Wetland Vulnerability Study: Shubenacadie Watershed, Nova Scotia

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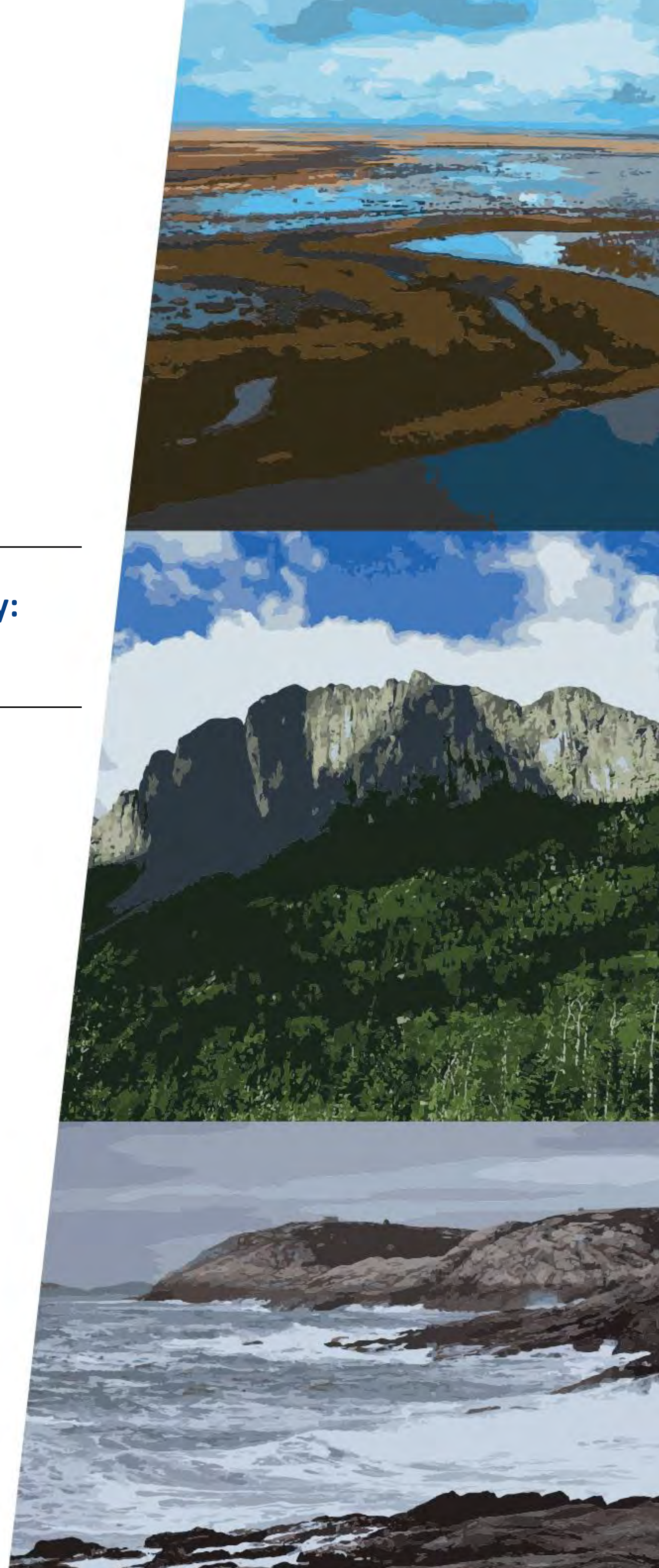

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EXECUTIVE SUMMARY

McCallum Environmental Ltd (MEL) are supporting Nova Scotia Department of Public Works (NSDPW) to complete Primary and/or Secondary wetland compensation within the Shubenacadie and/or Stewiacke Watersheds. Wetland compensation is required to offset wetland alterations associated with the construction of the Highway 102 Aerotech Connector Project (the Project). An approval was issued by Nova Scotia Environment and Climate Change (NSECC) in March 2022 for alteration to 3.16 hectares (ha) of wetland associated with the highway construction. As per the Letter of Intent (LOI) provided with the wetland application 6.32 ha of wetland compensation is required (i.e., 2:1), with a minimum of 50% (3.16 ha) of the required wetland compensation requirements to occur within the Shubenacadie and/or Stewiacke Watersheds.

MEL, who are acting as the wetland restoration professional (WRP) for the Proponent, in collaboration with the Shubenacadie Watershed Environmental Protection Society (SWEPS), proposed implementation of the Wetland Vulnerability Study (the Study) as a method of Secondary Wetland Compensation associated with the Aerotech connector compensation requirements. The objective of the Study was to develop a GIS-based tool to analyze and evaluate wetland vulnerabilities within the Shubenacadie Watershed, and to identify wetlands that could be considered for wetland management opportunities (i.e. Restoration, Enhancement, Protection, etc.). The Study has an end goal of creating a streamlined methodology to identify these wetlands in a GIS capable setting with readily available data without having to engage in extensive field assessments.

An extensive literature review with a focus on various studies completed within North America was completed to support the development of this Study. Literature surrounding the topics of watershed level wetland vulnerability techniques, GIS modelling methods, and wetland condition and stressor assessments were reviewed. Additionally, existing wetland functional assessment tools, such as NovaWET and WESP-AC, were considered throughout the review to gather additional information on wetland function, characteristics, and impacts from stressors.

Engagement sessions were conducted with various stakeholders including SWEPS, Halifax Water, Collins Park Watershed Advisory Committee (CPWAC), the Municipality of East Hants (MEH), and the Halifax Regional Municipality (HRM). Sessions were conducted from March to May 2023 to discuss local issues, areas of interest, and to obtain data and discuss existing and future development plans within the Study Area. These sessions provided a wealth of information on the Shubenacadie watershed and provided a greater understanding of stakeholder concerns throughout various portions of the Study Area.

Field assessments were completed by MEL biologists on 100 wetlands from Lake William to Milford Station in September-November 2023. Field assessments included completion of the rapid stressor checklist form, WESP-AC, and an internal MEL field form to gather information on wetland characteristics. The objective of the field assessments was to calibrate and validate the GIS modelling utilized within the Study.

As part of the Study, MEL assessed select wetlands within the Study Area where wetland management mechanisms could improve wetland function, water management and ultimately the health of the Shubenacadie Watershed. These assessments were completed at the request of SWEPS and other stakeholders to supplement the Study with the identification of potential on-the-ground wetland restoration, enhancement, creation, or protection opportunities. These wetlands/areas were selected based on suggestions identified during stakeholder engagement sessions, not through the modelling exercise.

The model output provides a shapefile of predicted wetland polygons with a series of attributes related to its vulnerability to a set of 10 potential proximal and tertiary land use stressors. The wetlands are ranked out of a possible 10 points for their current vulnerability baseline condition based on this predictive model. The lowest scoring wetlands received a 0 out of 10 meaning no stressors were present within the wetland or within 100 m of the wetland boundary and the tertiary watershed they were found in was over 75% natural undisturbed land cover. The highest scoring wetland received a 6 out of 10 for its current vulnerability baseline condition based on this predictive model. This showed that the wetland was under moderate to high risk of stressors and/or had high levels of disturbance within its tertiary watershed.

When comparing the model output to the field data collected to calibrate the model, the field data tended to score a wetland higher than the GIS model. Generally, the GIS output predicting wetland boundaries was capable of predicting wetland locations, but under predicted the extent of the wetlands. This information and all boundary points taken will be provided to NSECC to help refine and adjust their predicted wetland layer that was the basis for this project.

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1 INTRODUCTION

McCallum Environmental Ltd (MEL) are supporting Nova Scotia Department of Public Works (NSDPW) to complete Primary and/or Secondary wetland compensation within the Shubenacadie and/or Stewiacke Watersheds. Wetland compensation is required to offset wetland alterations associated with the construction of the Highway 102 Aerotech Connector Project (the Project). An approval was issued by Nova Scotia Environment and Climate Change (NSECC) in March 2022 for alteration to 3.16 hectares (ha) of wetland associated with the highway construction. As per the Letter of Intent (LOI) provided with the wetland application 6.32 ha of wetland compensation is required (i.e., 2:1), with a minimum of 50% (3.16 ha) of the required wetland compensation requirements to occur within the Shubenacadie and/or Stewiacke Watersheds.

MEL acting as the wetland restoration professional (WRP) for the Proponent in collaboration with the Shubenacadie Watershed Environmental Protection Society (SWEPS), proposed implementation of the Wetland Vulnerability Study (the Study) as a method of local Secondary Wetland Compensation associated with the Project's compensation requirements. An initial concept for the Study was presented to NSECC Wetland Specialist Marina Dulmage on May 30, 2022, and was approved on June 8, 2022.

1.1 Study Objectives

The primary goal of the Study is to create a streamlined methodology to identify vulnerable wetlands, or broader areas, in an open source GIS-capable setting with readily available data without having to engage in extensive field assessments. Strategic field assessments were employed to evaluate the effectiveness of these GIS predictions and calibrate the modelling.

This was completed via the main objectives of the Study:

- Develop an open source GIS-based tool to analyze and evaluate wetland vulnerabilities within the Shubenacadie Watershed.
- With this tool, identify vulnerable wetlands that could be considered for wetland management opportunities (i.e. Restoration, Enhancement, Protection, etc.).

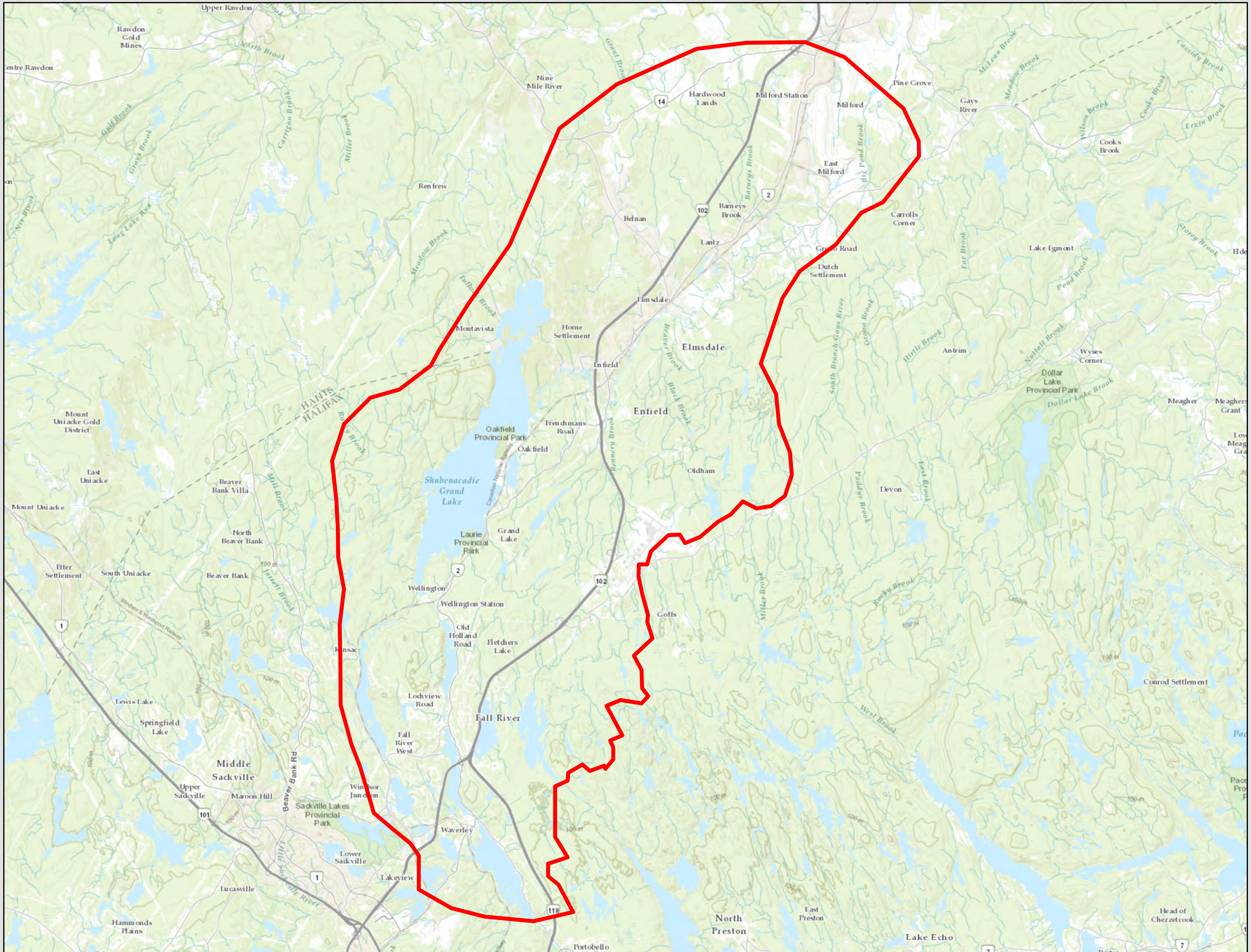
As part of a secondary deliverable, dedicated wetland/watercourse assessments were completed at the request of SWEPS to supplement the Study with the identification of potential on-the-ground wetland restoration, enhancement, creation, or protection opportunities (in addition to the primary desktop methods). The sites selected for assessment were guided by SWEPS areas of special interest and concern, as heard through engagement meetings and correspondences. The assessments were completed by desktop and/or field, depending on accessibility and property access permissions. These assessments are further discussed in Section 6.

1.2 Assessment Spatial Boundaries

The initial Study Area was developed in consultation with SWEPS during the preliminary design of the Study. Throughout stakeholder engagement sessions the Study Area was expanded on multiple occasions to address areas of concern brought forth by various stakeholders. The final Study Area, shown in in-text Figure 1, is approximately 400 km^2 ranging from Lake William to Milford Station.

The Study Area is located within Halifax Regional Municipality (HRM) and the Municipality of East Hants (MEH). The southern portion of the Study Area contains high levels of anthropogenic development, particularly in the areas of Waverley, Fall River, and Enfield. The northern portion of the Study Area is less developed and contains a higher frequency of agricultural land-use.

Notable points of interest within the Study Are include (but are not limited to); Bennery Lake Nature Reserve, Rawdon River Nature Reserve, Waverley-Salmon River Long Lake Wilderness Area (portion of), Bennery Lake Protected Water Area, and Halifax Stanfield International Airport.



Prepared for:
Nova Scotia Department of Public Works

Wetland Vulnerability Study

FIGURE 1

Study Area

Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 1.75 3.5 7 Km

1:140,000

Scale when printed @ 11" x 17"

Drawn By: LP
Reviewed By: LP

Project Number:
Date: 5/16/2024

McCallum Environmental Ltd.

Document Name: fig1

2 LITERATURE REVIEW

An extensive literature review was conducted on various wetland-related functional assessment and modeling topics, including wetland vulnerability, wetland stressors, wetland function, and GIS modelling techniques. A focus was placed on reviewing literature within Canada and the United States, however sources outside of North America were also reviewed. The literature review was an essential portion of the Study as it pertains to the selection of wetland stressors, which is described in more detail in Section 4.2. Thorough research was completed to understand various wetland stressors and their root causes and impacts on different types of wetlands. Throughout the review, a list of wetland stressors was developed then modified to fit the context and understanding of the Study Area, given the results of desktop review and engagement sessions. A literature review summary is provided in Table 1 for relevant studies reviewed, and a fulsome summary of the foundational studies utilized in the development of this Study follows.

Table 1 - Literature Review Summary

Source	Summary	Key Information to Support Study
Adams & Tilton (2010)	• Developed a GIS desktop screening tool that evaluates wetland value and function based on flood storage, water quality and wildlife habitat functions	• Provided detailed information on wetland hydrology functions and value to consider during field assessments and modelling
Adamus et al. (2001)	• Conducted a literature review on indicator variables to monitor for wetland integrity, condition, function, etc. • Summarized anthropogenic stressors to wetlands into eleven categories; enrichment/eutrophication/organic loading/DO, contamination toxicity, acidification, salinization, sedimentation/burial, turbidity/shade, vegetation removal, thermal alteration, dehydration, inundation, and others.	• Provided extensive information on wetland functions and condition • Assisted in the development of wetland stressors and establishing a list of field-indicators
Adamus, P. (2014).	• Conducted a literature review on impacts to wetlands from forestry practices • Provided further information on wetland stressors and impacts relating to vegetation removal	• Detailed information on the impacts of forestry and clearcutting to
AECOM. (2013)	• Study identified areas within the Shubenacadie Lakes sub watershed that were suitable and not suitable for development • Study provided general context/understanding of the Study Area, and environmental considerations within	• Extensive background information on the Shubenacadie watershed and existing environmental sensitivities and stressors

Source	Summary	Key Information to Support Study
Brooks et al. 2004 & 2006	• Utilized scaled level assessments of wetland vulnerability with a large focus on land-uses and human disturbance impacts to wetlands • Completed a field-assessment recording observed wetland stressors and combined field observations with GIS modelling to identify overall wetland vulnerability	• Brooks et al., provided the basis of the rapid stressor checklist and was a significant influence on the development of field methodologies utilized in the MEL Study • Outlined the parameters of a level-based assessment of wetland vulnerabilities utilizing both field-level and desktop-level assessments
Defne et al. (2020)	• Developed a wetland vulnerability index based on various data sources (field observations, remote sensing, regulatory information, and numerical models) • Ranked values to relative vulnerability (low, moderate, high, severe) • Calculated a wetland vulnerability index by taking the average of all indicator scores in a specific wetland	• Was reviewed to identify means/methodologies to rank wetland vulnerability as this study utilized similar field/desktop methodologies
Faber-Langendoen et al. (2016)	• Developed a rapid ecological integrity assessment for wetlands • Developed a stressor index score based on scope and severity of an observed stressor • Utilized stressor categories (Development, Recreation, Vegetation, Natural, Soil, and Hydrology) similar to Brooks et al. 2004 & 2006 and WESP-AC with field indicators within each	• Provided stressor categories with significant information on field-indicators of observed stressors • Utilized to assist in the development of this studies stressor checklist and to establish likely field-indicators of wetland stress to support field assessments
Gitay et al. (2011)	• Developed a framework to evaluate wetlands vulnerability to impacts stemming from climate change • Examined wetland condition, sensitivity, and adaptive capacity to a variety of stressors	• Reviewed for further information on wetland stressors and resulting impacts from various anthropogenically-induced wetland stressors

Source	Summary	Key Information to Support Study
Herlihy et al. (2018)	• Study was a component of the 2011 National Wetland Condition Assessment (NWCA) to examine wetland stressors and vegetative condition • Utilized field programs to monitor field indicators of wetlands stressors including vegetation removal/replacement, damming, ditching, hardening, filling/erosion, heavy metals, and soil phosphorus • Categorized sites into low, moderate, and high level of stressors then calculated the relative risk ratio of individual wetland sites based on their size and the magnitude of observed stressors	• Information on wetland stressors and field-indicators of stressors was carried forward into the rapid stressor assessment
Larsen & Alp. (2014)	• Completed a literature review on ecological integrity thresholds particularly in riparian wetlands • Concluded that hydrologic regime shifts most frequently was the root cause for abrupt shifts in riparian species composition • Concluded that nutrient input has the ability to cause significant changes in a wetlands biogeochemical functions	• Reviewed the literature review to provide further understanding of wetland function and stressors to assist in the development of field methodologies • Gathered further peer-reviewed studies from this literature review to further support the Study
Liu et al. (2018)	• Utilized a GIS interface powered by Whitebox Geospatial analysis tools and SQLite database to simulate hydrologic variables (ie. Water quality and quantity) throughout wetlands within a singular watershed • Developed various equations to calculate wetland storage and wetland water and sediment balances	• Was initially thoroughly reviewed for potential modelling methods/techniques • Ultimately was concluded that methodologies were not appropriate for the Study given heavy influence of agricultural/cultivated lands where the study was completed (Manitoba)
Stratford et al. (2011)	• Created a wetland vulnerability assessment method with four main components; assessing wetland value, threats to wetlands, identifying links between threats and values, and an overall vulnerability assessment • Wetland vulnerability assessment was conducted with a scoring system	• Identified the links between wetland threats/stressors and value/function

Source	Summary	Key Information to Support Study
Uuemma et al. 2018	• Utilized GIS techniques (LIDAR, topography, land use) to model site suitability for wetland restoration and creation opportunities • Ultimately found that most wetlands/areas highlighted for restoration or creation opportunities were mostly historically altered wetlands, often in agricultural settings	• Reviewed the use of LIDAR and land-use spatial datasets to support model development
Wright et al. (2006)	• Summarized numerous scientific studies on direct and indirect impacts of urbanization on wetlands and watershed quality/health	• Provided further information on urbanization impacts on wetlands, particularly focusing on potential indirect threats

Throughout the completion of the literature review, two studies emerged as foundational literature within the development of the Study, Brooks et al. 2004 and 2006. These two studies heavily influenced the development of MEL's Study methods, particularly the field assessment phase. This study based much of the field methodologies on Brooks et al., field-assessing wetlands with a rapid stressor checklist to make note of field-observed wetland stressors and to provide an understanding of stressor causes, if possible. The MEL study differed from Brooks et al., in modelling techniques and localized data. Brooks et al relied heavily on land-use layers within a set 1 km buffer of a wetland while the MEL study utilized a few more spatial layers, as discussed in Section 4.3.

The Brooks et al. studies relied on three levels of wetland assessments, ranging from desktop review, field assessments and GIS modelling exercises:

- Level 1: Utilize existing spatial layers such as wetland inventories, topography, stream network, and land use to evaluate the composition and condition of a 1 km buffer around the geographic centre of a wetland.
- Level 2: Include a site visit and completion of a rapid stressor checklist to note any observed wetland stressors, to assist in the development of a human disturbance score.
    - The rapid stressor checklist utilized within the Level 2 assessment served as the key source for the development of a similar stressor checklist for this Study (Appendix B) to note observed wetland stressors and land-use compositions during field assessments.
- Level 3: Combine both desktop and field data/observations to compute an overall condition for wetlands utilizing HGM and IBI models to identify specific sites for restoration opportunities.

Stressor scores were calculated to quantify wetland disturbance, impacts, and presence of stressors. Scores ranged from 0-100, with 0 being the least disturbed, and 100 being the most disturbed.

The following equation was used to calculate the scores in the Brooks et al. studies:

CF = 100 – {[%FLC* (10 - #Stressors/10)] + [Buffer Score – Buffer Hits]}

Where:

- CF = Calibration factor (100/114) to standardize the score to be on a scale of 0-100.
- %FLC = Percent Forested Land Cover in the buffer.
- #Stressors = Number of stressor categories that were observed.
- Buffer Score = Value between 0-14. Based on the buffer composition and width.
- Buffer Hits = Stressor indicators that allow the effects of land use to affect the wetland.

Additionally, wetland functional assessment tools were used to further research on the topics of wetland characteristics, functions, and stressor impacts. This included the current wetland functional assessment tool in Nova Scotia, the Wetland Ecosystem Services Protocol - Atlantic Canada (WESP-AC), and its predecessor NovaWET.

3 STAKEHOLDER ENGAGEMENT

Engagement sessions were conducted with various stakeholders including SWEPS, Halifax Water, Collins Park Watershed Advisory Committee (CPWAC), the Municipality of East Hants (MEH), and the Halifax Regional Municipality (HRM).

3.1 Engagement Sessions Overview

Engagement sessions were conducted from March to May 2023 to discuss local watershed considerations and areas of interest, obtain data, and discuss existing and future development plans within the Study Area. Engagement sessions served as a main source for identifying wetlands and general areas of interest throughout the reconnaissance of potential field assessment locations. Sessions were conducted in-person or through virtual settings, and also consisted of a SWEPS Public Meeting on April 19, 2023, including members of the general public and representatives from provincial and municipal government. Additionally, MEL presented preliminary results of the Study to SWEPS members on December 6, 2023.

Summaries of discussions with various stakeholder groups are provided below:

Shubenacadie Watershed Environmental Protection Society (SWEPS):

- Provided MEL with various areas of interest for field assessment, largely based off known stressors to wetlands and existing development pressures.
- Brought forth significant information on select sites within the Study Area such as Bennery Brook.
- Discussed data that SWEPS had available, and field work that SWEPS has completed throughout various areas within the Study Area.

- Raised concerns about the level of urban development occurring within the Study Area and the impacts of significant wetland loss within the Shubenacadie watershed.
- Requested information on the GIS modelling and layers being utilized (i.e.. Lidar, forestry, etc.).
- Expressed a desire for the model and results of this Study to be further utilized in development planning.
- Provided MEL with land-owner contacts for various sites.

SWEPS Public Meeting Input from General Public:

- Received questions on model and Study turnaround time and the ability to replicate the Study within other watersheds in Nova Scotia.
- Members of the public questioned the local MLA if they were aware of the study and if it could be brought forth to the Minister of Environment.
- Questioned on the comparison of the value of a GIS tool versus a Study that is entirely field assessment based.
- Received questions on the next steps for the GIS model moving forward in terms of future uses in a regulatory setting.

Halifax Water:

- Provided MEL with spatial data including source water protection zones and risk areas.
- Expressed concern about site specific locations.
- Raised importance of wetlands within drinking water supply areas.

Collin's Park Watershed Advisory Committee (CPWAC):

- Brought up concerns around the quality of wetland management work being completed, particularly on the lack of work being undertaken in urban areas and within the same catchment/watershed as the originally altered wetland.
- Expressed a desire for the Study Area to be further expanded south of Grand Lake to further be within Collins Park Watershed boundaries.
- Pushed that municipal government should be more involved with wetland permitting.
- Recommended that wetlands within drinking water supply areas, specifically Collin's Park and Bomont, should be designated as Wetlands of Special Significance (WSS) within the provinces *Wetland Conservation Policy*.
- Suggested a cost-benefit model to account for wetland value, rather than strict wetland compensation ratios.
- Requested that wetland creation be considered more by the provincial government within the umbrella of wetland management/compensation practices moving forward.

Please refer to Appendix A for CPWAC's full letter of recommendations.

Municipality of East Hants (MEH):

- Expressed an interest in numerous areas and provided MEL with high-risk area mapping pertaining to source water protection for consideration during field assessments.
- Suggested a Study Area expansion to include areas west of Grand Lake, specifically between Beaverbank Road (Highway 354) and Grand Lake/Kinsac Lake.
- Assisted with land-owner contact for numerous private lands.

Halifax Regional Municipality (HRM):

- Questioned on if this kind of Study can be utilized in other watersheds moving forward.
- Discussed HRM's publicly available open data sources.
- Discussed HRM's ongoing review of the regional plan and their work to involve climate, water, and wetlands to a higher degree in policy moving forward.
- Questioned if the goal of this study is to utilize similar GIS modelling methods moving forward as a means to predict/identify Wetlands of Special Significance.
- Discussed model outputs and how to quantify wetland vulnerability as an index or score.

The information and concerns provided by these stakeholder groups aided in the development of the Study Area boundaries and helped identify wetland concerns in these communities.

Engagement sessions served as a successful means to gather more context and important information about the Study Area, and particularly in curating a list of potential target sites identified by various stakeholders. Multiple revisions to the Study Area were completed in consultation with various stakeholders to include areas of high interest, notably areas of high urban development, industrial activity, etc.

A follow-up summary of how various stakeholder's questions and concerns have been considered is provided within Section 7. These responses are limited to queries/concerns MEL is capable of responding to given the objectives and scope of the Study, though we highly encourage further consideration of noted stakeholder concerns during development planning and work be done after this Study is complete.

4 METHODS

The following sections describe the desktop and field methods used to develop and calibrate the wetland vulnerability model.

4.1 Stressor Selection

Wetlands in developed and developing areas are susceptible to various anthropogenic disturbances, which are commonly referred to as "stressors" (Adamus et al., 2001). Wetlands that are exposed to stressors are at risk of reduced native flora and fauna diversity, as well as a decline in wetland functions such as water filtration, flood prevention, groundwater recharge/discharge, and critical habitat for rare species. The effect of a stressor largely depends on the location, landscape position, and size of the wetland, along with the severity of the stressors present (Wright et al., 2006).

The wetland stressors that were used to assess the condition of wetlands in the Study were selected based on the stressors identified by Adamus et al. (2001) and Brooks et al. (2004 & 2006) and are as follows:

- Hydrologic modification
- Sedimentation
- Vegetation stress
- Eutrophication
- Dissolved oxygen
- Contaminate toxicity
- Salinity
- Acidification
- Turbidity
- Thermal alteration

Each stressor category has one or more associated stressor indicators, which assist in determining the presence of the overall stressor. The stressor indicators identified in this Study were derived from the stressor checklist developed by Brooks et al. (2006) and then adapted for the Study Area. Stressor indicators were selected based on anthropogenic disturbances that are known or expected to be present in the Study Area according to feedback that was received during stakeholder engagement sessions and a desktop review of land use. Stressor categories, indicators, and their descriptions are described in Table 2 - Stressor categories and descriptions.

Table 2 - Stressor categories and descriptions

Stressor Category	Stressor Indicators	Description
Hydrologic Modification	Ditching	Infiltration and recharge of groundwater are diminished due to increased stormwater inputs.
	Tile drain	Drains water and alters wetlands.
	Dike	Alters the natural flow regime.
	Weir/Dam	
	Point source (non-stormwater)	Increased water inputs containing pollutants.
	Filling/grading/dredging	Alters the natural flow regime.

Stressor Category	Stressor Indicators	Description
	Roadbed/railroad	Increased stormwater runoff, decreased groundwater recharge, and flow constriction.
	Dead/dying trees	Indicates the presence of hydrologic stressors.
	Evidence of stormwater input (ditch, swale, culvert, etc.)	Infiltration and recharge of groundwater is diminished due to increased stormwater inputs. Also causes flow constriction.
	Excavation within the wetland	Alters the natural flow regime.
Sedimentation	Sediment deposits/plumes	Indicates excess sediment inputs.
	Eroding banks/slopes	Increased sediment loads.
	Forestry	Exposes soil and leads to increased sediment loads from erosion and surface water runoff.
	Active construction/plowing/heavy grazing/forest harvesting adjacent	Increased sediment loads due to disturbance of the soil.
	Silt on the ground or vegetation	Indicates excess sediment inputs.
	Urban/road stormwater inputs (i.e. culverts, storm drains)	Transports sediment to the wetland and leads to excess sediment inputs.
	Dominant presence (>50%) of sediment tolerant plants	Indicates excess sediment inputs.
	Evidence of water carried debris, sand and gravel, deposits, plumes	
Vegetation Stress	Mowing	Removal of natural vegetation increases stormwater runoff, which increases vegetation stress.
	Grazing	
	Tree cutting (>50% canopy removal)	
	Brush cutting	
	Removal of woody debris	Reduces shade and habitat.

Stressor Category	Stressor Indicators	Description
	Aquatic weed control	Indicates that invasive species may be present.
	Excessive herbivory	Removal of natural vegetation increases stormwater runoff, which increases vegetation stress.
	Dominant presence (>50%) of exotic or aggressive plant species	Indicates that the natural, native vegetation is under stress.
	Evidence of chemical defoliation	Reduces shade and alters natural vegetation.
Eutrophication	Direct discharges from agricultural feedlots, manure pits etc.	Increased nutrient load alters vegetation community structure and may lead to eutrophication.
	Direct discharges from septic or sewage treatment systems	
	moderate or heavy formation of algal mats	Indicates excess nutrient inputs.
	Dominant presence (>50%) of nutrient-tolerant species	
	Other (ex. Signs of excess nutrients, methane odour, dead fish)	
Dissolved Oxygen	Excessive density of aquatic plants or algal mats in water columns	Reduces dissolved oxygen, which leads to the death of aquatic organisms.
	Excessive deposition or dumping of organic waste	
	Direct discharges of organic wastewater or material	
Contaminate Toxicity	Severe vegetation stress	Indicates the presence of excess pollutants.
	Obvious spills, discharges, plumes, odors	
	Wildlife impacts (ex. tumors abnormalities)	
	Adjacent industrial sites, or near railroad	Hish risk of industrial pollutant inputs.

Stressor Category	Stressor Indicators	Description
Salinity	Obvious increase in the concentration of dissolved salts	High salinity measurements. Usually due to changes in the natural flow regime.
Acidification	Acid rock drainage discharges	Increased inputs of acidic water containing heavy metals.
	Adjacent mined lands/spoil piles	Increased risk of acidification.
	Excessively clear water	Indicates that acidification may be occurring.
	Absence of expected biota	
Turbidity	High concentration of suspended solids in the water column	Cloudy water reduces solar penetration.
	Moderate concentration of suspended solids in the water column	
Thermal Alteration	A significant increase in water temperature	Long-term significantly higher than normal water temperatures. This leads to poor water quality. Affects community structure.
	A moderate increase in water temperature	Long-term higher than normal water temperatures. This leads to poor water quality. Affects community structure.

Note: Information collected from the following sources: Brooks et al., 2006; Wright et al., 2006.

4.2 Data Review

A review of available provincial datasets and data provided through engagement was completed to identify data sources that may be of use in the modelling exercise. The main constraint was finding data sets that covered the entire Study Area and correlated with the defined stressors. Datasets that were publicly available were favored for their ease of access for future updating.

Other datasets were provided by stakeholders through engagement sessions including MEH, CPWAC, Halifax Water, and HRM. Many of these datasets, while considered, were not utilized during final selection of data layers to support model development.

While the stressors identified above are readily recognized in the field, they are much harder to predict or identify using GIS data and modelling. To capture as many of these stressors without specific associated data layers, a series of proxy datasets were used to help identify potential stress sources and predict where stressors might be found.

Table 3 describes the layers or features that were considered to support modelling methodologies.

Table 3 - Data Sources

Layer or feature	Data Source	Description
Stewiacke Wetland Predicted Layer	NSECC	Predicted wetland boundaries and types for Stewiacke Watershed
Forestry/Landcover	NS NRR	Used to determine forested vs non-forested landcover and overall land use
Non-forest - Urban or road or gravel pit	Forestry/landcover	Used as a proxy for hydrologic modification, vegetation stress, impervious surface, sedimentation - Impervious surfaces, high runoff/sedimentation potential
Misc or rail	Forestry/landcover	Used as a poxy for source for potential contaminate source (e.g. misc included areas of unknown industrial use)
Agriculture	Forestry/landcover	Used as a proxy for eutrophication and dissolved oxygen and sedimentation - Eutrophication, runoff, increased nutrient loading, managed vegetation
Clearcut	Forestry/landcover	Used as a proxy for turbidity, thermal alteration, vegetation stress and sedimentation - High sedimentation/runoff potential with full removal of canopy cover
Powerline or pipeline	Forestry/landcover	Used as a proxy for managed vegetation, sedimentation/runoff from recreational trails
Partial cut or plantation or rock barren or Christmas tree farm	Forestry/landcover	Used as a proxy for turbidity, thermal alteration, vegetation stress and sedimentation - More runoff potential/less buffering capacity than natural classes
Tertiary Watershed	NSECC	Clipped tertiary watershed layer as a boundary for catchment conditions
Protected Water Areas/Water Supply	Halifax Water	No, protections were not considered, only stressors at this time
Elevation	LiDAR data, NSTDB	Incorporated into base wetland layer
Bedrock Geology Unit – Halifax Formation	NS NRR	Used as a proxy for Acid Rock Drainage Potential

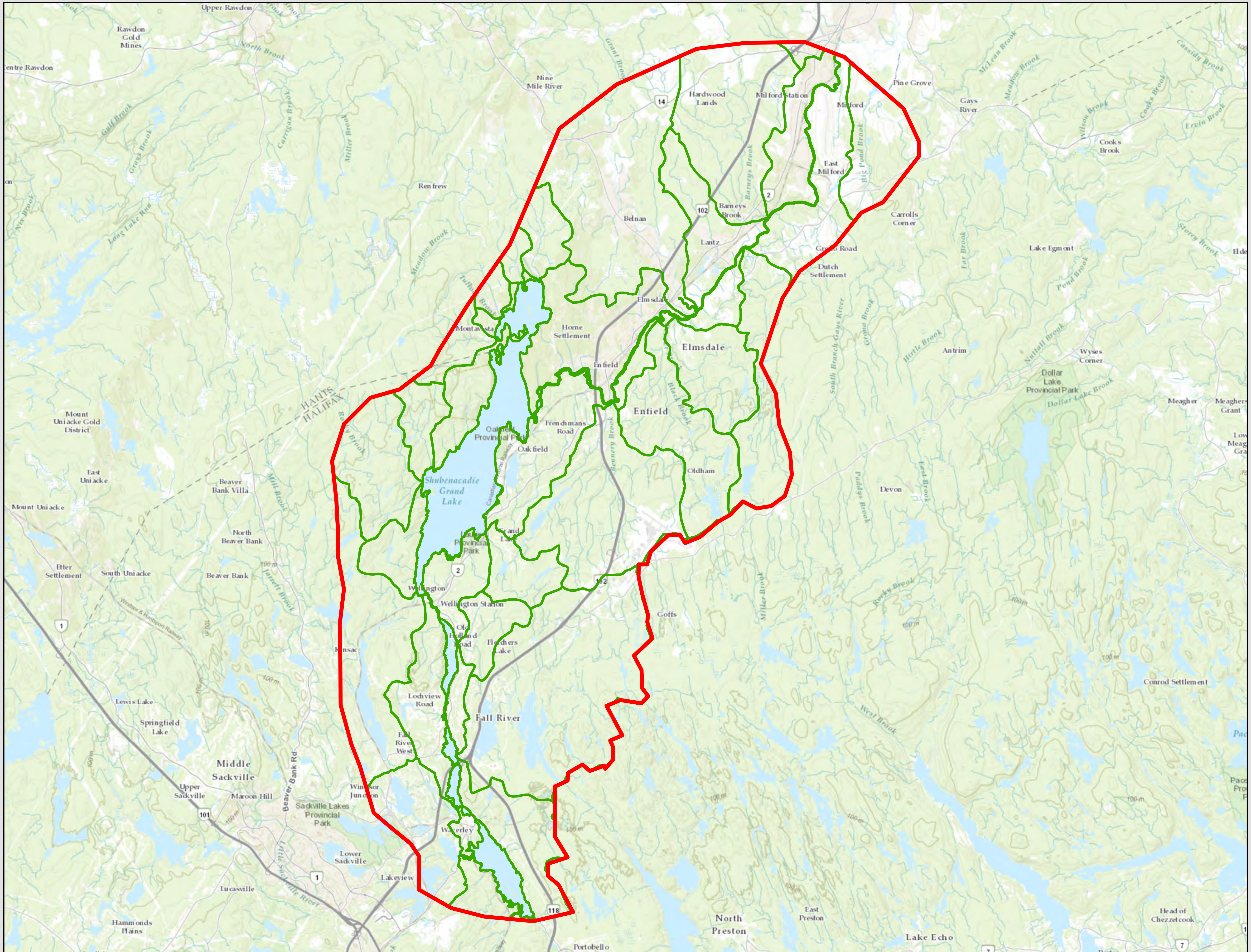
Data related limitations include:

- Limited data to support predicting hydrologic stressors (ie. Culverts, storm drains, artificially impounded water, frequency of inundation, water quality, etc.) inhibit the model's ability to predict and consider these stressors.
- Outdated spatial layers (ie. Forestry) limits the tools predictive capabilities.
- The NSNRR Forestry data is captured from 2007 photography, the scale of the photographs changed from 1:10,000 to 1:12,500 and the analog photos were digitally scanned and orthorectified so that editing/updating of forest stands could be done using ArcGIS.
- NSNRR notes that: "Areas of harvests and partial cuts updated from satellite imagery are locationally correct but may not have an exact representation of the boundaries due to pixel size. These areas have been entered on the interim between photo interpretation cycles to allow for on-going forestry analysis. The boundaries will be refined as photo re-interpretation occurs.
- The predictive wetland modelling provided by NSECC and utilized in this study as the base wetland spatial layer is a developing tool. This is one of the first times this layer has been utilized and assessed in the field and feedback from this study will help improve its accuracy.

