

Muskoka River Watershed IWM Natural Capital Inventory

Addendum 2: Refinement of Land cover Types

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November 10th, 2023

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4. REFERENCES ..... ERROR! BOOKMARK NOT DEFINED.



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INTRODUCTION AND OBJECTIVES

This assignment included updates to the training data and outputs for select land cover types. Updates include digitizing additional training data through orthophoto interpretation that represent the land cover types and using the resulting trained model to reclassify the predicted land cover types across the watershed. Emphasis was placed on agricultural lands that were classified as wetland, unclassified areas that are likely anthropogenic (e.g., golf courses, lawns, and other manicured spaces), and rock barren/anthropogenic impervious areas. The updated classification of rock barren focused on adding training data from the Georgian Bay shoreline areas. Machine learning tools were run on each of these training sets to produce land cover classifications. Each of these were subject to postprocessing and then reintegrated with the existing land cover layer.

METHODS

1.1 UPDATED CLASSIFICATION MODEL

1.1.1 LAWNS

Training data was manually digitized for lawns and other manicured areas such as golf courses and sports fields. A total of 798 features were digitized, encompassing an area of 451.23 hectares.
ArcGIS Pro's Export Training Data for Deep Learning geoprocessing tool was used to create a deep learning training dataset. The following parameters were used:

- Input raster: 1-metre orthophoto
- Image format: TIFF
- Tile Size: 100 x 100
- Stride: 80
- Minimum polygon overlap ratio: 0

Next, the model was trained using the Train Deep Learning Tool with the following parameters:

- Max epochs: 35
- Model type: U-Net
- Batch size: 8
- Backbone mode: ResNet-34
- Chip size: 224
- Validation %: 30

To produce the classified land cover layer, the Classify Pixels Using Deep Learning Tool was used with the follow parameters:

- Padding: 25
- Batch size: 4
- Tile size: 100

Accuracy metrics reported by the tool were as follows:

- Precision: 0.72
- F1: 0.65
- Recall: 0.59

Upon visual inspection of the classification results, results were comprehensive and overall satisfactory although the model did not always accurately capture the full extent of turf areas.

1.1.2 Agricultural Fields

Areas where a false positive for wetlands occurred in an agricultural area were identified by visual inspection. A new agricultural field training set was manually digitized, taking care to include all these areas as well as any other fields that had not been identified by the previous iteration of the classification tools. The resulting training dataset included 685 features (5,244.90 ha).

As with the lawns layer, ArcGIS Pro's Export Training Data for Deep Learning geoprocessing tool was used to create a deep learning training dataset. The following parameters were used:

- Input raster: 1-metre orthophoto
- Image format: TIFF
- Tile Size: 100 x 100
- Stride: 80
- Minimum polygon overlap ratio: 0

Next, the model was trained using the Train Deep Learning Tool with the following parameters:

- Max epochs: 35
- Model type: U-Net
- Batch size: 8
- Backbone mode: ResNet-34
- Chip size: 224
- Validation %: 30

Accuracy metrics reported by the tool were as follows:

- Precision: 0.83
- F1: 0.66
- Recall: 0.55

1.1.3 Rock Barrens

A new rock barren field training set was manually digitized, with a focus on the exposed rock areas along the Lake Huron shoreline and on nearby islands to the immediate west of the study area. The resulting training dataset included 781 features (270.53 ha).

To produce an updated classified layer representing rock barren areas, the same tools and general methodology were used as in the above two cases. ArcGIS Pro's Export Training Data for Deep Learning

geoprocessing tool was used to create a deep learning training dataset. The following parameters were used:

- Input raster: 1-metre orthophoto
- Image format: TIFF
- Tile Size: 100 x 100
- Stride: 80
- Minimum polygon overlap ratio: 0

Next, the model was trained using the Train Deep Learning Tool with the following parameters:

- Max epochs: 35
- Model type: U-Net
- Batch size: 8
- Backbone mode: ResNet-34
- Chip size: 224
- Validation %: 30

Accuracy metrics reported by the tool were as follows:

- Precision: 0.73
- F1: 0.69
- Recall: 0.64

Upon visual inspection of the classification results, the predicted land cover indicated occurrence of false positives where impervious surfaces such as paved roads were sometimes identified by the model as rock barrens.

1.1.4 POSTPROCESSING

For each of the three new datasets described above, the following postprocessing steps were employed:

- Majority Filter – To address irregular pixelation.
- Boundary Clean – To smooth feature edge boundaries.
- Region Group – To identify contiguous regions within the layer.
- Extract by Attributes – To remove areas of less than 100 m^2 as identified by the Region Group tool.

1.2 DATA INTEGRATION

While it was recognized that misclassifications had occurred between agricultural fields and wetlands in the original land cover model, the model and post processing performed well at delineating feature boundaries. So, rather than updating the geometry to reflect the new agriculture classification layer, the existing feature boundaries were used and updated where it was determined the land cover was likely agriculture.

To do this, a new analysis layer was created by combining the new classified layer, 'field' features from the FRI data, and the previous agriculture layer. The new layer contained a 'score' attribute to determine likelihood of the feature indeed being an agriculture field. Where scores of 3 or more intersected with a feature previously defined as wetland, the classification was updated to agriculture.

For lawns and rock barrens, because these features that were found to be sometimes absent in the previous deliverable and because accuracy metrics were higher than in the previous deliverable, geometry updates were included.

All three new layers were merged with the existing land cover layer to create a new raster.

1.3 CLASSIFICATION OF 'NODATA' AREAS

In the previous version of the Natural Capital report, it was noted that null (or 'NoData') areas were present in the land cover. Visual inspection of the data indicated that most of the missing areas represented lawns, recreational fields, and other developed land use types. Because the updated classification model included lawns, this issue was largely resolved by the new classification results. However, the new integrated layer still included a number of NoData areas requiring further processing.

To address this and create a complete, contiguous layer, NoData areas of greater than 100 m^2 were identified and exported using the Extract by Attributes tool, creating a new layer representing these undefined areas. These were joined with the FRI layer and assigned a classification based on FRI attributes. Remaining NoData areas (i.e., ≤ 100m^2 were amended using the Nibble tool to fill in the missing values with those of adjacent areas. The result was a complete land cover raster with no empty pixels.

This layer was converted to vector and schema updates were made to ensure attribute data was internally consistent and matched the format of the previous deliverable.

DELIVERABLES AND RESULTS

In total, approximately 4523 ha of additional land was classified using the updated model (Table 1). The largest change in land cover area was realized for Anthropogenic cover (increase of 4635 ha). The increase is attributed to the updated model classifying areas of 'Lawn' (including manicured areas such as ski hills, urban parks, and residential gardens) and reclassification of areas that were previously Agricultural Field. Furthermore, the largest increases in Anthropogenic cover were realized in the Lake Rosseau and Lake Muskoka – Muskoka River, and North Branch Muskoka River subwatersheds (collectively, the increases summed to 2383 ha, which is over 50% of the increase across the watershed). Similarly, the concomitant decrease in Agricultural Field was realized in same three subwatersheds (collectively, the decrease summed to 2510 ha).

The area of Rock Barren cover also increased using the updated model (increase of 2283 ha). The largest increases were realized within the Moon River Bay, Musquash River, Lake Rosseau, Lake Muskoka-Muskoka

River, and North Branch Muskoka River subwatersheds (collectively, the increase within these subwatersheds summed to 2153 ha).

The remaining land cover types had relatively small changes as a result of the updated model. This included:

- Forest cover decreased overall by 536 ha, with changes varying from a decrease of 365 ha in the Lake Muskoka – Muskoka River subwatershed to an increase of 83 ha in the Tea Lake – Oxtongue River subwatershed.
- Wetland cover increased by 500 ha, with increases across subwatersheds ranging from 7 ha in the North Branch Muskoka River subwatershed to 76 ha in the Lake Rosseau subwatershed.
- Aquatic cover increased by 267 ha.
- Shrub cover decreased by 4 ha.
- Meadow cover decreased by less than 1 ha.

Table 1. Watershed-scale area (ha) of land cover classes based on updated classification of Lawn/Manicured areas, Rock Barren, and Agricultural areas.

Land Cover Classification	2022 Area (ha)	2023 Area (ha)	Difference (ha)
Agricultural Field	9156.21	6533.58	-2622.63
Anthropogenic	8731.58	13366.62	4635.04
Aquatic	82558.03	82825.15	267.12
Barren	1897.35	4180.65	2283.31
Forest	338448.50	337912.73	-535.77
Meadow	33.65	33.39	-0.27
Shrub	2520.65	2516.53	-4.12
Wetland	94279.01	94779.13	500.12
Total	**537624.98**	**542147.78**	**4522.80**

The associated land cover mapping is presented at the watershed-scale (Map 1) and among subwatersheds (Maps 2-1 to 2-14). Details regarding the land cover changes within each subwatershed are included in the Appendix A.

