



**BURNSIDE**

**Hydrogeological Assessment,  
5431 Eighth Line, Erin**

**Homes in the Hills Inc.  
Erin, Ontario**

**R.J. Burnside & Associates Limited  
292 Speedvale Avenue West Unit 20  
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## 1.0 Introduction

R.J. Burnside & Associates Limited (Burnside) was retained by Homes in the Hills Inc. to complete a hydrogeological assessment for lands located in Erin, Ontario (Figure 1). The lands are slated for residential development and a hydrogeological study is required in support of the proposed development. The proposed development will be on approximately 25.6 ha of lands that are located north of Highway 124 and just west of Eighth Line in the Town of Erin. The legal address of the lands is 5431 Eighth Line, Part of Lot 14, Concession 9 in the geographic Township of Erin, Town of Erin, County of Wellington. Currently the lands include natural wetlands and woodlands, plantation and cultivated pasture areas. For the purposes of this study the lands are referred to as the subject lands and are shown in Figure 2.

### 1.1 Scope of Work

The scope of work completed for the hydrogeological study was developed based on criteria provided by Credit Valley Conservation (CVC) in a document entitled Hydrogeological Assessments - Conservation Authority Guidelines to Support Development Applications (2013). The scope of work was also enhanced based on Burnside's review of existing information and our experience in completing similar studies. In completing the current study, the scope of work included completion of the following tasks:

1. Compilation and review of available hydrogeological and geological data in the vicinity of the subject lands, including a review of the Ministry of the Environment and Climate Change (MOECC) online water well records. Borehole and well logs are provided in Appendix A. A list of the available MOECC water well records for local wells is provided in Appendix B.
2. Drilling and installation of seven monitoring wells (MW) and four piezometer (PZ) nest (with one shallow and one deep piezometer in each nest) to assess the shallow soil and groundwater conditions. The locations of the monitoring wells and piezometers are shown on Figure 2 and monitoring well construction details are provided on the borehole logs in Appendix A.
3. Surface water monitoring stations were established at key locations along the watercourses that cross the subject lands. When present, surface water flow was recorded as part of the evaluation of surface and groundwater interactions. Field observations of surface water features on the site were completed monthly from May 2017 to November 2017. Surface water monitoring data are provided in Appendix C.

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4. Groundwater level monitoring was completed in monitoring wells and piezometers to establish groundwater conditions. Monitoring was completed monthly from March 2017 to November 2017 to confirm the seasonal variations. Automatic water level recorders (data loggers) were installed in MW2-17, MW4-17, MW6A-17 and PZ3d. The groundwater monitoring data and hydrographs are provided in Appendix D.
5. In situ well testing of five monitoring wells (MW1-17, MW2-17, MW3-17, MW4-17 and MW6B-17) to assess hydraulic conductivity of soil types. The hydraulic conductivity field testing results are provided in Appendix E.
6. Infiltration testing at four locations to assess the potential infiltration rates of the surficial soils. The infiltration test results are provided in Appendix F.
7. Collection of groundwater samples from two monitoring wells (MW2-17 and MW6B-17) and one surface water sample (SS1) for laboratory testing to characterize the background water quality. The water quality results are provided in Appendix G.
8. An assessment of the subject lands for septic system suitability based on Ministry of Environment and Climate Change's Procedure D-5-4 Guidelines. Calculations are provided in Appendix H.
9. Pre-development (based on existing land use conditions) and post-development (based on the proposed development concept) water balance calculations were completed to assess the potential impacts of land development on the local groundwater conditions. The local climate data and detailed water balance calculations are provided in Appendix I.
10. Data compilation, assessment of site conditions and reporting.

## **1.2 Previous Work**

A hydrogeological study was completed by Naylor Engineering Associates Ltd circa 2004 as part of an initial Stage 1 hydrogeological study in support of proposed development for a previous owner. The Naylor work included the drilling of nine monitor wells and the completion of test pits. Information from this report was unavailable however the monitor wells were available for use during the current study and their locations are shown on Figure 2. It is understood that a door-to-door survey was conducted as part of the Naylor study however the results of the survey are not available at this time.

## **2.0 Site Characterization**

### **2.1 Physiography and Topography**

The subject lands are located in the broad physiographic region known as the Guelph Drumlin Field which is characterized by drumlins or groups of drumlins, edged with gravel terraces and swampy valleys (Chapman & Putnam, 1984). The topographic high on the subject lands is 433 metres above sea level (masl) that occurs along the side slope of a drumlin on the northern eastern property boundary (Figure 3). The topography is steep along the drumlin which grades into rolling fields for the remainder of the subject lands. The topography generally slopes towards watercourses that traverse the central portions of the subject lands with drainage from the south being towards the north and drainage from the north being generally south (Figure 3). Wetlands are located along the surface water features which form the low lying areas across the subject lands and have elevations of approximately 395 to 397 masl.

### **2.2 Drainage**

The subject lands are located in the West Credit River subwatershed within the jurisdiction of the Credit Valley Conservation (CVC). Three surface water courses enter the subject lands from the western property boundary (Figure 3). Two of the branches (Tributary A-1 and A-2) converge in the middle of the subject lands into Tributary A. Tributary A leaves the subject lands along the south eastern property boundary. A northern tributary (Tributary B), flows in a southeast direction converging with Tributary A just outside of the subject lands. The tributaries eventually drain to the Credit River (Erin Branch) located north-east of the subject lands. Surrounding the watercourses are wetlands that are part of the provincially significant West Credit River Wetland Complex.

### **2.3 Geology**

Surficial geology mapping published by the Ontario Geological Survey (2003) shows that the subject lands are underlain by ice-contact stratified deposits (Figure 4). Glaciofluvial deposits are mapped south of the subject lands and silty to sandy till is mapped east of the subject lands. The bedrock underlying the subject lands consists of dolostone from the Amabel Formation (Figure 5).

## **3.0 Surface Water Characterization**

There are two watercourses that traverse the subject lands and they are referred to as Tributary A (south tributary) and Tributary B (north tributary) (Figure 3). Tributary A begins as two branches (A-1 and A-2) that combine into one channel within the subject lands. Surface water monitoring stations were established on the subject lands to evaluate surface water/groundwater interactions. SS1 was located at a culvert just upstream of where Tributary A leaves the subject lands (Figure 3). SS2 was located

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off-property downstream of the confluence between Tributary A and Tributary B. This monitoring location was selected because it provided access to a defined channel for surface water measurements. Later it was discovered that there is a pipe that directs some of the flows from the Tributary around SS2. Future monitoring will include a third monitoring station to capture the flows from this pipe.

Two staff gauges were installed within the watercourses to measure surface water levels. SG-1 was located along Tributary A at the confluence of branches A-1 and A-2 (see Figure 2 for location). SG2 was located along Tributary B at the upstream side of a culvert that takes water from one wetland area to another; this location is also illustrated in Figure 3. Surface water levels were recorded from May 2017 to November 2017 and these data are provided in Tables C-1 and C-2, Appendix C.

Flow monitoring at SS1 (Table C-1) and water levels at SG1 (Table C-2) suggest that flow in Tributary A is perennial. Flows measured between May 2017 and November 2017 ranged from 2.6 L/s to 12.5 L/s. There is a well defined channel along Tributary A-1 and Tributary A.

Tributary B is not well defined, located in a marshy area of long grasses and wetland. SG2 is located at a culvert that takes the water below a crossing of the channel. Water is ponded upstream of the culvert and water level is measured as depth above the channel base which is below the grade elevation of the crossing. SG2 had surface water present during all monitoring events with levels ranging from 0.1 m aboveground surface (mags) to 0.21 m mags (Appendix C). Due to poor access and a poorly defined channel on the subject lands, flow monitoring was conducted downstream of the staff gauge at SS2. Flow at SS2 was intermittent, with surface water flows ranging from dry to 0.7 L.s. Further analysis of this monitoring location has shown that there is a diversion pipe in this area and it is concluded that the measured flows do not represent the total surface flows at this location.

## **4.0 Groundwater Characterization**

### **4.1 Borehole Drilling and Monitoring Well Installation**

There were nine existing monitoring wells on the subject lands installed as part of a previous study completed by Naylor Engineering. The existing wells ranged in depth from 1.7 m to 5.8 m and included three nests (a deep well and shallow well at the same location). Burnside made several unsuccessful efforts to obtain a copy of the Naylor report, however a full copy was never provided and we are therefore unable to provide the well logs for the wells completed as part of the Naylor study.

In February 2017, seven additional monitoring wells were installed using a conventional auger drilling rig at selected locations. One nest, consisting of one shallow and one deep well was installed at MW6 to monitor vertical flow conditions. At each borehole, an

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observation well was installed using 51 mm diameter PVC riser pipe with a 1.5 m long 10-slot PVC screen. Sand was put in place around the screen and borehole and bentonite was used to seal the well to surface. Borehole logs outlining the construction details are included in Appendix A. Locations of monitoring wells are indicated in Figure 2.

Piezometer nests were installed on the subject lands to assess the shallow groundwater elevations and vertical gradients beneath the surface water bodies. The data would also be used in the estimation of recharge and discharge at the groundwater/ surface water interface. The piezometer nests, which consisted of 1.5 m of steel pipe (for shallow) and 3.0 m of steel pipe (for deep) and a 0.31 m stainless steel drive point, were installed with a manual post pounder. The locations of the piezometers are shown in Figure 2.

## 4.2 Site Specific Geology

Subsurface investigations completed by Burnside indicate that the surficial soils generally consist of 0.2 m to 1.5 m of topsoil or peat overlying sand ranging in thickness of 1.2 m to 3.8 m. Underlying the surficial sand are layers of silt, sandy silt and sand. Silty clay was encountered at depths of 1.52 m at MW4-17 and 2.90 m at MW2-17. Limestone bedrock was encountered at depths of 5.3 m at MW3-17 and 12.2 m at MW1-7. The borehole logs completed during subsurface investigations are provided in Appendix A.

The MOECC maintains a database of geological records for water supply wells drilled in the province. A list of the available MOECC water well records for local wells is provided in Appendix B and the well locations are plotted on Figure 6. In conjunction with the site-specific geological information obtained from the geotechnical boreholes drilled on the site (logs provided in Appendix A), these MOECC records provide geology data that have been used to prepare several schematic cross-sections through the site to illustrate the local stratigraphy. The cross-section locations are shown on Figure 6, and the cross-sections are provided as Figures 7 and 8. The cross-sections show that the overburden is dominantly sand, silt and gravel with the occasional lens of silty clay. Bedrock under the subject lands is located 7 to 20 m below ground surface at elevations between 385 masl and 390 masl.

## 5.0 Hydrogeology

It is interpreted that the overburden sediments form a shallow aquifer below the subject lands and that these sediments may interact with the local wetlands and water features within the low lying areas of the subject lands. The shallow aquifer has a thickness that ranges from 5 m to 20 m. The bedrock forms a more regional aquifer that is the main source of water supply in the area.

## 5.1 Local Groundwater Use

The Village of Erin is supplied with municipal groundwater however there are still some private water supply wells that are used. A review of the MOECC well records for an area of approximately 500 m surrounding the subject lands identified 65 water well records. Of the 65 records, 57 records were for water supply wells and the other 8 records were for monitoring wells, test boreholes and well abandonment records. Of the 57 water supply wells, 50 of the wells are completed in the bedrock at depths ranging from 10 m to 68 m and 7 of the wells were overburden wells with depths ranging from 5 m to 28 m. The yield of the wells reviewed generally ranged between 15 L/min (4 gpm) and 75 L/min (20 gpm) with the exception of a municipal well rated at 378 L/min (100 gpm). Summaries of the MOECC records are provided in Appendix B.

## 5.2 Site Soil Hydraulic Conductivity

As part of the assessment of the properties of the local shallow aquifer soil hydraulic conductivity testing was conducted. There are various methods that can be used to assess soil hydraulic conductivity, i.e., the ability of the soil to transmit groundwater. To assess the in situ hydraulic conductivity of the shallow soils on the subject lands, bail-down tests were completed in monitoring wells MW1-17, MW2-17, MW3-17, MW4-17 and MW6B-17. Bail-down tests involve purging or removal of water from the monitoring well and measuring the recovery of the water level over time. The results from the tests were plotted and analyzed to calculate an estimated hydraulic conductivity of the sediments screened.

The results of the test were plotted (Appendix E) and analyzed to calculate hydraulic conductivity of the sediments screened. A summary of the results is provided below in Table 1.

**Table 1: Single Well Response Testing Results**

Monitoring Well	Screen Interval (mbgs)*	Formation Screened	Estimated Hydraulic Conductivity (cm/sec)
MW1-17	10.1 – 12.2	Silt	$2.1 \times 10^{-4}$
MW2-17	2.4 – 4.6	Silt, Sand, Silty Clay	$3.2 \times 10^{-4}$
MW3-17	3.2 – 5.3	Sand	$1.4 \times 10^{-3}$
MW4-17	3.9 – 6.1	Clayey Silt	$3.0 \times 10^{-6}$
MW6B-17	4.0 – 6.1	Sand, Sandy Silt	$9.5 \times 10^{-5}$

\*meters below ground surface

The single well response test analyses provide estimates for the hydraulic conductivity of the sediments underlying the subject lands. The sand layers have the highest hydraulic

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conductivity and since the sands are found at surface will control recharge to the water table. Finer grained layers beneath the sand have lower conductivities (ranging from  $10^{-4}$  cm/sec to  $10^{-6}$  cm/sec) that will slow down the flow of water vertically through the subsurface. These layers will impact the travel time for recharge to reach the limestone bedrock.

### 5.3 Infiltration Testing

A Turf-Tec double ring infiltrometer was used to conduct the infiltration tests. The tests were completed by removing the topsoil in the test area and installing the infiltrometer in the underlying soil. Both rings of the infiltrometer were then filled with water and time for the water level in the inner ring to fall 10 mm was recorded. This was repeated until a consistent rate was obtained. The locations of the infiltration tests are shown on Figure 2 and are identified as IT-1, IT-2, IT-3 and IT-4. The use of the infiltrometer for measuring infiltration has advantages over lab methods as it is representative of all conditions at the site including compaction, soil texture and fractures within the soil. The results of the infiltration tests are provided in Appendix F. The infiltration rate was determined by plotting infiltration per hour versus elapsed and then averaging the values where the curve begins to stabilize. At some of the locations multiple tests were completed to obtain a consistent rate. The infiltration rate is determined based on the curves where a stabilized rate has been obtained. A summary of the infiltration rates is provided in Table 2.

**Table 2: Infiltration Testing Results**

Location	Soil Type	Infiltration Rate (mm/hour)
IT-1	Sandy soil	245
IT-2	Sandy soil with some organics	148
IT-3	Dominantly organic (humus) soil	383
IT-4	Sandy soil	1121

The testing indicates that the soils on the subject lands have high infiltration rates.

### 5.4 Water Level Monitoring

Water levels in monitoring wells and piezometers were collected from November 2016 to November 2017 using a water level meter. Dataloggers (automatic water level recorders) were installed in March 2017 at MW2-17, MW4-17, MW6A-17 and PZ3d to provide continuous data (hourly readings) of water levels during the monitoring period. A barometric pressure logger was also installed to measure changes in barometric pressure. These data are used to correct the water level data by accounting for changes in atmospheric pressure.

Groundwater levels were collected from 17 monitoring wells and 8 piezometers located on the subject lands. The groundwater monitoring data show the following (refer to

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Figure 2 for the monitoring locations and the data tables and hydrographs in Appendix D):

- The groundwater elevations across the subject lands range between approximately 394 masl and 404 masl.
- The average depth to water table is about 1 m with depths ranging from 0.03 mbgs at MW6 to 4.9 mbgs at MW1-17.
- Seasonal variations observed in the water levels are typical for Southern Ontario with high groundwater levels in the spring months followed by a gradual decline over the summer months. Lowest levels were generally observed in November 2016 (following a dry summer) and highest levels were observed in the spring, May-June 2017. Seasonal variations in the wells ranged from 0.4 m (MW6) to 3.4 m (MW4d).
- Hourly automatic water level readings (datalogger readings) at monitoring wells show that the water table responds to individual precipitation events. -At MW2-17, the water level increased 0.23 m after a 31 mm rain event on May 4 and increased 0.4 m after a 80 mm rain event in June 2017 (Figure D-9). At MW4-17, responses were smaller responding 0.1 m to 0.2 m after large rain events (Figure D-11).
- At monitoring wells nests MW5s/d and MW6A/B-17 water levels in the deep well were consistently higher than levels in the shallow well indicating a downward gradient at these locations (Figures D-5 and D-13).
- At monitoring well nest MW4s/d the water levels in the deep well were higher than the shallow well in June, July, August and November 2017 and lower than the shallow well in November 2016, March, April, May and September 2017 (Figure D-4). These data suggest that groundwater gradient reversals are occurring in this area.

## 5.5 Surface Water/Groundwater Interactions

Piezometers were installed in the vicinity of surface water features on the subject lands to assess the potential for surface water/groundwater interactions and vertical gradients beneath the surface water features. The groundwater levels are provided in Table D-1 and Figures D-14 to D-18, Appendix D. Surface water levels measured at staff gauge are included in Table C-2, Appendix C.

PZ1s/d is located along Tributary A-1 as the tributary enters the subject lands. Groundwater levels at PZ1s and PZ1d are generally close to each other as a result of the screens being only 0.16 m apart. Due to soil conditions the deep piezometer could not be pounded to a deeper depth indicating a small gradient (Figure D-14). Despite the small separation of screens there are slight gradient changes observed through the year

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with upward gradients occurring in March, May, June and September and downward gradient in April.

PZ2s/d is located at the confluence of Tributary A-1 and Tributary A-2. Water levels at PZ2s/d generally indicate a downward gradient with the exception of May 2017 when the water level in the deep piezometer was higher than the shallow piezometer (Figure D-15, Appendix D). A downward gradient is representative of groundwater recharge conditions and it is interpreted that groundwater recharge occurs in this area.

PZ3s/d is located within the wetlands along Tributary A near the eastern property boundary. Automatic water level data from PZ3d shows that water levels respond rapidly to individual precipitation events. The water levels in the deep piezometer were generally lower than the shallow piezometer indicating a downward (recharge) gradient. The downward gradient is not present in June and July 2017 (Figure D-16, Appendix D) which is interpreted as being associated with the shallow system drying out faster than the deeper system. Water levels at this piezometer varied from 0.05 meters below surface (in spring 2017) to a low of 0.51 meters below ground surface (in September 2017).

PZ4s/d is located in Tributary B near a crossing of the undefined channel. The water levels at PZ4s and PZ4d were at ground surface from March to June, decreasing during the summer months (July to September) and at ground surface in November 2017. The water levels in the deep piezometer were slightly higher than the shallow piezometer suggesting an upward (discharge) gradient.

PZ5s/d is located within the wetlands of Tributary B downstream of PZ4s/d. The water levels collected at PZ5s/d show a seasonal trend with water levels highest in the spring (June), decreasing over the summer months (July to October) and recovered in November. There is a consistent downward (recharge) gradient observed at PZ5s/d.

The water level data collected from the stream piezometers indicates that generally there are downward gradients observed on the subject lands. Upward gradients are observed during high water table conditions or after a large rain event however most of the time downward gradients or recharge conditions are present.

## **5.6 Groundwater Flow**

Groundwater elevation data (June 2017) obtained from the monitoring wells and piezometers are shown on Figure 9, along with the interpreted groundwater elevation contours for the area. The groundwater movement in the shallow overburden on the subject lands is interpreted to flow towards low lying wetlands in the central and eastern part of the subject lands. The groundwater is influenced by the surface topography with groundwater moving from topographic highs towards topographic lows. Arrows perpendicular to the groundwater contours are used to illustrate the groundwater flow

directions. It is noted that groundwater flow is generally towards the south and south-east with slight convergence around watercourses and wetland areas. It is interpreted that groundwater is close to surface in the topographically low areas and also in areas close to wetlands.

## **5.7 Recharge and Discharge Conditions**

Areas where water from precipitation infiltrates into the ground and moves downward (i.e., areas of downward hydraulic gradients) are known as recharge areas. These areas are generally in areas of relatively higher topographic elevation. Areas where groundwater moves upward (i.e., areas of upward hydraulic gradients) are discharge areas and these generally occur in areas of relatively lower topographic elevation, such as along watercourses. Recharge and discharge may occur in local, intermediate and more regional flow systems. Infiltrating water at any given location may follow a shallow flow path and discharge a short distance away from the recharge area along the nearest slopes or in small watercourses, swales, agricultural ditches, wetlands, etc. This is referred to as a local groundwater flow system (i.e., flows that closely follow the existing topography with relatively short flow distances, e.g., up to a few hundred metres).

The sandy soils on the subject lands are ideal for recharge, however high water table conditions in some areas may impede recharge from occurring during high water table conditions. Underlying finer grained soils may also result in horizontal flow through the shallow groundwater flow system with discharge occurring along slopes, small watercourses, swales, wetlands, etc. Water level measurements in piezometers indicate potential for discharge in the wetlands and along the surface water features during high water table conditions and after large precipitation events. It is generally interpreted that the upland areas of the subject lands are recharge areas and that recharge will occur provided that the groundwater table is at a sufficient depth. During high groundwater table conditions, it is assumed that recharge is restricted and does not occur at these times. The wetlands on the subject lands are interpreted to occur in low lying areas and are interpreted to be supported by high groundwater table conditions. Groundwater recharge may occur in sections of the wetland that are sufficiently elevated from the local groundwater table while discharge occurs in areas where water table intersects the ground surface.

## **5.8 Water Quality**

To establish background water quality on the subject lands groundwater samples were collected on August 18, 2017. Water samples were collected from two groundwater wells (MW2-17 and MW6B-17) and one surface water location (SW1). The samples were sent to Maxxam Laboratories for analysis of general water quality indicator parameters and basic ions (e.g., pH, alkalinity, hardness, conductivity, chloride, nitrate, etc.) and selected metals. The analytical results from the laboratory are provided in

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Tables G-1 and G-2, Appendix G and are discussed below. The data reviewed showed the following:

- All wells exceeded the Ontario Drinking Water Quality Standards (ODWQS) for total hardness (100 mg/L) with values of 220 mg/L. Hardness in groundwater is caused by dissolved calcium and magnesium and is typically a result of the geologic material of the aquifer. Hardness is an aesthetic parameter and can be treated with a variety of residential systems including water softeners. It is also noted that domestic water is proposed to be provided by the municipal supply with no private wells being used. Based on this expectation, this exceedance has no implications for water supply.
- There were no other exceedances of the ODWQS in the groundwater sample results.
- Nitrate in the groundwater ranged from 0.21 mg/L to 0.95 mg/L indicating that the groundwater has not been impacted by surrounding land use activities such as septic systems or agricultural activities. Nitrate concentrations are important for the current assessment as individual private septic systems are proposed for the development.
- The surface water sample taken from SS1 did not exceed any of the Provincial Water Quality Standards for surface water.

## 6.0 Septic Suitability Assessment

The lots will be serviced with on-site sewage disposal systems. To examine the effects of the proposed septic systems, a nitrate impact assessment based on the MOE's Procedure D-5-4 (MOE, 1996) has been completed. The procedure involves a three step assessment process including:

**Step One – Lot Size Considerations** – D-5-4 indicates that a hydrogeological assessment may not be required for developments consisting of lot greater than one hectare, as long as it can be demonstrated that the area is not hydrogeological sensitive. The proposed lots range in size from 0.2 ha to 0.5 ha with an average lot size of 0.28 ha.

**Step Two – System Isolation Considerations** – Developments can be considered low risk where it can be demonstrated that sewage effluent is hydrogeologically isolated from existing or potential supply aquifers. As discussed in Section 5.0, the subsurface is underlain by an unconfined surficial aquifer overlaying a regional bedrock aquifer. Due to the coarse grained nature of the surficial sediments the sewage effluent would not be hydrogeological isolated from underlying aquifers.

**Step Three – Contaminant Attenuation Considerations** – Since it cannot be demonstrated that the sewage effluent is hydrogeologically isolated from potential supply aquifers a predictive assessment (residential developments) was completed.

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The predictive assessment was completed using the assumptions provided in D-5-4. The calculation assumes 1,000 L/day of flow per residential lot, 0.250 m of infiltration and effluent nitrate concentrations of 40 mg/L, which is consistent with effluent expected from conventional septic tank/leaching bed systems without additional treatment or denitrification. The infiltration value of 250 mm was used based upon the rationale provided in Section 22.5 in the MOE's 2008 "*Design Guidelines for Sewage Works*". A calculation worksheet detailing the predictive assessment is provided in Appendix H.

The calculations indicated that the effluent from 31 systems would result in a nitrate loading concentration of 6.1 mg/L which is below the ODWQS of 10 mg/L. Therefore, conventional septic tank/leaching bed systems are sufficient to meet the requirements of the D-5-4. It is recommended that leaching beds be located to maximize separation distances between individual systems and downgradient property boundaries. Fill-based (raised) leaching beds may be required on some lots to maintain minimum, mandatory vertical separation distances from the bottom of the trench to the seasonally high groundwater table.

## **7.0 Water Balance**

### **7.1 Methodology**

In order to assess potential land development impacts on the local groundwater conditions, a detailed water balance analysis has been completed to determine the pre-development recharge volumes (based on existing land use conditions) and the post-development recharge volumes that would be expected based on the proposed land use plan. The detailed monthly water balance calculations are provided in Appendix I.

The analytical approach to calculate a water balance for the subject lands involved monthly soil-moisture balance calculations to determine the pre-development (based on the existing land use conditions) and post-development (based on the proposed development plan) infiltration and runoff volumes. A soil-moisture balance approach assumes that soils do not release water as "potential recharge" while a soil moisture deficit exists. During wetter periods, any excess of precipitation over evapotranspiration first goes to restore soil moisture. Once the soil moisture deficit is overcome, any further excess water can then pass through the soil as infiltration and either become interflow (indirect runoff) or recharge (deeper infiltration).

A soil moisture storage capacity of 150 mm was used for the open pasture areas of the subject lands and a soil moisture storage capacity of 300 mm was used for the woodland areas. Table I-1 (for 150 mm retention) and Table I-2 (for 300 mm retention) in Appendix I detail the monthly potential evapotranspiration calculations accounting for latitude and climate, and then calculate the actual evapotranspiration and water surplus

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components of the water balance based on the monthly precipitation and soil moisture conditions.

The MOECC SWMP Design Manual methodology for calculating total infiltration based on topography, soil type and land cover was used and a corresponding runoff component was calculated. These water balance component calculations are shown on Tables I-1 and I-2 in Appendix I. The calculated water balance components from the table were then used to assess the pre-development water balance scenario based on the existing land use characteristics (open pasture and woodland/wetland areas). A post-development water balance has been calculated based on a preliminary draft plan.

## 7.2 Water Balance Components

A water balance is an accounting of the water resources within a given area. As a concept, the water balance is relatively simple and may be estimated from the following equation:

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

where:

P	=	precipitation
S	=	change in groundwater storage
R	=	surface water runoff
I	=	infiltration
ET	=	evapotranspiration/evaporation

The components of the water balance vary in space and time and depend on climatic conditions as well as the soil and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Runoff, for example, occurs particularly during periods of snowmelt when the ground is frozen, or during intense rainfall events.

Precise measurement of the water balance components is difficult and as such, approximations and simplifications are made to characterize the water balance of a study area. Field observations of the drainage conditions, land cover and soil types, groundwater levels and local climatic records are important input considerations for the water balance calculations.

The water balance components for the subject lands are discussed below:

### Precipitation (P)

The long-term average annual precipitation for the area is 946 mm based on data from the Environment Canada Fergus Shand Dam Climate Station (Station 6142400, 43°44'05.088" N, 80°19'49.098" W, elevation 417.6 masl) for the period between 1981 and 2010. The climate station is located 21.5 km west of the subject lands. Average

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monthly records of precipitation and temperature from this station have been used for the water balance calculations in this study (Appendix I).

### **Storage (S)**

Although there are groundwater storage gains and losses on a short-term basis, the net change in groundwater storage on a long-term basis is assumed to be zero so this term is dropped from the equation.

### **Evapotranspiration (ET)/Evaporation (E)**

Evapotranspiration and evaporation components vary based on the characteristics of the land surface cover (i.e., type of vegetation, soil moisture conditions, perviousness of surfaces, etc.). Potential evapotranspiration (PET) refers to the water loss from a vegetated surface to the atmosphere under conditions of an unlimited water supply. The actual rate of evapotranspiration (AET) is generally less than the PET under dry conditions (i.e., during the summer when there is a soil moisture deficit). The mean annual ET has been calculated for this study using a monthly soil-moisture balance approach considering the local climate conditions.

### **Water Surplus (R + I)**

The difference between the mean annual P and the mean annual ET is referred to as the water surplus. Part of the water surplus travels across the surface of the soil as surface or overland runoff (R) and the remainder infiltrates (I) the surficial soil.

#### **7.2.1 Water Balance Component Values**

The detailed monthly calculations of the water balance components are provided on Tables I-1 and I-2 in Appendix I. The calculations show that a water surplus is generally available from November to May (Tables I-1 and I-2, Appendix I). The monthly water balance calculations illustrate how infiltration occurs during periods when there is sufficient water available to overcome the soil moisture storage requirements. In winter climates, frozen conditions affect when the actual runoff and infiltration will occur, however, the monthly balance calculations show the potential volumes available for these water balance components.

The monthly calculations are summed to provide estimates of the annual water balance component values (Tables I-1 and I-2, Appendix I). A summary of these values is provided in Table 3.

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**Table 3: Water Balance Component Values**

<b>Water Balance Component</b>	<b>Open Space</b>	<b>Woodland</b>
Average Precipitation	946 mm/year	946 mm/year
Actual Evapotranspiration	579 mm/year	579 mm/year
Water Surplus	367 mm/year	367 mm/year
Infiltration	238 mm/year	275 mm/year
Runoff	128 mm/year	92 mm/year

### 7.2.2 Pre-Development Infiltration (Existing Conditions)

The pre-development water balance calculations are presented in Table I-3 in Appendix I. As summarized on Table I-3, the total area of the subject lands is about 25.6 ha. The water balance component values from Table I-1 and Table I-2 were used to calculate the average annual volume of infiltration across the subject lands. Based on these component values, the pre-development infiltration volume was calculated to be about 66,400 m<sup>3</sup>/year (Table I-3, Appendix I).

### 7.2.3 Potential Development Impacts to Water Balance

Development of an area affects the natural water balance. The most significant difference is the addition of impervious surfaces as a type of surface cover (i.e., roads, parking lots, driveways, and rooftops). Impervious surfaces prevent infiltration of water into the soils and the removal of the vegetation removes the evapotranspiration component of the natural water balance. The evaporation component from impervious surfaces is relatively minor (estimated to be 10% to 20% of precipitation) compared to the evapotranspiration component that occurs with vegetation in this area (about 61% of precipitation on the subject lands). For the purposes of the calculations in this study, the evaporation has been estimated to be 15% of precipitation. The remaining 85% of the precipitation that falls on impervious surfaces is assumed to become runoff. Therefore the net effect of the construction of impervious surfaces is that most of the precipitation that falls onto impervious surfaces becomes surplus water and direct runoff. The natural infiltration component is reduced. A calculation of the potential water surplus for impervious areas is shown at the bottom of Table I-1 in Appendix I.

To assess potential development impacts on infiltration, the post-development infiltration volumes have been calculated for the subject lands on Table I-3 in Appendix I. It is noted that the development concept consists of estate residential homes (approximately up to 4,000 square feet) within large residential lots. All lots would contain individual septic systems and driveways. The total areas for the proposed land uses on the subject lands have been estimated based on a draft Concept Plan dated May 15, 2017 (J.L. Cox Planning Consultants Inc.). The impervious factors for the applicable land uses were developed by Burnside. The infiltration and runoff components for the post-development land uses have been calculated using the MOECC SWM Planning

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and Design Manual (2003) methodology based on topography, soil type and land cover as shown on Tables I-1 and I-2 in Appendix I. In summary from these appendix tables, the average calculated post-development infiltration volume (without mitigation) is 54,900 m<sup>3</sup>/year.

Comparing the pre- and post-development infiltration volumes, shows that development has the potential to reduce the average infiltration on the subject lands from 66,400 m<sup>3</sup>/year to 58,000 m<sup>3</sup>/year, i.e., a reduction of about 8,400 m<sup>3</sup>/year or 13%.

It is noted that the proposed development will be serviced by municipal water supply but will use on-site waste water disposal systems. The use of septic systems will result in additional water for infiltration however may impact the water quality. Based on the assumption that the typical lot's septic system will discharge 1,000 L/day, 31 lots will provide approximately 11,300 m<sup>3</sup>/year of additional recharge which will further reduce the above deficit. Water quality impacts as a result of on-site waste water disposals systems is subject to MOECC D-5-4 guidelines for an individual on-site septic system water quality risk assessment is discussed in Section 6.0.

### **7.3 Feature Based Water Balance**

The components of the groundwater balance to a feature vary in space and time and depend on climatic conditions as well as the soil and land cover conditions (i.e., rainfall intensity, land slope, soil hydraulic conductivity and vegetation). Precise measurement of these components is difficult and as such, approximations and simplifications are made to characterize the groundwater balance of a feature. The previously completed water balance for the subject lands included an evaluation of pre-development conditions and concluded that a small deficit (13%) would be generated by the creation of impervious surfaces during development if no LID measures were implemented. Based on the hydrogeological interpretation of the subject lands it has been concluded that the wetlands are supported by groundwater discharge. Using the groundwater contours developed as part of the current study, the groundwater contributing areas for the wetlands have been determined based on a flow net approach.

As shown on Figure 10, the groundwater contributing areas may be delineated into flow nets that discretize groundwater flow into flow tubes. The borders of each flow tube are arbitrarily selected based on groundwater flow direction however it is recognized that groundwater does not cross flow tubes and hence any flow line can be used to represent a flow boundary. Using this approach the water balance was prepared for the area up gradient of wetland and within individual flow tubes. The flow within each flow tube was summed at the end to provide the overall groundwater flow to the feature. It should be noted that several assumptions and simplifications were undertaken to allow for the computations to be made. The computations should therefore be viewed as illustrative and not prescriptive as they provide an indication of the potential outcomes.