4.3 Model Methods

The Study benefitted greatly from the support of NSECC Wetland Specialists, who provided their preliminary predictive wetland layer for the Study Area. This layer was used as the base wetland layer and was compared to stressor layers and land cover disturbance to identify potential impacts.

Stressor layers were created by selecting landcover features that behave as wetland stressors in similar ways and grouping them into proxies as outlined in the data review and then spatially identifying them within the Study Area. All stressors were weighted equally and any wetland polygons within 100 m of a given stressor were assigned a stress value of 1. This analysis was applied to all polygons and all stressor proxy categories. To capture potential downstream issues within a catchment, the forested vs non-forest landcover within the tertiary watershed was calculated and assigned a watershed condition score from 0 to 3 correlated to the amount of disturbance/non-forest in the watershed catchment within the Study Area. Note that some tertiary watersheds in this study have been clipped to the study area and are smaller than their full extent for the purpose of keeping datasets comparable in this study. The tertiary watersheds are shown on Figure 2. Below is the step by step workflow of how the modeling was completed. This has been written to be used in GIS software such as ArcGIS or QGIS, which is a free open source software available to anyone.



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Wetland Vulnerability Study

FIGURE 2

Tertiary Watersheds within Study Area

Tertiary Watersheds (clipped to Study Area)

Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 1.75 3.5 7 Km

1:140,000

Scale when printed @ 11" x 17"

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Reviewed By: LP

Project Number:
Date: 5/16/2024

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Document Name: Fig2

4.3.1 GIS-Based Modelling Workflow

1. Clip the following layers to the Study Area:
    a. Predicted Wetlands
    b. Tertiary Watersheds
    c. Landcover layer
2. Reclassify the landcover layer based on the following:

Table 4 - Assigned Landcover Classes

Classes	Values included	Natural or non-forest	Justification for grouping
0	Urban or road or gravel pit	Non-forest	Impervious surfaces, high runoff/sedimentation potential
1	Misc or rail	Non-forest	Potential for contamination
2	Agriculture	Non-forest	Eutrophication, runoff, increased nutrient loading, managed vegetation
3	Clearcut	Non-forest	High sedimentation/runoff potential with full removal of canopy cover
4	Powerline or pipeline	Non-forest	Managed vegetation, sedimentation/runoff from recreational trails
5	Partial cut or plantation or rock barren or Christmas tree farm	Non-forest	More runoff potential/less buffering capacity than natural classes
6	Brush	Natural	Natural vegetation cover
7	Old Field	Natural	Natural vegetation cover
8	Windthrow or treated or Dead 2 or Burn	Natural	Disturbance regime causing impact to ability to buffer
9	Alders or Beaver Flowage or Dead 1	Natural	Density difference from 8, more impacted than 10
10	Water or wetland or natural or barren	Natural	Natural landscape features

3. Union Landcover layer to clipped tertiary watershed layer.
4. Calculate the area of each class within each tertiary watershed.
5. Calculate percentage non-forest within each tertiary watershed based on the Table 4 above.

6. Assign a value to each tertiary watershed based on percentage of non-forest cover (e.g., the higher the score, the more vulnerable the watershed is) as per Table 5.

Table 5 - Tertiary Watershed Condition Scoring

Percentage of Clipped Tertiary Watershed that is Non-Forest	Assigned Score for Tertiary Watershed Condition
0 – 24.9 %	0 (natural/minimal impact)
25 – 49.9 %	1 (low impact)
50 – 74.9 %	2 (medium impact)
75 – 100 %	3 (highly impacted)

7. Add assigned score as an attribute to all wetlands within that watershed.
8. Add attributes for the following stressors and assign "Buffer Hits" for each of the stressors by giving a value of 1 to all wetlands within 100 m of a stressor and a value of 0 to wetlands that do not interact with that stressor.
    a. Landcover Class 0, 1, 2, 3, 4, and 5 in Table 4 were each treated as their own stressor.
    b. Halifax formation polygons from the Bedrock Geology layer was included as an additional stressor layer
9. Add all Buffer Hits and Tertiary Wetland Condition Score to get total score out of 10 for each wetland.

4.4 Field Assessment Methods

Field assessments within the Study were completed to validate and compare modelled stressors to field-observed stressors. Additionally, an essential field component to support modelling validation was the auditing of the NSECC predictive wetland layer. This layer remains to be early in its development and has not been field-verified prior to this Study.

4.4.1 Desktop Review

A desktop review was performed to identify wetlands within the Study Area for potential field assessment to provide calibration points for the model. This involved reviewing the following datasets and information:

- Stakeholder engagement feedback
    - Wetlands/areas with known wetland stressors
    - Wetlands/areas facing development pressures
- NSECC Predictive wetland layer

- NSECC Predictive Catchment Areas
- Tertiary Watersheds
- NSODP Crown Parcels
- GeoNova Property Ownership
- NS Road Network
- NSTDB Mapped Watercourses/Waterbodies
- NSNRR Forestry Inventory

Wetlands were selected for field assessment based on accessibility, property access permission, wetland classification, wetland size, and location within the Study Area. Wetland type, size, and location were important considerations to ensure that the data collected was a representative selection of wetlands within the Study Area and captured noted areas of interest.

Additionally, an in-depth review of available aerial imagery of the Study Area was completed to identify areas and points of interest for consideration during field assessments. Throughout this review, wetlands and areas of interest for potential field assessments were selected based on:

- Landscape conditions (i.e., visibly stressed wetlands, areas of high disturbance)
- Wetlands with unnatural buffers (i.e., industrial sites, residential development, etc.)
- Achieving representative coverage of the Study Area

4.4.2 Field Assessment

In-field verification and calibration of predicted wetlands and wetland modelling commenced in August 2023 and concluded in November 2023. The goal of the field assessments was to calibrate and validate the GIS modelling aspect of the Study by collecting field data on wetland stressors, buffer type/condition, boundaries, species assemblages, and function. Additionally, WESP-AC assessments occurred alongside wetland vulnerability calibrations to evaluate wetland function and presence of stressors. The Study evaluated 100 wetlands in the field.

The primary method for data collection in this study was QField, a mobile version of QGIS. QField was used to complete field datasheets, including the rapid assessment stressor form and a MEL internal datasheet that collects wetland characteristic information. Additionally, QField was utilized to record true wetland boundary waypoints, and any points of interest. WESP-AC assessments were completed separately using latest the NSECC version.

Meandering transects were completed where land access was granted, and opportunistic true boundary points were taken to verify and calibrate the wetland boundaries modelled by the NSECC predictive wetland layer. When land access permission was not received, MEL assessed wetlands either on Crown Land or from public viewpoints (e.g. roads, rights-of-way). For wetlands where field staff were unable to physically walk the wetland (e.g., no access granted), true boundary points and stressor observations were taken based on visual observations from accessible locations.

Points of interest were also recorded (e.g., Culverts, inflow/outflow, cutting, beaver activity, etc.) to capture additional information about wetland characteristics and to further understand observed wetland stressors. After true boundary points and points of interest were recorded, the internal MEL datasheet was completed to summarize the general characteristics and function of the wetland. Subsequently, WESP-AC and the rapid assessment stressor form were completed.

The WESP-AC process involves the completion of three forms; a desktop review portion (Office Form) that examines the landscape level aerial conditions of the wetland, and two field forms identifying biophysical characteristics of the wetland (Field Form) and stressors within the wetland (Stressor Form). The process serves as a rapid method for assessing individual wetland functions and values. WESP-AC addresses 17 specific functions wetlands may provide:

- Water Storage and Delay
- Sediment Retention and Stabilization
- Phosphorus Retention
- Nitrate Removal and Retention
- Thermoregulation
- Carbon Sequestration
- Organic Matter Export
- Pollinator Habitat
- Aquatic Invertebrate Habitat
- Anadromous Fish Habitat
- Non-anadromous Fish Habitat
- Amphibian & Reptile Habitat
- Waterbird Feeding Habitat
- Waterbird Nesting Habitat
- Songbird, Raptor and Mammal Habitat
- Pollinator Habitat
- Native Plant Diversity

Wetland function relates to the wetland's ability to fulfill ecosystem services (i.e., water storage and filtration, habitat provisions), whereas wetland benefits are benefits of the function, whether it is ecological, social, or economic. The highest functioning wetlands are those that have both high 'function' and 'benefit' scores for a given function. WESP-AC enables a comparison to be made between individual wetlands within a province to gain a sense of the importance each has in providing ecosystem services.

For the purpose of this Study, the WESP-AC Field and Stressor forms were completed on all 100 wetlands, while the WESP-AC Office Form was completed only for the wetlands that scored high (75-100) (meaningful data outputs which warranted further assessment) on the rapid assessment stressor form (n=8 wetlands). Completing the WESP-AC Office form on these higher stressed wetlands offered a full functional assessment and further evaluation to provide further context and understanding of their function, stressors, and condition.

The rapid assessment stressor form that was used during the field assessments was developed based on the stressor checklist created by Brooks et al. (2006), as described in Section 4.2. The rapid assessment stressor form considers the buffer width and composition surrounding the wetland and includes all the stressor categories and indicators described in Table 2 - Stressor categories and descriptions. During the field assessment, any stressor indicators that were observed were noted, and a buffer of 30 m was characterized and given a score from 0-14. The establishment of a 30 m buffer was influenced by the definition of wetland buffers utilized within WESP-AC. The buffer scoring system was developed by Brooks et al. (2006) and is displayed in Table 6.

Table 6 -Buffer Assessment

Buffer Type	Buffer Width				
	0-3 m	3-10 m	10-30 m	30-100 m	>100 m
Natural forest	6	8	10	12	14
Shrub/sapling	4	6	8	10	12
Perennial herb	2	4	6	8	10
Other	0	0	0	0	0

Following the completion of the rapid assessment stressor form, a score was calculated to quantify the level of disturbance observed in the wetland. Scores range from 0-100, with 0 being the least disturbed, and 100 being the most disturbed (Brooks et al., 2006). The equation used for the calculation was based on that developed by Brooks et al. (2006), and is shown below:

CF = 100 – {[%FLC* (10 - #Stressors/10)] + [Buffer Score – Buffer Hits]}

Where:

- CF = 100/114
- %FLC = Percent Forested Land Cover in the buffer
- #Stressors = Number of stressors observed, weighted out of 10 based on the number of stressor indicators in a category
- Buffer Score = Value from 0-14 based on the buffer composition and width
- Buffer Hits = Stressor indicators that allow the effects of land use to affect the wetland

%FLC was determined by clipping the NS Forestry layer to the 30m buffer and calculating the percent of forested and non-forested landcover types within the buffer.

4.4.3 Field Program Limitations

The following limitations were encountered during field assessments:

- Limited Crown Land present throughout the Study Area meant MEL had to attempt to receive permission to access private lands during field assessments. Unfortunately, many of the sites identified during stakeholder engagement sessions as high priority for field assessments were not able to be assessed due to a lack of property access permissions. MEL attempted to obtain land permissions through landowner contact, coordinating with community groups (i.e., SWEPS), and correspondence with municipal governments (MEH and HRM). However, in many cases MEL were unable to obtain permission, or were unsuccessful in establishing landowner contact. While the model has been run on the entirety of the Study Area, many wetlands located on private property have not been field assessed. During field assessments, MEL assessed wetlands on Crown Land, lands where private permission had been granted, and wetlands that were visible from public roads.
- Data that was collected by MEL biologists may differ from that of others because of inherent subjectivity. Wetland classification and identification of soils, vegetation, wetland types, buffers, stressors, and general environmental characteristics have been completed by qualified professionals. However, a single assessment may not define the absolute status of wetlands conditions because conditions and characteristics may change over time, either naturally or through anthropogenic influences.
- All reasonable assessment programs will involve an inherent risk that some site conditions or characteristics may not be detected during surveys. Reports and analysis on such investigations will be based on reasonable interpretation from representative field sample points, supporting desktop interpretation and professional judgment.
- Most of the wetlands that were assessed within the Study Area were swamps. Bogs and shallow open water appear not to be well represented; however, they were also captured in the wetland complexes, which consist of two or more wetland classifications. Wetland classifications that occurred less frequently were targeted to ensure they were represented within the Study.

5 RESULTS

5.1 Model Output

The model output provides a spatial file of predicted wetland polygons with an associated series of attributes related to its vulnerability corresponding to 10 proximal and tertiary land use stressors used to calculate a total vulnerability score. An overview of the results is shown on Figure 3 below. The wetlands are ranked out of a possible 10 points for their current vulnerability baseline condition based on this predictive model. The lowest scoring wetlands received a 0 out of 10 meaning no stressors were present within the wetland or within 100 m of the wetland boundary and the tertiary watershed they were found in was over 75% natural undisturbed land cover. The highest scoring wetland received a 6 out of 10 for its current vulnerability baseline condition based on this predictive model. This showed that the wetland was under moderate to high risk of stressors and/or had high levels of disturbance within its tertiary watershed. The tertiary watershed condition scores are shown on Figure 4. The most impacted tertiary watershed was a small catchment along Highway 2 in Fall River that is highly developed. The next most impacted watersheds are up near Lantz and Millford where we see lots of agriculture and cleared land. Figure 5 shows the modelling results in a series to show detailed locations and conditions. Table 7 provides an overview of the numbers and percentages of polygons (ie – predicted wetlands) scored at each vulnerability score.

Table 7 - Number of Predicted Wetland Polygons by Vulnerability Scores

Vulnerability Score	# of Predicted Wetland Polygons	Percentage of Total
0 (good condition)	2,477	17.8%
1	3,649	26.1%
2	4,418	31.7%
3 (at risk)	2,419	17.4%
4	802	5.8%
5	157	1.1%
6 (under stress)	15	0.1%
7	0	0%
8	0	0%
9	0	0%
10 (Highly stressed)	0	0%
Total	**13,937**	**100%**

The majority of predicted wetlands within the Study Area scored between 1-3 meaning that they were stressors present, and they were at risk but not majorly impacted at this time. Fifteen wetlands received a vulnerability score of 6 which correlates to being under stress and likely facing issues within their tertiary watershed.

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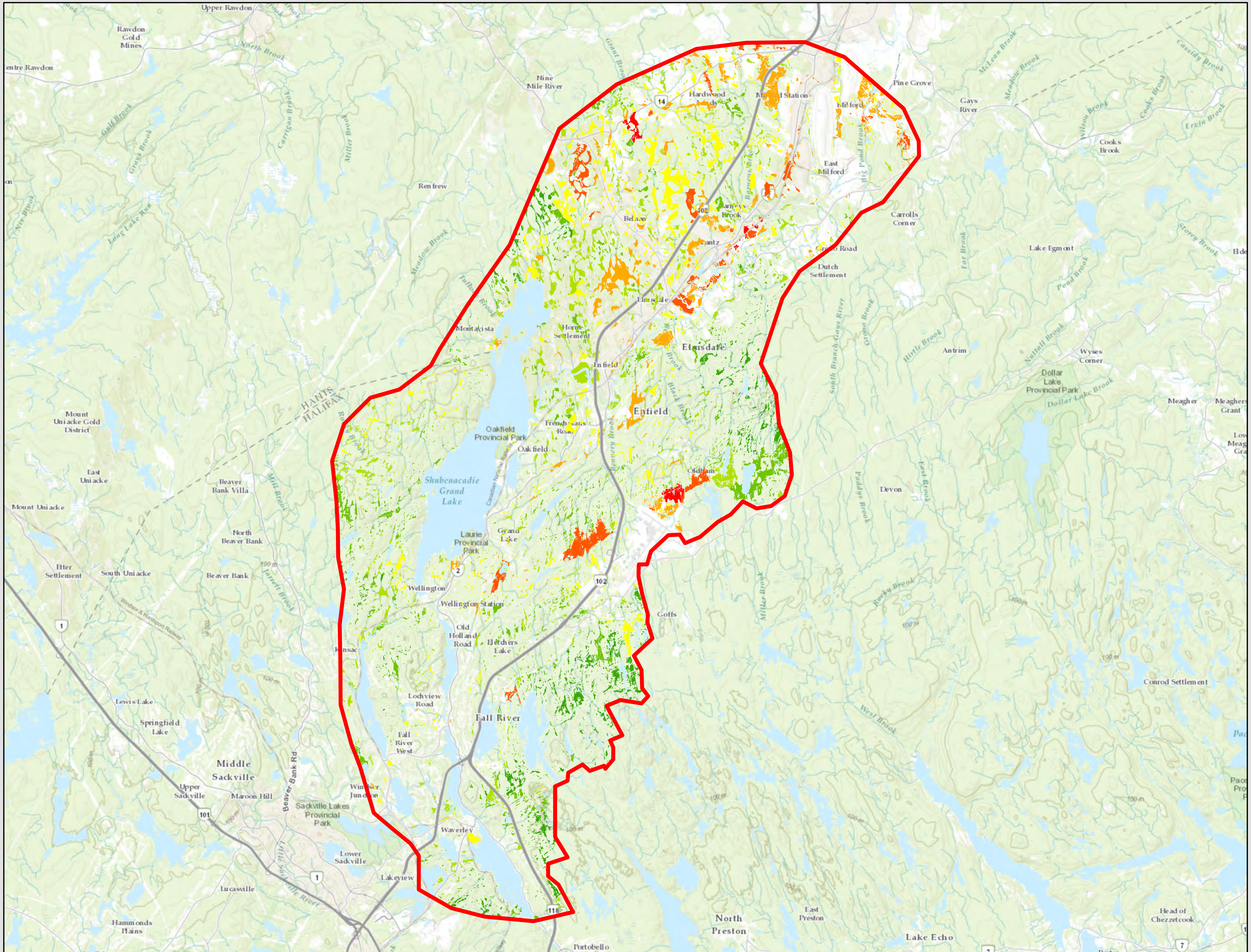
FIGURE 3

Predictive Wetland Vulnerability Model Overview



Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
- 3 - At Risk
- 4
- 5
- 6 - Under Stress
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 1.75 3.5 7 Km

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Document Name: Fig3

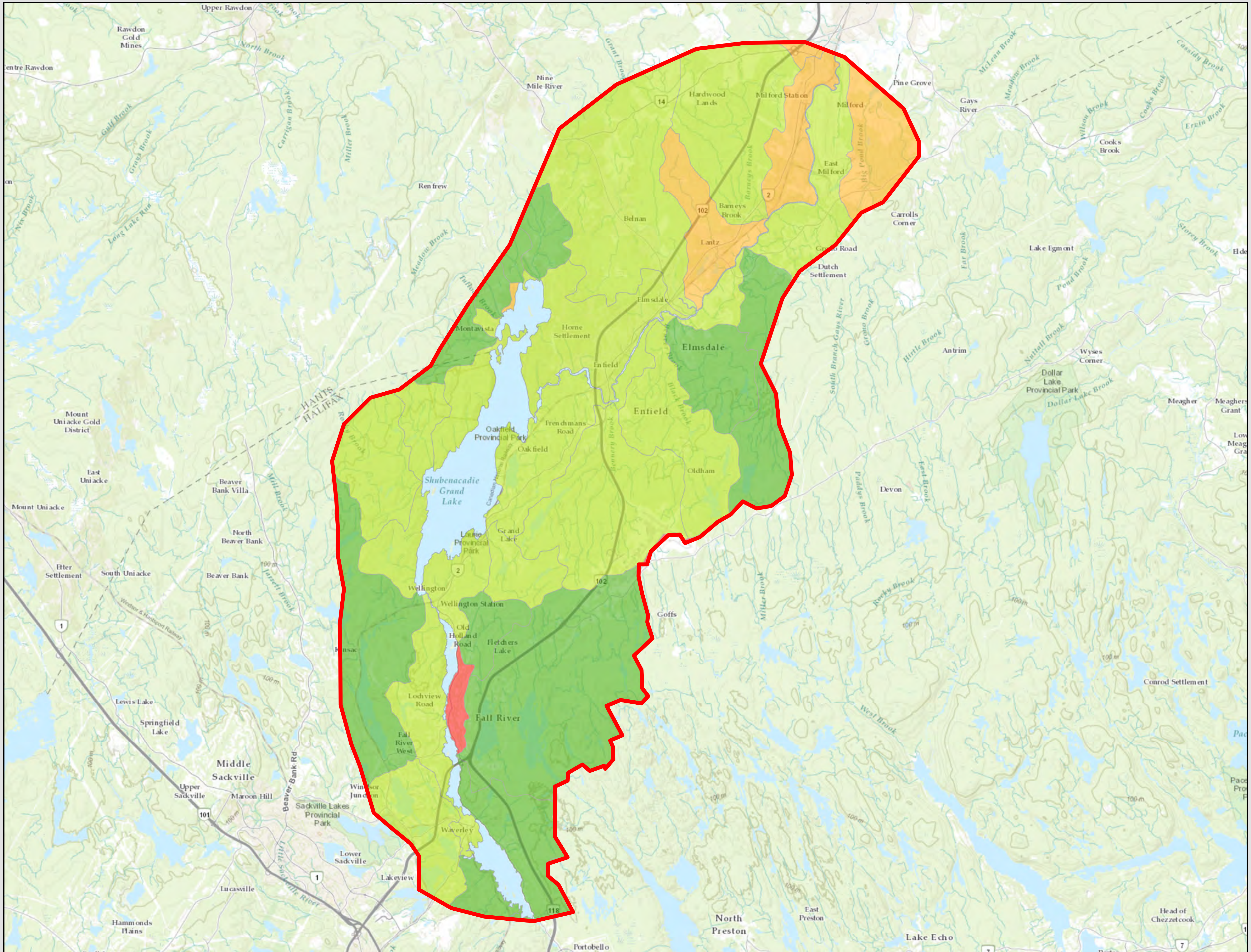

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FIGURE 4

Tertiary Watershed Condition Overview

Tertiary Condition Score

- 0 (Good)
- 1
- 2
- 3 (Poor)
- Study Area

Coordinate System: NAD 1983 CSRS UTM Zone 20N
Projection: Transverse Mercator
Datum: North American 1983 CSRS
Units: Meter

0 1.75 3.5 7 Km

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Reviewed By: LP

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Document Name: fig4

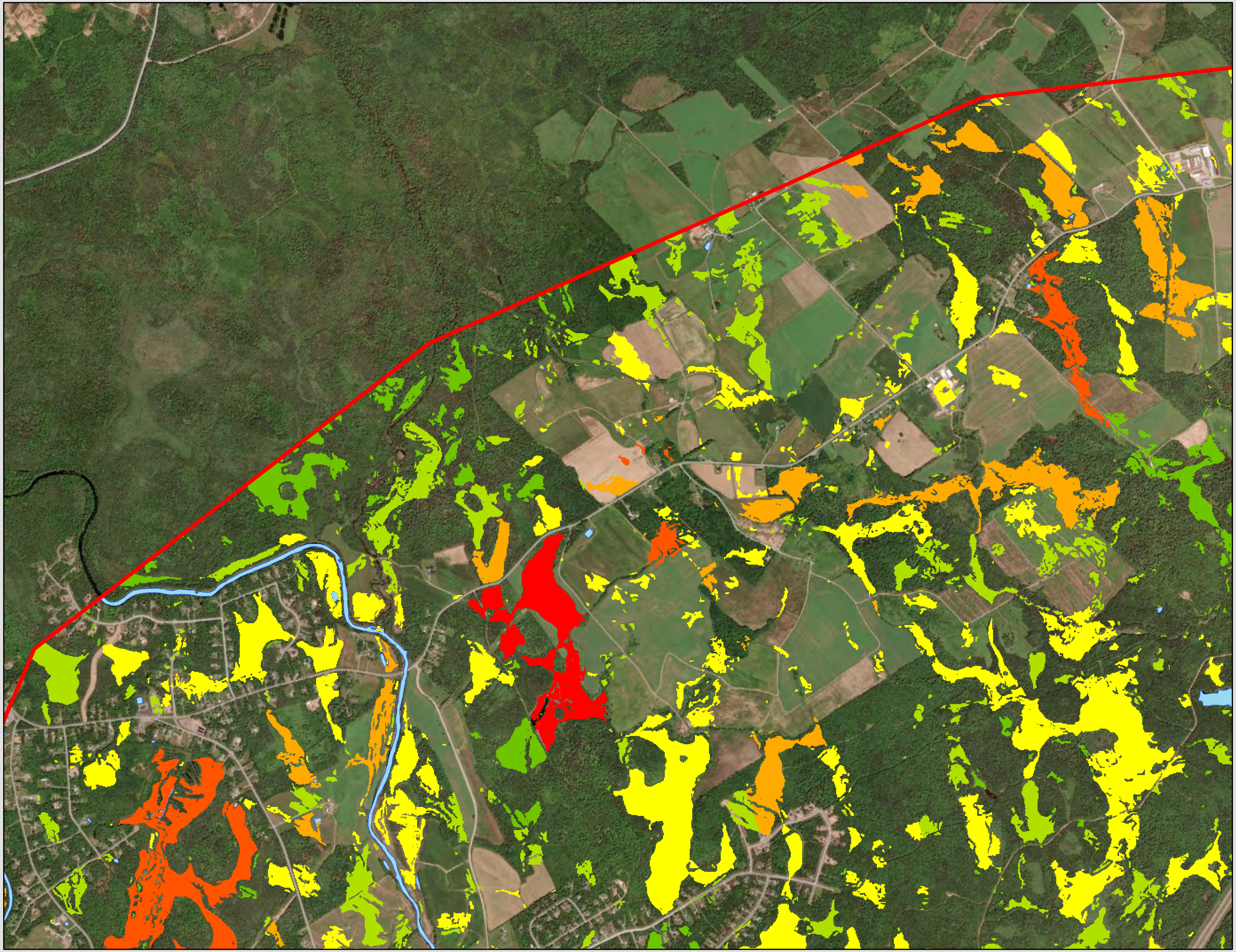

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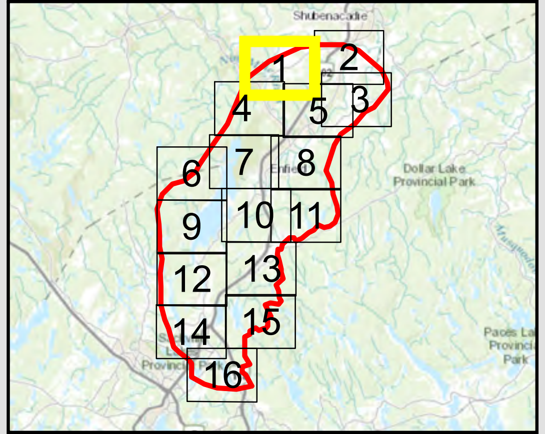
FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 1 of 16

Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
- 3 - At Risk
- 4
- 5
- 6 - Under Stress
- Open water
- Study Area



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Units: Meter

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Reviewed By: LP

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Document Name: Fig5

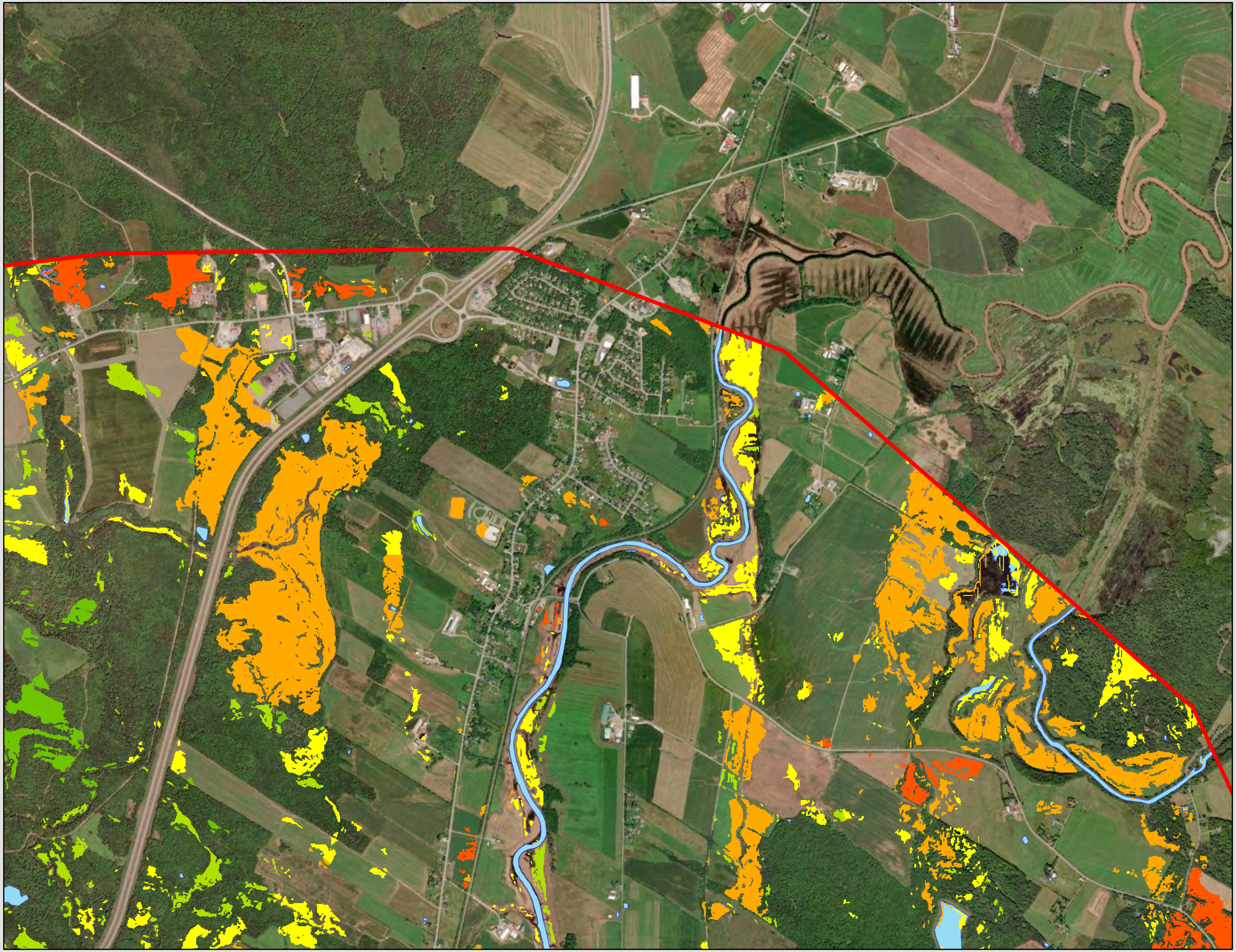

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 2 of 16

Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
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- Open water
- Study Area

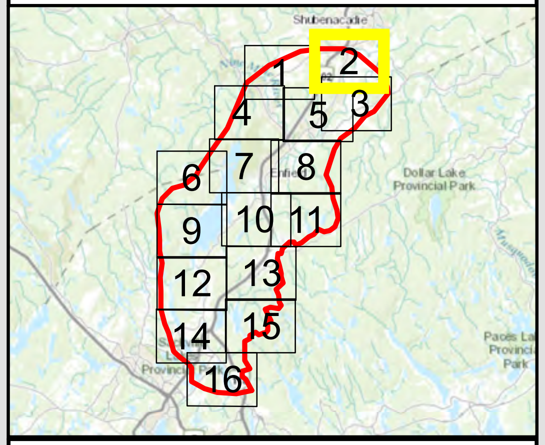

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 3 of 16

Predicted Wetland Stressors

- 0 - Good Condition
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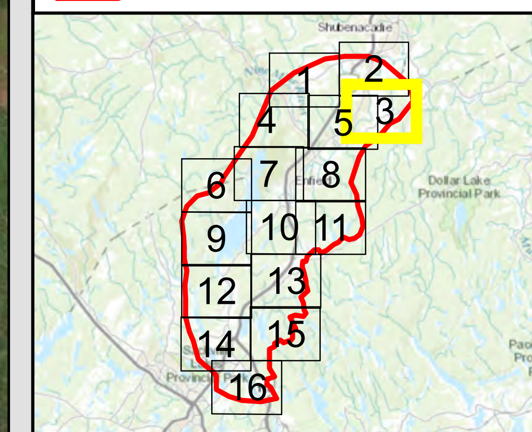

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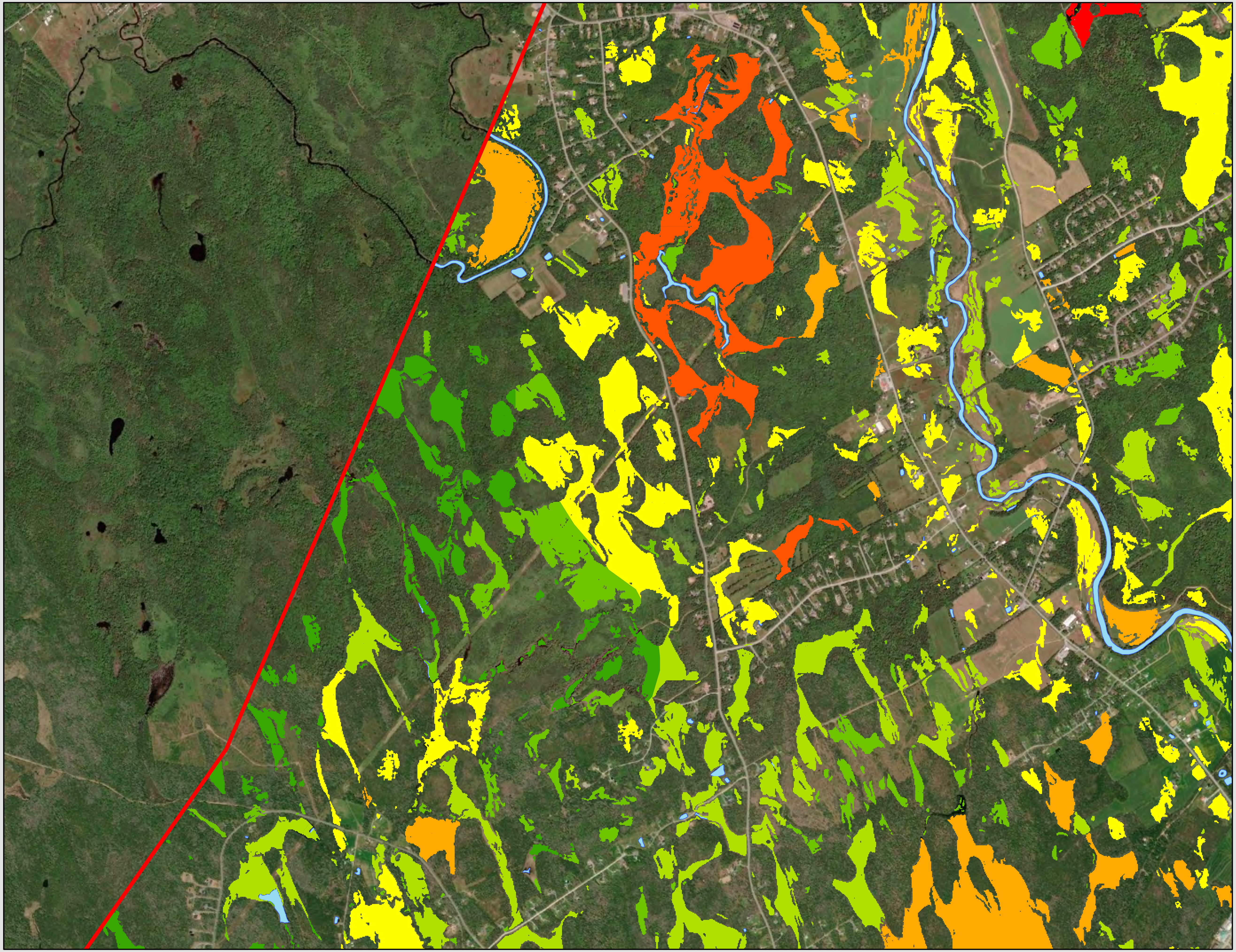

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 4 of 16

Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
- 3 - At Risk
- 4
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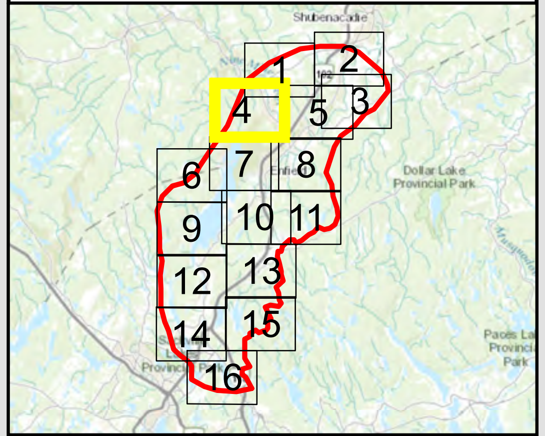
- Open water
- Study Area



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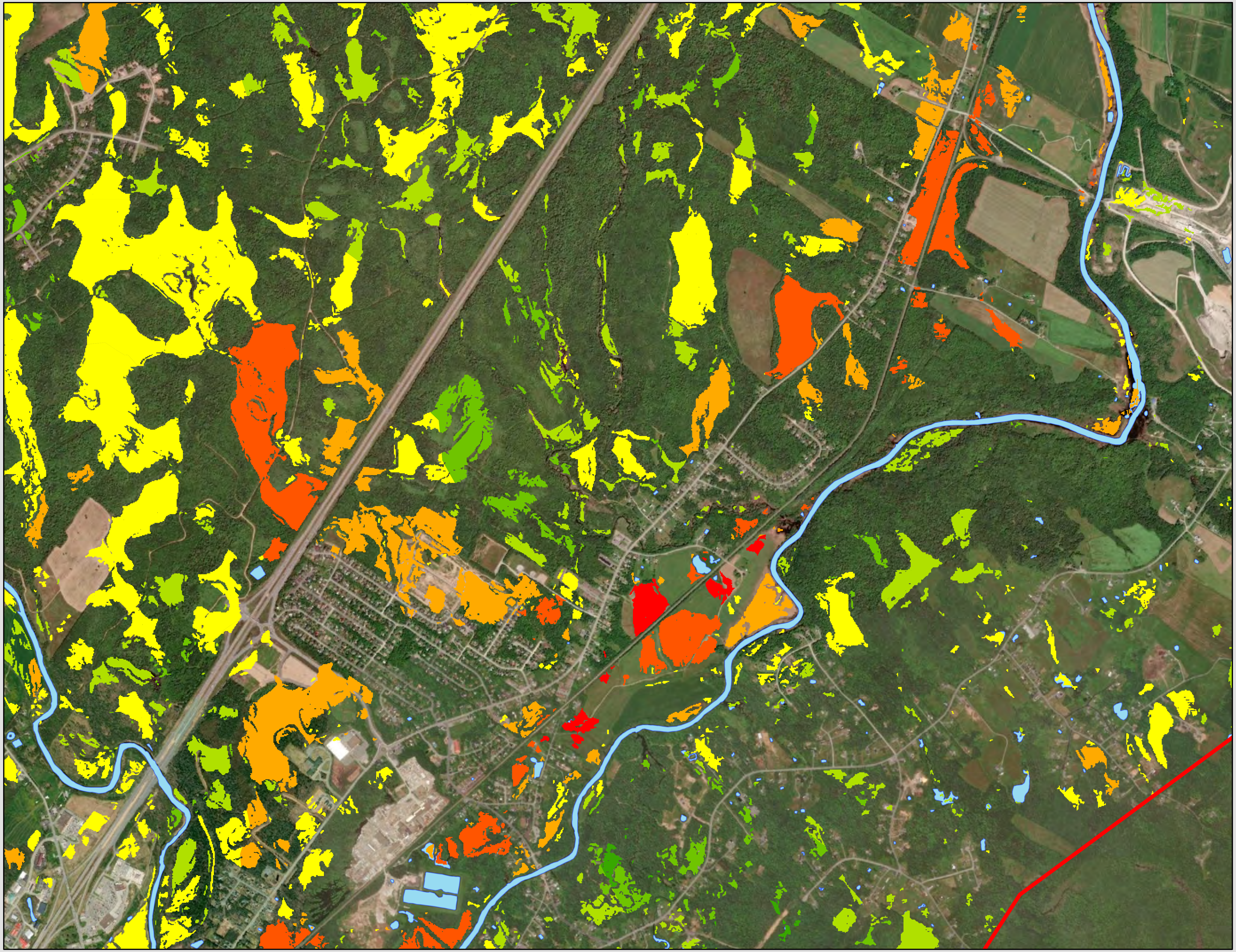