Respectfully Submitted,



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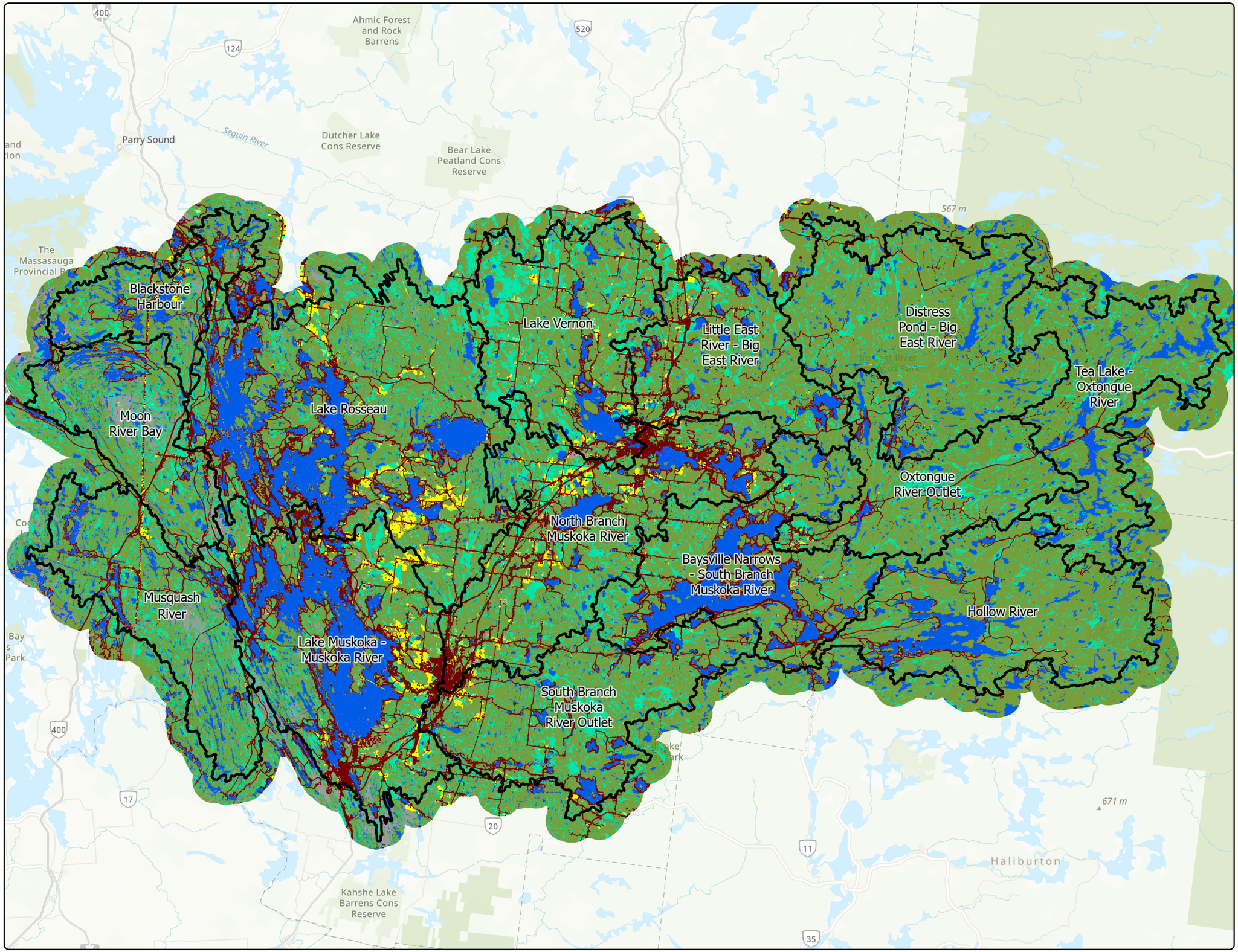

Map 1: Refined Land Cover

Muskoka River Watershed IWM -
Natural Capital Inventory
Addendum 2: Refinements of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 3,500 7,000 14,000

Metres

1:380,000

North American 1983 CSRS UTM Zone 17N

Basemap Source: Province of Ontario, Esri Canada, Esri, HERE, Garmin, SafeGraph, FAO, METI/NASA, USGS, EPA, NPS, NRCan, Parks Canada

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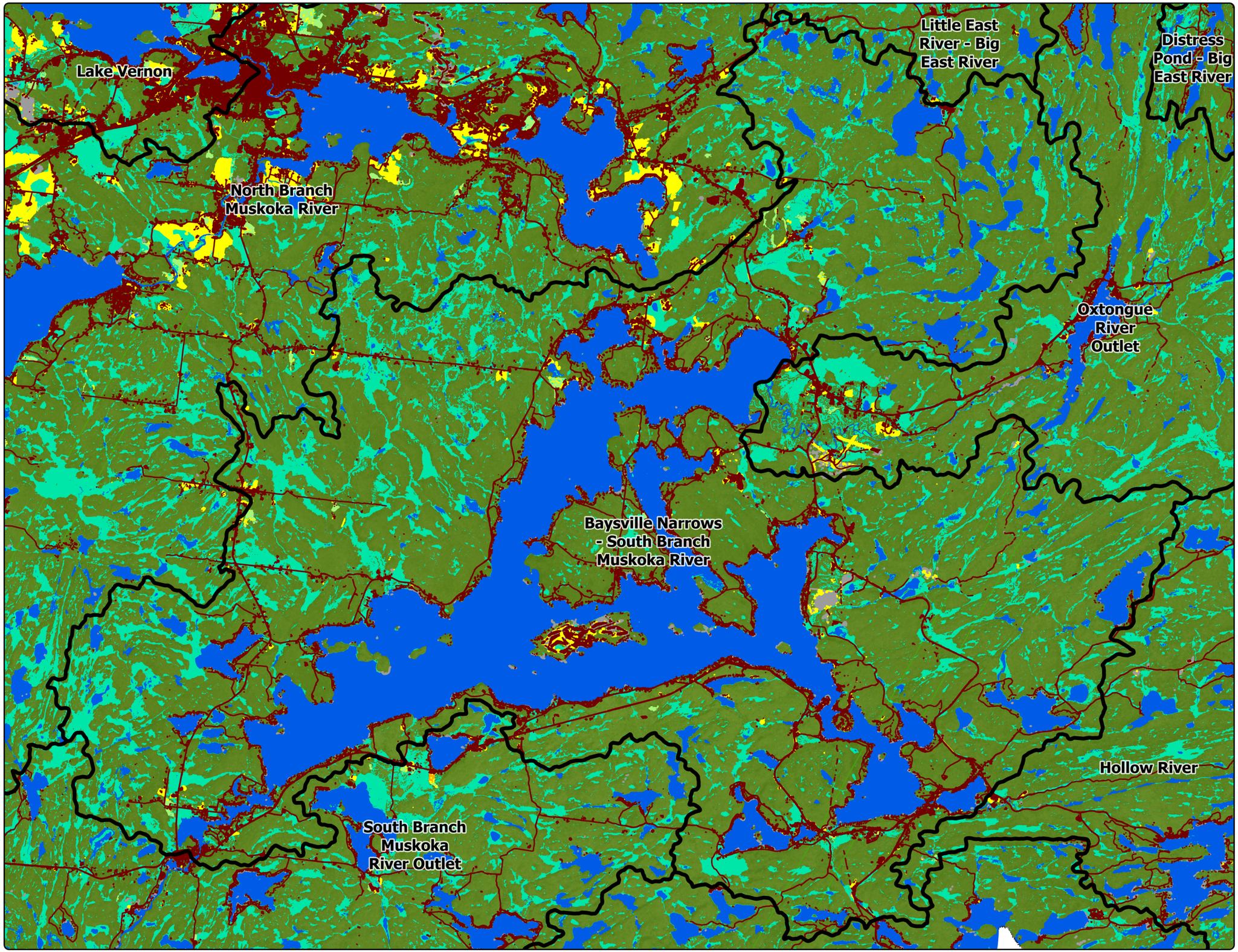

Map 2-1: Refined Land Cover Baysville Narrows - South Branch Muskoka River

Muskoka River Watershed IWM - Natural Capital Inventory

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 500 1,000 2,000

Metres

1:99,000

North American 1983 CSRS UTM Zone 17N

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Map 2-2: Refined Land Cover
Blackstone Harbour

Muskoka River Watershed IWM -
Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

