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Hydrogeologic Assessment, Municipality of Huron East Proposed Kelly Pit Amendment Part Lot 25, Concession 3 Municipality of Huron East, Huron County

Prepared For:

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1.0 INTRODUCTION

This report presents the results of a hydrogeologic assessment completed at the Municipality of Huron East existing Kelly Pit. The study site is located within Lot 25, Concession 3, Municipality of Huron East (formerly Grey Township), County of Huron, Ontario.

The pit is currently has a Class A License for above water table extraction. This study was completed as part of a Class A License amendment application under the Aggregate Resources Act (ARA) to extract aggregate from below the water table.

1.1 BACKGROUND

The Kelly Pit is located on the west side of Molesworth Line, between Jamestown Rd and Browntown Rd, approximately 4 kilometers (km) south of the Village of Molesworth, as shown in **Figure 1**. The site is currently an active aggregate pit. Surrounding land use in the general area is primarily agricultural, with some rural residential properties and other aggregate pits.

1.2 SCOPE

This hydrogeological assessment addresses the requirements of the recently updated *Aggregate resources of Ontario standards: A compilation of the four standards adopted by Ontario Regulation 244/97 under the Aggregate Resources Act* (MNRF, August 2020).

1.2.1 Summary of Provincial Standards

This study utilizes the current ARA related groundwater reporting standards (*Aggregate Resources of Ontario: Technical reports and information standards*, MNRF, August 2020) for a Class A Pit proposing to excavate below the maximum predicted water table.

The standards include the following water table assessment:

> *2.1 Maximum predicted water table report*
>
> *A report must be prepared that details how the maximum predicted water table is identified in metres above sea level, relative to the proposed depth of excavation at the site.*
>
> *The maximum predicted water table shall be determined by monitoring the ground water table at the site for a minimum of one (1) year to account for seasonal variations and influences due to precipitation, unless alternative information already exists (e.g. previous hydrogeological study, existing well data) to support a determination of the maximum predicted water table by a qualified person.*
>
> …
>
> *The number of drill holes and seasonal monitoring frequency shall be determined by a qualified person based on site conditions.*

The standards also include the following site groundwater characterization and impact assessments:

2.5. Water report

Excavation at a pit proposed above the water table may not occur within 1.5 metres above the maximum predicted water table. Excavation at a quarry proposed above the water table may not occur within 2 metres above the maximum predicted water table.

Applications proposing to excavate below the maximum predicted water table must complete the following:

Water report level 1:

Determine the potential for impacts to ground water and surface water resources and their uses (e.g. water wells, ground water aquifers, surface water courses and bodies, springs, discharge areas) and identify if the proposed site is in a Wellhead Protection Area for Quantity (WHPA-Q) set out in an applicable source water protection plan under the Clean Water Act. If so, identify applicable source water protection policies and mitigation measures that will be implemented at the site.

Water report level 2:

Where the results of Level 1 have identified a potential for impacts from the aggregate site on ground water and/or surface water resources and their uses, an impact assessment is required. The assessment is to determine the significance of the effect and the potential for mitigation.

The assessment must address the potential effects of the operation on any ground water and surface water features located within the zone of influence, including but not limited to:

a) water wells (includes all types e.g. municipal, private, industrial, commercial, geothermal and agricultural)

b) springs (e.g., place where ground water flows out of the ground)

c) ground water aquifers;

d) surface water courses and bodies (e.g., lakes, rivers, brooks)

e) wetlands

The assessment must include but not be limited to the following:

f) a description of the physical setting including local geology, hydrogeology, and surface water systems;

g) proposed water diversion, discharge, storage and drainage facilities;

h) water budget (e.g. how water is managed on-site);

i) the possible positive or negative impacts that the proposed site may have on the water regime;

The Level 2 water report must also contain:

j) monitoring plan(s); and

k) technical support data in the form of tables, graphs and figures, usually appended to the report.

The "maximum predicted water table report" provides an assessment of the water table elevation at the site relative to the proposed extraction. The Level 1 report examines the site relative to identified Source Protection Study groundwater quantity protection areas (WHPA-Q) to address quantity protection policies. In addition, the Level 1 report examines the extraction plan relative to the identified water table conditions and provides a general discussion of potential for impact in order to determine the need for a Level 2 report and "scope" the issues to be examined.

The Level 2 report provides a detailed groundwater characterization, examines the type and scale of any potential extraction related impacts, and, based on that assessment identifies any potential for adverse effects on groundwater and surface water resources (and their uses). The need for monitoring and/or mitigation is also assessed. If necessary, the Level 2 report also provides recommendations regarding monitoring and/or mitigation.

The Level 1 and Level 2 water reports are typically referenced by the Natural Environment Report (NER), which is also required as part of the ARA application.

1.2.2 Impact Assessment Approach

As part of the licensing process for the site some municipal planning review is expected to occur. An Environmental Impact Study (EIS) can be required as part of that process. This report follows a typical EIS type approach, which is identified as follows:

- an outline of the study methodology
- a description of the topographic setting, local surface water drainage and natural environment features (including springs, wetlands, etc.);
- a description of reported local water well locations;
- a description of the geologic and hydrogeologic setting (including aquifers, groundwater/surface water interaction, water budget, etc.);
- a description of the proposed extraction;
- an examination of the potential impact of the proposed extraction (impact assessment); and,
- conclusions and recommendations.

In addition, this study provides information relevant to expected County of Huron or Municipality of Huron East requirements related to:

- Natural Environment Feature protection; and,
- Well Head Protection Areas.

This report follows the general EIS approach to characterize the local setting and as a basis for the impact assessment.

2.0 METHODOLOGY

This assessment included a background information review to characterize the site setting, detailed site-specific fieldwork to characterize local conditions and the use of specific analysis methods for the water budget and impact assessment.

Standard hydrogeologic field and analysis methods are used for this study. The specific methodologies used for each step of the characterization and analysis are outlined in the respective Sections of this report.

2.1 INFORMATION REVIEW

As part of this study the following information sources were used:

1) Harrington McAvan Ltd.; *Kelly Pit Site Plan*.
2) Terrastory Environmental Consulting Inc.; December, 2020: *Natural Environment Report (Level I and II), Aggregates Resources Act Application, Kelly Pit, Municipality of Huron East.*
3) County of Huron interactive mapping website (https://www.huroncounty.ca/gis-services/interactive-mapping/)
4) Ministry of the Environment (MOE) water well records.
5) Ontario Base Map (OBM) 1:10,000 series topographic mapping.
6) MNRF, Land Information Ontario, 2015 SWOOP Orthophotography derived elevation data; available online at: https://geohub.lio.gov.on.ca/.
7) Ontario Geological Survey OGSEarth published geological mapping (KML files viewed using Google Earth®); available online at: http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth.
8) Ausable Bayfield Maitland Valley Drinking Water Source Protection studies as available online (www.sourcewaterinfo.on.ca).
9) Ministry of the Environment Conservation and Parks (MECP) Source Protection Information Altas online mapping application; available at: https://www.ontario.ca/page/source-protection.
10) Maitland Valley Conservation Authority 2018 Watershed Report Card.

Additional general references used are noted in the text of this report.

The description of the regional setting is compiled from the above referenced sources, including the Ausable Bayfield Maitland Valley Drinking Water Source Protection Plan and supporting documents. The description of overall (subwatershed scale) natural environment features is summarized from the Maitland Valley Conservation Authority (MVCA). Local scale natural environment information is based on the NER completed for the Kelly Pit (Riverstone). Site-specific geologic and hydrogeologic information was obtained as part of this study.

3.0 BACKGROUND REVIEW

The local site setting is shown in **Figure 2**. The pit (extraction) area consists of the majority of the property.

3.1 QUATERNARY GEOLOGY

Physiographic mapping available indicates the site is situated within a north-south trending Esker deposit which extends north from a Kame Moraine deposit (located south of the site). The kame and eskers are set within a Till Plain. Local gravel pits are centered on the sequence of eskers in this area.

Surficial geology mapping is included in **Appendix A**. The site is identified as situated within Ice-contact stratified deposits, described as sand and gravel with minor silt, clay and till. Eskers are identified within the Ice-contact deposit at and near the site. Some Glaciofluvial deposits (river deposits and delta topset facies, sandy) are mapped north and southeast of the site, within the Ice-contact deposit.

Till deposits, described as sandy silt to silty sand-textured till on Paleozoic terrain, are mapped at surface both east and west of the surficial sand/gravel deposits. Organic deposits of peat, muck and marl are mapped at surface near southwest corner of the site. Fine-textured glaciolacustrine deposits (silt and clay, minor sand and gravel, massive to well laminated) are mapped east of the site.

Based on the setting, the till unit is expected to underlie the surficial sand/gravel deposits (Ice-contact and Glaciofluvial), in addition to the Organic and glaciolacustrine deposits.

3.2 BEDROCK GEOLOGY

The underlying bedrock at the site is Paleozoic Limestone deposits of the Detroit River group of the Lucas Formation. Based on the water well record review (**Section 3.5**), depth to bedrock varies from approximately 27 to 70 m in the immediate area of the site.

3.3 NATURAL ENVIRONMENT FEATURES

On-site and local natural environment features are shown and described within the Natural Environment report (Terrastory). A copy of the Terrastory Biophysical Features and Conditions figure is included in **Appendix A** for reference. A copy of the existing approved Rehabilitation Plan is also included in **Appendix A** for reference.

Within the existing licence boundary there is currently an active gravel pit extraction area, and, adjacent woodlots and fields (see **Appendix A**). The existing approved extraction plan for the site includes extraction over the entire licenced area (apart from a 15 m perimeter set-back), including on-site woodlots and fields. The approved rehabilitation plan includes some remnant woodlot along the north and south boundaries (within the 15 m set-back), with the remaining area in agricultural use (pasture). However the proposed new extraction and rehabilitation plan would reduce the extraction footprint in order to protect woodlots and wetlands on-site. Further discussion regarding the proposed extraction is included in **Section 6.0**.

There are no natural surface water courses (e.g., lakes, rivers, brooks), or springs, within the existing License boundary or within 120 m of the site. There are several constructed features, as described below.

Wetland areas are mapped at the southwest corner of the site (NER Southern Wetland) and along the northeast site boundary (NER Northern Swamp and Forest Complex). These wetlands occur primarily off-site, however also extend into the licence boundary.

The Southern Wetland is mapped within woodlot areas on-site and adjacent to the site, and is described as a mixed swamp (SWM) south of Browntown Road. Within the woodlot adjacent to the site the wetland is described as a poplar mineral deciduous swamp (SWDM4-5) with a small area of graminoid mineral meadow marsh (MAMM-1). These wetlands occur at the mapped transition boundary between the off-site Till/Organic deposits and the on-site Esker deposit in this area.

A drainage system has been constructed within the Southern Wetland on-site, starting with a small dug pond which drains to a small ditch flowing northward off-site and into a small water retention area (corresponding to MAMM-1). This system is connected to a (buried) tile drain within the adjacent agricultural field immediately west of the licence, and flows northward. The small dug pond at the head of the system is the site of an upwelling discharge area (spring) and flow appears perennial within the small ditch. This water enters the water retention area and infiltrates (to the tile drain system), there is no surface outflow.

The Northern Swamp and Forest Complex is mapped within the woodlot areas on-site and extending northward. The wetland is described as Green Ash Mineral Deciduous Swamp (SWDM2-2) and Swamp Maple Mineral Deciduous Swamp (SWDM3-3). This wetland system occurs within the mapped Ice-contact/Glaciofluvial (primarily sand/gravel) deposits in this area. However monitor installation and soil testing, as described in **Section 4**, indicates that the organic soils within the wetland area are underlain by silt/clay (which is a more infrequent component of the Ice-contact deposit).

Several constructed ditches occur in this area to convey (seasonal) standing water within the pit and along the site edge. One ditch (near MW1, as described in **Section 4.2**) extends through the active pit perimeter berm in this area. One ditch, located further north, extends parallel to the perimeter berm. Some seasonal surface water collects within low areas of the wetland, and flows generally north through the wetland complex.

There are two constructed (aggregate extraction) ponds east of Molesworth Line and within 120 m of the site. One pond is located north of Browntown Road (Weber Pit pond) and one is located south of Browntown Road (Jacklin Pit 2 pond). The Weber Pit pond is the result of historical extraction (now complete). Extraction is ongoing at the Jacklin Pit.

A channelized (straightened) agricultural drainage course occurs further east of the site, at a distance of just over 120 m. The channel is located with the mapped Glaciolacustrine (silt/clay) deposits mapped in this area. This unnamed drainage channel flows northward, crossing Molesworth Line approximately 360 m northeast of the site and subsequently joining a small tributary of the south branch of the Little Maitland River. The overall study area is located within the Little Maitland Watershed as identified by the MVCA

The MVCA report cards for the Little Maitland Watershed provide generalized information, however indicates that on a watershed basis that surface water quality is rated as “fair”, forest conditions also as “fair” and wetland quality as ‘good”.

3.4 TOPOGRAPHY AND DRAINAGE

Please refer to the Site Plan for specific topographic information at the property. Local topography is also shown on **Figure 2**.

The highest ground surface elevations on-site occur along the eastern boundary of the property, as shown in **Figure 2**, and represent the original esker height. This height of land appears to be extended northward by a constructed perimeter berm (part of normal site operations). This boundary would act a drainage boundary at the site. Maximum ground surface elevations along the esker are approximately 364 metres above sea level (mASL). The lowest ground surface elevation at the site occur at the existing pit floor near the northern portion of the property, at approximately 348 mASL.

The surrounding natural topography along the boundary of the site ranges from approximately 359 mASL at Molesworth Line, to 349 - 352 mASL within the agricultural field west of the site, to 347 - 350 mASL within the wooded areas along the north edge of the site. The land surface slopes generally westward in the area.

Surface water runoff at the site follows topography. Most runoff within the existing working pit is retained on-site by perimeter berms or slopes. However some local pit floor drainage ditches exits via the constructed ditch at the east site edge. Existing runoff within the southern portion of the site is retained in the woodlot within the southwest corner of the property. The existing approved extraction and rehabilitation plan would direct most runoff within the licenced area to the pit floor and provides for one drainage outlet along the northeaster site edge, at an elevation of approximately 348 mASL. The proposed licence amendment would reduce the extraction area footprint and potential extraction related changes to on-site drainage. Additional discussion is provided in **Section 6.0**.

3.5 PRIVATE WATER WELLS AND LOCAL GROUNDWATER USE

There is only one residence located within 500 m of the site (Weber Pit property). As part of the field assessment for this study the homeowner of the property was interviewed. The owner indicates that the residence and farm is supplied by a shallow dug well located near the farm buildings.

The reported ground surface elevation near the buildings ranges from approximately 354 to 357 mASL. The Weber Pit pond elevation was determined to be 349.8 mASL at the time of survey, which also reflects the local water table elevation. Based on the elevations, the dug well intercepts the water table in which the Weber Pond is developed.

MECP well records with reported locations in the general area of the site were also examined to assess local water supply. Reported water well locations, based on MECP well records, are shown on **Figure B1** and summarized in **Table B1** in **Appendix B**. A total of 15 well records are reported within the review area, which extends more than 500 m from the site.

Of the 15 well records reviewed, 2 are abandonment records (both for drilled wells). In addition, 3 records represent water table monitors installed at the site as part of this study.

The remaining records indicate all of the reported existing wells are deep drilled wells completed in the confined bedrock aquifer.

Based on the records, depth to bedrock varies in this area from 14 to 70 m (below ground surface). Reported total well depths vary from 24 to 77 m and static levels vary from 0.6 to 5.2 m depth. All the wells reviewed are reported to be used for either domestic or stock (farm) water supply (or both).

The well record information at and near the site generally confirms the geologic setting discussed in **Sections 3.4** and **3.5**, consisting of surficial sand and gravel, overlying a till sequence that extends to bedrock. Occasional sand/gravel layers were encountered at depth within the till sequence.

3.6 WELL HEAD PROTECTION AREAS

There are no well head protection areas in the immediate area of the site, as identified by the Ausable Bayfield Maitland Drinking Water Source Protection and MECP Source Protection Information Atlas mapping websites. A map showing local source protection status is included in **Appendix A**. There are is no designated WHPA-Q in the area of the site. Designated Significant Recharge Areas and Highly Vulnerable Aquifer Areas are identified south of the site, however do not extend onto the Kelly Pit.

4.0 FIELD WORK

The on-site fieldwork completed for this assessment included site inspections, borehole drilling, monitor well construction, elevation survey of the monitor wells, response tests and monitoring of water levels. Water level measurements are ongoing.

4.1 SITE INSPECTION

Site inspections began in July 2019. The initial site visits involved identification of surface water features, and to determine drilling locations.