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 5 of 16

Predicted Wetland Stressors

- 0 - Good Condition
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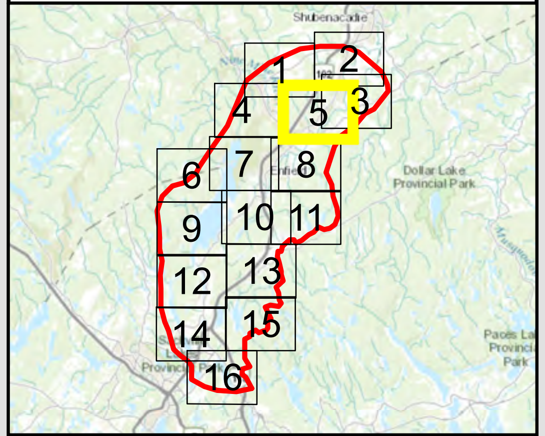
- Study Area



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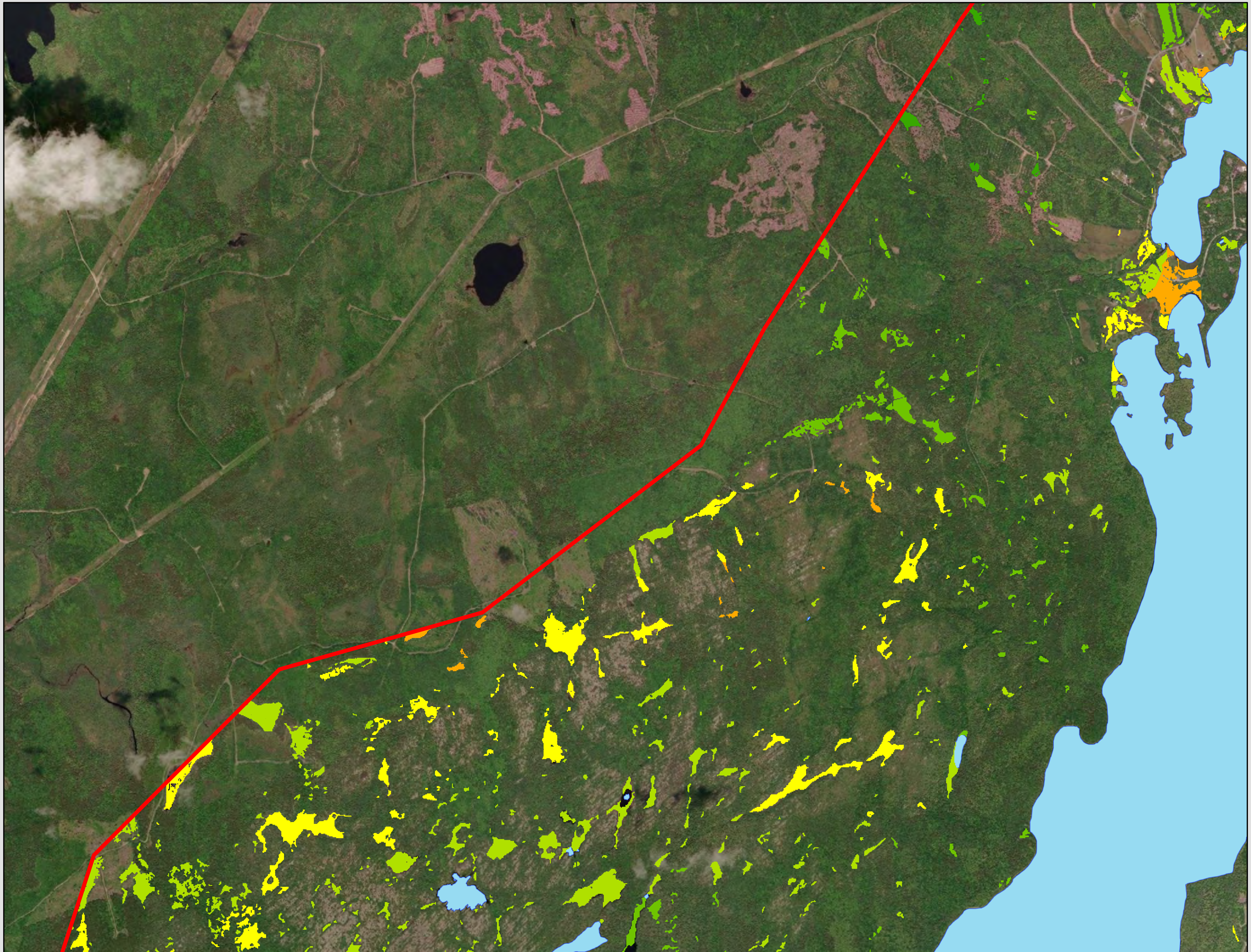

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 6 of 16

Predicted Wetland Stressors

- 0 - Good Condition
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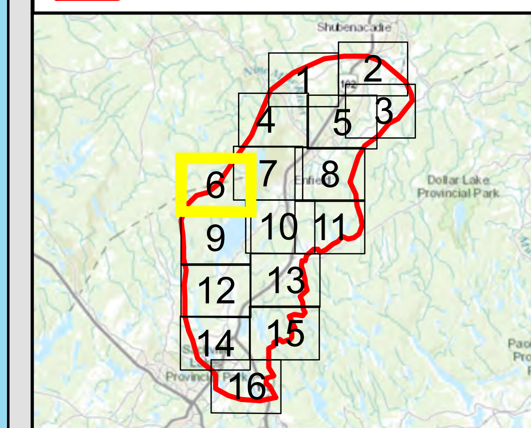

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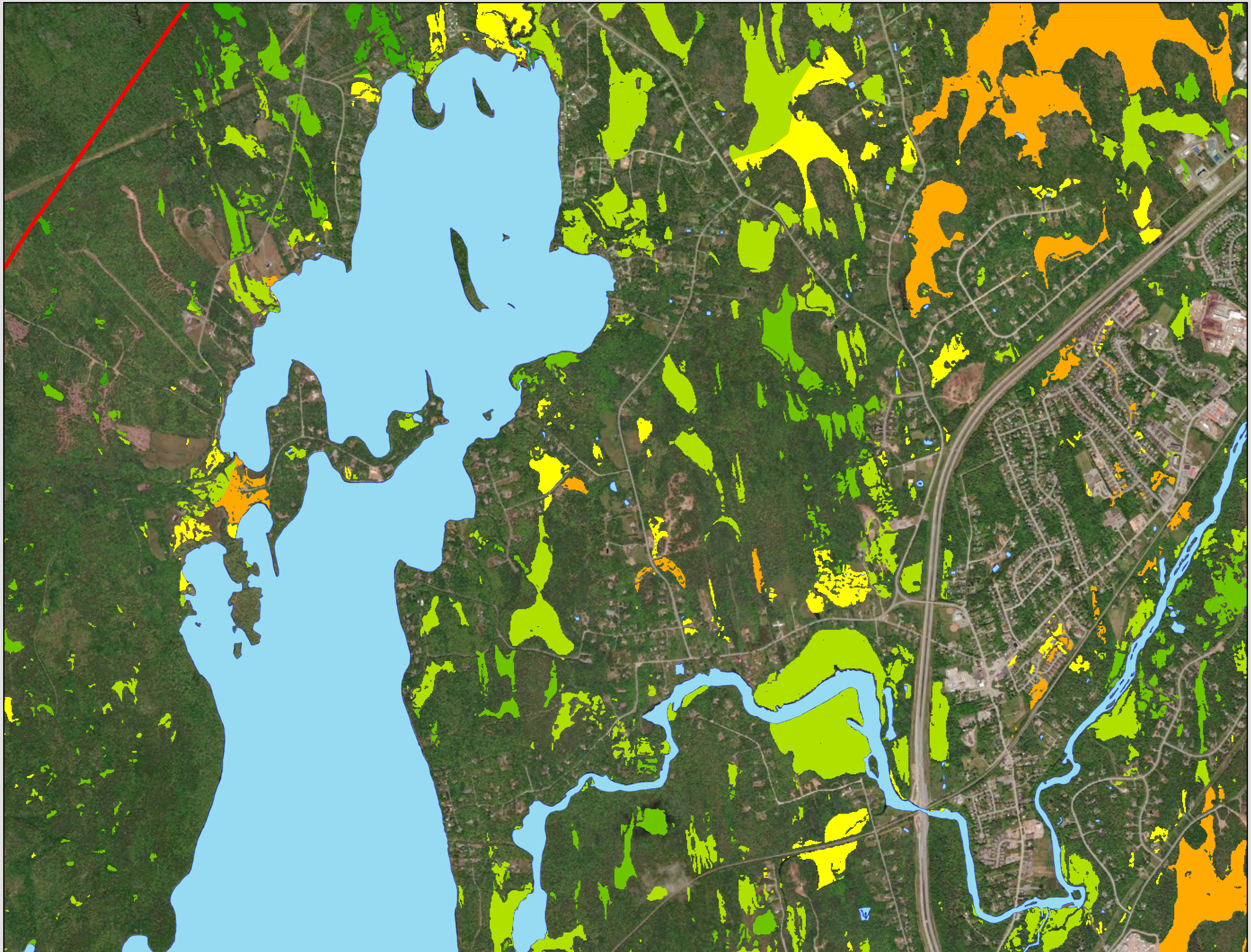

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 7 of 16

Predicted Wetland Stressors

- 0 - Good Condition
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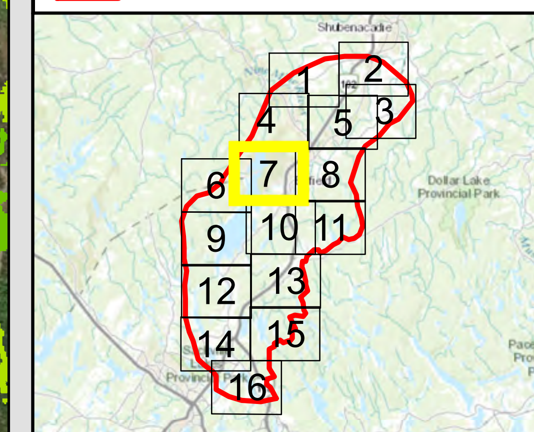

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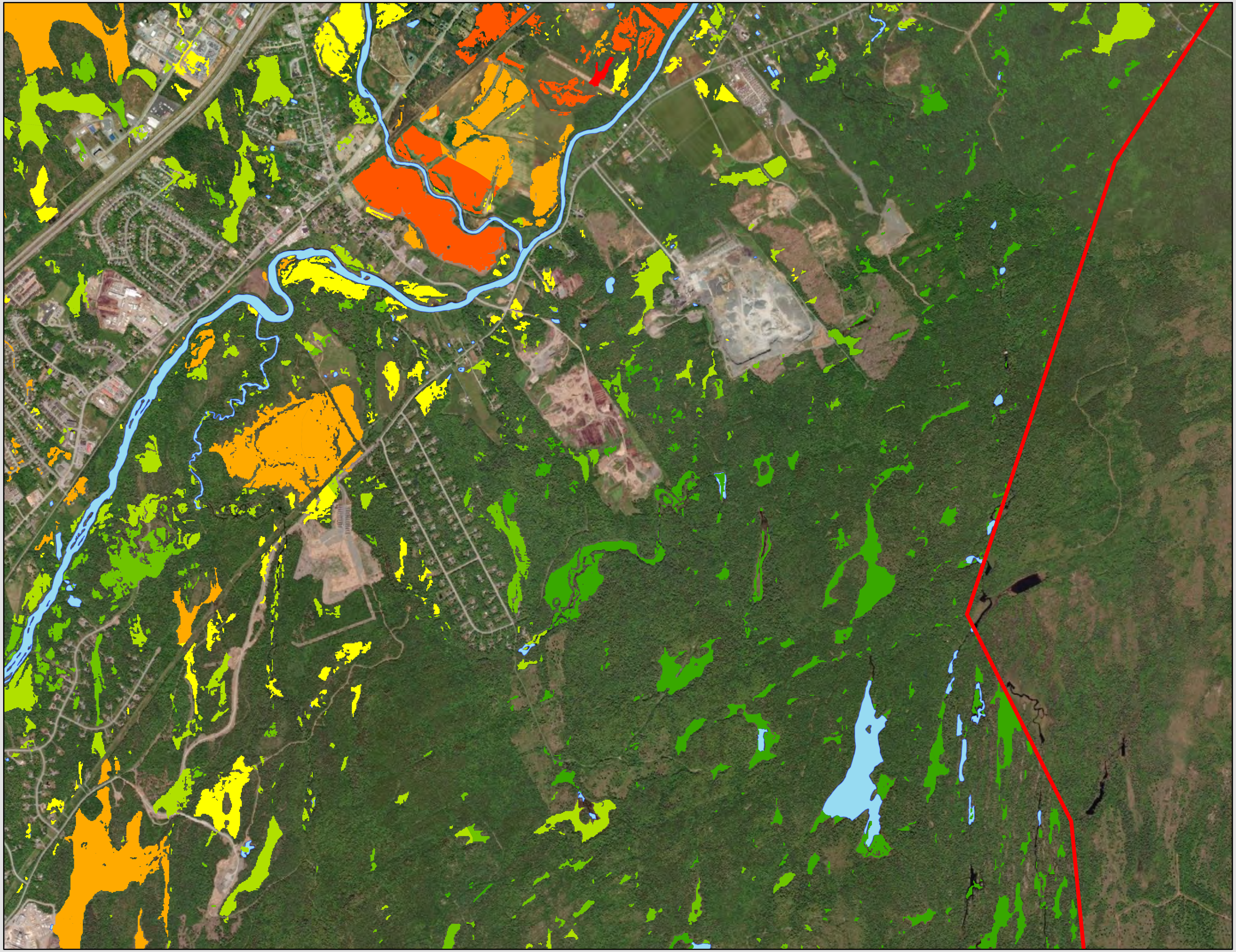

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FIGURE 5

Predictive Wetland Vulnerability Model Output

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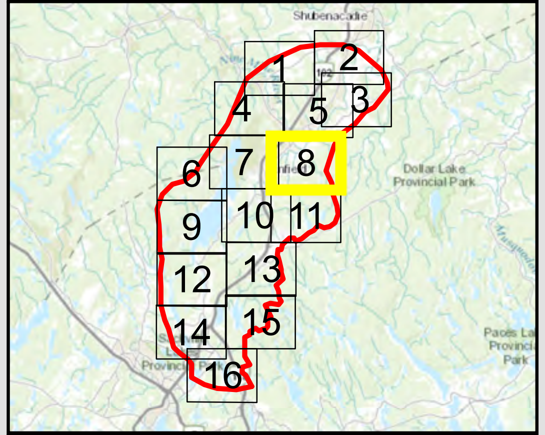

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FIGURE 5

Predictive Wetland Vulnerability Model Output

Page 9 of 16

Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
- 3 - At Risk
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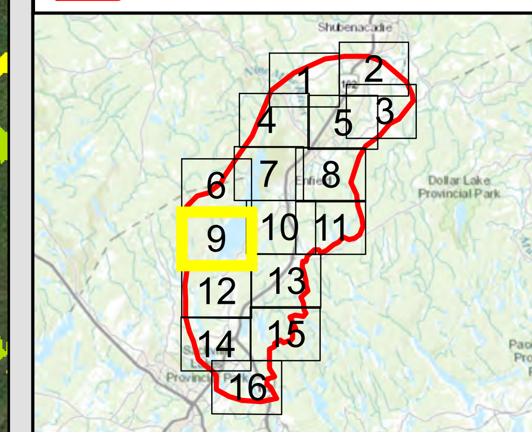
- 5
- 6 - Under Stress
- Open water
- Study Area



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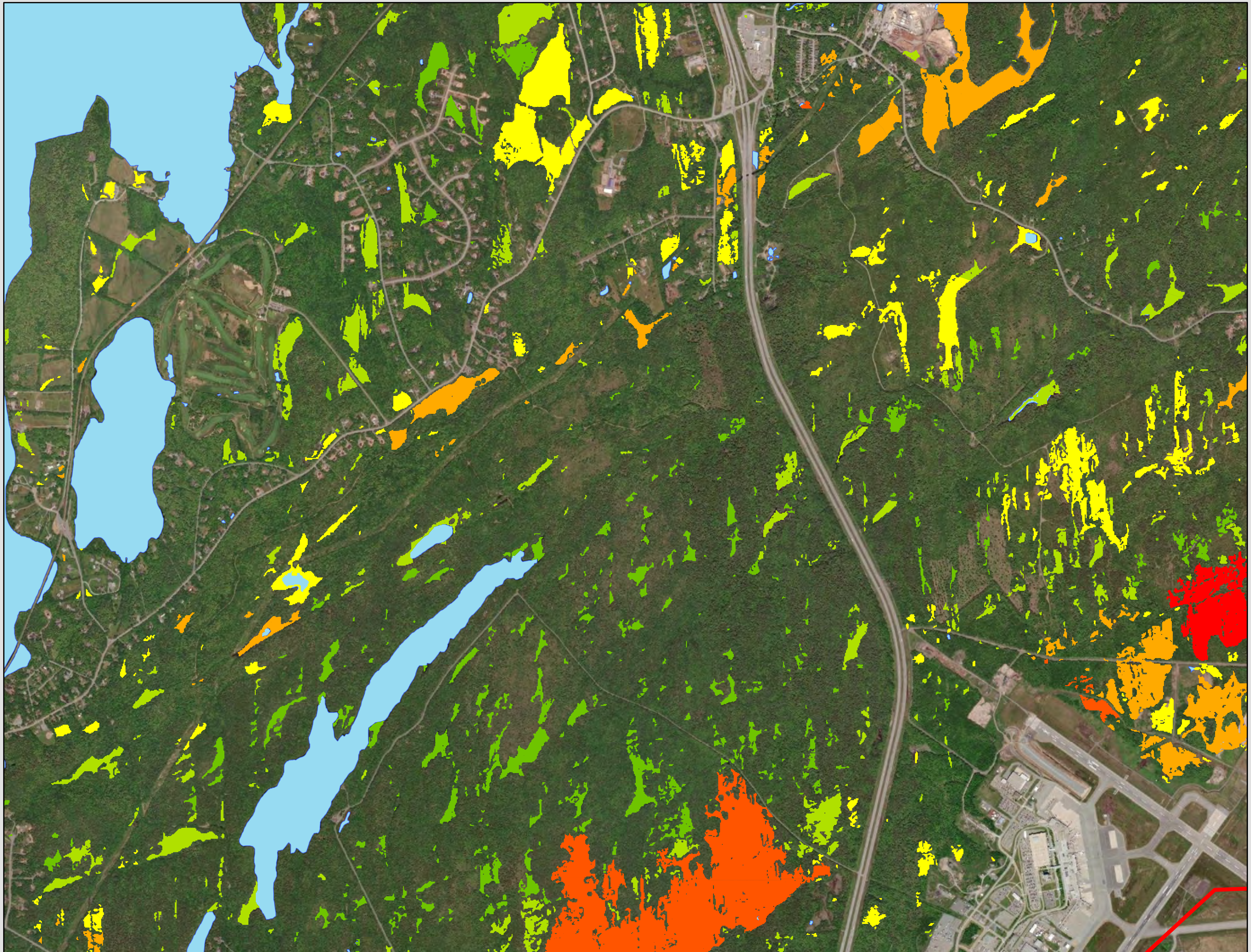

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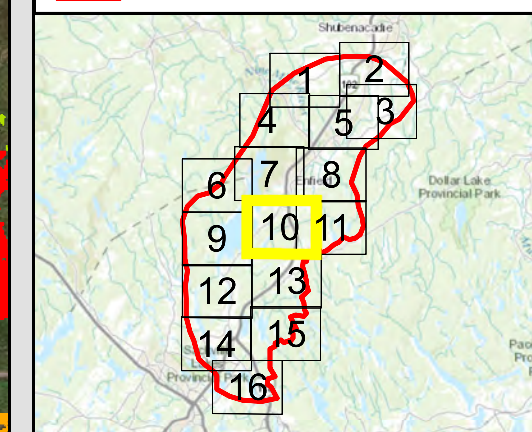
FIGURE 5

Predictive Wetland Vulnerability Model Output

Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
- 3 - At Risk
- 4
- 5
- 6 - Under Stress
- Open water
- Study Area



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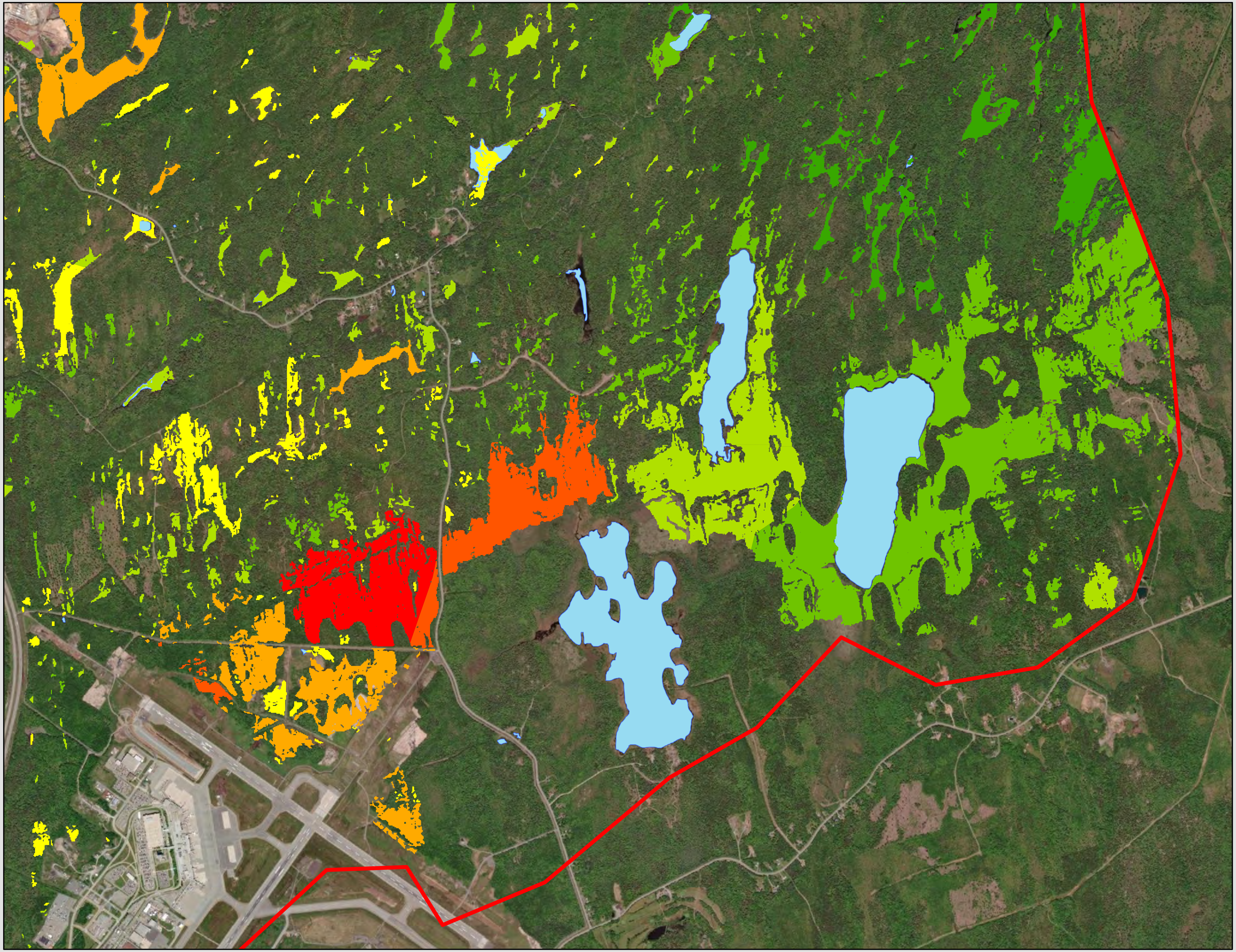

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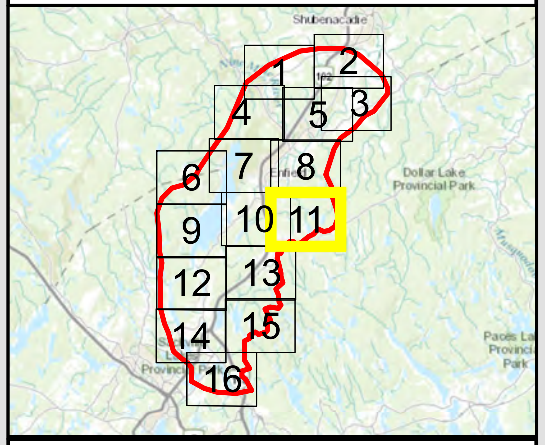

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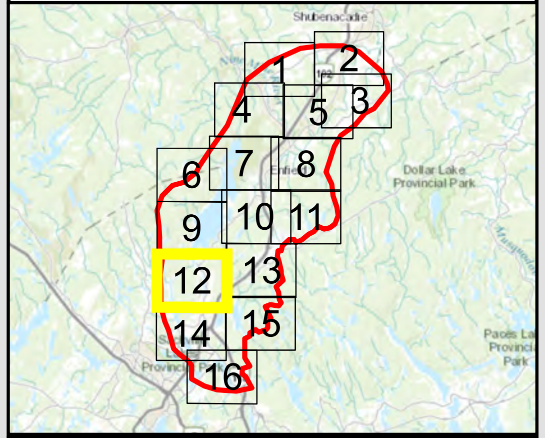

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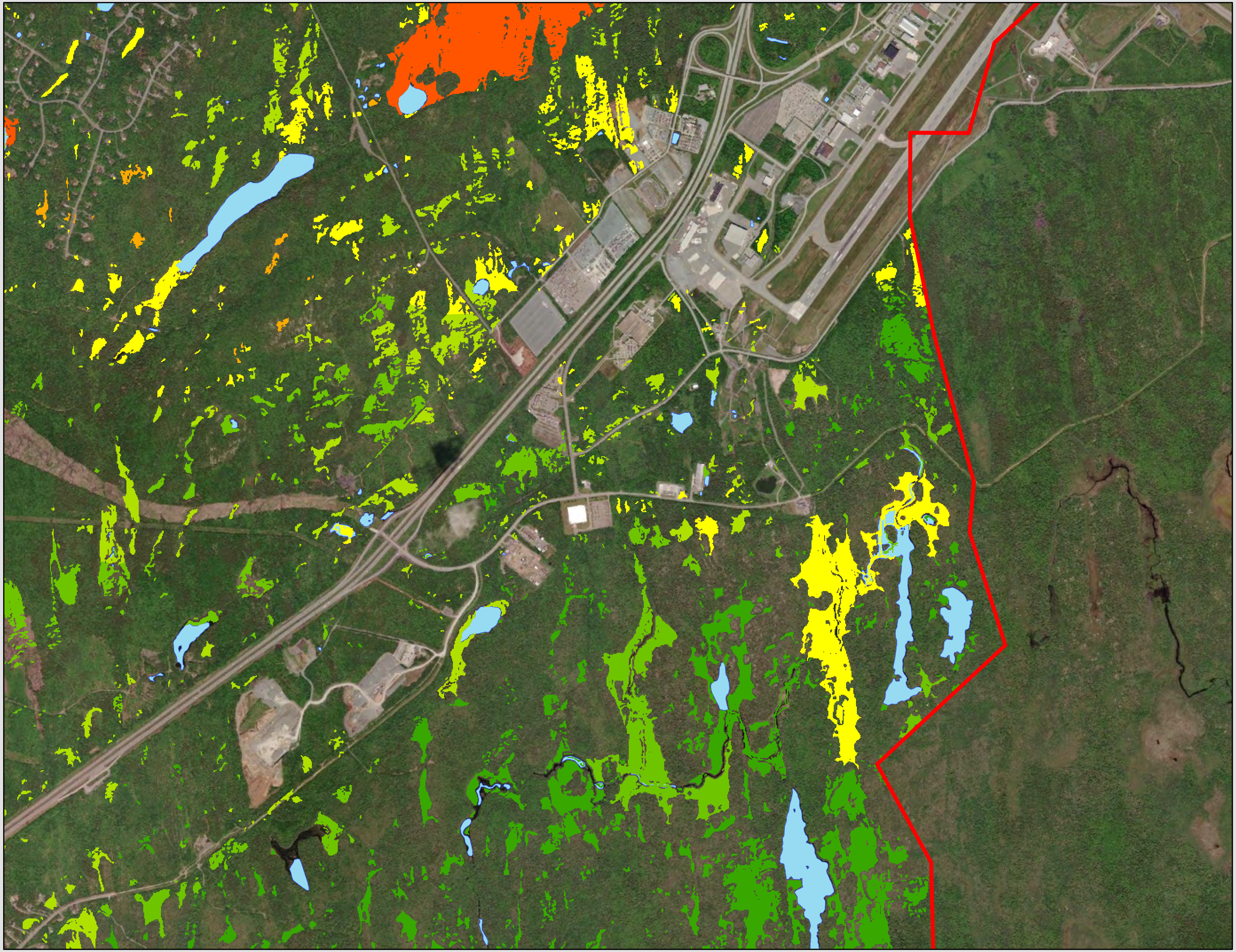

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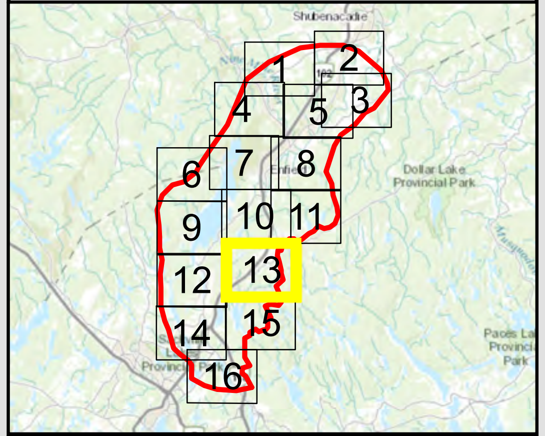

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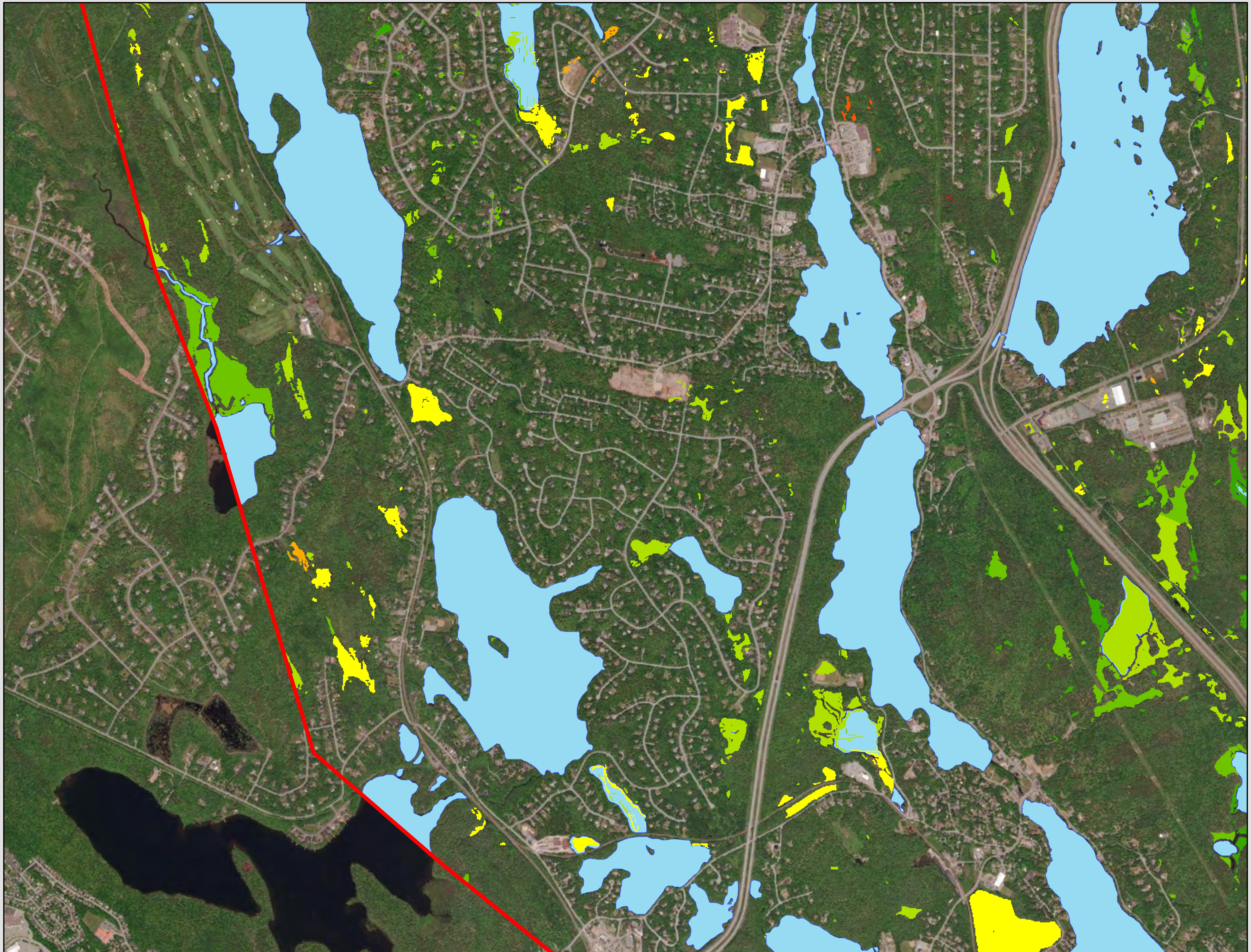

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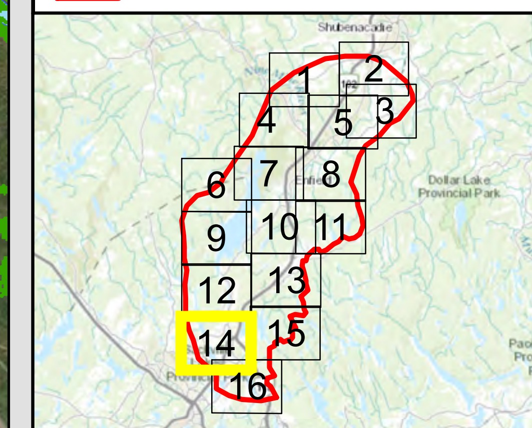

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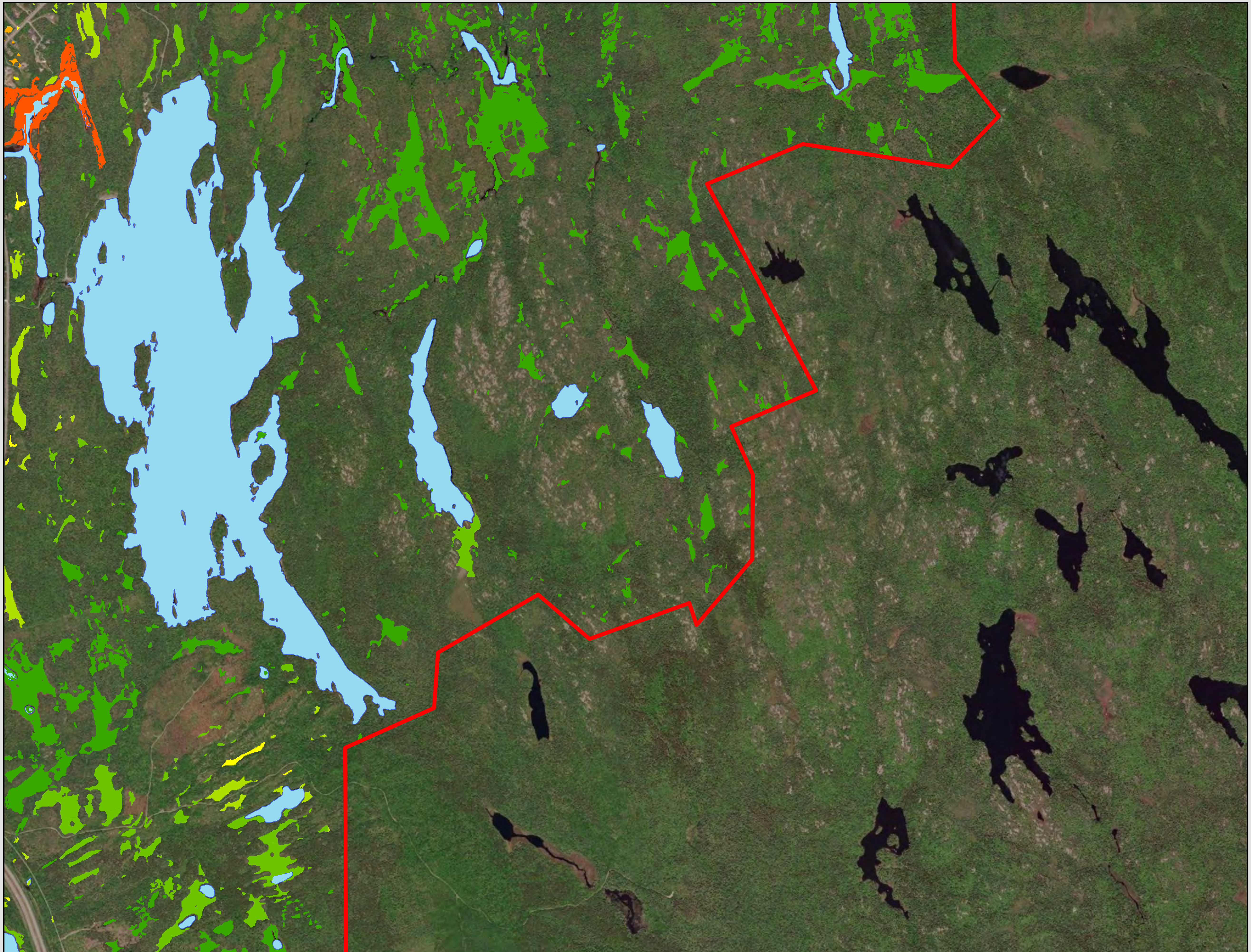

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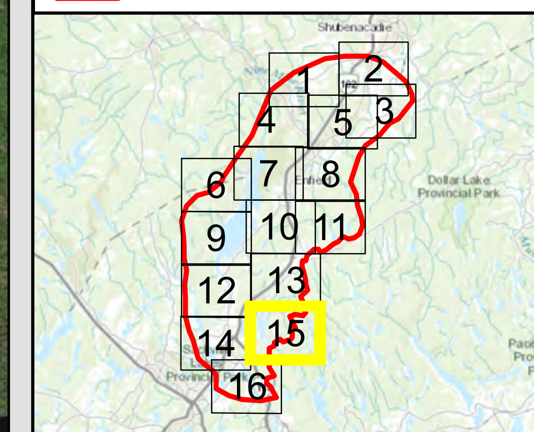

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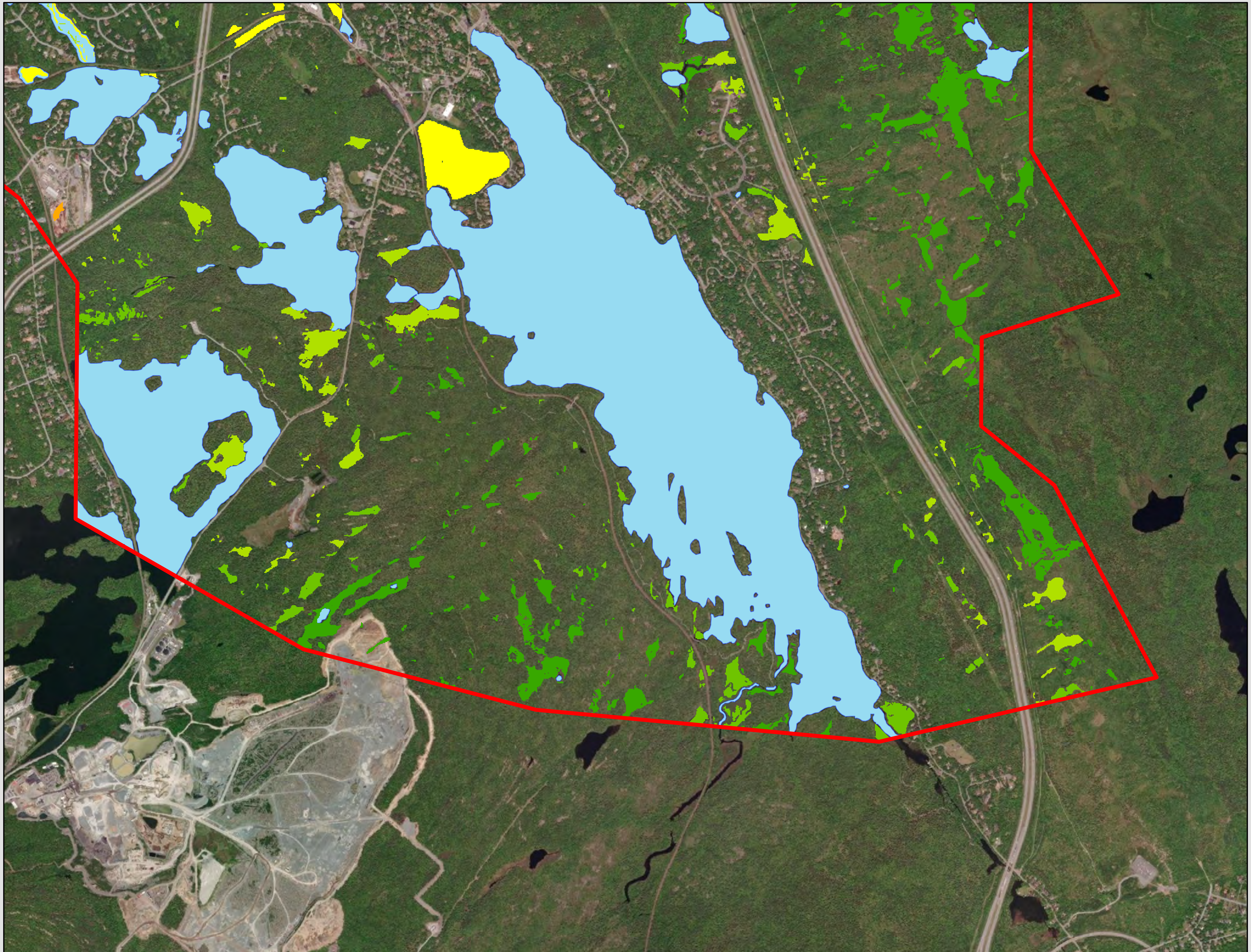

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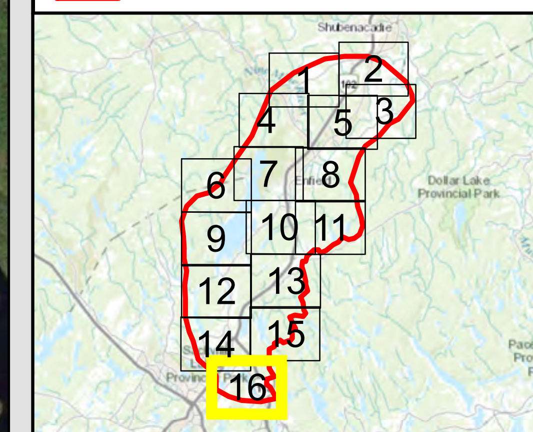

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5.2 Field Assessment

Between September and November 2023, a total of 100 wetlands were field assessed within the Study Area by MEL biologists to verify and calibrate the model. Field assessments ranged from Lake William to Milford Station and are represented in Figure 6 by the blue points within the Study Area.

