Saint Mary's University of Minnesota
GeoSpatial Services

Fieldwork Report and Technical Procedures Guidance for National Wetland Inventory Update, Vermont

Phase 1, Phase 2, Winooski, Otter Creek, Pike, and Lamoille

This report was prepared in May 2023 by Kevin Stark, Zachary Ansell, Katie Engelmann, Nicholas Lemcke, and Andrew Smith of GeoSpatial Services, Saint Mary's University of Minnesota for the State of Vermont and the U.S. Fish and Wildlife Service, National Wetland Inventory, Region 5.

GeoSpatial Services
Saint Mary's University of Minnesota
702 Terrace Heights,
Winona, MN 55987
geospatialservices.org

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GEOSPATIAL SERVICES • SAINT MARY’S UNIVERSITY OF MINNESOTA
702 Terrace Heights • Box 7 • Winona, MN 55987-2440 USA • 507-457-8746 • Fax 507-457-6604 • www.geospatialservices.org

Acronyms and Abbreviations

CIR – Color Infrared

DEM – Digital Elevation Model

ESRI - Environmental Systems Research Institute, Inc.

GSS – GeoSpatial Services

HUC - Hydrologic Unit Code

LiDAR - Light Detection and Ranging

LLWW – Landscape Position, Landform, Water Flow Path, Waterbody Type

NHD – National Hydrography Dataset

NWI - National Wetlands Inventory

SMUMN – Saint Mary's University of Minnesota

SSURGO - Soil Survey Geographic Database

TMU – Target Mapping Unit

USFWS - U.S. Fish and Wildlife Service

USGS - United States Geological Survey

VCGI – Vermont Center for Geographic Information

VDEC – Vermont Department of Environmental Conservation

1. Introduction

The purpose of this report is to summarize wetland information collected in the field for the current project areas in Vermont. This report will also serve as a technical procedures document (methods) as this field data will be an aid for mapping decisions and for developing mapping conventions.

Multiple field trips were conducted to collect baseline information for identifying and classifying habitat features within the National Wetlands Inventory (NWI) guidelines set forth in "Classification of Wetlands and Deepwater Habitats of the United States" (Cowardin, 1979). This fieldwork will guide mapping efforts through on-ground observations, photographs, and documentation of wetland parameters including hydrology, soils, and vegetation.

This report also illustrates information obtained from selective, in-field check sites to compare imagery signatures along with other collateral datasets to observations collected on the ground. This report describes correlations between imagery signatures, wetland parameter(s) and NWI classifications.

2. Project Area

The project area for this mapping work in Vermont is comprised of four separate contract areas and is broken up by 12-digit hydrologic unit code (HUC) sub-watersheds (Figure 1).

Phase 1 includes 126 HUC 12 watersheds. Main areas within Phase 1 include Lake Champlain and the Connecticut River Basin.

Phase 2 includes 64 HUC 12 watersheds. Main areas within Phase 2 include: Lake Memphremagog, Southern Lake Champlain, and Batten Kill-Walloomsac-Hoosic.

Winooski and Otter Creek Tactical Basins were also a part of this project which consisted of 51 HUC 12 watersheds. Headwaters Pike River HUC 12 watershed was also included in this contract area.

Lamoille included 4 HUC 12 watersheds and was completed by a previous contractor. Geospatial Services (GSS) was contracted to provide quality assurance and complete LLWW coding.

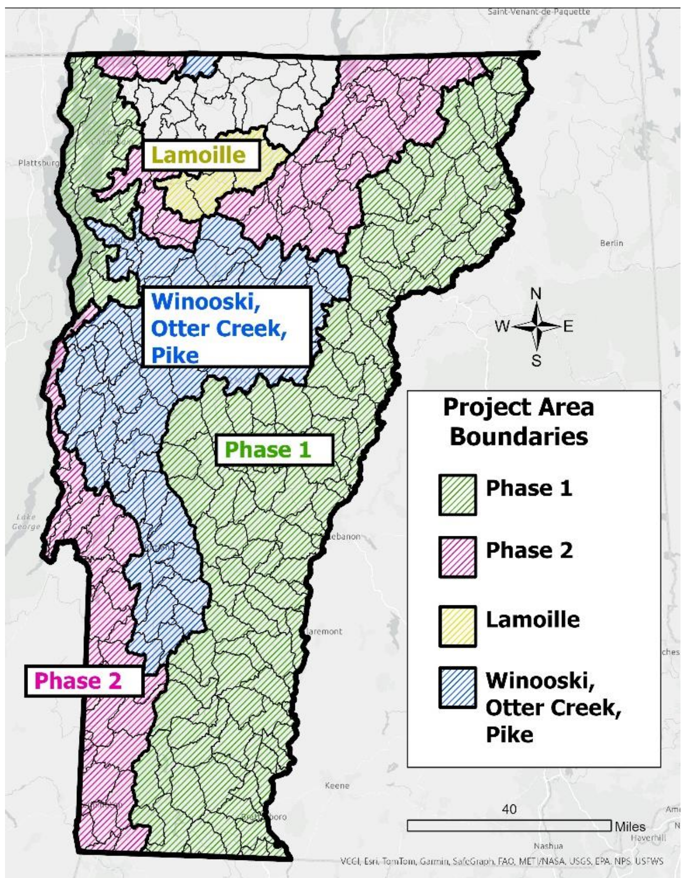


Figure 1. The project areas showing Phase 1 (green), Phase 2 (pink), Winooski/Otter Creek and Pike (blue), and Lamoille (gold). HUC 12 watersheds are also shown with black boundary.

2.1 Ecoregions

Ecoregions are areas where ecosystems (and the type, quality, and quantity of environmental resources) are generally similar (Griffith et al 2009). Level III Ecoregions are a more generalized grouping of ecoregions compared with the finest scale of Ecoregions in Griffith et al (2009), Level IV ecoregions. Most of Vermont falls withing the Northeastern Highlands Level III ecoregions with some of the western portion of the state, near Lake Champlain in the Eastern Great Lakes Level III ecoregion. Level III and IV ecoregions are shown in Figure 2.

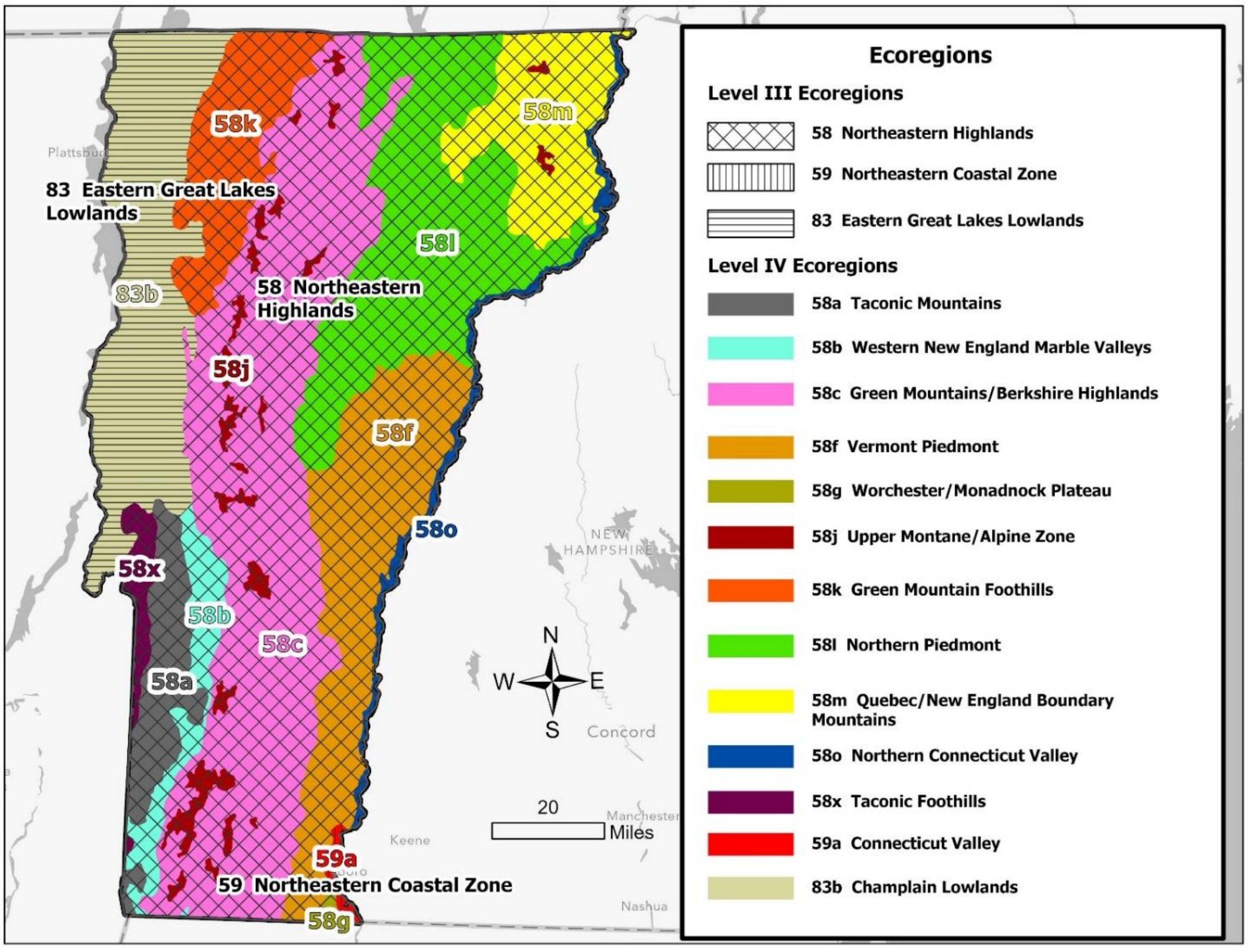


Figure 2. Level III and Level IV Ecoregions of Vermont (United States Environmental Protection Agency).

Descriptions of each Level III ecoregion from Griffith et al (2009) are as follows:

58 Northeastern Highlands: The Northeastern Highlands ecoregion covers most of the northern and mountainous parts of New England as well as the Adirondacks in New York. It is a relatively sparsely populated region compared to adjacent regions, and is characterized by hills and mountains, a mostly forested land cover, nutrient-poor frigid and cryic soils (mostly Spodosols) (*NOTE: Spodosols are not common in Vermont*), and numerous high-gradient streams and glacial lakes. Forest vegetation is somewhat transitional between the boreal regions to the north in Canada and the broadleaf deciduous forests to the south. Typical forest types include northern hardwoods (maple-beech-birch), northern hardwoods/spruce, and northeastern spruce-fir forests. Recreation, tourism, and forestry are primary land uses. Farm-to-forest conversion began in the 19th century and continues today. In spite of this trend, alluvial valleys, glacial lake basins, and areas of limestone-derived soils are still farmed for dairy products, forage crops, apples, and potatoes. In addition to the timber industry, recreational homes and associated lodging and services sustain the forested regions economically, but they also create development pressure that threatens to change the pastoral character of the region. Many of the lakes and streams in the region are sensitive to acidic deposition originating from industrial sources upwind from the ecoregion, particularly to the west.

59 Northeastern Coastal Zone: The Northeastern Coastal Zone ecoregion covers most of southern New England and the coastal areas of New Hampshire and southern Maine. Its landforms include irregular plains and plains with low to high hills. Appalachian oak forests and northeastern oak-pine forests are the natural vegetation types, with mostly mesic Inceptisol soils. Similar to the Northeastern Highlands (58), the Northeastern Coastal Zone contains relatively nutrient-poor soils and concentrations of continental glacial lakes, some of which are sensitive to acidification. This ecoregion, however, contains considerably less surface irregularity and greater concentrations of human population than Ecoregion 58. Although attempts were made to farm much of the Northeastern Coastal Zone after the region was settled by Europeans, land use now mainly consists of forests, woodlands, and urban and suburban development, with only some minor areas of pasture and cropland.

NOTE: This ecoregion is only in a very small part of SW Vermont.

83 Eastern Great Lakes Lowlands: This glaciated region of irregular plains bordered by hills generally contains less surface irregularity and more agricultural activity and population density than the adjacent Northeastern Highlands (58) and Northern Allegheny Plateau (60). Although orchards, vineyards, and vegetable farming are important locally, a large percentage of the agriculture is associated with dairy operations.

NOTE: the Champlain Valley which falls within the Eastern Great Lakes Lowlands is more agricultural landscape and has more urban environments than the much of the rest of the state of VT. The area also has large wetland complexes, is warmer and experiences less snowfall than the rest of the state.

2.2 Climate

According to the Koppen Climate Classification (Koppen, 1936; Kottek et al, 2006) the vast majority of Vermont is classified as a humid, continental climate with snowy winters and warm summers (Dfb). Annual precipitation averages range from approximately 33 inches per year in areas of lower relief, to over 68 inches in the mountainous alpine areas (Figure 3).

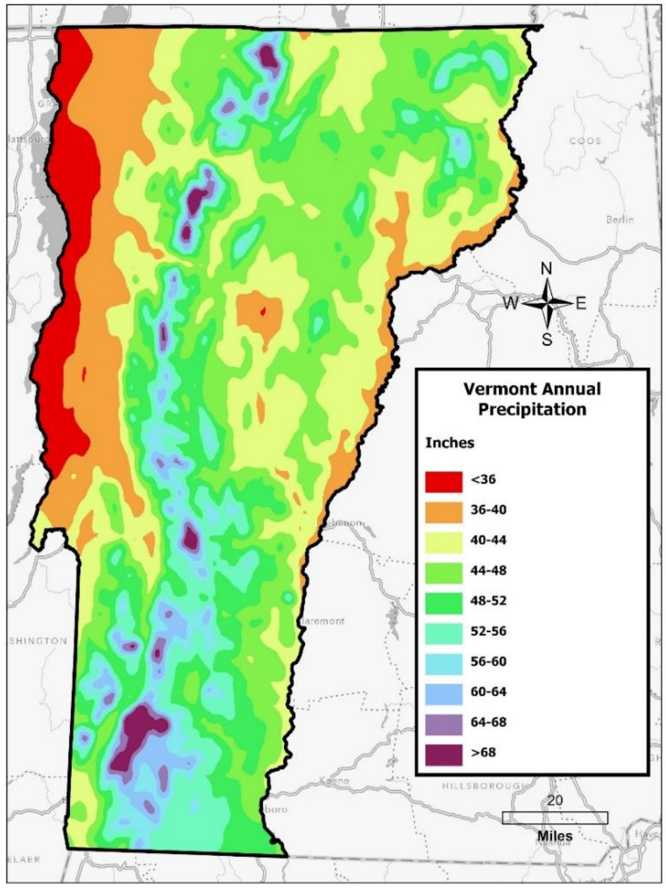


Figure 3. Statewide map of Vermont showing average annual precipitation data in inches (Natural Resources Conservation Service, Vermont).

2.3 Vegetation

A diversity of wetland types were reviewed for plant community verification to be related to aerial photo interpretation signatures. Photo interpretation signatures include grain, texture, and color pattern observed in base imagery. The field data collection is informative for determining appropriate NWI wetland classifications, and wetland/upland boundaries and boundaries between adjacent wetland classification types. Dominant forms of vegetation were observed and related to appropriate NWI alpha-numeric classification codes. Digital photos of each sample site were recorded. Locations of vegetation verification points were recorded using ArcGIS Fieldmaps technology.

Dominant vegetation strata are recorded (trees, shrubs, emergent) to define Class. Vegetation Class is determined by the uppermost layer of vegetation that comprises an aerial coverage of 30 percent or greater. Onsite verification of Subclasses according to leaf type (broad-leaved deciduous, needle-leaved evergreen) were also distinguished and recorded. For the purpose of wetland determinations, the wetland indicator status of dominant species were determined using the National List of Plant Species that Occur in Wetlands: Northcentral and Northeast Region.

2.4 Soils

Hydric soil indicators evaluated include: low chroma matrix; redoximorphic features including mottling, accumulations of Fe-Mn oxides nodules, concretions, masses and pore linings; grey/green/bluish colors associated with iron forms in a reduced stated; and presence of thick organic layers. Soil colors were determined by using Munsell Soil Color Charts (2000).

For example, on sloped, partially-drained farmland, soils were observed with a low chroma matrix and included redox concentrations and precipitated Fe lines along root channels. Poorly drained Cabot soils were observed in a northern white cedar swamp and in a sloped alder-willow swamp seep. In these examples, a hardpan held water near the surface. Organic, dark/black colored muck soil comprised of highly decomposed plant material was observed in a black spruce/tamarack peatland.

3. NWI Cowardin Classification System

Since its publication in 1979, Classification of Wetlands and Deepwater Habitats of the United States (Cowardin, 1979) has been used in the NWI conducted by the U.S. Fish and Wildlife Service (USFWS). Listed below are definitions of relevant wetland codes that are used in the study area (Cowardin, 1979).

3.1 NWI systems, subsystems, classes, and subclasses

3.1.1 Riverine (R)

The Riverine System includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts in excess of 0.5 parts per thousand.

<u>Riverine Subsytems:</u>

Lower Perennial (R2) - This Subsystem is characterized by a low gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists mainly of sand and mud. Oxygen deficits may sometimes occur. The fauna is composed mostly of species that reach their maximum abundance in still water, and true planktonic organisms are common. The gradient is lower than that of the Upper Perennial Subsystem and the floodplain is well developed.