4.2 BOREHOLE DRILLING AND MONITOR INSTALLATION

On August 8th 2019, three boreholes were drilled at the site by Aardvark Drilling Inc., under supervision of Groundwater Science. Drilling was completed using the hollow stem auger and split spoon drilling and sampling method. Samples were collected at 1.5 m intervals for the entire depth of each borehole. Upon completion, nominal 5.1 cm diameter PVC monitoring wells with 3 m long 10 slot screens were constructed in each of the three boreholes.

In order to assess groundwater-surface water interaction at the pit/wetland boundaries, 3 drive-point piezometers (DP1, DP2 and DP3) were installed in September 2019. The drive-point piezometers were installed by hand and consists of 0.3 m long nominal 3 cm (1.25 inch) diameter stainless steel manufactured screen (drive-point) and galvanized pipe riser. The piezometer were installed to allow measurements of both groundwater (GW - inside the pipe) and surface water (SW - outside of the pipe) levels.

The monitoring wells and drive-point piezometers were purged (developed) for several minutes to ensure that the screens were producing water with minimal sediment. Each of the monitoring wells produced water and could be pumped continuously. The three wells were then response tested (see **Section 4.4**).

Drive-points DP1 and DP2 recovered very slowly and could not be response tested. Based on the installation and development, these two locations are installed within silty/clayey material below the wetland organic soils. Drive-point DP3 also responds slowly, however is seasonally dry and could not be response tested. Soil sampling using a hand auger was undertaken at DP3 and at the adjacent discharge area. Within the wetland surficial organic soils were underlain by silty sand till and clay. Similarly, soil sampling within the discharge (pond) area indicated silty sand till underlain by clay.

A level survey of each monitor and the discharge area (spring) was completed relative to reported Site Plan elevations. In addition, the pond elevations at the adjacent Weber Pit and Jacklin Pit were surveyed on November 5, 2020.

The borehole and piezometer locations are shown on **Figure 3**. Borehole logs and elevation survey details are provided in **Appendix C**.

4.3 WATER LEVEL MONITORING

Routine monthly water level monitoring began at the site in August 2019. Water level measurements are summarized in table and hydrograph format in **Appendix C**. Measurements were obtained by Groundwater Science Corp. personnel as depth to water

below top of well casing using a Heron Instruments® electronic water level tape and recorded in the field. Measurements are currently ongoing.

The discharge (spring) elevation was surveyed to be 349.3 mASL. The elevation of the associated small pond was surveyed to be 349.5 mASL. The pond level appears to be relatively consistent, controlled by the elevation of the drainage ditch. No surface water was observed over the monitoring period at DP3 or in the wetland surrounding the discharge pond and drainage ditch. Water levels at DP3 vary from near ground surface in early spring, to well below ground surface (DP3 is dry) by July.

On November 5, 2020 the Weber Pit and Jacklin Pit ponds were surveyed to be 349.8 and 350.1 mASL respectively. These two ponds appear to have a slight seasonal variation, high (spring) levels appear to be approximately 20 cm higher.

A water table high was noted at the site in March 2020. High water table contours for the site, based on the March 2020 measurements, and adjacent pit pond (high) levels, are provided in **Figure 4**. The low water table was noted at the site in October 2019. Additional discussion regarding water levels at the site is provided in **Section 5.0**.

4.4 RESPONSE TESTS

After the on-site monitors were developed, response tests were completed to estimate the hydraulic conductivity (K) of the unconfined aquifer. The tests were completed on June 2, 2020 as falling head (slug) tests using dataloggers set to a 1 second sampling frequency and a slug of known volume. Tests were completed at all 3 monitoring wells, which represent the sand and gravel unit at the site. The response data was analyzed according to the Bouwer and Rice method using the AQTESOLV® computer analysis program.

The test analysis plots are included in **Appendix D**. The response test analysis is summarized in **Table 2**.

Monitor	Estimated Hydraulic Conductivity (m/s)
MW1	8.2×10^{-5}
MW2	4.8×10^{-5}
MW3	5.6×10^{-6}

Table 1: Response Test Results

Based on the results the sand and gravel unit can be considered to have a bulk (geometric mean) hydraulic conductivity value in the range of 2.8×10^{-5} m/s.

5.0 HYDROGEOLOGIC SETTING

The hydrogeologic setting is discussed in context of the reported regional and local geologic conditions, occurrence and location of surface water features in the area, and, the results of the site-specific investigation completed for this study.

The site consists primarily of a sand and gravel esker deposit which runs in a southeast to northwest direction through the area. Regionally, there are numerous esker deposits with a similar orientation cutting through a regional till plain.

In order to illustrate the hydrogeologic setting four schematic cross-sections have been developed through the site. The section locations are shown on **Figure 5**. The sections arte included as **Figure 6**, **Figure 7**, **Figure 8** and **Figure 9**.

Regional Section A (**Figure 6**) runs southwest to northeast, along Molesworth Line. The section illustrates the local topography, including the original projected esker surface, the geologic sequence and depth to bedrock. The overburden consists primarily of a till aquitard sequence that extends to bedrock. The surficial deposits as shown are based on the well record information, on-site drilling and installation results, and geologic mapping. As shown, relatively thin ice-contact sands/gravels occur at surface southeast of the site. Near the site, at DP3, there is a transition between the surficial sand/gravel, the underlying till, and the overlying organic deposits of peat/muck/marl. The sand/gravel may underlie portions of the organic deposit. The Southern Wetland (at DP3) is developed on silty/clayey soils associated with the organic peat/muck/marl (and till) deposits mapped in this area.

On-site the esker deposit will thicken to depth (as indicated by site drilling results and adjacent below water extraction). These deposits then transition to the glaciolacustrine and till deposits northeast of the site. At the site the Northern Swamp and Forest Complex is also developed on localized organic soil and fine grained deposits overlying the sand and gravel, however as noted previously, transitions to the glaciolacustrine/till deposits further north of the site.

Regional Section B (**Figure 7**) runs northwest to southeast through the site and adjacent Weber Pit. As shown, till is mapped at surface northwest of the site. The esker deposit sits on, and within, the till unit. The esker depth is illustrated by the Weber Pit pond depth. The ice-contact sand/gravel unit is mapped as extending southeast of the site, however is overlain by glaciolacustrine deposits near the drainage channel.

Local Section C (**Figure 8**) shows site-specific conditions and runs along the length of the site from DP3 to DP1. The proposed extraction would remove sand and gravel from the esker deposit, which is sitting within the till sequence. The exact transition boundary between the sand/gravel and till deposits along the southwestern edge (left hand side of the section) is unknown, however extraction would not extend within the till unit. As shown, the Southern Wetland, and associated discharge area, is developed on the silt/clay associated with the mapped organic soils and till deposits.

Water levels at DP3 vary seasonally from near ground surface and above the discharge elevation (in spring), to well below the discharge elevation (piezometer is dry in early summer). No surface water is observed near DP3. Therefore the DP3 area is “drained”, likely by a combination of the discharge area/ditch and tile drain system flowing north to

the adjacent agricultural field, and, by the underlying or adjacent sand and gravel (esker) deposit. The discharge area is maintained by a localized flow system within the fine grained (till and organic soil) deposits that extend into the site.

Based on observed conditions at DP1 (and DP2) the Northern Swamp and Forest Complex is developed on silty/clayey soils. Water levels at DP1 vary from above ground surface in the spring to well below ground surface in summer/fall periods. Some seasonal surface water occurs in this area in April and May, however by late May this area is noted to dry out. Therefore this area is also "drained", likely by the underlying sand/gravel unit.

Local Section D (**Figure 9**) shows site-specific conditions and runs from the Weber Pit pond to DP2. The proposed extraction would remove sand and gravel from the esker deposit, but would not extend "into" the till sequence. Based on observed conditions at DP2 the Northern Swamp and Forest Complex is developed on silty/clayey soils. Water levels at DP2 vary from above ground surface in the spring to well below ground surface (drive point is dry) in summer/fall periods. Some seasonal surface water occurs in this area in April, however by May this area is noted to dry out. Therefore this area is also "drained", likely by the underlying sand/gravel unit. Although some discharge potential is shown under highest water level conditions (one measurement in April), no actual discharge (e.g. spring or seepage) was observed, and, the condition is short-lived.

The water table occurs within the sand and gravel deposit at the site. The water table mapping indicates a flow direction of southeast to northwest from the gravel pit ponds south/southeast of the site, through the esker, and off-site near MW2 and DP2.

Based on the setting the esker system may provide a preferential flow pathway and "drain" the local shallow groundwater system (e.g. water table elevations within the adjacent till deposits may be higher). This is reflected in the need for a tile drainage system within adjacent agricultural fields west of the site, at elevations above the existing (dry) pit floor.

Based on the setting the esker deposit appears to act as a groundwater recharge area, contributing to flow off-site to the east/northeast. Groundwater flowing off-site may assist in maintaining soil moisture through the spring and early summer. Some groundwater may discharge to surface further north of the site, however no discharge or channelized flow is observed within near the site.

6.0 PROPOSED EXTRACTION

For details regarding existing site conditions or the extraction plan (including the proposed sequence of extraction) please refer to the Site Plan. An excerpt of the rehabilitation plan is included in **Figure 10** for reference.

The proposed Licence area is would remain unchanged, at 11.67 hectares (ha). The currently approved extraction limit would be reduced, allowing for increased set-back from the Southern Wetland and Northern Swamp and Forest Complex. Set-backs increase from the existing approved 15 m to the recommended 30 m (NER, Terrastory), resulting in an extraction area of 7.5 ha.

Below water extraction would occur over most of the site, creating a single final pond. Below water table extraction would extend to approximately 344 mASL. The pond would be approximately 4.9 ha in size.

Any fuel handing and use on-site would conform to all applicable regulations and standards. Similar to existing operations, no fuel storage is proposed at the site.

There are also no proposed new water diversion, discharge, storage or drainage facilities on-site. All drainage within the proposed extraction area would be directed toward the pit floor and/or pond. Drainage outside the proposed extraction area would be left undisturbed.

7.0 MAXIMUM PREDICTED WATER TABLE REPORT

The proposed extraction would occur within unconsolidated surficial sand and gravel deposits. Therefore the following definitions are used:

> *"ground water table" means*
>
> *a) for unconsolidated surficial deposits, the ground water table is the surface of an unconfined water-bearing zone at which the fluid pressure in the unconsolidated medium is atmospheric. Generally, the ground water table is the top of the saturated zone.*
>
> *"maximum predicted water table" means the maximum ground water elevation (metres above sea level) predicted by a qualified person who has considered conditions at the site and mean annual precipitation levels.*

The water table at the site was measured and determined by the installation of 3 water table wells and 3 drive-points. The measured water table at the site corresponds to the top of the saturated zone within the unconfined surficial sand and gravel aquifer.

At the Kelly Pit site the maximum predicted water table elevation is shown on **Figure 4**. and represents the seasonal high water levels measured at the site. The maximum predicted water table elevation varies across the proposed extraction area from approximately 350.5 mASL near MW3 to approximately 347.2 mASL at MW2.

Within the proposed pond below water extraction area the maximum predicted water table varies from approximately 348 to 350 mASL relative to a proposed depth of extraction of 344 mASL. The anticipated final pond level in this area is approximately 349 mASL, therefore the maximum anticipated pond depth is 5 m.

Within the remainder of the site extraction is to remain above the predicted maximum water table.

8.0 WATER REPORT LEVEL 1

The purposed of the Water Report Level 1 is to identify if the site is within a WHPA-Q area (and identify if related Source Protection Policies should be implemented), and, to determine the potential for adverse effects to groundwater and surface water resources and their uses (e.g. water wells, ground water aquifers, surface water courses and bodies, springs, discharge areas).

The site is not located within an identified WHPA-Q area as set out in an applicable source water protection plan under the Clean Water Act.

Based on the new proposed extraction footprint, the on-site portion of the Southwest Wetland remain undisturbed. The man made drainage system in that area (discharge area and drainage ditch flowing toward the off-site graminoid mineral meadow marsh) would also be maintained. The drainage system, and groundwater flow supporting the discharge area, is developed within the till and organic soil deposits. As long as the extraction does not extend into the till and/or organic soil deposits, there would be no impact to the spring, graminoid mineral meadow marsh or overall wetland system.

The proposed new 30 m set-back from the Southwest Wetland likely provides enough buffer to ensure the fine grained soils are not disturbed. In addition, if during the extraction fine grained soils are encountered it is expected that extraction would not continue in that area (the operations are to extraction sand and gravel, silt and clay are not useable products for the Municipality). To ensure the fine grained soils are not extracted in this area, and to ensure conditions at the Southwest Wetland are maintained, the following Site Plan note is recommended:

- *Extraction shall remove sand and gravel resources at the site, and shall not extend into the silt/clay till deposits or organic soil deposits near the Southwestern Wetland.*

Based on the size and location of the proposed pond, no overall change in site-scale groundwater flow direction would be anticipated. Some local changes along the perimeter of the pond may occur. These changes would include a decline in average water table elevation along the upgradient (southern) edge of the pond, and, an increase in average water table elevation along the downgradient (northern) edge of the pond. We note that the Northern Swamp and Forest Complex is located downgradient of the pond therefore groundwater flow and contribution to the wetland area will be maintained.

Potential physical changes to the groundwater system related to the proposed amendment that should be assessed include: temporary water table effects during below water table extraction; long-term changes to the water table at the upgradient edge of the proposed pond; and, changes in the overall site water balance due to the extraction.

There are no thermally sensitive features downgradient of the pond, therefore there are no potential thermal impacts related to the proposed extraction.

To assess the significance of potential on-site water table effects due to the proposed extraction on water wells and natural environment features in the area of the site, a Water Report Level 2 evaluation is required. The Level 2 evaluation is included as **Section 9** of this report.

9.0 WATER REPORT LEVEL 2

The Level 2 evaluation is completed to examine issues related to the potential for the proposal to affect the local water table or water balance at the site. In addition, any potential related impacts to local aquifers, water wells and natural environment features are also assessed.

9.1 POTENTIAL IMPACTS

The potential for impact is examined in the context of the site setting, existing extraction and proposed new extraction.

9.1.1 Site Water Balance

The water balance assessment area consists of lands within the proposed revised extraction area (7.5 ha). Water balance calculations are included in **Appendix E**.

Under existing conditions the proposed extraction area includes approximately 5.7 ha of current extraction (working) area where all runoff is retained. The remaining 1.8 ha is primarily wooded undisturbed area. The undisturbed area has some potential to generate runoff, some of which would flow into the on-site woodlot.

After the proposed extraction and rehabilitation, all overland flow within the extraction area would be directed toward the ponds.

The water balance is based on long-term average climate conditions (1981 – 2010 Climate Normals) reported by Environment Canada for the nearby Blyth station. The average annual precipitation is approximately 1,246.9 mm/year.

Evapotranspiration rates for existing and future land surfaces are calculated using the Thornthwaite and Mather method, assuming a Soil Moisture Retention of 300 mm (representative of closed mature forest on fine sand soil). The annual evapotranspiration rate at the site is estimated to be 579.75 mm/yr, which compares well with reported Source Protection assessment values.

The free water surface (pond) evaporation rate of 593.28 mm/yr is estimated based on the calculated Potential Evapotranspiration (PET) rate. For comparison a lake evaporation estimate is also provided, based on the calculated values from the United States Department of Commerce National Oceanic and Atmospheric Administration (NOAA), using values for Lake Huron, for the same long-term normal period (1981 to 2010). The relevant NOAA publication is: *Great Lakes Monthly Hydrologic Data, NOAA Data Reports GLERL-26 (1983) and GLERL (1993 - ongoing)*. The PET value is greater than the reported lake evaporation rate, therefore is used as a more conservative estimate for both pond evaporation and evapotranspiration within the wetland.

Runoff and infiltration rates within the remainder of the site (primarily farm fields) are estimated in accordance with MECP development application guidelines (*Hydrogeological Technical Information Requirements for Land Development Applications*, April 1995) and stormwater management guidelines (*Stormwater Management Planning and Design Manual*, March 2003).

Within the MECP methodology, the difference between precipitation falling on the assessment area (direct input) and evaporation/evapotranspiration (direct initial output) is

termed the water "surplus". Based on existing conditions (cultivate lands) the annual water surplus is estimated to be 667.15 mm/yr.

Surplus water within an assessment area can either infiltrate to recharge the groundwater system or form surface water runoff. Land surface runoff rates at the site are calculated according to the MECP development application guidelines methodology, which assigns an infiltration factor to apply to the water "surplus" in order to calculate recharge. The infiltration factor depends on individual factors related to topography, soil type and vegetation/cover. Based on a characterization of the woodlot (hilly esker edge, open sandy loam soil, woodland) an infiltration factor of 0.7 (70%) is estimated. The remainder of the surplus (30%) becomes runoff. Pit floor evapotranspiration is assumed to be equal to the vegetated surface rates.

Based on these factors, the existing average annual infiltration is estimated to be 0.619 m/yr (1.47 L/s at the site), which reflects the high recharge associated with current operations (runoff retention and open gravel pit floor). Average annual runoff is estimated to be 0.048 m/yr (0.11 L/s at the site).

