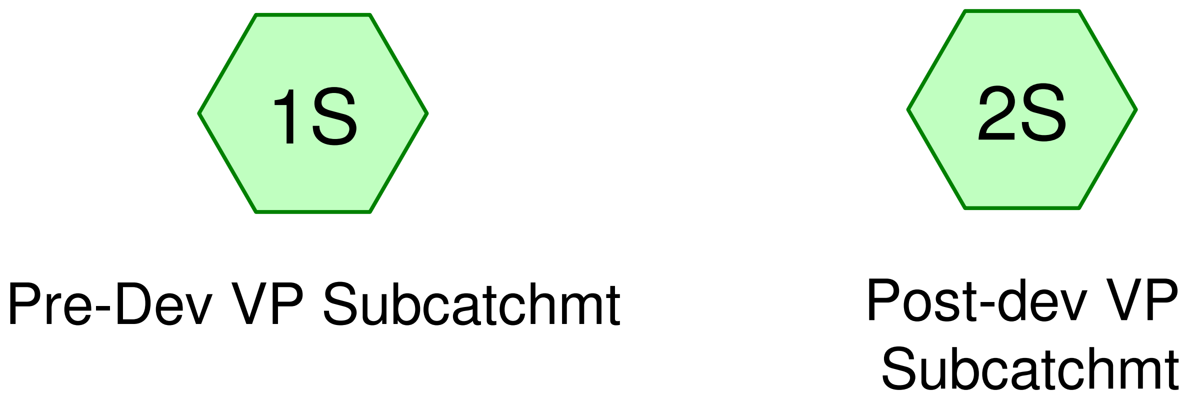
The Applicant appears to have omitted any analysis of impacts. In addition, the Applicant appears to have omitted any mitigation that might, depending on design, reduce impacts.

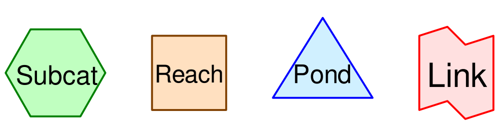
My professional opinion is that these impacts, individually and cumulatively, are in violation of the provisions in the WPA, and that the requested Order of Conditions should be denied.

Very truly yours,

Patrick C. Garner
Wetland Scientist, Hydrologist

Attachment: HydroCAD Water Budget Analysis





Routing Diagram for Byfield VP Analysis
Prepared by Patrick C Garner Co., Inc., Printed 10/7/2021
HydroCAD® 10.10-4b s/n 04330 © 2020 HydroCAD Software Solutions LLC

Rainfall Events Listing

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	1-Yr	Type III 24-hr		Default	24.00	1	2.69	2

Area Listing (all nodes)

Area (acres)	CN	Description (subcatchment-numbers)
0.683	61	Grass-open space (2S)
0.008	98	Retaining wall (2S)
0.049	55	Woods (2S)
0.300	77	Woods left natural (2S)
0.350	77	Woods, good (1S)
1.410	55	Woods, good (1S)
2.800	**62**	**TOTAL AREA**

Ground Covers (all nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	0.683	0.683	Grass-open space	2S
0.000	0.000	0.000	0.000	0.008	0.008	Retaining wall	2S
0.000	0.000	0.000	0.000	0.049	0.049	Woods	2S
0.000	0.000	0.000	0.000	0.300	0.300	Woods left natural	2S
0.000	0.000	0.000	0.000	1.760	1.760	Woods, good	1S
0.000	**0.000**	**0.000**	**0.000**	**2.800**	**2.800**	**TOTAL AREA**	

Time span=5.00-30.00 hrs, dt=0.05 hrs, 501 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Pre-Dev VP Subcatchmt Runoff Area=1.760 ac 0.00% Impervious Runoff Depth=0.20"
Flow Length=320' Tc=12.2 min CN=59 Runoff=0.14 cfs 0.030 af

Subcatchment 2S: Post-dev VP Subcatchmt Runoff Area=1.040 ac 0.77% Impervious Runoff Depth=0.40"
Flow Length=240' Tc=8.9 min CN=66 Runoff=0.30 cfs 0.035 af

