Maidstone Slide – STP 0271 (20)

Year 4 Report

Wetland and Invasive Species Monitoring and Control Recommendations

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Table of Contents

Tables

Figures

Appendix 1 – Photographic Documentation

Summary Conclusions and Recommendations

A fourth year of monitoring of the wetland impacted by the construction of a temporary access road was conducted in accordance with the Invasive Species Management, Planting and Monitoring Plan[1] for the Maidstone STP 0271(20) project. The temporary access road was constructed during spring 2013 and was restored following construction. During late September 2013, observation plots were used to assess the overall vegetative success in the restored wetland and the presence/ absence of invasive species. In mid-August 2014, 2015 and 2016 the same plots were resampled. Sampling plots in 2016, however, were slightly offset as we did not have accurate GPS data to position the plots precisely. Based on a comparison of GPS points taken in 2013 and 2016, Plot 1 aligned well with the original plot location; however, Plot 2 while in the correct east to west alignment was offset a couple of meters to the south of the original plot in 2016. Generally, the effects of 2016 plot placement on the vegetation data were minor; the several species for which data were more substantially affected are discussed in the report text and Tables 2 and 3. Year 4 assessment of site stability, wetland hydrology and wetland function was made by ecologist Marc Lapin.

We observed fewer changes in plant species composition from Year Three to Four than we had seen from Year Two to Three, which may represent a stabilization or a slowing down of the transition from species that favor disturbed, open-ground conditions to those that are more robustly competitive in this densely vegetated floodplain site. As in previous years, the wetland area disturbed by the construction of the access road appeared stable and showed successful revegetation with a species variety overwhelmingly dominated by natives. Vegetation cover was again estimated to be over 90 percent, with little change in total plant cover since Year 2. In the wetter portion of the restored roadway (represented by Plot 1) two strips that had been more open—access road ruts—were more covered with plants than they had been in the previous three years.

[1] Bear Creek Environmental, LLC. Biological Services Team. 2012. Invasive Species Management, Planting and Monitoring Plan for Maidstone STP 0271(20). Vermont Agency of Transportation-Slope Failure on VT Route 102 Adjacent to Connecticut River. Montpelier, Vermont.

Once again, a few individual invasive exotic plants were found in or directly adjacent to the re-vegetated area. Both glossy buckthorn and Eurasian honeysuckle were in the area and were flagged for future chemical control. The number and types of non-native herbaceous species remained stable from Year 3; none of these species are listed in Vermont or New Hampshire as invasive species. Control of wild parsnip by hand-pulling was again conducted during the 2016 growing season at the time of plot sampling. About the same number of wild parsnip was present in 2016 as in 2015, which does represent a decrease from the 2014 count. Chemical control of knotweed that occurred on the stabilized slope on August 31, 2015 was not entirely successful, as some live knotweed plants did persist in August 2016. No Japanese knotweed was seen in the restored wetland, however, in any of the sampling years. Reed canary grass continued to be present in low levels in the restored roadway; for the past two years it has not been present in either plot, nor does it appear to have spread in other parts of the wetland restoration outside of the sample plots. However, reed canary grass is abundant on the engineered slope between the restoration site and the river. Observations in these early years have not shown the invasive grass to be even a common species in the restored area, but the underground parts likely still persist and given appropriate coincidence of hydrologic conditions and changing competitiveness of other occurring species, it is possible for reed canary grass to proliferate by underground parts, seeds or both. We will continue to watch it in Year 5 sampling.

We continue to see no changes in the restored wetland's performance of the previously documented functions of water storage, surface and groundwater protection and erosion control. From a wetland functions perspective, the restoration has been successful within the four-year time period to date. As reported last year, differences pre- and post-construction in these functions are minor and are attributed to the microtopography of the wetland being altered and the presence of angular stone in scattered parts of the surface horizon. Alterations due to compaction and soil mounding were estimated in 2013 to be less than 5% of the project area. From 2014 through 2016 these alterations were largely hidden beneath the dense herbaceous vegetation and did not appear to be substantially detrimental to documented pre-disturbance

wetland functions. Small areas of bare muck and open, standing water at the northern end of the roadway that were easily observed in the first three years were heavily obscured by tall, dense to moderately dense vegetation in the fourth year. These small disruptions from the season of truck traffic have not significantly changed water storage capacity, but overall the site has slightly less water storage capacity than prior to construction, since the toe-slope stabilization included build-up of a berm adjacent to the river at the southern end of the restoration area.

As expected, we continue to see that wildlife habitat functionality is altered from the natural condition due to a shift from a forest-dominated wetland to herbaceous vegetation. It is hoped that this cover change is temporary, and we expect that tree and shrub cover will re-establish over a longer time frame (such as, two decades perhaps). Wildlife habitat functionality would be closer to the pre-disturbance character once a woody canopy establishes. Silver maple seedlings were common in scattered parts of the restoration, and vegetative sprouts of other trees continue to grow in and alongside the area. Woody plant regeneration is still very sparse, however.

Background

The Bear Creek Environmental, LLC Biological Services Team was retained by the Vermont Agency of Transportation to prepare an Invasive Species Management, Planting and Monitoring Plan for the Maidstone STP 0271(20) project. The Plan includes measures to reduce impacts to wetlands, to prevent the proliferation of invasive species, to restore wetland disturbed by the construction of a temporary access road, and to monitor the restored wetland. The following report provides a summary of the fourth year of monitoring after the construction of the temporary access road and subsequent restoration of the wetland. Monitoring of the restored wetland is a condition of the Army Corps of Engineers' Permit NAE-2011-0346 dated December 17, 2012.

The Maidstone STP 0271(20) project included the construction of a temporary road to allow construction access to repair a large slope failure on a cutbank of the Connecticut River that was threatening Route 102 in the town of Maidstone, Vermont

(Figure 1). The temporary access road (Figure 2) was constructed during May 2013 and in part followed the pathway of an existing woods road that was located between VT Route 102 and the Connecticut River. The former access road was approximately 20 feet wide and included a disturbance width of between 30 and 40 feet. Following construction, the wetland was restored by removing the geotextile and road gravels down to the original grades. The site was seeded with wetland native seed mix in wetland areas and upland native seed mix in non-wetland areas adjacent to the wetland and then mulched. Straw mulch was applied to avoid the introduction of weeds and invasive species. Per the Maidstone Plan, the seeds for two uncommon species were harvested and stored for planting following construction. These uncommon species include Wiegand's wild-rye (*Elymus wiegandii*) and rough avens (*Geum laciniatum*). Marc Lapin, Ecologist, sowed the seeds on June 23, 2013. The stabilized construction entrance was removed and planted with native trees and shrubs. The silt fence, located adjacent to the oxbow, was taken out during fall 2013 to allow flooding of the restored wetland. During the 2013 fall dormancy period, live dogwood and willow stakes were installed in the riprap in the wetland buffer.

Ecologist Marc Lapin of Ecosystem Conservation Science and Mary Nealon of Bear Creek Environmental, LLC visited the Maidstone site on August 18, 2016 to conduct the fourth year of monitoring. First-year monitoring had been conducted on September 27, 2013 and is summarized in Lapin and Nealon (2013).[2] Second-year monitoring occurred on August 19, 2014; Lapin and Nealon (2014)[3] reports those results. Third-year monitoring took place on August 21, 2015 and is reported on in Lapin and Nealon (2015).[4] The accepted plan calls for the site to be monitored for five years

[2] Lapin, M, and M. Nealon, 2013. Maidstone Slide – STP 0271(20) Year 1 Report: Wetland and Invasive Species Monitoring and Control Recommendations. Bear Creek Environmental Biological Services Team, Montpelier, VT.