After extraction all runoff would be retained within the site and directed toward the proposed pond. The total proposed pond area is approximately 4.9 ha in and is expected to experience evaporation rates higher than the current land surface evapotranspiration rate. The surrounding rehabilitated lands are assumed to be naturalized (tree and other vegetated cover). Based on the runoff retention and evapotranspiration/evaporation rates, the annual site recharge rate after rehabilitation is projected to be 0.658 m/yr (1.57 L/s at the site), which represents a slight increase in groundwater contribution (of 0.1 L/s).

On a site basis the proposed extraction would increase total groundwater recharge slightly, and therefore also slightly increase potential groundwater contribution to the local shallow groundwater system which supports downgradient wetland areas.

The change in runoff contribution to the woodlot on-site is relatively minor, and does not have the potential to change water availability within this area.

9.1.2 Temporary Water Table Effects

The below water excavation is expected to have a typical extraction rate is conservatively estimated to be on the order of 1,000 m^3/day. Actual extraction would likely be limited by demand or equipment used, and would likely be lower.

The removal of aggregate from below the water table results in an inflow of water to replace the solid material removed, forming a pond. As the aggregate is removed by excavator from the working edge of the pond, it is stockpiled adjacent to the pond and most of the retained groundwater drains back into the excavation. Using an average sand and gravel aquifer porosity of 0.3, 70% of the extracted volume is aggregate and 30% is groundwater. It is generally assumed that a water volume equivalent of 5% of the aquifer volume can be retained and removed with the aggregate, and 25% drains back into the excavation. Therefore an estimated total of 75% of the aggregate volume removed during excavation must be replaced by water inflow. The water filling the excavation can be groundwater inflow from the surrounding aquifer, direct precipitation or precipitation runoff from the surrounding area.

This effect is often analyzed as an equivalent pumping assuming all of the water flowing into the excavation is groundwater. However, it is important to note that little actual water is removed from the site. The "pumping" is essentially an intermittent transfer of water from the aquifer to the pond, generally resulting in a short-term water table decline in the vicinity of the excavation. Prior to extraction water is "stored" within the porosity of the sand and gravel deposit (generally assumed to be 30%). Once the aggregate is removed, the on-site storage volume increases within the extracted area (pond). The drawdown is short-term in that "recovery" occurs between excavation periods (overnight and on weekends); and, during rainfall recharge events.

Measurable drawdown at the pond and within the surrounding aquifer can occur in response to aggregate removal during the initial stages of extraction. However as the extraction pond enlarges and off-setting effects such as daily recovery and occasional precipitation recharge events begin to occur, actual drawdown at, and adjacent to, the pond becomes more difficult to measure. Once the pond is established the pond volume tends to buffer instantaneous pond level drawdown related to the aggregate removal. As a conservative approach for this impact analysis, it is assumed that below water extraction would occur on a continual basis for 60 days with no daily recovery or recharge events.

For the purposes of this discussion a theoretical maximum "equivalent pumping" effect at the proposed west pond was assessed using the Aqtesolv® pumping test analysis program. A forward Neuman unconfined aquifer analysis was completed using the following site-specific assumptions (in addition to the typical analytical assumptions associated with the Neuman method):

- aquifer thickness (b) of 5 m (pond depth), extends laterally in all directions;
- aquifer K = 2.8 x 10^{-5} m/s (from response test results), Kz/Kr = 0.1;
- T = Kb = 0.00014 m^2/s, S = 0.25 (drainable porosity);
- 60 day below water table extraction period, average pond depth of 5 m;
- below water table extraction of 1,000 m^3/day;
- groundwater inflow (75% of extraction volume) Q = 750 m^3/day (0.0651 m^3/min) averaged over 60 day extraction period;
- after 60 days pond area is 12,000 m^2, equates to a circle of radius 61.8 m;
- drawdown simulated using 8 wells (each 0.1 m radius) equally spaced along the outside of a circular "excavation pond" of radius 61.8 m, individual pumping rates of 0.0651 m^3/min;
- no precipitation recharge for analysis period.

The program output for the west pond is included in **Appendix F**. The drawdown analysis calculated the expected water level decline in an idealized aquifer at distances of 100 m, 150 m, 200 m, and 300 m from the excavation.

As illustrated by the analysis results, the expected drawdown within the aquifer system decreases with distance from the pond edge and will recover after the extraction ends each season. Note that the analysis does not include recharge, therefore the drawdown prediction as illustrated continues after the 60 day period, however we would expect recharge effects to moderate water levels over this period. Under the "worst case scenario" of 60 days of continual extraction at the pond and no recharge, the maximum

water table change at 100 m distance is projected to be approximately 18 cm. At additional distance no appreciable drawdown is projected over the 60 day period.

It is also important to note that the extraction pond represents an increase in storage, and there will be an increase in rainfall water volume retained on-site during fall and spring (outside of the annual operating period), specifically during snowmelt. This storage volume tends to reduce the daily response of the pond and water table to extraction.

9.1.3 Long-Term Water Table Effects

As the below water table extraction forms a pond, a level (pond) water surface replaces what was previously a sloping water table within the aquifer. In most cases the pond level is typically lower than the water table was on the upgradient side, and higher than the water was on the downgradient side. This typically causes a water table decline immediately upgradient of the pond and rise immediately downgradient of the pond. The magnitude of change is dependent on the final pond level, which in this setting would be the average of the original upgradient and downgradient elevations.

At the southern upgradient end of the pond a potential 1 m decline is expected. This water table effect will be largely confined to the esker deposit and would decrease rapidly with distance. The Weber Pit pond will act as a relative constant head boundary and maintain local water table levels. No impact would be expected further from the site.

As noted previously, water conditions at the discharge area and within the Southwestern Wetland will be maintained by limiting extraction in that area (proposed 30 m set back and Site Plan note to ensure till or organic deposits in this area are maintained).

A corresponding water table increase can be expected on the north edge of the pond. This water table increase may result in some localized increase in groundwater availability and/or increased flow potential along the esker and into the adjacent wetland areas.

9.1.4 Potential For Impact To Water Wells

Based on the setting, scale of projected groundwater volume and level changes, and, reported construction most private wells in the area (at depth in the confined bedrock aquifer), there is no significant potential for negative impacts to local water supplies at deep drilled wells. The one reported dug well is located east of the Weber Pit pond, and will be “protected” from water level changes by that pond.

To provide assurance that local water supplies are protected we recommended that the standard water well interference protocol existing between MNRF and MECP (to ensure water supply interruption complaints are investigated and that local water supplies are maintained) be referenced on the Site Plan.

9.1.5 Potential For Impact to Natural Environment Features

The proposed above water table extraction will increase local groundwater recharge at the site. Therefore overall groundwater flow volumes toward the Northern Swamp and Forest Complex will be maintained (and increased slightly). In addition, based on the setting no disruption to water availability at the Southwestern Wetland is expected.

Based on this assessment, there are no significant potential impacts to local natural environment features anticipated with the proposed extraction.

9.2 MONITORING, MITIGATION AND CONTINGENCY PLAN

The following limitation on extraction within the southern portion of the site should be listed on the Site Plan:

> *Extraction shall remove sand and gravel resources at the site, and shall not extend into the silt/clay till deposits or organic soil deposits near the Southwestern Wetland.*

The following general private water supply protection recommendation should be listed on the Site Plan:

> *Where the Ministry of Natural Resources and Forestry with the assistance of the Ministry of the Environment Conservation and Parks, according to existing water well interference complaint protocols, has determined that the operation of the pit has caused any well water to be adversely affected, the licensee shall, at the licensee's expense, either deepen the well or replace the well to ensure that historic water production quality standards are maintained for that well. If this pit operation has caused a water supply problem, the licensee shall, at their expense, ensure a continuous supply of potable water to the affected landowner.*

The following monitoring plan is recommended to be shown on the Site Plan:

1. *Water level measurements shall be obtained at the existing on-site monitoring well locations (as accessible) MW1, MW2, MW3, DP1, DP2 and DP3 on a quarterly basis during the first three years of below water operations.*
2. *At the end of three years of monitoring the data shall be summarized in a report provided to the Ministry of Natural Resources. The monitoring program shall be discontinued if no groundwater impacts are observed after 3 years.*
3. *The monitoring data shall be summarized in an annual report provided to the Ministry of Natural Resources and Forestry.*

Based on the limited potential for groundwater impact, no specific mitigation or contingency plans are recommended at this time (other than the well interference protocol listed above). Mitigation and contingency plans would be developed to the satisfaction of MNRF as needed if groundwater impacts are observed.

10.0 CONCLUSIONS

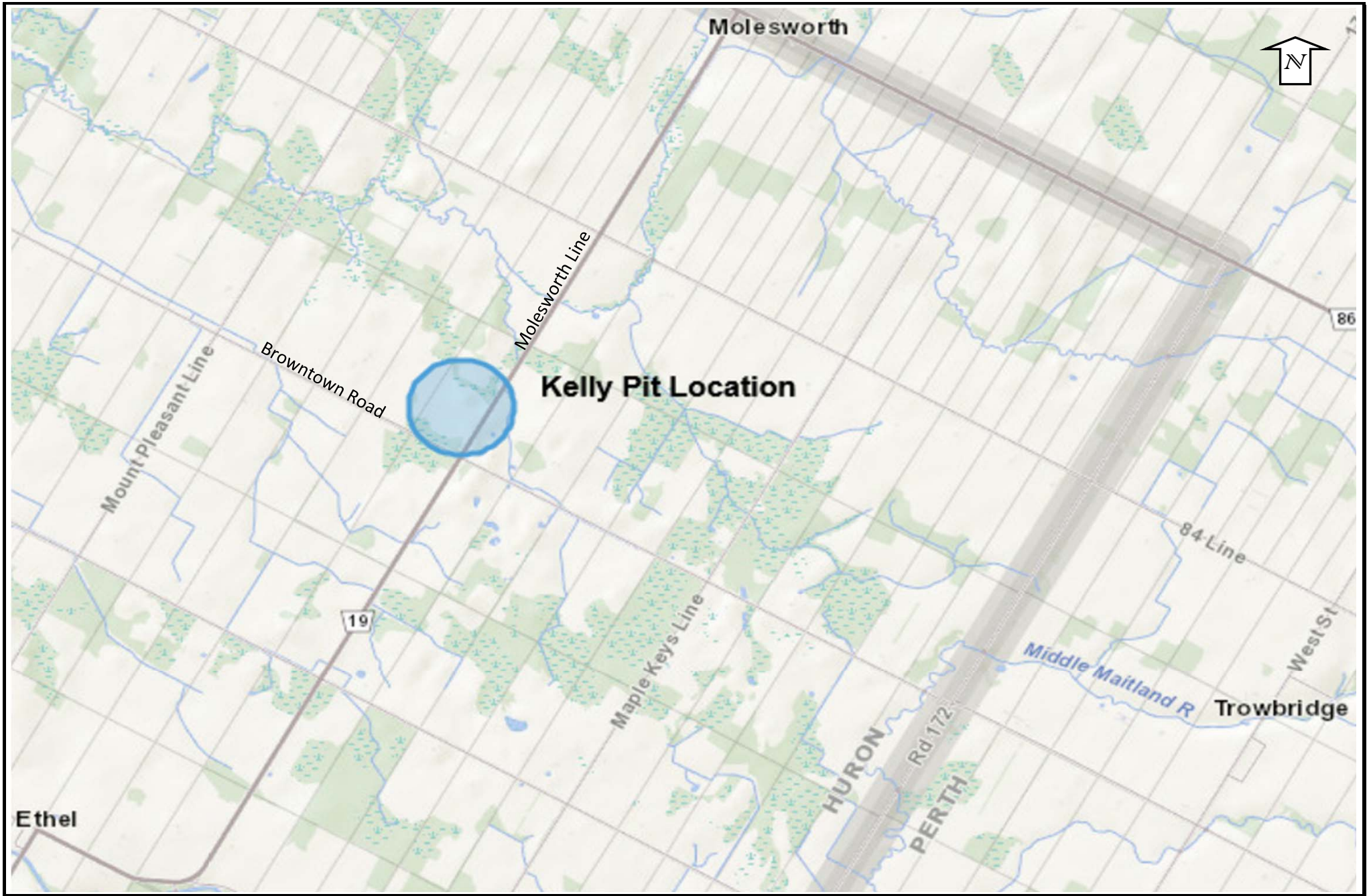
Based on the results of the impact assessment, and, proposed monitoring and mitigation plan, there are no potential for significant adverse effects to groundwater and surface water resources and their uses; and, there is no potential for significant impacts to local groundwater aquifers, natural environment features or water supply associated with the proposed Kelly Pit.

All of which is respectfully submitted,

David Nahrgang, P.Geo.
Project Hydrogeologist
Groundwater Science Corp.

Andrew Pentney, P.Geo.
Senior Hydrogeologist
Groundwater Science Corp.

Figures



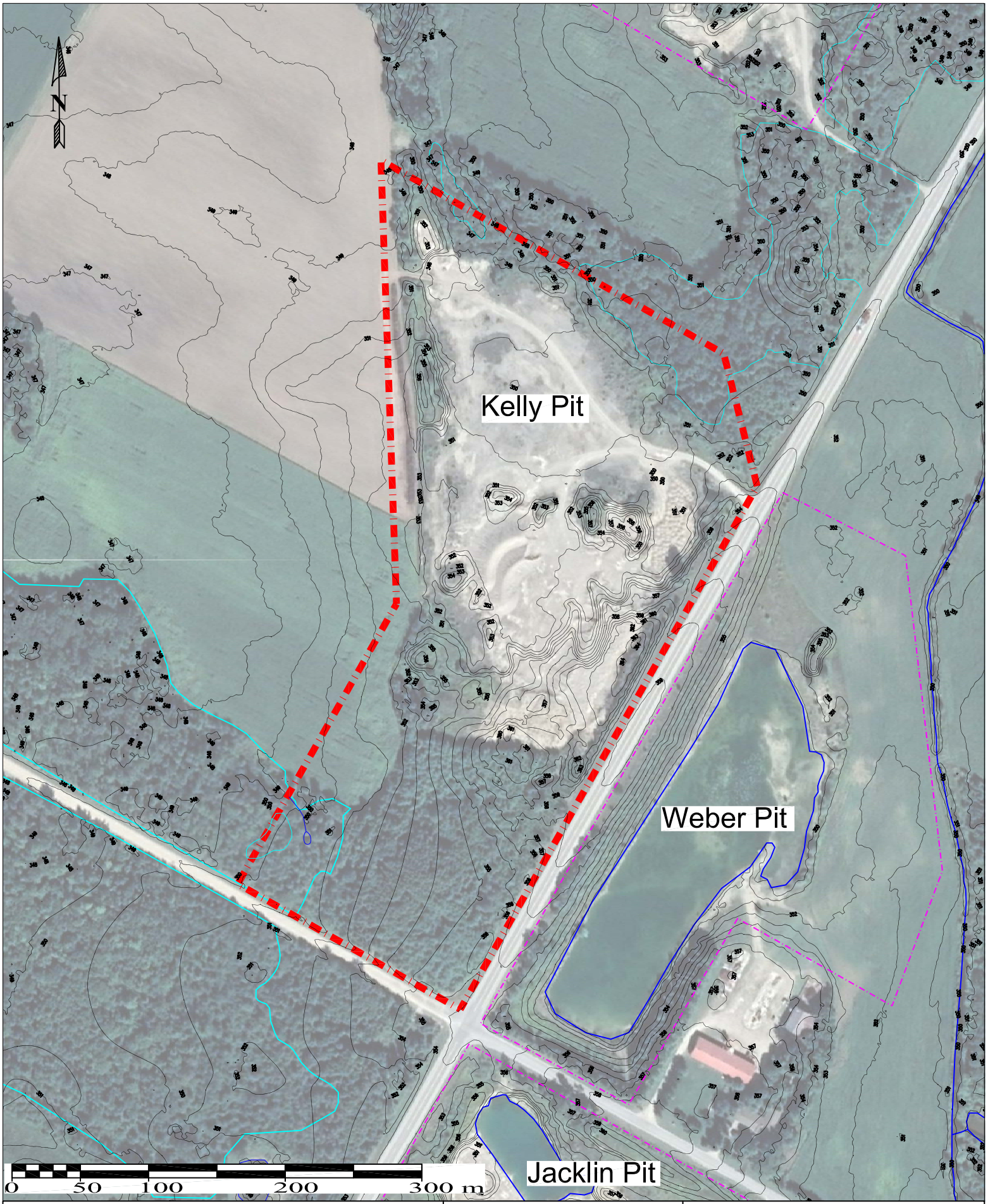
compiled from:
https://www.ontario.ca/page/make-natural-heritage-area-map

Date: December 2020
scale: not to scale

Figure 1: Site Location

Groundwater Science Corp.

