Technical Assessment Report
Groundwater Vulnerability Analysis
And Risk Assessment
Trout Creek Well Cluster
Municipality of Powassan

prepared for

North Bay - Mattawa Conservation Authority
15 Janey Avenue
North Bay, Ontario
P1C 1N1

Waters Environmental Geosciences Ltd.

Project No. 29-216, March 17, 2010

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March 17, 2010 29-216

North Bay - Mattawa Conservation Authority
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Attention : Francis Gallo
Water Resources Specialist, Source Water Protection

Dear Francis,

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1.0 INTRODUCTION

The Clean Water Act (receiving Royal Assent in October, 2006) set out a framework for the development and implementation of source protection plans in Ontario. Under Bill 43, source protection plans are being developed for all municipal drinking water systems focusing on a watershed-based approach. The lead agency for development of the present plan is the North Bay - Mattawa Conservation Authority and, to assist the Conservation Authorities, Source Protection Technical Studies Draft Guidance Modules were developed in 2006 (by the Ministry of the Environment) outlining in detail the necessary study components for the various technical studies carried out under the program. The publication of the Technical Rules in 2008 further clarified the technical reporting requirements for the lead agencies, in the publication of their assessment reports.

As part of on-going work in the Municipality of Powassan, the Ministry of the Environment recently made funds available to undertake a pilot study to investigate Source Water Protection issues related to private well clusters in areas not currently serviced by municipal water systems.

Well clusters, as such, are not defined in the Clean Water Act, but are currently considered a Type 2 System under the Act (R. Vantfoort, pers. com.), and fit the definition of a large municipal system (O.Reg. 170/03) containing 6 or more individual wells on one or more properties. The present study, therefore, was undertaken with the goal of examining the hydrogeological conditions in Trout Creek and determining the ways in which the Source Water Protection methodologies (under the Clean Water Act) could be applied to such a clustered well setting.

This report comprises the combined Groundwater Vulnerability Analysis and Risk Assessment for the Trout Creek well cluster. A combination of techniques was used to complete the assessment, and was based on the best available data, and in accordance with the objective of continuous improvement, data gaps and future data needs were identified for any follow-on study phases.

2.0 STUDY PROGRAM

In 2006, a study report on the groundwater conditions across the region covered by the North Bay - Mattawa Conservation Area was completed by Waterloo Hydrologic, Inc. and Tunnock Consulting Ltd. This report was completed to the standards of the 2001/2002 Municipal Groundwater Studies program (funded by the Ministry of the Environment), which provided valuable information for the Source Protection Study program which followed in subsequent years.

Trout Creek was included in the 2006 study as part of the regional groundwater characterization (with mapping being produced at a scale of 1:350,000). However, the Trout Creek setting (Figure 1) was not studied in detail under the Municipal Groundwater Study (2006) because there were no municipal wells in operation in Trout Creek, and the municipal groundwater study focused only on municipal well fields in Mattawa and Powassan.

The present study program followed a similar approach used in the study of the Powassan well field (Waters Environmental Geosciences Ltd., 2009). The key objectives of the study were to

- identify the source areas which contribute water to the aquifer (or aquifers) being used by the residents of Trout Creek,

- determine the time that it takes for water to move to the wells in the Trout Creek area (by computer modelling techniques), and

- identify any relevant land use activities (current or historical) which may threaten the quality of the Trout Creek drinking water source (or sources).

These objectives are discussed in more detail in the following sub-sections.

2.1 Source Area Definition

The identification of the areas which contribute water to a groundwater system are typically carried out by a detailed review of available data sources, including water well records, geotechnical borehole data, published aggregate mapping, consulting reports, geological mapping and topographical mapping. The sources which were reviewed in the present study included the following:

- Ministry of the Environment water well records (1947 to present)

- Ministry of Transportation geotechnical study reports

    - Geotechnical Foundation Report, Embankment Section, Trout Creek ByPass, Glen Roberts Road Construction, Stations 9+740 to 9+960, GWP No. 774-93-00, District 54, Sudbury (by Trow Consulting Engineers Ltd.), dated March, 1999

    - Geotechnical Foundation Report, Embankment Section, Trout Creek ByPass, North Bound & South Bound Lanes, Station 12+350 to 12+850, GWP No. 774-93-00, District 54, Sudbury (by Trow Consulting Engineers Ltd.), dated March, 1999

    - Foundation Investigation and Design Report, Bridge Structure, Highway 522 Underpass (Site 44-370) Trout Creek By-Pass (Kings Highway 11), District 54, Sudbury, Gwp No. 774-93-00, W.P. No. 770-93-01 (by Trow Consulting Engineers Ltd.), dated July, 1999

    - Design Report, Trout Creek By-Pass - King's Highway 11, Wick Drain Design And Monitoring Program, North Interchange Embankments, District 54, Sudbury, Ontario, GWP No. 774-93-00 (by Thurber Engineering Ltd.), dated September, 1999

- Foundation Investigation & Design Report, Bridge Structure & Approaches, Trout Creek (Site 44-371N), Northbound Lanes, Trout Creek By-Pass, King's Highway 11, District 54, Sudbury, Ontario, GWP No. 774-93-00 (by Trow Consulting Engineers Ltd.), dated November, 1999

- Foundation Investigation & Design Report, Bridge Structure & Approaches, Trout Creek (Site 44-371S), Southbound Lanes, Trout Creek By-Pass, King's Highway 11, District 54, Sudbury, Ontario, GWP No. 774-93-00 (by Trow Consulting Engineers Ltd.), dated November, 1999

- Ministry of Natural Resources publications

  - The Physiography of the Georgian Bay - Ottawa Valley Area of Southern Ontario, Geoscience Report 128, 1975

  - Ontario Geological Survey, Map 5041, Northern Ontario Engineering Geology Terrain Study, Data Base Map, North Bay, 1979

  - Ontario Geological Survey, Map 5502, Southern Ontario Engineering Geology Terrain Study, Data Base Map, Sundridge, 1981

  - Aggregate Resources Inventory of the North Bay Area, Districts of Nipissing and Parry Sound, Northern Ontario, Ontario Geological Survey, Aggregate Resources Inventory, Paper 70, 1984

  - Ontario Base Map Sheet 10-17-6250-50900, 2000

  - Ontario Base Map Sheet 10-17-6250-50950, 2000

- Geological Survey of Canada publications

  - Quaternary Geology of the North Bay - Mattawa Region, Paper 71- 26, 1972

- Consulting reports

  - Town of Trout Creek, Rehabilitation of Private Water and Sewage Systems, Volume 1 (by Northland Engineering Limited), dated 1983

In addition to these information sources, Waters Environmental Geosciences Ltd. carried out a preliminary site reconnaissance survey of the Trout Creek area on August 6, 2009.

2.1.1 Surficial Drainage Conditions

The available topographic mapping and digital elevation (DEM) databases (obtained from GeoBase.ca) were used to define the boundaries of the sub-watershed that encloses the Trout Creek townsite area (Figure 2). Care was taken to insure that a representative contributing area was delineated, without making the boundaries of the study area excessively large. The sub-watershed defined in Figure 2 was set as the outer model boundaries for the groundwater modelling part of the present study.

Trout Creek is situated in a flat-lying area bounded by significant topographic highlands to the east, and more subdued highland areas to the north, west and south. The major drainage feature in the study area is the South River, which flows northwards and passes by the southwestern edge of the study area (Figure 2). South River is the discharge area for all flow within the study boundaries, including both surficial drainage and groundwater discharge.

The central developed area of Trout Creek is drained by an un-named creek (referred to locally as Trout Creek) which extends northwards from beyond the study area (in the south, along the Ontario Northland rail corridor) to a point just south of the Highway 552 and old Highway 11 interchange, where it turns east to parallel Highway 552 and ultimately reports to the South River. This creek is joined by a tributary that drains the extensive low-lying areas to the north of the townsite, as well as by several tributaries that drain the bedrock highlands to the east of Trout Creek. The largest of these tributaries is an un-named creek (referred to locally as Sausage Creek) that originates at Sausage Lake (approximately 4 km southeast of the townsite of Trout Lake), which is located on top of the bedrock highland area.

Based on discussions with the North Bay - Mattawa Conservation Authority, it is our understanding that the surface water features within the study area are un-gauged and there is no flow information available.

2.1.2 Subsurface Geological Conditions

Within the defined area, the soil and bedrock conditions were evaluated through a detailed examination of the available subsurface drilling information and supplemented by airphoto interpretation techniques. A computer print-out of the water well information for the Trout Creek area (obtained in 1998) was reviewed and water well records applicable to the present study were identified. In order to augment the existing study information, contact was also made with the Sudbury Regional Office of the Ministry of the Environment (K. Hawley, Technical Support Section) and the available electronic spreadsheet database was compared against the original water well forms (held on-file at the Regional Office).

Where required, new water well records were added to the present study dataset using the printed records as a reference.

The computer database print-out is limited in the amount of information that can be presented electronically and, in particular, one feature that is not available is the driller's sketch map of the well location. Through consultation with the Ministry of the Environment, and by use of available topographical mapping and airphotos of the study area, UTM co-ordinates were assigned to many of the formerly "un-verified" water well records contained in the water well database. As well, corrections were made to the database in the case where the well locations were identified as being incorrectly plotted. These records were subsequently assessed for inclusion into the present study analysis.

Wherever possible, the water well records were also correlated with the information contained in the Northland Engineering Limited private services study report (1983). By our review of the water well records, approximately 62 % of the residents canvassed in the Northland Engineering Limited study opted for drilled wells in subsequent years (as replacements for shallow wells and/or low yielding drilled wells).

By this methodology, 152 water well records were incorporated into the present well cluster study analysis. In some cases, due to the long time span covered by the water well database, and the appearance of several "dry" well records, multiple well records were reported for some private properties. The total number of non-duplicated records was 96.

The remaining 56 records were grouped (by noting their respective UTM co-ordinates) and the geological properties (depths to water, depths to various soil horizons, etc.) were averaged for each location, resulting in the creation of 22 new virtual "wells" to be used in the assessment of the subsurface geological conditions. This averaging technique was considered to be justified based on the original level of detail used in assigning the UTM co-ordinates to the wells, which were assigned UTM co-ordinates based on 1:50,000 topographic mapping.

In total, therefore, 118 water well locations (representing 152 individual well records) were used to assess the subsurface hydrogeology in Trout Creek. These well locations are indicated on Figure 3. Based on our review of the well records, approximately 30 % of the recorded drilled wells were overburden wells (i.e. the wells obtained their water from the overburden soils, usually at the overburden-bedrock contact zone), while 70 % of the recorded drilled wells were completed as bedrock well constructions.

It should be noted that, prior to 1984, shallow dug well constructions and owner-constructed water wells were not required to be reported to the Ministry of the Environment, and the exact number of these types of water wells in use, and their geographical distribution, is unknown and under-reported in the Ministry water well database. Therefore, site-specific information on shallow overburden well use is very limited for the Trout Creek area, even though it is these overburden formations that constitute readily-accessible aquifers in many settings (such as Trout Creek). Some information is available from the 1983 private services study report, however, which indicates that approximately 59 % of the residences (surveyed in 1983) relied upon dug well constructions.

In addition to the information contained in the Ministry of the Environment's water well database, subsurface information is routinely gathered as part of the geotechnical investigations carried out in support of highway work. In 1999, several subsurface studies were completed for the Ministry of Transportation in support of the Highway 11 by-pass of Trout Creek and, from these study reports, 111 geotechnical borehole logs were reviewed and assessed for their applicability to the present study. Borehole information relevant to the present study included the depth to bedrock (and bedrock description), water level data and soil descriptions (to a geotechnical engineering standard).

As well as providing a more detailed soil description than is generally found in the water well database, the Ministry of Transportation geotechnical reports also contain soil grainsize analyses, which allow the calculation of soil properties useful for the groundwater model development. Although the geotechnical studies were specific to the highway re-alignment, they did provide valuable information in areas of poor coverage (i.e. due to the unavailability of the water well records).

