Resource Assessment and
Watershed Level Plan for Agriculture in the
Hungerford Brook Watershed,
Franklin County, Vermont – May 2018

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I. Background and Purpose of Plan

A. General overview of assessment area

Lake Champlain is a 6,000 square mile natural water body. Its contributing Basin (HUC-6 code 041504) has land in Vermont, New York, and Quebec. The lake is important to the Vermont economy, contributing to the recreation opportunities, transportation, water supply and environmental quality functions to half the state's land and 62% of its population. The State Capitol and four of its largest cities are in the Basin. The Hungerford Brook drainage area is a single sub-watershed at the 12-digit Hydrologic Unit Code (HUC-12) level in the National Watershed Boundary Dataset. It is located in what is known by EPA and state government as the Missisquoi Bay Basin segment of Lake Champlain.

B. Phosphorus as the primary constituent of concern

This watershed plan, developed by the Vermont NRCS and Vermont Association of Conservation Districts with support from the National Water Quality Initiative, is meant to address the need for more effective practice implementation of conservation plans on agricultural lands in one of the targeted watersheds of the Lake Champlain Basin. Past conservation practice implementation efforts have been broad in scope and have not resulted in any measurable improvements in water quality. In response to the new phosphorus TMDL for Lake Champlain and the availability of increased NRCS funding for the next five years, NRCS in Vermont has decided to use a more strategic and focused process for conservation practice implementation. Under this new process, NRCS will collaborate with the Vermont Department of Environmental Conservation (VTDEC) to contribute information for the Agricultural sections of Tactical Basin Plans (TBP's), or as updates to these. These agricultural watershed plans will provide a comprehensive inventory of land use and resource conditions in each of the targeted watersheds.

C. Opportunities and objectives for meeting water quality goals

These watershed plans also include the results of an analysis to establish phosphorus reduction goals (in lbs/yr) for each of the targeted watersheds using existing EPA tools such as the EPA BMP Scenario Tool and HUC-12 Tool for the Lake Champlain Basin. The percent reduction in phosphorus load identified by EPA for the larger HUC-8 watershed was used to estimate the required phosphorus load reduction for each HUC-12 watershed. The EPA phosphorus reduction goal set for the Missisquoi Bay segment and Hungerford Brook Watershed is 83%.

D. NRCS' plans to help partners reach watershed goals

The information provided will then be used by Local Watershed Teams working in each watershed to identify and target specific farms and fields for further resource assessment and the development of practice alternatives; this will become their Local Watershed Team Action Plan. These Local Watershed Teams will be initially established by NRCS, but will be directed by an appropriate local partner to bring all agricultural partners together to work in a coordinated and strategic effort. The Local Watershed Teams will also determine the length of the project for each watershed and what amount of phosphorus reduction they think the conservation partners and all levels of government can achieve during that time period. The timeline and amount of practice implementation may be determined to some extent by the amount of funds likely to be available, and the staff available to implement the Local Watershed Team Action Plan.

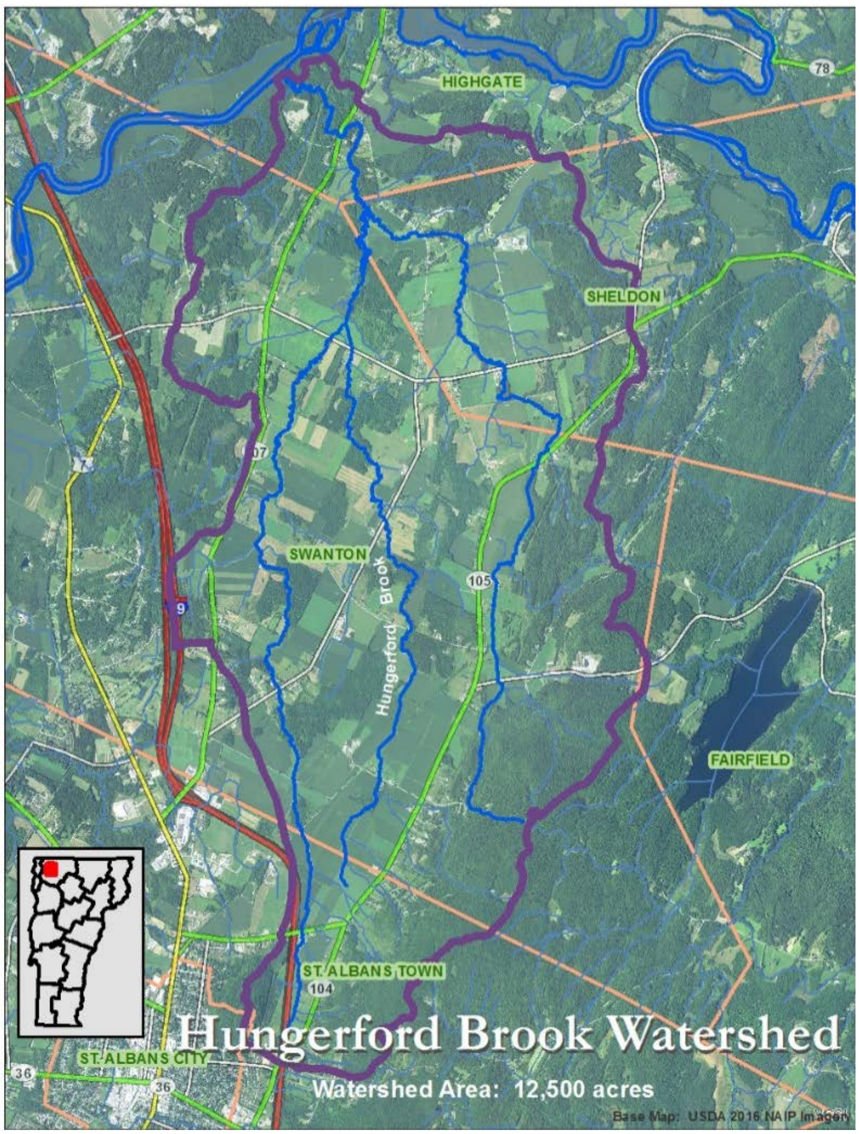
Based on the required reduction for each of the targeted watersheds, an example conservation practice scenario has been developed for the Hungerford Brook Watershed. This scenario includes a suite of individual practices and systems of practices, that when implemented will reduce phosphorus loading from agricultural lands by the required amount for each of the targeted watersheds (currently 83% for Hungerford Brook). The Local Watershed Team will modify this list of selected practices and the amount applied based on their more detailed assessment of the watershed. The amount of estimated phosphorus reduction from this modified suite of practices will be tracked on an annual basis. It is important to note that these phosphorus reduction amounts achieved by these specific practices are an estimate based on some fairly general modeling assumptions. These modeled loading reductions can be helpful in establishing goals for a watershed and for the tracking of progress. However, these numbers are not necessarily accurate enough to be used for regulatory purposes.

II. Watershed Overview

A. Location of Watershed within the drainage network

The Hungerford Brook watershed is located in Franklin County and is a tributary of Missisquoi River, which empties out into the Missisquoi Bay of Lake Champlain. The State of Vermont recognizes Hungerford Brook as a part of the Missisquoi Basin. The Missisquoi Bay is subject to frequent and sometimes severe cyanobacteria blooms during the summer months, since it is shallow, replenishment/flushing is constricted and therefore slowed, and phosphorus inputs from contributing streams can be high after storm events. These conditions highlight the need to do work in impaired watersheds in this section of the lake.

Figure 1 – Map of the Hungerford Brook Watershed



The total watershed area of Hungerford Brook is 12,534 acres, consisting primarily of forest and agricultural land, which contributes to the phosphorus pollution impacting Lake Champlain's Missisquoi Bay.

B. Landscape characteristics of the MLRA/Ecoregion in which the watershed resides

Hungerford Brook is located in Major Land Resource Area (MLRA) 142—St. Lawrence-Champlain Plain. This MLRA is characterized by glaciation and low relief, which has impacted the area's shallow lacustrine basins with low hills of glacial till, and fluvial activity that creates deep and narrow valleys. Glacial till covers most of the bedrock in this area resulting in areas of glacial outwash and eolian deposits. Lacustrine deposits are common in this area as well. Ground water is abundant in this MLRA and the dominant soils are Alfisols, Inceptisols, Spodosols, and Entisols which support hardwoods and sugar maple-beech-birch forest types. (USDA, Natural Resource Conservation Service. 2006. Land Resource Regions and Major Land Resource Areas of the United States, the Caribbean, and the Pacific Basin. U.S. Department of Agriculture Handbook 296.)

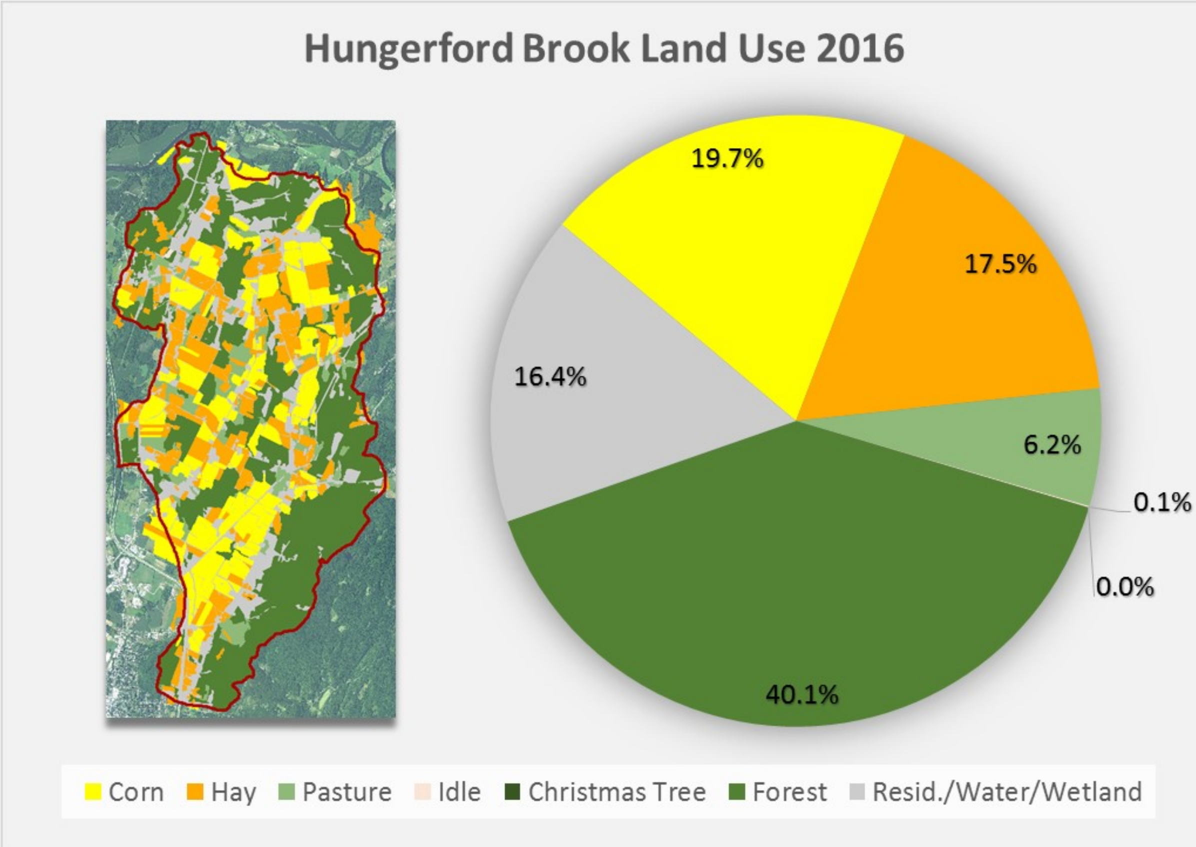
C. Climate, topography, geomorphology, geology and soils

The NRCS/Oregon State University PRISM climate database reports that Hungerford Brook receives an average of 37-47 inches of annual precipitation, with the highest amounts (above 40) of precipitation in the higher elevation areas in the southeastern portion of the watershed. The average temperature of Hungerford Brook is 44.05 degrees Fahrenheit. The highest elevation in the watershed is 1,165 feet in the southeast. Elevation is 109 feet at the confluence of Hungerford Brook and the Missisquoi River. For reference, the average elevation of Lake Champlain, just downstream, is 95 feet. A quarter of Hungerford Brook watershed is composed of Massena Loam, which has a parent material of coarse-loamy till and a typical profile of 0-8 inches loam, 8-25 inches silt loam, and 25-44 inches gravelly loam (NRCS Web Soil Survey). The next most abundant soil series is Georgia stony loam, making up 11% of the watershed. Massena series has a hydrologic soil group of C/D, which makes up 52.7% of Hungerford Brook's agricultural soils and 41.7% of all soils in the watershed. The C/D designation means that the soils are in hydrologic soil group D (wettest group) unless the fields are drained or ditched. The next most abundant hydrologic soil group is C, making up 22% of agricultural soils and 22.8% of all soils in the watershed. The geology of Hungerford Brook is defined by a fault on the eastern side of the watershed, which influences the higher elevations and more varied topography. East of the fault, there is quartzite and dolostone bedrock, whereas west of the fault the bedrock is mostly slate. Glacial till deposits are found throughout this watershed, as is evident from the loamy till soils.

D. General land cover/land use

As interpreted from 2016 NAIP Orthoimagery – the latest available, 43.4% of Hungerford Brook is in some sort of agricultural use. Corn has the highest percentage at 19.7%, followed by Hay (17.5%), Pasture (6.21%), and Christmas Tree Farms (0.01%). Hungerford Brook is composed of 40.1% forest and the remaining 16.4% is residential, surface water, and wetlands. Figure 2 displays these data.