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment



stream, pond

wetland (MNRF, Terrastory)

Kelly Pit Licence (approx)

Other Pit Licences (approx)

contours (mASL) as shown

air photo: Google Earth

modified from: OBM, SWOOP 2015

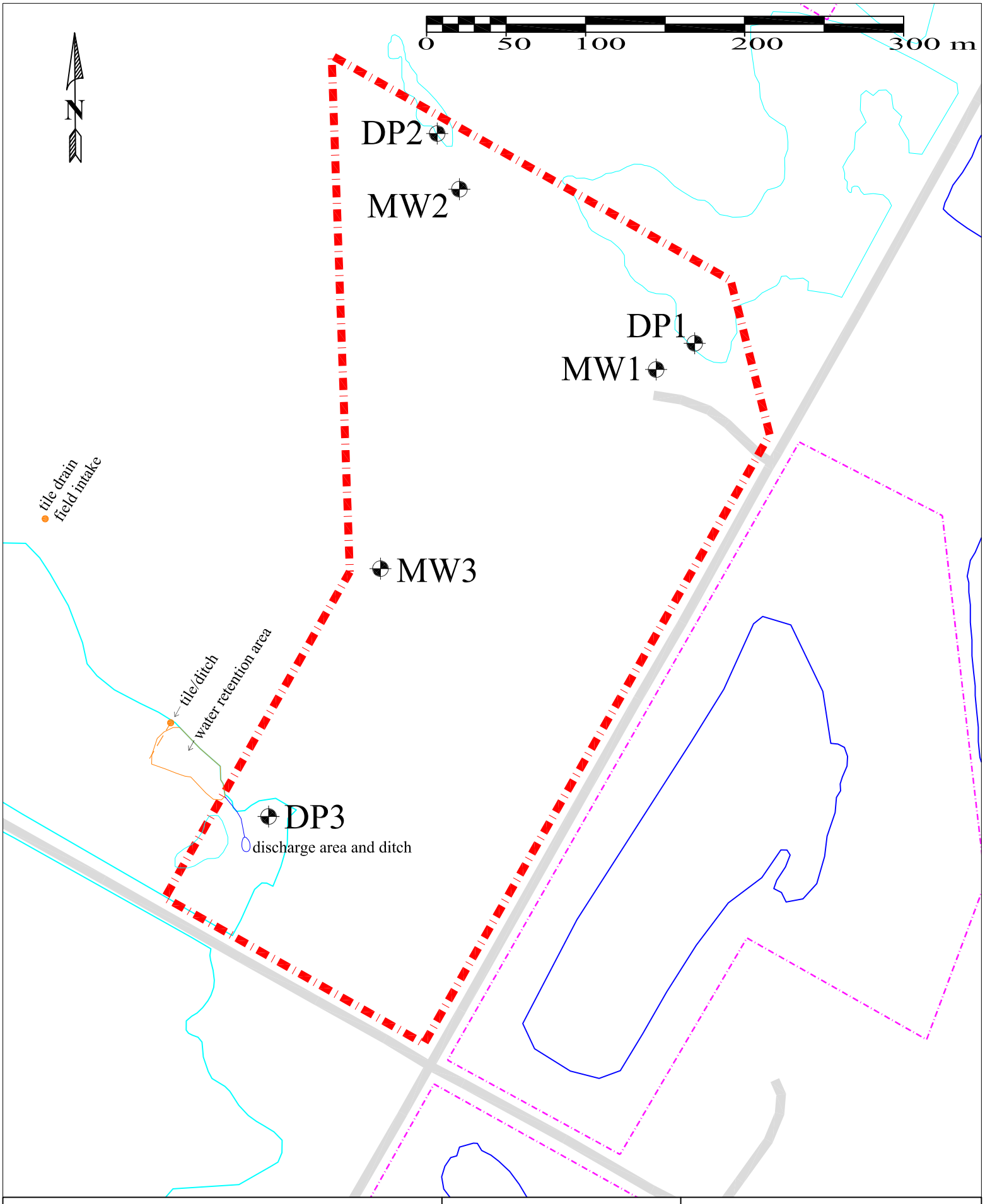
December 2020

Scale: as shown

Groundwater Science Corp.

Figure 2: Site Setting

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment



stream, pond

wetland (MNRF, Terrastory)

monitor location and reference

modified from: OBM mapping

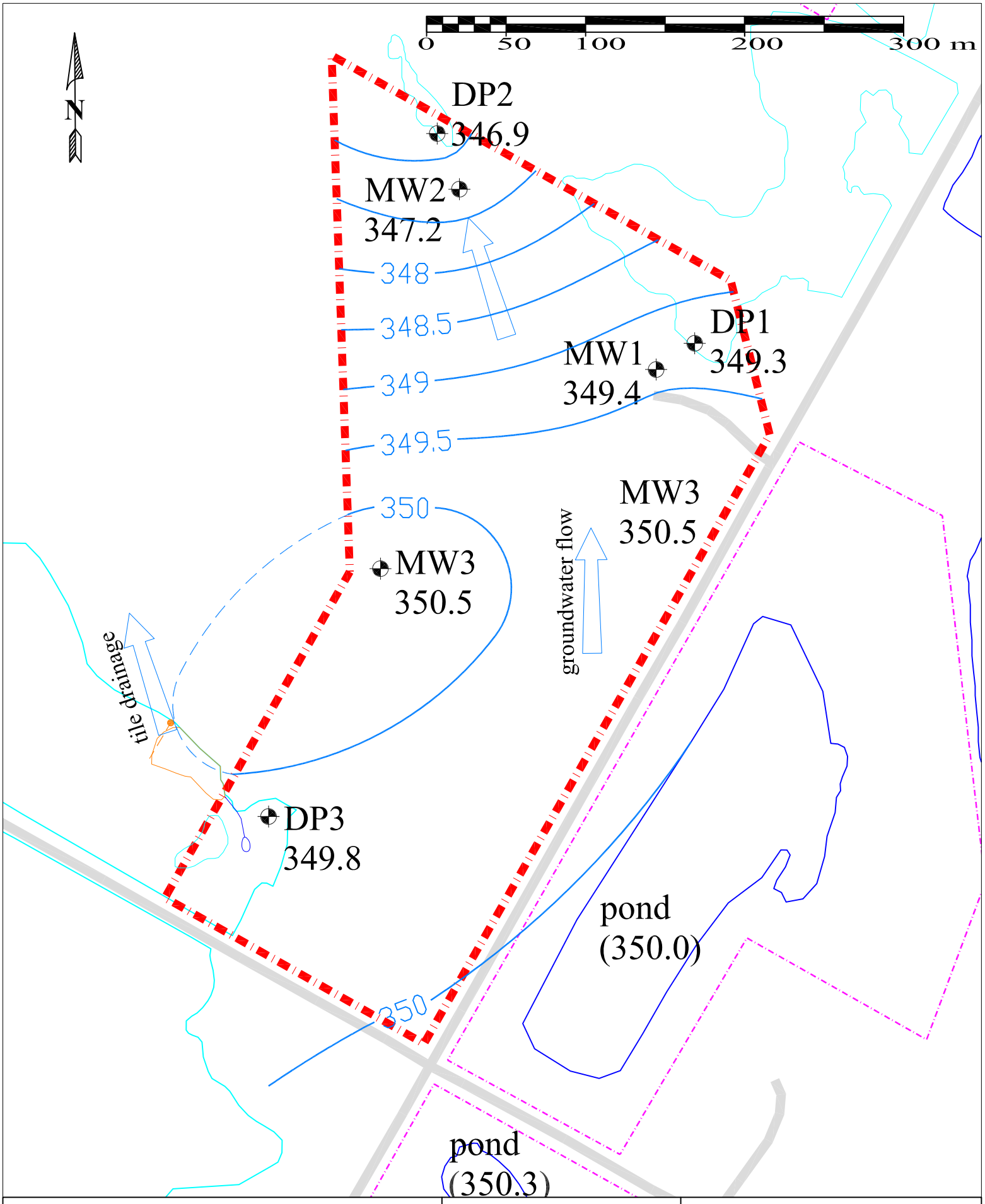
December 2020

Scale: as shown

Groundwater Science Corp.

Figure 3: Monitoring Locations

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment



stream, pond — water level elevations as shown (mASL)

wetland (MNRF, Terrastory)

projected water table contours (mASL)

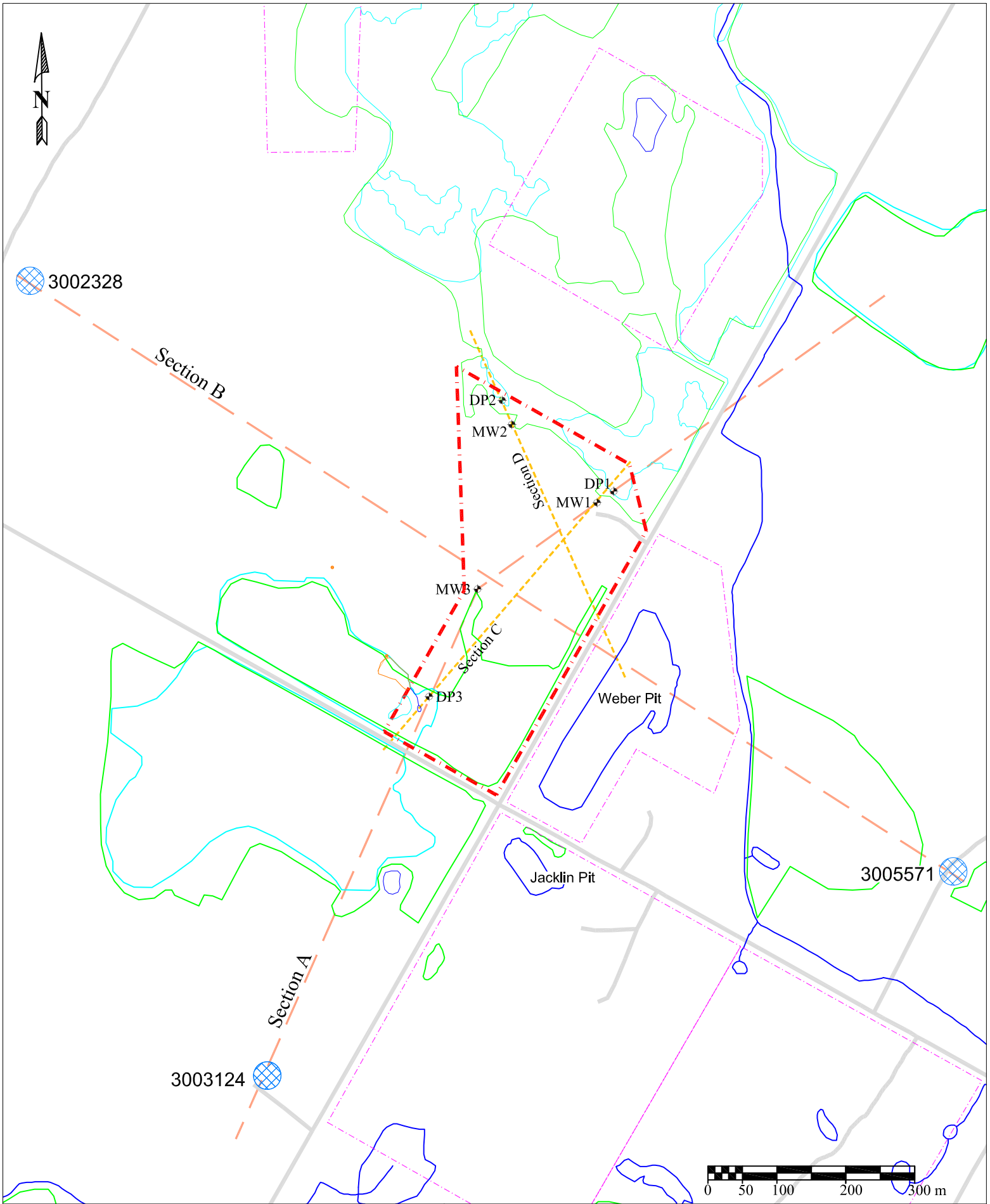
modified from: OBM mapping

December 2020
Scale: as shown

Groundwater Science Corp.

Figure 4: High Water Table

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment



stream, pond
wetland (MNRF, Terrastory)
section locations
water well record location

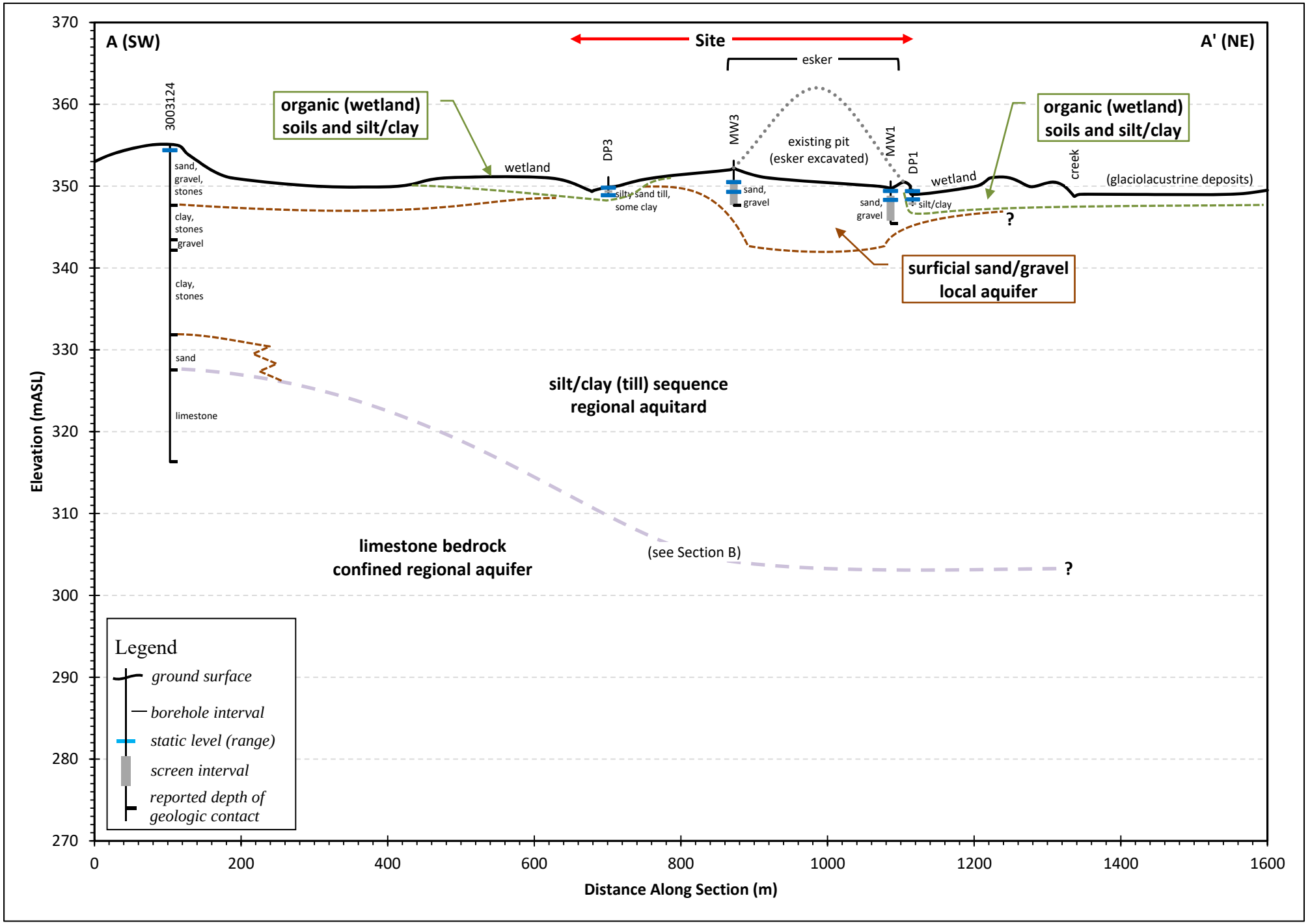
modified from: OBM, SWOOP 2015
UNDER LICENSE, WITHOUT PREJUDICE OR ENDORSEMENT, FROM THE QUEEN'S PRINTER OF ONTARIO, 2005