2.1.3 Hydrogeological Summary

Based on the information reviewed, the typical subsurface conditions in the well cluster area consist of between 2 m and 6 m of sandy outwash material, overlying approximately 20 m of silty clay, which overlies approximately 3 m of sand and gravel till, which in turn overlies bedrock. The surficial sandy outwash comprises an upper un-confined aquifer, while the sand and gravel till and bedrock contact zone comprise a lower confined aquifer. The silty clay zone constitutes an aquitard that separates the two water producing zones, and thereby creates two separate groundwater regimes in Trout Creek.

The till unit is the oldest surficial geological unit in the Trout Creek area (related to the last glacial events approximately 10,000 years ago), and (where present) lies directly on the underlying bedrock, both at depth (i.e. beneath the silty clay zone) and at surface in areas of bedrock outcrop (usually along the flanks of the bedrock ridges and knobs). In some localized areas, erosion by subsequent glacial lake action may have removed portions of the till unit (along with the deposition of the silty clays and sandy outwash deposits); however, it is reported consistently enough across the study area that it is considered to be a continuous unit (in the groundwater model development).

In terms of the Trout Creek groundwater systems, in places where the till is exposed at surface, it allows rainfall infiltration (and possible surficial drainage) to recharge the lower aquifer, and therefore it constitutes a valuable source area for the till/bedrock contact zone.

Recharge through the relatively thick silty clay zone is also possible, although the rate of groundwater movement through this unit is considered to be very slow (due to its characteristically-low hydraulic conductivity).

Actual geological unit thicknesses were noted to vary between individual well locations, and the quality of information (level of detail) reported on the water well records varied from driller to driller. In some cases, the above-indicated sequence of geological units may have individual layers missing (for example, because of a local rise in the elevation of the bedrock causing a layer to pinch out or terminate). However, in general, the indicated sequence was noted to be relatively consistent across the study area, and therefore a decision was made to use these typical unit thicknesses in the subsequent groundwater model development.

Groundwater conditions across the study area indicate a shallow depth to water (i.e. in the upper sandy outwash materials), which was also observed in the Northland Engineering Limited study (1983) and was confirmed by our observations of deep ditching carried out along many of the streets in Trout Creek (presumably to aid in lowering the water table). The water levels in the deeper till/bedrock contact aquifer were also similar to the shallow aquifer levels, although at some locations upward gradients were reported (i.e. flowing well conditions were noted in the water well records). An upwards gradient indicates a potential for groundwater discharge to surface water streams, and considering the confined aquifer setting and elevated potential recharge areas, is not unexpected in the lower elevation, flat-lying areas of Trout Creek.

2.2 Well Head Protection

2.2.1 Study Approach

Well head protection studies focus on identifying the areas that contribute water to a specific well location. The present pilot study program was undertaken, in part, to assess the degree to which the standard well head protection methodologies (as outlined in the Technical Rules, 2008) could be applied to a situation in which a single high-yield municipal well (or well field) is replaced by several dozen (or more) individual low-yield wells, distributed over a relatively large area.

Under the Technical Rules (2008), each municipal well field in a groundwater study area is to be assigned a wellhead protection area (WHPA) which represents the subsurface zone of the underlying aquifer which contributes water to the public water system. While the groundwater flow in the subsurface typically moves in three dimensions, in order to present the contributing groundwater flow on a two dimensional map view, the contributing volume of aquifer was projected upwards to the ground surface. The wellhead protection area is, therefore, a two dimensional representation (on a map view) of the lateral extent of the subsurface volume of aquifer which supplies water to the well field, but contains no information on the depth of the groundwater flowing to the well field.

The WHPA defines an area adjacent to a pumping well through which contaminants may enter the subsurface and ultimately reach the wells supplying the public water system. From a risk management perspective, the subsurface areas (within the WHPA) which are closest to the well intakes pose the highest risk to the public for contaminants moving in the subsurface, while the subsurface areas which are further away from the well intake carry a lesser risk from contaminant sources.

As identified in the Technical Terms of Reference (2001), the specific risks from contaminants vary throughout the WHPA. Bacterial contaminants have a limited lifespan, and the longer they take to travel in the subsurface from the point of release to the well intake, the less likely they are to remain active and at risk to human health. Similarly, some chemical contaminants can break down (degrade) over time and become absorbed into the aquifer soils as they travel through the subsurface, while others can become diluted as they flow through the groundwater system.

For these reasons, the WHPA identified for a given well field is sub-divided into various capture zones in order to reflect variations in the risk potential when moving outwards in the aquifer from the immediate well intake area. Under Part V.4 of the Technical Rules (2008), a total of four zones are established for each WHPA, based on the concept of “time of travel” (or TOT), or the time required for water to move from a specific location within the groundwater aquifer to the well intake. If the well system is classified as obtaining groundwater under the direct influence of surface water (or a GUDI system), additional consideration must be given to the identification of the potential interactions between the groundwater system and the nearby surface water source.

The various groundwater capture zones, as defined in the 2008 Technical Rules (for a Type 2 drinking water system under the Clean Water Act, 2006), were identified as follows:

- WHPA-A - being the surface and subsurface area centred on the well with an outer boundary identified by a radius of 100 metres,
- WHPA-B - being the surface and subsurface areas within which the time of travel to the well is less than or equal to two years, but excluding the WHPA-A,
- WHPA-C - being the surface and subsurface areas within which the time of travel to the well is less than or equal to five years but greater than two years and

- WHPA-D -being the surface and subsurface areas within which the time of travel is less than or equal to twenty-five years, but greater than five years.

As indicated previously, if the well field is classified as GUDI, additional areas are defined relating to the interaction of surface water with the groundwater capture zones.

The Technical Rules (2008) also prescribe the accepted methodologies which may be used to determine the time of travel to a wellhead. The present study continued with the application of VisualMODFLOW (using Version 4.3), which was used previously by Waters Environmental Geosciences Ltd. in the nearby Powassan study (2009).

The main difference between the Trout Creek study and the Powassan study was that, instead of a municipal well field comprising two high yield water wells at a fixed location in the aquifer, the Trout Creek study modelled an array of over 150 individual wells that were distributed over an approximate 93 ha land area, and over two different water producing zones (aquifers). The groundwater model was run in a steady-state mode, which assumed that all of the wells were pumping at their assigned average pumping rates until steady state conditions were attained.

2.2.2 Pumping Rates

The pumping rates assigned in the model were based on Ministry of the Environment guidelines for water supply assessment, as contained in "Procedure D-5-5, Technical Guideline for Private Wells : Water Supply Assessment" (dated 1996). In this document, the Ministry of the Environment suggests that developments based on private water well supplies should consider the basic requirement for domestic use as 450 litres per person per day as a minimum daily requirement. Assuming an average of 2.5 persons per household, this equates to a residential well demand of 1.125 m^3/day (i.e. per well).

For the unconfined portions of the aquifer, the dug wells were assumed to be screened in the sandy outwash deposit. Since much of the groundwater used by the residence is returned to the shallow aquifer via the wastewater septic system, the total well demand of 1.125 m^3/day is not considered to be consumptive (i.e. the waters are not irrecoverably lost from the shallow groundwater aquifer). Based on our review of the literature, it was assumed that only 20 % of this demand was effectively taken from the aquifer, resulting in a net pumping rate for the shallow dug wells as 0.225 m^3/day.

For the deeper confined aquifer, the drilled wells were assumed to be screened in the basal till unit, and were assessed as being 100 % consumptive (in that the water withdrawn from this deep aquifer was not immediately replenished to the deep aquifer). The deep aquifer wells were therefore assigned a full pumping rate of 1.125 m^3/day, 80 % of which (0.90 m^3/day) is assumed to return to the sandy outwash aquifer via the wastewater system discharge.

These rates were considered to be representative of the water usage rates in the area. For example, recent monitoring (G. Keown, pers. com.) of the water usage in Powassan has indicated a per capita use of between 425 l/day and 475 l/day, which effectively bracket the value used in this study.

2.2.3 Particle Tracking

The regions of the aquifer which contribute flow to a well head area can be identified by an analysis method referred to as “particle tracking”. Particle tracking is a feature within the groundwater model which allows the movement of individual particles of water to be traced (on a map view) from the point where recharge enters the groundwater flow system to the point where water leaves the groundwater flow system (at the well) . The exact pathway that the water particles follow depends on the subsurface soil and rock types, and the directions of groundwater flow in the aquifer. Within VisualMODFLOW, particle tracking is performed by a sub-program called MODPATH.

By using MODPATH, several dozen particles can be tracked simultaneously as they move through the groundwater flow system being modelled. The position of each particle can be described by the time it takes to travel a fixed distance in the groundwater flow system, and therefore particle tracking is the basis for developing the WHPA zones (identified previously) using their respective time of travel (TOT) characteristics.

Although this analysis is theoretical, and is based solely on a mathematical model of the real world conditions in the aquifer, it is the only way that such an analysis can be performed. Groundwater movement in an aquifer is very slow, and the use of chemical “tracers” to observe actual groundwater movement, at the scale needed for the present analysis, would take many decades to accomplish. Groundwater models can also allow changing conditions in the system (due to changes in land development, or climate change) to be simulated and evaluated.

The use of a sophisticated groundwater model, such as VisualMODFLOW, permits the detailed analysis of such slow groundwater movement, based on assumptions of the geology and hydrogeological inputs to the groundwater flow system. Although superior to other more simplified analytical methods, the model remains only a representation of the real world and is strongly dependent upon the conceptual understanding that was used in its development. In the present assessment, the model was developed using the best available data, and it is believed to be an accurate representation of the flow system being studied. The various input parameters and assumptions/interpretations relating to the hydrogeological model are presented in Appendix A.

In the present analysis, particle tracking was performed by assigning 118 particles to the identified 118 drilled deep well locations (the particles being placed at the mid elevation of the till aquifer unit). An additional 16 particles were assigned to locations of theoretical shallow wells more or less uniformly distributed across the townsite area. Since the exact locations of the shallow (dug) wells are presently unknown, this procedure was considered acceptable (for the present purposes) as a means of evaluating the particle tracking paths to potential shallow wells in the Trout Creek well cluster area.

The pumping rates used in the particle tracking exercise were as quoted previously for the net consumption from each well. The WHPA zones, as developed by the present analysis and following the time-of-travel methodology outlined in the Technical Rules (2008), are presented in Figure 4 (for the shallow unconfined aquifer) and Figure 5 (for the deep confined aquifer). The shape of the WHPA reflects the groundwater flow directions in the aquifers, as determined from the groundwater model.

In these figures, the WHPA-A zone, a fixed 100 m radius pathogen exclusion zone, has not been shown. The decision to leave the WHPA-A zone off the mapping was based on dialogue with, and direction received from, the North Bay - Mattawa Conservation Authority. The WHPA-A zone is not based on any particle tracking analysis, and can be evaluated separately without the use of a sophisticated groundwater model. In terms of well cluster developments, there was a concern (from both Waters Environmental Geosciences Ltd. and the North Bay - Mattawa Conservation Authority) relating to the practicality of applying and enforcing a 100 m restrictive land use zone in higher density settled areas (which rely upon individual on-site septic systems for wastewater discharge).

2.2.4 Intrinsic Vulnerability Assessment

A second component of the well head protection analysis is the assessment of the subsurface features which may affect the vulnerability of the underlying aquifers to surficial spills. The subsurface information, as was contained in the water well and geotechnical borehole logs, was reviewed and assessed using a technique which resulted in an Intrinsic Susceptibility Index (or ISI value) being generated for the various geological units which underlie the study area.

In an ISI analysis, individual areas of an aquifer (and the confining layers above it, if the aquifer is confined) are assigned a numerical score based on the unique hydrogeologic conditions at a particular location. The scores are determined using a combination of the saturated thickness of each unit and an index number related to the soil type, and as such, the scores reflect the susceptibility of the aquifer to contamination. Typically, the aquifer of interest is the uppermost aquifer (also referred to as the “water table”), since this is the zone most likely to be affected by surficial spills of contamination. The scoring technique is modified when confined aquifer conditions are encountered, and the methodology is described in detail in the original Technical Terms of Reference (2001).