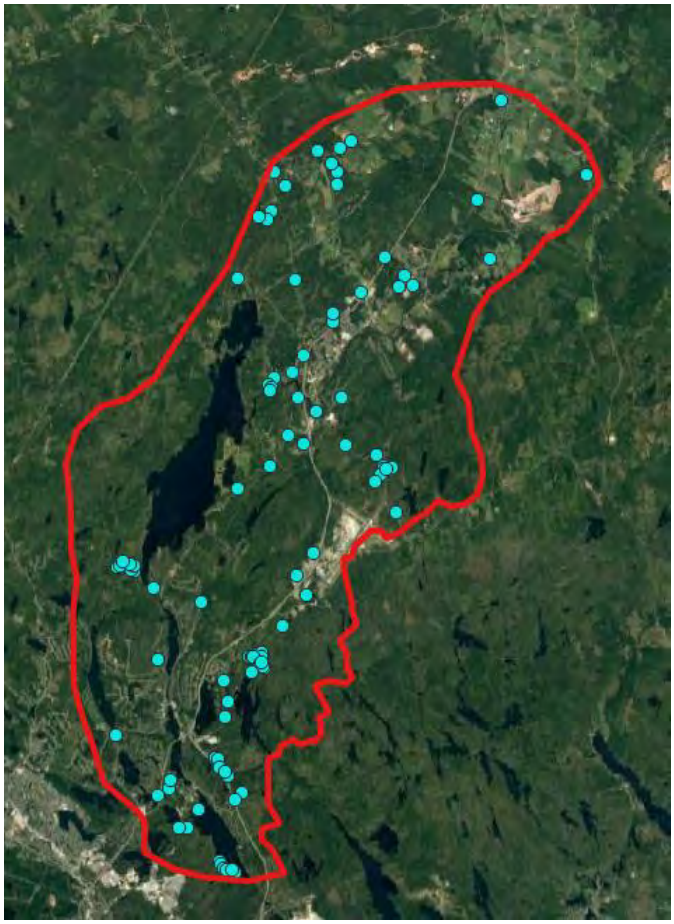

Figure 6 Field assessment locations

Table 8 provides representative photos of the different wetland classifications that were assessed within the Study Area, along with the number of occurrences.

Table 8 - Representative Wetland Photos

Wetland Classification	Occurrences	Photo
Swamp	49	
Complex	24	

Wetland Classification	Occurrences	Photo
Fen	16	
Marsh	8	

Wetland Classification	Occurrences	Photo
Bog	2	
Shallow Open Water	1	

During the field assessment, true wetland boundary points were recorded at each wetland to verify and calibrate the NSECC Predictive Wetland Layer, which was used as the base wetland layer in the Study. Throughout field assessments, the following observations were made regarding the performance of the predictive wetland modelling from NSECC:

- It performed well at predicting small, isolated wetlands, and treed swamps. Both of which are currently recognized struggles with the current NSECC mapped wetland inventory layer.
- At times, it struggled with riparian areas and distinguishing between waterbodies and wetlands. Inaccuracies were noted with shallow open water wetlands and fens, where the layer was consistently underpredicting wetland size, often fragmenting it into multiple different "wetlands"

when it was clear through aerial imagery review that the entire area was a singular wetland. An example of this is shown in Figure 6.

- Narrow connections of wetlands were often not predicted by the layer. In many cases, it was noted that the layer was predicting two wetlands near each other, however, in the field it was observed that the two wetlands were connected, and the modelling wasn't predicting narrow connections of wetland habitat.
- It struggled with predicting wetlands within agricultural areas. In many cases, the layer was predicting significant wetland habitat on cleared agricultural fields.
- On rare occasions, the model failed to predict a wetland. Generally, the layer predicted some level of wetland as present, but in a few cases throughout this Study a small number of wetlands were noted as being entirely unpredicted by the predictive model. These areas generally appeared to be shrubby swamps with limited canopy cover.

Figure 7 provides an example of true wetland boundary points for a well-predicted wetland boundary and a poorly predicted wetland boundary.

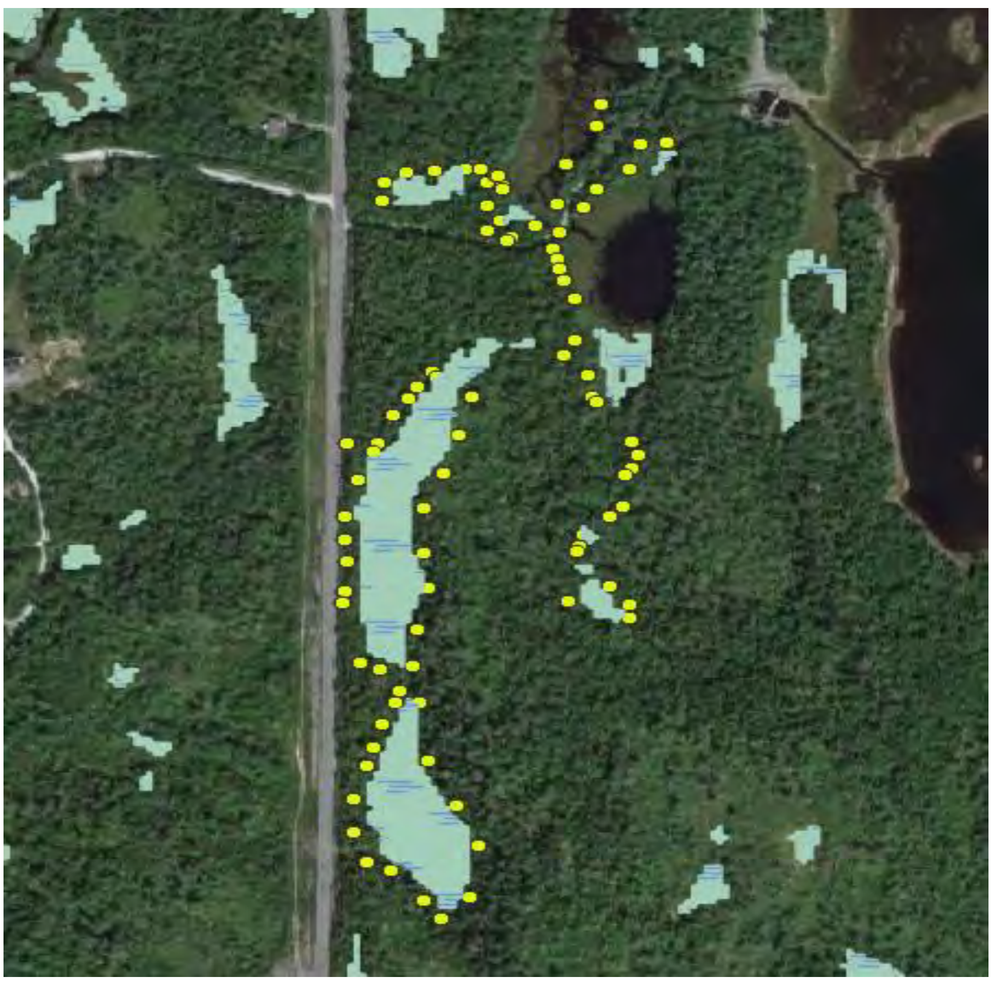

Figure 7 Examples of true wetland boundary points compared to the NSECC Predictive Wetland Layer

5.2.1 Rapid Assessment Stressor Form Results

The rapid assessment stressor form was completed for 100 wetlands within the Study Area between September and November 2023 (Appendix C). The most frequently occurring stressor category within the Study Area was hydrologic modification, with roads or trails being the most frequently observed stressor indicator. There were no clear patterns in the distribution of stressors within the Study Area, apart from there being more stressors in developed areas than undeveloped. Table 9 presents a summary of the stressors that were observed in the Study Area, number of occurrences, and the most observed stressor indicators.

Table 9 - Stressors Observed & Frequently Occurring Indicators

Stressor	Occurrences	Frequently Occurring Indicators	Photo
Hydrologic Modification	82	• Roadbed/railroad • ATV trails • Stormwater input	
Sedimentation	33	• Urban/road stormwater inputs • Dominant presence (>50%) of sediment tolerant plants	

Stressor	Occurrences	Frequently Occurring Indicators	Photo
Vegetation Stress	20	• Mowing • Dominant presence (>50%) of exotic or aggressive plant species	
None	17	• NA	
Eutrophication	16	• Dominant presence (>50%) of nutrient tolerant plants	
Contaminate Toxicity	11	• Adjacent to industrial sites or near a railroad	

Following the completion of the rapid assessment stressor form, stressor scores were calculated and categorized as negligible (0-24), low (25-49), moderate (50-74), and high (75-100). Brooks et al. (2004) influenced the development of the score categories used in this Study as this study considered a score of

0 to be ecologically intact, 66 to be moderately degraded, and 100 to be severely degraded. Table 10 shows the number of wetlands that fall within each category.

Table 10 - Stressor Scoring Results

Score Category	# of Wetlands
Negligible	39
Low	35
Moderate	18
High	8

Most of the wetlands assessed (74%) received negligible and low scores, whereas 26% had moderate and high scores. Generally, wetlands ranked as highly stressed are present in urban areas, and in agricultural areas, particularly in the northeastern portion of the Study Area, which is an expectation from stakeholder engagement sessions given the identification of numerous areas of interest, largely related to development stressors. Wetlands present in undeveloped areas, such as west of Grand Lake, Soldier Lake and the area east of Oldham typically rank as negligible level of stress, which was expected given the general undisturbed nature of the wetlands and large undisturbed buffers. Figure 8 shows the distribution of negligible (green), low (yellow), moderate (orange), and high (red) scores within the Study Area.

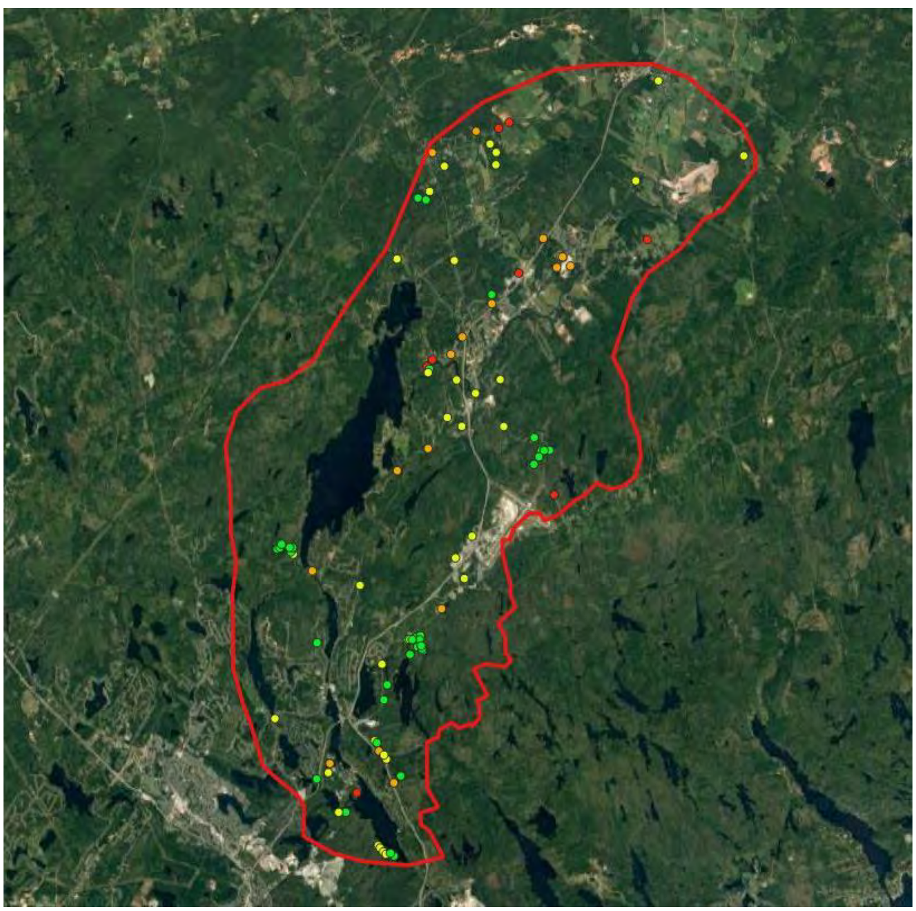

Figure 8 Distribution of wetland scores within the Study Area

Wetlands in developed areas scored higher than those in undeveloped areas. Three clusters of negligible-scoring wetlands are present in three areas of Crown Land. Wetlands in these areas were not expected to experience high levels of stress, or inadequate wetland buffers, however, they were an essential part of the Study to compare and examine how the modelling in the Study predicted wetland vulnerabilities for wetlands in natural areas with less threats compared to those in highly developed areas. The northern portion of the Study Area has a higher frequency of moderate and high scoring wetlands, which was expected due to agriculture and housing development.

The stressor score results for each wetland are provided in Appendix C.

5.2.2 WESP-AC Results

WESP-AC Field and Stressor forms were completed for the 100 wetlands that were assessed between September and November 2023. Following the calculation of the rapid assessment stressor scores, the Office form was completed for the 8 wetlands (17, 18, 43, 61, 64, 65, 70, and 98) that received a high score (75-100) to further assess the function and benefits of the highest-stressed wetlands. The WESP-AC results for those 8 wetlands are provided in Table 11.

Table 11 - WESP-AC Function-Benefit Product Score Categories

FBP Score Category								
Function-Benefit Product (FBP)	**WL17**	**WL18**	**WL43**	**WL61**	**WL64**	**WL65**	**WL70**	**WL98**
Hydrologic	Low	Low	Low	High	Low	Low	Low	High
Water Quality Support	Low	Low	Low	Low	Low	Low	Low	Low
Aquatic Support	Low	Low	Low	Low	Low	Low	Low	Low
Aquatic Habitat	High	High	Low	Low	Low	Low	Moderate	Low
Transition Habitat	Low	Low	Low	Low	Low	Low	Low	Low

Wetlands 17 and 18 scored high in the Aquatic Habitat group and wetland 70 received a moderate score. This group includes the following functions:

- Anadromous Fish Habitat
- Resident Fish Habitat
- Amphibian and Turtle Habitat
- Waterbird Feeding Habitat

- Waterbird Nesting Habitat

Wetlands that score high in this group include those that are adjacent to or contain flowing water. Wetlands 17 and 18 are both adjacent to the Shubenacadie River while WL 70 contained an open-water portion.

Wetlands 61 and 98 scored high in the Hydrologic group. This group evaluates the effectiveness of a wetland to store or delay the downslope movement of surface water. Wetlands that have the highest functions within this group include those that do not have surface water outlets. Wetlands 61 and 98 are both isolated from flowing surface water.

Wetlands 43, 64, and 65 scored low in all the function-benefit product groups.

5.3 Model Validation

A comparison of the stressor points, the wetland boundaries, and the vulnerability modelling output are shown on Figure 9. When comparing the model output to the field data collected, the field points tended to score higher than the GIS in points when the field 100 point scale is corrected to match the 10 point GIS scale.

Overall, the field surveys identified a higher number of wetlands ranking at the highest level of stress. One influence of such results is related to the accuracy of the NSECC predictive modelling. Six of the eight wetlands identified as highly stressed during field assessments are not predicted within the NSECC layer. Generally, these wetlands are in highly developed areas that often have an associated waterbody or watercourse feature, which is likely the reason for not being predicted given the layers struggles with waterbodies versus wetlands.

Largely, the wetland boundaries were capable of predicting wetland locations, but underpredicted the extent of the wetlands. This information and all boundary points taken will be provided to NSECC to help refine and adjust their predicted wetland layer that was the basis for this project.

The field surveys identified 8 wetlands ranking at the highest level of stress. Amongst these, only two were rated as high stress within the modelling completed. One influence of such results is related to the accuracy of the NSECC predictive modelling. Six of the eight wetlands identified as highly stressed during field assessments are not predicted within the NSECC layer, and therefore have not been accounted for within the vulnerability model. Generally, these un-predicted wetlands are in highly developed areas that often have an associated waterbody or watercourse feature, which is likely the reason for not being predicted given the layers struggles with waterbodies versus wetlands. Wetlands ranking as moderately stressed line up well amongst field versus modelled results. Upon a review of compared results, it is observed that overall, the results between field assessments and modelling line up well, rarely do field results indicate a high level of stress while model shows negligible stress or vice versa. Generally, wetlands ranked as highly stressed in both modelling and field results are present in urban areas, and in agricultural areas, particularly in the northeastern portion of the Study Area, which is an expectation from stakeholder engagement sessions. Wetlands present in undeveloped areas, such as west of Grand Lake, Soldier Lake and the area east of Oldham typically rank as negligible stress, which is in line with field assessments.

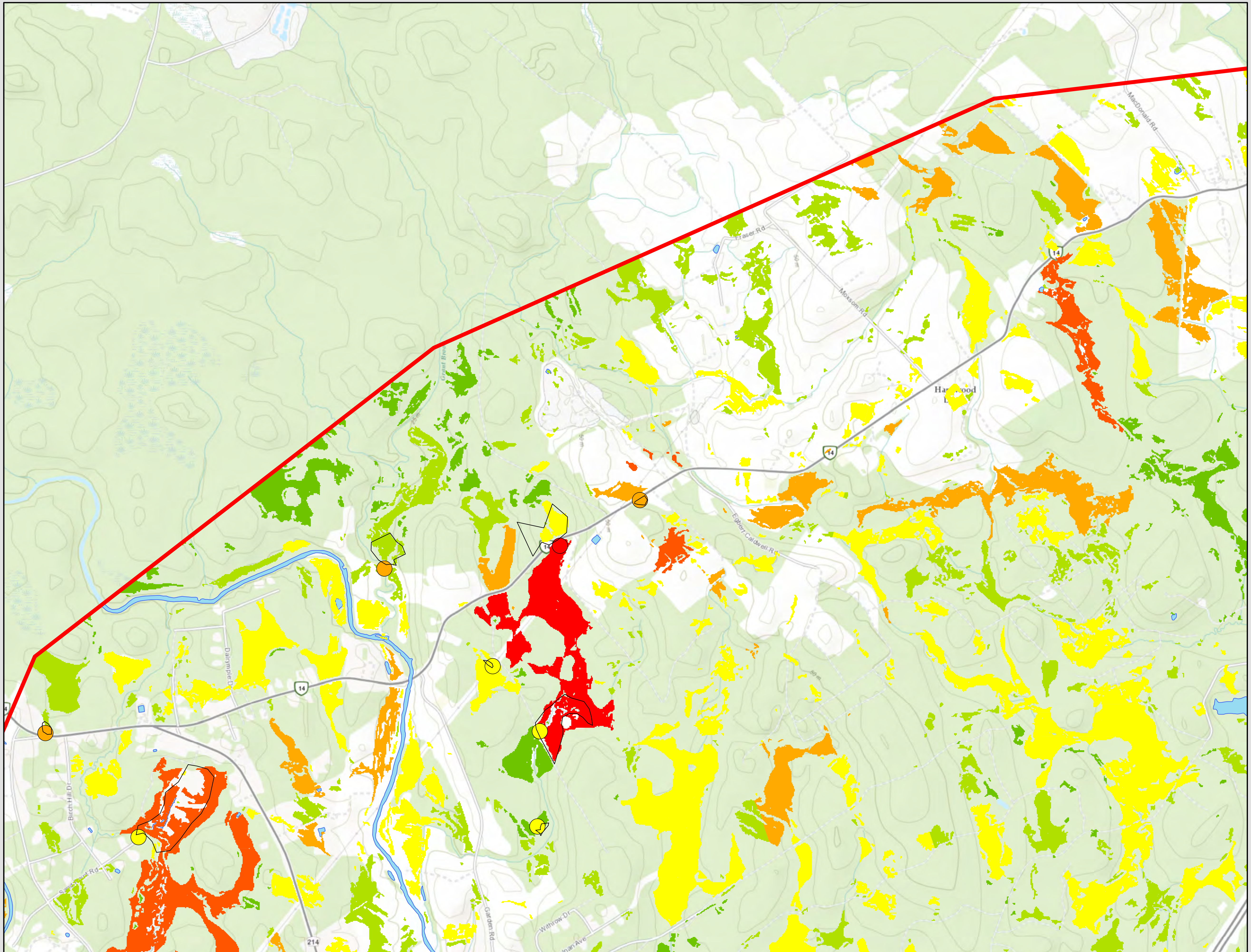

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FIGURE 9

Comparison of Field and Modelling Results

Page 1 of 16

Predicted Wetland Stressors

- 0 - Good Condition
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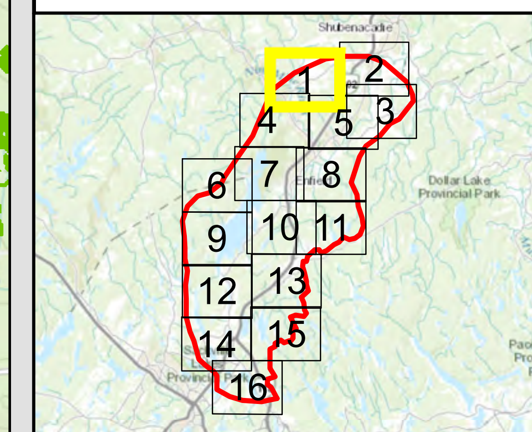
Field Stressor Scores

- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- Field Delineated Wetland Boundary
- Open water
- Study Area



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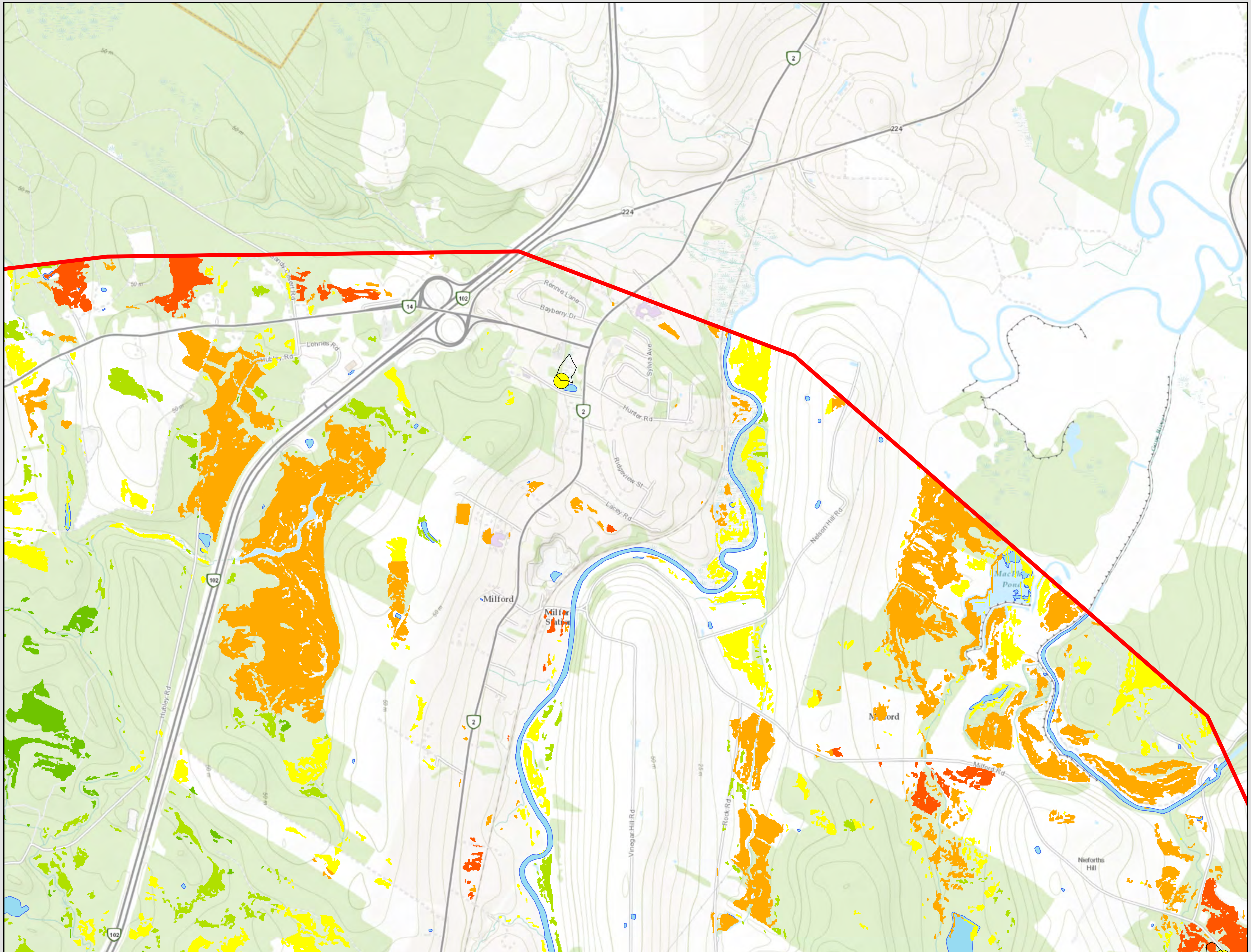

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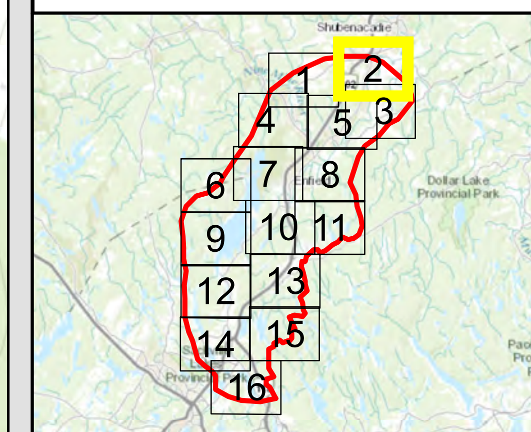

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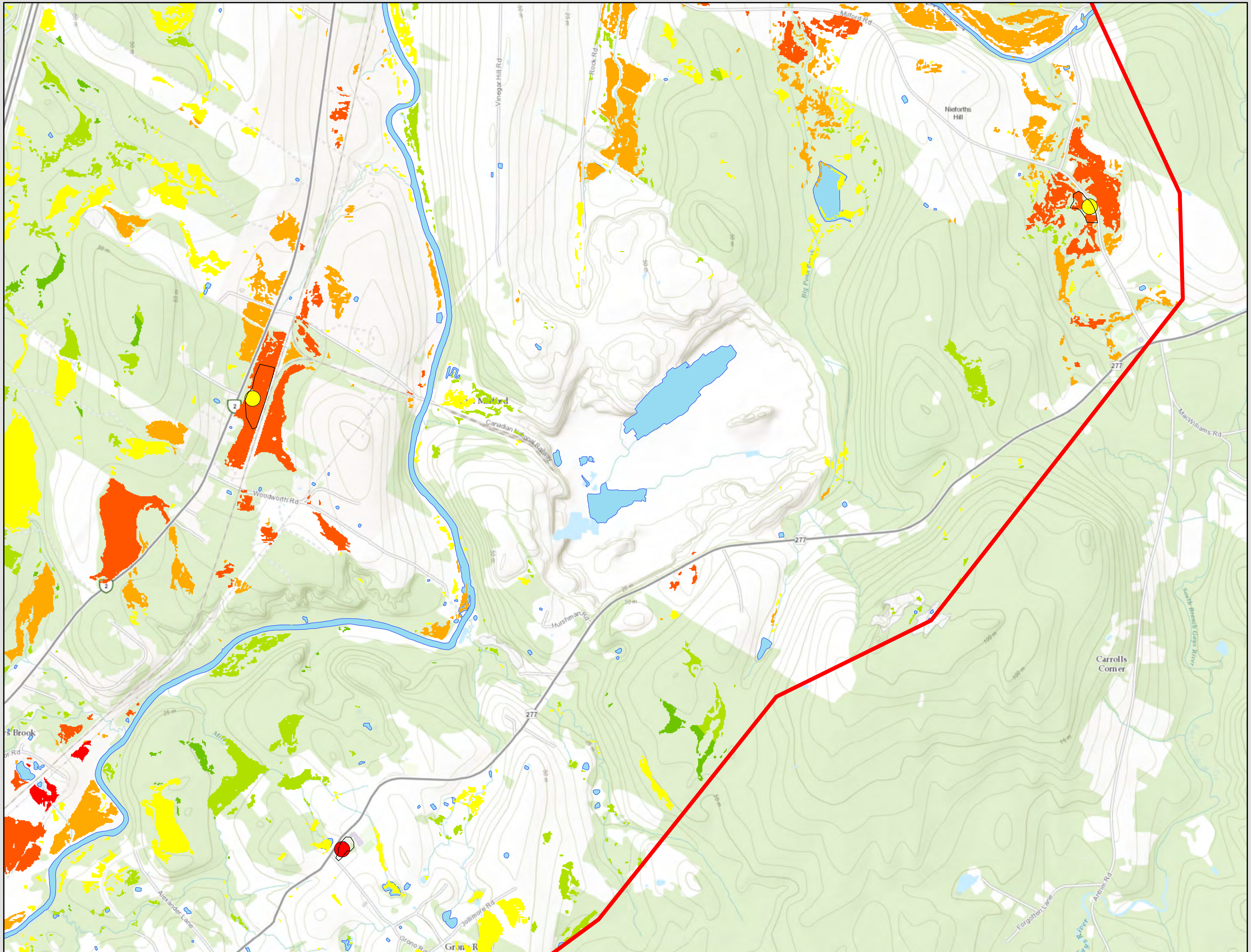

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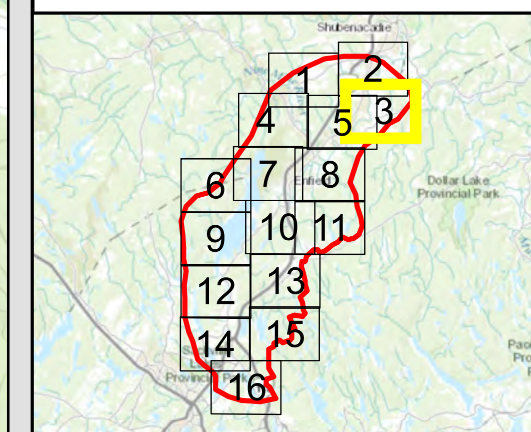

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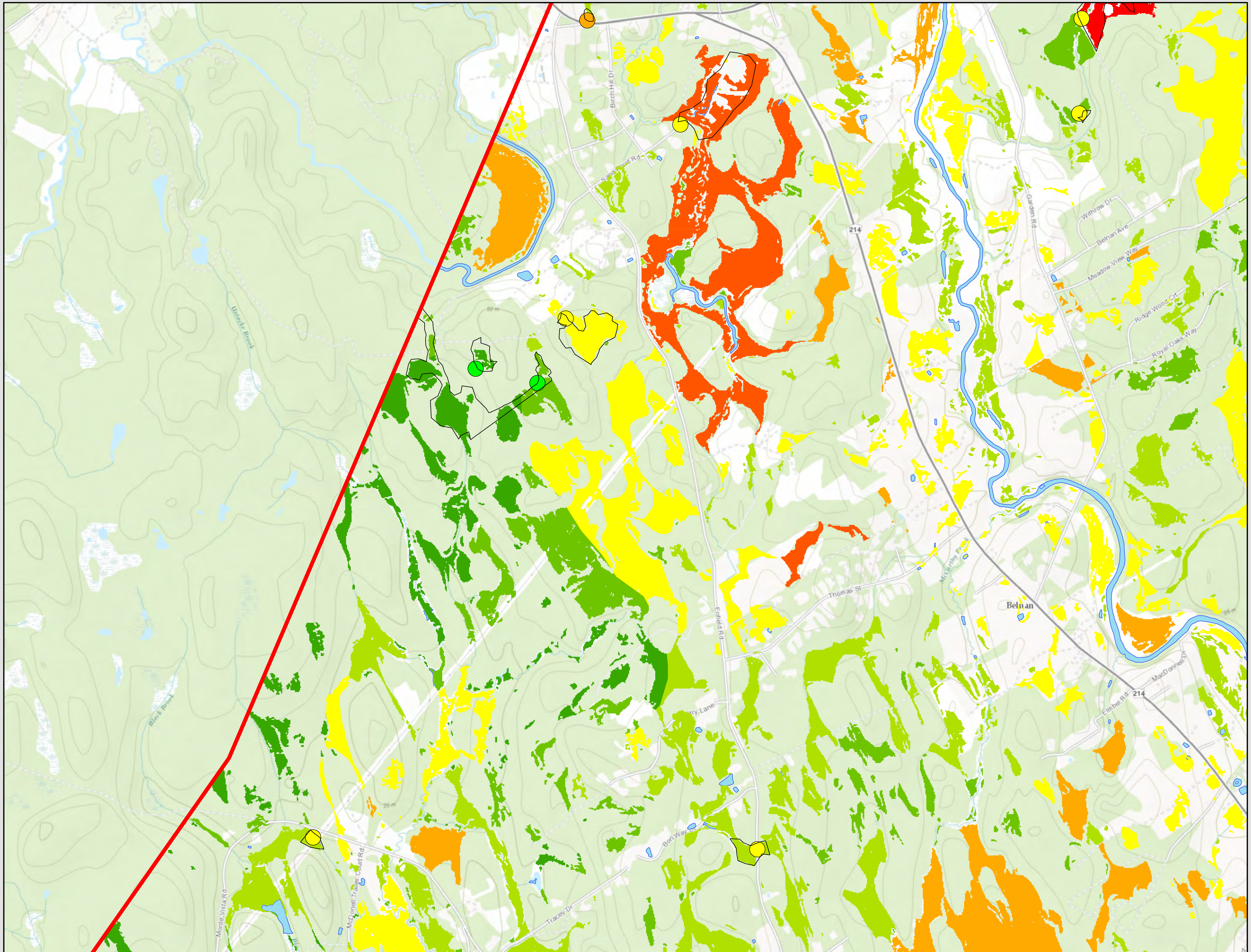

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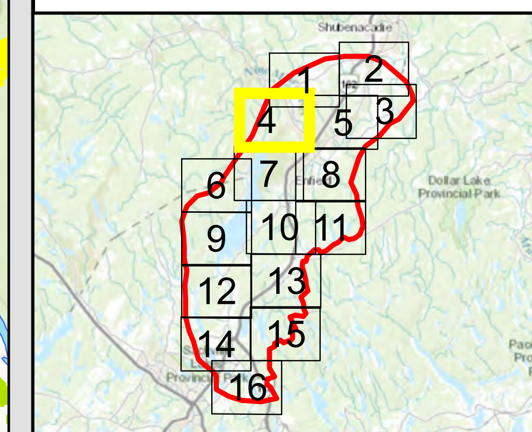