### 7.3.1 Feature Based Pre-Development Water Budget

In the pre-development scenario, the volume of groundwater each flow tube at the 398-water table contour from areas up gradient is calculated by the following equation:

$$dQ = K dh/ds * dm$$

Where

Q = groundwater flow

K = hydraulic conductivity

dh = change in head

ds = length of flow cell

dm = width of flow cell

The groundwater flow as computed for the various flow tubes in Figure 10 is provided below in Table 4.

**Table 4: Summary of Annual Groundwater Flow to Feature by Flow Tube**

Flow Tube	A	B	C	D	E	F	G
Flow (m <sup>3</sup> /year)	794	508	3,633	789	629	914	511
Flow Tube	H	I	J	K	L	M	Total
Flow (m <sup>3</sup> /year)	737	572	526	500	667	811	<b>11,591</b>

Based on the above assumptions the groundwater flow to the wetlands on the subject lands is calculated to be approximately 11,600 m<sup>3</sup>/year. This groundwater flow volume assumes that all areas of the subject lands contribute groundwater flow to the feature. Using this assumption, the infiltration calculated for the subject lands for pre-development conditions is assumed to represent the on-site infiltration volume of 66,400 m<sup>3</sup>/year. The feature is therefore supported by a total of approximately 78,000 m<sup>3</sup>/year of groundwater.

### 7.3.2 Feature Based Post-Development Water Budget

The post-development scenario was calculated assuming that estate lots would be built with onsite septic systems and municipal water supply. Roads would have rural cross-sections with no curb and gutter and road runoff directed to road side ditches. The scenario also considered that no development would take place in the wetland areas and hence the throughflow and infiltration from these areas remain as in the pre-development state. Groundwater through flow was not recalculated as this volume is

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provided from upgradient of the subject lands and is not likely to change based on development of the subject lands.

The quantification of the post-development water balance in Section 7.2.3 above indicated that a deficit of 8,400 m<sup>3</sup>/year was created by the proposed development. This deficit represents approximately 11% of the groundwater flow to the feature. As noted above each lot would be completed with an onsite septic system and it can be assumed that each system will provide approximately 1,000 L/day of water to the subsurface. Across a total of 31 lots, this volume represents an additional recharge of 11,300 m<sup>3</sup>/year. The use of onsite septic systems therefore potentially eliminates the deficit.

The table below summarizes the groundwater balance to the feature based on groundwater flow nets:

**Table 5: Groundwater Flow Net Water Balance Summary**

	<b>Pre-Development</b>	<b>Post-Development</b>
Infiltration (m <sup>3</sup> /year)	66,400	58,000
Through Flow (m <sup>3</sup> /year)	11,600	11,600
Septic Systems (m <sup>3</sup> /year)	-	11,300
<b>Total</b>	78,000	80,900

## **8.0 Mitigation and Development Considerations**

### **8.1 Low Impact Development Measures**

In order to minimize the potential impacts of development on the water balance, the use of Low Impact Development (LID) measures for stormwater management are generally recommended by the conservation authority. LID is based on the premise of trying to manage stormwater to minimize the runoff of rainfall and increase the potential for infiltration where possible. There are, as outlined in the MOECC SWMP Design Manual (2003) and Low Impact Development (LID) Stormwater Management Planning and Design Guide published by the CVC and TRCA (2010), a number of best management practices and mitigation techniques that can be used to increase the potential for post-development infiltration and mitigate the reductions in infiltration that occur with residential land development. Techniques to maximize the water availability in pervious areas such as designing grades to direct roof runoff towards lawns, side and rear yard swales, boulevards, parks, and other open space areas throughout the development where possible can increase infiltration and reduce the volume of runoff directed to stormwater management facilities.

Where feasible, measures to minimize development impacts on the water balance will be incorporated into the development design. Based on the water balance calculations presented above, the difference between the pre- and post-development recharge volumes is estimated to be about 11,500 m<sup>3</sup>/year (Table I-3, Appendix I).

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The on-site septic systems proposed for the development will provide additional water for infiltration into the ground. The development will be municipally serviced for water, so the additional water originates outside of the subject lands. Based on the assumption that the typical lot's septic system will discharge 1,000 L/day, 31 lots will provide approximately 11,300 m<sup>3</sup>/year of additional recharge.

The direction of roof runoff towards lawns, side and rear yard swales will also provide additional water for infiltration. It is noted that in estate lot developments such as those proposed for the subject lands these measures are readily implemented. To assess the potential effectiveness of this LID measure for the proposed development, water balance calculations have been completed assuming that half of the runoff from residential roofs is directed to half of the pervious areas. These calculations are provided in Table I-5. The calculations suggest that the direction of roof runoff to pervious areas could provide an additional 3,800 m<sup>3</sup>/year.

The above demonstrates that the implementation of LID measures will provide additional water for recharge that will reduce the development impacts and ultimately, pre-development infiltration can be maintained for the proposed development. As shown in Table 4, pre-development recharge can be met using on-site septic systems and the re-direction of roof runoff will provide additional recharge to ensure that pre-development recharge is satisfactorily met or exceeded.

## 8.2 Construction Below the Water Table

During construction of foundations and installation of servicing groundwater may be encountered. Due to the relatively high permeability of the sandy soils that are prevalent near surface on the subject lands, there is potential for significant groundwater flow volumes. An evaluation of the requirements for construction dewatering should be confirmed by the geotechnical investigations completed in support of detailed design.

In 2016 the MOECC introduced regulations that allow for construction related dewatering/depressurization to proceed under the Environmental Activity Sector Registry (EASR) process if dewatering volumes are above 50,000 L/d but below 400,000 L/d. Takings above 400,000 L/d require a Category 3 Permit to Take Water (PTTW). The determination of which process should be followed (PTTW or EASR) is based on the expected volume of taking; takings between 50,000 L/d and 400,000 L/d are required to register for the EASR while takings above 400,000 L/d are regulated by the PTTW process. It is recommended that based on the design of services, that an assessment of the dewatering requirements and method of permitting be undertaken.

The construction of buried services below the water table has the potential to capture and redirect groundwater flow through more permeable fill materials typically placed in the base of excavated trenches. To mitigate the potential for creating preferential pathways for groundwater flow, the installation of anti-seepage collars or clay plugs

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surrounding the pipes is recommended to provide barriers to flow and prevent groundwater flow along granular bedding material and erosion of the backfill materials.

Basements will need to be constructed at depths that allow for sufficient separation from the groundwater table in order to ensure that basement sump pumps do not run continuously. As part of detailed design, it is recommended that an evaluation of basement elevations versus groundwater table depths be undertaken. This assessment will inform which areas of the development are of concern for potential interactions between basements and groundwater table. Where this is a potential concern it is recommended that the use of foundation drain collectors (FDC) be evaluated. FDCs have been used in numerous locations in Ontario to serve to reduce groundwater table elevation and provide suitable separation between the water table and basements. FDCs are a passive groundwater control mechanism and do not require maintenance or operation of sump pumps to control groundwater.

The construction of the leaching beds must also be carefully considered, especially those areas of the subject lands where the shallow groundwater table is high. Fill based (raised) leaching beds are required in areas where a minimum, mandatory vertical separation distance of 0.9 m cannot be maintained from the bottom of the trench to the seasonally high groundwater table. As the depth to the groundwater table varies across the subject property it is recommended that test pits be excavated on each lot prior to building permit application in order to determine the soil type and elevation of the seasonally high groundwater table on each property.

### **8.3 Private Water Wells**

Most of the area surrounding the subject lands are municipally serviced however it is likely that there are some properties that still rely on private wells as a water supply. It is recommended that a water well survey be conducted prior to construction to determine if any private water supply wells are still in use within approximately 200 m of the subject lands and that a monitoring and mitigation strategy be established to ensure that private water wells are not impacted during construction.

### **8.4 Well Decommissioning**

Prior to or during construction, it is necessary to ensure that all inactive wells within the development footprint have been located and properly decommissioned by a licensed water well contractor according to Ontario Regulation 903. This regulation applies private domestic wells and to the groundwater observation wells installed for this study unless they are maintained throughout the construction for monitoring purposes.

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## 9.0 References

Armstrong et. al., 2007. Paleozoic Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release – Data 219.

Chapman, L.J. and D.F. Putnam, 1984. The Physiography of Southern Ontario, Third Edition; Ontario Geological Survey, Special Volume 2, 270p. Accompanied by Map 2715.

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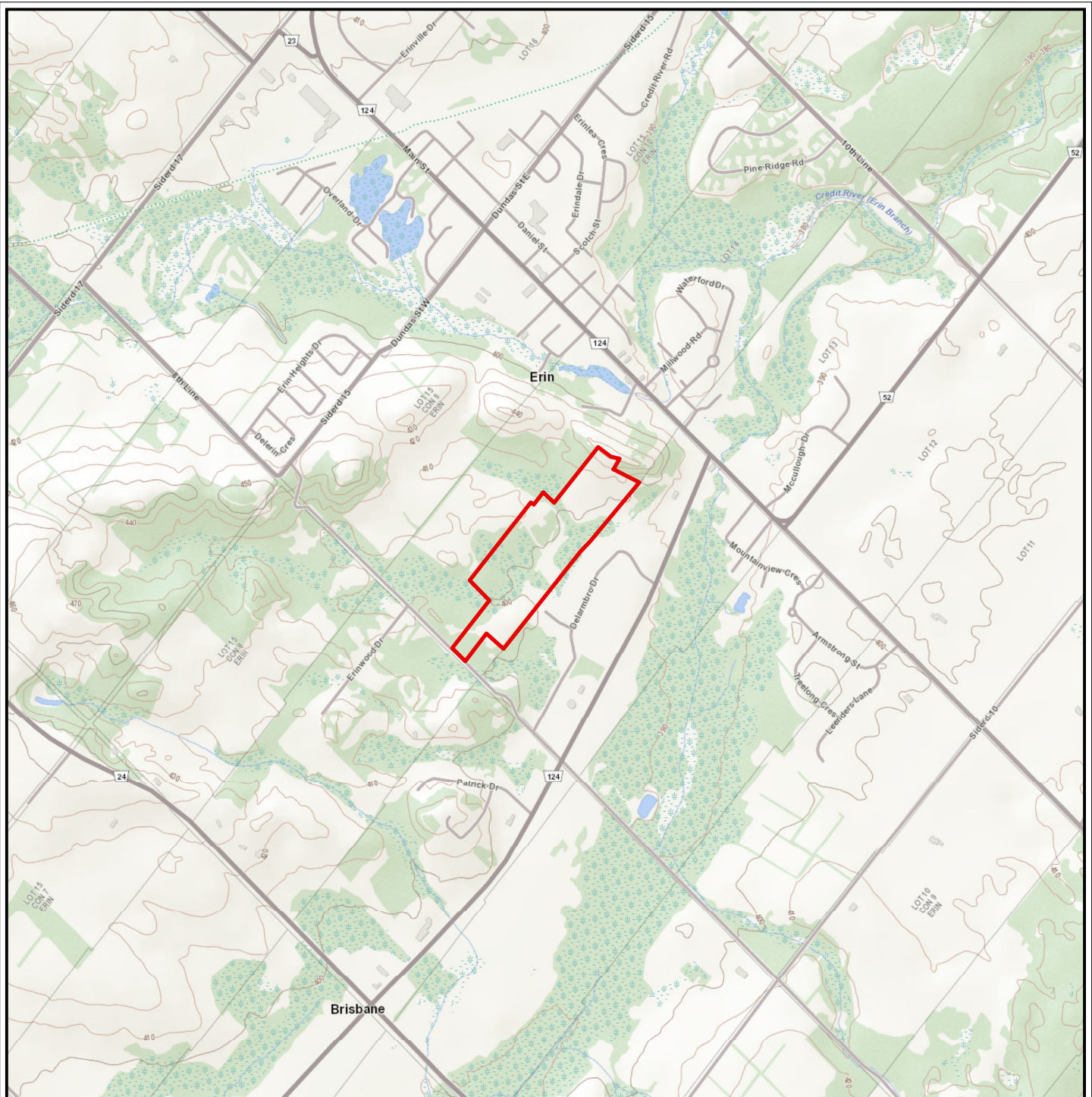


# BURNSIDE


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**Figures**



**LEGEND**

 SUBJECT LANDS



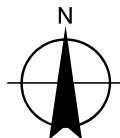
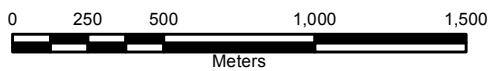
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**HYDROGEOLOGICAL ASSESSMENT**

Figure Title:

**SITE LOCATION**



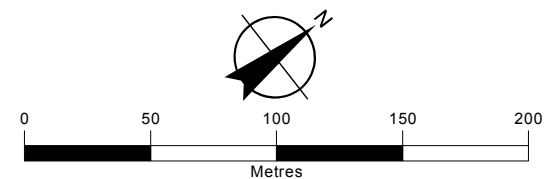
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Scale	Project No.		
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**LEGEND**

- SUBJECT LANDS
- WATERCOURSE (CVC, 2016)
- ⊕ MONITORING WELL
- DRIVE POINT PIEZOMETER
- STAFF GAUGE
- ▲ SURFACE WATER MONITORING LOCATION
- ⊕ INFILTRATION TEST LOCATION

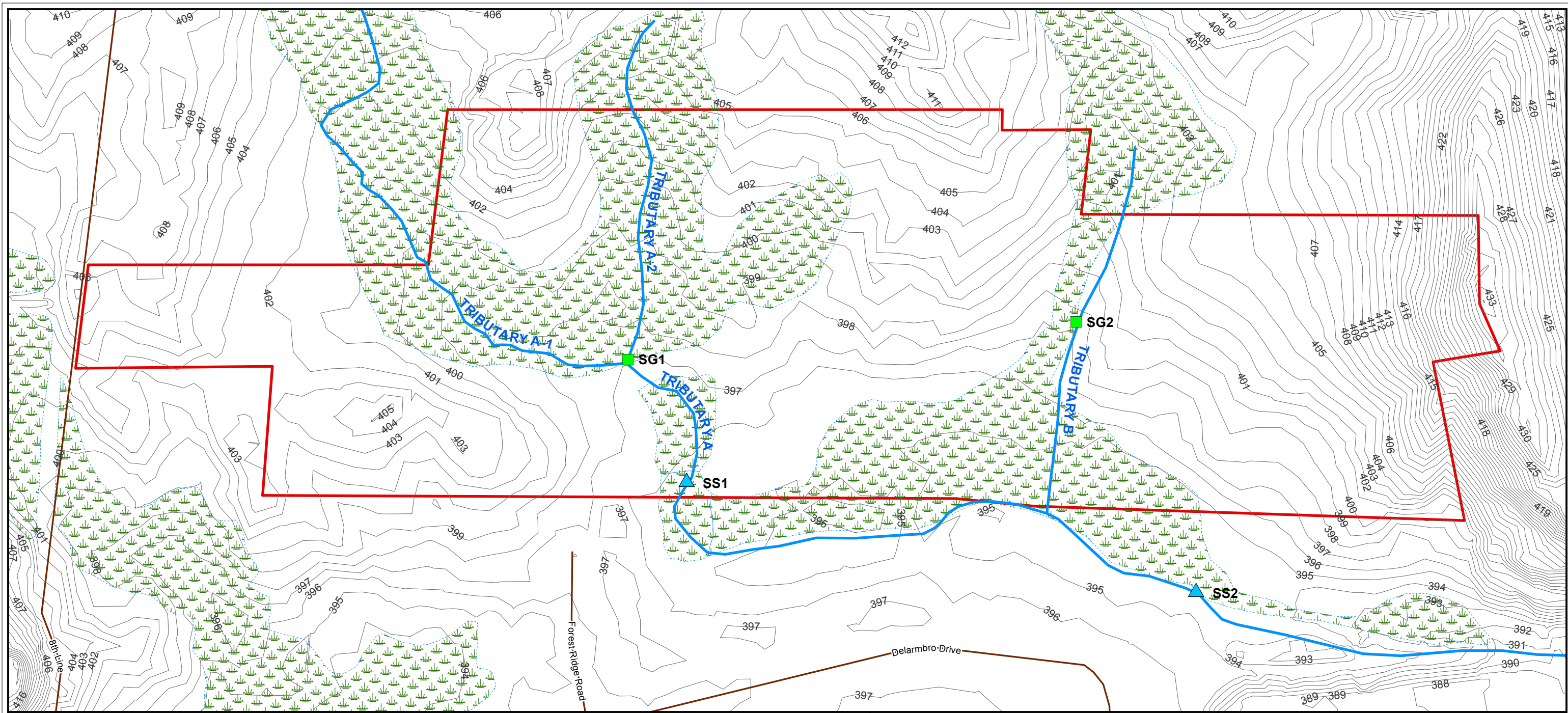
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 Satellite & Air Photo Source:  
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Figure Title  
**MONITORING LOCATIONS**

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SK	SC	December 2017	
Scale	Project No.		
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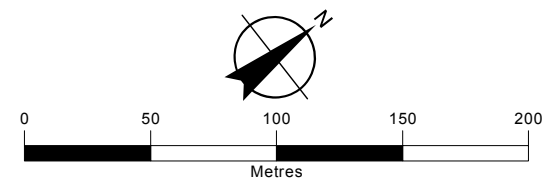
**LEGEND**

- SUBJECT LANDS
- WATERCOURSE (CVC, 2016)
- ROADWAY
- CONTOUR (1m intervals - masl)
- STAFF GAUGE
- SURFACE WATER MONITORING LOCATION
- WETLAND (MNFR, 2013)

**Sources:**

1. Ministry of Natural Resources, © Queen's Printer for Ontario
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Coord. System: NAD 1983 CSRS UTM Zone 17N  
Datum: North American 1983 CSRS



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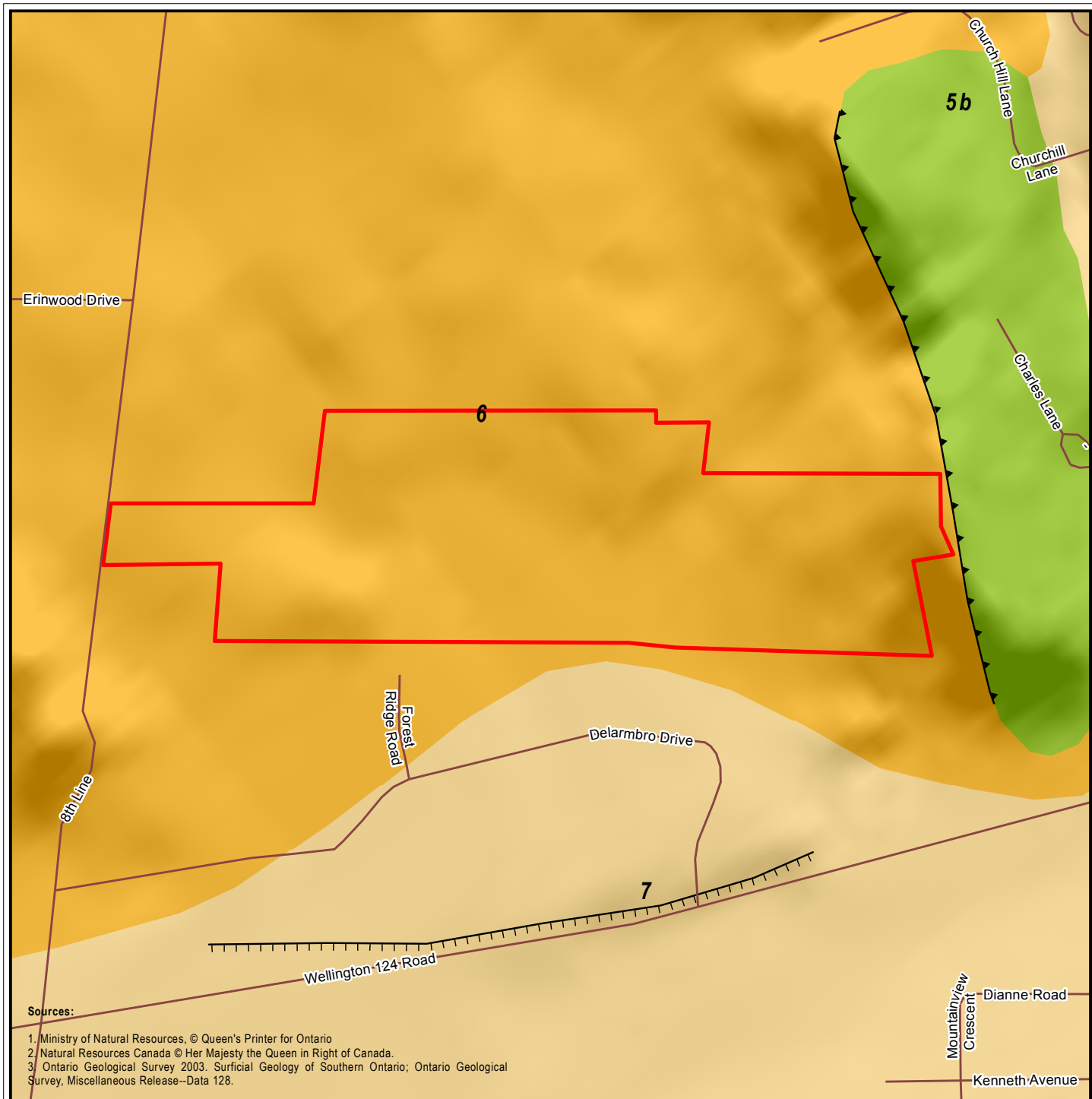
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Figure Title

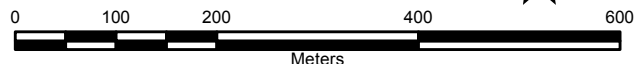
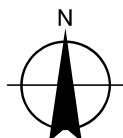
**TOPOGRAPHY AND DRAINAGE**

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SK	SC	December 2017	<b>3</b>
Scale	Project No.		
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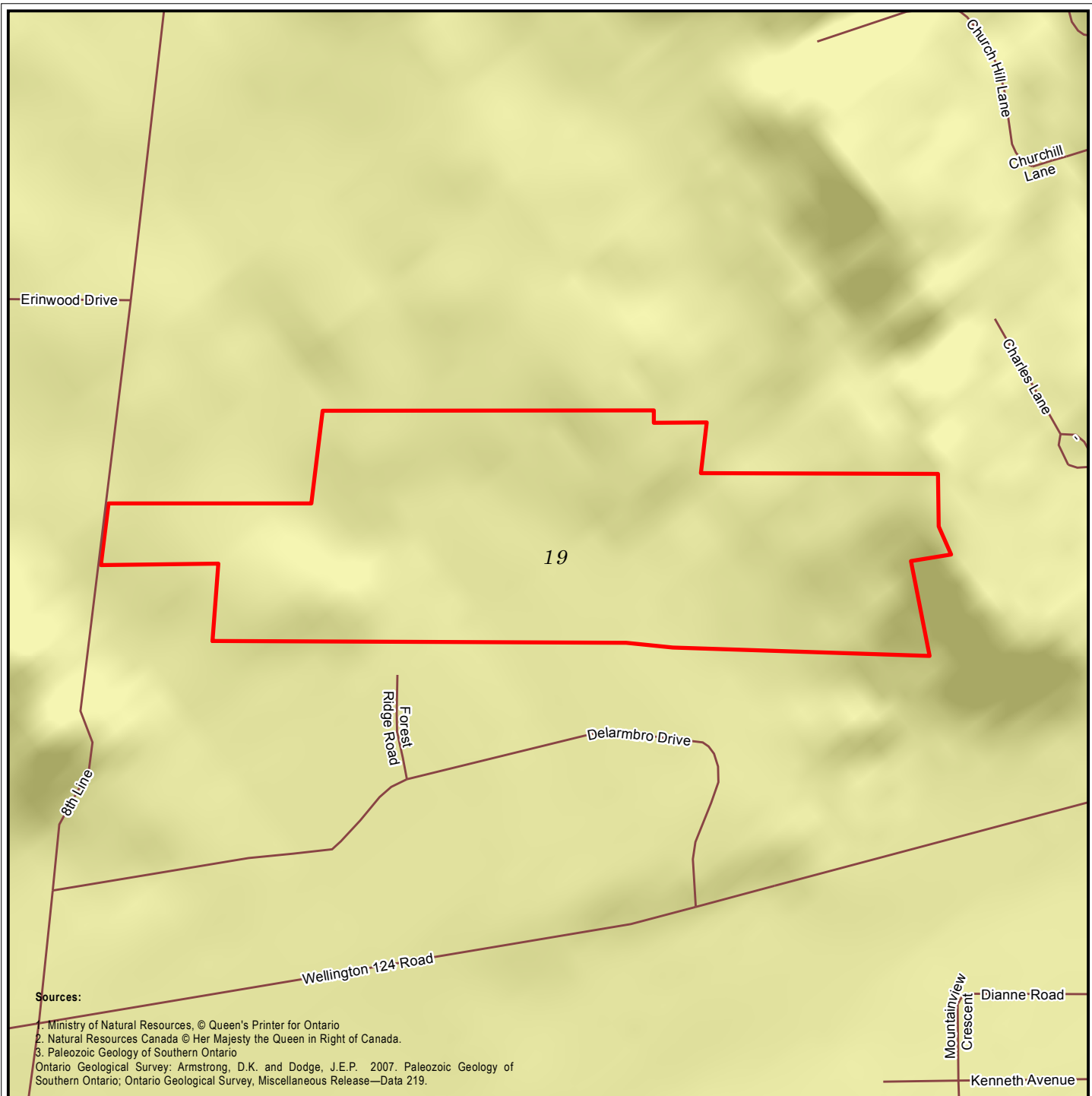
- SUBJECT LANDS
- ROADWAY
- WATERCOURSE
- 5b: Stone-poor, carbonate-derived silty to sandy till
- 6: Ice-contact stratified deposits
- 7: Glaciofluvial deposits
- Ice-Contact Slope
- Terrace



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Figure Title:  
**SURFICIAL GEOLOGY**

Drawn	Checked	Date	Figure No. <b>4</b>
SK	SC	December 2017	
Scale	Project No.		
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**Sources:**

- 1. Ministry of Natural Resources, © Queen's Printer for Ontario
- 2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.
- 3. Paleozoic Geology of Southern Ontario  
Ontario Geological Survey: Armstrong, D.K. and Dodge, J.E.P. 2007. Paleozoic Geology of Southern Ontario; Ontario Geological Survey, Miscellaneous Release—Data 219.

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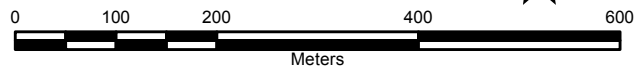
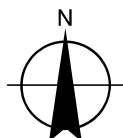
SUBJECT LANDS

WATERCOURSE

ROADWAY

**Silurian Period**

19: Amabel Formation: Dolostone



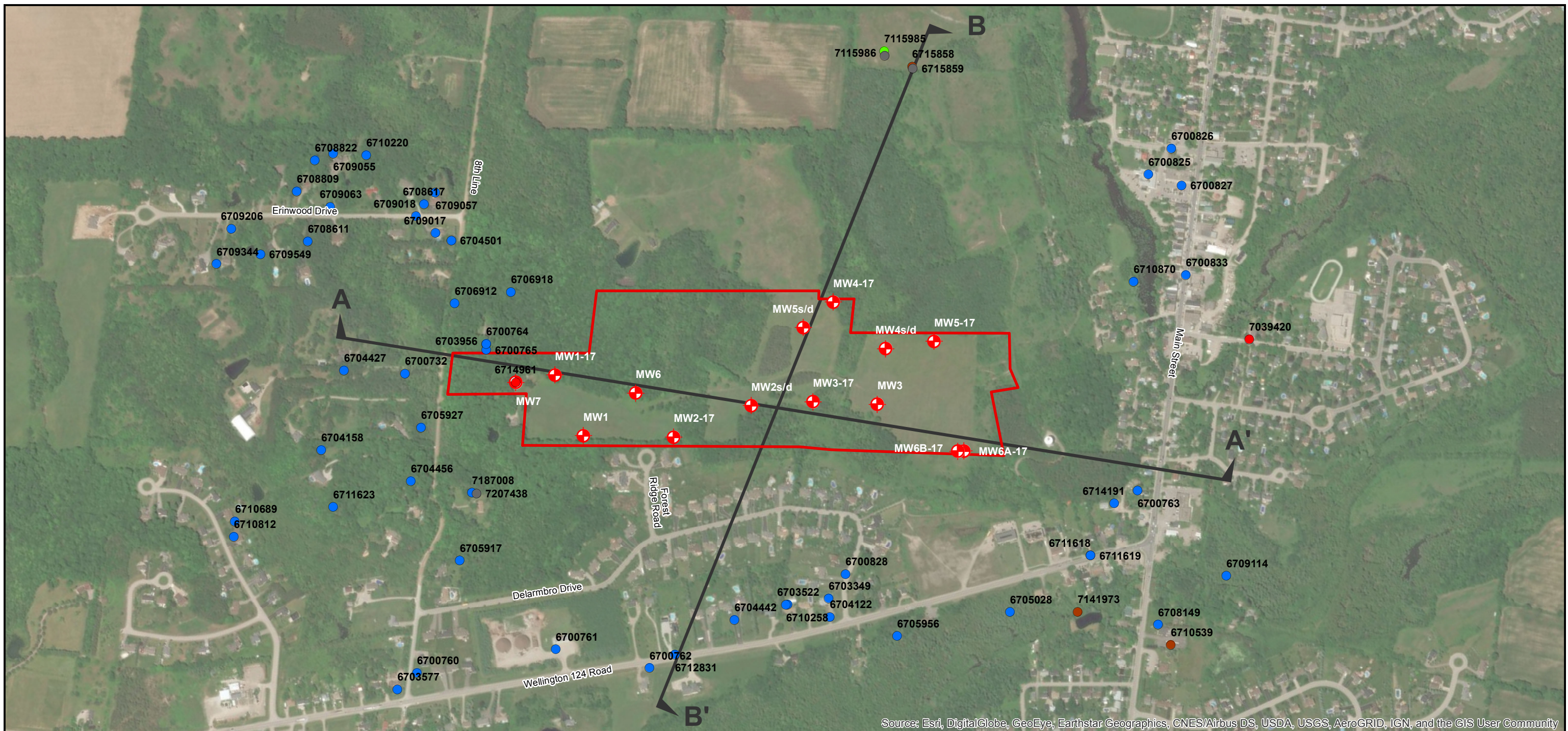
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Figure Title:

**BEDROCK GEOLOGY**

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- LEGEND**
- SUBJECT LANDS
  - + MONITORING WELL
  - MOECC WELL TYPE**
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  - OBSERVATION WELL
  - MONITORING AND TEST
  - TEST HOLE
  - ABANDONED - OTHER
  - CROSS SECTION LOCATION KEY

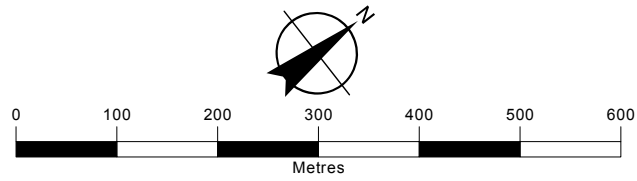
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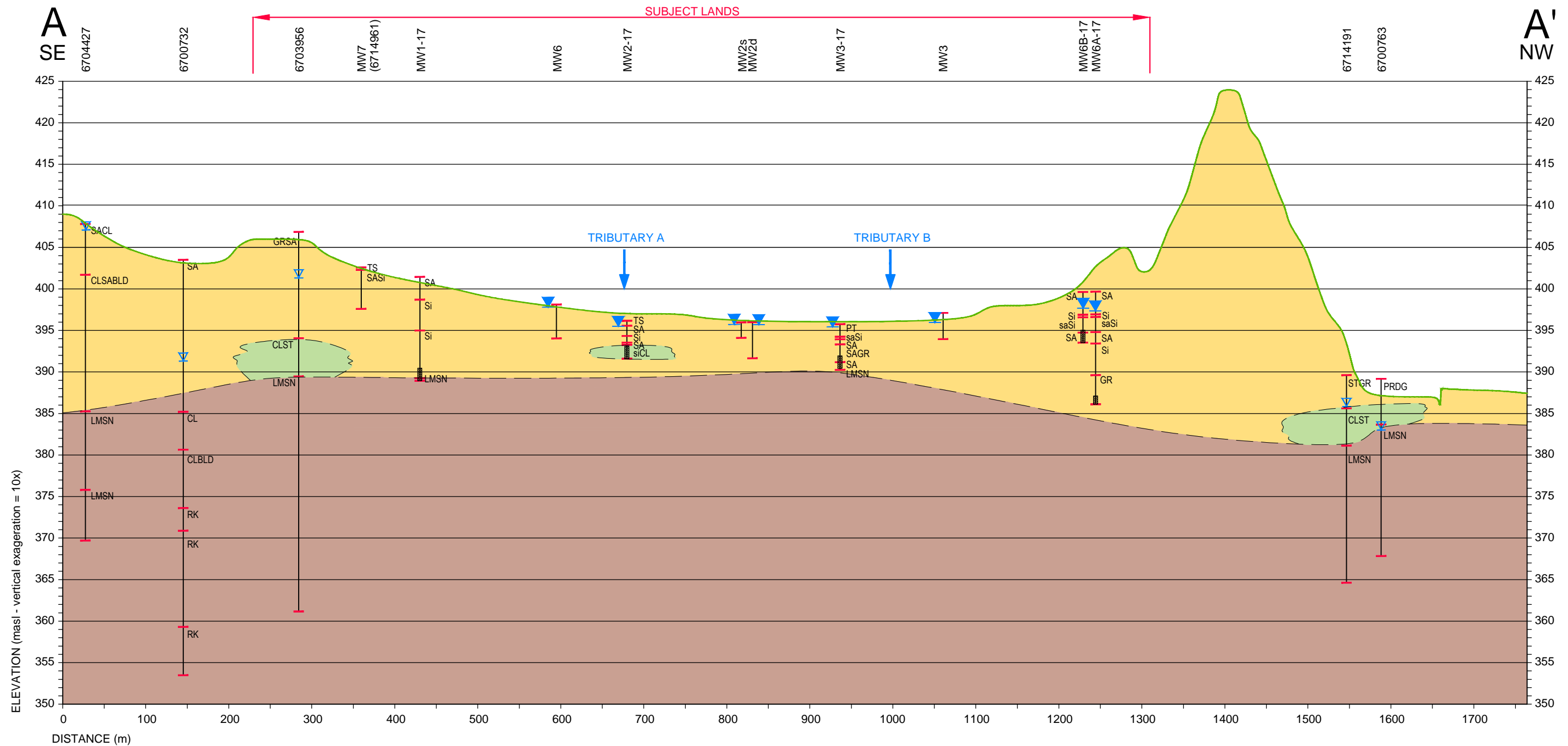


