REPORT

Hydrogeological Level 1 and 2 Assessment

Proposed Lanci Pit Expansion

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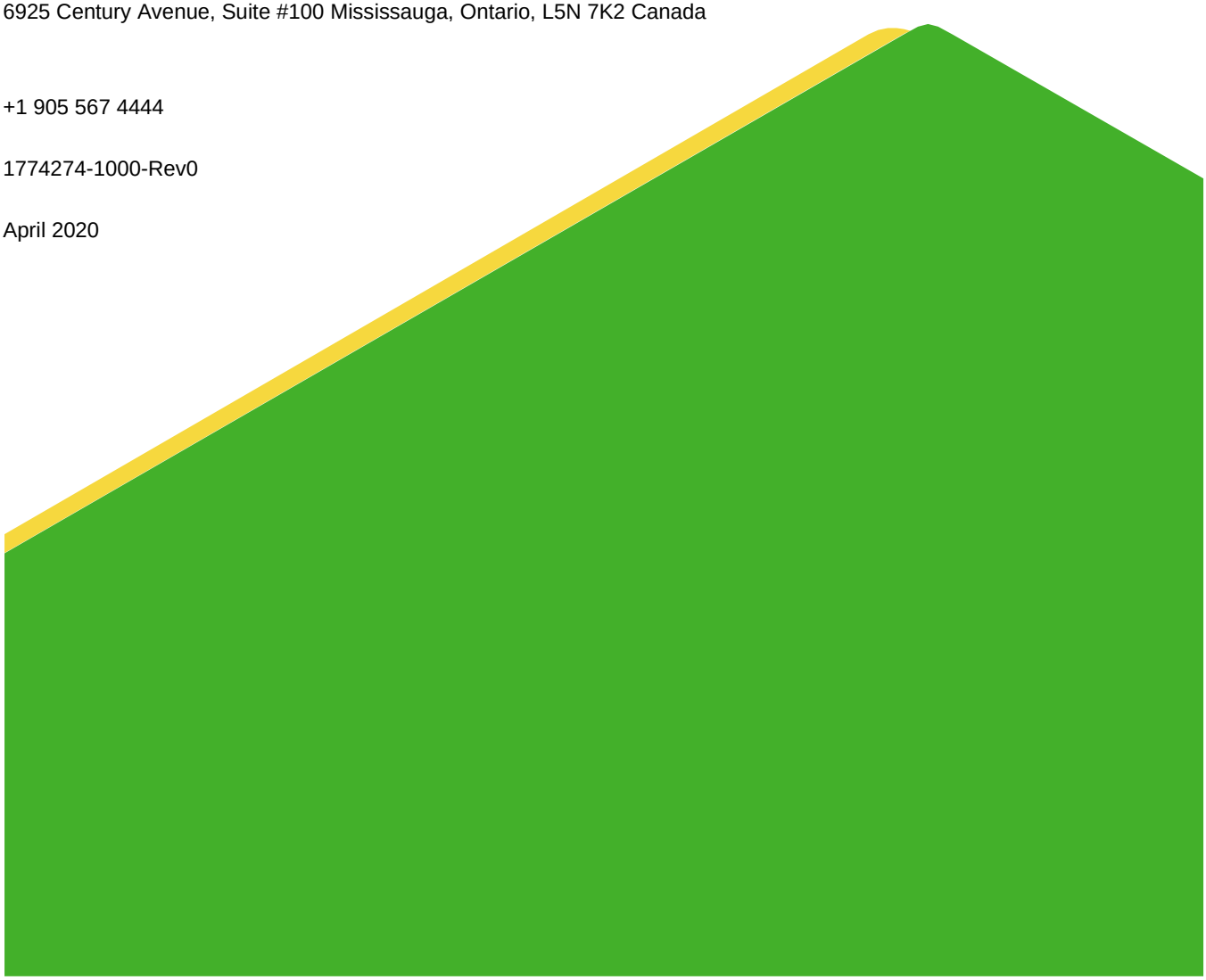

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) was retained by CBM Aggregates (CBM), a division of St. Marys Cement Inc. (Canada) (SMC) to carry out a hydrogeological assessment in support of an application to the Ministry of Natural Resources and Forestry (MNRF) for a new licence under the Aggregate Resources Act (ARA) to permit the extraction of sand and gravel resources from below the water table at the proposed Lanci Pit Expansion. The proposed Lanci Pit Expansion is located on Part of Lot 25, Concession 1, in the geographic Township of Puslinch in the County of Wellington (hereinafter referred to as "the Site"). The location of the Site is shown on Figure 1.

This report has been completed in accordance with MNRF requirements under the ARA for a Level 1/2 Hydrogeology Technical Report, as required for a Class A, Category 1, ARA Licence Application for a pit extending below the water table.

1.1 Main Study Objectives

The objectives of this assessment were to:

- characterize the existing hydrogeological and hydrological conditions in the vicinity of the Site and how they relate to the surrounding natural environment; and
- assess the potential impacts, if any, that the proposed below-water extraction would have on surface water and groundwater in the area, including groundwater users and groundwater and surface water dependent receptors within the surrounding natural environment.

1.2 Study Tasks

The terms of reference (Appendix A) were provided to the Ministry of Natural Resources and Forestry, County of Wellington, and Puslinch Township. The following tasks were completed in order to achieve the study objectives outlined above:

- a review of available data and published information relevant to the Site;
- an evaluation of the local groundwater users based on information from the Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS), supplemented by current information on private wells in the vicinity of the Site obtained through a door-to-door water well survey within one kilometre (km) of the Site;
- a field program that included: a site reconnaissance, test pit completion, borehole drilling and monitoring well installations, hydraulic conductivity testing, a continuous groundwater level and temperature monitoring program (via dedicated transducers) quarterly manual groundwater monitoring / confirmation sampling (water levels and temperatures), and baseline groundwater quality sampling; and
- an assessment of the potential impact of the proposed below-water extraction on surrounding groundwater and surface water receptors, including natural environment features and neighbouring private water wells.

1.2.1 Investigations by Others

The following relevant reports were provided to Golder and reviewed within the context of this assessment:

- Hydrogeological Assessment for Below-Water Extraction, CBM Aggregates Lanci Property, Township of Puslinch (Gartner Lee, 2005).

- 2011 Baseline Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2012).
- 2012 Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2013).
- 2013 Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2014).
- 2014 Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2015).
- 2015 Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2016).
- 2016 Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2017).
- 2017 Groundwater Monitoring Results, CBM Lanci Pit, Aberfoyle, Ontario (AECOM, 2018).
- City of Guelph and Township of Guelph/Eramosa Tier Three Water Budget and Local Area Risk Assessment (Matrix, 2017).

1.3 Proposed Pit Operation

Information on the proposed operation of the Site was obtained from Site Plans prepared by MHBC (2019). The Site is 14.8 hectares (Ha) with a proposed extraction area of 10.2 Ha. The proposed below water table extraction area is 6.1 Ha.

The total depth of below water table extraction will correspond to the undulating surface of the underlying till and bedrock units, which is anticipated to vary between elevations of approximately +- 288 and +-296 metres above mean sea level (masl) at the Site.

Reserve estimates indicate approximately 3 to 4 million tonnes of aggregate are present within the proposed extraction area of the Site. It is proposed that a maximum of 1 million tonnes of combined above and below water table aggregate would be extracted per annum, consistent with the current Lanci Pit operation. Extraction will begin with above water table aggregate with future extraction of aggregate below the water table using a dragline method. The resource will be stockpiled on-site, and pore water allowed to drain back to the pit pond prior to shipment off-site. Aggregate from the Site will not be processed onsite but will instead be routed through the Lanci Pit and ultimately processed across Concession Road #2 at the CBM Aberfoyle South operation.

The Site operations will not require any pumping or active dewatering. During extraction, there will be no direct off-site discharge of water to any watercourse or wetland; all internal drainage will be directed to the resulting pond created by the excavation.

There will not be on-Site storage or handling of significant quantities of any fuels, oils or potentially hazardous materials.

1.4 Rehabilitated Scenario

The proposed rehabilitation scenario will be a 6.1-Ha pond area connected to the existing Lanci Pit Pond (MHBC, 2019), creating a total pond area of approximately 20.5 Ha. As part of the final rehabilitation design, the extraction faces will be rehabilitated to a 3:1 (horizontal:vertical) slope above the water table and a 2:1 slope below water table (the side slope below water table will reflect the natural angle of repose). The future pond water elevation is estimated to be approximately +/- 306.5 masl, as described further below.

2.0 PHYSICAL SETTING

The following subsections provide a general overview of the Site and surrounding physical setting under the existing scenario.

2.1 Climate

The Site is located approximately 18 km east of the Environment Canada (EC) Kitchener / Waterloo climate station. The Kitchener / Waterloo period of record spans 29 years (1984-2013) and is a reasonable proximal dataset to characterize average climatological conditions in the vicinity of the Site.

Based on the Kitchener / Waterloo climate station data, average annual precipitation is 865 millimetres (mm) per year (mm/yr) and the average annual temperature is 7 Celsius.

2.2 Surrounding Land Use

The Site is bounded by the existing CBM Lanci Pit to the north, Sideroad 25 to the east (and beyond this road the CBM Puslinch Pit), the Dufferin-owned Mill Creek Pit to the west, and a woodlot to the south. The northern connection to the existing CBM Lanci Pit occurs through the western third (approximately 1.5 Ha) of the adjacent lot that was purchased by CBM (Figure 1). The existing Lanci Pit is located immediately to the north of the site (Category 1 Class A – Below Water) and encompasses an area of 24.7 Ha with 21.1 Ha approved for aggregate extraction.

2.3 Topography and Drainage

A ground elevation high of approximately 323 masl exists in the southeast corner of the Site whereas a low of approximately 310 masl occurs in the central portion of the Site (Figure 2).

The Site is located in the Middle Grand River watershed and the Mill Creek subwatershed (GRCA, 2019). Off-Site, there are aggregate pit ponds to the north (existing CBM Lanci Pit), west (Dufferin Mill Creek Pit) and east (CBM Puslinch Pit) of the Site. Additional details regarding local drainage patterns are described in Section 4.0 - Water Balance.

Mill Creek, a coldwater stream (LESPRTT, 2008), is located approximately 1.7 km west of the Site. Additionally, Aberfoyle Creek is located approximately 1.6 km northwest of the Site. Aberfoyle and Mill Creek reach a confluence point approximately 2.1 km west of the Site. There are no naturally occurring wetlands mapped within the Site boundary.

There are no surface water features located within the Site boundary. Additionally, there are no direct discharge points of surface water from the Site and no culverts or channels were identified. Despite the regional groundwater and surface water flow generally trending east to west, the Site is internally drained as a result of the coarse-grained deposits underlying the site.

During extraction, there will be no direct off-site discharge of water as all internal drainage will be directed to the excavation. Following rehabilitation, all drainage on-Site will be directed towards a permanent pond created on-site (MHBC, 2019).

2.4 Geology

The northern half of the Site is outwash gravel (OGS, 2010) and part of the ‘Aberfoyle Spillway’ physiographic landform (Chapman and Putnam, 1984). The southern half of the Site is defined as Wentworth Till (sandy silt till

deposit) (OGS, 2010) and falls within the Paris-Galt Moraine Policy Area (Wellington County, 2016)), although boreholes completed in the southern portion of the site (i.e. BH17-03 and MW17-01) show thick sand and gravel deposits, with little evidence of Wentworth Till. Lands in the Paris-Galt Moraine outside of WHPAs that are to be used for large scale mineral aggregate operations are “required to demonstrate that ground and surface water functions will be maintained and, where possible, restored and enhanced” (Policy 4.9.7.2 - Wellington County, 2019). The Site and surrounding area are within the Horseshoe Moraines physiographic region. The surficial coarse-grained deposits are underlain by till (which may consist of Wentworth Till) and extend to bedrock.

Bedrock at the Site and surrounding area is mapped as Paleozoic Guelph Formation Dolostone, a sucrosic, fossiliferous unit, noted to be locally biothermal and bituminous in some areas (Armstrong and Dodge, 2007).

Geologic / hydrostratigraphic cross-sections, based on Site borehole logs, are provided on Figures 3 and 4.

2.5 Regional Recharge and Groundwater Flow

Regional groundwater modelling undertaken for the Guelph / Eramosa Tier 3 Study suggest that recharge rates in the vicinity of the Site range between 300 and 400 mm/yr (Matrix, 2017).

Based on the same study, regional groundwater flow in the vicinity of the Site is generally to the west-southwest with groundwater elevations in +/- 300-310 masl range (Matrix, 2017).

2.6 Groundwater Use

2.6.1 MECP Water Well Records

Following a review of the Ontario Ministry of the Environment, Conservation and Parks (MECP) Water Well Information System (WWIS) database, there are 44 water well records within 1 km of the Site. The locations of the water well records are shown on Figure 5, with a summary of well information provided in Table 1. The following is noted:

- Twenty-nine of the records are water supply wells. The water supply wells are identified for livestock and/or domestic use, with the exception of two wells listed for “public” use but are inferred to also be private supply wells (Well ID 6705097 indicates the water supply is for St. Andrews Church; and Well ID 6708094 is for the Sunset Villa). The water supply wells were drilled between 1962 and 2017 to depths of 11 to 56 metres below ground surface (mbgs) and static water levels ranged from depth of 1.5 to 21.3 mbgs (where reported). Of the 29 water supply wells, nine are listed as overburden wells, two of the wells do not list type, and the remainder are listed as bedrock wells (however, it is noted that some of these wells are installed across the overburden-bedrock interface based on completion depth compared to depth to bedrock). The reported well yields for the water supply wells ranged from approximately 39 to 379 litres per minute (L/min).
- Eleven well records were listed as monitoring/test holes/observation wells, two of which were listed as ‘not used’.
- The remaining four well records were listed as “Abandoned-Other” or “Decommissioned.

2.6.2 Private Well Survey

A list of municipal addresses of properties within approximately 1 km of the Site was compiled from the County of Wellington interactive mapping website for the purposes of conducting a private well survey. A total of 18 private properties were included in the survey excluding aggregate pits.

On September 21, 2017, a notification letter with attached survey was hand delivered to each accessible residence in the survey area to request their participation in the well survey and to provide details on the date and time that a follow-up visit was scheduled. The option was also provided to submit the responses by facsimile or to call in for a telephone interview. At total of 14 properties had letters delivered and four properties that did not have letters delivered:

- MN4103 – no access (locked gate, no mailbox);
- MN4106 - cemetery,
- MN4135 - unfinished house with no mailbox, and
- MN4228 - CBM-owned vacant property with no buildings on-site.

The properties surveyed are summarized in Table 2.

Golder attempted to contact each resident through direct door-to-door visits on September 21, 2017 and September 28, 2017, at which time a short interview was conducted to obtain information about any water wells located on each property. Of the 14 properties that received letters, eight properties were successfully surveyed (in-person, or were subsequently completed via telephone surveys or facsimile submissions up to October 17, 2017). Golder did not receive a response from the remaining six properties. The results of the well survey are summarized in Table 2 and active wells identified by the survey are shown on Figure 5.

The survey identified eight active wells and one inactive well within 1 km of the Site. One of the active wells is owned by CBM (MN4248), associated with one of the existing residences on the Site. The remaining seven off-Site active wells were identified as drilled steel cased wells (apart from one noted to be in concrete casement) installed to depths ranging between approximately 24 and 37 mbgs. The inactive well was identified as a drilled steel cased well completed at an approximate depth of 20 mbgs. As indicated in Table 2, the identified wells supply water for domestic use (commercial/domestic in the instance of Sunset Villa). No well owners indicated issues related to water quantity or water quality; apart from elevated iron.

2.6.3 Municipal Supply Wells

There are no municipal supply wells within 1 km of the Site and the area is not serviced with a municipal water supply.

2.6.4 Existing Water Users

According to the MECP Permit to Take Water database (MECP, 2019), three Permit to Take Water (PTTW) records were identified within 1 km of the Site, as follows:

- Permit No. 5550-9V7HXS held by CBM Aggregates for aggregate washing (max daily water taking of 23,568 m^3/day from groundwater source – McNally Supply Pond).
- Permit No. 8520-A48LDY held by CRH Canada Group Inc. for aggregate washing (max daily water taking of 8,183 m^3/day from groundwater source – Phase 1 Pond).
- Permit No. 8520-A48LDY held by CRH Canada Group Inc. for ‘other – industrial’ purposes (max daily water taking of 17,000 m^3/day from groundwater source – Pond 4).

2.7 Source Water Protection Considerations

The Clean Water Act, 2006 was established to protect municipal sources of drinking water from contamination and over-use in Ontario. Under the Clean Water Act, source protection areas and regions were established, for which source protection plans were subsequently developed. The plans are now approved and in effect with a variety of policy tools that address risks.

The Site is located within the Grand River Source Protection Area (part of the Lake Erie Source Protection Region). The Site is not within a Well Head Protection Area (WHPA-A, -B, -C, or -D) based on the Grand River Source Protection Plan (2015) and there are no specific source protection policies for the Site and surrounding area (GRCA, 2019)

The Site is partially within the “Guelph-Guelph/Eramosa Wellhead Water Quantity Zone (WHPA-Q)”, for which a Tier 3 water budget study was conducted (Matrix, 2017).

3.0 FIELD PROGRAM

A Site field program was initiated in 2017 with the objectives of characterizing hydrogeologic conditions at the Site, including: geologic units, water levels, hydraulic conductivity and water quality. The following sections describe the methodology and results of the field program in detail.

3.1 Borehole Drilling and Monitoring Well Installation

The Site monitoring network includes four monitoring wells (MW17-01, MW17-02, GL-7 and GL-8) as shown on Figure 1. Table 3 presents a monitoring well and borehole summary, while detailed borehole logs are provided in Appendix B.

Well Location: The monitoring wells were strategically placed near the site boundaries to establish Site-wide water level patterns. The well locations and elevations were surveyed by an Ontario Land surveyor (OLS).

Well History: As part of an earlier program for the existing Lanci operation, three of the wells were constructed by others in 2003 and 2012 and included in the overall assessment of subsurface conditions and two of the wells were included in the monitoring program (GL-7 and GL-8). As part of the current investigation, four additional boreholes were drilled in June 2017. Two of those boreholes were advanced for aggregate resource evaluation purposes, and the other two boreholes were completed to further characterize subsurface conditions and facilitate installation of monitoring wells.

Methodology: The four additional boreholes (BH/MW17-01, BH/MW17-02, BH17-03 and BH17-04) were advanced between June 7 and 9, 2017, by Choice Sonic Drilling Ltd. under the supervision of Golder. The boreholes were each continuously cored using a track-mounted Rotasonic drill rig, which obtained a 114 mm diameter (4 ½”) soil core. The material was logged in the field and soil samples for grain size were collected approximately every 1.5 m from the continuous core of material. The boreholes were extended to bedrock, or to a maximum depth of 30 m if bedrock was not encountered. Two of the 2017 boreholes were completed as monitoring wells (MW17-01 and MW17-02). The monitors were constructed of 50-millimetre (mm) nominal diameter Schedule 40 PVC risers and 10-slot well screens. The borehole annulus around the well screens was backfilled with commercial filter sand to approximately 1.6 m and 1.2 m above the screens. The remainder of the borehole annulus was backfilled with granular bentonite to near ground surface. The wells were secured with an

above-ground lockable steel protective casing, cemented in place. Details of all monitoring well installations on-Site are provided on the Record of Borehole sheets in Appendix B.

A summary of well details is provided in Table 3. The approximate locations of the monitoring wells described above are shown on Figure 1.

Nine test pits were also completed on the property and helped confirm geological conditions in certain areas between borehole locations (see Figure 1).

3.1.1 Geology and Hydrostratigraphy

In general, the subsurface soil conditions encountered in the boreholes consisted of topsoil underlain by sand, gravel and cobbles in varying proportions, with trace to some silt. Silty layers were encountered within the coarse granular strata which was generally underlain by fine-grained deposits of fine sand, silty fine sand, sandy silt, silt, and/or silty clay. Grain size distribution curves are presented in Appendix C. Bedrock was encountered below the fine-grained deposits except at BH17-04 where bedrock was encountered directly below the coarse granular strata.

The surficial topsoil ranged in thickness from approximately 0.3 to 0.5 m across the Site. The total thickness of the aggregate resource was estimated to range between approximately 19.5 m and 22.8 m. Where encountered, the underlying fine-grained material occurring had a thickness of 2.0 m to at least 3.4 m. The subsurface conditions encountered in the nine test pits were consistent with those encountered in the boreholes and described above.

The encountered subsurface soil conditions support the conceptual hydrostratigraphy of an unconfined sand and gravel aquifer.

3.1.2 Groundwater Elevations

Groundwater level monitoring at the Site began in June 2017 with quarterly monitoring events occurring thereafter.

Six staff gauges, designated SG1 to SG6, were installed in surrounding pits to facilitate pond level measurements (Figure 1). Pond elevations are considered to be reasonably representative of the groundwater elevation across the pit area.

Pressure transducer dataloggers were installed in MW17-01 and MW17-02 in September and June 2017, respectively, and were configured to record water level and temperature at 30-minute intervals. Transducer data was downloaded on a quarterly basis between September 2017 and June 2018, and again in May 2019. The transducer readings were compensated for changes in atmospheric pressure and converted to water elevations using the surveyed reference elevations.

Manual water level monitoring was conducted at the four monitoring wells (MW17-01, MW17-02, GL-7 and GL-8) and six staff gauges (when monitoring conditions allowed) on a quarterly basis between June 2017 and June 2018, and again in May 2019. The measured water elevations are summarized in Table 4.

Figures 6 and 7 show the inferred groundwater elevation contours and flow directions across the Site for June 2017 and December 2017, respectively. These months correspond to the approximate seasonal groundwater high and low as observed over the period of record. The water elevation hydrographs are provided on Figure 8.

The following observations are noted:

- Depth to water ranges from 8 to 11 mbgs depending on the well and the time of year (Table 4). Corresponding groundwater elevations range from 305.81 masl to 306.57 masl with a Site-wide average of approximately +-306 masl. These elevations are approximately 12 m to 13 m above the proposed pit floor elevation of +- 293.5 masl, corresponding to a final pond depth of approximately 12 m to 13 m.
- The water levels in individual wells and staff gauges were observed to vary seasonally by approximately 0.5 to 0.7 m over the monitoring period (Figures 6 and 7). The trend in water level elevations was consistent across monitoring wells, with higher water levels measured in spring and lower water levels in winter.
- Inferred high-water table elevations are presented on Figure 6. Consistent with other monitoring events, the on-Site groundwater flow direction is towards the west-southwest.
- The maximum on-Site observed groundwater elevation during the monitoring period of record was 306.57 masl (MW17-01 – June 2017) and the minimum on-Site observed groundwater elevation was 305.81 masl (MW17-02 & GL-7 – December 2017).

3.1.3 Hydraulic Conductivity Testing

On June 28, 2018, slug testing was conducted in MW17-01 and MW17-02 to assess the hydraulic conductivity of the sand and gravel aggregate resource in the vicinity of the well screen.

A pressure transducer was installed below the water level to record changes in the height of the water column, programmed to record pressure at 0.5 second intervals. The displacement was initiated by lowering a slug of a known volume to rapidly raise the water level in the well. The subsequent falling water level was recorded with the pressure transducer (falling head test). Once the water level returned to static, a second slug test was initiated by removing the slug from the well causing a rapid drop in water levels and the subsequent rise in water level was recorded using the pressure transducer (rising head test). Pressure data for the rising head test was analyzed using the Hvorslev method (Hvorslev, 1951).

The hydraulic conductivity of the overburden material at the well screen interval was estimated, using the rising head tests, at 8 x 10^{-4} m/s at MW17-01 and 9 x 10^{-4} m/s at MW17-02. The analysis reports are provided in Appendix D.

3.1.4 Groundwater Flow Velocity

The groundwater flow velocity in the vicinity of the Site was estimated using the following equation (Freeze and Cherry, 1979):

$$\bar{v} = \frac{-K}{n}\frac{\partial h}{\partial l}$$

Where $\bar{v}$ is the average linear groundwater velocity in m/s; K is the hydraulic conductivity in m/s; n is the porosity of the material; and $\frac{\partial h}{\partial l}$ is the hydraulic gradient.

Hydraulic conductivity values were taken from the slug tests results, with an average value of 8.5 x 10^{-4} m/s applied. Hydraulic gradients were calculated from groundwater elevation monitoring (approximately 0.0003 m/m based on the June 2017 data and 0.0004 m/m based on the December 2017 data), and a porosity of 0.3 was estimated for the sand and gravel overburden encountered at the Site (Freeze and Cherry, 1979). Groundwater flow velocity across the Site was thus estimated to range between 0.09 and 0.1 m per day.

3.1.5 Groundwater Temperature

Dataloggers installed in MW17-01 and MW17-02 collected water level and temperature measurements at 30-minute intervals. These groundwater temperatures are presented on Figure 9.

Groundwater temperature profiles were measured in the four monitoring wells (MW17-01, MW17-02, GL-7 and GL-8) on a quarterly basis between September 2017 and June 2018, and again in May 2019. The profiles were measured using a Solinst water level meter with built-in temperature probe. The temperature in each well was measured at one-metre intervals from the bottom of the well to the top of the water table. The measured temperatures and respective depths from water table are summarized in Table 5 and the corresponding thermal profiles are shown on Figures 10 to 13.

Across the four monitoring wells, groundwater temperatures measured during profiles were recorded at depths below water table ranging from 0 to 6 m.

The highest groundwater temperatures were measured in GL-8, with temperatures from quarterly profiles ranging from 10.6 to 12.5 °C. The lowest groundwater temperatures were measured in MW17-02 and GL-7, which are proximal and installed at a similar depth. The temperatures from quarterly profiles at MW17-02 and GL-7 ranged from 8.8 to 9.4 °C.

Groundwater temperature variations due to seasonal conditions were generally more pronounced at shallow depths, with more consistent temperatures at depth. Observed groundwater temperatures at GL-8 appear to be influenced thermally from the CBM Puslinch Pond. MW17-02 and GL-7 are approximately 300 m downgradient from GL-8 and do not appear affected thermally by the CBM Puslinch Pond (i.e., the groundwater temperatures reflect background temperatures at MW17-02 and GL-7).

Thermal influence from the CBM Puslinch pond on GL-8 (approximately 125m downgradient) indicates that warmer conditions from the pond don't reach GL-8 until approximately 4 to 6 months later during winter months, with the highest temperature recorded in December. Similarly, the cool temperatures from the pond in the winter were recorded during the June monitoring events at GL-8.

3.1.6 Baseline Groundwater Quality

Baseline groundwater quality conditions were evaluated by collecting and analyzing water samples from the four monitoring wells (MW17-01, MW17-02, GL-7 and GL-8) in June 2017. The samples were collected using dedicated inertial pumps and polyethylene (Waterra) tubing. Prior to sampling, the wells were purged of a minimum of three well volumes of groundwater and allowed to recover to their static water level at the time of sampling.

The groundwater samples were collected using laboratory-supplied bottles. Samples for metals analysis were filtered in the field using 0.45 micron (µm) disposable in-line filters. The water samples were placed in coolers on ice and submitted under chain of custody procedures to Maxxam Analytical Services Ltd. in London, Ontario.

The groundwater samples were analysed for a suite of water quality indicator parameters, including general chemistry, nutrients, metals, inorganics and petroleum hydrocarbons. The analytical results are summarized in Tables 6 to 8 and a copy of the laboratory Certificate of Analysis is provided in Appendix E. Parameter concentrations were compared to the 'Table 2' groundwater standards from the MECP "Soil, Groundwater and Sediment Standards for Use under Part XV.1 of the Environmental Protection Act", dated April 2011 (MECP Table

2 Standards). The analytical results were also compared to the Ontario Drinking Water Standards (ODWS), amended December 2016. The following is noted:

- None of the inorganic parameters, including metals, were detected at concentrations greater than the Table 2 SCS criteria;
- Chloride was detected in all wells, below the applicable Table 2 criteria;
- Nitrate was detected in all wells, suggesting impacts from fertilizer application to farm fields;
- Hardness values ranged between 260 and 320 milligrams per litre (mg/L) as calcium carbonate ($CaCO_3$), indicating hard water; and
- Petroleum Hydrocarbons (PHCs) were not detected in the four wells.

None of the other groundwater parameters analyzed were detected at concentrations greater than the applicable MECP Table 2 Standards or ODWS criteria.

4.0 WATER BALANCE

This section discusses the surface water balance of the proposed sand and gravel pit expansion.

4.1 Methodology

The Meteorological Service Data Analysis and Archive division of Environment Canada (EC) provides monthly water budget summaries for meteorological stations with greater than 20 years of meteorological data. These water budgets include monthly values for all parts of the water budget (rainfall, snowmelt, potential evaporation, etc.) for each of the years in the historic record, as well as average monthly values over the entire record.

The water balance assessment was based on meteorological data from the EC Thornthwaite water budgets (Environment Canada averaged Kitchener/Waterloo station [ID #6144239] between 1984 and 2013), watershed boundaries, land use data, and the existing soil types.

This method describes water flux in a unit area of soil on a monthly basis based on a balance of precipitation (rainfall and snowmelt), evapotranspiration (ET), soil storage, and surplus. The water budget can be summarized as follows:

$$P = S + ET + R + I$$

Where: P = precipitation;

S = change in soil water storage;

ET = evapotranspiration;

R = surface runoff; and,

I = infiltration (groundwater recharge).

The various water budget components associated with catchment areas are typically presented in millimetres (mm) over their respective sub-catchments and represent the amount of water per unit of watershed area. This amount is related to specific soil properties, including field capacity and wilting point.

The water budget model combines accumulated rainfall and snowmelt to estimate total precipitation. Precipitation is assumed to be rainfall when monthly mean temperatures are greater than 0 °C. Snowmelt is initiated when snow is on the ground and monthly mean temperatures are greater than 0 °C. Hence, snowmelt is based on the depletion of snow storage (accumulated precipitation during periods of sub-zero temperatures). Precipitation data collected at the Kitchener/Waterloo monitoring station (1984 to 2013) indicated a mean annual precipitation (P) of 865 mm/year.

The potential or maximum ET is estimated, in this case, using the empirical Thornthwaite equation (using average monthly temperature and hours of daylight) and represents the amount of water that would be evaporated or transpired under saturated soil-water scenarios. The actual ET is the total evapotranspiration for the period of study based on evapotranspiration demand, available soil-water storage, and the rate at which soil water is drawn from the ground (as defined by an established drying curve specific to the soil type). The mean annual potential ET for the study Site is approximately 600 mm/year based on data provided by EC.

Annual water surplus is the difference between P and the actual ET (ignoring minor changes in storage from year to year). The water surplus represents the total amount of water available for either surface runoff (R) or groundwater infiltration (I) on an annual basis. On a monthly basis, surplus water remains after actual evapotranspiration has been removed from the sum of rainfall and snowmelt, and maximum soil or snowpack storage is exceeded. Maximum soil storage is quantified using a water holding capacity (WHC) specific to the soil type and land use.

4.2 Catchment Delineation

Site catchments were delineated using topographic mapping and site boundary information, as illustrated on Figures 14 through 16 and summarized in Table 9. As land use within the existing licence boundary and under existing pit operations is not expected to change, the water balance considered the catchment area of the proposed pit expansion only.

4.3 Water Balance Scenarios

Under existing conditions, the catchment is primarily composed of wooded areas and minor clearings with vegetated/grassed lands that contain several residential dwellings, as seen on Figure 14.

Under operational conditions, most of the site will be excavated to form the proposed pit leaving a narrow border of lightly vegetated area defined by the setback boundary, as seen on Figure 15. During operation, extraction will occur below the water table and the formation of a pond will result.

Final site conditions were also considered in this study to determine the water surplus after excavation has ceased and the pit is rehabilitated. Under rehabilitated conditions, a pond will remain where extraction has occurred below the water table and the areas where side sloping has been established to the extraction boundary above the water table are to be a combination of seeding to establish stable slopes and some wooded areas, as seen on Figure 16. For more detail on proposed rehabilitation for the Site, see also Golder NEL report and MHBC Site Plans, Rehabilitation Page. No drainage will be directed to natural watercourses, precipitation that does not infiltrate will be directed into the excavated pond.

4.4 Water Balance Parameters

Soil information was taken from the 2012 Ontario Quaternary Geology Mapping available for the area. Soils at the site are primarily composed of sandy loam for agricultural areas and silt loam for the wooded areas. Gravelly sand

was assumed to be the soil type for the area of the proposed pit expansion under operational conditions, based on existing borehole results as discussed in Section 3.1.

The maximum soil storage is quantified using a Water Holding Capacity (WHC) that is based on guidelines provided in Table 3.1 of the Ministry of the Environment (MOE) Stormwater Management Planning and Design Manual (MOE, 2003). The WHC represents the practical maximum amount of water that can be stored in the soil void space and is defined as the difference between the water content at the field capacity and wilting point (the practical maximum and minimum soil water content), respectively.

WHCs are specific to the soil type and land use, whereby values typically range from approximately 10 mm for bedrock to 400 mm for mature forest over silt loam. For temperate region watersheds, soil storage is typically relatively stable year-round, remaining at or near field capacity with the exception of the typical mid- to late-summer dry period. As such, the change in soil storage is a minor component in the water budget, particularly at an annual scale. Surplus water is caused after actual ET has been removed (ET demand is met) and the maximum WHC is exceeded (soil-water storage demand is met).

There are three main factors that determine the percent infiltration of the total surplus: topography, soil type and ground cover. The sum of the fractions representing the three characteristics establishes the approximate annual percentage of surplus which can be infiltrated in an area with a sufficient downward groundwater gradient.

Existing and proposed catchment areas are summarized by land use, WHC, soil type, and infiltration factor in Table 9.

For wooded areas, a WHC of 250 mm and an infiltration factor of 0.9 were used, representing flat land with an average slope of <0.6 m/km, sandy loam soil, and wooded land use.

For agricultural/grass areas under existing conditions, a WHC of 200 mm and an infiltration factor of 0.8 were used, representing flat land with an average slope of <0.6 m/km, sandy loam soil, and cultivated land use (moderately rooted crops/grass).

For the existing built-up areas, a WHC of 100 mm and an infiltration factor of 0.1 were used, under the assumption that only 10% of the precipitation will infiltrate the pervious surfaces (i.e. gravel roadways) and the remaining 90% of surplus will contribute to runoff.

For agricultural/grass areas under operating and rehabilitated conditions, a WHC of 100 mm and infiltration factor of 0.8 were assigned. The total surplus for these areas are expected to infiltrate on the Site and not generate any off-site runoff.

For the operational built-up areas, a WHC of 100 mm and an infiltration factor of 0.1 were used, under the assumption that 100% of the surplus will runoff and will be collected in the pit pond where it will be stored, evaporated or recharge to the groundwater system.

For the open water areas (flooded pit areas) it was assumed surplus equals the difference of the precipitation and potential ET and assumed infiltration factor of zero.

4.5 Water Balance Results

Surplus values were calculated as the annual precipitation minus annual actual evapotranspiration. Runoff was calculated as the difference between surplus and infiltration. The results of the full assessment can be found in

Appendix F. The water balance results for the existing, operational and rehabilitated conditions are provided in Table 10.

4.5.1 Existing Conditions

The total average annual surplus for the catchment area under existing conditions was estimated to be 275 mm or 40,596 m^3 per year and the estimated infiltration is approximately 238 mm or 35,169 m^3 per year. Runoff was calculated as the difference between surplus and infiltration and was estimated to be 37 mm or 5,427 m^3 per year. Based on the assessment, approximately 87% of the annual surplus infiltrates, while the remaining 13% is surface runoff under the existing condition. Currently no water is drained to natural watercourses. Surface runoff primarily drains into Lanci Pit with a portion draining to the neighbouring licenced aggregate pit to the west of the Site.

4.5.2 Operational Conditions (Full Extraction)

The total average annual surplus for the catchment area was estimated to be 287 mm or 42,307 m^3 per year and the estimated infiltration is approximately 85 mm or 12,501 m^3 per year. Runoff was estimated to be 202 mm or 29,807 m^3 per year. Based on the assessment, 30% of the annual surplus infiltrates, while the remaining 70% is surface runoff in the operational conditions.

4.5.3 Rehabilitation Conditions

The total average annual surplus for the catchment area was estimated to be 287 mm or 42,308 m^3 per year and the estimated infiltration is approximately 148 mm or 21,792 m^3 per year. Runoff was estimated to be 139 mm or 20,516 m^3 per year. Based on the assessment, 52% of the annual surplus infiltrates, while the remaining 48% is surface runoff in the operational conditions.

4.6 Water Balance Summary

A summary of the annual water balance considering surplus, infiltration, and runoff for the existing, operational, and rehabilitated conditions is provided in Table 11.

Under operational conditions, surplus is anticipated to increase slightly by 4.0% from 40,596 to 42,307 m^3 per year – representing a minor decrease in evapotranspiration due to the removal of agricultural and woodland areas. Infiltration is expected to decrease by 64,5% from 35,169 to 12,501 m^3 per year as the surplus from the flooded pit will be considered runoff, although it will not be discharged off-Site. This will effectively increase the total runoff from the Site to 200 mm/yr (29,807 m^3/yr). This equates to an overall increase in runoff of 71% or 24,380 m^3/yr.

Under rehabilitated conditions, the components of the water balance will continue to function very similarly to operational conditions, as the pit will remain ponded. The setback area will consist of vegetated lands, runoff will continue to drain to the Lanci Pit, and thus surplus is projected to only increase by 4.0% to 42,308 m^3 per year (compared to existing). Site runoff is expected to be conveyed to the pond and will remain in storage or leave the Site as either evaporation or recharge to the groundwater system. The infiltration is expected to decrease by 51.5% to 148 mm/yr (21,792 m^3/yr) and the runoff will increase by 73.5% to 139 mm/yr (20,516 m^3/yr).

5.0 IMPACT ASSESSMENT

The impact assessment seeks to estimate potential changes to the hydrogeologic / hydrologic system as a result of Site Operations and Rehabilitation Scenarios and the effect these changes may have on groundwater users and receptors. Our analysis focuses on impacts to the following:

- groundwater levels;
- baseflow;
- water well quantities;
- aquifer vulnerability and groundwater quality;
- groundwater temperature; and
- site water budget.

5.1 Groundwater Levels

The below-water operation will not involve any pumping or active dewatering. Rather, the majority of pore water "removed" during extraction will eventually return to the aquifer via passive drainage within the windrowed material, prior to being transported to the processing plant. Whereas some water may be lost to evaporation or transport off-Site, prior studies have indicated that this loss is typically small, ranging from 2% to 8% of total handled water (Golder, 2006).

Based on the proposed annual extraction limit of 1 million tonnes per year and 220 working days of below water operation each year, the volume of aggregate to be removed from below the water table daily is estimated to be a maximum of 4,545 tonnes if all extraction were to occur only below the water table and not in conjunction with above water table extraction. On a typical day, the volume of below water extraction, when combined with above water table extraction activities, is likely to be less than the maximum. However, conservatively assuming a below water extraction equal to 4,545 tonnes per day, an assumed density of 1.78 tonnes per cubic metre, a porosity of 0.3, and a moisture retention of 3%, the daily equivalent volume of water that is lost from the localized groundwater system from extraction is approximately 23 m^3 per day. This estimate assumes that following extraction, the aggregate is allowed to drain, with groundwater not retained on the aggregate freely infiltrating back into the subsurface.

During the below water extraction operations, an equivalent volume of water will be required to replace the volume of aggregate excavated from below water. This will potentially result in a small-scale localized transient reduction in the water table. The extraction is for only half the day maximum (i.e., 12hr operating day), does not operate for the full week (i.e., 5-6-day work week), and is seasonal in nature with cessation of below water extraction activities over the winter months. As such, it is anticipated that these influences to water table elevation will be temporary and relatively minor.

The principal mechanism for Site development to instigate long-term effects on groundwater levels is exposing the water table to the atmosphere. Below-water table aggregate extraction results in the eventual creation of a permanent on-Site pond that will generally "flatten" water levels in its vicinity. The area upgradient of the pond experiences water level drawdown whereas the area downgradient of the pond experiences water level rise. Typically, only drawdown is of concern with respect to water quantity impacts. This then considers the Rehabilitation Scenario to be the "worst-case" outcome with respect to long-term drawdown.

The Rehabilitation Scenario pond level is expected to approximate the average groundwater level within the below water extraction area. Under high water table conditions (Figure 6), the average water level within the pond area is estimated to be +/- 306.5 masl. An estimate of future drawdown along the upgradient (eastern) perimeter of the pond may be obtained by taking the existing upgradient high groundwater elevation of approximately 306.6 masl and subtracting the future pond elevation of 306.5 masl, resulting in a drawdown of 0.1 m at the upgradient pond perimeter. Likewise, a water level increase of approximately 0.1 m could be expected along the downgradient (western) perimeter of the future pond. Water level changes of similar magnitude could be expected during different times of the year as the pond and surrounding groundwater levels would jointly rise and fall over a seasonal timescale.

To estimate the extent of the pond's lateral zone of influence (i.e., where the drawdown reaches zero) we are able to use an analytical solution from Marinelli and Niccoli (2000). In summary, the Site-specific inputs are as follows:

- Recharge is assumed to be 275 mm/yr per the Site water budget
- The hydraulic conductivity of the sand and gravel unit is estimated to be 8.5×10^{-4} m/s based on the hydraulic conductivity testing
- The rehabilitated pit pond area is approximately 6.1 ha or 61,000 m^2. The effective radius is approximated as:
  - $A_{pond} = pi * r_e^2$
  - $r_e = [(61{,}000\ m^2) / (3.14159)]^{1/2}$
  - $r_e = 139$ m
- The pit pond floor is assumed to be +-293.5 masl. Under high water table conditions:
  - The initial (i.e., pre-extraction) saturated thickness is 306.6 m – 293.5 m = 13.1 m
  - The final (i.e., post-extraction) saturated thickness is 306.5m – 293.5 m = 13.0 m

Based on the theoretical calculation with the above discussed inputs, the 0.1 m drawdown is calculated to decrease to a point of zero drawdown 535 m from the centre of the pit pond or 395 m from the edge of the pit pond. This theoretical calculation does not consider the influence on drawdown of existing pit lakes to the north, east and west of the Site. The proximity of existing pit lakes will influence the point of zero drawdown and it is expected that measurable drawdown will occur only within close proximity to the pit pond.

5.2 Baseflow

Baseflow is the groundwater contribution of total flow to a surface water feature. Baseflow changes as a result of below-water extraction are related to water level changes. A surface water receiver downgradient of a water level decline may experience decreased baseflow to that feature; conversely, a surface water feature downgradient of a water level rise may experience increased baseflow. Typically, only baseflow decrease is of concern within the context of impact assessment.

The only mapped surface water features in the area lie several hundred metres downgradient of the Site. As such, there are likely no significant baseflow contributions at these locations. Nonetheless, as water levels will rise downgradient of the pit pond, and there is another pond between the proposed Site pond and downgradient features. As such, those features are not expected to realize any influence from the proposed extraction.

5.3 Water Well Quantities

The door-to-door well survey identified eight active wells located within approximately 1 km of the Site. The nearest off-site wells were identified at MN 4195 Sideroad 25 South, located approximately 240 m southeast of the Site, and MN 4219 Sideroad 25 South, located approximately 300 m east of the Site. Well MN 4195 is located cross-gradient to the site, while MN 4219 is located upgradient of the site. These wells are installed to depths of 36.9 and 36.6 m, respectively. Static water levels in this area range between 15 and 20 m from ground surface, indicating approximately 15 to 20 m of available water in these wells. On-Site drawdown estimates range to a maximum of 0.1 m. At the closest private well (MN 4195 – 240 m away), measurable drawdown is not expected to occur. However, even if the maximum onsite groundwater drawdown of 0.1 m is considered to arrive at this location, the predicted drawdown will not impact well operation and is, in fact, within the margin of error for estimating drawdown resulting from the pond at this distance.

Other identified wells are located more than 500 m off-Site and none are inferred to be located down-gradient. Based on the available information, the identified off-Site private wells are not anticipated to be adversely impacted by the below-water extraction at the Site.

5.4 Groundwater Quality

5.4.1 Operational Scenario

The Operational Scenario will not involve the on-Site storage or handling of significant quantities of any fuels, oils or potentially hazardous materials that could enter the groundwater system. Therefore, water quality is not expected to be adversely impacted. Nonetheless, CBM's Best Management Practices (BMP) for fuel handling will be followed for any on-site handling of fuel that does occur while equipment is being refueled.

5.4.2 Rehabilitation Scenario

The Rehabilitation Scenario will rehabilitate the pit to a naturalized pit lake. The removal of the overlying sand and gravel resource will result in a reduction of unsaturated zone thickness above the water table. It should be noted that the sand and gravel resource on this property is particularly coarse grained and, as such, the unsaturated residence time is low compared to travel through the saturated zone. As a result, the loss of unsaturated zone "filtering" capacity is considered to be minor. In coarse grained deposits, most of the filtering occurs within the saturated zone via horizontal groundwater flow through the aquifer.

The Site is bordered by active aggregate pits that are either currently extracting or have in the past extracted below the water table to the east, north, and west. The area in the vicinity of the Site has limited direct connections to agricultural land practices that may have influenced groundwater quality. Groundwater reporting to the future pit pond is not expected to introduce nitrates and/or pathogens in rehabilitated conditions.

5.4.3 Groundwater Temperature

The exposure of the water table to the atmosphere may result in an increase in groundwater temperatures emanating from the Site during summer months, and a lowering of groundwater temperatures emanating from the Site during the winter months. This can occasionally be a concern for aquatic species or habitat that require the influx of cool groundwater within a certain temperature range in order to maintain ecological function.

Prior studies in Ontario have indicated that thermal influence originating from below-water pits typically do not migrate further than 120 to 150 m downgradient of the pit pond before their effect becomes negligible (Yang, 1995 and Markle and Schincariol, 2007). Observed groundwater temperatures at the site suggest the thermal effects

emanating from the upgradient CBM Puslinch Pit Pond is observed at the eastern Site boundary, approximately 125m away, but are not observed approximately 400 m downgradient at the western Site boundary. No aquatic habitat lies within these distances from the pit pond and therefore off-Site migration of thermal influences will not cause any adverse impacts.

5.5 Potential Adverse Impacts to Surface Water Resources

There are no surface watercourses or waterbodies within the Site. Given that runoff drains internally to the existing Lanci Pit and the neighbouring aggregate pit to the west under current conditions, changes from existing to proposed conditions are not expected to have an impact on natural surface water features within the vicinity of the Site.

According to the Ministry of Natural Resources and Forestry Ontario topographic map tool, Mill Creek is located approximately 1.7 km west of the site. Additionally, tributaries of Mill Creek are located approximately 680 m northwest of the site.

The water balance assessment in Section 4.0 suggests that overall there is a very minor increase in surplus of 4.0% from 40,596 to 42,307 m^3 per year for the site under operational conditions. Rehabilitated conditions are expected to have a similar change in average annual surplus (i.e. 4.0% increase).

There is no expected change in runoff volume to receiving watercourses as water will continue to drain internally to pits and depressions in the area (including neighbouring pits). Overall no adverse impacts are predicted for surface watercourses in the surrounding area.

5.6 Paris-Galt Moraine Policy

A review of the potential changes to the groundwater and surface water systems resulting from the proposed aggregate extraction development (presented in Sections 5.1-5.5 above) suggest that the groundwater and surface water systems will generally be maintained during operations and throughout/following the rehabilitation process, consistent with the County's Paris-Galt Moraine Policy Area requirements in the Official Plan.

5.7 Guelph / Eramosa Wellhead Water Quantity Zone

A small portion of the northeast corner of the site falls within the Guelph-Guelph/Eramosa Wellhead Water Quantity Zone (WHPA-Q). No groundwater withdrawals or overall reductions in aquifer recharge have been identified for this site. In accordance to the 2017 Technical Rules under the Clean Water Act, the proposed site development activity would not be considered a drinking water quantity threat.

6.0 CUMULATIVE EFFECTS DISCUSSION

Existing aggregate extraction pits are located to the east, north, and west of the Site. Groundwater flow at the Site is expected to be west-southwest towards Mill Creek. Three Pit Lakes exist between this site and Mill Creek, two of which are actively operating. The existing Lanci Pit Lake, along with existing Pit Lakes upgradient of the Site. Long-term monitoring of Mill Creek (LRG, 2019) has shown that below water table aggregate extractions in this area have not resulted in measurable impacts on water temperatures and streamflows within Mill Creek.

No municipal water supply well capture zones extend to the Site. The proposed operation will not adversely impact on wellhead protection areas within the GRCA (WHPA-A, -B, -C, or -D).

Considering the above, including the observed long-term monitoring responses to a number of existing below water table aggregate operations, the proposed extraction will not have additional adverse impacts on the water resources of the area as has been outlined herein as part of the impact assessment for the Site.

7.0 CONCLUSIONS

A Level 1/2 Hydrogeological and Hydrological Study has been prepared in support of a Category 1, Class A, Pit Below Water licensing application for the proposed Lanci Pit Expansion. Existing, Operational, and Rehabilitated Scenarios were considered. The study involved two main aspects: 1) the establishment of baseline conditions for the Existing Scenario through background data review and field program data collection; and 2) an impact assessment for proposed Operations and Rehabilitated Scenarios. The following conclusions are drawn from the study:

7.1 Existing Scenario

- Average annual precipitation near the Site is 865 mm/yr. Evaporation is estimated to be 590 mm/yr with a resulting surplus of 275 mm/yr. The majority of the surplus becomes infiltration (238 mm/yr) with the remainder becoming runoff (37 mm/yr).
- There are no permanent surface water features on-Site and the Site is determined to be internally drained.
- The Site aggregate resource consists of a mapped sand and gravel unit with the southern portion mapped as Wentworth Till, although boreholes completed in the southern portion of the site (i.e. BH17-03 and MW17-01) show thick sand and gravel deposits, with little evidence of Wentworth Till. Site drilling suggests the sand and gravel deposit is approximately 20 m thick and estimated hydraulic conductivity values average $8.5x10^{-4}$ m/s.
- Groundwater flow in the vicinity of the site is generally to the west-southwest. Depth to groundwater at the Site ranges from 8 to 11 m.
- Groundwater quality results generally meet Table 2 SCS criteria. Chloride and nitrate were observed at the site, but all values below the Table 2 criteria.

7.2 Operational and Rehabilitated Scenarios

- The below-water operation will not involve any pumping or active dewatering. Rather, the majority of pore water “removed” during extraction will eventually return to the aquifer via passive drainage within the stockpiled material.
- Below-water aggregate extraction will result in the eventual creation of a permanent pond that will flatten water levels in its vicinity. The area upgradient of the pond (east) will incur water level drawdown, while areas downgradient of the pond (west) will incur water level rise. The magnitude of the water level change is estimated to be approximately 0.1 m at the upgradient pit pond edge.
- There is not expected to be any adverse impacts to baseflow at groundwater receptors as a result of the minor water level changes.
- There is not expected to be any adverse impacts to water quantity at surrounding private wells as a result of the minor water level changes.

- There will be no on-Site storage or handling of significant volumes of fuel, oils, or potentially hazardous materials that could be released into the groundwater system. There is not expected to be any adverse impacts to water quality.
- The exposure of the water table to the atmosphere may result in an increase in groundwater temperatures emanating from the Site during summer months and, conversely, a decrease in groundwater temperatures emanating from the Site during winter months. However, there are no groundwater-dependent aquatic habitats within the thermal zone of influence (120 to 250 m) downgradient of the Site and therefore no receptors will be adversely impacted.
- The proposed changes under operational and rehabilitated conditions are anticipated to result in increases to average annual surplus over the site footprint area of approximately 4.0%, for both scenarios.

8.0 RECOMMENDATIONS

The following is recommended:

- Groundwater monitoring will continue through Operations to confirm conclusions of the impact assessment. This monitoring will be incorporated into the existing monitoring program that is on-going for the current Lanci Pit operation.
- CBM's BMP for fuel handling will be followed while any refuelling of equipment is occurring on site.

9.0 LIMITATIONS

This report is based on data and information collected during the hydrogeological assessment of the subject property conducted by Golder. The assessment is based solely on the Site conditions encountered at the time of the assessment, supplemented by other information and data obtained by Golder as described in this report. No assurance is made regarding changes in conditions at the Site subsequent to the time of the assessment.

In evaluating the property, Golder has relied in good faith on information provided by CBM Aggregates and others. Golder has assumed that the information is factual and accurate. No responsibility is accepted by Golder for any deficiencies, misstatements or inaccuracies contained in this report as a result of omissions, misinterpretations or fraudulent acts of the persons interviewed or contacted.

The assessment of hydrogeological conditions and possible Site impacts presented has been made using the historical and technical data collected and information from sources noted in the report. There is no warranty, expressed or implied, by Golder that this investigation has identified all potential factors that may affect future or present conditions at the Site. This assessment is intended to address hydrogeological factors affecting the local groundwater and surface water resources only. No investigation with respect to potential Site contamination was conducted.

9.1 Use of the Report and its Contents

This report has been prepared for the exclusive use of CBM Aggregates (the client). The factual information, descriptions, interpretations, comments, recommendations, and electronic files contained herein are specific to the project described in this report and do not apply to any other project or site. Under no circumstances may this

information be used for any other purposes than those specified in the scope of work unless explicitly stipulated in the text of this report or formally authorized by Golder. This report must be read in its entirety as some sections could be falsely interpreted when taken individually or out-of-context. As well, the final version of this report and its content supersedes any other text, opinion or preliminary version produced by Golder.

Golder shall not be held responsible for damages resulting from unpredictable or unknown underground conditions, from erroneous information provided by and/or obtained from other sources than Golder, and from ulterior changes in the site conditions unless Golder has been notified by the client of any occurrence, activity, information or discovery, past or future, susceptible of modifying the underground conditions described herein, and have had the opportunity of revising its interpretations and comments. Furthermore, Golder shall not be held responsible for damages resulting from any future modification to the applicable regulations, standards and criteria, for any use of this report and its content by a third party, and/or for its use for other purposes than those intended. Golder shall not be held responsible for any decrease, real or perceived, of a property's value or any failure to complete a transaction, as a consequence of this report.

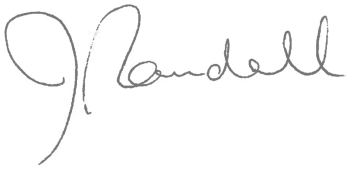
References to acts and regulations that may be contained in this report are informally provided on a technical basis. Since acts and regulations that may be contained in this report are subject to interpretation, Golder recommends the client to consult with legal counsel to obtain suitable advice.

10.0 CLOSURE

We trust that this information meets your present requirements. Curricula Vitae for the authors of this report are found in Appendix G.

Signature Page

Golder Associates Ltd.



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https://golderassociates.sharepoint.com/sites/11897g/shared documents/07 deliverables/phase 1000 - hydrogeology/final - level 1 and 2 hydrogeo study/ss/1774274-1000-r-rev0-lanci ext hydrogeological assessment-21apr2020.docx

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TABLES

Table 1
SUMMARY OF MECP WATER WELL RECORDS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

									DEPTH				TEST PUMPING			STRATIGRAPHY	
WELL ID	EASTING	NORTHING	YEAR DRILLED	CASING DIAMETER (mm)	DRILLING METHOD	WELL TYPE	WELL STATUS	WATER USE	TOTAL DEPTH (m)	BEDROCK (m)	WATER FOUND (m)	STATIC WATER LEVEL (m)	WATER LEVEL AFTER PUMPING (m)	RATE (L/min)	DURATION (HRS)	MATERIAL	DEPTH TO UNIT BASE (m)
6702287	567141.3	4809885.0	1964	152.4	Cable Tool	Bedrock	Water Supply	Livestock	22.9	16.5	21.9	3.4	7.6	76	1	PREVIOUSLY DUG MEDIUM SAND GRAVEL CLAY LIMESTONE	3.7 16.5 22.9
6702288	567978.3	4808489.0	1962	152.4	Cable Tool	Bedrock	Water Supply	Domestic	38.7	35.4	37.8	15.8	18.3	91	1	PREVIOUSLY DUG GRAVEL CLAY MEDIUM SAND LIMESTONE	15.2 18.3 35.4 38.7
6702325	567471.3	4810184.0	1964	152.4	Cable Tool	Bedrock	Water Supply	Livestock, Domestic	22.9	18	21.9	6.1	12.2	76	1	STONES GRAVEL MEDIUM SAND CLAY LIMESTONE	12.2 18.0 22.9
6702326	568032.3	4810227.1	1962	152.4	Cable Tool	Overburden	Water Supply	Domestic	14.6	0	14.6	7.9	10.7	61	1	GRAVEL STONES MEDIUM SAND GRAVEL GRAVEL	7.6 13.7 14.6
6703309	568134.3	4809933.0	1969	101.6	Cable Tool	Bedrock	Water Supply	Domestic	39.6	23.8	38.1	9.1	18.3	38	-	TOPSOIL CLAY STONES GRAVEL CLAY GRAVEL LIMESTONE	0.3 13.7 18.3 23.8 39.6
6703535	567884.3	4810143.0	1969	101.6	Rotary (Convent.)	Bedrock	Water Supply	Livestock, Domestic	52.4	21	50.9	13.7	13.7	38	1	GRAVEL MEDIUM SAND LIMESTONE ROCK LIMESTONE	21.0 29.9 39.6 52.4
6704693	568214.3	4809488.0	1973	152.4	Cable Tool	Overburden	Water Supply	Domestic	25.9	0	25.9	10.7	11.0	95	1	STONES GRAVEL GRAVEL CLAY GRAVEL SAND GRAVEL	9.1 23.8 25.3 25.9
6704719	568191.3	4809783.1	1973	-	Rotary (Convent.)	Bedrock	Water Supply	Domestic	40.2	22.3	30.5	8.5	10.7	38	4	GRAVEL BOULDERS LIMESTONE ROCK ROCK	22.3 32.6 39.6 40.2
6704794	567419.3	4810108.1	1973	-	Cable Tool	Bedrock	Water Supply	Domestic	30.5	17.1	19.8	1.5	3.0	76	1	TOPSOIL CLAY SAND STONES CLAY SAND STONES CLAY SAND GRAVEL ROCK ROCK	0.3 4.6 9.1 17.1 22.9 30.5
6705097	568464.3	4808857.9	1974	152.4	Rotary (Convent.)	Bedrock	Water Supply	Public	54.6	29.9	50.3	16.8	51.8	57	1	GRAVEL CLAY STONES GRAVEL LIMESTONE	6.1 29.9 54.6
6705330	568095.3	4809837.0	1974	127	Cable Tool	Bedrock	Water Supply	Domestic	31.1	27.4	31.1	9.8	18.3	76	1	TOPSOIL CLAY STONES CLAY GRAVEL SAND GRAVEL CLAY GRAVEL ROCK	0.3 6.1 16.8 24.4 27.4 31.1

Table 1
SUMMARY OF MECP WATER WELL RECORDS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

									DEPTH				TEST PUMPING			STRATIGRAPHY	
WELL ID	EASTING	NORTHING	YEAR DRILLED	CASING DIAMETER (mm)	DRILLING METHOD	WELL TYPE	WELL STATUS	WATER USE	TOTAL DEPTH (m)	BEDROCK (m)	WATER FOUND (m)	STATIC WATER LEVEL (m)	WATER LEVEL AFTER PUMPING (m)	RATE (L/min)	DURATION (HRS)	MATERIAL	DEPTH TO UNIT BASE (m)
6705385	568509.3	4808913.1	1974	152.4	Rotary (Convent.)	Bedrock	Water Supply	Domestic	26.5	24.7	25.6	8.2	24.4	76	1	STONES GRAVEL SAND MUCK LIMESTONE	3.0 7.6 24.7 26.5
6706259	568234.3	4808223.0	1976	-	Rotary (Convent.)	Bedrock	Water Supply	Domestic	36.6	33.5	35.1	14.6	33.5	189	1	CLAY SANDY STONEY LIMESTONE	33.5 36.6
6706916	568814.3	4810342.9	1978	127	Rotary (Convent.)	Overburden	Water Supply	Livestock, Domestic	31.7	0	30.5	8.8	9.1	38	2	CLAY BOULDERS GRAVEL STONES	25.0 31.7
6707457	567794.3	4809923.0	1981	-	Rotary (Air)	Overburden	Water Supply	Domestic	26.5	0	26.5	7	12.2	76	1	TOPSOIL CLAY STONES CLAY SAND GRAVEL HARDPAN GRAVEL CLAY SAND GRAVEL STONES	0.3 6.1 16.8 19.8 22.3 26.5
6707481	568007.3	4809145.0	1981	152.4	Cable Tool	Bedrock	Water Supply	Domestic	16.8	5.8	15.2	11.9	12.8	76	1	SAND GRAVEL LOOSE LIMESTONE HARD	5.8 16.8
6708094	568594.3	4808242.9	1983	152.4	Rotary (Air)	Overburden	Water Supply	Public	20.7	0	20.7	14.6	19.8	76	1	CLAY TOPSOIL GRAVEL GRAVEL	18.3 20.7
6710498	568554.3	4808252.0	1990	152.4	Rotary (Convent.)	Overburden	Water Supply	Domestic	25.9	0	25.9	15.2	21.3	95	1	TOPSOIL GRAVEL CLAY SAND GRAVEL	0.6 23.2 25.6 25.9
6710562	568664.3	4809522.0	1990	152.4	Rotary (Air)	Overburden	Water Supply	Domestic	40.5	0	40.5	21.3	39.6	379	1	CLAY STONES GRAVEL STONES CLAY GRAVEL CLAY GRAVEL STONES	18.3 27.4 39.6 40.5
6711197	568579.3	4808241.0	1993	152.4	Rotary (Air)	Overburden	Water Supply	Domestic	32	0	32.0	12.5	13.7	38	1	TOPSOIL CLAY SAND GRAVEL CLAY SAND BOULDERS COARSE GRAVEL	0.3 25.9 30.2 31.4 32.0
6711317	568454.3	4809354.0	1993	152.4	Rotary (Air)	Bedrock	Water Supply	Domestic	24.7	24.1	24.4	12.5	23.5	284	1	BOULDERS STONES CLAY GRAVEL STONES LIMESTONE	15.2 24.1 24.7
6711670	568703.3	4808305.0	1994	-	Rotary (Air)	Overburden	Water Supply	Domestic	27.4	0	27.4	21.3	23.8	57	1	CLAY SAND GRAVEL COARSE GRAVEL	24.4 27.4
6712959	568993.8	4809368.0	1999	152.4	Air Percussion	Bedrock	Water Supply	Domestic	34.1	31.1	31.4	17.7	27.4	114	1	CLAY GRAVEL SAND GRAVEL CLAY SANDY SAND GRAVEL GRAVEL SAND LIMESTONE	4.6 7.3 10.7 24.4 31.1 34.1
6713019	567376.3	4808973.9	1999	152.4	Air Percussion	Bedrock	Water Supply	Domestic	27.4	22.9	23.8	10.7	-	-	-	CLAY SANDY CLAY SANDY GRAVEL GRAVEL SAND LIMESTONE	4.6 9.1 22.9 27.4

Table 1
SUMMARY OF MECP WATER WELL RECORDS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

									DEPTH				TEST PUMPING			STRATIGRAPHY	
WELL ID	EASTING	NORTHING	YEAR DRILLED	CASING DIAMETER (mm)	DRILLING METHOD	WELL TYPE	WELL STATUS	WATER USE	TOTAL DEPTH (m)	BEDROCK (m)	WATER FOUND (m)	STATIC WATER LEVEL (m)	WATER LEVEL AFTER PUMPING (m)	RATE (L/min)	DURATION (HRS)	MATERIAL	DEPTH TO UNIT BASE (m)
6713113	568182.3	4809170.0	1999	152.4	Rotary (Air)	Bedrock	Water Supply	Domestic	31.1	26.5	31.1	9.4	-	-	-	TOPSOIL CLAY STONES CLAY SAND GRAVEL SAND CLAY CLAY SAND GRAVEL LIMESTONE ROCK LIMESTONE	0.3 4.6 15.2 24.4 26.5 28.3 31.1
6713350	567775.8	4809071.0	2000	152.4	Rotary (Air)	Bedrock	Water Supply	Domestic	55.8	27.4	30.5	8.8	-	-	-	TOPSOIL CLAY STONES CLAY SAND GRAVEL GRAVEL SAND CLAY SAND GRAVEL LIMESTONE	0.6 4.6 12.2 21.3 27.4 55.8
6714163	568431.6	4809206.0	2002	152.4	Rotary (Air)	Bedrock	Water Supply	Domestic	36.9	36.6	36.9	20.4	-	-	-	CLAY STONES BOULDERS SILT GRAVEL CLAY SILT LIMESTONE	18.3 24.4 36.6 36.9
6714950	567796.0	4809424.0	2004	50	Rotary (Convent.)	Bedrock	Observation Wells	Not Used	21.5	21.6	-	0	-	-	-	STONES MEDIUM SAND GRAVEL MEDIUM SAND COARSE SAND FINE SAND MEDIUM SAND FINE SAND FINE SAND LIMESTONE	4.5 7.5 12.0 16.0 21.5 -
6715345	568220.0	4810231.9	2004	50	Other Method	Overburden	Observation Wells	-	20.6	0	-	0	-	-	-	TOPSOIL SILT SAND SILT SAND STONES SAND GRAVEL	0.4 17.2 20.6
6715390	568660.0	4810406.0	2005	60	Boring	Overburden	Test Hole	Not Used	21.3	0	-	0	-	-	-	TOPSOIL LOOSE GRAVEL SAND DENSE SILT GRAVEL PACKED	0.5 19.8 21.3
6715748	568315.0	4808604.0	2006	51	Boring	Overburden	Observation Wells	-	6.4	0	4.0	0	-	-	-	SILT TOPSOIL SAND SILT GRAVEL	0.4 6.4
7045560	568173.0	4808503.0	2007	51	Boring	Overburden	Observation Wells	-	9.2	0	6.0	0	-	-	-	SAND SILT SAND SILT GRAVEL	1.1 9.2
7103672	568456.0	4808275.0	2008	403.098	Rotary (Air)	-	Water Supply	Domestic	11.5	0	11.5	17.4	-	-	-	CLAY STONES GRAVEL CLAY SAND LIMESTONE	4.2 9.7 11.5
7122479	568169.0	4808532.0	2009	51	Boring	-	Observation Wells	Monitoring	9.1	0	6.0	0	-	-	-	SILT TOPSOIL SILT SAND LOOSE SAND SILT GRAVEL SILT SAND GRAVEL	0.5 2.4 5.6 9.1
7141981	567688.0	4808317.0	2010	51	Boring	-	Test Hole	Monitoring	6.9	0	4.5	0	-	-	-	SILT TOPSOIL SILT SAND GRAVEL SAND SILT GRAVEL SILT CLAY	0.3 0.6 6.0 6.9
7141981	567712.0	4808424.0	2010	51	Boring	-	Test Hole	Monitoring	5.3	0	-	3	-	-	-	AS ABOVE	-
7141981	567765.0	4808332.0	2010	51	Boring	-	Test Hole	Monitoring	6	0	-	3	-	-	-	AS ABOVE	-
7141981	567751.0	4808262.0	2010	51	Boring	-	Test Hole	Monitoring	4.4	0	-	3	-	-	-	AS ABOVE	-

Table 1
SUMMARY OF MECP WATER WELL RECORDS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

									DEPTH				TEST PUMPING			STRATIGRAPHY	
WELL ID	EASTING	NORTHING	YEAR DRILLED	CASING DIAMETER (mm)	DRILLING METHOD	WELL TYPE	WELL STATUS	WATER USE	TOTAL DEPTH (m)	BEDROCK (m)	WATER FOUND (m)	STATIC WATER LEVEL (m)	WATER LEVEL AFTER PUMPING (m)	RATE (L/min)	DURATION (HRS)	MATERIAL	DEPTH TO UNIT BASE (m)
7143772	567765.0	4808332.0	2010	51	Boring	-	Test Hole	Monitoring	6.3	0	5.0	0	-	-	-	SILT	0.6
																SILT	0.8
																SAND GRAVEL	2.0
																SAND SILT	4.9
																SILT CLAY	6.0
																CLAY SILT	6.3
7143772	567715.0	4808263.1	2010	51	Boring	-	Test Hole	Monitoring	15	-	-	14.3	-	-	-	AS ABOVE	-
7143772	567744.0	4808419.0	2010	51	Boring	-	Test Hole	Monitoring	6	-	-	5.2	-	-	-	AS ABOVE	-
7158314	568377.0	4808226.0	2010	-	Boring	-	Test Hole	Monitoring	13.7	0	9.0	0	-	-	-	SILT TOPSOIL	0.2
																SAND SILT GRAVEL	4.5
																SILT SAND GRAVEL	12.0
																SILT	13.7
7185613	41098.0	567118.0	2012	-	-	-	Decommissioned	-	-	-	-	-	-	-	-	-	-
7243143	568097.0	4809917.0	2015	-	-	-	Abandoned-Other	Not Used	-	-	-	-	-	-	-	-	-
7243144	568091.0	4809898.0	2015	-	-	-	Abandoned-Other	Domestic	-	-	-	-	-	-	-	-	-
7285954	568795.0	4810369.0	2017	-	-	-	Abandoned-Other	Domestic, Livestock	-	-	-	-	-	-	-	-	-
7290538	568345.0	4809275.0	2017	50.8	-	-	Observation Wells	Test Hole, Monitoring	28	0	-	0	-	-	-	TOPSOIL SAND GRAVEL	0.3
																SAND GRAVEL SILT	11.6
																SAND GRAVEL OTHER	23.2
																SILT SAND GRAVEL	25.1
																ROCK FRACTURED	28.0
7290539	567964.0	4809212.0	2017	50.8	ROTO SONIC	-	Observation Wells	Test Hole, Monitoring	25.3	0	-	0	-	-	-	TOPSOIL SAND GRAVEL	0.3
																GRAVEL SAND OTHER	6.1
																SAND GRAVEL OTHER	10.4
																SAND GRAVEL WATER-BEARING	24.1
																ROCK FRACTURED	25.3
7294450	568597.0	4808727.0	2017	158.75	AIR ROTARY	-	Water Supply	Domestic	48.8	0	48.8	16.8	-	-	-	CLAY STONES	7.6
																CLAY GRAVEL	15.2
																CLAY BOULDERS	25.9
																CLAY SAND GRAVEL	29.0
																CLAY SAND	30.2
																ROCK	42.7
																ROCK	48.8

NOTES: mm = millimeters
m = meters
l/min = litres per minute
"-" = no data available

Table 2
SUMMARY OF PRIVATE WELL SURVEY RESULTS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

MN[1]	STREET	RESPONSE DATE[2]	EASTING[3]	NORTHING[3]	APPROXIMATE YEAR CONSTRUCTED	WELL TYPE	CASING TYPE	CASING DIAMETER (mm)	REPORTED WELL DEPTH (m)	REPORTED WATER QUALITY	WATER USE	COMMENTS
4092	Sideroad 25 S	28/Sep/2017	568657	4808245	2003	Drilled	Steel	152	32.0	Good, elevated iron	Domestic	Originally drilled in 1993.
4093	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	No response.
4095	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	No response.
4103	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	No access (locked gate, no mailbox).
4106	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	Cemetery. No letter delivered.
4135	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	House being built, no mailbox. No letter delivered.
4195	Sideroad 25 S	04/Oct/2017	568483	4809086	2002	Drilled	Steel	152	36.9	Excellent, elevated iron	Domestic	-
4207	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	No response.
4219	Sideroad 25 S	28/Sep/2017	568641	4809309	Approx. 1970s	Drilled	Concrete casement	-	36.6	Good	Domestic and gardening	No longer used for drinking water.
4222	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	Property owned by CBM, house occupied by tenant or vacant.
4228	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	Property owned by CBM, no buildings on-site.
4248	Sideroad 25 S	28/Sep/2017	568188	4809492	Approx. 1970s	Drilled	Steel	152	24.4	Good	Domestic and gardening	Property owned by CBM (Wahl Residence). Previous rainwater infiltration, fixed shortly after.
4225	Sideroad 25 S	-	-	-	-	-	-	-	-	-	-	No response.
7098 (a)	Concession 1	17/Oct/2017	568189.7	4808082.7	1976	Drilled	Steel	152	36.6	-	Domestic	Main well for Crieff Hills Community. Also supplies MN 7094 and MN 7120.
7098 (b)	Concession 1	17/Oct/2017	567789.5	4808078.7	1977	Drilled	Steel	152	20.1	-	Not used	Backup well for Crieff Hills Community, currently offline
7150	Concession 1	27/Sep/2017	568574, 568452	4808276, 4808283	Approx. 1990s and 2000s	Drilled	Steel	152	24.4 and 36.6	Good	Commercial / Domestic	Two supply wells for Sunset Villa. Also have eight monitoring wells on property.
7156	Concession 1	-	-	-	-	-	-	-	-	-	-	Church. No response.
7160	Concession 1	24/Sep/2017	568773	4808247	-	Bored	Steel, Concrete	1067	-	Good	Domestic	-
7176	Concession 1	-	-	-	-	-	-	-	-	-	-	No response.