[3] Lapin, M, and M. Nealon, 2014. Maidstone Slide – STP 0271(20) Year 2 Report: Wetland and Invasive Species Monitoring and Control Recommendations. Bear Creek Environmental Biological Services Team, Montpelier, VT.

[4] Lapin, M, and M. Nealon, 2015. Maidstone Slide – STP 0271(20) Year 3 Report: Wetland and Invasive Species Monitoring and Control Recommendations. Bear Creek Environmental Biological Services Team, Montpelier, VT.

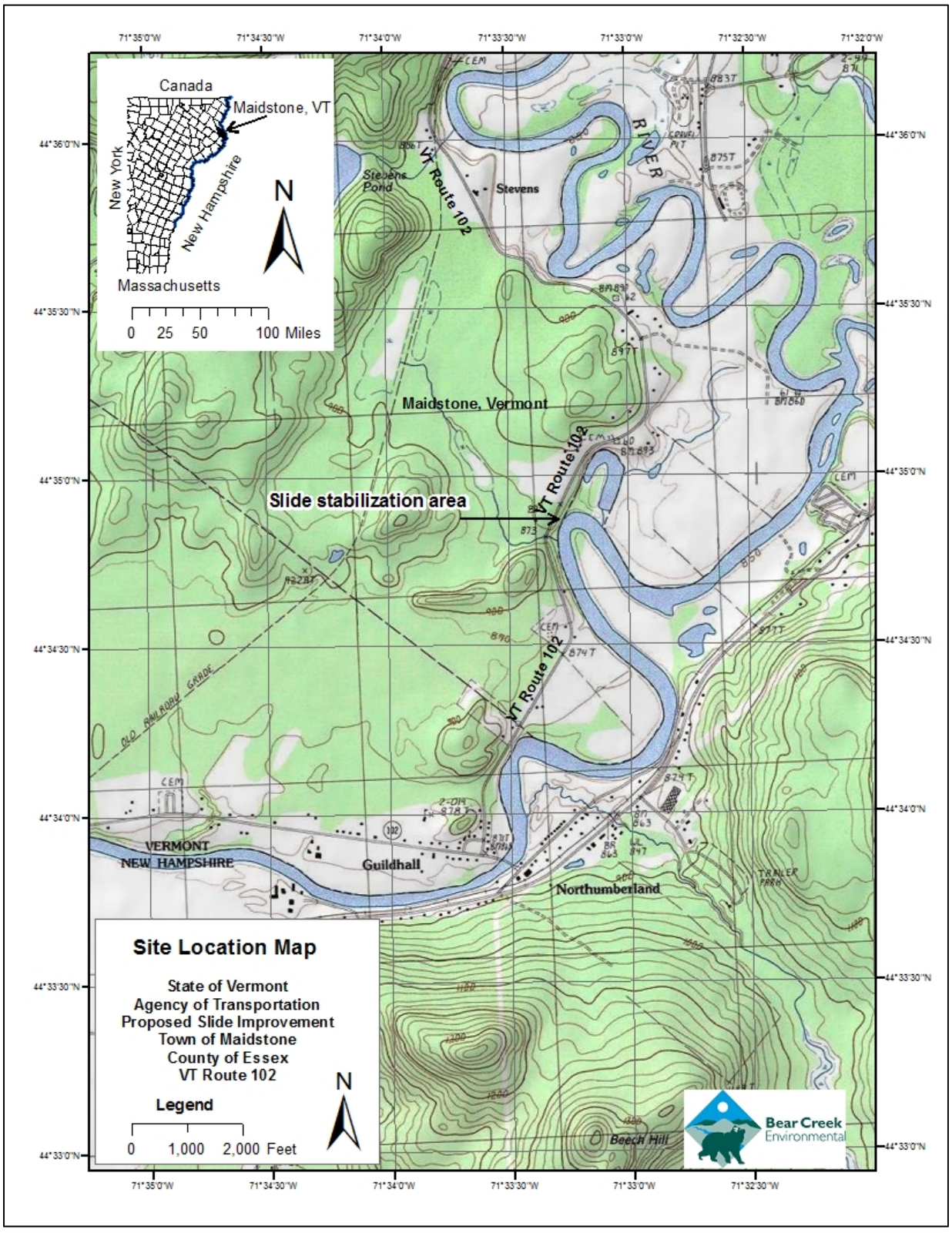

Figure 1. Site Location Map for Maidstone STP 0271(20) Project.