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Figure Title  
**WELL LOCATION PLAN**

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**LEGEND**

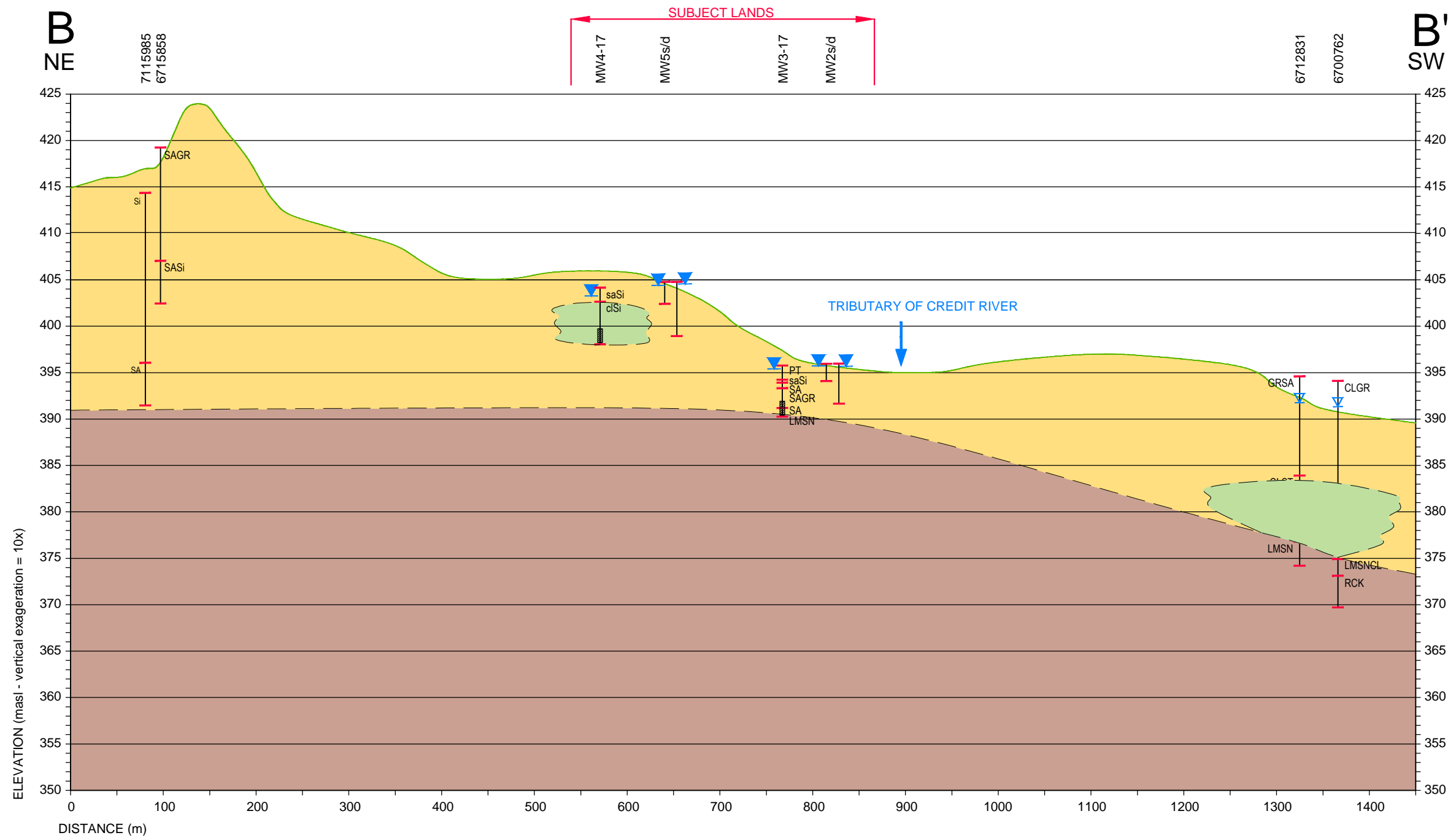
BH1	WELL NUMBER / ID	si	SILTY	↓	WATERCOURSE CROSSING
		sa	SANDY	---	INTERPRETED STRATIGRAPHY
		cl	CLAYEY	█	SAND / SILT / GRAVEL
		TS	TOPSOIL	█	SILT CLAY
---	EXISTING GROUND PROFILE	BLD	BOULDER	█	LIMESTONE BEDROCK
---	GEOLOGICAL CONTACT	PRDG	PRE-DUG		
▼	MEASURED WATER LEVEL (JUNE 26, 2017)	PT	PEAT		
▽	STATIC WATER LEVEL (MOECC WELL RECORD)	GR	GRAVEL		
█	WELL SCREEN	SA	SAND		
		Si	SILT		
		CL	CLAY		
		ST	STONES		
		LMSN	LIMESTONE		



Client / Report  
**HOMES IN THE HILLS, INC.**  
 ERIN, ONTARIO  
**HYDROGEOLOGICAL ASSESSMENT**

Figure Title  
**INTERPRETED GEOLOGICAL  
 CROSS SECTION A-A'**

Drawn S.K.	Checked SC	Date December 2017	Figure No. <b>7</b>
Scale 1:7,500	Project No. 300038924		



**LEGEND**

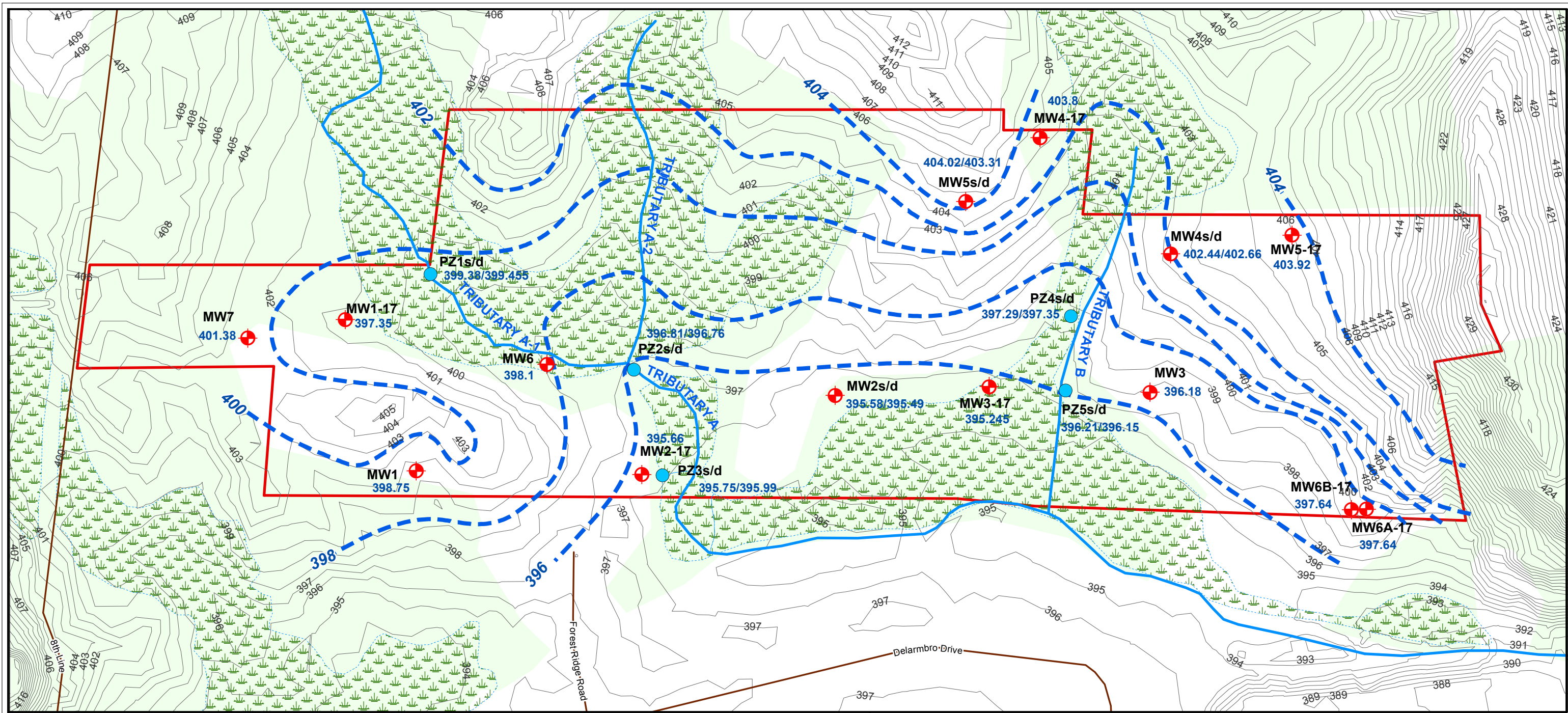
- |     |  |      |           |     |                          |
|-----|--|------|-----------|-----|--------------------------|
| BH1 | WELL NUMBER / ID                       | si   | SILTY     | ↓   | WATERCOURSE CROSSING     |
|     | EXISTING GROUND PROFILE                | sa   | SANDY     | --- | INTERPRETED STRATIGRAPHY |
|     | GEOLOGICAL CONTACT                     | cl   | CLAYEY    |     | SAND / SILT / GRAVEL     |
|     | MEASURED WATER LEVEL (JUNE 26, 2017)   | TS   | TOPSOIL   |     | SILT CLAY                |
|     | STATIC WATER LEVEL (MOECC WELL RECORD) | BLD  | BOULDER   |     | LIMESTONE BEDROCK        |
|     | WELL SCREEN                            | PRDG | PRE-DUG   |     |                          |
|     |  | PT   | PEAT      |     |                          |
|     |  | GR   | GRAVEL    |     |                          |
|     |  | SA   | SAND      |     |                          |
|     |  | Si   | SILT      |     |                          |
|     |  | CL   | CLAY      |     |                          |
|     |  | ST   | STONES    |     |                          |
|     |  | LMSN | LIMESTONE |     |                          |



Client / Report  
**HOMES IN THE HILLS, INC.**  
 ERIN, ONTARIO  
**HYDROGEOLOGICAL ASSESSMENT**

Figure Title  
**INTERPRETED GEOLOGICAL CROSS SECTION B-B'**

Drawn S.K.	Checked SC	Date December 2017	Figure No. <b>8</b>
Scale 1:7,500	Project No. 300038924		

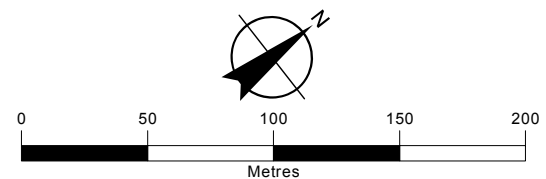


**LEGEND**

- SUBJECT LANDS
- WATERCOURSE (CVC, 2016)
- ROADWAY
- CONTOUR (1m intervals - masl)
- WOODED
- WETLAND (MNR, 2013)
- MONITORING WELL
- DRIVE POINT PIEZOMETER
- INTERPRETED GROUNDWATER CONTOUR (masl)
- 397.39 MEASURED WATER LEVEL - masl (JUNE 26, 2017)

<BOL>Sources:</BOL>

1. Ministry of Natural Resources & Forestry, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.
3. Topographical contours created from Ontario 2002 SWOOP data.



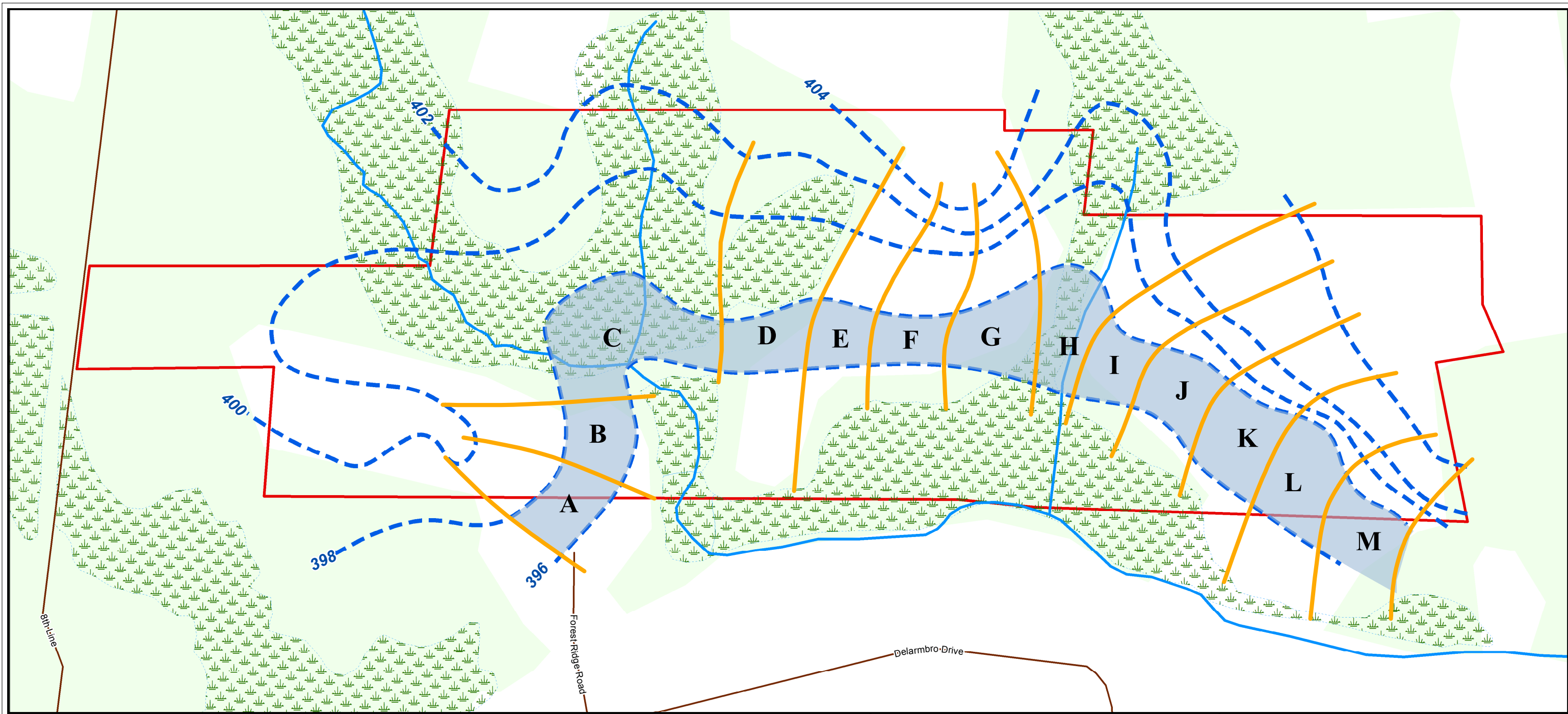
Client / Report

HOMES IN THE HILLS, INC.  
ERIN, ONTARIO  
HYDROGEOLOGICAL ASSESSMENT

Figure Title

**INTERPRETED  
GROUNDWATER FLOW**

Drawn SK	Checked SC	Date December 2017	Figure No. <b>9</b>
Scale 1:3,000		Project No. 300039324	

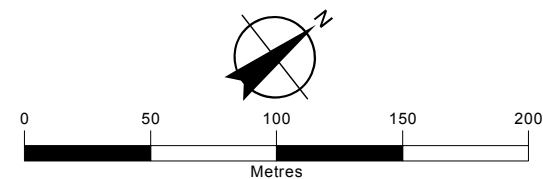


**LEGEND**

- SUBJECT LANDS
- WATERCOURSE (CVC, 2016)
- ROADWAY
- WETLAND (MNR, 2013)
- WOODED
- INTERPRETED GROUNDWATER CONTOUR (masl)
- GROUNDWATER FLOW TUBE
- A FLOW CELL

Source:

1. Ministry of Natural Resources & Forestry, © Queen's Printer for Ontario
2. Natural Resources Canada © Her Majesty the Queen in Right of Canada.



Client / Report

HOMES IN THE HILLS, INC.  
ERIN, ONTARIO

*HYDROGEOLOGICAL ASSESSMENT*

Figure Title

**INTERPRETED GROUNDWATER  
FLOW TO WETLAND**

Drawn	Checked	Date	Figure No.  <b>10</b>
SK	SC	January 2018	
Scale	Project No.		
1:3,000	300039324		



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## Appendix A

### Monitoring Well Logs

# LOG OF DRILLING OPERATIONS

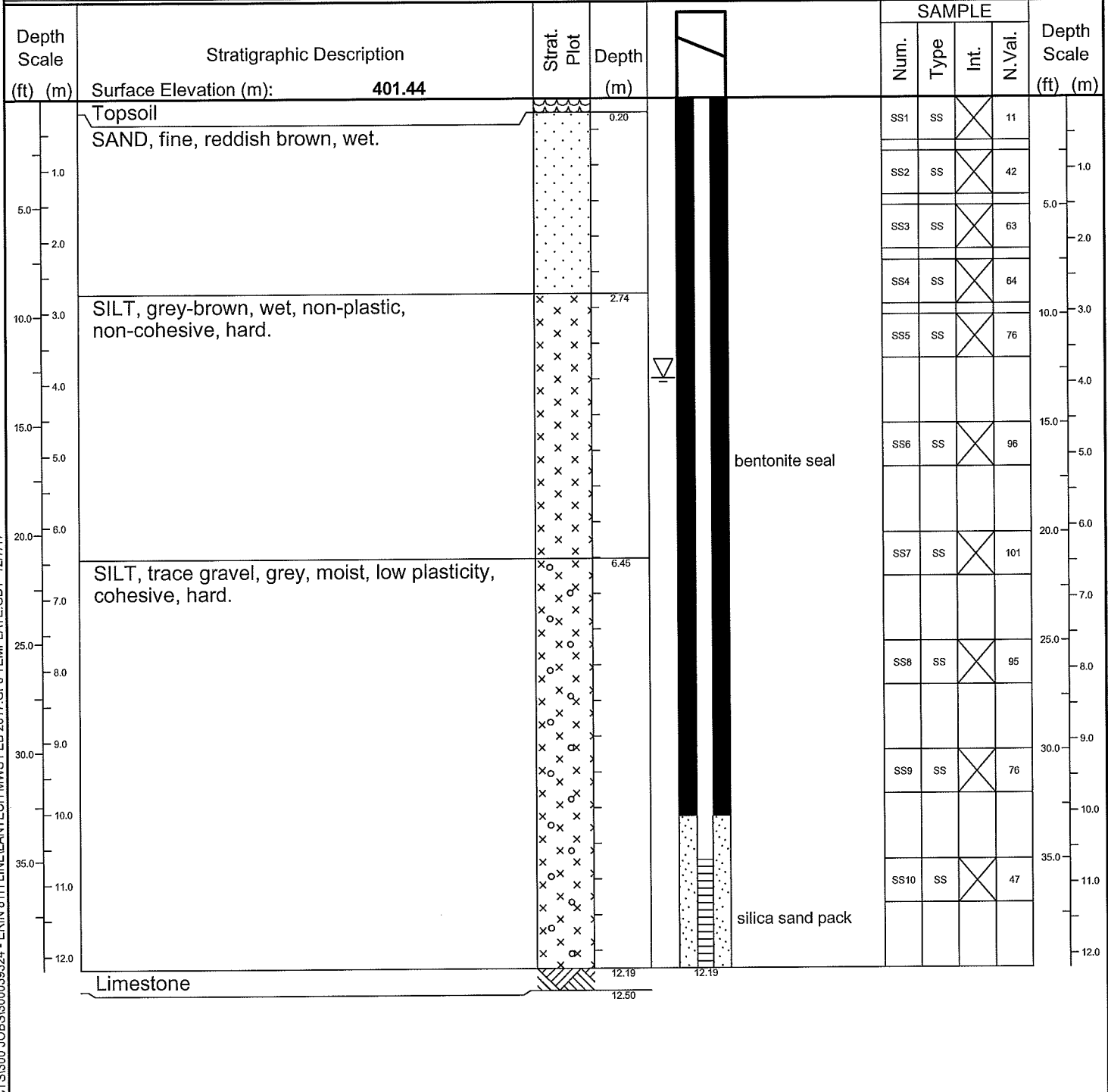


R.J. Burnside & Associates Limited  
 292 Speedvale Avenue West, Guelph, Ontario N1H 1C4  
 telephone (519) 823-4995 fax (519) 836-5477

**MW1-17**

Page 1 of 1

Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>401.44</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/8/2017</b>	Static Water Level Depth (m): <b>3.93</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/8/2017</b>	Sand Pack Depth (m) : <b>10.05 - 12.19</b>



BHLOG GUELPH P:\GINT\PROJECTS\300 JOBS\300039324 - ERIN 8TH LINE\LANTECH.MWS FEB 2017.GPJ TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann**      Checked By: **Dwight Smikle**      Date Prepared: **2/21/2017**  
 This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b>	<b>MONITORING WELL DATA</b>	<b>SAMPLE TYPE</b>
▼ Water found @ time of drilling ▽ Static Water Level - 3/30/2017	Pipe: <b>51 mm dia. PVC</b> Screen: <b>51 mm dia. PVC #10 slot</b>	AC  Auger Cutting    SS  Split Spoon CS  Continuous    AR  Air Rotary RC  Rock Core    WC  Wash Cuttings

# LOG OF DRILLING OPERATIONS

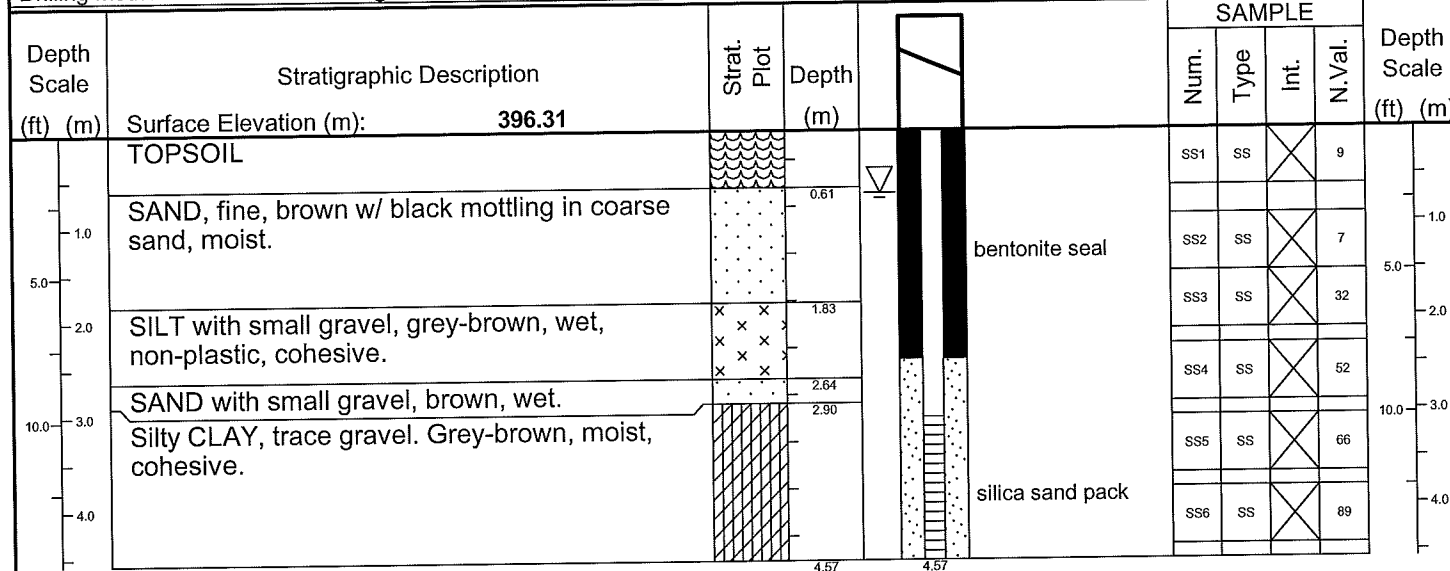
**MW2-17**



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Page 1 of 1

Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>396.31</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/8/2017</b>	Static Water Level Depth (m): <b>0.67</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/9/2017</b>	Sand Pack Depth (m) : <b>2.44 - 4.57</b>



B:\LOG GUELPH.P:\GINT\PROJECTS\300\_JOBS\300039324 - ERIN 8TH LINE\LANTECH MWS FEB 2017.GPJ TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann**      Checked By: **Dwight Smikle**      Date Prepared: **2/21/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b>	<b>MONITORING WELL DATA</b>	<b>SAMPLE TYPE</b>	
Water found @ time of drilling	Pipe: <b>51 mm dia. PVC</b>	AC	Auger Cutting
Static Water Level - 3/30/2017	Screen: <b>51 mm dia. PVC #10 slot</b>	CS	Continuous
		RC	Rock Core
		SS	Split Spoon
		AR	Air Rotary
		WC	Wash Cuttings

# LOG OF DRILLING OPERATIONS

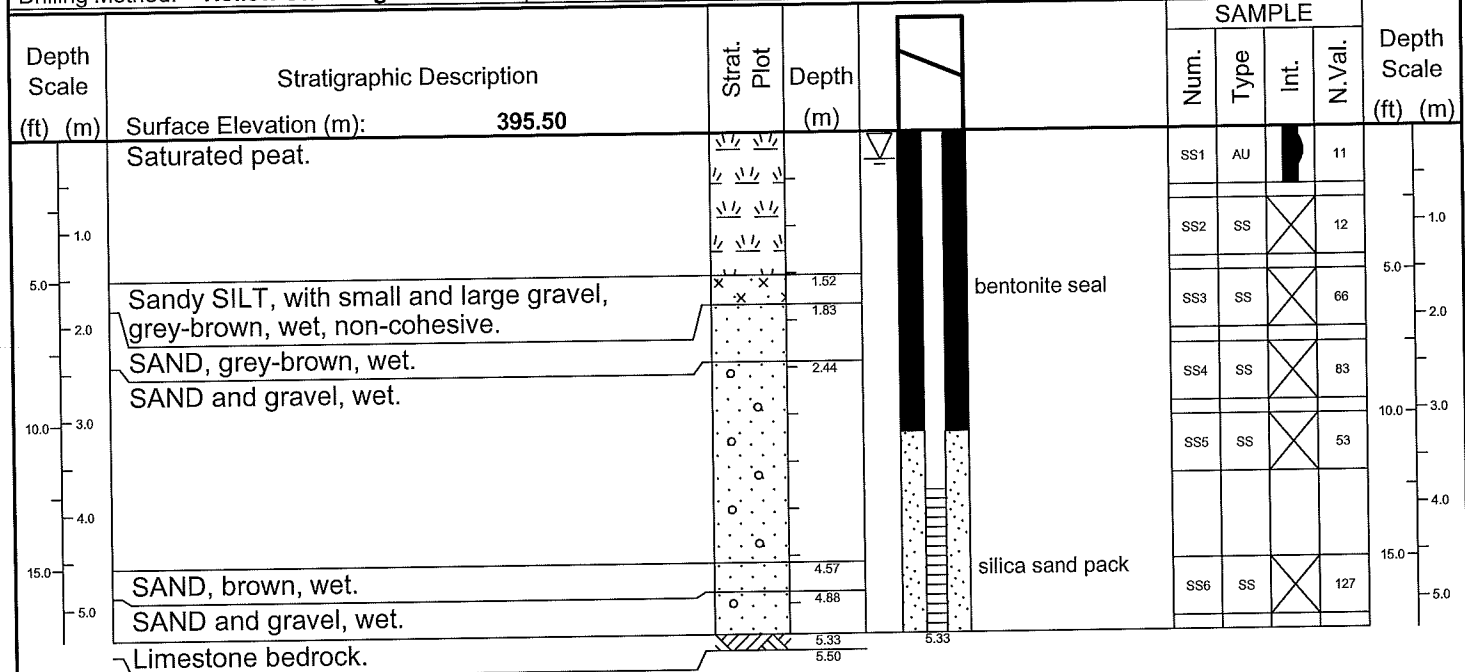
MW3-17

Page 1 of 1



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Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>395.5</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/9/2017</b>	Static Water Level Depth (m): <b>0.3</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/9/2017</b>	Sand Pack Depth (m) : <b>3.2 - 5.33</b>



B:\LOG GUELPH P:\GINT\PROJECTS\3000.JOBS\300039324 - ERIN 8TH LINE\LANTECH MWS FEB 2017.GPJ TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann** Checked By: **Dwight Smikle** Date Prepared: **2/21/2017**  
 This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b>	<b>MONITORING WELL DATA</b>	<b>SAMPLE TYPE</b>
▼ Water found @ time of drilling ▽ Static Water Level - 3/30/2017	Pipe: <b>51 mm dia. PVC</b> Screen: <b>51 mm dia. PVC #10 slot</b>	AC [Symbol] Auger Cutting CS [Symbol] Continuous RC [Symbol] Rock Core SS [Symbol] Split Spoon AR [Symbol] Air Rotary WC [Symbol] Wash Cuttings

# LOG OF DRILLING OPERATIONS

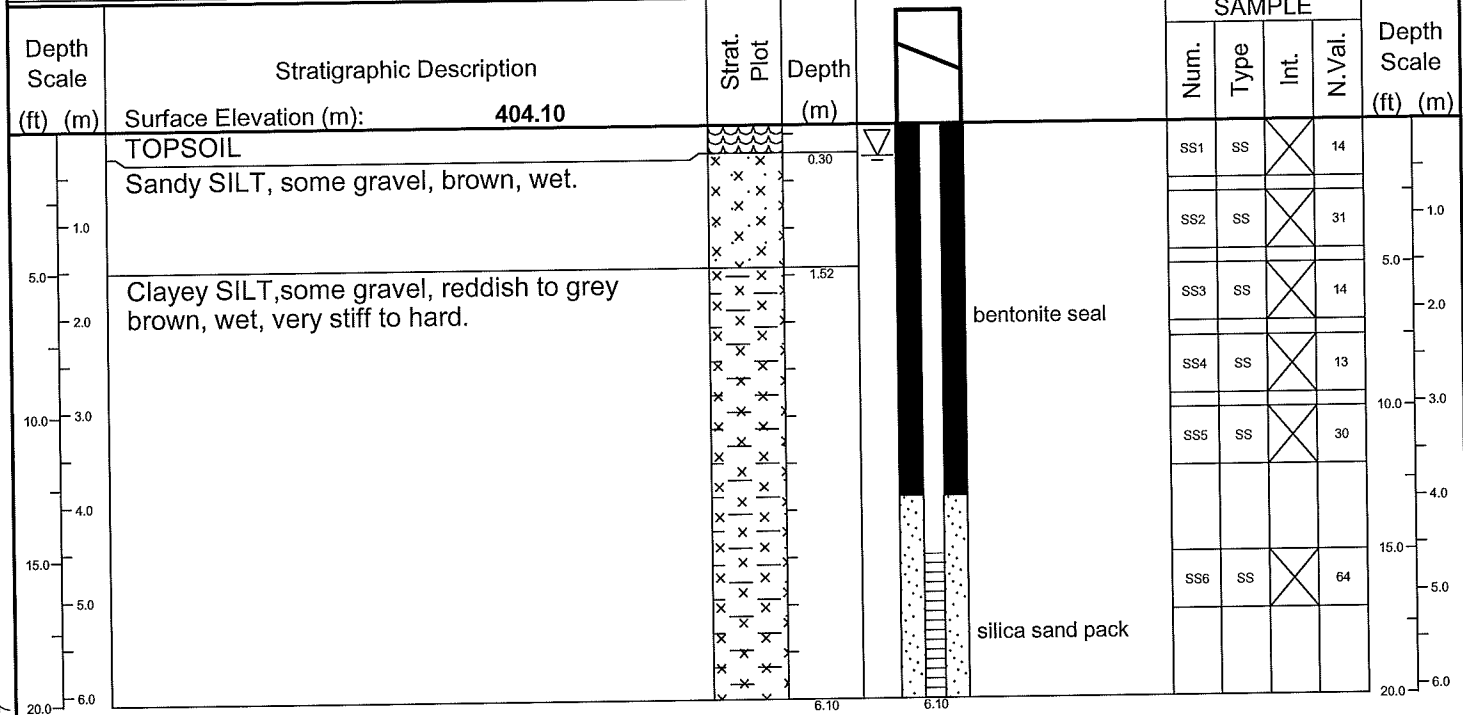
**MW4-17**

Page 1 of 1



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 292 Speedvale Avenue West, Guelph, Ontario N1H 1C4  
 telephone (519) 823-4995 fax (519) 836-5477

Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>404.1</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/9/2017</b>	Static Water Level Depth (m): <b>0.34</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/9/2017</b>	Sand Pack Depth (m) : <b>3.96 - 6.1</b>



BH:LOG GUELPH P:\GINT\PROJECTS\3000 JOBS\300039324 - ERIN 8TH LINE\LANTECH MWS FEB 2017.GPJ TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann**      Checked By: **Dwight Smikle**      Date Prepared: **2/21/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b>	<b>MONITORING WELL DATA</b>	<b>SAMPLE TYPE</b>	
▽ Water found @ time of drilling ▽ Static Water Level - 3/30/2017	Pipe: <b>51 mm dia. PVC</b> Screen: <b>51 mm dia. PVC #10 slot</b>	AC  Auger Cutting CS  Continuous RC  Rock Core	SS  Split Spoon AR  Air Rotary WC  Wash Cuttings

