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Geology, Hydrogeology and Geotechnical Report
Capital Region Resource Recovery Centre

REPORT

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Executive Summary

This report summarizes the results of the subsurface investigation, hydrogeological assessment and geotechnical assessment of the Capital Region Resource Recovery Centre Site (Site) to provide an evaluation of the use of the Site for the proposed diversion facilities and associated landfill for disposal of residual wastes. The Site is located on the east side of Boundary Road, just southeast of the Highway 417/Boundary Road interchange, on Lots 22 through 25, Concession XI, in the former Township of Cumberland (now part of the City of Ottawa). The property is east of an existing industrial park, north of Devine Road and west of Frontier Road and totals approximately 192 hectares (475 acres) in area.

A subsurface investigation was completed to characterize the overburden and bedrock beneath the Site, and to gather the necessary data to complete the required hydrogeological and geotechnical assessments. The field program involved the drilling of at least one, and as many as seven, boreholes at 25 investigation locations across the Site. The activities undertaken as part of the subsurface investigation included the following:

- Cone Penetration Testing at all 25 investigation locations;
- Deep borehole drilling program at seven investigation locations and a shallow borehole drilling program at 18 investigation locations;
- Detailed geological logging of continuous (direct push) overburden and bedrock samples collected during the borehole drilling program;
- Geotechnical laboratory testing on selected samples collected during the borehole drilling program;
- Installation of 66 monitoring wells within selected on-Site boreholes to allow for the measurement of groundwater levels, horizontal hydraulic conductivity testing, and to allow for the collection of groundwater samples;
- Groundwater level monitoring program to provide information on hydraulic gradients and the groundwater flow direction(s) at the Site;
- A groundwater and surface water sampling program to establish background water quality in the vicinity of the Site; and,
- Vertical seismic profile data was collected at two locations to calculate a detailed vertical seismic velocity profile of the subsurface at the Site.

Based on the results of the subsurface investigation, the subsurface conditions across the Site consist of about 0.05 to 0.3 metres of topsoil/peat underlain by about 0.3 to 2.7 metres of surficial sand and silt, overlying between about 26 to 37 metres of silty clay. The upper 0.1 to 1.3 metres of the clay deposit at most locations has been weathered to a red brown crust and has a stiff consistency. Within the upper portion of the underlying unweathered silty clay, at a depth of about 4 to 6 metres below ground surface, a 0.1-metre to 0.6-metre thick continuous silty layer was identified in all boreholes completed at the Site. The unweathered silty clay generally has a soft consistency to about 9 to 10 metres depth, followed by a firm consistency to about 15 to 18 metres depth, and is stiff to very stiff below that. The silty clay is underlain by loose to very dense glacial till that ranges from about 2 to 9 metres in thickness. The bedrock surface (Carlsbad Formation limestone and shale) was encountered beneath the glacial till deposit at depths between about 33 and 41 metres.

Laboratory permeability tests were conducted on three Shelby tube samples to provide information on the vertical hydraulic conductivity of the silty clay at the Site. The laboratory results of the hydraulic conductivity testing indicate the silty clay at the Site has a consistently low permeability at the various depths sampled (i.e., less than 1 x 10^{-9} metres per second). Assuming the silty clay has a horizontal to vertical anisotropy of 10:1, the horizontal hydraulic conductivity of the formation ranges from 7 x 10^{-9} m/sec to 2 x 10^{-8} m/sec (low permeability).

Based on the results of the *in-situ* hydraulic conductivity testing completed at the Site, the following ranges in horizontal hydraulic conductivities were observed in the following overburden and upper bedrock formations:

- Surficial silty sand: 9 x 10^{-8} m/sec to 2 x 10^{-5} m/sec (moderate hydraulic conductivity);
- Silty layer within shallow clay: 3 x 10^{-8} m/sec to 3 x 10^{-6} m/sec (moderate hydraulic conductivity);
- Glacial till: 8 x 10^{-9} m/sec to 2 x 10^{-4} m/sec (variably low to high hydraulic conductivity); and,
- Upper bedrock: 2 x 10^{-8} m/sec to 2 x 10^{-5} m/sec (low to moderate hydraulic conductivity).

The average horizontal gradients for the formations monitored at the Site are very low and ranged between 0.0006 and 0.0008, and the range in average linear groundwater velocity for the formations were: <0.01 to 1.8 metres per year for the surficial silty sand, <0.01 to 0.2 metres per year in the shallow clay with silty layer, <0.01 metres per year in the silty clay, <0.01 to 9 metres per year in the glacial till, and <0.01 to 4.4 metres per year in the upper bedrock zone.