Total Runoff Area = 2.800 ac Runoff Volume = 0.065 af Average Runoff Depth = 0.28"
99.71% Pervious = 2.792 ac 0.29% Impervious = 0.008 ac

Summary for Subcatchment 1S: Pre-Dev VP Subcatchmt

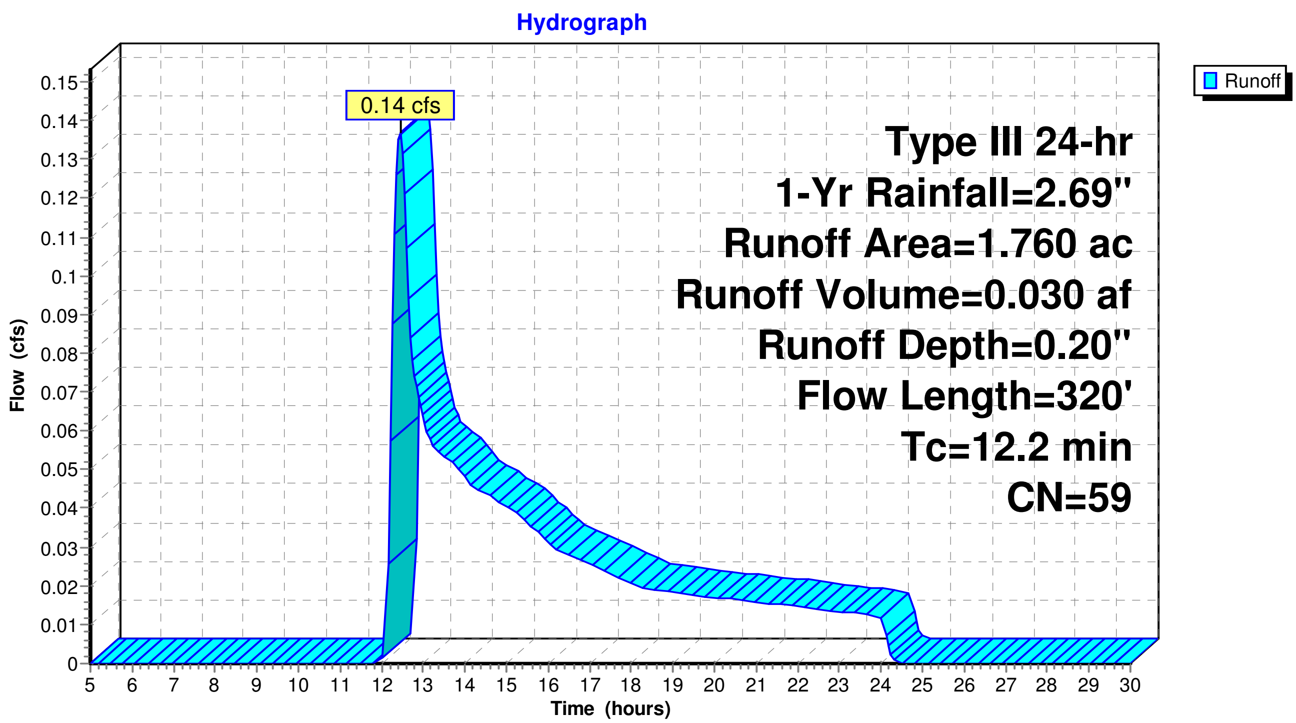
Runoff = 0.14 cfs @ 12.44 hrs, Volume= 0.030 af, Depth= 0.20"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 1-Yr Rainfall=2.69"

	Area (ac)	CN	Description
*	0.350	77	Woods, good
*	1.410	55	Woods, good
	1.760	59	Weighted Average
	1.760		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
8.2	50	0.0560	0.10		**Sheet Flow, Woods** Woods: Light underbrush n= 0.400 P2= 3.21"
4.0	270	0.0500	1.12		**Shallow Concentrated Flow, Shallow conc** Woodland Kv= 5.0 fps
12.2	320	Total			