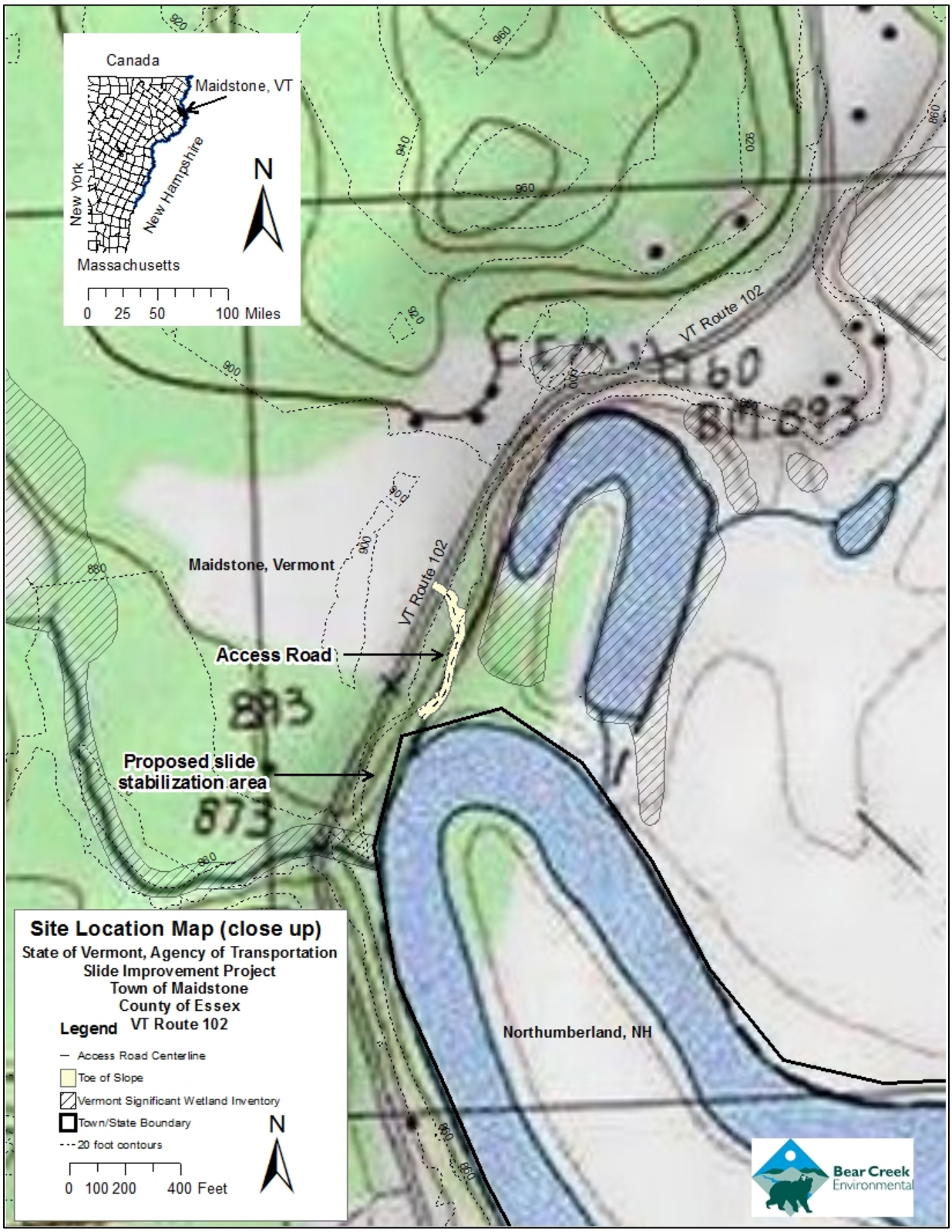

Figure 2. Location of Former Temporary Access Road.

during the growing season, beginning the first growing season following the completion of the restoration activities, and so next year may be the final monitoring year.

The five general monitoring objectives are:

1. Evaluation of the overall vegetative success in the wetland noting relative abundance of hydrophytic plant species within the restored wetland areas with a goal of 80 percent vegetative cover by native (non-invasive) species
2. Assessment of the presence/absence of invasive species within the restored wetland areas
3. General assessment of site stability and erosion control of wetland and adjacent area
4. General assessment of the presence of hydric soils and corresponding wetland hydrology
5. General assessment of wetland function

Methods

To quantitatively evaluate plant species composition two 5 x 5 m plots were established within the restored wetland area where the access road had been removed. Each permanent observation point was marked with a temporary stake and surveyed with a Mobile Mapper 100, GPS unit, capable of sub-meter accuracy. Documentation at the observation points included the identification of all vascular plant species present and a corresponding estimate of percent cover. An overall approximation of percent cover of invasive species on the site was made.

Presence/absence of the three recognized wetland indicators (i.e., dominance by hydrophytic vegetation, presence of hydric soils, and indication of wetland hydrology) were assessed within the restored wetland areas. Wetland function was evaluated using the U.S. Army Corps of Engineers New England District Highway Methodology Workbook (USACE 1999) as a general guide.

Re-Vegetation of the Restored Access Road

GENERAL VEGETATION PATTERNS. Successful revegetation of the restored roadway has continued through four growing seasons. Native plant establishment was very good after one growing season following removal of the road and has continued for the three subsequent years, although, as would be expected, there have been changes in both species composition and plant abundances. At the end of the first growing season over 85% of the area had plant cover, with 0% cover of invasive exotic shrubs. By late summer of the second growing season, plant cover was nearly 100%, a closed herbaceous canopy which has continued for the third and fourth years. The narrow, wet channels that had been bare in Years 2 and 3 were very nearly fully vegetated in 2016.

Vegetation of the wetter, northern section has undergone a noticeable transition through the four years since restoration began, although common arrowhead (*Sagittaria latifolia*) has consistently been a dominant or co-dominant species since the second year (Table 1). Growth the first two years was dominated by sedge (especially *Carex vulpinoidea*), rush (*Juncus pylaei*) and, by Year 2, also arrowhead. In Year 3 blue vervain (*Verbena hastata*) and spotted touch-me-not (*Impatiens capensis*) were prominent above a lush growth of several sedges, with common arrowhead (*Sagittaria latifolia*) dominating the lowest wet spots. Year 4 vegetation saw a decrease in touch-me-not, with those present mostly much smaller and lower than the prominent blue vervain, arrowhead and fringed willow-herb (*Epilobium ciliatum*).

The drier restored area has consistently featured smooth goldenrod (*Solidago gigantea*) as a dominant species (Table 2). Co-dominant Year 1 was the rather weedy, non-native brittle-stemmed hemp-nettle (*Galeopsis* tetrahit), which declined substantially after that first year. Eastern riverbank wild-rye (*Elymus* riparius) joined smooth goldenrod as a prominent species in Years 2 and 3, but that species, although strongly present, now looks to be declining somewhat with spotted touch-me-not and Virginia virgin's-bower (*Clematis virginiana*) having increased. Purple-stemmed American-aster (*Symphyotrichum puniceum*) is prominent also in parts of the drier restoration zone. The shrub black elderberry (*Sambucus nigra*) has consistently been present in the drier area, although due to the Year 4 drier plot being offset a couple of

meters to the south, the changes as shown by the plot data do not accurately represent changes on the ground for the elderberry or for several other species including redtop bentgrass, path rush and great burdock, which likely did not increase or decrease in coverage to the extent the data in Tables 2 and 3 would indicate.

In the entirety of the restored wetland area, we observed 115 species over four years of monitoring (Table 4). Fifty-four species were recorded in the two plots, as compared with 53 in Year 3 sampling, 64 species in the Year 2 sampling and 61 species the first year. Six species not previously recorded in the restoration were observed in Year 4; all are native species (Table 5). Sixteen non-native plants are included within the four-year species total of 115, but only six of those were present by Years 3 and 4. All species recorded by Gustafson in her pre-construction wetland delineation documentation of dominant species were present in the restoration area. None of those species were dominant after the fourth growing season of the restoration, but one would not expect such a rapid recovery to natural composition or structure of the vegetation after a disturbance as disruptive as construction of a temporary roadway.

Invasive and Non-Native Species Presence. The Year 4 total of non-native species in the restoration remained equal to the previous year, six species, three recorded in the plots and three present outside of the plots. Eight additional non-native species had been recorded in either or both of the first two years but not in Years 3 or 4. Invasive species plant cover has remained at a very low percentage in the restoration area through the four years of sampling. The shrub invasive species, glossy buckthorn (*Rhamnus frangula*) and Morrow's/Tatarian honeysuckle (*Lonicera morrowii/tatarica*), have appeared only at the upland periphery of the restoration; the herbaceous invasives, wild parsnip (*Pastinaca sativa*) and reed canary grass (*Phalaris arundinacea*), continue to grow in low numbers and low coverage in the mid-section of the restoration. Overall, invasive species coverage has not exceeded 5% in any of the four years since the restoration was initiated. Year 4 coverage of the invasives was at 1% to 2%.

A clear decrease of non-invasive, non-native plants was seen from Year 1 to Years 2 and 3 (Tables 1 and 2). The increase in creeping yellow-loosestrife in the wet

area plot in Year 4 (Table 1) is not indicative of the restoration as a whole, for that increase is spatially restricted to just one part of the wetter area. Nevertheless, creeping yellow-loosestrife may continue to expand; the moist, rich soils of floodplains are one of its preferred habitats and it can thrive under the shade of both woody and herbaceous canopies.

For a more detailed description, the invasive exotic shrubs in the general area, glossy buckthorn and the Eurasian honeysuckles continue to be observed at the western periphery of the restoration, adjacent to the upland slope at the top of which are sizeable populations of the invasive shrubs. In Year 4, as in the two preceding years, we observed a small population of wild parsnip (*Pastinaca sativa*) in the mid-section of the restoration area; the largest number, about a dozen plants, was observed in Year 2. Each year the observed wild parsnip have been hand-pulled, bagged, and removed from the site during the time of field sampling.