Figure 2 – Land Cover/Use for the Hungerford Brook Watershed



E. Current and planned water quality monitoring

Currently in the Hungerford Brook Watershed, flow monitoring data are being collected at two locations – mainstem and the main southeastern tributary – along Woods Hill Road in Swanton near their confluence. There is a monitoring station where Hungerford Brook crosses Rt. 207, a location marking the farthest downstream extent of agricultural land uses. An aquatic organism/water quality station closer to the mouth is positioned at an outflow from the lower watershed's forested land – a western tributary, no development or agriculture in that catchment. Another, called Hungerford Trib 4, assesses water quality and macroinvertebrate health at Cook Road, also in the lower watershed from the northeast corner of the watershed, where there is some residential development.

III. Resource Inventories and Planning

A variety of watershed land and farm assessments were undertaken in order to provide resource condition information on a watershed scale to the Local Watershed Teams. These various data layers can be used individually or in combination with each other to help the Local Watershed Teams to target areas for further on the ground assessment, and then if appropriate conservation practice implementation. Due to the large extent of information that could be potentially developed and the short time frame in which the data is needed, we have prioritized the development of the data layers to some extent based on feedback from local NRCS employees.

For each data layer a short narrative describes the data set, briefly how it was generated, provides a watershed wide map of the data, a more detailed example map if appropriate, and some tabular or graphical summary data when appropriate. Suggestions are provided as to how this data layer might be used in conjunction with other data layers. All Local Watershed Teams will be provided GIS based electronic files of each data layer for them to use in their more detailed assessments.

A. Farmstead mapping

The Farmstead Map shows the location of each active farmstead within the Hungerford Brook Watershed (Figure 3). The identification of farmsteads was conducted by visual interpretation of the 2016 NAIP imagery. Farmstead boundaries were based on the visual identification of structures and heavily disturbed ground surface. As can be seen in Figure 3, there was a total of 25 active farmsteads, covering 135 acres, identified in the watershed, with onsite verification conducted in 2017. These maps can be used to ensure that all farmsteads in the watershed are reviewed on the ground for potential waste management issues and to help identify farmsteads with potential resource concerns such as improperly constructed and/or maintained heavy use areas.

Figure 4 shows an example Farmstead Map for a location that has several barns, a manure storage facility and some heavy use areas, but shows no visible resource concerns. The close proximity of the manure pit to a surface ditch might warrant an onsite visual assessment of any potential resource concerns.

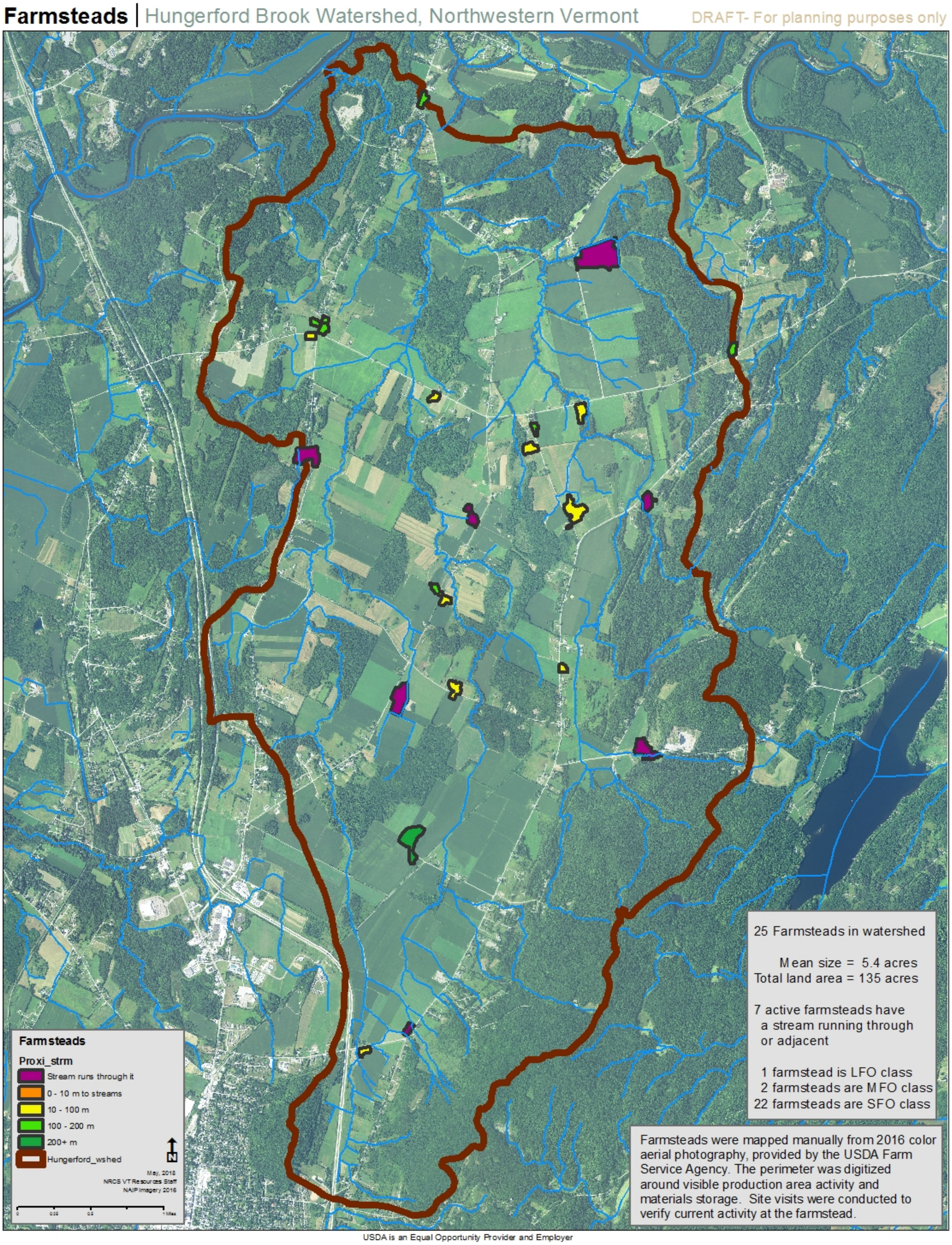


Figure 3 – Farmstead Locations in the Hungerford Brook Watershed

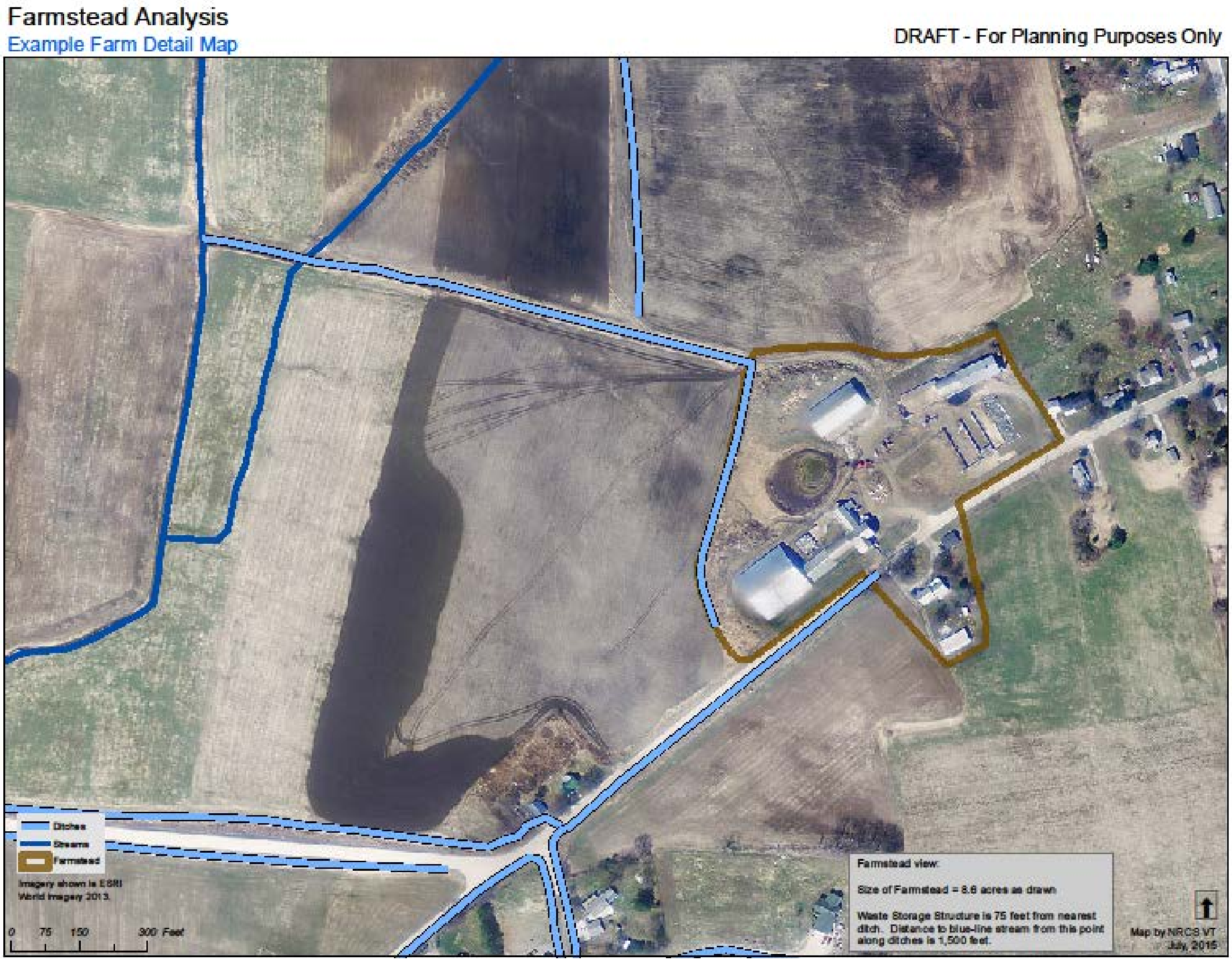


Figure 4 – Example Farm Scale Farmstead Map

B. Annual crop and hayland

Some of the basic pieces of information needed for agricultural watershed planning are the extent and types of land cover in the watershed. Annual crop and hay fields as well as pasture were visually identified in the Hungerford Brook Watershed using 2016 NAIP imagery. As such, the land cover is a "snapshot in time" since many crop and hay fields are rotated between annual crops such as corn and hay. An additional analysis identified fields in continuous annual crops.

Figure 5 shows the location and extent of annual cropland and hay fields in the Hungerford Brook Watershed. This information was digitized using the 2016 National Agriculture Imagery Program (NAIP), and as such may differ slightly from the National Land Cover Database (NLCD) data presented in Figure 2. According to the NAIP photography there was a total of 2,687 ac of annual cropland, 2,390 ac. of hay and 772 ac. of pasture (discussed later) in the Hungerford Brook Watershed in 2016. This comprises a total of 46.7% of the 12,534 ac. watershed.

Crop and Hay Fields | Hungerford Brook Watershed, Northwestern Vermont

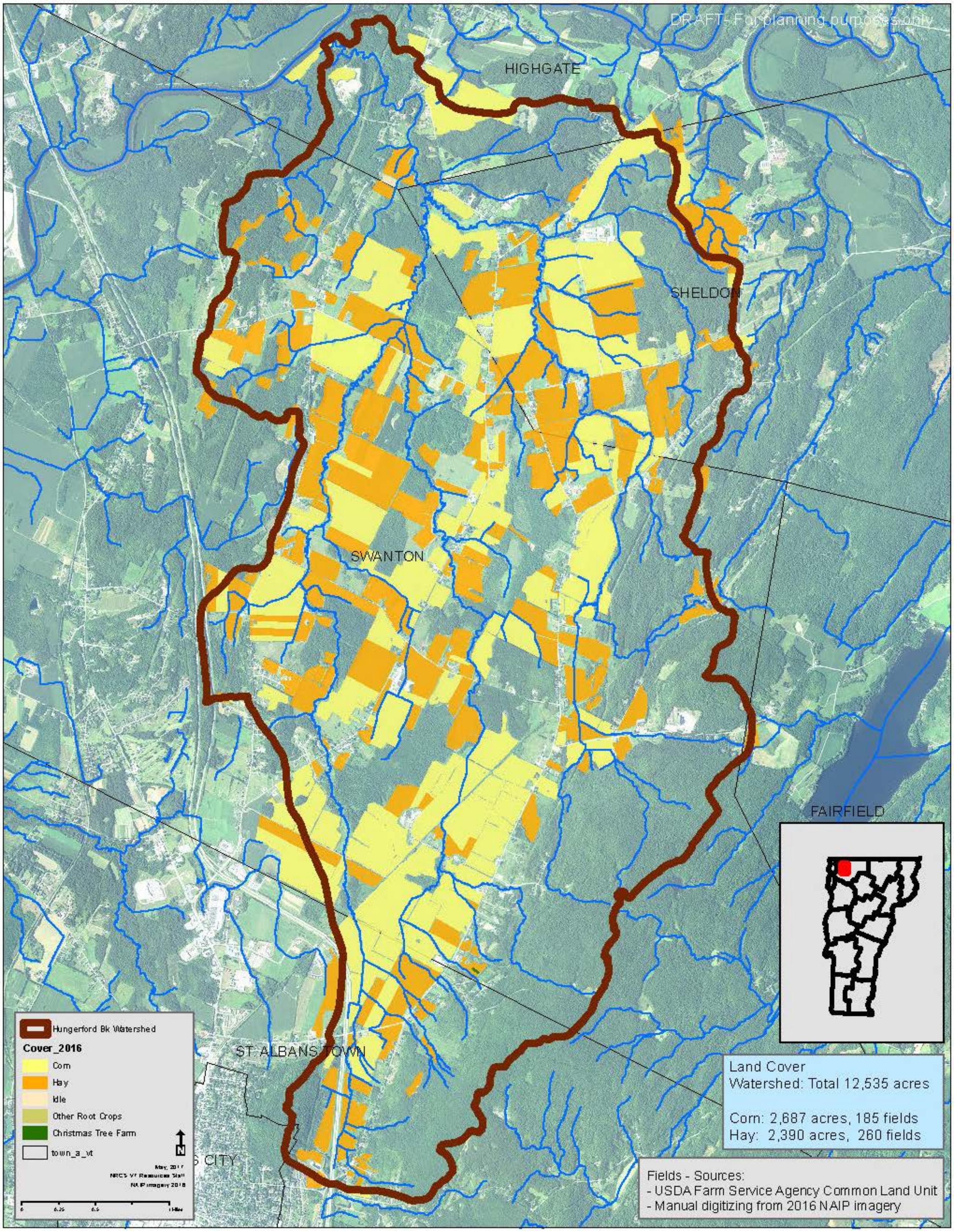


Figure 5 – Location and Extent of Annual Crop and Hayland in the Hungerford Brook Watershed

Field scale maps can be produced by conservation planners that are working as part of the Hungerford Brook Local Watershed Team. Figure 6 is an example of a field scale map for annual cropland and hayland. The Annual Crop and Hayland maps can be used alone or overlain with other several data layers such as the Erosion and Runoff Risk Potential Maps or the Pasture Maps to evaluate specific fields for erosion and runoff risk or suitability for various conservation cropping systems. It is important to remember that these Annual Cropland and Hayland maps will represent land cover in 2016 (the example in Figure 6 used 2014) and many of these fields may be in a corn/hay rotation.

