ATTACHMENT C

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ECOLOGICAL IMPACTS OF EPA'S PROPOSED REMEDY

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Executive Summary

EPA's proposed remedy for the Housatonic Rest of River, SED 9/FP 4 MOD, would involve the removal of close to one million cubic yards of sediment and soil, directly impacting over 400 acres of the Rest of River ecosystem, including approximately 370 acres of the stretch between the confluence of the East and West Branches of the River and Woods Pond Dam, known as the Primary Study Area (PSA). EPA concludes that this disruption will cause only short-term impacts because restoration will reliably reestablish the current ecosystem. In our paper entitled "A Scientific Response to EPA's Conclusion that Restoration of the Housatonic Rest of River Will Be Fully Effective and Reliable," we explain why this conclusion is not supported by the scientific literature. In this document, we describe the likely short-term and long-term impacts of SED 9/FP 4 MOD on each of the five key habitat types in the unique and diverse ecosystem of the PSA -- river and river banks, floodplains, impoundments, backwaters, and vernal pools. First, we address three overarching and unavoidable negative impacts of EPA's proposed remedy:

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The **integrity of the overall river-floodplain ecosystem** of the PSA will be compromised for two key reasons. First, remediation activities, including the construction of the access roads and staging areas necessary to support those activities, will cause extensive fragmentation of what is currently a fairly broad, nearly continuous ribbon of native vegetation, thus severing a forested "wildlife corridor" that extends along the Housatonic River, and also across the Housatonic River valley, between the intact forested hills that lie east and west. Second, there will be substantial "edge effects" that extend beyond the footprint of remediation, including sediment deposition, changes in microclimate, noise, and the invasion of exotic plants and animals. These effects will greatly increase the area negatively impacted by the remediation activities to the point that most of the PSA ecosystem will be degraded. These edge effects (other than noise) will continue long after SED 9/FP 4 MOD activities are completed.

Because of the profound soil disturbance that is unavoidable with SED 9/ FP 4 MOD, controlling the onslaught of invasive exotic plant species and restoring the current suite of native plant species in the PSA will be essentially impossible.

Two **temporal aspects** of SED 9/ FP 4 MOD are of significant concern. First, given the numerous animal and plant species that would be affected by SED 9/FP 4 MOD, each with its individual life cycle and growing season, there is no season in which construction work would not have a significant direct adverse impact on some species and the habitats to which they and other species would return in return in a different season. Second, the proposed duration of remediation in Reaches 5A through 5C – just 8 years – is far too short to allow any recovery of one area before an adjacent area is disrupted. In particular, within just 8 years, large silver maples will be replaced with saplings that will take at least 50 years to reach tree height, and probably well over 100 years for the development of full-size crowns and boles necessary to provide the full range of habitat values currently provided for wildlife.

Where **river channels** are targeted for remediation, aquatic macroinvertebrates and fish will be eliminated during the period of remediation. Impacts on the hyporheic zone (surface and groundwater interactions in the river substrate) will likely disrupt discharges of groundwater into the river in a way that cannot be repaired. Fish breeding sites will be eliminated. The time within which new breeding sites will be established, and for what species, is uncertain. Populations of stream and wetland insects and crustaceans, mussels, dragonflies and damselflies, and aquatic vascular plants, will be at least severely depleted for years to come, and perhaps eliminated for the foreseeable future. With important prey species like these depleted, the numbers of predators (e.g., pickerel, otter, kingfisher) – which are present now – will also decline precipitously. Regardless of the bank stabilization techniques selected (including bioengineering techniques), implementation of bank remediation and stabilization activities in Reaches 5A and 5B would permanently change the character of the **riverbanks** with major negative impacts on the river channel and current riverbank habitat in these subreaches.

Floodplains would be severely impacted by SED 9/FP 4 MOD, especially through the loss of mature floodplain forest. The infeasibility of locating a comparable source of soil to mimic current conditions in the floodplain make the re-establishment of the affected forested floodplain communities very unlikely. In general, restoration of shrub and shallow emergent wetland communities is expected to be more straightforward than restoring forested floodplain communities. However, at the scale of SED 9/FP 4 MOD there are numerous constraints that could adversely affect the recovery of even those wetland communities.

The restoration of **impoundments** and **backwaters** is more likely than that of all of the other habitats in the PSA ecosystem because excavation and capping procedures are more predictable. However the potential for colonization of invasive exotics is high (as evidenced by the current onslaught of these species in Woods Pond). Whether and how soon the current vegetation, invertebrate, and fish communities of the impoundments will recolonize them are uncertain.

Up to 43 of the 66 **vernal pools** in the PSA would be excavated with direct long-term impacts, including long-lasting changes in the hydrology of the vernal pools (which is extremely difficult to reproduce), in soil conditions in the pools (due to the inability of replacement soils to match the characteristics of the existing vernal pool soils), and in the vegetative characteristics of the pools (due to the loss of the complex and mature vegetative composition of the adjacent forest). There is also a high probability that invasive or other undesirable plant species and animal predators (such as green frogs, bullfrogs, and invertebrates) would invade pools where they did not previously exist. These alterations would, in all likelihood, result in the loss of obligate vernal pool species from most of these pools. The re-creation of the pre-remediation conditions in these vernal pools and their associated forested habitat is essentially impossible.

In **conclusion,** any remediation in the PSA should be weighed against the enduring loss of habitats and their associated animal and plant populations in the PSA. Where remediation activities occur, these animal and plant communities will be diminished for at least many years, in many instances 50 to 100 years or more, and in some instances even longer because there will be insufficient refugia for the native species that one would hope to return to the PSA after the remediation is completed. This will cause severe ecological consequences. Furthermore, the ecosystem integrity of the river and its associated floodplains will be seriously compromised by the fragmentation intrinsic to the proposed remediation activities, especially because their ecological impact will extend well beyond the footprint of remediation.

1.0 Introduction

SED 9/FP 4 MOD would involve the removal of close to one million cubic yards of sediment and soil, directly impacting approximately 370 acres of the PSA ecosystem. The impacts of disruption of this magnitude were specifically identified in the Revised Corrective Measures Study (hereafter referred to as "Revised CMS") on which we collaborated between 2008 and 2010. The Revised CMS also evaluated the extent to which these negative impacts could be mitigated and the inevitable long-term adverse impacts of work despite such mitigation. In the face of these detailed site-specific evaluations, EPA's Comparative Analysis for the Rest of River (May 2014) (hereafter, "Comparative

Analysis") concludes that any negative impacts of SED 9/FP 4 MOD, or any remedial alternative evaluated in the Revised CMS, can be quickly and effectively reversed. That conclusion ignores the Revised CMS, additional site-specific evaluations done by the Commonwealth of Massachusetts, and the "significant body of knowledge with respect to ecosystem restoration" to which EPA refers and which we discuss in detail in "A Scientific Response to EPA's Conclusion that Restoration of the Housatonic Rest of River Will Be Fully Effective and Reliable" (hereafter, "Restoration Response").

In fact, as discussed in Section 6.3.5.2 of the Revised CMS, there is no precedent for a remedial project of the ecological scope and spatial scale of SED 9/FP 4 MOD in an ecosystem like the PSA, a long and sinuous riparian corridor of diverse and ecologically sensitive habitats harboring numerous state-listed rare, threatened, endangered, and special concern species. SED 9/FP 4 MOD would involve substantial disturbances of that diverse and ecologically sensitive ecosystem.

Contrary to EPA's suggestion that "*restoration is expected to be fully effective and reliable in returning these habitats, including vernal pool habitat to their pre-remediation state*" (Comparative Analysis, page 26), there are significant constraints on the ability to re-establish the pre-remediation conditions and functions of the affected habitats. Any restoration attempted after a project of the nature and scope of SED 9/FP 4 MOD would not be fully effective or reliable in returning these habitats to their pre-remediation ecological condition. The best one could hope for is that these efforts would be partly effective at returning some types of habitat to a semblance of their pre-remediation state after an extended period. Larger combinations of sediment and soil removal like SED 9/FP 4 MOD would have a much greater negative impact on the PSA ecosystem than other combinations like SED 10/FP 9, the ecologically sensitive approach, or the alternative proposed by the Commonwealth of Massachusetts.

