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Hydrogeological Investigation Report
Proposed Residential Development
1842 King Street East
Hamilton, Ontario

Prepared for:

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<u>Appendices:</u>

1.0 INTRODUCTION

1.1 Background

Landtek Limited (Landtek) has been retained by New Horizon Development Group to complete a Hydrogeologic Investigation for the proposed residential development at 1842 King Street East, Hamilton Ontario (the Site or development).

The Site is rectangular in shape and comprises an area of approximately 2.7 hectares (6.63 acres). The Site is bounded by King Street East to the north follow by community property use (i.e., churches) and residential properties. Lawrence Road is located to the south of the Site followed by residential properties, to the east followed by residential properties followed by Rosedale Avenue and residential properties to the west of the Site. Further to the East past the residential properties are commercial properties. Site Location is shown on Figure 1 in Appendix A.

It is understood that the development is to comprise of four 12 Storey multiple dwellings and four, four storey stacked townhouses for a total of 1407 dwelling units with 1688 parking spaces in three levels of underground parking across the building area. Site Plan, Underground P1, Underground P2, and Underground P3 levels Plans are shown on Figures 2, 3, 4 and 5, respectively in Appendix A, as provided by GRAZIANI + CORAZZA ARCHITECTS.

The purpose of the Hydrogeological Investigation is to evaluate the groundwater conditions at the site, delineate possible development/post-development impacts, and suggest mitigation measures to minimize the effects to the shallow groundwater system during and post-development. Specifically, the report provides the following:

- A description of the hydrogeologic setting of the Site and a summary of the existing soil and groundwater conditions at the site.
- Identification of hydrogeologic features such as zones of significant groundwater recharge and discharge.
- Assess groundwater levels at the Site and determine seasonal high groundwater level.
- Assessment of the construction excavation dewatering requirement during construction, if any.
- Assess groundwater quality to compare against Sewer Use ByLaw criteria, if dewatering is required

1.2 Work Scope and Report Organization

The scope of work for this investigation includes the following:

- *Review of available background information.* A review of published works including available geologic and hydrogeologic information for the site, topographic and geologic maps and water well records. Meteorological data was also reviewed to assess the local climate.

- *Site Assessment.* A detailed visual inspection of the site and surrounding area to identify and document local topography, surface water drainage features, and the potential presence of significant hydrogeologic features such as closed depressions (areas of ground water recharge), seeps, springs, or the presence of phreatophytic vegetation.

- *A subsurface investigation.* A total of three (3) boreholes were drilled at the Site and completed as monitoring wells. The subsurface investigation of the property was done to characterize the overburden stratigraphy at the property as well as assess the site-specific groundwater conditions.

- *Hydraulic Conductivity Tests.* In-situ rising head tests in the three installed monitoring wells to assess hydraulic conductivity of the materials below the Site.

- *Groundwater Monitoring.* Groundwater level monitoring in all three monitoring wells in order to assess the depth of groundwater level across the site.

The report is organized as follows:

Section 1 contains a brief introduction to the project and the scope of work undertaken by Landtek.

Section 2 outlines the methodologies followed during completion of the desktop study and the field investigation.

Section 3 summarizes the findings of the investigation. It includes:
- a description of the physical setting
- the results of the field investigation

Section 4 provides Water Taking Evaluation and Impact Assessment

Section 5 provides Monitoring Plan.

Section 6 provides Mitigation Plan.

Section 7 provides Summary and Conclusions.

Section 8 provides recommendations.

Section 9 provides Closure.

Section 10 provides References.

Section 11 provides Limitations.

2.0 METHODOLOGY

2.1 Desktop Study

A review of published works was done of available geologic and hydrogeologic information for the site including topographic and geologic maps.

The Ministry of Environment, Conservation and Park (MECP) water well database for the local area was also accessed and the individual well record obtained for wells located within 500 m radius of the Site.

The following 2 reports completed for the Site were also reviewed:

1. Phase II Environmental Site Assessment, 1842 King Street East, Hamilton Ontario. Pinchin, April 2020.
2. Geotechnical Investigation Proposed Residential Development, 1842 King Street East, Hamilton Ontario. Landtek, November 2020.

2.2 Site Inspection to Assess Hydrogeologic Features

A detailed site inspection was conducted on August 22, 2021, to assess the presence of features which may be significant from a hydrogeologic viewpoint. In particular, the site was inspected to assess the following:

- The presence of closed drainage features, depressions, or sandy areas which may allow for ponding and significant or enhanced infiltration of water.
- Assessment of the presence of phreatophytic vegetation which may indicate seasonally high groundwater levels and/or groundwater discharge and seepage.
- Identification of any zones of visible seepage or groundwater discharge.

2.3 Field Investigation

2.3.1 Drilling and Well Installation

This site investigation was based on the following two (2) existing investigations completd at the Site.

<u>Phase II Environmental Site Assessment, PINCHIN. April 2020.</u>

Four (4) boreholes (BH01, BH02, BH03 and BH04) were drilled at 4 locations to a maximum depth of 9.14 mbgs, and BH01, BH02, BH03 completed as monitoring wells MW01, MW02, and MW03, respectively. The locations of the boreholes are shown on Figure 6 and a description of the subsurface stratigraphy encountered during the drilling program is documented in the borehole logs included in Appendix B-1.

The soil stratigraphy at the drilling locations below the grass at MW01 and MW02 consisted of sand and gravel until sampler refusal on inferred bedrock between 5.18 and 5.49 mbgs. The soil stratigraphy at the drilling locations below the asphalt at MW03 and BH04 generally consisted of fill material comprised of sand and gravel and a presumed concrete pad at approximately 3.35

and 3.51 mbgs. Native subsurface material underlying the fill material at MW03 was observed to generally consist of silt that extended to the maximum borehole completion depth of 9.14 mbgs. Wet soil conditions were not observed within the depths of the investigation.

Geotechnical Investigation. Landtek, November 2020.

Fieldwork undertaken by Landtek at the site included clearance of underground services, borehole layout, borehole drilling and soil sampling, and field supervision. A total of 10 boreholes were drilled between August 17 and 19, 2020. The Borehole Location Plan is shown on Figure 7 in Appendix A, and associated borehole logs are provided in Appendix B-2.

Boreholes BH2, BH4 and BH7 were completed as monitoring wells to monitor groundwater levels to target the anticipated excavation depths to be carried out during site development, and were subsequently renamed MW2, MW4 and MW7 respectively. The monitoring wells were constructed using new, 50 mm poly-vinyl chloride (PVC) screen with No.10 slots threaded onto a matching riser. The screens and risers were pre-threaded including o-ring seals such that no glues or solvents were used to connect the pipe sections. The annular space between the PVC well and the borehole was backfilled to approximately 0.3 m above the top of the screen section with sand pack, and then with bentonite to existing ground level. A J-Plug lockable air-tight cap was installed on the riser. The borehole logs in Appendix B-2 present the monitoring well installation details.

Borehole locations were established by Landtek using measurements and offsets relative to existing, permanent site structures and centerline chainages.

A summary of the monitoring well installation details is presented below in Table 1. The monitoring wells' locations are shown on Figures 6 and 7 in Appendix A.

Table 1. Construction Details (Landtek. November 2020)

Monitoring Well ID	Easting* (NAD83)	Northing* (NAD83)	Ground Surface Elevation (masl)**	Stick-up (m)	Well Depth (mbgs)	Screened Interval	Screened Material
PINCHIN – April 2020							
MWW01	NA	NA	NA	Flush Mount	4.85	1.85-4.85	Sand & Gravel
MW02	NA	NA	NA	Flush Mount	4.60	1.60-4.60	Sand & Gravel
MW03	NA	NA	NA	Flush Mount	9.14	6.14-9.14	Silt
LANDTEK – November 2020							
MW2	596666	4787253	105.8	0.66	15.6	12.6-15.6	Silty Clay
MW4	596765	4787209	105.8	0.78	11.1	8.1-11.1	Silty Clay
MW7	596712	4787152	103.6	1.15	12.6	9.6-12.6	Silty Clay

Notes:
[*] Values are approximate by GPS +/- 4 m
masl = meters above sea level
m = meters
[**] The approximate geodetic elevations reference the Phase Two Environmental Site Assessment completed by Landtek Limited dated December 2020.

2.3.2 Monitoring Well Development and Sampling

Well Development: Each of the installed monitoring wells (MW2, MW4, and MW7) was developed to remove any sediment that may have been introduced during installation and to improve the hydraulic properties of the formation against which the wells were screened. This work was completed by Landtek staff on August 24, 2020. Development employed electric well pump/waterra tubing with foot valves and each well was developed until a visible decrease in turbidity was observed.

Groundwater Sampling

City of Hamilton Storm Sewer Discharge Analysis

Groundwater quality sampling to compare against Sewer Use Bylaw criteria will be completed as this hydrogeological investigation has determined that construction dewatering is required at the Site.

2.3.3 Hydraulic Conductivity Testing

Hydraulic conductivity test was completed in the following three monitoring wells (MW2, MW4, and MW7), installed by Landtek in November 2020, to provide estimates of the hydraulic conductivity for the zones against which the screens for the wells were set. Rising head tests were conducted by Landtek on September 22, 2021. The tests involved the extraction of a known volume to displace the water level. A datalogger programed at 2 second interval was used to record the water level response during the tests.

Data Analysis: The rising head test data were analyzed using AqteSolve Professional Version 4.5 software package developed by Glenn M. Duffield of HydroSOLVE Inc. applying the Hvorslev analysis solutions, depending on hydrogeology

3.0 FINDINGS

3.1 Topography, Drainage and Hydrology

The approximate Geodetic elevation of the ground surface at the site ranges between approximately 104 m and 105 m. The topography of the area slopes gently from the southwest area to the northeast. The Site is located in the Hamilton Region Source Protection Area in a Highly Vulnerable Aquifer Area with Score of 6; and it is not located in a regulated watercourse or wetland designated area by the Hamilton Conservation Authority (HCA, 2021).

3.2 Regional Physiography

The site is located within the physiographic region known as the Iroquois Plain, which lies between the foot of the Niagara Escarpment and Lake Ontario (Chapman and Putnam, 1984; Chapman and Putnam, 2007). This Region resulted from inundation of the area in the late Pleistocene by glacial Lake Iroquois. The Iroquois Plain consists of lacustrine deposits and lake-bottom sediments that have been smoothed by wave action and extends around the western end of Lake Ontario. The width of the Plain in the Winona area is approximately 2.5 km. The plain is cut by a number of creeks between Lake Ontario and the Niagara Escarpment (City of Hamilton, 2010).

3.3 Climate

The site is located in the Mixedwood Plains ecozone of Ontario (Natural Resources Canada, 2012). The general climate data presented below in Table 2 was obtained from Environment Canada publications and from the Environment Canada online database. Average climate data was taken from the Hamilton A station (Hamilton Airport) for the period of 1981 to 2010.

Table 2. 1981 to 2010 Climate Normals for Hamilton A Station (as averages)

	Daily Average Temperature (°C)	Average Rainfall (mm)	Average Snowfall (cm)	Average Precipitation (mm)
January	-5.5	29.7	40.8	64.0
February	-4.6	28.2	35.1	57.8
March	-0.1	42.6	26.5	68.4
April	6.7	71.3	8.4	79.1
May	12.8	78.7	0.5	79.4
June	18.3	84.9	0.0	84.9
July	20.9	100.7	0.0	100.7
August	20.0	79.2	0.0	79.2
September	15.8	81.9	0.0	81.9
October	9.3	76.5	0.7	77.4
November	3.7	74.4	11.0	84.3
December	-2.3	43.8	33.5	73.0
Year	7.9	791.7	156.5	929.8

3.4 Regional Geology

The City of Hamilton is underlain by clastic and carbonate sedimentary rocks of Late Ordovician to Middle Silurian age, which make up parts of three major depositional sequences (Johnson et al., 1992). The oldest bedrock unit outcropping in the area, the Queenston Formation, is predominantly dark red, fissile, hematitic, calcareous shale (Liberty et al., 1976).

The Queenston Formation is found north of the Niagara Escarpment and consists in many places of up to 4 feet (1.2 m) of very weathered bedrock (red clay) which grades downward into typical brick-red shale. The Queenston shale is overlain by Halton Till in the area of the site.

The Late Wisconsinan Halton Till is a clay to clayey silt till and is exposed in the form of a till plain from Lake Ontario southward to the Niagara Escarpment. It is the youngest glacial unit in the region and has been found to be relatively thick (up to 30 m) in the buried bedrock valley between Grimsby and Grimsby Beach. The basal part of the till is red, relatively coarser textured, and consists almost entirely of Queenston shale. Proglacial Lake Iroquois clay, silt and sand is mapped as overlying the Queenston shale in the southern portion of the site. The lake terrace is mainly underlain by Queenston shale and Halton Till although a sheet of predominantly fine sand was deposited along the shoreline and is relatively thicker (up to 4.5 m) in the vicinity of Grimsby (Feenstra, 1974).

3.5 Regional and Local Hydrogeology

Regional hydrogeology conditions were assessed on the basis of local water well records and available ground investigation reports for the area.

The hydrostratigraphy (i.e., the vertical sequence and horizontal extent of aquifers and aquitards) in the overburden and bedrock generally follows the geologic layering. At the Site, coarse-textured glaciolacustrine deposits overlie till. Regionally, till formations in the overburden act as aquitards while the sandier units generally behave as aquifers. Shale generally acts as an aquitard with an upper weathered bedrock aquifer layer (City of Hamilton, 2010).

The till has low infiltration potential due to the composition of the clay and density of the till. The groundwater recharge potential is classified as moderate to low in the area.

3.6 MECP Water Well Records and Groundwater Resources

The site is located in the Halmilton Region Source Protection Area in a Highly Vulnerable Area with a Score of 6.0. The source water protection details for the site were referenced from the Ministry of the Environment and Climate Change (MECP) website on Source Water Protection for the Province of Ontario (MECP, 2021).

According to the Karst Map of Southern Ontario, the Site is not located in a potential Karst area – areas of carbonate rock units identified as most susceptible to karst processes (Ontario Geological Survey).

The Ministry of Environment, Conservation and Park (MECP) Water Well Information System is a publicly available database which contains information such as groundwater well location, well construction details, static water level, geologic units encountered with depth, general water quality observations, water use, date of construction, and screened interval.

The MECP records for wells located within approximately 500 meters of the site were reviewed to assess the general nature and use of the groundwater resource in the area and to characterize local hydrogeologic conditions.

Desk Top Study

A search of the MECP water well records within approximately 500 m of the site, conducted on September 8, 2021, returned a total of 20 wells comprising of six (6) observation wells, one (1) (1) test holes/monitoring well, seven (7) abandoned wells; and six (6) wells without information.

The records were reviewed to assess the general nature of the groundwater resource in the area and to characterize local hydrogeologic conditions. The locations of the MECP wells are shown on Figure 8 in Appendix A. The summary of the well records is provided in Appendix C.

A summary of the data obtained from the well survey is presented on the following page.

Well Construction

- Wells terminated in bedrock 1
- Wells terminated in overburden 3
- Well without information (assumed to be overburden) 16
- **Total..20**

Well Uses

- Observation Wells 6
- Test Hole/Monitoring Well 1
- Abandoned Wells 7
- No Information..6
- **Total..20**

Well Depth

- Less than 15 m 7
- No Data..13
- **Total..20**

Based on the well records, it was determined that there are no water wells within 500 m radius of the Site.

