Geotechnical Inventory and Evaluation

Johnston Road Land Use Study

City of Ottawa

Project No. 122410116 (1042983)

April 2010

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1.0 Introduction

This report provides a geotechnical inventory for several parcels of land to the north of Johnston Road in Ottawa, Ontario. The work was carried out by Jacques Whitford Limited, now Stantec Consulting Ltd., for the City of Ottawa as a component of the overall Johnston Road Land Use Study. The assignment proceeded in accordance with our proposal of June 16, 2008. Authorization was provided by the City under Purchase Order 45059900.

It is understood that the overall study is being undertaken as a result of mounting development pressure in the area. It is also understood that zoning for this area allows for 18 m high buildings, however, the zoning by-law designating this area for light industrial and commercial development will likely dictate the land use.

Past experience within the surrounding lands suggests that geotechnical conditions could influence the viability of development scenarios.

2.0 Scope of Work

Jacques Whitford now Stantec Consulting Ltd. was mandated to review existing data on the geotechnical environment of the study area. This area is bounded by Albion Road to the west, Johnston Road to the south, Conroy Road to the east and the Hydro One corridor to the north. A key plan is provided as Drawing No.1 in Appendix B.

Specifically, the work included the preparation of a report summarizing the existing geotechnical environment accompanied by a series of plans providing the following information:

- Surficial Soil Deposits
- Bedrock Formations
- Overburden Thickness

In addition, criteria were developed and utilized as a component of the evaluation of land development options for the study area.

3.0 Methodology

In addition to the information provided by the City of Ottawa and the reference material available in our files, geological and geotechnical data was obtained from the following agencies:

- Geological Survey of Canada
- Ontario Geological Survey
- Site Reconnaissance

A reference list is provided in Section 8 of this report.

A base plan for the study area was provided by the City of Ottawa. It included roadway, building and river locations.

The surficial soils map of the area was assembled based on the data gathered from the historical borehole records. Detailed borehole data was plotted, surficial boundaries were established manually, and a preliminary map was compared to published surficial deposit maps. For the purposes of this report, surficial soil is defined as the material at a depth of 1.0 metre below ground surface.

The Depth to Bedrock and Depth to Top of Glacial Till maps were derived from borehole data along with the other available geological and geotechnical information.

4.0 Results

The site is located within the central portion of the physiographic region identified by Chapman and Putnam 1984 as the “Ottawa Valley Clay Plains”. This region is characterized by clay plains interspersed with ridges of rock or sand.

4.1 SURFICIAL GEOLOGY

The study area is surrounded by a well developed area of Ottawa. Therefore, deposits of fill are present. More than 3 meters of fill can be found at locations within the boundaries of the site. The discussions provided herein will focus on the native soils.

The soils in the Ottawa area were deposited in the following stratigraphic sequence: the bedrock is generally overlain by glacial deposits; these in turn are overlain by soils deposited during the time in which the area was flooded by the Champlain Sea; the uppermost soils are those deposited since the recession of the Champlain Sea. Not all soil strata are present at all locations.

A review of the available information reveals that four different materials are present at shallow depth within the study area: peat, sand, clay, and glacial till. Drawing No. 2 in Appendix B

presents the surficial soil types within the study area. Note that the drawing presents an interpretation of native soil conditions at a depth of 1 m below ground surface. Other soil types may be found at greater depth in the profile.

4.1.1 Organic Deposits/Peat

A deposit of organic materials/peat is found at shallow depth within the south half of the site, as shown on Drawing No. 2 in Appendix B. These types of deposits typically form as swamps in poorly drained areas.

Typically the organic deposits/peat reported in the historic borehole records are described as very loose to soft, dark brown to black, fibrous material with wood. At some locations the peat becomes amorphous. Although the peat deposit is of limited thickness (typically 2 m or less), it is frequently found beneath a layer of fill. The fill consists of variable quality material and frequently contains a high organic content with a moisture content in excess of 200%. Minimal testing is reported for the peat layer however the limited moisture content testing also indicates a value in excess of 200%.

Clay soils are present beneath the organic and peat deposits.

4.1.2 Sand

A surficial layer of sand is present across the northern section of the site as well as in the south east corner.

The sand deposit is typically composed of medium grained sand material stratified with siltier layers. The deposits are in the form of fluvial terraces and channels cut into the underlying clay or as spits and bars within abandoned channels.

The sand layer is of limited thickness within the study area (less than 2 m typically) and is underlain by clay.

4.1.3 Offshore Marine Clay

Clay deposited in the marine environment of the post-glacial Champlain Sea is present either near ground surface or beneath shallow surficial deposits of sand and peat, throughout the study area. Stratigraphically, the clay is found overlying the glacial till.

Clay is a very fine grained, well sorted sediment. The properties of this deposit tend to vary with moisture content and depth. The upper 1 to 3 metres is usually desiccated and weathered, forming a grey-brown, firm to stiff crust. Below this weathered zone, the moisture content increases, shear strength decreases and the colour changes from a grey-brown to grey. The lower, grey clay is highly compressible and tends to lose much strength when disturbed. Laboratory testing reported by Golder 2007, indicates:

- Moisture contents ranging from 53% to 106%
- Liquid limits ranging from 33% to 78%

- Plasticity index ranging from 15% to 52%
- Unit weight ranging from 14.2 to 17.0 kN/m3
- Apparent preconsolidation pressure ranging from 45 kPa to 75 kPa
- Overconsolidation ratio ranging from 1.7 to 4.5
- Compression index ranging from 0.74 to 3.6
- Initial void ratio ranging from 1.4 to 3.0

Insitu vane test results are reported in the same document to range from 8 kPa to 19 kPa.

The presence of the silty clay beneath any particular location has a profound impact on the potential for development. Drawing No. 4 in Appendix B presents contour lines of the depth to the top of glacial till. This figure highlights the areas where thick deposits of compressible clay are likely. It is apparent that the glacial till is shallowest at the southeast and northwest corners of the study area, and that a significant proportion of the central and northeast sections may be underlain by a thick deposit of clay.

4.1.4 Glacial Till

Although it is not present at shallow depth, glacial till is found throughout the majority of the study area. Stratigraphically, glacial till is usually found directly overlying bedrock and underlying the silty clay.

In general, the till unit is a heterogeneous mixture of sediment ranging in size from clay to boulders. Most commonly, it is a silty sand containing gravel and minor quantities of clay, cobbles and boulders; however, the composition of the till does vary significantly. The moisture content of the till is estimated to range from 10 to 30%. The granular till is non-cohesive and generally dense to very dense.

Layers of sandy silt, silty sand, and sand are noted to occur at the top of the glacial till at some locations in the study area. This material is generally saturated and loose to very loose.

4.2 BEDROCK GEOLOGY

Based on the 1984 mapping carried out by the Ontario Geological Survey, the Carlsbad Bedrock Formation is present beneath the entire study area. The Carlsbad Formation consists of interbedded dark grey shale, fossiliferous calcareous siltstone and silty bioclastic limestone. No faults are indicated within the study area.

The depth to bedrock varies across the study area from less than 6 m in the south east to more than 14 m in the north east and south central sections. This information is presented on Drawing No. 3 in Appendix B.

4.3 SLOPE STABILITY

Based on the Slope Stability Study of the Regional Municipality of Ottawa-Carleton, Ontario, Canada by M.A. Klugman and P. Chung in 1976, there are no slopes within the study area which should be cause for stability concern.

5.0 Geotechnical Constraints

The following sections are presented for discussion purposes only and are not intended for use in design. All developments will require site specific geotechnical and hydrogeological investigation, analysis and design. Such work may result in more or less restrictive constraints for the specific location. Please note that although separate sections are provided for grading, foundations and groundwater, they are interrelated.

The geotechnical constraints discussed below are imposed on the study area by the following soil types:

- fill of a random nature
- peat material
- Champlain Sea clay which is highly compressible

A plan highlighting the various geotechnical constraints is provided in Appendix C.