The ISI is calculated by multiplying the saturated thickness (in metres) of each geological unit by its corresponding "K-factor" (which is assigned based on the hydraulic conductivity, or permeability, of the geological unit being considered). The ISI is an index value only, and does not equate numerically to any physical characteristic of a soil or rock type. An ISI value is calculated for each geological unit related to the aquifer being studied, and in the case of a layered sequence of materials, the individual values are summed (added) vertically to arrive at a final ISI for that particular location.

In the present analysis, a total of five geological units were considered in the groundwater model, and from the Guidance Module 3 tables, the following K-factors were assigned to each unit (Table 1):

Table 1 - Representative K-Factors For Selected Geological Materials

Geological Unit	K-factor
sandy outwash	3
sand and gravel till	3
silty clay	6
alluvium	4
bedrock	3

For the unconfined areas of the groundwater flow system, the depth to water table values were determined from the VisualMODFLOW output, and these values were then multiplied by the respective K-Factors (above) to arrive at an ISI for the unconfined areas. For the confined parts of the flow system, the thickness of the geologic units were determined from the VisualMODFLOW output, and these values were then multiplied by the respective K-Factors (above) to arrive at an ISI for each confining layer. The ISI values were then added together to arrive at a unique ISI for each location.

ISI mapping provides a qualitative interpretation of potential areas of concern, highlighting areas where the underlying aquifer is recognized as being vulnerable to surficial sources of contamination. Surficial sources of contamination refer to contaminants released onto the ground surface, or at shallow soil depths, which have the potential to infiltrate downwards and contaminate the underlying aquifer (or aquifers, if more than one aquifer is identified). In the present study, ISI mapping was carried out for both the shallow unconfined aquifer and the deeper confined aquifer.

The various areas of the aquifers were assigned low, medium and high intrinsic vulnerability scores through an application of previous data, professional judgement and hydrogeological interpretation.

As defined in the 2008 Technical Rules,

- an area having an ISI score of less than 30 is considered to be an area of high vulnerability,

- an area having an ISI score greater than or equal to 30, but less than or equal to 80, is considered to be an area of medium vulnerability and

- an area having an ISI score of greater then 80 is considered to be an area of low vulnerability.

The intrinsic vulnerability scores assigned to a groundwater flow system can vary from location to location, depending of the changes in the geology and depth to water. By contouring the scores across the broader study area, a map of the vulnerability of each aquifer was developed for later use in the risk assessment process outlined in Guidance Module 6.

The preliminary intrinsic vulnerability mapping for the Trout Creek WHPA, within the identified model domain, is presented in Figure 6 (shallow unconfined aquifer) and Figure 7 (deep confined aquifer). From these figures, it can be seen that the upper sandy outwash aquifer has been assigned predominantly a high vulnerability to surficial contamination, due to the more permeable soil type and shallow depth to groundwater. In contrast, the deeper till/bedrock contact aquifer has been assigned a medium to low vulnerability to surficial contamination, due to the predominance of a thick layer of lower permeability clayey silts in the central portion of the WHPA. The exceptions are the areas adjacent to the bedrock knobs and highland areas, which are interpreted to be recharge windows to the deeper aquifer.

2.2.5 Groundwater Vulnerability Scoring

The goal of the previous assessment methodologies is to arrive at a unique vulnerability score (or scores) for the Well Head Protection Area, that can then be used in the risk analysis of any identified contaminant sources within the WHPA. As outlined in the Guidance Document (Module 3), there are two main steps to be completed in arriving at the vulnerability scoring for the WHPA: (1) categorizing the intrinsic vulnerability of the aquifer as being either high, medium or low, and (2) mapping the various time of travel (TOT) zones within the WHPA and noting where the WHPA zones intersect with the relative vulnerability areas (on a map view).

The determination of the vulnerability scoring within the WHPA therefore involves a consideration of the flow characteristics within the aquifer (from a TOT perspective) coupled with a consideration of the relative susceptibility of the aquifer (within each TOT zone) to surficial contaminant sources. By the current methodology, the groundwater vulnerability scores range from the maximum value of 10 (representing vulnerable areas for the shallow aquifer in the higher-density central part of the well head area) to a minimum value of 2 (encountered in the deeper aquifer at the furthest distance from the well head area in a region of low intrinsic vulnerability).

The Technical Rules (2008) describe the vulnerability scoring ranges to be applied in the present analysis of the WHPA, and the scoring is outlined in the table which follows (taken from the 2008 Technical Rules)(Table 2):

Table 2 - Aquifer Vulnerability Scoring

Groundwater Intrinsic Vulnerability Category for the Area	Location Within a Well Head Protection Area			
	WHPA-A	WHPA-B	WHPA-C	WHPA-D
High	10	10	8	6
Medium	10	8	6	4
Low	10	6	4	2

The information in the above table was applied to the mapping presented previously, and the resultant vulnerability scores are presented for the various WHPAs in Figure 8 (shallow unconfined aquifer) and Figure 9 (deeper confined aquifer).

The vulnerability scoring methodology allows for adjustments to be made in the scores, for example if a particular land use activity causes the surface conditions above the groundwater aquifer to become more vulnerable to contamination, thereby changing the intrinsic vulnerability of the aquifer in that particular area. As indicated in the Guidance Document (2006), natural preferential pathways (in the form of fractures in bedrock or larger solution cavities in karst limestone formations) are already incorporated into the K-factors used in the ISI calculations. However, certain man-made activities, such as deep open excavations, large diameter well borings or abandoned water well casings, can offer a constructed preferential pathway which may justify raising the intrinsic vulnerability to the next level in the affected areas.

Road construction activities and geotechnical drilling boreholes along the by-pass route of Highway 11 were recognized as potential contaminant pathways, due to a concern for possible improperly-abandoned boreholes offering contaminant pathways to the subsurface units. Therefore, as identified in the Technical Rules (2008) the vulnerability of the aquifers were locally increased to reflect these potential anthropogenic pathways. The adjusted ISI values, incorporating these pathways, are presented in Figure 10 (shallow unconfined aquifer) and Figure 11 (deep confined aquifer).

The changes to the aquifer vulnerability scoring, as a result of the presence of potential pathways, are presented in Figure 12 (shallow unconfined aquifer) and Figure 13 (deep confined aquifer). The remaining areas are not considered to require adjustment of the assigned scoring based on the available information.

The vulnerability scoring contained in of Figure 12 and Figure 13 were used in the risk assessment and risk management parts of the study program, which are detailed in the sections which follow.

2.3 Risk Assessment And Risk Management

2.3.1 Risk Assessment Background

The risk assessment portion of the study relies upon the interpretations presented in the previous discussion concerning groundwater vulnerability, and carries forward with the assessment through a consideration of the potential groundwater quality issues and threats associated with the water supply system.

As identified in Guidance Module 5 (2006), a groundwater issue is a water quality problem that is documented and currently exists in the source water supply, or is a recognized problem that can reasonably be predicted to be a problem in the near future (based on an extrapolation of current trends in water quality at the source). The identification of a drinking water issue is based on documented evidence contained in municipal water quality monitoring reports, including information gathered in support of compliance monitoring activities by the Ministry of the Environment or in private consulting reports related to infrastructure maintenance work. The data assessment process also has a provision to consider drinking water concerns (identified through the public consultation process), which are potential drinking water issues which are believed to exist but for which data have not been collected or otherwise substantiated by monitoring (or other verification methods). A drinking water concern, however, cannot be elevated to an “issue” status without verification.

The drinking water issues evaluation is focused on linking observed water quality problems to specific drinking water threats (if possible), so that the appropriate mitigation and management techniques can be applied to reduce or eliminate the issue. However, in some cases, the appearance of a drinking water issue may be due to natural sources (such as the underlying geological formations), which cannot be attributed to a specific anthropogenic (man-made) threat. Although naturally-occurring, these water quality problems are still listed as “issues” following the recommendations of Guidance Module 6.

In contrast, a groundwater threat is a land use activity (either existing or historical), within the study area, which may cause a water quality issue to occur if managed improperly. In the present assessment, the study area was identified as being the well head protection areas (WHPAs) for the Trout Creek well cluster, within each WHPA, individual vulnerable areas were defined in the vulnerability analysis based on site-specific hydrogeological conditions and distance from the well intakes (based on time of travel considerations).

The identification of specific groundwater quality threats was based on inputs from several sources, including published environmental and land-use databases (maintained, for example, by the Ministry of the Environment, Technical Standards and Safety Authority and the Municipality), preliminary field reconnaissance work by Waters Environmental Geosciences Ltd., airphoto interpretation and land use mapping reviews. No lot-by-lot inventory of Trout Creek properties was undertaken during the present study, which was based on available data sources only.

At the initial level of evaluation (or Tier 1 level of study), the threats assessment focuses on developing an inventory (in spreadsheet format) which would be used to identify specific threats for which there is little supporting information and/or which pose a high risk to the drinking water source (i.e. within the well head area). Included in the documentation of the various drinking water threats is the identification of the contaminants of concern associated with each threat type, and the nature of the contaminant source (as either a point source, a non-point source or a corridor source).

In December, 2008, the Ministry of the Environment issued a publication entitled “Tables of Drinking Water Threats, Clean Water Act, 2006" in response to input received from several technical sessions and working groups held across the Province. The publication presented (via a “look-up” table of parameters) a means of carrying forward with the information gathered during the drinking water threats inventory. By combining the identified threats with the aquifer vulnerability scores of the groundwater vulnerability assessment, each threat was subsequently assigned a priority as being either a “significant risk”, “moderate risk” or “low risk”. This technique simplified the overall assessment process, replacing the methodology outlined in the Guidance Module (2006), and provided a degree of standardization across the Province for the risk assessment studies. More recently, the process has been updated through the provision of similar information on-line to the Source Protection team members.

Finally, in recognition that the information considered in this assessment covers a range of sources (of varying levels of confidence), the risk assessment portion of this study concluded with an assessment of the data and knowledge gaps, with the goal of assisting the North Bay - Mattawa Conservation Authority in subsequent data collection and continuous improvement activities.

2.3.2 Drinking Water Issues

Based on our inquiries and discussions with the North Bay - Mattawa Conservation Authority, there is very limited data available on the raw water quality in the wells in Trout Creek. The Northland Engineering Limited study (1983) identified several water quality concerns focused on the dug well supplies, and made recommendations to target the deeper till/bedrock contact aquifer for any future groundwater development. From our review of the water well database, a drilling program was subsequently undertaken by many of the residents. A follow up survey of the water quality, to our understanding, has not been undertaken, although in a recent public meeting regarding the study, the water quality in the deep aquifer has generally been commented on as being favourable and potable.

At this stage of the investigation, therefore, there are no known groundwater quality issues in Trout Creek.

2.3.3 Drinking Water Threats

The development of an inventory of drinking water threats within the WHPAs defined in the preceding sections was approached through several techniques. A primary assessment technique was to engage the services of a commercial database search consultant (Ecolog ERIS Ltd., Toronto). This work was completed in August, 2009, and focused on the townsite area plus an additional 0.25 km search radius beyond the previously-defined town limits. As well, information sessions with local residents were held on February 4, 2010, and March 11, 2010, at which time the public was invited to make comments and provide any relevant information that could be used to improve on the threats assessment components of this study.

The completed EcologERIS report is appended as Appendix B to this report. As indicated in the report, the database searches included several sources, and were listed as follows:

- abandoned mine information system
- certificates of approval
- ERIS historical searches
- Ontario Reg. 347 waste generators summary
- mineral occurrences
- pesticide register
- private fuel storage tanks
- retail fuel storage tanks
- Scott’s manufacturing directory
- water well information system

The Ecolog database search (Appendix B) was considered to be complimentary to the preliminary reconnaissance work performed by Waters Environmental Geosciences Ltd. and the information received through the North Bay - Mattawa Conservation Authority during public information sessions. However, to date, the results should be considered preliminary in that no detailed door-to-door surveys were completed, and the threats identification process should be considered on-going (extending beyond the lifespan of the present study report). In total, 17 individual records were uncovered in the Ecolog search, and were considered in the present study assessment.