Blackstone Harbour

Moon River Bay

Lake Rosseau

0 500 1,000 2,000
Metres

1:77,000

North American 1983 CSRS UTM Zone 17N

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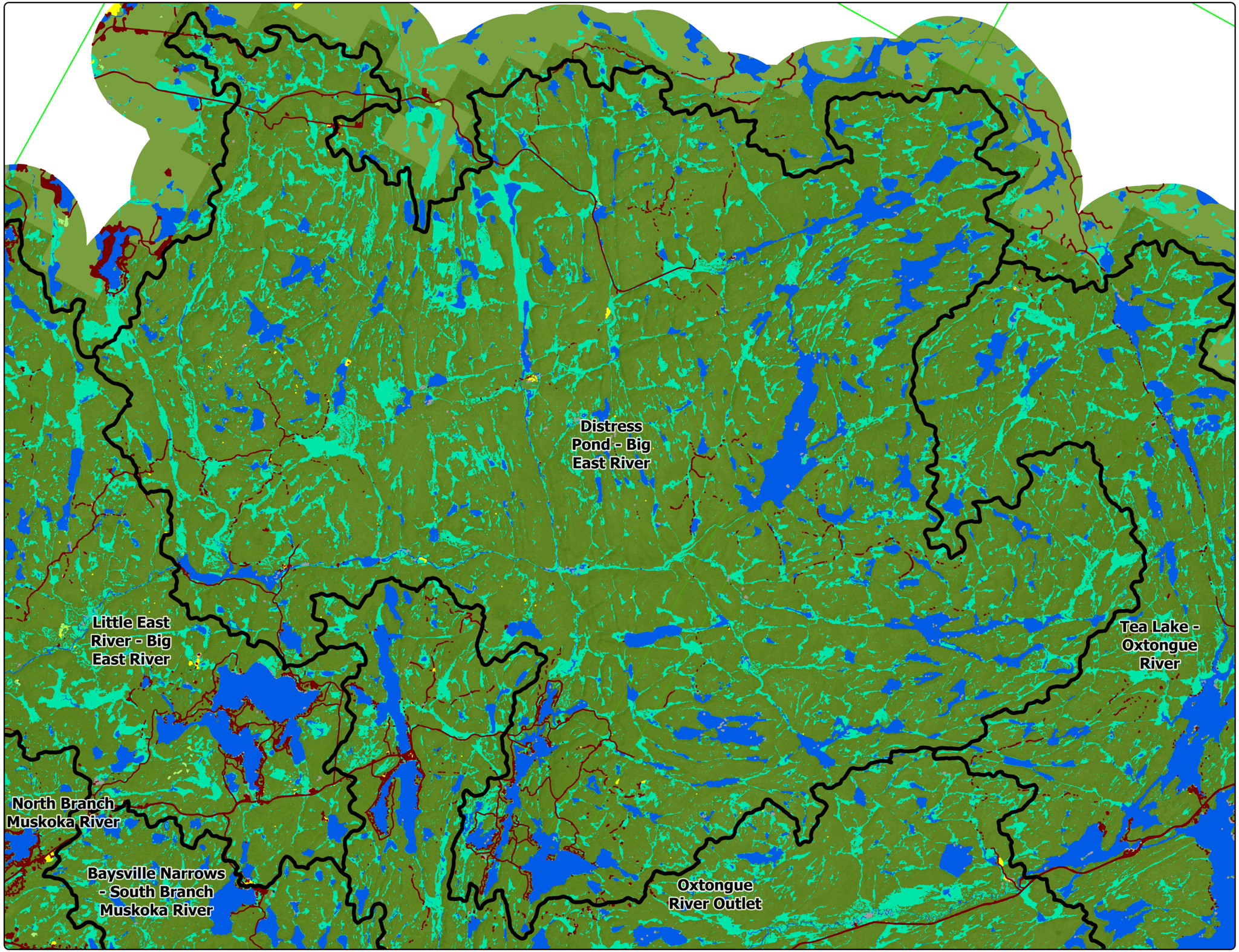

Map 2-3: Refined Land Cover Distress Pond - Big East River

Muskoka River Watershed IWM -
Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000
Metres

1:105,000

North American 1983 CSRS UTM Zone 17N

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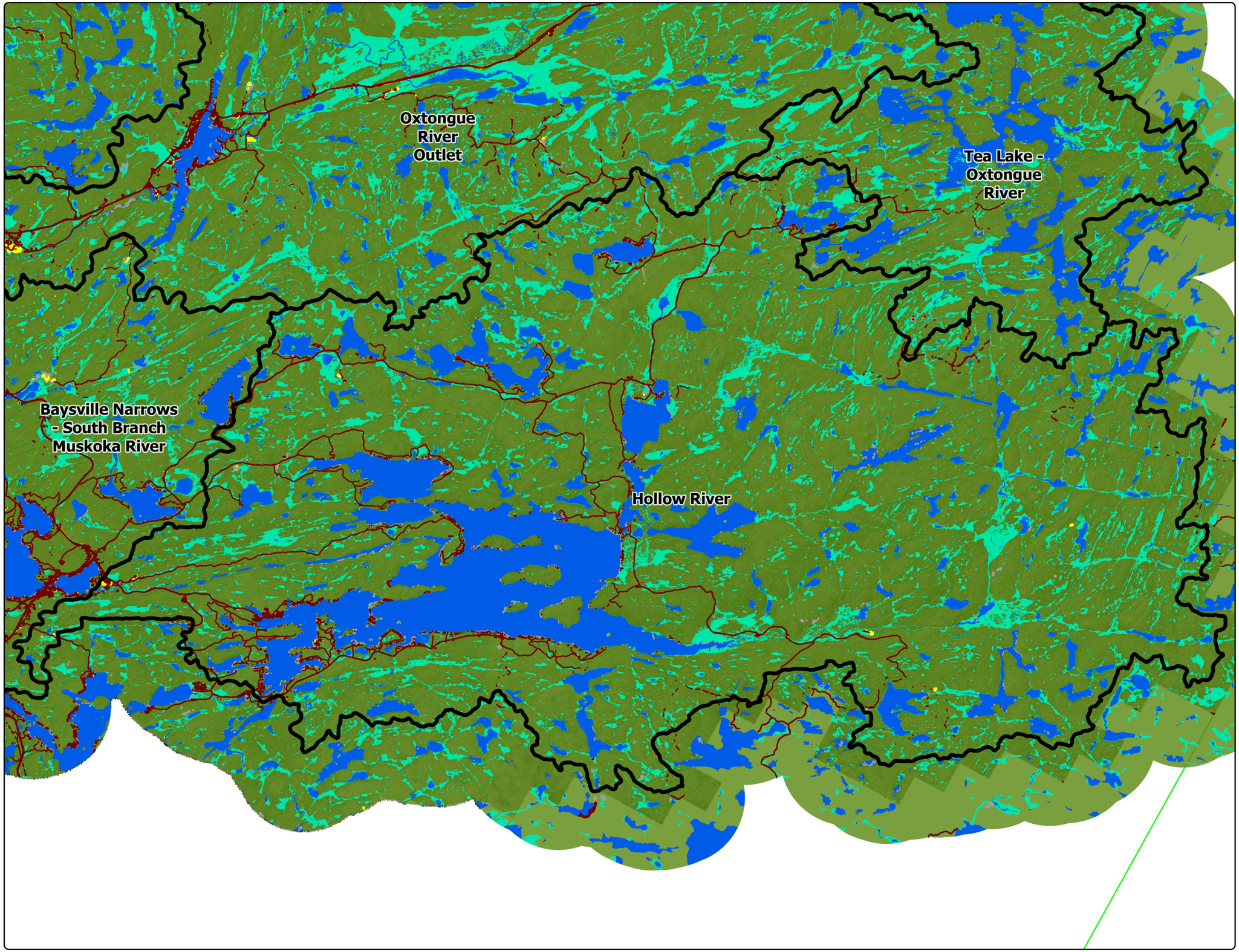

Map 2-4: Refined Land Cover Hollow River

Muskoka River Watershed IWM - Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000
Metres