5.1 GRADING

The organic deposits/peat are unsuitable materials for the envisioned use of the properties and should be removed prior to development. Replacement of relatively light weight peat with heavier fill needs to be considered in assessing the potential for settlement.

The dominant soil type within the subject area is a compressible clay. The settlement behavior of clay is described by consolidation theory such that the amount of settlement is related to the stress on the soil with respect to the pre-consolidation pressure. If the increase in load does not push the stress on the soil beyond the pre-consolidation pressure, there will be limited amounts of settlement. On the other hand, where the resulting stresses are in excess of the pre-consolidation pressure, there will be a significant amount of settlement, typically beyond normally tolerable limits for buildings. Our review of available information suggests that the pre-consolidation pressure for the clays at this site is as low as 30 kPa in excess of the existing effective stresses. This suggests that grade increases around buildings will need to be very limited to avoid crossing the pre-consolidation stress and inducing significant settlements.

A balance between the safe additional pressures which can be carried by the site soils and the anticipated loads from grade changes, foundation loads, floor loads and groundwater lowering is crucial to the success of development designs. Of significant concern is the combined impact of peat removal and replacement with stronger/heavier soils, with potential grade increases.

Potential mitigation measures are available which can allow grade increases. However solutions such as light weight fill, raft foundations, structural floor slabs on deep foundations and surcharging with or without wick drains all add to the construction cost and hence negatively affect the economic viability of potential developments.

5.2 FOUNDATIONS

The existing peat and fill materials are unsuitable to support foundations and would need to be removed.

5.2.1 Conventional Spread Footings

Areas identified as “peat over clay” should not be considered as suitable to support conventional spread footings due to the potential of undesirable settlements induced by material replacement, grading and foundations. For these areas the option given in the following sections should be considered.

The surficial sands as well as the upper portion of the clay layer (the crust) are potential candidates for conventional spread footing foundations, however, it is anticipated that the available geotechnical resistance at Serviceability Limit States is likely to be quite low. Other than for wood framed residential homes with basements, it will be advantageous to construct footings as high as possible in the soil profile to take advantage of the crust material and limit stress increases on the underlying compressible grey clay. Unfortunately, this technique would conflict with normal frost cover requirements leading to a need to provide foundation insulation. Construction of granular pads beneath spread footings could be considered as a potential method to achieve a slight increase in capacity.

In the case of one or two storey, wood framed residential homes with basements, the weight of soil removed for the basement significantly exceeds the weight of the house. Provided that the exterior grades surrounding the residences are maintained close to those existing, tolerable settlements would generally be anticipated.

In summary the use of conventional spread footings may be considered for very light buildings with limited floor loads provided that minimal grade increases are carried out.

Due to long-term environmental changes, an increase in the frequency of dry summers has been observed in Ottawa which causes the following concerns in areas underlain by Champlain Sea clay deposits.

- a natural progressive lowering of the water table can produce consolidation within the deeper clays which would result in some shifting of the foundations
- higher frequency of periods where the water demand on trees will exceed rainfall infiltration amounts

It would be recommended that some longitudinal reinforcement be provided in the foundation walls to help minimize cracking associated with foundation shifts and that tree planting be restricted to types with a lower water demand placed sufficiently far from residences.

5.2.2 Raft Foundations

Raft foundations are constructed by making the floor slab structurally integral with the walls and columns of the building. Thus the building and all of its loads are essentially carried on one

large footing. This distributes a reduced stress onto a larger area and forces settlements to occur in a more uniform fashion across the building.

Raft foundations can be utilized to support residential units within this study area. The unloading due to excavation for the basement can be balanced by the addition of the building loads to achieve a near net-zero scenario. Extra design efforts and construction costs are required for the structural slab and to accommodate the garage areas.

Raft foundations for commercial or industrial developments within the study area will likely be restricted to very light buildings with low floor loads, as these buildings do not typically include basements.

The suitability of raft foundations will need to be assessed once grading plans are developed.

5.2.3 Deep Foundations

Deep foundations using either steel piles or augered caissons can be used to bypass the compressible clay layers. Augered caissons are generally economical when the founding layer is at a depth of less than 6 m, thus their use would likely be restricted to small parcels in the northwest and southeast corners of the study area. Both augered caissons and steel piles would likely be adequately supported by the bedrock underlying the study area.

Foundation design for the deep foundations would likely require inclusion of down drag loads on the piles or caissons.

The grading plans and floor loads for particular developments would dictate if floor slabs would need to be structural slabs supported on deep foundations. For developments with no grade increase and a floor load of 10 kPa or less, it is likely that a conventional slab-on-grade floor slab would be suitable.

5.2.4 Seismic Site Classification

Based on the information available for review, and for preliminary purposes only, the study area should be considered a Site Class E with respect to seismic site response as defined by the Ontario Building Code. Geotechnical design for development should verify the classification with site specific investigations.

5.3 GROUNDWATER

The presence of shallow groundwater can lead to difficulties with respect to construction dewatering for temporary excavations such as service trenches. It can also necessitate instituting permanent groundwater management techniques for below grade facilities such as basements, loading docks and parking garages.

Temporary excavations into the clay within the study area will not likely generate large volumes of water. Significant inflows are more likely to occur in excavations in the glacial till and sands

below the water table. In addition care will be required to ensure excavation basal stability against uplift due to hydrostatic forces or soft clay deformation.

Past experience in the area immediately south of the subject lands suggests that groundwater lowering could also increase effective stresses which can lead to unacceptable levels of settlement. Furthermore, groundwater draw down has a radius of influence and the effects can cross property boundaries. Although hydrogeological investigation, modeling and design will be required for each separate development, the studies will need to be cognizant of the cumulative effects of the progressive developments in the area and demonstrate that nearby properties and facilities are not adversely affected.

Given the regional context, there needs to be concerted efforts to minimize groundwater lowering. Groundwater stops will be required in utility trenches to prevent development of French drain effects. Permanent excavations deeper than 1.5 m (such as for underground parking garages) should be constructed to be water tight to prevent regional-level groundwater lowering. Infiltration of precipitation should be encouraged by preserving green space where possible and by design (e.g. roof leads directed to sumps, possible use of permeable pavement).

5.4 SUMMARY

Residential Developments

- Conventional construction is not likely to be suitable in areas of peat over clay. Some form of special design such as raft foundations or lightweight fill should be considered.
- Conventional construction is likely suitable outside the peat over clay areas, however, increases to grades will need to be very limited.

Light Commercial

- Conventional construction is not likely suitable within the study area. Some form of special design such as deep foundations in peat over clay areas and shallow footings in conjunction with granular pads or raft foundations in other areas should be considered. Grade restrictions are likely required.

Heavy Buildings

- Heavy buildings will likely require deep foundations to support the building. Structural floor slabs on deep foundations are also likely required. Grade restrictions may be necessary to ensure integrity of service line connections at the building perimeters.

6.0 Alternative Evaluation

6.1 GEOTECHNICAL CRITERIA

Given the existing soil and groundwater conditions documented during the inventory as well as the nature of the geotechnical constraints to development, three geotechnical criteria were selected to assist in the comparison of the development options. The criteria are described in Table 6.1.

Table 6.1: Geotechnical Evaluation Criteria

Criteria	Description	Measurement
Groundwater: Potential for infiltration from surface	Cutting off infiltration by construction of hard surfaces (roofs and paved areas) could result in a lowered groundwater table leading to the potential for settlement.	Based on percentage of study area with soft surfaces for each option.
Groundwater: Potential to maintain existing water levels in areas of below grade facilities	Below grade facilities can lower groundwater levels and can lead to potential settlement concerns	Based on length of new roadways and area of anticipated below grade parking for each option.
Soils: Need for more than conventional foundations/floor slab designs in buildings	Soil conditions in some locations may require special geotechnical designs	Based on building type and anticipated soil conditions for each option.