# LOG OF DRILLING OPERATIONS

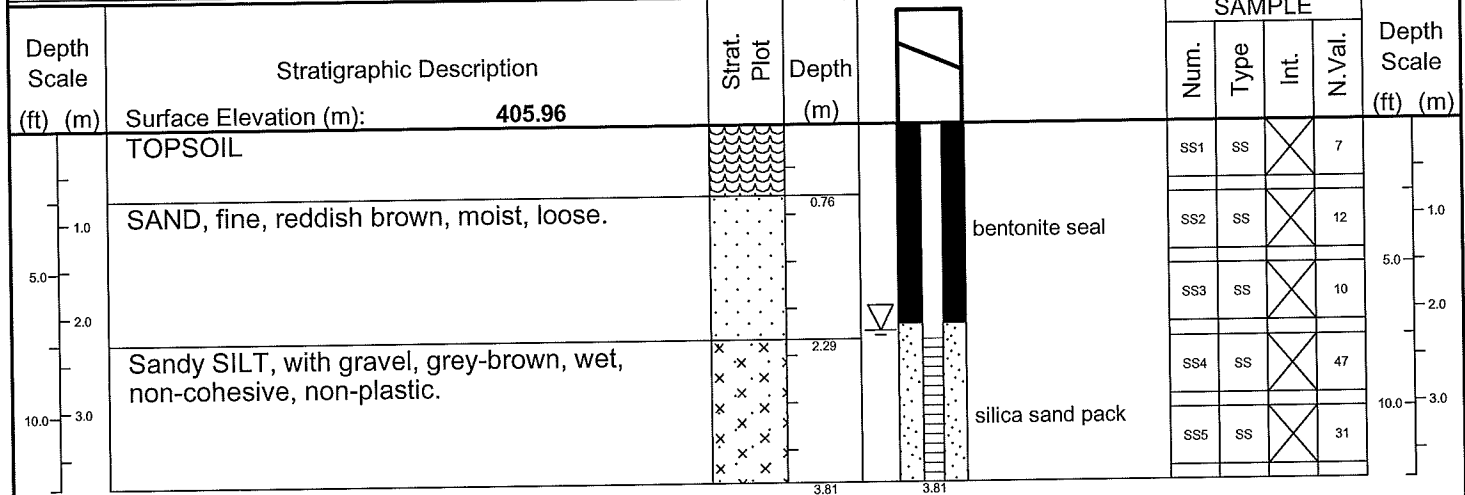
MW5-17

Page 1 of 1



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 292 Speedvale Avenue West, Guelph, Ontario N1H 1C4  
 telephone (519) 823-4995 fax (519) 836-5477

Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>405.96</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/9/2017</b>	Static Water Level Depth (m): <b>2.20</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/9/2017</b>	Sand Pack Depth (m) : <b>2.13 - 4.57</b>



B:\LOG GUELPH P:\GINT\PROJECTS\300 JOBS\300039324 - ERIN 8TH LINE\LANTECH MWS FEB 2017.GPJ TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann** Checked By: **Dwight Smikle** Date Prepared: **2/21/2017**  
 This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b> Water found @ time of drilling Static Water Level - 3/30/2017	<b>MONITORING WELL DATA</b> Pipe: <b>51 mm dia. PVC</b> Screen: <b>51 mm dia. PVC #10 slot</b>	<b>SAMPLE TYPE</b> AC  Auger Cutting CS  Continuous RC  Rock Core	SS  Split Spoon AR  Air Rotary WC  Wash Cuttings
---	--	---	--

# LOG OF DRILLING OPERATIONS

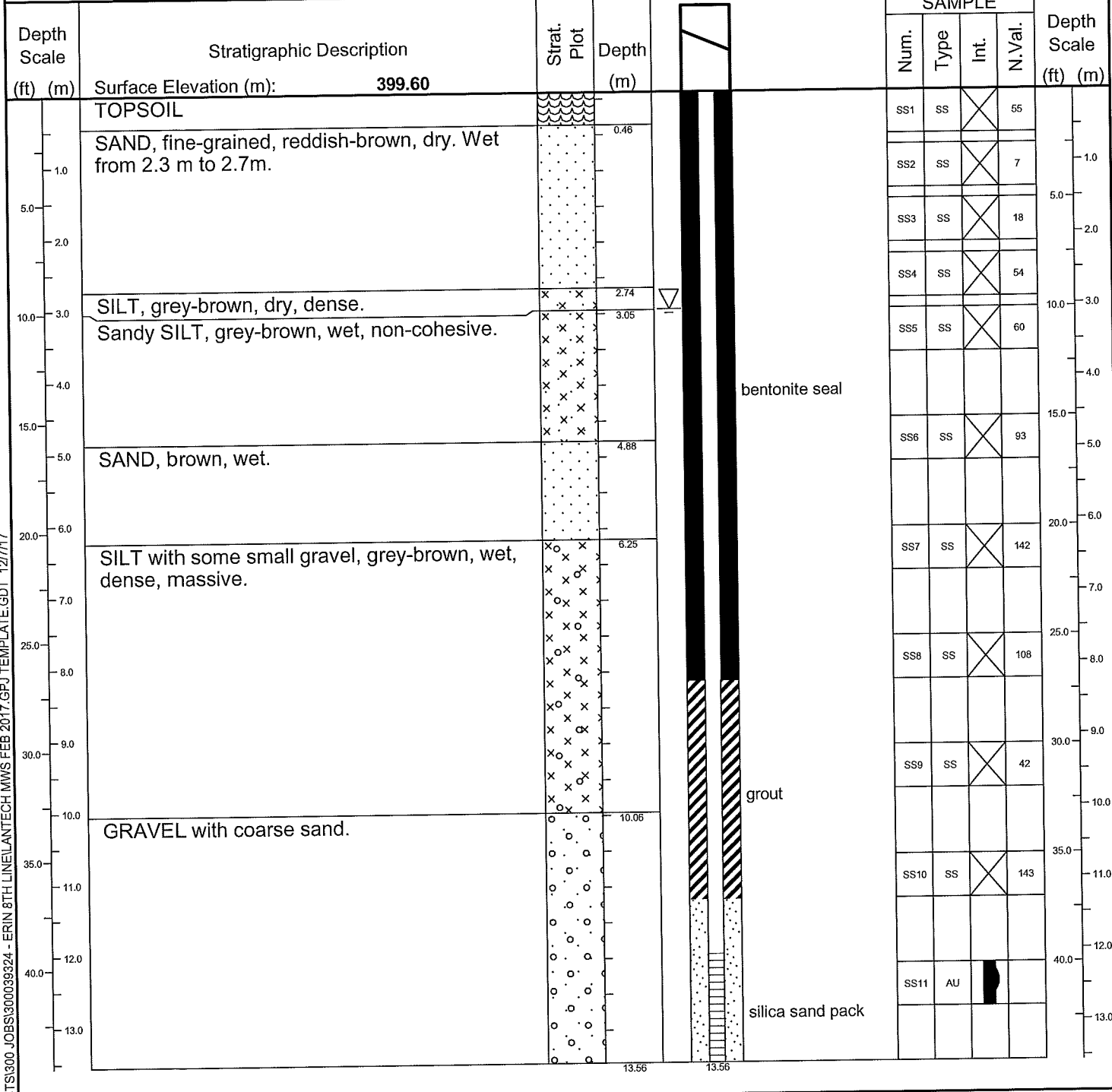
**MW6A-17**

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telephone (519) 823-4995 fax (519) 836-5477

Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>399.60</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/10/2017</b>	Static Water Level Depth (m): <b>3.04</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/10/2017</b>	Sand Pack Depth (m): <b>11.27 - 13.56</b>



BHLOG GUELPH P:\GINT\PROJECTS\300039324 - ERIN 8TH LINE\LANTECH\MWS FEB 2017.GPJ TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann**      Checked By: **Dwight Smikle**      Date Prepared: **2/21/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b>	<b>MONITORING WELL DATA</b>	<b>SAMPLE TYPE</b>	
Water found @ time of drilling	Pipe: <b>51 mm dia. PVC</b>	Auger Cutting	SS  Split Spoon
Static Water Level - 3/30/2017	Screen: <b>51 mm dia. PVC #10 slot</b>	CS  Continuous	AR  Air Rotary
		RC  Rock Core	WC  Wash Cuttings

# LOG OF DRILLING OPERATIONS

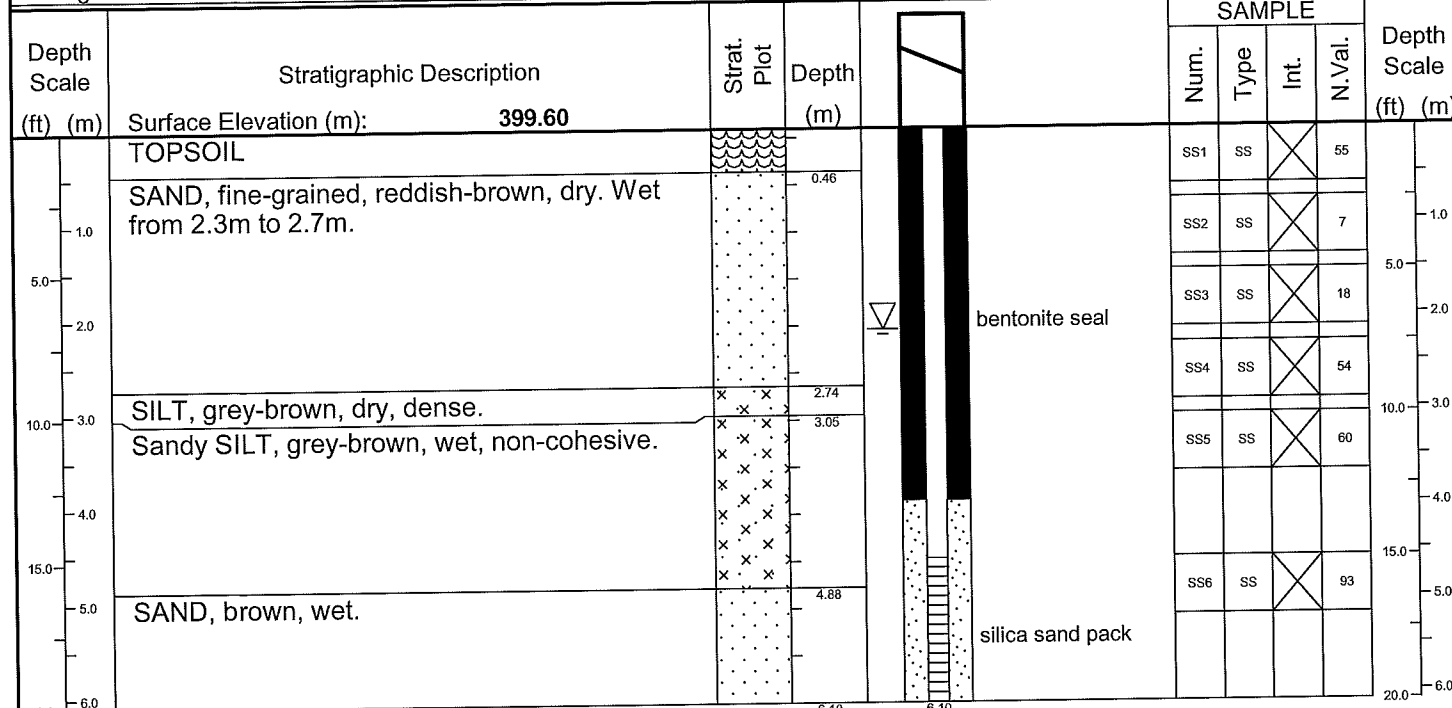
**MW6B-17**

Page 1 of 1



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 292 Speedvale Avenue West, Guelph, Ontario N1H 1C4  
 telephone (519) 823-4995 fax (519) 836-5477

Client: <b>Homes in the Hills</b>	Project Name: <b>8th Line Erin</b>	Logged by: <b>D. Beckmann</b>
Project No.: <b>300039324</b>	Location: <b>Erin, ON</b>	Ground (m amsl): <b>399.60</b>
Drilling Co.: <b>Lantech Drilling Services Inc.</b>	Date Started: <b>2/10/2017</b>	Static Water Level Depth (m): <b>2.14</b>
Drilling Method: <b>Hollow Stem Auger</b>	Date Completed: <b>2/10/2017</b>	Sand Pack Depth (m) : <b>3.96 - 6.1</b>



B:\LOG GUELPH P:\GINTY\PROJECTS\300 JOBS\300039324 - ERIN 8TH LINE\LANTECH MWS FEB 2017.GPJ\TEMPLATE.GDT 12/7/17

Prepared By: **Dan Beckmann**      Checked By: **Dwight Smikle**      Date Prepared: **2/21/2017**

This borehole log was prepared for hydrogeological and/or environmental purposes and does not necessarily contain information suitable for a geotechnical assessment of the subsurface conditions. Borehole data requires interpretation by R. J. Burnside & Associates Limited personnel before use by others.

<b>LEGEND</b> Water found @ time of drilling Static Water Level - 3/30/2017	<b>MONITORING WELL DATA</b> Pipe: <b>51 mm dia. PVC</b> Screen: <b>51 mm dia. PVC #10 slot</b>	<b>SAMPLE TYPE</b> AC  Auger Cutting      SS  Split Spoon CS  Continuous      AR  Air Rotary RC  Rock Core      WC  Wash Cuttings
---	--	--



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## Appendix B

### MOECC Well Logs

# Water Well Records

Friday, December 01, 2017

10:19:51 AM

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
ERIN TOWNSHIP	17 575833 4846109 W	2010/02 6607	2.00			MO		7141973 (M06516) A094797	BRWN SAND GRVL LOOS 0004 BLCK PEAT SAND SOFT 0008 BRWN SAND HARD 0010
ERIN TOWNSHIP	17 574750 4846479 W	2008/09 6809						7115986 (Z82809) A	0070
ERIN TOWNSHIP	17 575621 4846698 W	2006/12 6607	0.75	FR 0010			0011 5	7039420 (Z59642) A048426	BRWN FILL SAND SLTY 0010 GREY SAND SLTY 0020
ERIN TOWNSHIP CON 08	17 574281 4845565 W	1989/05 2332	5 5	FR 0150	9/10/10/1:30	DO		6710220 (59402)	BRWN FILL 0003 BLCK MUCK 0006 BRWN CLAY 0010 BRWN MSND 0035 BRWN MGVL CLAY 0058 GREY SHLE ROCK 0070 GREY ROCK 0080 GREY ROCK 0165
ERIN TOWNSHIP CON 08	17 574781 4845093 W	1994/10 3317	6 6	FR 0155	23/50/10/1:30	DO		6711623 (149980)	BRWN SAND CLAY 0048 GREY CLAY STKY 0055 GREY CLAY STNS 0085 GREY ROCK SHLY 0091 GREY LMSN 0155 GREY LMSN LYRD 0175
ERIN TOWNSHIP CON 08 008	17 575956 4846380 W	1987/11 3513	6	FR 0080	40/70/6/6:0	DO		6709114 (NA)	BRWN SAND 0032 BRWN SAND GRVL LYRD 0094
ERIN TOWNSHIP CON 08 013	17 575104 4845923 W	1969/10 3637	30 32	FR 0013	10/16/25/1:0	DO		6703577 ()	BRWN LOAM 0001 BRWN MSND CLAY STNS 0010 BRWN GRVL MSND 0018
ERIN TOWNSHIP CON 08 014	17 574343 4845372 W	1986/11 3317	5 5	FR 0157	27/30/12/1:15	DO		6708611 (01011)	SAND GRVL 0005 SAND 0060 CLAY SAND STNS 0085 GREY ROCK 0098 BRWN ROCK 0121 GREY LMSN 0159
ERIN TOWNSHIP CON 08 014	17 574232 4845270 W	1987/11 2332	5 5	FR 0205	26/52/9/1:30	DO		6709206 (18758)	BRWN FSND 0027 BRWN SAND CLAY 0085 GREY CLAY ROCK HPAN 0106 GREY ROCK LMSN 0225
ERIN TOWNSHIP CON 08 014	17 574317 4845448 W	1987/07 3317	5 5	FR 0130	5/10/12/1:15	DO		6709063 (09517)	BRWN CLAY SAND 0015 GREY CLAY 0050 GREY CLAY STNS 0065 BRWN LMSN 0082 GREY LMSN 0135
ERIN TOWNSHIP CON 08 014	17 574421 4845626 W	1987/10 3317	5 5	FR 0088	3/7/15/1:15	DO		6709057 (18053)	LOAM TILL 0009 SAND 0052 CLAY SOFT 0064 CLAY STNS 0081 BRWN ROCK 0091
ERIN TOWNSHIP CON 08 014	17 574239 4845516 W	1987/08 3317	5 5	FR 0130	26/35/10/1:30	DO		6709055 (18017)	BRWN SAND CLAY 0044 GREY CLAY STNS 0066 GREY ROCK 0075 GREY LMSN 0140
ERIN TOWNSHIP CON 08 014	17 574434 4845568 W	1987/07 3317	5 5	FR 0125	6/12/10/1:15	DO		6709018 (04227)	TILL 0005 BRWN SAND CLAY STNS 0015 GREY CLAY STNS 0066 BRWN LMSN 0081 GREY LMSN 0130
ERIN TOWNSHIP CON 08 014	17 574483 4845578 W	1987/07 3317	5 5	FR 0105	5/9/15/1:30	DO		6709017 (04228)	BRWN SAND CLAY 0060 GREY CLAY STNS 0087 BRWN LMSN 0115
ERIN TOWNSHIP CON 08 014	17 574268 4845205 W	1988/07 2332	5 5	FR 0143	47//12/1:0	DO		6709344 (35178)	BRWN FSND 0040 BRWN SAND CLAY 0084 HPAN 0108 GREY CLAY ROCK 0143
ERIN TOWNSHIP CON 08 014	17 574662 4845363 W	1965/09 2406	4 4	FR 0162	40/60/12/2:30	DO		6700732 ()	BRWN FSND 0060 BLUE CLAY 0075 CLAY BLDR 0098 GREY ROCK 0107 BRWN ROCK 0145 GREY ROCK 0164

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
ERIN TOWNSHIP CON 08 014	17 574227 4845480 W	1987/06 3317	5 5	FR 0130	27/35/14/1:15	DO		6708822 (09497)	BRWN CLAY SAND 0018 GREY CLAY 0053 GREY CLAY STNS 0079 BRWN ROCK 0104 GREY LMSN 0120 GREY LMSN PORS 0130
ERIN TOWNSHIP CON 08 014	17 574614 4845523 W	1978/09 3317	4 4	FR 0145	9/27/9/2:0	DO		6706912 ()	SAND SILT 0025 GREY CLAY STNS SAND 0060 GREY CLAY STNS 0085 GREY LMSN 0090 BRWN LMSN 0098 GREY LMSN 0150
ERIN TOWNSHIP CON 08 014	17 574514 4845593 W	1972/09 4320	4	FR 0135 FR 0145	0///:	DO		6704501 ()	BRWN SAND 0012 BRWN GRVL CLAY 0048 CLAY SAND BLDR 0086 GREY DLMT 0108 WHIT DLMT 0145
ERIN TOWNSHIP CON 08 014	17 574834 4845243 W	1972/08 3316	4 4	FR 0198 FR 0220	52/60/10/2:0	DO		6704456 ()	SAND CLAY 0060 GREY CLAY GRVL 0109 GREY CLAY 0129 WHIT LMSN 0145 GREY LMSN 0224
ERIN TOWNSHIP CON 08 014	17 574584 4845273 W	1972/06 3316	4 4	FR 0123	4/18/12/5:0	DO		6704427 ()	SAND CLAY 0020 CLAY SAND BLDR 0074 BRWN LMSN 0105 WHIT LMSN 0125
ERIN TOWNSHIP CON 08 014	17 574679 4845143 W	1971/08 3316	4 4	FR 0177	56/70/10/1:0	DO		6704158 ()	CLAY MSND 0063 CLAY GRVL MSND 0120 GREY LMSN 0185
ERIN TOWNSHIP CON 08 014	17 574253 4845415 W	1987/04 3317	5 5	FR 0130	35/50/10/1:30	DO		6708809 (01049)	BRWN SAND CLAY LYRD 0060 GREY CLAY STNS 0102 BRWN ROCK 0141
ERIN TOWNSHIP CON 08 014	17 574306 4845284 W	1988/07 3317	5 5	FR 0130	16/27/12/1:30	DO		6709549 (20138)	FILL 0002 BRWN SAND CLAY 0057 CLAY STNS 0082 BRWN ROCK 0110 GREY LMSN 0144
ERIN TOWNSHIP CON 08 014	17 574685 4844925 W	1991/06 2663	6 6	FR 0126	23//25/1:0	DO		6710689 (83491)	LOAM 0002 SAND 0042 GREY CLAY GRVL 0061 BRWN LMSN 0083 GREY LMSN 0101 WHIT LMSN 0115 GREY LMSN 0126
ERIN TOWNSHIP CON 08 014	17 574707 4844905 W	1991/08 3317	5 5	FR 0125	30/40/10/1:30	DO		6710812 (88429)	BRWN CLAY SAND 0030 GREY CLAY STNS SAND 0074 GREY LMSN 0135
ERIN TOWNSHIP CON 08 014	17 574425 4845595 W	1986/12 3317	5 5	FR 0105	2/7/30/1:30	DO		6708617 (01032)	FILL 0004 SAND CLAY 0060 GREY CLAY STNS 0079 GREY LMSN 0112
ERIN TOWNSHIP CON 09	17 575394 4846590 W	1991/09 2332	5 5	FR 0050	8/15/10/10:0	DO		6710870 (103727)	BLCK OBDN 0004 BRWN CGVL 0012 BRWN FGVL FSND 0014 GREY CLAY ROCK HARD 0024 GREY ROCK 0075
ERIN TOWNSHIP CON 09 012	17 576254 4845823 W	1970/03 1315	5	FR 0086	18/30//1:45	DO		6703656 ()	CLAY BLDR 0038 LMSN MUCK SILT 0070 LMSN 0086
ERIN TOWNSHIP CON 09 012	17 575014 4845623 W	1982/09 3317	5	FR 0015	6/15/11/2:0	ST		6707772 ()	GRVL CLAY HARD 0015 GRVL SAND 0020
ERIN TOWNSHIP CON 09 013	17 575135 4845023 W	1962/05 2414	5 5	FR 0062	6/30/6/0:30	DO		6700760 ()	LOAM 0001 BLDR GRVL 0028 CSND 0032 GREY CLAY 0039 BRWN ROCK 0062
ERIN TOWNSHIP CON 09 013	17 575265 4845264 W	1962/12 2414	6 5 5	FR 0120	9/30/15/8:0	DO		6700761 ()	LOAM 0001 STNS CLAY 0012 BRWN CLAY GRVL 0023 BRWN FSND 0097 GREY CLAY GRVL 0117 GREY ROCK 0120
ERIN TOWNSHIP CON 09 013	17 575752 4846005 W	1974/03 1906	5	FR 0040	2/18/15/3:0	DO		6705028 ()	BLCK SAND LOAM 0032 GRVL 0040
ERIN TOWNSHIP CON 09 013	17 574925 4845323 W	2012/08 7385	6.11 6.11	FR 0120	32/32/10/1:0			7187008 (Z156339) A130767	BRWN CLAY 0018 GREY CLAY STNS 0067 BRWN ROCK 0077 GREY ROCK 0120
ERIN TOWNSHIP CON 09 013	17 575654 4845803 W	1975/01 3413	30 24	FR	14/14/4/4:0	DO		6705956 ()	CLAY FILL 0004 BRWN CLAY 0010 STNS CGRD 0018

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
ERIN TOWNSHIP CON 09 013	17 575474 4845673 W	1969/08 3316	4 4	FR 0138	30/50/8/5:0	DO		6703522 ()	GRVL MSND 0055 WHIT LMSN 0070 BRWN LMSN 0107 GREY LMSN 0140
ERIN TOWNSHIP CON 09 013	17 575514 4845743 W	1969/05 1612	5	FR 0059	34/37/7/2:0	DO		6703349 ()	LOAM 0001 GRVL 0034 GRVL CLAY 0057 WHIT LMSN 0059
ERIN TOWNSHIP CON 09 013	17 575406 4845385 W	1967/11 3316	4 4	FR 0080	28/30/8/1:30	ST DO		6700762 ()	CLAY GRVL STNS 0063 LMSN CLAY 0069 GREY ROCK 0080
ERIN TOWNSHIP CON 09 013	17 575544 4845723 W	1971/12 1906	4	FR 0095	30/50/10/2:0	DO		6704122 ()	BRWN CLAY STNS GRVL 0062 LMSN 0096
ERIN TOWNSHIP CON 09 013	17 575775 4846105 W	1997/08 3317	6 6	FR 0085	5/50/9/1:30	DO		6712433 (181337)	FILL 0002 SAND 0003 GRVL CLAY 0045 GREY CLAY STNS 0048 GREY LMSN 0090 BRWN LMSN 0102
ERIN TOWNSHIP CON 09 013	17 575473 4845670 L	1990/03 2663	6 6	FR 0086	10//15/1:0	DO		6710258 (73118)	FILL 0002 GRVL 0025 GREY CLAY GRVL 0042 BRWN LMSN 0046 BRWN LMSN 0050 BRWN LMSN 0086
ERIN TOWNSHIP CON 09 013	17 575762 4846196 W	1994/11 3317	6 6	FR 0097	28/34/10/1:30	DO		6711618 (149989)	GRVL SAND BLDR 0040 GREY CLAY STNS SAND 0062 GREY CLAY STNS 0070 GREY LMSN 0105
ERIN TOWNSHIP CON 09 013	17 575762 4846196 W	1994/11 3317	5 5	FR 0028	26/29/6/1:30	DO		6711619 (149988)	LOAM 0002 GRVL 0033 SAND GRVL 0048
ERIN TOWNSHIP CON 09 013	17 574932 4845329 W	2013/08 7385				NU		7207438 (Z171228) A	
ERIN TOWNSHIP CON 09 013	17 575886 4846133 W	1974/03 1315	6 6	FR 0128	12/19/8/8:0	DO		6705080 ()	YLLW CLAY BLDR 0040 GRVL STNS MUCK 0097 LMSN 0124 LMSN 0131
ERIN TOWNSHIP CON 09 013	17 575416 4845440 W	1998/10 3317	6 6	FR 0075	31/37/10/1:30	DO		6712831 (192023)	GRVL SAND 0035 GREY CLAY STNS SAND 0067 GREY LMSN 0085
ERIN TOWNSHIP CON 09 013	17 575711 4846295 W	2002/09 7154	6 6	FR 0078	12/32/20/1:30	DO CO		6714191 (245743)	BRWN STNS GRVL 0013 GREY CLAY STNS 0028 BRWN LMSN 0082
ERIN TOWNSHIP CON 09 013	17 575000 4845500 W	2004/01 6607	1.97				0010 5	6714961 (Z07576) A007497	BRWN LOAM 0001 BRWN SAND SILT 0016
ERIN TOWNSHIP CON 09 013	17 575434 4845573 W	1972/07 3316	4 4	FR 0135	25/30/12/2:0	DO		6704442 ()	GRVL BLDR 0057 GREY LMSN 0138
ERIN TOWNSHIP CON 09 014	17 574664 4845623 W	1978/09 3317	4 4	FR 0135	18/33/10/1:0	ST DO		6706918 ()	SAND 0035 CLAY SAND LYRD 0050 GREY CLAY STNS 0068 GREY LMSN 0165
ERIN TOWNSHIP CON 09 014	17 575014 4845223 W	1975/08 3317	4 4	FR 0117	15/25/9/2:0	DO		6705917 ()	LOAM CLAY SNDY 0004 GREY CLAY 0060 GREY CLAY BLDR 0080 GREY LMSN 0117 GREY LMSN PORS 0126
ERIN TOWNSHIP CON 09 014	17 574723 4845516 W	1967/07 3316	4 4	FR 0105 FR 0146	18/35/10/1:0	DO		6700765 ()	MSND 0045 GREY CLAY STNS 0097 LMSN 0146
ERIN TOWNSHIP CON 09 014	17 575719 4846346 W	1948/07 4845	4 4 4	FR 0070	20/20/20/:	DO		6700763 ()	PRDG 0018 LMSN 0070
ERIN TOWNSHIP CON 09 014	17 574832 4845753 W	1967/09 2406	5 5	FR 0128	30/40/15/2:0	ST DO		6700764 ()	FSND STNS 0004 BRWN FSND 0012 STNS GRVL 0050 BLUE CLAY STNS 0080 BRWN ROCK 0086 GREY ROCK 0133

TOWNSHIP CON LOT	UTM	DATE CNTR	CASING DIA	WATER	PUMP TEST	WELL USE	SCREEN	WELL	FORMATION
ERIN TOWNSHIP CON 09 015	17 574742 4846484 W	2008/09 6809				MT		7115985 (Z82813) A073773	BRWN SILT 0005 GREY SILT GRVL 0060 GREY SAND WBRG 0075
ERIN TOWNSHIP CON 10 013	17 575995 4846212 W	1990/12 3317	6 5 5	UK 0037	7/15/100/4:0	MN		6710539 (88195)	BRWN GRVL CLAY 0012 BRWN GRVL SAND BLDR 0044 GRVL CLAY 0055
ERIN VILLAGE	17 575247 4846741 W	1951/09 4838	4 4	FR 0036	15/15/15/2:0	DO		6700825 ()	GRVL CLAY 0018 LMSN 0036
ERIN VILLAGE	17 575235 4846807 W	1951/10 4838	4 4	FR 0061	5/8/15/2:0	DO		6700826 ()	GRVL STNS 0010 LMSN 0061
ERIN VILLAGE	17 575304 4846779 W	1952/03 4838	4 4	FR 0033	8/15/10/1:0	DO		6700827 ()	LOAM 0004 GRVL CLAY 0008 ROCK 0015 LMSN 0033
ERIN VILLAGE	17 575497 4845798 W	1952/03 2414	6 6	FR 0075	30/35/5/5:0	ST DO		6700828 ()	PRDG 0034 BLUE CLAY STNS 0051 WHIT LMSN 0084
ERIN VILLAGE	17 575446 4846678 W	1954/09 2414	10 10	MN 0045	10/22/6/12:0	MN		6700833 ()	LOAM 0001 MSND 0025 GRVL 0028 BLUE LMSN 0062
ERIN VILLAGE	17 575532 4846985 W	2007/05 7215	0.38			NU	0016 16	7044065 (Z70373) A055266	
ERIN VILLAGE	17 574799 4846508 W	2006/07 6809	2				0050 5	6715858 (Z45808) A035714	BRWN SAND GRVL BLDR 0040 GREY SAND SILT 0055
ERIN VILLAGE	17 574803 4846507 W	2006/07 6809						6715859 (Z45809) A035715 A	

Notes:

UTM: UTM in Zone, Easting, Northing and Datum is NAD83; L: UTM estimated from Centroid of Lot; W: UTM not from Lot Centroid  
 DATE CNTR: Date Work Completed and Well Contractor Licence Number  
 CASING DIA: .Casing diameter in inches  
 WATER: Unit of Depth in Fee. See Table 4 for Meaning of Code

PUMP TEST: Static Water Level in Feet / Water Level After Pumping in Feet / Pump Test Rate in GPM / Pump Test Duration in Hour : Minutes  
 WELL USE: See Table 3 for Meaning of Code  
 SCREEN: Screen Depth and Length in feet  
 WELL: WEL ( AUDIT # ) Well Tag . A: Abandonment; P: Partial Data Entry Only  
 FORMATION: See Table 1 and 2 for Meaning of Code

**1. Core Material and Descriptive terms**

Code	Description	Code	Description	Code	Description	Code	Description	Code	Description
BLDR	BOULDERS	FCRD	FRACTURED	IRFM	IRON FORMATION	PORS	POROUS	SOFT	SOFT
BSLT	BASALT	FGRD	FINE-GRAINED	LIMY	LIMY	PRDG	PREVIOUSLY DUG	SPST	SOAPSTONE
CGRD	COARSE-GRAINED	FGVL	FINE GRAVEL	LMSN	LIMESTONE	PRDR	PREV. DRILLED	STKY	STICKY
CGVL	COARSE GRAVEL	FILL	FILL	LOAM	TOPSOIL	QRTZ	QUARTZITE	STNS	STONES
CHRT	CHERT	FLDS	FELDSPAR	LOOS	LOOSE	QSND	QUICKSAND	STNY	STONEY
CLAY	CLAY	FLNT	FLINT	LTCL	LIGHT-COLOURED	QTZ	QUARTZ	THIK	THICK
CLN	CLEAN	FOSS	FOSILIFEROUS	LYRD	LAYERED	ROCK	ROCK	THIN	THIN
CLYY	CLAYEY	FSND	FINE SAND	MARL	MARL	SAND	SAND	TILL	TILL
CMTD	CEMENTED	GNIS	GNEISS	MGRD	MEDIUM-GRAINED	SHLE	SHALE	UNKN	UNKNOWN TYPE
CONG	CONGLOMERATE	GRNT	GRANITE	MGVL	MEDIUM GRAVEL	SHLY	SHALY	VERY	VERY
CRYS	CRYSTALLINE	GRSN	GREENSTONE	MRBL	MARBLE	SHRP	SHARP	WBRG	WATER-BEARING
CSND	COARSE SAND	GRVL	GRAVEL	MSND	MEDIUM SAND	SHST	SCHIST	WDFR	WOOD FRAGMENTS
DKCL	DARK-COLOURED	GRWK	GREYWACKE	MUCK	MUCK	SILT	SILT	WTHD	WEATHERED
DLMT	DOLOMITE	GVLV	GRAVELLY	OBDN	OVERBURDEN	SLTE	SLATE		
DNSE	DENSE	GYPG	GYPG	PCKD	PACKED	SLTY	SILTY		
DRTY	DIRTY	HARD	HARD	PEAT	PEAT	SNDS	SANDSTONE		
DRY	DRY	HPAN	HARDPAN	PGVL	PEA GRAVEL	SNDY	SANDY SOAPSTONE		

**2. Core Color**

Code	Description
WHIT	WHITE
GREY	GREY
BLUE	BLUE
GREN	GREEN
YLLW	YELLOW
BRWN	BROWN
RED	RED
BLCK	BLACK
BLGY	BLUE-GREY

**3. Well Use**

Code	Description	Code	Description
DO	Domestic	OT	Other
ST	Livestock	TH	Test Hole
IR	Irrigation	DE	Dewatering
IN	Industrial	MO	Monitoring
CO	Commercial	MT	Monitoring TestHole
MN	Municipal		
PS	Public		
AC	Cooling And A/C		
NU	Not Used		

**4. Water Detail**

Code	Description	Code	Description
FR	Fresh	GS	Gas
SA	Salty	IR	Iron
SU	Sulphur		
MN	Mineral		
UK	Unknown		