Within the vicinity of the Site, the shallow groundwater flow within the surficial silty sand layer is influenced by local topography and the position of local surface water features, and is interpreted to be primarily horizontal. Within the marine clay deposits (at surface and at depth), there is minimal groundwater flow, and the groundwater flow direction is typically vertical. Based on the groundwater levels measured at the Site, the interpreted groundwater flow direction within the surficial silty sand, silty layer in the silty clay, silty clay, glacial till and upper bedrock zone is consistently towards the east or northeast. Based on the monthly and daily groundwater elevation data collected at the Site, vertical gradients are typically downward (recharge conditions) or absent between the surficial silty sand, the silty layer, silty clay, glacial till and upper bedrock formations at most monitoring locations.

Most residents/businesses in the vicinity of the Site use shallow dug wells to provide their water supply. Based on the results of a dug well assessment and testing program completed at two dug wells on the Site it was shown that: the dug wells obtain water primarily from the surficial silty sand layer; they are recharged locally (i.e., from silty sand close to the well); they can sustain a pumping rate of approximately four Litres per minute; and, under typical use, dug wells have a very localized radius of influence of less than 10 metres.

A groundwater and surface water quality monitoring program was undertaken to establish background water quality in the vicinity of the Site. Three rounds of samples were taken from monitoring wells completed in the overburden formations and upper bedrock at the Site. Groundwater samples were also collected from three dug wells in the vicinity of the Site. Based on the available information, groundwater quality at the Site varies from fresh to brackish and deteriorates with depth. The results of the water supply (dug wells) sampling program indicates that most parameters analyzed met their respective Ontario Drinking Water Quality Standards.

The surface water sampling program involved monitoring water quality from a total of nine surface water locations. Six of the surface water locations are situated within the Site, and three surface water stations are located east and downgradient of the Site. The surface water monitoring program included up to five sampling events completed on a seasonal basis between December 2012 and December 2013. The results of the background surface water quality sampling indicate that dissolved oxygen, total phosphorus and iron were the parameters found to typically exceed their respective Provincial Water Quality Objectives.

Structurally, the Site is located near the southeast end of the Ottawa-Bonnechere graben. The Ottawa-Bonnechere graben extends for approximately 700 kilometres into the Canadian Shield from the Sutton Mountains salient of the central Appalachian orogeny. The graben extends eastward beneath the Appalachian thrust sheets for approximately 30 kilometres. The Ottawa-Bonnechere graben is within the larger Western Quebec Seismic Zone.

The results of the geological evaluation have confirmed that the primary fault feature within the Local Study area is the Gloucester and Russell-Rigaud Fault system. The Gloucester Fault is comprised of a series of normal fault slices locally projected to occur within a zone approximately 0.75 kilometres in width where it passes beneath the community of Russell. The combined vertical offset associated with this fault zone is approximately 500 metres downward on the north side, which can be seen by the projected offset of the Oxford/March Formations across the fault zone. Small scale secondary faults associated with offsets in the range of several metres to several tens of metres are comparatively common throughout the Ottawa Valley, occurring within the intervening areas between primary faults.

An assessment of the potential for fault rupture at the Site was undertaken. Fault rupture at the ground surface is a potential geological hazard because the surface fault rupture causes localized differential displacements that can adversely affect engineered structures and facilities. A key layer for the evaluation of the potential for past surface fault rupture at this Site is the 0.1-metre to 0.6-metre thick silty layer about 4 to 6 metres below ground surface. This marker bed within the upper part of the silty clay deposit is sub-horizontal and reasonably interpreted to be continuous across the Site. The largely consistent elevation and lateral continuity indicates that this layer has not been offset in any significant way by vertical fault displacements at the CRRRC Site. It was reasonably concluded that there has been no surface fault rupture at the CRRRC Site since at least the deposition of the silty layer (i.e., in the past 8,000 to 10,000 years), and that the probability of future fault movement resulting in large differential displacements at the surface or shallow subsurface at or in the vicinity of the CRRRC Site is negligible.

Using the information gathered during the subsurface investigation, a geotechnical assessment of the proposed Site design was undertaken. The assessment focused on the landfill geometry and performance. The assessment included a seismic assessment, stability analyses and settlement analyses. The seismic assessment included dynamic analyses to investigate the seismic stability of the proposed landfill configuration when subjected to strong earthquake shaking. Seismic design guidelines established for solid waste landfills in the USA require that such facilities be designed to resist ground motions with a 2,475-year return period, which has been considered for the analysis of this landfill. The results of the seismic assessment indicate the proposed landfill configuration is stable under the design seismic loading conditions.

