NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Phase 2 Geoscientific Preliminary Assessment

Initial Findings

TOWNSHIP OF WHITE RIVER AND AREA, ONTARIO

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PHASE 2 GEOSCIENTIFIC PRELIMINARY ASSESSMENT

INITIAL FINDINGS, TOWNSHIP OF WHITE RIVER AND AREA, ONTARIO

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INITIAL FINDINGS,

TOWNSHIP OF WHITE RIVER AND AREA, ONTARIO

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EXECUTIVE SUMMARY

In 2014, a Phase 1 Geoscientific Desktop Preliminary Assessment was completed by AECOM to assess whether the White River area contained general areas that had the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's Adaptive Phased Management (APM) site selection process. The assessment was conducted using available geoscientific information and key geoscientific characteristics that could be realistically assessed at the desktop stage. The Phase 1 assessment revealed that the White River area contains at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors (AECOM, 2014; NWMO, 2010).

In 2015, as part of Phase 2 of the preliminary geoscientific assessment of the White River area, NWMO initiated a series of initial geoscientific field studies in two of the four general potentially suitable areas identified during Phase 1 preliminary assessment. The objective of these initial field studies was to advance understanding of the geology of these general potentially suitable areas, and assess whether it is possible to identify general Potential Repository Areas (PRAs).

The initial Phase 2 geoscientific preliminary assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over two of the general potentially suitable areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution geophysical (gravity and magnetic) data to better understand the bedrock geology (e.g. geological contacts, depth and extent of rock units, lithological and structural heterogeneity);
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic data to identify possible structural features such as fractures, shear zones and dykes; and
- Geological mapping to assess geologic characteristics, including lithology, structure, bedrock exposure and surface constraints.

In 2017, after several years of progressively more detailed study and engagement, the NWMO concluded that the community of White River would not be considered a potential host for the project.

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1.0 INTRODUCTION

In 2014, a Phase 1 Geoscientific Desktop Preliminary Assessment was completed by AECOM to assess whether the White River area contained general areas that had the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's site selection process (AECOM, 2014; NWMO, 2010). The desktop preliminary assessment built on an initial screening conducted by Golder Associates in 2012 (Golder, 2012). The Phase 1 preliminary assessment focused on the Township of White River and its periphery, as shown on Figure 1.1.

The Phase 1 Geoscientific Desktop Preliminary Assessment was conducted using available geoscientific information and key geoscientific characteristics that could be realistically assessed at the desktop stage. These included: bedrock geology; structural geology; interpreted lineaments; distribution and thickness of overburden deposits; surface conditions; and the potential for economically exploitable natural resources. The consideration of these key geoscientific characteristics revealed that the White River area contained at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors. Two of these areas are within the Anahareo Lake pluton, one is located in the Pukaskwa batholith and one is located in the Strickland pluton. Phase 1 preliminary assessment also identified geoscientific uncertainties associated with these areas, including the low resolution of available geophysical data over most of the potentially suitable areas, the influence of regional structural features and the numerous dykes (AECOM, 2014). In order to facilitate Phase 2 field studies, portions of land were temporarily removed from staking for mineral claims in the four identified general potentially suitable areas. These withdrawal areas are shown on Figure 1.2, which also shows the bedrock geology of the White River area.

In 2015, as part of Phase 2 of the preliminary geoscientific assessment of the White River area, NWMO initiated a series of initial geoscientific field studies focused in the two general potentially suitable areas identified in the Strickland pluton and the eastern portion of the Anahareo Lake pluton. These initial field studies included the acquisition and interpretation of high-resolution airborne geophysical surveys and geological mapping including Observing General Geological Features (OGGF) and Detailed Mapping. The objective of these initial field studies is to advance understanding of the geology of two of the four general potentially suitable areas identified in the Phase 1 Geoscientific Desktop Preliminary Assessment, and assess whether it is possible to identify general Potential Repository Areas (PRAs).

The high-resolution airborne geophysical surveys included both magnetic and gravity surveys that greatly improved understanding of the geological characteristics of the White River area. The high-resolution surveys provided new information on rock type, homogeneity, and the depth and extent of the potentially suitable host rock formations. High-resolution geophysical and remote sensing data were then used to conduct a magnetic and surficial lineament interpretation to identify the presence of potential structural features such as fractures and dykes. Geological mapping, including both OGGF and Detailed Geological Mapping, was conducted to better understand the lay of the land, and to assess the nature of key geological features such as fractures, rock types, extent of bedrock exposure and surface constraints. For the purpose of this report, OGGF and Detailed Geological Mapping will be collectively referred to as “Geological Mapping”.

The results from the initial Phase 2 field studies are documented in three supporting documents: Geophysics Interpretation report (SGL, 2017); Lineament Interpretation report (SRK, 2017); and Geological Mapping Report (Amec Foster Wheeler, 2017). This report provides the findings of Phase 2 initial field studies conducted in the White River area in 2015 and 2016. The main sections of this report provide: a description of the approach and evaluation factors used to conduct the Phase 2 preliminary geoscientific assessment (Sections 2.0 and 3.0); and a summary of the initial Phase 2 field studies methods and findings (Sections 4.0 and 5.0).

2.0 GEOSCIENTIFIC PRELIMINARY ASSESSMENT APPROACH

The objective of the geoscientific preliminary assessment is to assess whether the White River area contains general areas that have the potential to meet NWMO's site evaluation factors. The geoscientific preliminary assessment is conducted in two phases:

- **Phase 1 - Desktop Study**: For all communities electing to be the focus of a preliminary assessment. This phase involves desktop studies using available geoscientific information and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the preliminary assessment.
- **Phase 2 - Preliminary Field Investigations:** For a subset of communities selected by the NWMO, to further assess potential suitability. This phase involves the acquisition of high-resolution geophysical surveys, geological mapping and the drilling of deep boreholes.

A brief description of the project, the assessment approach and findings of the Phase 1 preliminary assessment are documented in the White River integrated Phase 1 preliminary assessment report (NWMO, 2014).

The subset of communities considered in Phase 2 of the preliminary assessment was selected based on the findings of the overall desktop preliminary assessment considering both technical and community well-being factors illustrated in the above diagram.

The Phase 1 Geoscientific Desktop Preliminary Assessment was completed for the White River area in 2014 (AECOM, 2014). Initial Phase 2 field studies, including high-resolution airborne geophysical surveys and Geological Mapping were conducted in 2015 and 2016. This report focuses on summarizing the findings of these initial field studies.

3.0 GEOSCIENTIFIC SITE EVALUATION FACTORS

As discussed in the NWMO site selection process document (NWMO, 2010), the suitability of potential sites is evaluated in a step-wise manner through a series of progressively more detailed scientific and technical assessments using a number of geoscientific site evaluation factors, organized under five safety functions that a site would need to ultimately satisfy in order to be considered suitable (NWMO, 2010):

- Safe containment and isolation of used nuclear fuel: Are the characteristics of the rock at the site appropriate to ensuring the long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances caused by human activities and natural events?
- Long-term resilience to future geological processes and climate change: Is the rock formation at the siting area geologically stable and likely to remain stable over the very long term in a manner that will ensure the repository will not be substantially affected by geological and climate change processes such as earthquakes and glacial cycles?
- Safe construction, operation and closure of the repository: Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- Isolation of used fuel from future human activities: Is human intrusion at the site unlikely, for instance through future exploration or mining?
- Amenable to site characterization and data interpretation activities: Can the geologic conditions at the site be practically studied and described on dimensions that are important for demonstrating long-term safety?

In the Phase 1 geoscientific desktop preliminary assessment of the White River area, the site evaluation factors were applied in two steps. The first step identified at least four general potentially suitable areas within the White River area using key geoscientific characteristics that could realistically be assessed at the desktop stage based on available information (Figure 1.2). The second step confirmed that the four identified potentially suitable areas had the potential to ultimately meet all of the safety functions outlined above.

4.0 INITIAL FIELD STUDIES

The initial Phase 2 geoscientific preliminary assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over two of the general potentially suitable areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution geophysical (gravity and magnetic) data to better understand the bedrock geology (e.g., geological contacts, depth and extent of rock units, lithological and structural heterogeneity);
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic data to identify possible structural features such as fractures, shear zones and dykes; and
- Geological mapping to assess geologic characteristics, including lithology, structure, bedrock exposure and surface constraints.

The approach, methods and findings for each of the above activities are described in detail in three supporting documents (SGL, 2017; SRK, 2017; and AMEC Foster Wheeler, 2017). This section provides a summary of the approach and methods for each activity. The findings are discussed in an integrated manner in Section 5.0.

4.1 High-resolution Airborne Geophysical Surveys

The objective of the airborne geophysical surveys was to provide additional information to further assess the geology of the White River area. The interpretation of the data acquired during the airborne surveys can be used to estimate the geometry and thickness of the potentially suitable host rock formation; the nature of geological contacts; bedrock lithology; the degree of geological heterogeneity and the nature of intrusive phases within the plutons in the area; as well as the nature of structural features such as fractures, shear zones and dykes. The newly acquired geophysical data (SGL, 2017) provides significantly higher resolution data compared to the data available in the Phase 1 preliminary assessment (PGW, 2014).

Sander Geophysics Limited (SGL) completed a fixed-wing high-resolution airborne magnetic and gravity survey in the White River area between July 31 and October 6, 2015, (SGL, 2017). The survey area included one large block located to the east of the Township of White River (Figure 4.1). This survey block was designed to cover two of the four general potentially suitable areas identified in the Phase 1 preliminary assessment, and to cover relevant geological features in the area.

The airborne survey in the White River area included a total of 14,383 km of flight lines, covering a surface area of approximately 1,100 km^2. Flight operations were conducted out of the

Manitouwadge Municipal Airport, Manitouwadge, Ontario using one of SGL's Cessna 208 Grand Caravan (Photograph 1). Data were acquired along traverse lines flown in a north-south direction spaced at 100 m, and control lines flown east-west spaced at 500 m. The survey was flown at a nominal altitude of 80 m above ground level, with an average ground speed of 100 knots (185 km/hour).

Airborne magnetic and gravity data were acquired along the flight lines using equipment having high sensitivity and accuracy. The airborne magnetic data was recorded using a magnetometer sensor mounted in a fibreglass stinger extending from the tail of the aircraft. The airborne gravity data was recorded using a gravimeter, which includes three orthogonal accelerometers that are mounted on a platform inside the cabin of the aircraft. A detailed description of the planning, execution and processing of the survey data is provided in SGL (2017). The interpretation of the survey data included both a geophysics interpretation (Section 4.2; SGL, 2017) and a lineament interpretation (Section 4.3; SRK, 2017).

Photograph 1 SGL's Cessna 208 Grand Caravan

4.2 Geophysical Data Interpretation

The geophysics interpretation was conducted for the White River area using the newly acquired high-resolution magnetic and gravity data sets (SGL, 2017). The assessment of geological contacts and bedrock lithology in the Phase 2 assessment was performed by analyzing the magnetic and gravity data, and determining the coincidence of magnetic responses with mapped lithology and structures for the White River area. Magnetic anomaly characteristics and interpreted contacts were compared to the current bedrock geologic maps in order to identify similarities and/or changes in the lithological contact locations.

In some cases, the geophysical data provided a refined interpretation of the bedrock geological contacts, especially in areas of limited bedrock exposure (e.g. under overburden or water cover). The magnetic data and its vertical derivative products were used for interpreting geological contacts, identifying lithological heterogeneity, and assessing the nature of structural features through the surveyed area. In addition, the gravity data was valuable for interpreting geological contacts between rock units with differences in density. The magnetic and gravity data are shown on Figure 4.1 and Figure 4.2, respectively. At the same time that the magnetic and gravity data were acquired, higher resolution Digital Elevation Model (DEM) topographic data was also generated from the airborne GPS and altimeter data (SGL, 2017), as shown on Figure 4.3.

In order to develop a rough approximation of the depth of the plutons in the White River area, preliminary forward modelling was conducted by SGL (2017). The preliminary modelling used the newly acquired high-resolution geophysical data and readily available information on the mapped bedrock geology at surface to provide a preliminary interpretation of the geometry and subsurface extent of the plutons and adjacent greenstone units. The preliminary modelling considered scenarios where the plutons have internal density variations or a constant density to assess influence on estimated depths. Findings from the geophysical interpretation are discussed in an integrated manner in Section 5.0.

4.3 Lineament Interpretation

The purpose of the Phase 2 lineament interpretation was to provide an updated interpretation of the geological and structural characteristics of the potentially suitable bedrock units located within the survey block, using the newly acquired high-resolution data. A magnetic and surficial lineament study was conducted for the survey block using the high-resolution magnetic and DEM data from the airborne survey, and purchased high-resolution digital aerial imagery (SRK, 2017).

Lineaments are linear features that can be observed on remote sensing and geophysical data, and which may represent geological structures. The presence of these features at depth would need to be confirmed through further field studies such as borehole drilling.

4.3.1 Lineament Interpretation workflow

The lineament interpretation workflow was designed to limit issues of subjectivity and reproducibility that are inherent to lineament interpretations (SRK, 2017). The workflow follows a set of detailed guidelines involving three stages:

- Step 1: Independent lineament interpretation by two separate interpreters for each data set and assignment of certainty level (low, medium or high certainty);

- Step 2: Integration of lineament interpretations for each individual data set, and determination of reproducibility (i.e. presence of the same lineament within each data set (DEM, aerial imagery, magnetic) as interpreted by each interpreter); and
- Step 3: Integration of lineament interpretations for the surficial data sets (DEM and aerial imagery) followed by integration of the combined surficial data set with the magnetic data set, with determination of coincidence in each integration step.

Over the course of these three stages, a comprehensive list of attributes for each lineament was compiled (SRK, 2017). The key lineament attributes and characteristics used in the assessment include certainty, length, density and orientation:

- Lineament Certainty: Certainty (low, medium or high) was defined based on the clarity of the lineament interpreted in the data, which provides confidence in the feature being related to bedrock structure. For example, where a surface lineament could be clearly seen on exposed bedrock, it was assigned a certainty value of high. Where a lineament represented a bedrock feature that was inferred from linear features, such as orientation of lakes or streams or linear trends in texture, it was assigned a certainty value of either low or medium. For magnetic lineaments, a certainty value of high was assigned when a clear magnetic susceptibility contrast could be discerned and a certainty value of either low or medium was assigned when the signal was discontinuous or more diffuse. The certainty classification for all three data sets involved expert judgment and experience of the interpreter. For the purpose of this assessment, emphasis was put on lineaments interpreted with high and medium certainty.
- Lineament Length: Interpreted lineaments were classified according to their length, which is calculated based on the sum of all segment lengths that make up a lineament. It is assumed that longer interpreted lineaments may extend to greater depths than shorter interpreted lineaments. In general, longer interpreted lineaments also tend to have higher certainty values.
- Lineament Density: The density of interpreted lineaments was determined by examining the statistical density of individual lineaments using ArcGIS Spatial Analyst. A grid cell size of 50 m and a search radius of 1.25 km (equivalent to half the size of the longest boundary of the minimum area size of a potential siting area) were used for this analysis. The spatial analysis used a circular search radius examining the lengths of lineaments intersected within the circular search radius around each grid cell.
- Lineament orientation: The orientation of interpreted lineaments was expressed in degrees ranging between 0 and 180. Lineament sets are defined by direction clustering of the data. The number of identified lineament sets, and their variation in orientation, provides a measure of the complexity of the potential individual fractures or fracture zones.

The following sections provide a summary of interpreted lineaments. A more detailed analysis is provided in Section 5.2, and in SRK (2017).

4.3.2 Magnetic Lineaments

Magnetic lineaments were interpreted using the new high-resolution magnetic data, which provides a significant improvement to the overall resolution and quality of magnetic data compared with the data available during the Phase 1 preliminary assessment. Lineaments interpreted using the magnetic data are typically less affected by the presence of overburden than surficial lineaments. Magnetic lineaments interpreted with medium and high certainty in the survey block are shown on Figure 4.4. A detailed analysis of magnetic lineaments interpreted within the vicinity of each potentially suitable area is provided in Section 5.2. An expanded view of interpreted magnetic lineaments for each withdrawal area is shown in Section 5.0.

4.3.3 Surficial Lineaments

Surficial lineaments were interpreted using newly acquired high-resolution topographic data (DEM) from the airborne survey (SGL, 2017), and purchased high-resolution digital aerial imagery (SRK, 2017). The digital aerial imagery data has a cell resolution of 0.4 m, which was a significant improvement compared to the lower resolution data (20 m) used during the Phase 1 preliminary assessment. Surficial lineaments were interpreted as linear traces along topographic valleys, escarpments, and drainage patterns such as river streams and linear lakes. These linear traces may represent the expression of fractures on the ground surface. However, it is uncertain what proportion of surficial lineaments represents actual geological structures and if so, whether the structures extend to significant depth. Figure 4.5 shows Phase 2 surficial lineaments interpreted for the White River area. The observed distribution and density of surficial lineaments is highly influenced by the presence of overburden cover and water bodies, which can mask the surface expressions of potential fractures. The distribution of overburden is shown on Figure 4.6. A detailed analysis of surficial lineaments interpreted within the vicinity of each potentially suitable area is provided in Section 5.2. Interpreted surficial lineaments for each area are shown in Section 5.0.

4.4 Geological Mapping

As part of the Phase 2 preliminary assessment, a geological mapping campaign was conducted by Amec Foster Wheeler and their subcontractor, Dr. Michael Cooley, during the summer of 2016 (Amec Foster Wheeler, 2017). Observation of General Geological Features was carried out over a period of 21 days in July 2016, followed by 34 days of Detailed Geological Mapping in August and September 2016.

The field observations were conducted at select locations to better understand the lay of the land and to assess the presence and nature of key geological features in the area (e.g. Photographs 2 and 3), including: bedrock character (lithology, structure, magnetic susceptibility, gamma spectrometry and rock strength); fracture character; bedrock exposure; and other surface constraints. A detailed description of the approach, methods and observations is provided by Amec Foster Wheeler (2017). This section provides an overview of the mapping planning and logistics, and use of Traditional Knowledge. The findings of the Geological Mapping are discussed in an integrated manner with findings from other initial Phase 2 field data throughout Section 5.0.

4.4.1 Mapping Plans and Logistics

Planning of the Phase 2 Geological Mapping comprised three stages: pre-mapping planning; mapping and synthesis and reporting. The pre-mapping planning stage involved a review of all available information for the White River area, including access, and the development of a priority outcrop location interpretation.

Photograph 2 Geological Mapping in the White River Area

Photograph 3 Coarse-grained Granodiorite from the Strickland Pluton in the White River Area

During the pre-mapping planning phase, potential outcrop locations were identified in GIS, filtered, and prioritized for use in planning and implementing Geological Mapping in White River, Ontario. The identified potential outcrop locations (Figure 4.7) were combined with geophysical anomalies and lineament interpretation (SGL, 2017; SRK, 2017) and existing bedrock mapping to define traverses or traverse areas to cover all features of geological interest.

The key geological attributes to be investigated, along with the methods identified to observe and capture the relevant information at each bedrock outcrop location, were defined during the pre-mapping stage. Field observations were then recorded (Photograph 2) using a digital data capturing method to allow for seamless integration of the observations into a GIS platform. In addition, hand-sized rock samples were collected (Photograph 3) to provide representative examples of the different rock types observed in the field. Field magnetic susceptibility and gamma measurements were obtained from fresh surfaces using a KT-10 magnetic susceptibility meter and an RS-125 gamma ray spectrometer respectively. Preliminary geomechanical characterization of the bedrock was undertaken by means of a visual estimation of fracture spacing, primarily of joints, and a simple field-based hammer test for intact rock strength (Amec Foster Wheeler, 2017).

The Observation of General Geological Features was undertaken in July 2016 mainly using 4×4 vehicle and / or ATV as the primary means of transportation. The Trans-Canada highway (Highway 17) passes through the centre of the White River area in a northwest direction. Highway 631 branches from Highway 17 in the White River area in an approximate northeast-southwest orientation, running directly through the northwestern half of the Strickland pluton withdrawal area. The Anahareo Lake pluton withdrawal area is accessed from Ontario Highway 519 from Dubreuilville, but there are no pathed roads through this withdrawal area. A network of gravel surfaced logging roads extend off the pathed roads noted above providing further access to the two withdrawal areas.

Traverses undertaken during the Observation of General Geological Features were along pathed (road cuts) or logging roads. The traverse areas examined during the Detailed Geological Mapping undertaken in August and further in September 2016 were refined based on the observations made during the Observation of General Geological Features. During Detailed Geological Mapping, mapping locations (Figure 4.7) were remote and accessed from roads by various methods, including foot, 4×4 truck, ATV, helicopter, float plane and motorized boat.

4.4.2 Local and Traditional Knowledge Activities

As part of NWMO's promise to develop partnerships with First Nation and Métis people, there is a commitment to interweaving local Traditional Knowledge in all phases of NWMO's work. Traditional Knowledge involves all aspects of Aboriginal people's unique understanding, relationship and how they connect the land to their way of life. This unique understanding influences the way in which Aboriginal people use the land. Prior to the commencement of mapping activities, all staff involved in Geological Mapping in the field participated in a Traditional Knowledge training at the NWMO offices. The training reminded both participating contractors and NWMO staff that as humans we are dependent on the land for sustaining life. Geological mapping activities were carried out in a manner that was respectful of the land.