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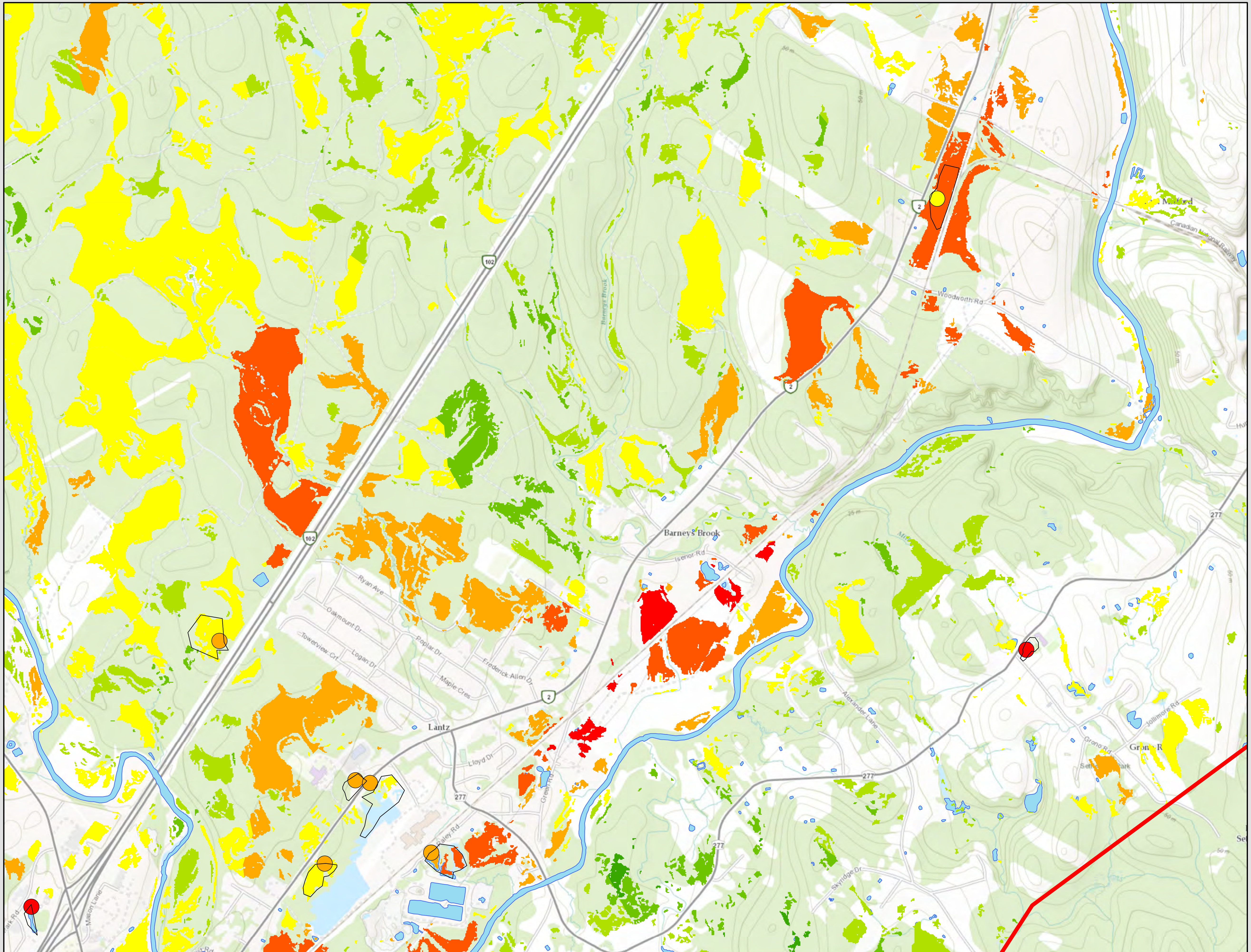

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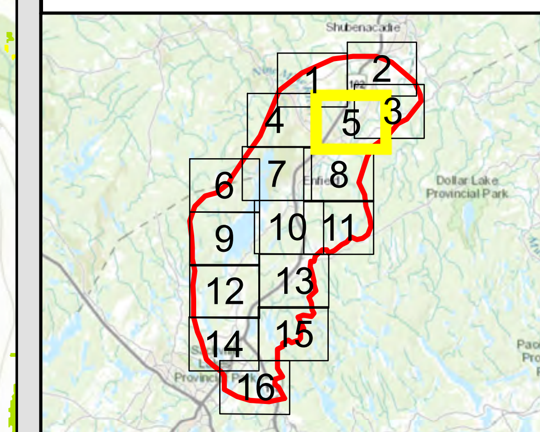

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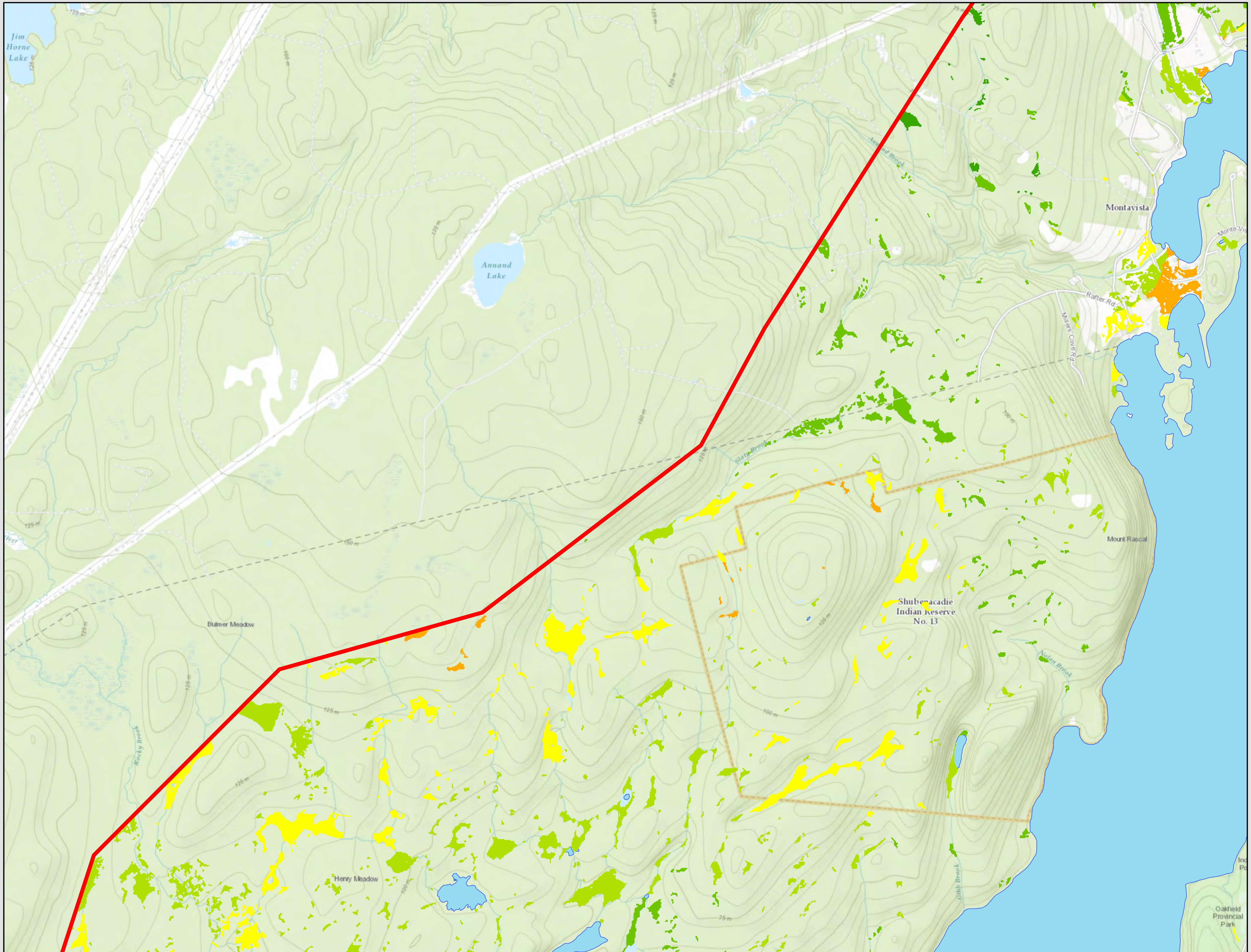

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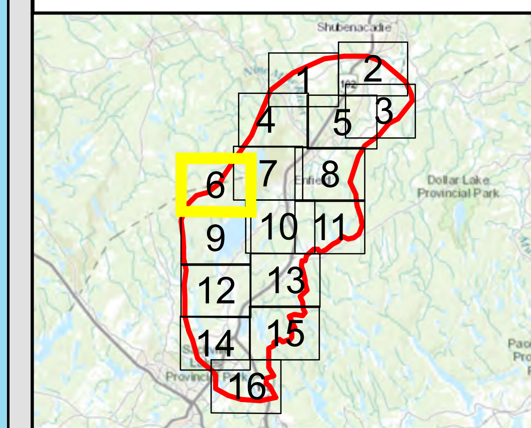
- 0 - 25
- 26 - 50
- 51 - 75
- 76 - 100
- Field Delineated Wetland Boundary
- Open water
- Study Area



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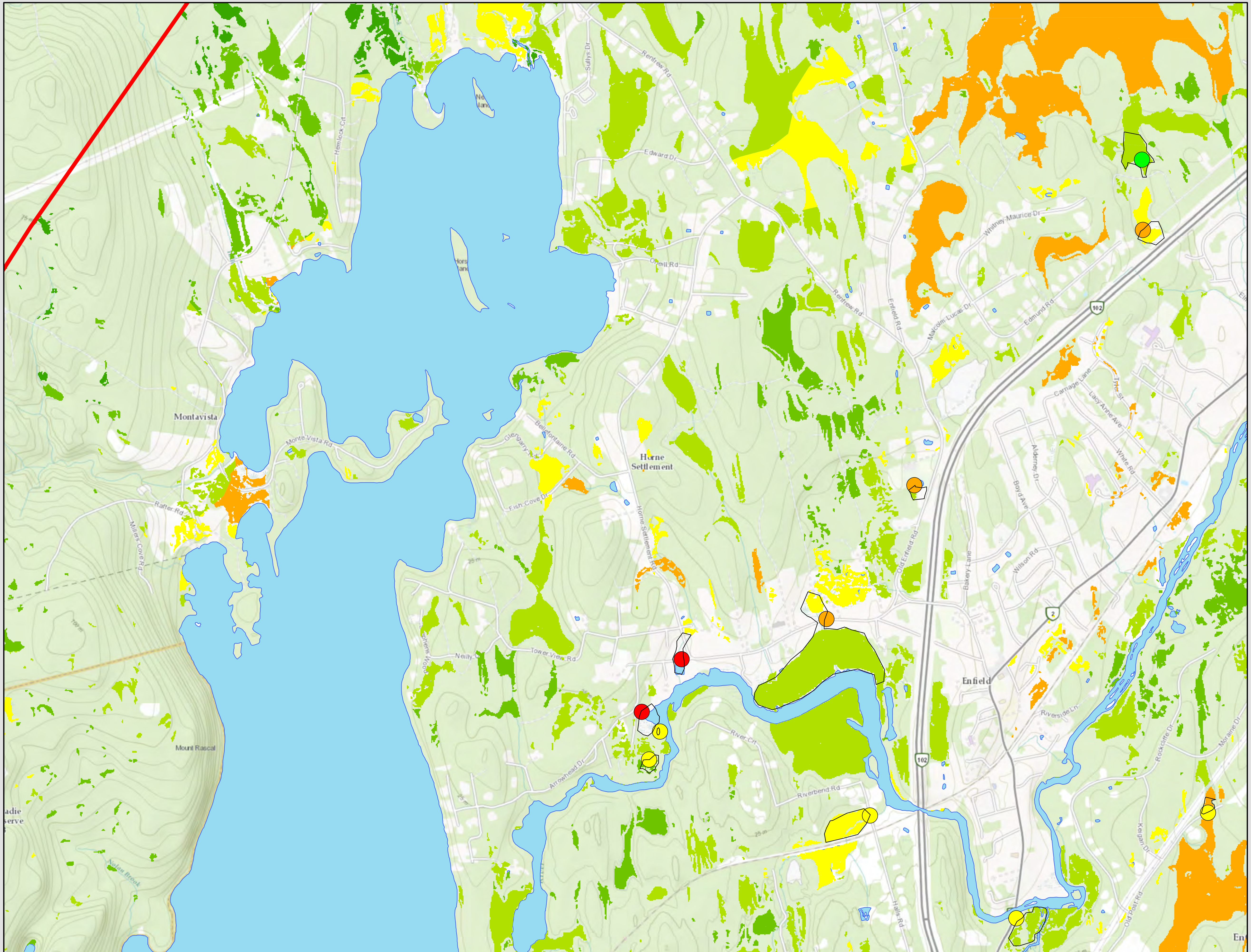

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Wetland Vulnerability Study

FIGURE 9

Comparison of Field and Modelling Results

Page 7 of 16

Predicted Wetland Stressors

- 0 - Good Condition
- 1
- 2
- 3 - At Risk
- 4
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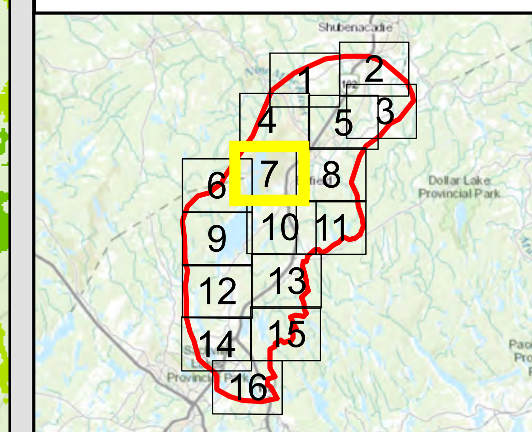

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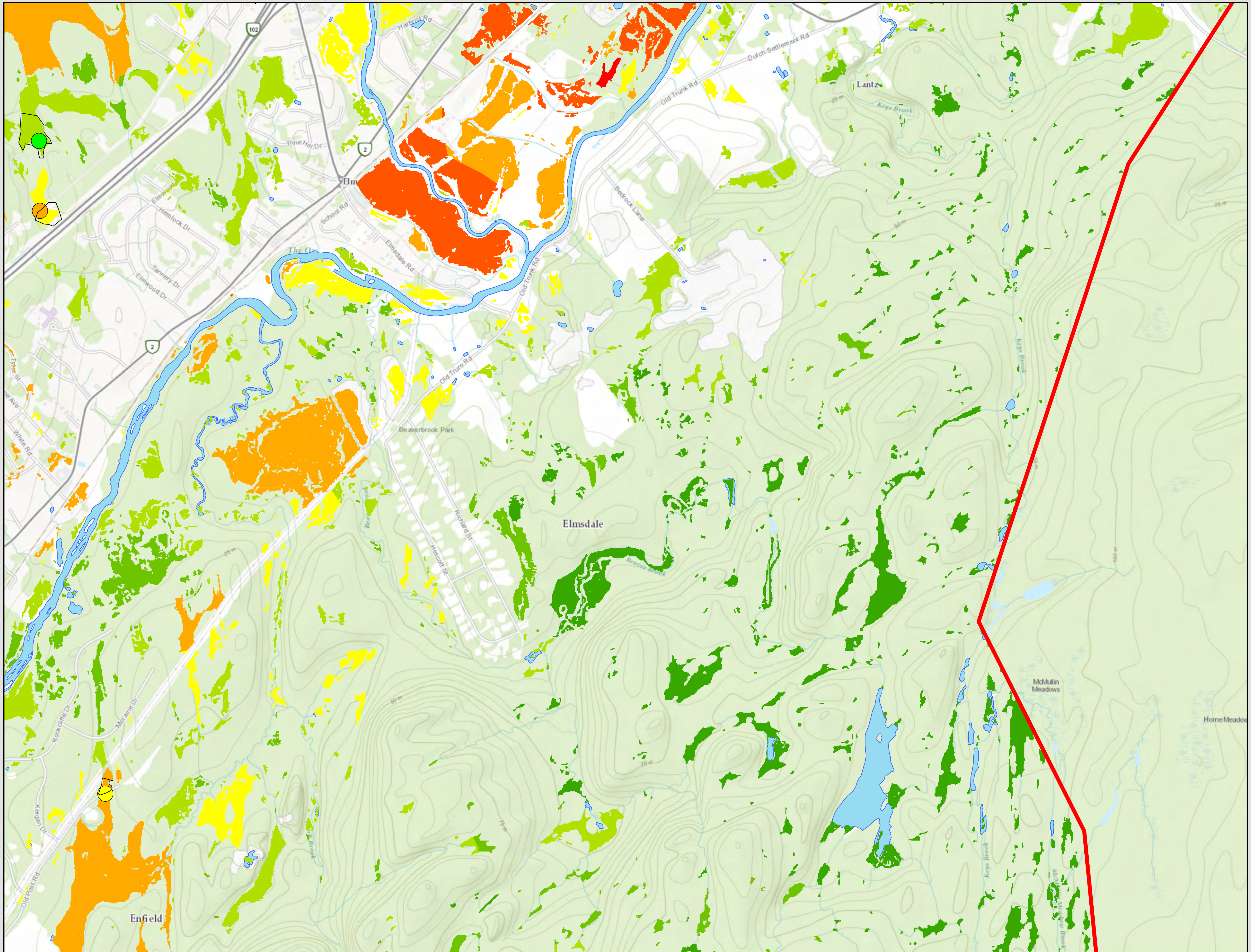

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FIGURE 9

Comparison of Field and Modelling Results

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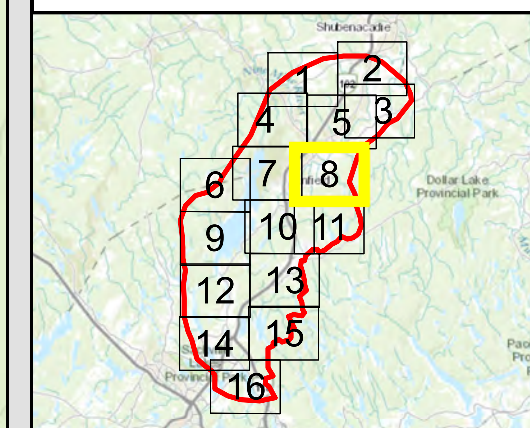

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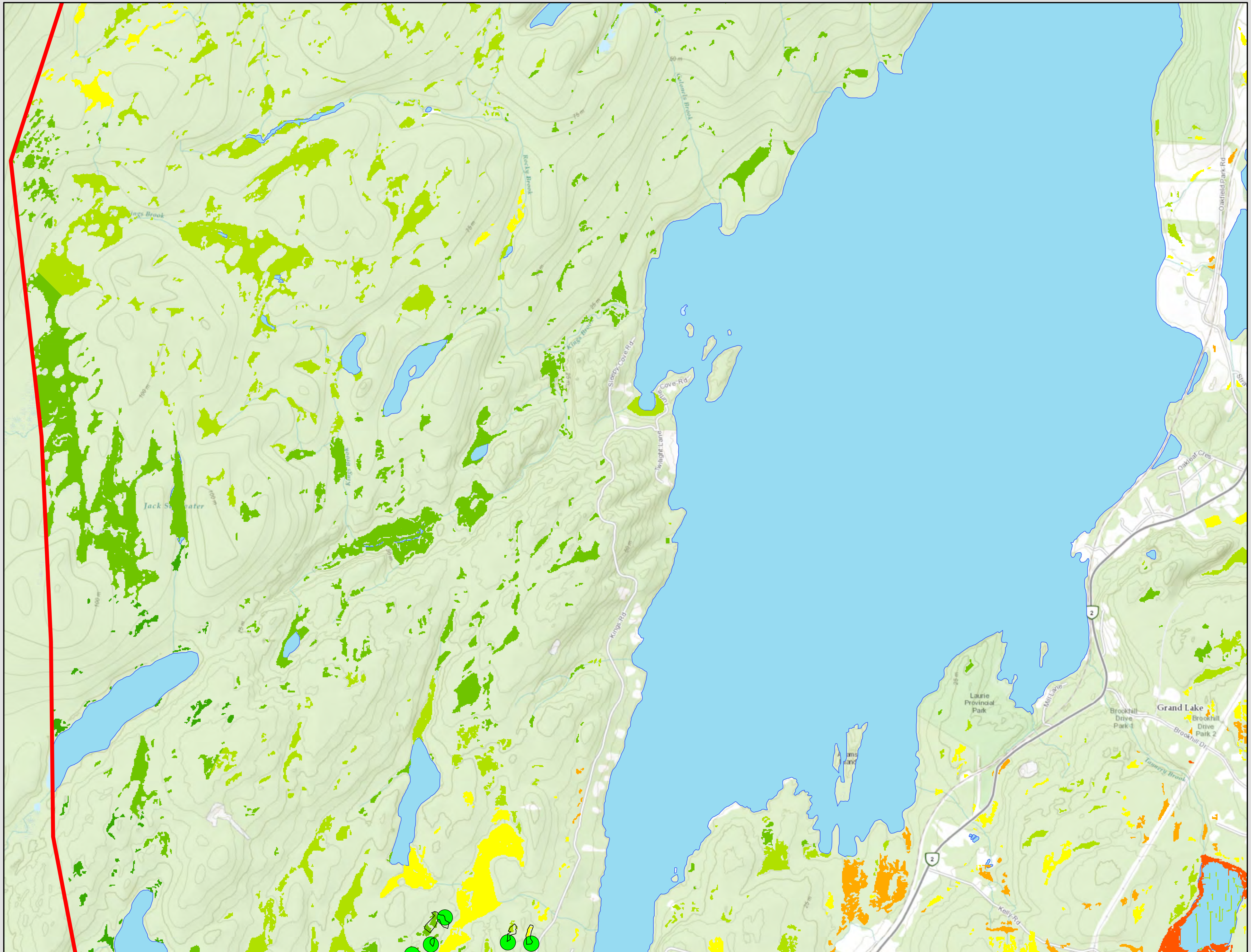

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FIGURE 9

Comparison of Field and Modelling Results

Predicted Wetland Stressors	**Field Stressor Scores**
0 - Good Condition	0 - 25
1	26 - 50
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3 - At Risk	76 - 100
4	Field Delineated Wetland Boundary
5	Open water
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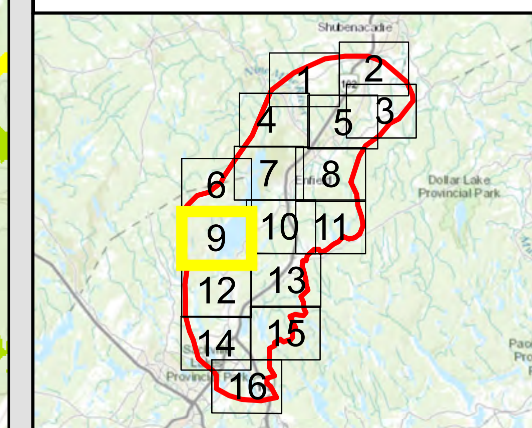

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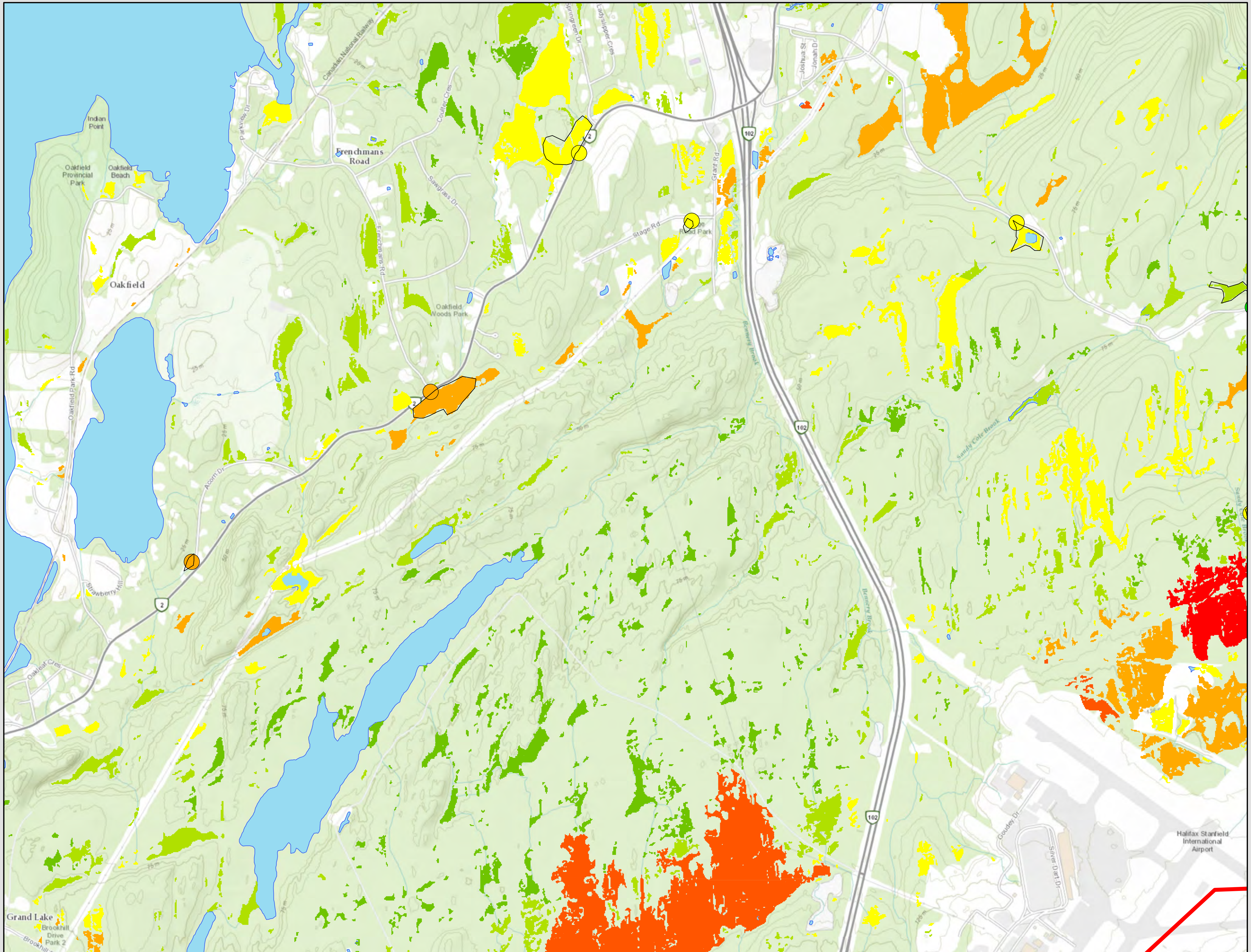

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FIGURE 9

Comparison of Field and Modelling Results

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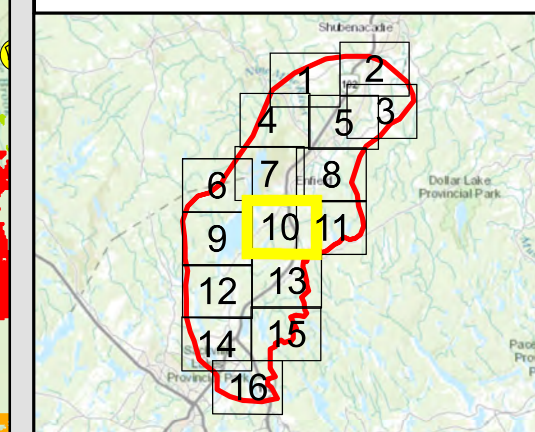

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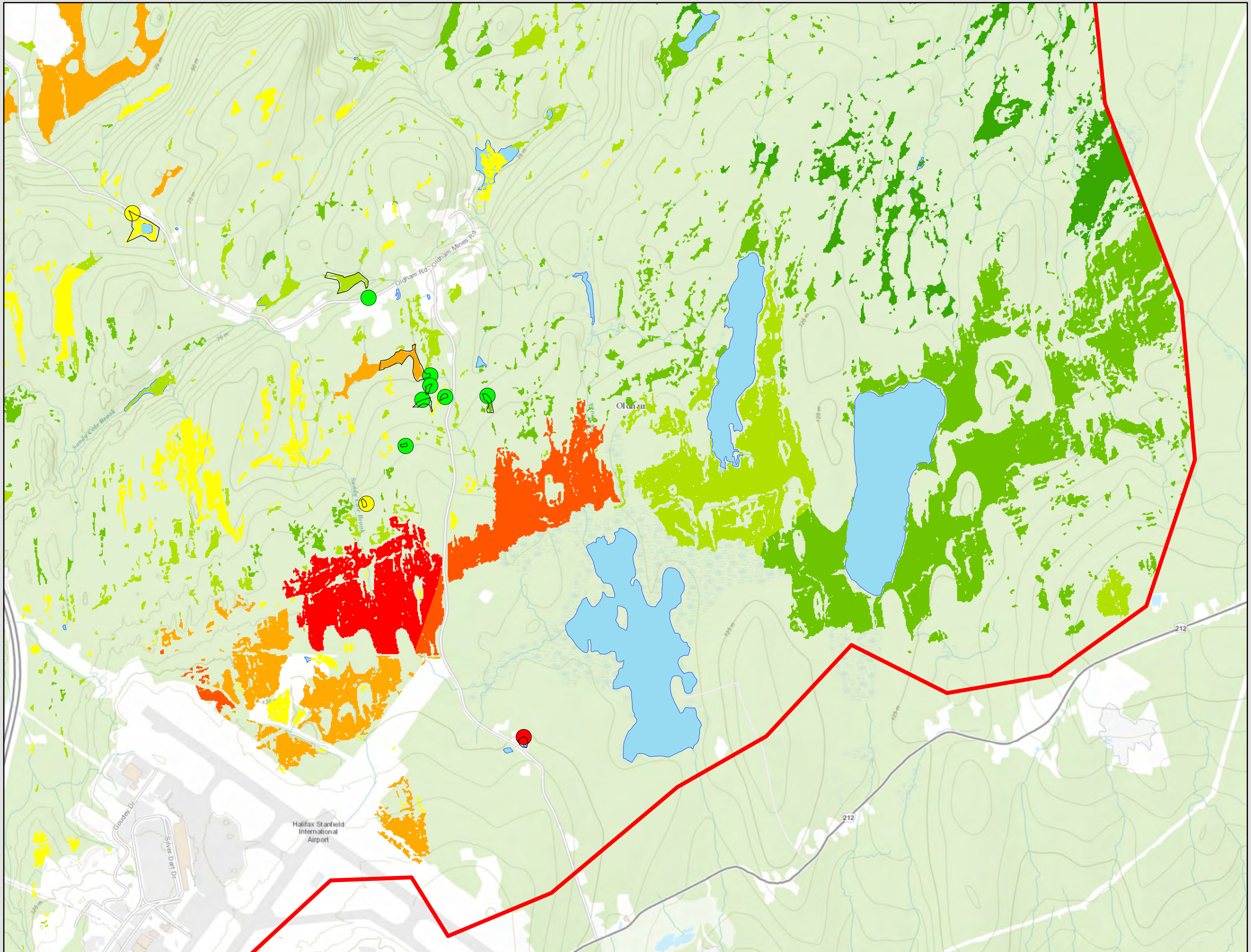

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Wetland Vulnerability Study

FIGURE 9

Comparison of Field and Modelling Results

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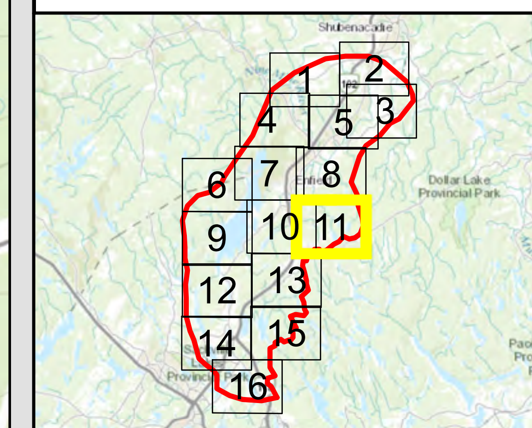

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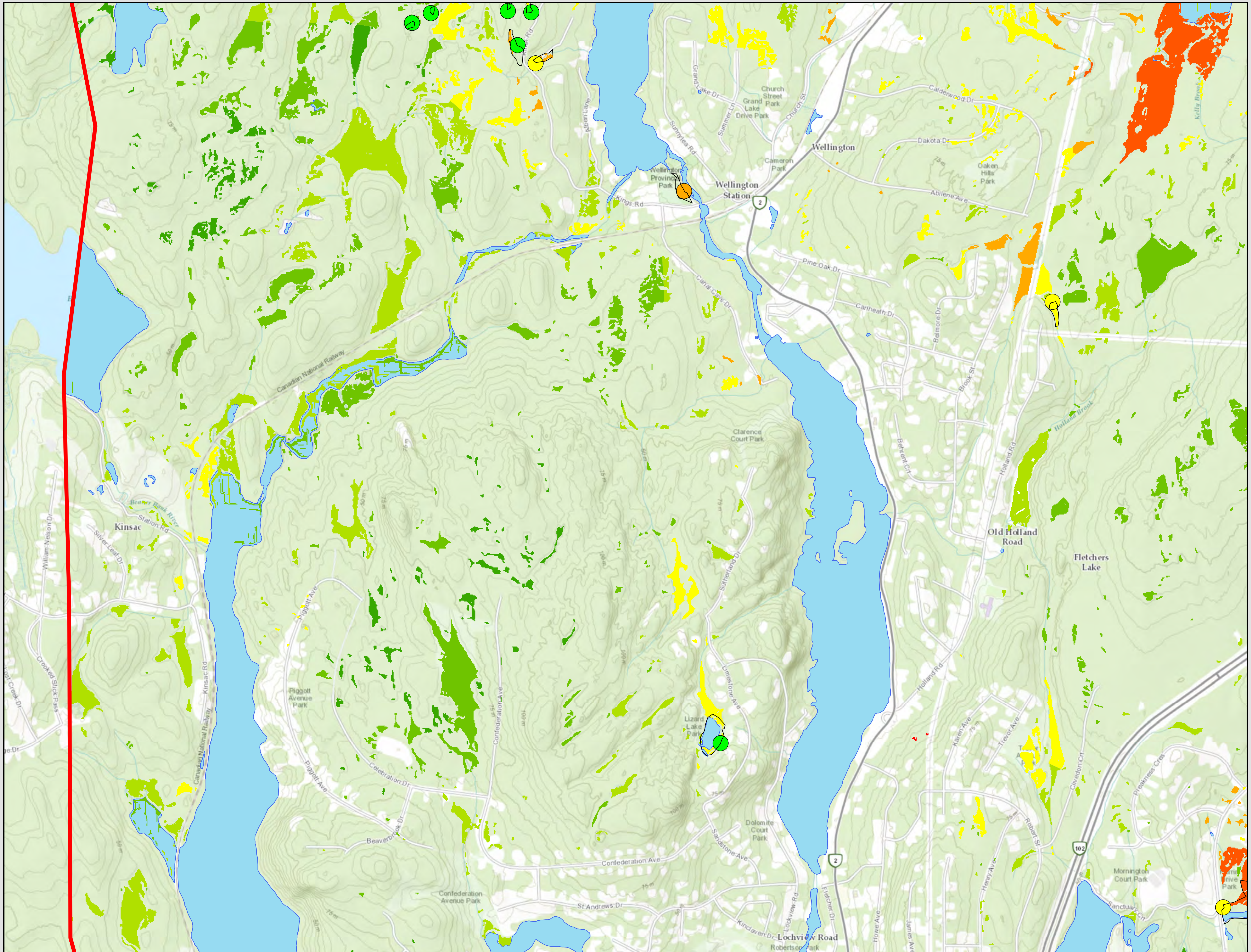

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Wetland Vulnerability Study

FIGURE 9

Comparison of Field and Modelling Results

Page 12 of 16

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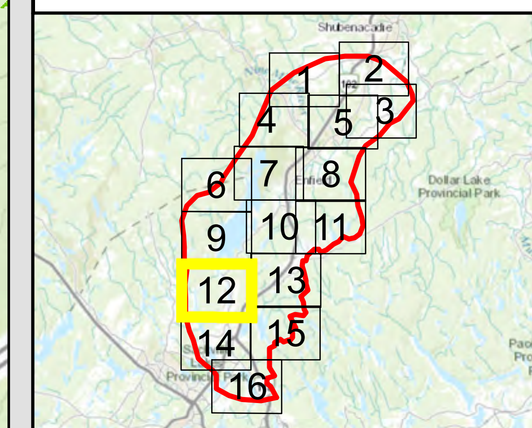

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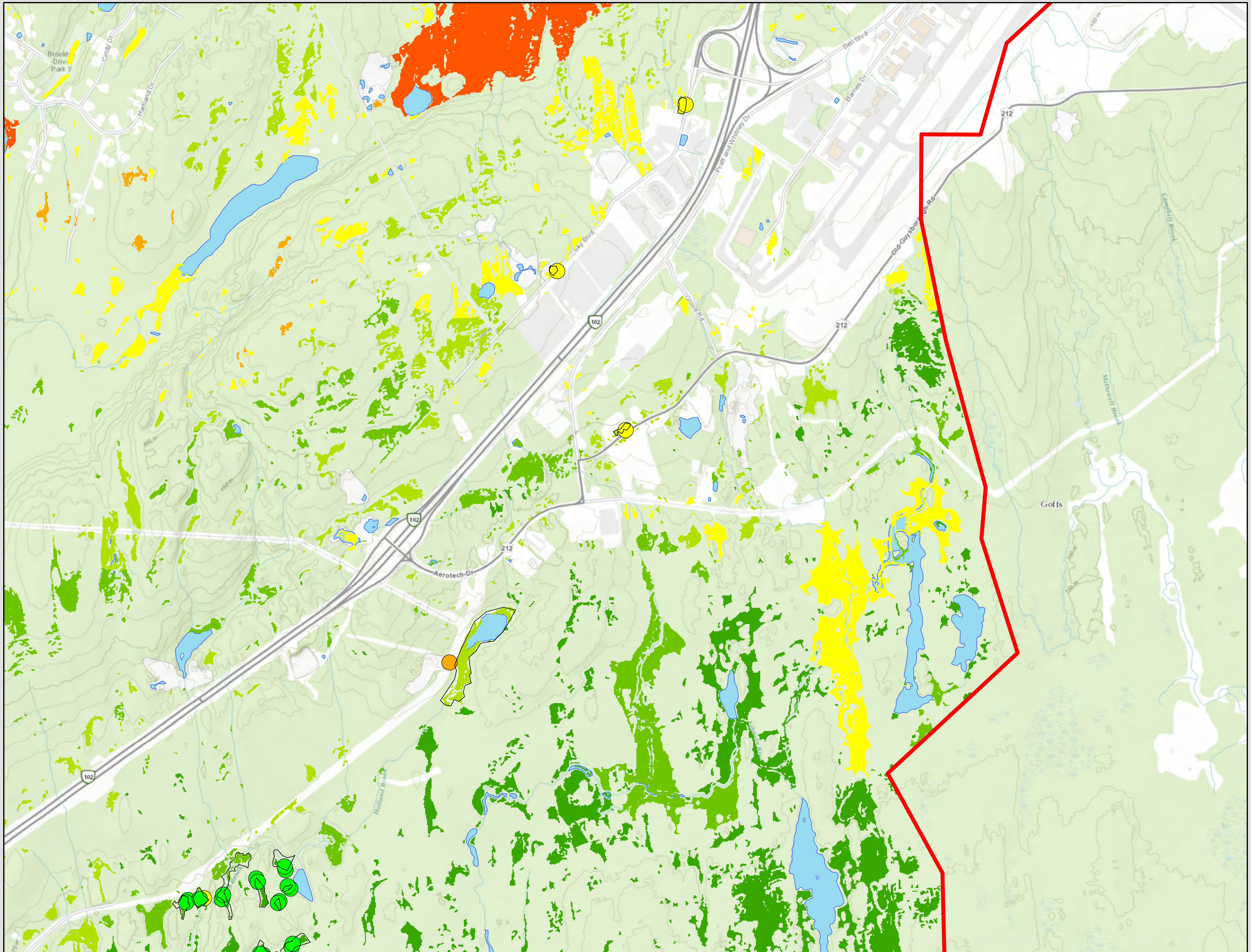