The threats assessment involved the combination of the groundwater vulnerability mapping with each specified threat identified in the current assessment. This combination of information was performed on a spreadsheet format, and is presented as Appendix C. Possible groundwater quality threats outside of the 25-year WHPAs were not included in the spreadsheet of Appendix C; this does not mean that the threats were not recognized, but re-affirms the focus of the present risk assessment to threats contained within the defined WHPAs only.

As outlined in the Technical Rules (2008), the documentation of drinking water threats within the WHPA is restricted to those vulnerable areas that have a vulnerability score of 4 or higher (corresponding to an associated risk score of greater than 40). Therefore, although drinking water threats may have been identified in all areas of the WHPA, the present reporting requirements focus on those areas (vulnerable areas) where the activities causing the threats have an associated threat classification of “significant”, “moderate” or “low”.

Appendix C, therefore, presents drinking water quality threats identified within the Trout Creek well cluster WHPAs. As required in Guidance Module 6, the threats were individually assigned a threat classification of significant, moderate or low. Based on the present analysis, and spanning both the upper and lower aquifers, there were 5 threats classified as “significant”, 7 threats classified as “moderate” and 16 threats classified as “low”.

The significant threats included the sites of former commercial fuel retail outlets (whose present status remains unknown and un-documented), the possible applications of pesticides to the railway corridor (which passes through the study area) and the existence of on-site septic systems (servicing all of the local residences). Additional field investigation, beyond the present study scope, would be required to positively identify the risk posed by any former fuel retail outlets within the WHPAs as well as the risks within the rail corridor area. The significant risk due to the on-site septic systems affects the shallow unconfined aquifer only, and was commented on previously in the Northland Engineering Limited 1983 site services study report.

2.3.4 Data Gaps and Limitations

The present analysis was based on the information available at the time of reporting. No lot-by-lot confirmation was carried out to investigate the conditions on the various properties making up the well cluster area. In the previous studies of the Mattawa and Powassan well fields (Waters Environmental Geosciences Ltd., 2009) , the assistance of the North Bay - Mattawa Conservation Authority in completing a preliminary environmental screening of properties allowed for a much more comprehensive inventory of potential water quality threats. For example, private storage of home heating oil fuel is a potential threat source that is not documented in the present study, and constitutes a data gap in the present analysis.

The present analysis of groundwater quality issues suffered from a lack of detailed raw water chemistry results for each private well in the Trout Creek well field. Although comments received at the public information session indicated that the public sees a value in conducting such a baseline study, the present program did not have sufficient funding to carry out such a large-scale water quality investigation as part of this study. The comments that there are no known water quality issues was based on comments received from the public, and the lack of any water chemistry data to substantiate this information is considered a data gap in the present analysis.

Uncertainty scores, in the spreadsheet of Appendix C, were assigned to the various vulnerable areas in this assessment, being flagged as either “high” or “low”. Since the locations and use of any shallow dug wells in the study area were assumed (and not verified by a lot-by-lot assessment), the modelling of the shallow unconfined aquifer WHPAs was assessed as having a “high” uncertainty score. By way of contrast, the deeper confined aquifer WHPAs were based on over 150 known well locations, and were interpreted to have a much better level of confidence, resulting in a “low” uncertainty score. Again, more detailed lot-by-lot assessment of the properties would greatly assist in resolving any uncertainties associated with the shallow unconfined aquifer, and is considered a data gap in the present analysis.

The use of a computer model, such as VisualMODFLOW in the present study, required that the geology of the study area be simplified, and in the present study, the geology was reduced to essentially four layers and five geological materials. In addition, assumptions were made concerning the number of pumping wells and their locations based on the best available data. These assumptions were made in recognition of the limited time available for the present study, and in consideration of budgetary constraints. No door to door assessments were made to determine the exact locations of the wells, or their current status. Should additional data become available, it is recommended that they be reviewed and assessed against the assumptions presented in this modelling exercise, so that improvements can be undertaken for the next planning cycle.

Since ongoing land use changes are a characteristic of most municipalities, improvements to the database should be made through periodic review and updating of the drinking water threats identified in Appendix C (for example, by an annual review).

The preceding analysis has been based on the best available site information provided by the North Bay - Mattawa Conservation Authority (and augmented by information collected by Waters Environmental Geosciences Ltd.). Should new information become available related to hydrogeology beneath the study area, it is recommended that Waters Environmental Geosciences Ltd. be allowed to review the data and determine if a modification (or amendment) to the present report is warranted.

Please note that the above recommendations have been based on the information provided to Waters Environmental Geosciences Ltd., and subsequent data collected by our firm, in accordance with the work program agreed to by you. No warranties, representations or liabilities of whatsoever nature are extended to other parties who may receive copies of this report (or abstracted information from it).

In no event shall Waters Environmental Geosciences Ltd. have any legal duty or responsibility to any third party reviewing this report unless it has a formal contractual relationship with such a third party. Contractors or others who are considering work activities based on information contained within this report should satisfy themselves of the site conditions reported herein before submitting quotations or work proposals for this site.

3.0 SUMMARY

An assessment of the groundwater vulnerability analysis and risk assessment for the Trout Creek well cluster has been completed. The assessment followed the methodology presented in the Guidance Modules (2006) and Technical Rules (2008), and resulted in the identification of drinking water threats within each vulnerable area of the well head protection area (WHPA).

At the pilot level of the present study program, the threats assessment resulted in the development of an preliminary inventory (in spreadsheet format) of specific threats which relate to identified land uses, and pose a potential drinking water threat to the WHPA. Although for the current Source Protection Committee reporting purposes, only significant threats are to be carried forward into the current action planning analyses, the present report (following the methodology of the Guidance Documents) included an assessment of all three levels of risk to the WHPA.

In performing this assessment, every effort was made to use the best available data. Areas of uncertainty have been identified, in the anticipation that later planning cycles may be able to supplement the interpretations presented in this document via the process of continuous improvement.

We thank you for the opportunity of working with the North Bay - Mattawa Conservation Authority on this project.

Yours truly,
WATERS ENVIRONMENTAL GEOSCIENCES LTD.

Peter A. Richards, M.Sc., P.Eng.
President

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North Bay – Mattawa

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ACT FOR CLEAN WATER

Trout Creek Well Cluster Technical Assessment Report

Figure 1 - Trout Creek Base Map

Waters Environmental Geosciences Ltd.

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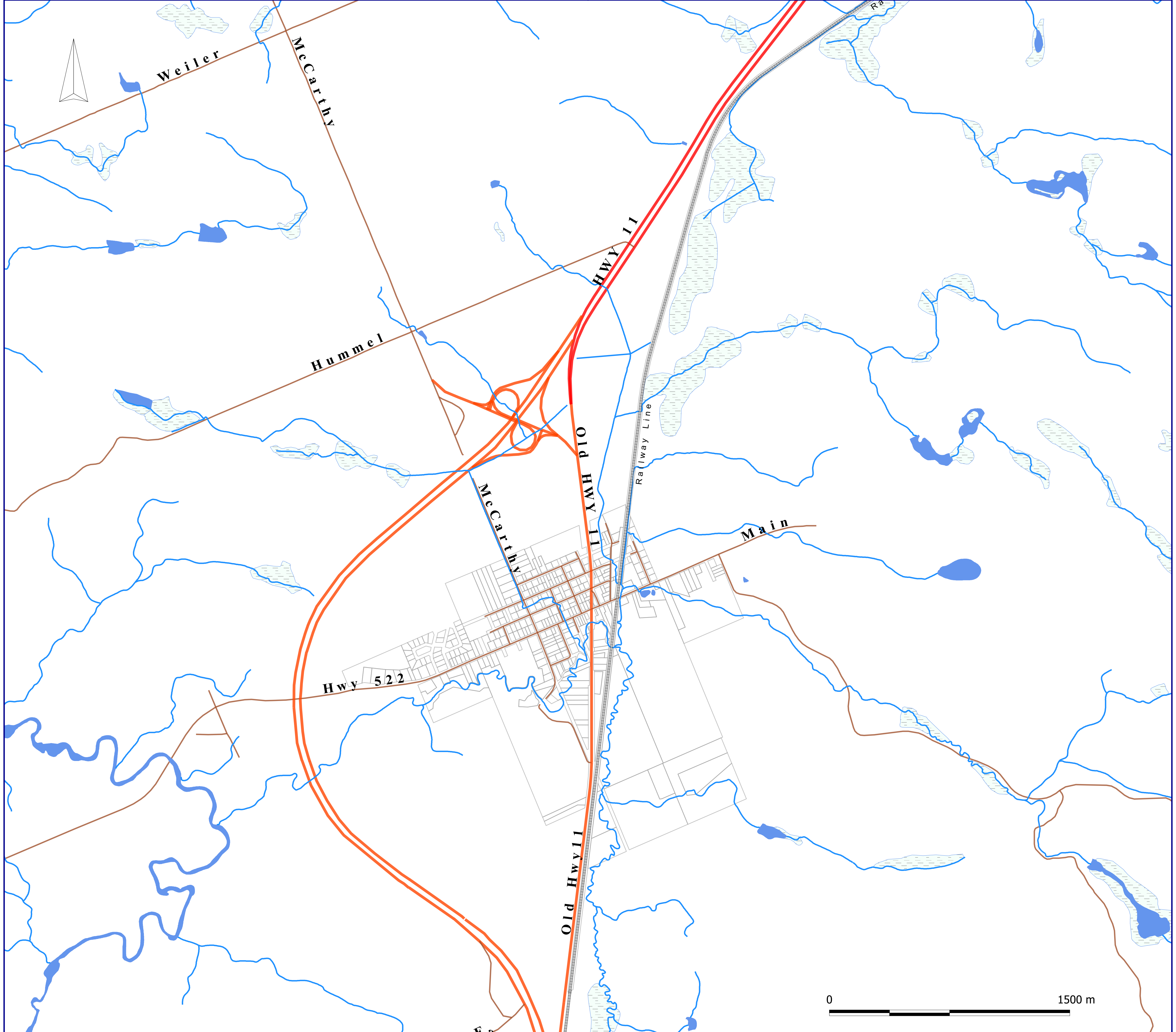

