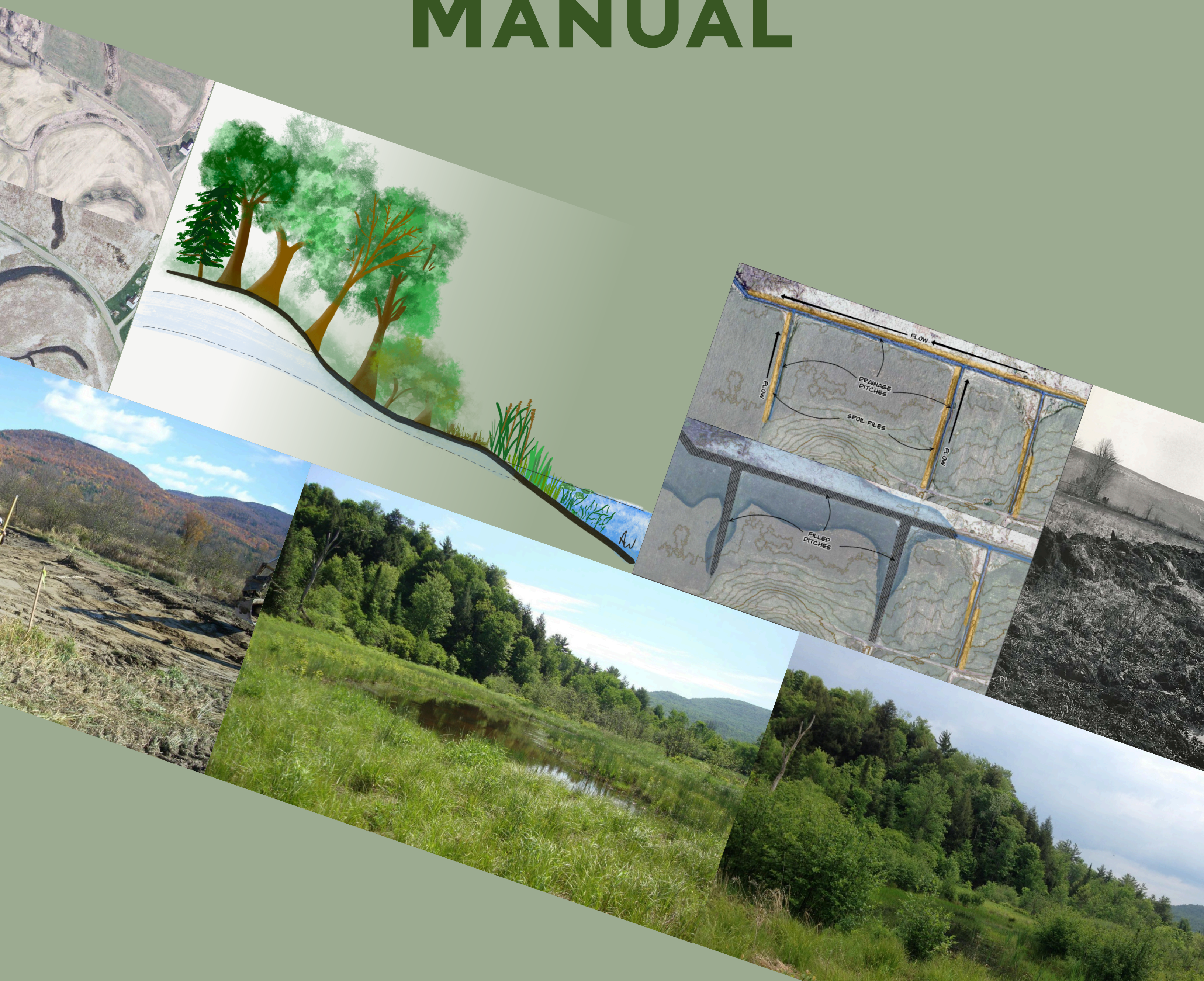
Vermont WETLAND Restoration Manual



Vermont Wetland Restoration Manual

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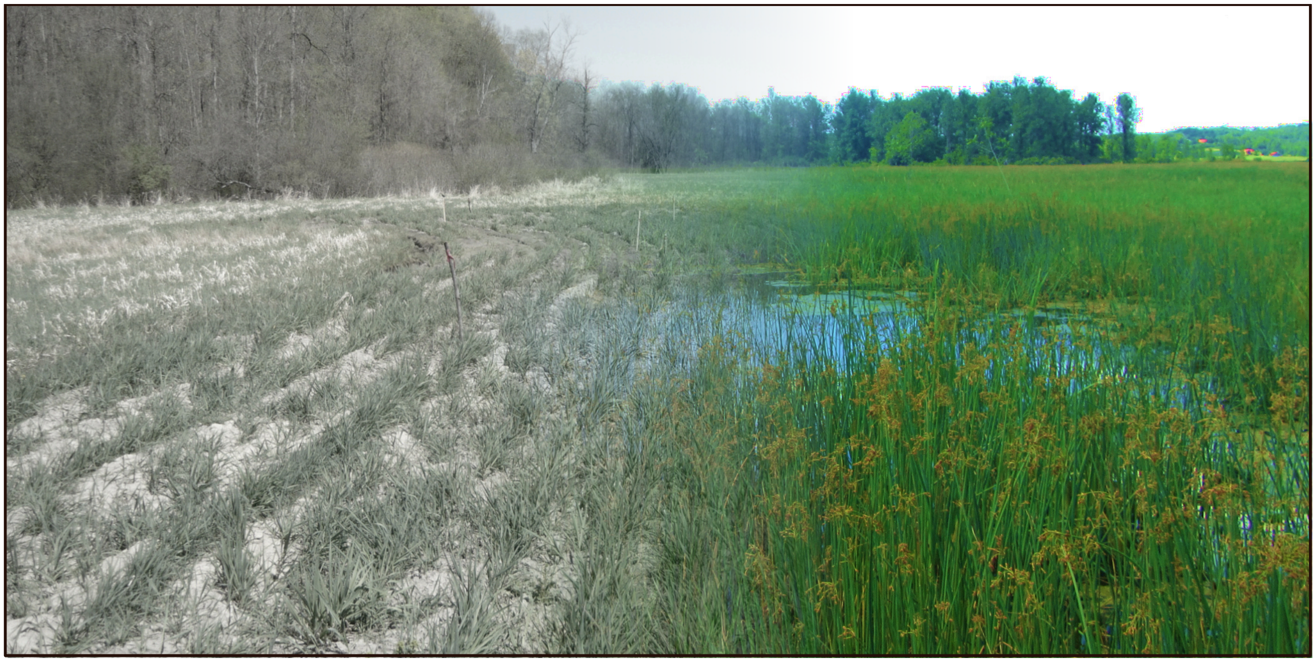


Chapter 1. Introduction

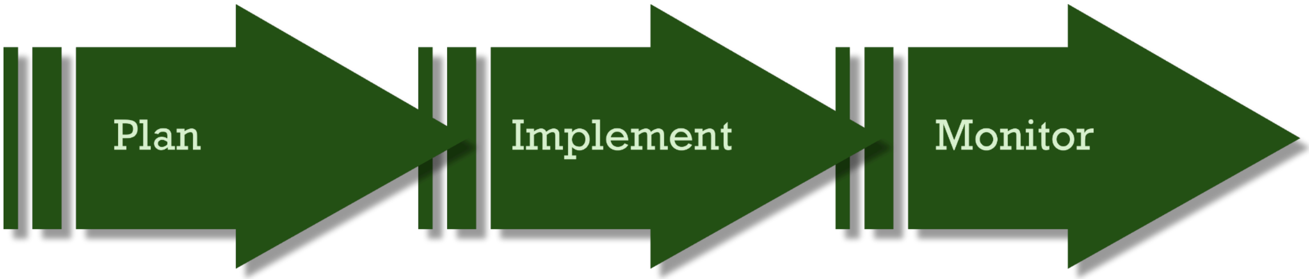
Goals of this Manual

This manual was written to provide a structure for understanding how to design and implement a successful voluntary wetland restoration project in Vermont. Following the recommendations found in this manual will also facilitate approval of restoration plans by the Vermont Department of Environmental Conservation Wetlands Program, as well as compliance with federal, state, and local regulations.

The manual covers everything from site selection and assessment to developing a plan and evaluating success. Enough information is provided in each section to convey the scope and purpose of the work involved, while also keeping the manual streamlined. This means that practitioners may need to look to other resources to supplement what is written here.

Wetland Restoration as an Allowed Use

The Vermont Wetland Rules serve to identify and protect significant wetlands, as well as their values and functions. These rules prohibit activity in many wetlands and their buffers unless the activity is an allowed use or authorized by a permit. Wetland restoration projects are considered an allowed use if they are enacted in accordance with a plan approved by the Vermont Wetlands Program.

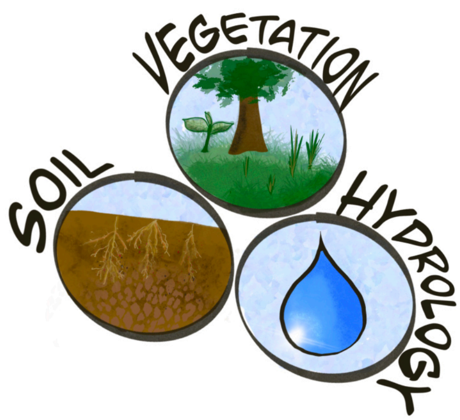


What are Wetlands, and Why Restore Them?

DEFINITION Wetlands are places that are flooded or saturated with water for enough time during the growing season to support plants that are adapted to saturated soils. Some places, such as cattail marshes or alder swamps, are easily recognizable as wetlands. Others, like wet meadows or small woodlands seeps, may be less obvious, but no less important.

Wetland ecologists in Vermont follow the Army Corps of Engineers Wetland Delineation Manual for mapping the boundary of a wetland, which generally requires that the following three criteria are met to confirm historic and ongoing wetland conditions:

1. Hydrophytic vegetation (plants adapted to saturated soils) is prevalent.
2. Hydric soils (soils developed in saturated conditions) are present.
3. Wetland hydrology thresholds are met. This means that the area is either flooded or saturated for at least 5% of the growing season in most years, which is about 14 days. Wetland hydrology is usually inferred from indicators rather than directly monitored.



During the growing season, microorganisms in the soil use oxygen to access the energy they need to live. When soils are saturated oxygen is less accessible, and so the microbes use up most of what is available. Only certain plants can tolerate and thrive in these anoxic conditions, which is why the presence of hydrophytic vegetation is a key component to identifying a wetland. The anoxic conditions also lead to distinct microbial processes and chemical reactions in the soil, which produce the characteristics of hydric soils. Examples of hydric soil characteristics include the presence of peat or muck (which form because microbes degrade dead plant material more slowly in anoxic conditions), or the presence of rusty mottling (a.k.a. redoximorphic features) in the soil (which forms from dissolved iron reacting to repeated wetting and drying).

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> 10 V.S.A. § 902 (5) states that wetlands are "those areas of the State that are inundated by surface or groundwater with a frequency sufficient to support significant vegetation or aquatic life that depend on saturated or seasonally saturated soil conditions for growth and reproduction. Such areas include marshes, swamps, sloughs, potholes, fens, river and lake overflows, mud flats, bogs, and ponds, but excluding such areas as grow food or crops in connection with farming activities."

Wetland Types

Hydrology, nutrient availability, soil formation, water and ice movement, and climate all work together to shape unique wetland communities. In Vermont, the book Wetland, Woodland, Wildland identifies over 40 wetland natural community types, which are organized into two broad categories.

Forested Wetlands

Forested wetlands contain trees with at least 25% canopy cover and are the most abundant type of wetland in Vermont. Forested wetlands are broken into four groups, each of which contain multiple natural communities:

- Floodplain Forests
- Hardwood Swamps
- Softwood Swamps
- Seeps and Vernal Pools

Open and Shrub Wetlands

In these wetlands, trees are sparse, with less than 25% canopy cover. Open and shrub wetlands are broken into four groups, each of which contain multiple natural communities:

- Open Peatlands
- Marshes and Sedge Meadows
- Wet Shores
- Shrub Swamps

Functions and Values

The English language contains many metaphors that reference wetlands, and most seem to convey a sense of frustration or worthlessness. A person feeling overwhelmed might say they're swamped, bogged down, or mired in some problem. And who wants to be a stick in the mud? The impediments wetlands present to cultivation and development explain these phrases, and also explain why more than 35% of the original wetlands in Vermont have been drained and lost.

But these sloughs, backwaters, swamps, and generally soggy places provide immensely important functions and values, all of which flow downstream. Wetlands are places that hold onto water and slow its travel. This reduces erosion, removes pollutants like phosphorous and nitrogen, minimizes flood damage, and recharges groundwater. Forested wetlands produce cool water, which is critical for many species of fish. Wetlands also provide a stage for water-requiring plants and animals to live out their lives, which increases biodiversity and the health of natural places. In addition, because saturated soils can become depleted of oxygen, the microbial decomposition of organic material (the carbon-rich remains of plants and animals) in wetlands is often slowed, which stores carbon in the soil instead of releasing it into the atmosphere.

> **i** Carbon Storage: Wetlands hold 20-30% of the Earth's soil carbon while only occupying 5-8% of its land surface (Nahlik & Fennessy, 2016).

Other Functions and Values of Wetlands:

- Education and research in natural sciences
- Recreational value and economic benefit
- Open space and aesthetics

Restoring Natural Ecological Processes

Restoration projects will vary widely in their goals, practices, and level of effort. However, all projects should generally strive to restore self-sustaining natural systems requiring minimal ongoing management. Along with other practices, this should be accomplished by recreating historic topography and hydrology, which sets the course for appropriate natural community reestablishment over time. When sites cannot be restored to their historic state, practitioners should create the best restoration possible within the limits of their situation.

> **!** This guide describes restoring degraded or former wetlands. We do not address or promote wetland creation, which involves converting a place that was never wetland to wetland.

Chapter 2. Background Assessment and Planning

Wetland restoration efforts will be more successful if time is spent to understand your goals and site early in the planning process. Creating a restoration plan that responds to what you learn will help ensure that you have the proper materials, personnel, machinery, and permits to maximize the quality and scope of your work within the limited budget and timeframe of your project. Additionally, in most cases, a restoration plan is required to be submitted to and approved by the Vermont Wetlands Program before work can begin. This chapter walks through the key steps involved in deciding on a project purpose, choosing a project location, assessing a site, and developing a restoration plan. A Site Assessment Worksheet is included to structure and guide the selection and assessment of your project site.

Site Selection

Project Purpose

The first step in creating a restoration plan is deciding on the main purpose of your project. If you already have a project site, having a clearly articulated purpose will help you decide which areas to treat and how to treat them. If you have not chosen a site yet, your project purpose can help you narrow down a long list of possibilities into a shortlist of sites with high impact.

The unifying goal of wetland restoration projects promoted in this guide is to restore degraded wetlands into self-sustaining natural systems, preferably as closely as possible to their pre-disturbance condition. When choosing sites and creating a plan, it is helpful to be specific in what you want to accomplish. Try choosing one or two primary goals for your project purpose, understanding that there may also be many secondary goals. It is also helpful to specify the geographic extent of possible project locations (such as within property, town, or watershed boundaries), as well as the general strategy for achieving your primary goals.

Primary and Secondary Goal Examples

- Improve water quality.
- Reduce erosion.
- Slow down and infiltrate stormwater.
- Increase groundwater recharge.
- Reduce downstream flood severity.
- Restore a diversity of wetland plant species.
- Expand wildlife habitat for wetland dependent species.
- Enhance fisheries.
- Reconnect floodplains.
- Restore habitat connectivity for wetland dependent animal species (e.g., amphibians and turtles).
- Restore habitat connectivity for a broad range of species (e.g., large terrestrial species).

Project Purpose Example

Reduce downstream flood severity and improve habitat connectivity for a broad range of species within town boundaries by reconnecting floodplains and revegetating wetlands and riparian buffers.

Site Selection Examples

The Lake Champlain Basin Wetland Restoration Plan identified improving water quality through nonpoint source phosphorous removal as its main purpose. This clear goal allowed planners to identify 200 top priority sites within the 2.9 million acres of Vermont's Lake Champlain basin.

Site selection can also be important at a much smaller scale. For example, a project team could search for sites within a farm boundary that contain actively eroding soils to reduce downstream erosion and improve water quality.

Desktop Review

Once you understand your project purpose you can move on to a desktop review. This is the stage where you take your project purpose and search for and review candidate project locations. The ANR Natural Resources Atlas online mapping tool is a great place to begin and may be able to provide much of the information you need for a thorough desktop review. In other cases, the data layers available won't be complete or up to date in your project area. Do your best and take note of what you need to assess or confirm in the field.

ANR Atlas Helpful Layers

DEFINITION

Reference Site: A nearby undisturbed natural area that has similar environmental conditions (soils, hydrology, and landscape position) to a degraded site. A reference site can provide target microtopography, hydrology, vegetation, and natural communities for a restoration project.

Resources: The book Wetland, Woodland, Wildland is a helpful resource for determining wetland community types in Vermont. The Vermont Fish & Wildlife Department also provides free online natural community fact sheets for each of Vermont's wetland community types.

Key site questions to answer are:

Wetland Presence	Do any data layers identify potential wetlands or flooding?
	Are any hydric soils mapped?
	Are there visual indicators in the aerial imagery of saturated soils or standing water?
	Are there any topographic indicators of saturated soil or standing water?
Characteristics	What are the current wetland types?
	Where are their approximate boundaries?
Alterations	How have the natural ecological processes been altered? Examples include ditching, impoundment, tile draining, fill, vegetation removal, grading, and fragmentation.
Context	What are the upstream and downstream land uses and ecosystem types?
	What are the nearby important habitat features?
	Where are the available water sources (e.g., groundwater and streams)?
	Are there any nearby intact wetlands that could serve as a reference site?

Identify Site Selection Challenges

Before moving ahead with a selected site, it is important to understand the challenges that may influence, or even prohibit, your restoration plans. Challenges to consider include:

> Professional wetland delineation will likely be needed if your work triggers State or federal permitting (see Chapter 4).

- ☐ Buildings, dams, or other structures
- ☐ Utilities, right-of-ways, easements, or other property issues
- ☐ Landowner willingness
- ☐ Incompatible adjacent land uses (either uses that could affect your project area or proposed project activities like restoring hydrology that could affect neighboring properties)
- ☐ Community use and expectations
- ☐ Presence of non-native invasive species (NNIS)
- ☐ Additional permitting requirements (see Chapter 4)
- ☐ Funding requirements (if outside funding is used)

How might the identified challenges affect the quality or scope of your restoration work? Does your selected site still seem like a good candidate for restoration, or should you search for another location?

Site Assessment

Now it is time to assess your site in greater detail to confirm or correct your restoration expectations, and to fill in knowledge gaps. Start with a general understanding of the site, and then narrow into the details as your plan develops. Depending on your project, you may need to move back and forth between desktop assessment, field assessment, and planning.

> Supplemental assessment: If you are interested in producing a repeatable and quantifiable metric of wetland quality, the Vermont Rapid Assessment Method for Wetlands (VRAM, see Chapter 5) could be a worthwhile addition to your initial site assessment.

Overview

General Conditions and Project Scope

- What are the current conditions of the site? Is it in agriculture?
- What factors led to the degradation or loss of the wetland?
- Where are the boundaries of the wetland on site?
- What was the likely extent of the wetland before disturbance?
- Identify preliminary boundaries of the restoration project. You may modify these as you learn more.

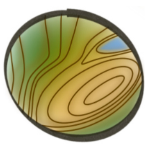
Landowner Knowledge

If you are not the landowner, it can be helpful to reach out and ask for their knowledge about the project area. Landowners likely know more about the project site than you can gather on your own. Keep them in mind as you continue your site assessment.

- What's the land use history of the site?
- How do they use or manage the area now, and what are their plans for the future?

Detailed Assessment

Topography



At a landscape scale, topography affects large drainage patterns, ambient temperature, and a site's exposure to sun and wind. On a smaller scale, microtopography affects how water moves across the surface of the ground, and the specific conditions that a plant germinates and grows in. Try using the ANR Atlas LiDAR Hillshade basemap and the contour layers (topographic lines).

- Where are there ridges, slopes, benches, basins, or flats?
- How would you expect water to flow through the landscape, and where would you expect it to accumulate under natural conditions?
- Where are there stream channels and ditches?
- What does the microtopography look like? Are there rough areas that have pit and mound formations? Are there areas that have been smoothed or leveled?
- How does microtopography differ from expected natural conditions or a reference site?

Landscape Position

The position a wetland occupies on the landscape impacts its functions and will influence your restoration goals and practices.

- What is the landscape position of the wetland? Is it the headwaters of a stream, a floodplain, a depression, or a seep? Something else?

Soils

Soils hold clues about the history and natural processes of a site, even when summer weather appears to dry up some wetlands. Dig a few shallow holes (10-20 inches) with a hand auger or shovel in wetland areas, upland areas, and their interface. Identify:

- Soil texture (mucky, loamy, or sandy; optional: color)
- Redoximorphic features (rusty mottling)
- Saturation
- Water table depth
- Sediment deposition
- Compaction or other disturbance
- Location and boundaries of hydric soils

Field Equipment List

- •Hand Auger
- •Shovel
- •Tape Measure
- •Camera
- •GPS
- •Data Forms
- •Base Maps

Hydrology

Hydrology refers to the location, duration, and movement of water, both in saturated soils and visible surface water. Assess your site's hydrology to:

- Identify existing water sources (e.g. streams, ditches, lakes or rivers, groundwater discharge, springs, and seeps), as well as how water moves out of the wetland.
- Identify the existing hydrologic regime (seasonal or semi-permanent saturation, flooding).
- Locate features that disrupt natural hydrology (e.g. ditches, tile drains, berms, and fill).
- Understand how current hydrology differs from expected natural conditions or a reference site.