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Wetland Vulnerability Study

FIGURE 9

Comparison of Field and Modelling Results

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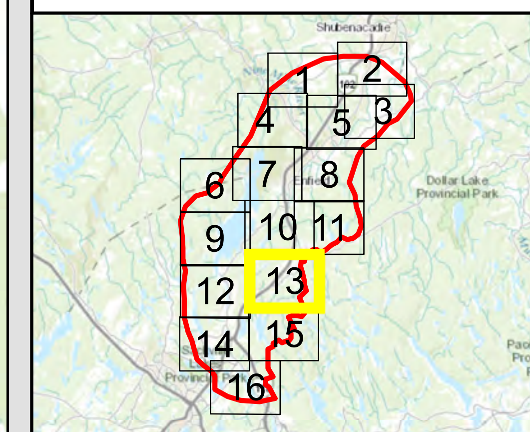

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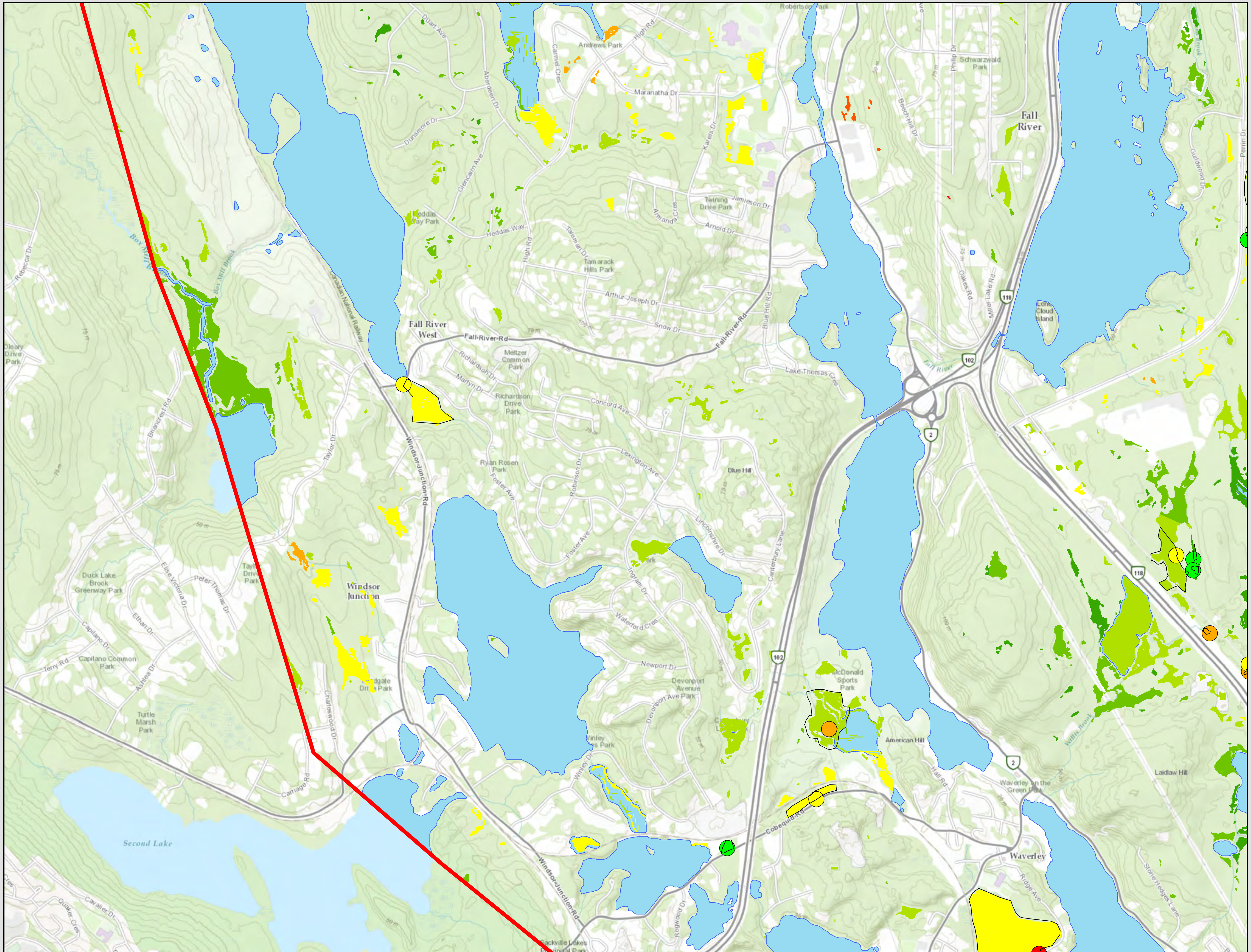

FIGURE 9

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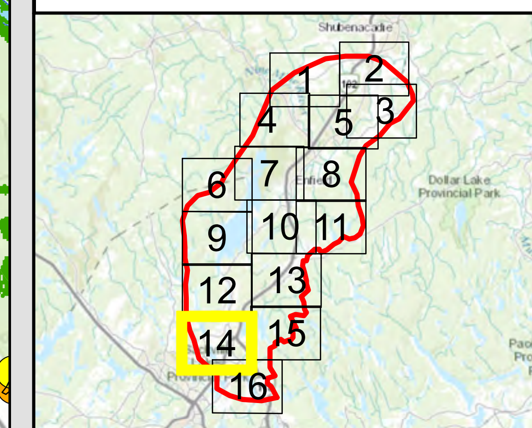

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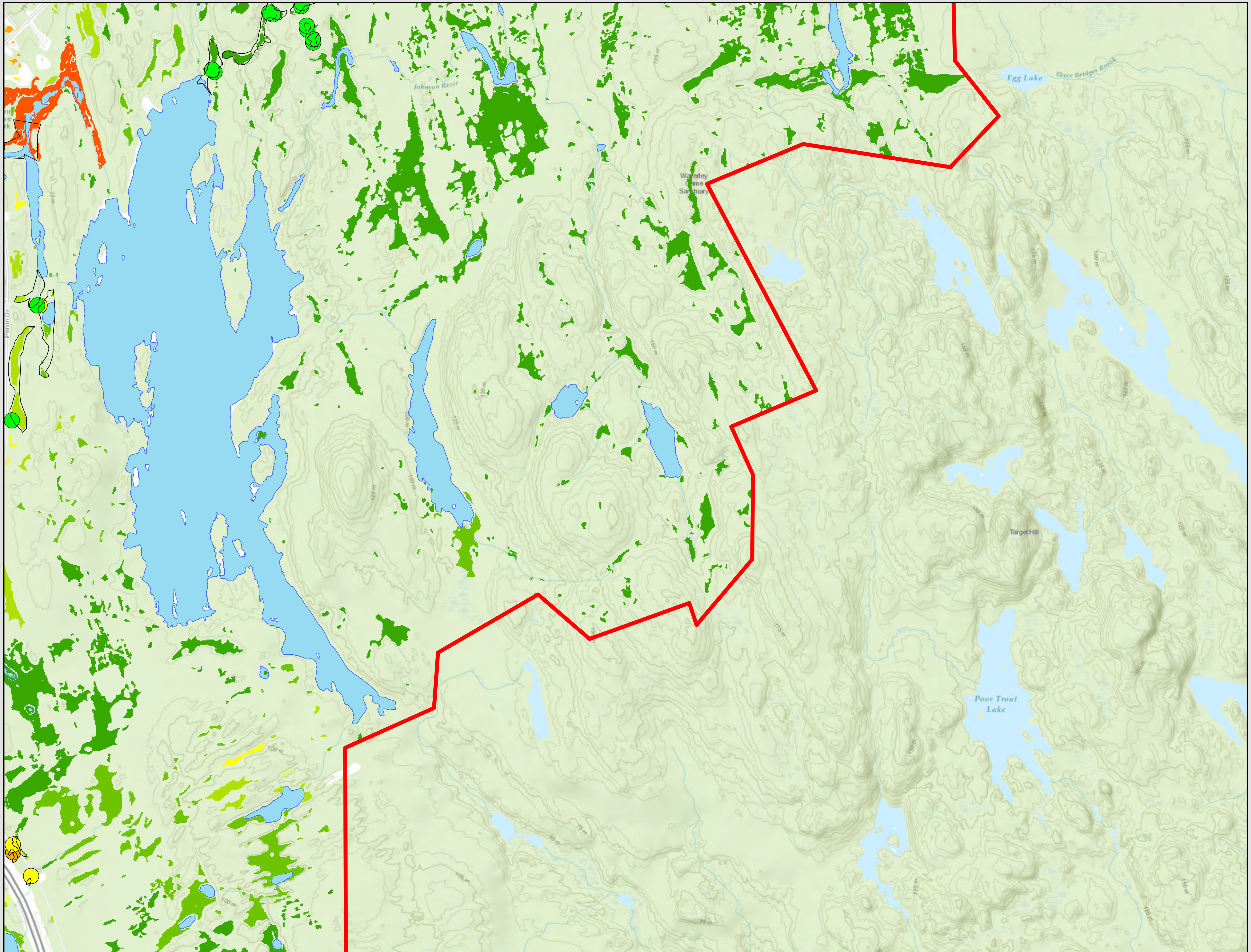

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Wetland Vulnerability Study

FIGURE 9

Comparison of Field and Modelling Results

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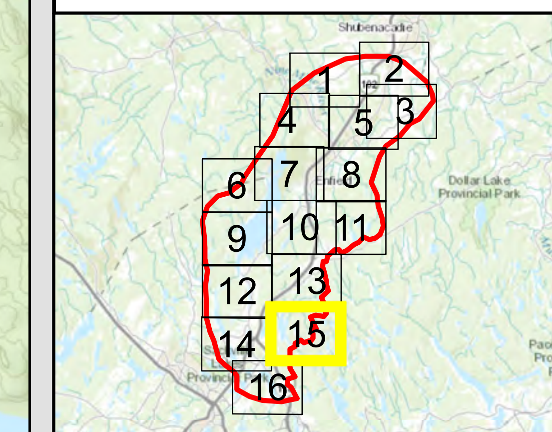

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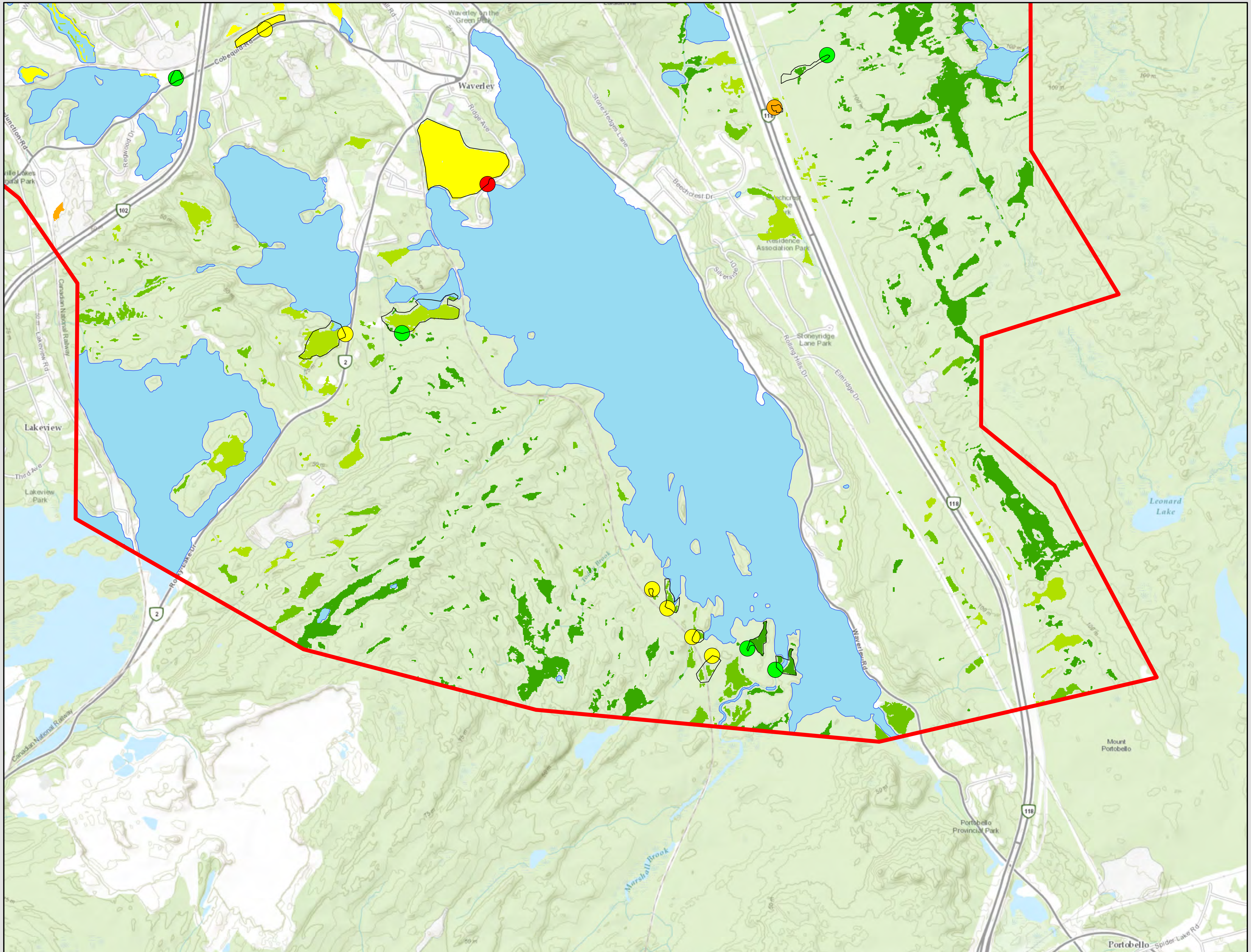

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Wetland Vulnerability Study

FIGURE 9

Comparison of Field and Modelling Results

Page 16 of 16

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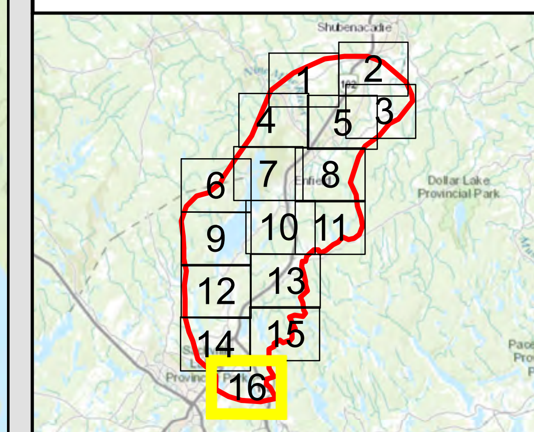

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Date: 5/16/2024

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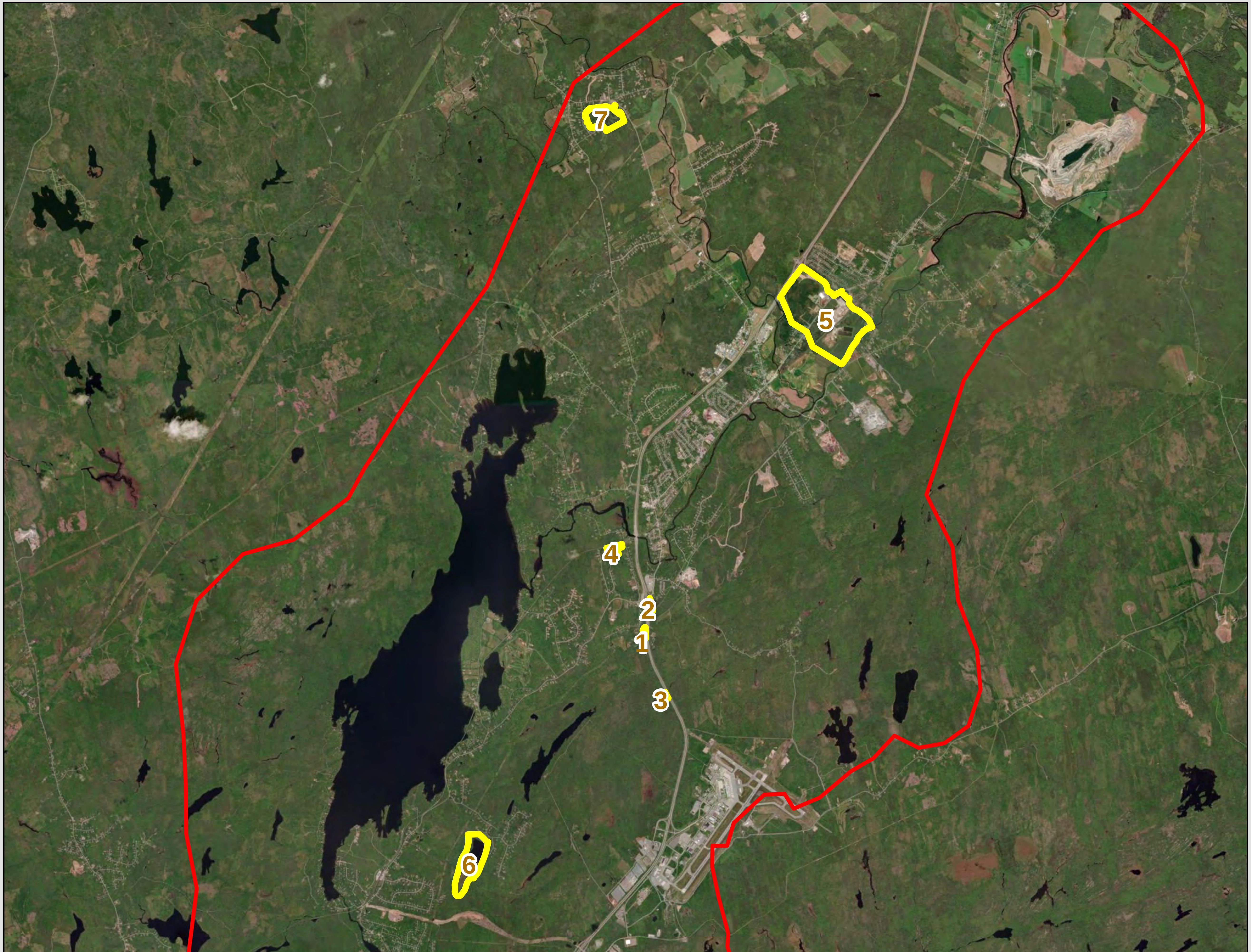
Document Name: Fig9

6 SWEPS WETLAND MANAGEMENT OPPORTUNITIES

As part of the Study, MEL assessed select wetlands within the Study Area where potential management mechanism could improve wetland function, local water management and ultimately the health of Shubenacadie Watershed. These assessments were completed at the request of SWEPS to supplement the Study with the identification of potential on-the-ground wetland restoration, enhancement, creation, or protection opportunities. The sites selected for assessment were guided by SWEPS areas of special interest and concern, as heard through engagement meetings and correspondences. The assessments were completed by desktop and/or field, depending on accessibility and property access permissions. While these are not necessarily sites informed by the study modelling results but rather by stakeholder interests, the sites selected are shown on Figure 10 with the results of the modelling for comparative purposes.



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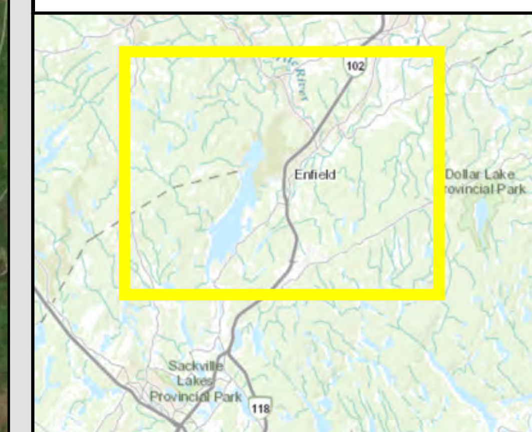
Wetland Vulnerability Study

FIGURE 10

SWEPS Site Assessment Locations

SWEPS Site Assessment Locations
Study Area



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6.1 Site Specific Assessments

Seven sites were reviewed as part of this assessment Table 12. This report detailed specific findings, recommendations and potential next steps to support SWEPS's conservation efforts in the Shubenacadie Watershed.

Table 12 - Wetland Assessment Summary

Site ID	Name	Assessment Method	PID	Land Ownership	Modelled Wetland Vulnerability Score	Management Potential
1	Bennery Brook at Grant Road	Field Visit	40551293	Private	3 & 4	Floodplain wetland expansion and enhancement
2	Bennery Brook Downstream of Hwy 102 Exit 7	Field Visit	00526756	NS Department of Public Works	3 & 4	Floodplain wetland expansion and enhancement
3	Bennery Brook Upstream at Sandy Cole Brook Confluence	Field Visit	40756280	Crown land	1 & 2	Fish passage repair and floodplain enhancement
4	Rail Line Wetland at Halls Road	Field Visit	40196438 40196420	Private	3	Wetland maintenance and protection
5	New Hwy 102 Exit Area at Lantz	Desktop	Multiple	Private	3-6 (Numerous wetlands)	Wetland maintenance and flow retention
6	Kelly Lake	Desktop	Multiple	Private	5	Wetland maintenance, possible road crossing consideration
7	Lower Nine Mile River at Hwy 14	Desktop	45123288	Private	5	Wetland restoration

6.1.1 Site 1 – Bennery Brook at Grant Road

Site 1 consists of a treed floodplain located between the banks of Bennery Brook and Highway 102, east of Grant Road at Exit 7 in Enfield, Nova Scotia (Figure 11). MEL (Andy Walter) visited this site with Tom Mills (SWEPS) on August 29, 2023.

Bennery Brook re-routed at this location in the 1970's to accommodate construction of Highway 102. The channel that currently exists was dredged to convey the flow of water, and the adjacent floodplain has since colonized with hardwood trees and saplings with and understory of forbs and graminoid species.

Since approximately 2018, SWEPS has been implementing fish habitat enhancement within Bennery Brook under the Adopt-a-Stream program, notably in the reach between Old Post Road and Oldham Road. As per discussions with SWEPS, Bennery Brook is known to support aquatic species, such as book trout, Creek chub, Gaspereau, American eel, and, historically, Atlantic salmon (one parr spotted by SWEP volunteer in 2018), as well as Snapping turtle. SWEPS have also identified that during periods of high flow sections of Bennery Brook, as well as the downstream extent prior to the Shubenacadie River (~1.5 km), experiences frequent flooding and erosion, which can damage some of the installed restoration features. Excess run-off from the up-stream airport and Highway 102 are thought to be the main contributors to the current conditions, including over widening of Bennery Brook. Furthermore, historical wetland alterations occurring in this area to accommodate the construction of Highway 102, and more recent widening of the Exit 7 off ramp to Enfield, have reduced the water storage capacity of this area. As shown in Figure 11 below, the adjacent Hwy 102 is only a few meters higher in elevation that the floodplain, resulting in flooding along the highway shoulder.

6.1.1.1 *Conceptual Approach*

While the current floodplain accepts water during periods of high flow, during typical summer conditions, apart from some low areas and a vernal pool, the floodplain remains relatively dry and does not offer much water storage or flow attenuation potential. There is potential to expand wetland habitat within the floodplain and enhance wetland function by increasing areas of water retention. A preliminary concept is described as follows and illustrated in the below Figure 11 and associated photolog in Table 13:

- Redirection of water within the floodplain through installation of diversion features (berms/logs) and drainage channels.
- Creation of additional depressional areas to increase water storage and slow flow (e.g., vernal pools).
- Setting outflow elevation spillway height to retain water within the floodplain and promote surface flooding within the area during flooding events.

It is the aim that the successful implementation of the above approaches would lead to the following wetland function enhancements:

- Increase water storage and retention;
- Reduce water flow velocities;
- Trap sediments transported from upstream and improve downstream water quality and potential fish habitat, and,
- Increase wetland vegetation and habitat integrity and diversity, including potential enhancement to fish habitat.

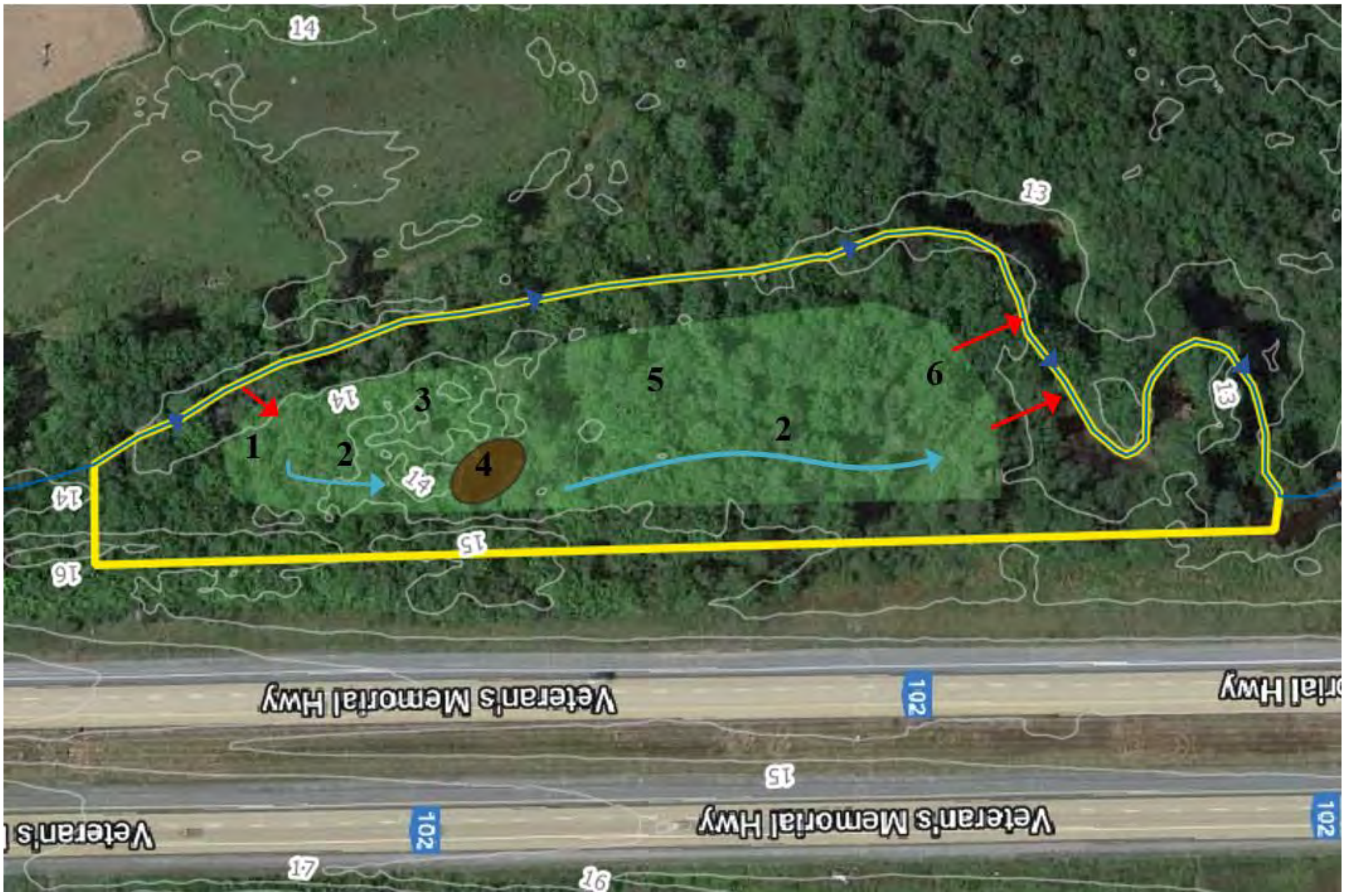

Figure 11 Current conditions of Site 1

The assessed area is in yellow. The shaded green area indicates the approximate floodplain extent, where the observed vernal pool is shown in brown (4). Inflows (1) and outflows (6) are denoted by red arrows. Light blue arrows show the observed drainage channel and primary flow path. Numbered areas are described in Table 13.

Table 13 - Site 1 Photolog and Water Control Considerations

Description	Photo
1. <u>Inflow</u> • Scoured channel where water from Bennery Brook inflows into the floodplain during periods of high flow. <u>Wetland Management Considerations</u> • Create stable, permanent inflow feature. **2.** Set elevation of inflow feature based on desired outcomes.	
3. <u>Drainage Route</u> • A drainage channel has been formed along the eastern area of Site 1 (adjacent to Hwy 102). <u>Wetland Management Considerations</u> • Install natural barriers to current flow path (e.g., earthen berms, pools) to slow flow and retain water in Site 1. • Create side channels/re-direct flow to other flow retention features (i.e., new ponds, areas 3 and 5).	 

Description	Photo
4. **<u>Intermittent Flood Area</u>** • Highest and driest area within Site 1. Evidence of intermittent flooding (compressed vegetation). <u>Wetland Management Considerations</u> • Redirect water to these areas more frequently. • Potential creation of ponds and connection with existing channelized drainage.	
5. **<u>Vernal Pool</u>** • Shallow (~0.5 m) vernal pond. <u>Wetland Management Considerations</u> • Potential to increase depth and water storage ability. • Create additional, similar ponds within Site 1 to help retain water in high flows.	

Description	Photo
6. Surface Flow Drainage • Lower lying land, discharge from pond. • Evidence of sheet flow through vegetation. Wetland Management Considerations • Install natural barriers (e.g., earthen berms, pools) to slow flow and retain water in Site 1. • Create side channels/re-direct flow to other flow retention features (i.e., new ponds).	
7. Channelized Drainage/Outflow • Defined drainage/outflow channel has been formed. • Two, narrow (~0.5m) scoured outflows to Bennery Brook. Wetland Management Considerations • Construct stabilized, permanent outflow. • Consider desired elevation for spillway and fish access through system. • Set elevation of outflow feature based on desired outcomes.	

Description	Photo
Installed digger log in Bennery Brook, August 27, 2023, under bankfull conditions (photo from SWEPS).	

6.1.2 Site 2 – Bennery Brook Downstream of Hwy 102 Exit 7

Similar to Site 1, Site 2 consists of a treed/shrub floodplain between the banks of Bennery Brook and Highway 102, north of the highway at Exit 7 in Enfield, Nova Scotia (Figure 12). MEL (Sarah Scarlett) visited this site on November 17, 2023. The floodplain along the west side of the brook, within the NS Department of Public Works right-of-way, was assessed (Figure 12). Lands to the east of the brook are privately owned and not included in this assessment.

The channel is widest at the upstream portion under Highway 102, with armoured banks. It's likely this portion of the brook was widened as part of crossing engineering and to adequately convey flow. Built up berms were observed along the portion of the brook immediately adjacent to the highway, a potential indication of regular high flows and flood mitigation along the highway. The channel narrows downstream of the highway crossing as it winds through a treed floodplain with a steep, undercut, entrenched channel, which transitions to an alder swamp before entering private property. There is evidence of beaver activity and lodges throughout this reach (no dams observed).

A low laying marsh area was observed at the northern extent of the assessed reach, between Bennery Brook and a service road which runs alongside Hwy 102. Evidence of flooding was observed in the marsh (e.g., vegetative drifts). As shown in Figure 12, the elevation difference between the marsh area and the cobble service road is ~1 m, which may result in water overtopping the road at this location under high flow conditions.

There is man-made pond dug in the floodplain between Hwy 102 and Bennery Brook. This pond appears in aerial imagery available back to 2003 and was likely created as part of highway construction. Currently this pond appears to be connected to Bennery Brook under high flow condition via a poorly defined inlet and outlet (see Figure 13) and may be acting as a spilt over holding pond under high flows.

As shown in in-text Figure 13 there was a temporary realignment of Hwy 102 along this reach in 2020 to preform maintenance on the south bound crossing. Reviewing aerial imagery, the temporary highway realignment and crossing was removed in 2022. However, as shown in the May 2022 imagery (Figure 13) this work appears to have encroached on the floodplain and left fill material following road removal, likely reducing the natural wetland size and functions in this area (do not have wetland delineation area to confirm previous extent).

6.1.2.1 *Conceptual Approach*

Similar to Site 1, while the current floodplain would accept and slow water during periods of high flow, there is evidence of large water level fluctuations and potential flood risk (e.g., low flow at time of assessment, deep, undercut, entrenched channels, beaver lodges, vegetation drifts, constructed berms near Hwy 102). Furthermore, there may be opportunities to expand wetland habitat to compensate for that which may have been lost to the temporary highway realignment. A preliminary concept is described as follows and illustrated in the below on Figure 12 and associated photolog in Table 14:

- Redirection of water within the floodplain through installation of diversion features (berms/logs) and drainage channels.
- Creation of additional depressional areas to increase water storage and slow flow (e.g., vernal pools).
- Setting outflow elevation spillway height to retain water within the floodplain and promote surface flooding within the area during flooding events.

It is the aim that the successful implementation of the above approaches would lead to the following wetland function enhancements:

- Increase water storage and retention;
- Reduce water flow velocities;
- Trap sediments transported from upstream and improve downstream water quality and potential fish habitat, and,
- Increase wetland vegetation and habitat integrity and diversity, including potential enhancement to fish habitat.

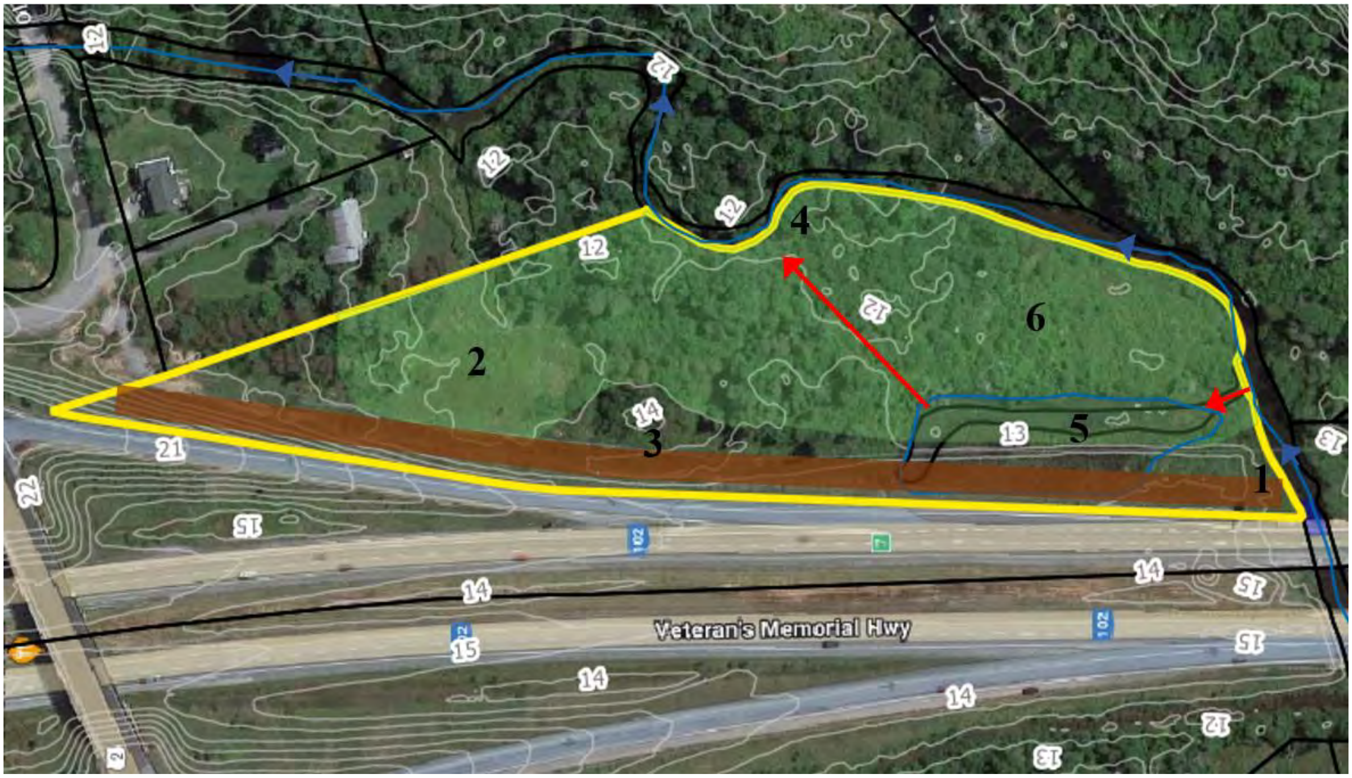

Figure 12 Conditions of Site 2 from 2019, pre-realignment

The assessed area is in yellow. The shaded green area indicates the approximate floodplain extent. The shaded brown area identifies the approximate realignment fill area and current service road. Red arrows denote the inflow and outflow from the man-made pond. Numbered areas are described in Table 14.

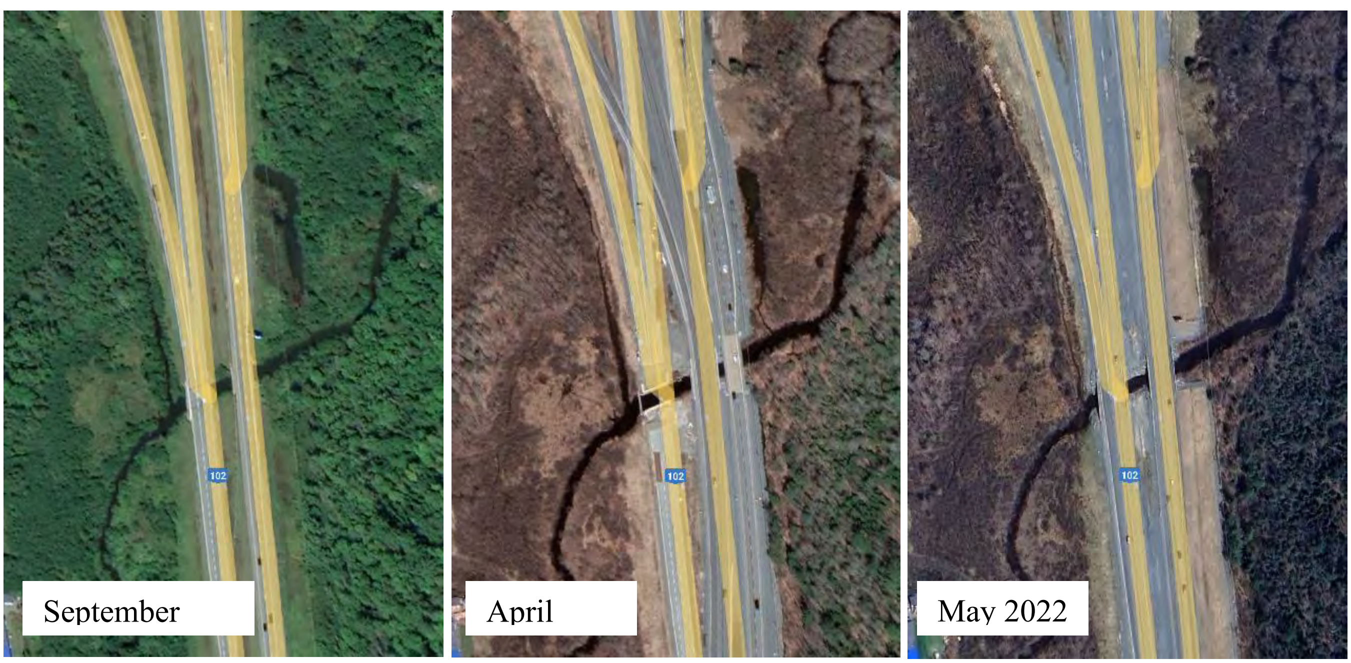

Figure 13 Temporary realignment of Hwy 102 at Site 2.