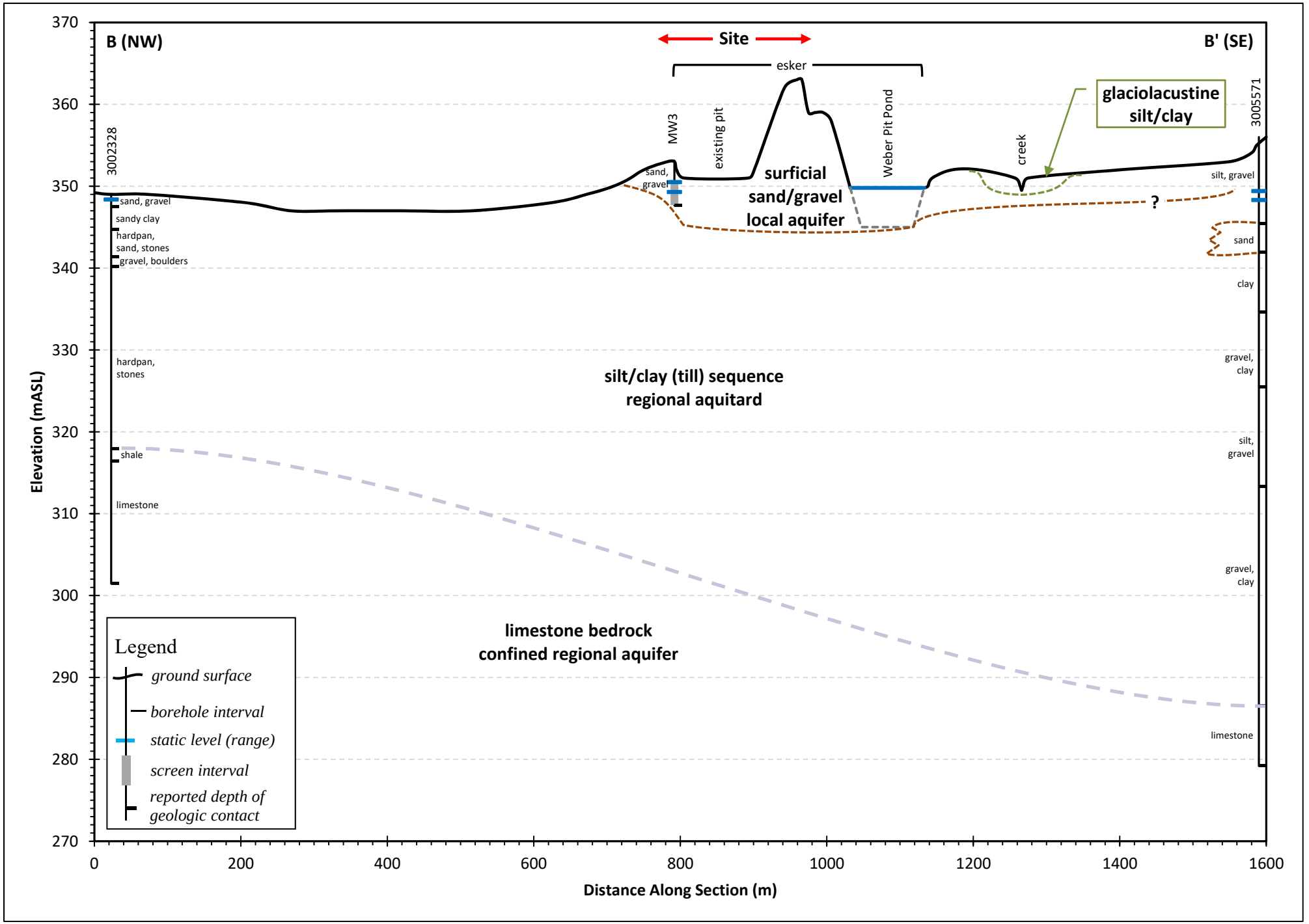
December 2020
Scale: as shown

Groundwater Science Corp.

Figure 5: Schematic Section Locations

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment

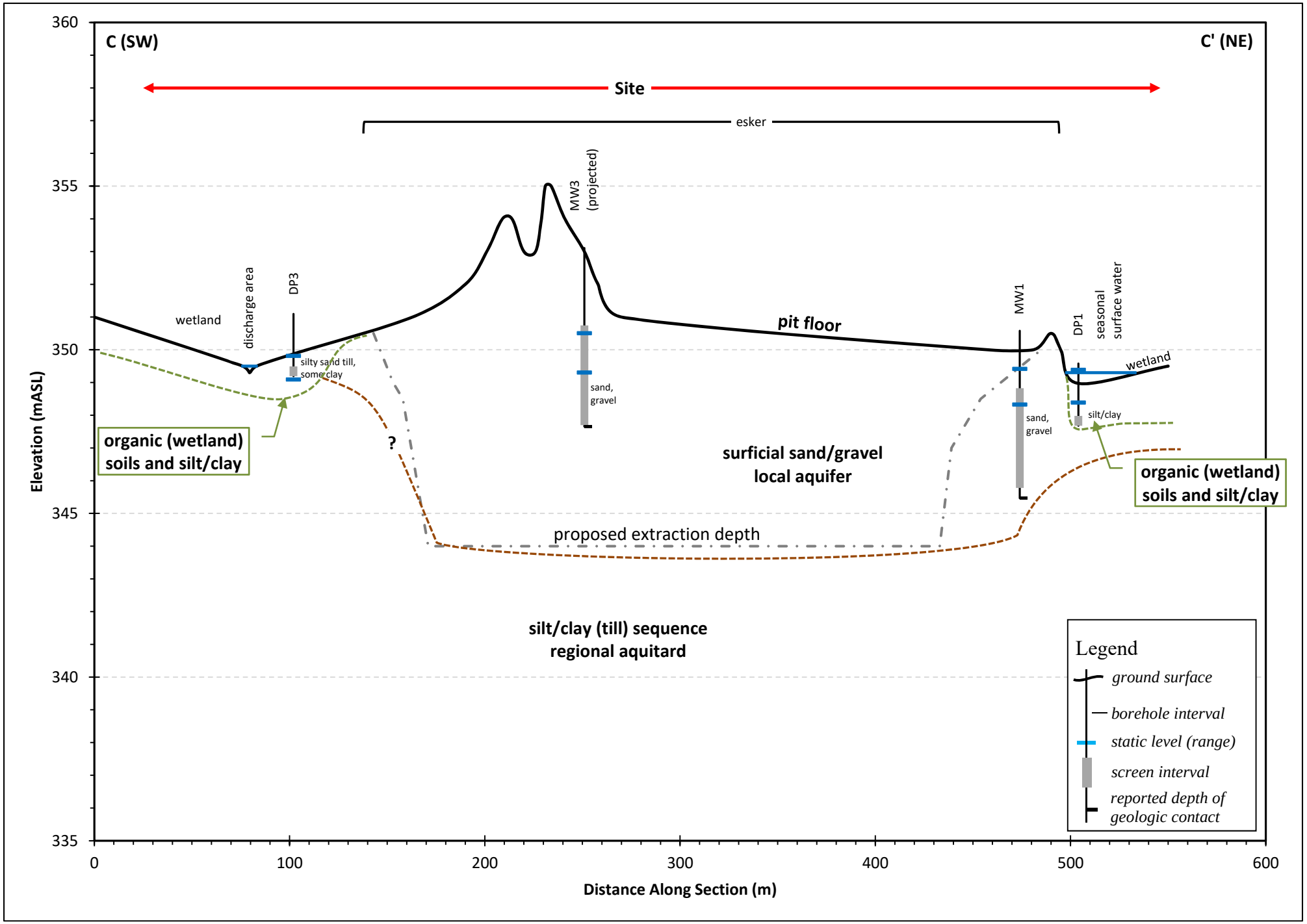

A (SW)
A' (NE)
Site
esker
3003124
organic (wetland)
soils and silt/clay
wetland
DP3
MW3
existing pit
(esker excavated)
MW1
DP1
wetland
creek
(glaciolacustrine deposits)
organic (wetland)
soils and silt/clay
sand,
gravel,
stones
clay,
stones
gravel
clay,
stones
sand
limestone
silty sand till,
some clay
sand,
gravel
sand,
gravel
silt/clay
?
surficial sand/gravel
local aquifer
silt/clay (till) sequence
regional aquitard
limestone bedrock
confined regional aquifer
(see Section B)
?
Legend
ground surface
borehole interval
static level (range)
screen interval
reported depth of
geologic contact
Elevation (mASL)
370
360
350
340
330
320
310
300
290
280
270
0
200
400
600
800
1000
1200
1400
1600
Distance Along Section (m)



Municipality of Huron East - Kelly Pit
Proposed Licence Amendment

Figure 7: Regional Section B

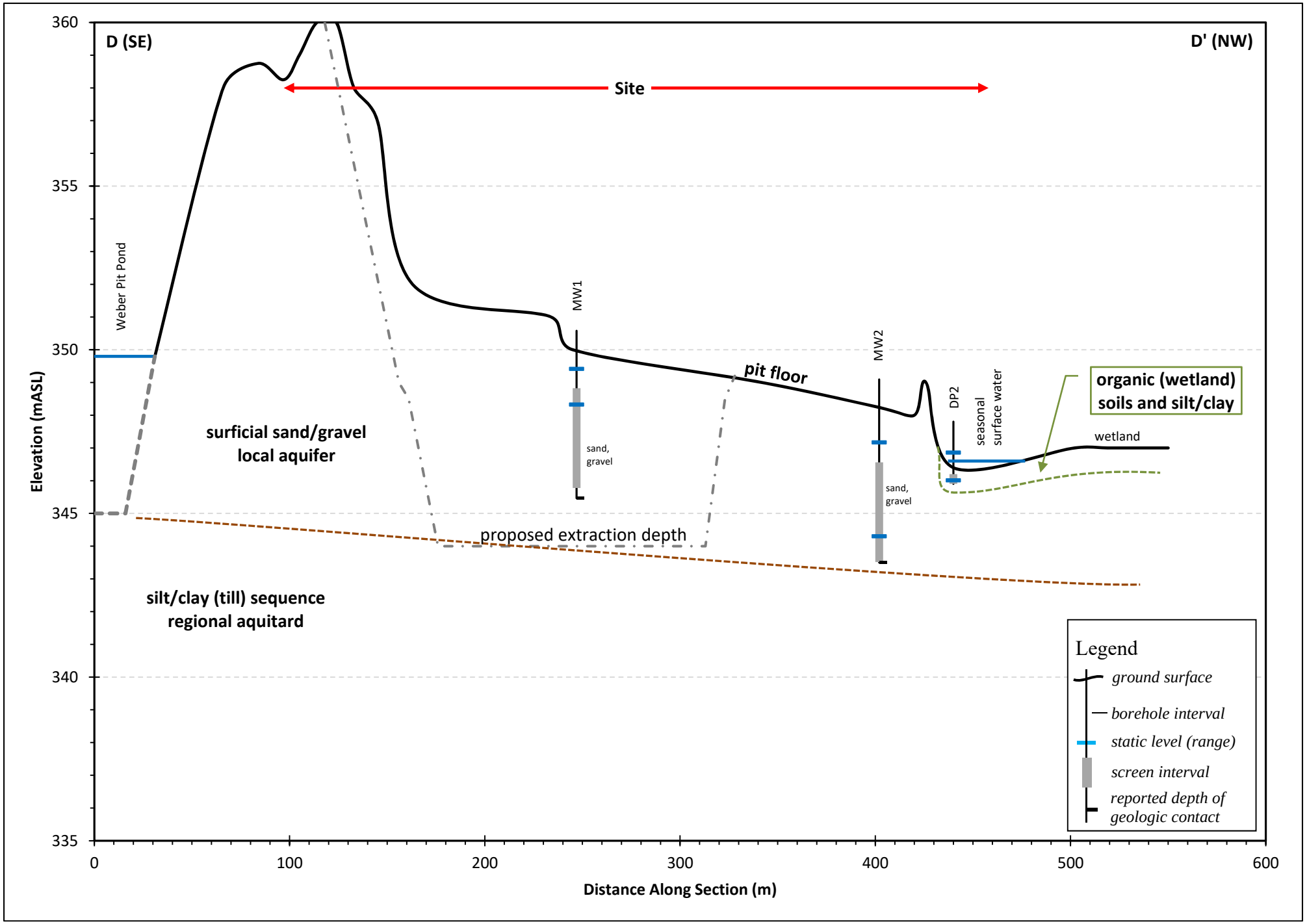
Groundwater Science Corp.
Hydrogeologic Assessment

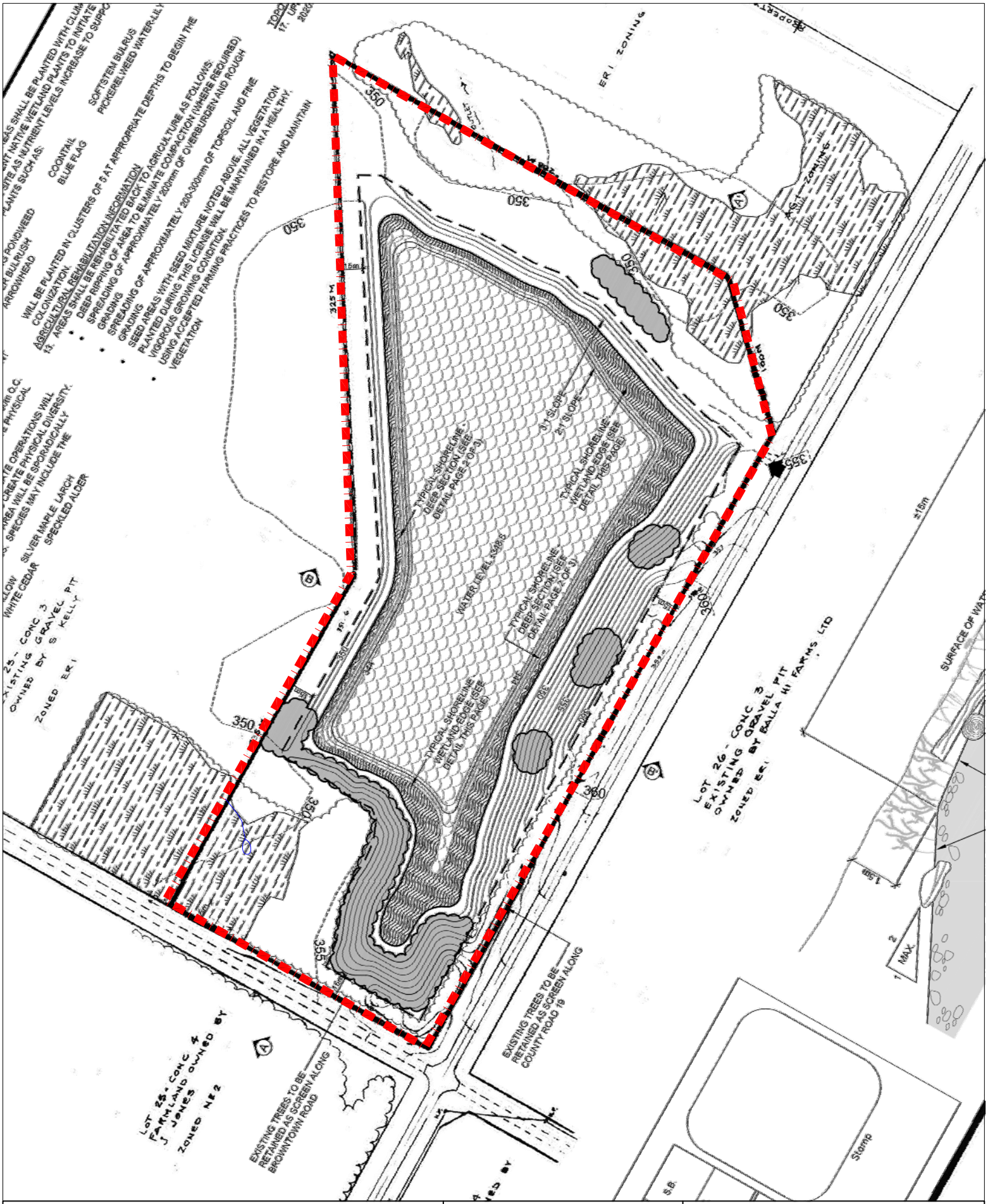


Municipality of Huron East - Kelly Pit
Proposed Licence Amendment

Figure 8: Site Scale Section C

Groundwater Science Corp.
Hydrogeologic Assessment


D (SE)
D' (NW)
Site
Weber Pit Pond
MW1
MW2
DP2
seasonal surface water
pit floor
organic (wetland) soils and silt/clay
wetland
surficial sand/gravel local aquifer
sand, gravel
sand, gravel
proposed extraction depth
silt/clay (till) sequence regional aquitard
Elevation (mASL)
Distance Along Section (m)
360
355
350
345
340
335
0
100
200
300
400
500
600
Legend
ground surface
borehole interval
static level (range)
screen interval
reported depth of geologic contact