5.0 KEY GEOSCIENTIFIC CHARACTERISTICS

The following subsections provide an updated description of the key geoscientific characteristics based on both Phase 1 preliminary assessment and the newly acquired field data during initial Phase 2 field work. The updated description focuses on two of the four areas that were identified as potentially suitable in the Phase 1 Geoscientific Desktop Preliminary Assessment. These include the Strickland pluton and the Anahareo Lake pluton areas, both to the east of the Township of White River (Figure 1.2).

5.1 Bedrock Geology

The bedrock geology of the White River area was described in detail in the Phase 1 Geoscientific Desktop Preliminary Assessment based on publically available reports and geological maps, as well as from the Phase 1 geophysical interpretation (AECOM, 2014; PGW, 2014). This section provides an updated description of the bedrock geology of two of the four general potentially suitable areas based on the integrated interpretation of Phase 2 field data.

5.1.1 Strickland Pluton

The Strickland pluton occurs in the northern portion of the White River area bordering the Dayohessarah and Kabinakagami greenstone belts. The pluton extends to the northeast of the study area, occupies an area of approximately 600 km^2 and has maximum dimensions of 34 km north-south and 55 km east-west (Figure 1.2).

Previous mapping described the Strickland pluton as a relatively homogeneous granodiorite, with granodiorite to tonalite and diorite mapped along the outer margin of the pluton adjacent to the Dayohessarah greenstone belt (Stott, 1999; Figure 1.2). In the area west of the Kabinakagami greenstone belt, Siragusa (1977) noted that massive quartz monzonite (i.e., monzogranite in modern terminology) intrudes the granodioritic and trondhjemitic rocks of the Strickland pluton in the form of dykes, small sills and irregular bodies.

Phase 2 Geological Mapping (Amec Foster Wheeler, 2017) identified two broad lithological domains within the Strickland Pluton area: a coarse-grained tonalite domain in the northern half of the Strickland pluton, and a granodiorite domain in the southern half. The southern contact of the tonalite domain is interpreted to trend roughly east-northeast as shown in Figure 5.1, which is generally parallel to observed igneous flow foliations on both side of the contact as discussed in Section 5.3.1. Lithology in the southern half of the Strickland pluton area dominated by coarse grained granodiorite, which locally grades into less common but texturally similar tonalite. The results from field magnetic susceptibility measurements correlate well with the airborne geophysical survey results (SGL, 2017) which show a slightly higher magnetic susceptibility in the tonalite relative to that in the southern part of the withdrawal area where granodiorite predominates.

The mapped boundary between the Strickland pluton and the gneissic tonalite Pukaskwa batholith to the south is not clearly identified in geophysical data. The large gravity anomaly observed in the centre of the withdrawal area (Figure 5.1) extends to the south into the gneissic tonalite unit with no associated change across the mapped boundary and it likely represents either the thickest section of the intrusions and/or the part of the body with the lowest density (SGL, 2017). However, mapping of gneissic tonalite along the shore of Nameigos Lake (Amec Foster Wheeler, 2017) supports the present mapped extent of the Pukaskwa batholith to the south of the Strickland pluton.

Preliminary 2.5D modelling of the gravity data interprets the Strickland pluton as a tabular body with a depth of approximately 2.3 km below mean sea level (SGL, 2017). When constant density models are considered, the estimated thickness of the pluton is of approximately 4 km in the centre of the intrusion, increasing to 5.5 km towards its southern edge; the constant density models also interpret a thinning out of the Strickland pluton to about 100 m on its western edge on the boundary to the Dayohessarah greenstone belt.

5.1.2 Anahareo Lake Pluton

The Anahareo Lake pluton (informal name adopted in this report as AECOM, 2014) is a large intrusion with a surface area within the White River area of approximately 690 km^2 (Figure 1.2). The intrusion was mapped by Siragusa (1977, 1978) as being dominantly granodiorite and quartz monzonite (i.e., monzogranite in modern terminology), with bedrock within the withdrawal area mostly consisting of granite to granodiorite. The authors also noted the occurrence of pegmatitic sills and dykes in the area.

Phase 2 Geological Mapping (Amec Foster Wheeler, 2017) documented a certain degree of lithological variability within the Anahareo Lake pluton area. In the northern half of the area, the predominant rock type is granite pegmatite (Figure 5.2), which mostly occurs as shallowly- north to northeast-dipping sill-like bodies that range from metres to tens of metres thick. The granite pegmatite intrudes, and is interlayered with granite, tonalite-granodiorite or a heterogeneous assemblage of metamorphosed gneisses and schists. The central part of the Anahareo Lake pluton within the withdrawal area comprises predominantly coarse-grained granite, with rare granodiorite. This area of granite extends beyond the previously mapped boundary with the gneissic tonalite to the west (Figure 5.2). In the southernmost part of the Anahareo Lake pluton area, the bedrock was mapped as tonalite-granodiorite (Figure 5.2) with moderately high magnetic susceptibility. This area coincides with a magnetic anomaly interpreted to potentially represent bedrock within increased magnetic mineral content (SGL, 2017; Figure 5.2).

A teardrop-shaped magnetic anomaly has been identified near the central part of the Anahareo Lake pluton withdrawal area, extending southwest from the magnetic anomaly associated with the Kabinakagami greenstone belt. Several small bodies of mafic metavolcanic rocks were mapped within the bounds of this anomaly by Siragusa (1978), and Phase 2 Geological Mapping (Amec Foster Wheeler, 2017) recorded similar observations adjacent to the anomaly. Geophysical and mapping data suggest that this area may be underlain by discontinuous or partially assimilated remnants of the Kabinakagami greenstone belt.

The area northwest of the withdrawal area has a unique magnetic fabric (SGL, 2017) and an anomaly was observed extending from the western side of the Kabinakagami Lake greenstone belt to the Dayohessarah greenstone belt (Figure 5.2). This zone may represent the remnants of a once larger greenstone belt that is now discontinuous and /or partially assimilated along the margins of the Strickland and Anahareo Lake plutons. The gravity anomaly identified within most of the withdrawal area may regionally represent a thickening of the Anahareo pluton, but may also be explained by density variation due to mineralogical variations

Preliminary modelling of gravity data interprets the Anahareo Lake pluton as a relatively tabular intrusion extending approximately 2 km below main sea level. The estimated depth of the pluton increases to up to 3.6 km below main sea level in the northern portion when a constant density model is considered (SGL 2017).

5.2 Lineament Analysis

This section provides an integrated analysis of interpreted lineaments (SRK, 2017) for the withdrawal areas assessed in the White River area, using the newly acquired high-resolution magnetic, topographic and aerial imagery data (Section 4.1).

Lineaments interpreted by SRK (2017) were classified into three general categories based on a working knowledge of the structural history and bedrock geology of the White River area. These categories include unclassified, brittle, and dyke lineaments, described as follows:

- Unclassified lineaments are typically characterized by curvi-linear magnetic lows and commonly truncated or offset the internal fabric of the rock (i.e., form lines). Unclassified lineaments are features interpreted to represent unclassified structures. This may include ductile shear zones (intensification of foliation across a narrow zone with associated fracturing) or brittle-ductile shear zones. Alternatively, these unclassified structures may represent the internal fabric of the rock (foliation or gneissosity).
- Brittle lineaments are commonly characterized by continuous, linear magnetic lows, and breaks in topography, vegetation, and/or linear shorelines. These are features interpreted as fractures (joints or joint sets, faults or fault zones, and veins or vein sets).
- Dyke lineaments are features interpreted as dykes, on the basis of their distinct character (e.g., orientation, geophysical signature and topographic expression). Dykes

were dominantly interpreted from the magnetic data set, and were typically characterized by continuous linear magnetic highs.

5.2.1 Strickland Pluton

Magnetic lineaments of high and medium certainty are shown on Figure 5.3 for the Strickland pluton area. Magnetic lineaments interpreted within and in the vicinity of the withdrawal area include mostly northwest-trending dyke and brittle lineaments, and to a lesser extent north to north-east trending lineaments. The density of magnetic lineaments is somewhat variable in the area, with few discrete zones of higher and lower lineament density. Higher magnetic lineament density is observed in the northeastern portion and southwestern edge of the withdrawal area, where bands of tightly spaced northwest-trending dyke lineaments exist. Higher magnetic lineament density is also observed along a northwest-trending band in the centre of the withdrawal area, where there is a cluster of brittle lineaments interpreted. The area of lowest density occurs to the southeast of Gourlay Lake where relatively few dyke lineaments occur.

Unclassified magnetic lineaments in the Strickland pluton area are mostly limited to the Kabinakagami Lake greenstone belt, and its interpreted westward remnant extension between the Strickland and Anahareo Lake plutons (see Section 5.1.2; Figure 5.3). Unclassified lineaments were also interpreted north of the withdrawal area, along the northern boundary of the intrusion.

Surficial lineaments of high and medium certainty are shown on Figure 5.4 for the Strickland pluton area. The density of surficial lineaments density is variable throughout the Strickland pluton with the lowest densities occurring to the east of Gourlay Lake and to the east and northeast of Nameigos Lake. The areas of lower surficial lineament density coincide with relatively flat areas where the presence of extensive overburden cover may hinder the interpretation of lineaments from surficial datasets (Figures 4.6 and 4.7). Similarly it is expected that an area of low density to the northeast of Beaton Lake is associated with a sandy till that was assessed to be greater than 3 metres during the geological mapping.

Figure 5.5 shows the density of integrated lineaments with high and medium certainty for the Strickland pluton area excluding the unclassified lineaments. In accordance with the descriptions above, the bands of northwest-trending, tightly spaced dyke lineaments in the northeastern portion and southwestern edge of the withdrawal area correspond to areas of increased integrated lineament density. Similarly, higher lineament density is observed in the southern portion of the withdrawal area where there are more brittle lineaments interpreted. Well defined areas of lower density of integrated lineaments are observed between higher lineament density areas.

5.2.2 Anahareo Lake Pluton

Magnetic lineaments of high and medium certainty are shown on Figure 5.6 for the Anahareo Lake pluton area. Similar to the Strickland pluton area, higher density of magnetic lineaments is observed along a band of northwest-trending, tightly spaced dyke lineaments that cross-cuts the withdrawal area. Higher magnetic lineament density is also observed in the southwestern part of the withdrawal area where a number of northeast-trending dyke and brittle lineaments are interpreted. Lineament density in the withdrawal area is the highest in its centre to the west of Anahareo Lake, where the band of northwest-trending dyke lineaments intersects the northeast-trending lineaments. A few areas of relatively low density of magnetic lineaments are observed on either side of the northwest-trending band of dyke lineaments (Figure 5.6).

Curvilinear unclassified lineaments are interpreted northwest of the Anahareo Lake pluton withdrawal area along a narrow east-northeast–trending zone extending from the southern part of the Kabinakagami Lake greenstone belt. As noted in Section 5.1.2, this zone may represent the remnant of a larger greenstone belt connecting the Kabinakagami Lake and Dayohessarah greenstone belts, most of which has since been eroded. Unclassified lineaments are also interpreted extending westward from the Kabinakagami greenstone belt into the withdrawal area, supporting the interpretation that this zone may be underlain by discontinuous or partially assimilated remnants of the older metamorphic basement rocks including some greenstones (Section 5.1.2).

Figure 5.7 shows surficial lineaments of high and medium certainty for the Anahareo Lake pluton area. Similar to the Strickland pluton, the surficial lineament density is variable throughout the Anahareo Lake pluton. Areas of relatively higher surficial lineament density are generally coincident with areas of better bedrock exposure and/or more topographic relief. The highest surficial lineament density occurs northwest of the withdrawal area where there are a series of ridges, streams, and aligned lakes. Within and in the vicinity of the withdrawal area, there are areas with relatively low density of surficial lineaments. In some instances, such as in the Anahareo Lake area, water and overburden coverage may hinder the interpretation of surficial lineaments.

The density of integrated lineaments with high and medium certainty is shown in Figure 5.8 for the Anahareo Lake pluton excluding the unclassified lineaments. Given that in this area there are more magnetic than surficial lineaments interpreted, the density of integrated lineaments mimics the density of magnetic lineaments to a certain degree. Increased lineament density is associated with the band of northwest-trending dykes that cross-cuts the withdrawal area and its intersection with northeast-trending dyke and brittle lineaments. Areas of relatively low density of integrated lineaments area observed within the withdrawal area.

5.3 Structural Geology

There is a limited number of mapped (unnamed) faults in the White River area indicated on public domain geological maps (Fenwick, 1966; Siragusa, 1977; 1978; Stott, 1995a; 1995b; 1995c; OGS, 2011), with only two of them mapped within the Strickland and Anahareo Lake pluton withdrawal areas. The longest of these mapped faults parallels the axis of Esnagi Lake in the east-central part of the White River area, southeast of the Anahareo Lake pluton withdrawal area (Siragusa, 1978; Figure 1.2). Mapped faults generally have either a northwest- or northeast-trending orientation.

Stott (1999) found that fault displacements in the Dayohessarah greenstone belt were not significant but noted that additional faults (i.e., unmapped) may exist along the narrow, northeast-trending bay of Strickland Lake and along a northwest-trending lineament through Strickland Lake (Stott, 1995b); however, no lateral offsets along these features could be confirmed. In the Kabinakagami greenstone belt, Siragusa (1977) reported that it is likely that northeast-trending strike-slip fault with horizontal displacement of 240 m is present in a narrow valley, to the north of the inlet of Kabinakagami River.

A northeast-trending mapped fault is located crossing the western margin of the White River area and is mapped as juxtaposing the Pukaskwa batholith against the Strickland pluton. A northwest-trending mapped brittle fault is located at the southern extent of Nameigos Lake that is shown offsetting the Kabinakagami Lake greenstone belt with a dextral strike-separation. A northwest-trending mapped fault is located within the Anahareo Lake pluton, southwest of Anahareo Lake. A mapped west-northwest trending fault is located at the northern extent of Nameigos Lake that is shown as truncating the Pukaskwa batholith against the Strickland pluton and the Kabinakagami Lake greenstone belt.

All five mapped faults within the geophysical survey block were at least partly reproduced in the lineament interpretation undertaken by SRK (2017). The predominance of structures (i.e. faults, joints and veins) on all scales striking either northwest parallel to the Matachewan dykes or northeast parallel to the Biscotasing dykes has been confirmed in both the Strickland and Anahareo Lake pluton areas with Phase 2 Geological Mapping (Amec Foster Wheeler, 2017), as discussed further below. The following subsections provide a summary of the mapped ductile (igneous flow foliations, tectonic foliations, brittle-ductile and ductile shear zones) and brittle structures (joints, faults, veins).

5.3.1 Strickland Pluton

Historical information on the structure of the Strickland pluton area was based predominantly on insights derived from structural investigations of the Kabinakagami and Dayohessarah greenstone belts, surrounding the Strickland pluton area to the east and west, respectively (Figure 1.2). Field data from Phase 2 Geological Mapping provided new structural information for the Strickland pluton area. Key findings from analysis of the structural observations collected during geological mapping are included below (Amec Foster Wheeler, 2017).

The most common ductile structure measured in the Strickland pluton is weakly to moderately well-developed igneous flow foliation in both the tonalite to the north and the granodiorite to the south. The igneous flow foliation is generally oriented parallel to the mapped contacts of the Strickland pluton. Tectonic foliations are limited to a north-trending belt of tonalite gneiss along the shores of Nameigos Lake southeast of the withdrawal area; an area mapped as part of the Pukaskwa Batholith (Santaguida, 2001).

Only few shear zones were identified in the area, including both ductile and brittle-ductile shear zones, with the former being very narrow (1 to several centimetres) and the latter having damage zones up to several metres wide. Overall, sinistral shear zones tend to strike north-northeast and dextral shear zones tend to strike northwest. Too few ductile and brittle-ductile shear zones were measured to make any broad regional-scale interpretations.

Jointing is the dominant brittle structure observed at the outcrop scale within the Strickland pluton area. The two main joint orientations strike broadly northeast-southwest and northwest-southeast, and predominantly dip at greater than 60°. A less prominent subhorizontal set of joints was also identified. Joint spacing is mostly within the 100-500 cm range. The subvertical joints are parallel and / or perpendicular to the two main Proterozoic dyke swarms (Matachewan and Biscotasing). Northeast-southwest and northwest-southeast orientations are also identified for the faults and veins with similar subvertical dips.

Two main fault orientation families were mapped with overall strike northeast-southwest and northwest-southeast with the majority of faults being subvertical. Damage zones may be up to several metres wide zones of tightly spaced fractures parallel to the fault plane, but displacement is limited to decimetres where offset markers are identified. Brittle faults are associated with quartz veins and hematite staining. A key observation is that the northern part of the Strickland pluton area, underlain by tonalite, is characterized by abundant mainly pink to orange (potassic) alteration and hematite staining within and around fracture surfaces. This type of alteration is less common elsewhere throughout the area. None of the mapped faults are in close proximity to the larger scale faults previously mapped (Section 5.3).

Orientations of the veins mapped are quite variable; northwest-southeast is broadly the most dominant strike orientation, with north-south and northeast-southwest also notable. In all vein orientation families the dips are mostly subvertical. Vein thickness varied from 1 cm to 50 cm with the most common infill being quartz.

About 33 % of all fractures (joints, faults and veins) are infilled with secondary minerals or exhibit some evidence of alteration. The most common secondary minerals/alteration observed include hematite staining, pink (potassic), quartz and epidote.

Figure 5.9 shows the field-verified lineaments for the Strickland pluton area. Within the area five magnetic lineaments were field-verified as brittle structures. The most prominent lineament field-verified as a brittle structure was a curvi-linear lineament extending from the central part of Nameigos Lake striking northwest to north through the entire withdrawal area (Figure 5.9) as noted initially by SGL (2017) and SRK (2017). This is both a surficial lineament and magnetic lineament and forms a notable topographic low in the field. Although the brittle feature itself is not exposed, outcrops along the topographic low are marked by subsidiary faults, veins with a pale-green siliceous material (possibly pseudotachylite) and pink (potassic) alteration and very low magnetic susceptibility. These observations were consistently made at outcrops where a surficial lineament has coincided with a magnetic low lineament (Figure 5.10). In many cases, bedrock exposure is poor along surficial lineaments as they are mostly valleys / low areas often covered with peat / bog and other surficial deposits. Nevertheless, despite the lack of field verification, there remains a reasonable likelihood that coincident surficial lineaments and magnetic low lineaments, particularly trending northwest or southeast, are brittle fault structures. There is both field evidence and evidence from the magnetic lineament data that these brittle lineaments either offset and / or deform Matachewan dykes. Field-verified dyke lineaments are discussed in Section 5.4.

5.3.2 Anahareo Lake Pluton

Information on the structure of the Anahareo Lake pluton area is also based mostly on structural investigations of the Kabinakagami and Dayohessarah greenstone belts, located to the northwest and northeast of the Anahareo Lake pluton area, respectively (Figure 1.2). Phase 2 Geological Mapping provided new structural information for the Anahareo Lake pluton area. Key findings from analysis of the structural observations collected during geological mapping are included below (Amec Foster Wheeler, 2017).

Overall the structural character of the Anahareo Lake pluton area is quite similar to that of the Strickland pluton area. The coarse-grained granite that underlies the centre of the Anahareo Lake pluton area is massive in character, and post-dates the main phase of ductile deformation. Ductile deformation, which includes mostly tectonic foliation, occurs primarily within xenolithic sheets of older metamorphosed igneous and metasedimentary rocks within the granite unit and within screens interlayered with granite pegmatite sills. The tonalite-granodiorite unit mapped mainly in the southern part of the Anahareo Lake pluton area is mostly massive, but very occasionally weakly foliated. Very few shear zones were identified in the area, and they were exclusively determined to be brittle-ductile in nature.

Joints are by far the predominant fracture type observed at the outcrop scale throughout the Anahareo Lake Pluton map area. The two main joint orientations observed strike broadly northeast-southwest and northwest-southeast, and predominantly dip at greater than 60°. A less prominent subhorizontal set of joints was also identified. Joint spacing is mostly within the 100-

500 cm range across the area. The subvertical joints are parallel and / or perpendicular to the two main Proterozoic dyke swarms (Matachewan and Biscotasing).

The fault and vein orientation families are similar in that they also have subvertical dips. However, the faults tend to strike north-northeast and the veins tend to strike north-northeast or north-northwest. The majority of faults are subvertical. Damage zones of faults range from thin, single slip surfaces to several metres wide, tightly spaced joints parallel to the fault plane. Fault displacement is limited to decimetres where offset markers are identified. Some of the mapped faults are in close proximity to a northwest-trending fault previously mapped southwest of Anahareo Lake (Section 5.3; Figure 1.2); however, the relationship of faults mapped during Phase 2 geological mapping to this previously mapped fault is uncertain.

About 35 % of all fractures (joints, faults and veins) are infilled with secondary minerals or exhibit some evidence of alteration. The most common secondary minerals/alteration observed include a pale-green siliceous material (possibly pseudotachylite), epidote, quartz and chlorite and pink (potassic) alteration.