**BURNSIDE**

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## Appendix C

### Surface Water Monitoring

**Table C-1  
Surface Water Flow Monitoring**

Date	Days since rain*:	Flow Rate (L/s)	
		SS1	SS2
28-May-17	2	10.4	2.3
26-Jun-17	0	12.5	0.21
17-Jul-17	1	-	Dry
18-Aug-17	3	4.2	Dry
21-Sep-17	2	2.6	Dry
19-Oct-17	4	9.9	Dry
23-Nov-17	1	9.8	0.7

Note:

<0.5 minimal flow not measurable with equipment (estimated)

"-" not measured

\* based on precipitation data from Fergus Shand Dam climate station

**Table C-2  
Staff Gauge Water Elevations**

	Ground Elevation* (masl)	28-May-17		26-Jun-17		17-Jul-17		18-Aug-17		21-Sep-17		19-Oct-17		23-Nov-17	
		Level (mags)	Elevation (masl)	Level (mags)	Elevation (masl)	Level (mags)	Elevation (masl)	Level (mags)	Elevation (masl)	Level (mags)	Elevation (masl)	Level (mags)	Elevation (masl)	Level (mags)	Elevation (masl)
SG1	397.00	0.08	397.08	0.08	397.08	0.055	397.06	0.07	397.07	0.05	397.05	0.07	397.07	0.075	397.08
SG2	397.30	0.21	397.51	0.22	397.52	0.205	397.51	0.21	397.51	0.2	397.50	0.21	397.51	0.21	397.51

\*Estimated from topography mapping



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## Appendix D

### Groundwater Monitoring

**Table D-1  
Groundwater Monitoring Data**

	Well Depth (mbgl)	Ground Surface Elevation (masl)	November 30, 2016		March 30, 2017		April 20, 2017		May 28, 2017		June 26, 2017	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
MW1	1.68	399.590	Dry	Dry	0.98	398.61	1.04	398.55	-	-	0.84	398.75
MW2d	4.33	395.990	1.92	394.07	0.35	395.64	0.39	395.60	0.41	395.58	0.50	395.49
MW2s	1.72	395.990	Dry	Dry	0.31	395.68	0.37	395.62	0.38	395.61	0.41	395.58
MW3	3.14	397.080	2.33	394.75	1.11	395.97	0.99	396.09	0.87	396.21	0.90	396.18
MW4d	7.48	403.150	3.87	399.28	1.11	402.04	1.19	401.96	-	-	0.49	402.66
MW4s	2.10	403.150	2.15	401.00	0.78	402.37	0.85	402.30	-	-	0.71	402.44
MW5d	5.85	404.690	3.68	401.01	1.31	403.38	1.40	403.29	1.39	403.30	1.38	403.31
MW5s	2.37	404.690	Dry	Dry	0.58	404.11	0.78	403.91	0.75	403.94	0.67	404.02
MW6	3.39	398.170	0.40	397.77	0.05	398.12	0.03	398.14	0.09	398.08	0.07	398.10
MW7	4.09	402.520	2.35	400.17	1.31	401.21	1.24	401.28	1.16	401.36	1.14	401.38
MW1-17	12.00	401.440	-	-	3.93	397.51	3.84	397.60	3.96	397.48	4.09	397.35
MW2-17	3.51	396.310	-	-	0.67	395.65	0.55	395.76	0.66	395.65	0.65	395.66
MW3-17	4.51	395.500	-	-	0.30	395.21	0.23	395.28	0.28	395.23	0.26	395.25
MW4-17	5.91	404.100	-	-	0.34	403.77	0.33	403.77	0.32	403.79	0.30	403.80
MW5-17	4.35	405.960	-	-	2.20	403.76	2.16	403.80	2.12	403.85	2.04	403.92
MW6A-17	13.51	399.600	-	-	3.04	396.56	3.05	396.55	3.01	396.59	2.93	396.67
MW6B-17	5.98	399.600	-	-	2.14	397.46	2.05	397.55	2.01	397.59	1.96	397.64
PZ1-d	1.48	399.60	0.71	398.89	0.15	399.45	0.14	399.46	0.13	399.47	0.15	399.46
PZ1-s	0.91	399.60	0.26	399.35	0.19	399.41	0.12	399.48	0.17	399.43	0.22	399.38
PZ2-d	1.43	397.00	0.32	396.68	0.22	396.78	0.12	396.88	0.15	396.85	0.24	396.76
PZ2-s	0.93	397.00	0.55	396.45	0.15	396.85	0.09	396.91	0.21	396.80	0.19	396.81
PZ3-d	1.57	396.00	0.70	395.30	0.17	395.83	0.08	395.92	0.14	395.86	0.01	395.99
PZ3-s	1.09	396.00	0.97	395.03	0.20	395.80	0.18	395.82	0.25	395.75	0.25	395.75
PZ4-d	1.57	397.31	1.46	395.85	-0.03	397.34	-0.01	397.32	-0.02	397.33	-0.04	397.35
PZ4-s	1.00	397.31	1.03	396.28	0.01	397.30	0.03	397.28	0.03	397.28	0.02	397.29
PZ5-d	1.79	396.41	1.61	394.80	0.32	396.09	0.30	396.11	0.27	396.14	0.26	396.15
PZ5-s	1.08	396.41	Dry	Dry	0.25	396.16	0.23	396.18	0.21	396.21	0.20	396.21

**Notes:**

"-" data not available

mbgs - meters below ground surface

masl - meters above sea level

**Table D-1  
Groundwater Monitoring Data**

	Well Depth (mbgl)	Ground Surface Elevation (masl)	July 17, 2017		August 18, 2017		September 21, 2017		October 19, 2017		November 23, 2017	
			Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)	Water Level (mbgs)	Water Elevation (masl)
MW1	1.68	399.590	1.35	398.24	-	-	1.36	398.23	-	-	1.34	398.25
MW2d	4.33	395.990	0.90	395.09	1.48	394.52	1.81	394.18	1.38	394.61	0.80	395.19
MW2s	1.72	395.990	1.07	394.92	1.48	394.51	Dry	Dry	1.37	394.62	0.78	395.21
MW3	3.14	397.080	1.05	396.03	1.46	395.62	1.60	395.48	1.59	395.49	1.43	395.65
MW4d	7.48	403.150	1.10	402.05	1.53	401.62	2.36	400.79	2.24	400.91	1.06	402.09
MW4s	2.10	403.150	1.30	401.85	2.76	400.40	1.77	401.38	2.12	401.03	1.23	401.92
MW5d	5.85	404.690	1.88	402.81	2.45	402.24	2.89	401.80	2.64	402.05	1.86	402.83
MW5s	2.37	404.690	1.24	403.45	1.83	402.86	2.23	402.46	2.23	402.46	1.29	403.40
MW6	3.39	398.170	0.16	398.01	0.22	397.95	0.43	397.74	0.33	397.84	0.22	397.95
MW7	4.09	402.520	1.43	401.09	1.68	400.84	1.91	400.61	1.87	400.65	1.69	400.83
MW1-17	12.00	401.440	4.22	397.22	4.46	396.98	4.93	396.51	4.83	396.61	4.80	396.64
MW2-17	3.51	396.310	1.06	395.25	1.38	394.94	1.55	394.76	1.38	394.93	1.14	395.17
MW3-17	4.51	395.500	0.34	395.17	0.26	395.25	0.90	394.61	0.45	395.06	0.35	395.16
MW4-17	5.91	404.100	0.41	403.69	0.44	403.66	0.75	403.35	0.52	403.58	0.41	403.69
MW5-17	4.35	405.960	2.22	403.74	2.37	403.59	2.57	403.39	2.64	403.32	2.45	403.51
MW6A-17	13.51	399.600	3.31	396.29	3.50	396.10	3.75	395.85	3.61	395.99	3.33	396.27
MW6B-17	5.98	399.600	2.25	397.35	2.46	397.14	2.68	396.92	2.61	396.99	2.49	397.11
PZ1-d	1.48	399.60	0.18	399.42	0.23	399.37	0.26	399.34	0.23	399.37	0.19	399.41
PZ1-s	0.91	399.60	0.26	399.34	0.26	399.34	0.28	399.32	0.23	399.37	0.20	399.40
PZ2-d	1.43	397.00	0.31	396.69	0.27	396.73	0.35	396.65	0.25	396.75	0.22	396.78
PZ2-s	0.93	397.00	0.23	396.77	0.20	396.80	0.26	396.74	0.20	396.80	0.18	396.82
PZ3-d	1.57	396.00	0.14	395.86	0.33	395.67	0.50	395.50	0.28	395.72	0.18	395.82
PZ3-s	1.09	396.00	0.45	395.55	0.46	395.55	0.62	395.38	0.38	395.62	0.29	395.71
PZ4-d	1.57	397.31	0.03	397.28	0.08	397.23	0.19	397.12	-	-	-0.02	397.33
PZ4-s	1.00	397.31	0.08	397.23	0.05	397.26	0.25	397.06	-	-	0.02	397.29
PZ5-d	1.79	396.41	0.38	396.03	0.60	395.82	0.96	395.45	1.57	394.84	0.41	396.00
PZ5-s	1.08	396.41	0.31	396.10	0.50	395.91	0.88	395.53	Dry	Dry	0.36	396.05

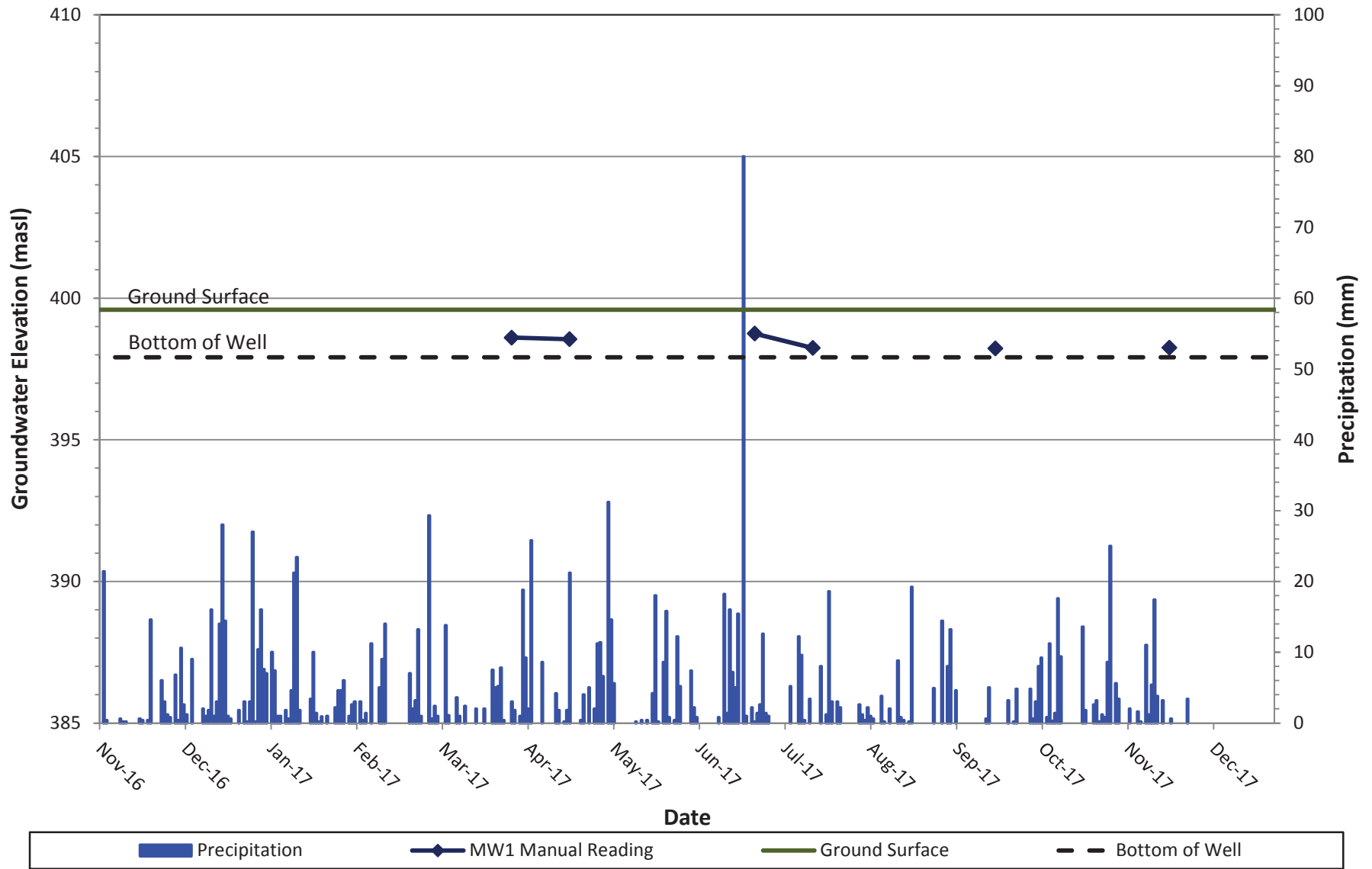
**Notes:**

"-" data not available

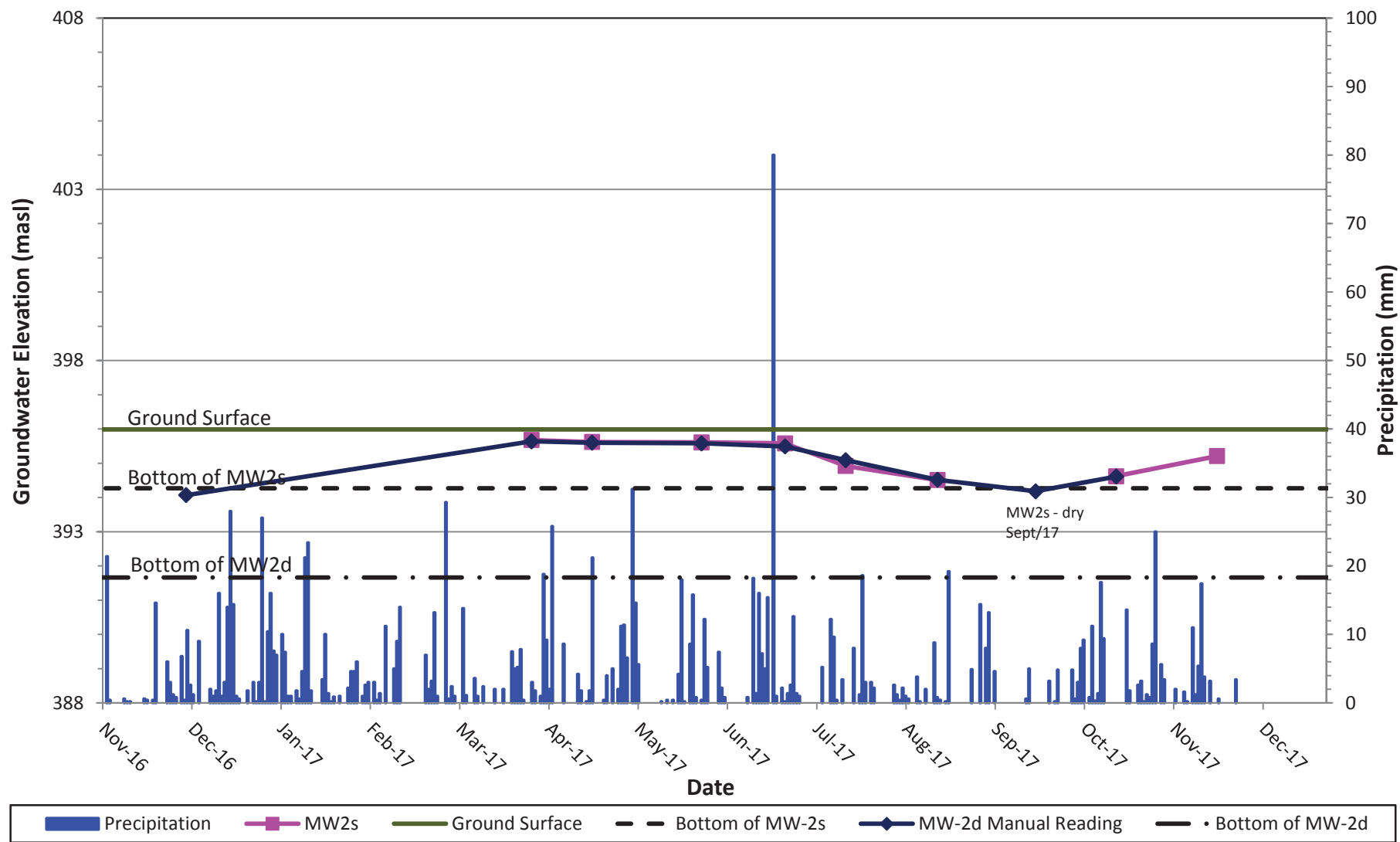
mbgs - meters below ground surface

masl - meters above sea level

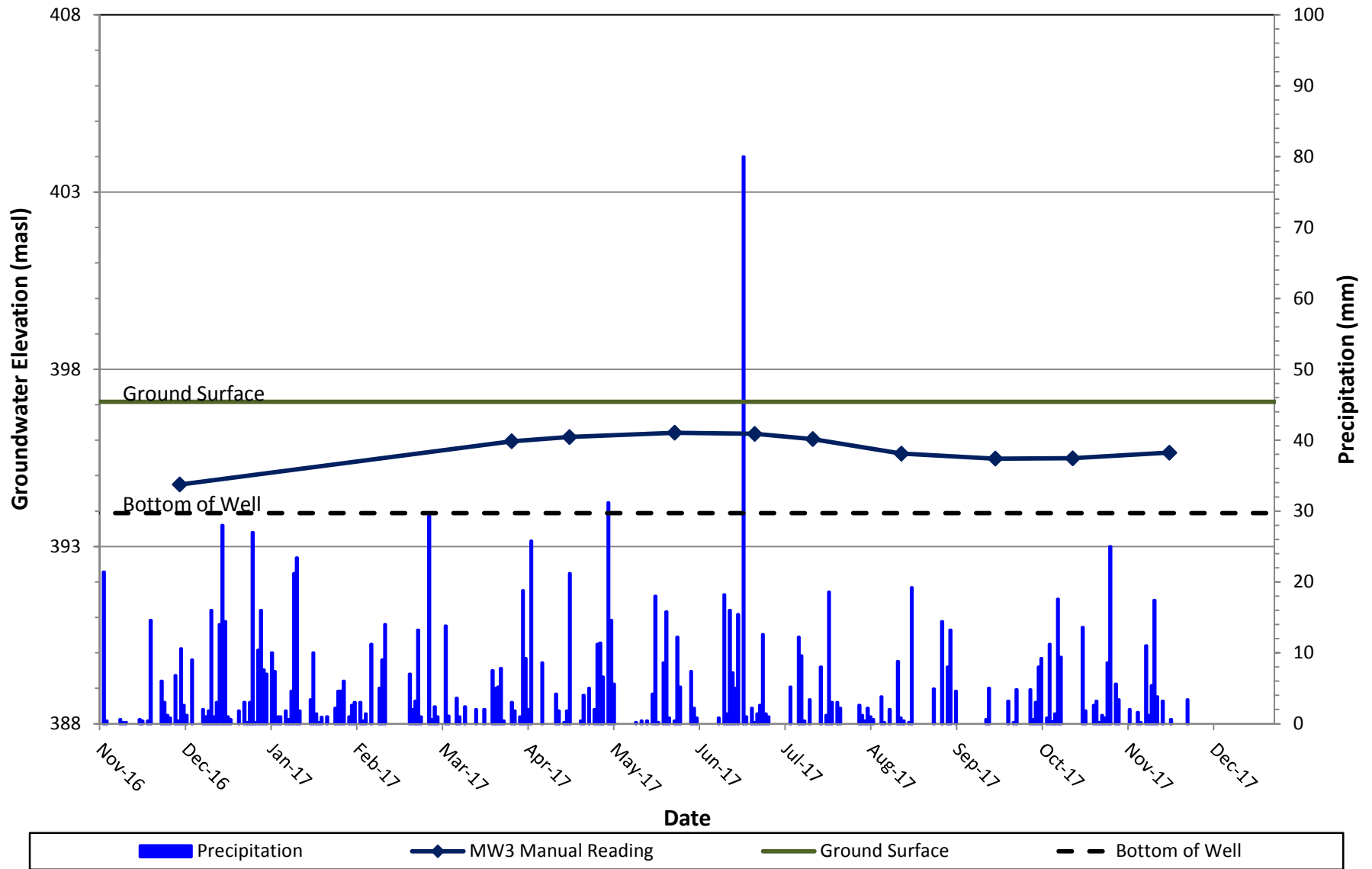
## MW1 (Well Depth: 1.7 m) Groundwater Elevations



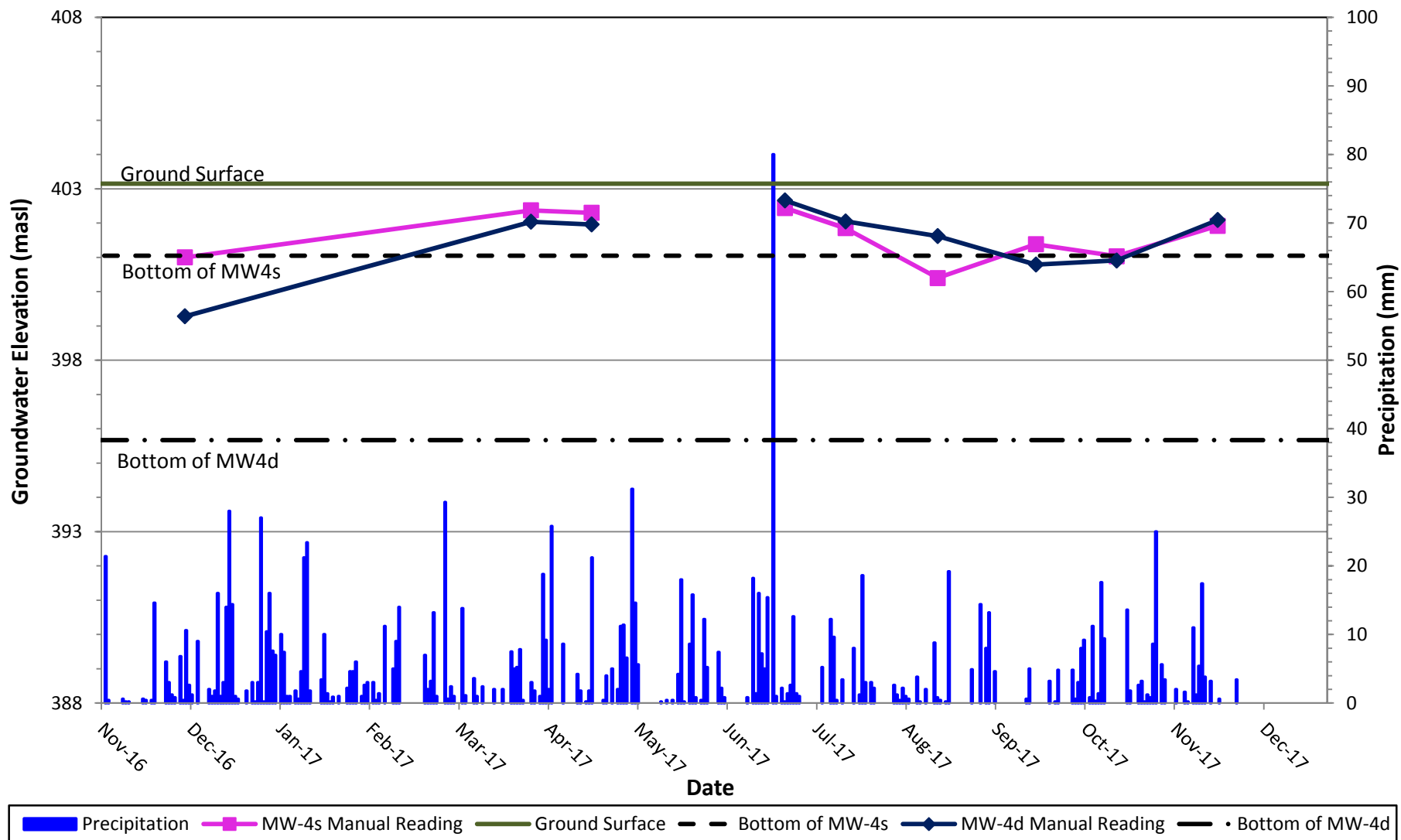
MW2s (Well Depth: 1.7 m)  
 MW2d (Well Depth: 4.3 m)  
 Groundwater Elevations



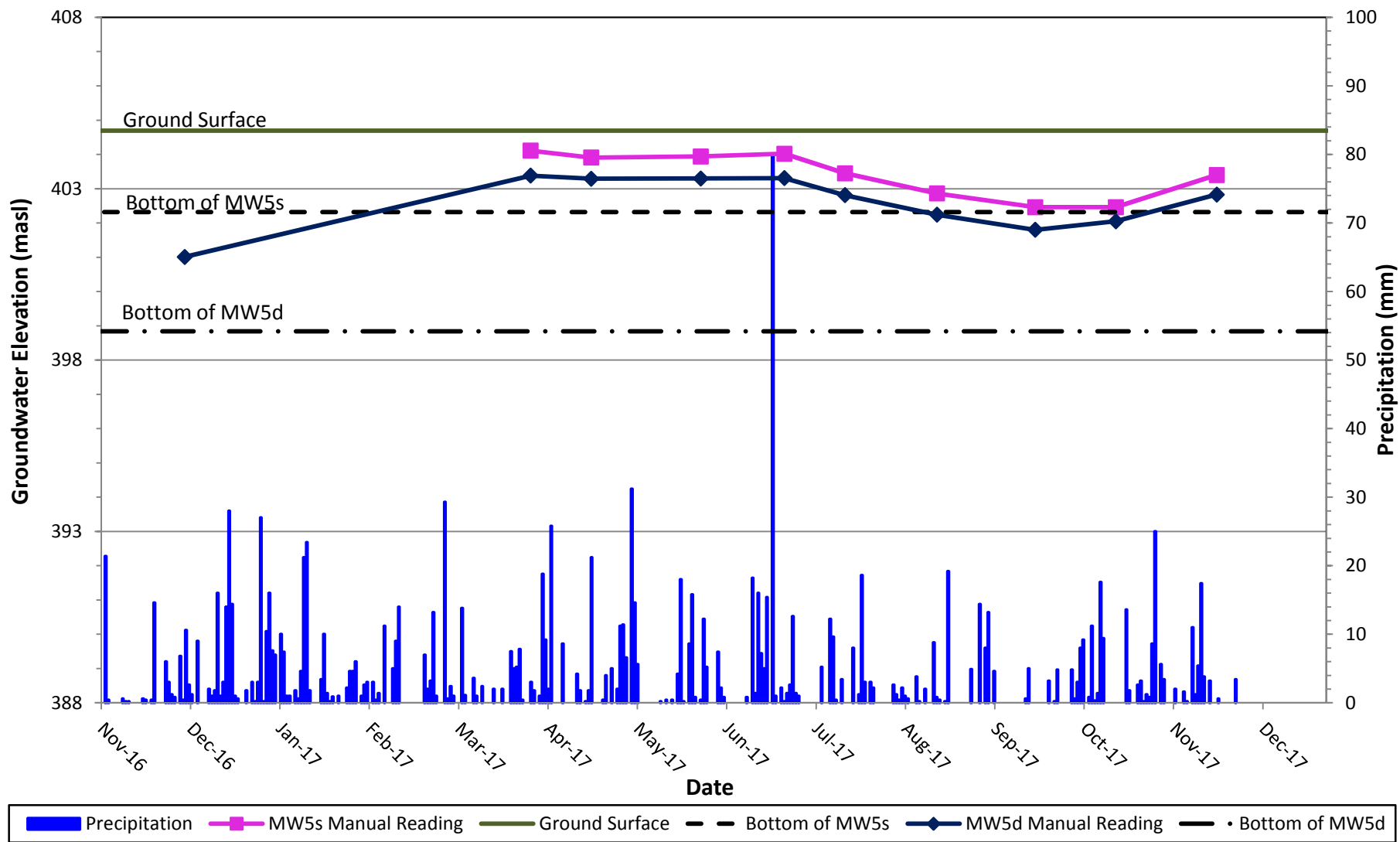
## MW3 (Well Depth: 3.1 m) Groundwater Elevations



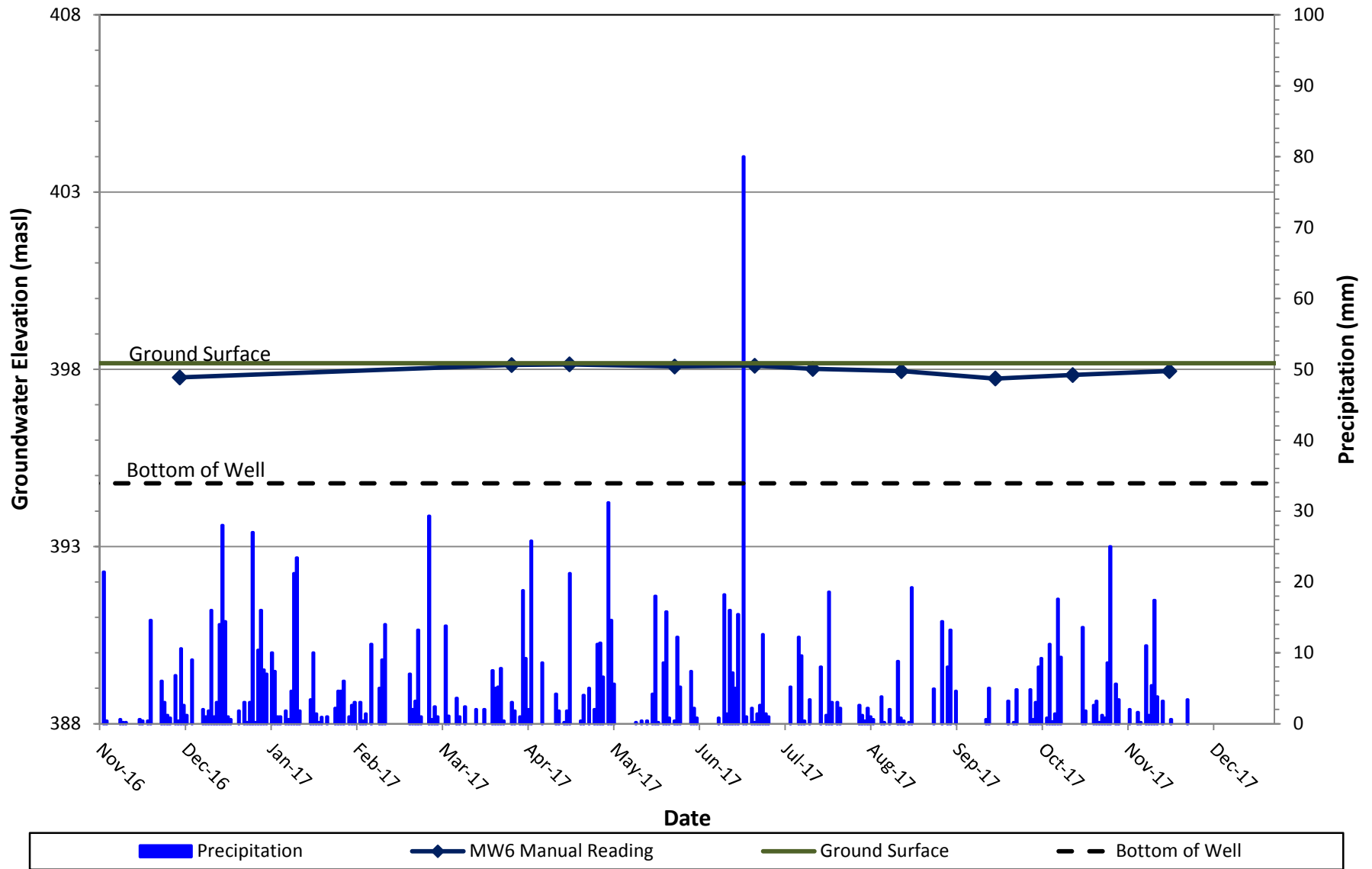
MW4s (Well Depth: 2.1 m)  
 MW4d (Well Depth: 7.5 m)  
 Groundwater Elevations



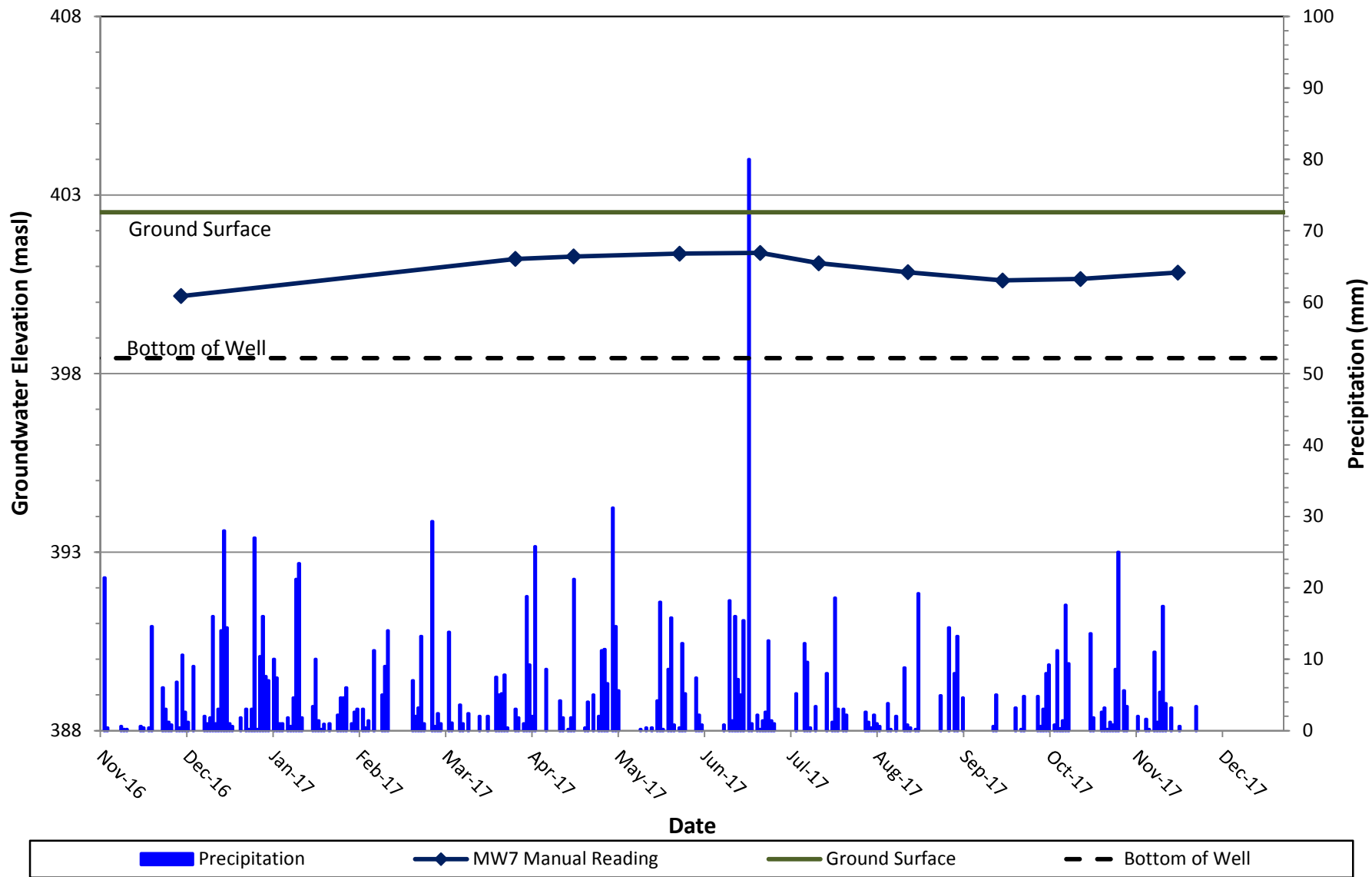
MW5s (Well Depth: 2.4 m)  
 MW5d (Well Depth: 5.9 m)  
 Groundwater Elevations