6.2 DEVELOPMENT OPTIONS

Three development options were generated by City Staff. The conceptual plans presented in Appendix C highlight the roadway networks as well as proposed land use throughout the project limits.

The three options were evaluated based on the criteria described in Table 6.1. The results are presented in the tables presented in Appendix C. The evaluation suggested that there is little to choose between the three options based on the three geotechnical criteria. As such the geotechnical criteria should be considered as overall design constraints for the study area.

It is understood that the three options were also assessed with respect to other criteria. A Proposed Concept Plan was then generated for the study area. A copy of the Proposed Concept Plan is included in Appendix C.

6.3 SITE APPLICATION

Challenging soil conditions are present throughout the study area. Control and/or mitigation from settlement of the underlying clays soils will be a primary design factor. Site specific geotechnical investigations will be required for individual, proposed developments at the Site Plan Application stage. It is anticipated that those investigations will conclude that only minor increases above existing grades will be tolerable. It is also anticipated that for all but the lightest of structures there will be a need to consider deep foundations (piles or caissons), raft foundations, light weight fills, structural floor slabs and other solutions.

The settlement of the soils present within and around the study area will also be influenced by the groundwater level. Given the regional context, it is important that the groundwater levels on adjacent properties not be lowered. Site specific hydrogeological investigations will be required for individual, proposed developments at the Site Plan Application stage. Groundwater modeling will be required and the hydrogeological reports supporting the proposed development applications will need to demonstrate that the proposed works will not adversely affect groundwater levels both on and off-site. The cumulative effect(s) of progressive developments must be considered in the analyses. Mitigative measures may be necessary to protect both the proposed developments and the surrounding properties from ground water lowering.

7.0 Closure

This report has been prepared for the sole benefit of the City of Ottawa and its agents, and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the City of Ottawa. Any use which a third party makes of this report is the responsibility of such third party.

The discussions presented in this report are in accordance with our present understanding of the project. The discussions have been provided as an aid to the planning process and are not intended for design. Additional investigations are required for future design stages.

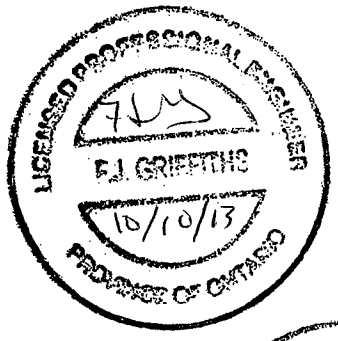
This report is based on the site conditions encountered by at the time of the work, and at the specific testing and or sampling locations and can only be extrapolated to a limited extent around these locations. The extent depends on the variability of soil and ground water conditions as influenced by geological processes, construction activities and site use. Should any conditions at the site be encountered which differ from those at the test locations, we require that we be notified immediately in order to permit reassessment of our findings.

The available information has been compiled from a variety of sources and was initially acquired for a variety of purposes. Stantec Consulting Ltd. assumes no responsibility for the accuracy of the information or subsequent interpretations. It is also noted that the information was acquired over a period of several decades and thus may not be representative of current conditions.

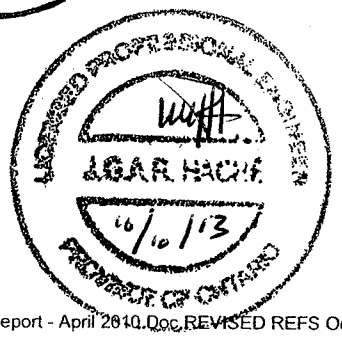
We trust that the above is satisfactory for your purposes at this time. If you have any questions please contact us at your earliest convenience.

Yours truly,

STANTEC CONSULTING LTD.



Fred J. Griffiths, Ph.D., P.Eng.
Principal and Group Leader
Geotechnical and Materials Engineering



J.G.A. Raymond Haché, M.Sc., P.Eng., PMP
Principal and Senior Service Director
Geotechnical and Materials Engineering

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APPENDIX A

Statement of General Conditions

STATEMENT OF GENERAL CONDITIONS

USE OF THIS REPORT: This report has been prepared for the sole benefit of the Client or its agent and may not be used by any third party without the express written consent of Stantec Consulting Ltd. and the Client. Any use which a third party makes of this report is the responsibility of such third party.

BASIS OF THE REPORT: The information, opinions, and/or recommendations made in this report are in accordance with Stantec Consulting Ltd.'s present understanding of the site specific project as described by the Client. The applicability of these is restricted to the site conditions encountered at the time of the investigation or study. If the proposed site specific project differs or is modified from what is described in this report or if the site conditions are altered, this report is no longer valid unless Stantec Consulting Ltd. is requested by the Client to review and revise the report to reflect the differing or modified project specifics and/or the altered site conditions.

STANDARD OF CARE: Preparation of this report, and all associated work, was carried out in accordance with the normally accepted standard of care in the state or province of execution for the specific professional service provided to the Client. No other warranty is made.

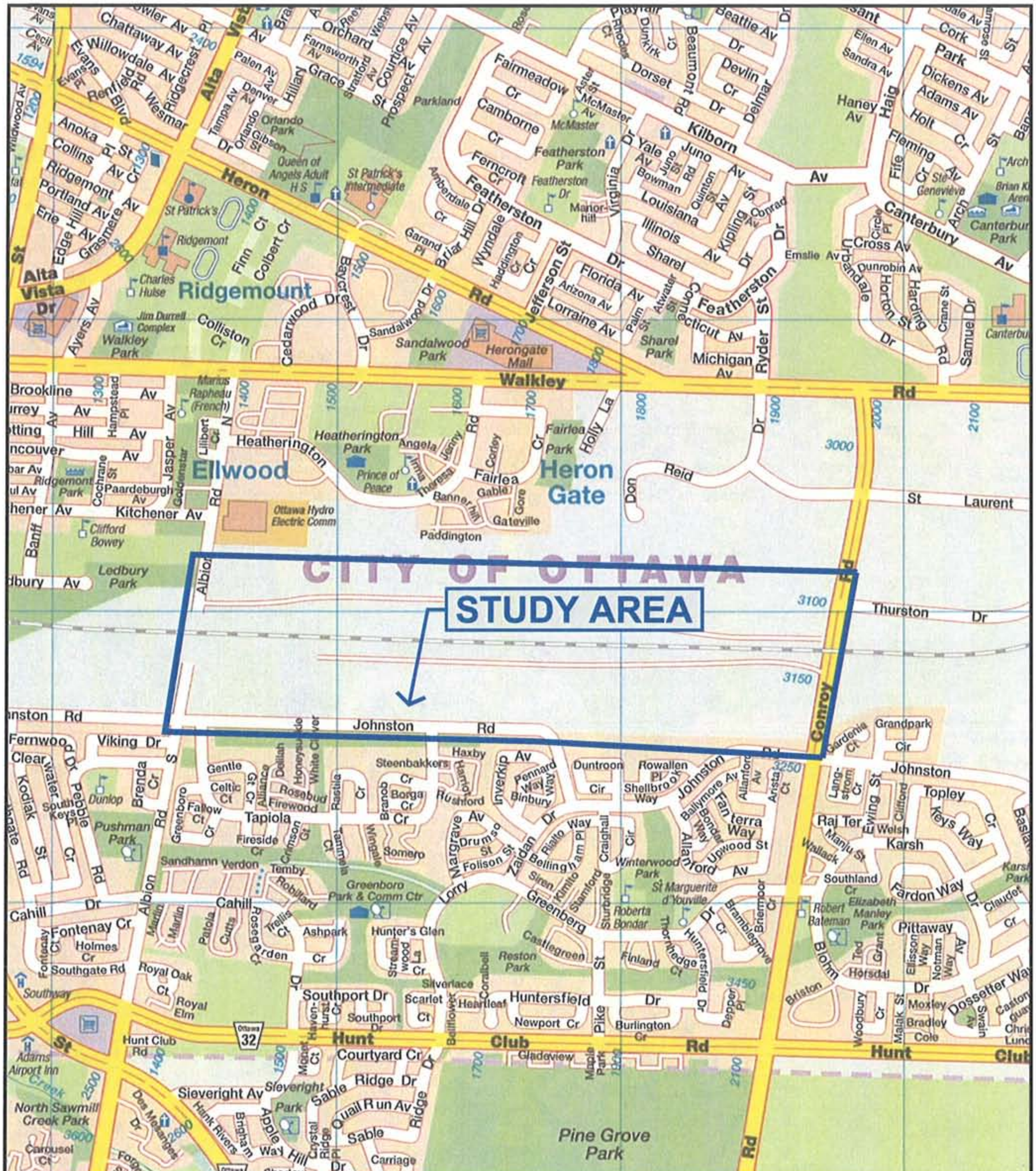
INTERPRETATION OF SITE CONDITIONS: Soil, rock, or other material descriptions, and statements regarding their condition, made in this report are based on site conditions encountered by Stantec Consulting Ltd. at the time of the work and at the specific testing and/or sampling locations. Classifications and statements of condition have been made in accordance with normally accepted practices which are judgmental in nature; no specific description should be considered exact, but rather reflective of the anticipated material behavior. Extrapolation of in situ conditions can only be made to some limited extent beyond the sampling or test points. The extent depends on variability of the soil, rock and groundwater conditions as influenced by geological processes, construction activity, and site use.