NOTES: 1. MN is the Municipal Number.
2. Notification letter delivered on September 21, 2017; initial door to door survey completed on September 28, 2017.
A response date after September 28, 2017 indicates the survey was subsequently completed by telephone interview or received by email.
3. Approximate UTM coordinates (NAD 83) estimated from mapping.
4. "-" indicates information not available or not applicable.

SUMMARY OF BOREHOLES AND WELL INSTALLATION DETAILS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

BOREHOLE / MONITORING WELL ID	DATE DRILLED	Easting (m)[1]	Northing (m)[1]	GROUND SURFACE ELEVATION (masl)[1]	BOREHOLE COMPLETION DEPTH (mbgs) / ELEVATION (masl)	TOP OF PIPE ELEVATION (masl)[1]	STICK UP (m)	WELL BOTTOM DEPTH (mbgs) / ELEVATION (masl)
MW17-01	08-June-2017	568,347.1	4,809,271.4	316.11	28.0 / 288.1	316.95	0.84	16.2 / 299.9
MW17-02	09-June-2017	567,965.6	4,809,213.2	316.96	25.3 / 291.7	317.77	0.81	16.5 / 300.2
BH17-03	07-June-2017	568,214.8	4,809,195.2	320.85	30.5 / 290.4	-	-	-
BH17-04	08-June-2017	568,172.1	4,809,333.5	311.56	26.2 / 285.4	-	-	-
GL-7	May 2003 (Gartner Lee)	567,937.0	4,809,274.5	316.51	20.4 / 296.1	317.26	0.75	14.5 / 302.1
GL-8		568,308.1	4,809,410.2	314.89	12.8 / 302.1	315.36	0.47	10.9 / 304.0

NOTES:

1. UTM coordinates and elevations surveyed by Van Harten on April 5, 2018.

Table 4

WATER ELEVATIONS

Hydrogeological Level 1, 2 Assessment

Proposed Lanci Pit Expansion

Puslinch, Ontario

MONITORING WELL ID	GROUND SURFACE ELEVATION (masl)[1]	TOP OF PIPE ELEVATION (masl)[1]	WATER ELEVATION[1] 08 and 09-Jun-2017	20-Jun-2017	21-Sep-2017	28-Sep-2017	14-Dec-2017	26-Mar-2018	05-Apr-2018	28-Jun-2018	03-May-2019	22-Aug-2019	02-Sep-2019	16-Dec-2019
MW17-01	316.11	316.95	306.57	306.57	306.23	306.19	305.91	306.06	306.10	306.28	306.42	--	306.30	306.10
MW17-02	316.96	317.77	--	306.44	306.10	--	305.81	305.98	306.01	306.16	306.32	--	306.19	306.01
GL-7	316.51	317.26	--	306.43	306.11	--	305.81	305.97	306.01	306.16	306.30	306.25	--	306.03
GL-8	314.89	315.36	--	306.55	306.23	--	305.91	306.05	306.09	306.27	306.39	306.36	--	306.10
STAFF GAUGE ID														
SG1	306.11	307.61	306.71	306.66	306.36	--	306.14	306.12	306.18	306.34	306.41	306.43	--	306.24
SG2	306.88	308.47	307.49	307.45	307.13	--	306.88	306.94	306.98	307.16	307.26	--	--	307.03
SG3	306.70	308.23	307.23	307.19	306.93	--	306.73	306.82	306.82	306.92	306.85	306.82	--	306.67
SG4	305.17	306.54	--	--	--	--	--	305.57	305.62	305.75	--	--	--	--
SG6	305.82	307.16	--	--	--	--	--	305.92	306.10	306.70	--	--	--	--

NOTES: 1. Elevations surveyed by Van Harten on April 5, 2018, reported as meters above sea level.

2. "--" not measured.

3. SG4 and SG6 were compromised prior to the elevation survey and were re-installed in March 2018. They were found to be compromised again in May 2019. SG5 was compromised prior to elevation survey and was not re-installed.

4. Table to be read in conjunction with accompanying report.

Table 5
GROUNDWATER TEMPERATURE PROFILES
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

			21-Sept-2017					14-Dec-2017					26-Mar-2018				
MONITORING WELL ID	GROUND SURFACE ELEVATION (masl)[1]	TOP OF PIPE ELEVATION (masl)	GROUNDWATER ELEVATION (masl)	DEPTH (mbgs)[2]	ELEVATION (masl)	DEPTH BELOW WATER (m)	GROUNDWATER TEMPERATURE (degrees C)	GROUNDWATER ELEVATION (masl)	DEPTH (mbgs)	ELEVATION (masl)	DEPTH BELOW WATER (m)	GROUNDWATER TEMPERATURE (degrees C)	GROUNDWATER ELEVATION (masl)	DEPTH (mbgs)	ELEVATION (masl)	DEPTH BELOW WATER (m)	GROUNDWATER TEMPERATURE (degrees C)
MW17-01	316.11	316.95	306.23	9.93	306.18	0.05	10.8	305.91	10.26	305.86	0.05	10.3	306.06	10.10	306.01	0.05	9.7
				10.93	305.18	1.05	10.0		11.26	304.86	1.05	10.5		11.10	305.01	1.05	10.2
				11.93	304.18	2.05	9.9		12.26	303.86	2.05	10.4		12.10	304.01	2.05	10.4
				12.93	303.18	3.05	10.0		13.26	302.86	3.05	10.3		13.10	303.01	3.05	10.4
				13.93	302.18	4.05	10.0		14.26	301.86	4.05	10.3		14.10	302.01	4.05	10.4
				14.93	301.18	5.05	10.1		15.26	300.86	5.05	10.3		15.10	301.01	5.05	10.4
				15.93	300.18	6.05	10.2		16.16	299.96	5.95	10.3		16.16	299.96	6.10	10.4
				16.16	299.96	6.27	10.2										
MW17-02	316.96	317.77	306.10	10.91	306.05	0.05	9.4	305.81	11.20	305.76	0.05	8.8	305.98	11.03	305.93	0.05	8.9
				11.91	305.05	1.05	8.9		12.20	304.76	1.05	8.9		12.03	304.93	1.05	9.1
				12.91	304.05	2.05	8.9		13.20	303.76	2.05	8.9		13.03	303.93	2.05	9.1
				13.91	303.05	3.05	8.9		14.20	302.76	3.05	8.9		14.03	302.93	3.05	9.1
				14.91	302.05	4.05	8.9		15.20	301.76	4.05	8.9		15.03	301.93	4.05	9.1
				15.91	301.05	5.05	8.9		16.20	300.76	5.05	8.9		16.03	300.93	5.05	9.1
				16.74	300.23	5.88	8.9		16.74	300.23	5.58	8.9		16.74	300.23	5.75	9.1
GL-7	316.51	317.26	306.11	10.46	306.06	0.05	9.4	305.81	10.75	305.76	0.05	9.0	305.97	10.59	305.92	0.05	9.0
				11.46	305.06	1.05	9.0		11.75	304.76	1.05	9.4		11.59	304.92	1.05	9.4
				12.46	304.06	2.05	8.9		12.75	303.76	2.05	9.3		12.59	303.92	2.05	9.4
				13.46	303.06	3.05	8.9		13.75	302.76	3.05	9.1		13.59	302.92	3.05	9.3
				14.40	302.12	3.99	8.9		14.40	302.12	3.69	9.0		14.40	302.12	3.85	9.3
GL-8	314.89	315.36	306.23	8.71	306.18	0.05	12.2	305.91	9.03	305.86	0.05	12.0	306.05	8.89	306.00	0.05	11.4
				9.71	305.18	1.05	11.8		10.03	304.86	1.05	12.4		9.89	305.00	1.05	11.6
				10.71	304.18	2.05	11.7		10.80	304.09	1.82	12.5		10.80	304.09	1.96	11.7
				10.80	304.09	2.14	11.7										

NOTES:
1. Elevations surveyed by Van Harten on April 5, 2018, reported as meters above sea level.
2. "mbgs" - meters below ground surface.
3. Table to be read in conjunction with accompanying report.

Table 5
GROUNDWATER TEMPERATURE PROFILES
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

			28-Jun-2018					03-May-2019					
MONITORING WELL ID	GROUND SURFACE ELEVATION (masl)[1]	TOP OF PIPE ELEVATION (masl)	GROUNDWATER ELEVATION (masl)	DEPTH (mbgs)	ELEVATION (masl)	DEPTH BELOW WATER (m)	GROUNDWATER TEMPERATURE (degrees C)	TEST DEPTH (MBTOP)	GROUNDWATER ELEVATION (masl)	DEPTH (mbgs)	ELEVATION (masl)	DEPTH BELOW WATER (m)	GROUNDWATER TEMPERATURE (degrees C)
MW17-01	**316.11**	**316.95**	306.28	9.88	306.23	0.05	9.6	10.58	306.42	9.74	306.37	0.05	9.8
				10.88	305.23	1.05	9.6	11.58		10.74	305.37	1.05	9.9
				11.88	304.23	2.05	9.7	12.58		11.74	304.37	2.05	10.0
				12.88	303.23	3.05	9.8	13.58		12.74	303.37	3.05	10.1
				13.88	302.23	4.05	9.9	14.58		13.74	302.37	4.05	10.3
				14.88	301.23	5.05	10.0	15.58		14.74	301.37	5.05	10.4
				15.82	300.29	5.99	10.2	16.58		15.74	300.37	6.05	10.4
								16.73		15.89	300.22	6.20	10.4
MW17-02	**316.96**	**317.77**	306.16	11.30	305.66	0.50	8.8	11.50	306.32	10.69	306.27	0.05	9.1
				12.30	304.66	1.50	8.9	12.50		11.69	305.27	1.05	9.1
				13.30	303.66	2.50	9.0	13.50		12.69	304.27	2.05	9.2
				14.30	302.66	3.50	9.0	14.50		13.69	303.27	3.05	9.2
				15.30	301.66	4.50	9.0	15.50		14.69	302.27	4.05	9.2
				16.30	300.66	5.50	9.0	16.50		15.69	301.27	5.05	9.2
				16.58	300.38	5.78	9.0	17.53		16.72	300.25	6.08	9.2
GL-7	**316.51**	**317.26**	306.16	10.41	306.11	0.05	8.9	11.01	306.30	10.26	306.25	0.05	9.0
				11.41	305.11	1.05	8.8	12.01		11.26	305.25	1.05	9.1
				12.41	304.11	2.05	8.9	13.01		12.26	304.25	2.05	9.2
				13.41	303.11	3.05	9.0	14.01		13.26	303.25	3.05	9.2
				14.41	302.11	4.05	9.0	15.01		14.26	302.25	4.05	9.2
				14.75	301.76	4.39	9.1	15.35		14.60	301.91	4.39	9.2
GL-8	**314.89**	**315.36**	306.27	9.12	305.77	0.50	10.8	9.02	306.39	8.55	306.34	0.05	10.6
				10.12	304.77	1.50	10.8	10.02		9.55	305.34	1.05	10.7
				11.02	303.87	2.40	11.0	11.02		10.55	304.34	2.05	10.9
								11.50		11.03	303.86	2.53	11.0

ANALYTICAL RESULTS FOR GENERAL CHEMISTRY AND NUTRIENTS IN GROUNDWATER

Hydrogeological Level 1,2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

Sample Location:		GL-7	GL-8	MW17-01	MW17-02	2011 MECP TABLE 2	
Sample Date:		20-Jun-17	20-Jun-17	20-Jun-17	21-Jun-17	STANDARDS[1]	ODWS[2]
Calculated Parameters	Units						
Anion Sum	me/L	7.50	8.11	8.21	7.45	--	--
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	180	250	270	190	--	--
Calculated TDS	mg/L	400	410	420	400	--	500[5]
Carb. Alkalinity (calc. as CaCO3)	mg/L	2.3	3.7	3.2	2.6	--	--
Cation Sum	me/L	7.41	7.68	7.93	7.19	--	--
Hardness (CaCO3)	mg/L	**260**	**290**	**320**	**260**	--	80 - 100[3]
Ion Balance (% Difference)	%	0.600	2.78	1.73	1.82	--	--
Langelier Index (@ 20C)	N/A	0.736	0.890	0.966	0.804	--	--
Langelier Index (@ 4C)	N/A	0.487	0.642	0.717	0.555	--	--
Saturation pH (@ 20C)	N/A	7.38	7.30	7.14	7.36	--	--
Saturation pH (@ 4C)	N/A	7.63	7.55	7.38	7.61	--	--
Measured Parameters							--
Total Ammonia-N	mg/L	0.050	0.071	<0.050	<0.050	--	--
Conductivity	umho/cm	740	760	770	730	--	--
Dissolved Organic Carbon	mg/L	0.39	0.67	0.60	0.39	--	5.0[5]
Orthophosphate (P)	mg/L	<0.010	<0.010	<0.010	<0.010	--	--
pH	pH	8.11	8.19	8.10	8.16	--	6.5-8.5[3]
Dissolved Sulphate (SO4)	mg/L	37	31	30	34	--	500[5]
Alkalinity (Total as CaCO3)	mg/L	190	260	270	190	--	30 - 500[3]
Dissolved Chloride (Cl)	mg/L	110	77	76	100	790	250[5]
Nitrite (N)	mg/L	<0.010	<0.010	<0.010	<0.010	--	1.0[4]
Nitrate (N)	mg/L	0.76	2.18	1.12	0.85	--	10.0[4]
Nitrate + Nitrite (N)	mg/L	0.76	2.18	1.12	0.85	--	--

NOTES:
1. O. Reg. 153/04 - Ministry of the Environment, Conservation and Parks (MECP). Soil, Groundwater and Sediment Standards for Use Environmental Protection Act (April 2011), Table 2 Standard is for a potable groundwater situation for all types of property uses.
2. O. Reg. 169/03 - Ontario Drinking Water Quality Standards (amended December 2016), Under Safe Drinking Water Act.
3. Reflects an Operational Guideline established for parameters that need to be controlled to ensure efficient and effective treatment and distribution of the water.
4. Maximum acceptable concentration or interim maximum acceptable concentration (health related criteria).
5. Reflects an Aesthetic Objective established for parameters that may impair taste, odour or colour of water, or which may interfere with good water quality practices.
6. "<" Below reportable detection limit.
7. Bolded indicate exceedance of applicable ODWS Standards, and highlighted value indicate exceedance of the MECP Table 2 Stanc
8. " **--** " No applicable criterion, or not analysed.

ANALYTICAL RESULTS FOR METALS AND INORGANICS IN GROUNDWATER

Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

Sample Location:		GL-7	GL-8	MW17-01	MW17-02	2011 MOE TABLE 2	
Sample Date:		20-Jun-17	20-Jun-17	20-Jun-17	21-Jun-17	STANDARDS[1]	ODWS[2]
Dissolved Metals	Units						
Aluminum (Al)	µg/L	5.1	5.3	7.3	8.5	--	100[3]
Antimony (Sb)	µg/L	<0.50	<0.50	<0.50	<0.50	6	6[4]
Arsenic (As)	µg/L	<1.0	<1.0	<1.0	<1.0	25	10[4]
Barium (Ba)	µg/L	85	48	92	84	1000	1000[4]
Beryllium (Be)	µg/L	<0.50	<0.50	<0.50	<0.50	4	--
Boron (B)	µg/L	11	22	18	10	5000	5000[4]
Cadmium (Cd)	µg/L	<0.10	<0.10	<0.10	<0.10	2.7	5[4]
Calcium (Ca)	µg/L	63000	55000	77000	64000	--	--
Chromium (Cr)	µg/L	<5.0	<5.0	<5.0	<5.0	50	50[4]
Cobalt (Co)	µg/L	<0.50	1.2	<0.50	<0.50	3.8	--
Copper (Cu)	µg/L	<1.0	4.8	1.5	<1.0	87	1000[5]
Iron (Fe)	µg/L	<100	<100	<100	<100	--	300[5]
Lead (Pb)	µg/L	<0.50	<0.50	<0.50	<0.50	10	10[4]
Magnesium (Mg)	µg/L	26000	38000	31000	25000	--	--
Manganese (Mn)	µg/L	5.8	47	48	27	--	50[5]
Molybdenum (Mo)	µg/L	1.2	3.9	2.7	2.0	70	--
Mercury (Hg)	µg/L	<0.1	<0.1	<0.1	<0.1	0.29	1[4]
Nickel (Ni)	µg/L	<1.0	1.1	<1.0	<1.0	100	--
Phosphorus (P)	µg/L	<100	<100	<100	<100	--	--
Potassium (K)	µg/L	2000	2100	1400	1600	--	--
Selenium (Se)	µg/L	<2.0	<2.0	<2.0	<2.0	10	50[4]
Silicon (Si)	µg/L	2900	2300	3300	3000	--	--
Silver (Ag)	µg/L	<0.10	<0.10	<0.10	<0.10	1.5	--
Sodium (Na)	µg/L	48000	41000	35000	44000	490000	200000[5]
Strontium (Sr)	µg/L	110	150	110	100	--	--
Thallium (Tl)	µg/L	0.064	<0.050	<0.050	<0.050	2	--
Titanium (Ti)	µg/L	<5.0	<5.0	<5.0	<5.0	--	--
Uranium (U)	µg/L	0.75	0.21	0.48	0.57	20	20[4]
Vanadium (V)	µg/L	<0.50	<0.50	<0.50	<0.50	6.2	--
Zinc (Zn)	µg/L	59	23	96	64	1100	5000[5]

NOTES:
1. O. Reg. 153/04 - Ministry of the Environment, Conservation and Parks (MECP). Soil, Groundwater and Sediment Standards for Use Environmental Protection Act (April 2011), Table 2 Standard is for a potable groundwater situation for all types of property uses.
2. O. Reg. 169/03 - Ontario Drinking Water Quality Standards (amended December 2016), Under Safe Drinking Water Act.
3. Reflects an Operational Guideline established for parameters that need to be controlled to ensure efficient and effective treatment and distribution of the water.
4. Maximum acceptable concentration or interim maximum acceptable concentration (health related criteria).
5. Reflects an Aesthetic Objective established for parameters that may impair taste, odour or colour of water, or which may interfere with good water quality practices.
6. "<" Below reportable detection limit.
7. Bolded indicate exceedance of applicable ODWS Standards, and highlighted value indicate exceedance of the MECP Table 2 Stand
8. " **--** " No applicable criterion, or not analysed.

ANALYTICAL RESULTS FOR PHC AND BTEX IN GROUNDWATER

Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

Sample Location:		GL-7	GL-8	MW17-01	MW17-02	2011 MECPTABLE 2 STANDARDS[1]	ODWS[2]
Sample Date:		20-Jun-17	20-Jun-17	20-Jun-17	21-Jun-17		
BTEX	Units						
Benzene	µg/L	<0.20	<0.20	<0.20	<0.20	5	1[4]
Toluene	µg/L	<0.20	<0.20	<0.20	<0.20	24	60[4]
Ethylbenzene	µg/L	<0.20	<0.20	<0.20	<0.20	2.4	140[4] , 1.6[5]
o-Xylene	µg/L	<0.20	<0.20	<0.20	<0.20	--	--
p+m-Xylene	µg/L	<0.40	<0.40	<0.40	<0.40	--	--
Total Xylenes	µg/L	<0.40	<0.40	<0.40	<0.40	300	90[4] , 20[5]
Petroleum Hydrocarbons							
PHC F1 (C6-C10)	µg/L	<25	<25	<25	<25	750	--
PHC F2 (C10-C16)	µg/L	<100	<100	<100	<100	150	--
PHC F3 (C16-C34)	µg/L	<200	<200	<200	<200	500	--
PHC F4 (C34-C50)	µg/L	<200	<200	<200	<200	500	--

NOTES:

1. O. Reg. 153/04 - Ministry of the Environment, Conservation and Parks (MECP). Soil, Groundwater and Sediment Standards for Use Under Part XV.1 of the Environmental Protection Act (April 2011), Table 2 Standard is for a potable groundwater situation for all types of property uses.
2. O. Reg. 169/03 - Ontario Drinking Water Quality Standards (amended December 2016), Under Safe Drinking Water Act.
3. Reflects an Operational Guideline established for parameters that need to be controlled to ensure efficient and effective treatment and distribution of the water.
4. Maximum acceptable concentration or interim maximum acceptable concentration (health related criteria).
5. Reflects an Aesthetic Objective established for parameters that may impair taste, odour or colour of water, or which may interfere with good water quality practices.
6. "<" Below reportable detection limit.
7. Bolded indicate exceedance of applicable ODWS Standards, and highlighted value indicate exceedance of the MECP Table 2 Stai
8. " **--** " No applicable criterion, or not analysed.

Table 9

SUMMARY OF CATCHMENT AREAS, WHC, SOIL TYPE AND INFILTRATION FACTOR

Hydrogeological Level 1, 2 Assessment

Proposed Lanci Pit Expansion

Puslinch, Ontario

EXISTING CONDITIONS					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m2)**
Mature Forest	250 mm	Wooded	Sandy Loam	0.9	128,977
Agricultural/Grass	200 mm	Tilled	Silt Loam	0.8	14,897
Built Up Area (Pervious)	100 mm	Roads and Roofs	Gravelly Sand	0.1	3,711
Total					**147,585**
OPERATIONAL CONDITIONS					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m2)**
Mature Forest	250 mm	Wooded	Sandy Loam	0.9	32,140
Agricultural/Grass	100 mm	Berm	Silt Loam	0.8	12,842
Built Up Area (Pervious)	100 mm	Excavation Pit	Gravelly Sand	0.1	27,157
Pond	Prec-PET	Flooded Pit	Gravelly Sand	0	75,447
Total					**147,585**
REHABILITATED CONDITIONS					
Type	**WHC**	**Type of Land Use**	**Soil Type**	**Infiltration Factor (%)**	**Catchment Areas (m2)**
Mature Forest	250 mm	Wooded	Sandy Loam	0.9	32,140
Agricultural/Grass	100 mm	Pasture and Shrub	Sand	0.8	39,999
Pond	Prec-PET	Flooded Pit	Gravelly Sand	0	75,447
Total					**147,585**

Table 10
WATER BALANCE RESULTS
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

EXISTING CONDITIONS							
Land Use	**Area**	**Surplus**		**Infiltration**		**Runoff**	
	(m^2)	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**
Mature Forest	128,977	273	35,211	246	31,690	27	3,521
Agricultural/Grass	14,897	282	4,201	226	3,361	56	840
Built Up Area (Pervious)	3,711	319	1,184	32	118	287	1,066
TOTAL	**147,585**	**275**	**40,596**	**238**	**35,169**	**37**	**5,427**
OPERATIONAL CONDITIONS							
Land use	**Area**	**Surplus**		**Infiltration**		**Runoff**	
	(m	**(mm/yr)**	**(m**	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**
Mature Forest	32,140	273	8,774	246	7,897	27	877
Agricultural/Grass	12,842	319	4,097	255	3,277	64	820
Excavation Area	27,157	319	8,663	32	866	287	7,797
Flooded Pit	75,447	265	19,993	0	0	265	19,993
TOTAL	**147,585**	**281**	**41,527**	**82**	**12,040**	**200**	**29,487**
REHABILITATED CONDITIONS							
Land use	**Area**	**Surplus**		**Infiltration**		**Runoff**	
	(m^2)	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**	**(mm/yr)**	**(m^3/yr)**
Mature Forest	32,140	273	8,774	246	7,897	27	877
Agricultural/ Grass	39,999	319	12,760	255	10,208	64	2,552
Rehabilitated Pit	75,447	265	19,993	0	0	265	19,993
TOTAL	**147,585**	**281**	**41,527**	**123**	**18,105**	**159**	**23,423**

Prepared by: NP
Checked By: CDV

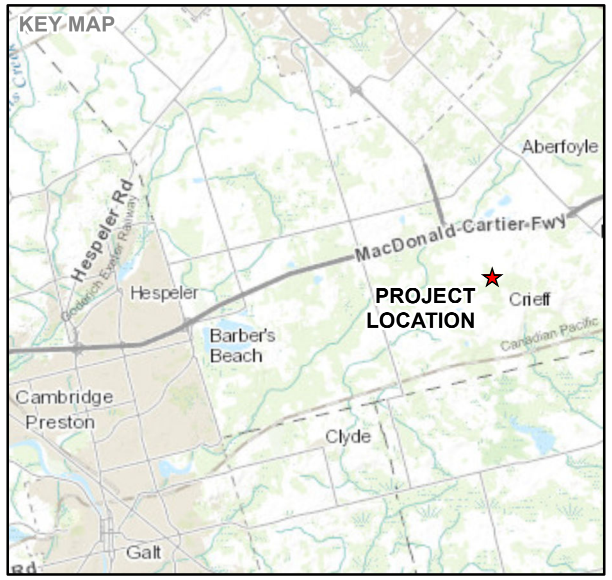
Table 11
WATER BALANCE SUMMARY
Hydrogeological Level 1, 2 Assessment
Proposed Lanci Pit Expansion
Puslinch, Ontario

Parameter	Existing Condition			Operational Condition			Rehabilitated Condition		
	(mm)	(m^3/yr)	(% of Surplus)	(mm)	(m^3/yr)	(% of Surplus)	(mm)	(m^3/yr)	(% of Surplus)
Surplus	275	40,596	-	281	41,527	-	281	41,527	-
Infiltration	238	35,169	86.60%	82	12,040	29.00%	123	18,105	43.60%
Runoff	37	5,427	13.40%	200	29,487	71.00%	159	23,423	56.40%

FIGURES

LEGEND

- TEST PIT LOCATION
- GOLDER BOREHOLE
- GOLDER MONITORING WELL
- GOLDER STAFF GAUGE
- AECOM MONITORING WELL
- AECOM STAFF GAUGE
- INFERRED CROSS-SECTION
- WATERCOURSE
- GROUND SURFACE ELEVATION CONTOUR - APRIL 2019 (5M INTERVAL)
- WETLAND
- WATERBODY
- LICENCE AREA
- EXTRACTION AREA



0 200 400 600

1:10,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

BASE DATA - MNR LIO, OBTAINED 2018
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
BASE IMAGERY SOURCE: ESRI, DIGITALGLOBE, GEOEYE, EARTHSTAR GEOGRAPHICS, CNES/AIRBUS DS, USDA, USGS, AEROGRID, IGN, AND THE GIS USER COMMUNITY
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
LOCATION PLAN

CONSULTANT

GOLDER

YYYY-MM-DD	2020-04-21
DESIGNED	JT
PREPARED	SO/PR
REVIEWED	AS
APPROVED	JR

PROJECT NO.	CONTROL	REV.	FIGURE
1774274			1

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

LEGEND

- GOLDER BOREHOLE
- GOLDER MONITORING WELL
- GOLDER STAFF GAUGE
- AECOM MONITORING WELL
- AECOM STAFF GAUGE
- GROUND SURFACE ELEVATION CONTOUR (1 M INTERVAL)
- INFERRED CROSS-SECTION
- WATERCOURSE
- WETLAND
- WATERBODY
- LICENCE AREA BOUNDARY
- EXTRACTION AREA BOUNDARY

0 50 100 150

1:3,000 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

BASE DATA - MNR LIO, OBTAINED 2018
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
CONTOURS - LIDAR DIGITAL TERRAIN MODEL (2016-18) - LIO. DOWNLOADED MAY 2019
BASE IMAGERY © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020)
DISTRIBUTION AIRBUS DS
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
SITE TOPOGRAPHY

CONSULTANT
GOLDER

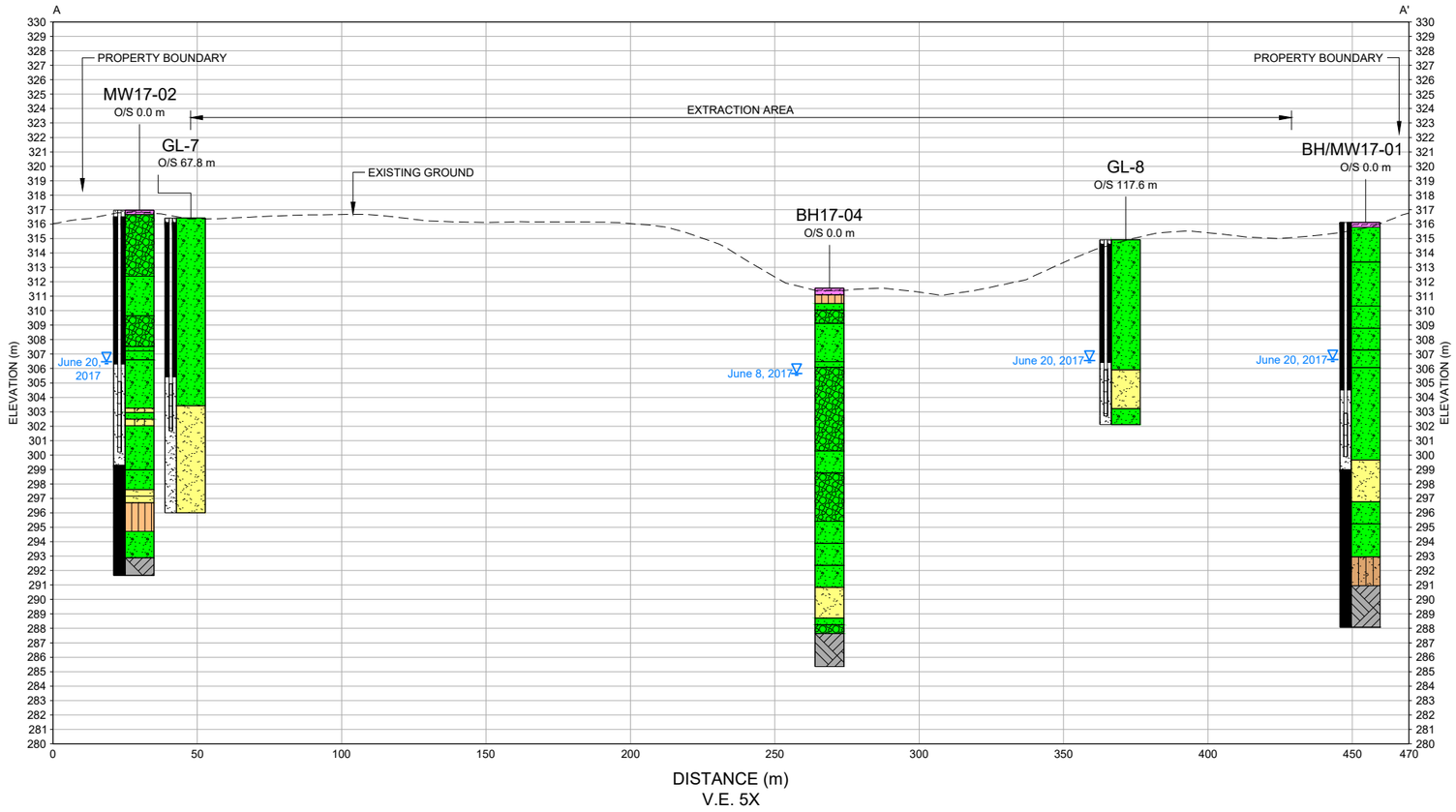
YYYY-MM-DD	2020-04-21
DESIGNED	JT
PREPARED	SO/PR
REVIEWED	AS
APPROVED	JR

PROJECT NO. 1774274 | CONTROL | REV. | FIGURE 2

25mm

0

S:\Clients\Victoriantim_Cimentos\Lanci_Pit99_PROJ\1774274\40_PROD\0009_Hydrogeology_Level1_2\1774274-0009-CH-0002.mxd



LEGEND

- TOPSOIL
- GRAVEL
- SAND AND GRAVEL
- SAND
- SILTY SAND
- SANDY SILT
- SILT
- BEDROCK

0 10 20
1:400 VERTICAL METRES

0 50 100
1:2,000 HORIZONTAL METRES

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXTENSION

TITLE
CROSS SECTION A-A'

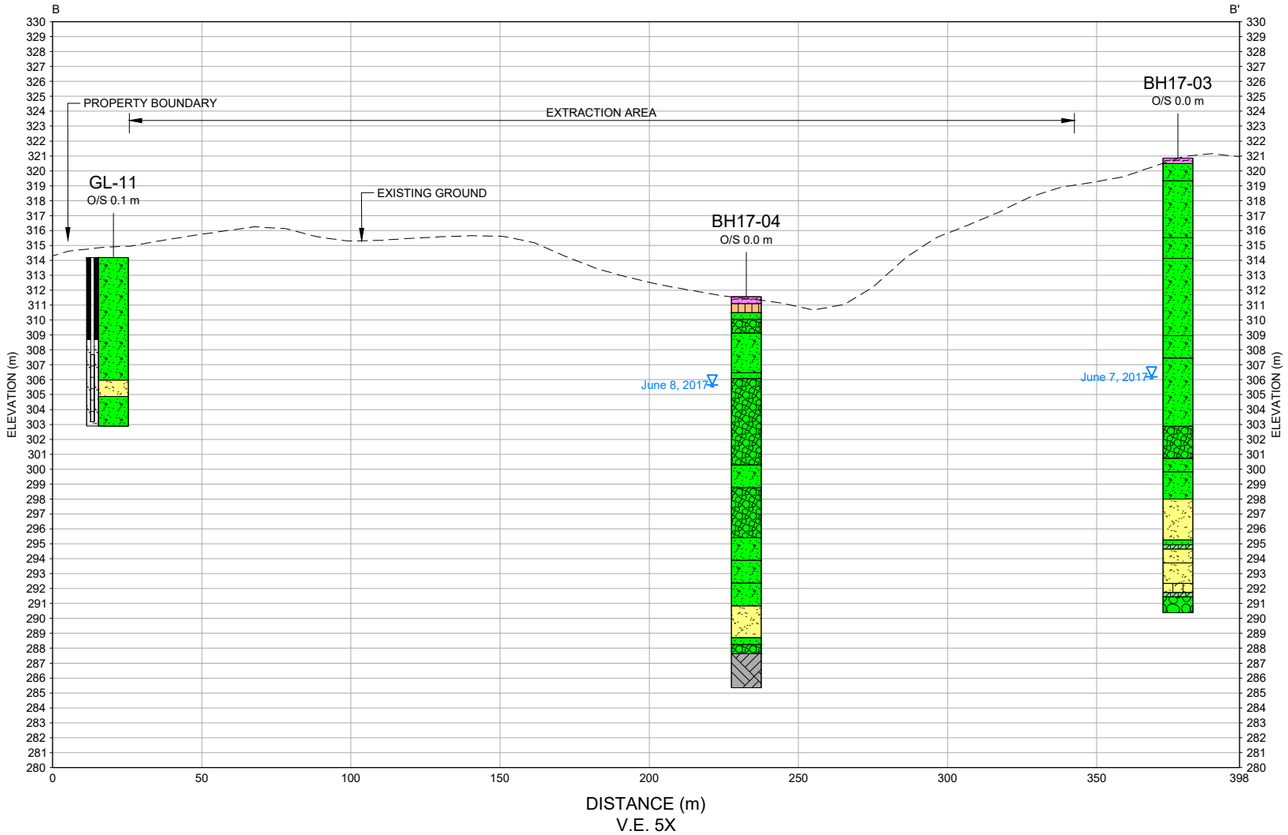
CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-21
DESIGNED	
PREPARED	DD
REVIEWED	AS
APPROVED	GS

PROJECT NO.	PHASE	REV.	FIGURE
1774274	(1000)	A	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25 mm



LEGEND

- TOPSOIL
- COBBLES
- GRAVEL
- SAND AND GRAVEL
- SAND
- SILTY SAND
- SILT
- SILTY CLAY
- BEDROCK

0 10 20
1:400 VERTICAL METRES

0 50 100
1:2,000 HORIZONTAL METRES

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXTENSION

TITLE
CROSS SECTION B-B'

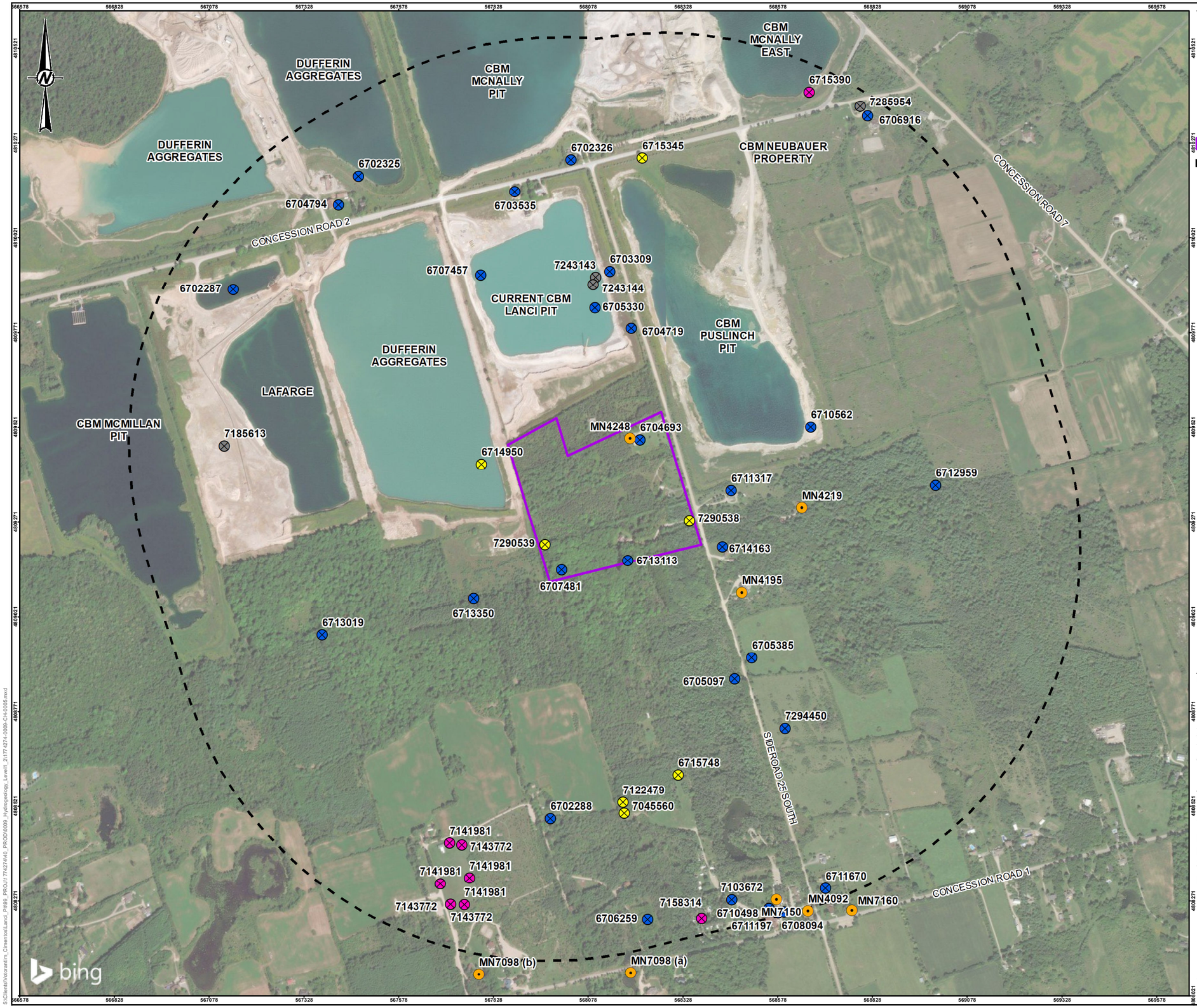
CONSULTANT
GOLDER

YYYY-MM-DD	2019-06-21
DESIGNED	
PREPARED	DD
REVIEWED	AS
APPROVED	GS

PROJECT NO.	PHASE	REV.	FIGURE
1774274	(1000)	A	4

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25 mm



LEGEND

- FIELD IDENTIFIED WELLS

MECP WATER WELL RECORD

- ABANDONED-OTHER
- OBSERVATION WELLS
- TEST HOLE
- WATER SUPPLY
- LICENCE AREA BOUNDARY
- BOUNDARY 1 km BUFFER

0 250 500 750

1:10,000 METRES

REFERENCE(S)

BASE DATA - MNR LIO, OBTAINED 2017
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
BASE IMAGERY © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020)
DISTRIBUTION AIRBUS DS
SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
MECP WATER WELL RECORDS OBTAINED OCTOBER 2018 (WELL RECORDS ARE UPDATED QUARTERLY)
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
MECP WATER WELL RECORDS

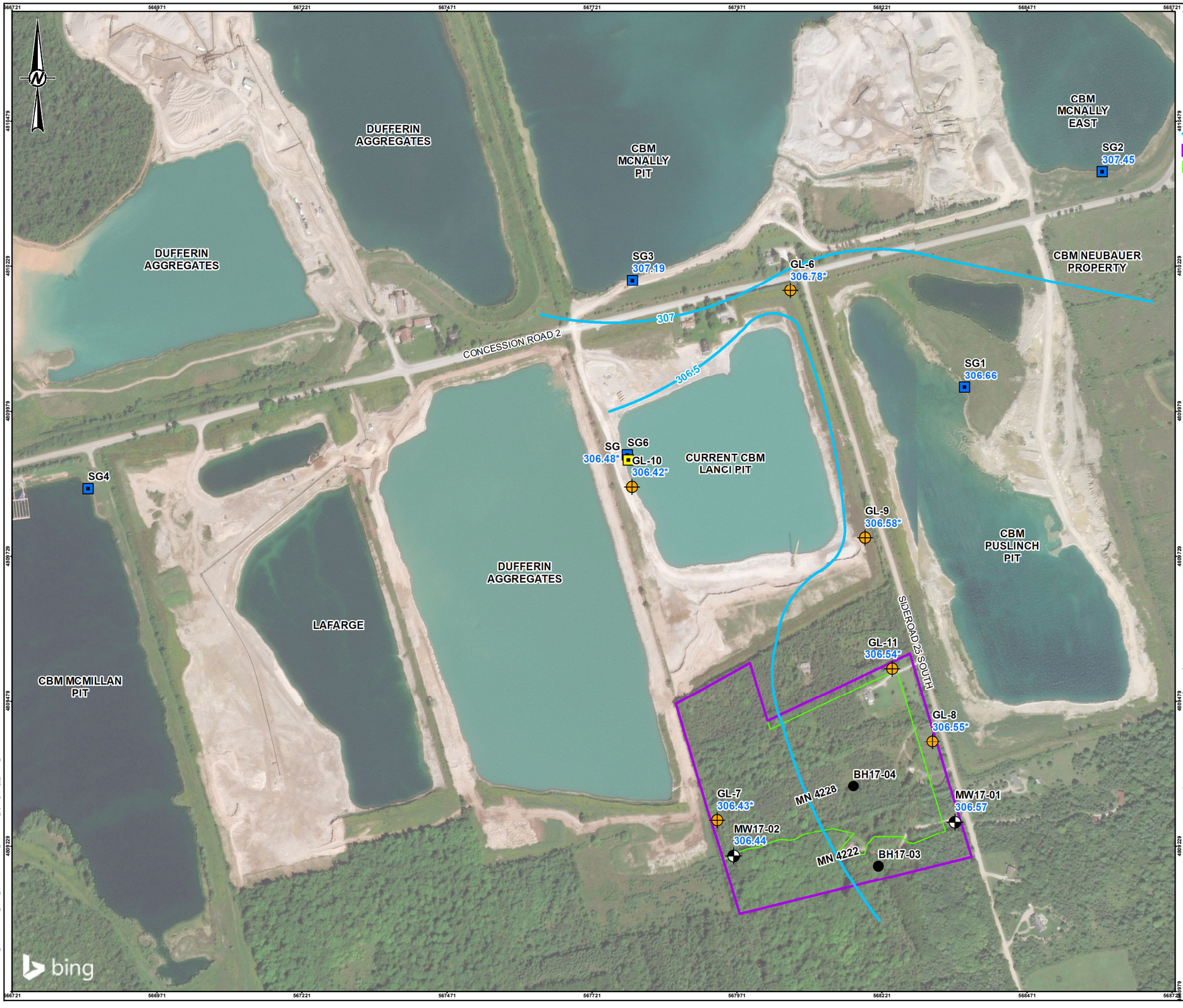
CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-20
DESIGNED	JT
PREPARED	SO/MM
REVIEWED	AS
APPROVED	JR

PROJECT NO. 1774274 CONTROL REV. FIGURE **5**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 0 25mm

S:\Clients\Vdaramtim_CementosLaval_P69_PROJ\1774274\40_PROD\0009_Hydrogeology_Level1_2\1774274-0009-CH-0005.mxd



LEGEND

- GOLDER BOREHOLE
- GOLDER MONITORING WELL
- GOLDER STAFF GAUGE
- AECOM MONITORING WELL
- AECOM STAFF GAUGE
- GROUNDWATER ELEVATION CONTOUR (MASL) (JUNE 20, 2017)
- LICENCE AREA BOUNDARY
- EXTRACTION AREA BOUNDARY
- REPORTED BY AECOM

0 100 200 300

1:6,500 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

BASE DATA - MNR LIO, OBTAINED 2018
INFERRED GROUNDWATER ELEVATION CONTOUR MEASURE BY GOLDER
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
BASE IMAGERY © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020)
DISTRIBUTION AIRBUS DS
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
GROUNDWATER ELEVATION PLAN (HIGH) – JUNE 2017

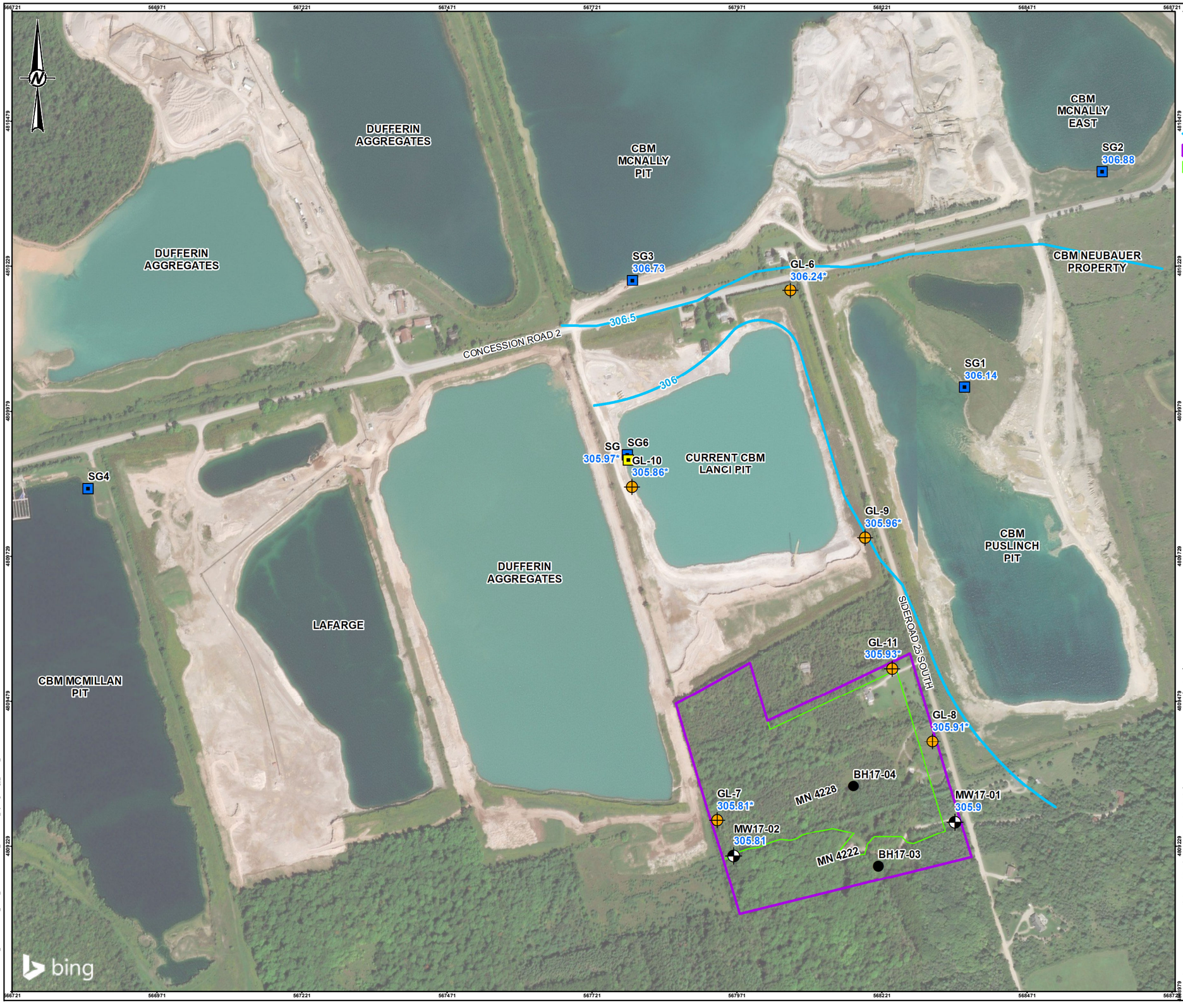
CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-21
DESIGNED	JT
PREPARED	SO/PR
REVIEWED	AS
APPROVED	JR

PROJECT NO. 1774274 CONTROL REV. FIGURE **6**

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm

S:\Clients\Vdcranitm_Cements\sLanci_Pit\99_PRO\1774274\40_PROD\0009_Hydrogeology_Level1_2\1774274-0009-CH-0006.mxd



LEGEND

- GOLDER BOREHOLE
- GOLDER MONITORING WELL
- GOLDER STAFF GAUGE
- AECOM MONITORING WELL
- AECOM STAFF GAUGE
- GROUNDWATER ELEVATION CONTOUR (MASL) (DECEMBER 14, 2017)
- LICENCE AREA BOUNDARY
- EXTRACTION AREA BOUNDARY
- REPORTED BY AECOM

DRAFT

0 100 200 300

1:6,500 METRES

NOTE(S)

1. ALL LOCATIONS ARE APPROXIMATE

REFERENCE(S)

BASE DATA - MNR LIO, OBTAINED 2018
INFERRED GROUNDWATER ELEVATION CONTOUR MEASURE BY GOLDER
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENCE FROM ONTARIO MINISTRY OF NATURAL RESOURCES, © QUEENS PRINTER 2017
BASE IMAGERY © 2020 MICROSOFT CORPORATION © 2020 DIGITALGLOBE ©CNES (2020)
DISTRIBUTION AIRBUS DS
PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM: UTM ZONE 17N

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
GROUNDWATER ELEVATION PLAN (LOW) – DECEMBER 2017

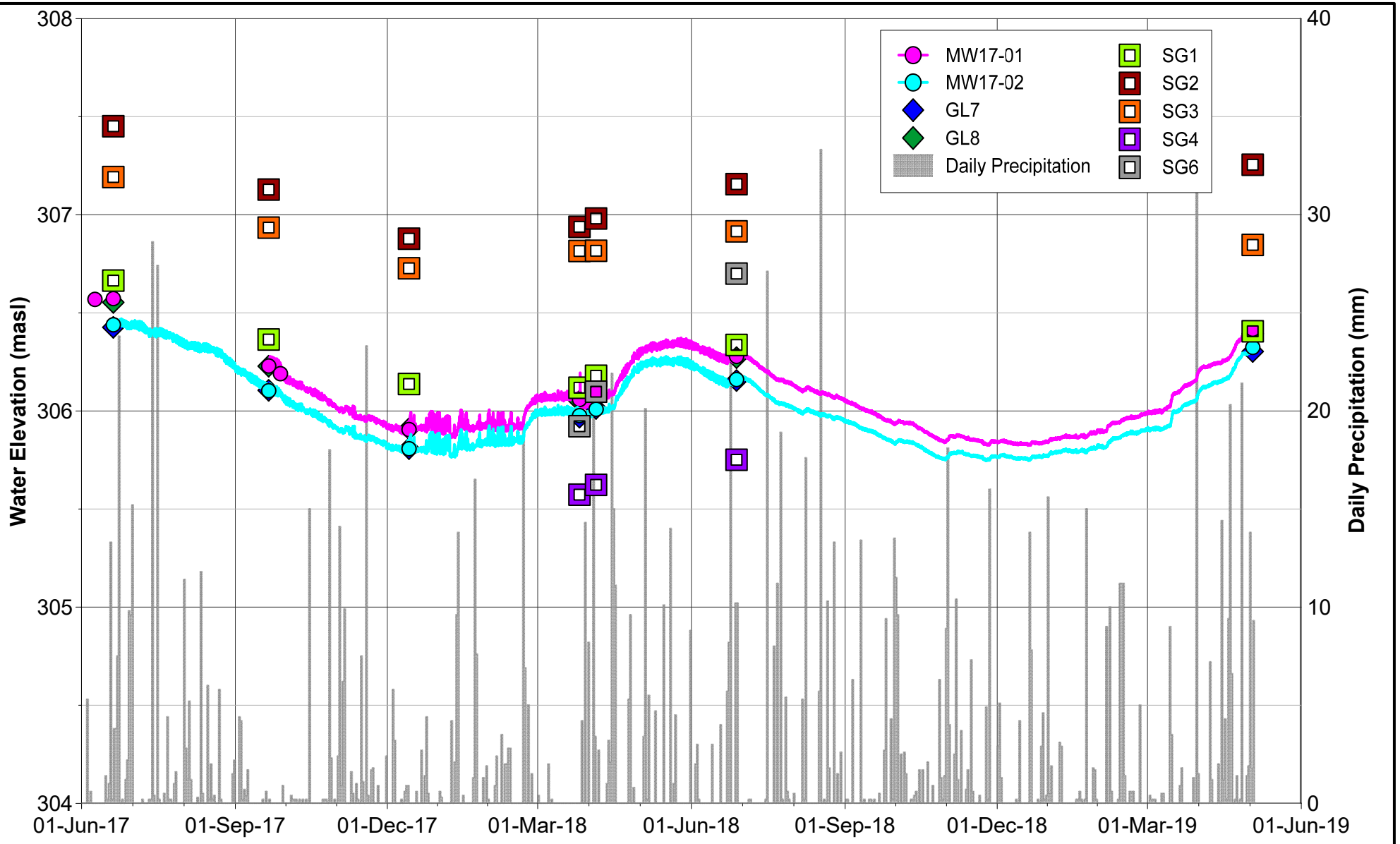
CONSULTANT
GOLDER

YYYY-MM-DD	2020-04-23
DESIGNED	JT
PREPARED	SO/PR
REVIEWED	AS
APPROVED	JR

PROJECT NO. 1774274 CONTROL REV. FIGURE **7**

S:\Clients\Vdcranitm_Cements\sLanci_Pit\99_PROJ\1774274\40_PROD\0009_Hydrogeology_Level1_2\1774274-0009-CH-0007.mxd

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: 25mm 0



Notes:
1. Precipitation data from Kitchener/Waterloo Climate Station.
2. To be read in conjunction with accompanying report.

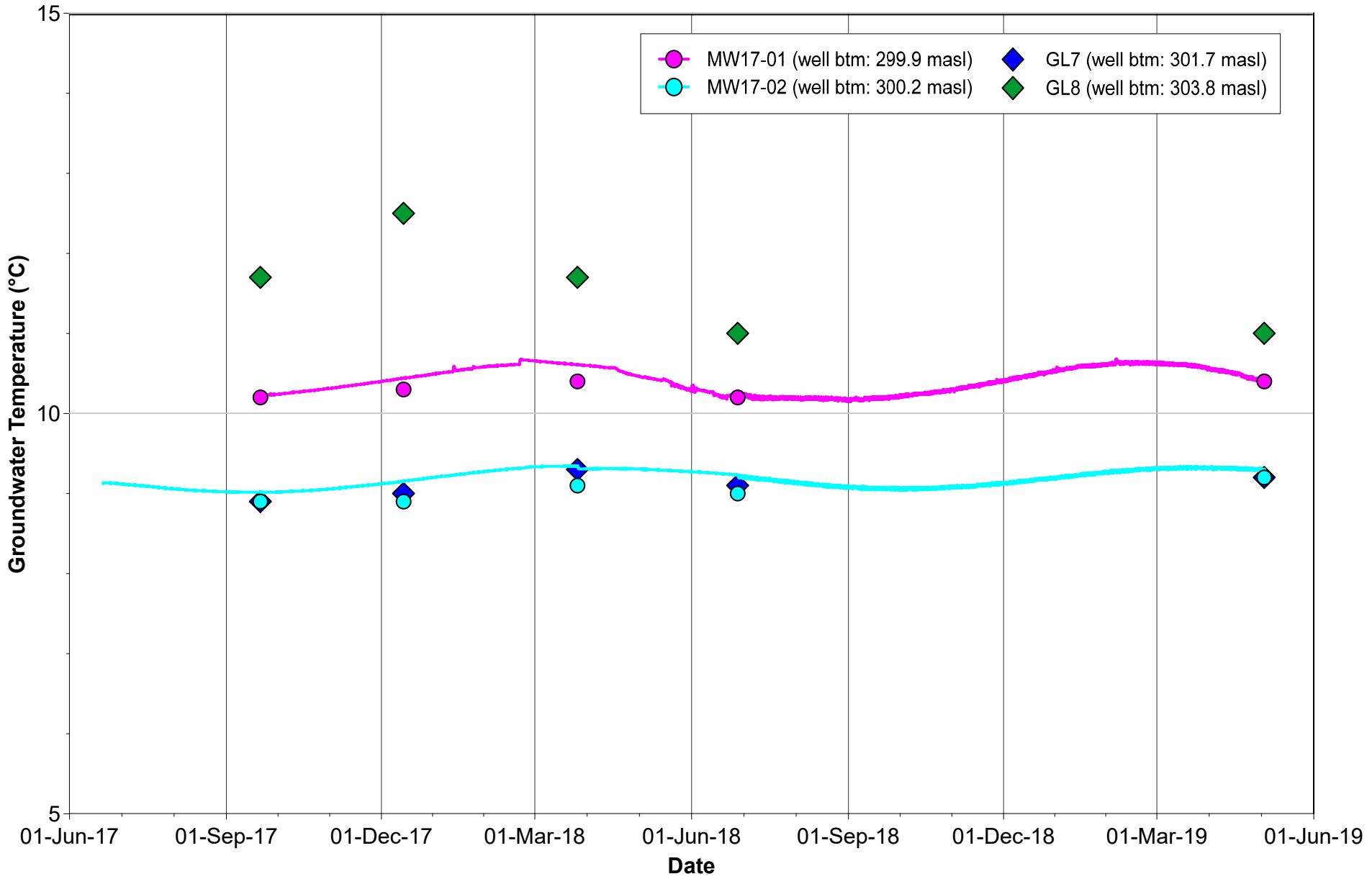
GOLDER

DATE	24-OCT-2019
DESIGN	AS
REVIEW	JR
APPROVED	GS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED LANCI PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
WATER ELEVATION HYDROGRAPHS

PROJECT NO.	REV	FIGURE
1774274	A	8



Notes:
1. Water temperature recorded near well bottom.
2. To be read in conjunction with accompanying report.

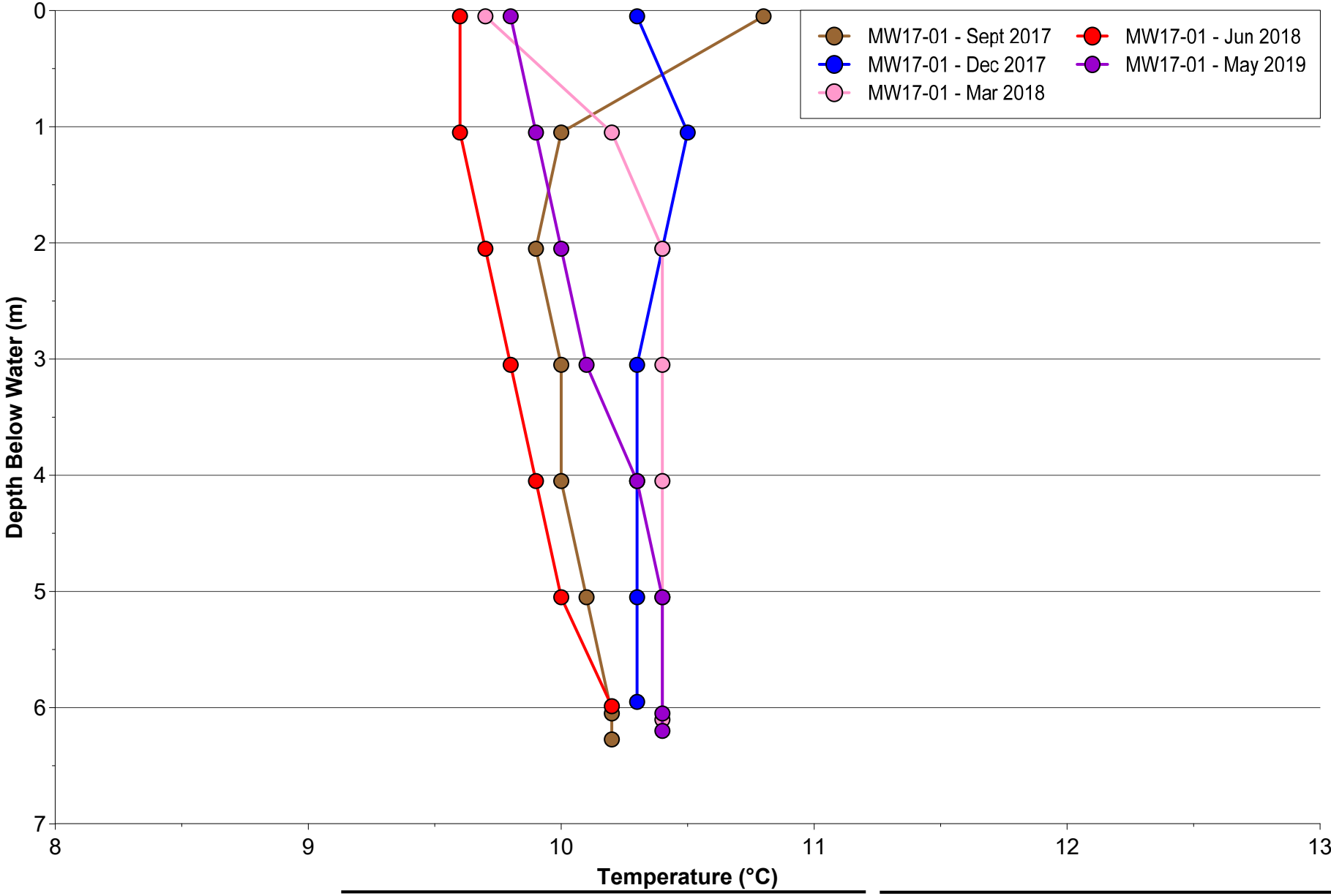
GOLDER

DATE	06-MAY-2019
DESIGN	AS
REVIEW	JR
APPROVED	GS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED LANCI PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
GROUNDWATER TEMPERATURE SUMMARY

PROJECT NO.	REV	FIGURE
1774274	A	9



Notes:
1. To be read in conjunction with accompanying report.

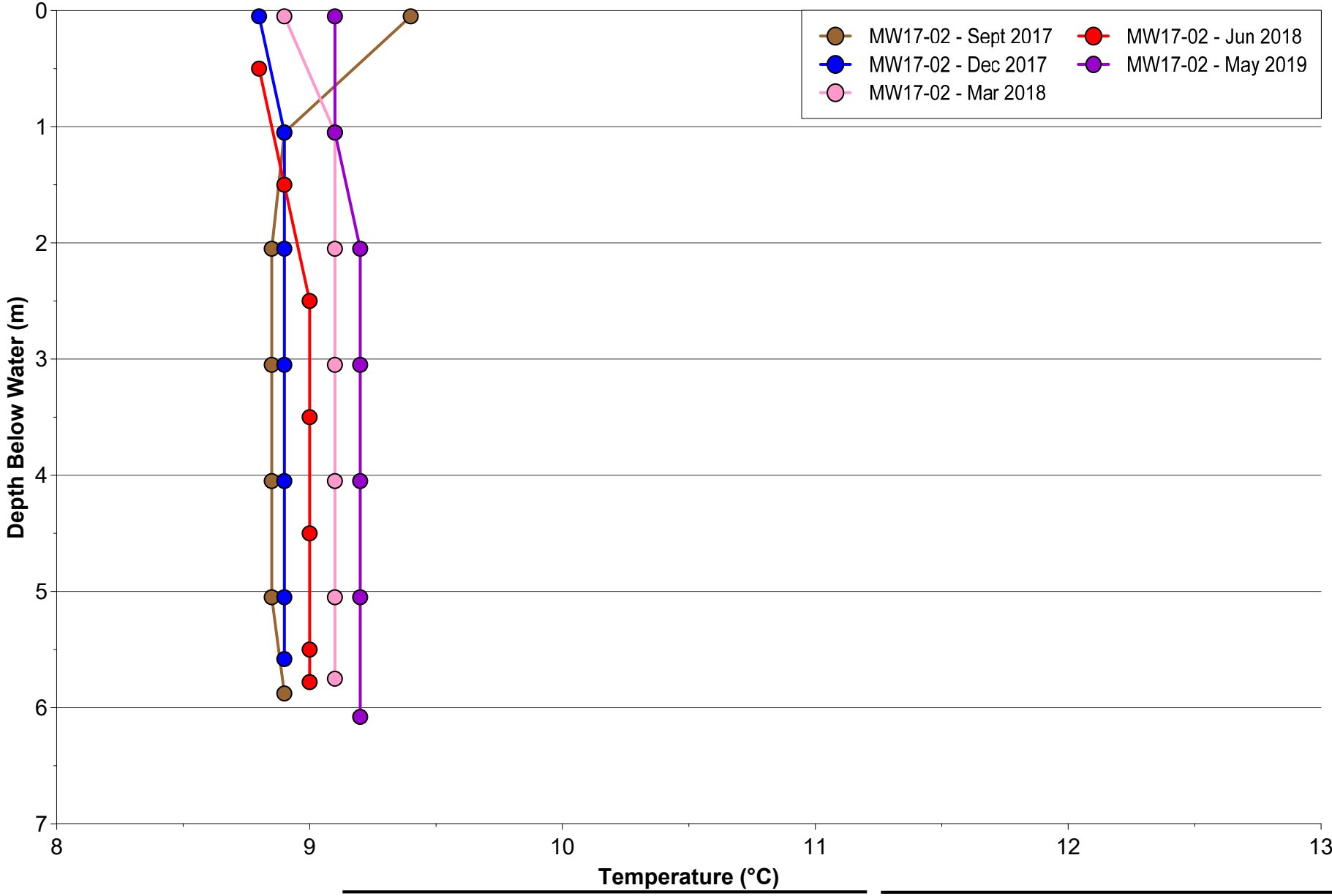
GOLDER

DATE	28-OCT-2019
DESIGN	AS
REVIEW	JR
APPROVED	GS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED LANCI PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
TEMPERATURE PROFILE: MW17-01

PROJECT NO.	REV	FIGURE
1774274	A	10



Notes:
1. To be read in conjunction with accompanying report.

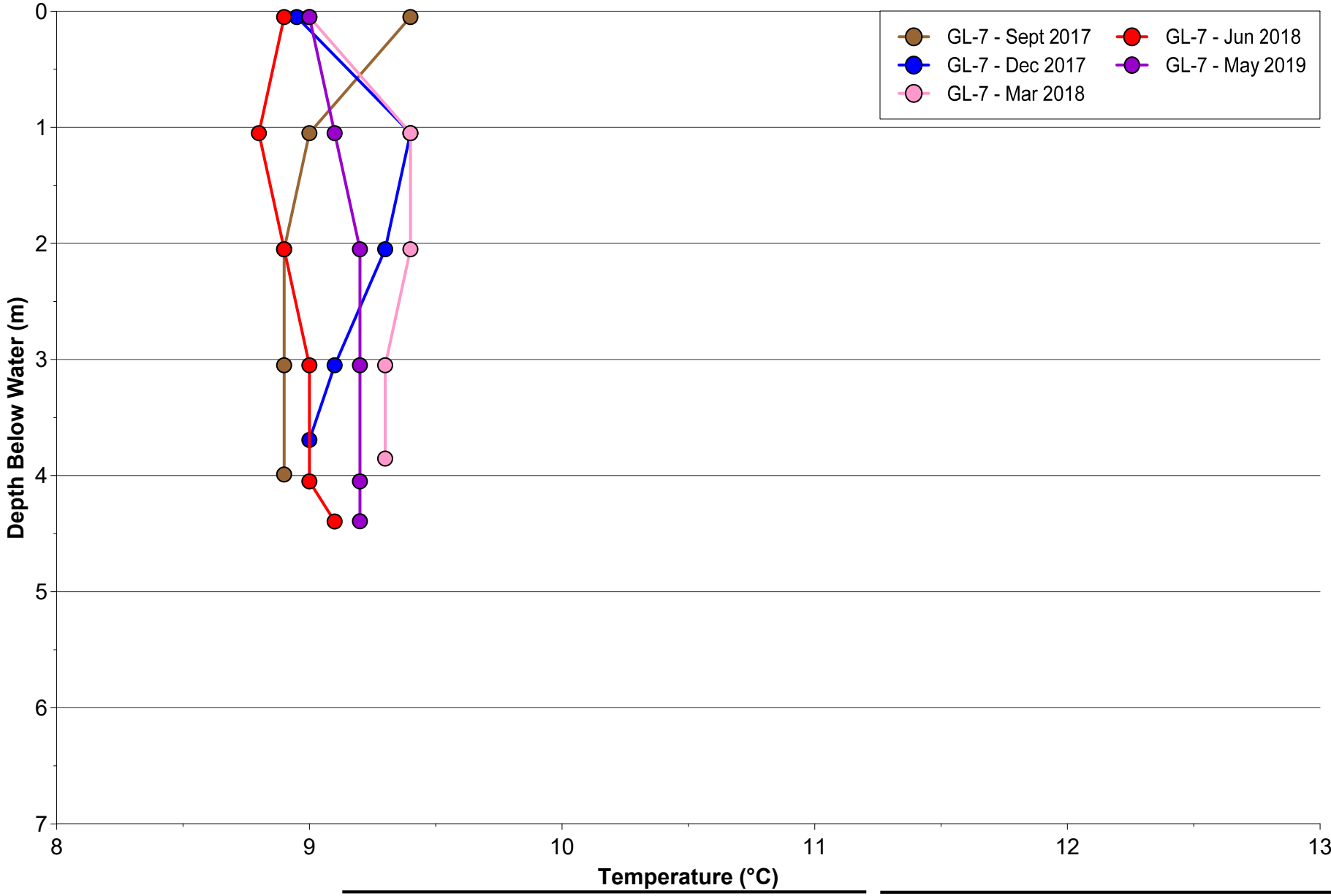
GOLDER

DATE	28-OCT-2019
DESIGN	AS
REVIEW	JR
APPROVED	GS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED LANCI PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
TEMPERATURE PROFILE: MW17-02

PROJECT NO.	REV	FIGURE
1774274	A	11



Notes:
1. To be read in conjunction with accompanying report.