Road
Highway
Rail
Water Body
Wetland
Water Course
Trout Creek Lots

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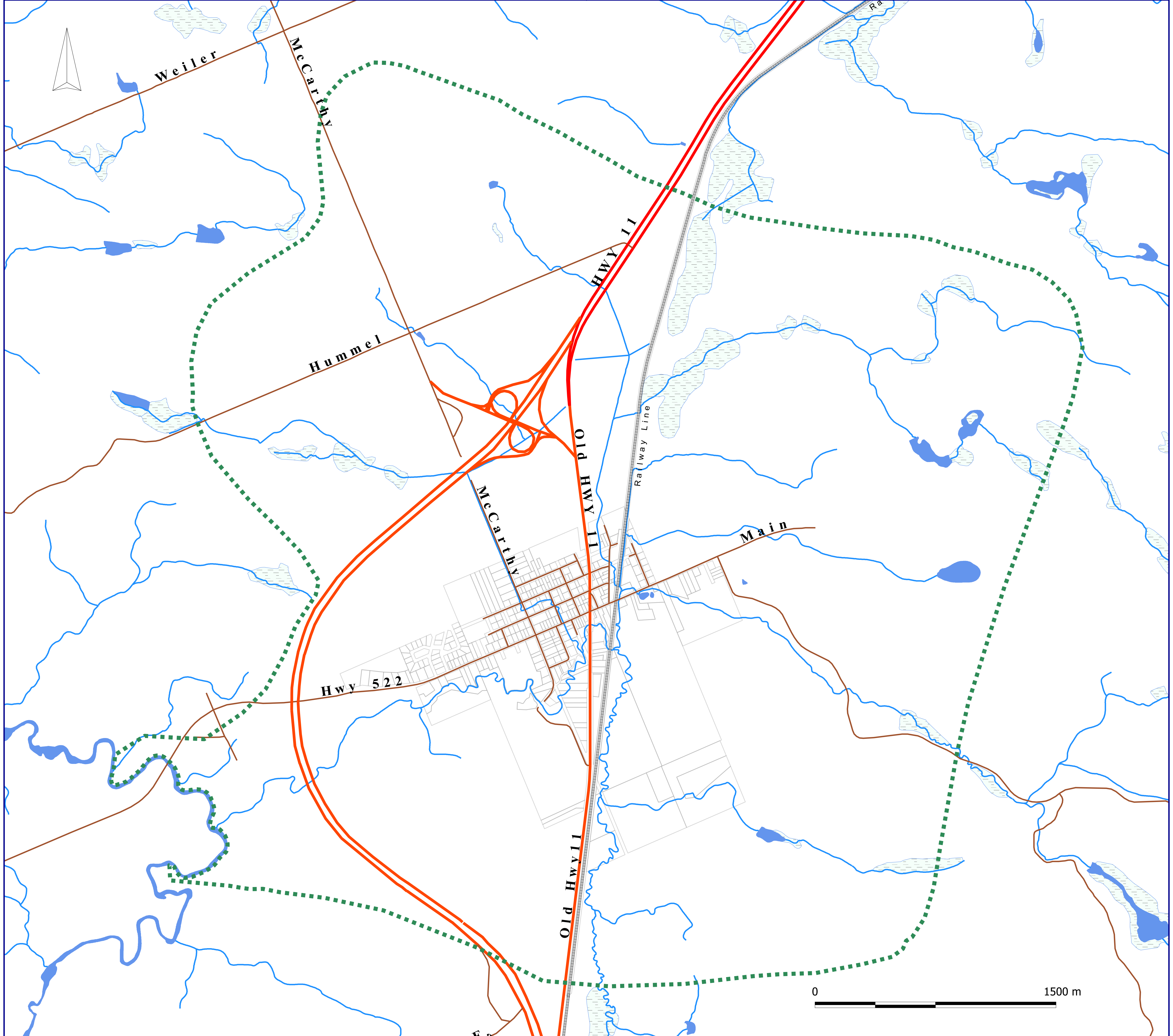

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Figure 2 - Study Area Boundary

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Legend
Study Area
Highway
Road
Rail
Water Body
Wetland Area
Water Course
Trout Creek Lots

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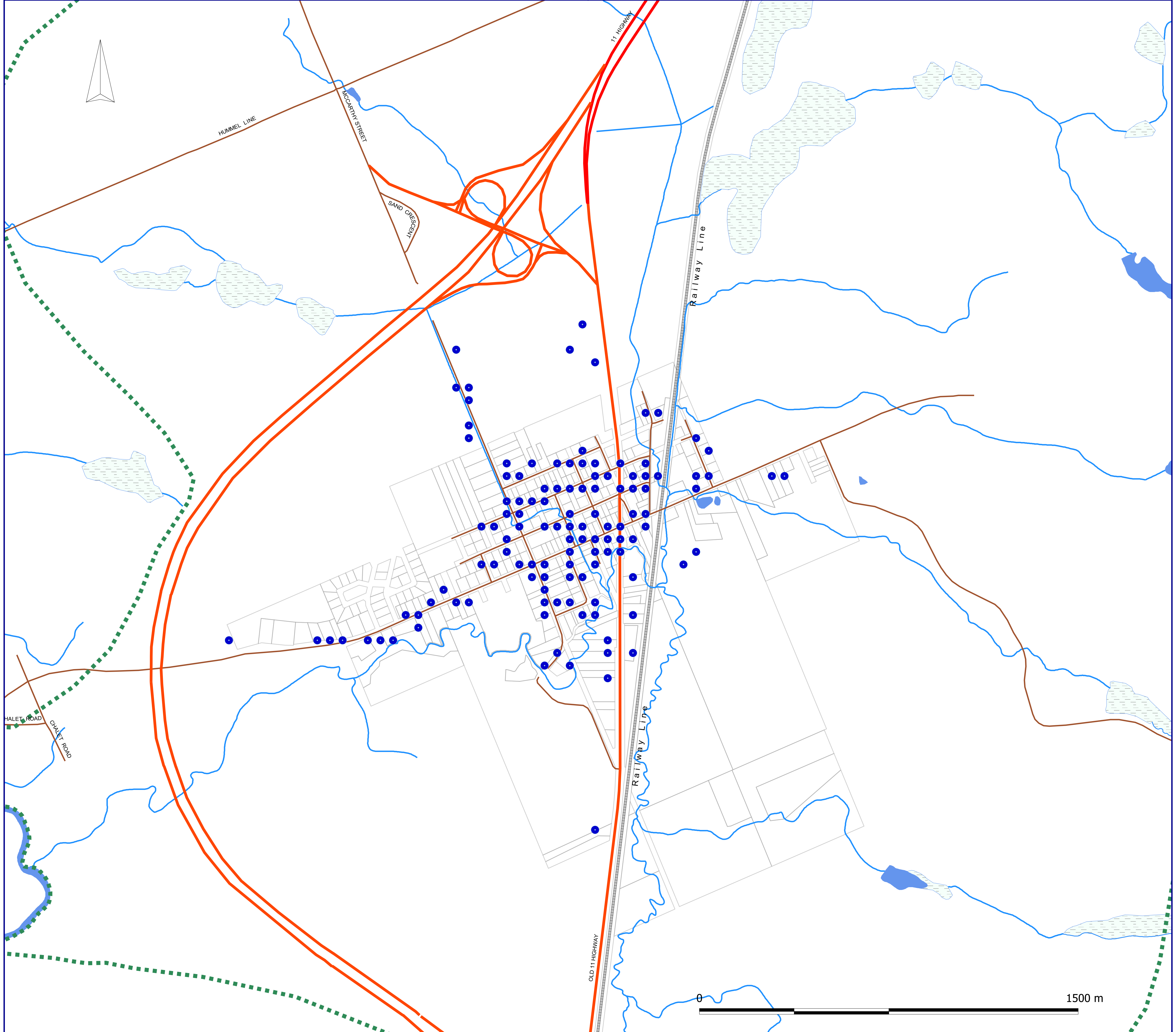
ACT FOR CLEAN WATER

Trout Creek Well Cluster Technical Assessment Report

Figure 3 - Recorded Well Locations



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NORTH BAY-MATTAWA CONSERVATION AUTHORITY

Legend
Study Area
MOE Recorded Well Locations
Highway
Road
Rail
Water Body
Wetland
Water Course
Trout Creek Lots

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Figure 4
Shallow Unconfined Aquifer WHPA

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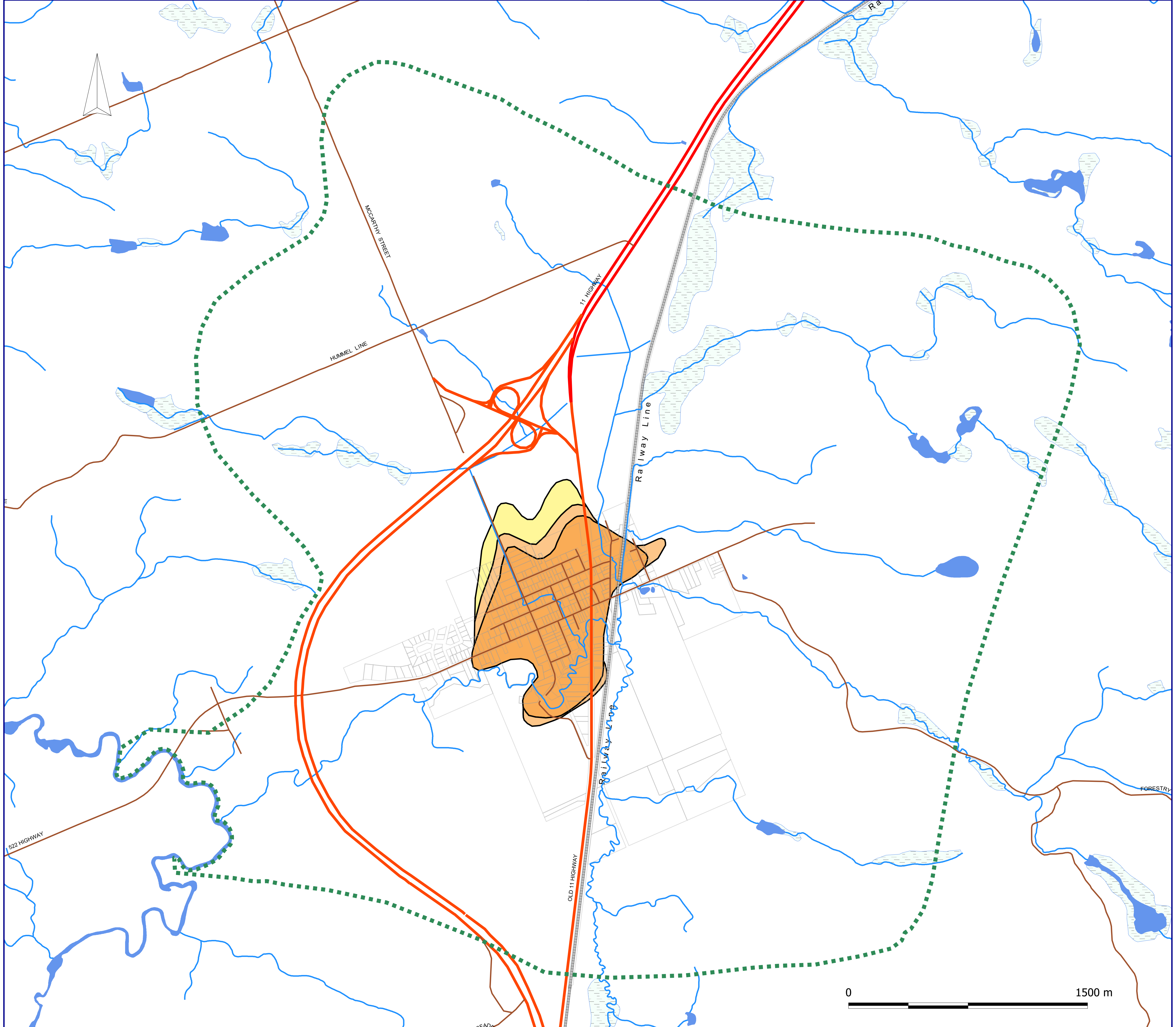

Study Area
Highway
Road
Rail
Water Body
Wetland Area
Water Course
Trout Creek Lots