VARYING OR UNEXPECTED CONDITIONS: Should any site or subsurface conditions be encountered that are different from those described in this report or encountered at the test locations, Stantec Consulting Ltd. must be notified immediately to assess if the varying or unexpected conditions are substantial and if reassessments of the report conclusions or recommendations are required. Stantec Consulting Ltd. will not be responsible to any party for damages incurred as a result of failing to notify Stantec Consulting Ltd. that differing site or sub-surface conditions are present upon becoming aware of such conditions.

PLANNING, DESIGN, OR CONSTRUCTION: Development or design plans and specifications should be reviewed by Stantec Consulting Ltd., sufficiently ahead of initiating the next project stage (property acquisition, tender, construction, etc), to confirm that this report completely addresses the elaborated project specifics and that the contents of this report have been properly interpreted. Specialty quality assurance services (field observations and testing) during construction are a necessary part of the evaluation of sub-subsurface conditions and site preparation works. Site work relating to the recommendations included in this report should only be carried out in the presence of a qualified geotechnical engineer; Stantec Consulting Ltd. cannot be responsible for site work carried out without being present.

APPENDIX B

Drawing No. 1 - Key Plan
Drawing No. 2 - Surficial Soils
Drawing No. 3 - Depth to Bedrock
Drawing No. 4 - Depth to Top of Glacial Till



REFERENCE: MAPART

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KEY PLAN JOHNSTON ROAD LAND USE STUDY JOHNSTON RD. FROM ALBION RD. TO CONROY RD., OTTAWA, ONTARIO	Job No.: 142983 Scale: 1 : 20 000 Date: 08/09/24 Dwn. By: GBB/OT App'd By:	Dwg. No.: 1	Jacques Whitford
Client: CITY OF OTTAWA			

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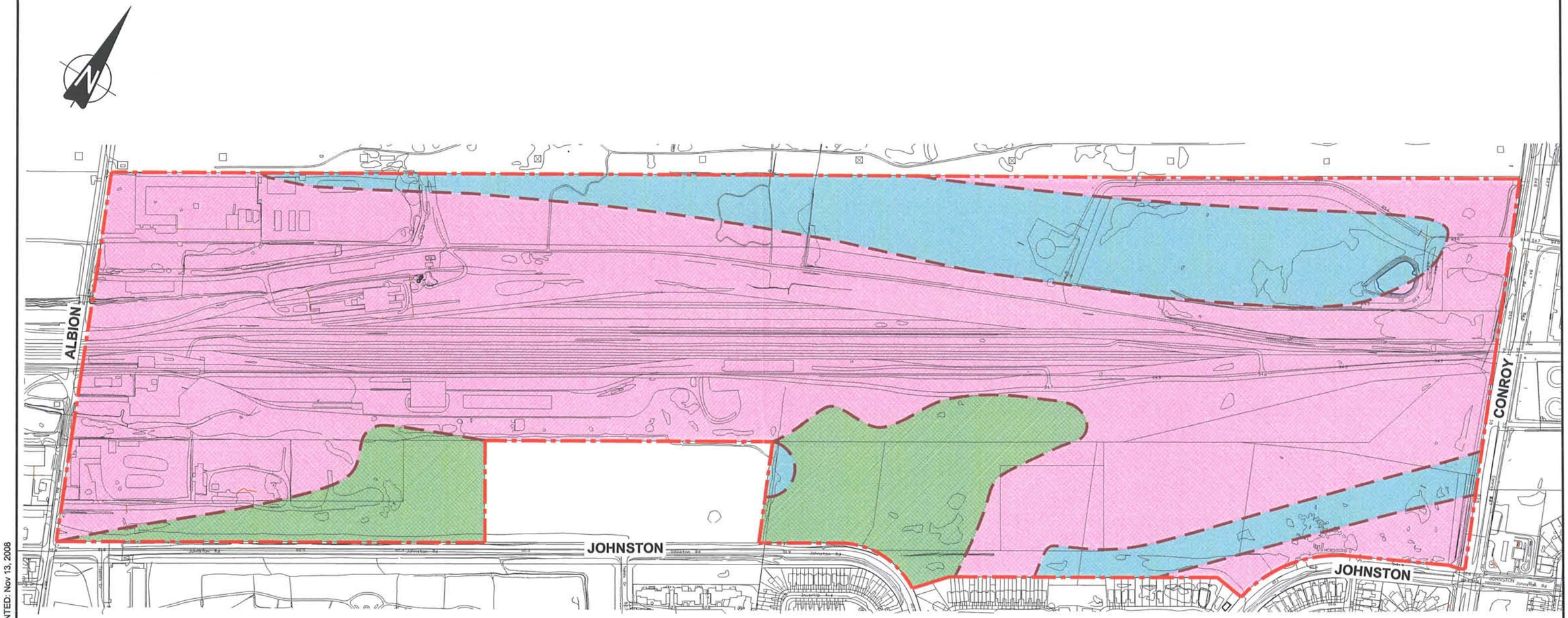

LEGEND:

- STUDY AREA
- PEAT OVER CLAY
- SAND OVER CLAY
- CLAY

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Reference: BASEPLAN PROVIDED BY CITY OF OTTAWA FILENAME: 12714.DWG	**Job No.:** 1042983 **Scale:** 1 : 6000 **Date:** 08/11/13 **Dwn. By:** GBB **App'd By:** TDV.	**Client:** CITY OF OTTAWA **Site Address** JOHNSTON ROAD FROM ALBION ROAD TO CONROY ROAD, OTTAWA, ONTARIO	JOHNSTON ROAD LAND USE STUDY	SURFICIAL SOIL TYPE	**Dwg. No.:** 2