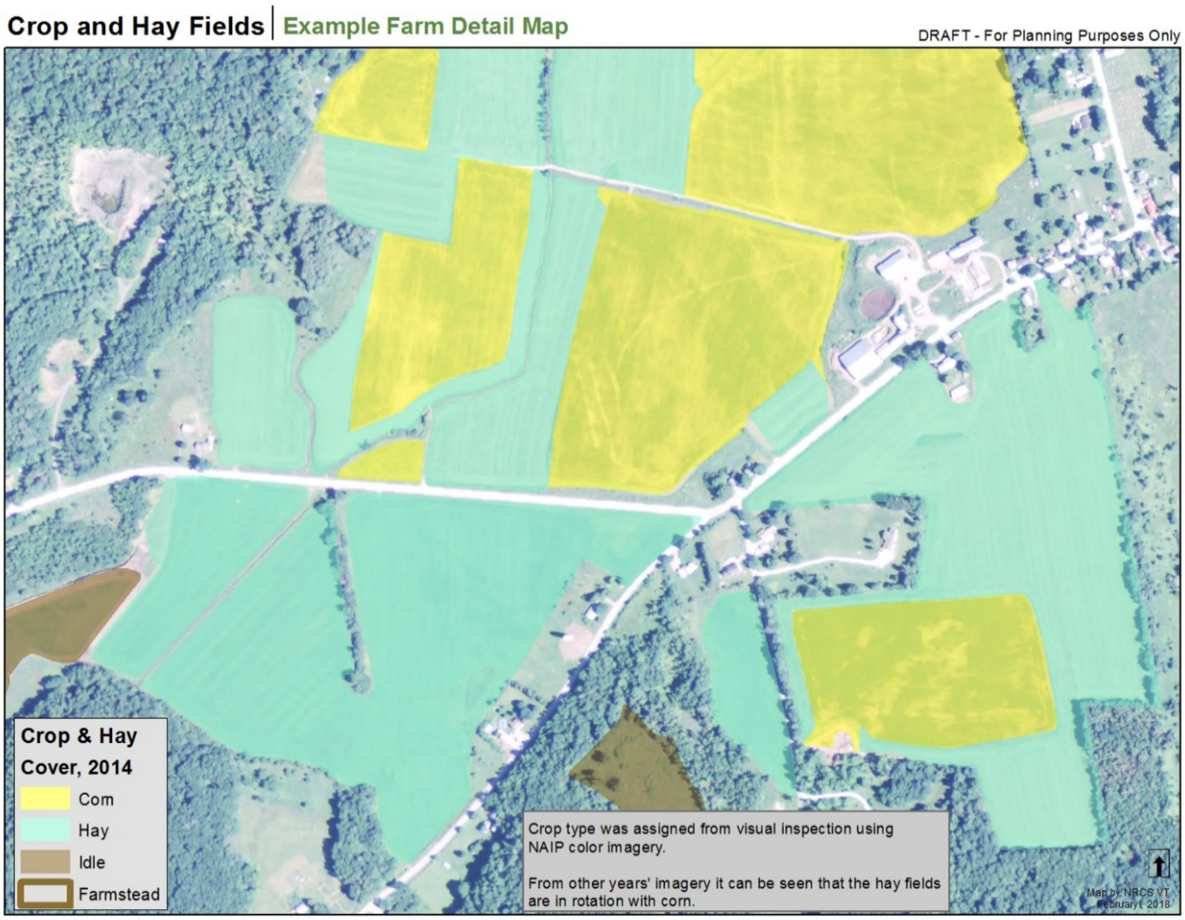


Figure 6 – Example Field Scale Map of Annual Cropland and Hayland

C. Fields in continuous annual crops

An additional analysis was performed to identify farm fields continuously planted to annual crops such as silage corn (Figure 7). These fields were visually identified using five years of aerial imagery (2009, 2011, 2013, 2014 and 2016). There were an estimated 2,110 acres of continuous cropland identified in the Hungerford Brook Watershed (78% of total cropland) in 2016. This analysis also provided an estimate of the total acres used for crop production (7,331 acres) and the amount of corn fields in a rotation of annual and perennial crops (in 2016, 1,068 acres were in corn, but will rotate with hay) which is also displayed in Figure 7.

Fields in continuous annual crops are likely to exhibit a number of resource concerns. These fields may have higher erosion rates, depleted organic, and higher nutrient application rates, among other concerns. For this reason these fields should be prioritized for more detailed and onsite evaluations. Any fields identified as continuous cropland, which also have a high Erosion and Runoff Risk Potential should be considered as especially vulnerable to significant resource concerns.

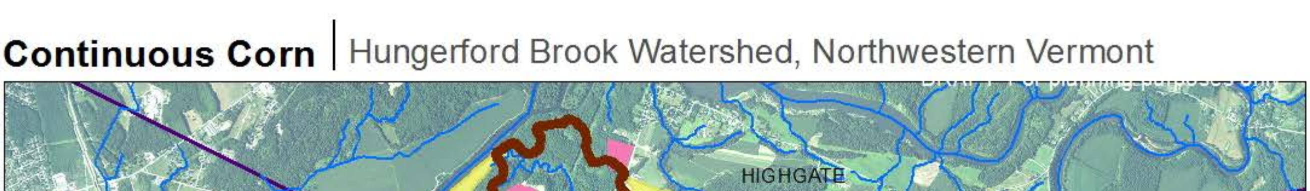


Figure 7 – Map of Fields in Continuous Annual Crops, and Corn in Rotation with Hay

D. Potential gully erosion and concentrated flow areas

The streams and rivers in the Hungerford Brook Watershed are deeply incised over much of the watershed. A small amount of the soils in this watershed are in Hydrologic Soil Group (HSG) A, making up 13% of the land area. These soils, well drained with no modification of topography or drainage, usually have loamy or fine sandy loam surface textures. Most (83%) of the watershed's soils are somewhat poorly or poorly drained (HSG C or D). They may alternatively be ditched or tile-drained soils (HSG B/D or HSG C/D). In this case, the soils on agricultural lands have been drained of excess water and are usually more accessible for farming, dependent on yearly rainfall amounts and storm magnitudes. Typically, the combination of heavy surface textures and/or excessive wetness and an adjacency to steep river banks leads to the development of gullies in these wet areas. These gullies often first form in the woods or on non-ag land adjacent to fields and then with time, head-cut into the crop fields.

This GIS analysis for gully erosion potential uses high-resolution terrain data layers derived from LiDAR elevation (slope and flow-accumulation layers) to find areas which are likely to experience excessive runoff in storms, and are susceptible to gully formation. In this watershed, agricultural areas are closely flanked by steep banks to the streams below. It is important to identify the location of potential gullies, as they can be direct conduits of nutrients and sediment into receiving waters. The results of the analysis for the Hungerford Brook Watershed are shown in Figure 8.

Potential Gully Erosion| Hungerford Brook Watershed

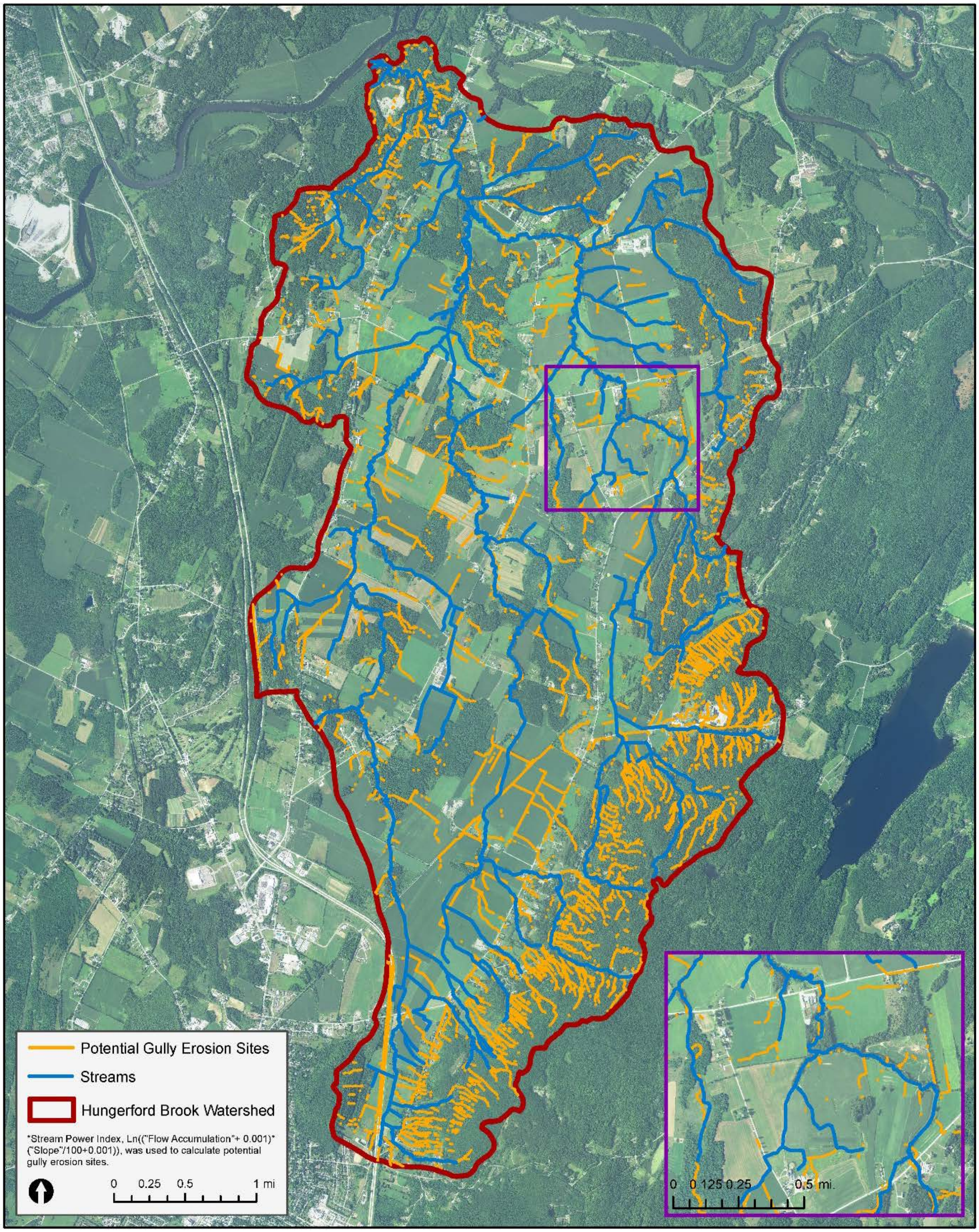


Figure 8 – Potential Gully Locations in the Hungerford Brook Watershed

Individual field scale maps, such as the one shown in Figure 9, can be developed to target in-field resource assessments. As part of the field assessment these areas should be visually checked to identify any areas with significant gully erosion. Though the steeper, forested areas in the southeast portion of the watershed appear more susceptible in this analysis, canopy cover and forest floor organic accumulation can mitigate the danger, such that very little erosion may actually be happening. Field verification is necessary.