The stability and settlement of the proposed landfill are controlled by the underlying silty clay material. The proposed design has an adequate factor of safety against slope instability. The calculated range of settlements over time, based on the combination of primary consolidation and secondary compression, indicate the total settlements under the highest portions of the landfill are expected to be in the order of 6 to 8 metres (approximately 100 years from the start of consolidation).

A hydrogeological conceptual model was developed based on the geological and hydrogeological data gathered as part of the subsurface investigation completed at the Site, as well as data available from previous work completed in the vicinity of the Site. A three-dimensional numerical groundwater flow model was constructed based on the conceptual model to provide a quantitative evaluation of hydraulic head drawdown, groundwater flow paths, groundwater seepage rates, and groundwater travel times resulting from the proposed development of the Site. Groundwater drawdown provides an indication of the extent to which the landfill could potentially affect groundwater quantity and off-Site dug well supply. Based on the modelling results, the simulated drawdown does not extend beyond the property boundary for any of the modelled scenarios, and therefore impact on the groundwater quantity (and off-Site dug well supply) outside of the property boundary is not predicted as a result of the proposed Site development.

Modelling of long-term groundwater quality impacts for new or expanding landfill sites is required under Ontario Regulation 232/98 to demonstrate that the proposed design will meet the requirements of Ministry of the Environment Guideline B-7 (Reasonable Use). Contaminant transport modelling for the proposed landfill was undertaken using POLLUTE to evaluate potential impacts on the groundwater. The results of the contaminant transport modelling indicate all parameters modelled meet the Reasonable Use performance objectives. Analyses also show that should the leachate collection system fail after 20 years beyond the mid-point of landfilling or 20 years beyond year 10 after filling commenced, the thickness and low hydraulic conductivity of the natural silty clay deposit would provide the required off-Site groundwater protection. Nevertheless, the leachate collection system while functioning will help ensure the protection of groundwater within the surficial silty sand layer by reducing leachate mounding on the proposed geosythetic clay liner (GCL) perimeter barrier. In addition, a leak detection and secondary collection system (LDSCS) will be installed within the surficial silty sand layer outside the GCL perimeter barrier. Monitoring of the LDSCS and leachate levels within the landfill will be ongoing during operations and post-closure, and determine the need for contingency measures to prevent leakage, seeps and breakouts that could potentially cause adverse impacts.

In terms of the engineering significance or potential effects of surface or subsurface displacements from potential future fault movement on the design and performance of the proposed CRRRC landfill, both the landfill mass itself and the proposed leachate containment and collection system (and its components), are very capable of withstanding significant differential displacements. There is no constructed or manufactured liner system at the base of the landfill as designed; rather, the containment of landfill leachate relies on the natural containment properties of the 30 metres of low permeability silty clay underlying the Site. The proposed leachate containment and collection system has been designed to withstand relatively large differential movements and continue to perform its intended function. For example, this containment and collection system has been designed to function when experiencing the predicted movements associated with long term consolidation of the clay deposit beneath the landfill, i.e., total settlements of 6 to 8 metres under the central portion of the landfill. The containment and collection system has also been designed to accommodate lateral displacements of up to 350 mm under seismic loading conditions. The groundwater analyses show that even if there was an early failure of the leachate collection system, then the thickness and low hydraulic conductivity of the natural silty clay deposit would provide the required off-Site groundwater protection. For these reasons, the effects of small-scale surface or subsurface displacements from fault displacement are, therefore, inconsequential for the engineering design and performance of the landfill component of the CRRRC.

A geotechnical monitoring program will be implemented for the purposes of confirming the performance/behaviour of the underlying foundation soils, and to provide information to optimize the design and/or operation of the landfill, as construction and filling progress. Groundwater, leachate and surface water monitoring programs have been proposed to monitor background water quality, leachate quality and water quality hydraulically downgradient of the landfill and other on-Site facilities. The monitoring programs have been designed to act as an early warning mechanism for detection of contaminant migration in groundwater or surface water before it reaches the Site boundaries. The proposed monitoring programs also include trigger mechanisms. The objectives of trigger mechanisms at the Site are to utilize the results of the ongoing surface water and groundwater monitoring programs to assess Site compliance and to trigger implementation of the contingency plans, if necessary.