see: Site Plan, Harrington McAvan

modified from: OBM mapping

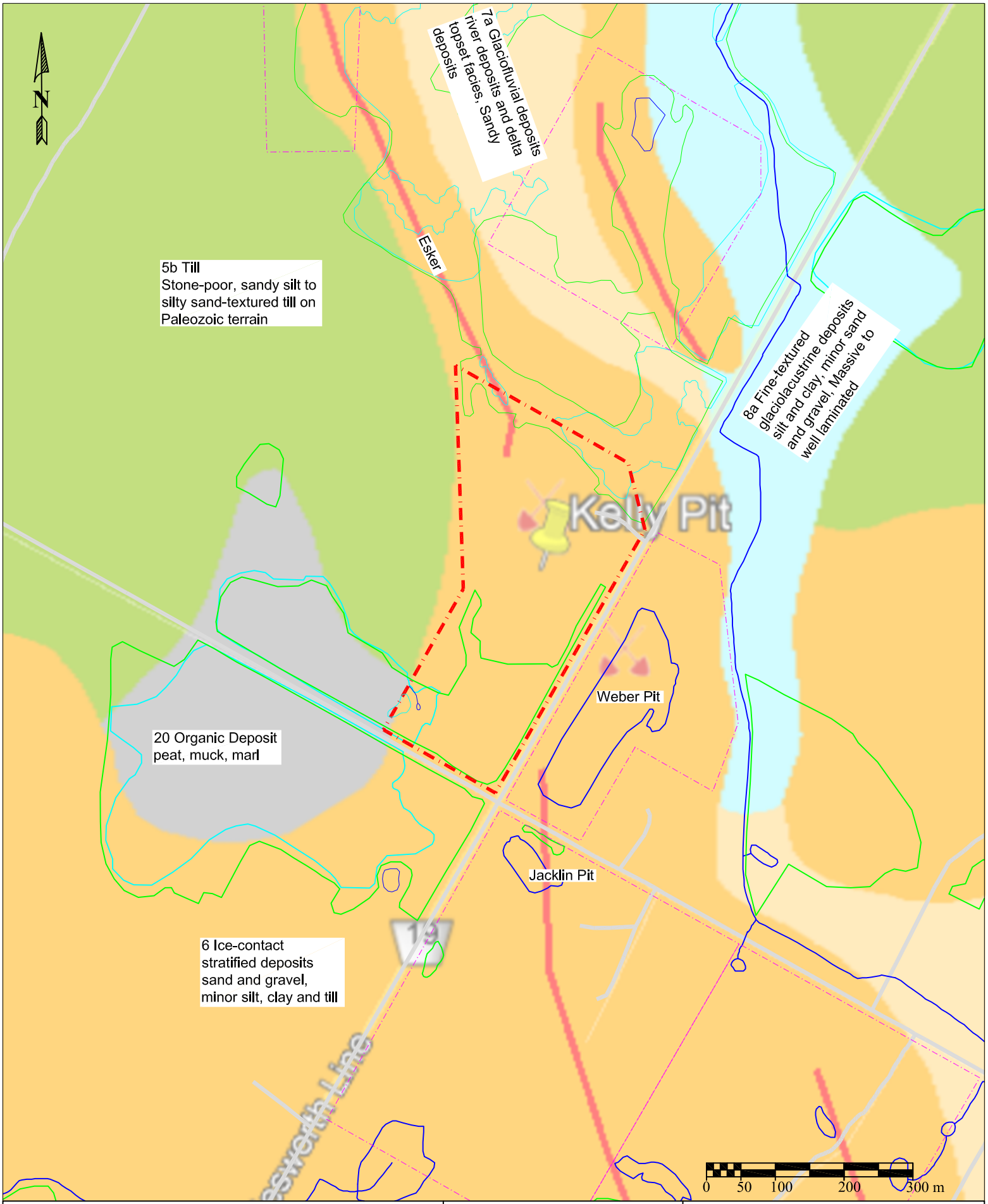
December 2020
not to scale

Groundwater Science Corp.

Figure 10: Proposed Rehabilitation

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment

Appendix A
Background Information



From:
Ontario Geological Survey OGSEarth published geological mapping
(KML files viewed using Google Earth®); available online at:
http://www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth

modified from: OBM, SWOOP 2015

December 2020
Scale: as shown

Groundwater Science Corp.

Surficial Geology

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment

-Although considerable efforts have been made to accurately situate all feature locations and extents, the information depicted herein should not be used in place of a professional survey.
-Scale text as shown (e.g., 1:500) is based on a 11x17 inch page.

Legend

Study Area
- Site
- Adjacent Lands (Site + 120 m)

Survey Stations
- Anuran Calling Stations
- Breeding Bird Survey Stations

Biophysical Conditions - Terrastory
- Vegetation Communities
- Runoff Direction
- Discharge/Spring
- Ditch
- Provincially Significant Molesworth/Jamestown Wetland Complex (Terrastory Update)
- Crest of Esker Slope

Vegetation Community Codes:

UPLAND
FOD: Deciduous Forest
FODM7: Lowland Deciduous Forest
FOMM4-2: Dry - Fresh White Cedar - Poplar Mixed Forest
FOMM4-3: Dry - Fresh White Cedar - Hardwood Mixed Forest
FOC: Coniferous Forest
FOCM4-1: Fresh - Moist White Cedar Coniferous Forest
FOCM6-1: Dry - Fresh White Pine Naturalized Coniferous Plantation
WOD: Deciduous Woodland
WODM5-1: Fresh -Moist Poplar Deciduous Woodland
THCM1-2: Dry - Fresh Coniferous Regeneration Thicket
TAGM5: Fencerow
MEMM3: Dry - Fresh Mixed Meadow

WETLAND
SWDM2-2: Green Ash Mineral Deciduous Swamp
SWDM3-3: Swamp Maple Mineral Deciduous Swamp
SWDM4-5: Poplar Mineral Deciduous Swamp
SWM: Mixed Swamp
MAMM1: Graminoid Mineral Meadow Marsh

TERRASTORY
environmental consulting inc.

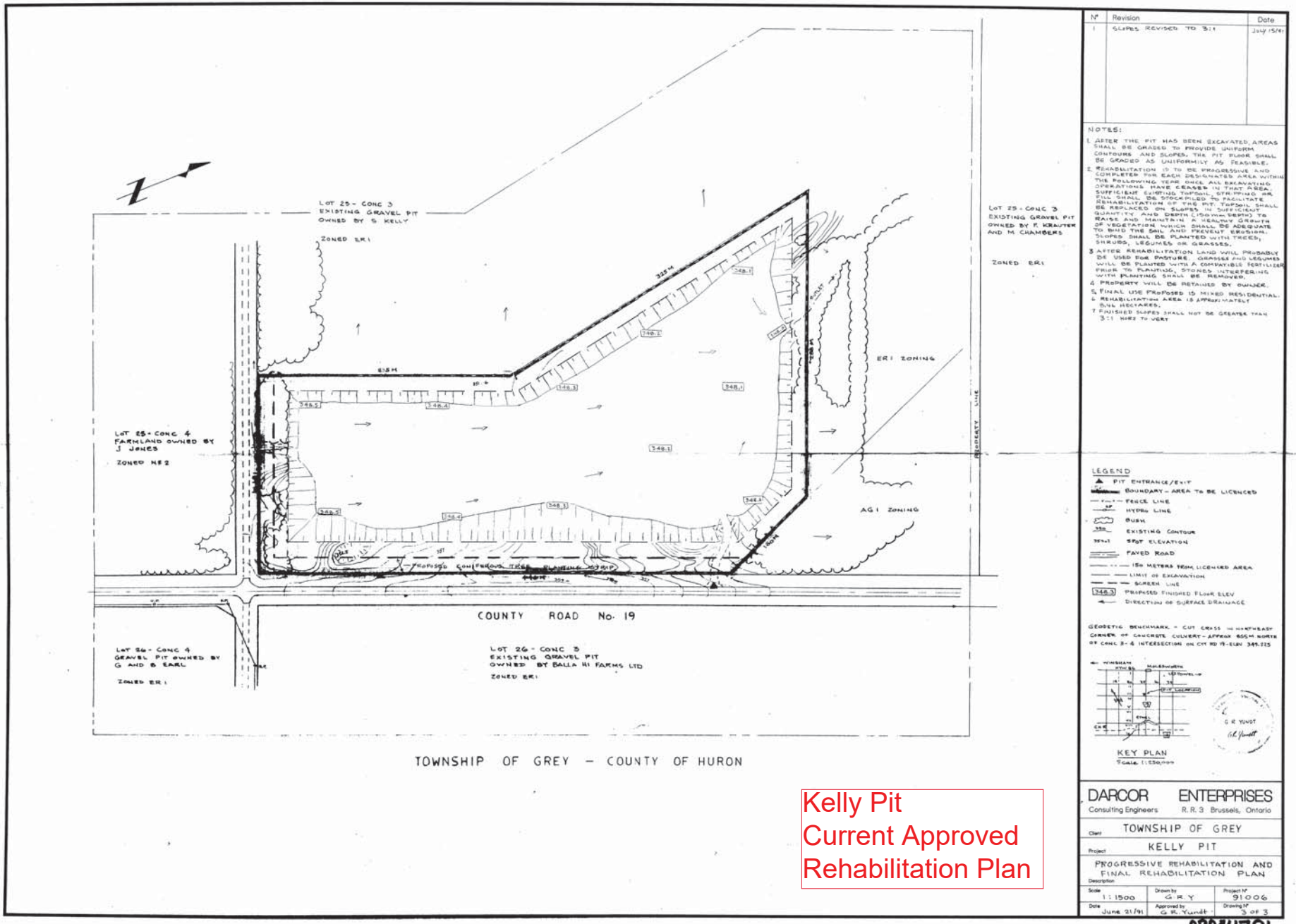
1:3,500	0 50 100 150 m

N	Project No.: 1954	By: TK	Date: 2020-12-20

Orthophotograph Date: 2015 (SWOOP).

Location: Kelly Pit, Municipality of Huron East.

Figure 2. Biophysical Features and Conditions.



N°	Revision	Date
1	SLOPES REVISED TO 3:1	JULY 15/91

NOTES:

1. AFTER THE PIT HAS BEEN EXCAVATED, AREAS SHALL BE GRADED TO PROVIDE UNIFORM CONTOURS AND SLOPES. THE PIT FLOOR SHALL BE GRADED AS UNIFORMILY AS FEASIBLE.
2. REHABILITATION IS TO BE PROGRESSIVE AND COMPLETED FOR EACH DESIGNATED AREA WITHIN THE FOLLOWING YEAR ONCE ALL EXCAVATING OPERATIONS HAVE CEASED IN THAT AREA. SUFFICIENT EXISTING TOPSOIL, STRIPPING OR FILL SHALL BE STOCKPILED TO FACILITATE REHABILITATION OF THE PIT. TOPSOIL SHALL BE REPLACED ON SLOPES IN SUFFICIENT QUANTITY AND DEPTH (150mm DEPTH) TO RAISE AND MAINTAIN A HEALTHY GROWTH OF VEGETATION WHICH SHALL BE ADEQUATE TO BIND THE SOIL AND PREVENT EROSION. SLOPES SHALL BE PLANTED WITH TREES, SHRUBS, LEGUMES OR GRASSES.
3. AFTER REHABILITATION LAND WILL PROBABLY BE USED FOR PASTURE. GRASSES AND LEGUMES WILL BE PLANTED WITH A COMPATIBLE FERTILIZER PRIOR TO PLANTING. STONES INTERFERING WITH PLANTING SHALL BE REMOVED.
4. PROPERTY WILL BE RETAINED BY OWNER.
5. FINAL USE PROPOSED IS MIXED RESIDENTIAL.
6. REHABILITATION AREA IS APPROXIMATELY 8.96 HECTARES.
7. FINISHED SLOPES SHALL NOT BE GREATER THAN 3:1 HORZ TO VERT

LEGEND

- PIT ENTRANCE/EXIT
- BOUNDARY - AREA TO BE LICENCED
- FENCE LINE
- HYDRO LINE
- BUSH
- EXISTING CONTOUR
- SPOT ELEVATION
- PAVED ROAD
- 150 METERS FROM LICENCED AREA
- LIMIT OF EXCAVATION
- SCREEN LINE
- 346.3 PROPOSED FINISHED FLOOR ELEV
- DIRECTION OF SURFACE DRAINAGE

GEODETIC BENCHMARK - CUT CROSS IN NORTHEAST CORNER OF CONCRETE CULVERT - APPROX 855M NORTH OF CONC 3-4 INTERSECTION ON CTY RD 19 - ELEV 349.225

KEY PLAN
Scale 1:50,000

G R YUNDT

DARCOR ENTERPRISES
Consulting Engineers R.R.3 Brussels, Ontario

Client: TOWNSHIP OF GREY

Project: KELLY PIT

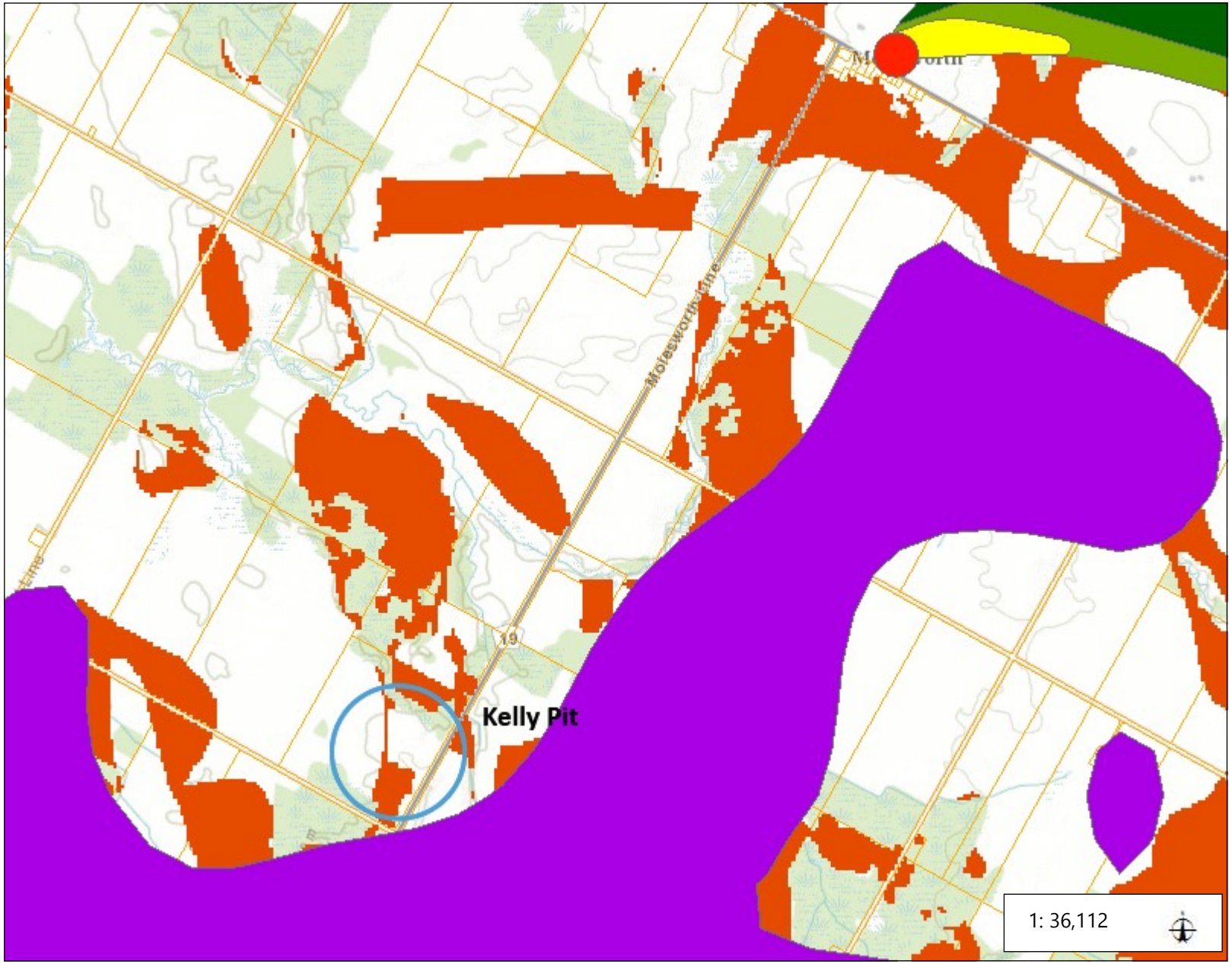
Description: PROGRESSIVE REHABILITATION AND FINAL REHABILITATION PLAN

Scale	Drawn by	Project N°
1:1500	G.R.Y	91006
Date: June 21/91	Approved by: G.R. Yundt	Drawing N° 3 OF 3

Kelly Pit
Current Approved
Rehabilitation Plan

ARA*4781

Source Protection Mapping



Legend

- Well
- Highly Vulnerable Aquifer
- Significant Groundwater Recha
- Well Head Protection Area
  - 2
  - 4
  - 6
  - 8
  - 10
- Parcel Fabric

Notes

1,834.5 0 917.24 1,834.5 Meters

WGS_1984_Web_Mercator_Auxiliary_Sphere

This map is a user generated static output from an Internet mapping site and is for reference only. Data layers that appear on this map may or may not be accurate, current, or otherwise reliable.

THIS MAP IS NOT TO BE USED FOR NAVIGATION

Appendix B
Water Well Record Review

study site (approximate)

reported water well record locations and references as shown

Date: December 2020
scale: not to scale

Reported Water Well Locations

Groundwater Science Corp.