Upper Perennial (R3) - This Subsystem is characterized by a high gradient. There is no tidal influence, and some water flows all year, except during years of extreme drought. The substrate consists of rock, cobbles, or gravel with occasional patches of sand. The natural dissolved oxygen concentration is normally near saturation. The fauna is characteristic of running water, and there are few or no planktonic forms. The gradient is high compared with that of the Lower Perennial Subsystem, and there is very little floodplain development.

<u>Riverine Classes:</u>

Unconsolidated Bottom (UB) - Includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%.

Unconsolidated Shore (US) - Includes all wetland habitats having two characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders or bedrock and; (2) less than 30 percent areal cover of vegetation. Landforms such as beaches, bars, and flats are included in the Unconsolidated Shore class.

3.1.2 Lacustrine (L)

The Lacustrine System includes wetlands and deepwater habitats with all of the following characteristics: (1) situated in a topographic depression or a dammed river channel; (2) lacking trees, shrubs, persistent emergents, emergent mosses or lichens with greater than 30% areal coverage; and (3) total area exceeds 8 ha (20 acres). Similar wetland and deepwater habitats totaling less than 8 ha are also included in the Lacustrine System if an active wave-formed or bedrock shoreline feature makes up all or part of the boundary, or if the water depth in the deepest part of the basin exceeds 2 meters (6.6 feet) at low water. Lacustrine waters may be tidal or non-tidal, but ocean-derived salinity is always less than 0.5 parts per thousand.

Lacustrine Subsystems:

Limnetic (L1) - This subsystem includes all deepwater habitats (i.e., areas > 2 m [6.5 ft.] deep below low water) in the Lacustrine System. Many small Lacustrine Systems have no Limnetic Subsystem.

Littoral (L2) - This subsystem includes all wetland habitats in the Lacustrine System. It extends from the shoreward boundary of the System to a depth of 2.5 m (8.2 ft.) below low water, or to the maximum extent of non-persistent emergents if these grow at depths greater than 2.5 m.

Lacustrine Classes:

Unconsolidated Bottom (UB) - Includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%.

Aquatic Bed (AB) - Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Unconsolidated Shore (US) - Includes all wetland habitats having two characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders or bedrock and; (2) less than 30 percent areal cover of vegetation. Landforms such as beaches, bars, and flats are included in the Unconsolidated Shore class.

Emergent (EM) - Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants (only applies to L2EM2 (non-persistent).

3.1.3 *Palustrine (P)*

The Palustrine System includes all non-tidal wetlands dominated by trees, shrubs, persistent emergents, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity due to ocean-derived salts is below 0.5 parts per thousand. It also includes wetlands lacking such vegetation, but with all of the following four characteristics: (1) area less than 8 ha (20 acres); (2) active wave-formed or bedrock shoreline features lacking; (3) water depth in the deepest part of basin less than two meters at low water; and (4) salinity due to ocean-derived salts less than 0.5 parts per thousand.

<u>Palustrine Classes:</u>

Unconsolidated Bottom (UB) - Includes all wetlands and deepwater habitats with at least 25% cover of particles smaller than stones (less than 6-7 cm), and a vegetative cover less than 30%

Aquatic Bed (AB) - Includes wetlands and deepwater habitats dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years.

Unconsolidated Shore (US) - Includes all wetland habitats having two characteristics: (1) unconsolidated substrates with less than 75 percent areal cover of stones, boulders or bedrock and; (2) less than 30 percent areal cover of vegetation. Landforms such as beaches, bars, and flats are included in the Unconsolidated Shore class.

Emergent (EM) - Characterized by erect, rooted, herbaceous hydrophytes, excluding mosses and lichens. This vegetation is present for most of the growing season in most years. These wetlands are usually dominated by perennial plants.

<u>EM Subclasses</u>

Persistent (1) - Dominated by species that normally remain standing at least until the beginning of the next growing season. This subclass is found only in the Estuarine and Palustrine systems.

Non-persistent (2) - Wetlands in this subclass are dominated by plants which fall to the surface of the substrate or below the surface of the water at the end of the growing season so that, at certain seasons of the year, there is no obvious sign of emergent vegetation.

Scrub-Shrub (SS) - Includes areas dominated by woody vegetation less than 6 m (20 feet) tall. The species include true shrubs, young trees (saplings), and trees or shrubs that are small or stunted because of environmental conditions.

<u>SS Subclasses</u>

Broad-Leaved Deciduous (1) - Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (Fraxinus nigra).

Needle-Leaved Deciduous (2) – This subclass, consisting of wetlands where trees or shrubs are predominantly deciduous and needle-leaved, is represented by young or stunted trees; e.g. tamarack (Larix laricina).

Broad-Leaved Evergreen (3) – Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that generally remain green and are usually persistent for a year or more; e.g. leatherleaf (Chamaedaphne calyculata).

Needle-Leaved Evergreen (4) – The dominant species in Needle-leaved Evergreen wetlands are young or stunted trees; e.g. black spruce (Picea mariana), northern white cedar (Thuja occidentalis).

Dead (5) – Dead woody plants less than 6 m tall dominate dead scrub-shrub wetlands. These wetlands are usually produced by a prolonged rise in the water table resulting from impoundment of water by landslides, man, or beavers. Current NWI policy restricts this attribute to water regimes of semi-permanently flooded or wetter.

Forested (FO) - In Forested Wetlands, trees are the dominant life form—i.e., the tallest life form with at least 30 percent areal coverage. Trees are defined as woody plants at least 6 m (20 ft) in height. All Water Regimes except Subtidal and Regularly

FO Subclasses

Broad-Leaved Deciduous (1) - Woody angiosperms (trees or shrubs) with relatively wide, flat leaves that are shed during the cold or dry season; e.g., black ash (Fraxinus nigra). Flooded-Tidal Fresh are included. Not all Water Regimes apply to all subclasses.

Needle-Leaved Deciduous (2) – This subclass, consisting of wetlands where needle-leaved deciduous species have the greatest areal coverage in the tree layer predominantly deciduous and needle-leaved. Tamarack is characteristic of the Boreal Forest Region, where it occurs as a dominant on organic soils. Relatively few other species are included in this Subclass.

Needle-Leaved Evergreen (4) – In this Subclass, needle-leaved evergreen species have the greatest areal coverage in the tree layer. Black spruce, growing on nutrient-poor organic soils, represents a major dominant of the Needle-leaved Evergreen Subclass in the North. Eastern arborvitae (Thuja occidentalis) dominates northern wetlands on more nutrientrich sites.

Dead (5) – This Subclass includes stands of dead woody plants at least 6 m tall, regardless of their density, with less than 30 percent cover of living vegetation. If living vegetation 36 Federal Geographic Data Committee FGDC–STD-004-2013 Classification of Wetlands and Deepwater Habitats equals or exceeds 30 percent in such stands, the Class and Subclass are based on the dominant life form of the living plants. Dead Forested Wetlands usually are produced by a prolonged rise in the water level resulting from impoundment by humans or beavers.

3.1.4 Upland:

The term upland means any land area that under normal circumstances does not satisfy wetland parameters (i.e., hydrology, hydrophytic vegetation, hydric soils) and does not lie below the ordinary high water mark or the high tide line of a jurisdictional water. Upland may consist of mountains and glaciers, highly sloped hills and cliffs, rock outcrops, areas without wetland plant species (non-hydrophytic), and roads or towns that have been human-modified on the natural landscape.

3.2 NWI Water Regimes

Water regimes are listed from wettest to driest in each list. Water regimes of G and J will not be used in Phase 1 and Phase 2 of the Vermont study areas. G – Intermittently exposed is a restricted regime for Region 5. J – Intermittently flooded is omitted due to NWI 3.0 conventions.

3.2.1 Inland Flooded - (Lacustrine, Riverine, Palustrine)

H - Permanently Flooded - Water covers the substrate throughout the year in all years.

G - Intermittently Exposed - Water covers the substrate throughout the year except in years of extreme drought.

F - Semi-permanently Flooded - Surface water persists throughout the growing season in most years. When surface water is absent, the water table is usually at or very near the land surface.

C - Seasonally Flooded - Surface water is present for extended periods especially early in the growing season, but is absent by the end of the growing season in most years. The water table after flooding ceases is variable, extending from saturated to the surface to a water table well below the ground surface.

A - Temporarily Flooded - Surface water is present for brief periods (from a few days to a few weeks) during the growing season, but the water table usually lies well below the ground surface for the most of the season.

J - Intermittently Flooded - The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.

K - Artificially Flooded - The amount and duration of flooding are controlled by means of pumps or siphons in combination with dikes, berms, or dams. The vegetation growing on these areas cannot be considered a reliable indicator of Water Regime. Examples of Artificially Flooded wetlands are some agricultural lands managed under a rice-soybean rotation, and wildlife management areas where forests, crops, or pioneer plants may be flooded or dewatered to attract wetland wildlife. Neither wetlands within nor resulting from leakage from man-made impoundments, nor irrigated pasturelands supplied by diversion ditches or artesian wells, are included under this Modifier. The Artificially Flooded Water Regime Modifier should not be used in the Riverine system or for impoundments or excavated wetlands unless both water inputs and outputs are controlled to achieve a specific depth and duration of flooding.

3.2.2 Inland Saturated - (Palustrine)

E – Seasonally Flooded/Saturated - Surface water is present for extended periods (generally for more than a month) during the growing season, but is absent by the end of the season in most years. When surface water is absent, the substrate typically remains saturated at or near the surface.

NOTE: The E water regime was used in some cases along low-gradient streams and in some lake margins in this project work.

D – Permanently Saturated - The substrate is saturated at or near the surface throughout the year in all, or most, years. Widespread surface inundation is rare, but water may be present in shallow depressions that intersect the groundwater table, particularly on a floating peat mat.

B – Seasonally Saturated - The substrate is saturated at or near the surface for extended periods during the growing season, but unsaturated conditions prevail by the end of the season in most years. Surface water is typically absent, but may occur for a few days after heavy rain and upland runoff.

3.3 Special Modifiers

Beaver (b) - These wetlands have been created or modified by beaver (Castor canadensis). Dam building by beaver may increase the size of existing wetlands or create small impoundments that are easily identified on aerial imagery. Such flooding frequently creates Dead Forested or Dead Scrub-Shrub Wetland initially, followed in a few years by Aquatic Bed and Emergent Wetland.

Partially ditched/drained (d) - A partly drained wetland has been altered hydrologically, but soil moisture is still sufficient to support hydrophytes. Drained areas that can no longer support hydrophytes are not considered wetland. This Modifier is also used to identify wetlands containing, or connected to, ditches. The Partly Drained/Ditched Modifier can be applied even if the ditches are too small to delineate. The Excavated Modifier should be used to identify ditches that are large enough to delineate as separate features; however, the Partly Drained/Ditched Modifier also should be applied to the wetland area affected by the ditching.

Farmed (f) - Farmed wetlands occur where the soil surface has been mechanically or physically altered for production of crops, but where hydrophytes would become reestablished if the farming were discontinued. Farmed wetlands should be classified as Palustrine-Farmed. Cultivated cranberry bogs may be classified Palustrine-Farmed or Palustrine Scrub-Shrub Wetland-Farmed.

Impounded (h) - These wetlands have been created or modified by a man-made barrier or dam that obstructs the inflow or outflow of water.

Excavated (x) - This modifier is used to identify wetland basins or channels that were excavated by humans.

3.4 NWI Classification Chart

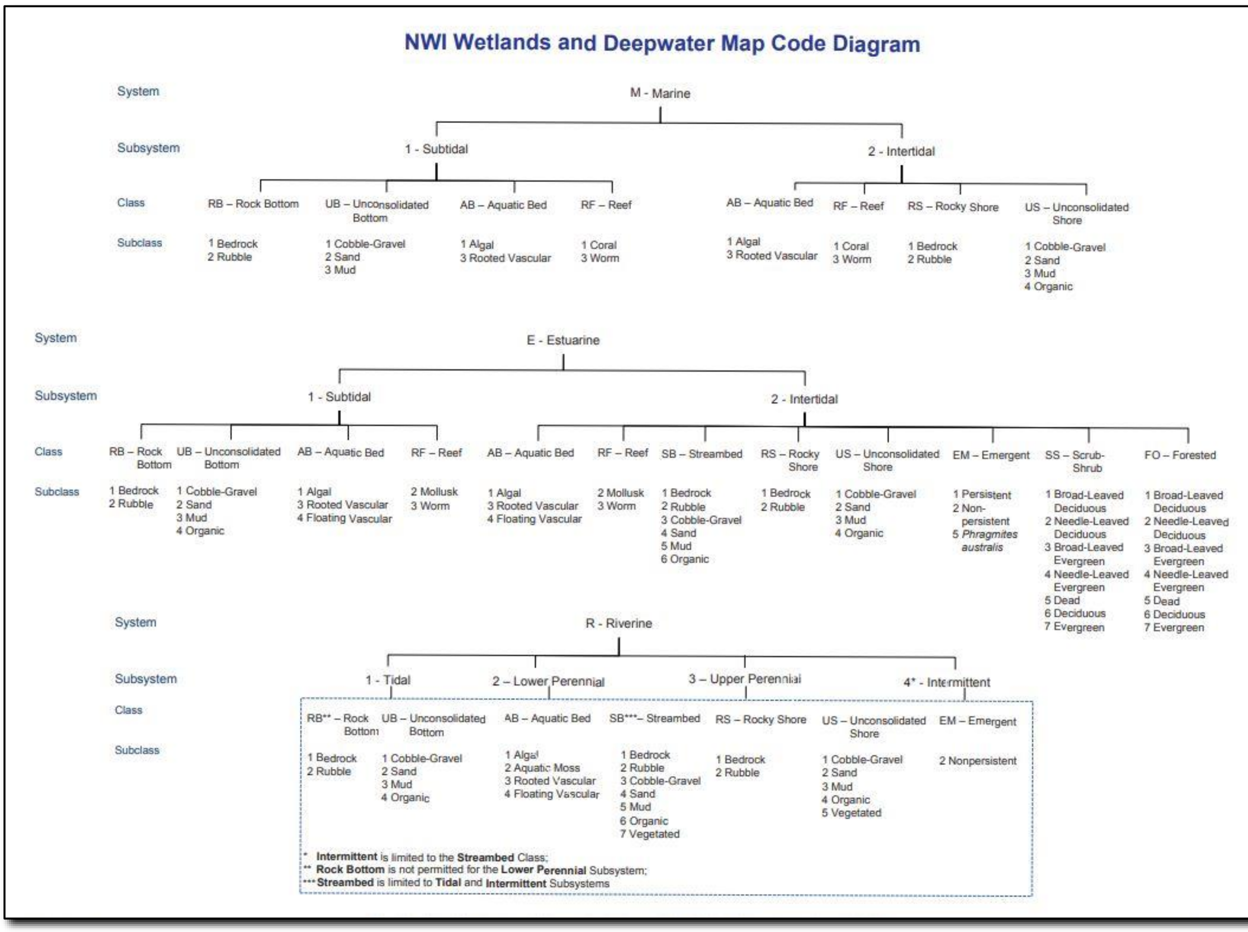


Figure 4. NWI Wetlands and Deepwater Map Code Diagram PART 1 (Cowardin, 1979).

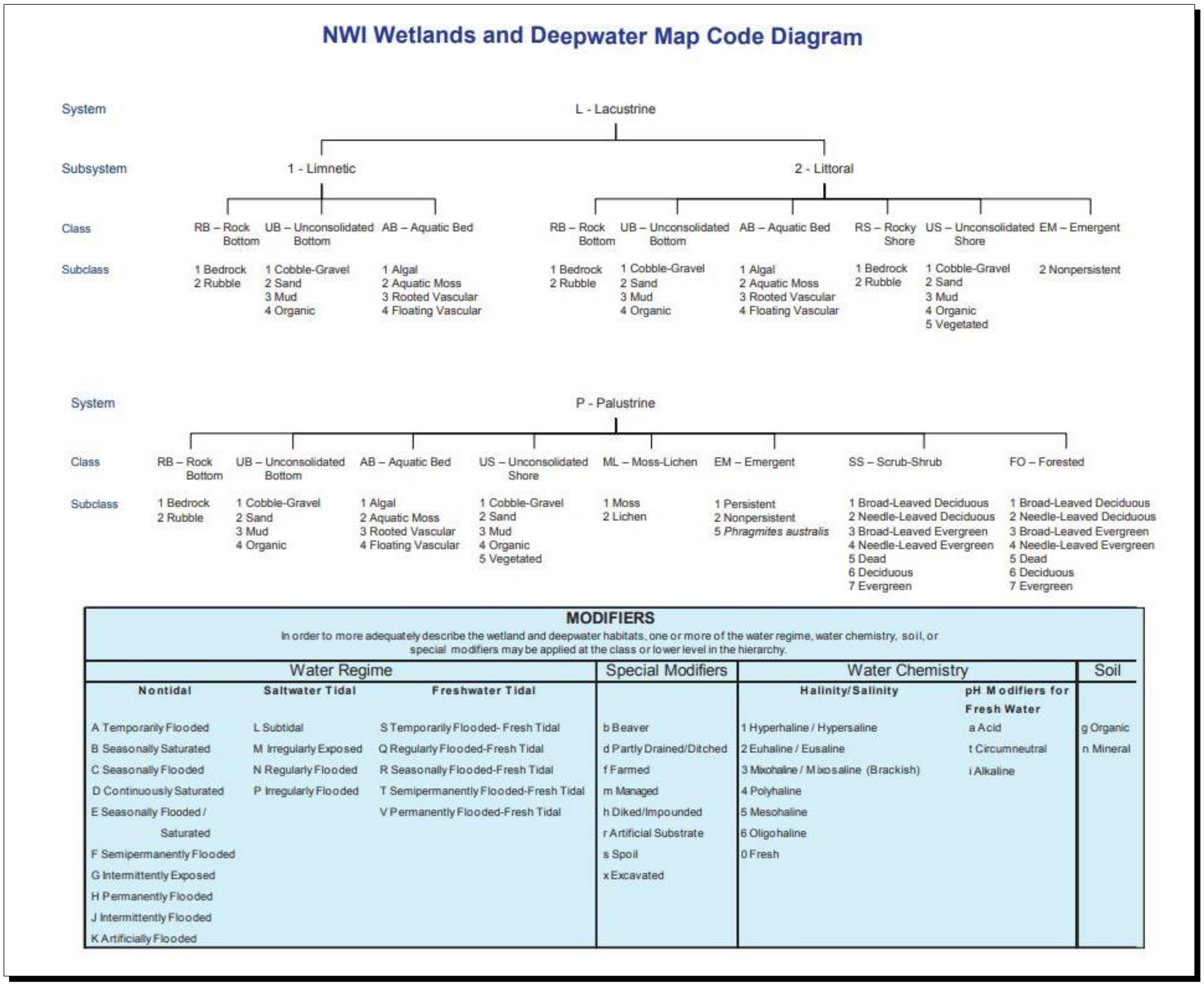


Figure 5. NWI Wetlands and Deepwater Map Code Diagram PART 2 (Cowardin, 1979).