The non-native herbaceous plant creeping yellow-loosestrife (*Lysimachia nummularia*) is on the New Hampshire Invasive Species Committee's watch list.[5] In Year 4, moneywort increased dramatically in the wettest part of the restoration, rising from 1% to 70% cover. Although it is well established, one does not notice the plant without looking purposefully at the ground among the stems of the much taller, robust wetland herbs that dominate the middle and upper sections of the herbaceous plant canopy. Moneywort has not been similarly successful in spreading through the drier part of the restoration, where the creeping herb continues to hover around 1% cover. The dense carpet in the wetter zone is not uncommon in seasonally inundated wetland types in our region. It will be of interest to see if the increase in moneywort appears to impact abundance of other plant species, but without targeted research on that question, it will not be possible to tease apart the effects of moneywort from other influences on vegetation change.

In the drier part of the restoration, climbing nightshade (*Solanum dulcamara*) continues to persist as scattered plants with low coverage; none was detected within the

[5] http://agriculture.nh.gov/divisions/plant_industry/documents/ invasive-watch-list.pdf; http://www.gencourt.state.nh.us/rules/state_agencies/agr3800.html

Year 4 plot. Also, reed canary grass has disappeared from both plots, but persists in a restricted part of the drier zone.

New in Year 4 was a dense growth of everlasting vetchling (*Lathyrus latifolius*) on the engineered slope between the restored portion of the roadway and the river. The vetchling was not an intended component of any of the seed mixes—neither of the custom mixes (wetland and upland) developed for this project nor the VTRANS Rural Areas Conservation Mix which was used on the slope stabilization areas adjacent to the restoration. The species was present at low levels on the stabilized slope between the drier part of the restoration and the river since the initial year post-construction, but it underwent a large coverage expansion in Year 4. Everlasting vetchling was co-dominant with reed canary grass on that portion of stabilized slope; these two non-native species have the potential to spread into the wetland restoration. We will document their status in Year 5 sampling.

TREE AND SHRUB RE-ESTABLISHMENT. Re-establishment of forest cover is one goal of the restoration, and as expected for these early years of tree and shrub recruitment back into the disturbed area has been very sparse. The woody plant dominants documented by Gustafson[6] in her wetland delineation are all present in the restoration except for highbush-cranberry (*Viburnum trilobum*). Of the two trees, black ash (*Fraxinus nigra*) and silver maple (*Acer saccharinum*), only the maple has appeared as seed regeneration. Black ash has resprouted from stumps. Based on four years of monitoring, we expect that woody plant coverage will show a trend of slow increase in the restoration, with likely fluctuation and some years showing slight declines. Establishment and recruitment of the tree dominants is expected to be very slow, on the order of decades before even an open canopy establishes.

Silver maple the dominant tree in the forest, has re-seeded into the wetter restoration area every year. Seedling numbers have varied in Plot 1 from a single individual in Year 2 to seven seedlings in Year 4, but there is no assurance or confidence that the one- or two-year-old regeneration will survive. Mortality among

[6] Gustafson, S. 2011. Memo to John Lepore, VT Agency of Transportation. Re: Maidstone Slide Wetlands Evaluation, December 31, 2011. Shelley Gustafson Environmental, Ferrisburgh, VT.

maple seedlings is characteristically very high, and seedlings on floodplains are susceptible to being uprooted or crushed by ice-rafting processes.

Photo documentation of the vegetation is included as Appendix 1.

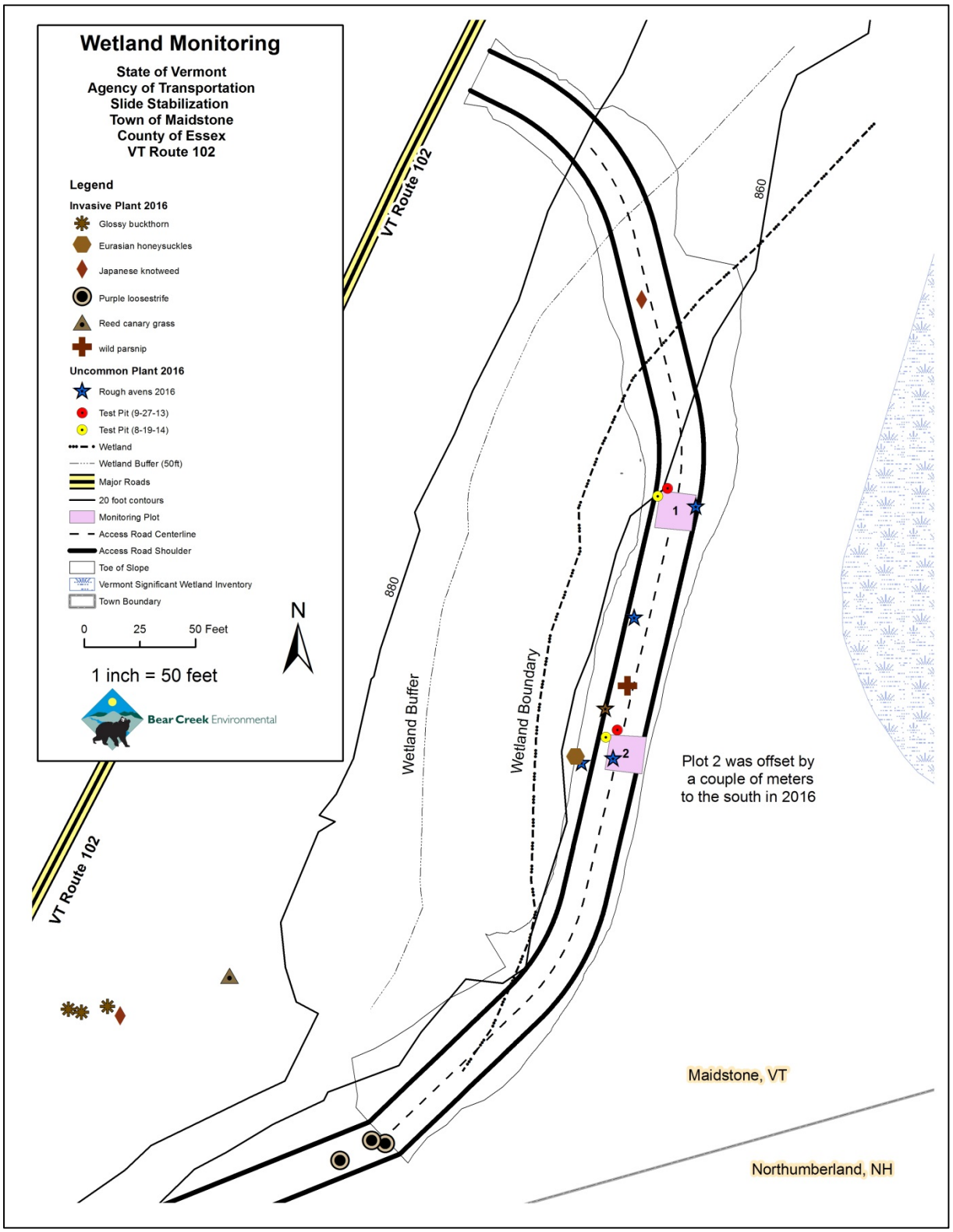

Figure 3. Wetland Restoration Monitoring Plots (sampled 9/27/13, 8/19/14, 8/21/15, and 8/18/2016).