Vegetation

The plants on any given site are influenced by topography, soil conditions, water regime, seed sources, and disturbance events. They in turn influence the rest of the food web. Assess vegetation in the wetland restoration and adjoining upland areas. Note:

- Strata present (tree, shrub, and herbaceous)
- Native plant species
- Natural communities
- Non-native invasive species
- Native plant species and natural communities in reference site

Wildlife

Wildlife may be difficult to observe directly, but often tracks and signs abound. Note:

- Expected wildlife for a historic or reference site
- Tracks, signs, and wildlife observations
- Wildlife habitat features (woody debris, snags, brush, mast trees, vernal pools, pollinator plants, riparian forest, and open water)
- Wildlife habitat features lacking

Feasibility Assessment

Use the information you have gathered to draft a concept restoration plan and make a feasibility assessment. Here are some questions to help guide you.

- Is wetland restoration needed for this site?
- What are the major challenges and project constraints?
- Which aspects of the site (topography, microtopography, soils, hydrology, vegetation, and wildlife) need restoration?

Describe the target conditions and the practices needed to get there (see Chapter 3).

- What are the minimum actions required to restore an acceptable amount of wetland function? Make these the primary focus of your project.
- What additional permitting requirements are likely to affect your project (see Chapter 4)?
- Is the project possible or practical? Does it need to be redefined?

If your project is complex, resource intensive, or if you have questions, this is a good moment to contact your Vermont Wetlands Program District Wetland Ecologist. Send them a concept plan (see Submitting a Restoration Plan below) and give them an opportunity to flag considerations or concerns before you move forward with the full plan.

Site Assessment Worksheet

SITE SELECTION	**Project Purpose**	Primary Goals *(choose one or two)*	
		Secondary Goals *(choose a few)*	
		Geographic Extent	
		General Strategy	
		Project Purpose *(primary goals and how you will achieve them)*	
	Desktop Review	Are there, or were there ever, wetlands here? What evidence suggests this?	
		What are the current wetland types, and where are their approximate boundaries?	
		How have the natural ecological processes been altered?	
		What is the surrounding landscape context?	
	Identify Challenges	Challenges *(structures, utilities, adjacent land uses, NNIS)*	
		How might the identified challenges affect the quality or scope of your work?	
		Does your selected site still seem like a good candidate for restoration, or should you search for another location?	
	Site Selection Notes		

Site Assessment Worksheet *(cont.)*

SITE ASSESSMENT	General Conditions	Current conditions	
		What factors led to the degradation or loss of the wetland?	
		What was the likely extent of wetland before disturbance? *(sketch or map below)*	
		What are the preliminary boundaries of the restoration project? *(sketch or map below)*	
	Landowner Knowledge	Are there, or were there ever, wetlands here? What evidence suggests this?	
		What is the land use history of the site?	
		How do they use or manage the area now, and what are their plans for the future?	
	Site Overview Sketch		

Site Assessment Worksheet *(cont.)*

SITE ASSESSMENT	Topography & Landscape Position	Identify and describe the major topographic features expected to impact the restoration project	
		What is the slope of the site? *(flat, moderate, steep)*	
		Identify and describe areas of intact and modified microtopography	
		How does microtopography differ from expected natural conditions or a reference site? *(e.g., cultivated, compacted, graded)*	
		Landscape position of the wetland? *(headwaters, floodplain, depression, seep etc.)*	
	Soils	Describe soil texture in wetland, transition zone, and upland. *(sand, loam, clay, muck, peat, etc.)*	
		Are there redoximorphic features present? Note the depth from the surface and % of soil	
		Other relevant soil characteristics	
	Hydrology	Existing water sources	
		Existing hydrologic regime *(seasonal or semi-permanent saturation, flooding, etc.)*	
		Features that disrupt natural hydrology *(e.g., ditches, tile drains, berms, fill)*	
		Expected hydrology under normal condition	
	Vegetation	Strata present *(tree, shrub, herbaceous)*	
		Native plant species and relative abundance	
		Natural communities	
		Non-native invasive species	
		Native plant species and natural communities in reference site	

Site Assessment Worksheet *(cont.)*

SITE ASSESSMENT	Wildlife	Expected wildlife for a historic or reference site	
		Tracks, signs, and wildlife observations	
		Wildlife habitat features *(woody debris, snags, brush, mast trees, vernal pools, pollinator plants, riparian forest, open water, etc.)*	
		Wildlife habitat features lacking	

FEASIBILITY ASSESSMENT	Is restoration needed for this site?	
	What are the major challenges and project constraints?	
	Which aspects of the site need restoration? *(topography, microtopography, soils, hydrology, vegetation, habitat)*	
	Describe the target conditions and the practices needed to get there *(see Chapter 3)*	
	What are the minimum actions required to restore an acceptable amount of wetland function?	
	What additional permitting requirements are likely to affect your project? *(see Chapter 4)*	
	Is the project possible or practical? Does it need to be redefined?	

COMMENTS	

Developing a Restoration Plan

Once you have confirmed that the project is practical and worthwhile, it is time to put together a restoration plan. Once complete, this plan needs to be submitted to your Vermont Wetlands Program District Wetland Ecologist, and their approval is required before work can begin.

Choosing the Right Amount of Complexity

Wetland restoration projects vary widely in their level of planning and difficulty. Some projects will only require passive treatment or a little replanting. Others may involve professional assistance (private wetland consultants or environmental engineers), multiple restoration practices, and heavy machinery. Here are a few guidelines to help identify the appropriate scope of work for your site.

Guardrails:

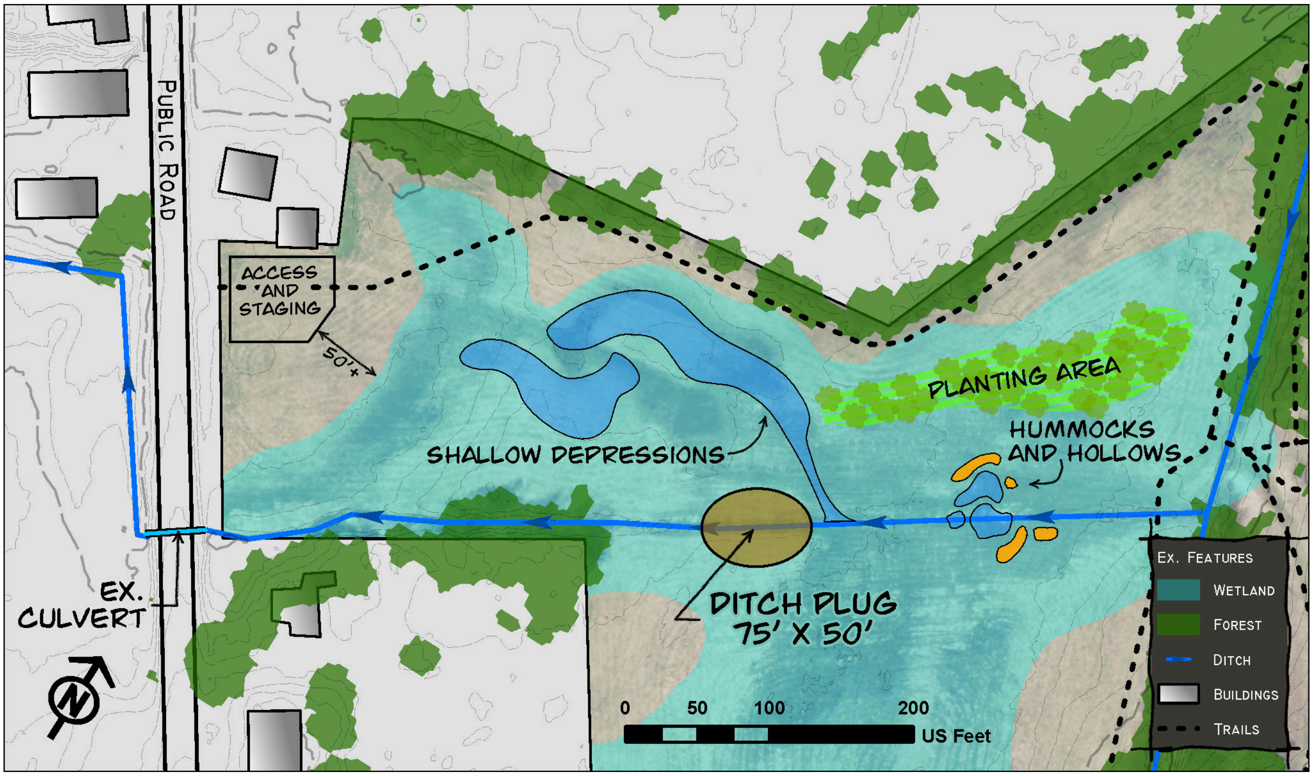
Keep your plans simple enough as to not require hydraulic analysis, but refrain from altering the hydrology of surrounding properties.

Keep it Simple, Don't Over-Engineer

It is better to do a simple job well than risk implementing a complex job poorly, especially if you are new to wetland restoration.

Reasons to Stop or Get Help:

- If a project is likely to affect other properties.
- If your plan includes hydrologic manipulations such as ditch plugs, tile drain removal, or surface water rerouting.
- If a site contains a lot of non-native invasive species. Avoid the worst of these sites.
- If a site contains sloped wetlands.
- If a plan requires permitting, such as when: constructing new access roads or trails, stockpiling soil in a wetland buffer, adding rock fill, creating a new discharge area, or installing beaver dam analogs and post-assisted log structures (see Chapter 4).



Example Restoration Plan-existing conditions and proposed practices

Plan Components

Outline Project Area

Identify wetland areas to be restored or impacted by restoration work. Identify nearby sensitive land uses, give them at least a 25-foot buffer, and ensure the project area doesn't encroach. If your restoration practices trigger additional permitting (see Chapter 3 and Chapter 4) you will likely need to hire a qualified professional to perform wetland delineations.

Map and Plan Restoration Practices

Identify which restoration practices you will be implementing (see Chapter 3), and where each practice will take place. Plan your materials, personnel, and equipment needs for each location.

Identify Work Zones Around the Restoration Area

Identify where equipment and material will be stored around the restoration area, as well as site access. Work zones within a wetland buffer will likely require permitting.

Outline Permitting Requirements

Chapter 4 provides an overview of potential permitting requirements. We've also flagged likely requirements associated with each restoration practice in Chapter 3. Using your site assessment, planned restoration practices, and identified work zones, outline your anticipated permitting requirements.

Project Schedule

Working backwards from hard deadlines, plan when each stage of the restoration project will take place. Take care to create a sensible order of operations such as planting after heavy machinery work and hydraulic manipulations are complete. Make sure to reserve plants, materials, and machinery well in advance.

Monitoring and Evaluating Success

Include a list of measurable objectives in your restoration plan that meet your project purpose (see Chapter 5). The metrics you monitor will depend on your goals, the restoration practices you implement, and any reporting requirements you may have. Example metrics include non-native invasive species (NNIS) monitoring, the Vermont Rapid Assessment Method, vegetation monitoring, plant survivability, etc. When possible, give each metric a timeline. Make assessments before restoration practices take place to establish a baseline, then follow up afterwards according to your timelines. Comparing metrics before and after will allow you to evaluate the success of your treatments.

Adaptive Management

Most restoration projects will require more than a single intervention (see Chapter 5). Make sure to plan for this adaptive management in your budget and timelines.

Submitting A Restoration Plan

Once your restoration plan is complete, visit the Vermont Department of Environmental Conservation website and navigate to the Wetlands Inquiry Portal. This portal will allow you to submit a request for project review and connect you with your District Wetland Ecologist. After submitting the form, you should email your wetland restoration plan directly to your District Wetland Ecologist. For more complicated projects, especially those involving permitting, expect a 3-6 month review period. Once your plan is approved, and you have obtained any required permits, you can begin restoration activities.

1. Request Project Review (*Wetland Inquiry Portal*)
2. Email Plan to District Wetland Ecologist
3. Plan Review (*may take up to 6 months*)
4. Plan Approval
5. Permitting, if required
6. Implement Plan

Chapter 3. Wetland Restoration Practices

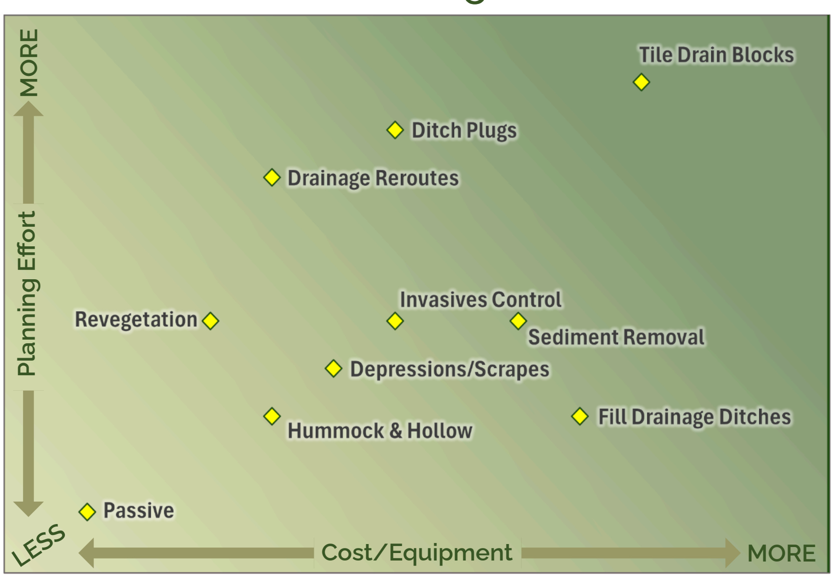
Healthy wetland ecosystems are resilient and self-sustaining, whereas degraded wetlands respond poorly to environmental stress. Wetland restoration strives to reestablish healthy conditions in degraded systems by implementing design practices that promote natural structures, composition, and processes.

Restoration practices can be divided into passive and active practices. Passive wetland restoration involves removing the source of wetland degradation without otherwise intervening. In some cases, this is all that is needed for successful restoration. Active wetland restoration involves physical onsite intervention and is appropriate when simply removing the source of degradation is not sufficient for recovery.

This chapter presents a selection of common restoration practices recognized by regulatory and conservation agencies in Vermont. These practices rely on straightforward, low risk methods and natural materials. Each section provides pre-construction planning and construction sequencing procedures for a particular restoration practice, along with clear details and specifications for implementation.

The chart below provides an estimated range of planning effort and cost for each primary practice on a scale of low, medium and high. In general, passive practices and revegetation require the least amount of planning effort and cost. Hydrologic manipulations, including ditch plugs and tile drain removal, involve the most pre-planning and expense. Practices can be used individually or in combination depending on the source and degree of impact, as well as the available physical and financial resources.

Cost/Planning Matrix



Depending on site conditions and desired outcomes, a wetland restoration project may only use one practice. In other cases, multiple practices may be employed at a single site. Combining practices can increase the time required for planning and implementation, but it can also lead to a more diverse and higher functioning wetland ecosystem. Strategically combining complementary practices (such as those that require excavating soil and depositing soil) can lead to significant cost savings.

Also included in this chapter are supplemental practices that may be appropriate components of a restoration plan, depending on the project. Supplementary practices include site stabilization procedures, woody material additions, beaver dam analogs, and conservation measures.

3.1 Passive Restoration

Wetland restoration projects vary in size, scope, and expense. There are many situations where taking a passive approach is all that is needed to restore a wetland. Passive restoration involves reducing or eliminating the sources of degradation and allowing the wetland time to recover naturally. This works when the restoration site still retains basic wetland characteristics and the source of degradation is an action that can be stopped (e.g. by removing grazing cattle, discontinuing mowing, etc.). Passive approaches are low cost and can often be implemented without a lot of pre-planning.

Passive Restoration

GOALS

Allow wetland condition to be restored by natural means

BENEFITS

Variable depending on the source of degradation: Improved water quality and improved biodiversity can be anticipated in most restoration projects

1. Identify degradation source
2. Demarcate project area limits
3. Remove source of degradation
4. Monitor for success

DEFINITIONS

Hydrology: The distribution and movement of water both above and below the ground.

Passive Restoration Examples

Natural revegetation: Mowing in wetlands results in reduced biodiversity and overall wetland function. Fertilizer applied to mowed fields diminishes water quality. Establishing no-mow zones (signs and maps can be helpful here) and discontinuing fertilizer management provides an opportunity for native wetland vegetation to reestablish and for improved water quality.

Abandon Management: Ditches in wetlands often fill with sediment resulting in periodic maintenance through dredging. Discontinuing ditch maintenance can over time result in the natural filling of the ditch and reestablishment of wetland hydrology.

Exclusion of Livestock: Cows, horses, sheep, and goats can all have negative impacts on pastured wetlands. Removing and fencing off livestock from wetland areas provides an opportunity for native wetland vegetation to reestablish as well as removes a water quality contaminant source.

Examples of agriculturally impacted wetlands

Passive restoration

Challenges & Solutions

- Future impacts: Passive restoration can be vulnerable to reversal, especially if a property is sold to a new owner. Permanent protection of a wetland restoration area is possible through conservation easements and/or deed restrictions, which protect the land for future generations.

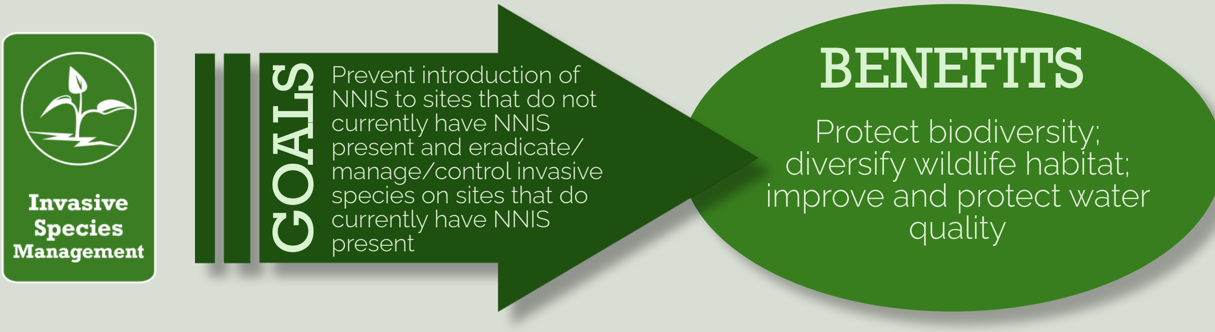
- NNIS: Since there is a preponderance of non-native invasive species (NNIS) on the landscape in some areas, there is a high likelihood of infestation, especially on open soils. Monitor for invasives that may introduce themselves, and make sure to remove them ASAP to prevent colonization.

> ! Abandoned management practices cannot be reestablished without additional permitting

Complementary Practices:

3.2 Invasive Species Control and Management

Native plant species help create a healthy ecosystem. Non-native invasive species (NNIS) compete with native species, often dominating the landscape and choking out native species. NNIS species are pervasive in our environment and represent a threat to most wetland restoration projects. On sites without NNIS present, prevention of NNIS establishment (especially when the soil is disturbed) is critical to maintain biodiversity in the restoration area. In cases where NNIS are currently established, control efforts may be integral to restoration success.



1. Collect Baseline Data
2. Develop NNIS Management Plan
3. Identify Disposal Location
4. Implement Control Measures
5. Monitor for Success

DEFINITIONS

Non-native invasive species (NNIS): Non-indigenous plants that threaten the diversity and survival of native species or the ecological stability of infested ecosystems.

Invasive Plants Common in Wetlands


Honeysuckles


Buckthorns


Japanese knotweed


Purple loosestrife


Multiflora rose


Common reed

Invasive Species Prevention
(The site does not have NNIS)

The key to prevention is frequent, ongoing monitoring and rapid response. Identify and remove NNIS before soil disturbance, and then at least once a year for at least 5 years, making sure to remove plants before they produce new seeds.

NNIS can become established from nearby populations via wildlife seed dispersal from rhizomes (underground stems), or from human introduction.

NNIS readily become established on areas of exposed soil.

Ask work crews to clean tools and boots and power-wash equipment before entering the restoration site.

Do not use soil from a location where NNIS are found if importing soil as part of the restoration.

Use certified weed-free straw to prevent accidental introduction of NNIS if using mulch for erosion prevention.

Invasive Species Resources

- Vermont Invasives Gallery
- Seek from iNaturalist
- Native Plant Trust GoBotany
- Vermont Agency of Natural Resources

Invasive Species Control
(The site has NNIS)

NNIS Baseline Mapping

- Identify the NNIS species on site and map distribution of each species.
- Describe the population including # of plants, density, and what % of the restoration area is covered by the plants.
- The baseline map will be used to gauge progress of the project.

NNIS Management Plan- *this plan should include:*

- Realistic goals for management of NNIS.
- Priorities for management, if more than one NNIS species is present.
- Specific control methods that will be used for each NNIS species present. These methods vary depending on the species, its abundance, and the goals of the restoration.
- Description of disposal methods for NNIS plant material. Removed plant material needs to be dealt with properly so that it does not resprout, often requiring it to be burned or bagged and disposed of in the trash.
- Plan for monitoring the success of any control actions. Keep notes about each treatment and track your progress.
- Timeline for all control and monitoring activities. Treatment often involves more than one year, and should be planned for.