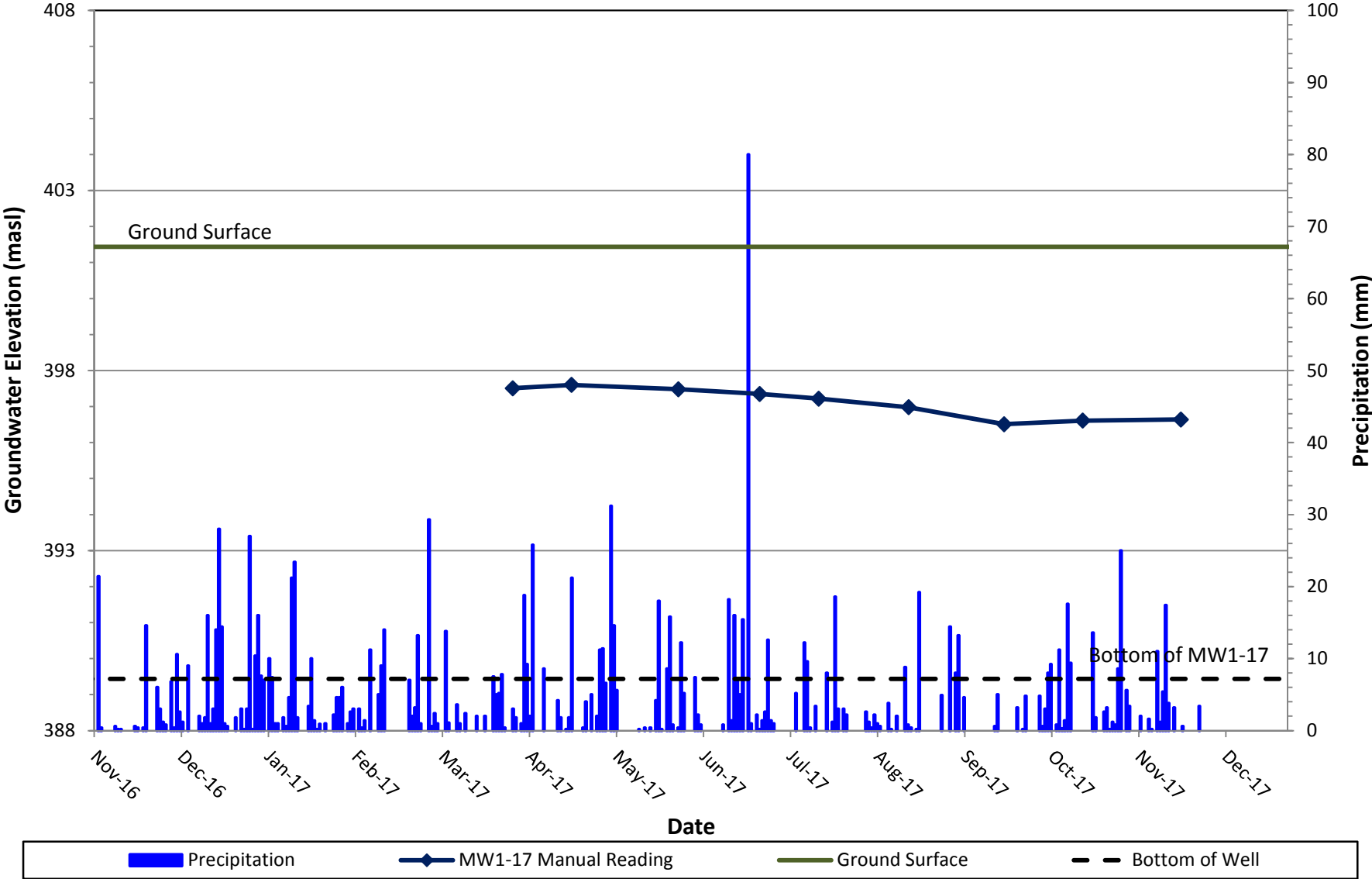
## MW6 (Well Depth: 3.4 m) Groundwater Elevations



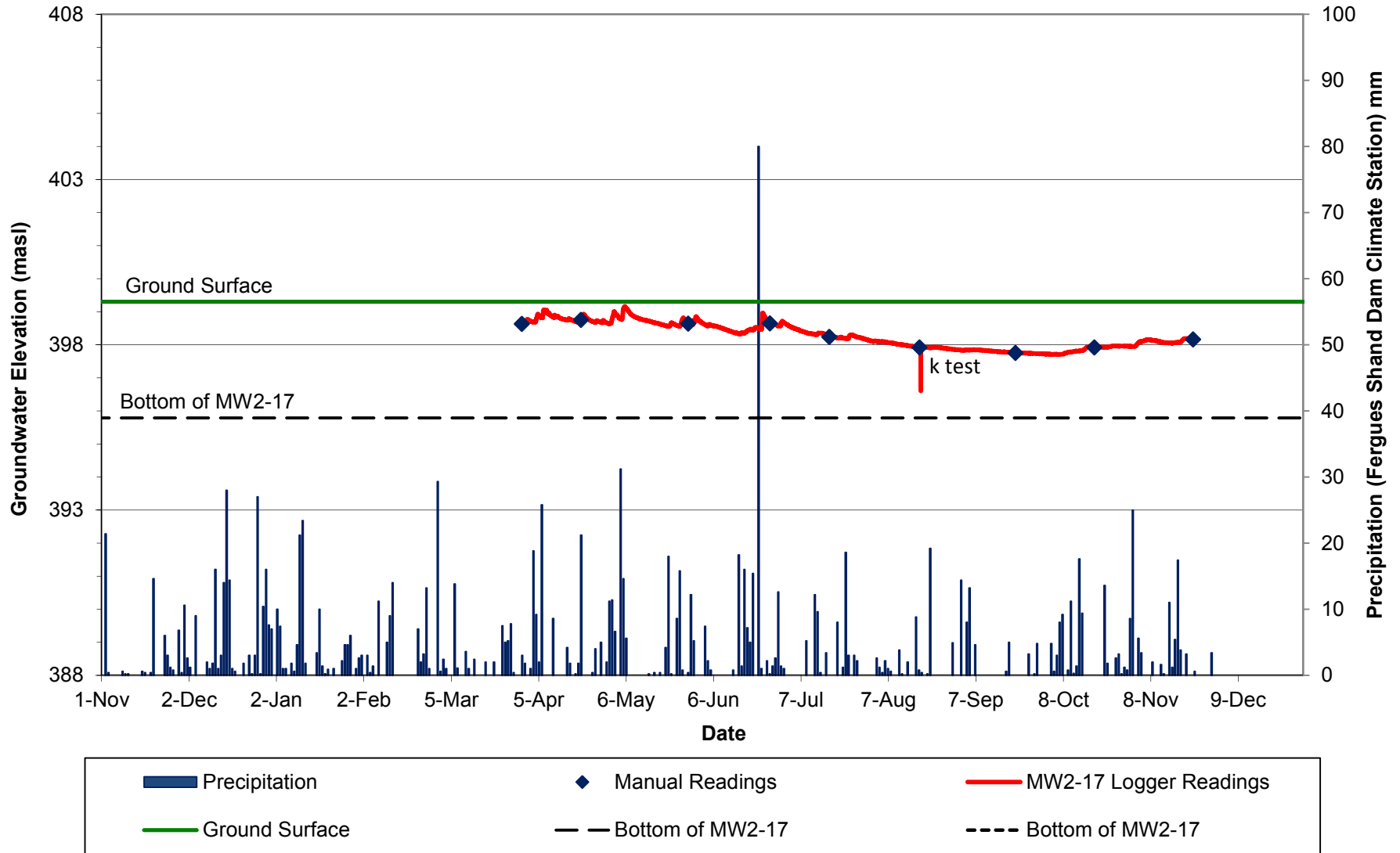
## MW7 (Well Depth: 4.1 m) Groundwater Elevations



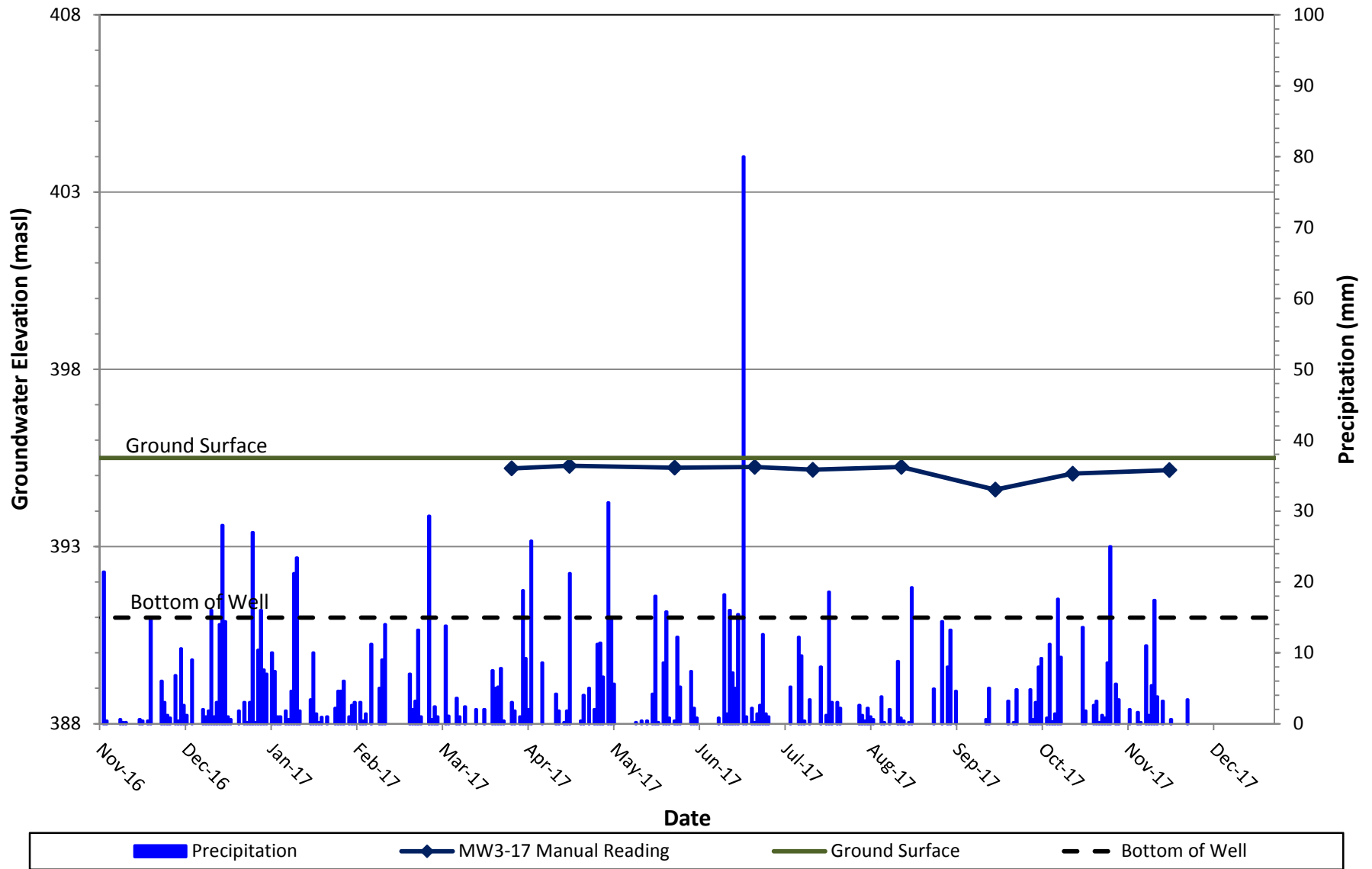
### MW1-17 (Well Depth: 12.0 m, Screened in Silt) Groundwater Elevations



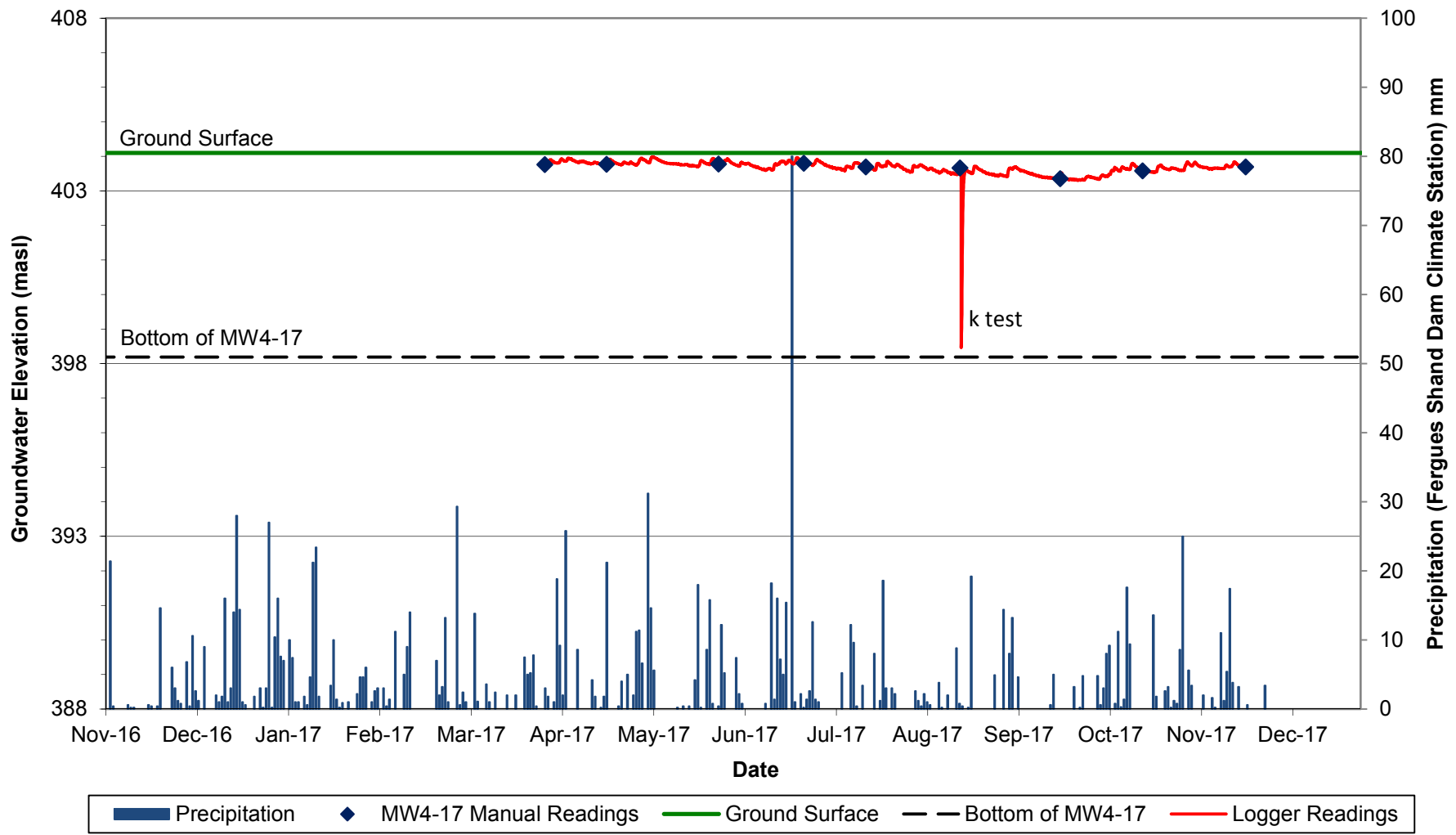
### MW2-17 (Well Depth: 3.5 m, Screened in Silty Clay) Groundwater Elevations



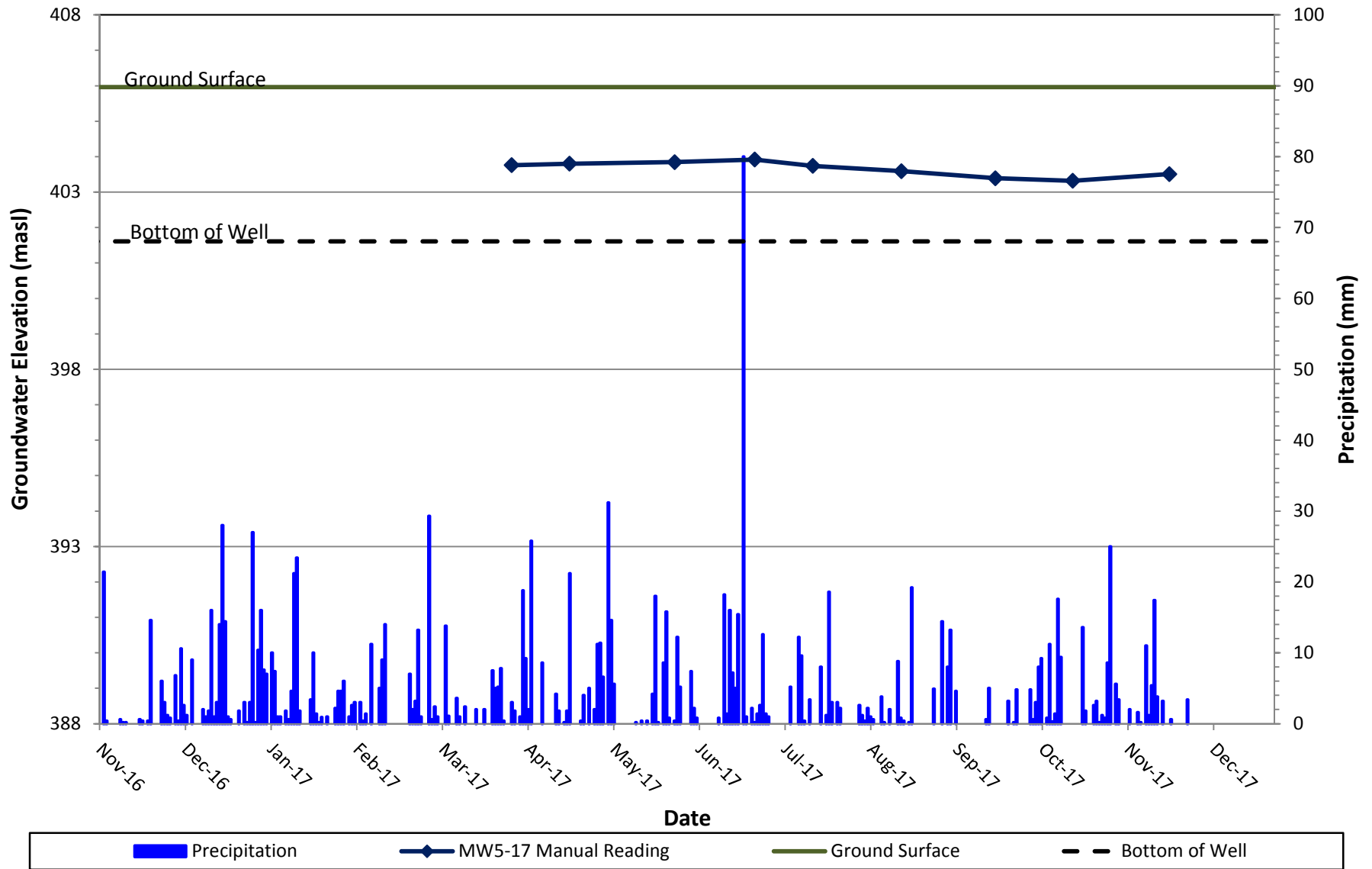
## MW3-17 (Well Depth: 4.5 m, Screened in Sand and Gravel) Groundwater Elevations



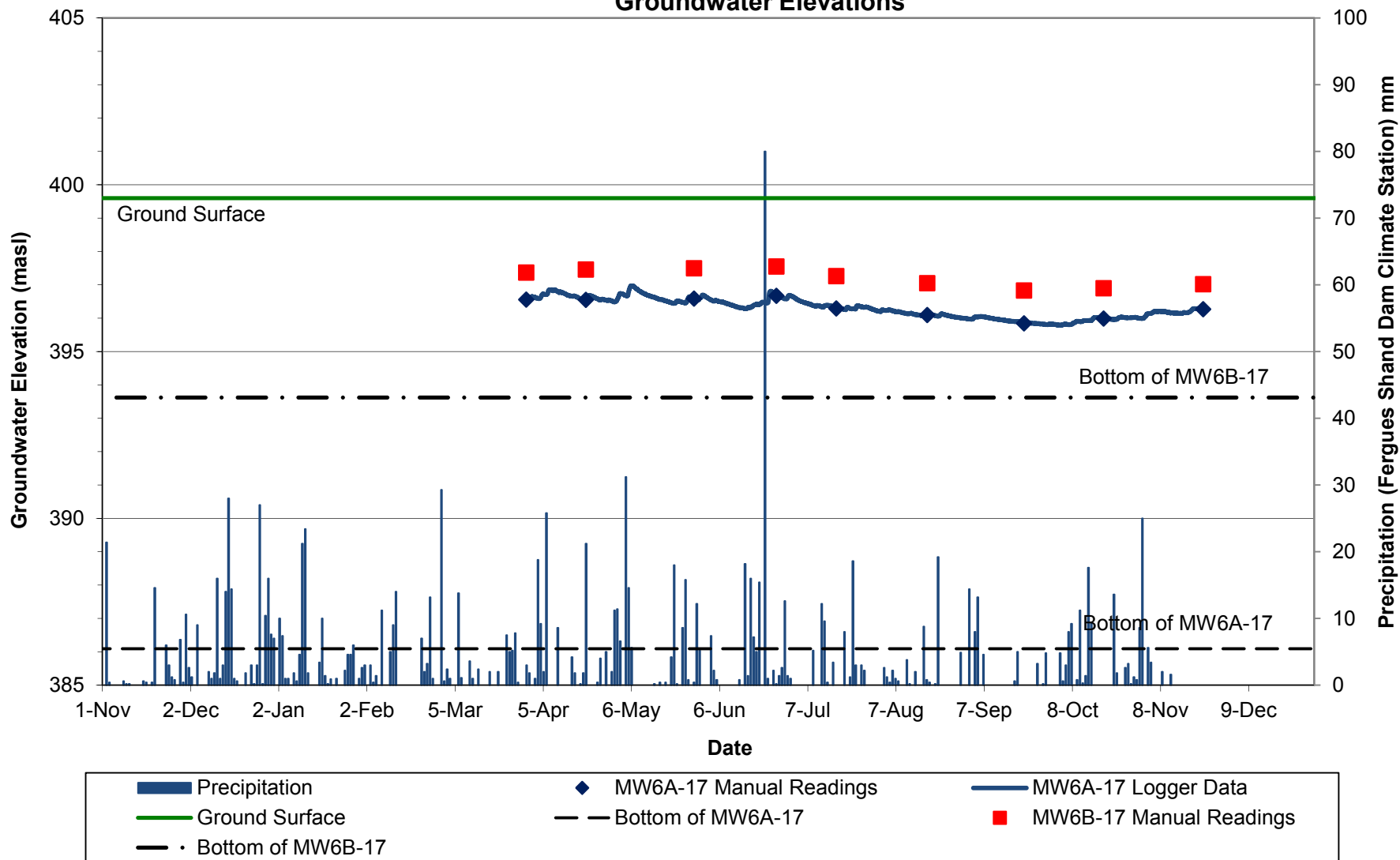
**MW4-17 (Well Depth: 5.9 m, Screened in Clayey Silt)  
Groundwater Elevations**



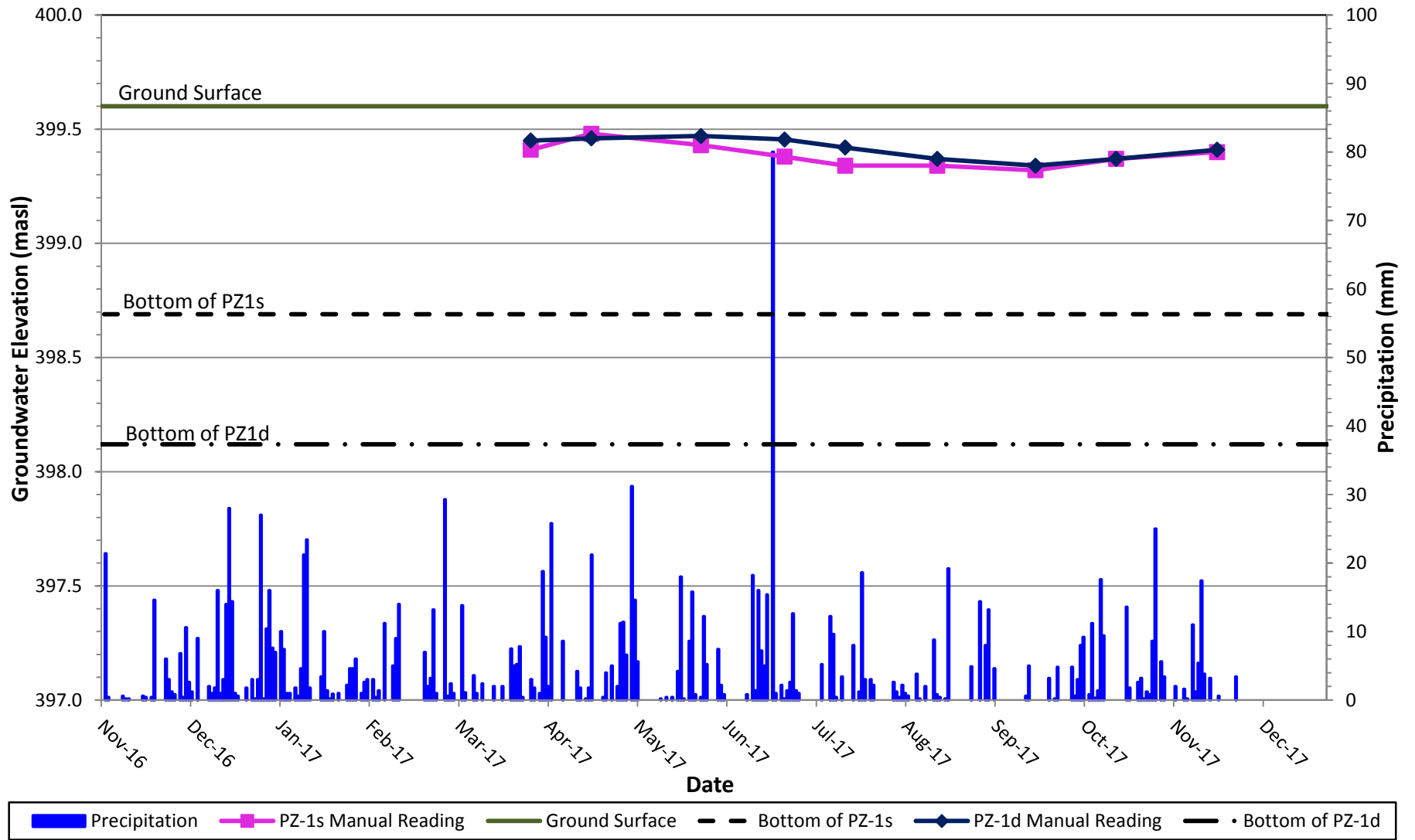
## MW5-17 (Well Depth: 4.4 m, Screened in Sandy Silt) Groundwater Elevations



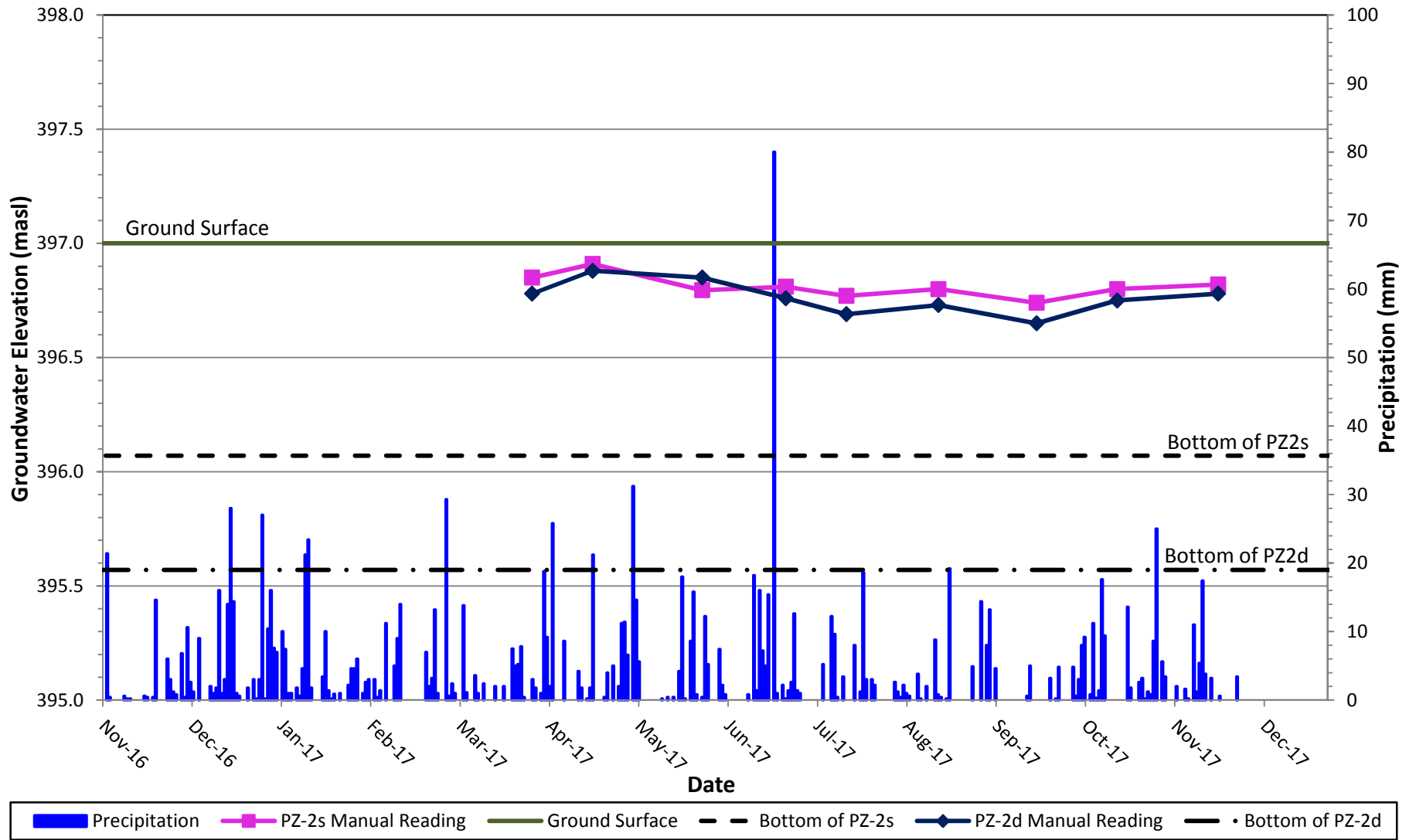
**MW6A-17 (Well Depth: 13.5 m, Screened in Sand and Gravel)  
 MW6B-17 (Well Depth: 6.0 m, Screened in Sand)  
 Groundwater Elevations**