Within the Anahareo Lake pluton, five magnetic lineaments were field-verified as brittle structures (Figure 5.11); none of these were coincident with previously mapped faults. Similar to the Strickland pluton, with presence of suitable outcrop, brittle structures have been usually field-verified where a surficial lineament coincides with a magnetic low lineament. Similar structures are observed such as pale-green siliceous material (possibly pseudotachylite) and epidote veins, less common pink-orange (potassic) alteration, high joint densities, as well as very low magnetic susceptibility (Figure 5.12). There is both field evidence and evidence from the magnetic lineament data that these brittle lineaments either offset and / or deform both Matachewan and Biscotasing dykes.

5.4 Mafic Dykes in the White River Area

Several generations of Paleo- and Mesoproterozoic diabase dyke swarms, ranging in age from 2.473 to 1.14 Ga, cut all bedrock units in the White River area (Figure 1.2). The most prominent of these dyke swarms are, in order of frequency of occurrence:

- Northwest-trending Matachewan Suite dykes (ca. 2.473 Ga; Buchan and Ernst, 2004). This dyke swarm is one of the largest in the Canadian Shield and most predominant of all dyke swarms recognized in the White River area. Individual dykes are generally reported as being up to 10 m wide, and have vertical to subvertical dips. The Matachewan mafic dykes comprise mainly quartz diabase dominated by plagioclase, augite and quartz (Osmani, 1991).
- Northeast-trending Biscotasing Suite dykes (ca. 2.167 Ga; Hamilton et al., 2002).
- North-trending Marathon Suite dykes (ca. 2.121 Ga; Buchan et al., 1996; Hamilton et al., 2002). These form a fan-shaped distribution pattern around the northern, eastern, and

western flanks of Lake Superior. The dykes vary in orientation from northwest to northeast, and occur as subvertical sheets, typically a few m to tens of m thick, but occasionally up to 75 m thick (Hamilton et al., 2002). The Marathon mafic dykes comprise quartz diabase (Osmani, 1991) dominated by equigranular to subophitic clinopyroxene and plagioclase.

Other Proterozoic diabase dykes that have been recognised in the White River area are:

- West-northwest–trending Sudbury Suite dykes (ca. 1.238 Ga; Krogh et al., 1987)
- Northeast-trending Abitibi Suite dykes (ca. 1.14 Ga; Ernst and Buchan, 1993)

SRK (2017) interpreted dyke lineaments of all five of these dyke swarms within the White River survey block. Based on their orientation, most of the interpreted dyke lineaments in the Strickland and Anahareo Lake plutons are of the Matachewan swarm. With the exception of the Sudbury dykes, at least one occurrence of all of these dyke swarms was verified in the field within the Strickland and Anahareo Lake plutons during Phase 2 Geological Mapping (Amec Foster Wheeler, 2017; Figures 5.9 and 5.11). Only one dyke lineament of the Abitibi dyke swarm was field-verified, based on interpreting its extremely low magnetic anomaly being due to reversed magnetisation, which is well documented for the Abitibi dyke swarm (Ernst and Buchan, 1993).

Dyke lineaments interpreted in the White River area are, for the most part, more than 10 km long (SRK, 2017). Based on geological mapping data, Matachewan dykes tend to be thicker than dykes from other swarms, with the majority of them having a minimum thickness of more than 10 m (Amec Foster Wheeler, 2017). The majority of the Biscotasing dykes mapped in the field had minimum thickness of 1-5 m, with only 25% being thicker than 10 m. Most of the Marathon dykes mapped in the field had a minimum thickness of more than 10 m with the remainder having a variable thickness lower than 10 m.

In general, the majority of mapped dykes correlate very well with dyke lineaments interpreted from magnetic data. Field verification of mafic dykes was 100% when outcrops were encountered along magnetic high lineaments. Mapped dykes that are coincident with interpreted dyke lineaments tend to have a significant width and also have a high magnetic susceptibility compared to the host bedrock. However, in several instances, thinner dykes (e.g., significantly < 10 m thick) mapped in the field do not correspond in location to an interpreted dyke lineament. It is possible that thinner mafic dykes (e.g. < 10 metres) may not be observable in the high-resolution magnetic data acquired at a nominal target altitude of 80 metres above ground surface; similarly, thinner dykes are less likely to be observed in the field compared to the widest dykes.

The observations on strike of dyke contacts mapped in the field were found to be similar with those reported in the literature and published maps, as well as those of dyke lineaments interpreted from magnetic data (SRK, 2017) for all dyke swarms. Field measured orientations of Marathon and Biscotasing dyke contacts tend to overlap from north-striking to northeast-striking, which complicates differentiation in the field of these two dyke swarms, particularly for the thinner (< 10 m) that are not associated with a magnetic lineament. Overall, most of the contacts (> 90 %) observed of Matachewan, Biscotasing and Marathon dykes were found to be intact or non-reactivated. Only one example was found of a strongly reactivated contact, which was at a Matachewan dyke where a fault could be traced for 30 metres along one of the contacts.

Jointing is the predominant structure measured within mapped dykes, which all had two consistent joint sets with respect to the orientation of the dyke. The dominant dyke joint set is perpendicular or sub-perpendicular to the dyke contact and tends to be prevalent at the dyke contact. The second subsidiary joint set is parallel or subparallel to the dyke contact and tends to occur in the centre of the dykes. Very little mineralisation or veining is associated with either joint set.

Spacing of joints mapped within dykes is variable, with joint spacing of 1 – 5 m in Matachewan dykes, and spacing of less than 1 m for the Biscotasing and Marathon dykes. Spacing of internal joints, however, may be biased by the measurements being made on thinner dykes for the latter two dyke swarms. In mapping stations where Matachewan dykes were well-exposed it was noted that dyke perpendicular joints are more closely spaced at dyke margins (Amec Foster Wheeler, 2017).

No apparent damage zone near dyke margins within the host rock was observed in the field that could be attributed to damage caused by the dyke intruding. Host rocks appeared to be no more or less fractured at the contacts with Matachewan mafic dykes than in areas away from mafic dykes.

5.5 Bedrock Exposure

The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. At this stage of the assessment, preference was given to areas with greater mapped bedrock exposures. The extent of area mapped as bedrock terrain in the White River area is shown on Figure 4.6. These areas are expected to be covered, at most, with a thin veneer of overburden and therefore considered amenable to geological mapping. The predicted bedrock outcrops, as discussed in Section 4.4.1 and shown on Figure 4.7, generally confirmed areas where overburden had limited thickness.

Geological Mapping (Amec Foster Wheeler, 2017) confirmed the presence of generally good bedrock exposure where outcrops had been predicted from the GIS analysis, as shown in

Figure 4.7. A few of the predicted bedrock outcrops were found to be a sandy till in excess of three metres thick, such as along recent logging roads traversing the highest elevations of the north portion of the withdrawal area in the Strickland pluton, east of Highway 631 to the northeast of Beaton Lake (Figure 4.7). With the exception of the Nameigos Lake shore, there are few bedrock outcrops in the central, southern and southeastern portions of the Strickland pluton area, as indicated by the predicted bedrock outcrop. The low-lying central, south, and southeastern areas are characterized by meandering river channels, small ponds and bogs, and where outcrop was encountered, it typically had overburden thicknesses less than one metre thick.

Bedrock exposure in the Anahareo Lake pluton area is more extensive in comparison to the Strickland pluton area, as indicated by the extent of predicted outcrop, particularly along a north-south trending central corridor where large exposures occurred (Figure 4.7). The area mapped as glaciofluvial terrain along the southwest edge of the Anahareo Lake pluton withdrawal area (Figure 4.6) had limited predicted outcrop, which was largely confirmed by the geological mapping (Amec Foster Wheeler, 2017).

5.6 Protected Areas

All provincial parks, conservation reserves and provincial nature reserves in the White River area were excluded from consideration (AECOM, 2014). The largest protected areas in the White River area include the Kwinkwaga Ground Moraine Conservation Reserve (126.5 km^2), the Pokei Lake / White River Wetlands Provincial Nature Reserve (17.68 km^2) and the Strickland River Mixed Forrest Wetland Conservation Reserve (16.38 km^2) (Figure 1.1). Other protected areas include the Kakakiwibik Esker Conservation Reserve and the White Lake Peatlands Provincial Park (AECOM, 2014). The preliminary Phase 2 assessment reaffirmed that the identified withdrawal areas are outside of these protected areas.

5.7 Natural Resources

Areas with known potential for exploitable natural resources such as the rocks of the greenstone belts were excluded from further consideration for the identification of potentially suitable areas (AECOM, 2014). All granitoid intrusions in the White River area have low potential for economically exploitable natural resources. In addition to the information collected during the Phase 1 preliminary assessment (AECOM, 2014), the newly acquired Phase 2 geophysical data (SGL, 2017) was used to identify geophysical anomalies that may be indicative of rock units that have mineral potential.

Interpretation of newly acquired geophysical data identified a magnetic anomaly extending from the western side of the Kabinakagami Lake greenstone belt to the Dayohessarah greenstone belt (Figure 5.2; SGL, 2017). Curvilinear unclassified lineaments were interpreted by SRK (2017) along the same zone. This zone is interpreted to potentially represent the remnants of a once larger greenstone belt that is now discontinuous and /or partially assimilated along the margins of the Strickland and Anahareo Lake plutons. Phase 2 geological mapping data locally support this interpretation.

A teardrop-shaped magnetic anomaly was also identified by SGL (2017), as described in Section 5.1.2, near the central part of the Anahareo Lake pluton withdrawal area, extending southwest from the magnetic anomaly associated with the Kabinakagami greenstone belt. Geological Mapping has shown that this correlates with a higher density of xenoliths / rafts of metamorphic rocks in the area. Geophysical and mapping data suggest that this area may be underlain by discontinuous or partially assimilated remnants of the Kabinakagami greenstone belt. The Kabinakagami Lake Greenstone Belt is considered to have high potential for economic gold deposits; potential for economic deposits of other metals is considered to be modest to low (AECOM, 2014).

In addition to the information gathered during the Phase 1 preliminary assessment (AECOM, 2014), the mineral resources and claim maps were updated as part of the initial Phase 2 assessment (Figure 5.13). Presently advanced exploration for gold is being undertaken at the Sugar Zone Property located in the Dayohessarah Greenstone Belt on the edge of the Strickland pluton west of the withdrawal area. Similarly, mining claims are currently in place along the zone between the Strickland and Anahareo Lake plutons interpreted to potentially contain remnants of a once larger greenstone belt, as described above.

5.8 Potential Surface Constraints

Phase 1 preliminary assessment of the White River area (AECOM, 2014) identified limited surface constraints in the Strickland and Anahareo Lake pluton areas. Phase 2 Geological Mapping (Amec Foster Wheeler, 2017) allowed a more detailed assessment of the potential surface constraints within these areas.

During geological mapping, areas of obvious topographic constraints (high density of steep slopes), large water bodies (wetlands, lakes), and areas of poor accessibility were documented. While areas with such constraints were not explicitly excluded from consideration, they are identified as potential surface constraints that would need to be considered when planning future field studies.

Distribution of large lakes in the White River is fairly limited, with only two large lakes within the Strickland and Anahareo Lake pluton areas: Nameigos Lake and Anahareo Lake respectively (Figure 1.2). While lake coverage is generally considered a constraint for conducting detailed mapping, field work confirmed that lake shores, such as Nameigos Lake, provide some of the best bedrock exposures for the purpose of geological mapping (Amec Foster Wheeler, 2017). Topography in the White River area is generally subdued, although considerable relief (>100 m) is observed between lakes and creeks in some areas, the most notable being in the northern part of the Anahareo Lake pluton withdrawal area (Figure 4.3).

Phase 2 Geological Mapping (Amec Foster Wheeler, 2017) documented that access and surface constraints vary across the two withdrawal areas in the White River area. Highway 631 passes north-northeast through the centre of the Strickland pluton withdrawal area (Figure 1.2). Many subsidiary logging roads extend to the west and east off of this main corridor, and were generally found to be passable. The southeast part of the Strickland pluton withdrawal area is more difficult to access. There are no logging roads and only a few open spaces suitable for helicopter landing. For the Anahareo Lake pluton withdrawal area, access is good along the existing main logging road that passes northwards through the centre of the area. Several branching secondary logging roads splay off the main north-south road (Figure 1.2), but most of these were not maintained and were generally severely overgrown, requiring the use of ATVs on a few of the old roads, and walking traverses on the majority of the old roads.

6.0 SUMMARY

In 2014, a Phase 1 Geoscientific Desktop Preliminary Assessment was completed by AECOM to assess whether the White River area contained general areas that had the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's Adaptive Phased Management (APM) site selection process. The assessment was conducted using available geoscientific information and key geoscientific characteristics that could be realistically assessed at the desktop stage. The Phase 1 assessment revealed that the White River area contains at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors (AECOM, 2014; NWMO, 2010).

In 2015, as part of Phase 2 of the preliminary geoscientific assessment of the White River area, NWMO initiated a series of initial geoscientific field studies in two of the four general potentially suitable areas identified during Phase 1 preliminary assessment. The objective of these initial field studies was to advance understanding of the geology of these general potentially suitable areas, and assess whether it is possible to identify general Potential Repository Areas (PRAs).

The initial Phase 2 geoscientific preliminary assessment included the following key activities:

- Acquisition and processing of high-resolution airborne geophysical (magnetic and gravity) data over two of the general potentially suitable areas identified in Phase 1 Geoscientific Desktop Preliminary Assessment;
- Detailed interpretation of high-resolution geophysical (gravity and magnetic) data to better understand the bedrock geology (e.g. geological contacts, depth and extent of rock units, lithological and structural heterogeneity);
- Detailed interpretation of surficial and magnetic lineaments using newly acquired high-resolution remote sensing and magnetic data to identify possible structural features such as fractures, shear zones and dykes; and
- Geological mapping to assess geologic characteristics, including lithology, structure, bedrock exposure and surface constraints.

In 2017, after several years of progressively more detailed study and engagement, the NWMO concluded that the community of White River would not be considered a potential host for the project.

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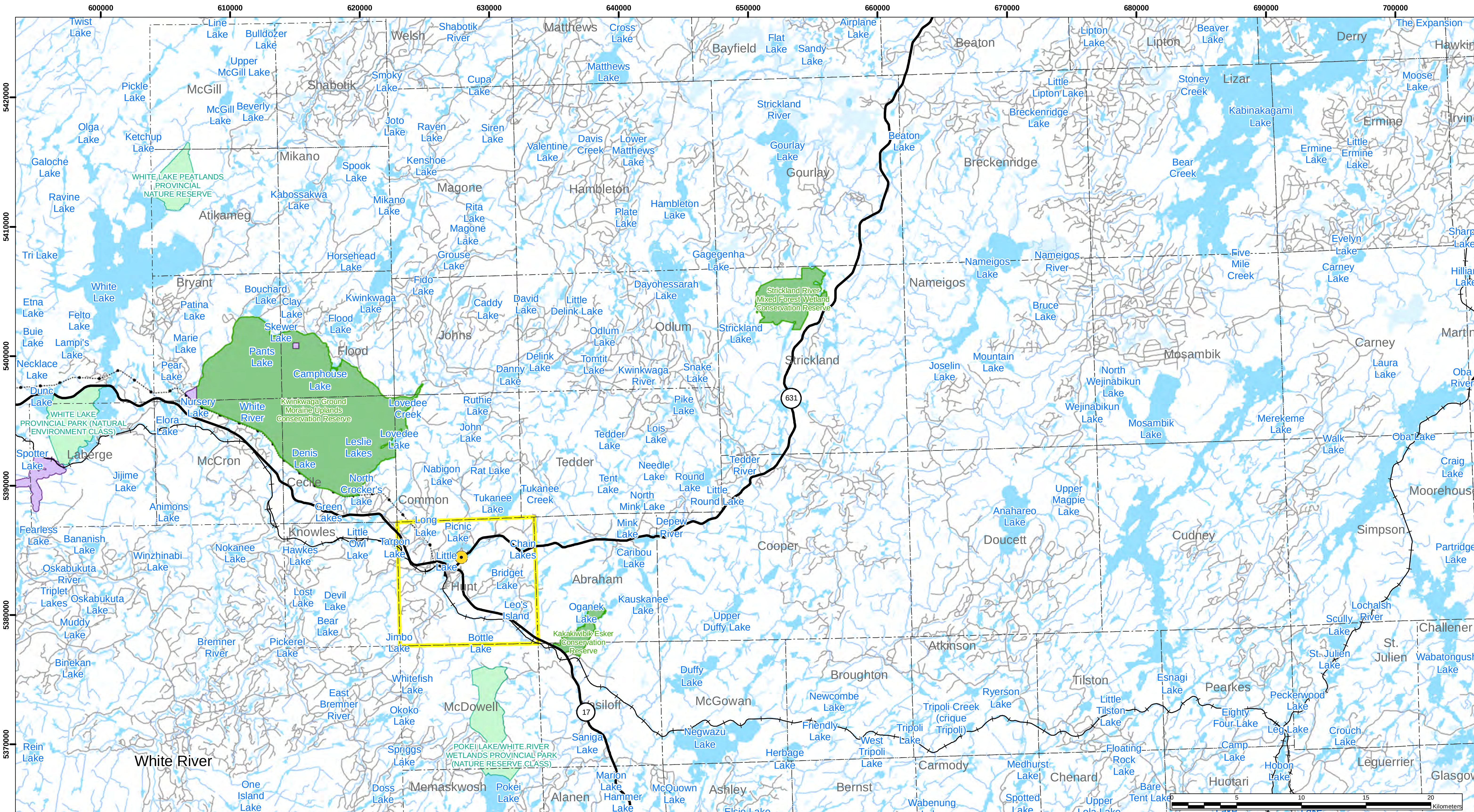
Stott, G., Mahoney, K.L. and Zwiers, W.G. 1995b. Precambrian geology of the Dayohessarah Lake area (central); Ontario Geological Survey, Preliminary Map P.3310, scale 1:20,000.

Stott, G., Mahoney, K.L. and Zwiers, W.G. 1995c. Precambrian geology of the Dayohessarah Lake area (south); Ontario Geological Survey, Preliminary Map P.3311, scale 1:20,000.

Stott, G.M. 1999. Precambrian geology of the Dayohessarah Lake area, White River, Ontario; Ontario Geological Survey, Open File Report 5984, 54p.