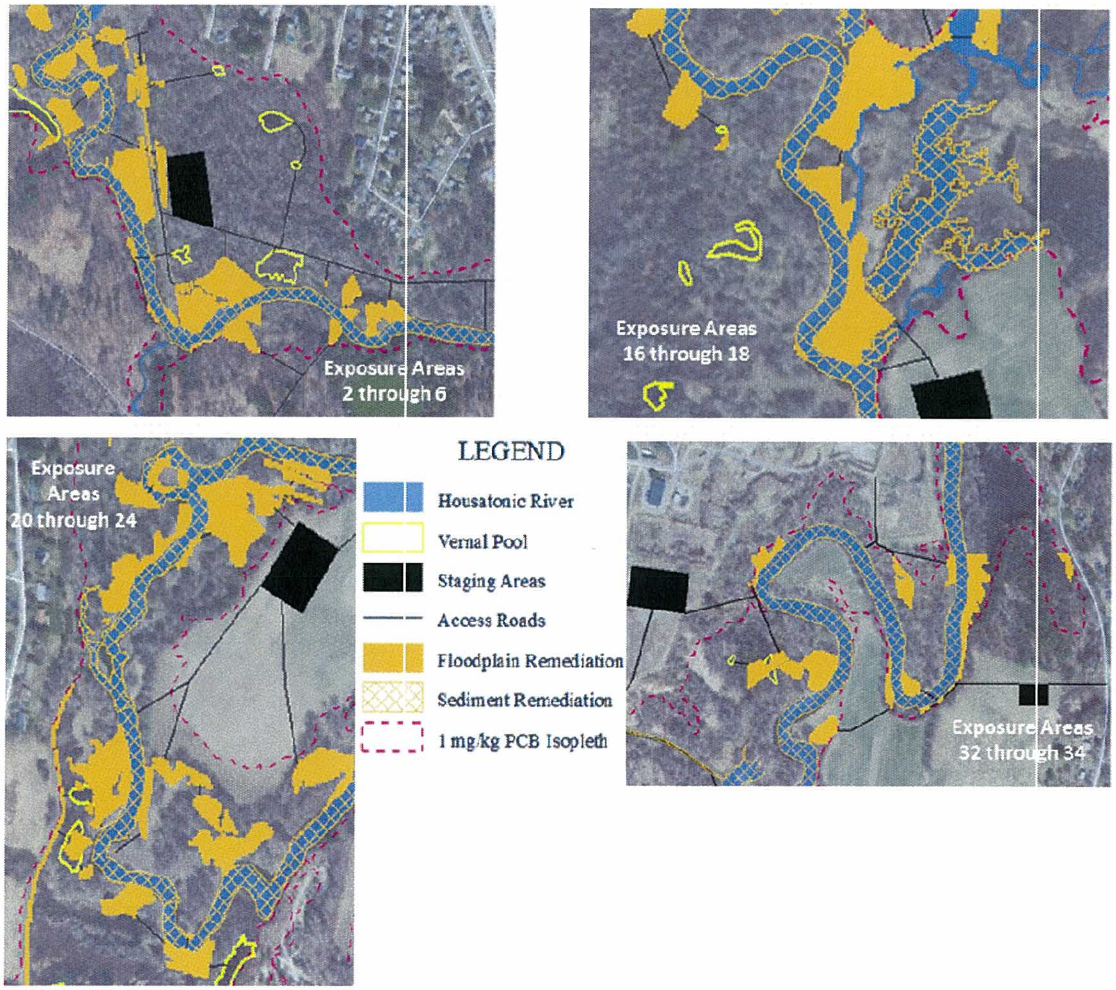
Most of this document is devoted to a habitat by habitat response to EPA's conclusions about SED 9/FP 4 MOD in the Comparative Analysis, but we begin by addressing three overarching issues that are pertinent to the overall PSA ecosystem.

1.1 Integrity of the Entire System

EPA's Comparative Analysis states: *"To fully restore the functions and values of a river and floodplain, the basis of a river restoration must embrace a whole systems approach. The goal of this whole systems approach is a fully functioning ecosystem that maintains the connection between the river and its unique, diverse and vital floodplain features."* (Page 6 of Attachment 12 of the Comparative Analysis)

We could not agree more with the core concept embodied in this statement, the importance of thinking about the integrity of the whole ecosystem. However, SED 9/ FP 4 MOD ignores this critically important concept, and therefore will fragment the PSA as a whole ecosystem. The negative effects of ecosystem fragmentation are well documented, and the patterns of landscape-scale fragmentation are quite evident if you examine aerial photographs of the Housatonic Valley. Briefly, the surrounding hills are reasonably intact but most of the lowlands are in an advanced state of fragmentation. A key, critical exception exists along the PSA, a fairly broad ribbon of native vegetation through the lowlands, extending downstream from the confluence of the East and West Branches in Pittsfield . It has been narrowly dissected by roads in a few places but remains remarkably intact. However, this would not be the case after the remediation proposed by EPA. There will be extensive perforation of the vegetation in Reaches 5A and 5B (i.e., numerous patches cleared of what is currently unbroken vegetation), and in some places SED 9/FP 4 MOD will sever the linear forested riparian corridor of the PSA, such as in and near Exposure Areas (EAs) 2-6, 16-18, 20-24, and 32-34 (Fig. 1). Indeed, in three of these places (all but EA 16-18), the proposed remediation reaches laterally across almost the whole PSA. The estimated total of 45 acres of floodplain that would be disrupted by SED 9/FP 4 MOD (see page 34 of the Comparative Analysis) may seem modest, but the locations of these areas are critically important given the narrowness of the riparian corridor in those areas. More importantly, EPA's estimates do not include the extensive area of access roads and staging areas, and related clearing that will be required in connection with the excavation of soil in these areas.

Fig. 1. Areas where SED 9/FP 4 MOD would adversely impact the ecological connectivity of the PSA.



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Furthermore, "edge effects" will cause significant negative impacts in areas extending beyond the footprint of the actual remediation work. These impacts will include potential increases in erosion and sedimentation, the spread of invasive exotic plant and animal species, changes in microclimate, and noise from construction and traffic that can disturb sensitive bird and mammal species. Exactly how far those edge effects reach could vary considerably. Some effects such as microclimate changes are usually measured in tens of meters but movement of invasive plants and animals may reach hundreds of meters (Laurance et al. 2002). If we look at the full impact of SED 9/FP 4 MOD, using 100 meters as a reasonable estimate of the lateral extent of edge effects, it is apparent that almost the entire PSA is likely to be affected (Fig. 2). These estimates likely understate the negative impacts of SED 9/FP 4 MOD because they do not include the substantial edge effects related to more than 3.5 miles of bank stabilization. Because banks are linear, they are particularly extensive sources of edge effects. Furthermore, despite EPA's stated goal of protecting what it has designated as Core Area 1 habitat (owing to its importance as habitat for immobile state-listed species), it is proposing the devegetation and excavation of areas within 100 meters around those areas. As depicted in Figure 3, the 100-meter wide area around Core Area 1 habitat should also be protected as a buffer because of the edge-effect phenomenon. Finally, it is noteworthy that all of these edge effects except for noise generated by remediation activities will persist long after the remediation work is complete, indefinitely in the case of invasive species that become established.

In short, the ecosystem integrity of the river and its associated floodplains will be seriously compromised by the fragmentation intrinsic to SED 9/FP 4 MOD, especially because the negative ecological impacts will extend well beyond the footprint of remediation.

Fig. 2. The cross-hatched area represents the extent of a 100-m wide edge effect zone around the areas in which EPA proposes remediation (and related access roads and staging areas) in Reaches 5A and 5B.

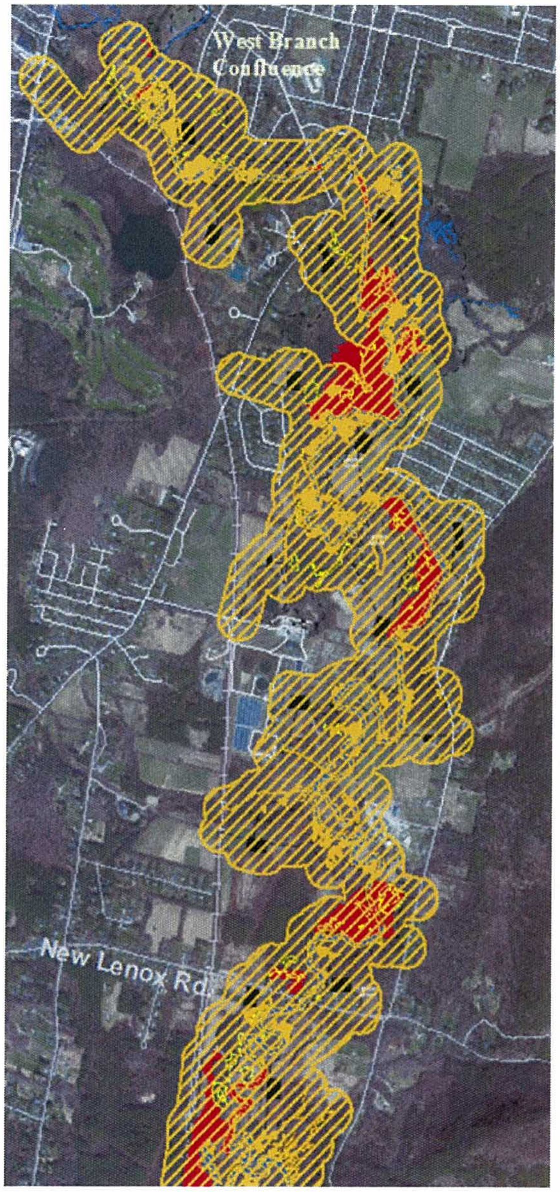

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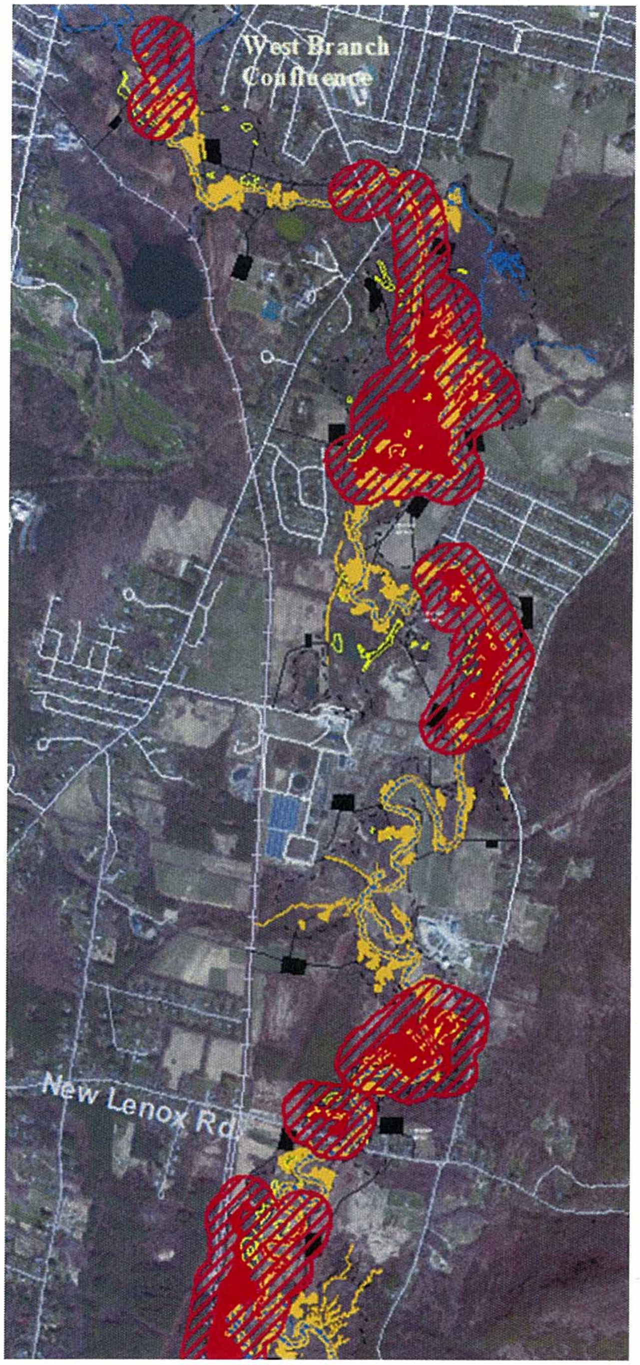
Fig. 3. The red-hatched area represents the area that falls within 100 m of a Core Area 1 and should be protected as a buffer zone because of edge effects.