1:109,000

North American 1983 CSRS UTM Zone 17N

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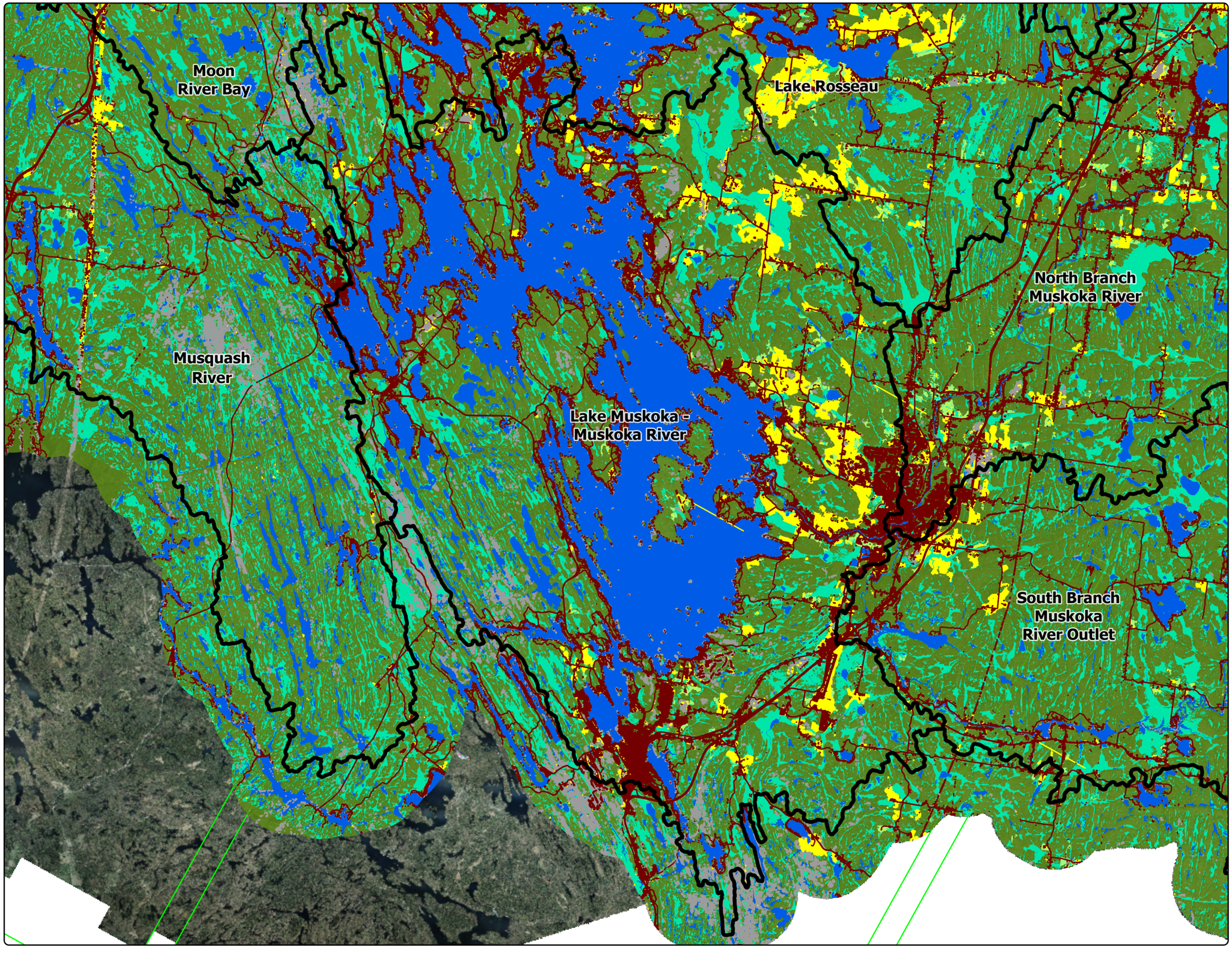

Map 2-5: Refined Land Cover
Lake Muskoka - Muskoka River

Muskoka River Watershed IWM -
Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,250 2,500 5,000
Metres

1:142,000

North American 1983 CSRS UTM Zone 17N

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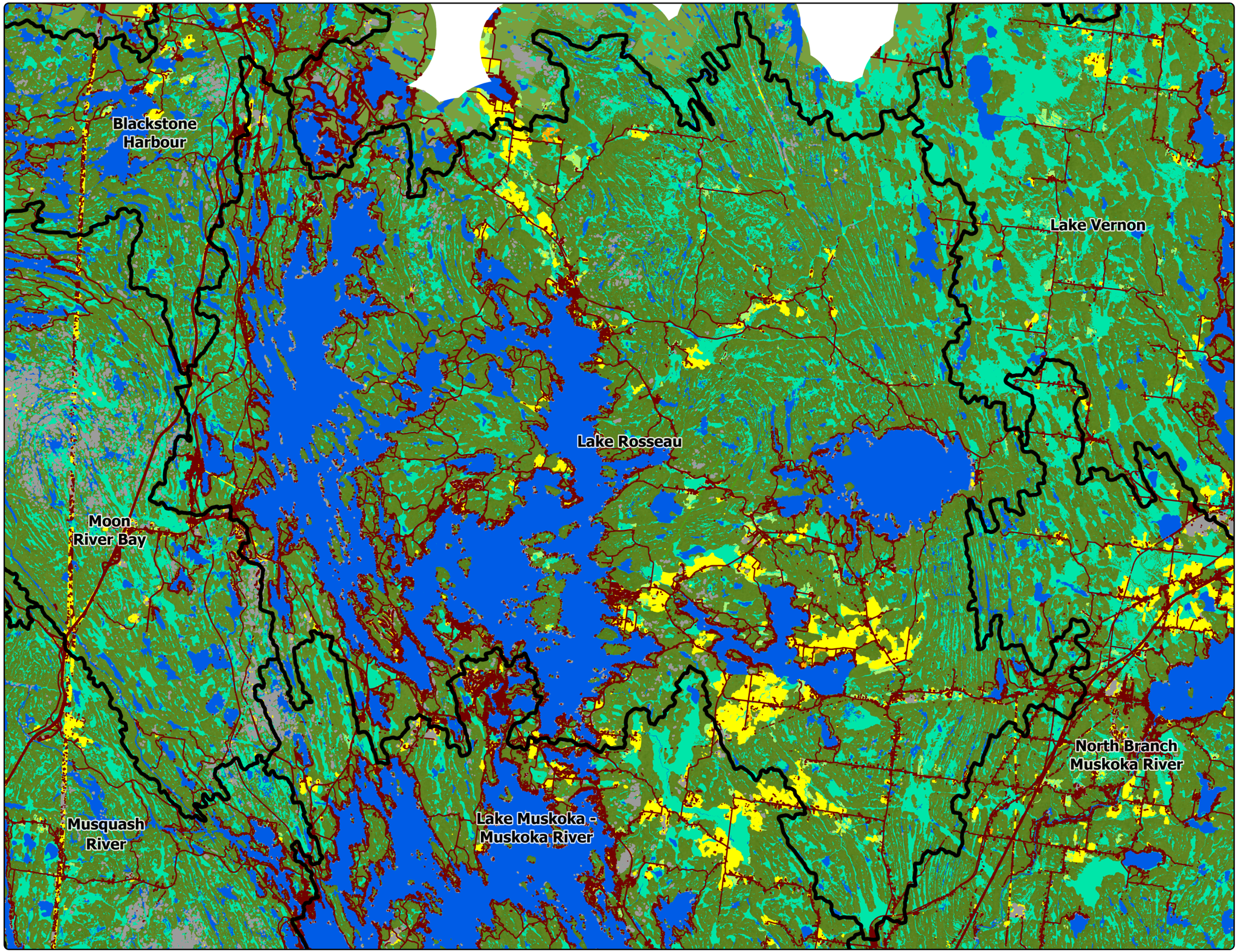

Map 2-6: Refined Land Cover Lake Rosseau

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Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,250 2,500 5,000
Metres

1:145,000

North American 1983 CSRS UTM Zone 17N

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Map 2-7: Refined Land Cover
Lake Vernon