3.7 Results of Site Inspection

A detailed site inspection was conducted on August 26, 2021, to assess the presence of features which may be significant from a hydrogeologic viewpoint.

The Site was found to be a predominantly flat and is currently the location of the Brock University Hamilton Campus and comprises of a one-storey brick-built structure situated centrally to the site. An asphalt parking lot is located in the west of the site, with the remainder covered pedestrian walkways and maintained landscaping.

Presence of significant hydrogeologic features such as closed depressions (areas of ground water recharge), seeps, springs, or the presence of phreatophytic vegetation were not observed during the inspection.

3.8 Results of Subsurface Investigation

The native soils comprising of a laterally variable sequence of sands, sand and gravel deposits and silts and clays overlying silty clay till. Bedrock was not encountered.

The detailed borehole logs are presented in Appendixes B-1 and B-2, with the subsurface conditions encountered by the boreholes drilled by Landtek in November 2020 discussed further in the following sections.

Existing Pavement Structure

Boreholes BH5, BH6, BH8 and BH10 were drilled in the existing pavement structures at the site, with asphalt thicknesses of approximately 50 mm to 75 mm being measured, where present. Pavement granular material was encountered either from surface or underlying pavement asphalt and consists of approximately 100 mm to 200 mm of a crushed limestone gravel product.

Organic Soil

An approximately 75 mm (borehole MW7) to 200 mm (boreholes BH1 and MW2) thick layer of organic soil was encountered from ground surface in boreholes BH1 to MW4, MW7 and BH9. The organic soil thicknesses may vary across the site, and the thickness measured at the borehole location may not be representative of the topsoil depth throughout the site.

Fill Material

Fill material was encountered in all boreholes underlying the organic soil and pavement granular material and extends to depths between approximately 0.4 m (borehole BH3) and 3.0m (borehole MW7) below existing ground level. The fill material generally comprises of silty clay (boreholes BH1 to MW4) and sand and gravel (boreholes BH5 to BH10).

Sand

Sand was encountered underlying the fill materials in all boreholes with the exception of boreholes BH1, MW2, BH3 and MW7. The sand deposits extend to depths between approximately 4.5 m (borehole MW4) and 9.1 m (borehole BH6), consist primarily of coarse-grained sand with trace silt and gravel, and are generally brown in colour.

Sand and Gravel

Sand and gravel deposits were encountered in borehole BH1 underlying a silty clay and boreholes MW2, BH3 and MW7 underlying the fill materials and extends to depths between approximately 3.0 m (borehole BH3) and 9.1 m (borehole MW2). The sand and gravel deposits include some cobbles, trace silt, and are generally brown in colour.

Silty Clay (Till)

Silty clay till was encountered in all boreholes, with the exception of boreholes BH3, BH5 and BH9, underlying the sands and gravels and extending to the maximum drill depth of approximately 15.6 m (boreholes MW2) and extends to a depth of 3.5 m below existing ground level. The silty clay till deposits contains traces of sand and gravel, red shale fragments, and is generally brown and grey in colour.

Bedrock

Bedrock was not encountered during this investigation.

<u>Groundwater</u>

During drilling, groundwater was encountered in boreholes MW2, BH6 and MW7 at depths at approximately 9.0 m below ground level. All remaining boreholes were noted to be dry. All boreholes remained open to the termination depths on completion.

It should be noted that groundwater conditions and surface water flow conditions are expected to vary according to the time of the year and seasonal precipitation levels. Water seepage is also expected from soil fissures above the water table.

3.9 Groundwater Monitoring

<u>Phase II Environmental Site Assessment, PINCHIN. April 2020.</u>

The monitoring wells were installed on March 12, 2020. Attempts were made to monitor the groundwater levels in the installed groundwater monitoring wells. However, the wells remained dry over this time period.

<u>Geotechnical Investigation. Landtek, November 2020.</u>

Depths to groundwater in all three monitoring wells installed by Landtek (MW2, MW4, and MW7) were obtained manually by Landtek staff on September 28, October 14, and December 10, 2020, and September 17 and 22, 2021. Based on the groundwater levels readings, depth to groundwater was determined to range from 9.0 mbgs to 11.10 mbgs, with the highest water level was recorded to be 9.0 mbgs at MW7 on September 17, 2021. The readings are presented below in Table 3 It should be noted that and groundwater monitoring is ongoing to determine the seasonal high groundwater level.

Based on the observation during the borehole drilling and groundwater monitoring wells installation, it appears the upper sand/gravel layer is dry and that groundwater occurrence is in the silty clay layer and not in the overlying sand/gravel layer.

Table 3. Groundwater Monitoring Data

MW ID	Date	Total Depth (mbgs)	Water Strike** (mbgs)	Water Level (mbgs)	Water Level (masl)**	Ground Elevation (masl)***
MW2*	28-Sep-20	11.00	9.0	Dry	-NA	105.8
	14-Oct-20			11.10	94.70	
	10-Dec-20			11.10	94.70	
	17-Sep-21			9.17	96.63	
	22-Sep-21			9.13	96.67	
MW4*	28-Sep-20	10.75	None	Dry	NA	105.8
	14-Oct-20			11.20	94.69	
	10-Dec-20			11.00	94.80	
	17-Sep-21			10.17	95.63	
	22-Sep-21			10.12	95.68	
MW7*	28-Sep-20	12.33	9.0	11.00	92.60	103.6
	14-Oct-20			10.10	93.50	
	10-Dec-20			9.20	94.40	
	17-Sep-21			9.00	94.60	
	22-Sep-21			8.95	94.65	

Notes:
[*] Landtek Monitoring Wells, November 2020
[**] water strike/groundwater seepage
mbgs = meters below ground surface
masl = meters above sea-level

[***] The approximate geodetic elevations reference the Phase Two Environmental Site Assessment completed by Landtek Limited dated December 2020.

3.10 Hydraulic Gradients and Flow

Vertical Hydraulic Gradient

Groundwater generally flows from the shallow to deeper aquifers as leakage across the aquitards. However, this may vary locally, and the direction of vertical flow depends on the relative heads in the different layers. Leakage rates vary locally depending on the magnitude of the vertical gradients and on the thickness and hydraulic conductivity of the confining units (City of Hamilton, 2010).

Horizontal Hydraulic Gradient

Groundwater contour diagram was generated by triangulation using groundwater level readings from monitored wells MW2, MW4 and MW7. The groundwater flow gradient on September 17, 2021, was determined to 0.022 m/m in a southeast direction. The groundwater flow contour diagram is shown on Figure 9 in Appendix A.

3.11 Estimated Hydraulic Conductivity

3.11.1 Hydraulic Conductivity Tests Analysis

The analyses were completed using the Hvorslev method (Fetter, 1994). The graphical results of the hydraulic conductivity analysis are presented in Appendix D, and the results are summarized below in Table 4.

Table 4. Hydraulic Conductivity Results

Monitoring Well	Hydraulic Conductivity (m/s)	Screened Material
MW2	3.156×10^{-7}	Silty Clay
MW4	3.575×10^{-6}	Silty Clay
MW7	6.157×10^{-7}	Silty Clay

The results indicate that the hydraulic conductivities of the screened overburden material vary within 2-order of magnitude, with a geometric mean of 8.856×10^{-7} m/s.

4.0 WATER TAKING EVALUATION & IMPACT ASSESSMENT

It is understood that the proposed development will comprise of three (3) underground levels. The Site Plan, P1 Level Plan, P2 Level Plan, and P3 Level Plan are shown on Figures 2, 3, 4 and 5 in Appendix A, as provided by **GRAZIANI CORAZZA**.

The assessment of the groundwater dewatering at the Site is therefore based on the proposed three underground levels development at the Site.

Groundwater Levels

Groundwater was observed at an approximate depth of 9.0 mbgs during the drilling activities completed at the Site and it appears groundwater only occur in the sitly clay layer below the dry overlying sand/gravel layer. The fill + sand/gravel layer extends from ground surface to approximately 9.6 mbg and the silty clay layer silty clay layer extends from 9.6 mbgs to the maximum drilling.

Depths to groundwater in all monitoring wells were obtained manually by Landtek staff on September 28, October 14, and December 10, 2020, and September 17 and 22, 2021. The readings are presented in Table 3. Based on the recorded groundwater levels, depth to groundwater was determined to range from 9.0 mbgs to 11.10 mbgs, the highest water level was recorded to be 9.0 mbgs at MW7 on September 17, 2021.

It should be noted that the above readings were recorded in September, October, and December. Groundwater level monitoring is ongoing to determine the seasonal highest water level at the Site.

As the seasonal highest groundwater level could not be determined, a conservation groundwater level of 6 mbgs was assumed for dewatering calculation.

Areas of Underground Levels

The P1, P2 and P3 Levels Plans are provided in Figures 3, 4 and 5, Appendix A. The approximate areas of these Levels are as follows:

P1 Level = ~174.633 m x 148.845 m

P2 Level = ~174.633 m x 148.845 m

P3 Level = ~174.633 m x 105.700 m

A conservative area of 174.633 m x 148.845 m is assumed for all underground levels at the Site for this dewatering assessment.

Depth of Underground Levels

The maximum depth of the underground parking is estimated to be 10.1 mbgs (Level 1 = 4.1 m, Level 2 = 3.0 m, and Level 3 = 3.0 m) and an elevator shaft of 1.5 m is assumed. As a result, a total of excavation depth of 11.6 mbgs is required for the construction. A dewatering depth of approximately 0.5 m below the excavation bottom (12.1 mbgs) is therefore required in order to keep the bottom of the excavation dry during construction.

4.1 Groundwater Dewatering Requirements

Groundwater seepage will occur where excavations are made below the groundwater level. If groundwater levels are intercepted within the excavation, adequate pumping must be provided to prevent significant groundwater volumes from accumulating.

In order to evaluate the potential groundwater control requirements during construction of the proposed underground parking levels, depth to groundwater of 6.0 mbgs was assumed for the entire Site. The assumed value is a conservative value of highest groundwater, as the highest groundwater level at the Site approximately 9.0 mbgs was recorded in September, October and December 2020; and September 2021, and not in Spring when highest ground water levels are usually observed due to relatively higher precipitations and snow melt. Additional groundwater level monitoring will be completed in Spring of 2022 and an update of the dewatering estimates completed, if deemed necessary.

The method suitable for dewatering an area depends on the locations, type, size and depth of the dewatering needs; and the hydrogeological conditions such as stratification, thickness, and hydraulic conductivity of the foundation soils below the water table into which the excavation extends or is underlain. It is assumed that any groundwater dewatering for the Site excavations would likely be completed with standard construction sump pump/well points or equivalent, depending on conditions encountered such as water table elevation and subsurface materials. The pumps must use appropriate techniques to prevent the pumping of fines and loss of ground during dewatering activities and the flow of water must be appropriate managed to that sediment is not pumped into the proposed discharge point.

For the purposes of this assessment, an open excavation was assumed. The use of conventional shoring could further reduce the amount of groundwater infiltration and would be determined in consultation with the selected subcontractor.

<u>Subsurface Stratigraphy</u>

Based on the subsurface drilling investigation at the site, the stratigraphy generally consists of a layer of sand/gravel to approximately 9.6 mbgs overlying silty clay which extends to the maximum depth of investigation of approximately 15.6 mbgs.

Considering the above, P1 Level which extends to approximately 4.1 mbgs, and P2 Level which extends to approximately 7.1 mbgs, will be complete in the sand/gravel layer; while P3 Level/Elevator Shaft which extends to approximately 11.6 mbgs will be completed in the silty clay layer.

4.1.1 Dewatering Calculations

<u>Underground Levels Excavation</u>

The potential groundwater flow rate to the underground level excavation was estimated using the dewatering equation for a fully penetrated well of unconfined aquifer fed by circular source (Powers, et. al., 2007):

$$Q = \pi K \, (H^2 – h_w^2)/(\ln R_o/r_e)$$

Where: Q = pumping rate [m^3/s]
K = hydraulic conductivity [m/s]
H = saturated thickness of the aquifer before dewatering [m]

h_w = saturated thickness of the aquifer after dewatering [m]
R_o. = radius of cone of depression [m]
r_e = equivalent radius [m]

The radius of cone of depression R can be estimated using:

$$R_o = Ch*Sqrt(K)$$

Where: C = is a factor equal to 3000 for radial flow to a pumping well

h = H- h_w =required drawdown [m]
K = hydraulic conductivity [m/s]

Dewatering of a rectangular area can be accomplished by using an equivalent radius (r_e) to assess drawdown where r_e is given by the following equation:

r_e = (a + b)/π) (applies when a/b<1.5 and R_o >> r_e)
r_e = Sqrt (length*width/π) (applies when a/b>1.5 and R_o << r_e)

<u>Radial Flow into Excavation</u>

The total amount of groundwater required to be pumped for dewatering the excavation associated with the underground levels construction assuming there is no rainfall was determined to be approximately 124,000 L/day (~ 1.44 L/s). These calculations and associated assumptions are provided on Table 1, Appendix E. This value is based on conservative estimate of the groundwater level of 6.0 mbgs. Groundwater monitoring is ongoing to determine the seasonal high-water level and the groundwater dewatering estimate will be updated if required.

4.2 Dewatering Considerations

4.2.1 Estimating Dewatering Volume

The dewatering rate for the proposed excavation must also consider management of direct precipitation input. As a result, dewatering volume is estimated from the following two contributions:

- Radial flow into an excavation under a water table condition (Section 4.1).
- Direct precipitation

<u>Direct Precipitation</u>

It is advised that dewatering should not be completed during period of active precipitation.

4.2.2 Short Term Dewatering Volume

The short-term dewatering rate outside periods of active precipitation was determined to be approximately 124,00 L/day (1.44 L/s), based on groundwater level monitoring completed in September, October and December 2020; and September 2021, outside Spring when highest ground water levels are usually observed due to relatively higher precipitations and snow melt. Additional groundwater level monitoring will be completed in Spring of 2022 and an update of the dewatering estimates completed.

Normal conditions are considered to be weather conditions that should be expected during the operation of the construction dewatering. Normal operation does not include extreme weather events.

4.2.3 Long Term Groundwater Control (Post Construction)

There will not be long-term dewatering at the Site as it is recommended that a suitable groundwater control be implemented at the site post construction, such as perimeter drainage, damp-proofing and water proofing.

4.2.4 Permit to Take Water

The estimated dewatering rate of groundwater for the proposed excavation is estimated to be approximately 124,000 L/day (radial inflow). An Environmental Activity and Sector Registry EASR registration will be required for this volume of water taking.

4.2.5 Dewatering Procedure

Based on the results of the hydraulic conductivity tests, seepage through the overburden beneath the Site should be feasible to be handled by a sump and/or well point dewatering system. The type of dewatering system to be used should be discussed with a dewatering contractor and be evaluated based on anticipated low and high volumes estimates.
The following general construction practices can be implemented to minimize the volume of water to be extracted:

- Schedule construction outside the spring period when the water table is typically elevated and avoid constructing during period of active precipitation.
- It is recommended that any excavations should be staged or constructed in such a manner to be able to manage dewatering volume conveniently.
- Reduce the length of time during which the open cut remains open.

4.2.6 Water Management and Discharge Plan

Water extracted during construction dewatering is required to be discharged into an approved location which could be storm, sanitary or combined sewers or surface water body near the Site.

As per the Sewers ByLaw, in order to issue a discharge approval, information relating to the quality and quantity of the discharge must be provided to City of Hamilton. It is strongly recommended that the applicant provide this information eight to twelve weeks prior to the proposed start of discharge.