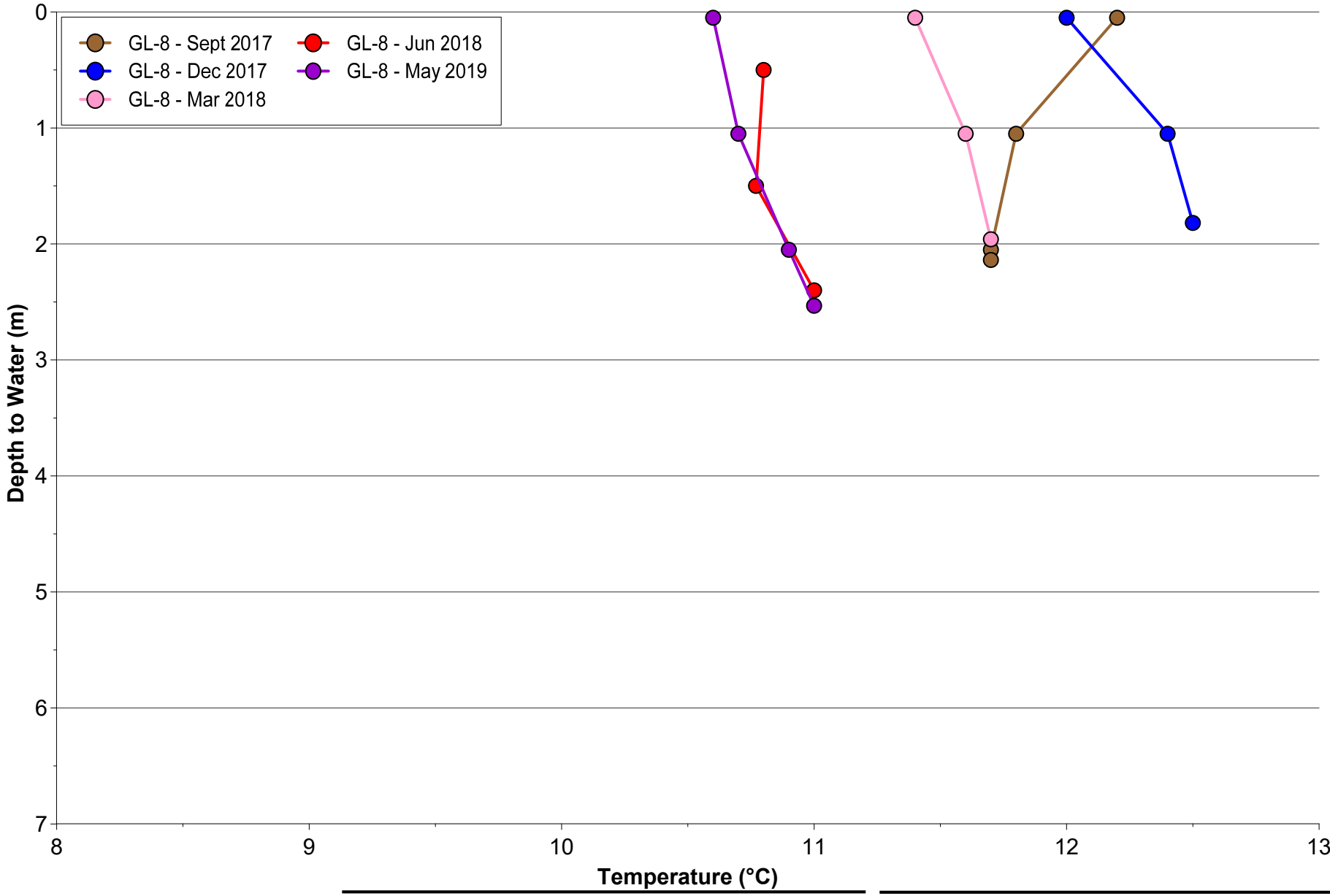
GOLDER

DATE	28-OCT-2019
DESIGN	AS
REVIEW	JR
APPROVED	GS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED LANCI PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
TEMPERATURE PROFILE: GL-7

PROJECT NO.	REV	FIGURE
1774274	A	12



Notes:
1. To be read in conjunction with accompanying report.

GOLDER

DATE	28-OCT-2019
DESIGN	AS
REVIEW	JR
APPROVED	GS

PROJECT
HYDROGEOLOGICAL LEVEL 1/2 ASSESSMENT
PROPOSED LANCI PIT EXPANSION
PUSLINCH, ONTARIO

TITLE
TEMPERATURE PROFILE: GL-8

PROJECT NO.	REV	FIGURE
1774274	A	13

LEGEND

- LICENCE AREA BOUNDARY
- EXTRACTION AREA BOUNDARY
- ROAD

LAND USE

- AGRICULTURAL
- BUILT UP
- GRASS
- WOODED AREA

0 50 100 150

1:2,500 METRES

REFERENCE(S)

1. BASE DATA - MNRF LIO, 2018
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENSE FROM
ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, © QUEENS PRINTER 2018
2. IMAGERY - SERVICE LAYER CREDITS: © 2020 MICROSOFT CORPORATION © 2020
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SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

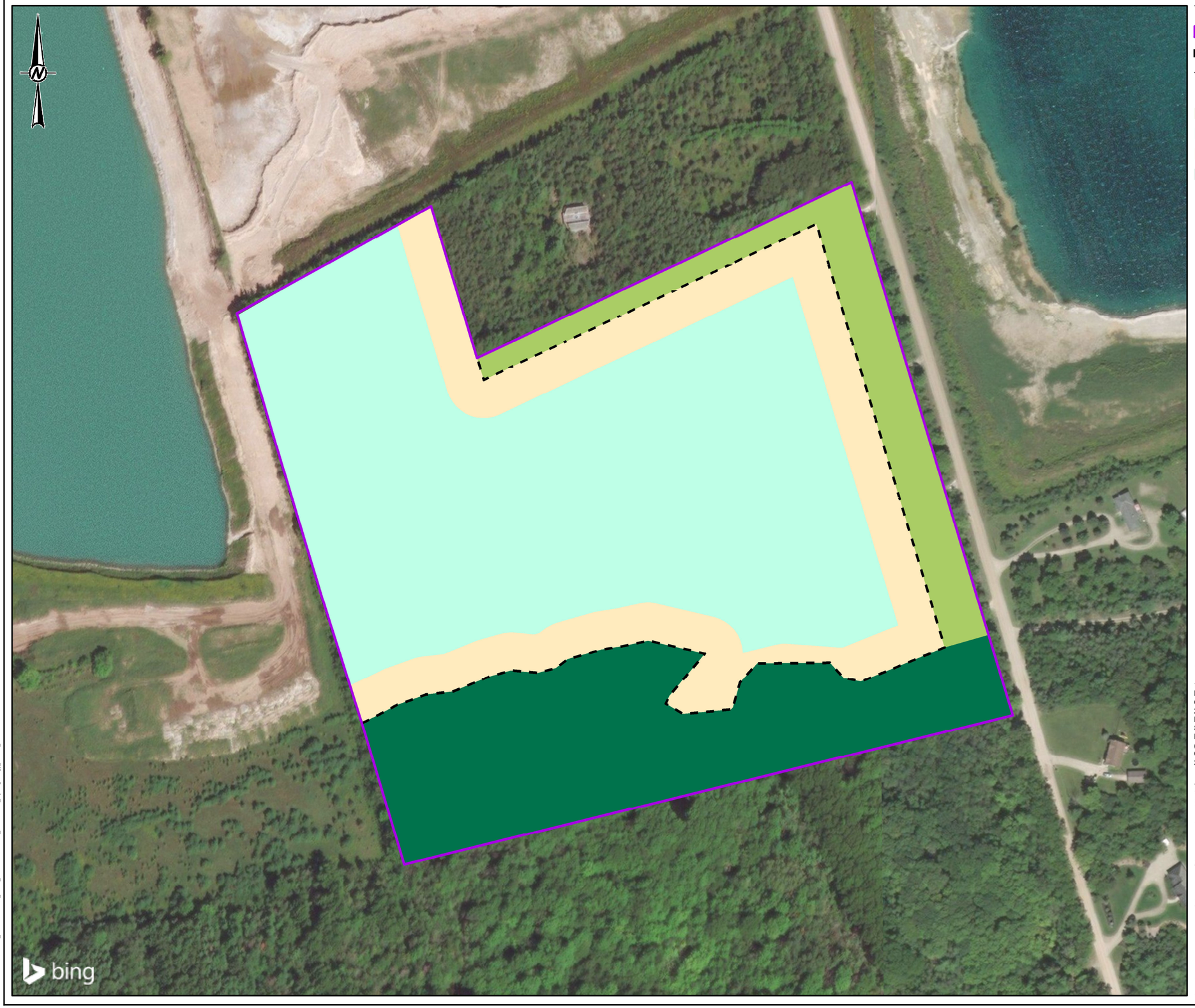
TITLE
LAND USE UNDER EXISTING CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-02-12
DESIGNED	PR
PREPARED	PR
REVIEWED	NP
APPROVED	CDV

PROJECT NO.	CONTROL	REV.	FIGURE
1774274			14

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B
0 25mm



LEGEND

- LICENCE AREA BOUNDARY
- EXTRACTION AREA BOUNDARY
- ROAD

LAND USE

- OPEN PASTURE
- PONDED
- EXCAVATION PIT
- WOODED AREA

0 50 100 150

1:2,500 METRES

REFERENCE(S)

1. BASE DATA - MNRF LIO, 2018
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENSE FROM
ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, © QUEENS PRINTER 2018
2. IMAGERY - SERVICE LAYER CREDITS: © 2020 MICROSOFT CORPORATION © 2020
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SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
LAND USE UNDER OPERATING CONDITIONS

CONSULTANT
GOLDER

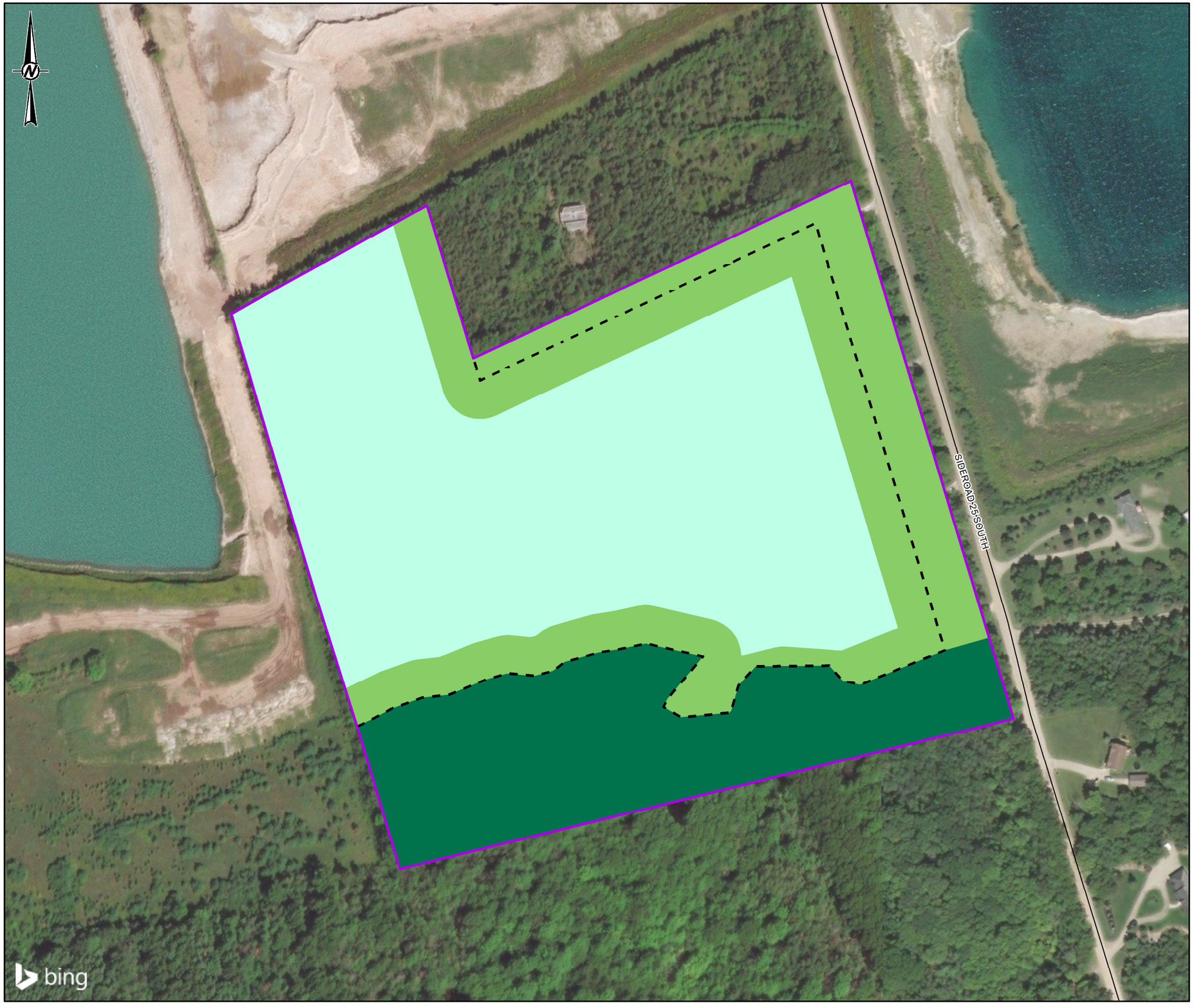
YYYY-MM-DD	2020-02-12
DESIGNED	PR
PREPARED	PR
REVIEWED	NP
APPROVED	CDV

PROJECT NO. 1774274 CONTROL REV. FIGURE 15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

0 25mm

PATH: S:\Clients\Votaranim_Cimentos\Lanci_Pit\09_PRO\1774274\440_PROD\00\09_Hydrogeology_Level1_2\1774274-0009-CH-0015.mxd PRINTED ON: 2020-02-12 AT: 2:18:12 PM



LEGEND

- LICENCE AREA BOUNDARY
- EXTRACTION AREA BOUNDARY
- ROAD

LAND USE

- OPEN PASTURE
- PONDED
- WOODED AREA

0 50 100 150

1:2,500 METRES

REFERENCE(S)

1. BASE DATA - MNRF LIO, 2018
PRODUCED BY GOLDER ASSOCIATES LTD UNDER LICENSE FROM
ONTARIO MINISTRY OF NATURAL RESOURCES AND FORESTRY, © QUEENS PRINTER 2018
2. IMAGERY - SERVICE LAYER CREDITS: © 2020 MICROSOFT CORPORATION © 2020
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SOURCES: ESRI, HERE, GARMIN, INTERMAP, INCREMENT P CORP., GEBCO, USGS, FAO, NPS, NRCAN, GEOBASE, IGN, KADASTER NL, ORDNANCE SURVEY, ESRI JAPAN, METI, ESRI CHINA (HONG KONG), SWISSTOPO, © OPENSTREETMAP CONTRIBUTORS, AND THE GIS USER COMMUNITY
3. PROJECTION: TRANSVERSE MERCATOR DATUM: NAD 83 COORDINATE SYSTEM:UTM ZONE 17

CLIENT
ST. MARYS CEMENT INC. (CANADA)

PROJECT
HYDROGEOLOGICAL LEVEL 1 AND 2 ASSESSMENT
LANCI PIT EXPANSION

TITLE
LAND USE UNDER REHABILITATED CONDITIONS

CONSULTANT
GOLDER

YYYY-MM-DD	2020-02-12
DESIGNED	PR
PREPARED	PR
REVIEWED	NP
APPROVED	CDV

PROJECT NO. 1774274 CONTROL REV. FIGURE 16

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM ANSI B

0 25mm

PATH: S:\Clients\Vdzaranitm_Cimentos\Lanci_Pit\6b_PRO\1774274\40_PROD\00\9_Hydrogeology_Level1_2\1774274-0009-CH-00116.mxd PRINTED ON: 2020-02-12 AT: 2:18:06 PM

APPENDIX A

Terms of Reference

July 13, 2018 Project No. 1774274

Stephen May
CBM Aggregates
55 Industrial Street
Toronto, Ontario
M4G 3W9

TERMS OF REFERENCE FOR NATURAL ENVIRONMENT AND HYDROGEOLOGY TECHNICAL STUDIES IN SUPPORT OF LICENSING THE EXTENSION OF OPERATIONS AT THE CBM LANCI PIT, ABERFOYLE, ONTARIO

Dear Mr. May:

Golder Associates Ltd. (Golder) has been retained by CBM Aggregates Inc. (CBM), a division of Votorantim Cimentos North America (VCNA) to carry out technical studies in support of an application to the Ministry of Natural Resources and Forestry (MNRF) for a new below the water table licence under the Aggregate Resources Act (ARA) for the extension of the existing Lanci Pit near Aberfoyle, Ontario (the site).

The technical studies for the ARA licence application will include a number of disciplines, including hydrogeology, surface water, and natural environment.

The technical requirements of these supporting studies are outlined in the document titled Aggregate Resources Act of Ontario, Provincial Standards, Version 1.0 (Provincial Standards). Golder's proposed approach to the project has been developed to meet the general requirements of the Provincial Standards.

The above studies will be integrated to ensure that any key linkages between the hydrogeological and hydrological components, and the receiving natural environment features, are holistically evaluated to support the completion of the potential impact assessments for the proposed expansion of the pit and the development of appropriate mitigation measures, if required.

We respectfully request that you review this Terms of Reference for the proposed water resource and natural environment technical studies and provide comments as appropriate.

Integrated Water Resource Assessment

The following provides the proposed scope of the water resources program consisting of hydrogeology (groundwater) and hydrology (surface water) components.

Hydrogeology

The program for hydrogeology consists of the following:

- Data review (monitoring reports to date and published geologic reports);
- Review of Ministry of Environment, Conservation and Parks (MOECP) water well records (formerly Ministry of Environment and Climate Change) and door to door survey of residences and businesses within one kilometre of the site;
- Site characterization:
  - Borehole drilling, grain size analysis, and monitoring well installation;
  - Baseline groundwater quality monitoring (general water quality parameters including major ions, metals and petroleum hydrocarbons);
  - Hydraulic conductivity characterization (single well response tests);
  - Groundwater monitoring program (dataloggers to record water level and temperature hourly and downloaded quarterly);
- Analysis and qualitative impact assessment; and
- Level 1/2 Hydrogeology Technical Report.

Surface Water Resources

An assessment of surface water resources in the area of the proposed expansion, as well as adjoining areas that may be affected by proposed expansion, will be completed to allow for quantification of potential effects. The surface water resources assessment consists of the following:

- Background review of the available information pertaining to within approximately 500 metres of the site. the information reviewed will consist of:
  i) Aerial photographs and topographic, physiographic, and geologic mapping;
  ii) Published water resources reports; and
  iii) Any existing permits or monitoring reports from the site.
- Site visit to identify and confirm drainage features and catchment boundaries adjacent to the pit. The site reconnaissance is also used to corroborate the findings of the information review and identify local features that were not apparent from the background review.

- A water budget and pit water balance using a Thornthwaite water budget tool, developed for the existing pit footprint area (footprint) and the proposed expansion lands. The Thorthwaite water budget information will be used to develop an annual pit water balance for the existing operation. A future pit water balance will be estimated by including future footprint and land-use information.
- An effects assessment on features within the catchment of the pit expansion that documents the magnitude and significance of expected changes in the water budget of the pit expansion.
- A report that describes the surface water assessments, including a description of existing and proposed conditions and expected effects, and will ultimately be included as an appendix into the Level 1 and 2 Hydrogeology Technical Report.

Natural Environment Assessment

Golder is undertaking a work program for a Natural Environment Level 1 and 2 Assessment in order to evaluate the natural features in the vicinity of the site. Golder will assess the potential impacts of the proposed below water extraction on those features and their ecological functions and, if necessary, recommend measures to prevent or mitigate negative impacts on any significant features. The proposed program consists of the following:

- Background data compilation and review of existing documents and information sources which will be focused on designated features in the vicinity of the site;
- Species at Risk screening focussing on those species listed under the Ontario Endangered Species Act (ESA) and federal Species at Risk Act (SARA);
- Field surveys including:
  - i) Plant community assessment based on Ecological Land Classification;
  - ii) Botanical inventory;
  - iii) Two breeding bird surveys;
  - iv) Bat habitat, exit surveys and acoustic surveys using a bat survey protocol approved by the MNRF;
  - v) Wildlife habitat assessment and general wildlife surveys (Visual Encounter Surveys);
- Analysis of the data collected in conjunction with the background data compilation and integration with the hydrogeological and surface water studies to complete a potential impact assessment; and
- Natural Environment Level 1 and 2 Technical Report.

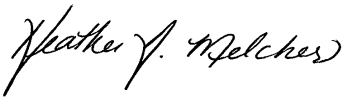
Closing

We trust this Terms of Reference meets with your approval. If you have any questions or comments, please do not hesitate to contact the undersigned.

Yours sincerely,

Golder Associates Ltd.

Amber Sabourin, B.Sc. (Hons)
Ecologist



Heather Melcher, M.Sc.
Associate, Senior Ecologist

HM/AVS/AS/JR/CD/wlm

https://golderassociates.sharepoint.com/sites/11897g/shared documents/07 deliverables/terms of reference/1774274-l-rev0-13jul2018-cbm lanci ne and hydrog tor.docx

APPENDIX B

Borehole Logs

PROJECT: 1774274 (1000)

LOCATION: N 4809271.38; E 568347.05

RECORD OF BOREHOLE: BH/MW17-01

BORING DATE: June 7 to 8, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80); SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}); WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		316.11							
0		Silty TOPSOIL (340 mm)		0.00 315.77							
		(GW) SAND and GRAVEL, some silt, some cobbles; brown; moist		0.34	1						
1											
					2						
2				313.37							
		(GW) Sandy GRAVEL and COBBLES, trace silt; brown; moist		2.74							
3					3						
4											
		Boulder encountered at approximate depth of 4.74 m to 4.94 m below ground surface			4						Holeplug
5	Sonic Drilling			310.32							
		(GW) SAND and GRAVEL, some silt, some cobbles; brown; moist		5.79	5						
6											
7				308.79							
		(GW) Sandy GRAVEL and COBBLES, trace silt; brown; moist		7.32	6						
8											
				307.27							
9		(GW) SAND and GRAVEL, some silt, some cobbles; brown; moist		8.84	7						▽ June 8, 2017
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

PROJECT: 1774274 (1000)

LOCATION: N 4809271.38; E 568347.05

RECORD OF BOREHOLE: BH/MW17-01

BORING DATE: June 7 to 8, 2017

SHEET 2 OF 3

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(GW) SANDY GRAVEL and COBBLES, trace to some silt; brown; moist to wet		306.05 / 10.06	8						Holeplug
11											
12					9						Sand
13											
14											
15					10A						Screen
16				299.65 / 16.46							
17		(SW) Gravelly medium to coarse SAND, some cobbles; trace silt; brown; wet			10B						Sand
18		Cobble layer encountered at approximate depth 17.8 m to 19.4 m below ground surface			11						Holeplug
19				296.76 / 19.35							
20		(GW) SAND and GRAVEL, trace to some cobbles, trace silt; brown; wet			12						
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

GTA-BHS 001 S:\CLIENTS\VOTORANTIM_CIMENTOS\LANCI_PIT\02_DATA\GINT\LANCI_PIT.GPJ GAL-MIS.GDT 20-2-7

PROJECT: 1774274 (1000)

LOCATION: N 4809271.38; E 568347.05

RECORD OF BOREHOLE: BH/MW17-01

BORING DATE: June 7 to 8, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		*--- CONTINUED FROM PREVIOUS PAGE ---*									
	Sonic Drilling	(GW) SAND and GRAVEL, trace to some cobbles, trace silt; brown; wet		295.23	12						
21		(GP) Medium to coarse SAND and GRAVEL, trace silt; brown; wet		20.88	13						
22											
23				292.95	14A						
		(ML) Sandy SILT, some gravel, some cobbles, trace to some clay; brown; wet		23.16	14B						
24											Holeplug
					15						
25				290.96							
		BEDROCK		25.15							
26											
					16						
27											
28				288.07							
		END OF BOREHOLE		28.04							
29		NOTE: 1. 50 mm monitoring well installed dia. screened from 13.2 m to 16.2 m below ground surface. 2. Water level measured at a depth of 9.5 m below ground surface (Elev. 306.6 m) upon completion of well installation.									
30											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

PROJECT: 1774274 (1000)

LOCATION: N 4809213.19; E 567965.60

RECORD OF BOREHOLE: BH/MW17-02

BORING DATE: June 9, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		316.96							
0		TOPSOIL (300 mm)		0.00 / 316.66							Cement
		(GW) GRAVEL and COBBLES, some sand, some silt; brown; moist		0.30	1						
1											
					2						
2											
					3						
3											
				312.39							
4		(GW) Sandy GRAVEL and COBBLES; trace silt; brown; moist Boulder encountered at approximate depth of 4.57 m- 5.18 m, 5.64 m- 6.10 m below ground surface		4.57	4						
	Sonic Drilling										Holeplug
5											
					5						
6											
				309.64							
7		(GW) GRAVEL and COBBLES, some sand, some silt; brown; moist		7.32	6						
8											
9				307.51							
		(SW) Gravelly fine to medium SAND, some silt; brown; moist		9.45 / 307.21	7A						
		(GW) SAND and GRAVEL, some cobbles, some silt; brown; moist		9.75	7B						
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

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PROJECT: 1774274 (1000)

LOCATION: N 4809213.19; E 567965.60

RECORD OF BOREHOLE: BH/MW17-02

BORING DATE: June 9, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
10		*--- CONTINUED FROM PREVIOUS PAGE ---*									
	Sonic Drilling	(GW) SAND and GRAVEL, some cobbles, some silt; brown; moist		306.60	7B						Holeplug
		(GW) Medium to coarse sandy GRAVEL, some cobbles, trace silt; brown; wet		10.36							June 20, 2017
11					8						Sand
12					9						
13		Sandy silt layer encountered at approximate depth 13.26 m to 13.41 m below ground surface		303.24							
		(SM) Silty sand, some gravel, trace clay; brown; wet		13.72 / 302.94	10B						
14		(GW) SAND and GRAVEL, trace silt; brown; wet		14.02 / 302.48	10A						Screen
		(SM) Silty SAND, some gravel, trace clay; brown; wet		14.48 / 302.02	10B						
15		(GP) Medium to coarse sandy GRAVEL, some cobbles; brown; wet		14.94	11						
16											
17					12						Sand
18				298.98							
		(GP) Medium to coarse sandy GRAVEL		17.98	13A						Holeplug
19				297.61							
		(SP) Medium to coarse SAND, some gravel; brown; wet		19.35 / 297.15	13B						
20				19.81	14A						
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

PROJECT: 1774274 (1000)

LOCATION: N 4809213.19; E 567965.60

RECORD OF BOREHOLE: BH/MW17-02

BORING DATE: June 9, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80)	SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕; Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3})	WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		*--- CONTINUED FROM PREVIOUS PAGE ---*											
	Sonic Drilling	(SW) Fine to medium SAND, trace gravel; brown; wet		296.69	14A								
		(ML) SILT, some clay, trace to some sand; brown; wet		20.27	14B								
21					15								
22				294.71									
		(SW) Gravelly medium to coarse SAND		22.25	16A								Holeplug
23		Layer of fine to medium sand; some silt at approximate depth 23.16 m to 23.32 m below ground surface			16B								
					16A								
24				292.88									
		BEDROCK		24.08	17								
25				291.66									
		END OF BOREHOLE		25.30									
26		NOTES:											
		1.50 mm dia. monitoring well installed, screened from 11.9 m to 16.8 m below ground surface.											
27		2. Water level measured at a depth of 10.5 m below ground surface (Elev.306.4 m) on June 20, 2017.											
28													
29													
30													

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

PROJECT: 1774274 (1000)

LOCATION: N 4809195.24; E 568214.81

RECORD OF BOREHOLE: BH17-03

BORING DATE: June 7, 2017

SHEET 1 OF 4

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		320.85							
0	Sonic Drilling	Gravelly TOPSOIL (370 mm), some sand		0.00 / 320.48	1A						
1		(GW) SAND and GRAVEL, some silt, trace to some cobbles; brown; moist		0.37 / 319.33	1B						
2		(GM) Silty SAND and GRAVEL, trace to some cobbles; brown; moist		1.52	2						
3					3						
4		Sandy silt layers encountered at approximate depth 5.33 m - 5.78 m below ground surface									
5					4A						
		(GW) SAND and GRAVEL, some silt, trace to some cobbles; brown; moist		5.33 / 315.52	4B						
6					5						
		(GW) Sandy GRAVEL, some cobbles, trace to some silt; brown; moist		6.71 / 314.14							
7					6						
8											
9					7						
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

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PROJECT: 1774274 (1000)

LOCATION: N 4809195.24; E 568214.81

RECORD OF BOREHOLE: BH17-03

BORING DATE: June 7, 2017

SHEET 2 OF 4

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(GW) Sandy GRAVEL, some cobbles, trace to some silt; brown; moist			7						
11					8						
				308.96							
12		(GW) SAND and GRAVEL, some cobbles, trace to some silt; brown; moist		11.89	9						
13				307.44							
		(GW) Sandy GRAVEL, some cobbles, trace silt; brown; moist to wet		13.41							
14					10						
											▽ June 7, 2017
15					11						
16											
17					12						
				302.87							
18		(GP) GRAVEL and COBBLES, some medium to coarse sand; brown; wet		17.98							
19					13						
20		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

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PROJECT: 1774274 (1000)

LOCATION: N 4809195.24; E 568214.81

RECORD OF BOREHOLE: BH17-03

BORING DATE: June 7, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. +, rem V. ⊕, Q - ●, U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp, W, Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
20				300.73	13						
		(GW) Sandy GRAVEL, some cobbles, some silt; brown; wet		20.12	14						
21		(GW) SAND and GRAVEL, trace silt; brown; wet		299.82 21.03	15						
22											
				297.99							
23		(SP) Medium to coarse SAND; some gravel; brown; wet Silt layers encountered at approximate depth 22.9 m to 24.1 m below ground surface		22.86	16						
24											
					17						
25	Sonic Drilling										
				295.25							
		(GW) Sandy GRAVEL; brown; wet		25.60	18A						
26		(CL) Silty CLAY; brown; wet		294.94 25.91	18B						
		(SP) Medium to coarse SAND; some gravel; brown; wet		294.64 26.21	18C						
27				293.72							
		(SW) Fine SAND; some gravel; some silt; brown; wet		27.13	19A						
28											
				292.35							
		(SM) Silty Fine SAND; brown; wet		28.50	19B						
29				291.74							
		(CL) Silty CLAY; brown; wet		29.11	20A						
		(GP-SM) COBBLES and BOULDERS and silty SAND		291.44 29.41	20B						
30											
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

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PROJECT: 1774274 (1000)

LOCATION: N 4809195.24; E 568214.81

RECORD OF BOREHOLE: BH17-03

BORING DATE: June 7, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
30		*--- CONTINUED FROM PREVIOUS PAGE ---*									
		(GP-SM) COBBLES and BOULDERS and silty SAND		290.37	20B						
		END OF BOREHOLE		30.48							
		NOTE:									
31		1. Water level encountered at a depth of 14.6 m below ground surface (Elev. 306.2 m) during drilling.									
32											
33											
34											
35											
36											
37											
38											
39											
40											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

PROJECT: 1774274 (1000)

LOCATION: N 4809333.50; E 568172.07

RECORD OF BOREHOLE: BH17-04

BORING DATE: June 8, 2017

SHEET 1 OF 3

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl; 10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		311.56							
0	Sonic Drilling	Silty TOPSOIL (460 mm)		0.00 311.10							
		(ML) SILT, some sand, trace clay; brown; moist		0.46 310.49	1A						
1		(GM) Silty SAND and GRAVEL, some cobbles; brown; moist		1.07 310.04	1B						
		(GP) GRAVEL, and COBBLES, some sand, trace silt; brown; moist		1.52 309.12	2						
2		(GM) Sandy GRAVEL and COBBLES, some silt; brown; moist		2.44	3						
3					4						
		- Boulders encountered at approximate depth of 3.72 m - 4.27 m and 4.72 m - 5.09 m below ground surface									
4					5A						
				306.47							
5		(GM) Silty SAND and GRAVEL, some cobbles; brown; moist		5.09 306.07	5B						
		(GW) GRAVEL and COBBLES, some sand; brown; moist to wet		5.49	6						▽ June 8, 2017
6											
7					7						
8											
9					8						
10		*CONTINUED NEXT PAGE*									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

GTA-BHS 001 S:\CLIENTS\VOTORANTIM_CIMENTOS\LANCI_PIT\02_DATA\GINT\LANCI_PIT.GPJ GAL-MIS.GDT 20-2-7

PROJECT: 1774274 (1000)

LOCATION: N 4809333.50; E 568172.07

RECORD OF BOREHOLE: BH17-04

BORING DATE: June 8, 2017

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp — W — Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		--- CONTINUED FROM PREVIOUS PAGE ---									
10	Sonic Drilling	(GW) GRAVEL and COBBLES, some sand; brown; moist to wet			8						
11				300.28							
		(GW) Sandy GRAVEL, some cobbles; brown; wet		11.28	9						
12				298.76							
		(GW) GRAVEL and COBBLES, some sand; brown; wet		12.80	10						
13											
14											
15					11						
16				295.41							
		(GW) Sandy GRAVEL, some cobbles; brown; wet		16.15	12						
17											
				293.88							
		(SP) Gravelly medium to coarse SAND; brown; wet		17.68	13						
18											
19				292.36							
		(GP) Medium to coarse SAND and GRAVEL; brown; wet		19.20	14						
20											
		CONTINUED NEXT PAGE									

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

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PROJECT: 1774274 (1000)

LOCATION: N 4809333.50; E 568172.07

RECORD OF BOREHOLE: BH17-04

BORING DATE: June 8, 2017

SHEET 3 OF 3

DATUM: Geodetic

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa (nat V. + Q - ● / rem V. ⊕ U - ○) (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT (Wp W Wl) (10 20 30 40)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
20		*--- CONTINUED FROM PREVIOUS PAGE ---*									
20	Sonic Drilling	(GP) Medium to coarse SAND and GRAVEL; brown; wet		290.83	14						
21		(SP) Medium to coarse SAND; brown; wet		20.73	15						
22				288.70							
23		(SP) Gravelly medium to coarse SAND; brown; wet		22.86	16A						
				288.24							
		(GP) Coarse GRAVEL, some sand; brown; wet		23.32	16B						
24				287.63							
		BEDROCK		23.93							
25					17						
26				285.35							
		END OF BOREHOLE		26.21							
27		NOTE: 1. Water level encountered at a depth of 5.9 m below ground surface (Elev. 305.6 m) during drilling.									
28											
29											
30											

DEPTH SCALE

1 : 50

GOLDER

LOGGED: MR

CHECKED: AS

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BOREHOLE LOG

PROJECT: 23-302

BOREHOLE: GL 7 1 of 1

Groundwater and Resource Investigation
Lanci Property, Aberfoyle
FOR: CBM Aggregates

DATE: 14 May 2003
LOGGED BY BPW
GROUND ELEV 316.42 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	N VALUE (15 30 45 60)	WATER CONTENT (%) (10 20 30 40)
0		**SAND AND GRAVEL** Brown sand and gravel, moist, very dense.		1		SS	50/ 0.08 m		10			
				2		SS	50/ 0.08 m		10			
				4		SS	50/ 0.03 m		10			
		-Increase in gravel fraction (cobbles and occasional boulders) below about 6.0 m.		5		SS	70/ 0.13 m		5			
				6		SS	63		80		>>	
		-Becoming saturated below about 11.3 m.		7		SS	50/ 0.05 m		5			
13.0				8		SS	36		80			
		-Becoming a medium to coarse sand with some gravel below about 13.0 m.		9		SS	91		100		>>	
				10		SS	77		100		>>	
		-Increase in gravel content between about 16.8 and 18.3 m, changing back to coarse sand some gravel.		11		SS	54		70			
				12		SS	29		50			
20.4		Borehole terminated at 20.42 m in sand.		13		SS	44		30			

Printed: 13 Dec 05
File Location:N:/Projects/2003/23-302/2003/WIP/BoreholeLogs
Scale: 22.5m

Gartner Lee Limited

BOREHOLE LOG

PROJECT: 23-302

BOREHOLE: GL 8 1 of 1

Groundwater and Resource Investigation
Lanci Property, Aberfoyle
FOR: CBM Aggregates

DATE: 20 May 2003
LOGGED BY BPW
GROUND ELEV 314.91 m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	N VALUE 15 30 45 60	WATER CONTENT (%) 10 20 30 40
0		**SAND AND GRAVEL**										
1		Brown sand and gravel, moist, very dense. Local increases in gravel fraction (cobbles and occasional boulders).										
2												
3												
4												
5				1		SS	60/ 0.10 m		2			
6				2		SS	88/ 0.18 m		30			
7												
8				3		SS	132/ 0.23 m		20			
9.0		-Becoming a gravelly coarse sand below about 9.0 m.		4		SS	47		40		■	
10		-Becoming saturated below about 10.1 m.										
11				5		SS	39		40		■	
11.7		-Changing back to sand and gravel below about 11.7 m.										
12				6		SS	78		50		>>■	
12.8		Borehole terminated at 12.80 m in sand and gravel.										

Printed: 13 Dec 05
File Location:N:/Projects/2003/23-302/2003/WIP/BoreholeLogs
Scale: 22.5m

Gartner Lee Limited

BOREHOLE LOG	PROJECT: 60246514-4	BOREHOLE: GL11 1 of 1
Water Table Monitor Installation Lanci - 4248 Sideroad 25 S **Client:** CBM Aggregates	**Northing:** 4809545 **Easting:** 568240 **Methodology:** Soil Augering **Contractor:** Atcost	**DATE:** July 11, 2012 **LOGGED BY** TLS **GROUND ELEV** 314.18 m ASL

DEPTH (m) (mASL)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
0		**SAND AND GRAVEL** Brown medium sand and sub-rounded gravel, moist, compact with cobbles and occasional boulders.		1		SS	>53/ 0.10 m		68		
1											
2				2		SS	40		84		
3											
4				3		SS	>65/ 0.31 m		41		
5											
6				4		SS	>50/ 0.07 m		90		
7											
8.2 306.0		- Rust coloured staining noted on gravel fragments at approximately 7.8 m, increase in moisture content. - Becoming saturated below approximately 8 m.		5		SS	>50/ 0.11 m		88		Water Level July 12, 2012, 8.15 m below ground
9				6		SS	64		51		
9.3 304.9		- Becoming grey-brown medium to coarse grained sand with some gravel from approximately 8.2 to 9.3 m.									
10		- Increase in gravel content below approximately 9.3 m, changing back to sand and sub-rounded gravel with occasional cobbles and fragments.		7		SS	64		44		
11.3 302.9		Borehole terminated at 11.28 m in sand and gravel.		8		SS	23		97		

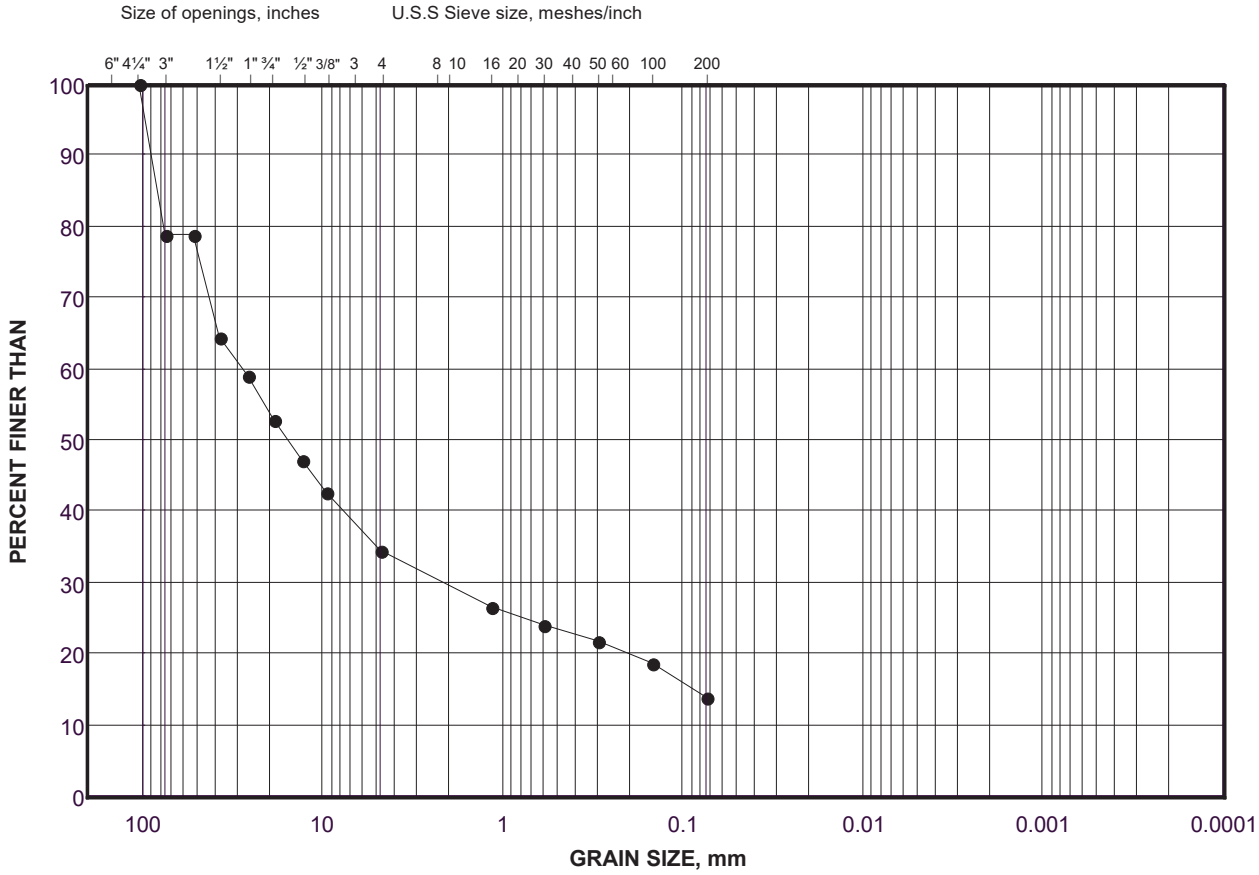
APPENDIX C

Grain Size Distribution Curves

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 1



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH (ft.)
●	BH/MW17-01	1	0.34-1.52	1.10-5.00

REMARKS
Fineness Modulus= 6.06

Project Number: 1774274

Checked By:

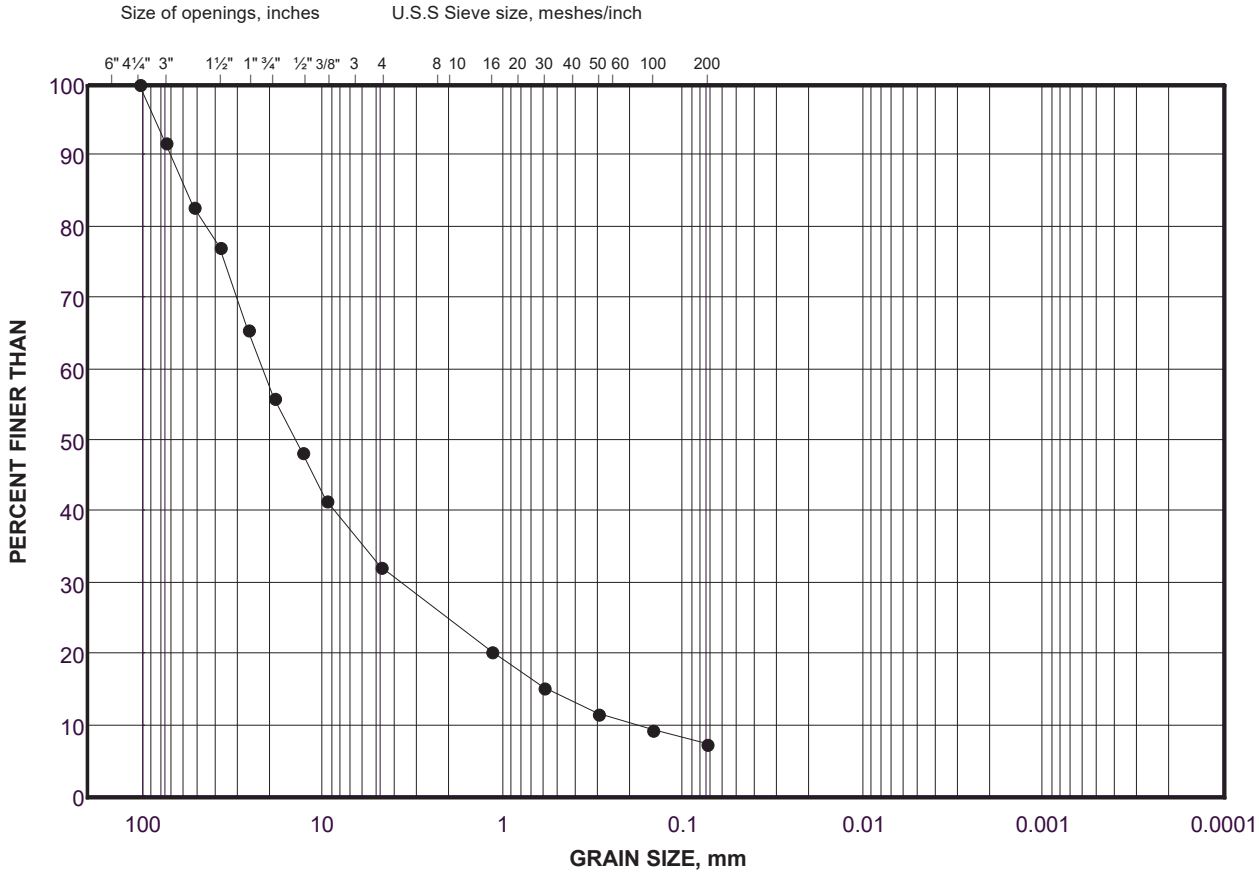
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 2



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	2	1.52-2.74	5.00-9.00

REMARKS
Fineness Modulus= 6.19

Project Number: 1774274

Checked By

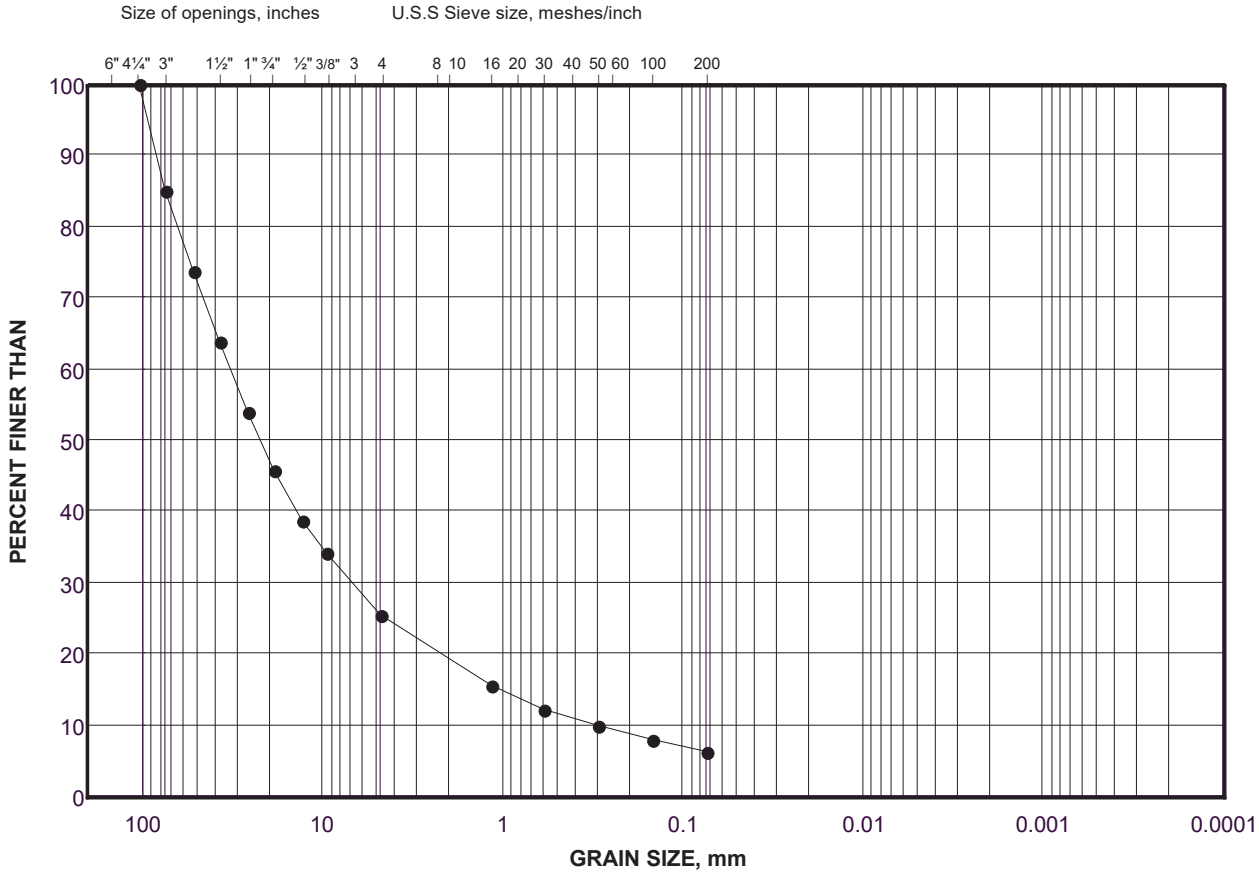
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 3



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	3	2.74-4.57	9.00-15.00

REMARKS
Fineness Modulus= 6.78

Project Number: 1774274

Checked By:

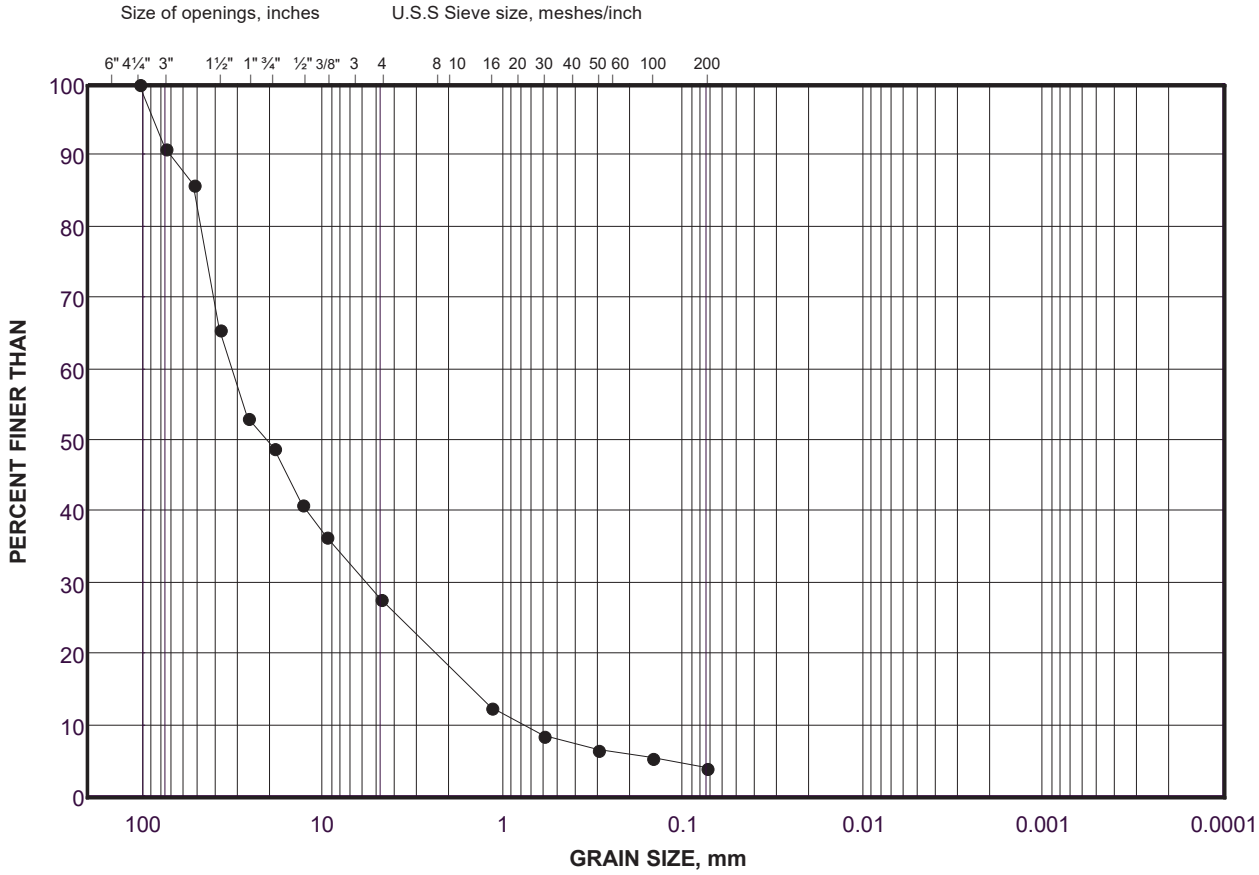
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 4



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	4	4.57-5.79	15.00-19.00

REMARKS
Fineness Modulus= 6.76

Project Number: 1774274

Checked By:

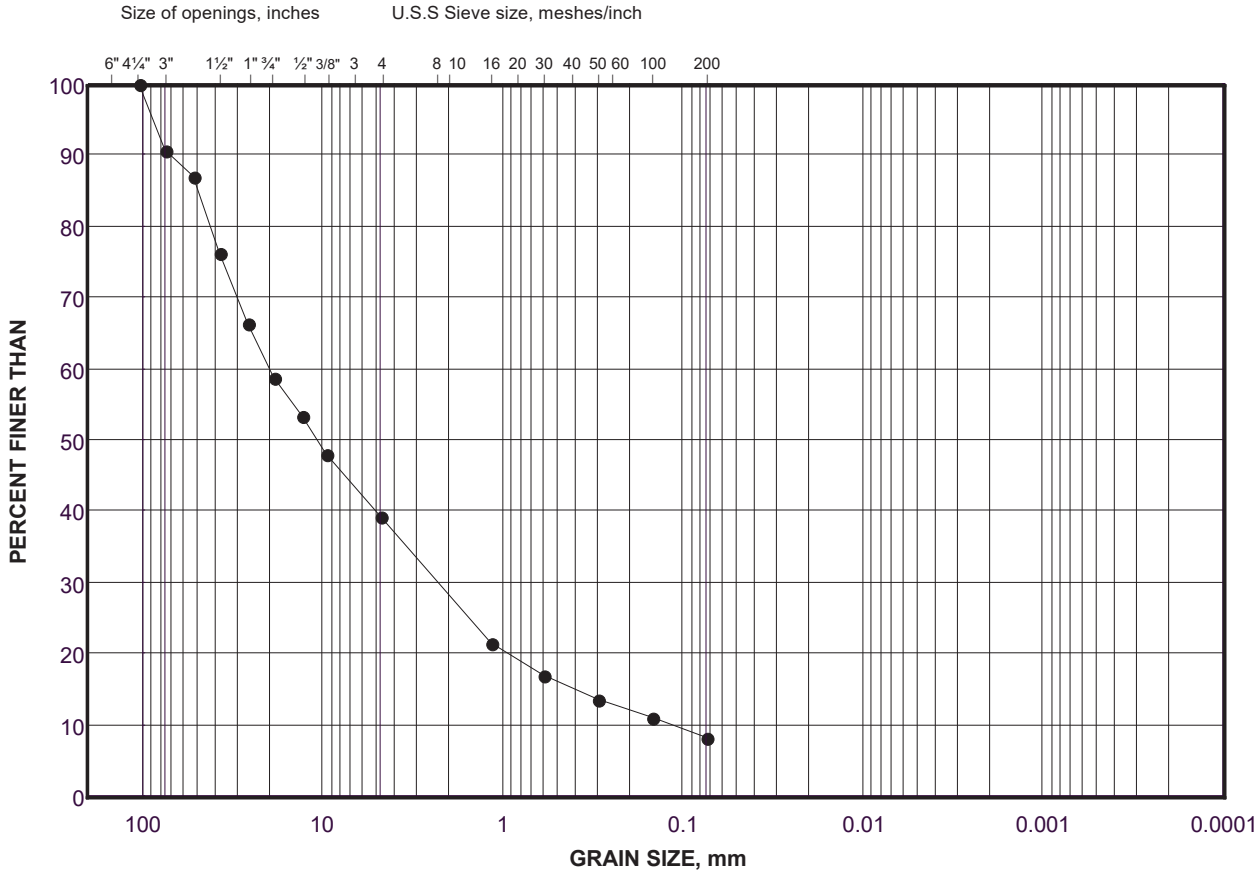
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 5



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	5	5.79-7.32	19.00-24.00

REMARKS
Fineness Modulus= 5.91

Project Number: 1774274

Checked By:

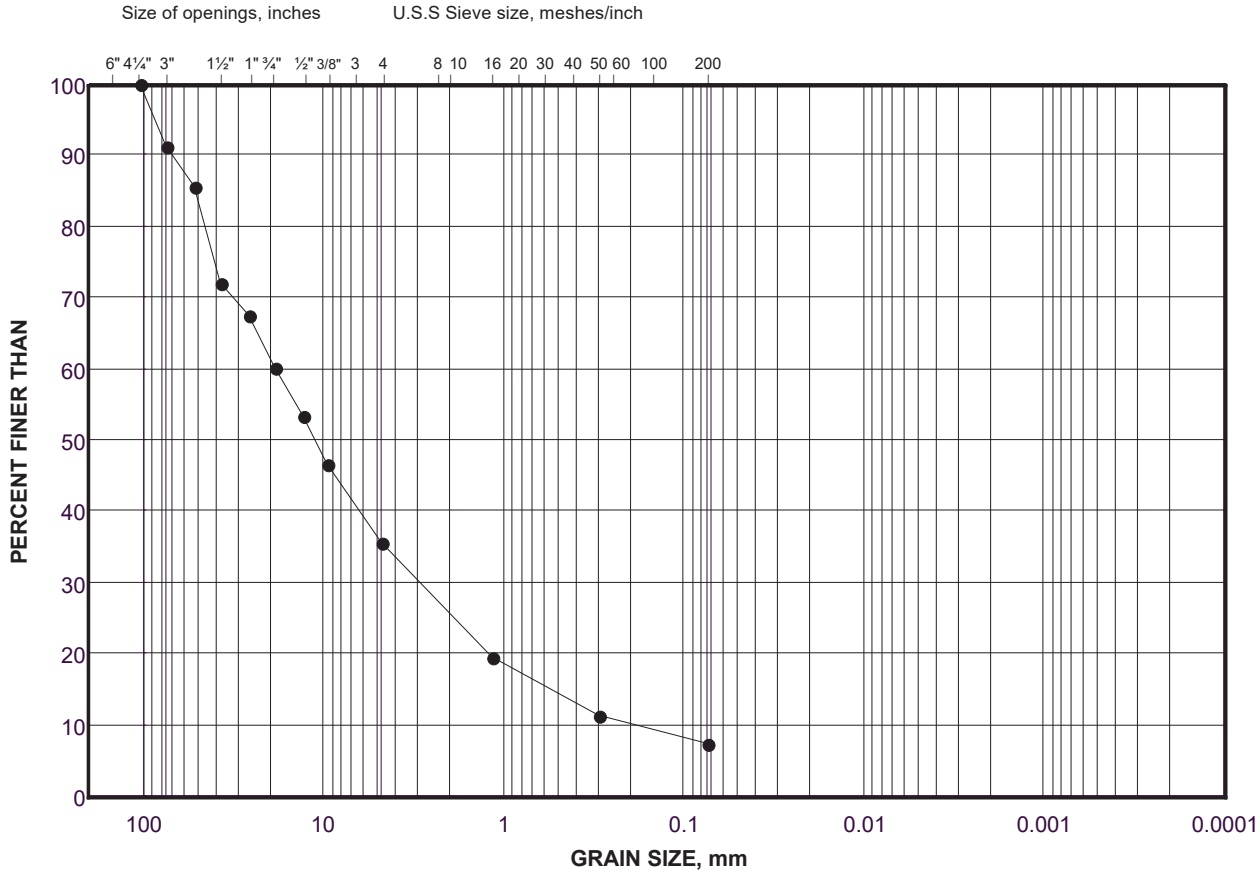
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 6



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	6	7.32-8.84	24.00-29.00

REMARKS
Fineness Modulus= 6.13

Project Number: 1774274

Checked By:

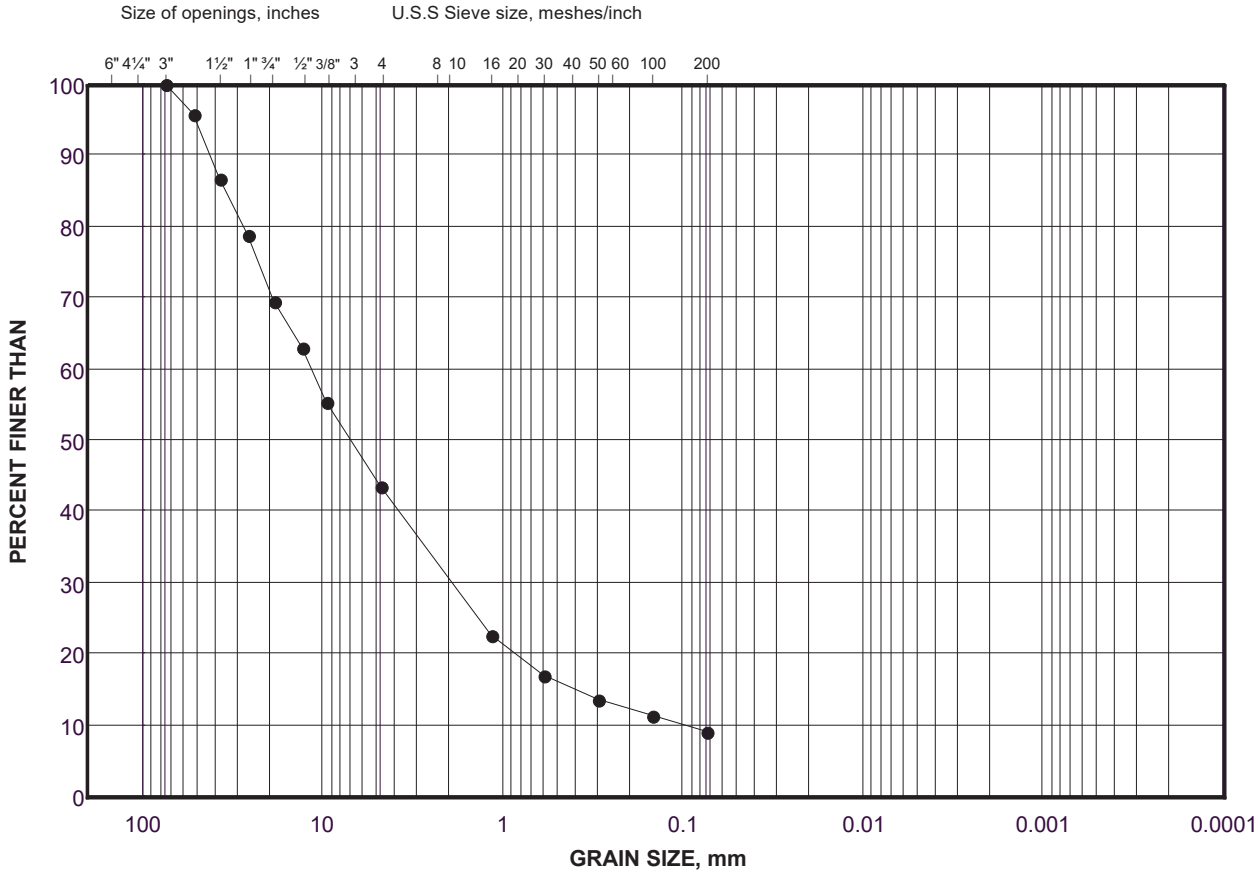
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 7



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	7	8.84-10.06	29.00-33.00

REMARKS
Fineness Modulus= 5.49

Project Number: 1774274

Checked By:

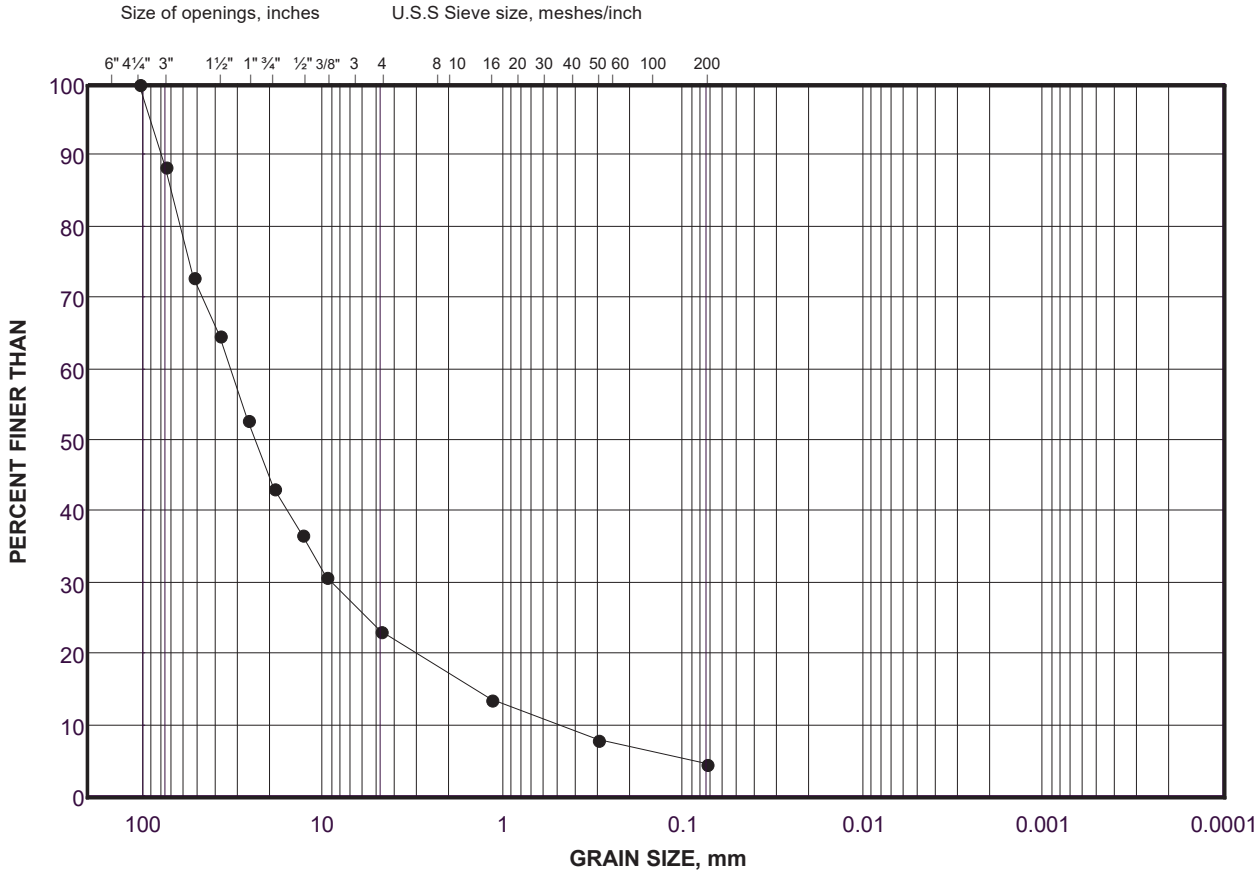
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 8



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	8	10.06-11.73	33.00-38.50

REMARKS
Fineness Modulus= 6.94

Project Number: 1774274

Checked By:

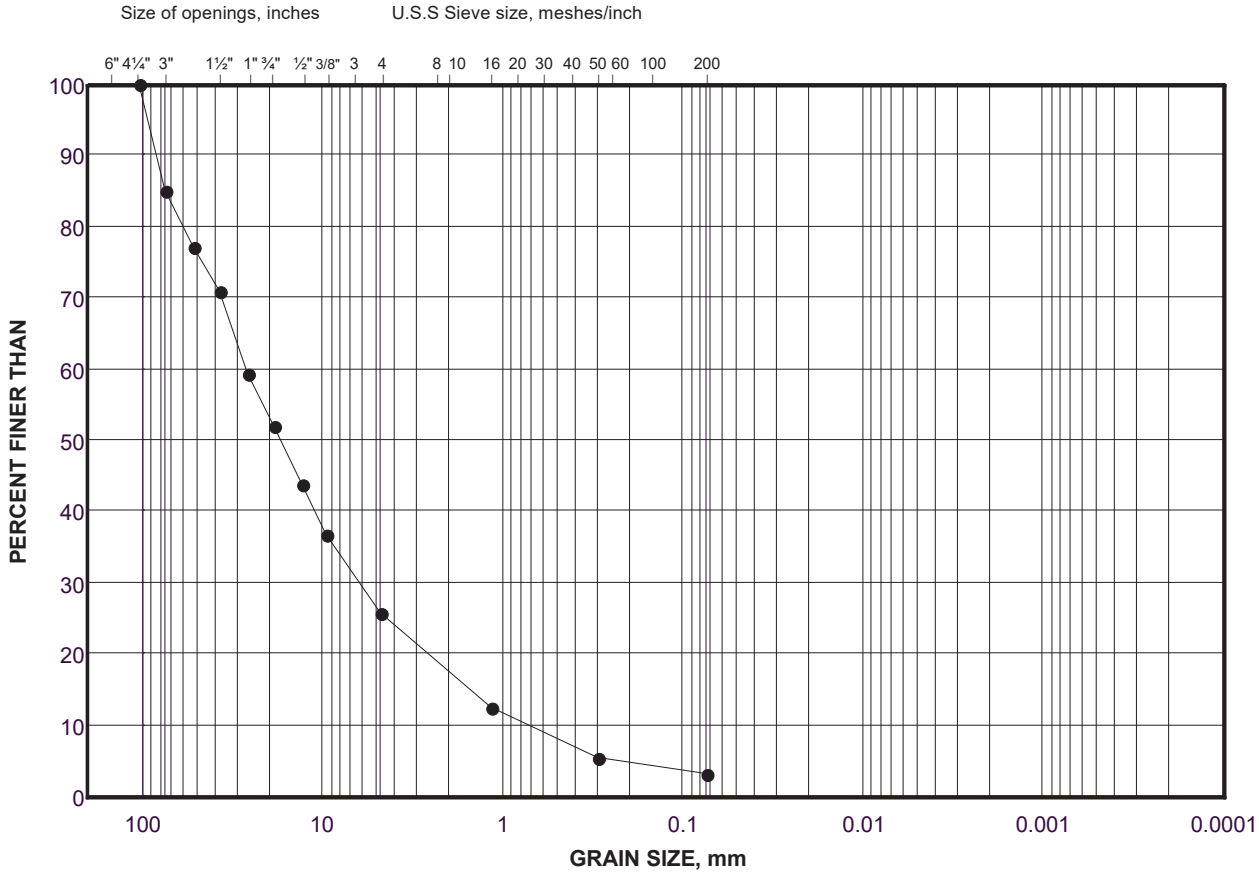
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 9