FIGURES



LEGEND

- White River Municipal Boundary (Township of White River)
- Geographic Township
- Community
- Main Road
- Local Road
- Railway
- Power Transmission Line
- Watercourse
- Waterbody
- Wetland
- Conservation Reserve
- Provincial Park
- Forest Reserve

SOURCE:
Base Data- MNR LIO obtained 2009-2015, CANMAP v2006.4

CLIENT: nwmo

Revision:	v3.0
NAD 1983 Zone 16N	
Drawn By: LJM	13/11/2017
Checked By: MS	13/11/2017
SCALE: 1:275,000	

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

The White River Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: 1.1

Amec Foster Wheeler Environment & Infrastructure
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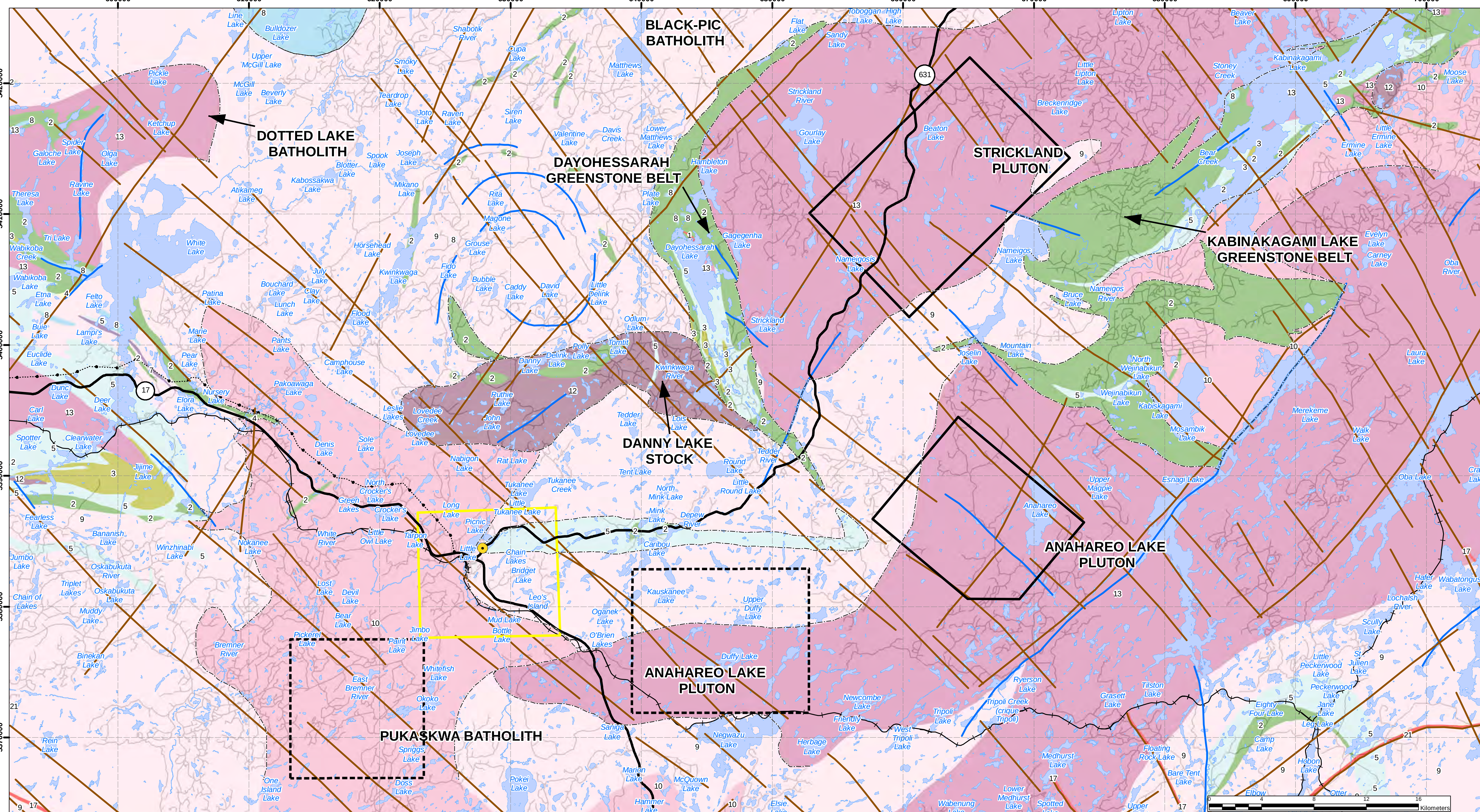
tel: 905-335-2053 www.amecfw.com



LEGEND

- Community
- Municipal Boundary (Township of White River)
- Withdrawal Areas
- Withdrawal Areas (Not Surveyed)
- Main Road
- Local Road
- Waterbody
- Geologic Dyke
- Geologic Fault

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 12: Diorite-monzonite- granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 8: Gabbro
- 7: Ultramafic plutonic rocks
- 5: Metasedimentary rocks
- 4: Felsic volcanic rocks
- 3: Felsic and intermediate metavolcanic rocks
- 2: Mafic metavolcanic Rocks

SOURCE:
Base Data- MNR LIO obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Faults: OGS MRD 126-REV1, 2011 (1:250,000)
Dykes: OGS MRD 126-REV, 2011 (1:250,000)

CLIENT: nwmo

Revision:	v3.0
NAD 1983 Zone 16N	
Drawn By: LJM	13/11/2017
Checked By: MS	13/11/2017
SCALE:	1:275,000

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Land Withdrawn to Facilitate Phase 2 Studies
in the White River Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: **1.2**

Amec Foster Wheeler Environment & Infrastructure
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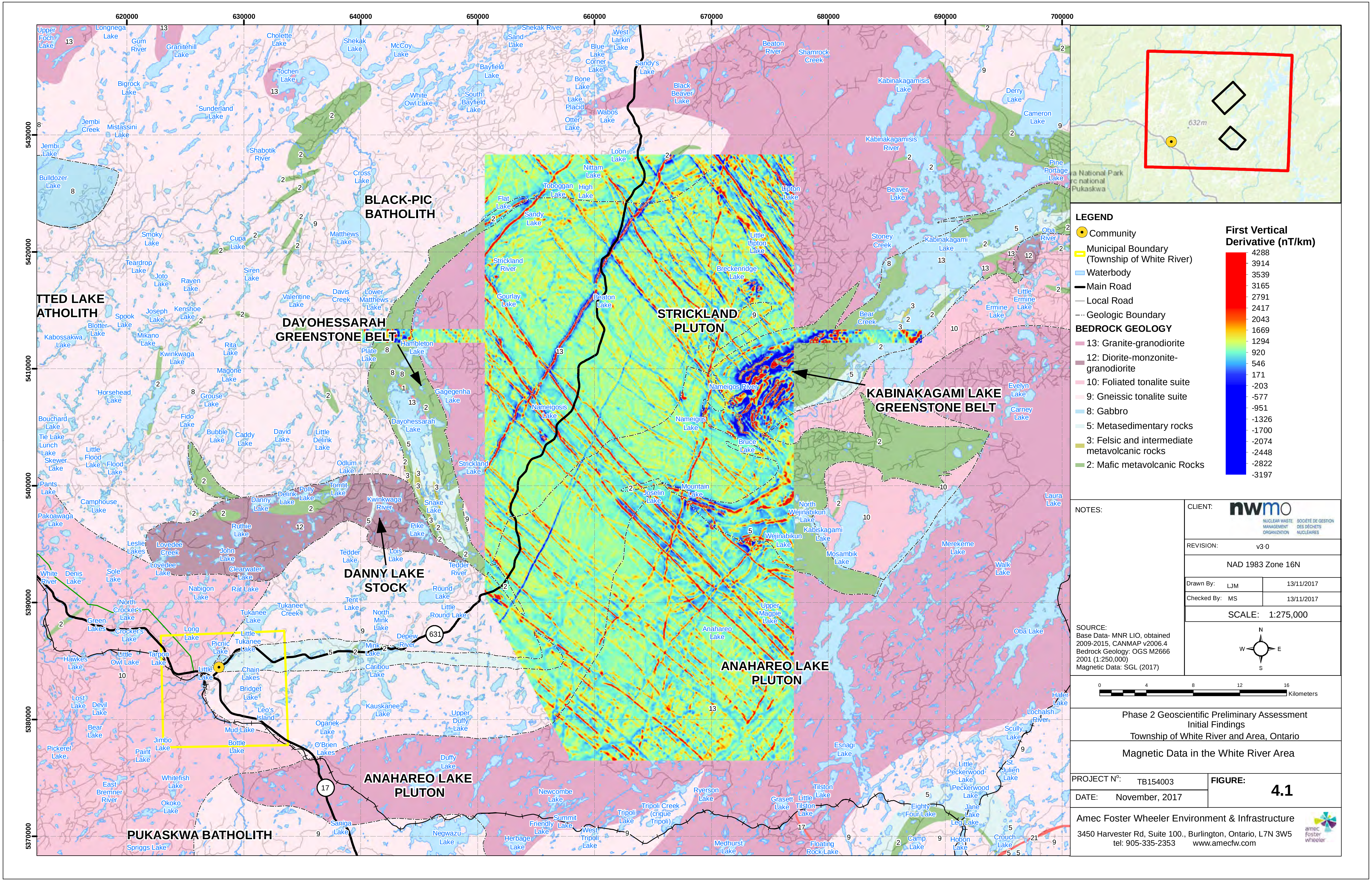
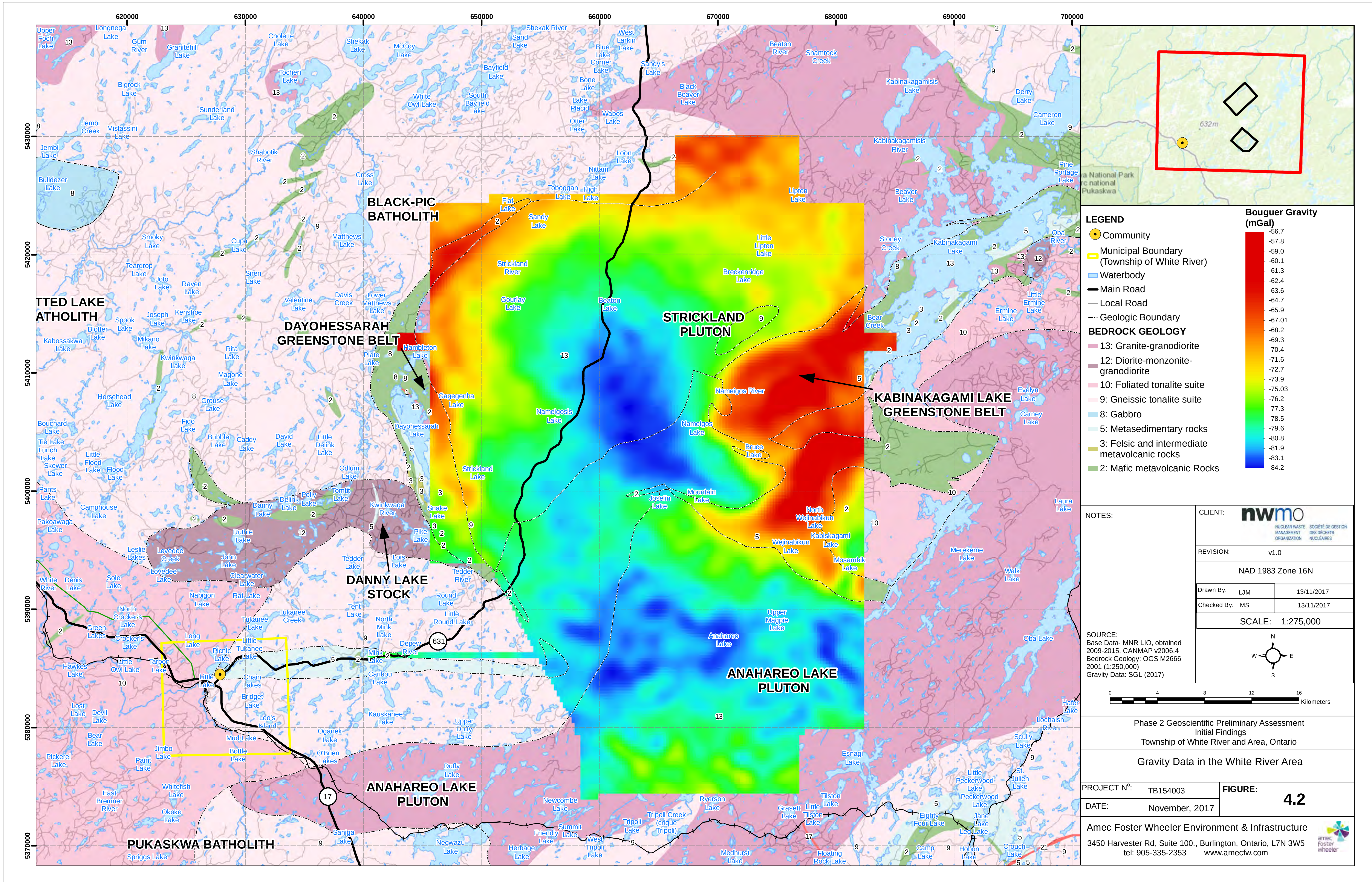
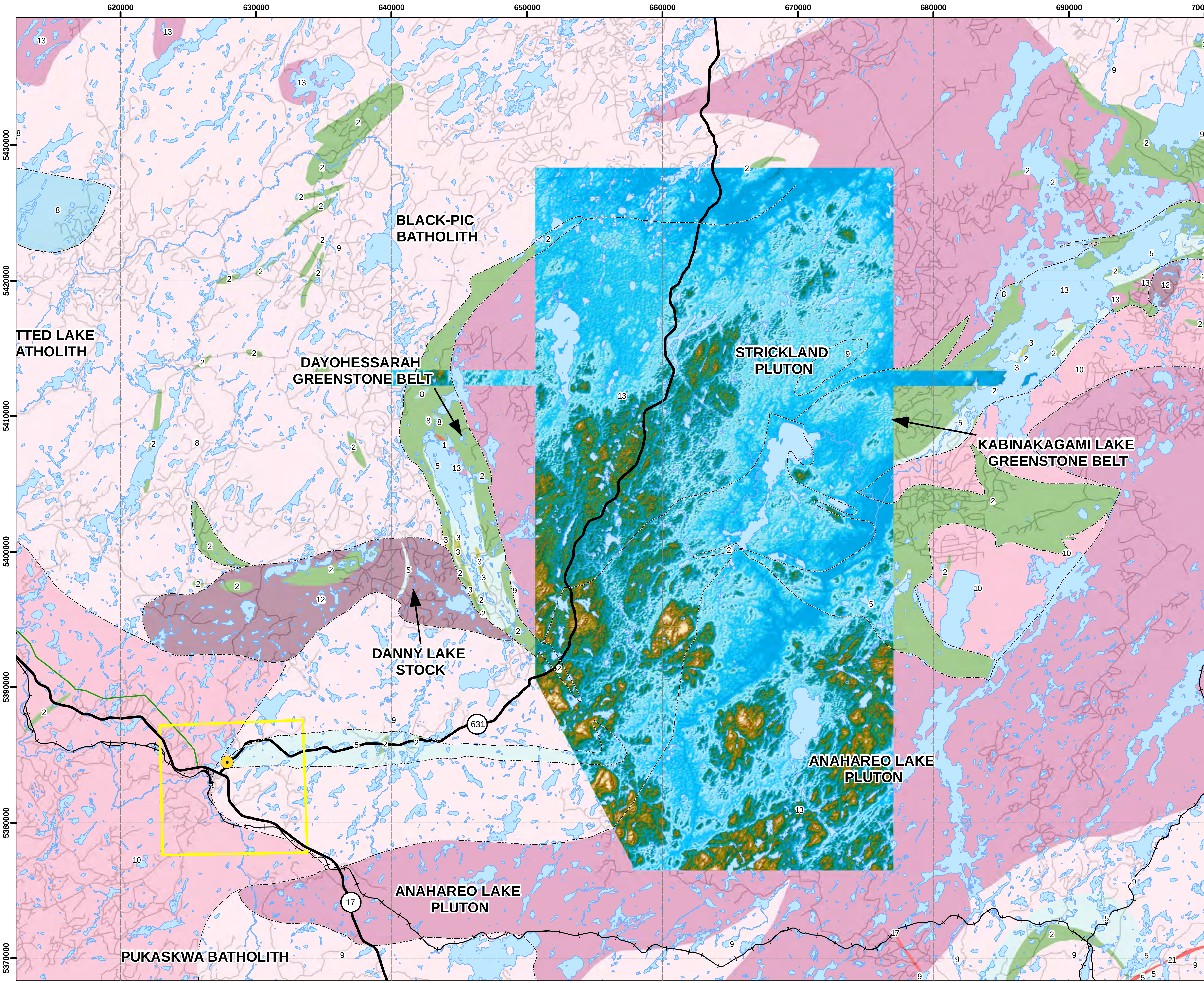
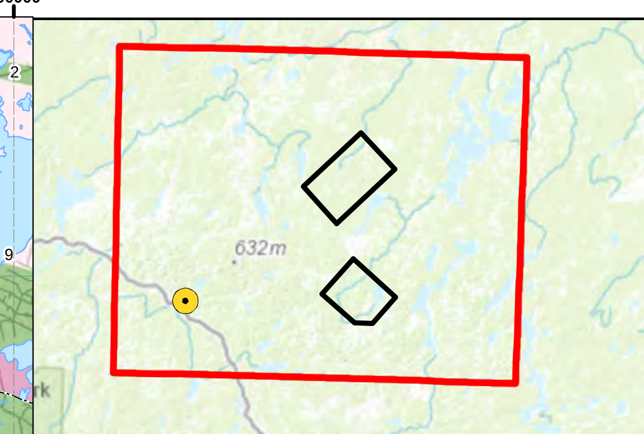


BLACK-PIC BATHOLITH
DAYOHESSARAH GREENSTONE BELT
STRICKLAND PLUTON
KABINAKAGAMI LAKE GREENSTONE BELT
DANNY LAKE STOCK
ANAHAREO LAKE PLUTON
PUKASKWA BATHOLITH
TTED LAKE ATHOLITH
LEGEND
Community
Municipal Boundary (Township of White River)
Waterbody
Main Road
Local Road
Geologic Boundary
BEDROCK GEOLOGY
13: Granite-granodiorite
12: Diorite-monzonite-granodiorite
10: Foliated tonalite suite
9: Gneissic tonalite suite
8: Gabbro
5: Metasedimentary rocks
3: Felsic and intermediate metavolcanic rocks
2: Mafic metavolcanic Rocks
First Vertical Derivative (nT/km)
4288
3914
3539
3165
2791
2417
2043
1669
1294
920
546
171
-203
-577
-951
-1326
-1700
-2074
-2448
-2822
-3197
NOTES:
SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666 2001 (1:250,000)
Magnetic Data: SGL (2017)
CLIENT:
REVISION: v3·0
NAD 1983 Zone 16N
Drawn By: LJM 13/11/2017
Checked By: MS 13/11/2017
SCALE: 1:275,000
0 4 8 12 16 Kilometers
Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario
Magnetic Data in the White River Area
PROJECT N°: TB154003
FIGURE: 4.1
DATE: November, 2017
Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Rd, Suite 100., Burlington, Ontario, L7N 3W5
tel: 905-335-2353 www.amecfw.com



BLACK-PIC BATHOLITH
DAYOHESSARAH GREENSTONE BELT
STRICKLAND PLUTON
KABINAKAGAMI LAKE GREENSTONE BELT
DANNY LAKE STOCK
ANAHAREO LAKE PLUTON
PUKASKWA BATHOLITH
TTED LAKE ATHOLITH
620000
630000
640000
650000
660000
670000
680000
690000
700000
5430000
5420000
5410000
5400000
5390000
5380000
5370000
LEGEND
Community
Municipal Boundary (Township of White River)
Waterbody
Main Road
Local Road
Geologic Boundary
BEDROCK GEOLOGY
13: Granite-granodiorite
12: Diorite-monzonite-granodiorite
10: Foliated tonalite suite
9: Gneissic tonalite suite
8: Gabbro
5: Metasedimentary rocks
3: Felsic and intermediate metavolcanic rocks
2: Mafic metavolcanic Rocks
Bouguer Gravity (mGal)
-56.7
-57.8
-59.0
-60.1
-61.3
-62.4
-63.6
-64.7
-65.9
-67.01
-68.2
-69.3
-70.4
-71.6
-72.7
-73.9
-75.03
-76.2
-77.3
-78.5
-79.6
-80.8
-81.9
-83.1
-84.2
NOTES:
CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES
REVISION: v1.0
NAD 1983 Zone 16N
Drawn By: LJM 13/11/2017
Checked By: MS 13/11/2017
SCALE: 1:275,000
SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666 2001 (1:250,000)
Gravity Data: SGL (2017)
0 4 8 12 16 Kilometers
Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario
Gravity Data in the White River Area
PROJECT N°: TB154003
DATE: November, 2017
FIGURE: 4.2
Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Rd, Suite 100., Burlington, Ontario, L7N 3W5
tel: 905-335-2353 www.amecfw.com





LEGEND

- Community
- Municipal Boundary (Township of White River)
- Waterbody
- Main Road
- Local Road
- Geologic Boundary

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 12: Diorite-monzonite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 8: Gabbro
- 5: Metasedimentary rocks
- 3: Felsic and intermediate metavolcanic rocks
- 2: Mafic metavolcanic Rocks

Elevation (mAMSL)

566.7, 554.7, 543.7, 533.7, 522.6, 511.6, 501.6, 490.6, 480.6, 469.5, 458.5, 448.5, 437.5, 426.4, 416.4, 405.4, 395.4, 384.4, 373.4, 363.3, 352.3, 341.3, 331.3, 320.3, 310.2

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M266, 2001 (1:250,000)
DEM Data: SGL (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION:	v3.0	
NAD 1983 Zone 16N		
Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017
SCALE: 1:275,000		

N / S / E / W

0 4 8 12 16 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Digital Elevation Model (DEM) Data in the White River Area