4. Imagery and Collateral Datasets

4.1 Primary Source Imagery

The primary image source from which all wetland boundaries will be derived is spring imagery with years spanning 2016-2020, leaf-off 24-bit orthophotography of the area, in color infrared (CIR) emulsion. This imagery, obtained from Vermont Center for Geographic Information (VCGI) and taken by Fugro Earth Data Inc., will be used as the base imagery to inform mapping decisions (Figure 6).

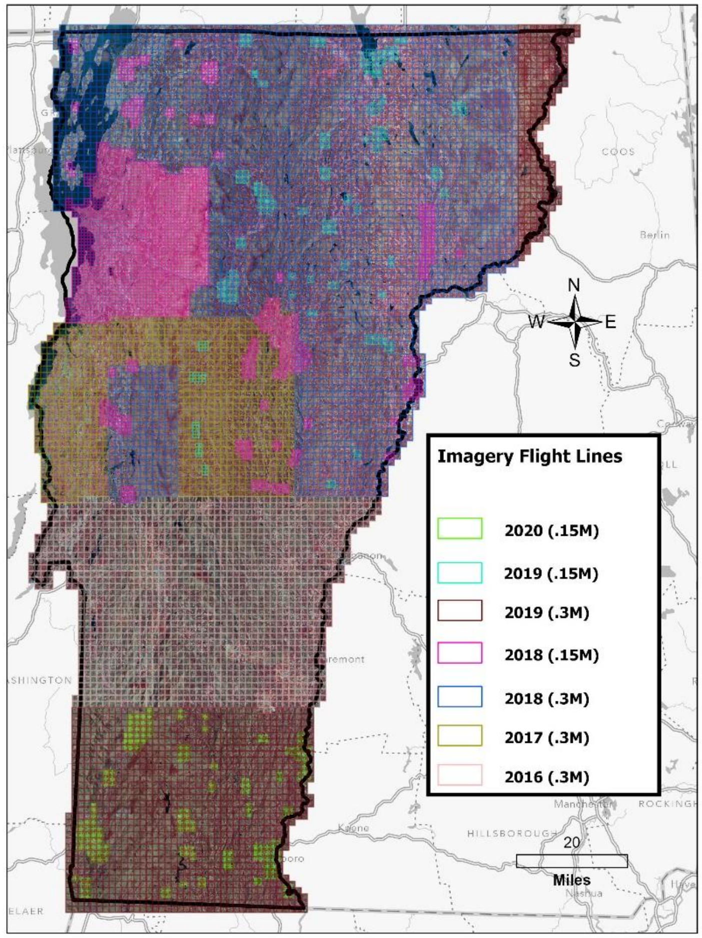


Figure 6. CIR Imagery and flight lines for different years (VCGI, Fugro Earth Data Inc.).

4.2 Secondary Imagery

In addition, .6 Meter resolution National Agricultural Imagery Program (NAIP) from 2021, natural color imagery will be consulted for decision support and wetland classification. NAIP imagery taken during the growing season in continental temperate climates can be particularly helpful in determining water regimes of wetlands.

4.3 Light Detection and Ranging (LiDAR) Derived Elevation Products

Elevation data is also critical for interpreting wetlands. For this project, hillshade layers and contours (2ft. and 5ft.) derived from a hydro-flattened LiDAR Digital Elevation Model (DEM) will be used to interpret wetland locations on-screen. GSS will also utilized a color-ramped DEM to visualize changes in elevation. The color-ramped DEM consists of a colorized bare-earth DEM with 50% transparency overlaid on the grey-scale hillshade. The DEM is set to “histogram equalize” with the dynamic range adjustment turned on. This means the view is non-static upon screen refresh. Each time an analyst pans or zooms in or out, the color DEM redraws based on the highest and lowest elevations. All LiDAR derived products were created by the VT LiDAR Initiative. The source CIR image, along with LiDAR collateral data products shown below (Figure 7).

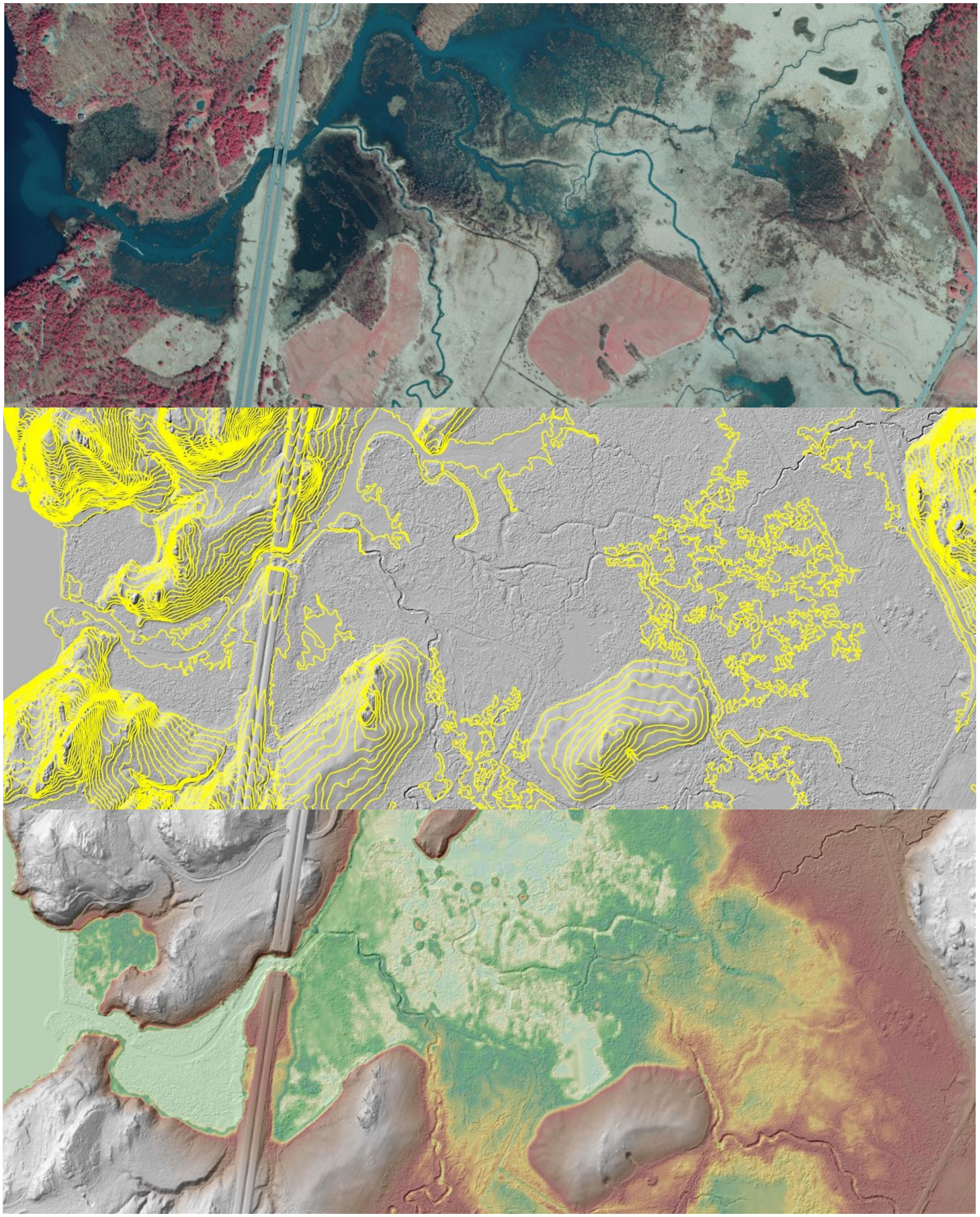


Figure 7. A wetland complex to the east of Lake Champlain in Chittenden County showing the source CIR (top), hillshade with 5-ft contours (middle), and the color-ramped DEM (bottom). Scale at 1:5,000. (73°10'15"W 44°34'18"N)

4.4 Soil Survey Geographic Database (SSURGO)

The Soil Survey Geographic Database (SSURGO) contains information about soil as collected by the National Cooperative Soil Survey over the course of a century. The information was gathered by walking over the land and observing the soil. Many soil samples were analyzed in laboratories (Soil Survey Staff). The SSURGO database was used to extract poorly and very poorly drained soils based on table joins (Figure 8).

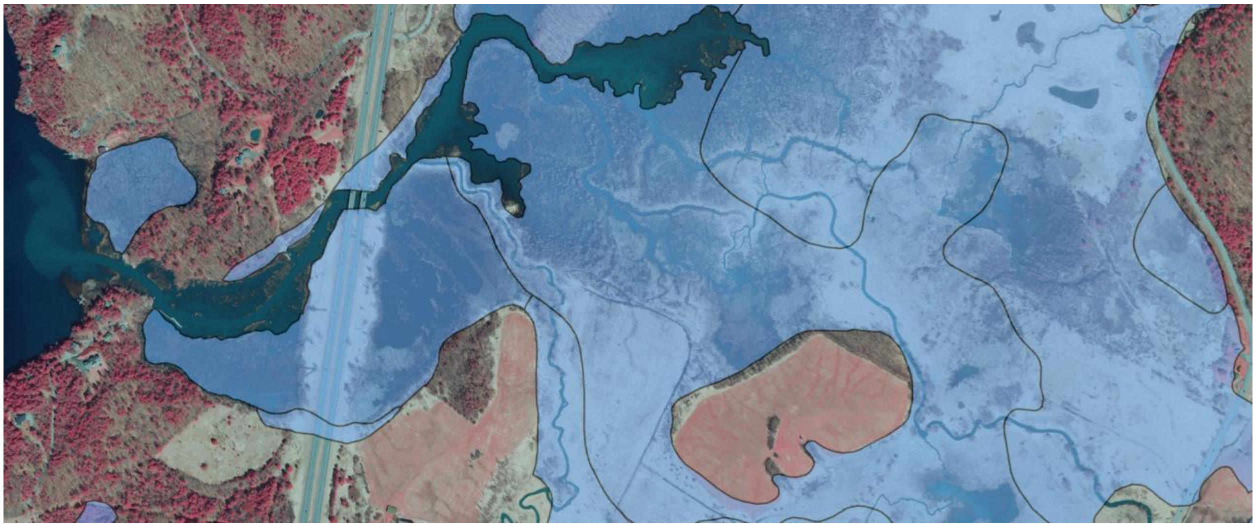


Figure 8. The same wetland complex in previous examples where SSURGO poorly drained and very poorly drained soils (blue) is overlaid on the source CIR imagery and used as a guide to map wetland habitat (Soil Survey Staff). Scale at 1:5,000. (73°10'15"W 44°34'18"N)

4.5 Potential Wetland Landscapes

The potential wetland landscapes layer, in which Saint Mary's University of Minnesota (SMUMN) created in-house was derived using LiDAR topographic derivatives as inputs for a supervised machine learning Random Forest (RF) classifier to predict and map the extent of wetlands in the Vermont phase 1 region. Processing was based on the methods used by the Wetland Identification Model (WIM) in Arc Hydro. The WIM model uses topographic metrics such as depth to water index (DTW), curvature and topographic wetness index (TWI) to identify areas of flow convergence and near-surface soil moisture that are indicators of wetland occurrence. Existing wetland data of known accuracy for a single HUC12 watershed was used as ground truth to train the RF classifier using the TWI, DTW and curvature predictor variables derived from the Vermont LiDAR DEM. The trained model was then used to predict the extent of wetlands within the entire phase 1 study area.

Accuracy assessments indicate that these RF models are effective in predicting the spatial extent of wetlands in a study area, i.e., low omission of wetlands, but can be prone to over prediction of wetlands, especially in areas where there has been significant alteration of the local hydrology due to agricultural or urban development. This limitation should be considered when interpreting and using the data. Possible applications for the data include using the layer as an initial automated classification of wetlands that can improve the mapping accuracy and efficiency of the manual interpretation of wetlands by helping identify areas where wetlands are most likely to occur due to hydrologic characteristics. Another potential application is for identification of potentially restorable wetlands. Areas that are identified as a potential wetland landscapes that currently have a land use that is incompatible with existing wetlands, such as agricultural land use, may be good candidates to investigate as possible locations for wetland restoration (Figure 9).

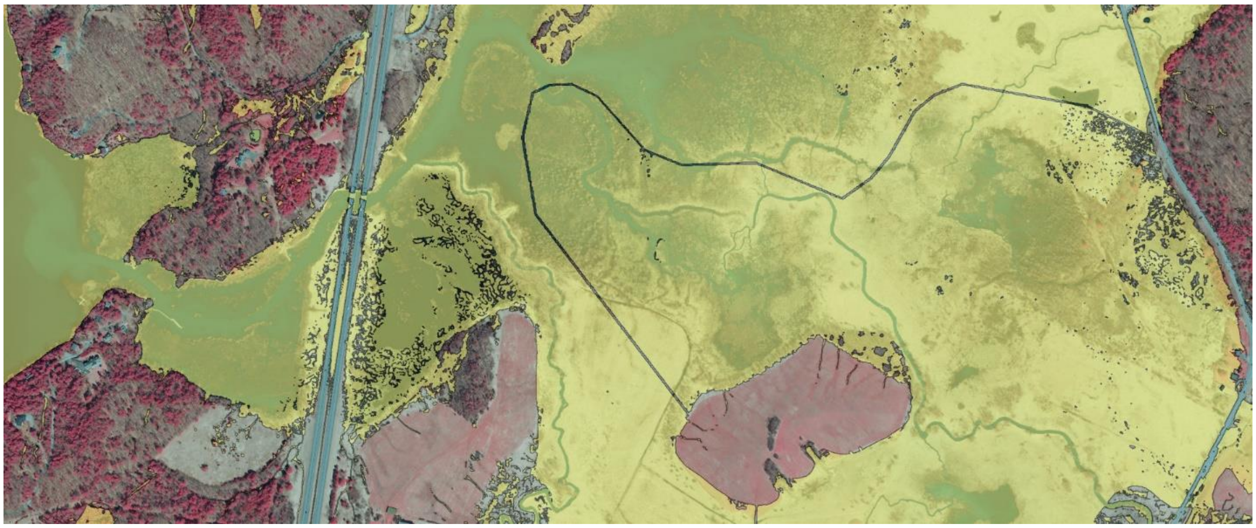


Figure 9. The same wetland complex in previous examples where SMUMN's potential landscape layer (yellow) is overlaid on the source CIR imagery and used as a guide to map wetland habitat. Scale at 1:5,000. (73°10'15"W 44°34'18"N)

4.6 USFWS NWI Historical Wetland Data

The NWI geospatial dataset is a digital representation of the location, type, and extent of the nation's wetland and deepwater habitats. The dataset supports an array of applications, including the U.S. Endangered Species Act, water quality modeling, infrastructure development planning, waterfowl population modeling and more. The dataset is publicly available via the online Wetlands Mapper, a trusted resource that is visited by more than half a million users annually. The Wetlands Mapper allows users to view, query, and print wetlands data. Data are available for the conterminous United States, Hawaii, Puerto Rico, the Virgin Islands, Guam, the major Northern Mariana Islands, and more than 40 percent of Alaska (National Wetlands Inventory).

4.7 State of Vermont In-house wetland mapping

The state of Vermont via Charlie Hohn has supplied GSS with detailed wetland mapping in certain areas that serve as baseline mapping for the project areas. These data are often more detailed than what is required by the NWI program (FGDC 2013).

4.8 Lake Bathymetry Data

Vermont Agency of Natural Resources (VT ANR) has lake bathymetry tables available hosted by VCGI showing lake depths (feet). These tables were then converted to X, Y data by using that latitude and longitude fields and exported to a feature class. These points were then symbolized to represent points less than 6.5 feet (littoral zone) and points greater than 6.5 feet (limnetic zone) to separate the two lacustrine subsytems (Figure 10).