It is expected that the rate and total volume of the discharge during dewatering be recorded. This would require that the discharge line be equipped with a flow meter capable of monitoring the discharge rate and a volume totalizer to record the total volume of water discharge. The discharge rate and total daily flow will need to be recorded with the records maintained on site. This can be accommodated by installing a flow meter on the discharge line.

If needed, a weir tank and filter bag can be utilized during dewatering to reduce total suspended solids (TSS) and turbidity prior to discharging of the water into either a sewer system or surface water.

A T-Coupling and valves should be installed downstream of the flow meter, which, if necessary, can be operated to divert flow for mitigation purposes.

4.3 Assessment of Potential Impacts and Water Management

4.3.1 Impact to Existing Groundwater Users

A search of the Ontario MECP within an area extending about 500 m outward from the edge of the excavation was completed, identifying a total of 20 wells in the database.

A summary of the well records is provided in Appendix C, and the approximate locations of the wells are shown on Figure 8 in Appendix A. Based on review, no water wells were identified within 500 m radius of the Site. The site and surrounding areas are located in an area provided with municipal water and sewer system by the City of Hamilton.

As, there is no water well within 500 m radius of the Site, it is not anticipated that there will be any impact to existing groundwater users.

4.3.2 Impact to Surface Water and Natural Functions of the Ecosystem

Redhill Creek located about 1.2 km southeast of the site was identified as the nearest surface and natural function of the ecosystem to the site. The drawdown generated as a result of dewatering will result in a localized lowering of the groundwater table within an estimated radius of influence of 17.2 m of the site (see Table 1 in Appendix E). The Creek is located outside the estimated radius of influence resulting from the proposed dewatering activities. As a result, it is not anticipated that there will be any impact to the Creek.

4.3.3 Contaminants Impacts

This occurs when pre-existing ground or groundwater contamination is mobilised and transported where transmission pathways are created.

Based on the Phase 2 Environmental Site Assessment report completed at the Site by Landtek in December 2020, surficial contamination was found in the fill layer at the Site to a depth of 0.6 mbgs. This surficial fill will be excavated and disposed of during excavation for the proposed underground levels construction. As a result, there is no potential for mobilization of contaminants or creation of transmission pathways during the planned groundwater dewatering activities.

4.3.4 Geotechnical Impacts

Geotechnical impacts occur where the geotechnical properties or state of the ground are changed by groundwater control activities. The most common type of impact in this category is ground settlement, with the corresponding risk of distortion and damage to structures, services and other sensitive infrastructure.

The site is located in a developed, predominantly mixed commercial and residential area of Hamilton. It is bounded by King Street East to the north and Lawrence Street to the south. Residential and commercial properties bound the site to the east and west.

Dewatering could be by pumping from a sump and well point dewatering system. These systems used for lowering the water table within the excavation must be properly screened and installed to ensure that pumping will not remove sediment from the overburden. Removal of significant fines may result in the formation of voids and the loss of ground. The radius of influence due to dewatering was estimated to be approximately 17.2 m (see Table 1in appendix E).

Based on the above, potential geotechnical impacts are anticipated during dewatering at the Site within an approximate radius of influence of 17.2 m. Surrounding buildings and roads should be monitored by geotechnical instrumentation to determine impact, if any.

The proposed monitoring and mitigation plans are presented in Sections 5 and 6, respectively.

5.0 GROUND SETTLEMENT EVALUATION AND PROPOSED MONITORING PLAN

Ground Settlement

Ground settlement can be caused by two principal mechanisms:

- Increases in effective stress as a result of lowering of groundwater levels, resulting in compression and consolidation of the ground. Such settlements are an unavoidable consequence of lowering of groundwater levels
- Removal of fine particles from the ground (loss of fines) which can occur when poorly controlled sump pumping draws out soil particles with the pumped water. With good design and implementation, loss of fines (and the associated settlement risk) can be avoided.

5.1 Settlement Monitoring

Implementation of a settlement monitoring plan should be completed within the estimated radius of influence from dewatering of an approximately 17.2 m at the Site. Prior to commencing dewatering condition surveys of adjacent properties that could potentially be affected by dewatering, considering anticipated effects and specific dewatering design should be completed.

A typical settlement monitoring system would comprise a series of settlement markers sited at various distances beyond and at the site, within the zone of influence of groundwater drawdown. Monitoring points should be surveyed to an accuracy of +/-2 mm. Note that the reference benchmark must be located beyond the extent of the anticipated influence of groundwater drawdown. For very high-risk projects, incorporation of piezometer standpipes will allow confirmation of the field groundwater drawdown and enable calibration of field settlement observation with theoretical assessments.

Alert and Action settlement thresholds should be set, selected though theoretical assessment of anticipated settlements and review of sensitivity of adjacent structures and infrastructure. It is prudent to implement staged groundwater drawdown, providing hold points to allow adequate time to enable observation of the delayed settlement response of the ground.

5.2 Construction Monitoring

Once construction dewatering is initiated it will be difficult to stop pumping or significantly reduce the rate of pumping without disrupting construction activities. It will however be possible to monitor the drawdown response at the construction site and to adjust the pumping rate to optimize drawdown and the associated pumping rate.

5.3 Management of Dewatering Abstraction

5.3.1 Monitoring, Trigger Levels and Management Responses

Abstraction management is critical to ensure target water levels within the construction zone are met, but that over-pumping does not occur.

Target groundwater levels in- and outside excavations will be set individually for each dewatering monitoring well based on location, aquifer and construction requirements, in-line with stated dewatering aims above.

Trigger levels for wells will typically be set 0.5 m above the dewatering target and 1.0 m below the dewatering target to give a 1.5 m target operational zone. These targets may be reviewed and adjusted to decrease size of the operational target zone and increase the factor of safety.

If monitoring indicates that dewatering zone groundwater levels exceed the upper trigger levels (i.e., required drawdown is not being achieved or maintained) management actions are available (in order of preference):

- Adjust automatic pump start and stop water levels.
- Increase pumping rates within the constraints of the system; and/or
- Install additional abstraction capacity (well points, spears or sump pumps).

If monitoring indicates that excavation zone groundwater levels are below the lower trigger levels (i.e., excessive drawdown) management actions available are (in order of preference):

- Adjust automatic pump start and stop water levels; and/or
- Decrease pumping rates; and/or
- Reduce the number of pumps operating.

5.3.2 Contingency Responses

If management responses prove to be insufficient to achieve and maintain the target levels, excavations may be slowed or suspended to enable contingencies to be implemented. Available contingency measures that will be assessed include (in order of preference):

- Construction of additional dewatering wells, spears or sumps.
- Construction of additional drains or groundwater control structures.

Excavation would resume when the required drawdown is able to be reliably obtained.

6.0 PROPOSED MITIGATION PLAN

The groundwater dewatering activities will result in localized depression of the groundwater table, and it is anticipated that there will be no impact beyond the radius of influence of 17.2 m.

Mitigation would involve the reduction or elimination of the impacts induced by construction dewatering. As noted above, the potential exists for dewatering to cause ground settlement, with the corresponding risk of distortion and damage to structures, services and other sensitive infrastructure.

Methods to limit adverse dewatering settlement are:

- Settlement associated with loss of fines can be mitigated through appropriate design of the dewatering system to control flow velocity and provide screens and/or filters matched to the grading of the in-situ soils. Entrainment of fines must be monitored during construction; actions could include analysis of TSS in discharge water and/or monitoring of accumulation of sediment in sedimentation tanks.
- Drawdown-induced ground settlement is mitigated though pre-construction estimation of groundwater drawdown and settlement coefficients to identify risk prior to drawing the groundwater down, and water level monitoring in monitoring boreholes to check that larger drawdown than anticipated at distance from the excavation is not occurring.
- Differential settlement is most problematic; this can be reduced by managing the rate of drawdown and understanding where clear changes in soil type occur. Should potentially damaging settlement be indicated, these can be mitigated by installing groundwater cut-offs to stem or restrict groundwater flow and limit drawdown beyond the site.
- Sufficient temporary support to excavations to maintain stability should be provided, where seeps might otherwise induce progressive collapse of the sides of the excavation.
- Staged drawdowns (where appropriate) should be implemented during dewatering and field settlement and water level changes beyond the immediate site should be monitored, comparing these against theoretical settlements and water levels to allow warning of potential dewatering settlement issues.

7.0 SUMMARY AND CONCLUSIONS

The following summarizes the results of the investigation:

- The Site is characterized by native soils comprising of a laterally variable sequence of sands, sand and gravel deposits overlying silty clay till. Bedrock was not encountered.

- Significant hydrogeologic features were not identified at the site and there were no areas of significant seepage or groundwater recharge areas on the site.

- In order to evaluate the potential groundwater control requirements during construction of the proposed underground parking levels, depth to groundwater of 6.0 mbgs was assumed for the entire Site. The assumed value is a conservative value of highest groundwater, as the highest groundwater level at the Site approximately 9.0 mbgs was recorded in September, October and December 2020; and September 2021, outside Spring when highest ground water levels are usually observed due to relatively higher precipitations and snow melt. Additional groundwater level monitoring will be completed in Spring of 2022 and an update of the dewatering estimates completed, if deemed necessary.

- The groundwater flow gradient on September 17, 2021, was determined to 0.022 m/m in a southeast direction.

- The short-term dewatering rate outside periods of active precipitation was determined to be approximately 124,00 L/day (1.44 L/s), based on groundwater level monitoring recorded in September, October and December 2020; and September 2021, outside Spring when highest ground water levels are usually observed due to relatively higher precipitations and snow melt. Additional groundwater level monitoring will be completed in Spring of 2022 and an update of the dewatering estimates completed.

- It is recommended that construction dewatering should not be completed during periods of active precipitation.

- There will not be a long-term dewatering at the Site as it is recommended that a suitable groundwater control be implemented at the site post construction, such as perimeter drainage, damp-proofing and water proofing.

- The estimated dewatering rate of groundwater for the proposed excavation is estimated to be approximately 124,000 L/day. An Environmental Activity and Sector Registry EASR registration will be required for this volume of water taking.

8.0 RECOMMENDATIONS

The following general construction practices are recommended to minimize the volume of water to be extracted:

- Schedule construction outside the spring period when the water table is typically elevated and avoid constructing during period of active precipitation.
- Reduce the length of time during which the open cut remains open.
- Install valves on the individual well point to allow for the flow adjustment.
- A suitable groundwater control should be implemented at the site post construction, such as perimeter drainage, damp-proofing and water proofing.

As per the Sewers ByLaw, in order to issue a discharge approval, information relating to the quality and quantity of the discharge must be provided to City of Hamilton. It is strongly recommended that the applicant provide this information eight to twelve weeks prior to the proposed start of discharge.

9.0 CLOSURE

We trust this report is satisfactory for your purposes. If you have any questions regarding our submission, please do not hesitate to contact Landtek.

Yours truly,

Landtek Limited

PROFESSIONAL GEOSCIENTIST
HENRY N. EREBOR
PRACTISING MEMBER
2792
ONTARIO

Henry Erebor, M.Sc., P.Geo.,

10.0 REFERENCES

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11.0 LIMITATIONS

The conclusions and recommendations given in this report are based on information determined at the borehole locations. Subsurface and ground water conditions between and beyond the boreholes may be different from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the geotechnical investigation. It is recommended practice that Landtek be retained during construction to confirm that the subsurface conditions throughout the site are consistent with the conditions encountered in the boreholes.

The comments made in this report on potential construction problems and possible remedial methods are intended only for the guidance of the designer. The number of boreholes may not be sufficient to determine all the factors that may influence construction methods and costs. For example, the thickness and quality of surficial topsoil or fill layers may vary markedly and unpredictably. Contractors bidding on the project or undertaking construction on the site should make their own interpretation of the factual borehole information and establish their own conclusions as to how the subsurface conditions may affect their work.

The survey elevations in the report were obtained by Landtek or others and are strictly for use by Landtek in the preparation of the geotechnical report. The elevations should not be used by any other parties for any other purpose.

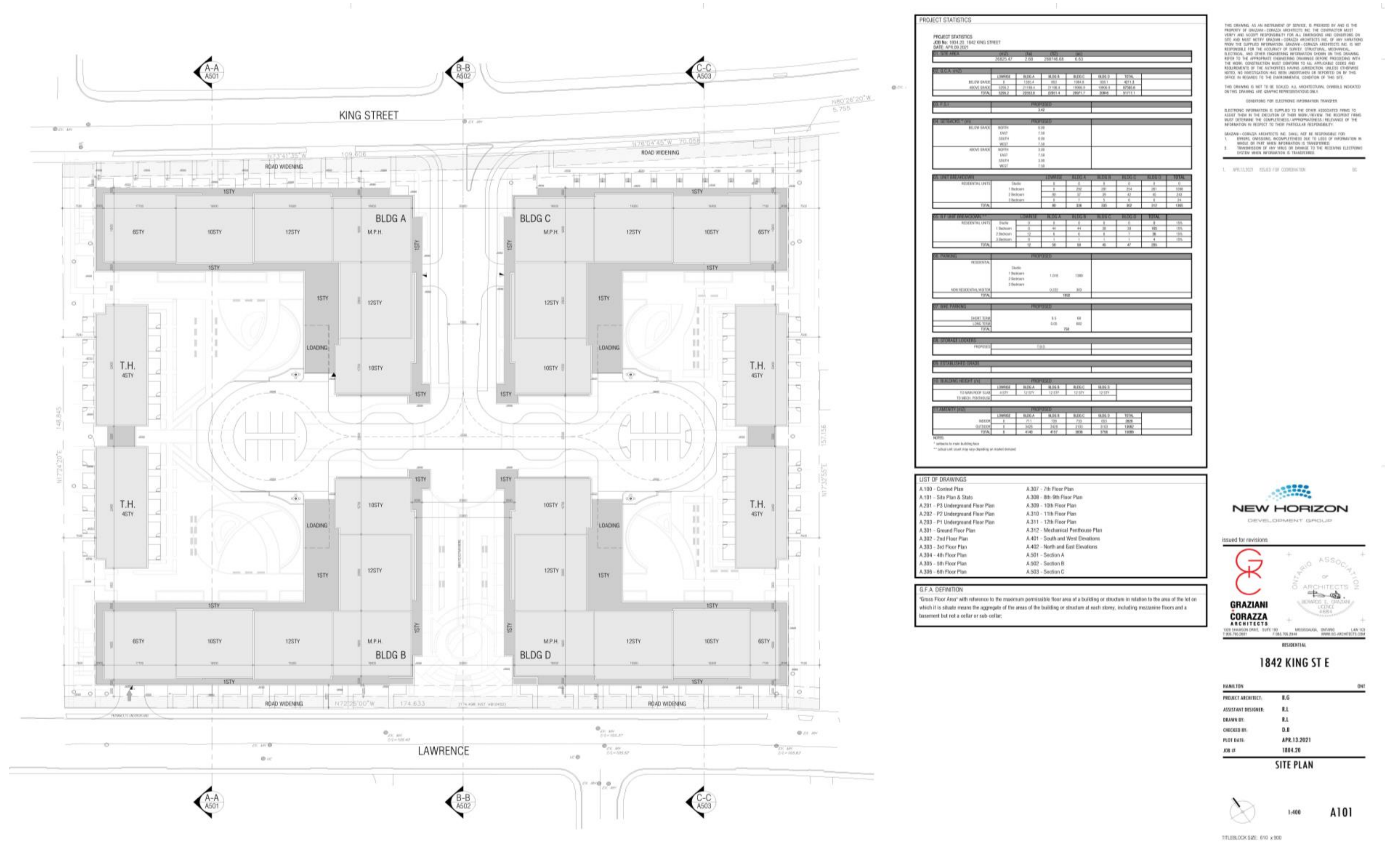
Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Landtek accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

This report does not reflect environmental issues or concerns related to the property unless otherwise stated in the report. The design recommendations given in the report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, it is recommended that Landtek be retained during the final design stage to verify that the design is consistent with the report recommendations, and that the assumptions made in the report are still valid.