Shallow Aquifer WHPA
2 year
5 year
25 year

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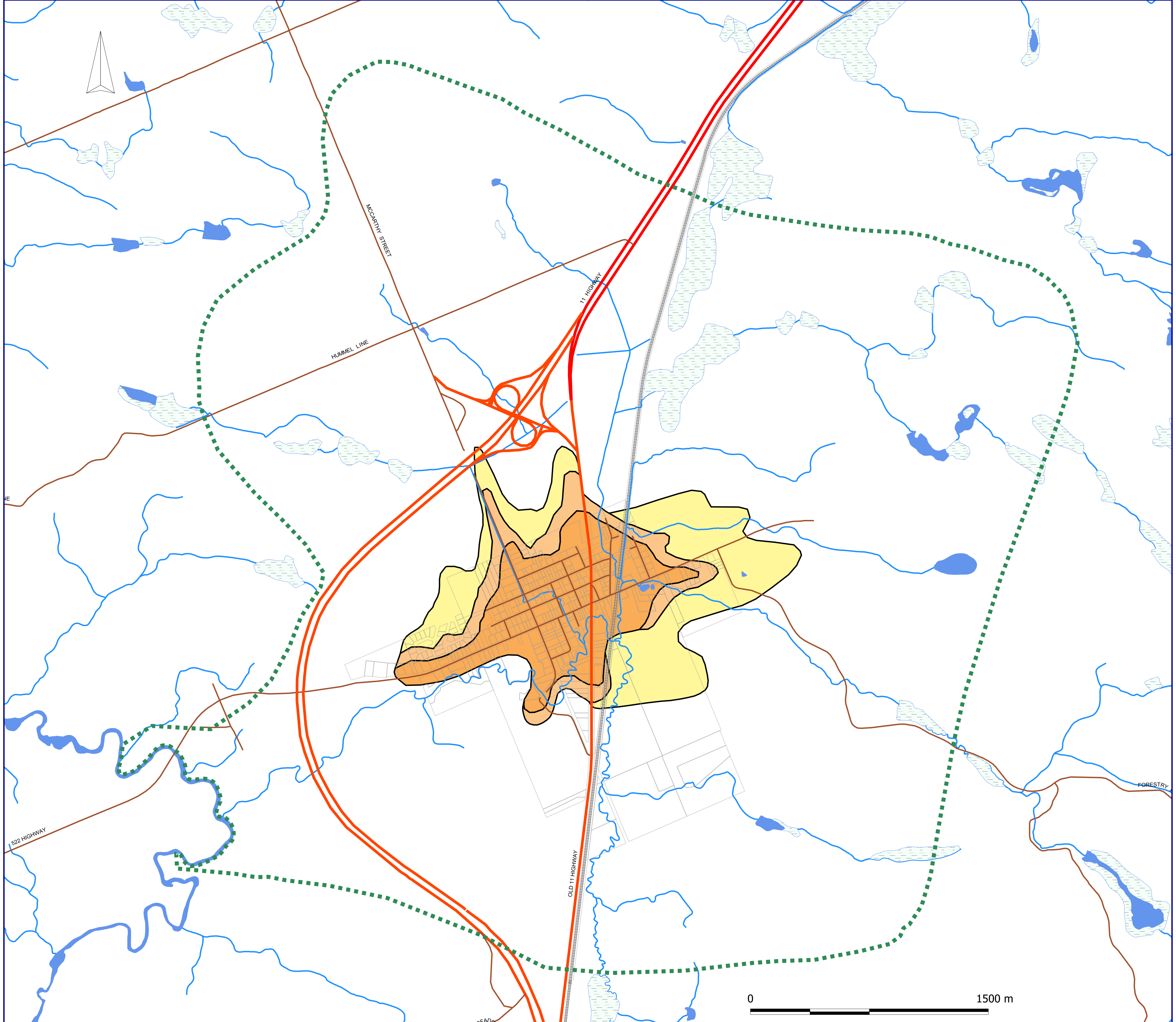
DRINKING WATER SOURCE PROTECTION
ACT FOR CLEAN WATER

Trout Creek Well Cluster Technical Assessment Report

Figure 5
Deep Confined Aquifer WHPA

Waters Environmental Geosciences Ltd.

NORTH BAY-MATTAWA CONSERVATION AUTHORITY



Study Area
Highway
Road
Rail
Water Body
Wetland
Water Course
Trout Creek Lots

Deep Aquifer WHPA
2 year
5 year
25 year

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Figure 6
Shallow Unconfined Aquifer Intrinsic Susceptibility Index

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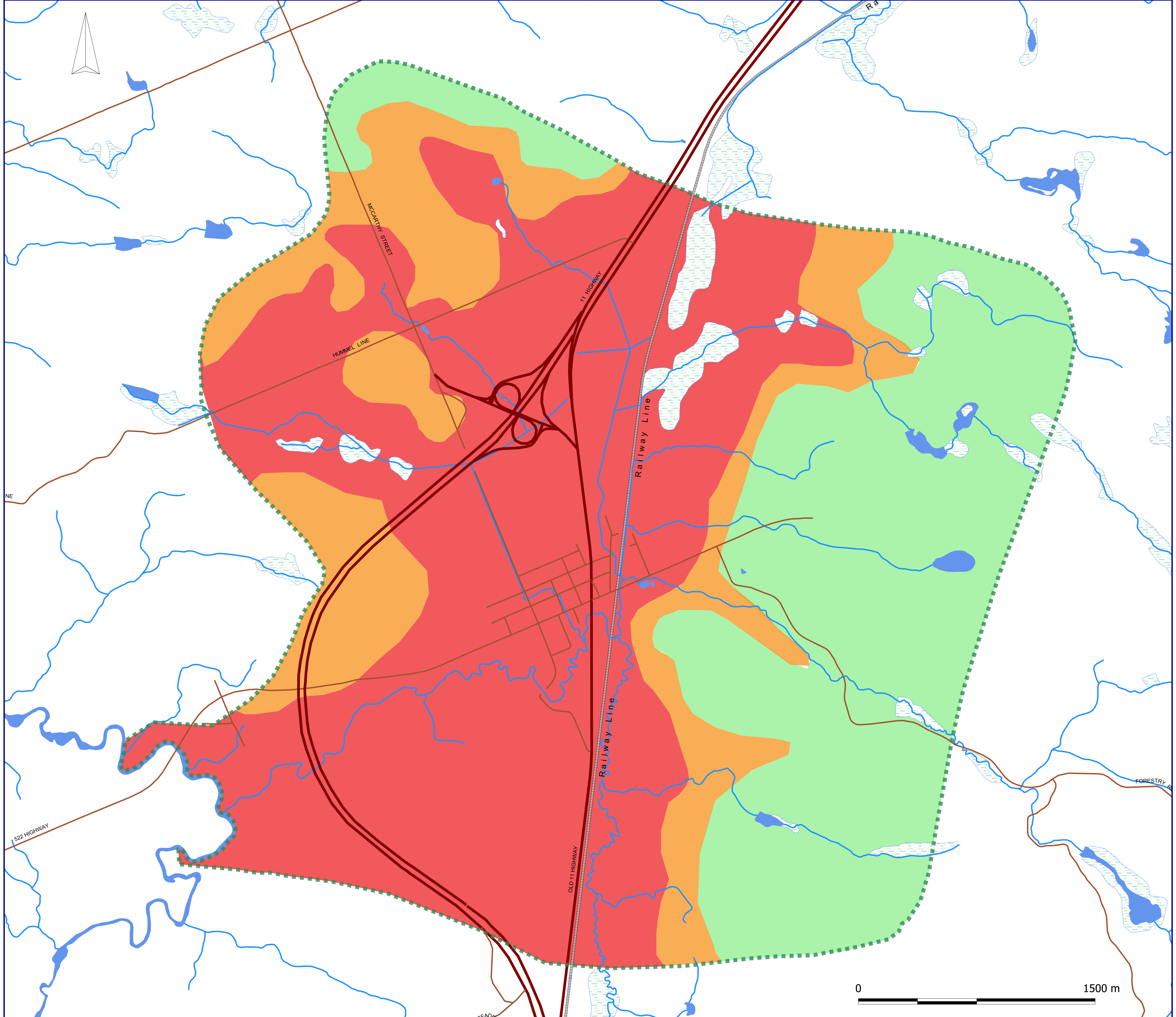

Study Area

Roads
Highway
Road
Rail

Water Body
Wetland
Water Course

Shallow Aquifer Susceptibility Index
LOW
MEDIUM
HIGH

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Figure 7
Deep Confined Aquifer Intrinsic Susceptibility Index

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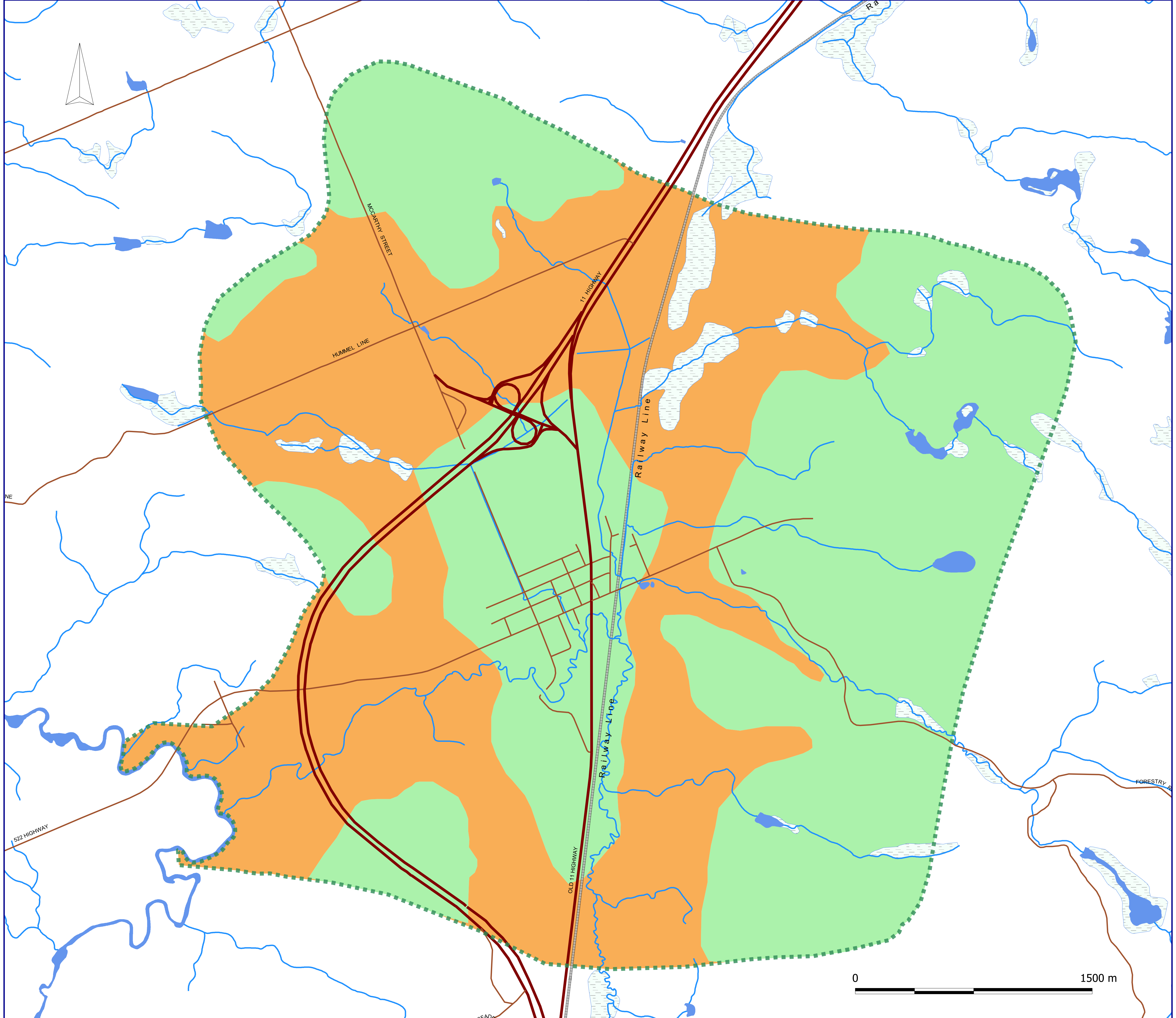

Study Area
Expressway / Highway
Local / Street
Rail
Water Body
Wetland
Water Course

Deep Aquifer Susceptibility Index
LOW
MEDIUM

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Figure 8
Shallow Unconfined Aquifer WHPA and Vulnerability Scores