Table 1.

Plant Cover in Plot 1 (wettest area of restored roadway) for first four years of growth after restoration. Bold denotes species included in wetland seed mix; underline denotes included in upland seed mix. Asterisk (*) indicates non-native species.

Scientific Name	Common Name	2016 Cover or Abundance if <1% cover	2015 Cover or Abundance if <1% cover	2014 Cover or Abundance if <1% cover	2013 Cover or Abundance if <1% cover
*Lysimachia nummularia**	Creeping Yellow-Loosestrife	70%	1%	o	o
Sagittaria latifolia	Common Arrowhead	60%	35%	15%	r
Epilobium ciliatum	Fringed Willow-Herb	20%	5%	r	o
Verbena hastata	Blue Vervain	15%	5%	o	
Leersia oryzoides	Rice Cut Grass	5%	1%	r	
Juncus pylaei	Pylae's Soft Rush	5%	o	65%	60%
Eupatorium perfoliatum	Boneset Thoroughwort	2%	1%	r	
Glyceria striata	Fowl Manna Grass	2%			
Galium asprellum	Rough Bedstraw	1%	2%	u	r
Scirpus cyperinus	Common Woolsedge	1%	r	o	r
Glyceria grandis	American Manna Grass	1%		r	
Carex lupulina	Hop Sedge	1%			
Ludwigia palustris	Common Water-Primrose	1%			
Sparganium emersum	Simple-Stemmed Bur-reed	1%			

Abundance ranking used if cover <1%

c=common, >10 plants, usually scattered widely through plot

o=occasional, 6-10 plants

u=uncommon, 3-5 plants

r=rare, 1-2 plants

NOTE: Percentages may total >100% due to layering of vegetation.

Bold denotes species included in wetland seed mix; underline denotes species included in upland seed mix.

‡ Assumed to be *J. effusus* in Year 1; determined to be *J. pylaei* in Year 2; advertised as *J. effusus* in seed mix; both are native species and both have been verified in the restored vegetation.

Scientific Name	Common Name	2016 Cover or Abundance if <1% cover	2015 Cover or Abundance if <1% cover	2014 Cover or Abundance if <1% cover	2013 Cover or Abundance if <1% cover
Impatiens capensis	Spotted Touch-Me-Not	c	1%	o	u
Persicaria sagittata	Arrow-Leaved Tearthumb	c	1%	o	c
Penthorum sedoides	Ditch-Stonecrop	o	1%	u	
Acer saccharinum	Silver Maple	o	c	r	r
Galium palustre	Marsh Bedstraw	o	u	r	r
Solidago gigantea	Smooth Goldenrod	o	u	r	o
Alisma triviale	Northern Water-Plantain	o	r	o	2%
Carex lurida	Sallow Sedge	u	r	o	1%
Symphyotrichum puniceum	Purple-Stemmed American-Aster	u	r	r	r
Lysimachia ciliata	Fringed Yellow-Loosestrife	u			
Athyrium filix-femina	Northern Lady Fern	r	u		o
Oenothera biennis	Common Evening-Primrose	r	u	r	
Onoclea sensibilis	Sensitive Fern	r	u	r	r
Agrimonia gryposepala	Common Agrimony	r	r		
Bromus ciliatus	Fringed Brome	r	r	u	
Eutrochium maculatum	Spotted Joe-Pye Weed	r	r	u	
Lycopus uniflorus	Northern Water-Horehound	r	r		
Scutellaria galericulata	Hooded Skullcap	r		u	
Dulichium arundinaceum	Three-Way Sedge	r		r	

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Scientific Name	Common Name	2016 Cover or Abundance if <1% cover	2015 Cover or Abundance if <1% cover	2014 Cover or Abundance if <1% cover	2013 Cover or Abundance if <1% cover
Osmundastrum cinnamomeum	Cinnamon Fern	r		r	r
Potentilla norvegica	Norwegian cinquefoil	r		r	
Laportea canadensis	Wood-Nettle	r			
Rubus hispidus	Bristly Blackberry	r			
Symphyotrichum lateriflorum	Calico American-Aster	r			
Carex scoparia	Pointed Broom Sedge		o	o	
Carex vulpinoidea	Common Fox Sedge		o	60%	
Solidago rugosa	Common Wrinkle-Leaved Goldenrod		o	r	r
*Galeopsis tetrahit**	Brittle-Stemmed Hemp-Nettle		u	r	1%
Poa sp.	Bluegrass		u		
Scutellaria lateriflora	Mad Dog Skullcap		u		
Iris versicolor	Blue Iris		r		
Sonchus sp.	Sow-Thistle		r		
Mimulus ringens	Allegheny Monkey-Flower			o	
Scirpus atrovirens	Dark-Green Bulrush			o	
Typha latifolia	Broad-Leaved Cat-Tail			u	r
Amphicarpaea bracteata	American Hog-Peanut			r	
Calamagrostis canadensis	Canada Reed Grass			r	o
Dichanthelium clandestinum	Deer-Tongue Rosette-Panicgrass			r	

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Scientific Name	Common Name	2016 Cover or Abundance if <1% cover	2015 Cover or Abundance if <1% cover	2014 Cover or Abundance if <1% cover	2013 Cover or Abundance if <1% cover
*Phalaris arundinacea**	Reed Canary Grass			r	
Bidens cernua	Nodding Beggar-Ticks				2%
*Echinochloa crus-galli**	Common Barnyard Grass				u
Antennaria sp.	Pussy-toes				r
Boehmeria cylindrica	Small-Spiked False Nettle				r
*Brassicaceae**	Mustard				r
Clematis virginiana	Virginia Virgin's-Bower				r
Eleocharis sp.	Spike-rush				r
Fragaria virginiana	Common Strawberry				r
Geum laciniatum	Rough Avens				single plant
Juncus cf. brevicaudatus	Short-tailed Rush				r
Persicaria arifolia	Halberd-Leaved Smartweed				r
Rubus allegheniensis	Common Blackberry				r
Rubus idaeus	Red Raspberry				r
*Rumex crispus**	Curly Dock				r

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Table 2.

Plant Cover in Plot 2 (dry area in restored roadway) for first four years of growth after restoration. Bold denotes species included in wetland seed mix; underline denotes included in upland seed mix. Asterisk (*) indicates non-native species. Dagger (†) indicates species whose 2016 cover/abundance data were likely substantially affected (either showing larger than actual increase/decrease or lack of presence) by the 2016 plot placement.

Scientific Name	Common Name	2016 Cover or Abundance if >1% cover	2015 Cover or Abundance if >1% cover	2014 Cover or Abundance if >1% cover	2013 Cover or Abundance if >1% cover
Solidago gigantea	Smooth Goldenrod	60%	60%	40%	20%
Impatiens capensis	Spotted Touch-Me-Not	15%	1%	o	1%
Agrostis gigantea	Redtop Bentgrass	15%†			o
*Arctium lappa**	Great Burdock	10%†	2%	10%	1%
Clematis virginiana	Virginia Virgin's-Bower	10%	1%	c	1%
Onoclea sensibilis	Sensitive Fern	5%	o	r	u
Elymus riparius	Eastern Riverbank Wild-Rye	3%†	15%	25%	
Athyrium filix-femina	Northern Lady Fern	3%	2%	2%	1%
Symphyotrichum puniceum	Purple-Stemmed American-Aster	1%	5%	r	
Prunus virginiana	Choke Cherry	1%	1%	2%	1%
*Lysimachia nummularia**	Creeping Yellow-Loosestrife	1%	u	o	10%
Verbena hastata	Blue Vervain	1%	u	u	
Matteuccia struthiopteris	Ostrich Fern	1%	r	r	r
Thalictrum pubescens	Tall Meadow-Rue	1%	r	o	r

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Bold denotes species included in wetland seed mix; underline denotes species included in upland seed mix.