Left: Cut & drip NNIS treatment, Katie Kain, USFWS
Right: Cut stump application, Ryan Creehan, USFWS

NNIS Species

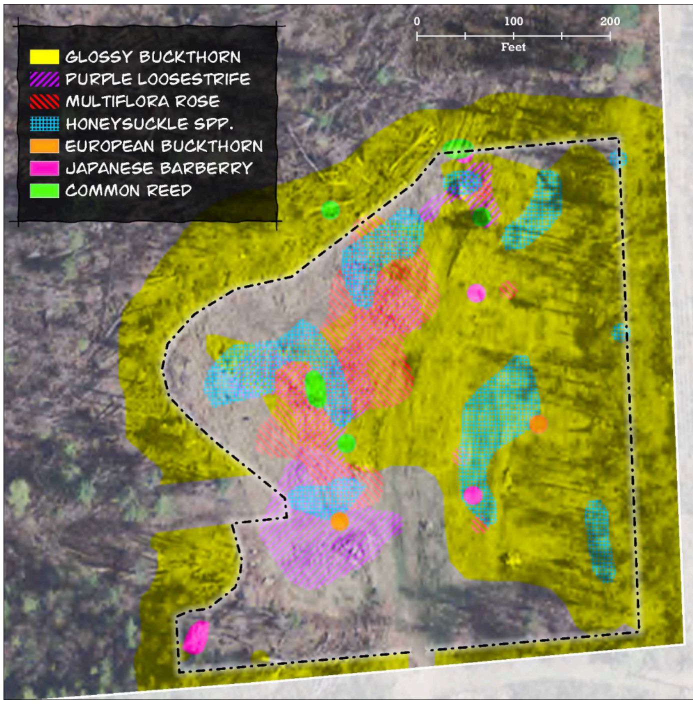
Group	Taxa	Common Name	NNIS List	Typical Habitat
Trees & Shrubs	*Frangula alnus*	Glossy buckthorn	Class B Noxious	Upland/Wetland
	Rhamnus cathartica	Common buckthorn	Class B Noxious	Upland
	Lonicera spp.	Honeysuckle	Class B Noxious	Upland
	Berberis spp.	Barberry	Class B Noxious	Upland
	Rosa multiflora	Multiflora rose	Watch List	Upland
Grasses	*Phalaris arundinacea*	Reed canary grass	Watch List	Wetland
	Phragmites australis	Common reed	Class B Noxious	Wetland
Herbs	*Lythrum salicaria*	Purple loosestrife	Class B Noxious	Wetland
	Alliaria petiolata	Garlic mustard	Class B Noxious	Upland/Wetland
	Hesperis matronalis	Dame's-rocket	Watch List	Upland
	Pastinaca sativa	Wild "poison" parsnip	Watch List	Upland
	Anthriscus sylvestris	Wild chervil	Watch List	Upland
	Fallopia japonica	Japanese knotweed	Class B Noxious	Upland/Wetland
	Aegopodium podagraria	Goutweed	Class B Noxious	Upland/Wetland
Vines	*Celastrus scandens*	Asiatic bittersweet	Class B Noxious	Upland

NNIS Control Methods

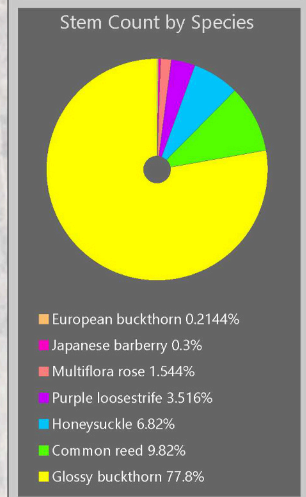
Method	Description	Advantages	Disadvantages	Typical Species
Hand-pulling	Manually pulling plants	Can be effective on small populations of certain species	Can be difficult to remove below-ground parts. Not realistic for mature woody individuals.	Garlic mustard, dame's rocket, seedlings of woody species
Uprooting with hand tools	Uprooting plants with shovels or "weed-wrenches"	Removes below-ground parts to prevent re-establishment; effective on small infestations of certain species	Labor-intensive; not realistic for large infestations; not realistic for mature woody individuals.	Young woody species such as honeysuckle, buckthorns, barberry, and multiflora rose
Mechanical uprooting	Uprooting plants with heavy machinery such as tractors or excavators	Removes below-ground parts to prevent re-establishment; effective on mature woody individuals	Can be expensive; danger of creating disturbed soil for NNIS establishment; not realistic for extensive infestations	Mature woody species such as honeysuckle, buckthorns, barberry, multiflora rose
Herbicide-Foliar spray	Broadcast spraying of herbicide	Can control larger infestations	Herbicide drift can create impacts on non-target organisms	Common reed, purple loosestrife, reed canary grass, buckthorns, honeysuckle, multiflora rose
Herbicide-Wipe	Manually applying herbicide to individual plants	More targeted than broadcast, reduces drift; can be used on moderate-sized infestations	Not realistic on large infestations	Common reed, purple loosestrife, buckthorns, honeysuckle
Herbicide-Cut Stump / Cut Drip	Cutting invasive plants and manually applying herbicide to plant stem or stump	More targeted than broadcast, reduces drift; can be used on moderate-sized infestations	Not realistic on large infestations	Buckthorns, honeysuckle, common reed, multiflora rose

Challenges and Solutions

- Effort and cost of management: NNIS control can be time consuming, costly, and has varying success. Weigh the costs and benefits of restoring a site that has NNIS present. Minimize long-term costs by treating NNIS immediately and managing new populations before they become established.



Species	Stem Count	Area (sqft)
European buckthorn	5	606 sf
Japanese barberry	7	1,618 sf
Common reed	229	2,150 sf
Honeysuckle	159	28,664 sf
Multiflora rose	36	29,978 sf
Purple loosestrife	82	30,939 sf
Glossy buckthorn	1814	215,812 sf

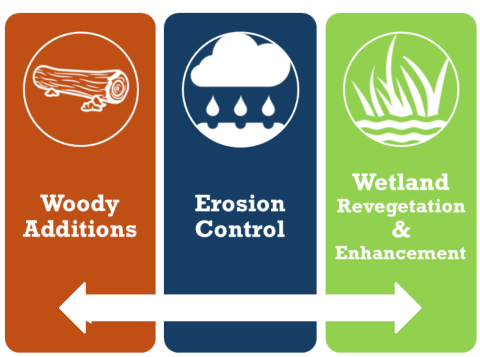


Sample Baseline NNIS Map

- Mowing and cutting: Simply cutting or mowing invasive species is generally not a recommended control method. Poorly timed cutting or mowing can often increase the growth of NNIS. Research recommended species-specific best management practices.
- Long-term management: Effective NNIS control is often only achieved by developing a long-term management plan that is specific to the site conditions, species present, and status of the NNIS populations. Multiple years of control are often required to manage NNIS species. Engaging experts for planning and control efforts is essential at sites with extensive NNIS.
- Likelihood of NNIS: Since there is a preponderance of NNIS on the landscape in some areas, there is a high likelihood of infestation, especially on open soils. If possible, choose sites with lower NNIS risk, and minimize opportunities for new infestations by minimizing soil disturbance.
- Established infestations: Ongoing monitoring and management of established infestations can be especially time consuming and costly. Research species-specific best management practices, and consider beginning to treat populations a year or more ahead of the main restoration work.
- Reed canary grass: This species can be an aggressive colonizer of wetlands and marginally wet fields throughout our region. Management can be a challenge since it can spread via underground stems (rhizomes) and form an abundant seedbank. The most common and reliable control method involves the use of herbicides and/or shading the grass out over time with woody species. On drier sites, a deep plow can turn the soil enough that other species can become established. Controlled burns (coordinated with local authorities) have also been used to kill or reduce the vigor of large stands of this grass. If reed canary grass is dominant on site, a phased approach to restoration may be required starting with reed canary grass control.

> You cannot apply herbicides on land that you do not own. Contact a Vermont Certified Invasive Plant Control Contractor.
>
> The Vermont Wetland Rules prohibit the use of herbicides in state-classified wetlands without approval by the Wetlands Program.

Complementary Practices:



3.3 Wetland Revegetation and Enhancement

Wetland revegetation and/or enhancement involves re-establishing site-appropriate natural community characteristics using plantings and/or natural revegetation. This is a low-tech practice that can use on-site native plant materials or a combination of on-site and locally sourced native plant materials. This practice complements most other wetland restoration strategies.

Wetland Revegetation & Enhancement

GOALS

Restore a diversity of plant species and communities

BENEFITS

Protect biodiversity; enhance wildlife habitat and connections; enhance fisheries; protect water quality; prevent erosion; infiltrate stormwater

1. Develop Planting Plan
2. Secure Materials
3. Implement & Install
4. Monitor for Success

DEFINITIONS

Natural Communities: Plants and animals growing and living together in landscapes characterized by specific soil, water, and climate conditions.*

Biodiversity: The abundance and mix of different plant and animal species in an area.

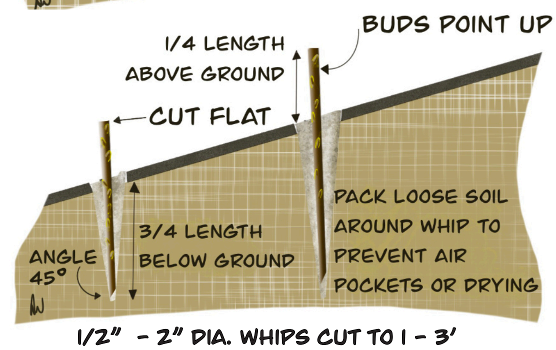
**See the book Wetland, Woodland, Wildland, or the Agency of Natural Resources' online Natural Community Fact Sheets.*

General Planting Guidelines

Tree and shrub plantings for wetland restorations are typically either container, bareroot, or live stakes/whips. Site preparation is critical to the success of plantings. One of the most common errors in tree planting is incorrectly planting the root ball by either digging the hole too deep or too shallow. Maintaining the integrity of the root ball is also important for keeping the roots from drying out.

- Container and Bareroot Plantings: Dig a hole twice as wide and to the depth of the root ball; loosen and detangle the roots a bit (for bareroot plants, make a cone of soil in the base of the hole to spread the roots around); fill soil in and tamp down with your fingers; mulch; and create a soil or mulch ring to hold water.

- Live Stakes/Whips: Harvest whips and install within 24 hours or store in cool, moist, shady conditions wrapped in burlap for up to 2 weeks. Soak stakes in a bucket for a day or two prior to planting. Plant stakes 1 to 3 feet apart.



Planting Plan Basic Components

Develop a planting plan well before work begins. The more detail included, the higher likelihood of success. Information collected in the site assessment (such as site topography, historic vegetation, existing native vegetation, existing invasive vegetation, and reference wetlands) will be used in developing the planting plan.

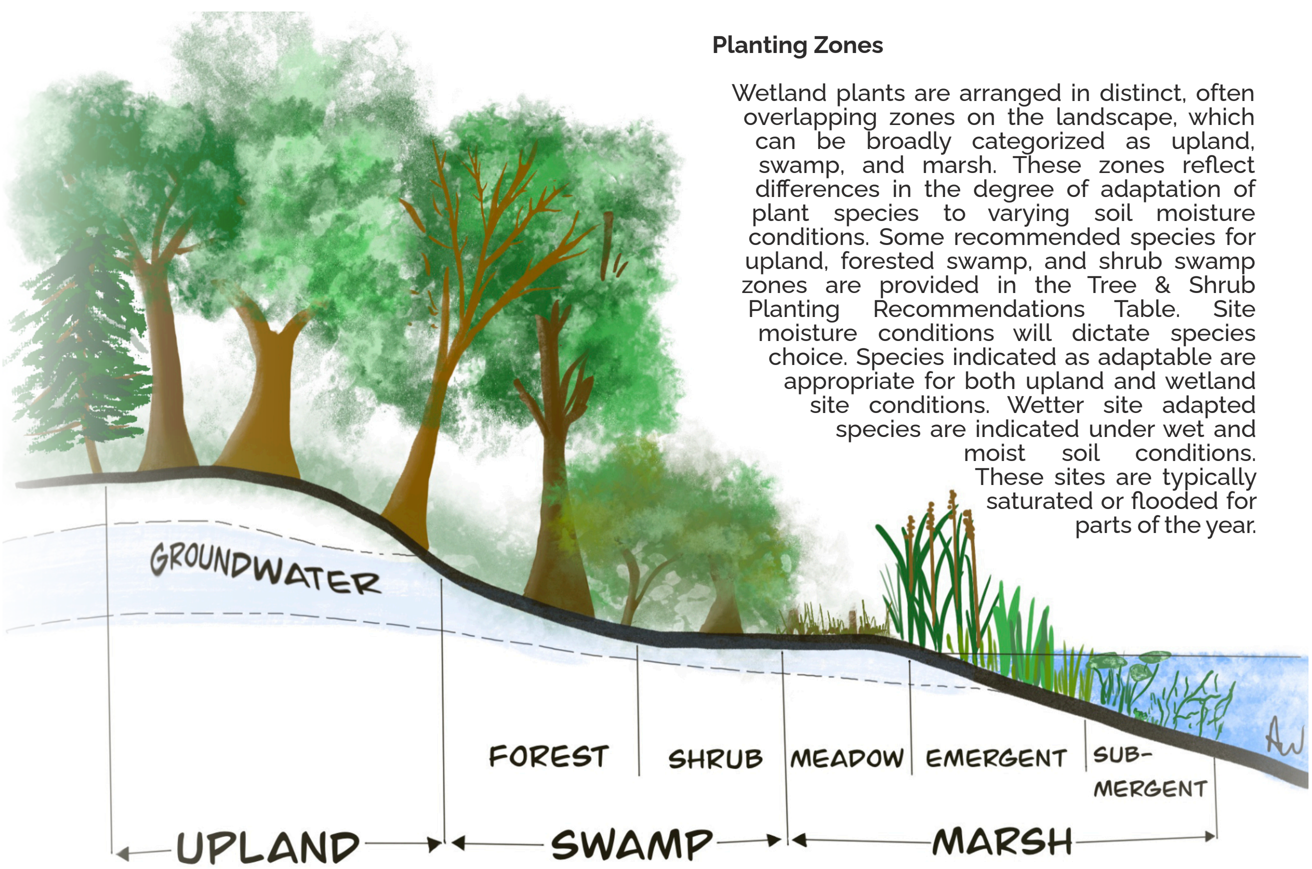
Planting Map	Identify planting zones to distinguish different vegetation communities and planting approaches, including areas to be left to naturally revegetate. Use site topography and hydrology to inform the design of planting zones (i.e., emergent marsh zone within low depressions prone to ponding water).
Plant List by Zone	Create a plant list for each planting zone. This can be done by assigning each planting zone a target natural community or vegetation mix based on expected pre-disturbance vegetation, existing vegetation, and reference wetland vegetation. Target communities can also be inferred from the ANR Atlas mapped soil series, which link to reports that indicate associated vegetation. The wetland indicator status of species can also be used to guide planting design. Show locations and quantities of plantings on the planting map. 500 woody stems per acre is a reasonable planting goal for shrub and tree dominated natural communities. Expect about 20-25% losses.
Planting Materials	Plants should be acquired from nurseries or growers who can provide locally sourced native trees and shrubs. Make sure to provide complete scientific names (genus, species, and subspecies, if appropriate) to avoid inadvertently introducing non-native plants. Check availability of desired plants early in the planning process, because nurseries often run out. Another option is to harvest native material on site (or locally from a willing landowner) to save on costs and promote local genetic diversity. This is appropriate for live stakes and seeds, but it is generally not a good idea to dig up and transplant whole plants.
Protection Strategies	Protect plantings from herbivores (deer, rodents, rabbits, cattle, etc.). Options include fencing the planted area, installing wire cages around planted seeds, roots, or shoots, and putting seedlings in plastic tubes.
Site Preparation	Describe site work to be done prior to planting. This will be informed by the other restoration practices you choose to implement. Strategies for weed control in post-agricultural areas can also include disk and/or cultivation (sometimes repeatedly) to remove seedlings and break up roots. Soil amendments can include weed-free compost or mulch (such as straw or bark).
Planting Schedule	Spring (April-June) or Fall (September-October) are the optimum times to plant. Phasing the planting plan is often encouraged, especially in situations where invasive species and/or weeds are being removed from the site. Time plantings to avoid disturbance from other restoration activities.
Maintenance	Provide a schedule for follow-up work including watering, weeding, and re-seeding/re-planting.
Seed Mixes	Purchase locally sourced native seed mixes and follow the manufacturer's instructions. Wetland seed mixes are typically applied at higher rates and not buried. Apply evenly to avoid bare spots where invasive species can colonize. If the restoration planting is being phased, use of cover crop seed may be necessary for site stabilization between phases.
Containerized and Bareroot Plantings	These plantings have well established root systems and are often used in combination with seeding. Spring planting is generally encouraged.
Live-Stakes/ Whips	Native willows and dogwoods are reliable candidates for live staking, and material can be purchased or harvested. Species happy to be a stick in the mud include pussy willow, black willow, red osier dogwood, silky dogwood, and gray dogwood. Harvest and plant during dormancy while the ground is not frozen (mid-October to mid-November and between mid-April and mid-May).

Tree & Shrub Planting Recommendations

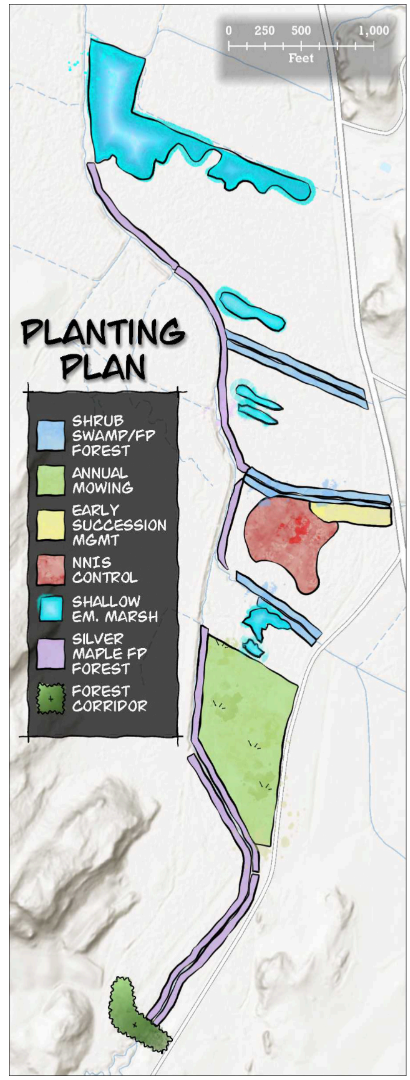
	Common Name	Taxa	Soil Conditions	Growth Rate	Mature Height
Trees	Green ash	*Fraxinus pennsylvanica*	moist	fast growing	50-70'
	N. white cedar	*Thuja occidentalis*	moist	slow growing	20-60'
	Black willow	*Salix nigra*	wet, moist	fast growing	25-40'
	Swamp white oak	*Quercus bicolor*	wet, moist	slow growing	50-70'
	Red maple	*Acer rubrum*	adaptable	fast growing	35-50'
	Eastern cottonwood	*Populus deltoides*	adaptable	fast growing	80-100'
	Silver maple	*Acer saccharinum*	adaptable	fast growing	90-120'
	Eastern hemlock	*Tsuga canadensis*	adaptable	slow growing	60-80'
	Balsam fir	*Abies balsamea*	adaptable	slow growing	35-60'
	Yellow birch	*Betula alleghaniensis*	adaptable	slow growing	40-60'
Shrubs	Buttonbush	*Cephelanthus occidentalis*	wet, moist	fast growing	3-8'
	Silky dogwood	*Cornus amomum*	wet, moist	fast growing	3-8'
	Red osier dogwood	*Cornus sericea*	wet, moist	fast growing	3-8'
	Sweetgale	*Myrica gale*	wet, moist	fast growing	2-6'
	Common winterberry	*Ilex verticillata*	wet, moist	slow growing	4-10'
	Black/Red elderberry	*Sambucus nigra,or S. racemosa*	adaptable	fast growing	4-8'
	Smooth arrowwood	*Viburnum dentatum*	adaptable	fast growing	6-10'
	Highbush blueberry	*Vaccinium corymbosum*	adaptable	slow growing	3-8'

Planting Zones

Wetland plants are arranged in distinct, often overlapping zones on the landscape, which can be broadly categorized as upland, swamp, and marsh. These zones reflect differences in the degree of adaptation of plant species to varying soil moisture conditions. Some recommended species for upland, forested swamp, and shrub swamp zones are provided in the Tree & Shrub Planting Recommendations Table. Site moisture conditions will dictate species choice. Species indicated as adaptable are appropriate for both upland and wetland site conditions. Wetter site adapted species are indicated under wet and moist soil conditions. These sites are typically saturated or flooded for parts of the year.



Bare root and container planting Katie Kain, USFWS

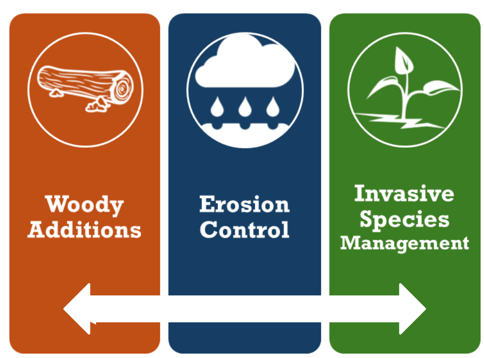


Challenges & Solutions

- Expense: The price of planting material ranges depending on size and volume. Seed mixes for wetland restoration can be expensive, but following the recommended application rates is important to successful establishment of vegetation. To minimize expenses, consider limiting your soil disturbance and subsequent replanting areas, harvesting or growing your own planting materials, or shopping around and contracting with a nursery ahead of time.
- NNIS: Since there is a preponderance of NNIS on the landscape in some areas, there is a high likelihood of infestation, especially on open soils. Ongoing monitoring and management are time consuming and can be costly, but vigilance can save time and resources in the end. Take care to avoid bringing in NNIS plants or seeds during site work and manage nearby populations before breaking ground.
- Herbivory: New tree and shrub plantings are often browsed by animals. Best to assume this will be a problem on your site and prepare in advance with protection strategies. Where heavy browse is anticipated, one strategy is to concentrate and fence plantings in clusters.
- Plant Mortality: 20-25% mortality for woody plantings in the first few years is not uncommon. Provided that enough plants survive and mature, this is OK, but minimize initial losses by choosing site appropriate plants, planting in spring or fall, and protecting against herbivory.
- Irrigation: If site and weather conditions require watering, it can be critical to the success of the project. Planting in already saturated conditions, or timing your planting efforts for the spring or fall most often eliminates the need for watering.

Don't forget to water! Make sure to water at planting time. Do not select non-native species or cultivars.

Complementary Practices:



3.4 Ditch Plugs

Ditches confine water, lower the water table, and route water quickly through wetlands. Wetlands with artificial drainage patterns have diminished capacity to slow down and store flood waters. Restoring a portion of a ditch to the natural ground level with an earthen wall can impound water, flood the ditch, and reconnect it with the surrounding wetland. These ditch plugs can be a quick and inexpensive hydrologic restoration practice for artificial drainageways but are not appropriate for stream channels, and care must be taken to ensure hydrology is not altered off site.