Table 14 - Site 2 Photolog and Water Control Considerations

Description	Photo
1. **Marsh Area** • Lowest area within Site 2. • Water table at surface at time of assessment. • Evidence of flooding. Wetland Management Considerations • Service road is within ~1 m of marsh surface elevation. • Use of blast rock on road may indicate potential flooding. Opportunity to consider road use and elevation in design.	
2. **Hwy 102 Crossing** • Leveling and stabilizing material likely left over from temporary crossing. • Berm running along edge of brook at this location may indicate potential to over top banks. Wetland Management Considerations • Potential to expand flood plain (area 3) and create additional ponds within Site 2 to help retain water in high flows and moderate channel flow.	

<table>
<tr><th>Description</th><th>Photo</th></tr>
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3. <u>Service Road and Fill Area</u>

- Realignment fill area and current service road.
- Potential spoil material deposit in the floodplain.

<u>Wetland Management Considerations</u>

- Alignment likely reduced the natural wetland size and functions.
- Potential to expand wetland into this area.

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4. <u>Treed Swamp Floodplain</u>

- Higher/drier area within Site 2. Evidence of intermittent flooding.
- Entrenched brook through treed swamp. Low flow at time of assessment.
- Evidence of beaver activity and lodges

<u>Wetland Management Considerations</u>

- Evidence of notable water level fluctuations
- Potential to enhance floodplain and create additional ponds and flow retention features within Site 2 to help retain water in high flows and moderate channel flow.

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<tr><th>Description</th><th>Photo</th></tr>
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5. **<u>Man-Made Pond</u>**

- >1 m deep pool (at measurable point)
- Potentially a result of highway construction (e.g. burrow pit)

<u>Wetland Management Considerations</u>

- Potential to increase depth and water storage ability.
- Create additional, similar ponds within Site 2 to help retain water in high flows (e.g., area 6).
- Stabilized permanent inflow and outflow. Consider desired elevation for spillway and fish access through system.

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6. **<u>Shrub Dominated Floodplain</u>**

- Moderate moisture regime
- Some observed natural vernal pools or flow retention features.

<u>Wetland Management Considerations</u>

- Create additional side channels or other flow retention features (i.e., new ponds) to re-direct, store and slow flow.
- Consider desired elevation for spillways and fish access through system.

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6.1.3 <u>Site 3 - Bennery Brook Upstream at Sandy Cole Brook Confluence</u>

Site 3 is ~1.5 km upstream of Site 1, where Sandy Cole Brook flows into Bennery Brook (Figure 14). MEL (Sarah Scarlett) visited this site on November 17, 2023. Two watercourse crossings, Sandy Cole Brook at Hwy 102 and Bennery Brook at an old trail, and the associated floodplain were assessed within this area. Site 3 lies entirely within Crown land. Current site conditions are shown in in-text Figure 14 and the associated photolog in Table 15.

The two crossings were observed to have perched culverts where culvert heights on the downstream outflow were 0.5 m to >1 m above the watercourse elevation (see Table 15). These may be a result of engineering constraints or best-practices at the time of installation, degradation of the crossing structure or erosion. The upstream inlet of the Bennery Brook crossing, under the old trail, was observed to be partially blocked due to debris (e.g., trees and boulders). At this location, ~10 m West of the main crossing, Bennery brook has scoured a secondary flow path (dry at the time of assessment) which has eroded through the trail rendering it impassible. There is evidence of a smaller diameter, broken concrete culvert at this location. This diversion and erosion may be due to the partial blockage and/or an undersized primary culvert. Debris from an old, corrugated steal culvert was found in the forest next to this crossing, indicating that the culvert was likely replaced by the existing concrete culvert(s) due to previous damages. The upstream inlet of Sandy Cole Brook on the East side of Hwy 102 was not assessed due to access and safety concerns, however no blockages or flow impediments were observed within the culvert.

There is a fairly expansive floodplain area at the confluence of Sandy Cole Brook and Bennery Brook. Evidence of routine high flows and flooding within the floodplain was observed (e.g., ephemeral side channels, scoured banks, downed trees, limited herbaceous vegetation). Upstream of this location, along both watercourses, is notably more entrenched with a narrow riparian area and quick transition to upland. Approximately 150 m downstream of the confluence, along Bennery Brook, there is evidence of an inundated treed swamp and beaver activity ~50 m west of the main channel. A dam ~ 50 long was observed in the treed swamp. This downstream area was assessed by SWEP on July 6, 2023.

In their current states, both crossings would pose a barrier to fish passage to upstream reaches. In the case of the Bennery Brook crossing, the flow and hydrologic regime of the watercourse is disrupted, and as a result may be altering the function and integrity of the downstream floodplain (e.g., flashier peak flows, accumulation of eroded material). Existing beaver activity and associated barriers/pools may be helping to retain water and slow flow.

6.1.3.1 *Conceptual Approach*

As observed in the downstream reaches of Bennery Brook, Site 3 has evidence of large water level fluctuations. Particularly along Bennery Brook, the current crossing design is resulting in notable erosion and infrastructure deterioration. Management considerations at this location may be two-fold, 1) to repair and improved flow regimes and fish passage at the watercourse crossings and, as result, 2) to enhance the integrity and functioning of the associated downstream floodplain area.

As with downstream reaches of Bennery Brook, there may be opportunity to work with the Adopt-a-Stream program and/or Department of Fisheries and Oceans (DFO) to improve fish passage and habitat at these crossings. In a recent 2023 publication, of culverts assessed by Adopt-a-Stream, only 11% of the Shubenacadie and Stewiacke Watershed crossings are barrier-free, with insufficient data for 36% of crossings.

A preliminary concept is described as follows:

- Repair, replacement or retrofit existing crossings in consideration of fish passage requirements, such as fish chutes/ladders, baffles, low flow barrier (backs water up through the culvert creating more depth and lower water velocities), or culvert bypass structures (e.g., Denil Structure).
- Repair trail at Bennery Brook crossing and install appropriately sized culverts with considerations for fish passage. Install erosion and sediment controls to reduce risk of future culvert blowouts.

- Remove culvert obstructions on upstream sides of culverts and further assess inlet elevations. Consider if low-flow retrofits are required on the upstream inlets.
- Assess integrity of beaver-made features in wetland floodplain and consider construction of additional berms and pools to slow and retain flow. Set outflow elevations in consideration of desired outcomes and fish passage.

It is the aim that the successful implementation of the above approaches would lead to the following watercourse and wetland function enhancements:

- Improve fish passage and access to upstream habitat,
- Reinstate natural flow regimes and reduce the velocities and amplitude of peak flows,
- Increase water storage and retention in floodplain areas,
- Reduce erosion and sediment transported from upstream,
- Support objectives of Site 1 and 2 through upstream flow attenuation and improved water quality,
- Increase riparian wetland function and integrity, including potential enhancement to fish habitat.

It should be noted that crossing repairs, replacement or retrofitting may not qualify for fish habitat offsetting credits by DFO, as it is their expectation that all culverts provide passage. Should this project be considered for offsetting, it is recommended that DFO be consulted early in project planning. Consider an assessment of upstream fish habitat quality to support reasoning for habitat access and enhancement.

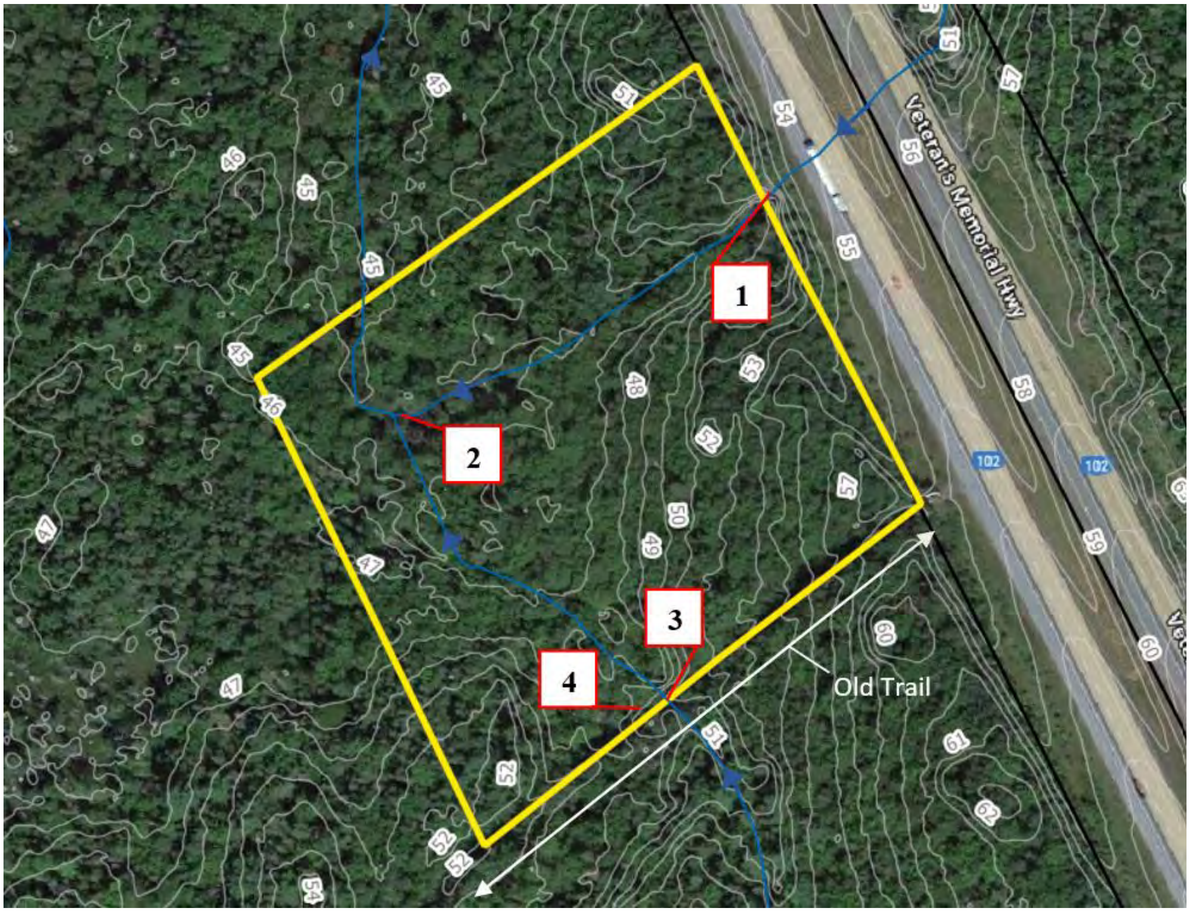

Figure 14 Conditions of Site 3

Site 3 is shown in yellow. Bennery Brook flows south to north. Sandy Cole Brook flows East to West under Hwy 102, terminating at Bennery Brook. Numbered features are described in the blow photolog.

Table 15 -Site 3 Photolog

Description	Photo
1. <u>Sandy Cole Brook Crossing at Hwy 102</u> • Downstream perched culvert outlet. • Top photo: Low flow (<5 cm) in culvert at time of assessment (top photo). • Bottom photo: High flow on July 6, 2023 (photo from SWEPs). • Upstream inlet not assessed. <u>Management Considerations</u> • Retrofit outlet with improved fish access/passage. • Consider low-flow improvements. Note perch even under high flow conditions. Assess connectivity and quality of upstream habitat.	 

<table>
<tr><th>Description</th><th>Photo</th></tr>
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2. <u>Floodplain at Confluence</u>

- Beaver activity and built pools.
- Evidence of routine high flows, flooding and scouring.

<u>Management Considerations</u>

- Assess beaver-made features, conder construction of additional berms/pools to retain and slow flow to downstream reaches.
- Set outflow elevations for desired outcomes and in consideration of fish passage.

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3. <u>Bennery Brook Crossing a Old Trail</u>

- Downstream perched culvert outlet.
- Flow partially obstructed at inlet.
- No baffles or fish passage infrastructure.

<u>Management Considerations</u>

- Replace or retrofit culvert with improved fish passage.
- Consider low-flow improvements.
- Assess connectivity and quality of upstream habitat.

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Description	Photo
4. <u>Bennery Brook Crossing at Old Trail</u> • Partially blocked inlet to perched culvert. • Obstructs flow and fish passage. • Culvert size and blockage like resulted in channel diversion and trail washout. <u>Management Considerations</u> • Remove culvert obstructions. • Further assess inlet elevations. Consider if low-flow retrofits are required.	
5. <u>Washed Out Trail at Bennery Brook Crossing</u> • Washed out trail at channel diversion, west of mail stream. • Scouring and erosion issues. • Debris from broken culvert(s). <u>Management Considerations</u> • Repair trail and reinstall appropriately sized culvert(s). • Considerations for fish passage. Potential location to install a fish passage bypass around the main culvert, if flow could be maintained under low flow conditions. • Install erosion and sediment controls to prevent further washouts and improved downstream water quality.	

6.1.4 Site 4 – Rail Line Wetland Crossing at Halls Road

Site 4 is a wetland bisected by a rail line east of Halls Road in Enfield, Nova Scotia (Figure 15). MEL (Andy Walter) visited this site on August 29, 2023. Site 4 lies entirely within private land but can be viewed from the rail line right-of-way. Current site conditions are shown in in-text Figure 15 and 16.

Figure 15 Site 4 up-gradient wetland area south of the rail line.

Figure 16 Site 4 down-gradient wetland area north of the rail line.

Management recommendations for Site 4 are to maintain current wetland conditions. The wetland appears to be functioning relatively naturally as a marsh-fen complex with a throughflow watercourse, retaining and slowing the flow of water before discharging to the Shubenacadie River ~250 m downstream. Historic aerial imagery does show minor ditching on the east side of the wetland, which has since grown in, and periods of impoundment on the upgradient (south) side of the rail line. However, even under extreme conditions, noted by regional flooding beyond the wetland, standing water in the wetland did not inundate the rail line. Figure 17 below shows regional flooding conditions in May 2003.

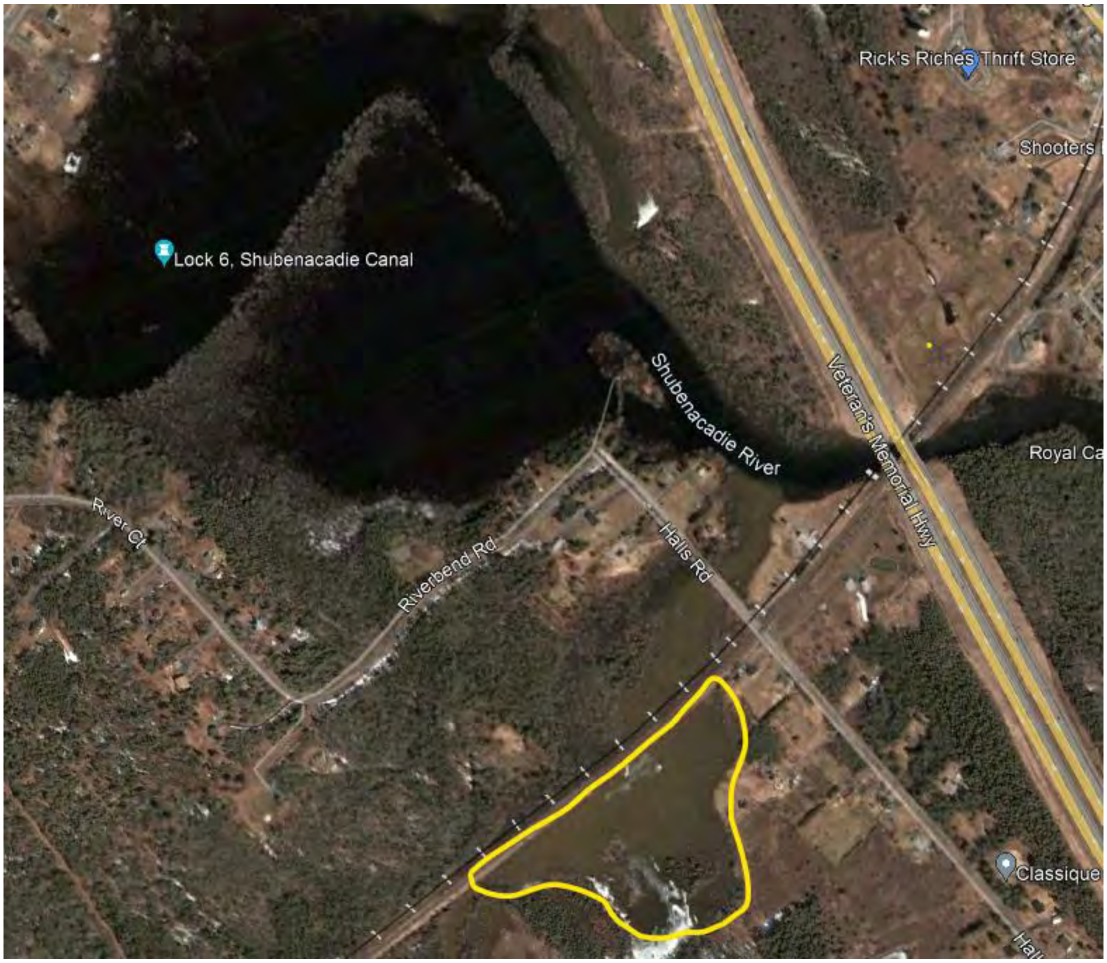

Figure 17 Site 4 shown in yellow under regional flooded conditions in May 2003

It is suggested this site be monitored for potential impoundment, specifically after heavy rainfall or abnormally wet seasonal conditions. It should be noted that Site 4 was visited following abnormally wet summer conditions and no imminent flooding impacts or risk to the rail line were noted at the time of assessment. Should issues with cross drainage under the rail line be observed in the future, Site 4 may be suitable for restoration opportunities.

6.1.5 Sites 5-7 – Desktop Assessments

Sites 5, 6 and 7 were assessed via desktop due to the scale of the assessment area and/or private land access restrictions. Where possible, attempts were made to contact private landowners for access permissions.

Site 5 includes an ~ 200 ha area south of the new Hwy 102 exit at Lantz, Nova Scotia (Figure 18). In this area, local topography slopes from the northmost corner, the new highway exit, southeast to Nine Mile River and southwest to the Shubenacadie River. Impoundment of water in this area is evidence in current and historic imagery (e.g., along the northwest edge of the Shaw Precast Solution development). Additional development is planned or underway in Site 5. It is broadly recommended that water and wetland maintenance and management strategies be considered in future development plans to adequately manage flood risks to downgradient properties and developments, which includes a rail line and water treatment plant adjacent to the Shubenacadie River.

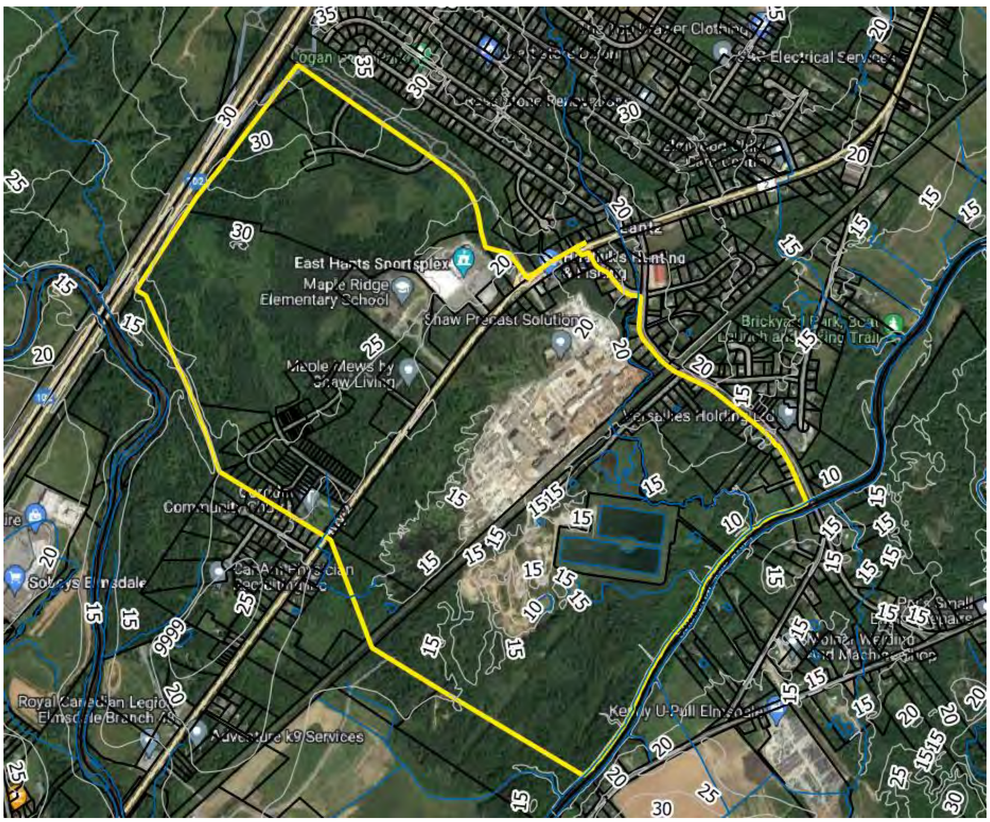

Figure 18 Site 5 Current Conditions (shown in yellow)

Site 6 is the Kelly Lake area (Figure 19). The riparian wetland associate with the lake is subdivided into individual residential development along the northeast boundary and multiple large undeveloped private property PIDs. Currently an old, unpaved extension of Kelly Lake Road bisects the wetland. Through a review of historic imagery, this road does not appear to be altering the hydrology of the wetland and is frequently inundated. Should future development be planned for these properties, it is recommended that adequate setbacks, inline with municipal and provincial regulations, be maintained to preserve the function and integrity of the riparian wetland, and ultimately Kelly Lake, which discharges to Grand Lake. Impacts to upgradient wetlands which may have direct or indirect hydrological connectivity should also be considered. Future development has the potential to impact wetland function, largely through changes to hydrology (e.g., water storage and flow paths) and water quality (e.g., nutrient and sediment runoff). Wetland hydrology may be particularly impacted where roads run perpendicular to the natural flow path and have a greater risk of causing upgradient impoundment if proper cross drainage is not installed.

Figure 19 Site 6 Current Conditions (shown in yellow)

Site 7 is a disturbed wetland located on private property in Lower Nine Mile River (Figure 20). MEL was unable to contact the landowner to gain access for the purpose of this study. Assessed through aerial imagery, the wetland appears to be a bog which drains to a tributary of the Nine Mile River. The wetland was irregularly ditched (likely in an attempt to drain it for agricultural or development purposes) prior to 2003. Should a landowner agreement be obtained, this site would be recommended as a potential restoration opportunity. Currently, unnatural ditching and open water features appear to be altering the wetland's natural functions by expediting and increasing drainage and promoting colonization of reed and shrub species typically not present in an open bog. Changes to bog hydrology are also likely impacting peat accumulation and carbon storage functions.

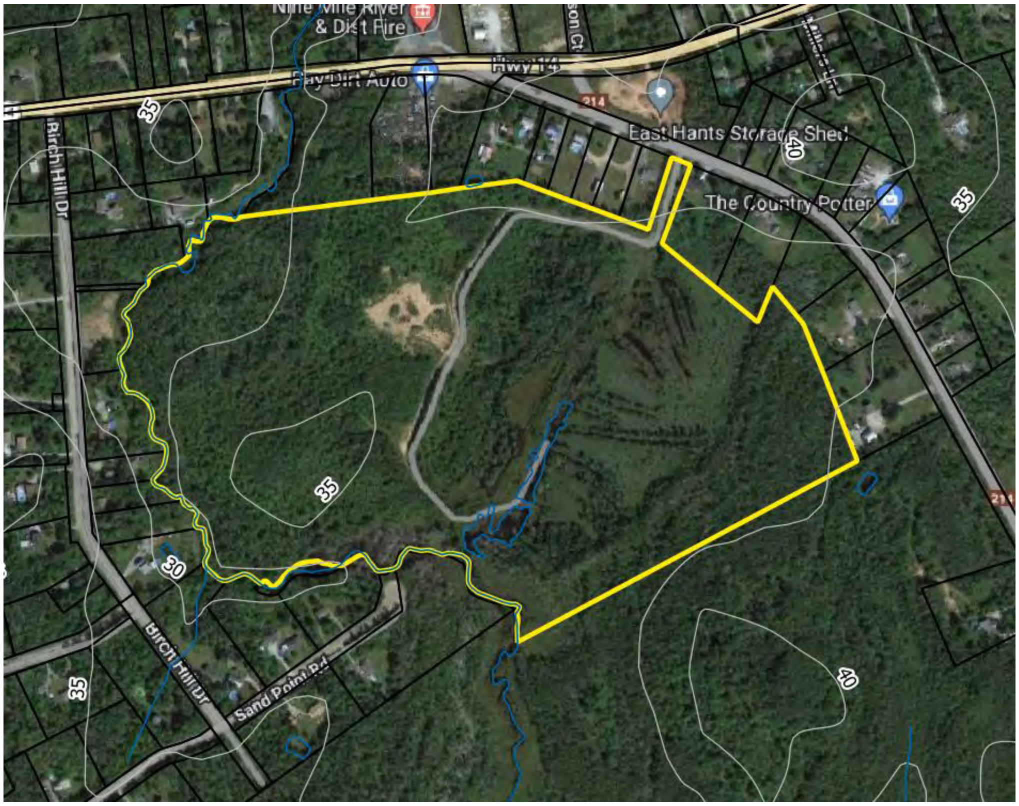

Figure 20 Site 7 Current Conditions (shown in yellow)

6.2 Next Steps for Conceptual Projects

In order to evaluate the feasibility of the conceptual management options discussed herein the following next steps are recommended:

- Consultation with appropriate regulators (e.g., NSECC, DFO) regarding wetland and/or watercourse restoration, enhancement or expansion opportunities as a method of wetland compensation and/or fish habitat offsetting.
- Obtain necessary landowner permission and access agreements.
- Baseline biophysical assessment including wetland and watercourse delineation and functional assessments, including desktop reviews and in-field surveys for rare or regulated species and features.
- Topographical data collection: ground elevations will determine initial feasibility for the project and determine objectives.

- Detailed design and submission of plan to regulators for approval.
- Regulatory permitting (if required).
- Project implementation and monitoring, as per permit conditions (if required)

7 FOLLOW UP ON ENGAGEMENT

Table 16 outlines MEL responses to various stakeholder concerns or questions raised during stakeholder engagement sessions that MEL was able to provide a response to based on the scope and outcomes of the Study. A full summary of stakeholder input, including points that MEL cannot provide a response to, is available in Section 3 – Stakeholder Engagement.

Table 16 - Engagement Session Responses

Stakeholder	Concern/Question	MEL Response
SWEPS/Halifax Water/CPWAC	Site-specific locations for field assessments	These stakeholders expressed a desire for numerous private-land locations throughout the Study Area to be field assessed, many of which MEL was unsuccessful in receiving property access permissions to conduct a field assessment. As such, field assessments were not completed on those private properties where land access was not permitted, however the model is not constrained by property access permissions, and these areas have been included in the GIS modelling performed.
SWEPS	Concerns around the level of urban development within the Study Area	The GIS model utilized in this Study can predict wetland vulnerabilities in relation to future urban development. This provides a means to compare current baseline wetland vulnerability conditions to a scenario where urban development is occurring within or adjacent to an area of interest.
Public/HRM	Questioned if the Study could be replicated in other watersheds within Nova Scotia	Yes, the Study would have to be fine-tuned to understand specific concerns and variables within the new Study Area as compared to the one utilized in this Study, and that would be done so through literature review and engagement sessions.

Stakeholder	Concern/Question	MEL Response
Public	Examining the value of a GIS model compared to a Study that solely utilizes field assessments	The GIS component of the Study aims to be a predictor of numerous vulnerabilities to wetlands rather than relying on extensive field assessments. Conducting a similar study that solely relies on field assessments creates multiple significant constraints such as the need to receive significant private property access permissions and the financial cost of conducting extensive field assessments. The field component of this Study was to serve as a tool to help calibrate and validate the performance of the GIS model.
Halifax Water	Provided two sites of particular interest to Halifax Water for consideration during field assessments.	MEL was unable to receive property access permissions for the two private land sites provided by Halifax Water. As the GIS model has been run on the entirety of the Study Area, these areas have been assessed at the desktop-GIS level.
CPWAC	Expressed an interest in the Study Area being revised to expand into areas south of Grand Lake and to further include Collin's Park Public Water Supply Area.	MEL revised the Study Area to further expand into areas south of Grand Lake to further include the Collin's Park Public Water Supply Area.
CPWAC	Raised various wetland management concerns	See Appendix A for full list of concerns/recommendations from CPWAC. MEL included the wetland management portion of this Study to further evaluate and identify specific wetlands/areas within the Study Area for wetland management opportunities and feasibility.
MEH	MEH provided seven areas of interest for Source Water Protection for consideration during field assessments.	MEL successfully completed field assessments within six of the seven areas highlighted by MEH. The GIS model has been run in all seven of the areas provided.
MEH	Suggested a Study Area expansion to include areas west of Grand Lake, specifically between Beaverbank Road (Highway 354) and Grand Lake/Kinsac Lake.	MEL revised the Study Area to include areas west of Grand Lake, including between Highway 354 and Kinsac Lake, and Windsor Junction.

Stakeholder	Concern/Question	MEL Response
HRM	Questioned on the involvement of WESP-AC functional wetland assessment in the Study	WESP-AC was utilized within the Study and performed on the 100 wetlands that were field assessed to further capture wetland function and stressors. WESP-AC was also included within the literature review to provide further information on wetland function, characteristics, and stressor impacts.

8 FINAL RECCOMENDATIONS

The wetland vulnerability model was able to provide large-scale insight into the current baseline state of the wetlands within the Study Area. This model has the potential to support future watershed scale planning through review of wetlands and tertiary watersheds identified as that may be most vulnerable and at greater risk of impact from development.

Modeled wetlands that exhibited higher vulnerability scores (in particular those that scored 5 or above) may provide wetland management opportunities, such as mitigations, protection, restoration, or enhancement. Most of these are surrounded by development or agricultural stressors reducing their ability to buffer. Wetlands with these classifications warrant further field investigation to assess on the ground conditions and management feasibility. Of these wetlands predicted to be highly stressed, 7 were assessed as part of the model field verification process where field results ranked them as medium to high impact. Additionally, a few of the selected SWEPS assessment sites exhibit moderate modeled stress scores (i.e., >5), where management opportunities were conceptually discussed in Section 6. Remaining wetlands within the tertiary watershed in Fall River that scored highly impacted for tertiary condition should be reviewed closely as a vulnerable area and potential protection or creation options in this catchment would help improve this score.

Various limitations between both the field and modelling portions of the Study are discussed in this report. A summary of the main overarching limitations is presented below:

- Data limitations limited the models predictive capabilities and this is recognized as the main limitation to the wetland vulnerability model.
- Limited data to support predicting hydrologic stressors (ie. Culverts, storm drains, artificially impounded water, frequency of inundation, water quality, etc.) inhibit the model's ability to predict and consider these stressors.
- Outdated spatial layers (ie. Forestry) limits the tools predictive capabilities.
- The predictive wetland modelling provided by NSECC and utilized in this study as the base wetland spatial layer is a developing tool. This is one of the first times this layer has been utilized and assessed in the field and feedback from this study will help improve its accuracy.

As forestry and landcover data becomes available or technology allows for easier updates of landcover modeling from areal imagery, the model inputs can be updated and re-run following the model process. It would also be possible to update single stressors and re-run the model to review how these stressors would impact the modelled values of surrounding wetlands.

All wetland boundary points, WESP-AC data and GIS model outputs will be provided to NSECC to further the design and update of their predicted wetland layer and understand the current conditions in this Study Area.

9 CLOSING

This report has considered relevant factors and influences pertinent within the scope of the assessment and has completed and provided relevant information in accordance with the methodologies described herein.

This report has been completed to meet the objectives of the NSDPW commissioned Study to develop a GIS-based tool to predict wetland vulnerability and complete field verification as part of Secondary wetland compensation within the Shubenacadie and/or Stewiacke Watersheds. Potential areas for restoration and enhancement have also been outlined in this report.

The conclusions presented in this report are based on available information and current industry standards at the time of the assessment. Please contact the undersigned with any questions with respect the methods or findings of this study at (902) 835-5560.

Thank you very much.

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APPENDIX A : CPWAC LETTER

Collin’s Park Watershed Advisory Committee
c/o 2 Park Ave., Lower Sackville
PO Box 8388, RPO CSC
Halifax, NS B3K 5M1

McCallum Environmental Ltd.
2 Bluewater Rd Suite 115, Bedford, NS B4B 1G7
c/o Andy Walter and Lee Pominville
andy@mccallumenvironmental.com
lee@mccallumenvironmental.com

Re: Wetland Compensation Recommendations to McCallum Environmental

Dear Andy and Lee:

This letter is in response to your generous invitation to the Collin’s Park Watershed Advisory Committee expressed at our meeting April 3 at the Gordon Snow Centre in Fall River, to provide comment for consideration in your Wetland Vulnerability Study (Study) that is part of a Wetland Compensation Project associated with the Highway 102 Aerotech Connector Road Project. We thank you for this opportunity. Our comments also pick up on what you presented at the Shubenacadie Watershed Environmental Protection Society (SWEPS) Blue Green Algae public information session on April 19, at the Inn on the Lake in Fall River.

We feel our comments and recommendations could help to develop a GIS tool that can help identify currently vulnerable (and could be improved) wetlands or will become vulnerable because of future land alteration that are important to watershed health and should be considered for additional protection. The Committee’s comments herein are expressed first in general terms about wetland compensation and vulnerability in Nova Scotia, followed by specific recommendations/comments about drinking water supply watershed wetlands of concern to the Committee.

General Comments about Wetland Compensation and Vulnerability

Generally, the Committee has concerns about how wetlands are treated and compensated for in Nova Scotia. Wetlands perform a host of incredibly valuable functions that include the following: waste and nutrient cycling; protection against erosion, floods and storms; water purification; food production; and are one of the richest known wildlife habitats and an essential link in the food chain according to the Genuine Progress Index (GPI) Atlantic Report by Sara Wilson (2000) – The GPI Water Quality Accounts: Nova Scotia’s Water Resource Values and the Damage Costs of Declining Water Resources and Water Quality.

The Nova Scotia Wetlands Conservation Policy (Policy), updated in 2019, refers to the GPI Atlantic Report (2000) stating that wetland loss to development in Nova Scotia equates to about $2 billion annually in lost ecological services like water purification and recharging drinking waters. Further, because there has been little effort to characterize wetland loss systematically throughout the province, there is considerable uncertainty about original conditions.

It is becoming apparent to governing agencies that conserving, constructing or restoring wetlands may be a more economical option than building water treatment systems to replace the water quality improvement functions that wetlands provide.

In consideration of the important role and economic value that wetlands play to enhance water quality for drinking water supplies and for flood control, the Committee stresses the importance of the province following its Policy for direction and framework for the conservation and management of wetlands in Nova Scotia. The province also should create regulations that support the Policy.

The part of the Policy most applicable to the Committee's specific concerns is the Implementation and Management Actions (IMA) section on page 11 as follows:

> Objective 1 – *To manage human activity in or near wetlands, with the goal of no loss in Wetlands of Special Significance and the goal of preventing net loss in area and function for other wetlands.*

The following Policy – Objective 1-A – applies to Halifax Water's *Bennery Lake Watershed Protected Water Area*, (which lies within the Study Area as shown on Map E attached):

> *A. Wetlands of Special Significance (WSS)*
>
> *Government considers … wetlands in designated protected water areas as described within Section 106 of the Environment Act to be WSS.*

Additionally, NSECC should apply the process, further described in Policy Objective 1-A below, to the wetlands in the Collin's Park and Bomont watershed areas, particularly in the high-risk zones (illustrated on Maps A and E attached) due to their significant hydrologic value to these drinking water supplies:

> *Government will develop a process for classifying additional wetlands or wetland types as WSS. Among the wetland characteristics, functions and services to be considered during this process are whether the area … has significant hydrologic value…*

If the "additional wetlands or wetland types" in the non-designated Collin's Park and Bomont drinking water supply watershed areas are not afforded WSS status by NSECC considering their significant hydrologic value for a drinking water supply area, then the mitigation sequence should be strictly adhered to for these watersheds as described in Objective 1-B as follows:

> *B. Other Wetlands*
>
> *Government will … require all those proposing projects that will negatively affect wetland areas or function to submit an application through the Wetland Alteration Approval process and/or Environmental Assessment process, as appropriate and adhere to the mitigation sequence (see definitions* [that follow]*) to achieve the objective of preventing net loss.*
>
> *"Mitigation sequence" is defined as a process for achieving wetland conservation through the application of a hierarchical progression of alternatives to the adverse effects of alterations. These alternatives include:*
>
> *a) Avoidance of adverse effects*
> *b) Minimization of unavoidable adverse effects*
> *c) Compensation for adverse effects that cannot be avoided*
>
> *Monitoring and an adaptive approach are essential* ***at all three sequence stages*** *to ensure net loss is prevented.*

Further, the Committee questions the model that McCallum Environmental Ltd. has been tasked with applying to determine and prioritise areas for wetland compensation, which NSECC uses province-wide, i.e., for every hectare of wetland lost to development, 2 hectares of compensation must be provided, which could be anywhere in the province and not necessarily within the affected catchment. This model has an inherent bias toward providing compensation in undeveloped, rural, or forested areas rather than in more intensively developed urban or suburban catchments where land costs are much higher.

In developed areas such as those within the suburban areas of the Collin's Park Watershed Area, much of the pre-existing wetland areas have been infilled, and options for compensation are fewer. Arguably, the need for wetlands is greatest in suburban areas where most residents rely on wells or surface water for their potable water. Considering these needs, a hectare of "urban wetland" is more valuable than a hectare of "rural wetland". Rather than a straight "hectare for hectare" compensation agreement, we suggest that NSECC develop a cost-benefit model that accounts for a wetland's value, to review proposals more accurately for wetland compensation.

Moreover, the Committee has observed, through its review of numerous development applications, NSECC's practice of approving the infilling of wetlands that provide resident time for stormwater and flood risk mitigation. The Committee questions this practice and recommends that it be stopped.

Specific Comments about Wetland Compensation and Vulnerability in the Study Area

Specifically, the Committee is concerned about the water quality of the Halifax Water drinking water supply areas that fall within the SWEPS Wetland Vulnerability Study (Secondary Wetland Compensation Project) area. The following comments correspond with many of your April 19 presentation headings as follows: study area; wetland policy; wetland management options; wetlands for consideration; data and resources; key wetland stressors; beneficiaries of the tool and who to share the study with; and outcomes resulting from the Study and recommendations.