Potential Gully Erosion | Example Farm Detail Map

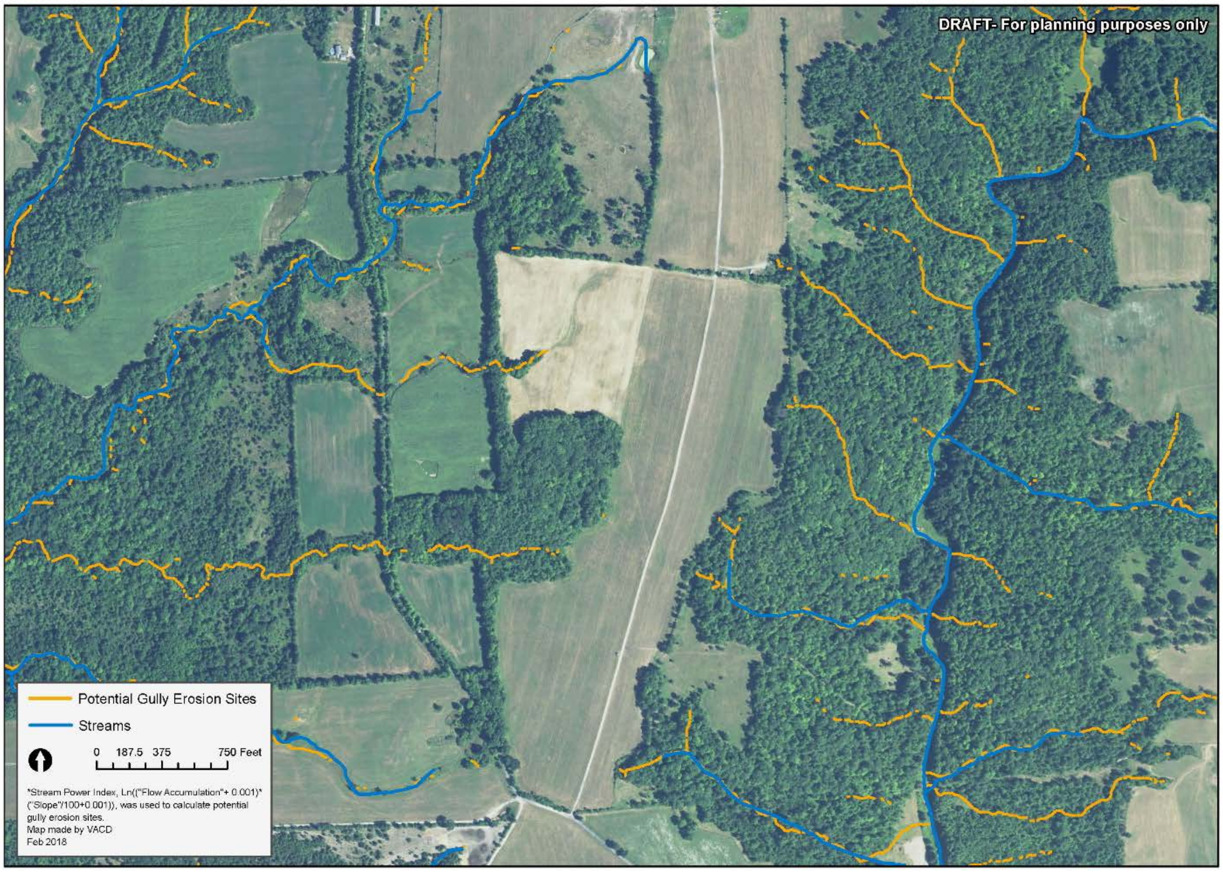


Figure 9 - Field Scale Map of Areas with Potential for Gully Erosion

E. Erosion and runoff risk potential

A GIS model was constructed to estimate the risk of erosion and runoff from farm fields based 4 factors. The factors included are the K value (soil erodibility based on surface texture of bare soil), hydrologic soil group, slope, and flooding potential of the soil map unit (based on Digital Elevation Model (DEM) data). The categories in the Erosion and Runoff Potential Maps are meant to represent the relative risk of **sheet and rill erosion** and runoff occurring from specific fields or portions of fields. As can be seen in Figure 13, some of the fields in the Hungerford Brook Watershed have been identified having a high or very high risk for erosion and runoff. These fields are often seen in the floodplains, and are Figure 14 provides an example of the type of field level maps that can be produced from this data. It is important to note that in many situations it is only a portion of a field that is identified as having high or very high risk.

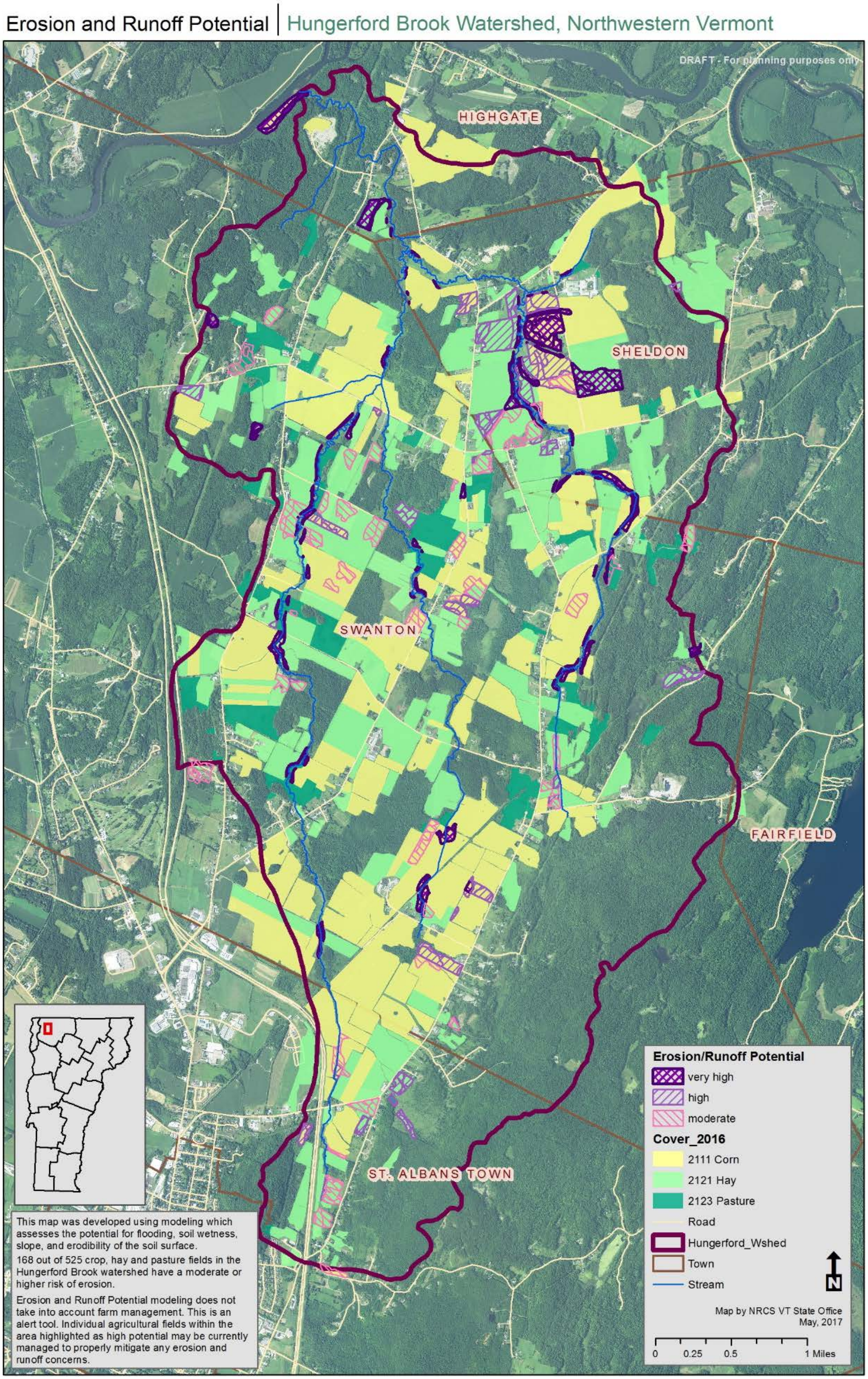


Figure 13 – Erosion and Runoff Risk Potential in the Hungerford Brook Watershed

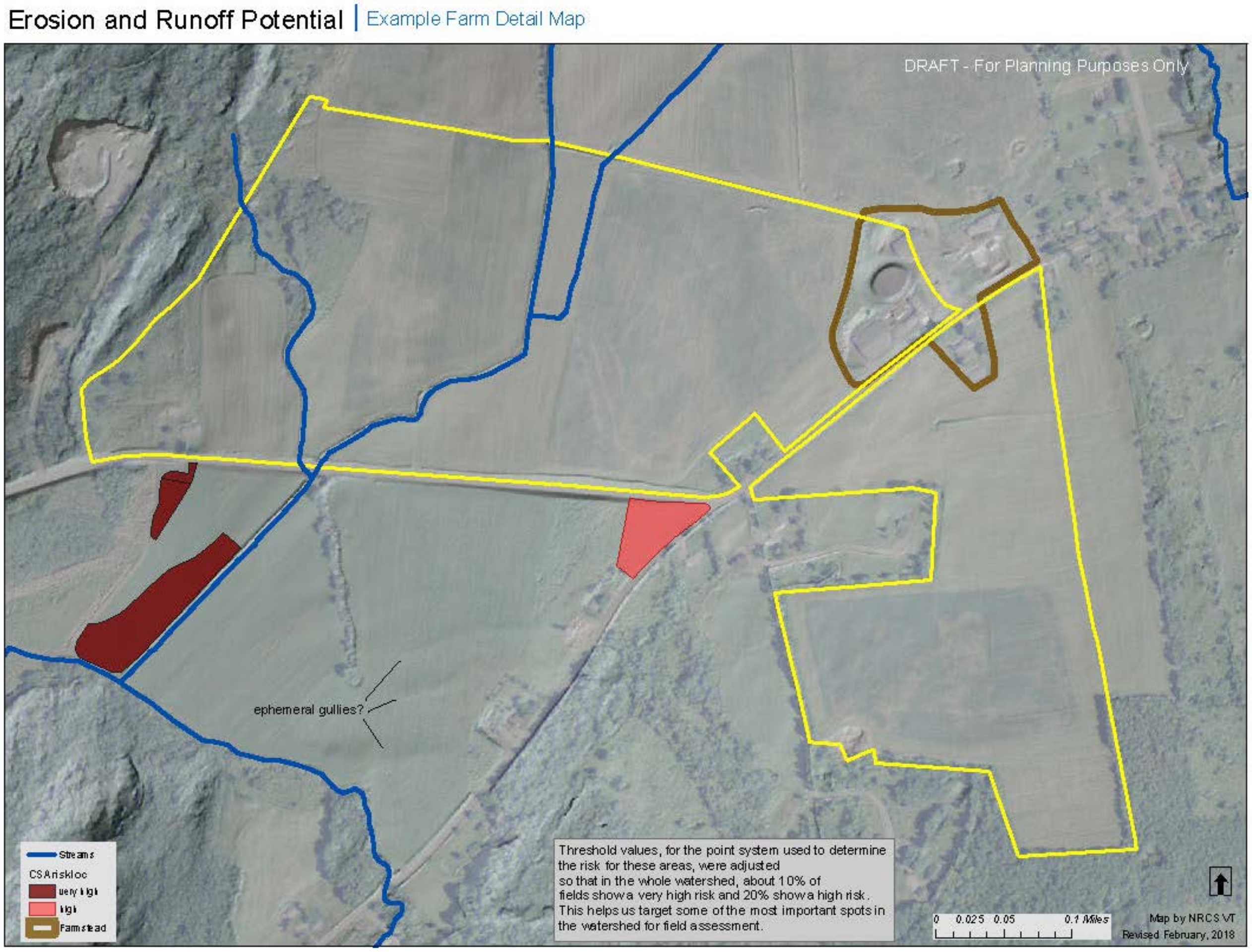


Figure 14 - Example Field Scale Erosion and Runoff Risk Potential Map

F. Farm ditch networks

Field ditches are common on agricultural land throughout the Lake Champlain Basin in Vermont. These waterways have the potential to readily transport both sediment and nutrients to streams and rivers. Under the Required Agricultural Practices recently passed by the State Legislature all ditches will be required to have a 10 ft. wide vegetated buffer adjacent to them. As such, it will become important to know the location of these ditches to ensure that the farmer has opportunities to install buffers on these ditches. Figure 15 shows the location of ditches and other drainage features in the Hungerford Brook Watershed. These drainage features were identified through visual interpretation of airphotos and LiDAR data, and as such **do not represent a completely accurate and complete depiction of drainage features in the watershed. These maps should be used for planning purposes only.** There were a total of 72 miles of field and roadside ditches identified in the Hungerford Brook Watershed. Field scale maps can also be developed as shown in Figure 16, where the ditch locations are overlain with crop field and farmstead location data. Gullies shown in Figure 15 are not modeled, they are channels picked up during visual airphoto interpretation, with LiDAR-based slope and hillshade data backdrops. While the channels certainly exist, visual interpretation methods cannot verify whether erosion is actually occurring in these areas. Thus the mapping should be considered an alert tool, for planning purposes only.