‡ Assumed to be *J. effusus* in Year 1; determined to be *J. pylaei* in Year 2; advertised as *J. effusus* in seed mix; both are native species and both have been verified in the restored vegetation.

Scientific Name	Common Name	2016 Cover or Abundance if >1% cover	2015 Cover or Abundance if >1% cover	2014 Cover or Abundance if >1% cover	2013 Cover or Abundance if >1% cover
Agrimonia gryposepala	Common Agrimony	o	o	u	o
Equisetum hyemale	Tall Scouring-Rush	o	r	u	o
Galium triflorum	Fragrant Bedstraw	o	r		
*Oxalis stricta**	Common Yellow Wood Sorrel	o	r	u	c
Persicaria sagittata	Arrow-Leaved Tearthumb	o	r		
Amphicarpaea bracteata	American Hog-Peanut	o			r
Carex sp.	Sedge	o			
Lysimachia ciliata	Fringed Yellow-Loosestrife	o			
Juncus effusus	Common Soft Rush	u	10%		
Dryopteris cristata	Crested Wood Fern	u	r	r	
Laportea canadensis	Canada Wood-Nettle	u			
Boehmeria cylindrica	Small-Spiked False Nettle	r	2%	o	r
Solidago rugosa	Common Wrinkle-Leaved Goldenrod	r	u	u	
Rubus hispidus	Bristly Blackberry	r	r	r	
Symphyotrichum lateriflorum	Calico American-Aster	r	r	r	r
Scutellaria lateriflora	Mad Dog Skullcap	r		o	
Juncus tenuis	Path Rush	†	20%		
*Galeopsis tetrahit**	Brittle-Stemmed Hemp-Nettle		2%		20%
Sambucus nigra	Black Elderberry	†	1%	5%	1%
*Solanum dulcamara**	Climbing Nightshade	†	c	r	u

Abundance ranking used if cover <1%

c=common, >10 plants, usually scattered widely through plot

o=occasional, 6-10 plants

u=uncommon, 3-5 plants

r=rare, 1-2 plants

NOTE: Percentages may total >100% due to layering of vegetation.

Bold denotes species included in wetland seed mix; underline denotes species included in upland seed mix.

‡ Assumed to be *J. effusus* in Year 1; determined to be *J. pylaei* in Year 2; advertised as *J. effusus* in seed mix; both are native species and both have been verified in the restored vegetation.

Scientific Name	Common Name	2016 Cover or Abundance if >1% cover	2015 Cover or Abundance if >1% cover	2014 Cover or Abundance if >1% cover	2013 Cover or Abundance if >1% cover
Carex lupulina	Hop Sedge		r		
Chelone glabra	White Turtlehead		r	r	
Dichanthelium clandestinum	Deer-Tongue Rosette-Panicgrass		r	r	
Eutrochium maculatum	Spotted Joe-Pye Weed		r		r
Galium asprellum	Rough Bedstraw		r		r
Galium palustre	Marsh Bedstraw		r	r	r
Geum laciniatum	Rough Avens		r	r	single plant
*Rumex crispus**	Curly Dock		r		r
Solidago flexicaulis	Zigzag Goldenrod		r		
Festuca rubra	Red Fescue			60%	60%
Leersia oryzoides	Rice Cut Grass			u	15%
*Phalaris arundinacea**	Reed Canary Grass			u	1%
Arisaema triphyllum	Jack-In-The-Pulpit			r	
Bromus ciliatus	Fringed Brome			r	
Epilobium ciliatum	Fringed Willow-Herb			r	r
Eupatorium perfoliatum	Boneset Thoroughwort			r	
Eurybia divaricata	White Wood-Aster			r	
Leersia virginica	White Cut Grass			r	
Muhlenbergia cf. frondosa	Wire-Stemmed Muhly			r	
*Pastinaca sativa**	Wild Parsnip			r	r
Rhus typhina	Staghorn Sumac			r	

Abundance ranking used if cover <1%

c=common, >10 plants, usually scattered widely through plot

o=occasional, 6-10 plants

u=uncommon, 3-5 plants

r=rare, 1-2 plants

NOTE: Percentages may total >100% due to layering of vegetation.

Bold denotes species included in wetland seed mix; underline denotes species included in upland seed mix.

‡ Assumed to be *J. effusus* in Year 1; determined to be *J. pylaei* in Year 2; advertised as *J. effusus* in seed mix; both are native species and both have been verified in the restored vegetation.

Scientific Name	Common Name	2016 Cover or Abundance if >1% cover	2015 Cover or Abundance if >1% cover	2014 Cover or Abundance if >1% cover	2013 Cover or Abundance if >1% cover
Calamagrostis canadensis	Canada Reed Grass				5%
*Setaria sp.**	Foxtail Grass				2%
Bidens cernua	Nodding Beggar-Ticks				1%
Hordeum jubatum	Foxtail Barley				1%
Dryopteris carthusiana	Spinulose Wood Fern				c
*Plantago cf. major**	Common Plantain				c
Carex cf. lacustris	Lakeside Sedge				r
Persicaria hydropiper	Water-Pepper Smartweed				r
*Persicaria maculosa**	Lady's-Thumb Smartweed				r
*Solanum nigrum**	European Black Nightshade				r
Symphyotrichum cordifolium	Heart-Leaved American-Aster				r
Asclepias incarnata	Swamp Milkweed				
Juglans cinerea	Butternut				
Oenothera biennis	Common Evening-Primrose				

Abundance ranking used if cover <1%

c=common, >10 plants, usually scattered widely through plot

o=occasional, 6-10 plants

u=uncommon, 3-5 plants

r=rare, 1-2 plants

NOTE: Percentages may total >100% due to layering of vegetation.

Bold denotes species included in wetland seed mix; underline denotes species included in upland seed mix.

‡ Assumed to be *J. effusus* in Year 1; determined to be *J. pylaei* in Year 2; advertised as *J. effusus* in seed mix; both are native species and both have been verified in the restored vegetation.

Table 3.

Plants in Restored Roadway Outside of Sample Plots, first four years. Asterisk (*) indicates non-native species. Dagger (†) indicates species that likely still persist in Plot 2 but are not shown as such due to the Year 4 plot position being slightly offset from previous years.