1.2 Native Flora vs. Invasive Exotics

There is a world of difference between making a site green and restoring some semblance of the native flora, the suite of plant species indigenous to a particular environment, as is discussed in Section 2.6.6 of the Restoration Response document.

The low success rate for reintroducing native plants increases the risk that the PSA will be overrun by invasive exotic plant species. Invasive exotic plants are already present in the PSA, with 18 problematic species identified, and SED 9/FP 4 MOD will most likely increase the extent of their coverage. Invasive exotics will outcompete the native species currently present in the PSA because of the extensive areas of exposed soil (both backfill and new sediments), less competition from natives removed during remediation, and more sunlight following forest canopy removal (a factor relevant to both aquatic and terrestrial species). Furthermore, roads, staging areas, and the movement of vehicles and soil will all increase invasions of propagules of invasive exotics. EPA implies that controlling invasive exotics is straightforward, but this is not the case. One analysis (Kettenring and Adams 2011) examined 335 research papers covering control of 110 invasive exotic plant species and reported: "*Regardless of control method, our meta-analysis revealed that few studies produced gains in native plant cover, density or biomass*." They also warned about the negative ecosystem impacts of invasive control: "*Herbicide was the most commonly implemented and, according to our meta-analysis, the most effective control method for reducing invasives. However, native species response to herbicide was highly variable, probably because this broad-scale approach can hinder native species establishment through seed limitation*." In fact, there can be unintended consequences of using particular techniques to control invasive exotics (see Skurski et al. 2013).

In summary, devegetating an ecosystem makes it practically impossible to restore even a reasonable semblance of the previous flora because both reintroducing native species and controlling invasive exotic species are extremely difficult tasks.

1.3 Temporal Issues: Seasons and Duration

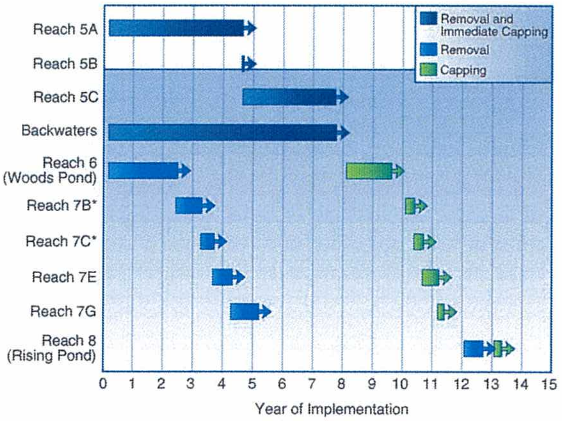
1.3.1 Work seasons: As is discussed in Section 5.2.3 of the Revised CMS, given the numerous animal and plant species that would be affected by SED 9/FP 4 MOD, with their individual life cycles and growing seasons, there is no way that the remedial construction work could be timed to prevent direct adverse impacts to all species. For example, sediment removal and/or capping could be scheduled to avoid working in the river during the breeding or emergence season for one generation of animals, such as dragonflies, mayflies, and possibly spawning fish (typically late spring and summer), but this approach would not avoid all adverse effects because the impacts would last well beyond the immediate construction season, affecting breeding and emergence in subsequent seasons. Similarly, for animals with high site fidelity, such as the American bittern, even if remediation work occurred only during periods when they are not present, only direct mortality would be avoided. The habitats would be negatively impacted for multiple years.

In most cases, loss of habitat equates to loss of populations, with subsequent negative impacts to food webs within the ecosystem.

With specific reference to plant species, there is no time of year that would avoid adverse impacts, since even winter removal activities would affect either the plants themselves (at least their underground roots and rhizomes) or their seed banks or both. Similarly, winter work would adversely affect the species that often spend the winter on the river bottom, such as the wood turtle or larvae of dragonflies. In short, there would be no time of the year in which remedial construction activities would not cause adverse impacts to many plant and animal species. Although a few temporal strategies could reduce the harm to some degree, the adverse impacts of SED 9/FP 4 MOD would still be significant.

1.3.2 Duration: Some remedial activities would have adverse effects that last many years, not just multiple seasons. For example, contrary to EPA's unsubstantiated suggestion, riverbank stabilization would result in the complete elimination of mature overhanging trees from the stabilized banks to prevent the destabilizing effect of large trees. Furthermore, the remediation proposed in Reaches 5A, 5B, 5C, and their associated backwaters is scheduled to be completed in just 8 years (Fig. 4). This means that extensive areas will be simultaneously denuded of their natural vegetation. This is of particular concern where the dominant vegetation is large silver maples. These trees are currently tall enough to support canopy-dwelling birds, have crowns wide enough to shade the river and backwaters, and have trunks old enough to provide dens for cavity-dwelling mammals and birds and to become large woody debris in the river. However, if SED 9/FP 4 MOD is implemented, these mature forests will, within just 8 years, be replaced with saplings that will take at least 50 years to reach tree height, and probably well over 100 years to develop full-size crowns and boles. Furthermore, where banks are stabilized, large trees will be removed and prevented from returning for the foreseeable future (see Section 2.2.2 below), which will affect the distance between the forest and the river in those areas for as long as the stabilized banks are maintained. EPA suggests that an Adaptive Management framework will be employed in the implementation of SED 9/FP 4 MOD but overlooks the fact that such a framework would require much more time than EPA proposes, especially when dealing with slow ecological processes like the growth and succession of vegetation.

Fig. 4. EPA's estimated timeline for cleanup activities (Fig. 5 from EPA's Statement of Basis).



2.0 River and Riverbanks

2.1 Context: River Channel and Riverbanks

SED 9/FP 4 MOD would directly impact 126 acres of aquatic riverine habitat and at least 3.5 miles of riverbank (in Reach 5A alone). This extensive disturbance to the PSA with its current high level of biodiversity and productivity will severely degrade this highly functioning ecosystem, resulting in the loss of valued riverine habitats and decreased plant and animal species diversity.

The riverbanks in Reaches 5A, 5B, and 5C are an integral part of the overall riverine ecosystem and provide a variety of habitat functions for a range of wildlife species. Exposed vertical banks and undercut banks are most prevalent in Reach 5A, less so in Reach 5B. These steep, primarily forested banks provide similar wildlife functions in both reaches. Mature overhanging trees are present in portions of these reaches, particularly in the upstream portions, where they offer shaded microhabitats within the river and foraging and perching sites for piscivorous and insectivorous birds. In the downstream portions of Reach 5B and in Reach 5C, where the banks are well vegetated with a shrub-dominated mix with some trees and herbaceous growth, the banks provide foraging habitat for a variety of amphibians, reptiles, birds, and mammals. The fate of the river channel and riverbanks are closely linked because they are structurally and functionally dependent upon each other. Impacts on both components will be considered together in this section.

2.2 Impact of Remediation on River Channel and Riverbanks

2.2.1 Impacts to the river channel. The dredging and/or capping of substrates and sediments in the river channel would cause a change in surface substrate type from present conditions (sand, sand and gravel, or silt) to an undetermined mix of textures, including armor stone. Because adjacent riverbanks will be disturbed simultaneously, the characteristics and stability of the river channel and associated riverbanks will be highly altered for extensive reaches of the PSA. When attempting to remove and replace the substrate of the entire river bottom for remediated reaches, the adjacent riverbanks will necessarily be affected, likely becoming unstable during construction, causing slumping and erosion of sediment into the river. If, as EPA proposes, riverbanks are remediated to remove contaminated sediments, and then structurally stabilized to reduce erosion and disallow meandering of the river, their ecological characteristics will be severely altered. In most reaches, the outcome will be lower slopes, use of stabilizing construction techniques at the base of the riverbank, such as riprap, and planting of herbaceous plants and shrubs. The resultant ecological character of the riverbanks will be quite different from the types of banks found in the current riverine system, to the detriment of plant and animal species that require them for habitat. For example, wood turtle, muskrat, beaver, river otter, belted kingfisher, bank swallows, and many dragonflies and damselflies will be negatively affected. Mature trees will be purposefully excluded, resulting in reduced shade, increased water temperature, and loss of woody habitat for cavity-nesting birds, cavity-denning mammals, and birds that hunt from perches, such as kingfishers and flycatchers. The dynamic movement of the river channel within the floodplain will be significantly curtailed causing unknown outcomes as the hydraulics of the river try to reach equilibrium.

The sediment removal and/or capping would remove or bury the existing aquatic vegetation and benthic invertebrates, and displace the fish. The substrate will be dependent on deposition from upstream to begin its recovery, but the timeframe for that process is uncertain. While some recolonization would occur, primarily by drift from upstream reaches of the river, it would be slow, taking years to decades. Of concern is that much of the Housatonic River upstream of the PSA is quite urbanized, meaning less diverse source populations will be available for recolonization downstream. It is likely that common and invasive species would arrive first, particularly those tolerant of changes in substrate materials. Less tolerant sensitive and rare species may never recolonize reaches where removal of the original substrate or riverbanks is extensive over long sections. SED 9/FP 4 MOD would destroy 126 acres of aquatic riverine habitat. Thus, aquatic communities are unlikely to match the pre-remediation communities in terms of composition, species richness, and relative abundance of species (e.g., Tullos et al. 2009, Sundermann et al. 2011).