Ditch Plugs

GOALS

Disrupt altered drainage patterns to restore wetland hydrology; restore functions of flood storage and water quality

BENEFITS

Prevent erosion; slow down and infiltrate stormwater; improve water quality; provide flood resiliency

1. Determine Plug Material
2. Identify Plug Locations
3. Identify Staging and Access
4. Construct Plugs
5. Stabilize Site
6. Monitor for Success

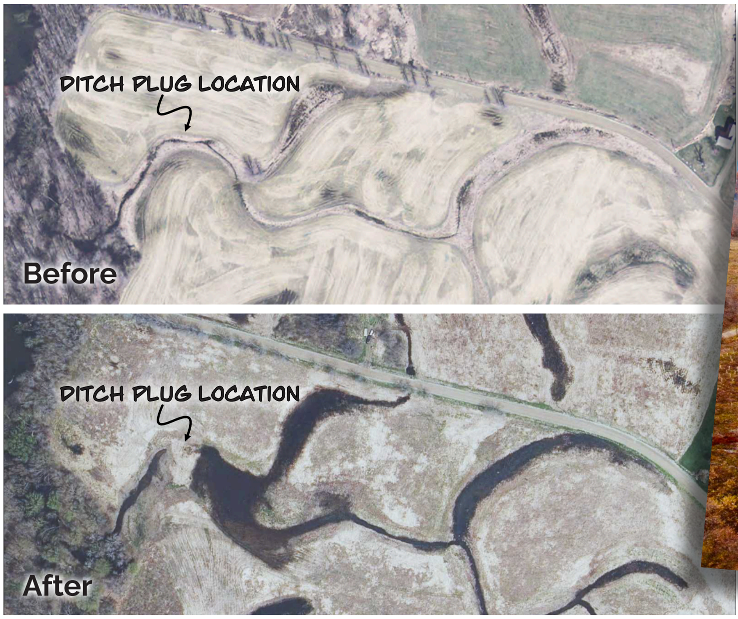
DEFINITIONS

Organic soil: Soils formed from sedimentation and primarily composed of organic matter (i.e., plant materials).

Mineral Soil: Soils formed from weathering of rocks which contains little organic matter.

Hydrology: The movement of water both on and below the ground surface.

Ditch Plug Example

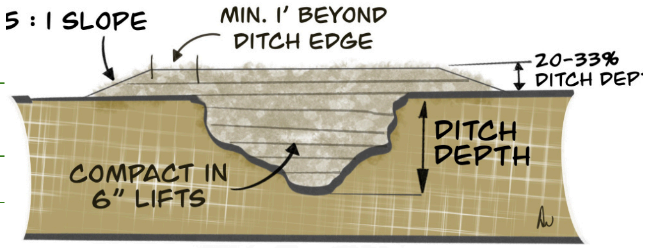


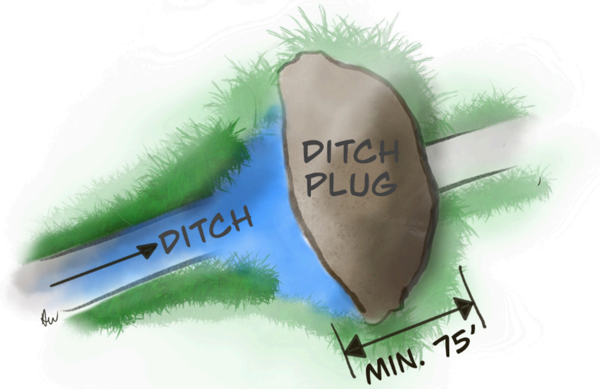
Ducks Unlimited VT ILF Program

Ditch Plug Specification

Ditch plugs are made from soil, which can be either sourced on site or imported from clean off site material.

Length	75-150+ feet
Side Slope	5 : 1
Material	Soil collected on-site, or imported
	Mineral Soil- i.e., clay soils
	Plug at least 75 feet of ditch
	Compact in lifts of 4-6 inches
	Rise 20% of ditch depth above surrounding ground
	Organic Soil- i.e., peat soils
	Plug at least 150 feet of ditch
	Compact in lifts of 4-6 inches
	Rise 33% of ditch depth above surrounding ground





Shorter plugs can be used with shallower ditches, generally less than 2 feet in depth. A length of less than 50 feet is not recommended.

Pre-Construction Planning

Identify Plug Material

Look for spoils from the original ditching along either side of the ditch. Additional sources of on-site material can come from other restoration practices (i.e. depression excavations). If importing soil, use clean fill from a location where non-native invasive species (NNIS) are not found.

Determine Plug Locations

A single plug can work in a relatively flat/level site. Locate the plug at the downstream edge of the desired wetland restoration area. Multiple plugs are needed on sloped sites. Locate one plug at the lowest elevation of the restoration area with additional plugs moving upslope. Spacing or stepping the plugs every one to three feet of vertical rise is recommended to reduce excessive pressure between the plugs.

Identify Staging Location

Find an onsite upland staging location for temporary storage of imported soils (as needed) and parking of equipment.

Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

Choose a contractor with previous experience working in wetlands and use low ground pressure equipment such as an excavator with wide tracks. Meet with the contractor to review project details including site access and staging location, the specifications for plug material and plug installation, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions with no/minimal flow present in the ditch.

Construction Sequencing

1. Stock pile imported soils in staging area. Use erosion control measures if storing for more than a week, or heavy rain is predicted.
2. Stake out location of plugs along ditch. Stakes at both ends of the plug will guide the contractor and prevent over/under filling.
3. Strip existing material from where the plug will be installed in the ditch. Remove all vegetation, roots, organic matter and unsuitable sediments. Depending on field conditions, the stripping could be done by hand, or with the machine.
4. Install depending on fill material per specifications above. Replace organic soils removed from the ditch as topsoil on the plug.
5. Securely stabilize the site through appropriate erosion control measures. Seed and mulch all disturbed soils (see Erosion Control Practices).

Plug in process, Ryan Crehan, USFWS

Challenges and Solutions

- Controlling impacts to upslope and downslope ditch property owners: If the subject ditch is not confined to the project property, do not place plugs where hydrology changes will affect neighboring land and no closer than within 25 feet of the property line. This will buffer the neighboring property from any unanticipated impacts from the ditch plugs.
- Settling of fill material: Overfilling the ditch is intended to offset settling, but addition of fill may be necessary over time.
- Erosion of the ditch plug before vegetation reestablishment: Timing of construction during low flow conditions and quick attention to seeding and mulching when construction is complete will assist with vegetation establishment and stability of the site.
- Introduction of invasive species: If work crews are used, ask them to clean tools and boots, and to power-wash equipment before entering the restoration site. Work with your contractor to minimize soil disturbance.

Complementary Practices:

> ! Additional permitting may be required for the construction of new access roads or trails, for the stockpiling of soil in a wetland or wetland buffer, or for the addition of fill to a floodplain.

3.5 Fill Drainage Ditches

Ditches confine water, lower the water table, and route water quickly through wetlands. Wetlands with artificial drainage patterns have diminished capacity to slow down and store flood waters. Completely filling a ditch can provide permanent restoration of hydrology and allow for recontouring and restoration of site topography. Ditch backfilling is intended for artificial drainageways, not stream channels.

Fill Drainage Ditches

GOALS

Restore wetland hydrology and native site topography; restore functions of flood storage and water quality

BENEFITS

Prevent erosion; slow down and infiltrate stormwater; improve water quality; provide flood resiliency

1. Identify Backfill Material
2. Identify Staging and Access
3. Construct and Recontour
4. Stabilize Site
5. Monitor for Success

DEFINITIONS

Compaction: Pushing soils together so tightly that there is little air between particles. Compaction is obtained by traveling over thin layers of soil a number of times with heavy equipment.

Ditching: Excavating a channel in a wetland to drain water.

Drainage Ditches

The United States lost over 50% of its wetlands since the early 1600s, and Vermont lost as much as 35%. Wetlands were seen as obstacles to development, agriculture, and travel, and were systematically drained and altered. Conversion of wetlands was an accepted practice as recently as the 1950s, and was even incentivized by government policies. Restoration is essential for rehabilitating wetlands that have been degraded. (VTDEC, website)

Historic ditching in Bennington County, NRCS

Filling a ditch to restore wetland function, Shayne Jaquith, The Nature Conservancy

Pre-Construction Planning

Identify Backfill Material

Look for spoils from the original ditching along either side of the ditch. Additional sources of on-site material can come from other restoration practices (i.e., depression excavations). If importing soil, use clean fill from a location where non-native invasive species (NNIS) are not found.

Identify Staging Location

Find an onsite upland staging location for temporary storage of imported soils (as needed) and parking of equipment.

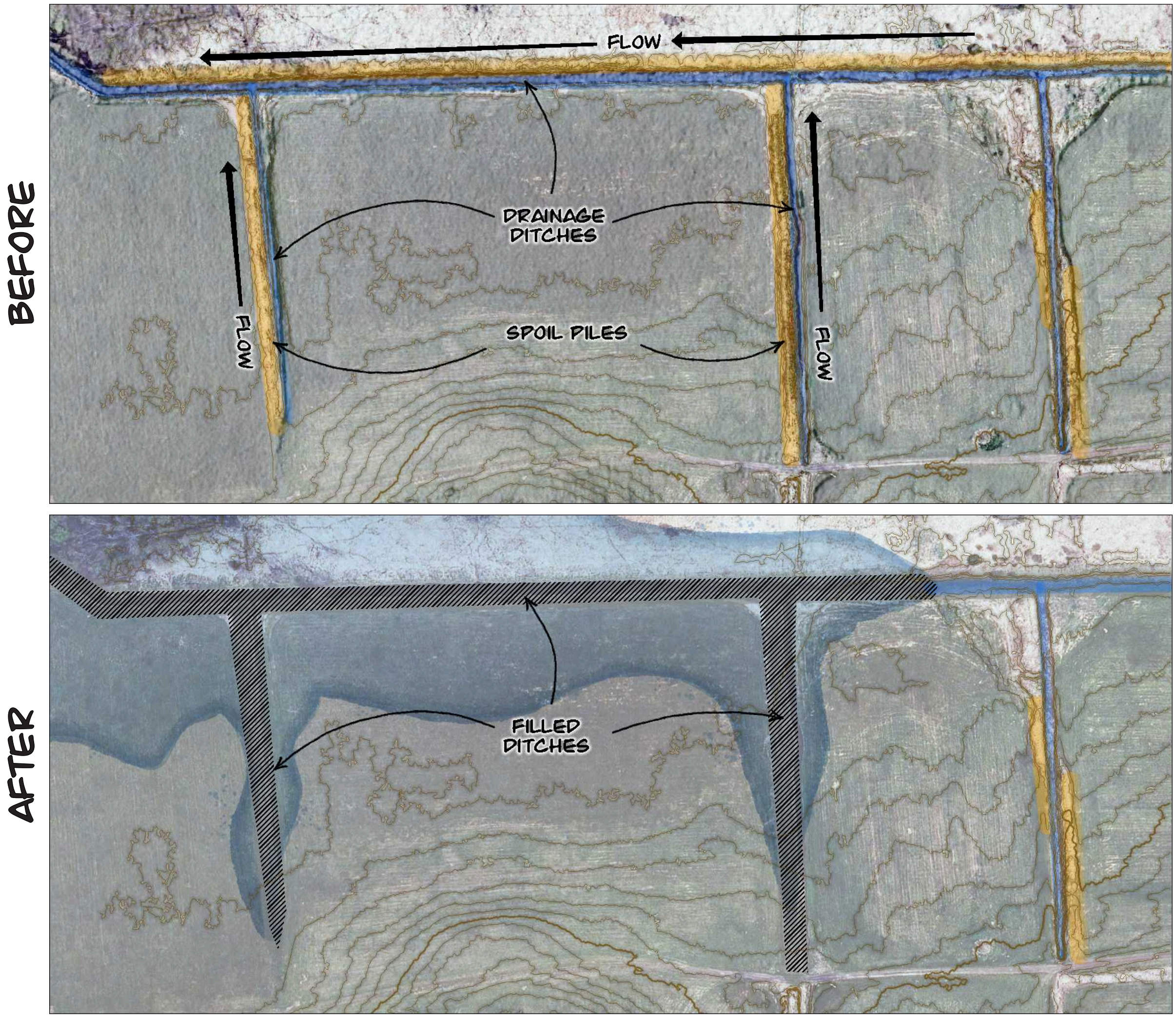
Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

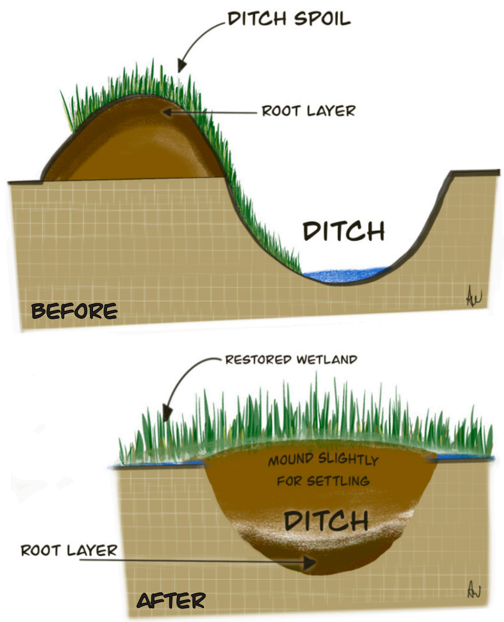
Choose a contractor with previous experience working in wetlands and who has low ground pressure equipment such as an excavator with wide tracks. Meet with the contractor to review project details including site access and staging location, the specifications for fill material and fill installation, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions with no/minimal flow present in the ditch.

Ditch Fill Illustration



Construction Sequencing

1. Stockpile imported soils in staging area. Use erosion control measures if storing for more than a week, or heavy rain is predicted.
2. Stake out extent of ditch fill. Stakes at both ends of the fill area will guide the contractor and prevent over/under filling.
3. Stripping of existing vegetation, roots, organic matter, and sediments in the ditch is not necessary; existing ditch spoil material can be pushed into the ditch without preparing the ditch. If NNIS are present in the fill material, have the contractor remove and push the surface layer first to form the bottom layer of the filled ditch.
4. Compaction of soils is important to prevent excessive settling. It may be difficult to compact the first few feet, especially if the ditch is wet. General guidance is to compact in 12 inch lifts after a base is established.
5. Build fill up 10%-20% over the level of the ground to allow for settling. This is particularly important in sloped wetlands. The slightly higher ditch fill will help spread surface runoff and prevent erosion of the backfill area.
6. Securely stabilize the site through appropriate erosion control measures. Seed and mulch all disturbed soils (see Erosion Control Practices).

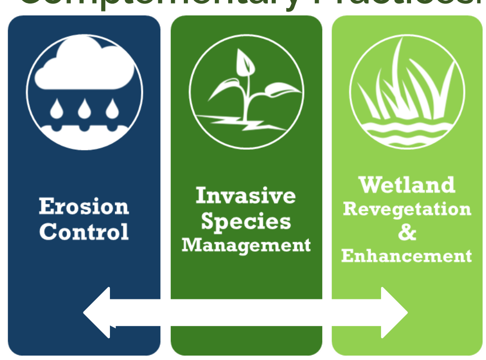


Challenges and Solutions

- Completely filling ditches can take a lot of material and is not feasible at all sites: Targeted ditch filling with ditch plugs can accomplish many of the same goals.
- Settling of fill material: Overfilling the ditch seeks to offset the settling but addition of fill may be necessary over time.
- Erosion of ditch fill before vegetation reestablishment: Timing construction during low flow conditions and quick attention to seeding and mulching when construction is complete will assist with vegetation establishment and stability of the site.
- Introduction of invasive species: If work crews are used, ask them to clean tools and boots and to power-wash equipment before entering the restoration site. Work with your contractor to minimize soil disturbance.
- Controlling impacts to upslope and downslope ditch property owners: If the subject ditch is not confined to the project property, do not fill within 25' of the property line. This will buffer the neighboring property from any unanticipated impacts from the ditch filling.

> Additional permitting may be required for the construction of new access roads or trails, or for the stockpiling of soil in a wetland or wetland buffer, or for the addition of fill to a floodplain.

Complementary Practices:



3.6 Remove Sediment and Fill

Wetlands have been historically filled with topsoil, gravel, concrete, rocks, and other waste, and then covered with soil. Another common practice was to construct berms along streams/rivers to prevent flooding of adjoining fields. Wetlands filled prior to the Vermont Wetland Rules are not violations and are good candidate projects for wetland restoration.

Remove Fill

GOALS

Remove historic fill and expose the original wetland soil layer; put back natural contours and microtopography

BENEFITS

Improve water quality; restore wildlife habitat; reestablish hydrology; reconnect floodplains

1. Determine Extent of Historic Fill
2. Identify Staging and Access
3. Identify Disposal Area
4. Excavate Fill and Recontour
5. Stabilize Site
6. Monitor for Success

DEFINITIONS

Floodplain: Level area of land next to a stream or river that floods.

Soil Auger: A hand-held steel rod attached to a large screw that can be used to take soil samples at various depths below the surface.

Solid Waste: Unnatural fill materials such as household garbage, plastic, tires, concrete, and scrap metal that are disposed of at a landfill.

Fill Removal

Finding native soil and removing sediment from a filled wetland

Pre-Construction Planning

Locate Underground Utilities

Mark locations of underground utilities in or adjacent to the excavation area.

Delineate Fill Area

Determine the nature and extent of the fill material to be excavated. Resources to assist with this task include historic and current aerial imagery, soil auger, posthole digger, and/or a backhoe.

Identify Disposal Area

Identify where the removed material will be disposed of (non-wetland/buffer location), depending on the nature of the fill.

Identify Staging Location

Find an onsite staging location for temporary storage of excavated fill material and parking of equipment.

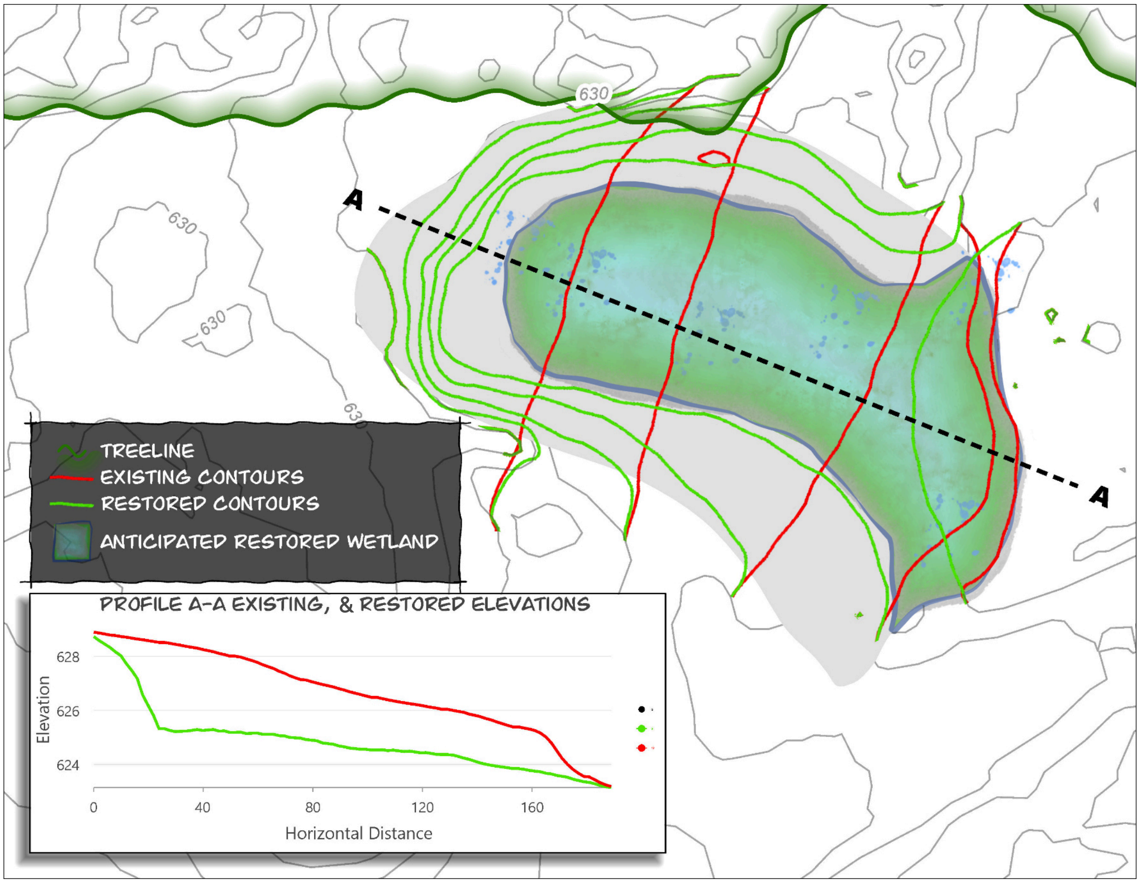
Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

Choose a contractor with previous experience working in wetlands and who has low ground pressure equipment such as a backhoe with wide tracks. Meet with the contractor to review project details including site access, staging location, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions.

Fill Removal Plan Example



Construction Sequencing

1. Flag the limits of the excavation area.
2. Install erosion control measures. Contained sites (depressions without outlets) do not generally need specific erosion control measures during construction. Uncontained sites of greater than 0.5 acres may require installation of silt fence at down slope extent to prevent discharge of sediment to sensitive resources (streams, wetlands) and/or neighboring properties.
3. Excavate the historically deposited fill. It is often easy to identify the native ground surface by looking for decomposing organic material (vegetation, woody stems). Encourage the contractor to work slowly so as not to excavate below that level. Leave the ground surface rough and instruct the contractor that a manicured final grade is not the goal. If all of the fill material is not being removed, or if the native ground surface is not identifiable, a more detailed plan for final grading will be needed. This will likely require site surveys and detailed site plans.
4. Dispose of fill material. Clean excavated material can be disposed of either on-site or off-site. Make sure that the disposal site is not located within wetland or wetland buffer resources. Solid waste needs to be disposed of at a certified landfill facility.

Securely stabilize the site through appropriate erosion control measures. Seed and mulch all disturbed soils (see Erosion Control Practices).