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	9	11.73-14.78	38.50-48.50

REMARKS
Fineness Modulus= 6.81

Project Number: 1774274

Checked By:

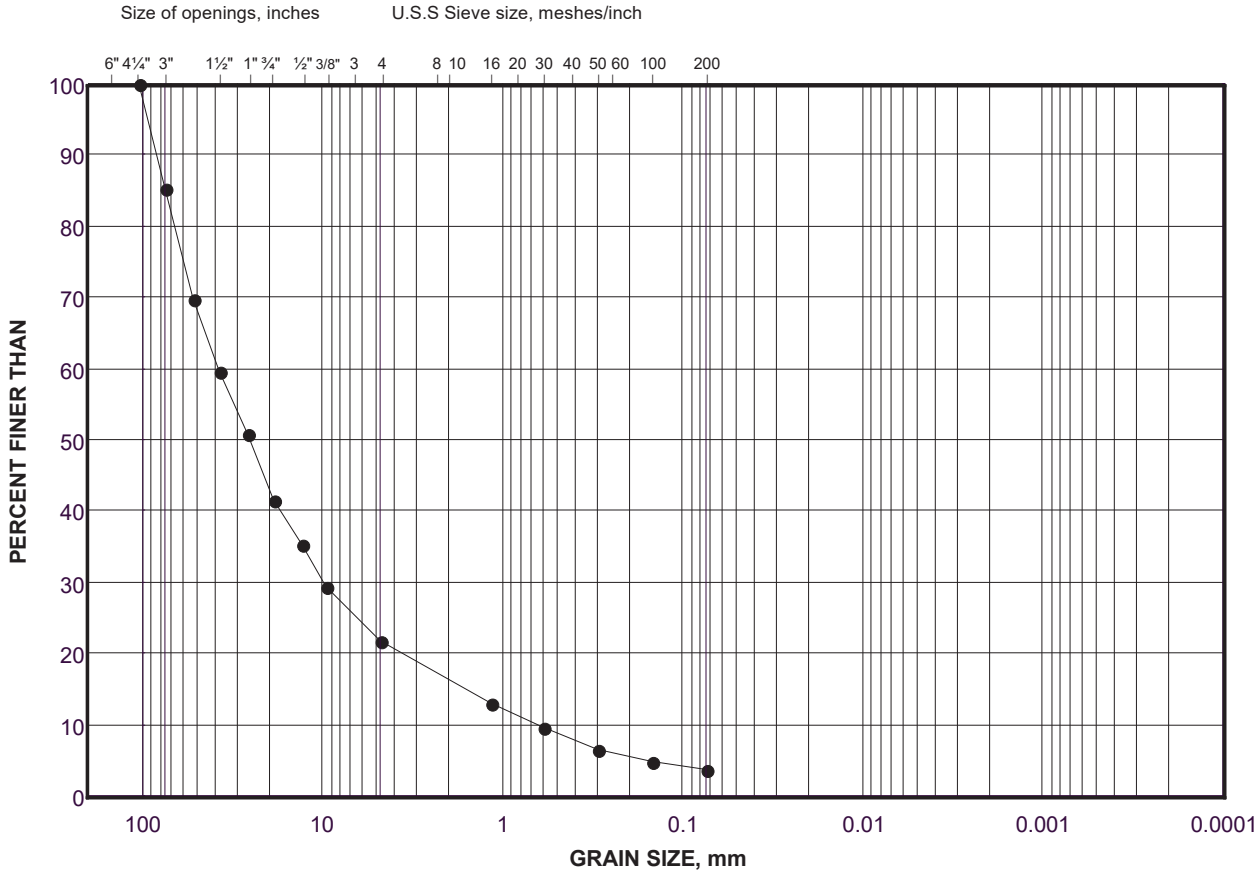
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 10



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	10A	14.78-16.46	48.50-54.00

REMARKS
Fineness Modulus= 7.11

Project Number: 1774274

Checked By:

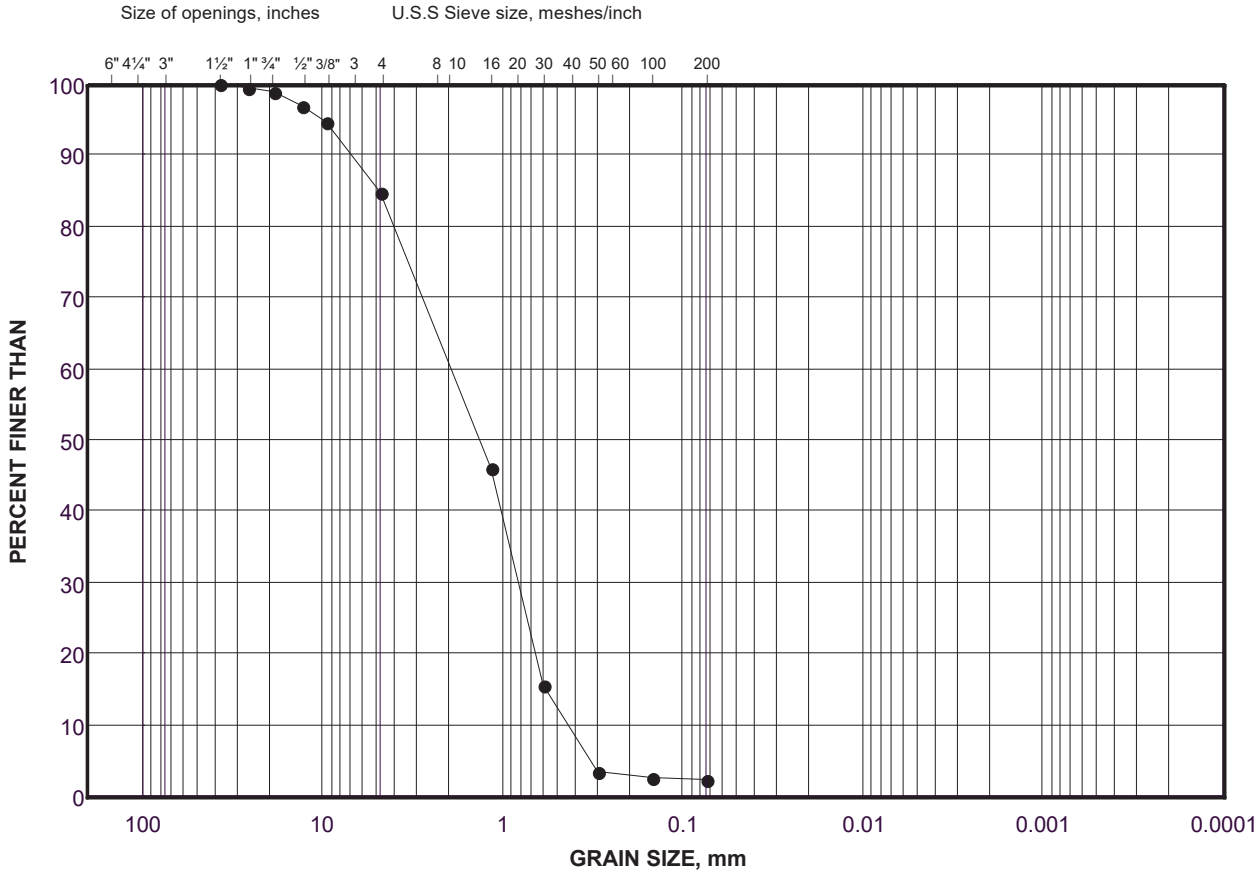
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 11



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	10B	16.46-17.83	54.00-58.50

REMARKS
Fineness Modulus= 3.87

Project Number: 1774274

Checked By:

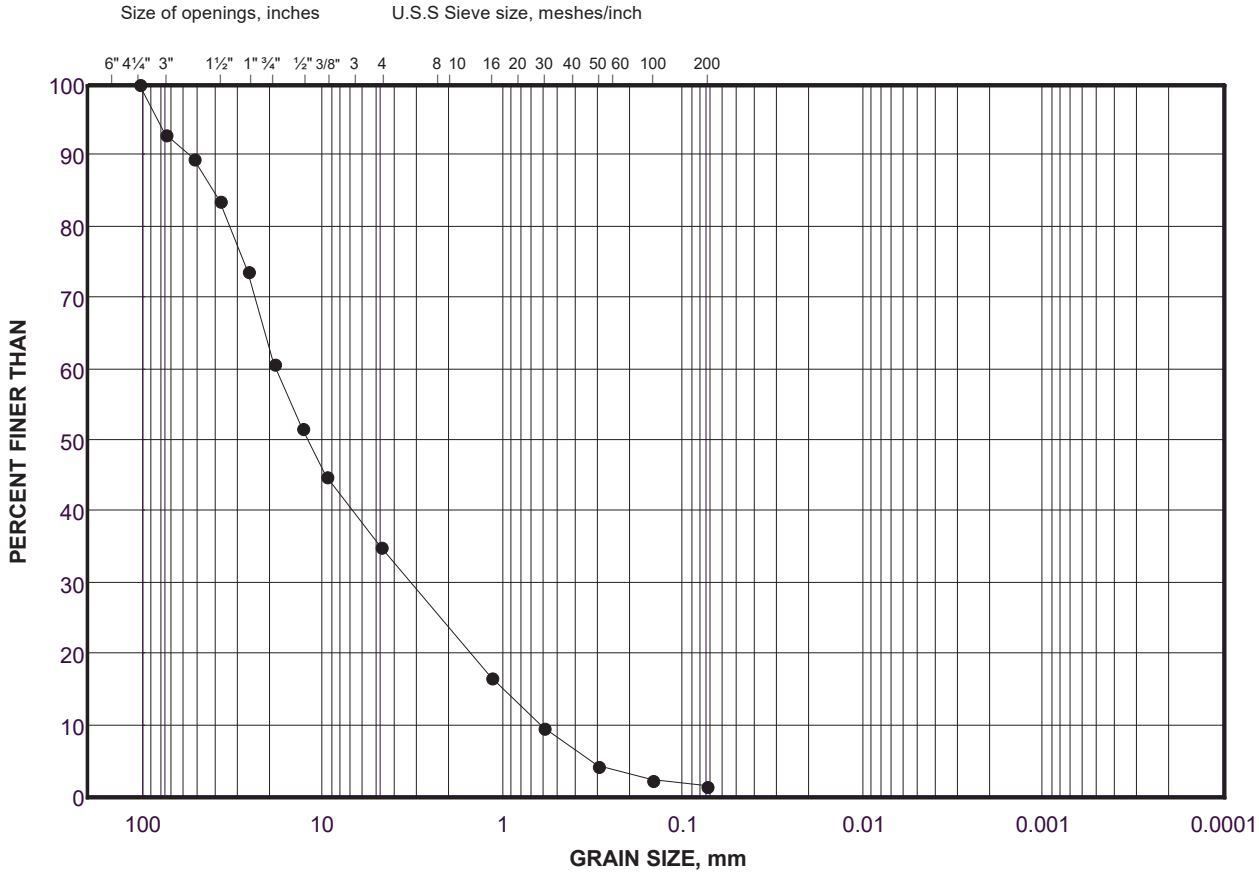
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 12



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	11	17.83-19.35	58.50-63.50

REMARKS
Fineness Modulus= 6.25

Project Number: 1774274

Checked By:

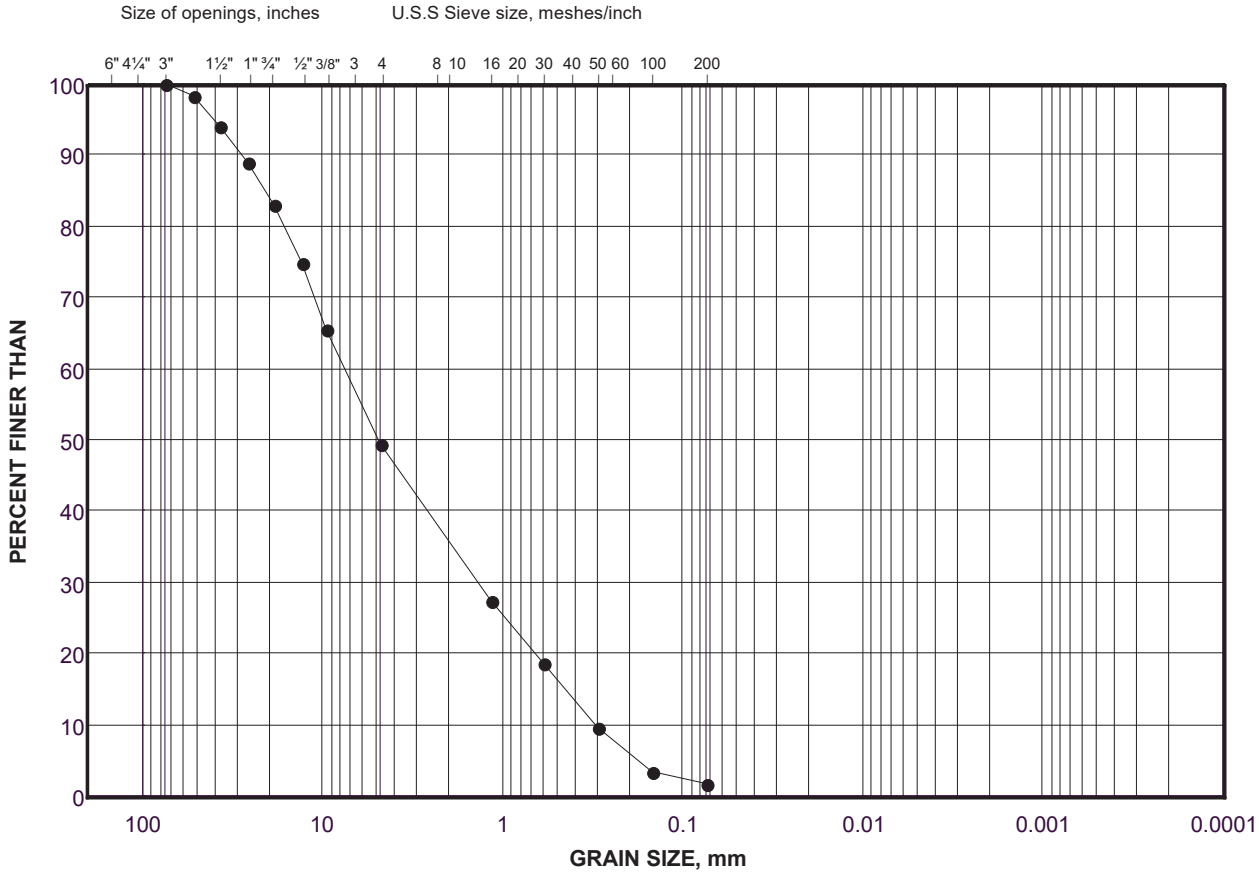
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 13



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	12	19.35-20.88	63.50-68.50

REMARKS
Fineness Modulus= 5.10

Project Number: 1774274

Checked By:

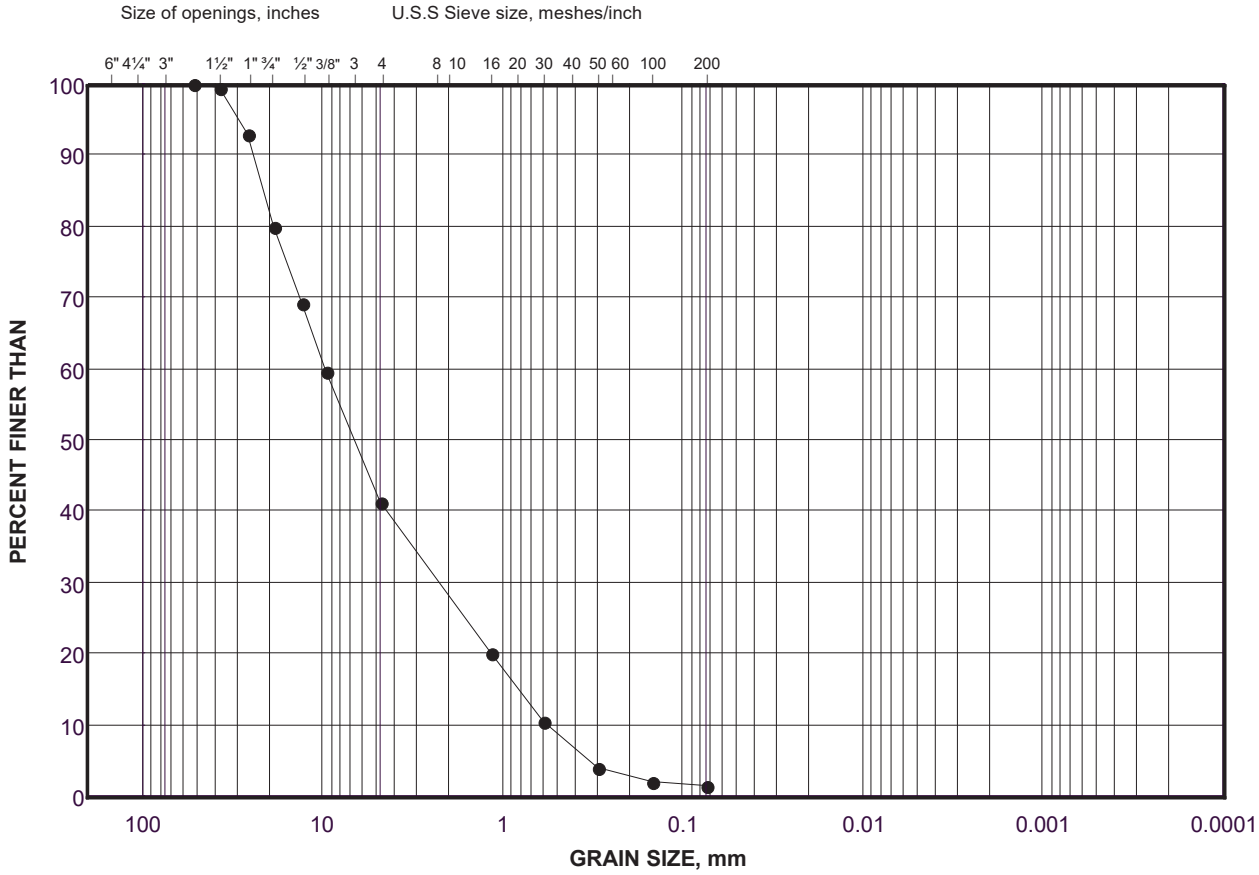
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 14



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	13	20.88-22.71	68.50-74.50

REMARKS
Fineness Modulus= 5.54

Project Number: 1774274

Checked By:

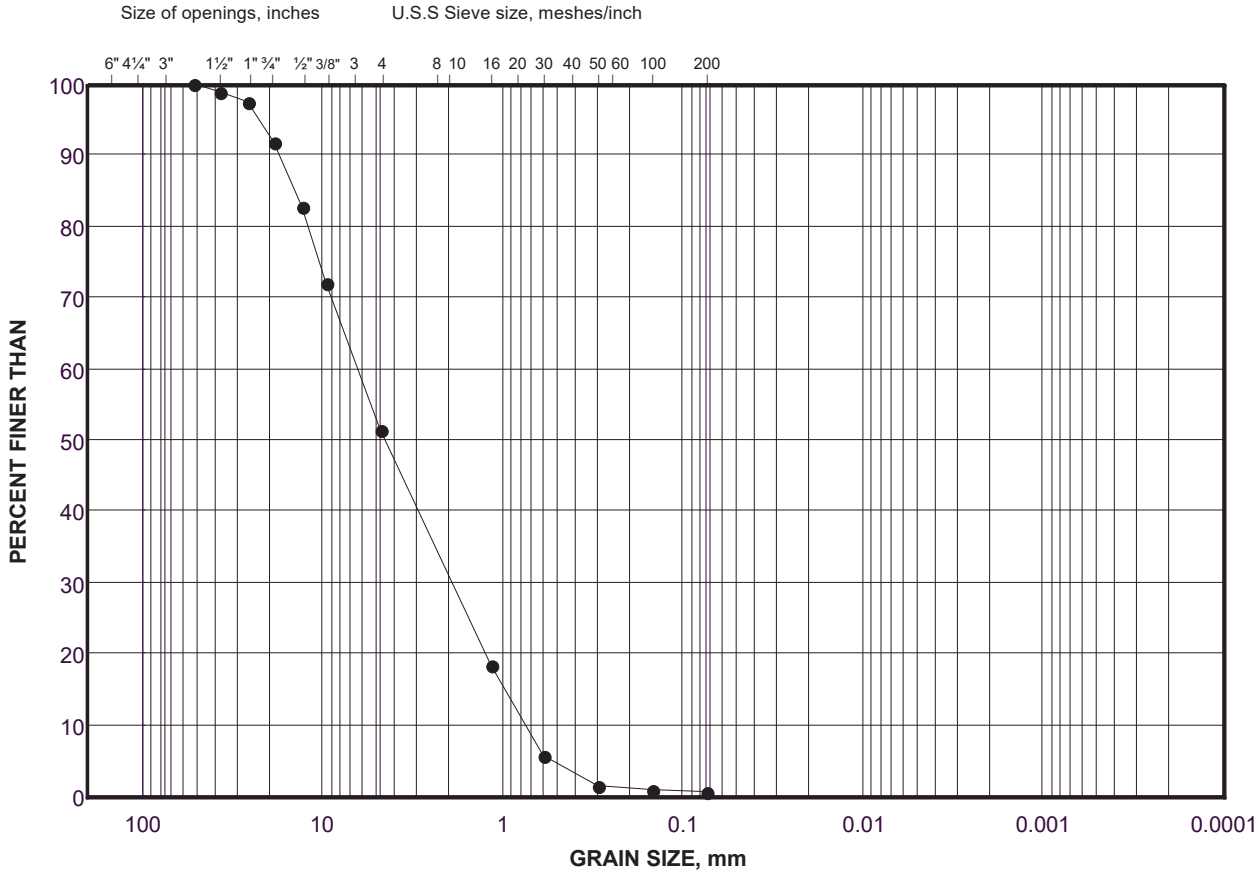
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 15



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	14A	22.71-23.16	74.50-76.00

REMARKS
Fineness Modulus= 5.24

Project Number: 1774274

Checked By:

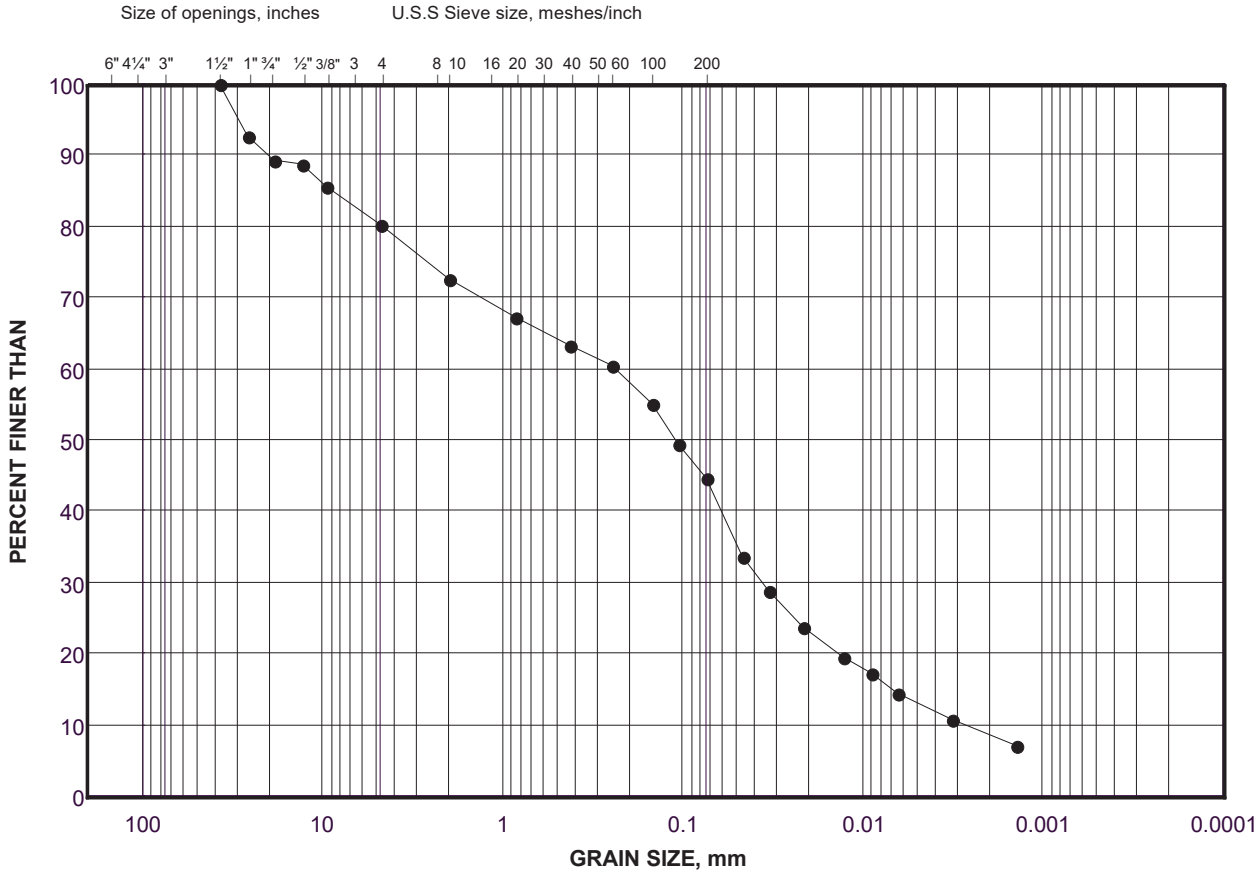
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 16



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	14B	23.16-24.08	76.00-79.00

REMARKS
Fineness Modulus= 2.21

Project Number: 1774274

Checked By:

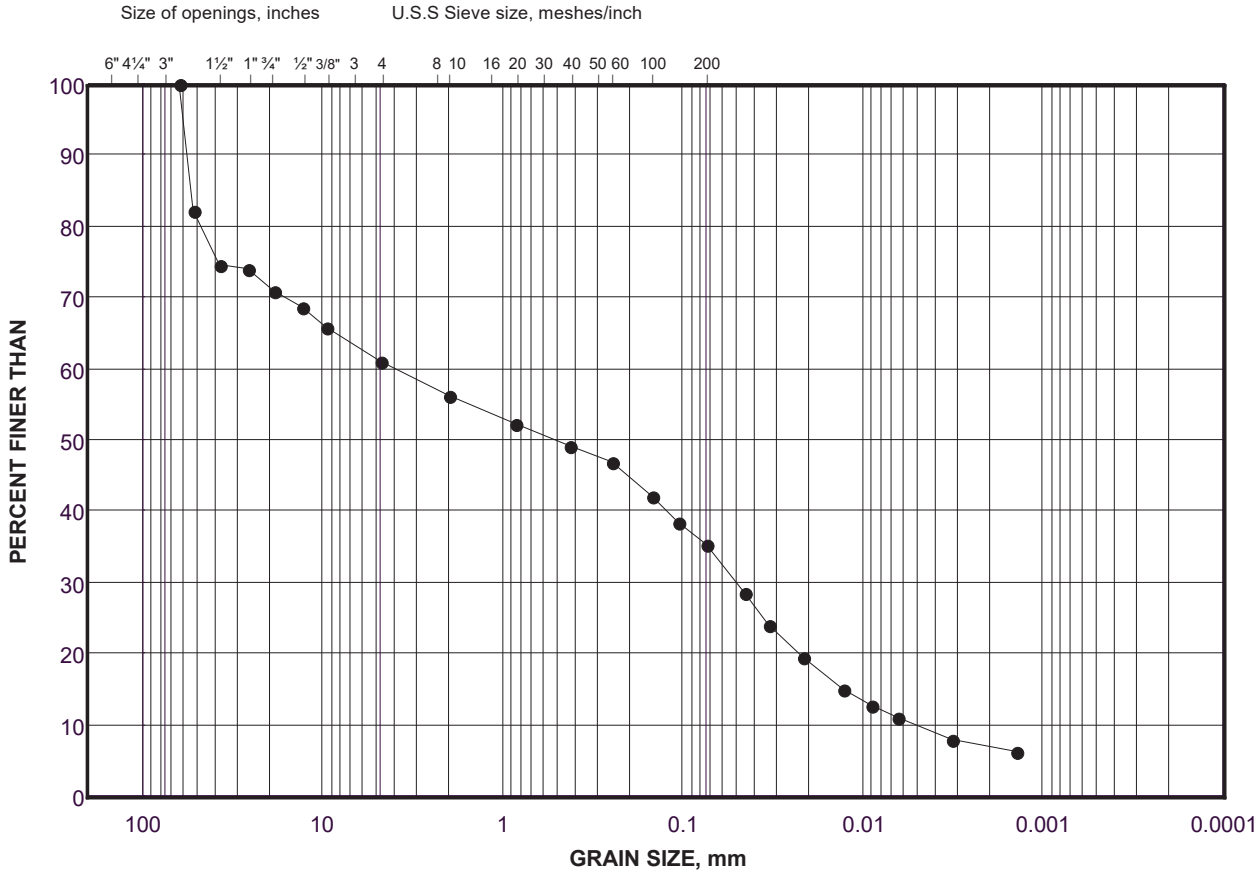
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 17



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-01	15	24.08-25.15	79.00-82.50

REMARKS
Fineness Modulus= 3.76

Project Number: 1774274

Checked By:

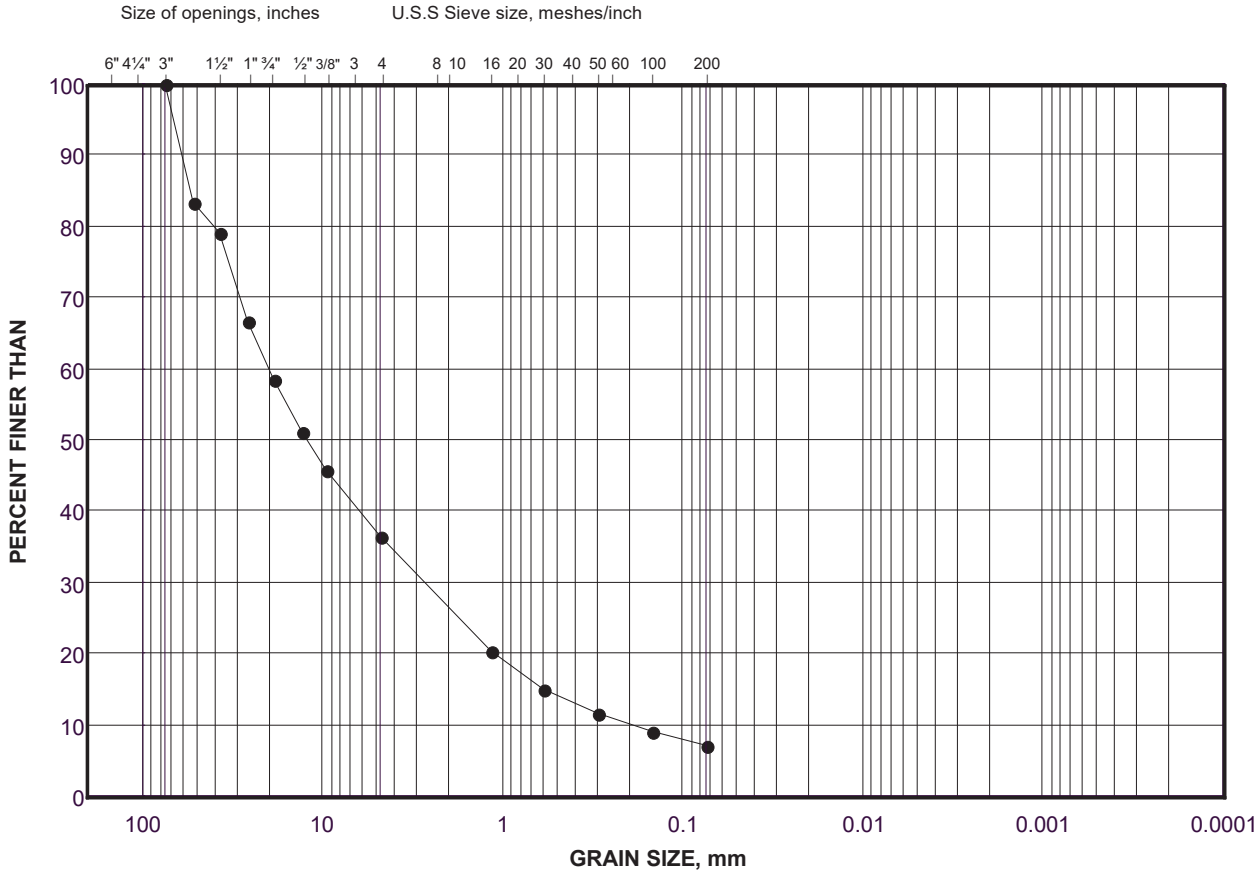
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 18



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	1	0.30-1.52	1.00-5.00

REMARKS
Fineness Modulus= 5.97

Project Number: 1774274

Checked By:

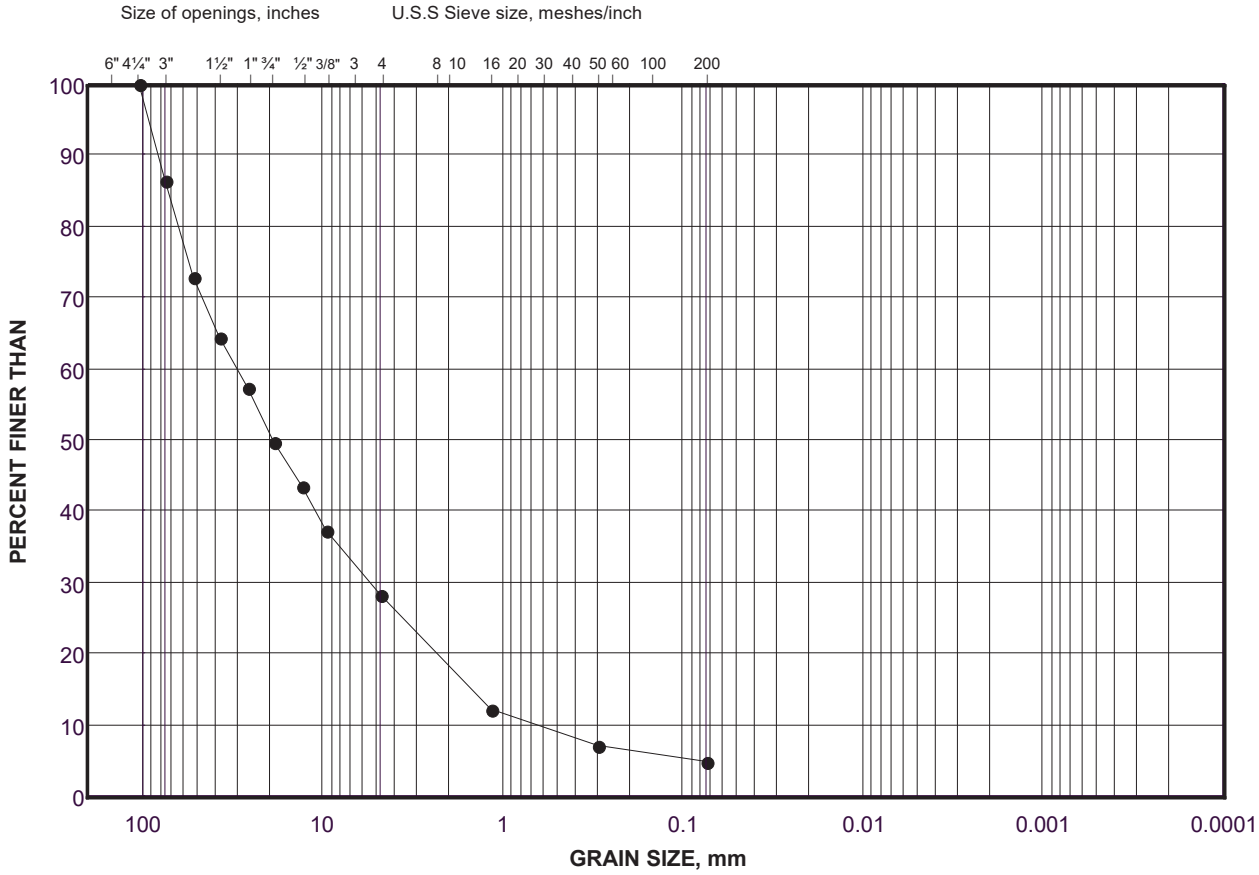
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 19



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	2	1.52-2.74	5.00-9.00

REMARKS
Fineness Modulus= 6.81

Project Number: 1774274

Checked By:

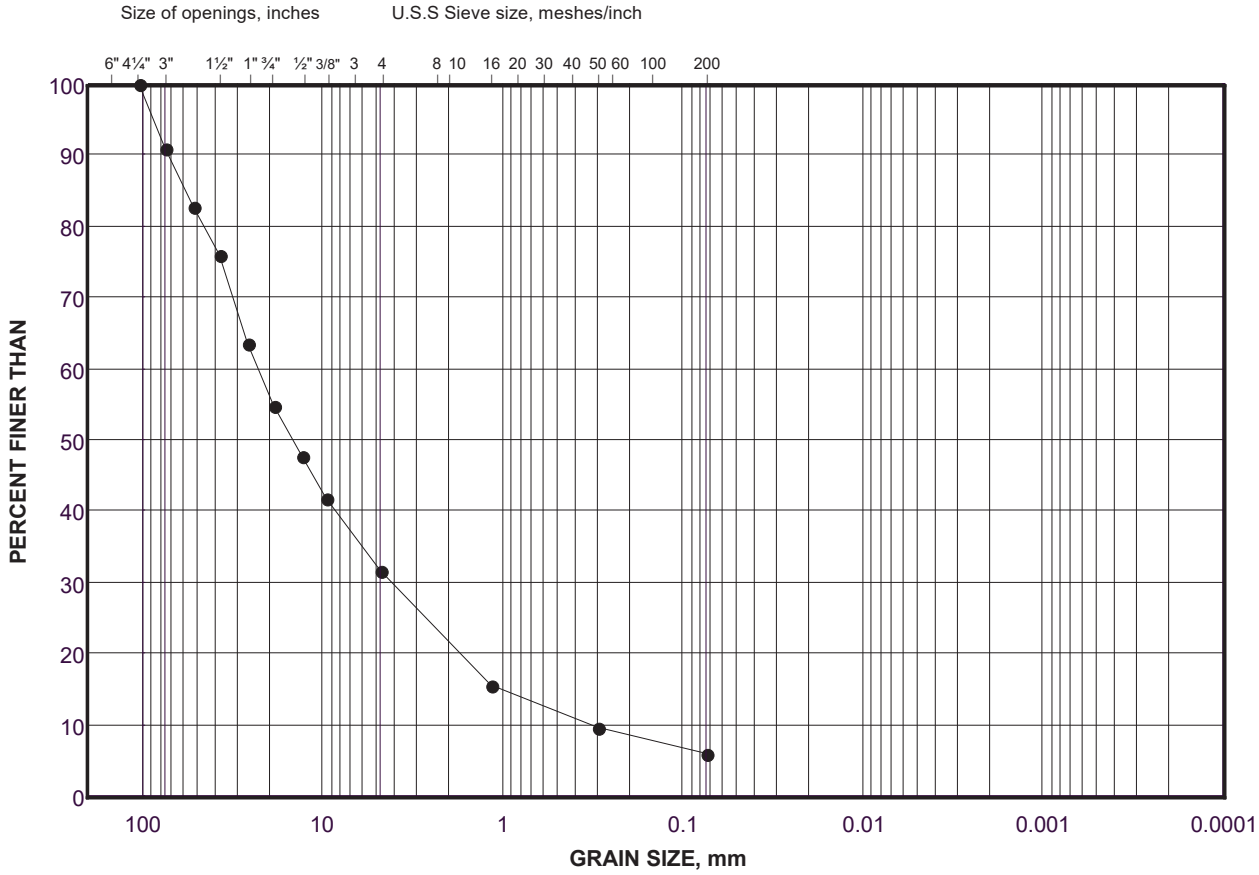
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 20



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	3	2.74-4.57	9.00-15.00

REMARKS
Fineness Modulus= 6.38

Project Number: 1774274

Checked By:

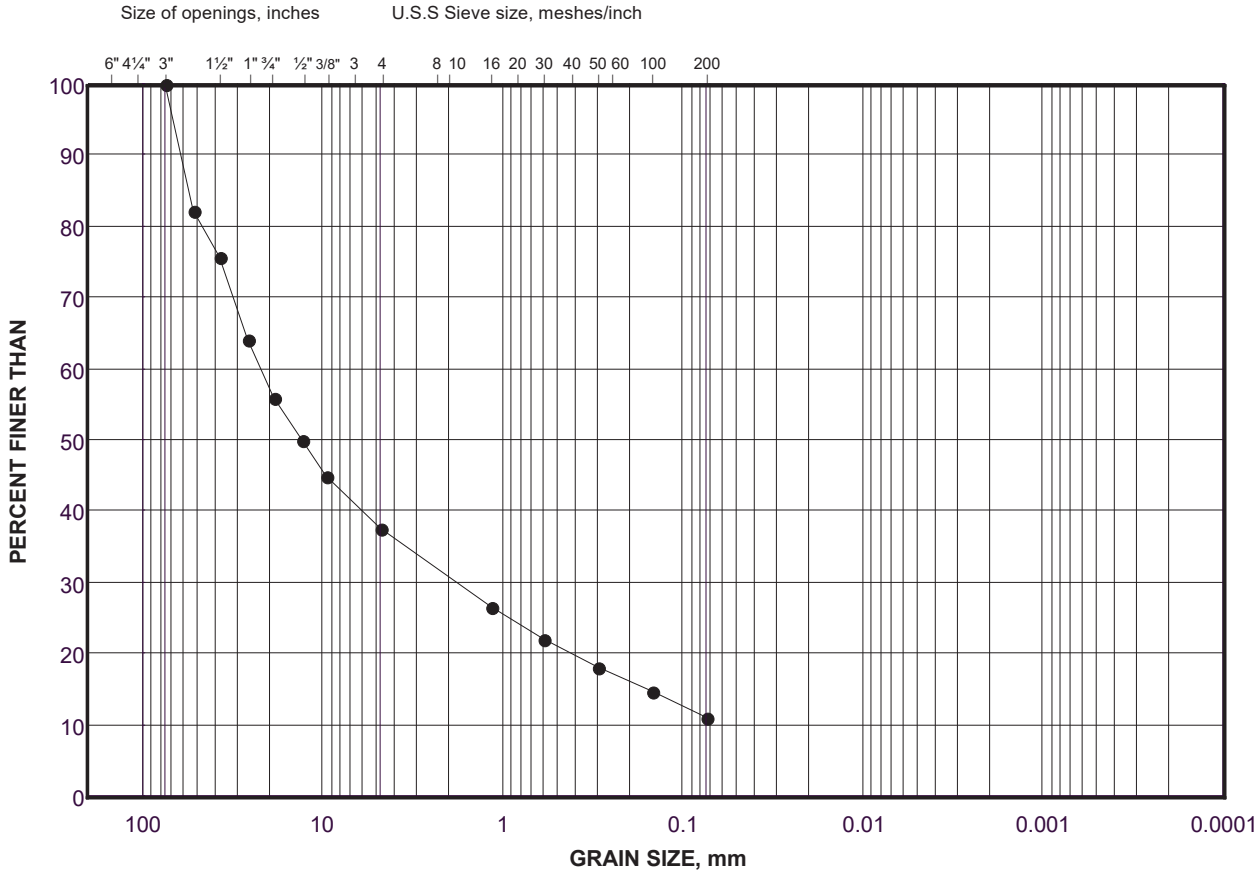
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 21



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	4	4.57-5.49	15.00-18.00

REMARKS
Fineness Modulus= 5.73

Project Number: 1774274

Checked By:

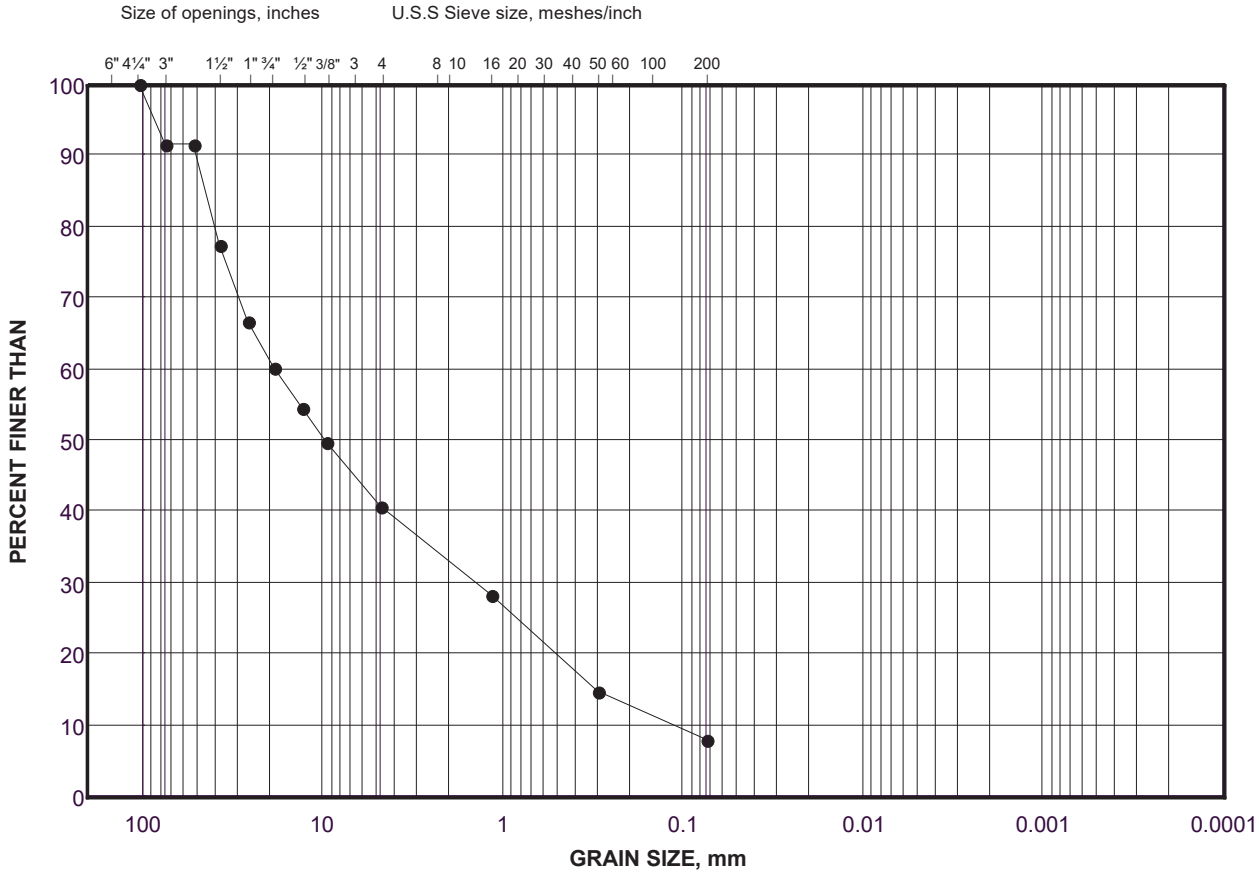
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 22



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	5	6.10-7.32	20.00-24.00

REMARKS
Fineness Modulus= 5.71

Project Number: 1774274

Checked By:

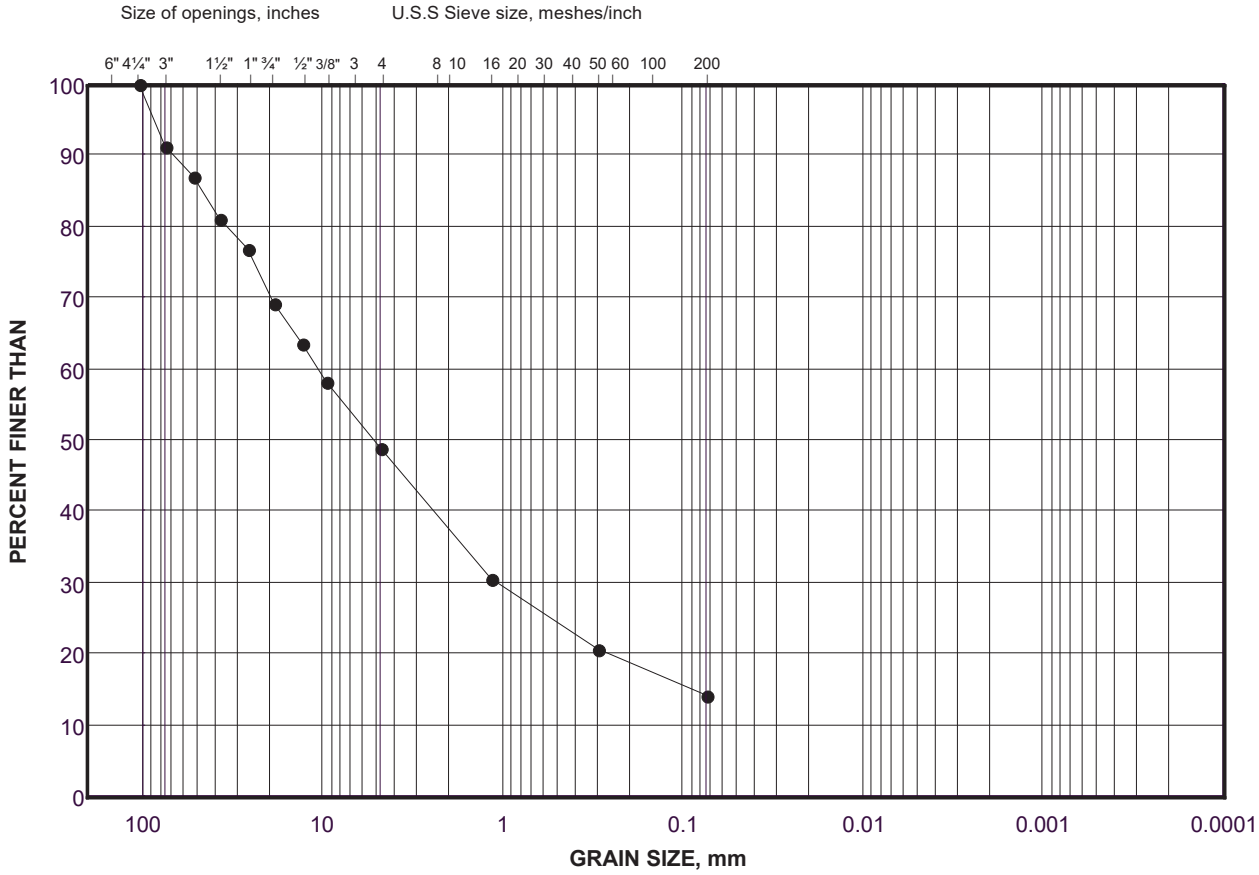
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 23



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	6	7.32-8.84	24.00-29.00

REMARKS
Fineness Modulus= 5.20

Project Number: 1774274

Checked By:

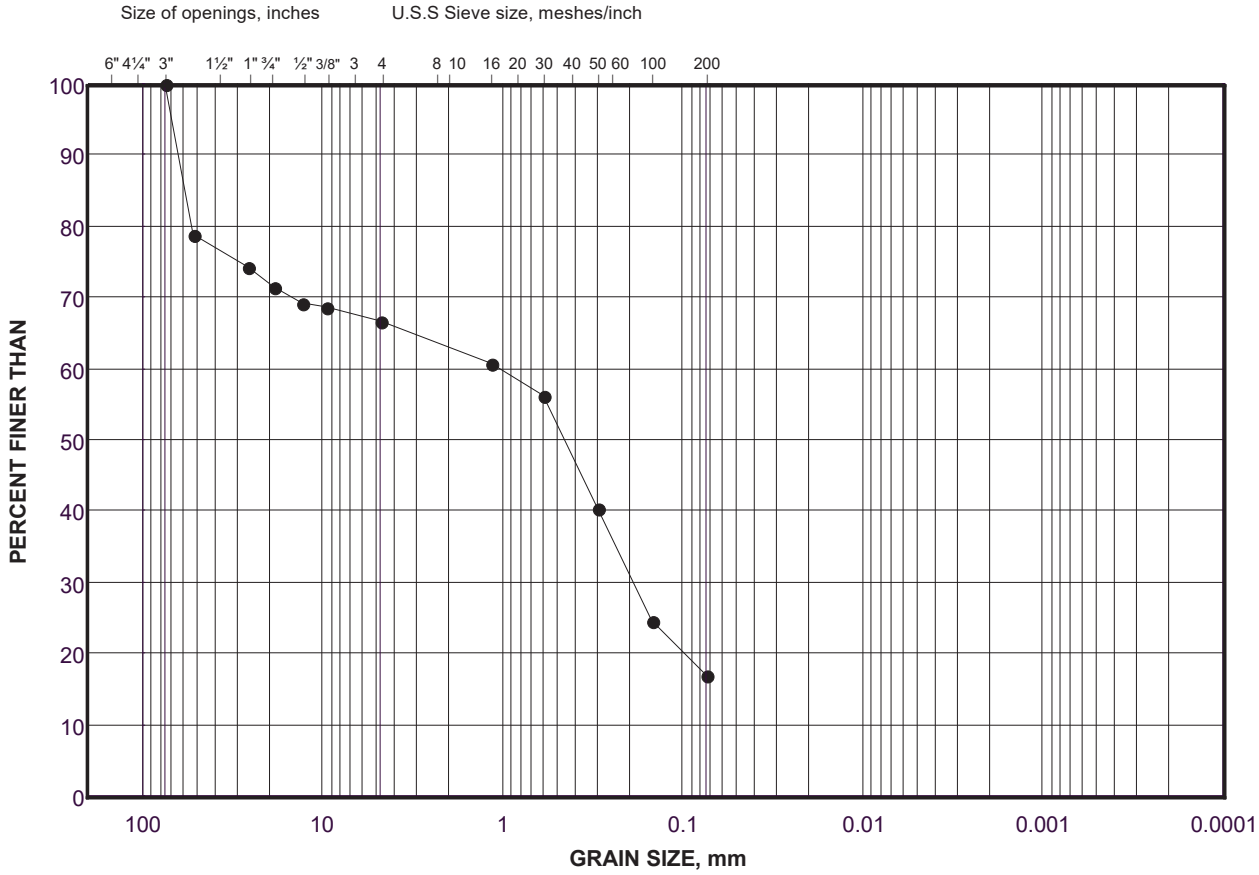
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 24



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	7A	9.45-9.75	31.00-32.00

REMARKS
Fineness Modulus= 4.38

Project Number: 1774274

Checked By:

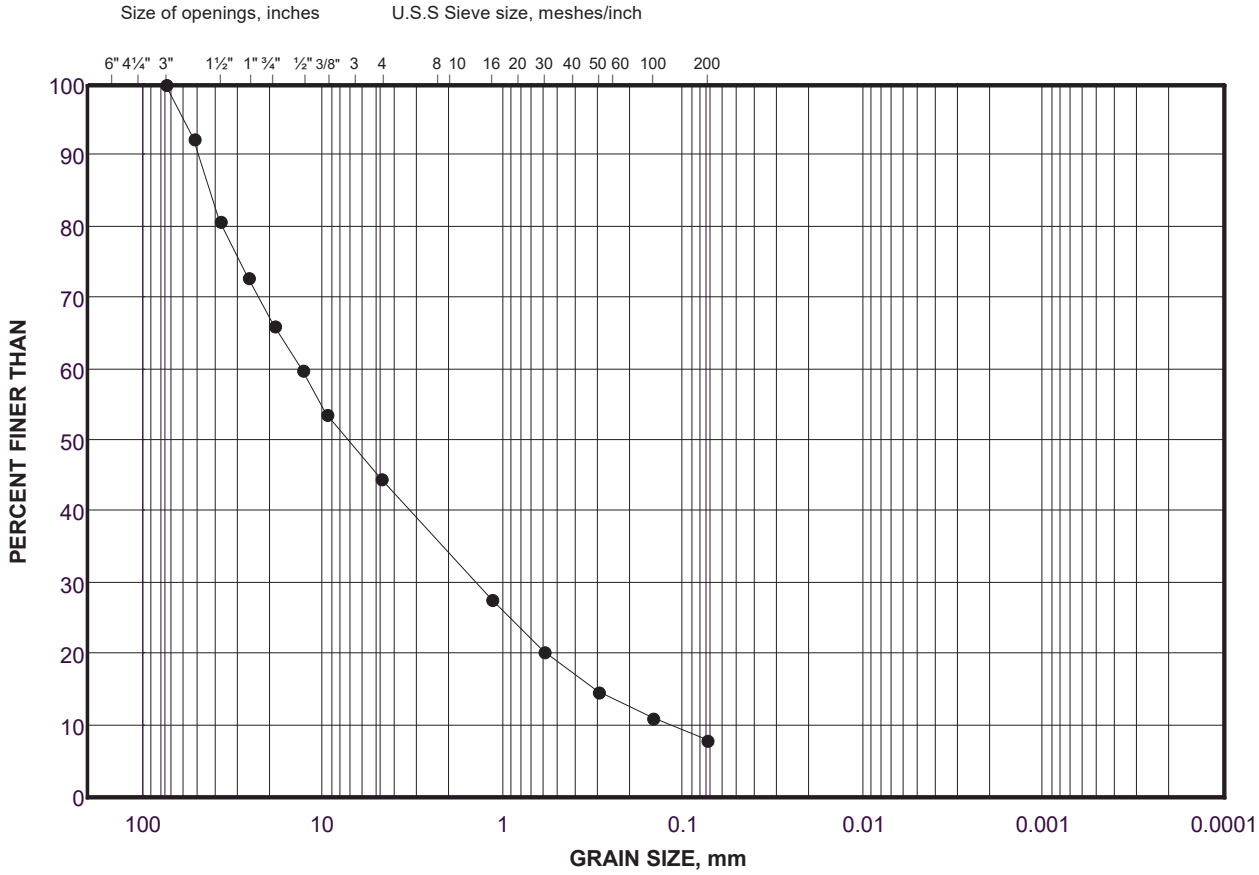
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 25



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	7B	9.75-10.36	32.00-34.00

REMARKS
Fineness Modulus= 5.46

Project Number: 1774274

Checked By:

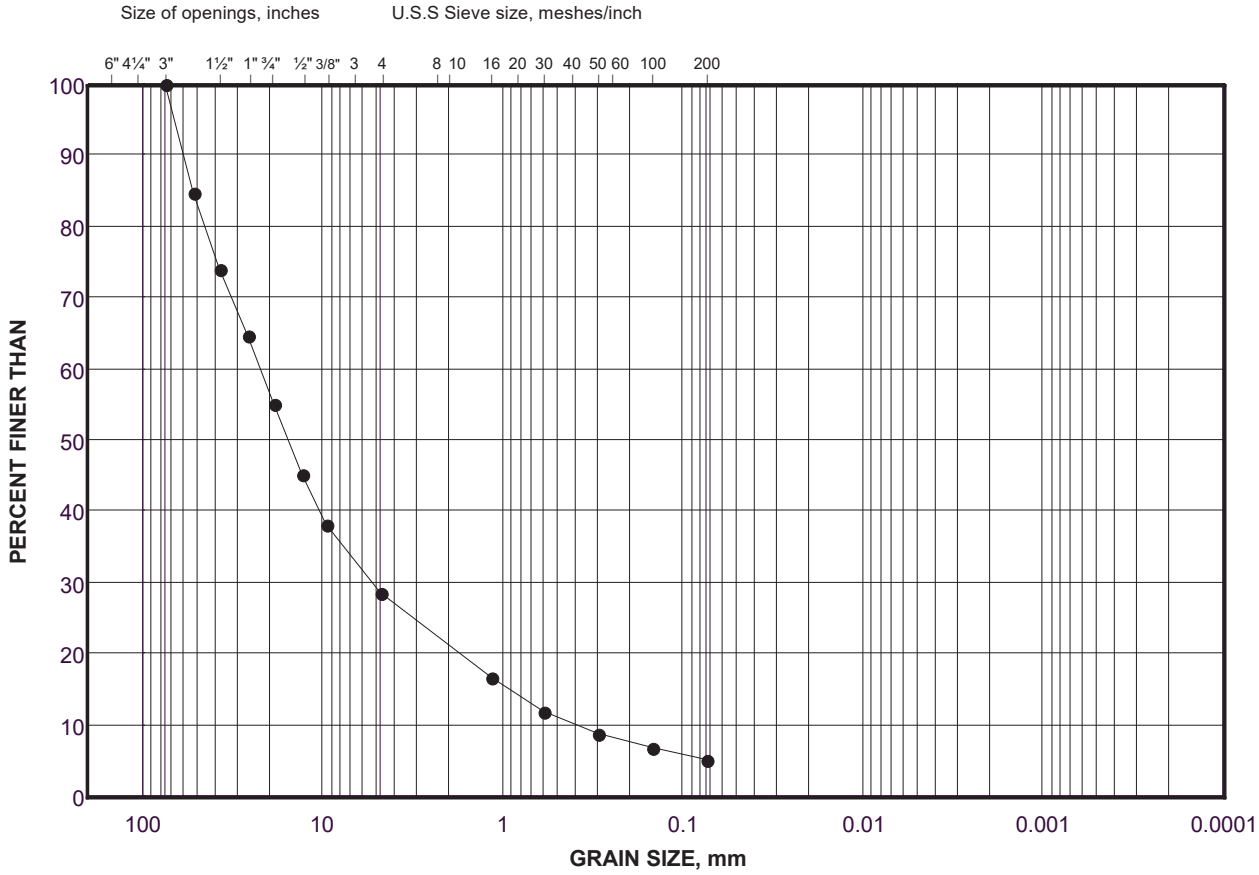
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 26



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	8	10.36-11.89	34.00-39.00

REMARKS
Fineness Modulus= 6.38

Project Number: 1774274

Checked By:

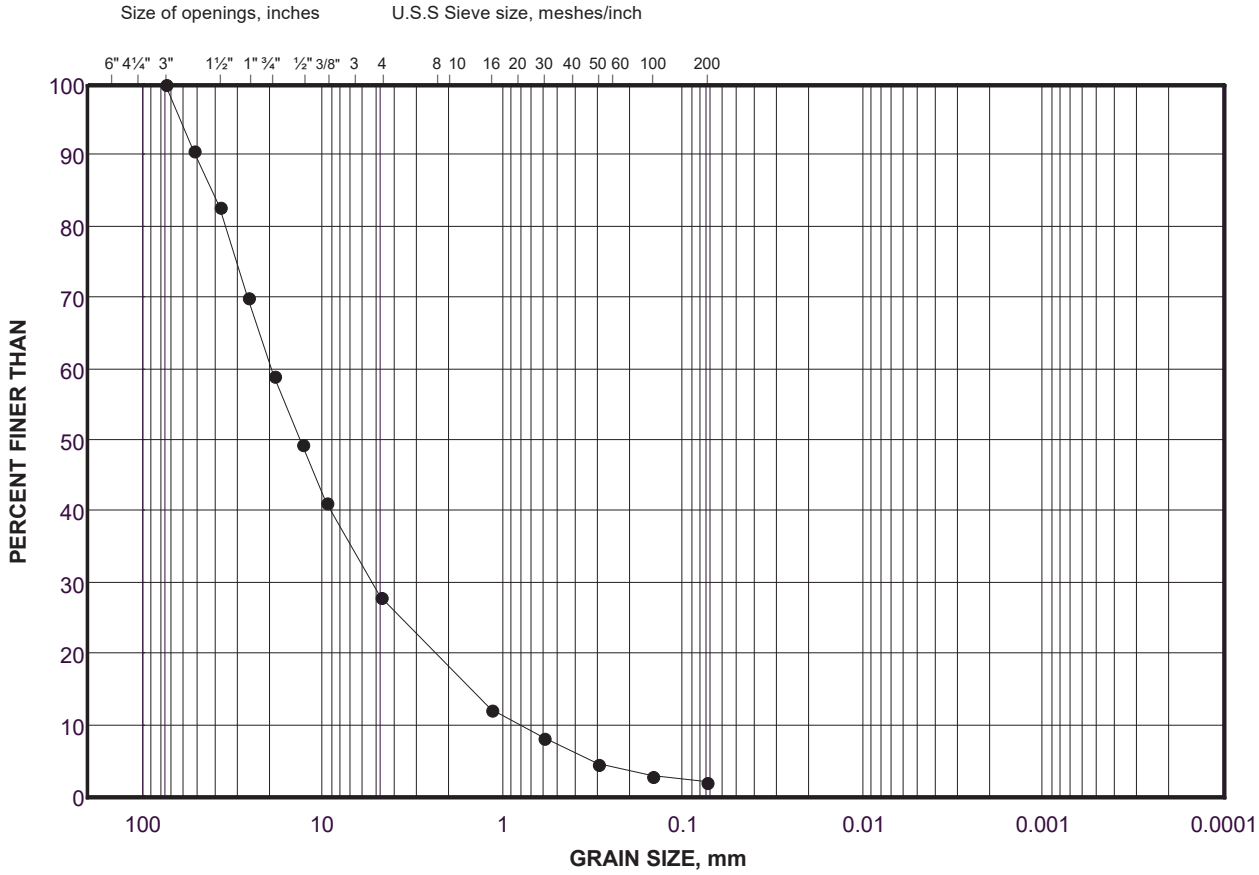
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 27



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	9	11.89-13.26	39.00-43.50

REMARKS
Fineness Modulus= 6.43

Project Number: 1774274

Checked By:

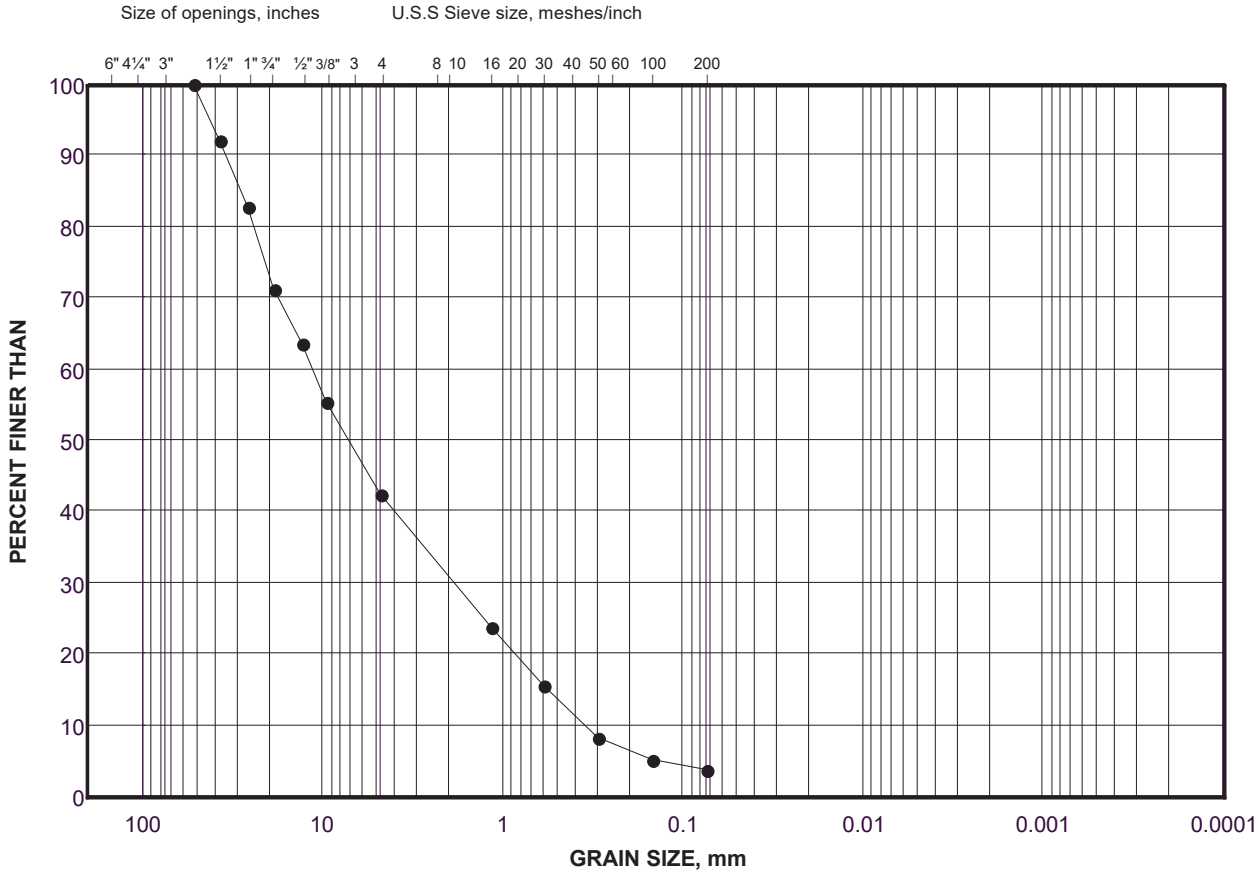
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 28



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	10A	14.02-14.48	46.00-47.50

REMARKS
Fineness Modulus= 5.53

Project Number: 1774274

Checked By:

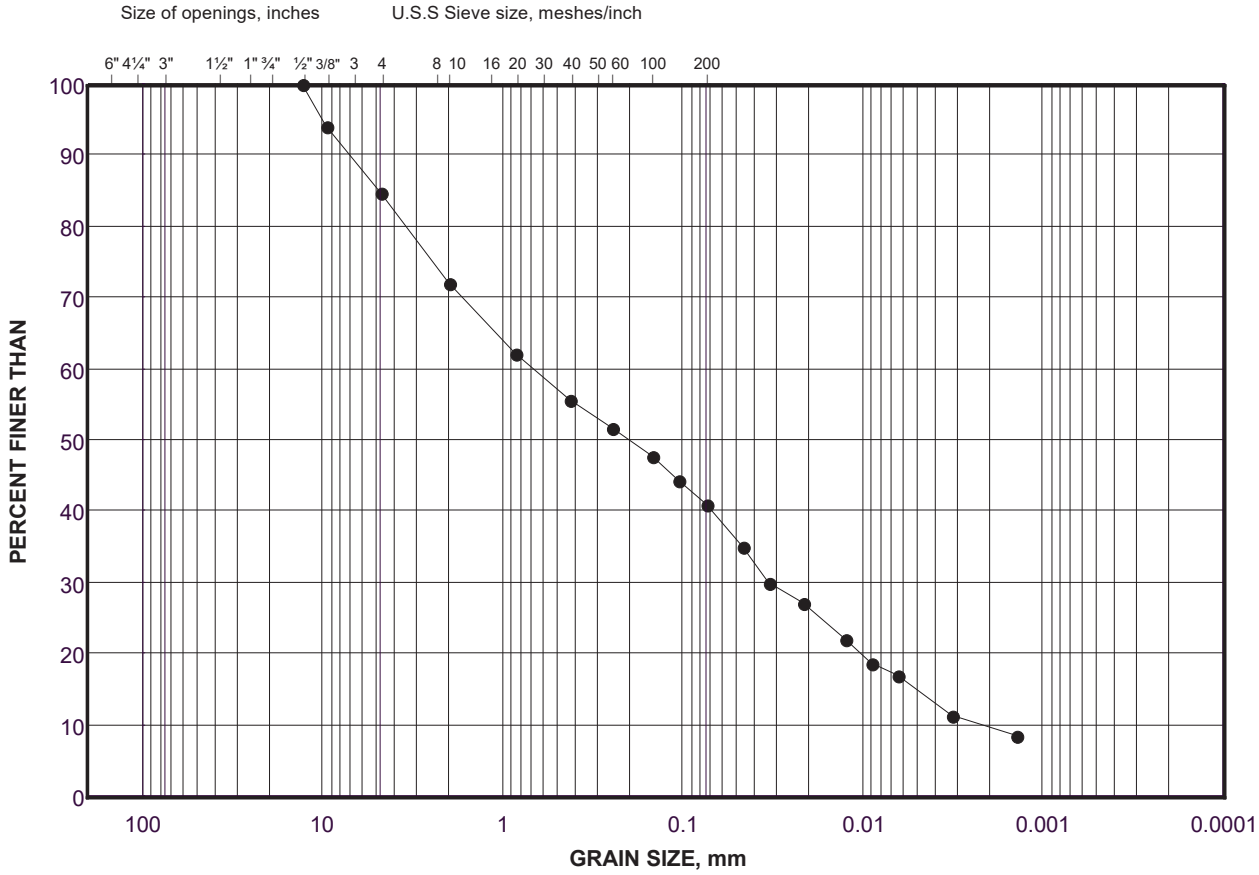
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 29



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	10B	13.72-14.94	45.00-49.00

REMARKS
Fineness Modulus= 2.21

Project Number: 1774274

Checked By:

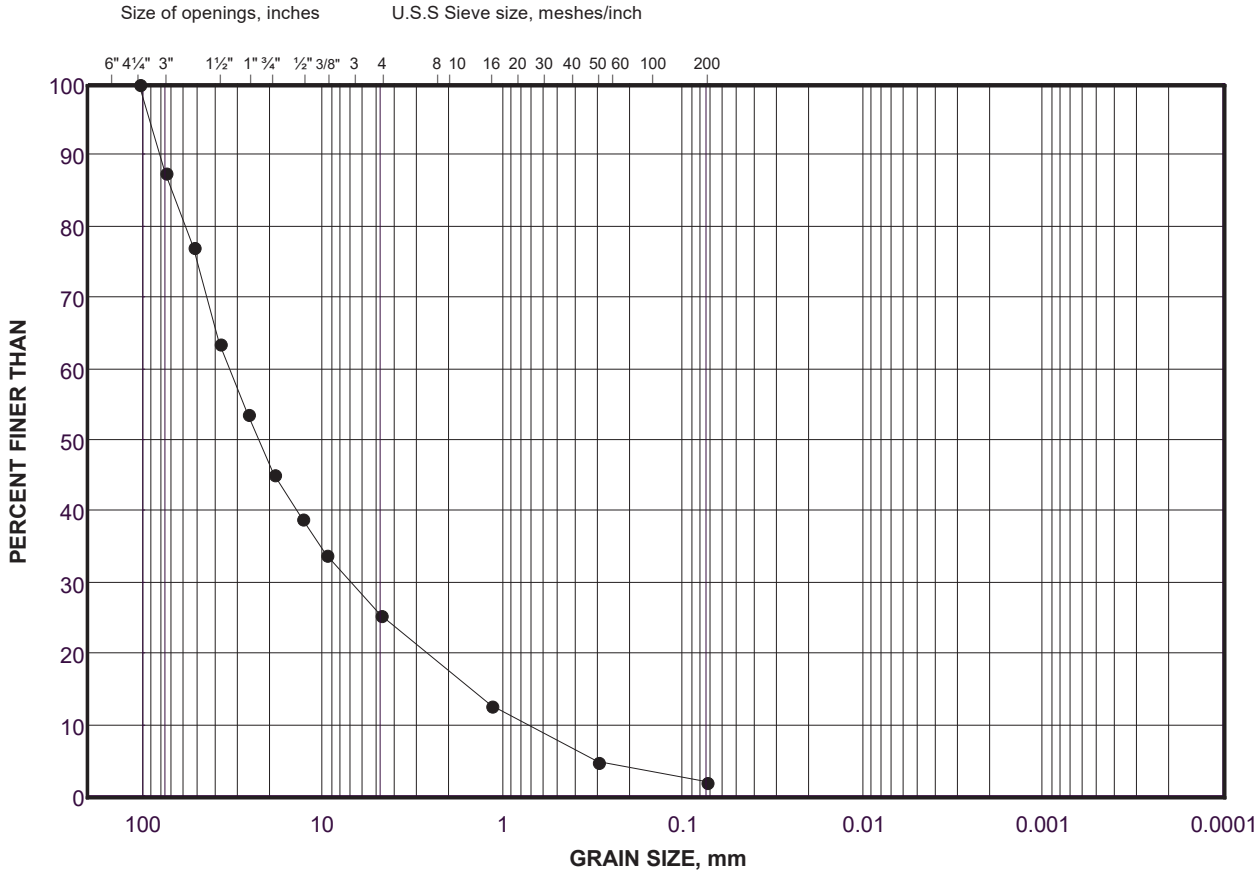
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 30



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	11	14.94-16.46	49.00-54.00

REMARKS
Fineness Modulus= 6.97

Project Number: 1774274

Checked By:

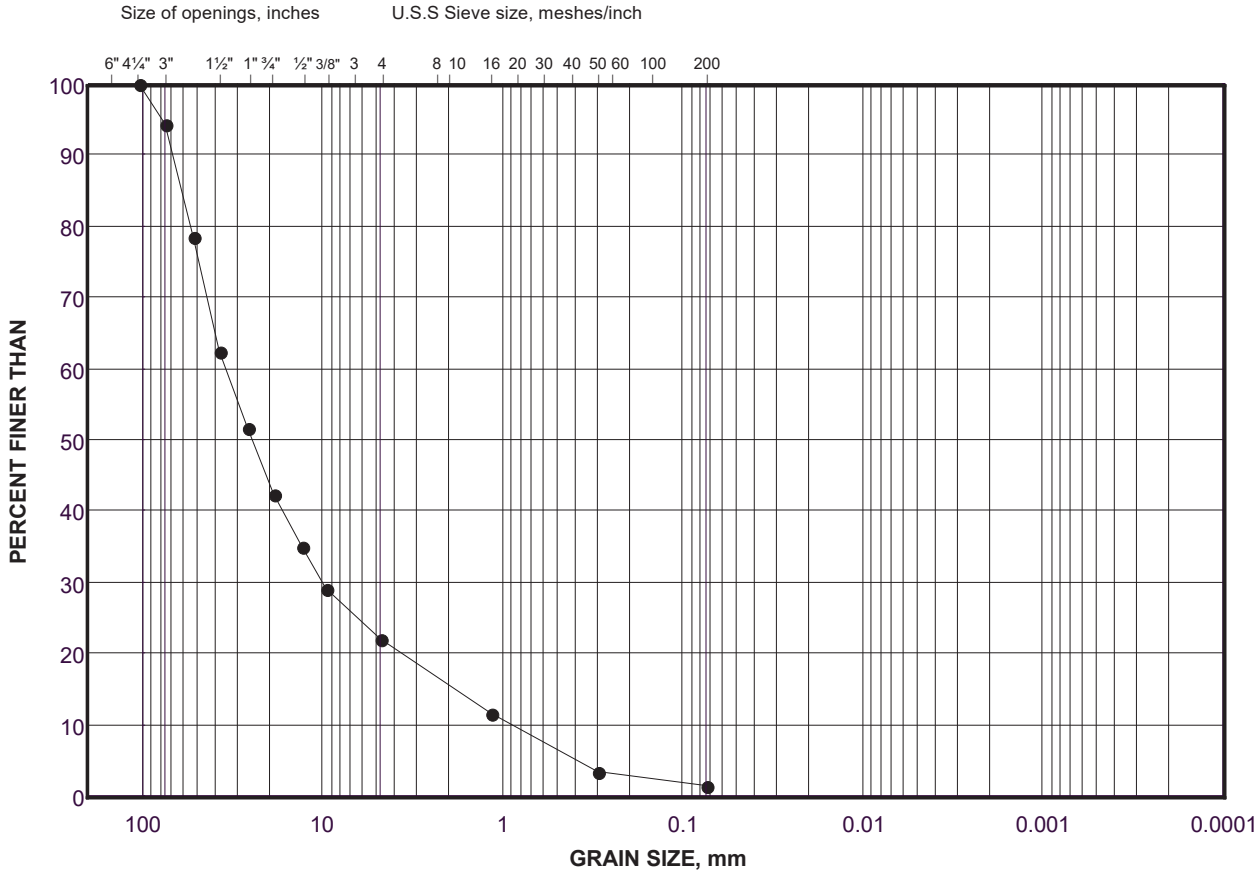
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 31



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	12	16.46-17.98	54.00-59.00

REMARKS
Fineness Modulus= 7.09

Project Number: 1774274

Checked By:

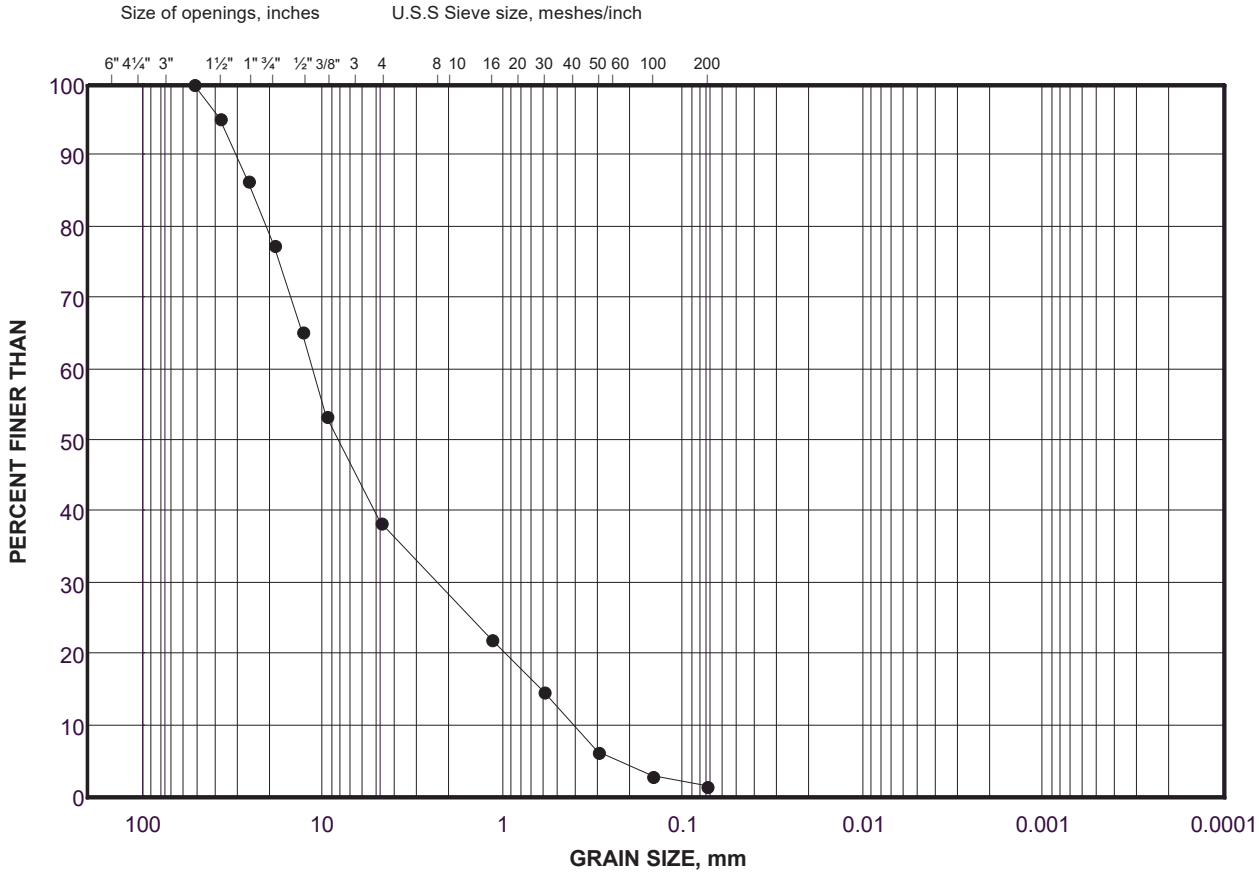
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 32



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	13A	17.98-19.35	59.00-63.50

REMARKS
Fineness Modulus= 5.60

Project Number: 1774274

Checked By:

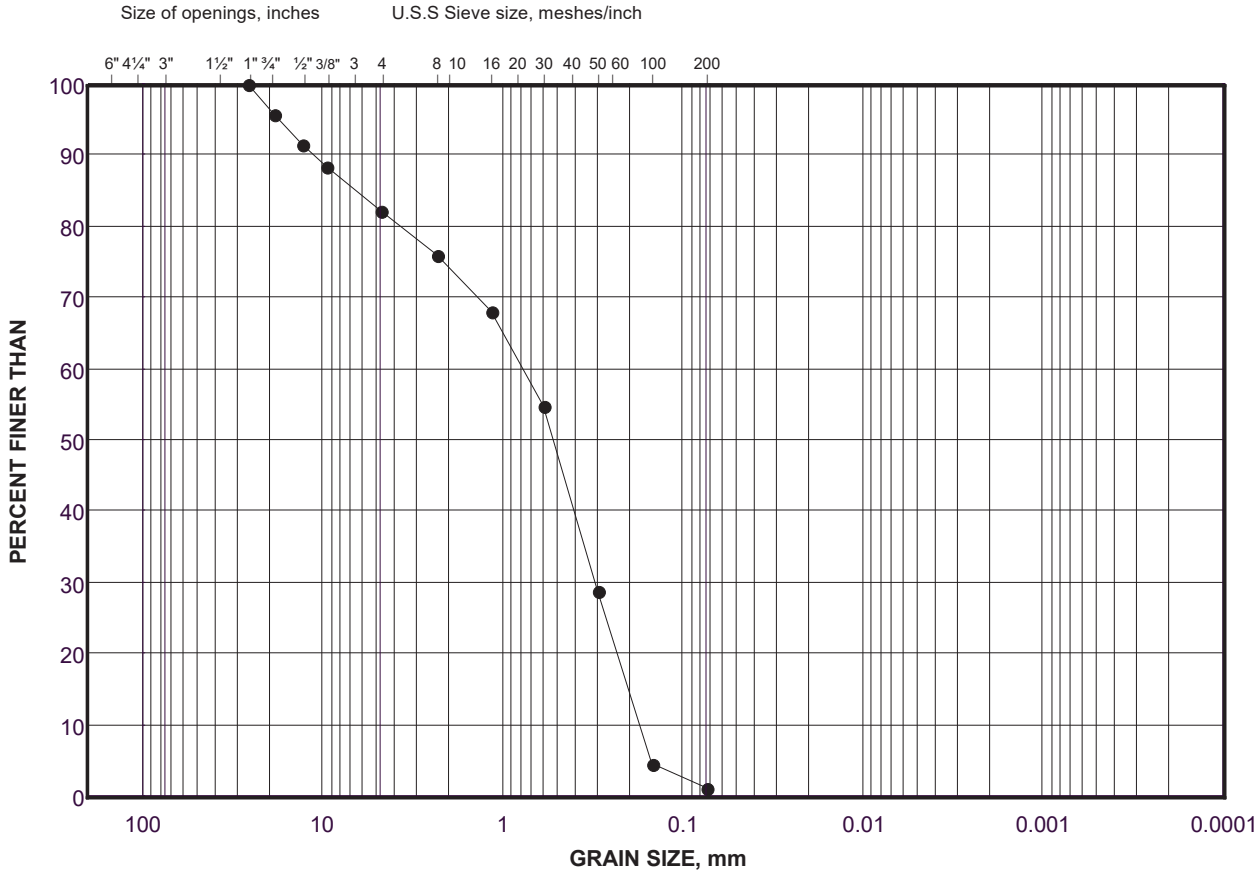
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 33



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	13B	19.35-19.81	63.50-65.00

REMARKS
Fineness Modulus= 3.01

Project Number: 1774274

Checked By:

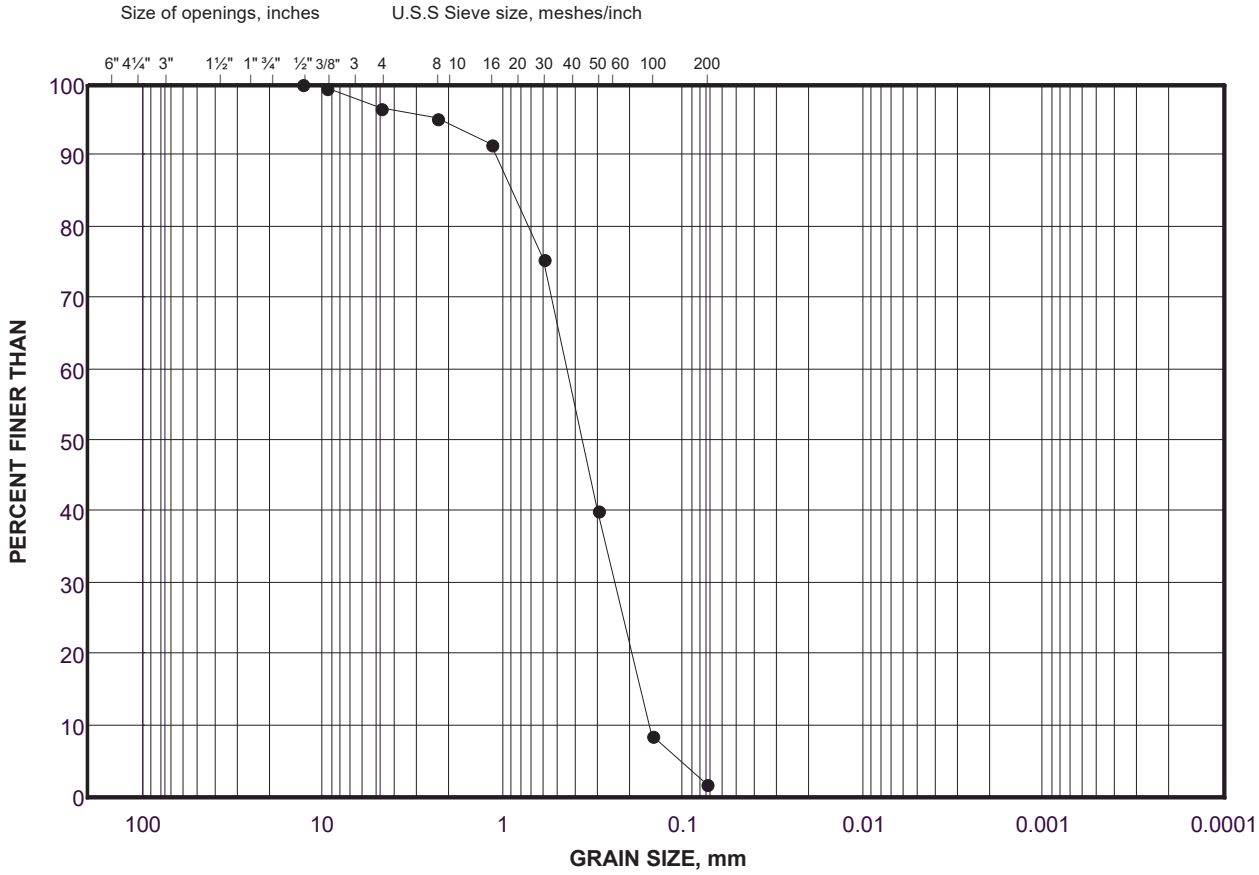
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 34



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	14A	19.81-20.27	65.00-66.50

REMARKS
Fineness Modulus= 1.93

Project Number: 1774274

Checked By:

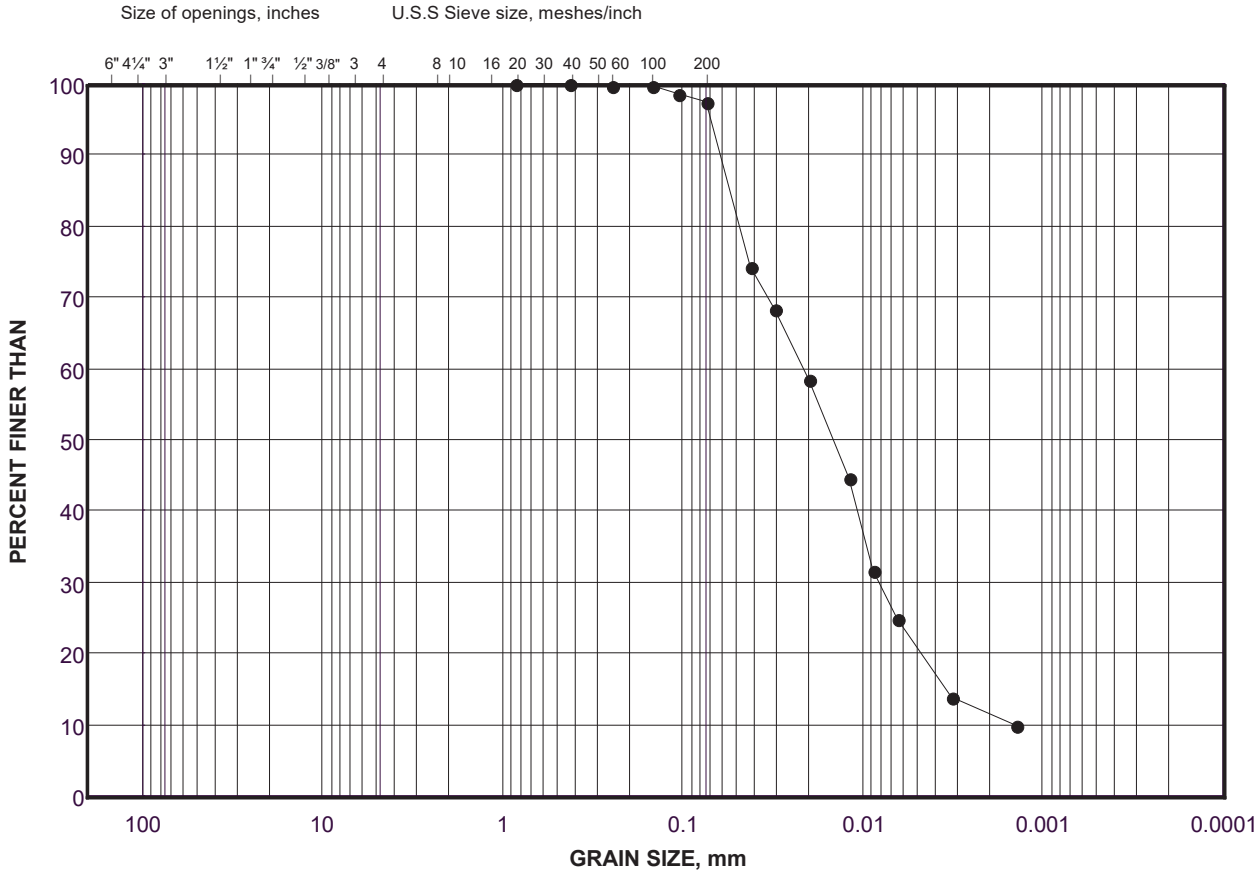
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 35



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	14B	20.27-21.03	66.50-69.00

REMARKS
Fineness Modulus= 0

Project Number: 1774274

Checked By:

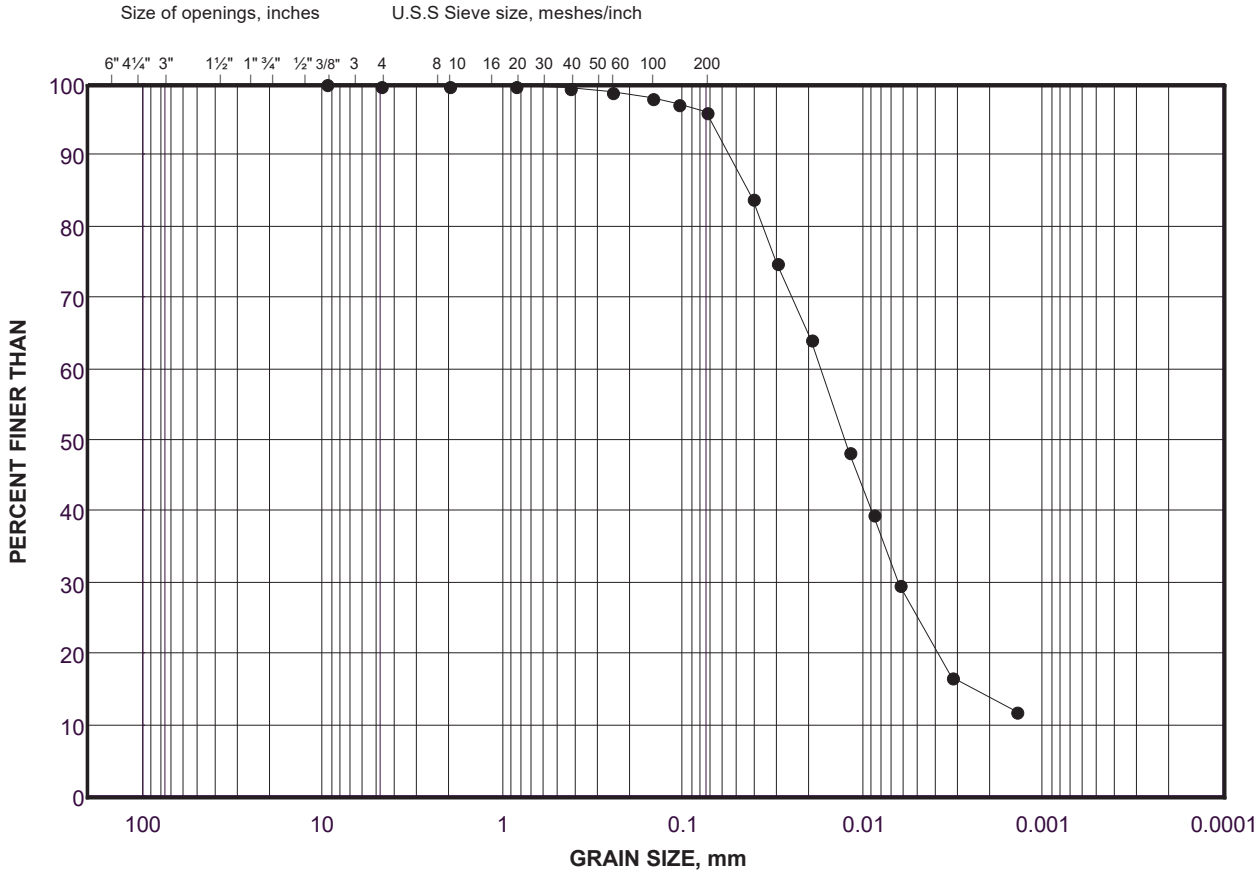
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 36



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	15	21.03-22.25	69.00-73.00

REMARKS
Fineness Modulus= 0.05

Project Number: 1774274

Checked By:

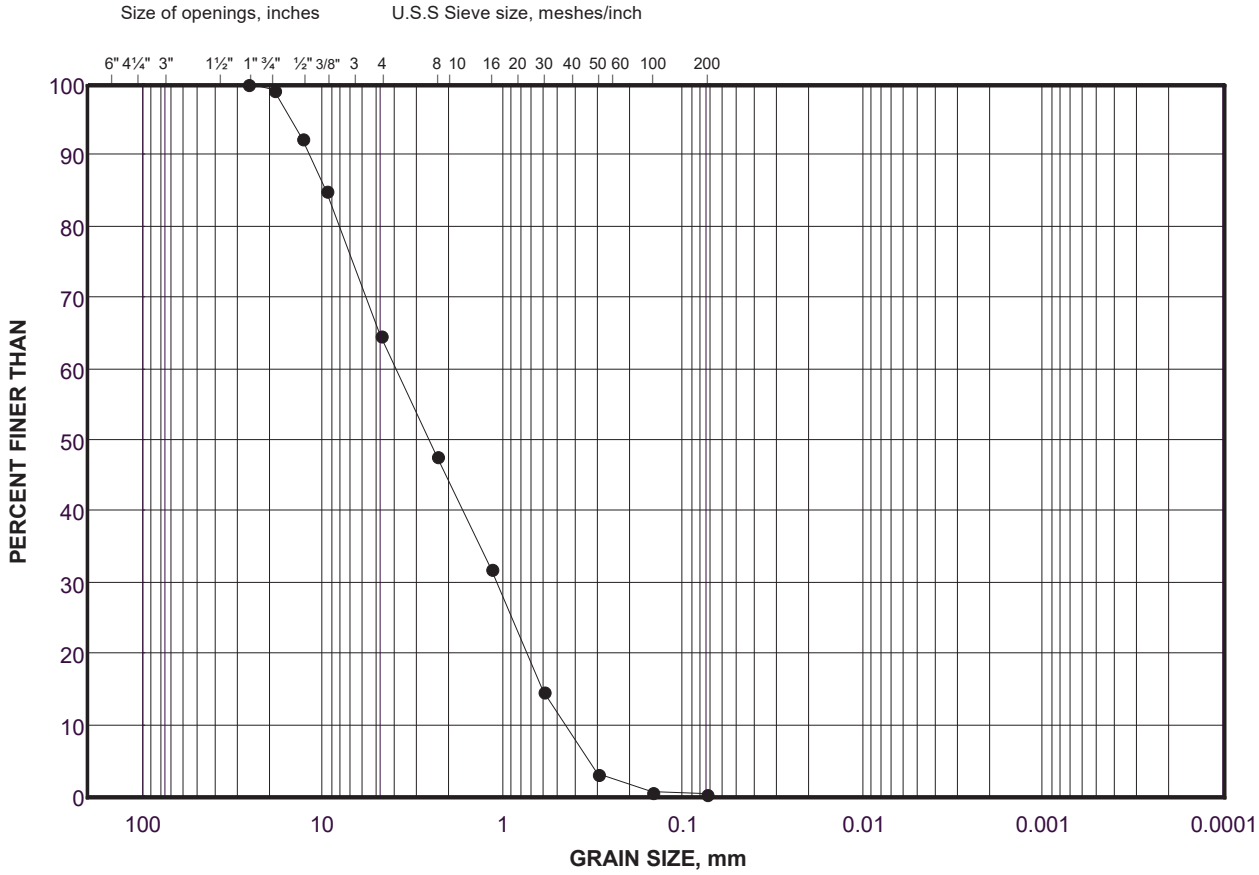
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 37



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	16A	22.25-24.08	73.00-79.00

REMARKS
Fineness Modulus= 4.53

Project Number: 1774274

Checked By:

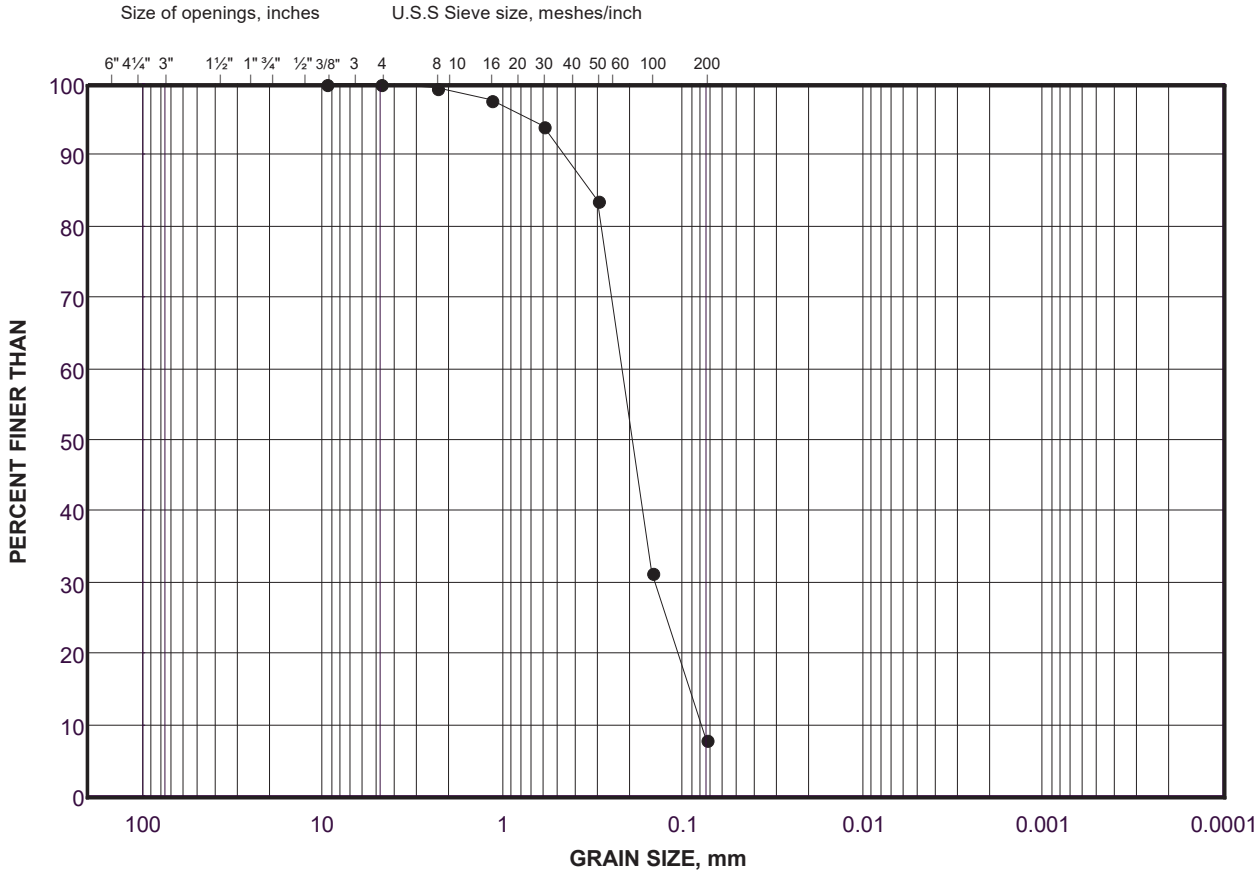
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 38



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH/MW17-02	16B	23.16-23.32	76.00-76.50

REMARKS
Fineness Modulus= 0.94

Project Number: 1774274

Checked By:

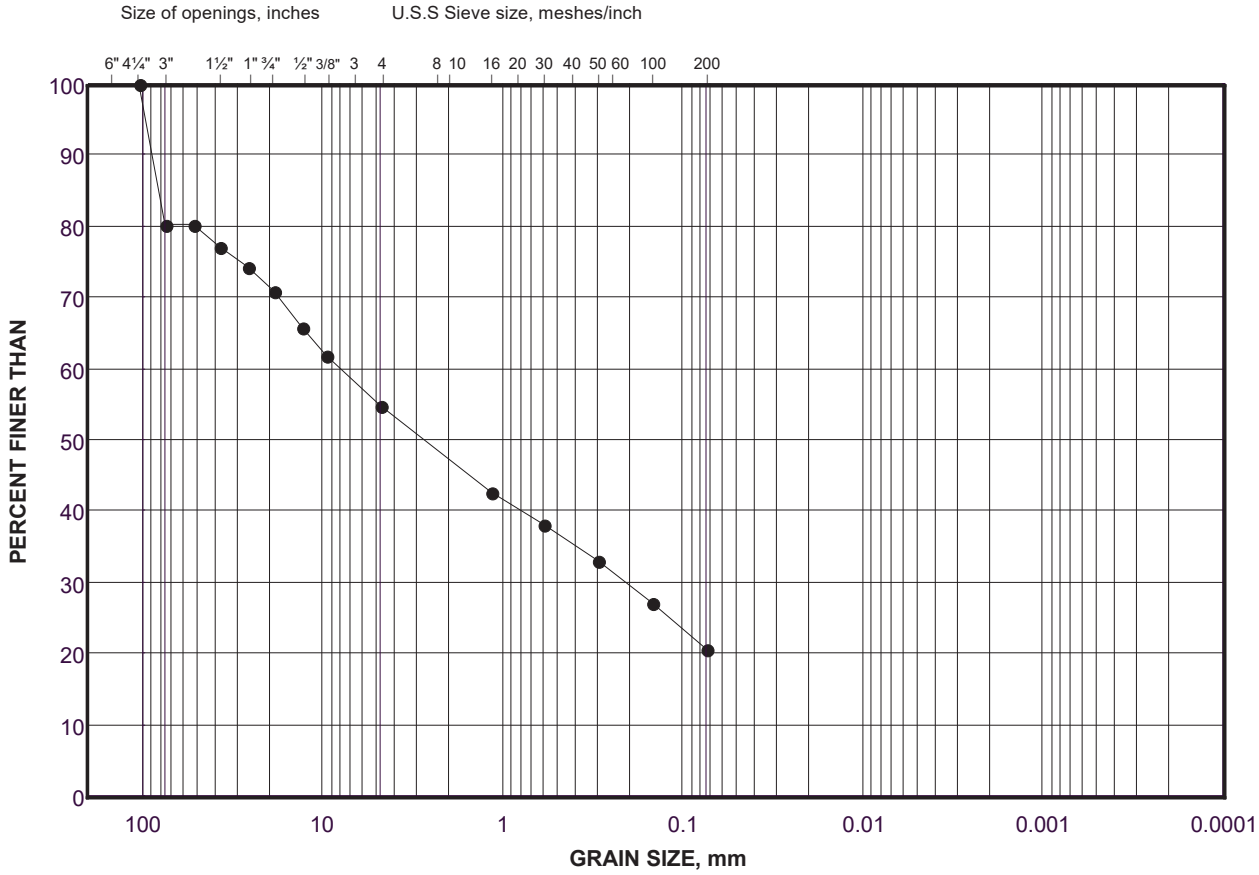
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 39



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	1B	0.43-1.52	1.40-5.00

REMARKS
Fineness Modulus= 4.64

Project Number: 1774274

Checked By

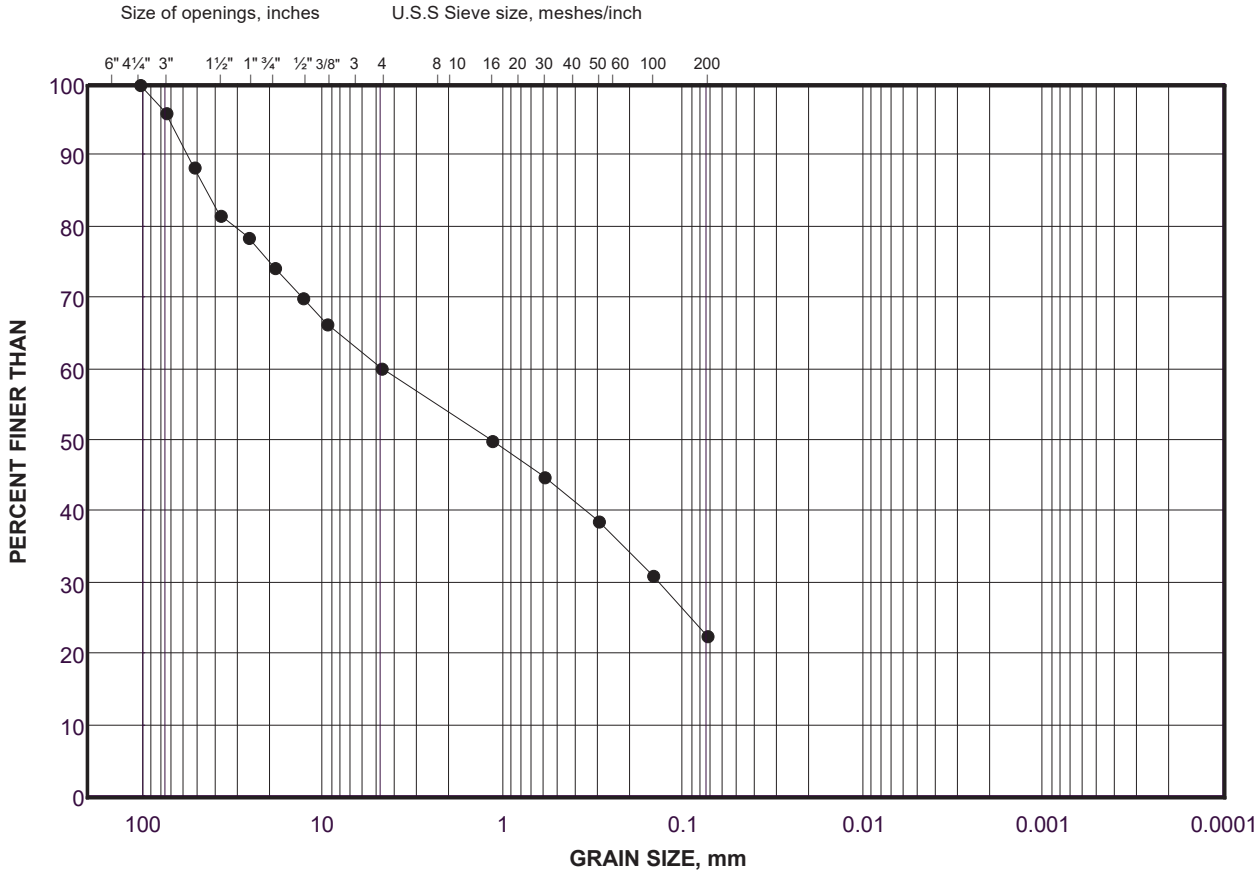
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 41



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	2	1.52-2.74	5.00-9.00

REMARKS
Fineness Modulus= 4.01

Project Number: 1774274

Checked By:

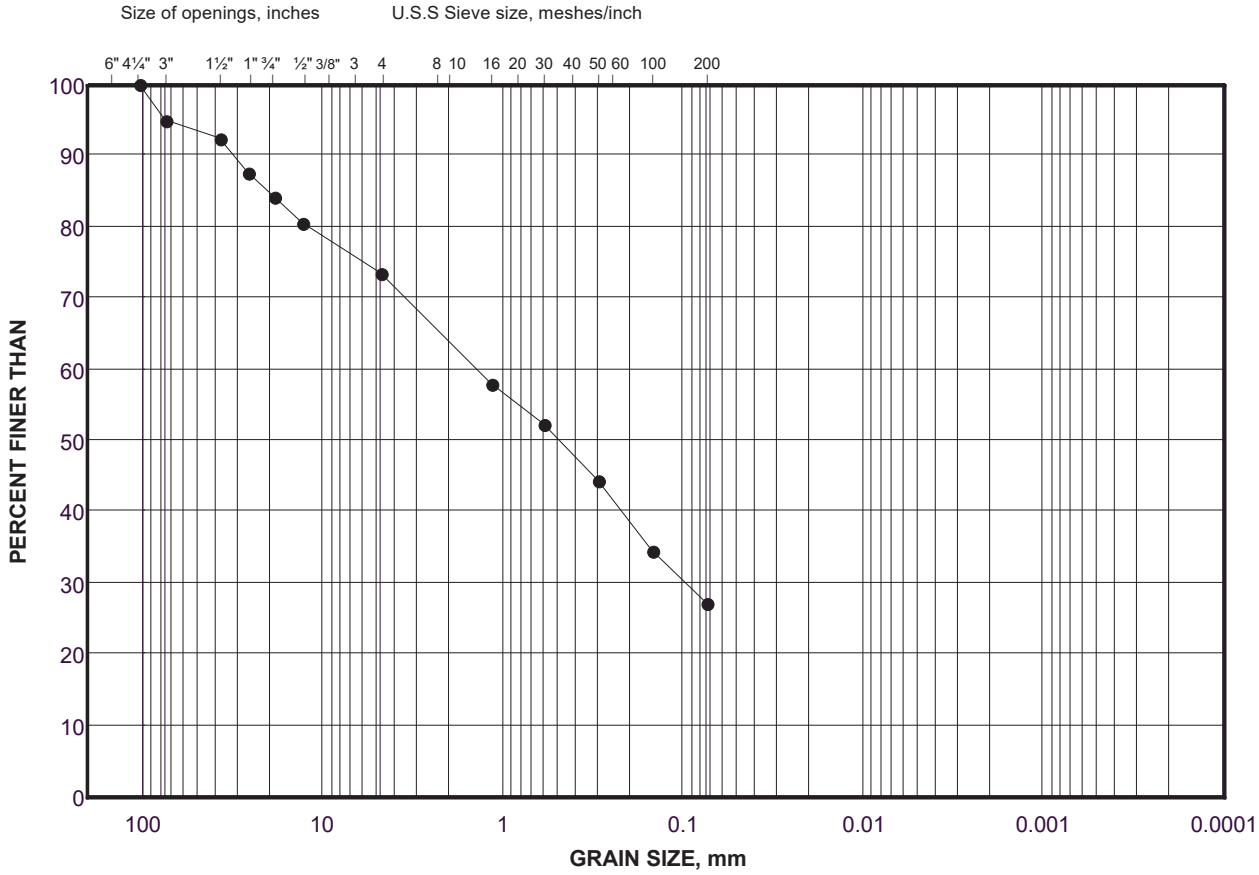
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 42



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	3	2.74-4.72	9.00-15.50

REMARKS
Fineness Modulus= 3.26

Project Number: 1774274

Checked By:

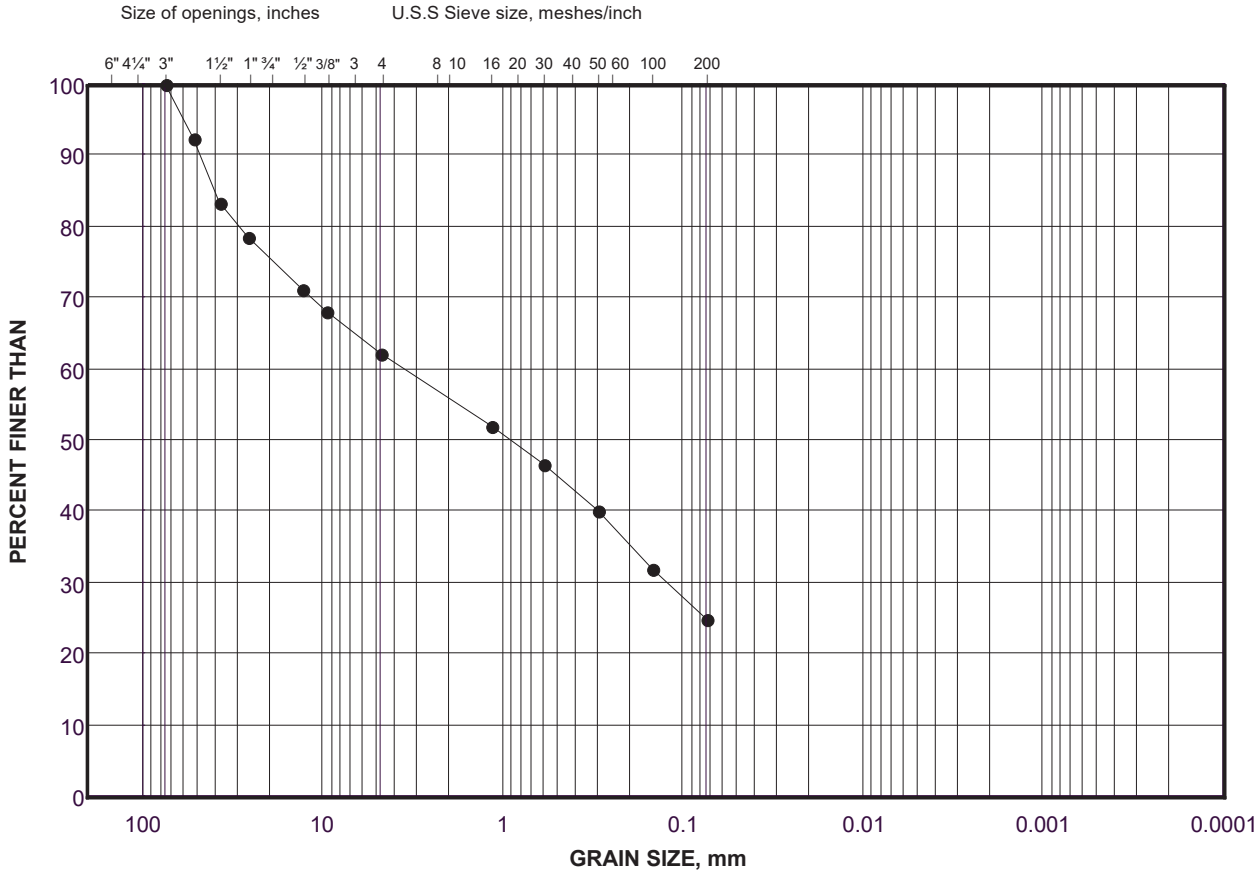
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 43



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	4A	4.72-5.33	15.50-17.50

REMARKS
Fineness Modulus= 3.85

Project Number: 1774274

Checked By:

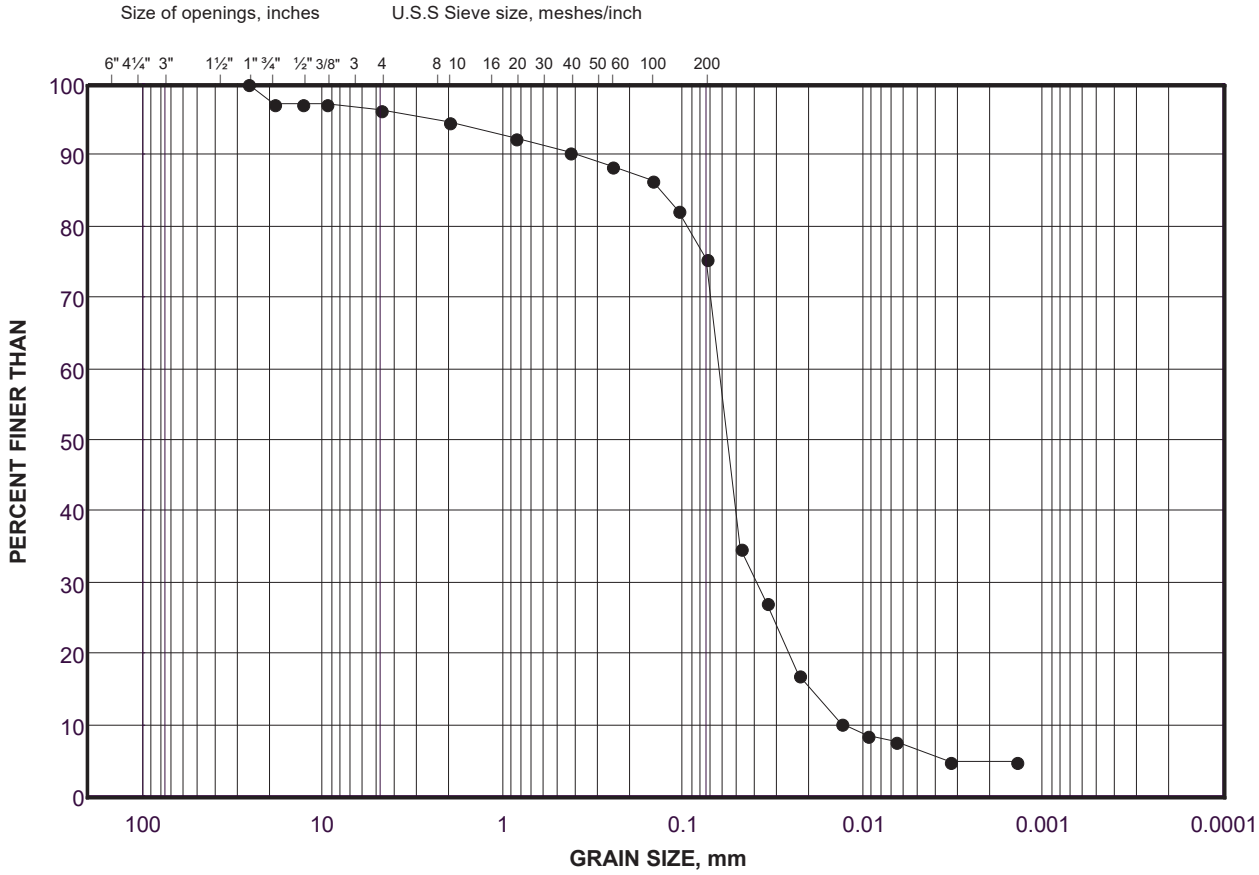
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 44



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	4B	5.33-5.79	17.50-19.00

REMARKS
Fineness Modulus= 0.55

Project Number: 1774274

Checked By:

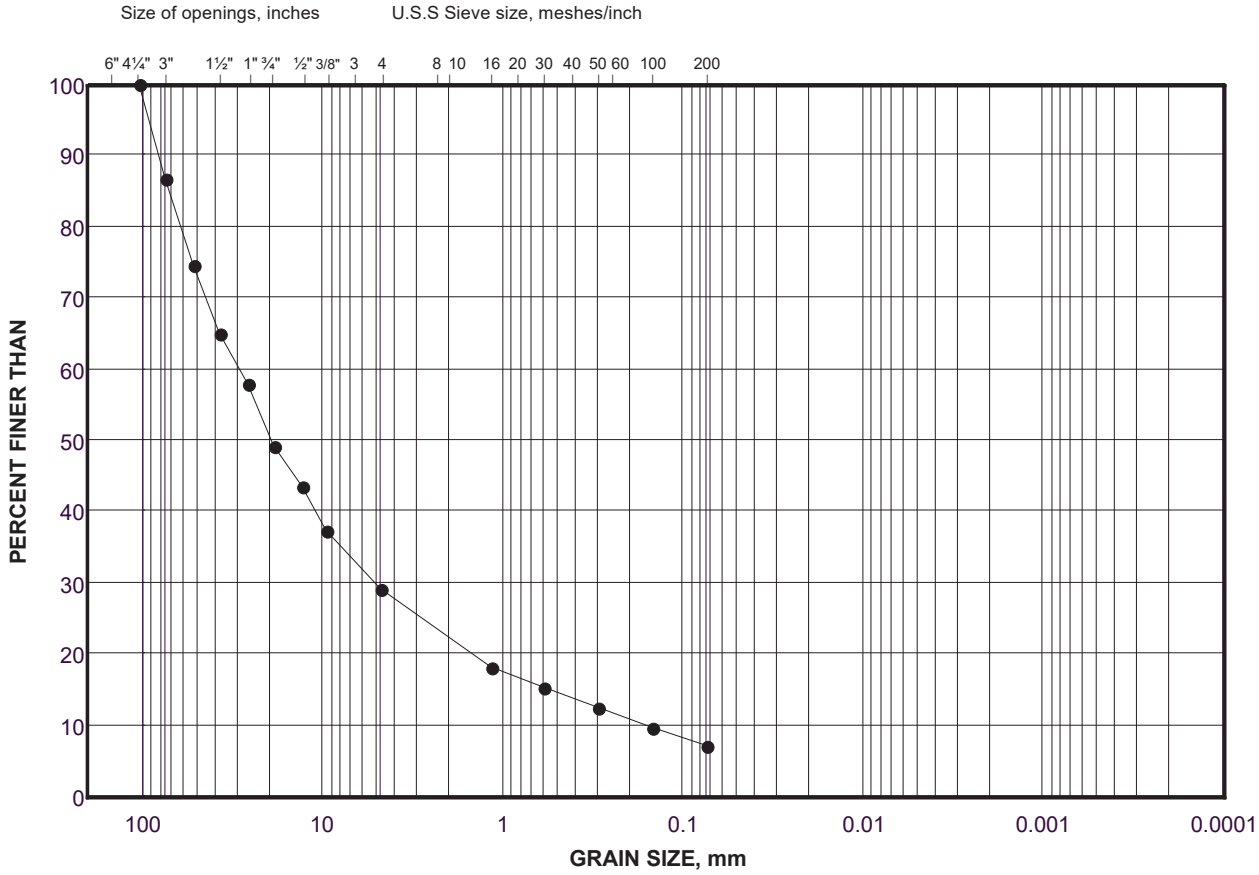
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 45



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	5	5.79-6.71	19.00-22.00

REMARKS
Fineness Modulus= 6.55

Project Number: 1774274

Checked By:

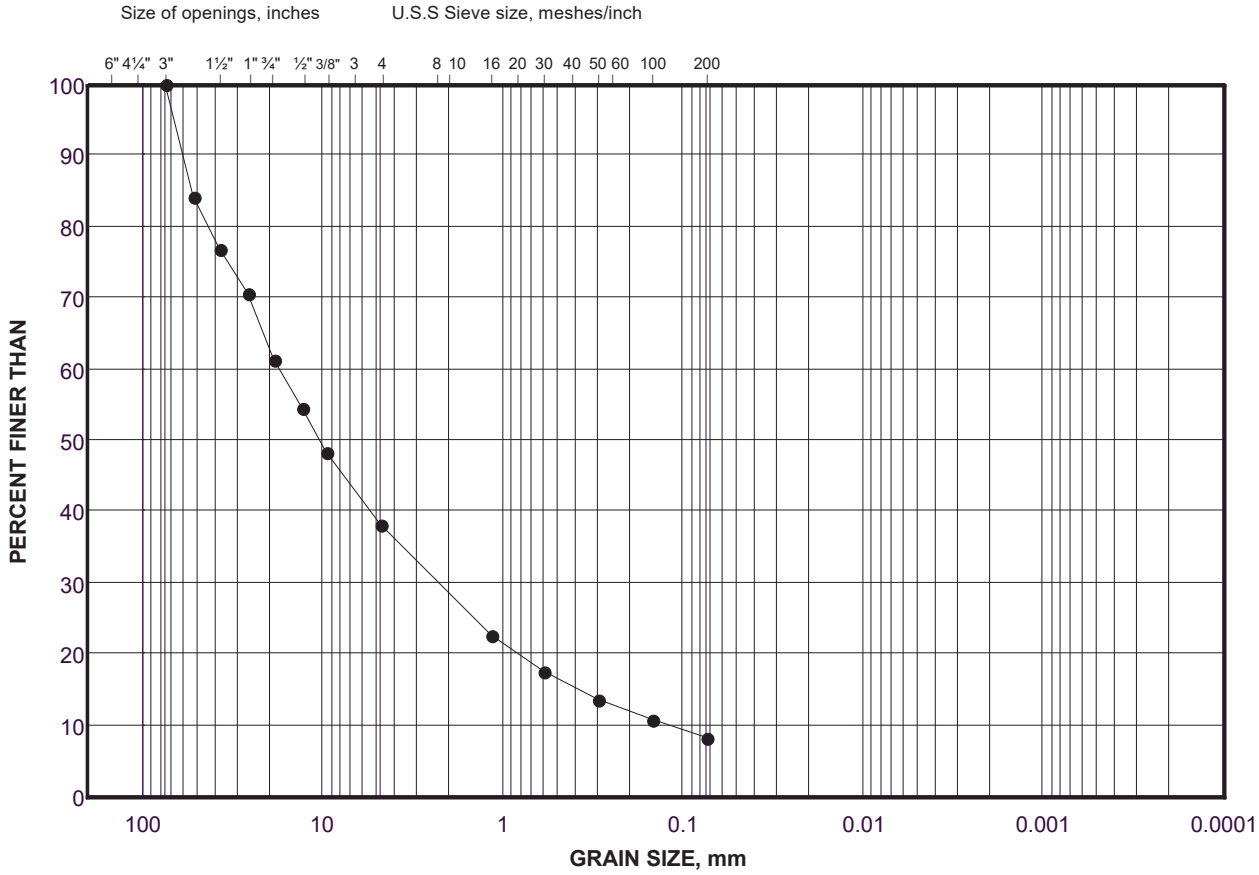
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 46



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	6	6.71-8.84	22.00-29.00

REMARKS
Fineness Modulus= 5.82

Project Number: 1774274

Checked By:

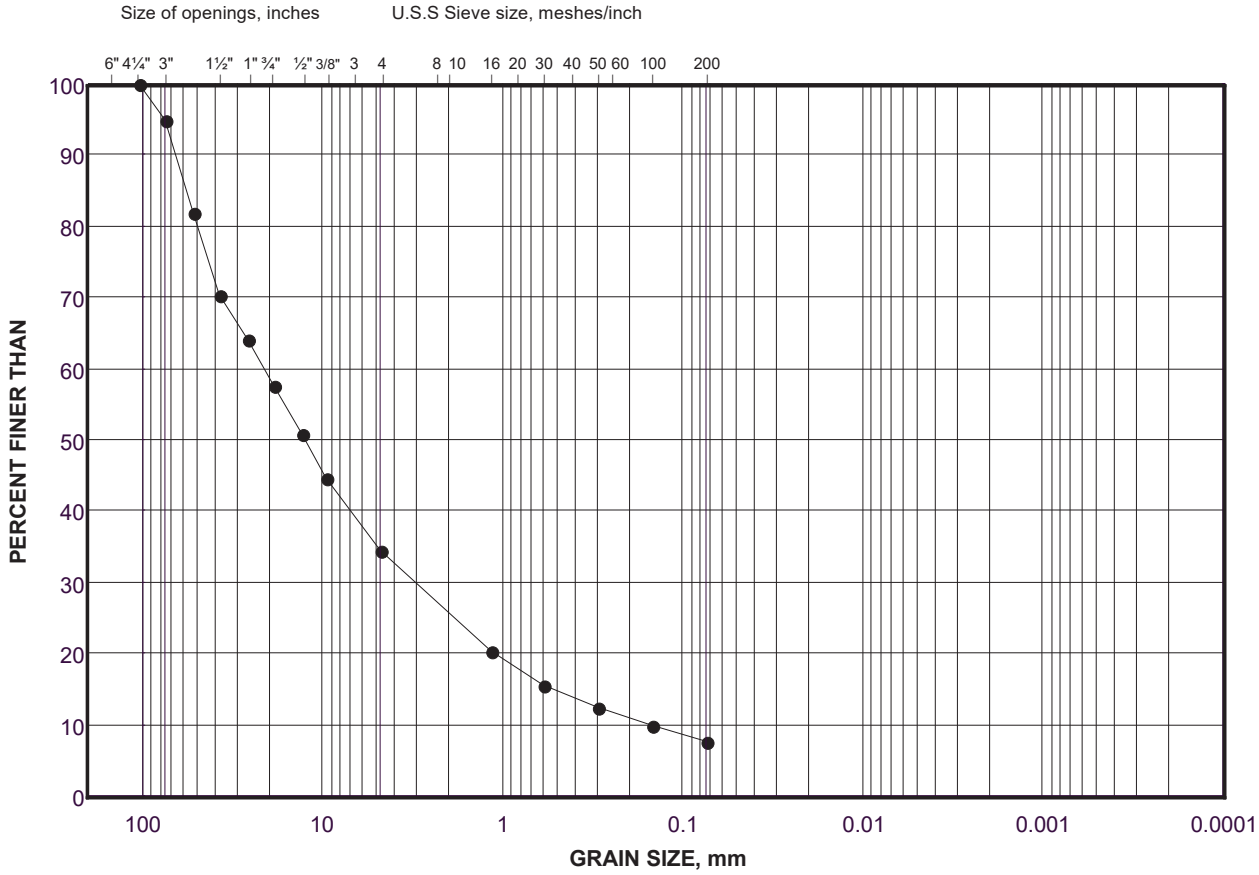
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 47



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	7	8.84-10.36	29.00-34.00

REMARKS
Fineness Modulus= 6.13

Project Number: 1774274

Checked By:

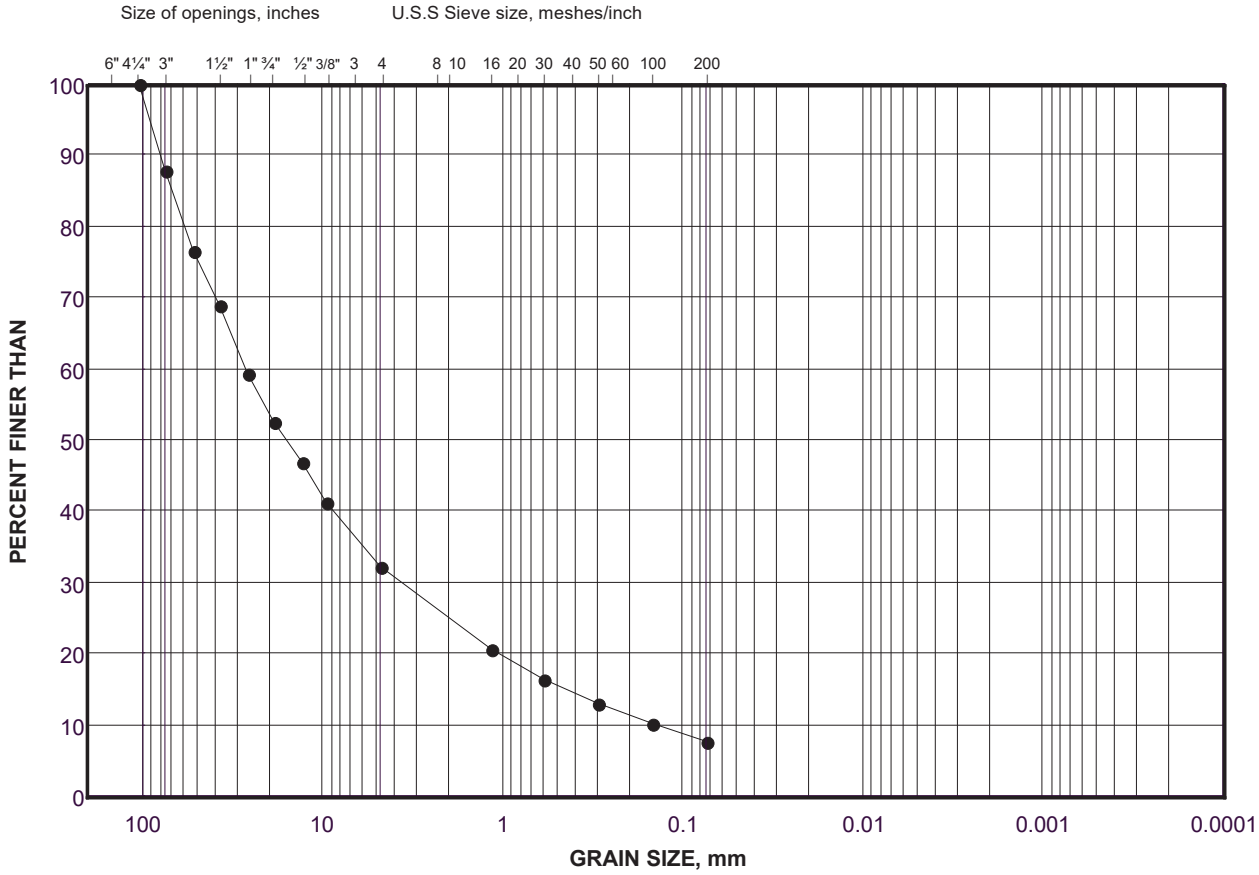
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 48



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	8	10.36-11.89	34.00-39.00

REMARKS
Fineness Modulus= 6.31

Project Number: 1774274

Checked By:

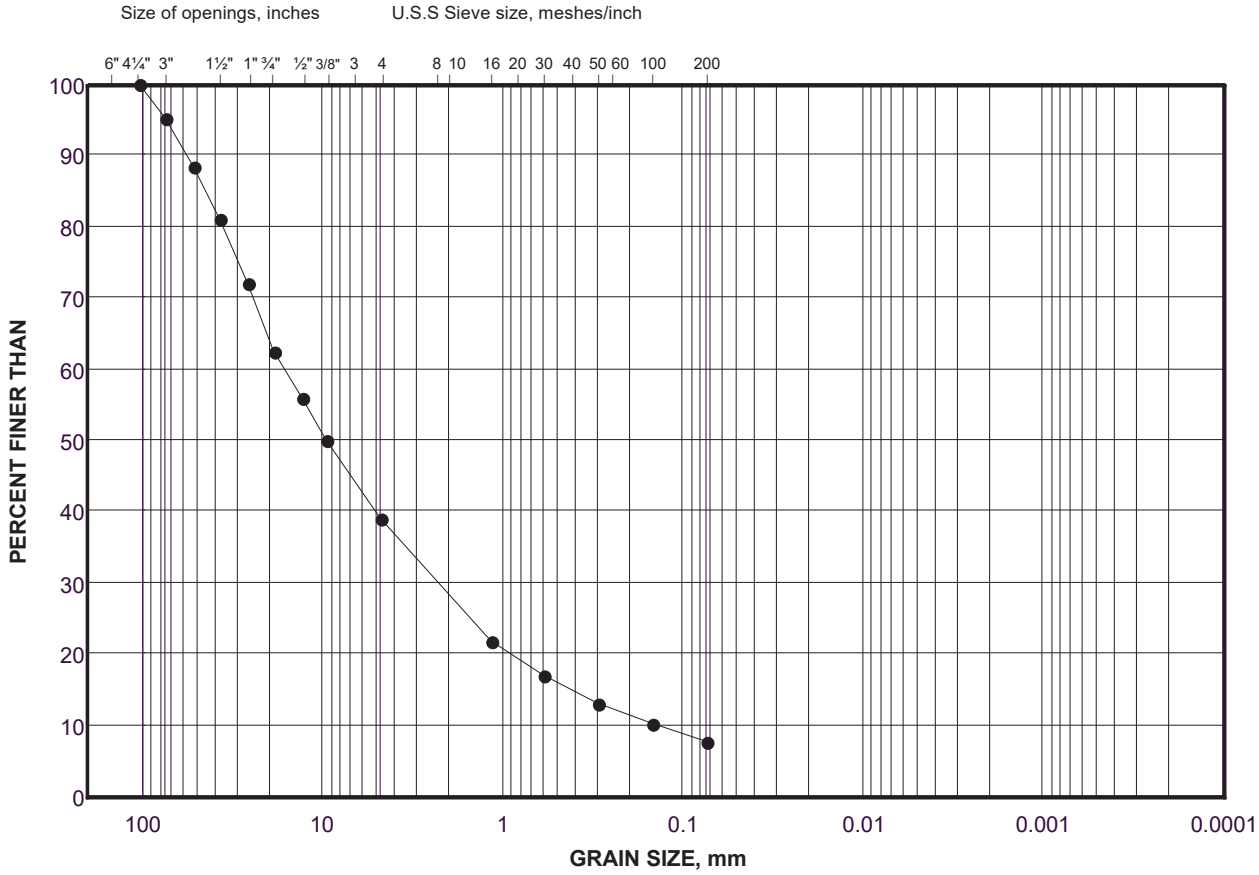
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 49



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	9	11.89-13.41	39.00-44.00

REMARKS
Fineness Modulus= 5.80

Project Number: 1774274

Checked By:

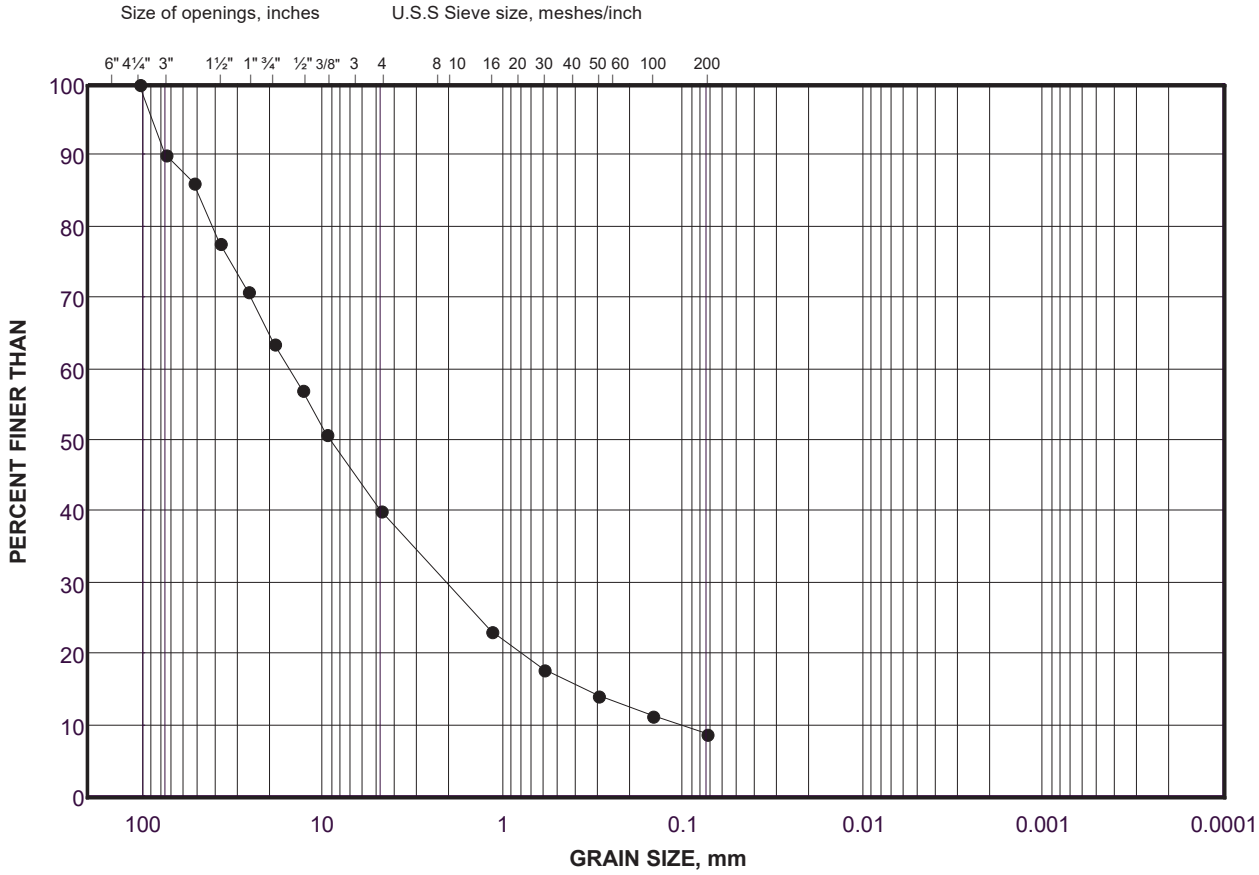
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 50



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	10	13.41-14.63	44.00-48.00

REMARKS
Fineness Modulus= 5.79

Project Number: 1774274

Checked By:

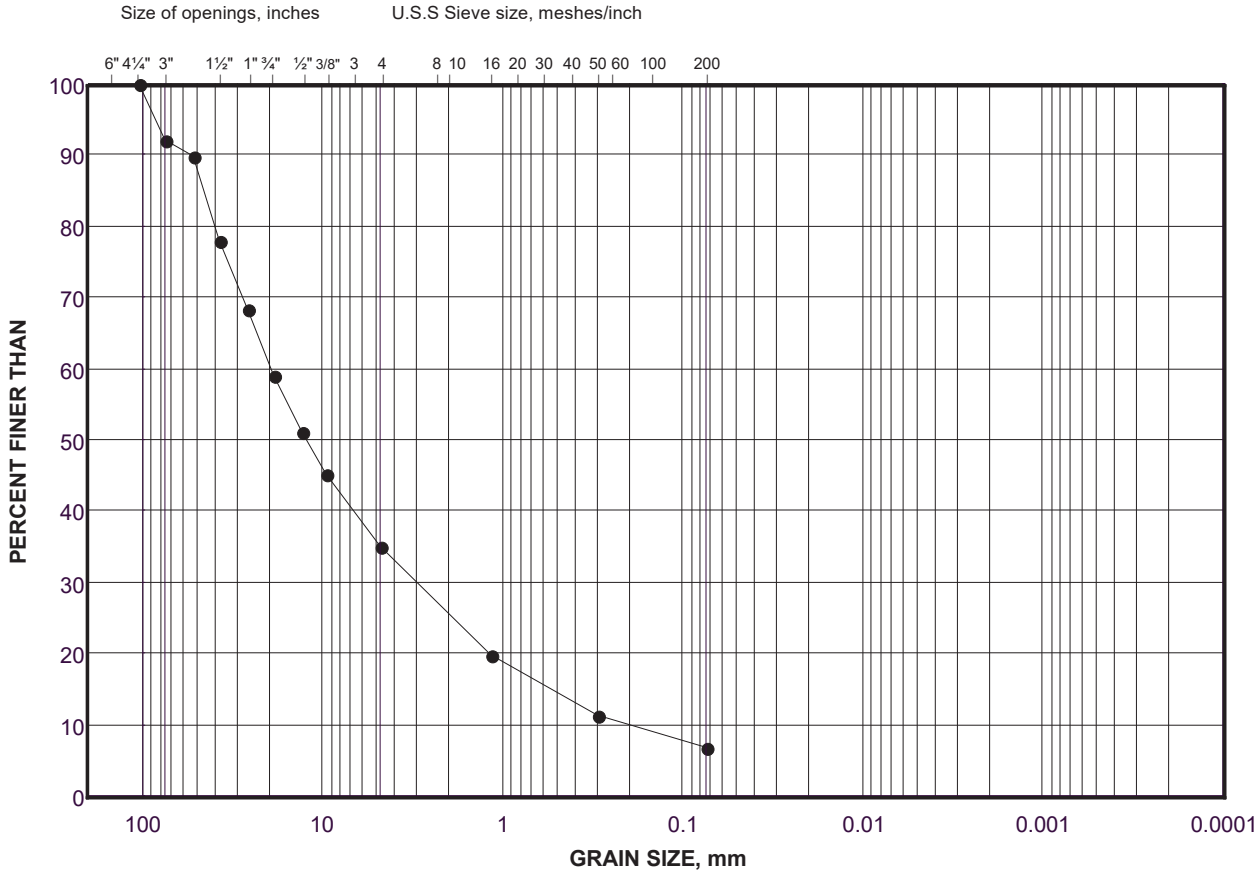
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 51



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	11	14.63-15.85	48.00-52.00

REMARKS
Fineness Modulus= 6.08

Project Number: 1774274

Checked By:

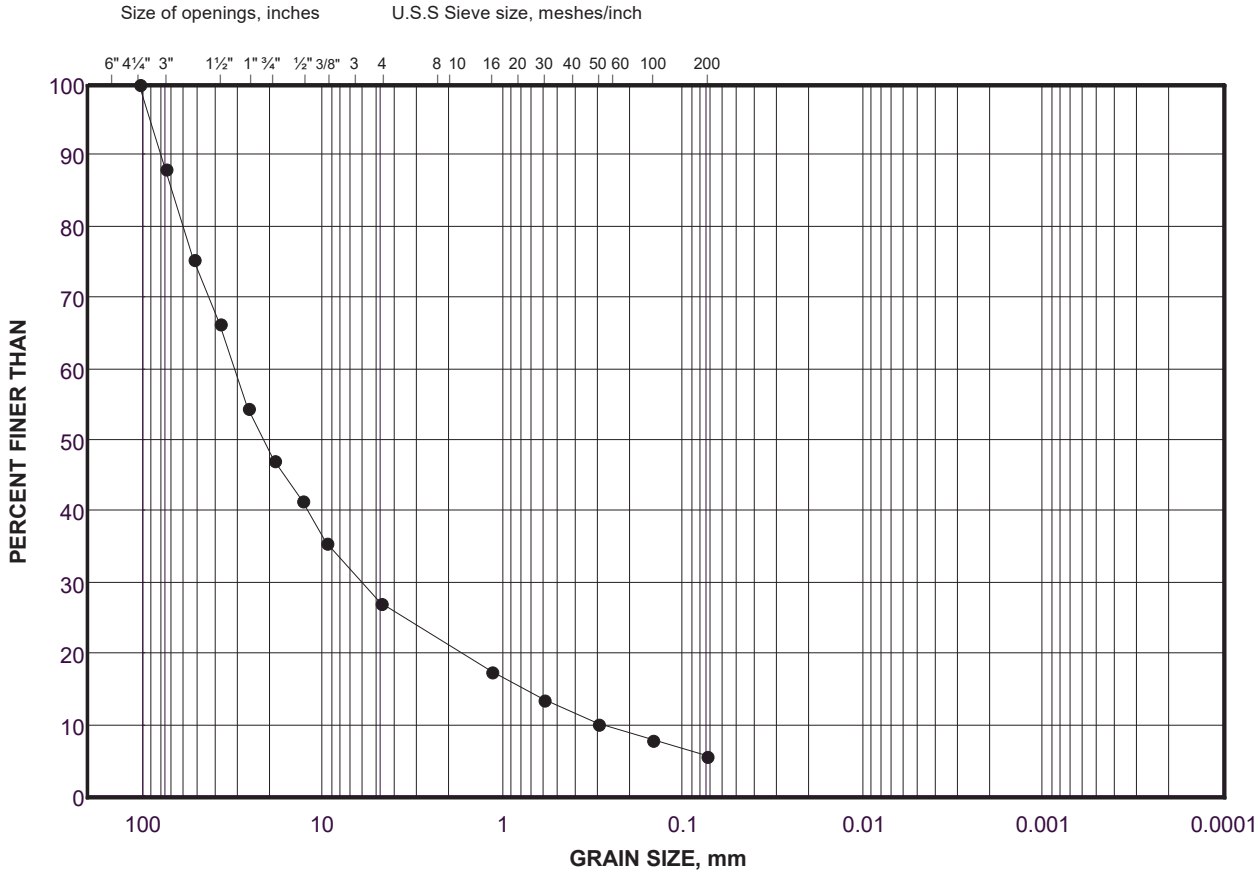
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 52



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	12	15.85-17.98	52.00-59.00

REMARKS
Fineness Modulus= 6.64

Project Number: 1774274

Checked By:

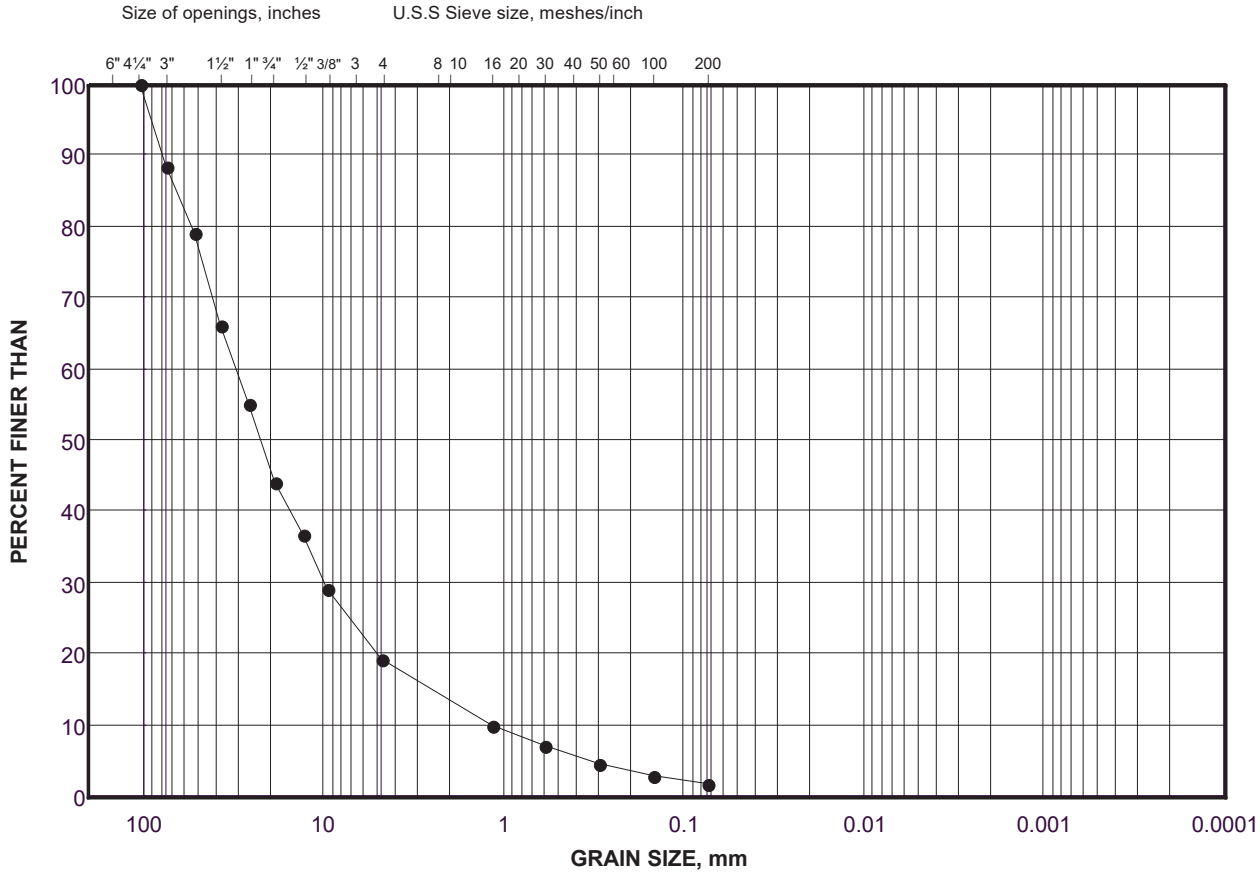
Golder Associates

Date: 22-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 53



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	13	17.98-20.12	59.00-66.00

REMARKS
Fineness Modulus= 7.14

Project Number: 1774274

Checked By:

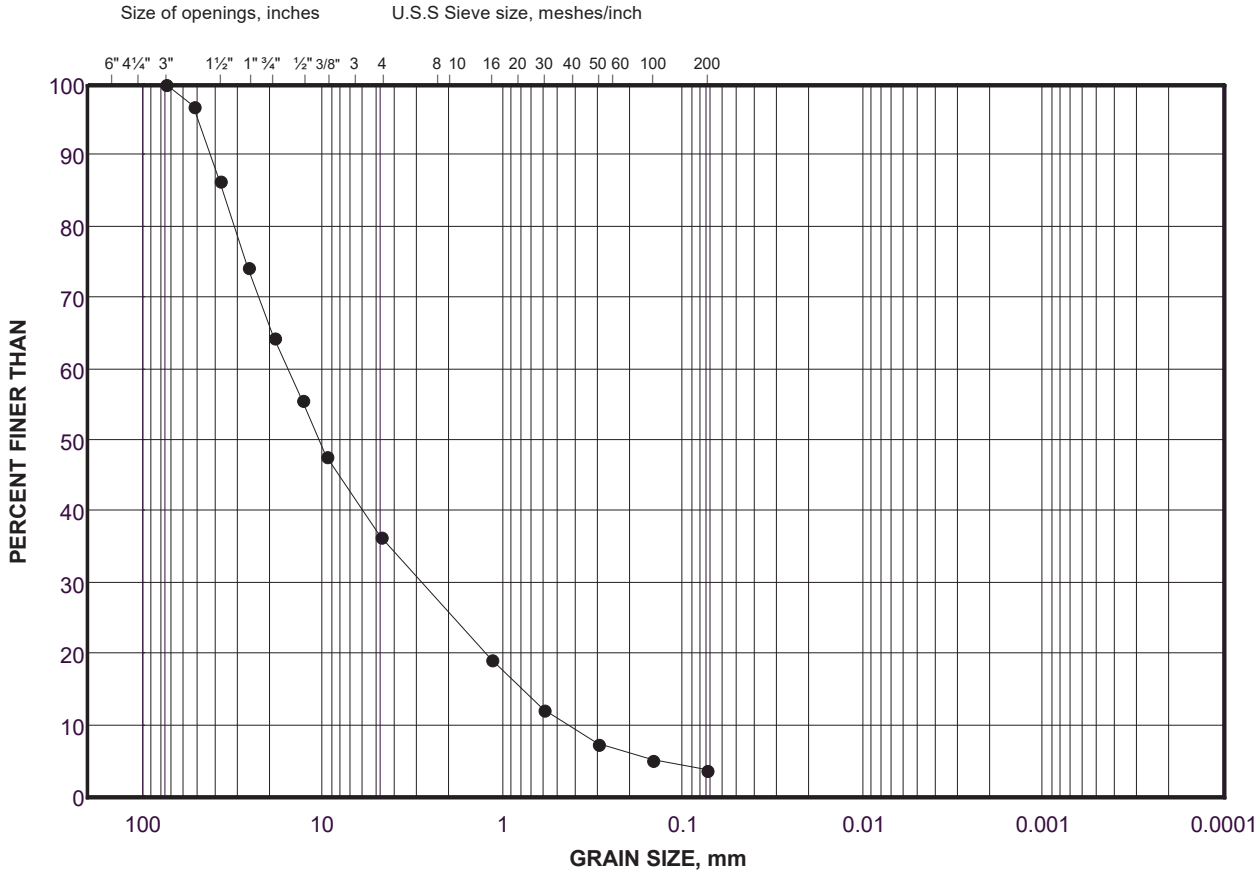
Golder Associates

Date: 22-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 54



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	14	20.12-21.03	66.00-69.00

REMARKS
Fineness Modulus= 5.94

Project Number: 1774274

Checked By:

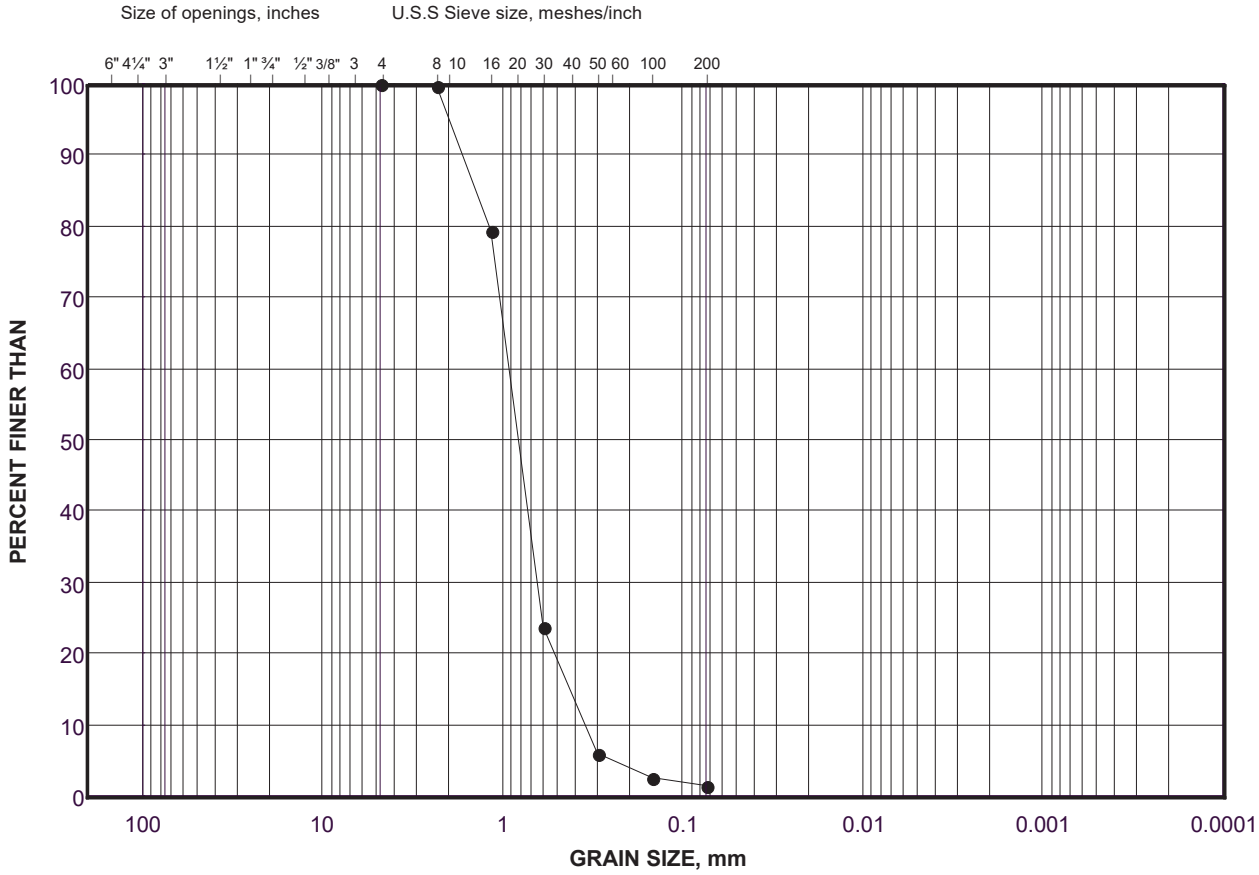
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 55



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	15	21.03-22.86	69.00-75.00

REMARKS
Fineness Modulus= 2.89

Project Number: 1774274

Checked By:

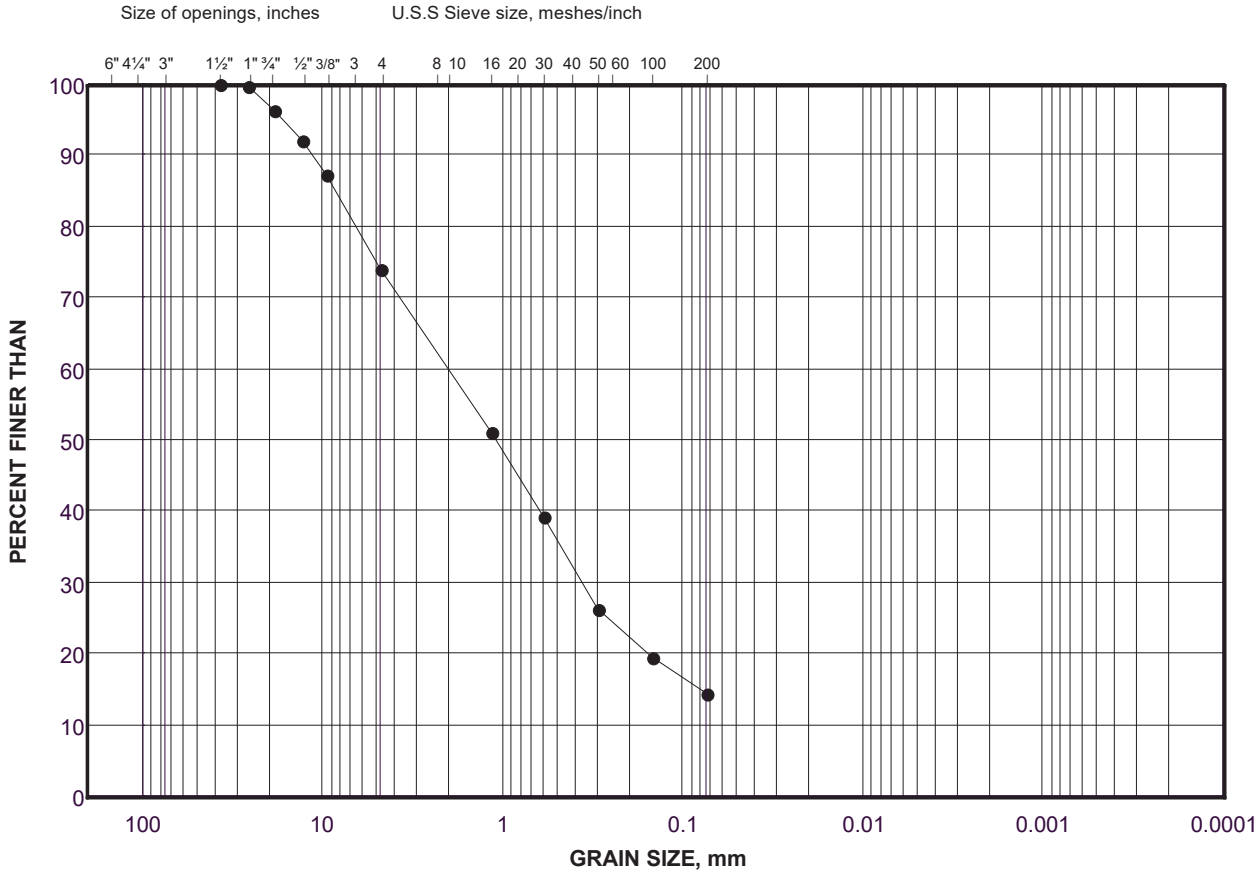
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 56



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	16	22.86-24.08	75.00-79.00

REMARKS
Fineness Modulus= 3.43

Project Number: 1774274

Checked By:

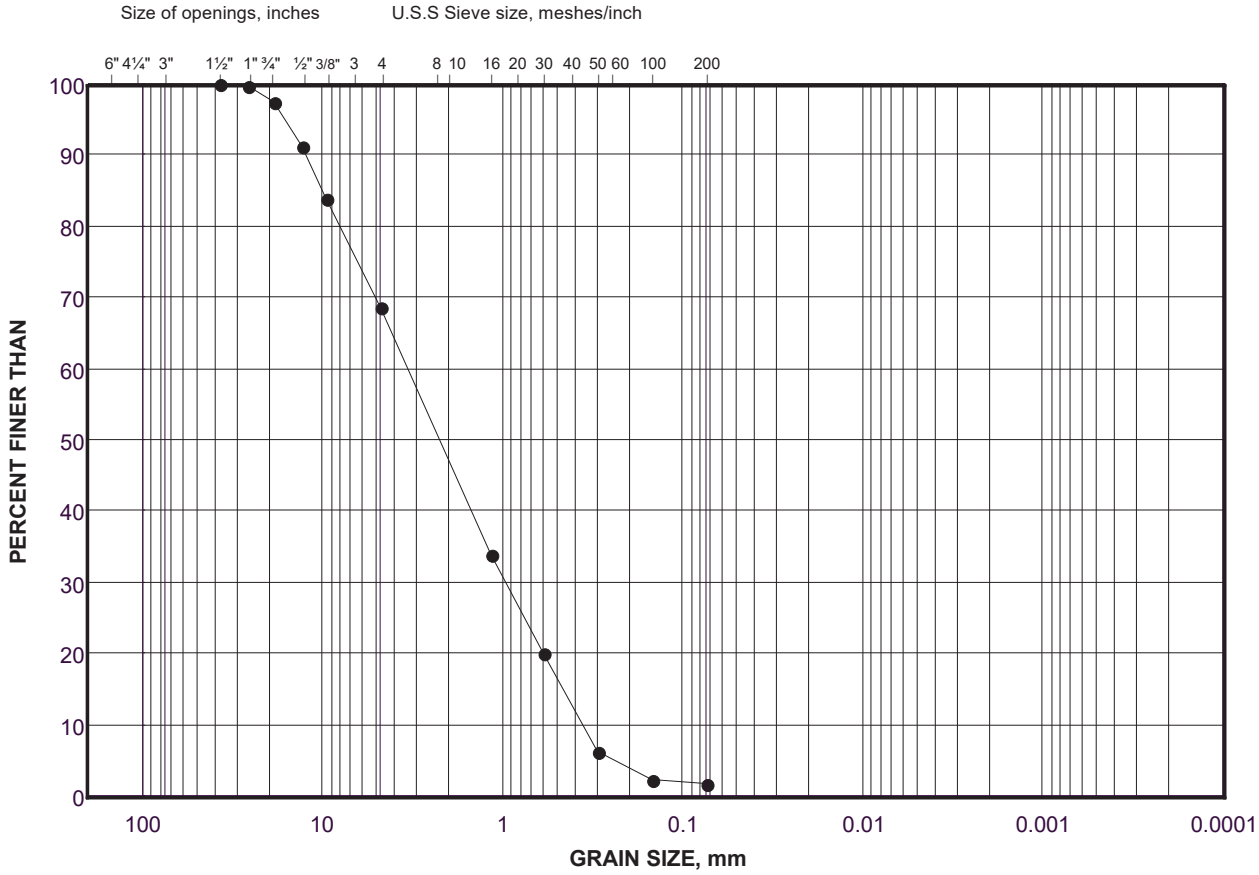
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 57



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	17	24.08-25.60	79.00-84.00

REMARKS
Fineness Modulus= 4.39

Project Number: 1774274

Checked By:

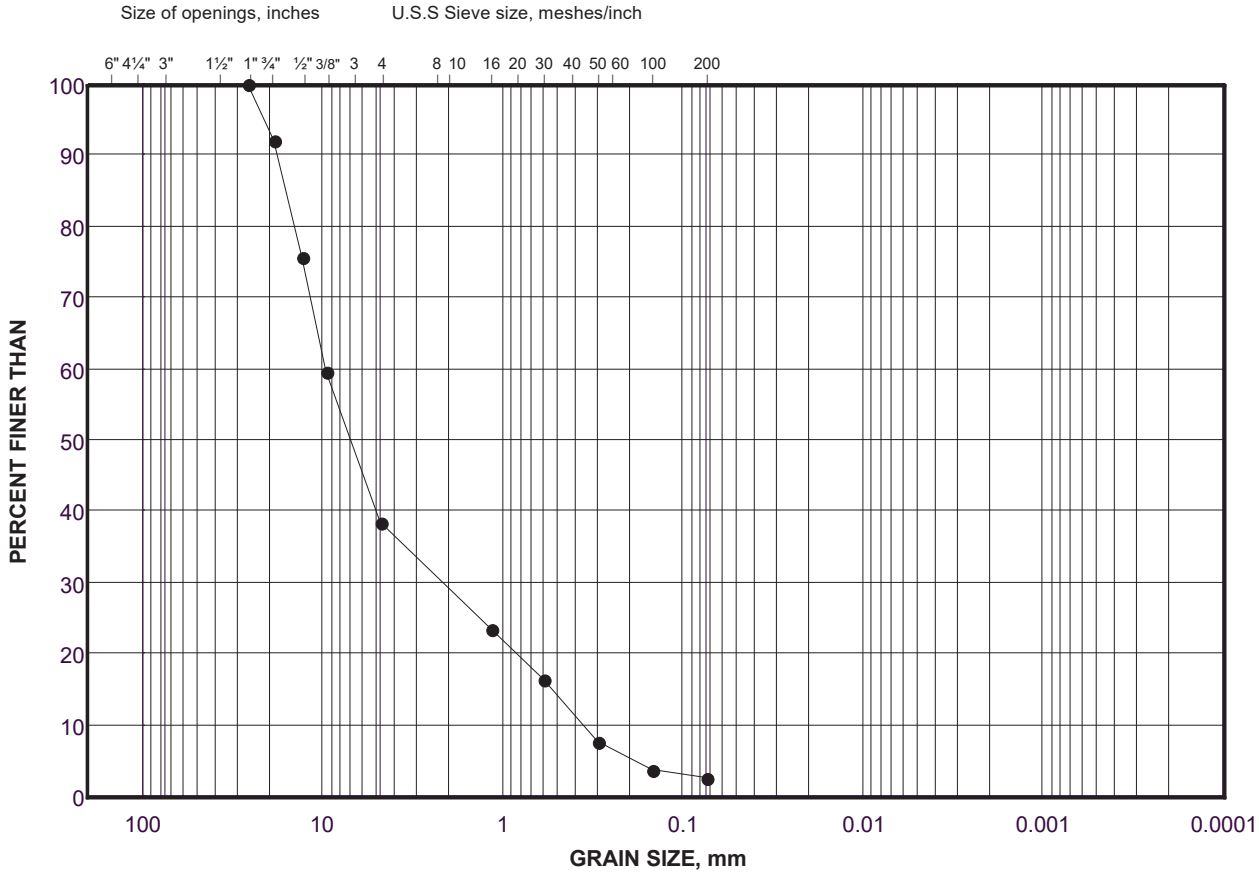
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 58



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	18A	25.60-25.91	84.00-85.00

REMARKS
Fineness Modulus= 5.29

Project Number: 1774274

Checked By:

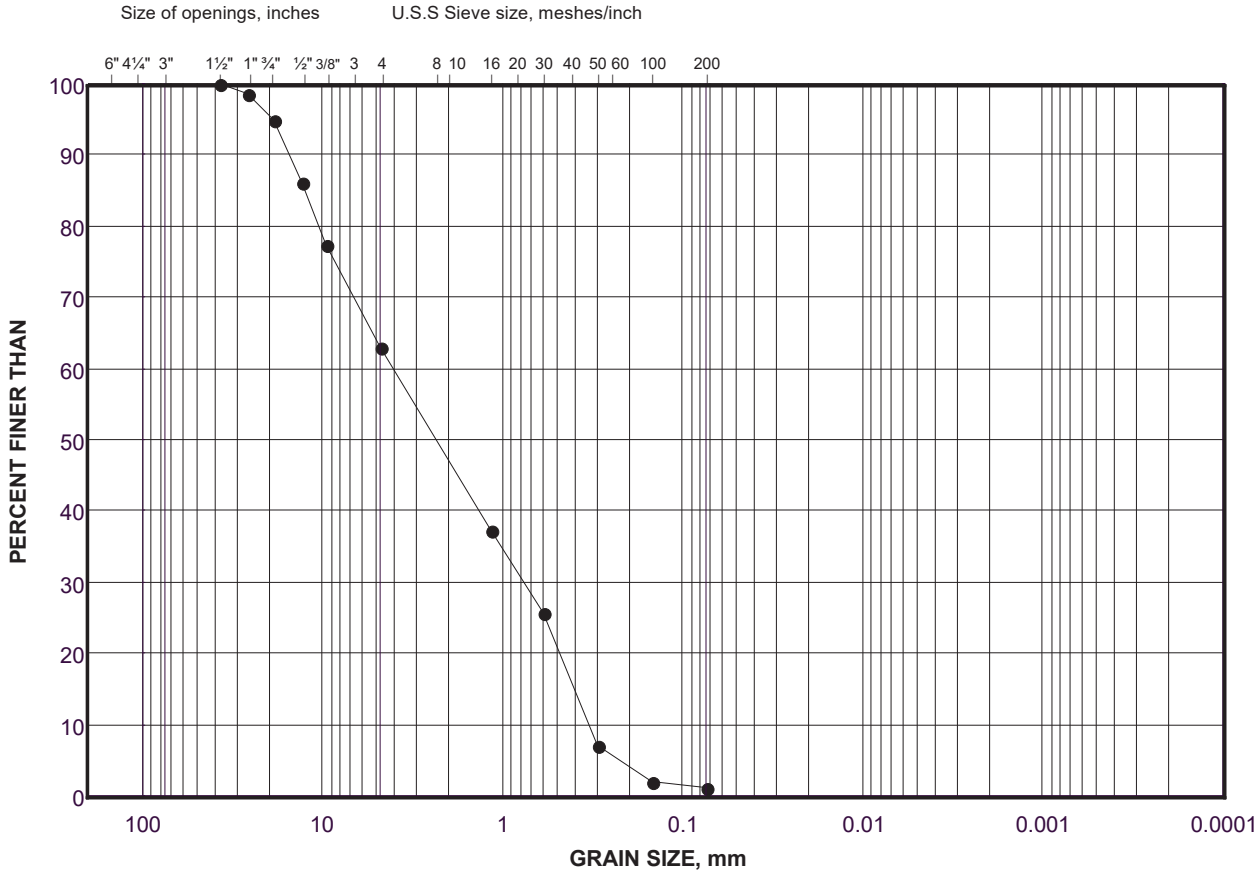
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 59



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	18C	26.21-27.13	86.00-89.00

REMARKS
Fineness Modulus= 4.42

Project Number: 1774274

Checked By:

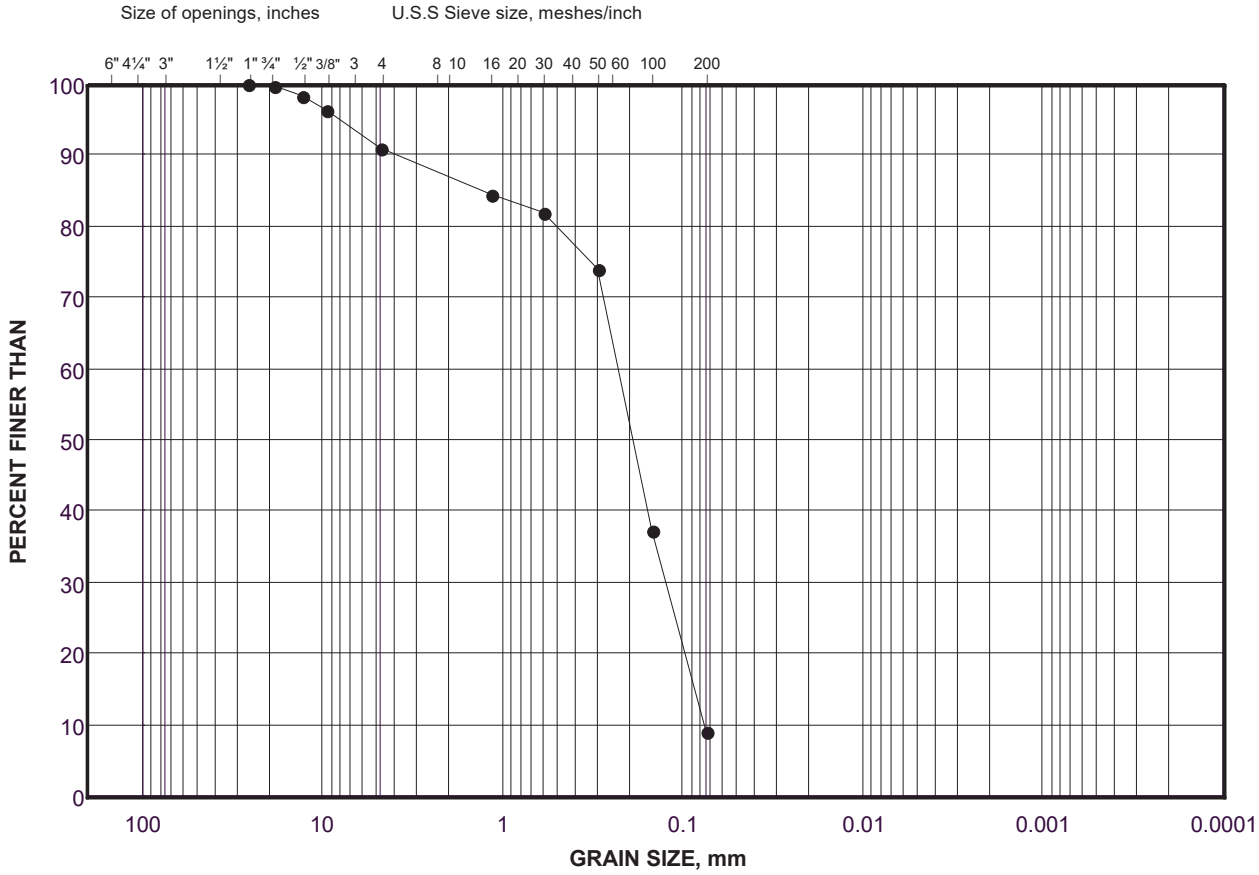
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 60



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	19A	27.13-28.50	89.00-93.50

REMARKS
Fineness Modulus= 1.48

Project Number: 1774274

Checked By:

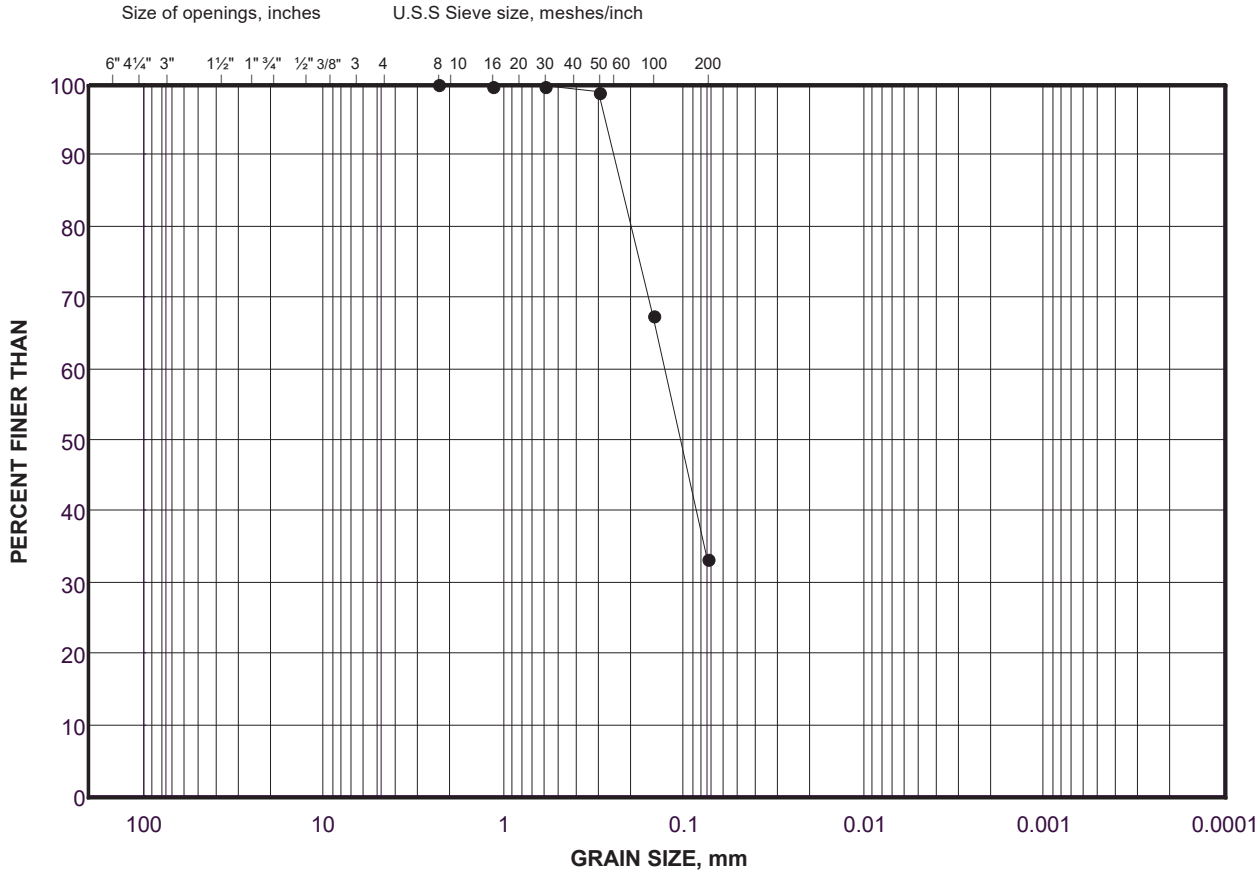
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 61



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	19B	28.50-28.96	93.50-95.00

REMARKS
Fineness Modulus= 0.34

Project Number: 1774274

Checked By:

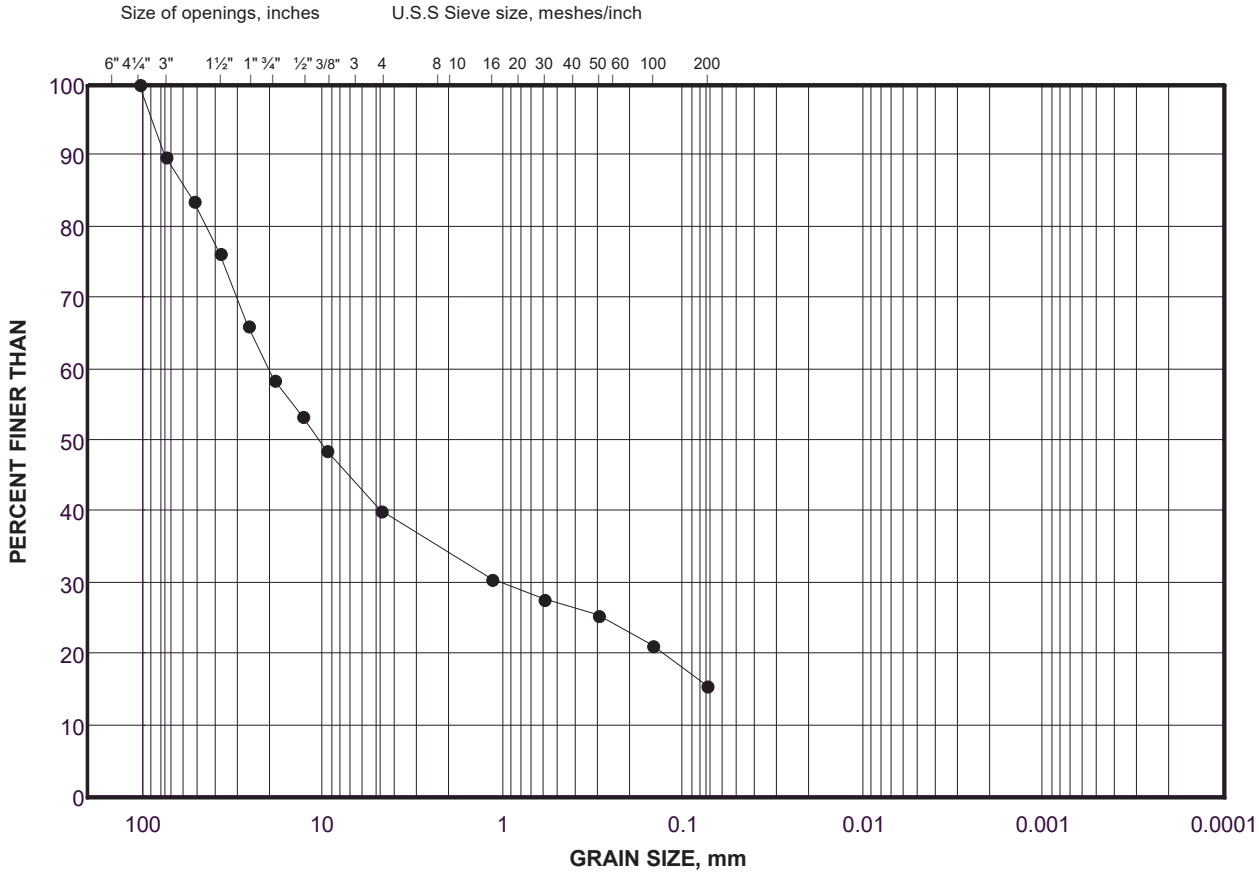
Golder Associates

Date: 22-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 62



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-03	20B	29.41-30.48	96.50-100.00

REMARKS
Fineness Modulus= 5.48

Project Number: 1774274

Checked By:

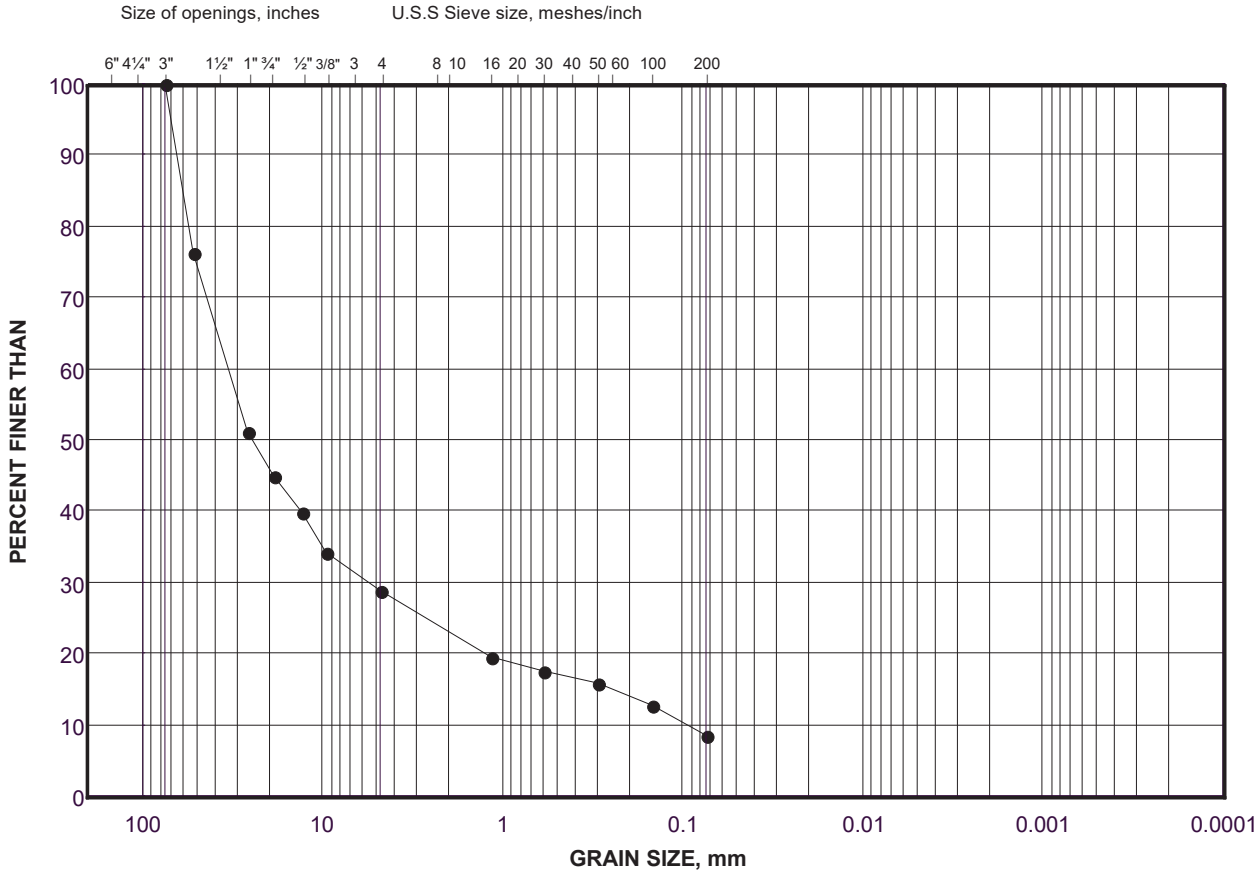
Golder Associates

Date: 22-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 63



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	1B	1.07-1.52	3.50-5.00

REMARKS
Fineness Modulus= 6.41

Project Number: 1774274

Checked By:

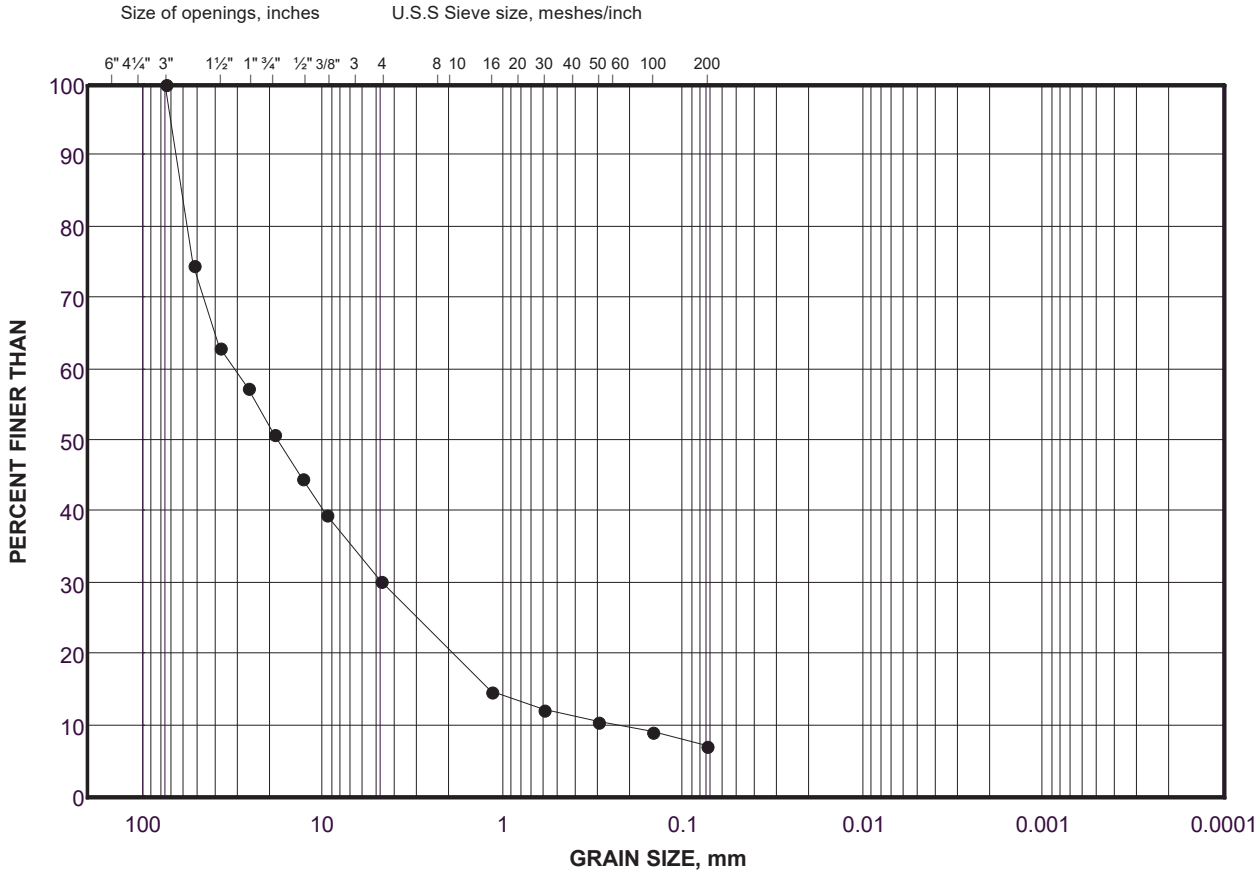
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 64



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	2	1.52-2.44	5.00-8.00

REMARKS
Fineness Modulus= 6.50

Project Number: 1774274

Checked By:

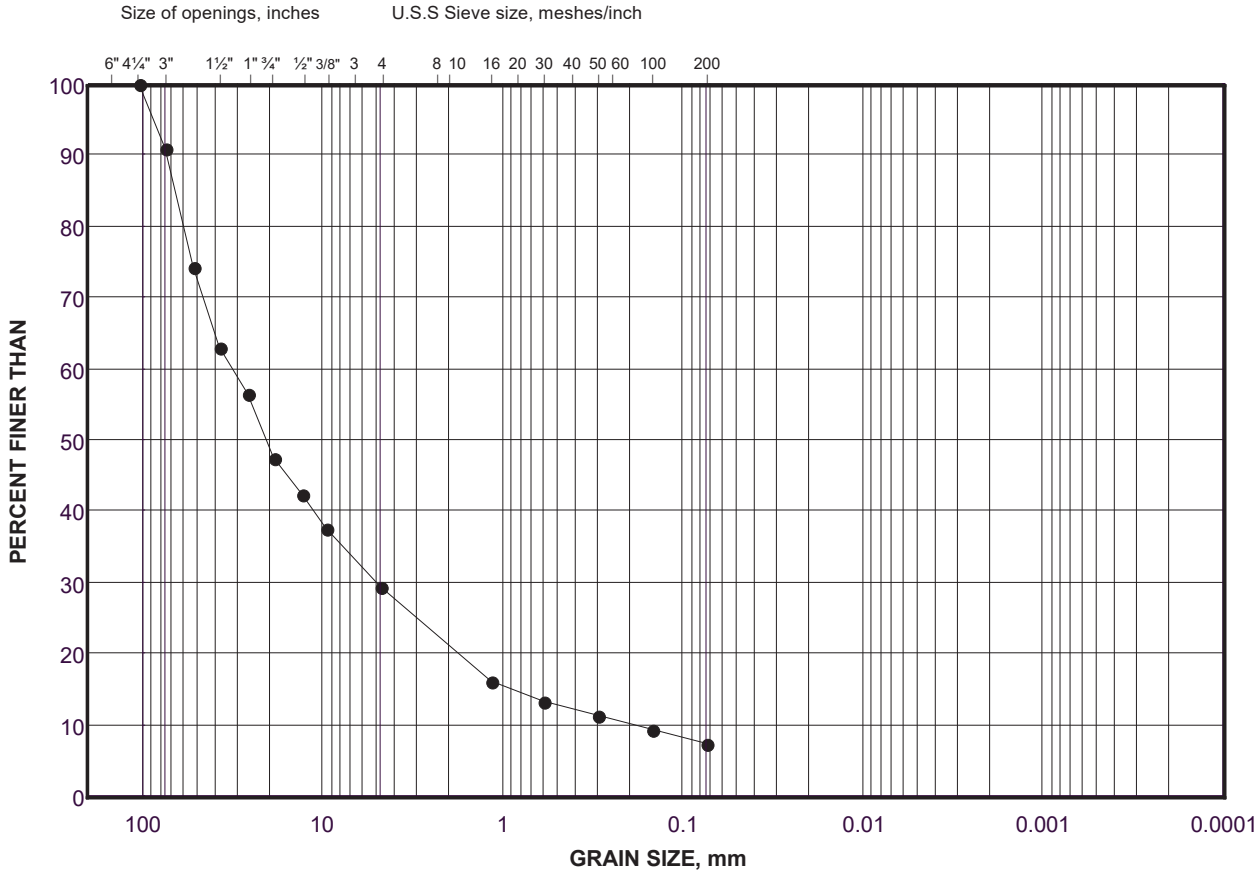
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 65



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	3	2.44-3.35	8.00-11.00

REMARKS
Fineness Modulus= 6.59

Project Number: 1774274

Checked By:

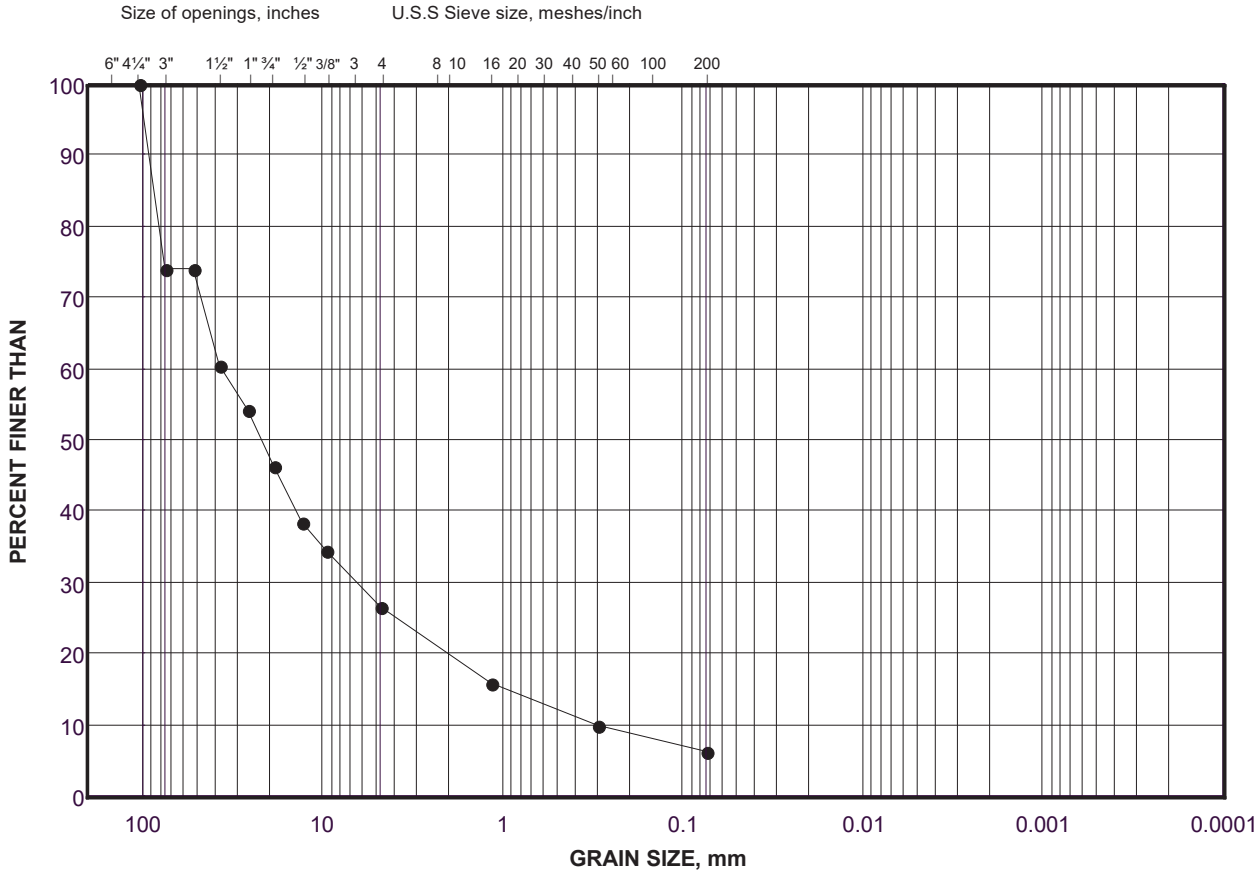
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 66



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	4	3.35-3.72	11.00-12.20

REMARKS
Fineness Modulus= 6.92

Project Number: 1774274

Checked By:

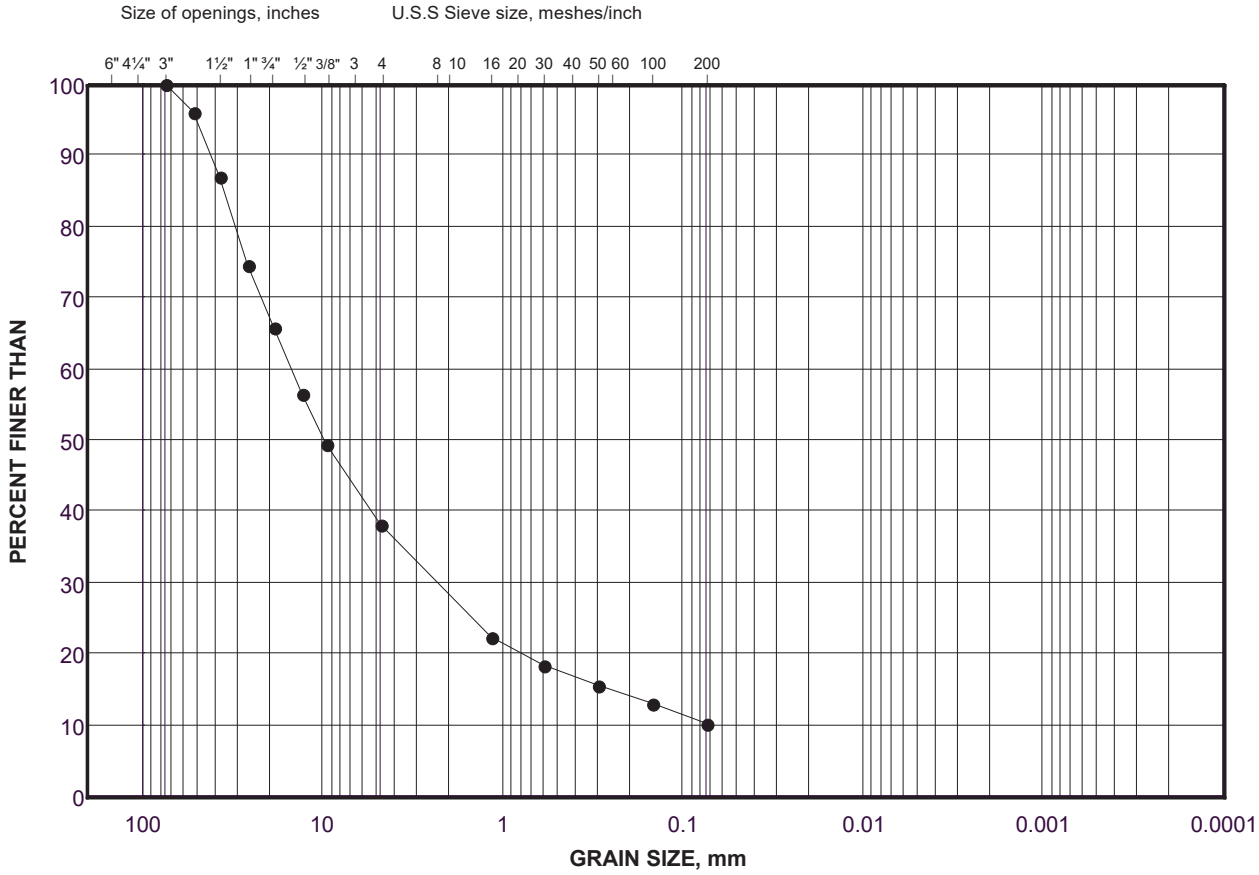
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 67



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	5A	4.27-5.09	14.00-16.70

REMARKS
Fineness Modulus= 5.61

Project Number: 1774274

Checked By:

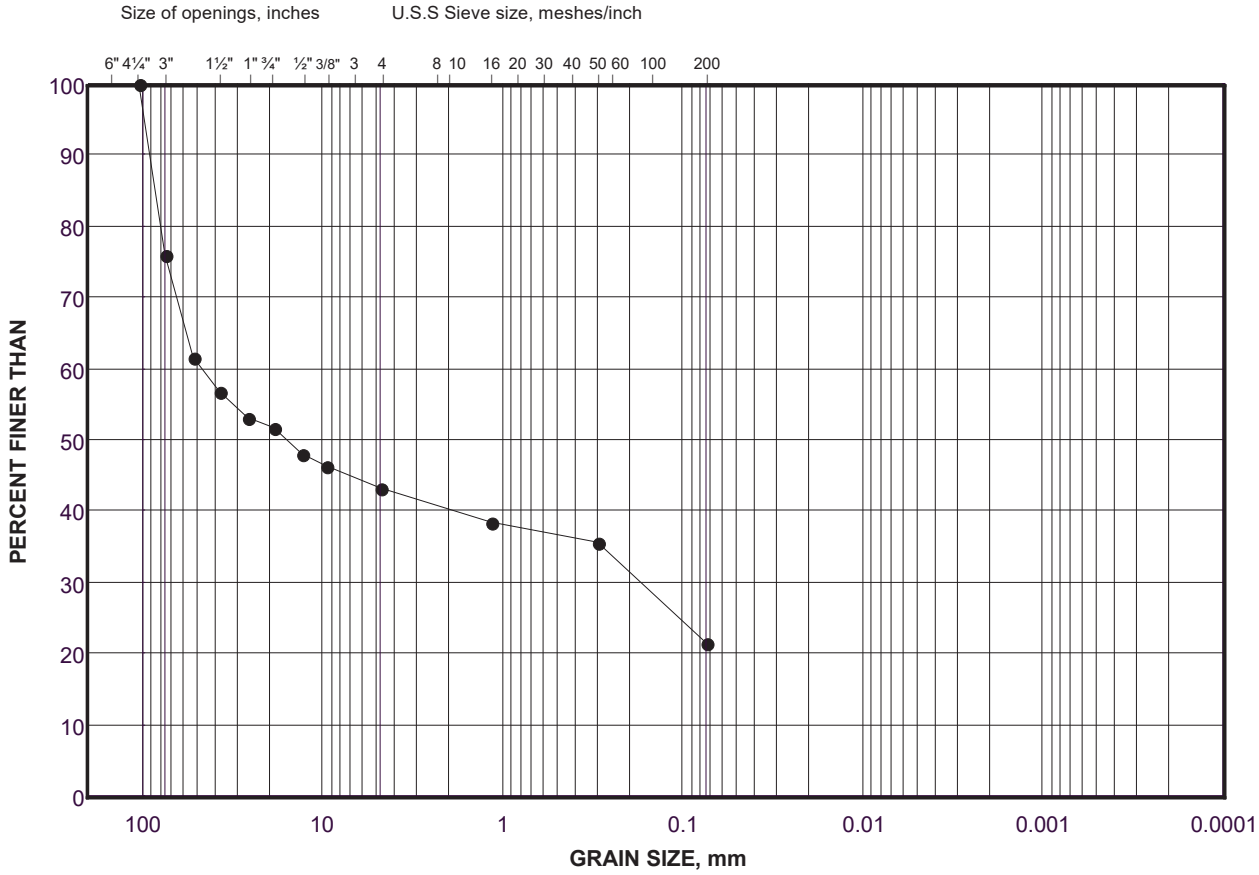
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 68



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	5B	5.09-5.49	16.70-18.00

REMARKS
Fineness Modulus= 5.43

Project Number: 1774274

Checked By:

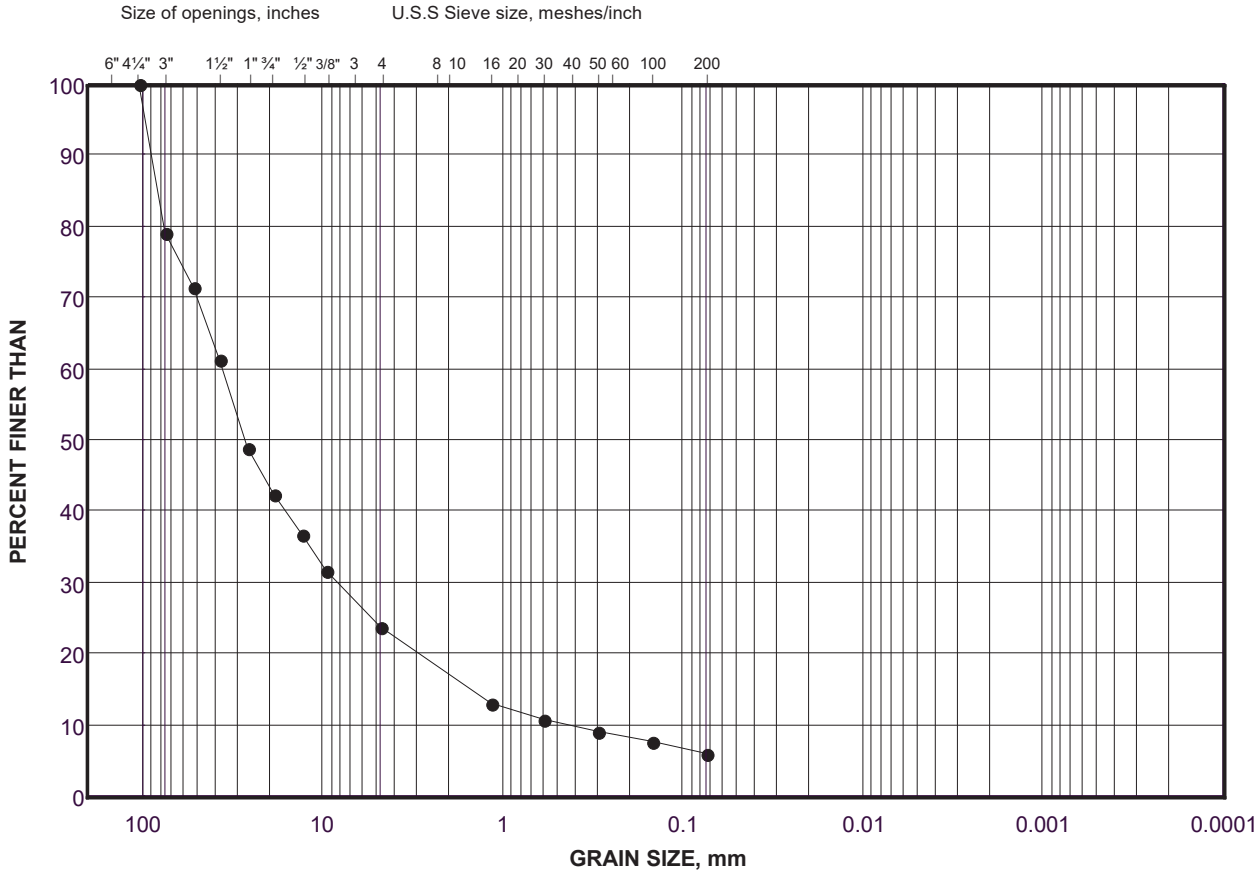
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 69