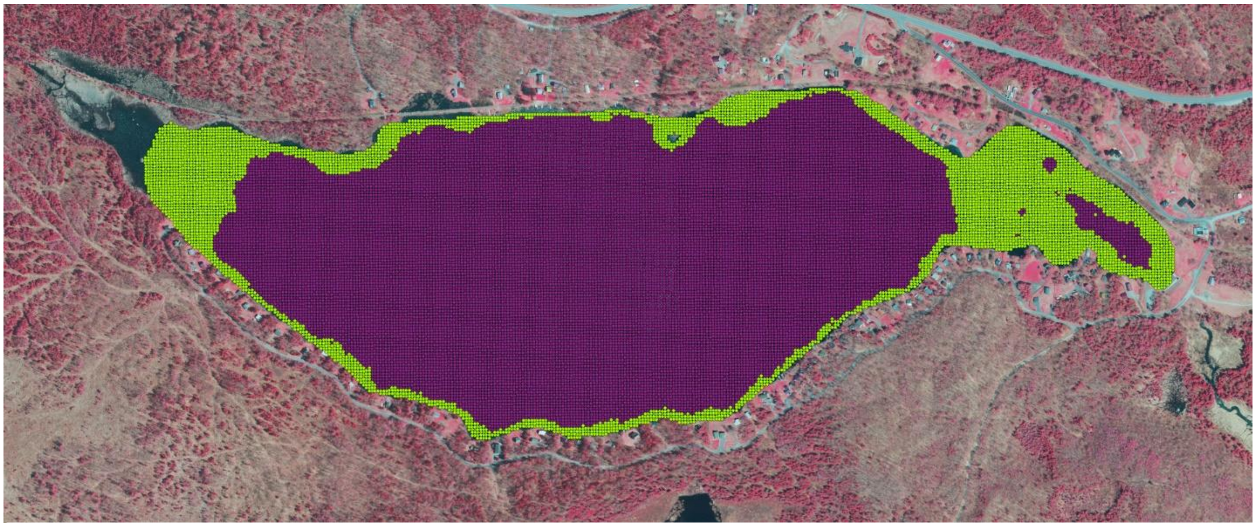


Figure 10. Bathymetry point data of Miles Pond near St. Johnsbury showing the separation of the shallower, littoral (L2) boundary in green and the deeper, limnetic (L1) boundary in purple (VT ANR). Scale at 1:5,000. (71°48'37"W 44°26'52"N)

4.9 Additional Collateral Layers

-VCGI hosted layers such as state and county boundaries, protected lands, and roads.

-National Hydrography Dataset (NHD) flow paths, waterbodies, and HUC 12 basins.

-United States Geological Survey (USGS) topographic maps and quadrangle boundaries.

-Google Earth imagery time slider and street view.

5. Regional Conventions and Attribute Development

This project uses an on-screen, heads-up, digitizing process with the use of Environmental Systems Research Institute, Inc. (ESRI) software ArcGIS PRO 2.0 or higher. This approach takes advantage of the editing tools available through ArcGIS PRO to delineate and classify wetland features based on photo signatures in CIR leaf off imagery and supporting collateral data. The Wetlands and Deepwater Habitats Classification includes NWI attributes by system, subsystem, class, subclass, water regime, and special modifiers.

5.1 Scale and Target Mapping Unit (TMU)

All mapping will be completed with at least 1:12,000 resolution with a Target Mapping Unit (TMU) of 0.25 acres, (NOTE: the FGDC standard uses a 0.5 acre TMU for this. For this project the Contractor aims for a 0.25-acre TMU given the resolution of the available imagery) and will comply with the National Wetlands Mapping Standard of the FGDC. The final product to VDEC Wetlands Program will be compatible with our schema and will match the projection of the base imagery, NAD 1983 State Plane Vermont FIPS 4400.

The projects will use geospatial techniques and image interpretation processes to remotely map and classify wetlands at a mapping scale between 1:3,000 and 1:5,000. However, these do not include narrow linear habitat polygons typically representing stream and ditch features.

5.2 Mapping Conventions

5.2.1 Riverine (R)

Riverine Mapping Conventions - Per NWI guidance, polygonal riverine features need to continue upstream until they narrow to below a width of 15 ft. on average, stopping at a confluence or obstruction that results in a significant change of width. The image below shows Pinneo Brook in Chittenden County in which mapping starts at the confluence, where upstream is below the 15 ft. width threshold (Figure 11).

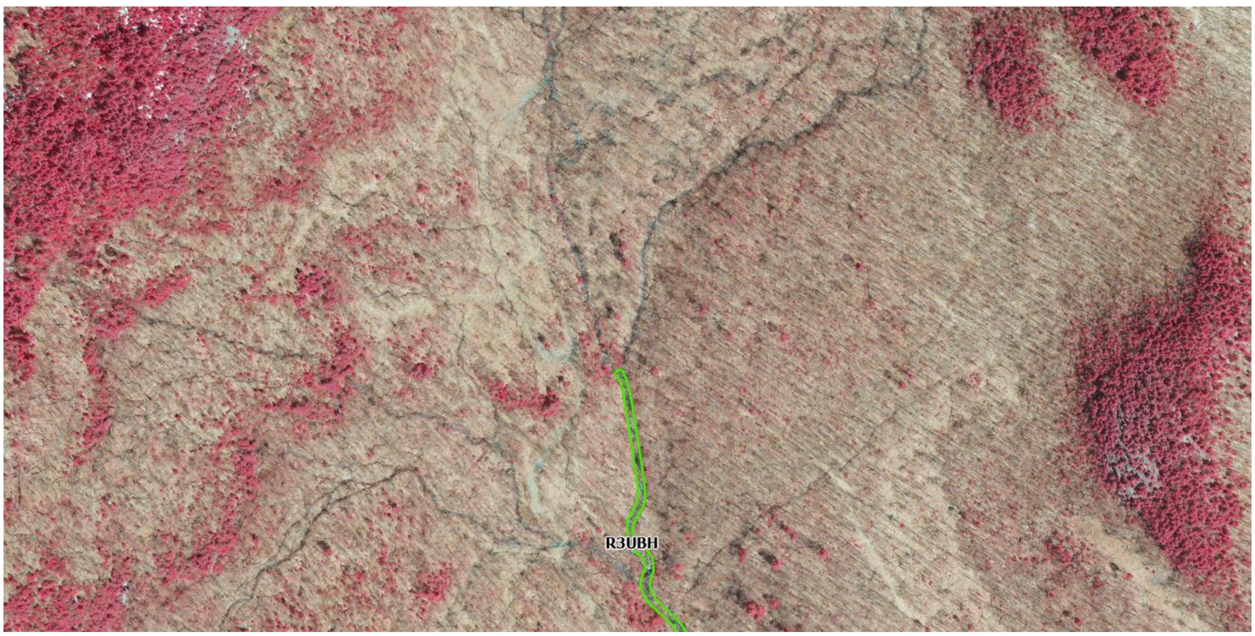


Figure 11. Pinneo Brook, in Chittenden County where mapping begins at the confluence, with smaller channels to the north being excluded because of the minimum average width threshold being below 15 ft. Scale at 1:3,000. (72°50'13"W 44°23'44"N)

While zoomed in on a very tight scale (1:300 to 1:800), the ArcPro measuring tool is utilized and measured from bank to bank to determine average riverine width. The starting mapping point at this particular confluence meets the standards as the channels to the north do not meet the average 15 ft. width threshold (Figure 12).

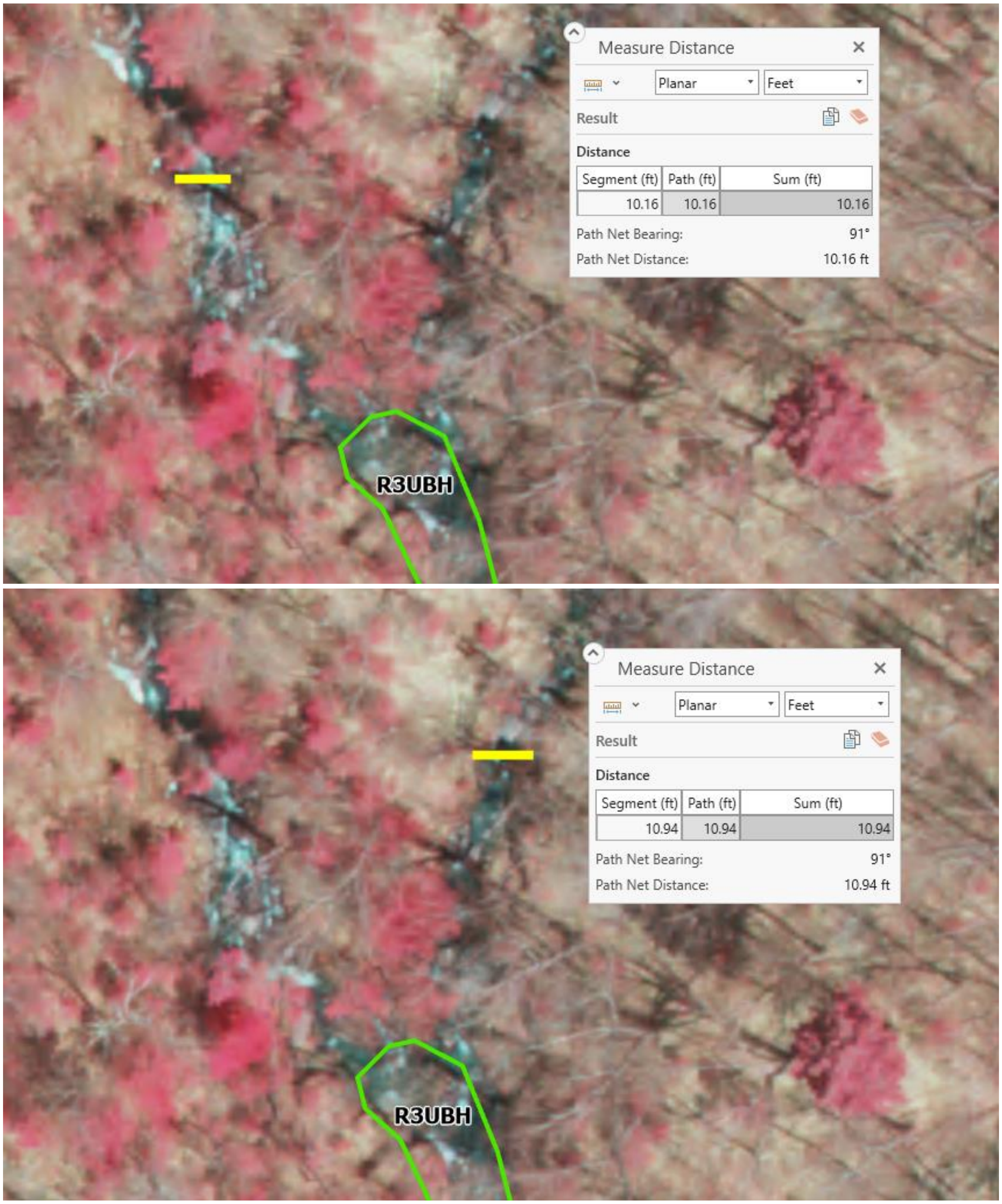


Figure 12. As shown above, when zoomed in on a very tight scale, the upper reaches of Pinneo Brook are approximately averaging a little more than 10 ft. in width and are excluded from the mapping. Scale at 1:300. (72°50'13"W 44°23'44"N)

Upper and Lower Perennial Rivers - High gradient rivers flowing down from mountainous areas and higher elevations will be classified as R3UBH (Upper Perennial), while low gradient rivers in the flats with lower relief will be classified as R2UBH (Lower Perennial) (Figure 13).

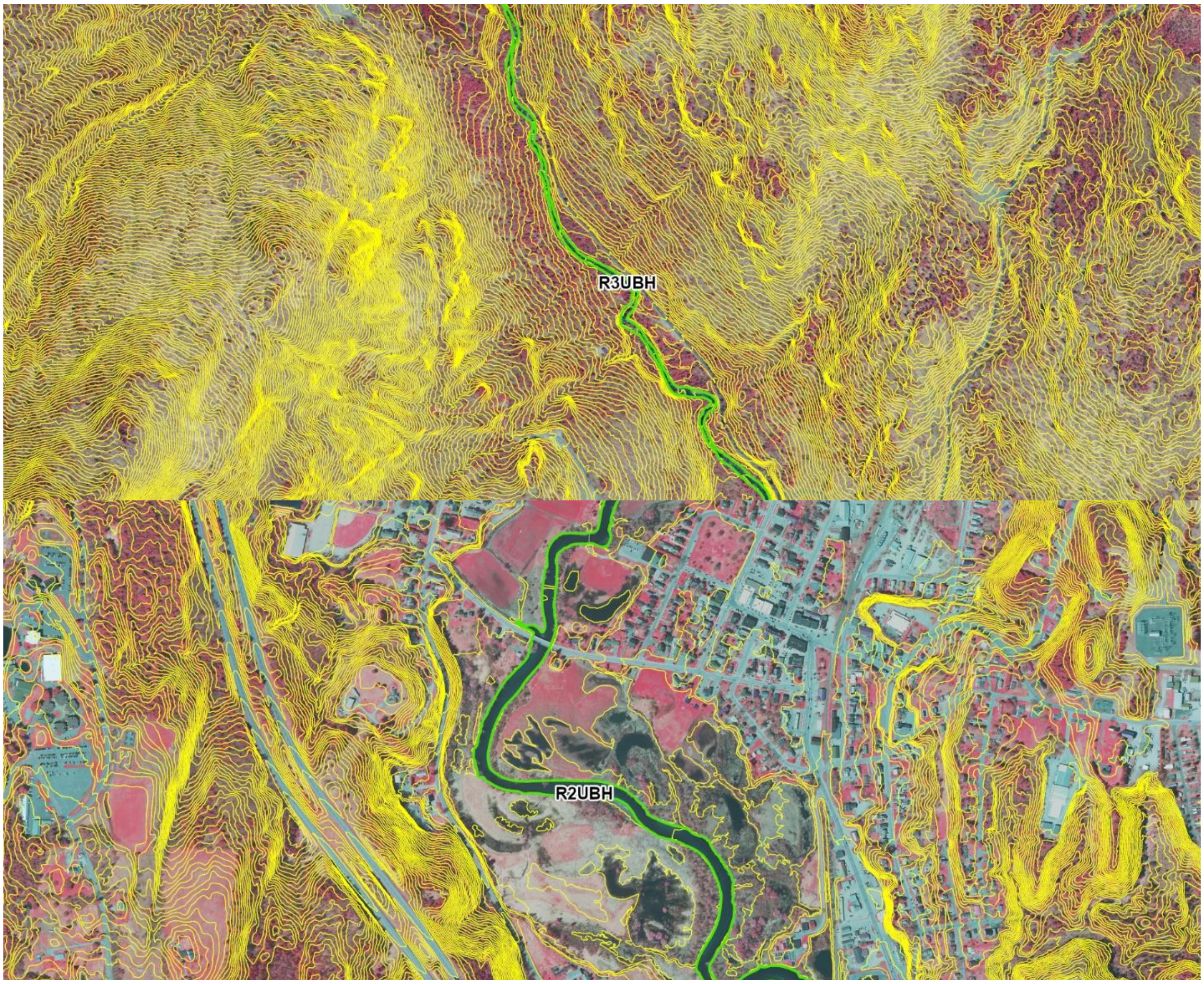


Figure 13. High gradient, faster moving rivers such as Moose River in Essex County will be classified as Upper Perennial, R3UBH (top) (71°48'29"W 44°37'34"N). Low gradient, slower moving rivers such as Passumpsic River in Caledonia County will be classified as Lower Perennial, R2UBH (bottom) (72°0'41"W 44°31'58"N). 5 Ft. contours (yellow) overlaid on source CIR imagery. Scale at 1:5,000.

High gradient floodplains - The gradient is too high in most areas such that there is large well-drained, alluvial material alongside them and stage heights don't appear to vary enough to justify wetlands along them. Please refer to the Cowardin manual for further characteristics of the R3 (high gradient rivers). Save mapping of these features for braided channel areas and newer erosional deposits that appear as lower benches in the LiDAR. These areas will be classified as temporarily flooded (A) water regime and are typically dominated by PSS1A and PFO1A classifications with an occasional mix of PFO4A (Figure 14).

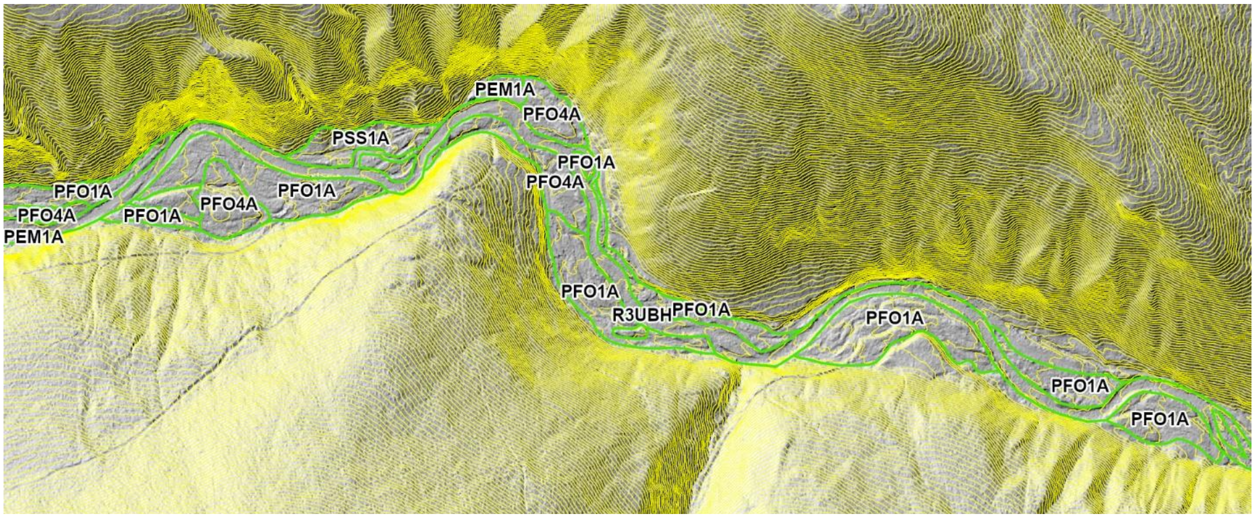


Figure 14. Willard Stream in Essex County, shows high gradient floodplain areas with evidence of lower benches and braiding in the hillshade. These areas will be designated as temporarily flooded (A) water regime. 5 Ft. contours (yellow) overlaid on hillshade. Scale at 1:3,500. (71°32'29"W 44°54'58"N)

Unconsolidated Bottom (UB) class and H water regime - As this project is following NWI 3.0 guidance, major rivers that average a minimum of 15 feet will be mapped. All rivers will be classified as Unconsolidated Bottom (UB) and given a permanently flooded (H) water regime.