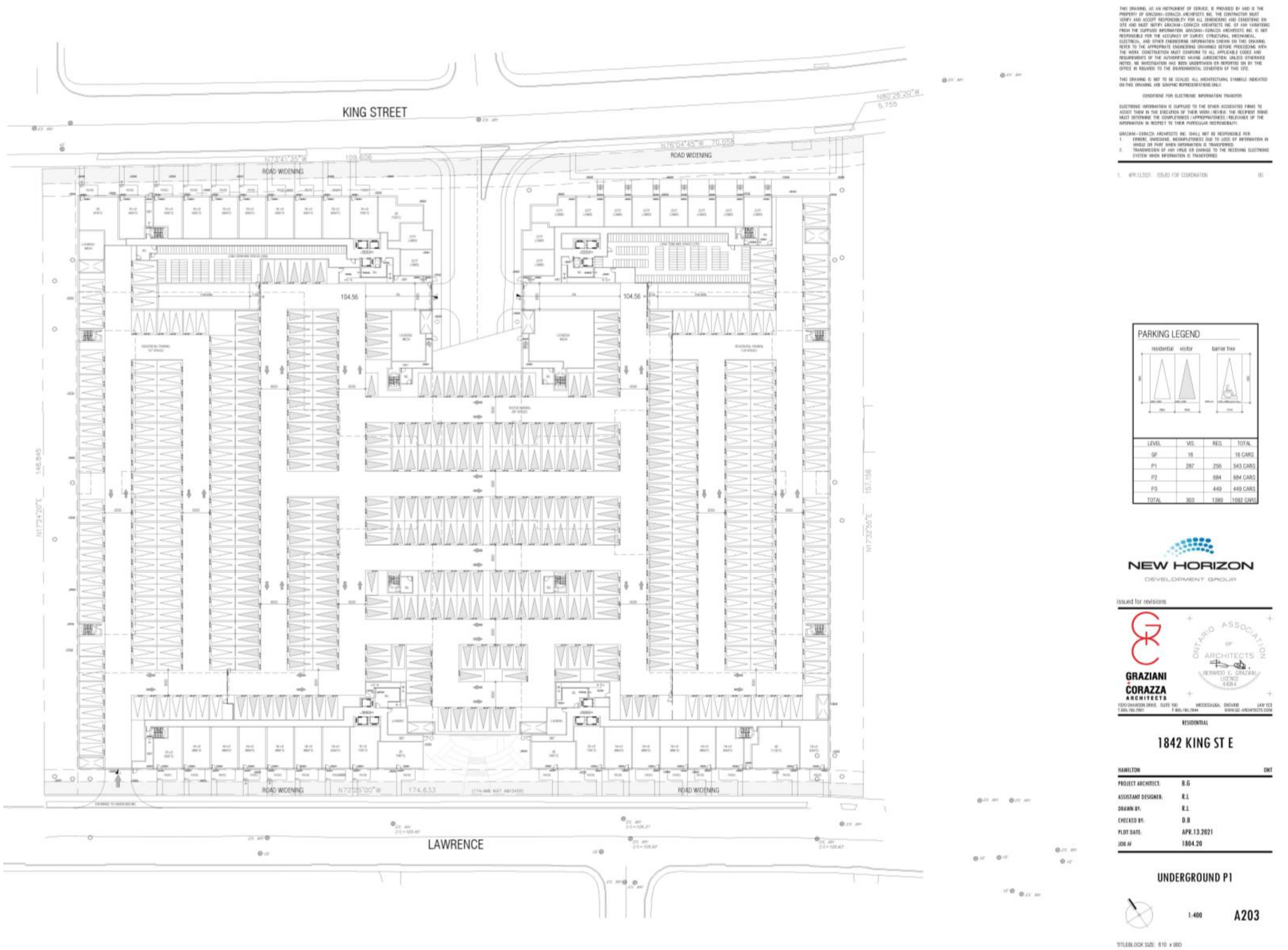
APPENDIX A

FIGURES

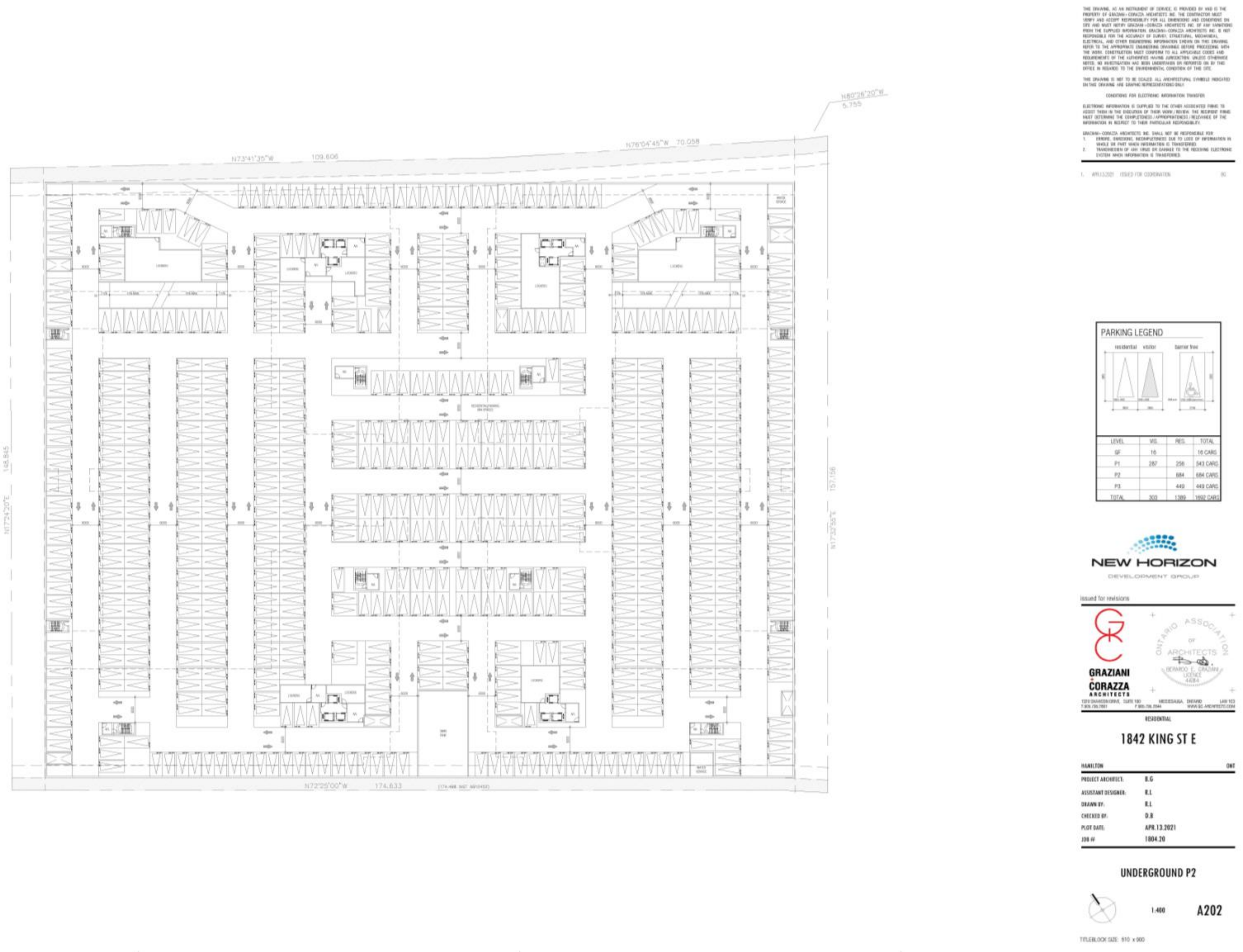
	LANDTEK LIMITED ***CONSULTING ENGINEERS*** **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: On Map	Date: September 2021
Project:	Hydrogeological Investigation 1842 King Street East Hamilton, Ontario	
Title:	Figure 1: Site Location	
Project No.	21334	



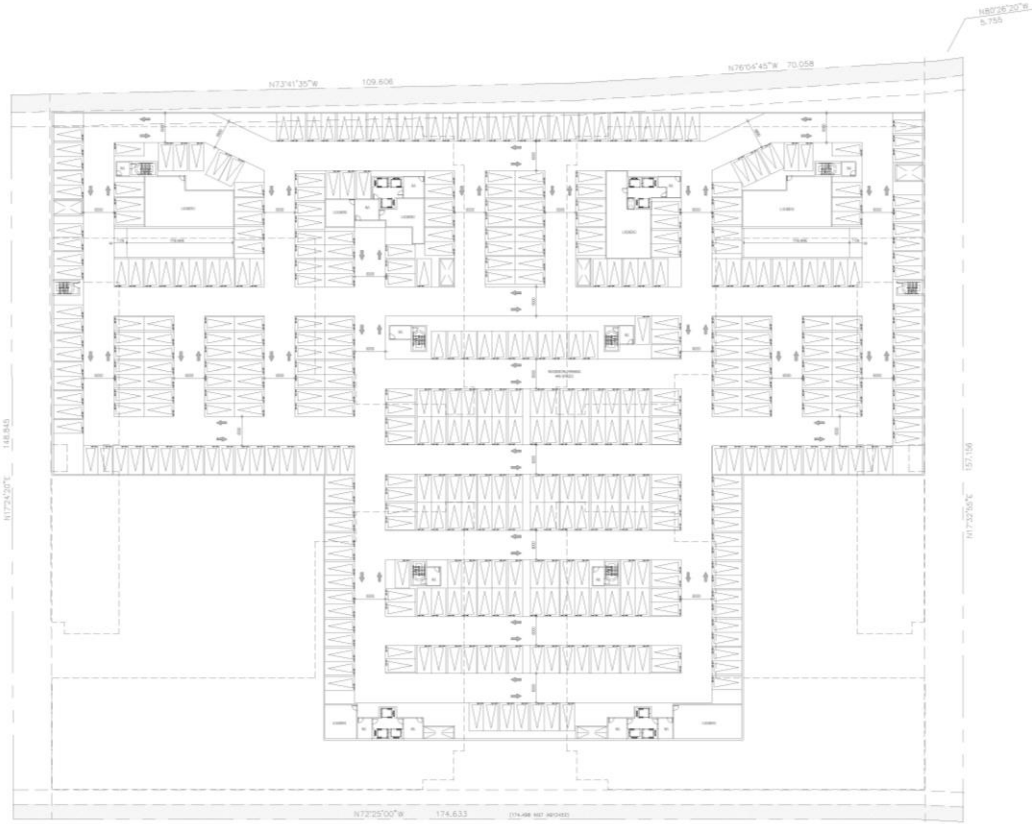
	LANDTEK LIMITED *CONSULTING ENGINEERS* **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**
	Scale: As Noted / Date: September 2021
Project:	Hydrogeological Investigation
	1842 King Street East
	Hamilton, Ontario
Title:	Figure 2: Site Plan
Project No.	21334



	LANDTEK LIMITED ***CONSULTING ENGINEERS*** **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: As Noted	Date: September 2021
Project:	Hydrogeological Investigation	
	1842 King Street East	
	Hamilton, Ontario	
Title:	Figure 3: Underground P1 Level Plan	
Project No.	21334	



	LANDTEK LIMITED *CONSULTING ENGINEERS* **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: As Noted	Date: September 2021
Project:	Hydrogeological Investigation	
	1842 King Street East	
	Hamilton, Ontario	
Title:	Figure 4: Underground P2 Level Plan	
Project No.	21334	



PARKING LEGEND

residential visitor barrier free

LEVEL	VIS.	RES.	TOTAL
SF	16		16 CARS
P1	287	256	543 CARS
P2		684	684 CARS
P3		449	449 CARS
TOTAL	303	1389	1692 CARS

NEW HORIZON
DEVELOPMENT GROUP

issued for revisions

GRAZIANI CORAZZA ARCHITECTS

RESIDENTIAL

1842 KING ST E

HAMILTON ONT

PROJECT ARCHITECT: B.G
ASSISTANT DESIGNER: R.L
DRAWN BY: R.L
CHECKED BY: D.B
PLOT DATE: APR.13.2021
JOB #: 1804.20

UNDERGROUND P3

1:400 A201

LANDTEK LIMITED

CONSULTING ENGINEERS

205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1

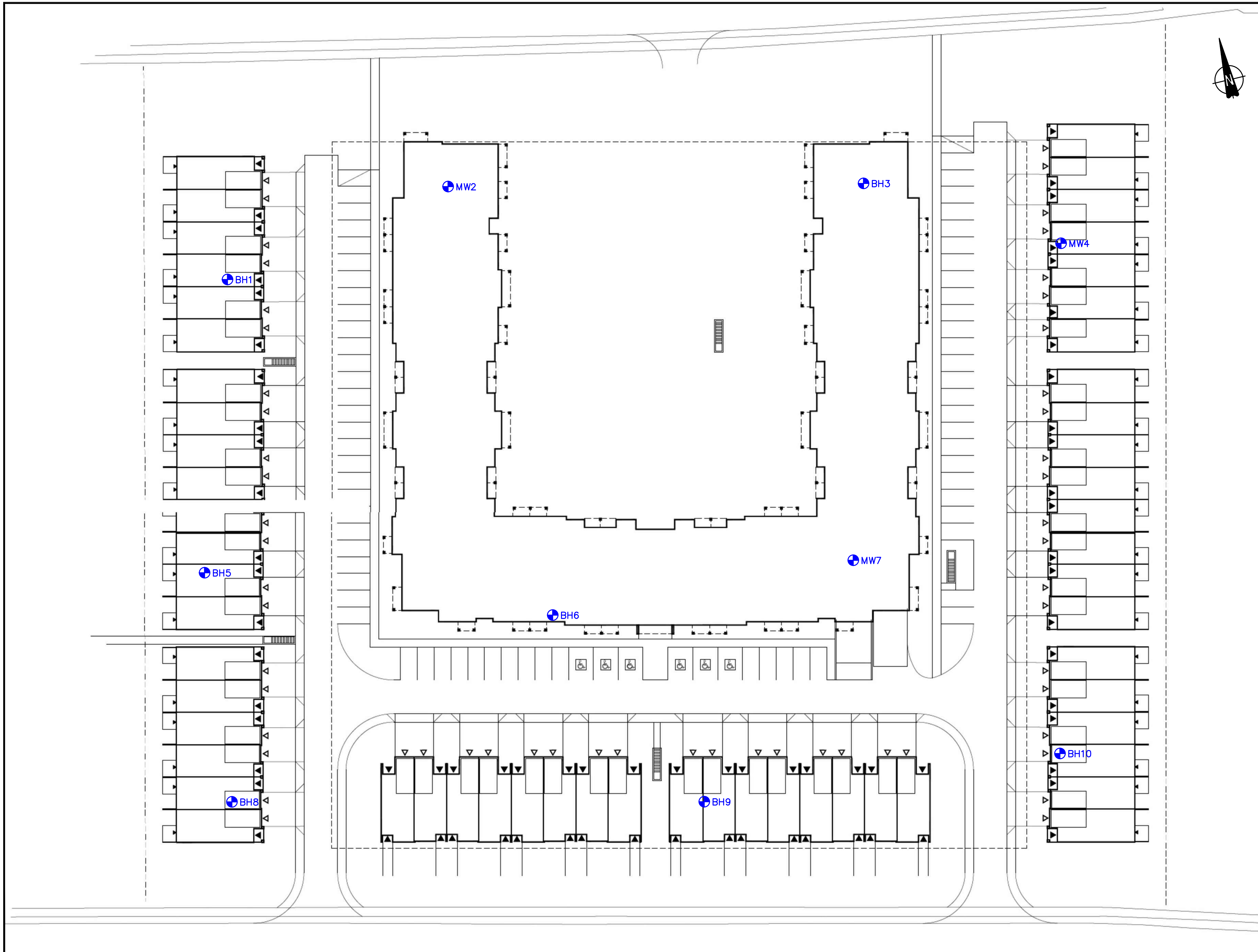
	Scale: As Noted	Date: September 2021
Project:	Hydrogeological Investigation	
	1842 King Street East	
	Hamilton, Ontario	
Title:	Figure 5: Underground P3 Level Plan	
Project No.	21334	

Figure 6: Boreholes & Monitoring Wells Locations Plan

LEGEND IS COLOUR DEPENDENT. NON-COLOUR COPIES MAY ALTER INTERPRETATION.