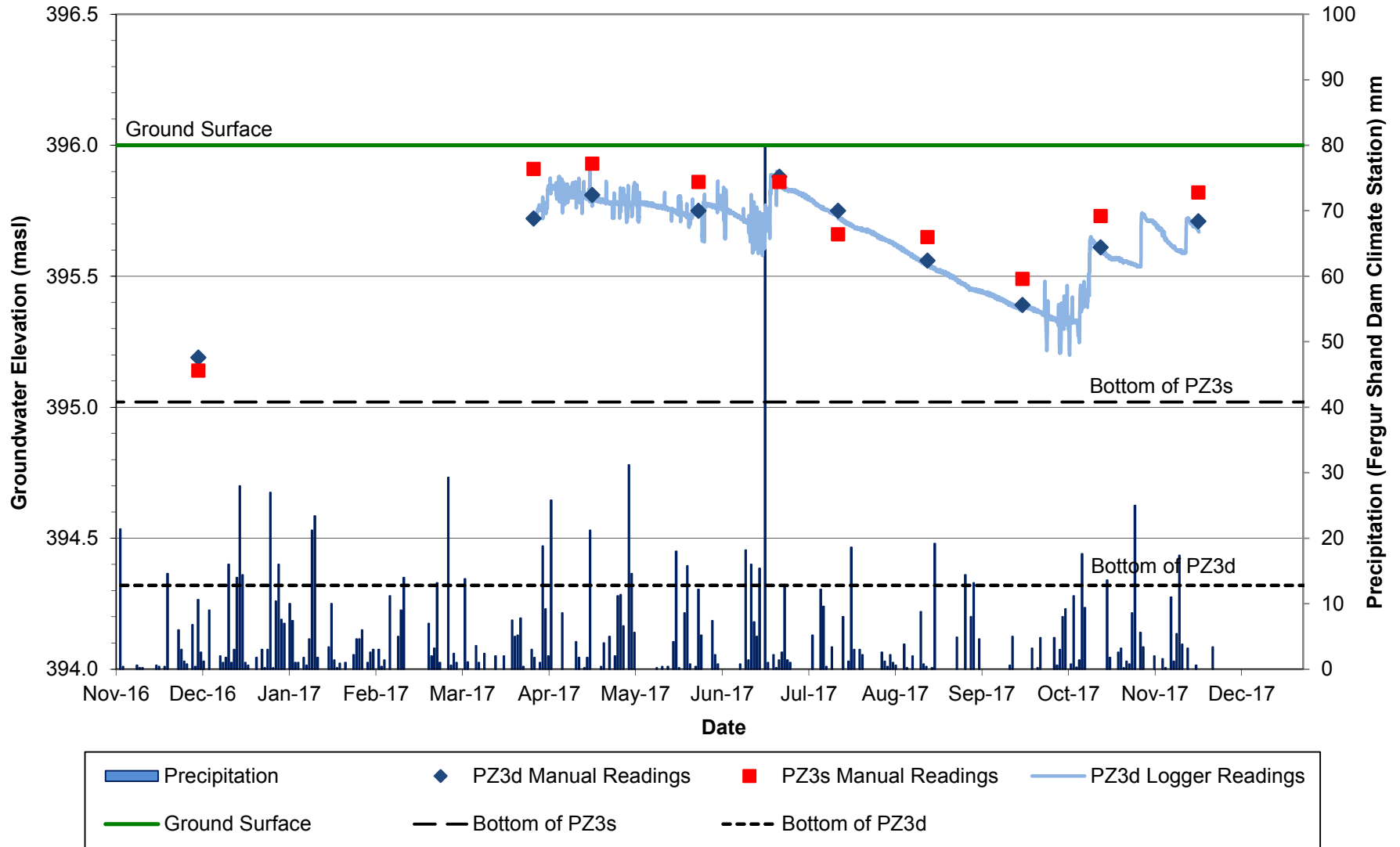
## PZ1s/d Groundwater Elevations



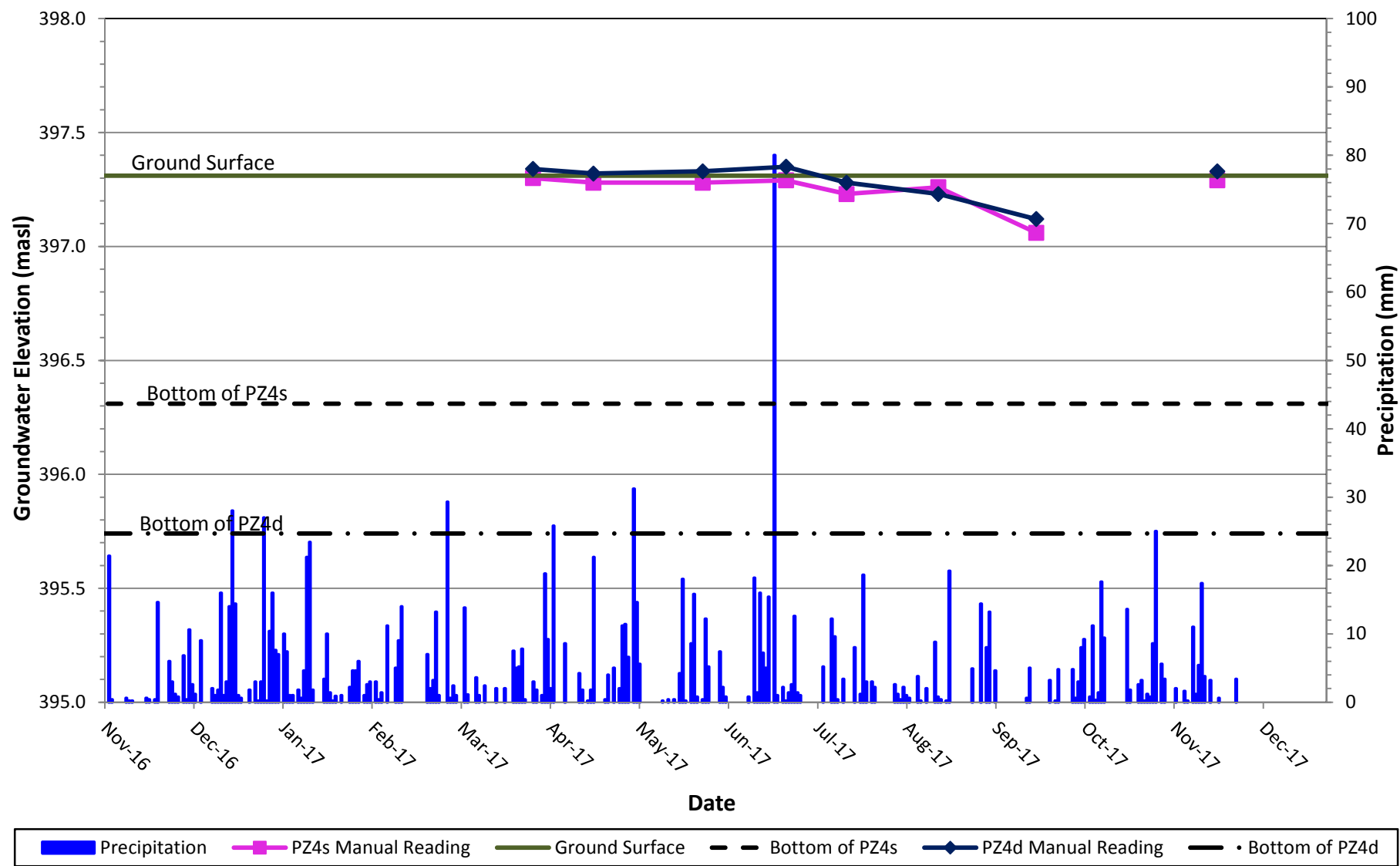
## PZ2s/d Groundwater Elevations



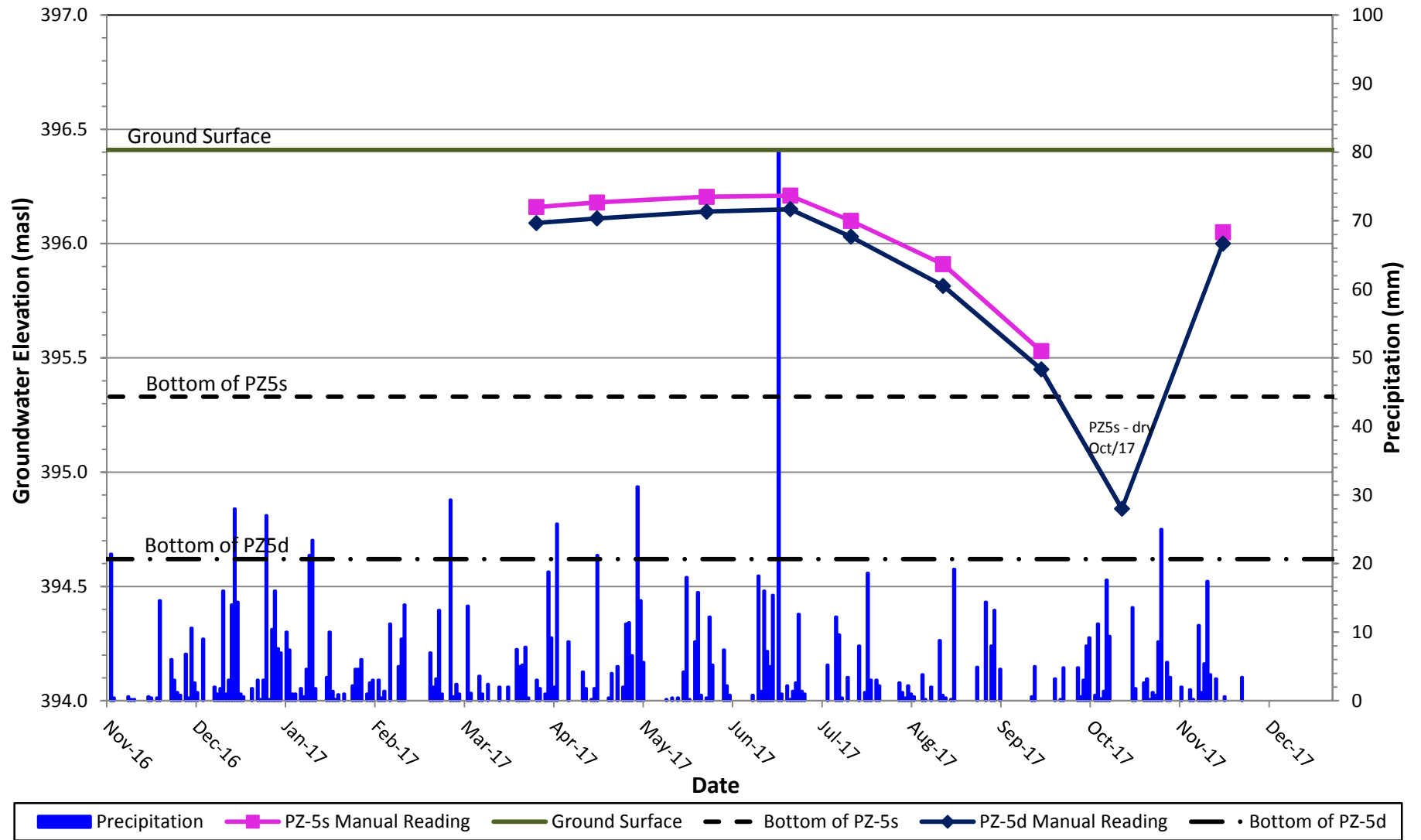
### PZ3s/d Groundwater Elevations



## PZ4s/d Groundwater Elevations



## PZ5s/d Groundwater Elevations





BURNSIDE

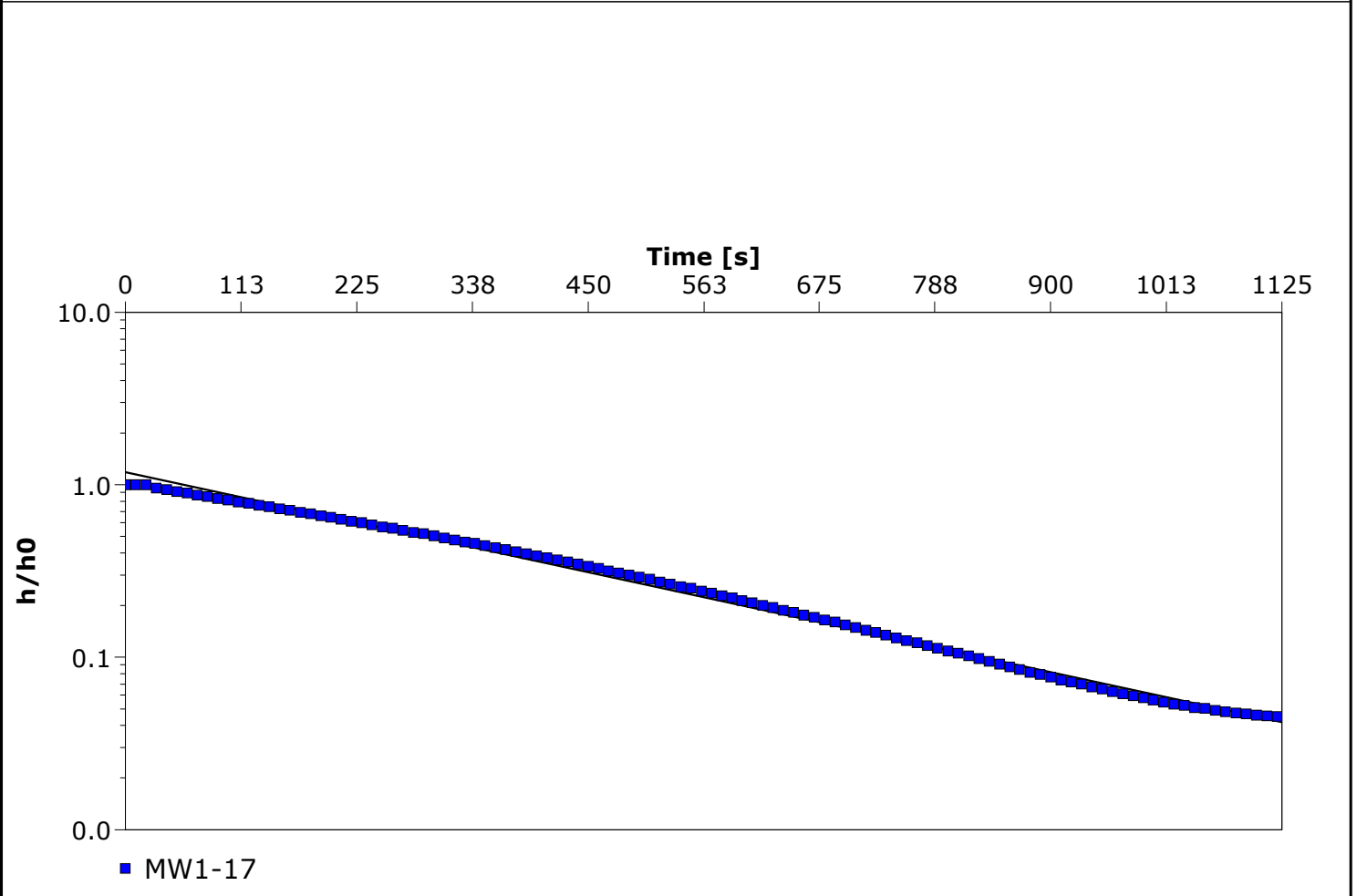
[ THE DIFFERENCE IS OUR PEOPLE ]

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## Appendix E

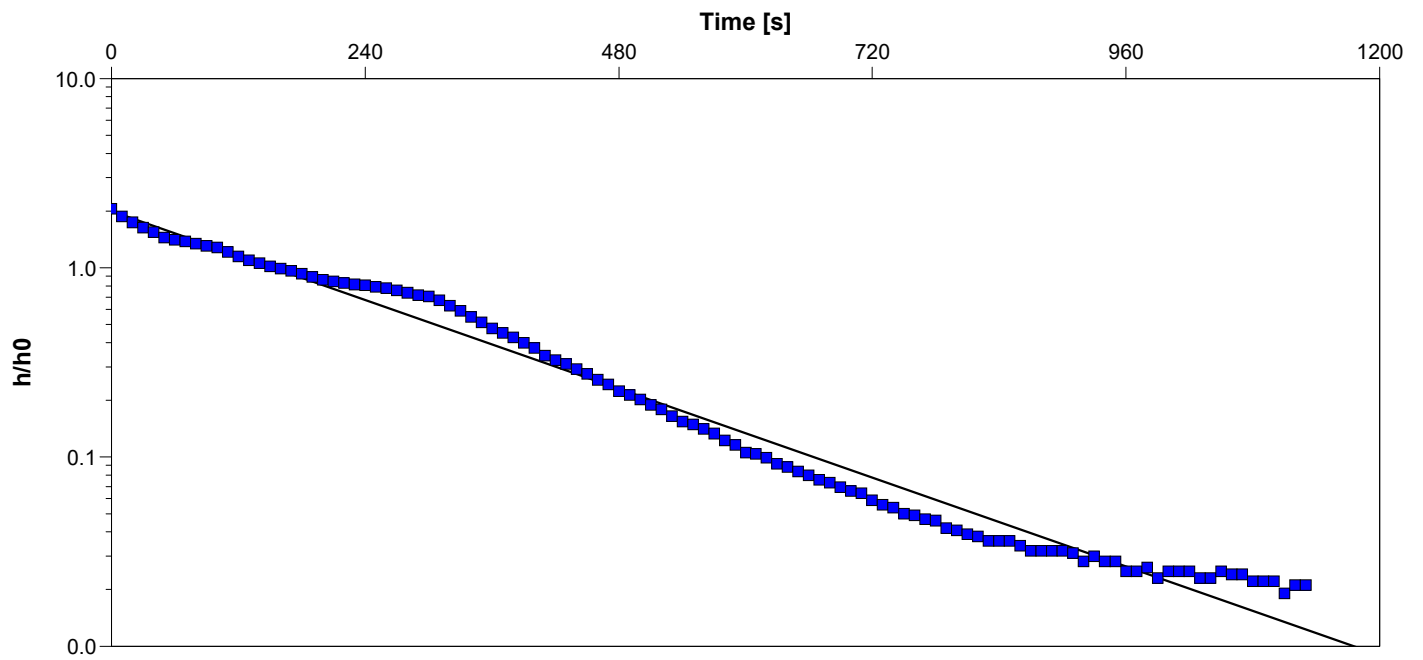
### Hydraulic Conductivity Testing

Location: 8th Line, Erin, ON	Slug Test: Bail Test	Test Well: MW1-17
Test Conducted by: DB		Test Date: 8/18/2017
Analysis Performed by: JD	MW1-17	Analysis Date: 12/5/2017
Aquifer Thickness:		



Calculation using Hvorslev		
Observation Well	Hydraulic Conductivity [cm/s]	
MW1-17	$2.14 \times 10^{-4}$	

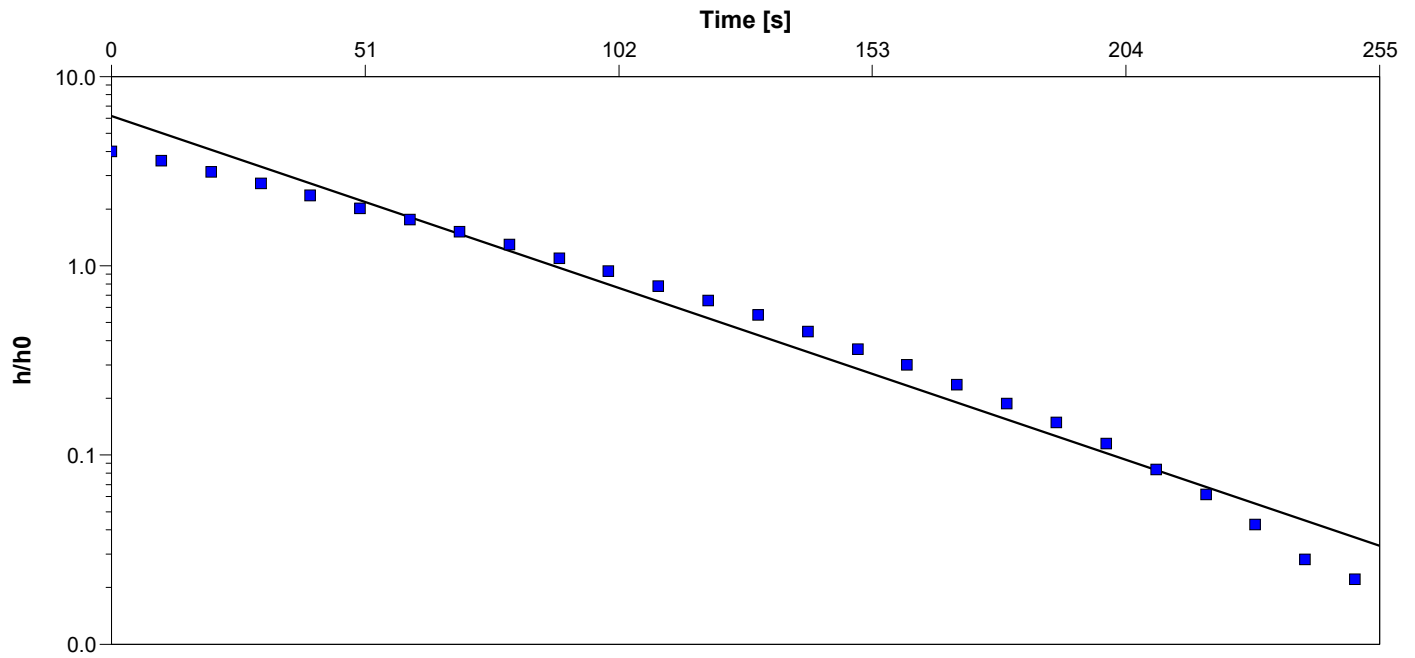
Location: 8th Line, Erin, ON	Slug Test: Bail Test	Test Well: MW2-17
Test Conducted by: DB		Test Date: 8/18/2017
Analysis Performed by: JD	MW2-17	Analysis Date: 12/5/2017
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW2-17	$3.24 \times 10^{-4}$	

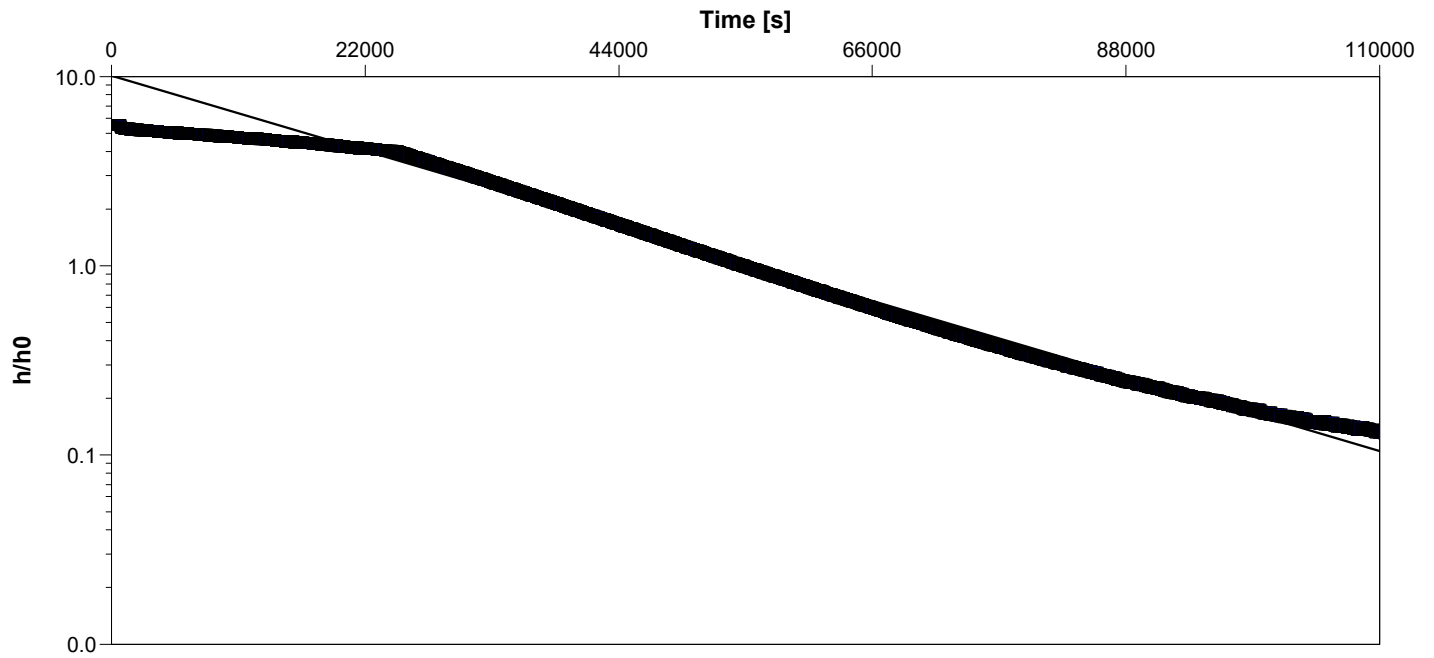
Location: 8th Line, Erin, ON	Slug Test: Bail Test	Test Well: MW3-17
Test Conducted by: DB		Test Date: 8/18/2017
Analysis Performed by: JD	Mw3-17	Analysis Date: 12/5/2017
Aquifer Thickness:		



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW3-17	$1.48 \times 10^{-3}$	

Location: 8th Line, Erin, ON	Slug Test: Bail Test	Test Well: MW4-17
Test Conducted by: DB		Test Date: 8/18/2017
Analysis Performed by: JD	MW4-17	Analysis Date: 12/5/2017
Aquifer Thickness:		

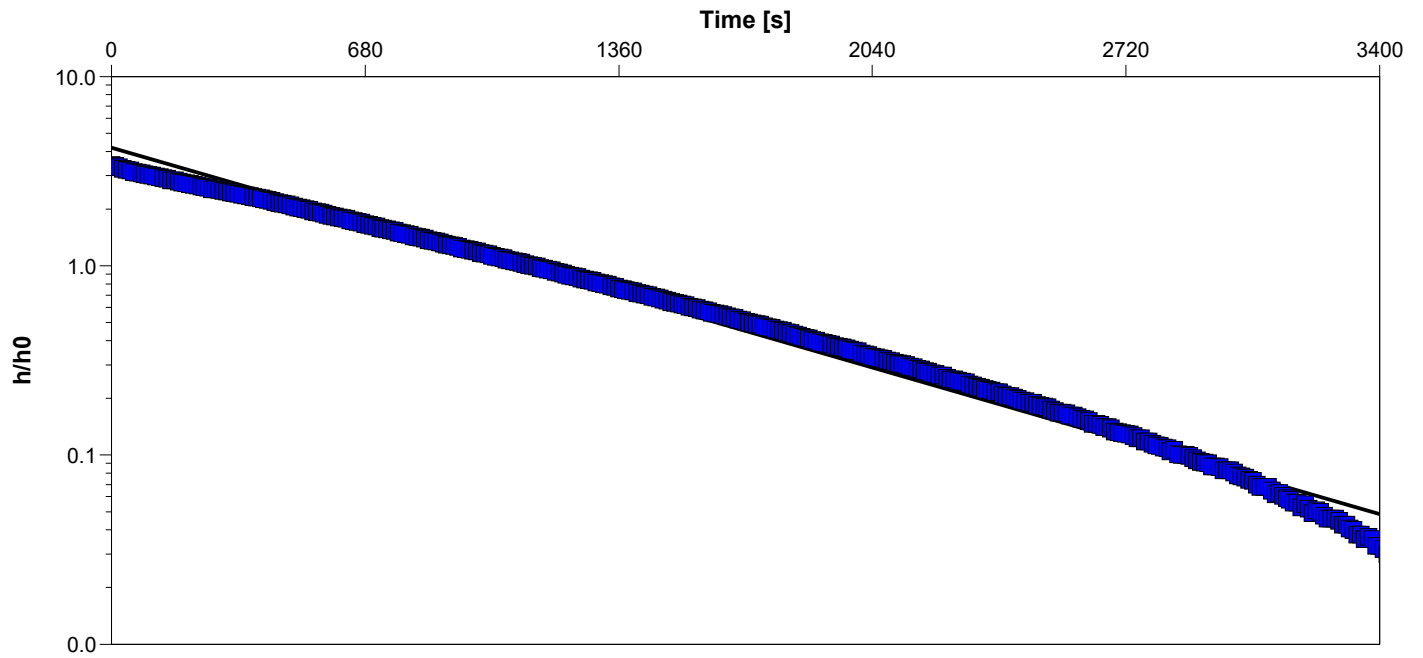


Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW4-17	$2.99 \times 10^{-6}$	

Location: 8th Line, Erin, ON	Slug Test: Bail Test	Test Well: MW6B-17
Test Conducted by: DB		Test Date: 8/18/2017
Analysis Performed by: JD	MW6B-17	Analysis Date: 12/5/2017

Aquifer Thickness:



Calculation using Hvorslev

Observation Well	Hydraulic Conductivity [cm/s]	
MW6B-17	$9.45 \times 10^{-5}$	



BURNSIDE

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**Appendix F**

**Infiltration Testing**

Appendix F

## Infiltration Test - IT-1

### IT-1 Test 1

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	10	0	0	0	0
1	0.02	13	3	3.18	190.50	4572.00
1.5	0.03	17	8	5.29	317.50	7620.00
2	0.03	21	11	5.56	333.38	8001.00
2.5	0.04	25	16	6.35	381.00	9144.00
3	0.05	29	19	6.35	381.00	9144.00
3.5	0.06	32	22	6.35	381.00	9144.00
4	0.07	35	25	6.35	381.00	9144.00
4.5	0.08	38	29	6.35	381.00	9144.00
5	0.08	41	32	6.35	381.00	9144.00
6	0.10	48	38	6.35	381.00	9144.00
7	0.12	52	43	6.12	367.39	8817.43
8	0.13	57	48	5.95	357.19	8572.50
9	0.15	62	52	5.82	349.25	8382.00
10	0.17	67	57	5.72	342.90	8229.60
11	0.18	71	62	5.63	337.70	8104.91
12	0.20	76	67	5.56	333.38	8001.00
13	0.22	81	71	5.50	329.71	7913.08
14	0.23	84	75	5.33	319.77	7674.43
15	0.25	89	79	5.29	317.50	7620.00
16	0.27	92	83	5.16	309.56	7429.50
17	0.28	95	86	5.04	302.56	7261.41

### IT-1 - Test 2

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	6	0	0	0	0
1	0.02	8	1.5875	1.59	95.25	2286.00
1.5	0.03	10	3.175	2.12	127.00	3048.00
2	0.03	13	6.35	3.18	190.50	4572.00
2.5	0.04	16	9.525	3.81	228.60	5486.40
3	0.05	19	12.7	4.23	254.00	6096.00
3.5	0.06	22	15.875	4.54	272.14	6531.43
4	0.07	24	17.4625	4.37	261.94	6286.50
4.5	0.08	27	20.6375	4.59	275.17	6604.00
5	0.08	30	23.8125	4.76	285.75	6858.00
6	0.10	35	28.575	4.76	285.75	6858.00
7	0.12	38	31.75	4.54	272.14	6531.43
8	0.13	44	38.1	4.76	285.75	6858.00
9	0.15	48	41.275	4.59	275.17	6604.00
10	0.17	52	46.0375	4.60	276.23	6629.40
11	0.18	57	50.8	4.62	277.09	6650.18
12	0.20	60	53.975	4.50	269.88	6477.00
13	0.22	64	57.15	4.40	263.77	6330.46
14	0.23	68	61.9125	4.42	265.34	6368.14
15	0.25	73	66.675	4.45	266.70	6400.80
16	0.27	76	69.85	4.37	261.94	6286.50
17	0.28	79	73.025	4.30	257.74	6185.65
18	0.30	83	76.2	4.23	254.00	6096.00
19	0.32	86	79.375	4.18	250.66	6015.79
20	0.33	89	82.55	4.13	247.65	5943.60
21	0.35	92	85.725	4.08	244.93	5878.29
22	0.37	95	88.9	4.04	242.45	5818.91

### IT-1 - Test 3

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	2	0	0	0	0
1	0.02	5	3	3.18	190.50	4572.00
1.5	0.03	8	6	4.23	254.00	6096.00
2	0.03	10	8	3.97	238.13	5715.00
2.5	0.04	13	11	4.45	266.70	6400.80
3	0.05	16	14	4.76	285.75	6858.00
3.5	0.06	17	16	4.54	272.14	6531.43
4	0.07	21	19	4.76	285.75	6858.00
4.5	0.08	22	21	4.59	275.17	6604.00
5	0.08	25	24	4.76	285.75	6858.00
6	0.10	30	29	4.76	285.75	6858.00
7	0.12	35	33	4.76	285.75	6858.00
8	0.13	38	37	4.56	273.84	6572.25
9	0.15	44	43	4.76	285.75	6858.00
10	0.17	48	46	4.60	276.23	6629.40
11	0.18	51	49	4.47	268.43	6442.36
12	0.20	56	54	4.50	269.88	6477.00
13	0.22	59	57	4.40	263.77	6330.46
14	0.23	64	62	4.42	265.34	6368.14
15	0.25	67	65	4.34	260.35	6248.40
16	0.27	70	68	4.27	255.98	6143.63
17	0.28	73	71	4.20	252.13	6051.18
18	0.30	76	75	4.15	248.71	5969.00
19	0.32	79	78	4.09	245.64	5895.47
20	0.33	83	81	4.05	242.89	5829.30
21	0.35	89	87	4.16	249.46	5987.14
22	0.37	92	90	4.11	246.78	5922.82
23	0.38	94	92	4.00	240.20	5764.70
24	0.40	95	94	3.90	234.16	5619.75
25	0.42	95	94	3.75	224.79	5394.96