The Study Area

The Committee is curious about how the Study Area was derived since it does not appear to follow subwatershed boundary areas. Currently, the Study Area encompasses the Collin's Park Watershed Area Intake Protection Zone (IPZ) (see Map A) and the Bennery Lake Protected Water Area, shown on your Study Area map – slide 3 of your April 19 presentation – and on Map D attached, and a portion of the Bomont Watershed Area (see Maps D and E).

The Committee feels that the Study Area should be expanded at least to incorporate all of the subwatershed area boundaries within the whole Collin's Park Watershed Area (see Map B) to ensure the hydrologic connections within each subwatershed area are captured, accounted for and identified as important hydrologic components of the drinking water supply watershed.

Consideration should also be given to the Bomont drinking water supply area (see Map C) (for which the Committee occasionally provides advice, at the request of Halifax Water, on issues that have the potential to impact the Bomont water supply), which is also partially contained in your Study Area. If considering all of this area is not feasible, at least consider the whole of each subwatershed area in the Bomont's Water Supply Area High Risk Area Zone (RAZ) (see Map E) in your Study Area, as it is currently partially contained in your Study Area.

The areas the Committee is suggesting should be included in the Study Area warrant protection from impacts that have the potential to impair raw drinking water quality to avoid the need for the water utility to upgrade or enhance its treatment application to mitigate such impacts.

Wetland Policy

Wetland Policy was discussed at length under the General Comments section above.

Wetland Management

The Committee's principal message is that all wetlands are important and should be preserved. As stated in the Policy, discussed under the general section of this document, if it is not possible to avoid the destruction of the wetlands, the Committee supports applying the alternatives outlined in the Mitigation Sequence defined in the Policy. In addition to these alternatives, the Committee suggests the following:

a. Engineered Wetlands

The Committee asks that the Study recommend the province reconsider wetland compensation for the Aerotech Connector, (and future compensation agreements), whereby the 1:2 ratio for compensation be suspended and consider development of artificial/engineered wetlands instead, considering the following: many large wetlands have already been lost within the Shubenacadie watershed area, leaving a dendritic pattern of small wetlands, which, despite their size, still play an important role in maintaining water quality. Many of these wetlands are too small to be mapped at a regional scale and are being progressively lost to development.

To compensate for the loss of small wetlands, the Committee suggests pursuing compensation scaling. There might be value in providing some credit to the developer in the multiplier for hectares restored, for their willingness to install an engineered wetland in the area of the damage or add an engineered wetland component to the remaining wetland with the emphasis on water flow. That might be highly beneficial in areas of a series of small, connected wetlands in suburban and urban areas since it maintains an enhanced filtering system in the immediate area.

b. Purchase Wetlands

The CPWAC recommends that the province consider purchasing wetlands for protection within the study area.

Wetlands for Consideration

The Committee has identified vulnerable wetlands for consideration based on future land alteration potential, per the definition of "vulnerable" in your April 19 presentation, i.e., *"wetlands that play crucial functions that if impacted in the future, could create significant issues (i.e., vulnerable)".*

Small Wetlands

While it may not be possible to identify all the smaller wetlands in the Study Area which the Committee considers vulnerable, we recommend more intensive data collection and verification of all wetlands in the high-risk drinking water quality impact zones, as identified in Halifax Water's Bomont and Collin's Park source water protection plans (see Maps A and E). Smaller wetlands provide stormwater resident time and are often infilled, as previously mentioned. A specific instance of this is described under "b." in the next section.

Specifically Vulnerable Wetlands to Consider for Protection

Two prime examples of vulnerable wetlands in the Collin's Park watershed area are demonstrated by developments proposed around and in wetlands, as described below.

a. Holland Road

A development is proposed off Holland Road around a >4-hectare wetland at the headwaters of two contiguous streams that flow through this wetland, one of which enters Lake Fletcher approximately 500 metres upstream of the Collin's Park water supply intake (see Map A – "significant wetland under immediate threat").

The Committee believes that due to this wetland's location, size and use as a natural filter for the streams flowing through it means it has "significant hydrologic value", per the Policy, which the CPWAC feels should classify this wetland as one of special significance, as discussed under the General Comments section under Objective 1.

This wetland is considered by the Committee as one under immediate threat because of a proposed "as-of-right" development. As of February 2022, 13 lots were registered, of which eight (8) (PIDs 41526864 (flag lot), 41526856 (flag lot), 41526872, 41526807 (flag lot), 41526880 (flag lot), 41526898 (flag lot), 41526781 and 41526773) contain a portion of the same contiguous wetland area. Of the eight (8) lots, three (3) are flag lots that direct the flag "pole" through the wetland. Before February 2022, portions of this >4 ha wetland were already contained in existing lots along Holland Road (PIDs 41356841, 00529248, 00527515, 00527440, 00527887, 00527911, 00528000, 00527671, 00527572, 00527622, 00527903, 00527689 and 00528166).

The current municipal bylaw states there must be a 20 m buffer around a wetland; however, once individual landowners have "custody" of the land containing the wetland, there are no guarantees that the wetlands and the buffer around it will not be encroached upon, due to the regulators' reliance on the public to report on neighbours who are violating bylaws and regulations, which, by and large, only then leads to inspectors visiting the properties that are in violation.

Additionally, the landowners of the three (3) flag lots could be permitted under the Policy to construct a driveway along the "pole" portion of the lot to Holland Road, should they so desire, potentially fragmenting an important wetland and creating a negative impact on the watershed area.

b. St. Andrew's Village Subdivision

The Committee reviewed a preliminary subdivision application for a property at 61 Maranatha Drive in Fall River in the St. Andrews Village Subdivision, where there is an unmapped wetland, situated downstream and east of the upper arm of "A" Lake, in the lower left quadrant of the IPZ (see Map A).

Upon review of the application, the Committee discovered that NSECC approved the infilling of the wetland (approval File # 41116153-2022-3003073), despite this wetland area being granted an approximate 11,000 square foot storm drainage easement in 2004 to provide resident time for stormwater in the area. Moreover, the preliminary subdivision application (# 24615) indicates an intention to apply to NSECC for an OSSDS in the approved infilled area.

The Committee questions why and how NSECC approved the infilling of a wetland that has a storm drainage easement attached to it and has expressed its concern about the infill approval and proposed OSSDS application in a letter to the Minister of Environment, dated January 20, 2023.

The Committee recommends that wetland infill practices be stopped within drinking water supply areas and to search properties for covenants that may designate wetland areas for stormwater catchment purposes to protect water quality, regardless of their location.

This example also underscores the importance of establishing and maintaining GIS data of all wetlands.

The potential development around, through and in these wetlands allows further loss of areas that otherwise could provide resident time for water to stay in the catchment rather than facilitate another conduit for stormwater runoff, which is bad for water. Consider, too, that these proposed developments and wetlands are currently situated in the IPZ, defined in the Collin's Park Source Water Protection Plan (SWPP) and illustrated on Map C attached.

The Collin's Park SWPP assesses risk areas within this large watershed according to the level of potential impact to the water. For instance, most of the land within the IPZ of the Collin's Park watershed area (shown on Map C) has the highest risk (red) rating because the drainage from these tertiary subwatershed area lands enter Lake Fletcher in the closest proximity to the water supply intake (shown on Map B). However, note that some of the land area in the IPZ was identified as a Medium (yellow) RAZ in 2018, which includes the area now proposed for the Holland Road development (a.), because there was limited land use impact at the time. However, the Medium (yellow) risk rating will change to the highest (red) RAZ rating once it is developed and OSSDS are installed; as stated in the Collin's Park SWPP (p. 88) "in the event of development activity, the risk would be increased to high (red) depending on the types of land use activity that are permitted, per HRM District 14/17 MPS RE (Resource Designation) Policies P-128 – P-131."

Considering these points, all wetlands inside the IPZ should be mapped as WSS, because of the potential impact to the public drinking water supply if their hydrology is interfered with.

Further, in addition to mapping the wetlands in the IPZ as WSS, also consider that wetland loss is assumed to be greater as one moves upstream in the Collin's Park Watershed area toward the more urban-developed Dartmouth area. Therefore, adherence to the mitigation sequence is paramount in these areas as well as within the IPZ. Moreover, as discussed under the General Comment section, all areas within the drinking water supply watershed should be considered WSS.

Data and Resources

The data requested by McCallum at our April 3 meeting, i.e., shapefiles and water quality information, is owned and maintained by Halifax Water, for which Halifax Water data sharing protocols apply. Halifax Water is working with McCallum to finalize the data transfer and required agreement.

Compilation of and maintaining a current wetland database will be a valuable benchmark and living document to not only determine where wetland compensation should be applied, but also for broader development and planning by HRM, NSCC and Halifax Water. The Committee encourages making the model and database available to the public.

Key Wetland Stressors

Collin's Park and Bomont Watershed Areas

The wetlands in the Collin's Park IPZ (see Map A) and Bomont's high (red) RAZ (see Map E) are constantly under stress due to current and future development as described above and throughout the Collin's Park and Bomont SWPPs, and correspond to the list provided in your April 19 presentation as follows:

i. Contaminants & eutrophication

ii. Industries (sod, farming, forestry, urban development, land cover disturbances – *the first three are especially applicable to the Bomont red RAZ*)

iii. Soil sediment alteration

iv. Flooding

v. Climate change

Beneficiaries of the Tool and Who to Share Study With

The Committee suggests sharing the Study and Tool with HRM Planning & Development for them to assess and consider as part of the HRM Regional Plan Review.

The compilation of the wetland database will be a valuable benchmark and living document to not just determine where wetland compensation should be applied but also for broader development and planning by HRM, NSECC and Halifax Water. We also encourage making the model and database available to the public.

HRM and East Hants Planning & Development, the HRM Wetland Working Group and NSECC will be copied on these Study recommendations/comments from and by the Committee.

Desired Outcomes and Overview of Recommendations

General Comments

The following is a recap of the comments and recommendations described above:

Wetland Policy

1. All wetlands are important and should be preserved. However, if it is not possible to avoid the destruction of the wetlands, the Mitigation Sequence defined in the Policy must be applied. Further, the province should create regulations that support the Policy.

2. In consideration of the important role wetlands play to enhance water quality for the Collin's Park and Bomont drinking water supply and for flood control, the Committee stresses the importance of the province following the Policy for direction and framework for the conservation and management of wetlands within these watersheds.

3. The province should reconsider wetland compensation for the Aerotech Connector, (and future compensation agreements), by suspending the 1:2 ratio for compensation and development of artificial wetlands.

4. Rather than a straight "hectare for hectare" compensation agreement, we suggest that NSECC develop a cost-benefit model that accounts for a wetland's value, to review proposals more accurately for wetland compensation.

5. Before approving wetland infilling, search properties for covenants that may designate wetland areas for stormwater catchment purposes that protect water quality.

Specific Watershed Comments/Recommendations

Study Area

6. Expand the Study Area to incorporate all of the subwatershed area boundaries within the whole Collin's Park Watershed Area (see Map B) to ensure that the hydrologic connections within each subwatershed area are captured, accounted for, and identified as important hydrologic components of the drinking water supply watershed.

7. Consideration should be given to the Bomont drinking water supply area (for which the Committee, on occasion, at the request of Halifax Water provides advice on issues that have the potential to impact the water supply), which is also partially contained in your Study Area (see Map C). If consideration of this whole watershed area is not feasible, consider the whole of each subwatershed area in the Bomont's Water Supply Area High RAZ (see Map E) in your Study Area, as some are currently only partially contained in your Study Area.

8. All of the areas the Committee recommends should be included in the Study Area warrant protection from impacts that have the potential to impair raw drinking water quality to avoid the need for the water utility to upgrade or enhance its treatment application to mitigate them.

Wetland Management

9. Pursue compensation scaling for wetland restoration and/or enhancement. There might be value in providing some credit to the developer in the multiplier for hectares restored for their willingness to install an engineered wetland in the area of the damage or add an engineered wetland component to the remaining wetland where the emphasis must be on water flow. That might be highly beneficial in areas of a series of small, connected wetlands in urban areas since it maintains an enhanced filtering system in the immediate area.

Vulnerable Wetlands for Consideration

10. The wetland off Holland Road, surrounded by a proposed development (a.), is an important feature of the Collin's Park municipal drinking water supply watershed area (see Map A: "*significant wetland under immediate threat*"), as it is situated at the headwaters of the last significant and largest input/tributary to Fletcher Lake upstream of the Collin's Park water supply plant. Considering the over-riding concern the Committee has with regard to maintaining water quality, this wetland should be protected from further development impacts that may include infilling and wetland fracturing.

11. All the wetlands inside the IPZ should be mapped as WSS, considering the potential impact to the public drinking water supply from hydrology interference.

12. Also consider that wetland loss is assumed to be greater as one moves upstream in the Collin's Park Watershed area toward the more urban-developed Dartmouth area; therefore, adherence to the mitigation sequence is paramount in this area as well as within the IPZ.

13. Small unmapped wetland infill practices should be stopped within drinking water supply areas, especially in urban and suburban areas.
14. NSECC must search properties for covenants that may designate wetland areas for stormwater catchment purposes to protect water quality, regardless of their location, before approving infilling.
15. The importance of establishing and maintaining GIS data of current wetlands cannot be understated.

Data Collection and Verification

16. Undertake intensive data collection and verification in the high-risk drinking water quality impact zones as identified in Halifax Water's Bomont and Collin's Park source water protection plans (see Maps) to ensure the smaller wetlands are accounted for.

Who to Share Tool, Study and Our Comments With

17. Share the study and tool with HRM Planning & Development for them to assess and consider as part of their Regional Plan Review.
18. HRM Planning & Development, the HRM Wetland Working Group and NSECC will be advised of these recommendations/comments by the Committee.

The Committee very much appreciates this opportunity to provide comment. We wish to continue this dialogue as the Study progresses and look forward to receiving any comments or questions you may have about these recommendations and comments. Please reach out to me at the email below.

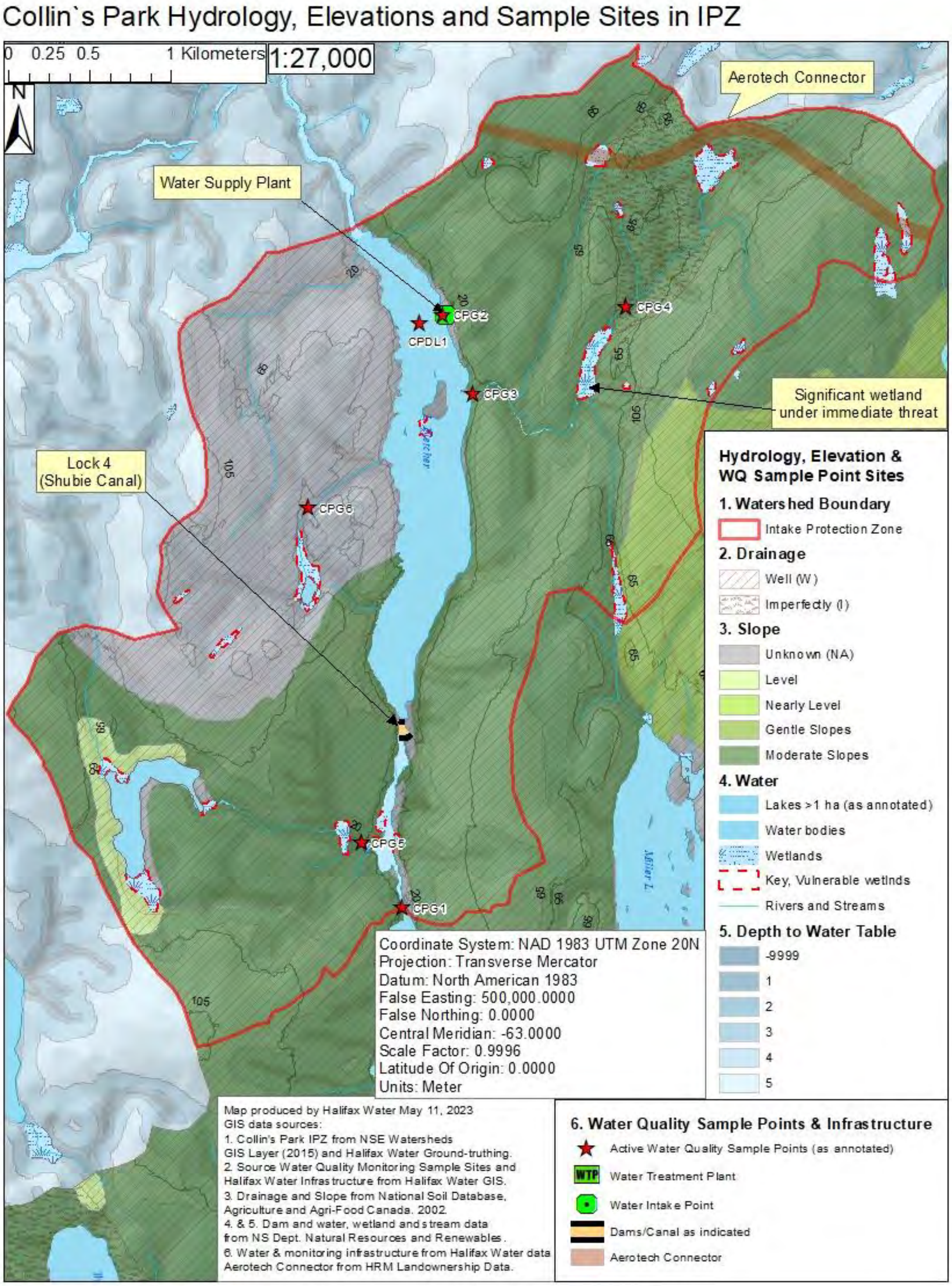
Respectfully,

ORIGINAL SIGNED

Dr. Richard Pickrill, Chair CPWAC
dpickrill@gmail.com

Cc:
Honorable Timothy Halman, Minister of Environment and Climate Change
Honourable Kim Masland, Minister of Public Works
Cathy Deagle Gammon, HRM District 1 Councillor
Elizabeth Kennedy, Director, Water Branch, Nova Scotia Environment and Climate Change
John Woodford, Director of Planning & Development, Municipality of East Hants
Jesse Hulsman, Director of Infrastructure & Operations at the Municipality of East Hants
Kelly Denty, Executive Director, Planning and Development, Halifax Regional Municipality
Kenda McKenzie, Director Regulatory Services, Halifax Water
Tom Mills, Chair, Shubenacadie Watershed Environmental Protection Society
Collin's Park Watershed Advisory Committee Members

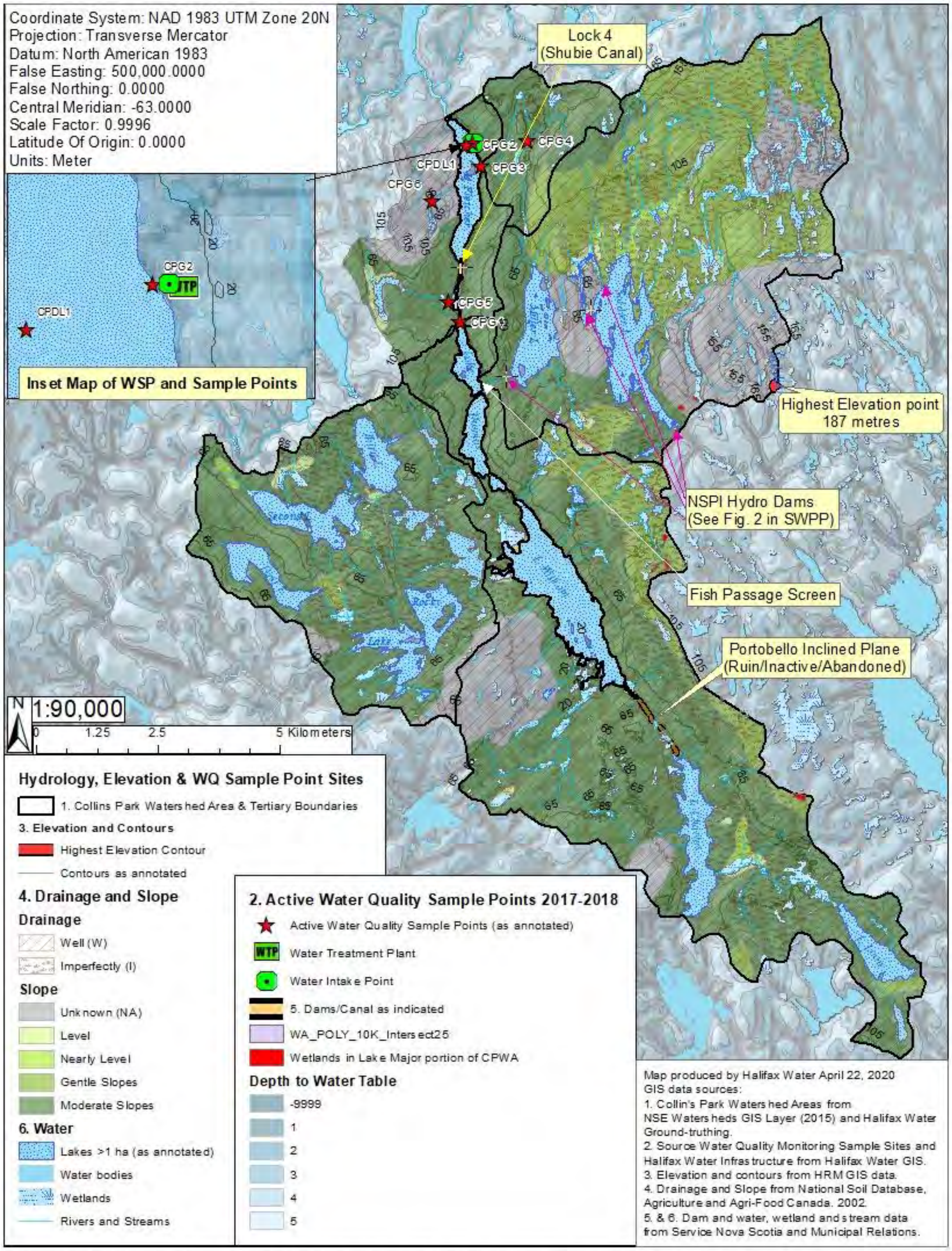
Map A



*This map is for informational purposes only and should not be used for legal, engineering or surveying purposes.

Map B

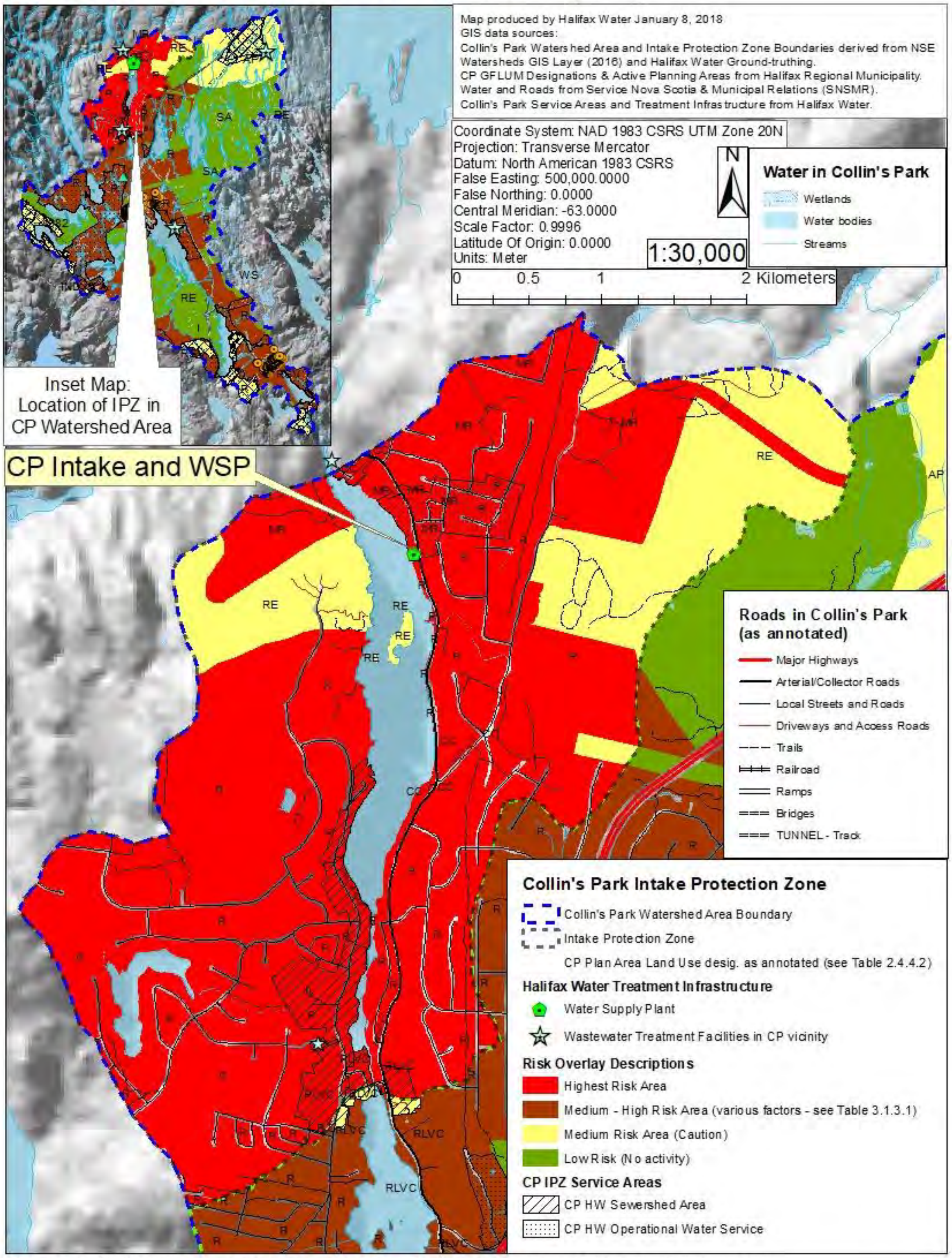
Collin`s Park Hydrology, Elevations and Sample Sites



*This map is for informational purposes only and should not be used for legal, engineering or surveying purposes.

Map C

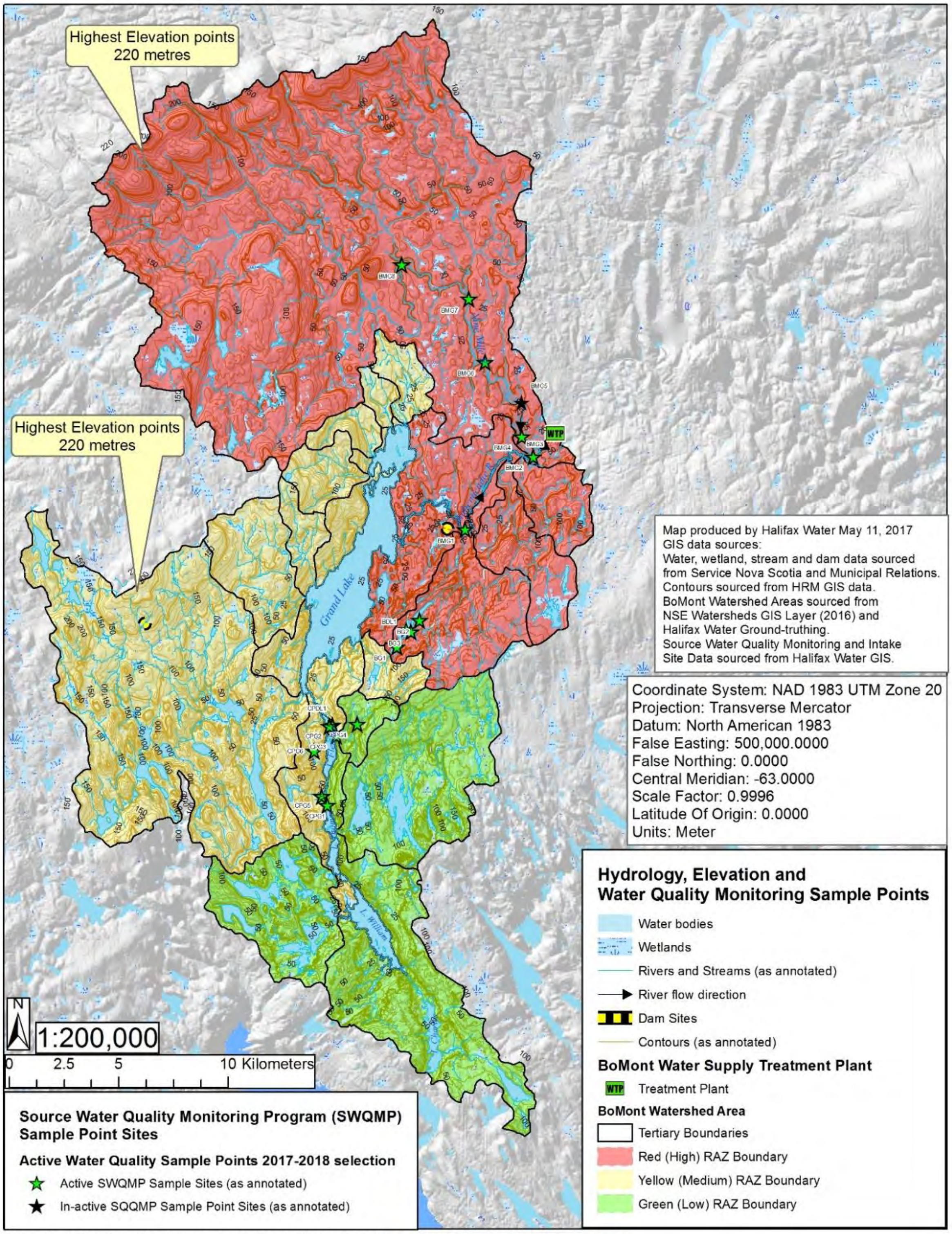
Collin's Park Intake Protection Zone (IPZ)



*This map is for informational purposes only and should not be used for legal, engineering or surveying purposes.

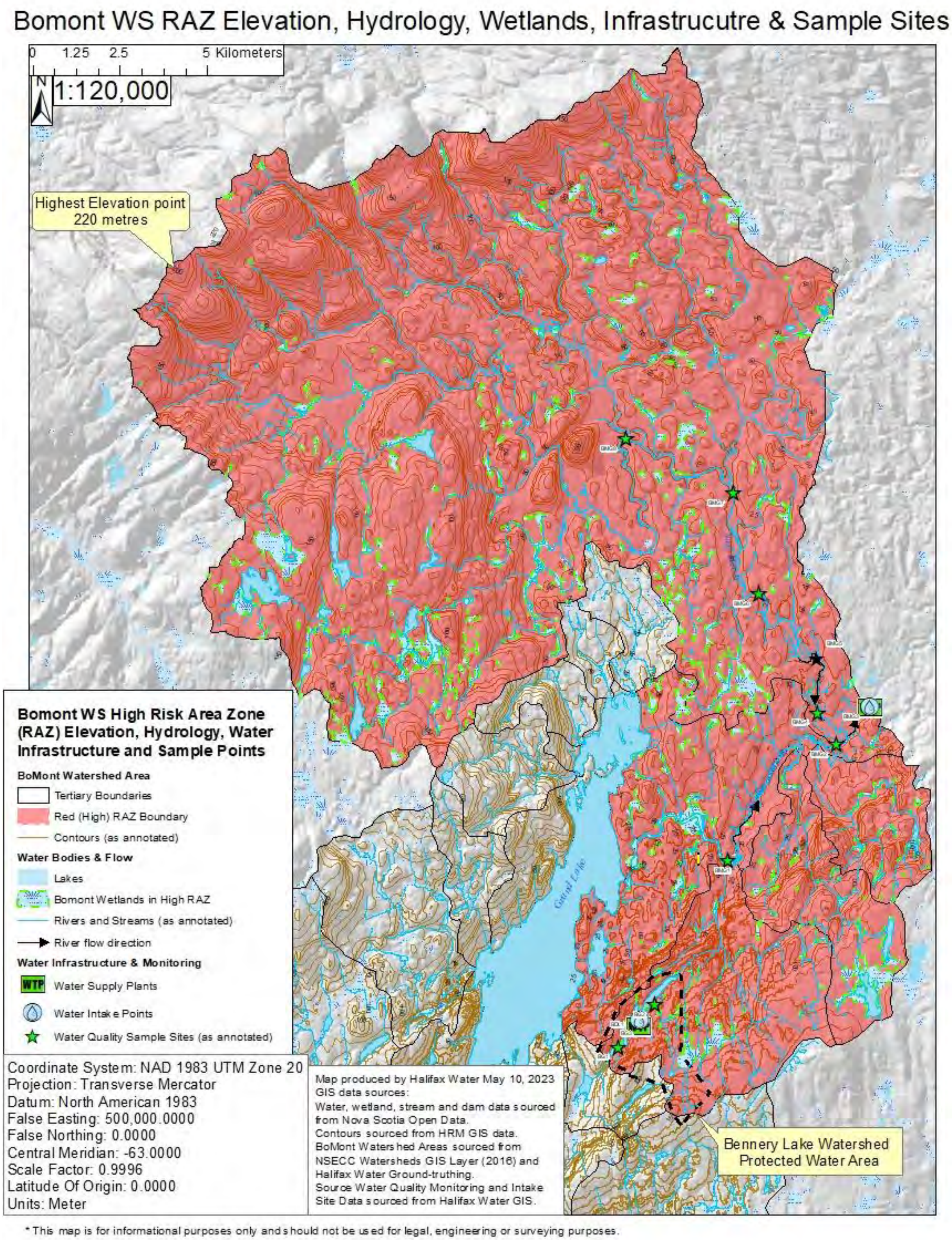
Map D

BoMont Hydrology, Elevations, Sample Sites and Risk Area Zones (RAZs)



* This map is for informational purposes only and should not be used for legal, engineering or surveying purposes.

Map E



Bomont WS RAZ Elevation, Hydrology, Wetlands, Infrastrucutre & Sample Sites
0 1.25 2.5 5 Kilometers
N
1:120,000
Highest Elevation point
220 metres
Bomont WS High Risk Area Zone (RAZ) Elevation, Hydrology, Water Infrastructure and Sample Points
BoMont Watershed Area
Tertiary Boundaries
Red (High) RAZ Boundary
Contours (as annotated)
Water Bodies & Flow
Lakes
Bomont Wetlands in High RAZ
Rivers and Streams (as annotated)
River flow direction
Water Infrastructure & Monitoring
WTP
Water Supply Plants
Water Intake Points
Water Quality Sample Sites (as annotated)
Coordinate System: NAD 1983 UTM Zone 20
Projection: Transverse Mercator
Datum: North American 1983
False Easting: 500,000.0000
False Northing: 0.0000
Central Meridian: -63.0000
Scale Factor: 0.9996
Latitude Of Origin: 0.0000
Units: Meter
Map produced by Halifax Water May 10, 2023
GIS data sources:
Water, wetland, stream and dam data sourced from Nova Scotia Open Data.
Contours sourced from HRM GIS data.
BoMont Watershed Areas sourced from NSECC Watersheds GIS Layer (2016) and Halifax Water Ground-truthing.
Source Water Quality Monitoring and Intake Site Data sourced from Halifax Water GIS.
Bennery Lake Watershed
Protected Water Area
Grand Lake
* This map is for informational purposes only and should not be used for legal, engineering or surveying purposes.

APPENDIX B : STRESSOR FIELD FORM

Wetland Stressor Form

Date: _________WL: _____ Assessor: ________

Northing: ____________ Easting: ____________

Weather: ____________ %FLC: ___________

	0-3m	3-10m	10-30m	30-100m	>100m
Natural forest	6	8	10	12	14
Shrub/sapling	4	6	8	10	12
Perennial herb	2	4	6	8	10
Other	0	0	0	0	0

True Boundary Points Taken? ___________

SAR/SOCI: ___________________________

Buffer Score: _______ Stressor Score: __________

Buffer Hits: ________

Hydrologic Modification Score: _______

- Ditching
- Tile drain
- Dike
- Weir/Dam
- Point source (non-stormwater)
- Filling/grading/dredging
- Roadbed/railroad
- Dead/dying trees
- Evidence of stormwater input (ditch, swale, culvert, etc.)
- Excavation within the wetland
- Other_____________

Sedimentation Score: _______

- Sediment deposits/plumes
- Eroding banks/slopes
- Forestry
- Active construction/plowing/heavy grazing/forest harvesting adjacent
- Siltiness on ground or on vegetation
- Urban/road stormwater inputs (i.e. culverts, storm drains)
- Dominant prescence (>50%) of sediment tolerant plants
- Evidence of water carried debris, sand and gravel, deposits, plumes
- Other_____________

Dissolved Oxygen Score: _______

- Excessive density of aquatic plants or algal mats in water columns
- Excessive deposition or dumping of organic waste
- Direct discharges of organic wastewater or material
- Other____________

Contaminate Toxicity Score: _______

- Severe vegetation stress
- Obvious spills, discharges, plumes, odors
- Wildlife impacts (ex. Tumors abnormalities)
- Adjacent industrial sites, or near railroad
- Other____________

Salinity Score: _______

- Obvious increase in concentration of dissolved salts
- Other____________

Vegetation Stress Score: _______

- Mowing
- Grazing
- Tree cutting (>50% canopy removal)
- Brush cutting
- Removal of woody debris
- Aquatic weed control
- Excessive herbivory
- Dominant presence (>50%) of exotic or aggressive plant species
- Evidence of chemical defoliation
- Other_______________

Eutrophication Score: ________

- Direct discharges from agricultural feedlots, manure pits etc.
- Direct discharges from septic or sewage treatment systems
- moderate or heavy formation of algal mats
- Dominant presence (>50%) of nutrient tolerant species
- Other (ex. Signs of excess nutrients, methane odor, dead fish) ___________

Acidification Score: _________

- AMD discharges
- Adjacent mined lands/spoil piles
- Excessively clear water
- Absence of expected biota
- Other____________

Turbidity Score: _________

- High concentration of suspended solids in water column
- Moderate concentration of suspended solids in water column

Thermal Alteration Score: _________

- Significant increase in water temperature
- Moderate increase in water temperature

APPENDIX C : STRESSOR RESULTS

WL ID	Stressor Score
WL1	5
WL2	2
WL3	0
WL4	0
WL5	2
WL6	9
WL7	21
WL8	30
WL9	11
WL10	5
WL11	35
WL12	24
WL13	20
WL14	5
WL15	0
WL16	0
WL17	82
WL18	79
WL19	25
WL20	30
WL21	74
WL22	40
WL23	61
WL24	49
WL25	24
WL26	23
WL27	8
WL28	2
WL29	23
WL30	14
WL31	39
WL32	0
WL33	0
WL34	62
WL35	60
WL36	4
WL37	37
WL38	38
WL39	52
WL40	39
WL41	20

WL ID	Stressor Score
WL42	14
WL43	91
WL44	61
WL45	37
WL46	41
WL47	63
WL48	45
WL49	46
WL50	56
WL51	28
WL52	37
WL53	53
WL54	26
WL55	46
WL56	58
WL57	43
WL58	53
WL59	62
WL60	31
WL61	81
WL62	20
WL63	21
WL64	77
WL65	75
WL66	64
WL67	60
WL68	53
WL69	71
WL70	80
WL71	20
WL72	35
WL73	31
WL74	31
WL75	35
WL76	18
WL77	18
WL78	26
WL79	28
WL80	24
WL81	30
WL82	0

WL ID	Stressor Score
WL83	41
WL84	18
WL85	35
WL86	20
WL87	47
WL88	18
WL89	55
WL90	25
WL91	33
WL92	31
WL93	18
WL94	31
WL95	37
WL96	31
WL97	43
WL98	90
WL99	60
WL100	15