PROJECT N°: TB154003 | FIGURE: 4.3
DATE: November, 2017

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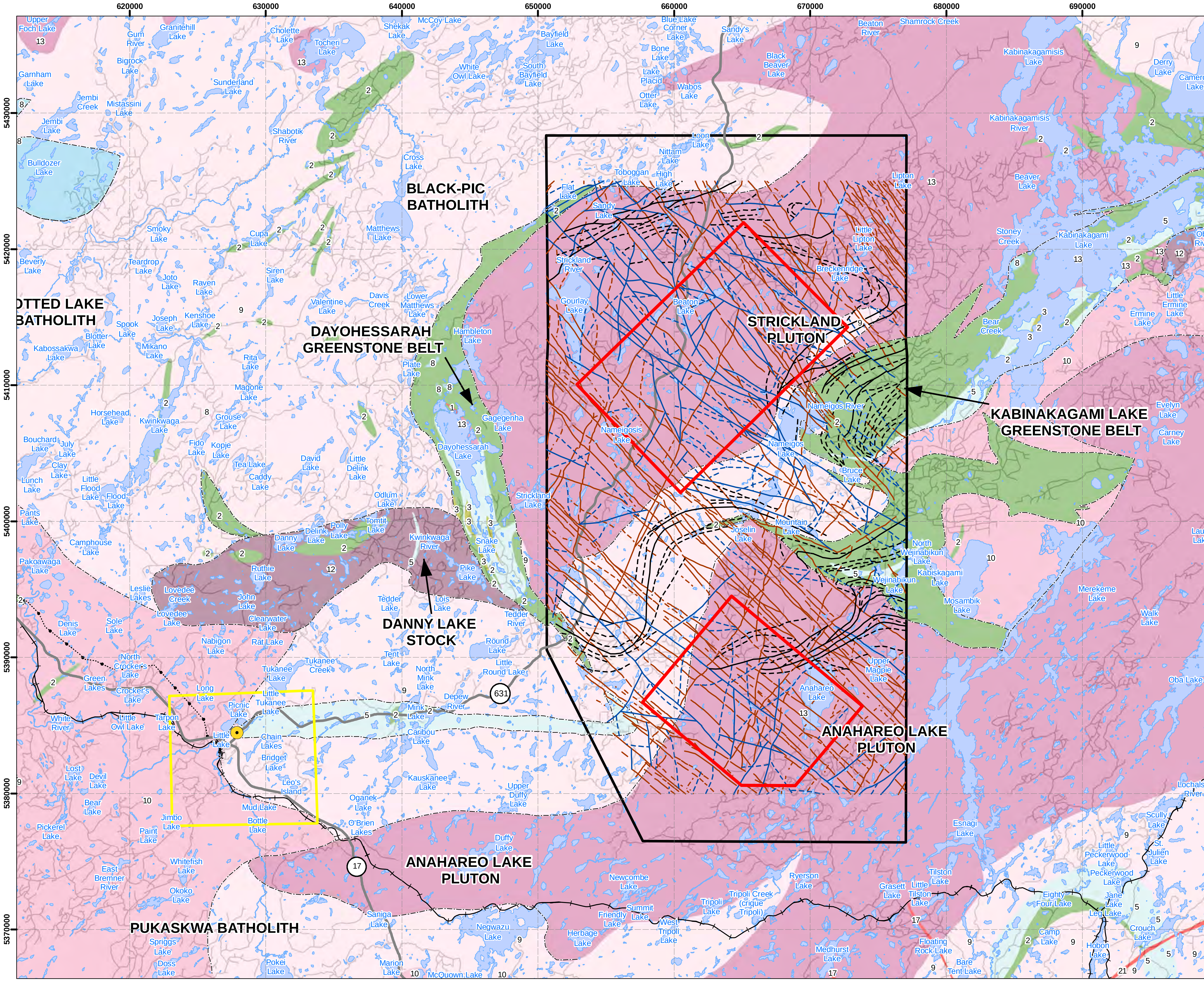
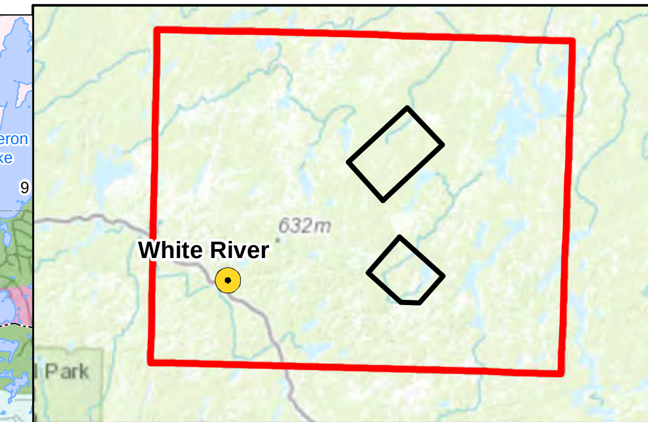
tel: 905-335-2353 www.amecfw.com





LEGEND

- Withdrawal Area
- Airborne Survey Block
- Municipal Boundary (Township of White River)
- Waterbody
- Main Road
- Local Road
- Geologic Boundary

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 12: Diorite-monzonite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 8: Gabbro
- 5: Metasedimentary rocks
- 3: Felsic and intermediate metavolcanic rocks
- 2: Mafic metavolcanic Rocks

Magnetic Lineaments

Dykes
- Medium Certainty
- High Certainty

Brittle
- Medium Certainty
- High Certainty

Unclassified
- Medium Certainty
- High Certainty

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology:OGS M2666, 2001 (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION: v3.0

NAD 1983 Zone 16N

Drawn By: LJM 13/11/2017
Checked By: MS 13/11/2017

SCALE: 1:275,000

0 4 8 12 16 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Magnetic Lineaments with High and Medium Certainty in the White River Area

PROJECT N°: TB154003
DATE: November, 2017
FIGURE: 4.4

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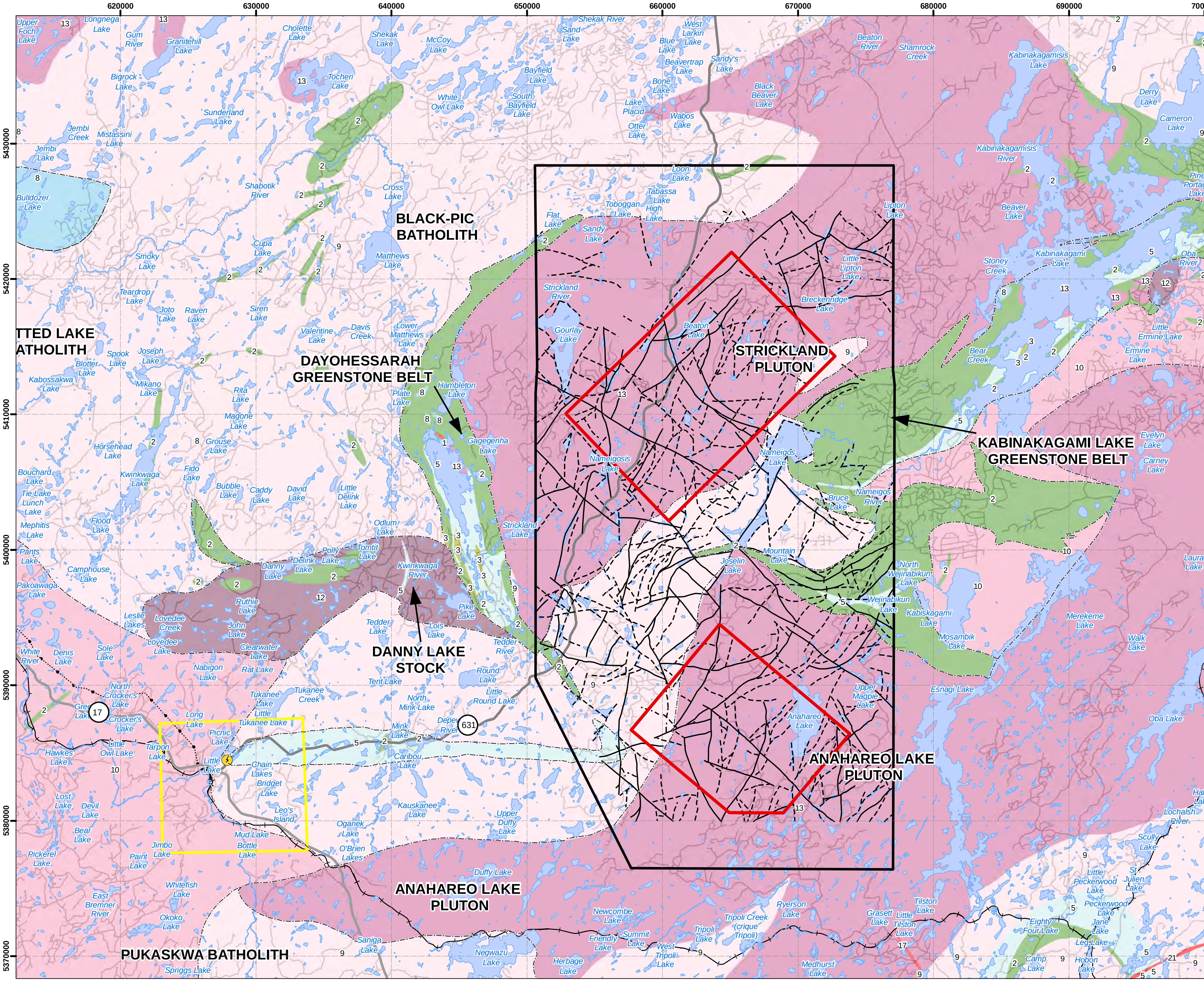
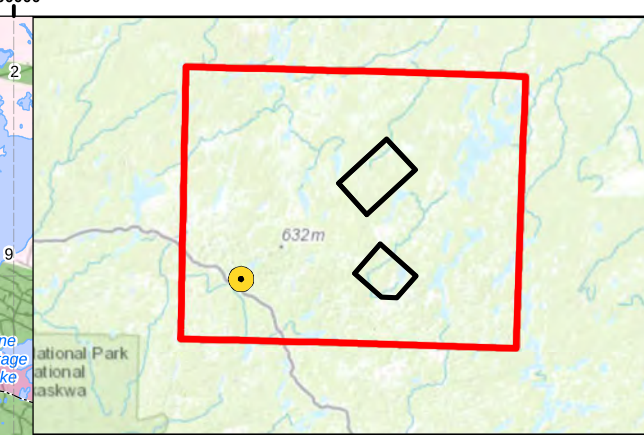
tel: 905-335-2353 www.amecfw.com





LEGEND

- Community
- Withdrawal Areas
- Airborne Survey Block
- Waterbody
- Municipal Boundary (Township of White River)
- Main Road
- Local Road

Surficial Lineaments

- Medium Certainty
- High Certainty
- Geologic Boundary

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 12: Diorite-monzonite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 8: Gabbro
- 5: Metasedimentary rocks
- 3: Felsic and intermediate metavolcanic rocks
- 2: Mafic metavolcanic Rocks

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION:	v3.0	
NAD 1983 Zone 16N		
Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017
SCALE:	1:275,000	

0 4 8 12 16 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Surficial Lineaments with High and Medium Certainty in the White River Area

PROJECT N°: TB154003

FIGURE: 4.5

DATE: November, 2017

Amec Foster Wheeler Environment & Infrastructure
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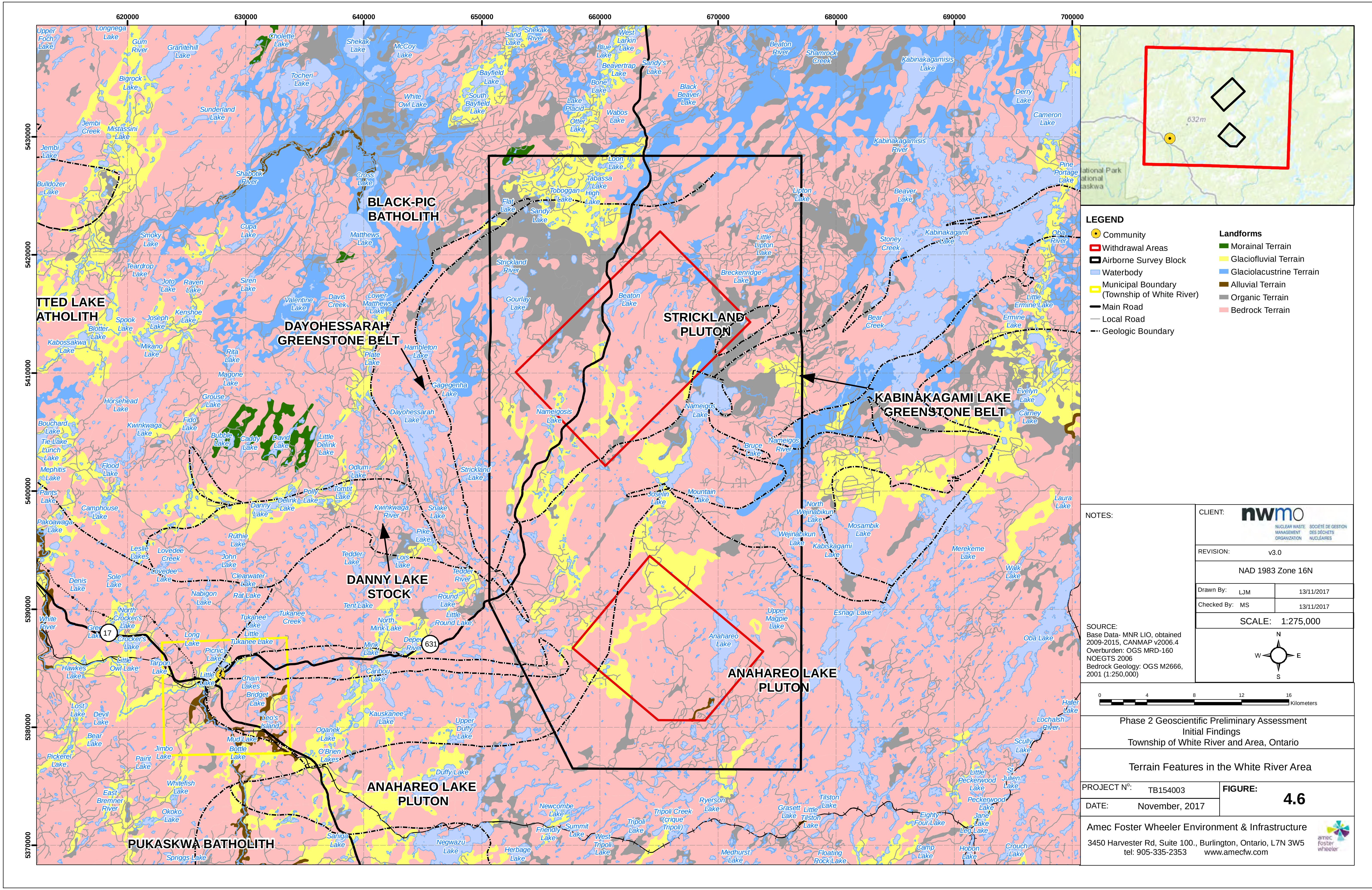
tel: 905-335-2353 www.amecfw.com



Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Terrain Features in the White River Area

PROJECT N°: TB154003
DATE: November, 2017
FIGURE: 4.6

Amec Foster Wheeler Environment & Infrastructure
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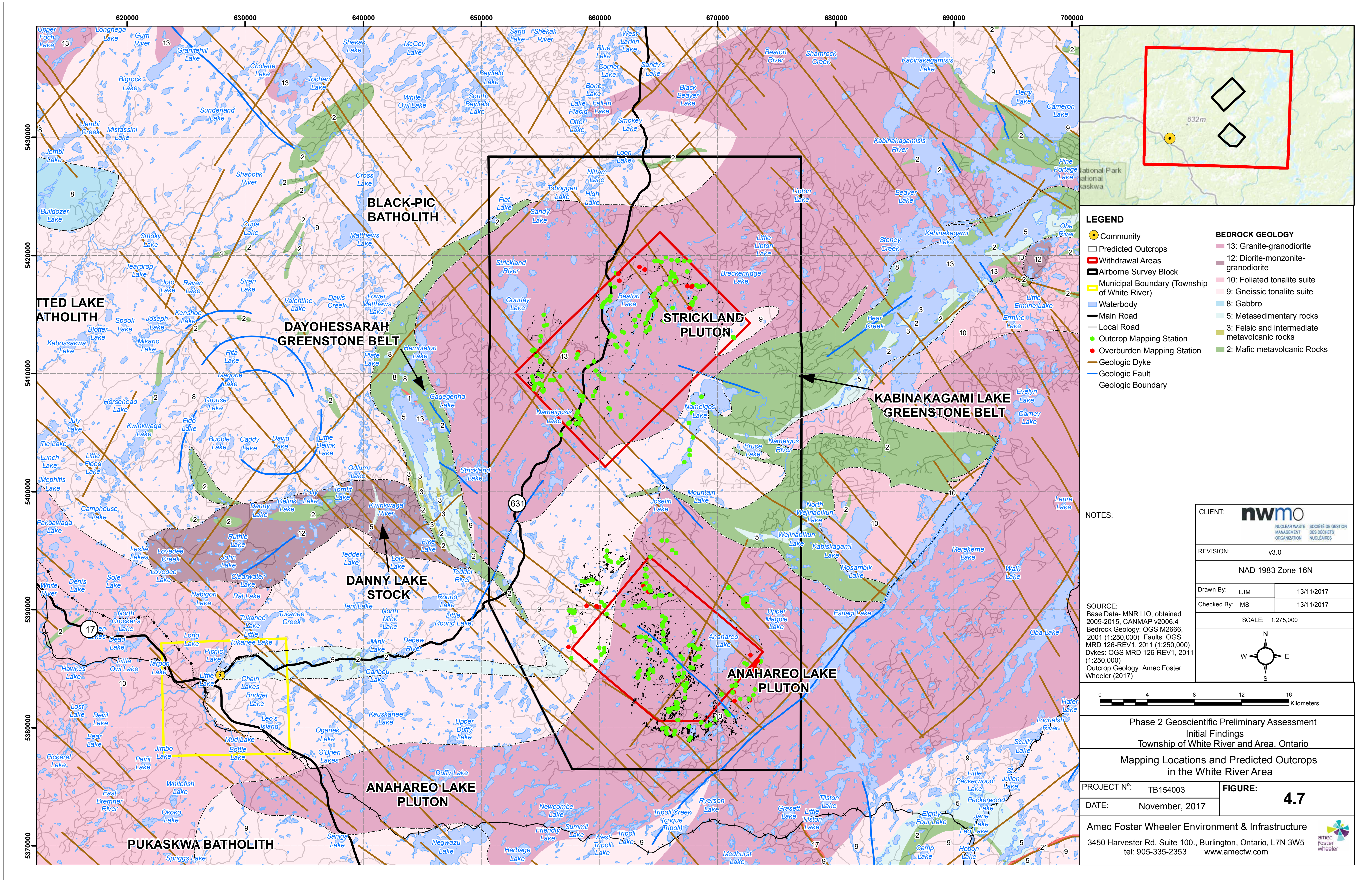
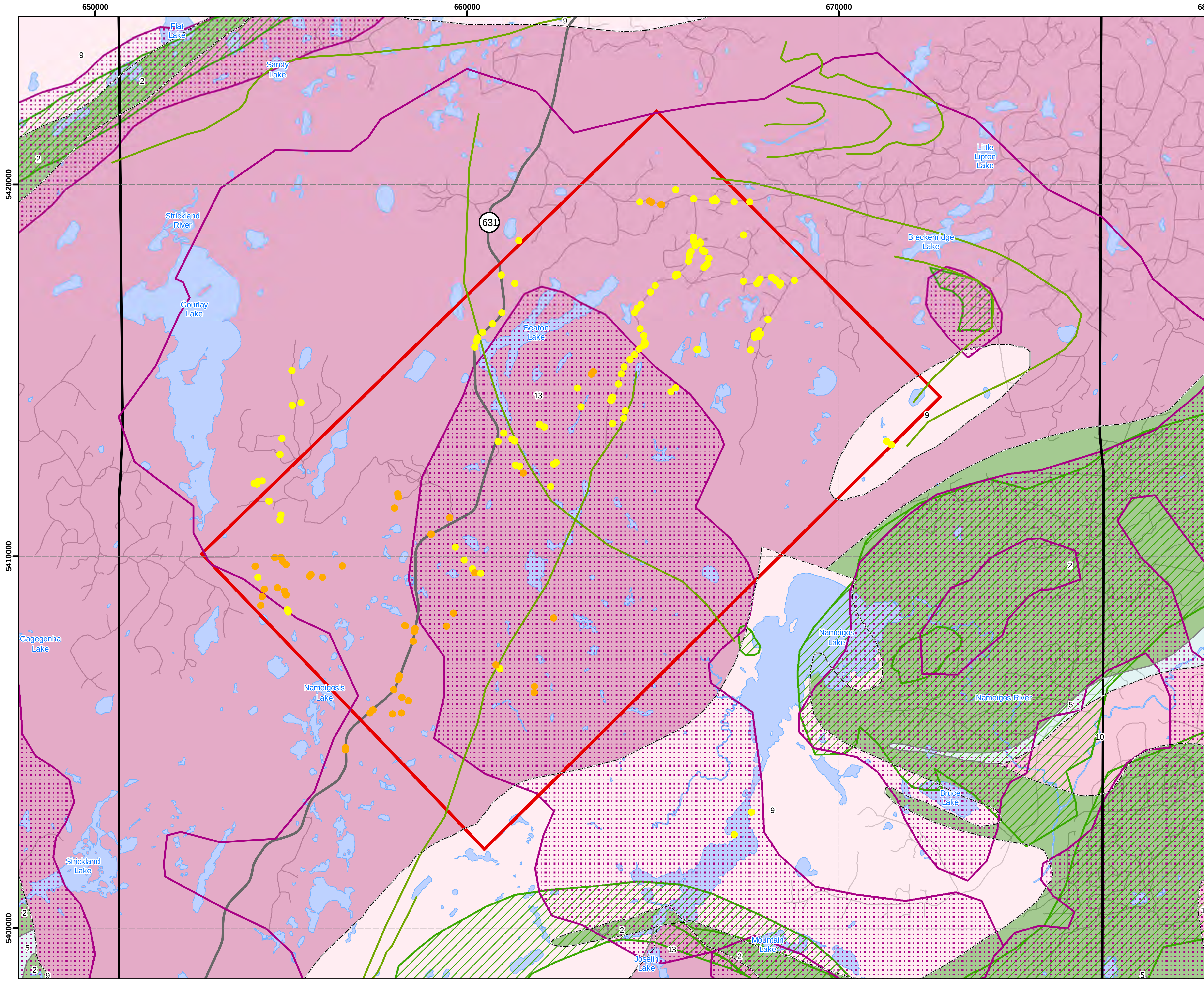
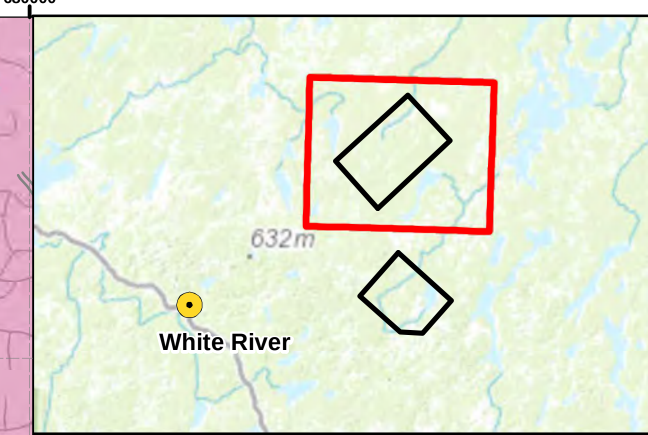
tel: 905-335-2353 www.amecfw.com