Subcatchment 1S: Pre-Dev VP Subcatchmt



Summary for Subcatchment 2S: Post-dev VP Subcatchmt

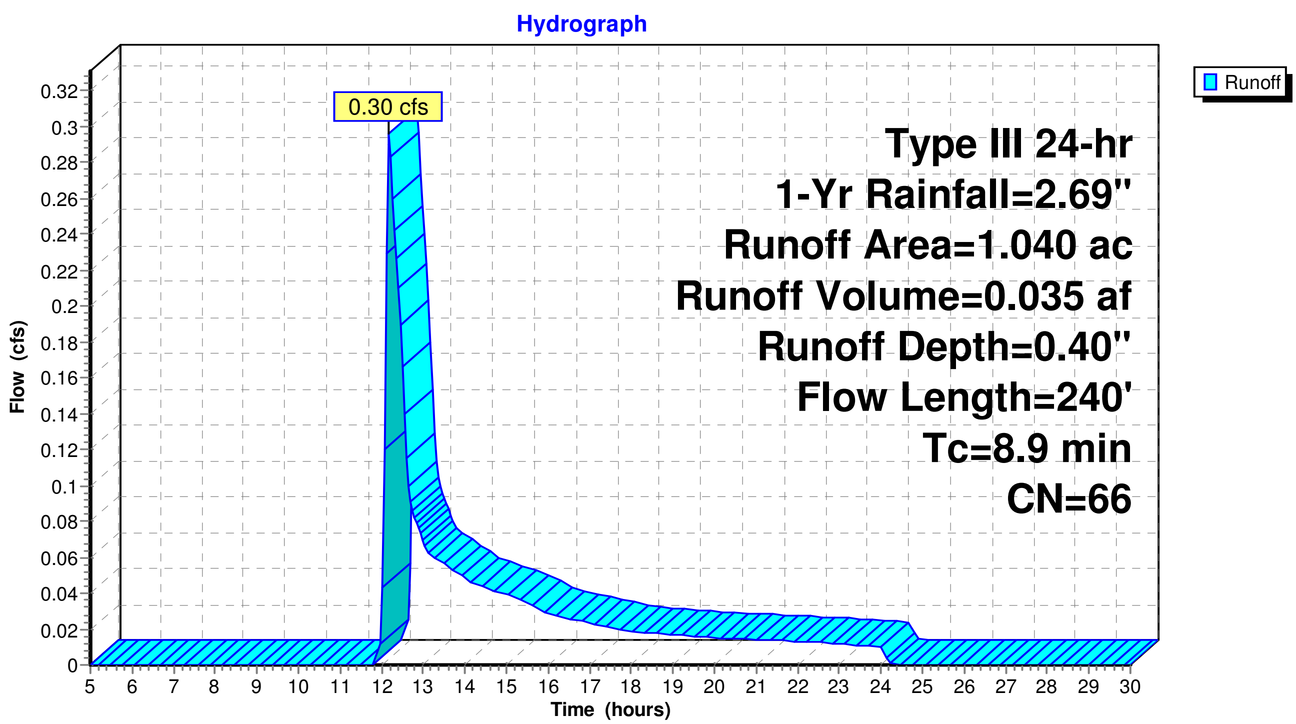
Runoff = 0.30 cfs @ 12.17 hrs, Volume= 0.035 af, Depth= 0.40"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 5.00-30.00 hrs, dt= 0.05 hrs
Type III 24-hr 1-Yr Rainfall=2.69"

	Area (ac)	CN	Description
*	0.300	77	Woods left natural
*	0.008	98	Retaining wall
*	0.683	61	Grass-open space
*	0.049	55	Woods
	1.040	66	Weighted Average
	1.032		99.23% Pervious Area
	0.008		0.77% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
6.2	50	0.0400	0.13		**Sheet Flow, Sheet flow, lawn** Grass: Dense n= 0.240 P2= 3.21"
0.7	130	0.0400	3.00		**Shallow Concentrated Flow, Shallow conc** Grassed Waterway Kv= 15.0 fps
2.0	60	0.0100	0.50		**Shallow Concentrated Flow, Wooded** Woodland Kv= 5.0 fps
8.9	240	Total			

Subcatchment 2S: Post-dev VP Subcatchmt



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