Removal and replacement of substrate will adversely affect groundwater processes that are critical to both vertebrates and invertebrates. In particular, groundwater provides a base flow to a river during times of reduced surface flows. Groundwater flows also create a hyporheic zone in the riverbed where invertebrate and fish larvae can flourish. Disturbance of these discharge pathways by dredging, capping, and bank remediation will adversely affect groundwater-dependent habitats and flow patterns, and also destabilize the base of riverbanks, resulting in bank slumping and further erosion (e.g., Hester and Gooseff 2010). For small sections of riffles, there is evidence that if substrate is properly constructed, a functioning hyporheic zone can be restored (Kasahara and Hill 2006), but the restoration of this zone at a scale of miles of riverbed is highly uncertain. Under SEP 9/FP 4 MOD, much of Reach 5A will be directly destroyed by direct remediation of riverbed and riverbanks. Those reaches not remediated will be isolated from intact riverine habitats and/or become highly disturbed due to construction activities above and below their location. Where bank remediation is conducted in sections of Reach 5B, those sections will suffer similar fates. Figures 1 and 2 show the extensive fragmentation generated by the road and staging area system required to access the areas that would be remediated.

In areas in which bank stabilization will purportedly be avoided, riverbanks composed of silts and sands are likely to become unstable when the river channel is excavated and bank-stabilizing vegetation is removed. This will have a long-term (many decades, possibly centuries) effect on large trees along the destabilized riverbanks that provide significant shade and woody debris to the aquatic ecosystem. To be more specific, woody debris provides cover and substrate that is important to many aquatic and semi-aquatic species, and shading limits water temperature increases. In the absence of this shade, aquatic plant growth and water temperature would likely increase and change the suitability of the habitat for temperature-sensitive species. This loss of cover would also result in a loss of wind protection, as well as decreased amounts of large woody debris and overall organic material. When riparian trees are removed from a previously closed-canopy stream, the underlying energy regime may change from allochthonous resources to an autocthonous one driven by primary production, and this may shift the stream further away from the desired ecological state, often toward algae-dominated streambeds (Sudduth et al. 2011). When combined with excess sediments (likely during bed and bank remediation), desirable periphyton (forming the base level of aquatic food webs) and benthic invertebrate communities can be severely depressed. Figure 1 identifies examples of places where, under SED 9/FP 4 MOD, the riverine corridor will be fragmented by removal of native vegetation, especially mature trees in the floodplain and along riverbanks, which will have all of these adverse effects.

It is likely that the disturbed areas would be colonized by invasive exotic plants or algae, which are impractical to control in a flowing river and thus are likely to dominate over the native vascular plants. Exotic invasives are already present in small patches within the ecosystem, and thus, can colonize and spread rapidly into new reaches. Kettenring and Adams (2011), in their review of the literature on plantings for restoration projects, have shown that there are serious limitations on our ability to control and/or manage invasive plants, particularly for large projects. This will further reduce any chances of restoring the existing communities and habitats.

2.2.2 Impacts to riverbanks. Under SED 9/FP 4 MOD, more than 3.5 miles of the riverbanks in the PSA would be subject to bank stabilization, with removal of bank soil where necessary as part of the stabilization. The types of bank stabilization activities that would be implemented are described in Appendix G to the Revised CMS. These activities would cause numerous significant adverse impacts on the riverbank habitat.

The bank stabilization activities would require removal of riverbank vegetation and woody debris from the riverbanks, as well as the cutting back and reshaping of banks and removal of bank soil in many locations. Contrary to EPA's hopeful suggestion (Comparative Analysis, pages 29-30), this would result in the loss of large mature trees alongside, overhanging, and adjacent to the river in the areas subject to stabilization, leading to an open canopy, sparsely vegetated terrestrial community adjacent to the river. The nearest mature trees would be located roughly 30 feet from the river since such trees would be removed from the banks to facilitate implementation of the remediation/stabilization and to avoid subsequent destabilization of the banks. This would also remove key habitat elements for the birds that currently use these large trees as perching or cavity nesting sites (such as wood ducks, woodpeckers, kingfishers, and owls and other raptors), the dragonflies (including five species of state-listed clubtails and two other state-listed species of dragonflies) that use these trees for perching and resting during their adult stage, and the reptiles and mammals that use the living and dead woody vegetation for shelter, resting, and basking (e.g., the state-listed wood turtle, salamanders, frogs and toads, and various small mammals). The removal of native vegetation on the riverbanks will also increase the likelihood of the spread of invasive exotic plant species.

The stabilization of the riverbanks would also, by design, have a direct and material impact on two of the current geomorphic processes that have allowed for the existing heterogeneous mix of riverbank types, including vertical and cut banks. These processes are bank erosion and lateral channel migration. The proposed bank stabilization measures are intended to prevent significant bank erosion over the long term (e.g., Eubanks and Meadows 2002). To do so, the stabilization measures would be designed to basically lock the existing channel in a stable state or geometry. Thus, if successful, these measures would prevent the processes of significant bank erosion and lateral channel migration from continuing, leading to the loss of the vertical and undercut banks: an impact entirely ignored by EPA in the Comparative Analysis. This would result in the direct elimination of habitat for a number of riparian species that utilize the banks. Of particular concern is the loss of nesting sites for belted kingfishers and bank swallows, which build nest burrows in vertical banks. These species are known to return to these nest burrows over multiple years, demonstrating very strong site fidelity, but would find the stabilized banks no longer suitable for nesting. Similarly, the state-listed wood turtle uses overhanging banks for cover and overwintering, and also has strong site fidelity to specific riverbanks. This species would lose critical habitats for those activities.

The implementation of bank stabilization techniques would cause other adverse impacts on the local wildlife as well. For example, slides, burrows, and dens of mammals such as muskrat and beaver would be removed from the banks. Unavoidable changes in riverbank slope, composition, and vegetation would impede safe movement between terrestrial and aquatic habitats required by a number of amphibian, reptile, and mammal species (such as leopard frogs, wood turtles, snapping turtles, beaver, and mink), as well as large mammals (such as deer and black bear) trying to drink from or cross the river during low water periods.

These impacts would not be "temporary" as EPA suggests (Comparative Analysis, page 30), because the proposed remediation techniques are explicitly designed to stabilize banks and keep the river channel from meandering to and fro in the floodplain. Under SED 9/FP 4 MOD, the remediated banks would remain suboptimal habitat for decades, and possibly longer, for many of the current species that use them.

The bank stabilization would also curtail or eliminate wildlife corridors in Reaches 5A and 5B for resident and migratory species that move along the banks during migration or dispersal. With riparian banks altered (at least 3.5 miles of bank in Reach 5A alone), species moving either along the riverbank edge or through the riparian cover at the tops of banks would lose travel and migratory corridors. Stabilized banks would force species into suboptimal habitat (where they would be subject to increased predation) or eliminate these sections as dispersal and migratory corridors. Daily use, dispersal, and migratory movements by species that require relatively natural habitats are fostered by having vegetation connectivity among their required resource patches (e.g., breeding, foraging, resting, and wintering sites). Migratory and resident raptors, such as broad-winged hawk, red-shouldered hawk, sharp-shinned hawk, Cooper's hawk, will be forced to seek habitat elsewhere – when few suitable habitats exist. Wide-ranging species (coyote, gray and red foxes, bald eagle), some preferring interior forested habitats (fisher, bobcat, black bear), all detected within the PSA, would be required to seek alternate travel corridors where few exist, with a likely increase in mortality (roadkills). Carnivores that are dependent on natural riparian habitats (river otter, mink) would have no opportunity to go elsewhere.

As clearly shown in Figure 1, especially near EAs 16-18 and 20-24, connectivity between aquatic habitats, including backwaters, floodplain depressions, and vernal pools, and adjacent upland areas, would be disrupted. This would impact virtually every animal and plant species in the affected reaches of the river and adjacent areas.

2.3 Potential for Restoration of River Channels and Riverbanks

In project after project, the scientific evidence is clear that restoration of structural components of the riverine ecosystem (i.e., channel form, substrate, physical habitat) does not translate to restoration of biological diversity, especially in the benthos (Jahnig et al. 2010, Palmer et al. 2010, Louhi et al. 2011). Recent review papers of river restoration, summarized in our Restoration Response document (e.g., Bernhardt and Palmer 2011, Palmer et al. 2014, Palmer et al. in press), have cautioned that expectations of success in river restoration projects are not supported by the scientific evidence or available case studies. Contrary to EPA's suggestions, our reviews have found no precedent for a stream restoration project on this scale in which a highly functioning aquatic ecosystem is first dismantled and then an attempt to replace the same habitat types has been successful. Thus, it is highly unlikely that, following the implementation of EPA's proposal, the PSA could be restored to its current high level of biodiversity and productivity.

2.4 Summary for River Channels and Riverbanks

What is of great concern for the Housatonic Rest of River is the area of river channel and length of riverbanks designated for remediation. Given the magnitude of SED 9/FP 4 MOD, the negative impacts – change in substrate, loss of shade, increasing temperatures, loss of critical breeding, resting, and overwintering habitats – will cause significant changes to the PSA, damaging the ecological integrity of this valued system.

Regardless of the bank stabilization techniques selected (including bioengineering techniques), implementation of bank remediation and stabilization activities would change the character of the banks and have major negative impacts on the river channel and riverbank habitats in the upper portions of the PSA. As a result of these impacts, the stabilized river channel and riverbanks would not return to their current condition or level of function, despite restoration efforts.