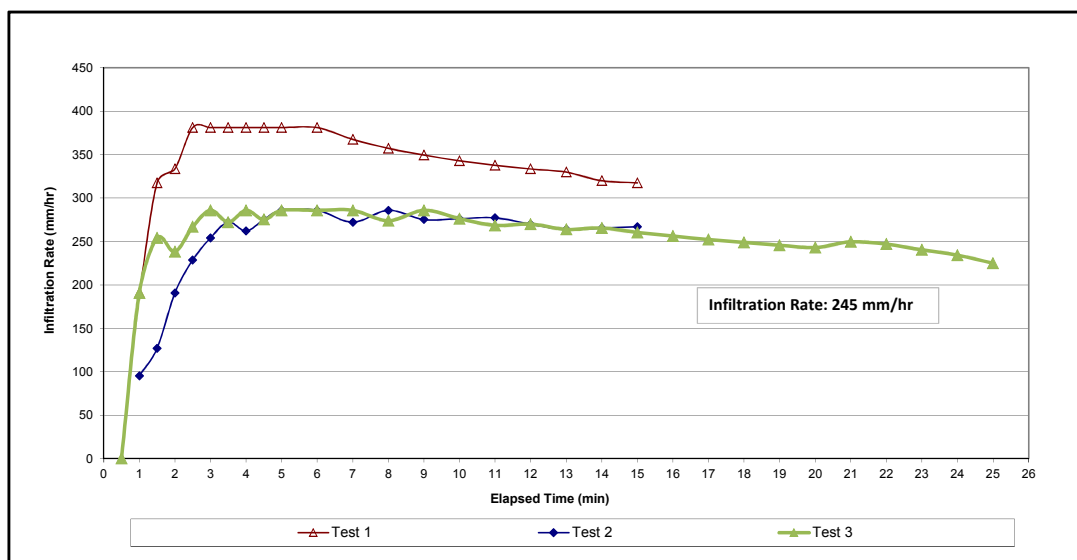
Infiltration Rate\*

4.1

245.6

5894.7

\*based on average of points where curve has stabilized



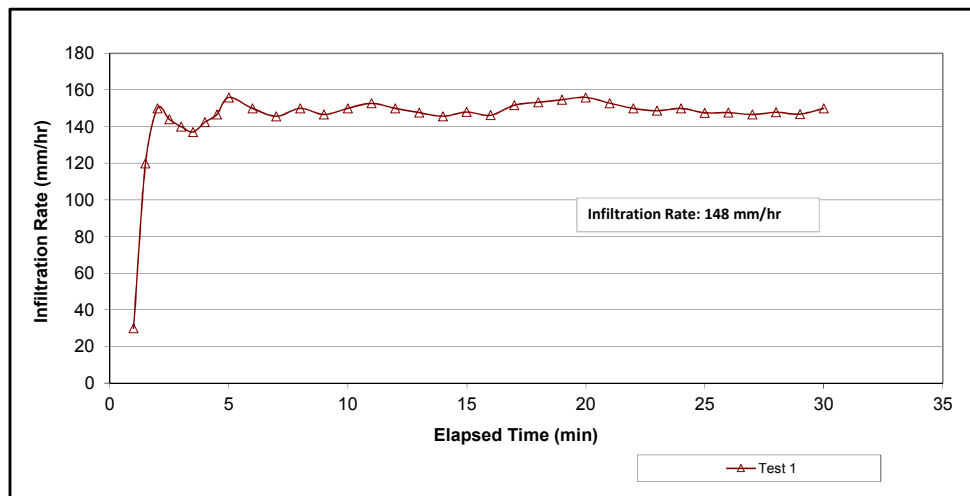
## Infiltration Test - IT-2

### IT-2 Test 1

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	3	0	0	0	0
1	0.02	3.5	0.5	0.50	30.00	720.00
1.5	0.03	6	3	2.00	120.00	2880.00
2	0.03	8	5	2.50	150.00	3600.00
2.5	0.04	9	6	2.40	144.00	3456.00
3	0.05	10	7	2.33	140.00	3360.00
3.5	0.06	11	8	2.29	137.14	3291.43
4	0.07	12.5	9.5	2.38	142.50	3420.00
4.5	0.08	14	11	2.44	146.67	3520.00
5	0.08	16	13	2.60	156.00	3744.00
6	0.10	18	15	2.50	150.00	3600.00
7	0.12	20	17	2.43	145.71	3497.14
8	0.13	23	20	2.50	150.00	3600.00
9	0.15	25	22	2.44	146.67	3520.00
10	0.17	28	25	2.50	150.00	3600.00
11	0.18	31	28	2.55	152.73	3665.45
12	0.20	33	30	2.50	150.00	3600.00
13	0.22	35	32	2.46	147.69	3544.62
14	0.23	37	34	2.43	145.71	3497.14
15	0.25	40	37	2.47	148.00	3552.00
16	0.27	42	39	2.44	146.25	3510.00
17	0.28	46	43	2.53	151.76	3642.35
18	0.30	49	46	2.56	153.33	3680.00
19	0.32	52	49	2.58	154.74	3713.68
20	0.33	55	52	2.60	156.00	3744.00
21	0.35	56.5	53.5	2.55	152.86	3668.57
22	0.37	58	55	2.50	150.00	3600.00
23	0.38	60	57	2.48	148.70	3568.70
24	0.40	63	60	2.50	150.00	3600.00
25	0.42	64.5	61.5	2.46	147.60	3542.40
26	0.43	67	64	2.46	147.69	3544.62
27	0.45	69	66	2.44	146.67	3520.00
28	0.47	72	69	2.46	147.86	3548.57
29	0.48	74	71	2.45	146.90	3525.52
30	0.50	78	75	2.50	150.00	3600.00
			<b>Average</b>	<b>2.40</b>	<b>144</b>	<b>3461</b>

Infiltration Rate\*      2.47                      148.38                      3561.09

\*based on average of points where curve has stabilized



### Infiltration Test - IT-3

#### IT-3 Test 1

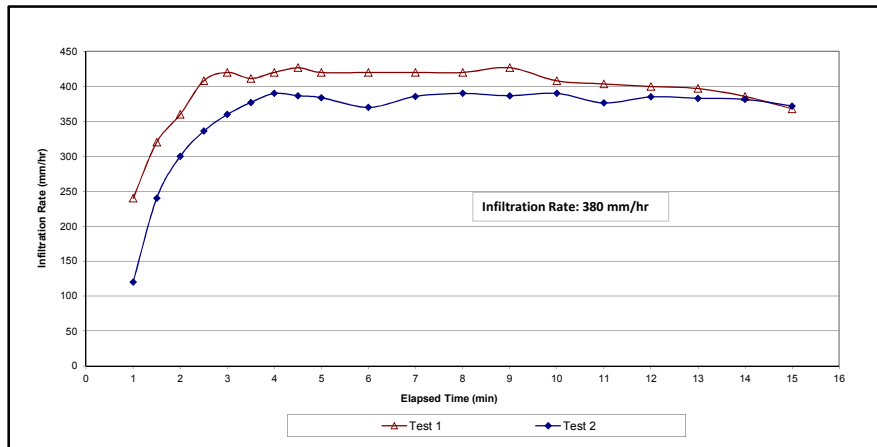
Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	2	0	0	0	0
1	0.02	6	4	4.00	240.00	5760.00
1.5	0.03	10	8	5.33	320.00	7680.00
2	0.03	14	12	6.00	360.00	8640.00
2.5	0.04	19	17	6.80	408.00	9792.00
3	0.05	23	21	7.00	420.00	10080.00
3.5	0.06	26	24	6.86	411.43	9874.29
4	0.07	30	28	7.00	420.00	10080.00
4.5	0.08	34	32	7.11	426.67	10240.00
5	0.08	37	35	7.00	420.00	10080.00
6	0.10	44	42	7.00	420.00	10080.00
7	0.12	51	49	7.00	420.00	10080.00
8	0.13	58	56	7.00	420.00	10080.00
9	0.15	66	64	7.11	426.67	10240.00
10	0.17	70	68	6.80	408.00	9792.00
11	0.18	76	74	6.73	403.64	9687.27
12	0.20	82	80	6.67	400.00	9600.00
13	0.22	88	86	6.62	396.92	9526.15
14	0.23	92	90	6.43	385.71	9257.14
15	0.25	94	92	6.13	368.00	8832.00
			<b>Average</b>	<b>7</b>	<b>393</b>	<b>9442</b>

#### IT-3 - Test 2

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	0	0	0	0	0
1	0.02	2	2	2.00	120.00	2880.00
1.5	0.03	6	6	4.00	240.00	5760.00
2	0.03	10	10	5.00	300.00	7200.00
2.5	0.04	14	14	5.60	336.00	8064.00
3	0.05	18	18	6.00	360.00	8640.00
3.5	0.06	22	22	6.29	377.14	9051.43
4	0.07	26	26	6.50	390.00	9360.00
4.5	0.08	29	29	6.44	386.67	9280.00
5	0.08	32	32	6.40	384.00	9216.00
6	0.10	37	37	6.17	370.00	8880.00
7	0.12	45	45	6.43	385.71	9257.14
8	0.13	52	52	6.50	390.00	9360.00
9	0.15	58	58	6.44	386.67	9280.00
10	0.17	65	65	6.50	390.00	9360.00
11	0.18	69	69	6.27	376.36	9032.73
12	0.20	77	77	6.42	385.00	9240.00
13	0.22	83	83	6.38	383.08	9193.85
14	0.23	89	89	6.36	381.43	9154.29
15	0.25	93	93	6.20	372.00	8928.00
			<b>Average</b>	<b>6</b>	<b>353</b>	<b>8481</b>

Infiltration Rate\*                      6.389                      380                      9201

\*based on average of points where curve has stabilized



## Infiltration Test - IT-4

### IT-4 - Test 1

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	10	0	0	0	0
1	0.02	26	16	16.00	960.00	23040.00
1.5	0.03	40	30	20.00	1200.00	28800.00
2	0.03	54	44	22.00	1320.00	31680.00
2.5	0.04	66	56	22.40	1344.00	32256.00
3	0.05	77	67	22.33	1340.00	32160.00
3.5	0.06	88	78	22.29	1337.14	32091.43
4	0.07	90	80	20.00	1200.00	28800.00

### IT-4 - Test 2

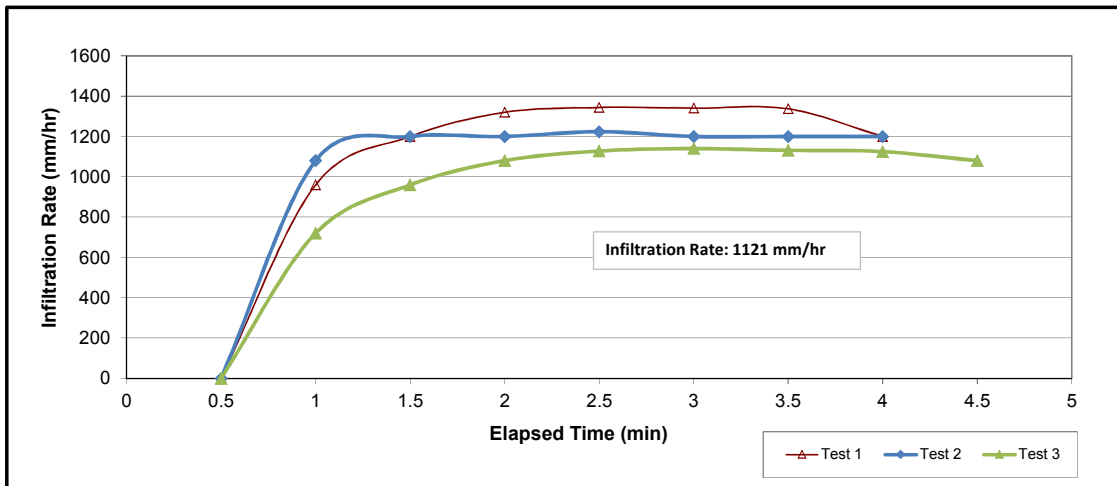
Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	15	0	0	0	0
1	0.02	28	18	18.00	1080.00	25920.00
1.5	0.03	40	30	20.00	1200.00	28800.00
2	0.03	50	40	20.00	1200.00	28800.00
2.5	0.04	61	51	20.40	1224.00	29376.00
3	0.05	70	60	20.00	1200.00	28800.00
3.5	0.06	80	70	20.00	1200.00	28800.00
4	0.07	90	80	20.00	1200.00	28800.00

### IT-4 - Test 3

Elapsed Time min	Elapsed Time hour	Readings mm	Infiltration mm	Infiltration Rate mm/min	Infiltration Rate mm/hr	Infiltration Rate mm/day
0.5	0.01	10	0	0	0	0
1	0.02	22	12	12.00	720.00	17280.00
1.5	0.03	34	24	16.00	960.00	23040.00
2	0.03	46	36	18.00	1080.00	25920.00
2.5	0.04	57	47	18.80	1128.00	27072.00
3	0.05	67	57	19.00	1140.00	27360.00
3.5	0.06	76	66	18.86	1131.43	27154.29
4	0.07	85	75	18.75	1125.00	27000.00
4.5	0.08	91	81	18.00	1080.00	25920.00

Infiltration Rate\*                      18.68                      1121                      26901

\*based on average of points where curve has stabilized





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## Appendix G

### Groundwater Quality

**Table G-1  
Groundwater Quality Results**

Monitoring Well				MW2-17	MW6B-17
Date Sampled				18-Aug-17	18-Aug-17
Parameter	Unit	RDL	ODWQS		
Electrical Conductivity	umho/cm	1		440	470
pH	pH Units	NA	(6.5-8.5)	7.94	8.01
Saturation pH				7.47	7.52
Langelier Index				0.471	0.494
Total Hardness (as CaCO3)	mg/L	1	(80-100)	<b>220</b>	<b>220</b>
Total Dissolved Solids	mg/L	1	500	250	270
Alkalinity (as CaCO3)	mg/L	1	(30-500)	230	240
Bicarbonate (as CaCO3)	mg/L	1		230	230
Carbonate (as CaCO3)	mg/L	1		1.9	2.2
Chloride	mg/L		250	3.6	6.1
Nitrate as N	mg/L	0.1	10.0	0.21	0.95
Nitrite as N	mg/L	0.01	1.0	0.21	0.95
Sulphate	mg/L	1	500	9.8	15
Ortho Phosphate as P	mg/L	0.010		<0.01	<0.01
Ammonia as N	mg/L	0.05		<0.05	0.18
Calcium	mg/L			66	59
Magnesium	mg/L			13.00	19.00
Sodium	mg/L		20 (200)	4.70	8.40
Potassium	mg/L			1.00	3.00
Aluminum	mg/L	0.005	0.1	0.0061	0.0055
Antimony	mg/L	0.0005	0.006	<0.0005	<0.0005
Arsenic	mg/L	0.001	0.025	<0.001	<0.001
Barium	mg/L	0.002	1	0.0200	0.0220
Beryllium	mg/L	0.0005		<0.0005	<0.0005
Boron	mg/L	0.01	5	0.0140	0.0240
Cadmium	mg/L	0.0001	0.005	<0.0001	<0.0001
Chromium	mg/L	0.005	0.05	<0.005	<0.005
Cobalt	mg/L	0.0005		<0.0005	<0.0005
Copper	mg/L	0.001	1	<0.001	<0.001
Iron	mg/L	0.1	0.3	<0.1	<0.1
Lead	mg/L	0.0005	0.01	<0.0005	<0.0005
Manganese	mg/L	0.002	0.05	0.0650	0.0600
Molybdenum	mg/L	0.0005		0.0016	0.0032
Nickel	mg/L	0.001		<0.001	<0.001
Selenium	mg/L	0.002	0.01	<0.002	<0.002
Silver	mg/L	0.0001		<0.0001	<0.0001
Strontium	mg/L	0.001		0.1300	0.1600
Thallium	mg/L	0.00005		<0.00005	<0.00005
Titanium	mg/L	0.005		<0.005	<0.005
Uranium	mg/L	0.0001	0.02	0.00061	0.00041
Vanadium	mg/L	0.0005		<0.0005	<0.0005
Zinc	mg/L	0.005	5	<0.005	<0.005

ODWQS - Ontario Drinking Water Quality Standards

RDL - Reported detection limits

Bold indicates an exceedence of the ODWQS

**Table G-2  
Surface Water Quality**

Sample Location				SS1
Date Sampled				18-Aug-17
Parameter	Unit	RDL	PWQS	
Electrical Conductivity	umho/cm	1		520
pH	pH Units	NA	(6.5-8.5)	8.29
Saturation pH				7.12
Langelier Index				1.18
Total Hardness (as CaCO3)	mg/L	1		270
Total Dissolved Solids	mg/L	1		310
Alkalinity (as CaCO3)	mg/L	1		240
Bicarbonate (as CaCO3)	mg/L	1		230
Carbonate (as CaCO3)	mg/L	1		4.3
Chloride	mg/L	0		16
Nitrate as N	mg/L	0.1		0.52
Nitrite as N	mg/L	0.01		<0.01
Sulphate	mg/L	1		26
Ortho Phosphate as P	mg/L	0.010		<0.01
Ammonia as N	mg/L	0.05		<0.05
Total Phosphorus	mg/L	0.004	0.03	0.014
Total Organic Carbon	mg/L	0.2		3.7
Turbidity	NTU	0.1		0.2
Calcium	mg/L	0.005		85
Magnesium	mg/L	0.05		15
Sodium	mg/L	0.5		9
Potassium	mg/L	1		1
Aluminum	mg/L	0.005	0.075	0.033
Antimony	mg/L	0.0005		<0.0005
Arsenic	mg/L	0.001	1	<0.001
Barium	mg/L	0.002		0.041
Beryllium	mg/L	0.0005		<0.005
Boron	mg/L	0.01	2	0.013
Cadmium	mg/L	0.0001	0.0002	<0.0001
Chromium	mg/L	0.005	0.009	<0.005
Cobalt	mg/L	0.0005		<0.0005
Copper	mg/L	0.001	0.005	<0.001
Iron	mg/L	0.1	0.3	0.27
Lead	mg/L	0.0005	0.001	<0.0005
Manganese	mg/L	0.002		0.029
Molybdenum	mg/L	0.0005	0.04	0.00053
Nickel	mg/L	0.001	0.025	<0.001
Selenium	mg/L	0.002	0.01	<0.002
Silver	mg/L	0.0001		<0.0001
Strontium	mg/L	0.001		0.15
Thallium	mg/L	0.00005	0.0003	<0.00005
Titanium	mg/L	0.005		<0.005
Uranium	mg/L	0.0001	0.005	0.0013
Vanadium	mg/L	0.0005		<0.0005
Zinc	mg/L	0.005	0.03	<0.005

PWQS - Provincial Water Quality Standards

RDL - Reported Detection Limit



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## Appendix H

### Septic Suitability Calculations

**Erin 8th Line, Homes in the Hills Development  
MOE Mass Balance Equation  
Nitrate Loading Calculations**

$$Q_t C_t = Q_e C_e + Q_i C_i$$

Where:

<b>Q<sub>e</sub></b>	11315 m <sup>3</sup> /year	Sewage Effluent Volume
<b>Q<sub>i</sub></b>	64094 m <sup>3</sup> /year	Infiltration Volume = (recharge * study area)
<b>Q<sub>t</sub></b>	75408.75 m <sup>3</sup> /year	Total Volume
<b>C<sub>e</sub></b>	40000 mg/m <sup>3</sup>	Concentration of sewage effluent
<b>C<sub>i</sub></b>	100 mg/m <sup>3</sup>	Concentration of precipitation
<b>C<sub>t</sub> =</b>	(Q <sub>e</sub> C <sub>e</sub> +Q <sub>i</sub> C <sub>i</sub> )/Q <sub>t</sub>	
<b>Q<sub>e</sub>C<sub>e</sub></b>	452600000 mg/year	
<b>Q<sub>i</sub>C<sub>i</sub></b>	6409375 mg/year	
<b>C<sub>t</sub> =</b>	6087 mg/m <sup>3</sup>	Concentration of nitrate after dilution
	<b>6.09 mg/L</b>	

**Input Parameters**

Daily Flow Rate per Lot (L/day)	1000
Number of Lots	31
Dilution Area (m <sup>2</sup> )	256375
Recharge (mm/year)	250
Concentration of sewage effluent (mg/L)	40
Concentration of precipitation (mg/L)	0.1



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## Appendix I

### Water Balance Calculations

**WATER BALANCE CALCULATIONS**

Homes in the Hills  
Erin, Ontario

Project No.300039324



**TABLE I-1**

**Monthly Water Balance Components**  
Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 150 mm (pasture land in sandy soils)  
Precipitation data from Fergus Shand Dam Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Average Temperature (Degree C)	-7.4	-6.3	-1.9	5.7	12.2	17.5	20.0	19.0	14.9	8.3	2.1	-3.9	6.7
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.22	3.86	6.66	8.16	7.55	5.22	2.15	0.27	0.00	35.1
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	26.65	59.36	86.76	99.85	94.61	73.26	39.58	9.32	0.00	489
Adjusting Factor for U (Latitude 43° 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	30	75	111	129	114	76	38	8	0	579
<b>COMPONENTS</b>													
Precipitation (P)	68	56	60	74	87	84	89	97	93	77	93	69	946
Potential Evapotranspiration (PET)	0	0	0	30	75	111	129	114	76	38	8	0	579
P - PET	68	56	60	44	12	-27	-40	-17	17	40	85	69	367
Change in Soil Moisture Storage	0	0	0	0	0	-27	-40	-17	17	40	27	0	0
Soil Moisture Storage max 150 mm	150	150	150	150	150	123	83	66	83	123	150	150	
Actual Evapotranspiration (AET)	0	0	0	30	75	111	129	114	76	38	8	0	579
Soil Moisture Deficit max 150 mm	0	0	0	0	0	27	67	84	67	27	0	0	
Water Surplus - available for infiltration or runoff	68	56	60	44	12	0	0	0	0	0	58	69	367
Potential Infiltration (based on MOE methodology*; independent of temperature)	44	36	39	29	8	0	0	0	0	0	38	45	238
Potential Direct Surface Water Runoff (independent of temperature)	24	20	21	15	4	0	0	0	0	0	20	24	128
<b>IMPERVIOUS AREA WATER SURPLUS</b>													
Precipitation (P)	946	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/year											
P-PE (surplus available for runoff from impervious areas)	804	mm/year											

<--From Environment Canada

<--From J. M. Lorente (1961). pp. 206

<--From Environment Canada

Assume January storage is 100% of Soil Moisture Storage

150 mm

<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

\*MOE SWM infiltration calculations

topography - hilly land and rolling land

0.15

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

soils - sandy loam

0.4

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

cover - cultivated lands

0.1

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

**Infiltration factor**

**0.65**

Latitude of site (or climate station)

43 ° N.

**WATER BALANCE CALCULATIONS**

Homes in the Hills  
Erin, Ontario

Project No.300039324



**TABLE I-2**

<b>Monthly Water Balance Components</b>													
<b>Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 300 mm (woodland in sandy soils)</b>													
<b>Precipitation data from Fergus Shand Dam Climate Station (1981 - 2010)</b>													

<b>Potential Evapotranspiration Calculation</b>	<b>JAN</b>	<b>FEB</b>	<b>MAR</b>	<b>APR</b>	<b>MAY</b>	<b>JUN</b>	<b>JUL</b>	<b>AUG</b>	<b>SEP</b>	<b>OCT</b>	<b>NOV</b>	<b>DEC</b>	<b>YEAR</b>
Average Temperature (Degree C)	-7.40	-6.30	-1.90	5.70	12.20	17.50	20.00	19.00	14.90	8.30	2.10	-3.90	<b>6.7</b>
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.22	3.86	6.66	8.16	7.55	5.22	2.15	0.27	0.00	<b>35.1</b>
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	26.65	59.36	86.76	99.85	94.61	73.26	39.58	9.32	0.00	<b>489</b>
Adjusting Factor for U (Latitude 43° 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.2	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	30	75	111	129	114	76	38	8	0	<b>579</b>
<b>COMPONENTS</b>													
Precipitation (P)	68	56	60	74	87	84	89	97	93	77	93	69	<b>946</b>
Potential Evapotranspiration (PET)	0	0	0	30	75	111	129	114	76	38	8	0	<b>579</b>
P - PET	68	56	60	44	12	-27	-40	-17	17	40	85	69	<b>367</b>
Change in Soil Moisture Storage	0	0	0	0	0	-27	-40	-17	17	40	27	0	<b>0</b>
Soil Moisture Storage max 300 mm	300	300	300	300	300	273	233	216	233	273	300	300	
Actual Evapotranspiration (AET)	0	0	0	30	75	111	129	114	76	38	8	0	<b>579</b>
Soil Moisture Deficit max 300 mm	0	0	0	0	0	27	67	84	67	27	0	0	
Water Surplus - available for infiltration or runoff	68	56	60	44	12	0	0	0	0	0	58	69	<b>367</b>
Potential Infiltration (based on MOE methodology*; independent of temperature)	51	42	45	33	9	0	0	0	0	0	44	51	<b>275</b>
Potential Direct Surface Water Runoff (independent of temperature)	17	14	15	11	3	0	0	0	0	0	15	17	<b>92</b>
<b>IMPERVIOUS AREA WATER SURPLUS</b>													
Precipitation (P)	946	mm/year											
Potential Evaporation (PE) from impervious areas (assume 15%)	142	mm/year											
P-PE (surplus available for runoff from impervious areas)	804	mm/year											

<--From Environment Canada

<--From J. M. Lorente (1961), pp. 206

<--From Environment Canada

Assume January storage is 100% of Soil Moisture Storage  
Soil Moisture Storage

300 mm

<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

\*MOE SWM infiltration calculations

topography - hilly land and rolling land

0.15

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

soils - sandy loam

0.4

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

cover - woodland

0.2

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

**Infiltration factor**

**0.75**

Latitude of site (or climate station)

43 ° N.

**WATER BALANCE CALCULATIONS**

Homes in the Hills  
Erin, Ontario

Project No.300039324



**TABLE I-3**

Water Balance - Existing Conditions and Post-Development												
Catchment Area	Approx. Land Area* (m <sup>2</sup> )	Estimated Impervious Fraction for Land Use*	Estimated Impervious Area (m <sup>2</sup> )	Runoff from Impervious Area** (m/a)	Runoff Volume from Impervious Area (m <sup>3</sup> /a)	Estimated Pervious Area (m <sup>2</sup> )	Runoff from Pervious Area** (m/a)	Runoff Volume from Pervious Area (m <sup>3</sup> /a)	Infiltration from Pervious Area** (m/a)	Infiltration Volume from Pervious Area (m <sup>3</sup> /a)	Total Runoff Volume to Feature (m <sup>3</sup> /a)	Total Infiltration Volume (m <sup>3</sup> /a)
<b>Existing Land Use</b>												
Open Space	112,302	0.00	0	0.804	0	112,302	0.128	14,406	0.238	26,754	14,406	26,754
Wooded Lands (including Wetland)	144,073	0.00	0	0.804	0	144,073	0.092	13,201	0.275	39,604	13,201	39,604
<b>TOTAL PRE-DEVELOPMENT</b>	<b>256,375</b>		<b>0</b>		<b>0</b>	<b>256,375</b>		<b>27,608</b>		<b>66,359</b>	<b>27,608</b>	<b>66,359</b>
<b>Post-Development Land Use</b>												
Estate Residential	80,000	0.24	19,200	0.804	15,437	60,800	0.128	7,800	0.238	14,485	23,237	14,485
Roads and Road Widening	32,302	0.50	16,151	0.804	12,986	16,151	0.128	2,072	0.238	3,848	15,058	3,848
Wooded Lands (including Wetland)	144,073	0.00	0	0.804	0	144,073	0.092	13,201	0.275	39,604	13,201	39,604
<b>TOTAL POST-DEVELOPMENT</b>	<b>256,375</b>		<b>35,351</b>		<b>28,423</b>	<b>221,024</b>		<b>23,073</b>		<b>57,937</b>	<b>51,495</b>	<b>57,937</b>
% Change from Pre to Post											187	13
Effect of development (with no mitigation)											1.9 times increase in runoff	13% reduction in infiltration

\* data based on concept plans provided by R.J. Burnside

\*\* figures from Tables I-1 and I-2

To balance pre- to post-,  
the infiltration target (m<sup>3</sup>/a)= **8,422**

**WATER BALANCE CALCULATIONS**

Homes in the Hills  
Erin, Ontario

Project No.300039324



**TABLE I-4**

**Post-Development Monthly Water Balance Components**  
Based on Thornthwaite's Soil Moisture Balance Approach with a Soil Moisture Retention of 75 mm (urban lawn in sandy loam soils)  
Precipitation data from Fergus Shand Dam Climate Station (1981 - 2010)

Potential Evapotranspiration Calculation	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
Average Temperature (Degree C)	-7.40	-6.30	-1.90	5.70	12.20	17.50	20.00	19.00	14.90	8.30	2.10	-3.90	<b>6.7</b>
Heat index: $i = (t/5)^{1.514}$	0.00	0.00	0.00	1.22	3.86	6.66	8.16	7.55	5.22	2.15	0.27	0.00	<b>35.1</b>
Unadjusted Daily Potential Evapotranspiration U (mm)	0.00	0.00	0.00	26.65	59.36	86.76	99.85	94.61	73.26	39.58	9.32	0.00	<b>489</b>
Adjusting Factor for U (Latitude 43° 44' N)	0.81	0.82	1.02	1.12	1.26	1.28	1.29	1.20	1.04	0.95	0.81	0.77	
Adjusted Potential Evapotranspiration PET (mm)	0	0	0	30	75	111	129	114	76	38	8	0	<b>579</b>
<b>COMPONENTS - Pervious Areas in Residential Area with Mitigation</b>													
Precipitation (P)	68	56	60	74	87	84	89	97	93	77	93	69	<b>946</b>
Potential Evaporation (PE) from impervious areas (assume up to 15% of P)	10	8	9	11	13	13	13	14	14	12	14	10	<b>142</b>
P-PE (surplus water from impervious areas, e.g., roof runoff capture)	58	48	51	63	74	71	76	82	79	66	79	58	<b>804</b>
Roof runoff directed over pervious area (see Note 1)	14	11	12	15	17	17	18	19	19	16	19	14	<b>190</b>
Total water supply directed to pervious areas (rain plus total roof runoff)	82	67	72	89	104	101	107	116	112	93	112	82	<b>1136</b>
Potential Evapotranspiration from pervious areas (PET)	0	0	0	30	75	111	129	114	76	38	8	0	<b>579</b>
Total water available to pervious areas - PET = total potential surplus on pervious areas	82	67	72	59	30	-10	-22	3	36	55	104	82	<b>557</b>
Change in Soil Moisture Storage	0	67	8	0	0	-10	-22	3	30	0	0	0	<b>75</b>
Soil Moisture Storage (max 75 mm)	75	142	150	150	150	140	118	120	150	150	150	150	
Actual Evapotranspiration (AET) = PET	0	0	0	30	75	111	129	114	76	38	8	0	<b>579</b>
Soil Moisture Deficit (max 75 mm)	0	8	0	0	0	10	32	30	0	0	0	0	
Total water surplus available for infiltration or runoff on pervious areas	82	67	72	59	30	-10	-22	3	36	55	104	82	<b>557</b>
Potential Infiltration (based on MOE methodology*; independent of temperature)	53	44	47	38	19	-7	-14	2	23	36	68	54	<b>362</b>
Potential Surface Water Runoff (independent of temperature)	29	24	25	21	10	-4	-8	1	12	19	36	29	<b>195</b>

**Post-Development Water Balance Inputs:**

Assume January storage is 100% of Soil Moisture Storage

Soil Moisture Storage -Urban Lawns - sandy loam soils

75 mm

<-- See "Water Holding Capacity" values in Table 3.1, MOE SWMPDM, 2003

\*MOE SWM infiltration calculations

topography - hilly land and rolling land

0.15

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

soils - sandy loam

0.4

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

cover - cultivated lands

0.1

<-- Infiltration Factors from the bottom section of Table 3.1, MOE SWMPDM, 2003

**Infiltration Factor**

**0.65**

Latitude of site (or climate station)

43 ° N.

**Note 1: Roof Runoff Capture x Ratio**

**Ratio of Roof Areas to Receiving Pervious Areas**

Low Density Residential - assume 50% roof directed to 50% pervious area

0.24

**WATER BALANCE CALCULATIONS**

Homes in the Hills  
Erin, Ontario

Project No.300039324



**TABLE I-5**

Water Balance - Existing Conditions and Post-Development With Direction of Roof Runoff to Pervious Areas													
Catchment Area	Approx. Land Area* (m <sup>2</sup> )	Estimated Impervious Fraction for Land Use**	Estimated Impervious Area (m <sup>2</sup> )	Runoff from Impervious Area*** (m/a)	Runoff Volume from Impervious Area (m <sup>3</sup> /a)	Estimated Pervious Area (m <sup>2</sup> )	Runoff from Pervious Area*** (m/a)	Runoff Volume from Pervious Area (m <sup>3</sup> /a)	Infiltration from Pervious Area*** (m/a)	Infiltration Volume from Pervious Area (m <sup>3</sup> /a)	Total Runoff Volume (m <sup>3</sup> /a)	Total Infiltration Volume (m <sup>3</sup> /a)	
<b>Existing Land Use</b>													
Open Space	112,302	0.00	0	0.804	0	112,302	0.128	14,406	0.238	26,754	14,406	26,754	
Wooded Lands (including Wetland)	144,073	0.00	0	0.804	0	144,073	0.092	13,201	0.275	39,604	13,201	39,604	
<b>TOTAL PRE-DEVELOPMENT</b>	<b>256,375</b>		<b>0</b>		<b>0</b>	<b>256,375</b>		<b>27,608</b>		<b>66,359</b>	<b>27,608</b>	<b>66,359</b>	
<b>Post-Development Land Use</b>													
Residential Estate Lots	Roofs Directed to Pervious Areas	7,200	1.00	7,200	0.804	5,789	0	n/a	0	n/a	0	0 <sup>a</sup>	0
	Roofs and Driveways not Directed to Pervious Areas	12,000	1.00	12,000	0.804	9,648	0	n/a	0	n/a	0	9,648	0
	Pervious Areas Receiving Roof Runoff	30,400	0.00	0	0.804	0	30,400	0.195	5,926	0.362	11,005	5,926	11,005
	Pervious Areas Not Receiving Roof Runoff	30,400	0.00	0	0.804	0	30,400	0.128	3,900	0.238	7,242	3,900	7,242
Roads and Road Widening	32,302	0.50	16,151	0.804	12,986	16,151	0.128	2,072	0.238	3,848	15,058	3,848	
Wooded Lands (including Wetland)	144,073	0.00	0	0.804	0	144,073	0.092	13,201	0.275	39,604	13,201	39,604	
<b>TOTAL POST-DEVELOPMENT</b>	<b>256,375</b>		<b>35,351</b>		<b>28,423</b>	<b>221,024</b>		<b>25,099</b>		<b>61,699</b>	<b>47,733</b>	<b>61,699</b>	
% Change from Pre to Post											173	7	
Effect of development											1.7 times increase in runoff	7% decrease in infiltration	

\* data based on concept plans provided by R.J. Burnside

\*\* figures from Tables I-1 and I-2

<sup>a</sup> - runoff directed to pervious areas

To balance pre- to post-,  
the infiltration target (m<sup>3</sup>/a)= **4,659**

**Table I-6  
Feature Based Water Balance  
8th Line Erin**

Groundwater Flow Net Analysis					
Cell ID	$\bar{d}h$ (m)	$\bar{d}s$ (m)	$\bar{d}m$ (m)	FLOW m3/sec	FLOW m3/year
A	2	49.3	62.10	2.52E-05	794
B	2	52.2	42.10	1.61E-05	509
C	2	39.8	229.30	1.15E-04	3634
D	2	64.8	81.10	2.50E-05	789
E	2	43.8	43.70	2.00E-05	629
F	2	43.4	62.90	2.90E-05	914
G	2	87.9	71.30	1.62E-05	512
H	2	69.4	81.20	2.34E-05	738
I	2	52.4	47.60	1.82E-05	573
J	2	69.2	57.80	1.67E-05	527
K	2	79.6	63.20	1.59E-05	501
L	2	60.2	63.70	2.12E-05	667
M	2	51.3	66.00	2.57E-05	811
				<b>TOTAL</b>	<b>11,599</b>
K = 1.0000000E-05					
The computation is based on the following formula					
$dQ = K \frac{dh}{ds} dm$					
Where:					
Q = Flow volume					
h = hydraulic head					
s = length of flow cell					
m = width of flow cell					