LEGEND
Community
Predicted Outcrops
Withdrawal Areas
Airborne Survey Block
Municipal Boundary (Township of White River)
Waterbody
Main Road
Local Road
Outcrop Mapping Station
Overburden Mapping Station
Geologic Dyke
Geologic Fault
Geologic Boundary
BEDROCK GEOLOGY
13: Granite-granodiorite
12: Diorite-monzonite-granodiorite
10: Foliated tonalite suite
9: Gneissic tonalite suite
8: Gabbro
5: Metasedimentary rocks
3: Felsic and intermediate metavolcanic rocks
2: Mafic metavolcanic Rocks
BLACK-PIC BATHOLITH
DAYOHESSARAH GREENSTONE BELT
STRICKLAND PLUTON
KABINAKAGAMI LAKE GREENSTONE BELT
DANNY LAKE STOCK
ANAHAREO LAKE PLUTON
PUKASKWA BATHOLITH
NOTES:
SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000) Faults: OGS MRD 126-REV1, 2011 (1:250,000)
Dykes: OGS MRD 126-REV1, 2011 (1:250,000)
Outcrop Geology: Amec Foster Wheeler (2017)
CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES
REVISION: v3.0
NAD 1983 Zone 16N
Drawn By: LJM 13/11/2017
Checked By: MS 13/11/2017
SCALE: 1:275,000
0 4 8 12 16 Kilometers
Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario
Mapping Locations and Predicted Outcrops
in the White River Area
PROJECT N°: TB154003
FIGURE: 4.7
DATE: November, 2017
Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Rd, Suite 100., Burlington, Ontario, L7N 3W5
tel: 905-335-2353 www.amecfw.com





LEGEND

- Withdrawal Area
- Airborne Survey Block
- Waterbody
- Main Road
- Local Road
- Gravity Anomalies
- Magnetic Anomalies
- Gravitiy Linear Trends
- Magnetic Linear Trends
- Geologic Boundary

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

MAIN LITHOLOGY

- Granodiorite
- Tonalite

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Geophysical Anomalies: SGL (2017)
Outcrop Geology: Amec Foster Wheeler (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION: v3.0

NAD 1983 Zone 16N

Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017

SCALE: 1:100,000

N E S W

0 1 2 3 4 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Bedrock Geology and Geophysical Anomalies
for the Strickland Pluton Area

PROJECT N°: TB154003

FIGURE: **5.1**

DATE: November, 2017

Amec Foster Wheeler Environment & Infrastructure
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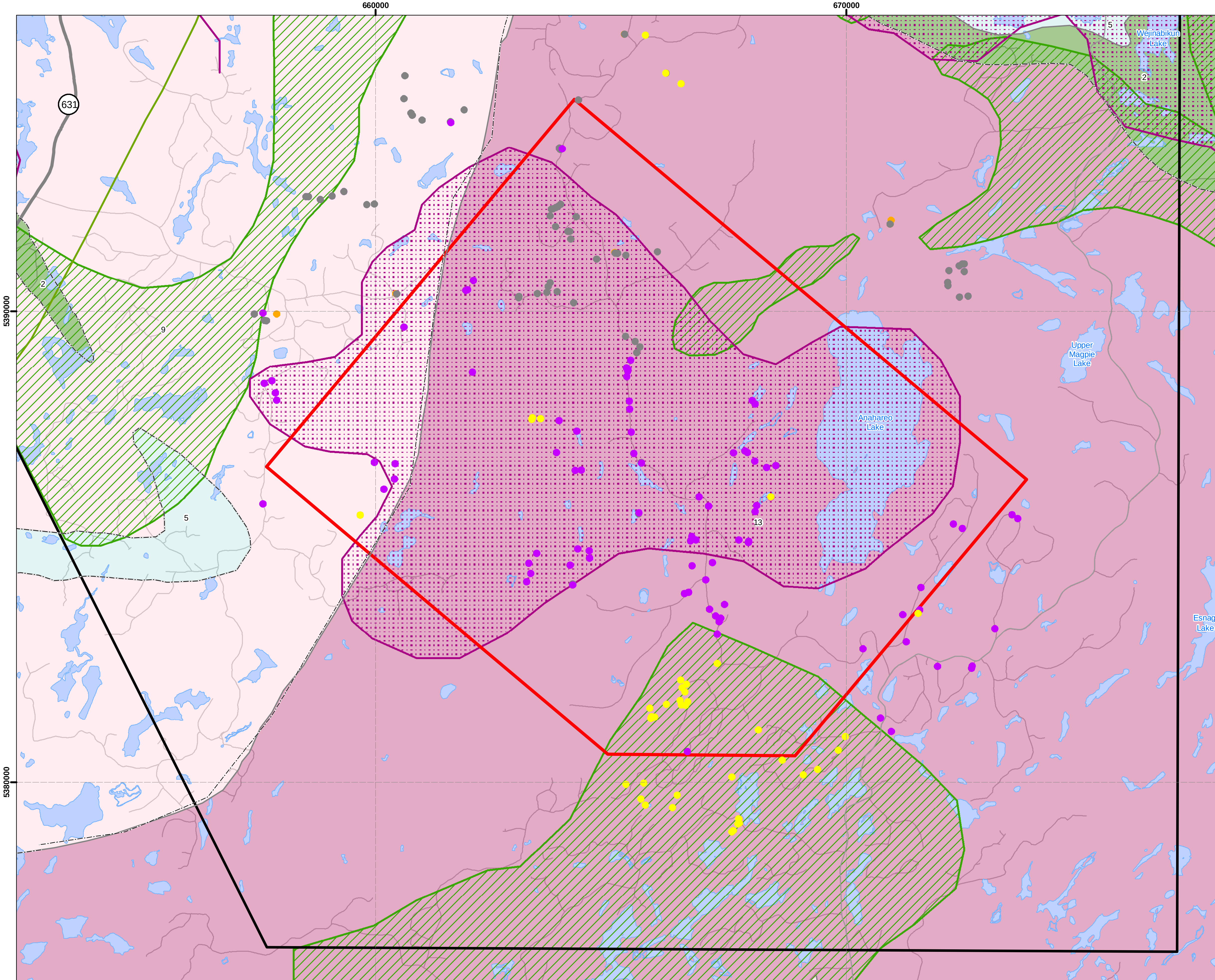
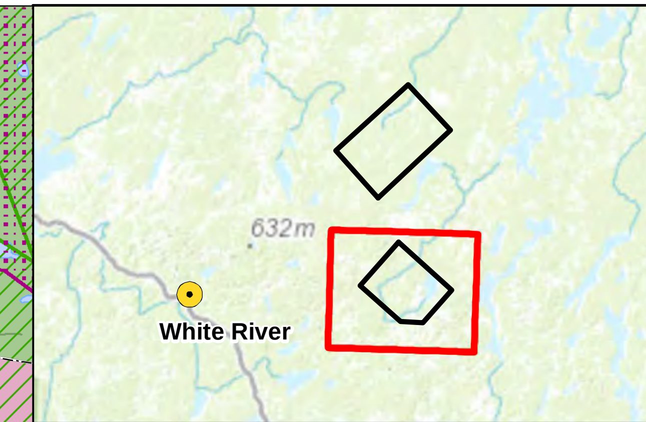




LEGEND

- Withdrawal Area
- Airborne Survey Block
- Waterbody
- Main Road
- Local Road
- Gravity Anomalies
- Magnetic Anomalies
- Gravitiy Linear Trends
- Magnetic Linear Trends
- Geologic Boundary

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

MAIN LITHOLOGY

- Tonalite-Granodiorite
- Granite
- Granite Pegmatite

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Geophysical Anomalies: SGL (2017)
Outcrop Geology: Amec Foster Wheeler (2017)

CLIENT:	nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES
REVISION:	v3.0
NAD 1983 Zone 16N	
Drawn By: LJM	13/11/2017
Checked By: MS	13/11/2017
SCALE: 1:80,000	

N E S W

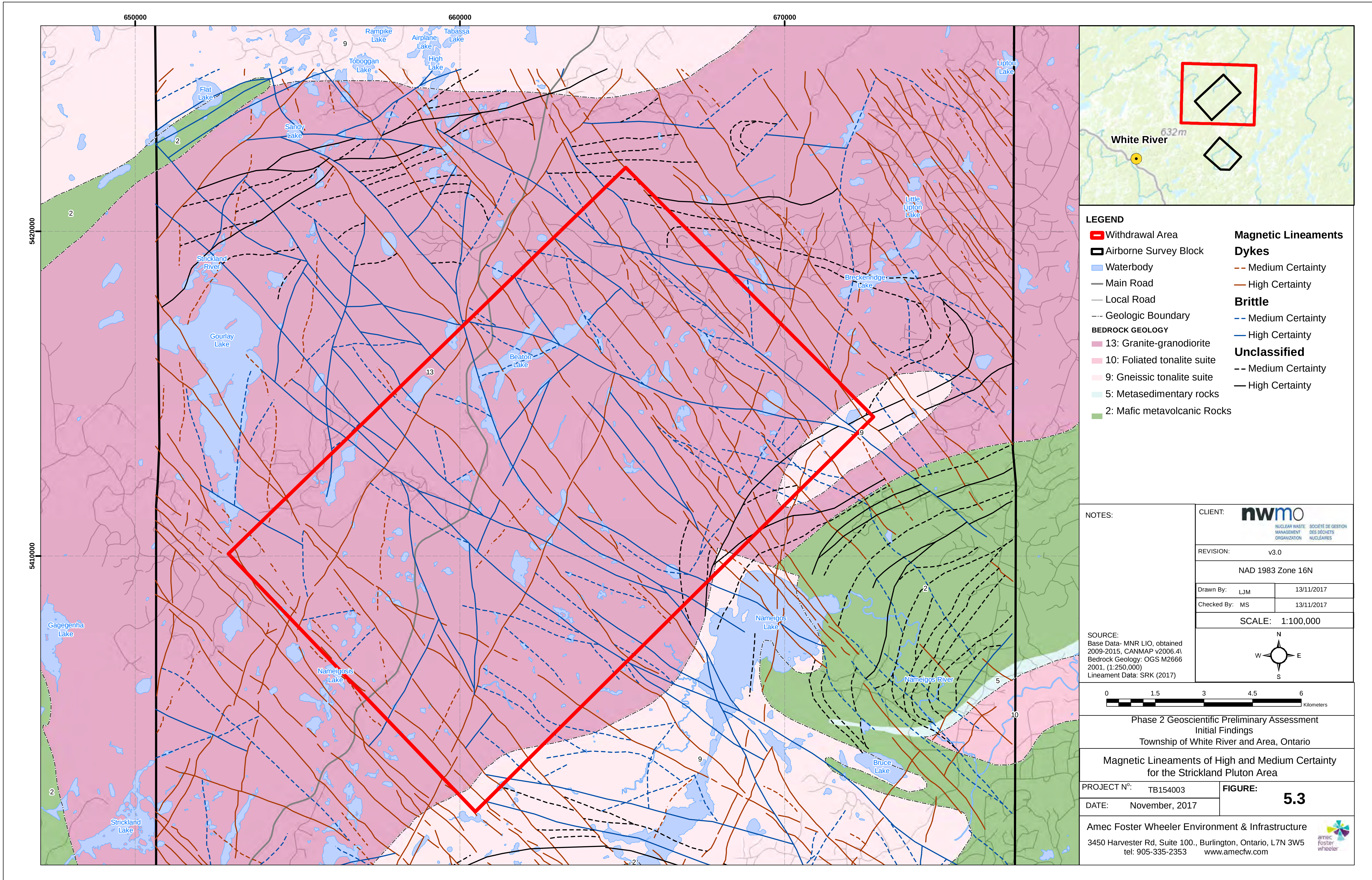
0 1 2 3 4 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Bedrock Geology and Geophysical Anomalies for the Anahareo Lake Pluton Area

PROJECT N°: TB154003	FIGURE: 5.2
DATE: November, 2017	

Amec Foster Wheeler Environment & Infrastructure
3450 Harvester Rd, Suite 100., Burlington, Ontario, L7N 3W5
tel: 905-335-2353 www.amecfw.com



650000
660000
670000
5420000
5410000
Rampike Lake
Airplane Lake
Tabassa Lake
Toboggan Lake
High Lake
Lipton Lake
Flat Lake
Sandy Lake
Little Lipton Lake
Strickland River
Breckenridge Lake
Gourlay Lake
Beaton Lake
Gagegenha Lake
Nameigosis Lake
Nameigos Lake
Nameigos River
Bruce Lake
Strickland Lake
White River
632m
LEGEND
Withdrawal Area
Airborne Survey Block
Waterbody
Main Road
Local Road
Geologic Boundary
BEDROCK GEOLOGY
13: Granite-granodiorite
10: Foliated tonalite suite
9: Gneissic tonalite suite
5: Metasedimentary rocks
2: Mafic metavolcanic Rocks
Magnetic Lineaments
Dykes
Medium Certainty
High Certainty
Brittle
Medium Certainty
High Certainty
Unclassified
Medium Certainty
High Certainty
NOTES:
CLIENT:
nwmo
NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES
REVISION: v3.0
NAD 1983 Zone 16N
Drawn By: LJM 13/11/2017
Checked By: MS 13/11/2017
SCALE: 1:100,000
SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4\
Bedrock Geology: OGS M2666 2001, (1:250,000)
Lineament Data: SRK (2017)
N
E
S
W
0 1.5 3 4.5 6
Kilometers
Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario
Magnetic Lineaments of High and Medium Certainty
for the Strickland Pluton Area
PROJECT N°: TB154003
FIGURE: 5.3
DATE: November, 2017
Amec Foster Wheeler Environment & Infrastructure
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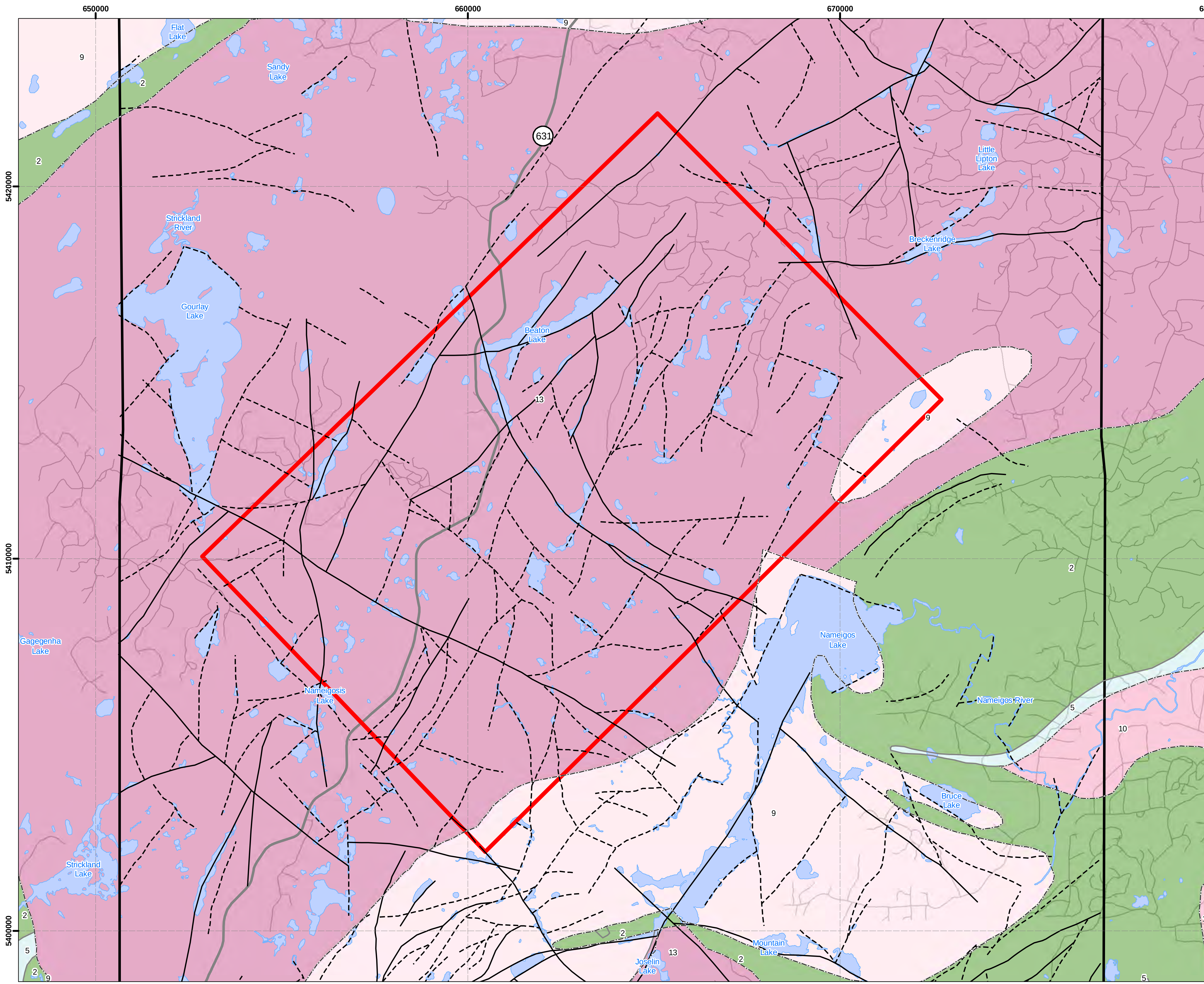

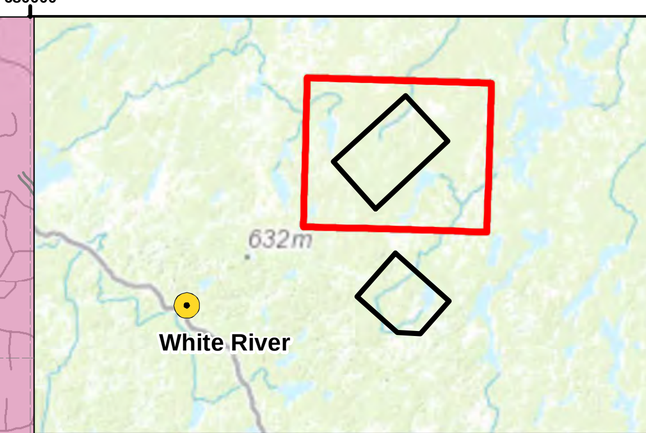

LEGEND

- Withdrawal Area
- Airborne Survey Block
- Waterbody
- Main Road
- Local Road
- Geologic Boundary

Surficial Lineaments

- Medium Certainty
- High Certainty

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION: v3.0

NAD 1983 Zone 16N

Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017

SCALE: 1:100,000

N / E / S / W

0 1.5 3 4.5 6 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Surficial Lineaments of High and Medium Certainty for the Strickland Pluton Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: 5.4