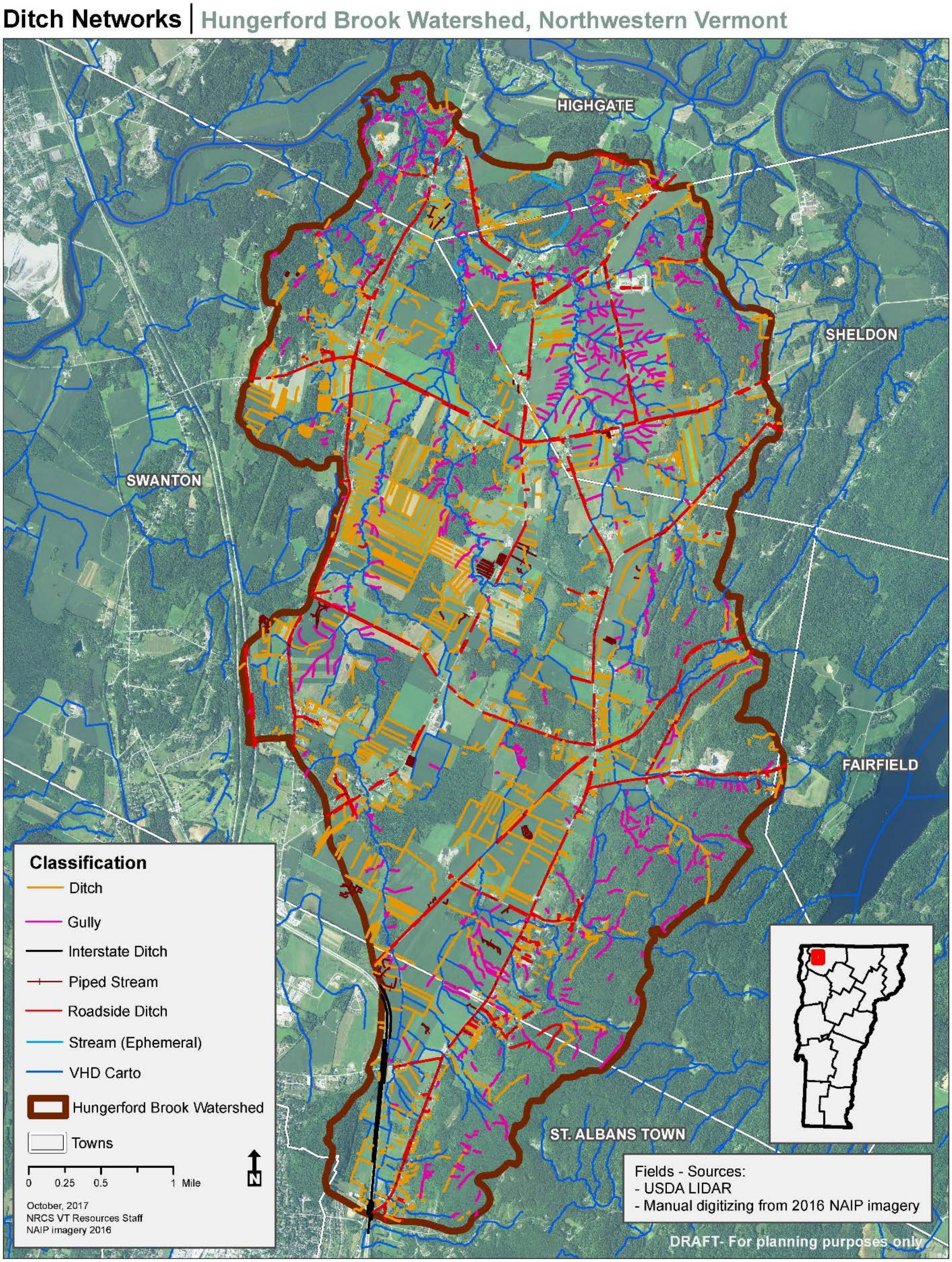


Figure 15 - Map of Field Drainage Features in the Hungerford Brook Watershed

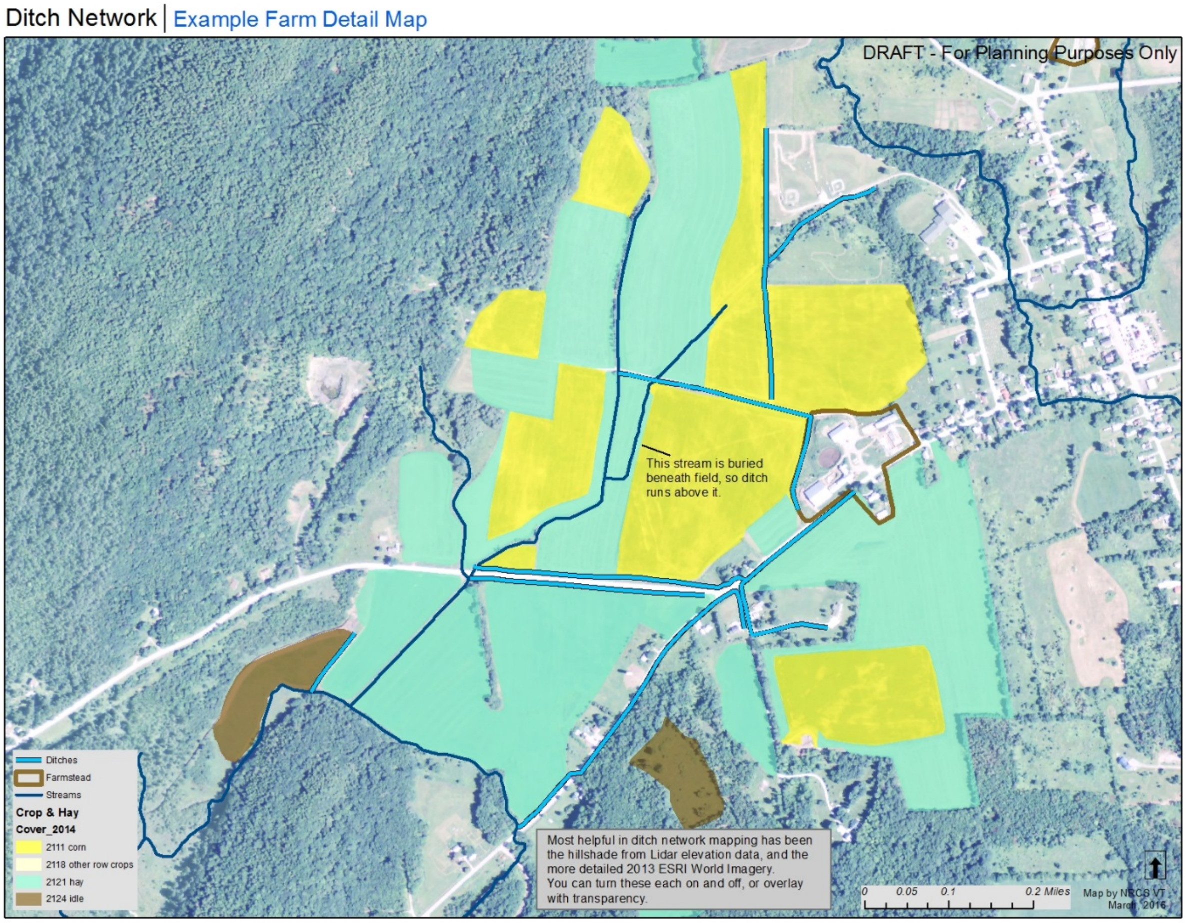


Figure 16 - Example Field Scale Map of Drainage Features

G. Riparian Buffer Gaps

Riparian corridors were evaluated in the Hungerford Brook Watershed to determine locations where adequate riparian buffers were lacking. The identification of these riparian buffer gaps was based on visual interpretation of 2016 aerial imagery and channel width information from the Vermont Department of Environmental Conservation (VTDEC) Rivers Program database (where available). Riparian zones were evaluated to determine whether at least a 25 foot wide vegetated buffer from top of streambank was present, either herbaceous or woody. Twenty-five feet was used as the minimum requirement since the NRCS practice standard for Filter Strip requires a minimum of 25 ft and the practice standard for Riparian Forest Buffer requires a minimum of 35 ft. Where channel width data were not available, stream orders were assigned standard channel widths from which to construct the buffers.

A total of 74.4 miles of streambank (both sides of each stream) were evaluated. Of these, 43.9 miles of streambank have an adequate buffer, and 60% of these support woody plant communities. However, it was estimated that 30.5 miles of streambank in the watershed do not have an adequately vegetated riparian buffer. It may be useful to overlay the Riparian Buffer Map data with continuous cropland and/or erosion and runoff risk potential data. These areas may exhibit greater rates of erosion and runoff and would be a priority for well-vegetated riparian buffers.

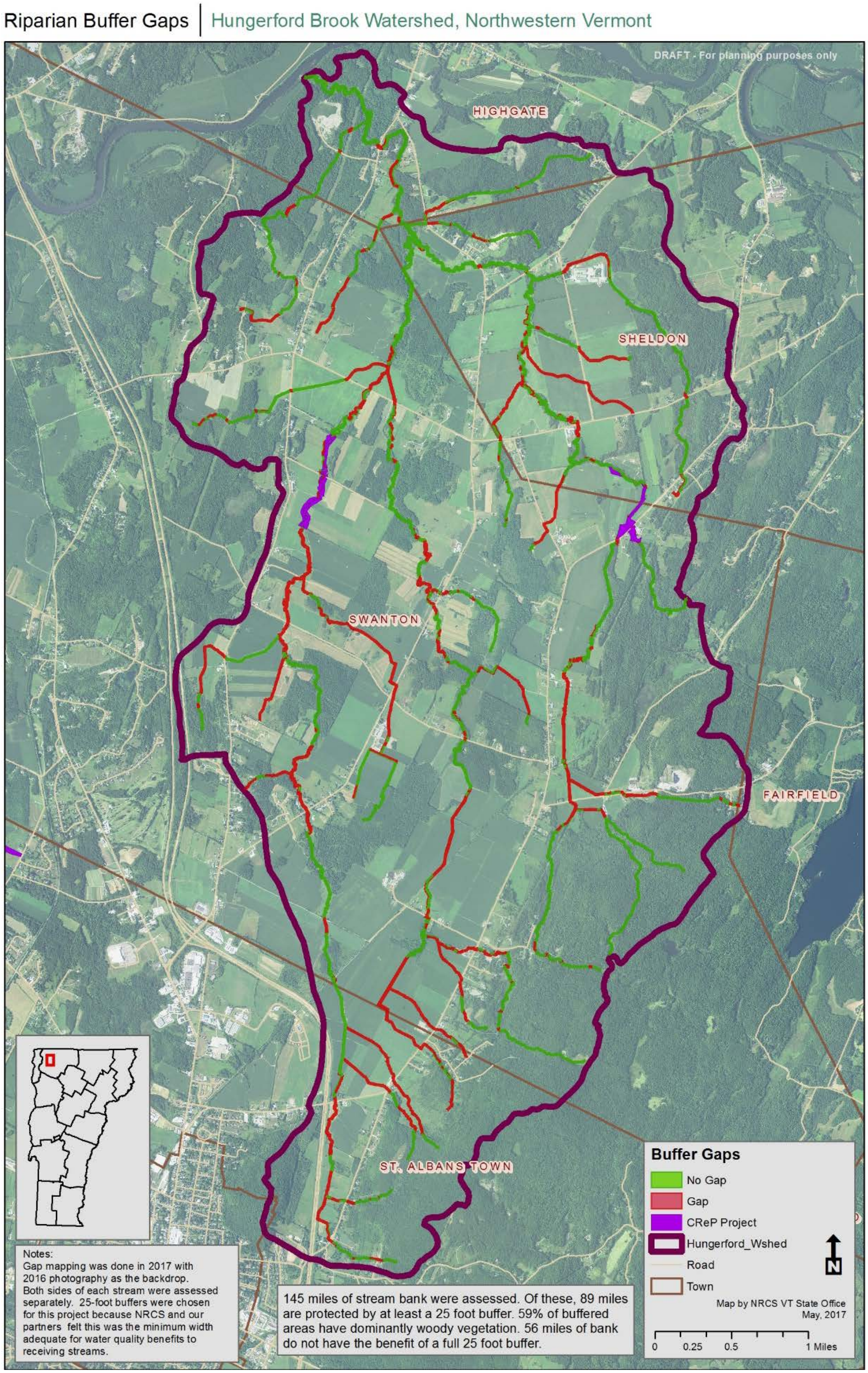


Figure 17 – Map of Riparian Buffer Gaps

H. Conserved Farmland

Recognizing that as development pressure expands outward from urban centers, the NRCS and its partners in Vermont conduct an active program to conserve farmland (prevent conversion to developed land uses) on exceptional soils. Figure 18 shows lands conserved by various agencies in and near the Hungerford Brook Watershed. There are 40 easements conserved so far, in the watershed, covering 2,707 acres.

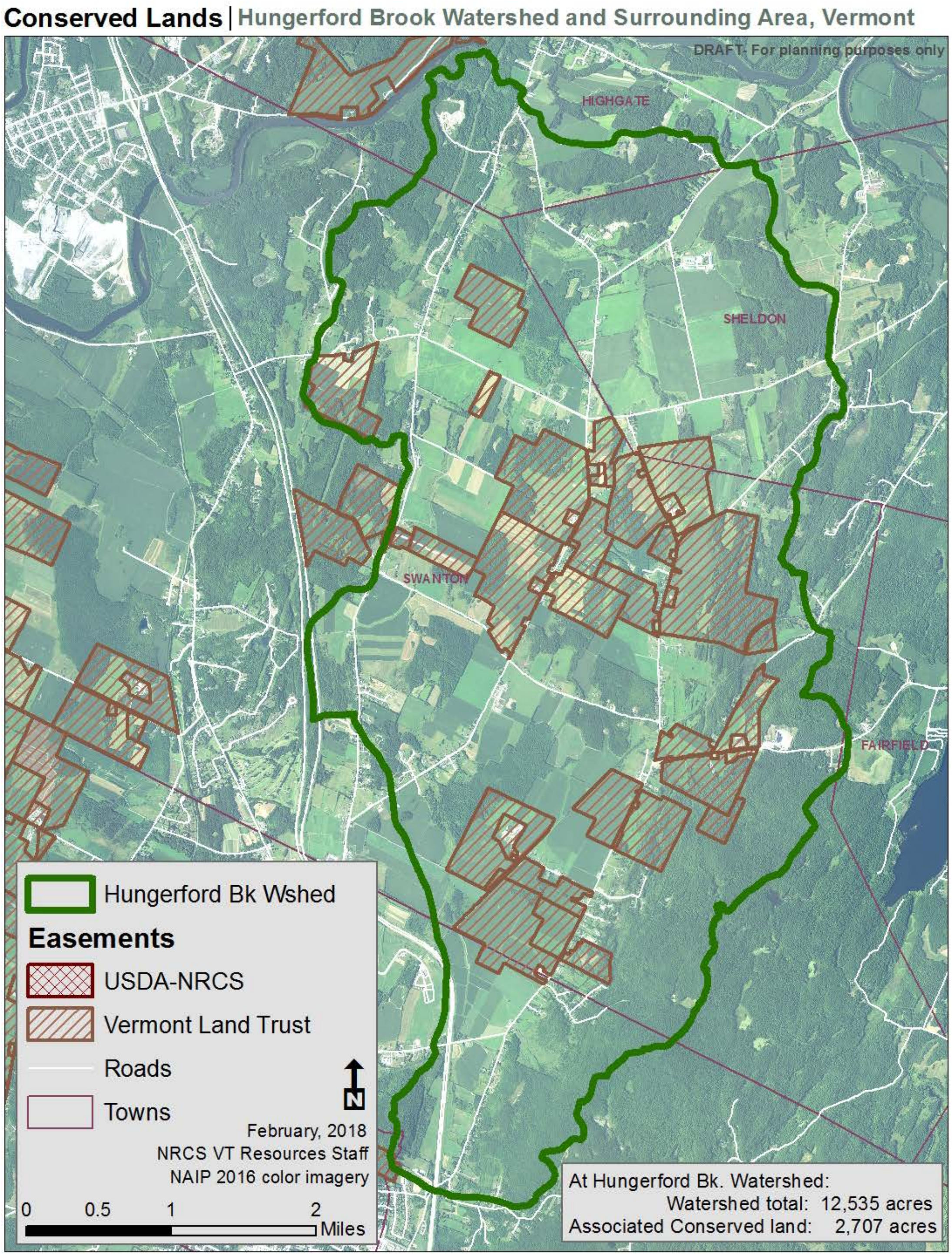


Figure 18 – Map of Conserved Lands in and near Hungerford Brook Watershed

I. Pasture land

We mapped pasture lands in the watershed using 2016 aerial imagery and supporting layers, and crop/hayland information. Figure 19 shows the pasture lands; there were 313 fields covering 1,645 acres in the watershed.