Jacques Whitford

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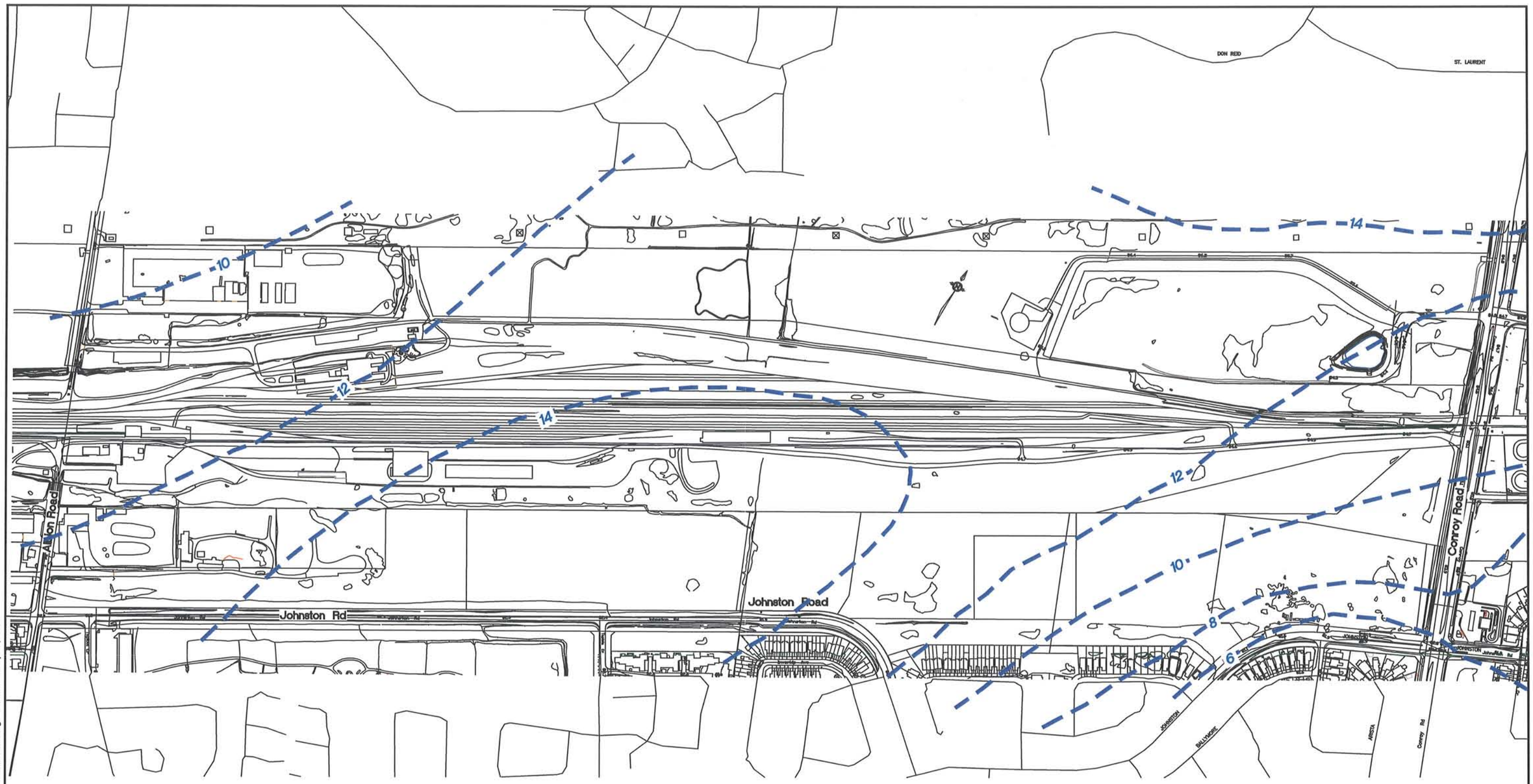

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— — 9.1 CONTOUR OF APPROXIMATE DEPTH TO BEDROCK IN METERS

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Jacques Whitford

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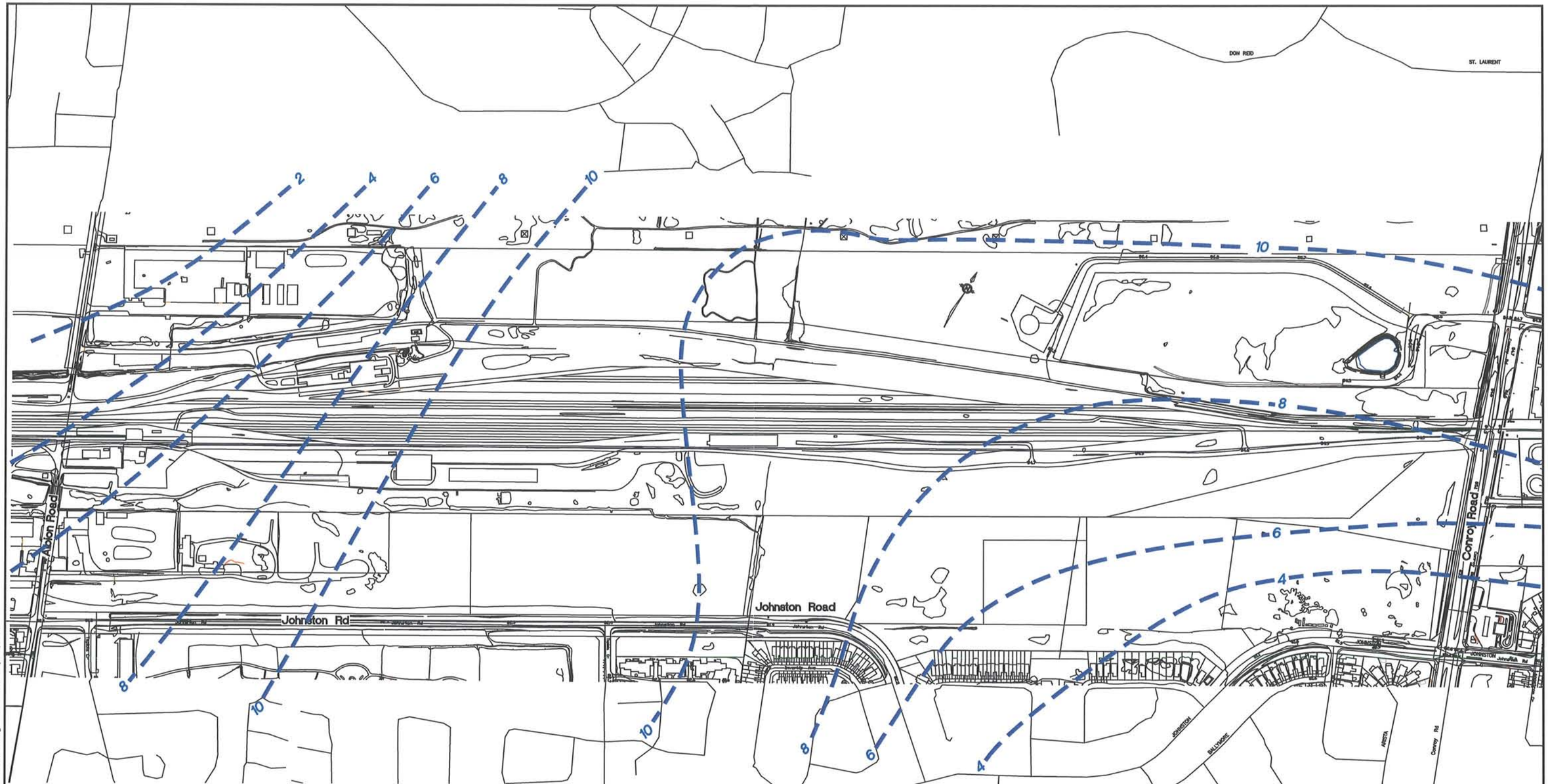

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10 — CONTOUR OF APPROXIMATE DEPTH TO TOP OF GLACIAL TILL IN METERS

Reference: BASEPLAN PROVIDED BY CITY OF OTTAWA FILENAME: 12714.DWG	**Job No.:** 1042983 **Scale:** 1 : 6000 **Date:** 08/09/19 **Dwn. By:** GBB **App'd By:** TDS	**Client:** CITY OF OTTAWA **Site Address** JOHNSTON ROAD FROM ALBION ROAD TO CONROY ROAD, OTTAWA, ONTARIO	JOHNSTON ROAD LAND USE STUDY	DEPTH TO TOP OF GLACIAL TILL	**Dwg. No.:** 4