PINCHIN

PROJECT NAME: PHASE II ENVIRONMENTAL SITE ASSESSMENT	
CLIENT NAME: BROOK UNIVERSITY	
PROJECT LOCATION: 1842 KING STREET EAST, HAMILTON, ONTARIO	
FIGURE NAME: BOREHOLE AND MONITORING WELL LOCATION PLAN	
PROJECT NUMBER: 268747.001	SCALE: AS SHOWN
DRAWN BY: SIN	REVIEWED BY: JL
DATE: APRIL 2020	FIGURE NUMBER: 6



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project location

Approximate location of boreholes as drilled by Landtek Limited on August 24, 2020.

Site Plan extracted from KNYMH drawing reference 19310-A100-001 *"Site Plan"*, dated July 13, 2020

Figure 7: Boreholes and Monitoring Wells Location Plan

revisions/ submissions

#	date	description
1	november 4, 2020	draft for review

client
New Horizon Development Group Inc.

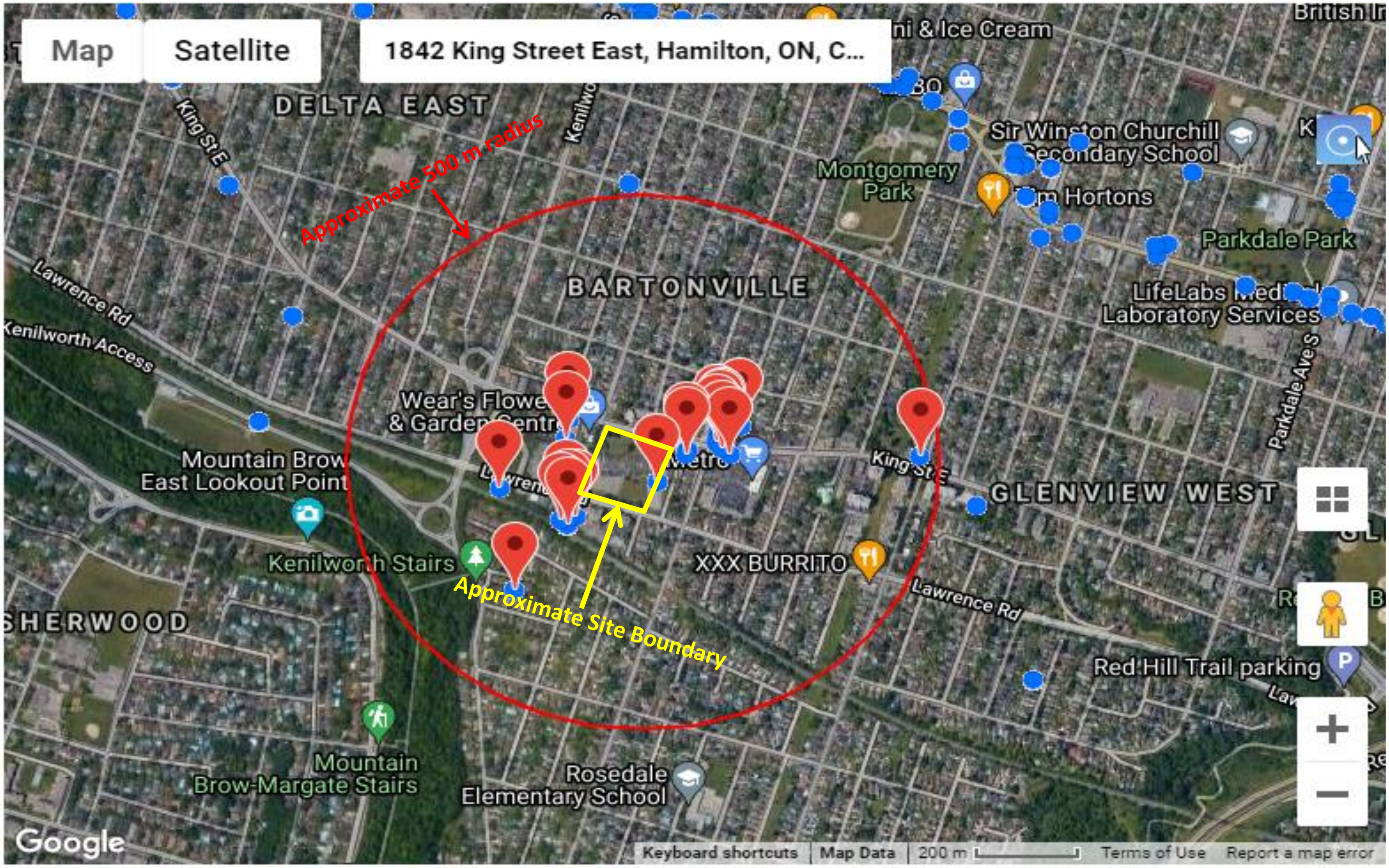
municipality
The Corporation of the City of Hamilton

project
Geotechnical Investigation
1842 King Street East

sheet
Borehole Location Plan

date: November 11, 2020
drawn: MD
checked: JD
project #: 20241
scale: NOT TO SCALE

20241-01



Latitude:43.22351, Longitude:-79.81812 (UTM Zone:17, Easting:595984, Northing:4786313)

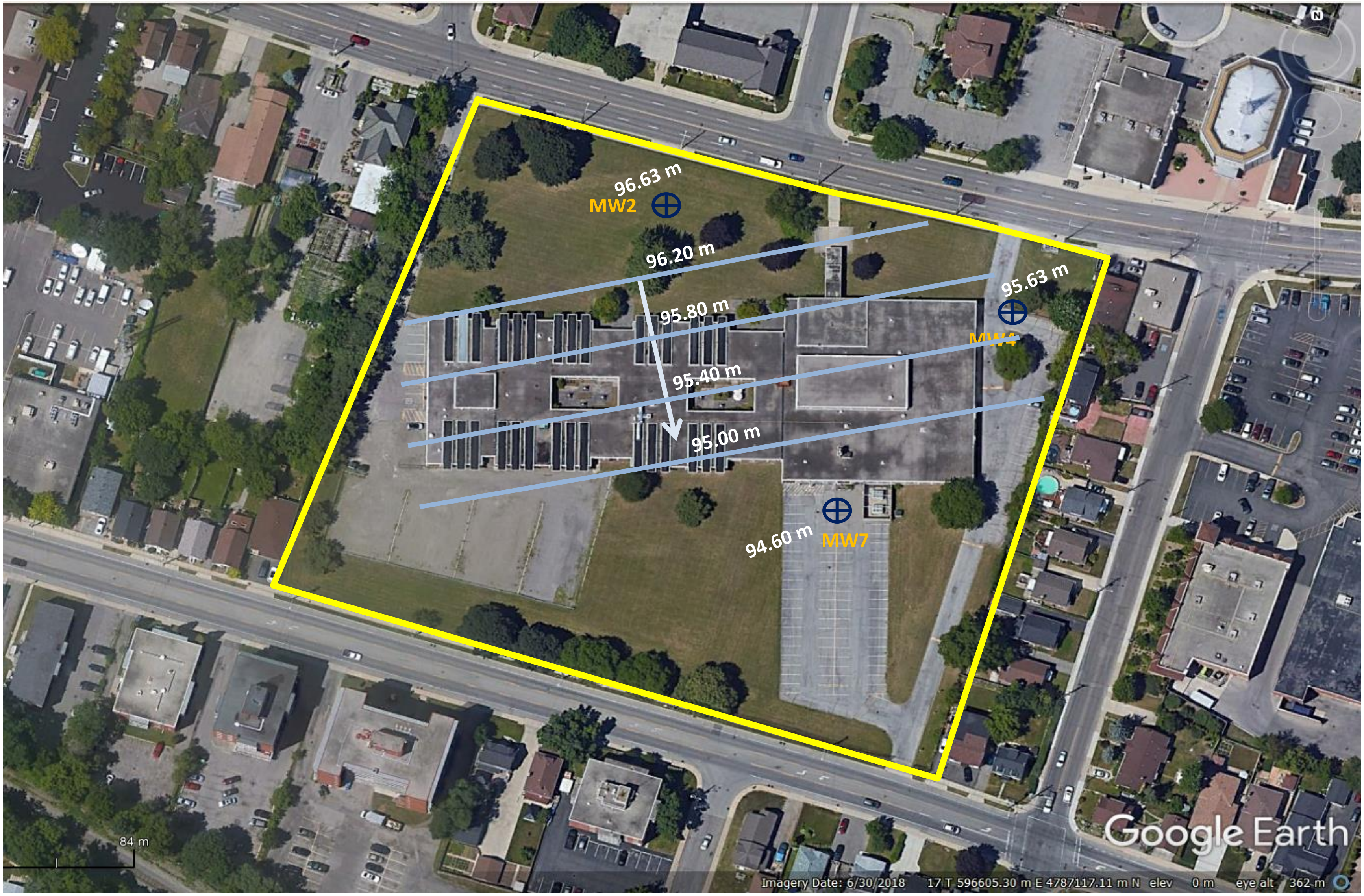
● MECP Wells

LANDTEK LIMITED

CONSULTING ENGINEERS

205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1

	Scale: On Map	Date:September 2021
Project:	Hydrogeological Investigation	
	1842 King Street East	
	Hamilton, Ontario	
Title:	Figure 8: MECP Wells Locations	
Project No.	21334	



Approximate Site Boundary

Monitoring Well

Groundwater Flow Direction

Groundwater Level Contour

90.00 m Groundwater Surface Elevation

	LANDTEK LIMITED ***CONSULTING ENGINEERS*** **205 NEBO ROAD, HAMILTON, ONTARIO, L8W 2E1**	
	Scale: On Map	Date: September 2021
Project:	Hydrogeological Investigation 1842 King Street East Hamilton, Ontario	
Title:	Figure 9: Monitoring Wells Locations	
Project No.	21334	

B-1

MONITORING WELL LOGS – PINCHIN, 2020

Log of Borehole: MW01

Project #: 268747.001 **Logged By:** JL

Project: Phase II Environmental Site Assessment

Client: Brock University

Location: 1842 King Street East, Hamilton, Ontario

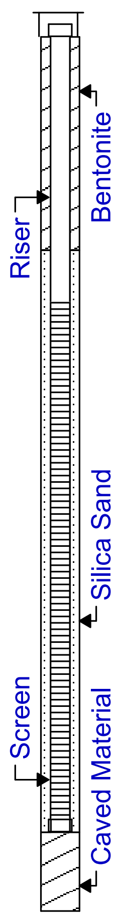
Drill Date: March 12, 2020

SUBSURFACE PROFILE

Depth (ft / m)	Description	Measured Depth (m)
0 / 0	Ground Surface	0.00
0 – 2.5 ft	**Sandy Silt** Brown, some gravel and moist. Topsoil to 0.07 mbgs.	0.76
2.5 – 17 ft	**Sand and Gravel** Brown, some silt and dry. Sampler and auger refusal on inferred bedrock.	5.18
	End of Borehole	

Soil vapour concentrations measured using a RKI Eagle 2 equipped with a photoionization detector (PID) and a combustible gas indicator (CGI).

Monitoring Well Details



Monitoring well dry as monitored on March 27, 2020.

SAMPLE

Recovery (%)	Sample ID	Soil Vapour Concentration (ppm) CGI/PID	Laboratory Analysis
30	BH01-1	20/1	
	BH01-2	<5/<1	
30	BH01-3	<5/<1	
	BH01-4	<5/<1	
70	BH01-5	<5/<1	
	BH01-6	<5/<1	
60	BH01-7	<5/<1	PHCs, VOCs, PAHs, Lead

Contractor: Strata Drilling Group

Drilling Method: Direct Push

Well Casing Size: 5.1 cm

Grade Elevation: NM

Top of Casing Elevation: NM

Sheet: 1 of 1

Log of Borehole: MW02

Project #: 268747.001 **Logged By:** JL

Project: Phase II Environmental Site Assessment

Client: Brock University

Location: 1842 King Street East, Hamilton, Ontario

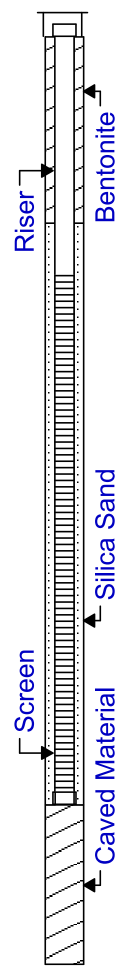
Drill Date: March 12, 2020

SUBSURFACE PROFILE

Depth (m)	Description	Measured Depth (m)
0	Ground Surface	0.00
0 – 0.61	***Sandy Silt*** Brown, some gravel and moist. Topsoil to 0.15 mbgs.	0.61
0.61 – 5.49	***Sand and Gravel*** Brown, some silt and dry. Sampler and auger refusal on inferred bedrock.	5.49
	End of Borehole	

Soil vapour concentrations measured using a RKI Eagle 2 equipped with a photoionization detector (PID) and a combustible gas indicator (CGI).

Monitoring Well Details:



Monitoring well dry as monitored on March 27, 2020.