Pasture Land | Hungerford Brook Watershed, Northwestern Vermont

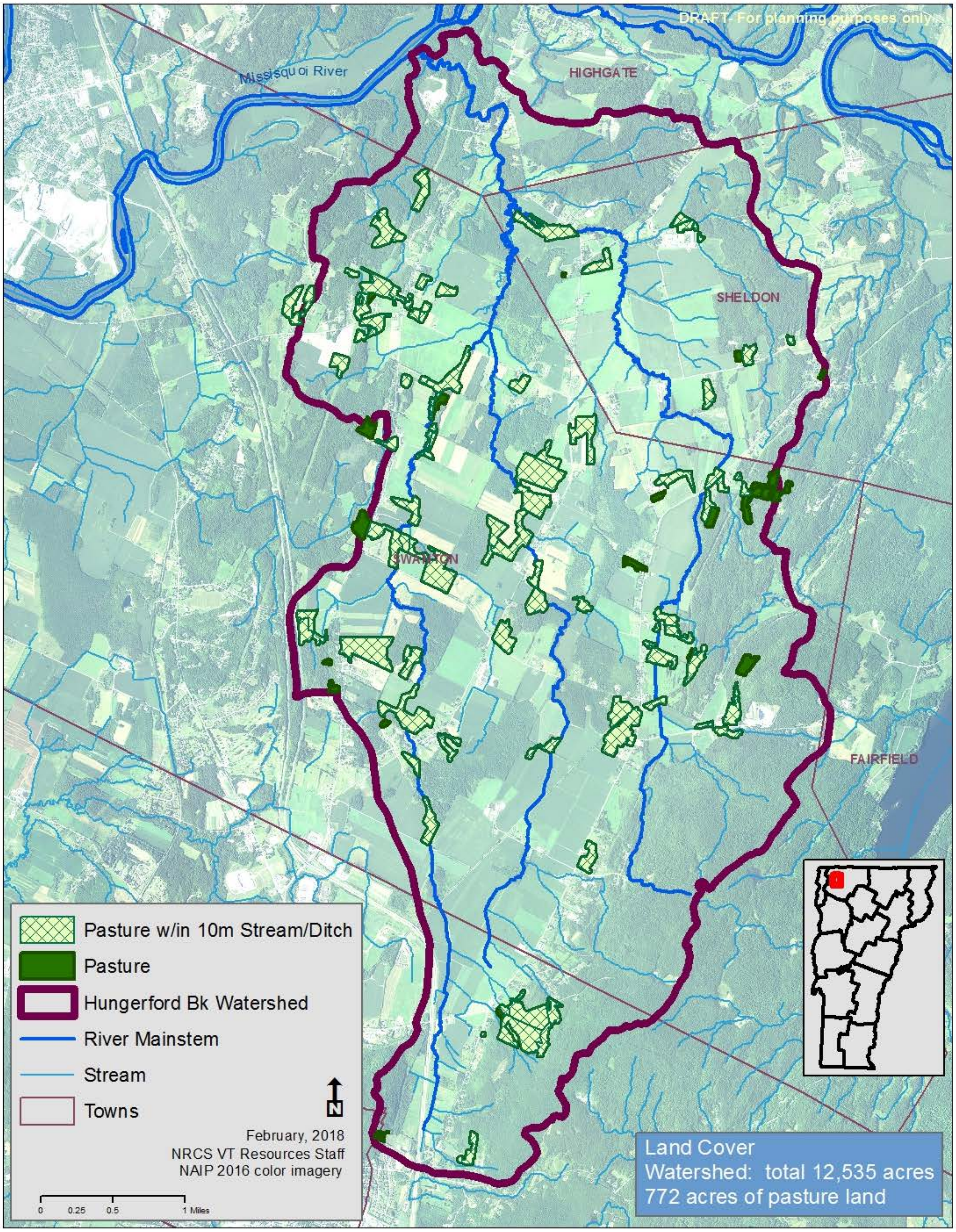


Figure 19 – Pasture fields in the Hungerford Brook Watershed

An analysis was performed to determine what proportion of the pasture fields are close to ditches or streams. In fact, 90 percent of the pastures in the watershed are in close proximity to these water features. On some, the stream runs directly through the pasture. Figure 20 is a farm-level detail map showing the pastures, both near and far from streams.

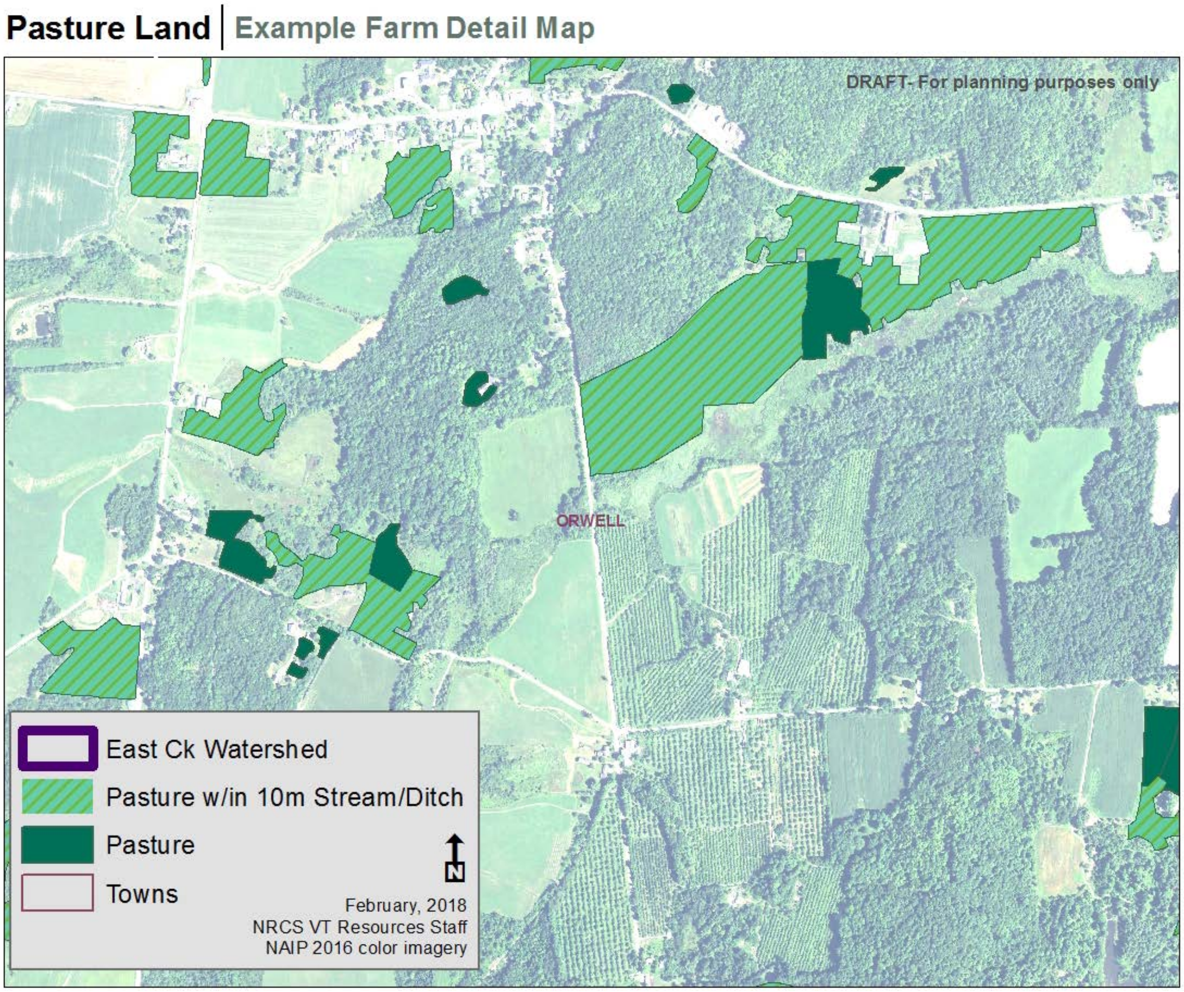


Figure 20 – Farm-level map of pastures, some in close proximity to either streams or ditches.

J. Wetland restoration potential

The Restorable Wetland data layer was developed by a variety of government agencies and private consultants in 2007. The main data input layers were: hydric soils, land-use / land-cover data from 2002 showing open land, percent slope (slopes under 5%), and National Wetland Inventory data showing disturbed wetlands. Once appropriate restoration sites had been delineated using GIS analysis, these areas were then run through a prioritization model that ranked the sites based their potential to retain phosphorus. Four prioritization categories for restoration were chosen: highest, high, moderate, and low. For further details on how the data layer was developed refer to the "Lake Champlain Wetland Restoration Plan" report.

Since this data is now 9 years old, land use changes have occurred over this time period. The data was edited to remove sites that contained house sites. The e911 "esites" data for 2017 was used to remove those areas that now show homes within the restorable wetlands. Additionally, State lands were also excluded from the data layer, since they are not eligible for NRCS wetland restoration programs. The extent and location of potentially restorable wetland areas in Hungerford Brook watershed are shown in Figure 21. These areas are located on private land and may have historic drainage and other modifications. These areas would only be available for restoration under a voluntary restoration program such as the Agriculture Conservation Easement Program for wetlands. Using field scale maps such as in Figure 22, it will be necessary for an on-site investigation to insure that they are eligible and capable of being restored to natural wetland conditions.

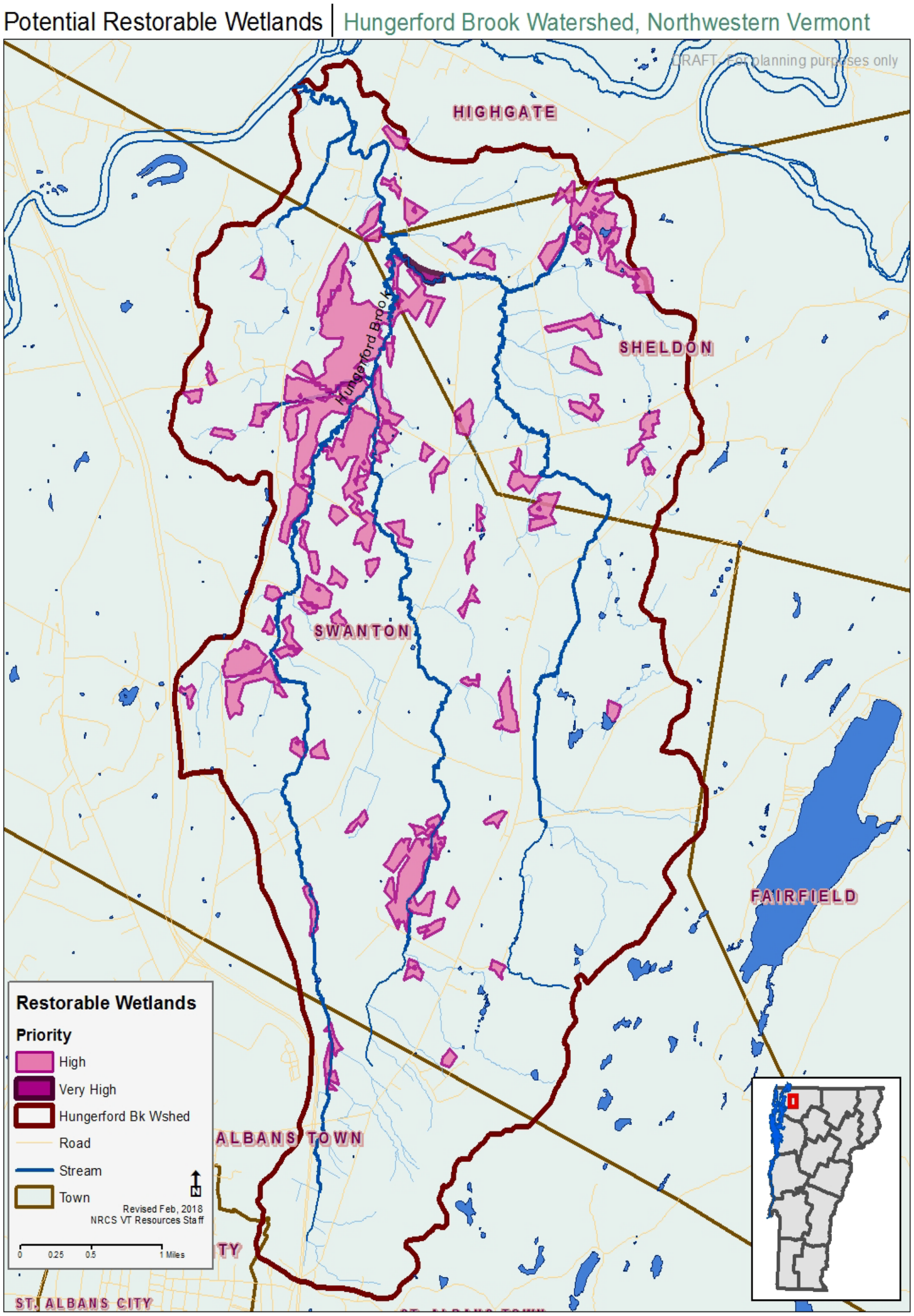


Figure 21 - Watershed Scale Map of Potentially Restorable Wetlands

The map in Figure 21 identifies over 1,037 aces of potentially restorable wetland in the Hungerford Brook Watershed. Of the potential sites, 73 are considered of high priority to restore, with 1 additional highest priority site. Priority assignment reflects the potential for a restoration project and subsequent function of the wetland to sequester and retain phosphorus (a water quality focus).