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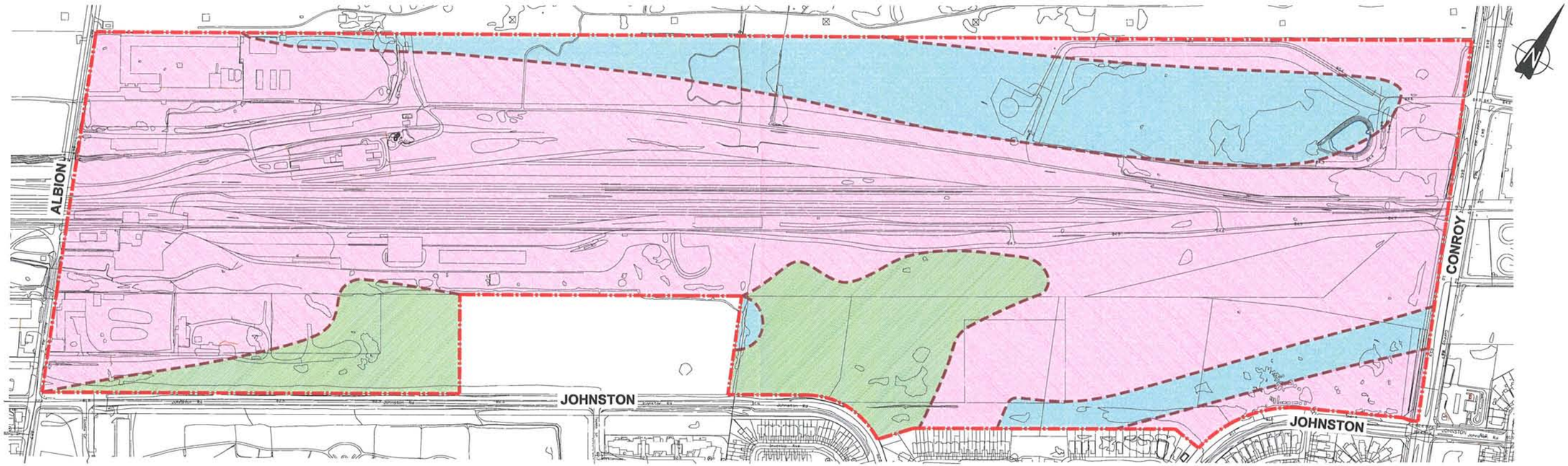
APPENDIX C

Surficial Soil Type Plan
Development Option A
Development Option B
Development Option C
Geotechnical Criteria Evaluation Table
Proposed Concept Plan

Geotechnical Constraints		
Scenario	**Foundations**	**Grade Changes**
Residential	Peat areas likely require special design	Restricted
Light Commercial	Peat areas likely require deep foundations Special designs likely required for remainder of study area	Restricted
Heavy Buildings	Deep foundations likely required	Restricted

Contraintes géotechniques		
Scénario	**Fondations**	**Changements de niveau du terrain**
Résidentiel	Les zones de tourbe exigent probablement une conception spéciale	Restreint
Commercial léger	Les zones de tourbe exigent probablement des fondations profondes Des conceptions spéciales seront probablement nécessaires pour le reste de la zone d'étude	Restreint
Bâtiments lourds	Des fondations profondes seront probablement nécessaires	Restreint



Legend:

- Study Area
- Peat Over Clay
- Sand Over Clay
- Clay

Légende:

- Zone d'étude
- Tourbe sur argile
- Sable sur argile
- Argile

JOHNSTON ROAD LAND USE STUDY
Étude sur l'utilisation des terrains du chemin Johnston

SURFICIAL SOIL TYPE
TYPE DE SOL SUPERFICIEL

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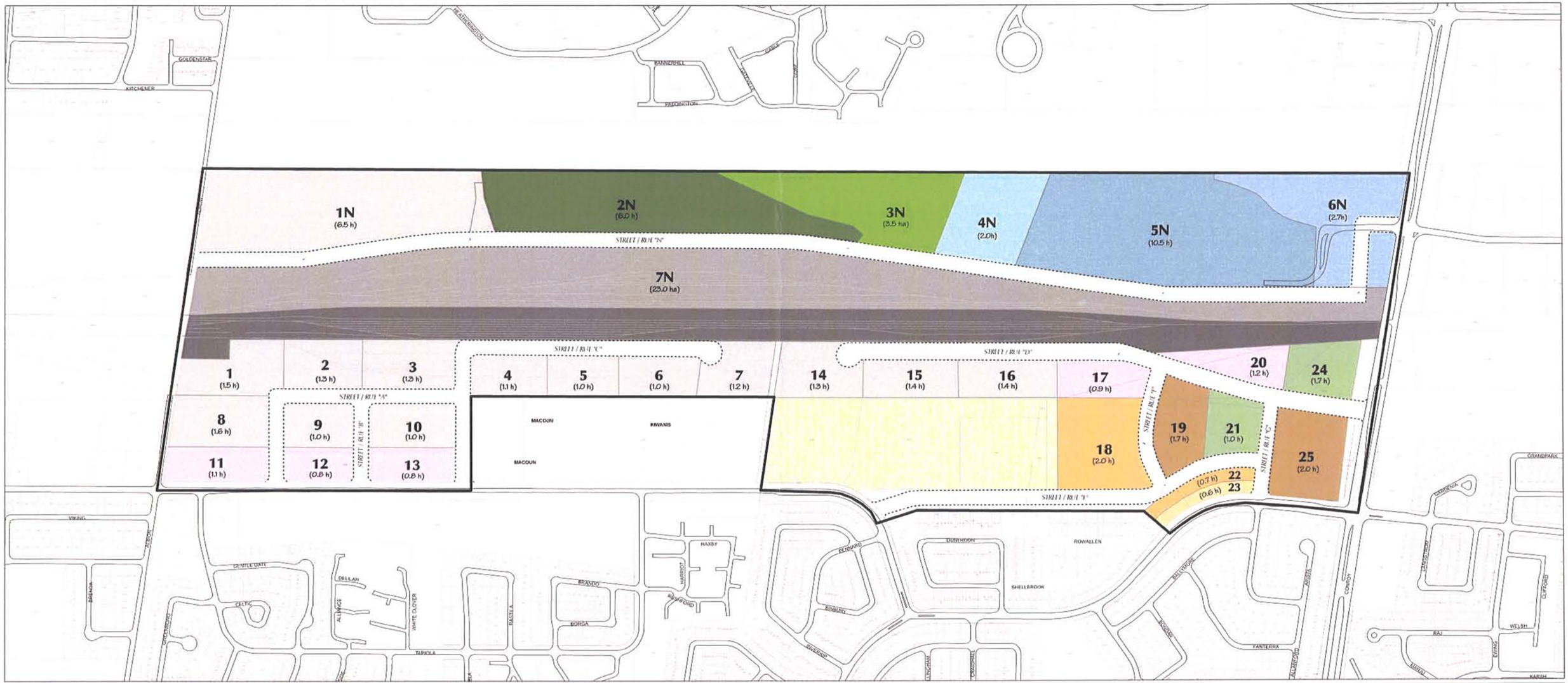
DME GENIVAR Jacques Whitford



JOHNSTON ROAD LAND USE STUDY
ÉTUDE SUR L'UTILISATION DU SOL DU CHEMIN JOHNSTON
Option "A"

- Light Industrial Use / Utilization d'industrie légère
- Industrial Use / Utilization d'industrie
- Heavy Industrial Use / Utilization d'industrie lourde
- Conroy Woods
- Open Space / Espace vert
- Elevated Water Tank / Réservoir surélevé
- Snow Disposal Facility / Dépôt de neige
- City Works Yard / Cour des Travaux publics
- Townhouse / Habitation multifamiliale contiguë
- Stacked Townhouse / Habitation superposée
- Apartments / Immeuble d'appartements
- Office / Bureau
- Park / Parc
- GreenboroTurtlehead Nature Area / L'espace naturel Greenboro Turtlehead
- Study Area Boundary / Limites de l'étude