5.2.2 Lacustrine (L)

Limnetic (L1) and Littoral (L2) boundary - L1 and L2 boundaries will be split out in areas where there is lake bathymetry data (See section 4.8). If there is no lake bathymetry data present, the entire lake will be classified as L1 and NAIP imagery along with Google Earth will be used to determine if L2 boundaries need to be sectioned out. NAIP Imagery and Google Earth will also be used to split out different classes such as Aquatic Bed (AB) from Unconsolidated Bottom (UB).

5.2.3 Palustrine (P)

Seasonally Saturated (B) - Seasonally saturated (B) water regime will be reserved for sloped wetlands with more consistent contour lines. These include forested areas with small seeps and subtle benches in mountainous areas. These can also be found in agricultural areas that are gently sloped and are typically dominated by emergent, often reed canary grass (Phalaris arundinacea) and a mix of scrub shrub species.

Continuously Saturated (D) - Continuously saturated (D) water regime will be reserved for bogs and wetlands occurring in the flats (toe of slope). Bogs typically occur in depressions with poor drainage, where precipitation is the only source of water and nutrients. It is common for bogs to form adjacent to lakes and other larger waterbodies.

Seasonally Flooded/Saturated (E) – Seasonally flooded/saturated (E) water regime will be reserved for wetlands that are predominantly saturated but also experience seasonal flooding caused by overland flow (rain, snow melt). Examples include transitional floodplain areas, vernal pools, or beaver influenced wetlands.

Shown below is an example of a wetland complex in which multiple water regimes are applied. (Figure 15).

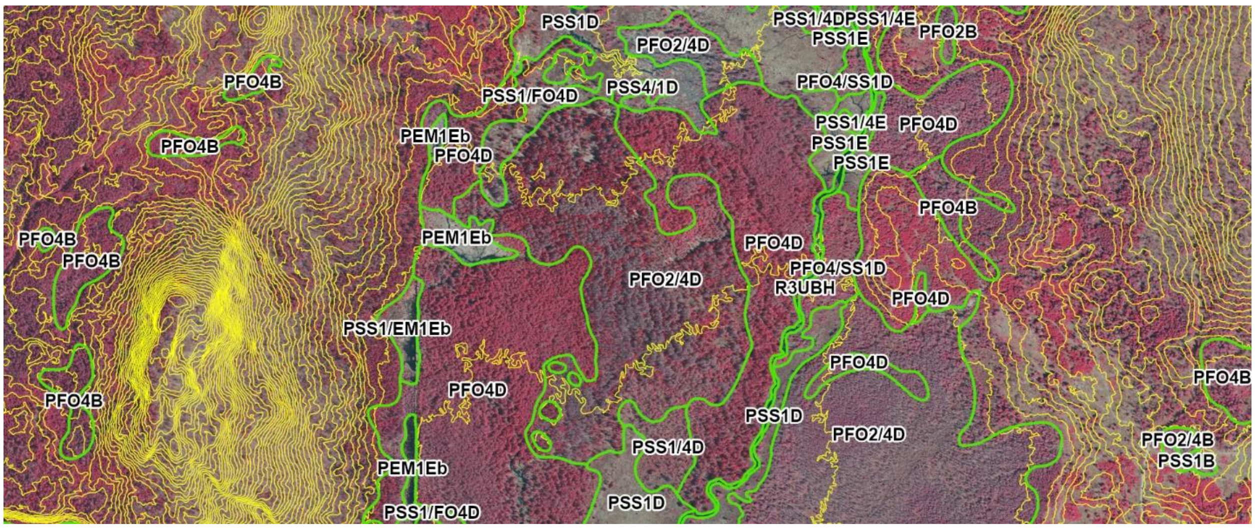


Figure 15. This wetland complex in Victory State Forest is comprised of seasonally saturated wetlands leaching down from the west (B), continuously saturated bog complex in the center (D), and seasonally flooded/saturated wetlands that include beaver impoundments and floodplain influence from the river (E). Scale at 1:5,000. (71°48'27"W 44°32'21"N)

Beaver influenced wetlands - Beavers are very active in the study area creating dams and altering the wetland landscape. These beaver impoundments create open water ponds (PUB or PAB) habitat and beaver meadows. Hardwood trees are often removed as a result and most beaver meadows are dominated by emergent (EM) or scrub shrub (SS) vegetation. It is common to utilize a split class of PEM/SS1 in beaver meadow areas. The beaver modifier (b) will be used on these areas and will be restricted to water regimes of permanently flooded (H), semi-permanently flooded (F), seasonally flooded (C), or seasonally flooded/saturated (E). Below is an example showing multiple beaver complexes in Essex County (Figure 16).

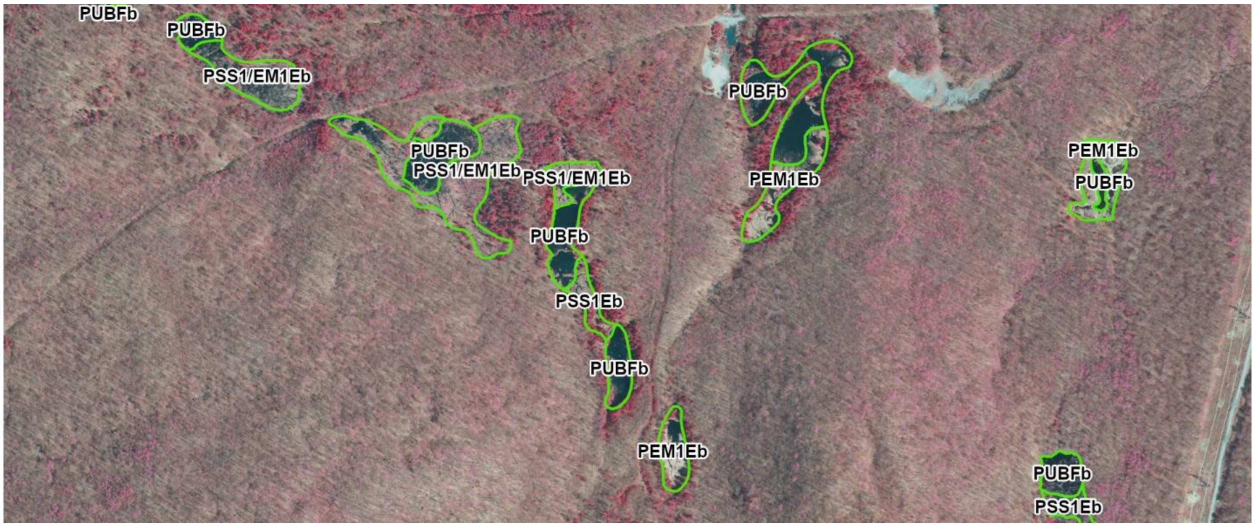


Figure 16. Multiple beaver influenced wetland complexes in Victory State Forest showing dammed ponds and mixture of emergent and scrub shrub beaver meadows. Scale at 1:3,500. (71°46'25"W 44°30'43"N)

<u>Beaver Ponds -</u> The majority of beaver influenced (b) ponds will be classified as semi permanently flooded (F), however, it is acceptable to call larger beaver ponds permanently flooded (H). Beaver ponds may have a class of unconsolidated bottom (UB) or aquatic bed (AB).

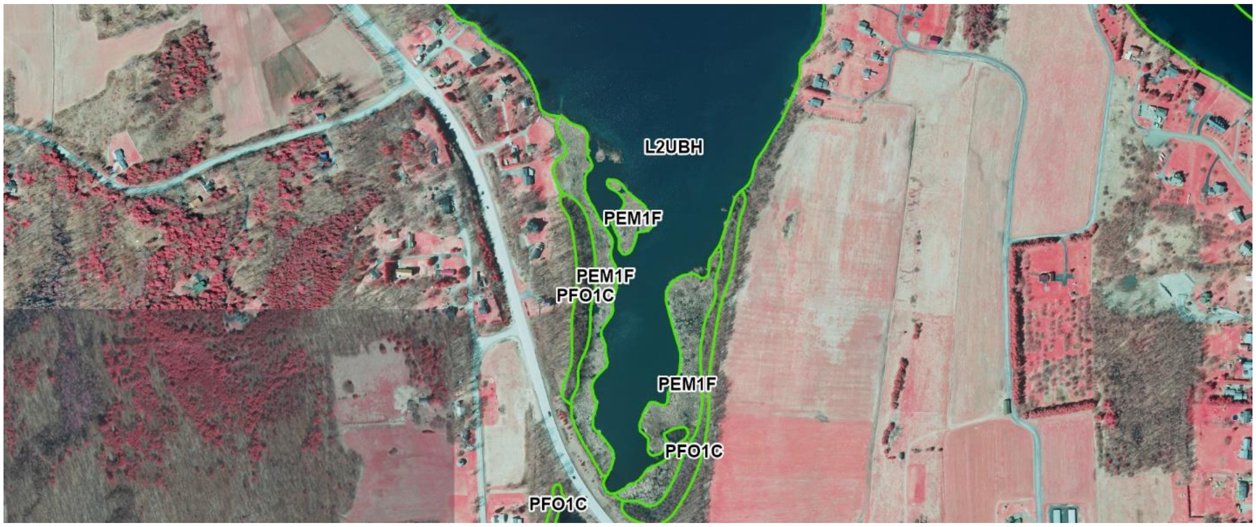
<u>Excavated Ponds -</u> All excavated (x) ponds, regardless of size will be classified using permanently flooded (H) water regime, as it is extremely rare that these ponds dry out. Excavated ponds may have a class of unconsolidated bottom (UB) or aquatic bed (AB).

<u>Artificially Flooded Ponds -</u> For all manure ponds and water treatment ponds, the water regime will be classified as artificially flooded (K). These ponds will have a class of unconsolidated bottom (UB) and the excavated (x) modifier will be applied.

<u>Impounded Ponds -</u> The majority of impounded ponds (h) will be classified as permanently flooded (H), however, it is acceptable to call smaller impounded ponds semi permanently flooded (F) if there is supporting evidence in imagery. Impounded ponds may have a class of unconsolidated bottom (UB) or aquatic bed (AB).

NOTE: Small constructed ponds are common in Vermont. Many of these are both excavated (x) into the surface and impounded (h) along some flow path. The NWI database does not allow both modifiers to be used on the NWI code. It's likely that if it appeared to the wetland interpreters to be a pond with a more pronounced berm on one side and in a flowpath, then the 'h' modifier was typically used. When the pond didn't appear to be in a flowpath and yet appeared to be constructed, the 'x' modifier was used.

<u>Lake Champlain fringe wetlands -</u> Polygonal wetlands adjacent to Lake Champlain will be classified as inland flooded water regimes (F, E, C, or A). Snowmelt in the spring as well has periods of heavy rainfall impact water levels that cause lakeside flooding (Figure 17).



Pf - Deeper depressions in the agricultural areas with significant crop stress (row crops), dark saturation signature, or evidence of standing water will be mapped as Pf (Figure 18).

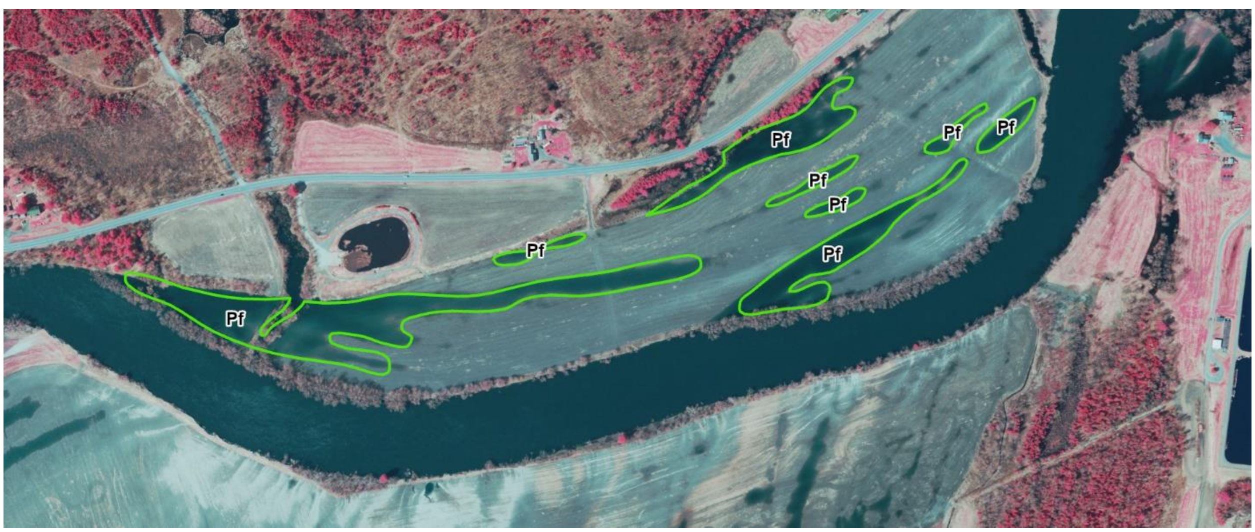


Figure 18. Areas such as this farm field in Essex County with depressions holding standing water will be mapped as Pf. Scale at 1:3,500. (71°36'23"W 44°29'11"N)

6. Overview of Fieldwork

6.1 Trip Timing

Fieldwork trips are planned in the early spring to coincide with the presence of seasonally high-water levels as this provides ideal wetland conditions. The dates of the trips were also scheduled around GeoSpatial Services (GSS), Vermont Department of Environmental Conservation (VDEC), and National Wetlands Inventory (NWI) staff availability.

6.2 Field Verification Methods

The field-verification process involved three stages: pre-trip check-site selection (in-office); in-field verification; and post-trip documentation. These steps were intended to verify whether imagery signatures represent wetland, deepwater habitat or non-wetland features. The field data collected is also informative in determining appropriate classifications, wetland/upland boundaries, and boundaries between adjacent wetland classification types.

Since confirming the signature of each possible point of interest in the field is logistically infeasible, selectivity is a necessity. Ground-truth locations were selected that are "typical" of those commonly found throughout project imagery. Anomalous or "atypical" signatures were also verified where the aerial coverage of these unusual signatures is significant.

6.2.1 Pre-trip Check-site Selection

Pre-selected locations (latitude/longitude) were established in the office using a desktop review of a combination of source CIR imagery, LiDAR elevation products, VT roads layer, and VT protected (public) lands layer, amongst other collateral data. These locations acted as list of potential sites that could be visited feasibly by automobile.

Site selections focused on identifying open water habitat, signatures of plant and forested communities, beaver meadows, flooded versus saturated vegetated wetlands, saturated slopes and basins, permanent bogs, and river floodplains.

Additional, 'ad-hoc' checksites could be added to the database if something noteworthy is observed by staff while driving to another checksite and is determined by staff to be of value to the in-office photo-interpretation staff.

6.2.2 In-Field Verification

In-field verification for checksites were done via observations from the ground. Field team members observed the dominant vegetation and hydrologic indicators to determine the wetland type. Wetland species were documented, along with photo signatures, wetland indicators, landscape position, and on-ground photographs. At selective sites, soil samples were taken as well.

Team members also had access of ESRI software, source CIR imagery, and all other collateral datasets on a laptop. A fieldwork collector application was built in ESRI and documentation was completed on an Apple iPad.

6.2.3 Post Trip Documentation

Upon return to the GSS office, field documentation, in-field delineations, and photographs were organized and compiled into a formal report.

6.3 Field Trip #1 – Spring 2023

GSS conducted fieldwork from April 26th-May 3rd, 2023 in Phase 2 of the study area. Regions in this area included the Connecticut River Basin in the east, the Lake Champlain Basin in the northwest, and a small part of the Hudson River Basin in the southwest corner. The eastern and western basins are divided by the Green Mountains, which run north-to-south through the state. The GSS team was joined in the field by staff from the VDEC and the NWI program. Together, they were able to observe a wide variety of wetlands from saturated, sloped wetlands in agricultural settings, bogs, black ash swamps, to semi-permanently flooded buttonbush shrub wetlands.

6.3.1 Site Selection Trip #1

Initially, 495 checksites were pre-selected in advance for both Phase 1 and Phase 2 of the project. For this particular fieldwork trip, GSS (in partnership with VDEC and NWI), were responsible for Phase 2 of the study area. In total, 171 checksites were visited and documented during this trip (Figure 19).