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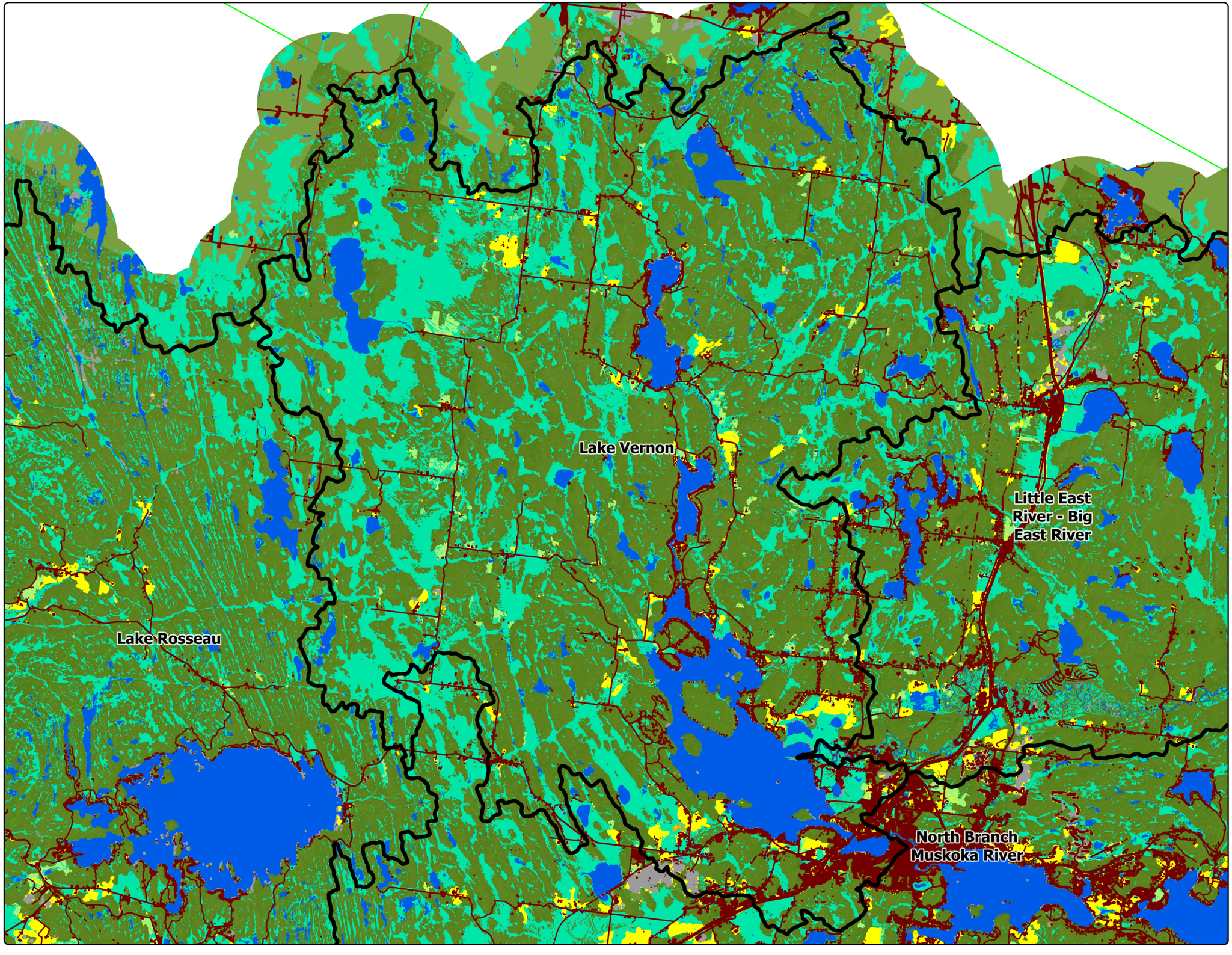
Natural Capital Inventory
Addendum 2: Refinement of Land Cover



Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000
Metres

1:106,000

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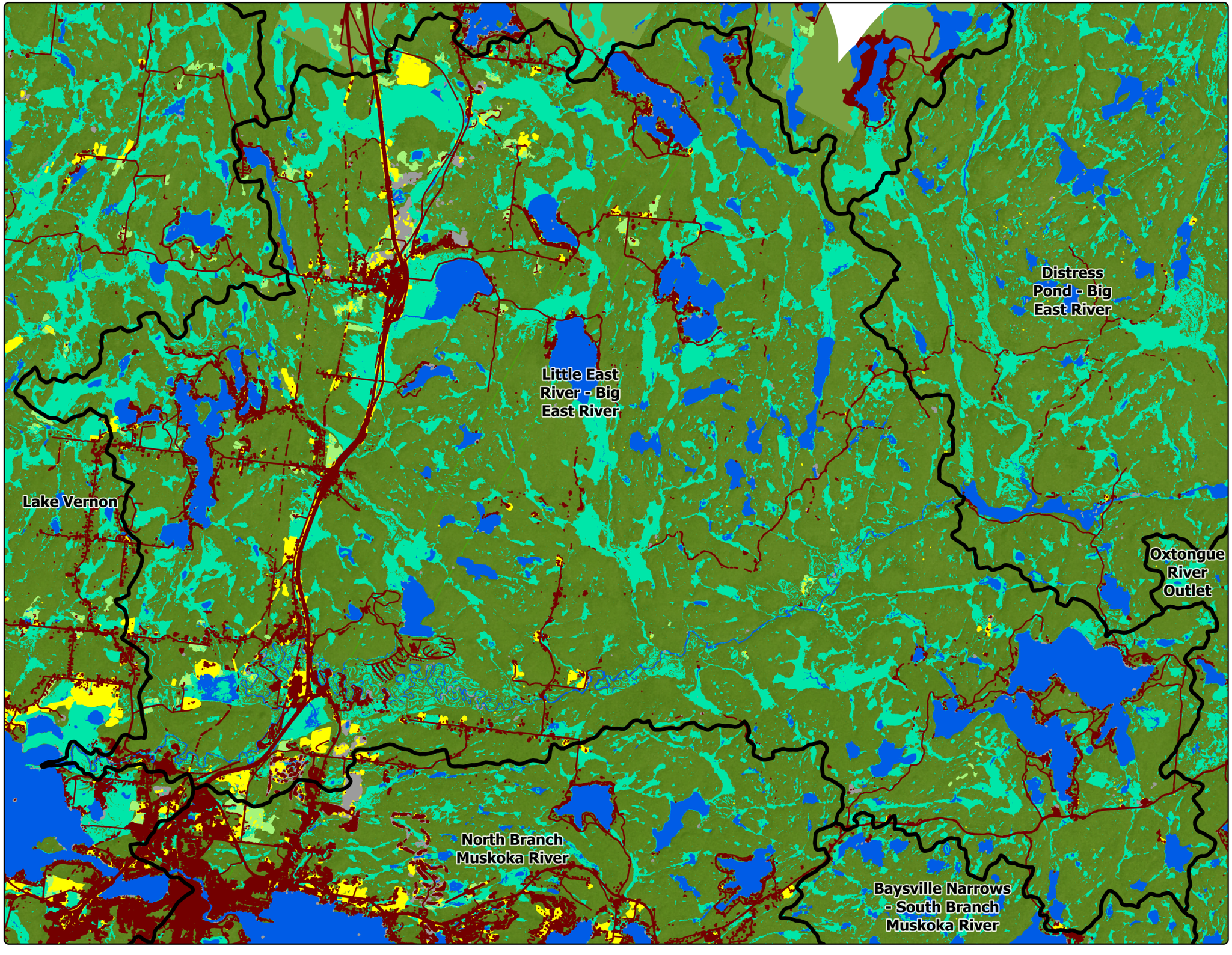

Map 2-8: Refined Land Cover
Little East River - Big East River

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Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 500 1,000 2,000
Metres

1:77,000

North American 1983 CSRS UTM Zone 17N

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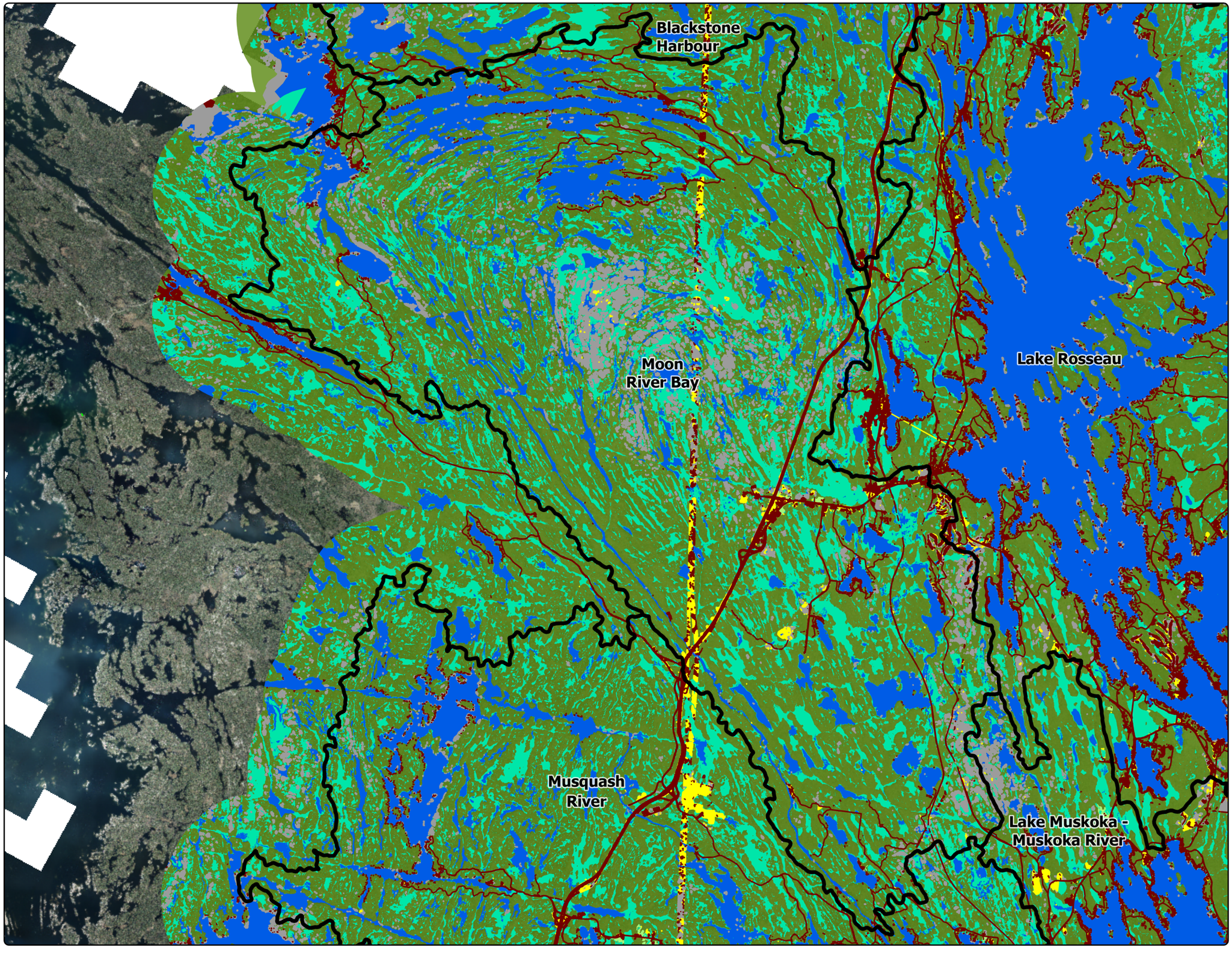