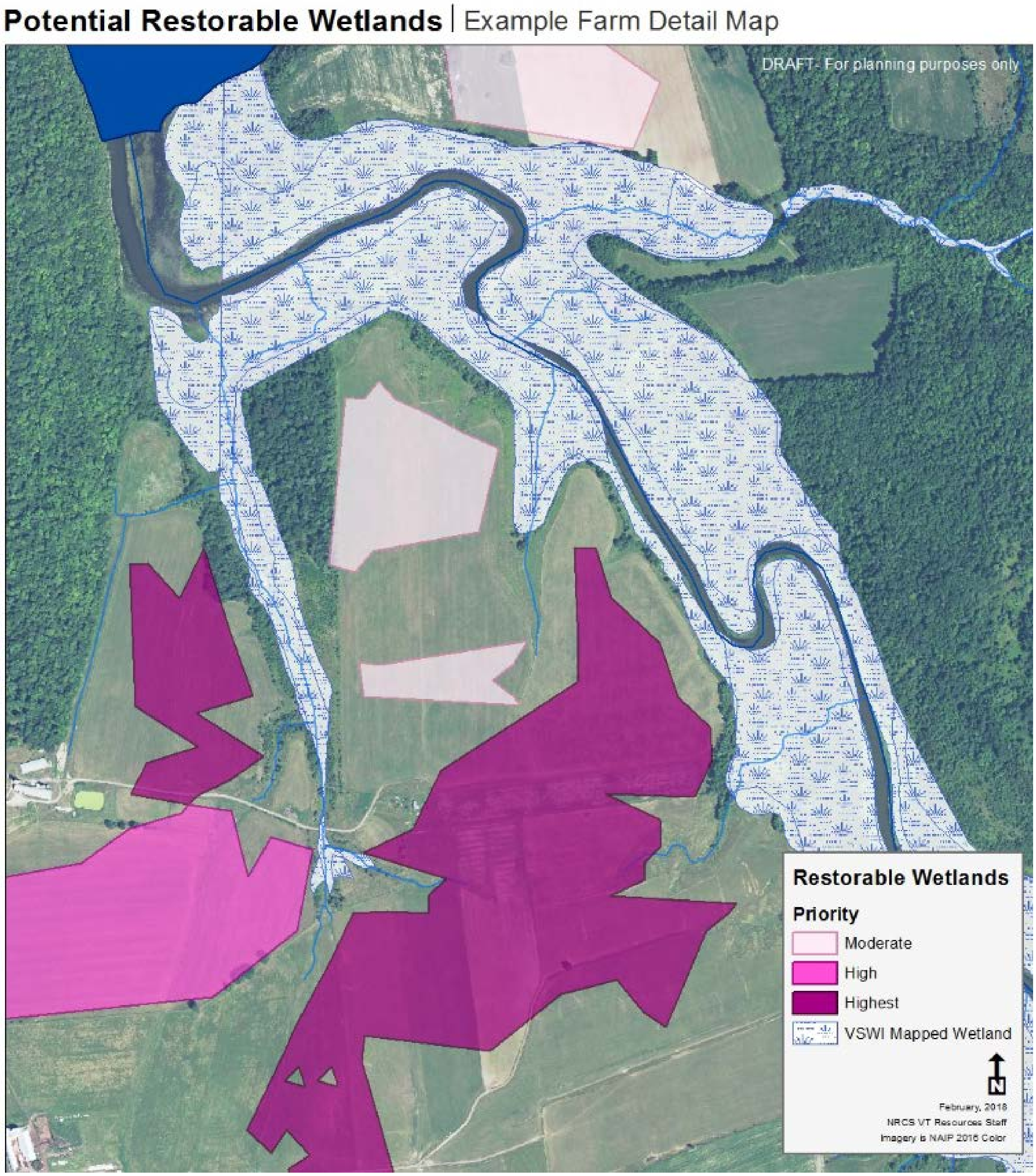


Figure 22 - Example Field Scale map of Potentially Restorable Wetlands

IV. Watershed Phosphorus Reduction and Practice Implementation Goals and Projected Costs

Under the 2016 phosphorus TMDL for Lake Champlain EPA has identified new phosphorus reduction goals for lake segments in Vermont. The new phosphorus reduction goal for the Missisquoi River watershed is 64% for all land uses. The phosphorus reduction goal for agriculture in this lake watershed is 83%.

NRCS has attempted to use the TMDL goals and EPA developed tools to estimate phosphorus loads and reductions to the extent possible for the Missisquoi River watershed. This includes use of the EPA HUC-12 Tool and the EPA Scenario Tool. All costs are based on NRCS payment schedules, except for a couple of situations where estimated practice costs were developed (ex. average farmstead wide practice costs). This process of estimating phosphorus reductions and projected costs is meant to be used for planning purposes only, it should not be used as a detailed accounting system for phosphorus reductions.

A. Watershed phosphorus reduction goals for agriculture

Watershed phosphorus reduction goals for agriculture were estimated using the EPA HUC-12 Tool. This tool provides an estimate of phosphorus loading for each land cover type at the HUC-12 level. Phosphorus loading from continuous corn, crop/hay rotation, continuous hay, pasture and farmland were totaled from the HUC-12 Tool to determine the total estimated phosphorus loading from agriculture. The needed amount of phosphorus reduction in lbs/yr was then estimated by multiplying the total agricultural load by the percentage reduction determined by EPA to be necessary for the larger HUC-8 watershed. Table 1 provides the necessary load reductions for the four targeted watersheds. For the Hungerford Brook Watershed the total agricultural loading was estimated to be 4,906 lbs/yr, the reduction goal was set by EPA to be 85%, and **the resulting agricultural phosphorus reduction goal for the Hungerford Brook was estimated to be 4,170 lbs/yr.**

Table 1 – Agricultural Phosphorus Reduction Goals for the Four Targeted Watersheds

2016 Priority Watershed Estimated Ag Phosphorus Loadings and Targeted Reductions August, 2015				
Watershed Name	**Watershed Area (acres)**	**Total Estimated Ag P Loading (lbs/yr)**	**TMDL Reduction Goal**	**Ag P Reduction Goal (lbs/yr)**
Rock River	22,743	19,248	83%**	15,976
Pike River	25,088	9,599	83%**	7,967

St. Albans Bay	33,515	23,047	35%	8,066
McKenzie Brook	21,222	43,276*	60%	29,966
East Creek	20,555	14,429	63%	9,090
Hungerford Brook	12,534	4,906	85%**	4,170

*Total loading reduced 25% to remove loading from East Creek (included in the BMP Scenario Tool)
**East Creek phosphorus loading was assumed to be 25% of South Lake A loading.

B. Individual practice and practice system efficiencies

The EPA Scenario Tool is a spreadsheet tool based on SWAT modelling of watersheds in the Lake Champlain Basin. It was developed by a private consultant under contract by EPA Region I. Early on in the model development EPA convened a workgroup of local experts to help develop reduction efficiencies for conservation practices that are included in the SWAT model. These efficiencies and ones produced by the model were then incorporated into the EPA Scenario Tool. As such the EPA Scenario Tool is subject to the same limitations as the SWAT model. Certain agricultural practices cannot be easily included in the SWAT model, including many farmstead related practices. In the EPA Scenario Tool efficiencies for a conservation practice vary based on factors such as cropping system, soil hydrologic group and slope.

Table 2 lists the agricultural conservation practices and systems of practices that are included in the EPA Scenario Tool and provides example efficiencies for each practice. It is important to consider when multiple practices are applied to the same field as a system since the individual efficiency of each practice will decrease as additional practices are added to the same field. The efficiencies used in the model will be adjusted as better information becomes available, such as information from the Vermont Edge of Field Monitoring Projects.

Table 2 - List of Available Ag Practice and Practice Systems in the EPA Scenario Tool and Example Practice Efficiencies*

1.	Change in crop rotation	25%
2.	Change in crop rotation and conservation tillage	63%
3.	Change in crop rotation, grassed waterway, ditch buffer and riparian buffer**	84%
4.	Change in crop rotation, grassed waterway riparian buffer	67%
5.	Change in crop rotation and riparian buffer	56%
6.	Conservation tillage	50%
7.	Cover crop	28%
8.	Cover crop, conservation tillage, grassed waterway, ditch buffer and riparian buffer	92%

9.	Cover crop, conservation tillage and manure injection	64%
10.	Cover crop and manure injection	28%
11.	Annual crop to permanent hay	23%
12.	Ditch buffer	51%
13.	Grassed waterway	25%
14.	Grassed waterway and riparian buffer	56%
15.	Manure injection and reduced manure P applied	5%
16.	Reduced manure P applied	5%
17.	Reduced manure P applied and grassed waterway	29%
18.	Annual cropland to permanent grass	92%
19.	Riparian buffer	41%
20.	Livestock exclusion/fencing/grazing system	73%
21.	Farmstead practices	80%

*BMP efficiencies vary with cropping system, soil type and slope

**Riparian forest buffers and grassed filter strips are both considered as riparian buffers

Note: These practice efficiencies should only be used for planning purposes and will change as better practice efficiency data is developed.

C. Existing and planned practice implementation and loading reduction estimates

NRCS has been working with farmers in the Hungerford Brook Watershed for an extended period of time. During this period farmers have signed contracts with NRCS to implement a variety of different conservation practices. Over time many of the early contracts have expired and some of the practices are either discontinued or not maintained. Table 3 provides the number of several different practices that were installed in the Hungerford Brook Watershed with NRCS support over the 7 year period from 2010 – 2017. During this period, practices were tracked to determine which specific years during that time period they were implemented. At this time, it cannot be determined which practices were continued after the contracted period.

The practices that were implemented to the greatest extent included cover crops (2,340.9 ac.), nutrient management (2,308.2 ac.), and residue and tillage management (reduced till) (944.6 ac). Table 3 also shows estimated phosphorus reductions as a result of the implementation of these practices. The largest phosphorus reductions resulted from cover crop (1,271.49 lbs/yr), residue and tillage management (reduced till) (440.14 lbs/yr), and nutrient management (258.12 lbs/yr). The total annual average reduction in phosphorus reduction resulting from the implementation of these practices was 2,128.15 lb/yr. It is important to note that this is 43% of the total reduction (4,906 lb/yr) that will be required under the new TMDL. However, we are unsure how many of these practices have been continued to date.

Table 3 – NRCS Practices Implemented in the Hungerford Brook Watershed, 2010 - 2017

NRCS Practices Implemented in the Hungerford Bk Watershed, 2010-2017								
Practice Group	Practice Code	Practice Name	Units	Number of Practices Applied	Sum of applied amount	Total P Load by Land Use: lb/yr	Average Annual P Reduction, treated acres: lb/yr	Cumulative P Reduced Over 7 yr Baseline: lb
Agronomic	104	Nutrient Management Plan - Written	no	4	4	0	0	0
	328	Conservation Crop Rotation	ac	11	54.9	102.32	24.56	171.90
	329	Residue and Tillage Management, No-Till	ac	12	53.4	0	0	0
	340	Cover Crop	ac	229	2340.9	4541.04	1271.49	8900.43
	345	Residue and Tillage Management, Reduced Till	ac	87	944.6	1760.56	440.14	3080.98
	362	Diversion	ft	1	0	0	0	0
	393	Filter Strip	ac	4	0.7	0	0	0
	512	Forage and Biomass Planting	ac	37	273.9	510.50	127.62	893.37
	590	Nutrient Management	ac	306	2308.2	4302.05	258.12	1806.86
	633	Waste Recycling	ac	40	561.6	0	0	0
Farmstead	313	Waste Storage Facility	no	1	1	1.86	6.21	43.47
	521A	Pond Sealing or Lining, Flexible Membrane	no	2	0	0	0	0
	558	Roof Runoff Structure	no	1	0	0	0	0
	560	Access Road	ft	4	350	0	0	0
	561	Heavy Use Area Protection	sq ft	2	0	0	0	0
	606	Subsurface Drain	ft	4	0	0	0	0
	620	Underground Outlet	ft	5	440	0	0	0
	634	Waste Transfer	no	2	0	0	0	0
Grazing	382	Fence	ft	3	5450	0	0	0
	578	Stream Crossing	no	1	0	0	0	0
Totals:				**756**	**12783.20**	**11218.33**	**2128.15**	**14897.02**

Contracts with farmers written during this period also include practices that are still planned for implementation. These planned practices are summarized in Table 4. This includes a significant amount of nutrient management (2,032.4 ac), cover crop (1,575.9 ac), and residue and tillage management, reduced till (618.7 ac). These recently implemented and planned practices should be considered when establishing practice implementation goals for the watershed.

Table 4 also summarizes the expected phosphorus reductions associated with the implementation of these practices over the lifespan of the practices. If implemented, waste storage facilities would provide the greatest reduction (2.7 lbs/yr/ac), followed by cover crop (0.5 lbs/yr/ac), residue and tillage management, reduced till (0.47 lbs/yr/ac), and forage and biomass planting (0.47 lbs/yr/ac). The total expected phosphorus reduction of all planned and implemented practices is 3,565.72 lbs/yr, which is 73% of the EPA target for agriculture in the watershed.