Filled wetland before restoration

Post restoration-fill removed, rough finish incorporating boulders

Challenges and Solutions

- Hauling and disposing of waste material can be expensive: Identifying nearby disposal sites is most economical. Make sure disposal area is not in wetland or wetland buffer.
- Introduction of invasive species: If work crews are used, ask them to clean tools and boots, and to power-wash equipment before entering the restoration site. Work with your contractor to minimize soil disturbance.

Additional permitting may be required for the construction of new access roads or trails, for the stockpiling of soil in a wetland or wetland buffer, or for the addition of fill to a floodplain.

Complementary Practices:

3.7 Surface Drainage Reroutes

Wetlands targeted for restoration commonly contain surface ditching that disrupts their natural hydrology. This ditching can extend upslope and downslope of the restoration area, as well as onto neighboring lands. Discharge from ditching into the restoration area is not always desired (e.g., water quality concerns), and for these cases a reroute of the approaching drainage system can be implemented. Here, the wetland restoration area would need to have other sources of hydrology to support the restoration effort. This practice is not intended for stream channels and may require consulting or engineering oversight.

Drainage Reroute

GOALS

Relocate or realign a drainage system so that it no longer flows through or impacts the wetland restoration area

BENEFITS

Improved water quality

1. Identify & Stake Out New Drainage Path
2. Identify Soil Stockpile Location
3. Identify Staging and Access
4. Excavate Channel
5. Stabilize Site
6. Monitor for Success

DEFINITIONS

Ditch: Channel or swale constructed in the ground, intended primarily for drainage.

Stream: A stream has a channel that periodically or continuously contains moving water, has a defined bed, transports sediment, and has banks that serve to confine water at low to moderate flows.

Surface drainage reroute, Ryan Creehan, USFWS

Surface drainage reroute, Shayne Jaquith, TNC

Pre-Construction Planning

Drainage Channel Siting

A new drainage section should be as far as possible from the wetland restoration area to avoid unintended lateral drainage impacts. Avoid significant ground elevation rise, which can result in increased cut depths, lengths, and costs.

Drainage Channel Design

Identify dimensions of the new drainage segment based on cross sectional dimensions of upslope and downslope connection points to the existing drainage system. Establish upslope and downslope elevations to blend into the existing system, avoiding steep slopes. Match grades in the new segment to grades in the existing system.

Locate Underground Utilities

Mark locations of underground utilities in or adjacent to the excavation area.

Identify Disposal Area

Identify where the excavated soils will be disposed of in an upland location.

Identify Staging Location

Find an upland staging location for the temporary storage of excavated fill material and parking of equipment.

Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

Choose a contractor with previous experience working in wetlands and low ground pressure equipment such as an excavator with wide tracks. Meet with the contractor to review project details including site access and staging location, the specifications for drainageway construction, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions.

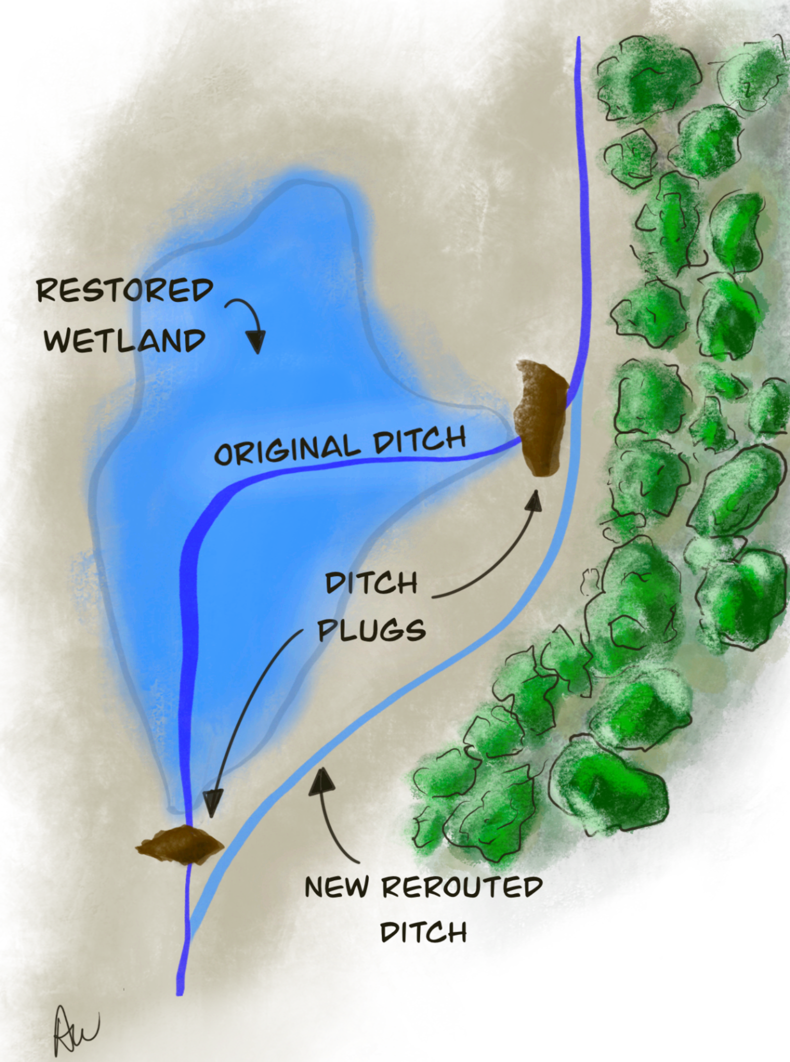
Construction Sequencing

1. Stake out limits of new drainage segment.
2. Excavate new drainage segment to match depth, width, and grade of upslope and downslope drainage connection. Do not make final connection with existing ditch system.
3. Securely stabilize new segment through appropriate erosion control measures. Secure the bed and walls of the channel with appropriate materials, and seed and mulch all disturbed soils (see Erosion Control Practices).
4. Construct ditch plugs on abandoned portion of ditch upslope and downslope of wetland restoration area (see Ditch Plugs).
5. Connect new drainage segment into existing network after stabilization has been achieved.
6. Securely stabilize remainder of new segment through appropriate erosion control measures. Seed and mulch all disturbed soils. (see Erosion Control Practices).
7. Proceed with restoration practices in area of abandoned segment (i.e., Ditch Plugs and/or Fill Drainage Ditches Practices).

Challenges and Solutions

- Construction costs: Hauling and disposing of excavated soil material can be expensive. Identifying nearby disposal sites is most economical.
- Maintaining wetland restoration area hydrology: It is important to understand the water inputs to the restoration area to make sure rerouting of a drainage does not starve the wetland of the hydrology needed for successful restoration.
- Controlling adverse impacts to upslope and downslope ditch property owners: If the subject ditch is not confined to the project property, leave 25 foot sections intact before the property line. This will allow a buffer to the neighboring property from any unanticipated impacts from the ditch rerouting.
- Erosion of the new drainage segment: Properly stabilize new channel segment before connecting into the existing network.
- Introduction of invasive species: If work crews are used, ask them to clean tools and boots, and to power-wash equipment before entering restoration site. Work with your contractor to minimize soil disturbance.

Drainage Reroute Example



Poorly executed surface water reroutes can lead to significant erosion problems, both upslope and downslope. In some cases, erosion risks may be too great to overcome, and a reroute should not be attempted.

Additional permitting may be required for the construction of new access roads or trails, for the stockpiling of soil in a wetland or wetland buffer, or for the addition of fill to a floodplain.

Complementary Practices:

3.8 Tile Drain Blocks

Underground drainage systems remove water from saturated soils, usually through a network of perforated tubes, or pipes commonly called tile drains. Drainage tiles are often buried (typically 2 to 5 feet below ground) in wetlands to improve their use for farming. Restoration of wetland hydrology involves rendering the drainage system ineffective by strategically removing or plugging some of the tiles. This is referred to as tile "blocking," and may result in less ground disturbance and reduced construction costs compared to removing the full tile drain system.

Tile Drain Blocks

GOALS

Restore hydrology to a drained wetland system

BENEFITS

Improved water quality; increased flood storage; improved erosion control

1. Map Tile Network
2. Map Out Plug/Block Locations
3. Acquire Plug/Block Materials (i.e., caps, grout)
4. Locate Backfill Material
5. Identify Staging and Access
6. Construct Blocks and/or Plugs
7. Backfill Trench
8. Stabilize Site
9. Monitor for Success

DEFINITIONS

Tile Blocking: Excavating and then removing or plugging a length of tile at strategic locations, followed by capping the exposed tile ends, and then backfilling and compacting the trench.

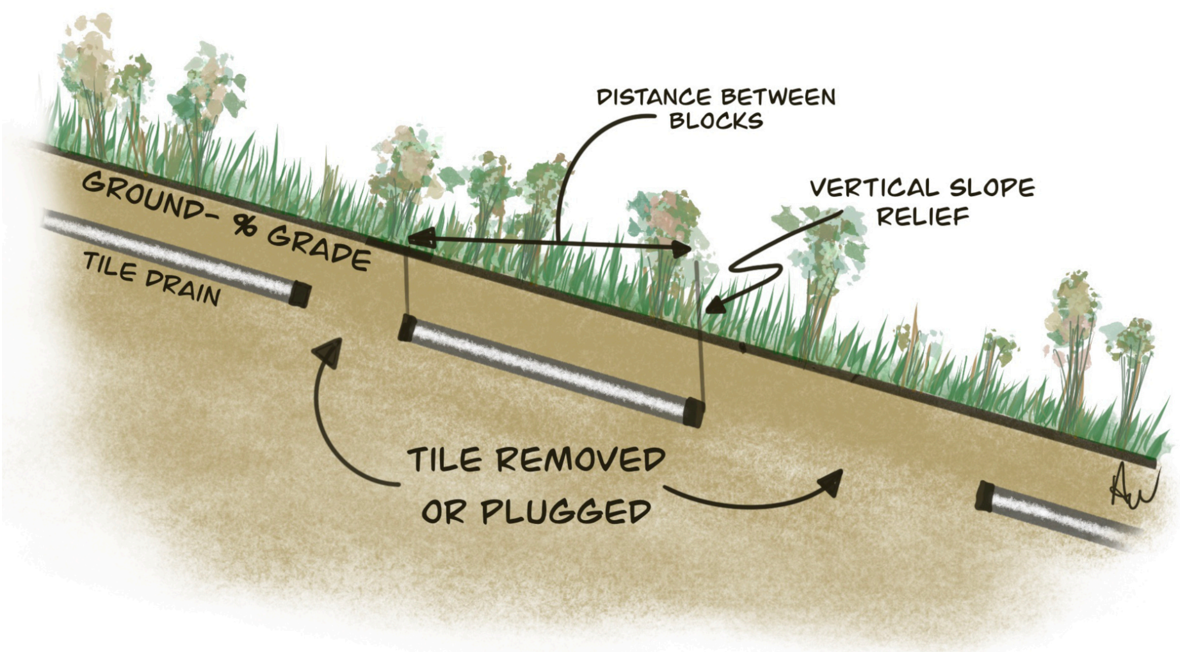
Tile Probe: A long, small diameter steel rod with a pointed tip mounted on a handle. Used to locate buried drainage structures.

Tile drain installation

Joshua Faulkner

Tile Block Specification

Plug Material	Concrete grout or clay.
Property Line Setback	Offset impacts 25 feet or more from project or property boundaries.
Level/Flat (<4%) Wetlands	*(Subsurface drainage is typically provided by just a single tile line or tile main. There may be one or more branches of the tile system that tie into the main tile line.)*
	Blocking one section on the main tile line will likely be sufficient to restore hydrology.
	Block spacing: 1-2 foot vertical slope relief.
	Begin the tile block at the anticipated restored wetland's edge and extend downslope.
	Minimum length of block: 50 feet in heavy clay soils to 150 feet in sandy or organic soils.
Sloped (>4%) Wetlands	*(Restoration of hydrology in sloped wetlands is challenging and may require more advanced design help.)*
	More than one block may be needed depending on the size of the restoration area and extent of the existing tile. The design will include tile blocks on each tile line running upslope through the wetland.
	Block spacing: Every 2-4 feet of vertical slope relief.
	Primary Block: Begin the lowest tile block at the anticipated restored wetland's edge and extend downslope 100 feet.
	Supplemental Blocks: Block 30 to 50 feet of tile upslope of anticipated wetland edge, spaced every 2-4 feet of vertical elevation change.
	Close spacing of the blocks in a stepped fashion will produce the best results for reestablishing hydrology. Longer lengths can be used in areas with more organic or sandy soils.



Pre-Construction Planning

Map Tile Drain Network

Determine type (clay, concrete, or plastic), sizes (diameter), locations, flow directions and outlets of existing drainage tile within and adjacent to the restoration area. Potential sources of this information include landowners, the Natural Resource Conservation Service (NRCS), and aerial photos.

Plan Block Locations

Identify the location and sizing of blocks per specifications for either sloped or level sites. Decide whether removal or plugging is most appropriate.

Acquire Block Materials

Caps are needed for both tile removal and plugging. These can often be found at a local hardware store. Plug material can include redimix concrete, clean clay fill, and expandable foam.

Identify Trench Fill Material

Additional sources of on-site material can come from other restoration practices (i.e., depression excavations). If importing soil, use clean fill from a location where non-native invasive species (NNIS) are not found.

Identify Staging Location

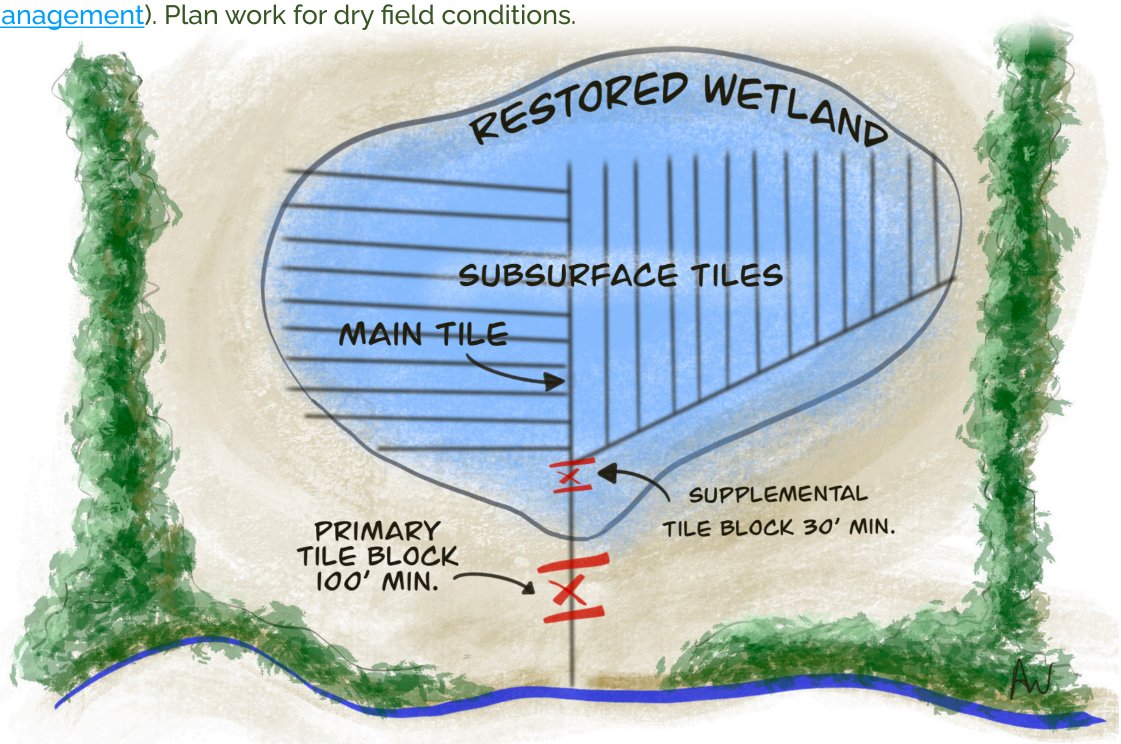
Find an upland staging location for temporary storage of imported soils (as needed), removed tile drains, and parking of equipment.

Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

Choose a contractor who has previous experience working in wetlands and use low ground pressure equipment such as an excavator with wide tracks. Meet with the contractor to review project details including site access and staging location, specifications for tile blocking construction, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions.



Construction Sequencing

1. Stockpile imported soils in staging area. Use erosion control measures if storing for more than a week or if heavy rain is predicted.
2. Stake out block and plug locations. Stakes at both ends of the block will guide the contractor.
3. Excavate trench and block tiles.
4. Seal or cap two exposed ends of tile system with manufactured cap. To ensure the tile is sealed from future flow, install a cement plug in the end of the tile break first. Pour enough concrete or grout to fill a couple of feet of line.

Tile drain removal for wetland restoration, Ducks Unlimited

5. Refill trench.
6. Compact spoils in the ditch (generally in lifts of 4-6 inches). Build spoils up 10%-20% over the level of the ground to allow for settling.
7. Securely stabilize the site through appropriate erosion control measures. Seed and mulch all disturbed soils (see Erosion Control Practices).
8. Proceed with restoration practices in the area of the abandoned tile drainage.

Additional permitting may be required for the construction of new access roads or trails, for the stockpiling of soil in a wetland or wetland buffer, or for the addition of fill to a floodplain.

Challenges and Solutions

- Sizes, grades, and locations of existing tile lines may be unclear: Ask the landowner, look at aerial photos for linear patterns that are unnatural, look for surface intakes, outlets, tile blowouts, and changes in vegetation, and explore with a tile probe.
- Leaky blocks: Incorrect sealing of blocks can result in leaking and erosion.
- Settling of fill material: Overfilling the ditch seeks to offset settling, but addition of fill may be necessary.
- Controlling adverse impacts to upslope and downslope property owners: If the subject drainage network is not confined to the project property, leave a 25 foot section of the existing system intact before the property line. This will buffer unanticipated impacts from the tile blocking.
- Introduction of invasive species: If work crews are used, ask them to clean tools and boots, and to power-wash equipment before entering the restoration site. Work with your contractor to minimize soil disturbance.

Complementary Practices:

3.9 Hummock/Hollow Creation

Hummocks, also called mounds, are typically initiated as the root masses and trunks of fallen trees rising above the wetland floor. The low-lying areas between hummocks are called hollows or pits. Hummocks provide necessary growing conditions for certain plants, while hollows provide breeding areas for amphibians and insects, feeding and drinking holes for birds and mammals, and contribute to ground water recharge.

Hummocks and Hollows

GOALS: Create diversity of wetland habitats by restoring or creating microtopography

BENEFITS: Wildlife habitat diversity; groundwater recharge

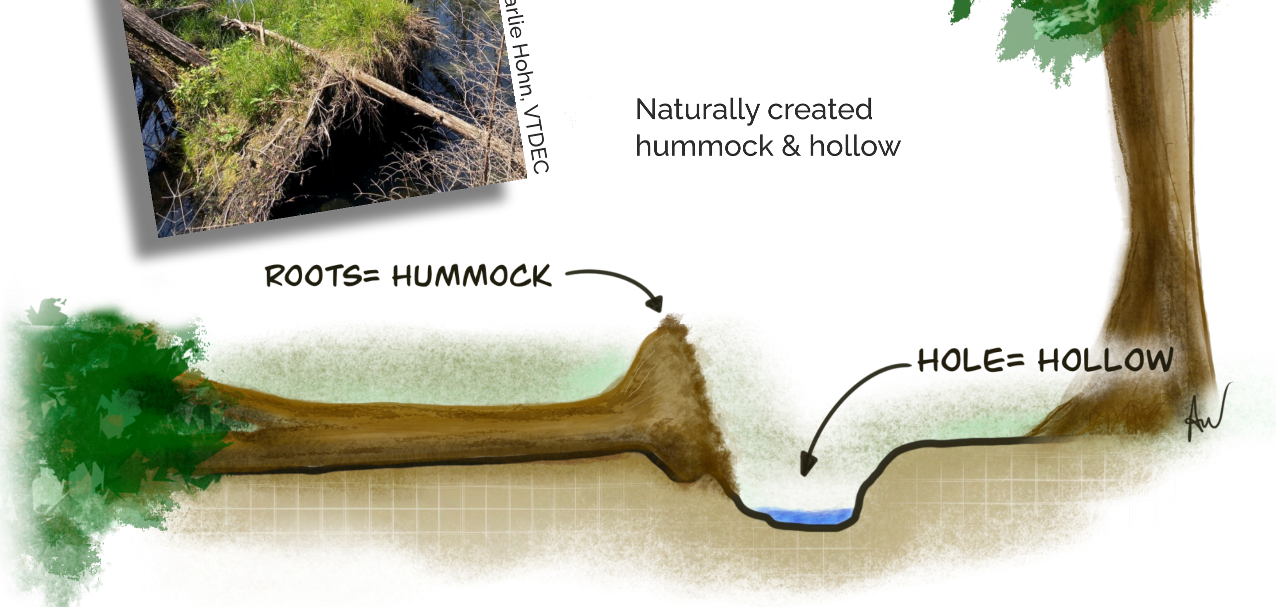
1. Design Hummock/Hollow Schematic
2. Identify Staging and Access
3. Excavate Hollows and Shape Hummocks
4. Stabilize Site
5. Monitor for Success

DEFINITIONS

Compaction: Pushing soils together so tightly that there is little air between particles.

Backhoe: A machine mounted on rubber tires with a wide bucket on the front for carrying soil and a smaller bucket attached to an arm in the back for digging holes.

Charlie Hohn, VTDEC



Hummock/Hollow Specification

Hollow Depth	Less than 6 inches of water (water stands for short durations)
Hummock Height	6 inches to 2 feet (variable)
Width	Not less than 3 feet
Side Slopes	5 : 1 Slope (where subject to wave action)
Surface Finish	Rough bottom and sides and a ragged boundary
Hummock Material	Excavated material from hollow/pit - do not compact

Hummocks & hollows constructed in a small sloped forested wetland restoration

Hummock & hollow creation in a low-gradient wetland restoration. Adam Huggins, Galiano Conservancy Association

Pre-Construction Planning

Schematic Plan

Develop a general detail for hummock/hollow sequence and specify an average density and spacing per acre of restoration. Random variations in shape, depth, and spacing are preferred.

Locate Underground Utilities

Mark locations of underground utilities in or adjacent to the excavation area.