3.0 Floodplains

3.1 Context: Floodplains

As discussed in the Revised CMS, a remedial alternative of the magnitude of SED 9/FP 4 MOD would cause severe ecological harm. The most significant and unavoidable impact on the floodplains of SED 9/FP 4 MOD would be the unavoidable loss of mature trees. Removing soils in the remediation work areas, and building the necessary access roads and staging areas to conduct the remediation, will devastate floodplain forests for decades to come. The proposed work in the floodplain is extensive (approximately 50 acres) and excavating floodplain soils creates severe ecological risk for both resident and migrant species that use the floodplain habitats. Floodplain soils develop from complex interactions between river flooding regimes and adjoining floodplains. The resultant soils provide substrate for soil organisms, burrowing vertebrates, and, of course, vegetation that forms the vertical structure of the forest. There is no way to acquire or create soils with equivalent parameters in the amounts that would be necessary to replace the soil that would be excavated in the course of SED 9/FP 4 MOD. With up to 21 species of state concern using all or portion of these habitats in the PSA, the potential for serious loss of biodiversity is very real. The area excavated will be severely altered, and there will also be significant negative edge effects in an even wider area (Fig. 2). The majority of the affected floodplain areas are forested (36 acres), which is the primary topic of concern discussed below. Floodplain areas with shrub and shallow emergent wetlands (14 acres) also will be impacted, and are considered in Section 3.2.4.

3.2 Impact of Remediation on Floodplains and Potential for Restoration

3.2.1 Soils: Excavating floodplain soils to a depth of one foot or three feet, as proposed by EPA, requires removal of all floodplain vegetation and at least one foot of soil. The upper layers of soil near the surface usually are those that have high organic matter, plant propagules, and soil biota. These soils also provide burrowing habitat for fossorial species of mammals, amphibians, reptiles, and invertebrates. Floodplain soils, particularly if saturated, serve as over-wintering habitat for those species of amphibian or reptiles that hibernate. The proposed remediation will kill individuals of animal and plant species during the excavation process as soils are removed and transported elsewhere, and eliminate their habitats for years to centuries.

3.2.2 Hydrology: There are multiple sources of water that feed these floodplain ecosystems (e.g., groundwater slope seepage, groundwater discharge from seasonally high water tables in the floodplain, and overbank flooding of the river). While efforts could be made to reconstruct the pre-existing swale systems to approximate current drainage patterns, the potential is high for larger overbank floods to cause erosion and destabilization in recently restored areas of the floodplain. The surface topography of the floodplain reflects the influence of floodwater dynamics. Thus, recently excavated soils will be highly exposed to erosion and transport by heavy precipitation and/or floodwaters because it is not possible to revegetate them quickly enough to risk exposure to a significant storm event. Exposing large areas of soil has the potential to subject other unaltered habitats in the floodplain and river to severely damaging sedimentation. Overbank flooding and subsequent floodplain deposition and erosion from surface flow patterns, along with remnant meander scars and levee formation, produce distinct surface topographic and soil variations that then affect biological conditions.

Soil removal and the related removal of trees and coarse woody material would affect the distinct floodwater-influenced microtopography of the floodplain forest, reducing the floodplain roughness that produces flow resistance and thus contributes to the important flood flow alteration function of the floodplain. Reduction in roughness cannot be countered because the vegetative cover would become less dense due to floodplain clearing activities, and no amount of planting can counter the reduction in roughness. These conditions would result in faster flows during flood events, more erosion, and less infiltration. Reduced infiltration will likely reduce sustaining base flow to the river.

3.2.3 Loss of biological structure and diversity in forested wetlands. Many of the trees found within the floodplain in Reaches 5A and 5B are about 50 to 75 years in age, and the mature forests bordering Reach 5C and around Woods Pond are most likely 75 to 100 years old or older. In EA 2, for example, cottonwood and silver maple occur as multi-stemmed clumps (about 8 trees/acre), 12-36 inches in diameter at breast height (dbh), with complex root masses. A multi-aged forest produced over time will have a portion of large-diameter stems (> 15-inch dbh) suitable for producing cavities. Cavity-nesting birds (e.g., screech owls, wood ducks, and pileated woodpeckers) and mammals (flying squirrels, bats) that use tree cavities and the bark of old trees return to these nesting, resting, and feeding sites over multiple years. Loss of the mature forest trees along the riparian corridor would remove these critical breeding habitats, and thus, many individuals of these species.

In the best case, it will take 50 to 100 years for the mature forest to be reestablished. However, reestablishment could take even longer due to the cumulative stresses of floods, changes in microclimate, changes in hydrology and colonization by invasive species. During the period of at least 50 to 100 years until the mature forest is re-established (if that occurs at all), the tree canopy would be more subject to sunlight and wind impacts and there would be a reduction in large woody material. The decrease in availability of mature trees and forested habitat would reduce the capacity of the floodplain forest to support species dependent on such habitat, such as pileated woodpeckers, thrushes, a variety of warblers and owls, and mammals such as the fisher and bobcat. As the replanted forest develops, it goes through stages of supporting different communities until such time as it reaches maturity. Younger, developing plant communities support a different wildlife community that is characteristic of early and mid-level successional habitats. Thus, EPA's conclusion regarding a "temporary loss" is inapplicable to these floodplain forests.

In fact, replicating the structure and composition of the existing floodplain forest is unlikely. Although it is feasible to replace emergent and shrub species within a few years with direct planting, replacing forested habitat is much more complex, as the successional trajectory for a forest is much different than that for emergent, herbaceous, or shrub communities. Through competition, forests go through a reduction in numbers of stems from seedlings (up to 3 feet tall, 5,000-10,000+ stems/acre) to saplings (3-10 feet tall, < 5 inches in diameter, 1,000-3,000 stems/acre) to pole stage after about 20-30 years (5-11 inches in diameter, 500-1,000 stems/acre) to mature trees (>11 inches in diameter, 100-200 stems/acre), usually occurring at more than 50 years after planting (Stoddard 1978). Moreover, forests often have uneven size/age classes, as does the forested floodplain in the PSA. Planting replacement trees in a cleared area all at the same time could not reproduce these characteristics. Thus, even under optimum conditions (i.e., with invasive exotic species kept under control, which is highly unlikely over large areas), the developing forest would be an even-aged community for more than 25 years, with minimal structural profile diversity and associated significant reduction in overall wildlife diversity.

The removal of trees would also result in the loss of woody material that provides structural wildlife habitat – i.e., for perching, basking, denning, nesting, cover, or escape habitat. While it is assumed that some of the coarse material left over from cut tree trunks could be re-used in the remediated floodplain for that purpose, conditions would not be the same as before remediation. Similarly, while some of this material could also be chipped and left on site as an organic amendment to the imported topsoil, it would not be a soil amendment that could mimic the natural and beneficial carbon:nitrogen ratio afforded by leaf litter. In addition, the tree removal would cause the loss of yearly leaf litter that is generated by the mature deciduous trees that populate the floodplain. Leaf litter on the floor of the floodplain forest is important as part of the food chain by affecting soil permeability, providing cover habitat for amphibians, reptiles, small mammals and invertebrates, and regulating soil temperatures and relative humidity. The loss of woody debris and leaf litter when the trees are cut and soils removed would place a severe constraint on efforts to restore forested floodplains for at least decades after remediation.

3.2.4 Impacts to shrub and shallow emergent wetlands. The main direct negative impact to shrub and shallow emergent wetlands from floodplain soil remediation would be from vegetation and soil removal. Vegetation clearing would cause substantial direct effects, as these wetlands provide: (1) nesting, burrowing, and/or escape habitat and food for birds, amphibians, reptiles, mammals, and invertebrates, including important nesting habitat for migratory neo-tropical songbirds and, in the emergent areas, nesting habitat for two state-listed bird species (American bittern – Endangered, and common moorhen – Special Concern, as of 9-7-14); (2) a significant yearly infusion of biomass, consisting of fallen leaves, decaying herbaceous plants, and woody material, which make up a significant component of the underlying organic layer and are part of the foundation of the food web of these ecosystems; and (3) an effective system for cycling and transforming nutrients, evapotranspiring significant quantities of water, and helping to attenuate flood flows by increasing vegetation roughness.

Shrub and shallow emergent wetlands typically contain soils with high organic content (typically mucky silt or histosols [organic soils]) that have formed over many decades. It is unlikely that sufficient volumes of comparable organic soils could be found for use in any restoration effort, and attempts to manufacture such soils are not reliable, since the soil chemistry and seed bank of the on-site soils are specific to the existing Housatonic River floodplain system. The use of heavy machinery in these areas would likely cause soil compaction, which would affect the permeability of these soils, which influences plant colonization (e.g., slows the process of recolonization by native species and makes surface soils more susceptible to proliferation of invasive exotics), as well as adversely affecting the groundwater recharge/discharge and flood flow alteration functions of the floodplain. Replacement soils would be less conducive to the formation of the necessary subterranean burrows required by certain animals for overwintering, hinder the re-establishment of a native plant community, and facilitate proliferation of invasive plant species. Soil compaction is particularly problematic in shallow emergent marshes. These wetland types contain soft, organic soils that are extremely difficult to work in with heavy machinery when wet – which is most, if not all, of the time – and very difficult to keep dewatered during construction. The likely result would be creation of wetlands that are not the same as those of the current ecosystem. The plant communities would be different, and they would be conducive to colonization by invasive exotics. These new marshes would become less suitable for the current community of wetland-dependent wildlife.

Due to the changes in hydrological conditions (as described above for the entire floodplain system), the vegetation currently present in the shrub and shallow emergent wetlands is likely to change. Species that can tolerate a broader range of conditions are likely to be more abundant than those species which require specific habitat conditions within shrub and shallow emergent wetlands. For example, the exotic species purple loosestrife might replace native buttonbush. These changes in vegetation would last until such time as soil and hydrological conditions comparable to pre-remediation conditions return to these wetlands so as to support a vegetative community similar to the pre-remediation community. Given the unpredictable and likely slow rate of organic soil accumulation, it could take a decade or more to reach conditions that would support shrub or emergent plant communities comparable to current communities. It is uncertain whether certain sensitive species, such as the state-listed species, would return.

The return of wildlife communities comparable to the pre-remediation communities in these shrub and emergent wetlands would depend on the return of soil, hydrological, and vegetative conditions. In the meantime, many common game and non-game avian species, as well as state-listed species (e.g., American bittern, common moorhen, wood turtle), would be lost from these wetlands, and the return of the state-listed species is doubtful. Where shrub and shallow emergent wetlands are disturbed by floodplain soil removal or ancillary facilities (access roads and staging areas), it is expected that restoration efforts would result in re-establishment of most pre-remediation functions of these wetlands over time. However, given the constraints described above, this recovery time is uncertain and would likely be measured in decades. In addition, there is a serious risk of additional invasive exotic species expansion into these areas. Moreover, depending on the extent of the disturbances and the length of time over which they last, some of the pre-remediation functions of these wetlands, such as providing habitat for state-listed species, may not return for a much longer period, if ever, in some of the affected wetland areas.