Scientific Name	Common Name	Year 1	Year 2	Year 3	Year 4
*Agropyron sp.**	Wheat Grass	x			
Alnus incana	Speckled Alder	x		x	x
Amphicarpaea bracteata	American Hog-Peanut			x	
Arisaema triphyllum	Jack-In-The-Pulpit	x			
Asclepias incarnata	Swamp Milkweed		x		
Bidens frondosa	Common Beggar-Ticks				x
Carex scoparia	Pointed Broom Sedge				x
Chelone glabra	White Turtlehead				x
Cornus sericea	Red-Osier Dogwood				x
Eurybia divaricata	White Wood-Aster	x			
Fraxinus americana	White Ash		x	x	x
Fraxinus nigra	Black Ash		x	x	x
Geum laciniatum	Rough Avens				x
Glyceria canadensis	Rattlesnake Manna Grass			x	x
*Hylotelephium erythrostictum**	Garden Stonecrop			x	
Juglans cinerea	Butternut		x	x	x
Juncus tenuis†	Path Rush				x
Lycopus uniflorus	Northern Water-Horehound		x		
Menispermum canadense	Canada Moonseed	x			
Mimulus ringens	Allegheny Monkey-Flower			x	
Muhlenbergia cf. frondosa	Wire-Stemmed Muhly	x		x	
*Pastinaca sativa**	Wild Parsnip				x
*Phalaris arundinacea**	Reed Canary Grass				x
Potentilla simplex	Old-Field Cinquefoil				x
*Rhamnus frangula**	Glossy Buckthorn			x	
Rhus typhina	Staghorn Sumac				x
Rubus allegheniensis	Common Blackberry		x	x	x
Rubus idaeus	Red Raspberry				x
*Rumex crispus**	Curly Dock		x		
Sambucus nigra†	Black Elderberry				x
Scirpus atrovirens	Dark-Green Bulrush				x
Sium suave	Water-Parsnip		x		x
*Solanum dulcamara**†	Climbing Nightshade				x
*Tussilago farfara**	Coltsfoot		x		
Typha latifolia	Broad-Leaved Cat-Tail			x	x

Table 4.

Changes in Plant Species Richness in the first four years.

	Year 1	Year 2	Year 3	Year 4
Total number of plant species observed all years	67	96	97	103
Number of plant species within both plots	61	64	53	54
Number of non-native plant species	16	7	6	6

Table 5.

Species Newly Observed in the Restoration in Year 4.

Scientific Name	Common Name	Wetter Zone	Drier Zone
Glyceria striata	Fowl Manna Grass	x	
Laportea canadensis	Wood-Nettle	x	x
Ludwigia palustris	Common Water-Primrose	x	
Lysimachia ciliata	Fringed Yellow-Loosestrife	x	x
Sparganium emersum	Simple-Stemmed Bur-reed	x	
Symphyotrichum lateriflorum	Calico American-Aster	x	

Invasive Species Observations

Through the first four years of the wetland restoration the invasive exotic shrubs common in the adjacent upland, glossy buckthorn (*Rhamnus frangula*) and Eurasian honeysuckles (*Lonicera tatarica*, and/or *L. morrowii*), have not seeded into the restoration area. Each year, however, a few of these shrubs have been observed at the base of the upland slope adjacent to the restoration (Figure 3). All observed individuals have been flagged each year. In early October 2014 and late August 2015 flagged plants were treated by a licensed pesticide applicator using a glyphosate-based herbicide.

Three non-native species observed in the restored area but not considered "noxious weeds" by either Vermont or New Hampshire—creeping yellow-loosestrife (*Lysimachia nummularia*), reed canary grass (*Phalaris arundinacea*) and wild parsnip (*Pastinaca sativa*)—continue to persist in the restored wetland. Of these three, only creeping yellow-loosestrife has been increasing, the growth of which comes as no surprise since the species is common in the ground flora of many floodplain forests in

Vermont. No new non-native species have been observed in Years 3 or 4; the number remained stable in those years. Similar to Year 3, approximately half a dozen wild parsnip were hand-pulled in Year 4, bagged in plastic, removed from the site, and disposed of in a landfill.

No reed canary grass was seen in either of the plots, but it remains present at low levels within the restoration. No control of the invasive grass has been undertaken in any of the four years, and, similar to what we saw in Year 3, the aggressive grass appears to be experiencing a population decrease in the entirety of the restored roadway. Reed canary grass has, however, had a population increase on the engineered area between the restoration and the river. We will continue to monitor reed canary grass abundance in subsequent sampling years. Although preliminary results continue to indicate that it is declining in the restored wetland, the underground parts likely still persist and given appropriate coincidence of hydrologic conditions and changing competitiveness of other occurring species, it is possible for reed canary grass to proliferate. Co-dominant on the engineered slope adjacent to the restoration is another non-native, everlasting vetchling, which increased rapidly in Year 4. This species will also be observed carefully in Year 5. It is a plant of anthropogenic habitats, disturbed sites, meadows and fields and is not classified as to wetland vegetation status.

The other “non-noxious” non-native herb common to wetlands, creeping yellow-loosestrife, increased dramatically in the wetter area in Year 4. Cover/abundance in Years 1 to 3 was occasional to 1%; coverage in Year 4 was 70%. In the drier plot, creeping yellow-loosestrife went from 10% in Year 1 to occasional and uncommon in Years 2 and 3, respectively. A slight increase to 1% was measured in Year 4, which may indicate a very slight increase or may be an artifact of the different plot placement in Year 4. The difference in behavior of creeping yellow-loosestrife in the wetter and drier areas is likely explained by one or more of the following factors: greater competition for light and space in the denser, more robust vegetation of the drier area; allelopathy from goldenrod in the drier area; and more favorable moisture conditions in the wetter area.

Invasive Species Recommended Control

After four years of vegetation succession in the restoration there is no indication that invasive, non-native species are proliferating. The coverage of non-native plants, both those considered invasive and non-invasive, has fluctuated a little but has been low in the restoration as a whole, on the order of 1% to 2% total coverage.

We recommend continued hand-pulling of wild parsnip in the restoration. The plants have occurred as single individuals or in small patches and have not been widespread throughout the restoration. Each year during our sampling we have removed the observed plants, and this seems to have thus far been effective at keeping the population at a low level. It is likely that a wild parsnip seed bank remains in the areas where we have been pulling plants in Years 3 and 4. These seeds likely came in on equipment during construction. Since the population has not been widespread, we suppose that not many seeds were brought in. We are confident that we did not allow any mature fruits of wild parsnip to remain on-site.

Reed canary grass has been present, but diminishing, in the restoration. No control has been undertaken; the decrease has been through natural changes in vegetation in the four years. Although a small population remains, we have not recommended control for 2016 and will re-evaluate reed canary grass in Year 5.

Chemical control of glossy buckthorn and Eurasian honeysuckle in the wetland adjacent to the restoration was conducted in Years 2 and 3, specifically on October 2, 2014 and August 31, 2015. We once again observed a few of these invasive shrubs on the western periphery of the wetland, but have not recommended chemical control in 2016, but instead opted to wait for a 2017 re-evaluation since population levels have consistently been very low.

Similarly, Japanese knotweed (*Fallopia japonica*) on the stabilized slope was treated on those dates in 2014 and 2015. We once again in Year 4 observed live Japanese knotweed on the slope but not in the restoration. The population on the slope is sparse and dispersed, and we have not recommended chemical control for 2016, but instead opted to wait to observe the 2017 population. Control in 2017 would likely be a more efficient use of dollars, and since there has been no spread of Japanese

knotweed into the restoration delaying control for a year does not seem too risky for the newly developing wetland restoration.