Identify Staging Location

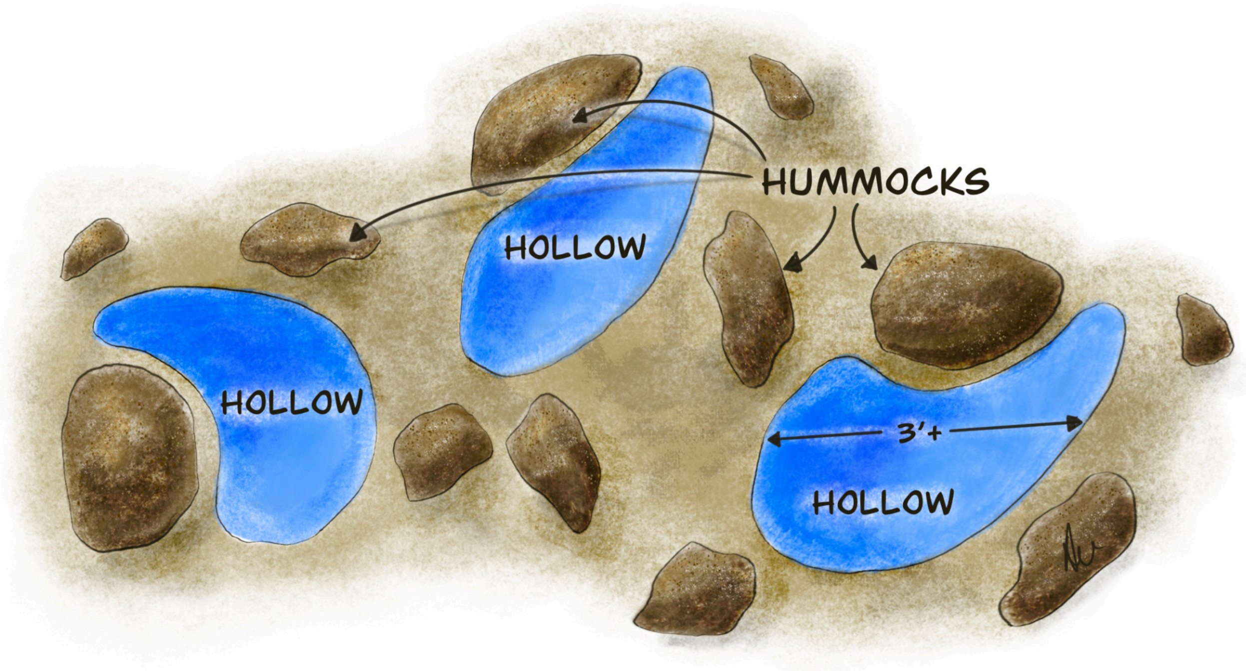
Find an upland location for temporary equipment parking. For this practice, soil for the hummocks comes from excavating the adjacent hollows, and you shouldn't need to store any soil.

Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

Choose a contractor with previous experience working in wetlands and use low ground pressure equipment such as a backhoe with wide tracks. Meet with the contractor to review project details including site access and staging location, the specifications for hummock/hollow construction, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions.



Construction Sequencing

1. Stake out location of each hummock/hollow treatment area.
2. Excavate hollows and shape hummocks, working from the interior of the restoration site to the exterior to avoid compaction by equipment.
3. Securely stabilize the restoration area through appropriate erosion control measures. Seed and mulch all disturbed soils (see [Erosion Control Practices](#)).

> Additional permitting may be required for the construction of new access roads or trails, or for the stockpiling of soil in a wetland or wetland buffer.
>
> This practice may not be appropriate in floodplains, so seek qualified advice. Additional permitting may be required.

Challenges and Solutions

- Introduction of invasive species: If work crews are used, ask them to clean tools and boots, and to power-wash equipment before entering the restoration site. Work with your contractor to minimize soil disturbance.

Complementary Practices:

3.10 Shallow Depressions/Scrapes

Many shallow, depressional wetlands have been filled by sedimentation from intensive land cultivation practices and other soil disturbing activities. Excavations within drained or altered wetlands improve wetland habitat by increasing wetland depths and providing microtopography. Depressions allow for water ponding which provides a degree of water storage capacity.

Shallow Depressions

GOALS

Restore wetland hydrology and microtopography

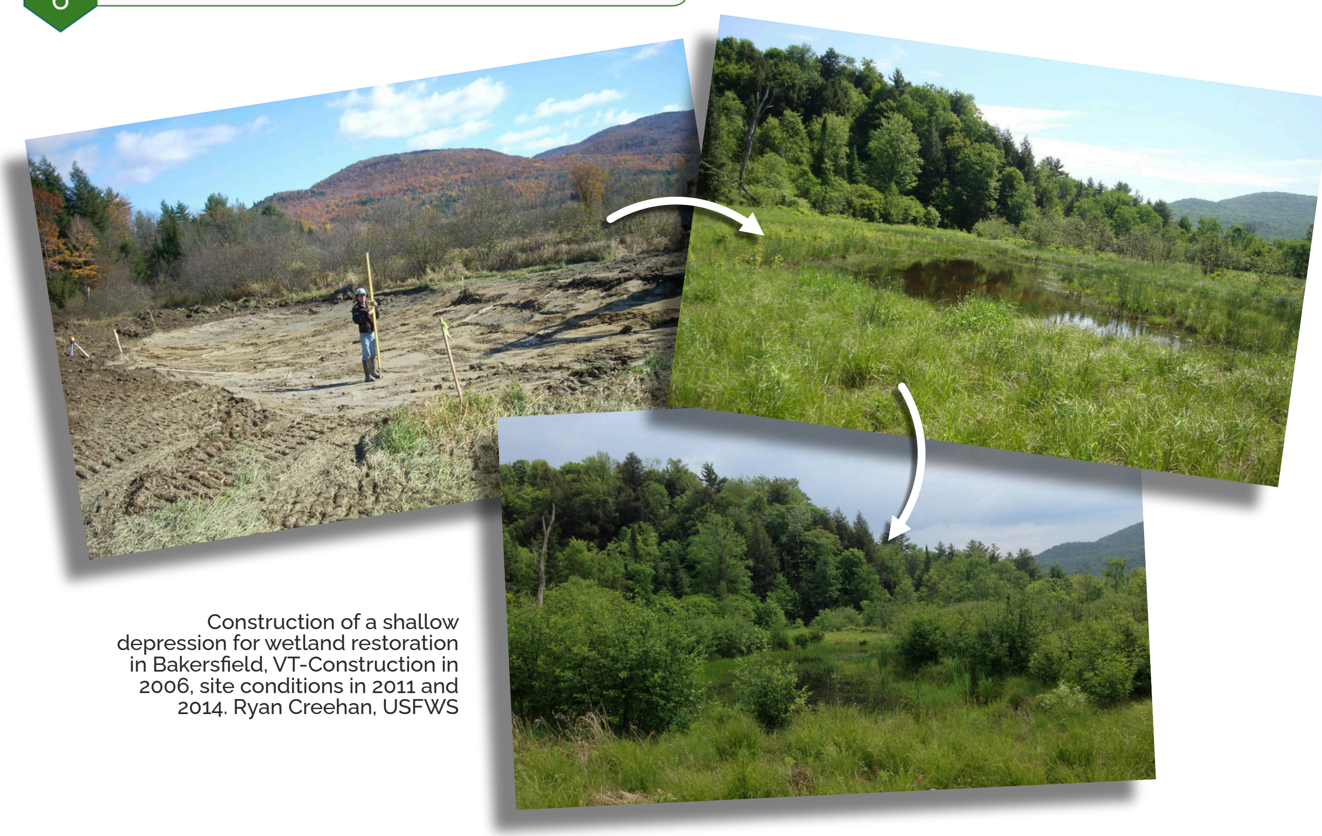
BENEFITS

Diversified wildlife habitat; improved water quality; increased flood storage

1. Design Depression/Scrape Schematic
2. Stake out Depression/Scrape Locations
3. Identify Staging and Access
4. Excavate Depressions
5. Stabilize Site
6. Monitor for Success

DEFINITIONS

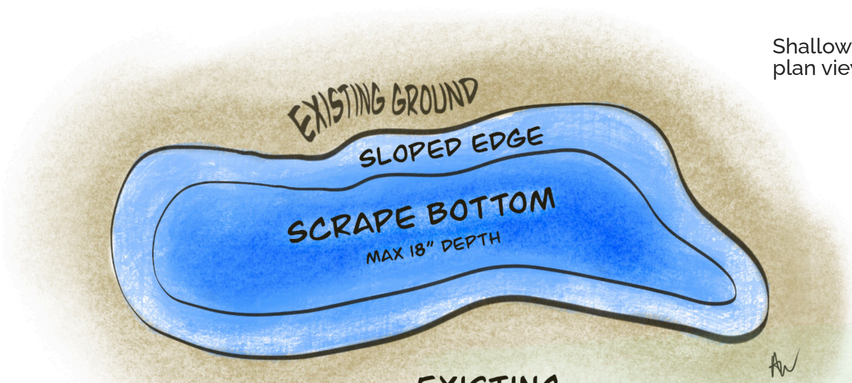
Scrape: A slight excavation in a wetland that allows for open water ponding.



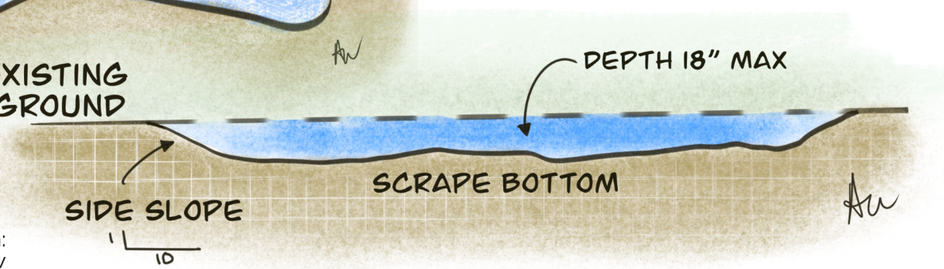
Construction of a shallow depression for wetland restoration in Bakersfield, VT-Construction in 2006, site conditions in 2011 and 2014. Ryan Creehan, USFWS

Shallow Depression/Scrape Specification

Depth	Maximum 18 inches
Slope	10:1 or flatter
Minimum Area	250 square feet



Shallow depression: plan view



Shallow depression: section view

Pre-Construction Planning

Develop Schematic Plan

Specify an average density and spacing per acre of restoration. Random variations in shape, depth, and spacing are preferred.

Locate Underground Utilities

Mark locations of underground utilities in or adjacent to the excavation area.

Spoils Removal Plan

Incorporate into other restoration elements. Spoils should not be shaped into a berm or disposed of in the restoration area, but intentionally incorporated into the restoration design. Excavated soils can be utilized to plug and/or fill ditches. The soil could also be loosely shaped into upland mounds, adding topographic diversity around the constructed depressions. Care should be taken to not obstruct floodwaters in known or potential floodplains.

Identify Staging Location

Find an upland location for temporary storage of materials and equipment parking.

Identify Access Routes

Use of existing roads and trails without improvement is allowed. Temporary use of swamp mats is also allowed if removed within one growing season, provided their use meets the United States Army Corps of Engineers General Permit conditions (see Chapter 5).

Select a Contractor & Equipment

Choose a contractor with previous experience working in wetlands and use low ground pressure equipment such as an excavator with wide tracks. Meet with the contractor to review project details including site access and staging location, the specifications for depression construction, and NNIS control/management procedures (see Invasive Species Control and Management). Plan work for dry field conditions.

Construction Sequencing

1. Stake and flag excavation locations: Clusters of depressions with varying size/depth/dimension create greater habitat diversity.
2. Conduct surface stripping.
3. Clearing and grubbing of woody vegetation or other material.
4. Native materials may be harvested for use in replanting.
5. Topsoil is stripped away to expose sub-surface soils and stockpiled.
6. Excavate sub-surface soils and follow spoils removal plan.
7. Create irregular edges and undulating bottom depths.
8. Redistribute topsoil over the surface of the newly formed depression.
9. Finish grade should be semi-rough and not smooth.
10. Minimize excessive use and travel of construction equipment to avoid compaction of soils, working from interior to exterior of the restoration site.
11. Securely stabilize the restoration area through appropriate erosion control measures. Seed and mulch all disturbed soils (see Erosion Control Practices).

> Topsoil containing NNIS species is not suitable for this restoration practice and should be removed from site.
>
> Additional permitting may be required for the construction of new access roads or trails, for the stockpiling of soil in a wetland or wetland buffer, or for the addition of fill to a floodplain.

Challenges and Solutions

- Introduction of invasive species: If work crews are used, ask them to clean tools and boots and power-wash equipment before entering restoration site. Work with the contractor to minimize soil disturbance.

Complementary Practices:

3.11 Supplemental Practices

Depending on your project, the following practices may enhance or augment the functions and values provided by your primary restoration treatments.

Woody Additions | Erosion Control | Beaver Dam Analogs | Conservation Easement

WOODY MATERIAL ADDITION

Woody Additions

Decaying woody material is an important component of healthy ecosystems. In wetlands, logs, stumps, and smaller branches provide habitat and shelter for animals, store sediment, increase water storage and infiltration, reduce erosion, and provide a carbon source for the microbial food web.

Woody Material Specification

Source	Look for logs, stumps, and/or branches onsite in upland locations.
Size	Select a range of sizes and stages of decay.
Staging	Utilize staging and access locations identified for the primary restoration practices.
Distribution	Scatter material throughout the restoration area to provide a variety of ecosystem functions.

Woody addition in restored wetland

Do not scavenge woody material from surrounding wetlands.

Do not transport ash wood outside of the Emerald Ash Borer Infested Area in Vermont.

Do not use woodchips or mulch for this supplementary practice.

EROSION CONTROL PRACTICES

Erosion Control

Sediment washing into streams is one of the largest water quality problems in Vermont. Excess sediment can kill fish and other aquatic organisms and damage aquatic habitat. Sloped sites have a higher risk of erosion than flat sites, though gullying can occur on flat sites if water flows are concentrated. Basic approaches can control erosion and prevent the discharge of sediment.

Causes of Erosion
Vegetation removal
Topsoil and organic matter removal
Changes to drainage
Failure to cover bare soil

Avoidance Measures
Avoid work in the rain
Avoid work in high flows
Avoid work in winter conditions: October 15 to April 15

Seeding and Mulch

Seeding and mulch is the best and cheapest erosion control tool for use with wetland restoration practices that involve earth disturbance and stockpiling of soils. Temporary seeding is used to quickly establish vegetation on disturbed soil to reduce erosion during construction and/or late in the growing season. For best results, seed and mulch disturbed areas as quickly as possible after completion of grading and work activities. Apply seed first. Straw (not hay, which can contain NNIS seeds) can be hand scattered or blown to a depth of 1 inch. Track mulch in as needed to prevent removal by wind. In winter, apply mulch to a depth of 3 inches. Seed and mulch soil stockpiles if storage is for more than a week or if heavy rain is predicted. Reapply mulch as needed to ensure bare soil is 80-90% covered.

> Except for temporary erosion control, use native seed mixes from Vermont or New England.

Timing and Application Rates for Typical Temporary Seeding Species

Complete all erosion control seeding by September 15 to ensure adequate growth and cover.

May 1 - Sept 15	Annual Rye at 20 lbs./acre
Sept 15 - May 1	Winter Rye at 120 lbs./acre

Mulch Timing and Application Rates

Mulch is used to stabilize soil and prevent erosion prior to vegetative growth. Mulch also holds seed in place and allows it to become established. Use weed free straw mulch to avoid the introduction of nuisance plant species to the restoration site.

April 15 - Sept 15	1-2 inches deep
Sept 15 – April 15	3 inches deep

Erosion Control Blankets

Erosion control blankets are a temporary practice used on steeper slopes (3:1 or steeper) and level drainage ditches (less than 20:1 slopes). They are designed to hold soil in place until vegetation can grow through them and they biodegrade. For wetland restoration projects, erosion control blankets must be netless and comprised of natural fiber to avoid wildlife mortality. Anchoring devices are used to secure the blankets in place during heavy rain or wind. Anchors are often made of metal, but live stakes from native plants could serve a dual purpose.

Eroson control blankets on slope above wetland restoration

Erosion Control Blanket Specification

Preparation	Seed area first.
Short Slopes	For slopes less than 8 feet, install blankets across the slope (horizontal).
Long Slopes	For slopes greater than 8 feet, install blankets up and down the hill (vertical). Unroll mats from top of the hill.
Key In	Trench matting in 8 inches at top of hills.
Anchor	Unroll mats and staple/anchor as unrolled. Use plenty of staples to keep blankets flat.
Coverage	Overlap blankets 6 to 8 inches on sides, tops, and bottoms. Staple through both blankets at areas of overlap.

Wetland Matting

Wetland matting ("swamp mats") provides temporary access for large equipment within the restoration area by giving machines traction and preventing equipment from becoming stuck. Mats are placed directly on top of existing vegetation (vegetation removal may require a permit), and then removed within one growing season. To avoid the need for permitting, use of swamp mats must meet the US Army Corps of Engineers General Permit conditions (see Chapter 5).

Wetland Matting Specification

Position	Run mats across wet areas until they reach solid ground.
	Place mats parallel to the direction of travel to distribute weight.
	No gaps should exist between mats.
Installation	Use machinery (such as track excavators) to place mats.
	More than one layer of mats may be necessary in areas that are inundated or have deep organic wetland soils.
	Use lifting bolts to install. Timber mats have two lifting bolts on each end, making it easy to lift and place them with machinery.
Removal	Matting is removed by backing out of the site while removing mats one at a time. Any rutting or significant indentations should be regraded, taking care not to compact soils.

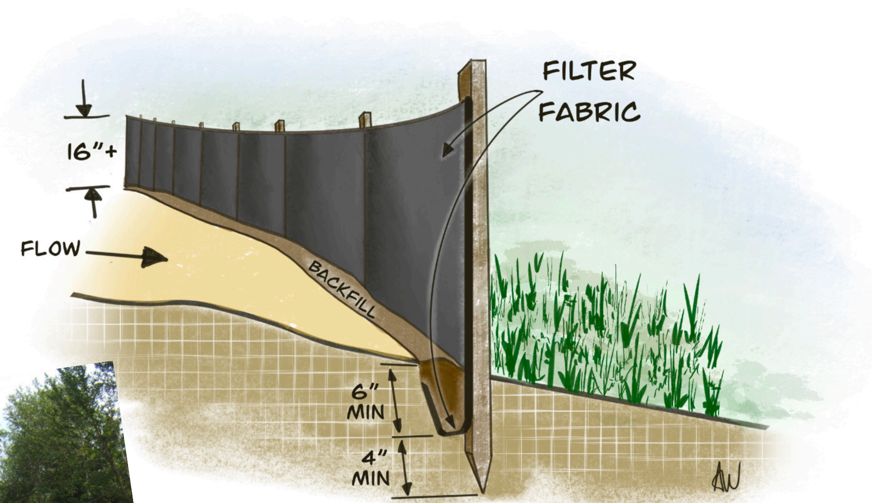
Layered wetland matting providing temporary wetland crossing

Silt Fence

Silt fencing is a type of sediment barrier recommended for use in large areas of soil disturbance (>0.5 acres) on slopes or near surface waters. The fence works by trapping sediment as water flows through it. Silt fences are made of geotextile fabric and supported by wooden stakes or metal posts.

Silt Fence Specification

Location	On sloped site, locate the fence downhill of the soil disturbance activity.
	On a site adjacent to surface waters, install the fence between the disturbed soil and the waterway.
Installation	Dig a trench 6 inches deep across (not up and down) the slope.
	Ensure stakes are on the downhill side of the fence.
	Join fencing by rolling the end stakes together.
	Drive stakes in against downhill side of trench.
	Push fabric into the trench, spreading it along the bottom.
	Fill trench with soil and pack down.
Maintenance	Remove accumulated sediment before it rises halfway up the fence.
	Ensure that the silt fence is trenched in the ground and that there are no gaps.
	Remove fence when restoration site is stabilized with vegetation.



Poorly installed silt fence-note lack of keying into soil at base

Silt fence failure

BEAVER DAM ANALOGS & POST-ASSISTED LOG STRUCTURES

Beaver Dam Analogs

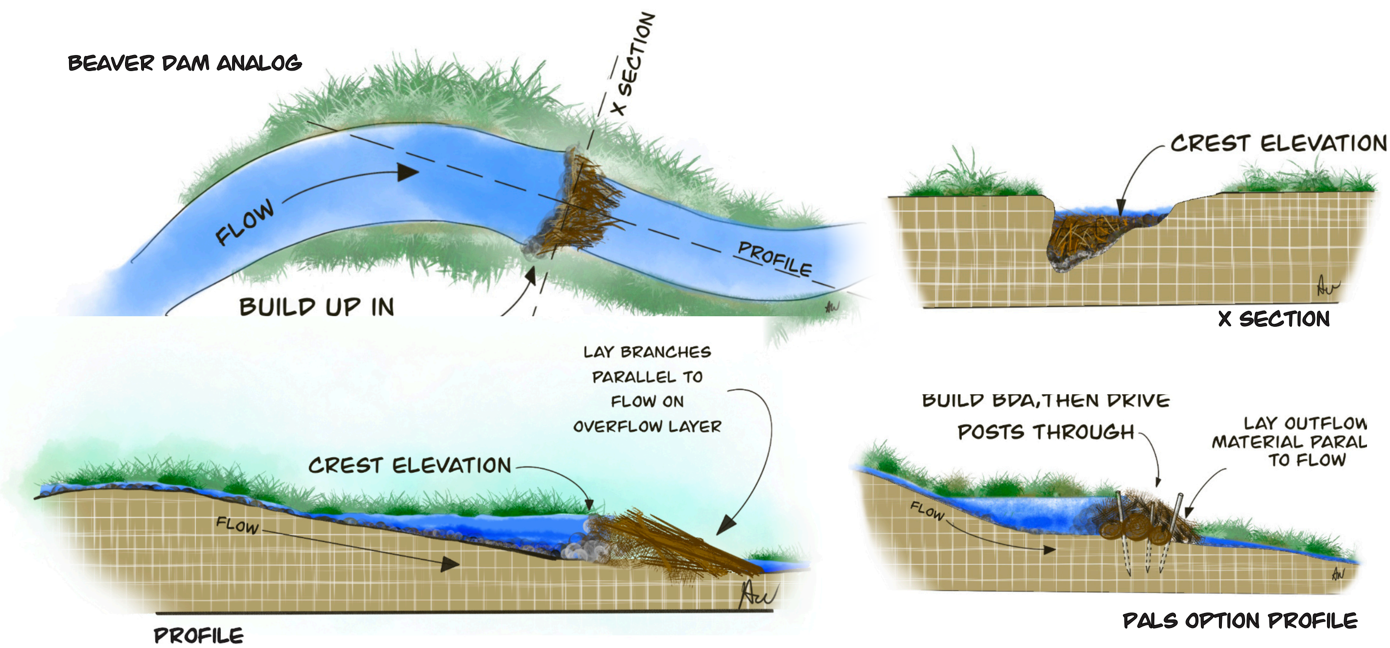
Beaver dam analogs (BDAs) and post-assisted log structures (PALS) are stream restoration practices that may complement a wetland restoration project that involves degraded streams lacking woody structure. These practices promote a self-sustaining riverscape with appropriate obstructions to flow, which create diverse habitats and reduce erosion. BDAs and PALS are non-engineered and hand-built with natural materials.