3.2.5 Other floodplain impacts: The implementation of remediation activities will have a long-term impact on other floodplain functions as well. For example, the removal of surface soils in the floodplain would alter soil moisture levels, soil infiltration rates, and groundwater flow. These changes, together with the removal of sediments in the river (which controls the rate and level of groundwater flow in the valley), would alter the groundwater recharge/discharge function of the affected floodplain areas. This function should return as flood deposition restores soil conditions and the disturbed areas become vegetated and root systems stabilize the floodplain soils, but such a return could take decades and would be dependent upon unpredictable flood dynamics, which themselves would be affected by alterations to the river channel and/or banks.

These changes to the PSA floodplain could result in either wetter conditions, such as from the loss of evapotranspiration due to tree removal or from soil compaction resulting in greater perching of surface waters, or drier conditions, such as from the use of sandier topsoils or from changes in overbank flooding and grading that result in decreased flood flows onto the floodplain. Without knowing the source of replacement soils or the dynamics of the reconfigured river channel, the potential hydrologic conditions of the remediated floodplain remain unknown, thereby reducing the chances of correcting problems through adaptive management.

The plant communities in primary successional systems, as would be formed by these extensive remediation activities, are generally dynamic, and it is under these conditions that aggressive and exotic species readily take hold. This is a very real risk to the overall success of restoration activities, as the plant community is one of the foundations of the overall ecosystem. If non-native species out-compete native ones, the animals that depend on the native plants may be lost as well. Successful replacement of shrub and shallow emergent wetlands is more likely than for forested components of the floodplain (Moreno-Mateos et al. 2011, Gebo and Brooks 2012) – the latter being highly unlikely – but is still fraught with numerous issues related to how the overall configuration of river channel, bank structure, and floodplain topography are integrated to produce the essential hydrologic, soil, and vegetation elements required of these systems. Regarding the potential success for floodplain plant communities, the significant lag time for growth of mature trees will always be an issue. As Kettenring and Adams (2011) found in their review of invasive plant management, there are limitations to controlling the colonization and spread of invasive plants in aquatic and riparian ecosystems. As proposed, the remediation plans are not likely to replace the structure, function, or biodiversity of the floodplain components of the existing riverine ecosystem.

3.3 Summary for Floodplains

A river's course meanders cutting back and forth through the floodplain, and in that process creates the tremendous diversity of river, floodplain, and wetland habitats found in an ecologically healthy riverine ecosystem. This, in turn, supports the extraordinary biodiversity which can be observed and has been documented in the PSA floodplain. This floodplain would be adversely impacted by the remediation proposed by EPA and those impacts would be severe.

The effects of the significant loss of mature floodplain trees and the impracticability of locating a comparable source of soil to mimic current conditions make restoring this system extremely vulnerable to the constraints described above. Overall, despite the implementation of the most up-to-date restoration methods, the re-establishment of the affected forested floodplain communities in the PSA is very unlikely. In general, restoration of shrub and shallow emergent wetland communities is expected to be more straightforward than restoring forested floodplain communities. However, the restoration of these communities is subject to numerous constraints that will likely adversely affect or at least delay their recovery

4.0 Impoundments of the Housatonic Rest of River

4.1 Context: Impoundments

There are 116 acres of impounded areas expected to be disturbed under SED 9/FP 4 MOD, of which 60 acres are in the PSA. These open water and shallow aquatic beds are tied closely to river dynamics. Such impounded areas are more easily restored than other habitat types, but there is uncertainty as to what aquatic plant and animal communities will recolonize these habitats once they are excavated and capped.

4.2 Impact of Remediation for Impoundments

Removal of sediment in the impoundments would also remove any viable propagules (the organisms and their eggs, seeds, or regenerative tissue of any kind) in the sediment removed. Capping or backfilling would change the substrate from organic sediment over silt and fine sand to a substrate composed of the capping or backfill material. Over time, invertebrates and aquatic plants would recolonize the impoundments, although different species would be expected to dominate, at least initially, due to the changed substrates. For example, there is a high probability of invasion by non-native species – such as water chestnut (already prevalent in Woods Pond), as well as Eurasian water milfoil, curly-leaf pondweed, and potentially others not yet able to establish populations under current conditions – in areas within the photic zone. Such species are likely to immigrate and dominate, with few management strategies to avoid this occurrence.

Since impoundment remediation would kill most occupying organisms and displace the rest, at least temporarily, biological recovery would depend on colonization from outside the impoundments from upstream sources. Commonly occurring macroinvertebrates from upstream areas would be expected to recolonize the impoundments, as would aquatic plants, with such plants or their propagules arriving with flow into the impoundments. While fish would move back into the remediated impoundments readily, the composition and relative abundance of fish would vary, at least initially.

4.3 Potential for Restoration of Impoundments

As sand and organic sediments are deposited from upstream, a biological community in the impoundments that is consistent with those conditions would be expected to develop. However, the length of time for such a community to develop, the number of organisms that may be present, and the presence of any specialized species are all uncertain. The restoration of impoundments is most likely to follow lake restoration technology, which is relatively mature. Although most lake restoration projects have been focused on vegetation and pollutant management, there is a substantial body of knowledge concern dredging of sediments to deepen water bodies and/or remove pollutants. Also, undesirable plant species can be more easily removed with aquatic harvesters compared to emergent, shrub, or forested sites (see National Research Council 1992 for a review of methods).

4.4 Summary for Impoundments

The potential of restoration of impoundments has a higher likelihood than for most other aquatic habitat types. Excavation and capping procedures are more predictable. However, there are still concerns about the potential colonization of invasive exotics and how soon the existing vegetation, invertebrate, and fish communities will recolonize these areas during recovery.

5.0 Backwaters in the Housatonic Rest of River

5.1 Context: Backwaters

SED 9/FP 4 MOD would involve sediment removal and capping in 50 acres of backwaters. This would have the long-term impacts on the open water habitats and aquatic beds of these systems. Most backwaters in the PSA are in Reach 5C and influenced by the Woods Pond Dam.

5.2 Impact of Remediation on Backwaters

Sediment removal and capping in the backwaters would cause changes in surface substrate type from silts or mucky organic material to sand, which would last until enough silt and organic material have been deposited through flood events to approximate current conditions – which could take a decade or longer. There would be changes in vegetative characteristics corresponding to the change in substrate type and elevation. With these changes in substrate and hydrology, there would be a proliferation of invasive exotic plant species.

There would be a change in the wildlife communities using the backwaters until such time as the substrate, hydrologic, and vegetative conditions of the backwaters return to conditions comparable to pre-remediation conditions – which is uncertain. There is high potential for the loss of certain sensitive (e.g., state-listed) species, such as the American bittern and common moorhen.

5.3 Potential for Restoration of Backwaters

The potential for restoration of backwaters is better than for most other aquatic habitat types. Backwaters, having direct connections to the river, will readily receive propagules of plant species and mobile animals can move into these areas rapidly. The techniques for their restoration are most like those used for lakes and reservoirs, and thus there is abundant information available on how to proceed. Although comparable habitats can probably be constructed, there remains a major question about whether the desired plant and animal species can be attracted to and flourish within the restored backwaters. The specter of overwhelming colonization by invasive exotic plants remains present.

5.4 Summary for Backwaters

There are concerns for introduction of invasive exotic species into newly remediated backwaters, but overall the potential for restoration is greater in this habitat type than in other types such as forested areas and vernal pools.

6.0 Vernal Pools in the Housatonic Rest of River

6.1 Context: Vernal Pools

EPA, through Woodlot Alternatives (2002), identified 66 vernal pools in the floodplain of the PSA. About two-thirds of these pools are located north of New Lenox Road, where there are numerous depressions in the forested floodplain that are seasonally filled with water due to overbank flooding of the Housatonic River, groundwater discharge, and surface water inputs from snowmelt or subsurface flow from the forest. The remaining one-third of vernal pools in the PSA occur south of New Lenox Road, where the river has a lower gradient and the floodplain is broader and flatter.

Based on recent visual observations (2011-2014), some of the vernal pools identified by Woodlot (2002) now function as permanently inundated, deep marshes or backwaters, rather than classic vernal pools that would meet the Massachusetts Wetlands Protection Act definition. However, these pools may still perform some vernal pool functions in certain places and times. For example, portions of these pools may contain physical structure (e.g., leaf litter, woody debris, aquatic emergent vegetation, and woody shrubs) that could provide refugia for developing larvae and thus make it possible for some of the pool-obligate species to continue breeding in these pools despite current hydrologic conditions. Moreover, such longer hydroperiod wetlands may provide critical breeding habitat for sensitive vernal pool species during periods of drought when nearby seasonally flooded vernal pools dry too soon for emergence of metamorphs. In any case, since these pools were identified as vernal pools by Woodlot and have been considered vernal pools in developing the remedial alternatives requiring vernal pool remediation, they are considered vernal pools in the evaluations presented herein. Pocket breeding refugia in larger, permanent wetlands are often insufficient to maintain the full suite of pool-breeding populations as fairy shrimp and wood frogs may be less successful in recruiting young in these habitats (Cunningham et al. 2007; but see Karraker and Gibbs 2009).

Access roads and staging areas are also an important part of the context for understanding impacts on vernal pools. While an effort has been made to site access roads away from vernal pools, this was not possible in connection with SED 9/FP 4 MOD because of the access required adjacent to and in the vernal pools. Additionally, many of the access road alignments for the floodplain alternatives are constrained by severe topography, the river itself, and logical connection points to existing public roads that would be integral to the construction process. The adjustment of access road locations would not prevent the impacts that would unavoidably occur from soil removal and replacement within and near the vernal pools targeted for remediation.