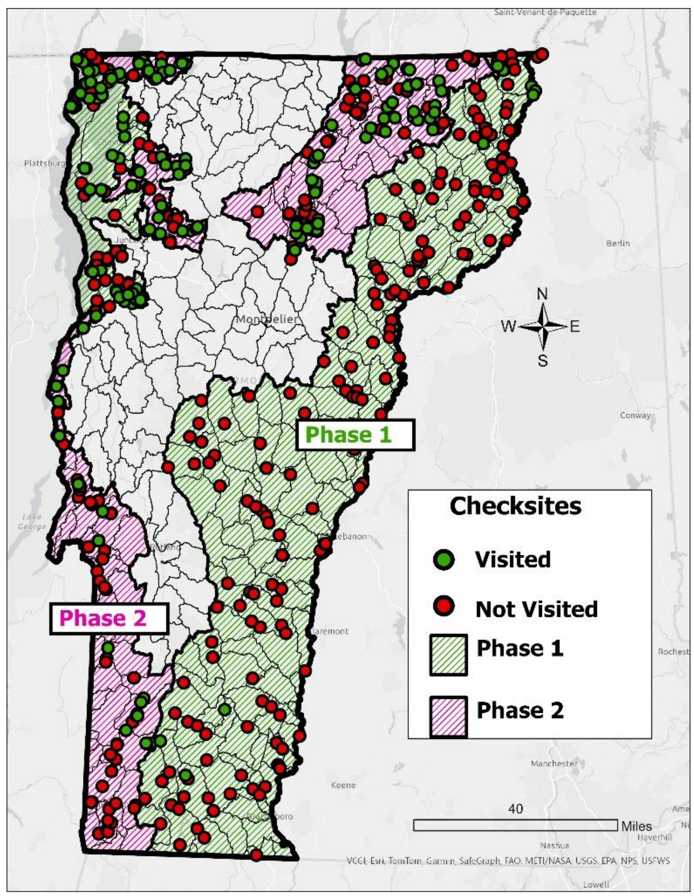


Figure 19. All checksites symbolized in green are areas that were visited and documented during the trip. All checksites in red were not visited during the trip.

6.3.2 Field Verification Team Trip #1

VDEC

Laura Lapierre – Wetlands Program Manager
Charlie Hohn – Wetlands Ecologist
Cassidy Gale – Environmental Analyst
Elijah Schumacher – Environmental Analyst

GSS

Kevin Stark – Assistant Director
Zachary Ansell – GIS Analyst
Katie Engelmann – Natural Resource and GIS Analyst

NWI

Amanda Pachomski – Wetlands Coordinator (Regions 3 and 5)

6.4 Field Trip # 2 – Spring 2024

From May 13th-May 17th, 2024 GSS spent a week conducting fieldwork in the Winooski and Otter Creek tactical basins of central Vermont, ground-truthing wetland mapping for the NWI update. The GSS team was joined in the field by staff from the VDEC and the NWI program. Vermont is a very diverse landscape and contains many different wetland types, including open water ponds, floodplains, marshes and swamps, bogs, fens, wet meadows, and vernal pools. Over the week, the crew traveled an area roughly between Montpellier, Burlington, and Middlebury, visiting various wetlands from the Winooski River floodplain to Chittenden Reservoir in the Green Mountain National Forest. Different focuses were on saturated forested wetland environments, agricultural fields, and river floodplains.

6.4.1 Site Selection Trip #2

Initially, 129 checksites were pre-selected in advance for the Winooski and Otter Creek Tactical Basins. GSS (in partnership with VDEC and NWI) visited and documented 84 checksites during this trip (Figure 20).

6.4.2 Field Verification Team Trip #2

VDEC

Charlie Hohn – Wetland Ecologist
Krystal Sewell – Wetland Ecologist
Elijah Schumacher – Environmental Analyst
Sam Buswell – Environmental Analyst

GSS

Kevin Stark – Assistant Director
Zachary Ansell – GIS Analyst
Nicholas Lemcke – GIS Analyst

NWI

Amanda Pachomski – Wetlands Coordinator (Regions 3 and 5)

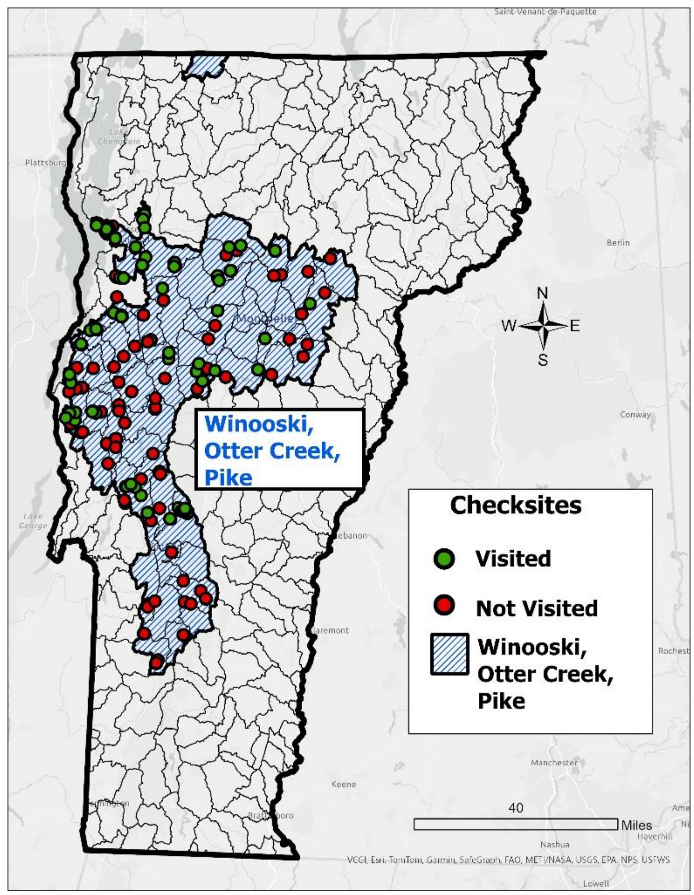


Figure 20. All checksites symbolized in green are areas that were visited and documented during the trip. All checksites in red were not visited during the trip.

6.5 Field Verification by Vermont Staff

Throughout the project period from 2022 to 2024, Vermont DEC staff conducted field verification at over 800 additional locations statewide. The data collected was entered into an ArcGIS field Maps application by VDEC staff, enabling SMUMN wetland interpreters to access the information via the web and make informed mapping decisions.

6.6 Associated Data Products

A file geodatabase showing checksite locations, in-field documentation, and attached photograph. Example of Site ID 431 shown below (Figure 21).

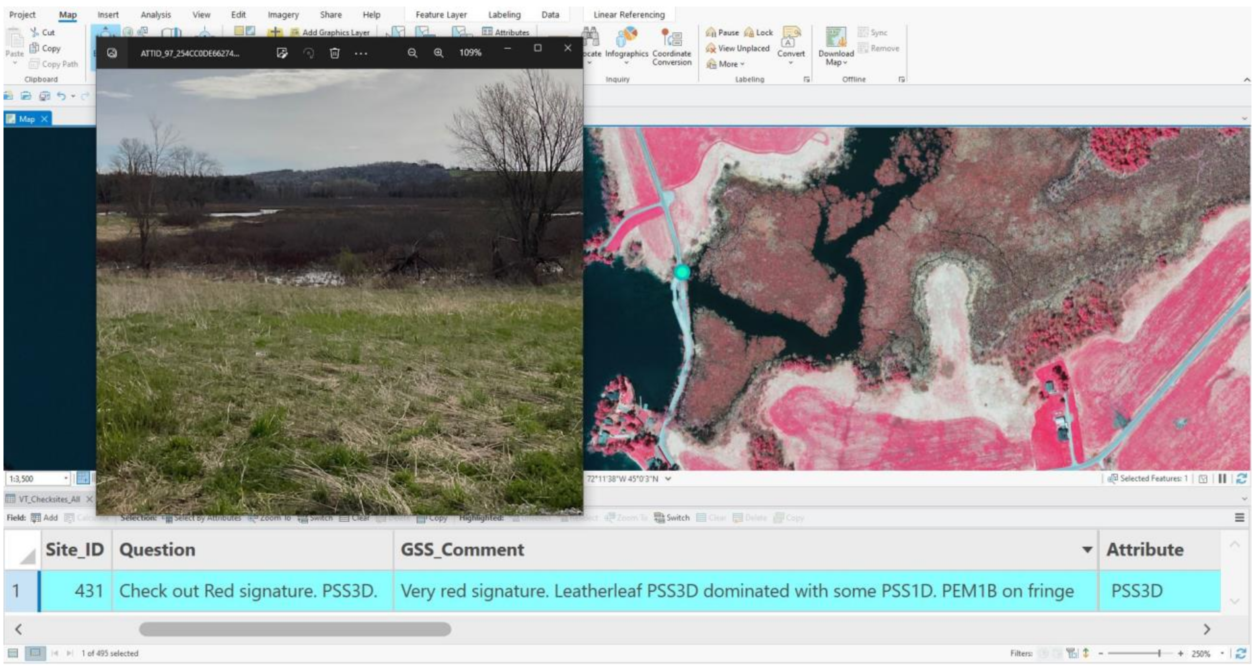


Figure 21. Example checksite showing point location, field notes, and photograph of a leatherleaf complex (PSS3D). Scale at 1:3,500. (72°11'50"W 44°59'57"N)

7. Mapping Convention Plates

Each plate (page) contains a specific NWI attribute (NWI code) that is further depicted through a set of three images; each image contained within a plate will not be referred to as a "Figure", but the entire page as a plate. In the majority of cases these three images are: 1) on ground-level photograph, 2) source layer CIR aerial photography with wetland feature of interest delineated, and 3) DEM, most often the grey-scale hillshade with 5 ft. contours, although occasionally the color-ramped histogram equalized raster with 2 ft. contours will be shown in low relief areas. Each image has a brief description, including: location of checksite by place-name and latitude/longitude, vegetation or class type, image signature description, photo direction, and landscape depiction. All exports of CIR imagery and LiDAR are at a scale of 1:3,500. The arrow in each of the CIR photos indicates location and direction of photo.

This is a “selective key” in which typical signatures were chosen and compared to ground conditions. Wetland parameters of hydrology, soils, or vegetation were documented. This report describes correlations between imagery signatures, wetland parameter(s) and NWI classifications. The classifications listed on the following pages and their associated image signatures represent common wetland types and signatures found within the project area, but do not include all classifications that will be present in the finalized database.

L1UBH (Site ID 466:   43°37’54”N 73°13’56”W)

Lacustrine, Limnetic, Unconsolidated Bottom, Permanently Flooded.

Field Photo

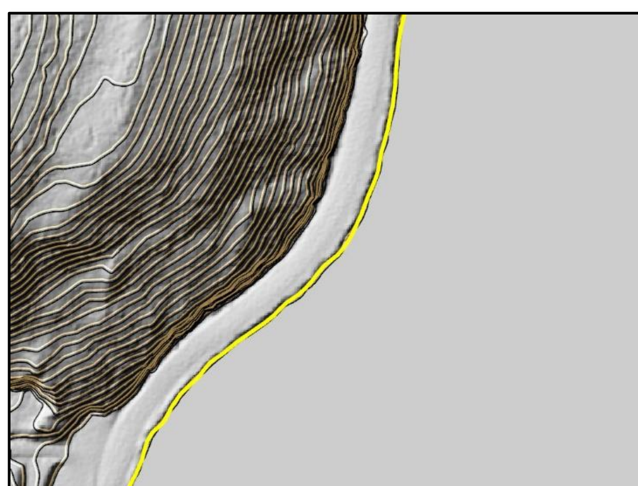
If there are no lake bathymetry data available, it is acceptable to classify the entirety of the lake as limnetic (greater than 2m deep) (L1). Deeper lakes, such as Lake Bomoseen in Rutland County, drop off precipitously from the shore and there is a very minimal littoral (less than 2m deep) fringe. This photo is taken facing southeast while standing on the shore.

CIR Imagery

Deeper open water features will almost always appear as a dark black to dark blue signature in the CIR imagery with very smooth texture. Shallower open water features often times have tint of blue to them.

Hillshade with 5-ft contours

Substantial open water features in the hillshade will appear flat with a smooth texture do to hydro-flattening algorithms. Below the hillshade depicts a steep slope to the west leading down to the lake basin.



PEM1B (Site ID 435:   44°58'07"N 72°57'52"W)

Palustrine, Emergent, Persistent, Seasonally Saturated.

<u>*Field Photo*</u>

Patches of emergent vegetation on gentle slopes will be classified as seasonally saturated. This emergent wetland in Franklin County consists of reed canary grass (*Phalaris arundinacea*) and small pockets of cattail (*Typha*). The brown and beige grasses were senesced vegetation from the previous year and the green grass is new vegetation growth from this year. This photo was taken facing southwest as this sloping emergent wetland drains down to the open water feature.

<u>*CIR Imagery*</u>

In CIR imagery these emergent wetlands will range in appearance from dusty grey to bright white due to the senesced vegetation.

<u>*Hillshade with 5-ft contours*</u>

Typically these sloped emergent wetlands appear bumpy in texture, as opposed to the adjacent fields that have a smooth signature in the hillshade.

PEM1B (Site ID 1007: 44°55'49"N 71°58'44"W)

Palustrine, Emergent, Persistent, Seasonally Saturated.

Field Photo

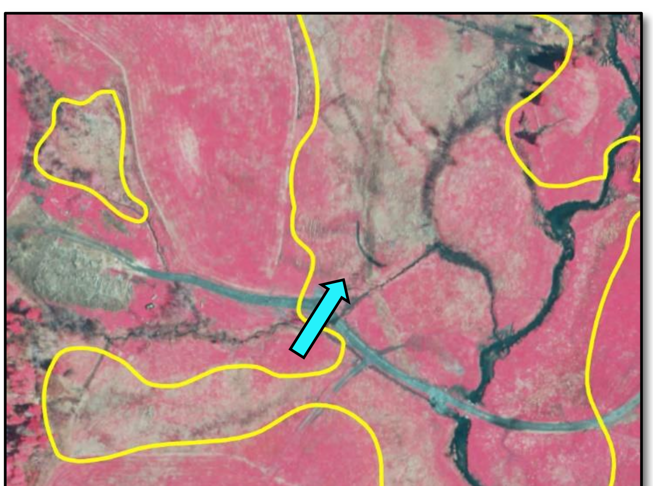
Located in Orleans County, the dominant vegetation in this slope emergent wetland are sedges (*Carex*). In the photo, tussocks are evident in the pasture due to cattle grazing. This photo was taken facing northeast as this seasonally saturated emergent wetland eventually filters down slope to the stream.

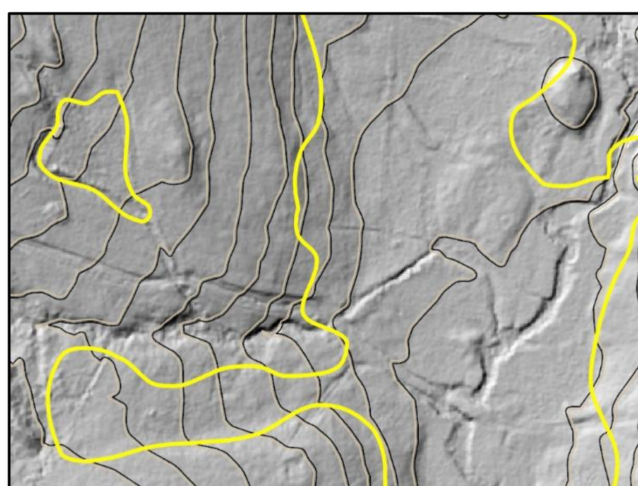
CIR Imagery

The emergent signature in the CIR imagery is a dusty grey color, with speckles of grey and white (tussocks) spots within the farm pasture (shown as red). Typically these slope emergent are adjacent to streams or other open water features.

Hillshade with 5-ft contours

The hillshade and contours show slope draining down from the west, with a fairly subtle slope as the wetland nears the stream.





PEM1B ***(Site ID 1011:   44°58'14"N 72°00'18"W)***

Palustrine, Emergent, Persistent, Seasonally Saturated.

Field Photo

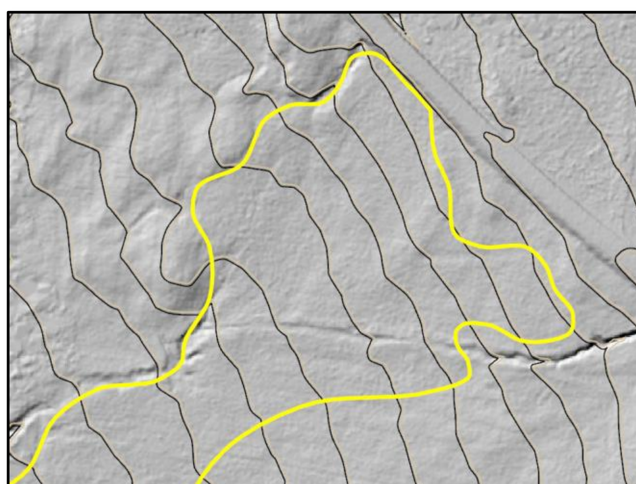
A good example of a sloping emergent wetland in Orleans County. This wetland and similar wetlands will be classified as seasonally saturated due to the consistent slope. Tussocks evident in the photo are a good wetland indicator. This photo was taken facing southwest looking down the slope.