Map 2-9: Refined Land Cover Moon River Bay

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Natural Capital Inventory
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Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 500 1,000 2,000
Metres

1:97,000

North American 1983 CSRS UTM Zone 17N

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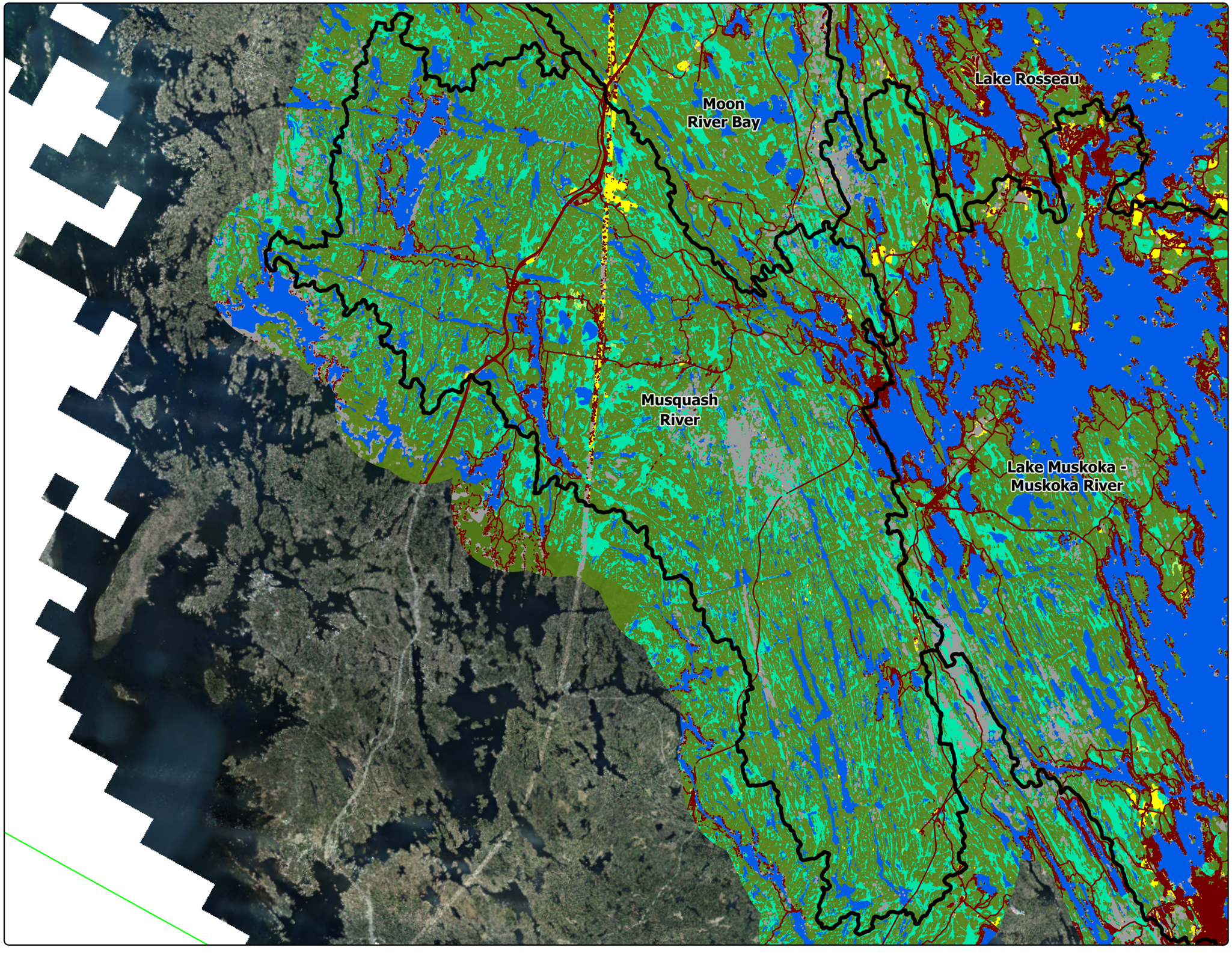

Map 2-10: Refined Land Cover Musquash River

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Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000
Metres

1:127,000

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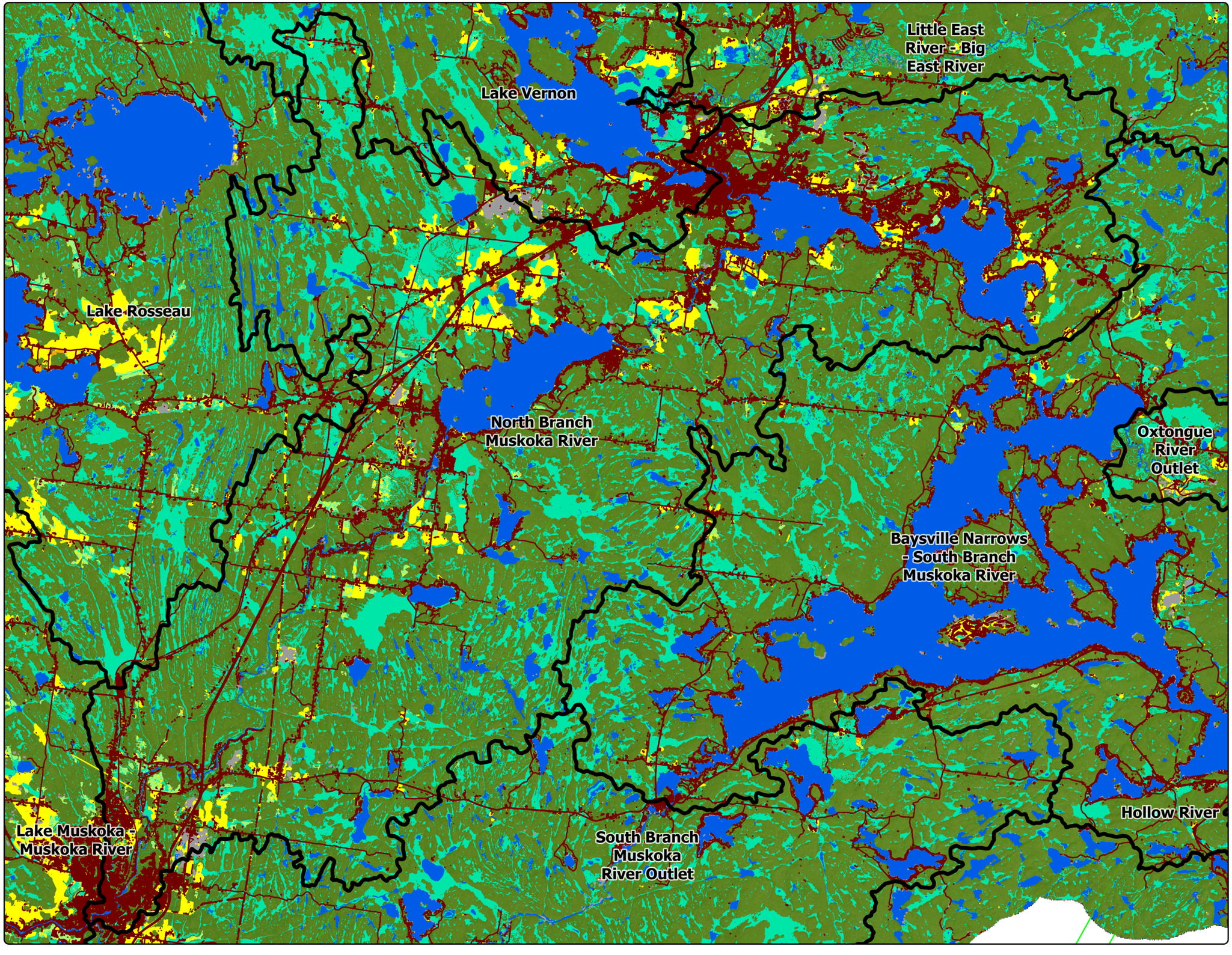