Kelly Pit Proposed Licence Amendment
Hydrogeologic Assessment

Record No.	Total Depth (m)	Type		Use	Static Level (m)	Bedrock Depth (m)	Source Classification
		constr.	source unit				
3002328	47.5	drilled	limestone	stock, domestic	0.6	31.1	confined bedrock aquifer
3002975	26.2	drilled	limestone	stock, domestic	3.7	24.4	confined bedrock aquifer
3003124	38.7	drilled	limestone	stock, domestic	0.6	27.4	confined bedrock aquifer
3003145	24.4	drilled	limestone	stock	3.0	18.6	confined bedrock aquifer
3003983	41.5	drilled	limestone	domestic	4.0	30.8	confined bedrock aquifer
3004133	54.3	drilled	limestone	stock, domestic	3.0	22.6	confined bedrock aquifer
3005571	76.8	drilled	limestone	stock, domestic	0.6	69.5	confined bedrock aquifer
3006227	42.7	drilled	limestone	domestic	3.0	28.7	confined bedrock aquifer
3006351	29.0	drilled	limestone	domestic	5.2	14.6	confined bedrock aquifer
7237477	-	decommission record - drilled well			-	-	
7261724	42.7	drilled	limestone	stock, domestic	1.9	26.5	confined bedrock aquifer
7268588	-	decommission record - drilled well			-	-	
7339870	4.0	drilled	sand, gravel	site monitoring well	-	-	unconfined surficial aquifer
7339871	4.6	drilled	sand, gravel	site monitoring well	-	-	unconfined surficial aquifer
7339872	4.6	drilled	sand, gravel	site monitoring well	-	-	unconfined surficial aquifer

Appendix C
Borehole Logs and Monitoring Results

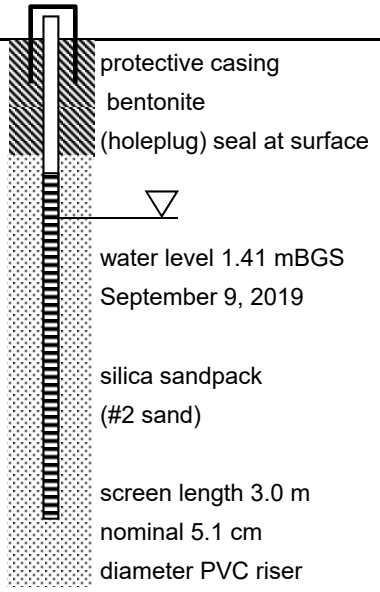
BOREHOLE LOG

Borehole: MW1

Project: Kelly Pit
Location: Northern treeline, along pit entrance lane
Method: Hollow Stem Auger
Samples: split spoon (S) and auger cuttings (A)

Date: August 8, 2019
Supervisor: DN
Elevations TOC: 350.58 mASL
GS: 349.77 mASL

Depth Ft.	Depth m.	Sample type	Sample no.	Sample Interval (metres)	Sample Rec.	Description	Monitor Installation
0	0	A				**Gravel**	protective casing
						- well graded gravel, with cobbles and sand, brown, dry	bentonite (holeplug) seal at surface
	1	A					
5		A					
		S	1	1.5 to 2.1	0.25	- wet at 1.5 m	water level 1.41 mBGS September 9, 2019
	2					**Sand**	
						- wet, fine to medium brown sand, clean	silica sandpack (#2 sand)
10	3	A					
		S	2	3.0 to 3.7	0.28		screen length 3.0 m nominal 5.1 cm diameter PVC riser and slotted screen
	4	A					
15						**End of Hole at 4.3m**	
	5						
20	6						
	7						
25		A					
	8						
30	9						
	10						
35	11						
40	12						



Groundwater Science Corp.

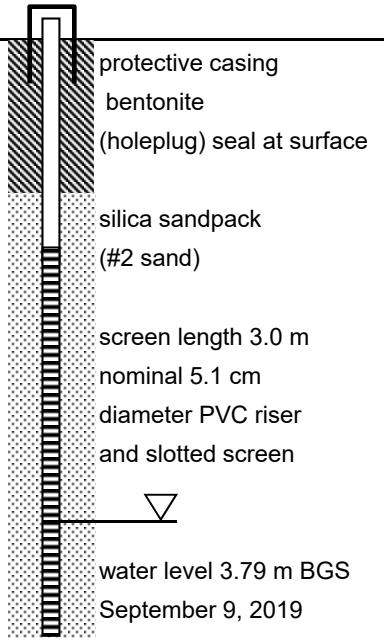
BOREHOLE LOG

Borehole: MW2

Project: Kelly Pit
Location: Northern treeline, near NW corner of pit
Method: Hollow Stem Auger
Samples: split spoon (S) and auger cuttings (A)

Date: August 8, 2019
Supervisor: DN
Elevations TOC: 349.09 mASL
GS: 348.24 mASL

Depth Ft.	Depth m.	Sample type	Sample no.	Sample Interval (metres)	Sample Rec.	Description	Monitor Installation
0	0	A				**Sand, Gravel**	protective casing
		A					bentonite
	1					- fine brown sand with gravel to cobbles	(holeplug) seal at surface
5		A				- some silt content, increasing with depth	silica sandpack
		S	1	1.5 to 2.1	0.36		(#2 sand)
	2					- fine sand in lenses, intermittent within gravel	screen length 3.0 m
							nominal 5.1 cm
		A				- wet at 3.0 m	diameter PVC riser
10	3	S	2	3.0 to 3.7	0.41		and slotted screen
						- silty wet fine brown sand, some gravel	▽ water level 3.79 m BGS
	4						September 9, 2019
		A					
15						**End of Borehole at 4.6m**	
	5						
20	6						
	7						
25							
	8						
30	9						
	10						
35							
	11						
40	12						



Groundwater Science Corp.

BOREHOLE LOG

Borehole: MW3

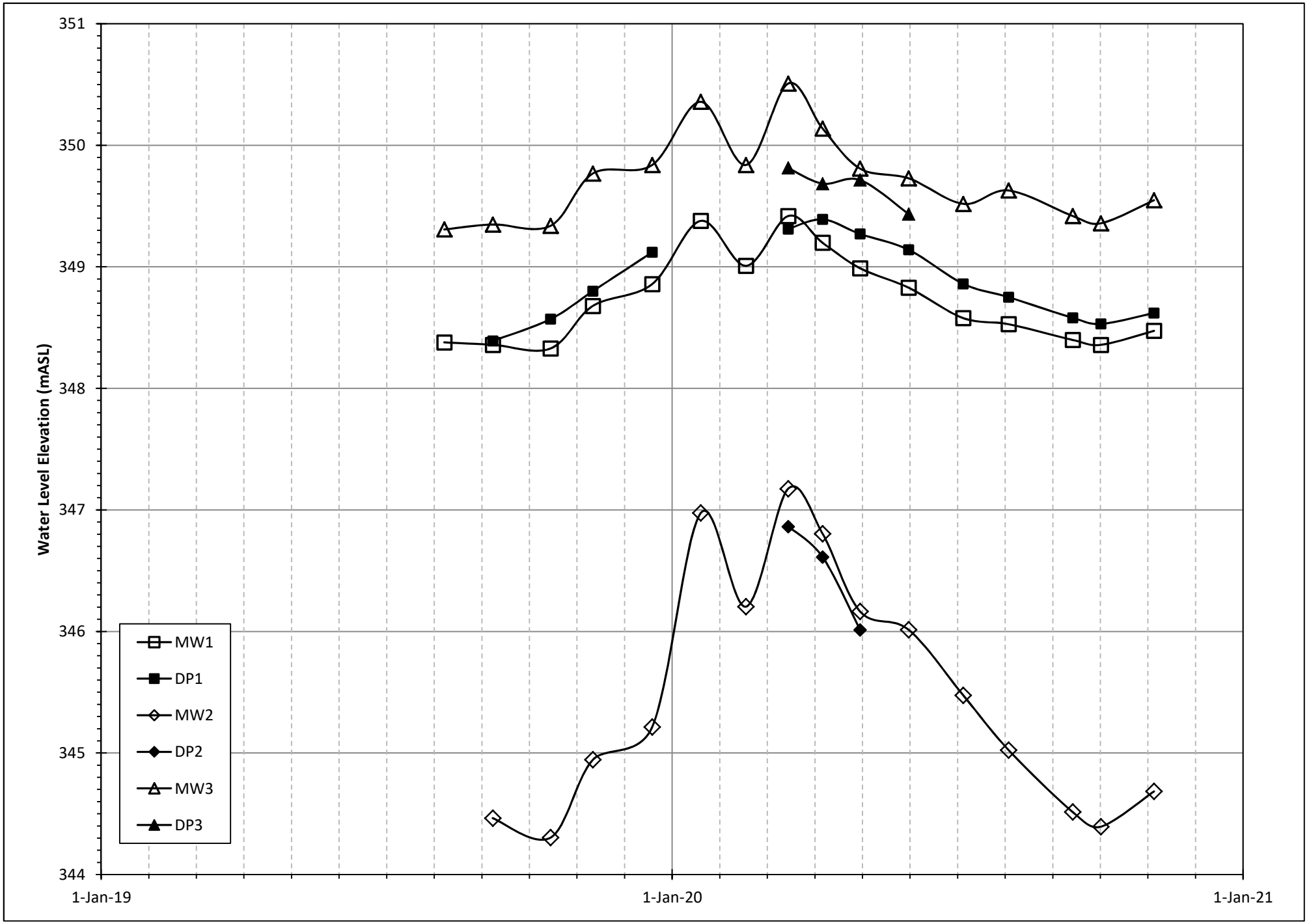
Project: Kelly Pit
Location: SW corner of property near agricultural field
Method: Hollow Stem Auger
Samples: split spoon (S) and auger cuttings (A)

Date: August 8, 2019
Supervisor: DN
Elevations TOC: 353.11 mASL
GS: 352.25 mASL

Depth Ft.	Depth m.	Sample type	Sample no.	Sample Interval (metres)	Sample Rec.	Description	Monitor Installation
0	0	A				**Sand** - yellow brown fine to silty fine sand, dry	protective casing bentonite (holeplug) seal at surface
		A					
	1						
		A				**Sand, Gravel** - silty fine brown sand, with gravel, dry	
5		S	1	1.5 to 2.1	0.61		silica sandpack (#2 sand)
	2						
						Gravel - coarse gravel to cobbles - wet at 3.0 m	
		A					
10	3	S	2	3.0 to 3.7	0.48		water level 2.86 mBGS September 9, 2019
	4						screen length 3.0 m nominal 5.1 cm diameter PVC riser and slotted screen
		A					
15						**End of Borehole at 4.6m**	
	5						
20	6						
	7						
25							
	8						
30	9						
	10						
35							
	11						
40	12						

Date	Water Level Elevation (mASL)								
	MW1	MW2	MW3	DP1	DP1 SW	DP2	DP2 SW	DP3	DP3 SW
9-Aug-19	348.38		349.31						
9-Sep-19	348.36	344.46	349.35	348.39	dry	dry	dry	dry	dry
16-Oct-19	348.33	344.30	349.34	348.57	dry	dry	dry	dry	dry
12-Nov-19	348.68	344.94	349.77	348.80	dry	dry	dry	dry	dry
20-Dec-19	348.86	345.21	349.84	349.12	dry	dry	dry	dry	dry
20-Jan-20	349.38	346.97	350.36	fr	fr	fr	fr	fr	dry
18-Feb-20	349.01	346.20	349.84	fr	fr	fr	fr	fr	dry
16-Mar-20	349.42	347.17	350.51	349.31	fr	346.86	fr	349.81	dry
7-Apr-20	349.20	346.80	350.14	349.39	349.30	346.61	346.60	349.68	dry
1-May-20	348.99	346.16	349.81	349.27	349.13	346.01	dry	349.71	dry
1-Jun-20	348.83	346.01	349.73	349.14	dry	dry	dry	349.43	dry
6-Jul-20	348.58	345.47	349.52	348.86	dry	dry	dry	dry	dry
4-Aug-20	348.53	345.02	349.63	348.75	dry	dry	dry	dry	dry
14-Sep-20	348.40	344.51	349.42	348.58	dry	dry	dry	dry	dry
2-Oct-20	348.36	344.39	349.36	348.53	dry	dry	dry	dry	dry
5-Nov-20	348.47	344.68	349.55	348.62	dry	dry	dry	dry	dry

notes:
mASL = metres above sea level

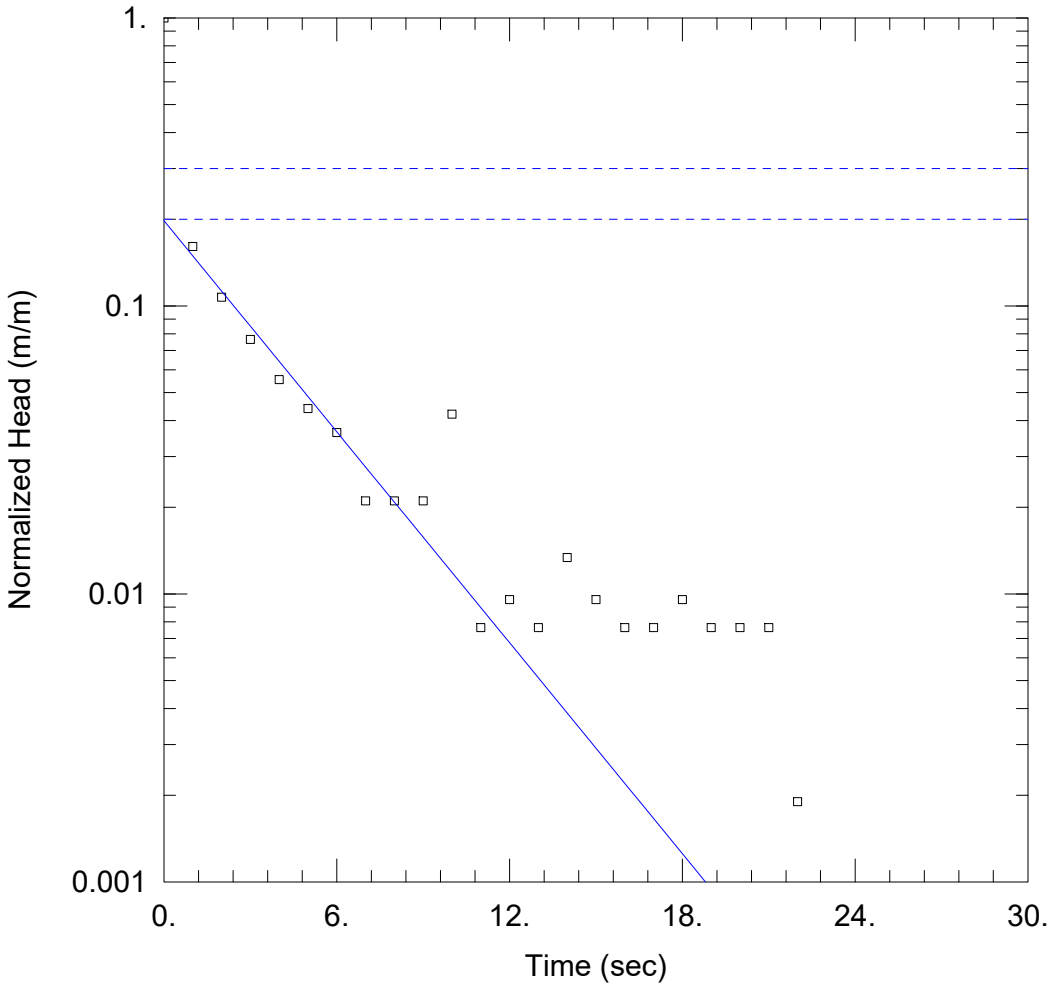


Municipality of Huron East
Kelly Pit

Water Level Hydrograph

Groundwater Science Corp.
Hydrogeologic Assessment

Appendix D
Response Test Analysis



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Huron East
Location: Kelly pit
Test Well: MW1
Test Date: June 1 2020