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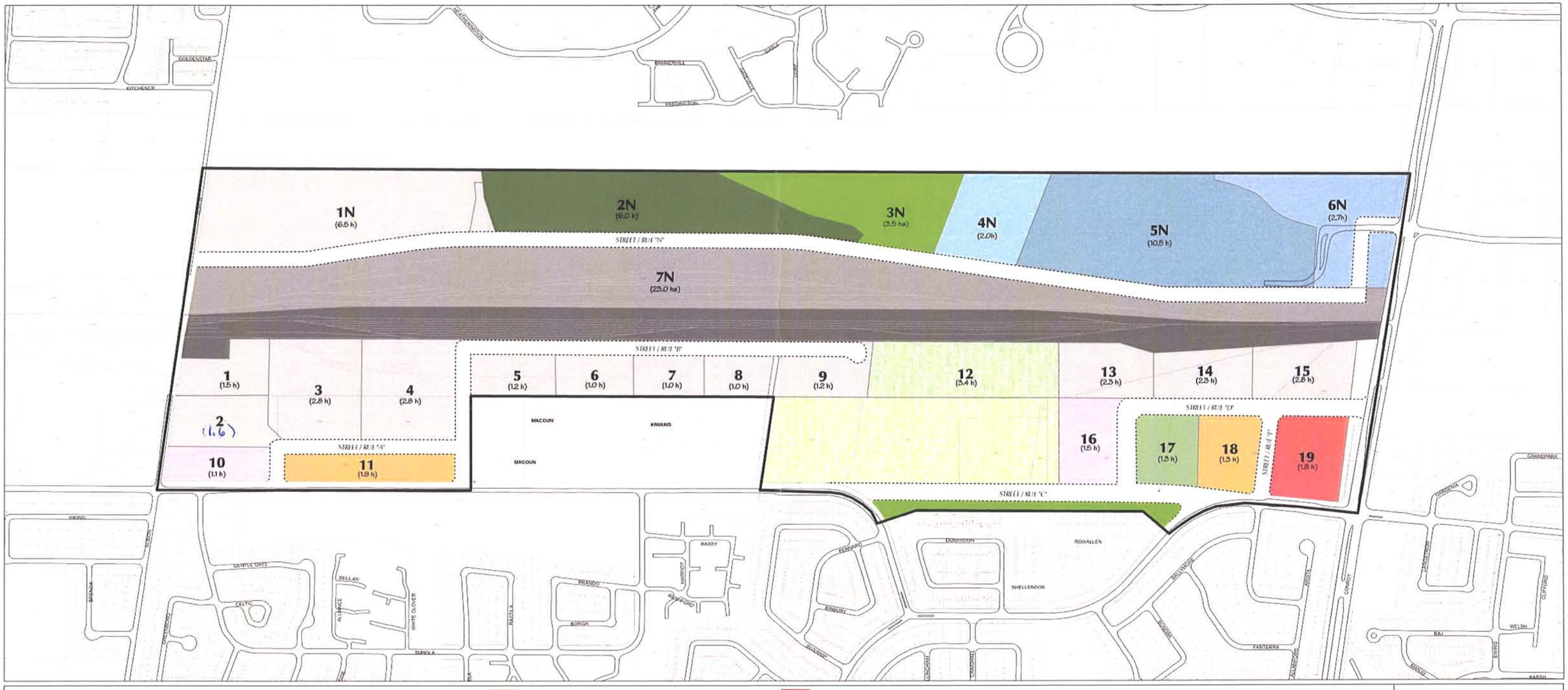

JOHNSTON ROAD LAND USE STUDY
ÉTUDE SUR L'UTILISATION DU SOL DU CHEMIN JOHNSTON
Option "B"

- Light Industrial Use / Utilization d'industrie légère
- Industrial Use / Utilization d'industrie
- Heavy Industrial Use / Utilization d'industrie lourde
- Conroy Woods
- Open Space / Espace vert
- Elevated Water Tank / Réservoir surélevé
- Snow Disposal Facility / Dépôt de neige
- City Works Yard / Cour des Travaux publics
- Commercial / Commercial
- Stacked Townhouse / Habitation superposée
- Office / Bureau
- Park / Parc
- GreenboroTurtlehead Nature Area / L'espace naturel Greenboro Turtlehead
- Greenboro Turtlehead Nature Area Expansion / Prolongement de l'espace naturel Greenboro Turtlehead
- Study Area Boundary / Limites de l'étude

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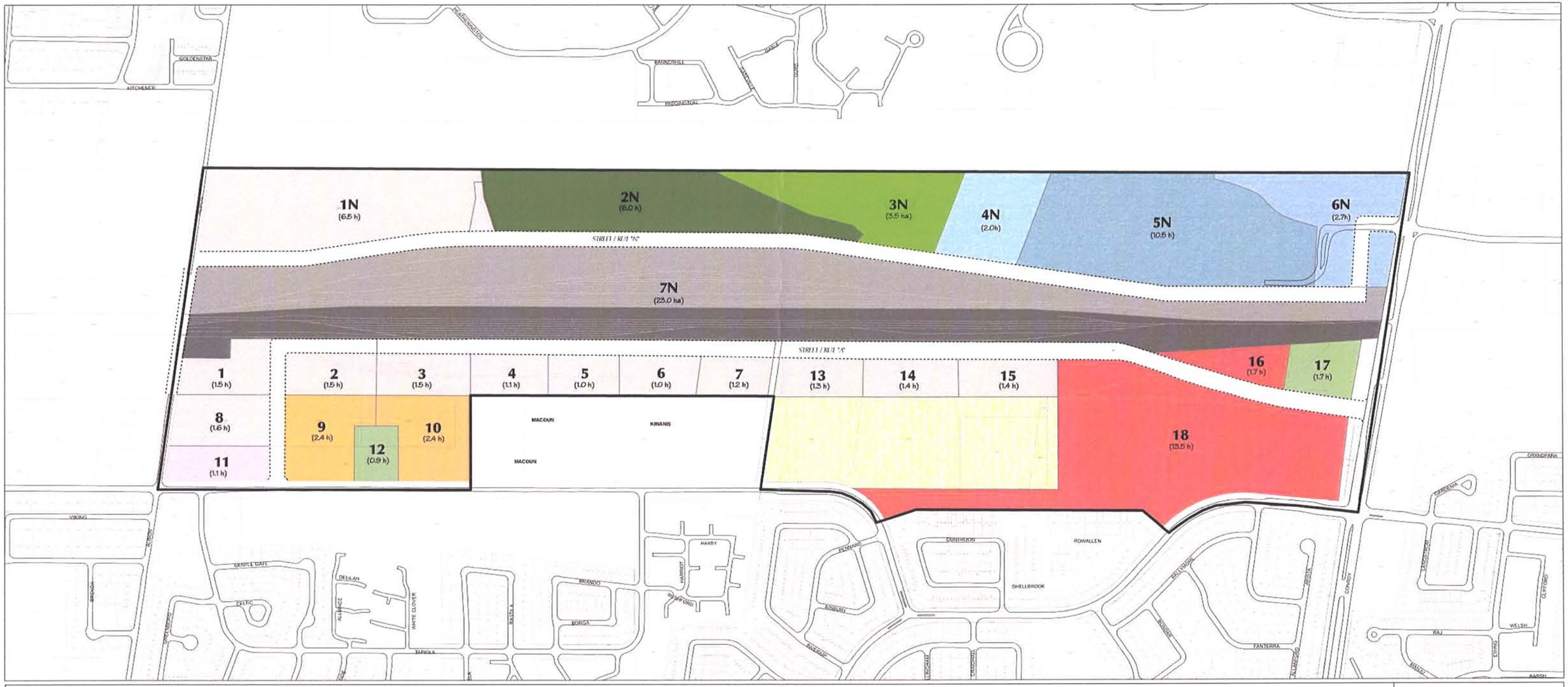