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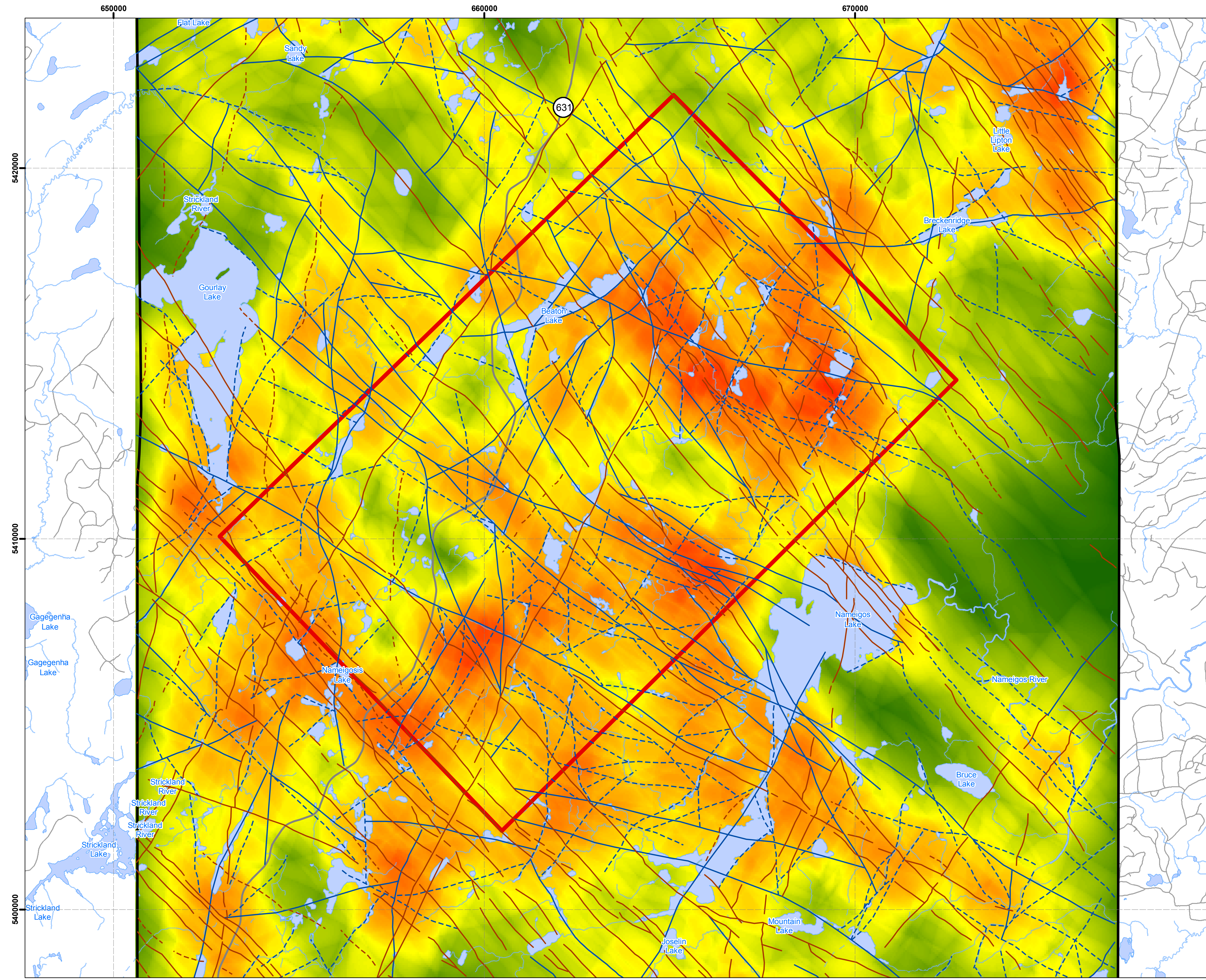

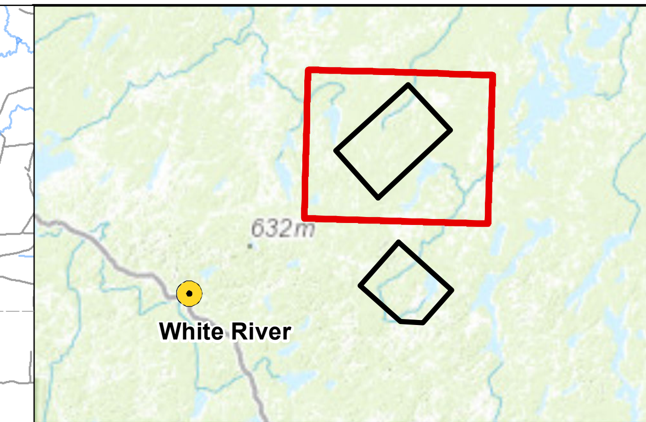

LEGEND

- Withdrawal Area
- Airborne Survey Block
- Waterbody
- Main Road
- Local Road

Lineament Density (km/km^2)
High : 4.7497
Low : 0

Integrated Lineaments

Dykes
- Medium Certainty
- High Certainty

Brittle
- Medium Certainty
- High Certainty

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION:	v3.0	
NAD 1983 Zone 16N		
Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017
SCALE:	1:100,000	

N W E S

0 1.5 3 4.5 6 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Density of Integrated Lineaments with High and Medium Certainty for the Strickland Pluton Area

PROJECT N°:	TB154003	FIGURE:	5.5
DATE:	November, 2017		

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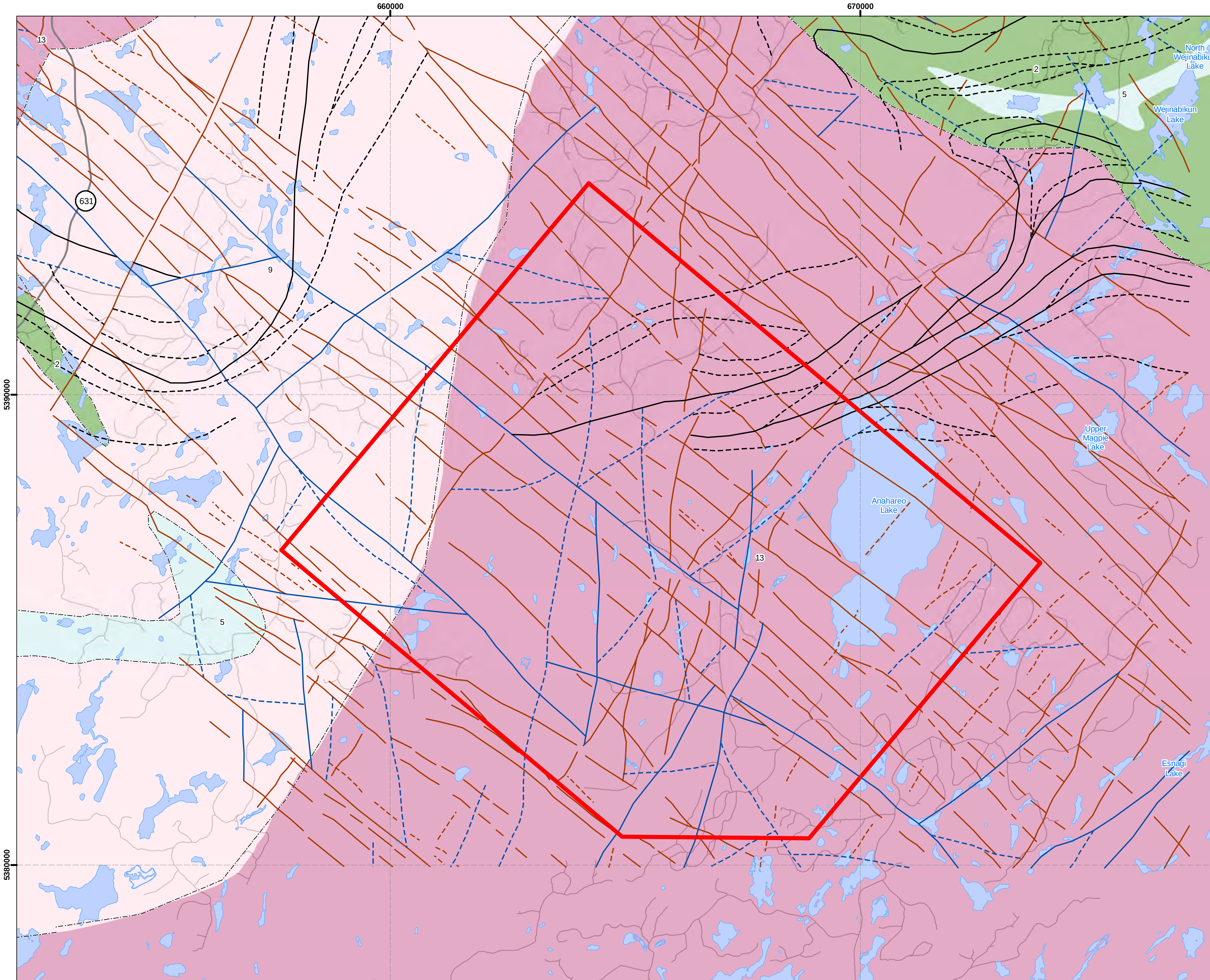

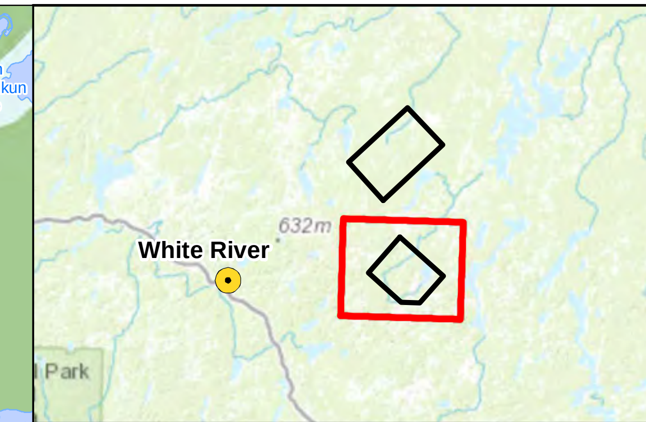

LEGEND

- Withdrawal Area
- Waterbody
- Main Road
- Local Road
- Geologic Boundary

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

Magnetic Lineaments

Dykes

- Medium Certainty
- High Certainty

Brittle

- Medium Certainty
- High Certainty

Unclassified

- Medium Certainty
- High Certainty

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION:	v3.0
NAD 1983 Zone 16N	
Drawn By: LJM	13/11/2017
Checked By: MS	13/11/2017
SCALE: 1:80,000	

N / W / E / S

0 1 2 3 4 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Magnetic Lineaments of High and Medium Certainty for the Anahareo Lake Pluton Area

PROJECT N°:	TB154003	FIGURE:	5.6
DATE:	November, 2017		

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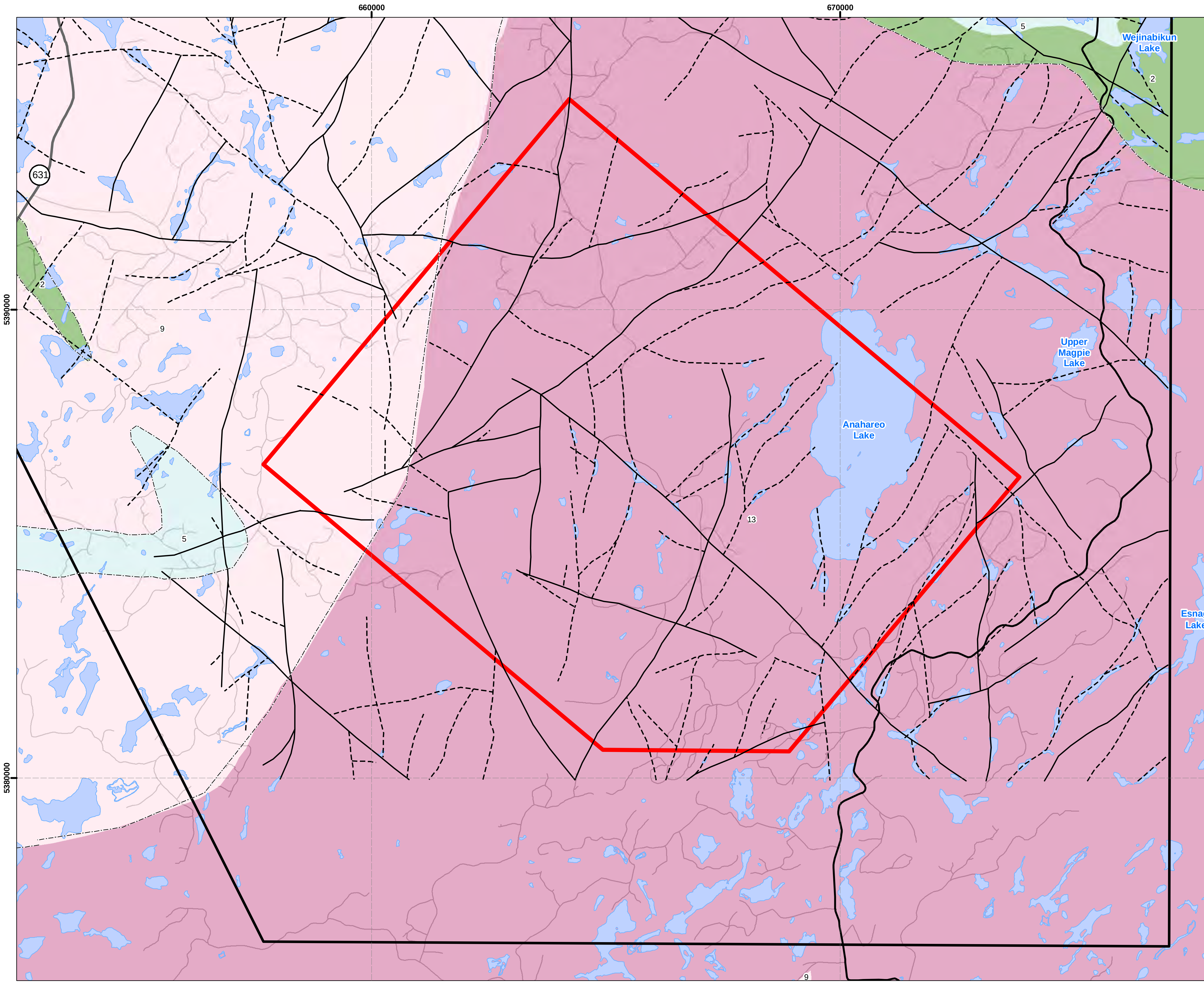

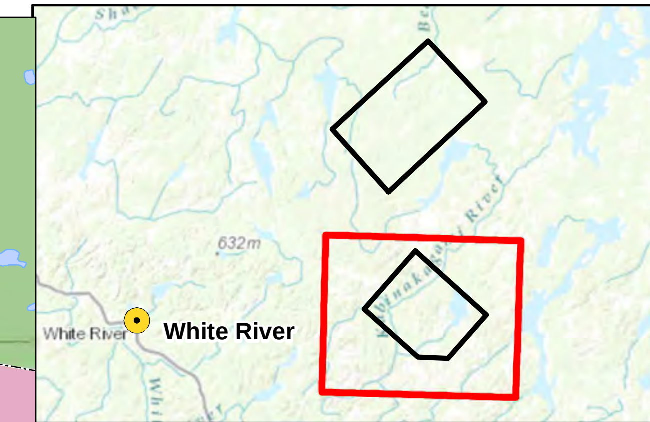

LEGEND

- Withdrawal Areas
- Airborne Survey Block
- Waterbody
- Main Road
- Local Road
- Geologic Boundary

Surficial Lineaments

- Medium Certainty
- High Certainty

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001 (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION: v3.0

NAD 1983 Zone 16N

Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017

SCALE: 1:80,000

N / E / S / W

0 1 2 3 4 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Surficial Lineaments of High and Medium Certainty
for the Anahareo Lake Pluton Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: **5.7**

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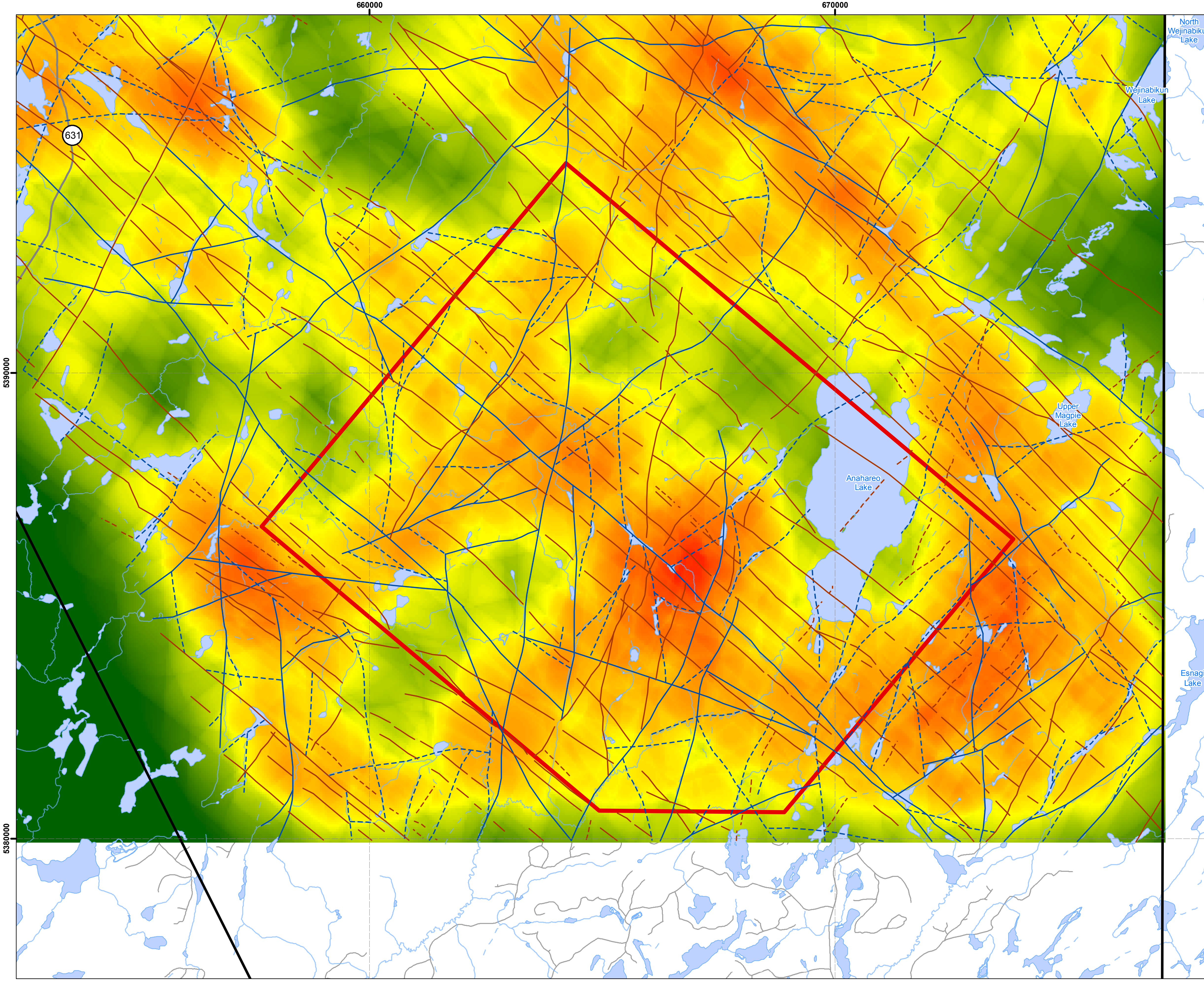

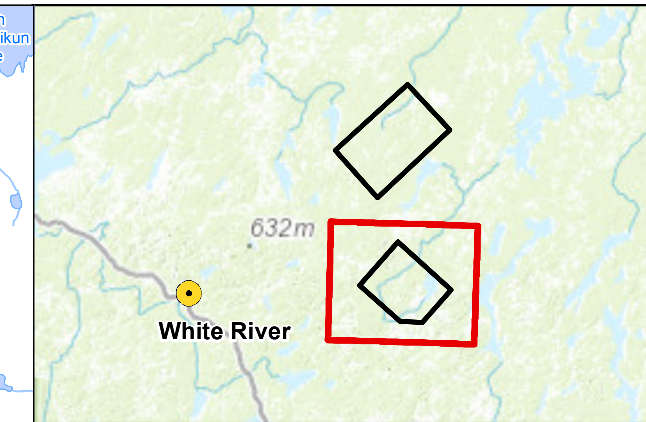

LEGEND

- Withdrawal Area
- Airborne Survey Block
- Waterbody
- Main Road
- Local Road

Lineament Density (km/km^2)

High : 4.7497

Low : 0

Integrated Lineaments

Dykes

- Medium Certainty
- High Certainty

Brittle

- Medium Certainty
- High Certainty

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Lineament Data: SRK (2017)

CLIENT:	nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES
REVISION:	v3.0
NAD 1983 Zone 16N	
Drawn By: LJM	13/11/2017
Checked By: MS	13/11/2017
SCALE:	1:80,000

0 1 2 3 4 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River Area, Ontario

Density of Integrated Lineaments with High and Medium Certainty for the Anahareo Lake Pluton Area