CIR Imagery

CIR imagery showing the dusty grey signature correlating with wetland vegetation. These slope wetlands often contribute to streams downslope as shown in the imagery. Notice in this case the area has been pastured and therefore hummocks have formed on much of the saturated surface.

Hillshade with 5-ft contours

Consistent slope indicated by the contours that the water regime is seasonally saturated as opposed to seasonally flooding.



***PEM1Bd* (Site ID 248: 44°37'51"N 72°22'44"W)**

Palustrine, Emergent, Persistent, Seasonally Saturated, partly drained/ditched.

Field Photo

This emergent wetland is located in Orleans County. Vegetation observed in the meadow was predominantly cattail (*Typha*). While this area is relatively flat and may occasionally be influenced by overland flooding, the flooding aspect is very minimal as this wetland is outside of the floodplain. In this area, there is heavy ditching as well so this wetland will be classified as seasonally saturated with a partially drained modifier. This photo was taken facing northwest.

CIR Imagery

The wetland signature in the CIR imagery shows grey signature, with patches of darker signature in the deeper pockets indicating water inundation. Also prevalent are multiple ditches to justify the use of the drained modifier.

Hillshade w/ color-ramped DEM & 2-ft contours

Color-ramped DEM showing the low relief area as well as the ditch lines.

GEOSPATIAL SERVICES • SAINT MARY'S UNIVERSITY OF MINNESOTA
702 Terrace Heights • Box 7 • Winona, MN 55987-2440 USA • 507-457-8746 • Fax 507-457-6604 • www.geospatialservices.org

***PEM1E** (Site ID 252: 44°39'30"N 72°23'51"W)*

Palustrine, Emergent, Persistent, Seasonally Flooded/Saturated.

Field Photo

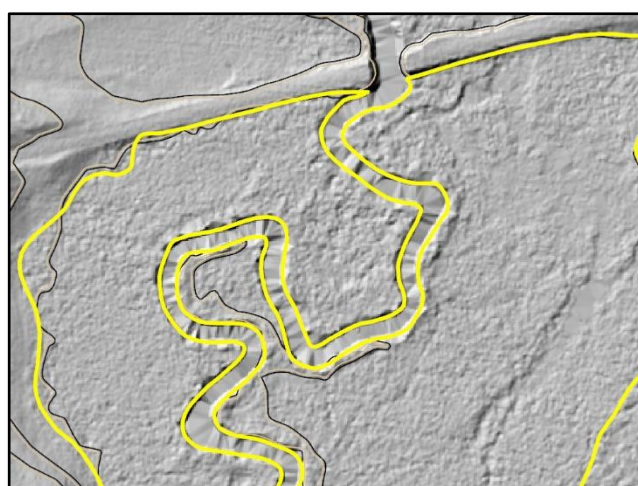
Transitional areas where saturated wetlands are also affected by flooding (river floodplains) will be classified by seasonally flooded/saturated. This wetland in Orleans County is a good example of seasonal flooding that occurs in the spring due to fluctuating river levels. While surface water is absent in the late growing season, soils remain saturated near the surface. This photo was taken facing south.

CIR Imagery

CIR Imagery shows significant flooding adjacent to the river. Grey signature represents emergent wetlands while dark black signature represents standing water.

Hillshade with 5-ft contours

Hillshade detailing bumpy, rough texture adjacent to the river as a good indicator of wetland landscapes.



PEM1Eb (Site ID 240: 44°29’38”N 72°26’32”W)

Palustrine, Emergent, Persistent, Seasonally Flooded/Saturated, beaver modified.

<u>*Field Photo*</u>

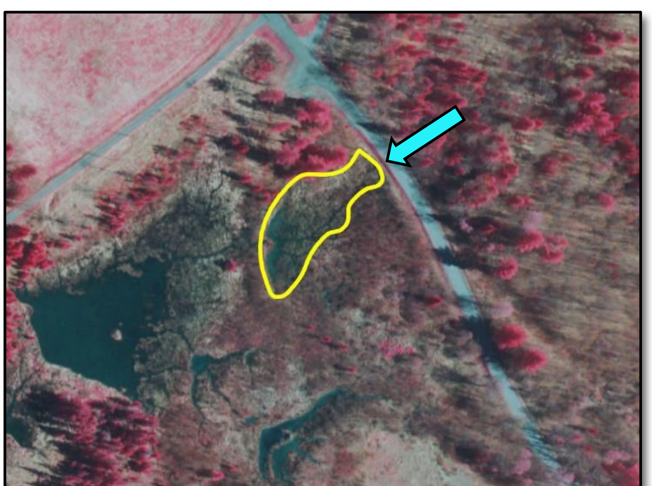
Beavers are very prevalent in the study area as shown in this beaver complex in Lamoille County. Dam building by beavers result in the creation of small open water ponds and beaver meadows that are dominated be emergent and scrub shrub vegetation. In this particular example the wetland is dominated by emergent vegetation. Beavers typically like slow moving streams and saturated environments to build their dams, and as a result, such flooding occurs to create their habitat and will be classified as seasonally flooded/saturated with a beaver modifier. This photo was taken facing southwest.

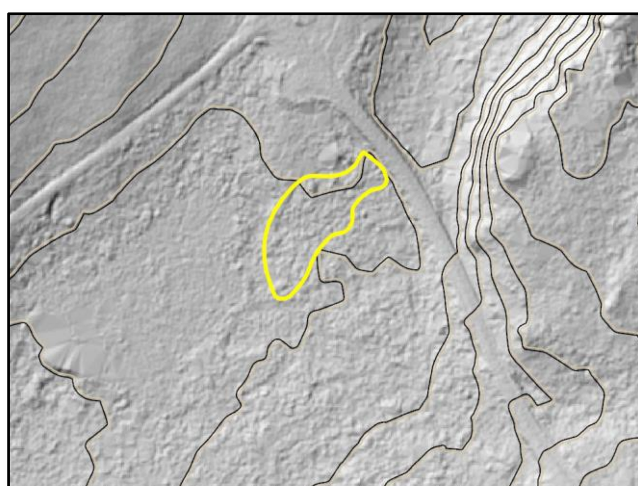
<u>*CIR Imagery*</u>

Beaver signatures may include a small open water feature, with a beaver meadow beyond. In some cases, dead trees and shrubs may be present do to the increase of open water. CIR imagery shows sequential beaver ponds and meadows that have altered the landscape.

<u>*Hillshade with 5-ft contours*</u>

Hillshade showing areas of rough texture for the beaver meadows and more smooth texture that indicates the presence of small open water ponds.





PEM1F *(Site ID 194: 44°23'56"N 73°14'05"W)*

Palustrine, Emergent, Persistent, Semi-permanently Flooded.

<u>*Field Photo*</u>

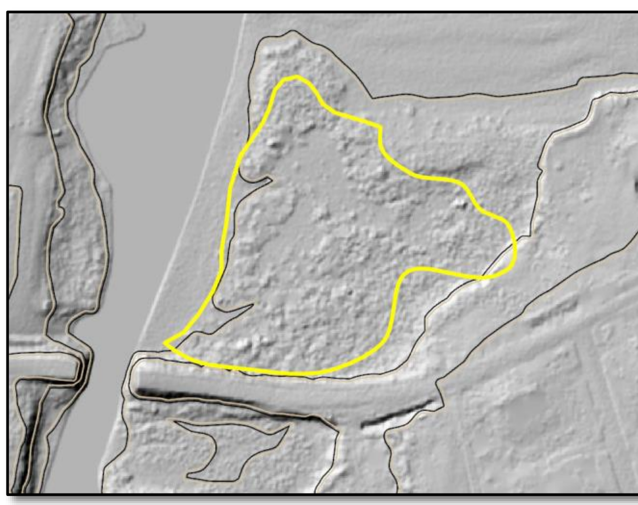
This fringe wetland complex along Shelburne Bay in Chittenden County will be classified as semi-permanently flooded. This wetland is dominated by cattail (*Typha*) and gets significantly inundated in the spring due to the rise in lake level of Lake Champlain. Photo was taken facing east from the boat launch.

<u>*CIR Imagery*</u>

CIR imagery shows blotches of open water mixed in with the vegetation. This is deep fringe basin adjacent to Shelburne Bay.

<u>*Hillshade with 5-ft contours*</u>

Rough, bumpy texture in the hillshade indicates areas of vegetation, while smooth texture is the open water.



***PFO1B** (Site ID: 444:   44°54'33"N 73°14'21"W)*

Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Saturated.

<u>*Field Photo*</u>

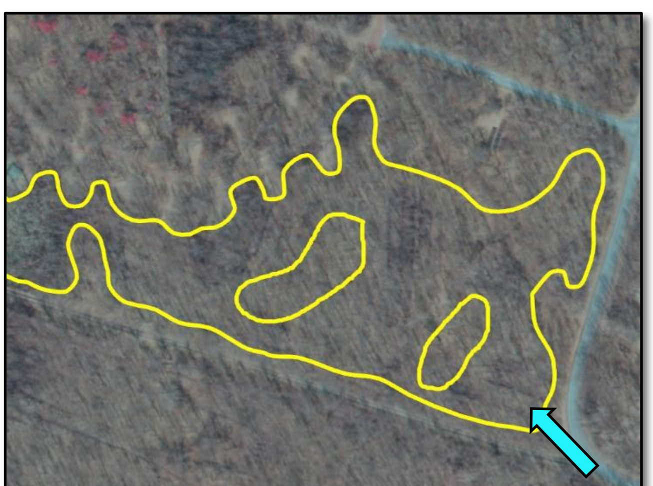
These seasonally saturated, forested areas in Grand Isle County (North Hero State Park) will be classified as seasonally saturated. These areas are made up of broad-leaved deciduous communities including ash (*Fraxinus*) and maple (*Acer*) trees. Photo was taken facing northwest from roadside.

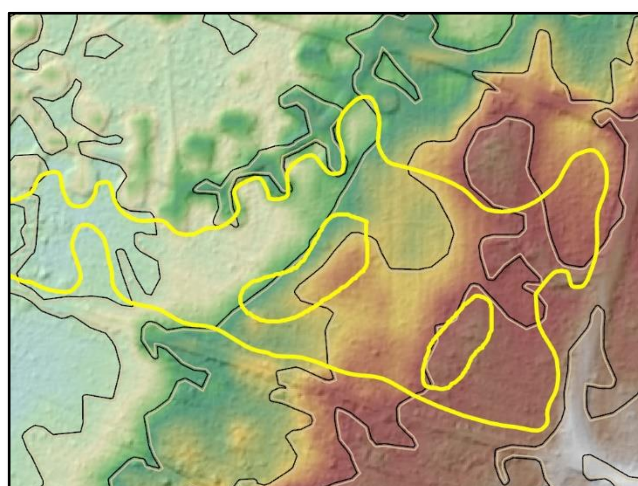
<u>*CIR Imagery*</u>

The signature in CIR imagery consists of very subtle, dark patches. Some areas of low relief are darker in color and serve as good baseline indicators of these forested wetland areas.

<u>*Hillshade w/ color-ramped DEM & 2-ft contours*</u>

These areas are extremely flat and wetland delineations will require the use of combination of imagery, color-ramped DEM, and 2 ft. contours. If below target mapping unit, some upland inclusion may be lumped into the wetland delineation boundary.





PFO1C *(Site ID 370:   43°55’33”N 73°23’30”W)*

Palustrine, Forested, Broad-Leaved Deciduous, Seasonally Flooded.

Field Photo

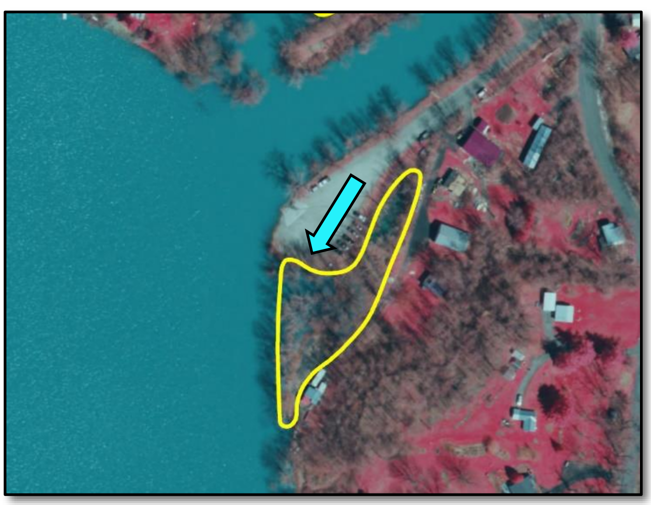
Forested wetlands, such as this example in Addison County, bordering Lapham Bay, will be classified as seasonally flooded due to the rise of lake levels in the spring. Photo was taken facing southwest from the boat launch.

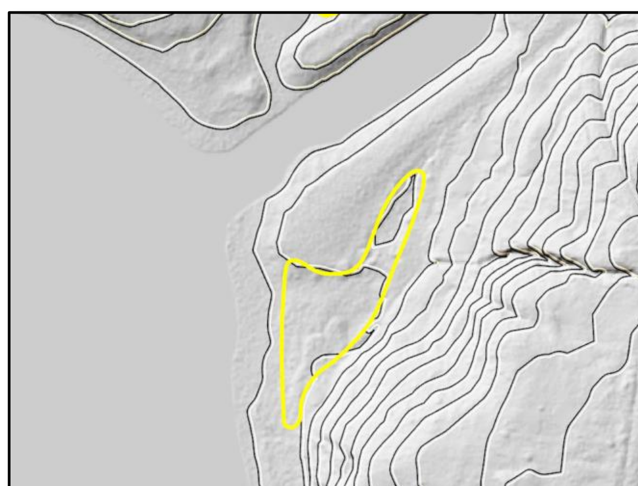
CIR Imagery

CIR imagery shows patches of inundated water in these forested wetlands adjacent to Lapham Bay. Snow melt in the spring, along with high precipitation events are driving factors for the lakeside flooding.

Hillshade with 5-ft contours

Hillshade showing the rough texture of the forested wetland adjacent to the smooth texture of the lake itself.





PFO2D ***(Site ID: 348:   44°33'02"N 73°00'26"W)***

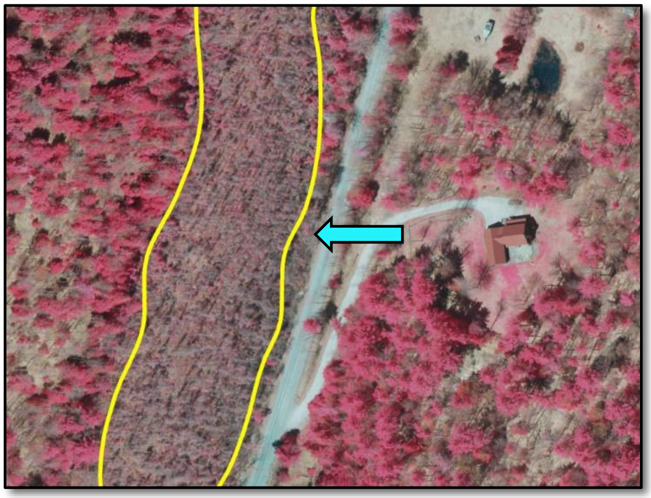
Palustrine, Forested, Needle-Leaved Deciduous, Continuously Saturated.

Field Photo

This continuously saturated stand of needle-leaved deciduous trees is located in Chittenden County. A majority of the time these needle-leaved deciduous, dominated by tamarack (*Larix laricina*) will be classified as continuously saturated. However, in rare cases if there is substantial slope it is acceptable to classify as seasonally saturated. Photo was taken facing west.

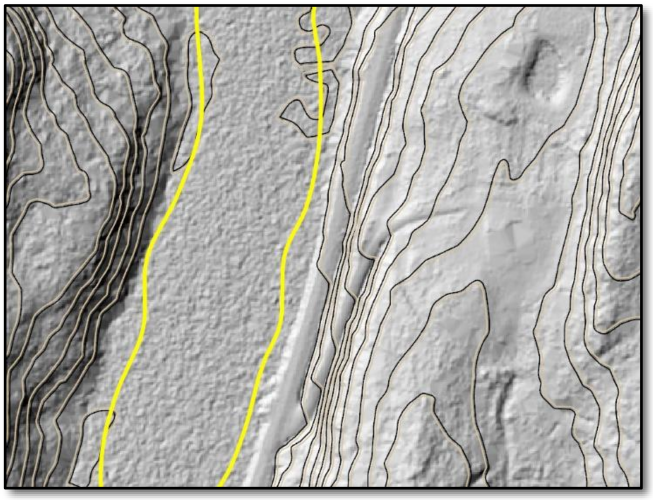
CIR Imagery

Tamarack (*Larix laricina*) signature often appears as a lighter pink with a grey hue in the CIR imagery. The trees have a stippled texture and often cast shadows throughout the signature.



Hillshade with 5-ft contours

Permanent tamarack (*Larix laricina*) bogs will have a rough texture in the hillshade and have very few, if any contour lines crossing through it.



PFO4B (Site ID 1009: 44°58'01"N 71°37'54"W)

Palustrine, Forested, Needle-Leaved Evergreen, Seasonally Saturated.