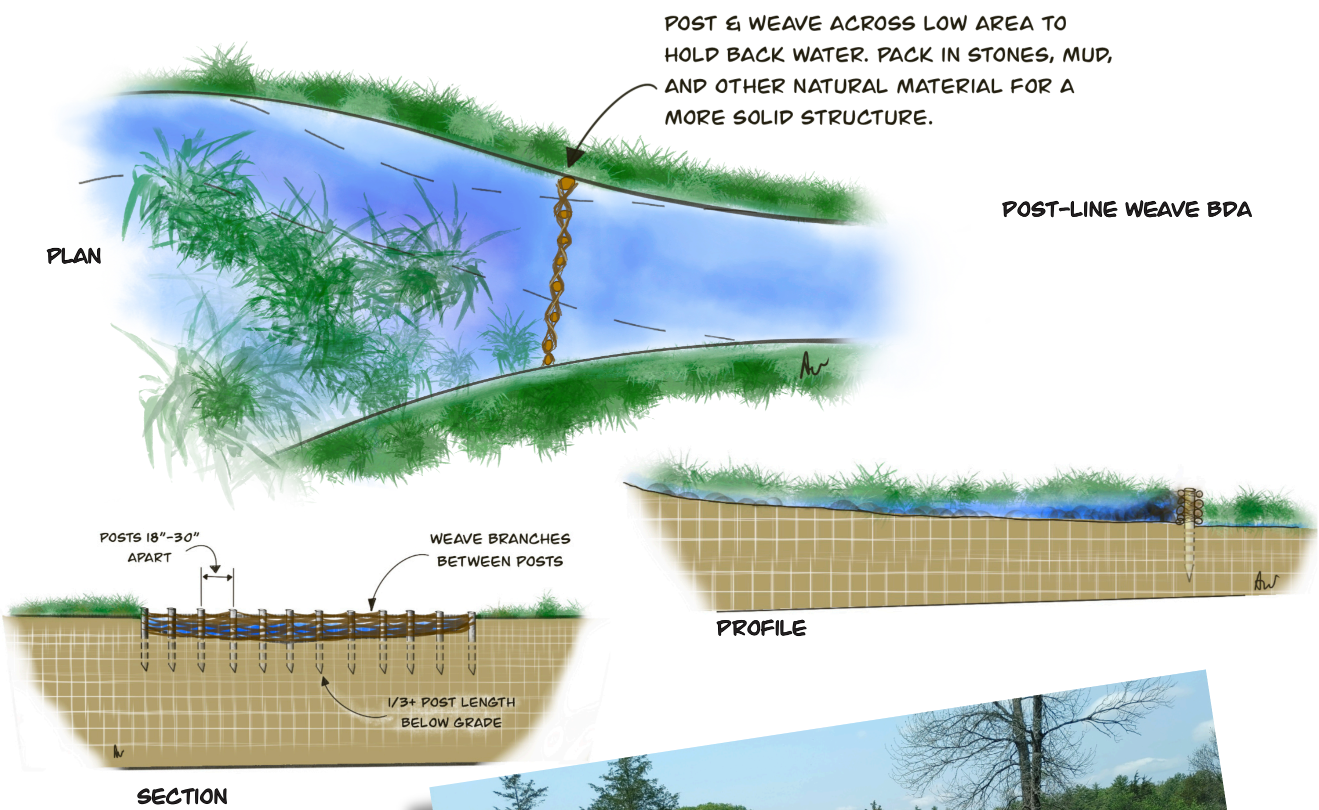
BDA: A permeable, channel-spanning structure with a constant crest elevation, constructed with a mixture of woody debris and fill materials to form a pond and mimic a natural beaver dam.

PALS: Woody material of various sizes pinned together with untreated wooden posts driven into the substrate to mimic natural wood accumulations. Can be channel spanning, bank-attached, mid-channel, or on the floodplain.

Specification

Source	Collect locally sourced materials to construct BDAs. Non-treated natural wood commercial posts may be used in PALS.
Material	Use mud, stones, and a range of sizes and species of wood. Living stems, branches, and trunks from native willows can be used, which may root and form a living structure. Average diameter for weaving branches is 2 inches.
Layering	Build up in 6 to 12 inch lifts. Make sure each layer is holding back water and ponding. Start with wide base to support the desired height.
Overflow Mattress	Branches woven parallel to flow at downstream end of structure. Combination of branches, brush, and cobble.
Posts	Optional. For higher flow conditions. Untreated wood, or robust native live stakes. Minimum 2 inch diameter for post and weave, 6 inch diameter for PALS. 18-30 inch gap between posts. Drive post through entire structure, with at least 1/3 the length of post into the underlying streambed.





Post weave BDA, Shayne Jaquith, The Nature Conservancy

Challenges and Solutions

- Can be too robust: BDAs and PALS that are too robust may be barriers to fish, hold back too much water, and flood neighboring properties. Build them only high enough to flood areas where inundation is appropriate. If fish passage is an issue, design strategic gaps in the structure.

- Can be too fragile: BDAs and PALS are temporary structures that will break down over time, and this should be planned for. Loose wood can block downstream culverts and flood roads if the structures are built too near upstream, and maintenance will be required if the structures break down before a self-sustaining riverscape becomes established. Thoughtful planning and regular monitoring can mitigate these challenges.

> Installation of BDAs and PALS likely triggers other State and Federal approval or permitting. Consultation with USACE and State River Engineer is encouraged early in the design process, and further design support from a consultant may be necessary. See State of Vermont Policies for more information on requirements (Vermont Rivers Program Policy on Wood and Structure Addition as a Restoration Strategy. 12/16/21).

CONSERVATION EASEMENTS

Conservation Easement

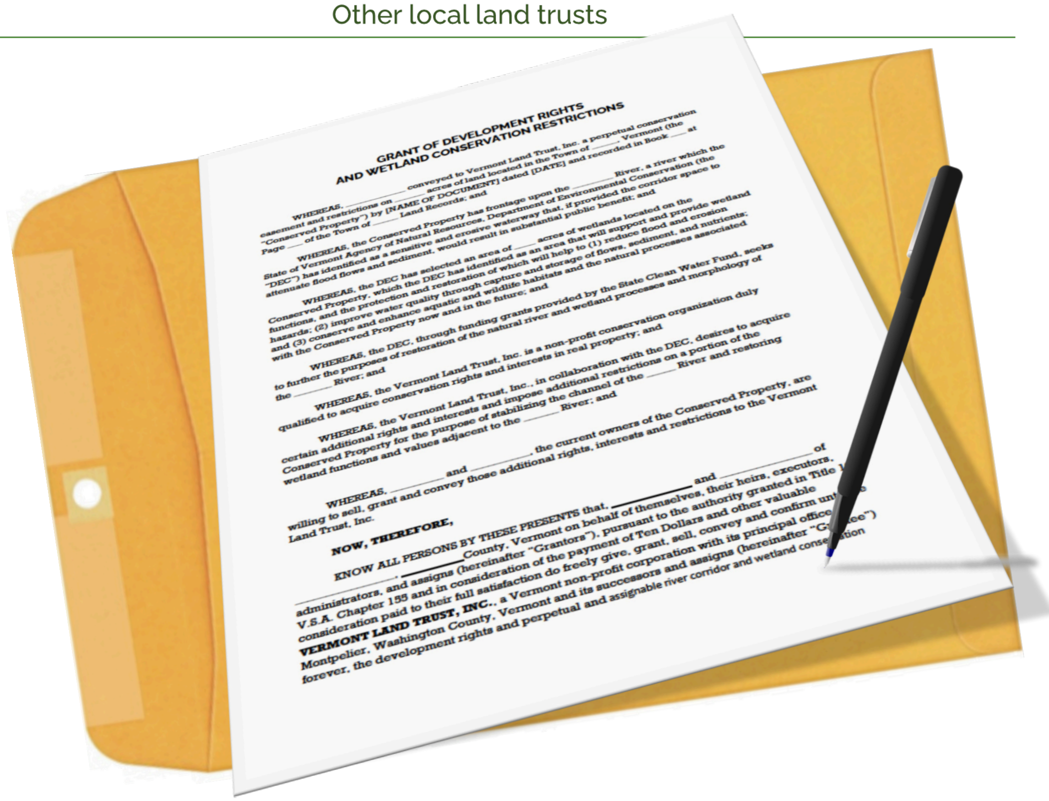
The restoration practices described in this guide are intended to enhance the functions and values of degraded wetlands across the landscape. These efforts are worthwhile because they help reduce flood damage, increase water quality, improve wildlife habitat, and more. Conservation easements are a unique practice in that they don't directly enhance wetland function, but instead ensure that restoration efforts aren't reversed as land ownership changes hands.

Conservation easements permanently protect a wetland restoration area through a legal agreement between the landowner and a land trust or government agency. Easements indicate the location and acreage of a Wetland Protection Zone (WPZ) and establish what uses and management activities are supported there. Management activities typically supported within a WPZ include the control of NNIS, management of beaver dams to the extent necessary to prevent or mitigate flooding outside the restoration area, and revegetation planting.

Resources

There are many organizations and agencies in Vermont that support conservation easements and deed restrictions. Examples include:

Department of Environmental Conservation, Vermont Agency of Natural Resources
Natural Resources Conservation Service, U.S. Department of Agriculture
The Vermont chapter of The Nature Conservancy
Vermont Land Trust
Other local land trusts



Chapter 4. Regulatory Considerations

All wetland restoration projects in Vermont need to comply with federal, state, and local regulations. Depending on the size and complexity of the project, as well as the size and significance of the associated wetlands, this process will vary in the amount of time and effort involved. So, plan accordingly. Anything more involved than passive restoration or simple revegetation will likely at least require submitting a restoration plan to the Vermont Wetlands Program and receiving approval before work can begin.

In the sections below, we help you navigate the regulatory framework by describing the most relevant federal, state, and local regulations in turn. You will need to consider how each category of regulations may impact your project and understand that it is the responsibility of the project proponent to apply for and obtain all required approvals. While we lay out the basic framework of the relevant regulations here, it is always recommended to read the most current regulations and permitting conditions for yourself.

Regulatory Quick Reference Guide

MAJOR CONSIDERATIONS	Federal	U.S. Army Corps of Engineers General Permit	If your project is eligible for self-verification under General Permit 10, no application or notification is required. If not, Contact New England District of the USACE for pre-construction notification.
MAJOR CONSIDERATIONS	State	Vermont Wetland Rules	All projects, with few exceptions, must submit a restoration plan to the Vermont Wetlands Program and receive approval before work can begin. If your project involves placing fill or cutting trees in a wetland or its buffer, or constructing new access routes or trails, further State permitting may be required.
MAJOR CONSIDERATIONS	State	Vermont Stream Alteration Rule	If your project involves modifying a stream channel you may need a Stream Alteration Permit. Modifications greater than 10 cubic yards in perennial streams require permitting. Contact the District River Management Engineer.
MAJOR CONSIDERATIONS	Local	Zoning, Land Use, and Local Ordinances	Investigate your local regulations and contact the town Zoning Administrator or town Planning Commission to ask about any local concerns.

OTHER CONSIDERATIONS	**National Historic Preservation Act**: Applies to historical sites and archeological artifacts and remains. Contact the Division for Historic Preservation (VDHP).	**Flood Hazard and River Corridors:** Check ANR Atlas for nearby areas and corridors. Contact Town if project is located near a river or large stream.
OTHER CONSIDERATIONS	**Lake Encroachment Permitting and the Shoreline Protection Act:** May apply if project is within 250 feet of a lake or pond. Contact regional Lake and Shoreland Permit Analyst for technical assistance.	**Rare, Threatened, and Endangered Species:** Check ANR Atlas for nearby occurrences. Contact Vermont Fish & Wildlife Department if relevant.
OTHER CONSIDERATIONS	**Construction Stormwater Permit:** May apply for certain thresholds of earth disturbance. Contact Vermont Stormwater Division.	**Act 250:** Restoration projects must comply with the terms of existing Act 250 permits.
OTHER CONSIDERATIONS	**Easements and Covenants:** Restoration projects must comply with the terms and conditions of existing easements and covenants.	

Federal Regulations

In Vermont, the New England District of the U.S. Army Corps of Engineers (USACE) regulates work conducted in navigable waterways under the Rivers and Harbors Act, as well as the discharge of dredged or fill material into wetlands and aquatic areas under the Clean Water Act. This effectively means that all work within any wetland, stream, river, pond, or lake requires a permit from USACE.

U.S. Army Corps of Engineers - General Permits

To make the process more efficient, the New England District has issued general permits (GPs) for certain activities with minimal adverse effects on the aquatic environment. If your project qualifies for what is called self-verification authorization, the project may proceed in compliance with federal regulations without application or notification to the USACE. If it does not qualify for self-verification, a pre-construction notification must be submitted to the USACE, and written verification must be obtained before starting work. If you have any questions, contact information is available on the New England USACE website, and pre-application meetings are encouraged.

> Self-verification eligible projects must also comply with other federal laws such as the National Historic Preservation Act, the Endangered Species Act, and the Wild and Scenic Rivers Act. The Vermont Division of Historic Preservation must be contacted if any previously unknown historic, cultural, or archeological remains or artifacts are discovered during permitted work.

The most relevant GP for wetland restoration projects is GP 10, Aquatic Habitat Restoration and Enhancement Activities. It is important to note that USACE GPs are valid for 5 years and their conditions may change when they are renewed. Ensure that you are reviewing the most current GP criteria.

Example GP 10 from the 2022-2027 Department of Army General Permits for the State of Vermont:

<table>
<tr><td colspan="2">GP 10. Aquatic Habitat Restoration, Establishment and Enhancement Activities (Sections 10 and 404): Activities in waters of the United States (WOTUS) associated with the restoration, enhancement, and establishment of wetlands and riparian areas; the restoration and enhancement of streams and other open waters; the relocation of non-navigable WOTUS, including streams and associated wetlands for reestablishment of a natural stream morphology and reconnection of the floodplain; and the restoration and enhancement of shellfish, fin fish and wildlife, provided those activities result in net increases in aquatic resource functions and services.</td></tr>
<tr><td colspan="2">Not authorized under GP 10: Stream channelization activities.</td></tr>
<tr><td>Self-Verification Eligible</td><td>Pre-Construction Notification Required</td></tr>
<tr><td>1. No fill in Lake Champlain, Lake Memphremagog, Wallace Pond and adjacent wetlands
2. Permanent and temporary impacts are < 5,000 SF in waterways and/or wetlands
3. The activity does not convert a stream to wetland or vice versa, or wetland to a pond or uplands
4. Temporary structures in navigable WOTUS not exceeding 30 days</td><td>1. Work not eligible for self-verification
2. Permanent or temporary impacts are:
a. In Lake Champlain, Lake Memphremagog, Wallace Pond, adjacent wetlands; or
b. ≥5,000 SF in all other waterways and/or wetlands
3. Permanent structures in navigable WOTUS
4. Sea Lamprey control projects
5. Water impoundments
6. Dam removals
7. Restoration, establishment and/or enhancement activities approved for use by a USACE-approved in-lieu fee program or USACE-approved mitigation bank, with impacts of any size</td></tr>
</table>

Other GP General Conditions:

- No impacts on historic properties
- No impacts to federally threatened and endangered species
- No more than minimal impact on navigation
- Construction mats are allowed as temporary impacts
- Areas of temporary fill and/or cofferdams must be included in total impacts to determine eligibility
- No dewatering shall occur with direct discharge to waters or wetlands. Discharge points back into waters and wetlands shall use energy dissipators and erosion and sediment controls
- The material in sandbags shall not be released during removal
- In-stream work shall be conducted during the low flow period of July 1 to October 1 in any year

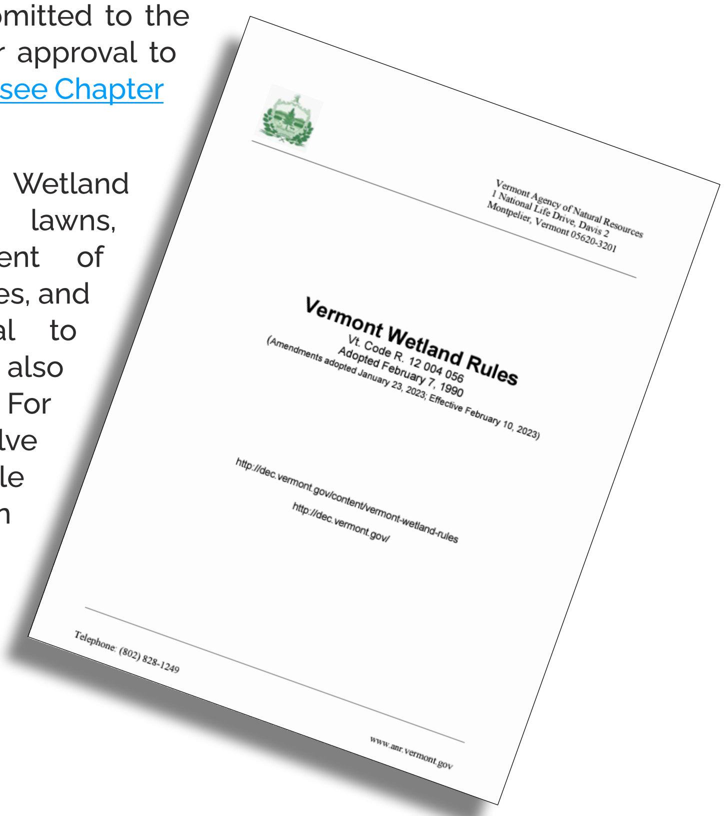
State Regulations

There are two major pieces of state legislation regulating activities likely to occur during wetland restoration: the Vermont Wetland Rules and the Vermont Stream Alteration Rule. We cover each in turn. Other potential state regulatory considerations are described at the end of the section.

Vermont Wetland Rules

Allowed Use

Wetland restoration, including invasive species management, is currently an allowed use under the Vermont Wetland Rules, provided that the activities are carried out in accordance with an approved plan. This means that wetland restoration projects taking place within wetlands or their buffers may not always need a permit, but they do always require a restoration plan to be submitted to the Vermont Wetlands Program, and for approval to be administered before work begins (see Chapter 2).



THE EXCEPTION: According to the Wetland Rules, "Activities within existing lawns, including mowing, the placement of barbecue pits, sand boxes, bird houses, and other similar activities incidental to ordinary residential use" are also considered an allowed use. For restoration projects that only involve passive restoration or simple revegetation planting, a restoration plan may not be necessary. If in doubt, contact the Vermont Wetlands Program for advice.

Permit Triggers

Though wetland restoration is an allowed use, there are certain activities that may be part of a restoration project that still require permitting. Your District Wetland Ecologist will determine whether or not your project requires permitting. Here are some guidelines:

FILL
Placement of fill within a regulated wetland or its buffer often triggers a permit requirement. This may be relevant if a project involves stockpiling soil or creating a new access route with roadbed material or other fill. However:
Fill used directly to restore ecological processes (such as when plugging ditches) likely won't trigger permitting.
Access routes built from temporary timber mats do not need a permit, so long as there is no cutting of woody vegetation, minimal soil compaction, and the mats are in place for less than one growing season.
Access routes that do not involve fill and are later restored during the project may not need a permit.
TRAILS
Creating new trails may require a permit.

Site Visits and Wetland Delineations

As part of the restoration plan review, the District Wetland Ecologist may require a site visit. This is more likely in scenarios where permits are potentially required, which is also when a formal wetland delineation conducted by a qualified professional would be required.

> i Most wetland delineations will need to be conducted during the growing season.

Vermont Stream Alteration Rule

The Vermont Stream Alteration Rule applies to perennial streams and watercourses. These streams generally have a watershed greater than 0.5 square miles and surface flows that are not frequently interrupted during normal seasonal low flow periods. A summarized version of the rule is as follows:

> *A person shall not change, alter, or modify the course, current, or cross section of any watercourse (i.e., perennial stream) by movement, fill, or excavation of ten cubic yards or more of instream material in any year, unless authorized.*

Many restoration projects will not involve the movement, fill, or excavation of ten cubic yards or more of instream materials, in which case authorization will not be necessary. If your plans do involve significant stream alteration, project managers should contact the DEC District River Management Engineer early in the planning process. They may require a site visit and can help you navigate the permitting process. Habitat improvement projects will likely be covered under the Vermont Stream Alteration General Permit.

> **Stream Alteration Planning Guidance:**
>
> Instream earthwork, bank stabilization, berm removal, and floodplain reconnection must be conducted between July 1 and October 1.
>
> Restoration practices that may, depending on the area affected, trigger the Vermont Stream Alteration Rule:
>
> - Woody Material Addition
> - BDA and PALS installation

Other State Considerations

Flood Hazard Areas and River Corridors

Flood hazard areas and river corridors are regulated by both municipalities and the state. These areas are defined in the Vermont Flood Hazard Area and River Corridor Rule, and maps of flood hazard areas and river corridors can be found on the ANR Atlas. If a flood hazard area, river corridor, or any perennial stream falls within 50 feet of your project area, you may need to obtain a permit. Contact your town Zoning Administrator or Planning Commission first to ask how to proceed. Then contact your regional River Scientist or regional Floodplain Manager if necessary. In general, projects will have to meet a No Adverse Impact Standard to avoid restricting or diverting the flow of flood waters.