SED 9/FP 4 MOD will adversely impact up to 43 vernal pools (the number of pools in the PSA with PCB concentrations above EPA's ecological standard that are outside Core Area 1) covering 27 acres. In addition, SED 9/FP 4 MOD would adversely impact approximately 10 acres within 100 feet of the vernal pools in the PSA and approximately 60 acres within 100 to 750 feet of those vernal pools. The adverse impacts will include the removal of the existing trees and other vegetation, change in water drainage patterns on the floodplain, and excavation of the native soil. These impacts are likely to result in significant losses to local amphibian subpopulations in the PSA and the species that rely on those amphibian populations for the reasons discussed below.

6.2 Impacts to Vernal Pools from Proposed Remediation

6.2.1 Hydrology: The most important and distinguishing feature of vernal pools is their hydroperiod, or the timing of flooding (when and how long before they dry down). The hydroperiod is what distinguishes these environments from permanent ponds and lakes by providing breeding habitat for obligate vernal pool species that excludes breeding populations of predatory organisms (e.g., bull frogs, green frogs, snapping turtles) (Calhoun and deMaynadier 2008). Hydroperiod is influenced by hydrogeomorphic setting (HGM), defined by where a pool occurs in the landscape (e.g., groundwater or surface water depression, floodplain or perched setting) (Leibowitz and Brooks 2008) and in-pool characteristics (e.g., sediment types and stratigraphy, microtopography, foliage cover). It is very unlikely that soils that will be used to replace the soil excavated from the vernal pools and the adjacent areas will have the same permeability as the current soils in the vernal pools, particularly given the complex inter-bedding of silt and mucky soil layers in the existing soils. Replacement soils with a different permeability would not retain comparable amounts of surface waters and may not allow for comparable flow of groundwater into or out of the pools. Pool replacement soils may subside, leading to longer hydroperiods. Attempts to reestablish hydroperiod are unlikely to be successful (see Calhoun et al. 2014).

Similarly, the reconstruction of the swales that convey water into and out of the vernal pools and re-establishment of riverbank conditions that would preserve the overbank flooding into the swales are unlikely to result in conditions that match current conditions. Minor changes in the surface elevations at control points where surface water is conveyed into and through the swales could significantly alter the quantity of flow to the vernal pools. In addition, loss of mature trees surrounding vernal pools would change rates of evapotranspiration, usually making the habitats wetter, and thus less suitable for obligate vernal pool species.

When existing pools are disturbed, as will be the case for as many as 43 vernal pools in the PSA, efforts to reproduce the full complement of soil and hydrologic characteristics are unlikely to re-establish existing or comparable hydroperiods within the vernal pools.

6.2.2 Soils: Vernal pool remediation would involve the removal of the surficial soil, together with the vegetative cover, tree stumps, roots, and woody debris, in all or a portion of the vernal pools and the adjacent areas. These soil disturbances would have a significant direct effect on vernal pool wildlife. They would result in the mortality of any amphibian and/or invertebrate eggs, larvae, or adults in the pools (or affected portion thereof) at the time of remediation. Moreover, the use of heavy equipment in the remediation and restoration would result in direct mortality of animals in their post-breeding habitat (typically up to 1 km from a breeding pool). This could have a particularly serious effect on the formation of subterranean burrows by shrews and other small mammals in areas around the pools, which are used by ambystomatid salamanders as both summer refugia and hibernation sites (Montieth and Paton, 2006). Juvenile and adult wood frogs resting in shallow depressions beneath the leaf litter in the pools and in the adjacent terrestrial habitat (Baldwin et al. 2006a) would be crushed or excavated during soil removal operations. The soil compaction associated with the remediation, as previously discussed in connection with shrub/emergent wetlands, would similarly result in long-term changes in hydrologic patterns. The remediation would also remove physical components of the vernal pools that are critical to vernal pool ecology – e.g., the organically enriched soils, which provide a medium that supports the food chain (microbial nutrient transformers), affect permeability so as to keep the pools from drying out too soon, and facilitate groundwater flow in groundwater-influenced vernal pools (Leibowitz and Brooks 2008). Further, the remediation would affect the surrounding landscape characteristics that affect the timing and quantity of surface water and groundwater inputs into the pool and conveyance of water out of the pool (e.g., their juxtaposition with fluvial swales that flood waters into the pools). As a result, important elements of the vernal pool animals' life cycles, including breeding for obligate vernal pool species, would be disrupted.

6.2.3 Vegetation removal: Tree clearing within and immediately adjacent to the vernal pools would also produce substantial direct adverse effects on the vernal pool ecosystem, as these mature trees provide shade that moderates surface water, soil, and air temperatures and evaporative losses, and additionally provide a significant yearly infusion of biomass (fallen leaves, twigs, and branches) that serves as the base of the detrital food web and as cover from predators (Baldwin et al. 2006b).

In addition, where the remediation would involve the removal of vegetation in the larger areas around the pools to facilitate remedial soil removal or to allow the construction of access roads, it would further exacerbate the adverse impacts on the vernal pool communities. The forested areas surrounding vernal pools provide important non-breeding habitat functions, including cover, temperature and moisture regulation, foraging sites, and overwintering sites, for the vernal pool species. Thus, as recognized by habitat management guidelines developed for forestry activities (Calhoun and deMaynadier 2004), any such disturbances to the non-breeding habitats surrounding a vernal pool – especially within 100 feet of the pool (Regosin et al. 2003), but also within the 100- to 750-foot critical life zone (see Calhoun et al. 2005; Regosin et al. 2005) – would negatively impact the local amphibian subpopulations and could result in significant losses of amphibians through degradation of the post-breeding life zone. SED 9/FP 4 MOD would adversely impact up to 52 percent of the 100-foot zone and up to 29 percent of the 100- to 750-foot critical life zone for the individual vernal pools in the PSA. In total, SED 9/FP 4 MOD would negatively impact approximately 10 acres within 100 feet of the vernal pools and 60 acres within 100 to 750 feet of the vernal pools. This is likely to result in significant losses to local amphibian subpopulations in the PSA.

6.2.4 Additional impacts on vernal pool species: In addition to the impacts on the breeding and non-breeding habitats described in the prior subsections, EPA's proposed remediation would have other adverse impacts on the populations of vernal pools species in the PSA. Vernal pools may function as discrete aquatic systems, but they often occur in clusters, allowing a metapopulation (a set of sub-populations) of amphibians to disperse among the pools (Gibbs and Read, 2008). It is the proximity of vernal pools with slightly differing, but generally suitable habitat characteristics, as currently present in the PSA, which provides the necessary network of breeding sites to keep the local population of a species intact. Vernal pool amphibians display a high degree of fidelity to breeding sites (Berven and Grudzien, 1990; Vasconcelos and Calhoun 2006), but opportunities for occasional exchange of genetic material among individuals by dispersing juveniles from different subpopulations are important to avoid reproductive isolation (Gibbs and Read, 2008). This exchange can occur when pools are present within an appropriate habitat matrix, such as the contiguous area of mature forest in the PSA. If the physical structures or hydrologic regimes of the pools are altered, or the habitat matrix shifts to a non-forest habitat type, as would occur if SED 9/FP 4 MOD is implemented, then amphibian populations are at risk. Adult and emigrating juvenile amphibians have been shown to avoid clearcut areas adjacent to vernal pools (Patrick et al. 2006). Disruption of connectivity that is essential for dispersing animals, along with loss of the critical features of the forest floor that provide cover, temperature and moisture regulation, foraging sites, and overwintering sites to vernal pool species (see deMaynadier and Hunter 1998; Calhoun and deMaynadier 2004), as would occur under SED 9/FP 4 MOD, would constrain subsequent colonization and recolonization of the impacted vernal pools by obligate vernal pool species. Additionally, conversion to more open pools (e.g., less shade and forest cover) will likely promote use of those pools by habitat generalists such as green frogs or bullfrogs, both voracious predators of pool obligates (Vasconcelos and Calhoun 2006).

Other species reliant upon vernal pools in an intact forest riparian corridor would also be negatively impacted by the proposed remediation. For example, the vegetation cutting would negatively impact the wide-ranging wood turtles that forage in vernal pools (Compton et al. 2002), star-nosed moles that burrow and forage along moist edges, and migratory songbirds like the northern and Louisiana waterthrush that forage along the pool edges under forest cover during both breeding and migratory seasons (Mitchell et al. 2008).

6.2.5 Timing issues: The impacts of SED 9/FP 4 MOD on vernal pools and associated habitat would be largely unavoidable as impacts would be significant regardless of the time of year of operations. Working in the pools when the amphibians have left the pools for the season would avoid one set of impacts (i.e., to the breeding and larval stages), but would simply displace impacts to the terrestrial life stage of the vernal pool amphibians, as vernal pool amphibians spend the majority of their annual life cycle in the surrounding forest. Even if the remediation work were to occur during the low-flow season and after the spring breeding and migration period, this would not avoid direct mortalities to vernal pool juveniles and adults living in the leaf litter or in shallow burrows. These are slow-moving organisms that are especially vulnerable to ground disturbance or soil compaction. Further, the impacts of remediation in a given pool would last multiple years beyond the season in which that remediation takes place, thereby adversely affecting the breeding potential of the local population. Because vernal pool amphibians have strong site fidelities, they may unsuccessfully attempt to return to disturbed vernal pools, even if the pools are no longer suitable for breeding as we expect would be the case here.

6.3 Potential for Restoration of Vernal Pools

A recent publication by Calhoun et al. (2014) summarized the current peer-reviewed published literature on vernal pool creation and the authors concluded (bolded text ours):

> *[The literature indicates] that vernal pool creation is an imperfect science and should be used as a* ***last resort*** *after exhausting more reliable protective methods (Calhoun et al. 2005; Windmiller and Calhoun 2008; Denton and Richter 2013). The practice is perhaps appropriate in landscapes that have been subjected to severe wetland losses, such as former agricultural landscapes where forests have recovered but drained and destroyed wetlands have not.* ***Vernal pool ecosystems are difficult candidates for creation because the community structure is as tied to the surrounding forested ecosystems as to the actual pool depression and because pool function is so tightly tied to hydrology****. In addition, ideal breeding site characteristics may vary among pool-breeding species regionally (Snodgrass et al. 2000; Petranka et al. 2007) as do post-breeding habitat quality tolerances (Windmiller et al. 2008). For these reasons, mitigation efforts must, first and foremost,* ***consider conserving existing pools in a suitable landscape****, and, if that is impossible, seek to emulate pools in the region in terms of hydrogeomorphic setting, spatial distribution, and natural amphibian communities.*

For these reasons, it is not scientifically defensible to destroy high-functioning vernal pool landscapes like that present in the PSA that are intact, and that, by all available measures, are thriving.