Map 2-11: Refined Land Cover North Branch Muskoka River

Muskoka River Watershed IWM -
Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000
Metres

1:124,000

North American 1983 CSRS UTM Zone 17N

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CLIENT: District of Muskoka

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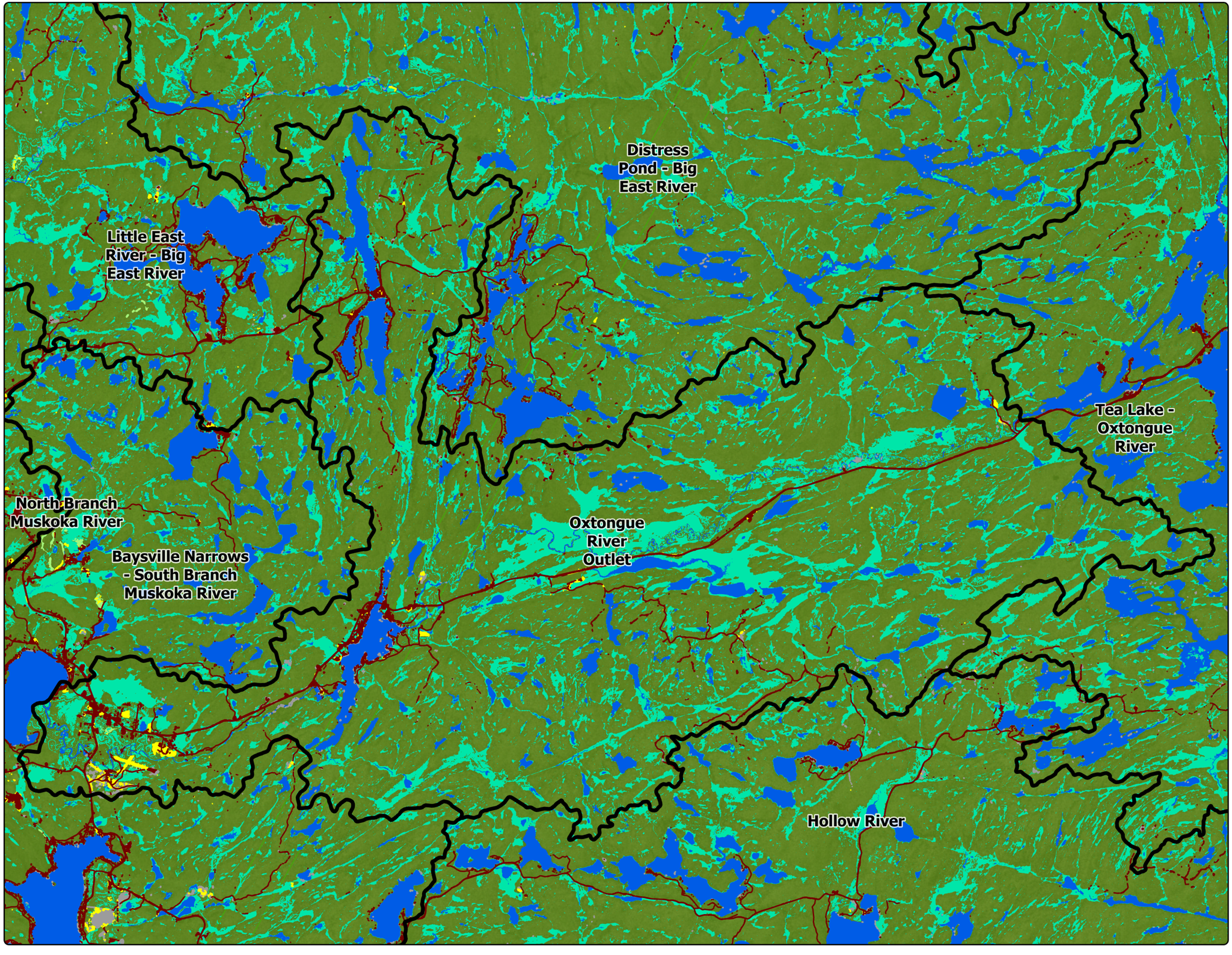

Map 2-12: Refined Land Cover Oxtongue River Outlet

Muskoka River Watershed IWM - Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 500 1,000 2,000
Metres

1:100,000

North American 1983 CSRS UTM Zone 17N

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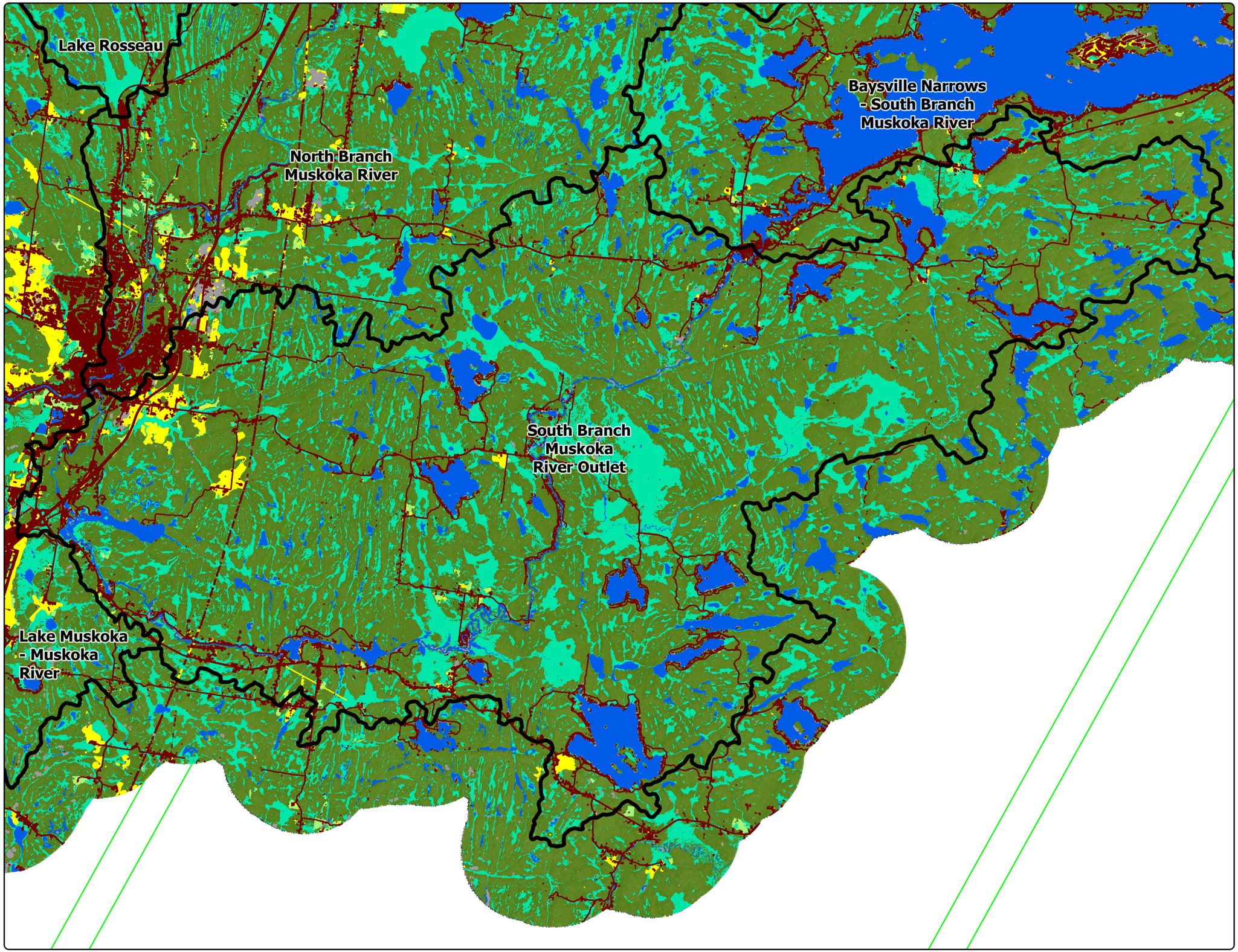