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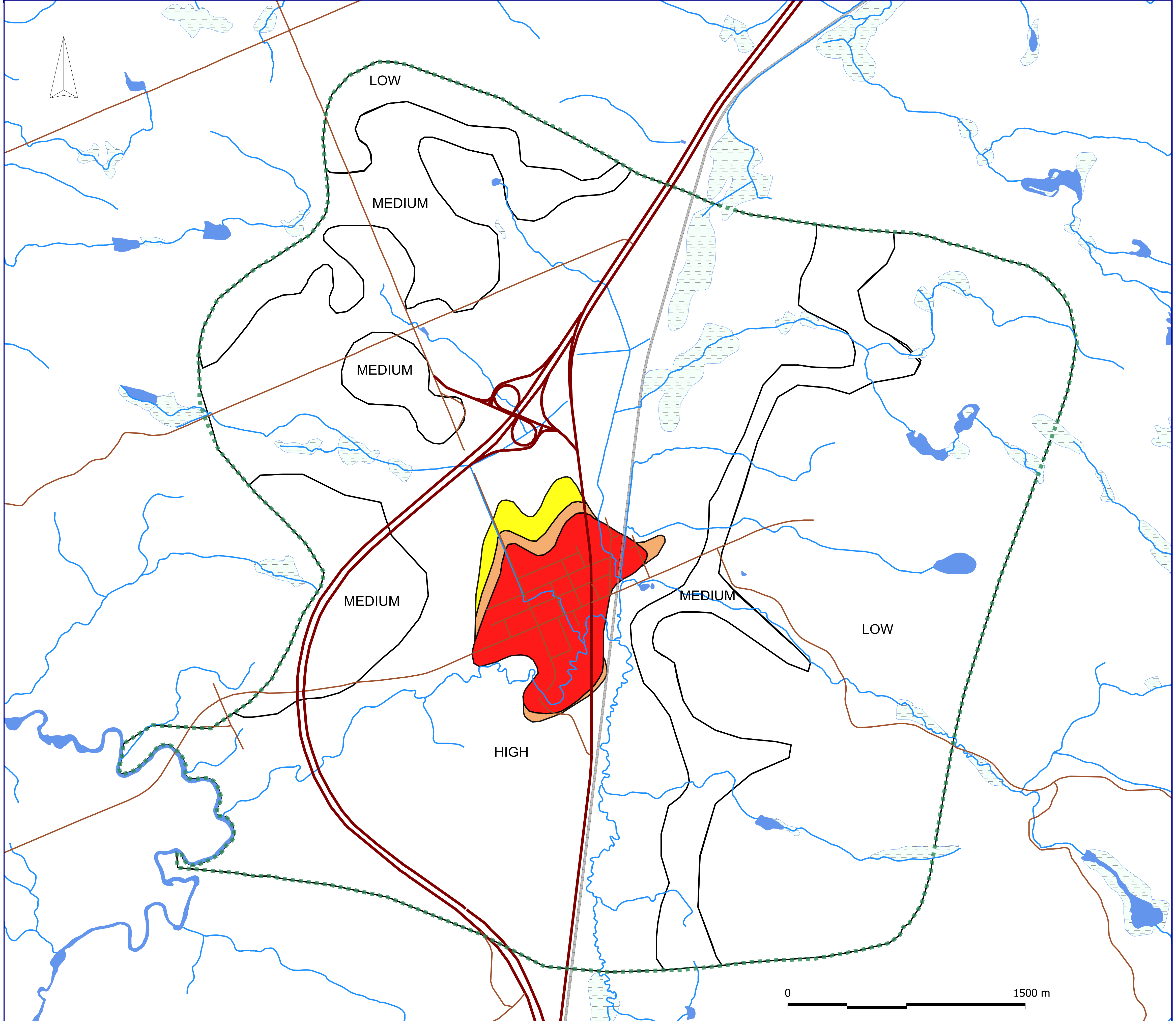

Study Area
Highway
Road
Text
Water Body
Wetland
Water Course
Shallow Aquifer WHPA
Vulnerability Scores
10
8
6
Shallow Aquifer ISI Rank

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ACT FOR CLEAN WATER

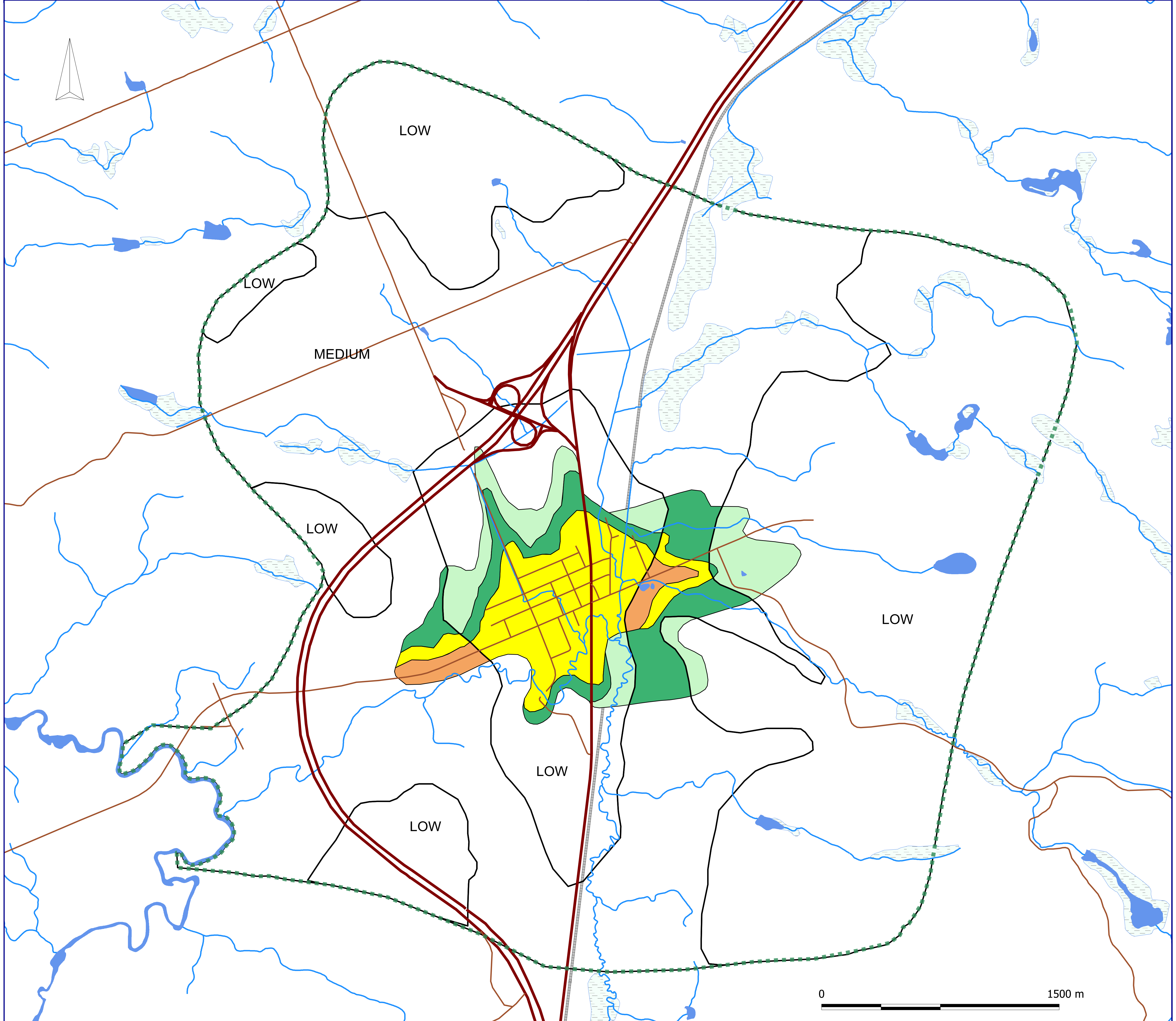

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Figure 9
Deep Confined Aquifer WHPA and Vulnerability Scores

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NORTH BAY-MATTAWA CONSERVATION AUTHORITY

Study Area
Highway
Road
Rail
Water Body
Wetland
Water Course

Deep Aquifer WHPA Vulnerability Scores

2
4
6
8

Deep Aquifer ISI Area

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ACT FOR CLEAN WATER

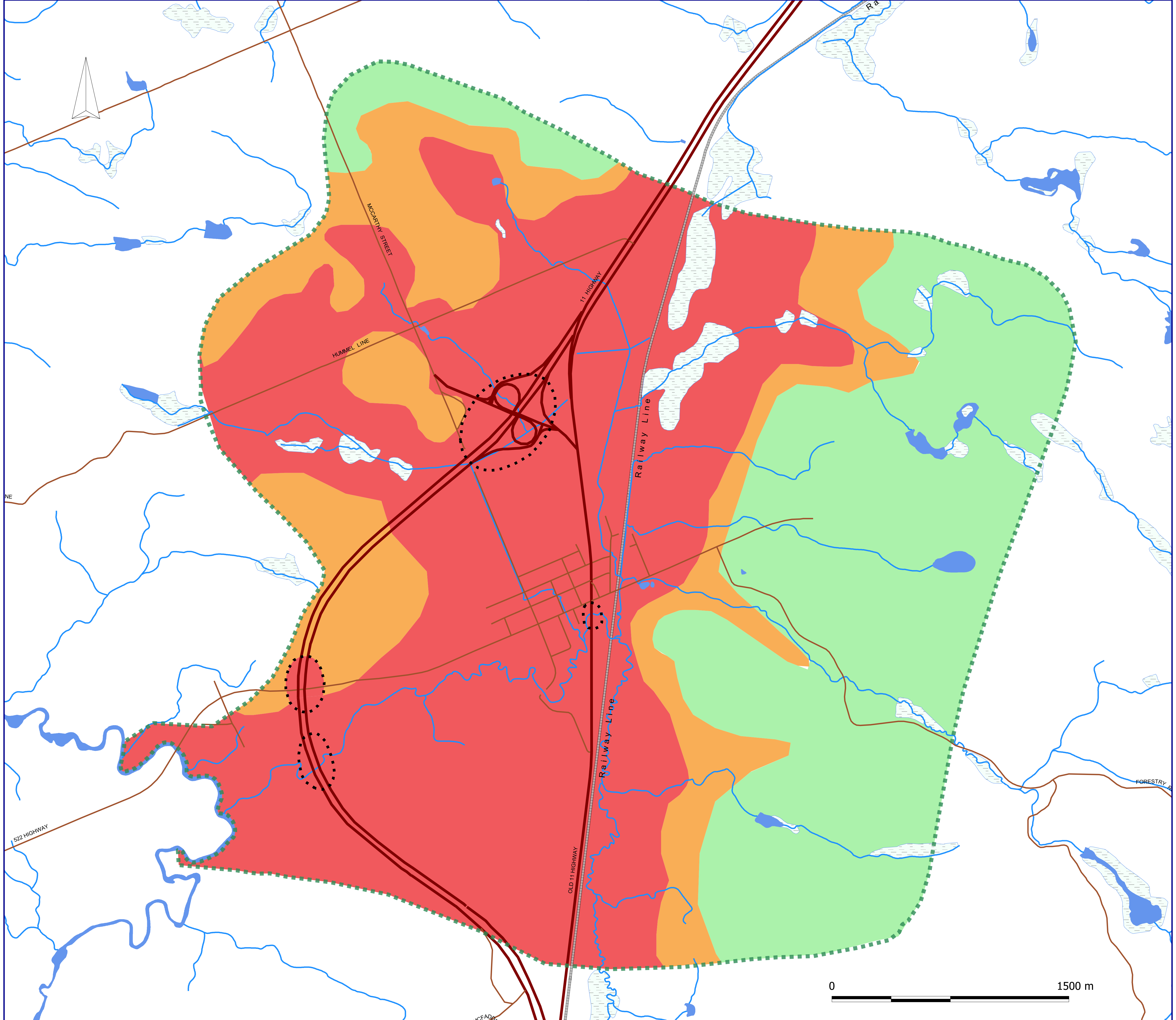

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Figure 10
Shallow Unconfined Aquifer Adjusted ISI Scores