JOHNSTON ROAD LAND USE STUDY
ÉTUDE SUR L'UTILISATION DU SOL DU CHEMIN JOHNSTON
Option "C"

- Light Industrial Use / Utilization d'industrie légère
- Industrial Use / Utilization d'industrie
- Heavy Industrial Use / Utilization d'industrie lourde
- Conroy Woods
- Open Space / Eepace vert
- Elevated Water Tank / Réservoir surélevé
- Snow Disposal Facility / Dépôt de neige
- City Works Yard / Cour des Travaux publics
- Stacked Townhouse / Habitation superposée
- Office / Bureua
- Park / Parc
- GreenboroTurtlehead Nature Area / L'espace naturel Greenboro Turtlehead
- Commercial / Commercial
- Study Area Boundary / Limites de l'étude

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GEOTECHNICAL CRITERIA EVALUATION

GROUNDWATER Potential for infiltration from surface, based on percentage of area with soft surfaces.								
ID #	**Land Use**	**Option A**	**Option B**	**Option C**	**Do Nothing**	**Parcels**	**% Overall Land Area**	**Special Notes**
1	Conroy Woods	6.0	6.0	6.0		2N		
2	Open Space	3.5	4.2*	3.5		3N		*includes strip of land south of Street C
3	Townhouse	0.6	0.0	0.0		A: 23		
4	Stacked Townhouse	2.7	3.2	4.8		A: 18 & 22 B: 11 & 18 C: 9 & 10		
5	Park	2.7	1.3	2.6		A: 21 & 24 B: 17 C: 12 & 17		
6	Water Tank	2.0	2.0	2.0		4N		
7	Snow Disposal	10.5	10.5	10.5		5N		
	Total	28.0	27.2	29.4				Hectares
		23.8 %	23.1 %	25.0%	>50%			Percentage of total area of 117.6 ha
	OVERALL SCORE	M	L	M	H			
	"Do nothing" provides most opportunity for surface infiltration. Option C has next most opportunity.							

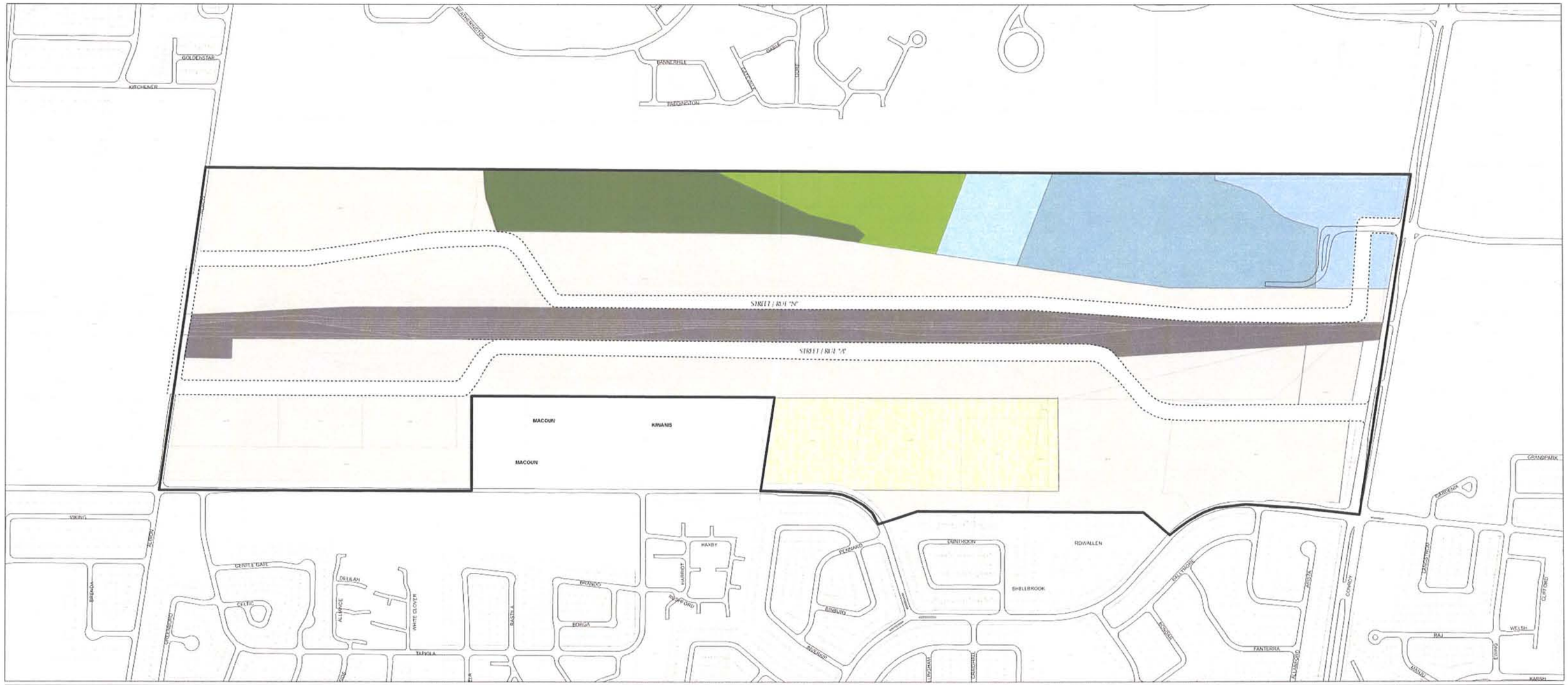
GEOTECHNICAL CRITERIA EVALUATION

GROUNDWATER: Potential to maintain water levels in areas of below grade facilities, based on length of new roadways and anticipated below grade parking.								
ID #	**Item**	**Option A**	**Option B**	**Option C**	**Do Nothing**	**Parcels**		**Special Notes**
1	Length of new roadways	5.5 km	4.8 km	4.3 km	0			
2	Area of apartment buildings	44 ha	0	0	0	A: 19 & 25		
3								
4								
5								
6								
7								
8								
	OVERALL SCORE	L	M	M	H			
	"Do nothing" provides most potential to maintain water levels in areas of below grade facilities. Option C has next most opportunity.							

GEOTECHNICAL CRITERIA EVALUATION

SOILS: Need for more than conventional foundations/floor slab designs in buildings, based on building type and anticipated soil conditions.								
ID #	**Item**	**Option A**	**Option B**	**Option C**	**Do Nothing**	**Parcels**		**Special Notes**
1	Light industrial	22.6 ha	28.0 ha	21.0 ha				Special designs may be required throughout study area
2	Industrial	23.0 ha	23.0 ha	23.0 ha				Special designs may be required throughout study area
3	Heavy Industrial	11.1 ha	11.1 ha	11.1 ha				Special designs may be required throughout study area
4	Townhouse	0	0	0				Special designs may be required in peat areas.
5	Stacked Townhouse	2.7 ha	3.2 ha	4.8 ha				Special designs may be required throughout study area
6	Apartments	3.7 ha	0	0				Special designs may be required throughout study area
7	Office	4.8 ha	2.6 ha	1.1 ha				Special designs may be required throughout study area
8	Commerical	0	1.8 ha	15.2 ha				
		67.9 ha	69.7 ha	76.2 ha	0			
	OVERALL SCORE	M	M	H	L			
	"Do nothing" provides least area with special building designs. Option A has next least area.							

Special designs could include
Townhouses: raft foundations may be required in peat areas, grade restrictions
Light Commercial: deep foundations, raft foundations, grade restrictions
Heavy Buildings: deep foundations, structural floor slabs, grade restrictions



JOHNSTON ROAD LAND USE STUDY
ÉTUDE SUR L'UTILISATION DU SOL DU CHEMIN JOHNSTON

Proposed Concept Plan

- Light Industrial Use / Utilization d'industrie légère
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