SAMPLE

Recovery (%)	Sample ID	Soil Vapour Concentration (ppm) CGI/PID	Laboratory Analysis
60	BH02-1	<5/<1	pH
	BH02-2	<5/<1	
70	BH02-3	<5/<1	
	BH02-4	<5/<1	
70	BH02-5	<5/<1	
	BH02-6	<5/<1	
50	BH02-7	<5/<1	PHCs, VOCs, PAHs, Lead

Contractor: Strata Drilling Group

Drilling Method: Direct Push

Well Casing Size: 5.1 cm

Grade Elevation: NM

Top of Casing Elevation: NM

Sheet: 1 of 1

Log of Borehole: MW03

Project #: 268747.001 **Logged By:** JL

Project: Phase II Environmental Site Assessment

Client: Brock University

Location: 1842 King Street East, Hamilton, Ontario

Drill Date: March 12, 2020

SUBSURFACE PROFILE

Description	Measured Depth (m)
Ground Surface	0.00
Asphalt	
Sand and Gravel Grey and dry.	3.43
Silty Sand Brown, some gravel and dry. Sampler refusal on inferred concrete layer, augered to 4.57 mbgs and continued sampling.	4.57
Sand and Gravel Grey to brown and dry.	4.88
Silt Brown to grey, some clay and moist. Soil vapour concentrations measured using a RKI Eagle 2 equipped with a photoionization detector (PID) and a combustible gas indicator (CGI).	6.40

Monitoring Well Details: Riser; Screen; Bentonite; Silica Sand; Screen; Silica Sand

Depth scale: ft 0–21; m 0–6

SAMPLE

Recovery (%)	Sample ID	Soil Vapour Concentration (ppm) CGI/PID	Laboratory Analysis
40	BH03-1	10/1	
	BH03-2	<5/<1	
40	BH03-3	<5/<1	
	BH03-4	<5/<1	
50	BH03-5	<5/<1	
	No Sample		
80	BH03-6	<5/<1	
	BH03-7	<5/<1	PHCs, BTEX, PAHs
	BH03-8	<5/<1	pH, grain size

Contractor: Strata Drilling Group

Drilling Method: Direct Push

Well Casing Size: 5.1 cm

Grade Elevation: NM

Top of Casing Elevation: NM

Log of Borehole: MW03

Project #: 268747.001 ***Logged By:*** JL

Project: Phase II Environmental Site Assessment

Client: Brock University

Location: 1842 King Street East, Hamilton, Ontario

Drill Date: March 12, 2020

SUBSURFACE PROFILE					SAMPLE			
Depth (ft / m)	Symbol	Description	Measured Depth (m)	Monitoring Well Details	Recovery (%)	Sample ID	Soil Vapour Concentration (ppm) CGI/PID	Laboratory Analysis
22–30 ft / 7–9 m		***Silt*** Brown to grey, some clay and moist.	9.14	Screen; Silica Sand	100			
						BH03-9	<5/<1	
					100	BH03-10	<5/<1	
						BH03-11	<5/<1	
30–42 ft / 9–12 m		End of Borehole		Monitoring well dry as monitored on March 27, 2020.				

Depth scale: 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42 (ft); 7, 8, 9, 10, 11, 12 (m)

Soil vapour concentrations measured using a RKI Eagle 2 equipped with a photoionization detector (PID) and a combustible gas indicator (CGI).

Contractor: Strata Drilling Group

Drilling Method: Direct Push

Well Casing Size: 5.1 cm

Grade Elevation: NM

Top of Casing Elevation: NM

Sheet: 2 of 2

Log of Borehole: BH04

Project #: 268747.001 **Logged By:** JL

Project: Phase II Environmental Site Assessment

Client: Brock University

Location: 1842 King Street East, Hamilton, Ontario

Drill Date: March 12, 2020

SUBSURFACE PROFILE					SAMPLE			
Depth (ft / m)	Symbol	Description	Measured Depth (m)	Monitoring Well Details	Recovery (%)	Sample ID	Soil Vapour Concentration (ppm) CGI/PID	Laboratory Analysis
0 / 0		Ground Surface	0.00	No Monitoring Well Installed				
		Asphalt			50	BH04-1	<5/<1	
		Sand and Gravel Grey and dry.				BH04-2	<5/<1	
					20	BH04-3	<5/<1	
			3.20		50	BH04-4 and BH04-5	<5/<1	PHCs, BTEX, PAHs
		Silty Sand Brown, some gravel and dry.						
		End of Borehole Sampler refusal on inferred concrete layer.						

Depth scale: ft 0–21; m 0–6.

Soil vapour concentrations measured using a RKI Eagle 2 equipped with a photoionization detector (PID) and a combustible gas indicator (CGI).

Contractor: Strata Drilling Group

Drilling Method: Direct Push

Well Casing Size: 5.1 cm

Grade Elevation: NM

Top of Casing Elevation: NA

Sheet: 1 of 1

APPENDIX B-2

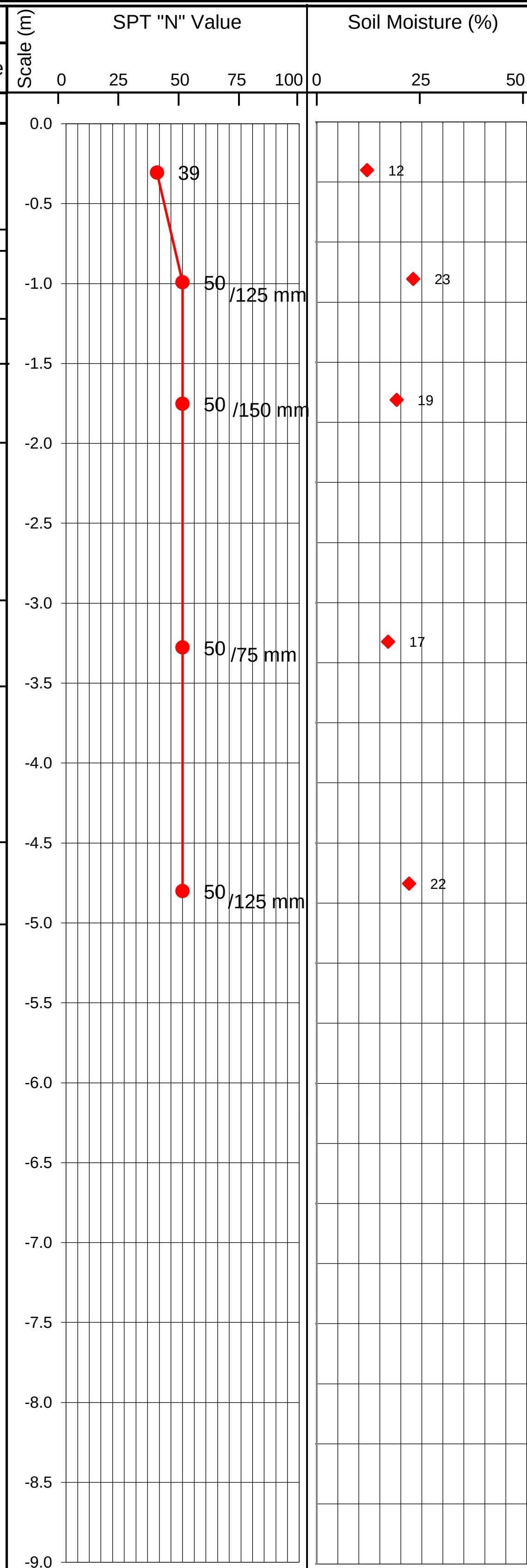
MONITORING WELL LOGS – LANDTEK, 2020

LANDTEK LIMITED

BH 1

Project No.:	20241	Drill Date:	August 17, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. / Depth	Sample No.	Sample Type	SPT "N" Value	Soil Moisture (%)	GWL	Monitor Details	Test Data
Ground Surface								
±200 mm of Topsoil	0.0							
FILL: silty clay, trace gravel, brown and grey, moist		1	SS	39	12			
SILTY CLAY: trace cobbles, brown, very dense, moist	0.8	2	SS	50/125 mm	23			
		3	SS	50/150 mm	19			
SAND AND GRAVEL: coarse, trace red shale fragments, brown, very dense, damp to wet	3.1	4	SS	50/75 mm	17			
		5	SS	50/125 mm	22			
BOREHOLE TERMINATED DUE TO SPOON REFUSAL	5.0							



Notes:
1. On completion, borehole open to 5.0 m
2. Groundwater not encountered

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LANDTEK LIMITED

MW 2

Project No.:	20241	Drill Date:	August 17, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. / Depth
Ground Surface	
±200 mm of Topsoil	0.0
FILL: silty clay, trace gravel, brown and grey, moist	
CLAYEY SILT: trace gravel, brown, hard, moist	0.6
SAND AND GRAVEL: some cobbles, trace silt, dense to very dense, brown moist	2.4
SILTY CLAY: trace sand, trace red shale fragments, grey, stiff to very stiff, moist, becoming wet	9.1
BOREHOLE TERMINATED AT TARGET DEPTH	15.6

Sample No.	Type	SPT "N" Value	Soil Moisture (%)
1	SS	18	12
2	SS	38	23
3	SS	34	19
4	SS	43	17
5	SS	27	17
6	SS	50	22
7	SS	29 /100 mm	22
8	SS	33	23
9	SS	14	24
10	SS	14	25
11	SS	17	26

Scale (m): 0.0 to -18.0. SPT "N" Value: 0, 25, 50, 75, 100. Soil Moisture (%): 0, 25, 50. GWL. Monitor Details. Test Data.

Monitor Details: sand backfill to 7.7 m; 8.0 m; 3.0 m of slotted 50 mm dia. PVC pipe; 11.0 m

Notes:
1. On completion, borehole open to 15.6 m
2. Groundwater encountered at approximately 9.0 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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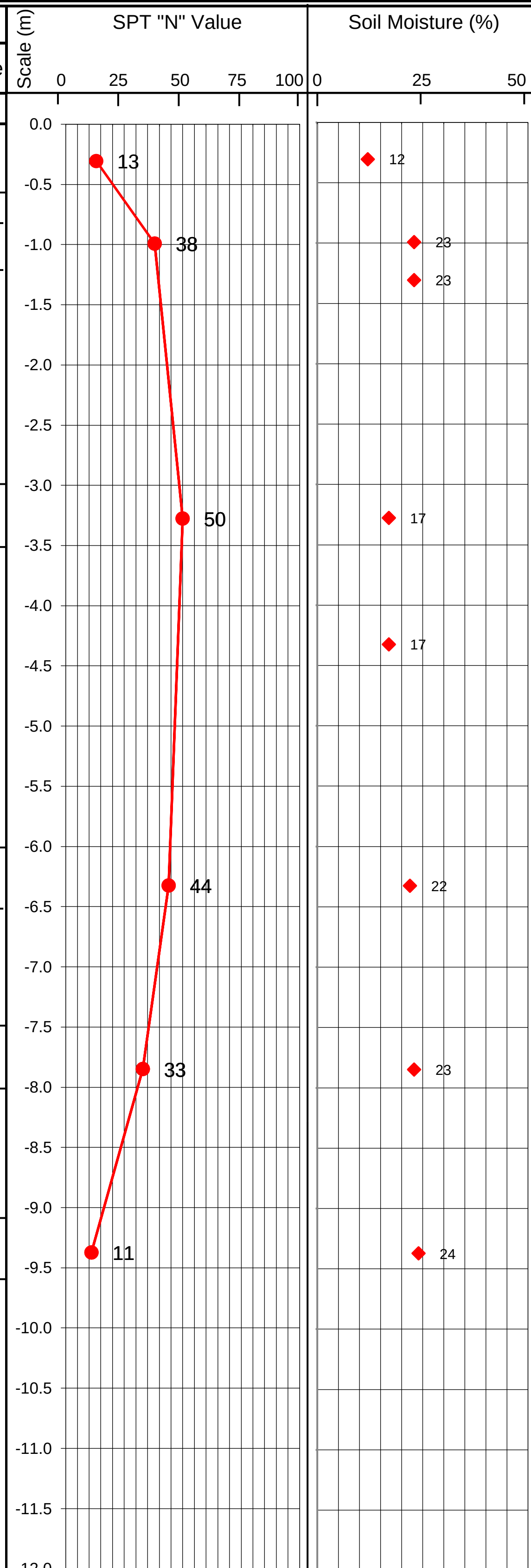
BH 3

Project No.:	20241	Drill Date:	August 17, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Symbol	Elev. / Depth	Sample No.	Sample Type
Ground Surface				
±150 mm of Topsoil		0.0	1	SS
FILL: silty clay, trace gravel, brown and grey, moist		0.4		
SAND AND GRAVEL: some cobbles, trace silt, trace clay, dense to very dense, moist			2	SS
SAND: trace gravel and red shale fragments, brown, very dense, moist.		3.0	3	SS
at 6.0 m to 6.5 m: trace silty clay.			4	SS
at 7.5 m to 8.0 m: no gravel, dense to compact			5	SS
			6	SS
BOREHOLE TERMINATED AT TARGET DEPTH		9.6		



GWL | Monitor Details | Test Data

Notes: 1. On completion, borehole open to 9.6 m
2. Groundwater not encountered

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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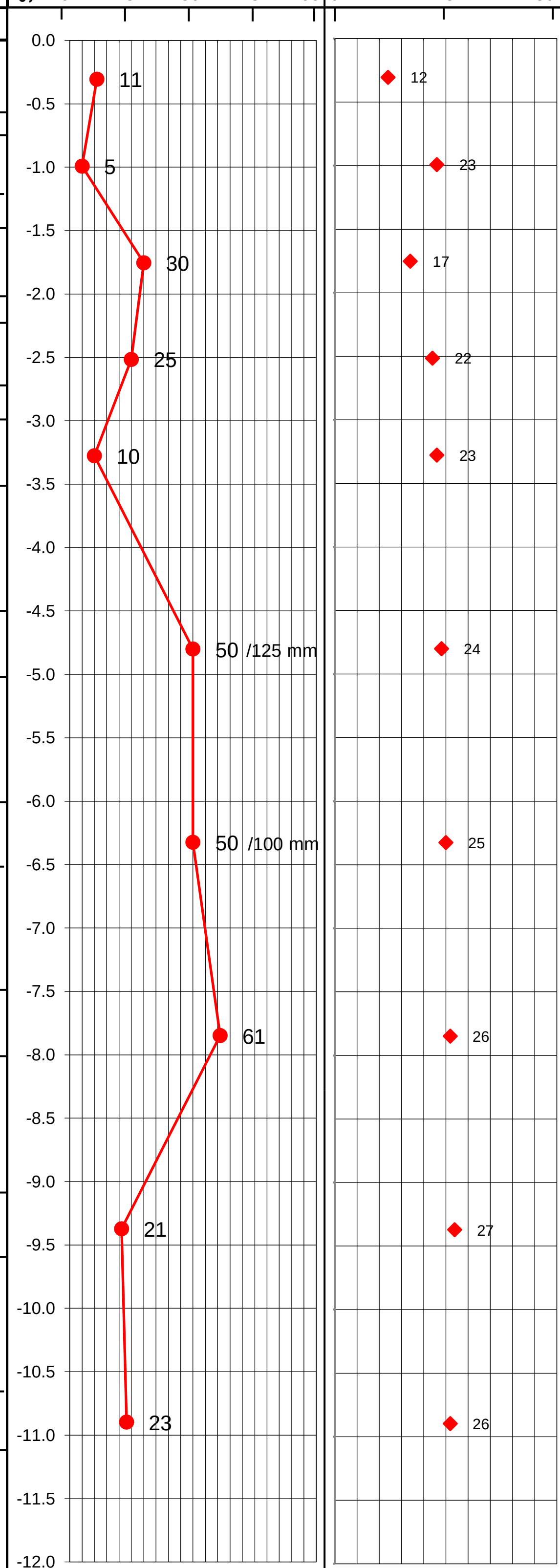
LANDTEK LIMITED

MW 4

Project No.:	20241	Drill Date:	August 17, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. / Depth (m)
Ground Surface	
±150 mm of Topsoil	0.0
FILL: silty clay, trace gravel, brown very stiff, moist.	
SAND: trace silt, brown, coarse, dense to compact, moist **at 3.0 m to 3.5 m:** trace gravel.	0.7
SILTY CLAY: trace sand, trace gravel, brown, hard to very stiff, moist	4.5
BOREHOLE TERMINATED AT TARGET DEPTH	11.1