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	6	5.49-6.55	18.00-21.50

REMARKS
Fineness Modulus= 7.03

Project Number: 1774274

Checked By:

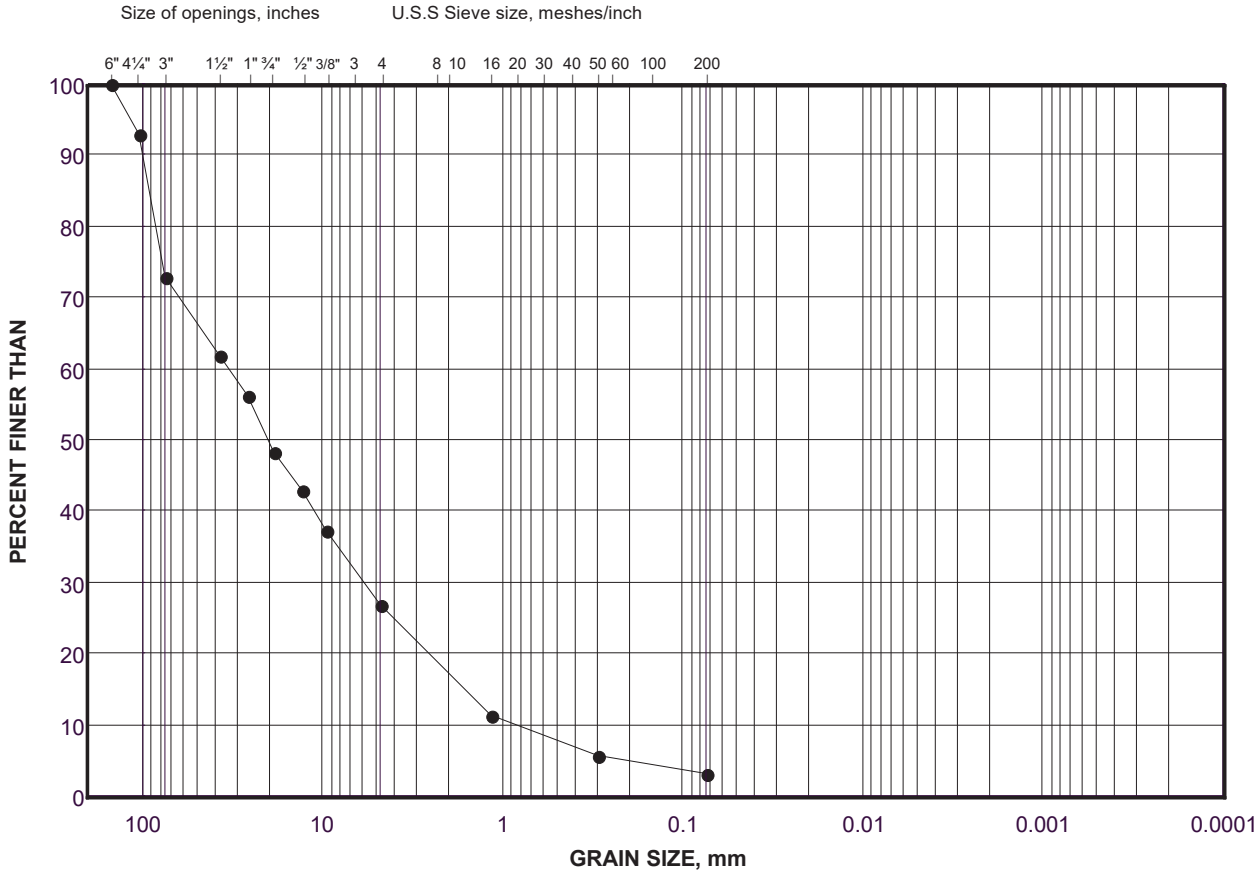
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 70



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	7	6.55-8.53	21.50-28.00

REMARKS
Fineness Modulus= 7.07

Project Number: 1774274

Checked By:

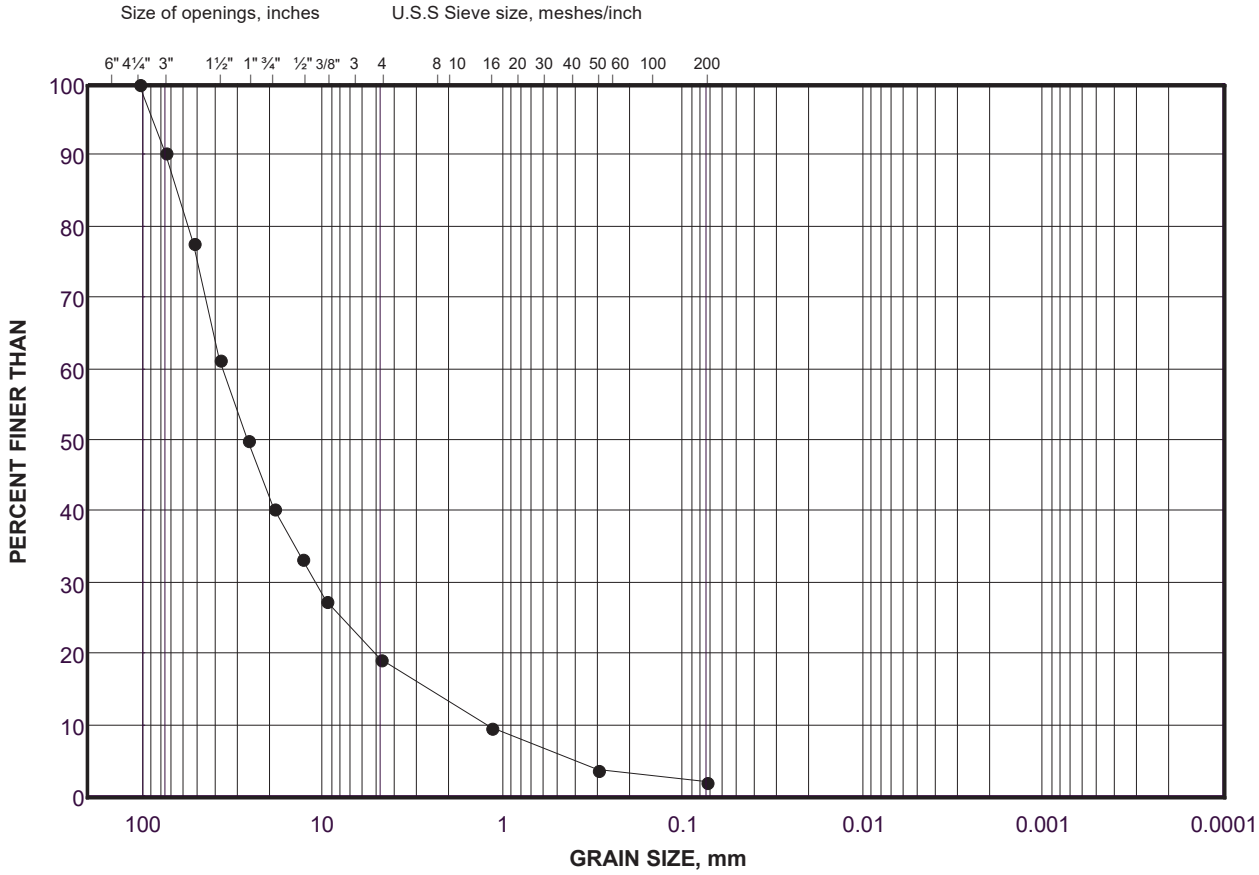
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 71



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	8	8.53-11.28	28.00-37.00

REMARKS
Fineness Modulus= 7.25

Project Number: 1774274

Checked By:

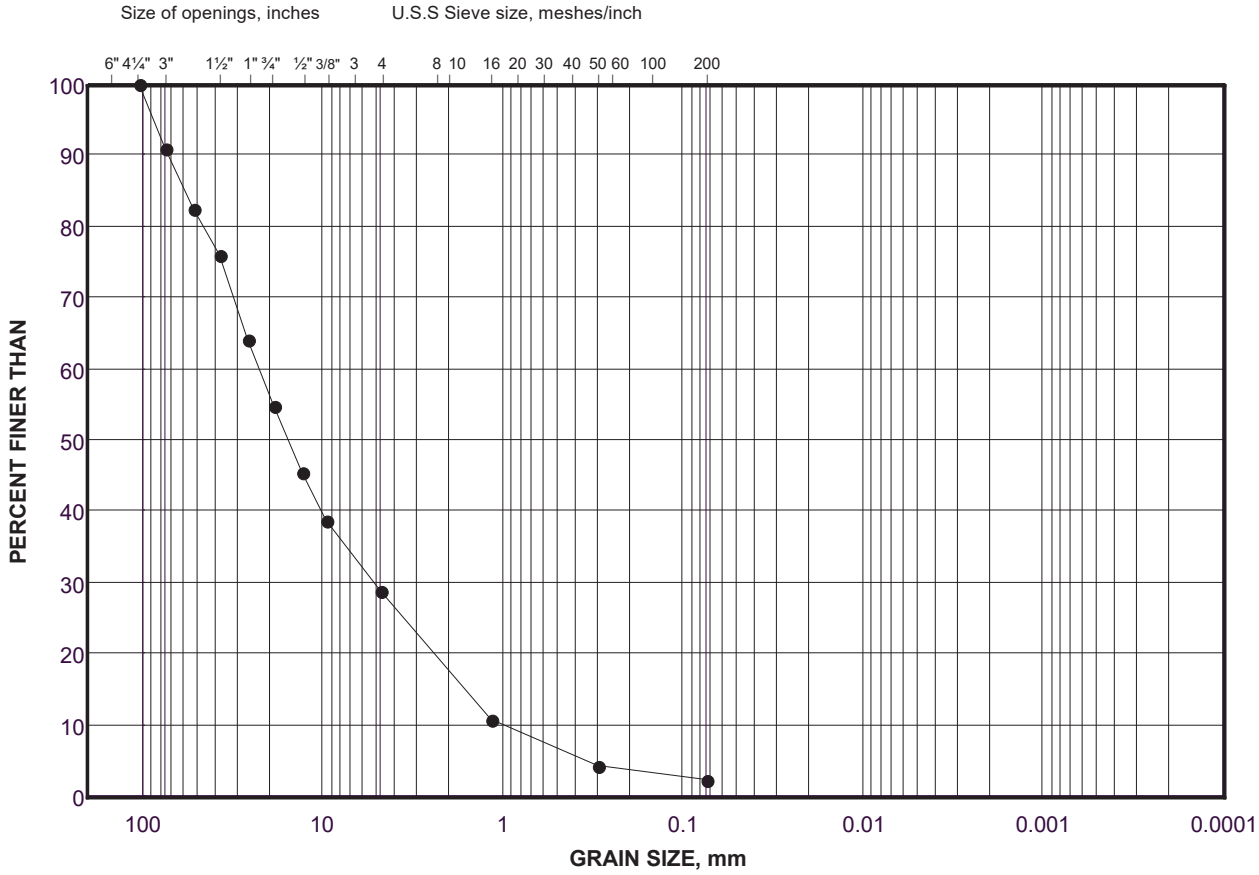
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 72



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	9	11.28-12.80	37.00-42.00

REMARKS
Fineness Modulus= 6.68

Project Number: 1774274

Checked By:

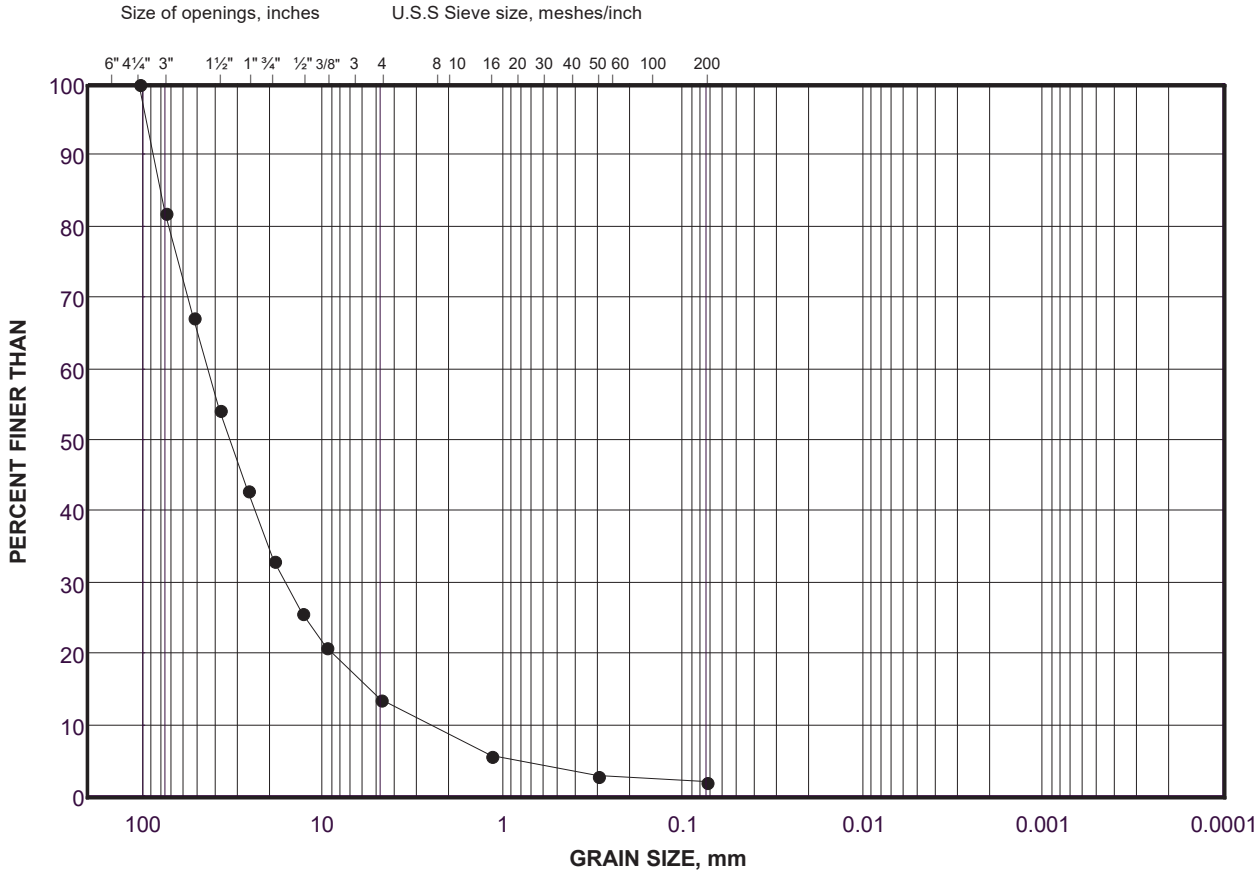
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 73



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	10	12.80-14.63	42.00-48.00

REMARKS
Fineness Modulus= 7.73

Project Number: 1774274

Checked By:

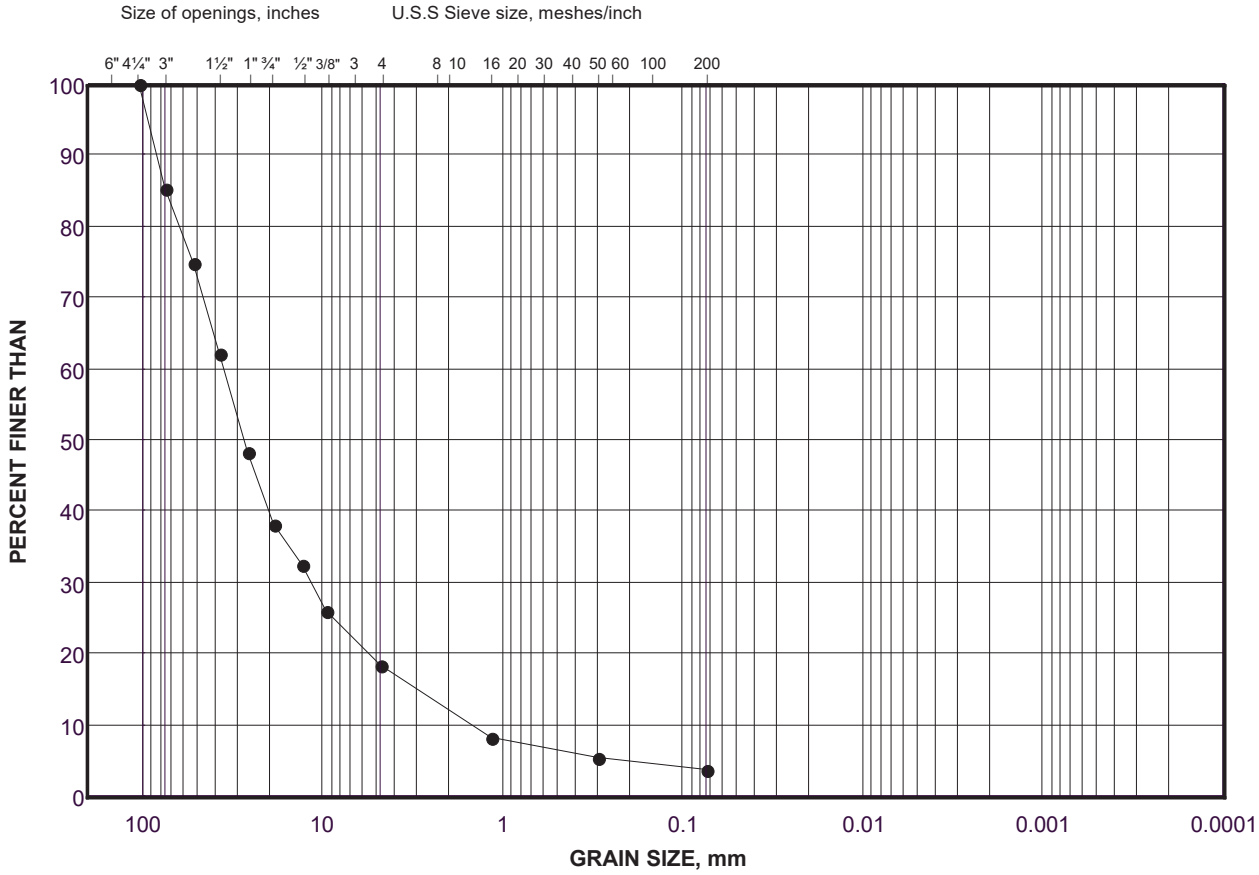
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 74



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	11	14.63-16.15	48.00-53.00

REMARKS
Fineness Modulus= 7.33

Project Number: 1774274

Checked By:

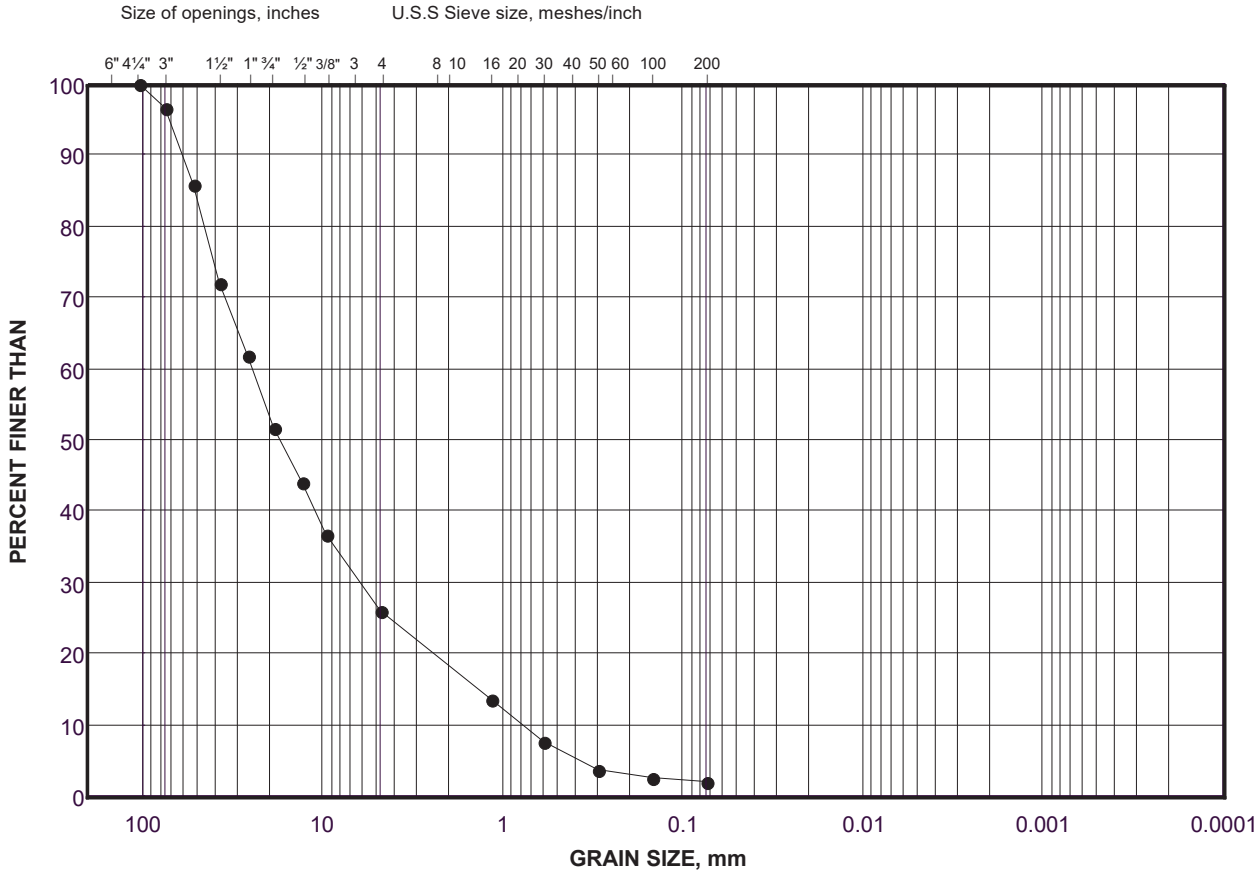
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 75



COBBLE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT AND CLAY SIZES
SIZE	GRAVEL SIZE		SAND SIZE			FINE GRAINED

LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	12	16.15-17.68	53.00-58.00

REMARKS
Fineness Modulus= 6.69

Project Number: 1774274

Checked By:

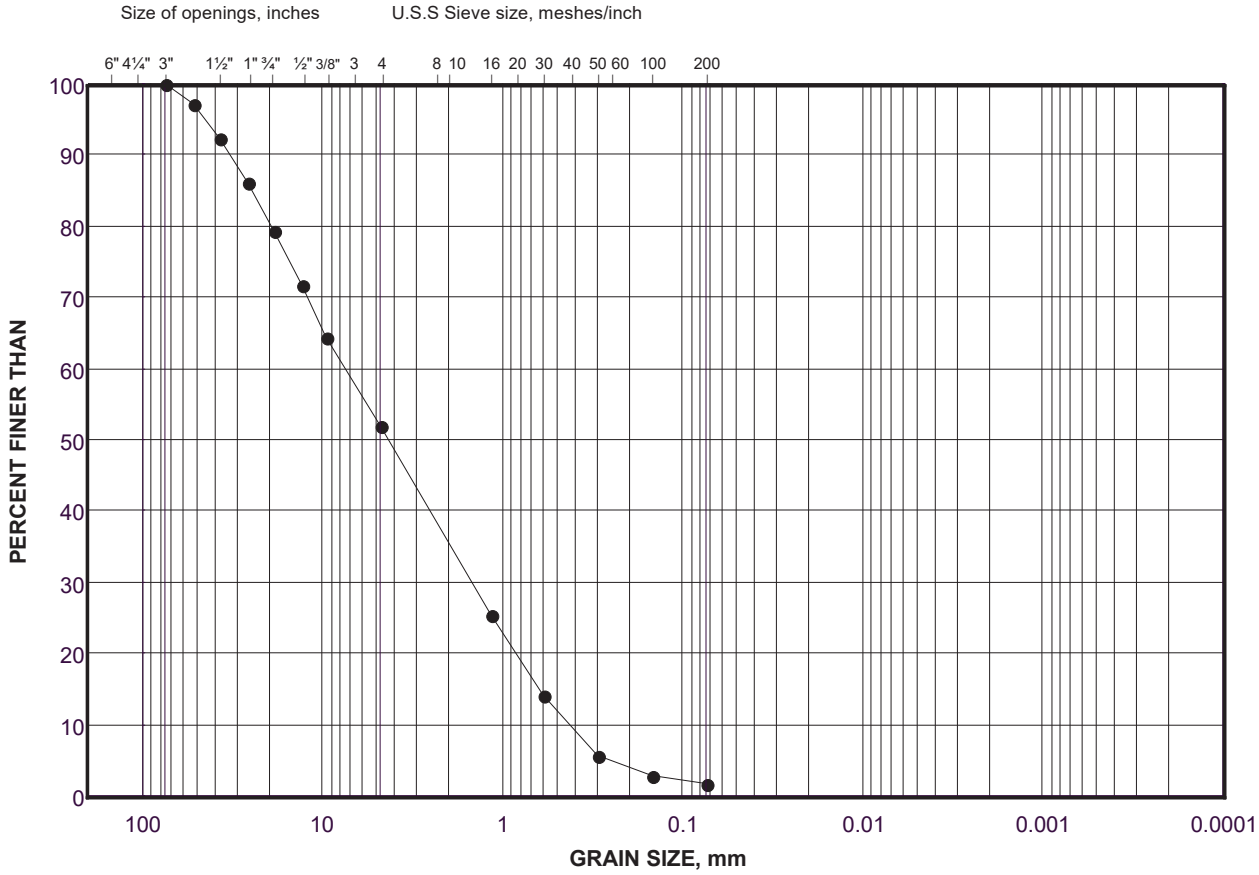
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 76



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	13	17.68-19.20	58.00-63.00

REMARKS
Fineness Modulus= 5.24

Project Number: 1774274

Checked By:

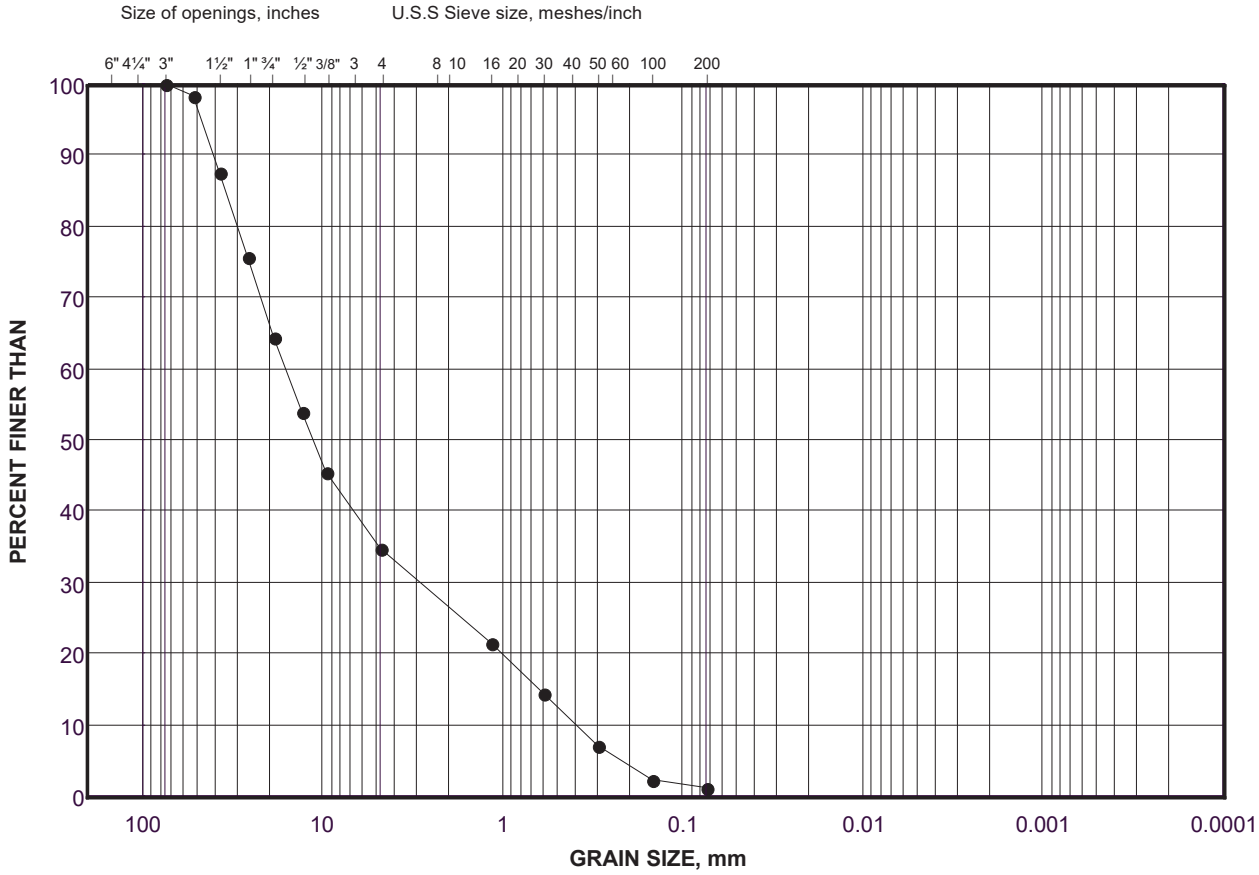
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 77



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	14	19.20-20.73	63.00-68.00

REMARKS
Fineness Modulus= 5.94

Project Number: 1774274

Checked By:

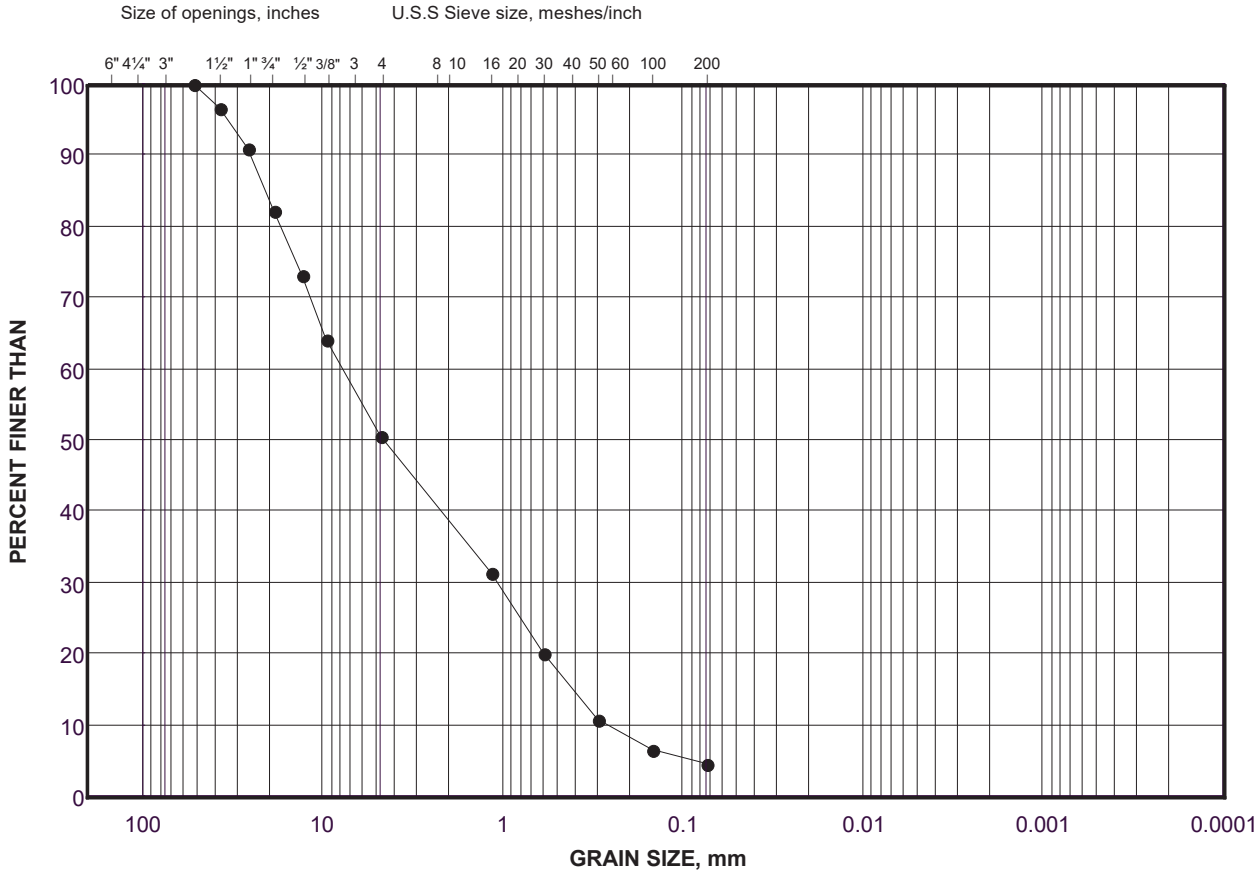
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 78



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	15	20.73-22.25	68.00-73.00

REMARKS
Fineness Modulus= 4.97

Project Number: 1774274

Checked By:

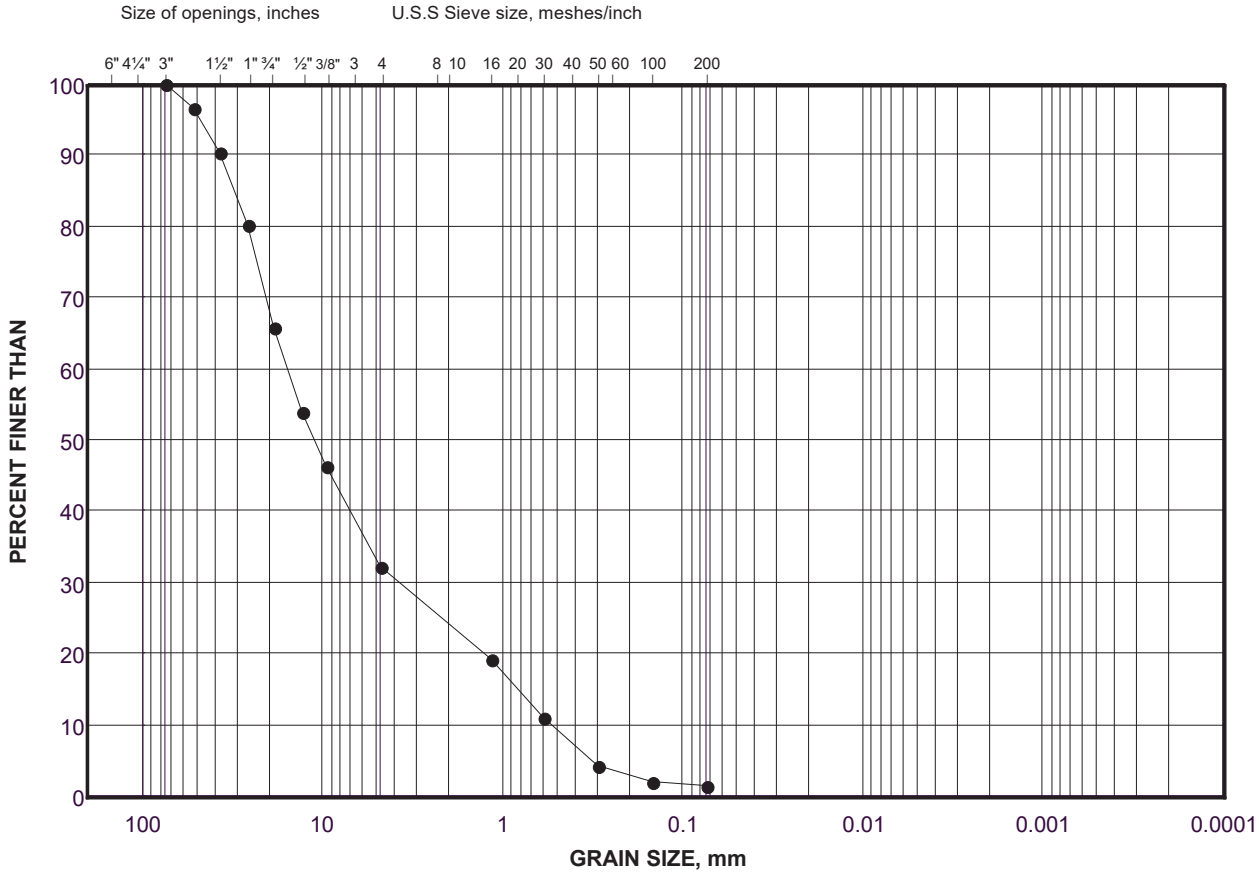
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 79



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	16A	22.86-23.32	75.00-76.50

REMARKS
Fineness Modulus= 6.03

Project Number: 1774274

Checked By:

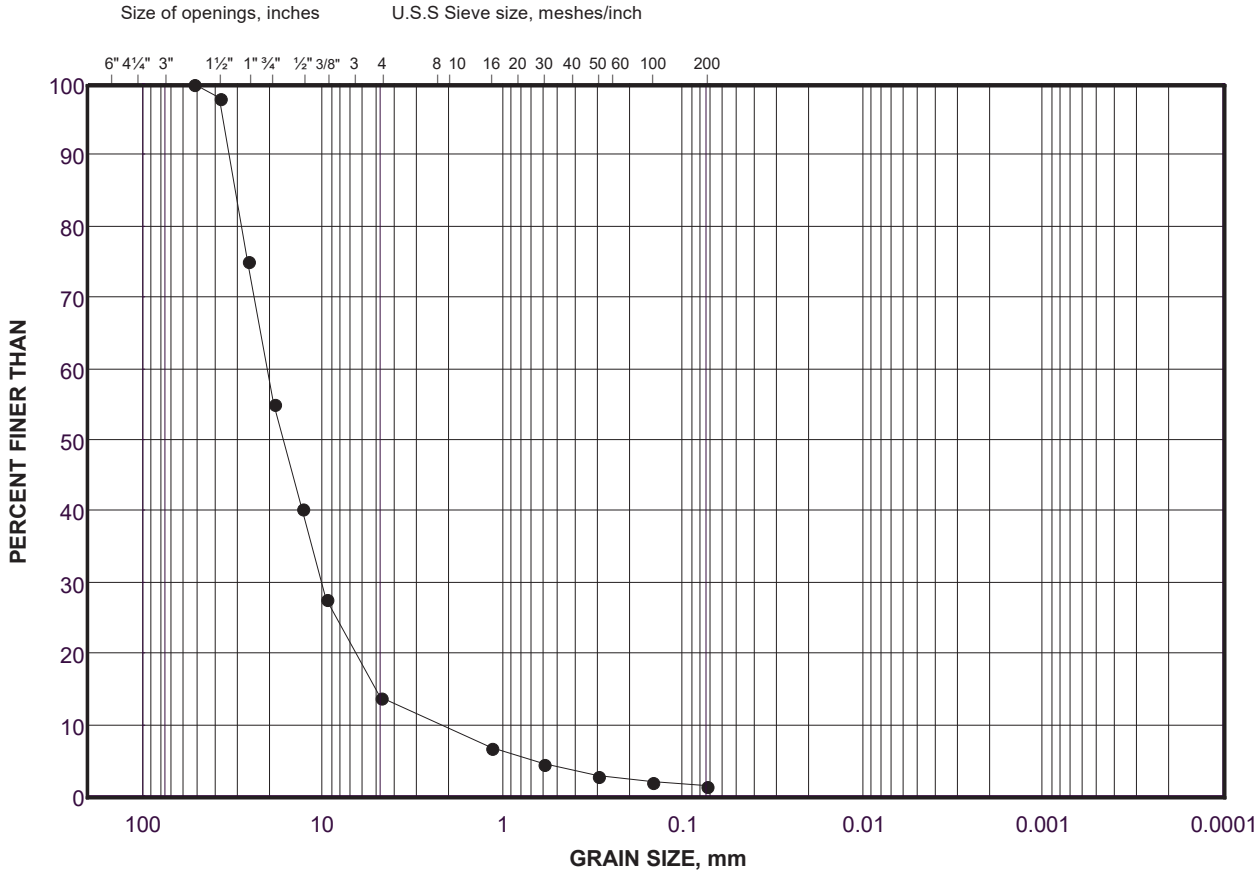
Golder Associates

Date: 20-Feb-19

GRAIN SIZE DISTRIBUTION

Lanci Pit Expansion

FIGURE 80



LEGEND

SYMBOL	BOREHOLE	SAMPLE	DEPTH(m)	DEPTH(ft)
●	BH17-04	16B	23.32-23.93	76.50-78.50

REMARKS
Fineness Modulus= 6.80

Project Number: 1774274

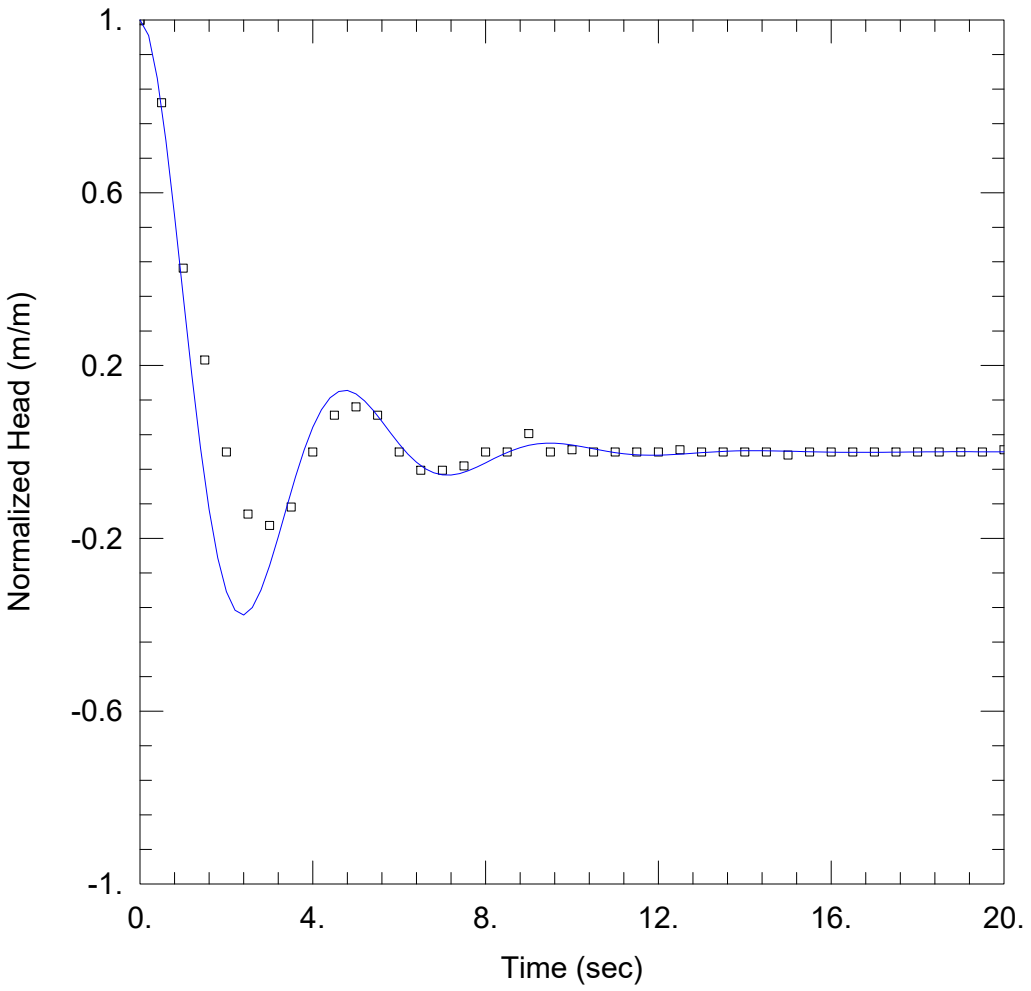
Checked By:

Golder Associates

Date: 20-Feb-19

APPENDIX D

Hydraulic Conductivity Testing



RISING HEAD TEST

Date: 05/02/19 Time: 13:21:02

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: CBM Aggregates
Project: 1774274
Location: Lanci Pit Expansion
Test Well: MW17-01
Test Date: June 28, 2018

AQUIFER DATA

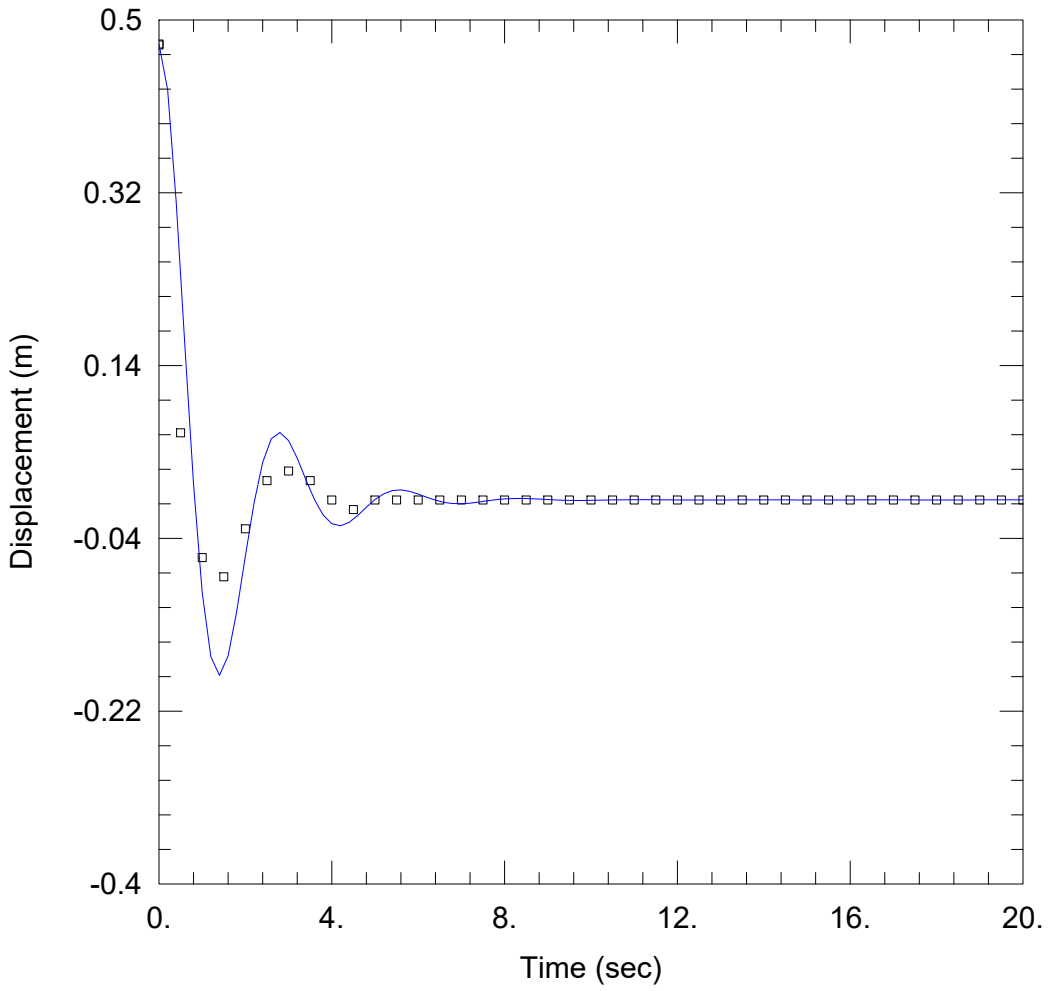
Saturated Thickness: 6.47 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW17-01)

Initial Displacement: 0.235 m
Total Well Penetration Depth: 6.47 m
Casing Radius: 0.0254 m
Static Water Column Height: 6.47 m
Screen Length: 3.1 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 0.0008007 m/sec
Le = 5.099 m



RISING HEAD TEST

Date: 05/02/19 Time: 13:30:08

PROJECT INFORMATION

Company: Golder Associates Ltd.
Client: CBM Aggregates
Project: 1774274
Location: Lanci Pit Expansion
Test Well: MW17-02
Test Date: June 28, 2018

AQUIFER DATA

Saturated Thickness: 5.64 m
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW17-02)

Initial Displacement: 0.475 m
Total Well Penetration Depth: 5.64 m
Casing Radius: 0.0254 m
Static Water Column Height: 5.64 m
Screen Length: 4.6 m
Well Radius: 0.076 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Springer-Gelhar
K = 0.0009342 m/sec
Le = 1.754 m

APPENDIX E

Groundwater Quality - Laboratory Certificates of Analysis

Maxxam
A Bureau Veritas Group Company

Your Project #: 1774274 LANCI
Site#: 1774274
Your C.O.C. #: 616700-01-01

Attention:Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
N6L 1C1

Report Date: 2017/06/28
Report #: R4562278
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7D0017
Received: 2017/06/21, 08:05

Sample Matrix: Water
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Alkalinity	4	N/A	2017/06/24	CAM SOP-00448	SM 22 2320 B m
Carbonate, Bicarbonate and Hydroxide	4	N/A	2017/06/26	CAM SOP-00102	APHA 4500-CO2 D
Chloride by Automated Colourimetry	3	N/A	2017/06/23	CAM SOP-00463	EPA 325.2 m
Chloride by Automated Colourimetry	1	N/A	2017/06/26	CAM SOP-00463	EPA 325.2 m
Conductivity	4	N/A	2017/06/24	CAM SOP-00414	SM 22 2510 m
Dissolved Organic Carbon (DOC) (1)	4	N/A	2017/06/23	CAM SOP-00446	SM 22 5310 B m
Petroleum Hydro. CCME F1 & BTEX in Water	4	N/A	2017/06/25	CAM SOP-00315	CCME PHC-CWS m
Petroleum Hydrocarbons F2-F4 in Water (2)	4	2017/06/26	2017/06/27	CAM SOP-00316	CCME PHC-CWS m
Hardness (calculated as CaCO3)	4	N/A	2017/06/27	CAM SOP 00102/00408/00447	SM 2340 B
Dissolved Mercury in Water by CVAA	4	2017/06/27	2017/06/27	CAM SOP-00453	EPA 7470A m
Dissolved Metals by ICPMS	4	N/A	2017/06/27	CAM SOP-00447	EPA 6020B m
Ion Balance (% Difference)	4	N/A	2017/06/27		
Anion and Cation Sum	4	N/A	2017/06/27		
Total Ammonia-N	4	N/A	2017/06/27	CAM SOP-00441	EPA GS I-2522-90 m
Nitrate (NO3) and Nitrite (NO2) in Water (3)	4	N/A	2017/06/23	CAM SOP-00440	SM 22 4500-NO3I/NO2B
pH	4	N/A	2017/06/24	CAM SOP-00413	SM 4500H+ B m
Orthophosphate	3	N/A	2017/06/23	CAM SOP-00461	EPA 365.1 m
Orthophosphate	1	N/A	2017/06/26	CAM SOP-00461	EPA 365.1 m
Sat. pH and Langelier Index (@ 20C)	4	N/A	2017/06/27		
Sat. pH and Langelier Index (@ 4C)	4	N/A	2017/06/27		
Sulphate by Automated Colourimetry	3	N/A	2017/06/23	CAM SOP-00464	EPA 375.4 m
Sulphate by Automated Colourimetry	1	N/A	2017/06/26	CAM SOP-00464	EPA 375.4 m
Total Dissolved Solids (TDS calc)	4	N/A	2017/06/27		

Remarks:

Maxxam Analytics' laboratories are accredited to ISO/IEC 17025:2005 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by Maxxam are based upon recognized Provincial, Federal or US method compendia such as CCME, MDDELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in Maxxam's profession using

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Your Project #: 1774274 LANCI
Site#: 1774274
Your C.O.C. #: 616700-01-01

Attention:Alexandra Smofsky

Golder Associates Ltd
309 Exeter Rd
Unit 1
London, ON
N6L 1C1

Report Date: 2017/06/28
Report #: R4562278
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B7D0017
Received: 2017/06/21, 08:05

accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and Maxxam in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported: unless indicated otherwise, associated sample data are not blank corrected.

Maxxam Analytics' liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. Maxxam has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by Maxxam, unless otherwise agreed in writing.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.

Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) Dissolved Organic Carbon (DOC) present in the sample should be considered as non-purgeable DOC.
(2) All CCME PHC results met required criteria unless otherwise stated in the report. The CWS PHC methods employed by Maxxam conform to all prescribed elements of the reference method and performance based elements have been validated. All modifications have been validated and proven equivalent following "Alberta Environment's Interpretation of the Reference Method for the Canada-Wide Standard for Petroleum Hydrocarbons in Soil Validation of Performance-Based Alternative Methods September 2003". Documentation is available upon request. Modifications from Reference Method for the Canada-wide Standard for Petroleum Hydrocarbons in Soil-Tier 1 Method: F2/F3/F4 data reported using validated cold solvent extraction instead of Soxhlet extraction.
(3) Values for calculated parameters may not appear to add up due to rounding of raw data and significant figures.

Encryption Key

Christine Gripton
Senior Project Manager
28 Jun 2017 16:32:51

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Christine Gripton, Senior Project Manager
Email: CGripton@maxxam.ca
Phone# (800)268-7396 Ext:250

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

RCAP - COMPREHENSIVE (WATER)

Maxxam ID			EPL557		EPL558		EPL559		
Sampling Date			2017/06/20 11:30		2017/06/20 12:15		2017/06/20 13:00		
COC Number			616700-01-01		616700-01-01		616700-01-01		
	UNITS	Criteria	GL-7	QC Batch	GL-8	QC Batch	MW17-01	RDL	QC Batch
Calculated Parameters									
Anion Sum	me/L	-	7.50	5039380	8.11	5039380	8.21	N/A	5039380
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	-	180	5039478	250	5039478	270	1.0	5039478
Calculated TDS	mg/L	-	400	5038292	410	5038292	420	1.0	5038292
Carb. Alkalinity (calc. as CaCO3)	mg/L	-	2.3	5039478	3.7	5039478	3.2	1.0	5039478
Cation Sum	me/L	-	7.41	5039380	7.68	5039380	7.93	N/A	5039380
Hardness (CaCO3)	mg/L	-	260	5039730	290	5039730	320	1.0	5039730
Ion Balance (% Difference)	%	-	0.600	5038966	2.78	5038966	1.73	N/A	5038966
Langelier Index (@ 20C)	N/A	-	0.736	5038290	0.890	5038290	0.966		5038290
Langelier Index (@ 4C)	N/A	-	0.487	5038291	0.642	5038291	0.717		5038291
Saturation pH (@ 20C)	N/A	-	7.38	5038290	7.30	5038290	7.14		5038290
Saturation pH (@ 4C)	N/A	-	7.63	5038291	7.55	5038291	7.38		5038291
Inorganics									
Total Ammonia-N	mg/L	-	0.050	5042636	0.071	5042636	<0.050	0.050	5042636
Conductivity	umho/cm	-	740	5042856	760	5042856	770	1.0	5042856
Dissolved Organic Carbon	mg/L	-	0.39	5042767	0.67	5042767	0.60	0.20	5042767
Orthophosphate (P)	mg/L	-	<0.010	5042006	<0.010	5043840	<0.010	0.010	5042006
pH	pH	-	8.11	5042838	8.19	5042838	8.10		5042838
Dissolved Sulphate (SO4)	mg/L	-	37	5042001	31	5043838	30	1.0	5042001
Alkalinity (Total as CaCO3)	mg/L	-	190	5042848	260	5042848	270	1.0	5042848
Dissolved Chloride (Cl)	mg/L	**790**	110	5041994	77	5043837	76	1.0	5041994
Nitrite (N)	mg/L	-	<0.010	5042566	<0.010	5041376	<0.010	0.010	5041376
Nitrate (N)	mg/L	-	0.76	5042566	2.18	5041376	1.12	0.10	5041376
Nitrate + Nitrite (N)	mg/L	-	0.76	5042566	2.18	5041376	1.12	0.10	5041376
Metals									
Dissolved Aluminum (Al)	ug/L	-	5.1	5043417	5.3	5043417	7.3	5.0	5043417
Dissolved Antimony (Sb)	ug/L	**6.0**	<0.50	5043417	<0.50	5043417	<0.50	0.50	5043417
Dissolved Arsenic (As)	ug/L	**25**	<1.0	5043417	<1.0	5043417	<1.0	1.0	5043417
Dissolved Barium (Ba)	ug/L	**1000**	85	5043417	48	5043417	92	2.0	5043417
Dissolved Beryllium (Be)	ug/L	**4.0**	<0.50	5043417	<0.50	5043417	<0.50	0.50	5043417
Dissolved Boron (B)	ug/L	**5000**	11	5043417	22	5043417	18	10	5043417
Dissolved Cadmium (Cd)	ug/L	**2.7**	<0.10	5043417	<0.10	5043417	<0.10	0.10	5043417

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)
Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition
Potable Ground Water- All Types of Property Uses - Medium and Fine Texture Soil
N/A = Not Applicable

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

RCAP - COMPREHENSIVE (WATER)

Maxxam ID			EPL557		EPL558		EPL559		
Sampling Date			2017/06/20 11:30		2017/06/20 12:15		2017/06/20 13:00		
COC Number			616700-01-01		616700-01-01		616700-01-01		
	UNITS	Criteria	GL-7	QC Batch	GL-8	QC Batch	MW17-01	RDL	QC Batch
Dissolved Calcium (Ca)	ug/L	-	63000	5043417	55000	5043417	77000	200	5043417
Dissolved Chromium (Cr)	ug/L	**50**	<5.0	5043417	<5.0	5043417	<5.0	5.0	5043417
Dissolved Cobalt (Co)	ug/L	**3.8**	<0.50	5043417	1.2	5043417	<0.50	0.50	5043417
Dissolved Copper (Cu)	ug/L	**87**	<1.0	5043417	4.8	5043417	1.5	1.0	5043417
Dissolved Iron (Fe)	ug/L	-	<100	5043417	<100	5043417	<100	100	5043417
Dissolved Lead (Pb)	ug/L	**10**	<0.50	5043417	<0.50	5043417	<0.50	0.50	5043417
Dissolved Magnesium (Mg)	ug/L	-	26000	5043417	38000	5043417	31000	50	5043417
Dissolved Manganese (Mn)	ug/L	-	5.8	5043417	47	5043417	48	2.0	5043417
Dissolved Molybdenum (Mo)	ug/L	**70**	1.2	5043417	3.9	5043417	2.7	0.50	5043417
Dissolved Nickel (Ni)	ug/L	**100**	<1.0	5043417	1.1	5043417	<1.0	1.0	5043417
Dissolved Phosphorus (P)	ug/L	-	<100	5043417	<100	5043417	<100	100	5043417
Dissolved Potassium (K)	ug/L	-	2000	5043417	2100	5043417	1400	200	5043417
Dissolved Selenium (Se)	ug/L	**10**	<2.0	5043417	<2.0	5043417	<2.0	2.0	5043417
Dissolved Silicon (Si)	ug/L	-	2900	5043417	2300	5043417	3300	50	5043417
Dissolved Silver (Ag)	ug/L	**1.5**	<0.10	5043417	<0.10	5043417	<0.10	0.10	5043417
Dissolved Sodium (Na)	ug/L	**490000**	48000	5043417	41000	5043417	35000	100	5043417
Dissolved Strontium (Sr)	ug/L	-	110	5043417	150	5043417	110	1.0	5043417
Dissolved Thallium (Tl)	ug/L	**2.0**	0.064	5043417	<0.050	5043417	<0.050	0.050	5043417
Dissolved Titanium (Ti)	ug/L	-	<5.0	5043417	<5.0	5043417	<5.0	5.0	5043417
Dissolved Uranium (U)	ug/L	**20**	0.75	5043417	0.21	5043417	0.48	0.10	5043417
Dissolved Vanadium (V)	ug/L	**6.2**	<0.50	5043417	<0.50	5043417	<0.50	0.50	5043417
Dissolved Zinc (Zn)	ug/L	**1100**	59	5043417	23	5043417	96	5.0	5043417

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)
Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition
Potable Ground Water- All Types of Property Uses - Medium and Fine Texture Soil

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

RCAP - COMPREHENSIVE (WATER)

Maxxam ID			EPL560	EPL560		
Sampling Date			2017/06/20 14:15	2017/06/20 14:15		
COC Number			616700-01-01	616700-01-01		
	UNITS	Criteria	MW17-02	MW17-02 Lab-Dup	RDL	QC Batch
Calculated Parameters						
Anion Sum	me/L	-	7.45		N/A	5039380
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	-	190		1.0	5039478
Calculated TDS	mg/L	-	400		1.0	5038292
Carb. Alkalinity (calc. as CaCO3)	mg/L	-	2.6		1.0	5039478
Cation Sum	me/L	-	7.19		N/A	5039380
Hardness (CaCO3)	mg/L	-	260		1.0	5039730
Ion Balance (% Difference)	%	-	1.82		N/A	5038966
Langelier Index (@ 20C)	N/A	-	0.804			5038290
Langelier Index (@ 4C)	N/A	-	0.555			5038291
Saturation pH (@ 20C)	N/A	-	7.36			5038290
Saturation pH (@ 4C)	N/A	-	7.61			5038291
Inorganics						
Total Ammonia-N	mg/L	-	<0.050		0.050	5042636
Conductivity	umho/cm	-	730		1.0	5042856
Dissolved Organic Carbon	mg/L	-	0.39		0.20	5042767
Orthophosphate (P)	mg/L	-	<0.010		0.010	5042006
pH	pH	-	8.16			5042838
Dissolved Sulphate (SO4)	mg/L	-	34		1.0	5042001
Alkalinity (Total as CaCO3)	mg/L	-	190		1.0	5042848
Dissolved Chloride (Cl)	mg/L	**790**	100		1.0	5041994
Nitrite (N)	mg/L	-	<0.010	<0.010	0.010	5042566
Nitrate (N)	mg/L	-	0.85	0.85	0.10	5042566
Nitrate + Nitrite (N)	mg/L	-	0.85	0.85	0.10	5042566
Metals						
Dissolved Aluminum (Al)	ug/L	-	8.5		5.0	5043417
Dissolved Antimony (Sb)	ug/L	**6.0**	<0.50		0.50	5043417
Dissolved Arsenic (As)	ug/L	**25**	<1.0		1.0	5043417
Dissolved Barium (Ba)	ug/L	**1000**	84		2.0	5043417
Dissolved Beryllium (Be)	ug/L	**4.0**	<0.50		0.50	5043417
Dissolved Boron (B)	ug/L	**5000**	10		10	5043417

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)
Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition
Potable Ground Water- All Types of Property Uses - Medium and Fine Texture Soil

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

RCAP - COMPREHENSIVE (WATER)

Maxxam ID			EPL560	EPL560		
Sampling Date			2017/06/20 14:15	2017/06/20 14:15		
COC Number			616700-01-01	616700-01-01		
	UNITS	Criteria	MW17-02	MW17-02 Lab-Dup	RDL	QC Batch
Dissolved Cadmium (Cd)	ug/L	**2.7**	<0.10		0.10	5043417
Dissolved Calcium (Ca)	ug/L	-	64000		200	5043417
Dissolved Chromium (Cr)	ug/L	**50**	<5.0		5.0	5043417
Dissolved Cobalt (Co)	ug/L	**3.8**	<0.50		0.50	5043417
Dissolved Copper (Cu)	ug/L	**87**	<1.0		1.0	5043417
Dissolved Iron (Fe)	ug/L	-	<100		100	5043417
Dissolved Lead (Pb)	ug/L	**10**	<0.50		0.50	5043417
Dissolved Magnesium (Mg)	ug/L	-	25000		50	5043417
Dissolved Manganese (Mn)	ug/L	-	27		2.0	5043417
Dissolved Molybdenum (Mo)	ug/L	**70**	2.0		0.50	5043417
Dissolved Nickel (Ni)	ug/L	**100**	<1.0		1.0	5043417
Dissolved Phosphorus (P)	ug/L	-	<100		100	5043417
Dissolved Potassium (K)	ug/L	-	1600		200	5043417
Dissolved Selenium (Se)	ug/L	**10**	<2.0		2.0	5043417
Dissolved Silicon (Si)	ug/L	-	3000		50	5043417
Dissolved Silver (Ag)	ug/L	**1.5**	<0.10		0.10	5043417
Dissolved Sodium (Na)	ug/L	**490000**	44000		100	5043417
Dissolved Strontium (Sr)	ug/L	-	100		1.0	5043417
Dissolved Thallium (Tl)	ug/L	**2.0**	<0.050		0.050	5043417
Dissolved Titanium (Ti)	ug/L	-	<5.0		5.0	5043417
Dissolved Uranium (U)	ug/L	**20**	0.57		0.10	5043417
Dissolved Vanadium (V)	ug/L	**6.2**	<0.50		0.50	5043417
Dissolved Zinc (Zn)	ug/L	**1100**	64		5.0	5043417

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)
Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition
Potable Ground Water- All Types of Property Uses - Medium and Fine Texture Soil

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID			EPL557	EPL557	EPL558	EPL559	EPL560		
Sampling Date			2017/06/20 11:30	2017/06/20 11:30	2017/06/20 12:15	2017/06/20 13:00	2017/06/20 14:15		
COC Number			616700-01-01	616700-01-01	616700-01-01	616700-01-01	616700-01-01		
	UNITS	Criteria	GL-7	GL-7 Lab-Dup	GL-8	MW17-01	MW17-02	RDL	QC Batch
Metals									
Dissolved Mercury (Hg)	ug/L	1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	5047114

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Lab-Dup = Laboratory Initiated Duplicate
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)
Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition
Potable Ground Water- All Types of Property Uses - Medium and Fine Texture Soil

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Report Date: 2017/06/28

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Sampler Initials: MC

O.REG 153 PETROLEUM HYDROCARBONS (WATER)

Maxxam ID			EPL557	EPL558	EPL559	EPL560		
Sampling Date			2017/06/20 11:30	2017/06/20 12:15	2017/06/20 13:00	2017/06/20 14:15		
COC Number			616700-01-01	616700-01-01	616700-01-01	616700-01-01		
	UNITS	Criteria	GL-7	GL-8	MW17-01	MW17-02	RDL	QC Batch
BTEX & F1 Hydrocarbons								
Benzene	ug/L	**5.0**	<0.20	<0.20	<0.20	<0.20	0.20	5044035
Toluene	ug/L	**24**	<0.20	<0.20	<0.20	<0.20	0.20	5044035
Ethylbenzene	ug/L	**2.4**	<0.20	<0.20	<0.20	<0.20	0.20	5044035
o-Xylene	ug/L	-	<0.20	<0.20	<0.20	<0.20	0.20	5044035
p+m-Xylene	ug/L	-	<0.40	<0.40	<0.40	<0.40	0.40	5044035
Total Xylenes	ug/L	**300**	<0.40	<0.40	<0.40	<0.40	0.40	5044035
F1 (C6-C10)	ug/L	**750**	<25	<25	<25	<25	25	5044035
F1 (C6-C10) - BTEX	ug/L	**750**	<25	<25	<25	<25	25	5044035
F2-F4 Hydrocarbons								
F2 (C10-C16 Hydrocarbons)	ug/L	**150**	<100	<100	<100	<100	100	5045373
F3 (C16-C34 Hydrocarbons)	ug/L	**500**	<200	<200	<200	<200	200	5045373
F4 (C34-C50 Hydrocarbons)	ug/L	**500**	<200	<200	<200	<200	200	5045373
Reached Baseline at C50	ug/L	-	Yes	Yes	Yes	Yes		5045373
Surrogate Recovery (%)								
1,4-Difluorobenzene	%	-	100	99	99	99		5044035
4-Bromofluorobenzene	%	-	101	101	100	101		5044035
D10-Ethylbenzene	%	-	102	103	100	104		5044035
D4-1,2-Dichloroethane	%	-	103	102	103	102		5044035
o-Terphenyl	%	-	100	119	101	101		5045373

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
Criteria: Ontario Reg. 153/04 (Amended April 15, 2011)
Table 2: Full Depth Generic Site Condition Standards in a Potable Ground Water Condition
Potable Ground Water- All Types of Property Uses - Medium and Fine Texture Soil

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

TEST SUMMARY

Maxxam ID: EPL557
Sample ID: GL-7
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5042848	N/A	2017/06/24	Neil Dassanayake
Carbonate, Bicarbonate and Hydroxide	CALC	5039478	N/A	2017/06/26	Automated Statchk
Chloride by Automated Colourimetry	KONE	5041994	N/A	2017/06/23	Deonarine Ramnarine
Conductivity	AT	5042856	N/A	2017/06/24	Neil Dassanayake
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5042767	N/A	2017/06/23	Azadeh Shahbazi
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5044035	N/A	2017/06/25	Abdikarim Ali
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5045373	2017/06/26	2017/06/27	Ksenia Trofimova
Hardness (calculated as CaCO3)		5039730	N/A	2017/06/27	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5047114	2017/06/27	2017/06/27	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5043417	N/A	2017/06/27	Prempal Bhatti
Ion Balance (% Difference)	CALC	5038966	N/A	2017/06/27	Automated Statchk
Anion and Cation Sum	CALC	5039380	N/A	2017/06/27	Automated Statchk
Total Ammonia-N	LACH/NH4	5042636	N/A	2017/06/27	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5042566	N/A	2017/06/23	Chandra Nandlal
pH	AT	5042838	N/A	2017/06/24	Neil Dassanayake
Orthophosphate	KONE	5042006	N/A	2017/06/23	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5038290	N/A	2017/06/27	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5038291	N/A	2017/06/27	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5042001	N/A	2017/06/23	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5038292	N/A	2017/06/27	Automated Statchk

Maxxam ID: EPL557 Dup
Sample ID: GL-7
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Dissolved Mercury in Water by CVAA	CV/AA	5047114	2017/06/27	2017/06/27	Ron Morrison

Maxxam ID: EPL558
Sample ID: GL-8
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5042848	N/A	2017/06/24	Neil Dassanayake
Carbonate, Bicarbonate and Hydroxide	CALC	5039478	N/A	2017/06/26	Automated Statchk
Chloride by Automated Colourimetry	KONE	5043837	N/A	2017/06/26	Alina Dobreanu
Conductivity	AT	5042856	N/A	2017/06/24	Neil Dassanayake
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5042767	N/A	2017/06/23	Azadeh Shahbazi
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5044035	N/A	2017/06/25	Abdikarim Ali
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5045373	2017/06/26	2017/06/27	Ksenia Trofimova
Hardness (calculated as CaCO3)		5039730	N/A	2017/06/27	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5047114	2017/06/27	2017/06/27	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5043417	N/A	2017/06/27	Prempal Bhatti
Ion Balance (% Difference)	CALC	5038966	N/A	2017/06/27	Automated Statchk
Anion and Cation Sum	CALC	5039380	N/A	2017/06/27	Automated Statchk

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

TEST SUMMARY

Maxxam ID: EPL558
Sample ID: GL-8
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Total Ammonia-N	LACH/NH4	5042636	N/A	2017/06/27	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5041376	N/A	2017/06/23	Chandra Nandlal
pH	AT	5042838	N/A	2017/06/24	Neil Dassanayake
Orthophosphate	KONE	5043840	N/A	2017/06/26	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5038290	N/A	2017/06/27	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5038291	N/A	2017/06/27	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5043838	N/A	2017/06/26	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5038292	N/A	2017/06/27	Automated Statchk

Maxxam ID: EPL559
Sample ID: MW17-01
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5042848	N/A	2017/06/24	Neil Dassanayake
Carbonate, Bicarbonate and Hydroxide	CALC	5039478	N/A	2017/06/26	Automated Statchk
Chloride by Automated Colourimetry	KONE	5041994	N/A	2017/06/23	Deonarine Ramnarine
Conductivity	AT	5042856	N/A	2017/06/24	Neil Dassanayake
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5042767	N/A	2017/06/23	Azadeh Shahbazi
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5044035	N/A	2017/06/25	Abdikarim Ali
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5045373	2017/06/26	2017/06/27	Ksenia Trofimova
Hardness (calculated as CaCO3)		5039730	N/A	2017/06/27	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5047114	2017/06/27	2017/06/27	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5043417	N/A	2017/06/27	Prempal Bhatti
Ion Balance (% Difference)	CALC	5038966	N/A	2017/06/27	Automated Statchk
Anion and Cation Sum	CALC	5039380	N/A	2017/06/27	Automated Statchk
Total Ammonia-N	LACH/NH4	5042636	N/A	2017/06/27	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5041376	N/A	2017/06/23	Chandra Nandlal
pH	AT	5042838	N/A	2017/06/24	Neil Dassanayake
Orthophosphate	KONE	5042006	N/A	2017/06/23	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5038290	N/A	2017/06/27	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5038291	N/A	2017/06/27	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5042001	N/A	2017/06/23	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5038292	N/A	2017/06/27	Automated Statchk

Maxxam ID: EPL560
Sample ID: MW17-02
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Alkalinity	AT	5042848	N/A	2017/06/24	Neil Dassanayake
Carbonate, Bicarbonate and Hydroxide	CALC	5039478	N/A	2017/06/26	Automated Statchk
Chloride by Automated Colourimetry	KONE	5041994	N/A	2017/06/23	Deonarine Ramnarine
Conductivity	AT	5042856	N/A	2017/06/24	Neil Dassanayake
Dissolved Organic Carbon (DOC)	TOCV/NDIR	5042767	N/A	2017/06/23	Azadeh Shahbazi

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Maxxam Job #: B7D0017
Report Date: 2017/06/28

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

TEST SUMMARY

Maxxam ID: EPL560
Sample ID: MW17-02
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Petroleum Hydro. CCME F1 & BTEX in Water	HSGC/MSFD	5044035	N/A	2017/06/25	Abdikarim Ali
Petroleum Hydrocarbons F2-F4 in Water	GC/FID	5045373	2017/06/26	2017/06/27	Ksenia Trofimova
Hardness (calculated as CaCO3)		5039730	N/A	2017/06/27	Automated Statchk
Dissolved Mercury in Water by CVAA	CV/AA	5047114	2017/06/27	2017/06/27	Ron Morrison
Dissolved Metals by ICPMS	ICP/MS	5043417	N/A	2017/06/27	Prempal Bhatti
Ion Balance (% Difference)	CALC	5038966	N/A	2017/06/27	Automated Statchk
Anion and Cation Sum	CALC	5039380	N/A	2017/06/27	Automated Statchk
Total Ammonia-N	LACH/NH4	5042636	N/A	2017/06/27	Charles Opoku-Ware
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5042566	N/A	2017/06/23	Chandra Nandlal
pH	AT	5042838	N/A	2017/06/24	Neil Dassanayake
Orthophosphate	KONE	5042006	N/A	2017/06/23	Alina Dobreanu
Sat. pH and Langelier Index (@ 20C)	CALC	5038290	N/A	2017/06/27	Automated Statchk
Sat. pH and Langelier Index (@ 4C)	CALC	5038291	N/A	2017/06/27	Automated Statchk
Sulphate by Automated Colourimetry	KONE	5042001	N/A	2017/06/23	Alina Dobreanu
Total Dissolved Solids (TDS calc)	CALC	5038292	N/A	2017/06/27	Automated Statchk

Maxxam ID: EPL560 Dup
Sample ID: MW17-02
Matrix: Water

Collected: 2017/06/20
Shipped:
Received: 2017/06/21

Test Description	Instrumentation	Batch	Extracted	Date Analyzed	Analyst
Nitrate (NO3) and Nitrite (NO2) in Water	LACH	5042566	N/A	2017/06/23	Chandra Nandlal

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	2.3°C

Results relate only to the items tested.