AQUIFER DATA

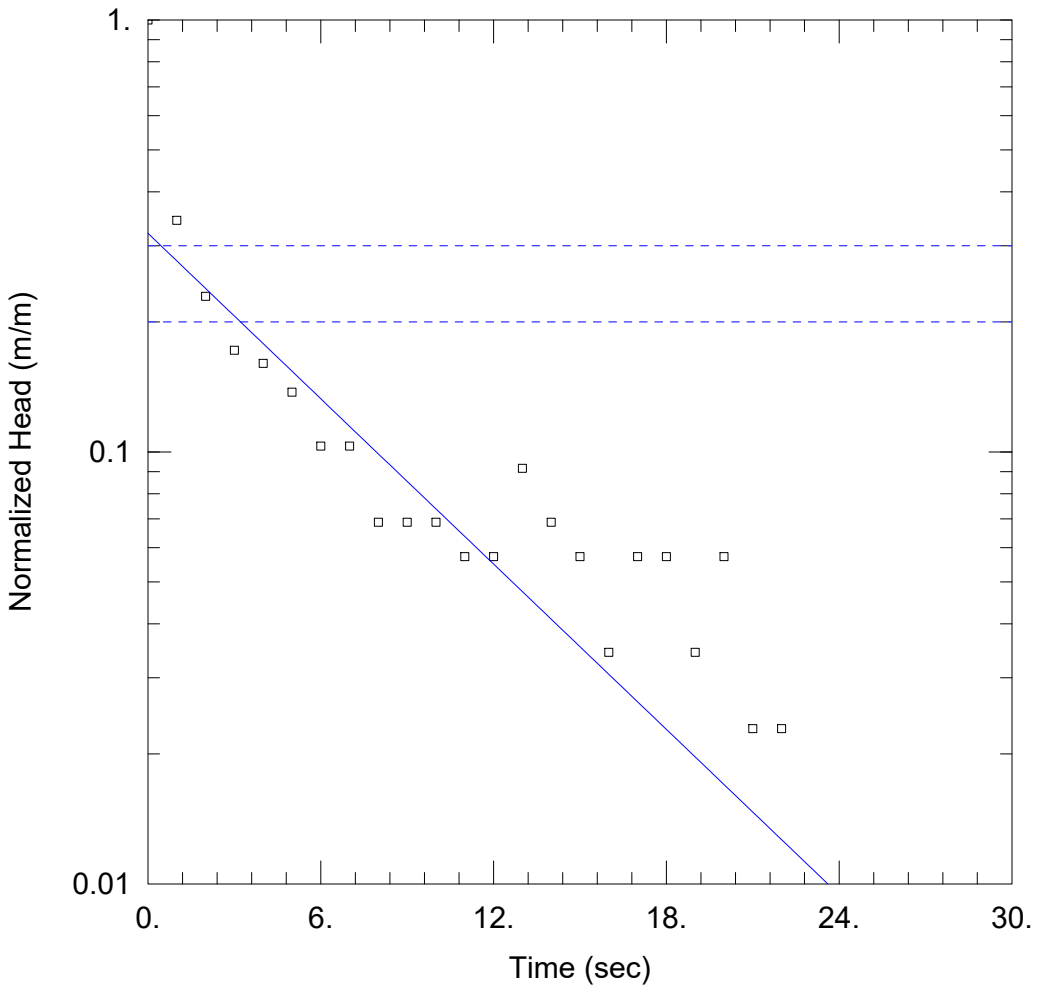
Saturated Thickness: 2.95 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW1)

Initial Displacement: 0.479 m
Total Well Penetration Depth: 3.58 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.95 m
Screen Length: 3. m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
K = 8.185E-5 m/sec
Solution Method: Bouwer-Rice
y0 = 0.09464 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Huron East
Location: Kelly pit
Test Well: MW2
Test Date: June 1 2020

AQUIFER DATA

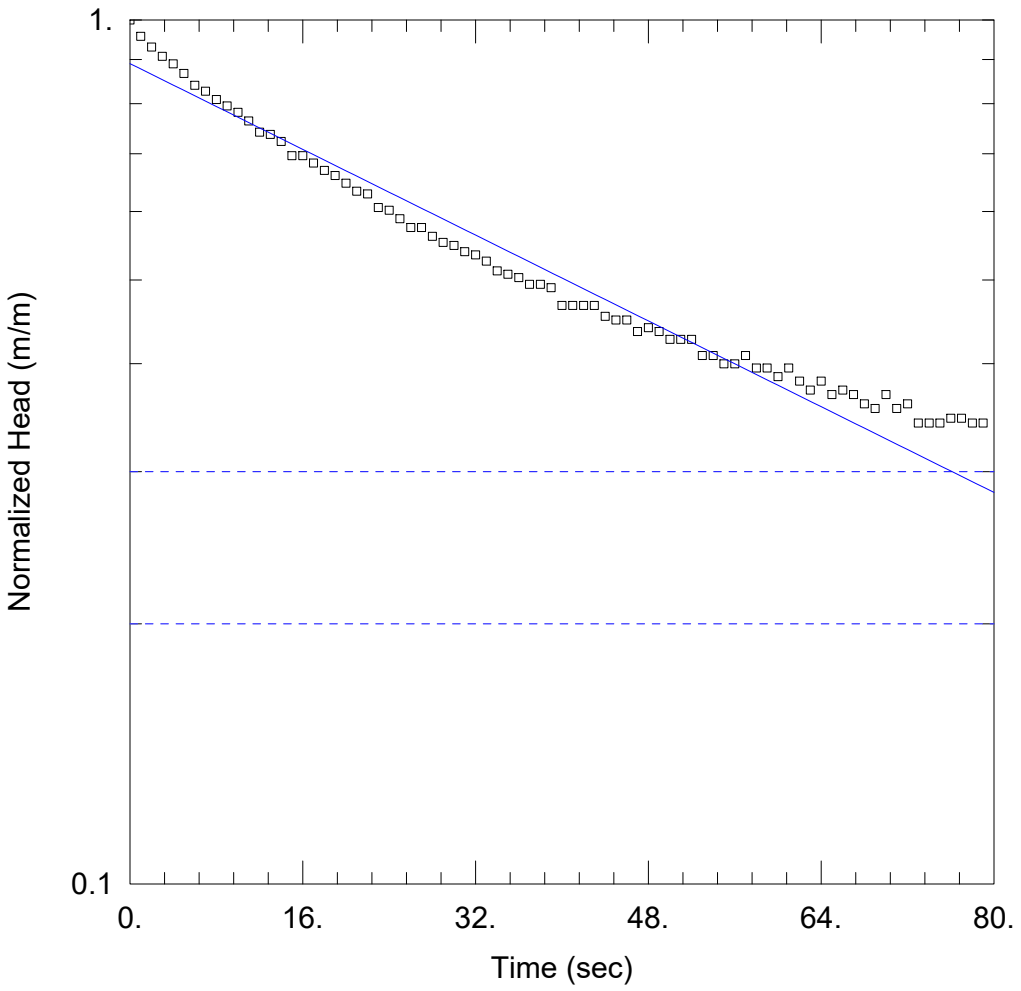
Saturated Thickness: 2.5 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW2)

Initial Displacement: 0.08 m
Total Well Penetration Depth: 3.1 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.5 m
Screen Length: 3. m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
K = 4.798E-5 m/sec
Solution Method: Bouwer-Rice
y0 = 0.02565 m



WELL TEST ANALYSIS

PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Huron East
Location: Kelly pit
Test Well: MW3
Test Date: June 1 2020

AQUIFER DATA

Saturated Thickness: 2.02 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW3)

Initial Displacement: 0.204 m
Total Well Penetration Depth: 3.1 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.02 m
Screen Length: 3. m
Well Radius: 0.1016 m

SOLUTION

Aquifer Model: Unconfined
K = 5.63E-6 m/sec
Solution Method: Bouwer-Rice
y0 = 0.1816 m

Appendix E
Water Balance Calculations

Proposed Kelly Pit Below Water Extraction - Recharge Water Balance

Purpose:

To assess present and future recharge contributions to the local groundwater system

Assumptions:

- climate conditions at the site represented by Environment Canada reported 1981 - 2010 Climate Normals Blyth ON Station
- evapotranspiration rates estimated using the Thornthwaite and Mather method
- pond evaporation rates estimated using Potential Evapotranspiration (calculated maximum).
- runoff rates estimated using MOE Infiltration Factors (*MOEE Hydrogeological Technical Information Requirements For Land Development Applications* , April 1995).
- the assessment area consists of the proposed total extraction area, approximately 7.5 ha.
- current runoff from approximately 5.6 ha is retained within existing pit
- remaining runoff from the current undisturbed area (southern portion of site) can flow off-site to the west
- under future conditions runoff within the assessment area is retained
- area of total proposed pond (open water and wetland) is 4.9 ha

1) Water Balance Components

Infiltration Factor for Land Surface Within Runoff Areas

Hilly Land	0.1		surplus = precipitation - evapotranspiration
Open sandy loam	0.4		
Woodland	0.2		
Factor:	0.7	70	% of surplus becomes infiltration recharge
	0.3	30	% of surplus becomes runoff

General Site Recharge Calculation (includes pond areas)

site recharge = precipitation - evapotranspiration - runoff

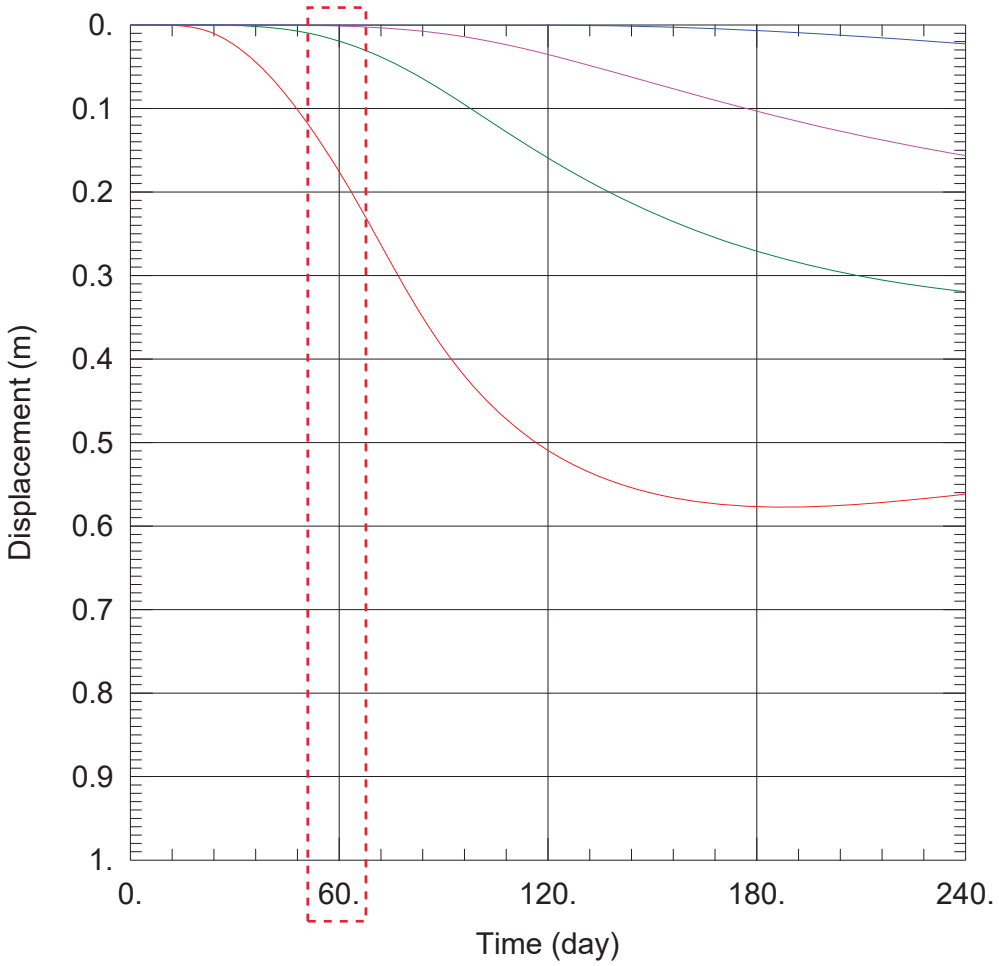
1) Estimate of Existing Recharge

Precipitation Rate =	1.24690	m/yr
PET Rate =	0.59328	m/yr
Evapotrans. Rate =	0.57975	m/yr
Water Surplus =	0.66715	m/yr
Recharge Rate =	0.46701	m/yr
Runoff Rate =	0.20015	m/yr
Assessment Area =	7.5	ha
=	75,000	m^2
Existing Runoff Area =	1.8	ha
	18,000	m^2
Site Precip. Input =	93,518	m^3/yr
Site Evapotrans. =	43,481	m^3/yr
Site Runoff =	3,603	m^3/yr
Existing Recharge =	46,434	m^3/yr
Average Site Rate =	0.619	m/yr
=	1.47	L/s
Existing Runoff =	3,603	m^3/yr
Average Site Rate =	0.048	m/yr
=	0.11	L/s

2) Estimate of Future Recharge

Pond Evaporation Rate =	0.59328	m/yr
Proposed Pond Area =	4.9	ha
=	49,000	m^2
Naturalized Area =	2.6	ha
=	26,000	m^2
Site Precip. Input =	93,518	m^3/yr
Site Evapotrans. =	15,074	m^3/yr
New Pond Evap. =	29,071	m^3/yr
Site Runoff =	0	m^3/yr
Future Recharge =	49,373	m^3/yr
Average Site Rate =	0.658	
=	1.57	L/s

Appendix F
Drawdown Projection



PROJECT INFORMATION

Company: Groundwater Science Corp.
Client: Municipality of Huron East
Location: Kelly Pit
Test Well: Pond Extraction Simulation

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
1	0	61.8
2	18.1	105.5
3	61.8	123.6
4	105.5	105.5
5	123.6	61.8
6	105.5	18.1
7	61.8	0
8	18.1	18.1

Observation Wells

Well Name	X (m)	Y (m)
▫ 100 m	223.6	61.8
▫ 150 m	273.6	61.8
▫ 200 m	323.6	61.8
▫ 300 m	423.6	61.8

SOLUTION

Aquifer Model: Unconfined
Solution Method: Neuman

T = 0.00014 m^2/sec
S = 0.25
Sy = 0.1
Kz/Kr = 0.1

Appendix G
Qualifications

Groundwater Science Corp.

Unit 2, 465 Kingscourt Drive,
Waterloo, ON N2K 3R5
Phone: (519) 746-6916
groundwaterscience.ca

QUALIFICATIONS

December 2020

Andrew Pentney, B.Sc., P.Geo.

Current Position

Principal, Senior Hydrogeologist

Groundwater Science Corp., Waterloo, ON

Providing hydrogeological consulting expertise to regulatory agencies, environmental consultants and industry. Services ranging from individual consulting and assessments to project support for larger study teams, including testimony at OMB hearings.

Over 28 years of hydrogeologic consulting experience.

Education

B.Sc. (1987) : University of Waterloo, Waterloo, ON

General Science, including Geology courses (stratigraphy, quaternary geology and hydrogeology).

Professional memberships

Registered Professional Geoscientist in Ontario

Licenced MOE Well Technician and Contractor

Range of Experience

- Technical consultation for 8 Subwatershed Scale characterization studies (GRCA, CVC). Focus on assessing groundwater – surface water interaction (at rivers, streams, wetlands, ponds).
- Planning approval and environmental peer review, watershed planning support to Credit Valley Conservation on an as-needed basis from 2001 to 2014. Focus on protecting stream and wetland systems.
- Community Scale Septic System Impact studies for Alton, Cheltenham and Erin as part of Village Planning Assessments.
- Water supply development, testing and impact assessment, Permit To Take Water consulting, Source Water Protection characterization and water balance studies for municipal water supplies, golf courses, industrial supply (over 20 assessments).
- Aggregate Resource Act Level 1 and Level 2 Assessments, and associated Zoning and Official Plan amendment impact assessments, at over 30 above water and 28 below water extraction sites. Extensive assessment and analysis of groundwater-surface water interactions (most studies assessed rivers, streams, wetlands and/or ponds).
- Aggregate Resource Act compliance monitoring at over 30 above water or below water extraction sites. Includes measurement and analysis of water level, water quality, thermal impact and groundwater-surface interaction at streams, wetland and ponds.

Groundwater Science Corp.

Unit 2, 465 Kingscourt Drive,
Waterloo, ON N2K 3R5
Phone: (519) 746-6916
groundwaterscience.ca

QUALIFICATIONS

December 2020

Dave Nahrgang, B.Sc., P.Geo.

Current Position

Project Hydrogeologist
Groundwater Science Corp., Waterloo, ON
Responsible for the design and implement hydrogeological monitoring and assessment projects.
Over 13 years of hydrogeologic consulting experience.

Education

B.Sc. (1987) : University of Western Ontario, London, ON
Geology and Environmental Science.

Professional memberships

Registered Professional Geoscientist in Ontario
Licenced MOE Well Technician

Range of Experience

- Hydrogeologist at Golder Associates Ltd. (Cambridge ON) from 2007 to 2012. Hydrogeologist and Well Technician at Well Initiatives Limited (Guelph ON) and Lotowater Limited (Paris ON) from 1999 to 2007.
- Wide variety of groundwater assessment and monitoring experience related to water supply, site characterization, investigations and aggregate assessments.
- Supervised extensive drilling and data collection programs for large-scale municipal and industrial/commercial water supply and dewatering projects. Supervised borehole geophysics, downhole video inspection and other diagnostic testing of existing municipal water supply and test wells. Supervised well rehabilitation programs at high capacity water supply wells.
- Aggregate Resource Act compliance monitoring at over 30 above water or below water extraction sites. Includes measurement and analysis of water level, water quality, thermal impact and groundwater-surface interaction at streams, wetland and ponds.