Sample No.	Type	SPT "N" Value	Soil Moisture (%)
1	SS	11	12
2	SS	5	23
3	SS	30	17
4	SS	25	22
5	SS	10	23
6	SS	50 /125 mm	24
7	SS	50 /100 mm	25
8	SS	61	26
9	SS	21	27
10	SS	23	26



Monitor Details / Test Data:

bentonite backfill

sand backfill to 7.8 m

8.1 m

3.0 m of slotted 50 mm dia. PVC pipe

11.1 m

Notes:
1. On completion, borehole open to 11.1 m
2. Groundwater not encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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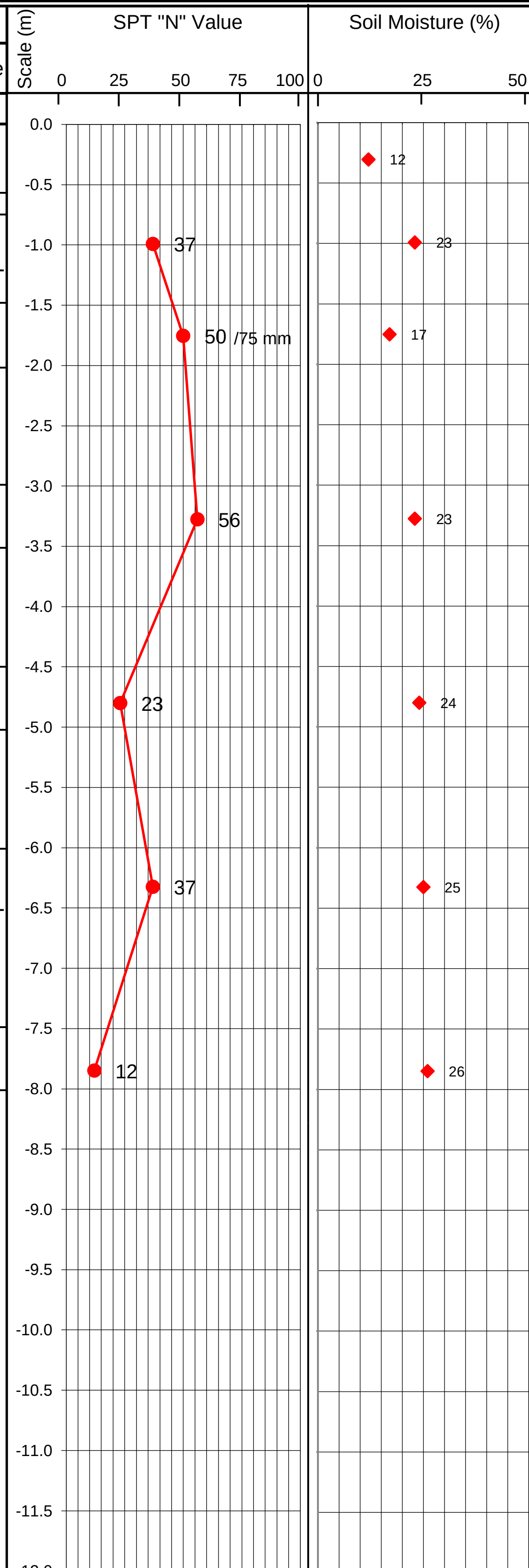
BH 5

Project No.:	20241	Drill Date:	August 17, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. / Depth	Sample No.	Sample Type
Ground Surface			
±75 mm of Asphalt	0.0	1	SS
±200 mm Pavement Granular			
FILL: sand and gravel, grey, moist		2	SS
SAND: trace gravel, coarse, brown, very dense, moist	1.5	3	SS
at 3.0 m to 3.5 m: trace silt, trace clay		4	SS
at 4.5 m to 5.0 m: compact		5	SS
		6	SS
		7	SS
BOREHOLE TERMINATED AT TARGET DEPTH	8.0		



GWL | Monitor Details | Test Data

Notes: 1. On completion, borehole open to 8.0 m
2. Groundwater encountered at approximately 7.0 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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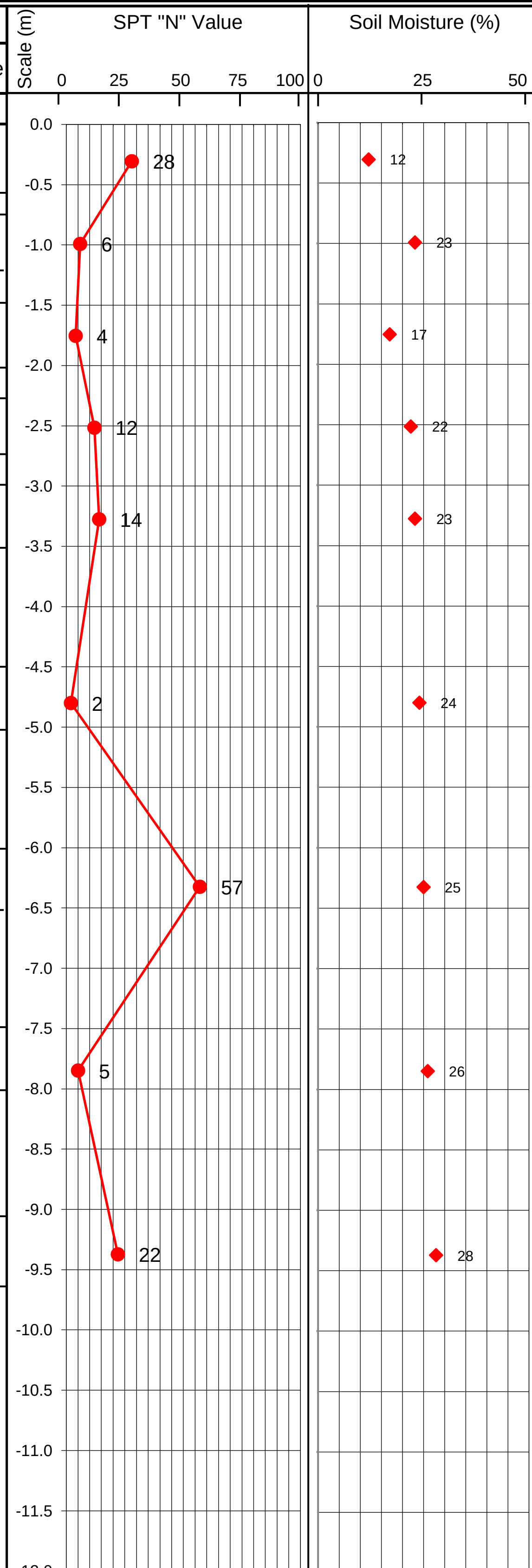
BH 6

Project No.:	20241	Drill Date:	August 19, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. / Depth	Sample No.	Type	SPT "N" Value	Soil Moisture (%)
Ground Surface	0.0				
FILL: sand and gravel, grey, moist		1	SS	28	12
		2	SS	6	23
SAND: trace gravel, coarse, brown, loose to compact, moist	1.5	3	SS	4	17
		4	SS	12	22
		5	SS	14	23
at 4.5 m to 5.0 m: loose		6	SS	2	24
at 5.0 m to 6.5 m: very dense		7	SS	57	25
at 7.5 m to 8.0 m: loose		8	SS	5	26
SILTY CLAY: trace sand, trace gravel, grey, very stiff, wet	9.1	9	SS	22	28
BOREHOLE TERMINATED AT TARGET DEPTH	9.6				



GWL | Monitor Details | Test Data

Notes:
1. On completion, borehole open to 8.0 m
2. Groundwater encountered at approximately 7.8 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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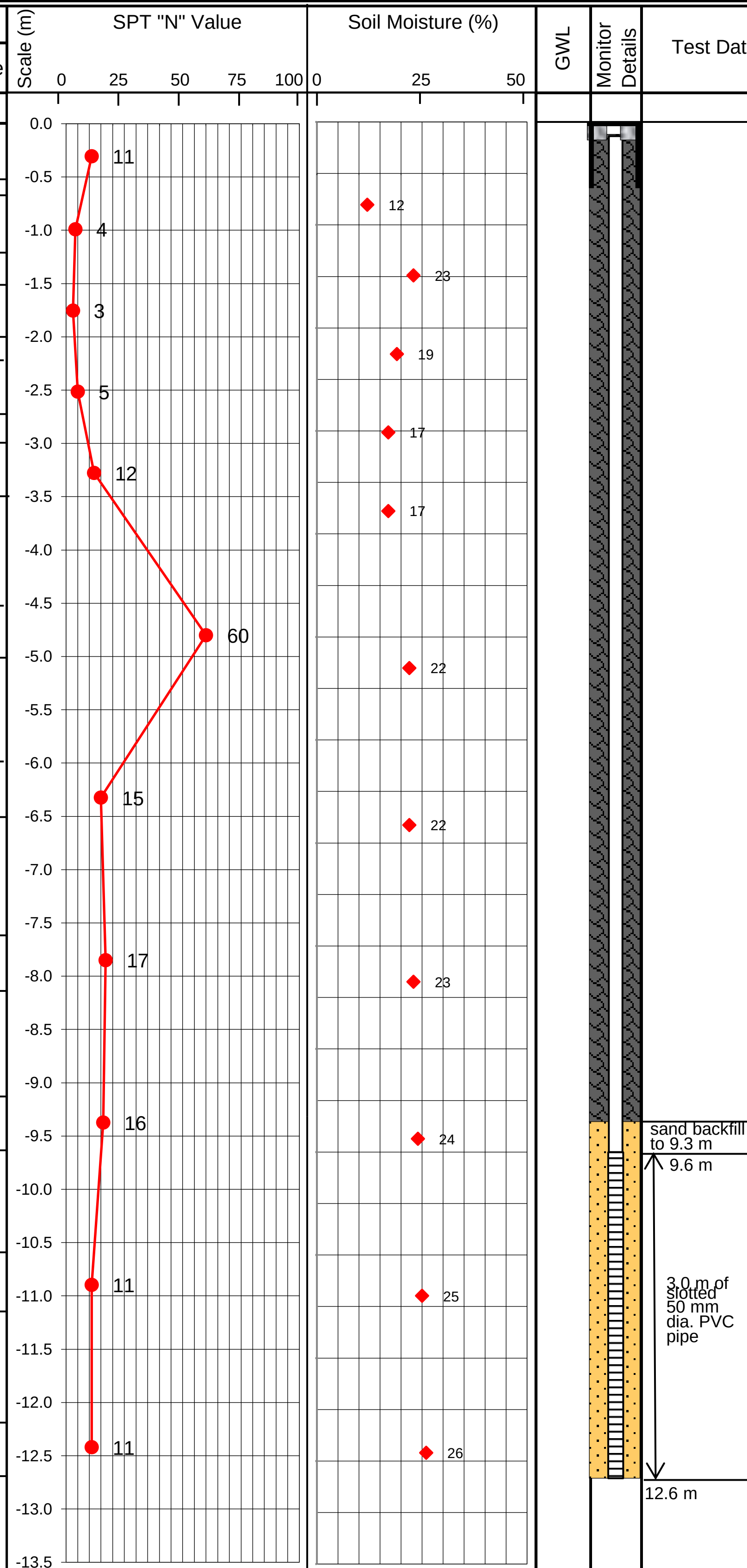
MW 7

Project No.:	20241	Drill Date:	August 18, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. / Depth	Sample No.	Type
Ground Surface			
±75 mm of Topsoil	0.0		
FILL: sand and gravel, trace silt, brown and grey, dry		1	SS
		2	SS
		3	SS
		4	SS
SAND AND GRAVEL: trace silt, brown, compact, moist	3.0	5	SS
at 4.5 m to 5.0 m: very dense		6	SS
SILTY CLAY: trace sand, trace gravel, brown and grey, very stiff to stiff, moist.	6.0	7	SS
		8	SS
		9	SS
at 10.6 m to 11.1 m: wet		10	SS
		11	SS
BOREHOLE TERMINATED AT TARGET DEPTH	12.6		



Notes:
1. On completion, borehole open to 12.6 m
2. Groundwater encountered at approximately 9.0 m below ground surface.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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BH 8

Project No.:	20241	Drill Date:	August 17, 2020
Project:	Geotechnical Investigation	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	1842 King Street East, Hamilton, Ontario	Datum:	Ground Level

Material Description	Elev. Depth	Sample No.	Sample Type	SPT "N" Value	Soil Moisture (%)	GWL	Monitor Details	Test Data
Ground Surface								
±200 mm of Granular Fill **FILL:** sand and gravel, trace red shale fragments, brown, moist	0.0	1	SS	16	12			
at 0.7 m to 1.2 m: trace silt		2	SS	47	23			
SAND: trace silt, trace gravel, coarse, brown, dense to compact, moist	1.5	3	SS	32	17			
		4	SS	32	23			
		5	SS	12	24			
at 5.0 m to 6.5 m: trace iron staining very dense to compact		6	SS	45	25			
SILTY CLAY: trace sand, trace gravel, grey, very stiff, moist	7.5	7	SS	23	26			
BOREHOLE TERMINATED AT TARGET DEPTH	8.1							

Scale (m): 0.0 to -12.0

Notes:
1. On completion, borehole open to 8.1 m
2. Groundwater not encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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APPENDIX C