The non-invasive alien creeping yellow-loosestrife in Year 4 substantially increased cover in a limited section of the wetter part of the restoration. The Forest Service literature review of creeping yellow-loosestrife states that although the plant can occasionally become dominant in plant communities, it is generally thought to have only a moderate impact on native vegetation.[7] The Forest Service document further states that control may be complicated by the plants ability to sprout from stems and possibly roots following treatment, and suggests control effectiveness most likely must rely upon multiple measures, such as herbicides, prescribed fire, seeding and other methods that decrease creeping yellow-loosestrife spread and favor native species. In short, control is a complex task and perhaps is often ineffective.

Uncommon Species

The two uncommon species that were present prior to construction and restoration, rough avens (*Geum laciniatum*) and Wiegand's wild-rye (*Elymus wiegandii*), have fared very differently. Seeds of both species were collected in October 2012, and dispersed within the restoration area on June 23, 2013. Rough avens has established in the restored roadway, whereas Wiegand's wild-rye has not. We consider the collection, storage and dissemination of rough avens to be successful for reintroducing the uncommon species to a site where it would otherwise have been nearly or fully extirpated by the transportation project.

Year 4 monitoring continues to verify establishment and fruiting of rough avens within both the drier and wetter parts of the restoration area (Figure 3). The plants definitely appear to be producing viable seed and have established in a larger area of the restoration each year. We counted 13 rough avens during the Year 4 sampling; seven of the 13 were reproductive with mature or dispersing fruits. Also, it is likely that there are a few more small, first-year plants that we did not see. As mentioned in

7 Innes, Robin J. 2011. Lysimachia nummularia. In: Fire Effects Information System, [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: http://www.fs.fed.us/database/feis/ [2016, November 23].

previous years' reports, close to the river, where the bulk of the original population had been located, does not appear to be suitable habitat, as it has been engineered with fill as a lower-slope area to help support the reconstructed slope and cannot be considered part of the wetland restoration.

Wiegand's wild-rye, which has not recolonized the restoration area continues to reveal the opposite story, which can be attributed to the fact that this grass's very specific habitat was not restored as part of the project. The uncommon grass frequently occupies only a very narrow band (about 5 meters) close to the river, and since the restoration area does not actually extend fully to the river due to the engineering of the slope for stability, the preferred habitat has not been restored. The population atop the riverbank in the unaltered floodplain forest adjacent to the project area continues to be sizable and vigorous, with an apparently stable population in the undisturbed portion of the floodplain upstream of the construction zone.

Soils in the Restored Access Road Site

As in Year 3, we decided it would be better not to disturb another two meter-square pits to make further soil observations in 2016, since observations of soils pits that were dug adjacent to each plot in 2013 and 2014 showed soils had been restored to hydric soils. Soil changes in the restored area will be on a time scale of decades to centuries; it is therefore not necessary to continue sampling each year of the initial five-year monitoring.

Site Stability

The Year 4 observations continue to support our initial finding that wetland site stability has been well restored. Pre-construction, the site was fully forested and had no bare soil. At the end of Year 1 the site had at least 85% vegetation cover; 15% or less of the site was covered by either open water or straw mulch. Late in the growing season of both Years 2 and 3 the site had over 90% vegetation cover; less than 5% of the site featured open water. In Year 4 the vegetation cover had increased slightly, most notably where ruts that had been the open water 5% of the area had become

nearly fully vegetated with no bare soil showing through the herbaceous plant canopy. Once again, no erosion was noted in either 1) the restored area, 2) the adjacent portion of floodplain forest that was disturbed by tree and shrub removal but was not part of the temporary access road, or 3) the engineered slope section that was a combination of wetland buffer and some floodplain forest (identified as "Area 4 – Riprap in Wetland Buffer" in the Planting Plan). The area where the only construction disturbance was tree and shrub removal continued to support re-sprouting trees and shrubs and dense herbaceous floodplain vegetation.

The wetland buffer engineered slope that extends south of the restored roadway to the river's edge continued to be well stabilized by the now-decaying coir matting and dense herbaceous vegetation. Plant dominants in the area between the river and the restoration were two non-natives—reed canary grass and everlasting vetchling (*Lathyrus latifolius*)—along with smooth goldenrod and blue vervain. The vegetation of this part of the project area has changed dramatically over the four years and is now dominated by neither plants from the upland seed mix nor the volunteer "weeds" of the earlier years, (i.e., brittle-stemmed hemp-nettle, common agrimony and curly dock). Interesting to note, the *New Flora of Vermont*[8] does not show everlasting vetchling as having been collected in Essex County, and the New England Wild Flower Society's on-line flora of New England[9] does not show it from Coos County in New Hampshire. This does not indicate that the non-native vine of disturbed areas has not been present in those counties, only that it has not been collected. It does suggest that it is not widespread in these two northernmost counties.

Wetland Functions

We see no reason to alter our Year 1, 2 and 3 assessments stating that the wetland's previously documented functions have not been substantially altered. Four growing seasons post-restoration the functional capacities for water storage, surface

[8] Gilman, A.V. 2015. New Flora of Vermont. The New York Botanical Garden Press, Bronx, NY.
[9] New England Wild Flower Society. GoBotany. https://gobotany.newenglandwild.org/species/lathyrus/latifolius/?pile=alternate-remaining-non-monocots Accessed 15 November 2016.

and ground water protection, and erosion control are very close to the initial levels. Changes continue to be minor and related to 1) the structural changes to vegetation, and 2) the limited areas of soil compaction and mounding in the project area. Additionally, diminishment of wildlife habitat functionality was also minor and was related to changes in vegetation composition and structure. As stated above, since very few seedlings of trees were found in the restored area, we expect recovery to forest habitat to be relatively slow. The presence of black elderberry, sprouting white and black ash stumps, and new in 2016 red-osier dogwood, are good signs for the recovery of some woody canopy within one to two decades. Red-osier dogwood was planted both in the upland slope of the access road and in the rip-rapped slope; it now appears to be spreading into the restoration area. Additional positive early results show that non-native woodies are not moving into the restoration area, but remain at the edge.

APPENDIX 1.

Photographic Documentation

Figure 4. Overview with wetter area (Plot 1) in foreground and drier area (Plot 2) in background. Tree line shows general condition of the whole site prior to clearing of the floodplain forest. Prominent plants in flower are blue vervain and smooth goldenrod; speckled alder is shown sprouting at the edge of the restored area.

Figure 5. Vegetation of Plot 1 in fourth year of restoration. Several-year-old silver maple seedling, with common arrowhead, sedge leaves and small spotted touch-me-not.

Figure 6. Vegetation of Plot 1 fourth year of restoration, showing dominant plant cover of common arrowhead and fringed willow-herb in the foreground, with tall stems of blue vervain in upper left.

Figure 7. Vegetation of Plot 1 fourth year of restoration. Photo shows old tire rut now vegetated with creeping yellow-loosestrife, a variety of sedges, common arrowhead, and small spotted touch-me-not.

Figure 8. Vegetation of Plot 2 in fourth year of restoration. Smooth goldenrod is the dominant plant; also showing are Virginia virgin's-bower, blue vervain, crested wood fern and tall meadow-rue.

Figure 9. Wiegand's wild rye and ostrich fern at edge of disturbed area. Directly behind the grass and ferns is engineered slope with smooth goldenrod, blue vervain and reed canary grass.

Figure 10. Rough avens with mature fruit.

Figure 11. Engineered area between Plot 2 and the river. Everlasting vetchling and reed canary grass co-dominate a portion of this area.