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QUALITY ASSURANCE REPORT

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5044035	1,4-Difluorobenzene	2017/06/25	98	70 - 130	98	70 - 130	99	%		
5044035	4-Bromofluorobenzene	2017/06/25	99	70 - 130	99	70 - 130	100	%		
5044035	D10-Ethylbenzene	2017/06/25	92	70 - 130	94	70 - 130	103	%		
5044035	D4-1,2-Dichloroethane	2017/06/25	103	70 - 130	102	70 - 130	102	%		
5045373	o-Terphenyl	2017/06/26	105	60 - 130	113	60 - 130	103	%		
5041376	Nitrate (N)	2017/06/23	NC	80 - 120	102	80 - 120	<0.10	mg/L	0.29	20
5041376	Nitrite (N)	2017/06/23	95	80 - 120	94	80 - 120	<0.010	mg/L	3.1	20
5041994	Dissolved Chloride (Cl)	2017/06/23	NC	80 - 120	100	80 - 120	<1.0	mg/L	1.5	20
5042001	Dissolved Sulphate (SO4)	2017/06/23	NC	75 - 125	100	80 - 120	<1.0	mg/L	0.033	20
5042006	Orthophosphate (P)	2017/06/23	119	75 - 125	99	80 - 120	<0.010	mg/L	3.7	25
5042566	Nitrate (N)	2017/06/23	96	80 - 120	101	80 - 120	<0.10	mg/L	0.80	20
5042566	Nitrite (N)	2017/06/23	100	80 - 120	94	80 - 120	<0.010	mg/L	NC	20
5042636	Total Ammonia-N	2017/06/27	95	80 - 120	95	85 - 115	<0.050	mg/L	1.1	20
5042767	Dissolved Organic Carbon	2017/06/23	97	80 - 120	99	80 - 120	<0.20	mg/L	0.020	20
5042838	pH	2017/06/24			102	98 - 103			0.19	N/A
5042848	Alkalinity (Total as CaCO3)	2017/06/24			99	85 - 115	<1.0	mg/L	0.27	20
5042856	Conductivity	2017/06/24			102	85 - 115	<1.0	umho/cm	0.30	25
5043417	Dissolved Aluminum (Al)	2017/06/27	108	80 - 120	103	80 - 120	<5.0	ug/L		
5043417	Dissolved Antimony (Sb)	2017/06/27	107	80 - 120	100	80 - 120	<0.50	ug/L	NC	20
5043417	Dissolved Arsenic (As)	2017/06/27	102	80 - 120	96	80 - 120	<1.0	ug/L	NC	20
5043417	Dissolved Barium (Ba)	2017/06/27	102	80 - 120	99	80 - 120	<2.0	ug/L	1.6	20
5043417	Dissolved Beryllium (Be)	2017/06/27	99	80 - 120	96	80 - 120	<0.50	ug/L	NC	20
5043417	Dissolved Boron (B)	2017/06/27	95	80 - 120	95	80 - 120	<10	ug/L	8.2	20
5043417	Dissolved Cadmium (Cd)	2017/06/27	102	80 - 120	97	80 - 120	<0.10	ug/L	NC	20
5043417	Dissolved Calcium (Ca)	2017/06/27	NC	80 - 120	99	80 - 120	<200	ug/L		
5043417	Dissolved Chromium (Cr)	2017/06/27	104	80 - 120	97	80 - 120	<5.0	ug/L	NC	20
5043417	Dissolved Cobalt (Co)	2017/06/27	102	80 - 120	99	80 - 120	<0.50	ug/L	NC	20
5043417	Dissolved Copper (Cu)	2017/06/27	104	80 - 120	104	80 - 120	<1.0	ug/L	NC	20
5043417	Dissolved Iron (Fe)	2017/06/27	100	80 - 120	96	80 - 120	<100	ug/L		
5043417	Dissolved Lead (Pb)	2017/06/27	100	80 - 120	96	80 - 120	<0.50	ug/L	NC	20
5043417	Dissolved Magnesium (Mg)	2017/06/27	NC	80 - 120	97	80 - 120	<50	ug/L		

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QUALITY ASSURANCE REPORT(CONT'D)

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5043417	Dissolved Manganese (Mn)	2017/06/27	102	80 - 120	97	80 - 120	<2.0	ug/L		
5043417	Dissolved Molybdenum (Mo)	2017/06/27	109	80 - 120	103	80 - 120	<0.50	ug/L	0.055	20
5043417	Dissolved Nickel (Ni)	2017/06/27	96	80 - 120	92	80 - 120	<1.0	ug/L	0.51	20
5043417	Dissolved Phosphorus (P)	2017/06/27	101	80 - 120	105	80 - 120	<100	ug/L		
5043417	Dissolved Potassium (K)	2017/06/27	106	80 - 120	101	80 - 120	<200	ug/L		
5043417	Dissolved Selenium (Se)	2017/06/27	102	80 - 120	97	80 - 120	<2.0	ug/L	NC	20
5043417	Dissolved Silicon (Si)	2017/06/27	100	80 - 120	99	80 - 120	<50	ug/L		
5043417	Dissolved Silver (Ag)	2017/06/27	91	80 - 120	95	80 - 120	<0.10	ug/L	NC	20
5043417	Dissolved Sodium (Na)	2017/06/27	NC	80 - 120	97	80 - 120	<100	ug/L	0.41	20
5043417	Dissolved Strontium (Sr)	2017/06/27	103	80 - 120	97	80 - 120	<1.0	ug/L		
5043417	Dissolved Thallium (Tl)	2017/06/27	101	80 - 120	98	80 - 120	<0.050	ug/L	NC	20
5043417	Dissolved Titanium (Ti)	2017/06/27	101	80 - 120	98	80 - 120	<5.0	ug/L		
5043417	Dissolved Uranium (U)	2017/06/27	102	80 - 120	93	80 - 120	<0.10	ug/L	16	20
5043417	Dissolved Vanadium (V)	2017/06/27	101	80 - 120	95	80 - 120	<0.50	ug/L	NC	20
5043417	Dissolved Zinc (Zn)	2017/06/27	99	80 - 120	96	80 - 120	<5.0	ug/L	NC	20
5043837	Dissolved Chloride (Cl)	2017/06/26	101	80 - 120	103	80 - 120	<1.0	mg/L	0.091	20
5043838	Dissolved Sulphate (SO4)	2017/06/26	92	75 - 125	102	80 - 120	<1.0	mg/L	0.63	20
5043840	Orthophosphate (P)	2017/06/26	120	75 - 125	101	80 - 120	<0.010	mg/L	NC	25
5044035	Benzene	2017/06/25	94	70 - 130	97	70 - 130	<0.20	ug/L	3.0	30
5044035	Ethylbenzene	2017/06/25	90	70 - 130	93	70 - 130	<0.20	ug/L	8.6	30
5044035	F1 (C6-C10) - BTEX	2017/06/25					<25	ug/L	4.9	30
5044035	F1 (C6-C10)	2017/06/25	91	70 - 130	96	70 - 130	<25	ug/L	5.9	30
5044035	o-Xylene	2017/06/25	98	70 - 130	96	70 - 130	<0.20	ug/L	9.0	30
5044035	p+m-Xylene	2017/06/25	93	70 - 130	95	70 - 130	<0.40	ug/L	9.7	30
5044035	Toluene	2017/06/25	94	70 - 130	94	70 - 130	<0.20	ug/L	NC	30
5044035	Total Xylenes	2017/06/25					<0.40	ug/L	9.5	30
5045373	F2 (C10-C16 Hydrocarbons)	2017/06/26	NC	50 - 130	101	60 - 130	<100	ug/L	NC	30
5045373	F3 (C16-C34 Hydrocarbons)	2017/06/26	101	50 - 130	116	60 - 130	<200	ug/L	NC	30
5045373	F4 (C34-C50 Hydrocarbons)	2017/06/26	109	50 - 130	123	60 - 130	<200	ug/L	NC	30

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QUALITY ASSURANCE REPORT(CONT'D)

Golder Associates Ltd
Client Project #: 1774274 LANCI
Sampler Initials: MC

			Matrix Spike		SPIKED BLANK		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
5047114	Dissolved Mercury (Hg)	2017/06/27	104	75 - 125	97	80 - 120	<0.1	ug/L	NC	20

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

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VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Cristina Carriere

Cristina Carriere, Scientific Services

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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APPENDIX F

Water Balance Results

Table F1: Water Balance Existing Condition CBM Lanci Pit Expansion

					Mature Forest			Agricultural/Grass			Built Up Area (Impervious)									
					WHC	250 mm		WHC	200 mm		WHC	100 mm								
					Total Area (m^2)	128,977		Total Area (m^2)	14,897		Total Area (m^2)	3,711								
					Infiltration Factor	0.9		Infiltration Factor	0.8		Infiltration Factor	0.1								
Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspiration Mature Forest Areas	Surplus		Actual Evapotranspiration Agricultural/Grass Areas	Surplus		Actual Evapotranspiration Built Up Area (Impervious) Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.2	60.0	2	2	28	3,611	2	32	477	2	40	148	4,237	2	95	3,646	1	590	0
February	28	-5.8	52.0	1	1	40	5,159	1	43	641	1	46	171	5,970	2	148	5,173	2	798	0
March	31	-0.9	58.0	10	10	72	9,286	10	73	1,088	10	76	282	10,656	4	239	9,256	3	1,400	1
April	30	6.1	67.0	33	33	37	4,772	33	37	551	33	37	137	5,461	2	126	4,750	2	711	0
May	31	12.3	78.0	76	76	16	2,064	76	16	238	76	16	59	2,361	1	53	2,054	1	307	0
June	30	17.4	81.0	110	110	3	387	110	3	45	107	3	11	443	0	10	385	0	58	0
July	31	19.8	94.0	128	127	2	258	126	2	30	114	2	7	295	0	7	257	0	38	0
August	31	18.9	73.0	112	107	2	258	103	2	30	86	2	7	295	0	7	257	0	38	0
September	30	14.7	87.0	75	70	9	1,161	68	9	134	65	9	33	1,328	1	31	1,155	0	173	0
October	31	8.5	75.0	39	38	8	1,032	38	8	119	38	10	37	1,188	0	27	1,028	0	160	0
November	30	2.4	78.0	12	12	23	2,966	12	24	358	12	37	137	3,461	1	80	2,970	1	492	0
December	31	-3.4	62.0	2	2	33	4,256	2	33	492	2	41	152	4,900	2	110	4,239	2	661	0
Total			***865.0***	***600.0***	***588***	***273***	***35,211***	***581***	***282***	***4,201***	***546***	***319***	***1,184***	***40,596***	***16***	***932***	***35,169***	***13***	***5,427***	***2***
Average		***7.0***													***1***			***1.1***		***0.2***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table F2: Water Balance Operational Condition CBM Lanci Pit Expansion

					Mature Forest			Agricultural/Grass			Built Up Area (Pervious)			Flooded Pit									
					WHC	250 mm		WHC	100 mm		WHC	100 mm		WHC	Prec-PET								
					Total Area (m^2)	32,140		Total Area (m^2)	12,842		Total Area (m^2)	41,604		Total Area (m^2)	61,000								
					Infiltration Factor	0.9		Infiltration Factor	0.8		Infiltration Factor	0.1		Infiltration Factor	0.0								
Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspiration Mature Forest Areas	Surplus		Actual Evapotranspiration Agricultural/Grass Areas	Surplus		Actual Evapotranspiration Built Up Area (Pervious) Areas	Surplus		Actual Evapotranspiration Flooded Pit Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.2	60.0	2	2	28	900	2	40	514	2	40	1,664	2	58	3,538	6,616	2	148	1,387	1	5,228	2
February	28	-5.8	52.0	1	1	40	1,286	1	46	591	1	46	1,914	1	51	3,111	6,901	3	171	1,821	1	5,080	2
March	31	-0.9	58.0	10	10	72	2,314	10	76	976	10	76	3,162	10	48	2,928	9,380	4	210	3,180	1	6,200	2
April	30	6.1	67.0	33	33	37	1,189	33	37	475	33	37	1,539	33	34	2,074	5,278	2	122	1,604	1	3,673	1
May	31	12.3	78.0	76	76	16	514	76	16	205	76	16	666	76	2	122	1,507	1	34	694	0	814	0
June	30	17.4	81.0	110	110	3	96	107	3	39	107	3	125	110	-29	-1,769	-1,509	-1	-35	130	0	-1,639	-1
July	31	19.8	94.0	128	127	2	64	114	2	26	114	2	83	128	-34	-2,074	-1,901	-1	-43	87	0	-1,988	-1
August	31	18.9	73.0	112	107	2	64	86	2	26	86	2	83	112	-39	-2,379	-2,206	-1	-49	87	0	-2,293	-1
September	30	14.7	87.0	75	70	9	289	65	9	116	65	9	374	75	12	732	1,511	1	35	390	0	1,121	0
October	31	8.5	75.0	39	38	8	257	38	10	128	38	10	416	39	36	2,196	2,998	1	67	376	0	2,622	1
November	30	2.4	78.0	12	12	23	739	12	37	475	12	37	1,539	12	66	4,026	6,780	3	157	1,199	0	5,580	2
December	31	-3.4	62.0	2	2	33	1,061	2	41	527	2	41	1,706	2	60	3,660	6,953	3	156	1,546	1	5,407	2
Total			***865.0***	***600.0***	***588***	***273***	***8,774***	***546***	***319***	***4,097***	***546***	***319***	***13,272***	***600***	***265***	***16,165***	***42,307***	***16***	***973***	***12,501***	***5***	***29,806***	***11***
Average		***7.0***																***1***			***0.4***		***1.0***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

Table F3: Water Balance Rehabilitated Condition CBM Lanci Pit Expansion

					Mature Forest			Agricultural/Grass			Flooded Pit										
					WHC	250 mm		WHC	100 mm		WHC	Prec-PET									
					Total Area (m^2)	32,140		Total Area (m^2)	54,446		Total Area (m^2)	61,000									
					Infiltration Factor	0.9		Infiltration Factor	0.8		Infiltration Factor	0.0									
Month	Days	Temp	Precipitation	Potential Evapotranspiration	Actual Evapotranspiration Mature Forest Areas	Surplus		Actual Evapotranspiration Agricultural/Grass Areas	Surplus		Actual Evapotranspiration Flooded Pit Areas	Surplus		Total Surplus	Total Surplus (Runoff and Infiltration)		Total Infiltration		Total Runoff	
		(°C)	(mm)	(mm)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(mm)	(mm)	(m^3)	(m^3)	(L/s)	(L/min)	(m^3)	(L/s)	(m^3)	(L/s)
January	31	-6.2	60.0	2	2	28	900	2	40	2,178	2	58	3,538	6,616	2	148	2,552	1	4,064	2
February	28	-5.8	52.0	1	1	40	1,286	1	46	2,505	1	51	3,111	6,901	3	171	3,161	1	3,740	2
March	31	-0.9	58.0	10	10	72	2,314	10	76	4,138	10	48	2,928	9,380	4	210	5,393	2	3,987	1
April	30	6.1	67.0	33	33	37	1,189	33	37	2,014	33	34	2,074	5,278	2	122	2,682	1	2,596	1
May	31	12.3	78.0	76	76	16	514	76	16	871	76	2	122	1,507	1	34	1,160	0	348	0
June	30	17.4	81.0	110	110	3	96	107	3	163	110	-29	-1,769	-1,509	-1	-35	217	0	-1,727	-1
July	31	19.8	94.0	128	127	2	64	114	2	109	128	-34	-2,074	-1,901	-1	-43	145	0	-2,046	-1
August	31	18.9	73.0	112	107	2	64	86	2	109	112	-39	-2,379	-2,206	-1	-49	145	0	-2,351	-1
September	30	14.7	87.0	75	70	9	289	65	9	490	75	12	732	1,511	1	35	652	0	859	0
October	31	8.5	75.0	39	38	8	257	38	10	544	39	36	2,196	2,998	1	67	667	0	2,331	1
November	30	2.4	78.0	12	12	23	739	12	37	2,014	12	66	4,026	6,780	3	157	2,277	1	4,503	2
December	31	-3.4	62.0	2	2	33	1,061	2	41	2,232	2	60	3,660	6,953	3	156	2,740	1	4,213	2
Total			***865.0***	***600.0***	***588***	***273***	***8,774***	***546***	***319***	***17,368***	***600***	***265***	***16,165***	***42,307***	***16***	***973***	***21,791***	***8***	***20,516***	***8***
Average		***7.0***													***1***			***0.7***		***0.7***

Notes:

The Surplus values in (mm) are calculated using rainfall, melt and Actual Evapotranspiration

P = ET + R + I + S

APPENDIX G

Project Team CVs

Education

MSc. Earth Sciences, University of Waterloo, 1995

BSc. Honours Earth Sciences, Physics Minor, University of Waterloo, 1987

Areas of Experience

Large Project Management

Aggregates

Water Resources and Protection

Nuclear Waste Management

Mine Site and Tailings Investigations

Explosives Site Assessment

Contaminated Site Assessment

Geothermal Energy

Waste Management

Engineering Geophysics

Archaeology

Applied Geophysics Research

George Schneider, MSc., P.Geo.

PROFESSIONAL SUMMARY

George Schneider is a Senior Geoscientist and Principal with Golder's Greater Toronto Area (GTA) Operations and has over 30 years of professional experience. George received his B.Sc. (1987) and M.Sc. (1995) in Earth Sciences from the University of Waterloo. From 1987 to 1995, he was a researcher in the Geophysics Laboratory at the Centre for Groundwater Research at the University of Waterloo and has co-authored more than 25 technical publications. George joined Golder in 1995; he became an Associate in 2002 and a Principal in 2006. George is a Professional Geoscientist registered in the Province of Ontario.

EMPLOYMENT HISTORY

Principal / Senior Geoscientist, Golder Associates (2013 to Present)

Cambridge, Ontario

Project Manager / Director responsible for multi-disciplinary projects including: nuclear waste management, explosives site remediation, mine site rehabilitation, aggregate resource studies, and groundwater supply and source water protection studies. George has been with Golder for 23 years, he is currently a leader of the Canadian Nuclear Services Group, responsible for project management, business development and client relations.

George is currently serving as a member of the Lake Erie Source Protection Committee (LESWPC) and the Waterloo-Wellington-Brant Regional Committee of the Ontario Stone Sand and Gravel Association (OSSGA).

Principal / Division Manager, Golder Associates (2006 to 2013)

Mississauga, Cambridge and Whitby, Ontario

Project director responsible for a range of multi-disciplinary projects including: environmental investigations at explosive contaminated sites and mine sites, aggregate resource studies, groundwater supply and management studies and nuclear waste management. Managed the Environmental Services Division in the GTA including: Geosciences, Geophysics, Site Characterization and Restoration, Environmental Due Diligence, Hydrogeology and Waste Management and Field Technician Groups.

Associate / Senior Project Manager, Golder Associates (2002 to 2005)

Mississauga, Ontario

Senior geoscientist responsible for the management of a diverse range of projects including: environmental investigations at explosive contaminated sites, aggregate resource studies, hydrogeological studies and geophysical investigations in support of hydrogeological studies, environmental site

assessments, mine site developments, aggregate resource studies and geotechnical investigations.

Intermediate, then Senior Geoscientist, Golder Associates (1995 to 2002)

Waterloo, then Mississauga, Ontario

Responsible for project management, performing geophysical, geological and hydrogeological field investigations, numerical data analysis, data assessment, and reporting for: aggregate resource studies, groundwater resource studies, permits to take water, assessment of contaminated sites, geotechnical investigations and hydrogeologic characterization of mine tailings disposal and open pit mine sites.

Collected, processed and interpreted data for a variety of land and marine geophysical techniques including: time and frequency domain electromagnetics, magnetics, gravity, ground penetrating radar (GPR), seismic reflection and refraction, acoustic tomography, pulse velocity testing of man-made structures, cross-hole seismic testing, leak detection, vertical seismic profiling (VSP), electrical resistivity imaging (ERI), borehole camera logging and geophysical well logging including: natural gamma, gamma-gamma, neutron, temperature, deviation, inductive conductivity, magnetic, caliper, resistivity, heat-pulse flowmeter and optical televiewer.

Geophysicist, Waterloo Centre for Groundwater Research (1987 to 1995)

University of Waterloo, Waterloo, Ontario

Conducted geophysical field investigations and drilling programmes under the direction of Dr. J.P. Greenhouse and Dr. P.F. Karrow in the Waterloo Region related to the quaternary geology and the assessment of water resources in the Region including: seismic surveys, borehole geophysical surveys and two Rotasonic drilling programmes. Compiled three editions of a catalogue of geophysical logs for the Waterloo Region from 1988 to 1993. Co-authored more than 20 research papers, reports and posters, including 13 publications on the quaternary geology and/or water resources of the Waterloo Region.

Designed and constructed borehole and resistivity geophysical instruments, digital data acquisitions systems and developed innovative computer software for geophysical and hydrogeological applications. Carried out surface, borehole and laboratory geophysical investigations in support of more than 85 groundwater-related research projects including: geophysical investigations of DNAPL/LNAPL contamination, delineation of aquifers, groundwater contaminant plumes and karst features.

Other duties included: teaching assistance for University of Waterloo Earth Sciences and Geophysics courses and organization of technical conferences, short courses and field demonstrations.

RELEVANT EXPERIENCE

Project Experience – Large Project Management (>$1M)

Phase 2 Initial Drilling and Testing, Ignace - NWMO (2017- 2020)
Ignace, Ontario

Project manager and senior geoscientist responsible for the Phase 2 Initial Borehole Drilling and Testing in the Ignace Area. Main point of contact to NWMO responsible for project management, HSSE, QA/QC, schedule tracking, budget and earned value tracking, change management, and subcontractors. Managed daily activities on the project including planning and coordination of multiple work packages, including site infrastructure setup, drilling, core logging, core sampling, downhole geophysics, hydraulic testing, and the installation of Westbay monitoring systems.

Phase 1 and Phase 2 Geoscientific and Environmental Studies - NWMO (2009-2017)
Canada

Project manager responsible for geoscientific, geophysical and environmental studies conducted by Golder for NWMO including reports on: assessment of geophysical methods for site characterization, Initial Screenings, Phase 1 Geoscientific Assessments, Phase 1 Reports on Environment and Safety, and Phase 2 OGGF and Detailed Mapping. Specific experience at Ignace and other communities in northern Ontario and Saskatchewan.

IUS Project – Region of Waterloo (2005-2014)
Waterloo Region, Ontario

The hydrogeological assessment and permitting of existing and potential new Municipal supply Wells for the Region of Waterloo's Integrated Urban Supply System. Project manager, responsible for technical tasks, invoicing, budgeting, tendering and contract administration, presentations, interim and final reporting. Performed a technical role in the water supply development and expansion tasks carried out at the Chicopee, Breslau, Fountain Street, Lancaster, Seagrams and Waterloo North study areas.

Coldstream Mine Site - EWL Management Ltd. (2003-2015)
Kashabowie, Ontario

Project Manager and senior geoscientist responsible for environmental investigations and remediation at this former mine site. Work has included surface water, groundwater and ecological studies, assessment of above water and below water tailings management areas, ecological and human health risk assessment, tailings relocation, spillway and watercourse improvements, predictive modelling, public consultation, and negotiations with regulatory agencies.

CIL Explosives Site – Akzo Nobel Coatings Ltd. (1998-2019)
Parry Sound, Ontario

Project Manager and senior geoscientist responsible for environmental investigations and remediation at this former mine site. Work has included surface water, groundwater and ecological studies, assessment of above water and below water tailings management areas, ecological and human health risk assessment, tailings relocation, spillway and watercourse improvements, predictive modelling, public consultation, and negotiations with regulatory agencies.

McMasterville Site – Akzo Nobel Coatings Ltd. (1999-2016)
McMasterville, Quebec

Project manager for the assessment and remediation of this former explosives and fertilizer manufacturing site, which operated from the 1890 to 1999 and manufactured a wide range of products including TNT, nitroglycerine, PETN, slurries, and fertilizers. Work has included: geophysical investigations, remote control drilling for explosives contaminants, Phase I ESA, Phase II ESA, risk assessment, ecological assessment, diversion and repatriation of a creek, construction of an onsite landfill and risk-managed area, and ongoing surface water and groundwater monitoring.

Project Experience – Aggregates

Aggregate Licence Investigations (2019-present) Caledon, Ontario	Project Director and Senior Technical Reviewer for resource and hydrogeological technical studies at the Caledon properties for CBM Aggregates for a future below water table quarry licence application near Caledon, Ontario.
Aggregate Licence Investigations (2018-present) Peterborough, Ontario	Project Director and Senior Technical Reviewer for hydrogeological, natural environment and cultural heritage technical studies at the Blezard property for CBM Aggregates near Peterborough, Ontario.
Resource Evaluation – CBM (2018) Ayr, Ontario	Project Manager and Senior Technical Reviewer for an aggregate resource assessment at the Bromberg Pit for CBM Aggregates near Ayr Ontario.
Resource and Hydrogeological Investigation – CBM (2018) Dorchester, Ontario	Project Director and Senior Technical Reviewer for aggregate resource and hydrogeological studies at the Dorchester Pit for CBM Aggregates to support a Site Plan Amendment.
Resource and Hydrogeological Investigation – CBM (2018) Thamesford, Ontario	Project Director and Senior Technical Reviewer for aggregate resource and hydrogeological studies at the Thamesford Pit for CBM Aggregates to support a Site Plan Amendment.
Aggregate Licence Investigations – CBM (2018-present) Puslinch, Ontario	Project Director and Senior Technical Reviewer for hydrogeological, natural environment and cultural heritage studies at the Lake property for CBM Aggregates in Puslinch, Ontario.
Resource and Hydrogeological Investigation – CBM (2017) Puslinch, Ontario	Project Director and Senior Technical Reviewer for aggregate resource and hydrogeological studies at the Lanci Pit for CBM Aggregates to support a Site Plan Amendment.
Resource Evaluation – CBM (2017) North Dumfries, Ontario	Project Manager and Senior Technical Reviewer for an aggregate resource assessment at the Dabrowski Pit for CBM Aggregates.
Resource Evaluation – CBM (2017) Puslinch, Ontario	Project Manager and Senior Technical Reviewer for an aggregate resource assessment at the McNally Pit in support the expropriation of land for highway development at the McNally Pit for CBM Aggregates.
Resource and Hydrogeological Investigation – CBM (2016) North Dumfries, Ontario	Project Director and Senior Technical Reviewer for an aggregate resource evaluation and Level 1&2 Hydrogeological Assessment at the Dance Pit for CBM Aggregates in North Dumfries, Ontario.
Imported Fill Investigation – CBM (2016) Limehouse, Ontario	Project Manager for a soil sampling investigation to confirm imported soil quality at the CBM Pit near Limehouse, Ontario.

Resource Evaluation – CBM (2016) Orangeville, Ontario	Project Director and Senior Technical Reviewer for an aggregate resource evaluation at the Gray Pit for CBM Aggregates near Orangeville, Ontario.
Resource and Hydrogeological Investigation – CBM (2016) North Dumfries, Ontario	Project Director and Senior Technical Reviewer for an aggregate resource evaluation and Level 1&2 Hydrogeological Assessment at the Dance Pit for CBM Aggregates in North Dumfries, Ontario.
Aggregate Investigations - MTO Northeast (2015) North Bay, Ontario	Project Manager for aggregate investigations on numerous Crown land sites for MTO Northeast. Work included resource assessments, Level 1 / 2 Hydrogeological, Natural Heritage and Cultural Heritage Assessments, in support of Pit and Quarry Permits.
Resource Evaluation and Expert Testimony- Ministry of Transportation Ontario (2013-2014) Ontario	Provided specialized forensic engineering / geological advice and services related to aggregate resources on a property in northern Ontario. Work included resource modelling and resource valuation for a variety of potential land development scenarios.
Resource Evaluation Arriscraft International (2011) Ontario	Conducted a geological testing program and completed a resource evaluation of the Hill Top Pit Property in Kitchener, Ontario. Resource evaluation results were used in the appraisal of the property for the purposes of acquisition.
Aggregate Properties Valuation – Confidential (2011) Ontario, Alberta	Conducted valuation studies of more than a dozen aggregate properties in Ontario and Alberta to estimate the net present value of these properties for the purposes of financing.
Aggregate Source Investigations – MTO (2010-2011) Northeastern Ontario	Project Director and senior technical reviewer for the geological and hydrogeological components of the 2010 Northeastern Region Aggregate Source Investigation (MTO Assignment NO. 5010-E-0003) which included assessment and permitting studies for 23 sites across Ontario.
Resource Evaluation, Weeks Pit and Quarry – Altus Group (2010-2011) Parry Sound, Ontario	Senior technical review for an investigation to estimate the total aggregate resources available at the Weeks Pit and quarry property, in order to assist in the valuation of the property to settle an expropriation dispute with the owner and the MTO.
Feasibility Assessment – Lafarge (2010) Harvey Township, Ontario	Senior technical review for an investigation to assess the feasibility for the development of a limestone quarry on the Buckhorn Property in support of the renewal of a mining lease for the property.
Soil Borrow Search - IBI Group (2009-2010) Niagara, Ontario	Senior technical reviewer for a soil borrow search in the Niagara Region for the MTO, in support of new construction activities on Highway 406.
Geophysical Investigation – Confidential (2007) Ontario	Project manager and senior technical advisor for a geophysical and test pitting investigation at a confidential quarry site in Ontario to assess the potential presence of buried waste, as part of a legal claim.

Preliminary Resource Evaluation – SCAW (2004) Caledon, Ontario	Directed junior staff in a preliminary assessment of the potential for aggregate resources to be present on a property in Caledon, Ontario on behalf of the property owner.
Borehole Geophysical Logging – Confidential (2004) Brechin, Ontario	Acquired gamma and conductivity borehole geophysical logs at a property near Brechin, Ontario for a confidential client.
Acton Quarry Escarpment Seep Investigation - Dufferin Aggregates (2003) Acton, Ontario	Led a multidisciplinary project team in an investigation to assess hydrogeologic conditions at Phase 2 of the Acton Quarry and develop conceptual designs for short term and long term hydrogeologic mitigation systems to maintain seep flow in the Guelph-Amabel Formation along the Niagara Escarpment, immediately adjacent to advancing quarry workings.
Resource Evaluation – Dufferin Aggregates (2003) Ontario	Led a project team to carry out a resource evaluation of the Mosport West Pit property for Dufferin Aggregates. The project involved the integration of high quality coring methods, gradation testing of core samples and ERI (electrical resistivity imaging) geophysical surveying to develop realistic 3D subsurface geologic models for these properties, from which available resources were then estimated and areas of preferred extraction were identified. Duties included: planning, ERI field QA/QC, ERI interpretation, correlation of geophysical and gradation data to establish empirical relationships between ERI response and resource quality and reporting.
ERI Investigation – Nelson Aggregates (2003) Burlington, Ontario	Directed junior staff in an ERI geophysical investigation to map overburden thickness and assess the underlying rock for karst potential as part of a Level 2 Hydrogeological Assessment under the Aggregate Resources Act, for the planned expansion of the Nelson Quarry in Burlington, Ontario.
Aggregate Resource Evaluation – Confidential (2003) Sudbury, Ontario	Carried out an evaluation of the potential aggregate resources present on properties in Dill Township near Sudbury, Ontario in support of the appraisal of the properties, which were to be expropriated from the owner by the MTO for the construction of an interchange and highway realignment.
Overburden Investigation – Dufferin Aggregates (2002) Milton, Ontario	Conducted an ERI (electrical resistivity imaging) and test pitting investigation to develop a 3D model of overburden thickness and the top of bedrock to assist in planning overburden stripping requirements for Dufferin Aggregates in the Western Extension of the Milton North Quarry. Responsible for all aspects of planning, acquisition, processing, interpretation and reporting, as well as client liaison.
Gravel Pit Evaluation - Township of Perth East (2002) Shakespeare, Ontario	Conducted an investigation to complete a resource evaluation, assess the net present value and make recommendations for optimization to the Perth East Gravel Pit near Shakespeare, Ontario. The Project Team consisted of Golder Associates Ltd., Beck and Associates GeoConsultants Inc. and MHBC Planning Ltd.
Aggregate Properties Valuation – Confidential (2002) Ontario	Led a multidisciplinary project team which conducted valuations studies of four large aggregate properties in Ontario to estimate the net present value of these properties for the purposes of obtaining bank financing. The Project Team consisted of Golder Associates Ltd., Beck and Associates GeoConsultants Inc. and MHBC Planning Ltd.

Acton Quarry Resource Evaluation – Dufferin Aggregates (2002)
Acton, Ontario

Conducted a resource evaluation and estimated overburden stripping requirements for Phase 3 of the Acton Quarry, which involved ERI geophysical surveying, test pitting and drilling. Responsible for all aspects of planning, acquisition, processing, interpretation and reporting, as well as client liaison.

Overburden Investigation – Dufferin Aggregates (2001)
Milton, Ontario

Conducted a GPR and test pitting investigation to develop a 3D model of overburden thickness and the top of bedrock to assist in planning overburden stripping requirements for Dufferin Aggregates in the Milton North Quarry. Responsible for all aspects of planning, acquisition, processing, interpretation and reporting, as well as client liaison.

Quarry Resource Assessment – Dufferin Aggregates (2001)
Ontario

Acquired, processed, interpreted and reported gamma and conductivity geophysical log surveys in test boreholes at the Ogden Point Limestone Quarry to identify the stratigraphy within a Regional context and infer the suitability of strata within the quarry for use in the manufacture of cement products, based on experience elsewhere in Ontario.

Resource Evaluations – Dufferin Aggregates (1998-1999)
Ontario

Helped conduct sand and gravel resource evaluations as part of a multidisciplinary project team for Dufferin Aggregates at sand and gravel properties in Ontario including Mosport Pit 1 and 2, Bethany, TRT, Mill Creek, Paris and Naylor properties. The projects involved the integration of high quality coring methods, gradation testing of core samples and ERI (electrical resistivity imaging) geophysical surveying to develop realistic 3D subsurface geologic models for these properties, from which available resources were then estimated and areas of preferred extraction were identified. Duties included: ERI modelling and interpretation, 3D geological modelling, correlation of geophysical and gradation data to establish empirical relationships between ERI response and resource quality, volume and tonnage estimates and reporting.

Project Experience – Water Resources and Protection

Hydrogeological Assessment – Cambridge Zone 3 Class EA – Region of Waterloo (2016-2019) Cambridge, Ontario	As a subcontractor to GM BluePlan, completed a hydrogeological assessment for the Region of Waterloo of the Cambridge Zone 3 Well Field, as part of a class EA, to examine options to increase the sustainable water supply capacity of the well field. Project Director and Senior Technical Reviewer.
Hydrogeological Assessment – Harrington McAvan (2015 – 2019) Puslinch, Ontario	Carried out a hydrogeological and geotechnical assessment to support the re-zoning and future redevelopment of a property near Puslinch, Ontario for Farhi Holdings, including a preliminary assessment of potential water resources and septic capacity. Project Manager and Senior Technical Reviewer.
Municipal Well Construction and Testing (2015-2019) Waterloo Region, Ontario	Project manager, contract administrator and senior technical reviewer for the construction and testing of new municipal supply wells in 2015 at K21, K4A and W6A/B and in 2016 at NH3 and Maryhill. Designed, constructed and permitted new supply wells at each of these sites in order to replace older wells with performance problems, provide system redundancy and help ensure the well fields can deliver their full permitted capacity.
Hydrogeological Assessment of Production Wells K23 and K24 (2014-2018) Waterloo Region, Ontario	Senior technical reviewer for the hydrogeological assessment of wells K23 and K24, initiated in 2014 to better understand increasing nitrate concentrations in the wells due to nearby anthropogenic sources, primarily septic systems and agricultural fertilizers. The investigation is developing an improved understanding of the hydrogeology, aquifer vulnerability and water quality in areas around the supply wells and the interrelationships between the wells and potential contaminant sources.
Hydrogeologic Data Analysis Software System Update (2014-present) Waterloo Region, Ontario	Project manager and senior technical reviewer for the selection and implementation of a new hydrogeologic data analysis (HDA) system for the Region. The project involved a detailed assessment of the Region's current and future data needs, the procurement and evaluation of potential commercial software solutions, and the implementation of the new software database and tools.
Hydrogeologic and Source Water Protection Services (2013-2018) Centre Wellington, Ontario	Senior technical reviewer for hydrogeologic and source water protection services provided on an as-needed basis to the Township of Centre Wellington. The work includes on-going investigations and monitoring related to source water "Issues", as well as the evaluation of the hydrogeological aspects of infrastructure and development projects on behalf of the Township.
Hydrogeologic Services - Cambridge Aggregates (2008-present) North Dumfries and Brant, Ontario	Senior technical reviewer for various projects for Cambridge Aggregates related to the development of large volume groundwater supply wells and Permits to Take Water for aggregate washing, and hydrogeological assessments in support of new licence applications and licence expansions under the Aggregate Resources Act.
Water Supply Class EA – Region of Waterloo (2010-2012) West Montrose, Ontario, Canada	Senior technical reviewer for the hydrogeological component of a Water Supply Class Environmental Assessment for West Montrose. The hydrogeological component involved the exploration for an additional water supply within West Montrose. Through a field program involving drilling, hydraulic testing and water quality sampling a potential groundwater supply source was identified and carried forward as part of the assessment.

TICS Project – Region of Waterloo (2009-2012) Waterloo Region, Ontario	Project manager for the Threats Inventory and Circumstances Survey (TICS) project for the Region of Waterloo. The project involved conducting Canada's largest drinking water census across the Waterloo Region and the evaluation of potential threats to drinking water sources in the Waterloo Region for each well field and surface water intake source.
Waterloo North Water Supply Class EA – Region of Waterloo (2008-2012) Waterloo Region, Ontario	Senior technical advisor to the class EA project carried out for the Region of Waterloo with AECOM to develop additional groundwater supply wells in North Waterloo and Erbsville. The project involved the drilling of a new test supply well and a long term pumping test of three new supply wells, along with an extensive groundwater monitoring program.
New Wells Project – Region of Waterloo (2008-2009) Waterloo Region, Ontario	Senior technical advisor to the project to install over 40 new monitoring wells nests throughout the Waterloo Region. Focus was on senior technical review and the interpretation of overburden and bedrock stratigraphy based on core logs, core photographs and samples, grain size analysis and geophysical logs, using nomenclature recently developed by the Ontario Geologic Survey (OGS).
Land Use Designations for Source Water Protection – Brookfield Homes (2007) Paris, Ontario	Manager and senior technical review on a project to evaluate potential changes in land use designation within WHPAs and the associated change in risk to groundwater to well fields, that have high aquifer vulnerability ratings for a proposed development in Paris, Ontario.
Geophysical Investigation, Middleton Wellfield – Stantec (2005) Cambridge, Ontario	Manager and senior technical reviewer on a project to use geophysical methods to map the top of bedrock and identify buried infrastructure around the Middleton Wellfield, in order to identify potential contaminant pathways to the shallow bedrock aquifer system.
IUS Project – Region of Waterloo (2005-present) Waterloo Region, Ontario	The hydrogeological assessment and permitting of existing and potential new Municipal supply Wells for the Region of Waterloo's Integrated Urban Supply System. Assistant project manager, responsible for technical tasks, invoicing, budgeting, tendering and contract administration, presentations, interim and final reporting. Performed a technical role in the water supply development and expansion tasks carried out at the Chicopee, Breslau, Fountain Street, Lancaster, Seagrams and Waterloo North study areas.
Permit to Take Water – Lafarge (2002) Guelph, Ontario	Completed a hydrogeologic study to support a permit to take water (PTTW) application for Lafarge Canada at the Guelph Asphalt and Ready Mix Concrete Plant in Guelph, Ontario.
Permit to Take Water – Lafarge (2002) New Lowell, Ontario	Completed a hydrogeologic study to support a permit to take water (PTTW) application for Lafarge Canada at the Home Pit in New Lowell, Ontario.
Permit to Take Water – Heritage Golf Club (2002) Barrie, Ontario	Completed a hydrogeologic study to support a permit to take water (PTTW) application for Heritage Golf Club near Barrie, Ontario. The work included the supervision and analysis of a 24 hour pumping test.
Geophysical Logging Investigation – Golder (1994) Cambridge, Ontario	Acquired, processed, interpreted and reported on gamma and neutron geophysical logs in a test supply well in Cambridge East, Ontario as part of a water supply development programme for Golder Associates.

GPR, Seismic Refraction and Borehole Geophysical Logging - Walkerton (2000) Walkerton, Ontario	Acquired, processed, interpreted and reported on GPR, seismic refraction and geophysical logging surveys at Municipal well fields in the Town of Walkerton, Ontario in the hydrogeological investigation following the E. coli tragedy in the summer of 2000. These surveys were used to help develop a conceptual geologic and hydrogeologic model for the site, and to identify fractured rock zones in the wells and assess the integrity of the well casing seal to the formation.
Groundwater Study - Victoria County (2000) Oak Ridges Moraine, Ontario	Acquired gamma and conductivity geophysical logs in deep boreholes in the Oak Ridges Moraine as part of the Groundwater Study for Victoria County.
Oxford County Groundwater Study – Oxford County (2000) Stratford, Ontario	Acquired gamma, conductivity, heat pulse flowmeter and optical televiewer geophysical logs in Municipal Supply wells in the Town of Stratford, Ontario, as part of the Oxford County Groundwater Study.
Permit to Take Water – Lafarge (2001) New Dundee, Ontario	Completed a hydrogeologic study to support a permit to take water (PTTW) application for Lafarge Canada at Warren Bitulithic's Seibert Pit in New Dundee, Ontario.
Rotasonic Drilling Programme – Waterloo Region University of Waterloo (1990-1991) Waterloo, Ontario	Under the direction of Dr. P.F. Karrow, carried out all aspects of two drilling programmes in 1990 and 1991 including: siting, permitting, utility clearances, drill supervision, well development, geophysical logging, vertical seismic profiling and reporting.
Borehole Geophysical Logging and Well Log Catalogue for the Waterloo Region University of Waterloo (1987-1993) Waterloo, Ontario	Under the direction of Dr. J.P. Greenhouse, acquired the first digital geophysical logs in the Waterloo Region including: gamma, density, neutron, resistivity, conductivity and caliper log data. Collected and digitized historic logs, as well as digital logs from local consultants. Compiled these logs into a Catalogue in Viewlog format. This log catalogue formed the basis of the current understanding of the quaternary geology and overburden aquifer system in the Waterloo Region.
Seismic Reflection and VSP Studies – Waterloo Region - University of Waterloo (1987-1995) Waterloo, Ontario	Under the direction of Dr. J.P. Greenhouse, carried out pioneering investigative work to optimise high resolution shallow seismic reflection and vertical seismic profiling geophysical methods for the characterisation of geology and aquifers in the Waterloo Region. This work culminated in the development of a controlled vibratory source for high resolution seismic surveys.

Professional Affiliations

Practising Member, Association of Professional Geoscientists of Ontario

Active Member, Society of Exploration Geophysicists

Member, Canadian Nuclear Society

Publications

Monier-Williams, M.E., Davis, R.K., Paillet, F.L., Turpening, R.M., Sol, S.J.Y. and Schneider, G.W. 2009. Review of Borehole Based Geophysical Site Evaluation Tools and Techniques. NWMO Technical Report TR-2009-25, 174 p.

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contamination in Kitchener-Waterloo: A case study with policy implications. Waterloo '94, Abstracts of GAC-MAC Annual meeting, May, 1994.

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Karrow, P.F., Greenhouse, J.P., Paloschi, J.V.R., and Schneider, G.W., 1993. The 1990-91 Rotasonic drilling programme. Final Report to the Ontario MOEE as part of work under grant #E564G, 181 p.

Schneider, G.W. 1993b. Geophysical well logs for the Waterloo Region and surrounding areas: A catalogue (Third Edition). Quaternary Sciences Institute Publication #9, Department of Earth Sciences, University of Waterloo, 699 p.

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Greenhouse, J.P., Nobes, D.C., and Schneider, G.W., 1990. Groundwater beneath the city: A geophysical study. Ground Water Management, Vol. 2, pp. 1179-1191. Proceedings of the Fourth Annual Outdoor Action Conference on Aquifer Restoration, Groundwater Monitoring and Geophysical Methods, Las Vegas, Nevada, USA.

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Schneider, G.W., and Greenhouse, J.P., 1988a. Geophysical well logs for the Waterloo Region and surrounding areas: A catalogue. Report of the Geophysics Lab, Department of Earth Sciences, University of Waterloo, 110 p.

Nobes, D.C., Schneider, G.W., and Hodgson, S., 1987. Discussion on: "Effects of porosity and clay content on wave velocities in sandstones". Geophysics, Vol. 52 pp. 1439.

Golder Associates Ltd. – Cambridge

Education

B.A.Sc. Geological Engineering, University of Waterloo, Waterloo, Ontario, 2003

M.A.Sc. Civil Engineering, University of Waterloo, Waterloo, Ontario, 2005

Languages

English – Fluent

Jeff Randall, M.A.Sc., B.A.Sc.

Mr. Randall, M.A.Sc., is a geological engineer in Golder's Cambridge office, specializing in numerical groundwater modelling and data management, analysis, and visualization. Mr. Randall has experience with database applications and tools such as MS Access and Visual Basic for Applications, and conceptual model development and data visualization software such as ArcGIS, Surfer, and Tecplot. Mr. Randall has numerical modelling experience with software including FEFLOW, Visual MODFLOW, MODFLOW-Surfact, MODHMS, Groundwater Vistas, HydroGeoSphere, and Frac3DVS. Recently, Mr. Randall has been responsible for data management and the construction and calibration of regional and local scale groundwater flow and transport models in support of environmental impact assessments in Canada and internationally.

Employment History

Golder Associates Ltd. – Guelph, Ontario

Groundwater Modeller – Environmental Sciences Division (May 2008 to Present)

Responsible for technical components of groundwater flow and contaminant transport numerical modelling in support of Environmental Impact Assessments, groundwater resource studies and site characterization projects.

HydroGeoLogic, Inc. – Kitchener, Ontario

Associate Engineer (2005 to 2008)

Responsible for conducting groundwater flow, contaminant transport and integrated surface water-groundwater numerical model studies. Developed project specific Visual Basic applications to facilitate numerical model construction. Prepared conceptual and flow model reports and presentations.

University of Waterloo – Waterloo, Ontario

Research Assistant, M.A.Sc. (2003 to 2005)

Collaborative effort with researchers at the University of Waterloo (Earth Sciences and Civil Engineering) to develop and test the application of an integrated surface water – groundwater numerical modelling code. The HydroGeoSphere code was used to simulate a small and well instrumented watershed near Foot's Bay, Ontario.

PROJECT EXPERIENCE – NUMERICAL MODELLING

York Region Ontario, Canada	Lead modeller for an update and re-calibration of the York Tier 3 regional groundwater model to reflect a new conceptual hydrogeological model. The updated model was used to develop new WHPA and Vulnerability Scoring assessments for new and existing regional pumping wells.
Confidential Client USA	Lead modeller for construction and calibration of 2D / quasi-3D cross-sectional FEFLOW models in support of Life-of-Mine stability assessment for an open-pit mining operation. Simulations to match historical pit conditions and future mine plans were completed. Predictive simulations of dewatering plan designs were completed to support geotechnical slope stability assessments.
Teck Frontier Project Alberta, Canada	Responsible for the compilation and analysis of hydrogeological data as well as the construction and calibration of regional groundwater flow models. Predictive numerical models were constructed and simulated in support of the impact assessment to estimate seepage from tailings storage areas.
Brukunga South Australia, Australia	Constructed a local-scale 3D groundwater flow model (FEFLOW - converted to HydroGeoSphere) to support on-going rehabilitation efforts at the site. The model was used in the evaluation of proposed co-disposed tailings impoundment designs.
Eastbank Aquifer System - Public Utility District 1 of Chelan County Washington State, USA	Modelling lead for construction and calibration of a local-scale 3D groundwater flow and heat transport model (FEFLOW) to support operational planning at the Public Utility District. Model calibration was completed using parameter estimation software (PEST) and focused on transient groundwater temperature and hydraulic head data. The model was used to simulate the hydraulic and thermal aquifer responses to possible future external stresses.
PCS - Patience Lake Saskatchewan, Canada	Constructed and calibrated regional- and local-scale 3D groundwater flow and transport simulation models (FEFLOW) to support on-going groundwater management operations at the Patience Lake Site. These models were used to evaluate potential brine migration pathways / mechanisms and help in the development of groundwater containment strategies.
Key Lake Tailings Management Facility Saskatchewan, Canada	Developed and calibrated multiple regional-scale 3D groundwater flow simulation models (MODFLOW) to support the preparation of an Environmental Impact Assessment. These models were constructed to include updated site hydrogeological data and were used to evaluate the groundwater system response (groundwater quantity and quality) to numerous possible future operational conditions.
Vale - Saskatchewan Potash Project Saskatchewan, Canada	Constructed a regional-scale numerical groundwater flow model (MODFLOW) for a proposed potash mine site in Saskatchewan. This model was used to help guide additional hydrogeologic drilling programs and to identify potential seepage pathways from proposed salt storage facilities at the mine site.
Western Potash - Milestone Project Saskatchewan, Canada	Developed a regional-scale 3D numerical MODFLOW model to assess possible hydrogeologic impacts and to determine potential seepage pathways from a proposed potash mine in Saskatchewan.

Potash One - Legacy Mine Saskatchewan, Canada	Developed regional- and local-scale 3D numerical MODFLOW models in support of an Environmental Assessment for a proposed potash mine in Saskatchewan. The purpose of the model was to determine potential transport pathways from proposed on-site salt storage facilities.
Agrium - Triton Mine Saskatchewan, Canada	Constructed and calibrated regional- and local-scale 3D numerical MODFLOW models in support of an Environmental Assessment for a proposed potash mine in Saskatchewan. The modelling was completed to assess any potential impacts of groundwater pumping withdrawals and to evaluate potential transport pathways from the proposed mine site.
Key Lake Tailings Management Facility Key Lake, Saskatchewan, Canada	Responsible for the completion of a regional-scale 3-D groundwater flow model (MODFLOW). This model was used to gain a better understanding of the groundwater flow system and evaluate groundwater responses to several potential pump-and-treat operations at the Key Lake Mine.
Kabanga Tanzania	Lead modeller responsible for the development and calibration of a regional-scale 3D numerical MODFLOW model to evaluate regional groundwater flows in support of the Kabanga EA for a potential mining operation in Tanzania. The impact of mine dewatering was evaluated for various mine development scenarios and schedules to identify potential impacts on groundwater resources in neighbouring communities.
Confidential Client Southern Ontario, Canada	Responsible for the construction of a local-scale groundwater flow model for the subject property. The groundwater model was used to refine the understanding of the groundwater flow patterns beneath the site and to provide an assessment of the potential impact on groundwater conditions due to the construction of permeable reactive barrier and bentonite slurry barrier walls.
U.S. Bureau of Reclamation San Joaquin Valley, California, USA	Lead modeller for an integrated surface water-groundwater model of the San Joaquin Valley, CA. This project includes data compilation and development of a three-dimensional HydroGeoSphere model to simulate integrated surface and subsurface flow regimes within the San Joaquin Valley. Model construction and data processing were completed using ArcGIS, Microsoft Access, VBA, GridBuilder, Tecplot and HydroGeoSphere.
Southwest Florida Water Management District Florida, USA	Lead modeller for the Northern District Water Resources Assessment Project. This project includes the development of a regional-scale groundwater flow model for Pasco, Sumter, Citrus, Hillsborough, Hernando, Marion, Lake, Polk, Levy, Alachua and Putnam counties, Florida. The MODFLOW-based finite-difference groundwater flow code, MODHMS, was used to simulate and calibrate a regional-scale model to pre-development and post-development conditions. The calibrated model was used to establish parameter sensitivities, evaluate long-term regional impacts of groundwater withdrawals and provide boundary and initial conditions for density dependent saltwater transport models. The density dependent transport models can be used to assess potential saltwater intrusion along coastal boundaries, as well as to assess the long-term impacts of groundwater withdrawals on inland saltwater migration. Groundwater Vistas, VBA, ArcGIS, PEST, ViewHMS and MS Access were used throughout model construction.

PROFESSIONAL AFFILIATIONS

Registered Professional Engineer, Ontario

PUBLICATIONS

Conference Proceedings

Lawrence, Karl P., Jefferey E. Randall, Ashley Mathai, Rob McLaren and Willy Zawadzki. 2013. *Simulation of Horizontal Well Depressurization in Groundwater Flow Models*. MODFLOW and More 2013, June. Golden, United States.

Sykes, J.F., S.D. Normani, M.H. Brouwers and J.E. Randall. 2006. *The analysis of the impact of aquatic fauna on a watershed in a crystalline rock setting using an integrated surface water and groundwater model*. HydroEco'2006 International Conference on Hydrology and Ecology: The Groundwater / Ecology Connection, September. Karlovy Vary, Czech Republic.

Sykes, J.F., J.E. Randall and S.D. Normani. 2006. *The analysis of seasonally varying flow in a crystalline rock watershed using an integrated surface water and groundwater model*. XVIth International Conference on Computational Methods in Water Resources, June. Copenhagen, Denmark.

Other

Randall, J. E. 2005. "The Analysis of Seasonally Varying Flow in a Crystalline Rock Watershed and Calibration of an Integrated Groundwater and Surface Water Model" M.A.Sc. Thesis, Department of Civil and Environmental Engineering, University of Waterloo, Waterloo, Ontario.

Education

BSc Engineering (Co-op), University of Guelph, Guelph, Ontario, 2007

Languages

English – Fluent

Golder Associates Ltd. – Mississauga

Employment History

Golder Associates Ltd. – Mississauga, Ontario
Water Resources Specialist (2007 to Present)

Responsible for conducting water quantity and water quality investigation programs that include hydraulic and hydrologic modelling, analysis of riverine and lacustrine environments, the design, execution and management of meteorological, hydrological and water quality field programs and development of water balance and water quality modelling analyses. Currently working on various surface mine and mine rehabilitation investigations of hydrology and water quality. Completes water resources projects from desktop reviews to design, construction monitoring and erosion and sediment control inspection.

Golder Associates Ltd. – Mississauga, Ontario
Water Resources (Co-Op) (May 2006 to December 2006)

University of Guelph, Environmental Biology – Guelph, Ontario
Co-Op Student (May 2005 to August 2005)

Ontario Clean Water Agency – Toronto, Ontario
Water Resources (Co-Op) (January 2005 to April 2005)

Hydromantis Inc., Consulting Engineers – Toronto, Ontario
Co-Op Student (June 2004 to September 2004)

PROJECT EXPERIENCE – WATER SUPPLY FORECASTING

City of Iqaluit Iqaluit, Nunavut, Canada

Developed a water balance model (using GoldSim) to quantify water deficit risks under future population growth and climate change scenarios. Analytical output and recommendations were subsequently provided in order to assist the City in water license application process for a supplementary source and provide a risk matrix of long-term probabilistic water supply deficits. (2012 to 2013)

City of Rankin Inlet Rankin Inlet, Nunavut, Canada

Water supply deficits were evaluated using a water balance model (using GoldSim) under future growth and climate change scenarios. The model evaluated water taking from the supply reservoir and an adjacent river while maintain use for aquatic live and social activities. (2015)

PROJECT EXPERIENCE – CHANNEL / CROSSING DESIGN

County of Northhumberland Cobourg, Canada

Ongoing support regarding a channel remediation design/assessment for the County of Northhumberland on a reach of Brookside Creek located downstream of the closed Eagleson Landfill to reroute unaffected surface water flows away from a zone of leachate influenced groundwater – conducted field studies, fluvial geomorphic and hydraulic analyses, preparation of conceptual/detailed design plans, liaison with contractor and reporting. (2009 to 2015)

Region of Durham Whitby, Canada	Completed a hydraulic analysis and fluvial geomorphic assessment at East Corbett Creek and tributary of East Corbett Creek. The analyses were conducted in support of a proposed extension of Consumers Drive that includes culvert crossings at the two watercourses – conducted field investigations, fluvial geomorphic analyses, hydraulic modelling, environmental permitting and reporting. (2014 to 2016)
Confidential Client Timmins, Canada	Ongoing support of a natural channel diversion design/assessment for a proposed pit mine. The channel design incorporates fluvial geomorphic processes to accommodate fish passage and habitat. Hydraulic modelling was conducted to limit erosion and maintain stability of the channel banks and crossings. (2015)
Canadian National Railway Southern Ontario, Canada	Many rail crossings were evaluated at locations of aging bridges, collapsed culverts and areas of flooding. Sites were visited and surveyed to confirm conditions and provide detailed data for desktop analysis. Hydraulic analyses were completed for each site to evaluate existing infrastructure. New crossing designs were evaluated based on MTO and CN guidelines and developed to conceptual and final designs. (2016 to 2018)

PROJECT EXPERIENCE – ENVIRONMENTAL COMPLIANCE APPROVALS, WATER DISCHARGES

Canadian National Railway Algonquin Park, Ontario, Canada	Completed an Environmental Compliance Approval for Industrial Sewage Works for a temporary water treatment facility which was designed to treat contaminated water and sediments from a historic train derailment. The facility discharged to a nearby lake within the Park. (2015 to 2017)
Essroc Aggregates Cambridge, Ontario, Canada	Managed and completed an Environmental Compliance Approval for Industrial Sewage Works for an aggregate pit and wash plant in Cambridge, Ontario. The application included supporting documentation of the wash ponds which only discharged to the environment through the groundwater. (2016 to 2017)
Fish and Bird Emporium Innisfil, Ontario, Canada	Lead a team that completed an Environmental Compliance Approval for Industrial Sewage Works for a tropic fish warehouse and distribution centre. The application included multiple water filtration facilities designed to reduce the effluent contaminant concentrations without impacting the health of the fish at the site. (2016)
Lafarge Canada Inc. – Soares Dundas, Ontario, Canada	Carried out field investigations, water budget analysis and coordinated various project tasks related to the proposed Lafarge Soares License Application. (2007 to 2009)
Amherst Quarries Ltd. Windsor, Ontario, Canada	Performed reconnaissance of the local watersheds and hydrologic features of the quarry sumps. Carrying out quarterly volumetric flow monitoring and water quality sampling. Local drainage channels were evaluated using computer models including HEC-RAS. Developed a water balance to model drainage from the site and the adjacent Canard River. (2008)

O'Shanter Development Company – Arbour Farms Dufferin, Ontario, Canada	Conducting annual dry weather volumetric flow monitoring and groundwater well monitoring related to the Arbour Farms assessment of the proposed quarry. (2007 to 2012)
Brampton Brick – Norval Norval, Ontario, Canada	Performed field investigations and coordinated various project tasks related to the proposed Brampton Brick Norval quarry development. (2007 to 2008)
Lafarge Canada Inc. West Paris, Ontario, Canada	Completed baseline monitoring, including flow and water level monitoring, water quality monitoring. Supported license applications for extension properties and Permit to Take Water applications and continued site plan monitoring. (2016 to 2019)
Nelson Aggregate Company Burlington, Ontario, Canada	Carried out volumetric flow monitoring throughout neighbouring watersheds for the proposed Lafarge Nelson License Application. Performed wetland mapping on the proposed quarry site. (2006 to 2007)
CBM Aggregates Various Sites in Southern Ontario	Various aggregate properties have been monitored and evaluated for aggregate license applications. this monitoring included water level monitoring, stream flow monitoring, groundwater piezometer monitoring and meteorological monitoring. Detailed site water balances as well as site and water course characterization have been evaluate and reported as part of the multidisciplinary applications. (2007 to 2018)

PROJECT EXPERIENCE – SITE REHABILITATION

Client Confidential Bancroft, Ontario, Canada	Completed surface water investigations at a decommissioned mine site (uranium) near Bancroft, Ontario, including meteorology, flow and water quality monitoring. Developed a detailed water balance to evaluate the site drainage and adjacent stream networks. Characterized and reported the surface water networks and their impacts. (2010 to 2020)
Client Confidential Near Kenora, Ontario, Canada	Completed surface water investigations at a former mine (nickel) near Kenora, Ontario, including meteorology, flow monitoring, water column profiling and water quality sampling. Flow regimes were characterized and modelled to evaluate impacts of adverse water quality on downstream environments. (2009 to 2018)
Niagara Peninsula Conservation Authority Welland, Ontario, Canada	Completed stream sediment investigations on Lyon's Creek, downstream of the Welland Canal, including a stream survey, sediment sampling, loading, scour and re-suspension analysis. Reported investigation results as part of the Niagara River remedial options. (2009 to 2010)
Lafarge Canada Inc. Bath, Ontario, Canada	Reporting annually on volumetric flow monitoring and water quality data collected monthly on and adjacent to the Lafarge Bath cement kiln dust landfill and rehabilitation. Engineering drainage features on site was also completed. (2006 to 2008)

Canadian Gypsum Company Ltd. Haggersville, Ontario, Canada	Performing volumetric flow monitoring, water quality and continuous water level monitoring on Boston Creek adjacent to the mine site. Annual reporting was also conducted until rehabilitation completion. (2006 to 2013)

PROJECT EXPERIENCE – THREATS ASSESSMENT

Hanson Brick Ltd. – Tremaine Bronte Creek Burlington, Ontario, Canada	Evaluated the risks of a potential drinking water intake on Bronte Creek. Risks in the watershed were evaluated and analysed using plume dispersion algorithms to estimate contaminate impacts on the potential intake. Evaluation was completed using computer models including HEC-RAS. (2008)
Teck Resources Elk Valley, British Columbia, Canada	Conducted water quality modelling to support mine site investigations for a mining project in British Columbia. Water quality parameters were modelled throughout the watersheds from natural sources, mining and metal processing activities as well as their reactions within the watershed. Modelling efforts were used to evaluate treatment options and water handling / management. (2013 to 2015)

PROJECT EXPERIENCE – URBAN WATER MANAGEMENT

Metrolinx Toronto, Ontario, Canada	Project manager for the program which included stormwater sampling of a Metrolinx rail yard. The sample results were compared to the municipal stormwater sewer quality limits and reported at the season. (2017 to 2018)
Toronto Transit Commission Vaughan, Ontario, Canada	Task Manager of the stormwater monitoring and reporting as part of the ECA requirements at the 407 subways station. The monitoring involved storm event water quality monitoring to evaluate Stormwater Management Pond performance, erosion and sediment control inspections, annual reporting and recommendations for performance improvements. (2018 to 2019)
Town of Oakville Oakville, Ontario, Canada	Project manager for the program which included dry weather outfall sampling and wet weather storm sewer sampling. Results were analysed to develop water quality trends in order to estimate contaminate sources and evaluate the effectiveness of Best Management Practices and Stormwater Management Plans (Town of Oakville). (2008 to 2012)
City of Barrie – Barrie Flow Monitoring Barrie, Ontario, Canada	Performing volumetric flow monitoring under flash flooding or melting conditions in areas of low permeability in the City of Barrie. (2008)
Black and McDonald Ltd. – Castrol Toronto, Ontario, Canada	Conducted reconnaissance and water quality sampling regarding the Castrol Oil storm water discharge to the city storm sewer. Testing performance of the on-site water treatment equipment and evaluating replacements. (2007)

PROJECT EXPERIENCE – MINING OPERATIONS AND EXPLORATION

Adrianna Resources Lac Otelnuk, Quebec, Canada	Conducted transducer installations and collected cross sectional geometry information at surface water points of interest influencing site drainage and watersheds adjacent to Lac Otelnuk. (2010)
Xstrata, Copper Las Bambas, Peru	Conducted transducer installations at surface water points of interests influencing the site drainage and watersheds located on and adjacent to site Las Bambas. (2008)
Xstrata, Copper Antapaccay, Peru	Conducted transducer installations at surface water points of interests influencing the site drainage and watersheds located on and adjacent to site Antapaccay. (2008)
Xstrata, Nickel Loma Miranda, Dominican Republic	Managed and carried out quarterly field campaigns for Loma Miranda and Energy Conversion Project, which involved installation and monitoring of river hydrology, water quality sampling and rain data collection. Quarterly reporting was conducted, summarizing campaigns. (2007 to 2010)

PROJECT EXPERIENCE – PIPELINE WORK

Trans Canada Pipelines Channel Rehabilitation Ontario, Canada	Designed a stream channel rehabilitation to remediate TransCanada Line 100-1 exposure caused by erosion and beaver activity near Dryden, Ontario. The project progressed from conceptual design through to construction monitoring. The final design was focused on improving channel stability over the pipelines to reduce meander and erosion. (2017)
Trans Canada Pipelines New Gas Line Ontario, Canada	Managed and supported continuous instream turbidity monitoring of many watercourse crossings as part of the Vaughan Mainline pipeline construction and Gravenhurst pipe replacement. This program included site reconnaissance, equipment installation, intensive 24-hour monitoring and troubleshooting, daily and final reporting. (2017 to 2018)
Trans Canada Pipelines Channel Rehabilitation Ontario, Canada	Developed the design and supported construction of channel rehabilitation works at a tributary of Bear Creek that is crossed by TransCanada pipelines Line 100-1 and Line 100-2 near Barrie, Ontario. The goal of the rehabilitation is to improve long term channel stability at the watercourse crossing. The work includes the completion of field studies and hydraulic modelling, development of conceptual designs, and the preparation of environmental permitting. (2016 to 2017)
Trans Canada Pipelines New Gas Line Ontario, Canada	Completed watercourse baseline investigations for Eastern Mainline Expansion in Ontario (260 km long new gas pipeline spanning central and eastern Ontario). Responsible for field data collection of baseline conditions at major watercourse crossings and evaluating the hydrotechnical characteristics of each potential crossing. (2015 to 2016)
Trans Canada Pipelines Gas Line Construction Ontario, Canada	Designed drainage improvements at a gas pipeline valve station to control flooding in the area to allow maintenance staff to work safely. The work involved conservation authority permitting and negotiation with landowners and other stakeholders. (2018 to 2019)

PROJECT EXPERIENCE – ENVIRONMENTAL ASSESSTMENT AND PERMITTING

Walker Environmental Group Inc. Ingersol, Ontario, Canada	Completed baseline evaluation and impact assessment for the proposed landfill in the Town of Ingersol. This included the flow and water quality monitoring of the Thames River and local tributaries. Desktop analysis of the potential impacts utilized hydrologic models, climate change predictions, water quality models and stormwater design. (2018-2019)
Marten Falls First Nation Marten Falls, Ontario, Canada	Drafted existing surface water conditions report and impact assessment to support the proposed all season road from Marten Falls to Nakina Ontario. This work involved watercourse crossing surveys utilizing helicopter transportation. The field studies visited a subset of the crossings to evaluate the impacts of the road alignment. (2019)
NextBridge Northern Ontario, Canada	Completed water quality and hydrotechnical analysis to support the NextBridge Infrastructure East-West Tie Transmission Line Project in Northern Ontario (430 km long new transmission line). Conducted baseline studies, effects evaluations, permitting support through hydrotechnical analysis and preliminary design criteria. (2018)

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