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NORTH BAY-MATTAWA CONSERVATION AUTHORITY

Study Area
Highway
Roads
Rail
Water Body
Wetland
Water Course

Potential Man-Made Pathway

Shallow Aquifer Adjusted ISI Rank
LOW
MEDIUM
HIGH

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ACT FOR CLEAN WATER

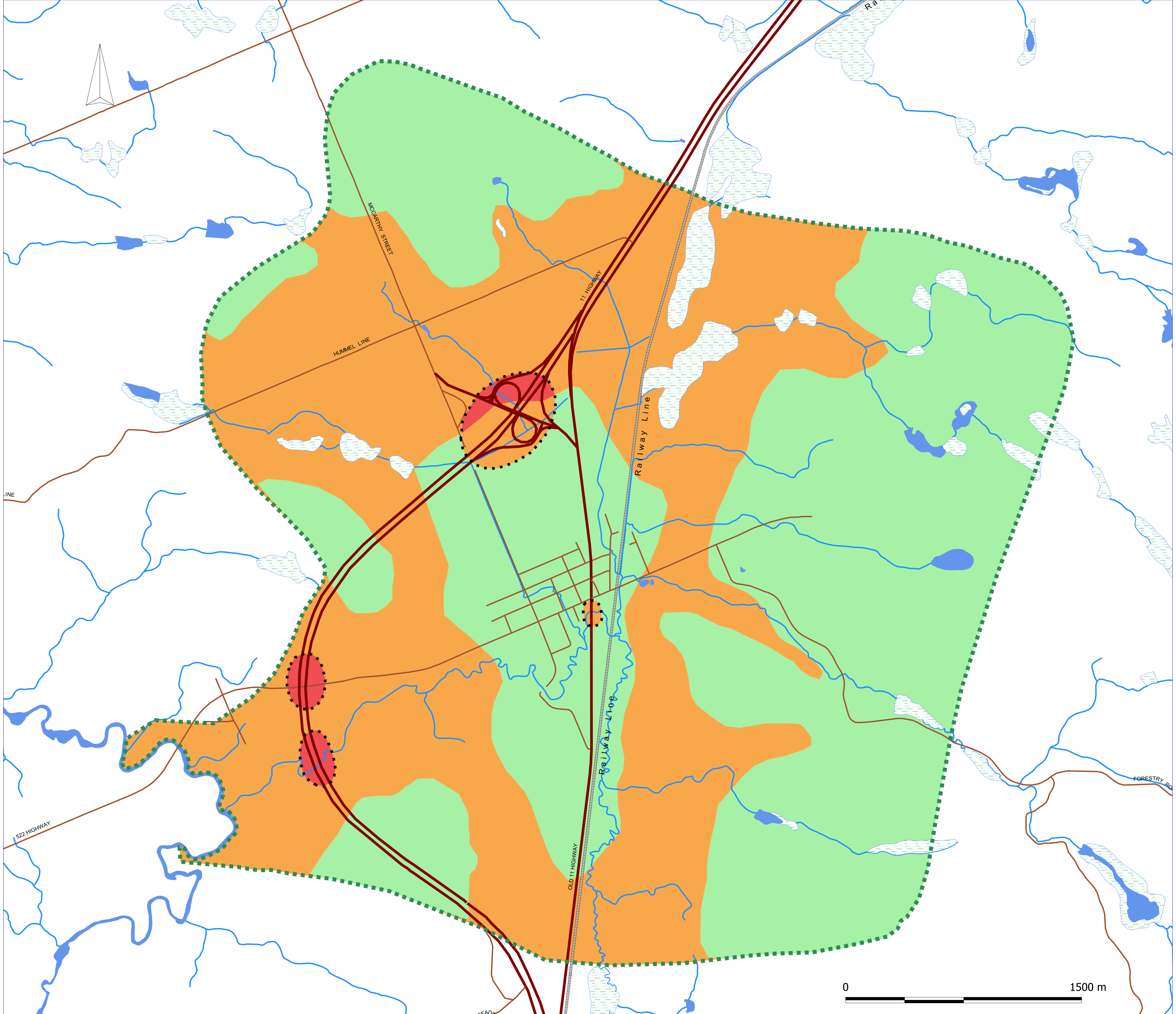

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Figure 11
Deep Confined Aquifer Adjusted ISI Scores

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NORTH BAY-MATTAWA CONSERVATION AUTHORITY

Study Area
Highway
Road
Rail
Water Body
Wetland
Water Course

Potential Man-Made Pathway

Deep Aquifer Adjusted ISI Rank
LOW
MEDIUM
HIGH

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ACT FOR CLEAN WATER

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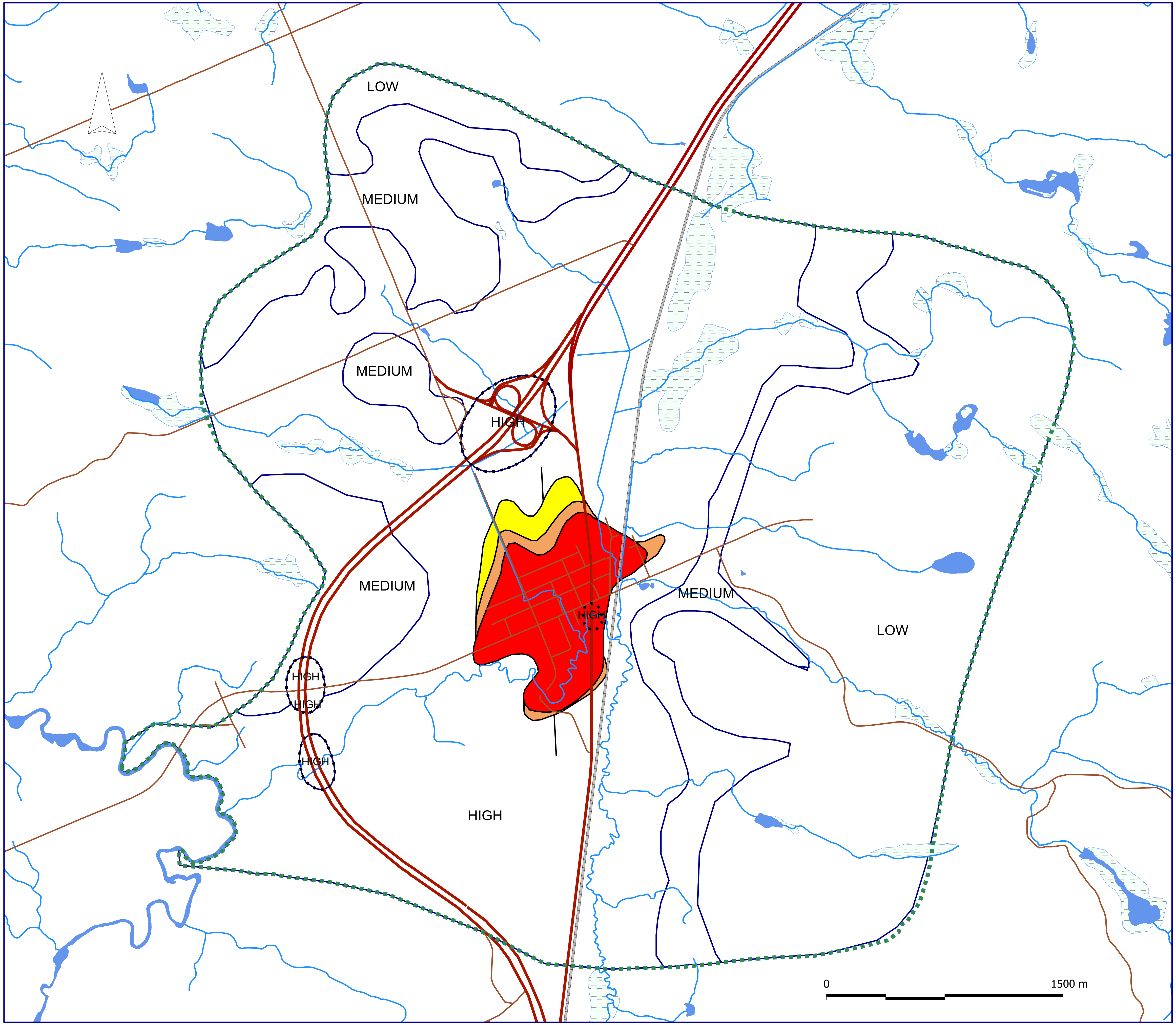
Figure 12
Shallow Unconfined Aquifer WHPA and Adjusted Vulnerability Scores



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NORTH BAY-MATTAWA CONSERVATION AUTHORITY

Study Area
Highway
Road
Rail
Water Body
Wetland
Water Course

Potential Man-Made Pathway

Shallow Aquifer WHPA Adjusted Vulnerability Scores
6
8
10

Shallow Aquifer Adjusted ISI rank

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ACT FOR CLEAN WATER

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Figure 13
Deep Confined Aquifer WHPA and Adjusted Vulnerability Scores

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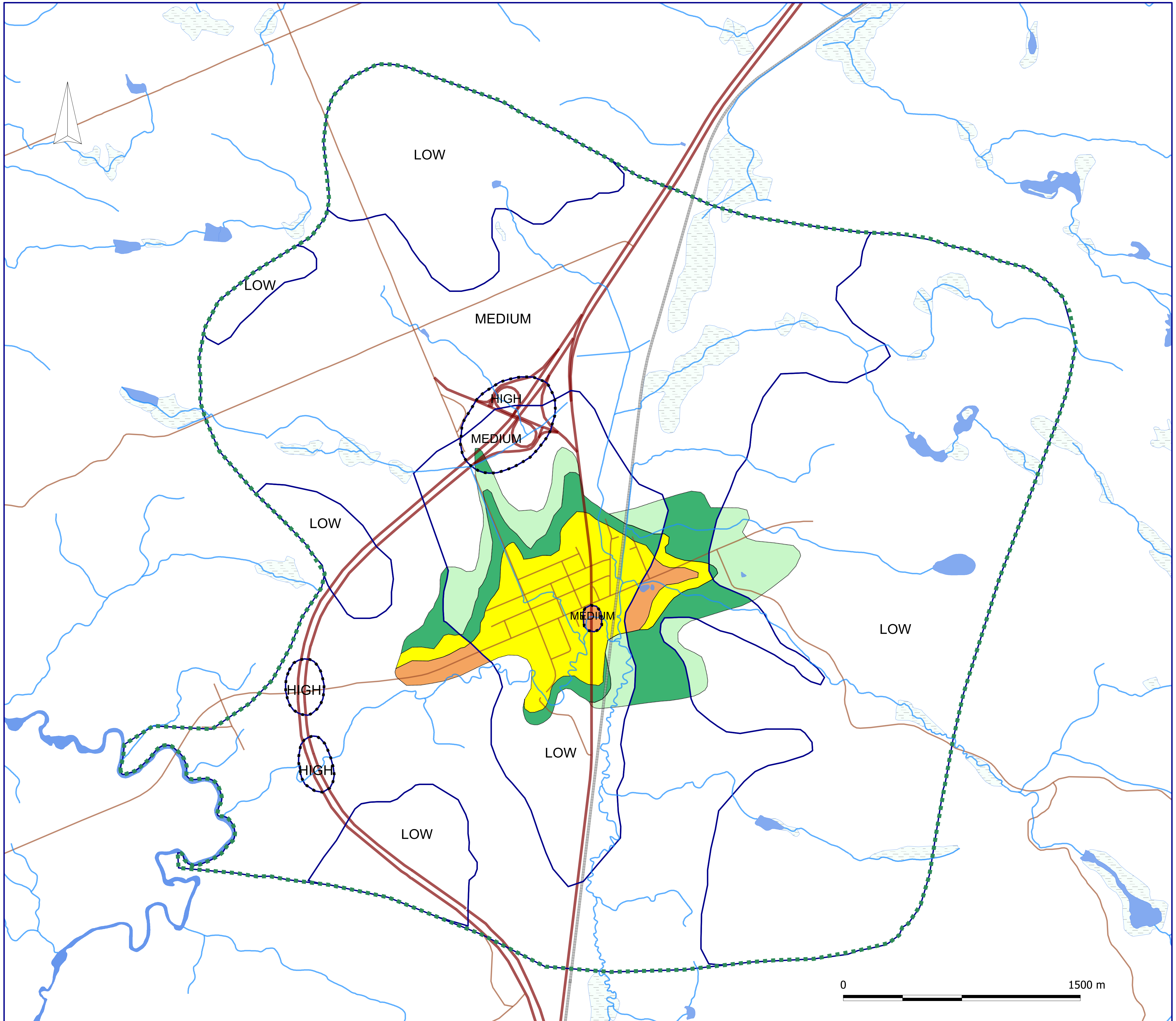

Study Area
Highway
Road
Rail
Water Body
Wetland
Water Course

Potential Man-Made Pathway
Deep Aquifer WHPA Adjusted Vulnerability Scores
2
4
6
8

Deep Aquifer Adjusted ISI rank

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