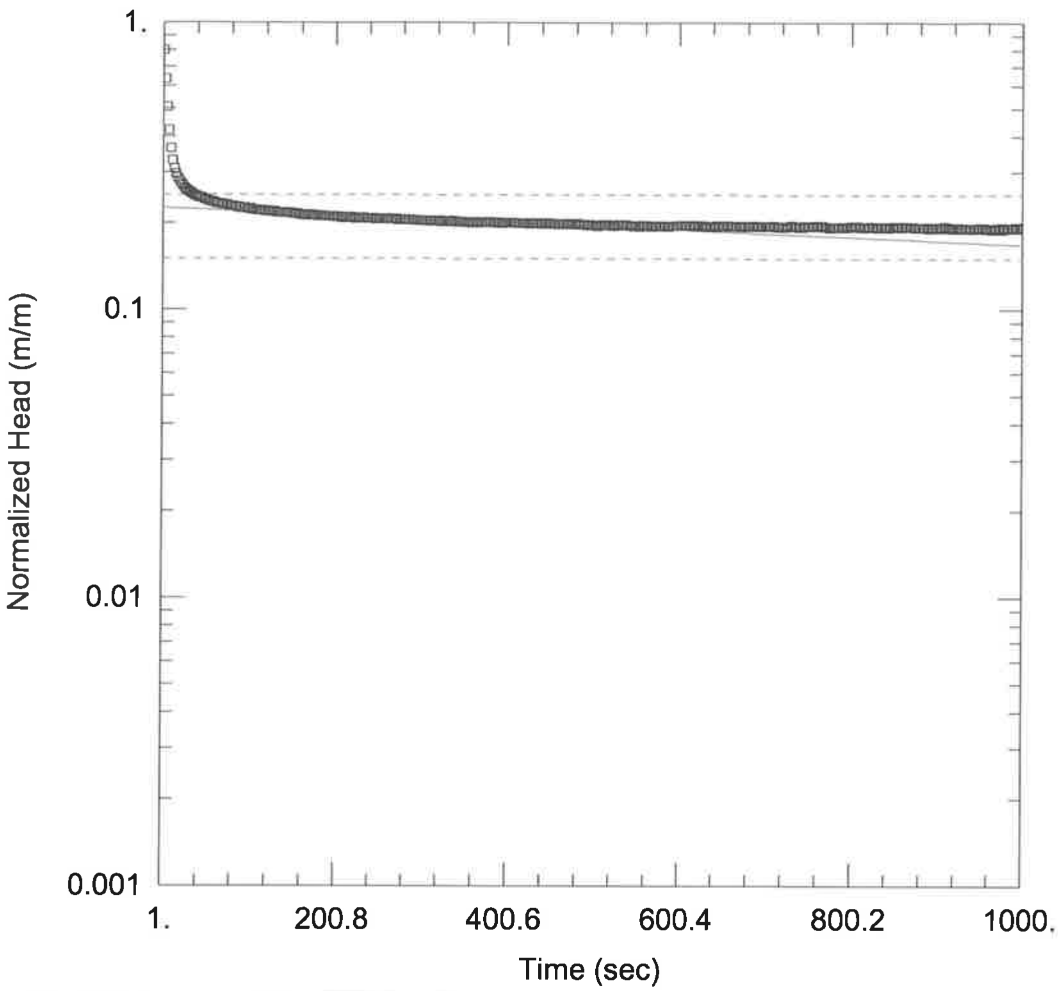
MECP WELLS RECORDS

Summary of MECP Well Records

Well #	WELL_ID	DATE_COMPLETED	DATE_RECEIVED	EAST83	NORTH83	WATER_FOUND_DEPTH (FT)	Static Water Level (ft)	KIND	FINAL_STATUS	USE_1ST	USE_2ND	DEPTH_TO (ft)	DEPTH_TO (m)	Well Construction	STREET	CITY/TOWNSHIP
1	7115137+B2:Q21	18-Nov-08	26-Nov-08	596541.0	4787055	NA	NA	NA	Observation	Monitoring	NA	19.7	6.01	Overburden	710 Lawrence Road	Hamilton City
2	7115139	18-Nov-08	26-Nov-08	596556.0	4787074	NA	NA	NA	Observation	Monitoring	NA	19.7	6.01	Overburden	710 Lawrence Road	Hamilton City
3	7115140	18-Nov-08	26-Nov-08	596543.0	4787073	NA	NA	NA	Observation	Monitoring	NA	19.7	6.01	Overburden	710 Lawrence Road	Hamilton City
4	7132563	23-Sep-09	27-Oct-09	596539.0	4787285	NA	NA	NA	Mon & TH	Mon & TH	NA	23	7.01	Bedrock	1800 King Street East	Hamilton City
5	7133810	14-Oct-09	13-Nov-09	596535.0	4787243	NA	NA	NA	Abandoned	Mon & TH	NA	NA	NA	NA	1800 King Street East	Hamilton City
6	7212214	24-Oct-13	02-Dec-13	596438.0	4786913	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Hamilton City
7	7240842	26-Mar-15	05-May-15	596858.0	4787214	NA	NA	NA	NA	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
8	7240843	26-Mar-15	05-May-15	596877.0	4787278	NA	NA	NA	Abandoned	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
9	7240844	26-Mar-15	05-May-15	596833.0	4787261	NA	NA	NA	Abandoned	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
10	7240845	26-Mar-15	05-May-15	596839.0	4787250	NA	NA	NA	Abandoned	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
11	7240846	26-Mar-15	05-May-15	596830.0	4787240	NA	NA	NA	Abandoned	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
12	7240847	26-Mar-15	05-May-15	596842.0	4787254	NA	NA	NA	Abandoned	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
13	7240873	26-Mar-15	05-May-15	596841.0	4787226	NA	NA	NA	Abandoned	NA	NA	NA	NA	NA	652 Lawrence Road	Hamilton City
14	7294162	17-Jul-17	03-Sep-17	596405.0	4787133	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Hamilton City
15	7336000	02-Apr-19	26-Jun-19	597233.0	4787216	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Hamilton City
16	7344762	05-Sep-19	09-Oct-19	596536.0	4787094	NA	NA	NA	Observation	Monitoring	NA	17	5.18	NA	700 Lawrence Road	Hamilton City
17	7344763	05-Sep-19	09-Oct-19	596527.0	4787066	NA	NA	NA	Observation	Monitoring	NA	18	5.49	NA	700 Lawrence Road	Hamilton City
18	7359208	12-Mar-20	20-May-20	596715.0	4787152	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Hamilton City
19	7359209	12-Mar-20	20-May-20	596774.0	4787224	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	Hamilton City
20	7359210	12-Mar-20	20-May-20	596773.0	4787212	NA	NA	NA	Observation	Mon & TH	NA	15	4.57	NA	842 King St E	Hamilton City

APPENDIX D

HYDRAULIC CONDUCTIVITY TESTING ANALYSIS RESULTS



HDROGEOLOGICAL INVESTIGATION

Data Set: F:\Landtek Slug Tests 2020-21\21334 - 1842 King Street East Hamilton\AqteSolve\MW2.aqt
Date: 09/28/21 Time: 10:28:05

PROJECT INFORMATION

Company: Landtek Limited
Client: New Horizon
Project: 21334
Location: 1842 King Street East Hamilton
Test Well: MW2
Test Date: September 22, 2021

AQUIFER DATA

Saturated Thickness: 1.59 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW2)

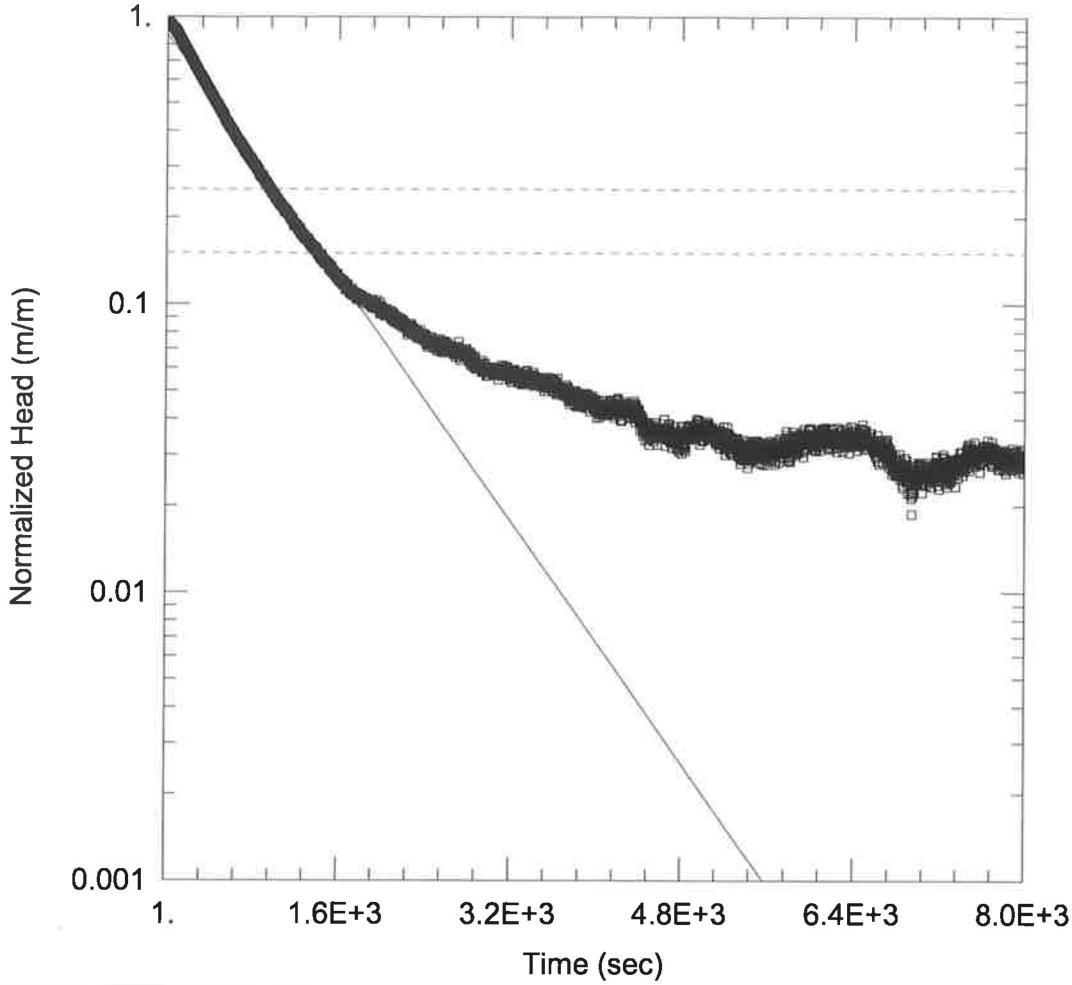
Initial Displacement: 0.3744 m
Total Well Penetration Depth: 1.59 m
Casing Radius: 0.0254 m

Static Water Column Height: 1.59 m
Screen Length: 1.59 m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev

K = 3.156E-7 m/sec
y0 = 0.08427 m



HDROGEOLOGICAL INVESTIGATION

Data Set: F:\Landtek Slug Tests 2020-21\21334 - 1842 King Street East Hamilton\AqteSolve\MW4.aqt
Date: 09/28/21 Time: 10:28:22

PROJECT INFORMATION

Company: Landtek Limited
Client: New Horizon
Project: 21334
Location: 1842 King Street East Hamilton
Test Well: MW4
Test Date: September 22, 2021

AQUIFER DATA

Saturated Thickness: 0.58 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW4)

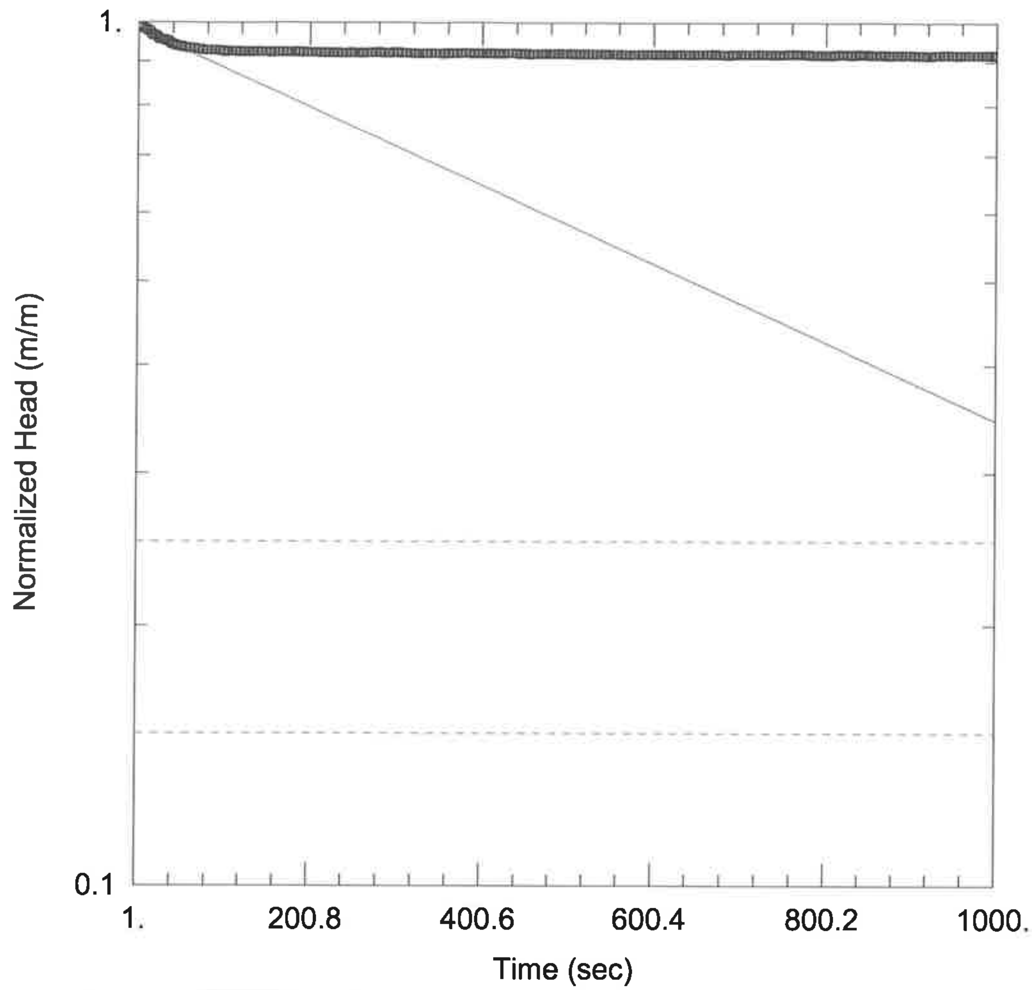
Initial Displacement: 0.1659 m
Total Well Penetration Depth: 0.58 m
Casing Radius: 0.0254 m

Static Water Column Height: 0.58 m
Screen Length: 0.58 m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined Solution Method: Hvorslev

K = 3.575E-6 m/sec y0 = 0.1438 m



HDROGEOLOGICAL INVESTIGATION

Data Set: F:\Landtek Slug Tests 2020-21\21334 - 1842 King Street East Hamilton\AqteSolve\MW7.aqt
Date: 09/28/21 Time: 10:28:34

PROJECT INFORMATION

Company: Landtek Limited
Client: New Horizon
Project: 21334
Location: 1842 King Street East Hamilton
Test Well: MW7
Test Date: September 22, 2021

AQUIFER DATA

Saturated Thickness: 3.33 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW7)

Initial Displacement: 0.4391 m
Total Well Penetration Depth: 3.33 m
Casing Radius: 0.0254 m
Static Water Column Height: 3.33 m
Screen Length: 3. m
Well Radius: 0.0254 m
Gravel Pack Porosity: 0.

SOLUTION

Aquifer Model: Confined
Solution Method: Hvorslev
K = 6.157E-7 m/sec
y0 = 0.4317 m

APPENDIX E

DEWATERING ASSUMPTIONS AND CALCULATIONS – UNDERGROUND LEVELS EXCAVATION

Table 1 – Underground Levels Dewatering Calculations

$$Q = \pi K (H^2 - h_w^2)/\ln(R_o/r_e)$$

Equation 1: The potential groundwater flow rate to the excavation for the proposed underground levels was estimated using the dewatering equation for a fully penetrated well of unconfined aquifer fed by circular source (Powers, et al., 2007).

Where: Q = pumping rate (m^3/s)
K = hydraulic conductivity (m/s)
H = saturated thickness of the aquifer before dewatering (m)
h_w = saturated thickness of the aquifer after dewatering (m)
R = radius of cone of depression (m)
r_e = equivalent radius (m)
C = 3000

$R = C*(H - h)*\sqrt{(K)}$ Radius of Influence - Sichardt's equation

$r_e = \sqrt{(L * B)/\pi}$ (applies when a/b>1.5 and R0 << rs)

$r_e = (L + B)/\pi$ (applies when a/b<1.5 and R0 >>rs)

Underground Levels	H (m)	h_w (m)	R (m)	r_e (m)	Q m3/s	Q L/day
	9.6	3.5	17.2	103.0	1.439 x 10-3	~124,000

Assumptions for hydrogeological setting:

1. An unconfined aquifer is presumed to exist locally with the existing water table estimated to at 6.0 mbgs and extending to an estimated depth of approximately 15.6 mbgl (Maximum geotechnical investigation drilling depth, Landtek 2020).
2. An ideal aquifer is assumed for the preliminary calculations of pumping rates and drawdown, as described by Powers, et al., 2007).
3. The maximum dewatering depth of construction activities is assumed to be 12.1 mbgl (0.5 m below bottom of Excavation).
4. It is assumed that as a requirement of the proposed construction activities the excavation will be pumped dry.
5. The hydraulic conductivity values for the silty clay/clayey silt overburden beneath the site was determined to be 8.856×10^{-7} m/s