Map 2-13: Refined Land Cover South Branch Muskoka River Outlet

Muskoka River Watershed IWM - Natural Capital Inventory

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000

Metres

1:108,000

North American 1983 CSRS UTM Zone 17N

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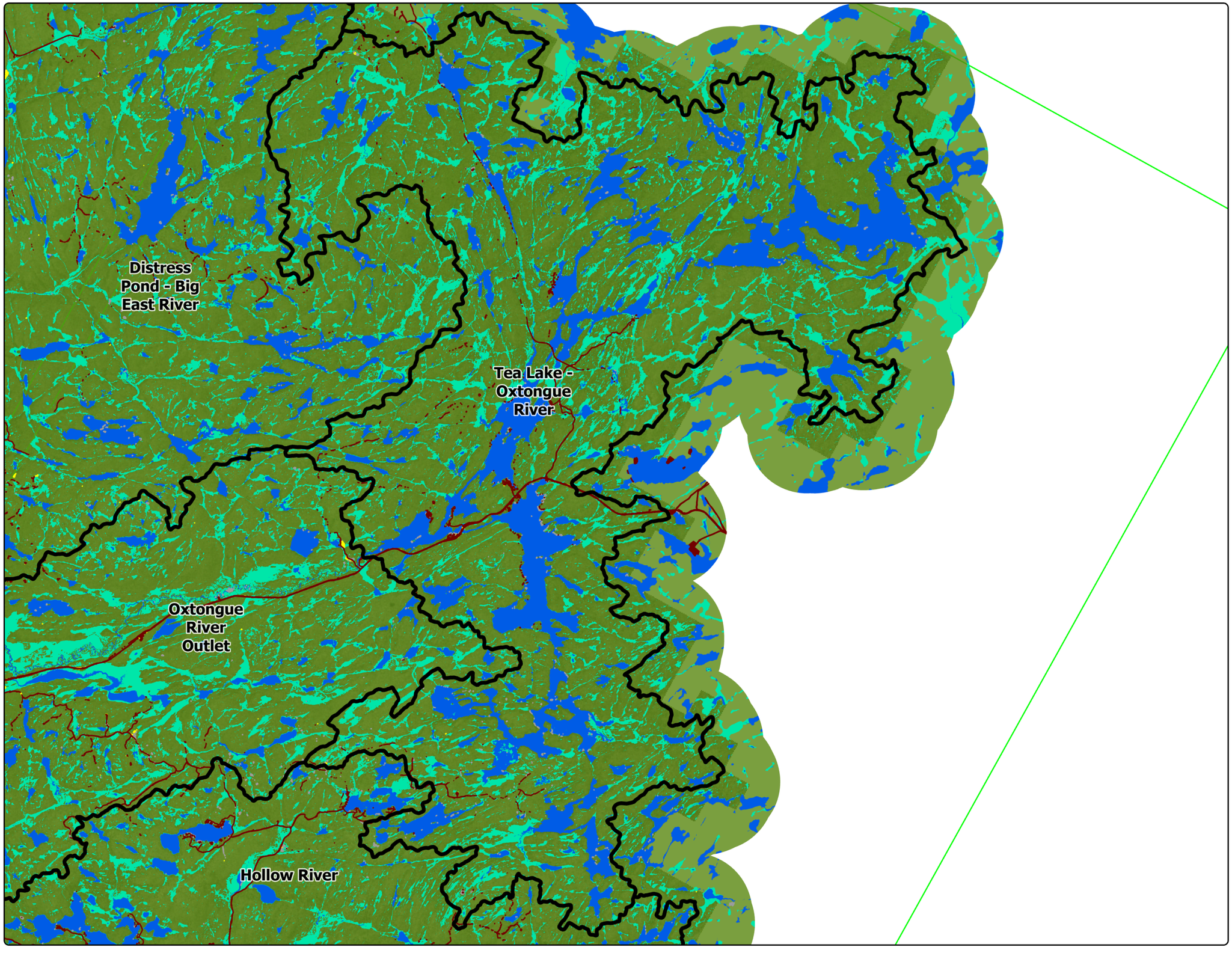

Map 2-14: Refined Land Cover
Tea Lake - Oxtongue River

Muskoka River Watershed IWM -
Natural Capital Inventory
Addendum 2: Refinement of Land Cover

Land Cover

- Anthropogenic
- Field
- Meadow
- Shrub
- Barren
- Wetland
- Aquatic
- Forest

Quaternary Watersheds

0 1,000 2,000 4,000
Metres

1:122,000

North American 1983 CSRS UTM Zone 17N

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APPENDIX A: LANDCOVER AREA SUMMARIES FOR SUBWATERSHEDS

Table A1: Land Cover Type area for each Muskoka River subwatershed

	Landcover Area (ha)													
	Lower Subwatersheds			Middle Subwatersheds							Upper Subwatersheds				
Land Cover Type	Blackstone Harbour	Moon River Bay	Musquash River	Lake Rosseau	Lake Muskoka - Muskoka River	Lake Vernon	North Branch Muskoka River	South Branch Muskoka River Outlet	Little East River - Big East River	Baysville Narrows - South Branch Muskoka River	Distress Pond - Big East River	Oxtongue River Outlet	Hollow River	Tea Lake - Oxtongue River	Land Cover Area
Forest	10550.64	13853.53	19075.40	43405.13	24037.14	21969.77	29376.55	24141.74	18609.05	23901.32	35729.20	19527.05	29761.91	23974.28	337912.73
Wetland	2825.49	5458.03	7299.48	12657.71	7613.97	9770.88	9544.67	7774.20	5144.27	5030.43	6897.84	5193.52	4658.12	4910.51	94779.13
Barren	258.65	860.67	532.15	576.03	1027.74	95.04	334.39	94.40	127.76	140.44	18.13	42.24	53.15	19.87	4180.65
Meadow				21.61		0.99	8.31	2.47							33.39
Shrub	50.75	15.69	32.54	767.59	428.32	380.23	477.02	103.43	186.00	65.61	1.54	6.42	1.41		2516.53
Aquatic	3152.38	3301.26	4180.24	18071.57	14839.56	3353.16	4463.62	3130.03	2387.51	8771.51	3693.49	1915.23	6191.90	5373.68	82825.15
Anthropogenic	449.57	377.75	479.49	2254.50	2798.21	893.22	2715.58	836.54	817.34	1011.44	119.21	275.87	249.32	88.58	13366.62
Agricultural Field	158.64	130.03	147.62	1776.96	1720.83	480.43	1345.20	300.53	286.22	112.66	5.94	59.70	6.60	2.20	6533.58
Subwatershed Area	17446.13	23996.96	31746.93	79531.11	52465.76	36943.74	48265.35	36383.34	27558.15	39033.41	46465.35	27020.03	40922.41	34369.13	542147.79

Table A2: Land Cover area change based on comparison of update landcover classification model (2023) compared to original model (Phase 1, 2022).

	Landcover Area Change (ha)														
	Lower Subwatersheds			Middle Subwatersheds							Upper Subwatersheds				
Land Cover	Blackstone Harbour	Moon River Bay	Musquash River	Lake Rosseau	Lake Muskoka - Muskoka River	Lake Vernon	North Branch Muskoka River	South Branch Muskoka River Outlet	Little East River - Big East River	Baysville Narrows - South Branch Muskoka River	Distress Pond - Big East River	Oxtongue River Outlet	Hollow River	Tea Lake - Oxtongue River	Land Cover Area Change
Forest	45.60	-83.85	-267.79	-110.20	-365.43	5.62	-10.58	0.61	35.97	-21.71	76.02	77.44	-1.19	83.72	-535.77
Wetland	23.09	47.53	41.05	75.98	26.93	62.15	6.83	16.23	37.37	24.45	47.73	53.61	29.19	7.97	500.12
Barren	50.75	294.72	419.61	426.73	748.39	43.48	263.35	64.68	22.30	108.57	-60.30	-46.45	4.86	-57.37	2283.31
Meadow	0.00	0.00	0.00	-0.03	0.00	-0.01	-0.21	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	-0.27
Shrub	-0.12	0.11	0.00	-2.80	-0.01	-0.26	-0.85	-0.09	-0.08	0.02	-0.01	-0.01	-0.01	0.00	-4.12
Aquatic	14.63	16.20	21.82	40.54	25.41	12.80	9.80	10.19	10.54	26.34	26.31	12.63	17.38	22.51	267.12
Agricultural Field	59.23	-84.99	56.17	-1143.43	-987.86	-199.17	-378.75	-120.55	55.41	75.64	5.94	30.93	6.60	2.20	-2622.63
Anthropogenic	171.57	377.75	131.37	829.98	741.81	280.53	812.04	249.95	329.52	401.10	62.30	123.70	75.38	48.05	4635.04
Subwatershed Area Change	364.75	567.48	402.23	116.77	189.23	205.14	701.63	221.00	491.03	614.42	157.99	251.85	132.21	107.08	4522.81