Field Photo

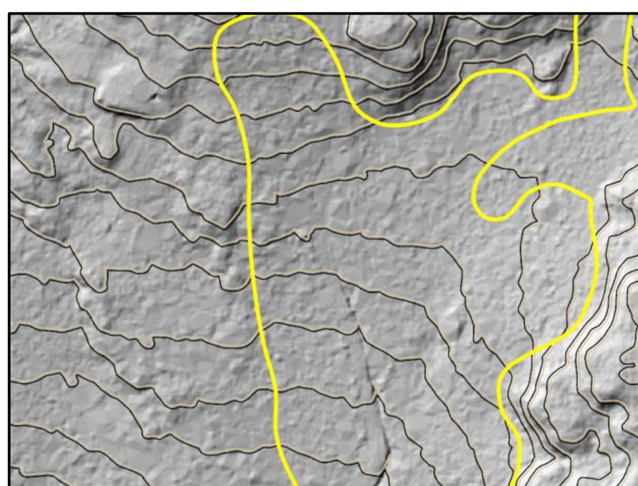
This sloped, seasonally saturated stand of mixed needle-leaved evergreen trees is located in Essex County. Common wetland species for needle-leaved evergreen trees in the study area include black spruce (*Picea mariana*), northern white cedar (*Thuja occidentalis*), and balsam fir (*Abies balsamea*). Photo was taken facing east.

CIR Imagery

CIR image signature for need-leaved evergreens can range from a lighter red to a deep maroon depending on the species.

Hillshade with 5-ft contours

This gently sloped wetland complex shows a slight, sloped depression and bumpy signature in the hillshade and consistently spaced contours.



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PFO4D *(Site ID 254:   44°43'24"N 72°23'01"W)*

Palustrine, Forested, Needle-Leaved Evergreen, Continuously Saturated.

Field Photo

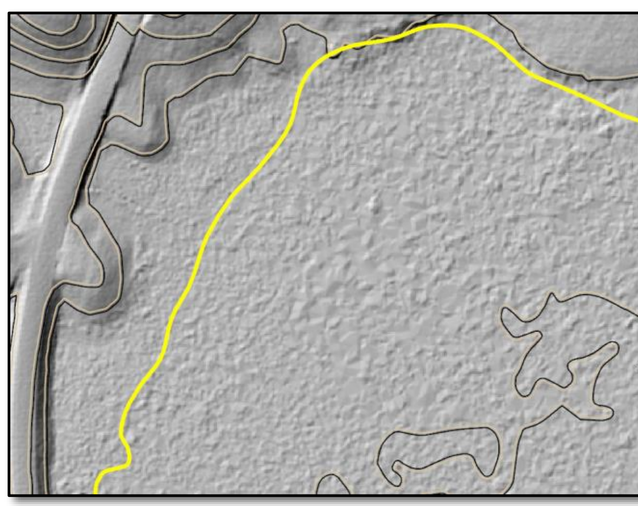
This continuously saturated stand of mixed needle-leaved evergreens is located in Orleans County. In this nutrient poor, low lying bog, species are slow growing and often stunted due to the wet soil conditions. To the forefront, a continuously saturated emergent wetland is visible. Photo was taken facing east.

CIR Imagery

These trees are conical in shape and often cast shadows in the CIR imagery. Color can range from a lighter red to a deeper maroon, depending on species.

Hillshade with 5-ft contours

These continuously saturated wetland features are typically very flat, with little or no contours intersecting the wetland boundary. Texture in the hillshade has a bumpy, rutted look and signature is in a clear depression.



***PFO4D** (Site ID: 393: 43°03'14"N 73°02'07"W)*

Palustrine, Forested, Needle-Leaved Evergreen, Continuously Saturated.

Field Photo

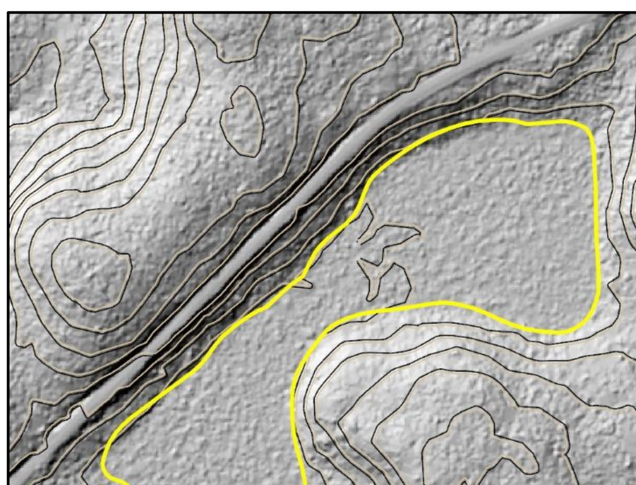
Located in Bennington County (Green Mountain National Forest), this needle-leaved evergreen bog is dominated by black spruce (*Picea mariana*). As shown in the photo, this peat bog was saturated to the surface with pockets of standing water, it was easy to sink into the muck when walking into the wetland complex. This bog, along with similar bog environments will be classified as continuously saturated. Photo, capturing ground conditions was taken facing southeast.

CIR Imagery

Typically, black spruce (*Picea mariana*) are fairly stunted and have a conical shape to them. Colors of a darker magenta are usually good indicators of the particular tree species.

Hillshade with 5-ft contours

These bogs form in depressions and the texture in the hillshade has a bumpy, rutted look to it. Generally around the edges of these bog depression, the boundary between upland and wetland is very distinguishable.



PSS1E ***(Site ID 389: 43°07’56”N 73°04’36”W)***

Palustrine, Scrub-Shrub, Broad-Leaved Deciduous, Seasonally Flooded/Saturated.

Field Photo

This seasonally saturated/flooded complex is located in Bennington County. In this example, the wetland complex is dominated by scrub shrub vegetation. The source of water for this wetland is a combination of overland flooding and saturated soils. Common scrub shrub species in the study area consist of alder (*Alnus*), buttonbush (*Cephalanthus occidentalis*), and various willow species (*Salix*). Photo was taken facing southeast.

CIR Imagery

Scrub shrub species typically have a rough, stippled texture to them in the CIR imagery. Broad-leaved deciduous species will appear a mix of grey to dark brown in color. It is fairly common to map split classes of scrub shrub with either emergent or forested species.

Hillshade with 5-ft contours

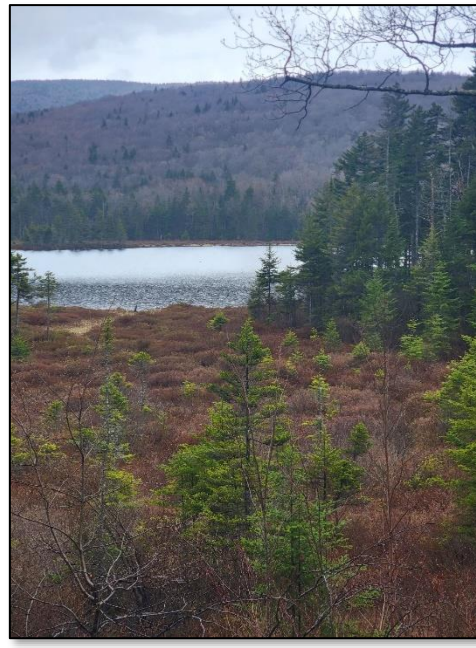
This stand of scrub shrub is located in the low lying depression in the hillshade and typically will have an abrasive texture to it.

PSS3D *(Site ID: 394: 43°03'18"N 73°01'57"W)*

Palustrine, Scrub-Shrub, Broad-Leaved Evergreen, Continuously Saturated.

Field Photo

Located in Bennington County (Green Mountain National Forest), this broad-leaved evergreen wetland is dominated by leatherleaf (*Chamaedaphne calyculata*). Typically situated in bog environments, all broad-leaved evergreen wetlands will be classified as continuously saturated. Photo was taken facing south.

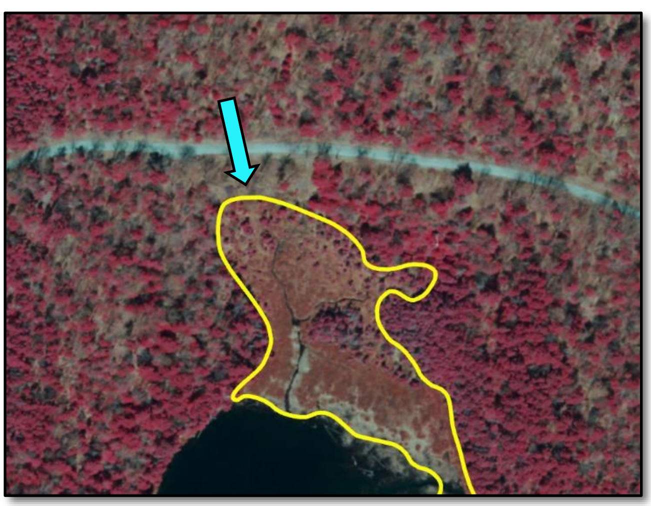


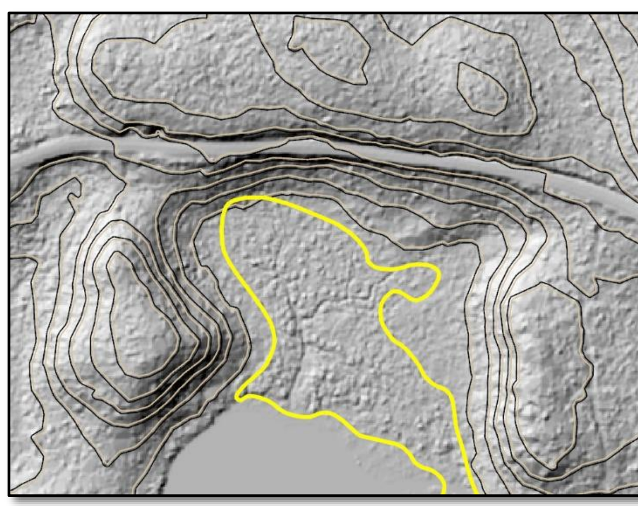
CIR Imagery

Leatherleaf (*Chamaedaphne calyculata*) appears as a very distinct salmon color in the CIR imagery and is typically associated with bogs or fringe areas of open water features.

Hillshade with 5-ft contours

In this example, the wetland complex is located adjacent to an open water feature. These wetlands are often in low lying bog environments and usually show clear depressions in the hillshade.





Pf *(Site ID: 358:   44°30'59"N 73°02'31"W)*

Palustrine, farmed.

Field Photo

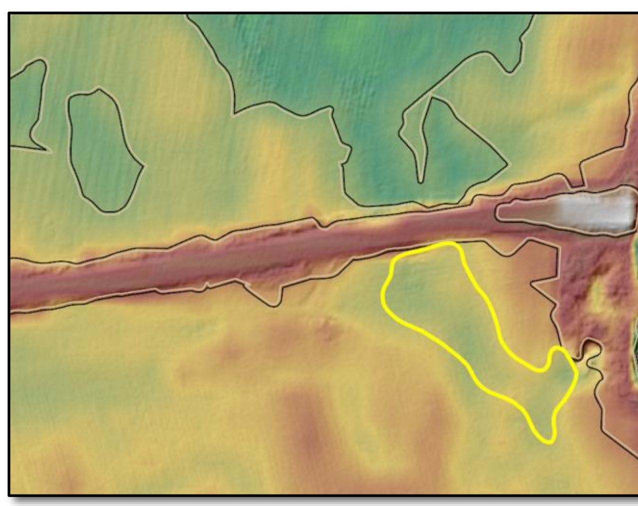
Basins in farm fields that show either standing water or significant crop stress will be mapped as Pf. This example in Chittenden County shows water inundation in the depression. Photo was taken facing southeast.

CIR Imagery

Signatures for farmed wetlands vary from a blueish tint to darker black in color.

Hillshade w/ color-ramped DEM & 2-ft contours

The color-ramped hillshade represents the depression as seen below as water is backing up due to the influence of the road.



***R2UBH** (Site ID: 233:   44°31'20"N 72°24'57"W)*

Riverine, Lower Perennial, Unconsolidated Bottom, Permanently Flooded.

Field Photo

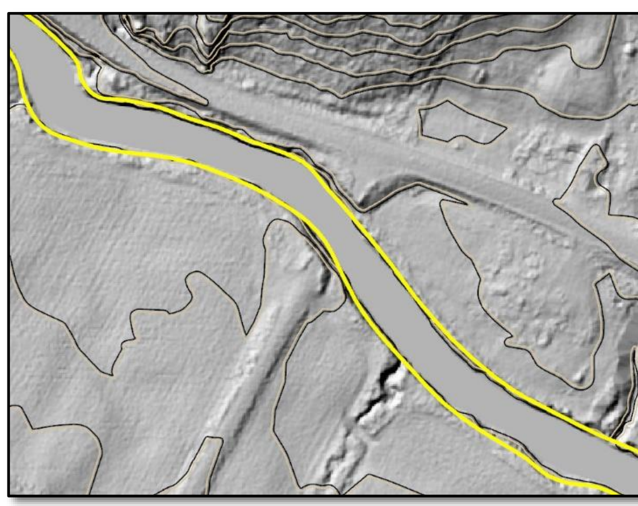
Low gradient rivers such as Lamoille River in Lamoille County will be classified as lower perennial. These rivers are slow moving, incised, and floodplains are well developed. All lower perennial rivers will have a class of unconsolidated bottom and water regime as permanently flooded. Photo was taken facing southeast.

CIR Imagery

Rivers commonly appear dark blue or even black in color with a smooth texture in the CIR imagery. Lower perennial rivers are typically wider and more established than upper perennial rivers.

Hillshade with 5-ft contours

As with most rivers, the open water has been hydro-flattened and appears smooth in the hillshade. Contours support calling this lower perennial due to contours being well spaced apart.

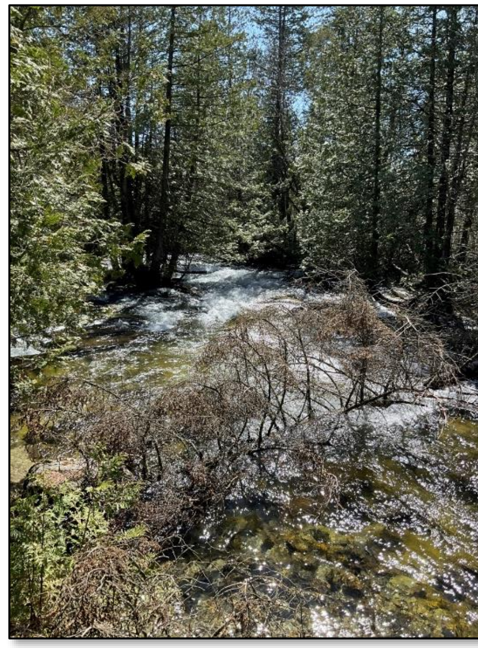


***R3UBH** (Site ID: 267: °50’45”N 71°59’15”W)*

Riverine, Upper Perennial, Unconsolidated Bottom, Permanently Flooded.

Field Photo

High gradient rivers such as this stream in Orleans County will be classified as upper perennial. These rivers are fast moving with little floodplain development. All upper perennial rivers will have a class of unconsolidated bottom and water regime of permanently flooded. Photo taken facing southeast.

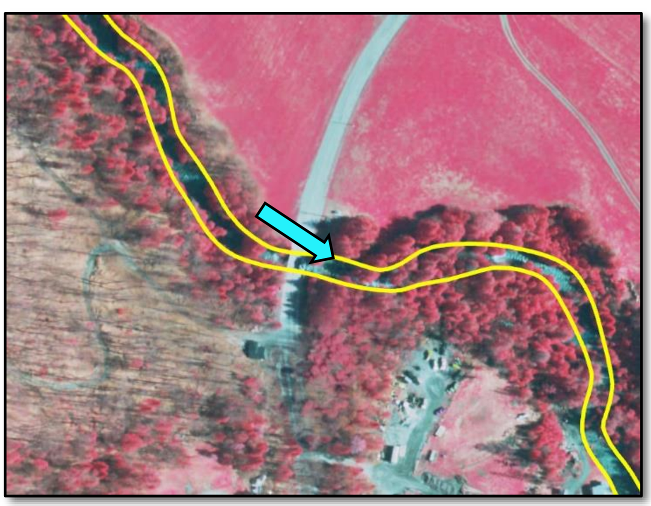


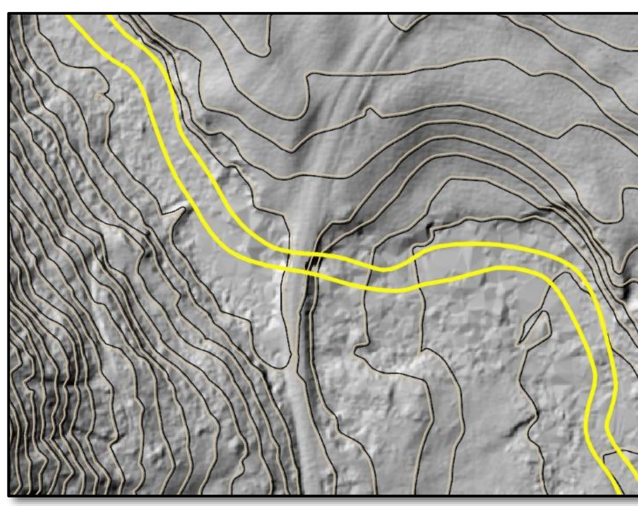
CIR Imagery

Rivers commonly appear dark blue or even black in color with a smooth texture in the CIR imagery. Upper perennial rivers are usually smaller channels and less established than lower perennial rivers.

Hillshade with 5-ft contours

Upper perennial rivers are not always hydro flattened, due to them typically being smaller in width. Contours support calling this upper perennial as multiple contour lines are crossing the feature.





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