Table 4 – Practices Planned for Implementation in the Hungerford Brook as of February 2018

Practices Planned for Implementation in the Hungerford Brook as of February 2018								
Practice Group	**Practice Code**	**Practice Name**	**Units**	**Count of Practices Applied**	**Sum of planned Amt**	**Total P Load by Land Use: lb/yr**	**Average Annual P Reduction, treated acres: lb/yr**	**Cumulative P Reduced Over 7 yr Baseline:lb**
Agronomic	328	Conservation Crop Rotation	ac	6	126.8	236.33	56.72	397.04
	329	Residue and Tillage Management, No-Till	ac	9	153.8	0	0	0.0
	340	Cover Crop	ac	100	1575.9	3057.04	855.97	5991.79
	345	Residue and Tillage Management, Reduced Till	ac	34	618.7	1153.14	288.29	2018.00
	362	Diversion	ft	1	335	0	0	0
	393	Filter Strip	ac	2	0.8	0	0	0
	512	Forage and Biomass Planting	ac	10	14.2	26.47	6.62	46.32
	590	Nutrient Management	ac	152	2032.4	3788.01	227.28	1590.97
Farmstead	313	Waste Storage Facility	no	1	1	3.33	2.67	18.66
	521A	Pond Sealing or Lining, Flexible Membrane	no	2	2	0	0	0
	558	Roof Runoff Structure	no	1	1	0	0	0
	560	Access Road	ft	3	675	0	0	0
	561	Heavy Use Area Protection	sq ft	2	1800	0	0	0
	606	Subsurface Drain	ft	4	2140	0	0	0
	620	Underground Outlet	ft	4	800	0	0	0
	634	Waste Transfer	no	2	2	0	0	0
Grazing	382	Fence	ft	1	450	0	0	0
	578	Stream Crossing	no	1	1	0	0	0
Totals:				**335.00**	**10729.60**	**8264.32**	**1437.54**	**10062.77**

D. Potential phosphorus load reductions associated with one practice scenario

A suite of individual practices and practice systems was develop as an example scenario to try and meet the required phosphorus reduction for agriculture in the Hungerford Brook Watershed. This example practice scenario was developed to provide additional guidance to the Local Watershed Team and is intended as an example for planning purposes only. The actual amount and the suite of practices identified and implemented by the Local Watershed Team will be different than the example provided here. Using this suite of practices, at the level specified, falls short of meeting the reduction goal by approximately half. The example does provide several pieces of useful information, it indicates the magnitude of the work that needs to be accomplished in order to meet the reduction goal, it provides a comparison of the effectiveness of different practices or practice systems, it provides information on the extent of available land area for different practices or practice systems and it provides one cost estimate of the necessary practices.

Table 5 provides summary information on land use in the Hungerford Brook Watershed, an example conservation practice scenario list, estimated extent of practice application, estimated phosphorus reductions by conservation practice and estimated costs. Some of the underlying assumptions built into this scenario include:

- that approximately 15% of the land in corn in 2016 was continuous corn
- this scenario represents a high implementation rate of these conservation practices
- that 50% of off annually tilled cropland will be planted to cover crops
- that the average cost of a grazing system that includes livestock exclusion is $50,000
- That the average cost of improvements necessary on a farmstead is $200,000

From Table 5 you can see that the greatest reduction in phosphorus loading is achieved with conservation tillage on continuous corn (467 lbs/yr), cover crop on continuous corn (289 lbs/yr), and waste management improvements (240 lbs/yr).

Table 5 – Hungerford Brook Example Practice Scenario with Phosphorus Reductions and Costs | February 2018

Hungerford Brook Example Practice Scenario with Phosphorus Reductions and Costs | February 2018

Based on a Reduction Goal of 85% of Total Agricultural Loading

Cropping System	No. of Acres	Notes
Corn in 2017	2,468	
Hay in 2017	2,192	
Pasture in 2017	779	
Farmstead in 2017	184	42 Farmsteads
Cont. Corn	1,906	
Corn-Hay Rotation	7,090	

Scenario Components	Selected BMP	No. of Acres Applied	% of Total Acres	TP Load Reduction (lbs/yr)	Practice Cost	Cost (Maximum Payment Period)	Assumptions
Cont. Corn	Conservation Tillage	476	25%	467	$16.37	$23,376	Assumed 25% of fields treated.
Corn/Hay	Conservation Tillage	140	25%	20	$16.37	$6,875	Assumed 25% of fields treated.
Cont. corn	Cover Crop	952	50%	289	$63.66	$181,813	Assumed 50% of field cover cropped annually.
Corn/Hay	Cover Crop	280	50%	60	$63.66	$53,474	Assumed 50% of field cover cropped annually.
Cont. Corn	Crop Rotation	190	10%	97	$8.66	$4,936	Assumed 25% of fields would go into rotations.
Corn/Hay	Crop Rotation	56	10%	49	$8.66	$1,455	Assumed 25% of fields need longer rotations.
Cont. Corn	Riparian Buffer	164	25%	139	$1,333.90	$43,752	170 acres of riparian buffers missing. Goal is to plant 50% Each acre treats 5 acres of runoff
Corn/Hay	Riparian Buffer	48	25%	42	$1,333.90	$12,805	170 acres of riparian buffers missing. Goal is to plant 50% Each acre treats 5 acres of runoff
Cont. Corn	Reduced Manure P (Nutrient Management and CAP)	190	10%	33	$26.00	$17,020	Assumed 10% of fields would see reduced P applications due to nutrient management planning
Corn/Hay	Reduced Manure P (Nutrient Management and CAP)	56	10%	7	$26.00	$6,568	Assumed 10% of fields would see reduced P applications due to nutrient management planning
Cont. Corn	Ditch Buffer	145	37%	161	$628.02	$18,213	Assumed a 10ft vegetative buffer. 1acre of bufer treats 5 acres of runoff.
Corn/Hay	Ditch Buffer	43	37%	53	$628.02	$5,401	Assumed a 10ft vegetative buffer. 1acre of bufer treats 5 acres of runoff.
Farmstead	Waste Management Improvements	46	25%	240	$200,000.00	$8,400,000	Assumed 25% of HQ's need significant improvements and assumed average cost of $200,000 per farmstead.

Total Estimated Reduction	1656
Watershed Reduction Target	4,170
Percentage of Goal Reached	40%
Total Cost	$8,775,689

E. Estimated costs of P reduction by practice and system, total for scenario and costs per lb of phosphorus

Important information for the Local Watershed Teams will be the cost of practice implementation. This information will be important for the Local Watershed Teams to establish reasonable reduction goals for their local project and the timeline necessary to implement the project. The costs presented in Table 5 are the NRCS costs (based on 2017 payment schedules) provided payments to farmers to implement these practices and as such represent an average of 75% of the total cost. The greatest costs are for implementing waste management improvement ($8,400,000), cover crop on continuous corn ($181,813), cover crop on corn and hay rotation ($53,474), and riparian buffer on continuous corn ($43,752). Farmstead costs are high because of the high cost of structural practices.

The total cost of using the practices in this scenario to meet the phosphorus reduction goals for agriculture is $8,755,689. This does not include any cost inflation factor if the implementation of practices is extended over a long time period. Another concern not addressed in this scenario is the relatively short time period for which NRCS can financially support annual practices such as cover crops. This scenario assumes only 3 years of financial support for cover crops and 3 years for other annual practices. It is unclear who will support the farmers to continue these annual practices after their NRCS contract expires or if farmers will continue these practices without financial support.

One way to reduce the total cost of a project such as this one in the Hungerford Brook Watershed is to focus on implementing those practices where you get the greatest reduction of phosphorus per dollar. Table 6 shows the phosphorus reduction efficiency of the different practices based on cost per pound of phosphorus. According to these calculations change in crop rotation on continuous corn ($10/lb of P) and conservation tillage on continuous corn ($16.67/lb of P), are the most cost effective practices in reducing phosphorus losses while the farmstead practices are the least cost effective at over $38,284.91 per lb of P.

However, there may not be much flexibility in the Hungerford Brook Watershed to maximize phosphorus reduction based on cost because the underlying assumption with this scenario was that it represented all reasonable practices that could be implemented by farmers.

Practice cost efficiency was calculated for the practices and practice systems included in the Hungerford Brook scenario example. These costs are based on the total cost of implementing the practice. In general, for the field based practices it costs between $10 and $1575.04 to reduce one pound of phosphorus per year. Farmstead practices cost much more ($38,284.91) to get a pond of phosphorus reduction. This is partially due to the high cost of structural practices, the low loading rate currently in the model for farmsteads, and using 5 years to average the costs over. Many structural practices have an expected lifespan longer than 5 years.

Table 6 – Cost Efficiency of Available Conservation Practices

Agricultural Conservation Practice Efficiency in Cost Per Pound of Phosphorus Reduced per year Averaged Over a Five Year Period			
Conservation Practice	NRCS Payment	Total Practice Cost	Practice Cost Efficiency ($/lb P reduction)*
1. Conservation tillage – Continuous corn	$16.37	$43.75	$16.67
1a. Conservation tillage – Corn/hay rotation	$16.37	$43.75	$115.50
2. Cover crop – Continuous corn	$63.66	$112.00	$209.84
2a. Cover crop – Corn/hay rotation	$63.66	$112.00	$299.45
3. Change in crop rotation – Continuous corn	$8.66	$15.75	$16.96
3a. Change in crop rotation – Corn/hay rotation	$8.66	$15.75	$10.00
4. Riparian buffer – Continuous corn	$1,333.90	$2,334.50	$1,575.04
4a. Riparian buffer – Corn/hay rotation	$1,333.90	$2,334.50	$1,528.54
5. Reduced manure P applied – Continuous corn	$26.00	$45.50	$149.38
5a. Reduced manure P applied – Corn/hay rotation	$26.00	$45.50	$220.14
6. Ditch buffer – Continuous corn	$628.02	$1,099.00	$565.83
6a. Ditch buffer – Corn/hay rotation	$628.02	$1,099.00	$510.38
7. Farmstead practices (estimated average)	$200,000	$350,000	$38,284.91
NA- practice was not included in example scenario		75% of practice cost	
*Based on the total NRCS cost			
**Assumes NRCS payment of $550/ac			
***Error in Model			

V. NEPA concerns and compliance

The National Environmental Policy Act of 1964 requires all federal agencies to conduct an environmental review of all federal actions. This requirement also applies to area wide or watershed planning activities. As part of these plans the responsible federal agency is required to evaluate the individual and cumulative effects of the actions being proposed. Any project that has significant environmental impacts must be evaluated with an Environmental Assessment (EA) or Environmental Impact Statement (EIS) unless the activities are already covered under a categorical exclusion or by an existing EA or EIS.

NRCS utilizes a planning process that incorporates an evaluation of potential environmental impacts using an Environmental Evaluation checklist. NRCS also has categorical exemptions for a number of different activities that include many of our conservation practices. These categorical exemptions include conservation practices that reduce soil erosion, involve the planting of vegetation and/or restore areas to natural ecological systems.

The watershed plan for the Hungerford Brook Watershed calls for the accelerated implementation of conservation practices that have been used in the region for many years. These practices include a number of erosion control, field-based practices that are covered by categorical exclusions, and a range of structural practices that are used to address waste management issues on the farmstead. A list of practices that are likely to be used to implement the plan are included in Table 7.

Table 7 - List of Practices and Practice Systems Likely to be Used to Implement the Hungerford Brook Watershed Plan
(CE = categorically excluded, EA = included in existing environmental assessment)

1) Change in crop rotation	CE
2) Change in crop rotation and conservation tillage	CE
3) Change in crop rotation, grassed waterway, ditch buffer and riparian buffer**	CE
4) Change in crop rotation, grassed waterway riparian buffer	CE
5) Change in crop rotation and riparian buffer	CE
6) Conservation tillage	CE
7) Cover crop	CE
8) Cover crop, conservation tillage, grassed waterway, ditch buffer and riparian buffer	CE
9) Cover crop, conservation tillage and manure injection	CE
10) Cover crop and manure injection	CE
11) Annual crop to permanent hay	CE
12) Ditch buffer	CE
13) Grassed waterway	CE
14) Grassed waterway and riparian buffer	CE
15) Manure injection and reduced manure P applied	CE
16) Reduced manure P applied	CE
17) Reduced manure P applied and grassed waterway	CE
18) Annual cropland to permanent grass	CE
19) Riparian buffer	CE
20) Livestock exclusion/fencing/grazing system	CE
21) Farmstead practices	EA

As mentioned above, as part of the planning process each planned practice will be evaluated individually and combination with other planned practices to ensure it meets the criteria of the categorical exclusions and any existing Environmental Assessments. Any significant negative practice impacts, either individually or cumulatively, will first try to be avoided, then minimized and/or mitigated to the extent possible or eliminated from the individual farm plan if necessary. There is not an expectation that the practices planned for implementation in the Hungerford Brook Watershed will necessitate an Environmental Assessment or an Environmental Impact Statement.

VI. Appendix – Local Watershed Team Materials

This Hungerford Brook Watershed Plan will be provided to the Local Watershed Team and other partners. The information in this plan is not considered confidential and will be available to all partners and the public. The Local Watershed Team will develop a number of products to guide and coordinate their conservation practice implementation, some these products will be considered confidential and only available to "1619 agreement" partners, these include:

Field Scale Land Cover and Resource Maps – These maps will be developed by the Local Watershed Team based on the spatial data layers provided to them and described in the Watershed Plan. The data layers may be used alone or overlain with layers as suggested in the Watershed Plan or as deemed necessary by the Team members.

Local Watershed Team Action Plan - This plan will be developed by the Hungerford Brook Local Watershed Team. It will include a brief summary of the key watershed features, phosphorus and practice implementation goals for the selected time period, and a list of clear objectives, goals and action items for the watershed. This action plan will be available to all interested parties.

Tracking Database – An interim tracking database will be developed to track identified resource concerns at the farm and field scale along with practices implemented. This database will eventually be replaced by the "partner database" that is currently under development by the VAAFM and their consultant. This database will also aid in the coordination of staff resources among all the partners. Each farm with resource concerns that need to be addressed will be assigned to a specific partner or team of partners.