PROJECT N°:	TB154003	FIGURE:	5.8
DATE:	November, 2017		

Amec Foster Wheeler Environment & Infrastructure
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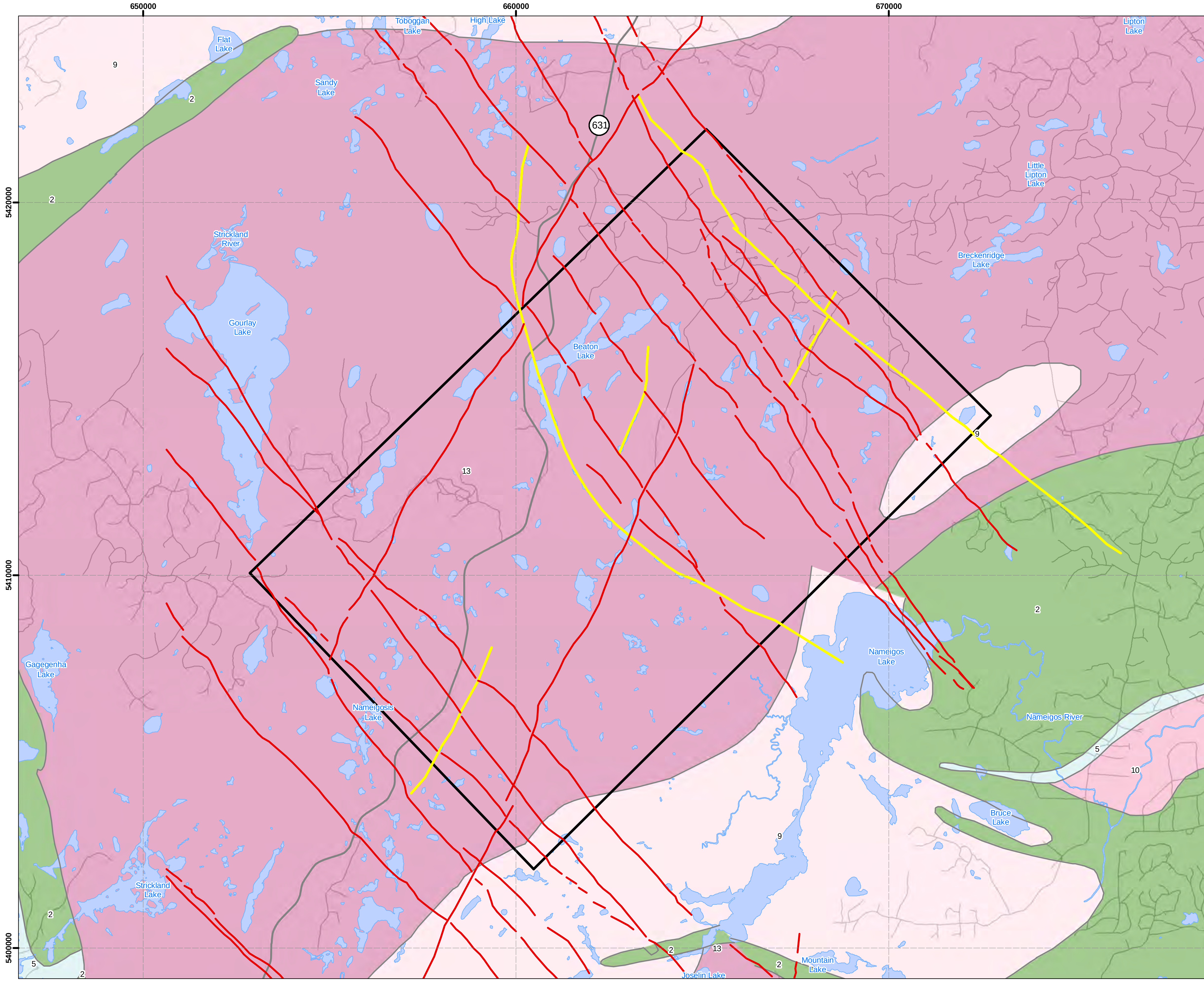
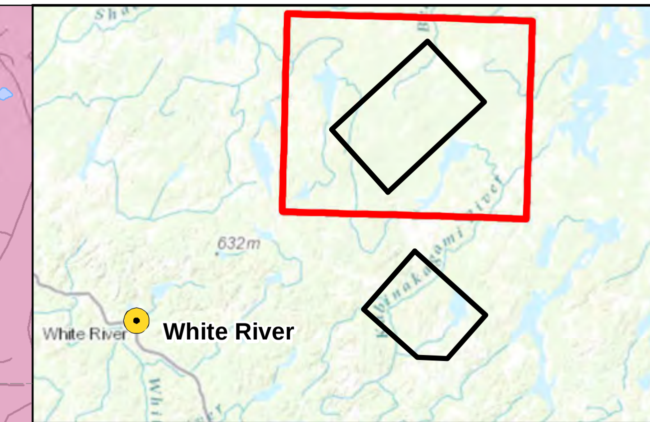
tel: 905-335-2353 www.amecfw.com





LEGEND

- Withdrawal Areas
- Main Road
- Local Road
- Waterbody
- Field-verified Dyke Lineament
- Field-verified Brittle Lineament

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001, (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION / SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION: v3.0

NAD 1983 Zone 16N

Drawn By: LJM 13/11/2017

Checked By: MS 13/11/2017

SCALE: 1:100,000

N W E S

0 1.5 3 4.5 6 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Field-verified Lineaments for the Strickland Pluton Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: 5.9

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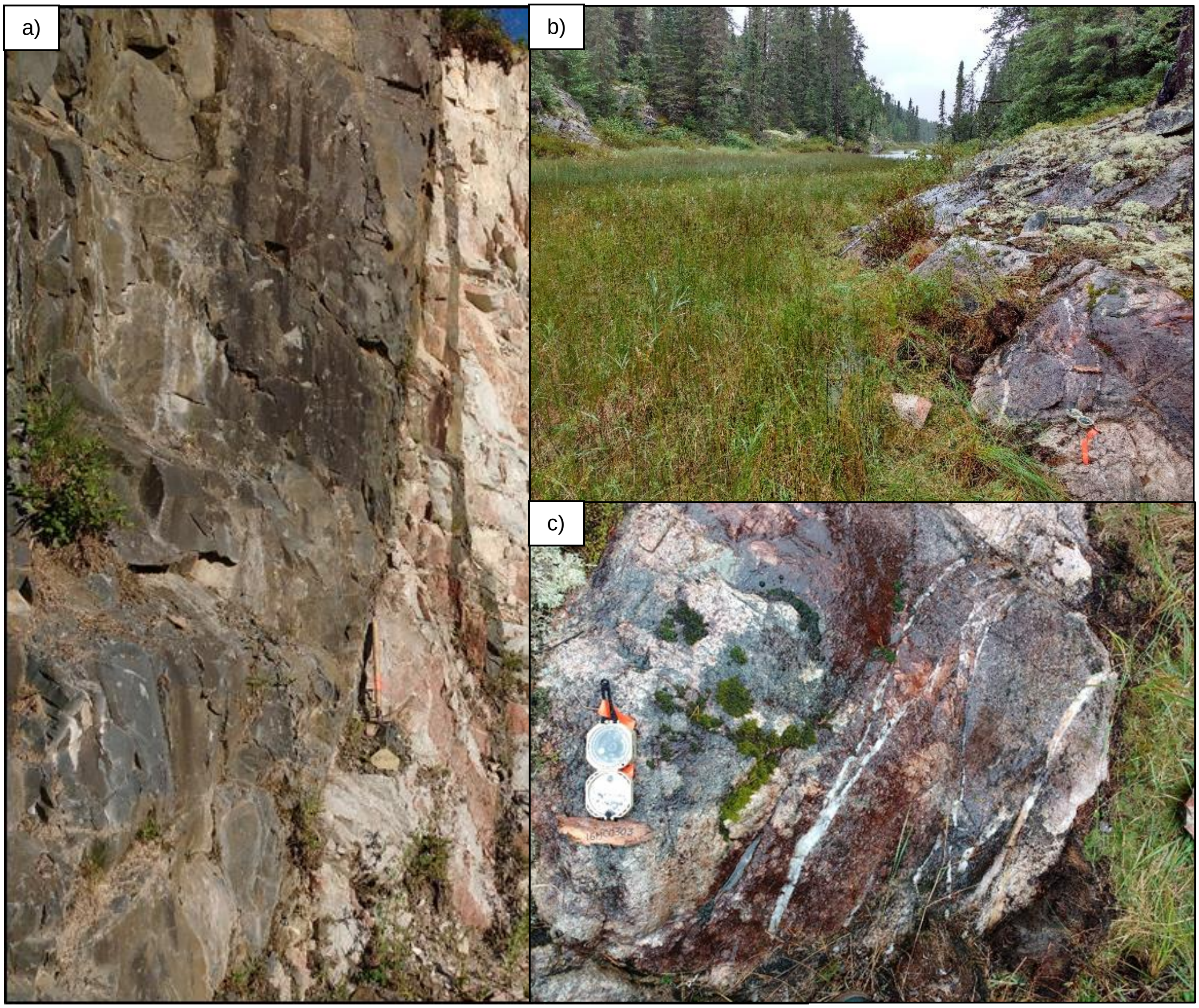
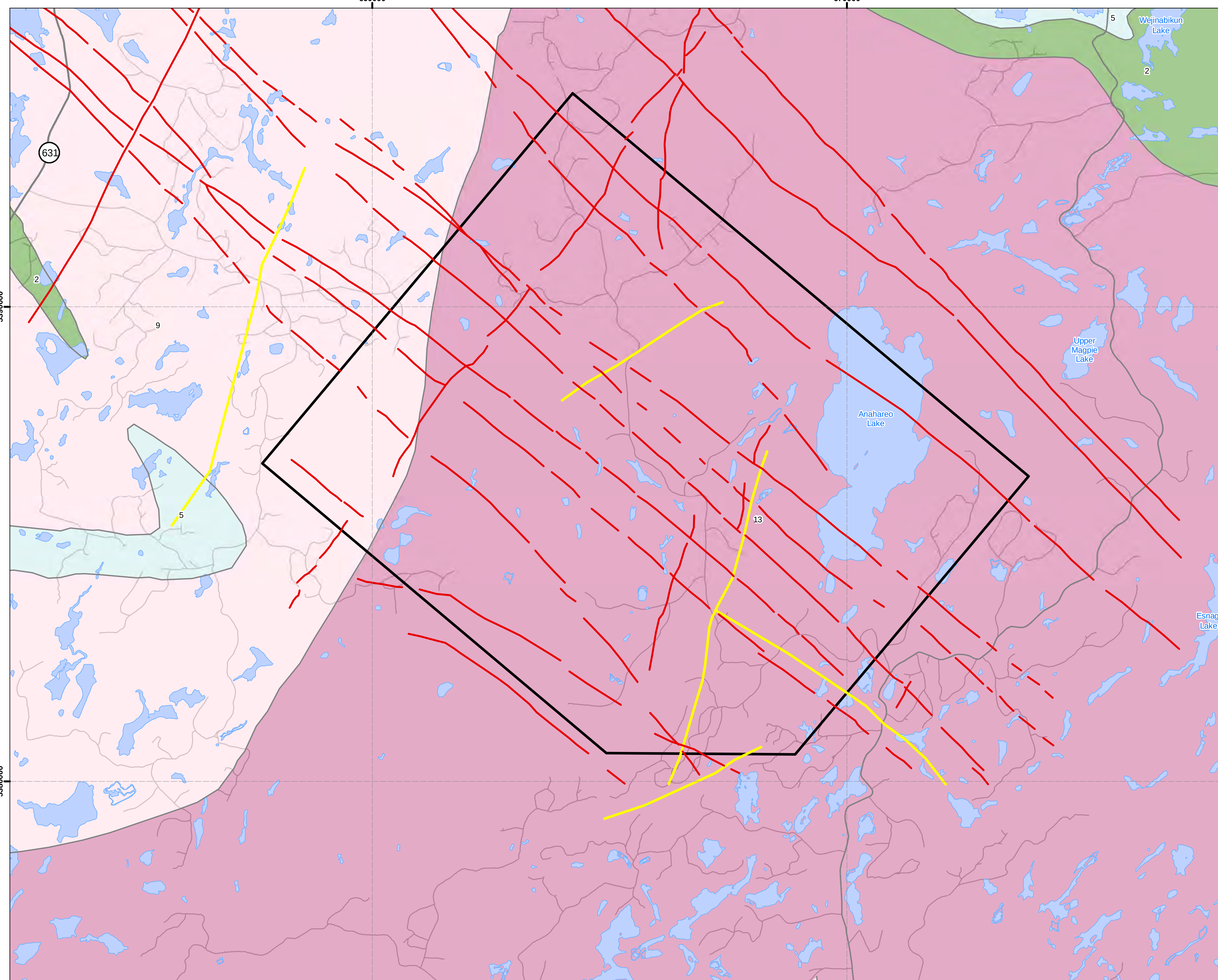


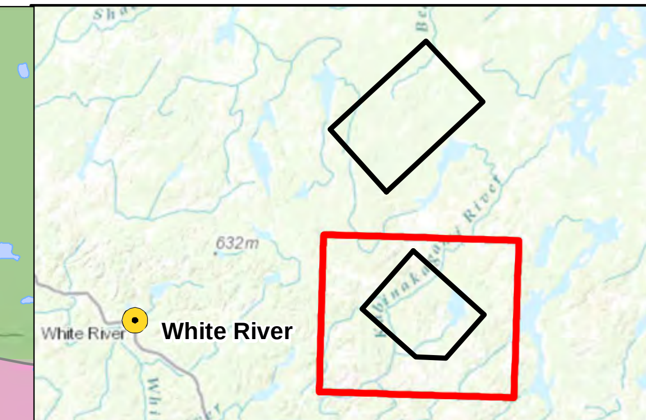
Figure 5.10 Photos of Field Evidence of Lineaments for the Strickland Pluton Area

a) Large outcrop of Matachewan mafic dyke outcrop on Highway 613, northeast contact (Station 16MC0103; hammer for scale, 68 cm long, view to northwest)

b) Field-verified Lineament #5 (Amec Foster Wheeler, 2017), Interpreted Lineament #179 (SRK, 2017) – view to the SSW along a conspicuous linear creek valley, which is also likely a fault zone with parallel quartz veins in foreground at right (Station 16MC0303; compass for scale, 22 cm long, points north)

c) Field-verified Lineament #5 (Amec Foster Wheeler, 2017), Interpreted Lineament #179 (SRK, 2017) – NNE-striking quartz veins that lie along and parallel to a NNW-trending aeromagnetic low anomaly zone. Pink potassic alteration occurs along these veins and the magnetic susceptibility in these rocks is anomalously low. are described in this outcrop (right photo) (Station 16MC0303; compass for scale, 22 cm long, points north)





LEGEND

- Withdrawal Areas
- Main Road
- Local Road
- Waterbody
- Field-verified Dyke Lineament
- Field-verified Brittle Lineament

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 9: Gneissic tonalite suite
- 5: Metasedimentary rocks
- 2: Mafic metavolcanic Rocks

NOTES:

SOURCE:
Base Data- MNR LIO, obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001, (1:250,000)
Lineament Data: SRK (2017)

CLIENT: nwmo NUCLEAR WASTE MANAGEMENT ORGANIZATION SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

REVISION: v3.0

NAD 1983 Zone 16N

Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017

SCALE: 1:80,000

N W E S

0 1 2 3 4 Kilometers

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Field-verified Lineaments for the
Anahareo Lake Pluton Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: 5.11

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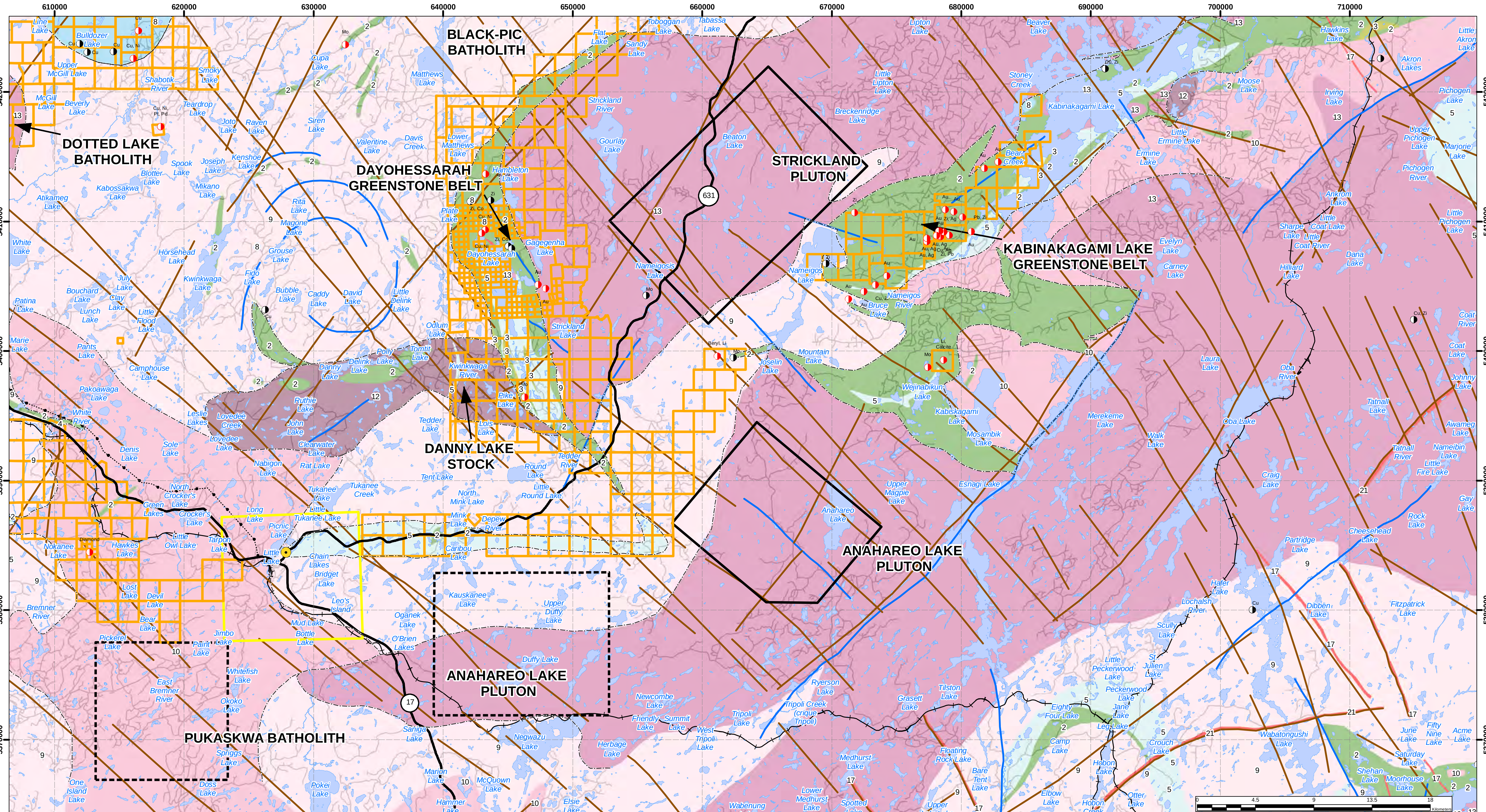
Figure 5.12 Photos of Field Evidence of Lineaments for the Anahareo Lake Pluton Area

a) Field-verified Lineament #6 (Amec Foster Wheeler, 2017), Interpreted Lineament #291 and 294 (SRK, 2017) – North-striking dark grey quartz vein stockwork with potassic altered clasts and host adjacent host rock of pink stained altered granite (Station 16MC0175; compass for scale, 22 cm long points north)

b) Field-verified Lineament #7 (Amec Foster Wheeler, 2017), Interpreted Lineament #356 (SRK, 2017) – View to the northeast along the southeastern edge of a conspicuous fin-shaped outcrop of strongly altered granite; the base of the cliff is an interpreted brittle fault zone (Station 16MC0133; hammer for scale, 68 cm long)
c) Field-verified Lineament #8 (Amec Foster Wheeler, 2017), Interpreted Lineament #323 (SRK, 2017) – View to the north-northeast along steep cliff face formed by prominent joint set that parallels the lineament (Station 16MC0016; compass for scale, 22 cm long points north)
d) Field-verified Lineament #8 (Amec Foster Wheeler, 2017), Interpreted Lineament #323 (SRK, 2017) – north-northeast-striking pseudotachylite vein with conjugate north-northwest-striking intersecting veinlets (Station 16MC0017; compass for scale, 22 cm long points north)



LEGEND

- Community
- Municipal Boundary (Township of White River)
- Withdrawal Areas
- Withdrawal Areas (Not Surveyed)
- Main Road
- Local Road
- Waterbody
- Mineral Occurrence
- Discretionary Occurrence
- Mining Claims
- Geologic Dyke
- Geologic Fault

BEDROCK GEOLOGY

- 13: Granite-granodiorite
- 12: Diorite-monzonite- granodiorite
- 10: Foliated tonalite suite
- 9: Gneissic tonalite suite
- 8: Gabbro
- 7: Ultramafic plutonic rocks
- 5: Metasedimentary rocks
- 4: Felsic volcanic rocks
- 3: Felsic and intermediate metavolcanic rocks
- 2: Mafic metavolcanic Rocks

SOURCE:
Base Data- MNR LIO obtained 2009-2015, CANMAP v2006.4
Bedrock Geology: OGS M2666, 2001, (1:250,000)
Active Mining Claims:MNDM accessed April 2017
Mineral Inventory: OGS MDI-2011
Faults: OGS MRD 126-REV1, 2011 (1:250,000)
Dykes: OGS MRD 126-REV1, 2011 (1:250,000)

CLIENT: nwmo

Revision: v3.0

NAD 1983 Zone 16N

Drawn By:	LJM	13/11/2017
Checked By:	MS	13/11/2017

SCALE: 1:275,000

N W E S

Phase 2 Geoscientific Preliminary Assessment
Initial Findings
Township of White River and Area, Ontario

Mineral Occurrences and Active Mining Claims in the White River Area

PROJECT N°: TB154003

DATE: November, 2017

FIGURE: 5.13

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