Lake Encroachment Permitting and the Shoreline Protection Act

If your project is within 250 feet of a lake or pond you may need to navigate Lake Encroachment Permitting and the Shoreline Protection Act. Contact your regional Lake and Shoreland Permit Analyst for technical assistance.

Stormwater Construction Program

Construction activities that result in earth disturbance may require a Construction Stormwater Permit. This is generally for disturbances greater than 1 acre, but all projects involving earth disturbance should investigate the permitting requirements.

Rare, Threatened, and Endangered Species

Rare, threatened, and endangered species, both plants and animals, require special protection. Check for nearby occurrences and populations on the ANR Atlas and contact the Vermont Fish and Wildlife Department for advice if there are any within a half-mile of the project area.

Act 250 (Existing)

If a property has an existing Act 250 permit, you will need to make sure that the restoration project complies with the conditions of the permit. Contact your Act 250 District Coordinator for assistance.

Local Regulations and Property-Specific Restrictions

In addition to State and Federal permitting programs, individual towns, and some private properties may be encumbered by restrictions, rules, or regulations relevant to a wetland restoration project.

Local Regulations

Local regulations may also impact restoration projects, but are too varied to address in this manual. The best approach is to investigate any relevant local regulations early in the planning process and contact the town Zoning Administrator or Planning Commission to ask if they have any local concerns.

Easements and Covenants

If a property has an easement or covenant, you will need to make sure that the restoration project complies with their terms and conditions. Research the property ownership and easement holdings in the municipal land records. Relevant items may include conservation easements, utility rights-of-way, public trails, and public access easements.

Chapter 5. Monitoring, Evaluating Success, & Adaptive Management

Voluntary wetland restoration may not have monitoring or reporting requirements. However, a basic monitoring program is still a good idea and may be important if your project has sources of funding that require reporting. Monitoring allows you to understand how a restoration site changes over time and provides insight into the effectiveness of your treatments. Monitoring also helps you to catch issues early and respond accordingly.

Choose Your Monitoring Protocols

A good monitoring program is tailored to the project's goals, restoration practices, and reporting requirements. Start by figuring out what you need to know to evaluate success and avoid issues. Then choose a handful of monitoring protocols that give you the information you need without creating such a burden that monitoring becomes a waste of resources or fails to be completed.

If you choose to implement some of the more technical monitoring protocols, such as vegetation or wildlife surveys, it may be helpful to contact a state agency, local non-profit, or resource professional dedicated to environmental monitoring for assistance in establishing a useful and achievable design. When possible, try to use established methodologies and join monitoring efforts already occurring in Vermont. This will minimize the effort needed to design monitoring protocols while also ensuring reliable methods. Tapping into existing monitoring frameworks will also produce standardized data that can contribute to regional knowledge. Suggestions for ongoing monitoring programs to tie into are listed in the tables below.

Aerial drone photography of completed restoration sites, Ducks Unlimited

If You Do Nothing Else

At a minimum, you should include sufficient monitoring protocols to ensure your project is not causing more harm than good. Wetland restoration efforts can have unintended consequences, and it is better to catch potential problems before they get out of control.

Suggested Minimum Monitoring Protocols	
NNIS	NNIS monitoring is a specialized type of vegetation monitoring where only non-native invasive species are targeted. Because restoration practices usually disturb the soil or alter growing conditions in some way, all restoration projects should include NNIS monitoring. Any NNIS management efforts will also require follow-up monitoring for multiple years. NNIS monitoring can be as simple as walking the restoration site and noting or mapping where NNIS occur. iNaturalist can be a good tool for identifying unknown plants and documenting NNIS. An internet search of "Vermont invasive plant species" will turn up a lot of resources, and the VT Fish & Wildlife Department website is a good place to start.
Nearby Impact	Restoration projects taking place near other property boundaries or sensitive use areas will require regular monitoring to catch potential issues before they cause problems.
Erosion	Practices that involve disturbing soil, changing hydrology, or both, can result in unintended erosion. Some erosion is to be expected until successful plant establishment, but too much can cause water quality issues or lead restoration practices to fail. It is a good idea to regularly monitor fragile areas until they stabilize, especially during and after heavy rains or snowmelts. Be ready to implement adaptive erosion control practices as necessary.
Hydrology	Some of the practices involve altering a site's hydrology. In these cases, it is important to monitor the wetland and surrounding areas for ineffective treatments or unintended drying or flooding.
Maintenance	Some practices, such as BDA or PALS installation, may require maintenance until revegetation successfully stabilizes a site. These structures can also inadvertently send loose wood downstream, which may block culverts or cause other issues.

Restored depression, Ryan Creehan, USFWS

If You Want to Assess Overall Wetland Quality

Vermont Rapid Assessment Method for Wetlands (VRAM)

VRAM is a standardized and relatively rapid protocol designed to be used by a wide range of people to measure information about wetland function, value, and condition. It produces a repeatable and quantifiable metric of overall wetland quality that can be submitted to the Vermont Wetlands Program and contribute to public research into wetland restoration. VRAM should be the first monitoring protocol considered for assessing overall wetland quality.

VRAM is supported by the Vermont Wetlands Program, and the most up to date protocol can be found with an internet search for "Vermont Rapid Assessment Method for Wetlands User's Manual and Scoring Form." It may also be possible to receive VRAM training, especially in the winter months when the Wetlands Program is a little less busy.

Vermont Rapid Assessment Method	
VRAM	VRAM can be used to compare and select potential restoration sites, establish the baseline condition of a wetland prior to restoration, determine which components of a wetland would most effectively be restored, and compare the change in wetland condition after restoration and over time. Collect a VRAM score before any restoration activities, and then again 3-5 years after.

Restoration should aim to move a wetland towards the natural conditions expected for a site. Because VRAM is designed to assess the function of both intact and restored wetlands, not all indicators should be targets of restoration efforts. For example, a wetland receives a higher VRAM score if it is connected to a stream, but a restoration project should not force a stream connection that is not expected to occur naturally.

The table at right includes all the metrics and questions that make up a VRAM score. The table also marks the Restoration Indicators of Success, which are the useful and appropriate targets of restoration efforts.

VRAM Metrics and Restoration Indicators of Success	
Metric/Question	Restoration Indicator of Success?
Metric 1: Wetland Area	
Metric 2: Upland Buffers and Surrounding Land Use	
Question 2a: Average Buffer Width	**Yes**
Question 2b: Intensity of Predominant Surrounding Land Use(s)	
Metric 3: Hydrology	
Question 3a: Sources of Water	
Question 3b: Connectivity	
Question 3c: Average Maximum Water Depth	
Question 3d: Average Duration of Inundation/Saturation	
Question 3e: Human Modifications to Natural Hydrology	**Yes**
Metric 4: Habitat Alteration and Development	
Question 4a: Substrate/Soil Disturbance	**Yes**
Question 4b: Habitat Development	**Yes**
Question 4c: Habitat Alteration	**Yes**
Metric 5: Vermont's Natural Heritage	
Metric 5: Habitat Structure and Microtopography	
Question 6a: Vegetation Cover Types	**Yes**
Question 6b: Diversity of Habitat Types	**Yes**
Question 6c: Coverage of Invasive Plants	**Yes**
Question 6d: Microtopography	**Yes**

If You Want Specialized Information

You may want to include a small number of supplemental monitoring protocols and reporting metrics into your plans if you or your funders are interested in specific information. Examples are included below.

Other Potential Monitoring Metrics and Protocols	
Vegetation Monitoring	Vegetation monitoring can allow you to compare changes in vegetation before and after treatment, compare differences in vegetation between control plots and treatment plots, and quantify trends over time. A vegetation monitoring protocol based on a permanent plot system could provide more information about plant diversity, abundance, and structure than is collected in VRAM. GPS points, stakes, posts, or other markers are useful for establishing reliable locations. It is a good idea to place your plot in a representative part of your project area, or to pick a few different plot sites if conditions are variable. A simple vegetation monitoring method is to estimate a percent cover of the different vegetation layers (for example bare ground, herbaceous, shrub, tree). Another useful option is to create a plant list for each natural community type in your restoration area. If you are looking for more detailed methods, the Vermont Wetlands Program's Biological Monitoring of Vermont's Wetlands report provides an example of a standardized monitoring protocol in Vermont. Another option is to use the Vermont Fish and Wildlife Natural Community Citizen Reporting Form.
Revegetation Efforts	Documenting the quantity and species of plants planted can be useful for communicating your revegetation efforts. This could be number of stems, stems per acre, area seeded, or area treated with live stakes.
Plant Survivability	Expect that some percentage of a revegetation planting will die. Depending on the size of the treatment area, you could monitor every plant or establish a sampling protocol. Plant survivability monitoring can be used to quantify revegetation success, direct replanting efforts, and discover trends in planting success.
Wildlife Monitoring	Wildlife monitoring protocols could include amphibian egg mass surveys, camera traps, track and sign observation, bird surveys, invertebrate surveys, or whatever suits your project needs. The Vermont Center for Ecostudies is a great resource for amphibian egg mass surveys, bird surveys, and invertebrate surveys, and other non-profits or agencies could be helpful resources as well. Even if you do not conduct formal surveys, pictures of wildlife and wildlife tracks can offer exciting evidence of wildlife use of a restored wetland. Creating ongoing observation lists using eBird, Merlin Bird ID, and iNaturalist can also paint a rich picture of the biodiversity of your site.
Wetland Extent	Many of the wetland restoration practices will result in an increased extent of saturated soils and surface water. Surface area, number of pools created, and water storage volume can all be reported. These metrics can be used to confirm the completion of restoration treatments, document the extent of habitat enhancement, and describe potential stormwater mitigation or water infiltration. Some large projects may want to install monitoring wells to track hydrology patterns over time.
Treatments Completed	Completed restoration treatments should be documented. Depending on your treatments, this could be the length of filled ditching, area of tile drain rendered ineffective, area treated with hummock/hollow creation, or number of BDAs or PALS installed.
Garbage Removed	The weight of refuse material (e.g., old buildings, infrastructure, fill, trash) removed from site can be a useful metric of restoration impact.
Repeat Photo Points	Photographs taken at the same location and angle across time can convey multiple qualitative features of a site before, during, and after restoration. GPS points, stakes, posts, or other markers are useful for establishing reliable locations.
Volunteer Input	Documenting volunteer hours or number of volunteers contributing to a restoration project can be useful for quantifying in-kind contributions and community engagement.
Educational Impact	Measures of student involvement, number of educational signs created, annual visitors, or the reach of any engagement material produced about the restoration can be used to quantify educational impact.

Timelines

Give each monitoring protocol or reporting metric a timeline, as appropriate. Some monitoring, such as erosion monitoring, should be completed regularly until the site is stabilized. Other metrics could be given a more formal timeline, such as a yearly plant survivability assessment for the first 3 years, or vegetation monitoring at years 0, 2, 5, and 10.

Make necessary assessments before restoration practices take place to establish a baseline, then follow up afterwards according to your timelines.

Evaluating Success

To reliably evaluate the success of your restoration project, set objective and verifiable goals that are based on conditions observed in a reference site.

Some components of a restoration project will be successful just by being completed. If you remove all the garbage and old buildings from a site, that is a success. Likewise, aiming to remove a certain amount of ditching, plant a certain density of plants, or increase the area of wetlands on a site, then completing those tasks is a success. Other components of restoration might show signs of success in a year or 2. Sometimes a newly created shallow depression can start functioning as a vernal pool with successful amphibian breeding as soon as the next spring, while other components of a restoration project might take years, or even decades, of development before you know if you have been successful or not. Trees take a long time to grow to maturity, and plant communities go through many successional changes.

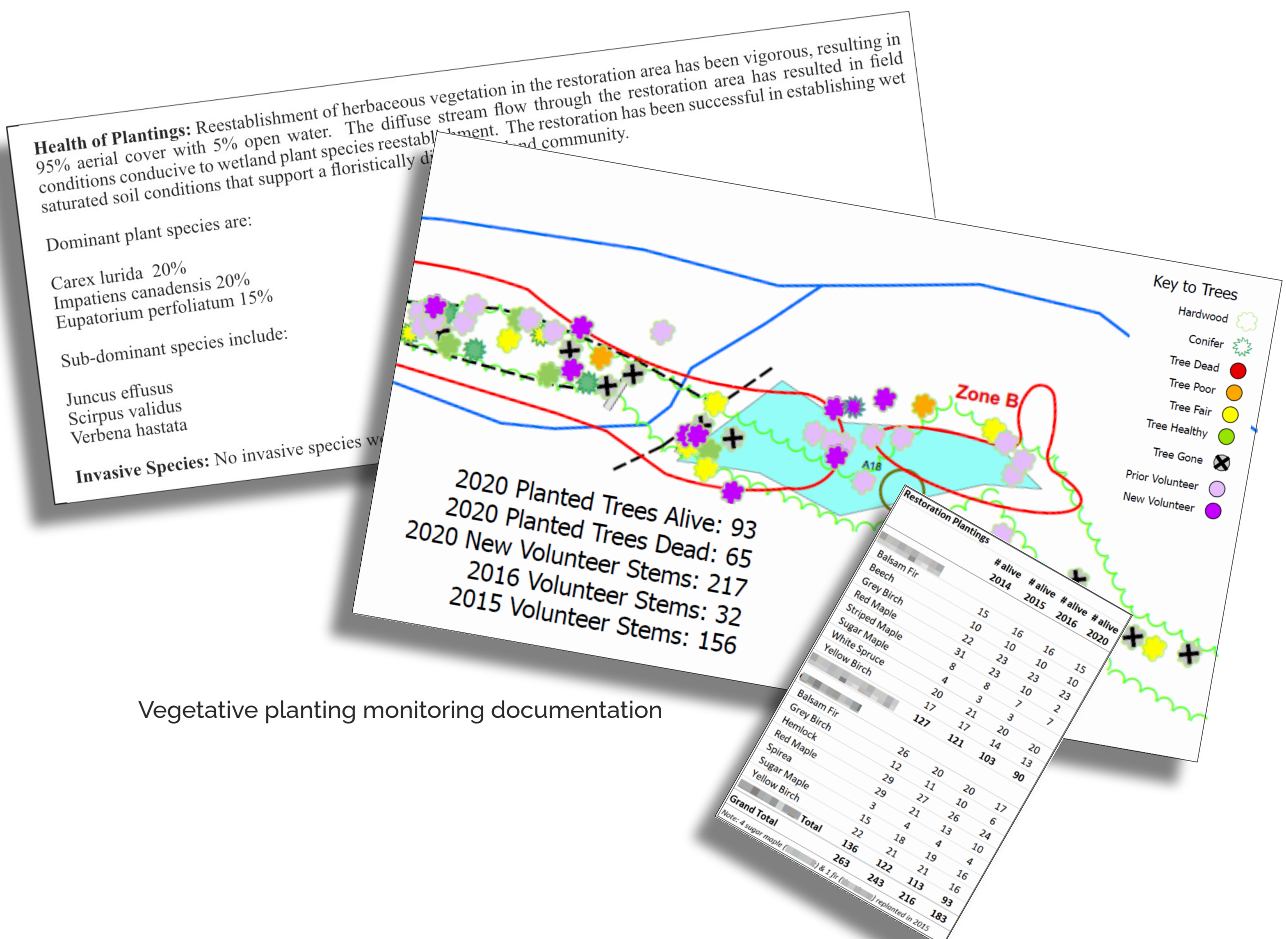
Example Measures of Success
All slopes, soils, substrates, and constructed features within and adjacent to the restoration site(s) are stable immediately after construction.
Target water depth and hydroperiod met within the first year after construction.
At least 500 surviving trees and shrubs per acre, by year 5, in the forested cover types.
>60% coverage by native species by the end of the first growing season, >85% by the end of the second growing season, and >95% by the end of the monitoring period.
Soil has documented evidence of redoximorphic (rusty mottling) features developing by the third year after construction.
NNIS target species are treated yearly and eliminated by year 5.
By year 5, there is evidence of expected natural colonization as documented by the presence of at least 100 volunteer native trees and/or shrubs at least 3 feet in height per acre.
Along any stream channel, to ensure stream shading, banks have >95% cover with native woody species which are >5 feet in height by the end of the fifth growing season.
The year 5 and year 10 monitoring reports contain documentation that all vegetation within the buffer areas is healthy and thriving and the average tree height of all established and surviving trees is at least 5 feet.
Site will have documented use by breeding populations of target species (e.g., spotted salamanders and wood frogs).
The site will have documented use by target macroinvertebrates by year 3 (e.g., caddisflies).

Adaptive Management

Further management will often be required after the initial restoration treatment, and this should be accounted for in timelines and budgets. Your chosen monitoring protocols will guide you here. Dead plants may need to be replaced, erosion issues may need to be fixed, and non-native invasive species will need follow-up treatments. When running water is involved, be prepared for the unexpected. Fragile banks may need to be fortified with additional plantings to control and/or prevent erosion. If things don't go as planned, it may not necessarily be a bad thing. Sometimes natural processes (for example, beaver activity) may take over, and expectations and management decisions will need to be updated to reach long-term goals.

Challenges and Solutions

- ◻ Monitoring can be time consuming, expensive, and require expertise. Find the balance between too little monitoring, which can lead to unaddressed issues and a poor understanding of restoration effectiveness, and too much monitoring, which may be unnecessary, costly, or performed poorly.
- ◻ Some metrics may benefit from pre-treatment monitoring to tell a full story, so plan accordingly.
- ◻ Monitoring goals may extend beyond funding timelines. Plan for this by setting aside money, finding other funding sources, or paring down your monitoring plans.
- ◻ Adaptive management should be expected and budgeted for.
- ◻ Forested wetlands may take many decades to reach maturity, and evaluation measures will have to account for this. Try evaluating the trajectory of target species.



Restoration Plantings

	#alive 2014	#alive 2015	#alive 2016	#alive 2020
[redacted]				
Balsam Fir	15	16	16	15
Beech	10	10	10	10
Grey Birch	22	23	23	23
Red Maple	31	23	10	2
Striped Maple	8	8	7	7
Sugar Maple	4	3	3	
White Spruce	20	21	20	20
Yellow Birch	17	17	14	13
[redacted]	**127**	**121**	**103**	**90**
[redacted]				
Balsam Fir	26	20	20	17
Grey Birch	12	11	10	6
Hemlock	29	27	26	24
Red Maple	29	21	13	10
Spirea	3	4	4	4
Sugar Maple	15	18	19	16
Yellow Birch	22	21	21	16
[redacted] Total	**136**	**122**	**113**	**93**
Grand Total	**263**	**243**	**216**	**183**

Note: 4 sugar maple ([redacted]) & 1 fir ([redacted]) replanted in 2015

Vegetative planting monitoring documentation

Conclusion

Wetland restoration is about doing our best to improve the health and function of degraded wetland ecosystems. If a plan starts to become large and overwhelming, remember that oftentimes simple is just as effective as complex, and all efforts large and small are important. We hope that this guide helps you make sense of the ecosystems around you and achieve your restoration goals. Thank you for your interest and efforts.

Outline for an Effective Wetland Restoration Project

Define your project purpose and select a site

- Choose one or two primary goals.
- Compare site restoration potential with project goals.

Understand your site

- What does your site look like now?
- What would the site look like without human-caused disturbance?
- How have natural ecological processes been altered?
- What are the minimum restoration practices necessary to achieve healthy ecosystem function and your project goals?
- Identify challenges.

Draft a concept restoration plan and make a feasibility assessment

- Contact the Vermont Wetlands Program to make sure you're on the right track.

Develop a restoration plan

- Keep it simple and effective.
- Map and plan restoration practices.
- Outline permitting requirements.
- Outline project schedule.
- Describe monitoring and management expectations.

Submit plan and apply for any necessary permits

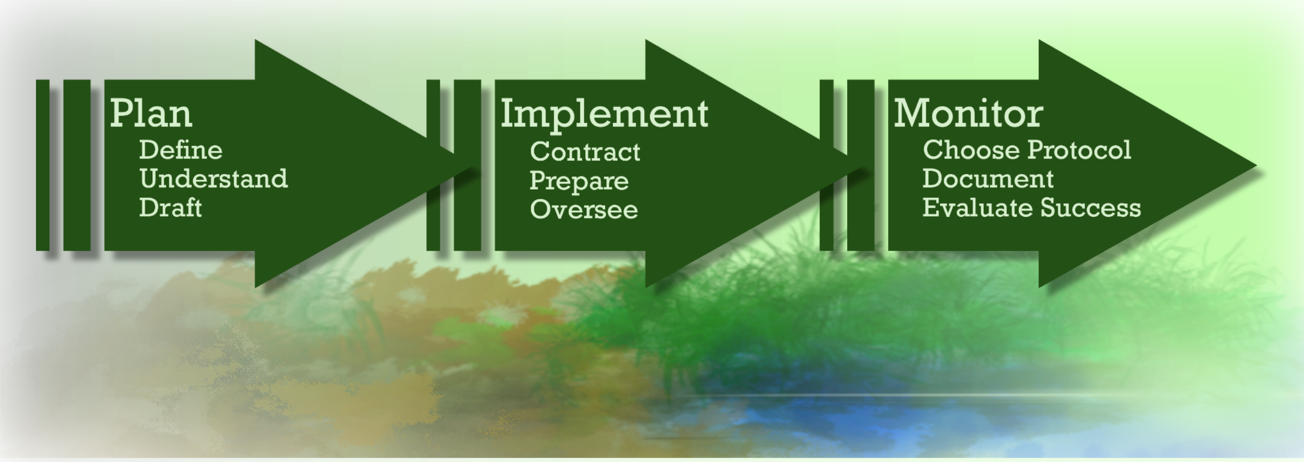
- Work cannot begin until plan is approved and any necessary permits are acquired.

Begin restoration activities

- Adapt to site conditions while following plan and permits requirements.

Conduct post-treatment monitoring and adaptive management

- Catch any issues before they cause damage or become difficult to deal with.



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