There are significant constraints on the ability to restore vernal pools. Here we list key constraints in pool restoration; details on each of these topics and the relevant literature review for each constraint can be found in Calhoun et al. (2014).

1. Restoration of a vernal pool would require, first and foremost, the re-establishment of the requisite *hydrologic regime*, which, in turn, is dependent on specific surface flow patterns through the floodplain as well as micro-topographic and soil conditions that have developed within the floodplain depressions. Each of these factors would be very difficult to reproduce for a single created vernal pool, let alone a complex of such pools like the vernal pool network present in the PSA (as discussed earlier).

2. Restoration would require the reestablishment of the pre-existing *soil composition* of the vernal pool and the composition and structure of the native vegetation within and around the pool, each of which would also be very difficult to reproduce in even one vernal pool and would be impracticable in the event of the disruption of up to 43 vernal pools as is proposed for SED 9/ FP 4 MOD. These difficulties are reflected in literature describing vernal pool creation efforts that have not successfully produced the full range of vernal pool functions due to an inability to produce the correct hydrology or soil composition (Korfel et al., 2009; Gamble and Mitsch, 2009) and/or a situation in which sensitive vernal pool species, such as wood frogs, were driven out by more aggressive species such as green frogs (Vasconcelos and Calhoun, 2006; Gamble and Mitsch, 2009). For example, as discussed above, it is very unlikely that replacement soils will have the same permeability as the current soils in the vernal pools,

particularly given the complex interbedding of silt and mucky soil layers in the existing soils. Also, degraded water quality (e.g., from unstable soils), extended hydroperiods, and temperature increases due to loss of mature tree canopy can cause adverse effects on the developing amphibians (e.g., reduction in oxygen to developing embryos due to silty soils settling on egg masses; Ranavirus associated with warmer water temperatures) (Gahl and Calhoun 2010). Similarly, these factors can cause excessive growth of filamentous algae or aquatic plants such as duckweed, which may adversely affect the suitability of a pool for amphibian breeding. In addition, the surface structure of leaves and twigs on the pool bottoms would be extremely difficult, if not impossible, to sustain on a long-term basis, since this process occurs naturally under a forest canopy.

3. Restoration of *within-pool vegetation* and associated habitat functions is related to adequate re-establishment of microtopography, soils, and pool hydroperiod; if the resulting hydrologic conditions are too wet or too dry, as discussed above, they would result in completely different plant communities and succession. Establishing vegetative cover within the affected vernal pools, along with placement of other organic material such as leaf litter and coarse woody debris, would be part of the restoration effort for the vernal pools. However, the complex and mature organic vegetative composition (alive and dead) of these pools cannot be re-established in a predictable period, and numerous factors could derail the plant succession process and result in undesirable vegetative growth (e.g., invasive exotics or other aggressive species which are present in the PSA). Under optimum conditions, and assuming that invasive species could be effectively controlled without damaging newly planted and naturally colonizing native species (which is, in fact, unlikely), growth rates of the types of shrub species that would be used in these vernal pools typically range from 1 to 2 feet per year (Dirr, 1998) following development of an established root system (i.e., usually 1 to 2 growing seasons). Under such conditions, as herbaceous and shrub layers develop within the pools and around the pool edges, some of the physical aspects and habitat functions associated with the loss of these vegetation strata could recover within 5 to 15 years following restoration. However, flooding may impede the success or timing of this recovery process. Moreover, other vegetation strata would take longer to recover. As discussed for the forested floodplain, the return of mature trees would take at least 50 to 100 years if not impeded by floods or invasive species encroachment.

4. Another key constraint to successful vernal pool restoration is the impact of the remediation work on the *forested habitat surrounding the pools*. The restoration of vernal pools would be strongly influenced by the extent to which the connectivity among the various vernal pools in the floodplain and between the pools and important post-breeding forested habitat for amphibians is adversely affected. Most wetland-dependent amphibians do not have the capability to disperse or migrate if the matrix between habitat elements (breeding and non-breeding sites) is highly disturbed (deMaynadier and Hunter 1998; Patrick et al. 2006; Semlitsch et al. 2009); therefore, habitat connectivity is key to the viability and sustainability of amphibian populations. Under SED 9/FP 4 MOD, which would involve significant habitat alteration over widespread areas of the floodplain, it is likely that the connections among some number

of vernal pools, and between vernal pools and other related habitats, would be degraded or lost entirely. Even small impacts to the non-breeding habitats adjacent to vernal pools have the potential to reduce the value of this habitat for the vernal pool amphibians and thus to impact the functions required for a viable vernal pool ecosystem.

5. Further, even if the hydrology and soil structure and composition within the pools and the vegetation within and adjacent to these pools were eventually returned to their current condition, the interim loss or reduction of sensitive vernal pool species such as wood frogs, and/or their displacement by more aggressive species during that time, would create a high potential that those sensitive species would not be restored. For example, wood frogs breed only one or two times over their 3-5 year life span, and thus a few years of eliminated or severely lowered recruitment levels can negatively impact a local subpopulation. Hence, if there are not sufficient wood frogs in the area to migrate into the vernal pools to breed after the new vegetation is established, those pools may no longer support wood frogs. Moreover, the disturbance of the vernal pools would increase the likelihood of colonization by more opportunistic amphibian species such as green frogs and bullfrogs, whose larvae are aggressive predators of wood frog and salamander eggs and larvae (Calhoun et al. 2014). Thus, there would likely be a long-term loss of wood frogs and salamanders from these pools. Even if these more sensitive species did return to pools with more permanent hydrology, the pools could serve as an "ecological trap" for those species.

6.3.1 Restoration of a single pool—8-VP-1: EPA has previously pointed to the prior post-excavation restoration of a single vernal pool, 8-VP-1, located near the upper part of the PSA, as evidence of the ability to restore a remediated vernal pool. However EPA ignores the fact that this *one* vernal pool had the benefit of intact mature forest and nearby vernal pools to aid its recovery. This pool now provides appropriate breeding habitat for wood frogs in some but not all years (following a dry-down year) and serves as a potential sink in years when hydrologic conditions allow green frogs to successfully breed there (see memoranda from Weston Solutions to EPA dated January 11, 2012 and March 13, 2013 and memoranda from Stantec to Weston Solutions dated May 3, 2012, June 10, 2013, and April 29, 2014, reporting on inspections of this pool). Following the recovery of a single pool in a relatively undisturbed area tells us nothing about the effect of the remediation that EPA has proposed for the PSA. The relevant study here would require baseline research on amphibian breeding populations of an analogous section of river with multiple pools and associated terrestrial habitat followed by a recovery study. Since that has not been done, one needs to rely on broader scale studies that compare reference pools to mitigated pools with sample sizes large enough to be statistically significant (Calhoun et al. 2014). Findings from these studies are more relevant to guiding decision-making with respect to pool integrity in this system than are findings from a single, relatively undisturbed site where there is a strong local population of pool-breeders to recolonize a pool.

6.3.2 Activated carbon: There is no published research on the effect of the use of activated carbon on vernal pool breeding invertebrates and amphibians. The case studies referenced by EPA have no relevance to vernal pools as EPA's own consultant, the

Isosceles Group, recognized (see Attachment 3 to the Comparative Analysis). It would be reckless to research the potential impacts of this treatment technique in the sensitive ecology of the PSA. In any event, vernal pools in which activated carbon was used as an alternative to excavating the pools would still be adversely affected by the clearing and excavation of the 100-foot and the 100- to 750-foot zones around the pools.

6.4 Summary: SED 9/FP 4 MOD would include excavation and replacement of the surface soils and vegetation in up to 43 of the 66 vernal pools in the PSA, impacting up to 27 acres of vernal pools, approximately 10 acres within 100 feet of the vernal pools, and approximately 60 acres within 100 to 750 feet of the vernal pools. The direct long-term impacts of SED 9/FP 4 MOD would include long-lasting changes in the hydrology of the vernal pools and in soil conditions in the pools (due to the inability of replacement soils to match the characteristics of the existing vernal pool soils). There is also a high probability that invasive exotics or other undesirable plant species and animal predators (such as green frogs or bullfrogs) would invade pools where they did not previously exist. These alterations would, in all likelihood, result in the loss of obligate vernal pool species from many of the pools (Calhoun et al. 2014).

Moreover, the additional forest disturbance would cause great disruption to the critical non-breeding amphibian habitat around the vernal pools. These disturbances would result in direct mortality and disrupt important aspects of those areas' non-breeding functions for the vernal pool amphibians.

Given the extensive impacts of SED 9/FP 4 MOD on the vernal pools and the forested habitats around the vernal pools, it is highly likely that the full complement of characteristics that contribute to vernal pool functions would not be re-established for most of the affected pools. This is consistent with the body of broader scale studies comparing reference pools to restored pools with sample sizes large enough to be statistically significant, as summarized in our recently peer-reviewed and published paper in *Wetlands* (Calhoun et al. 2014). These unavoidable impacts to a high-functioning floodplain vernal pool landscape are why the Commonwealth of Massachusetts concluded that "any potential benefits associated with remediation to achieve ecological IMPGs [the sole reason for EPA's proposed vernal pool remediation] would be far outweighed by the short and long-term damage" and that "[w]e believe that restoration of these vernal pools will not result in the actual replication of the vernal pools and associated amphibian communities that existed prior to the removal of the pools." (Commonwealth letter to EPA, January 31, 2011, at pages 8 and 11). We agree.

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